

# SMART Card for ZX Spectrum 48 by Phil / retroleum.co.uk

Full Manual 06-11-2018: Firmware.v11 & Snapload.v32

(Download: [www.retroleum.co.uk/smart.zip](http://www.retroleum.co.uk/smart.zip) for latest files)

**WARNING: As with any Spectrum interface, the power should be disconnected before attaching or removing the SMART Card otherwise damage can occur to the Spectrum and / or interface. To prevent movement of the edge connector contacts, do not connect anything to the SMART card or change its DIP switch settings when the power is on. The SMART Card was not designed to be used in conjunction with any other Spectrum Interface.**

## Brief Description:

The SMART Card is an expansion interface PCB for the Sinclair ZX Spectrum, it offers ROM substitution, SD card support, a Kempston joystick interface and buffer SRAM. It is intended primarily as a simple low-cost game loader / freezer for 48K Spectrums and/or a diagnostic cartridge for all models of Spectrum.

The interface forces the Spectrum to boot from one of sixteen external ROMs instead of its internal BASIC ROM. In normal operation, the first ROM in the SMART (called the Firmware) is always executed at power up, though its code contains a switching mechanism which can select one of the other fifteen ROMs automatically or manually, depending on whether the GOTO feature is set (or the Zero key is held on power up). As supplied, GOTO is set to Slot C which contains the game loader ROM.

External ROM code provides a way for diagnostic software to run even when the Spectrum's ROM and RAM are faulty. To this end the Retroleum DiagROM is supplied in ROM Slot B. DIP Switch 3 forces the SMART Card to boot this slot directly, providing a way to quickly access diagnostic software on faulty Spectrums. (The GOTO setting is irrelevant when the switch is set to "Diag" as the Firmware in Slot A is not booted first in this mode).

As supplied, the ROM slots are configured as follows:

Slot A: "Firmware" - ROM Menu / Manager program. Maintains an index of ROMs installed.  
Slot B: "DiagROM" - Spectrum test software  
Slot C: "Snapload" - Game loader / freezer  
Slot D: "Toolkit" - Used to format SD Cards with the FAT16 filesystem  
Slots E-P are empty.

(To manually select a ROM, hold down the Zero key on power up to go to the ROM Menu)

The V1 SMART Card is aimed primarily at the Spectrum 48 (at present, the software only supports 16K/48K games) but it does have a jumper which allows it to work on other models. When the jumper is on the left side marked "48", the interface can be used with the Spectrum 48 and 128 (and the grey +2 model, although the V1 SMART Card won't physically fit the machine without removing its case). When the jumper is set on the right side (marked AB3) the interface can be used on the black 128+2A/B and +3 machines (again, it won't actually fit the case – but can be used for diagnostics when the Spectrum case is removed). The SMART Card has not been tested on non-UK models or clones.

## Disabling the SMART Card / Accessing Sinclair BASIC:

The interface can be disabled in various ways without removing it.

1. In hardware: Set DIP Switch 1 to OFF (down) This mode is usually only necessary for programming a blank or corrupted SMART Card.
2. To go to Sinclair BASIC from the Snapload game loader, press Caps Shift + Space. You will still be able to use the NMI button features (POKEs, save snapshots of the memory).
3. To go to Sinclair BASIC from the Firmware ROM Menu, hold the Zero key on power up, then press "S" on the ROM menu screen (the NMI button features will NOT be available because they are part of the Snapload ROM which will not have run).

## Buttons, Switches and LEDs:

- The left button resets the system.
- The right button issues a Non-Maskable Interrupt (NMI) . When the NMI button is pressed whilst playing a game loaded from the snaploader, a menu will appear allowing POKEs to be entered or a snapshot of the "frozen" game to be saved. When other ROMs are selected, the NMI button will trigger whatever NMI handling code is in that particular ROM.
- The blue LED lights up whenever an external ROM image is active (when the internal Sinclair ROM is in control this LED is off).
- The red LED lights up when EEPROM writes are enabled.
- The green LED lights during SD Card activity.

## DIP Switches:

- DIP Switch 1 enables / disables the SMART Card.
- DIP Switch 2 enables / disables writes to the onboard EEPROM (keep this set OFF unless required)
- DIP Switch 3 forces a boot from SLOT B (where the diagnostic ROM usually resides) when set to ON
- DIP Switch 4 enables / disables the joystick port (on PCB versions from v1.05)

## Kempston Joystick Interface:

The joystick port is wired as a standard Kempston (Port 31) format - 2 fire buttons are supported. A small amount of power is available on pins 5 and 7 for joysticks that require it (EG: Megadrive pads). On PCB versions v1.05 and above, DIP Switch 4 enables/disables this port.

## **Firmware (ROM Menu / Manager) – Default Slot A**

When starting up, the firmware tests to see if the Zero key is held, if it is then the ROM menu is displayed. If not, the code checks to see if the GOTO feature is set – if it is then a ROM slot is automatically selected and the system resets (thus booting the desired ROM). To remove the GOTO permanently (and have the system boot to the ROM menu each time) just set it to go to Slot A with option 6 in the ROM Manager.

### **ROM Manager:**

On pressing ENTER on the ROM menu screen, the ROM Manager options appear. This option allows ROM slots to be loaded, erased, copied, renamed etc - most of the options are self-explanatory. Note that there is a special option (1) for updating the Firmware (IE: The ROM menu / manager program itself) - this is to protect the ROM index which is also located in SLOT A.

Notes:

- Video glitches during FlashRAM writing are normal (an artefact of the EEPROM programming protocol)
- The Config option for V2 SMART Cards allows the joystick port to be disabled, should that be desired.

If for any reason the ROM Manager needs to be restored, it can be reloaded from tape via the EAR socket. For files and instructions see the troubleshooting section of this document.

## **Diagnostic ROM – Default Slot B**

This ROM can be used to test and diagnose faults with Spectrums. It can be started from the ROM menu like any other ROM, however since the Spectrum under test may have faults that prevent user interaction it is best to use the Diag Mode switch to force the SMART Card to boot slot B directly. (The DiagROM itself does not need any good RAM to start). See the Diagnostic ROM manual for more information.

## **Snapload ROM – Default Slot C**

This ROM is a game loader / freezer / snapshot saver. You can navigate the files on your SD card with the keys Q,A,O,P and Enter, or with a joystick. The SD card needs to be formatted to FAT16. (.sna files and most .tap files of Spectrum 48K games are supported) To activate .tap support, a patched version of the Sinclair ROM must be installed in any slot (Amstrad have a caveat in their Sinclair ROM distribution permissions which states their ROM code cannot be pre-installed on new hardware). However, this patched ROM can be automatically generated and installed the first time a .tap file is selected – you will see a prompt for this. Please note: some .tap files may not work - see the technical section for more info about Spectrum game file types.

The following key combinations are active in the file browser:

- Caps Shift+Space (Break) = Boot Sinclair BASIC. The NMI button features will still be available meaning games loaded from physical tape with LOAD "" etc can have snapshots saved.
- Symbol Shift + D = Delete a file
- Symbol Shift + N = Make a new folder
- Symbol Shift + 0 = Reboot to ROM selection menu (In LOAD mode) or quit back to the freezer menu (in SAVE mode).

## **NMI Menu**

### **Entering Pokes:**

To use this feature, load a game and press the NMI button - you should hear a beep and be prompted with a menu, press "P" for POKES. A window with "POKE -----,---" will appear. First, type the address of the value you want to change (5 digits). The current byte at that address will appear. You can now type a new value over the top (3 digits, range 000-255). (Press the Caps-shift key to redo the address or value). When a value is entered, the data scrolls up and you can enter another POKE or quit back to the freezer menu (with Enter).

### **Saving snapshots:**

When playing a game, press the NMI button. Select "S" for Save Snapshot. You can immediately type a filename (and press Enter to save the file), or browse the SD card to locate it in a different folder. To go into file browser mode, press Caps Shift at the filename prompt. Once you have moved to the destination folder, press Caps-Shift again to enter a filename (or press ENTER on an existing file to overwrite it).

### **Tape position:**

When loading a .tap file, the current tape position can be stored and updated later (these options don't appear in the NMI menu when a .sna file is loaded as they are irrelevant to them).

### **A note about NMI limitations:**

Some games may not restart if frozen at certain points – this is unavoidable as they will have been programmed with very tight constraints regarding stack use. However, freezing during the title screen or whilst paused will usually get around this.

## **Toolkit ROM – Default Slot D**

At present, this ROM has only one feature – it provides the ability to format any SD Card to FAT16 in situ.

## **Troubleshooting:**

### **Problem:**

Spectrum does not boot when SMART Card is connected.

### **Solutions:**

1. Check that the Spectrum's edge connector is clean. Use isopropyl alcohol on a cotton bud to clean it, upper and lower sides.
2. Check the Spectrum model jumper is connected correctly.

### **Problem:**

Card is not recognised.

### **Solution:**

Use a good brand card such as Kingston and Sandisk (4GB max) and make sure it is formatted to FAT16. Windows will not (by default) format cards bigger than 4GB to FAT16, but it is possible – see the instructions included elsewhere in this archive. For Mac users there is formatting information at: [tinyurl.com/macsdifat16](http://tinyurl.com/macsdifat16)

### **Problem:**

.sna files do not start when loaded.

### **Solutions:**

1. A tiny minority of Spectrums have out-of-spec Z80 CPUs - when replaced, this problem goes away.
2. Check the Spectrum's memory with the DiagROM.

### **Problem:**

Even when a ROM with a valid NMI handler is active, the NMI button crashes the Spectrum or does unexpected things.

### **Solution:**

Some Z80 CPUs do not seem to handle non-maskable interrupts correctly. Replacing the CPU invariably fixes this.

**Problem:**

Firmware or other ROMs do not run.

**Solution:**

You can check the data integrity of the EEPROM with the ROM Manager options (if you can get that far). If, for some reason a ROM has become corrupt – simply reinstall it.

If the firmware (Slot A) has been corrupted you will need to restore it from tape. Download the latest files from the project archive here: <http://www.retroleum.co.uk/smart.zip>

Next, with the Spectrum powered off - set the DIP switches as follows:

- 1 - OFF (down)
- 2 - ON (up)
- 3 - OFF (down)
- 4 - (doesn't matter)

Connect the Spectrum EAR socket to a device that is able to play .wav files loud enough for the Spectrum to pick up.

Type LOAD "" ENTER and play the file **smart\_fw06\_initializer.wav** from the folder **"firmware/fresh\_install\_from\_tape"** (you can use the .tap file with a tool such as TAPIR instead if you wish.)

Follow the on-screen instructions when loaded (basically, hold ENTER). The border will flash during re-programming. Upon completion, power off and set DIPSW 1 to ON (up). The card should now work as normal.

If necessary, please update the firmware to the latest version using the ROM manager tools, option 1 (the tape installed version may not be current). Also note that the above procedure will have erased the ROM index (but not the ROM slot contents) so you'll want to either manually rename the slots or just reinstall the ROMs with the ROM Manager.

When all done, power off and set DIP SW 2 to OFF (down) to prevent accidental writes to the EEPROM.

## The Technical Section:

### Control Ports:

**FlashRAM** selection / switching is controlled from **IO port \$FAFB** - this is a read / write port which is cleared on power up or when the reset button is pressed.

- Bit      0:3 - Select the 16KB section of FlashROM that appears to the CPU @ \$0000-\$3FFF\*  
          4:5 -Not used, reads back as written.  
          6   - Prime the ROM switch-out system for restarting snapshot files\*\*  
          7   - Disable the SMART card's memory IE: Use Spectrum's own ROM (software equiv. of DIP switch 1)

\* When DIP Switch 3 is set to ON, the value in [0:3] is ignored, Slot B always selected.

\*\* When set, the SMART card's memory is automatically paged out when the Program Counter reads from address \$xx72 (bits 6,5,4 and 1 are decoded). When reading, this bit always returns 0.

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**SRAM selection** is controlled by **IO port \$FAF3**, this is also a read/writeable port that is cleared upon reset.

- Bits:    0:3 – Selects which 8KB bank of SRAM appears at \$2000-\$3FFF (when enabled)  
          4   – Serial TX when written to, Serial RX when read.  
          5   – AUX SPI\_CS signal (see 4x2 header) 1 to select, 0 to deselect (output is inverted by PCB)  
          6   – SD Card CS control (write 1 to select SD card, 0 to deselect) – also activates green access LED  
          7   – SRAM enable\*. When set, SRAM replaces FlashRAM in memory locations \$2000-\$3FFF.  
             Note if the SMART card's memory is disabled, this has no effect.

\* Note: The onboard FlashRAM chip is type 39SF020. The write protocol for this chip requires address \$2AAA (and \$5555) to be written before each programmed byte (which is why video “glitches” can be seen whilst data is written to the chip). Enabling SRAM at \$2000-\$3FFF prevents the FlashRAM chip being selected for address \$2AAA so it cannot be written to in this mode.

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**Data to from the SD card** is controlled via **IO port \$FAF7** – this is a read/write port.

Bit 0:7 Data for SD card

Note: There is no serializer busy flag – Make sure at least 12 3.5MHz Z80 CPU cycles elapse between accesses to this register. (The SPI clock runs at 8MHz.)

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**The joystick** is read from IO port \$1F as defined by the Kempston standard (address bits 7:0 are decoded.) Bits that are set indicate that a direction is selected (IE: The interface inverts the input level of the pins).

- |               |              |
|---------------|--------------|
| Bit 0 – Right | 4 - Button 1 |
| 1 – Left      | 5 - zero     |
| 2 – Down      | 6 - zero     |
| 3 – Up        | 7 - Button 2 |

## Connectors / Pin headers:

The Joystick DSUB-9 pins are connected as follows:

Pin	1 – Up (10K pull-up)	6 – Button 1 (10K pull-up)
	2 – Down (10K pull-up)	7 – 3.3 v (via the same 47 ohm resistor)
	3 – Left (10K pull-up)	8 – GND
	4 – Right (10K pull-up)	9 – Button 2 (10K pull-up)
	5 – 3.3v (via 47 ohm resistor)	

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The 4x2 pin (or 5x2\*\*) header has the following layout / pin-outs:

**1 3 5 7 (9\*\*)**  
**2 4 6 8 (10\*\*)**

- 1 – Serial RX (input to bit 4 of port \$FAF3 when read) \*
- 2 – 5 volts
- 3 – SPI\_CS (inverted output from bit 5 of port \$FAF3)
- 4 – Serial TX (output from bit 4 of port \$FAF3 \*
- 5 – SPI D\_out (IE: Input to CPLD)
- 6 – SPI D\_in (IE: Output from CPLD)
- 7 - GND
- 8 – SPI\_Clock
- 9 – NMI input to CPLD (pulled high via 10K, button pulls this low) \*\*
- 10 – Reset input CPLD (pulled high via 10K, button pulls this low) \*\*

Notes:

SPI bus lines D\_out, D\_in and SPI\_Clock are shared with the SD card, the SPI\_CS line is dedicated to this port).

\* On PCB versions 1.06 and above these are logic level input / outputs (LVTTL 3.3v output, 5v tolerant input). Previously, they were used for RS232 level I.Os if an optional ST232 level converter chip was fitted. By default, to keep costs down this chip (and its support capacitors) were generally NOT fitted to the SMART Card and these pins unconnected.

\*\* Only on PCB version 1.08 and above. The NMI input is de-bounced (for button switch) by CPLD core logic.

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The 6x1 pin header is for JTAG configuration of the CPLD:

**1 2 3 4 5 6**

- 1 - TMS
- 2 - TDI
- 3 - TDO
- 4 - TCK
- 5 - GND
- 6 – Vcc (3.3v output - provided by onboard voltage regulator).

To re-program the CPLD, disconnect the interface from the Spectrum, connect 5volts to pin 2 / Gnd to pin 7 of the 4x2 header) and a JTAG cable header to this connector:

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**The 3x1 pin header** is used to select compatibility with the different edge connectors used across the Spectrum range. IE: It determines whether ROM\_CS is applied to pin 25 or pin 15 of the lower edge connector. (The ROM\_CS signal is always sent to upper pin 4)

The jumper must be set appropriately for the host machine. (It will almost always be set to “48” since the SMART Card will not physically fit the Spectrum 128+2 onwards, at least when the top of the case is attached.)

### 1 2 3

- When the jumper is across pins 1-2, the edge connector mode is set for the original Sinclair Spectrum style - this includes the Spectrum 128 (known as the “toast rack”) and Amstrad's Spectrum 128 +2 (the grey-cased version).
- When the jumper is across pins 2-3, the edge connector mode is set for the Amstrad Spectrum +2A, +2B or +3)

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### Game File Types:

**.SNA files:** These are simple snapshots of the Spectrum's memory (and CPU registers) taken at some point when a game was running. With these files it is straightforward to load a game back into memory and continue where it left off. However, games which loaded extra data (for levels etc) cannot be accommodated. (.Z80 is a variation of this format and not currently supported by the SMART Card).

**.TAP files:** These files are a dump of a game's entire cassette tape, so multi-load games can be supported. To use .tap files on a real Spectrum, the SMART Card game loader redirects calls made to the Sinclair ROM loading routines to its own SD Card-based file handler. In theory this provides a system-transparent method of handling tape loading via SD card. However, things are not quite this straightforward: Most commercial games used non-standard loading routines (for protection etc) which did not call the ROM's loading code. There is no way of intercepting their tape loading routines as they vary from one game to another. To get around this, most .tap games on World Of Spectrum have been modified to remove the protection. (Sometimes .tap games will pause midway through loading until a key is pressed – they will then continue loading).

**.TZX files:** These are a more complex version of .TAP files which can encode non-standard loading protocols (turbo loaders etc) directly. This is really only useful for PC-based emulation and these files are not supported by the SMART Card.

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### Files for SMART ROMs etc:

All ROM files (except the FIRMWARE) are 16KB – they're simply .bin files with the extension renamed to show a version number. Firmware update files are shorter (12KB) because the final 4KB of SLOT A in the EEPROM is used for the ROM index etc and is not to be overwritten.

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For more information you can contact me at: [smart-info@retroleum.co.uk](mailto:smart-info@retroleum.co.uk)