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Wireless Sensor Network for Data Center Monitoring and Alerting System

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Abstract:

Bluetooth is a kind of short distance wireless communications technology. This Project explains the technical characteristics, network topology structures and application prospects of Bluetooth. And then a scheme on wireless data center monitoring and alerting system based on Bluetooth was proposed.

Through some related experimental results proved that the temperature monitoring system worked stably and wireless signals transmission had high accuracy, and the results verified that Bluetooth technology is an ideal solution to realize the wireless monitoring network.

To get accurate results of the temperature we are using an LM 35 sensor which has the ability to monitor the temperature up to 100 degree Fahrenheit, and this temperature is then transmitted to the status control section to monitor the room temperature through Bluetooth technology.

INTRODUCTION

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result.

Introduction of Embedded System:

An Embedded System is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function. A good example is the microwave oven. Almost every household has one, and tens of millions of them are used every day, but very few people realize that a processor and software are involved in the preparation of their lunch or dinner.

This is in direct contrast to the personal computer in the family room. It too is comprised of computer hardware and software and mechanical components (disk drives, for example). However, a personal computer is not designed to perform a specific function rather; it is able to do many different things. Many people use the term general-purpose computer to make this distinction clear. As shipped, a general-purpose computer is a blank slate; the manufacturer does not know what the customer will do wish it. One customer may use it for a network file server another may use it exclusively for playing games, and a third may use it to write the next great American novel.

Frequently, an embedded system is a component within some larger system. For example, modern cars and trucks contain many embedded systems. One embedded system controls the anti-lock brakes, other monitors and controls the vehicle's emissions, and a third displays information on the dashboard. In some cases, these embedded systems are connected by some sort of a communication network, but that is certainly not a requirement.

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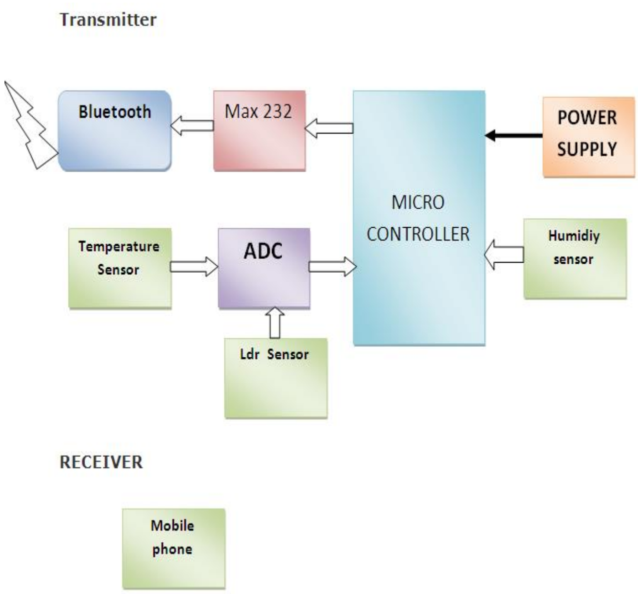
At the possible risk of confusing you, it is important to point out that a general-purpose computer is itself made up of numerous embedded systems. For example, my computer consists of a keyboard, mouse, video card, modem, hard drive, floppy drive, and sound card-each of which is an embedded system. Each of these devices contains a processor and software and is designed to perform a specific function. For example, the modem is designed to send and receive digital data over analog telephone line. That's it and all of the other devices can be summarized in a single sentence as well.

If an embedded system is designed well, the existence of the processor and software could be completely unnoticed by the user of the device. Such is the case for a microwave oven, VCR, or alarm clock. In some cases, it would even be possible to build an equivalent device that does not contain the processor and software. This could be done by replacing the combination with a custom integrated circuit that performs the same functions in hardware. However, a lot of flexibility is lost when a design is hard-cooled in this way. It is mush easier, and cheaper, to change a few lines of software than to redesign a piece of custom hardware.

Block Diagram



MICROCONTROLLERS:

Microprocessors and microcontrollers are widely used in embedded systems products. Microcontroller is a programmable device. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip. The fixed amount of on-chip ROM, RAM and number of I/O ports in microcontrollers makes them ideal for many applications in which cost and space are critical.

LPC2148:

Features

- 16 -bit/32-bitARM7TDMI-Smicrocontroller in a tinyLQFP64package.
- 8kBto40kBofon-chipstaticRAMand32kBto512kBofon-chipflashmemory. 128bitwideinterface/acceleratorenableshigh-speed60MHzoperation.
- In-SystemProgramming/In-ApplicationProgramming(ISP/IAP)viaon-chipbootloader software.Singleflashsectororfullchiperasein400 msandprogrammingof 256bytesin1 ms.
- Embedded ICERT and Embedded Trace interfaces offerreal-timedebuggingwiththe on-chip Real Monitorsoftwareandhigh-speedtracingofinstructionexecution.
- USB2.0Fullspeedcompliantdevicecontrollerwith2kBofendpointRAM.Inaddition,theLPC2146/48provides8kBofon-chipRAMaccessibletoUSBbyDMA.
- Oneortwo(LPC2141/42vs.LPC2144/46/48)10bitADCsprovideatotalof6/14analoginputs,withconversiontimesaslowas2.44μsperchannel.
- Single 10-bitDACprovidesvariableanalogoutput(LPC2142/44/46/48only).
- Two32-bittimers/externaleventcounters(withfourcaptureandfourcompare channelseach),PWMunit(sixoutputs)andwatchdog.

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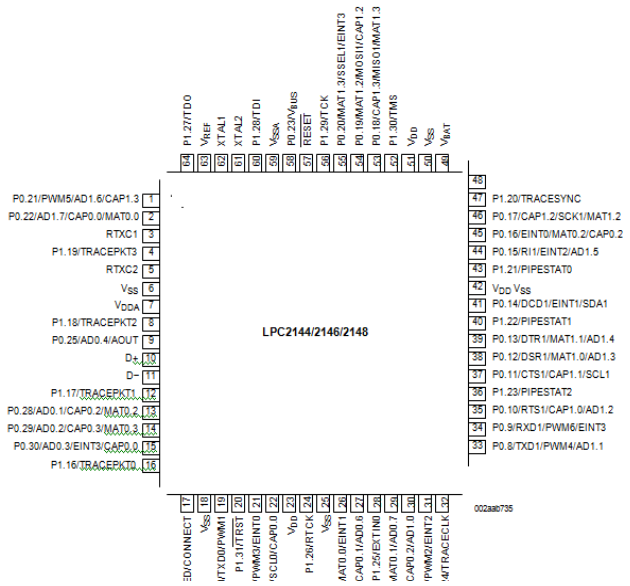
- LowpowerReal-TimeClock(RTC)withindependentpowerand32 kHzclockinput.

1. Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
2. Vectored Interrupt Controller (VIC) with configurable priorities and vector addresses.
3. Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.
4. Up to 21 external interrupt pins available.
5. 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 μs.
6. On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz.
7. Power saving modes include Idle and Power-down.
8. Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
9. Processor wake-up from Power-down mode via external interrupt or BOD.
10. Single power supply chip with POR and BOD circuits:
11. CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads.



DB9 CONNECTOR:

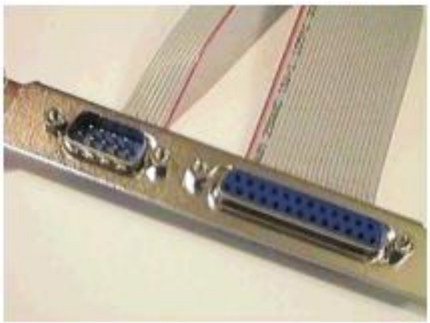
The D-subminiature or D-sub is a common type of electrical connector used particularly in computers. Calling them "subminiature" was appropriate when they were first introduced, but today they are among the largest common connectors used with computers.
The widest application of D-subs is for RS-232 serial communications, though the standard did not make this connector mandatory. RS-232 devices originally used the DB25 25-pin D-sub, but for many applications the less common signals were omitted, allowing a DE9 9-pin D-sub to be used. The standard indicates a male connector for terminal equipment and a female connector for modems, but many variations exist. IBM PC compatible computers tend to have male connectors at the device, while modems have female connectors.

On PCs, 9-pin and 25-pin plugs are used for the RS-232 (serial) ports and 25-pin sockets are used for the (parallel) printer ports (instead of the Centronics socket found on the printer itself). 25-pin sockets on Macintosh computers are typically SCSI connectors (again in contrast to the Centronics C50 connector typically found on the peripheral).

A male DE9 connector on the back of an IBM-PC-compatible computer is typically a serial port connector. IBM introduced the DE9 connector for RS-232 on PCs with the Personal Computer AT in 1984. A female 9-pin connector on the same computer may be a video display output: monochrome, CGA, or EGA. Even though these all use the same connector, the displays cannot all be interchanged and monitors or video interfaces may even be damaged if connected to an incompatible device using the same connector. Later analog video (VGA and later) adapters replaced these connectors by DE15 15-pin high-density sockets, which have three rows of five contacts each in the space that was previously occupied by two rows of contacts, five in the top row and four in the bottom row. Other common names for DE15 connectors are

HD15, where HD stands for High Density, and (less accurately) DB15 and DB15HD.

From the late 1970s and all through the '80s, DE9s without the pair of fastening screws were used as game controller connectors in a variety of video game consoles and home computers, quite possibly due to the success of the revolutionary Atari 2600 game console that used them. Computer systems using them included the Atari 8-bit and ST lines; the Commodore VIC-20, 64, 128, and Amiga; the Amstrad; the SEGA Master System and Genesis. The Sinclair ZX Spectrum, which did not have a built in joystick connector of any kind, was commonly used with adapters for DE9 joysticks. They were not used in the Apple and PC systems, nor in most newer game consoles. Wired in the standard way, they supported one digital (3 positions x 2 axes, 1 button) joystick or one pair of analog paddles; on many systems a computer mouse or a light pen was also supported through these sockets, however these mice were not usually interchangeable between different systems.
DA15S connectors are used for PC joystick connectors, where each DA15 connector supports two joysticks each with two analog axes and two buttons. In other words, one DA15S "game adapter" connector has 4 analog potentiometer inputs and 4 digital switch inputs. This interface is strictly input-only, though it does provide +5V DC power. Some joysticks with more than two axes and/or more than two buttons use the signals designated for both joysticks. Conversely, Y-adapter cables are available that allow two separate joysticks to be connected to a single DA15 game adapter port; if a joystick connected to one of these Y-adapters has more than two axes or buttons, only the first two of each will work. The IBM DA15 PC game connector has been modified to add a (usually MPU-401 compatible) MIDI interface, and this is often implemented in the game connectors on third-party sound cards, particularly the Sound Blaster line from Creative Labs. The "standard" straight game adapter connector (introduced by IBM) has three ground pins and four +5V power pins, and the MIDI adaptation replaces one of the grounds and one of the +5V pins, both on the bottom row of pins, with MIDI In and MIDI Out signal pins. (There is no MIDI Thru provided.)



RS232 CABLE:

To allow compatibility among data communication equipment, an interfacing standard called RS232 is used. Since the standard was set long before the advent of the TTL logic family, its input and output voltage levels are not TTL compatible. For this reason, to connect any RS232 to a microcontroller system, voltage converters such as MAX232 are used to convert the TTL logic levels to the RS232 voltage levels and vice versa.

MAX 232:

Max232 IC is a specialized circuit which makes standard voltages as required by RS232 standards. This IC provides best noise rejection and very reliable against discharges and short circuits. MAX232 IC chips are commonly referred to as line drivers.
To ensure data transfer between PC and microcontroller, the baud rate and voltage levels of Microcontroller and PC should be the same. The voltage levels of microcontroller are logic1 and logic 0 i.e., logic 1 is +5V and logic 0 is 0V. But for PC, RS232 voltage levels are considered and they are: logic 1 is taken as -3V to -25V and logic 0 as +3V to +25V. So, in order to equal these voltage levels, MAX232 IC is used. Thus this IC converts RS232 voltage levels to microcontroller voltage levels and vice versa.

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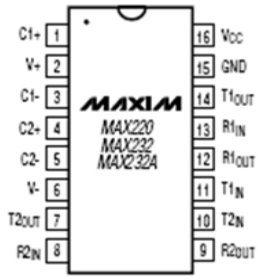
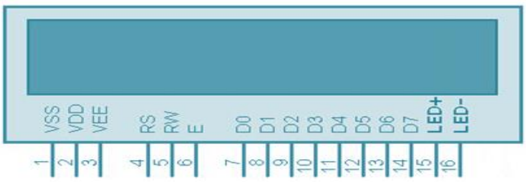


Fig: Pin diagram of MAX 232 IC

LCD (Liquid Crystal Display):

Liquid Crystal Display also called as LCD is very helpful in providing user interface as well as for debugging purpose. The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780 controllers.

Pin Description



Pin No.	Name	Description
1	VSS	Power supply (GND)
2	VCC	Power supply (+5V)
3	VEE	Contrast adjust
4	RS	0 = Instruction input 1 = Data input
5	R/W	0 = Write to LCD module 1 = Read from LCD module
6	EN	Enable signal
7	D0	Data bus line 0 (LSB)
8	D1	Data bus line 1
9	D2	Data bus line 2
10	D3	Data bus line 3
11	D4	Data bus line 4
12	D5	Data bus line 5
13	D6	Data bus line 6
14	D7	Data bus line 7 (MSB)
15	LED+	Back Light VCC
16	LED-	Back Light GND

DDRAM - Display Data RAM

Display data RAM (DDRAM) stores display data represented in 8-bit character codes. Its extended capacity is 80 X 8 bits, or 80 characters. The area in display data RAM (DDRAM) that is not used for display can be used as general data RAM. So whatever you send on the DDRAM is actually displayed on the LCD. For LCDs like 1x16, only 16 characters are visible, so whatever you write after 16 chars is written in DDRAM but is not visible to the user.

CGROM - Character Generator ROM

Now you might be thinking that when you send an ASCII value to DDRAM, how the character is displayed on LCD? So the answer is CGROM. The character generator ROM generates 5 x 8 dot or 5 x 10 dot character patterns from 8-bit character codes. It can generate 208 5 x 8 dot character patterns and 32 5 x 10 dot character patterns.

CGRAM - Character Generator RAM

As clear from the name, CGRAM area is used to create custom characters in LCD. In the character generator RAM, the user can rewrite character patterns by program. For 5 x 8 dots, eight character patterns can be written, and for 5 x 10 dots, four character patterns can be written.

BF - Busy Flag

Busy Flag is a status indicator flag for LCD. When we send a command or data to the LCD for processing, this flag is set (i.e. BF =1) and as soon as the instruction is executed successfully this flag is cleared (BF = 0). This is helpful in producing and exact amount of delay for the LCD processing.

To read Busy Flag, the condition RS = 0 and R/W = 1 must be met and The MSB of the LCD data bus (D7) act as busy flag. When BF = 1 means LCD is busy and will not accept next command or data and BF = 0 means LCD is ready for the next command or data to process.

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Instruction Register (IR) and Data Register (DR)

There are two 8-bit registers in HD44780 controller Instruction and Data register. Instruction register corresponds to the register where you send commands to LCD e.g. LCD shift command, LCD clear, LCD address etc. and Data register is used for storing data which is to be displayed on LCD.

When send the enable signal of the LCD is asserted, the data on the pins is latched in to the data register and data is then moved automatically to the DDRAM and hence is displayed on the LCD. Data Register is not only used for sending data to DDRAM but also for CGRAM, the address where you want to send the data, is decided by the instruction you send to LCD.

Commands and Instruction set

Only the instruction register (IR) and the data register (DR) of the LCD can be controlled by the MCU. Before starting the internal operation of the LCD, control information is temporarily stored into these registers to allow interfacing with various MCUs, which operate at different speeds, or various peripheral control devices.

The internal operation of the LCD is determined by signals sent from the MCU. These signals, which include register selection signal (RS), read/write signal (R/W), and the data bus (DB0 to DB7), make up the LCD instructions (Table 3). There are four categories of instructions that:

- Designate LCD functions, such as display format, data length, etc.
- Set internal RAM addresses
- Perform data transfer with internal RAM
- Perform miscellaneous functions

Although looking at the table you can make your own commands and test them. Below is a brief list of useful commands which are used frequently while working on the LCD.

No.	Instruction	Hex	Decimal
1	Function Set: 8-bit, 1 Line, 5x7 Dots	0x30	48
2	Function Set: 8-bit, 2 Line, 5x7 Dots	0x38	56
3	Function Set: 4-bit, 1 Line, 5x7 Dots	0x20	32
4	Function Set: 4-bit, 2 Line, 5x7 Dots	0x28	40
5	Entry Mode	0x06	6
6	Display off Cursor off (clearing display without clearing DDRAM content)	0x08	8
7	Display on Cursor on	0x0E	14
8	Display on Cursor off	0x0C	12
9	Display on Cursor blinking	0x0F	15
10	Shift entire display left	0x18	24
12	Shift entire display right	0x1C	30
13	Move cursor left by one character	0x10	16
14	Move cursor right by one character	0x14	20
15	Clear Display (also clear DDRAM content)	0x01	1
16	Set DDRAM address or cursor position on display	0x80+add	128+add
17	Set CGRAM address or set pointer to CGRAM location	0x40+add	64+add

Sending Commands to LCD

To send commands we simply need to select the command register. Everything is same as we have done in the initialization routine. But we will summarize the common steps and put them in a single subroutine. Following are the steps:

- Move data to LCD port
- Select command register
- Select write operation
- Send enable signal
- Wait for LCD to process the command

Sending Data to LCD

To send data we simply need to select the data register. Everything is same as the command routine. Following are the steps:

- Move data to LCD port
- Select data register select write operation

KEIL SOFTWARE PROGRAMING PROCEDURE

Keil compiler is software used where the machine language code is written and compiled. After compilation, the machine source code is converted into hex code which is to be dumped into the microcontroller for further processing. Keil compiler also supports C language code.

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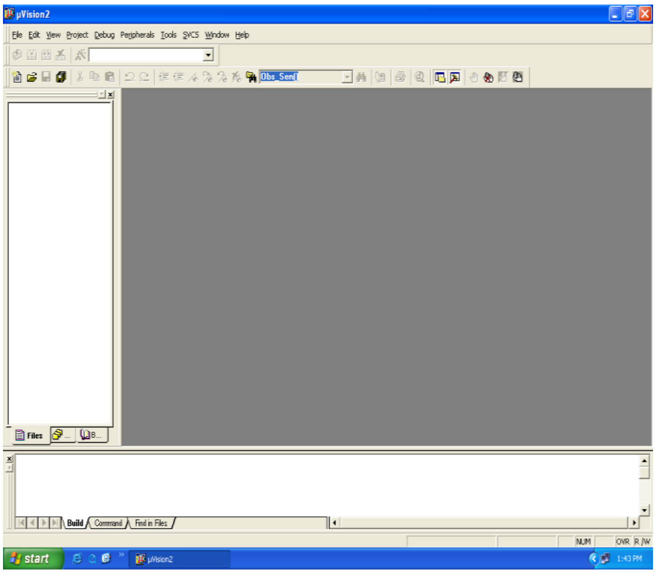
How to write Embedded C Program in Keil Software.

Procedure Steps

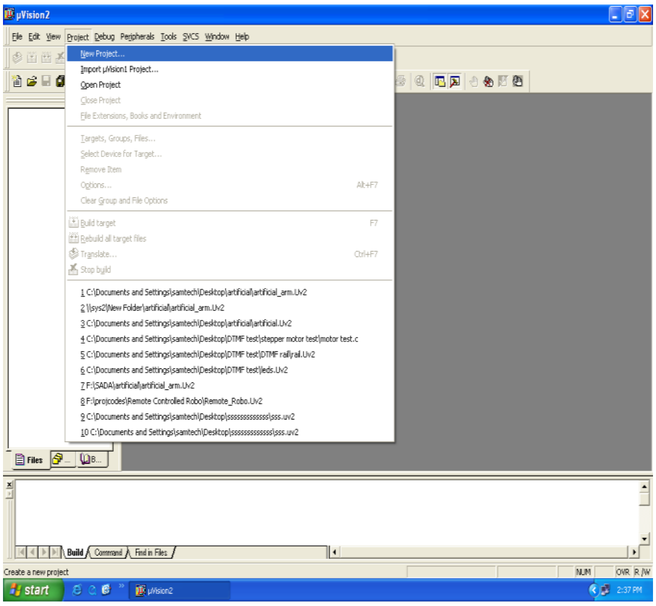
Step-1:

Install Keil MicroVision-2 in your PC, Then after Click on that "Keil UVision-2" icon. After opening the window go to toolbar and select Project Tab then close previous project.



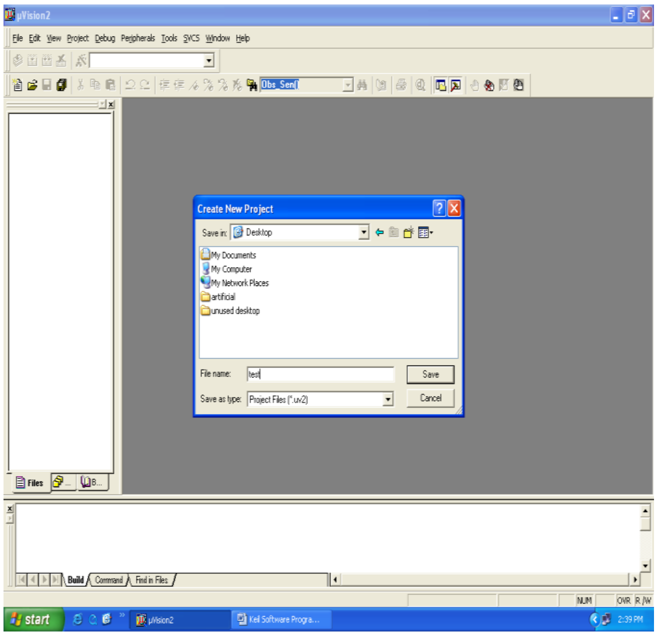
Step-2:

Next select New Project from Project Tab.



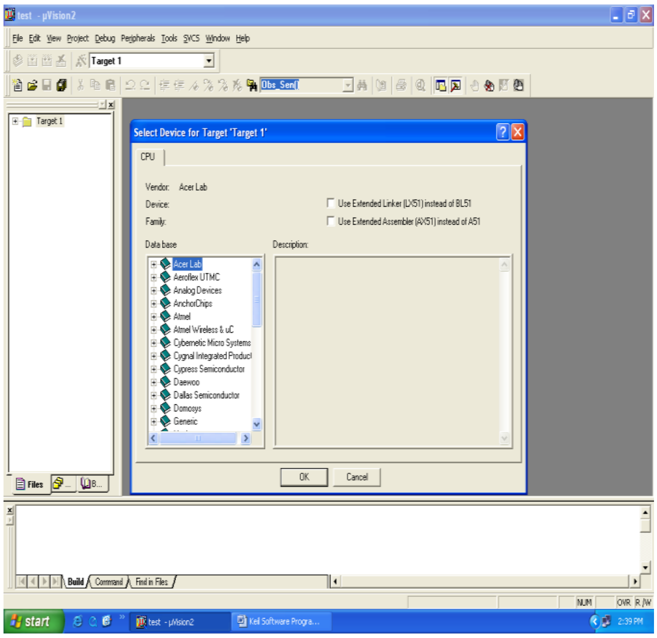
Step-3:

Then it will open "Create New Project" window. Select the path where you want to save project and edit project name.



Step-4:

Next it opens "Select Device for Target" window, It shows list of companies and here you can select the device manufacturer company.



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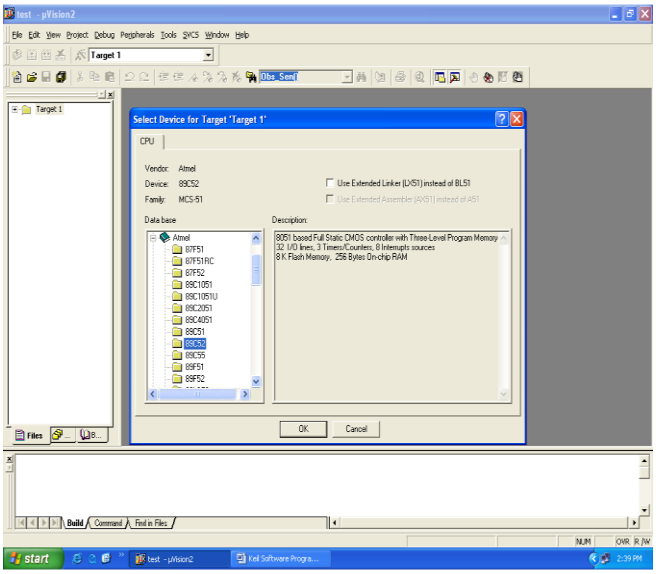
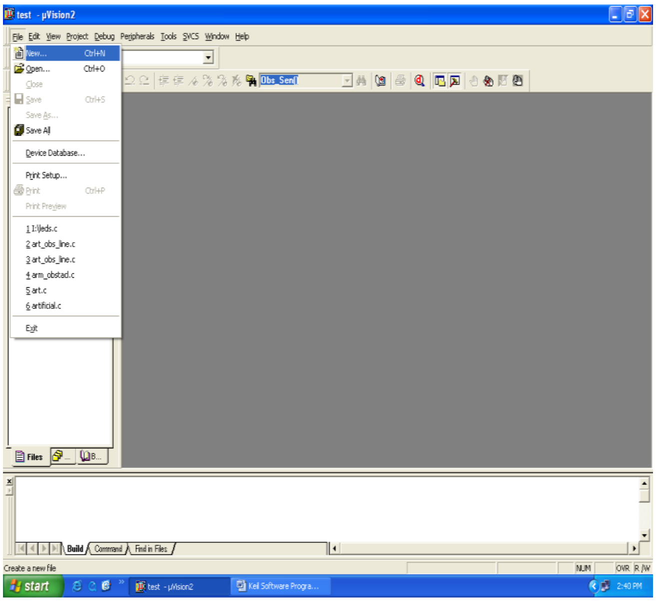
Step-5:

For an example, for your project purpose you can select the chip as 89c51/52 from Atmel Group. Next Click OK Button, it appears empty window here you can observe left side a small window i.e, "Project Window". Next create a new file.



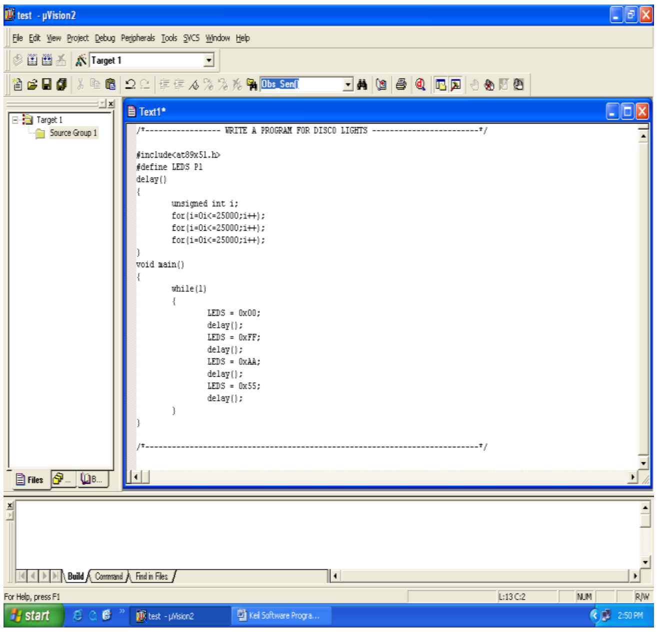
Step-6:

From the Main tool bar Menu select "File" Tab and go to New, then it will open a window, there you can edit the program.



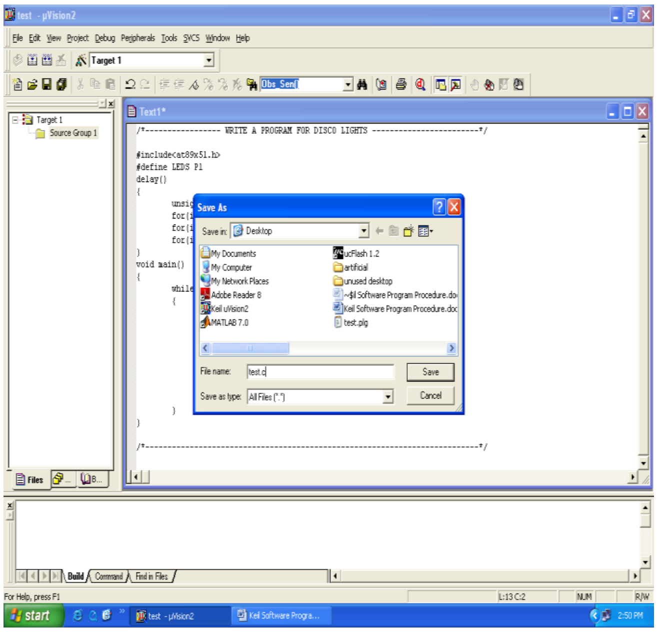
Step-7:

Here you can edit the program as which language will you prefer either Assembly or C.



Step-8:

After editing the program save the file with extension as ".c" or ".asm", if you write a program in Assembly Language save as ".asm" or if you write a program in C Language save as ".c" in the selected path. Take an example and save the file as "test.c".



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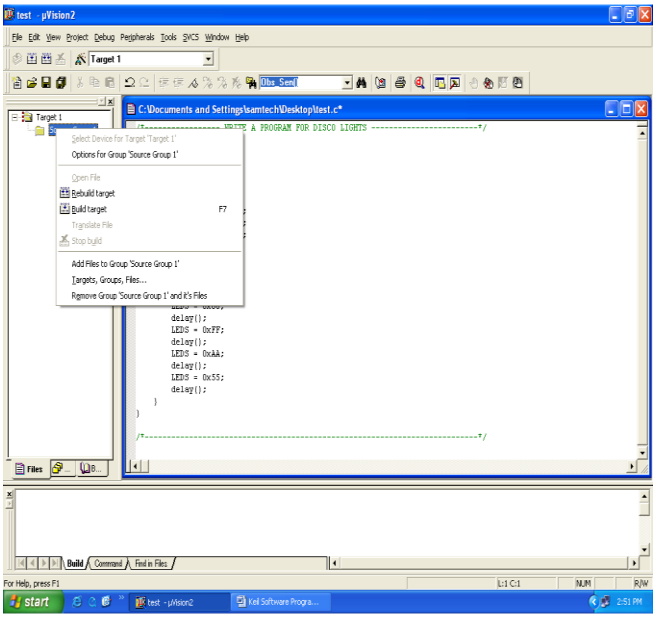
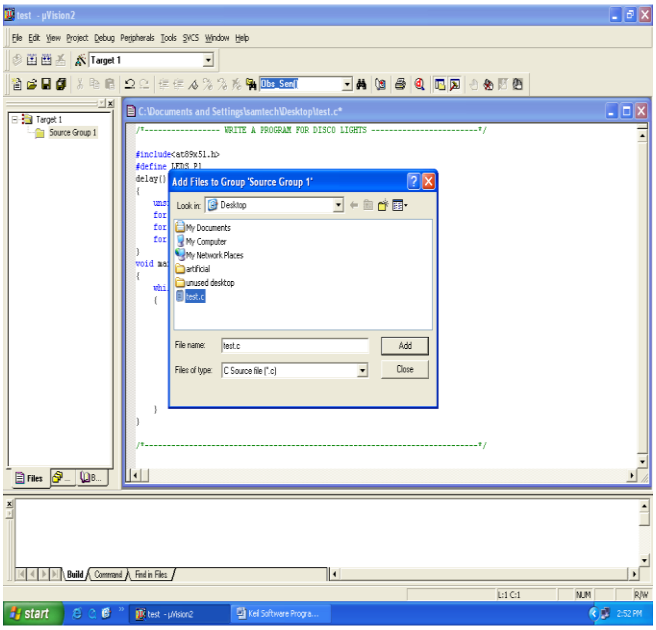
Step-9:

Then after saving the file, compile the program. For compilation go to project window select "source group" and right click on that and go to "Add files to Group".



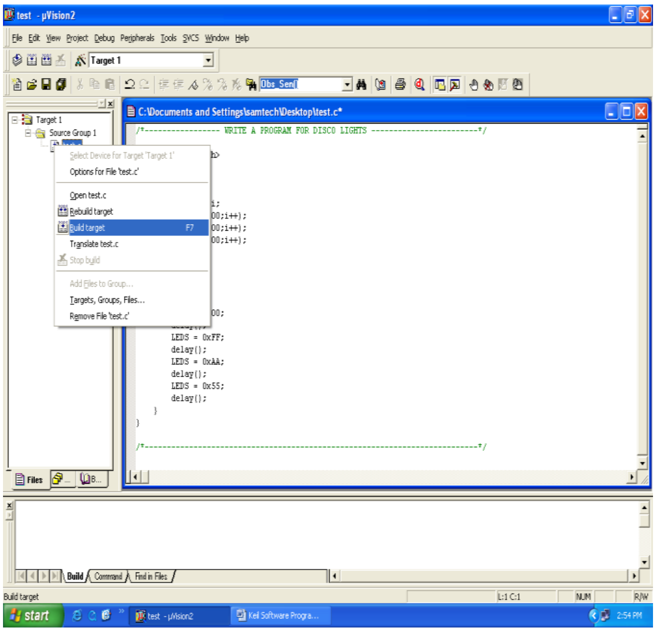
Step-9:

Here it will ask which file has to Add. For an example here you can add "test.c" as you saved before.



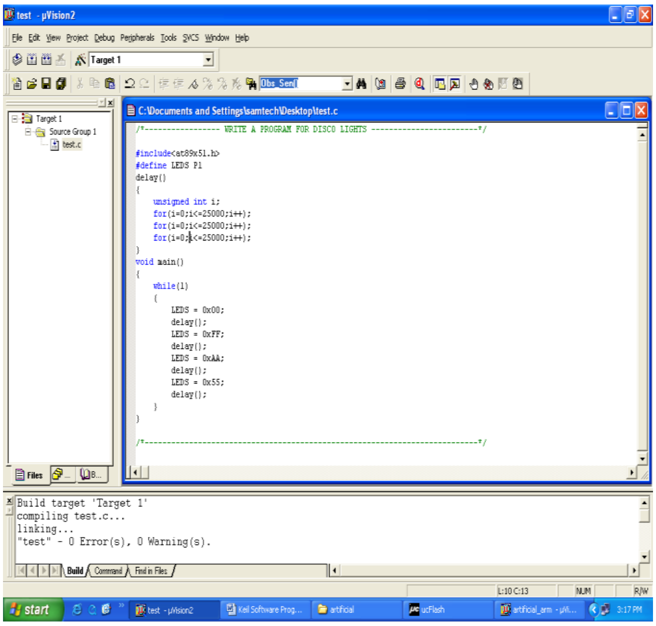
Step-9:

After adding the file, again go to Project Window and right click on your "c file" then select "Build target" for compilation. If there is any "Errors or Warnings" in your program you can check in "Output Window" that is shown bottom of the Keil window.



Step-10:

Here in this step you can observe the output window for "errors and warnings".



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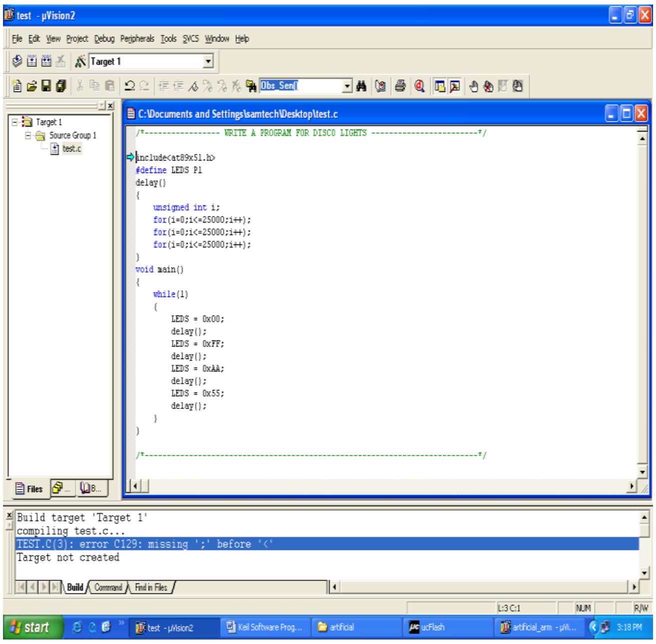
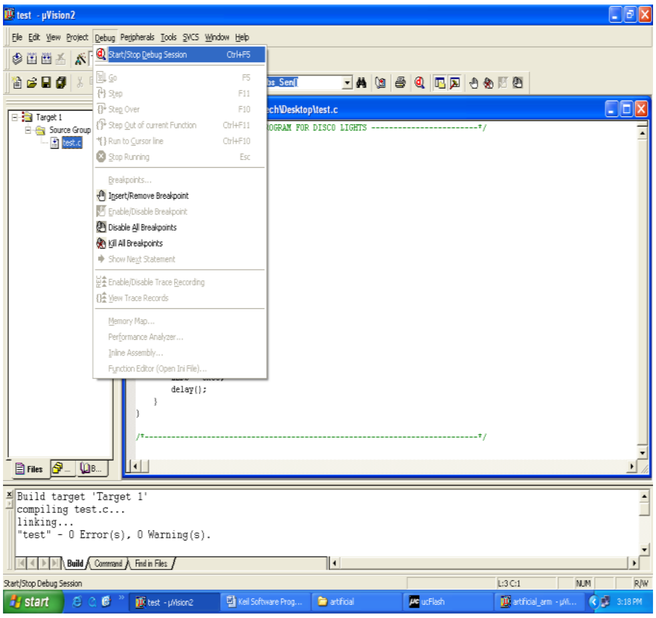
Step-11:

If you make any mistake in your program you can check in this slide for which error and where the error is by clicking on that error.



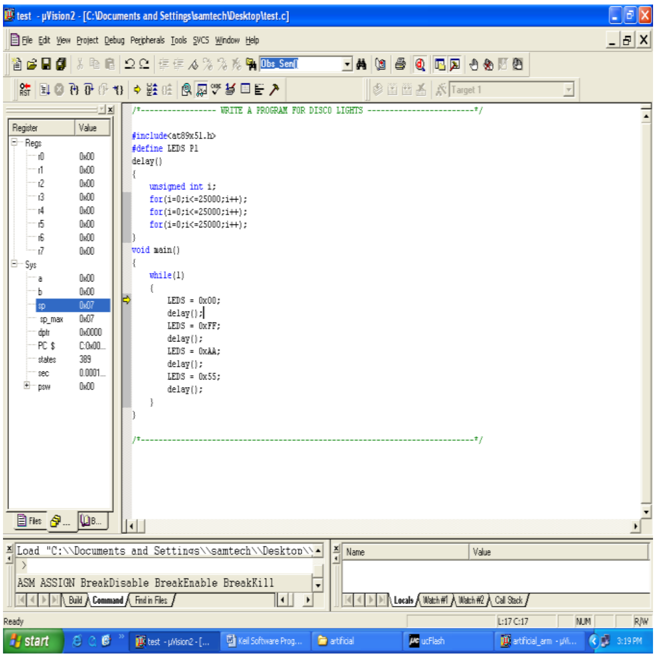
Step-12:

After compilation then next go to Debug Session. In Tool Bar menu go to "Debug" tab and select "Start/Stop Debug Session".



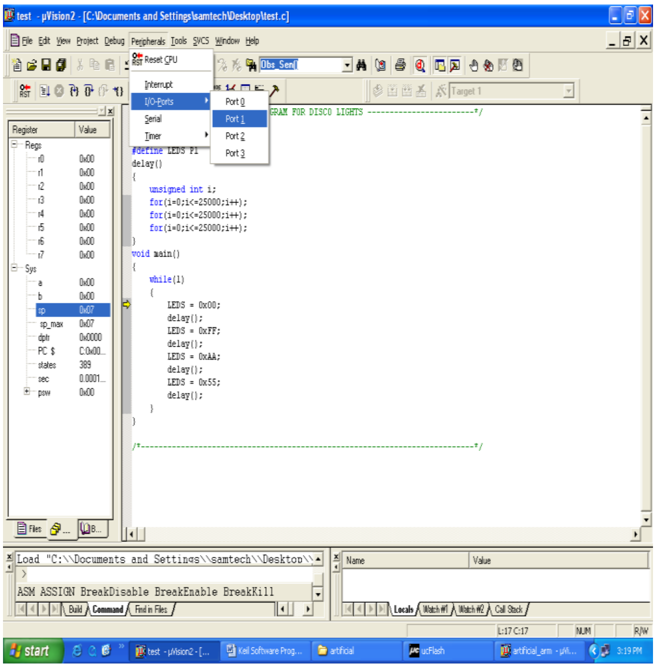
Step-13:

Here a simple program for "Leds Blinking". LEDS are connected to PORT-1. you can observe the output in that port.



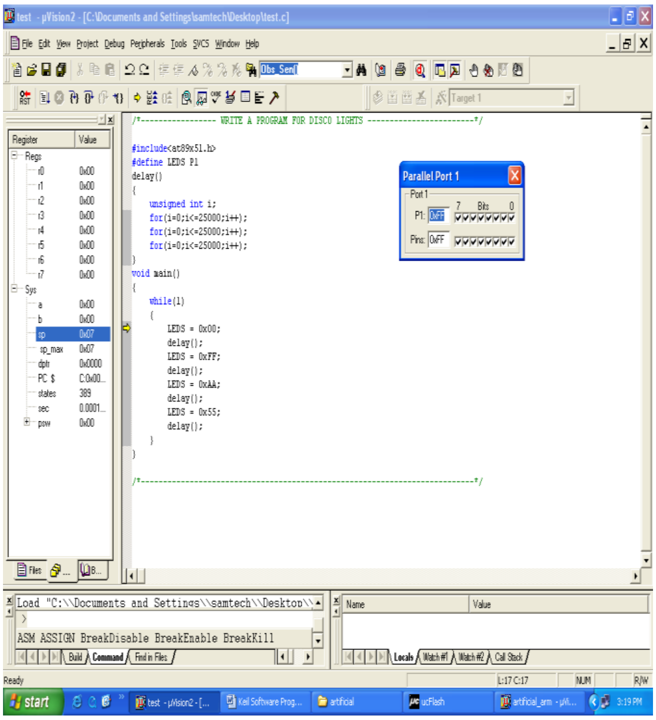
Step-14:

To see the Ports and other Peripheral Features go to main toolbar menu and select peripherals.



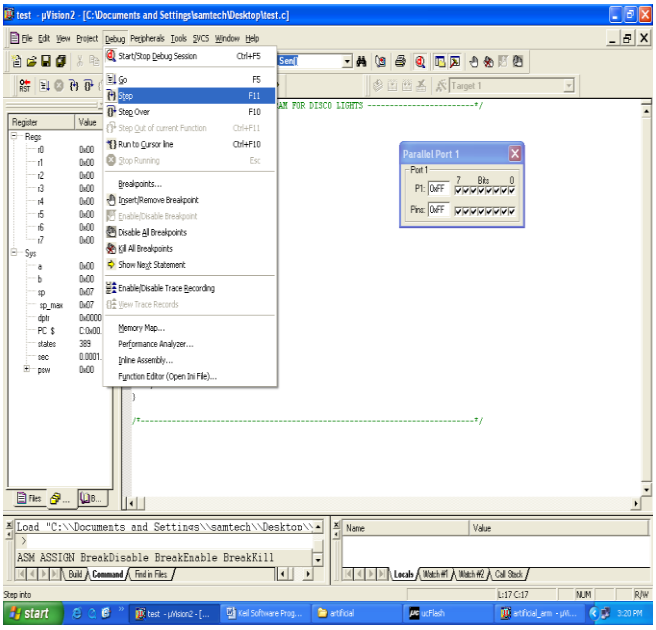
Step-15:

In this slide see the selected port i.e, PORT-1.



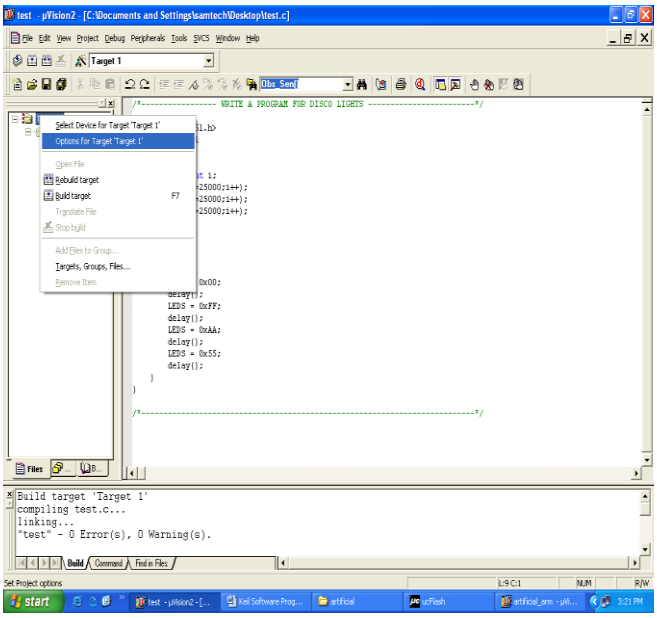
Step-16:

Start to trace the program in sequence manner i.e, step by step execution and observe the output in port window.



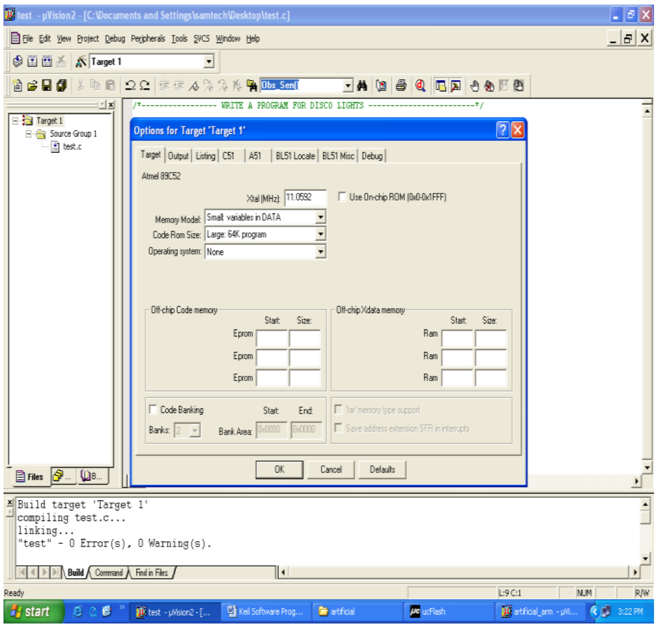
Step-17:

After completion of Debug Session Create an Hex file for Burning the Processor. Here to create an Hex file go to project window and right click on Target next select “Option for Target”.



Step-18:

It appears one window; here in “target tab” modify the crystal frequency as you connected to your microcontroller.



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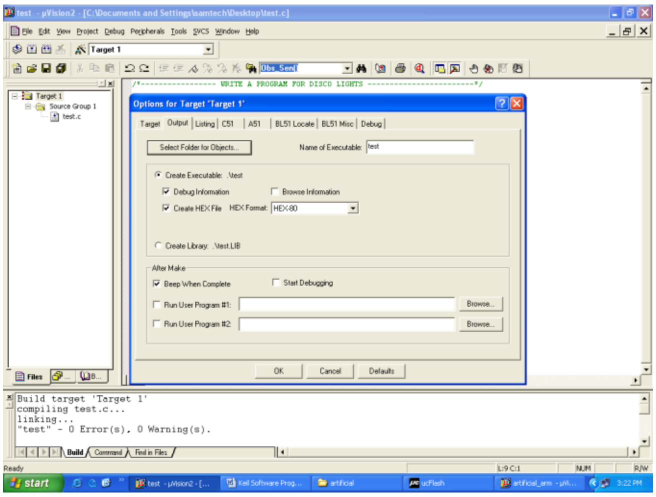
Step-19:

Next go to "Output' tab. In that Output tab click on "Create HEX File" and then click OK.



CONCLUSION

The web based data centre monitoring and alerting system is discussed in this paper. The system fulfills many of the basic requirements of the data centre monitoring like to report cooling system malfunctioning, alerting, temperature and humidity monitoring etc. It also provides dedicated web GUT which the administrators can use to effectively monitor their data centres. The software can also be improved to support monitoring multiple data centres. The system can further improved by controlling the cooling system instead of alerting. But for already deployed systems this may not feasible because of proprietary nature of the controlling protocol. Future systems can be designed as wireless controllable cooling systems.

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