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

Full Manual 01-05-2017

(Download: www.retroleum.co.uk/smart.zip for latest version)

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 (16 banks, 16KB each), SD card support, a Kempston joystick interface and buffer SRAM. It is intended primarily as a simple low-cost game loader for 48K Spectrums and/or a diagnostic cartridge for all models of Spectrum (note that the card will not physically fit +2 / +3 model Spectrums with their cases on.)

As supplied, the first ROM slot (Slot A) is occupied by a Menu / Manager program (which is referred to in this document as the “firmware”). Slot B contains a Spectrum hardware test ROM and Slot C contains a snapshot game loader. The firmware maintains an index of the ROMs that are installed and allows new 16KB ROM images to be loaded, selected etc.

Buttons and Switches:

The left button resets the system (and also clears the ROM / SRAM bank select registers thus enabling the SMART Card's memory – as long as it not disabled by DIP Switch 1).

The right button issues a Non-Maskable Interrupt (NMI) and re-enables the SMART Card's memory (following a snapshot file load). There needs to be an NMI handler in the currently selected ROM for anything useful to happen - if not, pressing this button will usually just crash / reset the Spectrum.

The DIP switches have the following functions:

- Switch 1 – Enables / Disables SMART Card memory. When set to ON, the internal Spectrum ROM is disabled and the SMART Card's ROM takes over, indicated by the blue LED being lit. (There is also a software control that can override this to force Spectrum internal ROM mode.)

- Switch 2 - Enable / Disable SMART Card EEPROM writes . The FlashRAM on the SMART card can only accept new data when this switch is set ON. (The red LED is lit when writes are enabled).

- Switch 3 - Bank B Override Mode. When set to ON, the SMART card starts directly from - and can only access - ROM slot B. This is useful when using the card as a diagnostic tool to test faulty Spectrums (as long as a suitable DiagROM is loaded into Slot B, of course!). Rationale: The firmware relies on good working memory and always runs before switching to other slots via the GOTO mechanism. Bad memory could crash the Spectrum before a diagnostic ROM has chance to execute.

- Switch 4 is used on PCB versions 1.05 and above to enable/disable the Kempston joystick port. Previously it was unused.

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

The ROM Menu tests to see if the GOTO feature is set. If not, a menu is displayed with a prompt for the user to select a ROM (or press ENTER to use the ROM Manager.) If a GOTO slot has been set up then that slot is selected and the system resets. The GOTO feature can be overridden by holding down the Space key on power up. Afterwards, Keys A-P select their respective ROMs and Enter brings up the ROM Manager. To remove the GOTO permanently, just set it back to Slot A with option 6 in the ROM Manager.

ROM Management Tools:

On pressing ENTER on the ROM menu screen, the ROM Manager options appear. This option allow 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:

- The write enable DIP switch must be ON to update anything in the SMART card's FlashRAM.
- The GOTO feature can be used to make the SMART card switch immediately to a different ROM.
- Video glitches during FlashRAM writing are normal (an artefact of the EEPROM programming protocol)

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 the firmware relies on the Spectrum having good RAM so it may not start if it is faulty. Therefore, it is best to use the "Slot B override" switch (DIP Switch 3) to force the SMART Card to boot slot B directly. (The Diag ROM itself does not need any good RAM to run). See the Diagnostic ROM manual for more information.

Snapshot Loader – Default Slot C

This ROM is a simple snapshot file selector. You can navigate with the keys QAOP and Enter, or with a joystick. An SD card formatted to FAT16 which contains your snapshots must be inserted. The snaploader ROM supports 48K .sna files - and from v.03 - some .tap files.

Tap file support: To activate .tap support, a patched version of the Sinclair ROM must be installed in slot D. Unfortunately Amstrad have a caveat in their Sinclair ROM distribution permissions which prevents the ROM being pre-installed on new hardware. However, the patched ROM can be automatically installed the first time a .tap file is selected (EEPROM writes must be enabled – ie: DIP Switch 2 set to ON). Please note: some .tap files may not work - see the technical section for more more info.

Entering POKEs

(This feature is currently in beta-test)

The patched Spectrum ROM generated by Snaploaд V07 also allows POKES to be entered **in games loaded from .tap files** (previously, this required a 3rd party ROM). To use this feature, load a game from a .tap file and press the NMI button - you should hear a beep and be prompted with "POKE -----,---" at the bottom of the screen.

First, type the address you want to change (5 digits). The current value at that location will appear. At this point you can press ENTER to just use the same value ie: leave it unchanged) or type a new value over the top (3 digits, range 000-255).

When a value is entered, the data scrolls up and you can enter another POKE or quit back to game (with Enter) - The game should continue where it left off.

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. For Mac users there is formatting information at: tinyurl.com/macsdfat16

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)

(continued..)

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 at 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 [0:4] 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.

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.

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.)

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)	

The 4x2 pin (or 5x2) header** has 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
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 – 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.

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:

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)

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.

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. The FIRMWARE.Vxx file is 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.

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