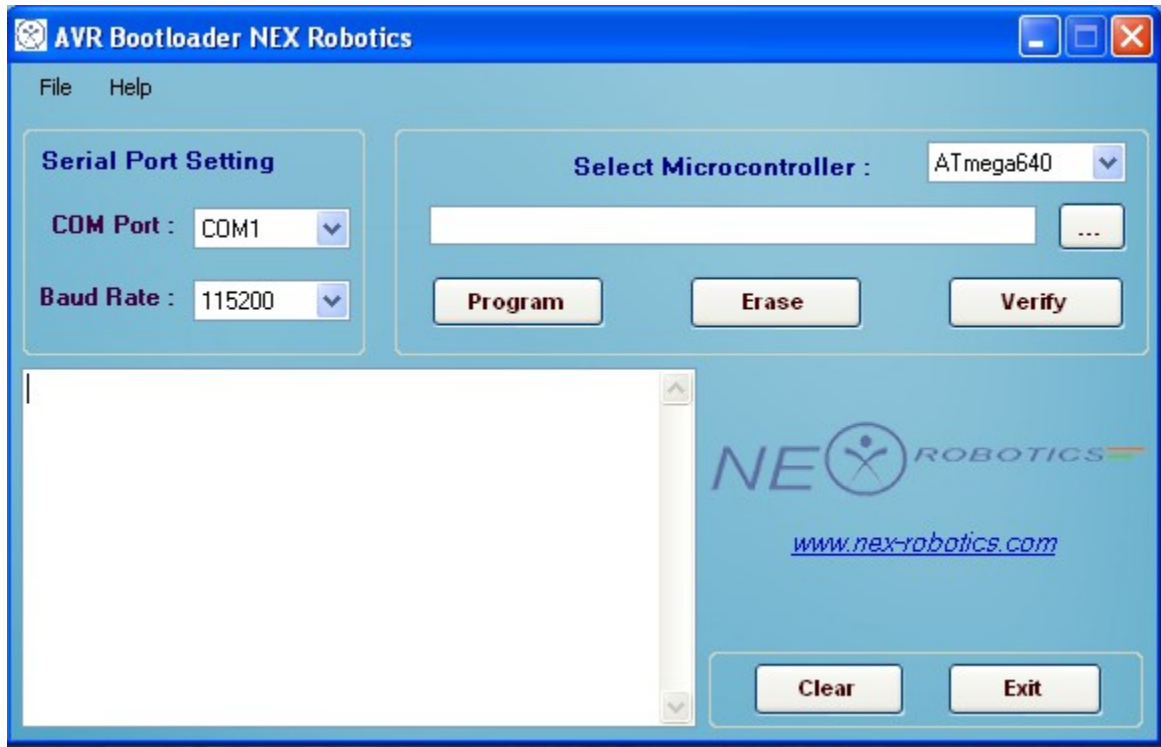


## AVR Boot loader by NEX Robotics

All AVR microcontrollers can be programmed using various methods such as In System Programming (ISP), parallel programming and boot loading etc. Advantage with the boot loader is that you don't need any external hardware to load .hex file on the microcontroller. It also prevents any accidental changes in the fuse settings of the microcontroller.



AVR Bootloader by NEX Robotics

### 1. Boot loader operating principle

If boot loader firmware is loaded on the microcontroller, it allows in system programming directly via serial port of the microcontroller. Code responsible for In System Programming via serial port (boot loader) resides in the configurable boot memory section of the microcontroller. When signaled using external switch while resetting the microcontroller it gets active and waits for communication from the PC for loading .hex file on the microcontroller's flash memory. PC sends the .hex file to the microcontroller. Code residing in the boot section loads the .hex file on the microcontroller's flash memory. After the boot loading process is complete, newly loaded code can be executed by pressing reset. Once the code is loaded on the microcontroller UART is free and can be used for other applications. **Boot loader is get invoked only if boot switch is kept pressed while microcontroller is reset using reset switch.**

## 2. Minimum hardware requirement for boot loader:

1. Microcontroller with the basic components for its operation (mainly Power, Crystal, Reset Switch, Power on reset circuit etc.)
2. A boot loader switch connected to specific I/O pin of Microcontroller with 10K pull-up connected to the Vcc. For pin details refer to the online boot loader resources on the NEX Robotics website.
3. Either a RS232 to TTL converter such as MAX232 or MAX202 if bootloading is to be done via Serial port of the PC or USB to UART converter such as FT232 if bootloading is to be done by USB port of the PC.
5. ISP programmer such as AVR ISP mkII from ATMEL for loading boot code for the first time on the microcontroller.

**Note:** Almost all the development boards from NEX Robotics are sent with the boot loader loaded on the microcontroller.

## 3. Boot loader firmware

Boot loader firmware is loaded on the boot memory of microcontroller prior to use the boot loader. Every boot loader code (.A90 file) is unique in terms of microcontroller type, Crystal frequency supported, baud rate and Pin connected to the boot switch.

Table 1 shows representative example of the bootloader files for different types of the microcontrollers. For latest updated table, refer to the online resources on the NEX Robotics website.

| Microcontroller | Crystal(MHz) | UART  | Baud Rate(bps) | Boot load pin | BOOTSZ (BOOTSZ) |
|-----------------|--------------|-------|----------------|---------------|-----------------|
| ATMEGA 2560     | 14.7456      | UART2 | 115200         | PE7           | 2048            |
| ATMEGA 2560     | 14.7456      | UART1 | 115200         | PE7           | 2048            |
| ATMEGA 2560     | 14.7456      | UART0 | 115200         | PE7           | 2048            |
| ATMEGA 2560     | 14.7456      | UART0 | 115200         | PD6           | 2048            |
| ATMEGA 2560     | 11.0592      | UART2 | 115200         | PE7           | 2048            |
| ATMEGA 2560     | 11.0592      | UART1 | 115200         | PE7           | 2048            |
| ATMEGA 640      | 14.7456      | UART0 | 115200         | PE7           | 2048            |
| ATMEGA 640      | 14.7456      | UART0 | 115200         | PD6           | 2048            |
| ATMEGA 128      | 14.7456      | UART0 | 115200         | PD7           | 2048            |
| ATMEGA 32       | 16.0000      | UART0 | 115200         | PD7           | 1024            |
| ATMEGA 16       | 16.0000      | UART0 | 115200         | PD7           | 1024            |
| ATMEGA 16       | 7.3728       | UART0 | 115200         | PD7           | 1024            |

**Table 1 AVR Bootloader configuration (representative table. For latest updates, refer to table on the NEX Robotics website)**

Download Boot loader firmware for AVR microcontrollers from the following link:  
<http://www.nex-robotics.com/resources/avr-bootloader.html>

#### **4 Loading the boot loader firmware on the boot memory of ATMEGA2560 microcontroller**

The Boot loader firmware is loaded into microcontroller memory using the ISP Programmers such as AVR ISP mkII from ATMEL for loading the boot code for the first time on the microcontroller.

The following sections will explain you the loading of Bootloader firmware into ATMEGA2560 microcontroller. For loading bootloader on any supported microcontroller follow the same process.

Download the “M2560\_FBV\_14\_7456MHz\_115200\_UART2\_PE7.a90” Bootloader firmware for ATMEGA2560 microcontroller on the PC from NEX Robotics website. The file name indicates that the firmware is for ATMEGA2560 running at 14.7456MHz crystal, boot switch connected to PE7, UART2 with baud rate set of 115200 is used for boot loading.

#### **Example: Loading the Bootloader firmware into ATMEGA2560 microcontroller with AVRISP mkII programmer from ATMEL**

AVRISP mkII programmer from the ATMEL is the most versatile programmer for AVR microcontrollers.

Before you start using the AVRISP mkII programmer, we need to install the WINAVR and AVRStudio IDE (Integrated Development Environment). While installing the AVR Studio, select the ‘Install / upgrade Jungo USB Driver’ to support In System Programming (ISP) by AVRISP mkII programmer.

You can download WINAVR from

<http://sourceforge.net/projects/winavr/files/WinAVR/20090313/>

and AVR Studio from

<http://www.atmel.com/tools/studioarchive.aspx>

**Important:** If “Install / upgrade Jungo USB Driver” is not selected, then AVRISP mkII programmer will not work with the AVR Studio.

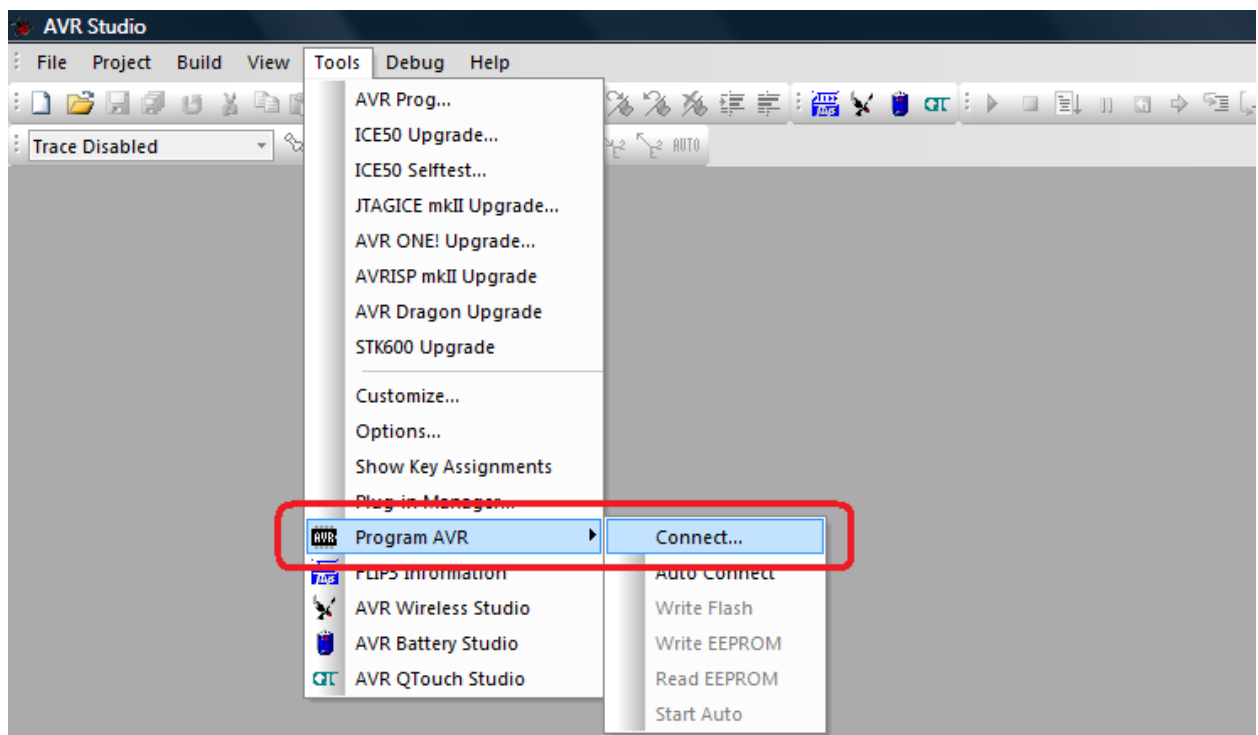
After installing the AVR Studio IDE, follow the steps below.



**Figure 1: AVRISP mkII**

**Step 1:**

1. Connect AVRISP mkII to the PC. It will install driver automatically provided that USB driver installation option is selected while installing AVR Studio.
2. Start AVR Studio
3. Go to “Tools” tab and click on “Program AVR”. Select ‘**connect**’ option.
4. Window as shown in Figure 2 will open.



**Figure 2**

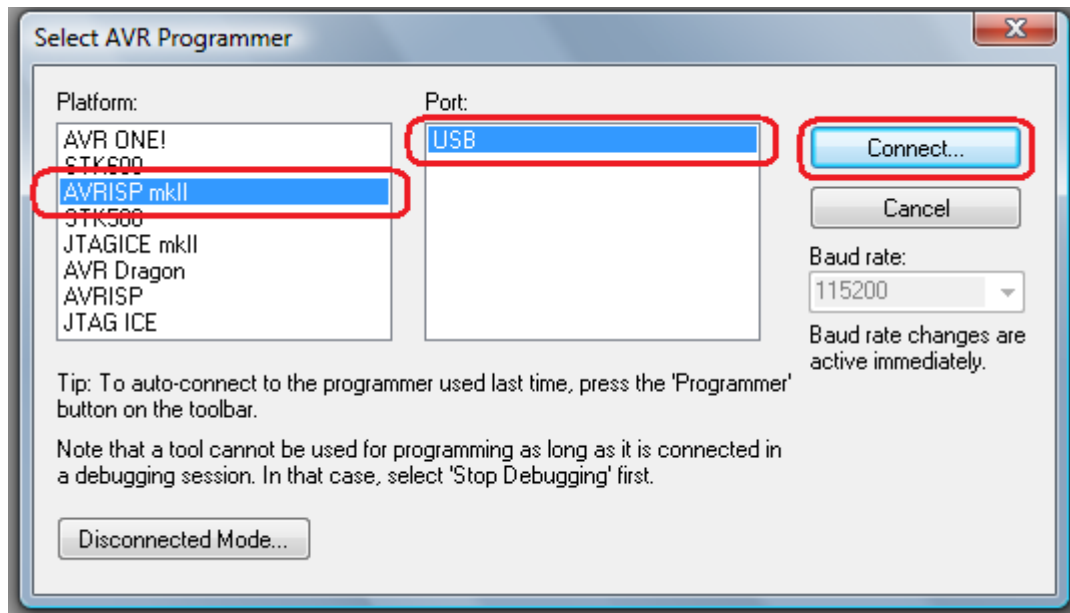


Figure 3

5. Select platform as AVRISP mkII and Port as USB Port and press connect.
6. Window as shown in Figure 3 will appear.

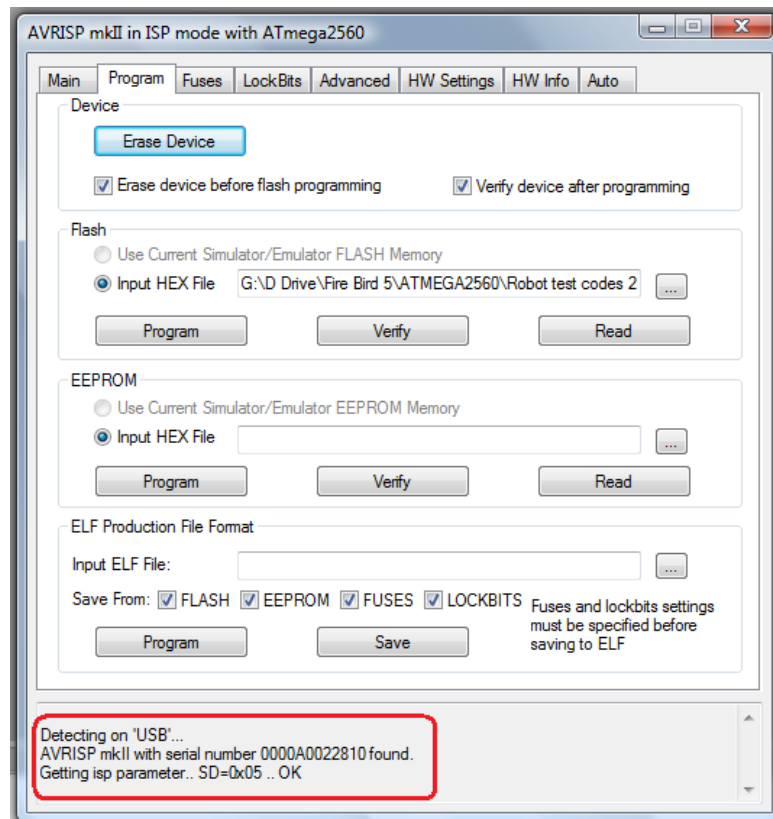
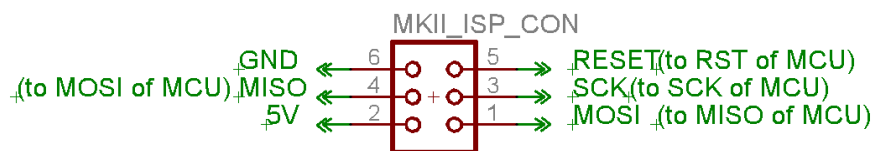


Figure 4

**Step 2:**

Connecting AVRISP mkII with the ATMEGA2560 board

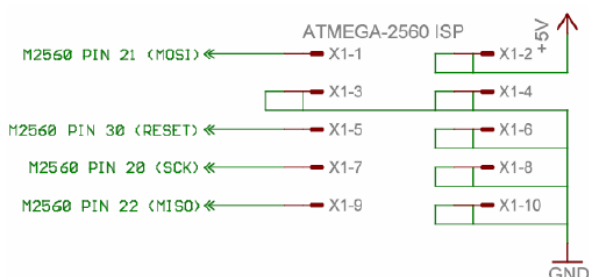
For ISP standard 6 pin or 10 pin FRC connectors are used. AVRISP mkII uses, 6-pin FRC connector for ISP. Figure 5 shows the ISP connector pin out for AVRISP MKII



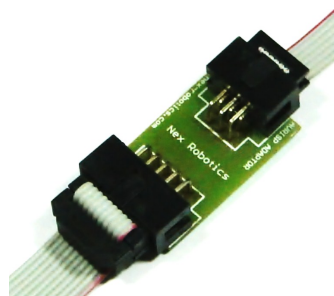
**Figure 5: 6-pin SPI connector configuration of AVR MKII ISP Programmer**

If your board has 10-pin FRC connector, then you will need AVRISP adaptor from NEX Robotics for converting 6 pin ISP socket to 10 pin ISP socket. Figure 6 shows pin out of the 10 pin ISP socket and AVRISP adaptor.

1. Connect AVR ISP mkII with the ATMEGA2560 development board. You can use AVRISP adaptor if required.
2. Turn on the ATMEGA2560 board



**Figure 6: ATMEGA2560 board ISP Socket**

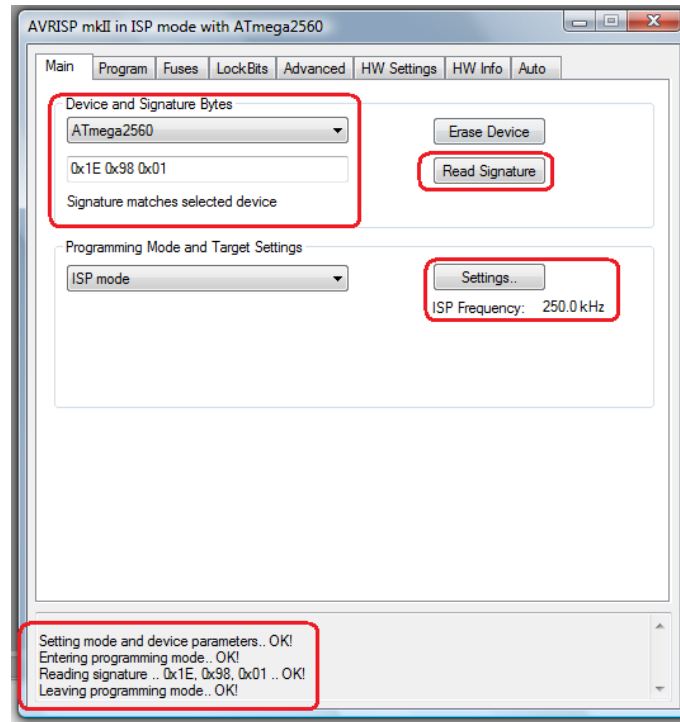


**Figure 7: AVRISP adaptor**

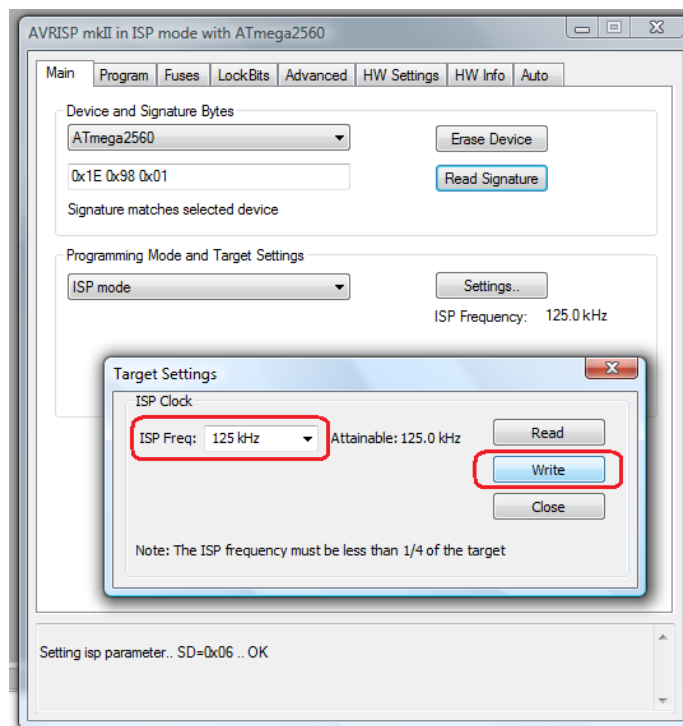
**Step 3:**

Reading the microcontroller signature

1. Go to Main tab
2. Select "ATMEGA2560" microcontroller. (You should select the microcontroller that you are going to use)
3. Click on the "Read Signature" button.
4. It will read the signature and if its matches with the microcontroller signature, we will get the confirmation as "Signature matches selected device" as shown in the below window. Now we are ready to load bootloader on the ATMEGA2560 microcontroller.

**Figure 8**

If ISP does not work properly then try to reduce the ISP frequency and try it again by clicking on the “Settings” button which is located inside the “Programming Mode and Target Settings frame”. Refer to figure 8.

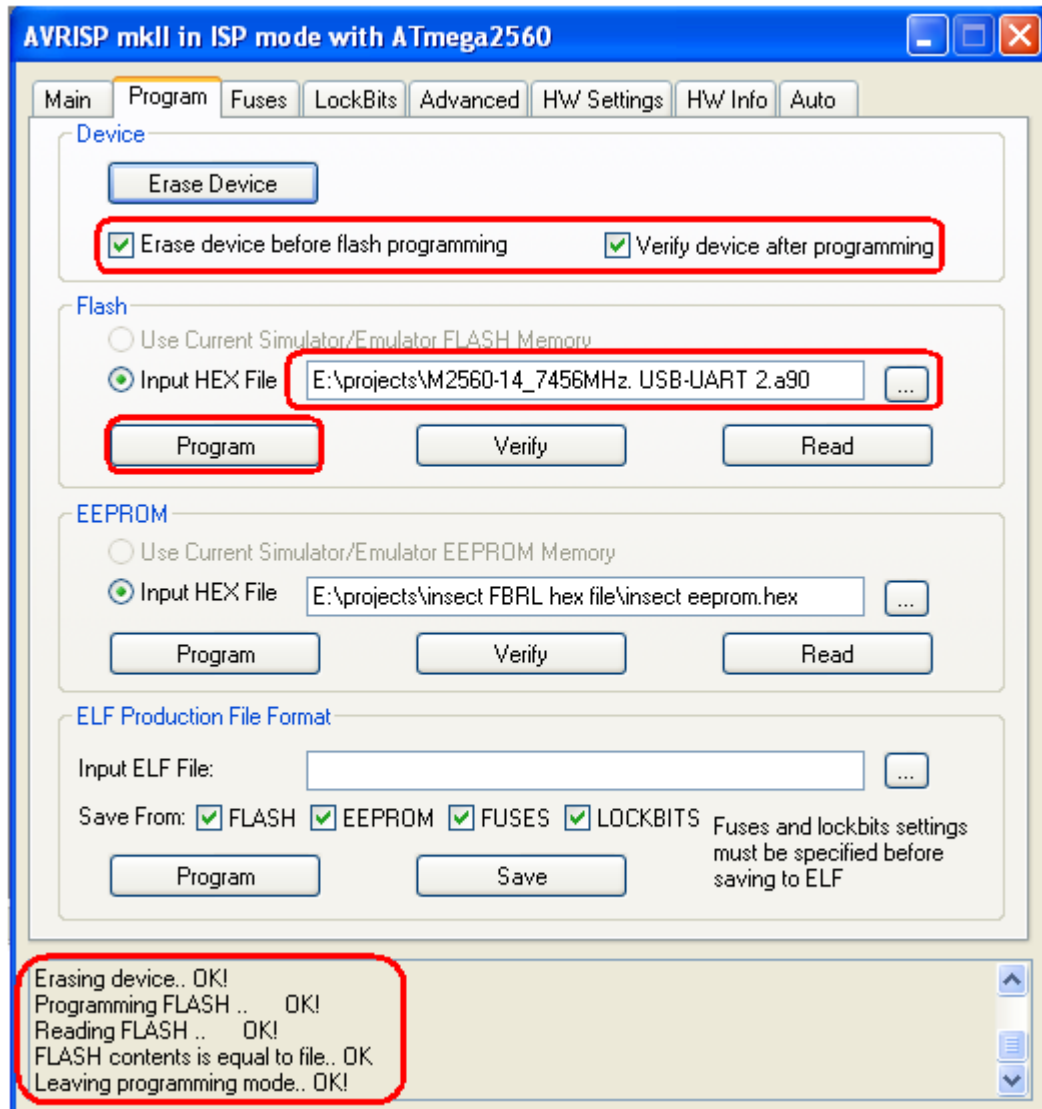
**Figure 9: Changing ISP frequency if required**

**Note:**

If you want to load program at faster speed you can increase the ISP frequency.  
If you notice any instability while programming then reduce the ISP frequency.

**Step 4:**

Loading “M2560\_FBV\_14MHz\_115200\_UART2\_PE7.a90” file on the microcontroller



**Figure 10**

1. Go to “Program” tab.
2. Check on Erase device before programming and Verify device after programming check box.
3. Browse and select the desired i.e.  
“M2560\_FBV\_14\_7456MHz\_115200\_UART2\_PE7.a90” file in the flash section
4. Press “Program” button
5. Look at the comments at the bottom to verify that file is loaded in the flash.



### Fuse settings of ATMEGA2560 microcontroller for using AVR boot loader

To check the fuse settings click on the Fuses tab. Window shown in Figure 11 will appear. To verify the fuse settings press “Read”. To write fuse settings after modifications press “Program”. Make sure that “Auto Read”, “Smart warning” and “Verify after programming” are checked.

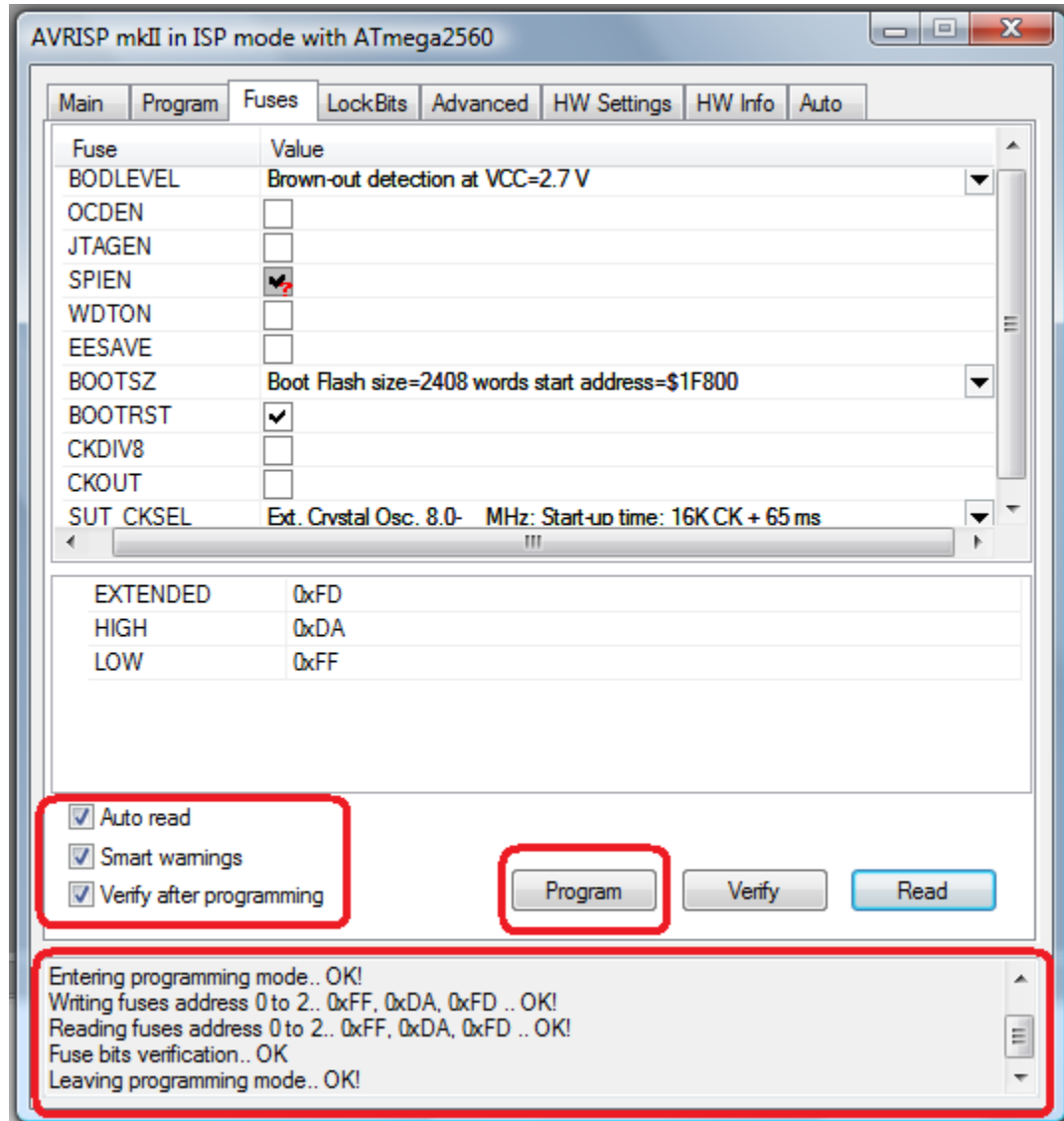


Figure 11

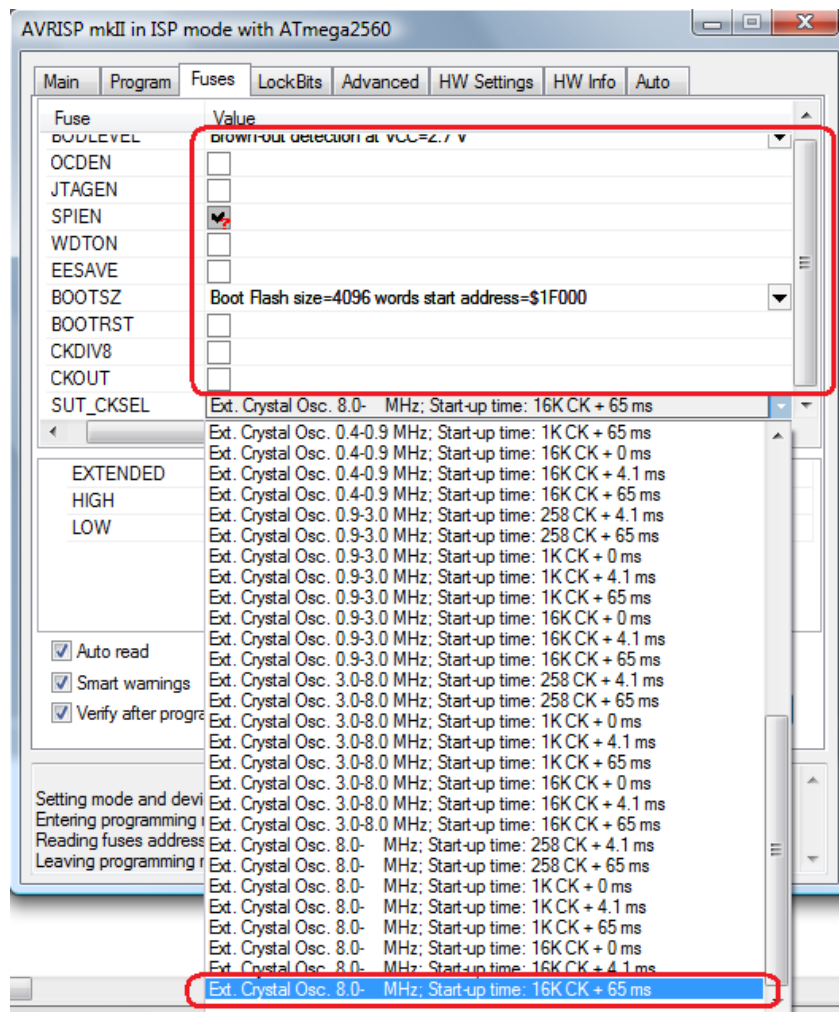


Figure 12

Following fuse settings are done:

1. Brown-out detection set at 2.7V (checked) You can also set any other value if required.
2. JTAG enabling is disabled (JTAGEN) (unchecked), this is an optional step.
3. Boot size is selected at 2408 bytes.
4. BOOTRST is enabled. This will enable the boot mode detection at the predetermined I/O pin of the microcontroller. In this case it is PE7. This pin is held logic low while microcontroller is reset. (checked) to go in to bootload mode.
5. Clock option (SUT CKSEL) set as external crystal of more than 8MHz i.e. “Ext. Crystal Osc. 8.0- MHz; Start-up time: 16K CK + 65ms” This will enable external crystal oscillator.

**Note:** The above fuse settings are with respect to ATMEGA2560 Microcontroller. Fuse setting are remains same for other microcontroller except the ‘BOOTSZ’ (Boot size). Boot size is mentioned in the last column of the Table 1.

After successful loading the Bootloader firmware, remove the ISP connector from the Microcontroller Board.

## 5. Programming the Microcontroller via Boot loader from NEX Robotics

In this section we will cover loading .hex file using Boot loader GUI from NEX Robotics. In this example FT232 based USB to serial converter is used. In this example UART 2 of the ATMEGA2560 is interfaced with the FT232 USB to serial converter.

Before using USB port we need to install drivers for the FT232 USB to serial converter. Driver installation will be covered in the documentation of the board that you are using. Steps to install drives for FT232 USB to Serial Converter and to identify and change the COM port number are also covered in USB to Serial Converter Manual. You can download the manual from this link: [http://www.nex-robotics.com/images/downloads/USB to RS-232 Converter.pdf](http://www.nex-robotics.com/images/downloads/USB%20to%20RS-232%20Converter.pdf)

### Important:

1. If COM port number is set to more than 8 by the PC then you have to change it in the range of COM 2 to COM 8 else AVR Bootloader will not program the microcontroller. To identify and change the COM port number are covered in USB to Serial Converter Manual.
2. When using USB port for the communication, for proper operation, first turn on the ATMEGA2560 microcontroller board, then insert the USB cable in the board. We have to follow this sequence because USB to serial converter chip is powered by USB. If any fault occurs then turn off the board and remove the USB cable and repeat the same procedure.

**Note:** If you are using the Serial port for boot loading then driver installation for the USB port will not be required. In this case select COM 0 as the communication port.

## 6. Installation of AVR Bootloader

AVR Bootloader Application is located inside a **“Documentation CD\Software and Drivers\AVR Bootloader”** which is provided with product documentation CD. First copy AVR Bootloader application from documentation CD to your PC.

Otherwise, Download the bootloader Application from the following link:

<http://www.nex-robotics.com/resources/avr-bootloader.html>

### Step 1:

Open the Bootloader GUI folder on your PC and click on the “setup” application file (not on AVR Bootloader Setup).

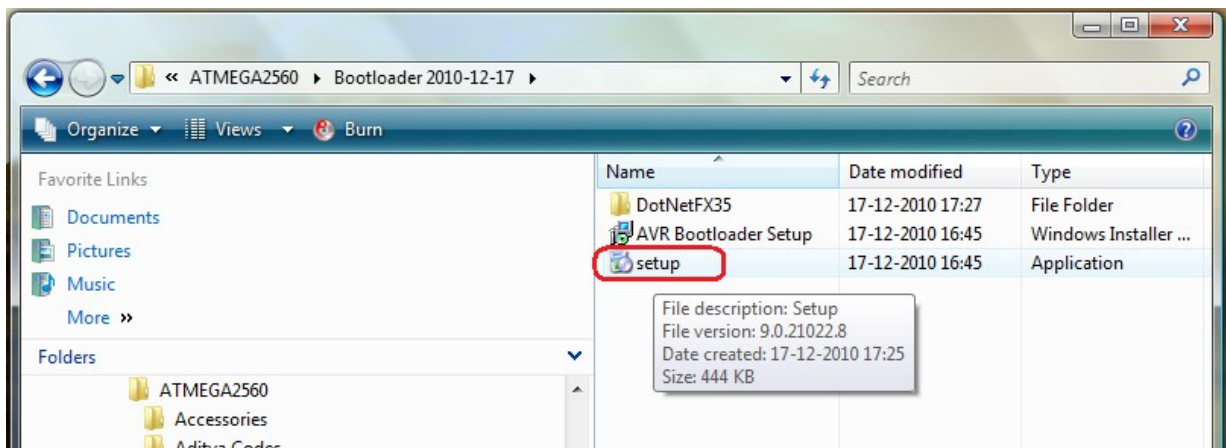


Figure 13

### Step 2:

Follow the installation steps to complete the installation.

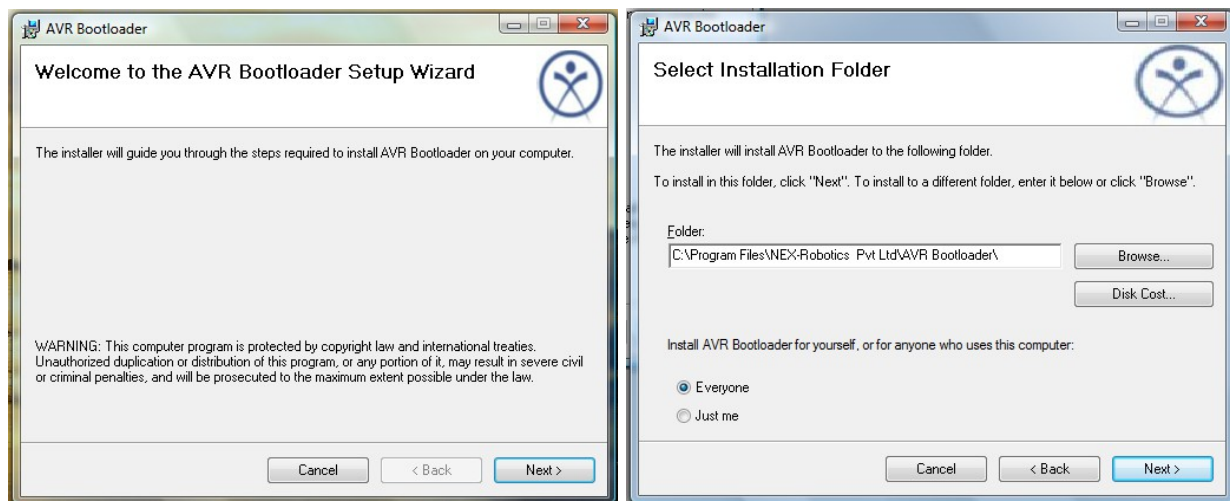


Figure 14

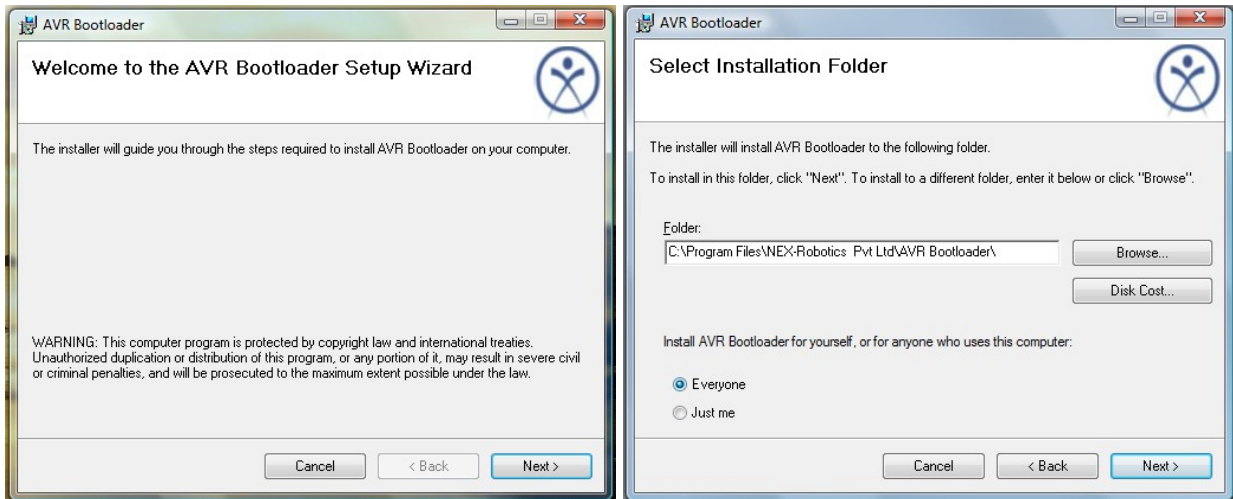


Figure 15

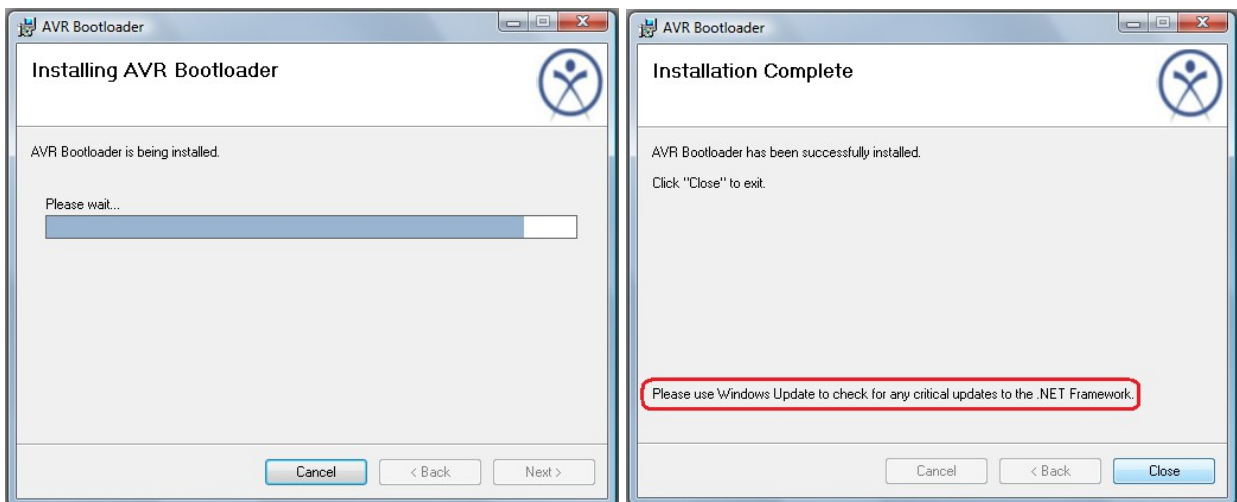


Figure 16

## 7. Demonstration of AVR Bootloader

### Step 1:

Go to Start Menu, next click on “Nex Robotics”, then right click on AVR Bootloader and “Run as Administrator”. AVR Bootloader application will start.

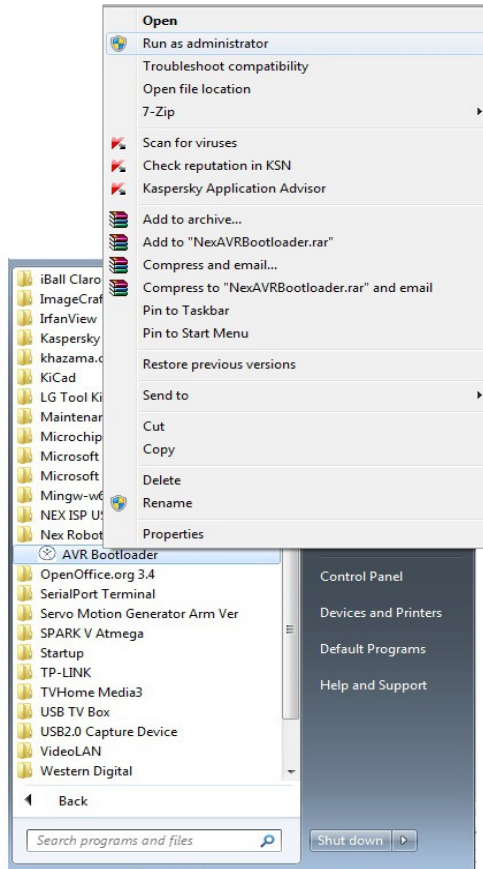


Figure 17

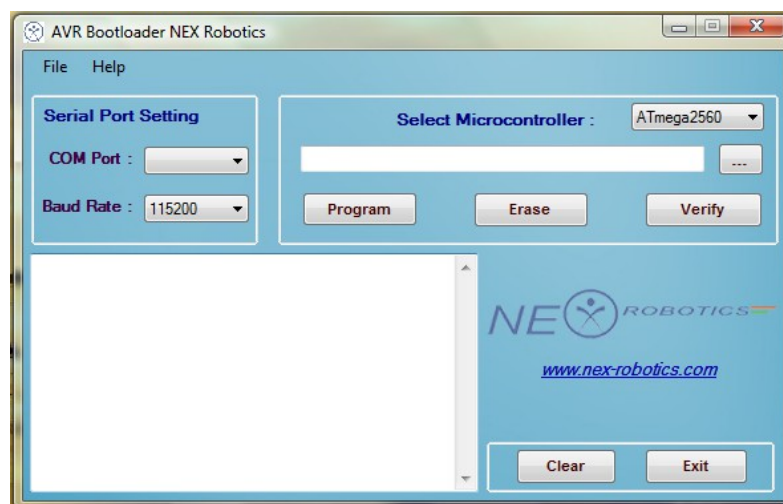
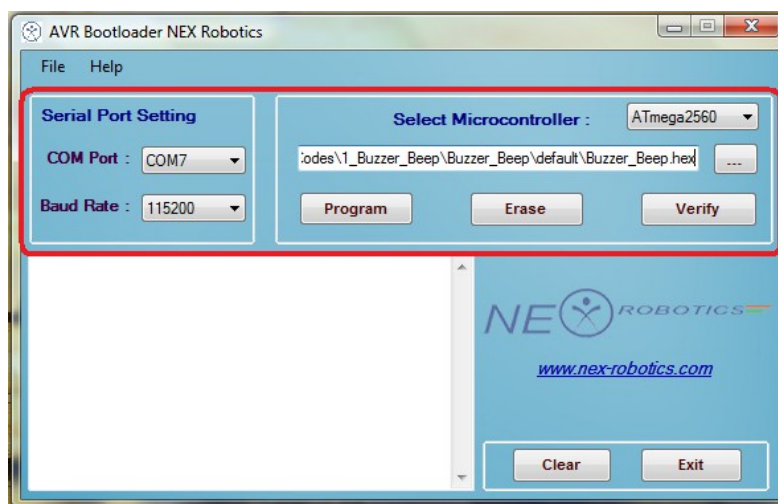


Figure 18



**Step 2:****Figure 19**

In this step we will configure port settings,

1. Make sure that drivers for FT232 USB to serial converter are installed.
2. Turn on the board.
3. Connect USB wire between board and the PC and wait for 2 seconds.
4. AVR Bootloader software will auto detect the COM port number.
5. Click on the COM port number. It will show the detected COM port numbers. If multiple COM port numbers are detected then to identify COM port number associated with the board by going in the device manager. To do this refer to the [http://www.nex-robotics.com/images/downloads/USB to RS-232 Converter.pdf](http://www.nex-robotics.com/images/downloads/USB%20to%20RS-232%20Converter.pdf)
6. If the COM port number is more than COM8 then change it to any COM port number between COM1 to COM8.
7. Set the Baud rate at 115200 bps.
8. Select microcontroller as per requirement. For example we are select here ATMEGA2560 microcontroller.
9. Browse for the target .hex file.

Now we are ready to load .hex file on the ATMEGA2560 microcontroller.

**Step 3:**

In this step we will load the .hex file on the ATMEGA2560 microcontroller.

1. First press the boot switch. Keep it pressed. Press the reset switch for at least 1 second while boot switch is pressed and release the reset switch. Now release boot switch. In this case when reset switch is pressed while holding PE7 low, ATMEGA2560 will go in to bootloading mode.
2. Press program button on the GUI to load the .hex file. You can see the activity on the TX and RX LEDs of the FT232 USB to Serial Converter (if used) Figure 20 shows the comments in the message box after successfully programming the ATMEGA2560 microcontroller.

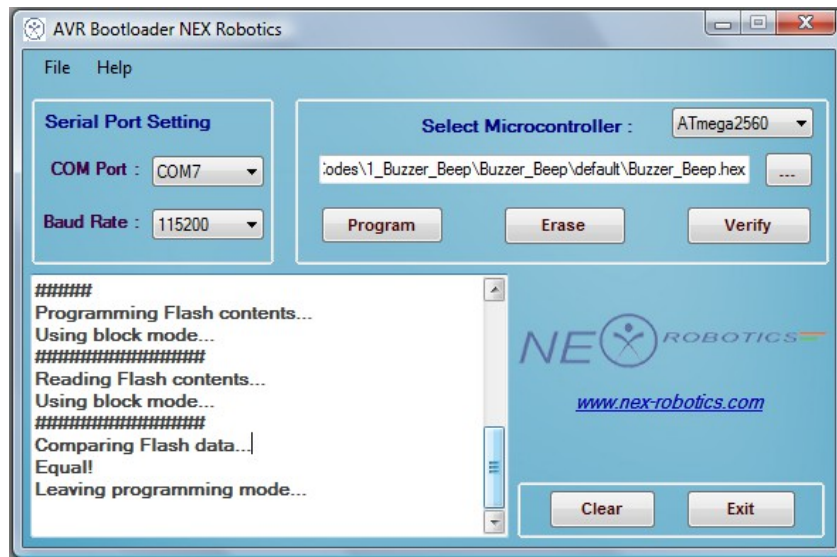


Figure 20

**After successfully programming following text will appear in message box:**

```
Serial port timeout set to 5 sec.
Found AVRBOOT on COM7!
Entering programming mode...
Parsing XML file for device parameters...
Parsing '\ATmega2560.xml'...
#####
```

```
Saving cached XML parameters...
Signature matches device!
Erasing chip contents...
Reading HEX input file for flash operations...
```

```
#####
#####
#####
#####
```

```
Programming Flash contents...
Using block mode...
#####
```

```
Reading Flash contents...
Using block mode...
#####
```

```
Comparing Flash data...
Equal!
Leaving programming mode...
```



### **Boot Loading via serial Port**

For boot loading via serial port, we need to connect UART2 to RS232 transceiver such as MAX232 or MAX202 on ATMEGA2560 board. Repeat the same steps mentioned as above except that select COM port as COM0.