

SMART Card V2 for ZX Spectrum 48 by Phil Ruston

www.retroleum.co.uk

Full Manual 11-05-2020 for Firmware.v12 & Snapload.v32

(Download: 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 or disconnect anything to the SMART card 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. The "Mode" switch on the back of the PCB 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 the ROMs installed.
Slot B: "DiagROM" - Spectrum test software
Slot C: "Snapload" - Game loader / freezer
Slot D: "Toolkit" - Used to format SD Cards of all sizes to FAT16
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 V2 SMART Card automatically detects the Spectrum model so should work on all the standard UK Spectrums (48 / 128 / +2)(AB) / +3) although at present the software only supports 16K/48K games. It has not been tested on overseas models or clones.

Disabling the SMART Card / Accessing Sinclair BASIC:

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

One-time options:

- Hold the reset switch on power up (and release after 1 second) The card is disabled until the power is removed and is usually only necessary for programming a blank or corrupted SMART Card.
- At the Snapload ROM file lister, press Caps Shift + Space. You will still be able to use the NMI button features (ie: Enter POKEs and save snapshots of the memory).
- At the Firmware's ROM menu (hold the Zero key on power up) 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).

"Permanently" - (Firmware V12 onwards)

- Hold the Zero key whilst powering up to go to the ROM menu. Press Enter to go to the ROM Manager, then choose option 9 – Configuration. Finally Press 3 or 4 to disable or re-enable the SMART Card. When the SMART Card is disabled the Spectrum will boot from its internal ROM (unless Zero is held to go to the ROM menu). The Kempston joystick port will still be usable unless it too is disabled. Note: When the card is in Diag mode, this setting is ignored (because the interface then skips the Firmware ROM and boots directly from the ROM in Slot B).

Buttons, Switches and LEDs:

- The left button resets the system. If the reset switch is held during power-up, the SMART Card's external ROM is disabled so the Spectrum boots to the internal Sinclair ROM – this persists until the power is removed.
- 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 slide switch selects the operating mode. "Norm" is normal mode (SMART Card boots from Slot A, and observes the GOTO setting). "Diag" forces the SMART Card to boot directly from (and is locked into) SLOT B where the diagnostic ROM usually resides
- 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 green LED lights during SD Card activity.

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). The joystick port can be disabled using the Config option in the ROM Manager options.

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.

Snaploader 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. There is a caveat in the Sinclair ROM distribution agreement which states the code cannot be pre-installed on new hardware, however, this patched ROM is automatically generated and installed the first time a .tap file is selected. 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:

From SNAPLOAD.V32 it is possible to store the current tape position and restore it later – this can be used for reloading levels in multi-load games etc. These options only appear in the NMI menu when a .tap is loaded (as they are irrelevant for .sna files).

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.

The Spectrum tends to crash on returning to BASIC programs from an NMI freeze. This is likely a consequence of the way the SMART CARD switches ROMs without relying on a working CPU M1 signal.

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:

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

Problem:

On booting (to the Snapload ROM) you see a large scrolling message saying there was a memory error.

Solutions:

This occurs if the Snapload ROM was not able to copy data to the SMART Card's onboard RAM – first check that the Spectrum's edge connector is clean (no corrosion). Next check the Spectrum's own RAM is OK with the DiagROM (select with the switch on the back of the PCB). Finally, check the SMART Card's RAM with the program “memtest.bin” found in the Apps folder (Warning: memtest.bin deletes all ROMs on the SMART Card apart from the firmware).

Problem:

SD Card is not recognized.

Solution:

Use a good brand card such as Kingston and Sandisk (4GB max) and make sure it is formatted to FAT16. If in doubt you can use the SD Card Formatter in the SMART Card's Toolkit ROM (hold ZERO at power on and then select this ROM by pressing the appropriate key). This may be preferable because Windows will not (by default) format cards bigger than 4GB to FAT16, though it is possible – instructions included elsewhere in this archive. For formatting with a Mac information can be found at at: tinyurl.com/macsdfat16

Problem:

.sna files do not start when loaded.

Solutions:

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

Problem:

NMI button crashes/resets the Spectrum.

Solution:

- The active ROM must have a valid NMI handler. Ordinary Sinclair BASIC does not have such a routine – however the Snaploader ROM sets things up so that it takes over when the NMI button is pressed (even if Caps Shift + Space was pressed to go to Spectrum BASIC).

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, as follows (these instructions assume a standard 48K Spectrum is being used).

1. Download the latest files from: <http://www.retroleum.co.uk/smart.zip>
2. Unzip the file and copy the firmware file (EG: Firmware.v07) from the “Reinstall” folder onto your SD Card.
3. Connect the Spectrum EAR socket to a device that is able to play .wav files loud enough for the Spectrum to pick up.
4. Put the SD Card in the SMART Card. Hold the SMART Card's reset button for 2 seconds whilst powering on the spectrum, then release it – the Spectrum should boot to BASIC.
5. Enter the command LOAD "" [ENTER]
6. Play the file “firmware_installer.wav” from the “Reinstall” folder. (You can use the .tap version of this .wav file with a PC app such as TAPIR instead if you wish)
7. Follow the on-screen instructions when the program has loaded. (Basically, you'll browse to and select the Firmware.Vxx file you placed on the SD Card earlier. The border will flash during re-programming.)
8. Upon completion, power off and back on, the card should boot to the ROM Selector.
9. Press Enter to go to the ROM Manager, using option [6] set the GOTO bank back to “C”

Please note: The above procedure will have erased the ROM index (but not the contents of the ROM slots) so you'll want to either manually rename the slots or just reinstall any missing ROMs using the ROM Manager. (The DiagROM goes in Bank B, Snapload goes in bank C – these can be found in the ROMs folder)

The Technical Section:

Control IO Ports:

\$FAFF – V2 Config Port – WRITE ONLY

- Bit 0 – EEPROM write enable (set = writes enabled, see also bit 7) Cleared on power on / reset button.
 1 - Joystick port enable (set = joystick port disabled, see also bit 7) Cleared on power on only.
 2 – SRAM Control Feature (1 = Switch out SRAM upon next external ROM access, self-resetting)
 3:6 – Not used
 7 – Controls whether writes to bit 0 and 1 are set or reset*

* This mechanism allows discrete writes to bits 0 and 1 without affecting the other bits. EG: Writing \$81 to this port sets the EEPROM write enable flip-flop without changing the joystick enable flip flop (writing \$01 clears the write enable flip-flop.. etc)

\$FAFB – External ROM (flash RAM) bank selection / switching control. Read / write port. Cleared on power on / reset button

- Bit 0:3 - Select the 16KB section of FlashROM that appears to the CPU @ \$0000-\$3FFF*
 4 - Not used, always reads back as 1 on SMART Card V2 (previously it read back as written)
 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)

* In Diag mode, 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.

\$FAF7 - Data to / from the SD card - 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.)

\$FAF3 - SRAM selection - Read / Write port. 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.

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)	

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

External device header pads: 5x2 pins - Uses the following layout / pin-outs:

1 3 5 7 9
2 4 6 8 10

- 1 – Serial TX (output from bit 4 of port \$FAF3 *
- 2 – 5 volts output (can also be used to power the SMART Card if not connected to Spectrum)
- 3 – SPI_CS (inverted output from bit 5 of port \$FAF3)
- 4 – Serial RX (input to bit 4 of port \$FAF3 when read) *
- 5 – SPI D_out (IE: Input to CPLD)
- 6 – SPI D_in (IE: Output from CPLD)
- 7 - GND
- 8 – SPI_Clock
- 9 – Reset switch input (pulled high via 10K, the left button pulls this low) **
- 10 –NMI switch input (pulled high via 10K, the right button pulls this low) **

Notes:

The functions of pins 1&4 and 9&10 are swapped compared to the V1 SMART Card

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).

* These are logic level input / outputs (LVTTTL 3.3v output, 5v tolerant input). Input has a 10K pull down resistor.

** The NMI button input has an RC/Diode de-bounce circuit.

JTAG Config:

The V2 SMART Card does not have a pin header but still has JTAG pads arranged in 2x3 format:

A B	A = 3.3v	B = GND
C D	C = TDO	D = TCK
E F	E = TDI	F = TMS

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

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 so 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. As a rule, if a .tap shows non-standard border stripe colours on loading under a PC emulator, then it won't work on the SMART Card. (Note: 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. These files are only useful for PC-based emulation and are not supported by the SMART Card.

Files for SMART ROMs etc:

All ROM files (except firmware updates) 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 when updating.

For more information you can contact me at: smart@retroleum.co.uk