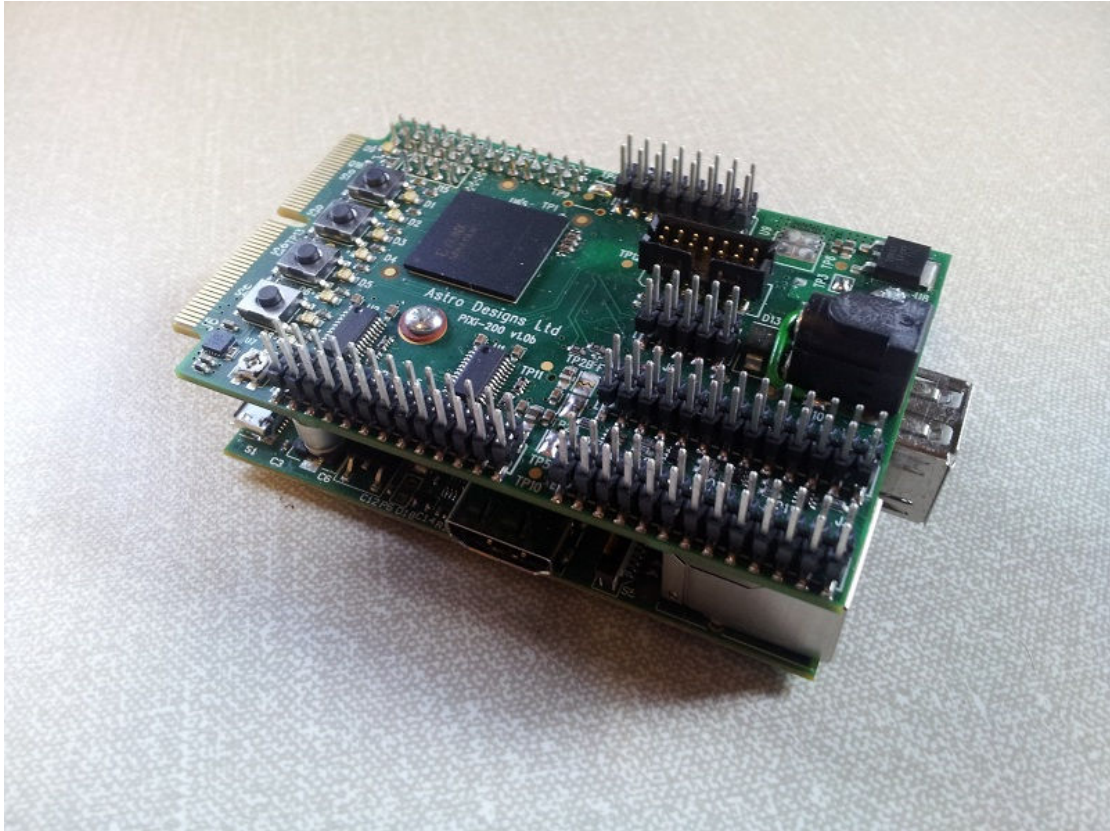


Application Note AN-005 (v1.0)

Using the GPIO Ports on the PiXi 1.0b



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 TSM series header.

Board reference: J3

Fitted: Yes

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

Table 1 GPIO1 Pin-out

The location of Pin 1 is indicated by a square pad on the bottom surface copper layer 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: 26-pin (2x13) Samtec TSM series header.

Board reference: J4

Fitted: Yes

Pin	Function	Pin	Function
1	GPIO2_V+	2	GPIO2_V+
3	GPIO2-0	4	GPIO2-1
5	GPIO2-8	6	GPIO2-9
7	GPIO2_V+	8	GPIO2_V+
9	GPIO2-2	10	GPIO2-3
11	GPIO2-10	12	GPIO2-11
13	GPIO2_V+	14	GPIO2_V+
15	GPIO2-4	16	GPIO2-5
17	GPIO2-12	18	GPIO2-13
19	GPIO2_V+	20	GPIO2_V+
21	GPIO2-6	22	GPIO2-7
23	GPIO2-14	24	GPIO2-15
25	GND	26	GND

Table 2 GPIO2 Pin-out

The location of Pin 1 is indicated by a square pad on the bottom surface copper layer 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 was designed to be compatible with a typical 3-pin radio-control style servo connector or radio-control speed controller. Unfortunately, an error in the design led to the pin-out not being as compatible as it was intended. Consequently the pins for power and PWM signal are in the wrong location and are incompatible with typical radio-control servos. To make them compatible the sockets on the servos need to have the positive supply socket swapped with the central 'PWM' signal socket.

The power supply for GPIO2 (GPIO2_V+) can be selected from one of several sources. It can use the on-board 5V supply or it can use the on-board 3.3V supply. Or, if the poser supply link is left un-soldered, an external supply of up to 12V may be connected to any of the GPIO2_+V pins on the connector. If using an external supply then it is recommended to use pins 19 & 20 for the positive power connection and pins 25 & 26 for the GND / return connection. The use of an external supply is recommended if more than two servos are

going to be connected. This reduces transients on the 5V supply which have been known to reset the Raspberry Pi.

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	GPIO3-9
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	N/C	16	N/C
17	I2C-SCL (3.3V)	18	I2C-SDA (3.3V)
19	GPIO3-12	20	GPIO3-13
21	GPIO3-14	22	GPIO3-15
23	LCD Contrast	24	N/C
25	GND	26	GND

The location of Pin 1 is indicated by a square pad on the bottom surface copper layer 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 are designed to be compatible with a 14-pin connector found on some LCD & vacuum fluorescent 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 fluorescent 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 fluorescent display to the PiXi.

Note: The GPIO3 port on the PiXi 1.0b is limited in that the I/O direction of GPIO3(7:0) are all tied together, similarly the I/O direction of GPIO3(15:0) are tied together too. This means that all eight signals in each of these banks are either input or output – it is not possible to mix input with output within a single bank. This is due to be fixed in a later version of the PiXi.

To configure the banks as input or output, use the configuration registers described later in this document to set the direction of GPIO3(0) or GPIO3(8). The configuration of these signals is used to configure the entire upper or lower bank.

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.

Acknowledgements

"Raspberry Pi" is a trademark of the Raspberry Pi Foundation.

Preliminary