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Control and Monitoring of Home Appliances from a Remotely Located Cellular Phone

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1. Introduction

The main inspiration for this project was drawn from the recent hikes in the electricity charges in India. It is a general habit to leave all the light, fans and other electrical appliances (such as mobile phone charger etc) switched on even after we leave our homes; sometimes in haste and most of the times in sheer carelessness, costing us huge electricity bills. Also it is a general practice in educational institutions (particularly in colleges) to keep the lights and fans of all the classrooms on, even when no classes are taking place. Our project aims at developing a device that would allow a user to remotely control and/or regulate and monitor multiple home appliances using a cellular phone. This system will be a flexible tool that would be able to offer this service at any time, and from anywhere within the constraints of the technologies being applied. Possible target appliances include (but are not limited to) security systems, lights, fans, etc. In short anything with an electrical interface can be regulated using this device. Nowadays, the communications have become very simple, fast, interactive and more compact, that makes the globe as a small village. So it is very easy for anyone to subscribe in the local or global telecommunication networks with individual mobile phone device. Mobile devices, such as mobile phones, are becoming multipurpose devices. These devices are capable of storing data as well as running custom application. As more people adopt these devices and begin to use them for personal or business tasks, the need for controlling access to the data stored within the devices will become vital.

1.1 Summary of the Project

In order to control the device, one needs to make a call to the cell phone attached to the device from any phone, which sends DTMF tones on pressing the numeric buttons. The cell phone in the device is to be kept in a setting called AUTO-ANSWER mode. So, after a ring, the cell phone accepts the call. Otherwise, some arrangements should be made to make sure that the call is received.

Now one may press any button on the calling (which is operating the device) mobile to perform specific actions . The DTMF tones thus produced are received by the cell phone on the receiver side. These tones are fed to the circuit by the head-set/audio output port of the cell phone. The DTMF decoder IC decodes these tones to generate BCD outputs. These BCD output signals are then used to drive a D flip-flop which acts as a buffer/delay and holds the value of the signal.The output of the flip-flop is then used to switch On and OFF, a transistor-relay switching assembly. According to the state of the relay switch, the device starts responding.

1.2 Application of the Project

Home Automation has become an all-round technology which is used for all the purposes. It is used in many ways for different services. Some of the applications are:

- **HVAC:** The first and the foremost applications used in any industry are heating, ventilating and air conditioning which include temperature control and humidity control. It in turn saves the money of the owner.
- **Security -** Including fire alarm and detection systems, access control, as well as the intercoms. Security cameras can be accessed, allowing the user to observe activity around a house or business right from a monitor or a touch panel. Security systems can include motion sensors that will detect any kind of unauthorized movement of a person and notify the user through the security system or via cell phone. Sensors are used for maintaining the security in any organization.
- **Lighting:** Even for lighting control, automation of electricity and water metering home automation systems are used. Lighting control techniques can be used for switching on/off of the electrical bulbs around the home.
- **Telecom:** Automation devices are used in day to day objects, safety and security issues, even in new telecom and management production. Many of the home automation devices have the facility of the caller ID information and the even the information of incoming and outgoing messages.
- **Health Care:** Home automation is being implemented into more and more homes of the elderly and disabled in order to maintain their independence and safety. Automation can provide both the elderly and disabled with many different types of assistance systems, security features, fall prevention, automated timers, and alerts.
- **Video/Audio:** Even in the Video or Audio communication systems switching devices are used which are again automated devices only.
- **Kitchen Appliances:** Kitchen appliances are mostly a part of the automated systems. Some of the appliances like dish washer, microwave oven, for sprinkling of water, for turning on/off of washing machine etc. are some examples of home automated systems.

2. Project Block Diagram

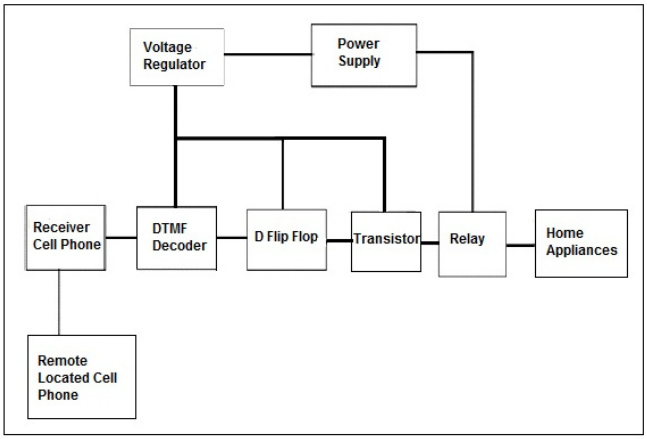

Figure 1: Project Block Diagram

3. Working Procedure

- Our project uses DTMF decoder cs9370dgp IC which decodes tone generated by the keypad of cell phone.
- When you press any keys in your mobile Phone while call in progress, the other person will hear some tones with respect to keys pressed. These tones are based on the DTMF (Dual Tone Multi Frequency) technology.
- Data transmitted in terms of pair of tones. The receiver detects the valid frequency pair and gives the appropriate BCD code as the output of the DTMF decoder IC.
- DTMF signal can be tapped directly from the microphone pin of cell phone device.
- If we cut the microphone wire and we will be able to see 4 wires. Among these wires we need only 2 wires, Ground and Right.
- We select the right wire and connect it as the DTMF input to the decoder circuit. Ground should be connected to common ground of our circuit.
- The signals from the microphone wire are processed by the DTMF decoder IC which generates the equivalent binary sequence as a parallel output as Q1, Q2, Q3, and Q4.
- The output Q4 from the DTMF decoder IC is fed to the clock input of IC 7474 d flip flop which acts as a buffer to the output from cs9370dgp DTMF decoder IC.
- IC7474 is configured as Toggling mode that is if it gets a clock pulse the output of this IC (Pin 5) sets to high and further clock pulse reset back the IC. (The outputs toggle whenever a key is pressed).
- When we press and release any of the keys among 1, 3, 5, 7, 9 and * keys, the DTMF decoder IC generates a high pulse which acts as a clock to our flip flop and sets the output flip lop to high.
- The output of flip flop is connected to the relay driver circuit via 100Ω resistor; this output energizes the relay coil through BC547 transistor and turns ON the bulb that connected at the normally open terminal of relay circuit.

4. Result Analysis

4.1 The Transistor as a Switch

When used as an AC signal amplifier, the transistors Base biasing voltage is applied in such a way that it always operates within its "active" region, that is the linear part of the output characteristics curves are used. However, both the NPN & PNP type bipolar transistors can be made to operate as "ON/OFF" type solid state switches by biasing the transistors base differently to that of a signal amplifier.

Solid state switches are one of the main applications for the use of transistors, and **transistor switches** can be used for controlling high power devices such as motors, solenoids or lamps, but they can also used in digital electronics and logic gate circuits. If the circuit uses the **Bipolar Transistor as a Switch**, then the biasing of the transistor, either NPN or PNP is arranged to operate the transistor at both sides of the " I-V " characteristics curves we have seen previously.

The areas of operation for a transistor switch are known as the **Saturation Region** and the **Cut-off Region**. This means then that we can ignore the operating Q-point biasing and voltage divider circuitry required for amplification, and use the transistor as a switch by driving it back and forth between its "fully-OFF" (cut-off) and "fully-ON" (saturation) regions as shown below.

5. Operating Regions

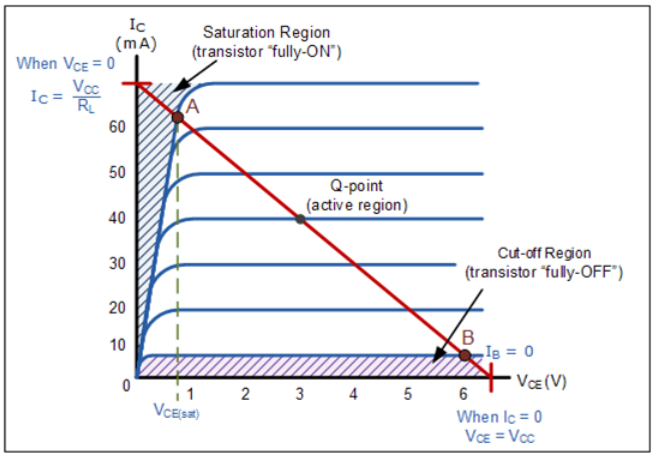

Figure 2: Operating regions of a transistor in this setup

The pink shaded area at the bottom of the curves represents the "Cut-off" region while the blue area to the left represents the "Saturation" region of the transistor. Both these transistor regions are defined as:

5.1 Cut-off Region

Here the operating conditions of the transistor are zero input base current (I_B), zero output collector current (I_C) and maximum collector voltage (V_{CE}) which results in a large depletion layer and no current flowing through the device. Therefore the transistor is switched "Fully-OFF".

5.2 Cut-off Characteristics

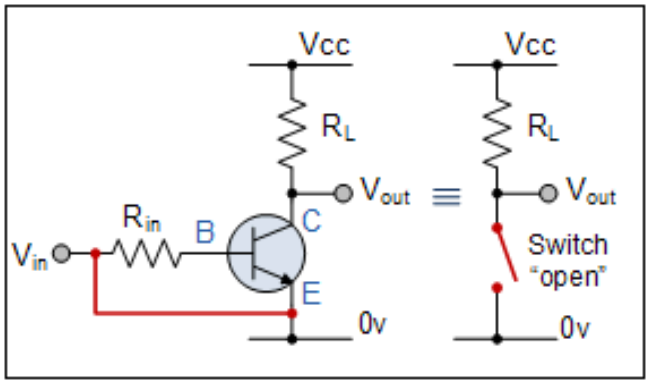

Figure 3: Circuit equivalent in cut-off region

- The input and Base are grounded (0v)
- Base-Emitter voltage VBE < 0.7v
- Base-Emitter junction is reverse biased
- Base-Collector junction is reverse biased
- Transistor is "fully-OFF" (Cut-off region)
- No Collector current flows (IC = 0)
- VOUT = VCE = VCC = "1"
- Transistor operates as an "open switch"

Then we can define the "cut-off region" or "OFF mode" when using a bipolar transistor as a switch as being, both junctions reverse biased, V_B < 0.7v and I_C = 0. For a PNP transistor, the Emitter potential must be negative with respect to the Base.

5.3 Saturation Region

Here the transistor will be biased so that the maximum amount of base current is applied, resulting in maximum collector current resulting in the minimum collector emitter voltage drop which results in the depletion layer being as small as possible and maximum current flowing through the transistor. Therefore the transistor is switched "Fully-ON".

5.4 Saturation Characteristics

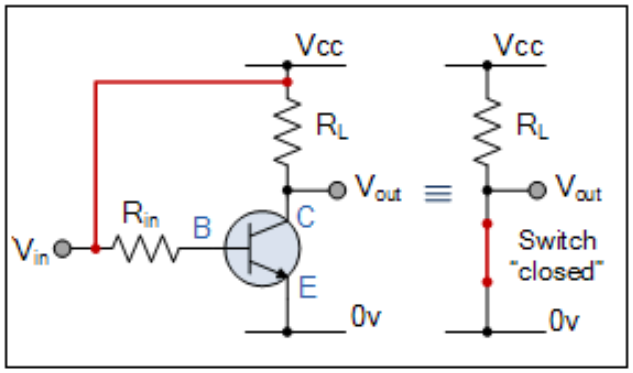

Figure 4: Equivalent circuit in saturated region

- The input and Base are connected to VCC
- Base-Emitter voltage VBE > 0.7v
- Base-Emitter junction is forward biased
- Base-Collector junction is forward biased
- Transistor is "fully-ON" (saturation region)
- Max Collector current flows (IC = Vcc/RL)
- VCE = 0 (ideal saturation)
- VOUT = VCE = "0"
- Transistor operates as a "closed switch"

Then we can define the "saturation region" or "ON mode" when using a bipolar transistor as a switch as being, both junctions forward biased, V_B > 0.7v and I_C = Maximum. For a PNP transistor, the Emitter potential must be positive with respect to the Base.

Then the transistor operates as a "single-pole single-throw" (SPST) solid state switch. With a zero signal applied to the Base of the transistor it turns "OFF" acting like an open switch and zero collector current flows. With a positive signal applied to the Base of the transistor it turns "ON" acting like a closed switch and maximum circuit current flows through the device.

6. Conclusion

In this project on “Home Automation “ we have tried to demonstrate the basic principle behind a simple cost effective solution to the increasing automation needs all over the world. During this project we have had to work under several constraints notably:

- The cost of the setup
- Limitations of our knowledge about more advanced technologies.
- Lack of better computer programming knowledge
- Time constraints
- Laboratory constraints

In spite of these we have tried to implement our knowledge gathered during our course duration to device this mechanism. Here the basic idea has been demonstrated and based on which, if and when one or more of the constraints such as cost, complexity and knowledge are addressed, a much more advanced and versatile mechanism can be devised. During our project we had faced problems involving voltage and current mismatches between the different components of the setup. Also we had initially thought of implementing this using a microcontroller but could not due to unidentified errors in the format of the c code used to generate the hex code for the microcontroller. This apparently happened due to our lack of proper knowledge of how to address the ports of the selected microcontroller and the lack of resources available to verify our code also added to it.Still we managed to figure out the working principle of the system using a microcontroller and prepared a model which we believe, if carefully examined by a more competent authority would work after a few modifications. So although with some compromisations, we believe we managed to achieve our main goal of making a cost effective and simple model of remotely controlled home automation system. Also we must mention that without the proper guidance of our respected mentor and other faculties this might have been a failure.

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Aranya Sarkar received the B.Tech degree in Electronics and Instrumentation Engineering from West Bengal University of Technology in 2013. After graduating, he is working with Capgemini India. He will be going for his M.Sc in OVGU Magdeburg, Germany in Electrical Engineering and Information Technology.