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SPECTRUMPEDIA

English edition

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VOLUME 2

Introduction

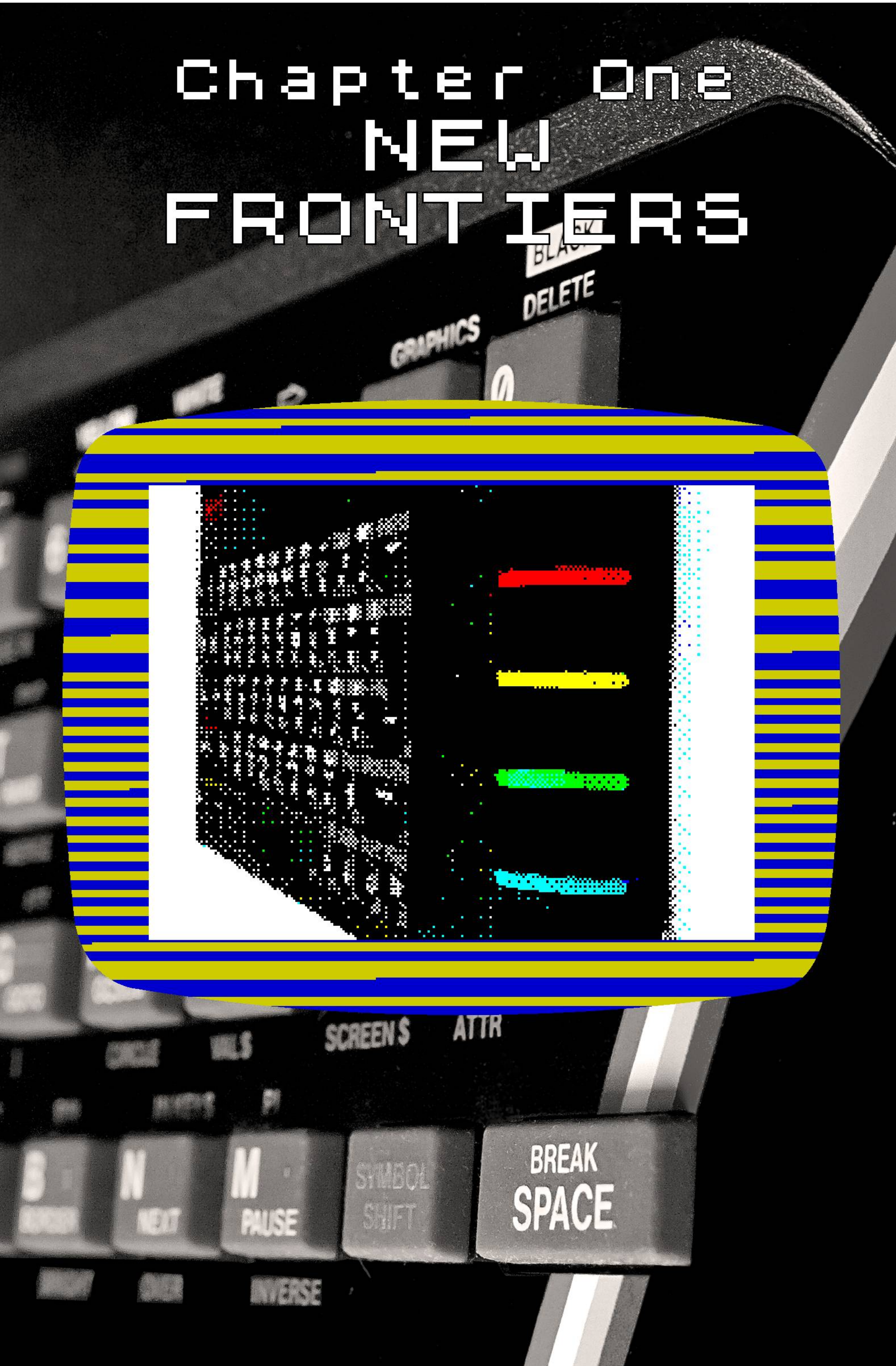
This work stems from the aspiration to bring together 40 years of activity and knowledge of the Spectrum from several points of view: historical, technological, cultural and so on. It was originally designed specifically for the Italian public, since the vast majority of the documentation used as a source is exclusively available in English, Spanish and Russian. That said, it can be valuable for everyone interested in the Spectrum or in retrocomputing and retrogaming in general.

The four chapters of this volume are arranged in the following order:

1. *New frontiers:* here, the most advanced achievements of the Spectrum enthusiast community are examined, from new hardware architectures to software coding, alternative graphic modes and peripherals created on the basis of the most recent research, to the interaction between the Spectrum and the PC.
2. *Emulation:* this chapter focuses on the concept of Spectrum emulation via software. It deals with file formats and programs that emulate the hardware of historical machines, clones and peripherals. The final part is dedicated to the emulation of other systems on the Spectrum itself.
3. *The Spectrum in Italy:* a presentation of the diffusion of the Spectrum in Italy and of the peculiarities of the Italian situations.
4. *Sources and more:* some general suggestions about websites concerning the Spectrum and everything else connected with it; a brief view at the only museum specifically dedicated to it; the bibliography and the list

of web resources used for this work, plus credits for the photos appearing in both volumes (except a few ones whose authors could not be identified at the moment of publishing).

Chapter One
NEW FRONTIERS



From 1993, when the production of the Spectrum was stopped, to the present day, the community of enthusiasts and independent hardware and software developers has continued to work, creating not only clones with extraordinary specifications, as seen in the previous chapter, but also a large quantity of peripherals and expansions, new architectures, extended video modes, utilities and games for the 'canonical' Spectrums as well as for their 'heirs'. Even the historical Sinclair brand has reappeared, on the ZX Vega video game console and the ZX Spectrum Next – the latter, in particular, aims to establish a continuity with the official line. There is no doubt that this phenomenon received huge impetus from the spread of the Internet and the practice of emulation, discussed in the second chapter.

In the following pages, a profile of this path is traced through the examination of hardware systems specifically connected to the Spectrum. It starts from those reassuming the Sinclair brand, then moves on to peripherals, alternative video modes, operating systems, utilities and games. It must be said that the amount of hardware and, above all, of software produced for the Spectrum by enthusiasts in the last two decades is such that it cannot even allow a completely exhaustive discussion here. Therefore, this chapter will deal with the most incisive innovations, and, for the Next, the fundamental features. Chapter four, where sources are listed, includes the indications for finding information on everything else.

This chapter does not deal with applications for creating and/or manipulating files for emulators; they are discussed in the next one.

SINCLAIR-BRANDED SYSTEMS

ZX SPECTRUM NEXT

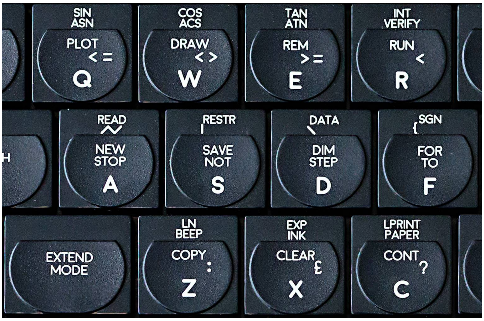
The ZX Spectrum Next was born as an evolution of the TBBlue, a motherboard designed by Victor Trucco and Fabio Belavenuto and based on the Brazilian Spectrum clone Microdigital TK95. Together with Henrique Olifiers, also Brazilian but resident in the United Kingdom for some time, the three, initially almost as a joke, planned to transform the TBBlue into a complete remake of the Spectrum and involve Rick Dickinson, the great designer responsible for the unmistakable style of all Sinclair computers from the ZX80 to the QL, into the project. Subsequently, several other developers joined, and at the beginning of 2016 the design phase of the new home computer began.

The fundraising campaign on Kickstarter starts in April 2017 with an initial goal of £250,000, which is reached after about a day and a half. Eventually £723,390 will be raised from 3,113 supporters. After the delivery of 'naked' motherboards, which took place as early as the end of 2017, complete units were sent

TECHNICAL SPECIFICATIONS	
Processor	Z80N at 3.5 MHz with ‘turbo’ modes at 7, 14 and 28 MHz
RAM	1 MB (internally expandable to 2 MB)
Video	2, 15, 256 and 512-colour modes at 256×192, 320×256, 512×192; hardware sprites, expanded ULA, Layer 2, Tilemap, Copper
Audio	9 channels via 3 AY-3-8912 stereo chips, plus 2 8-bit DACs
Keyboard	58 independent plastic elements on a synthetic rubber mat and underlying 5-layered contact membrane; multi-function cursor; automatic repetition for all keys, with user-definable interval and acoustic signal
Joystick	2 Cursor, Kempston and Sinclair compatible ports
Mass storage	Combined MIC/EAR input/output for loading from and saving to tape; SD card input compatible with DivMMC protocol
Connectivity	RGB, VGA, HDMI at 50/60 Hz video output; PS/2 port for mouse with Kempston emulation or external keyboard; expansion port; accelerator card connector
Optional hardware	Accelerator card with graphic processor, 1 Ghz CPU, 512 MB RAM, Wi-Fi module, real time clock
Operating system	NextZXOS and NextBasic with expanded command set; Multiface functionality for memory access, snapshots, cheats etc.
Dimensions (mm)	330×145×25

to backers. The enthusiastic reception of the Next then prompted the group of developers – who unfortunately lost Dickinson, passed away in April 2018 – to launch a second campaign on Kickstarter. It was even more successful than the first, accumulating as many as £1,847,106 given by 5,236 backers.

THE OUTSIDE



The Next takes up the main design lines and proportions of the 128, and thus sets itself already on a path of ideal continuity from this point of view. The plastic case is carefully assembled: the keyboard layout fully retains the appearance of the Plus and 128, with keywords and symbols engraved in white at the top of each key. To the touch, it is more comfortable than the original, both in typing and in gaming use, since the keys offer less resistance to pressure and are almost flat rather than concave, without the edges of the 'old type' ones. However, it is possible to use a PS/2 keyboard, or a USB one equipped with a special adapter, through the connector on the back. This can also be employed to attach a mouse for use with programs compatible with the Kempston mouse.

The elegance of the whole is then revealed in the group of four coloured plastic arches, placed on the right side, recalling the typical red-yellow-green-blue four-colour stripe, associated with the Spectrum since its first appearance. This element is only apparently decorative – its function is precisely to underline the Next's descent from the original series.

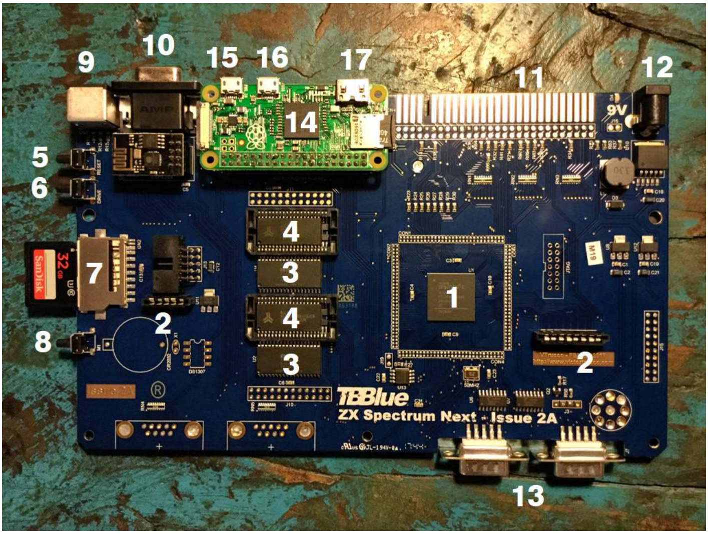
During the prototype's assembling stage, the red arch was ordered from the manufacturer twice, because the first came out in a sort of orange colour, too different from that of previous Spectrums. This gives an idea of how much care the design team took in transferring the Next from an abstract drawing to a real object, even in the most minute details. Also to notice is the rounded 'Sinclair' logo.

The back of the machine shows a series of connectors: VGA/RGB and HDMI video outputs, the stereo audio output and combined EAR/MIC output to connect a tape recorder (for both loading and saving), two USB Mini-A ports, the aforementioned PS/2 connector and the expansion port, protected by a cover. The two joystick ports are located on the front.

THE 'PERSONALITIES'

The Next can take on different 'personalities', thanks to the internal structure based on an FPGA –*Field Programmable Gate Array* – Xilinx Spartan 6 architecture. In very simple terms, an FPGA is a set of circuits that can be arranged and connected to each other in real time, so as to faithfully reproduce the operation of multiple platforms. In this case, the historical Spectrum models, including the 128 Investronica, and others such as the Brazilian Microdigital clones (not surprising, given the origins of the Next's creators), or alternative ROMs for the 48K like the GOSH Wonderful. There is also a setting that enables the timings of clones developed in the USSR. It is much more, then, than a simple emulation. Beyond the remarkable charm of being able to handle an 'exotic' machine without resorting to emulation on a PC, for a developer there is the indisputable advantage of being able to test the compatibility of their software even on these platforms, which although being less widespread still maintain their own user base.

The Next's operating system, called *NextZXOS,* is stored on a supplied SD card, also necessary for updating the firmware and for hosting software to be run on the computer. In practice, everything the machine has to be 'fed' with goes on the SD card, or another one which should include the necessary system files anyway, indispensable for booting up the computer.



Components of an 'accelerated' ZX Spectrum Next:

1) *FPGA chip*
2) *Keyboard connectors*
3) *Integrated 1024 KB RAM*
4) *Optional 1024 KB RAM on sockets*
5) *Reset button*
6) *DivMMC non-maskable interrupt button*
7) *SD card reader for the integrated DivMMC*
8) *CPU non-maskable interrupt button*
9) *PS/2 connector*
10) *VGA/RGB analog video output*
11) *Expansion port*
12) *9V power input*
13) *Atari-type joystick ports*
14) *Raspberry Pi Zero accelerator*
15) *Analog audio output*
16) *EAR/MIC connector*
17) *HDMI audio/video output*

Components 15-17 cannot be seen in the photo because they are covered by the accelerator card.

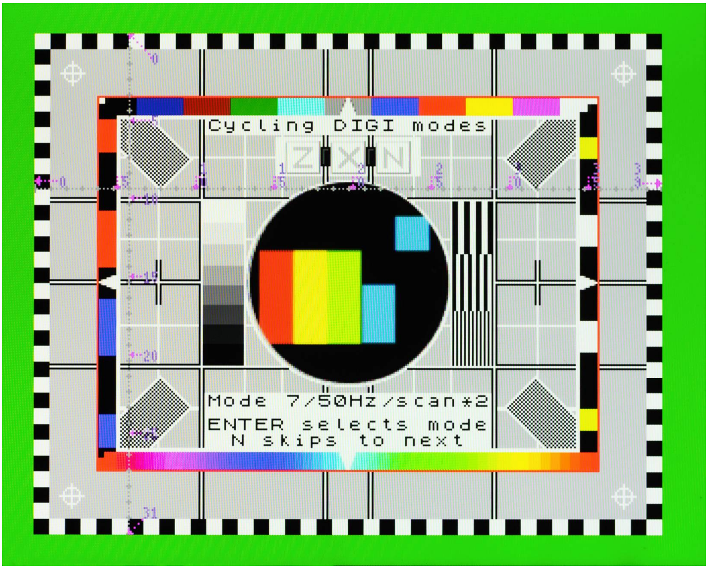
The 3.5 mm jack for loading from tape (and also for saving, since it combines the functionality of EAR and MIC) can only be employed when the Next is on. Among the 'personalities', there is the 128 with the DivMMC interface, which requires the ESXDOS system files to be copied on the SD card. This feature is particularly useful for those who already have such an interface and wish to load games, demos and applications already prepared for use with that device on the Next.

As additional hardware, the 'accelerated' configuration mounts an auxiliary Raspberry Pi Zero daughter board, which includes a graphics co-processor, a Wi-Fi module and a real-time clock. It has to be used within the main personality.

VIDEO MODES AND SCREEN MANAGEMENT

Video outputs are RGB, VGA and HDMI at 50 and 60 Hz. The best image quality is obtained with HDMI: pixels appear clearly distinct from each other, colours are bright and without 'smudging', and elements on the screen move smoothly.

This setting, however, has the drawback of not displaying multicolour – the effect obtained with graphic routines like BIFROST*, NIRVANA or similar – properly. The problem, as explained by the developers of the Next themselves, is due to the very nature of HDMI, which is more complex than VGA, and is not easy to solve. It is not a critical defect: after all, multicolour only appears in a small number of games and demos. However, when the Next is required to run software implementing these routines, there is no choice but 'falling back' on the VGA output, whose image quality is not in the same league of HDMI, although higher than RGB/SCART.



Test screen displayed by the ZX Spectrum Next during the video mode selection procedure

VGA modes are indicated by a number ranging from 0 to 6 and can, like HDMI, run at 50 or 60Hz. For a faithful recreation of the Spectrum, however, VGA 0 at 50Hz gives the best result, as the others cause an increase in the internal clock frequency clearly shown by a noticeable upward shift of audio frequencies. In other words, sounds are transposed up by a semitone with each mode change.

In any case, it is necessary to be armed with a certain amount of patience and check which of the modes ensures the greatest compatibility with the monitor, especially when it has an aspect ratio different from the 4:3 of the traditional Spectrum video image. To avoid getting a 'squashed' image on a 16:9 or similar screen, it is required to change the monitor settings until the desired image is displayed.

The VGA connector, unlike the HDMI one, does not carry the audio signal as well. To hear sounds produced by the computer a 3.5 stereo jack cable is therefore needed to connect the AUDIO OUT socket of the Next to an external speaker. This must also be done if the monitor does not have any speakers.

The Next allows you to manipulate the screen through four layers numbered from 0 to 3. Layer 2 can be assigned a priority bit so that what is displayed on it can 'cover' everything else, such as in the case of an element displayed upon a background in an animated scene. Other new features are a memory area dedicated to 16×16 sprites, viewable up to a maximum of 64 at a time, and the possibility of establishing a RAM block as the *Tilemap,* in order to store 8×8 and 16×16 graphic elements. Layer 3 and the sprite area also include the BORDER part, thus reaching a maximum resolution of 320×256 pixels. In addition to the video mode inherited from the historical Spectrum, there are two taken from the Timex Sinclair TS 2068: *HiColour* with 32×192 blocks of 8×1 pixels each, with specific attributes, and *HiRes,* 512×192 at two colours. Also present are the *ULAplus* and the two *Radastan* and *LoRes Layer* modes (the latter is also called *Radasjimian*). Both of them feature 128×96 blocks of 4 pixels each in a square pattern, which can take a single colour, with a maximum of 16 or 256 on-screen colours respectively. Layers 1 and 2 and the sprite area are arranged in 8 possible combinations using the LAYER OVER command, while PALETTE activates the expanded ULA functionality. The latter ignores the BRIGHT and FLASH values and ensures that INK and PAPER can assume up to 256 different values, taken from a palette of 512 total colours, for each individual pixel. Layer 3 has two graphics and text modes as well, at 320×256 pixels, 40×32 attribute blocks, and 640×256, 80×32 attribute blocks, both with 16 colours from a maximum of 256. They are not directly accessible from NextBASIC.

THE PROCESSOR AND THE COPPER

The Next's CPU is called *Z80N.* It is similar to a traditional Z80, but has some additional instructions and can operate at frequencies of 3.5, 7, 14 and 28 MHz.

The Next includes a co-processor called *Copper,* a term taken from the eponymous mode of the Commodore Amiga's *Agnus* chip. Its task is to update the Next's internal registers at regular intervals, synchronizing them with the screen refresh. Examples of Copper use are: sending sound samples to the audio circuitry, making rapid colour changes on the screen to obtain particular visual effects, modifying the priority of Layer 2, enabling or disabling the layers' modes and even more.

THE OPERATING SYSTEM

Written by Garry Lancaster, NextZXOS is the operating system of the Next and an evolution of the +3e/IDEDOS, also the work of Lancaster, in turn derived from the +3DOS of the Spectrum +3. The main features of NextZXOS are:

- FAT16 and FAT32 support;
- compatibility with IDEDOS/+3DOS;
- long file name support;
- proper subfolder/subdirectories;
- memory management facilities;
- virtual file systems in tape and disk images;
- menu-driven file manager with associations;
- ESXDOS emulation for every Spectrum-compatible machine with 'dot' commands support;
- automatic execution of software on boot;
- command-line interface;

- data streaming support;
- virtual memory support (swap partitions);
- timekeeping facilities;
- disk and file management on 48K legacy modes;
- compatibility with all ZX family computers;
- support for several snapshot formats;
- multi-lingual and multi-font capabilities;
- extended windowing facilities;
- increased speed of operation compared to the previous versions;
- proper CP/M 3 compatibility.

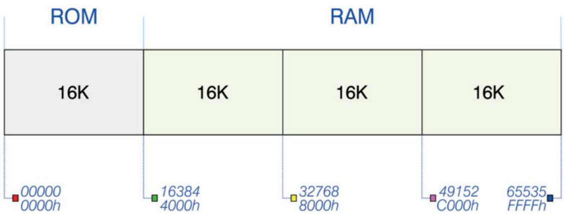
The programming language for interacting with NextZXOS is NextBASIC, based on Sinclair BASIC with the addition of several new features, some specific to the Next, others borrowed from other BASIC 'dialects'. Among the former, there is the display management by means of the SPRITE, LAYER and PALETTE commands and memory bank management with BANK. The latter include: the ON ERROR command to direct program flow in the event of an error; DEFPROC, PROC and ENDPROC for the creation of procedures capable of accepting up to 8 parameters; REPEAT, WHILE and REPEAT UNTIL to build more complex loops than those based on the canonical FOR and NEXT.

THE MEMORY

The Next's memory follows the traditional distinction between ROM and RAM, where the 'real' ROM does not identify with the computer's operating system as in the Spectrum, but contains the configuration of the FPGA board. The ROM of the personality selected by the user is recalled from a special INI configuration file present on the SD card hosting the

NextZXOS operating system and ROMs of other personalities, then copied to a special portion of the RAM that cannot be modified by the user, thus behaving like a ROM.

The RAM portions take the name of 'banks' in the Next too. Their configuration changes according to the current active personality. There are two: standard and MMU *(Memory Management Unit)*. In both cases, the CPU can address a total of 65,536 memory locations at a time, as usual.



ZX Spectrum Next standard memory configuration

The standard configuration follows that of the historical Spectrum: it is divided into four compartments of 16 KB each, of which the first houses the ROM. As in the +3, there are four banks available for the ROM, and 48, or as many as 112 in the Next expanded to 2,048 KB, for the RAM. The total amount is 832 KB, the rest is for other uses, such as for the DivMMC interface's memory. The total available RAM is therefore 768 KB, which becomes 1,792 in the expanded Next. Banks are managed through a specific BASIC command, BANK. In general, banks 9 and up are always available, and can be accessed by means of the BANK command, while for the others the following conditions apply:

- bank 0 can be used after a CLEAR that sets RAMTOP below address 49152;

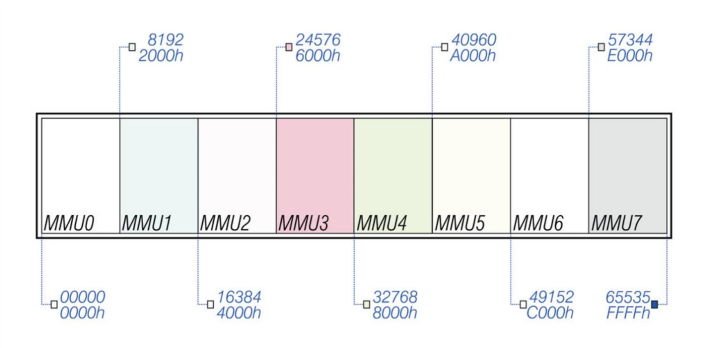
- bank 2 can be used after a CLEAR that sets RAMTOP below address 32768;
- banks 1, 3, 4 and 6 can be used after issuing a BANK 1346 USR command;
- banks 7 and 8 can never be used;
- bank 5 should be used with caution, as it contains the screen area and 48K system variables.

By default, banks 9, 10 and 11 are used by Layer 2, but can be employed for other purposes if Layer 2 is not being used or if they have been reassigned with a LAYER BANK command. Thus, on boot the four 16 KB slots contain the ROM and banks 2, 5 and 0 respectively.

Bank	Description	Range
0	Standard Spectrum 48K memory	49152-65535
1	RAM disk	
2	Standard Spectrum 48K memory	32768-49151
3	RAM disk	
4	RAM disk	
5	Standard Spectrum 48K memory	16384-32767
6	RAM disk	
7	NextZXOS workspace and data structures	
8	NextZXOS additional screen data and other	
9-111	Available for user programs	

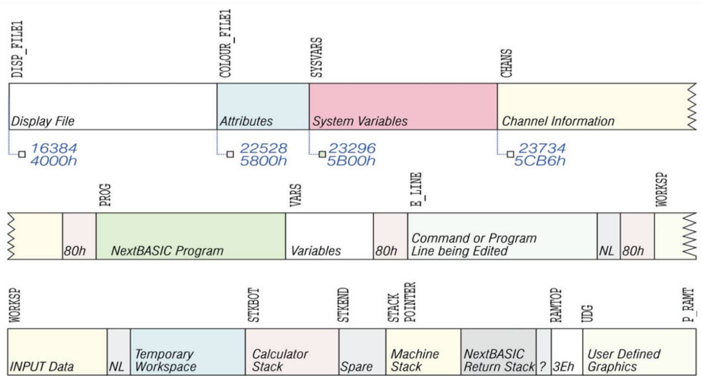
Default allocation of the ZX Spectrum Next's memory banks

The MMU configuration is more flexible and allows for the partition of CPU accessible memory into 8 slots of 8 KB called Memory Management Units. Each of them can contain an 8 KB RAM bank, therefore in this configuration the RAM includes 96 banks, or 224 on an expanded Next.



MMU memory configuration

However, this does not mean that the computer's memory can haphazardly accommodate everything. Just like the other Spectrums, the Next has a memory map too, which essentially recalls that of the previous models.



ZX Spectrum Next memory map

THE MENUS

The NextZXOS menu system is based on that seen from the 128 onwards and includes numerous items. The one displayed at start-up lists: a browser for files stored on the SD card; the command prompt, mainly dedicated to operations with disk devices (both real and virtual); the NextBASIC editor for programming, with support for 64 and 85 characters per column in addition to the canonical 32, and the ability to reorder line numbers of programs being written; the calculator; tape loading. Other menus allow for the use of CP/M functionalities, loading data stored on Sinclair ZX Interface 2 or Dandanator cartridges in both 48K and 128 mode and set the classic 48K and Plus command prompt. It is also possible to change the processor frequency between 3.5, 7, 14 and 28 MHz.

NextZXOS bootup menu

ZX SPECTRUM VEGA/VEGA+

On 8 July 2015, in the meeting room of the Highgate Road Chapel in London, the first Sinclair-branded hardware system since the APC386SX was officially presented: the *ZX Spectrum Vega*, or simply the 'Vega' for short.

Chris Smith, former author of Spectrum games and expert of the Sinclair computer's ULA, drew inspiration for the Vega from the TV-connectable joystick including 30 games for the Commodore 64. In 2012 Smith conceived a similar product, called 'Spectrastick'. From a meeting held in London that year in September came the idea of creating a console that echoed the lines of the Spectrum itself. With Clive Sinclair's support, Retro Computers Ltd (henceforth, RCL), a company aiming at carrying out the project, was founded. Then, a subscription was launched on Indiegogo, which quickly raised £155,682, well over the planned goal of £100,000. The initial production run at SMS Electronics Ltd's facility in Beeston, Nottinghamshire was of 1,000 units, to be distributed to fundraising patrons in

Germany, France, Italy, Spain, USA, Australia and other countries as well as in the United Kingdom. At the time of release, a second batch of 3,000 units was scheduled for market launch at a price of £100 (about €140) each.[1]

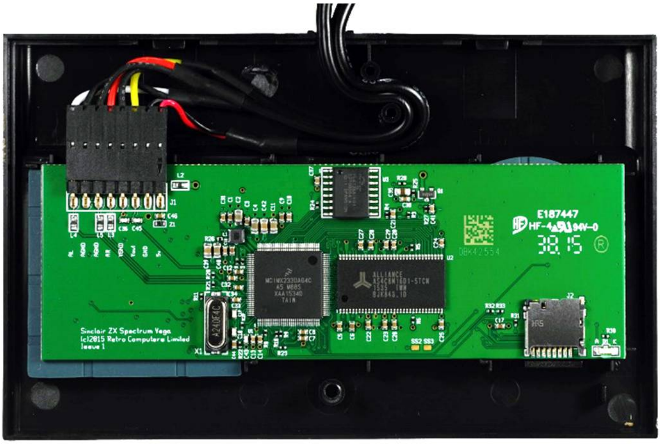
The Vega is a small video game console: dimensions are 18×10×2 centimeters and weight is very light, about 200 grams. It has to be connected to a TV through the RCA composite input and is compatible with PAL and NTSC systems. The external aspect shows on the left a red directional cross, on the right four buttons for commands such as fire, jump and so on; the vast majority of Spectrum games – at least arcade ones – do not use any more. Small buttons call up the options and game selection menus, superimposed while the currently running title is paused. As a whole, the Vega recalls the look of the 16/48K Spectrum; not even the four-colour strip in the lower right corner is missing. This is no coincidence, since the console was designed by Rick Dickinson.

One of the most important improvements in the test phase was the modification of the length of the 'teeth' operating the micro-switches placed under the directional cross, made in a single piece, in order to strengthen the impression, on the part of the user, of the correspondence between physical action (pressure on the device) and on-screen results.[2] The material of keys and buttons resembles the silicone-based compound of early Spectrums' keyboard mats.

The 'heart' of the Vega is an ARM SOC (*System On a Chip,* that is to say, a circuit including, besides the central processor,

[1] Author's interview to Chris Smith at the Vega presentation, *www.gamesark.it/mostra_speciale.asp?c=167201520002716132*
[2] *Ibidem.*

controllers to manage the other components) microcontroller containing the necessary firmware to interpret and execute the code of the games, stored in turn on a 16 MB SDRAM. The actual 'library' containing data to be recalled from time to time consists of a 64 MB SPI (*Serial Peripheral Interface,* a synchronous serial communication full-duplex bus) flash memory.



ZX Spectrum Vega inner view

All this is placed on a motherboard equipped with an input for a Micro SD expansion card, on which programs can be stored in formats readable by the Vega, i.e. TAP tape images or Z80 and SZX snapshots. This system allows for firmware update: once the code is saved on the Micro SD card, the console recognizes it and automatically makes the necessary changes. The Vega is able, without further hardware additions, to emulate both the audio beeper and the General Instrument AY-3-8912 sound chip mounted on Spectrum models from the 128 onwards, and to display additional colours for those games that employ the ULAplus advanced video mode.

Since it receives power for its operation through a special USB port, by means of an external power supply unit or by connecting directly to another USB port that may be present on the TV, the console does not require batteries.

Cousin Horace ***on the ZX Spectrum Vega***

Around a thousand games are distributed with the console, including some Ultimate titles, of which Rare, owner of the related rights, has for years denied distribution in digital form. A somewhat extravagant feature is that some text adventures are also included in this starter set. There is a way to enter text through a combination of movements with the directional cross, namely by selecting characters on an overlay window, similar to what happens with the options menu. However, typing commands into the parser that way requires enough patience to make it functional only when you need to enter keywords in order to advance to the next levels of a game spanning across different parts.

In February 2016, a second fundraising campaign was launched on Indiegogo for another console capable of running Spectrum games, but this time it would have been a fully portable one. Also designed by Dickinson, the new console, called *ZX Spectrum Vega+,* would have been equipped with a small liquid crystal display, and, like the previous model, a thousand pre-installed games, with the possibility of loading others through a MicroSD card.

ZX Spectrum Vega+

The campaign was overwhelmingly successful: just 48 hours after its start, the initial target of £100,000 had already been exceeded. The market launch was set for September 2016, still at a price of £100. 4,772 backers funded the project, gathering together a total of £512,790.[3]

Nonetheless, on 8 April 2016, shortly after the campaign's end, Smith and managing director Paul Andrews resigned from their positions at RCL, citing 'irreconcilable differences' with the

[3] *www.indiegogo.com/projects/the-sinclair-zx-spectrum-vega-plus-console* (click on 'About this campaign')

company's general manager, David Levy.[4] This was followed by a series of announcements, issued by RCL over the next two years and promptly disproven by facts, about the manufacturing and distribution of the first units, thus fueling a very long trail of controversy on the media and social networks.

Only on 26 July 2018, RCL announced the shipping of a first batch of 400 units, for those subscribers who had agreed to receive the console without preloaded games (except for a group of 18 titles, the work of Jonathan Cauldwell), since the company had announced that it was no longer able to maintain the rights to them.[5] Early comments were mostly negative: in particular, the poor quality of materials and build was highlighted.[6] Another reason for controversy was the discovery that the Vega+ emulated the Spectrum through Philip Kendall's open source *FUSE* emulator, unbeknowst to him. Moreover, *FUSE*'s GNU GPL version 2 distribution license and source code were not provided with the console.[7]

On 1 August, Sky Group Ltd, owner of the rights to the Sinclair brand obtained in July 2007 following the acquisition of Amstrad, confirmed the announced definitive revocation of

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[4] Rhiannon Williams, *Retro computer project directors row,* 9 August 2016, *www.bbc.com/news/technology-37023310*

[5] Matt Wales, *Backers have finally started to receive the beleaguered ZX Spectrum Vega Plus,* 30 July 2018, *www.eurogamer.net/articles/2018-07-30-backers-have-started-to-receive-the-beleaguered-zx-spectrum-vega-plus-but-early-impressions-arent-great*

[6] Leo Kelion, *Vega+ to be stripped of Sinclair and ZX Spectrum brands,* 1 August 2018, *www.bbc.com/news/technology-45024267*

[7] Gareth Cornfield, *ZX Spectrum Vega+ blows a FUSE: It runs open-source emulator,* 9 August 2018, *www.theregister.com/2018/08/09/zx_spectrum_vega_plus_hands_on_review/*

their concession to RCL, which, in fact, meant for the remaining backers the end of their hopes of receiving the console. This sparked further arguments between Levy and his former partners.[8]

In February 2019, RCL went into liquidation at the request of Private Planets Ltd, headed by a former director of RCL, Janko Mrsic-Flogel. Since then there have been no further developments; Vega+ patrons have given rise to several initiatives to get their money back, but their outcome is still uncertain.

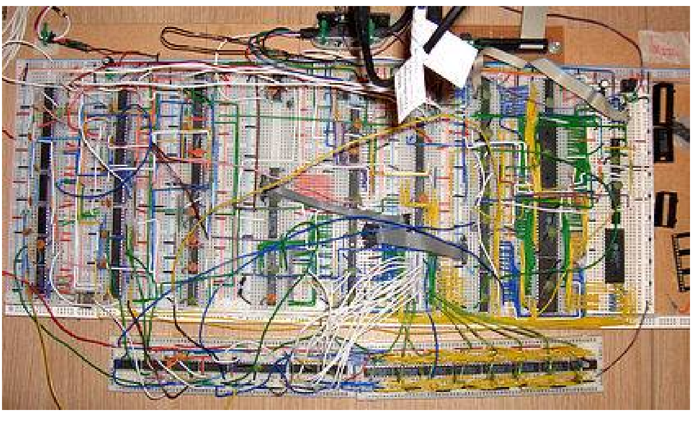
[8] Matt Wales, *Maker of the troubled Vega Plus told it can no longer use Sinclair and ZX Spectrum trademarks,* 1 August 2018, *www.eurogamer .net/articles/2018-08-01-maker-of-the-troubled-vega-plus-told-it-can-n o-longer-use-sinclair-and-zx-spectrum-trademarks*

SPECIFIC COMPLETE SYSTEMS

HARLEQUIN

The Harlequin is a work in progress by independent developers from different parts of the world. Initially born as a project to study the workings of the Spectrum ULA, it was gradually expanded, eventually becoming a new and interesting clone.

The story begins in Wales in 2007. Chris Smith, the already mentioned creator of the Vega and Vega+ consoles, finds some of his old notes on an EPROM programmer and a display project. He begins to investigate the ULA of the Spectrum, to reach a perfect emulation of the computer's video timings and repair those Spectrums that suffered damage to the ULA, since it is very difficult to obtain or replicate exactly. Project development was carefully noted by Smith on the *www.zxdesign.info* website, and in 2009 a working prototype was presented during a retrocomputing event in Oxford. Smith gave his brainchild the name of Harlequin.



Harlequin prototype

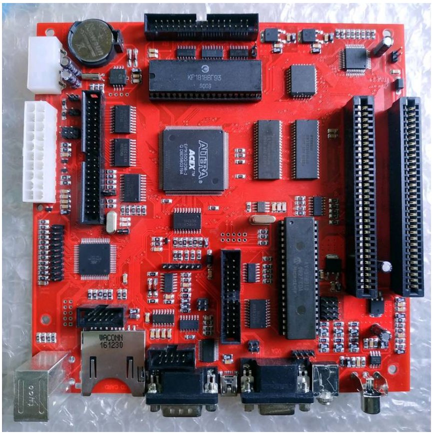
This prototype is able to recreate the operation of the ULA without using anything other than ordinary, easily available logic circuits. Based on this experience, Smith published a 324-page essay entitled *The ZX Spectrum ULA: How to design a microcomputer,* where he explained the genesis and structure of the Ferranti ULA and how the entire Sinclair machine was built around it.

The Harlequin revised and assembled by J. L. Novellón Martínez recognizes a DivIDE and its CF card (2012 test)

Smith's example is followed by an American amateur, known as Don 'Superfo', who designs a printed circuit diagram for the clone according to the previous indications, but arranged in such a way that it can be inserted into the case of a 16/48K Spectrum. This scheme is then further reworked in Spain by José Leandro Novellón Martínez and Miguel Angel Rodriguez Jodar. Martínez builds the first example of the Harlequin and tests it successfully in 2012.

The last revision of the documentation appeared in November 2015. Since then, many other enthusiasts have assembled 'their' Harlequins, or made other clones starting from its architecture.

ZX-EVOLUTION (ZX-EVO, PENTEVO)



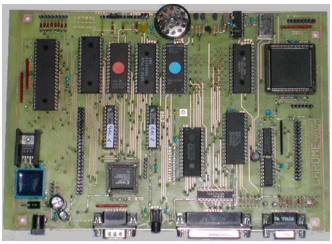
Also known by the abbreviated name of *ZX-Evo,* it is a project carried out by three members of the NedoPC collective: Vadim Alekseyevich Akimov ('Lord Vader'), Roman Pavelevich Chunin ('CHRV') and Dmitry Dmitrev ('DDP'). The first version, called 'revision A', dates back to 2009; it was followed by revisions B and C. Current technical specifications are:

- quad flat package Z80 CPU at 3.5 MHz (classic mode), 7 MHz ('turbo' mode without CPU wait cycles) and 14 MHz ('mega turbo' mode with CPU wait cycles);
- 4 MB RAM and 512 KB ROM;
- MiniITX (172×170 mm) mainboard with 2 ZX-Bus slots and FPGA Altera EP1K50 chip;
- ATMEGA128 microcontroller for peripherals;
- compatibility with PS/2 keyboard and mouse;
- interfaces for: Beta Disk-compatible floppy drive (WDC1793); IDE (one channel, up to 2 peripherals in master/slave mode); SD/SDHC memory card; RS232 with USB converter; printer;

- de-interlaced VGA video output;
- PAL codifier connector;
- AY, beeper and Covox (pulse frequency modulation) sound;
- compatible with original keyboard and joysticks;
- tape connector (input/output);
- internal real-time clock.

The ZX-Evolution can already emulate the Pentagon 1024 SL at hardware level (it is also called *PentEvo* for this reason) and the ATM Turbo +. If desired, the ZX-Evolution can also work with an unofficial firmware called *ScorpEvo* (from *Scorpion Evolution*), so that it can clone the Scorpion ZS 256 Turbo + as well.

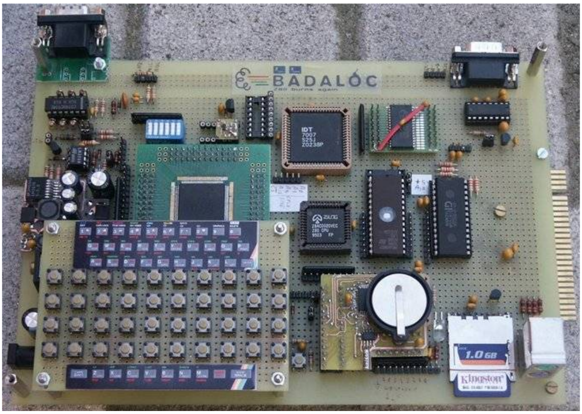
CHROME




Made by Mario Prato between 2003 and 2004 based on a previous project called *SpeccyBob,* the Chrome features an architecture based on two Xilinx CPLD *(Complex Programmable Logic Device)* chips. It has a 3.58 MHz Zilog Z80C processor, with the possibility of 'turbo' mode at 7 MHz, and can emulate both the 48K and 128. Includes 160 KB of RAM, in banks of 16 KB each, as well as 64 KB of ROM for the BASIC interpreter and floppy drive controller. The latter has an integrated Plus D interface, therefore allowing for the management of up to 2 drives for double-density 3” ½, 800 KB floppy disks.

The Chrome is also equipped with a standard Kempston compatible joystick interface, RGB SCART video output, parallel printer port, I2C interface, jack connector for tape recorder. Sound is generated by both the common beeper and the AY-3-8912 chip. An additional interface makes it possible to employ a common PC keyboard. The author declares 99.9% compatibility with the original Spectrum, stating that some demos do not yet run perfectly.

ZX-BADALOC

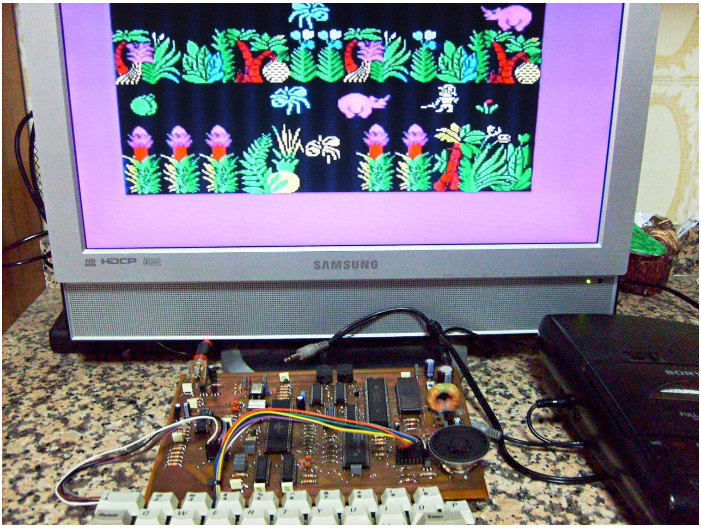


Designed by Alessandro Poppi in 2006, this clone of the 48/128/+2/+2A/+3 Spectrum owes its name to a typical expression used in Modena, Italy meaning ‘at full speed’, since the processor can run at 3.5, 7, 14, 21, 28 and 42 MHz. In 2008 the project undergoes a further evolution with the transition from a CPLD architecture to one based on a Xilinx Spartan-3E FPGA. This greatly simplifies its hardware structure, concentrating the functions of several chips in one and eliminating the problem of needing a mass of cable connections that plagued the previous version.

Video output for VGA monitors at 100Hz vertical is implemented by means of a scan converter integrated into the main circuit (ULA3). The converter's RAM is directly accessible to the Z80, which allows for a high-resolution video mode at 320×256 pixels, 4 bits per pixel, in addition to the standard one and the ULAplus. The firmware and the original ROMs reside on a flash ROM programmable through a RS-232 interface. The system RAM consists of 8 banks of 512 KB each. Sound is produced by both the beeper and the AY-3-8912 chip.

The Badaloc has a small matrix keyboard, later replaced by the original one of a 16/48K Spectrum. A mouse, PS/2 keyboard and programmable 16-input joystick can also be connected to the clone. A high-speed (1.3 Mb/sec) SD/MMC interface allows the user to capture snapshots of any running program. The firmware then makes it possible to change its name (32 characters) as well as its characteristics: Z80 clock, INT mode and so on. The date and time, read by a special date chip with a buffer battery, are also saved. The time required to recover a program captured in 128 mode is approximately 0.12 seconds, while for 48K mode it is 45 milliseconds. There are a 115 Kbit/sec UART receiver-transmitter and communication firmware as well, activated by means of a non-maskable interrupt, which interacts with a Windows program called *ZX-Com*. This way it is possible to read from or write to any memory area, change the processor frequency and other parameters, and capture a snapshot of the running program. This snapshot can be saved to disk, read back and sent back to the hardware, which then resumes execution from the point where it was stopped.

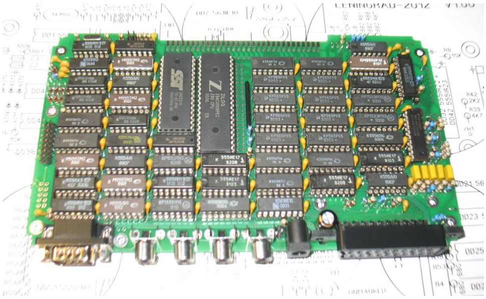
ZX-REMAKE



Gennaro Montedoro announced his Spectrum clone on 1 January 2009, indicating its main features: low consumption, only 360 mA; two 41464 DRAMs for the 16 KB bank; a 62256 SRAM for the 32 KB bank; just two voltages (+5V and +12V, the latter used only by the LM1889 chip); possibility of using the original Sinclair power supply.

The ZX-Remake is designed to be easy to make: compared to the original, there is a saving of 15 integrated circuits, i.e. 6 for the 16 KB bank, 7 for the 32 KB bank plus the two 74LS157 chips, which are unnecessary as the 62256 SRAM has all the addressing lines from A0 to A14, and being static it does not need to 'refresh', since it can be addressed directly by the CPU. Sound is limited to the classic beeper. The author claims that the clone is fully compatible with the Spectrum.

LENINGRAD 2012



This project takes up in its name the legacy of the Leningrad, the first Spectrum clone marketed in the Soviet Union, in 1987. Announced on 19 November 2011 by Vadim Mirzhanovich Sabirzhanov on the *zx.pk.ru* forum,[9] it is the continuation of an experimental device, the Leningrad 2010, by the same author. The Leningrad 2012 clones the 48K Spectrum and is based on a 6 MHz Z84C0006PEC CPU, with 8 K565RU5 RAM chips and 128 KB DIP-32 flash memory with SE BASIC firmware. The video circuitry has been redesigned in order to obtain a more stable image and ensure compatibility with ULAplus mode. Video output is RGB-SCART, a connection that also carries the audio signal to the TV. Other connectors are for PS/2 keyboard, Kempston joystick, MP3 recorder or player, ZX-Bus and Z-Connector.

ZX-UNO/ZX GO+/ZX-DOS/GOMADOS+

The ZX-Uno project was started in Spain in 2013 with the aim of creating a clone of the entire Spectrum range, taking advantage of the possibilities offered by FPGA architecture. Over a period of three years, it reached its goal.

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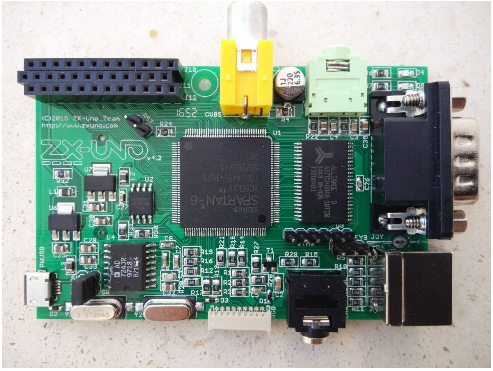
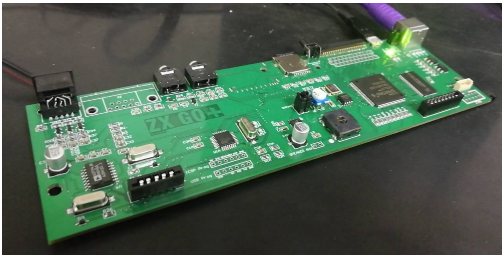
[9] *zx-pk.ru/showthread.php?p=437581*



ZX-Uno

The ZX-Uno takes on the personalities of the 48K and 128 Spectrum and of the Russian Pentagon clone. Others, up to a maximum of 8, can be assumed if ‘cores’, i.e. instructions for setting up the FPGA circuitry according to a certain platform’s hardware architecture, are added to the firmware. Available cores include, among others, the Commodore 64, Amstrad CPC 464, SAM Coupé, BBC Micro, Apple II and Atari 800XL, plus the Sega Master System and Nintendo NES video game consoles. Clock frequency can range from the canonical 3.5 MHz to 7, 14 and 28 MHz. Video modes, in addition to the classic one, include the 8×1 and HiRes 512×192, seen on the Timex Sinclair TS 2068, Radastan and the ULAplus. It also features composite video output, PS/2 connectors and Kempston mouse, multi-standard joystick port (Kempston, Sinclair, Protek or Fuller), two AY sound chips for Turbo Sound, integrated SpecDrum interface, EAR input for loading from tape.

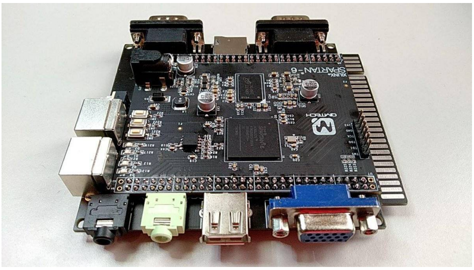
Its mass memory is an SD card formatted as FAT 16 or 32 and managed through a DivMMC interface with ESXDOS operating system. The ZX-Uno has 512 KB of total RAM, but normally only 384 are accessible to the user; 128 are reserved for the DivMMC. The whole RAM can only be used by manipulating a special register called MASTERMAPPER, but with caution, because there is a risk of overwriting the areas of RAM reserved for the copy of the currently active machine's ROM and ESXDOS system files. A revision of the ZX-Uno features 2 MB of RAM, VGA video output, 16 MB flash chip for 45 different personalities and 2 joystick ports.



ZX GO+

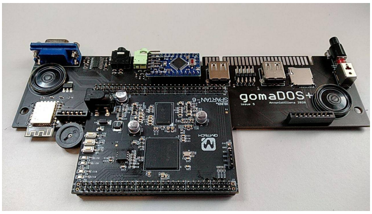
The *ZX GO+* is a derivative of the ZX-Uno designed by Manuel Fernández ('ManuFerHi') for assemblage into a 16/48/+ Spectrum case, although it retains compatibility with external PS/2 keyboards. To save space, it uses a Micro SD card as its mass storage.

The *ZX-DOS* is the evolution of the ZX-Uno. Developed by Antonio Villena, it is based on a Xilinx Spartan 6 XC6SLX16 FPGA board, the same as the Next, whose core it can run. Compared to its predecessor, it adds advanced features, such as the ability to disable memory sharing for total compatibility with the Pentagon 128, choose whether the Spectrum keyboard should be read according to the Issue 2 or 3 standard, select ULA timings between 48K, 128 and Pentagon 128 and the screen refresh rate for VGA output, activate and deactivate the registers for memory banks management, load another core directly from the main Spectrum one, and so on.



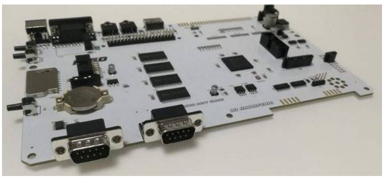
ZX-DOS

The *gomaDOS+*, another work by Antonio Villena, is the ZX GO+ equivalent for the ZX-DOS.



gomaDOS+

N-GO

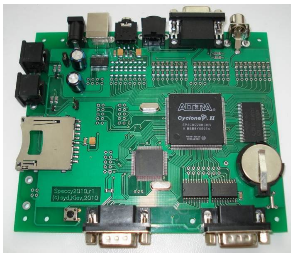


Clone of the 'accelerated' ZX Spectrum Next with 2 MB RAM, developed by Manuel Fernández. It is supplied as a 'naked' motherboard to be installed within that machine's case, or for use with a PS/2 keyboard and a compatible 5V/2A power supply unit. It includes the ZX-Uno personality alongside the Next one.

SPECCY 2007/2010

In December 2007, Pyotr Kitsun ('Syd'), from Kiev, published the schematics for the *Speccy 2007,* a clone of the 48K Spectrum he made with only eight components: Z80 processor, Altera EPM7128 CPLD, ATMega16 AVR microcontroller, two static RAM 62256 microcircuits, ROM, two AP6 buffers. The microcontroller manages a PS/2 keyboard and an SD/MMC card to load TAP, TZX and SNA files. In March 2008, support for TR-DOS was implemented through the new ATMega32 microcontroller. The clone is not completely compatible with the original Spectrum: port 255 (FFh) is missing, the processor slows down during 'polling' (peripherals status check routinely performed by the CPU) of port 254 (FEh), and internal timings are different.

Speccy 2007



Speccy 2010

Building on this experience, Kitsun created another clone, the *Speccy 2010,* which expands the characteristics of the previous one and corrects its defects. Based on an EP2C8Q208C8N FPGA and an ARM STR755FV2T6 or STR750FV2T6 microcontroller programmed by means of a special USB port, the second clone mounts 16 MB of SDRAM (32 in an alternative configuration). Video outputs are RGB, composite, S-Video and VGA. It also features two PS/2 connectors for keyboard and mouse and two standard Atari joystick ports.

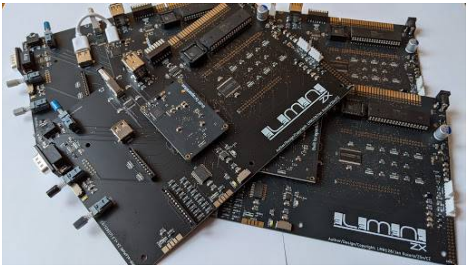
ZXM-777/ZXM-PHOENIX/ZXM-ZEPHYR

Starting in 2006, Mikhail Tarasov designed and built three Spectrum clones inspired by the KAY-256: the *ZXM-777, ZXM-Phoenix* and *ZXM-Zephyr* (left), all developed on a mATX board with a TMPZ84C00-8 CPU at 3.5 MHz and 7 MHz 'turbo' mode. The 777 has 64 KB of ROM and 128 of RAM, the Phoenix 64 KB of ROM and 1024 or 2048 of RAM, the Zephyr 512 KB of ROM and 512 or 1024 of RAM. Sound is produced by the classic beeper as well as a YM2149F chip; the Zephyr adds a SA1099 alongside them.

The Phoenix and Zephyr include the Nemo IDE controller for two ZX-Bus type slots and integrate the ZXMC card (ZX Multi Card) developed by Kamil Karimov from ATMega8515 and ATMega162 microcontrollers. The ZXMC plugs into the Spectrum expansion port and the ZX-Bus slot, for clones that have one. It offers connectivity with PC/AT keyboards, PS/2 and Kempston mouse and external modems with RS232 interface. It includes a real-time clock, too.

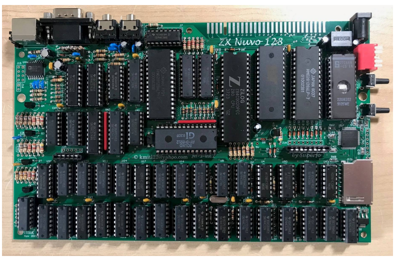
ELEMENT ZX

Clone made in 2021 by Jan Kučera, to be used in conjunction with an Alchitry Au Artix-7 FPGA board and inserted into a +2/+2A case. The core includes the personalities of the 48, 128 and +2A Spectrum, and of the Pentagon 128, 512 and 1024 v2.2. The processor can be adjusted normally at 3.5, 7, 14 and 20 MHz or overclocked at 22, 28 and 30 MHz. The memory is a 2048 KB SRAM, expandable to 4096 KB. Available video modes, in addition to the legacy Spectrum one, are 8×1, HiRes 512×192 in two colours, Gigascreen, Radastan, ULAplus and two native ones: HiResColour (512×192 with 64×48 attribute blocks) and HiResTrueColour, similar to the ULAplus but with an expanded colour palette.



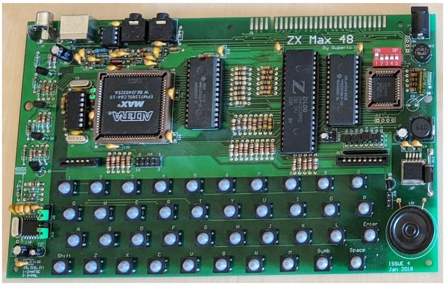
Regarding audio, the eLeMeNt ZX is equipped with two TurboSound FM chips, is compatible with SounDrive, Stereo Covox and SpecDrum and includes implementation for the MOS Technology SID chip. It has an interface for DivSD type SD cards, with ESXDOS operating system and Beta Disk and Z-Controller emulation. There is also the possibility of including firmware cores of other platforms, for example ZX Spectrum Next, KAY, Profi, Scorpion, SAM Coupé, ZX-Uno.

ZX NUVO 128



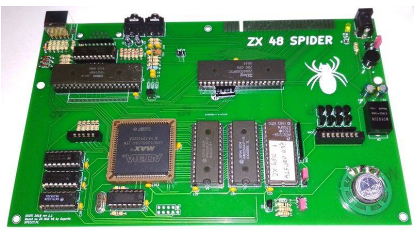
Another creation by Don 'Superfo', the Nuvo is a clone, also derived from the Harlequin, of the Spectrums with 128 KB RAM. The most recent version is 4 which can host the ROM of the 128, +2, + 2A, +3 and + 3e Spectrum, the latter created by Garry Lancaster. It can use two SD cards managed by a DivMMC with 128 KB of RAM and an external floppy drive interface for use with the +3 ROM. Includes RGB and composite video outputs and a Kempston joystick port.

ZX MAX 48



This computer is another variation of the Harlequin made by Don ‘Superfo’. It is a clone of the 48K Spectrum with an Altera Max7000 EPM7128S CPLD. The card is designed to fit inside the case of a ZX81. In addition to the normal 48K features, it includes a double capacity EPROM (2×16 KB) to mount alternative ROM images, AY sound chip with stereo output, Kempston joystick interface and RGB and composite video outputs.

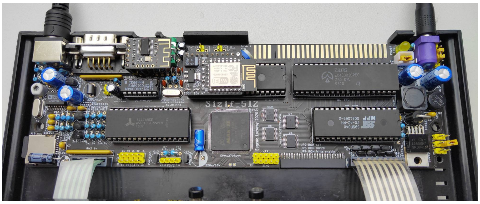
ZX 48 SPIDER



Clone of the 48K Spectrum created by a developer known as ‘konkotgit’, based on the ZX Max 48. It can be inserted in an original case.

ZX SIZIF-512

Designed by Russian Eugene Petrovich Lozovoy (‘UzixLS’), the Sizif-512 is based on the Altera EPM1270 CPLD architecture, can fit inside a 48K Spectrum case and takes on the personalities of the 48, 128, +3e Spectrums and Pentagon.

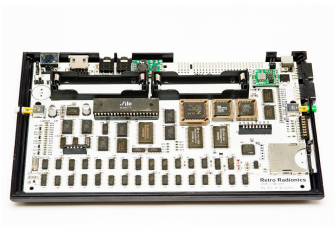


It features a Z80 processor with selectable frequency at 3.5, 4.4, 5.2, 7 and 14 MHz, 512 KB RAM and an AY-3-8910 sound chip with adjustable ABC, ACB or mono output as in a historical Spectrum, with support for Covox mono and SounDrive. It includes the ULAplus video mode, while video outputs are analog PAL/RGB and digital, for EGA monitors and VGA deinterlacing filters (‘scandoubler’). The Sizif-512 uses microSD cards as mass memories with an integrated DivMMC interface and can load from real tape via a 3.5 jack and Bluetooth. It can be also fitted with a Wi-Fi module managed through a software designed by Aleksandr Sharikin (‘Nihirash’).

HUMBLE 48

A small clone of the 48K Spectrum, compatible with the original case. It is equipped with a real Z80 CPU, the rest is implemented via a Xilinx 95144XL CPLD chip. The latest revision is 3.1b of 10 December 2017.

ZX OMNI 128HQ

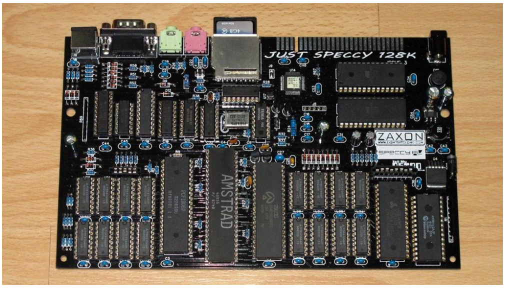



Clone produced by RetroRadionics, a company founded by Serbian developer Djordje Mitić. The Omni derives from the Harlequin and is equipped with 128 KB of RAM, an integrated DivMMC interface to manage two SD cards, two Atari joystick ports, RGB and composite video outputs (HDMI is optional), Wi-Fi card. It is available in three configurations: naked motherboard without accessories; placed in a 48K Spectrum replica case; as an unusual 'laptop' with a 9-inch LCD screen.

KARABAS-128

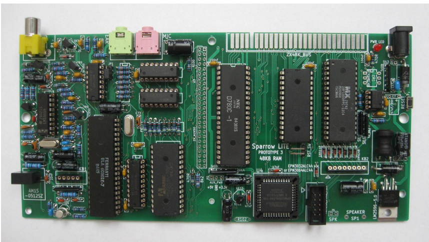
The Karabas-128, a work by Ukrainian Andy Karpov, is a clone of the Spectrum 128 based on the Altera EPM7128STC100 CPLD. It takes its cue from the Harlequin 48K (rev. G) and the Speccy 2007. It is currently in the working prototype stage (rev. B1).

JUST SPECCY 128K



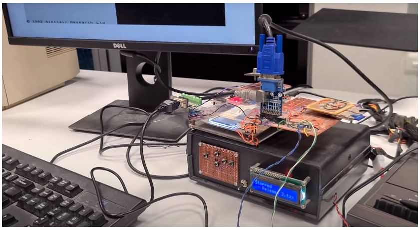
Clone made in Poland by Piotr Bugaj ('Zaxon'). The board can fit in a 16/48/+ Spectrum case. It is equipped with 128 KB of RAM, RGB video output, stereo AY sound, integrated DivMMC interface with ESXDOS operating system, Kempston joystick port, non-maskable interrupt button.

SPARROW 48K



Previously known as Sparrow LITE, it is a project by a Czech developer known as 'Jiiira' aimed at reviving old, out-of-order 48K Spectrums. Some of the original chips, such as the ULA, are mounted on a board of the same size as the original, while others are replaced by more modern components. For instance, the 74LS chips are replaced by an Altera EPM3032ALC44 CPLD, the ROM is housed in a 128 KB flash memory, capable of containing 8 ROMs of 16 KB each and video output is composite instead of RF. At the moment, the Sparrow 48K is in the working prototype stage, fourth revision.

PRISM

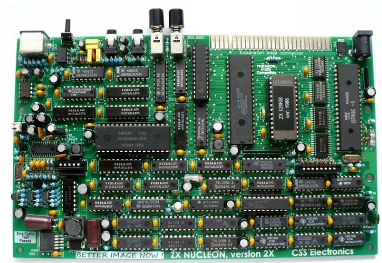


The ZX Prism 512 project was started in 2011 by Jeff Braine. It is a Spectrum clone currently based on an Altera Cylclone IV EP4CE15 FPGA with 512 KB RAM. It includes the 16/48/128/+2A/+3 firmwares and the +3e and SE BASIC 4 alternative ROMs. CPU frequency can be set to 3.5, 7, 14 and 28 MHz. It integrates the functionality of the ZXMMC interfaces and DivMMC.

The clone is characterized by the presence of a large number of video modes, some not found elsewhere, including: 128×128 and 256×128 at 256 colours per pixel; 256×192 at 16 colours per pixel; 128×192, 128×384 and 256×384 at 4 colours per 4×8 pixels block; 512×192, 256×384 and 512×384 with standard attribute mapping; Gigablend, a hardware implementation of Gigascreen; 8×1; HiRes 512×192 with two colours; Radastan mode; ULAplus. As for audio, the Prism integrates three YM2149F chips for Turbo Sound and AY sound, SounDrive and SpecDrum, the SAM Coupé SAA1099 chip and two sigma-delta modulators for audio output.

Development of the Prism is still ongoing. Braine has built a working prototype, shown at the September 2021 meeting of the Amiga Retro Group in Brisbane (Australia). An interview to Braine, done on that occasion, can be seen at this address: *youtu.be/cO-PU2gwq44*

ZX NUCLEON



The ZX Nucleon, a project by Czech company CSS Electronics, is conceived for compatibility with the Pentagon 512, rather than with historical Spectrum models. The motherboard is designed to fit into the original case or a replica of it, being the same size as that of an Issue 3B Spectrum. The Pentagon was chosen as the basis for the clone to make a ‘new’ Spectrum able to run those programs written for the Russian clone that are not compatible with the original machine due to the Pentagon’s peculiar timings.

Although the maker claims that the ZX Nucleon ‘is somewhat 90% identical in terms of hardware’ to the Pentagon 512, there are a number of differences between the two machines. Among them: the absence of a Beta Disk floppy controller, both for reasons of space and because that interface is not so widespread in Europe, unlike Russia, so that each user can connect the storage they prefer; an expansion port largely compatible with the 48K/128 Spectrum; a completely redesigned RGB and video signals circuitry; the possibility to disable the 512 KB RAM paging and put the computer in 128 KB mode to enhance software compatibility.

The first fully working version was 1B, in August 2019. The latest is 3B, released in April 2021.

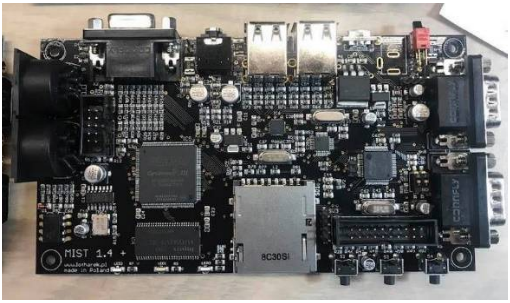
NON-SPECIFIC COMPLETE SYSTEMS

This section focuses on those recent complete systems that do not originate as a specific hardware recreation of the Spectrum, but provide for the possibility of it. These are mostly FPGA-type architectures. It is worth reminding that FPGA stands for *Field Programmable Gate Array:* in very simplified terms, the FPGA is an integrated circuit made up of millions of microscopic switches called 'logic gates', which can be arranged, through a specially designed programming, in a myriad of different ways, in order to reproduce the operation of other integrated circuits. This programming is made possible by the FPGA's internal memory, which houses the necessary data for the logic gates arrangement. A data set for reproducing the workings of a whole determined hardware platform is called a 'core' and allows the device, in practice, to 'turn' into it, assuming, so to speak, its 'personality'.

MIST/MISTER/MISTICA/SIDI

The *MiST* is an Altera Cyclone EP3C25 FPGA-based system and features 32 MB of 16-bit SDR-SDRAM with VGA video output, analog stereo audio output, two Atari joystick ports, SD card slot, four USB ports and a Micro USB port. The latest revision is 1.4.

The MiST was born in 2016 on the initiative of Przemyslaw Krawczyk, a Polish Atari enthusiast better known under the pseudonym of 'Lotharek', with the aim of recreating the main 16-bit platforms of the 1980s on a single device, that is, the Atari ST, Amiga and Apple Macintosh. Subsequently, the community of enthusiasts developed cores to implement the personalities of many other 8 and 16-bit computers, including, in addition to the various Spectrum models (including the Next), the ZX81 and QL: Commodore 64, VIC-20 and C16/Plus 4, Amstrad CPC, Atari 800/XL, BBC Micro, TI-99/4A, SAM Coupé, Acorn Archimedes (a 32-bit platform). There are also cores for videogame consoles such as the ColecoVision, Sega Master System and Megadrive, Nintendo NES, SNES and Gameboy, PC Engine and even for about 200 coin-op games.



MiST board revision 1.4

As for the Spectrum core, it recreates the personalities of the 48K, 128, +3 and Pentagon 128 with Pentagon 1024 and Profi memory cards; for the Next there is a separate core. The CPU can be accelerated to 7, 14, 28 and 56 MHz. It includes Timex 8×1 and HiRes 512×192 video modes and the ULAplus, and Turbo Sound audio modes with two YM2149F chips and General Sound. It integrates the +3DOS functions for the +3 floppy disk drive and the Beta Disk, Plus D, DivMMC, ZXMMC, Multiface 128 and +3 interfaces. It reads TZX, TAP and CSW tape image files, IMG, DSK, MGT and TRD disk images and can also load from tape, using a suitable adapter.

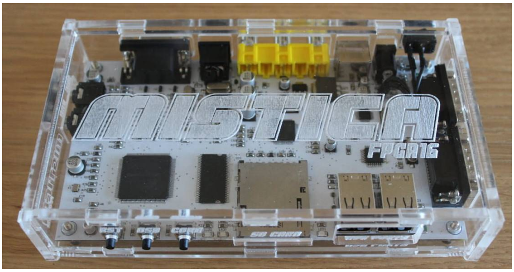
Derived from the MiST, the *MiSTer* is an open source project started by Aleksey Melnikov ('sorgelig'), later joined by other developers; together they form a group called MiSTer-devel.

The main board is a Terasic DE10-Nano, equipped with an Altera Cyclone V SE FPGA, dual-core ARM Cortex A9 processor and 1 GB DDR3 RAM. It can be fitted with daughter cards to expand its functionalities. In particular, the developers recommend a card with SDR-SDRAM, in order to lighten the workload of the mainboard memory, shared between the CPU and the FPGA, and to recreate the RAM timings of older systems.

The MiSTer has audio/video HDMI output, but if desired, an I/O daughter card can be added, with VGA video output and analog stereo audio output through a 3.5 mm jack. In turn, a small adapter with another 3.5 mm jack for audio input can be mounted on this card, in order to load programs from an external tape recorder.

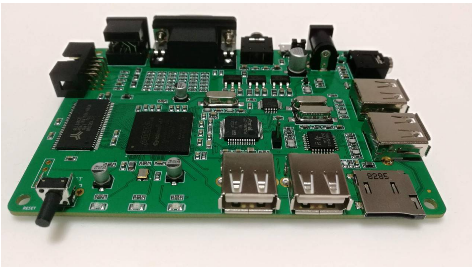
MiSTer complete configuration with daughter boards and cooling fan

Like the MiST, the MiSTer uses SD cards for mass storage. Internal operations are handled by a custom operating system, based on Linux Ubuntu 16.04. Currently available cores are numerous and include, in addition to those already listed for the MiST, many other platforms, both computers and consoles, for example: Commodore PET, Sharp MZ, TRS-80 Model 1, Altair 8800, Mattel Intellivision, Sega MegaCD, Atari Lynx, SNK NeoGeo.



Mistica in a transparent case

The *Mistica* is another machine similar in design to the MiST, based on the Altera EP3C25E144 FPGA with an ARM AT91SAM7S256 I/O microcontroller and 64 MB of SDRAM. It has VGA, RGB DIN9, composite RCA and SVideo video output. The 3.5 mm audio output is flanked by a connector of the same type for audio input from a cassette recorder. It shares its cores with the MiST.



SiDi

The *SiDi,* developed by Manuel Fernández ('ManuFerHi'), is designed as a low-cost alternative to the MiST. Its FPGA is an Altera Cyclone IV EP4CE22 with 32 MB of 16-bit SDRAM and an ARM AT91SAM7S56 I/O controller. Video outputs are VGA and RGB DIN9, the audio one is analog stereo. It uses MicroSD cards and has a 3.5 mm jack connector for tape loading.

NEPTUNO

Platform designed and built by Antonio Villena around an Altera Cyclone IV EP4CE55F23C8N FPGA. It has 8 MB of flash RAM for the system cores to be implemented, 32 MB SDRAM and 2 MB SRAM. It uses MicroSD cards and has a 3.5 mm jack connector for tape loading. Includes: VGA video output, two Atari joystick ports, PS/2 connector, ESP8266 Wi-Fi module, ZX-DOS-compatible expansion port.

RETROPIE

Operating system dedicated to the emulation of several home computers and videogame consoles. It was designed for installation on the Raspberry Pi microcomputer (hence the name), or, alternatively, Odroid C1/C2 and PC with Linux Ubuntu or similar distributions (Debian, Mint). To do this, other peripherals must be connected to the microcomputer: keyboard, mouse, power supply unit and HDMI or RCA cable to connect it to a monitor or TV. The management firmware, emulator code and finally the ROM, tape or disk image files to read must be copied onto the MicroSD card employed by the device. Games can also be controlled by USB joysticks or joypads. In the case of the Spectrum, the emulator can be *FUSE*, its derivative *LR-FUSE* (for use with the API Libretro programming libraries) or *FBZX*. RetroPie relies on it to read files of the following types: SNA, SZX, Z80 snapshots; TAP, TZX tape images; UDI, MGT, IMG, TRD, SCL, DSK disk images; GZ compressed archives.

VIRTUAL SYSTEMS

'Virtual systems' means hardware architectures developed starting from that of the Spectrum that did not reach the working prototype stage, or remained at the design stage. They exist only as virtual machines, emulated by some programs.

ZX SPECTRUM SE

A system designed by Andrew Owen and Jarek Adamski with the intention of merging the features of the Timex Sinclair TS 2068 and Timex Computer TC 2048 into an architecture compatible with Spectrum software. The CPU is a 3.5 MHz Z80A like for the Spectrum, the ROM is replaced by a 64 KB EPROM equipped with an exact copy of the Spectrum BASIC, plus Beta Disk ROM calls. Total RAM is 280 KB, divided into three blocks called EX, DOCK and HOME of 64, 64 and 144 KB respectively, together with 8 KB PRAM (Parameter RAM). HOME represents the entire Spectrum standard memory (including contention between 16384 and 32767). EX and DOCK are divided into 8 memory banks of 8 KB each, accessible according to different configurations. Video modes include the Timex ones, i.e. 8×1 with 15 colours and Hi-Res 512×192 with two colours. The 'snow' effect of the traditional ULA, also present in the TC 2048 video circuitry, has been corrected. The ZX Spectrum SE is emulated by *EightyOne* and *FUSE.*

CHLOE 280 SE/140 SE

Originally, the Chloe 280 SE was a blueprint for the production of the ZX Spectrum SE. It later became another kind of FPGA-based design, not related to the Spectrum. There are several differences between its technical specifications and the original idea. The CPU is a Z84C0020 with a 21 MHz accelerated mode that can be invoked via software. Timings are identical to those of the 48K Spectrum. Total RAM is 256 KB: 224 of uncontended memory (96 in the HOME block) and 32 of contended video memory in banks 5 and 7 of the HOME block. The ROM is held in a 32 KB flash memory without Beta Disk calls and has SE BASIC 4, also by Andrew Owen, as its default firmware. All video modes support ULAplus. The sound chip is a YM2194F.

The Chloe 140 SE is a simplified version of the ZX Spectrum SE. Compared to the 280 SE, it has no additional RAM banks for emulating the TC 2068 memory configuration, so it cannot run programs written for that computer. Total RAM is 128 KB, 96 of which are uncontended (in the HOME block).

Both systems are emulated by *ZEsarUX.*

128KE

Modification project aimed at eliminating bugs in the Spectrum 128 and later ROMs and mutual incompatibilities between them, in order to create an ‘ideal’ Spectrum characterized by maximum hardware and software compatibility. A +2A is used as the base machine for the intervention. Emulated by *Zero*.

PERIPHERALS AND EXPANSIONS

MB01/MB02/MB02+/MB03+

MB02+ with 512 KB single chip SRAM connected to a +2

The MB series of disk interfaces was born in Slovakia in 1992 on the initiative of Róbert Letko ('Robo'), owner of MDK, a small electronic manufacturing company in Bratislava, and Slavomir Labsky ('Busy'). The two devised an expansion for the Spectrum that would not only be an alternative to the Didaktik D40 and D80 floppy disk drives common in their country, but would also allow connection to hard drives. The result was the MB01 (from MDK and Busy), featuring a special Z80-based DMA circuit, a 2 KB EPROM and a 128 KB (2×64) SRAM powered by an on-board battery.

At the request of two other developers, Czech brothers Oldřich and Jan Páleníček, Letko and Labsky developed a revised version, the MB02. This was extended by the Páleníčeks with a memory expansion slot, a Kempston joystick port, a printer port and a non-maskable interrupt button, while maintaining full compatibility with the previous model. Then they modified the interface to house it on a single large printed circuit instead of two smaller boards as before, also inserting a system clock powered by a coin battery. The new device, called MB02+, has an internal operating system called BS-DOS to manage up to 256 folders and 65,279 files; its latest revision is 3.09. It also has the advantage of being fully compatible with tape loading and, through a software emulator called ED80, with the Didaktik D80 system. The MB02+ was therefore handcrafted and put on sale: up to the end of 2001, 70 units were sold.

Curiosity aroused by the MB02+ among enthusiasts in various European countries provided the basis for several revisions and updates to the interface since 2000. Some developers involved in them were:

- Petr Petyovsky ('Poke Studio'): single 512 KB SRAM chip revision, introduced on 5 January 2006;
- Jan Kučera ('Last Monster', 'LMN128'): additional expansion board for IDE controller, based on an interface already developed by Lubomir Blaha ('Tritolsoft') and Pavel Riha ('PVL'); it underwent three revisions – MB-HDD1 (11.11.2005), MB-HDD2 (12.12.2008) e MB-HDD3 (18.05.2008) – and can also be used by itself; Flash Utility EPROM expansions at 32 KB and 64/128 KB (divided into banks of 32 KB each);
- Ingo Truppel: redesigned IDE interface, provided with an adapter for Compact Flash cards.

The Z80-DMA circuit was also built by Jiří Veleba ("Velesoft") as a stand-alone expansion with graphics acceleration functionality, called Data Gear 2007 or, jokingly, 'poor man's Blitter'.

In 2020, Jan Kučera created the latest evolution of the MB, the MB03+. It is based on a Xilinx Spartan 7 XC7S50 FPGA board with 16 MB SRAM, 4 MB fast SRAM and 2MB flash RAM, Z80-DMA, DS3234 internal real-time clock, three AY sound

modules, audio support for the SAM Coupé's sound chip SAA1099, SounDrive, Stereo Covox, SpecDrum and General Sound, with stereo mini-jack output. Connectivity is ensured by a port for Compact Flash cards and two ports for Micro SD cards, all managed by an integrated DivMMC with ESXDOS or BS-DOS operating system, plus two USB ports, one of which is dedicated to operating a mouse with Kempston emulation, and a DB9 connector for joysticks or joypads. A Wi-Fi module for networking is optional. The March 2021 revision implements the HiResColour video mode, native to the eLeMeNt ZX clone.

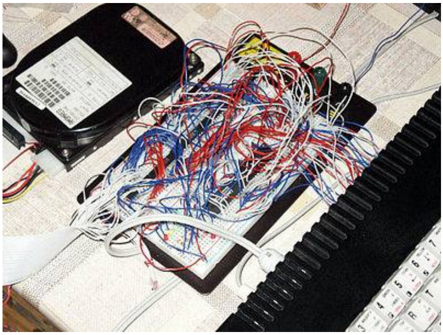
DIVIDE

The DivIDE interface, which – as the name implies – has the primary aim to connect peripherals through the widespread IDE standard, originates from the first devices of this type, that is to say the MB series and the IDE and IDE Flash interfaces (for Compact Flash cards) designed by Pera Putnik as early as 1996. Putnik's interfaces, however, had the problem of working at 16 bits against the 8 bits of the Spectrum CPU, so that the effective capacity of the hard disks connected to them was half of the nominal one. Therefore, Lubomir Blaha and Pavel Riha modified Putnik's scheme by replacing the single-channel I/O structure with a six-channel one. With this system it was also possible to use two IDE peripherals at the same time as 'master' and 'slave'. Their interface was called *ZX-IDE.*

Building on the ZX-IDE and Putnik's researches, another Czech developer, Pavel Cimbal ('Zilog'), made in February

2002 a working prototype of a new interface he named *DivIDE 42r2,* that included 8 KB ROM and 32 KB RAM. The first publicly released version is 57, dated August 2002. Several revisions will follow, by Cimbal himself and other developers.

The DivIDE 42r2 prototype connects a Didaktik Gama to a 170 MB Conner CP30174E hard disk

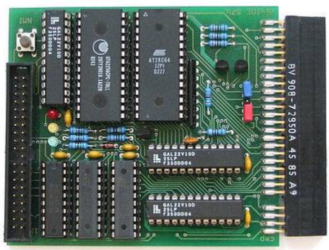


The initial technical specifications of the DivIDE are:

- use of the whole 16 bits of the ATA bus;
- compatibility with all Spectrums and relative clones;
- 218 KB/sec nominal data transfer speed;
- 8 KB flash and shadow ROM for the firmware, plus 32 KB of additional RAM in banks of 8 KB each;
- shadow ROM auto-addressing to main entry points to emulate standard tape loading;
- extended BASIC;
- menu recalled by a non-maskable interrupt;
- DISCiPLE/Plus D and Beta Disk emulation;
- MAPRAM feature for testing software under development, eliminating the necessity to modify the shadow ROM's content; can emulate a further 8 KB ROM if needed;
- compatibility with every ATA peripheral;
- TAP, SNA, Z80 and SCR file formats reading.

Such features are enabled by means of particular firmware:

- *FATware:* read-only support of up to 8 standard FAT-16 partitions with long file names; allows for loading of TAP, SNA, Z80, SCR and interlaced SCR files;
- *DEMFIR (DTP's EMulator FIles Runner)*: manages the CD-ROM ISO 9660 file system and allows for data loading from CDs or ISO image files; reads TAP, SNA, Z80, MFC and SCR file formats;
- *MDOS3:* improved version of the MDOS/MDOS2 operating system employed by D40/D80 floppy disk drives; operates on floppy disk image files and manages up to four virtual drive units;
- *+DivIDE:* adaptation of the GDOS/G+DOS operating system of DISCiPLE and Plus D interfaces; manages virtual disks of 1,600 sectors each on the ATA drive through low-level LBA logic access;
- *TBIOS:* hardware test utility.



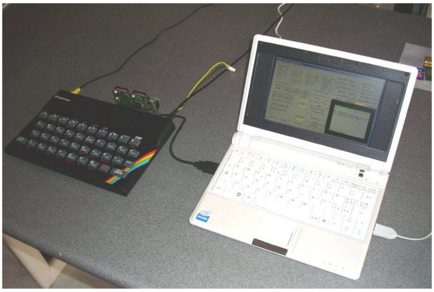
DivIDE 57 rev. b

As mentioned before, other developers continued to modify the DivIDE. In Poland, Jarek Adamski and Jurek Dudek are the authors of the *DiwIDE,* from which the *DivIDE Plus* originated. This enhanced version of the interface is equipped with 512 KB of both RAM and ROM, a Compact Flash card reader, six firmwares – those previously seen, plus *ResiDOS* (more on this below) – and is compatible with both the original DivIDE and the MB02+. Its RAM is supported by a battery allowing ResiDOS to use virtual disks in the same RAM for data storage and FATware to remember the last file loaded through the internal command interface browser. Jiří Veleba made the *DivIDE 512,* provided with 512 KB SRAM and 128 KB ROM, with SD cards for mass storage.

Firmware has also been subject to changes, either by improving and expanding its features and eliminating its defects, or by programming some completely new ones to replace those already existing. In the first case, it should be noted the work of developers such as the aforementioned Veleba, author of alternative versions of FATware and an adaptation of BS-DOS, already in use on the MB, specially designed for the DivIDE (BS-DOS 3.09). In the second, Garry Lancaster's ResiDOS project, an extension of Sinclair BASIC installed in the DivIDE RAM along with a modified copy of the Spectrum ROM. Its purpose is to equip the computer with new BASIC commands to manage files on the hard disk or Compact Flash card and to use the extra RAM present on the same interface, as well as enabling the non-maskable interrupt button to launch a task manager for switching between different programs in memory. Even more ambitious is ESXDOS, which due to its importance is dealt with in a separate entry.

ZXMMC/ZXMMC+

The ZXMMC *(ZX Multi Media Card)* is an expansion card designed in 2007 by Alessandro Poppi, author of the ZX-Badaloc clone, from which it derives. It allows a Spectrum +2A/+3 to use one or two SD/MMC cards for both reading and writing. In some ways it is a reworking of a similar project, the ZXCF/ZXCF+ by Swedish Sami Vehmaa, which uses CF cards for data storage instead. The ZXMMC may also work on older Spectrum models, but since it is soldered to the motherboard there is physically no space to house it in their cases. There are two variants, one simple, the other with a Kempston joystick port and a TTL RS232 serial port.



A ZXMMC+ connects a 48K Spectrum to a PC via USB

Poppi developed a second version the following year, called ZXMMC+, which mounts 512 KB RAM maintained by a coin battery for use with ResiDOS and 512 KB flash ROM, two ZX Interface 1-compatible ports for local network and RS232 (at 19,200 baud), a button for the generation of non-maskable interrupts and a reset button, in addition to a Kempston joystick port. This card can be attached to all Spectrums through the expansion port. A further revision is equipped with a USB adapter, designed by Pino Giaquinto, to connect the Spectrum to PCs running Microsoft Windows without an RS232 interface. In Windows Explorer, the card or cards inserted in the ZXMMC+ are displayed as a 'ZXMMC+ COMx' peripheral.

DIVMMC

On 5 May 2012, Miguel Guerreiro, author of the ESXDOS firmware for the DivIDE, sent an email to Alessandro Poppi, suggesting the idea of 'emulating' a DivIDE together with the

ZX-One logic core (created by Poppi in 2011 for the Commodore 64 C-One clone), perhaps using an SD card instead of the IDE peripheral. Poppi was interested in the idea of creating a new interface, a sort of hybrid between the DivIDE and his ZXMMC, and proposed *DivMMC* as the name of the project.

Thus, an intense work began. It also involved other developers, namely Jiří Veleba ('Velesoft') and Mario Prato, author of the Chrome clone, consulted by Poppi about the possibility of a concrete realization of the interface. In fact, it was Prato, in 2013, that made the first version of the DivMMC: a device built upon a CPLD architecture taking on the DivIDE's functionalities and adopting ESXDOS as its main operating system. It is still compatible with FATware, but uses SD cards instead of Compact Flash ones for data storage.

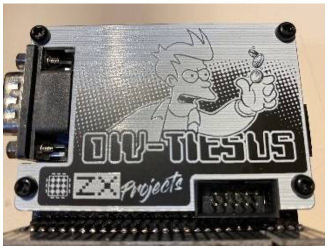
DivMMC prototype by Mario Prato

Compared to the DivIDE, the DivMMC presents other differences. Internal RAM is at least 128 KB and is compatible with SDHC cards in addition to the classic SD. The ESXDOS firmware handles all operations and can be integrated with other components, like alternative browsers by David Pesqueira Souto ('Dr. Slump') or 'Bob Fossil'. The second in particular supports long file names and was designed for the ZX-Uno, but can also be used with the DivMMC on historical Spectrums, the Next and various clones.

Reworkings of the DivMMC (like the DivMMC EnJoy!, left) have more internal RAM, MicroSD card ports and Atari joystick ports with Kempston emulation. Due to its ease of use and the versatility of the ESXDOS operating system, the DivMMC has become the most popular mass memory interface in the Spectrum 'galaxy', also being integrated into the circuitry of the Next and of the most recent clones.

DIVTIESUS

The DivTIESUS is a DivMMC compatible interface, designed and produced by Miguel Angel Rodriguez Jodar ('McLeod'/ 'Ideafix'). It is not based upon Mario Prato's reference design, but on a completely new one,



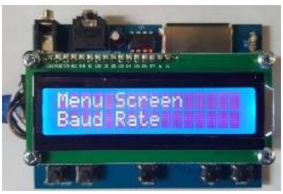
which makes it possible to integrate more functions inside the CPLD, thus minimizing real state on the circuit board and the number of components. Besides the usual functionalities found in more recent memory card-based interfaces (model auto-detection, Atari Kempston-compatible joystick port, ESXDOS firmware and so on), the DivTIESUS can load the +3e ROM images from the SD card, install them as the system ROM using its own RAM and make them available to the computer, while disabling the automapping feature, needed for ESXDOS but not for +3e DOS. This allows the user to operate a +2A/+3 as a +3e without having to open the case and exchange the ROM chips. This 'soft +3e' feature can also be used to boot any Spectrum with a 16/32/64 KB custom ROM.

TZXDUINO/MAXDUINO/ARDUITAPE

The TZXduino is a peripheral for reading tape image files from SD and MicroSD cards, developed by Andrew Beer and Duncan Edwards around the well-known Arduino hardware architecture built in 2005 at the Interaction Design Institute in Ivrea (Turin). It features an OLED display for information about files being read and configuration menus, plus five command buttons for virtual tapes. In addition to the Spectrum's TAP and TZX files, it can read ZX80, ZX81, Acorn Electron and Amstrad CPC cassette image files. Due to its small size, some enthusiasts have inserted it into the case of a car radio cassette adapter, for use with the Spectrum +2 and +2A Datacorder, or even inside a real Spectrum.

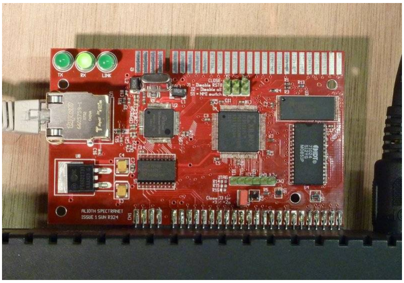
MAXduino is a firmware for the TZXduino developed by Rafael Molina to unify the TZXduino features with those of a similar device from Beer and Edwards, the CASduino. It adds virtual tape reading for the MSX, BBC Micro, Dragon 32/64, Jupiter Ace, Oric-1 and Oric Atmos.

The Arduitape, the work of Edwards alone, is an evolution of the TZXduino capable of also reading audio recordings from cassettes in 8-bit WAV format at 22050 Hz.



Up: TZXduino. Right: TZXduino inserted into a 48K Spectrum by Davide Barlotti.

SPECTRANET



A project started by a developer known as 'Winston' with the purpose of supplying the Spectrum with an Ethernet interface. Its goals are:

- compatibility with common hardware such as the ZX Interface 1, DivIDE, DivIDE+, Kempston and similar joysticks;
- support TCP, UDP, ICMP and DHCP, plus access to raw IP and Ethernet;
- highest performance possible – at least the full speed of an LDIR or INIR instruction for transferring data;
- compatibility with all the Sinclair and Amstrad models (compatibility with others if they have the standard edge connector);
- compact PCB to reduce risk of wobbling and fall over (which could cause serious damage to hardware when the computer is on);
- through port;
- finished cost of £30 or less (without enclosure).

From a hardware point of view, the project involves the use of a single-chip WIZnet W5100 Ethernet device, while the glue logic (i.e. interfacing functionality for the whole architecture) is entrusted to a Xilinx XC9572 CPLD of 100-pin, TFPQ (*Thin Quad Flat Pack,* a surface mount component structure for space optimization and cost reduction) design. Memories are a 128 KB Am29F010 flash ROM, also programmable from the Spectrum, and a static IDT71024 RAM, also 128 KB, as a working space for programs stored in the ROM and for general use. As for software, minimum objectives are:

- a socket library for Assembly and C programs, as close as possible to the standard BSD *(Berkeley Software Distribution)* socket library found on virtually every operating system running today;
- possibly, an interface to Sinclair BASIC;
- a simple network file system (TNFS, *Tiny Network File System*) designed for 8-bit systems;
- a network filesystem browser, either triggered by the non-maskable interrupt button or from BASIC extensions.

Winston is also keen to point out that his project is open to anyone who wants to experiment with it for fun or profit, like other expansion projects for the Spectrum, for instance the MB or DivIDE. Schemes and source codes are released under the MIT license.

The first public demonstration of the Spectranet dates back to 20 June 2010, on the occasion of the first edition of the Vintage Computing Festival, hosted by the National Museum of Computing in the historical headquarters of Bletchley Park (United Kingdom). Winston connected the interface to a Spectrum +3, making it a workstation to send messages on Twitter and arousing considerable interest.[10]

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[10] Chris Vallance, *Vintage computers inspire next generation of scientists,*

Spectranet demonstration at the Vintage Computing Festival, Bletchley Park, 20 June 2010

Since 2014, the Spectranet project can be considered complete and fully functional. Third-party manufacturers began to sell pre-assembled versions, with or without enclosures. The *FUSE* emulator can recreate its functions via software. The latest firmware revision is R600, dated 30 November 2020.

ZXPC

Interface designed by Johan Koelman ('Dr BEEP') to connect a Spectrum to a PC through the parallel port. It is a simple and small tool – it fits comfortably inside a cassette case – but undoubtedly useful, since it allows the Spectrum to read SCR, TAP, Z80 and SNA files directly from the PC (the latter two

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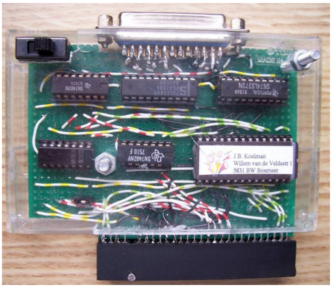
21 June 2010, *www.bbc.co.uk/news/10364135* ; Andrew Orlowski, *Twitter on a ZX Spectrum. And other wonders from the Vintage Computing Fair,* 21 June 2010, *www.theregister.co.uk/2010/06/21/vintage_computer_fair/*



only in 48K version) and save data on the PC in TAP format. The device works by means of an EPROM on which a slightly modified version of the original Spectrum ROM is stored: LOAD and SAVE commands read and record data to and from the PC instead of the tape. A server program on the PC quickly sends the data to the Spectrum and saves them on the hard drive in case of saving: an average TAP file is loaded or saved in less than 7 seconds.

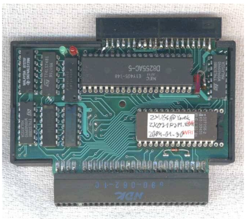
ZXATASP

Made by Sami Vehmaa, this interface connects a Spectrum with at least 48 KB RAM to a hard drive via a 16-bit IDE connection. The latest version (2.0) mounts a 128 or 512 KB SRAM in 16 KB blocks 'read' by the system instead of the normal Spectrum ROM (with which it can be alternated). It can host several alternative operating systems for disk access, such as the aforementioned ResiDOS, or the contents of ZX Interface 2 ROM cartridges. It can also be programmed from BASIC. SDRAM content is made non-volatile by the presence of a backup battery. A Compact Flash card reader completes the interface, but it is only compatible with SanDisk cards at normal data transfer speeds. Vehmaa recommends not to use connection cables longer than 46 cm with the interface for both 3" ½ and 2" ½ hard drives (for the latter, a cable with a maximum length of 30 cm is preferable).

YABUS.IDE8255/YAMOD.ATBUS 8 BIT IDE/ PL3MEM

A series of interfaces created by Jarek Adamski to equip the Spectrum with an 8-bit IDE connection, plus additional RAM and operating systems.

The YABUS is built on the basis of the IDE 8255 controller. Reading in PIO mode 1 allows the Z80A to read data at a speed of approximately 180 KB per second, while writing is in PIO Mode 0. The YAMOD.ATBUS is a card for the YABUS equipped with an interpreter between the 8-bit logic of the Z80A and the 16-bit logic of the IDE interface. It increases the transfer speed of the YABUS and makes it possible to connect

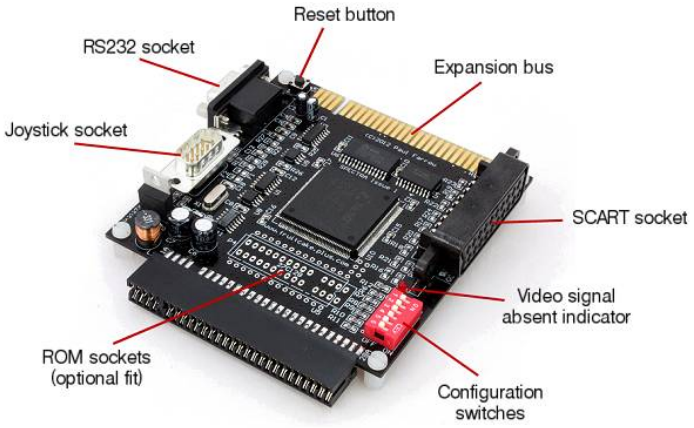


the Spectrum to other devices, for instance CD players, ZIP drives and CF cards. The PL3MEM (left) integrates the characteristics of the two previous interfaces and adds a 32 KB RAM and a 128 or 512 KB EPROM module. In the latter, various alternative operating systems can be stored, like Garry Lancaster's IDEDOS or the ZXVGS, a multi-platform development environment, the work of Adamski himself, which can run on the ZX Spectrum +3 after modifying some circuits or with an auxiliary module.

SOUNDRIVE/COVOX

8-bit and 4-channel stereo digital audio interface derived from the famous *Covox Speech Thing*. For this reason, some of its variants are called "Covox". The first version was devised in Russia in 1996 by the Omega Hackers Group for the Pentagon 128. It was later partially redesigned by Jiří Veleba to work with canonical Spectrums.

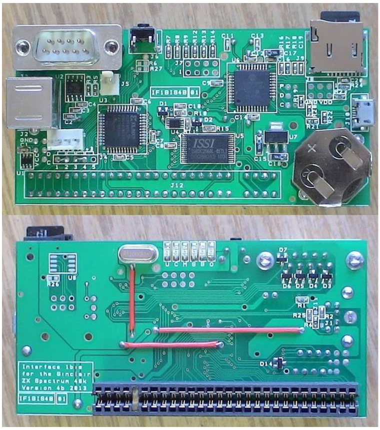
SPECTRA

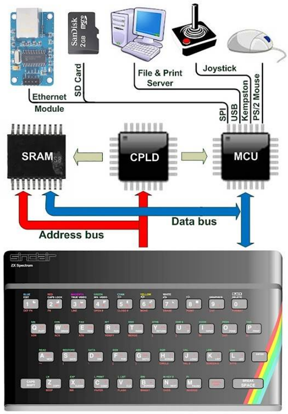


A multi-function interface designed by Paul Farrow, primarily to connect the 16/48K Spectrum to a TV through the SCART socket. With the Spectra, a video image of great clarity and stability is thus obtained, comparable to the RGB image of the Sinclair/Investronica ZX Spectrum 128 and later. This was previously only possible through the modification known as 'composite mod', which consists in bypassing the internal RF modulator circuitry, in order to send the composite video signal directly to the TV. It also redirects audio to the TV speaker.

The Spectra has however other functions. The most interesting one is the possibility of expanding the computer's colour palette so as to use 64 different colours simultaneously, both at the usual resolution of 32×24 attribute blocks, and at three new resolutions: 48×32, 96×32 and 192×32. The latter must only work in a 'hybrid' mode due to the limitations of the supplied RAM: 32 KB, of which only 16 can be activated each time.

INTERFACE 1 BIS

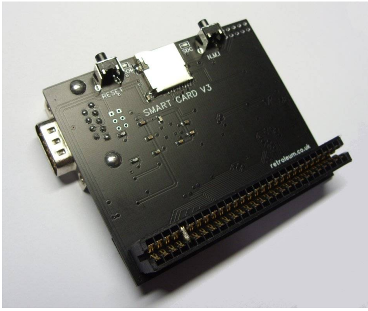




Made by a South African amateur, Dan Antohi, in 2013, the Interface 1 Bis is a functional replica of the Sinclair ZX Interface 1, fully backwards compatible in terms of BASIC commands and ROM entry points, but at the same time considerably expanding its capabilities.

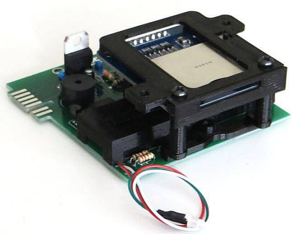
The device connects directly to the expansion port of the original computers or to an Interface 1. It uses MicroSD cards as mass storage, managed through the same commands for the Microdrive. It has a Kempston joystick port, a PS/2 port, compatible with the Kempston mouse, and a MicroUSB port, to connect the Spectrum to a Windows PC on which drivers downloadable from the official website have been installed. The PC recognizes the peripheral as a serial port; with a command line application, the Spectrum can perform operations on the Windows file system as if it were a physical drive marked with the letter V. File names are displayed in 8+3, case sensitive format.

SMART CARD



Expansion card made by Phil Ruston with different functions. It includes 128 KB SRAM, a Kempston joystick port, a reset button, another button to generate a non-maskable interrupt in order to view and modify running code or save memory snapshots, and a MicroSD card reader. The latter is driven by a firmware that allows for instant SNA and TAP files loading, with support for long file names. Besides the internal firmware, the SMART Card can host and manage up to 15 ROMs of 16 KB each, and includes a diagnostic ROM, also written by Ruston. The current version is V3, which introduces support for the Spectrum 128 and later games.

VDRIVE ZX



A hardware ZX Microdrive emulator. It reads cartridge image files in MDR format stored on a SD card, emulates up to eight Microdrives and can be used with the ZX Interface 1 alone or in conjunction with real Microdrives. It is compatible with FAT16 or FAT32 formatted cards with up to 32 GB capacity. It supports all Spectrum ROMs from the 16K to the +2, including French and Spanish as well as the Gosh Wonderful and Swedish Beckman ones. The device's dimensions allow it to be housed inside a Microdrive case.

BETA DISK 128C/128X/128 MINI CONTROLLER

A series of Beta Disk-compatible floppy disk drive controllers manufactured by CSS Electronics, the company behind the ZX Nucleon clone. All of them can control up to 4 disk drives, can be connected to a 48/128/+2 Spectrum or a Didaktik M and are incompatible with the +2A/+3 due to the non-standard ROMCS signal on its expansion port and changes in its ROM.

128C

128X

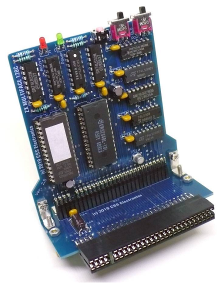
128 Mini

The 128C is made up with two connected printed circuit boards, employs a standard FDC1793 controller, has a through connector on the bottom board to attach other devices to the computer and must be powered by an external source. It can use a 16 KB EPROM for the original TR-DOS, or a 32 KB one for two different versions of the operating system, the official 5.04T and the custom 5.05cz revision, selectable by an external switch. The 128X is compatible with the ZX Nucleon and can switch between four versions of TR-DOS, the official 5.04T and the 5.041, 5.05cz, and 6.11Q custom revisions – the latter is specifically designed for the Pentagon 512/1024 and the ZX Nucleon. The 128 Mini is the smallest of the three; it is also compatible with the ZX Nucleon and can employ the same TR-DOS versions as the 128X. It is made up with a single board, lacks the FDC1793 controller and the through port and is powered directly by the computer instead of relying on an external power source like the other two models.

D80+K CONTROLLER

CSS Electronics's D80+K is a controller for 1 or 2 floppy disk drives, similar to the 128 Mini but compatible with the Didaktik MDOS. The latter can be switched between version 2.0 and 2.1 according to the machine the device is attached to: 2.1 only for the ZX Nucleon and 128/+2 Spectrum; 2.0 or 2.1 for the 48K Spectrum and Didaktik Gama/M. Like the 128 Mini, the interface is powered by the computer itself and is not compatible with the +2A/+3, for the same reasons. The D80+K uses an original GM82C765B or a WD37C65B floppy disk controller. The '+K' in its name indicates the presence of a Kempston joystick port.

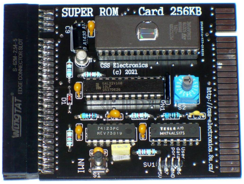
MULTIFACE 128C



Another project by CSS Electronics, the Multiface 128C is a clone of Romantic Robot's Multiface. The device can generate a non-maskable interrupt to freeze a running program, monitor the contents of the memory and processor registers, and save a snapshot file of the current RAM contents. In addition to this, the 128C features a 16 KB ROM and a single 74LS00 chip, while the original had an 8 KB ROM and two of the same ICs, and can switch between two I/O ports, 31 and 159 like the old Multiface or the new 63 and 191. It also corrects some flaws of the original interface, such as the invalid detection of port 32765 on the Spectrum 128 or the separation of its NMI output signal to avoid conflicts with NMI signals generated by other connected peripherals. The current version is 2.5.

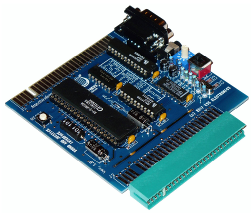
EXTERNAL ROM CARD 64 KB/128 KB/SUPER ROM CARD 256 KB

A series of cards for any Spectrum by CSS Electronics, for using or testing custom ROMs, or for diagnostic purposes. They can hold 4, 8 or 12 16 KB ROMs respectively; the Super ROM card (below) can also store two 32 KB ROMs and is compatible with the ZX Nucleon and the 128/+2 memory paging. All three cards connect to the expansion port and have a through connector and a button to generate a non-maskable interrupt.

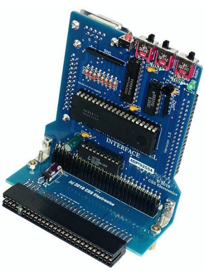


ORPHEUS

Another CSS Electronics product, an expansion card combining together an AY-3-8910/8912 sound chip – or similar, more modern chips like the JFC95101, KC89C72 and WF19054 –, a through port and a joystick interface. The latter can emulate the Sinclair 1, 2 and Cursor joysticks as well as the widespread QAOPM keyboard scheme.



ADPI8255A

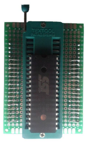


This interface, also by CSS Electronics, provides the Spectrum with three 8-bit bidirectional parallel ports to connect the computer to a wide range of devices. It is based upon an Intel 8255A or similar chip and is equipped with a Kempston-compatible joystick port, a printer port and a through port for other peripherals.

PAUL FARROW'S CARTRIDGES/KARTUSHO/ NOXROM

Since 2004, Paul Farrow has designed and built ZX Interface 2 cartridges that exceed the limits of the original ones. Version 4, released in 2014, has a full 4 MB of available flash ROM, divided into 256 banks of 16 KB each.

The Kartusho is another custom cartridge for use with the Interface 2, made by Antonio Villena. The most advanced version is the fifth, capable of hosting 32 16 KB ROMs on a surface mount EEPROM chip.



In 2018, Rui Martins developed the NOXROM, another kind of Interface 2-compatible cartridge, with a flash ROM paged memory storage of 128, 256 or 512 KB.

QUAZAR ZX-ECUTOR/ZX-SAM ROM/ROM SLOT

Colin Piggot ('Quazar') is a SAM Coupé enthusiast who in 2019 designed and built the ZX-ECUTOR, a device to use ZX Interface 2 ROM cartridges on the MGT computer. It was followed by a 16-bank flash ROM cartridge to store as many 16K ROM images selected by a rotary control. The chip can be written to on the SAM Coupé through the ZX-ECUTOR, while Spectrum users will need an external EPROM programmer to do the same. Piggot also made a simple interface to add a ROM slot to any Spectrum.

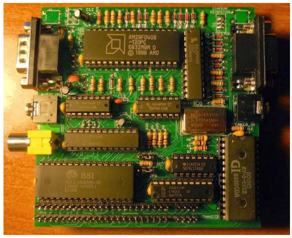
ZX DANDANATOR! MINI

The Dandanator! Mini is a cartridge, or more precisely, an EEPROM external memory hardware adapter for loading instant SNA and Z80 files taken from both 48K and 128 memory. Its content can be directly updated from the Spectrum and stored in compressed format. It also allows the insertion of external ROMs and a library of POK files to 'hack' programs, for example to enable infinite lives in games, and to capture screenshots. From version 2.0 it also includes a Kempston joystick interface. The most recent revision is 6.3.

9-game **PowerUp! Action Pack** ***compilation on Dandanator! Mini***

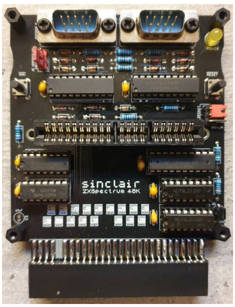
The peripheral has 512 KB of internal memory, fits into the computer's expansion port and is controlled by an on-screen menu. There are no switches or jumpers to configure: the Dandanator! Mini is 'plug and play'. When not in use, it remains disabled and does not interfere with other programs or peripherals. It is compatible with all historical Spectrum models, the Next and a large number of old and new clones: CZ Spectrum, Microdigital TK90 and TK95, Timex Sinclair/Computer 2048 and 2068, Didaktik M, Inves Spectrum, Harlequin (revisions D, F and G), ZX Nuvo 128, ZX Omni 128HQ, Karabas-128 and Just Speccy 128K. Furthermore, it can be used in conjunction with other peripherals such as the DivIDE, DivMMC, Opus Discovery, ZX Interface 1 and 2, or even another Dandanator! Mini.

SPECCY SUPERUPGRADE



Interface created by Alejandro Valero Sebastián (‘wilco2009’) to give a 16K Spectrum the potential of a +3. The RAM increases to 128 or 512 KB depending on two configuration, the first for Spectrum 128 games that do not need access to the floppy drive, the second for games developed in TR-DOS environment for Pentagon and other Russian clones. The interface also includes a reset button and one to generate an non-maskable interrupt, the alternate +3e ROM to connect an IDE peripheral, an AY sound chip, an audio input to unify the beeper sound with the AY one, a composite video output and an expansion bus.

ZX INTERFACE 2.021



The work of Norwegian developer Tor-Eirik Bakke Lunde, it is a replacement for the ZX Interface 2, designed to be easy and inexpensive to build. It features two Atari joystick ports. The author also devised a new cartridge type, capable of mounting four 512 KB ROMs divided into 32 16 KB banks, for a total of 4 MB.

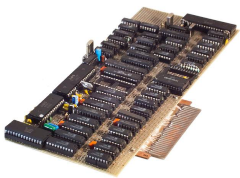
LEC

In early 1987, Jiří Lamač, a Czech developer, designed the LEC, a memory expansion to be integrated on the Spectrum’s motherboard, even on 48K/+ cards, with the addition of a small control circuit. It is based on the replacement of 4332 chips with 41256 DRAM memories. There are three possible configurations: 80, 272 and 528 KB. Lamač also created an optional alternative ROM, compatible with the original one, and a customized version of the CP/M 2.2 operating system for Spectrums modified according to his project. The expansion is emulated by *ZXMAK2, LnxSpectrum* and *JSpeccy.*

RECREATED ZX SPECTRUM

A Bluetooth device reproducing the appearance of a 16/48K Spectrum, manufactured by Elite Systems, Richard Wilcox's historical software house. It controls an application for iOS, Android or Web-based capable of running games and other types of programs on mobile devices or on Windows or Mac PCs, by downloading them. It is powered by USB or two rechargeable AA batteries.

SID-BLASTER



A sound card for playing Commodore 64 SID audio files on a Spectrum. The designer and firmware coder is Aleksandr Aleksandrov ('Byteman') while Sergey Bagan ('Prusak') is responsible for the hardware as well as for the debugging and management software for the Spectrum. The card is controlled by the main machine but essentially autonomous. Its CPU is that of the C64, the MOS 6510, whose clock frequency can be alternated by software between PAL (985 KHz) and NTSC (1023 KHz). There are also two SID 6581 and 8580 chips, again alternated through software, 64 KB SRAM and 16 KB ROM. The connection is of the ZX-Bus type. There is a working prototype of the SID-Blaster, but since 18 July 2012 the authors have not reported any further progress.

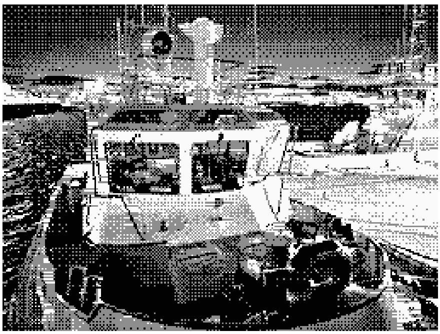
ALTERNATIVE VIDEO MODES

Throughout the history of the Spectrum, alternative video modes have arisen in order to overcome, as far as possible, the limits of its display. Initially they were mostly limited to the display of static images, and only in recent times dynamic applications, such as games or demos, were created. Below is a summary of these modes, accompanied by sample images, some emulated by the *Retro-X* PC-Windows program. Images are not exactly scaled to each other for space reasons, but are indicative of how the modes in question would appear on real hardware.

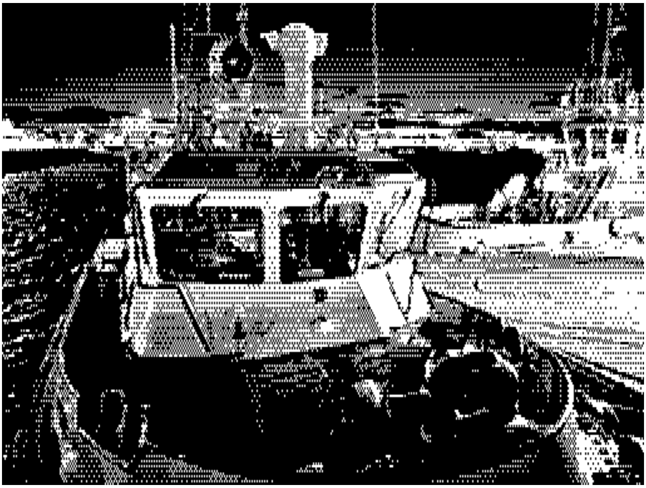
Reference image. Reykjavík harbour, Iceland, August 2010.

Standard mode. Screen division zones according to the attribute map are clearly visible.

8×1. Also known as *Multicolour, HiColour, Rainbow Graphics* or *FLI (Flexible Line Interrupt)*. In each attribute block, the rows of pixels can take different colour and brightness values from the following ones. From it, IFLI *(Improved FLI)* 8×2 or 8×4 modes derive. This mode is present in the Timex Sinclair TS 2068 and its derivatives (Timex Computer TC 2068/2048, Unipolbrit 2086), as well as in the most recent revisions of the Pentagon, in the Z80-DMA circuit, in its derivative Data Gear 2007 and in the Next. Since the ULA of ordinary Spectrums re-reads the attributes information on each pixel row when it draws the image, 8×1 can be emulated via software by inserting a change of attributes in the interval between the generation of one line and that of the next one. However, the Z80A is not fast enough to cover the full screen width this way, so the effect is limited to 16 out of 32 columns of the attribute map. The BIFROST* routine overcomes this limit, bringing it to 18 columns.



Multitech. High resolution with 15 shades of grey and 32×192 attribute map, similar to a monochrome 8×1. Present in the Z80-DMA circuit and in its Data Gear 2007 derivative.



2-colour HiRes 512×192. Present in every Timex clone, in several other clones (under CP/M) and in the Next. Available configurations are: white/black, blue/yellow, red/cyan, magenta/green.

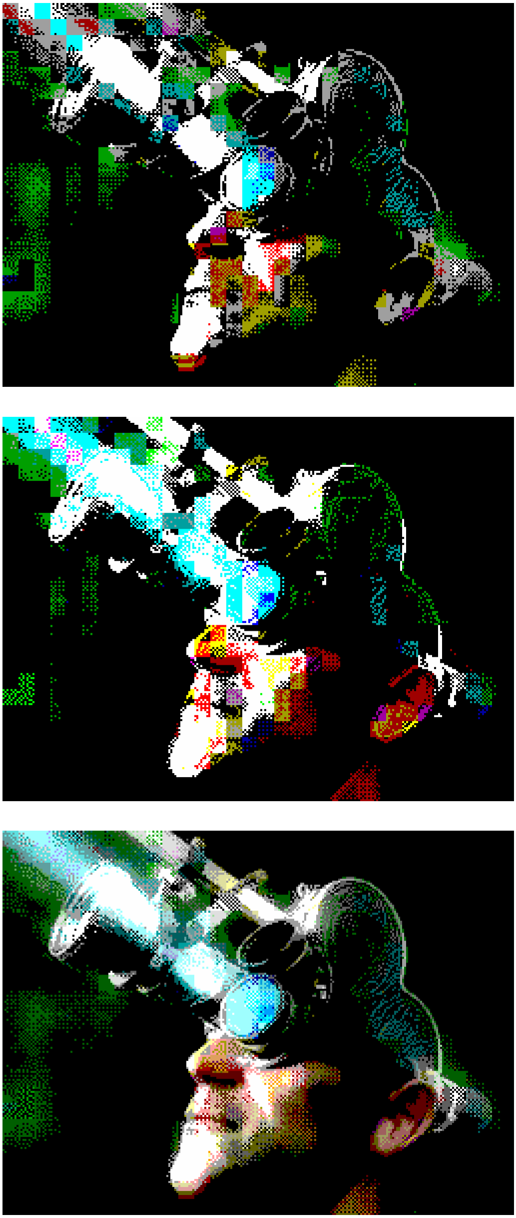
384×304. Video mode created by Dmitry Mikhailovich Bystrov ('Alone Coder'), from Ryazan (Russia), in 1999. The final version is due to his fellow citizen Sergey Anatolevich

Koluzanov ('KSA-7G') and is found on the Pentagon 1024 SL. It takes advantage of a larger screen area, including the border, normally unusable. The screen is divided into 9 sectors instead of 3 as in the traditional mode; the partitioning between foreground and background colours and attributes is unchanged.

16col. It is the work of Dmitry Bystrov too. 256×192 at 16 colours per pixel, in fact 15 (the usual 7+7 plus black) despite the name. Made for the ATM Turbo 2 in 2005, it is a development of the 'false EGA' (pairs of adjacent pixels, non-planar) found on the ATM Turbo. Not being planar, 16col recreates colours beyond the available 15 through the multi-coloured pixels diffusion techinque called 'dithering'.

Gigascreen/DithvIDE/BZither/Multiscreen

Gigascreen, more than a real video mode, is a technique consisting in quickly alternating two conventional images with different attributes, in order to give the human brain the impression that they merge into one. With this expedient it is also possible to blend different basic colour shades to obtain up to 102 total colours. The Pentagon 1024 SL and later are able to implement Gigascreen in hardware mode, combining the two images together in the output video signal, in order to reduce flicker occurring when doing the same via software.



Gigascreen example. By combining the first two images together, the final result is the third image.

Contribution of each of the two 'halves' is estimated at 50%. The chromatic component of each one of them contributes 66% to the normal brightness colours of the final image, and 100% to the high brightness colours, according to the formula:

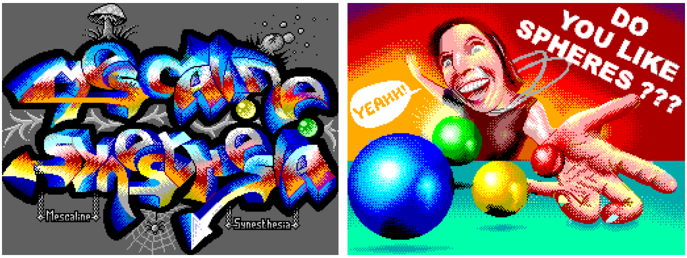
$$\mathbf{C = (C0 / 3 * 2 + C0 * I0 / 3 + C1 / 3 * 2 + C1 * I1 / 3) / 2}$$

where C0, C1 indicate the corresponding colour (R-G-B) of the 0 and 1 screens for each pixel, according to values of 0 and 1, I indicates the brightness which can be, as usual, 0 or 1, and C is the resulting colour, which intensity can range from 0 to 1, 0 being the minimum level and 1 the maximum level.

DithvIDE and BZither, developed by Pavel Cimbal and Milos Bazelides respectively, are two video modes that combine Gigascreen and the colour diffusion technique called 'dithering'. Like the original Gigascreen, they are capable of displaying up to 102 total colours.

Ruthesford's Revenge, ***by 'Blacker' (2003), an example of combination between Gigascreen and dithering***

Multiscreen is a combination of Gigascreen with 8×1 mode or with IFLI 8×2 and 8×4 modes. It can reach up to 83 total colours.



The* Mescaline Synesthesia *demo (2009), code and graphics by Aleksandr Vyacheslavovich Solodkov ('TimeKeeper'), music by Aleksey Patkaeev ('Zeebr') and Sergey Sergeevich Sokov ('MmcM'), uses Multiscreen mode.

Tricolor

A mode similar to Gigascreen. It combines together the three red, green and blue channels of the video image, according to the principle of additive synthesis, at a frequency of 16.6 Hz. Tricolor causes strong flicker, which makes it suitable for still images only.

Flashcolor

Hardware modification for the Pentagon and Scorpion designed by VG-Studio in Cherkasy (Ukraine). It eliminates the FLASH attribute to get 46 unique colours (128 on a black screen with dithering).

ULAplus

This video mode has its origins in the ZX Spectrum SE, an extended architecture model designed by Andrew Owen and Jarek Adamski in 2000. Among other things, it included a modified version the Timex Sinclair TS 2068 ULA. However, it was thanks to the work of the already mentioned Chris Smith that the internal structure of the Spectrum ULA was finally clear. Thus, an ULA model compatible with that of the Spectrum but equipped with a palette of 260 total colours was devised. This new expanded ULA is known as *ULAplus* and allows a maximum of 64 colours, selected from a palette of 260, to be simultaneously displayed on the screen.

To make ULAplus work with one of the tens of thousands of programs available for the Spectrum, a BASIC program containing data relating to the selected colours must be loaded first. There are special palette editors, made available by Owen and others, that allow to create specific colour combinations for certain games.

Since ULAplus only increases the number of available colours for the Spectrum both in the BASIC environment and in machine code by means of a colour palettes exchange, it does not eliminate 'colour clash'. From 2009 onwards, some games able to exploit it natively have been released. In February 2011 Alessandro Dorigatti inserted the ULAplus logic into an FPGA-based architecture, which was done in the following years also with the ZX Spectrum Next and various clones.

Sgt. Helmet Zero (2009), by Mojon Twins, was one of the first games to be released with support for ULAplus.

HAM256

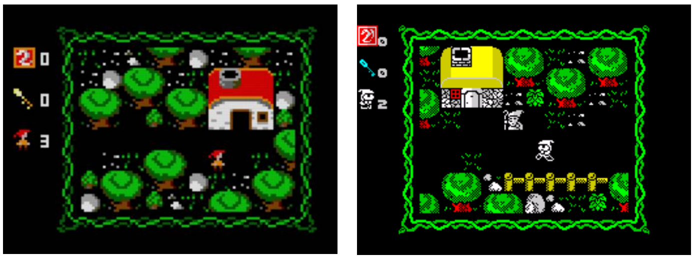
HAM256 is a software display mode for ULAplus-equipped Spectrums. A standard ULAplus screen can contain a maximum of 64 colours from a palette of 256, but a HAM256 screen can contain all 256 colours. This is achieved by changing the palette entries while the screen is being drawn. Because this is quite CPU intensive it is only possible to change the entire palette every 16 screen lines. To avoid updating palette entries that are still being drawn the mode is restricted to 32 colours per row. This is done by using alternate CLUTs (Colour Look-Up Table). The first row uses CLUT 0 and 1, the next row uses 2 and 3, the next row uses 0 and 1 and so on. To ensure the border remains a consistent colour, it is necessary for the 8th palette register to always have the same value (usually zero). This colour will be used when BORDER is set to 0. The Timex variant of this mode uses the hardware 8×1 mode. The palette cannot be updated much faster so the restriction of 32 colours per row remains.

Upper left: original (24-bit).
Upper right: HAM256 (256).
Lower left: ULAplus (64).

HAM256 gives 32 colours per row from 256. There are 24 rows and 2 colours per cell.

Radastan (or Radastanian) mode

Video mode named after the nickname of its author, Miguel Angel Montejo Raez. It sacrifices a part of resolution to place more colours to the screen. Its distinguishing feature is a 128×96 display, where each pixel can take a distinct colour, up to a maximum of 16 from a palette of 256. The mode is present on the ZX-Uno, ZX-DOS and ZX Spectrum Next.



The game* Mag The Magician*, by Radastan, in Radastan mode on the ZX-Uno and in Spectrum standard mode

Radasjimian mode

Another name for the *LoRes Layer,* a mode similar to the previous one, but which allows the simultaneous use of all of the 256 palette colours. It can be found on the ZX Spectrum Next.

HiResColour

A mode developed in 2020 for the eLeMeNt ZX clone and subsequently implemented in the MB03+ interface. It displays 512×192 pixels with 64×48 attribute blocks: this means that each group of 8×4 pixels can assume its own attributes.

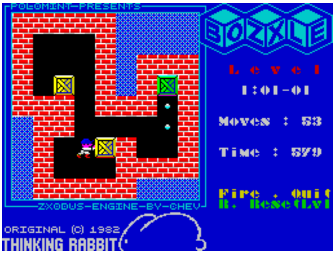
ZXodus/BIFROST*/NIRVANA

Born in 2011 as a technical exercise by Andrew Owen, the ZXodus engine has evolved into a full graphics routine. In fact, it is not a "real" video mode: it does not depend on additional hardware, but stems from programming the standard Spectrum ULA in an unconventional way.

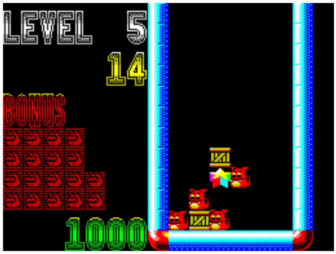
The journey of ZXodus began two years earlier, when Owen wrote *ColorTILE,* a graphic editor of 'tiles' for games based on non-animated sprites (for example, *Ultima*-style RPGs), able to exploit the Timex Sinclair TS 2068's 8×1 mode, which, as seen earlier, allows each 8-pixel row to assume separate values of INK, PAPER and BRIGHT.

***'Tiles' made by Andrew Owen with* ColorTILE**

From here, Owen tried to obtain a similar result via software on a normal Spectrum. The outcome was ZXodus, which allowed to draw sprites of the same type in BASIC as well as in machine code programs. British programmer 'Polomint' used ZXodus in his game *Bozxle,* an unofficial Spectrum version of *Boxxle,* a clone of the famous *Sokoban* puzzle by Thinking Rabbit, produced for the Nintendo Game Boy by Fujisankei in 1989. *Bozxle* was released in October 2011. At the same time, another game using the 8×1 effect appeared: *Buzzsaw+,* created by Jason J. Railton and inspired by the Namco *Cosmo Gang The Puzzle* coin-op. The difference is that in *Buzzsaw+* sprites are animated rather than static like in *Bozxle.* Both novelties aroused the interest of a Brazilian aficionado of the Spectrum and its Microdigital clones, Einar Saukas.



Bozxle



Buzzsaw+

Impressed by the ability of ZXodus to draw 'tiles' starting from simple data tables entered by the programmer and Railton's multi-coloured and animated sprites, Saukas started working on a new graphic routine to fuse together the advantages of both solutions, combining them with a technique devised by two other developers, 'AMW' and Matthew Westcott ('Gasman'), capable of bringing the displayed columns from 16 to 18 by emulating 8×1 mode.

Thus, in March 2012, the *BIFROST** engine was born. An evolution of the results achieved by the aforementioned authors, to the point that Saukas considers Owen a co-author of his project, BIFROST* is a code that makes it possible to draw both static and animated sprites on the screen in 8×1 mode, with a lower processor usage. Animation frames are alternated on the screen in real time; this means that sprites can have up to four animation frames. BIFROST* is basically a ZXodus re-adapted in order to circumvent limitations caused by memory contention between CPU and ULA. The routines for drawing single pixel rows are synchronized with the delays that occur when the screen is drawn, in order to avoid flicker due to lack of synchrony between memory access and picture drawing.

Sprites drawn by David Hughes using BIFROST*

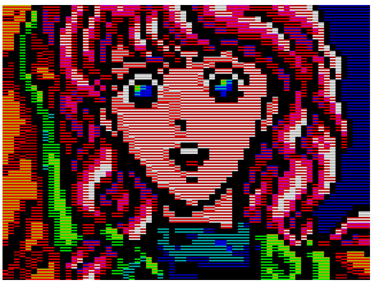
Two months later, version 1.1 adds the possibility of use on the Spectrum 128 and later, also taking into account the timing differences between the video signal produced by the 128/+2 ULA and the +2A/+3 one. Like ZXodus, BIFROST* can also be inserted into programs written in both BASIC and machine code.

In July 2012, version 1.2 arrived. Its code, available in two variants called 'low' and 'high' for different kinds of applications, is optimized in terms of both size and speed and permits greater flexibility for on-screen sprite drawing. According to the author, this was to be be the final version. At the same time, some games implementing BIFROST* were developed by Saukas himself, with graphics by both him and David Hughes ('R-Tape').

In November 2013, Saukas announced the successor of BIFROST*: the *NIRVANA* engine. Compared to the previous one, it does not include the 8×1 multicolour mode, but another one conceived by Saukas and called *Bicolor 8×2* by him, where attributes are defined in blocks of two 8-pixel rows each. Also, automatic sprite animation is no longer available. However, the fundamental feature of the new graphic engine is that it is no longer limited to a portion of the screen: it allows to exploit almost the entire Spectrum display, excluding only an outer edge, one attribute block wide. The usable area therefore measures 30×22 attribute blocks instead of 32×24. A later revision, released in September 2015 and called *NIRVANA+*, expands the usable area to 32×23 attribute blocks, leaving out only the first horizontal display row to facilitate the timing of screen image drawing, so as to avoid flicker.

Left: COMPLICA DX, by Einar Saukas, made with BIFROST*.
Right: Gandalf Deluxe, by Cristian Gonzáles and others, made with NIRVANA+.

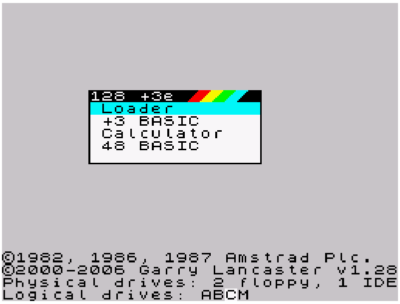
Stellarmode



First appeared in 1997 on the Pentagon within the *Eye Ache 2* demo, Stellarmode divides the screen in blocks of 4×4 pixels, where each row can alternate between two colours. The resulting blending effect allows up to 64 different combinations. In 2018, Matthew Westcott brought the mode on the Spectrum 128, exploiting its double video buffer in the *Buttercream Sputnik* demo. The effect won't be properly displayed on the +2A/+3, whose memory map is different: the demo's code would have to be reworked.

FIRMWARE AND OPERATING SYSTEMS

ZX SPECTRUM +3E



The ZX Spectrum +3e ('enhanced') is a modification of the ZX Spectrum +3 ROM version 4.0 made by Garry Lancaster, the author of ResiDOS. In addition to correcting many of the bugs of the original operating system, it introduces new BASIC commands and the ability to use other storage media, like hard disks and memory cards, alongside traditional tapes and 3" disks. In fact, the + 3e includes operating systems for managing interfaces like the DivIDE, DivIDE+, ZXMMC, ZXMMC+, ZXCF, ZXCF+, YAMOD.IDE8255, ZXATASP and more. There is even the firmware of Alessandro Poppi's ZX-Badaloc, from which the +3e can therefore 'inherit' many connectivity features.

The +3e must be installed in the computer by replacing the two original 40092 and 40093 ROM chips with two 32 KB EPROMs of the common 27C256 type, expressly programmed with the firmware made available by the author. The two ROM chips are socket-mounted, so it is not necessary to unsolder them from the motherboard. Anyone who does not have an EPROM programming device can contact Lancaster himself, who can perform the task upon payment of postage for sending them back to the recipient. In this case, it can be asked which firmware for external peripherals to include in the + 3e, and if the ROM should be in English or Spanish – the latter is in fact reworked from the ROM of the +3 marketed in Spain.

The +3e employs a custom hard disk, floppy disk and memory card partitioning scheme called IDEDOS, which not only allows to create partitions information about file allocation in a compact and particular way for each device used, but also to store the system files of different firmware as partitions. For example, this makes it possible to create a single boot disk for multiple configurations, or save data on a single medium relating to different systems or environments of use. This possibility is called 'shared disk' and was introduced by Jarek Adamski.

+3 ROM BY CRISTIAN SECARĂ

Cristian Secară is a Romanian enthusiast who reworked the ZX Spectrum +3 ROM version 4.1, the last revision carried out by Amstrad. Version 4.1 eliminated several flaws of version 4.0, but introduced a new one: any error in disk copy operations always generated a *Drive not ready* message.

Secară's ROM fixes this bug and introduces some small but important changes, in case the +3 is connected to an external 3" ½ floppy drive, or has undergone the removal of the original 3" drive and its replacement with a 3" ½ one for 720 KB single density disks, according to a procedure described by Secară himself. For example, drive head timings have been increased to 4 milliseconds, the limit of 64 entries per folder displayed by the CAT command has been removed, and disks can be copied directly one on another if both drives are of the 720 KB type.

+2B ROM SET/SE BASIC

Despite the name, this is not a reissue of the +2B ROM, but a new project, aiming to replace the +2A/+3 ROM with a set of alternative operating systems. The work of Andrew Owen, it is divided into five options.

SE BASIC represents the most innovative part of the project, an expanded and enhanced version of Sinclair BASIC, which roots lie in the ZX81's BASIC, hence the *1981 Nine Tiles Networks Ltd* start-up message. It fixes the traditional ROM bugs; eliminates cursor modes but allows for keyword abbreviations; introduces new commands (DIR, PEN, ON ERROR, PALETTE, RENUM, SOUND etc.) for screen management, program flow, sound chip and ULAplus; has new functions to manage both decimal and hexadecimal values; gives more space to programs and changes the use of the COPY command due to the removal of ZX Printer support; raises available line numbers to 16383 instead of 9999 as in the traditional ROM; determines a greater program execution speed.

BBC BASIC is the BBC Micro's BASIC, very well known in the United Kingdom due to the diffusion of that computer in schools in the 1980s. It is present here in a Spectrum version adapted by John Graham Harston.

Also part of the set: *128 BASIC,* bug-free version, with a new command menu and support for a virtual numeric keypad; *48*

BASIC, the original 1982 ROM with disabled memory paging; *USR 0,* the original 1982 ROM with enabled memory paging.

ROMs are presented in two series of binary files: two of 32 KB each, to be recorded on EPROMs which are then inserted in place of the computer's original chips – as for the ZX Spectrum +3e ROM – or four 16 KB ones, to be chained together for use with an emulator. SE BASIC is also available on its own; the latest version is 4.2, named 'Cordelia'.

DERBY PRO

Another creation of Andrew Owen, Derby Pro is the final stage of *Derby+* and *Derby++* firmware, named after the preliminary ROM written in 1985 during the development of the Sinclair/ Investronica ZX Spectrum 128.

Derby Pro is available in a 32 KB version suitable for the 128 and the +2, and a 64 KB one for the +2A, +3 (without internal floppy drive support), SE, ZX Omni 128, ZX-Uno, ZX Nuvo 128, and other clones with support for a 64 KB alternate ROM. Features added by Derby Pro are many, including: faster 128 BASIC, with bug-free full-screen editor and built-in support for Spectranet, Multiface 128/+3, ULAplus, Turbo Sound with 6 AY channels and ESXDOS; original 48 BASIC ROM; ULAplus with default CGA 16-colour palette; numeric keypad support; TR-DOS support with menu-driven loading; +2 and ULAplus diagnostic mode.

ESXDOS

ESXDOS (also spelled esxDOS) stands for *ENhanced Speccy eXperience*. Its origins date back to 2001, when two developers, Miguel Guerreiro and Neil Laws ('LaesQ'), were studying the possibility of an operating system for an interface for the ZX Spectrum +3 called *Project Backbone*. This device was supposed to connect the computer to peripherals such as IDE hard drives and CD-ROM and floppy drives. It was not made, both due to lack of time and the advent of the DivIDE, which achieved the objectives that the two had set for themselves. Therefore, Guerreiro continued to work on the new operating system aimed at the DivIDE. A first trial, undisclosed version (0.5 beta) appeared in 2005, but it was only in 2009 that Guerreiro announced a public version, 0.7.3 beta.

In 2012, coinciding with the thirtieth anniversary of the launch of the Spectrum, it was the turn of the first stable version, 0.8.0. This result was also possible thanks to the contribution of other developers, who joined the main work done by Guerreiro: ‘UB880D’, Neil Laws, Matthew Westcott (‘Gasman’) and Jiří Veleba (‘Velesoft’). With the advent of the DivMMC, a version parallel to that for the DivIDE was developed for such interface; Alessandro Dorigatti and Phil Ruston gave it a fundamental contribution.

In the following years, ESXDOS was considerably enriched thanks to some commands that can be directly entered from the Spectrum BASIC prompt. They can be recognized by the dot (.) preceding them, for which they are called ‘dot commands’.

ESXDOS includes many very interesting features, like the compatibility with FAT16 and 32 and TAP files for both reading and writing. One of the most important is certainly the support for TR-DOS disk image files, first only TRD, then also SCL, from version 0.8.5 onwards. The selection of files to open is performed through a special internal browser, the work of UB880D. It is recalled by pressing the button to generate a non-maskable interrupt placed on the interface. Currently, it does not support filenames longer than 8 characters. There are alternative browsers, by David Pesqueira Souto ('Dr Slump'), with 64 characters per line, and 'Bob Fossil', with support for long file names. Both also offer many additional features.

ESXDOS reached version 0.8.9 on 18 April 2021. Due to its many qualities and its ability to expand itself through 'dot' commands and alternative browsers, it established itself as the *de facto* standard operating system of the most widespread memory card-based interface for the Spectrum, the DivMMC.

GOSH WONDERFUL/LOOKING GLASS

Two modified versions of the 16/48K Spectrum ROM, made by Geoff Wearmouth in 2003 and 2018 respectively. The GOSH Wonderful fixes many bugs in the original firmware; allows to switch between writing keywords letter by letter and the traditional cursor modes by typing STOP and introduces a series of new commands, entered via a REM followed by options 'streams', 'delete', to eliminate entire blocks of a program at once, and 'renumber', to redefine the progression of BASIC line numbers. It is part of the personality of the Next, accessible by choosing '48 BASIC' from the start-up menu. The most recent revision is 1.33 of 2 July 2017.

The Looking Glass ROM, in addition to the innovations of the previous one, does without the 'E' (extended) cursor mode, still present in the GOSH Wonderful, and eliminates Renumber and Block Delete. The latest release is 0.7 of 1 July 2018.

ROM BY JOHN GRAHAM HARSTON

In 1985 John Graham Harston decided to create an alternative ROM for the 16/48K Spectrum, to fix the original's bugs and add new features. The project, which came to a first realization, remained inactive until 2003, when Harston resumed it, until version 0.77 of 8 February 2015. Among the main points: keyword writing letter by letter, hexadecimal digits input and output P and C channels to send signals to a Centronics port controlled by I/O port 251, system font inspired by that of the BBC Micro and several new internal routines.

ROM BY HENK DE GROOT

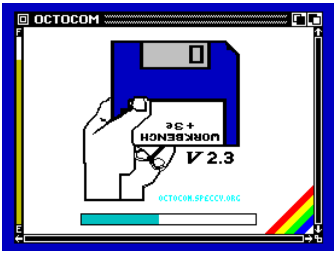
A 16/48K Spectrum ROM modified by Henk de Groot in 1994. Fixes the bugs of the original, starts the screen in black with white characters and the © *New Zx Spectrum ROM READY* initial message, introduces native support for the Dk'Tronics optical pen and for Epson printers, through a Z80-PIO chip and a Centronics port.

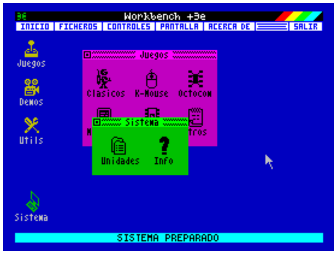
ROM BY IAN COLLIER

16/48K Spectrum ROM modified by Ian Collier. It fixes the bugs of the original, starts with a black screen and white charcters and the message *Altered by Ian Collier 1985*, replacing the original font with a custom one. It introduces several new features, including: an additional cursor, similar to the one present in the BBC Micro, for easier editing of program lines;

a non-maskable interrupt routine; modified CONTINUE and LIST commands. Furthermore, Collier made a revision of the ZX Interface 1 ROM, correcting bugs and adding new features.

OCTOCOM WORKBENCH +3E



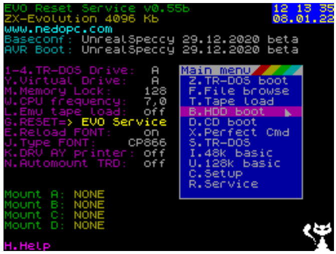


Visibly inspired by the Amiga Workbench, it is a window-based system for managing hard drives connected to a +2A/+3 Spectrum or to a ZX-Uno clone, provided they are equipped with +3e system ROMs. There is also a modified version for use with the MiST and derivatives. The pointer is controlled with a Kempston-type mouse or a Sinclair joystick in port 2. Besides selecting and launching programs with a simple click, Workbench +3e also makes disk organization and exploration simpler, copies files and makes or recalls disk backups. The latest version is 2.3.

MR GLUK RESET SERVICE/EVO RESET SERVICE

Mr Gluk Reset Service is a firmware created in 1996 by Renat Mamedov ('Mr Gluk') and Roman Gavrilov ('Reanimator'), from Ivanovo (Russia), for the Pentagon 1024SL. Since 2000, development has been handled by Dmitry Bystrov ('Alone Coder'). When the system starts, it displays a menu with many options, including: boot from hard disk or CD-ROM; Perfect Commander, a floppy disk manager; system monitor; 48 or

128 BASIC with TR-DOS support; memory clearing and RAM disk creation for TR-DOS 6.xxE. The user interface is controlled by a Kempston mouse or a Sinclair joystick, therefore allowing the keyboard input for the latter. It is the default configuration of the *UnrealSpeccy* emulator.



A derivate of Mr Gluk is *Evo Reset Service,* the basic operating system for the ZX-Evolution clone, written by Vyacheslav Savenkov ('Savelij13').

ROMS BY RODOLFO GUERRA

Rodolfo Guerra, a long-time Spectrum Uruguayan user, made new ROM files for the 48/128/+2/+2A/+3 and the Brazilian Microdigital TK90X clone, popular in his country too. Among the many new features: faster keyboard reading speed; freely movable cursor and accented letters (via UDGs) on both the 48K and TK90X; renumbering tool; instant screen movement in memory; POKE facility via NMI; native turbo mode for TZX files at 4000 bauds. For the latter, specially converted TZX files must be used, by means of a *TZX2TURBO* utility made by Juan José Ponteprino and supplied with the ROMs themselves.

CODING AND DEVELOPMENT APPLICATIONS

BASIN/BASINC

Programmed by Paul Dunn ('Dunny') in 2003, BASin is a development environment for Sinclair BASIC that runs under Windows. The BASin editor is similar to that of the 128, but has additional tools such as a user definable character editor, program line rearranger, graphics editor, tape image file creator, assembler and BASIC to machine code compiler. It also includes a monitor/debugger to control program execution: results are shown from an internal emulator's window. Programs can be saved as TAP tape image files for emulators, or recorded on cassette to be run on a real Spectrum.

Dunn updated the program up to version 14c. A version 15 remained in its preliminary state for years, until Arda Erdikmen obtained his approval for a parallel project, called *BASinC.* Its latest version is 1.79 of 19 June 2022.

ZX-EDITOR

Part of Claus Jahn's ZX-Modules program suite for Windows. It is a very versatile text editor, also useful for writing programs in Sinclair BASIC and Beta BASIC. Its main features are:

- reading and writing files in proprietary ZED format, including 8×8 raster fonts and in-text graphics;
- reading and writing text and ASCII files;
- inclusion of all Spectrum colours, with BRIGHT and FLASH effects;
- program editing under 48, 128 and Beta BASIC versions

3 and 4 with the relative cursor modes and keywords (the latter can also be written letter by letter);
- automatic arrangement of program lines written without consistent spacing;
- loading and editing of BASIC blocks to and from TAP, TZX and DSK files;
- use of the clipboard to copy, cut or paste any part of the editing area to another ZX-Editor window, or to copy plain text to other Windows applications;
- inserting images in BMP, JPG and GIF format or other types of Spectrum files in the editing area;
- support for files created with BASin;
- use of fonts and graphics created with ZX-Paintbrush or SevenuP;
- compatibility with TR-DOS $* (Hobeta), SCL and TRD files.

ZX BASIC COMPILER

Work of Jose Rodríguez, known as 'Boriel', for which it is also known as 'Boriel's BASIC'. It is a BASIC compiler which result can be rendered into Spectrum machine code. It is compatible with Sinclair BASIC, but expands it considerably, integrating it with many advanced commands and functions, taken from modern 'dialects' of that language, like FreeBASIC. So, for example, you can omit line numbers, use labels (even line numbers, if present, are considered as such), insert DO-WHILE or DO-LOOP-UNTIL loops instead of the usual FOR-NEXT ones, nest conditions with ELSE and ELSEIF, change the value of 16-bit memory locations with a single POKE command, easily create functions and procedures, manipulate bits with the appropriate logical operators BAND, bOR, bNOT and bXOR, integrate lines of Z80 Assembly into the BASIC program.

ZX BASIC runs under Windows, Linux and macOS, but being written in Python it requires an interpreter of this language to reside on the target computer (the 32-bit Windows distribution includes all the necessary files). In fact, it is a set of three utilities.

ZXBc is the main compiler, which converts a BAS file (BASIC program in ASCII characters) into a binary BIN file or a TAP or TZX tape image file, or translates a BAS file into a Z80 Assembly source. *ZXBasm* is a cross-platform Z80 code assembler, which compiles ASM source files into machine code, saving them in TAP, TZX or BIN format. *ZXBpp* is a precompiler, modelled after similar existing programs for languages such as C: it has the function of re-elaborating the source code to optimize it before compiling it with ZXBc.

Furthermore, ZX BASIC can be integrated with other software through codes called 'libraries'. For instance, you can include the BIFROST*, NIRVANA and NIRVANA+ graphics engines, or the Z80 Assembly routines for extracting data compressed with ZX0 and ZX7.

In recent years, ZX BASIC experienced an ever-increasing popularity: it was used to create several games for both the historical Spectrum and the Next. Some of them, among those mentioned in this same chapter in the section about games, are recalled here: *Ad Lunam, Ad Lunam Plus,* the entire *Red Raid* series, *Knights And Demons DX, Earthraid, Italia 1944, Binary*

Land, Souls Remaster, Stela, Stela II, The Tales Of Grupp, Yumiko In The Haunted Mansion, Pets Vs Aliens Prologue, Transylvanian Castle II, Mechwars Arena, Mechwars Centipede, Cuadragon Next, Xeno Brigade.

TOMMYGUN

Integrated development environment for games and other software types for the Spectrum and other 8-bit systems, by Tony Thompson. It runs under Windows and is divided into various applications for the creation of images, sprites, game maps or two-dimensional backgrounds and related individual elements, and finally machine code, to combine the result of work done with the tools. TommyGun does not convert machine code to binary files by itself; to do this, it is necessary to install an assembler – the author suggests the use of Pasmo – and connect it to the TommyGun editor. The result can be tested on an emulator, also chosen by the user.

Due to its modular structure, it is also suitable for software development for the Amstrad CPC 464, 664 and 6128, SAM Coupé, Commodore 64 (only in high resolution), Commodore VIC 20 (only in high resolution and MultiColor), Jupiter Ace (limited support for 64×48 mode), Jupiter Ace 2000 (full support for 256×192 mode), Enterprise 64/128 and MSX 1 (partial support). However, the development of TommyGun stopped at version 1.4, of 4 September 2017.

PLATFORM GAME DESIGNER

Application for the 48K Spectrum and later models, by Jonathan Cauldwell, to create platform games in the style of *Manic Miner* or *Jet Set Willy*. It allows the insertion of conveyor belt platforms, 'deadly' blocks that make the character lose a life upon contact, platforms that crumble when the character walks upon them, intermittent platforms and more.

Released in 2005, PGD has not been used much: until the end of 2021 there were only 14 titles made with its help.

SHOOT ‘EM UP DESIGNER

A program written by Jonathan Cauldwell for the creation of simple horizontal or vertical scrolling shooters on the 48K Spectrum and later models. In addition to the design of sprites for the player and enemies and of the backdrops, it allows to define enemy movement patterns and, by means of a simple internal programming language, various aspects of game logic. For example, it is possible to implement fuel consumption, to be restored by collecting appropriate icons, or enhance the player’s shots; set the number of hits needed to destroy enemies; collision with the background elements may or may not be lethal.

SEUD, as it is usually called, has some limitations. All sprites measure 16×16 pixels, with the exception of ‘bosses’ which measure 32×32; enemies cannot shoot, but only collide with the player-controlled sprite; sound effects, unless calling an external routine from within the code, are only for the AY chip; it is not possible to control the games with a joystick, except by redefining the keys according to the Sinclair or AGF input schemes; sprites and backgrounds must all have the same combination of INK and PAPER, so that the game is only in two colours; sprites are not masked; to prevent the game from starting over once the last level is reached, its code must be modified.

There are bugs, too. Bonus icons are automatically collected as they disappear from the screen due to scrolling; the background colour cannot be changed; sound effects generated after the first are ignored. Cauldwell himself indicated corrections for the first two drawbacks. However, to this day SEUD has not been revised after the initial version 1.0 of 2008.

Few titles have been made with SEUD. Until October 2022, there were 13, plus two (*Apulija-13* and *Cousin Horace*) where the game made with this tool is only part of a larger whole.

ARCADE GAME DESIGNER/MULTI-PLATFORM ARCADE DESIGNER/AGDX(MINI)/MUSICIZER

The third development tool by Jonathan Cauldwell, Arcade Games Designer – *AGD* for short – is more generic than the first two: it lacks some distinctive features, such as conveyor belts for platform games or the attack wave generator for shoot-em-ups as well as the screen scrolling routines. On the other hand, in addition to being, unlike PGD and SEUD, distributed for free, it is a much more flexible tool, suitable for creating arcade or arcade adventure games of different genres, for instance platforms with jumping, platforms and ladders or maze.

AGD runs on the Spectrum (128 KB RAM are required from version 3.0 onwards) and is divided into several modules. It relies on an internal programming language for game logic scripts and is able to render the final result in a wholly independent program. Modules concern the character set, drawing and animation of sprites and objects, design and type definition of one-character blocks needed to compose screens, playing area size, jump trajectory for platform games, text messages and more. The script programming language includes many commands, functions and variables and is much more complex than that of SEUD.

Initially, the possibilities offered by AGD were rather limited, but the interest aroused among enthusiasts prompted the author to update it, introducing new features and expanding the scripting language. With version 4.0, released on 4 April 2013, AGD assumed a variable physiognomy through three 'specializations', for the inclusion in games of special visual effects, scrolling messages, drop-down menus for object management. Furthermore, sprites can have dimensions of 16×24 pixels next to the usual 16×16 and a different colour from that of background blocks.

AGD ended its history with the experimental version 4.8 of 16 February 2019. It was a draft of 5.0, designed by Cauldwell but later abandoned in favour of a Windows program: *Multi-Platform Arcade Game Designer, MPAGD* for short. Its user interface is controlled by the PC's keyboard and mouse: each module is managed from a separate window. 'Multi-Platform' means that games made with MPAGD can be exported to other platforms based on the Z80 processor besides the Spectrum, for instance the Amstrad CPC, MSX, ZX Spectrum Next, Timex Sinclair TS 2068. Game code cannot be used immediately, but it must be exported as a Z80 Assembly file and compiled with an external assembler.

With MPAGD, the end of the dependency on the Spectrum's RAM allows for longer and more detailed games to be built, while scripts, being stored as normal ASCII text files, are much easier to create and modify. Some instructions already present were renamed, while a specific CALL command was introduced to call external routines, where previously an ASM 205 instruction (Z80 Assembly numeric code of CALL) had to be entered directly followed by two other ASM codes containing the routine address in 'little-endian' format, the byte order followed by the Z80. Collision detection, always a weak point of AGD, was made more precise.

Parallel to the emergence of MPAGD, the old AGD Spectrum code was revised and expanded by another developer, Allan Turvey ('Highriser'). Thus, *AGDX* was born, an evolution of the program with a large number of improvements like keyboard shortcuts, the ability to copy and paste scripts or more effective internal memory management. AGDX, in turn, is frequently revised with the addition of new features and bug fixes. Turvey then wrote external routines to implement effects normally absent from the AGD base code, for example conveyor platforms and flashing objects. Also by Turvey is *AGDX Mini,* a version of AGDX where all sprites have the size of a character block (8×8 pixels) and it is possible to insert a maximum of 40 sprites in each screen, against the 12 of AGD and AGDX. The utility includes a new sound effects generator for AY chips written by David Saphier.

All the ‘manifestations’ of AGD share the same limitations. The program allows to create arcade titles that fall into certain well-defined types, which gameplay mechanics, although user-definable, are always conditioned by the intrinsic limits of the script language. The games thus obtained are conceived for the 48K, therefore those extended on several levels to be integrated together in the 128 KB of later models’ RAM require each level to be created as a single game in its own right, recalled through a code external to AGD; this, however, has been done in very few cases so far. Sprite masking is absent; Allan Turvey has devised a code to overcome this missing feature, which however requires a large amount of RAM.

Sound effects can be only defined for the AY chip, while for the beeper there is a bland effect of variable length generated with the BEEP command, which is flanked in MPAGD by a generic noise generated by the CRASH command. More elaborate sound effects should be stored as external routines to be called via the ASM or CALL instructions. The same must be done to insert background music generated by the AY chip, composed with a program such as Vortex Tracker II and recalled with a special Z80 Assembly ‘player’ code. To make this last operation easier, David Saphier created *AGD Musicizer,* a utility to add one or more AY tunes to a game made with AGD, using memory bank 4 of the 128 KB RAM.

In October 2020, Jonathan Cauldwell resumed work on AGD by creating *Arcade Game Designer ROM,* a version of the program that replaces the computer’s firmware. According to the author himself, this is a feasibility study to verify if it is possible to insert as many functions of the 128 AGD in a 16 KB ROM. It is mainly used with an emulator, by loading the binary file instead of the 48K ROM.

AGD and its derivatives gave life, up to October 2022, to 345 games, mostly platform arcades, ranging from simple titles that can be completed in a few minutes to relatively complex and multi-level adventures, supplemented by start menus, intermission and end-of-game screens and other additional features. In one case, even an isometric 3D game, *Qbox,* was made.

MT ENGINE MK1 'LA CHURRERA'/MK2/MK3

Designed by Spanish development group Mojon Twins, the MT Engine is a set of applications for creating single-screen maze or platform games. Some are the work of the Mojon Twins, others of third parties. The main ones are:

- the *Z88DK* compiler, by Dominic Morris and others;
- Alvin Albrecht's *splib2* graphics library;
- Emmanuel Marty's *Apultra* data compressor;
- *BIN2TAP,* a utility by 'mike' and 'zeroteam' for converting machine code binary files into TAP tape image files;
- *BAS2TAP,* a program by Martijn van der Heide that converts Sinclair BASIC programs written in plain text format into TAP tape image files;
- Jaime Tejedor Gómez's *SevenUp* drawing program for sprites and screen elements;
- the *Mappy* program for the design and arrangement of screens;
- the *Ponedor* program for inserting and defining the movement of sprites other than that of the main character.

Furthermore, the authors indicate among development tools a simple ASCII text editor chosen by the user and a music composition program for the 48K beeper, suggesting *Beepola* in this regard. A script file called *config.h* contains all the settings that determine the game's physiognomy.

The first MK1 version, nicknamed 'La Churrera', appeared in 2010. Its update was suspended in 2014, when MK2 was launched, then resumed in 2020, on the occasion of the tenth anniversary of its release. A third version, MK3, is in an experimental state and has not yet been made public.

Among its features, the MT Engine offers inertial movement, sprite masking, jumping even in games viewed from above, a period of invulnerability for the player character after contact with an enemy or a lethal obstacle, management of conversation windows for arcade adventures, the ability to create games with multiple levels or for 128 KB RAM models with background AY music as well, automatic insertion of an initial menu for control choice between keyboard, Kempston and Sinclair joystick and a game completion screen.

Conversely, there are also inevitable limitations. The MT Engine is strongly oriented to the creation of platform or maze games, so it is less flexible than a utility like AGD. Sprites can only have two animation frames each, and no more than four can be present on each screen at a time. 'Tiles' (4-character block squares) for screen designing are limited to 16, or 48 if the game does not include objects to collect or move or interact with, for example doors and keys. The use of tiles often makes game environments visually similar to each other. Despite this, the MT Engine is the most popular game creator after AGD: until October 2022, there were 84 games made with the MK1 version, 11 with MK2 and only two with MK3.

INPAWS

Development environment for text adventures along the lines of Gilsoft's *Professional Adventure Writer.* The author is known under the pseudonym of 'Mastodon'. InPAWS creates a source code structured in its own syntax, derived from the one of PAW, which is then compiled into code for use on Spectrum or Amstrad CPC.

InPAWS proves to be a much more flexible tool than that, still of considerable utility, it is inspired by. Instead of the usual PAW codes, user-chosen names can be assigned to locations, objects, messages and game flags, thus making programming easier. Answers, processes, vocabulary and messages can be defined separately according to the relative locations or objects, while in PAW they had to be combined into a single block. It can also import and use graphics and character sets made with PAW and can extract script data from Z80 and SNA snapshot files saved under emulation at the start of adventures written with PAW, in order to obtain a source code that can be modified and recompiled.

BAS2TAP

Utility by Martijn van der Heide to convert Sinclair BASIC programs written in ASCII plain text format to TAP tape image files. It is compatible with the classic 48 BASIC and the extended 128 one.

BIN2DATA

Work of Bob Stains. It creates a TAP or TZX file from a binary data file, stored in a memory location chosen by the user.

BIN2REM

Written by Paolo Ferraris, BIN2REM generates a TAP file containing an auto-starting BASIC program from a code in Z80 Assembly. It is particularly useful for creating machine code loaders to use with a simple LOAD “” command, or from the 128 and later models’ main menu.

CROSS-PLATFORM APPLICATIONS

This selection lists some multi-platform applications, that is to say, for developing software targeted at various systems, commonly used for the Spectrum as well.

Z88DK

Z88DK is a cross compiler capable of writing programs in Z80 machine code starting from a Small-C source, a derivate of C designed by Ron Cain and James Hendrix and precisely aimed at the simplest computing architectures. The name derives from the first versions, devised for the Cambridge Z88. Libraries coming with Z88DK are designed to be as generic as possible, in order to allow the writing of software for potentially every Z80-based machine. The Spectrum is in fact one of the main objectives of the compiler, but not the only one: currently included programming libraries provide support for more than thirty different platforms. These range from the most popular ones, like the Spectrum, ZX81, Amstrad CPC, MSX and Sega Master System, to more niche systems, for instance the Z88 itself, TRS-80, Tatung Einstein and SAM Coupé, up to others known mostly to enthusiasts, such as the Yugoslavian Galaksija educational computer, the Jupiter ACE and the Sprinter.

Z88DK was initially created by Dominic Morris, who was later joined by other programmers. It is available in binary executable format for Windows, macOS, and Linux. The latest version is 2.1 of 7 February 2021.

Z80 ASSEMBLERS

Command line interface programs that compile a Z80 Assembly source code file in binary format. When used for compiling Spectrum code, they can also create TAP or TZX tape image files, or SNA snapshots.

Pasmo. A work of Julián Albo, one of the most popular assemblers in the Spectrum scene. The latest version is 0.5.5 of 5 March 2022. There is a preliminary 0.6.0 version, but the writer experienced some compilation errors with it, and what is more, it has not been updated since 13 January 2007, therefore its use is not recommended.

SjASM. By Sjoerd Mastijn, it is characterized by the possibility of inserting 'false' instructions in the Z80 Assembly code to make it more orderly and intuitive to understand, which however prevents it from being used with other assemblers. Development stopped at version 0.42c of 6 November 2011.

SjASMPlus. Made by 'Aprisobal' and Branislav Bekes ('z00m'), it is based on the SjASM code, of which it constitutes the evolution, reprising its features, including 'false' instructions, and adding new ones, for example the ability to export code in Beta Disk or NEX disk image format, or to integrate Lua scripts into it. For Windows, macOS, Linux, BSD, Raspberry Pi.

RASM. Its authors are Édouard Bergé and Stéphane Sikora. Widely used by Amstrad users, it also includes specific development features for the Spectrum. For Windows, macOS, Linux.

DATA COMPRESSORS

Command line utilities to compress data, so as to take up less space in RAM or storage media. They need a Z80 Assembly code for decompression.

ZX7/ZX0/ZX1/ZX2/ZX5/RCS. Family of compressors for Windows, the work of Einar Saukas, which implements the LZ77 and LZSS algorithms. They are characterized by an optimal ratio between compression and execution speed and do not need buffer memory for decompression.

ZX7 was the first, launched in 2012 and superseded by ZX0 in 2021. From it, ZX1 and ZX2 are derived, which sacrifice the compression ratio for higher decompression speed, and ZX5, an experimental program with a slightly better compression capacity than ZX0, but much slower in execution. The author then released a version written in Kotlin, faster than the standard one, but which requires the installation of Java version 8 or higher. Decompression routines are available in four versions. In increasing order of speed and size they are: ‘standard’, ‘fast’, ‘turbo’ and ‘mega’. For each one of them, there is an alternative code for ‘backwards’ data decompression, that is, from a higher to a lower address in the RAM.

RCS is an additional algorithm designed specifically for compressing SCR video memory files and permits a further performance improvement of ZX7 and ZX0 when compressing such kind of data. Screens compressed with RCS require a conversion back to SCR after decompression.

Apultra/APC12spke/oapack/aPLib pack 2. Compressors based on Jørgen Ibsen’s *aPLib* library, built on the LZ algorithm: *Apultra,* by Emmanuel Marty; *oapack,* by Eugene

Larchenko; *APC12spke,* by Sven Dahl, Antonio Villena and Aleksey Pichugin; *aPLib pack2* by 'r57shell'. All these programs run under Windows, have very similar performance and can use the same Z80 Assembly decompression routines.

LZSA. Another implementation of the LZ algorithm, made by Emmanuel Marty and Aleksey Pichugin. It favours decompression speed over compression efficiency.

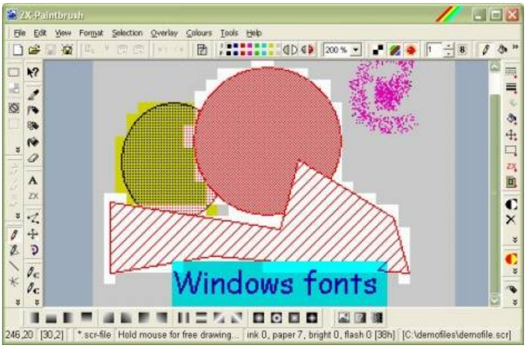
Exomizer. Compressor designed by Magnus Lind for use with systems based upon the MOS 6502 processor and compatible CPUs. Jaime Tejedor Gómez ('Metalbrain') wrote the decompression codes for Z80-based systems, later optimized by Antonio Villena and 'Urusergi'. Exomizer has an excellent compression ratio, but is quite slow in the decompression phase and requires a temporary work area of 256 bytes.

Salvador. Another work by Emmanuel Marty, it uses the ZX0 algorithm. It can reach compression levels similar to ZX0's in significantly shorter times, about 5-10% compared to Einar Saukas' program. Files generated by Salvador can be decompressed with the same routines used for ZX0.

RIP (Real Information Packer)/mRIP. RIP is a compression scheme implementing LZ algorithm, Huffman coding and offset reuse, devised by Roman Petrov. It has a very high compression ratio, but is rather slow, uses a lot of memory and is recommended for files shorter than 100 KB. mRIP, developed by Dmitriy Bystrov, is a simplified version of RIP, which employs a smaller decompression code while mantaining a good compression ratio. Both schemes have been implemented on the PC by Eugene Larchenko.

GRAPHICS APPLICATIONS

ZX-PAINTBRUSH

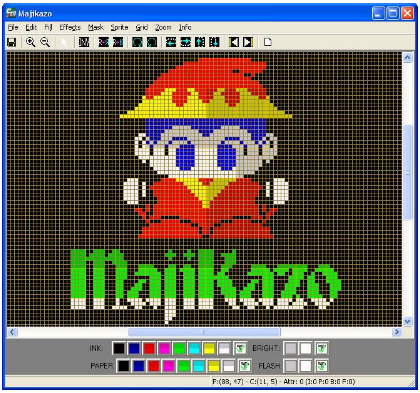


An advanced graphics editor for Windows to create and modify Spectrum image video files. It is part of Claus Jahn's ZX-Modules suite. This program offers many possibilities:

- freehand and geometrical shapes drawing with different fill styles – solid, texture or with an user-imported image;
- writing with fonts available on the system in use, in four different directions with shading and contour effects;
- spraycan and floodfill tools – floodfill can also have special filling styles;
- mirroring, rolling, scrolling and inverting tools for the whole screen or selections;
- three zoom levels;
- transparency effects;
- import interface for BMP, GIF and JPG pictures, with conversion dialog to adjust brightness, contrast and size;
- export to TAP and TZX tape image files, SCR video images or ZED format for use with ZX-Editor;

- clipboard memory in ZXP or Windows format;
- support for transparent and coloured overlay images;
- font editor for characters in different formats;
- can open SevenUP SEV files;
- can open and edit ULAplus palette files
- can open Timex image video files, also with ULAplus.

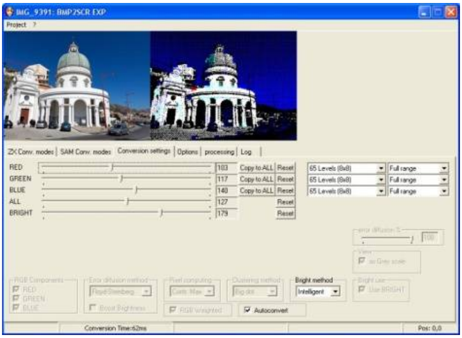
SEVENUP



A graphics editor for screens and sprites, by Jaime Tejedor Gómez ('Metalbrain'), available for Windows, Linux, FreeBSD, macOS.

It reads Spectrum SCR video files and BMP, GIF, JPG, PNG, PCX, TIF, IFF and XPM image formats, saves in SCR format and exports in BMP, JPG, PNG, PCX, TIF and XPM. It also reads and writes in a native format, SEV. It can also export image data in binary BIN format as well as in ASM machine code and C source files. Among its advanced features there are the ability to set mask layers to intervene only on certain areas of the image, texture filling and multiple zoom levels.

BMP2SCR/RETRO-X



Windows program to convert BMP, JPG, PNG, GIF and IFF images into SCR and other special formats, like 8×1, IFLI, low resolution and others, with options for solid colour, ordered dithering or diffusion error, colour or black and white. Red-green-blue channels or, in the case of black and white images, brightness levels can also be manipulated. The author, Leszek Chmielewski Daniel ('LCD'), turned it, after version 2.11, into another project, *Retro-X,* more ambitious than the previous one, with many more video modes available for emulation and conversion to other formats – it was also used to produce examples of the new video modes in this book – and a graphics editor to manipulate the converted images. Retro-X is a suite of programs, but some of its parts, such as the tracker or internal emulator, are not yet operational. Progress has not gone further than the 2007 Alpha 8 version.

IMAGE TO ZX SPEC

Another image converter, which instead of directly emulating the video modes of the Spectrum and its clones, offers a wide range of possibilities for the transformation of the original source. Coded by Benjamin Brown, it is written in Java and can therefore run under any operating system compatible with Java 6 and newer.

A unique feature is the conversion of AVI or MOV video clip files in Spectrum format, but with limitations due to the poor ability of the Java Media Framework API library to recognize codecs for video compression. The author suggests converting the movies to the Spectrum's native 256×192 resolution and saving them in an uncompressed format, for instance Radius Cinepak. Image data can be exported as PNG and JPG bitmap files, SCR video memory files, TAP files for loading into an emulator or on a real Spectrum, and as animated GIFs, chaining multiple images together.

IMAGE SPECTRUMIZER

Created by Jari Komppa, Image Spectrumizer converts bitmap image files into Spectrum format image data, with a wide range of editing possibilities. The program, rather than automating changes to the starting image, considers them as separate steps, the order of which can be changed, while the final result is displayed in real time. The author himself encourages users to experiment with the various possible combinations until the desired effect is obtained.

Converted images are then saved in PNG bitmap format, as a binary file or C/Z80 Assembly source code.

MAC2SPEC

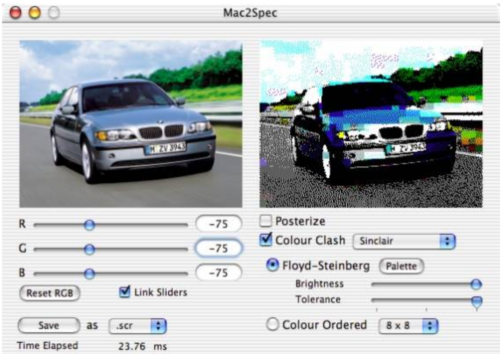


Image converter for macOS made by James Weatherley. It can convert JPG, GIF, PNG, PICT, PDF, EPS, BMP (colour-only) images, and MOV and AVI clips. It produces images in both standard graphic mode and 8×1 multicolour graphics and exports them in SCR and TAP format.

SCRPLUS/IMAGE2ULAPLUS

Image converter that can produce files in ULAplus mode, even with the aid of custom colour palettes, and modify the YUV space of the source. It also includes 8×1 multicolour mode. Its author, Edward Cree, makes it available for Windows, macOS, Linux, FreeBSD, Solaris.

Image2ULAplus, by Claus Jahn, is a revision of this program, which also opens Timex SCR video image files, with or without ULAplus, as well as those in ZX-Paintbrush's native ZXP format.

ZX SCREENS/ZX SCREEN SNAPPER/ZX MAPS CREATOR

These three applications for Windows are the work of Pavel Plíva ('Pavero') and constitute a sort of suite for creating game maps, activities in which the author has been engaged for years.

ZX Screens is an image viewer capable of converting SCR, BMP, GIF and PNG files into each other. *ZX Screen Snapper* is a memory resident program that captures Spectrum screens generated by some emulators at the push of a button. These can then be combined together with *ZX Maps Creator* in order to create, as mentioned, the map of the locations of a game.

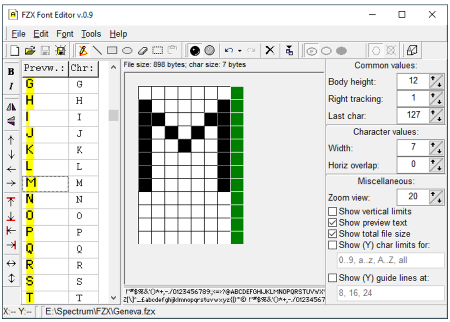
SPECVIEW

A program by Richard Chandler with two main objectives: saving start screens of snapshot files for emulators and discovering 'Easter eggs' hidden in loading screens. The latter purpose is achieved thanks to a special menu command to activate or deactivate screen attributes, in order to reveal possible hidden messages. Finally, it allows for some simple image manipulation operations and their printing in 6"×4" (15.24×10.16 cm) or A4 format.

LGK/OPAL

Programs made by Dmitry Malychev ('Lethargeek'), specifically intended for the compression of Spectrum screen image data. LgK is the actual compressor, while OpAL is an attribute optimizer to be used before compression with LgK. Compression is very efficient, and it is possible to integrate the decompression routine into the resulting binary file, before the compressed data. However, decompression is rather slow, so the use of LgK is preferable where memory saving is a priority over execution speed.

FZX FONT EDITOR



A program by Claus Jahn program to create and modify custom character sets, for classic 8×8 fonts as well as extended and proportional FZX type fonts. FZX was designed by Andrew Owen.

SOUND APPLICATIONS

VORTEX TRACKER II

This tracker for Windows is an evolution of Vortex Tracker, developed by Sergey Vladimirovich Bulba and Roman Sherbakov along the lines of the famous *Pro Tracker* for the Amiga, of which it can import files up to version 3. It imports data in many other formats, like sequences for the sound chips of the Spectrum and compatible platforms, the AY. Of course, a new sequence can be created from scratch.

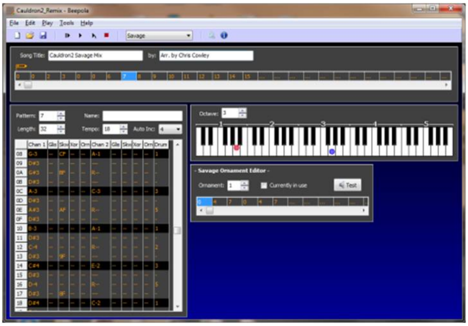
The program includes an internal emulator of the AY-3-8910/8912 and YM2149F chips and of the timings of the Spectrum, Pentagon, Amstrad CPC and Atari ST processors. Tracks are saved as VT2 native format as well as Pro Tracker 3 (PT3), or in AY or tape image file (TAP) or Beta Disk (SCL). They can also be exported in text format for their possible modification with an editor such as Windows Notepad. Vortex Tracker II is currently being developed by Ivan Pirog.

AY PLAYER

Its full name is *ZX Spectrum Sound Chip Emulator*. In fact, it is more than a simple audio file reader: it is a real emulator of the sound chips of the Spectrum and its clones, with numerous user-editable parameters for sound performance. Like Vortex Tracker II, it was programmed by Sergey Bulba and runs under Windows; the graphic user interface is due to Ivan Nikolayevich Reshetnikov. AY Player reads many sequential file formats, precisely all those that can be opened by Vortex Tracker II. With the addition of the optional BASS dynamic libraries, it can also read audio file formats like MP3, OGG, WAV, WMA, APE, FLAC, AC3, MTM, MOD and more. It supports Winamp M3U playlist files as well as its own list type, with AYL extension. In addition to that, it also reads not only AY files containing data for the AY-3-8910/8912 and YM2149F chips, but music composed with the Spectrum beeper.

BEEPOLA

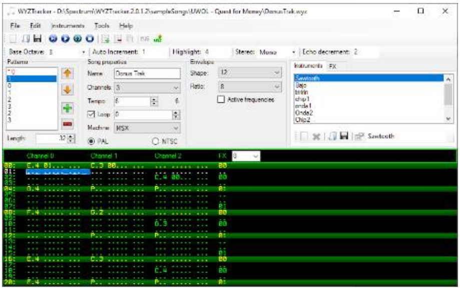
A Windows tracker for composing music pieces with the Spectrum beeper, made by Chris Cowley. The user interface is similar to that of other programs of this kind, with the two main channels for notes, one for effects (if present) and finally one for percussion. However, the real strength of Beepola lies in the different available acoustic rendering methods, each one with its specific features:



- *Special FX:* 4 sound and 1 percussion channel, with note sustain;
- *Phaser 1:* 5 full octaves for both channels, of which the second is a programmable synthesizer with up to 100 unique instruments for each piece; 1 percussion channel with 8 high quality sampled sounds or 9 synthetic sounds; it has no detuning effects, typical of other methods;
- *Music Box:* it does not use any CPU interrupt service routine, so it can create code for generating music to play during a game or while other tasks are running;
- *Music Studio:* 2 channels, of which one can be dedicated to percussions, for which 13 sounds are available; generates sawtooth tones; like the previous one, it does not use any ISR;
- *Savage:* 1 percussion channel with 5 sounds; up to 31 ornaments for each piece; glissato effect; timbre changes for both channels; possibility of using additional sound effects.

Beepola can also import audio data from TAP or Z80 files, if created with Music Box or Phaser 1.

WYZ TRACKER



Written by Augusto Ruiz, WYZ Tracker is a music composition program for the AY-3-8912 chip. Mainly used in the Amstrad scene, it is natively supported by Mojon Twins's MT Engine: games created with this tool do not need an external code to play tunes in WYZ format.

The program, for Windows, includes all the options of a classic tracker, including the ability to create instruments or to import and modify ready-made instruments. Timings can be set, other than for the Spectrum, for the Amstrad CPC and the MSX.

GAMES

The following pages host a selection of new games released since 1994, the first year after the end of the Spectrum's commercial life. It proceeds through the following years up to the end of 2021 (in 2000, in the opinion of the writer, no titles of particular importance were registered). For each title, the title, producer – plus the author if they do not coincide –, genre, minimum required RAM in kilobytes – 48/128 for those coming in two distinct versions – and the language or languages are indicated. A series of illustrative screens completes each sheet.

The games listed are freely downloadable from public archives hosted by sites such as *World Of Spectrum* or *Spectrum Computing,* except those whose title is preceded by an asterisk (*) to indicate that the game is paid and must be purchased from its distributor. Many of these can be found on the *itch.io* website.

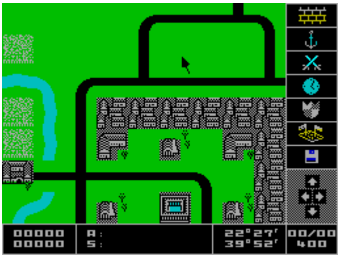
Only complete versions have been listed, with the partial exception of *Klass Of '99,* which, although indicated by its author as being in progress, is completely playable, despite the fact that its code is not yet fully optimized. Please refer to the aforementioned archives for the complete list of games released in each year.

1994				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
End is Nigh, The	Zenobi	48	text adventure	English
Hexxagon	WE	48	puzzle	English
King Valley	WE	128	puzzle	English
Montana Jones II	Home Masters	128	arcade	English
Peloponéská Válka	Proxima	48	strategy	Czech
Quadrax	Ultrasoft	48	puzzle	Czech
Randex	RA Soft	48	arcade	English
Towdie	Ultrasoft	48	dynamic adventure	English, Slovak

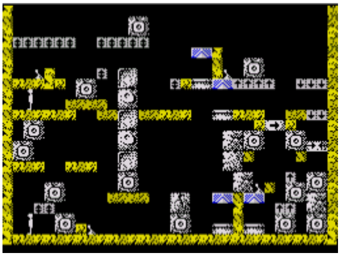
1995				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Caves Of Skull, The	Zenobi/ M. Freemantle	48	text adventure	English
Feuerfaust, Die	FSF Adventures/ L. Horsfield	48	text adventure	English
Hop 'n' Chop	Redwood Designs/ G. A. Shaw	48	arcade	English
Loose Ends	Zenobi/ J. Scott, S. Boyd	48	text adventure	English
Magic Block	DAB Laboratory	48	puzzle	Russian
Twilight	Ultrasoft	128	dynamic adventure	English, Slovak

Hexxagon

King Valley



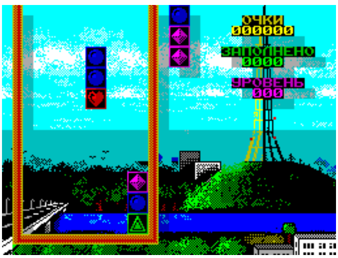
Peloponéská Válka



Quadrax

Randex

Towdie



Magic Block

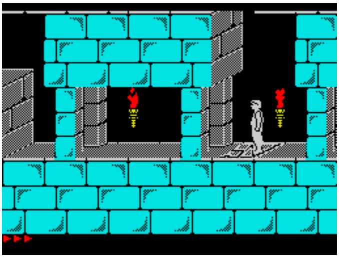
Twilight

1996				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Mutiny	Zenobi/ J. Scott, S. Boyd	128	text adventure	English
Prince Of Persia	Magic Soft/ Nicodim	128	arcade	Russian
Robo	Bitmunchers	48	puzzle	English

1997				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Diamond Mine	Shuric Program	48	arcade	English
Murder Mystery Weekend, A	Zenobi/ J. Scott, S. Boyd	48	text adventure	English

1998				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Kolobok Zoom II	Asphyxia/ Freeman	128	arcade	English

1999				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Gift For Diver	Light Future	48	puzzle	English
Eugene Lord Of The Bathroom	Vidar Eriksen	48	arcade	English
Pussy Love Story From Titanic	Fatality/LCD Freeman	128	puzzle	English
Supaplex	Flymansoft A. Mushnikov	128	arcade	English
Towerpod	Studio Stall	128	arcade	English, Russian



Prince Of Persia

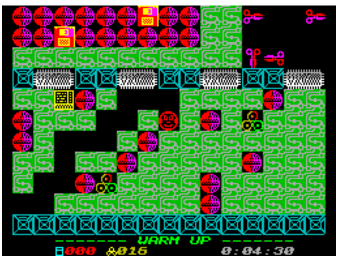
Robo

Diamond Mine

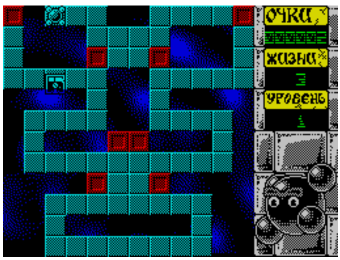
Kolobok Zoom II

Eugene Lord Of The Bathroom

Pussy Love Story From Titanic



Supaplex



Towerpod

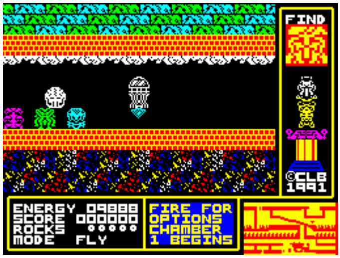
2001				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Dizzy XII Underground	Sergey A. Smirnov	128	dynamic adventure	English, Russian
One Man And His Droid II	Clive Brooker	128	arcade	English

2002				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Abe's Mission Escape	Perspective G.	128	arcade	English, Russian
Adventures Of Sid Spider	David Pegg	48	puzzle	English

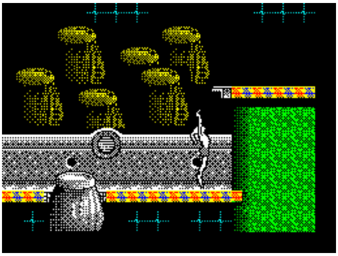
2003				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Egghead In Space	Jonathan Cauldwell	48	arcade	English
Fire 'n Ice	Discovery	128	puzzle	Russian
Maria Vs Some Bastards	Vidar Eriksen	48	arcade	English

2004				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
ZX Football Manager 2005	Perspective G./ Triumph GL	48 128	sports simulation	English, Russian

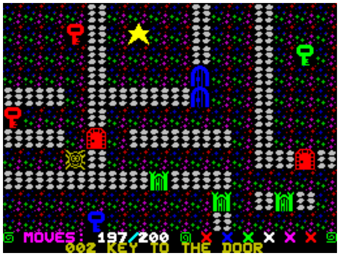
Dizzy XII Underground



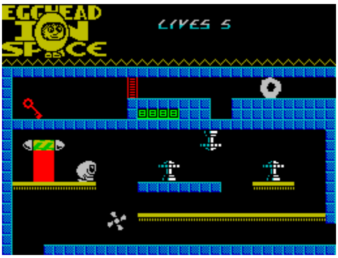
One Man And His Droid II



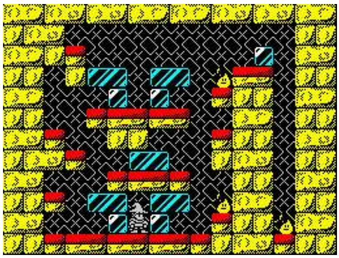
Abe's Mission Escape



Adventures Of Sid Spider



Egghead In Space



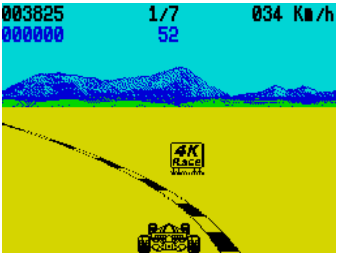
Fire 'n Ice

Maria Vs Some Bastards

ZX Football Manager 2005

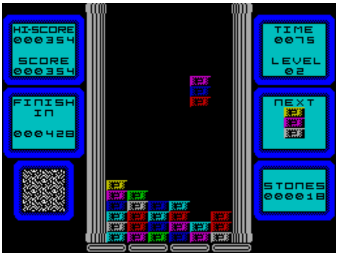
2005				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
4K Race Refueled	Paolo Ferraris	128	car races	English
Beastie Feastie	Beyker Soft	128[11]	arcade	English
Columns	CEZ	128	arcade	English
Dominetris	Cronosoft/ Bob Smith	48	arcade	English
Jet Set Willy In Paris	Hervé Ast	128	arcade	various
Maria On Tour	BaSe1 PrOdUcTiOnZ	48	arcade	English
Stranded	Cronosoft/ Bob Smith	48	arcade	English
Tower Of Barad	Zakiagatgo	48	text adventure	English
Turbomania	Jonathan Cauldwell	48	arcade	English

[11] Runs only on the +2A/+3. A modified version able to run on the other Spectrums exists.

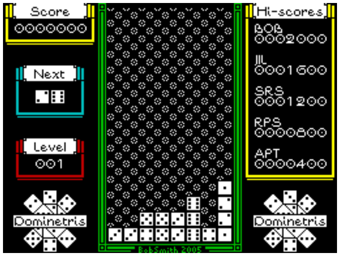


4K Race Refueled

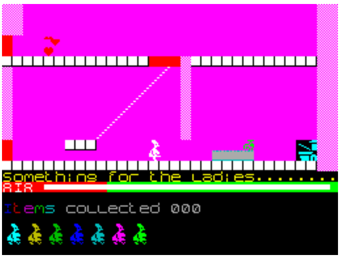
Beastie Feastie



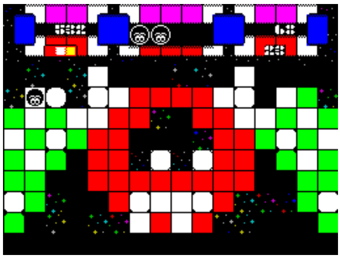
Columns



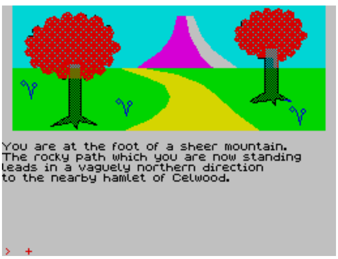
Dominetris



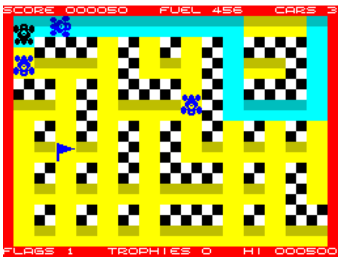
Maria On Tour



Stranded

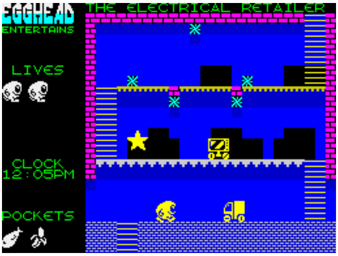


Tower Of Barad



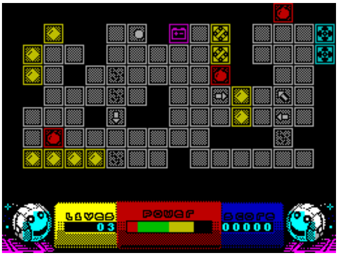
Turbomania

2006				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Egghead IV	J. Cauldwell	48	arcade	English
Farmer Jack In Harvest Havoc!	Cronosoft/ Bob Smith	48	arcade	English
Gamex The Games Exchange	Cronosoft/ J. Cauldwell	48	arcade	English
Iron Sphere	Cronosoft/ I. Munro	48	arcade	English
Land Beyond Time, The	Simon Allan	48	text adventure	English
Maru-Ja!	Beyker Soft	48	puzzle	Spanish
Pandemia	Octocom	48	arcade adventure	Spanish
Paradoxion	Perspective G./ SAM Style	48	puzzle	English
Phantomas Saga Infinity	CEZ	48	arcade	English
Ragnablock	CEZ	48	arcade	English
Sokoban	Compiler	48	puzzle	English, Spanish
Square Mania	Perspective G./ Aprisobal	48	arcade	English
Ultimate Manic Miner	I. Makovsky	128	arcade	English
Willy On A Transatlantic Cruise	Hervé Ast	128	arcade	various



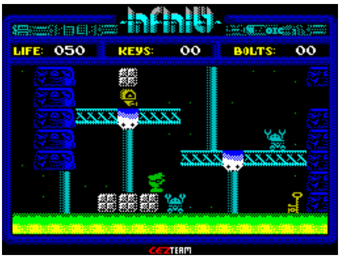
Egghead IV

Farmer Jack In Harvest Havoc!

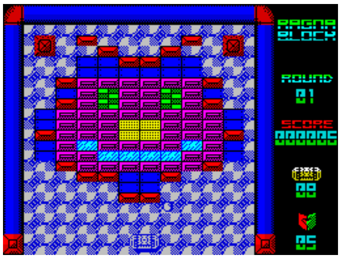


Iron Sphere

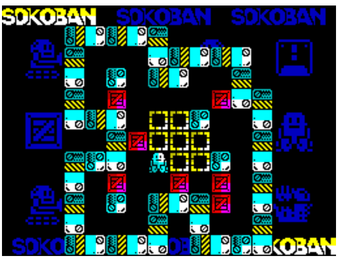
Pandemia



Phantomas Saga Infinity



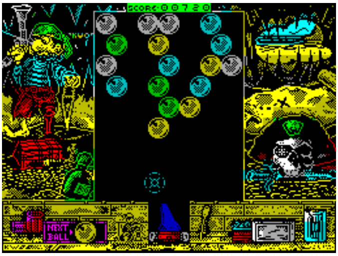
Ragnablock



Sokoban

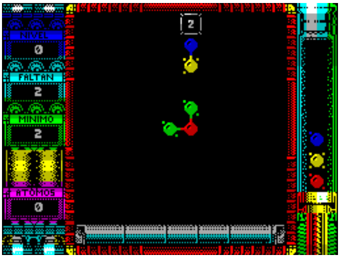
Ultimate Manic Miner

2007				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Astro 2008	Cañadul	48	puzzle	Spanish
BeTiled!	CEZ/ Mojon Twins	48	arcade	English, Spanish
Cannon Bubble	CEZ	128	arcade	English, Spanish
Egghead Round The Med	Cronosoft/ J. Cauldwell	128	arcade adventure	English
Isotopia	Octocom	128	puzzle	Spanish
Justin	CNG Soft	48	arcade adventure	various
Nanako in CJMC	CEZ	48	arcade	Spanish
On Reflection	Cheese Freak	128	text adventure	English
Phantomasa II	CEZ/ Mojon Twins	48 128	puzzle	English
Quantum Gardening	Cronosoft/ J. Cauldwell	48	arcade	English
Stranded 2.5	Cronosoft/ Bob Smith	48	arcade	English
Stronghold	Red Triangle	48	puzzle	various
Sudoku	Tangram Design	48	puzzle	English
Viaje Al Centro De La Tierra VE	Topo Siglo XXI	48	arcade	Spanish
Wizard Of Wor	Weird Science	48	arcade	English
Wizard, What Wizard?	Simon Allan	48	text adventure	English

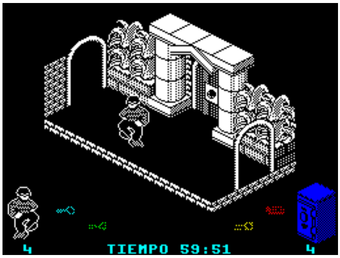


Cannon Bubble

Egghead Round The Med



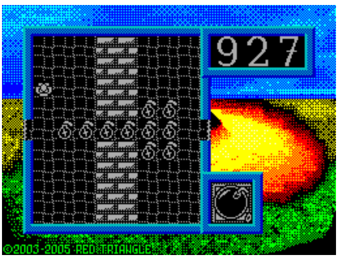
Isotopia



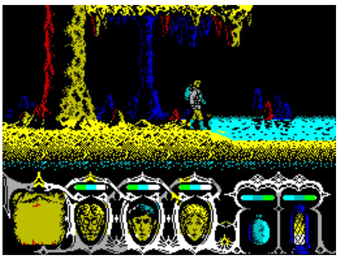
Justin

Phantomasa II

Quantum Gardening



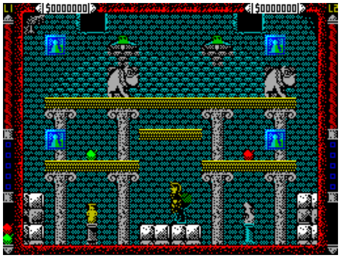
Stronghold



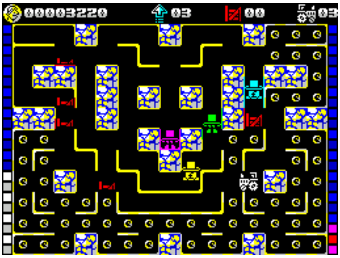
Viaje Al Centro De La Tierra VE

2008				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Albatrossity	Jonathan Cauldwell	48	puzzle	English
*Escuela De Ladrones	World XXI Soft	128	arcade	English, Spanish
Farmer Jack & Hedge Monkeys	Cronosoft/ Bob Smith	48	arcade	English
Farmer Jack Treasure Trove	Cronosoft/ Bob Smith	48	arcade	English
iLogicAll	CEZ	128	puzzle	English, Spanish
JINJ	CEZ	48	arcade	English, Spanish
Mockatetris	Rafal Miazga	48	puzzle	English
Moonscape	Simon Allan	48	text adventure	English
Rallybug	Jonathan Cauldwell	48	arcade	English
splATTR	Cronosoft/ Bob Smith	128	arcade	English
Willy And The Dodecahedron	Stuart Hill	128	arcade	English
Willy The Man Who Sold …	BaSe1 PrOdUcTiOnZ	48	arcade	English

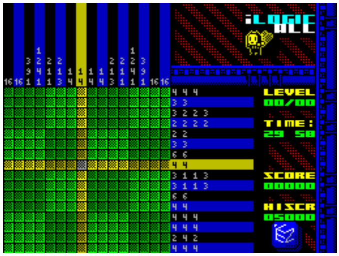
Albatrossity



Escuela De Ladrones

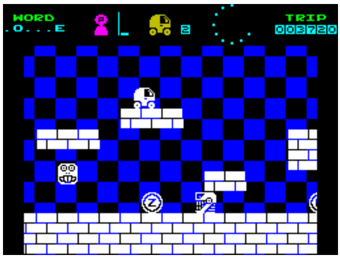


Farmer Jack Treasure Trove

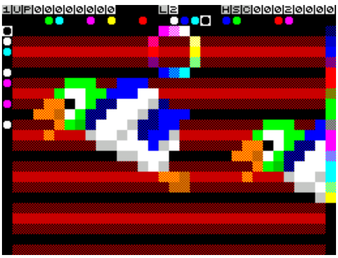


iLogicAll

Moonscape



Rallybug



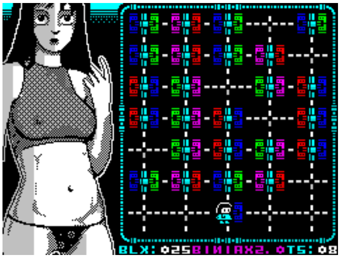
splATTR

Willy The Man Who Sold…

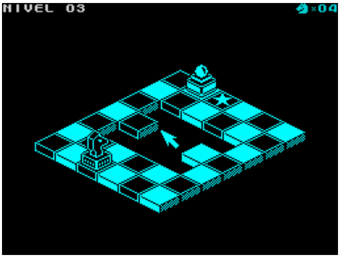
2009				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
All Present And Correct	Bob Smith	48	puzzle	English
Banger Management	Jonathan Cauldwell	48	arcade	English
Battery's Not Precluded	Jonathan Cauldwell	48	puzzle	English
Biniax 2	Ubhres Prod./ Mojon Twins	48	puzzle	English, Spanish
Black Horse	Digital Brains	48	puzzle	English
Corona Encantada, La	RELEVO/ Karoshi Corp.	48	arcade	English, Spanish
Está En La Caja	RELEVO	48	text adventure	Spanish
Factory Daze	Bob Smith	48	arcade	English
Frogger	Deanysoft	48	arcade	English
Gommy Defensor Medieval	RetroWorks/ Pagantipaco	48	arcade	English, Spanish
Heritage	Rafal Miazga	48	arcade	English
Homebrew	Jonathan Cauldwell	48	arcade	English
King's Valley	RetroWorks	48	arcade	English
Miles Mad Mission	BaSe1 PrOdUcTiOnZ	128	arcade	English

2009				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Mushroom Man	Hajo Spuunup	128	puzzle	English
Nanako Descends To Hell	Ubhres Prod./ Mojon Twins	128	arcade	English, Spanish
Phantomas Tales #1 Marsport	Ubhres Prod./ Mojon Twins	48 128	arcade	English, Spanish
Pharaoh's Shadow, The	Digital Brains	48	puzzle	English
Preliminary Monty	Andrew Zhiglov	48	arcade	English
Sgt. Helmet Zero	Ubhres Prod. Mojon Twins	128	arcade	English, Spanish
Skyscraper Of Doom	Rafal Miazga	48	dynamic adventure	English
Subacuatic	Ubhres Prod./ Mojon Twins	128	arcade	English, Spanish
Subacuatic Reloaded	Ubhres Prod./ Mojon Twins	128	arcade	English, Spanish
Uwol Quest For Money	Ubhres Prod./ Mojon Twins	128	arcade	English
W*H*B	Bob Smith	48	puzzle	English

Battery's Not Precluded

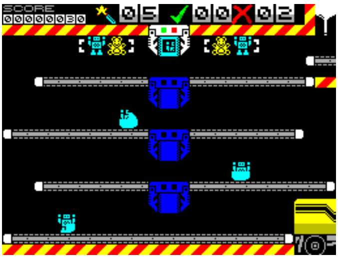


Biniax 2



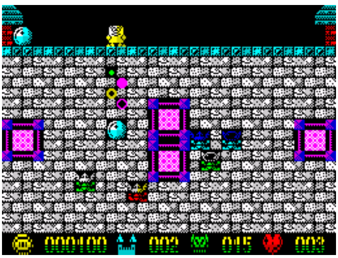
Black Horse

La Corona Encantada

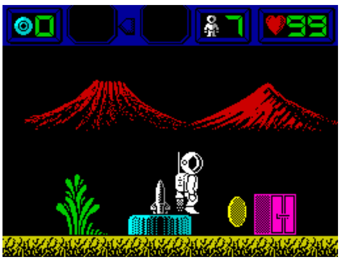


Factory Daze

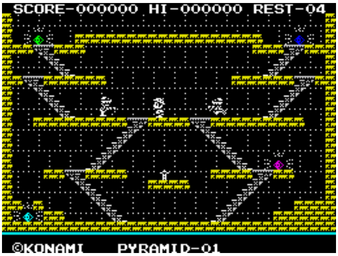
Frogger



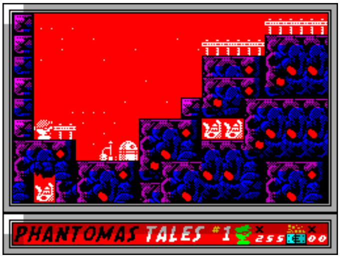
Gommy Defensor Medieval



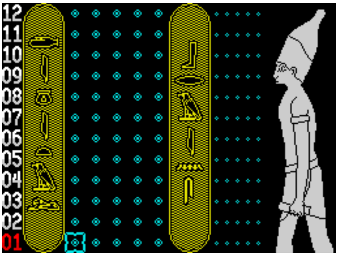
Heritage

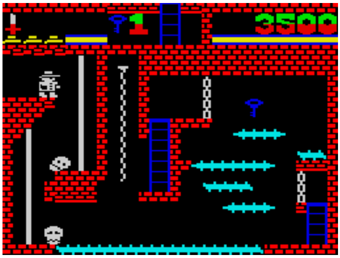


King's Valley



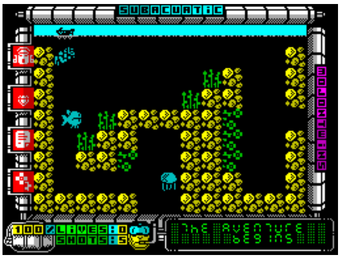
Phantomas Tales #1 Marsport


The Pharaoh's Shadow

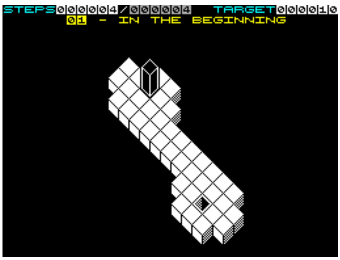


Preliminary Monty

Skyscraper Of Doom


Subacuatic

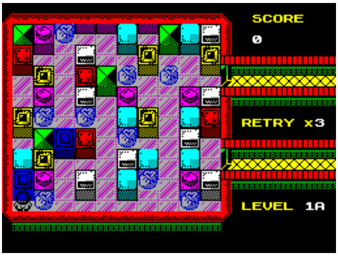
Uwol Quest For Money



*W*H*B*

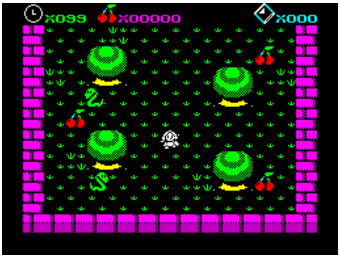
2010				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Box Reloaded	Beyker Soft	48	puzzle	English
Cheril Of The Bosque	Ubhres Prod./ Mojon Twins	48	arcade	English
Está En El Pantano	RELEVO	48	text adventure	Spanish
Forest Raider Cherry	Timmy	48	arcade	English
Genesis	RetroWorks	48	arcade	English
Ghost Castle	CodenameV	48	puzzle	English
Ghost Castle II	CodenameV	48	arcade	English
Gloop Troops	Little Shop Of Pixels	48	arcade	English
Heart Stealer	Timmy	48	arcade	English
Horace In The Mystic Woods	Bob Smith	48	arcade	English
Invasion Of The Zombie Monsters	RELEVO	48	arcade	English
Jet Set Willy 2010 Megamix	D. Gromann	48	arcade	English
Karlos Und Schatze Der Azteken	Perspective G.	48	puzzle	English
Magic Tokens	Perspective G./ Shiru	48	puzzle	English
Mine Worker	Firestarter	48	arcade	English
Moggy Adventure	Ubhres Prod./ Mojon Twins	48	arcade	English

2010				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Oddi The Viking	Digital Brains	48/128	puzzle	English
Petulant Poogslay Powerful Parade	Mojon Twins	48	arcade	English
Phaeton	Rafal Miazga	48	arcade	English
Sea Dragon	Andrew Zhiglov	48	arcade	English
Sid Spanners	Digital Prawn	48	arcade	English
Sir Ababol	Ubhres Prod./ Mojon Twins	48	arcade	English
Stratego 2K	YRS	48	board game	English
Teodoro No Sabe Volar	RetroWorks/ Pagantipaco	48	arcade	various
Viaje Al Centro De La Napia	Ubhres Prod./ Mojon Twins	48	arcade	English
What Willy Did Next	R. North	128	arcade	English
Xyzolog	Retrogames C./ Murzen	128	arcade	English
Zombie Calavera Prologue	Ubhres Prod./ Mojon Twins	48	arcade	Spanish

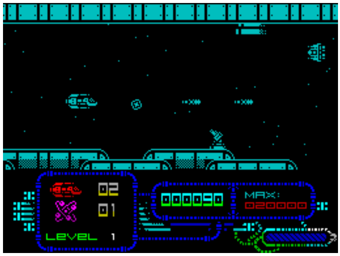


Box Reloaded

Cheril Of The Bosque



Forest Raider Cherry

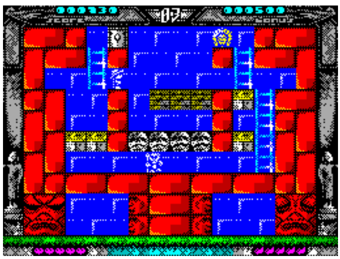


Genesis

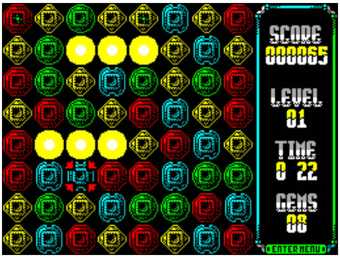
Ghost Castle

Horace In The Mystic Woods

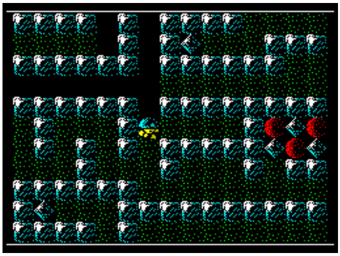
Invasion Of The Zombie Monsters



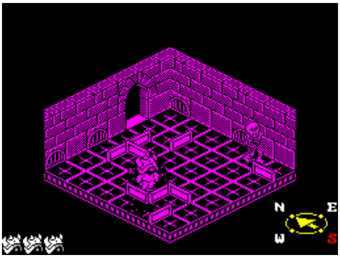
Karlos Und Schatze Der Azteken



Magic Tokens

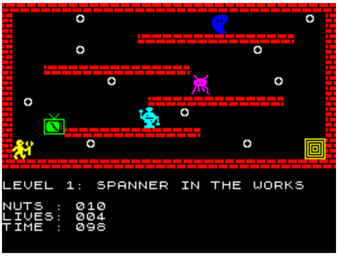


Mine Worker



Oddi The Viking

Sea Dragon



Sid Spanners

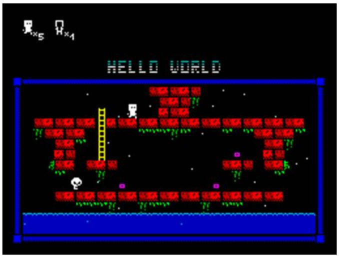
Teodoro No Sabe Volar

Xyzolog

Zombie Calavera Prologue

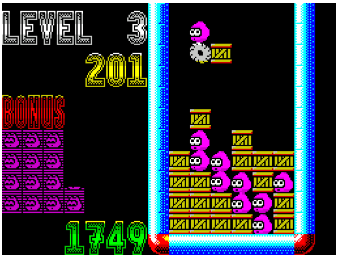
2011				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
4K Tap-N-Join	Tom Dalby	48	puzzle	English
Alter Ego	Denis Grachev	48	puzzle	English
Azzurro 8Bit Jam	RELEVO	48	arcade	Spanish, English
Bozxle	Polomint	48	puzzle	English
Buzzsaw Plus	Jason J. Railton	48	puzzle	English
Byte Me	Jonathan Cauldwell	48	arcade	English
Chessboard Attack	LCD	48	board game	English
Chopper Drop	Paul Jenkinson	48	arcade	English
Clopit	BaSe1 PrOdUcTiOnZ	128	arcade	English
Cray-5	RetroWorks	128	arcade	English
Dingo	Tardis Remakes	48	arcade	English
Flynn's Adventure in Bombland	Tom Dalby	48	arcade	English
Frank N Stein Re-booted	Colin Stewart	48	arcade	English
Future Looter	Timmy	48	arcade	English
*Ghost Castle II Special Edition	Cronosoft/ Bog Brothers	48	arcade	English
Gloop Troops The Lost Crown	Little Shop Of Pixels	48	arcade	English
Heroes Of Magic	Josep Coletas Caubet	48	RPG	English

2011				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Horace Goes To The Tower	Mojon Twins	48	arcade	English
Poxoft Tatriz SE	Uzeroniq	48	puzzle	English
Retroinvaders	Climacus	48	arcade	English
Sid Spanners 2 The Slackening	Digital Prawn	48	arcade	English
Space Disposal	Paul Jenkinson	48	arcade	English
Stamp Quest	Stonechat Productions	48	arcade	English
Stela	JBGV	48	puzzle	English
Streets Of Doom	Rafal Miazga	48	dynamic adventure	English
Trabajo Basura	Mojon Twins	48	arcade	English
The Wicker Woman	Monster's Legs	48	text adventure	English



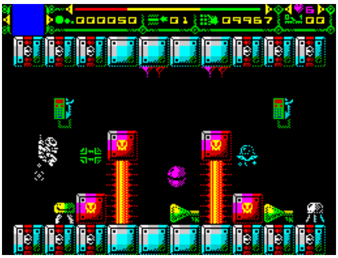
Alter Ego

Azzurro 8bit Jam



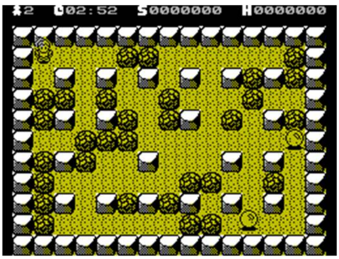
Buzzsaw Plus

Chopper Drop



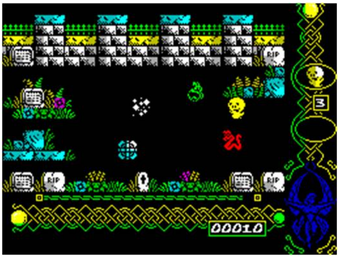
Cray-5

Dingo

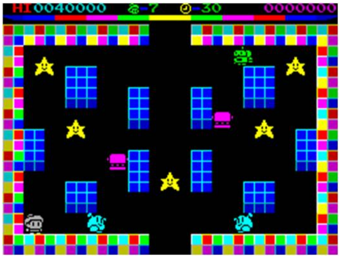


Flynn's Adventure in Bombland

Future Looter



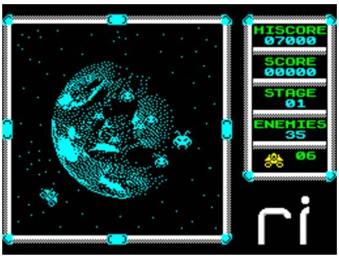
Ghost Castle II Special Edition



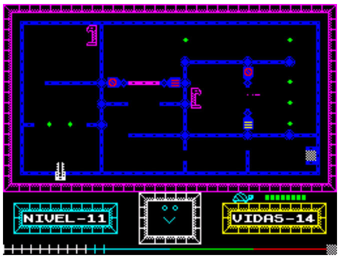
Gloop Troops The Lost Crown

Horace Goes To The Tower

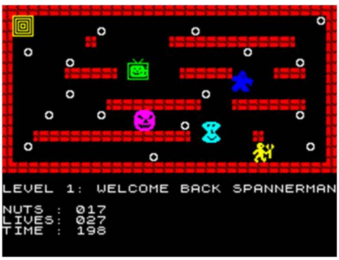
Poxoft Tatriz Special Edition



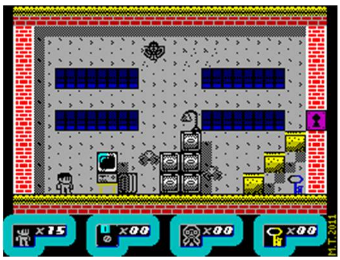
Retroinvaders



Stela



Sid Spanners II The Slackening



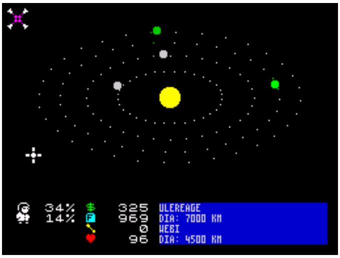
Trabajo Basura

2012				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Antiquity Jones	Paul Jenkinson	48	arcade	English
Barbarians	Damien Walker	16	strategy	English
Bouncing Bomb Redux	Retroleum/ Phil Ruston	48	puzzle	English
*Carlos Michelis	World XXI Soft	48	arcade	English, Spanish
Earthraid	LCD	48	strategy	English
Encyclopedia Galactica	RetroFusion	128	arcade adventure	English
Freddie Laker's Airline Capers	Rutlemore Games	48	arcade	English
JINJ II	RetroWorks	48	arcade	English
Klass Of '99	J. McKay	128	arcade adventure	English
Knightmare ZX	Climacus	48	arcade	English
Lost In My Spectrum	Zanklesoft	48/ 128	arcade	various
Lost Tapes Of Albion, The	Stonechat Productions	48	arcade	English
LumASCII	Bob Smith	48	arcade	English
Majikazo	RetroWorks	48	arcade	English
Maritrini Freelance Monster Slayer	Ubhres Prod./ Mojon Twins	128	arcade	English

2012				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
More Tea, Vicar?	Cronosoft/ J. Cauldwell	128	arcade	English
Pariboro	Zeroteam	48	puzzle	English
Phantomas En El Museo	Ubhres Prod./ Mojon Twins	48	arcade	Spanish
Phantomas T4 Severin Sewers	Ubhres Prod./ Mojon Twins	128	arcade	Spanish
Speccy Bros	Climacus	48	arcade	English
Survivisection	Sanchez	128	arcade	various
Toofy In Fan Land	Paul Jenkinson	48	arcade	English
Willy Meets The Beatles	S. D. Lee, P. Arus	128	arcade	English
Yumiko In The Haunted Mansion	Fun Forge/ L. Chmielewski	48	arcade	English

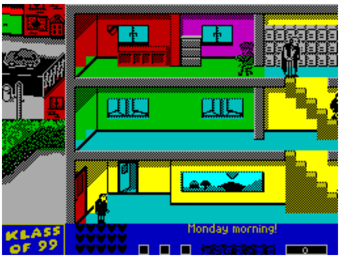
Barbarians

Carlos Michelis



Encyclopedia Galactica

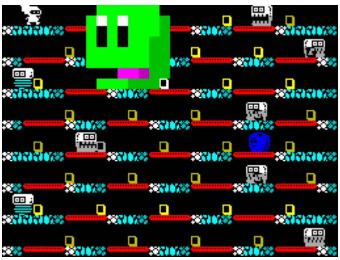
Freddie Laker's Airline Capers



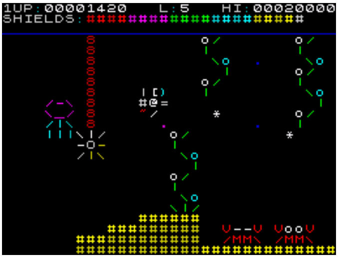
Klass Of '99

Knightmare ZX

Lost In My Spectrum

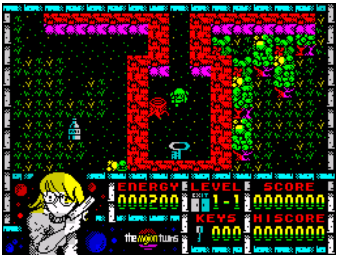


The Lost Tapes of Albion



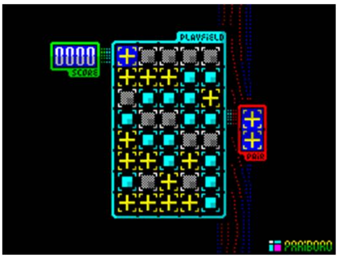
LumASCII

Majikazo

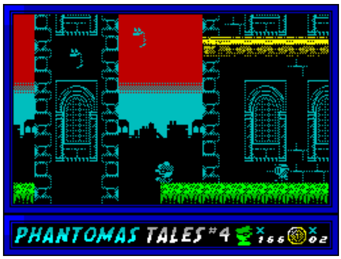


Maritrini Freelance Monster Slayer

More Tea, Vicar?

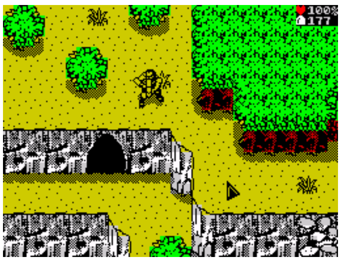


Pariboro



Phantomas Tales #4 Severin Sewers

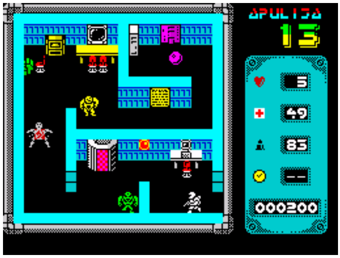
Speccy Bros



Survivisection

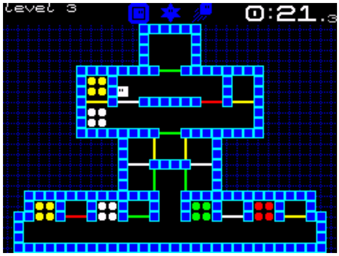
2013				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Amores De Brunilda, Los	Retroworks	128	dynamic adventure	various
Apulija-13	Zanklesoft	48/ 128	arcade adventure	various
Balachor's Revenge	Lasasoft	48	arcade adventure	English
Cattivik	Gabriele Amore	128	arcade adventure	English
Cronopios Y Famas	Zanklesoft	48/ 128	dynamic adventure	various
Doner Kebab	Cöbra Laser	48	arcade	English
Gem Chaser	Bob's Stuff	48	puzzle	English
Gem Chaser II	Bob's Stuff	48	puzzle	English
Hedgehogs	Aleksey Kashkarov	48	puzzle	English
Hunt The Wumpus	Fun Forge/ L. Chmielewski	48	puzzle	English
Janosik	Rafal Miazga	48	arcade	English
Knights And Demons DX	Kabuto Factory	48	puzzle	English
Ossuary	Cyningstan	16	RPG	English
Ramiro El Vampiro	Mojon Twins	48	arcade	English, Spanish
Request In Peace	Climacus	48	arcade	English
Souls Remaster	Retrobytes Productions	48	arcade adventure	Spanish
Speccies	Tardis Remakes	48	puzzle	English
Toofy's Winter Nuts	Paul Jenkinson	48	arcade	English

Los Amores De Brunilda



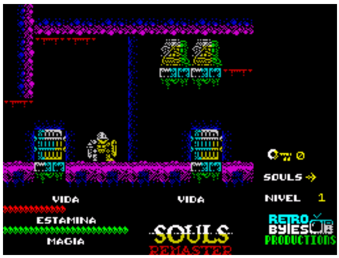
Apulija-13

Balachor's Revenge

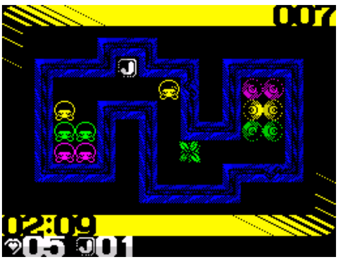


Gem Chaser II

Knights And Demons DX



Souls Remaster



The Speccies

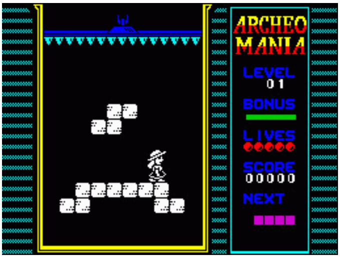
Toofy's Winter Nuts

2014				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Abbaye Des Morts, L'	DarkHorace	48	arcade	English
Amusement Park	Jonathan Cauldwell	48	management	English
Archeomania	Rafal Miazga	48	puzzle	English
Bomb Munchies	Matthew Carrier	48	arcade	English
Captain Drexx	Hacker VBI	48	arcade	English
Charm, The	Retroworks	48	arcade	English
Cousin Horace	Zanklesoft	48	arcade adventure	various
Dogmole Tuppowski	Jarlaxe	128	arcade	English, Spanish
Dreamwalker (Alter Ego II)	Denis Grachev	48	puzzle	English
El Stompo	Stonechat Productions	48	puzzle	English
Gravibots	Denis Grachev	48	puzzle	English
Leonardo's Last Lost Invention	various	128	arcade adventure	English
Leovigildo	Mojon Twins	48	arcade adventure	English, Spanish
Metal Man Reloaded	Oleg Origin, Stella Aragonskaya	48	arcade	various
Mystery	Aleksey Kashkarov	128	arcade	various
Ninjajar	Mojon Twins	128	arcade adventure	English, Spanish
Ninja Twins	SAM Style	48	puzzle	English

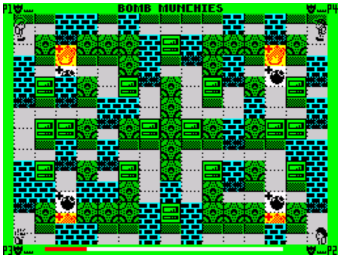
2014				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Pets Vs Aliens Prologue	Einar Saukas	128	board game	English
Sector Invasion	Denis Grachev	48	arcade	English
Sgt Helmet's Training Day	Mojon Twins	48	arcade	English, Spanish
Sir Ababol II	Mojon Twins	48	arcade	English, Spanish
Sunbucket	Stonechat Productions	48	arcade	English
Wanderers	SAM Style	128	RPG	English
X=Y=Z	Bob's Stuff	48	puzzle	English
Zen	Einar Saukas	48	puzzle	English

L'Abbaye Des Morts

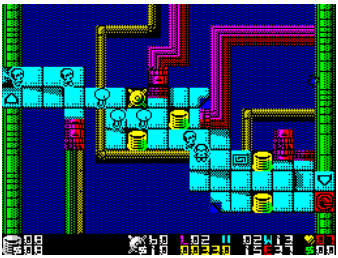
Amusement Park



Archeomania



Bomb Munchies

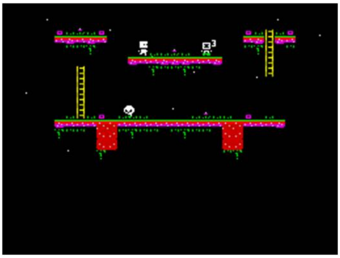


Captain Drexx

Cousin Horace

The Charm

Dogmole Tuppowski

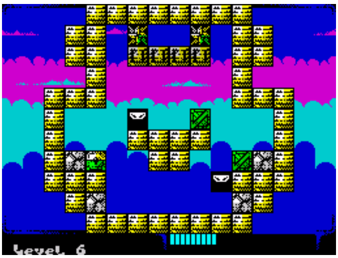


Dreamwalker

El Stompo

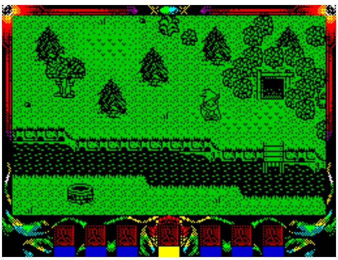
Metal Man Reloaded

Ninjajar

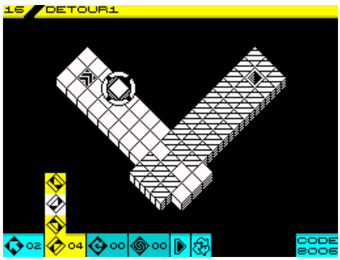


Ninja Twins

Pets Vs Aliens Prologue



Wanderers

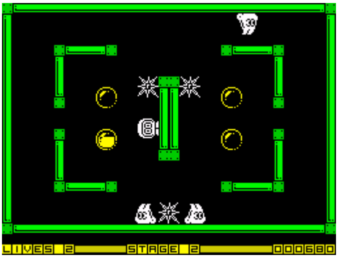


X=Y=Z

2015				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Aquanoids	Neil Parsons	48	arcade adventure	English, Spanish
Descending Dungeons	James Broad	48	RPG	English
Flype	Repixel8	48	arcade	English
Gamex II Playing Dividends	Jonathan Cauldwell	48	arcade	English
Knightmare 2 ZX	Climacus	48	arcade	English
Lirus	Denis Grachev	48	arcade	English
Order Of Mazes	Tom Dalby	48	puzzle	English
Pentacorn Quest	Nightwolf Games	128	arcade	English
Return Of Traxtor	Juan J. Martinez	48	puzzle	English
Save The Trees!	M/ZX/ Robert Mezei	48	puzzle	English
Stars (Gumi)	Aleksey Kashkarov	48	puzzle	English
Stormfinch	Stonechat Productions	48	arcade	English
Tales Of Grupp	Retrobytes Productions	48	RPG	English
Zen II	Einar Saukas	48	puzzle	English

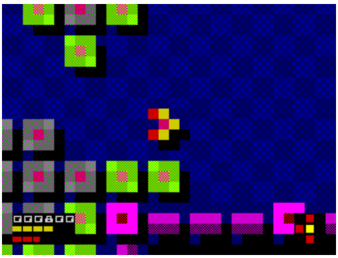
Aquanoids

Descending Dungeons

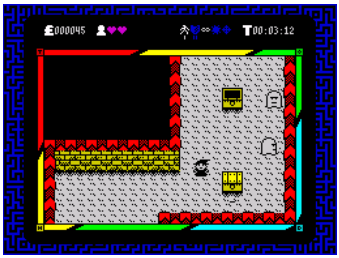


Flype

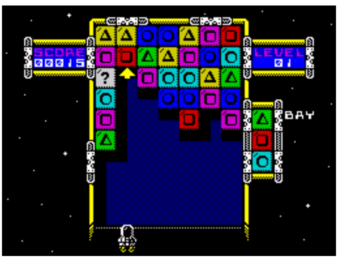
Knightmare 2 ZX



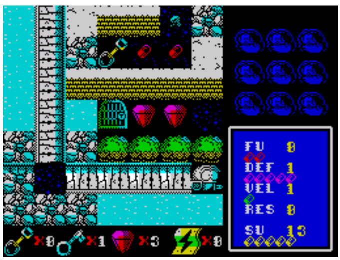
Lirus



Order Of Mazes, The

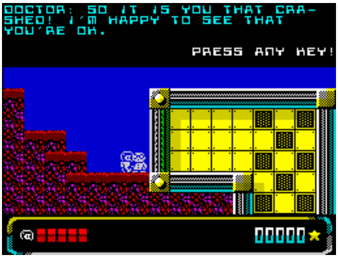


Return Of Traxtor



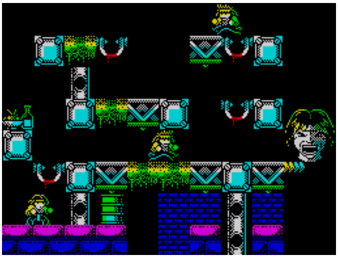
Tales Of Grupp

2016				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Castaway	Juan J. Martinez	48	arcade adventure	English
Castlevania Spectral Interlude	Sanchez	128	arcade adventure	various
ComplicaDX	Einar Saukas	48	board game	English
Dark Castle	Aleksey Kashkarov	48	arcade	English
Double Bubble	Miguetelo	48	arcade	English
Fist-Ro Fighter	Alejandro Layunta	48	beat-em-up	Spanish
Harbinger Convergence	Apsis	128	arcade	English
Pietro Bros	Cristian M. Gonzales	48	arcade	English
Sam Mallard	Monument Microgames	48	text adventure	English, Spanish
Seto Taishō Vs Yōkai	Monument Microgames	128	arcade	various
Snake Escape	Einar Saukas	48	puzzle	English
Spec Ball	ZozoSoft	48	arcade	English
Specsit	Climacus	48	puzzle	English
Stela II	La Moderna/ JBGV	48	puzzle	Spanish
Vallation	Tardis Remakes	48/ 128	arcade	English



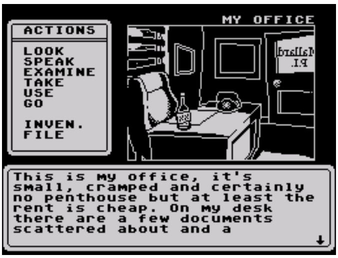
Castaway

Castlevania Spectral Interlude



Fist-Ro Fighter

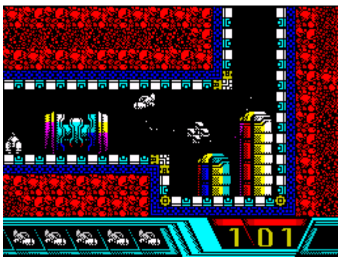
Harbinger Convergence



Sam Mallard

Seto Taishō Vs Yōkai

Snake Escape



Vallation

2017				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Biscuits In Hell	Monument Microgames	48	arcade	English
Crystal Kingdom Dizzy 2017	various	128	dynamic adventure	English
Egghead VI	Cronosoft/ J. Cauldwell	48	arcade adventure	English
Hyperkill	Mat Recardo	48	arcade	English
Incredible Shrinking Professor, The	Rucksack Games/ John Blythe	48	arcade	English
Jilly's Farm Volume 1	Bob's Stuff	48	puzzle	English
Jubbles	Jonathan Cauldwell	48	puzzle	English
Knockabout	Bob Fossil	48	puzzle	English
Mag The Magician	Radastan	16	arcade adventure	English
Mazeract	Jari Komppa, Antti Tiihonen	48	puzzle	English
Ooze	Bubblesoft	48	arcade	English
Qbox	Sergio Llata Pena	48/ 128	arcade	English
Royal Game Of Ur	Rikokun	48	board game	English
Seto Taishō To Kazan	Monument Microgames	128	arcade	various
Sophia	Zanklesoft	128	arcade	various

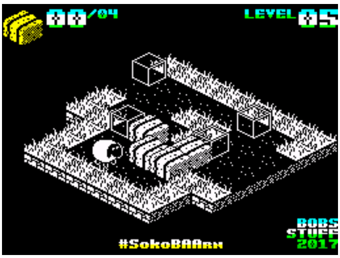
2017				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Sword Of Ianna, The	Retroworks	128	arcade adventure	English, Spanish
*Terrapins	Allan Turvey	48	arcade	English
Three Octopuses	Aleksey Kashkarov	48	arcade	English
Wunderwaffe	Rafal Miazga	48	arcade	English
Xelda Quest For The Golden Apple	Andrew Dansby	128	arcade adventure	English
Zukinox	Jaime Grilo	48	arcade	English

Crystal Kingdom Dizzy 2017

Egghead VI

Hyperkill

Incredible Shrinking Professor



Jilly's Farm Volume 1


Mag The Magician

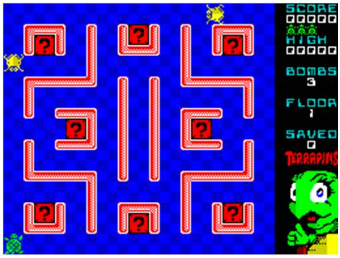
Mazeract

Ooze

Qbox

Sophia

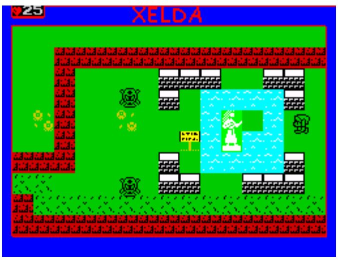
Sword Of Ianna



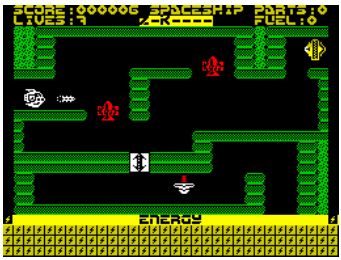
Terrapins

Three Octopuses

Wunderwaffe



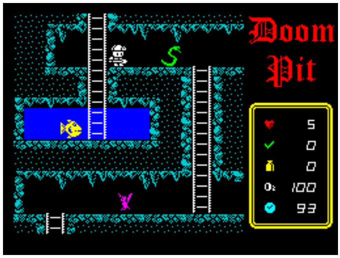
Xelda Quest For The Golden Apple



Zukinox

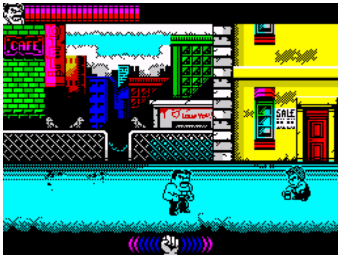
2018				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Aeon	Sunteam/ Paul Weller	48	arcade	English
Bean Brothers	Stonechat Productions	48	arcade	various
Bobby Carrot	various	48/ 128	puzzle	English
Doom Pit	Monument Microgames	128	arcade	various
Gandalf Deluxe	Noentiendo	128	arcade	English
Gimmick! Yumetaro Odyssey	Greenwebsevilla	128	arcade	English, Spanish
Harbinger II The Void	Apsis	128	arcade	English
Maze Death Rally-X	Tom Dalby	48	arcade	English
Mighty Final Fight	Sanchez	128	beat-em-up	English
Mister Kung-Fu	Uprising Games	48	beat-em-up	English
Ninja Gaiden Shadow Warriors	various	48	arcade	English
Nixy The Glade Sprite	Bubblesoft	48	arcade	English
Old Tower	Denis Grachev	48/ 128	arcade	English
Quadron	Andrew Beale	48	arcade	English
RetroForce	Climacus, Karl McNeil	48/ 128	arcade	English
ROVR	Paul Jenkinson	48	arcade	English
Rubicon	Rucksack Games/ John Blythe	48	arcade	English
Unhallowed	Bleroktron	128	text adventure	English
ZXombies Dead Flesh	James Broad	48	arcade	English

Bobby Carrot

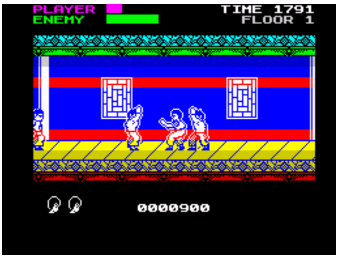


Doom Pit

Gandalf Deluxe



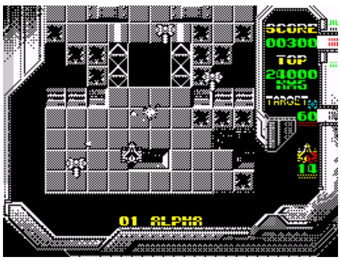
Mighty Final Fight



Mister Kung-Fu

Ninja Gaiden Shadow Warriors

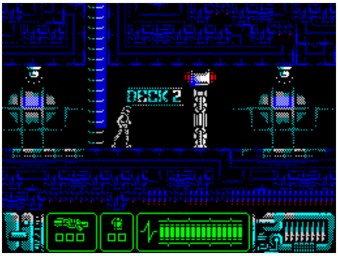
Quadron



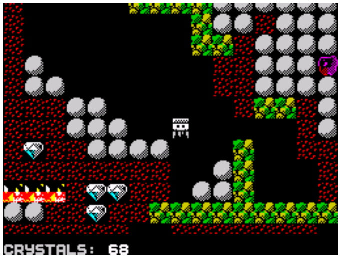
Retro Force

2019				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Ad Lunam	Zanklesoft	48	simulation	various
Aliens Neoplasma	Sanchez	128	arcade	various
Astro Blaster	Matt Jackson	48	arcade	English
Automated Cave Explorer	Aleksey Borisov	48	arcade	English
Booty The Remake	S. Cantero, D. Sánchez	128	arcade	English
Cómeme El Chip	Beyker Soft	48	puzzle	English
Dirty Dozer	Miguetelo	48	puzzle	English
Gluf	Denis Grachev	48	puzzle	English
Godkiller N.T.E.	Apsis	128	arcade	English
Lovecraft Mythos	Ancient Bytes	48	arcade	English, Spanish
Manic Pietro	Noentiendo	128	arcade	English, Spanish
Moon And The Pirates	Iadvd	48	dynamic adventure	English, Spanish
Mr Do!	Adrian Singh, Mark R. Jones	48	arcade	English
*Ninjakul 2	Pat Morita Team	128	arcade	English
Order Of Sleeping Dragon, The	E. Zapolnova, N. Zapolnov	128	RPG	English, Russian

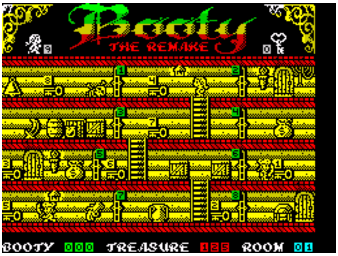
2019				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Pre-ZU	Vyacheslav Tretyak	128	puzzle	English
Redshift	World XXI Soft	128	arcade	English, Spanish
Resistance	Andy McDermott	48	text adventure	English
Sophia II	Zanklesoft	128	arcade adventure	various
Space Monsters Meet The Hardy	Mayhem & Conscience	128	arcade	English
Sprouty	Stonechat Productions	48	arcade	various
Tiki Taca	Climacus, Errazking	48	arcade	English
Valley Of Rains	Zosya	48	arcade	English



Aliens Neoplasma

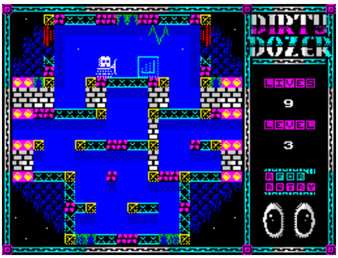


Automated Cave Explorer



Booty The Remake

Comeme El Chip

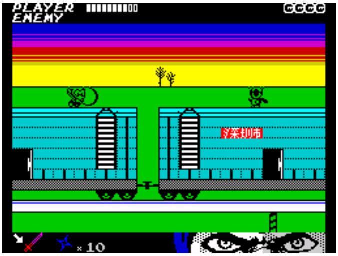


Dirty Dozer

Manic Pietro

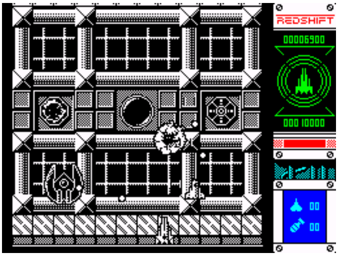
Moon And The Pirates

Mr Do!

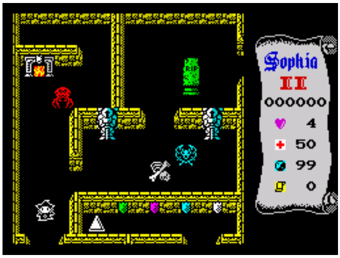


Ninjakul 2

The Order Of Sleeping Dragon

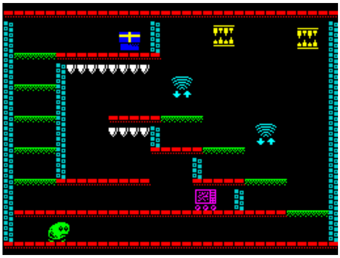


Redshift

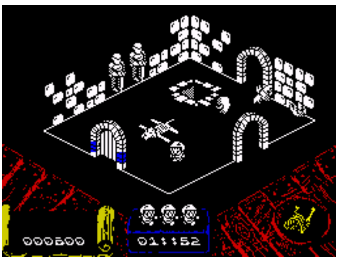


Sophia II

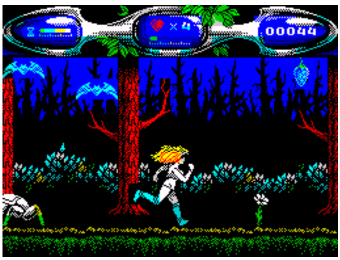
Space Monsters Meet The Hardy



Sprouty



Tiki Taca



Valley Of Rains

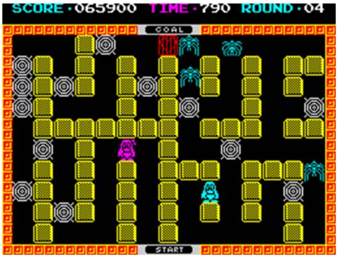
2020				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Ad Lunam Plus	Zanklesoft	128	simulation	various
Alchemist II The Dungeons	Francesco Forte	48	dynamic adventure	English, Italian
*Alien Girl	Javier Fopiani	128	arcade	English, Spanish
Binary Land	Joflof	48	arcade	English
*Black And White	Pat Morita Team	128	arcade	English
Block Z	Raymond Russell	48	puzzle	English
Cocoa And The Time Machine	Bruce Groves	48/ 128	arcade adventure	English
Code-112	PC Nono Games	48	arcade adventure	English, Spanish
Coloristic	D.Krautwurst, M. Borik	48	puzzle	English
Cosmic Payback	John Connolly	48	arcade	English
*Delta's Shadow	Sanchez	128	arcade	various
*Devwill Too ZX	Amaweks/ Paulo Villalva	48/ 128	arcade	English, Portuguese
Dizzy VIII Wonderful Dizzy	various	128	dynamic adventure	English
Duckstroma	Ultranarwhal	48	arcade	English
Dungeons Of Gomilandia	RetroWorks	48	arcade	English

2020				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Federation Z	Furillo Productions	48	simulation	English, Spanish
Funky Fungus Reloaded	Zanklesoft	128	arcade	various
Godkiller II Exile N.T.E.	Apsis	128	arcade adventure	English
Hell Yeah	Andy Precious	48	arcade	English
HERO Returns	Gusivision	48	arcade	English
Ishido II Legacy Of The White Crane	Robert Mezei, David Willis	48	board game	English, Hungarian
Krpat	Peter Macej	48	arcade	Slovak
MagicAble	Francisco Urbaneja	48	arcade	English
Manic Panic	Norman Sword	48	arcade	English
Marsmare Alienation	Drunk Fly	128	arcade	various
*Neadeital	Matt Birch	48	dynamic adventure	English
Pataslocas	Beyker Soft	48	arcade	English
Red Raid The Beginning	ZX-Bitles	48	arcade adventure	various
Reliquia, La	Ángel Colaso	48/128	arcade adventure	English, Spanish
Restless Andre	Jaime Grilo	48	arcade	English, Portuguese

2020				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Run	Roman Cikryt	48	arcade	English
Russian Railway Magnate	Andrey Sharin	48	management	English
Tesoros Perdidos De Tulum, Los	RetroWorks	128	arcade	English, Spanish
Transylvanian Castle	Fitosoft	48	RPG	English, Spanish
Tristram Island	Hugo Labrande	128	text adventure	English
Twenty-Four Hours Parsley People	Bruce Groves	48	arcade adventure	various
Vampire Vengeance	Ariel Endaraues	48	arcade	English
White Jaguar	Romancha	48	arcade	English
Witch, The	Serranito	48	arcade	English, Spanish
Wudang	Ariel Ruiz	48	arcade	English, Spanish
Yoyo’s Great Adventure	Rafal Miazga	48	dynamic adventure	English

Ad Lunam Plus

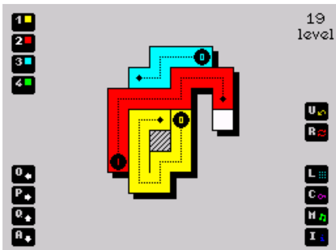
Alien Girl



Binary Land

Black And White

Code-112



Coloristic

Cosmic Payback

Delta's Shadow

Dewvill Too ZX

Dizzy VIII Wonderful Dizzy

Dungeons Of Gomilandia

Federation Z

Godkiller II The Exile N.T.E.

Hell Yeah

Krpat

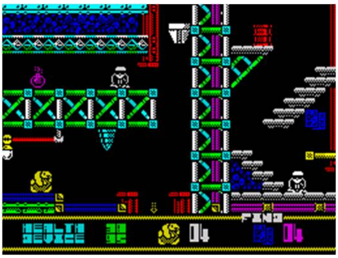
MagicAble

Marsmare Alienation

Neadeital

Pataslocas

Red Raid The Beginning



Twenty Four Hours Parsley People

Vampire Vengeance

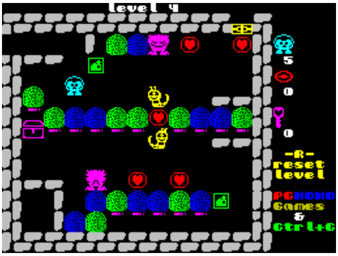
White Jaguar

Wudang

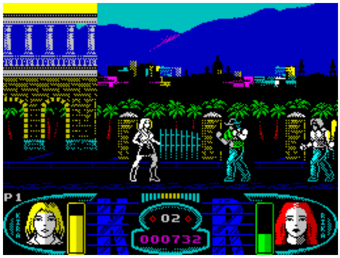
2021				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
*Adventures Continue	PC Nono Games	48	arcade	English
Aerial	Inufuto	48	arcade	English
Angels	Zosya	128	arcade	English
*Attack Of The PETSCII Robots	D. Murray, mr278cc, Shiru	48	strategy	English
Aztec	Rui Martins	48	puzzle	English
Battlot	Inufuto	48	arcade	English
Black Sea	Mananuk	48	arcade	English
Brickrick Graveyard Shift	usebox.net/ J.J. Martinez	128	arcade	English
Cosa De La Poza, La	Furillo Productions	128	text adventure	English, Spanish
Cyclus	Miguetelo	48	puzzle	English
Dark Lost Pages, The	Zosya/ Oleg Origin	48	arcade	English
Dark Redux, The	Zosya/ Oleg Origin	48	arcade	English
Desolate	Nikita Zimin	48	arcade adventure	English
Dream Walker	Gareth Pitchford	48	text adventure	English
Escape From MONJAS	Rastersoft	48	dynamic adventure	English, Spanish

2021				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Experimento, El	EJVG	128	text adventure	Spanish
Get Out Of Mars	Noentiendo	48	arcade	English
Golden Fleece, The	Saucerbrain	48	adventure	English
Hallowed Knight	EJVG	48	arcade	English
Humans, The	Gabriele Amore	128	puzzle	English
Italia 1944	Zanklesoft	48	adventure/ RPG	various
Last Escape, The	Ariel Endaraues	48	dynamic adventure	English
Mahjong Solitaire	Under4Mhz	48	board game	English
Mazy	Inufuto	48	arcade	English
Mechwars Arena	ZX Bitles	48	arcade	English
Mechwars Centipede	ZX Bitles	48	arcade	English
Metamorphosis	ITNL-Team	48	arcade	English
Nothing	Sergey A. Smirnov	128	arcade	English
Pitman	Under4Mhz	48	puzzle	English
Red Raid The Infiltrating	ZX Bitles	48	arcade adventure	English

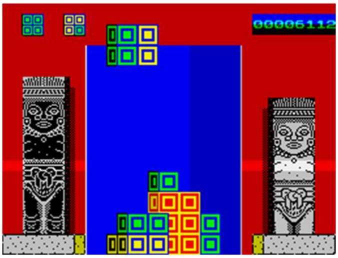
2021				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Red Raid The Sinking	ZX Bitles	48	arcade adventure	English
*Shovel Adventure	Pat Morita Team	128	arcade	English
*Snowed Under	various	48	arcade	English
SoLo	Ángel Colaso	48	arcade	English, Spanish
Somewhere In Hell	Francisco Urbaneja	48	arcade adventure	English
Sorcery Island	José Manuel Gris	48	arcade	English
Space Racing	Voxel Tower	128	arcade	English
Spec Quest	Geoff Neil	128	adventure/ RPG	English
Swarm Is Coming, The	Bruce Groves	48	arcade adventure	English
*Tetris	Bubu Marcianito	48	puzzle	English
*Tokimal	Pat Morita Team	128	arcade	English
Travel Through Time Vol. 1	Zosya	128	arcade	English
Virgil's Purgatory	Amaweks	48	arcade	English, Portuguese
Yanga Plus	Vitali Serdjuk	48	puzzle	English
*Zoinho No Jardim Dos Tolos	Bitnamic/ Ricardo Nunes	48	arcade adventure	Portuguese



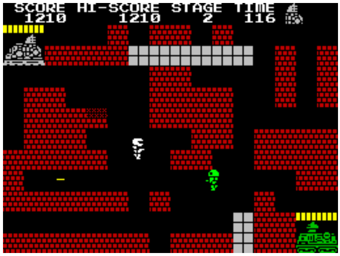
Adventures Continue



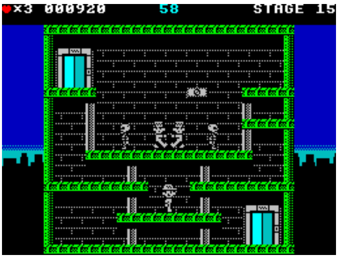
Angels



Aztec

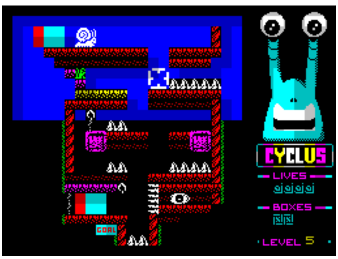


Battlot

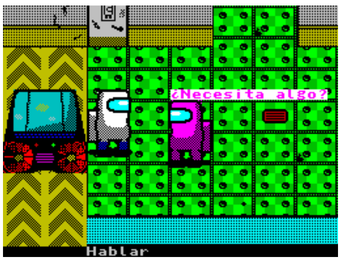


Brickrick Graveyard Shift

La Coza De La Poza



Cyclus



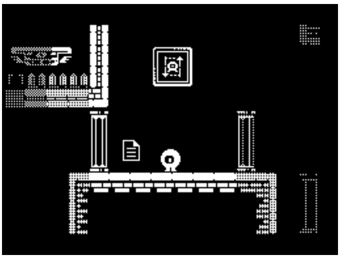
Escape From MONJAS

Get Out Of Mars

Humans, The

Italia 1944

Metamorphosis



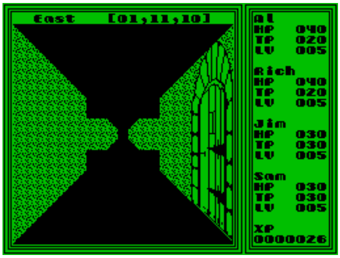
Nothing

Pitman

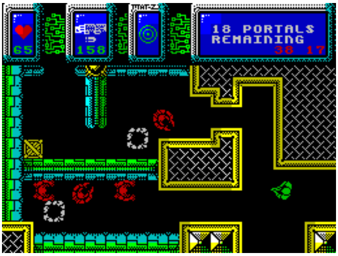
Red Raid The Infiltrating

SoLo

Space Racing



Spec Quest

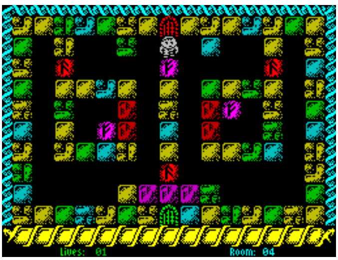


The Swarm Is Coming

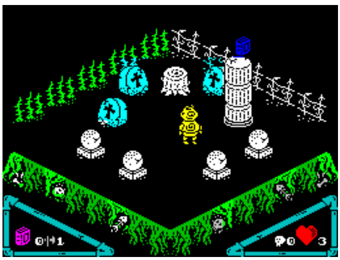
Tokimal

Transylvanian Castle II

Virgil's Purgatory



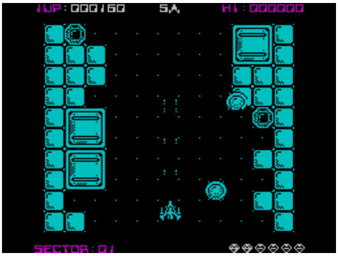
Yanga Plus



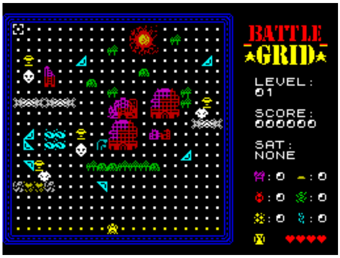
Zoinho No Jardim Dos Tolos

2022				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
*Alien Astro Frenzy	Vintage Software Systems	48	arcade	English
Ascend	Inufuto	48	arcade	English
Battle Grid	Gusmanb	48	arcade/ puzzle	English
Bomb Bomb Buster	Packobilly	128	arcade	English
Bufonada	Ángel Colaso	48	arcade adventure	English, Spanish
Cacorm	Inufuto	48	arcade	English
*Colonos III	José Manuel Griz	48	arcade	English, Spanish
Colour Beyond Time	Jamie Bradbury	48	text adventure	English
Don Quixote 16K	Zosya	16	dynamic adventure	English
Federation Underwater	Furillo Productions	128	arcade adventure	English, Spanish
*Hakkenkast	Bruce Groves	48	arcade	English
Loxley	World XXI Soft	128	arcade	various
Merged!	Dimon	48	puzzle	English
Ramiro El Vampiro III	Mojon Twins	48	arcade	English, Spanish
Rubinho Cucaracha	Zosya	48	car races	English

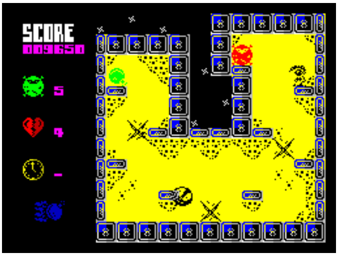
2022				
Title	**Prod./Author**	**RAM**	**Genre**	**Language**
Spekku-Man	Art-Top, Grongy	48	arcade	English
Smudge Bad Moonee Rising	Clebin Games/ Chris Owen	48	arcade	English
TCQ	Amaweks	48	arcade	English
Tournament Arkanoid	Mart, Jed	48	arcade	English
*White Jaguar 2022	various	48	arcade	English



Aliens Astro Frenzy

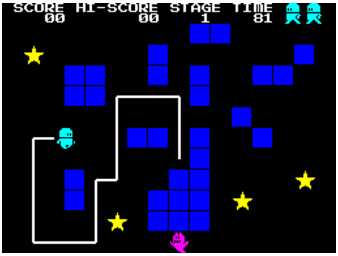


Battle Grid



Bomb Bomb Buster

Bufonada



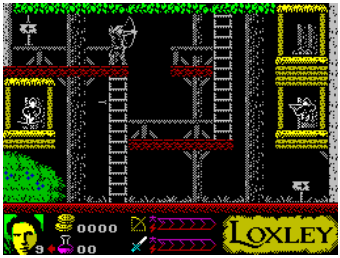
Cacorm

Colonos III

Colour Beyond Time

Federation Underwater

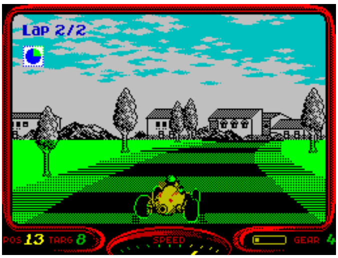
Hakkenkast



Loxley

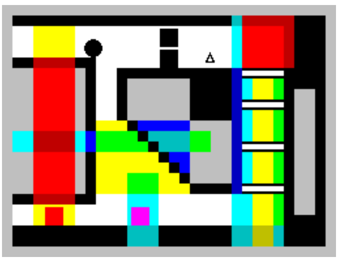
Merged!

Ramiro El Vampiro III



Rubinho Cucaracha

Smudge Bad Moonee Rising



TCQ

Tournament Arkanoid

GAMES FOR THE ZX SPECTRUM NEXT				
Title	**Prod./Author**	**Anno**	**Genre**	**Language**
4K Race Next	Paolo Ferraris	2020	car races	English
Angry Bloaters	Lampros Potamios	2020	arcade	English
Aventuras De Rudolphine Rur, Las	David Carbonell	2020	text adventure	Spanish
*Baggers In Space	Rusty Pixels	2020	arcade	English
Bikers	Cavern Games	2020	motorbike races	English
Bomb Jack	Manuel Fernández	2022	arcade	English
Bubblegum Bros	Adrian Cummings	2019	arcade	English
Crowley World Tour	Rusty Pixels	2019	puzzle	English
*Cuadragon Next	Duefectu	2021	adventure/ RPG	English, Spanish
Curse Of Rabenstein, The	Puddle/ Stefan Vogt	2020	text adventure	English
*Delta's Shadow	Sanchez	2020	arcade	various
Delta Star	Adrian Cummings	2018	arcade	English
Dungeonette	Adrian Cummings	2018	dynamic adventure	English
Dweebs Drop	Adrian Cummings	2019	puzzle	English
*Farmer Sam's Dog Day	Marco's Retrobits	2019	arcade	English

GAMES FOR THE ZX SPECTRUM NEXT				
Title	**Prod./Author**	**Anno**	**Genre**	**Language**
Foreign Cabinet	Lampros Potamios	2020	puzzle	English
*Golden Seas	Sunteam/ Paul Weller	2022	text adventure	English
Grelox Contagion	Sunteam/ Paul Weller	2020	text adventure	English
*Hollow Earth Hypothesis, The	Lampros Potamios	2020	arcade adventure	English
Lords Of Midnight	Matt Davies	2020	adventure/ strategy	English
Magnetic Scrolls Compilation, The	Strand Games	2020	text adventure	English
Montana Mike	Adrian Cummings	2018	arcade	English
Mystery City	Loopdigital/ Rogerio Biondi	2020	text adventure	various
Rite Of The Druid	Sunteam/ Paul Weller	2020	text adventure	English
*Treasure Hunters	Sanchez	2021	arcade	English
*Tristam Island	Hugo Labrande	2020	text adventure	English, French
*Vradark's Revenge	Sanchez	2022	arcade	English
*Warhawk	Rusty Pixels	2019	arcade	English
*Xeno Brigade	Bitmap Soft/ Les Greenhalg	2021	strategy	English

Angry Bloaters

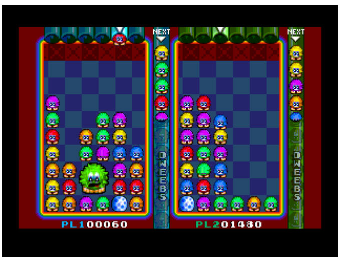
Baggers In Space

Bikers

Bubblegum Bros

Cuadragon Next

Delta's Shadow

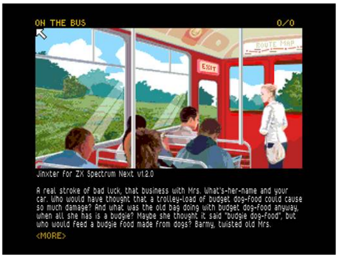


Dweebs Drop

Golden Seas

Grelox Contagion

The Hollow Earth Hypotesis

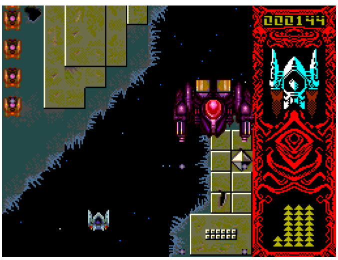


The Magnetic Scrolls Compilation

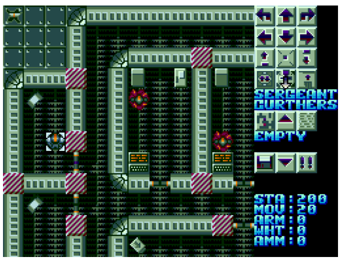
Mystery City

Shpeed

Vradark's Revenge



Warhawk



Xeno Brigade

PUBLISHERS OF SPECTRUM GAMES ON PHYSICAL MEDIA

Since the 2000s, in conjunction with the ever-increasing number of homebrew Spectrum games, new software publishers have been established. They released several games in physical format, on cassette or, in the case of the Next, on an SD card. Some have titles for other 'retro' platforms in their catalogues as well. Below are those active until July 2022; the † symbol indicates publishers who also develop the games they sell.

BITMAP SOFT
www.bitmapsoft.co.uk

BITNAMIC SOFTWARE
www.bitnamic.com.br

BUBU MARCIANITO †

bubu.marcianito@gmail.com
Note: it does not have a website, but a YouTube channel.

BUMFUN SOFTWARE
www.bumfungaming.com

CRONOSOFT
www.cronosoft.co.uk
Note: its catalogue also lists the two game authoring utilities *Platform Game Designer* and *Shoot-Em Up Designer*.

DUEFECTU CORP. †
cuadragonnext.duefectucorp.com

HOBBY RETRO
hobbyretro.com

MATRA COMPUTER AUTOMATIONS
www.matranet.net
Note: its website states that activities will soon cease, however it has released new titles until December 2021.

MONUMENT MICROGAMES
www.monumentmicrogames.co.uk

PC NONO GAMES †
www.pcnono.es

PHOENIXWARE
www.phoenixware.org

PLAY ON RETRO
www.playonretro.com
playonretro.itch.io
Note: it distributes games and compilations on Dandanator! Mini cartridges.

POLY.PLAY
www.polyplay.xyz

PSYTRONIK SOFTWARE
www.psytronik.store

RETROWORKS †
www.retroworks.es

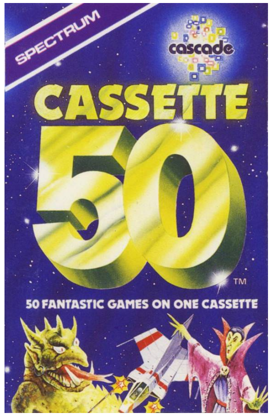
THE FUTURE WAS 8-BIT
www.thefuturewas8bit.com

ZOSYA ENTERTAINMENT †
www.zosya.net

ZX ONLINE
zxonline.net

A CURIOUS 'TRADITION': THE *CSSCGC*

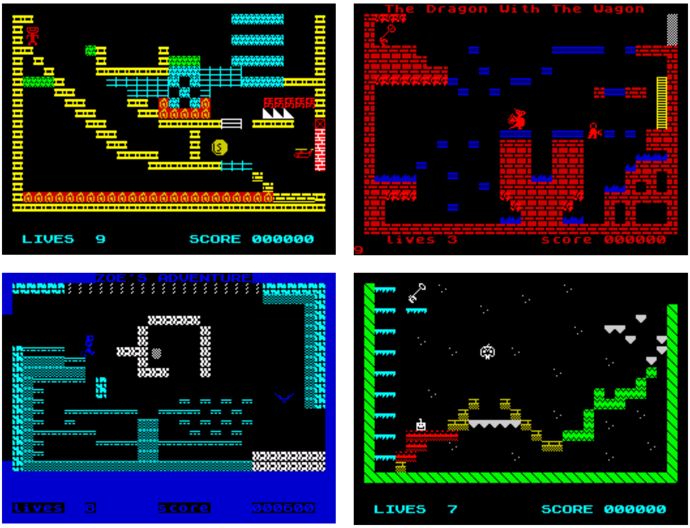
Born in 1996 from an idea by Lee Tonks ('Blood') launched on the *comp.sys.sinclair (CSS)* newsgroup – which at the time was the reference point for the fledgling web community of Spectrum enthusiasts – the *CSS Crap Games Competition* has reached its twenty-sixth edition in 2022 (it was not held in 2019). It is an ironic 'tribute' to the infamous *Cassette 50,* a collection of 50 games released by Cascade in 1983 for the 16K ZX Spectrum, Amstrad CPC, BBC Micro, VIC-20, C64, ZX81 and other platforms. It was sold for £9.95, with a complimentary Timex digital calculator watch. The games were of very low quality: written in BASIC, with rudimentary graphics and sound and practically no playability.



The competition, therefore, rewards not the best, but the worst game among those presented by the contestants: the one that best evokes the 'crapness' of Cassette 50. Games can run on all Sinclair computers, Next included, and also on the Z88, SAM Coupé and Jupiter Ace. The winner receives absolutely nothing, while the author placed last in the final standings – that is to say, the one whose game is judged to be the least 'crap' – is rewarded with the dubious honour of organizing the competition for the following year. Up to the 2021 edition, a total of 1209 games were submitted.

THE SPECTRUM AT SCHOOL IN THE 21ST CENTURY: THE BEARSDEN EXPERIENCE

Beginning in 2019, Douglas McGregor, a primary school teacher in Bearsden, Scotland, conceived and implemented a project to teach a group of pupils between 9 and 11 years of age to code simple games for Spectrum using *Arcade Games Designer* under emulation. The aim is to introduce the practice of computer programming by means of a simple architecture combined with a tool that is easy to master and gives immediate results.



Some of the games created as part of the project

The project aroused the interest of the young recipients, and of their parents too, many of whom owned a Spectrum. The pupils created 32 platform games taking care of every aspect in complete autonomy, from the basic concept to the AGD scripts and sprite graphics. According to McGregor, the main advantage of AGD is that pupils have to study and understand the meaning of each line of the scripts, so that they become aware of what to do in order to achieve a certain effect and trace errors if the result does not match what is to be expected.

The Spectrum aficionados community looked at the project with attention and warmth. Clive Townsend, author of the well-known *Saboteur* and *Saboteur II* games, even designed a loading screen for one of the games. McGregor illustrated his experience in an interview published in the 2021 issue of the annual electronic magazine *WOOT!*[12] and made available all the titles developed by his students through the *Spectrum Computing* website's archive.[13]

[12] The interview is contained in the *BackToBeardzen.tap* file within the ZIP archive containing the various sections of the magazine, which can be downloaded from: *stonechatproductions.co.uk/zxgames/WOOT_ZXMAS2021(Bundle).zip*

[13] Web page: *spectrumcomputing.co.uk/list?label_id=18994*

Chapter Two
EMULATION

In computing language, *emulation* generally means replicating the operation of a device by means of another or of a suitable program. Thus, for example, the characteristics of the Spectrum's ULA chip are emulated in many clones by a combination of integrated circuits which replicate, more or less faithfully, its functions. What this chapter is about is a specific aspect of emulation, namely those programs, called *emulators,* that replicate the operation of different Spectrum models and of some of its clones.

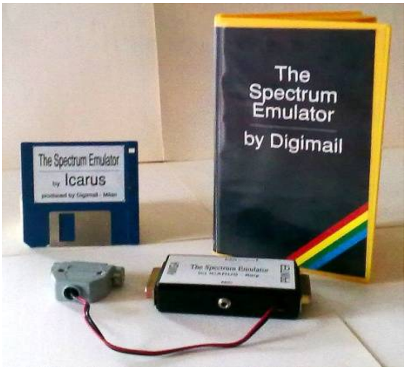
The discussion begins with a reconstruction of the history of the emulation of the Spectrum, part of that broader framework of attempts, arising from the end of the 1980s onwards, to emulate computers and video game consoles on systems and environments such as the Commodore Amiga, Atari ST, MS-DOS, Microsoft Windows, macOS, Unix and others. This is followed by a list of the main file types associated with Spectrum emulation, divided by category. Emulators and some applications for managing emulation-related files are then examined. In the final section, cases of emulation on the Spectrum are shown.

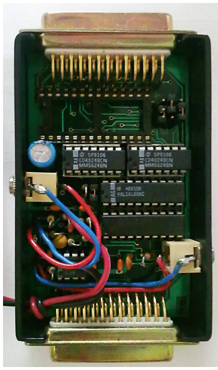
HISTORICAL PROFILE

Excluding clones, the first examples of Spectrum emulation appeared in 1986 with the launch of the *Speculator,* a peripheral produced for the Tatung Einstein by Memotech in 1986. Based on the same CPU as the Sinclair machine, it was equipped with 64 KB of RAM, which in their 16 KB "shadow" part housed a copy of the Spectrum ROM, rewritten for the occasion by altering some features, like tape management, for greater efficiency. Furthermore, the Speculator mounted some proprietary logic circuits that mimicked the Spectrum's display and keyboard scanning, as well as the same Texas Instruments video chip found on MSX computers. The device worked in conjunction with an emulator written by Syntaxsoft and could only load about sixty games, since dedicated loading routines were required for each one of them, hosted on three disks. The Speculator had a 3.5 mm input jack to connect to the tape recorder; the disc loader routine had to be run first, before the Spectrum game could be loaded from cassette. On page 14 of issue 1 of the *Einstein Monthly* fanzine, an article explaining how to get around this limitation was published. This was achieved by renaming the files to load and changing their respective destination in memory. However, this was only possible in the absence of high-speed and/or protected loading schemes.

The first Spectrum software emulators appeared on the Amiga and MS-DOS in the late 1980s. It is not yet completely clear which was the first ever, but a candidate with a good chance for this record is the *ZX Spectrum Emulator* for the Amiga by Vincenzo Gervasi and Antonio Schifano, marketed by Digimail S.r.l. in Milan. The program has been known since the beginning of 1990, but was already fully functional in

September 1989, when it was presented at that year's *SMAU* (*Salone Macchine e Attrezzature per l'Ufficio,* 'Office Machinery and Equipment Exhibition') in Milan. The authors installed it on an Amiga 2000 and amused themselves by secretly watching visitors as they noticed the computer showing the famous © *1982 Sinclair Research Ltd* start-up message[14]. It was then that Enrico Di Zenobio of Digimail proposed an agreement to the authors to distribute the emulator. The latter therefore deserved a review on page 11 of issue 17 (February 1990) of the popular Italian *The Games Machine* magazine, written by Carlo Santagostino, followed by a note on page 5 of issue 201 (June-July 1990) of the Spanish *MicroHobby* magazine.





ZX Spectrum Emulator set and detail of the internal interface. The name 'Icarus' was chosen by Gervasi and Schifano for the programming team.

The emulator was a mixture of hardware and software. To read cassettes, a cartridge was needed, where a copy of the 48K Spectrum ROM had to be stored. The firmware had to be

[14] The Author wishes to thank "SyX", Carlo Santagostino and Gervasi and Schifano themselves for the information about the emulator, plus Marco C. for the photos.

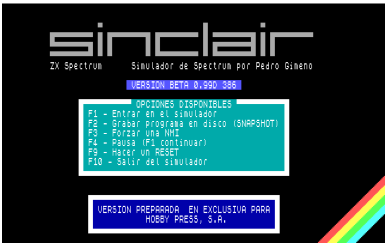
obtained separately from an authorized dealer, since it could not be included with the emulator for copyright reasons, as the original was then exclusive property of Amstrad. Then the cartridge had to be connected to the parallel port and the floppy disk drive port; the program transferred the Spectrum ROM to the Amiga's RAM as soon as it was launched. In addition to that, the Z80's flags and R register were only partially emulated and timings were not guaranteed. Furthermore, in the emulated environment there was no write protection for the ROM, which therefore had to be reinitialized at each boot to avoid self-destruction. Nevertheless, compatibility was quite high, despite the impossibility of loading programs recorded with schemes other than the ROM one. To load from tape, it was required, first of all, a common audio sampler to be installed on a parallel port. Files were written on floppy disks with the usual Trackdisk formatting; they could not be read directly by the Amiga DOS, but by a proprietary system, called ZDOS and managed by the emulator itself, which redirected the Microdrive commands to the disk, allowing to use 890 KB of space for a maximum of 500 files.

The ZX Spectrum Emulator was able to run 48K programs at an average speed of 60-70% on the Amiga 500. To increase it, there were three colour emulation modes: the faster one was a monochrome mode, where INK and PAPER values were chosen by the user; one with limited colouring; last, one that emulated the entire Spectrum colour palette, but at the cost of a slower emulation. Other functions concerned the emulation of the Kempston joystick on port 2 of the Amiga and the Centronics parallel interface, the saving of video memory as an IFF image and of the program on disk in as a snapshot file. The emulator was written in 68000 Assembly, except for the proprietary DOS, coded in C for convenience. To free the CPU as much as possible, the specific Amiga video signal generation modes originating from the custom Agnus chip were used: 'Blitter', for the quick copy of video memory in order to lighten the work of the CPU, and 'Copper', to change the resolution, horizontal frequency of the image and quantity of colours, as well as to manage the Blitter independently from the CPU. Through the Copper it was also possible to create a Spectrum-like display on the Amiga, in order to speed up the video conversion routines. In monochrome mode there was in fact no conversion: the video memory of the emulated Spectrum was displayed directly.

In principle, the external interface was not necessary, as the ROM could be loaded from a file as well, and any sampler could be used to load from tape. However, it was Digimail that imposed the special interface for the recorder, for fear of piracy and legal troubles with Amstrad. Unfortunately, its development slowed the launch of the ZX Spectrum Emulator on the market by about twenty months (well into 1991). By then, commercialization became almost impossible, due to the release, a few months after the announcement, of free emulators such as *KGB,* by the eponymous Danish group, Jeroen Kwast's *ZX-Spectrum,* Toni Pomar's *ZXAM* and Peter McGavin's *Spectrum.* The complete set of the ZX Spectrum Emulator costed 94,000 Italian liras plus 18% VAT, a significant amount for those times. It did not therefore enjoy a great commercial success, but nevertheless represented a milestone in the history of the emulation of the Spectrum.

At the same time, the development of emulators for MS-DOS began. For a long time, it was believed that three programs contended for the title of first ever: *Nutria* by Juan Antonio Fernández-Madrigal, *JPP* by Arnt Gulbrandsen and *Z80* by Gerton Lunter, all initially released in 1991. As a matter of fact, Pedro Gimeno already had a first version of his own *Spectrum* in operation in 1989, roughly at the same time of Gervasi and Schifano's emulator for the Amiga. Unlike this, however, Spectrum did not require any additional device to run. The 1989 version, called *EGASPEC,* simulated the Spectrum display in EGA, but the first to be officially released was 0.99A, whose executable integrated both EGA and VGA modes. Before that, a preliminary version called *VGASPEC* was publicly distributed by some unknown user, without authorization from Gimeno.

Interestingly, in 1995 the 0.99D Beta 386 version of Spectrum was included with *Arctic Moves,* a MS-DOS game by Dinamic. Typing CLASICOS at the command prompt took the player to a screen for choosing between the two previous chapters of



the series, *Army Moves* and *Navy Moves.* Precisely, the choice was between the first or second part for each one of them. Then the initial screen appeared, allowing a few operations, like the recording on the PC disk of a memory snapshot and the generation of a non-maskable interrupt. Pressing F1 started the chosen part of the selected game. The latest version was 0.99F of July 1998.

Nutria, in turn, appeared in three versions. The first was *Nutria-I,* entirely written in Intel 286 Assembly on a PC equipped with a CGA video card, so neither the border colour nor the attribute map could be emulated. The ROM was obtained from a 48K Spectrum through a custom-built device that connected the expansion port to the parallel port of the PC. The same system was used by Fernández to transfer the snapshots of some games to the PC. It also included a disassembler that displayed, on the right of the screen, the contents of the memory in real time, as well as an ‘explorer’ of the CPU registers. Subsequently it was the turn of *Nutria-2,* with MCGA graphics (320×200 in 256 colours) and of *Nutria-3,* which introduced a pop-up menu interface written in C and also emulated the edge of the screen, while the integrated disassembler was replaced by a statistical indicator of the instructions being executed. With Nutria-3, the development of the emulator ended.

JPP takes its name from the LOAD “” command (composed on the 16/48/+ Spectrum keyboard by pressing in sequence first the J key in K cursor mode, then Symbol Shift+P twice). It emulates the 48K Spectrum in VGA on PCs mounting at least a 386 processor. Its support for tape recorder input was admittedly rudimentary: Gulbrandsen himself did not guarantee it to work and recommended to convert snapshots captured with the DISCiPLE or Plus D in the most common SNA format, through the supplied utilities *SPCONV,* written by Henk de Groot, for the conversion between different snapshot formats, and *SPECDISC,* by Brian Havard, which converted SNP snapshots, saved by the aforementioned devices, in their SNA equivalents, intelligible to the emulator.

In return, JPP had some peculiar characteristics on its side. It included two executables: the main one, JPP.EXE, for slower PCs, and an advanced one, PJPP.EXE, for faster machines, which showed on the right side of the screen an indicator of the percentage of the exact clock speed of the Z80A. The speed of execution was due to the direct transfer of the Z80A registers to those of the 386, a tactic already successfully employed by Peter McGavin in his emulator for the Amiga. Sound was rendered by the PC’s internal speaker. Besides that, JPP was provided with two alternative ROMs: the one written by de

Groot for the 48K Spectrum and that of the Microdigital TK95, one of the two Brazilian clones of the Spectrum. It is not known why the latter was present; in any case JPP – which after version 1.0 of 9 August 1992 was definitely discontinued by Gulbrandsen – was the first Spectrum emulator to include among its options both a reworked ROM and that of a clone.

Gerton Lunter's Z80 was one of the best Spectrum emulators of its generation. It could boast very advanced features compared to the others, like: emulation of the 128, Interface 1 and Microdrive, DISCiPLE, Plus D, Currah MicroSpeech, Multiface 1 and 128, cursor and Sinclair joysticks in addition to Kempston ones; reading of TAP and TZX cassette and MDR Microdrive cartridge image files; the 'Intelli-in' system for loading programs on tape directly from the PC audio input even with some accelerated loading schemes. All these features emerged during the development of the program in the first half of the 1990s. Z80 also emulated a custom interface built by Lunter with Johan Koelman called *SamRam,* consisting of a 32 KB static RAM chip with a modified copy of the 48K Spectrum ROM, some utilities, a system monitor and a button to insert the 32 KB 'shadow' RAM from Lunter's computer. This RAM was in fact the other half of the 64 KB memory chip mounted on his Spectrum, which was obviously not one of those defective chips employed in order to curb manufacturing costs.

Z80 was therefore considered an essential benchmark for the state of Spectrum emulation. The interest raised was such that Lunter soon added a version for Windows 3.1, distributed as shareware like the MS-DOS one. Registration for each version costed £15 and £20 for both: it unlocked the 30-day usage limit and some special features, for instance the ability to load directly from tape, to emulate the DISCiPLE in the Windows version or to set emulation speed in the MS-DOS one. The latest version of Z80, 4.00, is dated 6 March 1999, but since 1996 James McKay had been inspired by it for his own emulator for MS-DOS, *X128,* also meant to become a reference point for Spectrum emulation. X128, whose development went from 2 February 1996 to 2 September 2002 with the final 0.94 version, was also one of the very first programs to emulate the Didaktik D80 and Beta 128 Disk interfaces and the Pentagon 128 and Scorpion ZS 256 clones.

Z80 also includes, among the ways to load programs from TAP files, a 'Warajevo mode' to increase compatibility with some programs recorded with non-standard loading schemes. What Warajevo is, and what is its importance for the purposes of this discussion, we will see shortly, but first, it is necessary to examine the context as a whole.

In 1992 Zeljko Jurić and Samir Ribić are two students of electronic and computer engineering at the University of Sarajevo, the capital of the Socialist Republic of Bosnia and Herzegovina, part of the Federal Socialist Republic of Yugoslavia. The situation in the Federation has already been dramatic for a year: independence proclaimed by Slovenia and Croatia the previous year, with the first bloody episodes of civil war between Serbs and Croats, also pushes the Bosnian government to hold a referendum for the secession from Yugoslavia, despite the fact that the population is not entirely convinced of the need for such a step. Above all, it is the part of Serbian origin that is opposed to leaving the Federation. The referendum is held between 29 February and 1 March 1992. The turnout is 63.4%, but the result is a resounding 99.7% in favour of secession. Independence was then declared on 5 March. This makes contradictions within the newly formed Republic of Bosnia and Herzegovina explode and leads to a civil war between Croats and Bosnians on one side and Serbs on the other. It will be the most violent conflict fought on European soil since the Second World War: a succession of atrocities and devastation that in almost four years will claim about 100,000 lives, of which more than a third civilians, leaving behind a materially and morally devastated country.

The very long siege of Sarajevo by Bosnian Serb forces began on 5 April 1992 and officially ended only on 29 February 1996, three and a half months after the Dayton Agreement of November 1995. It became infamous for cannon fire on unarmed civilians in the streets or at the market, for the snipers stationed on the roofs of ruined buildings who shot at everything that moved, for the terrible shortages of food, water, electricity, fuel, medicines. Even more devastating, if possible, were the psychological consequences of the fact that those who were slaughtering each other were people that, until the outbreak of the war, lived side by side, knew each other, frequented the same places and even had friendly relations. In such a hell, the inhabitants of Sarajevo tried in every way to survive, even remembering the past times, when life flowed between the small and great things of every day. This was the intention that in April 1993 led Jurić and Ribić to develop an emulator of the Spectrum, the computer that, in their imagination, was linked to the carefree years of adolescence, in contrast with the deadly desolation of the present. This emulator then took the name of *Warajevo,* contraction of 'war' and Sarajevo.

Each of the two friends owned a PC AT 286 as early as the late 1980s, but they had not forgotten their Spectrums. In June 1991, they found on the SEZAM BBS, based in Belgrade, a rudimentary Spectrum emulator for MS-DOS of Slovenian origin, written – according to a newspaper of the time – by a certain Peter Kroselj, on which there is no other information apart from that provided by themselves. Among other things, it displayed the © *1991. Roman & easy inc.* start-up message, did emulate neither the BORDER area nor any connections other than that for the tape recorder and showed glaring compatibility problems with Spectrum software. However, it was a starting point when, two years later, during the siege of Sarajevo, Jurić and Ribić wished, for the reasons we have seen, to code their Spectrum emulator.

Warajevo is therefore an absolutely unique emulator, for the very circumstances it was developed in alone. The most serious problem was the shortage of electric power, at a time when a hospital might not have it for even two months straight. Power was delivered during the night for just 2-3 hours, and not always every night. Jurić worked at home on his 286 equipped with a Hercules card and 40 MB hard disk, using a TASM assembler, while Ribić at the city barracks on another 286, hooked to a monochrome VGA monitor and a 2400 bps modem but without a hard drive, which was lost due to the many power surges that continually occurred in the building, even when someone turned on an electric coffee maker. The current was in fact supplied by an improvised generator, whose voltage ranged from 150 to 300 volts. It consisted of a car engine without a carburettor, adapted to run on natural gas from a local pipeline and connected to an electric motor capable of delivering about 30 kW for 100 rooms.

The two authors divided their tasks: Jurić devoted himself to the emulator kernel, while Ribić wrote, in Turbo Pascal 5.5, the applications for converting tapes and managing image files. It was then that one of the most peculiar features of the emulator surfaced: the TAP image file format (not to be confused, as it will be explained later, with the TAP devised by

Gerton Lunter) would have contained, in compressed form, the original data sampled from the tapes, in order to preserve even those programs recorded with unconventional methods and take up much less space than samples in VOC format, because the two did not have enough floppy disks, nor the money to purchase a larger hard disk. The programs were transferred to a PC through a self-produced cable that connected the RS232 port to Jurić's Spectrum 128. Ribić, on the other hand, when he did not risk his life by serving among the forces in defence of the city, risked it by defying sniper fire in order to borrow Spectrum cassettes from the last software pirate staying in the city, who practically lived on the siege front line. To get there, Ribić had to move along the bed of the Milijacka river, which flows through Sarajevo from east to west.

Meanwhile, development of the emulator proceeded, between the food shortage of the summer of 1993 – when 3-4 thousand grenades a day fell on the city, and Jurić and Ribić lost 1 Kg of weight each per week – and the breaks between one war action and the other. Their project was an opportunity to keep their minds free, even for a short time, from the fatigue and horrors they were forced to experience every day. In November they learned about the Z80 emulator from a newspaper coming from enemy territory, which motivated them to try and do the same, even though they themselves believe they probably would not even have started working on Warajevo, had they already known about the existence of Lunter's emulator. On the initiative of the Soros Foundation, the first e-mail service in Sarajevo was established in April 1994, thanks to which, the following June, the two friends received a copy of Lunter's program, as well as news about other Spectrum emulators for the PC made all over Europe. This was a further incentive for them to do their best.

The first version of Warajevo was 1.0, which appeared in late 1994. This was followed by 1.1 in March 1995 and 1.11 two months later. In November, the Dayton Agreement led to peace and the two authors were discharged from the Bosnian army, thus being able to devote themselves to perfecting the emulator. The final version, 2.51, preceded by 1.5 (July 1996), 2.0 (February 1998) and 2.5 (October 1998), was released in December 1998. The latter benefited from the contribution of Rui Ribeiro, in particular for reading tapes through the Sound Blaster card and managing them, as well as rewriting part of the code to make the emulator capable of running even under Windows. Warajevo emulates under MS-DOS environment: ZX Spectrum 48/128/+2, Timex Sinclair TS 2068, ZX Printer, ZX Interface 1 with local network, ZX Microdrive, the MIDI interface and the numeric keypad of the 128.

Among the features of Warajevo there are the very low system requirements, the presence of an internal windowed shell with mouse support, the ability to open a large number of file formats, including those compressed in ZIP archives, a tape image file editor, the possibility of defining the colour palette in use and creating a program archive, an internal system monitor, the conversion of ASCII files into formats intelligible to numerous applications for the Spectrum (Sinclair BASIC, Hisoft Pascal, Tasword 2 and 3, The Last Word, Sinclair Logo, Abersoft Forth etc.) and vice versa. It also includes several separate applications for converting between various file formats and one for transferring from the memory of the Spectrum 128 to the RS232 port of the PC. On the other hand, the authors themselves do not hide its shortcomings, among which: the absence of emulation of the +3 and +2A/B, disk interfaces and Multiface, the impossibility of emulating beeper sound on the Sound Blaster or AdLib sound cards (as it happens with sound generated by the AY-3-8912 chip instead; the beeper is only heard through the PC speaker), the limitation of the internal database to 4,500 entries, the not exact screen aspect ratio, the slowness of RAM paging in Spectrum 128 emulation and execution under Windows. In addition, Jurić and Ribić's TAP file storage format did not receive much favor over Lunter's TAP, although it was more faithful to the original data. The TZX format, devised by Tomaz Kac, will definitely take its place as a means of preserving the structure of tape data. However, it is undeniable that the wealth of features presented by Warajevo as early as 1995 and especially the terrible circumstances in which it was developed make it a cornerstone of the history of emulation, not only of the Spectrum, but in general, for its enormous symbolic value.

Gerton Lunter converted Z80 for Windows 3.1, but the first native emulator for Windows is *WSpecem* by Rui Ribeiro, an open source project first appeared in 1995, then proposed as the subject of a dissertation written by the author the following year at the University of West England, at the end of an Erasmus course. In the rest of the decade, it was followed by Vaggelis Kapartzianis's *ZX32,* Ignacio Burgueño's *Gleck,* Daniele Orro's *ZX,* Mark Swinhoe and Justin Wood's *ZX Plus,* and Mark Woodmass's *SpecEmu.* For the first few years, however, ZX32 was one of the most widespread, if not the most popular ever, at least until the advent of even more advanced programs such as *Spectaculator,* by Jonathan Needle, which soon established itself for its great ease of use.

A separate discussion should be made for *RealSpectrum,* the work of the Ramsoft Group, composed of Luca Bisti and Stefano Donati. RealSpectrum stands out as the most interesting emulator of the period between the 1990s and the 2000s. It runs under many graphic resolutions, emulates Gigascreen, 8×1 multicolour mode and, in the latest versions, the ULAplus. Sound output can be 8- and 16-bit mono and stereo, digitally mixed for the AY-3-8910/8912 and YM2149F chips, 256-step stereo panning, surround and separate volumes for the beeper and chip. RealSpectrum is also the first program to emulate the Didaktik Kompakt, complete with D40 and D80 interfaces, as well as peripherals like the MB02+, SMUC, ZXCF, ZXMMC+ and Pera Putnik's IDE interfaces. Another unique feature of RealSpectrum is the ability to read and write disk image files in a large number of different formats, and even to operate on real floppy disks using the PC's 3" ½ drive. Lastly, it can save and load data through the tape recorder, employ the RS232 serial and parallel ports of the PC, record an AVI video file of the activity, or an AIR file that stores all the key pressings or joystick movements, ideal for reviewing gaming feats, provided with a specific mode designed for videogaming competitions as well.

The user interface was the real weakness of RealSpectrum, as it was created at a time when emulators for MS-DOS were the most popular. Thus, it often resulted less friendly for the increasing number of users more accustomed to windows, pull-down menus, file type and program associations, drag-and-drop file operations, and so on – features commonly found in many of the early 2000s Spectrum emulators for Windows. To provide RealSpectrum with a more intuitive graphic user interface, the *RealX* project was started in 2001. The transition to Windows XP with its new APIs, the evolution of DirectX and the consequent difficulty, due to lack of time, in staying behind all these innovations meant that it was not even possible to produce even a partially complete version, stable enough to be publicly distributed, of the repeatedly announced RealX, despite the fact that at the Varese Retrocomputing event in 2003 a prototype working only in full screen mode was presented, whereas RealSpectrum could also run in a window under Windows. RealX was eventually discontinued, while development of RealSpectrum continued until the last version, 15 (v0.98.14) of 31 December 2009.

Many other emulators have surfaced since the mid-2000s, mostly for Windows. Team MAME, responsible for the well-known program initially created to revive coin-op video games on the PC, also launched a parallel project called MESS (Multi Emulator Super System) for the emulation of home computers and gaming consoles, later integrated in the main one, which includes Spectrum emulation. Similarly, some of the newer programs, for example *ZEsarUX, Xpeccy, EightyOne* or *DSP,* also emulate the ZX80, ZX81 and QL or non-Sinclair machines, for instance the Jupiter Ace, Amstrad CPC 464 and even consoles like the Sega Master System or Nintendo NES and GameBoy. Many allow to emulate real clones (Pentagon and Scorpion ZS being the most recurrent), recent peripherals, from the most popular like the DivIDE or DivMMC to other in a working prototype state, configurations with alternative ROMs (French, Spanish, SE BASIC, + 3e etc.). Some even emulate hardware left in the design state, such as the ZX Spectrum SE, Chloe 140 SE/280 SE, ULAX.

FILE TYPES

Files used in Spectrum emulators are usually divided into at least four categories:

- *snapshot:* they contain the data of a particular state of the memory of the real or emulated computer, plus any other data: video images, multi-load game levels, etc.;
- *tape image:* they store a sequence of data blocks, read by the emulator as if they were on a tape loaded by the recorder;
- *disk image:* they contain data stored on a floppy disk;
- *others:* all files that do not fall within the three previous categories.

SNAPSHOT FILES

ACH. Snapshot file format specific to *Speccy!,* emulator for machines running Acorn RISC OS, by Carsten Witt.

DAT. Snapshot file format specific to *XZX-Pro.*

DSP. Snapshot file format specific to *DSP.*

ESP. Snapshot file format specific to *Es.pectrum.* It is opened like a ZIP compressed file; contains data in BIN format and configuration files in INI format.

FRZ. 'Frozen' file. Snapshot file format specific to *CBSpeccy,* emulator for the Amiga by the Code Busters group.

FSU. Snapshot file format specific to *Es.pectrum.*

PRG. Snapshot file format specific to *SpecEm,* emulator for MS-DOS by Kevin J. Phair.

SAV. 'Save state'. Snapshot format specific to *GP2Xpectrum* and *Xpectroid.*

SCS. Snapshot file format specific to *ASCD* (also used in Sam Coupé emulation, allowed by the same program).

SEM. Snapshot file format specific to *SPECEMU,* emulator for MS-DOS by Bernd Waschke (not to be confused with the similarly named *SpecEmu,* by Mark Woodmass).

SIT. Snapshot file format specific to *Sinclair,* emulator for MS-DOS by Pedro Salas.

SLT. Acronym for *Super Level loader Trap,* modification of the Z80 format conceived by Damien Burke in collaboration with James McKay, Gerton Lunter, Rui Ribeiro and Darren Salt specifically for multi-load games, that is, those that load their levels separately. Previously, Z80 snapshots captured at game start had to load levels from separate files placed in the in the same folder, containing the respective level data and reading them from time to time with a different 'level loader trap', i.e. the peculiar loading routine of each multi-load game. This made the rendering in multiple files to be used under emulation rather fiddly. SLT, on the other hand, embeds everything in a single file, whose overall length is less than that of the equivalent Z80 snapshot together the level files, because level data are compressed as well, following the same method used for the computer's RAM content. SLT also includes a table through which the emulator reconstructs the correct sequence of levels and their location within the file itself.

SNA. One of the most widespread snapshot file formats, due to its ability to 'photograph' the contents of the entire Spectrum RAM almost without any alteration. It can be of two types, depending on whether it has been 'captured' by a 48 or 128 KB RAM Spectrum.

In the first case, it is 49,179 bytes long and includes the 49,152 bytes of RAM plus another 27 for information on registers status, interrupt flags, border colours, stack pointers, etc. When the file is saved, the program counter is moved to the Z80 stack pointer to execute a RETN command and resume emulation from the capture point, overwriting 2 bytes. However, if there is no space in memory for the stack, the contents of all memory below the pointer will be altered. It is a very rare problem, but Rui Ribeiro proposed a remedy that consists in replacing the two corrupted bytes with zeros and increasing the pointer.

In the second case (128 KB), length depends on the RAM paging status and can be 131,103 or 147,487 bytes. There is also a special reserved variable for the program counter, in order to avoid the risk of data corruption.

SNP. Snapshot saved from the DISCiPLE or Plus D. Register information (a total of 30 bytes) is located at the end of the file, rather than at the beginning like in the previous formats. JPP includes a SPECDISC utility, written by Brian Havard, to convert SNP snapshots into SNA, which the emulator can open.

SNX. Snapshot file format specific to Specci, emulator for the Atari ST, by Christian Gandler. It is an extension of SNA that employs a simple compression algorithm.

SP. Snapshot file format used by Pedro Gimeno's Spectrum and similar in structure to SNA. The header is 38 bytes long while the total length of the file can be 16,422 or 49,190 bytes depending on whether the saved content comes from a 16K or 48K Spectrum.

SPG. Snapshot file format specific to the ZX-Evolution clone.

SZX. Properly called *zx-state,* it is a format introduced by Jonathan Needle in his *Spectaculator* emulator from version 2.5 on. The purpose of SZX is to overcome the limitations of traditional SNA and Z80 snapshot files, making it possible to record the status of all hardware emulated by Spectaculator, reduce the file size as much as possible by means of Zlib compression, make a special plug-in for Spectaculator to manage these snapshots, in order to allow compatibility across subsequent releases of the same program and to create an open file format for use by other emulator authors.

SZX files have a modular structure. At the beginning there is a header that identifies the file version and the model of Spectrum or clone thereof to which it refers. It can in fact include data saved from the RAM state of all Spectrums and the following clones and modified versions: ZX Spectrum 48K NTSC, + 3e, SE and 128Ke, Pentagon 128, 512 and 1024, Timex Sinclair TS 2068, Timex Computer TC 2048 and 2068, Scorpion ZS 256. Then, a series of blocks comes, arranged in no particular order, where information relating to the state of the hardware present at the time of saving is stored. Version 1.4 includes 35 blocks concerning a wide range of devices, from the Covox to the Beta Disk, Plus D or ZX Printer, from interfaces such as the ZXCF and ZXATASP to possible custom ROMs. The current version of the SZX specifications is 1.4 of 8 December 2010.

XNA. Snapshot file format specific to *ZX ULAX,* which preserves the colour information loaded from the DUX file.

Z80. This is also a very popular snapshot file format. It was devised by Gerton Lunter for his emulator of the same name and has undergone three revisions, in versions 1.45, 2.0 and 3.0 of the emulator respectively. Such revisions are therefore conventionally indicated as Z80 version 1, 2 and 3. Compared to SNA, it does not have a fixed length, since, after the initial header containing the data relating to the status of the registers, flags, interrupts, joystick (if present) etc. the contents of the RAM are compressed with a method based on the replacement of sequences of at least five equal bytes with a four-byte code structured as follows: 'EDh EDh xx yy', ie 'byte yy repeated xx times'. There are exceptions for byte sequences consisting of EDh and for bytes immediately following an EDh byte. The end of the RAM data block is marked by the byte sequence: '00h EDh 00h 00h'.

Version 1 has a 30-byte long header. Versions 2 and 3 have, after it, an additional header that records other information, such as the model of machine in use, including the Pentagon 128, Scorpion ZS 256, Didaktik Kompakt, Timex Sinclair TS 2068, Timex Computer TC 2068 and 2048, with the corresponding memory paging, the possible use of AY sound, joystick mapping, or the possible presence of the Multiface or DISCiPLE in the expansion port at the time of saving.

ZLS. Snapshot file format specific to *ZX-Live.*

ZX. Snapshot file format specific to *KGB.*

ZXS. Snapshot file format specific to *ZX32.*

TAPE IMAGE FILES

BLK. Another name of the classic TAP format.

DDH. HiLow Data Drive tape image file.

LTP. Tape image file format almost identical to TAP but not interchangeable with it, specific to Nuclear ZX, emulator for MS-DOS, by Radovan Garabik and Lubomir Salanci.

PZX. *Perfect ZX* tape acronym. Format designed by Patrik Rak in order to offer emulator authors a simpler and more streamlined alternative to TZX, as it does not require to insert information about the loading scheme and hardware to be used in specific block types. It includes just six kinds of block, four mandatory and two optional. The current revision is 1.0.

PZX consists of a sequence of blocks, each identified by one of four possible codes: PZXT, PULS, DATA and PAUS. PZXT is the header block and as such is always placed at the beginning of the file; it contains, in addition to the file revision number, spaces reserved for any information on the author, publisher, release year, type and language of the program etc., similar to TZX's ID 32 block. PULS represents the arbitrary sequence of pulses, i.e. sounds recorded on tape, and carries information about the duration and pitch of the sounds. DATA indicates data in binary format, rendered through specific sequences of pulses, bit by bit, starting with the most significant bit. Lastly, PAUS sets pauses of a certain length between blocks.

Next to these four mandatory types there are two whose presence is not required to make the file compatible with the PZX specifications: BRWS, which serves as a pointer for those programs that allow the user to browse the contents of the file, and STOP, to stop the virtual tape at a specific point.

TAP (CLASSIC). Contains a copy of data saved on tape, in the common format of the recording routine of the Spectrum ROM. Its structure is simple, as it is composed of a data block or a group of two or more data blocks in sequence. Size can range from zero – total absence of data – to considerable figures, as the file can hold a large number of blocks. The first two bytes of each block contain information about its length. A header is 19 bytes long but of four possible types, depending on the nature of the block: BASIC program, also self-starting; numerical data; string data; video image data or machine code. After the header there are the actual data. TAP files can also be chained at the MS-DOS command prompt like normal binary files by using a COPY command with the /B option.

TAP/TAPW (WARAJEVO). This file format only shares its extension with the classic TAP. Actually, it is much more complex, as it compresses data and can even contain tape samples.

The header of each Warajevo TAP file is composed of, in the following order: four bytes containing the pointer to the first block; four bytes containing the pointer to the last block; lastly, four bytes of value FFFFh (65535), the typical final marker of Warajevo. The block list comes after. In turn, each block with a length of less than 65,534 contains, in the following order: four bytes as the pointer to the previous block, always equal to zero for the first block; four bytes as the pointer to the next block or to the end-of-file marker, in the case of the last block; two bytes for block size, without flag; one flag byte, that can assume the values: 0 for standard header, 255 for standard data, 1-254 for custom data; finally, the data bytes.

If the block is 65,534 bytes long, it hosts tape samples. In this case it contains, after the pointer bytes: two bytes containing the value 65534 (FFFEh); one status byte, whose bits from 0 to 2 indicate the number of bits used in the last byte of the block, 3 to 4 indicate the sampling frequency, according to the scheme 00 = 15,000 Hz, 01 = 22,050 Hz, 10 = 30,303 Hz, 11 = 44,100 Hz, while the last two bits are not used; two bytes indicating the uncompressed data size; two bytes indicating the compressed data size (if the last two blocks contain the same value, data is not compressed); two digital signature bytes to notify the presence of compressed data to the emulator; lastly, the sampled data – eight samples are inserted in a byte, from bit 7 to bit 0 – in compressed or uncompressed format; the last byte does not need to contain all eight bits.

If the block is 65,535 bytes long, data is compressed. The block contains, after the pointer bytes: two containing the value 65535; one flag byte that can assume the values: 0 = standard header, 255 = standard data, 1-254 = custom data; two bytes indicating the uncompressed data size; two bytes indicating the compressed data size; two digital signature bytes to notify the presence of compressed data to the emulator; the actual compressed data bytes.

Compressed data are stored with an algorithm similar to PKLITE, decompressed by following the track recorded in the two digital signature bytes. Incidentally, this was the algorithm developed by Samir Ribić in more than a month in the terrible summer of 1993, mainly working on paper in the pauses between combat actions during the defence of Sarajevo.

TZX. A file format designed in order to fully preserve tapes, including any non-standard loaders, as it contains all the information necessary for the emulator to reconstruct the loading scheme. TZX was conceived by Tomaz Kac and maintained by him until revision 1.13, after which it was entrusted for a short time to Martijn van der Heide, the founder and administrator of the *World Of Spectrum* website, and later to the Ramsoft group, who took care of the final 1.20 revision. The following description refers to the latter.

Each TZX file begins with a 10-byte header, with the first 7 bytes making up the *ZXTape!* text. This is followed by the end-of-file marker byte (1Ah) and two other bytes that respectively indicate the major revision number (1) and the minor revision number (in this case 20, therefore 1.20) of the file itself. The structure is made up of a series of blocks, each one marked by an identifier (see the table on the next page). It is an extremely flexible kind of arrangement that makes TZX a very useful format for storing tape data as close to the original as possible.

Each block type performs a particular task. Many have a series of internal options whose modification determines a different behaviour on the part of the emulator. There is also the possibility of inserting pauses, jumps from one block to another, comments or other information relating to the original tape, including specific timings for ‘turbo’ schemes and/or with sounds inserted at a certain point between data blocks as anti-copy measures, typical, for example, of Speedlock.

ID	Description
10	Standard speed data block
11	Turbo speed data block
12	Pure tone
13	Sequence of pulses of various lengths
14	Pure data block
15	Direct recording block
18	CSW (Compressed Square Wave) recording block
19	Generalized data block
20	Pause (silence) or 'Stop the tape' command
21	Group start
22	Group end
23	Jump to block
24	Loop start
25	Loop end
26	Call sequence
27	Return from sequence
28	Select block
2A	Stop the tape if in 48K mode
2B	Set signal level
30	Text description
31	Message block
32	Archive info
33	Hardware type

DISK IMAGE FILES

$B/$C/$D (HOBETA). Virtual images of TR-DOS disks hosting only one file to be used in a BASIC environment. The letters are the same as the extensions recognized by TR-DOS and indicate the file type: $B for a BASIC program, $C for machine code and $D for numeric or alphanumeric data arrays.

D80. Didaktik D40/D80 disk image.

DSK/EXTENDED DSK. Image files of floppy disks used by the Spectrum +3 as well as the Amstrad CPC range, since they share the same internal Hitachi floppy disk drive. The simple DSK format has an information block at offset 0 containing the *MV - CPC* ASCII identifier and indications on the number of tracks and the number of sides (1 or 2) of the disk itself. In turn, every track has a specific information block that precedes sector data and stores the track's number, side, sector size and number of sectors. All tracks must be the same size, no matter if their space is entirely or only partially filled.

The extended DSK format – sometimes referred to by the acronym *EDSK* – has the *EXTENDED CPC DSK File* ASCII identifier in the disk information block. It includes an offset table, to store the size of each individual track on the disk on one side, or more on both sides, and some additional identifiers indicating, among other things, the data rate and recording mode. These are carried out through the internal clock of the drive's NEC µPD765A/B controller chip, which allows data to be written in either IBM 3740 single density format (FM), or IBM System 34 double density format (MFM) including double-sided recording. By manipulating the recording rate through the chip's clock, it is possible to record data on the disk in such a way that it would be impossible to make a copy of it.

A typical use scenario is the recording of ‘weak’ or random (‘floating’) sectors: each time the sector is read one or more bytes will change, the value may be random between consecutive reads of the same sector. Due to the ability to store such information, the extended DSK format is used to create image files of copy-protected disks.

FDI. Acronym for *Full Disk Image,* another TR-DOS disk image format, more detailed than TRD. It is identified by the *FDI* letters placed at the beginning, followed by a byte to indicate whether the disk is write-protected or not and information about the disk’s geometry, two bytes for each of the following: number of cylinders, number of heads, location of the optional description of the disk and location of data, whose size and sequence depend on the disk format established by the preceding parameters. The header of each track, in addition to the information about geometry and the number of sectors, includes, among sector information, a byte whose bits from 0 to 5 are used for a cyclic redundancy check (CRC), in order to identify writing errors in the sector itself.

IMG/MGT. DISCiPLE/Plus D disk image.

IPF. Acronym of *Interchangeable Preservation Format.* Cross-system data preservation format born on the Amiga on the initiative of the Software Preservation Society. Spectaculator is the only Spectrum emulator that can open this file format, currently limited to read-only +3 disk images.

MBD. MB02+ disk image.

OPD/OPU. Opus Discovery disk image. It can be single-sided with 40 tracks and 180 KB, or double-sided, with 80 tracks and 360 KB. Each track is divided into 18 sectors of 256 bytes each.

Geometry information is stored at the beginning of the file and may, within certain limits, be customized by the user.

SCL. It is not a real disk image, but simply a data set in TR-DOS format that can be read by an emulator. To be physically readable by a Beta Disk drive, it must be converted to TRD. 'SCL' derives from the *SINCLAIR* digital signature placed at the beginning. A byte follows to indicate the number of files present in the SCL file, then the headers of each of them, each one 14 bytes long and including the name and extension of the file, according to TR-DOS rules (B = BASIC, D = numeric or alphanumeric data array, C = machine code and # = print file), as well as information about the length measured in sectors and the physical locations of the files, and last the data itself.

TD0. Teledisk compressed disk image file.

TRD. TR-DOS disk image. It can contain 1 or 2 sides with 40 or 80 tracks per side, each consisting of 16 sectors of 256 bytes each. Disks therefore come in four possible combinations. The first track is reserved for the file allocation table, where both name (in case sensitive format) and extension of each file are specified (B = BASIC, D = numeric or alphanumeric data matrices, C = machine code and # = print file), their position on the disk, and information about the disk type, including the label and the number of free sectors. From sector 16 onwards, actual data begins.

UDI. Format that stores data from both disks and Microdrive cartridges (for which there is a specific MDR format) and data encoding schemes based on the FM/MFM combination, as well as any 'weak' or random ('floating') sectors, present as copy protection, like in the extended DSK format. UDI includes data compressed with the Zlib algorithm too.

OTHER FILE TYPES

AIR/RZX. Files that store joystick movements or keys pressed under emulation in order to record, for instance, a gaming session, in order to show a walkthrough, or to be submitted to a competition. The former always needs to be associated with a Z80 snapshot in order to work, while the latter already includes it, unless it has been recorded in tournament mode. In this case, it requires a specific snapshot file, usually provided by the organizers, to prevent the use of altered Z80 files to one's advantage.

BIN. Binary data file format.

CHR/CH4/CH6/CH8. Normal 8×8 or FZX extended and proportional character set file, designed by Andrew Owen and implementable through a driver written by Einar Saukas.

CSW. Acronym of *Compressed Square Wave*. Compressed audio file format, specifically developed by Ramsoft for tape sampling.

DCK. Timex cartridge image file.

DUX. Colour data, used by ZX ULAX.

FMF. Acronym of *Fuse Movie File,* video recording file format specific to FUSE. It must be converted in other formats by means of the *fmfconv* utility, part of the *FUSE Utilities* suite.

HDF. Image of an IDE hard drive, designed by the Ramsoft group. The header is 6 bytes long and identifies the file type by means of the *RS-IDE* string. This is followed by: one byte for the end of file marker (1Ah); one byte for the revision number (for example 11h, i.e. 1.1); one byte indicating the halving of sector data, i.e. only the least significant byte of each sector's word is stored, due to the discrepancy between the 8-bit architecture of the Z80 and the 16-bit architecture of IDE; two bytes for the disk data offset (0080h) – when it is set, it means that the sector size specified by the IDE identification data is actually halved in the HDF file, to reduce the HDF file size, by storing only the 'usable' significant data; 11 reserved bytes (to be set on 00h); 106 bytes for IDE/ATA identification, as indicated by the ATA ECh command, containing information about the disk drive geometry (cylinders, heads, sectors, sector size), the device model's name, supported features and so on.

MDR. ZX Microdrive cartridge image. It contains 254 sectors of 543 bytes each, and a final flag byte which, if does not store a value of zero, indicates that the cartridge is write protected. Therefore, total length amounts to 137,923 bytes. Each sector is divided into three blocks: one header, one for records, and one for data. Each block includes a checksum byte to verify data integrity.

MLT. Video memory image file format able to store screen data in multicolour mode, either implemented through dedicated hardware or emulated by BIFROST* and NIRVANA graphic routines.

MP3/OGG/VOC/WAV. Audio file formats, used for tape sampling.

POK. Created in 1996 for the Spectrum Games Database, it is a simple text file that contains values to be inserted into RAM to alter game features, usually to obtain infinite lives, unlimited ammo and energy, freeze time and so on. The syntax is:

N[modification name]
M [bank] [location] [new value] [original value]
Z [bank] [location] [new value] [original value]
Y

The first letter is Z if only the content of a single memory location has to be modified, otherwise M for all those preceding the last, which is indicated by Z. The memory bank (only for the Spectrum 128 and later models) on which to intervene follows: it is usually set to 8 (ignore), as it is rarely known. Then come the location address, the new value to write in it and the original one. The latter can be set to 0 if it is not known, but in this case, it is not possible to undo the change. Y is the end-of-file marker.

RAW. Raw data file.

ROM (FIRMWARE). File containing firmware for the various Spectrum models, clones, associated peripherals or alternative operating systems.

ROM (ZX-ROM). ZX-ROM ZX Interface 2 or ZX Dandanator! Mini cartridge image file.

SCR. Video memory content image file. As such, they are always 6,912 bytes long, of which the first 6,144, divided into three blocks of 2,048 bytes each, represent the pixel map (256×192) and the last 768 the attribute map (32×24).

WDR. Wafadrive cartridge image file.

ZX SPECTRUM NEXT SPECIFIC FILE TYPES

NEX. Instruction set necessary to load and start a specific program. The file always begins with a 512-byte long header, including the indications for the correct execution of the program: the amount of required RAM, the RAM memory banks to load, the stack pointer, the colour mode used, the location starting point for each bank, cyclic redundancy checks and more. After the header, there may be optional data, for instance loading screens in various colour modes.

NPL. 9-bit with transparency colour palette file.

NXI. Screen Layer 2 data file format, with optional palette. Basically, it is the set of data of the six MMUs used by Layer 2.

PAL. 9-bit colour palette file.

SHC. 8×1 mode (256×192, 15 colours) video memory content image file.

SHR. HiRes mode (512×192, two colours) video memory content image file.

SLR. LoRes/Radasjimian mode (128×96, 256 colours) video memory content image file.

SL2. Layer 2 (256×192, 256 colours) video memory content image file.

EMULATORS

On the following pages, a list of Spectrum emulators is shown. It is divided into five sections, according to the operating system they run on: Microsoft Windows, Unix and Unix-derived operating systems, macOS, other systems and Web-based emulators. Each entry begins with the program's name and is in turn divided as follows:

System	Only present in the fourth section: indicates the system the emulator runs on.
Author	The emulator author(s).
Computers	Emulated Spectrum models and derived machines.
Peripherals	Emulated peripherals. Joysticks are not listed, since practically every listed program emulates at least the Kempston joystick, together with Sinclair and AGF/cursor.
File formats	File formats the emulator can open and/or save, in alphabetical order. In the case of programs able to emulate systems other than the Spectrum and derived machines as well, formats compatible with such hardware architectures are not mentioned.
Version	The most recent stable version available at November 2022, with release date.
Website	The emulator's web page (if existing).
Notes	Further information, if any.

Versions for other systems, when existing, are mentioned in the major release notes. For example, FUSE (Free Unix Spectrum Emulator) is listed in the Unix section, whereas its versions for other systems are listed in the notes to the relevant sheet.

EMULATORS FOR WINDOWS

SPECTACULATOR	
Author	Jonathan Needle
Computers	ZX Spectrum 16/48/128/+2/+2A/+3, Pentagon 128, Scorpion ZS 256
Peripherals	ZX Interface 1, ZX Microdrive, ZX Printer, Multiface 1/128/3, Plus D, Beta Disk, Currah MicroSpeech, Cheetah SpecDrum, Covox, General Sound, AMX/Kempston mouse
File formats	BIN, BLK, CSW, DSK, FDI, IMG, IPF, MDR, MGT, POK, RAW, ROM, RZX, SCL, SCR, SNA, SZX, TAP, TRD, TZX, UDI, VOC, WAV, Z80
Version	8.0.0.3092 (22.12.2012)
Website	*www.spectaculator.com*
Notes	Versions for Android and iOS. Shareware: 30-day trial, registration costs €11.99/£9.99 (€22.99/£19.99 with free lifetime upgrades).

SPECEMU	
Author	Mark Woodmass
Computers	ZX Spectrum 16/48/128/+2/+3, Pentagon 128, TC 2048, TK90X
Peripherals	ZX Interface 1, ZX Microdrive, ZX Printer, Multiface 1/128/3, Expandor SoftROM, DivIDE, Plus D, Beta Disk, CBI-95, Currah MicroSpeech, Currah MicroSource, Covox, Cheetah SpecDrum, IDE/ATA hard disk
File formats	BLK, CSW, DSK, HDF, IMG, MGT, PZX, ROM, RZX, SCL, SCR, SNA, SNX, SP, SZX, TAP, TRD, TZX, WAV, Z80
Version	3.2 build 06.12.2022
Website	*keybase.pub/woodywoodster/specemu*
Notes	Support for ULAplus. Includes the code of Simon Owen's *Pac-Man* emulator, that can be run if the relevant ROM image files are present.

UNREALSPECCY	
Author	Current: Dmitry M. Bystrov (‘Alone Coder’), ‘DimkaM’, ‘LVD’. Previous: ‘SMT’, ‘Deathsoft’
Computers	Pentagon 128/512/1024 with 48 KB ROM, Scorpion ZS 256/1024 with 64 KB ROM /PROF-ROM with support for SMUC (128/256/512 KB), KAY-256/1024 with 64 KB ROM, Profi 1024, ATM Turbo v4.50 512/1024 with 64-1024 KB ROM, ATM Turbo 2+ v7.10 128/512/1024 with 64-1024 KB ROM
Peripherals	Beta Disk, SMUC/Nemo/Nemo(A8)/ATM IDE, ISA modem, SounDrive, AY/Kempston mouse
File formats	$B, $C, $D, CSW, FDI, SCL, SCR, SNA, SP, TAP, TD0, TRD, TZX, UDI, Z80
Version	0.39.0 rev. 1036 (21.11.2022)
Website	*svn.zxevo.ru/listing.php?repname=pentevo* (navigate to *unreal-fix/0.39.0/fix_labels/x32/*)
Notes	Support for 8×1, HiRes, 16col, 2-colour 80×25 and 512×240, 384×304, EGA (non-planar) 320×200 and 640×200, Flashcolor. Saves audio as WAV and VTX (Yerzymey’s Chiptune).

ZX-SPIN	
Author	ZX Spin Team (Paul Dunn et al.)
Computers	ZX Spectrum 16/48/+/128/+2/+2A/+3/+3e, Pentagon 128
Peripherals	ZX Interface 1, Multiface 1/128/3, Plus D, Beta Disk, DivIDE, Currah MicroSpeech, Cheetah SpecDrum, Fuller Box, Kempston mouse, Magnum Light Phaser, Expandor SoftROM
File formats	BLK, CSW, DSK, HDF, ROM, SCR, SNA, SZX, TAP, TZX, WAV, Z80
Version	0.7s (01.12.2009)
Website	-
Notes	Support for Gigascreen and ULAplus. Includes a machine code assembler (experimental).

ES.PECTRUM	
Author	Javier Chocano
Computers	ZX Spectrum 16/48/128 Investronica/ 128/+2/ +2A/+2E/+3/+3e, Inves Spectrum +, TC 2048, TS 2068, Unipolbrit 2086, TK90X/95, Orel BK-08, Pentagon 128/512/1024 SL v2.x, Scorpion ZS 256/256 Turbo +, Leningrad, Dubna 48K, ATM Turbo/Turbo 2+, ICE-Felix HC-91, BK-01
Peripherals	ZX Interface 1, ZX Microdrive Dandanator, DivMMC, Spectranet, Multiface 1/128/+3, Turbo Sound, Covox, SpecDrum, Kempston mouse, Gun Stick, Magnum Light Phaser
File formats	$B, $C, $D, BIN, CSW, DCK, DSK, FDI, FSU, HDF, MDR, PZX, RAW, ROM, RZX, SCL, SNA, SP, TAP, TRD, TZX, VOC, WAV, Z80
Version	0.10.0 (08.02.2022)
Website	*www.habisoft.com/espectrum/*
Notes	Includes the following ROMs: 16/48K Spanish, Swedish and Arab; +2 Spanish, French and Arab; +2E/+3/+3e/Microdigital TK95 Spanish. Support for Timex video modes and ULAplus.

EIGHTYONE	
Author	Michael D. Wynne, Paul Farrow
Computers	ZX Spectrum 16/48/128/+2/+2A/+3/SE, TS 2068, TC 2048
Peripherals	ZX Interface 1, ZX Printer, Beta Disk, Opus Discovery, DISCiPLE, Plus D, DivIDE v1/v2, ZXCF, Piters CF/8-bit/16-bit, Kempston mouse, TS 2050, Multiface, Currah MicroSpeech
File formats	DSK, IMG, MGT, OPD, OPU, SNA, TAP, TRD, TZX, WAV, Z80
Version	1.29 (11.06.2022)
Website	*sourceforge.net/projects/eightyone-sinclair-emulator/*
Notes	Based on FUSE. Also emulates: ZX80, ZX81, QL, Jupiter Ace, Timex Sinclair TS 1000/1500, Lambda 8300, Ringo R470, Microdigital TK85, ZX97 Lite.

MAME	
Author	MAME Team (various developers)
Computers	ZX Spectrum 16/48/128/+2/+2A/+3/+3e, Pentagon 128/1024 SL, Scorpion ZS 256, ATM, ATM Turbo 2, KAY 1024, Microdigital TK90X/TK95, CIP-01/03, Bajt, Kvorum 48K, Kompan'on, Profi, Elwro 800 Junior, Magic-06, Didaktik Gama 87/88/89/M 90/M 91/M 92/M 93/Kompakt, Inves Spectrum +
Peripherals	ZX Interface 1/2, DISCiPLE, Plus D, Wafadrive, Opus Discovery, +3e ZXATASP, +3e ZXCF, simple 8-bit +3e IDE, 80 KB RAM expansion, Kempston mouse
File formats	RZX, SNA, TAP, Z80
Version	0.250 (30.11.2022)
Website	*www.mamedev.org*
Notes	Superseded the MESS side project. Also emulates: ZX80, ZX81, Timex Sinclair TS 1000/1500, Jupiter Ace and SAM Coupé. Versions for Linux, FreeBSD, macOS, OS/2, Android, Xbox etc.

ZXSEC	
Author	Cesar Nicolás-González
Computers	ZX Spectrum 48/128/+2/+3, Pentagon 128
Peripherals	Beta Disk, ZX Dandanator! Mini, Turbo Sound, Covox, Melodik, Gun Stick
File formats	CSW, GZ, MLD, ROM, SCL, SNA, SP, TAP, TRD, TZX, WAV, Z80
Version	20220806 (06.08.2022)
Website	*cngsoft.no-ip.org/cpcec.htm*
Notes	Project derived from the Amstrad CPC CPCEC emulator, distributed together with it and the Commodore 64 CSFEC emulator. Requires the Beta Disk ROM image file (with the name TRDOS.ROM) in order to open SCL and TRD files. Support for Gigascreen and ULAplus.

LNXSPECTRUM	
Author	‘Lanex’
Computers	ZX Spectrum 48/128, Didaktik Gama 80/192, Sparrow 48K
Peripherals	Beta Disk, DivIDE, Z80-DMA, DivIDE, MB03+, BT-100 printer, Kempston mouse, General Sound
File formats	LSN, SCR, SNA, TAP, TZX (90% compatibility)
Version	1.8.7 (01.11.2022)
Website	*www.ilnx.cz*
Notes	Emulates 80 and 528 KB LEC expansions. Support for Gigascreen and ULAplus. Emulates a virtual Blitter (LnxBlitter 6) and an alternative graphics system (HGFX). Requires Microsoft .NET 4.0 and XMA Framework 4.0.

XPECCY	
Author	Aleksandr Sinyakov
Computers	ZX Spectrum 48/128/+2/+3, Pentagon 128/512/1024 SL, Scorpion ZS 256/1024 with PROF-ROM, ZXM Phoenix, Profi, ATM Turbo 2, ZX-Evolution (Base and TS configurations)
Peripherals	Beta Disk, Nemo, Nemo A8, Nemo Evo, SMUC, ATM, SMK512, General Sound
File formats	$B, $C, $D, DSK, FDI, SCL, SNA, SPG, TAP, TD0, TRD, TZX, UDI, WAV, Z80
Version	0.6.20220219 (19.02.2022)
Website	*github.com/samstyle/Xpeccy*
Notes	Also emulates: MSX, MSX 2, Gameboy Color, NES, Commodore 64, BK0010. ROMs other than the 48K one must be downloaded separately. Support for ULAplus. Emulates the AY-3-8912 and YM2149F sound chips at the user’s choice, either mono or stereo, in various configurations.

CSPECT

Author	Mike Dailly
Computers	ZX Spectrum Next
Peripherals	All those compatible with the ZX Spectrum Next
File formats	All those that can be opened by NextOS
Version	2.16.6 (23.10.2022)
Website	*dailly.blogspot.com*
Notes	NextOS and the programs to run on the machine must be inserted in an SD card image file, to be specified at launch from the command prompt. Requires Microsoft .NET and OpenAL. Versions for Linux and macOS.

SOFTSPECTRUM 48

Author	Magnus Krook
Computers	ZX Spectrum 48/128/+2/+2A/+3/+3e (1.43)
Peripherals	Beta Disk (48/128/+2 only), Kempston mouse
File formats	POK, SCL (read-only), SNA, TAP, TRD (read-only), TZX, Z80
Version	Build 12.08.2022
Website	*softspectrum48.weebly.com*
Notes	Includes the following ROMs: 16/48K Swedish, GOSH Wonderful, OpenSE BASIC 3, +2A/+3 4.0 and 4.1. Support for ULAplus.

ZX SPECTRUM 4

Author	Tim Butler, Richard Butler
Computers	ZX Spectrum 16/48/128/+2/+3
Peripherals	ZX Printer, Kempston mouse, Trojan light pen
File formats	DSK, SNA, TAP, TZX, WAV, Z80
Version	1.0.8305 Build 21215 (27.09.2022)
Website	*www.zxspectrum4.net*
Notes	Shareware with very limited functionality. Registration is required to enable all features, at a cost of £10. Includes a Z80 assembler. Emulates the connection between two Spectrums via TCP/IP.

REALSPECTRUM (RS32)	
Author	Ramsoft (Luca Bisti, Stefano Donati)
Computers	ZX Spectrum 16/48/128/+2/+2A/+3, Pentagon 128, Scorpion ZS 256, Didaktik Kompakt
Peripherals	ZX Printer, ZX Interface 1, ZX Microdrive, Multiface 1/128/3, Multiprint, Plus D, Beta Disk, Wafadrive, Opus Discovery, DISCiPLE, Didaktik D40/80, MB02+, Softcrack, Spec-Mate, SMUC, ZXCF, ZXMMC+, 8-bit simple 48K/128/+3e IDE, SounDrive, Stereo Covox, Cheetah Music Machine, SpecDrum, Kempston mouse, Magnum Light Phaser
File formats	AIR, CSW, D80, DSK, HDF, MDR, MGT, MP3, OGG, OPD, OPU, ROM, RZX, SCL, SCR, SLT, SNA, TAP, TRD, TZX, WAV, Z80
Version	0.98.14 (31.12.2009) [final]
Website	-
Notes	Support for 8×1, Gigascreen and ULAplus.

DSP	
Author	‘Leniad’
Computers	ZX Spectrum 48/128/+3
Peripherals	Magnum Light Phaser, Gun Stick, AMX/Kempston mouse
File formats	CSW, DSK, DSP, PZX, SNA, SP, SZX TAP, TZX, WAV, Z80, ZX
Version	0.19 (08.04.2021); 0.21WIP4 for Windows 32-bit only (25.10.2022)
Website	*github.com/leniad/dsp-emulator*
Notes	Also emulates: Commodore 64, Amstrad CPC, coin-ops, various consoles (NES, Game Boy, Game Boy Color, ColecoVision, Sega Master System etc.). Emulates Lenslok protection. Support for ULAplus. Versions for Linux and macOS.

INKSPECTOR 2	
Author	Mark Incley
Computers	ZX Spectrum 16/48/128/+2/+2A/+3
Peripherals	ZX Interface 1/2, ZX Microdrive, Kempston mouse, Fuller Box, Fuller Orator, Currah MicroSpeech, Currah MicroSource, Didaktik Melodik, Multiface 1/128/+3, Cheetah SpecDrum
File formats	CSW, DSK, MDR, MLT, POK, PZX, ROM, RZX, SCR, SLT, SNA, SNX, SP, SZX, TAP, TZX, WAV, Z80
Version	2.0.3 (07.02.2022)
Website	*www.inkland.org.uk/inkspector/index.htm*
Notes	Also emulates: ZX80, ZX81, Jupiter Ace. Command typing assistant in the 16/48K BASIC prompt.

ZX ULAX	
Author	Dmitry Malychev
Computers	ZX Spectrum 48/128, Pentagon 128
Peripherals	Beta Disk
File formats	DUX, FDI, ROM, RZX, SCL, SNA, TAP, TRD, XNA, Z80
Version	Beta 28 (06.02.2022)
Website	*cloud.mail.ru/public/3Rzu/33GtNmUof/*
Notes	Started as a study project for an interface called ULAX, capable of eliminating 'colour clash' and displaying a wider colour range than the default one. It emulates these visual effects using colour data contained in DUX files, which make it possible to colourize the sprites of a game loaded in the emulator. Each game therefore requires a custom DUX file. There are currently around 120, with more in development.

SPECCY	
Author	Marat Fayzullin
Computers	ZX Spectrum 16/48/128/+2/+2A/+3, TS 2068, TC 2048, Pentagon, Scorpion ZS 256, Didaktik Gama, SAM Coupé (partial)
Peripherals	ZX Printer, TS 2040, Alphacom 32, Multiface 1/128/3, Beta Disk, ZX Interface 1 (partial), Plus D (partial), DISCiPLE (partial), Kempston/AMX mouse (partial)
File formats	DSK, FDI, MID, POK, SCL, SCR, SNA, TAP, TRD, TZX, Z80
Version	5.9 (17.03.2021)
Website	*fms.komkon.org/Speccy/*
Notes	Support for 8×1, HiRes, 16col and ULAplus. Versions for Linux and Android.

SPECTRAMINE	
Author	'Weiv'
Computers	ZX Spectrum 16/48/128/+2/+2A/+3, Pentagon 128, Scorpion ZS 256, TC 2048
Peripherals	Beta Disk
File formats	$B, CSW, DSK, ROM, RZX, SCL, SCR, SNA, SZX, TAP, TRD, TZX, WAV, Z80
Version	1.06 (07.11.2022)
Website	*files.fm/u/q5wjvqhtk*
Notes	Support for ULAplus.

ZERO	
Author	Arjun Nair
Computers	ZX Spectrum 48/128/+3, Pentagon 128 (including 128KE ROM)
Peripherals	-
File formats	CSW, DSK, PZX, RZX, SCL, SCR, SNA, SZX, TAP, TRD, TZX, Z80
Version	0.8 (01.01.2022)
Website	*github.com/ArjunNair/Zero-Emulator*
Notes	Support for Gigascreen and ULAplus.

RETRO VIRTUAL MACHINE

Author	Juan Carlos González Amestoy
Computers	ZX Spectrum 48/128 Investronica/128/+2/+2A/+3/+2E/+3e, Inves Spectrum+, ZX-Uno 4.1 (512 KB RAM, 4 MB flash RAM)/4.2 (2048 KB RAM, 16 MB flash RAM)
Peripherals	DivMMC, Turbo Sound, Recreated ZX Spectrum, Kempston mouse
File formats	CSW, DSK, PZX, SNA, TAP, TZX, Z80
Version	2.0 beta-1 R7 (10.07.2019)
Website	*www.retrovirtualmachine.org*
Notes	Includes the following ROMs: 48K Spanish; +2 French and Spanish; +2/+2A/+2E/+3/+3e Spanish. Also emulates the Amstrad CPC 464/664/6128. Versions for macOS and Unix-based systems.

SPECIDE

Author	Marta Sevillano Mancilla
Computers	ZX Spectrum 48/128 Investronica/128/+2/+2A/+3, Pentagon 128
Peripherals	Turbo Sound (2/4 chips)
File formats	CSW, DSK, TAP, TZX
Version	Build 10.07.2022
Website	*github.com/MartianGirl/SpecIde*
Notes	Includes the +2/+2A/+3 Spanish ROMs. Support for Gigascreen. Emulates the AY-3-8912 and YM2149F sound chips at the user's choice. Can be compiled for macOS and Unix-based systems.

RUSTZX

Author	Vladyslav Nikonov
Computers	ZX Spectrum 48/128
Peripherals	Kempston mouse
File formats	SCR, SNA, TAP
Version	0.15.0 (17.10.2021)
Website	*github.com/pacmancoder/rustzx*
Notes	Entirely written in Rust.

ASCD	
Author	Aley Keprt
Computers	ZX Spectrum 48/128, SAM Coupé
Peripherals	ZX Printer, Fuller Box, 3×8-bit DAC
File formats	AIR, DSK, SCS, SNA, TAP, Z80
Version	1.5 (30.01.2022)
Website	*www.keprt.cz/progs/#sam*
Notes	Based on the *Sim Coupé* SAM Coupé emulator by Allan J. Skillman.

SPUD	
Author	Richard Chandler
Computers	ZX Spectrum 16/48/128/+2/+2A/+3
Peripherals	Recreated ZX Spectrum
File formats	SEM, SNA, SNX, SP (48K-only), SZX, TAP, TZX, Z80
Version	0.306 (25.12.2021)
Website	*1drv.ms/u/s!Ar4VkKtk_3JziGs0CEQYrMs_O5-N?e=KXuhcW*
Notes	Support for ULAplus.

ZXMAK2	
Author	Aleks Makeev
Computers	ZX Spectrum 48/128/+3 (without floppy drive), Pentagon 128/512/1024, Scorpion ZS 256/1024/PROF-ROM 256/1024, ATM Turbo 4.50/7.10, PentEvo 4096K, Profi 3.xx/5.xx, Sprinter, Kvorum (Quorum) 64/256, Leningrad 1, Byte 48K
Peripherals	Beta Disk, SMUC
File formats	$B, $C, $D, CSW, FDI, SCL, SCR, SIT, SNA, SZX, TAP, TD0, TRD, TZX, UDI, WAV, Z80, ZX
Version	2.9.3.8 (23.07.2018)
Website	*github.com/zxmak/ZXMAK2*
Notes	Evolution of *ZXMAK* and *ZXMAK.NET*. Emulates the 528 KB LEC and the Delta-S ULA.

Z80STEALTH	
Author	Kirill Kolpakov, 'Hacker KAY'
Computers	ZX Spectrum 128, Pentagon 128/512/1024, Scorpion ZS 256 Turbo+, Profi 1024 (partial), KAY 1024 (partial)
Peripherals	Beta Disk, Covox, SounDrive, Kempston mouse
File formats	ACH, PRG, PZX, SCL, SIT, SLT, SNA, SP, TAP, TRD, TZX, Z80
Version	1.23 (20.08.2014)
Website	*z80.emu-russia.net*
Notes	Emulates a 16 KB RAM disk for Pentagon and the AY-3-8912 and YM2149F sound chips at the user's choice Support for HiRes, 16col, Gigascreen, Flashcolor.

EMUZGL	
Author	Vladimir Kladov
Computers	ZX Spectrum 48/128/+2/+2A/+3, Pentagon 128/ 256/512/1024, Scorpion ZS 128/256/1024, KAY 256/1024, Profi 256/512/576/768/1024, ATM1/2 512/ 1024
Peripherals	ZX Interface 1, ZX Microdrive, ZX Printer, Beta Disk, Covox, Stereo Covox, General Sound, AMX/ Kempston/AY mouse, Magnum Light Phaser, Gun Stick
File formats	$B, $C, BLK, FDI, MDR, RZX, SCL, SCR, SNA, SLT, TAP, TD0, TRD, TZX, UDI, Z80, ZX
Version	Alpha 233 K (16.06.2008)
Website	-
Notes	Evolution of the earlier *EmuZWin*. Support for Gigascreen. SNA and Z80 snapshot files may be associated with colour palette files (GFX) to run programs at 256 colours: the program stored in each snapshot must be associated with a specific palette.

EMULATORS FOR UNIX AND UNIX-DERIVED OPERATING SYSTEMS

FUSE (FREE UNIX SPECTRUM EMULATOR)	
Author	Philip Kendall
Computers	ZX Spectrum 16/48/128/+2/+2A/+3/+3e/SE, TS 2068, TC 2048/2068, Pentagon 128/512/1024, Scorpion ZS 256
Peripherals	ZX Interface 1, ZX Microdrive, ZX Printer, Plus D, Beta Disk 128, Didaktik 80/40, DISCiPLE, Opus Discovery, Kempston mouse, Fuller Box, Covox, Melodik, SpecDrum, TTX2000 S, DivIDE, DivMMC, ZXATASP, ZXCF, ZXMMC, Recreated ZX Spectrum, Spectranet, SpeccyBoot
File formats	D40, D80, DCK, DSK, FDI, HDF, IMG, LTP, MDR, MGT, OPD, OPU, ROM, RZX, SCL, SLT, SNA, SNP, SZX, TAP (both classic and Warajevo), TD0, TRD, UDI, Z80, ZXS
Version	1.6.0 (27.02.2021)
Website	*fuse-emulator.sourceforge.net*
Notes	Emulates the 48K with NTSC video signal. Also reads SAM Coupé SAD and SDF disk image files. Support for ULAplus. Other versions for: macOS, by Frederick Meunier; Windows, by Sergio Baldovi; Android, by Bogdan Vatra: Wii, by Björn Giesler; Xbox (*FuseX*), by 'Crabfists'; PSP, by Akop Karapetyan; GP2X, by Ben O'Steen; Windows Mobile 2003 (*FuseSP),* by Keith Orbell; PocketPC (*PocketClive),* by Anders Holmberg; Amiga OS 4, by Chris Young; MorphOS, by 'Q-Master'; OpenDingux, by Pedro Luis Rodríguez González; Gizmondo, by an unknown author.

ZESARUX	
Author	Cesar Hernández Bañó
Computers	ZX Spectrum 16/48/128 Investronica/128/+2 /+2A /+3/+3e/Next, Inves Spectrum+, Timex Sinclair TS 2068, Timex Computer TC 2048/2068, TK90X/95, Pentagon, Chrome, Prism 512, ZX-Uno (Base and TS configurations)
Peripherals	ZX Printer, Beta Disk, Multiface 1/128/+3, DMA Datagear/MB02/ZX-Uno, ZXMMC, DivMMC, DivIDE, ZX Dandanator! Mini, Kartusho, Speccy Superupgrade, SamRam, Defcon, Dinamid 3, HiLow Data Drive/Barbanegra, Interface 007, MicroHobby Pokeador Automático, Phoenix, Ramjet, Spec-Mate, Transtape, 2-channel and 3-AY channel Turbo Sound, MIDI, SpecDrum, Covox, General Sound, Magnum Light Phaser, Gun Stick, Recreated ZX Spectrum, Kempston mouse
File formats	AY, DCK, DDH, DSK, HDF, POK, PZX, ROM, RZX, SP, SPG, TAP, TRD, TZX, WAV, Z80, ZX
Version	10.2 (26.10.2022)
Website	*github.com/chernandezba/zesarux*
Notes	Includes the following ROMs: Spanish 16/48K/+2/+2A/+3/TK90X/TK95; French +2; SE BASIC; Derby+/++. Also emulates: MK14, ZX80, ZX81, QL, Cambridge Z88, SAM Coupé, Jupiter Ace, Amstrad CPC 464/4128, MSX, TK 80/82/82C/83/85, Timex Sinclair TS 1000/1500, Spectravideo 318/328, Coleco Vision, Sega SG1000/Master System and the Chloe 140 SE/280 SE virtual Spectrum clones. Support for 8×1, HiRes, 16col, Gigascreen, Radastan and ULAplus. Many functionalities for monitoring and debugging. Internal ZRCP protocol for remote control via Telnet client. Versions for Windows, macOS, FreeBSD 64-bit, Raspberry Pi plus others developed by third parties for Arch Linux, Slackware, RetroPie, Open Pandora, PocketCHIP, MorphOS.

FBZX	
Author	Sergio Costas Rodríguez
Computers	ZX Spectrum 16/48/128 Investronica/128/+2/ +2A
Peripherals	ZX Interface 1, ZX Microdrive, Kempston mouse
File formats	SNA, TAP, TZX, Z80
Version	4.8.0 (30.05.2021)
Website	*www.rastersoft.com/programas/fbzxesp.html*
Notes	Support for ULAplus. Nintendo Wii version (*FBZX Wii)* by Fabio Olimpieri ('Oibaf').

GZX - GEORGE'S ZX SPECTRUM EMULATOR	
Author	Jiri Svoboda
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	AY, SNA, TAP, TZX, WAV, Z80
Version	2020.1 (03.03.2020)
Website	*github.com/jxsvoboda/gzx*
Notes	Also for Windows.

SPIFFY	
Author	Edward Cree
Computers	ZX Spectrum 48K
Peripherals	ZX Printer
File formats	SLT, SNA, TAP, TZX, Z80
Version	Build 28.08.2013
Website	*github.com/ec429/spiffy*
Notes	Support for ULAplus. Windows version by 'Guesser'.

GLUKALKA 2

Author	Dmitry Sanarin
Computers	ZX Spectrum 48K/128, Pentagon 128, Scorpion ZS 256
Peripherals	Beta Disk
File formats	SCL, SNA, TAP, TRD, TZX, WAV, Z80
Version	(27.12.2011)
Website	*www.sanarin.ru*
Notes	Developed from the earlier *Glukalka*. Versions for macOS and Windows.

HIGGINS

Author	'Someone Higgins'
Computers	ZX Spectrum 48K/128/+2
Peripherals	-
File formats	SNA, TAP, TZX (parziale), Z80
Version	8.10 alpha 3 (23.05.2008)
Website	*jhiggins.narod.ru*

XZX-PRO

Author	Erik Kunze
Computers	ZX Spectrum 48K/128/+2/+3/, Pentagon, Scorpion ZS, Didaktik Kompakt
Peripherals	ZX Interface 1, ZX Microdrive, ZX Printer, Beta Disk, Plus D, D80, Multiface 1/128/3, Fuller Box, Kempston mouse
File formats	$B, $C, $D, D80, DAT, DSK, FDI, IMG, MGT, POK, SCL, SCR, SLT, SNA, TAP, TZX, VOC, Z80
Version	4.6 (22.12.2006) [final]
Website	*web.archive.org/web/20150211123250/http://erik-kunze.de/xzx/*

EMULATORS FOR MACOS

CLOCK SIGNAL	
Author	Thomas Harte
Computers	ZX Spectrum 16/48/128/+2/+2A/+3
Peripherals	-
File formats	DSK, SNA, SZX, TAP, Z80
Version	Build 25.11.2022
Website	*github.com/TomHarte/CLK*
Notes	Also emulates: ZX80, ZX81, Commodore VIC-20, Acorn Electron, Amstrad CPC, Apple II/II+/IIe, Atari 2600, Atari ST, ColecoVision, Enterprise 64/128, Macintosh 512ke/Plus, MSX, Oric 1/Atmos, Sega Master System. Version for Unix-based systems installable from Snapcraft.

ZXSP	
Author	Günter Woigk
Computers	ZX Spectrum 16/48/128/+2A, Inves Spectrum+
Peripherals	Multiface 1/128/+3
File formats	ROM, SCR, SNA, TAP, TZX, Z80
Version	0.8.0 pre27 (18.05.2015)
Website	*zxsp.blogspot.com/p/about-zxsp.html*
Notes	Emulates the French and Spanish +2/+2A as well as the ZX80, ZX81 and Jupiter Ace.

EMULATORS FOR OTHER SYSTEMS

JSPECCY	
System	Java (multi-platform)
Author	José Luis Sánchez
Computers	ZX Spectrum 16/48/128/+2/+2A/+3
Peripherals	ZX Interface 1, ZX Microdrive
File formats	CSW, ROM, SCR, SNA, SP, SZX, TAP, TZX, Z80
Version	0.93.1 (08.08.2015)
Website	*jspeccy.speccy.org*
Notes	Support for ULAplus. Emulates the 528 KB LEC expansion. Versions for Windows *(WJSpeccy)* and macOS *(Fjord)* by Andrew Owen.

Z64K	
System	Java (multi-platform)
Author	William McCabe
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	SNA, TAP, Z80
Version	2 build 10.10.2022
Website	*www.z64k.com*
Notes	Also emulates the C64/128, VIC-20, Atari 2600.

ZXBAREMULATOR	
System	Raspberry Pi
Author	José Luis Sánchez
Computers	ZX Spectrum 48/128/+2A
Peripherals	Mouse Kempston, Multiface 1/128/+3
File formats	TAP, TZX
Version	3.2 (20.01.2020)
Website	*zxmini.speccy.org*
Notes	Must be installed on the Raspberry Pi as an operating system. Accelerated file loading. A real Spectrum keyboard can be connected to the GPIO pins. Support for the Recreated ZX Spectrum.

ZX-LIVE	
System	Amiga OS 3 and later
Author	Dmitry Vladimirovich Zhivilov
Computers	ZX Spectrum 48/128, Pentagon 128
Peripherals	Beta Disk, Kempston mouse
File formats	$B, $C, $D, ACH, BLK, FRZ, POK, PRG, SCL, SCR, SEM, SIT, SLT (partial), SNA, SNP, SNX, SP, TAP, TRD, TZX (partial), Z80, ZLS, ZX
Version	0.53 (03.06.2021)
Website	*aminet.net/package/misc/emu/ZXLive*

ZXDS	
System	Nintendo 3DS/2DS/DS/DS Lite/DSi
Author	Patrik Rak
Computers	ZX Spectrum 48/128/+2/+2A/+3, Pentagon
Peripherals	Beta Disk, Wi-Fi, Kempston mouse
File formats	DSK, EDSK, POK, PZX, ROM, RZX (sola lettura), SCL, SCR, SNA, SZX, TAP, TRD, TZX, Z80
Version	2.2.1 for 3DS/2DS (20.01.2022); 1.4.0 for DS/DS Lite/DSi (23.04.2022)
Website	*zxds.raxoft.cz*
Notes	Shows a virtual keyboard in the console's lower screen. Support for ULAplus.

MARVIN	
System	Android
Author	?
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	SNA, TAP, TZX, Z80
Version	1.7.2 (19.07.2015)
Website	-
Notes	In-built POK database.

XPECTRUM (XPECTROID/IXPECTRUM)

System	Android (Xpectroid), iOS (iXpectrum)
Author	'SplinterGU', 'Seleuco', Jaime Tejedor Gómez ('Metalbrain')
Computers	ZX Spectrum 48/128/+2/+2A/+3
Peripherals	-
File formats	DSK, POK, SCR, SAV, SNA, SZX, TAP, TZX, Z80
Version	Xpectroid: 1.2.1 (13.09.2011) iXpectrum: 1.3.1 (31.07.2010)
Website	*code.google.com/archive/p/xpectrum/*
Notes	Derives from GP2Xpectrum.

GP2XPECTRUM

System	GP2X
Author	'Hermes/PS2R', 'Seleuco', Jaime Tejedor Gómez ('Metalbrain')
Computers	ZX Spectrum 48/128/+2/+2A/+3
Peripherals	-
File formats	DSK, POK, SCR, SNA, SZX, TAP, TZX, Z80
Version	1.7.2 (29.08.2008)
Website	*wiki.gp2x.org/articles/g/p/2/GP2Xpectrum.html*
Notes	Partially based on FUSE. Also loads snapshot saved as the GP2X's SAV native format. Versions for Dingoo A320, Symbian 60, Symbian UIQ, iPhone/iPod Touch, GP2X Wiz.

STECCY

System	STM32F407VET microcontroller
Author	'ukw100'
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	TAP, TZX, Z80
Version	1.5.2 (25.04.2021)
Website	*github.com/ukw100/STECCY*
Notes	Loads files from an SD card. Version for Unix-based systems.

WEB-BASED EMULATORS

JSSPECCY	
Author	Matthew Westcott ('Gasman')
Computers	ZX Spectrum 48/128, Pentagon 128
Peripherals	-
File formats	SNA, SZX, TAP, TZX, Z80
Version	3.1 (26.08.2021)
Website	*jsspeccy.zxdemo.org*

QAOP	
Author	Jan Bobrowski
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	SCR, SNA, ROM, TAP, Z80
Version	-
Website	*torinak.com/qaop*

R.A.Z.E.	
Author	Rodrigo Rivas Costa
Computers	ZX Spectrum 48/128
Peripherals	-
File formats	TAP, TZX, Z80
Version	-
Website	*rodrigorc.github.io/raze/*

ZX DREAM	
Author	Evgeny Zeyler
Computers	Pentagon 128
Peripherals	Beta Disk, mouse Kempston
File formats	FDI, SCL, SNA, TRD
Version	-
Website	*zx.researcher.su*

APPLICATIONS FOR EMULATORS

MAKETZX/MAKETZX WINGUI

A program by the Ramsoft group for rendering tape samples into TZX files or to create TZX files in real time, directly from tape recorder input. It exists in Windows, MS-DOS, Linux and Amiga versions. Under Windows it can be used both at the command prompt and through a graphical user interface by the same authors, *MakeTZX WinGUI.* It reads samples in VOC, WAV, IFF, CSW and OUT formats and decodes the SpeedLock 1-7, Alkatraz, SoftLock, BleepLoad, Paul Owens, Activision/Multiload, PowerLoad, Biturbo I/II/III, Injectaload/Excelerator, ZetaLoad (a specific format created by Ramsoft themselves) loading schemes, in addition of course to the ordinary ROM one. Loading schemes can be automatically detected or set by the user before proceeding. Custom timings written into an INI file can be inserted in the user interface, for example those of the cassettes attached to some British magazines such as *Sinclair User* or *Your Sinclair.*

The vast majority of Spectrum tapes can be faithfully converted by MakeTZX thanks to the many filters it comes with, but the program has difficulties in some cases. A typical example is the loading scheme employed by The Edge, unintelligible to MakeTZX even in presence of correct timings in the INI file. In this case, it is necessary to convert the sampling with WAV2TZX and manually adjust the timings of the 'turbo' data blocks with Tapir.[15]

[15] The Author wishes to thank Andrew Barker for the information he personally provided in this regard.

WAV2TZX

Reworking made by Miguel Angel Rodriguez Jodar of the old *VOC2TZX* application, by Tomaz Kac and Martijn van der Heide, adapted to convert samples in WAV audio format into TZX files, instead of the now obsolete VOC format. It works from the command prompt and like MakeTZX includes a wide range of options and filters for a correct rendering of data from tape samples.

TAPER (SG SOFTWARE)

A Windows program by Sergey Gordeyev, which incorporates the functionality of a historical MS-DOS application of the same name. Manages and displays the content of TAP and TZX files, allowing to perform simple operations on blocks such as moving, adding, deleting and reordering. Block data can be displayed in multiple ways: byte, text, screen, etc. It imports and exports WAV audio recordings and records data from the cassette in real time for later conversion to TZX.

TAPIR

Like the previous application, this utility for Windows created by 'Mikie' takes its inspiration from the historical *Taper*. It is mainly used to create and manipulate TZX files: moving blocks, inserting new ones, modifying the timings of data blocks, inserting pauses between them, looking into BASIC programs, disassembling machine code blocks and more. It is a tool as powerful as it is simple to operate, very useful for the management of this file type. Tapir can also open TAP files and allow the user to work on them, but can only save them as TZX. It can convert TZX and TAP files into audio signals to send them to the audio input of a real Spectrum, or to a cassette adapter in the case of the +2/+2A, in order to load the data stored in them. Signals can also be saved as a WAV file.

MDR VIEW

Another utility by 'Mikie', similar in concept to Tapir but for MDR Microdrive cartridge image files. Shows the map and contents of the virtual cartridge's sectors; these can be saved as raw data or TAP file.

ZX-BLOCKEDITOR

Another program from Claus Jahn's ZX-Modules suite: it is used to open and/or edit many different file types. In reading and writing, ZX-Blockeditor is compatible with:

- tape image file formats (BLK, CSW, PZX, TAP, TZX);
- +3 and CP/M disk images (DSK);
- TR-DOS disk images and data files ($B, $C, $D, SCL, TRD);
- DISCiPLE/Plus D disk images (IMG, MGT);
- SNA snapshots;
- BASin files, both BASIC (BAS) and machine code (BSC);
- video memory files (SCR);
- SevenuP video image files (SEV);
- large fonts created with ZX-Editor (CHX);
- ZXB data files, a format specific to ZX-Blockeditor.

As read-only, it opens:

- Warajevo tape image files (TAP, TAPW);
- BASin data files (BSD);

- snapshot files (ACH, PRG, RAW, SEM, SIT, SLT, SNP, SNX, SP, SZX, Z80, ZX);
- ZX Microdrive cartridge images (MDR);
- character set files (CHR, CH4, CH6, CH8); text files (ASC, TXT, ZED, ZIB, ZXE);
- raster image files (BMP, GIF, JPG, JPEG, PNG, ZXP);
- POK files;
- several compressed file formats.

For each open file, the program shows the internal structure, identifying data types with different icons and showing the specific blocks of the file type. These can then be shown in an ‘exploded’ view, i.e. divided into several sub-blocks, each one concerning a particular area of the main block: video memory, BASIC program and so on. Many operations can be performed on blocks: rearrangement, starting address modification, conversion of tape headers to disk headers and vice versa, etc. BASIC programs and variables can be edited directly from within ZX-Blockeditor by sending them to ZX-Editor, while video image blocks can be sent to ZX-Paintbrush, provided that these two utilities are also installed on the current system.

ZX-EXPLORER

This utility from Claus Jahn’s ZX-Modules suite is similar to Windows resource manager, but is specifically aimed at Spectrum emulators files. Features in detail are:

- browsing through all storage devices;
- information updated in real time during the exploration;
- displays the contents of compressed files;
- integration with the *World Of Spectrum* online database through a special, periodically updated DAT file and the

ability to download all files already known to the program, if absent from the archive of the same site;
- integration with ZX-Blockeditor and ZX-Preview;
- option to view files as thumbnail preview images;
- possibility to rename (even in batch, on the basis of the relative information), delete, copy or move files.

ZX-FAVOURITES

A program to archive files for Spectrum emulators, heir to the old SGD (Spectrum Game Database) for MS-DOS, whose development ceased in 2001. It is part of Claus Jahn's ZX-Modules suite and is a reworking of the database included in his previous *ZX-Rainbow* project. In addition to organizing files in fields and records like any database, ZX-Favourites allows to open them with an associated emulator or in the file editing program of the same suite, ZX-Editor. It can also import data saved by ZX-Rainbow, SGD and other similar but no longer updated applications, such as *SpecBase* or the one included with the Warajevo emulator.

ZX-PREVIEW

The last utility in Claus Jahn's ZX-Modules suite discussed here, ZX-Preview provides the user with a preview of the contents of data blocks in files used with emulators: video memory, ASCII text, system variables and more. It can be used alone or in combination with ZX-Blockeditor and ZX-Explorer, with which files can be opened and blocks explored. Binary data can be shown as bytes or machine code in ASM format, while video images in different sizes and formats. In this regard, ZX-Preview can also open images in 8×1 and ULAplus modes.

FUSE UTILITIES

A program suite created by Philip Kendall. It was originally distributed with his own FUSE emulator, but he later made them available as a stand-alone package. It is made up of:

- *audio2tape:* converts an audio file into a tape format;
- *createhdf:* creates a blank IDE hard disk image in HDF format;
- *fmfconv:* converts FMF format movie files, native to FUSE, into other formats;
- *listbasic:* extracts the BASIC program from a snapshot or tape image file and saves it to a text file;
- *profile2map:* converts Fuse profiler output into Z80-style map format;
- *raw2hdf:* creates an HDF hard disk image from a raw data file;
- *rzxcheck:* verifies the 'competition mode' signature in an RZX input recording file;
- *rzxdump:* displays the input recordings stored in an RZX file;
- *rzxtool:* adds, extracts or removes the memory snapshot included in an RZX file, or compresses/decompresses the file;
- *scl2trd:* converts TR-DOS SCL disk image files into TRD ones;
- *snap2tzx:* converts a snapshot into a TZX tape image file;
- *snapconv:* converts between various snapshot formats;
- *snapdump:* describes the machine status and the attached peripherals stored in a snapshot.;
- *tape2pulses:* dumps the pulse information from tape images to text files;
- *tape2wav:* converts a tape image file into a WAV audio

recording file;

- *tapeconv:* converts between TZX and TAP tape image files;
- *tzxlist:* outputs a description of the contents of TZX, TAP (classic or Warajevo) or PZX tape image files.

WINTZX

The primary purpose of this application made by Patrick Delvenne is to convert CSW (audio), TAP and TZX tape image files, MDR Microdrive cartridge image files or BIN binary data files into CSW, VOC, WAV or MP3 audio files, or to obtain from them the audio signal to send to the Spectrum's EAR input, as if it were a virtual recorder. Audio in MP3 format can also be received from a multimedia player connected to the Spectrum.

WinTZX includes an 'expert mode', humorously indicated by the famous portrait of Albert Einstein showing his tongue, where the user can take a more precise control over the conversion process, for example by selecting the type of audio file to write and the use of the CSW scheme. The program can perform the same operations with tape image files for Commodore 64 and Amstrad CPC emulators.

Z802TZX

Windows command prompt utility to convert Z80 and SNA snapshots into TZX files. Written by Tomaz Kac, it has several options, including transfer speed, ranging from 1,500 bits per second as the Spectrum ROM loading routine, to 2,250, 3,000 and 6,000, even if the latter, in practical terms, is too high to be actually useful.

SNAPTOTAP

An application by Arda Erdikmen that converts SNA or Z80 snapshots into TAP or MDR files or BIN plain binary data format. It consists of a window where to drag the file, then the saving format has to be chosen. TZX files are saved with the standard ROM scheme. It cannot convert 128 KB SNA files.

DAMTAPE

A program created by Andrea Giannotti to save data blocks from damaged tapes sampled as 44,100 Hz mono WAV files. It automatically recovers the BASIC program chunks contained in intact parts of the medium between interruptions due to damage, and generates text files containing listings and the related TAP files. It also creates binary files storing the contents of the variable area and video memory, as well as machine code, data arrays, custom character sets, etc. It is then up to the user to reconstruct the pattern of the program blocks, if necessary. DAMTAPE only works with data recorded with the common ROM loading scheme.

MDR2TAP

Converts MDR files into TAP files. Designed by Andrea Giannotti, with an option to convert LOAD commands from the Microdrive syntax to that used for tapes.

FDRAWCMD.SYS

It is not exactly an application, but it is very useful anyway. FDRAWCMD.SYS is a driver for Windows, the work of Simon Owen, to enable an internal PC floppy disk drive to read disks formatted with different systems, as well as to create an image file of them. It recognizes 'weak' or intentionally wrong sectors for copy protection purposes.

Being a driver, FDRAWCMD.SYS must not be used alone, but in conjunction with a program capable of carrying out the operations for which it is necessary. Among the applications that use it, there are RealSpectrum and SAMdisk. It does not work with external USB floppy drives, as these devices contain a separate floppy controller chip, which is not directly accessible from the host PC. Without direct hardware access, it is not possible to support formats beyond those the external drive can read, typically 720 KB and 1.44 MB DOS formats only.

SAMDISK

A program by Simon Owen to read from and write to real floppy disks compatible with a standard PC floppy disk drive controller. It creates disk image files from real floppy disks and vice versa, as well as HDF hard disk images from real disks or Compact Flash/SD memory cards and vice versa. In all cases, there are multiple options for creating images, referring to the capacity and internal structure of the disks, 'weak' sectors present in floppy disks as a copy protection measure, the number of cylinders of the hard disks and so on. Created files can be read under DivIDE/DivMMC emulation.

HDFMONKEY/HDFGOOEY

HDFMonkey is a command line program, the work of Matthew Westcott ('Gasman') used to manipulate HDF files, hard disk or memory card images. It was initially released for Linux only; another developer known as 'Uto' made a

Windows version. Possible uses include: creating or cloning disk images, creating or deleting folders within them, inserting external files or extracting them from the images and so on.

HDFGooey is a graphical user interface for Windows, created by David Saphier ('em00k') to simplify the usage of HDFMonkey, allowing to take advantage of all its features in a more immediate way.

SPXFR

Utility designed by Davide Guida to transfer data from the memory of a Spectrum with ZX Interface 1 to the PC and vice versa at the maximum speed of 19,200 bits per second. To work, it needs a do-it-yourself cable for connecting the Interface 1 to the PC. The cable consists of six conductors to be soldered to a 9-pin female RS232 connector on one side, and a male analog on the other; the author gives all the required information for this purpose. All data transferred from the Spectrum can be converted to single-block TAP, TZX or SCR (in the case of video memory) files on the PC.

ZX TAPE PLAYER

An application by Andriy Somak for Android and iOS smartphones to use such devices as virtual recorders to connect to the audio input of a Spectrum. It reads TZX or TAP files and identifies them by connecting itself to the open source ZXInfo database.

EMULATION ON THE SPECTRUM

TIME GAL

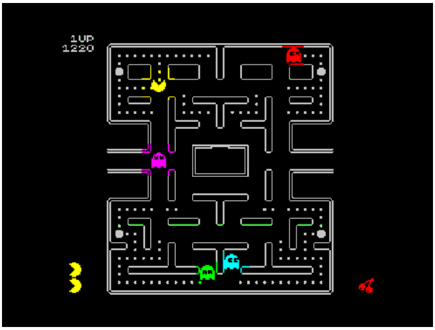
In the year 4001, time travel is already a reality: a machine prototype was built for this purpose. Unfortunately, a criminal named Luda takes possession of it to change history and try to establish his dominion on the Earth. Special Agent Reika Kirishima pursues Luda through sixteen levels, each one corresponding to a different era, starting from prehistory, in order to defeat him and recover the stolen machine. This is the plot of *Time Gal,* a coin-op of the 'laser game' genre produced by Taito in 1985. Its animations were made by Toei Animation studios, responsible for famous 'anime' series such as *Tiger Mask, Ufo Robot Grendizer, Mazinger Z, Devilman, Captain Harlock, Galaxy Express 999, Steel Jeeg, Dr. Slump, Fist of the North Star, Candy Candy, Sailor Moon* and many others.

Time Gal was converted for the Sega CD and Sony PlayStation in 1993. The latter version was the basis upon which Dmitry Mikhailovich Bystrov ('Alone Coder'), Aleksandr Sergeyevich Semyonov ('Shiru') and Maksim Anatolyevich Timonin ('Maksagor'), in January 2006, began working at a conversion for the Pentagon and ATM Turbo 2 Spectrum clones. The game uses the 16col mode designed by Bystrov, which, not being planar like standard EGA, recreates colours through a dithering technique. The game window is 224×160 pixels, surrounded by a black border where the indications of the controls to select in order to negotiate the current scene appear. Video update is not complete, but only affects certain areas of the screen at a time, which causes a certain flickering effect. The Pentagon version is silent, while the ATM Turbo 2 one has 8-bit mono audio sampled from the original.

Despite the inevitable limitations, this ‘unofficial’ conversion of *Time Gal* is an extraordinary example of the results that a hardware architecture derived from that of the Spectrum can be pushed to.

Screenshots from* Time Gal, *emulated through UnrealSpeccy

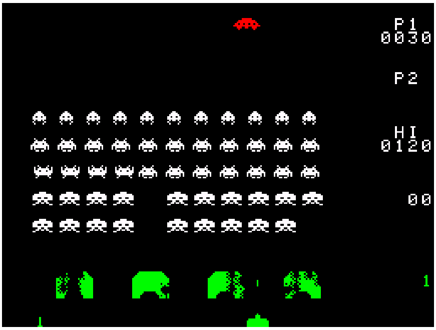
PAC-MAN EMULATOR



Developed by Simon Owen in November 2011, *Pac-Man Emulator* emulates the videogame *par excellence, Pac-Man,* on the Spectrum +2A/+3, employing the original title's ROM dumps normally used by the MAME emulator. Of course, Owen does not distribute the four ROM image files of the coin-op –*pacman.6e, pacman.6f, pacman.6h* and *pacman.6j* – required for this purpose, but only the raw code of the emulator to be placed in a folder and assembled together with the ROMs by means of an included batch file. This can be performed under Windows, macOS and Linux: the result is a TAP file to load on a real Spectrum or in an emulator. *Pac-Man* can then be viewed in colour or black and white. Pressing the H key at game start sets the difficulty level to 'hard'. The emulator works only on the Spectrum models mentioned above, because it uses a peculiar memory configuration only available on them: paging of RAM at address 0 (0000h) and of video memory used by banks 5 and 7 at address 16384 (4000h). Be that as it may, experiencing such a piece of gaming history on a Spectrum is a true impact.

Mark Woodmass's *SpecEmu* emulator includes Owen's one. *Pac-Man* can be launched if the relevant ROM files are present in the *pacman\roms* folder of *SpecEmu.*

SPACE INVADERS ARCADE EMULATOR



A developer known as '4OCrisis' took inspiration from Simon Owen's *Pac-Man* emulator to create a similar project, dedicated to another videogaming milestone: *Space Invaders*. The result is also in this case amazing. For the usual copyright reasons, 4OCrisis only provides the programs needed to create a TAP file to upload to the Spectrum, without including the four Taito coin-op ROM image files: *invaders.h*, *invaders.g*, *invaders.f* and *invaders.e*. Just like *Pac-Man Emulator*, the program runs on the Spectrum +2A/+3 due to the memory configuration required by its code and only available on these models. Indeed, the Spectrum 128 and +2 can make it run by loading it from a DivMMC interface, because the device's internal RAM can load machine code at addresses 0 and 16384 (0000h and 4000h), thus imitating the memory configuration of the +2A/+3.

ZXZVM

In text adventure enthusiasts, the name Infocom alone stirs a sense of admiration resulting in reverence. From the fantasy *Zork* and *Enchanter* series to the Lovecraft-styled atmospheres of *The Lurking Horror*, from the circus misadventures of

Ballyhoo to the Kafkaesque ones of *Bureaucracy*, passing through a successful license such as *The Hitchhiker's Guide To The Galaxy* (which Douglas Adams himself collaborated with) or the 'risque farce' of *Leather Goddessess of Phobos,* Infocom games were, for most of the 1980s, the 'state of the art' of text adventures. Their witty and ingenious style was characterized by neither mundane nor predictable puzzles, not infrequently requiring a good dose of 'lateral thinking' and well integrated into the context of game world locations, described in an often detailed and evocative way.

Founded on 22 June 1979 by Dave Lebling together with a small group of students and workers from the well-known MIT (Massachusetts Institute of Technology), Infocom made itself known in the fledgling computer gaming scene with its first work, *Zork.* This text adventure, which today would be called a 'dungeon crawl', was planned the previous year by a team also led by Lebling. In 1980 it was adapted for various platforms, to which others would be added over the years, through a special programming language, *ZIL (Zork Implementation Language),* otherwise known as *Z-Code,* conceived for a standard 'virtual machine', the *Z-Machine:* a custom interpreter for each platform, in fact a sort of specialized emulator.

This scheme allowed Infocom to release its titles in many versions, either simultaneously or converting them as new home computers appeared on the market. Recurring platforms were the Apple II, Atari 8-bit and ST, Commodore 64 and Amiga, Tandy TRS-80, IBM PC and compatibles, as well as machines equipped with the popular CP/M operating system designed by Gary Kildall in 1974, for example the Amstrad CPC and PCW series, but not the ZX Spectrum. Infocom was an American software house, and given the short and not very incisive presence of the Spectrum on the US market, characterized by the unfortunate Timex Sinclair TS 2068 clone, it never made a specific Z-Machine interpreter for that platform. However, given the popularity of its games even among users of Clive Sinclair's best known and most popular product, there were several attempts to make up for this lack.

The first known appeared in issue 37 (January 1989) of the British magazine *Your Sinclair*. The text adventure expert Mike Gerrard announced that through the CP/M Plus operating system launched a few months earlier by Locomotive Software for the +3 – that already came with native support for CP/M – it was possible to run on the Sinclair machine the CP/M version of the Z-Machine recorded on the peculiar 3" floppy disks typical of Amstrad CPC and PCW systems, as well as of the +3 itself. It goes without saying that this method would still be valid today, having not only a +3 in good and working condition available, but also the CPC/PCW floppy disks of the Infocom games, as well as a copy of CP/M Plus, which is still for sale by Locomotive, nowadays Locoscript.

It is easier to employ a Z-Machine interpreter specifically designed for the Spectrum, able to run on the +3 as well as on the other versions of the Sinclair computer, provided they are fitted with a modern DivIDE interface with Garry Lancaster's ResiDOS operating system installed on. This interpreter is called *ZXZVM (ZX Zork Virtual Machine),* was developed by John Elliott and integrated by Lancaster. ZXZVM creates a 'virtual machine' on the Spectrum, capable of running Z-Machine version 3, 4, 5 and 8 text adventures. There are a few limitations: in particular, the impossibility, due to the insufficient amount of RAM, to implement the UNDO command. SAVE and RESTORE are available instead. Versions are recognized by the extension of the original 'story' file, containing the program data: for example, a file with the

Z5 extension must be opened by Z-Machine 5. The most recent version of ZXZVM is 1.12 of 15 May 2016.

Upon loading, ZXZVM copies itself to the game disk, or to the disk image if playing under emulation or through a DivIDE, together with the graphic font file used. In fact, every time the ZXZVM.BAS boot file is loaded from the computer's start-up menu, it may be chosen whether to display 32 or 64 characters per line on the screen. The second mode is a little less easy to read on the Spectrum's 256×192 display, but indispensable for some titles like *Beyond Zork*.

With ZXZVM, the following titles can be played: *Ballyhoo, Beyond Zork, Border Zone, Bureaucracy, Cutthroats, Deadline, Delusions, Enchanter, The Hitchhiker's Guide To The Galaxy, Hollywood Hijinx, Infidel, Leather Goddesses of Phobos, The Lurking Horror, A Mind Forever Voyaging, Moonmist, Nord and Bert Couldn't Make Head or Tail of It, Planetfall, Plundered Hearts, Seastalker, Sherlock The Riddle of the Crown Jewels, Sorcerer, Spellbreaker, Starcross, Stationfall, Suspect, Suspended, Trinity, Wishbringer, The Witness, Zork, Zork II, Zork III, Zork The Undiscovered Underground.* The latter was not made by Infocom, but was written by Marc Blank and Michael Berlyn and launched for promotional purposes by Activision, which currently owns the rights to Infocom games, on the occasion of the release of *Zork Grand Inquisitor* in 1997. Being a text-only interpreter, ZXZVM cannot be used to play the three graphic adventures released by Infocom in the last part of its history: *Arthur The Quest For Excalibur, James Clavell's Shogun, Journey.*

To transfer Z-Code format files to a +3 disk image, CPCFS v.0.9.0, an utility by Derik van Zuetphen and Kevin Thacker, is required. It also works from the Windows command prompt, by clicking on the *CPCXFSW.EXE* file once the ZIP archive has been decompressed. In a couple of steps, a new DSK disk image file is created, wherein to store the Z-Code ‘story’ file for use with ZXZVM, as long as the file’s version is readable by the interpreter.

In order to employ a DivIDE or similar interface, equipped with the ResiDOS operating system, the ‘story’ file and the ZXZVM.TAP tape image file must be copied onto the Compact Flash or SD card used by the interface. The boot program it contains will then be loaded to launch the Z-Code interpreter. For ESXDOS users, Bob Fossil inserted the ZXZVM code into a ‘dot’ command, so it is enough to copy the files to the BIN folder of the memory card and type *.zxzvm* followed by the name of the ‘story’ file, possibly preceded by *-c1* or *-c2* to choose 32 or 64 characters per line respectively.

OTHER EMULATION ON THE SPECTRUM

Paul Farrow wrote a ZX80 and a ZX81 emulator for use in the ResiDOS environment. Both require 128 KB RAM, since the screen area is used for program data and therefore the additional video memory available from the Spectrum 128 and later is required. Snapshot files can be either loaded or saved on memory card or disk. He also wrote an emulator of the Jupiter Ace for the Timex Sinclair TS 2068 and Timex Computer TC 2068 Spectrum clones.

Simply called *ZX81,* the emulator of the Spectrum’s predecessor is the work of Claus Jahn and runs on a normal 48K/+. It runs at about 40% of the speed of the original machine and requires the conversion of P-specific tape image files to TAP through a special *XTEN2TAP* utility supplied with the emulator.

Thomas Goering converted for the 48K Spectrum the Apple I emulator written by Simon Owen for the SAM Coupé.

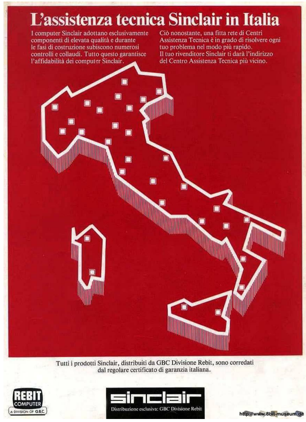
Simon Owen developed, initially for the SAM Coupé, and later for the Spectrum, a Commodore VIC-20 emulator with basic RAM, plus an additional 3 KB expansion and 4-channel sound emulation. The result is very slow – about 1/10 the speed of the VIC-20 – and made approximate by the imperfect correspondence of the Commodore computer's colour palette with that of the Spectrum and the limitations of the AY-3-8912 sound chip regarding the generation of noise. Moreover, the program requires, for the same reason already seen in coin-op emulators, the specific memory configuration of the +2A/+3. Such limitations are found in another VIC-20 emulator, developed by James Smith, except that it can run (without sound) even on a 48K and use the +2A/+3's additional memory to emulate 8 and 16 KB game cartridges.

Slovenian developer Tomaz Kac ('Tom-Cat') programmed an emulator of the Galaksija, a computer based on a Z80 CPU designed in Yugoslavia by Voja Antonić in 1983. It requires the memory configuration of the +2A/+3, too.

Johan Koelman made an emulator of the ZX81 and one of the Philips Videopac, another name of the Magnavox Odyssey 2 videogame console. They both run on the 48K Spectrum.

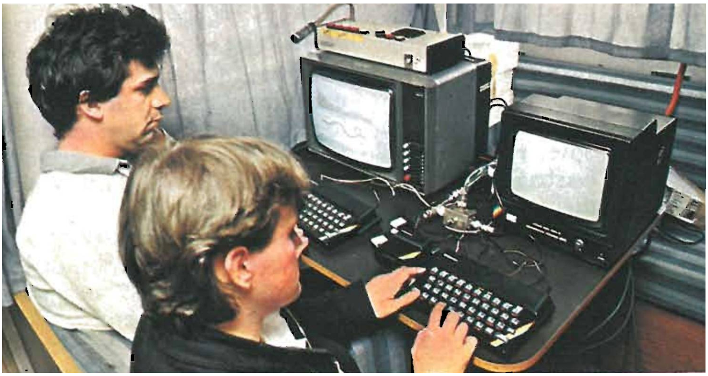
Chapter Three
THE SPECTRUM IN ITALY

HISTORICAL OVERVIEW



The ZX Spectrum debuted in Italy at the end of March 1983, imported by a subsidiary of GBC Italiana S.p.A., Rebit Computer S.r.l., which took care of distribution as well as technical assistance. The first retail prices were ITL 360,000 for the 16K and ITL 495,000 for the 48K, not including 18% VAT. After exactly one year they dropped to ITL 339,000 and ITL 423,000 respectively, again not including VAT. These were rather high figures for average Italian salaries of that time. However, this was a common case with electronic goods of foreign production, subject to considerable import duties. Anyway, even in Italy the Spectrum could play the lower price card, because, although its cost was not as low as in its country of origin, it was still less than that of its competitors.

For about two years, the Spectrum maintained a leading position on the Italian market. This was mainly due to the absence of competitors that could boast a comparable price-performance ratio and software availability. As in other countries, in Italy the Spectrum was considered a home computer for the most demanding amateur users, that is, not just for entertainment – although video games played a not insignificant role in encouraging its diffusion there as well – but also to learn BASIC and the fundamentals of computer science, keep the household accounts, catalogue data or carry out rather unusual tasks. As an example of the more peculiar situations in which the Spectrum was used in the country, it would be enough to mention the two 48Ks connected in a local network through the ZX Interface 1, that RAI (Italian State TV and radio) employed with the mobile station following the 67th Giro d'Italia in 1984. Their use was the result of an agreement between RAI and GBC Italiana: the two machines produced graphics for the broadcast daily sent on RAI 2 after the end of each stage, with the general and mountain classifications, biographical and sports data of athletes and other statistical curiosities. For the record, the following year the same task was assigned to a QL.



The two 48K Spectrums employed by RAI's mobile station to produce graphics for broadcasts from the 67th Giro d'Italia (from* Sperimentare*, July-August 1984)

It was therefore no coincidence that the slogan the Spectrum was advertised in Italy with was *ZX Spectrum. Un vero computer* ('ZX Spectrum. A real computer'), just to underline its distance from machines perceived at best as consoles with keyboards, at worst as decorative items with no real use due to an endemic lack of programs to run. The Spectrum's popularity in Italy in the first half of the 1980s meant that companies manufacturing and distributing peripherals for that computer were established in the country as well. The main ones were Sandy and Tenkolek, while it was not until 1985 that the first videogame entirely made in Italy and released as a stand-alone product appeared: *Camel Trophy Game.* Publishing houses such as JCE (Jacopo Castelfranchi Editore) or Gruppo Editoriale Jackson, founded by Paolo Reina and Giampietro Zanga, two former employees of JCE, printed books and magazines on whose pages the Spectrum was one of the absolute protagonists, employed for such tasks as studying programming languages, graphics or trigonometry, trying one's luck with the *Totocalcio* or *Totip* pools or designing solar power systems. The catalogues of these and other publishers unambiguously show that in Italy at the time the publishing offer for the Spectrum far exceeded that for every other home computer.

The initial success of the Spectrum in Italy was therefore such that at the end of 1984 a Sinclair branch was founded in the country, *Sinclair Italiana S.p.A.,* headed by Vincenzo Garlaschelli. In a note entitled *Cari Sinclairisti* ('Dear Sinclairists'), appeared on the *Sinclair Computer* magazine, issue 11 of February-March 1985 at page 56, Garlaschelli explained what the objectives of the newborn company would be:

- organize new clubs of Sinclairists for the QL and collaborate with existing ones, through program exchanges and software updates;
- follow a new development philosophy for application software, in order to create a generation of programs that would allow the affirmation of the Sinclair standard;
- publish programs and documentation, both software and hardware, in Italian;
- make available to everyone not only computers and software, but also peripheral units: monitors, floppy disks, hard disks, modems etc.;
- create a network of technical assistance centres throughout the national territory at standard costs;
- pay particular attention to applications in the telematics sector.

It seemed, then, that the Spectrum was bound to consolidate the good success gained with the Italian public. Things began to change from that same year instead. The Commodore 64, after a slow start in Italy, also due to the significantly high initial prices, gradually established itself as the dominant machine on the local 8-bit computer market, until the tables were turned in the second half of the 1980s and the C64 snatched the primacy from the Spectrum.

There are several reasons for this fact. First of all, while the Sinclair distribution chain in Italy was for a long time entrusted to a subsidiary of GBC, a company that produced and sold electronic goods of various kinds, Commodore had the foresight to establish from the beginning its direct subsidiary in the country, Commodore Italiana S.p.A. This allowed a more widespread distribution of its products in the area, better customer service and above all an insistent advertising campaign in both the press and television, which reached its peak between 1985 and 1986.

Spectrum programs became more and more difficult to find, even in medium-large cities, so that the peculiar Italian 'tape magazine' kind of piracy caught on. Needless to say, as elsewhere, the popularity of the C64 in Italy was eminently due to videogaming, given that, compared to the Spectrum, the presence of application, management or educational software for that machine, as well as books or magazines not focused on gaming, was in much smaller proportion.

The crisis of Sinclair Research and the subsequent acquisition of the rights to its computers by Amstrad dealt another blow to the status of the Spectrum in Italy. Amstrad was known in the country mainly for hi-fi systems manufactured in East Asia and rebranded; the CPC range was much less popular. This meant that after the the withdrawal of Sinclair Research from the home computer market and the handover from Sinclair Italiana S.p.A. to Amstrad Italia S.p.A., models from the Spectrum +2 onwards had little luck in Italy and were mostly limited to Action Packs for the +2A. Commodore, on the other hand, did not suffer from any of the problems that led to the crisis of Sinclair Research. This allowed it not only to keep its dominant position in Italy, but also to prepare a very favourable ground there for the launch of its new computer, the Amiga, that, starting from 1987-1988, repeated the success obtained by the C64 two years earlier.

It is true that the C64 began its decline in that same period, because an ever-increasing number of its users switched to the Amiga, which explains the relatively modest success of the Atari ST in Italy, the irony being that the ST derived from a project carried out independently by Jack Tramiel, the creator of the C64, after leaving Commodore in January 1984. Spectrum users, on the other hand, remained mostly loyal to their computer even when moving to a superior system, allowing it to remain at least a 'second force' in the 8-bit range behind the C64 in Italy, until its definitive exit from the scene in 1993.

Even in Italy, therefore, there is still a community of Spectrum enthusiasts who make a significant contribution to the international Sinclair retrocomputing scene. Suffice it to recall that two of the most important historical emulators, the ZX Spectrum Emulator and RealSpectrum, are the work of Italian authors.

HARDWARE

SANDY

The company was based in Senago (Milan) in Via Monte Rosa 22 and was known to Spectrum users, first of all, for its floppy disk drive, released in 1984 in a first version and subsequently in a revision called FDD2. It came with an interface and internal SP-DOS operating system, very similar to TR-DOS. The drive was available in three versions of 100, 200 and 400 KB for the type that used 5” ¼ disks and two of 200 and 400 KB, for the 3” ½ type. The drive is connected to the Spectrum expansion port by means of the interface, in turn connected to the drive by a flat cable. On the back of the drive there are connections for the 3.5 tape recorder plugs and the ZX Interface 1. The drive is compatible with both 16K and 48K Spectrums. Disks formatted with both types have 40 tracks of 256 bytes each. When turning on the Spectrum after connecting the drive, the SP-DOS prompt appears, marked by the message:

```
* SP-DOS Ver. 1.0 *

© 1984 SANDY PERSONAL PRODUCT.

MILANO ITALY.
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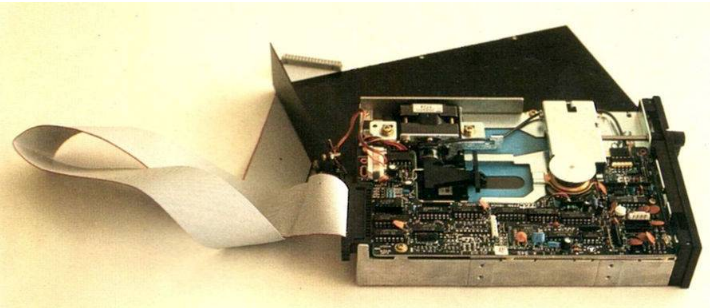
A disk access password is then requested, to be set at the time of formatting, without which it is not possible to access the data contained therein. Version 2 is also equipped with a disk containing a demonstration program that clearly displays the characteristics of the system, a disk copier, a file copier, the FORMAT program and a word processor.

Commands of version 1 are mostly autonomous: PUT and GET to modify and read the contents of memory locations (in hexadecimal format), ERA to erase, BAS to return to Sinclair BASIC and so on. In version 2, on the other hand, a syntax almost analogous to that for tapes and Microdrives is used. The CAT command accesses the catalogue of files stored on the disk, displayed in two columns with the letter B, C or D to the left of each one, corresponding to BASIC programs, machine code or data arrays respectively, as in TR-DOS. Then SAVE, LOAD and RUN to save, load and run BASIC or machine code programs; NEW to rename files; MOVE to move them; POKE and PEEK instead of PUT and GET respectively; RETURN to return to BASIC. In any case, the unit's operating system can be accessed by entering RANDOMIZE USR 15000 for a 'cold' start, that is from the command prompt, while the 'hot' start from the BASIC program, without directly entering the DOS, is achieved with RANDOMIZE USR 15363.

Regarding the speed of the unit, a review appeared in the *Sperimentare* magazine of 7 August 1985 attests that a program the size of *Jet Set Willy* was loaded in less than 10 seconds and a screen file in about 3.



The Sandy system for the use of floppy disks with the Spectrum was further enriched with a third version, developed in collaboration with Kempston Microelectronics Ltd – thus it was called Sandy Kempston – and supplied with:

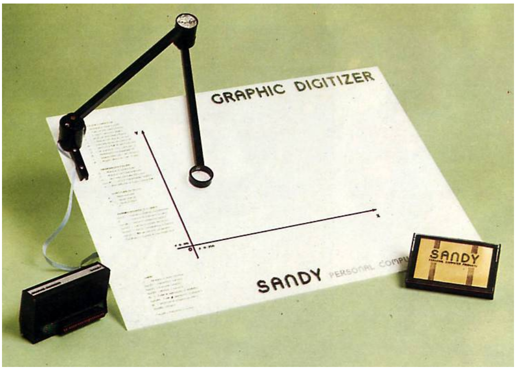
- a Kempston floppy drive interface;
- a 1 MB Sandy floppy disk drive with 56-pin pass-through connector for an additional drive;
- two Sandy printer interfaces, one serial RS232 TTL and one parallel Centronics;
- a programmable Kempston joystick interface;
- an RCA connector for monitors.

The drive uses standard 3" ½ disks with a nominal capacity of 1 MB and real, after formatting, of 800 KB, on two sides for a total of 80 tracks. The transfer rate is 250 Kbit per second, while that of LOAD and SAVE is 15 bytes per second. In this version too, the interface's ROM includes the SP-DOS operating system, but unlike the previous one, the utilities, including an application for tape-to-disk copy, are also part of the firmware. The syntax has remained almost unchanged, but the maximum amount of drives that can be connected at the same time is now four compared to three in version 2. The drive is self-powered and can be used for other platforms such as the QL, MSX and Amstrad as well.

Prices were high, for which reason the diffusion of Sandy interfaces remained limited. A version 2 disk interface for the Spectrum initially costed ITL 610,000 excluding 18% VAT, while the Sandy Kempston was offered at a relatively lower price, when taking the included accessories into account: ITL 622,000 including VAT. The RS232, Centronics and Kempston interfaces of the Sandy Kempston package could be purchased separately at the prices, respectively, of ITL 90,000 (later dropped to 55,000), 120,000 (later dropped to 115,000) and 69,000, again excluding VAT.

Other products of the Sandy range aimed at the Spectrum were (prices in ITL excluding VAT):

- a professional keyboard with numeric keypad and housing for the power supply and any interfaces, compatible with the ZX81 as well (above, 140,000);



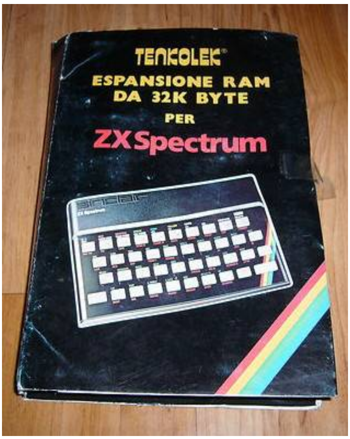
- a graphic digitizer tablet (above, 165,000);
- the Superface, a speech synthesis interface with sound generator, sound amplifier, joystick interface and recorder (145,000);
- an EPROM 2716/2732/2764/27128 chip programmer, complete with software (270,000);
- a modem (155,000);

- a 32 KB RAM expansion kit for the 16K Spectrum (75,000);
- a joystick (23,000).

In addition, Sandy distributed the Mannesmann Tally MT80 dot matrix printer with 80 columns and 80 characters per second, complete with interface for the Spectrum or QL, priced at ITL 660,000 excluding VAT.

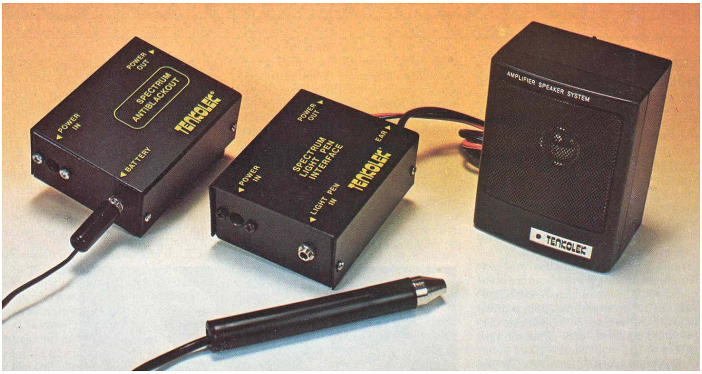
Sandy folded in 1987, after the failure of the attempt to create the Futura, a computer conceived as an evolution of the QL. The project was led by Tony Tebby, one of the 'fathers' of the QL, and involved both Sandy and its British subsidiary, Sandy UK. Some remaining components of the Futura were found in 2010 by Urs König thanks to Giuseppe Rizza, former technician of the Milanese company, and Bruno Grampa.

TENKOLEK



Tenkolek was a division of Exelco, a company that distributed accessories and parts for computers and other electronic devices. In the 1980s, its headquarters were in Cusano Milanino, in the province of Milan, Via Giuseppe Verdi 23/25.

Tenkolek produced several peripherals for the Spectrum, as well as a 32 KB IC kit to expand the 16K's RAM (above), sold at ITL 110,000 including VAT, later dropped to 69,000.

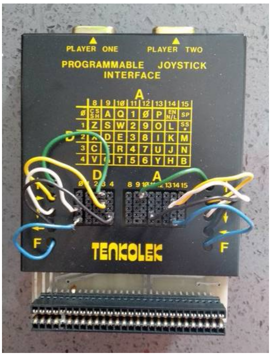


Tenkolek peripherals. Left to right: anti-blackout, light pen, sound box.

The first Tenkolek peripheral to mention is a uninterruptible power supply with an anti-blackout function. It acoustically signaled the interruption of the mains current and was specifically designed for the Spectrum, while being however adaptable to various other machines. It costed ITL 31,000 including VAT.

Tenkolek offered a light pen too, coming with an interface with a potentiometer to adjust its sensitivity and a management program with 16 options for drawing straight lines, curves, polygons and other shapes on the screen. The interface is placed between the pen and the Spectrum – it is connected to the computer's EAR output. The pen consists of an amplified photocell that sends the video refresh signal to the Spectrum, while the program projects a horizontal line in BRIGHT 1 on the screen when a key is pressed. The crossing between the pen and the line produces a change of state in the phototransistor of the pen, thus causing current variation. The software detects this variation, as it does when it 'hears' the sound of a recorded tape, and behaves accordingly, placing a black reference square on the screen in order to identify the coordinates where the screen is being drawn on. The system, similar to that found in other light pens and videogame guns like the Magnum, was somewhat cumbersome and produced acceptable results only if the brightness of the TV and the sensitivity of the device were optimally adjusted. The price was ITL 44,900 including VAT.

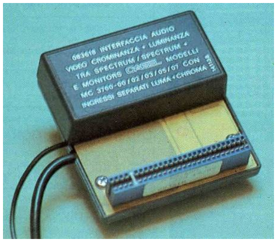
A third peripheral was a ‘sound box’, a simple loudspeaker, self-powered by three 1.5V AA batteries, that amplified the sounds coming from the Spectrum, even during tape loading. It was sold for ITL 24,900 including VAT.



Other Tenkolek products were: the Tape Interface, to switch between the EAR and MIC line according to the need (loading or saving), for those old recorders that while saving redirected to the loudspeaker, and therefore to the EAR sound output of the Spectrum, the amplified signal; a programmable joystick interface, initially offered at ITL 99,000 plus VAT, later dropped to 49,000.

CABEL

Cabel Electronic was based in Curno, in the province of Bergamo, in Via Enrico Fermi 40, and mostly manufactured computer monitors. They could also be used with the Spectrum, by means of the model 083618 interface, to be inserted into the expansion port and the EAR socket, thus redirecting the audio output to the monitor’s speaker, if present. The interface had separate inputs for luminance and colour in order to obtain the highest possible image quality and was equipped with a through I/O connector on its back.

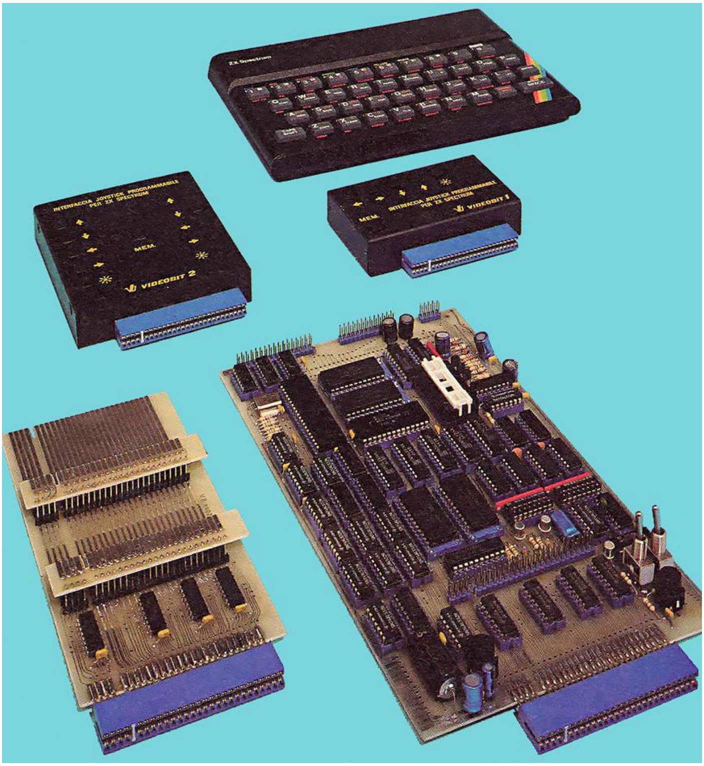


Specifically designed for use with Cabel monitors model MC 3700-00/02/03/05/07, it could in fact be combined with any monitor that provided a luminance/chrominance input. It was placed on the market at the end of 1985 at a price of ITL 33,000 including VAT.

VIDEOBIT

Headquartered in Via Console Marcello 18/5, Milan, Videobit was active in the mid-1980s and offered a series of peripherals for the Spectrum. The most important was the S 80 (left), a large interface with: floppy disk drive controller with 100 KB internal memory for one or two units; RS232 and Centronics ports; 2764-27128 EPROM programmer; 8 KB service RAM; 128 KB expansion with in-built graphics, word processing and management utilities; debugger; sound output amplifier; reset button. It was sold at ITL 390,000, or at ITL 890,000 in a bundle with a floppy disk drive, a small case and an external power supply unit. The S 80 did not use any of the computer's memory, since the internal operating system hosted in its own 56 KB shadow ROM took care of everything.

The Videobit price list also included a buffered motherboard for ITL 55,000, a single programmable joystick interface for ITL 70,000 and a double one for 90,000 (excluding VAT). In 1986 these prices dropped to ITL 30,000, 50,000 and 70,000 respectively.



Overall view of Videobit peripherals for the Spectrum. From top to bottom and left to right: double and single programmable joystick interfaces; buffered motherboard; S 80 expansion card.

DISCOVOGUE

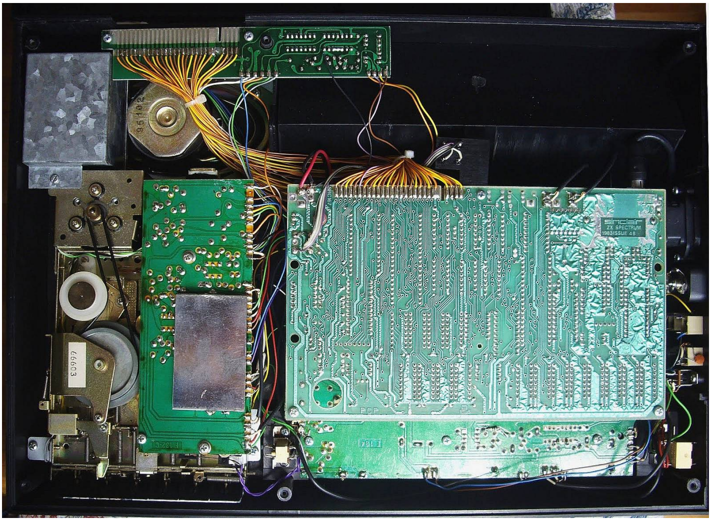
Based in Modena, Discovogue made the 102 DigiSaveLoad, a simple save/load switch for the 16/48/+ Spectrum, fitted with an internal sensor and LED operation indicators. It served as a bridge to the computer power supply as well. It costed ITL 53,000 already assembled and 39,000 as a do-it-yourself kit (prices including VAT).

AT COMPUTER SYSTEMS

The origin of this hardware modification of the 48K ZX Spectrum is not clear. It is known to have been distributed by the Encyclopedia Britannica in Italy around 1983. Its name Sinclair Spectrum Language IT/UK Learn Computer explains that it was intended for teaching English in Italian schools.

The Learn Computer is a set consisting of a 48K Spectrum (the unit in the photos has an Issue 4B motherboard), a cassette recorder integrated into the case, and a built-in power supply unit. Although it has an internal speaker, the system includes a connection for headphones, which allows the user to listen to language course tapes without disturbing other students in the class. An integrated container, divided into 18 slots and protected by a transparent cover, allows the 10 cassettes of the course, and more, to be housed, in order to listen to them through the recorder. Recording and playback volumes can be adjusted separately using the sliders located at the bottom, as well as teacher or classmate volume and tone.

The interior shows that the RF, EAR and MIC connectors, placed on the left side of the device, are connected to the motherboard with cables soldered on it. Similarly, the expansion port is connected to the outside by a set of cables soldered onto it and an additional board. The power supply unit is located between the recorder and the small expansion connector board (top left in the photo).



In addition, there are a composite video output, a reset button, a microphone jack, and a switch to mute the sound from the internal speaker when using headphones.

The keyboard (with the membrane) is that of the Spectrum without any modification. It sits directly on top of the case, and is internally connected to an intermediate board acting as a bridge with the motherboard.

The device includes, as said before, a 10-audio cassette English course: each cassette contains six lessons, three per side. Two tapes containing exercise programs were provided as well, and this could explain the role of the Spectrum in the whole picture. One of the sources of information[16] argues that the Spectrum might have served as a way to attract students too, since normally, at the end of the course, the student was allowed to keep the device.

The Learn Computer is a singular and extremely rare example of the use of the Spectrum in Italy: so far, the writer has been able to determine the existence of only two units, which suggests that it was manufactured in very small numbers.

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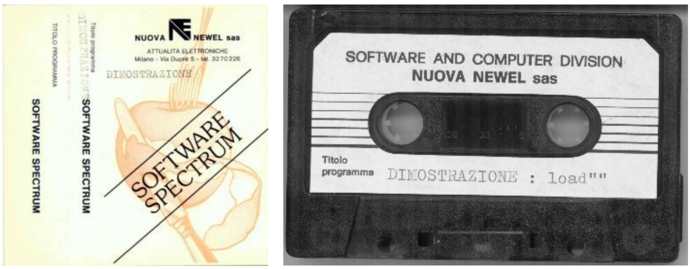
[16] The author wishes to thank José Antonio Ortigueira Amor and Salvatore Lasorella for information and photos related to the Learn Computer.

SOFTWARE

For a long time, the Italian productive landscape did not present autonomous software development companies with an importance comparable to those found, without going very far, in neighboring France, country of origin, to mention just one name, of the Ubisoft giant. This consideration is all the more true for the years in which the Spectrum was marketed. It is no use to look for an equivalent of Dinamic, Infogrames or Proxima in Italy: there is none to find. Even at the time when the Spectrum made a major impact in the country, the few existing developers were still employed by the two main information technology publishing houses, JCE and Jackson. Computer software was not seen as a product capable of producing wealth for itself, and it played a subordinate role to the traditional publishing market.

There is no doubt that the main cause of this situation was the colossal delay of Italy at the time in computer literacy, usually limited to those who had attended technological or industrial school and/or university studies. Computers were practically absent on the desks of middle and high schools, contrary to what happened in much of Europe, from Spain to the Soviet Union, albeit with different emphasis. In some fields, such as medicine, finance, commerce and services, things were better, but the use of computers mostly concerned office automation, a sector in which Italy could at that time boast a position of absolute importance thanks to Olivetti, one of the largest European manufacturers of computers and systems for business computing. Unfortunately, due to the serious crisis of Olivetti that took place between the second half of the 1990s and the beginning of the 2000s, Italy would have lost this primacy.

Another factor that made investors unwilling to finance activities related to the production of computer software was the widespread practice of piracy, favoured by the scarce attention paid to this phenomenon by law enforcement and by inadequate legislation, despite Italy's adherence to the Paris and Berne conventions for the protection of intellectual property and copyright, signed in 1971 and 1978 respectively. The market, already negatively affected by the difficult penetration of information technologies among the general public, was further penalized by the circulation of illegal software, an activity carried out in the open by many retailers scattered from North to South.

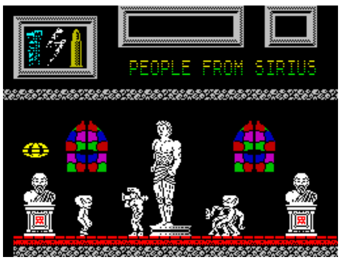


Inlay and cassette of Nuova Newel's 'Dimostrazione', actually an unauthorized translation of the* Horizons *tape.

Some of them, like Nuova Newel in Milan, sold independently pirated editions of games and applications for the Spectrum, characterized by a cassette inlay with a drawing of a peeled apple and the program title written with a typewriter. Among them, 'Formula 1', i.e. *Chequered Flag* by Psion, or *Pssst* by Ultimate, passed off as their own. Nuova Newel even went so far as to distribute an 'illegal' Italian translation of the *Horizons* demonstration cassette, with the title 'Dimostrazione', whose official Italian version only arrived in 1984 together with the Spectrum +.

It was therefore not surprising that, in such a situation, not only companies that imported and distributed original software in Italy faced a difficult task, but also those who tried to undertake an independent economic activity by making computer programs, on the model of foreign software houses. This is what John Holder, then owner of the Varese software distribution company Leader, stated in an interview published on pages 56-58 of *Commodore Gazette* magazine, issue 6 of September 1987:

The software market, because of piracy, is asphyxiated. […] No games and programs in Italian, closer to people's tastes and abilities, are being made. There are few magazines, fewer books are sold, fewer meetings are held, fewer clubs are established. In short, our field is not very lively: this is the real consequence of piracy. […] Sure, there is something, but it is the hundredth part of what could be done […] I recently had the satisfaction of selling to US Gold an Italian program, an arcade adventure called *People from Sirius,* made for the Spectrum and MSX by Mauro Spagnolo, an Italian young promise. [Commodore] 64 and Amstrad versions will be coded in England. But if the author was able to commit for months to creating the product, it was because he knew he could count on an outlet in foreign markets – had it been for Italy only, it would not have been worth it.



People From Sirius, ***by Mauro Spagnolo, was released in the United Kingdom by US Gold, as well as in Spain by Topo Soft under the title*** **El mundo perdido.**

Piracy will be dealt with later, in the section about cassette magazines, which, with a few minor exceptions, represented its most macroscopic aspect. As far as the Spectrum is concerned, there were exceptions to this depressing scenario, largely represented by the most creative branch of the software industry, namely the videogame one. In fact, there were individual authors, such as the prolific author of text adventures Bonaventura Di Bello, or development teams such as Softidea from Como, programmer of Jackson's *Video BASIC* course, capable of showing that even in Italy there was an alive and fruitful scene. The pinnacle would have been reached in 1985 with *Camel Trophy Game,* which due to its importance is here discussed in a separate section. After that, the hegemony of the C64 on the Italian 8-bit computer scene would have held back further developments.

BONAVENTURA DI BELLO

Born in Centola, near Salerno, in 1963, Di Bello became interested in text adventures due to of a curious combination of events. The owner of a 16K Spectrum, in 1984 he decided to enhance its RAM to 48 KB and received an original game on cassette from the store where he bought the expansion. It was a text adventure, *Planet Of Death* by Artic Computing. After the initial wonder of discovering a game genre completely unknown to him until then, Di Bello became so passionate about it that he spent the summer of that year in an attempt, crowned with success, to complete the adventure. Later, by reading a British magazine, he learned of the existence of Gilsoft's *The Quill* and purchased a complete copy of the *Illustrator* add-on module. The first adventure written by Di Bello was *Dimensione Sconosciuta,* that took part in a contest organized by the *Load 'n' Run* tape magazine; the prize was a QL. Di Bello received a letter from the magazine's editorial staff, stating that the game could not be admitted to the competition, but in any case, it deserved to be published on tape. This happened much later, however, in issue 37 of April 1987, which earned Di Bello a prize of around ITL 200,000.

Dimensione sconosciuta, defined by its author himself as 'most of all, an experiment in using the development system'[17] composed of *Quill* and *Illustrator,* was the first step on a path that led Di Bello to become the Italian Scott Adams. In fact, his videogame retailer talked about him with a publisher looking for someone who could program text adventures for the Spectrum.

Thus it was that Di Bello was hired by Edizioni Hobby S.r.l. in Milan to write at least three games a month, to be published in a tape magazine titled *Epic 3000,* the first issue of which came out on newsstands nationwide in May 1986 at the price of ITL 8,000. *Epic 3000* cassettes hosted three original adventures on the A side for the C64 and as many for the Spectrum on the B side. From January 1987 on, *Epic 3000* was renamed *Viking,* keeping its double composition but with an increased price of ITL 10,000; it lasted until November of the same year.

For the Sinclair machine, Di Bello wrote a total of 55 games, some of which were also converted for the C64 or MSX. This is how he himself describes their genesis:[18]

First of all, I decided the genre (fantasy, science fiction, war, mythology, western, horror, etc.). For each genre I had a character/ protagonist who would be impersonated by the player in the

[17] Interview by Stefano Guida to Bonaventura Di Bello on *ZX Notizie* issue 6 (December 2004-January 2005), p. 6.
[18] *Ibidem.*

adventure. At this point, I decided the goal of the game and began to mentally outline the setting and scenery. During this first stage, the main puzzles were designed, which would then be joined by all the others (objects and object-action combinations) during the first draft of the map, where I would also define all the places and the connections between them. Of course, editing within the development system and debugging came after.

After the end of his experience with Edizioni Hobby, Di Bello became editor-in-chief of *ZZap!,* the Italian edition of the British Newsfield magazine *ZZap64,* the equivalent for the C64 of *Crash* for the Spectrum. Unlike the original, *ZZap!* also hosted, at least until 1990, some (rare) reviews of games for the Sinclair computer and other 8-bit platforms, signed by Di Bello himself and other Italian editors. Afterwards, Di Bello was editor-in-chief of *The Games Machine,* which also began as an Italian edition of a Newsfield magazine, in this case aimed at 16-bit computers, still existing as an independent publication. He currently works as a freelance professional for website development and IT publishing.

ORIGINAL SOFT

Author of various games and utilities in BASIC published on *Load 'n' Run.* Among them, *La Scopa,* a digital version of the eponymous card game (issue 13, February 1985) and an 'office simulator' called *Speed Office* (issue 15, April 1985), with simple telephone book and word processing functions, that saved data on tape or 'diskette' (actually the Microdrive cartridge). It seems that behind the name Original Soft there was a certain E. Dassi, not otherwise known than from references placed inside programs or indications published in the *Load 'n' Run* booklets, in particular the instructions for *Speed Office.*

SOFTIDEA

Development studio based in Como. It worked for Gruppo Editoriale Jackson. Its main realization was the software part of the *Video BASIC* course, here examined in the section on publishing houses.

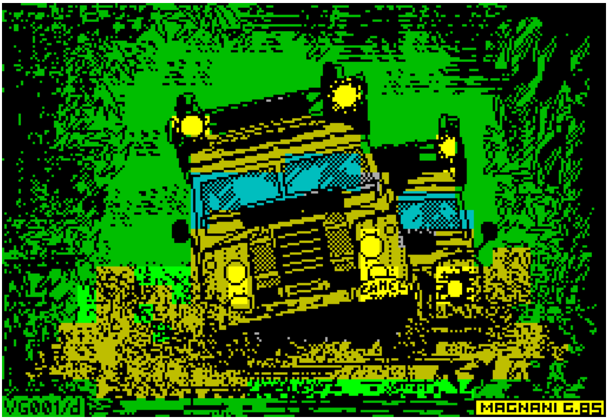
ALBERTO BROGGI

Born in Parma in 1966, he was the author of six games for *Load 'n' Run,* all arcade games of various genres characterized by a title consisting of two words of three letters each. The most interesting one is a vertical scrolling shooter entitled *Bug Zum,* published in issue 19 of September 1985 and 'dedicated to reason, so that it can unmask every actor'. After an intense research career in the fields of engineering and artificial intelligence, Broggi is now general manager at VisLab S.r.l., an Italian company working on computer vision and environmental perception for vehicular applications.

GIOVANNI ZANETTI

Although he is the author, together with Paolo Malnati, of two worthy games, *Pippo* from Mastertronic and *Draughts Genius* from Rack-it, Hewson's budget label, he is better known to Italian Spectrum users under the pseudonym of 'G.B. Max', the most active local game cracker for that machine. His story will be told in detail in the section about tape magazines.

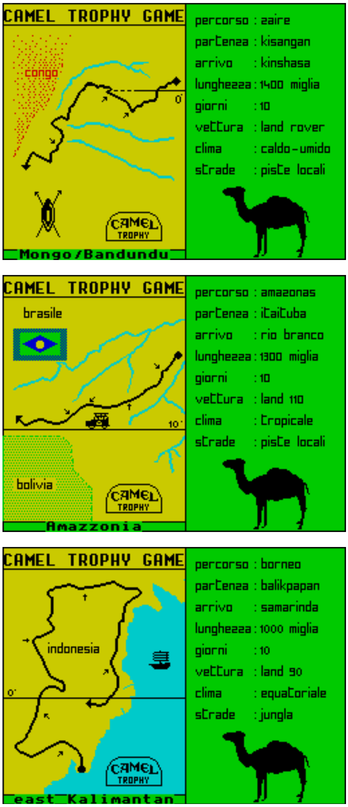
THE GREAT ITALIAN GAME FOR THE SPECTRUM: *CAMEL TROPHY GAME*



The history of *Camel Trophy Game* begins in the autumn of 1984, when Simone Majocchi, editor of the *Run* tape magazine for the Spectrum, published by Edizioni Aquarius in Milan, proposed to his collaborators Bruno Molteni, Eugenio Ciceri and Stefano Kulka to write a game inspired by Camel Trophy, at that time one of the world's major off-road competitions. Therefore, the first contacts with the Milanese agency then in charge of handling the promotion of the tournament on behalf of Worldwide Brands Inc., owner of the Camel brand, were established. From them two basic considerations that would have determined the course of following events soon emerged.

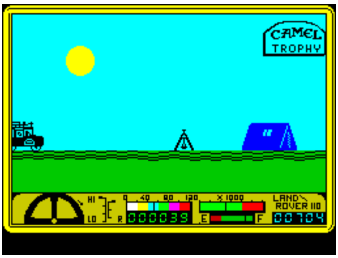
The first consideration was that the commercial potential of such an operation was considerable and this would have made even a partial economic return very likely. This gave the project the approval of all parties involved, although in the mid-1980s the combination of marketing and video games was still an almost unexplored field, full of uncertainties.

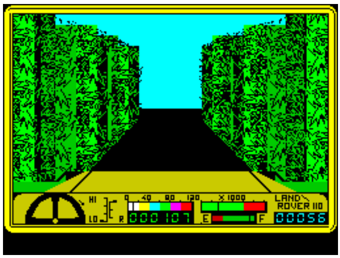
The second was linked to the specific identity of the Camel brand: the game had to keep a certain percentage of realism to stay in tune with the spirit of the competition it took inspiration from. For this reason, the player was able to choose between three courses based on the most recent editions of the Trophy at that time, namely Zaire (now Democratic Republic of Congo) in 1983, Amazonas (Amazonia, Brazil) in 1984 and Borneo (Indonesia) in 1985, plus a custom one (DIY, i.e. Do-It-Yourself), and a preliminary test based on the questions used in the selections for the real Camel Trophy was also present.



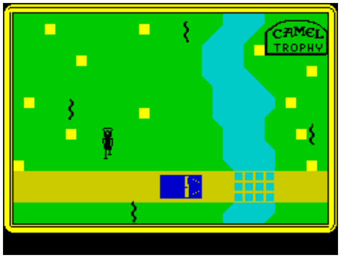
The Camel staff imposed the authors some curious decisions as well. One of the game sections featured a camping tent whose colour was quickly changed from red to blue, as red recalled a competing cigarette brand. The Borneo route map contained a graphic decorative element, the drawing of a machete, which had to be replaced by that of a junk because it was deemed too 'violent'. Strangely enough, the same observation was not made about the shield and spears on the Zaire map.

From a technical point of view, the test and the course choice were separated from the actual arcade game, so that the latter could take advantage of as many resources available from the limited hardware of the Spectrum. The final storyboard was approved in early June 1985: the programming group was asked to complete the work by mid-September. Development was carried out by means of a 48K Spectrum modified in order to get the composite video signal before the RF modulator, thus allowing to connect it to the Hantarex CRT monitors of the *Run* editorial team. The computer was also equipped with a Sandy Kempston 3” ½ floppy drive. Software tools used were *Beta BASIC* for the preliminary sections, and the *GENS3/ MONS3* assembler and monitor/disassembler combination from the *HiSoft Devpac* package for the arcade part. Graphics were made with *Masterdraw,* a utility by Mario Bianchi and Giovanni Restano derived from *Melbourne Draw* and published in the twelfth issue of *Run,* which Gianluca Magnani used to draw the loading screen.





The multiple-choice test was created first. It is not mandatory to go through it to play the actual game; however, it is possible to undertake an unnamed course of medium difficulty by directly loading the arcade part. The test consists of 32 questions, first 22 concerning driving theory, then the remaining 10 about survival techniques. Possible answers are almost always three, one of which is correct and one acceptable although not totally correct. At the end of the test, the player receives a four-character alphanumeric code, where the first character indicates the correct answers for driving theory, the second the acceptable answers for driving theory, the third the correct answers for survival and the fourth the acceptable answers for survival. By making a simple calculation, it can be understood that from a basic A3A7 code the player can therefore reach a maximum score of W3K7.



Development was not easy; it was in fact marked by a series of extravagant difficulties, overcome in an even more bizarre way, as it happened when Ciceri managed to make a damaged floppy disk, of which there was not a backup copy, readable again: he ripped the disk jacket open, took the actual floppy disk within, splashed it with suntan lotion, rinsed it with soap and tap water, dried it and reassembled it. This series of inconveniences was jokingly referred to as 'the humpback's course' and touched hilarious points, like when a cassette containing a copy of the source code was burnt in a plastic ashtray – that was strangely not affected at all by fire, as it was by cigarettes instead – for apotropaic purposes.

In order to meet the delivery times of the finished game, an intense overhaul job was required, whose price was paid by a helicopter that had to appear in a scene where it had to pull the player's Land Rover out of a quagmire but was later eliminated, because there was no more space left in memory for its animation code. However, the helicopter sprite remained 'hidden' within the final program. Other problems occurred with packaging, due to Camel's request to colour packages with a non-existent Pantone 116C tint – so that each element ended up taking on a slightly different shade of yellow – and the need

to fold by hand tens of thousands of brochures with the entry form for Camel Trophy selections, too large to fit in the box. As if it were not enough, only at the last moment became it clear that the price had not been printed on the package. It was therefore inevitable to apply, again by hand, on all copies of the game a round sticker bearing the text *PREZZO ECCEZIONALE LIRE 12.000* ('Exceptional price ITL 12,000'). Fortunately, this unbelievable sequence of snags did not affect the marketing schedule for *Camel Trophy Game,* which was presented on 17 September 1985, the day after the recording of the duplication master, with the following press release:

From now on, the Camel Trophy adventure can also be experienced from the comfort of your own home.

In fact, *Camel Trophy Game* for the 48K ZX Spectrum is born: a videogame that from 25 September on will be on sale in newsstands at the price of ITL 12,000, as a supplement to the September issue of RUN.

The game obviously has adventure as its dominant feature. In a single program, the courses of the latest editions of Camel Trophy are revived: Borneo (1985), Amazonia (1984) and Zaire (1983).

For those with imagination, there is the 'Do it yourself' option that allows the player to create an imaginary course in compliance with Camel Trophy rules.

The game is developed in three phases: the first phase, focused on technical knowledge and survival experience, allows you to determine the first difficulty coefficients for *Camel Trophy Game.*

The second allows to examine the roadmaps of the three courses (Borneo, Amazonia and Zaire) and advises the player on the most suitable path for his abilities. At this stage of the game, the 'Do it yourself' option is included to create your own *Camel Trophy Game.*

The actual game begins with the third and final stage. A careful simulation of the dashboard of a Land Rover practically puts the player in the driving seat of this legendary car.

The path appears on the screen prospectively or sideways, depending on the various situations, always offering the maximum yield.

Each course is divided into ten days and each day includes the alternation of special challenges and travel in the jungle.

The player must always get the most out of his Land Rover while accumulating the fewest penalties.

As in Camel Trophy, the player will have to face technical difficulties related to the mechanical vehicle (Land Rover) but will also have to beware of the dangers of the jungle.

We wish all 48K Sinclair Spectrum owners to have fun with *Camel Trophy Game.*

Camel Trophy Game was advertised on the SPER Italia Radio national broadcasting network from 25 September to 25 October 1985, with a 30-second spot. It was enthusiastically received by its commissioners and met with great favour from the public, selling very well, despite the fact that the specialized press was not very impressed, perhaps due to the fact that the game was presented as an arcade, rather than, more precisely, as a simulation, a genre not yet very popular at the time. It would also have been the greatest achievement of *Run*'s editorial staff; the last issue was number 14 of February-March 1986.

[Text adapted from Stefano Kulka's website, *www.rescogita.com*]

PUBLISHING HOUSES

JACOPO CASTELFRANCHI EDITORE

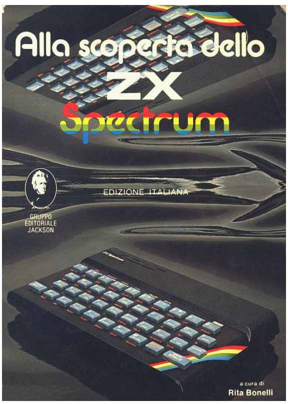
For almost half a century, from its foundation in 1957 to its final absorption within the Gruppo Sole 24 Ore in 2006, JCE was one of the leading Italian publishing houses covering the information and communications technology sector.

In the period 1984-1986, more than half of the titles in the JCE catalog concerned the Spectrum alone. There were books on programming and software development, mostly translated from English like William Tang's *Spectrum Machine Language For The Absolute Beginner* and Ian Logan's *Spectrum Microdrive Book*. However, there was no lack of works by local authors, for example *Grafica e suono per il lavoro o il gioco con lo Spectrum* ('Graphics and sound for work or play with the Spectrum') by Rossella and Massimo Boaron.

Alongside books, often coming with a cassette recording of part or all of the listings published there, JCE distributed software, mostly educational or management applications, as well as some games such as *Super EG*, the Italian version of the Spanish original. *Tuneles Marcianos* by Ventamatic. Among the most important programs translated into Italian by JCE, it has to be mentioned *Masterfile* by Campbell Systems.

GRUPPO EDITORIALE JACKSON

Founded by Pietro Reina and Giampietro Zanga, two former JCE employees, Gruppo Editoriale Jackson, located in Via Rosellini 15 in Milan, was another essential reference point for those who, for various reasons, had to do with electronics and information technology. Its activity was not limited to the translation of foreign books, but led to the creation of wide coverage works entirely edited by Italian authors, among which the famous *EI - Enciclopedia di Elettronica e Informatica* ('Encyclopedia of Electronics and Computer Science') in eight volumes, written in collaboration with the Texas Instruments Learning Center and published between 1984 and 1985 in the form of weekly booklets sold on newsstands, to be bound later.



The history of Jackson, as the Gruppo Editoriale Jackson is still usually called today, is intertwined with that of the Spectrum in Italy for more than one reason. First, it published the Italian translation of the two manuals included with the 16/48K Spectrum, in a single volume entitled *Alla scoperta dello ZX Spectrum* ('Discovering the ZX Spectrum'). It was edited by Rita

Bonelli, while the actual translation was made by Giacomo Bortone and Andrea Mazzini. The book was given free to those who bought a 48K, while 16K owners had to purchase it separately for the price of ITL 22,000. The translation was quite faithful, although there were some inaccuracies in quoting error messages. Also, the meaning of some parts was lost in translation, as in the case of the pun between 'EVIL' and 'evil' (which one of them is the 'lesser evil') in Chapter 23, erroneously translated as 'DEMONE' and 'demone' ('demon'), thus losing the humour of the original. The second edition appeared in 1984, but was published by JCE instead.

Between 1983 and 1986, Jackson published various other books concerning the Spectrum. The percentage of texts related to Sinclair's most popular computer was always the greater one, although on the whole there was more balance than in the JCE catalog. Another difference with the latter was that translations of foreign works, for instance *Programming Your ZX Spectrum* by Tim Hartnell and Dilwyn Jones, were fewer than texts written by Italian authors, including *77 programmi per lo Spectrum* ('77 programs for the Spectrum') by Gaetano Marano, *Spectrum Tool* by Roberto Rigo and above all the *Video BASIC* course. This publication made its debut in newsstands throughout Italy on 1 February 1985; editions for the C64 and VIC-20 came out at the same time.

Video BASIC consisted of 20 booklets and 20 cassettes, published every two weeks at the price of ITL 8,000 per issue. Each of the 32-page booklets was divided into three sections, in order: *Hardware,* which illustrated both the structure of the Spectrum and its peripherals and elements of general IT architecture; *Il linguaggio* ('The language'), explaining commands, functions and syntax of Spectrum BASIC; *Programmazione* ('Programming'), with practical usage examples of the topics covered in the previous section. The last page, called *Videoesercizi* ('Video Exercises'), hosted some drills related to the content of the booklet.

Cassettes hosted software specifically made by Softidea and entirely programmed in BASIC. Recordings were identical on both sides. The succession of their different parts was the same of the respective booklet, with a summary at the beginning, an animated intermission in the middle and a simple videogame before the preview of the following issue's contents, which closed the sequence. *Video BASIC* found considerable interest outside of Italy as well: it was translated into Spanish by Ingelek Jackson and into Portuguese by Edições Latinas.

Most *Video BASIC* cassettes contained at their end a bonus videogame whose rights were held by Jackson. Games ranged from simple BASIC programs by Softidea itself to the reissue of three titles previously published in *Jackson Soft Oro,* a series distributed on newsstands by Jackson from May 1985 to

January 1986 at a price of ITL 10,000 for each issue: Mikro-Gen's *Pyjamarama* and *Automania*, the only ones in the whole series officially translated by Jackson into Italian, and *Brian Bloodaxe* (The Edge). The other Spectrum games exclusively distributed by Jackson in *Jackson Soft Oro* were: *Everyone's A Wally*, *Herbert's Dummy Run* (both by Mikro-Gen), *That's The Spirit* (The Edge) and *The Way Of The Exploding Fist* (Melbourne House). Games came with a 16-page booklet containing their instructions, plus news and curiosities from the Sinclair world and advertisements.

Jackson launched a label called *J.Soft* for some of its newsstand products. In June 1984, the first issue of *Super Sinc* came out, a monthly magazine costing ITL 3,500 initially dedicated to the Spectrum and the ZX81. The latter was replaced after a short time by the QL. Each copy was accompanied by a cassette with the recordings of programs whose listings appeared on the pages of the magazine. *Super Sinc* lived until December 1985.

The J. Soft brand was also featured in the *Paper Soft* weekly, a 32-page listings magazine sold at ITL 1,000. There were three series of it. The first, from June 1984 to April 1985, presented programs, in addition to the Spectrum, for the Apple II, TI-99/4A, C64 and VIC-20. From April to September 1985, the magazine was split into three editions, one for the Spectrum and the others for the C64 and VIC-20 and the Apple II, TI-99/4A and MSX respectively. In October 1985, editions were reduced to two: one for the C64 only, the other for the

Spectrum and other platforms. The last issue of *Paper Soft* came out on 27 December 1985.

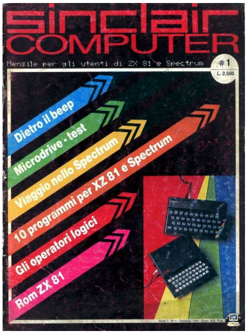
After 1986, Jackson's interest in the Spectrum waned. In 1992, the group ceased to exist as an autonomous entity, becoming Jackson Libri, a division of Gruppo Editoriale Futura, to which Paolo Reina joined. Giampietro Zanga had already started his own business since 1989, founding Hobby & Work Publishing.

MCGRAW-HILL

This important publisher of works about computing, economics and science translated into Italian some texts of British origin concerning the Spectrum: *Learn and Use Assembly Language on the ZX Spectrum* by Toni Woods; *Spectrum Interfacing and Projects* by Graham Bishop; *Assembly Language for Arcade Games and other Fast Spectrum Programs* and *The Spectrum Games Machine,* both by Stuart Nicholls.

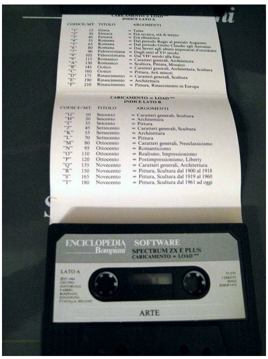
SYSTEMS EDITORIALE S.R.L.

Established in 1977 by Michele Di Pisa, journalist and editor. Mainly linked to the Commodore world, in February 1984 it launched the *Sinclair Computer* monthly magazine, one of the most complete Italian publications for the Spectrum. On the 64 pages of each of its issues there was space for news, hardware and software reviews, direct contact with readers and listings of various kinds, at a cost of ITL 3,000. *Sinclair Computer* lasted until December 1985, for a total of 19 issues. From January 1986 on, it was merged with the *Commodore* and *MSX* magazines by the same publisher in a single product, *Personal Computer.*



OTHER PUBLISHERS AND MAGAZINES

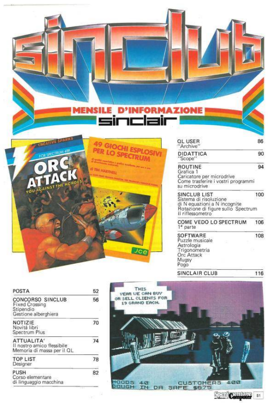
Among known books about the Spectrum by other publishers there are: *BASIC per lo Spectrum* (BASIC for the Spectrum) by Maurizio Ariena and Clizio Merli, Edizioni Acanthus; the translation of Adrian Dickens's *Spectrum Hardware Manual,* issue 42 of the *Biblioteca Tascabile Elettronica* ('Pocket Electronics Library') series, published by Franco Muzzio & C. Editore; the translation of *Sixty Programs for the Sinclair ZX Spectrum* by Robert Erskine and Humphrey Walwyn, published by Zanichelli. The Italian edition of the latter hosts only 57 programs of the originary 60; it is not known which ones are missing and why. All of these books came out in 1984.



In the same year, Bompiani published a first example of a multimedia encyclopedia, a version of which was produced for the 48K Spectrum. The software part consisted of 13 cassettes, each relating to a specific sector (Art, Medicine, Literature, Philosophy, Religion, Natural Sciences, etc.) and containing data and information complementary to the paper one.

Between 1983 and 1988, several applied electronics magazines dedicated a fixed space to Sinclair computers, especially the Spectrum. Contents included: schemes for hardware modifications, for example to make the power supply used with the 16/48/+ more stable and interfaces to open the Spectrum to the outside world even more – amateur radio reception, telephony, etc. –; listings of utility programs of all kinds, for the design and study of electronic circuits, the development of *Totocalcio* betting systems, monoscopes for screen calibration, POKEs for games and more. Besides, there was no shortage of hardware reviews, with many articles dedicated to the QL, and information on what was happening across the Channel. Prominent magazines hosting Spectrum-related contents were *Nuova Elettronica, MC Microcomputer, Sperimentare* and *Elettronica 2000.*

Sperimentare, by JCE, hosted from March 1983 to June 1985 *Sinclub,* a central insert undertitled 'Sinclair information monthly' or 'The club of Sinclair clubs', entirely dedicated to the Spectrum's manufacturer. *Sinclub* reappeared, at the request of readers, in *EG Computer,* another magazine by the same publisher, from February to September 1986.


sinclub
MENSILE D'INFORMAZIONE sinclair

QL USER 86
"Archive"

DIDATTICA 90
"Scope"

ROUTINE 94
Grafica 1
Caricatore per microdrive
Come trasferire i vostri programmi su microdrive

SINCLUB LIST 100
Sistema di risoluzione di N equazioni a N incognite
Rotazione di figure sullo Spectrum
Il riflessometro

COME VEDO LO SPECTRUM 106
1ª parte

SOFTWARE 108
Puzzle musicale
Astrologia
Trigonometria
Orc Attack
Mugsy
Pogo

SINCLAIR CLUB 116

POSTA 52

CONCORSO SINCLUB 56
Fixed Crossing
Stipendio
Gestione alberghiera

NOTIZIE 70
Novitá libri
Spectrum Plus

ATTUALITA' 74
Il nostro amico flessibile
Memoria di massa per il QL

TOP LIST 78
Designer

PUSH 82
Corso elementare di linguaggio macchina

Sperimentare Computer 51

Elettronica 2000 launched two other publications, which later became independent: *Run* and *Load 'n' Run,* the first Spectrum tape magazines of the Italian publishing scene, as well as the only ones to present a peculiar mix of pirated games translated into Italian and original programs created by their editors or readers.

TAPE MAGAZINES

The most distinctive aspect of the 8-bit era, as experienced in Italy, is the presence of magazines with attached cassettes containing unprotected games, often only partially translated or even left in the original language, with the title and name of the authors/publishers deleted or replaced by invented names to circumvent copyright. This phenomenon particularly affected the Spectrum and Commodore 64, the two historically most popular 8-bit computers in the country, but similar products for the MSX also appeared. It was a very large business that relied primarily on the low disposable income of many teenagers, for whom the prices of original software were often too high in comparison to illegal alternatives proposed by these publications or by local resellers themselves, who may have shown the originals in the window, but in fact sold copies of them. This way, a vicious circle was created, because the small sales volumes of the Italian market, not comparable to the figures in thousands or tens of thousands of copies sold in countries such as Spain – not to mention the United Kingdom – did not allow for high profit margins. Consequently, software houses could not apply discounts for resellers, as it happened in other countries instead. It was not uncommon to find in those magazines advertisements of 'importers' offering Spectrum programs 'directly from England' at bargain prices, complete with name, surname, address and telephone number.

An 'amateur' form of piracy was that of user groups. Through the payment of a registration fee, to be periodically renewed, members received by mail cassettes containing an electronic fanzine with reviews, comments, utility software written by the editors, machine code routines to include in their own programs and simple BASIC games. Membership also gave –

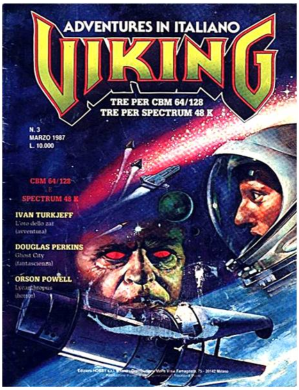
and this is the most interesting aspect for our purposes – the opportunity to choose a certain number of games from a list as a 'gift for members'. A typical example was the GUCS (*Gruppo Utilizzatori Computer sezione Sinclair,* 'Computer Users Group, Sinclair section'), based in Naples, which showed its animated presentations on a blackboard-shaped window with a caricature of Clive Sinclair on the right side. A list of games available for members choice in the months to come was enclosed with some issues. Games were recorded on common audio cassettes and sometimes 'signed' with the caption, shown by the first loading block, 'CRAKED [sic] BY GUCS – NAPLES'.

Piracy was a practice underestimated by Italian law for years, and the few actions aimed at sanctioning, with fines of the maximum order of ITL 10,000,000 at the time, the translation and abusive software publishing were usually undertaken by the few legal importers who also existed. The writer remembers the case of a publisher sued by Jackson in 1985 and forced to compensate it for having included in one of its newsstand collections an illegal Italian C64 version of *Pyjamarama,* whose rights for translation and distribution in Italy were held, as we have seen, by the Milanese publishing group. The possibility of being forced to pay a fine to silence legal distributors was a 'toll' that publishers of tape magazines were still willing to pay in order to continue to pursue their business, which often guaranteed high profits, in opposition to, after all, low costs.

In relation to the Spectrum, however, there was also another cause for the proliferation of tape magazines, that is the progressive disappearance from store shelves of programs for that machine, concurrently with the advance of the C64 on the Italian market. After 1986, only in large cities was it possible to find any shops who continued to offer Spectrum software.

Of course, there was also legal distribution. There were importers that cared about adopting strict policies, in sales to both wholesalers and retailers, and offered goods directly to their customers by mail order. Such was the case of Soft Mail, a division set up for this purpose by Como-based importer Lago, that since 1985 officially distributed in Italy software of various genres for the Spectrum, Commodore 64, Amstrad, MSX, Amiga, Atari ST and IBM-PC, earning itself a good reputation for its care in the selection of offers and customer assistance.

Those who were lucky enough to be able to find in newsagents not only pirated game cassettes, but also magazines from the United Kingdom, could take yet another path, certainly more challenging in an age when neither the Schengen Agreement or money transfer through the Internet existed, but undoubtedly advantageous: buying directly from British retailers, who offered the programs, already about six months after their release on the local market, at significantly reduced prices. After purchase and shipment, paid together by international postal order, delivery times ranged from four to six weeks, but the length of the wait was largely compensated by the economic convenience, even considering the exchange rate between the Italian lira and the British pound, and by the wide choice of titles, which also included software never seen in Italy. It was with this procedure, for example, that the writer obtained, in October 1990, a copy of the Blade edition of *Laser Squad* for about ITL 15,000, including shipping costs. The retailer's list, in this case Software City, in Wolverhampton, was noticed on page 43 of *Sinclair User* issue 103 (August 1990). In Italy, assuming that such game had ever been officially imported (and in fact it was not), it would have costed no less than ITL 18,000, to which at least another 5,000 had to be added for shipping if ordered from a mail order retailer. For the majority of Italian Spectrum users, however, the loss of their computer's dominance on the local software market to the advantage of the Commodore 64 meant having to turn to the offer of 'newsstand cassettes'.



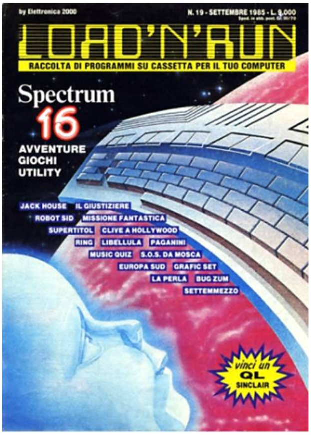
Italian tape magazines for the Spectrum can be divided into three groups. The first consists of those including only original software. Publishers following this policy were: Hobby Editions, which produced the *Epic 3000* and *Viking* magazines; Editoriale Video with its collection of BASIC games and utilities *Computing Videoteca,* 7 monthly issues from 1984 to 1985; Fabbri Editori with the utility series *Libreria di Software* (mixed C64/Spectrum cassette) in 30 issues published every two weeks from 1984 to 1985; Gruppo Editoriale Jackson with *Super Sinc.* As already mentioned, Jackson also distributed on newsstands the *Video BASIC* course and the games of the *Jackson Soft Oro* series.

The second includes magazines containing both original and pirated and translated software. It includes the two publications first created as supplements to *Elettronica 2000* and later autonomous, namely *Run* and *Load 'n' Run.*

As mentioned above, *Run* was a product of Milanese publisher Edizioni Aquarius. It was released every two months for a total of 14 issues, starting from November-December 1983 until February-March 1986. Each issue costed ITL 9,000.

***Cover of* Run *issue 6. Featured game 'Palombaro' is in fact CRL's* Glug Glug.**

Run stood out from other tape magazines for more than one reason. Booklets were extremely short, since articles were in digital format, recorded on the cassette itself. Pirated games were absent in the first three numbers and appeared on issue 4 and from issue 6 onwards. Then, their number increased and became a substantial part of the contents, especially in issues 7 and 8, which included eight of them. However, *Run* editors did not only wish to exploit the 'grey zone' offered by the legislative shortcomings of the time, but to create the first true Italian electronic magazine for the Spectrum, as evidenced by several features like information on the activities of Sinclair Research, hardware news from other manufacturers and various utility programs and educational software for learning BASIC or machine code, present in every issue. *Run* was therefore an innovative product, and it was impossible not to notice the care taken in its realization. In addition to this, it should not be forgotten that three of its editors were the authors of *Camel Trophy Game* and that Mauro Spagnolo was also among its collaborators. It was perhaps to try to increase sales that it too ended up, in the last part of its publishing history, hosting 'cracked' games presented as original titles.



The same can hardly be said for *Load 'n' Run,* which was presented just as a collection of games, utilities and demos, with some occasional educational or information software. Established in January 1984, it usually featured 16 programs per issue, about half of them being pirated games translated into Italian. The rest was original software, mostly programmed in BASIC, ranging from games such as text adventures, puzzles and some simple arcade to management or graphic and sound development applications, or animations. The printed part contained instructions for the programs, indicating the authors of the original ones and an invitation for readers to submit their works to the editorial staff. In the event of a favorable judgment, they would be rewarded with publication and a prize of ITL 100,000. Issues were sold at ITL 9,000 each.

As time passed, games were increasingly drawn from previous years' releases and translated less and less precisely. From January 1989 the original part, already greatly reduced in comparison with the early years, was completely eliminated and *Load 'n' Run* was reduced to a container of 9-10 pirated games per issue. The magazine folded in October 1989 with issue 64. *Load 'n' Run* had a Spanish edition too, also including both pirated and translated into Castilian and (to a lesser extent) original software. It went on until October 1986.

The third group of tape magazines is by far the largest and includes all those that exclusively featured pirated games. Not all of them were aimed solely at the Spectrum; many of them, including the most successful ones, offered games for the Sinclair machine on one side and for Commodore machines on the other, usually for the C64 but sometimes also for the C16/Plus4 or the VIC-20.

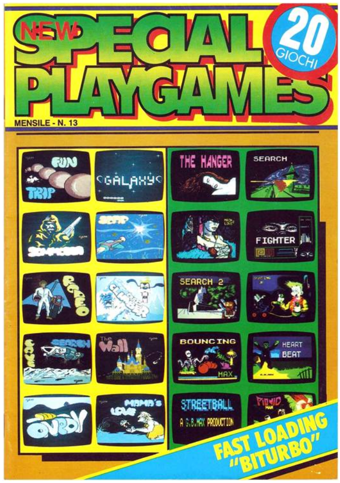
Most of the time, the intervention of 'crackers' on games was limited to removing protection, for titles recorded with anti-copy systems, loading screens, if any, and text in start menus indicating the real title, authors and publishers. Games were not always translated into Italian; indeed, the translation was mostly limited to the options, leaving much of the internal text in English, especially in the final years. Few magazines offered a complete translation on the model of *Run* or the first years of *Load 'n' Run.* As a consequence, game genres with many written parts, such as text adventures, strategy or management titles, were left out, because they would have required too much time and effort to translate, in a context where 5 to 10 games had to be published every month.

The most popular and long-lived of such magazines were those published by SIPE Edizioni S.r.l. in Milan, appearing in Italian newsstands from 1984 to 1992. Half of the titles in each issue were for the Spectrum and the other half for the Commodore 64. There were two, *Program* with 20 games in total and *Playgames* with 14, which subsequently changed their name to *Special Program* and *Special Playgames,* and the latter, from September 1987, to *New Special Playgames,* with 20 games as the other. Spectrum games were recorded on side B, while side A included those for the C64. If the former, at least until 1989, were overall of better quality and more recent, even with the shortcomings we shall see later, C64 games were in general older and less valid. There was a period, between the 1987 and 1988, when at least one of them was a less than mediocre 'homebrew' shooter created with Sensible Software's *Shoot 'em*

Up Construction Kit. Each issue costed ITL 8,000 and was published on a monthly basis. In July, special issues of 26 games each came out, that in 1987 and 1988 included a white cotton T-shirt, decorated with the magazines' logos and a colourful picture, as a gift for readers.

The Spectrum section was edited by the aforementioned Giovanni Zanetti, also known as 'G.B. Max'. His interest in Sinclair computers goes back to a study trip to the United Kingdom, when he was able to test a ZX80 at a Dixons chain store. In the early 1980s he collaborated with Nuova Newel in Milan, among other things hacking *Ant Attack* with the title 'Ant City' and renaming its protagonists, originally referred to simply as 'girl' and 'boy', with the names 'Gianna' and 'Berto'. Through the company's owner, Zanetti was contacted by a certain Barigazzi, the head of SIPE, to whom he proposed the idea of distributing pirated and translated games in newsstands, until then marketed by retailers such as Nuova Newel itself. In fact, Zanetti knew British tape magazines like *16/48,* published by Magnetic Magazines since 1983. The not insignificant difference with respect to these publications was that Zanetti's proposal consisted in distributing non-original and illegally manipulated software.

Thus, SIPE tape magazines were born. At first, the publishers themselves purchased games directly in the United Kingdom. Almost always they were arcade titles, or 'spara-spara' ('shoot-shoot') as Barigazzi called them, both at full price and in the 'budget' range. Other game genres, specifically text adventures, simulations, strategy and management, were, as we have seen, considered unprofitable or too laborious to hack. First-rate titles such as *Elite, Laser Squad, Tau Ceti, Vulcan, Gunship, Football Manager II* or text adventures by CRL, Adventure Soft U.K. or Level 9 never appeared on these cassettes, not just from SIPE, for this reason. More ostracism was directed at versions for the 128 and later Spectrums or to games specifically made for them, presumably in the belief that the user base of such machines was not large enough. Only in the final issue of Special Program (92, December 1992) two 128K titles were found: 'Home Race' *(Hard Drivin')* and 'Last Rescue 2' *(Double Dragon II).*



Later, to reduce expenses, publishers entrusted the task of getting the original games to Zanetti himself, but without changing the basic decisions. In any case, Zanetti unprotected them and changed their loading screens, removing the original titles and logos and replacing them with fake ones. Then, he modified the internal texts, trying as much as possible not to corrupt the code, and leaving his pseudonym as a 'signature'. This was done with a self-built device very similar to the Videobit S 80. Lastly, games were saved to the master for duplication with an accelerated loader of about 300 baud per second, double the normal Spectrum ROM loading scheme. Designed by Zanetti himself and named by himself 'Biturbo', it underwent two subsequent revisions, called 'Biturbo II' (1987), different from the first only for the coloured lines displayed in the BORDER area, and 'Biturbo III' (1989), slightly slower. The first 'Biturbo' was, at the beginning, so fast that the duplication system on which SIPE relied, calibrated for music cassettes and operating at 10 times higher than normal writing speed, did not allow for effective tape copying, also due to the not excellent quality of the tapes themselves, despite the fact that the stereo head had been replaced for the occasion by a mono one in order to increase the reliability of software recording. Zanetti therefore had to reduce the transfer speed of 'Biturbo' to make it compatible with duplication. All of these schemes have been decrypted by the Ramsoft group and can be rendered in TZX format thanks to *MakeTZX.*

An example of Giovanni Zanetti's 'treatment' of game loading screens: **Hyper Active.** ***The original was by Jonathan Smith and freely given with*** **Sinclair User** ***75 (June 1988).***

In the course of 1987, tight schedules meant that Zanetti's work, initially quite accurate, became more and more slapdash. Translations left something to be desired, and in some cases, like *Stormbringer* published in issue 1 (September 1987) of *New Special Playgames* under the false title 'White Knight', text rewriting was so clumsy as to be incomprehensible, effectively making the game impossible to play. Sometimes, code manipulation made the game crash and caused a system reset when the player reached a certain point. This happened with *Exploding Fist II,* seen on *Special Program* 31 (March 1987) and *Livingstone Supongo,* again on *New Special Playgames* 1.

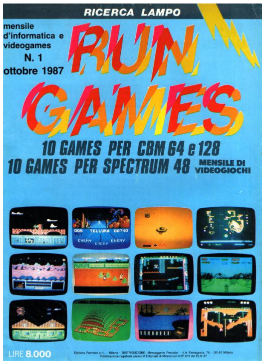
Even worse, to make up the numbers, trial versions taken from cassettes given free with British magazines, but passed off as complete games were included: for instance, the *Street Fighter* demo from *Sinclair User* issue 74 (May 1988) and the *Dark Side* demo given with *Crash* issue 54 (July 1988), both released on *New Special Playgames,* issues 11 (July-August 1988) and 13 (October 1988) respectively. There were also cases of multi-load games with only one level available, usually the first, because there was not enough room on the tape (e.g. *Road Runner, Psycho Soldier* and *Rambo III,* all on *New Special Playgames*), or which did not load them even though being present (*R-Type,* also on *New Special Playgames*). Games in two or more parts, like many Dinamic titles, were 'split' and published on different issues, presenting second parts as 'follow-ups' of the first. From 1989 onwards, it was common practice to recycle games already published in previous years by the same magazines, simply by changing the old fake title with a new one. The English proverb 'you get what you pay for' could not have received a better confirmation.

The 32-page booklets hosted a summary of the instructions and controls for each game. It goes without saying that none of the extras coming with the original titles, such as maps, fiction or keyboard overlays, were included. They also contained advertisements for other SIPE magazines and some hardware or software reviews, most of the time taken from British magazines. Sometimes, especially from 1987 onwards, translations were so bad as to even generate effects of involuntary humour, as in the case of 'arcade' constantly rendered as 'da bar', literally 'of bars', probably due to the wide diffusion of coin-operated videogames in Italian bars in the 1980s. The continuous presence of 'azione da bar', i.e. 'bar action' – a clumsy translation of 'arcade action' – gave the impression that *Tapper* clones were popping up everywhere. In the early years, however, a few original articles were also published. They were much more interesting, because they focused on typical features of the Italian scene, for example Sandy floppy disk drives or the Videotel videotex system.

Readers' classifieds closed the booklets. Particularly hilarious were the constant requests of those Commodore 64 owners 'desperately' looking for the program that 'turns [sic] the C64 into a 48K Spectrum': it was actually the Sinclair BASIC simulator by Whitby Computers, capable of running simple programs written in that language and nothing more. Any attempt to run software written in Z80 Assembly was greeted by the *Can't do machine code* message. The urban legend of the existence of such miraculous software lasted for years.

None of SIPE's competitors ever managed to match its sales volumes. Pubblirome/Edigamma in Rome was the one that came closest, with its 5-game cassettes of the *Tutto Spectrum* series and special issues *Gustolungo, Super Spectrum* and *Maxi Spectrum,* the latter containing 30 titles, and mixed Commodore 64/Spectrum tapes *Special Games, Game 2000* and *Super Game 2000.* Sometimes games were almost entirely left in English, but had no loading problems. Booklets were very small and placed inside the cassette cases themselves. *Tutto Spectrum* issue 4 hosts the only known case of an original program released by this publisher: *Il tastierista,* a music composition utility by Luca Missora. *Special Games* was the longest running series: 27 issues, from April 1987 to September 1989. Its Spectrum part was recorded with an accelerated loader, by an unknown author.

Linguaggio Macchina, by Edizioni Foglia S.r.l. in Cremona, hosted 6 games for the C64 and as many for the Spectrum. It included listings for both machines, programming lessons, reader advertisements and prizes ranging from ITL 200,000 to 350,000 for the publication of original programs. Spectrum games were signed by a certain 'Macloc', whose true identity remained a mystery. *Linguaggio Macchina* was on newsstands from December 1984 to April 1987.



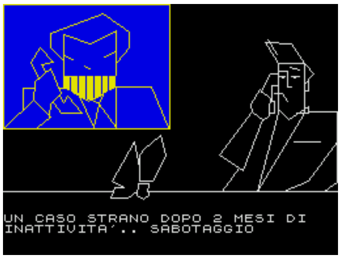
POKE, Hit Games and *Run Games*, by Fermont Editore S.r.l. in Milan, appeared from 1985 to 1989. They contained collections of games sometimes taken from snapshots saved with the Multiface 1, as shown by the blue loading screen with the flashing yellow text 'M1 LOADING' at the bottom. It is likely that the games were taken from other similar magazines, as they not infrequently presented the same translations with the same blunders and the same problems of memory corruption that caused some to crash always at the same point. *Satellite Killer,* a compiled BASIC game written by a *Load 'n' Run* reader, Gildo Di Domenico, even appeared twice on them. The game was originally published in *Load 'n' Run* issue 21 in November 1985, then it appeared the following month in *POKE* issue 8 with the title 'Difesa Spaziale' and on *Run Games* issue 12 in October 1988 with the title 'Scudo stellare'.

Other magazines, such as *Open Game* by Centro Studi Editoriale S.r.l. in Milan and *Computer Set* by Publiflash/ Logica 2000, only had an ephemeral existence, being just mere attempts at imitation of a successful model, bound to disappear into nothingness after a few issues.

1992 marked the end of tape magazines. The Spectrum and Commodore 64 commercial life cycle was coming to its final act. There were no longer the profit margins of the past; moreover, the adoption of new and severe measures against piracy made it too risky to continue producing them. Thus, the era of ‘Italian-style piracy’ ended. The *www.edicola8bit.com* website rebuilt it, not only for the Spectrum, but for all the platforms affected by this phenomenon. From the site, which lists the original names of the games alongside the fake ones, you can download the image files of the cassettes and the scanned booklets in PDF format. There are also the official Jackson series and *Epic 3000* and *Viking* magazines, articles explaining how to create tape image files, accounts of the era and much more.

RADIO AND BBS

In Italy, in the 1980s, remote data transmission experiments were carried out for the Spectrum through frequency modulated radio waves and BBS (Bulletin Board System), the forerunners of electronic mail and peer-to-peer. Today, BBSes are almost forgotten, but at that time they were well known to electronics and computer enthusiasts, as well as to pirates, who took advantage of them to send and receive data packets from which to reconstruct programs in their entirety. This led to the dismantling of many mostly innocent BBSes in the infamous *Italian Crackdown* police operation in 1994.



An agreement between RAI Radio 3, the third channel of Italian State radio, and ARCI Media Research and Studies Division led in 1984 to *Radiotext,* an experimental broadcast of Spectrum software over the air. Programs could be loaded directly from the radio by connecting the headphone output to the EAR input or recorded on tape to load them later. A total of four were sent this way, all edited by Fabio Guidi: a sort of vector graphics cartoon; the calendar of the Olympic Games held that year in Los Angeles; a simple music composition utility; the collection of machine code subroutines used by RAI for the broadcast itself, complete with instructions and available to users for inclusion in their programs.

The presence of BBSes in Italy prompted some Spectrum enthusiasts as early as the mid-1980s to try to set up Sinclair areas within them. In 1986, one appeared inside the MC-Link BBS. Like all BBSes, it worked in text mode and required special software not only to connect the Spectrum to it through a modem, but also to exchange files by means of ASCII text messages. Files were encoded as characters, then decoded upon receipt. It was the users themselves who wrote these programs, as BBSes at the time did not yet have dedicated areas for file swapping, therefore it would not have been possible to send them, had that system not been invented.

When, again in 1986, the first Italian node of the FidoNet network was opened on the initiative of Giorgio Rutigliano, special spaces were introduced to exchange files, but the problem remained as there was no specific file format for the Spectrum at the time: TAP and TZX were still to come. The header information was also sent using the text encoding/decoding workaround, which allowed the file to be received and repositioned correctly in the Spectrum's RAM. Following the requests of Sinclair users, the Sinclair.ita exchange area was created specifically for them. Local coverage BBSes, such as Joe Cocker or Andromeda, both based in Rome, were used by Spectrum and QL enthusiasts until around 1997, when their place was taken by the Internet.[19]

[19] The author wishes to thank Enrico Maria Giordano, Luca Zabeo and Pasquale Antonio for the information about the presence of Spectrum users in Italian BBSes.

Chapter Four
SOURCES AND MORE

GENERAL RESOURCES

Compared to the autumn of 2012, when the first edition (in Italian) of this book was published, the situation regarding the sources, resources and in general the presence of the Spectrum on the Web deeply changed. In the ten years passed since then, retrocomputing and retrogaming knew an even wider and more intense diffusion than before, through social networks and the propagation among the masses of 'retro' culture. It would be enough to consider how many films, videogames, publications and consumer objects of all kinds have been inspired by it.

Spectrum-shaped bag for sale in a shop in Barcelona

As a result, dozens of websites, blogs, forums, YouTube channels, Facebook groups etc. specifically dedicated to the Spectrum have been established, not to mention those, generally concerned with the retrocomputing and retrogaming world, where the Spectrum plays a leading role. Other books have been released, in both printed and electronic format, and the historical British magazine *Crash!* even resumed publication, in digital format. It is therefore not possible to mention here everything Spectrum-related resource now accessible, both physically and online. The present chapter will then be limited to some general indications the reader can consider as a starting point to explore this vast area.

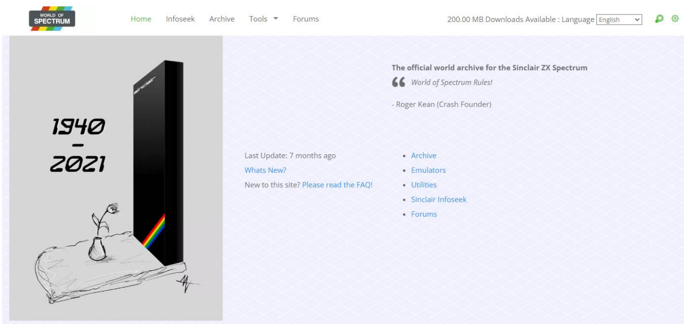
SPECTRUM COMPUTING
www.spectrumcomputing.co.uk

Born in April 2016, Spectrum Computing established itself in the following years as the virtual meeting place for Spectrum enthusiasts on a planetary level, especially regarding its forum, the most active and participated among those dedicated to Sinclair computers and everything that revolves around them: historical and modern games, emulators, hardware, publications and more.

The internal archive is based on the *ZX Database,* in short *ZXDB,* a public and open source database that not only includes resources for Spectrum, but also for ZX80, ZX81, QL, SAM Coupé, Next and clones such as the Pentagon, Scorpion, ZX-Evolution or Timex Sinclair TS 2068. It is constantly updated with new releases reported on the forum or to the site editors. For each title, the relevant sheet includes, if available, resources such as files for emulators, images, user manuals, links to reviews published in period magazines, first of all the classic *Sinclair User, Your Spectrum/Your Sinclair, Crash!* and

MicroHobby, and other sites, for example *The Tipshop,* edited by Gerard Sweeney, that since 2001 has been collecting tricks, tips and solutions for games. To read historical magazines, there are direct links to scans on the Internet Archive *(www.archive.org),* while books, when available, can be downloaded in PDF format either directly from the archive or from the Internet Archive itself. Emulators are listed in a specific page that however needs updating, so it is better to refer to the relevant section of the forum. A specifically dedicated space for manuals and utility programs is lacking: the former must be consulted from the database, while the latter are reported on the forum.

WORLD OF SPECTRUM
www.worldofspectrum.org



Founded by Martijn van der Heide in 1995, *World Of Spectrum* was for two decades the reference site *par excellence* about the best-known Sinclair computer and everything else that can be connected in some way to it, from the ZX80 and ZX81 to the SAM Coupé, from Z80 Assembly to clones and peripherals, as well as emulators, applications and new software made by the enthusiasts community, whose lively participation was testified by a very popular forum.

Towards 2015, Van der Heide's commitment to managing the site began to wear off for personal reasons, which prompted him, in November 2017, to definitively leave not only *World Of Spectrum,* but the 'retro' scene altogether. The site therefore went through a period of stasis and uncertainty, in which the direction to take was not clear. The internal archive was left without updates for a long time, as well as the emulator and utility sections, just at a time when interest in the Spectrum was experiencing a considerable increase.

In June 2020, *World Of Spectrum* was radically renewed in both its appearance and internal structure, but this caused other perplexities. The new consultation interface seemed cumbersome to many users, many of the pages containing information and documents had disappeared and connections to external resources no longer worked. In disagreement with this choice, and more generally with the new management of the site, *World Of Spectrum Classic (worldofspectrum.net)* was created: a site, still under construction, reproducing the old one as faithfully as possible, but without the forum and with several parts still absent or only partially recovered.

Nevertheless, *World Of Spectrum* remains a worthwhile point of reference for anyone interested in Sinclair computers. In particular, the forum, although less active than in the past, continues to be a real treasure trove of technical information, code snippets, useful information and more general knowledge accumulated there over the years.

SPECCY.ORG

www.speccy.org

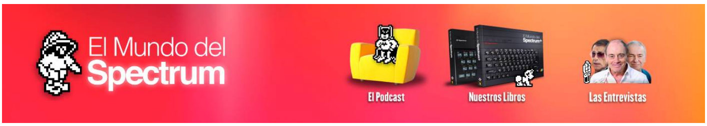
Spain, the ‘second homeland’ of the Spectrum, cannot fail to have its portal dedicated to the most famous Sinclair computer. *Speccy.org* hosts, in addition to a forum gathering users also from Latin America and other countries, a myriad of sub-sites, all having to do in one way or another with the Spectrum. Some examples:

- *SPA2 (Spanish Spectrum Archive),* a project aimed at collecting and preserving all Spectrum software made in Spain; it contributes to the *World Of Spectrum* and *Spectrum Computing* archives;
- *El Trastero Del Spectrum,* a vast archive of utilities and games preserved from the originals or in customized versions, scanned books and magazines, guides to programming and hardware modifications, accounts of the era and much more;
- *El Hardware Del Spectrum,* extensive collection of technical information on the Spectrum, its peripherals and clones, and a section about repairing the most common faults;
- *Mhoogle,* a search engine for articles published in *MicroHobby,* the historical Spanish magazine dedicated to the Spectrum, whose entire collection can be consulted online;
- the complete collection, with scans and tape image files, of the Spanish edition of *Load ‘n’ Run;*

- the official web pages of the ZX-Uno clone, the Pasmo assembler, the SevenUp graphics design program, the Octocom development team and of emulators such as ZX Baremulator and JSpeccy;
- Uto's web page, with software and information of various kinds, from the creation of text adventures to guides for using the DivIDE/DivMMC and the ZX-Uno;
- two sites (only one of them, however, is still updated) on the Argentine Czerweny clones.

EL MUNDO DEL SPECTRUM

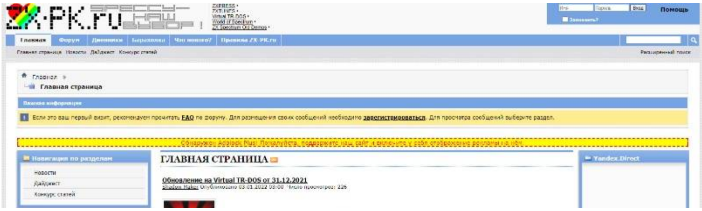
www.elmundodelspectrum.com



Since 1996, *El Mundo Del Spectrum* has been one of the most active information portals about everything related to the Spectrum. In addition to articles, it regularly releases podcasts. Naturally, since the staff and collaborators are Spanish, the site pays particular attention to the history and the 'retro' scene of the Spectrum in the Iberian country.

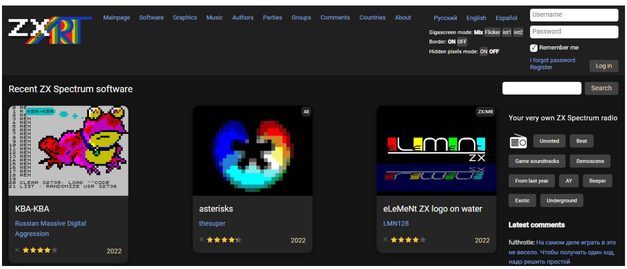
In particular, there are many news and accounts about the 'golden age' of Spanish software, including a section dedicated to interviews with personalities such as Steve Turner, Andrew Hewson, David Perry, Clive Townsend, Jon Ritman, José Manuel Muñoz, Enric Cervera and others. The site's editors – Alejandro Ibáñez, Jesús Martínez del Vas, Javier Ortiz and Juan Torres – also wrote two books on the history of the Spectrum, *El Mundo Del Spectrum* and *El Mundo Del Spectrum +*.

ZX-PK
zx-pk.ru



ZX-PK is the main site of interest for the large and active community of Sinclair users from the former USSR. As for the previous ones, the liveliest part is represented by the forum, divided in a very specific way. For example, in the 'ZX Spectrum software' section there are subsections for operating systems, graphics, music and demos in addition to the more usual ones for games and utilities. The home page collects news from the local scene. Other features include a blog, a space for the purchase and sale of used material and a collection of the latest forum interventions.

ZX-ART
zxart.ee



ZX-Art collects a huge quantity of Spectrum-related contents, frequently updated. The main part deals with graphics, even in modes other than the standard one, and to music for the AY chip. Contents mainly come from 'demo parties', historical and recent games, or are individually created. The site also hosts animations, demos, games and other software, such as electronic fanzines, the latter mostly coming from Russia. *ZX-Art* is also available in a simplified version for those who connect through Spectrum-based 'clients'.

LO ZX SPECTRUM IN ITALIA

zxspectrum.hal.varese.it

The website founded by Stefano Guida in 2003 is the main source for the knowledge of the history of the Spectrum in Italy. The site was one of the first, if not the first ever, to collect scans of various Italian publications on the subject, especially tape magazines sold in newsstands, accompanied by TZX image files of their cassettes. Here and there, some inaccuracies may however be found. For example, the '100% Italian programs' page hosts software which origin is all but Italian. Furthermore, the site has not been updated since 20 November 2016, and in the meantime other web portals such as *Edicola 8-bit, Microatena* or the Internet Archive undertook the preservation of the same contents. That said, the sheer amount of information and data available, including the *ZX News* bulletin, edited by Guida himself until 2005, makes the site a must not only for Italian enthusiasts, but for Spectrum enthusiasts as a whole.

PLANET SINCLAIR
rk.nvg.ntnu.no/sinclair

The historical site edited by Chris Owen was the first online archive of information on the ‘Sinclair world’. Founded in 1994, it has been for years the most important source of news on the history of Clive Sinclair, including many curiosities and background, and on the products he designed, from the small radio receivers of the 1960s to electric vehicles, and of course computers, including those launched after the Amstrad acquisition, and unrealized projects. Other sections concern clones, British magazines of the time and so on.

At the beginning of the 2000s, after a major restructuring, site updates became less and less frequent, and completely stopped in 2003. Not a few of its contents are now dated or partial, and obviously there is nothing to be found about the expansion of the retrocomputing and retrogaming scene in the 21st century. Nevertheless, *Planet Sinclair* is still an interesting starting point for the discovery of this ‘world’, especially with regard to its origins.

THE LOAD ZX SPECTRUM MUSEUM

There are several computer and videogame museums where Sinclair machines are exhibited. But only one in the world is expressly dedicated to them and in particular to the Spectrum. It is located in Cantanhede, a town in central Portugal halfway between Coimbra and Aveiro: the *Museu LOAD ZX Spectrum.*

There is a specific historical link between the country and Sinclair. In the early 1980s, Timex Portugal plants assembled ZX81 clones Timex TS 1000 and 1500 and 16/48K Spectrums. Later, they made the Timex Computer TC 2068 – a revision of the US Timex Sinclair TS 2068 – and the Timex Computer TC 2048 Spectrum clones, entirely developed and manufactured by Timex Portugal as the FDD and FDD 3000 floppy disk systems and the Timex Terminal 3000 for CP/M. It is no surprise, then, that the Spectrum made a name for itself in Portugal, and that a large and active community of enthusiasts is still present there.

After a temporary exhibition, on 17 October 2020, on the initiative of the municipality of Cantanhede and the local collector João Diogo Ramos, LOAD ZX Spectrum was inaugurated. It is housed in the premises of the former Conde

Ferreira primary school. The number of exhibits was enriched thanks to the contribution of many donors, so much that the museum, currently spread over an area of 100 square meters, is destined to expand further in the future. The collection includes a large amount of items, not only Sinclair or Timex computers, but also peripherals, other Sinclair branded products such as flat screen TVs and the C5, various Spectrum clones and other 8-bit machines, books and magazines. There is even the reconstruction of a room of a typical Portuguese house from the 1980s, with the Spectrum on display.



On the museum's website *(loadzx.com),* a virtual visit can be taken. It also hosts a vast digital archive, the result of the synergy between LOAD ZX Spectrum and the *Planeta Sinclair* blog by André Leão. Contributors also include Filipe Veiga from *Espectro* magazine, Pedro Pimenta, the creator of the *Timex Computer World* website João Encarnado and Brazilian Marcus Garrett Chiado, editor of *Jogos 80* magazine.

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Note: neither the latest 0.9d version nor the previous ones can be downloaded from the links in the website copies. The last version available is 0.9c2, downloadable from: *www.alessandrogrussu.it/zx/winTZX0.9c2.zip*

DamTape/MDR2TAP: *web.tiscali.it/andregiax/damtape/*
FDRAWCMD.SYS: *simonowen.com/fdrawcmd/*
SAMdisk: *simonowen.com/samdisk/*
HDFMonkey: *github.com/gasman/hdfmonkey*
HDFMonkey (Windows):
uto.speccy.org/downloads/hdfmonkey_windows.zip
HDFGooey: *zxbasic.uk/files/hdfgooey-latest.zip*
SPXFR: *www.angelfire.com/games6/atari2600/spxfr/index.html*
ZX Tape Player: *github.com/semack/zx_tape_player*
Time Gal project:
atmturbo.nedopc.com/download/cdsoft/time_gal/time_gal.htm
Pac-Man Emulator: *simonowen.com/spectrum/pacemuzx/*
Space Invaders Arcade Emulator:
www.alessandrogrussu.it/zx/SIAE.zip
ZXZVM: *www.seasip.info/ZX/zxzvm.html*

Chapter Three

Davide Barlotti shows the restoration and operation of a Videobit S 80: *www.youtube.com/watch?v=Bsc9Gqsmnrg*
Biblioteca della Fondazione Museo del Computer ONLUS: *museodelcomputer.org/index.php/nav=Biblioteca.40*
Note: it includes PDF scans, made by Gianfranco Mazzarello, of Italian books about the Spectrum and other platforms.
Microatena digital library, edited by Gianfranco Mazzarello: *www.microatena.it*
'Gli amici di Hal' old computers museum, by Bruno Grampa: *www.museo-computer.it*
Note: it gathers a large quantity of Italian magazines, not only focused on the Spectrum but on the 8 and 16-bit computing scene as a whole, which can be browsed directly from the site. Among others, it hosts several issues of *Super Sinc* and the complete series of *Sinclair Computer.*

Stefano 'Steed' Kulka's website: *www.rescogita.com*

Sinclub: *archive.org/details/Sinclub*

Carlo Altieri's web page with information on his game *The Magicland of Landlords,* released on *Load 'n' Run* issue 27 (May 1986): *users.libero.it/c_altieri/mlol.htm*

Spanish edition of *Load'n'Run*: *loadnrun.speccy.org*

Edicola 8 bit: *www.edicola8bit.com*

Italian ZX Spectrum mailing list, maintained by Enrico Maria Giordano: *www.freelists.org/list/zxspectrum*

Sinclair Italy blog, maintained by the Apulia Retrocomputing cultural association: *sinclairitaly.wordpress.com*

Web portal of information and videogaming culture with a Spectrum section edited by the writer: *www.gamesark.it*

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