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Wireless Infrared Remote Controller for Multiple Home Appliances

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Abstract: **The infrared (IR) remote control devices are used to operate in the most of modern household applications, such as television, DVDs, Set top box, Home theatre And Air conditioner etc. With the development of the society and smart home, there are more and more home appliances and more infrared remote control devices used to operate them. A single IR remote controller can't be used to manipulate the different kinds of home appliances; as they are not compatible which leads to the wastage of resources. This paper proposes an application and design of single-chip microcontroller based IR remote system, which can control multiple devices, code and decode all of the infrared remote control protocol, and integrate with the transmission and receiver. The remote can operate over range of 15 ft, easy to use, and also reliable. This new universal remote replaces over 2000 codes from different "world famous" brands of TV, DVD player, satellite receiver and air conditioners. Main objective of this work is to create a complete and functional product, starting from scratch. A single IR remote control is developed for controlling several home appliances like Television, DVD, Set top box, Home theatre and Air Conditioner. This includes several programming features.**

Keywords: **Remote Controller Unit (RCU), Microcontroller (MC), Programming Features.**

1. INTRODUCTION

In most of consumer and entertainment Electronic equipments, from camcorders to stereo equipment, an infrared remote control is usually always included. Video and audio apparatus, computers and also lighting installations nowadays often operate on infrared remote control. The carrier frequency of such infrared signals is typically in the order of 36k Hz. The control codes are sent in serial format modulated to that 36k Hz carrier frequency (usually by turning the carrier on and off). There are many different coding systems in use, and generally different manufacturers use different codes and different data rates for transmission.

"IR" stands for infrared. Infrared light is invisible since its frequency is below that of visible red. Otherwise, it is like any other light source, operating under the same laws of physics. In most cases, the IR signals are produced by an LED source.

TV remotes sent commands only in one way, in a low-speed burst for distances of up to 30 feet. They use directed IR with LEDs that have a moderate cone angle to improve ease-of-use characteristics. The IR signal sent out by those devices is generally modulated to around 38k Hz carrier using amplitude shift keying (carrier on or off). The data rate send is generally in range of 100-2000bps. There are some IR systems which use other frequencies and other modulation systems.

IR transmit and receive systems are inexpensive and are generally reliable. However, interference from other IR sources can be a minor issue. Interference can come from IR remote controls, IR audio systems (these broadcast an IR signal continuously) or other IR sources. Interference can also be caused by other light sources such as fluorescent lights (the ballast can cause IR interference). Sometimes some electronic ballasts powered light can cause interference problems. In order to avoid any interference with this kind of equipment, the operating frequency of all electronic ballasts has to be chosen so that problems in the 36k Hz frequency area are out of the question.

Many existing IR systems modulate the IR light at around 36-40k Hz (this is the frequency of the IR carrier and should not to be confused with the actual frequency of the IR light itself). The possibility of interference is more likely around the 40k Hz frequencies. One way to limit interference is to use higher IR carrier frequencies. Some IR systems now use carrier frequencies into the megahertz region.

Generally infrared remote controls are a 32-40k Hz modulated square wave for communication. This square wave is then send to IR transmitter (IR LED). The carried frequency is amplitude modulated by the data, usually full on/off type modulation. The data rate is typically in 50-1000 bit/s range depending on the system used. Usually the transmitter part is constructed so that the transmitter oscillator, which is driving the infrared transmitter LED, can be turned on/off by applying a TTL voltage on the modulation control input (the signal that goes here is usually serial data from remote control keyboard decoding IC).

On the receiver side a photodiode takes up the signal. The integrated circuit inside a typical receiving chip is sensitive only around a specific frequency in the 32-40k Hz range. The output is the demodulated digital input, just what was used to drive the transmitter. The output is the demodulated digital input, just what was used to drive the transmitter. Usually this kind of receivers work so that when IR the carrier is present, this output is high. When no carrier is detected, the output is low. This type of circuits can usually transmit a 1-3k Hz digital signal through infra light. When trying to receive IR signals, leave demodulation to one of the special IC's/modules meant for this and deal with the data only.

The free air IR data transmission, IR remote control as well as the most optoelectronic sensors and light barrier systems work with a wavelength between 870nm and 950nm.

The system described above is not the only one IR remote system in use, it is just the most commonly used one. A system that use unmodulated signals of a 1k Hz or 100k Hz (and several other frequencies) exist as well.

2. BASICS OF IR TRANSMITTER AND RECEIVER

2.1 IR Remote Control Theory

The cheapest way to remotely control a device within a visible range is via Infrared light. Almost all-audio and video equipment can be controlled this way nowadays. Due to this wide spread use the required components are quite cheap, thus making it ideal for us hobbyists to use IR control for our own projects. This part of my knowledge base will explain the theory of operation of IR remote control, and some of the protocols that are in use in consumer electronics.

2.2 Infra-Red Light

Infrared actually is normal light with particular colors. Humans can't see these colors because its wavelength of 950nm is below the visible spectrum. That's one of the reasons why IR is chosen for remote control purposes, we want to use it but we're not interested in seeing it. Another reason is because IR LEDs are quite easy to make, and therefore can be very cheap. Although humans can't see the Infrared light emitted from a remote control doesn't mean it can't make it visible. A video camera or digital photo camera can "see" the Infrared light as shown see in Figure 2.1. By using web cam, point a remote to it, press any button and see the LED flicker.

Unfortunately for us there are many more sources of infrared light. The sun is the brightest source of all, but there are many others, like: light bulbs, candles, central heating system, and even our body radiates infrared light. In fact everything that radiates heat, also radiates infrared light. Therefore we have to take some precautions to guarantee that our IR message gets across to the receiver without errors.

Figure 2.1: IR light emitted from a RC

2.3 Modulation

Modulation is the answer to make our signal stand out above the noise. With modulation we make the IR light source blink in a particular frequency. The IR receiver will be tuned to that frequency, so it can ignore everything else. You can think of this blinking as attracting the receiver's attention. We humans also notice the blinking of yellow lights at construction sites instantly, even in bright daylight.

In Figure 2.2, a modulated signal driving the IR LED of the transmitter on the left side. The detected signal is coming out of the receiver at the other side.

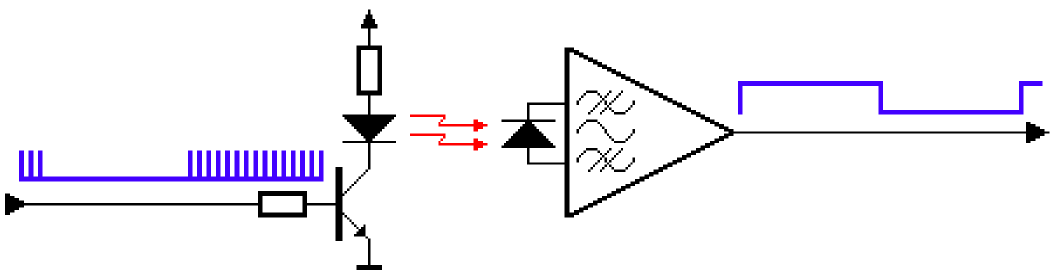


Figure.2.2: Signal modulation.

In serial communication we usually speak of 'marks' and 'spaces'. The 'space' is the default signal, which is the off state in the transmitter case. No light is emitted during the 'space' state. During the 'mark' state of the signal the IR light is pulsed on and off at a particular frequency. Frequencies between 30kHz and 60kHz are commonly used in consumer electronics. At the receiver side a 'space' is represented by a high level of the receiver's output. A 'mark' is then automatically represented by a low level. Note that the 'marks' and 'spaces' are not the 1-s and 0-s we want to transmit. The real relationship between the 'marks' and 'spaces' and the 1-s and 0-s depends on the protocol that's being used. More information about that can be found on the pages that describe the protocols.

2.4 Transmitter

The transmitter usually is a battery-powered handset. It should consume as little power as possible, and the IR signal should also be as strong as possible to achieve an acceptable control distance. Preferably it should be shock proof as well. Many chips are designed to be used as IR transmitters. The older chips were dedicated to only one of the many protocols that were invented. Nowadays very low power microcontrollers are used in IR transmitters for the simple reason that they are more flexible in their use. When no button is pressed they are in a very low power sleep mode, in which hardly any current is consumed. The processor wakes up to transmit the appropriate IR command only when a key is pressed.

The current through the LED (or LEDs) can vary from 100mA to well over 1A! In order to get an acceptable control distance the LED currents have to be as high as possible. A trade-off should be made between LED parameters, battery lifetime and maximum control distance. LED currents can be that high because the pulses driving the LEDs are very short. Average power dissipation of the LED should not exceed the maximum value though. You should also see to it that the maximum peek current for the LED is not exceeded. All these parameters can be found in the LED's data sheet. A simple transistor circuit, as shown in Figure 2.3, can be used to drive the LED. A transistor with a suitable HFE and switching speed should be selected for this purpose.

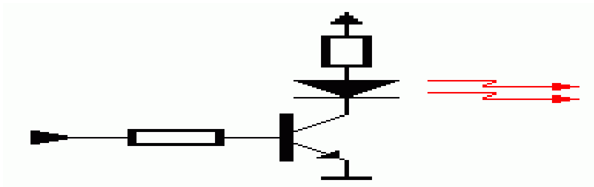


Figure.2.3: IR LED transistor circuit.

The resistor values can simply be calculated using Ohm's law. Remember that the nominal voltage drop over an IR LED is approximately 1.1V. The normal driver, described above, has one disadvantage. As the battery voltage drops, the current through the LED will decrease as well. This will result in a shorter control distance that can be covered. An emitter follower circuit can avoid this. The 2 diodes in series, as shown in Figure 2.4 will limit the pulses on the base of the transistor to 1.2V. The base-emitter voltage of the transistor subtracts 0.6V from that, resulting in a constant amplitude of 0.6V at the emitter. This constant amplitude across a constant resistor results in current pulses of a constant magnitude. Calculating the current through the LED is simply applying Ohm's law again.

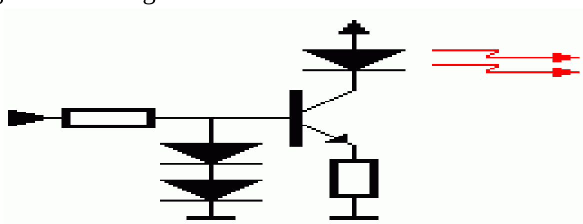


Figure.2.4: IR LED transistor circuit with two diodes in series.

3. DESIGN

The remote controller is based SAMSUNG-S3F80PB microcontroller. The programming is done in assembly language using openice compiler. The programming features of the remote controller implemented are as follows:

a. Direct code set up

If a valid code has been entered, the visible LED will blink twice. Upon entry of an invalid code there shall be one long blink. Upon entry of the invalid key sequence or invalid code remote control shall default to the previously programmed valid ID.

b. Software blink back

It helps to indicate the software stored in the RCU. When we enter the software blink back feature code it will blinks the LED number of times, by counting the LED blink we find the software number.

c. ID Lock and Unlock

It helps to lock and unlock the remote controller, here we are assigning some id number, when we enter that id number remote get lock and unlock. When ID lock is enabled into a specific Mode, software should block the all function from that Mode, if user attempts to use function under this condition the software will generate an error after the last key is pressed. If a function is in a specific Mode and then ID is locked to that Mode, the functions under that Mode should not be delete-able unless the ID Lock is unlocked.

d. Power Toggle

It mostly used to send power signals like power on or power off the devices. In india we are using off and on buttons, but in other countries we are using digit 1 for on the devices.

e. Back light enable and disable

In remote having some backlight LED, using this we are enabling and disabling the LED glowing.

f. Brand set enable and disable

It helps to select the different brand TV, DVD, VCR, Air conditioner codes from the respective brands, in RCU memory have set of brand sets and codes by enabling this feature we choose the code sets.

g. Factory test mode

In this mode remote controller test all the keys working properly, Press 1 and 3 simultaneously within 6 seconds of inserting batteries to enter the Factory Test Mode. Upon entering FTM, the CABLE LED will flash four times to indicate the remote is in the factory test mode. FTM should not be permitted by the software when a Low Voltage condition is encountered, the remote will generated a long blink (error blink).

h. Manufacturing reset

It helps to reset the all manufacturing codes and keep the flash memory as empty. Once the RCU will be under goes manufacturing reset RCU not work.

i. Operational reset

In this it reset the remote control unit and reset all previous and present operations, codes.

j. Mode mover

In this RCU having different modes for different devices, here it helps to shift mode from one mode to another mode to control devices.

k. Blink out

This is used to get feedback on the device code selected. The number of blinks after pressing each 1, 2, 3 and 4 keys is the 4 digit ID code set up for that mode. There is an approximate 0.5 seconds delay between each blink. There is an approximate 0.5 second time delay after each key press.

l. Volume lock and Unlock

The user can globally lock the volume controls to one source mode. When the Volume Lock feature is selected by the programmer, it will be stored in the FLASH so that it is retained permanently.

m. Channel lock and unlock

The unit shall blink two times upon being locked and blink 4 times when unlocked. The unit shall time out after 10 seconds during programming.

Releases the channel controls function to follow the mode selected. If no channel control keys exists for the current device it will follow the pick on the functional key-chart.

When the Channel Lock feature is selected by the programmer, it will be stored in the FLASH so that it is retained permanently.

n. Learning

To optimize success, the learning process should be conducted in an area where there is a low level of IR emission. High levels of “natural light” or energy efficient fluorescent lights could interfere with a learning event. The source and target (learner) remotes should be no more than 1 to 2 inches apart during a learning event and the IR LED of the two units should be aligned with each other.

3.2 Flowchart

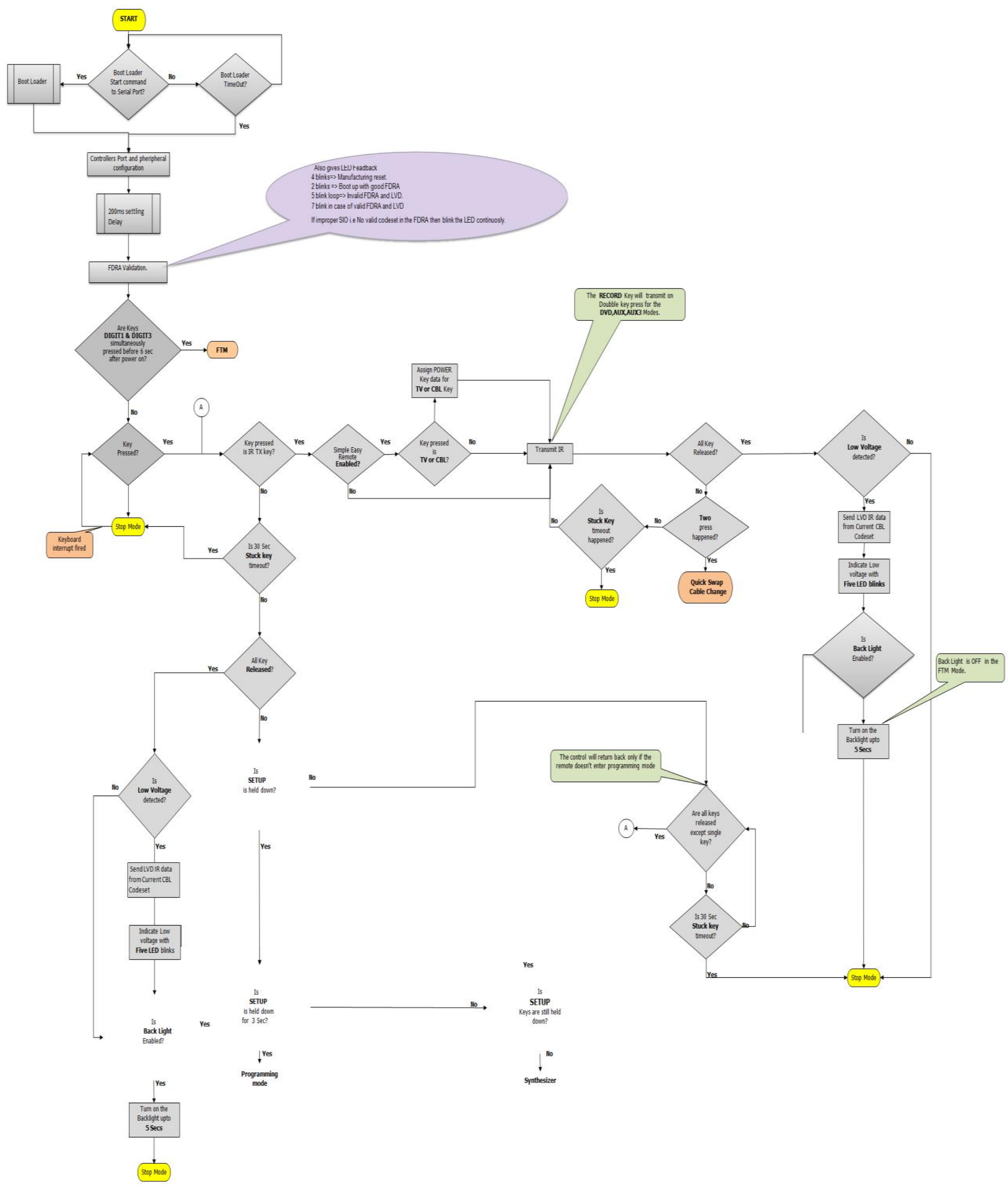


Figure.3.1: Flowchart for RCU

4. IMPLEMENTATION

We implement the remote controller and programming features listed above in two separate components of the system. The first component is the hardware involved in modifying devices to be able to operate. The second component is the software which involved in making such programming features possible and operates properly.

4.1 Block diagram

Figure.4.1 shows the block diagram of remote controller. It consists of microcontroller, 8*8 key pad, back light led's, mode led's and learning circuit. Details of pin configuration of the RCU is given in the fig 4.2

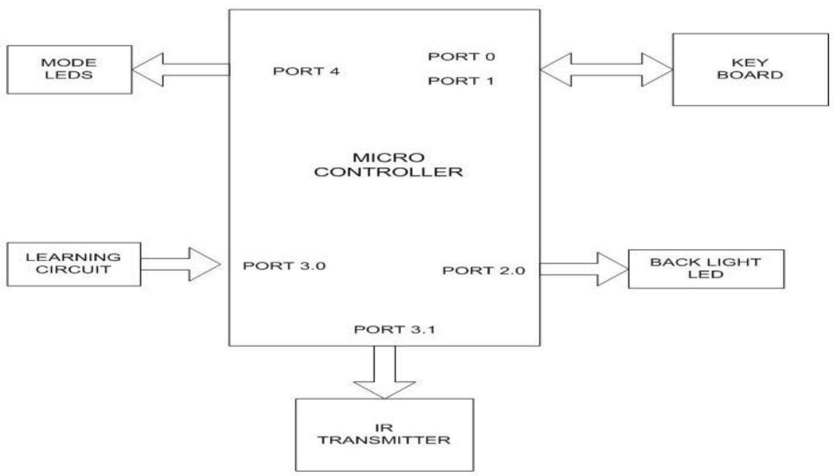


Figure.4.1: Remote controller unit

4.2 Hardware used

i. 66 Physical Keys, plus 1 logical (phantom) keys
ii. Universal Cable Library with Universal TV, VCR, DVD, PVR, AMP, Tuner library.
iii. 8 Red LED (under device keys)
iv. IR LED
v. Microcontroller Samsung S3F80PB 60K (5K Partition for memory retention, upgrade and learning)
vi. Product library
vii. 2AA-3V batteries, Alkaline for Back-Lit version , HD
viii. For regular units.

Circuit diagram

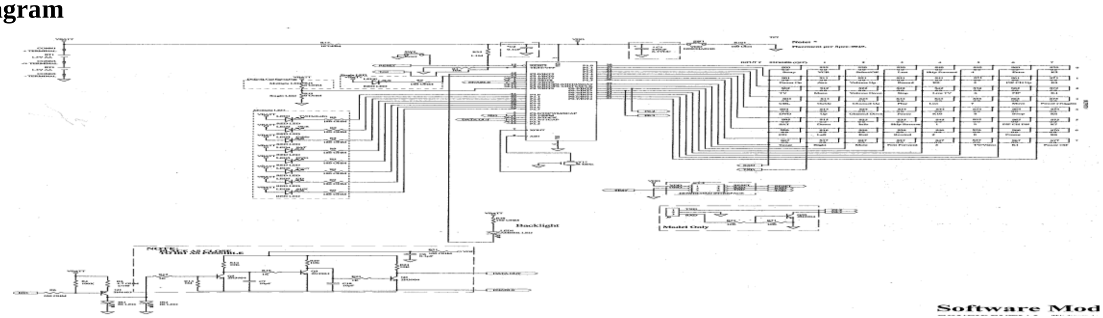


Figure.4.2: circuit diagram for RCU

4.2.1 Key board

The key board used to interfacing is a matrix keyboard. This key board is designed with a particular rows and columns. These rows and columns are connected to the microcontroller through its ports of the micro controller S3F80PB. Here normally use 8*8 matrix key board. So only two ports of microcontroller can be easily connected to the rows and columns of the key board. Whenever a key is pressed, a row and a column gets shorted through that pressed key and all the other keys are left open. When a key is pressed only a bit in the port goes high. Which indicates microcontroller that the key is pressed By this high on the bit key in the corresponding column is identified.

4.2.2 IR LED

An Infrared Emitter Diode is a Light Emitting Diode (LED) that produces a light in the infrared range. Although this light cannot be seen by humans, it can be detected by infrared sensors. A light emitting diode is a diode that produces a light of a certain frequency when current is passed through it. Like the diode, it will only conduct electricity in one direction. The negative side of an LED can be identified by its shorter leg and flat spot.

Figure.4.3. IR LED

4.2.3 Samsung S3F80PB Microcontroller

The S3F80PB single-chip CMOS microcontroller is fabricated using a highly advanced CMOS process and is based on Samsung's newest CPU architecture.
The S3F80PB is the microcontroller which has 60 K byte Flash Memory ROM.
Using a proven modular design approach, Samsung engineers developed S3F80PB by integrating the following peripheral modules with the powerful SAM8 RC core:

i. Internal LVD circuit and 16-bit programmable pins for external interrupts.
ii. One 8-bit basic timer for oscillation stabilization and watchdog function (system reset).
iii. One 8-bit Timer/counter with three operating modes.
iv. Two 16-bit timer/counters with selectable operating modes.
v. One 8-bit counter with auto-reload function and one-shot or repeat control.
vi.

Features

CPU

i. SAM8 RC CPU core

Memory

i. Program memory:
ii. 63 K byte Internal Flash Memory
iii. 10 years data retention
iv. Endurance: 10,000 Erase/Program cycles
v. Byte Programmable
vi. User programmable by "LDC" instruction
vii. Executable memory: 1 K byte RAM
viii. Data memory: 272 byte general purpose RAM

Instruction Set

i. 78 instructions

ii. IDLE and STOP instructions added for power-down modes

Instruction Execution Time

i. 500 ns at 8 MHz f OSC (minimum)

Interrupts

i. 24 interrupt sources with 18 vectors and 9 levels.

I/O Ports

i. Four 8-bit I/O ports (P0–P2, P4) and 6-bit port (P3) for a total of 38 bit-programmable pins. (44-QFP)

ii. Three 8-bit I/O ports (P0–P2) and one 2-bit I/O port (P3) for a total of 26-bit programmable pins. (32-SOP)

iii. Three 8-bit n-channel open-drain pins (P1, P2, P4) and one 2-bit n-channel open-drain pins(P3) (44-QFP)

iv. Two 8-bit n-channel open-drain pins (P1, P2) and one 2-bit n-channel open-drain pins(P3) (32-SOP)

Carrier Frequency Generator

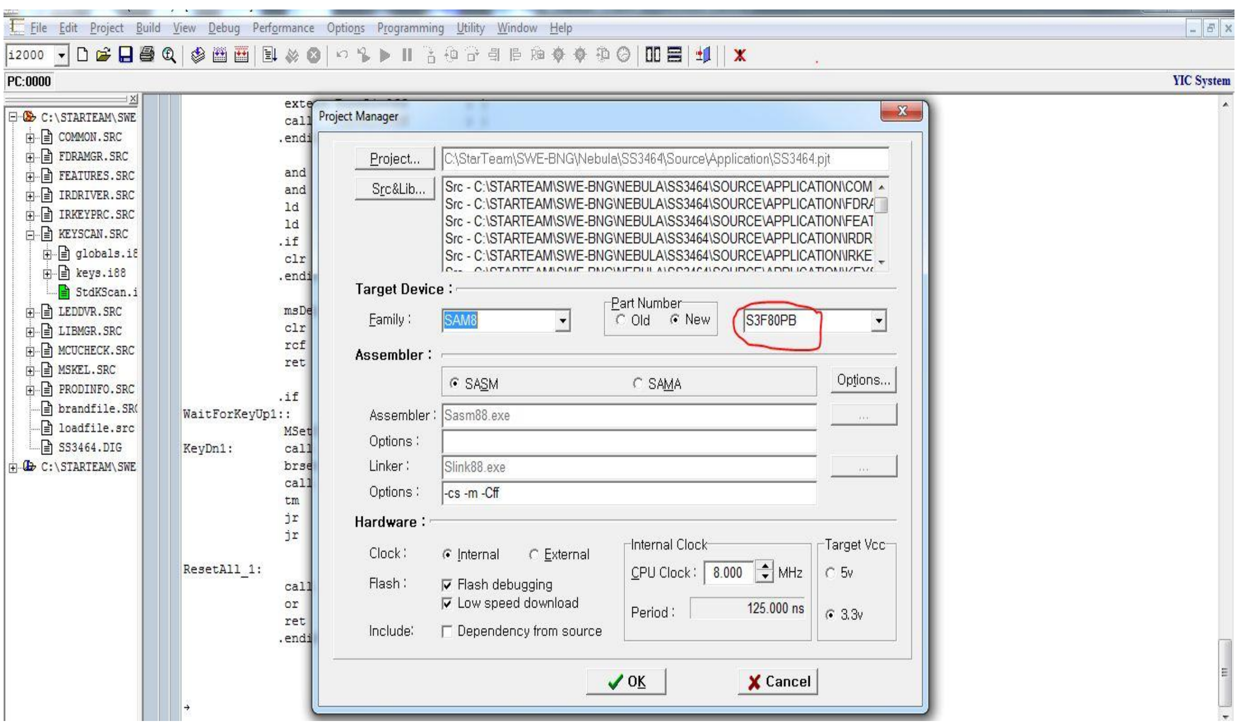
i. One 8-bit counter with auto-reload function and one-shot or repeat control (Counter A)

4.2.4 Product library

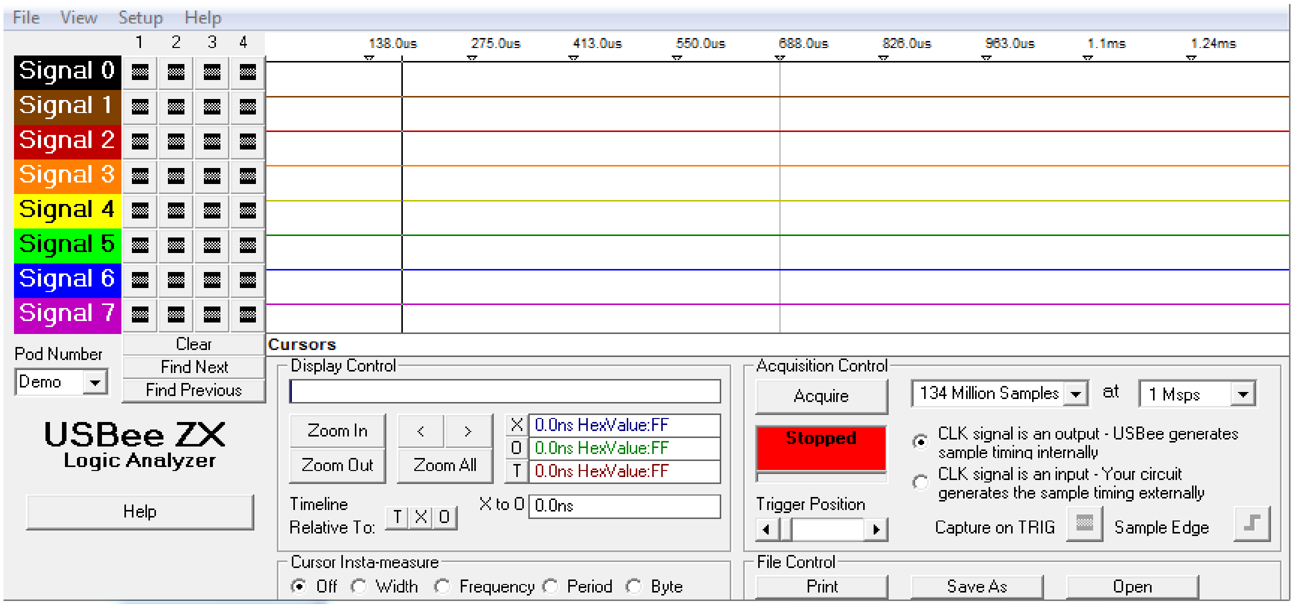
The library consists of a set of codes that represents various manufacturers whose IR waveforms for the supported equipment are included in the RAM. The waveforms are accessed by a combination of mode selection and load code. The hand held remote control shall have EIGHT physical modes –TV, CBL, DVD, AC, AUX, SAT, AUX2 and AUX3.

4.3 Software used

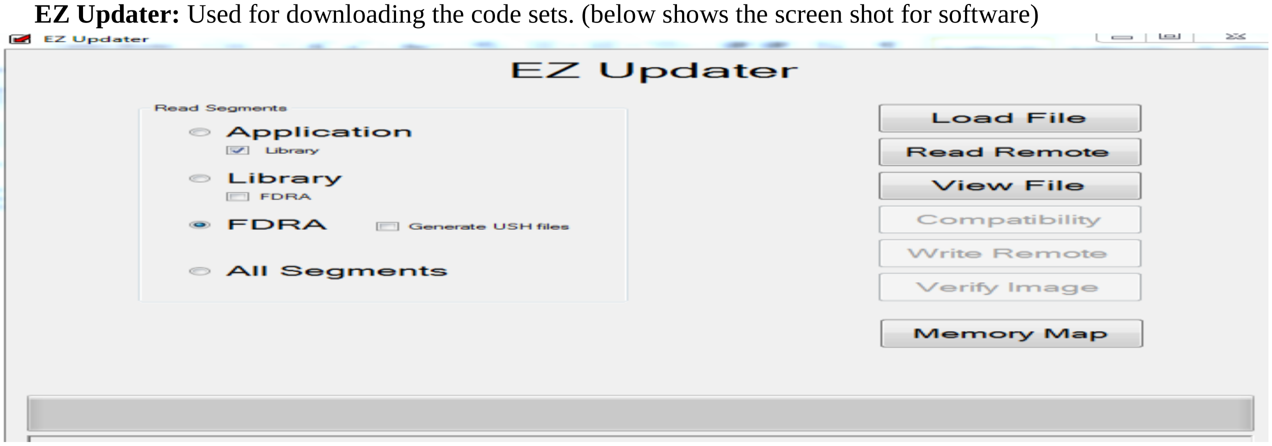
i. **Openice 2000**: This is IDE tool used for writing assembly code and executing codes, it convert assembly level code to equivalent hex code. (below shows the screen shot for software).



i. **Use Ax logic analyzer**: Used for checking blinking indication and number of frames transmitted in the signal. (below shows the screen shot for software)



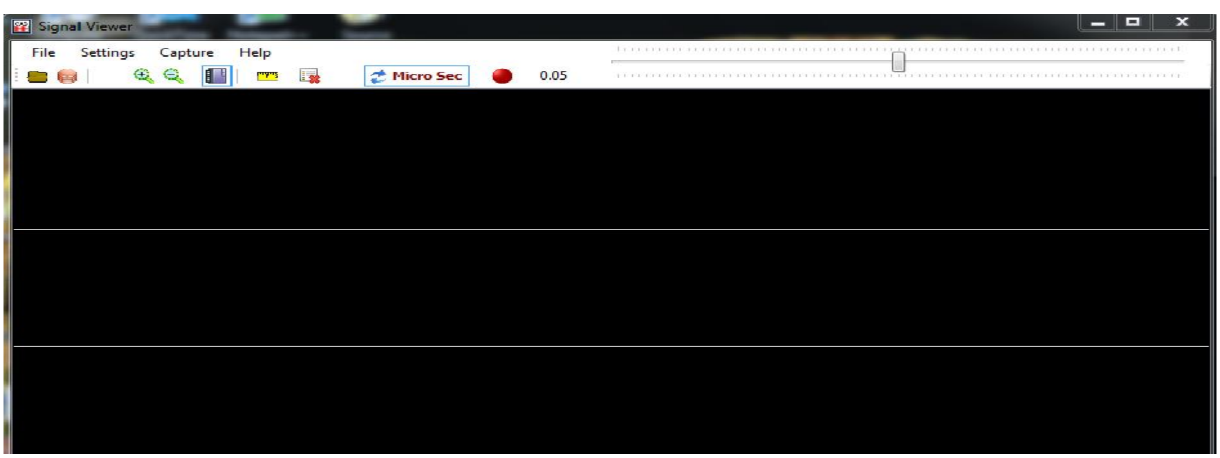
ii. **EZ Updater:** Used for downloading the code sets. (below shows the screen shot for software)



iii. **IR Mastro:** Used for verification of key data in a particular code set.

iv. **Image crafting** : Used for down loading the code sets from master data base which are not present in the remote.

v. **Signal viewer:** Used for verifying keys in the factory test mode using NEC protocol. (below shows the screen shot for software)



5. RESULT AND CONCLUSIONS

5.1 Result

The preliminary hardware test is done. Verification of key data in particular code set is done using IR Maestro, after pressing the key each key sends signals and that signals will be verified. Transmission of signal is verified using signal viewer. Programming features are developed .Result are verified.

5.2 Conclusion

Remote controller is one of the applications of electronics to increase the facilities of life. It gives one the ability to control multiple home appliances from a distance within the specification. Using this RCU we can control the multiple devices with extra added programming features. A single IR remote controller can be used to manipulate the different kinds of home appliances; as they are compatible which leads to the wastage of resources.

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