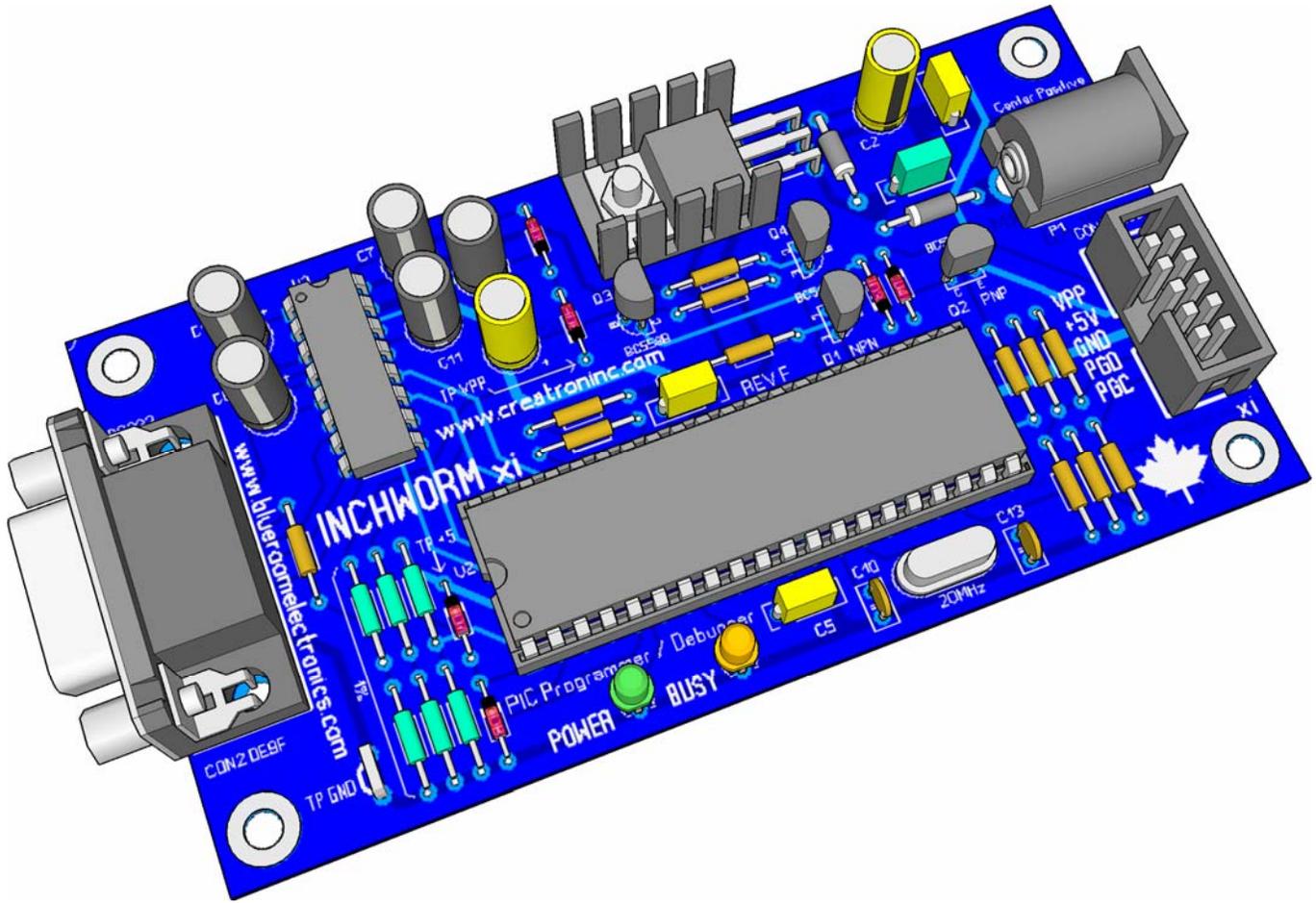


Inchworm ICD2 Assembly Instructions



Introduction

The Inchworm is both a Microchip® PIC™ programmer and debugger. It can program the majority of FLASH based PICs including the 16F and 18F series microcontrollers. It uses Microchips own MPLAB™ IDE and had been tested with MPLAB 7.42 *latest version as of this writing*. Also included is an extremely useful *you'll wonder how you programmed without it* debugger. Although the debugger mode is not built-in on all 16F series PICs *the smaller (less than 18pin) PICs often require a special ICD version*; it is available on all 18F and dsPIC microcontrollers. The debug mode allows you to set a breakpoint(s) in your program. When the program stops you can view and even modify internal registers on the PIC.

Unlike many other inexpensive PIC programmers the Inchworm...

- Is both a Debugger and Programmer
- Always supports the latest PICs (MPLAB will update the firmware)
- Can power target (5V @ 500ma) or be target powered
- Uses an inexpensive 2.5mm center positive 9VDC - 12VDC @ 500ma wall adapter

What it can't do

- VPP voltage is not programmable; it is set to approximately 12.5V
- It works with 5V only targets
- +5V on ICD connector is not switchable

Circuit Description

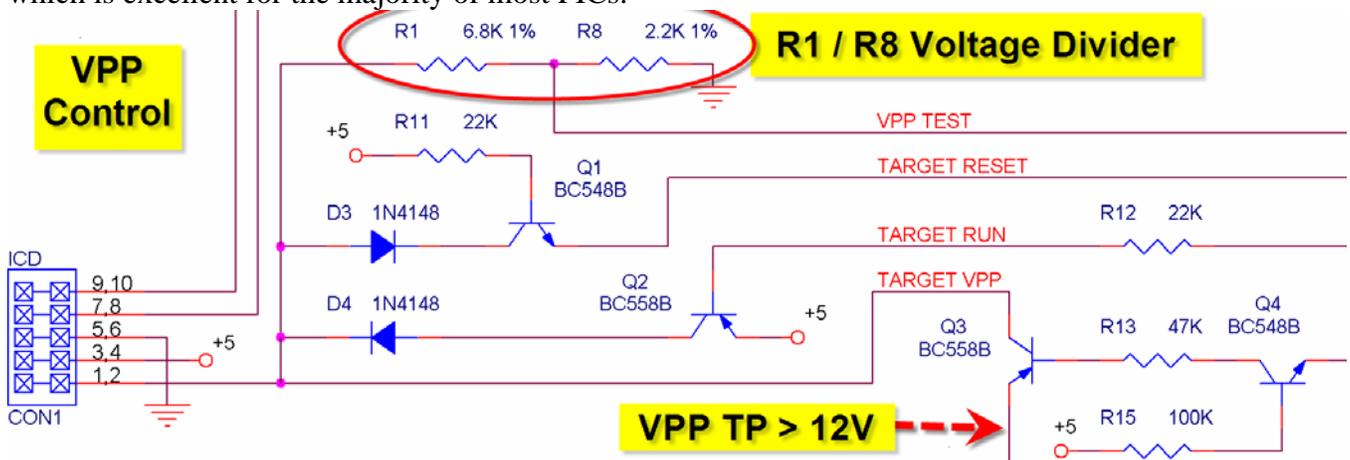
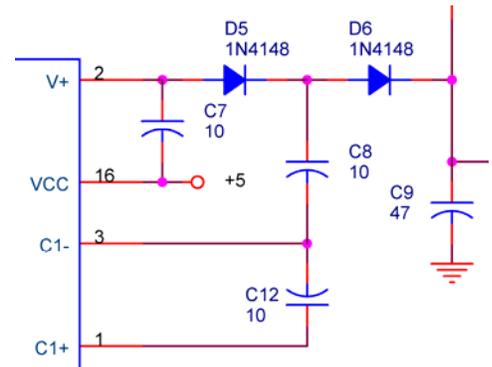
The Inchworm was designed to be easy to assemble and use. It only contains three ICs as almost all of the work is done inside the 16F877A. *That's the beauty of microcontrollers.*

The other ICs include U1 a LM7805 voltage regulator and U3 a RS232 level converter with built in switched capacitor voltage doublers.

VPP > 12V is generated from 5V using the MAX232s' own internal voltage doublers.

Diode D5 and capacitor C8 act as part of a voltage multiplier circuit. In a lossless circuit there would be approximately 15V at the cathode of D5 but because of voltage drops both internally to the MAX232 and across D5 (approx 0.7V) the voltage is actually closer to 14V. D6 rectifies and C9 filters the voltage down to approx 13.5VDC

Additionally Q3 switches target VPP on or off drops the voltage an additional 0.7V to the final VPP target voltage of roughly 12.5V which is excellent for the majority of most PICs.



VPP control is done with transistors Q1 thru Q4. Diodes D3 & D4 prevent reverse current from flowing into transistors Q1 & Q2. Transistor Q4 and resistors R15 & R13 act as an emitter follower limit the amount of current allowed to flow through Q3. Also shown is a typical voltage divider (*the Inchworm has a total of three R1/R8, R3/R10 and R16/R17*) that connect directly to analog inputs RA0, RA1, RA3 on U2. Lastly DTR controls U2s reset, since RS232 levels are generally greater than the 5V permitted the pin is clamped using diodes D7 & D8 and current is limited by R18.

The majority of the work is done inside the 16F877A microcontroller (U2). In a nutshell it does all the accurate timing for VPP levels and serially clocking data (*PGC & PGD*) into the target PIC.

The +5V power supply is a typical LM7805 design. Diode D2 insures correct polarity from the power adapter and diode D1 acts as protection for the regulator.

Firmware Notes

Your Inchworm kit includes a preprogrammed 16F877A. You can *and should* program a spare 16F877A just in case you damage your original. The 16F877A "ICD2_BOOTLOADER_A.HEX" can be downloaded from <http://www.bluroomelectronics.com>. If you damage the 16F877A you can order another preprogrammed one from one of the sources on the back cover of this document or you could hand assemble a 16F877A programmer from one of the many designs you can find searching the web. Searching the internet for "JDM PIC Programmer" should provide many results.

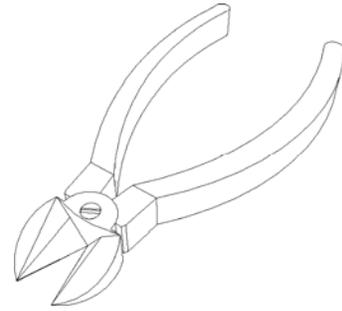
Note: If your Inchworm has a 16F877-20 you must use a different bootloader firmware

"BL010101.HEX" which can be found in the MPLAB ICD2 directory when you install MPLAB.

Necessary Tools (not included in kit)

As with any electronic kit the following tools are essential:

- Low wattage fine tip soldering iron <50W
- Resin core solder
- Wire cutters or side cutters (small)
- Needle nose pliers (small)
- Slotted screwdriver (small)
- Phillips screwdriver (small)
- Wire strippers
- Multimeter (this really is a must for any electronics project)



Assembly

Traditionally it's easiest to assemble a circuit board from smallest to largest part.

Install 1% (blue epoxy) resistors R8, R17, R3, R10, R1, R16

Install remaining 5% resistors (tan epoxy)

Power diodes D1, D2 (Black 1N4001)

Switching diodes D3 thru D8 (Red 1N4148)

Note: diodes use a colored band to denote polarity

IC sockets U2 and U3 (notice notch orientation)

Crystal Y1 and capacitors C10, 13

Transistors Q1, Q4 (BC548B) / Q2, Q3 (BC558B)

Note: LEDs use a flat side indicating polarity

LED1 (green / power), LED2 (amber / busy)

Capacitors C1, C3, C4, C5 (note lead spacing)

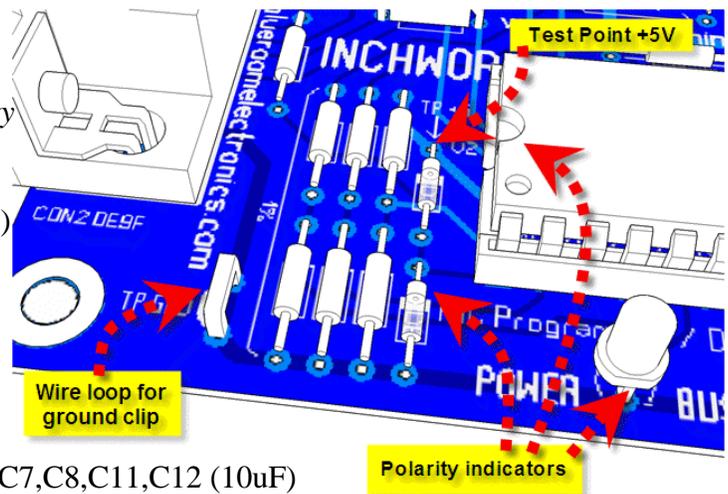
Connectors CON1, CON2 (note the notch)

2.5mm coax power jack P1

U1 and heatsink (test fit before soldering)

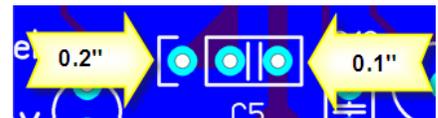
Capacitors (note polarity) C2, C9 (47uF) then C6, C7, C8, C11, C12 (10uF)

Optionally you can install a small wire loop at TP GND for testing



Initial Testing

Before installing ICs U2 and U3 apply power to the board using a typical AC wall adapter 2.1 mm ID rated between 9 – 15 VDC @ 300ma to 1000ma (*Note: if you're powering your project from the Inchworm use >750ma*). The green POWER LED (pictured above) should glow. If you have a multimeter test for +5V using **TP +5** and >+12V using **TP VPP** (*Note: TP VPP should not be above 15V*).



Final Assembly

Remove power before inserting U3 (MAX232) and U2 (PIC16F877A). It is **very important** to insert the ICs carefully (*don't bend the pins*) and in the proper direction (*notice the notch on the IC*). ICs inserted in the wrong direction when power is applied will usually damage the IC. If you're unsure look at the main illustration on page one of this document. You're now ready to apply power. If the POWER LED does not light immediately unplug the power and recheck that all ICs are properly inserted.

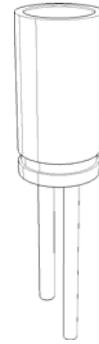
Optional: The Inchworm can be mounted in a Hammond 1591B case bottom half, this will protect both the bottom of the PCB and your desk from damage.

Note: you must file or trim the top lip of the 1591B case directly under the DE9 serial connector approx 0.1" (2.5mm) to insure a proper fit.

Parts List INCHWORM

Capacitors

1	C1	0.33uF 25V
2	C2,9	47uF 25V
3	C3,4,5	0.1uF
5	C6,7,8,11,12	10uF 16V
2	C10,13	33pF



Resistors 1/4W 5% Carbon (tan body, 4 color bands)

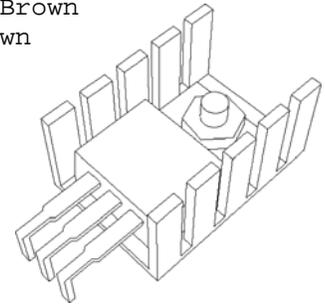
5	R2,4,7,9,14	330	Orange, Orange, Brown, Gold
1	R18	1K	Brown, Black, Red, Gold
2	R5,6	4.7K	Yellow, Green, Red, Gold
2	R11,12	22K	Red, Red, Orange, Gold
1	R13	47K	Yellow, Green, Orange, Gold
1	R15	100K	Brown, Black, Yellow, Gold

Resistors 1/4W 1% Metal Film (blue body, 5 color bands)

2	R8,17	2.2K 1%	Orange, Orange, Black, Brown, Brown
2	R3,10	4.7K 1%	Yellow, Green, Black, Brown, Brown
2	R1,16	6.8K 1%	Blue, Grey, Black, Brown, Brown

Semiconductors

2	D1,2	1N4001 Diode
6	D3,4,5,6,7,8	1N4148 Diode
1	LED1 (POWER)	3mm GREEN LED
1	LED2 (BUSY)	3mm AMBER LED
2	Q1,4	BC548B NPN
2	Q2,3	BC558B PNP
1	U1	LM7805 TO-220
1	U2	PIC16F877A (preprogrammed ICD2_BOOTLOADER_A.HEX)
1	U3	ST232(MAX232) or equivalent

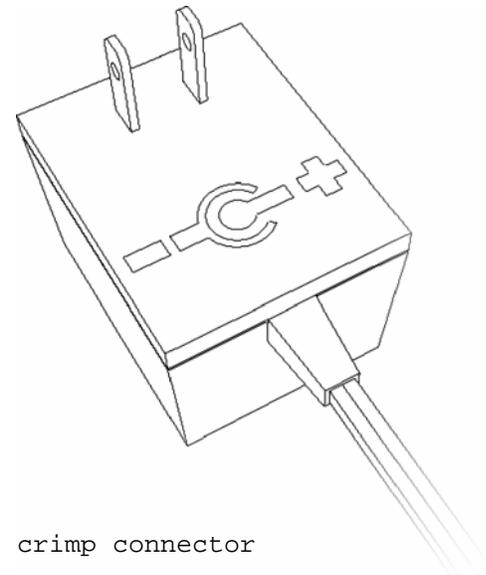


Crystals

1	Y1	20MHz Crystal low profile HC49
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Connectors

1	CON1	ICD 2x5 PCB Male
1	CON2	DE9 RA Female
1	P1	2mm PCB RA Coax Jack



Miscellaneous

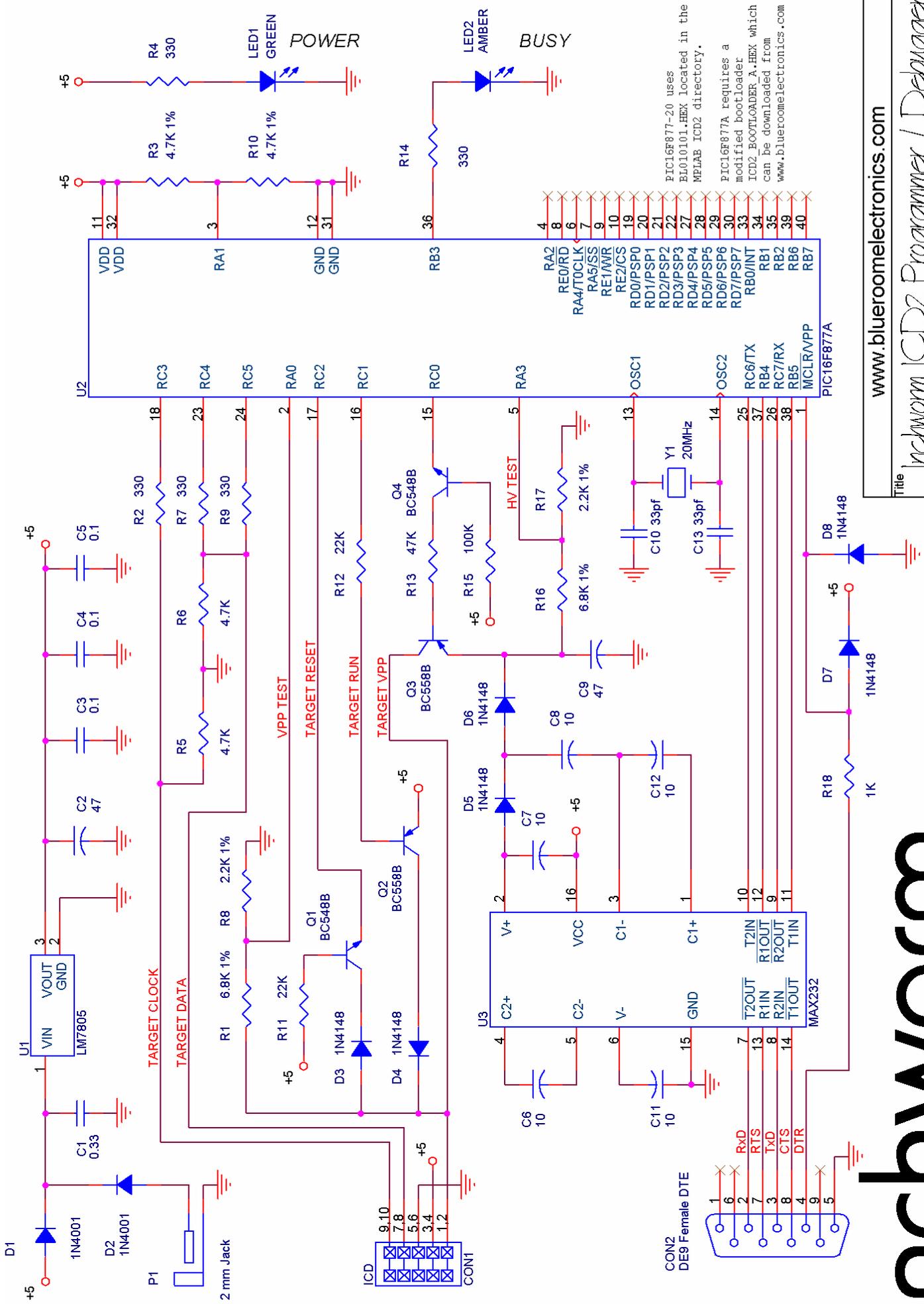
1	40-pin	IC Socket
1	16-pin	IC Socket
1	Heatsink	TO-220 style
lea	Screw, Nut & Lockwasher	(for LM7805 and heatsink)

Optional Accessories

1	Enclosure	Hammond 1591B (112mm x 62mm)
1	5-pin	Berg connector or 10-pin female crimp connector
8"	10-conductor	Ribbon cable
1	10-pin	IDE female crimp connector
1	9-15VDC Adapter*	9-15VDC 2.1mm center positive coax AC adapter @300-1000ma

* The Inchworm ICD2 requires about 60ma; choice of an AC adapter depends on your target requirements





PIC16F877-20 uses BL010101.HEX located in the MPLAB ICD2 directory.
 PIC16F877A requires a modified bootloader ICD2_BOOTLOADER_A.HEX which can be downloaded from www.bluroomelectronics.com

inchworm

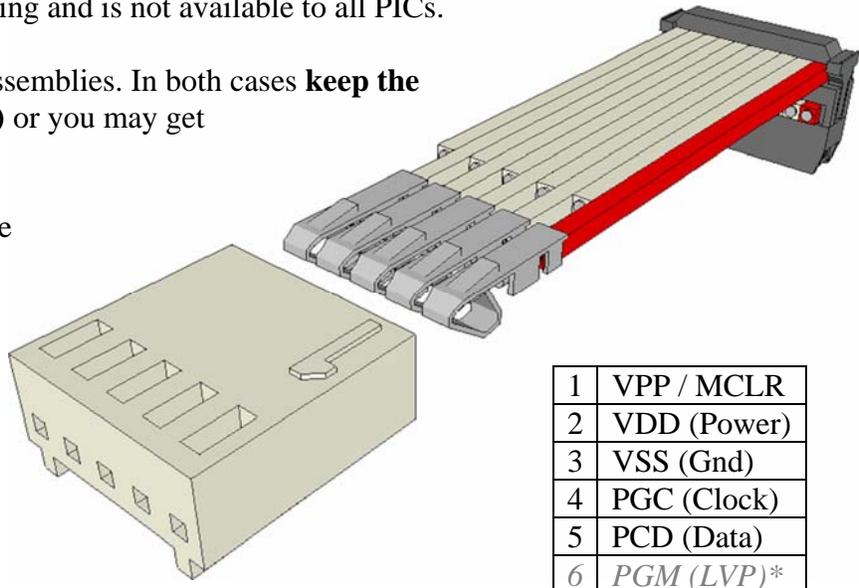
www.bluroomelectronics.com	
Title	inchworm ICD2 Programmer / Debugger
Size	Document Number
A	wrichardson@bluroomelectronics.com
Date:	Thursday, September 14, 2006
Sheet	1 of 1
Rev	E

The ICD Cable

The Microchip ICD2 uses a RJ11 type connector. Although this is convenient when you're using an RJ11 on your target PCB it's not so handy when you use the more common inline connector. Also the Microchip ICD2 cable often uses six pins; this extra pin is called **PGM** (*usually pin 6*) and allows for **LVP** *low voltage programming* on the target PIC. It is not commonly used as it ties up an I/O pin even after programming and is not available to all PICs.

Shown below are two ICD cable assemblies. In both cases **keep the ribbon cable less than 8" (20mm)** or you may get programming errors.

Pictured to the right is a typical five pin ICD2 inline target type. ICD pinouts and connectors can vary, check your targets ICD pinout before connecting.



Advantages:

Requires little target PCB space.
Common.

Disadvantages:

*Can be tricky to assemble the small five or six pin inline connector.

Inchworm "i" type (designed for [blueroomelectronics](#) projects)

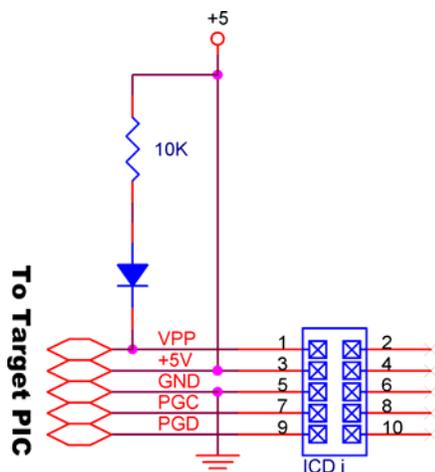
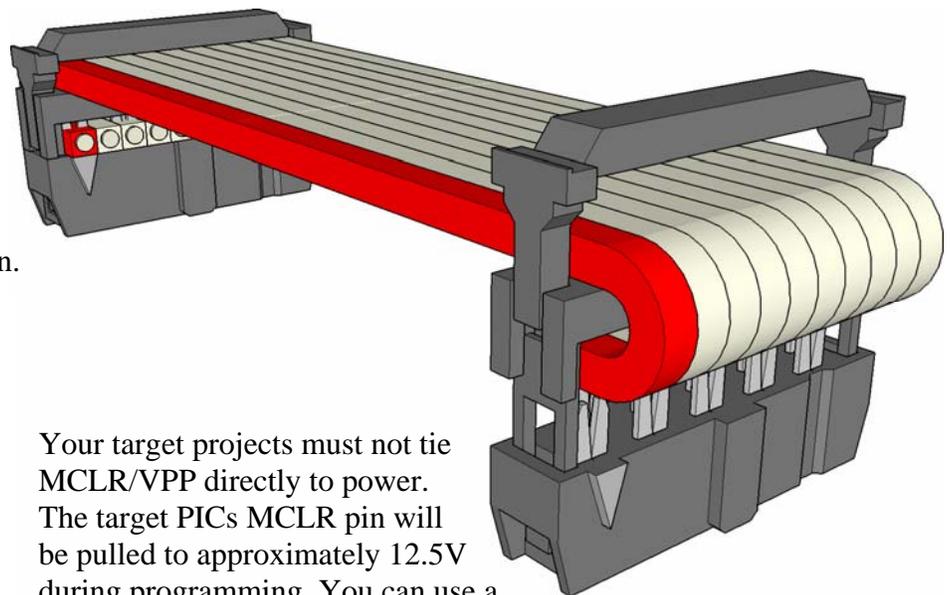
This is the type used for [blueroomelectronics](#) projects. It's very easy to assemble as the connectors are simply crimped together.

Advantages:

Easy to assemble.
Rugged (*strain relief*)

Disadvantages:

Not as common as inline version.



Your target projects must not tie MCLR/VPP directly to power. The target PICs MCLR pin will be pulled to approximately 12.5V during programming. You can use a small resistor with a value between 10K and 100K; the diode *a 1N914 or 1N4148* is optional but recommended. Also low resistance or high capacitive loads on PGC and PCD (*usually RB6(PGC) / RB7(PGD)*) must be avoided to insure reliable ICD communications.

* If you need low voltage programming **PGM / LVP** use a 6-pin inline connector and ground pin 6.



A Brief Introduction to MPLAB® IDE

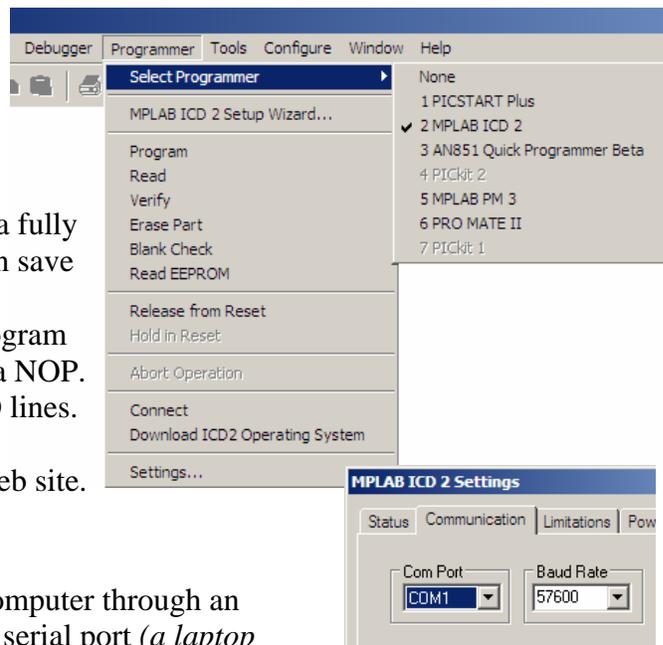
Before you begin you will need to download and install Microchips MPLAB IDE

<http://www.microchip.com>

About the debugger, although it's not as powerful as a fully featured ICE (In Circuit Emulator costing \$\$\$\$) it can save countless hours of head scratching.

The debugger does require the upper 256 bytes of program memory and on some PICs location 0x0000 must be a NOP. Both the program and debugger also require three I/O lines.

Full documentation can be found on the Microchip web site.



Connecting Your Inchworm

The Inchworm connects to your Windows™ based computer through an RS232 port. If your computer does not have a RS232 serial port (*a laptop computer for example*) you will need a USB to RS232 adapter. These common devices can be purchased at most computer retailers.

Notes:

- You can only use COM1 or COM2 *this may change, read the MPLAB readme*
- You must disable the (COM1 or COM2) FIFO buffer in Windows™ control panel
- From Select Programmer choose 2 MPLAB ICD 2
- Select Settings... and select your Com Port (either COM1 or COM2)
 - If you get communication errors try changing the Baud Rate to 19200
- You may have to Download ICD2 Operation System.
 - This feature can be set to automatic.

Supported PICs

This is only a partial list; see Microchips website for a complete list of ICD2 supported PICs.

Debugger & Programmer Support

PIC16F737	PIC16F747	PIC16F767	PIC16F777	PIC16F818	PIC16F819
PIC16F87	PIC16F88	PIC16F870	PIC16F871	PIC16F872	PIC16F873
PIC16F873A	PIC16F874	PIC16F874A	PIC16F876	PIC16F876A	PIC16F877
PIC16F877A	PIC16F913	PIC16F914	PIC16F916	PIC16F917	PIC16HV785
PIC16F946	All dsPIC30F and 18F series PICs support both debug and program modes				
*PIC10F2xx	*PIC12F5xx	*PIC12F6xx	*PIC16F627A	*PIC16F628A	*PIC16F648A
*PIC16F684	*PIC16F687	*PIC16F688	*PIC16F689	*PIC16F690	*PIC16F716
*PIC16F785	*PIC16F505	*PIC16F630	*PIC16F636	*PIC16F639	*PIC16F676

**Normally these PICs have programmer only support, but there are ICD versions also available. They include a small PCB with a socket adapter and ICD2 (Microchip) RJ-6 header. They have the advantage of no I/O loss on the target PIC but the drawback is a much higher cost.*

Programmer Support Only

PIC16F72	PIC16F73	PIC16F74	PIC16F76	PIC16F77	PIC16F84
PIC16F84A	PIC16F505	PIC16F54	PIC16F57	PIC16F59	PIC16F627
PIC16F628	<i>Note: These tend to be older PICs, they all have modern replacements</i>				



The Inchworm and other *blueroomelectronics* projects are available at

Retail Sales



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Ontario, Canada
Tel (416) 977-9258
Fax (416) 977-4700
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