MicroTRAK/AVR-C Training Kit

User's Guide

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BiPOM Electronics warrants MicroTRAK for a period of 1 year. If the product becomes defective during this period, BiPOM Electronics will at its option, replace or repair the product. This warranty is voided if the product is subjected to physical abuse or operated outside stated electrical limits. BiPOM Electronics will not be responsible for damage to any external devices connected to the microcontroller system. BiPOM Electronics disclaims all warranties express or implied warranties of merchantability and fitness for a particular purpose. In no event shall BiPOM Electronics be liable for any indirect, special, incidental or consequential damages in connection with or arising from the use of this product. BiPOM's liability is limited to the purchase price of this product.

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INTRODUCTION

The objective of the MicroTRAK is to give students, engineers, technicians, hobbyists and other users experience with micro-controllers by developing practical applications using C and Assembly language. **The MicroTRAK Lab Book** consists of several labs that vary from simple to complicated.

When used in a school environment, it is recommended that the labs accompany a micro-controller course during the semester. Depending on the duration of each lab during the week, each lab in the student manual can be covered during one or two lab weeks. Based on the remaining time during the semester, the instructor may have the students work on one or more advanced projects. Some advanced project ideas are listed in **Advanced Project Ideas** section of this manual.

This User's Guide is intended for the instructor to get familiar with and setup the MicroTRAK for the upcoming labs. The MicroTRAK Lab Book should be given to each student group in the lab to perform various exercises during the semester.

MicroTRAK can also be used as a Project Kit for rapid prototype development and proof-of-concept. Keypad, LCD, microcontroller board and peripheral boards are already mounted on the carrier board, resulting in a presentable, single-piece assembly for demonstration purposes. LCD and keypad also facilitate software debugging.

MicroTRAK consists of:

- MINI-MAX/AVR-C Micro-controller Board
- Training Board (TB-1), PROTO-1 Prototyping Board
- Demo version of BASCOM-AVR BASIC Compiler
- Full version of WinAVR C Compiler
- AVR Studio with Assembler, Debugger and Simulator (free download from ATMEL web site)
- MicroIDE Integrated Development Environment/Simulator/Debugger
- Serial cable, Power Supply
- Example Lab book and this User's Guide

The following external items are required for each Training Kit station:

- IBM Compatible Personal Computer (PC) with
  - Minimum 32MB memory and 50 MB of available hard disk space.
  - One available RS232 Serial Port.
  - Windows 95/98/ME/NT/2000/XP/Vista/Windows 7 (32-bit only).
- (Optional) Digital Voltmeter

INSTALLATION

Installing the Hardware

1. Place MicroTRAK on a clean, **non-conductive** bench top (preferably on an anti-static mat)

Connect the provided power supply to the power plug on the MicroTRAK . Do not connect the power supply to the outlet yet.

CAUTION: Do not use a power supply other than the one that is supplied with the MicroTRAK . Use of another power supply voids the warranty and may permanently **DAMAGE** the board or the computer to which the board is connected!

2. Make sure the PC is powered off.

3. Connect the 10-pin header of serial cable to X8 connector of MINI-MAX/AVR-C board as shown on Figure 1. Mini-Max/AVR-C board uses UART1 as BOOT serial port.

4. Connect the other end of the serial cable to your PC's COM port.

5. Install JP1 jumper as shown on Figure 2. When this jumper is installed, the board runs in BOOT mode.

6. Connect the 6VDC power supply to a suitable wall outlet. Red LED on MINI-MAX/AVR-C board will turn ON.

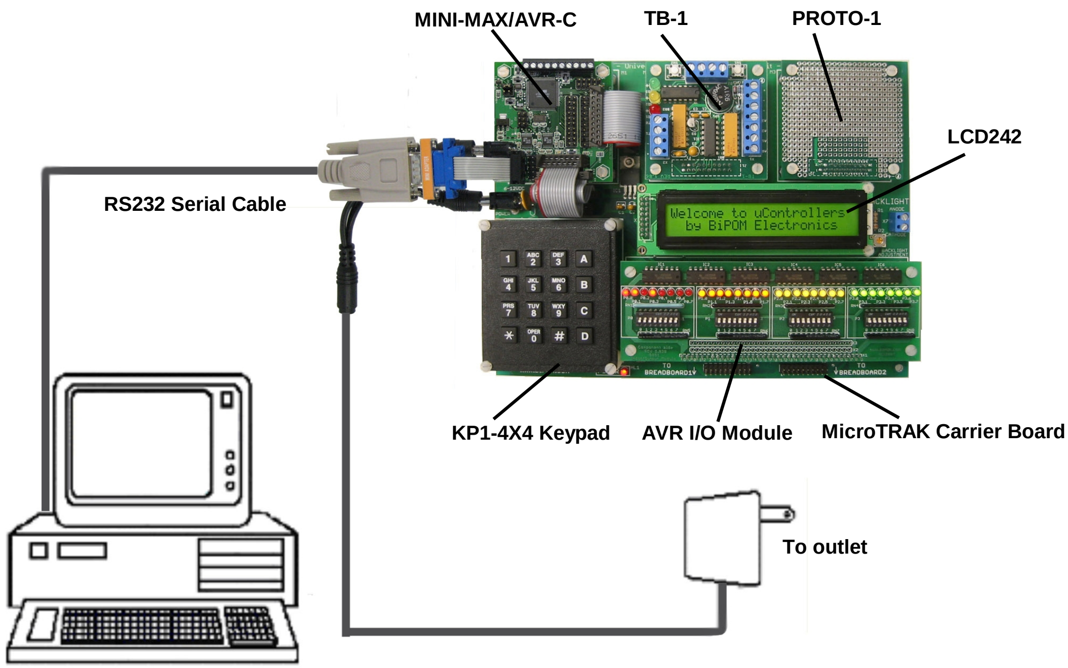


Figure 1

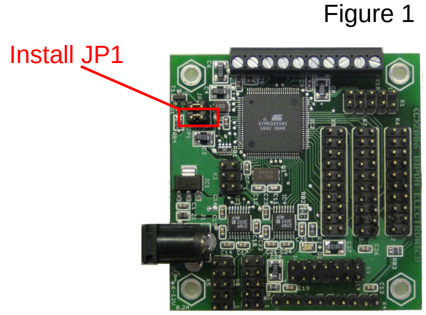
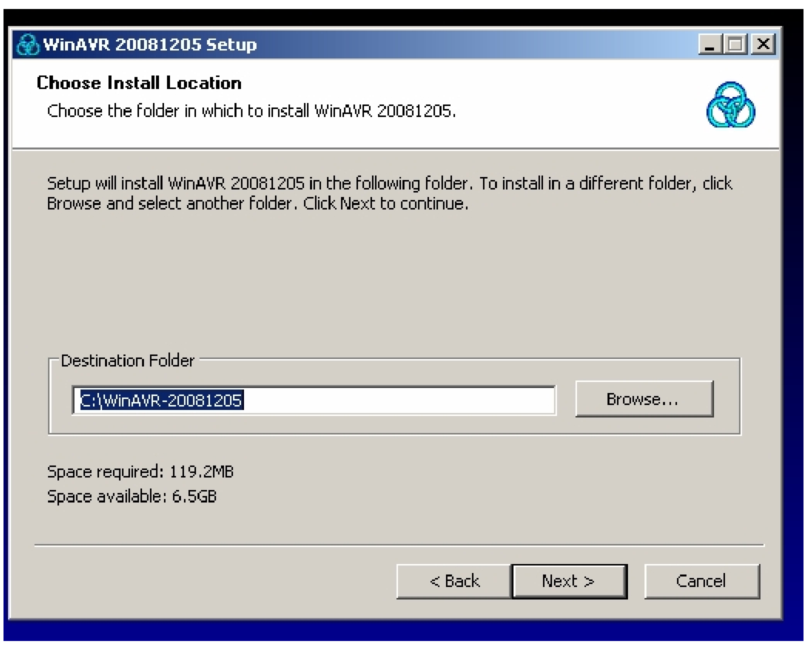
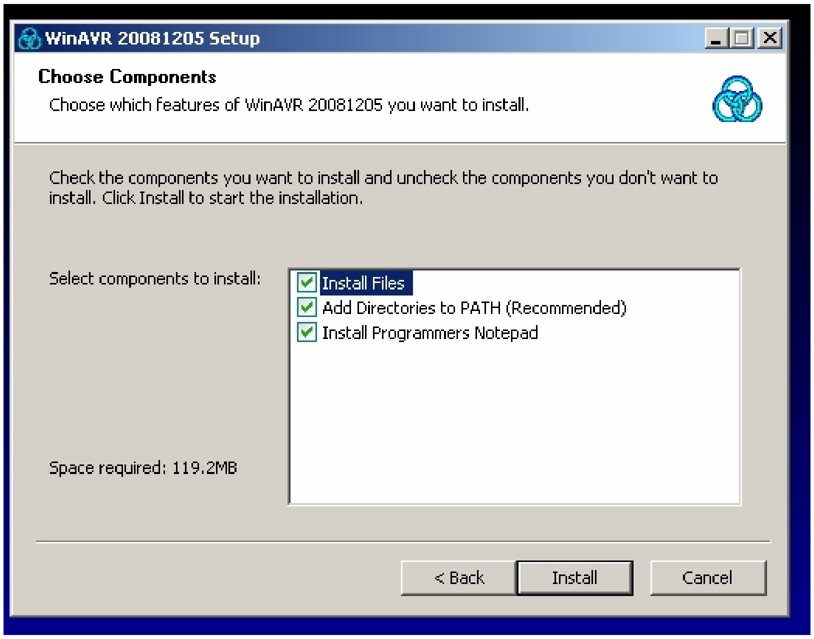


Figure 2

Installing the Software

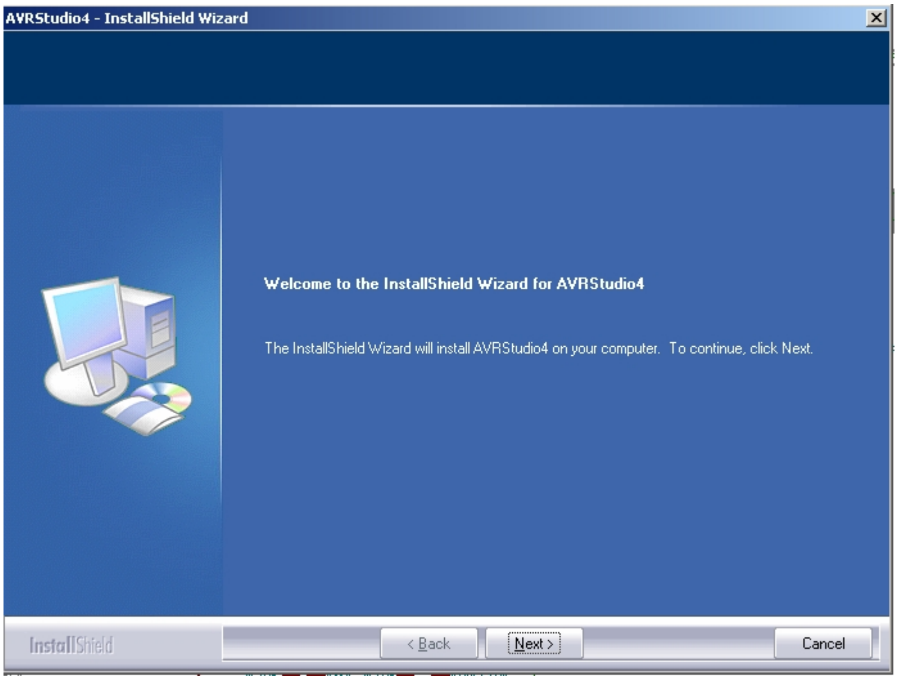
Download and install WinAVR from http://winavr.sourceforge.net/

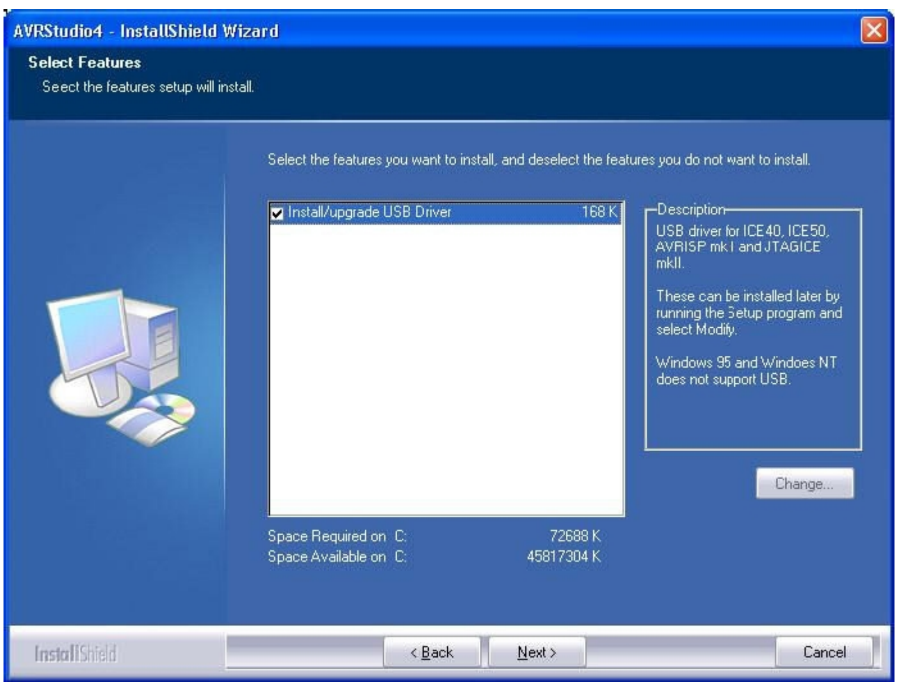



WinAVR 20081205 Setup
Choose Components
Choose which features of WinAVR 20081205 you want to install.
Check the components you want to install and uncheck the components you don't want to install. Click Install to start the installation.
Select components to install:
Install Files
Add Directories to PATH (Recommended)
Install Programmers Notepad
Space required: 119.2MB
< Back
Install
Cancel


WinAVR 20081205 Setup
Completing the WinAVR 20081205 Setup Wizard
WinAVR 20081205 has been installed on your computer.
Click Finish to close this wizard.
< Back
Finish
Cancel

Download and install AVR Studio 4.16 or later from http://www.atmel.com/avrstudio. Also download any service pack for AVR Studio that may be available on ATMEL website. Service pack should be installed after AVR Studio has been installed.

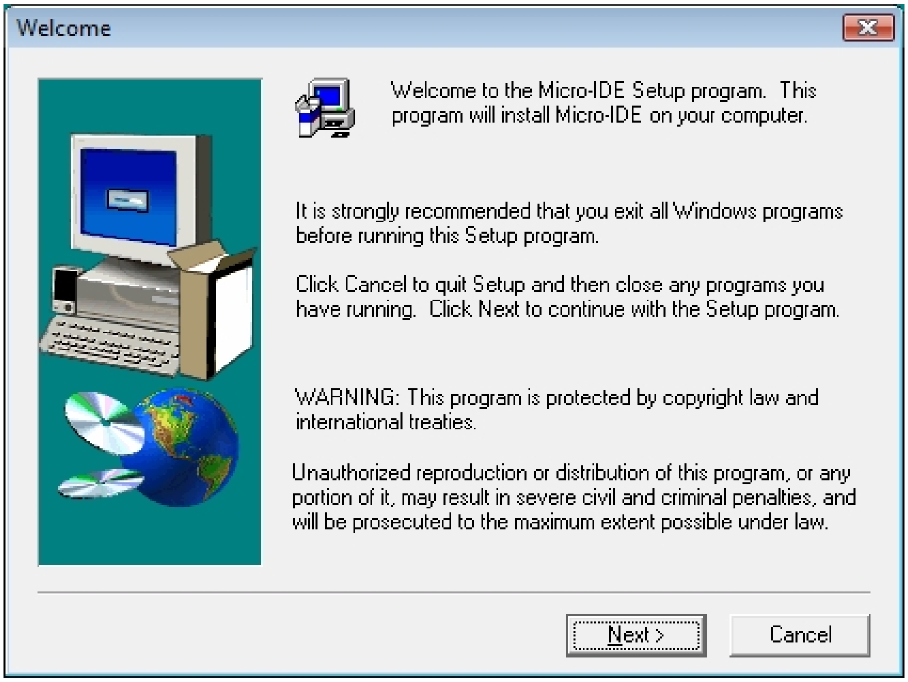


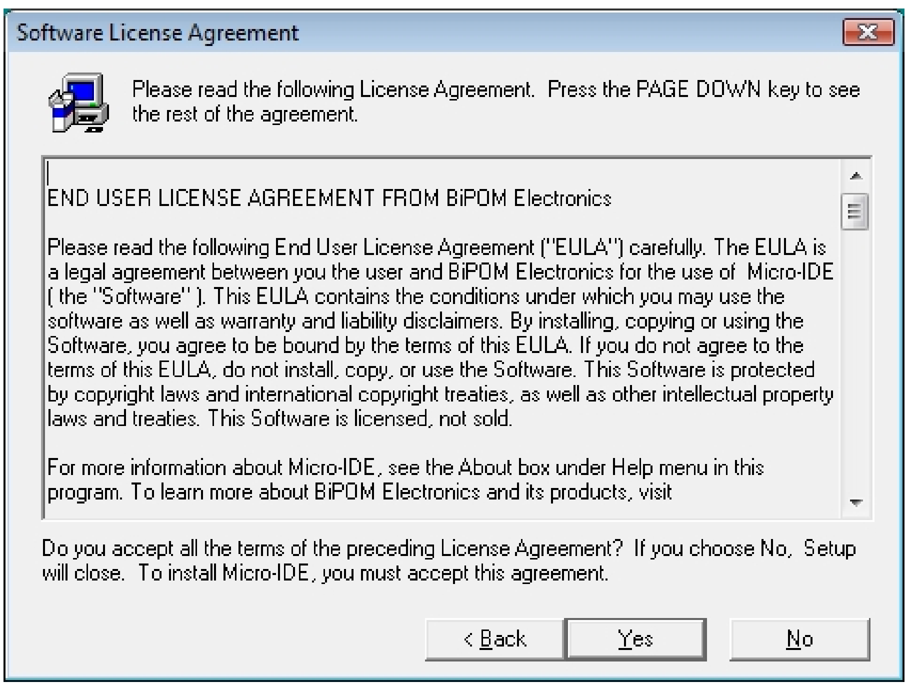


Micro-IDE is a part of BiPOM's ARM Development System.

Download and install the development system from http://www.bipom.com/armdev_down.php

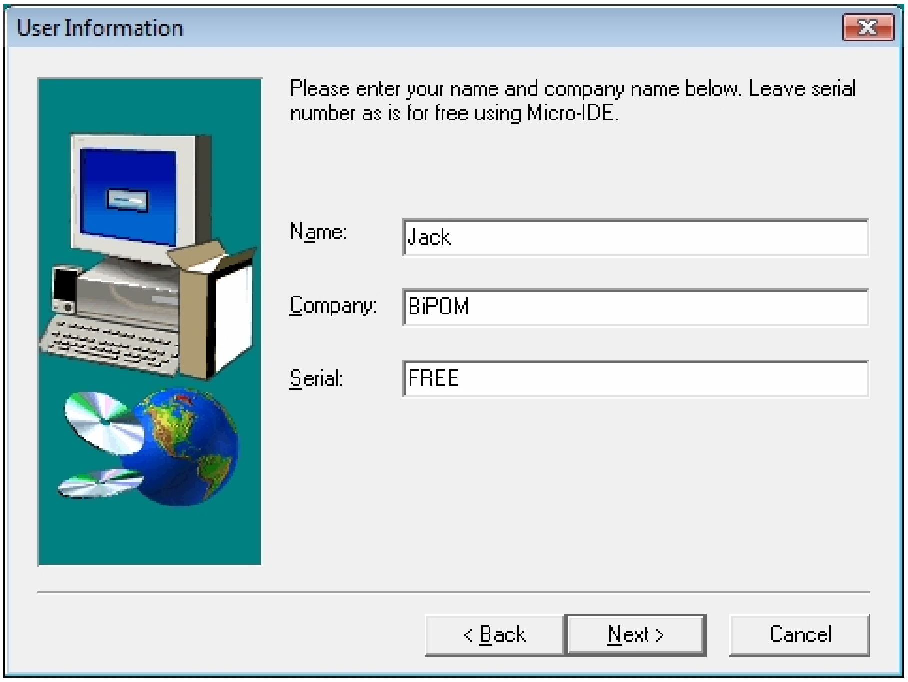
Unzip the armdev.zip file to any folder of your hard drive and run setup.exe.





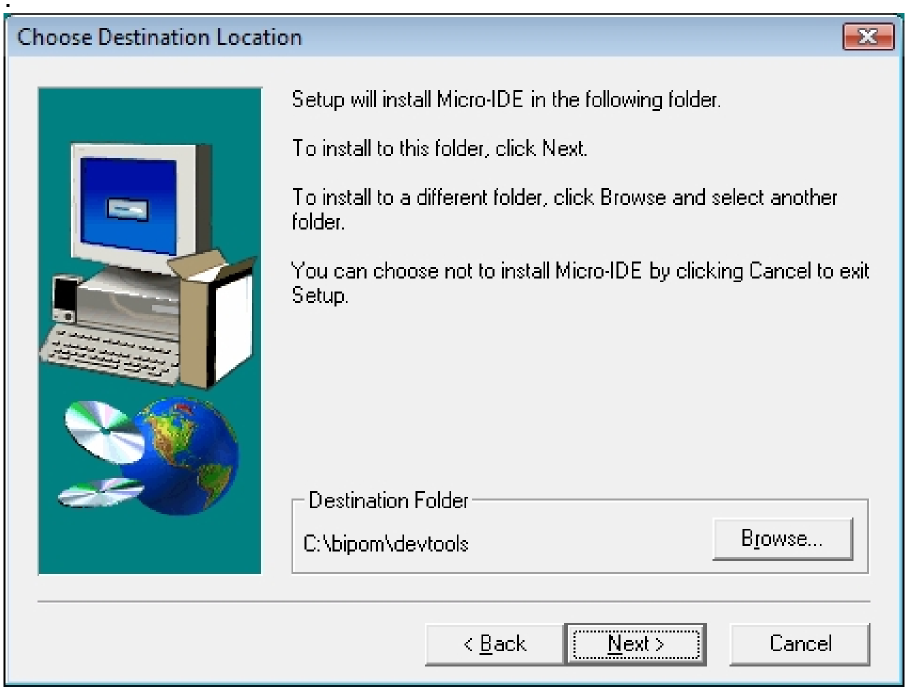
Please read the agreement and click Yes to continue.

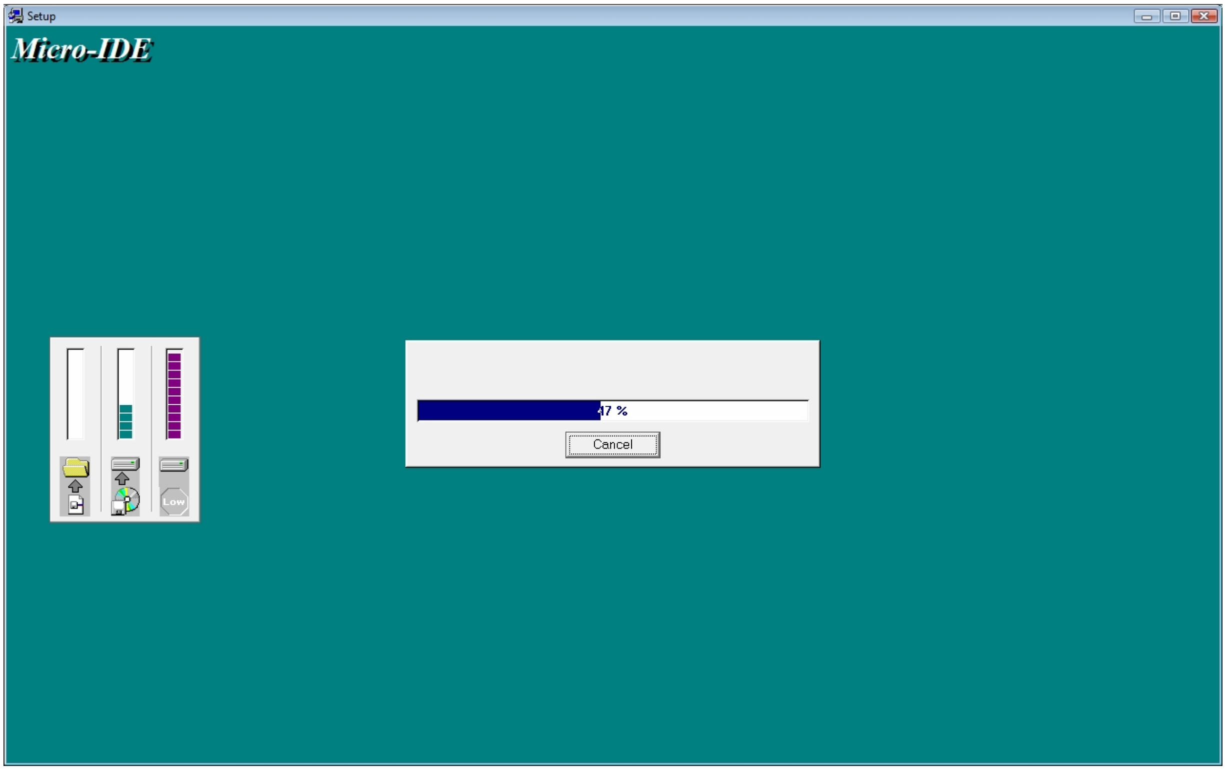
Enter your name, company and 'FREE' as a serial number. Then click the Next button.

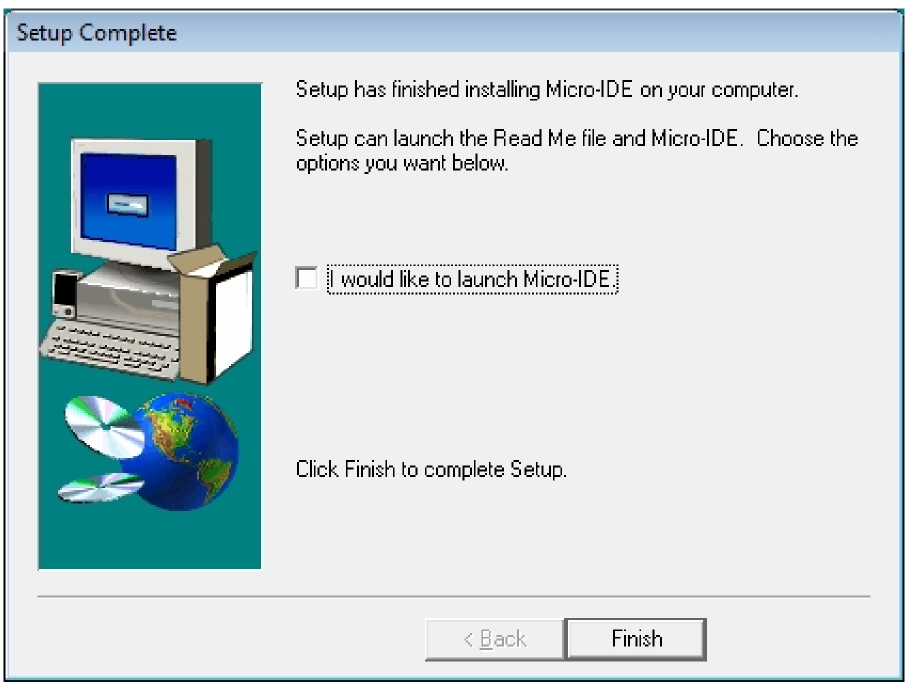


Select the disk location where the software has to be installed. The default location (c:\bipom\devtools) is recommended. Click the Next button to start the installation.

.



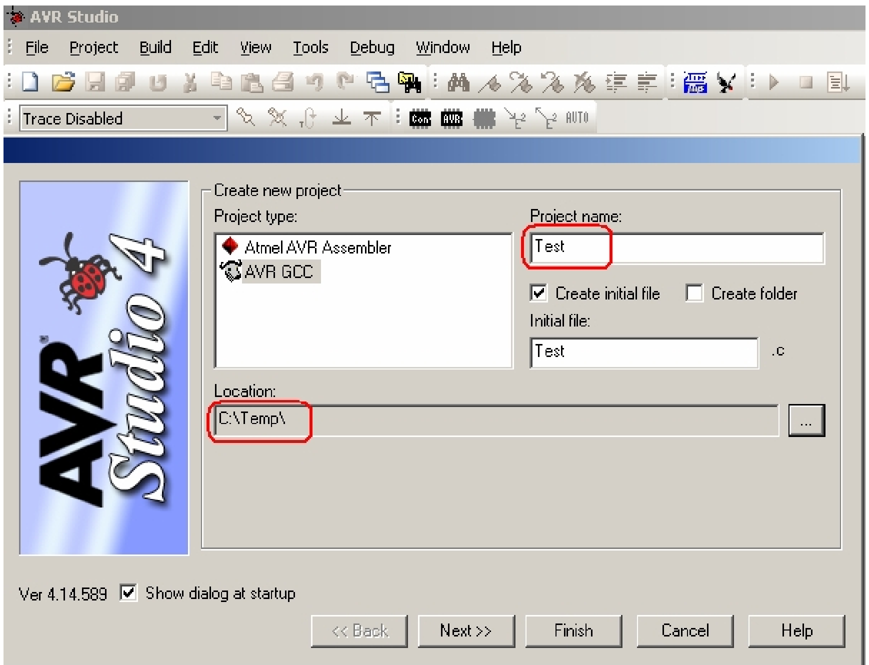




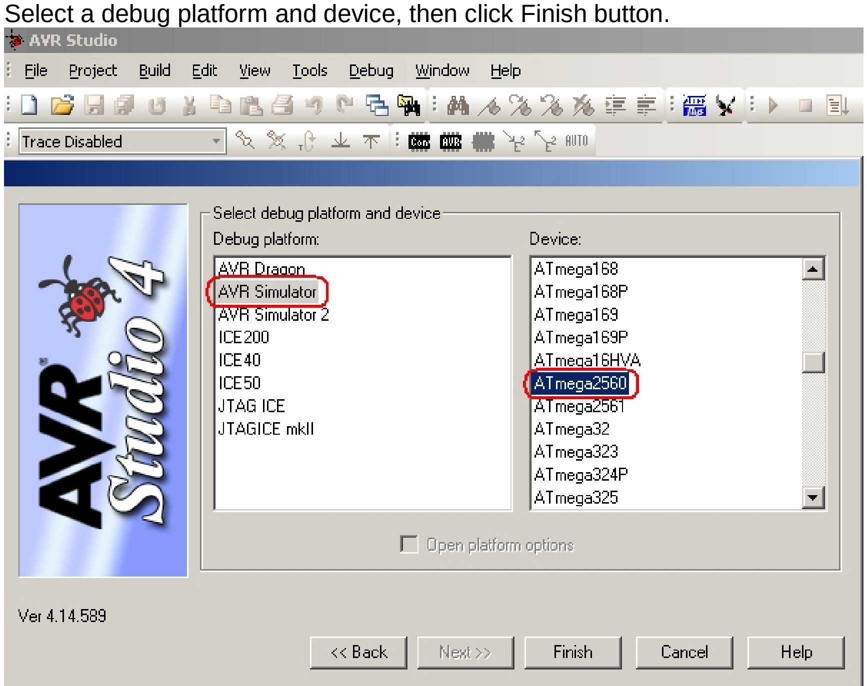
Uncheck the “I would like to launch Micro-IDE” option and click the Finish button.

Test example

To create your own test project please run AVR Studio, select Project menu and select New Project. This will display the New Project dialog (see below). Select AVR GCC, enter the name of the new project and its location and click Next button.

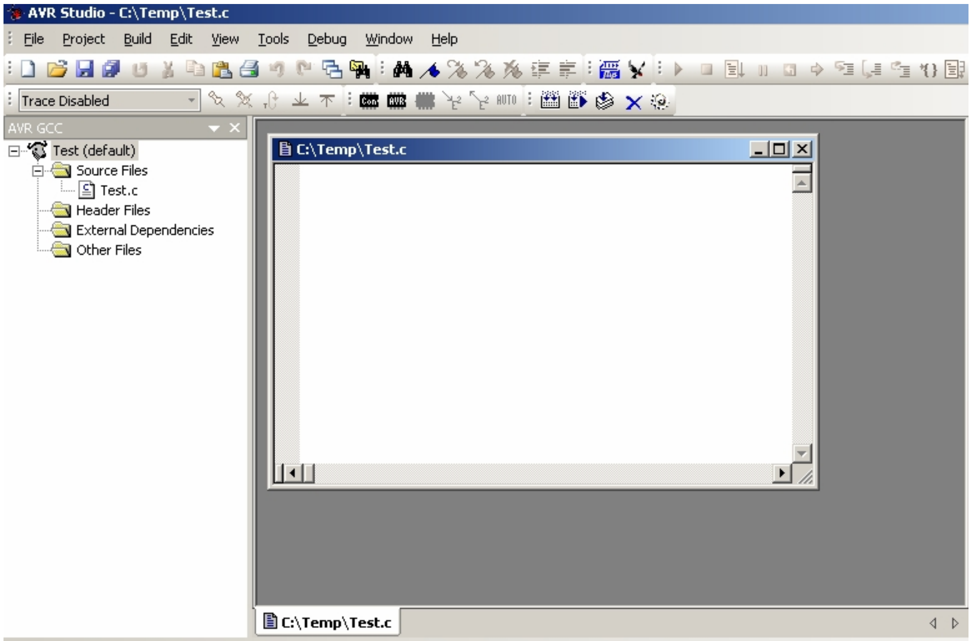


Select a debug platform and device, then click Finish button.



The new project with 'Test' name will be created under c:\Temp.

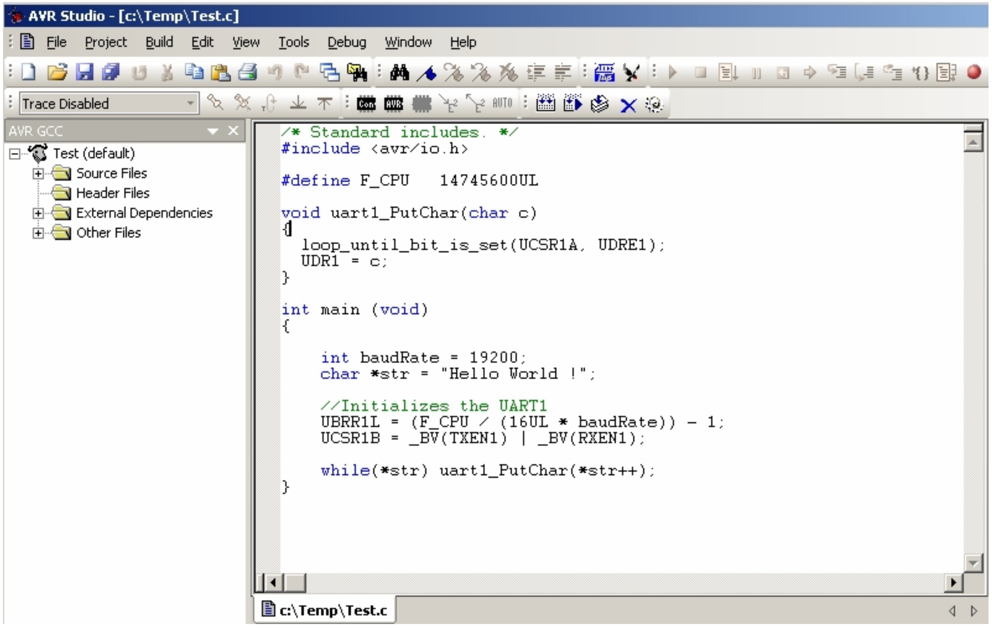
A blank C file (Test.c) will be created automatically as well.



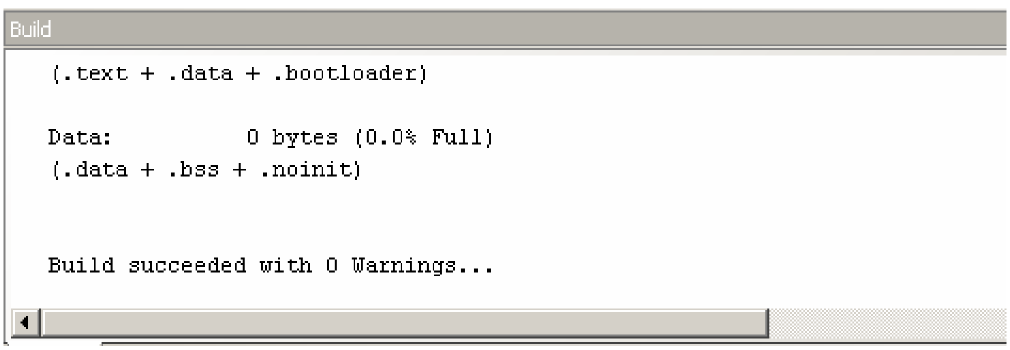
Type the following C-code:

```
/* Standard includes. */
#include <avr/io.h>

#define F_CPU 14745600UL

void uart1_PutChar(char c)
{
            loop_until_bit_is_set(UCSR1A, UDRE1);
            UDR1 = c;
}

int main (void)
{

         int baudRate = 19200;
         char *str = "Hello World !";

         //Initialize the UART1
         UBRR1L = (F_CPU / (16UL * baudRate)) - 1;
         UCSR1B = _BV(TXEN1) | _BV(RXEN1);

         while(*str) uart1_PutChar(*str++);
}
```

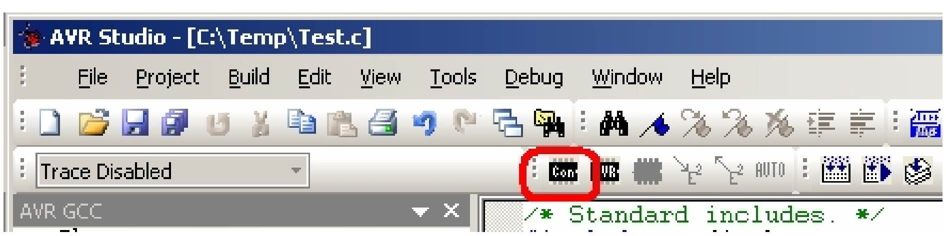
The complete C program should look like this:



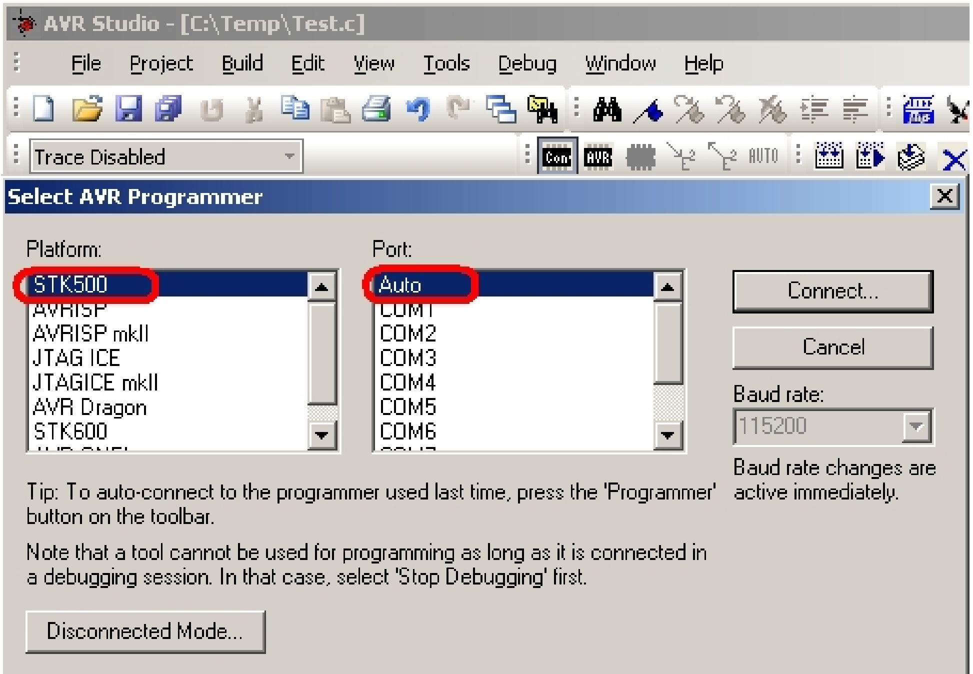
Build the program by clicking the Build button. If the program builds successfully, you will see the following messages on the Build Window.



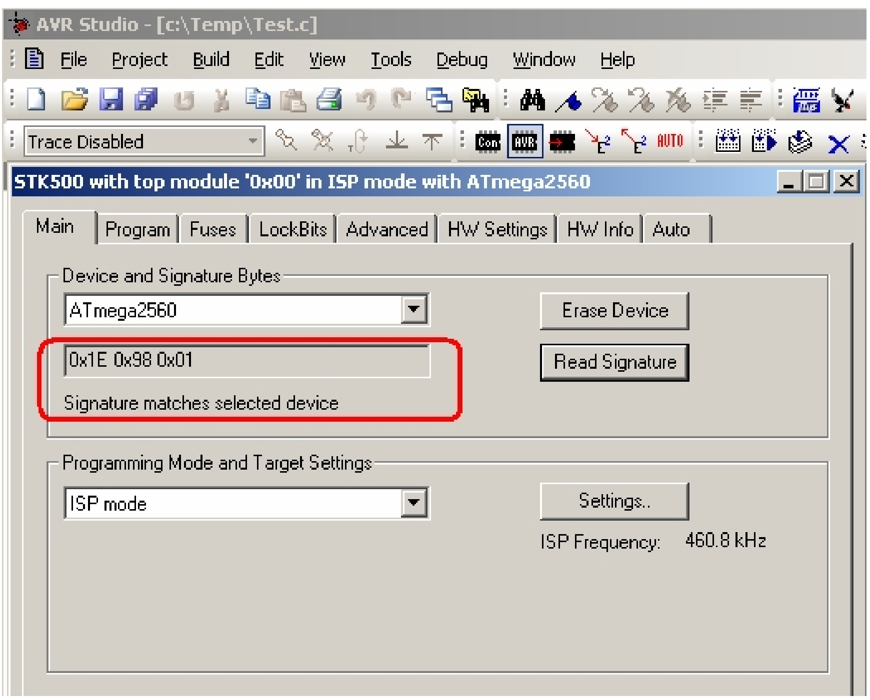
To download the compiled Test.hex firmware to the board, please click the Con icon button on the toolbar.



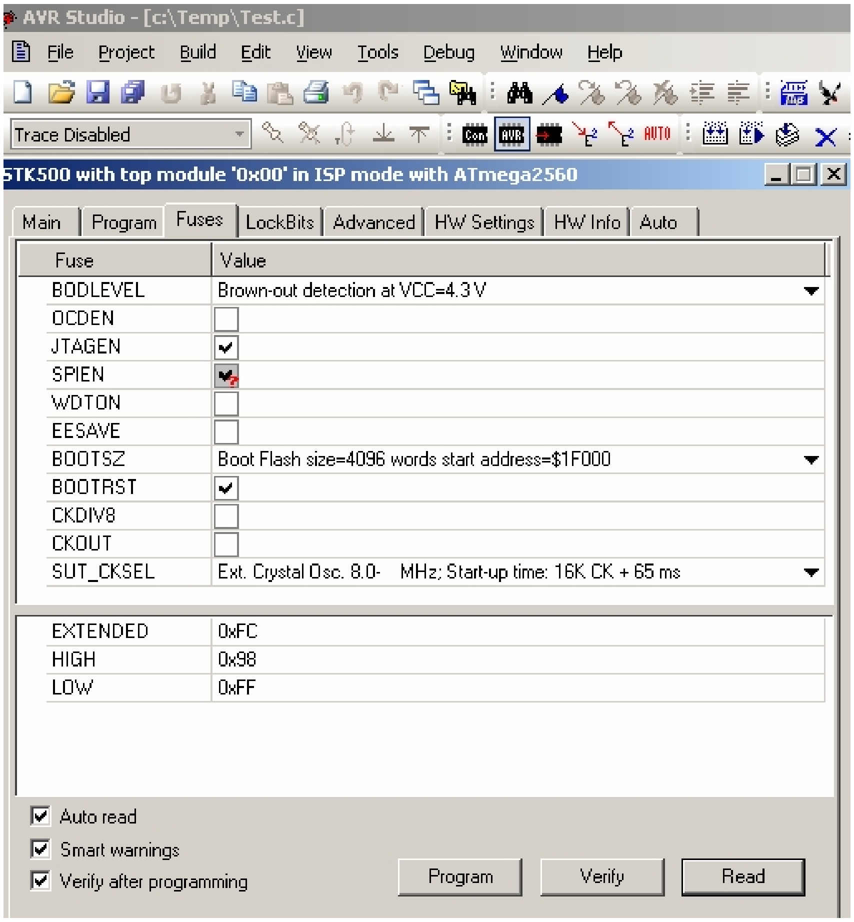
Select STK500 platform, select Auto, and then click the Connect button.



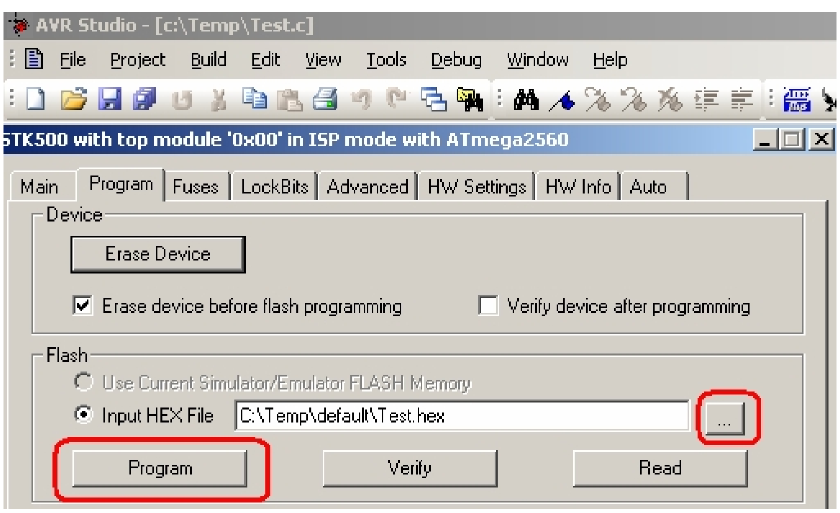
Select ATmega2560 device and click the Read Signature button.
The signature should match ATmega2560.



Check fuses

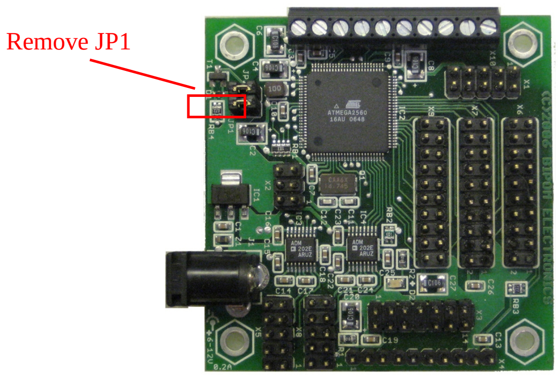


The fuses cannot be changed using the serial boot loader.
To do that it is necessary to use a real programmer such as AVR ISP or AVR Dragon.
Select Test.hex file and click the Program button

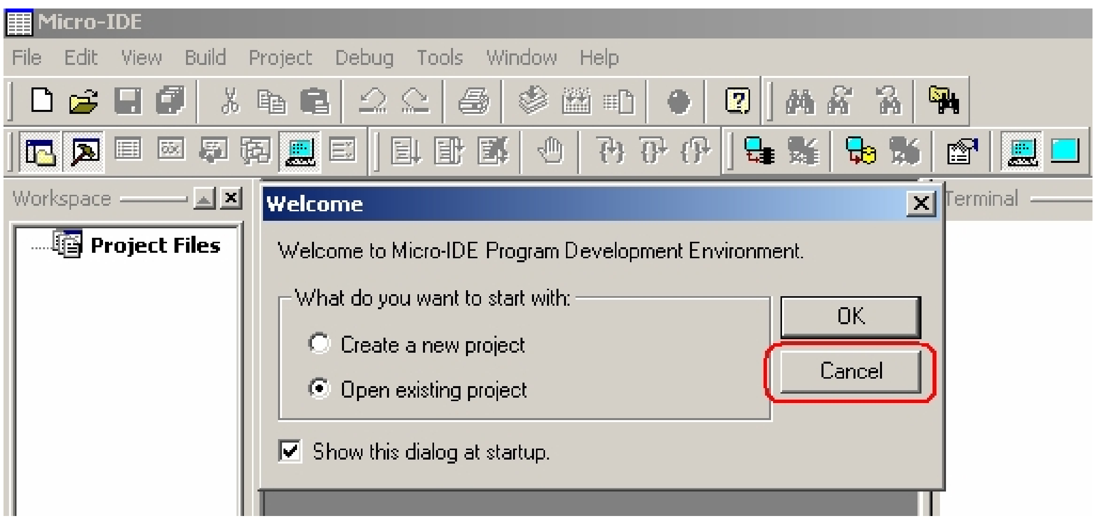


Close AVR Studio dialog to release the PC COM port.

Turn off power to the MINI-MAX/AVR-C. Remove the JP1 jumper.



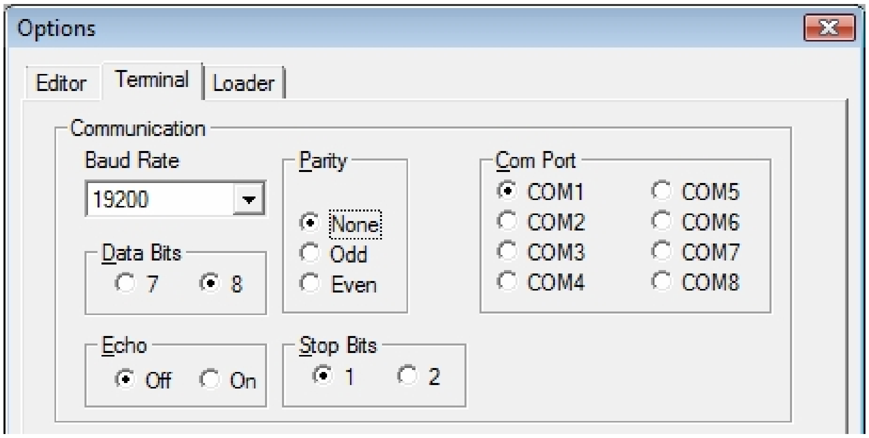
To see the 'Hello World!' messages that the board sends to the serial port, Micro-DE terminal window is used. This is because the AVR Studio does not have its own terminal window. Run Micro-IDE from Start->Programs->Micro-IDE.



Click the Cancel button.

We don't need to create any project.
We need only a terminal window. Instead of Micro-IDE, you can also use any other terminal program that can receive messages through a COM port (for example, HyperTerminal).

To specify the correct terminal settings please select Tools->Options menu:

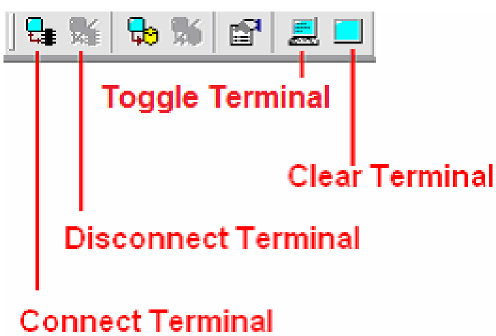


Select the correct PC COM port you have connected the MINI-MAX/AVR-C.
The following settings match the example we run on the Mini-Max/AVR-C board:

Baud rate: 19200
Parity: None
Data Bits: 8
Stop bits: 1
Echo: Off

Click the OK button.

Open the terminal window using the Toggle Terminal icon button



Connect Terminal connects the terminal window to the PC COM port. If a board sends data to the serial port, the messages will appear in Terminal window.

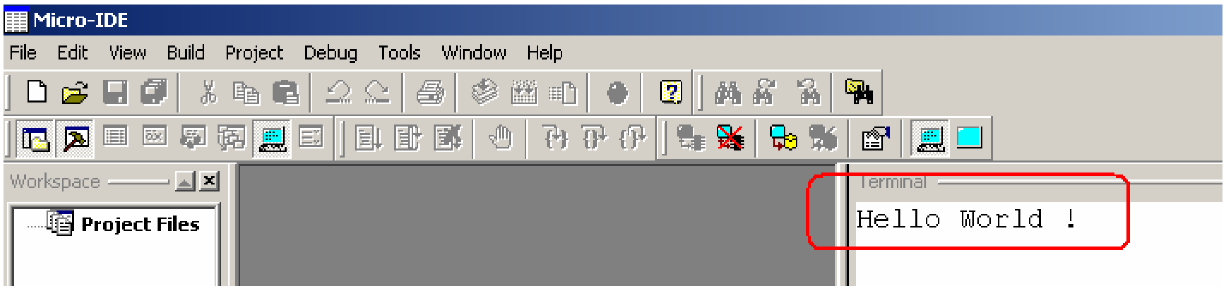
Disconnect Terminal disconnects the terminal window from the PC COM port.

Toggle Terminal shows/hides the terminal window.

Clear Terminal clears all messages in the terminal window.

Click the Connect icon button to connect the terminal window to the board.

Power the board. The “Hello World!” message appears in the terminal window.

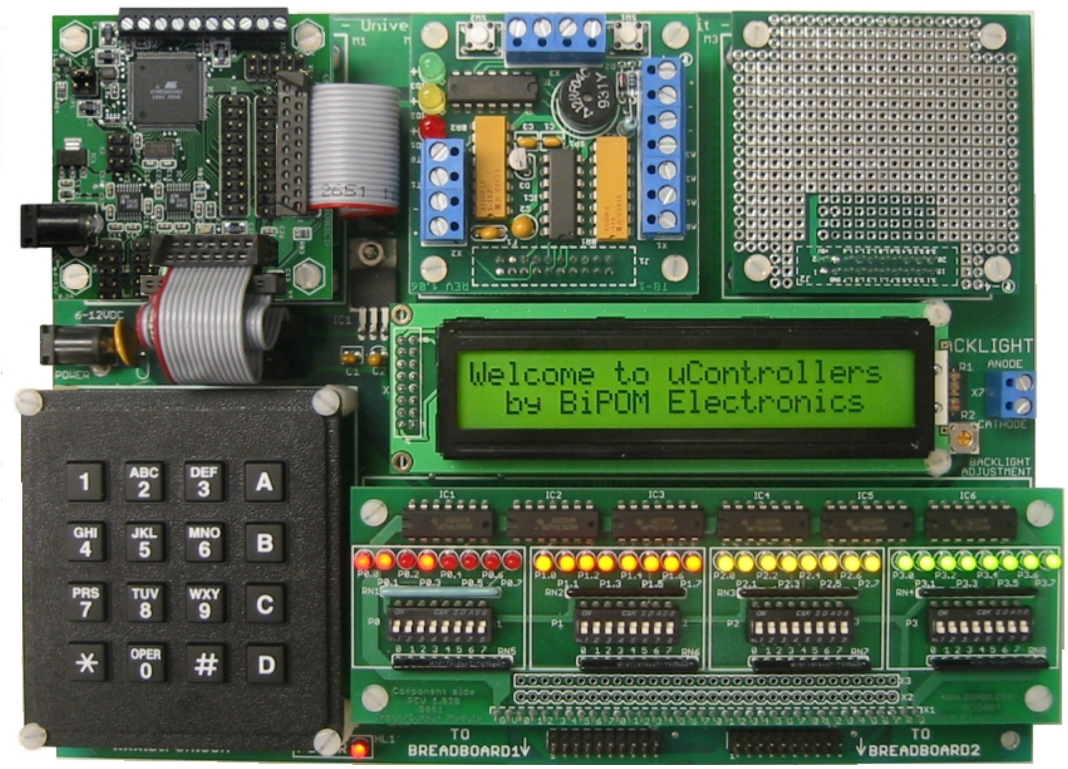


Congratulations!!! You have created and executed your first program on the MINI-MAX/AVR-C. **J**

MicroTRAK/AVR-C Complete Carrier Board

Overview

MicroTRAK/AVR-C Complete includes MicroTRAK Carrier Board, MINI-MAX/AVR-C Microcontroller Board, TB-1 Training Board, PROTO-1 Prototyping Board, AVR I/O Module, LCD242 LCD, KP1-4X4 Keypad, Cables, Adapter, Training Manuals, Labbook, Demo version of BASCOM-AVR BASIC Compiler, WinAVR C Compiler, Micro-IDE, example projects, AVR Studio with Assembler, Debugger and Simulator (free download from ATMEL), Serial downloader.



MicroTRAK carrier board has the following configuration:

- Sockets for a microcontroller board
- Sockets for dual peripheral boards
- Keypad interface
- Industry-standard display interface for alphanumeric LCD and VFD displays.
- Connectors and cables for connection to a standard breadboard
- Expansion port for a microcontroller-specific pluggable module (for example, AVR I/O Module) with port connectors, port indicator LED's and port control DIP Switches.
- Configuration of the high speed input via 3 jumpers.
- Single operating unregulated voltage 6 … 12VDC
- On-board 5 Volt regulator
- Dimensions are 8.8 X 6.7 inches (22.4 X 17.0 centimeters).
- Mounting holes of 0.15 inches (3.8 millimeters) are on four corners.
- 0° - 70° C operating, -40° - +85° C storage temperature range.

MINI-MAX/AVR-C Micro-controller Board

Overview

MINI-MAX/AVR-C is a general purpose, low-cost and highly-expandable micro-controller system. It is based on the ATMEL ATMEGA2560-16 single-chip Flash micro-controller. This micro-controller features

- Up to 16 MIPS Throughput at 16 MHz
- 256 Kilobytes of In-System Re-programmable Downloadable Flash Memory
- 8 Kilobytes bytes of RAM
- 4 Kilobytes bytes of EEPROM
- Two 8 bit Timer/Counters and four 16 bit Timer/Counters
- Programmable Watchdog Timer
- Four Programmable Enhanced UART Serial Interfaces
- SPI Serial Interface
- 2-wire Serial Interface (I^2C)
- 12 Pulse Width channels
- 16 channel 10-bit ADC with selectable 2.56V or 1.1V Reference Voltage
- 86 general purpose I/O pins
- Real time In-System debug support through JTAG Interface

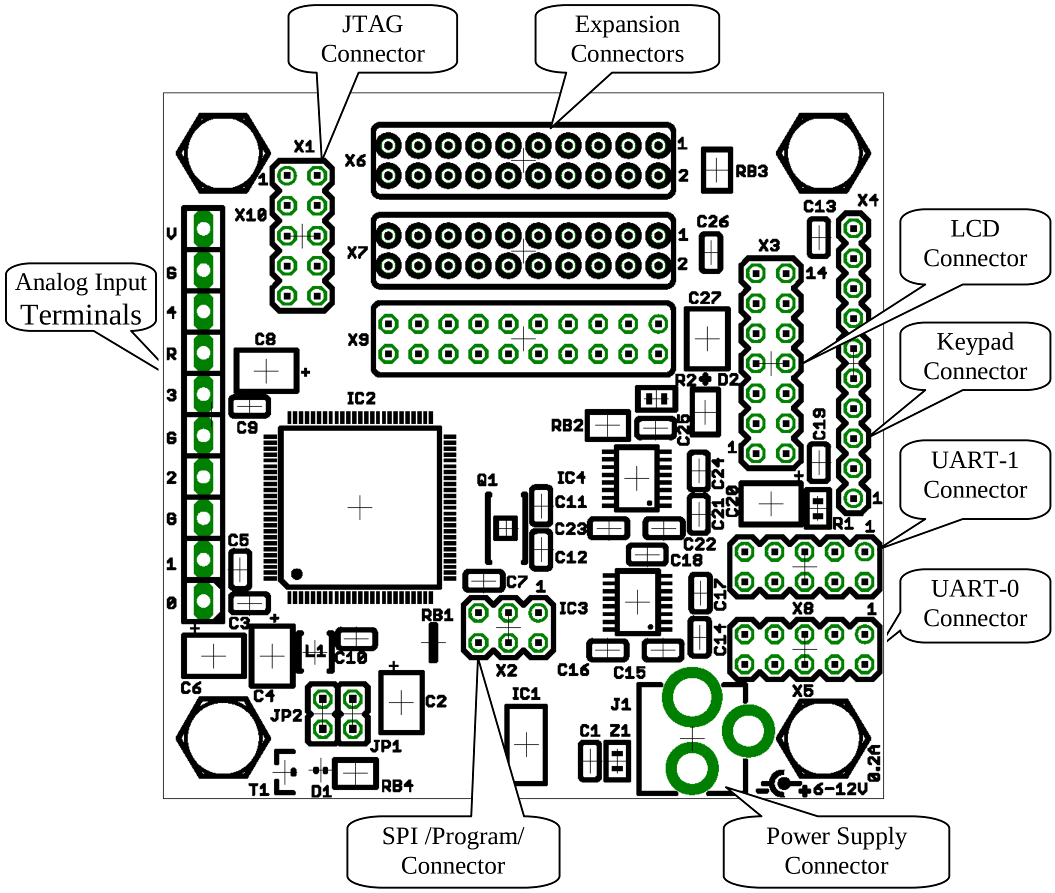
MINI-MAX/AVR-C board complements these features by providing

- In-circuit Programming and debugging of the micro-controller through either the JTAG or SPI interface
- Two RS232 Serial Ports and two UART Ports with 5V signals for data communications
- 5-channel 10-bit ADC with selectable 2.56V or 1.1V internal Reference Voltage
- Keypad connector
- LCD connector (with programmable contrast adjustment for LCD)
- Expansion bus interface to low-cost peripheral boards such as
    - Instrumentation amplifiers
    - Pressure inputs
    - Strain-gage inputs
    - 12 and 16-bit Analog-to-Digital Converters
    - Digital Input/Output cards
    - LED and LCD displays.

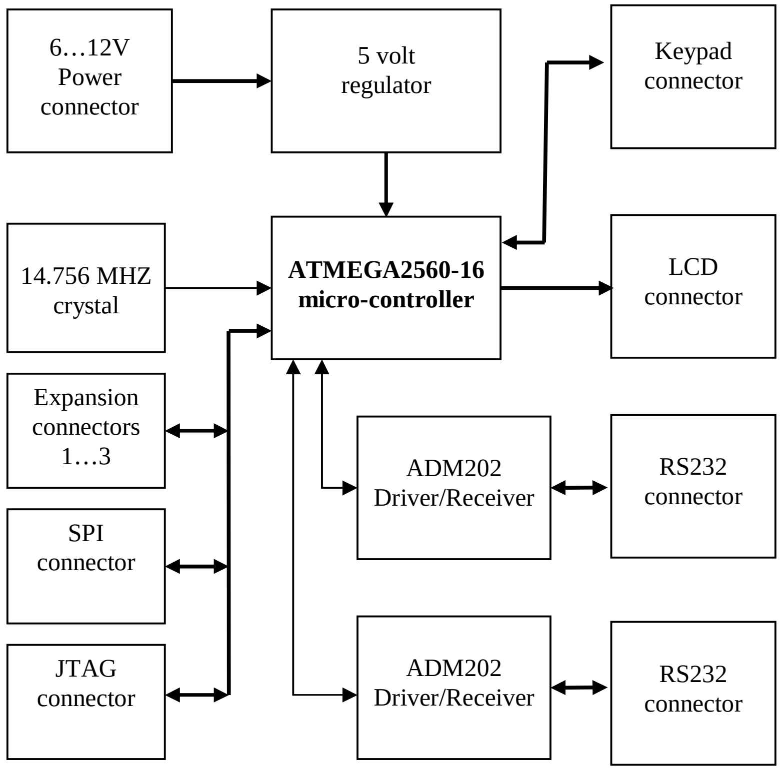
The Flash micro-controller can be serially programmed while in the target application circuit. Customers can program the micro-controller with the most recent firmware or custom firmware. This function of the FLASH micro-controller simplifies new program development and debugging. Downloading of a program to the micro-controller typically takes few seconds.

Board Layout

Layout of MINI-MAX/AVR-C board is shown below:



Functional Block diagram



JTAG Port connector

JTAG port is available on a 10-pin male connector X1.
Table 1 shows the pin assignments for the JTAG port connector

JTAG Port Connector (X1)

Name	Signal	Pin
TCK	MINI-MAX/AVR Test clock Input	1
GND	**GND**	2
TDO	MINI-MAX/AVR Test Data Output	3
VDD	MINI-MAX/AVR Power Output	4
TMS	Test Mode Select Input	5
/RST	MINI-MAX/AVR Reset Input	6
VCC	MINI-MAX/AVR Power Output	7
-	Not Connected (NC)	8
TDI	MINI-MAX/AVR Test Data Input	9
GND	**GND**	10

Table 1

SPI Port connector

SPI port is available on a 6-pin male connector X2.
Table 2 shows the pin assignments for the SPI port connector

SPI Port Connector (X2)

Name	Signal	Pin
MISO	SPI Data Input/Output	1
VCC	**+5V output**	2
SCK	SPI clock	3
MOSI	SPI Data Input/Output	4
/RST	MINI-MAX/AVR Reset Input	5
GND	**GND**	6

Table 2

LCD Connector

Alphanumeric LCD displays can be connected directly to MINI-MAX/AVR-C.
For example, **LCD242,** Alphanumeric 24 Characters x 2 lines
http://www.bipom.com/documents/peripherals/lcd242.pdf.

LCD Connector (X3)

Signal	Pin	Pin	Signal
LD3 (PL3)	14	13	LD2 (PL2)
LD1 (PL1)	12	11	LD0 (PL0)
Not connected	10	9	Not connected
Not connected	8	7	Not connected
STROBE (PL6)	6	5	READ (PL5)
LD4 (PL4)	4	3	Vee (V-PWM)
VCC (+5V) output	2	1	GND

Table 3

Keypad Connector

8 port pins of the MINI-MAX/AVR-C are connected to the Keypad Connector (X4). Matrix keypads (3 x 5 or 4 x 4) can be connected directly to the connector. 5 Volt and Ground power lines are also available on the connector.

The keypad connector can also be used as a general-purpose 8-pin input/output port.

Table 4 shows the pin assignments for the Keypad connector.

Keypad Connector (X4)

Name	Signal	Pin
VCC	+5V output	10
GND	Ground	9
Key 7	PH7 In/Out	8
Key 6	PH6 In/Out	7
Key 5	PH5 In/Out	6
Key 4	PH4 In/Out	5
Key 3	PK3 In/Out	4
Key 2	PK2 In/Out	3
Key 1	PK1 In/Out	2
Key 0	PK0 In/Out	1

Table 4

Asynchronous Serial Port 0

Asynchronous RS232 serial port 0 is available on a 10-pin male connector X5.

Table 5 shows the pin assignments for the RS232 serial port 0 connector

Serial Port Connector (X5)

Name	Signal	Pin
-	Not Connected (NC)	1
PGM	MINI-MAX/AVR Input	2
RXD0	MINI-MAX/AVR Input	3
RTS0	MINI-MAX/AVR Output	4
TXD0	MINI-MAX/AVR Output	5
CTS0	MINI-MAX/AVR Input	6
-	NC	7
-	NC	8
GND	**GND**	9
-	NC	10

Table 5

Asynchronous Serial Port 1

Asynchronous RS232 serial port 1 is available on a 10-pin male connector X8.

Table 6 shows the pin assignments for the RS232 serial port 1 connector

Serial Port Connector (X8)

Name	Signal	Pin
-	Not Connected (NC)	1
-	NC	2
RXD1	MINI-MAX/AVR Input	3
RTS1	MINI-MAX/AVR Output	4
TXD1	MINI-MAX/AVR Output	5
CTS1	MINI-MAX/AVR Input	6
-	NC	7
-	NC	8
GND	**GND**	9
-	NC	10

Table 6

Expansion connectors

50 control pins and 5 Volt power supply pins are available on 3 20-pin connectors (X6, X7, X9) for interfacing to peripheral boards. A peripheral board can be connected to MINI-MAX/AVR-C board either as a piggyback daughter-board using standoffs or can be placed away from the micro-controller board using a 20-wire ribbon cable (Part #: EXPCABLE-6).

Signals TXD, RXD of the UART port 2 and SPI signals are available on the 20-pin connector X6.
Signals TXD, RXD of the UART port 3 are available on the 20-pin connector X7.
Tables 7, 8, 9 shows the pin assignments for the X6, X7, X9 connectors.

Connector X6

Signal	Pin	Pin	Signal
/RXD2	20	19	/TXD2
IO6	18	17	MISO
SCK	16	15	SS
IO22	14	13	MOSI
IO1	12	11	IO0
IO3	10	9	IO2
IO5	8	7	IO4
I2C SCL	6	5	I2C SDA
VCC (+5V)	4	3	GND
VCC (+5V)	2	1	GND

Table 7

Connector X7

Signal	Pin	Pin	Signal
/RXD3	20	19	/TXD3
IO20	18	17	IO21
IO8	16	15	IO9
IO10	14	13	IO11
IO12	12	11	IO13
IO14	10	9	IO15
IO16	8	7	IO17
IO18	6	5	IO19
VCC (+5V)	4	3	GND
VCC (+5V)	2	1	GND

Table 8

Connector X9

Signal	Pin	Pin	Signal
D1	20	19	D0
D3	18	17	D2
D5	16	15	D4
D7	14	13	D6
A3	12	11	A2
A1	10	9	A4
IOR	8	7	A0
AEN	6	5	RESET
IOW	4	3	INT0
VCC (+5V)	2	1	GND

Table 9

Analog Input connector

Table 10 shows the pin assignments for the input connector

Analog Input Connector X10

Name	Signal	Pin
AN0	Analog input 0	1
AN1	Analog input 1	2
AGND	Analog Ground	3
AN2	Analog input 2	4
AGND	Analog Ground	5
AN3	Analog input 3	6
VREF	Output	7
AN4	Analog input 4	8
AGND	Analog Ground	9
AVcc	Output	10

Table 10

Power Supply

External power supply should be able to supply 6…16 Volts DC at 100 mA current

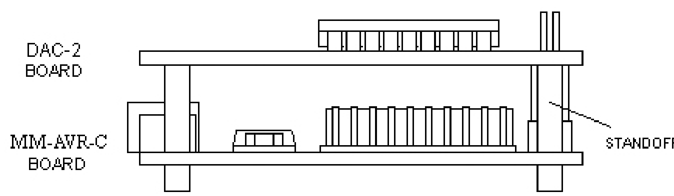
WARNING: Correct polarity should be observed when applying external DC supply to Expansion connector.

Peripherals

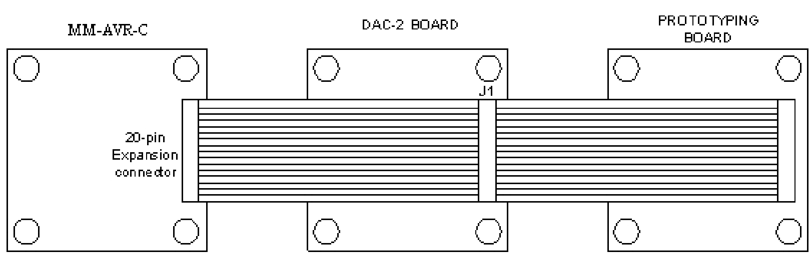
MINI-MAX/AVR-C can be connected to a wide variety of low-cost peripheral boards to enhance its functionality. Some options are:

- Prototyping board (PROTO-1)
- Training Board (TB-1)
- Digital Input/Output Expander Board (DIO-1)
- 12-bit Analog-To-Digital Converter Board (DAQ-2543, DAQ-2543-DA1)
- Relay peripheral boards (RELAY-2, RELAY-4, RELAY-4REED)
- Real Time Clock boards with a Multi Media Card socket (RTC board, MMC/RTC board)
- A peripheral board with four 7-segment LED displays with decimal point (LED-1)
- Additional MINI-MAX/AVR Boards
- Temperature Sensor Interface Board
- Pressure Sensor Interface Board

Peripheral boards can either be stacked on top of MINI-MAX/AVR-C using stand-offs or connected in a chain configuration using flat ribbon cable. First diagram below shows how MINI-MAX/AVR-C can be connected to a peripheral board in a stacked fashion. Second diagram shows the chain connection.



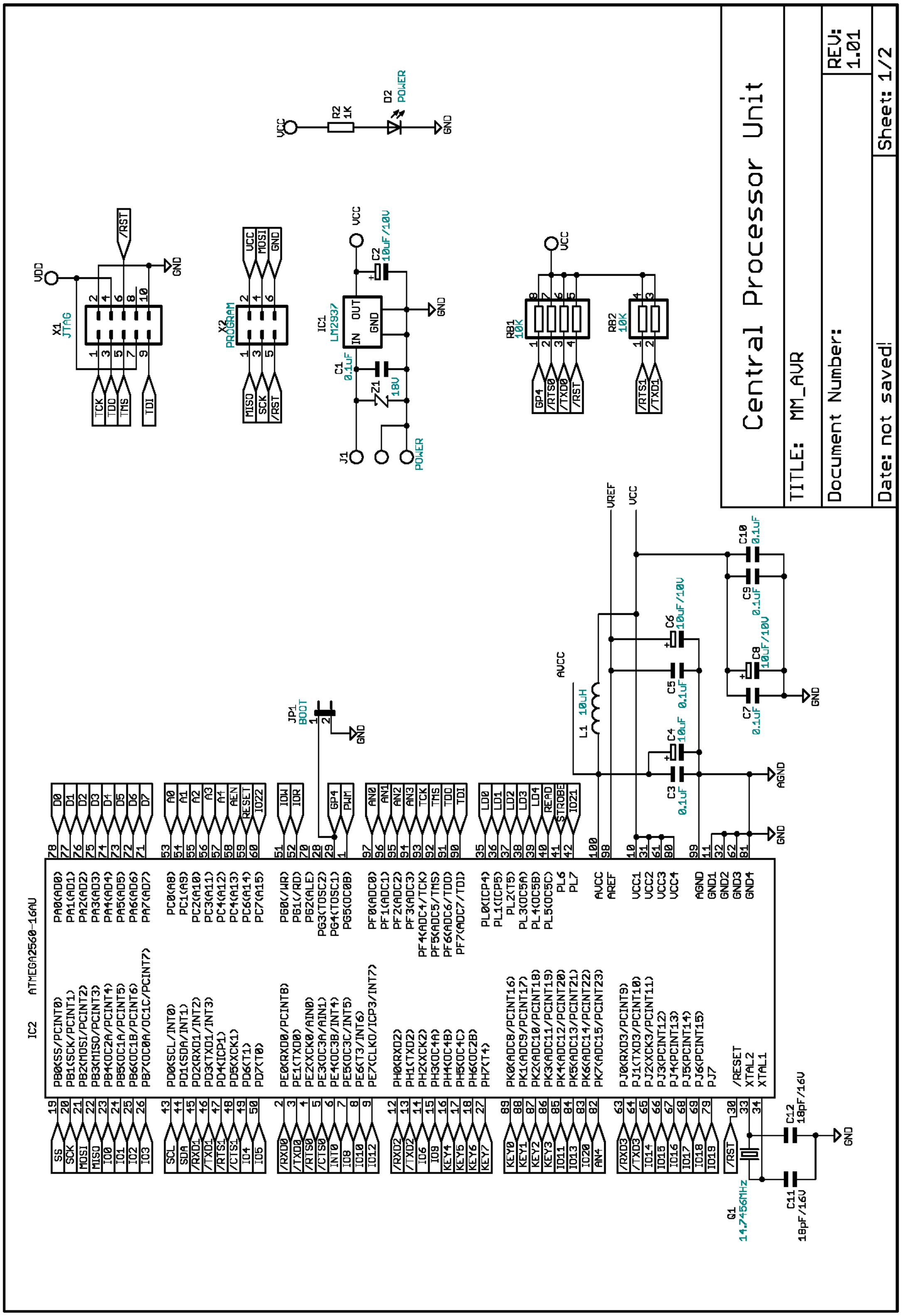
STACK CONNECTION

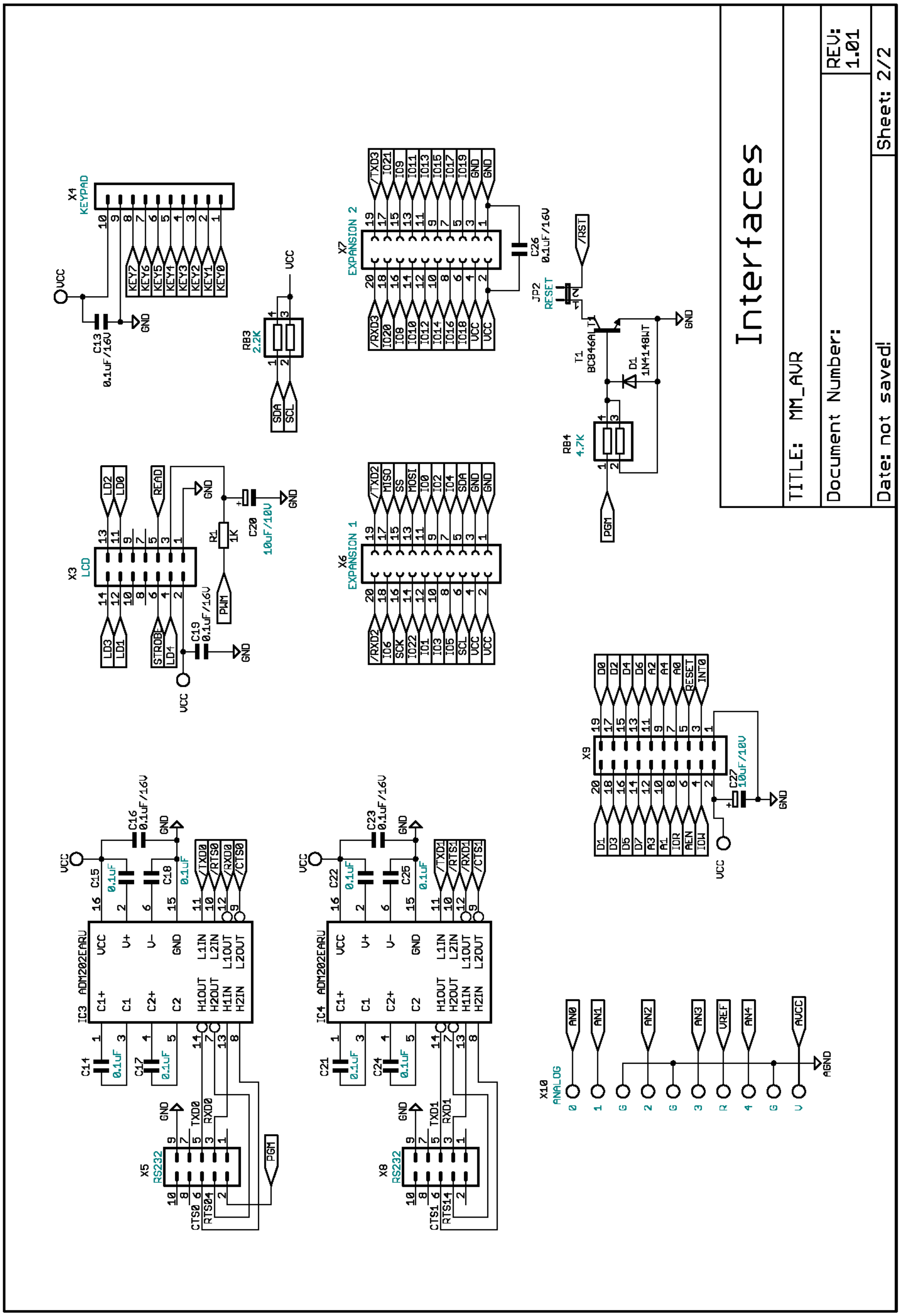


CHAIN CONNECTION

More details on BiPOM Peripheral boards are available from
http://www.bipom.com/periph_cat/us/44/0.html

MINI-MAX/AVR-C Schematics





X4 KEYPAD
X3 LCD
X6 EXPANSION 1
X7 EXPANSION 2
IC3 ADM202EARU
IC4 ADM202EARU
X5 RS232
X8 RS232
X9
X10 ANALOG
RB3 2.2K
RB4 4.7K
T1 BC846ALT1
D1 1N4148WT
JP2 RESET
R1 1K
C20 10uF/10V
C27 10uF/10V
Interfaces
TITLE: MM_AVR
Document Number:
REV: 1.01
Date: not saved!
Sheet: 2/2

TB-1 TRAINING BOARD

Overview

Training Board TB-1 allows performing various experiments with most microcontrollers.

TB-1 features:

- 3 Traffic light LED’s (red, yellow, green)
- 2 interrupt inputs
- 2 switch inputs (in parallel with interrupt inputs)
- 2 timer/counter inputs
- 4 channels of 8-bit analog inputs
- Programmable buzzer
- Expansion bus to other boards

TB-1 is already connected to the MINI-MAX/AVR-C board as part of the MicroTRAK.

Specifications

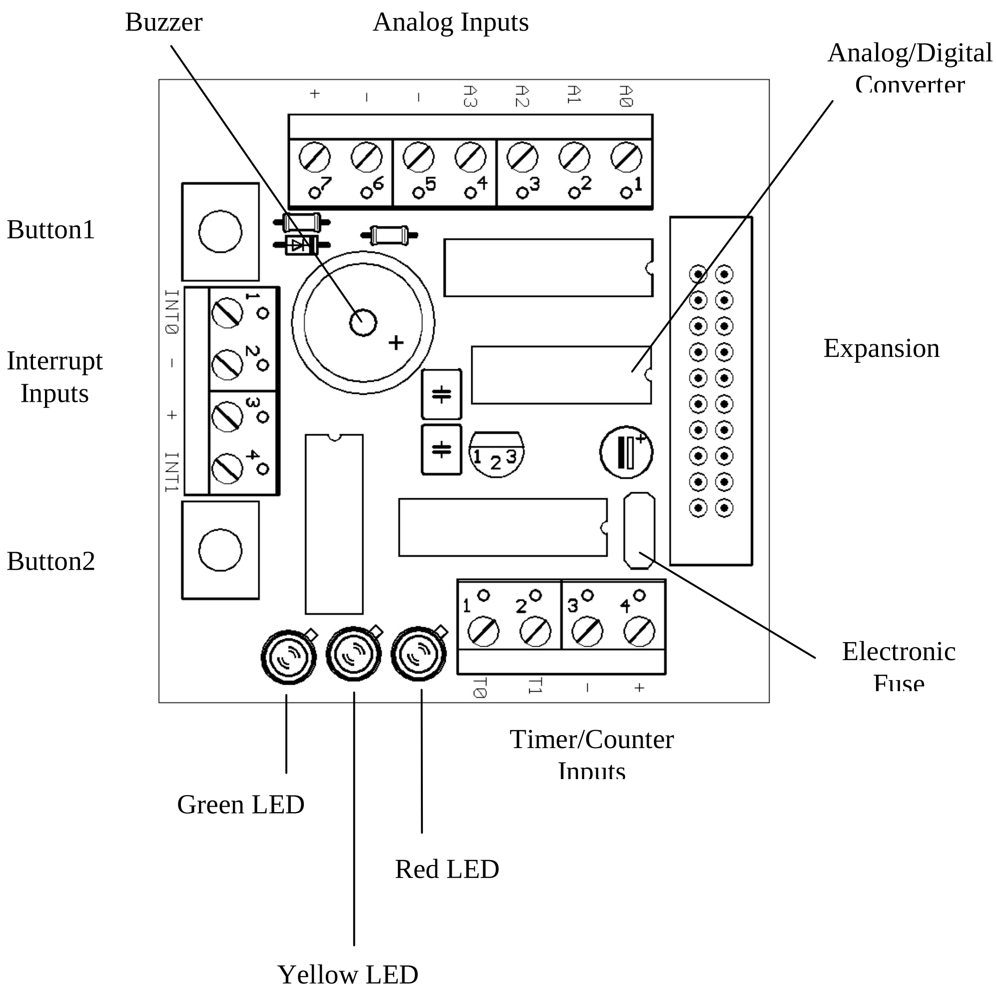
Dimensions are 2.35 X 2.40 inches (5.97 X 6.10 centimeters).

Mounting holes of 0.125 inches (3 millimeters) on four corners.

0° - 70° C operating, -40° - +85° C storage temperature range

Board Layout

Layout of TB-1 board is shown below:



Functional Blocks

Expansion

TB-1 is connected to MINI-MAX/AVR-C and other boards through the Expansion Connector (J1).

Table 4 shows the pin assignments for the Expansion Connector.

Expansion (J1)

Signal	Pin	Pin	Signal
P3.0	20	19	P3.1
P3.2	18	17	P3.3
P3.4	16	15	P3.5
P3.6	14	13	P3.7
P1.0	12	11	P1.1
P1.2	10	9	P1.3
P1.4	8	7	P1.5
P1.6	6	5	P1.7
VCC	4	3	GND
VCC	2	1	GND

Table 4

LED's

TB-1 has 3 Light Emitting Diodes (LED's) that are connected in a traffic light pattern. Red and green LED's are on each side and the yellow LED is in the middle.

LED's are driven by a 7407 buffer (IC2). Each LED has two pins; cathode (negative terminal) and anode (positive terminal). The current through the LED's are limited through current limiting resistors that tie the anode pins to Vcc. To turn an LED on, the cathode is pulled to ground through the corresponding gate of the 7407 buffer. To turn an LED off, the corresponding gate of the 7407 buffer is deactivated by setting the input of the gate to a logic high level.

Buzzer

Because the buzzer requires higher current than the LED's, buzzer is driven by three 7407 buffer gates that are connected in parallel. Due of the inductive nature of the buzzer, a freewheeling diode (D4) is used to clamp reverse voltages that may be induced on the buzzer when the buzzer is being turned on or off.

Buttons

There are 2 push buttons on the TB-1. Each button is connected through a protection resistor to an interrupt input (P3.2 and P3.3) on the micro-controller. Pressing a button forces a logic low level on the corresponding micro-controller input.

Interrupt Inputs

AT89C51ED2 has port pins (P3.2 and P3.3) that can be used either as general-purpose inputs/output or as interrupt inputs. A high to low logic transition or a low logic level on those inputs can cause a hardware interrupt to be generated.

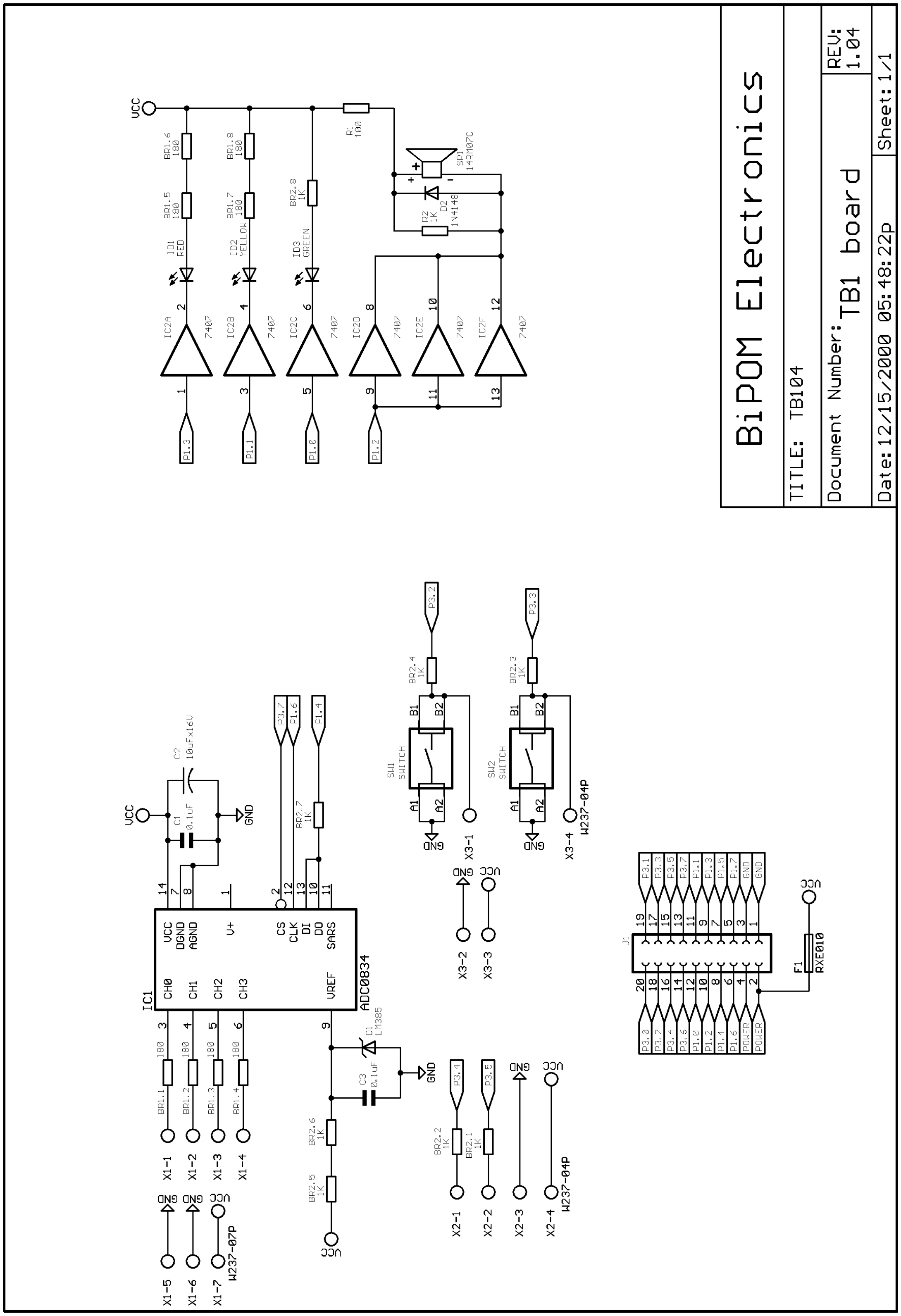
Timer/Counter Inputs

AT89C51ED2 has port pins (P3.4 and P3.5) that can be used either as general-purpose inputs/output or as timer/counter inputs. Logic level changes on these inputs can be counted by the timer hardware on the micro-controller eliminating the need for software polling loops.

Analog/Digital Converter (ADC)

TB-1 has a type ADC0834, 4-channel, 8-bit Analog/Digital converter. Analog inputs are available on X1 terminal block. Analog/Digital Converter is controlled by the micro-controller through 4 port lines. Chip Select (CS) is an input to the ADC. Chip Select enables data conversion when it is logic low and disables data conversion when it is logic high. Clock is an input to the ADC. Mode of operation (single-ended versus differential) and channel number is entered through the DI pin one bit at a time (on every transition of the Clock input). The 8-bit data that corresponds to the voltage on the selected channel is output on DO one bit at a time (on every transition of the Clock input).

TB-1 Schematics



Advanced Project Ideas

- Connecting a printer to the MicroTRAK: In this exercise, the student connects a parallel port printer to the MINI-MAX/AVR-C board using available ports. Student then develops an AVR program to print characters on the printer.

- Using the MicroTRAK as a frequency counter: Student develops an AVR program to measure the frequency and/or period of an incoming signal using AVR's interrupt inputs. The results are then displayed on the terminal window. Input signal is provided from a lab signal generator.

- Using the MicroTRAK as a temperature controller: Student develops an AVR program to connect LM35 or similar temperature sensor to the analog inputs. Depending on the temperature reading one of red, yellow or green LED's are illuminated. If the temperature goes above a preset threshold, the buzzer sounds.

- Using the MicroTRAK EEPROM and the Analog-To-Digital Converter as a multi-channel data logger.