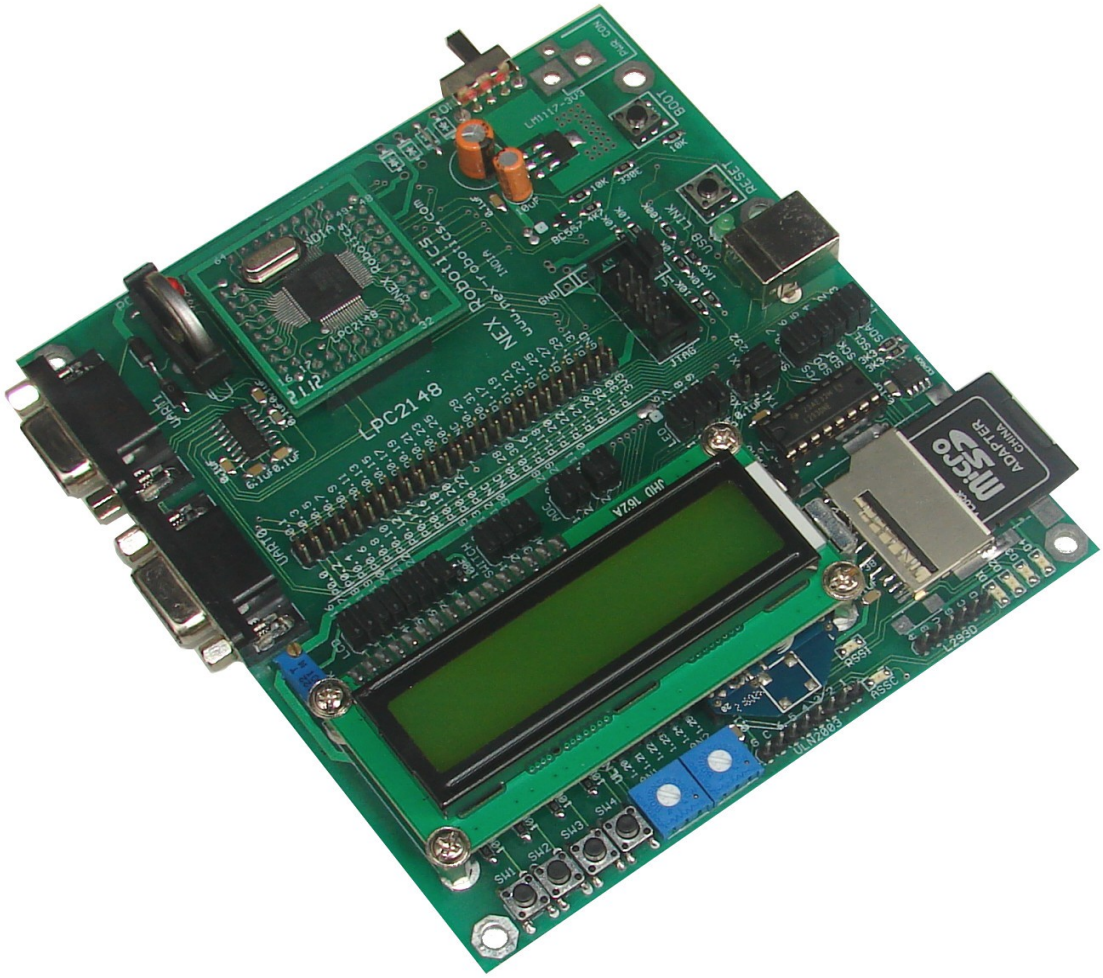
LPC2148 DEVELOPMENT BOARD



NOTICE

The contents of this manual are subject to change without notice. All efforts have been made to ensure the accuracy of contents in this manual. However, should any errors be detected, NEX Robotics welcomes your corrections. You can send us your queries / suggestions at
info@nex-robotics.com

- **Product's electronics is static sensitive. Use the product in static free Environment.**
- **Read the user manual completely before start using this product**

Recycling:
Almost all the part of this product is recyclable. Please send this product to the recycling plant after its operational life. By recycling we can contribute to cleaner and healthier environment for the future generations.

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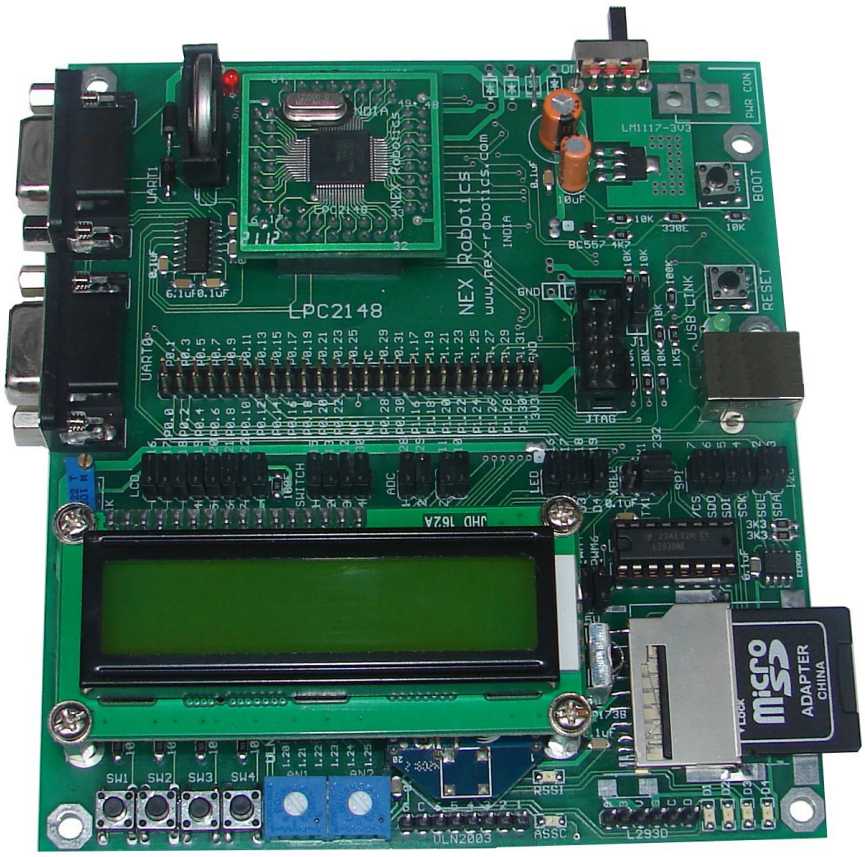
1.0 INTRODUCTION



1.1 Board Features

LPC2148 Pro Development Board is a powerful development platform based on LPC2148 ARM7TDMI microcontroller with 512K on-chip memory. This board is powered by USB port and does not need external power supply. It is ideal for developing embedded applications involving high speed wireless communication (Zigbee / Bluetooth / WiFi), USB based data logging, real time data monitoring and control, interactive control panels etc. The on-chip USB controller provides direct high speed interface to a PC/laptop with speeds up to 12Mb/s. The UART boot loader eliminates need of an additional programmer and allows you to program using serial port. The on board peripherals include SD/MMC card interface, USB2.0 interface, 4Kbit I2C EEPROM, Xbee wireless module interface, ULN2003 500mA current sinking driver, L293D DC motor controller, 16X2 character LCD and many more. The on-chip peripherals and the external hardware on the development board are interconnected using pin headers and jumpers. The I/O pins on the microcontroller can be accessed from a 50 pin male header. The board is made from double sided PTH PCB board to provide extra strength to the connector joints for increased reliability.

Note:

1. Xbee / Bluetooth/ WiFi wireless module and SD/MMC card are not included with the board and it can be bought separately from Nex Robotics website.

Specifications:

- Microcontroller: LPC2148 with 512K on chip memory
- Crystal for LPC2148: 12Mhz
- Crystal for RTC: 32.768KHz
- 50 pin Berg header for external interfacing
- Wireless module adapter for 2.4GHz ZigBee (Xbee) / Bluetooth / WiFi connectivity
- 512 bytes of I2C external EEPROM
- USB Type B Connector
- SD / MMC card holder
- 10pin(2X5) FRC JTAG connector for flashing and debugging
- 50 Pin Expansion header
- 2x16 Character Alphanumeric LCD
- L293D 600mA Dual DC motor Driver
- ULN2003 500mA driver
- Dual RS232 UARTs for external communication
- Real-Time Clock with Battery Holder
- 2 Analog Potentiometers connected to ADC
- TSOP1738 IR receiver
- 4 USER Switches
- 4 USER LEDs
- Reset and Boot loader switches
- 3V button cell for on chip RTC
- ON/OFF switch
- Buzzer
- Schematics and Application examples in KEIL provided in the documentation CD

Kit Contains:

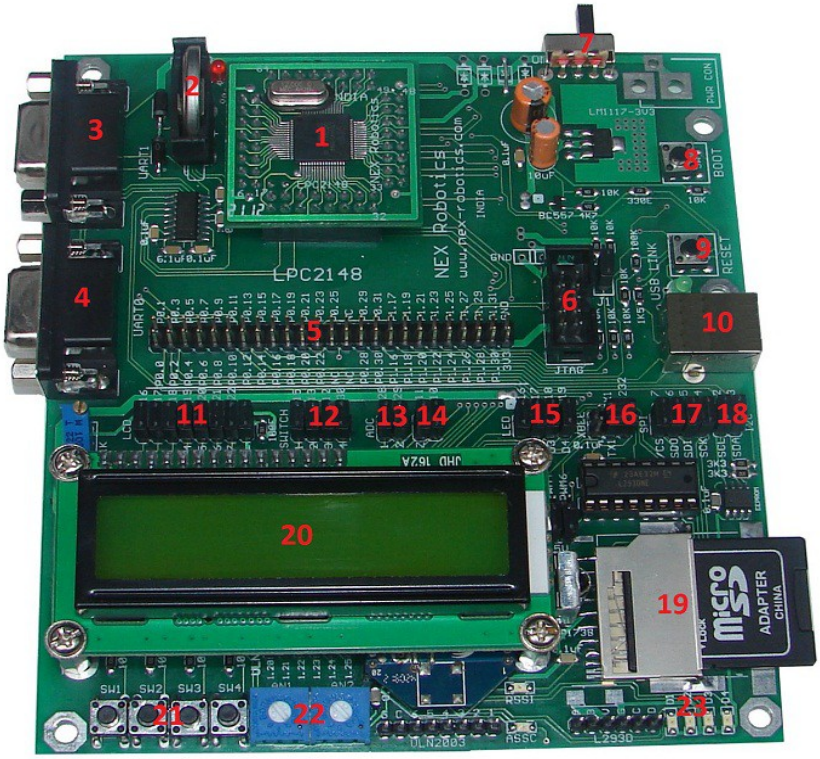
1-LPC2148 Pro Development Board
1-USB Cable
1-DB9 Serial Cable
A set of 10 1-1 cables
Documentation CD contains:
I. Schematic
II. Programming Software
III. Example Codes

LPC2148 Features:

- 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 40 kB of on-chip static RAM and 512 kB of on-chip flash memory.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software.
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high-speed tracing of instruction execution.
- USB 2.0 Full-speed compliant device controller with 2 kB of endpoint RAM.
- Two 10-bit ADCs provide a total of 14 analog inputs
- Single 10-bit DAC provides variable analog output
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.

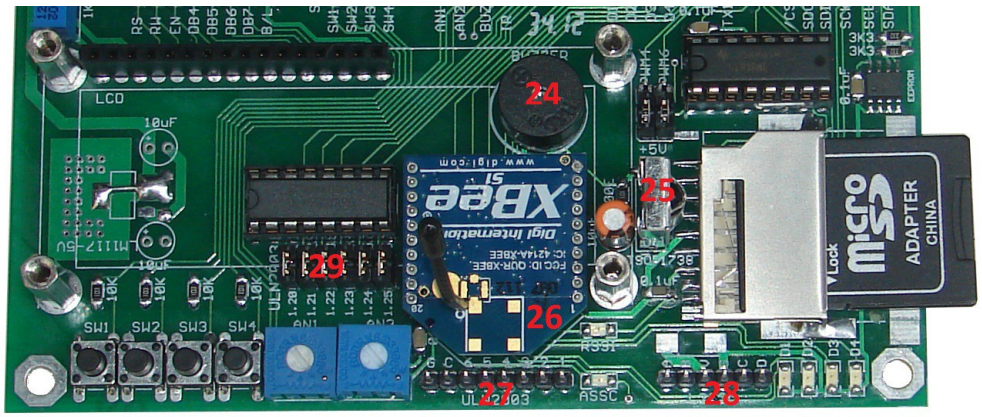
- Multiple serial interfaces including two UARTs, two Fast I²C-bus (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
- Vectored Interrupt Controller (VIC) with configurable priorities and vector addresses.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 us.
- On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz
- Power saving modes include Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt or BOD.
- Single power supply chip with POR and BOD circuit
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V +- 10 pct) with 5 V tolerant I/O pads.

1.2 LPC2148 Pro Development Board Overview



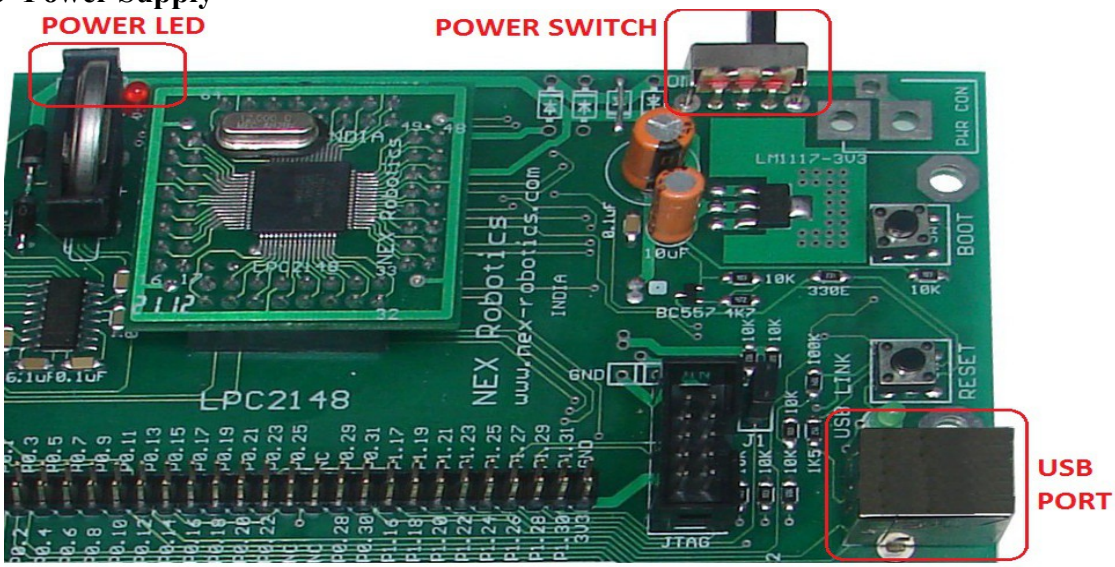
1. LPC2148 Plug-in module
2. 3V cell holder for RTC
3. UART1 DB9 connector
4. UART0 DB9 connector
5. 50-pin expansion header
6. 2X5 JTAG header
7. ON/OFF slide switch
8. Boot loader switch
9. Microcontroller reset switch
10. USB connector B-type
11. Jumpers for LCD interface
12. Jumpers for Switches
13. Jumpers for Trim pots
14. Jumpers for Buzzer and IR Receiver
15. Jumpers for LEDs
16. Jumpers for selection between UART1 and Xbee
17. Jumpers for SPI – SD/MMC interface

18. Jumpers for I2C EEPROM
19. SD/MMC card socket
20. 16X2 character LCD
21. Four user switches
22. Two trim pots connected to ADC
23. Four user LEDs



24. Buzzer
25. TSOP1738 IR Receiver
26. Xbee module interface
27. ULN2003 driver side header
28. L293D o/p header
29. Jumpers for ULN2003

1.3 Power Supply



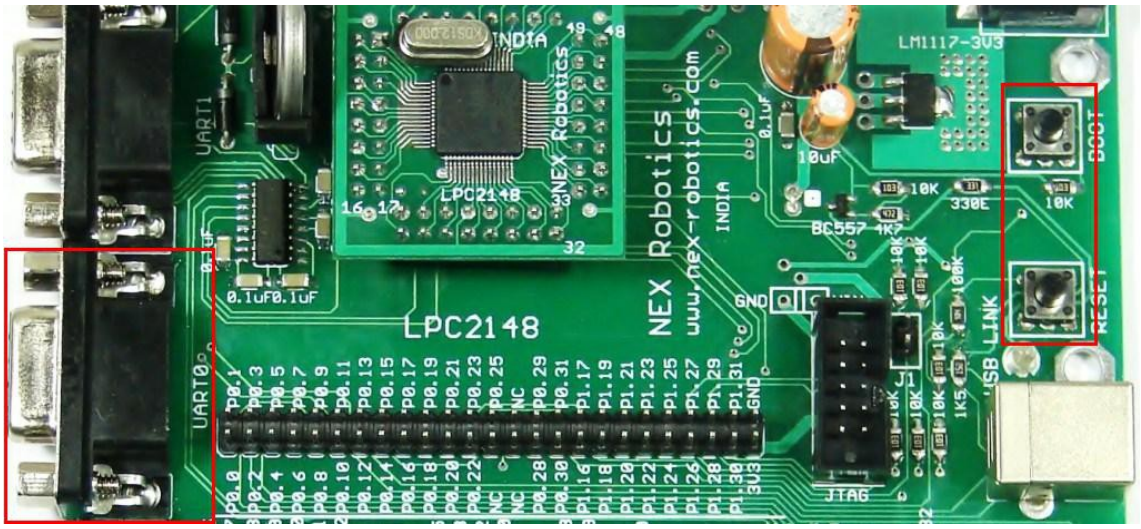
The USB powered version of LPC2148 development board is powered using USB port.

Slide the power switch to ON position to turn the board ON. The red LED will glow indicating that the board is powered.

Warning: Please make sure that the USB port on your PC or any other device is capable to source at least 400mA current.

1.4 In System Programming via UART0

LPC2148 microcontroller incorporates a capability to self program itself using the on-chip UART boot loader. This eliminates the need of an external programming hardware. The boot loader code is dedicated to use UART0 on the microcontroller. Once the code is loaded on the microcontroller UART0 is free to be used in the application. The host, in this case PC or Laptop, requires software to transmit the hex file to the microcontroller over the serial link.
For demonstration purpose we will use Flash Magic programming utility. The installation procedure is explained in section 2.2.1.



To enter in to the boot load mode follow the steps mentioned below:

1. Connect a DB9 cable between the selected **COM** port on your PC and the **UART0** port on LPC2148 development board.
2. Plug in an **USB** cable to the development board and slide power switch to **ON** position.
3. The board enters bootloader mode when **BOOT** switch is held down at the time of **RESET**. To enter the bootloader mode, keep the **BOOT** switch pressed and then press and release **RESET** switch. You can release the **BOOT** switch after reset.

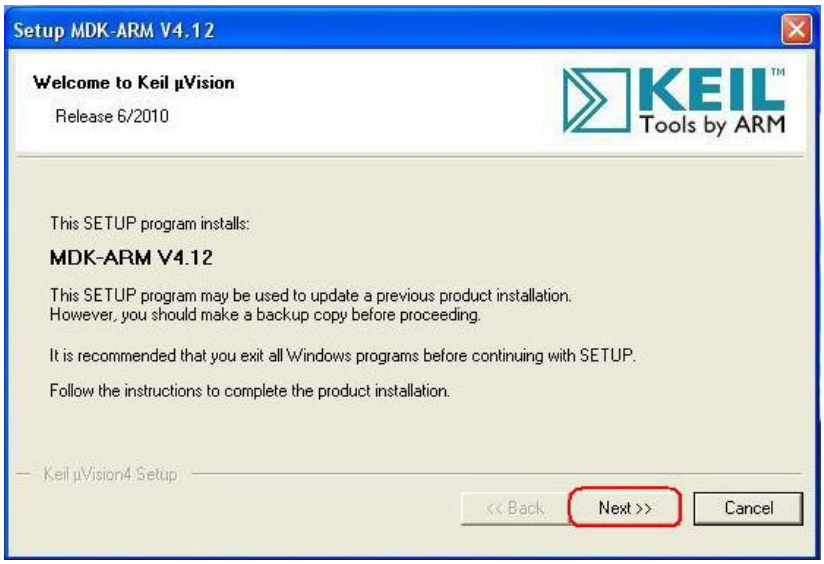
2.0 KEIL µVISION4 IDE

The LPC2148 microcontroller is supported by various commercially available IDEs for compiling and debugging of the code. Keil being one of them is the widely used IDE for LPC family of microcontrollers. The µVision4 IDE is Windows-based software development platforms that combines a robust editor, project manager, and make facility. µVision4 integrates all tools including the C compiler, macro assembler, linker/locator, and HEX file generator. The evaluation version of Keil µVision4 IDE is used for demonstrating the sample codes that are included in the CD.
The open source community has been doing a lot in the development of open source tools for ARM architecture based microcontrollers. The open source tools are available at zero cost and are being improved with time. Eclipse being one of them and is most commonly used IDE due to its unique features like auto complete, project tree, etc. It requires GCC tool chain for code compilation.

2.1 Installing Keil µVision4 IDE

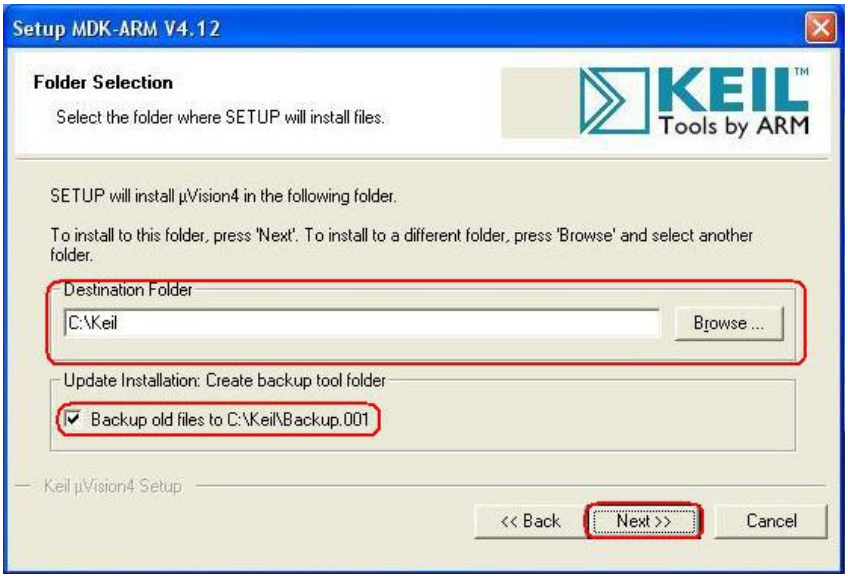
To install **Keil µVision4 IDE**, Go to "Software" folder in the documentation CD and locate "**mdk412.exe"** file. Click on "**mdk412.exe**" to start the installation process. Once the installation process is started Keil µVision welcome screen will appear.

Please read the instructions on the welcome window and click **Next>>** to start the installation.

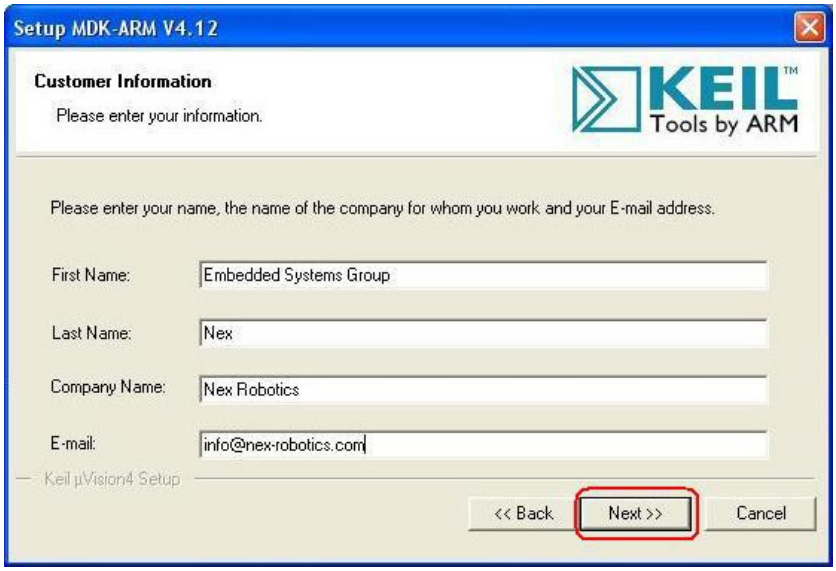


Please read the license agreement carefully. If it is acceptable click the check box and click **Next>>** to continue.

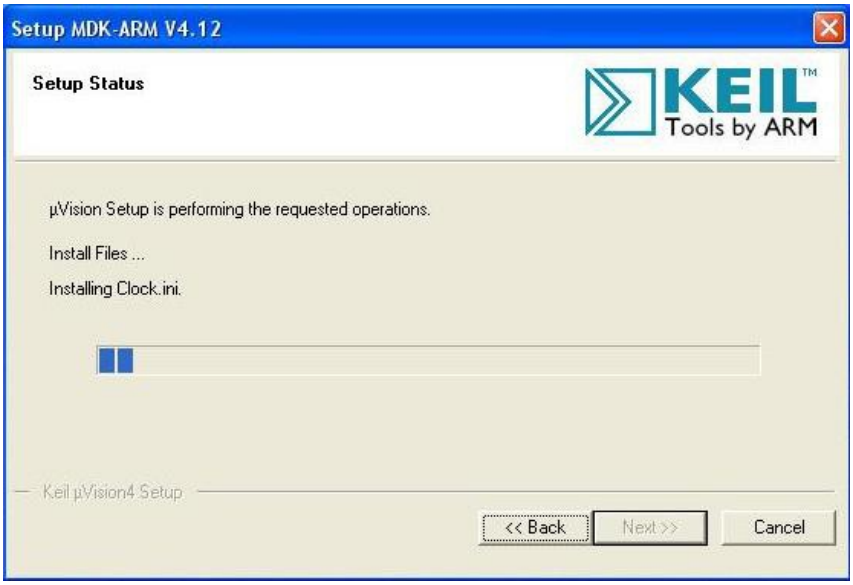
Select the destination folder where setup will install files. It is always recommended to select the default location. To create backup of old installation select the backup option and click **Next>>** to continue.



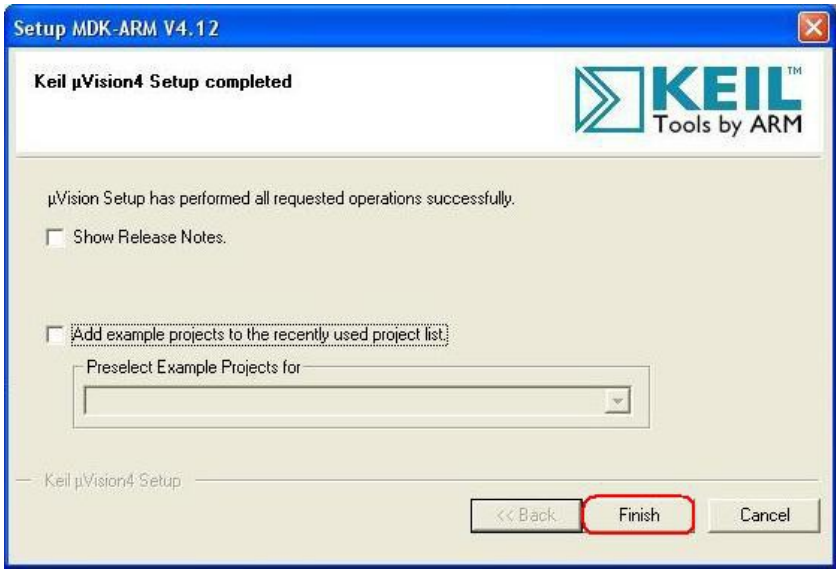
In the next window enter your information and click **Next>>** to continue.



On clicking next the file copying process will begin. Wait till setup is complete.



Click **Finish** to complete installation process.



2.2 Using Flash Magic Tool

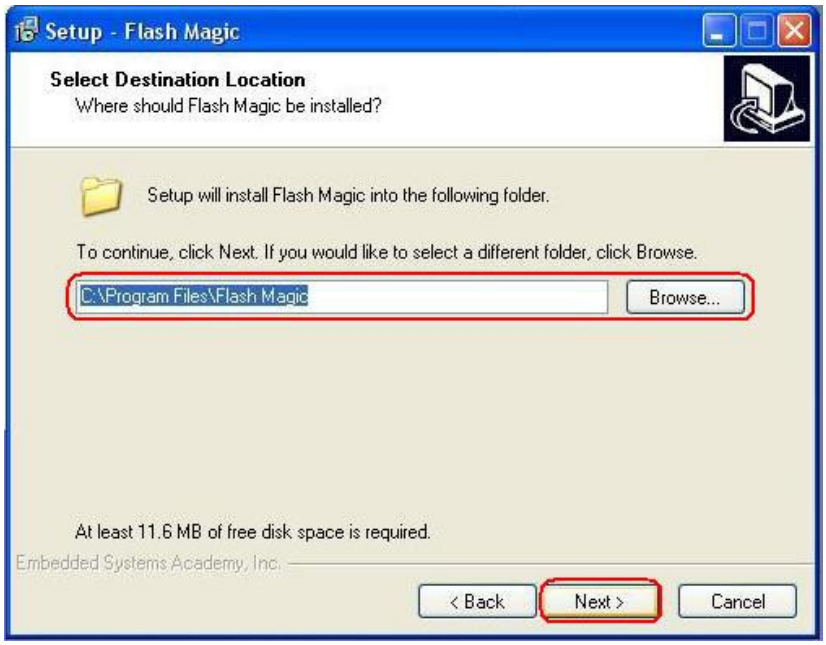
The LPC series of microcontrollers are preloaded with the boot loader firmware which allows self programming of microcontrollers using serial port. Flash magic is a utility which provides an interface for reading, writing and verifying the flash memory of the microcontroller.

2.2.1 Installing Flash Magic Tool

To install **Flash Magic**, Go to "Software" folder in the documentation CD and locate "**FlashMagic.exe"** file. Click on "**FlashMagic.exe**" to start the installation process. Once the installation process is started Flash Magic welcome screen will appear.

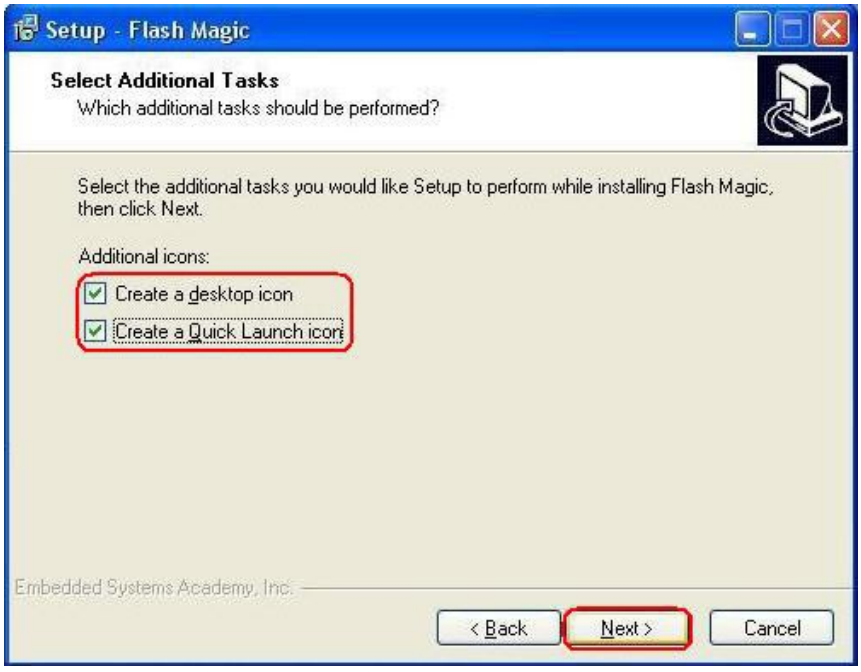
Please read the license agreement carefully. If it is acceptable click the radio button and click **Next>>** to continue.

Select the destination folder and click **Next>** to continue.



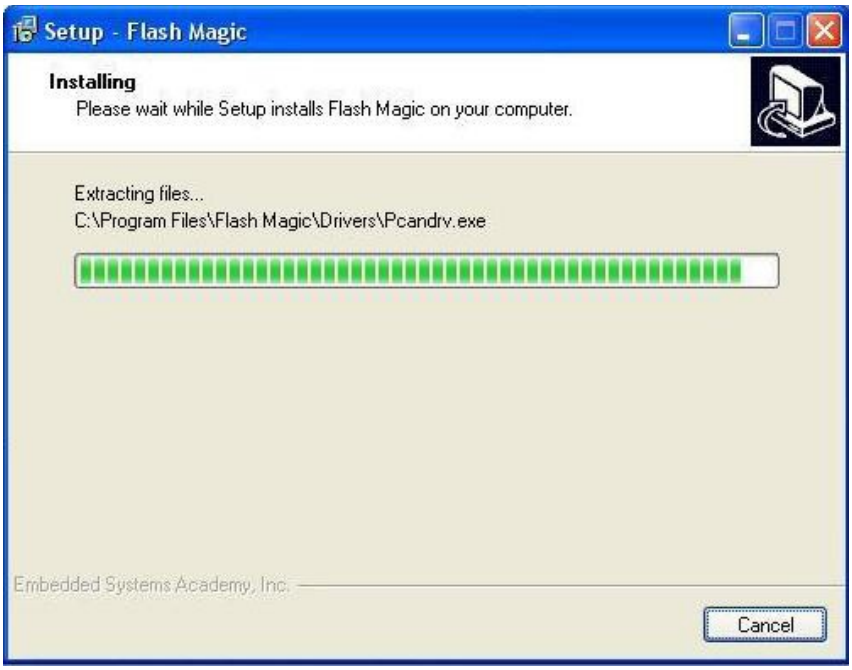
In the next window choose the appropriate folder and click **Next>** to continue.

Select the desired option and click **Next>** to continue.



Setup is now ready to begin installing flash magic. Click **Install** to continue.

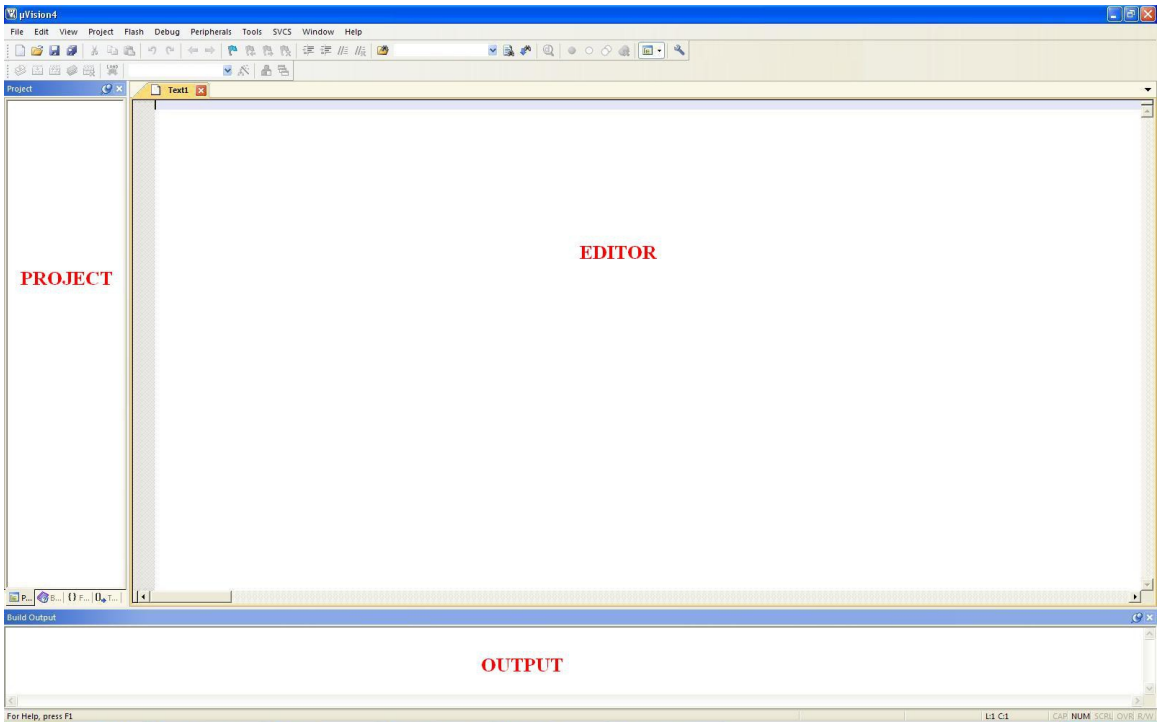
Wait till setup installs Flash Magic on your computer.



Click Finish to complete the installation process

2.3 Overview of Keil µVision4 IDE

To start Keil IDE click Start>Programs>Keil µVision4. The initial screen will appear followed by the main window.

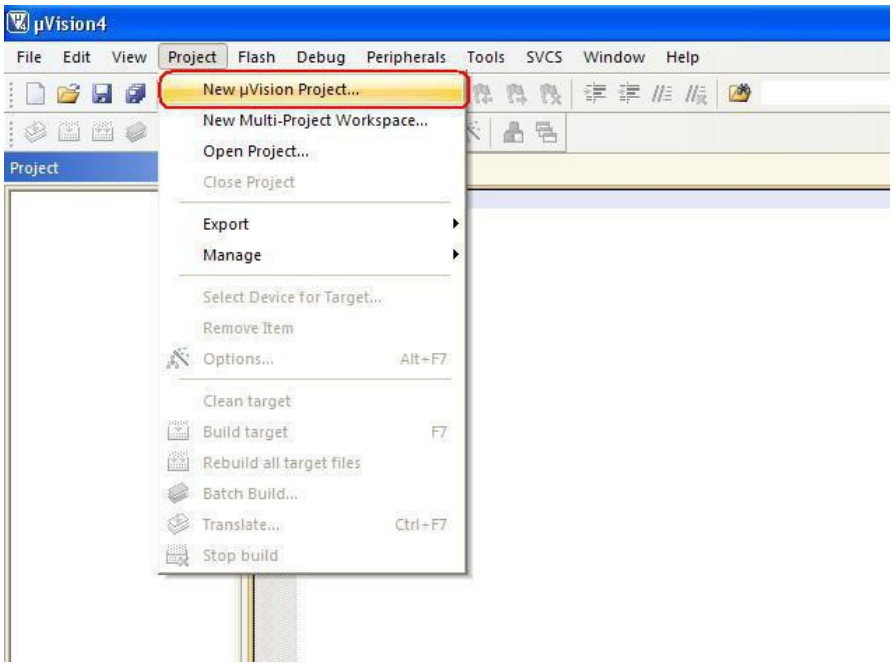


The Keil IDE main window in basic configuration is mainly divided into three areas.

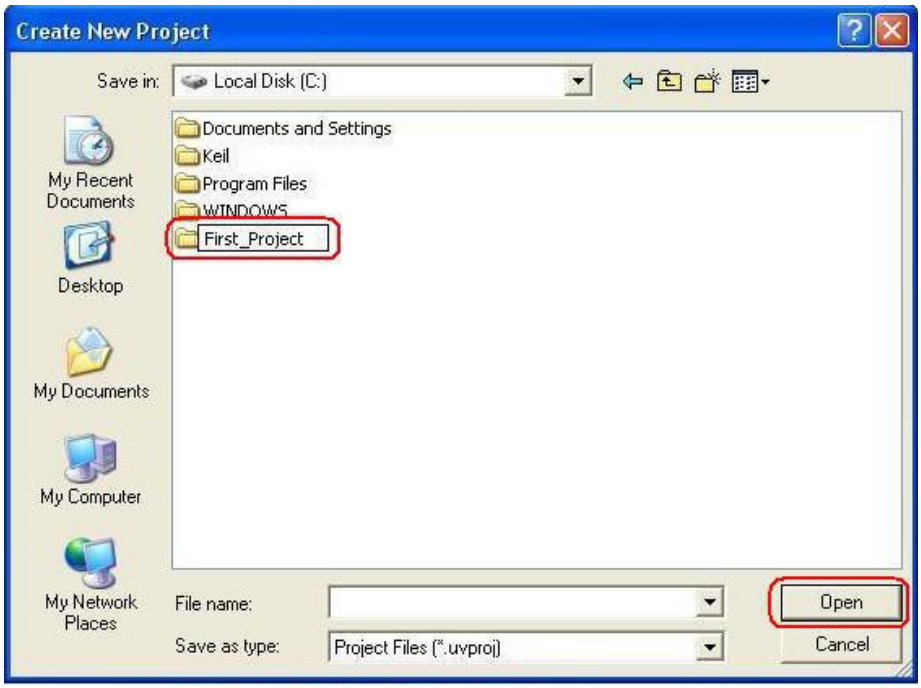
Editor - It is the area where .c and .h files of the project are edited.
Project Explorer- It shows the project tree.
Output Window- This window shows the messages related to compiling, project building and debugging.

2.3.1 Create a Project in Keil for LPC2148 development board

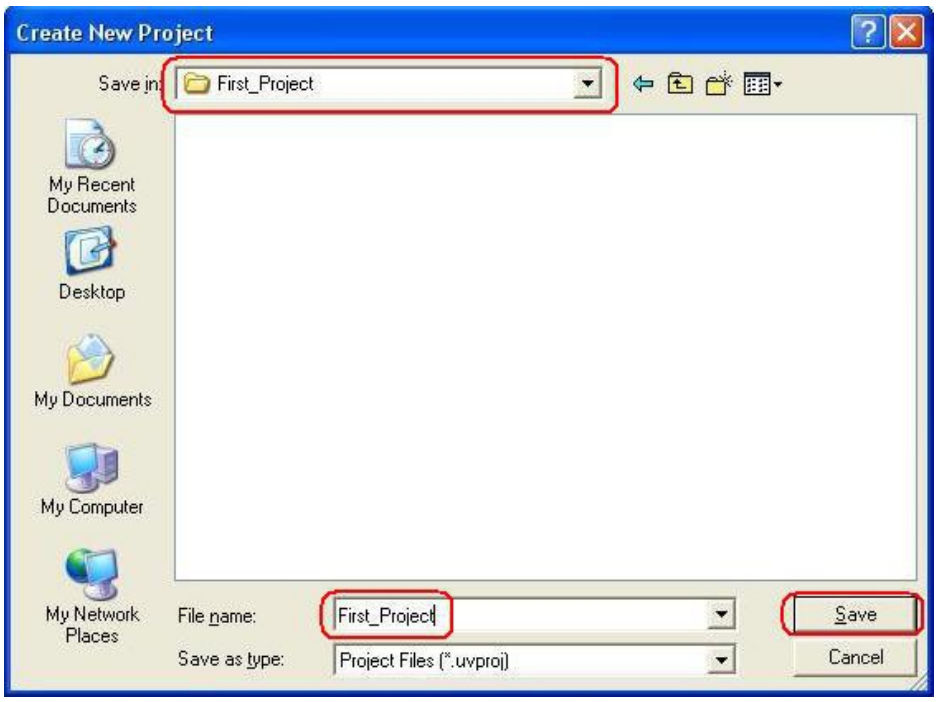
1. To create a new project, Select **Project>New uVision Project** from the main menu.



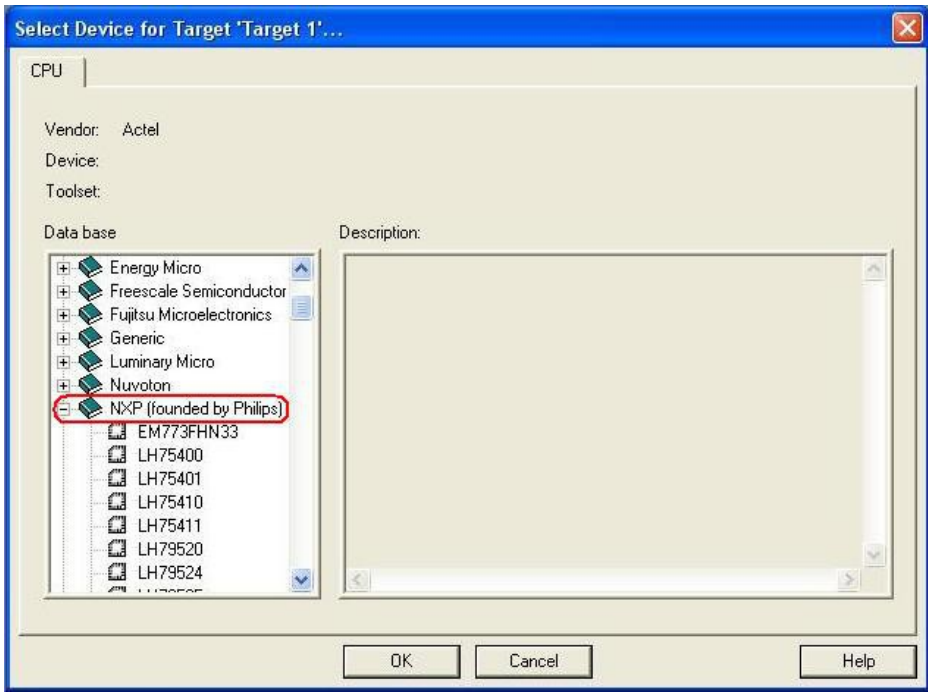
2. Create a new directory and name it as **First_Project**. Click open to enter in to this directory.



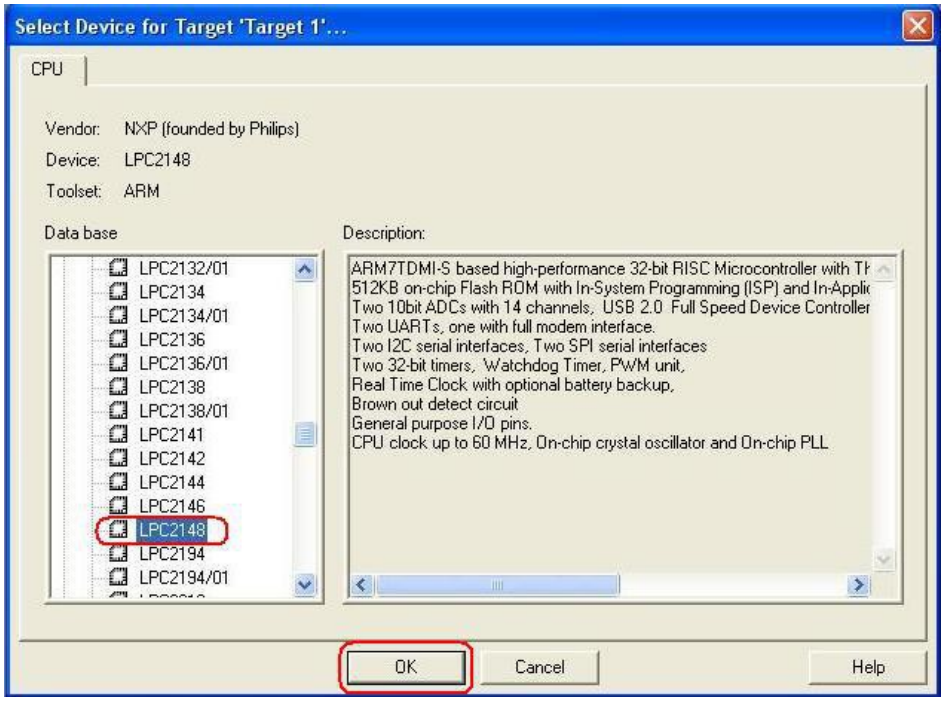
3. Inside this directory create a new project and name it as **First_Project** and click **Save** to continue.



4. In the next window locate **NXP (founded by Philips)** tree and expand it.

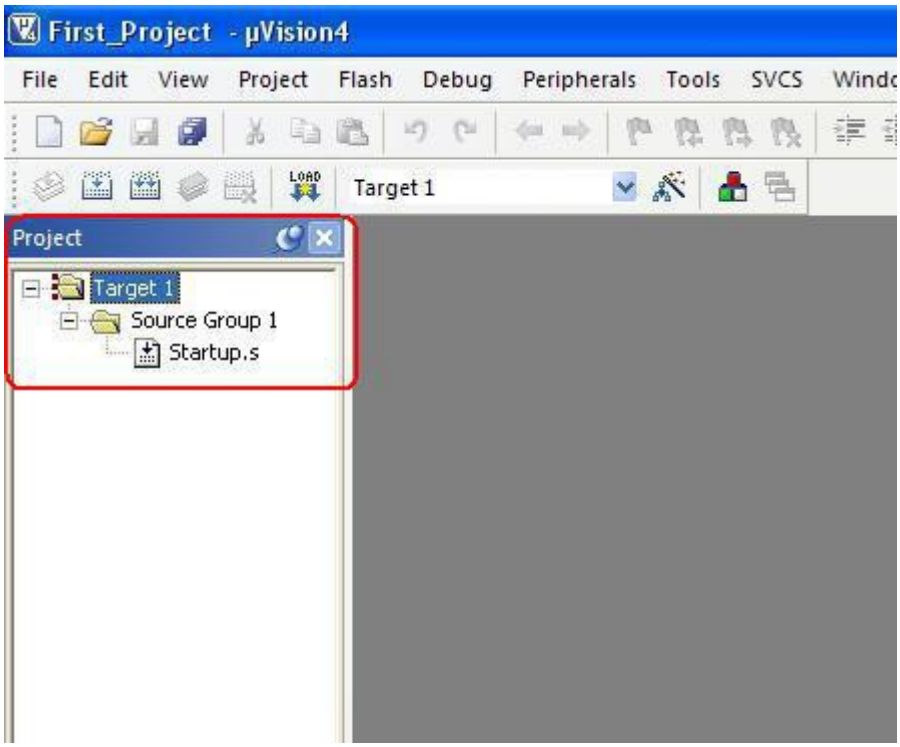


5. Now select target device as **LPC2148** and click **OK** to continue.

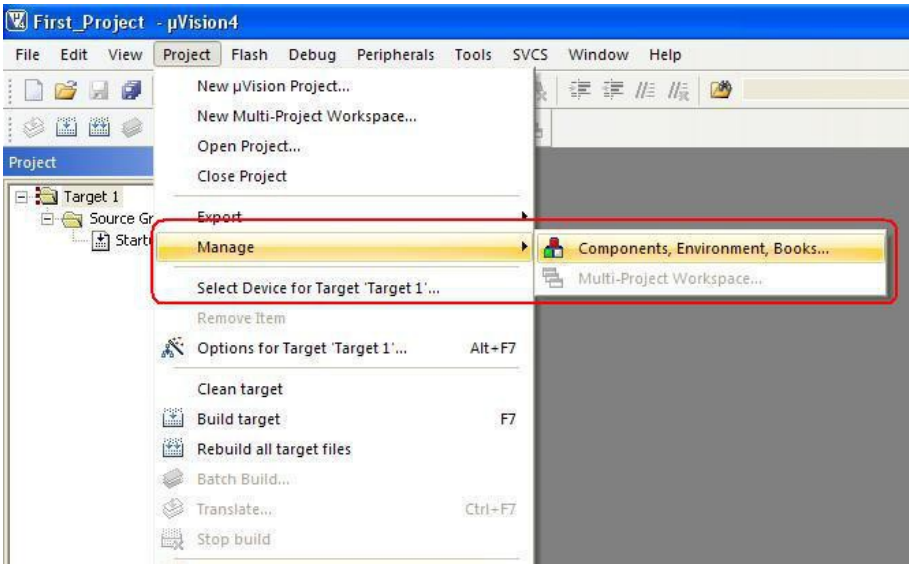


6. Click **Yes** to copy **Startup.s** file to project folder. This file configures stack, PLL and maps memory as per the configurations in the wizard. It is discussed in the later sections.

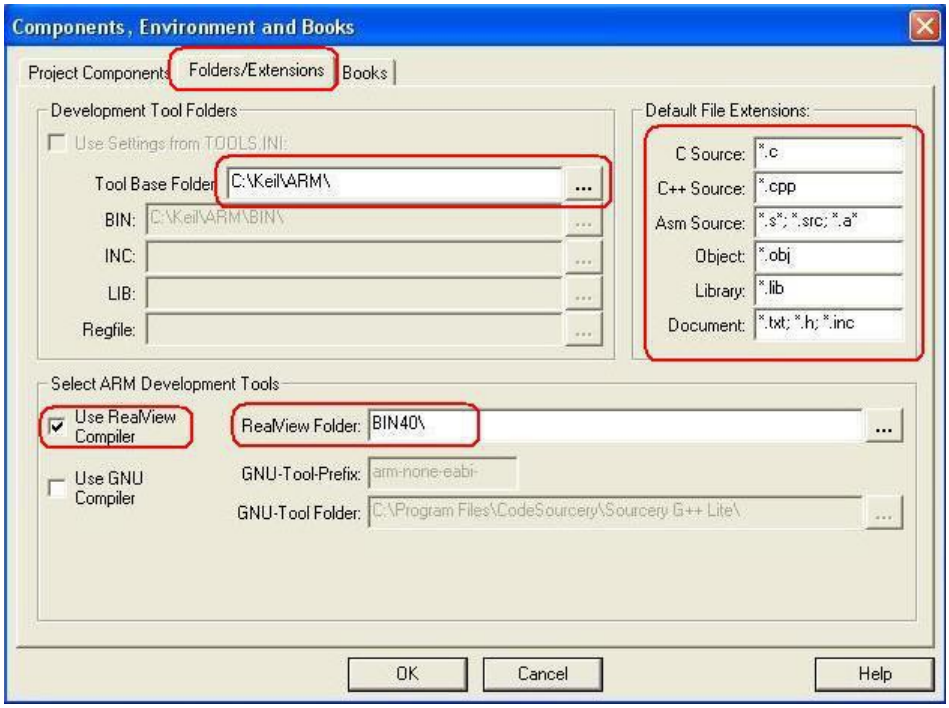
7. Observe the project explorer area in the main window.



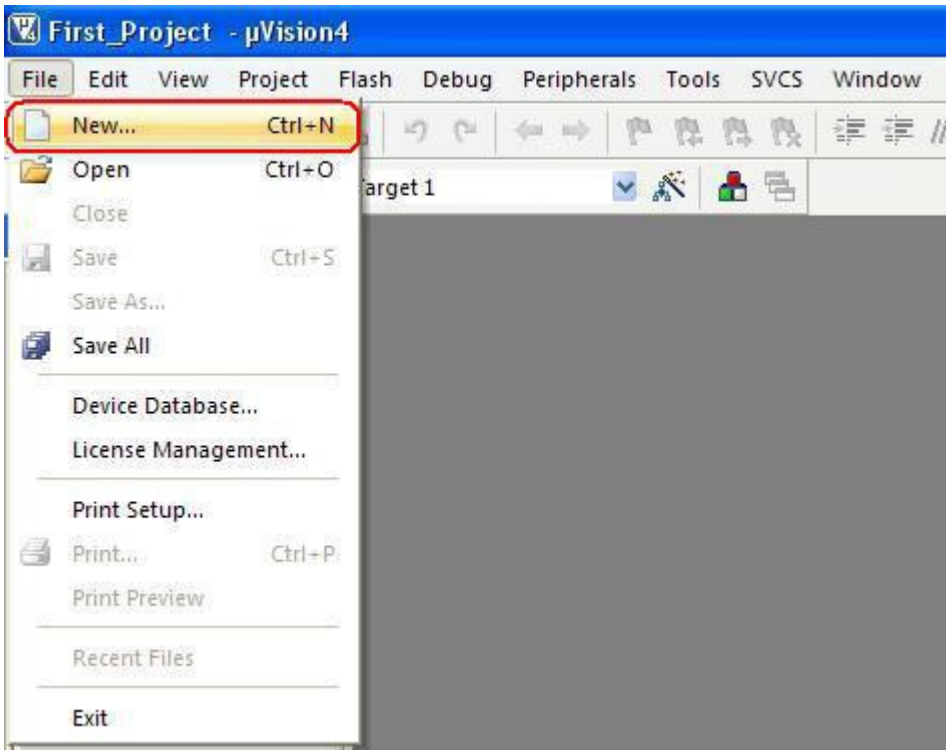
8. Now click **Project>Manage>Components, Environments, Books** from the main menu to ensure compiler settings.



9. In the **Folders/Extensions** tab ensure the compiler settings are as shown in the fig. below. If you have installed keil software at a different location then change **Tool Base Folder** location. Click **OK** to continue.



10. Now click **File>New** to create a new file.



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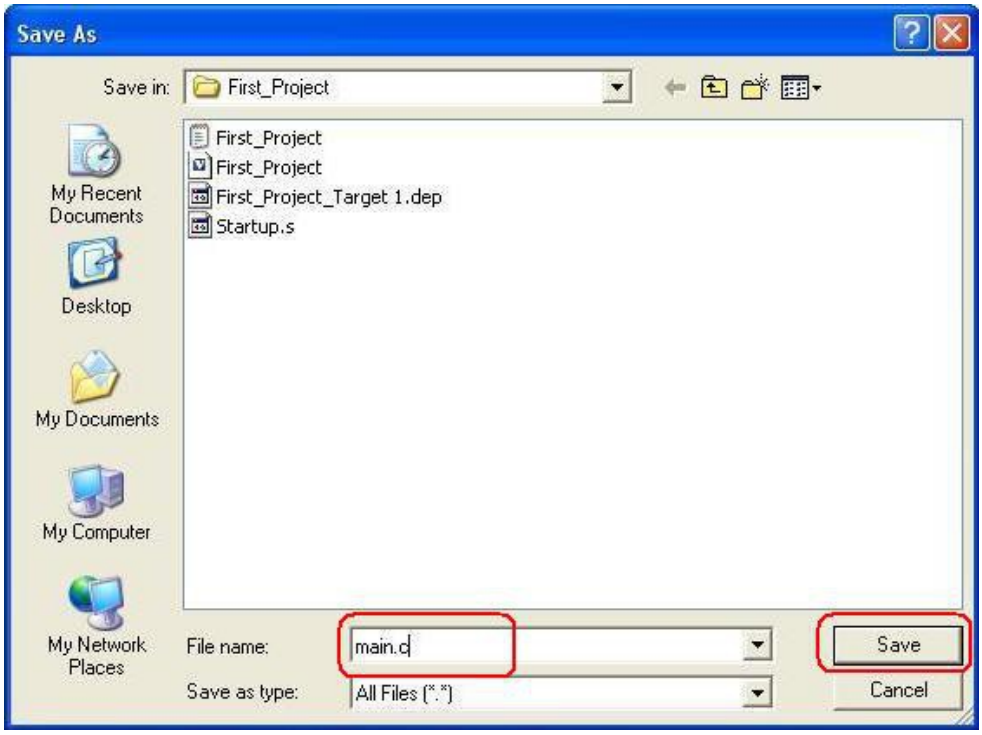
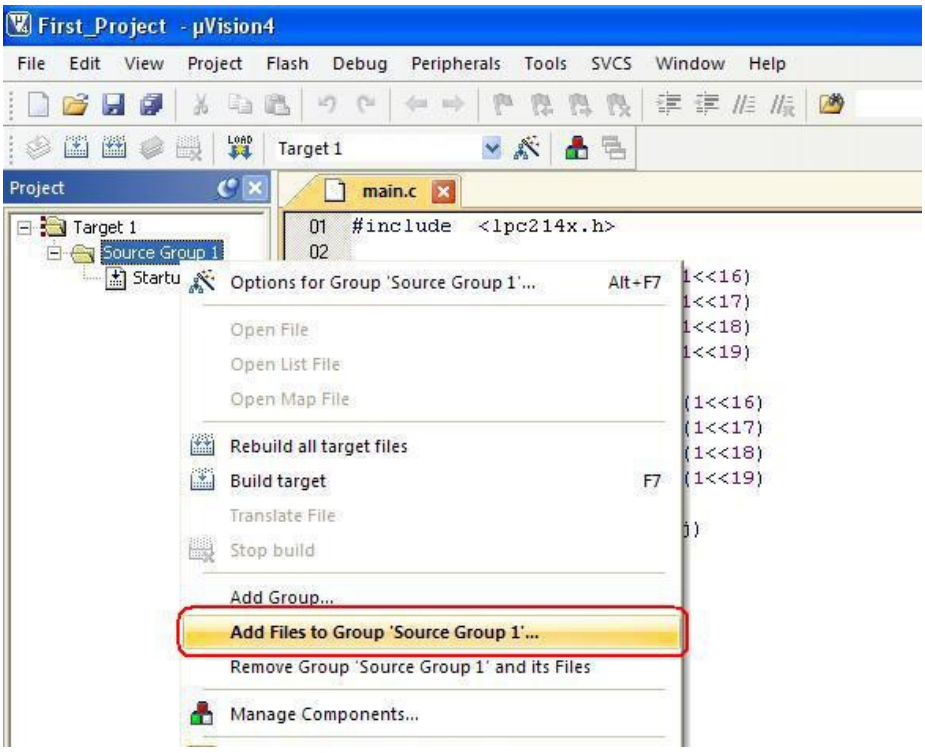
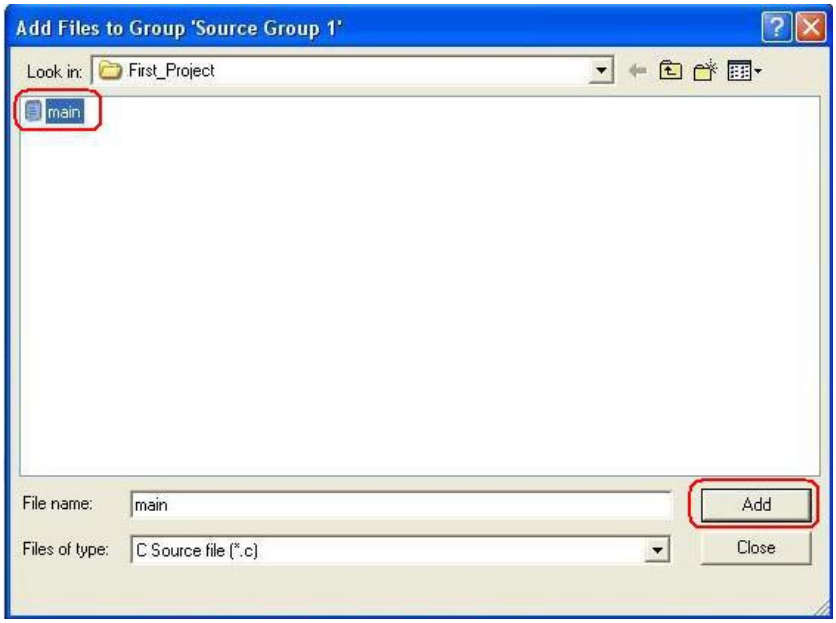
11. Save the new file in to the same folder that was created earlier and name it as **main.c** and click **Save** to continue.



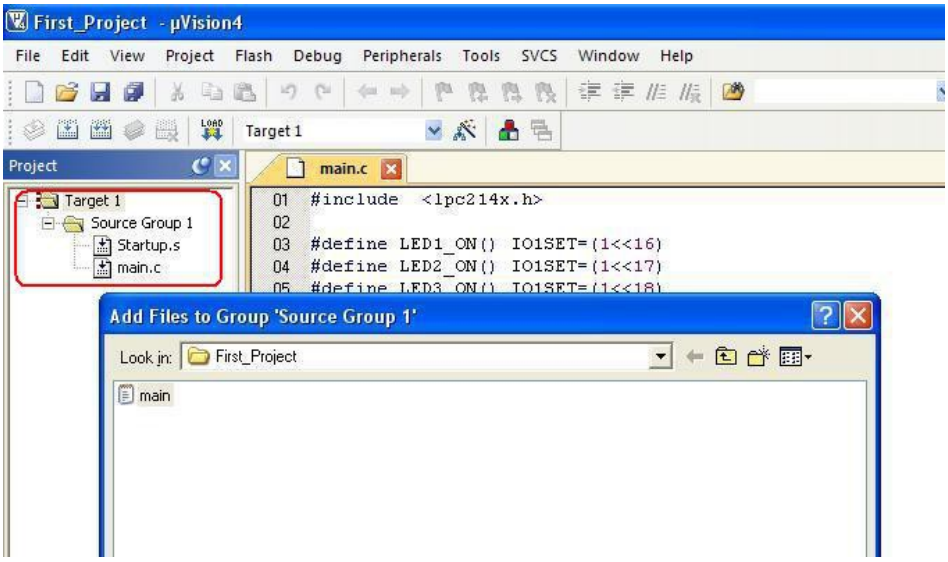
12. Now add "**main.c**" to the source group by right clicking on the **Source Group 1** from the project explorer and select the highlighted option as shown in the fig. below.



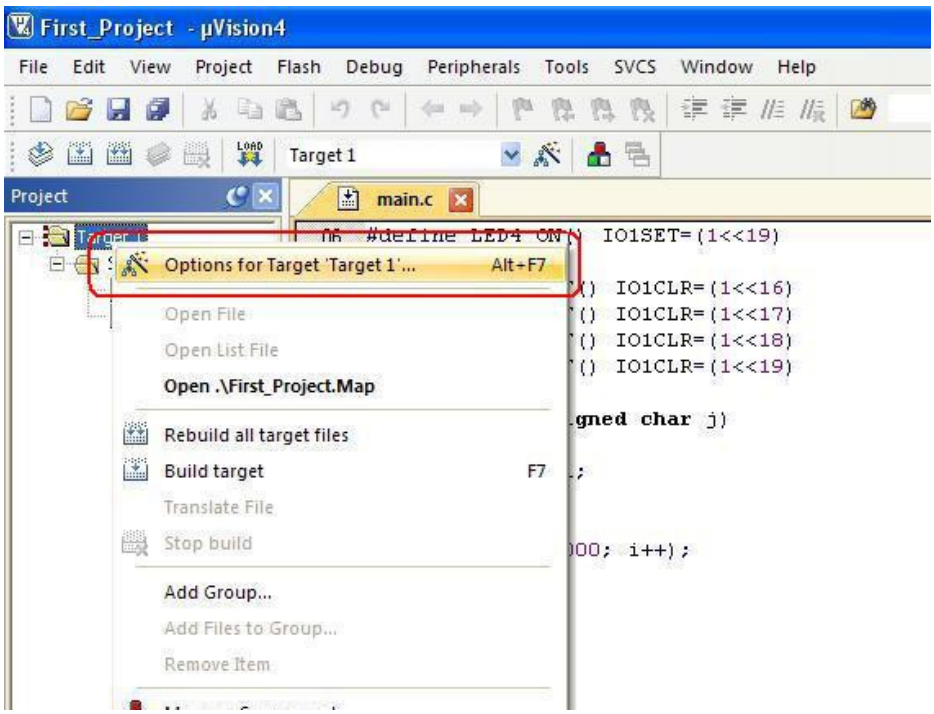
13. Select "**main.c**" file to be added and click **ADD** to continue.



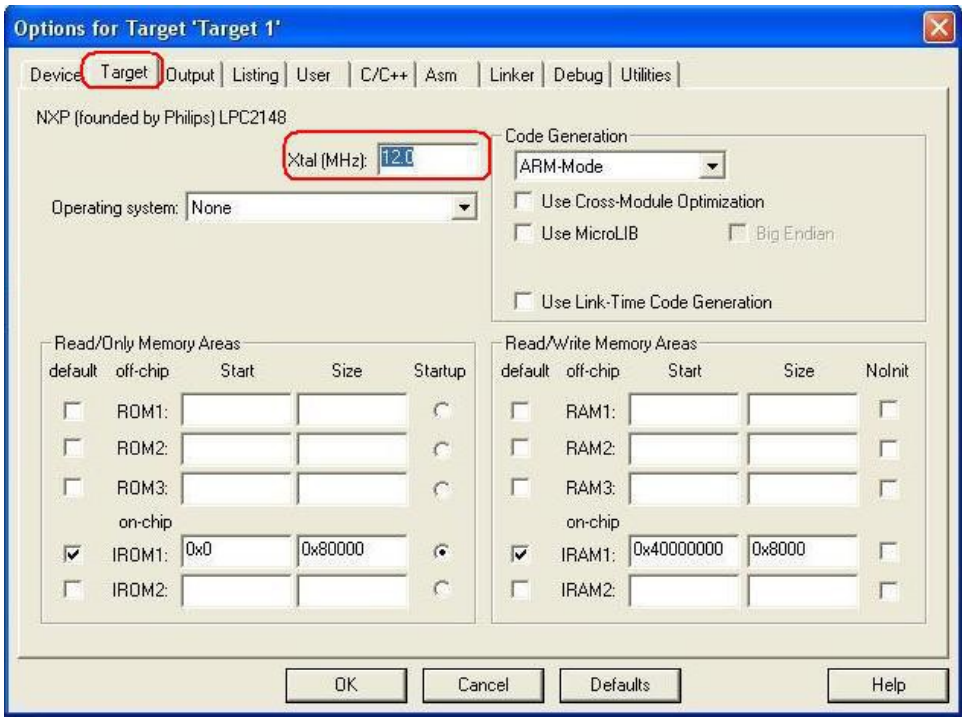
14. Observe that **"main.c"** file is added to the source group in the project explorer window.



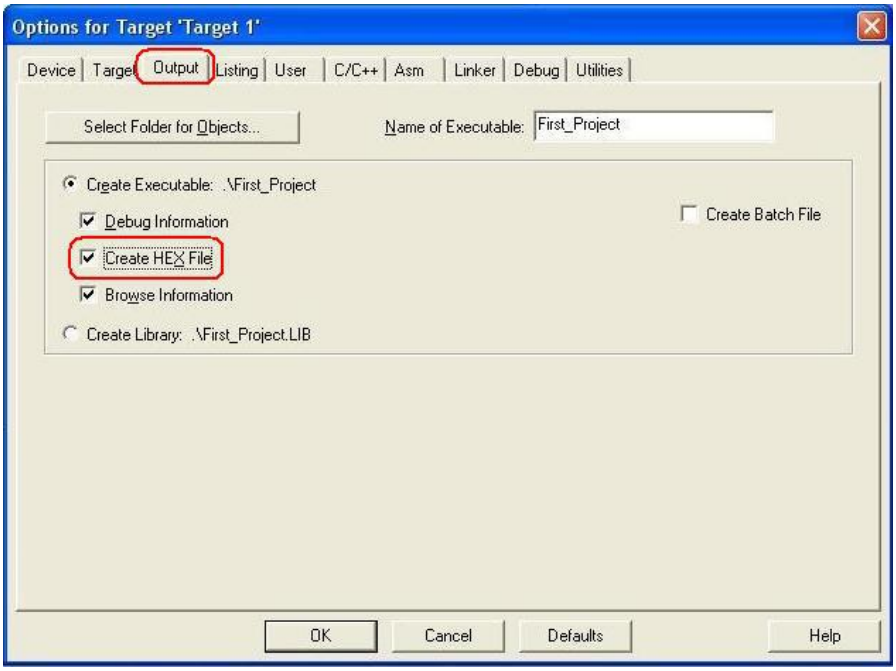
15. Right click **Target1** in the project explorer window and select the highlighted option as shown in the fig. below.



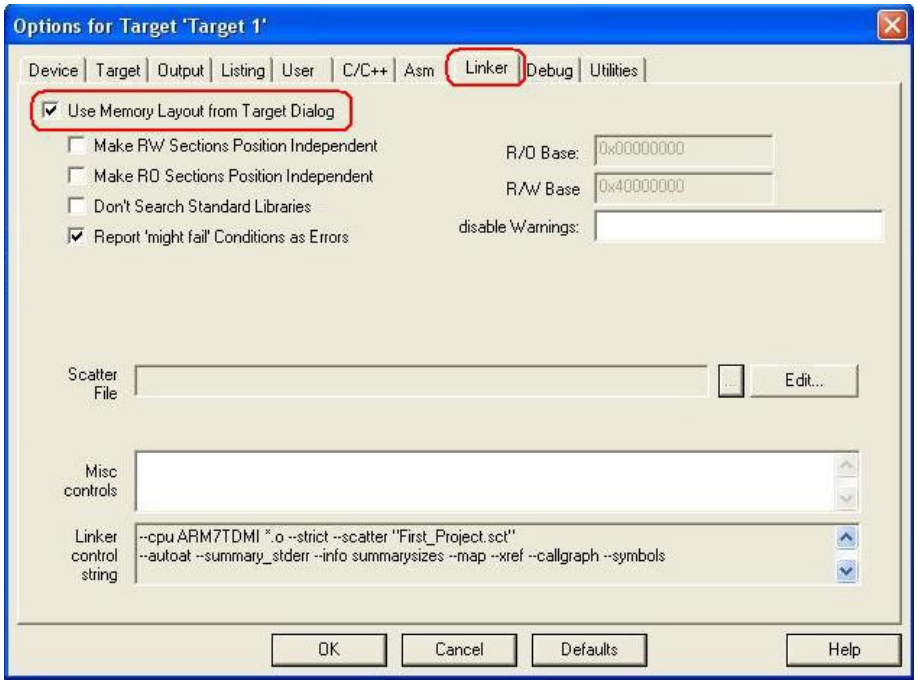
16. In the appearing window select **Target** tab and set Xtal. frequency as 12MHz.



17. In the **Output** tab ensure that **Create HEX File** option is selected.



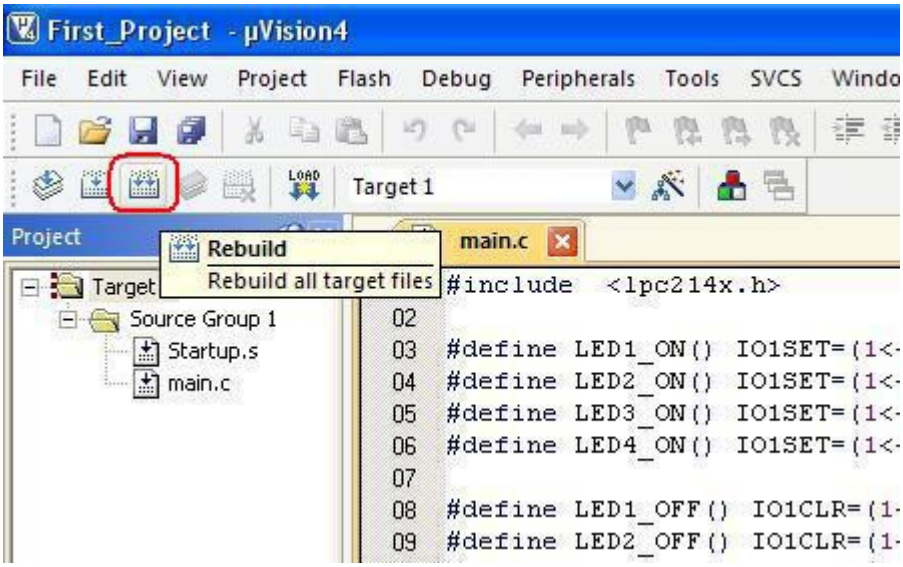
18. In the **Linker** tab ensure that the highlighted option is selected and click **OK** to continue.



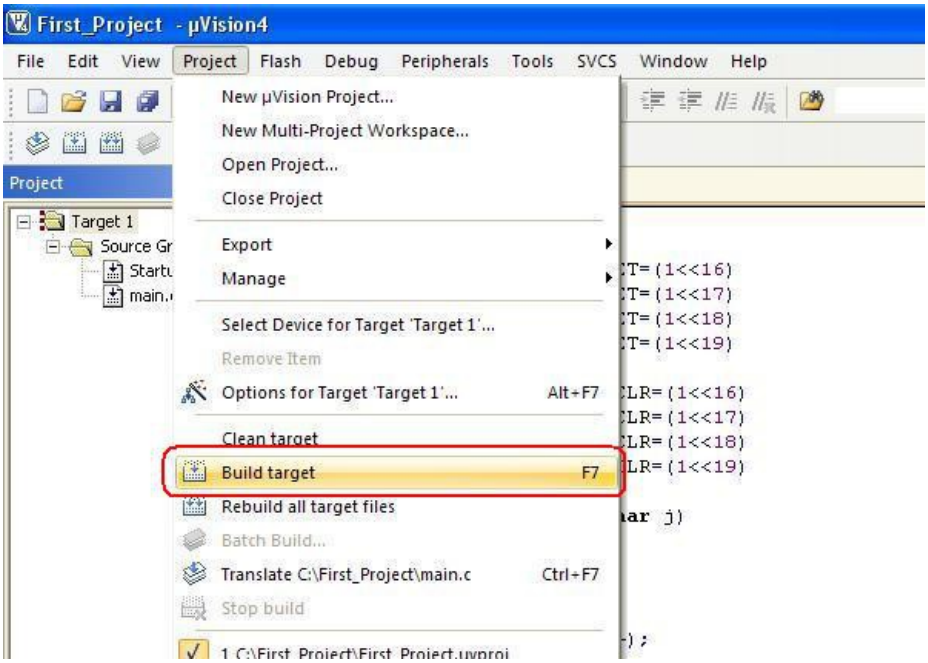
19. Now since the project is almost setup we can start writing code in the "**main.c**" file that was created earlier. For demonstration purpose you can copy the following code and paste it in the "**main.c**" file. This code is written to blink LEDs on LPC2148 development board in the sequential order starting from LED1. Refer jumper settings for LEDs from the hardware description section 3.2.

```
#include <lpc214x.h>

#define LED1_ON() IO1SET=(1<<16)
#define LED2_ON() IO1SET=(1<<17)
#define LED3_ON() IO1SET=(1<<18)
#define LED4_ON() IO1SET=(1<<19)

#define LED1_OFF() IO1CLR=(1<<16)
#define LED2_OFF() IO1CLR=(1<<17)
#define LED3_OFF() IO1CLR=(1<<18)
#define LED4_OFF() IO1CLR=(1<<19)

void Delay(unsigned char j)
{
 unsigned int i;
 for(;j>0;j--)
 {
  for(i=0; i<60000; i++);
 }
}


int main(void)
{
 PINSEL0 = 0x00000000;         // Enable GPIO on all pins
 PINSEL1 = 0x00000000;
 IO1DIR = (1<<19) | (1<<18) | (1<<17) | (1<<16); // Set P1.16, P1.17,
P1.18, P1.19 as Output


 while(1)
 {
  LED1_ON();
  Delay(25);
  LED1_OFF();
  LED2_ON();
  Delay(25);
  LED2_OFF();
  LED3_ON();
  Delay(25);
  LED3_OFF();
  LED4_ON();
  Delay(25);
  LED4_OFF();
 }
 return(0);
}
```

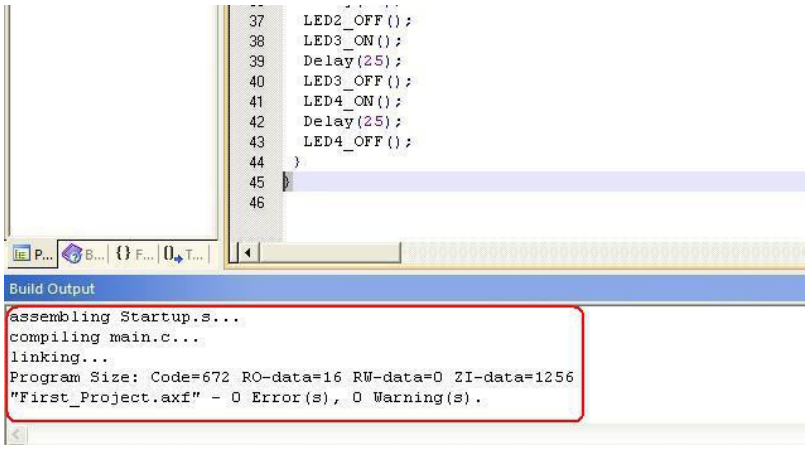
20. Now build the project by clicking on **Rebuild** button on the main toolbar.



21. You can alternatively build project by clicking on **Project>Build Target** from the main menu.



22. You can observe the build process in the output window. If any errors, rectify it by double clicking on it and you will be pointed to the erroneous line.



2.3.2 CODE WALKTHROUGH

```
#include <lpc214x.h>
```

The first line of code includes the header file for LPC2148 microcontroller. These file contains the definitions of special function registers related to this device. This file can be found in Keil uVision 4 install directory.

```
#define LED1_ON() IO1SET=(1<<16)
#define LED2_ON() IO1SET=(1<<17)
#define LED3_ON() IO1SET=(1<<18)
#define LED4_ON() IO1SET=(1<<19)
```

The above 4 lines define the macro functions for turning ON LEDs.

For e.g. when `LED1_ON(); is called,` it will execute `IO1SET=(1<<16).`
This will set 16 th bit on PORT1

```
#define LED1_OFF() IO1CLR=(1<<16)
#define LED2_OFF() IO1CLR=(1<<17)
#define LED3_OFF() IO1CLR=(1<<18)
#define LED4_OFF() IO1CLR=(1<<19)
```

The above 4 macro functions are used to turn OFF respective LED. Please refer LPC2148 user manual for more information on GPIO.

```
void Delay(unsigned char j)
{
 unsigned int i;
 for(;j>0;j--)
 {
  for(i=0; i<60000; i++);
 }
}
```

The `Delay(unsigned char j)` function is used to provide some finite delay between Led ON and OFF events.

```
int main(void)
{
 PINSEL0 = 0x00000000;         // Enable GPIO on all pins
 PINSEL1 = 0x00000000;
 IO1DIR = (1<<19) | (1<<18) | (1<<17) | (1<<16); // Set P1.16, P1.17,
P1.18, P1.19 as Output


 while(1)
 {
  LED1_ON();
  Delay(25);
  LED1_OFF();
  LED2_ON();
  Delay(25);
  LED2_OFF();
  LED3_ON();
  Delay(25);
  LED3_OFF();
  LED4_ON();
  Delay(25);
  LED4_OFF();
 }
 return(0);
}
```

It is the main function of the code. The first and second line will initialize GPIO function on all PORT0 pins.

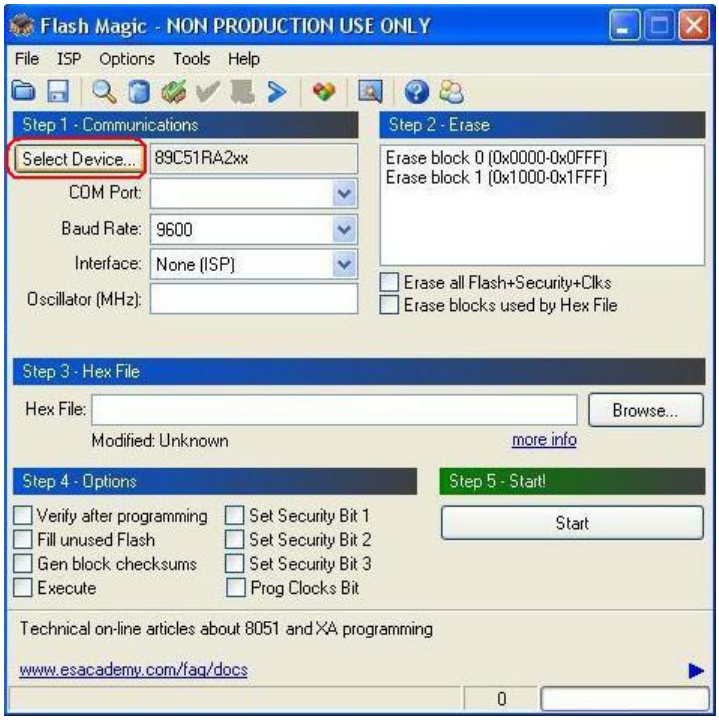
`IO1DIR = (1<<19) | (1<<18) | (1<<17) | (1<<16);`
The above statement will make port1 pins P1.16, P1.17, P1.18, P1.19 as output.

`while(1)` statement will continuously execute the code inside its loop.
The first line `LED1_ON();` will turn on LED1 and it will remain ON till delay function is executed. The third line will turn OFF LED1 and turn ON LED2 and it will remain ON till delay function is executed. Similarly as the code progresses the LEDs will turn ON & OFF and it will appear as if LEDs are chasing each other.

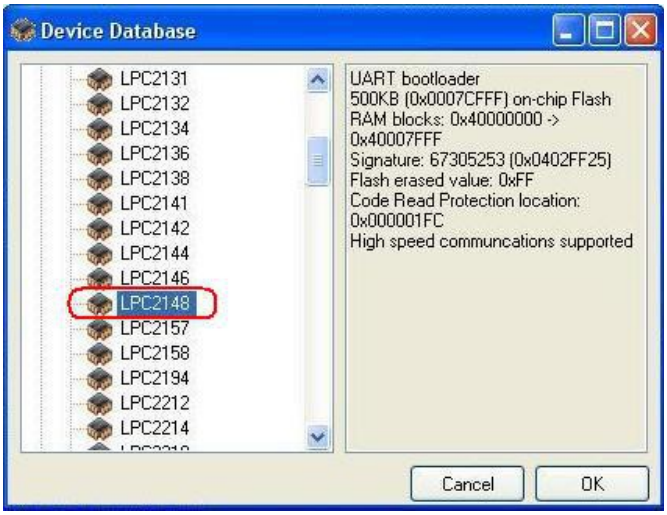
The next step is to load the hex file in to the microcontroller using Flash magic utility.

1. Click **Start>Programs>Flash Magic>Flash Magic** to start Flash Magic utility.

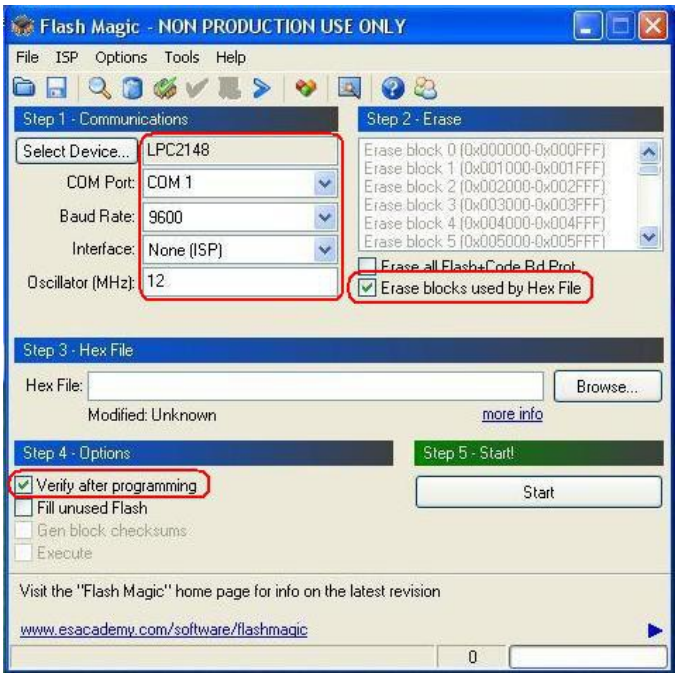
2 . Click **Select Device** to select LPC2148 microcontroller.



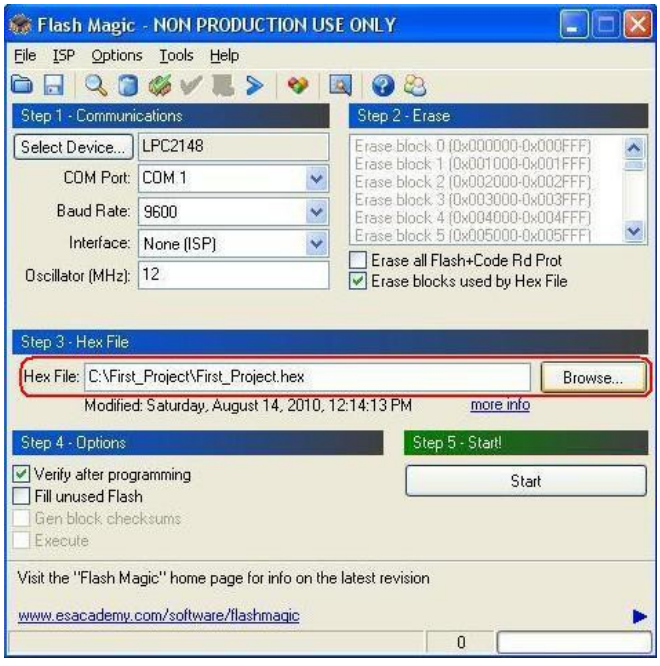
3. Expand the ARM7 tree and select **LPC2148** from the displayed list of microcontrollers.



4. After selecting the microcontroller, select the COM port that you are going to use and ensure that other settings are as shown in the figure below.



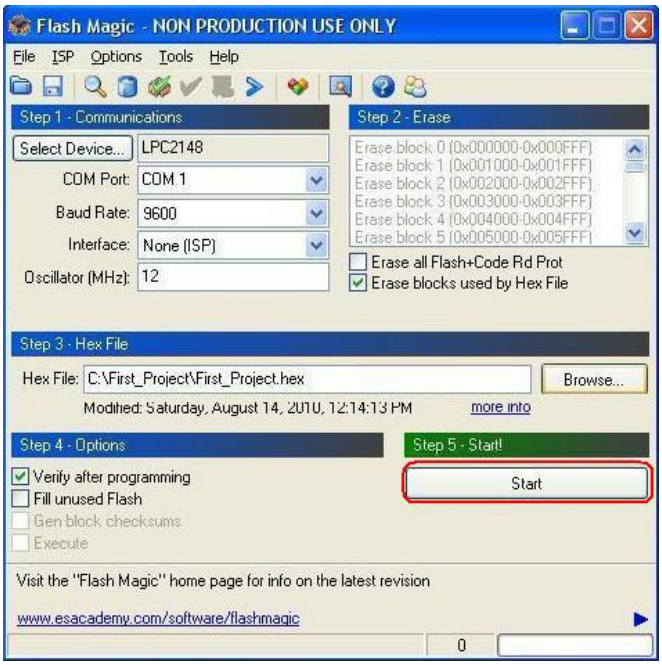
5. To select the hex file click **Browse** and point to the folder that was created earlier and select the hex file.



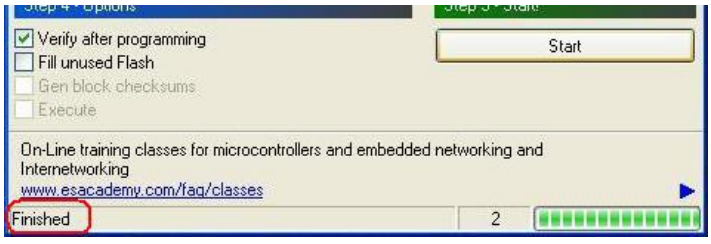
6. Before loading the hex file prepare LPC2148 development board by doing the following hardware setup.

i. Connect a DB9 cable between the selected **COMx** port on your PC and the **UART0** port on LPC2148 development board.
ii. Plug in USB cable to the development board and slide ON/OFF switch to **ON** position.
iii. Enter in to boot load mode by keeping the **BOOT** switch pressed and then press **RESET** switch, release **RESET** switch and then release **BOOT** switch.

7. After ensuring the hardware setup in step 6 click start to begin programming the hex file.



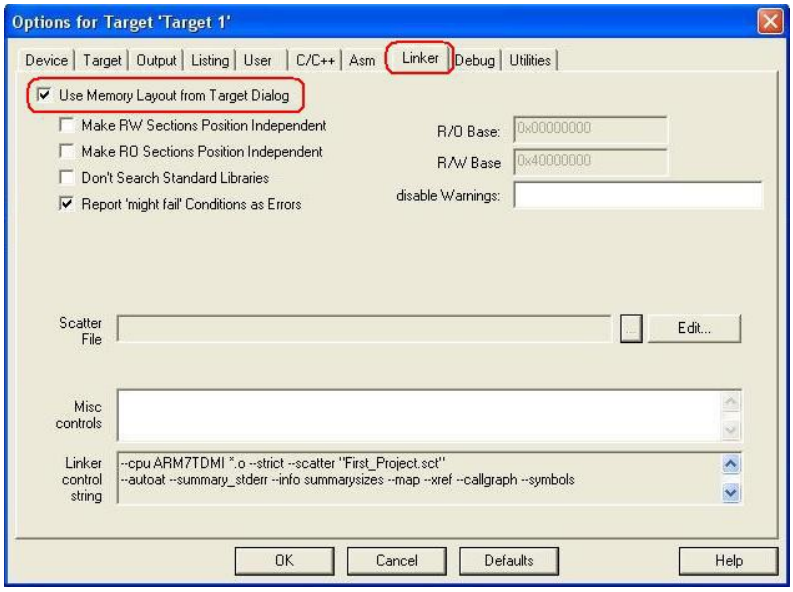
8. Observe the status bar at the bottom of the Flash Magic tool. Wait for the "**Finished"** status and press "**Reset"** on the LPC2148 development board and observe the LEDs.



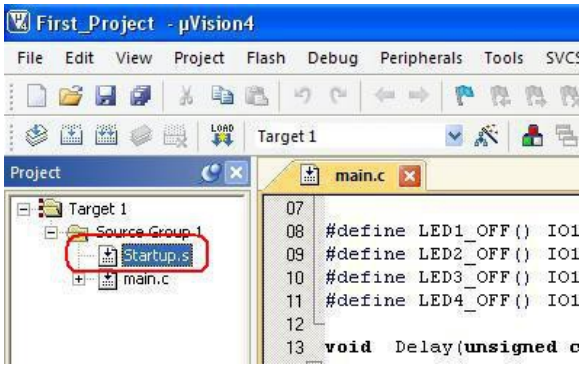
If not successful then repeat again from step 6.

2.3.3 Configuring Startup.s File using Configuration wizard

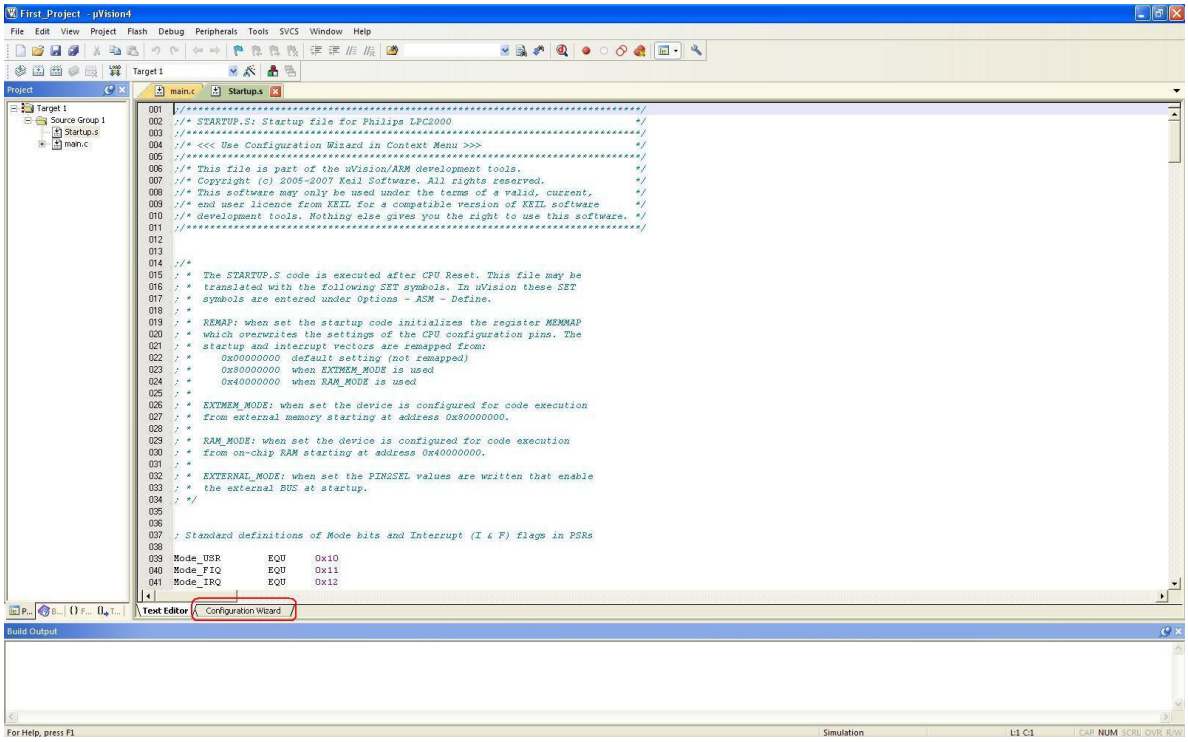
The "**startup.s**" is the collection of assembly instructions that is supposed to be executed at the start-up of the application code. The start up file contains information about the PLL settings, peripheral clock divider, stack configuration, etc. This file can be found in the Keil installation directory. On creating a new project keil allows you to copy this file to the project source folder so that you can modify the settings as per your application requirements without modifying the original file. To execute the start up code on reset please ensure that following setting is done. To do this setting refer step 18 in section 2.3.1.



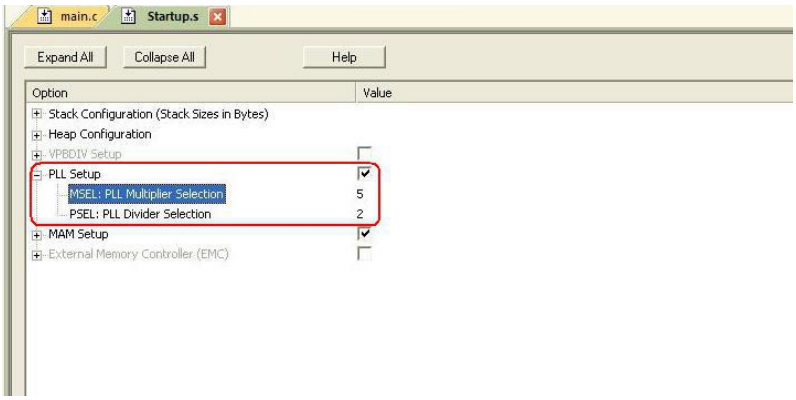
1. In the Project explorer double click on **"startup.s"** file.



2. The startup.s file will open up as assembly file. To open the wizard click **Configuration Wizard** as shown in figure below.

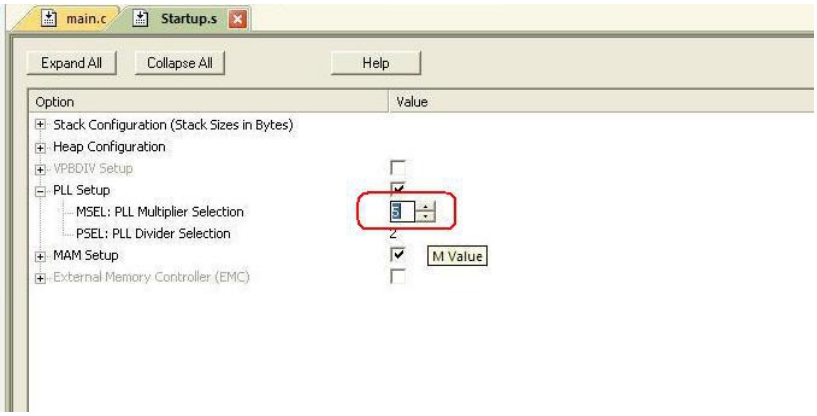


3. Expand the PLL Setup tree to observe the default the PLL settings.

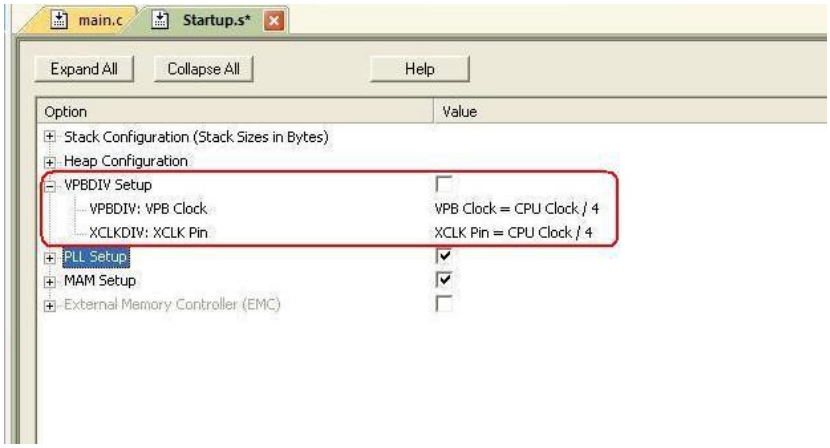


To include the PLL code in the startup file select the checkbox next to PLL setup heading. Here MSEL setting indicates that the onboard crystal frequency (12MHz) will be multiplied by 5. This indicates that the CPU core frequency will be 60MHz and this is the maximum operating frequency for LPC2148 microcontroller. Care should be taken while selecting the multiplier value to ensure that the CPU core frequency is not beyond the maximum value. When using the PLL setup the minimum on board crystal frequency should be at least 10 MHz.

The PLL divider selection maintains the frequency of internal current controlled oscillator in the range of 150-320MHz. For more information please refer LPC2148 user manual. The default setting for **MSEL** is 5 and for **PSEL** it is 2. So the core frequency (FCLK) is 60MHz.
To change any setting just click on it and make use of the up/down arrows.



4. Now expand VPBDIV Setup tree and observe its settings. It is used to prescale the peripheral clock (PCLK).



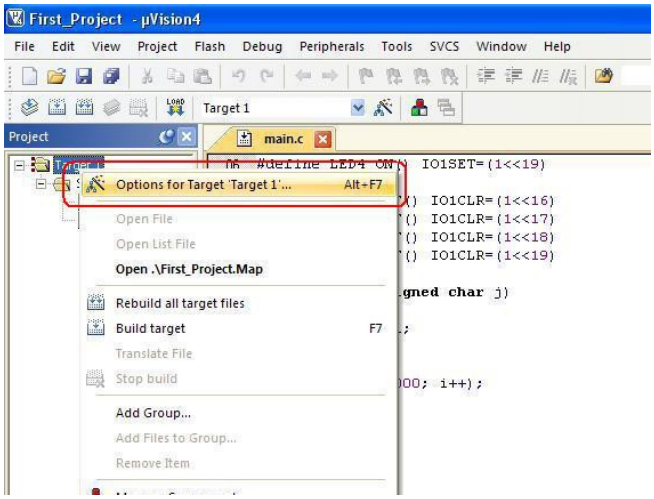
Observe that in the default mode it is not included but at reset the VPBDIV loads the default value that is ¼ of the CPU clock. Using the configuration wizard you can set the peripheral clock as:
¼ of CPU clock or
½ of CPU clock or
equal to CPU clock.

For other settings please refer LPC2148 microcontroller user manual.
After you have done using configuration wizard rebuild the project.

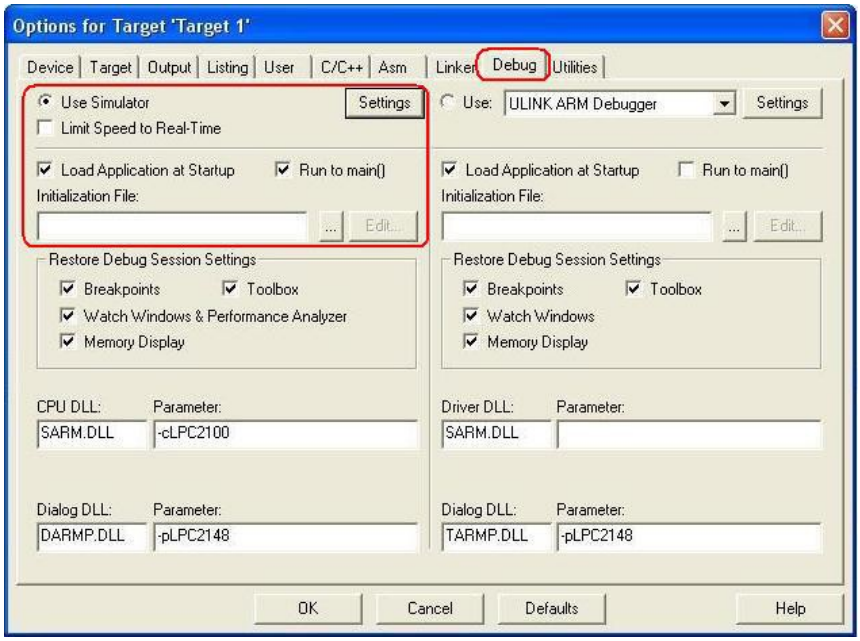
2.4 Using uVision Debugger in simulator mode

To use Debugger in simulator mode first we need to setup the debugger so as to use simulator.

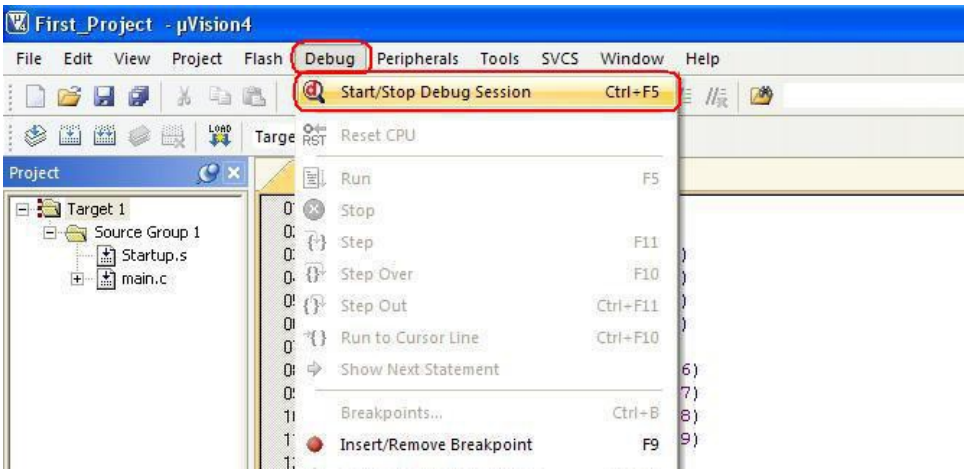
1. Right click **Target 1** and select the highlighted option as shown in the figure below.



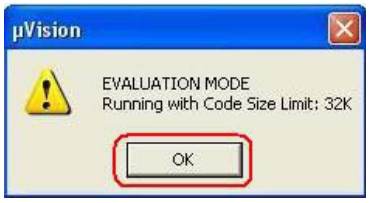
2. In the debug tab make sure that the highlighted settings are done. Click **OK** to continue.



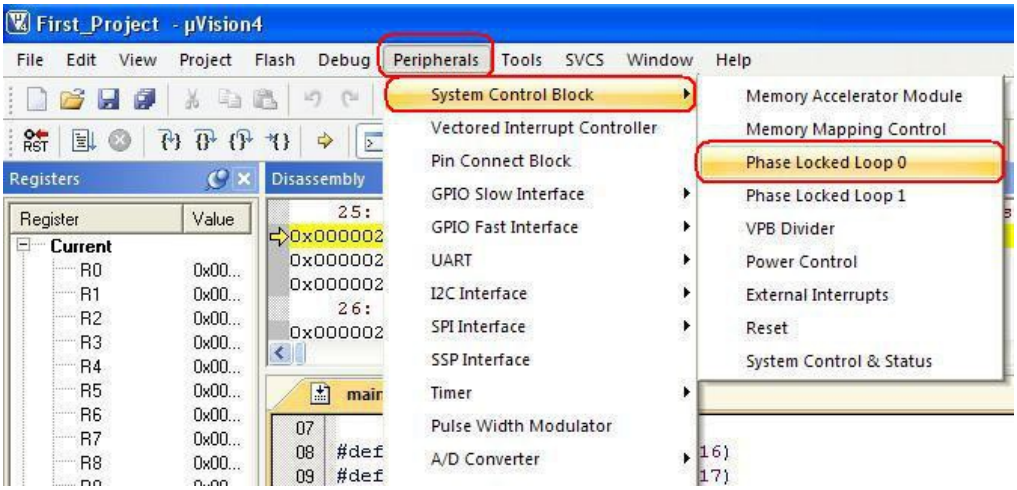
3. Start Debug session by clicking on **Debug>Start/Stop Debug Session** from the main menu. Alternatively you can press Ctrl+F5 to toggle between starting and stopping of debug session.



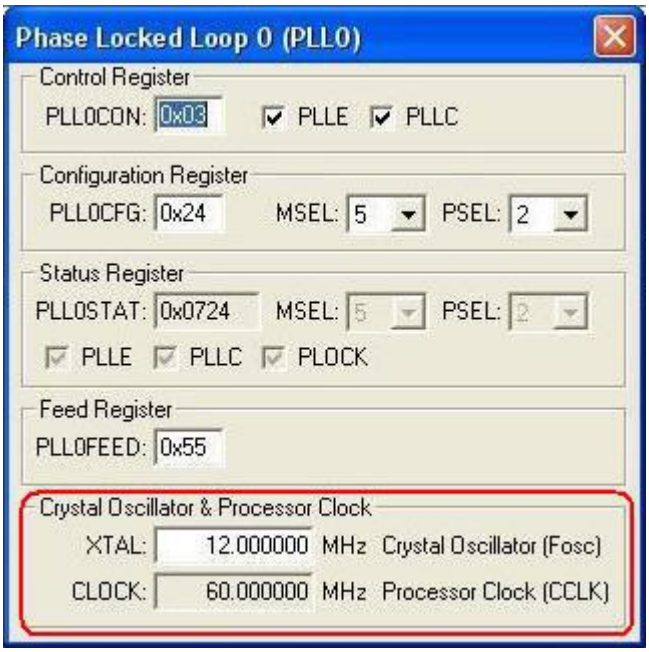
4. Click **OK** to continue.



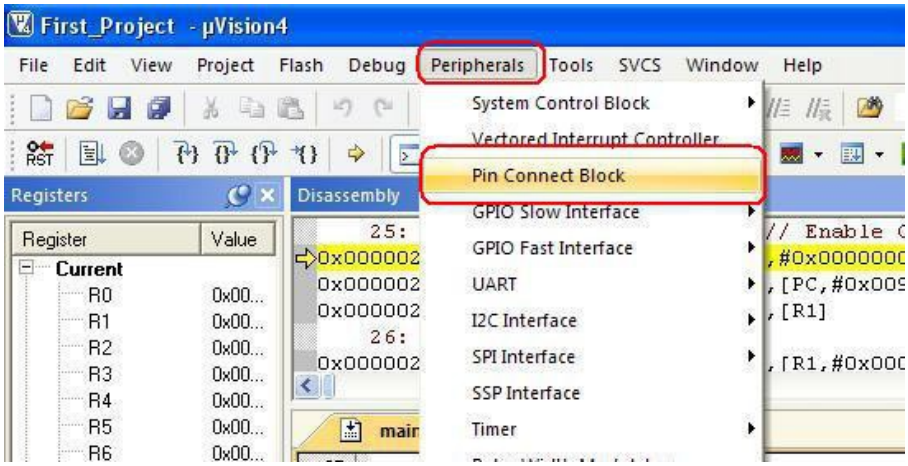
5. Go to **Peripherals>System Control Block>Phase Locked Loop 0** to observe the PLL settings on the microcontroller.



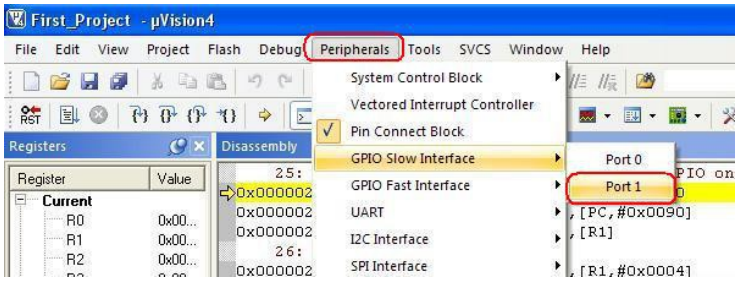
6. In the **Crystal Oscillator & Processor Clock** section observe that XTAL is 12MHz and CCLK is 60MHz. This is because the debugger has already executed the start up code when we started the debug session. It also ensures that PLL settings that we had done in the configuration wizard of the startup code are properly working.



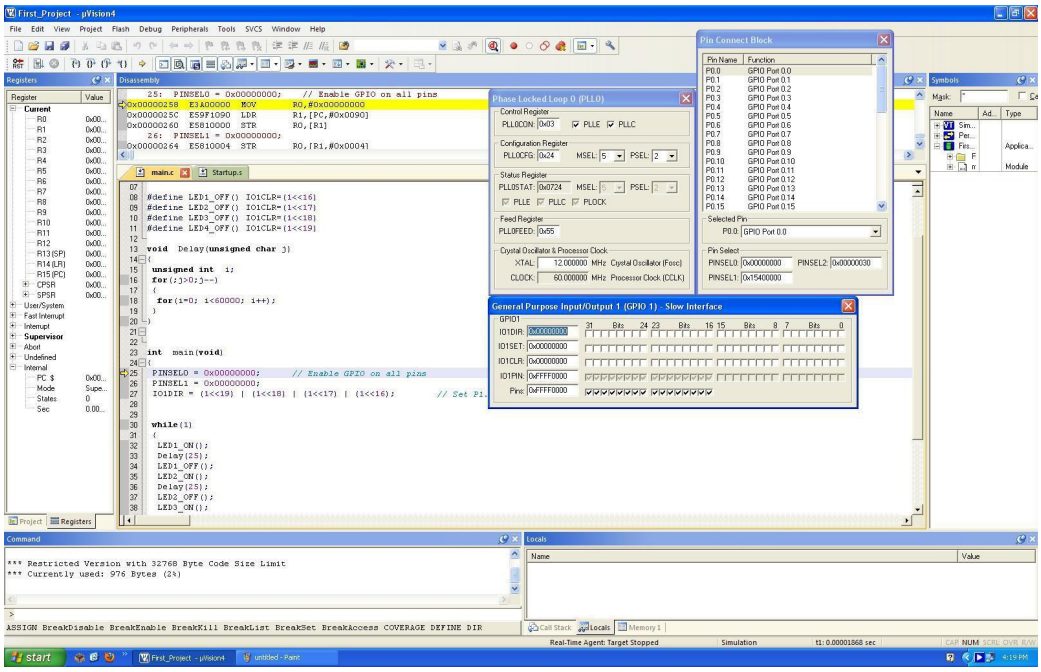
7. Now click **Peripherals>Pin Connect Block** to include pin connect block,



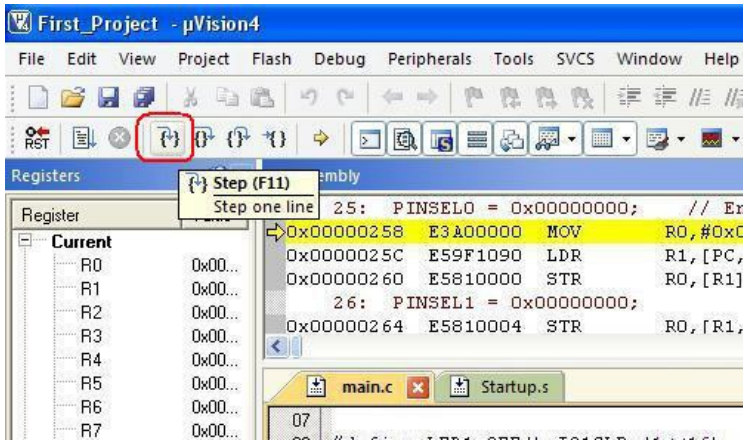
8. Similarly select **Port 1 window.**



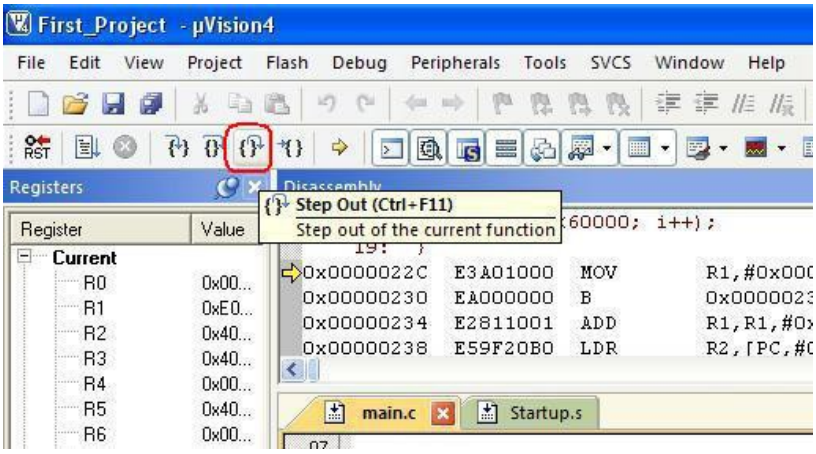
9. Arrange the windows as shown in figure below.



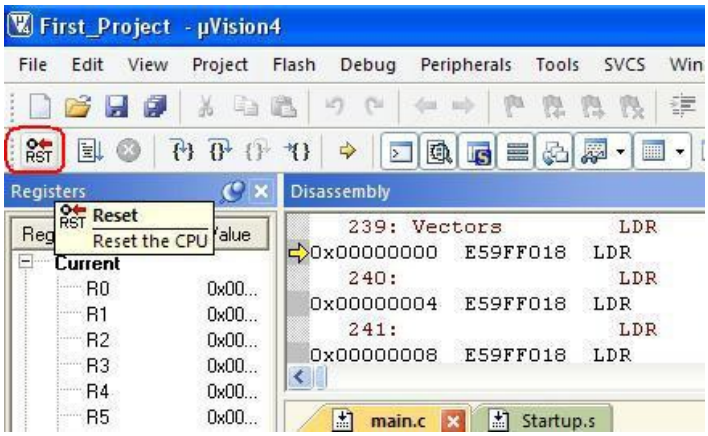
10. Now use **Step** function to step through the code. Alternatively you can press Ctrl+F11. Observe the changes in the Pin connect block and Port1 block as you step through the code.



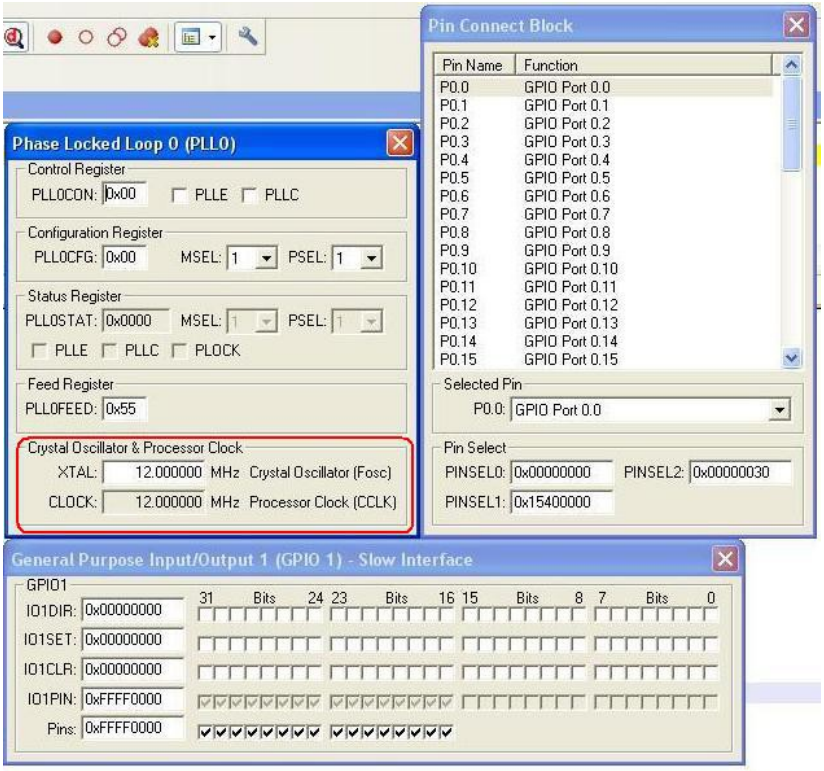
11. When you encounter the delay function you can simply use Step Out function. It will execute the delay function and take execution to the next line immediately after the delay function.



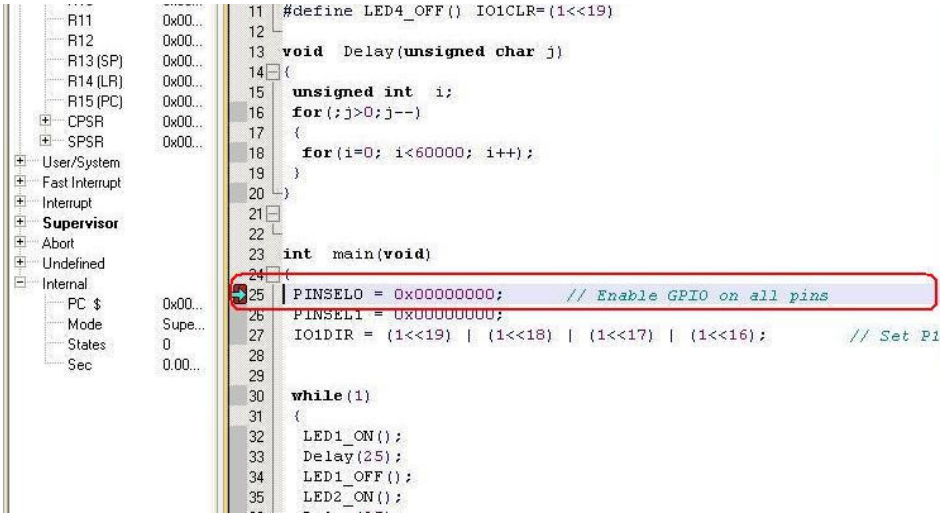
12. Now press the Reset button to Reset the CPU and observe the PLL window.



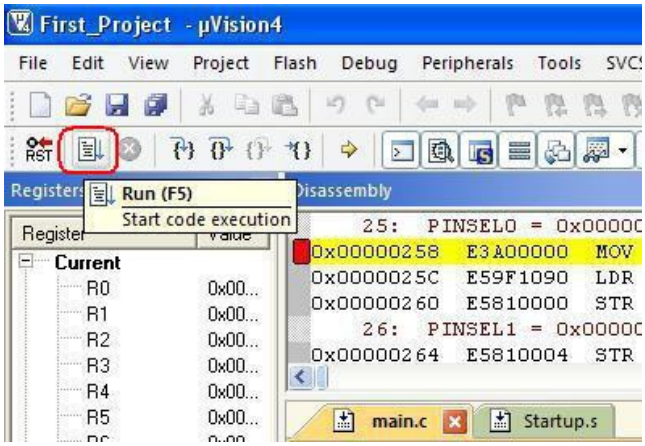
13. Observe that CCLK is also reset and now it is equal to XTAL frequency. Similarly the GPIO and pin connect block vales are also reset.



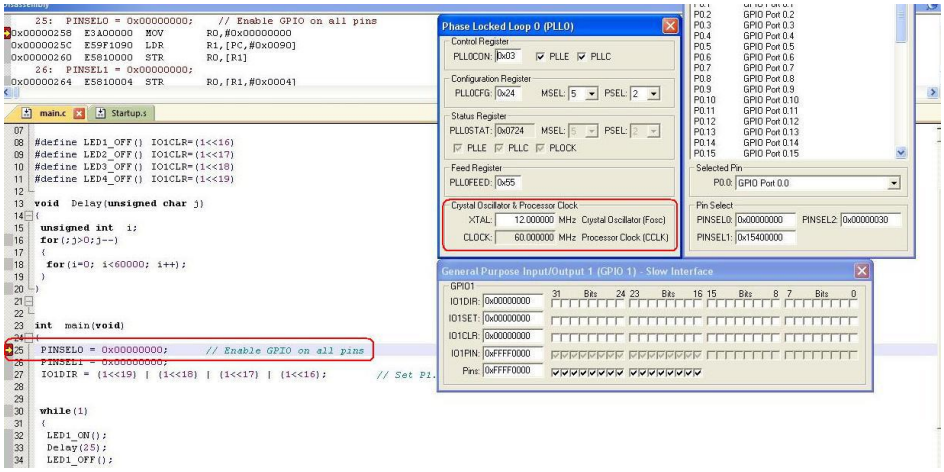
14. Now let us setup a break point at line no. 25 i.e. at the beginning of the main function. It will halt the execution when the debugger encounters this line.



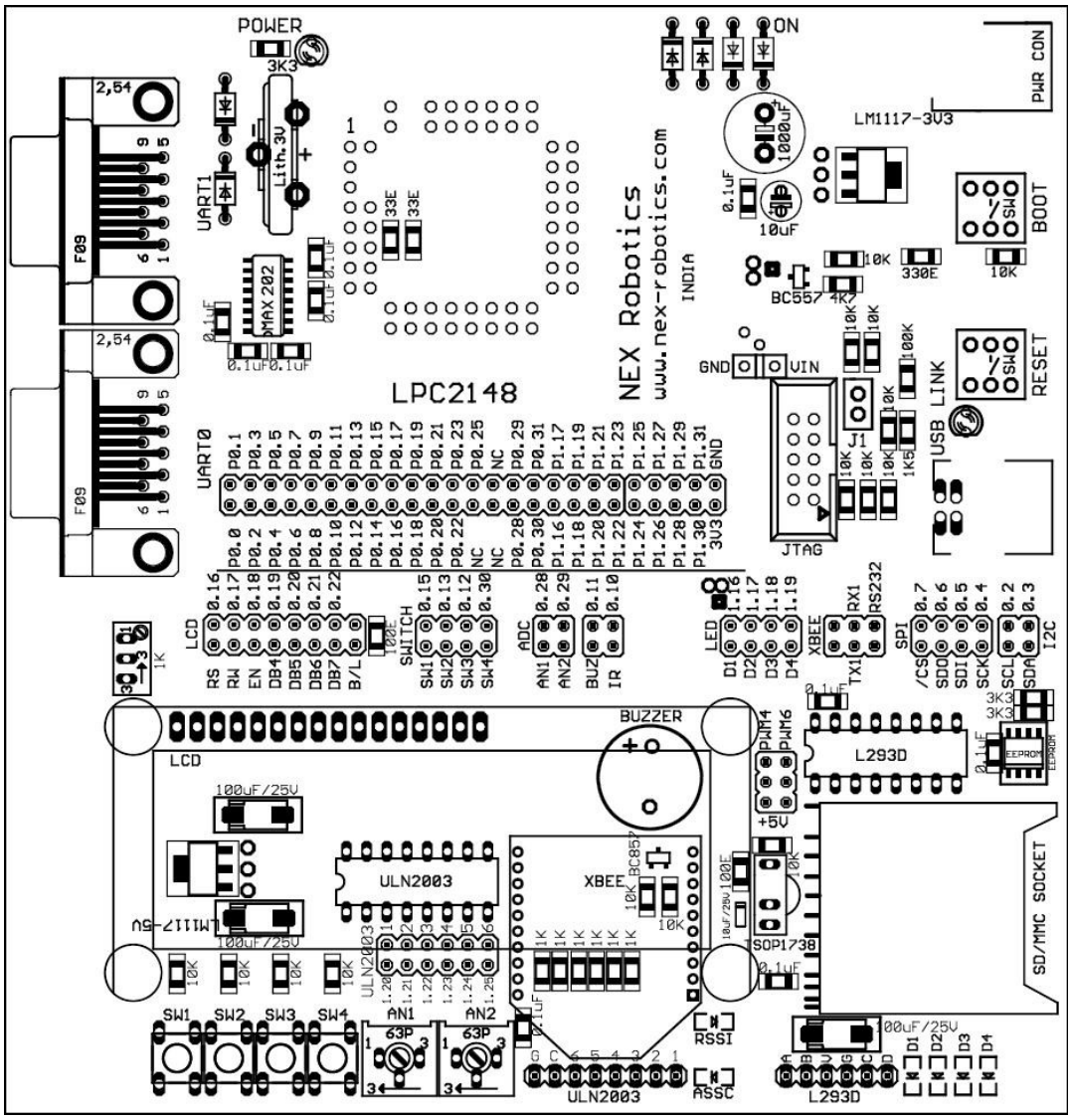
15. Now click Run to start the execution.



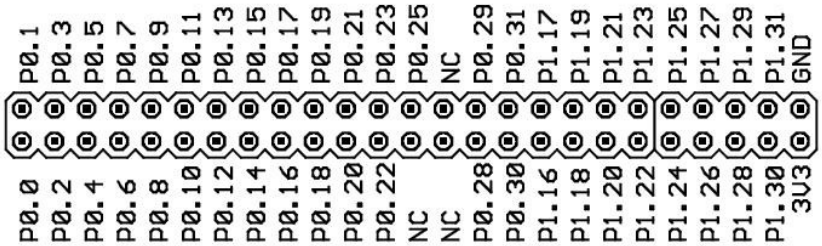
16. After clicking on RUN observe the change in the CCLK field. The execution has also halted at the breakpoint that was setup earlier. Now again if you click Run the code will continue to execute.



3.0 HARDWARE DESCRIPTION



3.1 Main Expansion Header

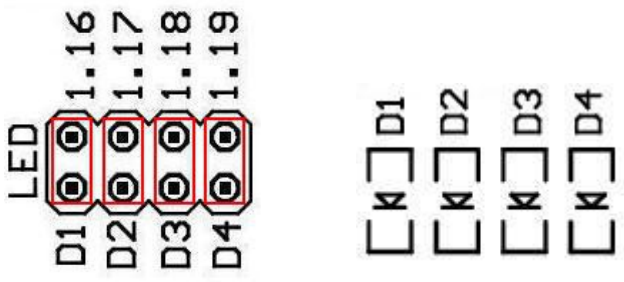


All port pins on LPC2148 microcontroller are accessible on the 50 pin main expansion header. 50 pin FRC wire can also be connected to this connector. The expansion header allows user to interface external peripherals to LPC2148 microcontroller. Apart from port pins, it also includes 3.3V supply which can be utilised to power external devices. When using the expansion header, it is necessary to disconnect the on-board peripherals connected to these pins by removing the jumpers which links these pins to the on-board peripherals. Refer following sections for jumper settings.

Note: 1. Total current drawn by all external peripherals must not be more than 150mA.

2. Do not connect any external supply to the 3V3 pin on the expansion header

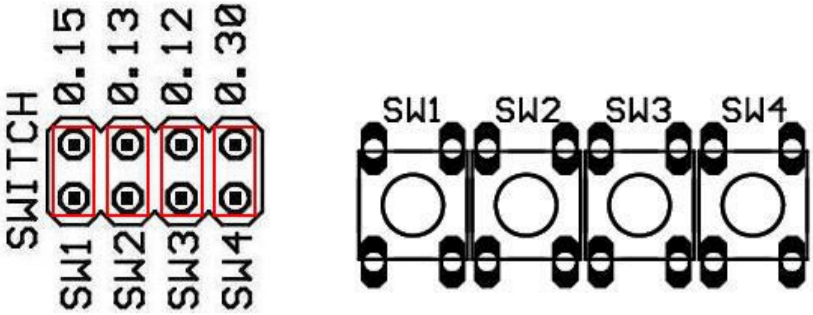
3.2 LEDs



LPC2148 development board has 4 user programmable LEDs. The port pins for LEDs are as shown in the above figure. Jumper D1 is associated with Led D1 and so on. Jumper positions are as shown in the above figure. Alternatively you can make connection between any port pin and LED directly using 1to1 cables. All LEDs are common ground with series resistor of 1K.

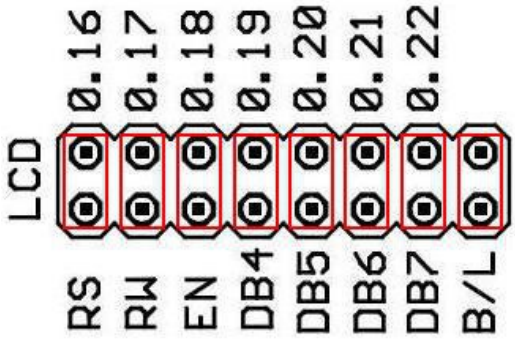
Note: 1. Port pins P1.16, P1.17, P1.18 and P1.19 are also used for L293D direction inputs.

3.3 USER SWITCHES



LPC2148 development board has 4 user programmable switches. The ports pins and jumper settings are as shown in the above figure. When a switch is pressed it will pull the associated pin to logic ‘0’. Port pins P0.15 and P0.30 features alternate function of external interrupts. Jumper SW1 is associated with switch SW1 and so on.

3.4 LCD INTERFACE



The LPC2148 development board is included with 4-bit HD44780 based LCD interface. It can be used to interface 16x1, 16x2, 20x4 characters LCD display. The board is shipped with 16x2 character LCD display. The jumper positions and port pins are as shown in the above figure. The **B/L** jumper setting is used to control LCD backlight. On removing this jumper LCD backlight will turn OFF.

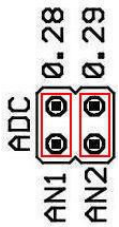
3.5 BUZZER

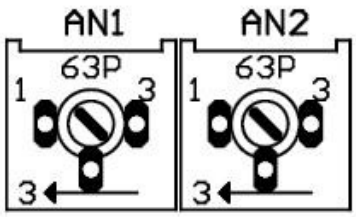
Buzzer is connected to P0.11 of LPC2148 microcontroller. Logic '0' on P0.11 will turn ON buzzer. P0.11 is open drain type and it requires external pull-up for proper operation. The LPC2148 development board have a pull-up on buzzer side. If using this pin for some other purpose then it is recommended to use a pull-up of 10Kohms on the external board.

3.6 IR RECEIVER

There is a TSOP1738 IR receiver on LPC2148 development board. The jumper position is as shown in the above figure. Alternatively IR receiver can be connected to any port pin using 1-1 cable.

3.7 TRIMPOTS





LPC2148 development board has two trimpots connected to AD0.1 and AD0.2 on the LPC2148 microcontroller. The jumper positions are as shown in the above figure. Jumper AN1 represents trimpot AN1 and AN2 represents trimpot AN2. The trimpot voltage range lies between 0-3.3V.

3.8 UART1/XBEE/BLUETOOTH/WIFI

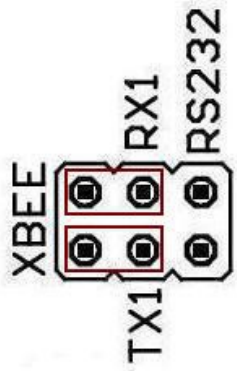


Fig.3.1

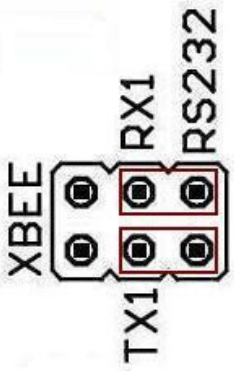
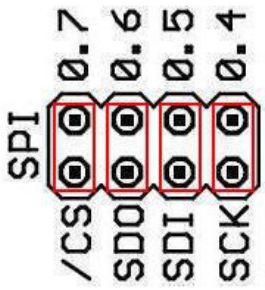


Fig.3.2

The LPC2148 development board has a provision for interfacing XBee / Bluetooth / WiFi wireless modules. The wireless modules use UART for the communication with microcontroller. The UART1 on LPC2148 microcontroller can be used for this purpose. The jumper positions for the desired operation are shown in above figures. If jumper positions are as per fig.3.1 then UART1 is selected for Xbee wireless communication. If jumper positions are as per fig.3.2 then UART1 is selected for RS-232 serial communication.

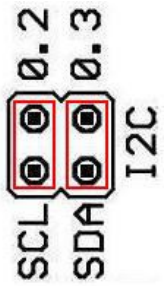
3.9 SPI INTERFACE



The LPC2148 microcontroller features 2 SPI interfaces i.e. SPI0 and SPI1. On LPC2148 development board SPI0 is used for interfacing SD/MMC card. The SPI expansion

header contains 4 signals related to SPI0. The jumper positions and associated pins for SPI-SD/MMC interface are shown in the above figure. To use SPI0 for the external interfacing, remove these jumpers. The SPI0 pin conventions on the expansion header are with respect to master i.e. LPC2148 microcontroller.

3.10 I2C INTERFACE



The I2C0 peripheral on LPC2148 development board is used for interfacing 24LCxxx EEPROM memories from microchip. The above figure describes the jumper positions and pins used for I2C interface.

3.11 ULN2003

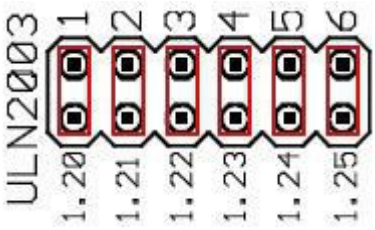


Fig.3.3 Logic Header

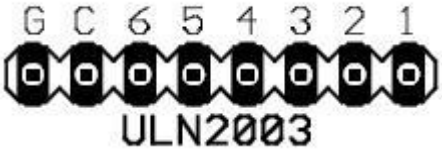
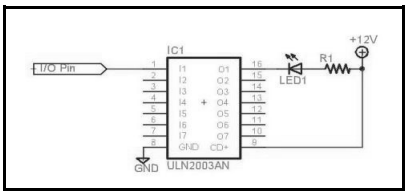


Fig.3.4 Driver header

The LPC2148 development board features a high current ULN2003 driver. It has 7 darlington transistor array. Each transistor can sink current up to 500mA. This device is useful for driving a wide range of loads including solenoids, relays, DC motors, LED displays filament lamps, thermal print heads and high power buffers etc. *For more information on ULN2003 refer to data sheet included in the CD.* Fig.3.3 describes the jumper positions for logic inputs to the ULN2003 driver. To use any channel insert a jumper in its respective position. Fig.3.4 describes the expansion header for connecting relays, stepper motors, LEDs or any inductive load. Logic '1' on input channel will drive the load connected to the corresponding channel. The application circuit used in the experiment is shown in the figure below.



The cathode of LED is connected to the pin named as '1' on Driver header and I/O pin connected is connected to pin named as '1' on Logic header by placing a jumper in its position.

3.12 L293D 600mA Dual DC MOTOR DRIVER

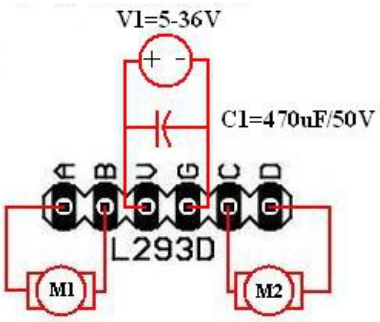


Fig.3.5 Supply and motor connections

The LPC2148 development board has one L293D motor driver IC. L293D is designed to provide bidirectional drive currents of up to 600mA at voltages from 5V to 36V. *For more information on L293D motor driver IC refer device data sheet included in the CD.*
Each motor driver channel requires two I/O pins for direction control and 1 I/O pin for velocity control of a DC motor. The motor power supply is separated from the logic supply. The logic supply is provided from the on board power supply. The motor supply should be provided externally as shown in fig.3.5.

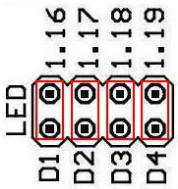


Fig. 3.6

The L293D direction control port and LED port uses same pins on LPC2148 microcontroller. So in order to use L293D driver all the jumpers on the LED header should be inserted as shown in the fig.3.6.
The velocity of the DC motor can be varied using the PWM port on the LPC2148 microcontroller or it can be fixed to maximum velocity by connecting velocity pins to 5V. For this purpose, LPC2148 development board has a header for selecting the source of velocity signal.

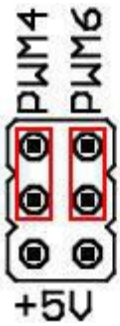


Fig. 3.7a

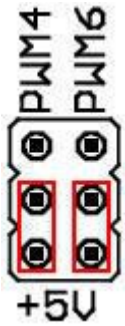
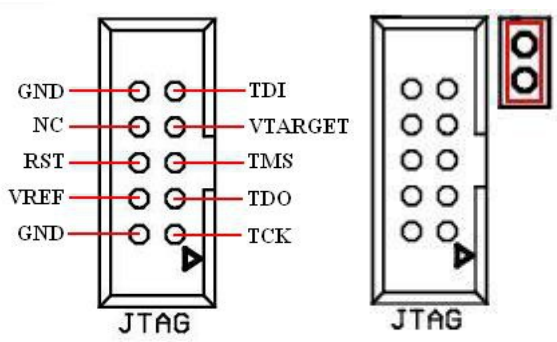


Fig. 3.7b

If jumper positions are as shown in fig. 3.7a, PWM channels 4 & 6 are selected as source of velocity signal. If jumper position are as shown in fig. 3.7b, +5V is selected.

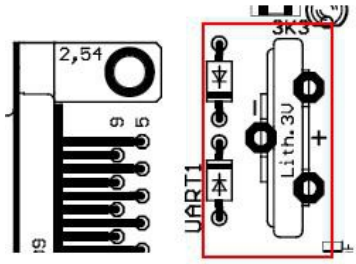
Note: PWM channels 4 & 6 are multiplexed with UART1 RX and TX signals on LPC2148 microcontroller. When PWM function is enabled on these pins do not insert any jumper in the XBEE/UART header.

3.13 JTAG PORT



The LPC2148 development board has a 10pin (2X5) JTAG box header for on chip debugging. JTAG debugging requires pulling P1.26 low on reset in order to enter into debug mode. To achieve this there is a 2 pin jumper on the development board as shown in the figure above.

3.14 RTC



The LPC2148 microcontroller features an in-built RTC and it provides Seconds, Minutes, Hours, Day of Month, Month, Year, Day of Week, and Day of Year. It has a dedicated 32.768 kHz oscillator or programmable prescaler from VPB clock. It also has a dedicated power supply pin that can be connected to a battery or to the board supply of 3.3V. LPC2148 development board has battery holder for providing battery back up to the internal RTC.

4.0 SAMPLE PROGRAMS

The following sample programs are included in the CD. The sample programs are written in keil uVision IDE version 4 by using the Real View complier**.**
The hex file can be loaded on the microcontroller flash memory using Flash Magic utility. Detailed instructions for loading a hex file using Flash magic utility are provided in section 2.3.2.
The default clock settings for all sample programs:

Clock Settings	
FOSC	12MHz
PLL	M=5, P=2
CCLK	60MHz
PCLK	15MHz

4.1 LED CHASER

Hardware Setup: Insert LED jumpers D1-D4.

Load the LED_CHASER.hex file from LPC2148>codes>LED CHASER folder using flash magic on the microcontroller flash memory.

Description: After loading the hex file, press reset switch. This application code will blink D1-D4 LEDs sequentially. The code explains how to use GPIO registers of LPC2148 microcontroller.

4.2 IO INTERFACING

Hardware Setup: Insert LED jumpers D1-D4.
Insert Switch jumpers SW1-SW4

Load the IO_INTERFACING.hex file from LPC2148>codes> IO INTERFACING folder using flash magic on the microcontroller flash memory.

Description: After loading the hex file, press reset switch. This application demonstrates simple IO interfacing on LPC2148 development board. The program basically explains how to read a pin and control the output. To see the result, press any switch and observe the corresponding LED glow.

4.3 BUZZER

Hardware Setup: Insert SW4 Jumper.
Insert Buzzer Jumper

Load the BUZZER.hex file from LPC2148>codes>BUZZER folder using flash magic on the microcontroller flash memory.

Description: After loading the hex file, press reset switch. This application code explains how to use external hardware interrupts. Switch SW4 is used to trigger Ext interrupt EINT3. When switch SW4 is pressed buzzer beeps at different speeds.

4.4 LCD INTERFACING

Hardware Setup: Insert all LCD jumpers.

Load the LCD_INTERFACING.hex file from LPC2148>codes>LCD INTERFACING folder using flash magic on the microcontroller flash memory.

Description: After loading the hex file, press reset switch. This application code demonstrates LCD interface on LPC2148 development board. LCD will display "Nex Robotics ARM LPC2148".

4.5 UART0 COMM (9600 bps)

Hardware Setup: Connect a DB9 cable between PC and UART0. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Enable terminal to receive data in string format.

Load the UART0_COMM_9600.hex file from LPC2148>codes>UART0 COMM 9600 folder using flash magic on the microcontroller flash memory.

Description: This application code demonstrates UART0 peripheral on LPC2148. On reset, it sends a string of characters to the terminal software running on the PC. It then asks for a character to be sent from the PC to complete the communication test.

4.6 UART1 COMM (9600 bps)

Hardware Setup: Refer jumper settings for using UART1 from section 3.8.
Connect a DB9 cable between PC and UART1. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Enable terminal to receive data in string format.

Load the UART1_COMM_9600.hex file from LPC2148>codes>UART1 COMM 9600 folder using flash magic on the microcontroller flash memory.

Description: This application code demonstrates UART1 peripheral on LPC2148. On reset, it sends a string of characters to the terminal software running on the PC. It then asks for a character to be sent from the PC to complete the communication test.

4.7 ADC

Hardware Setup: Insert trimpot jumpers AN1 & AN2.
Connect a DB9 cable between PC and UART1. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Enable terminal to receive data in string format.

Load the ADC.hex file from LPC2148>codes>ADC folder using flash magic on the microcontroller flash memory.

Description: After loading the hex file, press reset switch. This application code demonstrates ADC interfacing on LPC2148. The two trimpots are connected to AD0.1 and AD0.2 analog input channels of the microcontroller. The digital data is used to represent the measured voltage and it is sent to the terminal software running on the PC. AN1 is connected to AD0.1 and AN2 is connected to AD0.2. By varying the potentiometer you can observe the change in values on serial terminal software running on the PC.

4.8 I2C EEPROM

Hardware Setup: Insert LED jumpers D1-D4. Insert I2C jumpers SDA & SCL
Connect a DB9 cable between PC and UART0. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Load the I2C_EEPROM.hex file from LPC2148>codes> I2C EEPROM folder using flash magic on the microcontroller flash memory.

Description: This application code explains reading and writing on I2C EEPROM 24LC04. On reset, microcontroller will write 16 bytes of DATA on the EEPROM 24LC04 and read back the same data. The read data is then sent to UART0, which can be observed on the receive window of terminal software.

4.9 SD MMC INTERFACE

Hardware Setup: Insert SPI jumpers SCK, SDO, SDI and /CS.
Insert SD/MMC card into the socket. Connect a DB9 cable between PC and UART1. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Enable terminal to receive data in string format.

Load the SD_MMC_INTERFACE.hex file from LPC2148>codes> SD MMC INTERFACE folder using flash magic on the microcontroller flash memory.

Description: This application code demonstrates SD/MMC interface on SPI bus. On reset microcontroller writes a string of data as " NEX ROBOTICS" on the memory card and reads back the same data. This data is sent to UART0, which can be observed on receive window of terminal software.

4.10 DC MOTOR CONTROL

Hardware Setup: Insert LED jumpers D1-D4.
Insert Switch jumpers SW1-SW4
Insert PWM jumpers for +5V
Connect Motor i/p supply (12V) to the V pin on L293D header

Load the DC_MOTOR_CONTROL.hex file from ,
LPC2148 > codes >DC MOTOR CONTROL folder using flash magic on the microcontroller flash memory.

Description: This application demonstrates, how to use L293D for controlling DC motor. SW1 is used to Start/Stop Motor1 connected across terminals A & B on the L293D o/p header. SW2 is used to control direction of Motor1. SW3 is used to Start/Stop Motor2 connected across terminals C & D on the L293D o/p header. SW4 is used to control direction of Motor2.

4.11 STEPPER MOTOR CONTROL

Hardware Setup: Insert ULN2003 jumpers 1-4. Connect common wire on the stepper motor to external supply as per the motor's rating. Connect the other 4 wires i.e. Coil 1 to coil 4 to the inputs 1 to 4 on the ULN header. If stepping sequence is inappropriate then alter the connection sequence.

Load the STEPPER_MOTOR_CONTROL.hex file from LPC2148>codes>STEPPER MOTOR CONTROL folder using flash magic on the microcontroller flash memory.

Description: This application code drives unipolar stepper motor using ULN2003 driver on the LPC2148 development board

4.12 RTC UART0

Hardware Setup: Connect a DB9 cable between PC and UART0. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Load the RTC_UART0.hex file from LPC2148>codes>RTC UART0 folder using flash magic on the microcontroller flash memory.

Description: This application code demonstrates RTC peripheral on LPC2148. It transmits current time in 24h format on UART0. Enable terminal to receive data in string format. By pressing reset switch, the current time of RTC can be displayed on receive window of terminal software.

4.13 XBEE/BLUETOOTH/WIFI WIRELESS COMMUNICATION

Hardware Setup: Refer jumper settings for using Xbee from section 3.8. Connect Xbee USB adapter module to PC and install drivers. To install drivers refer Xbee USB adapter module documentation available in the CD. Setup the terminal software with following settings:

Baudrate	9600
Databits	8
Parity	None
Stopbits	1

Enable terminal to receive data in string format.

Load the XBEE_WIRELESS_COMM.hex file from LPC2148 > codes > XBEE WIRELESS COMM folder using flash magic on the microcontroller flash memory.

Description: This application code uses Xbee wireless module for communication over UART1 peripheral on LPC2148. The jumpers settings are required to be changed in order to select Xbee for UART1 on LPC2148 development board(see section 3.8). We will also require a Xbee USB adapter module for receiving and transmitting data on the PC side. Enable terminal to receive data in string format. After loading the hex file, press reset switch. on microcontroller board, The microcontroller board will send the below message, which can be observed on the receive window of terminal software on PC, where the Xbee USB module is connected,

" Nex Robotics PVT LTD
ARM7LPC214x Development Board
Communication Test
Send any character to continue"

As instructed in the last line of the above message, please type any character in transmit window of terminal software. This character is received by the development board via Xbee module present on board. The development board will reply by sending the message as "Test Passed" to the terminal software running on PC. This message can be observed in receive window of terminal software.

4.14 BOARD DEMO

Hardware Setup:

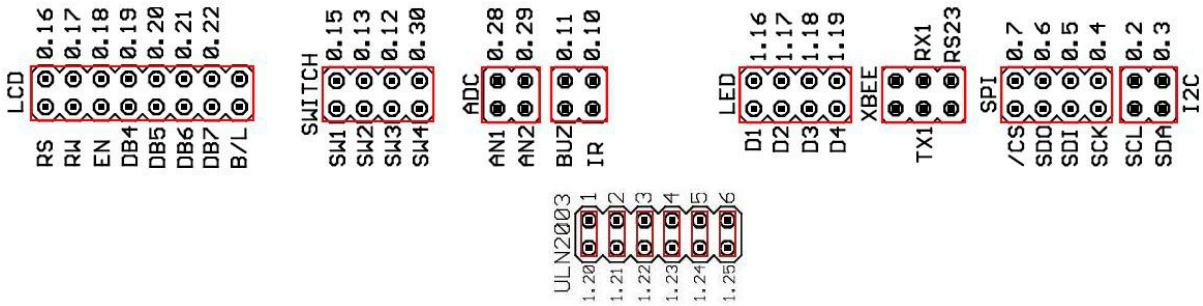


Fig. 4.1

1. Insert jumpers as highlighted in fig. 4.1
2. Insert any SD/MMC card of size up to 2GB in the SD/MMC slot.
3. Load hex file using flash magic and follow the instructions on LCD display.

Load the BOARD_DEMO.hex file from LPC2148>codes>BOARD DEMO folder using flash magic on the microcontroller flash memory.

Description: The Demo program is used to test all the peripherals on the development board. After loading the hex file refer instructions on the LCD display.

References

Volume 1: LPC214x User manual
AN10406-Accessing SD/MMC card using SPI on LPC2000
AN10404-Initialization code/hints for the LPC2000 family
AN10331-Philips LPC2xxx family phase lock loop
SanDisk SD Card Product Manual