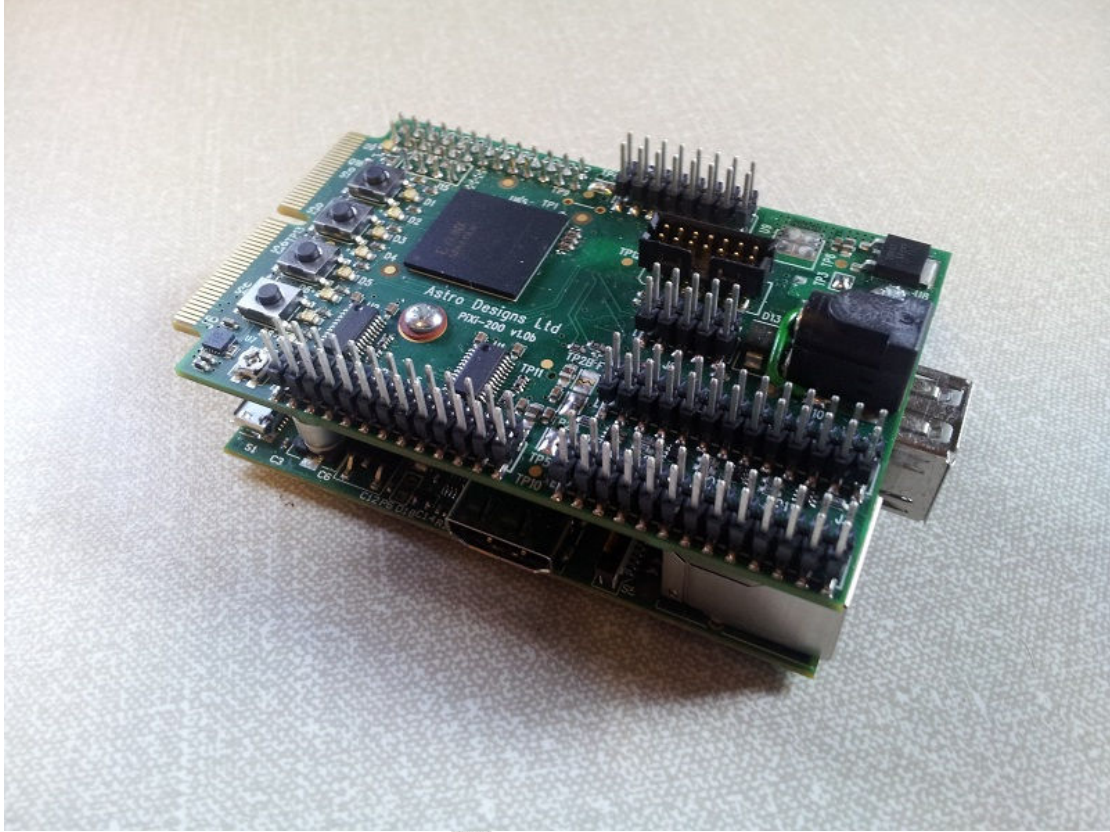


Application Note AN-006 (v1.0)

Using the RS232 Serial 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 explains how to use the RS232 serial ports on the PiXi. The Raspberry Pi provides a 3.3V TTL/CMOS compatible serial interface on pins 8 & 10 of the Raspberry Pi's P1 connector but to use these with an RS232 serial port just like the serial ports that are typically found on a desktop PC, a TTL/CMOS to RS232 level-shifter is required. The PiXi includes a level shifter on-board to provide this function. In addition to this the PiXi hardware is designed to make it very easy for the user to access this interface.

Interface Pin-out

The serial interface is pinned-out as follows:

Pin	Function	Pin	Function
1	N/C	2	N/C
3	RX	4	RTS / TX2
5	TX	6	CTS / RX2
7	N/C	8	N/C
9	GND	10	N/C

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

Connecting up the Serial Interface

The RS232 serial port has been designed so that the user can quickly bring the serial port out on a standard 9-way 'D' connector, providing an interface that is fully compatible with other products using an RS232 serial interface such as computers and telecommunication products. Figure 1 illustrates how a simple cable can be made up using ribbon cable and IDC connectors.

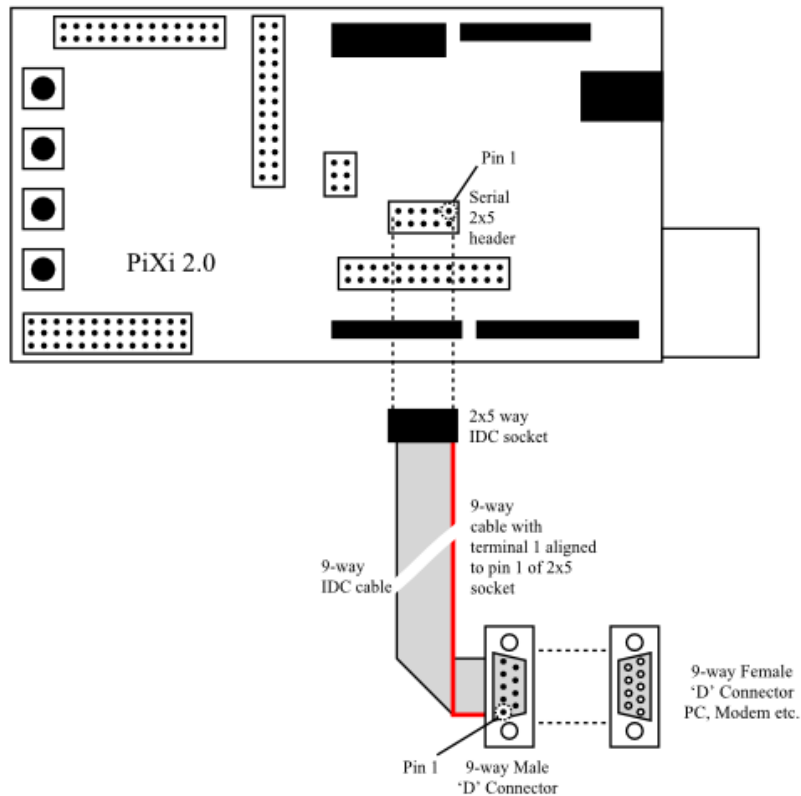


Figure 1: Making up a serial cable assembly

The following parts can be used to make a serial cable assembly:

1. 1 x 2x5 terminal IDC socket (e.g. RS 192-7445 or Farnell 2112420);
2. 1 x IDC 9-way 'D' connector (e.g. RS 409-3292 or Farnell 1849925);
3. 1 length of 0.05" pitch, 9-way ribbon cable (up to 10m should can be used) (e.g. RS 719-3409 or Farnell 1207434);

When assembling the ribbon cable into the 2x5 way socket that goes at the PiXi end of the cable assembly, care should be taken to ensure that the coloured strand of the cable (indicating terminal 1) is connected to terminal 1 of the socket. Terminal 10 of the 2x5 way socket should have no connection in this case. Similarly, the coloured strand should connect to pin 1 of the 9-way 'D' connector. Figure 2 illustrates the completed cable assembly.



Figure 2: Completed serial port cable assembly

One Port or Two?

The primary RS232 serial port provides connections for RXD, TXD, RTS & CTS although at this time RTS & CTS are not supported in the FPGA. Instead the RTS & CTS pins can be used as a second serial port using one of the two 16550-compatible UARTs built in to the standard FPGA.

Need More Serial Interfaces?

The PiXi is not just limited to providing RS232 standard serial ports. If 3.3V or 5V TTL/CMOS serial ports are required, the standard FPGA provides the capability to connect the Raspberry Pi's RXD/TXD ports or the RX/TX ports of the two internal UARTs over 3.3V GPIO or 5V I/O through specific pins on the GPIO1 or GPIO3 ports.

With some FPGA design work, even more UARTs could be added if required, using GPIO1 or GPIO3 to connect these to the outside world via a 3.3V or 5V TTL/CMOS interface.

Enabling and Configuring the RS232 Serial Interface

No setup is required to use the primary RS232 serial port on the PiXi. The default setup of the FPGA supplied with the PiXi connects the serial RXD/TXD pins of the Raspberry Pi's P1 connector to the RX/TX pins of the serial port via the RS232 level shifter which is powered up and enabled by default. The primary RS232 serial port can therefore immediately be used to communicate directly with the Raspberry Pi.

The second serial port can be enabled and accessed through one of the two UARTs built into the FPGA.

Register Map

The standard FPGA on the PiXi provides register-mapped control & status registers for the serial interface which can be accessed through the SPI interface on the Raspberry Pi. A single register is used to configure the serial port however if 3.3V or 5V serial ports are needed on GPIO1 and / or GPIO2 then a few more registers need to be set up.

The GPIO1 & GPIO2 ports can operate in several modes. Each bit can be separately configured as input, output or a number of special functions. The Raspberry Pi's serial port, UART1 or UART2 are three of these special functions. The full range of special functions for GPIO1 & GPIO3 are described in detail in application note AN-005. The following modes are reserved for the serial port options:

GPIO mode 8 :	Raspberry Pi's RXD/TXD
GPIO mode 9 :	UART1 RX/TX
GPIO mode 10 :	UART2 RX/TX

Note: In each case, when a GPIO bit is set to this mode, even numbered bits always become RX (input) and odd numbered bits become TX (output).

The serial port and GPIO1 / GPIO3 functions can be accessed and set-up over SPI at the following addresses:

Address:	Read / Write	Register Function
0x1F [31]	W	Serial Port Configuration Register
0x27 [39]	W	GPIO1 Port Configuration Register
0x28 [40]	W	GPIO1 Port Configuration Register
0x29 [41]	W	GPIO1 Port Configuration Register
0x3A [58]	W	GPIO1 Port Configuration Register
0x3B [59]	W	GPIO1 Port Configuration Register
0x3C [60]	W	GPIO1 Port Configuration Register
0x2C [44]	W	GPIO3 Port Configuration Register
0x2D [45]	W	GPIO3 Port Configuration Register
0x2E [46]	W	GPIO3 Port Configuration Register
0x2F [47]	W	GPIO3 Port Configuration Register

Serial Port Configuration Register (0x1F)	
Bit(s)	Function:
2:0	RX / TX pin Configuration "000": Raspberry Pi RXD/TXD (Default) "001": UART1 RX/TX "010": UART2 RX/TX
3	Not used
6:4	CTS/RX2 / RTS/TX2 pin Configuration "000": Raspberry Pi RXD/TXD "001": UART1 RX/TX (Default) "010": UART2 RX/TX
15:7	Not used

GPIO1 Port Configuration Register (0x27, 0x28, 0x28, 0x3A, 0x3B, 0x3C)	
Bit(s)	Function:
(0x27) 3:0	GPIO1 bit(0) function select "1000": Raspberry Pi RXD (Default) "1001": UART1 RX "1010": UART2 RX
(0x27) 7:4	GPIO1 bit(1) function select "1000": Raspberry Pi TXD (Default) "1001": UART1 TX "1010": UART2 TX
(0x27) 15:8	GPIO1 bits(3:2) function select (each formatted as GPIO1 bits 0,1 above)
(0x28) 15:0	GPIO1 bits(7:4) function select (each formatted as GPIO1 bits 0,1 above)
(0x29) 15:0	GPIO1 bits(11:8) function select (each formatted as GPIO1 bits 0,1 above)
(0x3A) 15:0	GPIO1 bits(15:12) function select (each formatted as GPIO1 bits 0,1 above)
(0x3B) 15:0	GPIO1 bits(19:16) function select (each formatted as GPIO1 bits 0,1 above)
(0x3C) 15:0	GPIO1 bits(20:23) function select (each formatted as GPIO1 bits 0,1 above)

GPIO3 Port Configuration Register (0x2C, 0x2D, 0x2E, 0x2F)	
Bit(s)	Function:
(0x2C) 3:0	GPIO3 bit(0) function select "1000": Raspberry Pi RXD (Default) "1001": UART1 RX "1010": UART2 RX
(0x2C) 7:4	GPIO3 bit(1) function select "1000": Raspberry Pi TXD (Default) "1001": UART1 TX "1010": UART2 TX
(0x2C) 15:8	GPIO3 bits(3:2) function select (each formatted as GPIO1 bits 0,1 above)
(0x2D) 15:0	GPIO3 bits(7:4) function select (each formatted as GPIO1 bits 0,1 above)
(0x2E) 15:0	GPIO3 bits(11:8) function select (each formatted as GPIO1 bits 0,1 above)
(0x2F) 15:0	GPIO3 bits(15:12) function select (each formatted as GPIO1 bits 0,1 above)

All of these registers can be set up using the Raspberry Pi's SPI interface. PiXi-Tools provides some general-purpose functions for writing to and reading the PiXi FGAs registers over SPI. Please see application note AN-020 for more information on installing and using the PiXi-Tools applications and libraries.

The two internal UARTs that are built-in to the standard FPGA design can be fully configured and used using the Raspberry Pi's SPI interface. PiXi-Tools provides a convenient and easy to use library of functions that make it easier to build these UARTs into an application.

Further Reading

The PiXi User Manual (UM-002) has complete information on the pin functions for serial and other interfaces 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

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