Department of Electrical Engineering, Syed Babar Ali School of Science and Engineering, Lahore University of Management Sciences, Pakistan

Course Project (EE-340 Devices and Electronics)

Design and Simulation Report

Appliance Control by demodulating and Decoding IR Remote Signals

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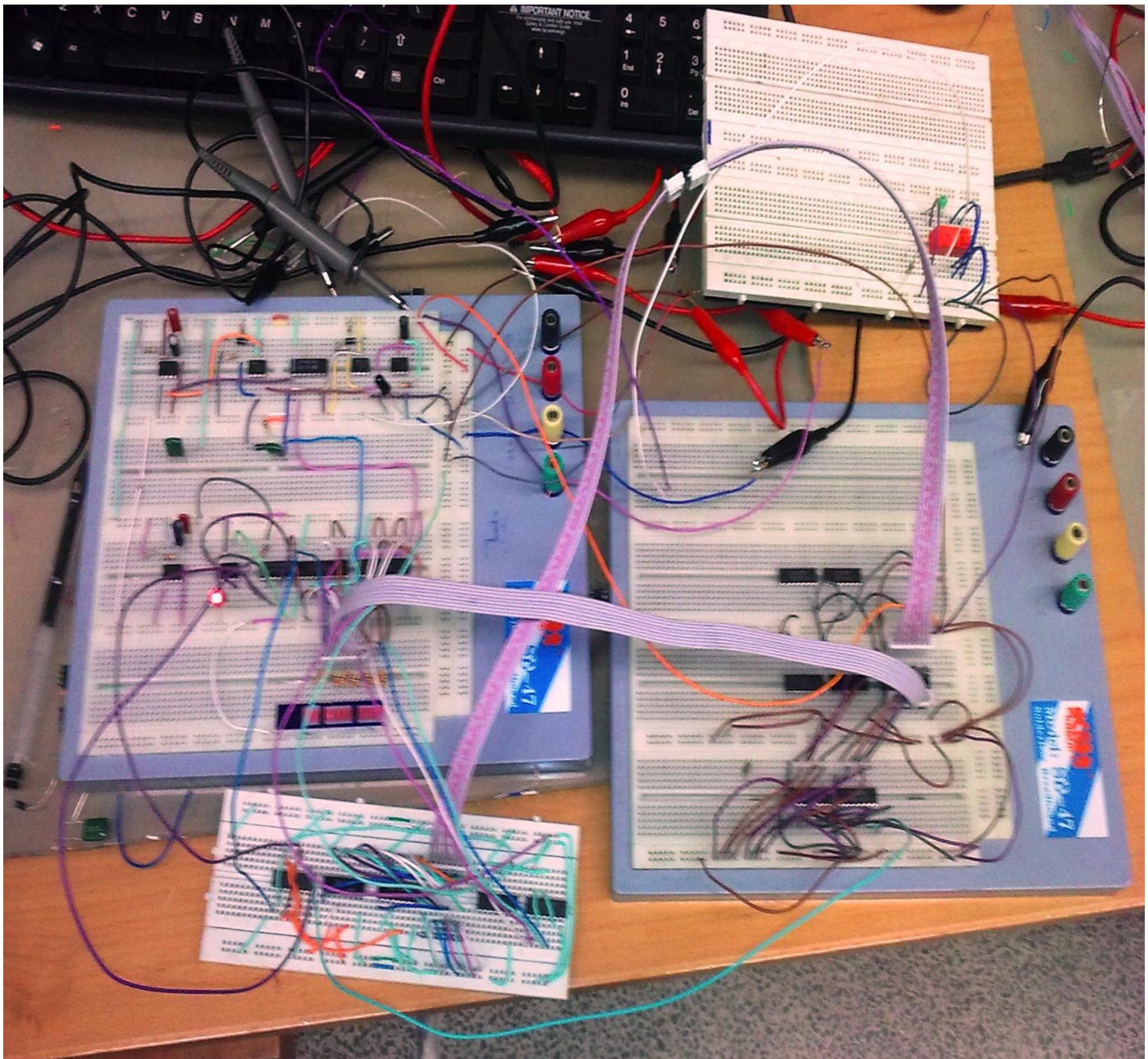

IMPORTANT NOTICE

Introduction

In this project we have designed a circuit which can be used to demodulate and decode IR signals in the range of 36-40 KHz coming from remote controls of various home appliances. This demodulated signal is then used to operate different appliances. We have implemented this project with a novel technique by using ICs and discrete components instead of microcontrollers, keeping in consideration cost and energy optimization.

Objectives Achieved

- To understand the whole theory of IR remote control signal modulation, including TDM (Time domain Multiplexing) and its transmission at 36-40 KHz range.
- To develop an efficient receiving circuit using IR sensors and then amplification of this weak signal (~50 mV) to output levels of 0-5V. It also involves extraction of this weak signal from embedded 60Hz noise coming from AC mains.
- Analogue to digital conversion of the incoming signal in which a 1.2 ms pulse is detected as 1 and 0.6ms pulse is registered as 0.
- Translation of various combinations of input sequences into their corresponding signals (i.e. which button was pressed) by the use of digital comparators.
- Finally driving various devices by the input signals using relays and bi-stable multi-vibrators.

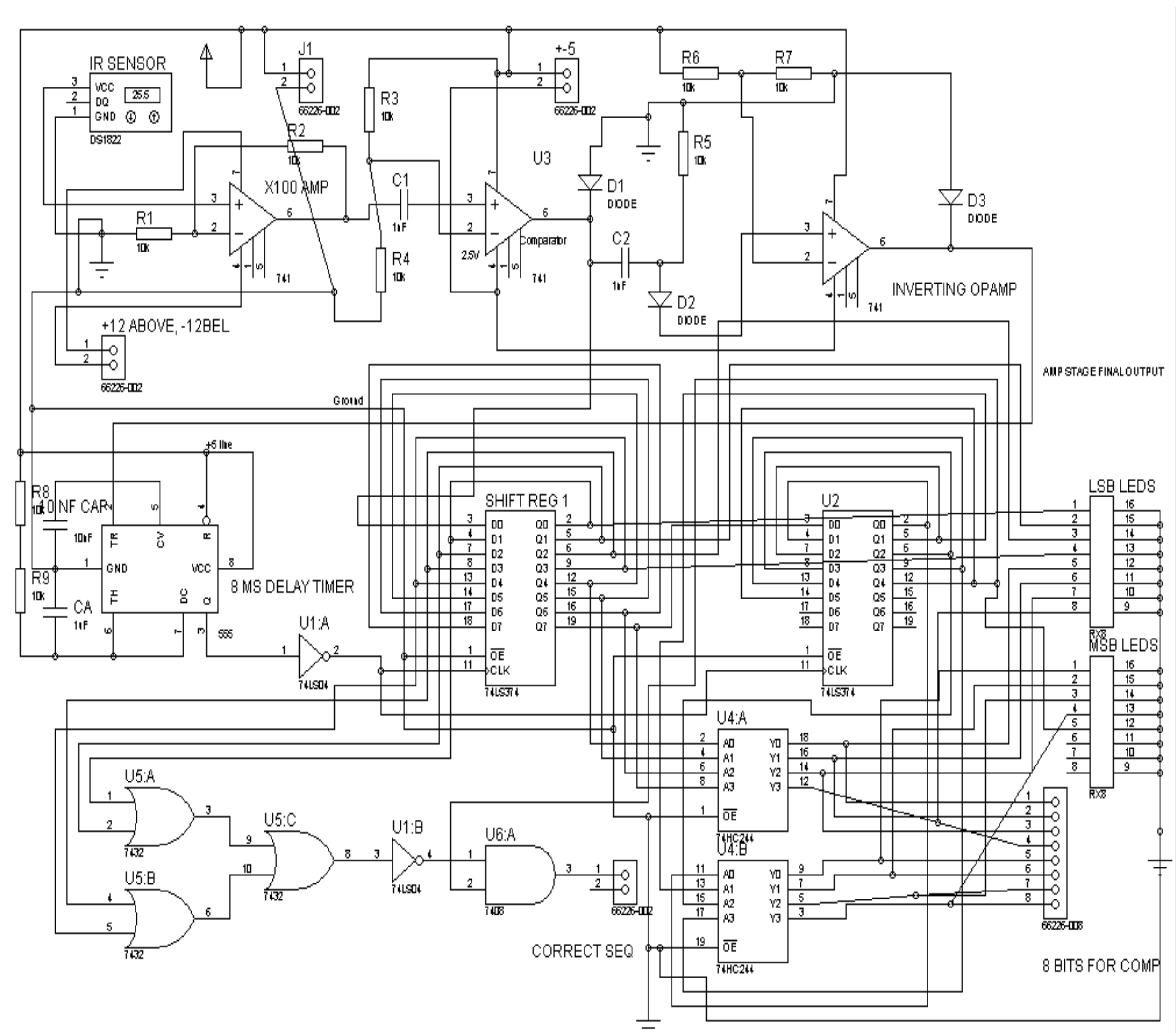
Circuit Diagram and Explanation:

The project is divided into two parts:

1. Sequence detection
2. Operating devices on the basis of input signal

The two parts are explained separately below:

1) Sequence Detecting Circuit (The Analog Realm)



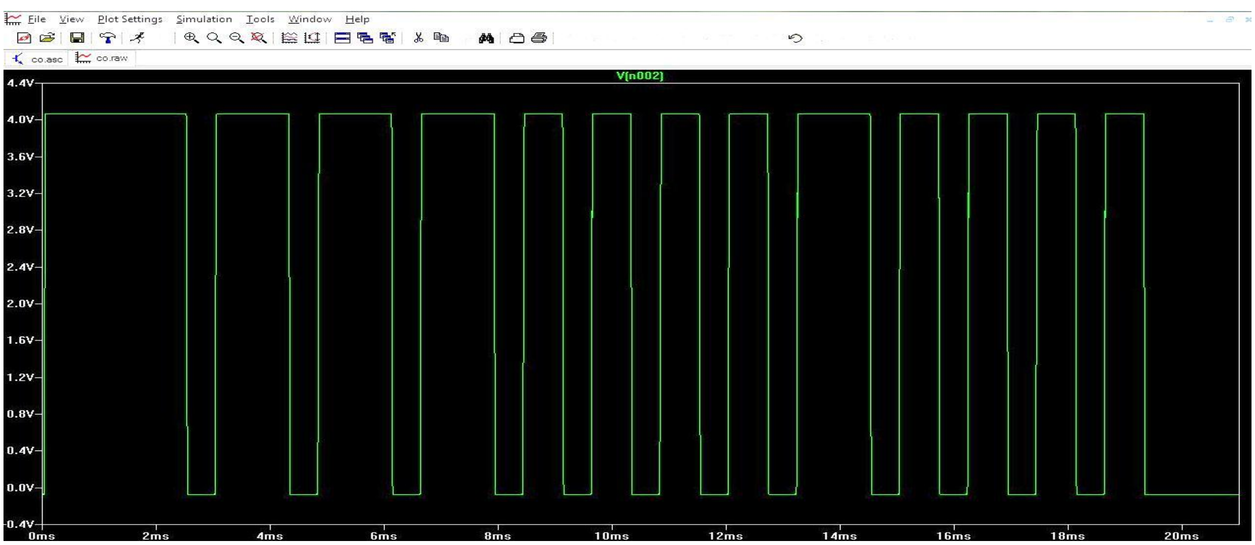
a) IR Sensor and Amplification:

The incoming remote signal is received by using a standard IR sensor.

The signal is very weak (~50mV) depending on the location of remote and also embedded in AC noise. This signal is then fed to a 741 OP-AMP with an inverted gain of around 100. This way our signal is amplified to levels of +12V to -12V.

b) Analog to Digital Conversion:

The output of the first stage amplifier is then fed to second OP-AMP which is used as a comparator. We compare the input signal to 2.5V. In this way the noise which varied between 0-2V gets rejected and the input signal is correctly decoded to levels of 0 and 5V (Digital Output). The output of second OP-AMP looks like:

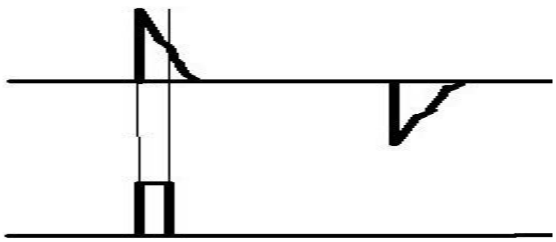


Input Sequence has following Specs:

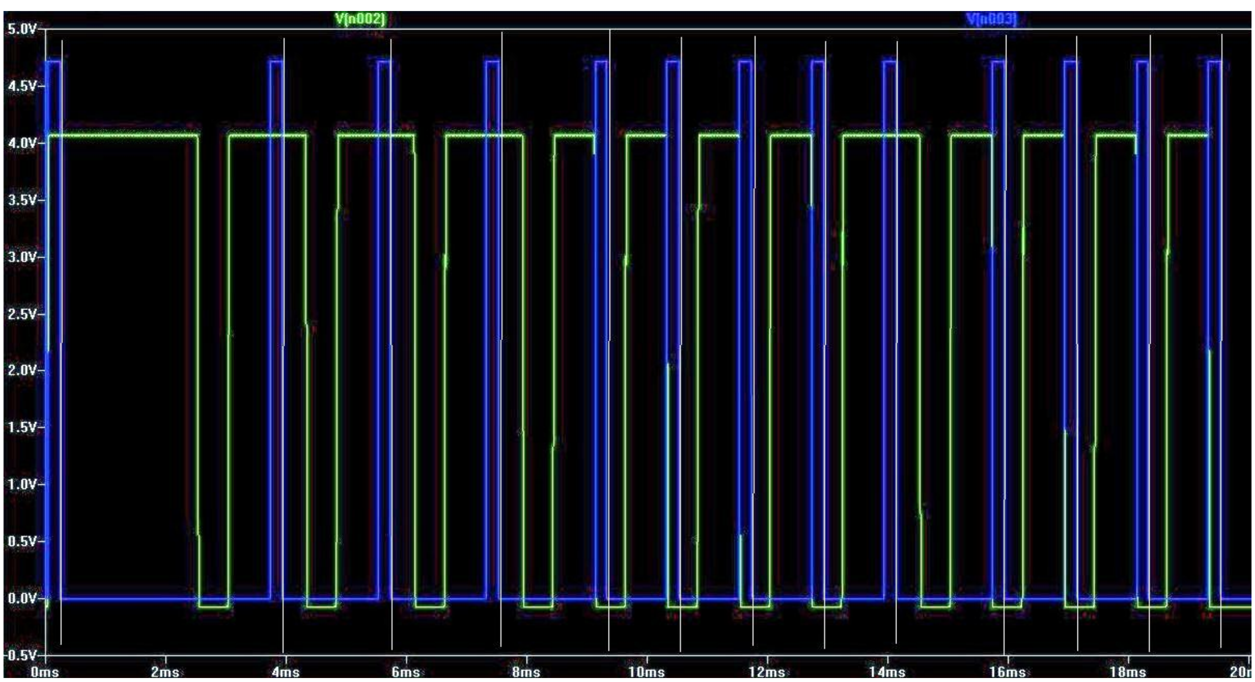
- "1" is denoted by 1.2 ms long pulse while "0" by 0.6 ms long pulse.
- First bit is 2.4ms long indicating Start-bit and the last 4 bits are always 0's

c) Generation of Delayed Clock Pulse:

For this we first need a clock pulse. The output of comparator is passed through a capacitor and then a parallel combination of 10k resistor and a diode in reverse bias. In this way we get a positive spike (as the negative spike is blocked by the diode). This "spike" is then fed to a third 741, also acting as a comparator which converts this spike into a pulse:



This pulse is then fed to a 555 timer, acting as a *Mono-stable Multi-vibrator* which gives a 0.8 ms delay. Now this delayed pulse is passed through a NOT gate as we need a rising edge for the shift register. The inverted pulse, when superimposed on the original signal, can easily sample 0's and 1's as shown in following diagram:



- Here white lines show positions of inverted write pulses where samples are stored.

d) Storage of Input Sequence:

We have used a Serial-In, Parallel Out (74LS374) shift register to store input. The Digital input signal is fed to data in, while inverted pulse of 555 timer acts as a clock. The result of this is displayed on the LED bank. Here we have achieved our first goal i.e. demodulation and storage or input sequence.

2) Operating devices based on input signal (The Digital Realm)

a) Valid Sequence Detection:

We first needed to confirm that the sequence stored in the register is not any intermediate stage; instead it is the final "Steady-State" signal corresponding to a specific button on the remote. For this, we ORED the last four bits, inverted them and then ANDED with the first bit. We called this output the "correct bit" which shows that the output is of "steady state".

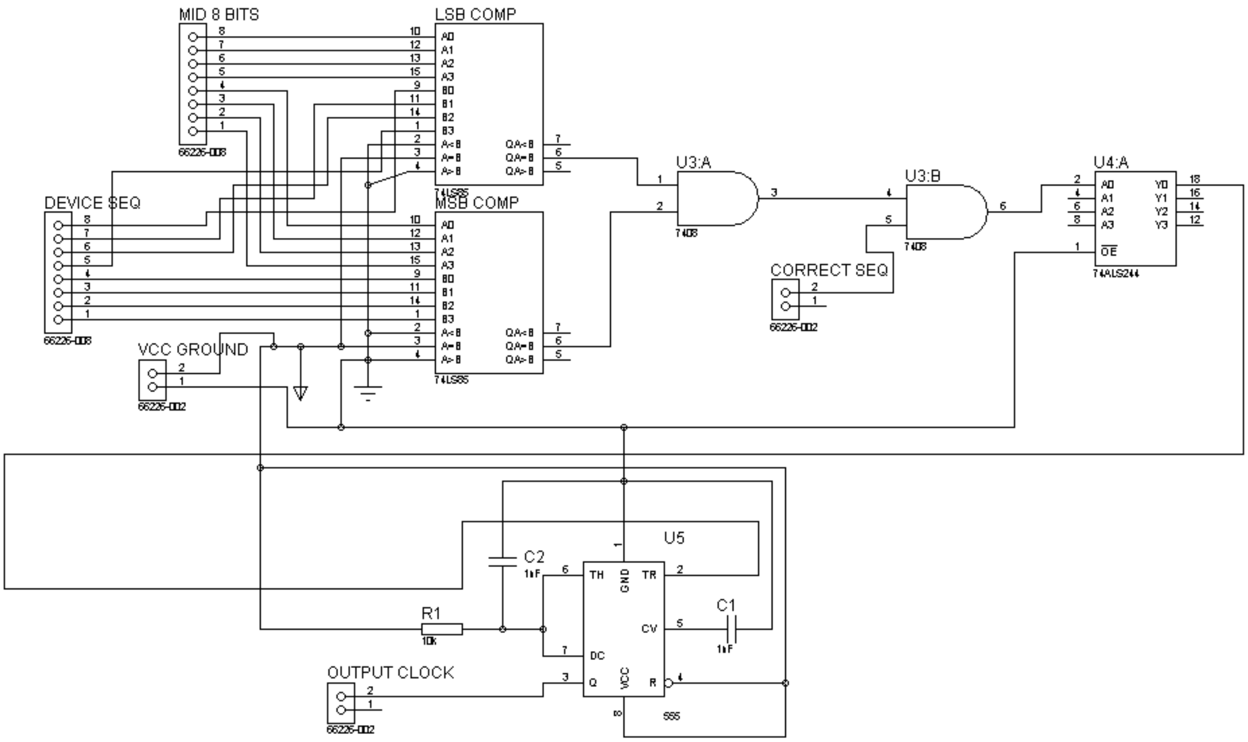
b) Device Comparators:

To link an input signal to a particular device, we used separate 8-bit comparators (74LS85) for each button; their output was ANDED with the "correct bit". The final output of this AND gate tracks down the signal to its button on remote.

c) Device Control:

We have assigned two buttons for each device; one turns it on and the other off. To achieve this goal, we operated another 555 timer in *Bistable Multi-vibrator* mode. The input signal from OFF button is connected to the RESET input of timer while the signal from ON button is connected to the TRIGGER input of the multi-vibrator. The output of this timer is connected to a RELAY circuit, which can be used to derive any device as desired.

The circuit diagram of this portion is as follows:



Final Operation:

- When the ON button is pressed, it triggers the timer and the corresponding device is turned on. Then if any other button on the remote is pressed, the sequence is not matched with that of device, the device keeps on running. Even if the ON button is pressed repeatedly, there is no effect on the bistable 555. The device can only be turned off using the OFF button corresponding to this device, which resets the timer.
- We can operate $2^8/2=128$ different devices with this single circuit.

WHY THIS PROJECT?

We selected this project after due thought as this project has a lot of learning value. First, we had to go through whole theory of IR remote controls and how the signal is demultiplexed in time domain. After that we devised this circuit all on our own as normally this is implemented by using microcontrollers. This project also helped us explore the bridge between Analog and Digital realms, the analog realm being less predictable, hiding its useful signals in the clutches of 50 Hz noise while the digital domain being more certain, working on the principles of Boolean Algebra. However, this project showed us how important; no matter how hard the Analog world is; because this is the medium where real life signals are generated and transmitted.

Difficulties Faced:

1. As we were working with very high frequencies at around ~40 KHz it was very hard to work in the time domain, as the signal that appeared was in the domain of milliseconds, and to design a timer of such a small time was very difficult.

2. Once the circuit was disconnected, it did not work the same way as it did the last time, this took a lot of debugging time.

3. The overall project time was quite less so we could not extend our project to a proper appliance that could be used in homes.