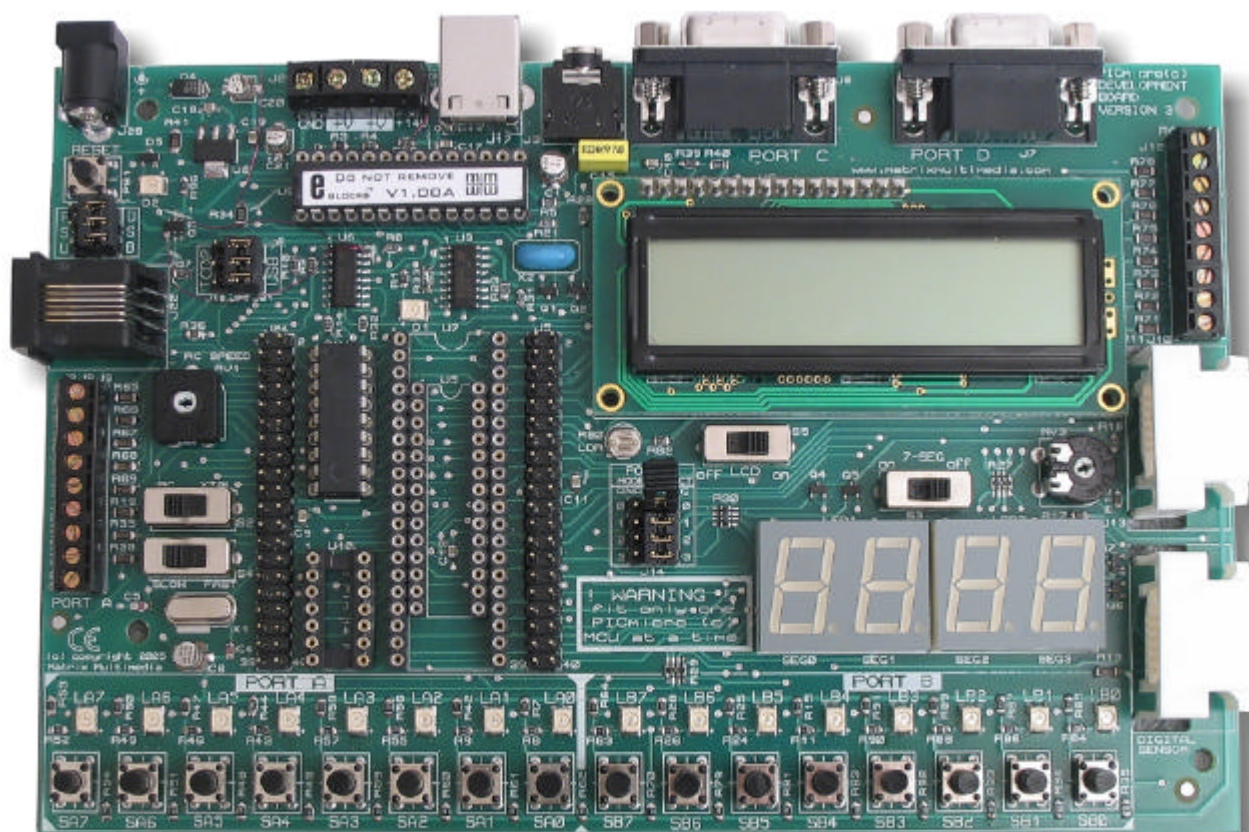


PICmicro® Microcontroller Development Board Datasheet



Contents

- 1 General information
- 2 Features
- 3 Block schematic
- 4 Getting started
- 5 General description
- 6 Programming software
- 7 Testing the development board
- 8 Supported PICmicro microcontrollers
- 9 Pin out details and bus connections
- 10 Liquid crystal display
- 11 On-board analogue sensors
- 12 External sensors
- 13 Circuits

1 General information

The Matrix PICmicro microcontroller (MCU) development board is designed to form part of the World's best solution for learning PICmicro programming.

The remit of all Matrix products is to Make Education Easier. This philosophy is fulfilled with this development board in two ways:

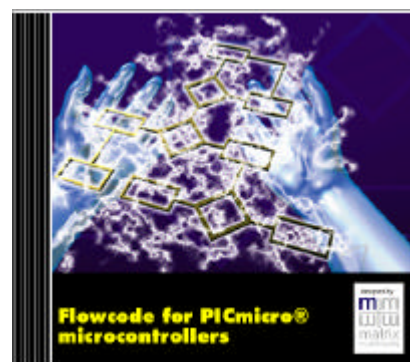
Makes it easier to teach and learn PICmicro programming

- Designed for educational use
- 3 CD ROM based resources in assembly, C, and flow chart programming are available
- Free download software, PPP, provides seamless send and verify functions

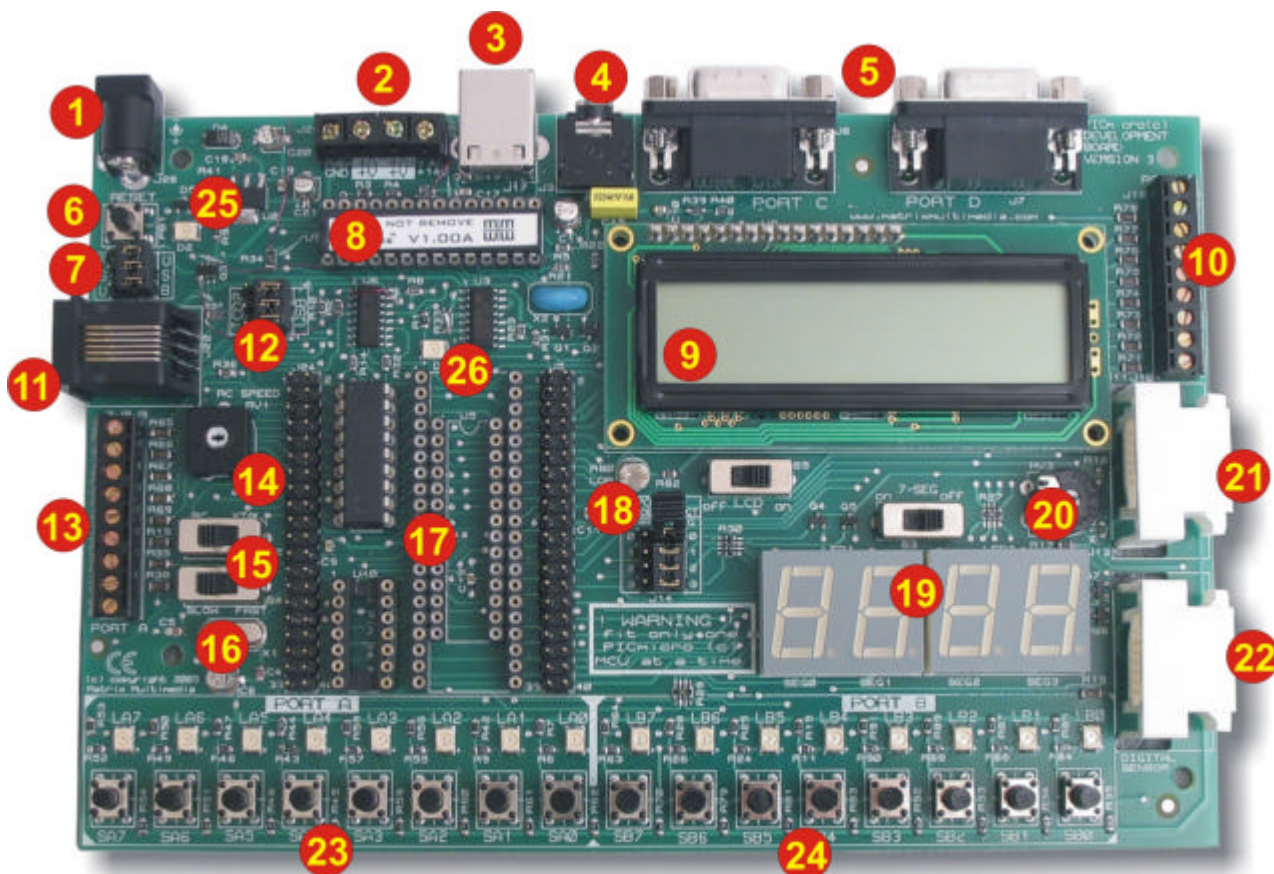
Makes it easier to develop PICmicro projects

- Supports low cost Flash-programmable PICmicro devices
- Fully featured displays - 16 individual LEDs, quad 7-segment display and LCD display
- USB programmer
- Supports PICmicro microcontrollers with A/D converters
- On-board sensors
- A comprehensive range of external analogue and digital sensors are available for project work
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection
- E-Blocks compatible with 2 E-Blocks connectors fitted to ports C and D

Three courses and programming systems compatible with this product are available on CD ROM:



2 Development board features



1. Power supply connector
2. 5V outputs for E-blocks connection
3. USB connector
4. Single bit audio output
5. E-blocks connectors for ports C and D
6. Reset switch
7. Power selector link block—USB or Power connector
8. USB interface chip
9. 2 line 16 character alphanumeric display
10. Screw terminal connectors for port B
11. In Circuit Debug socket
12. ICD/USB programming selection
13. Screw terminal connectors for port A
14. RC speed potentiometer
15. Oscillator mode selection switches
16. Removable crystal
17. Sockets for programming 8, 14, 18, 28 and 40 pin PICmicro devices
18. On-board light sensor
19. Quad 7-segment displays
20. Analogue input potentiometer
21. External analogue sensor input
22. External digital sensor input
23. Port A switches and LEDs
24. Port B switches and LEDs
25. Power indicator
26. Programming indicator

4 Getting Started

4.1 Installation instructions - Software

Installing PPP v3

To install run PPPv3.exe, which is located at <D>:\PPPv3\PPPv3.exe and follow the instructions provided. <D> refers to your CD drive.

By default PPPv3 is installed into:

C:\Program Files\Matrix Multimedia\Common\PPPv3\

There are four 'Features' that can be installed.

* PPP v3 core files - this is PPP v3 itself, and should be installed.

* Update ASM4PICs - This feature allows you to update ASM4PICs to use PPP v3.

* Update C4PICs - This feature allows you to update C4PICs to use PPP v3.

* Update Flowcode - This feature allows you to update Flowcode to use PPP v3.

The three updates will be automatically installed. Select the 'X' 'Do not install option' if you do not to update a feature.

If you need to update a product at a later date you can re-run the install and update that feature.

There is more help and information available on the CD provided at <D>:\PPPv3\readme.txt

<D> refers to your CD drive.

Installing in the PICmicro Development Board

When you connect the PICmicro Development Board to your computer, via the USB cable, the first time there will be installation routine for this 'new hardware'. For most users this will be a 'plug and play' routine where your computer will automatically recognize the hardware.

Running on Windows 2000 / ME / XP

These programs allow 'plug and play' for your new hardware. Therefore when you first connect the PICmicro Development Board to your computer you will receive a pop-up screen that indicates that there is new hardware connected to the computer. The program itself will deal with any installation of any drivers that it requires internally. Therefore you can use your PICmicro Development Board immediately.

Running on Windows 98 (you will need the Windows 98 CD at hand)

When you connect the PICmicro Development Board to the computer your Windows 98 program will run a 'New Hardware Wizard'. This procedure is straightforward and easy to understand. Follow the on-screen instructions. Once this has been completed the PICmicro Development Board will be ready to use.

There is more detailed information and help on the CD provided at <D>:\blocks\Installation Guide.doc

Programming the PIC16F88

Testing the PICmicro Development Board – RC_LVP.hex

The following instructions explain the steps to test and use your PICmicro® Development Board. The instructions assume that PPP is installed and functional. It also assumes that you are confident in sending a program to the PIC via the PICmicro Development Board.

More information on the procedures of programming via PPPv3 are given in the document located at <D>:\blocks\Installation Guide.doc and in the PPPv3 help file.

Follow these instructions to test the PICmicro Development Board

1. Ensure power is supplied to all the Development board
 - USB cable required
 - PSU cable recommended
2. Set Jumper J29 to appropriate position
 - Left hand side labelled 'PSU' if using PSU power supply
 - Right hand side labelled 'USB' if ONLY using USB cable as power supply
3. Ensure Jumper J20 set to USB
4. Ensure that the PICmicro Development Board is in correct configuration
 - RC mode (SW2 towards the EDGE of the board)
 - FAST mode (SW4 towards the CENTRE of the board)
 - Ensure that a 19.6608MHz crystal is inserted in the PICmicro Development Board
5. J14 jumpers ALL set to 'DIG' (right hand side)
6. Program the a PIC16F88 with the test program RC_LVP.hex found in the directory <D>:\PICmicro Development Board\HP488\RC_LVP.hex
7. Check the illumination of all LEDs
 - Note that LB3 will not illuminate due to the fact that the board is set to Low Voltage Programming mode

This should satisfy that the PICmicro Development Board is fully functional!

Please note C4PICs V1 & V2 and FLOWCODE V1 will NOT program the PIC16F88.

Ensuring correct polarity for power supply

Positive Inner/Positive Outer polarity

To set up the correct polarity the connection symbols on the jack need to match those shown below.

	Connector dimensions The PSU is supplied with a number of connectors. The correct connector for Matrix Multimedia products is: Type D 5.0mm external diameter 2.1mm internal diameter “D” is marked on one side, down by the pins, and “5.0x2.1” is marked on the other side. PICmicro Development Board requires Positive Outer power supply
--	---

The two arrows – one on the connector socket and one on the connector pin, help you select the correct side of the power jack, and the symbol shows the correct outer connection.

5 General Description

The PICmicro development board is designed for learning how to program PICmicro applications in educational and industrial context. It also allows a wide range of PICmicro microcontrollers to be programmed and the 'seamless' nature of the programming software supplied with the product ('PPP') makes it suitable for the development of a range of PICmicro projects.

The board is optimised for use with a PIC16F88 from Arizona Microchip, which has a number of features:

- Crystal or RC operation
- 2 ports: Port A - 5 pins and Port B - 8 pins i.e.: 15 programmable pins that can all be used as inputs and outputs.
- Flash programmable - up to 1,000,000 programming cycles
- On-board A/D, internal clock, internal USART and a host of other functions and features

The PIC16F88 has analogue capability and is a very functional PICmicro. It has been selected for use with this development board for a number of reasons:

- It is a low cost device - suitable for project work in schools
- It is electrically re-programmable
- Features are up-ward compatible with larger chips – such as the PIC16F877A

A full list of other PICmicros that the board can support is listed below.

The board has been designed to allow those with little or no experience of embedded microcontroller programming to be able to produce highly functional designs in as short a time as possible. With this in mind we have included switches on port A and B input/output pins, a quad 7-segment display, a 2 line 16 character alphanumeric display, a choice of crystal or RC oscillator, simple on-board analogue sensor (light) and sensor simulator (potentiometer) and the ability to interface the board to a host of external sensors including motion, temperature, pH, humidity etc. Ports A and B are also connected to screw terminals on the sides of the board via 150ohm resistors which protect the device on the board itself.

The board can be used with ZIF sockets if required: please bear in mind that you may need to insert one or more turned pin DIL sockets to raise the height of some ZIF sockets to clear surrounding components.

Full tutorials in programming the PICmicro in Assembly code, C, and flowcharts are available. These sets of tutorials are available on CD ROM and require no other software - all compilers and development environments are included on the CDs themselves.

Schematic description - please refer to block schematic

The board is based on a flexible topology that allows the inputs and outputs to be used in a number of ways depending on switch settings on the board. This flexibility means that students will, as they use additional features, need to be aware of how a single input-output (I/O) pin can be used for a number of functions dictated by the circuitry attached to it. This is explained in the Circuits section of this document.

The architecture of the board is split into two main buses - the port A bus and the port B bus. Each line on each bus can be used as either an input or as an output. The connectors and displays on the board are all wired in parallel on the PIC pins for convenience but clearly connecting more than one device to one pin will result in conflict: **students will need to be made aware of this.**

Port A bus

Under normal operation all of the jumper links in the J14 link block are in the Digital position. This means that the Port A I/O pins are routed to the push switches and LEDs. The actual circuit is described in the Circuits section. Note that operating the push switches whilst a voltage is connected to port A via the external screw terminals is not advisable, as it will result in unpredictable results. Port A screw terminal connectors are fed to the pins on the PICmicro via 150 ohm resistors which provide short circuit protection.

With J14 links in the Digital position port A is routed to its push switches (SA0 to SA4), LEDs, digital Vernier sensor I/O, and the quad 7-segment display. Bits RA0, RA1, RA2 and RA3 are used for the common anodes of each of the four 7-segment displays. RA0 is used for tone generation via the jack plug, and bit RA2 is used for the digital Vernier sensor input.

With J14 links in the Analogue position port A is switched to the analogue sensor section of the board. This means that RA0 is connected to the on-board light sensor, RA1 is connected to the potentiometer resistor to form an adjustable voltage divider for sensor simulation, and bit RA2 is connected to the external analogue Vernier sensor connector.

With J14 links in the Analogue position you should be aware that on-board switches and LEDs will not operate.

If you want to use the external port A screw terminal connectors for analogue inputs you should remove the links off J14 altogether.

Port B Bus

Port B I/O pins are routed to its push switches (SB0 to SB7), the LEDs (LB0 to LB7), the quad 7-segment displays, the LCD display and the screw terminal connectors. Note that the screw terminal connectors are fed to the pins on the PICmicro via 150ohm resistors, which provide short circuit protection. However operating the push switches whilst a voltage is connected to Port B is not advisable as it will result in unpredictable results.

Port B is also used for programming the PICmicro - the PPP software used for programming the PICmicro will automatically take over pins required for programming, verifying and resetting the PICmicro on the board.

Port C & D E-Block Bus Connection

Ports C and D of the PICmicro MCU are fed out onto 9 way D-type connectors at the back of the board. These can be used to add one of 25 separate E-blocks boards to the development board. E-blocks vary from simple LED and switch boards through to more complex subassemblies like Bluetooth boards, CAN bus, internet boards, IrDA transceivers etc.

The addition of E-blocks boards allows you to considerably expand the functionality of your system to develop a verywide range of electronic systems.

Port E Bus Connection

Port E is available on larger PICmicro MCU devices. This is not a full port (only three bits) and therefore most users will not need to use this port. This port is available on the IDC header pins (J5 and J24). The details of the actual pins on this header can be found in the "Pin comparison chart" section of this document.

Clock circuitry

During early stages of learning PICmicro programming students often want each clock cycle to be large (1 second) so that they can see code executing very slowly (flashing LEDs don't simply become 'less bright' LEDs). The PIC16F88 supports this feature by having an RC mode of operation.

Use of RC mode also reduces component count and cost for small projects.

S2 selects between RC mode and Crystal mode.

S4 selects fast or slow operation when RC mode is selected.

RV1 adjusts the speed of the clock within a range dictated by S4.

However more advanced students require a faster clock speed, for setting up parameter such as the LCD module. Therefore the board is supplied with a 19.6608MHz crystal (selected to set easily set-up appropriate baud rate). The crystal is supplied mounted in ultra low profile sockets – allowing the crystal to be changed.

Power supply circuit

The board is normally operated from an unregulated DC supply of 12V. This allows full operation including programming.

The board can be operated in Low -voltage mode via solely the USB cable provided. However care must be taken, as there is only limited power that can be taken from a computers USB port. Also only certain chips can be reprogrammed in this Low -voltage mode, refer to the specific chip datasheet to determine if it has LVP function. The PIC16F88 provided with this board has been set-up to accept low -voltage programming (LVP), but some features are not available in this mode, such as LB3. If this mode is disabled then the 12V unregulated DC power supply must be used, and only this high-voltage programming mode can re-enable the low -voltage programming. Please refer to the specific PIC datasheet regarding LVP function. Please note that not all chips have the Low -Voltage Programming function and therefore these chips must be programmed using an external power supply as stated above.

The jumper link system, J29, allows the user to decide on the source of the power supply. If using an unregulated 12V power supply the jumper should be positioned to the left hand side of the jumper system labelled 'PSU'. If using USB power place the jumper on the right hand side of the jumper system. The jumper should always be orientated so that the 3 links in the jumper block are always position horizontally – thus connecting the centre pins to either the left hand or right hand pins.

Please note that both USB and the PSU cables should be removed for the development board BEFORE changing the position of this jumper.

The optional power supply shipped with the PICmicro board (UK versions) is rated at a maximum of 500mA. You should be aware that the board could consume more current than this if you are connecting several external devices on the external I/O.

Displays

The LCD display is connected to Port B I/O. The LCD display is turned on by switch S5.

The quad 7-segment display is connected to both Port A and Port B. Port B is used to control each of the 8 segments (7 for the main character and 1 for the full stop). Port A bits 0 to 3 are used to select each of the 4 characters. The quad 7-segment display is turned on by switch S3.

Note that turning on the display will affect the operation of Port B I/O and when using the quad 7-segment displays it is recommended that you do not use Port B for any other purposes. Under certain circumstances you will notice that segments of the quad 7-segment display may be lit up very dimly by Port A/B operation even when S3 is in the off position. This is a feature of the low cost driver circuitry and is unavoidable.

Microchip® In-Circuit Debugger (ICD2)

The board is compatible with the Microchip® ICD2 in-circuit debugging tool. This allows the debugging of the actual hardware and the software program that is programmed onto the chip. The ICD2 allows the user to step through the program whilst it is actually programmed on the chip – therefore allowing the hardware to be tested with the software. The ICD2 can also program the targeted chip as well. For more information regarding the ICD2 please visit the Microchip website: www.microchip.com

The ICD2 for Microchip® plugs directly into the ICD socket (J22) on the Development board. Jumper J20 must be moved to the left hand side of the pins, into the 'IDC2' position. This means that the ICD2 can now control the programming and the in-circuit debugging of the hardware.

6 Programming software

The PICmicro Parallel Programmer [PPP] allows an assembled program to be sent to virtually any FLASH PICmicro microcontroller on the PICmicro Development board. Both raw OBJ files generated by TASM, and ASCII-encoded HEX files generated by MPASM can be sent using PPP. PPP uses a simple user interface that is explained in the accompanying help file. PPP is supplied free with the development board. Features include: -

- Operates with the latest parallel port / USB standards
- HEX and OBJ file compatible
- Range of Xtal and RC operation modes
- Reads content of any non-protected PICmicro
- Confirms each byte of code sent
- Bit selection on configuration word available for advanced users

Minimum requirements

Pentium 100MHz, USB and / or Parallel printer port, 1 Megabyte of hard drive space, 16Megabytes of RAM, Windows 95/98/ME/NT/2000/XP

Installation

Insert the CD supplied with the PICmicro development board, navigate to the CD drive on the target computer and execute the install file named "PPP install". A shortcut will be added to the desktop and to the Start menu.

[Administrator Privileges are required to install on Windows NT/2000]

Setup

Insert the power supply into a wall outlet, and then connect to the PICmicro board.
Connect the USB cable to both the computer's parallel port and to the PICmicro board.

Configuration

Before sending a program to the PICmicro board, PPP should be set up correctly. Start the PPP program then on the toolbar click on the "Configure the PICmicro" icon [Ctrl - C]. In the configuration box -

- Select chip type
- Select the oscillator type [HS if using the on-board crystal, or RC if using the on-board resistor and capacitor]
- Leave both the watchdog timer and the power-up timer unchecked unless the program to be sent requires them.
- If the contents of the PIC should not be read, Enable code protection.
- [N.B. The configuration word can be altered manually - please refer to PICmicro datasheets for details.]

Sending

To open a file click on the "Open a PICmicro code file" icon on the toolbar [Ctrl - O], navigate to the file to be sent. To send the file click on the "Send the code to the PICmicro" icon on the toolbar [Ctrl - P]. As the code is sent to the PICmicro board the Program LED flashes. When all the code has been sent the LED turns off. If verification has been selected the LED turns on, whilst the code is being read. After all the code has been read the LED turns off and PPP informs the user if all the code had been sent correctly.

7 Testing the development board

When you first receive your development board you should check its operation. There are two parts to this - checking that the hardware works correctly and check that you can download programs into the PIC16F88 that is supplied with the board.

Your board will be supplied with a PIC16F88 that already has a test program in it. This simple test program simply flashes the I/O port LEDs in turn. Simply connect the power supply (or USB cable – ensure jumper J29 set to USB or PSU dependant on the power supply you are using) to the development board: if the Port A and B LEDs make a 'knight rider' effect then you know that your PICmicro is up and running and your basic circuitry is operational.

Note that LED LB3 will not light up as the PIC is in low-voltage programming mode (LVP).

Note that the switch settings for this core program are:

S2 : - RC position
S4L - FAST
J14: - Digital position
S5: - LCD display off
S3: - 7-seg display off

You can now test the board can communicate with the PC. To do this first erase the PICmicro. Open the PPP program. Click on File - > Erase PICmicro. Your development board should now be inactive - basically there will be no program in the PIC16F88.

Next send the program RC_LVP.hex to the PICmicro. Once this is complete then your board should be running the same 'knight rider' program as before.

You now know that your development board is up and running correctly. Further test programs for this development board will be available from our web site: www.matrixmultimedia.co.uk.

8 Supported PICmicro microcontrollers

Currently PPP and the development board support the following devices:

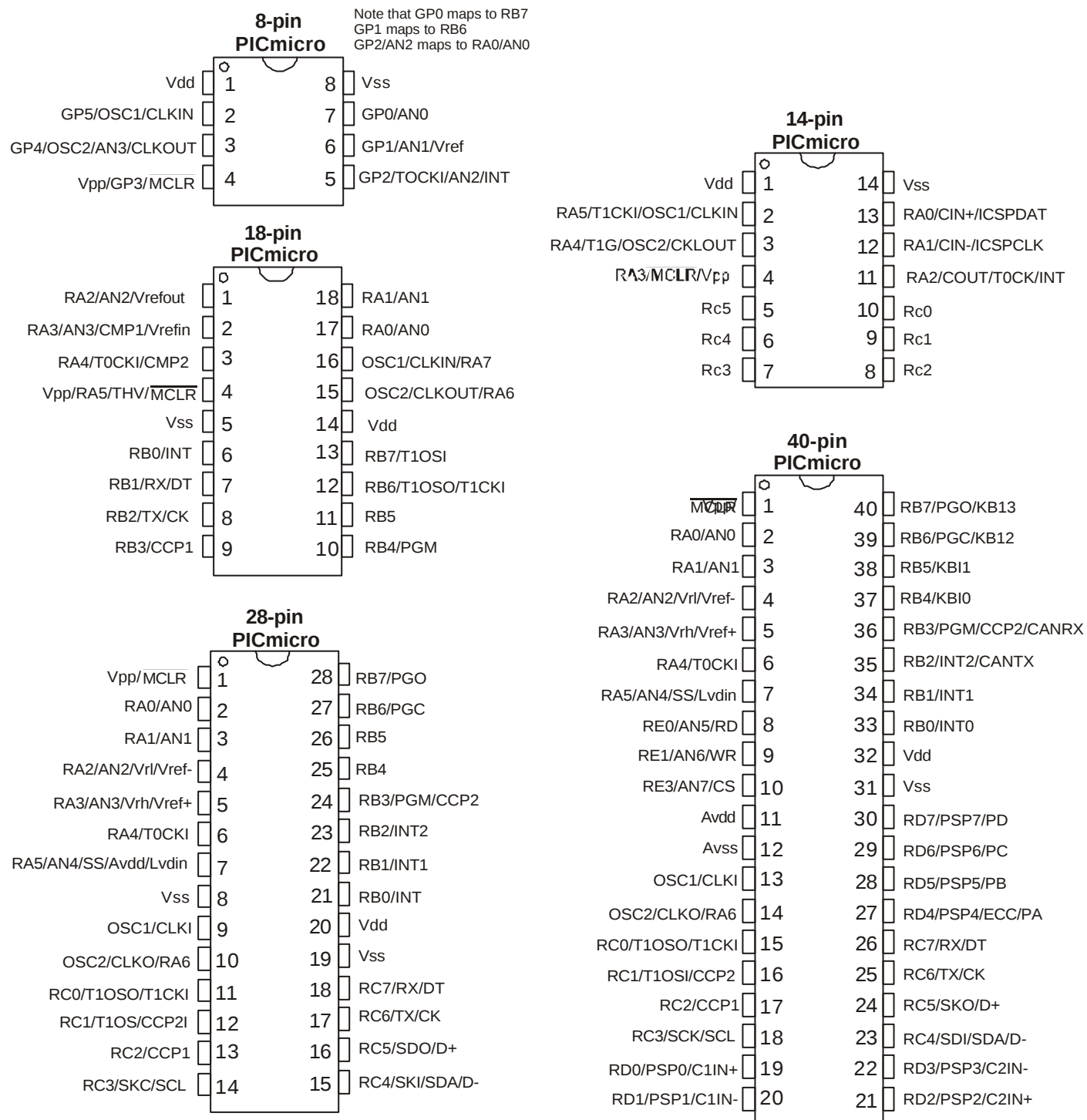
PIC12F629, PIC12F675, PIC12F635, PIC12F683

PIC16F627A, PIC16F627, PIC16F628A, PIC16F628, PIC16F630, PIC16F648A, PIC16F676, PIC16F684, PIC16F688, PIC16F636, PIC16F716, PIC16F72, PIC16F737, PIC16F73, PIC16F747, PIC16F74, PIC16F767, PIC16F76, PIC16F777, PIC16F77, PIC16F818, PIC16F819, PIC16F83, PIC16F84A, PIC16F84, PIC16F870, PIC16F871, PIC16F872, PIC16F873A, PIC16F873, PIC16F874A, PIC16F874, PIC16F876A, PIC16F876, PIC16F877A, PIC16F877, PIC16F87, PIC16F88

PIC18F242, PIC18F248, PIC18F252, PIC18F258, PIC18F442, PIC18F448, PIC18F452, PIC18F458, PIC18F1220, PIC18F1320, PIC18F2220, PIC18F2320, PIC18F2331, PIC18F2410, PIC18F2420, PIC18F2431, PIC18F2439, PIC18F2455, PIC18F2510, PIC18F2515, PIC18F2520, PIC18F2525, PIC18F2539, PIC18F2550, PIC18F2585, PIC18F2586, PIC18F2610, PIC18F2620, PIC18F2680, PIC18F2681, PIC18F4220, PIC18F4320, PIC18F4331, PIC18F4410, PIC18F4420, PIC18F4431, PIC18F4439, PIC18F4455, PIC18F4510, PIC18F4515, PIC18F4520, PIC18F4525, PIC18F4539, PIC18F4550, PIC18F4585, PIC18F4586, PIC18F4610, PIC18F4620, PIC18F4680, PIC18F4681

9 Pin out details and bus connections

Broadly speaking the ranges of PICmicro devices are designed to be upwards compatible: the pin functions on an 18-pin device are available on a 28-pin device and a 40-pin device. This can be seen from the following information taken from the Microchip product selector card:



This has allowed us to wire the 8, 18, 28, and 40 pin devices in parallel on the development board. Whilst the board is optimised for a PIC16F88 (an 18 pin device) it can also therefore be used for almost any PICmicro. The following table shows you the pin comparison chart for all devices. You will find this chart a useful reference tool.

Matrix Multimedia PICmicro® microcontroller training solutions

Version 3 PICmicro development board datasheet

HP48830

Pin Comparison Chart

Bus Name	PICmicro Pinout				
	18 Pin	8 Pin	14 Pin	28 Pin	40 Pin
Vpp/MCLR	4	4	4	1	1
Vdd	14	1	1	20	11 & 32
Vss	5	8	11	8 & 19	12 & 31
OCS1	16	2	2	9	13
OCS2	15	3	3	10	14
RA0/AN0	17			2	2
RA1/AN1	18			3	3
RA2	1			4	4
RA3/AN3	2			5	5
	3			6	6
RA5/AN4	4			7	7
RB0	6			21	33
RB1	7			22	34
RB2	8	5*	11*	23	35
RB3	9			24	36
RB4	10			25	37
RB5	11			26	38
RB6	12	6*	12*	27	39
RB7	13	7*	13*	28	40
RC0			10	11	15
RC1			9	12	16
RC2			8	13	17
RC3			7	14	18
RC4			6	15	23
RC5			5	16	24
RC6				17	25
RC7				18	26
RD0					19
RD1					20
RD2					21
RD3					22
RD4					27
RD5					28
RD6					29
RD7					30
RE0/AN5					8
RE1/AN6					9
RE2/AN7					10

Matrix Multimedia PICmicro® microcontroller training solutions

Version 3 PICmicro development board datasheet

HP48830

Expansion bus

The pin connections on the expansion bus exactly mirror the pin numbering on the 40 pin DIL socket. The best way of connecting devices to the expansion bus is by using an IDC cable.

Connections on J5

Bus Name	40 Pin	IDC connector
Vpp/MCLR	1	1
VCCchip	11 & 32	18 & 21
GND	12 & 31	20 & 23
OCS1	13	25
OCS2	14	27
RA0/AN0	2	3
RA1/AN1	3	5
RA2	4	7
RA3/AN3	5	9
RA4/AN4	6	11
RA5	7	13
RB0	33	16
RB1	34	14
RB2	35	12
RB3	36	10
RB4	37	8
RB5	38	6
RB6	39	4
RB7	40	2
RC0	15	29
RC1	16	31
RC2	17	33
RC3	18	35
RC4	23	36
RC5	24	34
RC6	25	32
RC7	26	30
RD0	19	37
RD1	20	39
RD2	21	40
RD3	22	38
RD4	27	28
RD5	28	26
RD6	29	24
RD7	30	22
RE0/AN5	8	15
RE1/AN6	9	17
RE2/AN7	10	19

Connections on J24

Bus Name	IDC connector
Vpp/MCLR	1
VCCchip	21 & 22
VCC	29
VPPmain	19
VBUS	17
GND	23 & 24
OCS1	26
OCS2	28
RA0/AN0	4
RA1/AN1	6
RA2	8
RA3/AN3	10
RA4/AN4	12
RA5	14
RA6	25
RA7	27
RC0	30
RC1	32
RC2	34
RC3	36
RD0	38
RD1	40
RE0	16
RE1	18
RE2	20
PRB0	15
PRB1	13
PRB2	11
PRB3	9
PRB4	7
PRB5	5
PRB6	3
PRB7	1
PRA0	31
PRA1	33
BRB3	35
BRB6	37
BRB7	39

Note J5 is a set to copy the 40-way DIL socket

10 Liquid Crystal Display

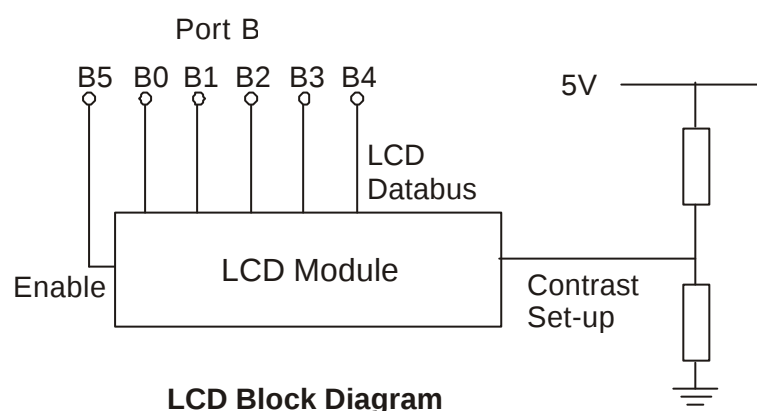
The LCD is a 16 character x 2 lines module. Internally it is 40 characters x 2 lines. Line 1 ranges from H'00' to H'27' and Line 2 ranges from H'40' to H'67'.

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67

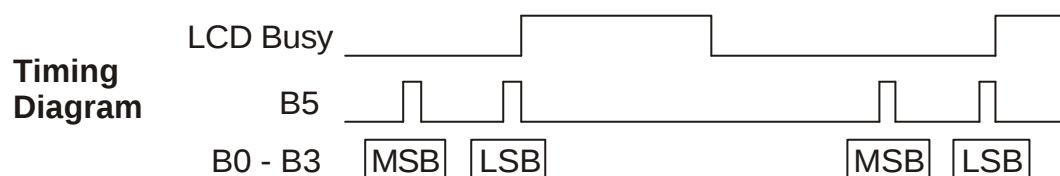
Display Window [16x2] Internal [40x2]

The LCD Module uses a Samsung KS0066U controller, which is similar to the Hitachi HD44780 controller.

The PICmicro board uses port B [B0 to B5] to program the LCD, as shown in the circuit diagram below. When the PICmicro board is turned on, data can only be sent to it after 30ms, this is the time taken for the LCD to initialize [as it clears all the RAM and sets up the Entry Mode].



To send a command to the LCD, data must be sent in two steps, the MSB followed by the LSB [byte is data on B0 to B3]. As each byte is sent to the LCD, B5 must be go high then low, for the LCD to acknowledge the byte. After the second byte has been acknowledged the LCD executes the command. The PICmicro board must wait for at least the length of the execution time for that command, before the next command can be sent. A timing diagram of this process is shown below.



The first command to be sent to the LCD must be 'Function Set' [to setup the LCD], this is usually followed by 'Display Control' and then 'Clear Display'. According to 'Entry Mode Set' after each character is sent to the LCD, the position of the cursor changes [by default it is incremented].

Matrix Multimedia PICmicro® microcontroller training solutions

Version 3 PICmicro development board datasheet

HP48830

LCD Instruction Set

Instruction	Code					Description	Execution Time
	MSB LSB	B4	B3	B2	B1	B0	
Clear Display	0	0	0	0	0	Clear all display data. Set DDRAM address to 0. Move cursor to home position. Entry mode set to increment.	1.53 ms
Return Home	0	0	0	0	0	Set DDRAM address to 0. Move cursor to home position.	1.53 ms
Entry Mode Set	0	0	0	0	0	Sets cursor move direction (I/D), specifies to shift the display (S). These operations are performed during data read/write.	39 us
Display Control	0	0	0	0	0	D is Display ON/OFF bit. C is Cursor ON/OFF bit. B is Blink Cursor ON/OFF bit.	39 us
Cursor/Display Shift	0	0	0	0	1	Sets cursor-move or display-shift (S/C), shift direction (R/L). DDRAM contents remains unchanged.	39 us
Function Set	0	0	0	1	0	Configuration data for setting up LCD. [Send First]	39 us
Set CGRAM Address	0	0	1	A5	A4	Sets the CGRAM address. CGRAM data is sent and received after this setting.	39 us
Set DDRAM Address	0	1	A6	A5	A4	Sets the DDRAM address. DDRAM data is sent and received after this setting.	39 us
Write Data to RAM	1	D7	D6	D5	D4	Writes data to CGRAM or DDRAM.	43 us

DDRAM is Display Data RAM
DDRAM address is location of cursor
CGRAM is Character Generator RAM
X is Don't Care

Bit Name	0	1
I/D	Decrement cursor position	Increment cursor position
SH	No display shift	Display shift
D	Display off	Display on
C	Cursor off	Cursor on
B	Cursor blink off	Cursor blink on
S/C	Move cursor	Shift display
R/L	Shift left	Shift right

LCD Character Set

Higher Lower bit	0000	0001	0011	0100	0101	0110	0111	1010	1011	1100	1101	1110	1111
00000000	(0)	0	1	P	Q	R	S	T	U	V	W	X	Y
00000001	(1)	!	"	#	\$	%	&	'	(	)	*	+	,
00000010	(2)	!	1	A	Q	a	q	.	7	4	ä	q	
00000011	(3)	"	2	B	R	b	r	'	ı	ı	ı	ı	ı
00000100	(4)	#	3	C	S	c	s	ı	ı	ı	ı	ı	ı
00000101	(5)	\$	4	D	T	d	t	ı	ı	ı	ı	ı	ı
00000110	(6)	%	5	E	U	e	u	.	7	4	ä	q	
00000111	(7)	&	6	F	V	f	v	ı	ı	ı	ı	ı	ı
00001000	(8)	'	7	G	W	g	w	ı	ı	ı	ı	ı	ı
00001001	(1)	<	8	H	X	h	x	ı	ı	ı	ı	ı	ı
00001010	(2)	>	9	I	Y	i	y	ı	ı	ı	ı	ı	ı
00001011	(3)	*	:	J	Z	j	z	ı	ı	ı	ı	ı	ı
00001100	(4)	+	;	K	[	k	[	ı	ı	ı	ı	ı	ı
00001101	(5)	,	<	L	¥	ı	ı	ı	ı	ı	ı	ı	ı
00001110	(6)	-	=	M	ı	m	ı	ı	ı	ı	ı	ı	ı
00001111	(7)	.	>	N	^	n	ı	ı	ı	ı	ı	ı	ı
00010000	(8)	/	?	0	_	ı	ı	ı	ı	ı	ı	ı	ı

Hint
please look at our web
site for examples of code
that shows how to
program the 7-segment
display. (TEST40.ASM
factory test routine.)

11 On-board analogue sensors

To use an analogue sensor, the PICmicro board must manually be set to analogue mode and an analogue-capable PIC must be used. Whilst in analogue mode certain port A pins [A0/RA0,A1/RA1 etc] are able to convert an analogue signal to an 8 or 10 bit digital signal, using the on-board A to D converter inside the PICmicro device.

Please refer to Microchip data sheets for more details.

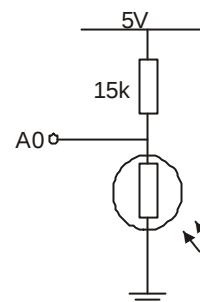
The analogue sensors are not normally connected to the PICmicro pins but are switched to them under the control of the jumpers on J14.

Several analogue sensors are relevant:

LDR

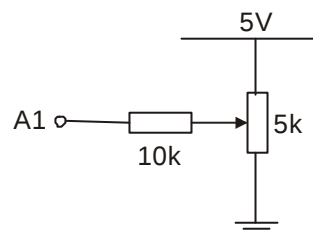
A compact cadmium sulphide light dependent resistor is soldered onto the development board. When J14 link RA0 is in the 'analogue' position it is connected to A0 on the PICmicro microcontroller. The resistance of this device reduces as light falling on it increases.

Technical specification	
Dark resistance	1M Ohm
Resistance @ 10 Lux	10-20k Ohm
100 Lux	2-4k Ohm
Peak spectral response	540 nm



Potentiometer

Most passive sensors are based on a simple potential divider circuit. In order to get your code up and running as simply as possible it is therefore useful to have a simulation of the full operation range (0V to 5V) that a sensor might provide. This function is simulated by a simple 4k7 preset potentiometer (RV3) with a series 10k resistor, which produces a voltage in the range of 0V to 5V on RA1. Note that J14 / 1 will need to be in the analogue position to use this circuit.



External analogue sensor

In addition to the above the link J14 / 3 also switches a voltage from a range of external active sensors onto pin A3/RA3 of the PICmicro microcontroller. These active sensors are designed specifically for educational purposes. Details of some sensors are given below.

12 External sensors

We recommend that customers who want to introduce their students to sensors purchase a core set that will introduce students to different techniques and strategies of gathering real world data in both analogue and digital form. In brief these are:

Sensor	Output/action	Coding strategy
Temperature probe	Simple potential divider	A/D conversion, calibration, value look up, display
Motion detector	Gives out a digital pulse correlating to distance	Active sensor, pulse time measurement, conversion and display
Heart rate monitor	Gives out an analogue voltage pulse	Data slicing, and timing
Photogate and pulley wheel	When IR light path is interrupted, digital output changes	Various

Fast response Photogate



Description
Photogates can be used to study free fall, rolling objects, air track collisions, pendulums, etc. These inexpensive, ready-to-use photogates are similar to the traditional PASCO photogate, but have no stand.

Photogates become particularly useful when used with the smart pulley adaptor (code HSSPA) for measuring speed, the picket fence (code HSPF) which is used for measuring g or the bar tape (code HSTAPE) which replaces ticker tape.

Specification
Digital sensor

Code: HSVPG

Several accessories for the Photogate are also available.

Smart pulley code: HSSPA
Bar tape code: HSTAPE

Motion detector



Description
The Motion Detector functions like the automatic range finder on a Polaroid camera. This sonar device emits ultrasonic pulses and waits for an echo. The time it takes for the reflected pulses to return is used to calculate distance, velocity, and acceleration. The range is 0.4 to 6 meters. Our Motion Detector has a pivoting head, rubber feet, and a clamp for mounting.

Specification
Digital sensor
Frequency of the ultrasound: 49.4 kHz
Resolution: 1 mm, Range: 0.40 to 6.0 meters

Temperature probe



Description
This rugged and durable temperature probe has a sealed stainless steel shaft and tip that can be used in organic liquids, salt solutions, acids, and bases. The reading from the temperature probe is the resistance value of a thermistor.

Specification
Analogue sensor

Code: HSTMP

Also available is an extra long temperature probe with wider range: see our web site for details.

Current probe



Description
Use the Current Probe to measure currents in low-voltage AC and DC circuits. With a range of ± 0.6 A, this system is ideal for use in most "battery and bulb" circuits. Use it with the Differential Voltage Probe to explore Ohm's law, phase relationships in reactive components, and much more. Use multiple sensors to explore series and parallel circuits. It can also be used in electrochemistry experiments.

Specification
Analogue sensor
 ± 0.6 A
Resolution: 0.6mA

Code: HSDCP

Differential voltage probe



Description
Use the Differential Voltage Probe to measure low-voltage AC and DC circuits. With a range of ± 6.0 V, this system is ideal for use in most "battery and bulb" circuits. Use it with the Current Probe to explore Ohm's law, phase relationships in reactive components, and much more. This differs from the Voltage Probe that comes with your interface in that neither clip is connected to ground. Use multiple sensors to explore series and parallel circuits

Specification
Analogue sensor

Code: HSDVP

Heart rate monitor



Description
The Exercise Heart Rate Monitor is ideal for determining the heart rate of actively moving individuals. With this sensor, a person's heart rate can be monitored during, as well as after exercise. The Exercise Heart Rate Monitor consists of a wireless transmitter belt and a receiver module. The transmitter belt senses the electrical signals generated by the heart much like an ECG. For each heartbeat detected, a signal is transmitted to the receiver module, and a heart rate can be determined.

Specification
Analogue sensor

Code: HSEHR

Full list of sensors and accessories

Sensors	Bar Tape	HSTAPE
	Barometer	HSBAR
	Calcium ion-selective sensor	HSCA
	Chloride ion-selective sensor	HSCL
	CO2 Gas sensor	HSCO2
	Colourimeter 3	HSCOL
	Conductivity probe 3	HSCON
	Current probe 3	HSDCP
	Differential voltage probe	HSDVP
	Dissolved oxygen probe	HSDO
	Dual-range force sensor 3	HSDFS
	EKG electrodes	HPELEC
	EKG sensor	HPEKG
	Extra long temperature probe	HSTPL
	Fast response photogate	HSVPG
	Flow rate sensor	HSFLO
	Gas pressure sensor	HSGPS
	Heart rate monitor	HSEHR
	Instrumentation amplifier	HSINA
	Low-g accelerometer	HSACC
	Magnetic field sensor 3	HSMG
	Microphone 3	HSMCA
	Motion detector	HSMD
	Nitrate ion-selective sensor	HSN03
	O2 gas sensor 3	HSO2
	pH sensor and amplifier	HSPH
	Picket Fence	HSPF
	Radiation monitor 3	HSRM
	Relative humidity sensor 3	HSRH
	Respiration monitor belt (requires gas pressure sensor)	HSRMB
	Rotary motion sensor	HSRMS
	Smart pulley attachment	HSSPA
	Thermocouple	HSTCA
	Three range light sensor 3	HSLS
	Turbidity sensor	HSTRB
	Wide range stainless steel temperature probe	HSTMP

Using external analogue sensors

To make use of the analogue sensors you will need a PICmicro that has an in-built Analogue to Digital converter (ADC). The PICmicro shipped with the board - the PIC16F88 - does have an ADC built in. Other examples of PICmicros that do have A/D converters built in are:

PIC16F710 4 off 8 bit ADC channels
PIC16F877A 4 off 10 bit ADC channels

There are two steps in using an analogue sensor:

1. Reading the value of the voltage at the ADC input
2. Understanding how this relates to the analogue parameter being measured.

Reading the value of the voltage at the ADC input is simply a matter of setting up your ADC and you should refer to the Microchip datasheet for further instructions on this advanced feature.

Relating the resulting hex value to the actual analogue parameter should be possible with the information supplied above and a small amount of mathematics. The results should be of a suitable accuracy for the majority of applications.

If you require higher accuracy you will need to calibrate your sensor to relate the hex values read in by the PICmicro to exact known light levels, pH levels etc. Calibrating the sensors to a high level of accuracy will invariably involve using a known piece of test equipment that is already calibrated.

Using external digital sensors

Several external digital sensors can be attached to the PICmicro board. The input to the sensor is on A2 and the output from the sensor goes to A4.

Matrix Multimedia PICmicro® microcontroller training solutions

Version 3 PICmicro development board datasheet

HP48830

Full list of extra accessories

Software	Assembly for PICmicro MCUs V3.0 CD ROM Single user	ELPICS13
	Assembly for PICmicro MCUs V3.0 CD ROM 10 user	ELPIC103
	Assembly for PICmicro MCUs V3.0 CD ROM Site licence	ELPICSL3
	C for PICmicro MCUs V2.0 CD ROM Single user	ELPCCSI2
	C for PICmicro MCUs V2.0 CD ROM 10 user	ELPCC102
	C for PICmicro MCUs V2.0 CD ROM Site licence	ELPCCSL2
	Flowcode for PICmicro MCUs V2 CD ROM Single user	TEFLCSI2
	Flowcode for PICmicro MCUs V2 CD ROM 10 user	TEFLC102
	Flowcode for PICmicro MCUs V2 CD ROM Site licence	TEFLCSL2
PICmicro devices	PIC16F877 - 10 off	HP16F877
	PIC16F84 - 10 off	HP16F84
	PIC16F628 - 10 off	HP16F628
	PIC16F88 - 10 off	HP16F88
	PIC18F2220 - 10 off	HP18F2220
	PIC18F4431 - 10 off	HP18F4431
Accessories	Version 2 PICmicro development board	HP488
	1A new power supply	HPPSU2
	Backplane	BP232
	Actuators training panel	HPACT
	PICmicro microcontroller buggy kit	HPBUG
	Alex animated head	HPALEX
	Shallow plastic tray	HP2045
	4 section insert for tray	HP2935
	Foam for shallow tray	HP3844
	Lid for plastic tray	HP4039
E-blocks	E-blocks screw terminal board	EB002
	E-blocks sensor interface	EB003
	E-Blocks LED board	EB004
	E-Blocks LCD board	EB005
	E-Blocks Switch board	EB007
	E-blocks power board	EB011
	E-blocks IR/IRDA transmitter receiver	EB012
	E-blocks SPI memory and D/A board	EB013
	E-blocks Keypad	EB014
	E-blocks RS232 board	EB015
	E-Blocks Prototype board	EB016
	E-blocks patch board	EB017
	E-blocks CAN board	EB018
	E-blocks internet board	EB023
	E-blocks Bluetooth board	EB024
	E-blocks home automation board	EB028
	E-blocks IDC cable	EB634

Please note that this list was correct at time of going to press. However there may now be more items that are not on this list. Please visit www.matrixmultimedia.co.uk for full and up-to-date details of all our products.

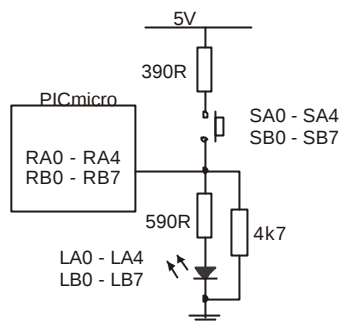
13 Circuits

Switches and LED's

Port A [A0 – A7] and Port B [B0 - B7] on the PIC can be directly used for I/O on the PICmicro board, using onboard switches and LED's. The basic circuit that allows the same PICmicro connector I/O pin to be used as either an input or an output is shown below.

Note that Port A [A5] is only available on larger devices such as the PIC16F877A.

Note that Port A [A6-A7] are not currently available on PIC chips, but have been provided for further development.

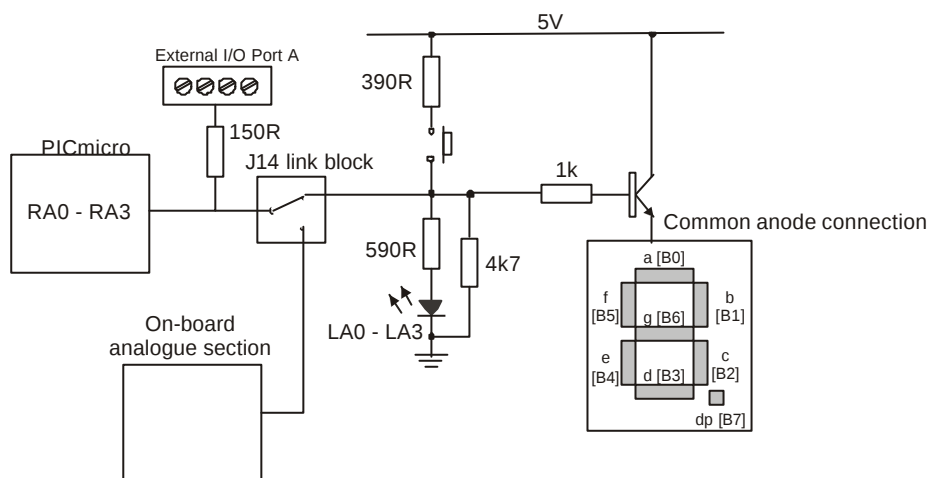


Multiple connections

The development board allows several variations on this basic circuit by the inclusion of switches and links on the board. There are a number of variations of this as follows:

RA0 to RA3

RA0 to RA3 are used to select which 7-segment display is used, are used for analogue inputs and are also connected to the screw terminals. The actual circuit used here is:



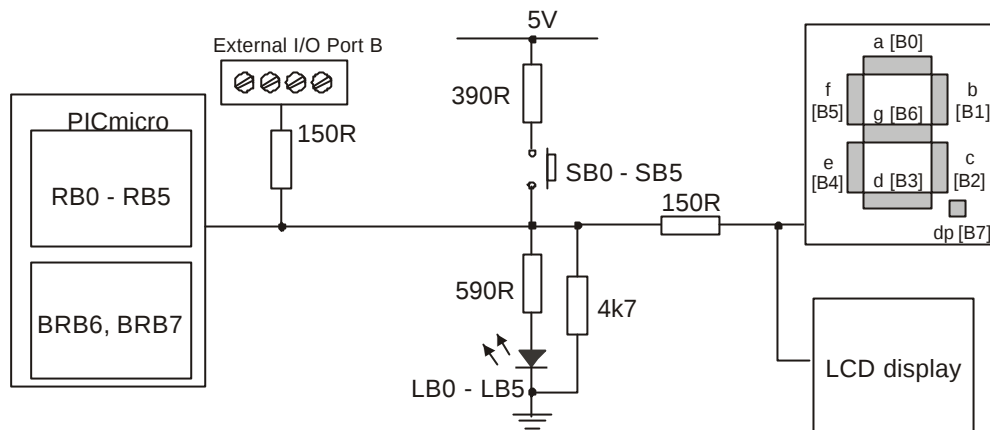
J14 allows students to effectively switch RA0 to RA3 to analogue or digital circuitry. Removing the link altogether will connect RA0 to RA3 only to the Port A screw terminal connectors via 150 ohm protection resistors. Note that the on-board analogue section consists of a potential divider provided by a light sensor, a potentiometer or an external sensor that provides a voltage between 0 and 5V. Under normal operation the links on J14 should be put into the 'digital' position.

RA4

RA4 is not switched by jumper link on J14. It is not connected to the 7-segment displays or the analogue section. RA4 is used for the external Vernier digital sensor.

RB0 to RB5

RB0 to RB5 are all connected to the switches and LEDs as well as to the I/O screw terminals, via 150-ohm protection resistor, and to the LCD and the cathodes of the 7-segment displays.

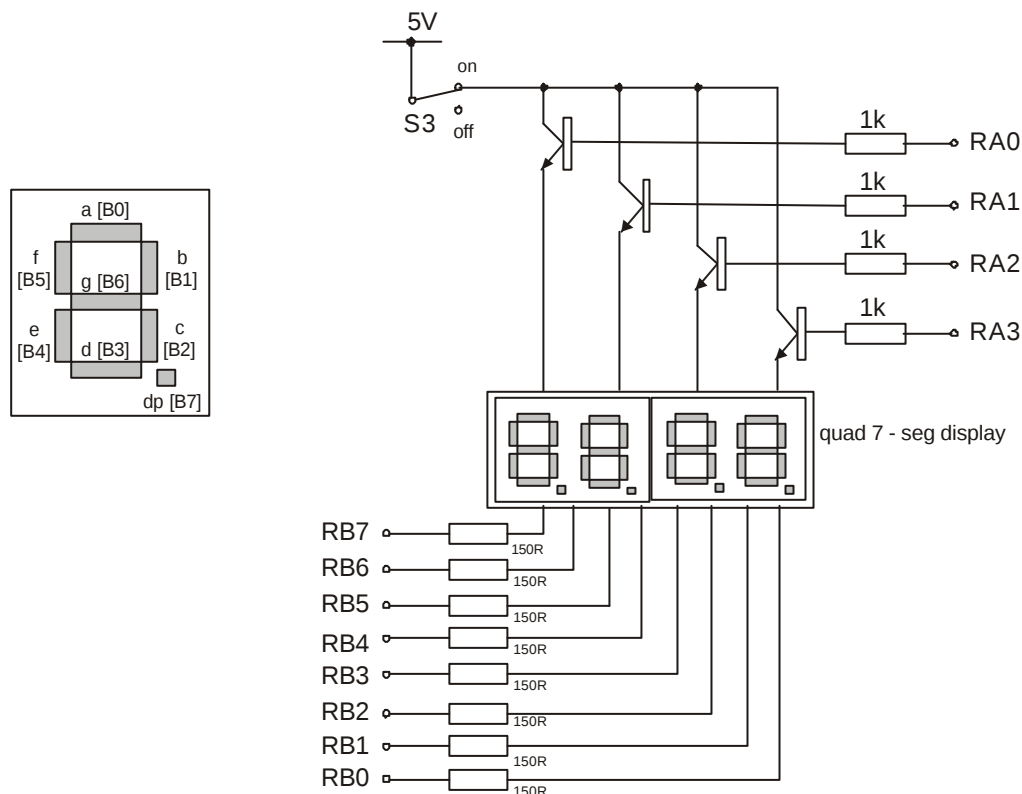


RB6 and RB7

RB6 and 7 have the same circuit as above but are connected to the PICmicro via an analogue switch - Buffered RB6 and Buffered RB7. This circuit is shown in the core PICmicro circuit below.

Quad 7-segment display

To use the quad 7-segment displays S3 must be in the 'on' position. Port A [A0 (left) - A3 (right)] is used to select which of the four 7-segment display digits is active and the voltages on Port B [B0 - B7] dictate which segment is lit. To display data on all four 7-segment displays a simultaneously multiplexing program is required.



The '745 also controls the programming circuitry – the 4053 (U3) and 4052 (U6) multiplexer chips. These 4053 chip is used to control the voltage levels set on /MCLR pins of the targeted chip. The target PIC chip requires +13V, +5V or 0V depending on the action required by the PIC. The pins RB3, RB6 and RB7 are used on the PICmicro device for both programming and reading data and the '745 needs direct control of these devices. This is facilitated by the use of 4052 multiplexer chip. The 4052 controls when these signals are used for programming or when they are used for standard I/O. It also forms an isolation circuit – that allows the programming pins to be 'clean' when in programming mode. The '745 automatically resets the target PICmicro after programming.

S2 selects between RC oscillation mode and crystal mode. The value of X1 is chosen to produce accurate timing. When RC mode is selected S4 selects fast or slow operation and RV1 controls the RC constant and hence clock speed within the range dictated by S4.

Page 22

Matrix Multimedia PICmicro® microcontroller training solutions

Version 3 PICmicro development board datasheet

HP48830

13 Schematic Diagram

