

DivMMC USB HID Adapter

Feature Reference v1.0

USB HID adapter for ZX Spectrum DivMMC. Adds USB mouse, keyboard, and joypad support via SAMD21E18A microcontroller and Gowin GW1N FPGA. Supports up to 3 devices simultaneously, including composite USB dongles (Dell, Logitech).

SPI Communication Protocol

15-byte packet from SAMD21 to FPGA at 4 MHz SPI clock. Each device type has dedicated byte offsets with zero conflicts.

Byte	Contents	FPGA Module
0	Mouse buttons [0 0 0 0 0 mid right left]	mouse_port
1	Mouse delta X (signed)	mouse_port
2	Mouse delta Y (signed)	mouse_port
3	Mouse scroll wheel (signed)	mouse_port
4	Joypad buttons [fire4 fire3 fire2 fire1 R L D U]	joystick_port
5-12	Keyboard rows 0-7 (active low, ZX matrix)	keyboard_overlay
13	Keyboard-joy [0 0 fire2 fire1 R L D U]	joystick_port
14	Commands [0 0 0 0 0 reset btn_r btn_l]	MAIN (button logic)

GPIO Status Pins (SAMD21 to FPGA)

Pin	Signal	Description
PA00	mouse_connected	High when USB mouse is present
PA01	keyboard_connected	High when USB keyboard is present
PA02	joy_connected	High when USB joypad is present
PA03	arrows_as_joy	High when F3 joy mode is active

USB Keyboard Mapping

Letters, Numbers and Direct Keys

All alphanumeric keys (A-Z, 0-9) map directly to ZX Spectrum equivalents. Enter and Space also map directly.

Modifier Keys

USB Key	Normal Mode	Joy Mode (F3)
Left / Right Shift	CAPS SHIFT	Right only: CAPS SHIFT
Left Ctrl	SYMBOL SHIFT	Fire 1

USB Key	Normal Mode	Joy Mode (F3)
Left Alt	SYMBOL SHIFT	Fire 2
Right Ctrl	SYMBOL SHIFT	SYMBOL SHIFT
Right Alt	SYMBOL SHIFT	SYMBOL SHIFT

Special Keys

USB Key	ZX Spectrum Action
Escape	CAPS SHIFT + 1 (EDIT mode)
Backspace	CAPS SHIFT + 0 (DELETE)
Delete	CAPS SHIFT + 0 (DELETE)
Tab	CAPS SHIFT + SYMBOL SHIFT (Extended mode)
Caps Lock	CAPS SHIFT + 2 (CAPS LOCK toggle)

Arrow Keys

In normal mode, arrow keys map to ZX Spectrum+ cursor keys with CAPS SHIFT (CAPS+5, CAPS+6, CAPS+7, CAPS+8). When F3 joy mode is active, arrows become joystick directions instead.

Arrow	Normal Mode	Joy Mode (F3)
Up	CAPS SHIFT + 7	Joy Up
Down	CAPS SHIFT + 6	Joy Down
Left	CAPS SHIFT + 5	Joy Left
Right	CAPS SHIFT + 8	Joy Right

Punctuation (SYMBOL SHIFT Combos)

USB Key	ZX Equivalent	USB Key	ZX Equivalent
-	SYMBOL + J	,	SYMBOL + N
=	SYMBOL + L	.	SYMBOL + M
;	SYMBOL + O	/	SYMBOL + V
'	SYMBOL + 7	#	SYMBOL + 3

Numpad Keys

Numpad Key	ZX Equivalent	Numpad Key	ZX Equivalent
0-9	Digits 0-9	Enter	ENTER
+	SYMBOL + K	-	SYMBOL + J
*	SYMBOL + B	/	SYMBOL + V

Function Keys

F1, F2, and F5 send one-shot command pulses to the FPGA via SPI byte 14. They behave identically to the physical buttons on the DivMMC board. F3 toggles joystick emulation mode locally in the SAMD firmware.

Key	Action	Mechanism
F1	Button L (menu / select in DivMMC)	SPI command pulse
F2	Button R (NMI / back in DivMMC)	SPI command pulse
F3	Toggle arrows-as-joystick mode	SAMD toggle + PA03
F4	Reserved (no function)	--
F5	Reset Z80	SPI command pulse

Joystick Modes

The FPGA supports 7 joystick modes configured via the DivMMC menu. Modes are split into two implementation types:

Mode	Type	Port(s)	Implementation
0	Kempston	Port 31	Bus drive
1	Sinclair 1	0xF7FE (keys 1-5)	Keyboard row injection
2	Sinclair 2	0xEFFE (keys 6-0)	Keyboard row injection
3	Protek	0xEFFE + 0xF7FE	Keyboard row injection
4	Fuller	Port 127	Bus drive
5	QAOP SPACE	Multiple 0xFE ports	Keyboard row injection
6	QAOP M	Multiple 0xFE ports	Keyboard row injection

Bus drive modes (Kempston, Fuller): joystick_port drives the data bus directly when the Z80 reads the joystick I/O port.

Keyboard row injection modes (Sinclair, Protek, QAOP): joystick_port outputs active-low bits on joy_kbd_row0..7, which are AND'd with the USB keyboard rows inside keyboard_overlay. This avoids bus conflicts -- joystick and keyboard coexist on port 0xFE reads.

Arrows-as-Joystick Mode (F3 Toggle)

When F3 is pressed, arrow keys become joystick directions and Left Ctrl / Left Alt become fire buttons. This mode is **automatically suppressed** when a physical USB joypad is connected (PA02 high). Disconnecting the joypad re-enables the mode if F3 toggle is still on.

The FPGA joystick_port selects the data source based on PA02 and PA03 signals: physical joypad uses byte 4 (joy_buttons), keyboard-joy uses byte 13 (kbd_joy). In key-emulation modes (Sinclair, QAOP, etc.) the keyboard-joy data is injected into keyboard rows, identical to how a physical joypad is handled.

FPGA Module Architecture

Module	Function
atsamd_spi_slave	15-byte SPI slave, separates all fields into dedicated outputs
mouse_port	Kempston mouse interface (ports 0xFADF, 0xFBDF, 0xFFDF)
joystick_port	7 joystick modes with dual source (physical joypad / keyboard-joy)
keyboard_overlay	Port 0xFE overlay, ANDs USB keyboard rows with joystick key rows

LED indicators: LED0 = keyboard connected, LED1 = mouse connected, LED2 = joypad connected (solid) or F3 joy mode active (blinking).