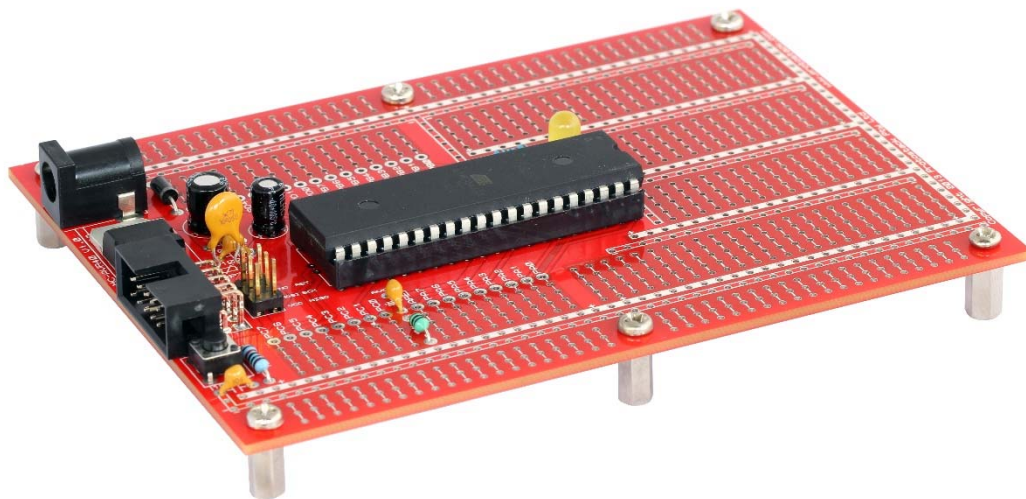


# **PB-MC-AVR40 40 Pin AVR Full Size Development Board**



## **User's Guide**

**Version 1.0**  
30 May 2013

**PB-MC-AVR40-UG**



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## 1. Overview

### 1.1. Introduction

The Protostack 40 Pin AVR Full Size Development Board is designed for ATMEL AVR Microcontrollers that are available in the PDIP 40 pin package. This board performs the following functions:

- a. Provides the infrastructure necessary to support the microcontroller,
- b. “Untangles” the I/O ports in order to present them in an orderly fashion, and
- c. Provides area for the user to add their own circuitry

This board conforms to the Protostack full size board form factor and is able to be stacked with other full size or half size boards.

### 1.2. References

#### 1.2.1. Board Versions

This user's guide applies to the following versions of the 40 Pin Full Size AVR Board:

- a. Version 1.0

#### 1.2.2. Referenced Documents

The documents referenced in this User's Guide are listed in Table 1.

Document	Version	Date
PB-MC-AVR40 Datasheet	1.0	16-May-2013
ATMega32A Datasheet	Rev. 8155C - 02/11	

Table 1. Referenced Documents

#### 1.2.3. Acronyms and Abbreviations

The acronyms and abbreviations utilised in this User's Guide are listed in Table 2.

Acronym and Abbreviation	Description
AVCC	Analogue VCC
AVR	Advanced Virtual RISC
DIL	Dual Inline
DIP	Dual Inline Package
ESR	Equivalent Series Resistance
IC	Integrated Circuit
IDC	Insulation-Displacement Connector
I/O	Input/Output
ISP	In System/Service Programming
LED	Light Emitting Diode
mil	Unit of measure corresponding to 1/1000 <sup>th</sup> of an inch
PDIP	Plastic Dual Inline Package
SIL	Single Inline
VCC	Positive supply voltage

Table 2. Acronyms and Abbreviations

#### 1.2.4. Definitions

The definitions utilised in this User's Guide are listed in Table 3.

Term	Definition
Firmware	Firmware is a software program or set of instructions programmed onto the microcontroller. It provides the necessary instructions for how the device communicates with the other hardware.
Flash	Non-volatile computer memory that can be electrically erased and reprogrammed
Protostrip	A strip of 2 or more holes (pad) on a prototyping board that are connected together

Table 3. Definitions

### 1.3. Supported Microcontrollers

Table 4 lists the microcontrollers that are supported by the 40 Pin AVR Development Board.

Microcontroller	Flash	EPROM	SRAM	Speed	Vcc (V)	Notes
ATMEGA16A-PU	16 KB	512 Bytes	1 KB	16 MHz	2.7 to 5.5	
ATMEGA32A-PU	32 KB	1 KB	2 KB	16 MHz	2.7 to 5.5	
ATMEGA8535-16PU	8 KB	512 Bytes	512 Bytes	16 MHz	4.5 to 5.5	
ATMEGA8535L-8PU	8 KB	512 Bytes	512 Bytes	8 MHz	2.7 to 5.5	
ATMEGA164A-PU	16 KB	512 Bytes	1 KB	20 MHz	1.8 to 5.5	
ATMEGA164P-20PU	16 KB	512 Bytes	1 KB	20 MHz	2.7 to 5.5	
ATMEGA164PV-10PU	16 KB	512 Bytes	1 KB	10 MHz	1.8 to 5.5	
ATMEGA164PA-PU	16 KB	512 Bytes	1 KB	20 MHz	1.8 to 5.5	
ATMEGA324A-PU	32 KB	1 KB	2 KB	20 MHz	1.8 to 5.5	
ATMEGA324P-20PU	32 KB	1 KB	2 KB	20 MHz	2.7 to 5.5	
ATMEGA324PV-10PU	32 KB	1 KB	2 KB	10 MHz	1.8 to 5.5	
ATMEGA324PA-PU	32 KB	1 KB	2 KB	20 MHz	1.8 to 5.5	
ATMEGA644A-PU	64 KB	2 KB	4 KB	20 MHz	2.7 to 5.5	
ATMEGA644P-20PU	64 KB	2 KB	4 KB	20 MHz	1.8 to 5.5	
ATMEGA644PV-10PU	64 KB	2 KB	4 KB	10 MHz	1.8 to 5.5	
ATMEGA644PA-PU	64 KB	2 KB	4 KB	20 MHz	2.7 to 5.5	
ATMEGA1284-PU	128 KB	4 KB	16 KB	20 MHz	1.8 to 5.5	
ATMEGA1284P-PU	128 KB	4 KB	16 KB	20 MHz	1.8 to 5.5	
ATMEGA16L-8PU	16 KB	512 Bytes	1 KB	8 MHz	2.7 to 5.5	Obsolete
ATMEGA16-16PU	16 KB	512 Bytes	1 KB	16 MHz	4.5 to 5.5	Obsolete
ATMEGA32L-8PU	32 KB	1 KB	2 KB	8 MHz	2.7 to 5.5	Obsolete
ATMEGA32-16PU	32 KB	1 KB	2 KB	16 MHz	4.5 to 5.5	Obsolete
ATMEGA164-20PU	16 KB	512 Bytes	1 KB	20 MHz	2.7 to 5.5	Obsolete
ATMEGA164V-10PU	16 KB	512 Bytes	1 KB	10 MHz	1.8 to 5.5	Obsolete
ATMEGA324-20PU	32 KB	1 KB	2 KB	20 MHz	2.7 to 5.5	Obsolete
ATMEGA324V-10PU	32 KB	1 KB	2 KB	10 MHz	1.8 to 5.5	Obsolete
ATMEGA644-20PU	64 KB	2 KB	4 KB	20 MHz	2.7 to 5.5	Obsolete
ATMEGA644V-10PU	64 KB	2 KB	4 KB	10 MHz	1.8 to 5.5	Obsolete

Table 4. Supported Microcontrollers

## 1.4. Warnings



Some of the components discussed in this document are very sensitive to electrical static discharges. The reader should take precautions to ensure that components are protected against these discharges.



Whilst the voltages typically seen in microcontroller circuits are low, the reader should be aware of the risk of working with electrical circuits and take necessary precautions.



## 2. Board Schematic

The schematic for the 40 pin AVR full sized board is shown in Figure 1.

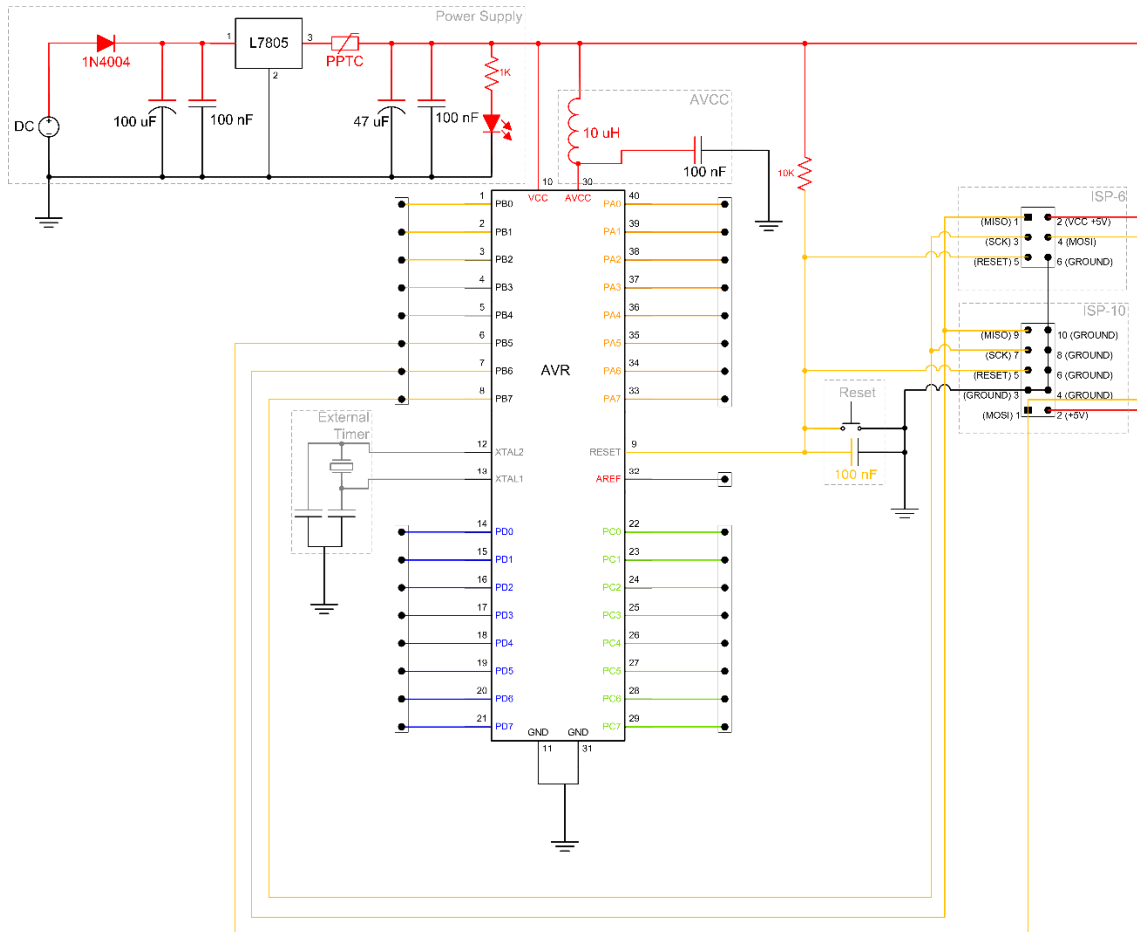


Figure 1. Board Schematic

### 3. Board Layout

Figure 2 shows the AVR specific features of the Protostack 40 Pin AVR Full Size Development Board, whilst Figure 3 shows the general features of the board.

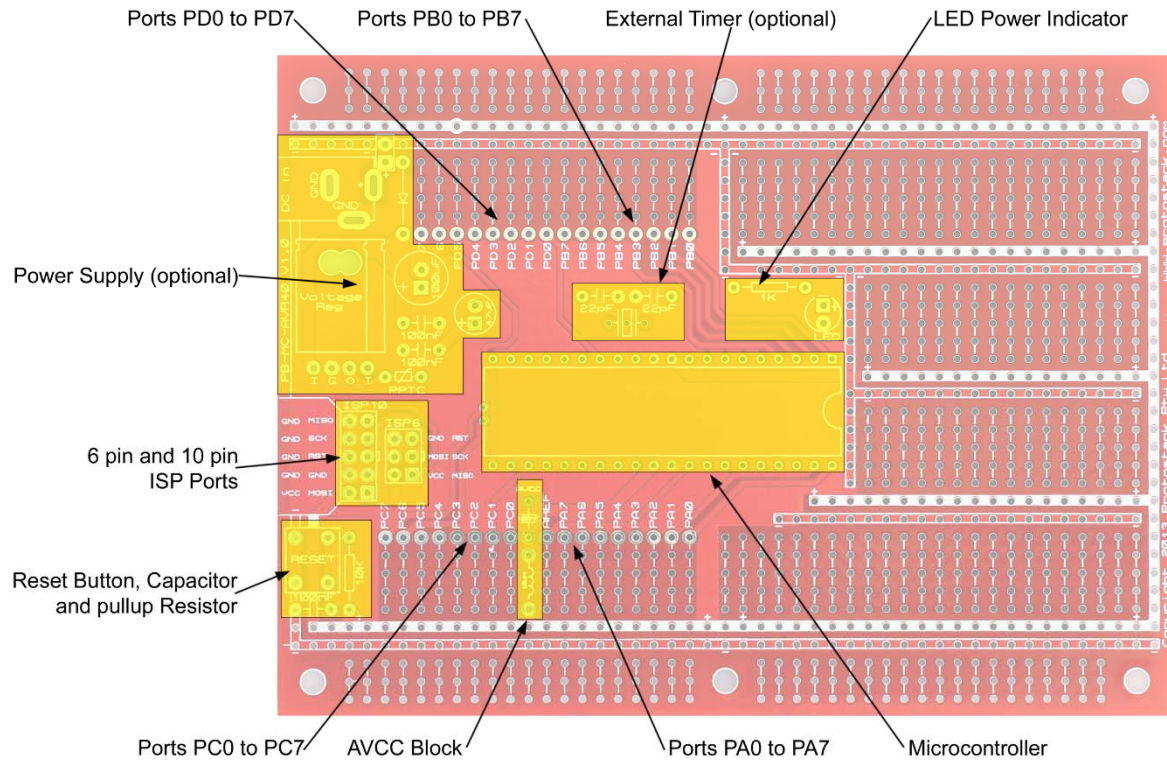


Figure 2. Board layout – AVR Specific features

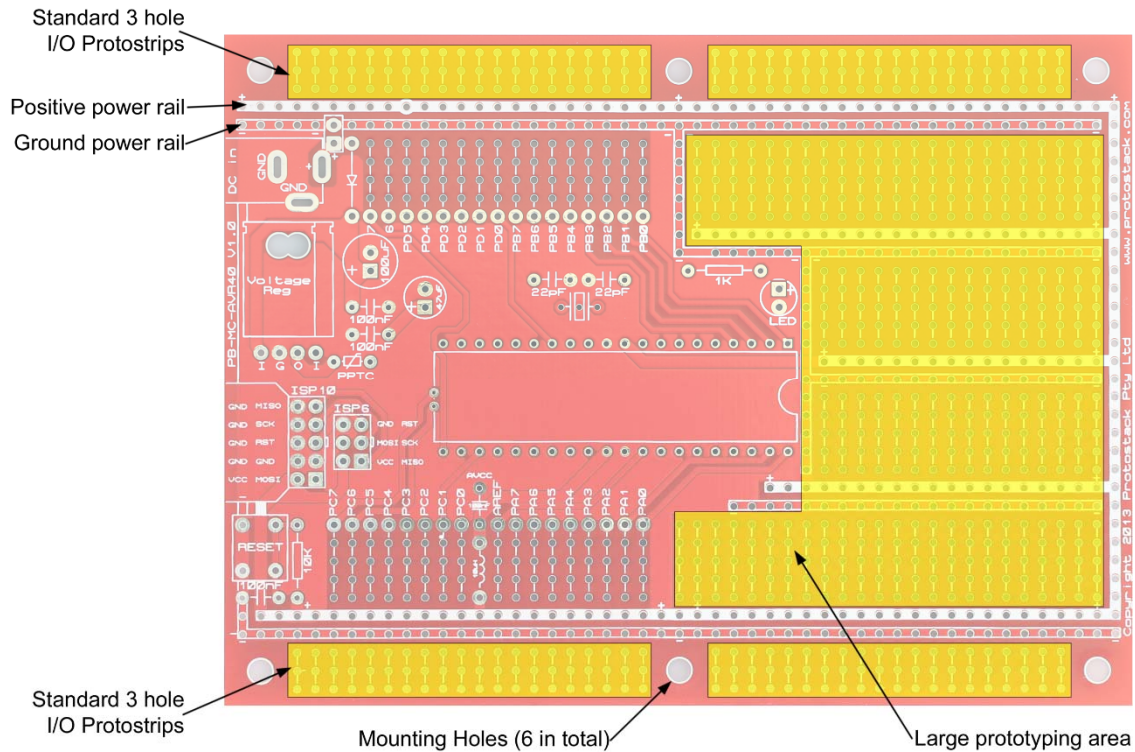


Figure 3. Board layout – General Specific features

### 3.1. Microcontroller

The microcontroller is the heart of this board. Figure 4 shows the microcontroller section on the board and identifies the location of pin 1. The screen printing on the board also show the location of the “dimple” on the microcontroller PDIP package.

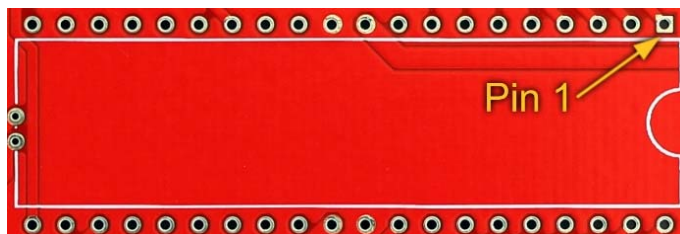


Figure 4. Microcontroller location on Board

### 3.2. Pull-up resistor and Reset Button

Reset (Pin 9) is held high for normal operation. To achieve this, a 10K $\Omega$  resistor is added to the board. When the reset switch is pressed, pin 9 is momentarily grounded, initiating the microcontroller reset. A space to add a switch de-bounce capacitor has also been provided.

This is all shown in Figure 5.

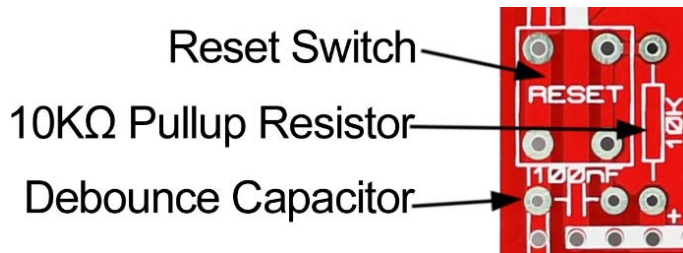


Figure 5. Pull-up resistor, reset switch and de-bounce capacitor

### 3.3. ISP Ports

The ISP connector allows you to load firmware onto the microcontroller. This is achieved by connecting an AVR programmer up to the computer's USB or serial port then running software such as AVRdude to load the firmware.

This board has 2 ISP interfaces:

- a. A 10 pin (2x5) interface suitable for a 10 pin IDC connector; and
- b. A 6 pin (2x3) interface

Figure 6 shows the pinout for the 10 pin interface whilst Figure 7 shows the pinout for the 6 pin interface.

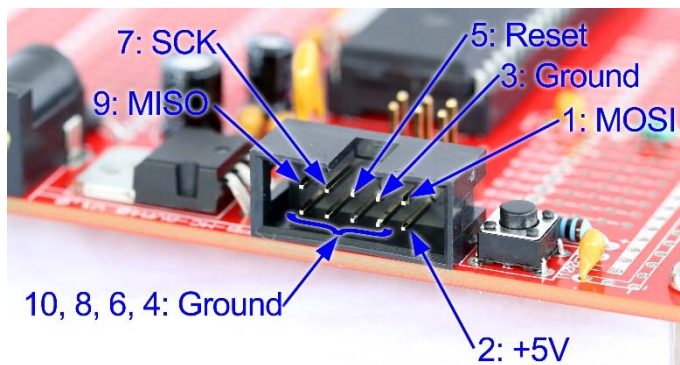


Figure 6. 10 pin ISP port pinout

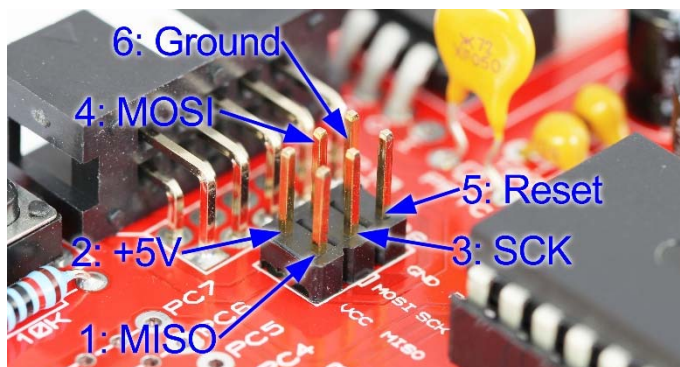


Figure 7. 6 pin ISP port pinout

### 3.4. AVCC Block

The AVCC pin (pin 30) provides power to the AD Converter. Although this can be connected directly to VCC it is recommended that a low pass filter be installed as AVCC must stay within the VCC  $\pm 0.3V$ .

The ATMEL Datasheets for the supported AVR Microcontrollers recommend that the low pass filter comprise of a  $10\mu H$  inductor and a  $100nF$  Capacitor as show in Figure 8.

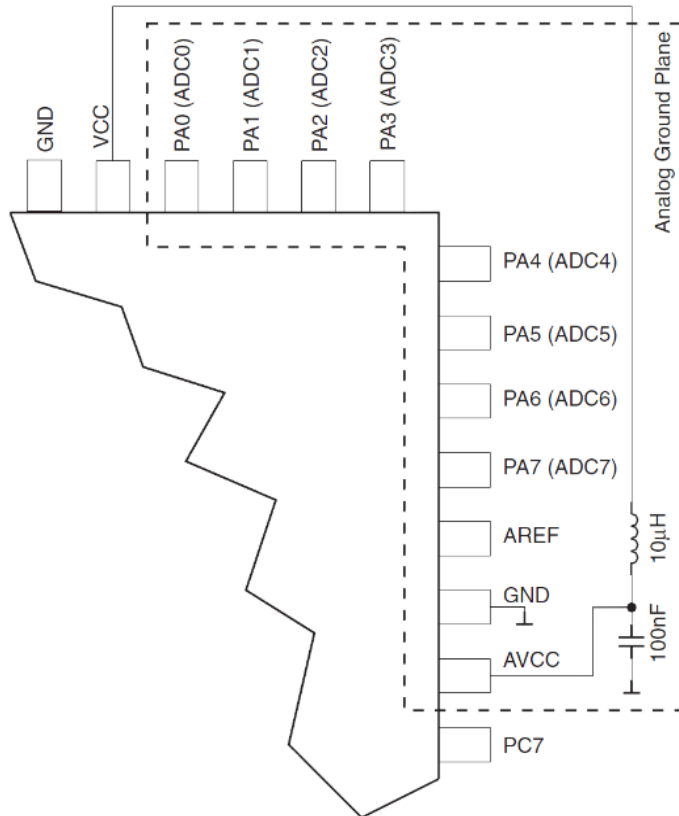


Figure 8. AVCC Low Pass Filter

The 40 Pin AVR full size development board supports both approaches. AVCC can be connected directly to VCC by using a piece of wire, or a low pass filter can be added to the board. This is discussed further in section 4.4.

### 3.5. External Oscillator

The microcontrollers this board supports all have excellent internal timers. There are times when more precision is required and hence the need for an external Oscillator.

Using an external oscillator involves the setting of fuses and is beyond the scope of this document. The board however does support the oscillator hardware which comprises of a crystal and 2 capacitors.

### 3.6. Ports PA0-PA7, PB0-PB7, PC0-PC7 and PD0-PD7

One of the important functions of this board is to “untangle” the data ports and present them in a more orderly fashion. Data ports are presented in 4 groups on the board:

- a. PA0 to PA7,
- b. PB0 to PB7,
- c. PC0 to PC7, and
- d. PD0 to PD7.

Although these ports are identified by port numbers, the microcontroller pins that they correspond to may be used for other purposes. Table 5 lists the data ports and their uses on the various microcontrollers.



As Identified on Board	Microcontroller Pin (PDIP 40)	ATMega8535(L)	ATMega16A ATMega32A ATMega16(L) ATMega32(L)	ATMega164(P)A ATMega324(P)A ATMega644(P)A ATMega1284(P)A ATMega164(V) ATMega324(V) ATMega644(V)
PA0	40	PA0 (ADC0)	PA0 (ADC0)	PA0 (ADC0/PCINT0)
PA1	39	PA1 (ADC1)	PA1 (ADC1)	PA1 (ADC1/PCINT1)
PA2	38	PA2 (ADC2)	PA2 (ADC2)	PA2 (ADC2/PCINT2)
PA3	37	PA3 (ADC3)	PA3 (ADC3)	PA3 (ADC3/PCINT3)
PA4	36	PA4 (ADC4)	PA4 (ADC4)	PA4 (ADC4/PCINT4)
PA5	35	PA5 (ADC5)	PA5 (ADC5)	PA5 (ADC5/PCINT5)
PA6	34	PA6 (ADC6)	PA6 (ADC6)	PA6 (ADC6/PCINT6)
PA7	33	PA7 (ADC7)	PA7 (ADC7)	PA7 (ADC7/PCINT7)
PB0	1	PB0 (XCK/T0)	PB0 (XCK/T0)	PB0 (PCINT8/XCK0/T0)
PB1	2	PB1 (T1)	PB1 (T1)	PB1 (PCINT9/CLKO/T1)
PB2	3	PB2 (INT2/AIN0)	PB2 (INT2/AIN0)	PB2 (PCINT10/INT2/AIN0)
PB3	4	PB3 (OC0/AIN1)	PB3 (OC0/AIN1)	PB3 (PCINT11/OC0A/AIN1)
PB4	5	PB4 (SS)	PB4 (SS)	PB4 (PCINT12/OC0B/SS)
PB5	6	PB5 (MOSI)	PB5 (MOSI)	PB5 (PCINT13/ICP3/MOSI)
PB6	7	PB6 (MISO)	PB6 (MISO)	PB6 (PCINT14/OC3A/MISO)
PB7	8	PB7 (SCK)	PB7 (SCK)	PB7 (PCINT15/OC3B/SCK)
PC0	22	PC0 (SCL)	PC0 (SCL)	PC0 (SCL/PCINT16)
PC1	23	PC1 (SDA)	PC1 (SDA)	PC1 (SDA/PCINT17)
PC2	24	PC2	PC2 (TCK)	PC2 (TCK/PCINT18)
PC3	25	PC3	PC3 (TMS)	PC3 (TMS/PCINT19)
PC4	26	PC4	PC4 (TDO)	PC4 (TDO/PCINT20)
PC5	27	PC5	PC5 (TDI)	PC5 (TDI/PCINT21)
PC6	28	PC6 (TOSC1)	PC6 (TOSC1)	PC6 (TOSC1/PCINT22)
PC7	29	PC7 (TOSC2)	PC7 (TOSC2)	PC7 (TOSC2/PCINT23)
PD0	14	PD0 (RXD)	PD0 (RXD)	PD0 (PCINT24/RXD0/T3)
PD1	15	PD1 (TXD)	PD1 (TXD)	PD1 (PCINT25/TXD0)
PD2	16	PD2 (INT0)	PD2 (INT0)	PD2 (PCINT26/RXD1/INT0)
PD3	17	PD3 (INT1)	PD3 (INT1)	PD3 (PCINT27/TXD1/INT1)
PD4	18	PD4 (OC1B)	PD4 (OC1B)	PD4 (PCINT28/XCK1/OC1B)
PD5	19	PD5 (OC1A)	PD5 (OC1A)	PD5 (PCINT29/OC1A)
PD6	20	PD6 (ICP1)	PD6 (ICP1)	PD6 (PCINT30/OC2B//ICP)
PD7	21	PD7 (OC2)	PD7 (OC2)	PD7 (OC2A/PCINT31)

Table 5. Data Port Mappings

### 3.7. Power Supply

The power supply block allows you to build many different power supply circuits including an L7805 base circuit and a CR2032 battery clip. The following photos show examples of what can be done. Section 4.6 goes into this area in much greater detail.

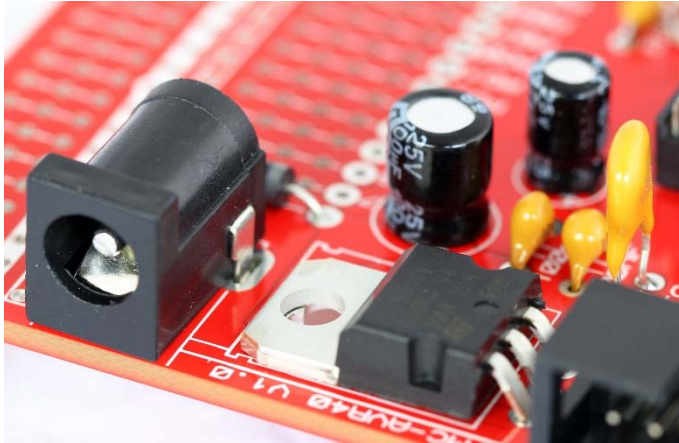


Figure 9. Power supply block with 2.1 x 5.5mm barrel connector



Figure 10. Power supply block with CR2032 battery clip

### 3.8. Positive and Ground power rails

As with other Protostack boards, positive and ground power rails are routed throughout the board. The positive rail is identified with a solid strip whilst the ground rail is identified with a hollow strip. This is shown in Figure 11





Figure 11. Positive and ground power rails

### 3.9. 3 hole I/O Protostrips

Like other Protostack boards, this board has 3-hole I/O protostrips on the top and bottom edges. Although you can use these strips for many other purposes they were designed to be used for:

- a. Getting data or power to the board from outside the system, and/or
- b. Interfacing to other layers in the stack using stacking headers.

Figure 12 shows a 3 board stack with a set of 8 pin stacking headers running data up and down the stack. Figure 13 shows an 8 pin polarised header on the 3 hole I/O protostrips.

*Note: if a polarised header is to be used to bring data and/or power to the board then a better way would be to use a right angle header and connect it to the 5 hole protostrips or directly to the AVR ports.*

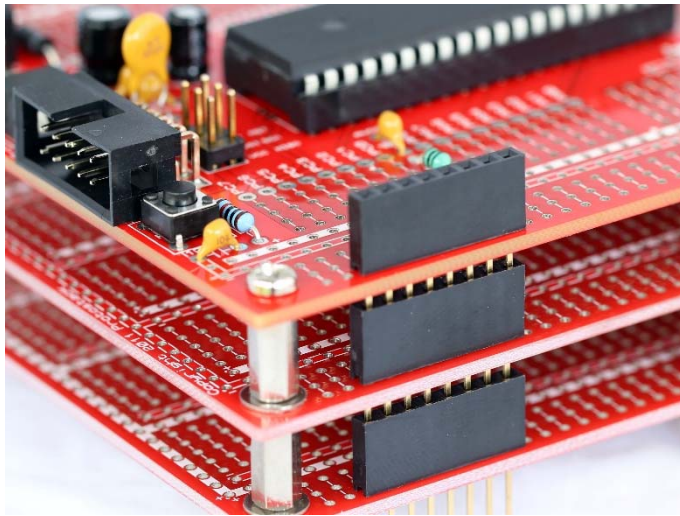


Figure 12. Stacking headers used in a 3 board stack

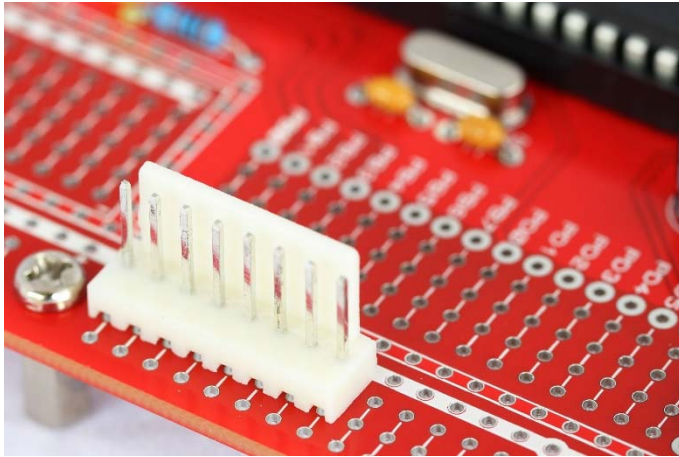


Figure 13. Polarised header used on 3 hole protostrips

### 3.10. Small and large prototyping areas

The prototyping areas are based on the layout of a breadboard and consist of:

- a. Positive Power Rail,
- b. Ground power rail, and
- c. A number of 5-hole protostrips arranged parallel to each other.

This is shown in Figure 14.

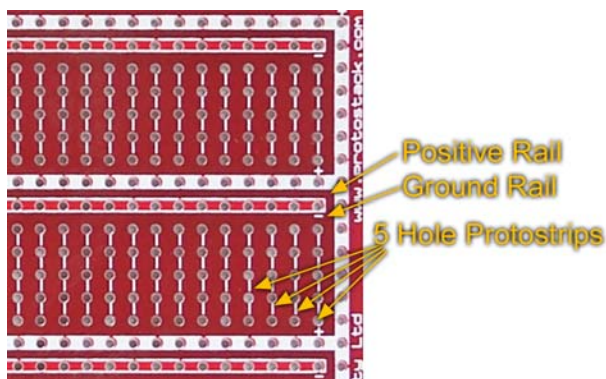


Figure 14. Prototyping areas

#### 3.10.1. Using the prototyping area to interface to the board

In general the 3 hole I/O protostrips on the top and bottom of the board are used for interfacing between boards in a stack or to the outside world. A useful exception is the use of right angled polarised headers directly onto the 5 hole protostrips.

Mounting these onto the 5 hole protostrips allows them to sit further back, thereby not hanging over the edge of the board.

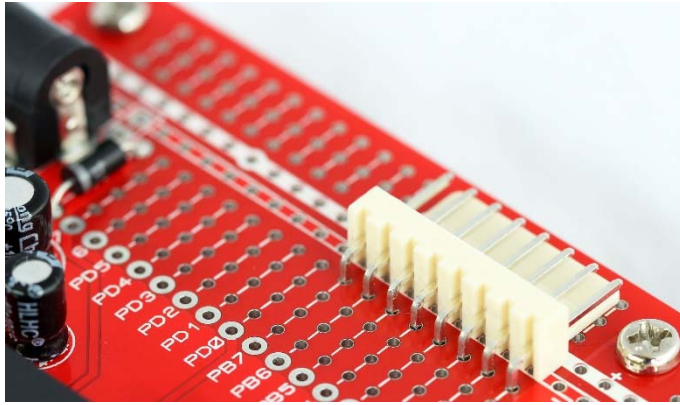


Figure 15. Right angle polarised header on board

### 3.11. Mounting Holes

This board conforms to the standard form factor for full size protoSTACK boards. This includes 6 mounting holes which can be used for stacking boards together with hexagonal spacers and/or mounting the boards to a faceplate or case.

## 4. Board Setup

This section describes the process involved to get your board operational.

### 4.1. Attach the microcontroller

Like most ICs using a PDIP package, the AMTEL AVR series of Microcontrollers has a small dimple on one end showing you how to orient the chip and the location of pin 1. Figure 16 shows the location of the dimple and pin 1.

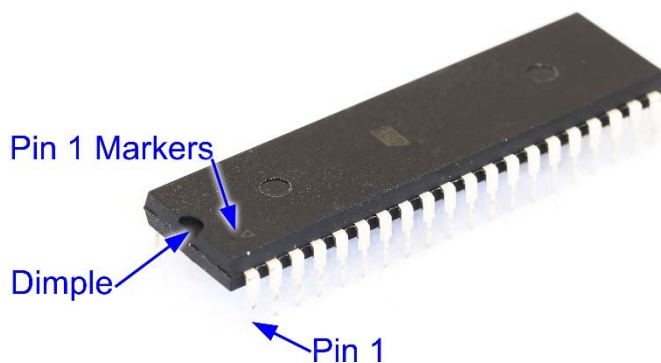


Figure 16. Microcontroller markings and orientation

To make IC orientation easier, a white outline on the board shows the location of the dimple and pin 1 is further highlighted with a square pad.

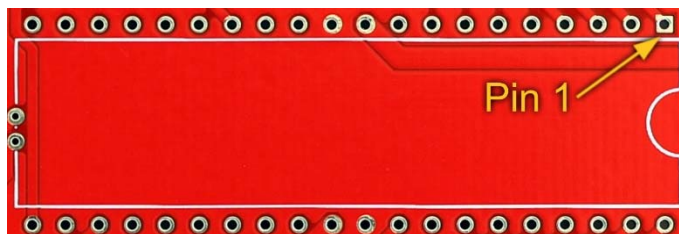


Figure 17. Microcontroller location on board

Although the microcontroller can be soldered directly onto the board, many people prefer to solder an IC socket onto the board then insert the microcontroller into the socket. This option protects the microcontroller to the high temperatures of soldering. This approach also allows for the removal and substitution of the microcontroller in the event that your project requires more flash memory or additional microcontroller features.

Figure 18 shows the IC socket on the board.

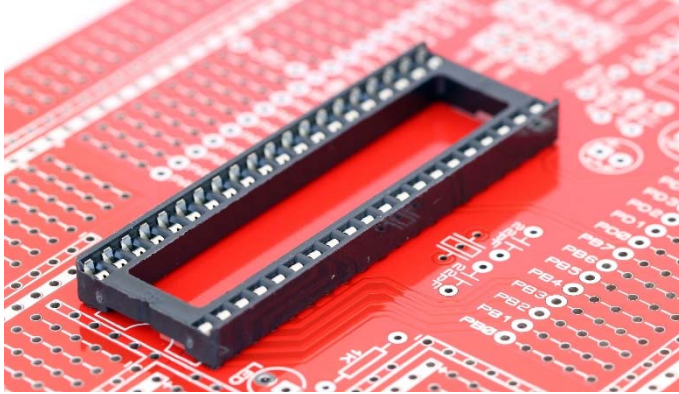


Figure 18. IC Socket on board

Once the IC Socket is soldered in, you will need to bend the pins on the microcontroller inwards slightly in order to push it into the socket.

Figure 19 shows the Microcontroller in the IC Socket.

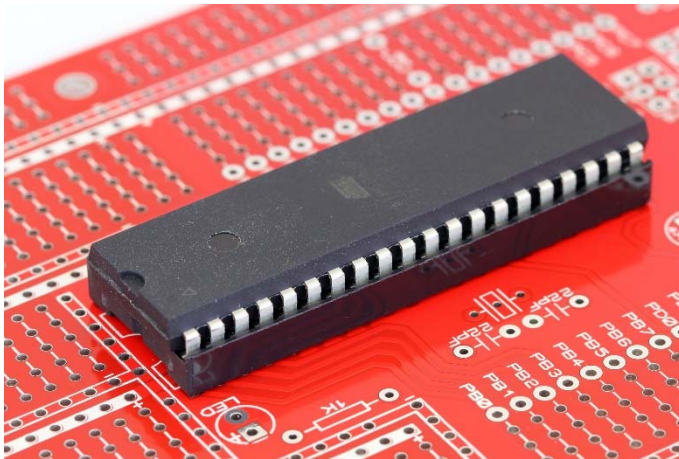


Figure 19. Microcontroller in socket

## 4.2. Add the pull-up resistor, reset switch and de-bounce capacitor

Add a 10K $\Omega$  pull-up resistor as shown in Figure 20.



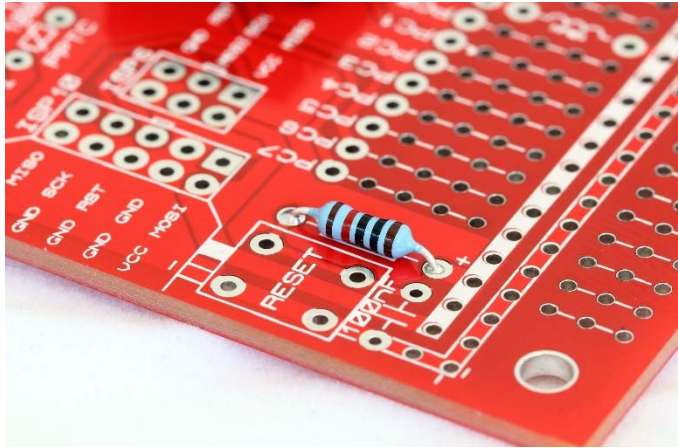


Figure 20. 10KΩ pull-up resistor for reset (pin 1)

This board includes a space to mount a de-bounce capacitor for the reset switch. If required, add it now.

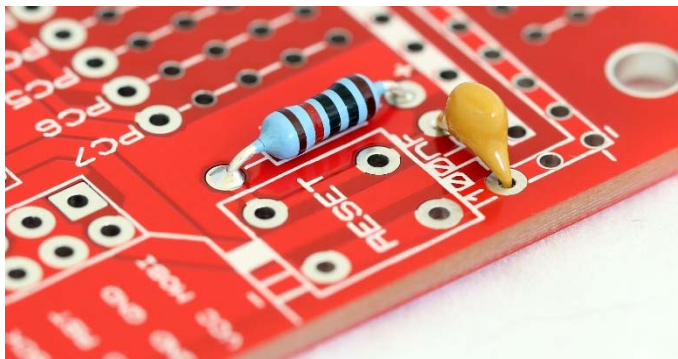


Figure 21. De-Bounce Capacitor for Reset Switch

The next step is to add a reset switch. This board is designed to use a 4 pin micro tactile switch. This switch has 2 pairs of pins with each pin in the pair connected to each other. When the button is pressed, then each pair is momentarily connected to each other. This is shown in Figure 22.



Figure 22. Pin pairs on micro tactile switch

Using the continuity tester function on a multimeter, determine which pin corresponds to each pair and connect the switch to the board as per Figure 23.

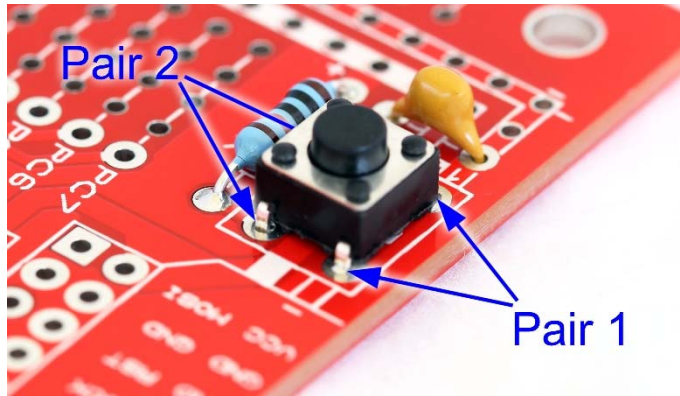


Figure 23. Reset button on board

### 4.3. Add the ISP Connector

Connect the 10 pin connector to the board in the location provided. Figure 24 shows the orientation of a right angle connector whilst Figure 25 shows the orientation of a standard straight pin connector. In both cases take note of the notch in the connector box.

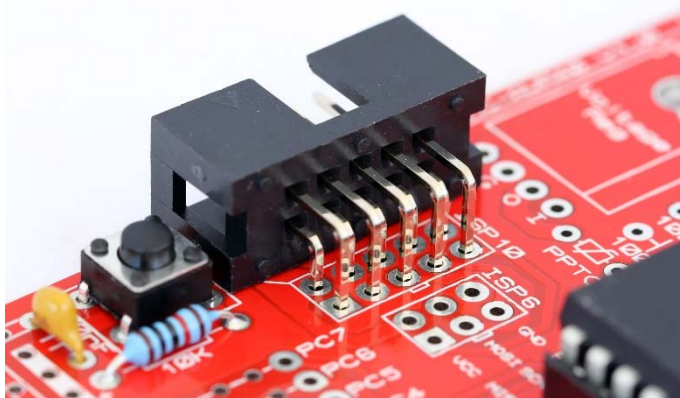


Figure 24. ISP Right Angle Connector

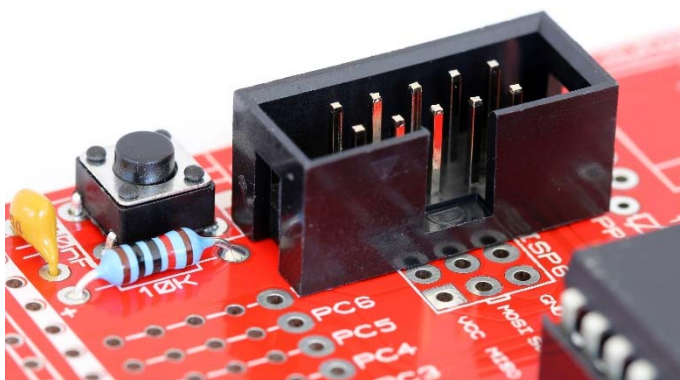


Figure 25. ISP Straight Pin Connector

*Note: The right angle connector is preferred if you are using a multi board stack as it can be accessed from the side of the stack.*

You can also wire up a 6 pin ISP connector. This is shown in Figure 26 and Figure 27 below.

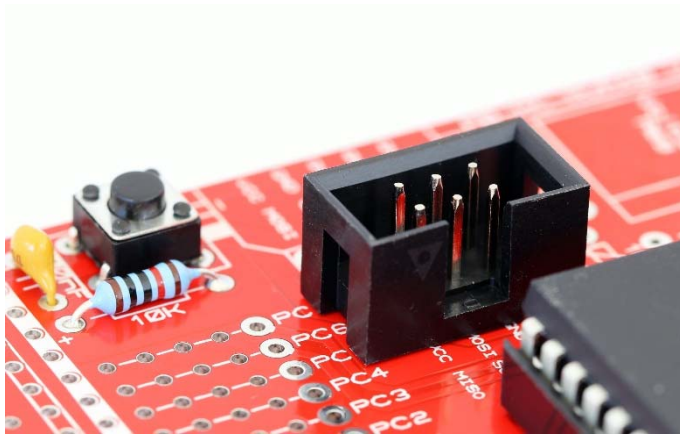


Figure 26. 6 pin ISP connector

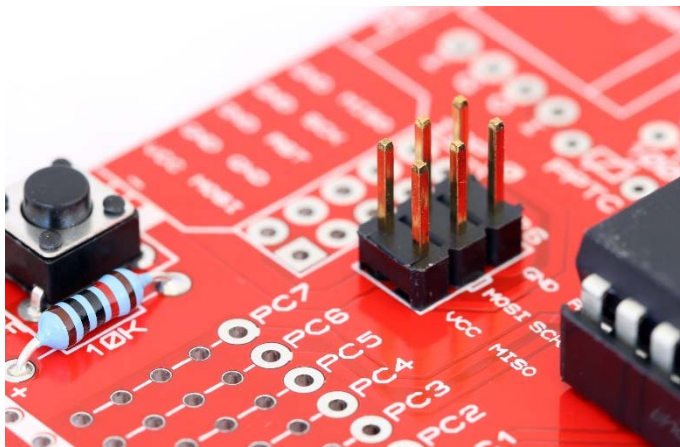


Figure 27. 6 Pin ISP Connector

#### 4.4. Wire up the AVCC Block

This board allows AVCC to be connected directly to VCC or connected via a low pass filter. Figure 28 shows AVCC connected to VCC with the low pass filter (10 $\mu$ H inductor and 100nF capacitor).

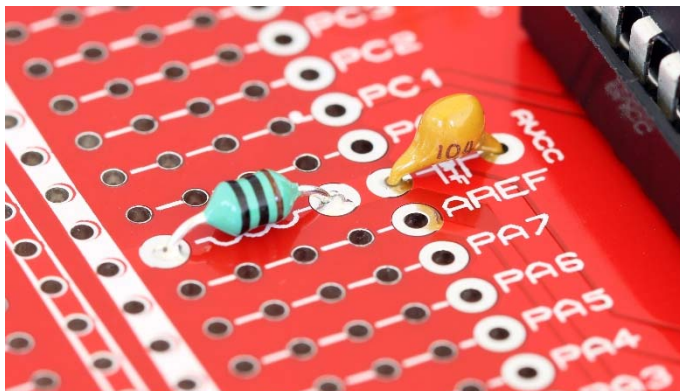


Figure 28. AVCC Connected to VCC with Inductor and capacitor



In the event that an AVCC is not required, use a piece of wire instead of the inductor and leave the space assigned to the capacitor empty.

## 4.5. Add an external Oscillator

Add the crystal oscillator and capacitors to the board as per Figure 29.

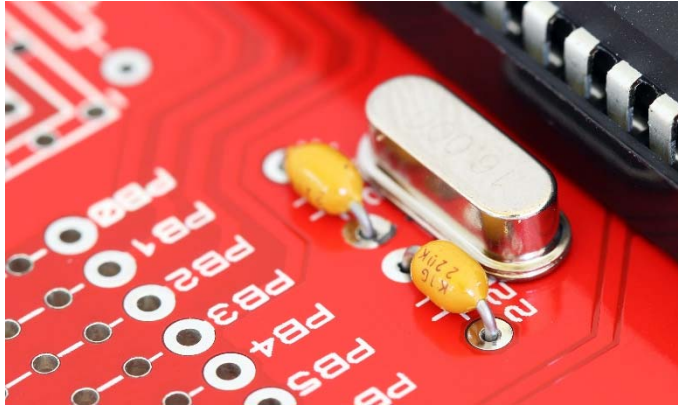


Figure 29. External Oscillator on board

Please consult your microcontroller data sheet for Capacitor sizes and fuse settings.



*Note: Incorrect fuse settings can leave your microcontroller inoperable, so caution is advised.*

## 4.6. Add a power source

One of the strengths of this board is the many ways you can bring power to it. The different methods can be summarised as:

- Mount a CR2032 battery clip directly to the board (see section 4.6.3),
- Bring regulated power to the board from an external source (see section 4.6.4), or
- Step down and regulate the power from an external source (see section 4.6.5).

### 4.6.1. Add power indicator LED (optional)

Regardless of which method you choose, you will probably want an LED which indicates if the board is powered on.

Solder the LED and resistor onto the board. Remember that LEDs are diodes, so they have to go in the right way. Like the electrolytic capacitors, the LED has the positive lead a bit longer than the negative one. The positive lead goes into the whole that is marked with a “+”.

The recommended resistor size is 1K $\Omega$  which provides 3ma of current through the LED at 5V. Depending on the type of LED you are using, how bright you want it and the voltage you are using, anything from 40 $\Omega$  to 1K $\Omega$  will work. Use the following LED resistor calculator to determine the best size for you.

[http://www.ohmslawcalculator.com/led\\_resistor\\_calculator.php](http://www.ohmslawcalculator.com/led_resistor_calculator.php)



Figure 30. Power indicator LED and resistor

#### 4.6.2. Add Vcc side capacitors

Microcontroller circuits typically have power requirements that fluctuate dramatically over time. We deal with this by adding 2 capacitors. The suggested sizes are:

- a. 47uF electrolytic, and
- b. 100nF ceramic.

Using both capacitors together is recommended because the electrolytic capacitor gives you the reserve you need, whilst the ceramic capacitor has a low ESR and will therefore has a faster response time.

The electrolytic capacitor is polarised, so you need to make sure you insert it in the right way. You will notice that one of the leads is longer than the other. This is the positive lead and it goes into the square hole.

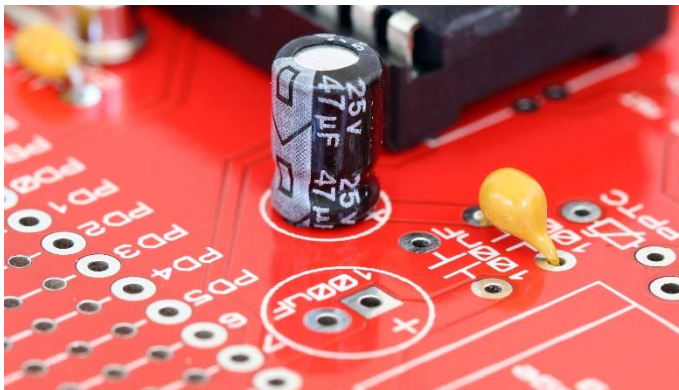


Figure 31. Vcc side capacitors

#### 4.6.3. Method 1: Mount a CR2032 battery clip directly to the board

The first method is to mount a CR2032 battery clip directly to the circuit board. The positive power rail has a circle where the positive pin of the battery clip goes. This is shown in Figure 32 below.

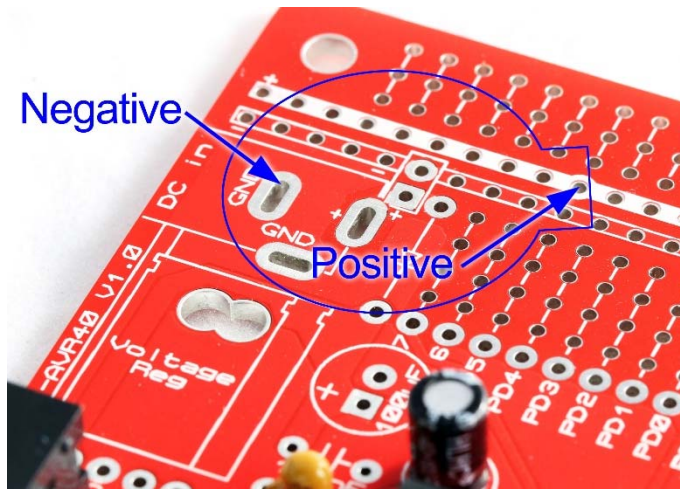


Figure 32. Placement of CR2032 battery clip on PCB

Figure 33 shows the battery clip soldered in place.

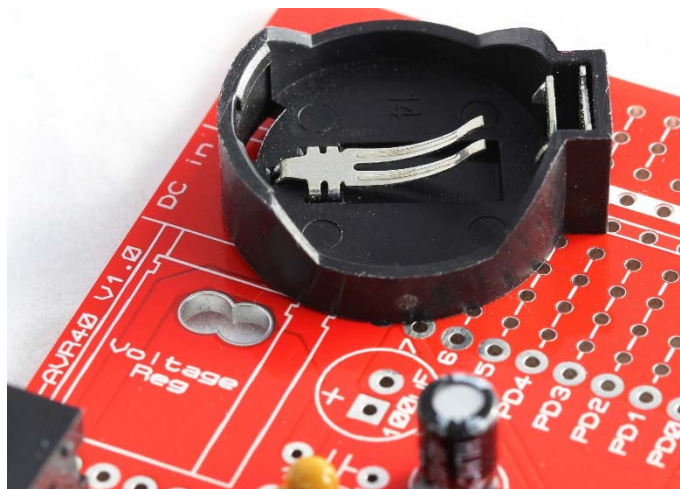


Figure 33. CR2032 battery clip on PCB

When using this method it is important to note that many microcontrollers run at a lower speed on 3V. Please consult the microcontroller datasheet.

#### 4.6.4. Method 2: Bring regulated power to the board from an external source

If you have regulated power at the right voltage level you can connect it directly to the board. This will most commonly be 5V but depending on the microcontroller used, anything between 1.8V and 5.5V might work (see Table 4).

The figures below show different types of connectors being used for this purpose.

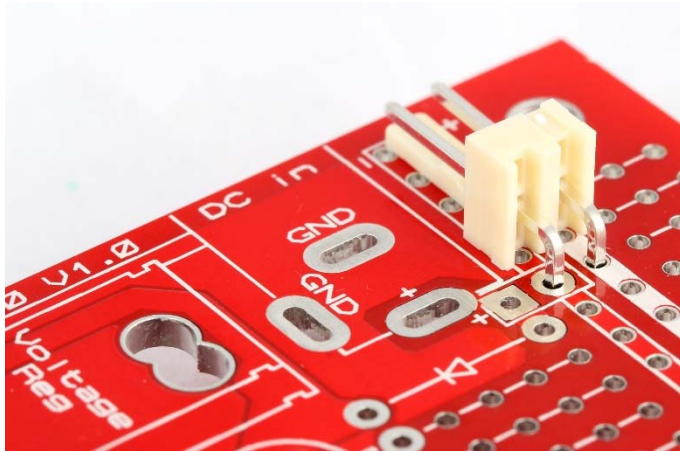


Figure 34. Polarized header for regulated power

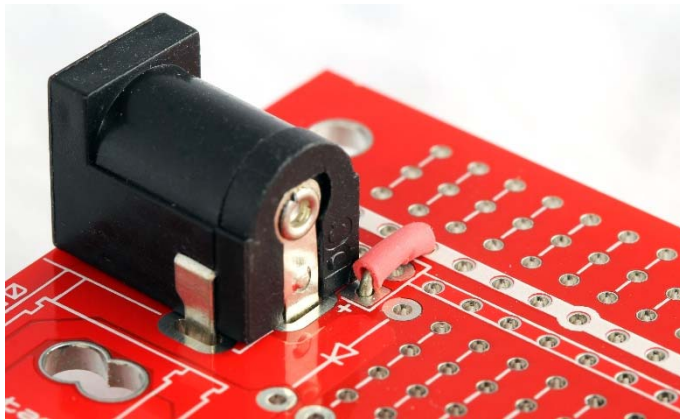


Figure 35. 2.1 x 5.5mm barrel jack for regulated power

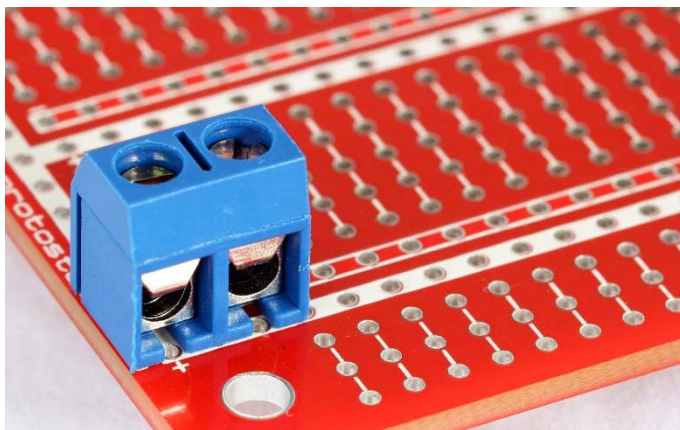


Figure 36. Terminal block for regulated power

#### 4.6.5. Method 3: Step down and regulate the power from an external source

This last and most common method is to bring power from a battery or wall wart and regulate it down to the desired voltage. It is important to understand that you will have a voltage drop from both the diode and regulator, so consult your datasheets and factor these in when choosing your power source.



The first step is to solder your connector. As in the previous method, there are many options available.

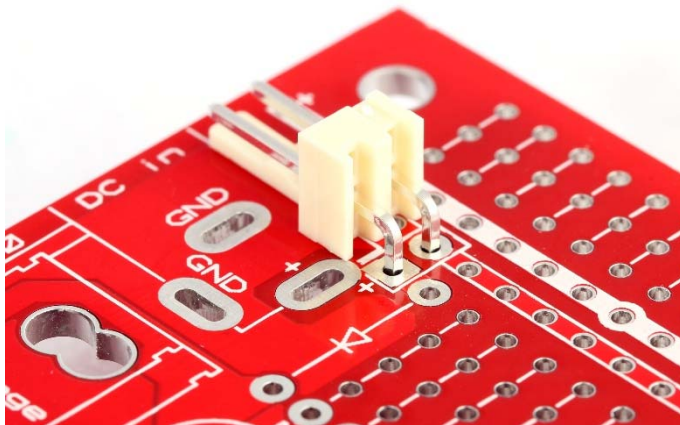


Figure 37. Polarized header for unregulated power

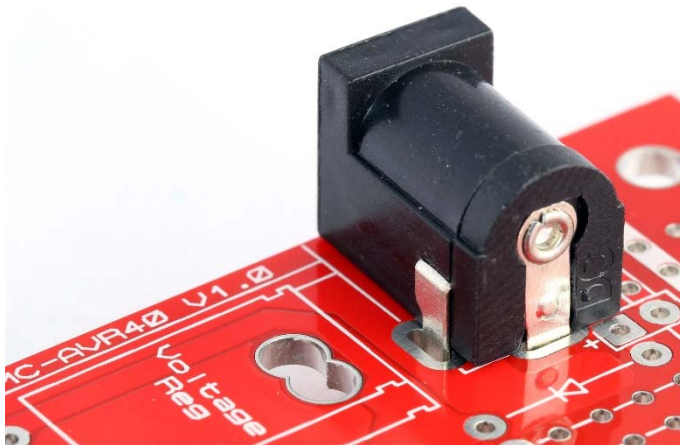


Figure 38 2.1 x 5.5mm barrel jack for unregulated power

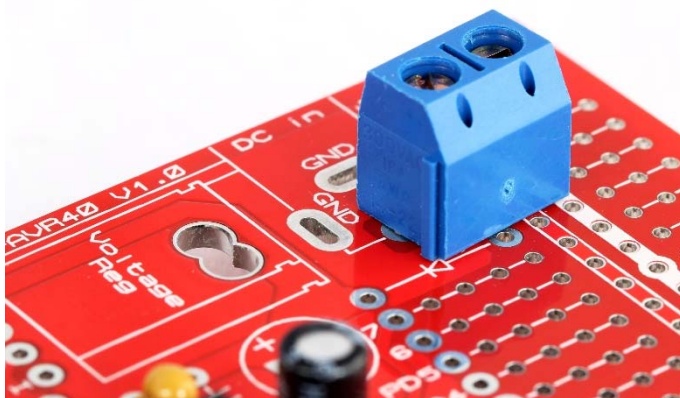


Figure 39. Terminal block for unregulated power

Now that the connector is in place, solder a 1N4004 rectifier diode. This diode is used to protect the circuit against reverse polarity. If you do not need this protection simply solder a piece of wire instead.

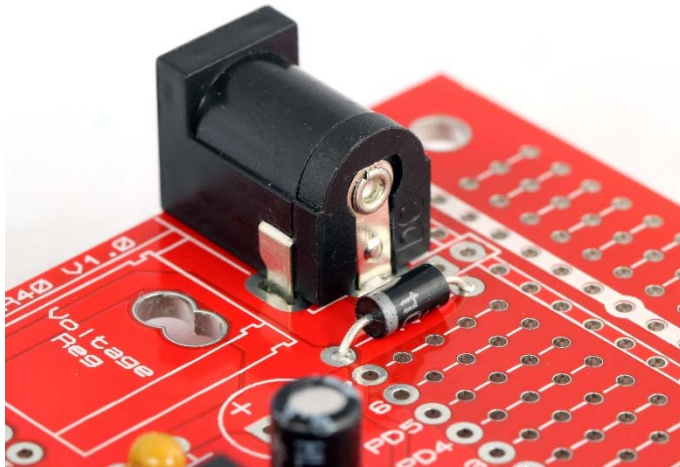


Figure 40. 1N4004 diode soldered into place

The next step is to solder in a voltage regulator. This board supports 2 different regulator pinouts

- a. Input/Ground/Output – IOG (e.g. L7805)
- b. Ground/Output/Input – OGI (e.g. LD1117)

Figure 41 and Figure 42 below show both styles of regulator on the board.

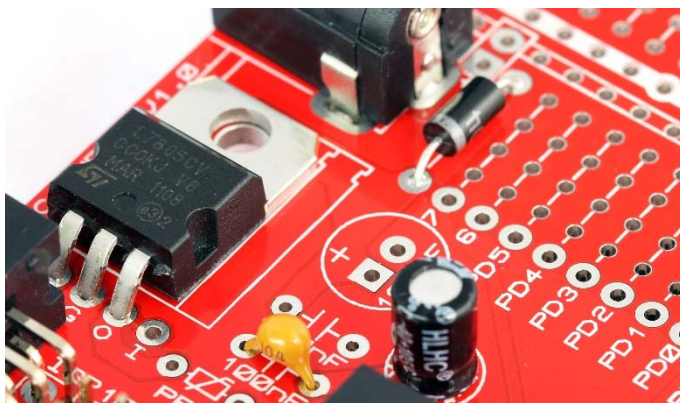


Figure 41. IOG style voltage regulator

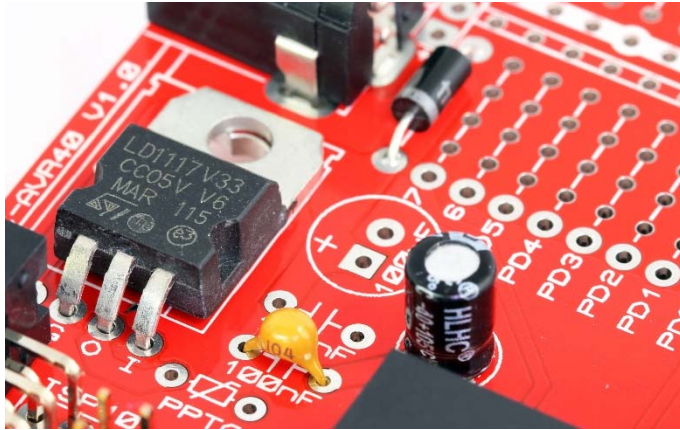


Figure 42. GOI style voltage regulator

Now we add some input side capacitors. A 100uF electrolytic and 100nF ceramic capacitor is recommended here.

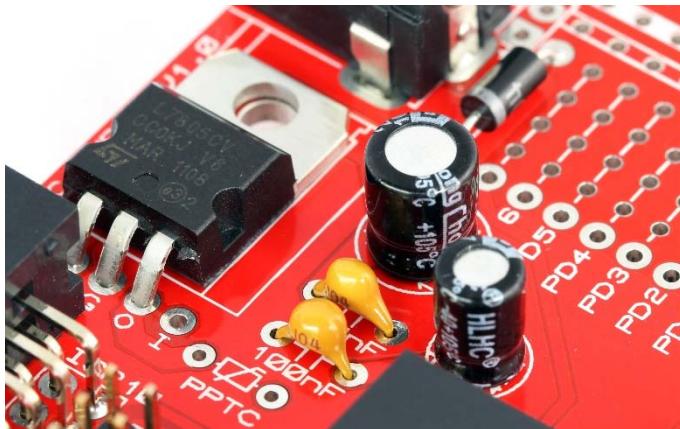


Figure 43. Input side power capacitors

Lastly we add a resettable fuse. We used a 500ma fuse PPTC fuse here, but use a value that suits your own requirements. If you don't want any protection, just use a piece of wire.

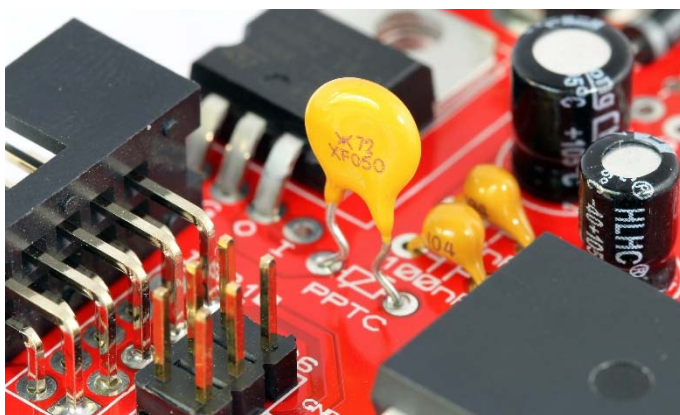


Figure 44. PPTC resettable fuse

## 4.7. Add some I/O

If you have made it this far you will have a microcontroller that can be programmed with firmware and can execute the loaded firmware. However if the microcontroller is unable to receive inputs or all outputs are ignored, then it isn't all that useful. This is where the real fun begins.

There is plenty of room in the prototyping sections to build circuits that can interface to the microcontroller. If more space is needed then additional boards can be added and a stack created. Data and power between the boards in the stack can be share using stacking headers.



## **5. Board Release Notes**

### **5.1. Version 1.0**

Initial public release

## 6. Comment and Questions

If you have any questions or comments regarding this documentation or any of our products, please contact us at [http://www.protostack.com/index.php?main\\_page=contact\\_us](http://www.protostack.com/index.php?main_page=contact_us)