

Application Note AN-005 (v1.0)

Using the GPIO Ports on the PiXi (2.0)



Summary

The PiXi add-on board is designed to expand the general-purpose I/O capabilities of the Raspberry Pi and provide a low cost means of introducing the user to the world of digital electronics and FPGA technology as well as giving the 'Pi Enthusiast' a few more features to play with. The low product cost and feature-packed specification of the PiXi makes it ideal for applications in computing, hobby-electronics, education, training and product development.

This application note describes the range of GPIO functions available on the PiXi, including pin out tables & mode settings.

GPIO1

Interface: 24 x 3.3V general-purpose I/O

Connector: 26-pin (2x13) Samtec TSW series header.

Board reference: J2

Pin	Function	Pin	Function
1	Power (+3.3V)	2	GND
3	GPIO1-0	4	GPIO1-1
5	GPIO1-2	6	GPIO1-3
7	GPIO1-4	8	GPIO1-5
9	GPIO1-6	10	GPIO1-7
11	GPIO1-8	12	GPIO1-9
13	GPIO1-10	14	GPIO1-11
15	GPIO1-12	16	GPIO1-13
17	GPIO1-14	18	GPIO1-15
19	GPIO1-16	20	GPIO1-17
21	GPIO1-18	22	GPIO1-19
23	GPIO1-20	24	GPIO1-21
25	GPIO1-22	26	GPIO1-23

The location of Pin 1 is indicated by a small dot on the silk-screen of the PiXi PCB.

The I/O standard for each pin on GPIO1 defaults to 3.3V CMOS, with an I/O drive current of 5mA. The I/O standard may be changed to other standards based around 3.3V by changing the FPGA design. The GPIO1 interface has been designed to support both single-ended and differential signalling.

Each pin may be individually configured as an input, output or other special functions using the GPIO1 mode registers.

The default FPGA configuration provided with the PiXi provides access to GPIO1 input & output functions over the SPI interfaces from the Raspberry Pi.

Important note: GPIO is connected directly to the FPGA. While the FPGA is tolerant to some levels of static and accidental miss-use, care should be taken to avoid static discharge on these pins and to avoid shorting the output pins or power connections to conflicting outputs.

GPIO2

Interface: 16 x 3.3V – 14V open-collector I/O

Connector: 39-pin (3x13) Samtec TSW series header.

Board reference: J1

Pin	Function	Pin	Function	Pin	Function
1	GND	2	GPIO2_V+	3	GPIO2-0
4	GND	5	GPIO2_V+	6	GPIO2-1
7	GND	8	GPIO2_V+	9	GPIO2-2
10	GND	11	GPIO2_V+	12	GPIO2-3
13	GND	14	GPIO2_V+	15	GPIO2-4
16	GND	17	GPIO2_V+	18	GPIO2-5
19	GND	20	GPIO2_V+	21	GPIO2-6
22	GND	23	GPIO2_V+	24	GPIO2-7
25	GPIO2-8	26	GPIO2_V+	27	GPIO2-9
28	GPIO2-10	29	GPIO2_V+	30	GPIO2-11
31	GPIO2-12	32	GPIO2_V+	33	GPIO2-13
34	GPIO2-14	35	GPIO2_V+	36	GPIO2-15
37	GND	38	GPIO2_V+	39	+5V

The location of Pin 1 is indicated by a small dot on the silk-screen of the PiXi PCB.

GPIO2(7:0) provides eight low-current open-collector (pull-to-GND) outputs with a 10k internal pull-up resistor to GPIO2_V+. The NPN transistors used can sing up to 100mA (absolute max) although it is recommended to keep the current below 50mA.

GPIO2(15:8) provides eight high-current onen-collector (pull-to-GND) outputs with no pull-up resistor. If a pull-up resistor is needed then this has to be added externally. The MOSFETS used are rated to switch a continuous current of 2A.

The pin-out is designed to be compatible with a typical 3-pin radio-control style servo connector or radio-control speed controller.

The power supply for GPIO2 (GPIO2_V+) can be selected from one of several source. It can use the on-board VIN supply which comes direct from the power inlet, it can use an external supply by connecting an external supply across pins 25 & 26 of the GPIO2 connector, it can use the on-board 5V supply via a diode to reduce the risk of any over-voltage on the 5V supply if an external supply is accidentally connected, or it can use a direct connection to the on-board 5V supply by shorting out pins.

JP1 provides the option to use the on-board 5V supply through a diode for protection, or to use the on-board VIN supply. Linking pins 1-2 on JP1 will enable the on-board 5V / Diode supply to GPIO2. Linking pins 2-3 on JP1 will enable the on-board VIN supply to GPIO2. Leave JP1 off completely if using an external supply connected across GPIO2 pins 37 & 38 or if using the on-board 5V supply without diode protection by shorting GPIO2 pins 38 & 39.

The supply for GPIO2 “GPIO2_V+” is fitted with a large 16V, 1000uF capacitor to help support the transient currents needed to drive some servos. It is recommended that the supply to GPIO2 is kept under 14V. **DO NOT EXCEED 16V** as this may lead to irreversible damage to the board.

Important note: Do not change the power configuration for GPIO2 while the power is switched on as this can cause the board to reset.

Preliminary

GPIO3

Interface: 24 x 5V (or 3.3V) general-purpose I/O

Connector: 26-pin (2x13) Samtec TSW series header.

Board reference: J2

Pin	Function	Pin	Function
1	GPIO3_V+	2	GND
3	GPIO3-8	4	V_Contrast
5	GPIO3-10	6	GPIO3-11
7	GPIO3-0	8	GPIO3-1
9	GPIO3-2	10	GPIO3-3
11	GPIO3-4	12	GPIO3-5
13	GPIO3-6	14	GPIO3-7
15	Backlight (K) (GND)	16	Backlight (A)
17	GND	18	GND
19	I2C-SCL (3.3V)	20	I2C-SDA (3.3V)
21	GPIO3-12	22	GPIO3-13
23	GPIO3-14	24	GPIO3-15
25	GPIO3-9	26	N/C

The location of Pin 1 is indicated by a small dot on the silk-screen of the PiXi PCB.

GPIO3 is designed to provide 16 level-shifted 5V input or output functions. It also includes I2C connections that connect directly to the 3.3V I2C port of the Raspberry Pi, plus it provides a contrast adjustment control pin, set by potentiometer VR1, designed to set the contrast on an LCD if one is connected to this interface.

GPIO3 Pins 1 – 14 (or 1-16) are designed to be compatible with a 14-pin (or 16-pin) connector found on some LCD & vacuum florescent display modules. If this interface is required then a 26 pin IDC socket may be used with the first 14 signal wires separated to allow them to fit a 14 pin IDC socket at the opposite end of the cable. Note: The IDC header on the LCD or vacuum florescent display probably needs to be fitted to the underside of the display board to ensure that pin functions, particularly +5V & GND, match correctly. Please check compatibility before connecting the LCD or VFD as you can easily blow a fuse on the LCD or VFD if power & GND are swapped. See application note AN004 for more information about connecting an LCD or vacuum florescent display to the PiXi.

The power supply for GPIO3 can be set at either 3.3V or 5V using JP[TBD]. Bridging pins 1-2 on JP6 will connect the +3.3V supply to GPIO3_V+. Bridging pins 2-3 on JP6 will connect the +5V supply to GPIO3_V+. **Important note: always remove the power before changing JP6 as this could otherwise cause irreversible damage to the board.**

Register Map

The standard FPGA on the PiXi provides register-mapped control & status registers for the GPIO which can be accessed through the SPI interface on the Raspberry Pi.

PiXi-Tools is a library of functions written in 'C' to provide easy access to the standard features on the PiXi, including SPI & I2C functions. The latest release of PiXi-Tools is available for download from www.astro-designs.com. Application note AN-020 "Installing PiXi-Tools on the Raspberry Pi" has more information on Installing & using PiXi-Tools.

The GPIO functions can be accessed and set-up over SPI at the following addresses:

GPIO Input Output Registers		
Address:	Read / Write	Register Function
0x20 [32]	R/W (8b)	GPIO1(7:0) Input / Output
0x21 [33]	R/W (8b)	GPIO1(15:8) Input / Output
0x22 [34]	R/W (8b)	GPIO1(23:16) Input / Output
0x23 [35]	R/W (8b)	GPIO2(7:0) Input / Output
0x24 [36]	R/W (8b)	GPIO2(15:8) Input / Output
0x25 [37]	R/W (8b)	GPIO3(7:0) Input / Output
0x26 [38]	R/W (8b)	GPIO3(8:0) Input / Output

GPIO Mode Control Registers		
Address:	Read / Write	Register Function
0x28 [40]	R/W (16b)	GPIO1(3:0) Mode
0x29 [41]	R/W (16b)	GPIO1(7:4) Mode
0x2A [42]	R/W (16b)	GPIO1(11:8) Mode
0x2B [43]	R/W (16b)	GPIO1(15:12) Mode
0x2C [44]	R/W (16b)	GPIO1(19:16) Mode
0x2D [45]	R/W (16b)	GPIO1(23:20) Mode
0x2E [46]	R/W (16b)	GPIO2(3:0) Mode
0x2F [47]	R/W (16b)	GPIO2(7:4) Mode
0x30 [48]	R/W (16b)	GPIO2(11:8) Mode
0x31 [49]	R/W (16b)	GPIO2(15:12) Mode
0x32 [50]	R/W (16b)	GPIO3(3:0) Mode
0x33 [51]	R/W (16b)	GPIO3(7:4) Mode
0x34 [52]	R/W (16b)	GPIO3(11:8) Mode
0x35 [53]	R/W (16b)	GPIO3(15:12) Mode

Each GPIO bit on each port can be individually set to one of several modes. Please note that not all modes are available for all GPIO or all GPIO pins. If a custom GPIO function map is needed then the FPGA design can be modified to create a GPIO function map that may better suit the application. Please see application note AN003 for more information about how to modify the FPGA design on the PiXi.

GPIO1 Mode Control Register 1 (0x28)	
Bit(s)	Function:
3:0	GPIO1(0) Mode: "0000": Input (read pin status at register 0x20, bit0) "0001": Output (set using register 0x20, bit0) "0010": Matrix keypad I/O "1000": Raspberry Pi RXD (Input)
7:4	GPIO1(1) Mode: "0000": Input (read pin status at register 0x20, bit1) "0001": Output (set using register 0x20, bit1) "0010": Matrix keypad I/O "1000": Raspberry Pi TXD (Output)
6:4	GPIO1(2) Mode: "0000": Input (read pin status at register 0x20, bit2) "0001": Output (set using register 0x20, bit2) "0010": Matrix keypad I/O "1000": UART1 RXD (Input)
15:7	GPIO1(3) Mode: "0000": Input (read pin status at register 0x20, bit3) "0001": Output (set using register 0x20, bit3) "0010": Matrix keypad I/O "1000": UART1 TXD (Output)

GPIO1 Mode Control Register 2 (0x29)	
Bit(s)	Function:
3:0	GPIO1(4) Mode: "0000": Input (read pin status at register 0x20, bit4) "0001": Output (set using register 0x20, bit4) "0010": Matrix keypad I/O "1000": UART2 RXD (Input)
7:4	GPIO1(5) Mode: "0000": Input (read pin status at register 0x20, bit5) "0001": Output (set using register 0x20, bit5) "0010": Matrix keypad I/O "1000": UART2 TXD (Output)
6:4	GPIO1(6) Mode: "0000": Input (read pin status at register 0x20, bit6) "0001": Output (set using register 0x20, bit6) "0010": Matrix keypad I/O "1000": UART3 RXD (Input)
15:7	GPIO1(7) Mode: "0000": Input (read pin status at register 0x20, bit7) "0001": Output (set using register 0x20, bit7) "0010": Matrix keypad I/O "1000": UART3 TXD (Output)

GPIO1 Mode Control Register 3 (0x2A)	
Bit(s)	Function:
3:0	GPIO1(8) Mode: "0000": Input (read pin status at register 0x21, bit0) "0001": Output (set using register 0x21, bit0) "0010": Matrix keypad I/O "1000": Raspberry Pi RXD (Input)
7:4	GPIO1(9) Mode: "0000": Input (read pin status at register 0x21, bit1) "0001": Output (set using register 0x21, bit1) "0010": Matrix keypad I/O "1000": Raspberry Pi TXD (Output)
6:4	GPIO1(10) Mode: "0000": Input (read pin status at register 0x21, bit2) "0001": Output (set using register 0x21, bit2) "0010": Matrix keypad I/O "1000": UART1 RXD (Input)
15:7	GPIO1(11) Mode: "0000": Input (read pin status at register 0x21, bit3) "0001": Output (set using register 0x21, bit3) "0010": Matrix keypad I/O "1000": UART1 TXD (Output)

GPIO1 Mode Control Register 4 (0x2B)	
Bit(s)	Function:
3:0	GPIO1(12) Mode: "0000": Input (read pin status at register 0x21, bit4) "0001": Output (set using register 0x21, bit4) "0010": Matrix keypad I/O "1000": Raspberry Pi RXD (Input)
7:4	GPIO1(13) Mode: "0000": Input (read pin status at register 0x21, bit5) "0001": Output (set using register 0x21, bit5) "0010": Matrix keypad I/O "1000": Raspberry Pi TXD (Output)
6:4	GPIO1(14) Mode: "0000": Input (read pin status at register 0x21, bit6) "0001": Output (set using register 0x21, bit6) "0010": Matrix keypad I/O "1000": UART1 RXD (Input)
15:7	GPIO1(15) Mode: "0000": Input (read pin status at register 0x21, bit7) "0001": Output (set using register 0x21, bit7) "0010": Matrix keypad I/O "1000": UART1 TXD (Output)

GPIO1 Mode Control Register 5 (0x2C)	
Bit(s)	Function:
3:0	GPIO1(16) Mode: "0000": Input (read pin status at register 0x22, bit3) "0001": Output (set using register 0x22, bit0)
7:4	GPIO1(17) Mode: "0000": Input (read pin status at register 0x22, bit3) "0001": Output (set using register 0x22, bit1)
6:4	GPIO1(18) Mode: "0000": Input (read pin status at register 0x22, bit3) "0001": Output (set using register 0x22, bit2)
15:7	GPIO1(19) Mode: "0000": Input (read pin status at register 0x22, bit3) "0001": Output (set using register 0x22, bit3)

GPIO1 Mode Control Register 6 (0x2D)	
Bit(s)	Function:
3:0	GPIO1(20) Mode: "0000": Input (read pin status at register 0x22, bit5) "0001": Output (set using register 0x22, bit4)
7:4	GPIO1(21) Mode: "0000": Input (read pin status at register 0x22, bit5) "0001": Output (set using register 0x22, bit5)
6:4	GPIO1(22) Mode: "0000": Input (read pin status at register 0x22, bit6) "0001": Output (set using register 0x22, bit6)
15:7	GPIO1(23) Mode: "0000": Input (read pin status at register 0x22, bit7) "0001": Output (set using register 0x22, bit7)

GPIO2 Mode Control Register 1 (0x2E)	
Bit(s)	Function:
3:0	GPIO2 bit(0) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit0) "0010": PWM Ch0
7:4	GPIO2 bit(1) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit1) "0010": PWM Ch1
11:8	GPIO2 bit(2) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit2) "0010": PWM Ch2
15:12	GPIO2 bit(3) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit3) "0010": PWM Ch3

GPIO2 Mode Control Register 2 (0x2F)	
Bit(s)	Function:
3:0	GPIO2 bit(4) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit4) "0010": PWM Ch4
7:4	GPIO2 bit(5) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit5) "0010": PWM Ch5
11:8	GPIO2 bit(6) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit6) "0010": PWM Ch6
15:12	GPIO2 bit(7) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x23, bit7) "0010": PWM Ch7

GPIO2 Mode Control Register 3 (0x30)	
Bit(s)	Function:
3:0	GPIO2 bit(8) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit0) "0010": '1' (fixed to enable GND on servo connector)
7:4	GPIO2 bit(9) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit1) "0010": PWM Ch8
11:8	GPIO2 bit(10) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit2) "0010": '1' (fixed to enable GND on servo connector)
15:12	GPIO2 bit(11) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit3) "0010": PWM Ch9

GPIO2 Mode Control Register 4 (0x31)	
Bit(s)	Function:
3:0	GPIO2 bit(12) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit4) "0010": '1' (fixed to enable GND on servo connector)
7:4	GPIO2 bit(13) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit5) "0010": PWM Ch10
11:8	GPIO2 bit(14) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit6) "0010": '1' (fixed to enable GND on servo connector)
15:12	GPIO2 bit(15) Mode: "0000": Not used (input is not supported on GPIO2) "0001": Output (set using register 0x24, bit7) "0010": PWM Ch11

GPIO3 Mode Control Register 1 (0x32)	
Bit(s)	Function:
3:0	GPIO3(0) Mode: "0000": Input (read pin status at register 0x25, bit0) "0001": Output (set using register 0x25, bit0) "0010": LCD / VFD (D1) "0111": PWM Input Ch0
7:4	GPIO3(1) Mode: "0000": Input (read pin status at register 0x25, bit1) "0001": Output (set using register 0x25, bit1) "0010": LCD / VFD (D0) "0111": PWM Input Ch1
6:4	GPIO3(2) Mode: "0000": Input (read pin status at register 0x25, bit2) "0001": Output (set using register 0x25, bit2) "0010": LCD / VFD (D3) "0111": PWM Input Ch2
15:7	GPIO3(3) Mode: "0000": Input (read pin status at register 0x25, bit3) "0001": Output (set using register 0x25, bit3) "0010": LCD / VFD (D2) "0111": PWM Input Ch3

GPIO3 Mode Control Register 2 (0x33)	
Bit(s)	Function:
3:0	GPIO3(4) Mode: "0000": Input (read pin status at register 0x25, bit4) "0001": Output (set using register 0x25, bit4) "0010": LCD / VFD (D5) "0111": PWM Input Ch4
7:4	GPIO3(5) Mode: "0000": Input (read pin status at register 0x25, bit5) "0001": Output (set using register 0x25, bit5) "0010": LCD / VFD (D4) "0111": PWM Input Ch5
6:4	GPIO3(6) Mode: "0000": Input (read pin status at register 0x25, bit6) "0001": Output (set using register 0x25, bit6) "0010": LCD / VFD (D7) "0111": PWM Input Ch6
15:7	GPIO3(7) Mode: "0000": Input (read pin status at register 0x25, bit7) "0001": Output (set using register 0x25, bit7) "0010": LCD / VFD (D6) "0111": PWM Input Ch7

GPIO3 Mode Control Register 3 (0x34)	
Bit(s)	Function:
3:0	GPIO3(8) Mode: "0000": Input (read pin status at register 0x26, bit0) "0001": Output (set using register 0x26, bit0) "0010": LCD / VFD (RS)
7:4	GPIO3(9) Mode: "0000": Input (read pin status at register 0x26, bit1) "0001": Output (set using register 0x26, bit1) "0010": Input (read pin status at register 0x26, bit1)
6:4	GPIO3(10) Mode: "0000": Input (read pin status at register 0x26, bit2) "0001": Output (set using register 0x26, bit2) "0010": LCD / VFD (#WR)
15:7	GPIO3(11) Mode: "0000": Input (read pin status at register 0x26, bit3) "0001": Output (set using register 0x26, bit3) "0010": LCD / VFD (#RD)

GPIO3 Mode Control Register 4 (0x35)	
Bit(s)	Function:
3:0	GPIO3(12) Mode: "0000": Input (read pin status at register 0x26, bit4) "0001": Output (set using register 0x26, bit4) "0010": Input (read pin status at register 0x26, bit4) "0111": PWM Input Ch8
7:4	GPIO3(13) Mode: "0000": Input (read pin status at register 0x26, bit5) "0001": Output (set using register 0x26, bit5) "0010": Input (read pin status at register 0x26, bit5) "0111": PWM Input Ch9
6:4	GPIO3(14) Mode: "0000": Input (read pin status at register 0x26, bit6) "0001": Output (set using register 0x26, bit6) "0010": Input (read pin status at register 0x26, bit6) "0111": PWM Input Ch10
15:7	GPIO3(15) Mode: "0000": Input (read pin status at register 0x26, bit7) "0001": Output (set using register 0x26, bit7) "0010": Input (read pin status at register 0x26, bit7) "0111": PWM Input Ch11

Further Reading

The PiXi User Manual (UM-002) has complete information on the pin functions for all interface on the PiXi.

If you want to learn more about programming the FPGA on the PiXi to customise the serial port, please take a look at application notes AN-002 "Programming the FPGA on the PiXi" and AN-003 "FPGA Development on the PiXi".

PiXi-Tools is described in more detail in application note AN-020 "Installing PiXi-Tools on the Raspberry Pi".

The full register map for the PiXi can be found in application note AN-025 "PiXi SPI & I2C Register Map".

All of these documents are available for download from www.astro-designs.com.

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Preliminary