Integrated Sensing System for Housing Appliances

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ENGN3227 Group Project
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1.0 Abstract

Integrated Sensing System for Housing Appliances is a project taken up by three engineering students: Ahmed Arif, Wenhai Huang and Chi hang Ip. The design aims to make life easier and safer around households by implementing integrated sensing technologies. In specific the circuits can be used to auto control of heating elements, remote control of electric devices using sound, auto control of lights/security systems using day/night sensors and detecting impostors around the house of strong rooms using shadow detectors.

The circuits are implemented using simple analogue electronics theory and components. The analogy of circuits can be divided into three parts. Sensing and control based on sound, light and temperature. For all three part of this project the actual circuit are desired to be only base circuits. Around each base a multiple number of circuits can be constructed for different applications.

The project started early in semester 2 and all the experimentation were completed before 20th October 2006. A demonstration for the circuit is scheduled for the team on Friday the 27th October. Each member of the team contributed equal amount of work towards every components (i.e. planing, design, experiments, and report) of this project.

2.0 Introduction

Home automation is about to utilize sensing and control devices for the automation requirements of private homes to improve comfort and security of its residents. In many applications, home automation is also considered as means to energy saving. Some automated tasks may include detection of the presence of a person, setting the air conditioning to right temperature, switching on lights or open doors when people present, and turn off electrical appliances when the person leaves. The principle of automation operation is simple: there are sensors that detect the environmental changes, sending information to the control unit, and then the control unit activates devices accordingly. For advance automation, usually microprocessors or a computer is implemented.

This project is focusing on three types of sensing and controls: thermal, light and sound. It aims to develop and construct a system that provides basic home automation in the three areas at very low cost. The end product includes three individual units: a thermal unit that is to turn on any electrical switch when the surrounding temperature goes too high; a light sensing unit that signals when light intensity drops; a sound unit that can be triggered by clapping.

For further consideration, here's a short list of application for each part of the circuit:

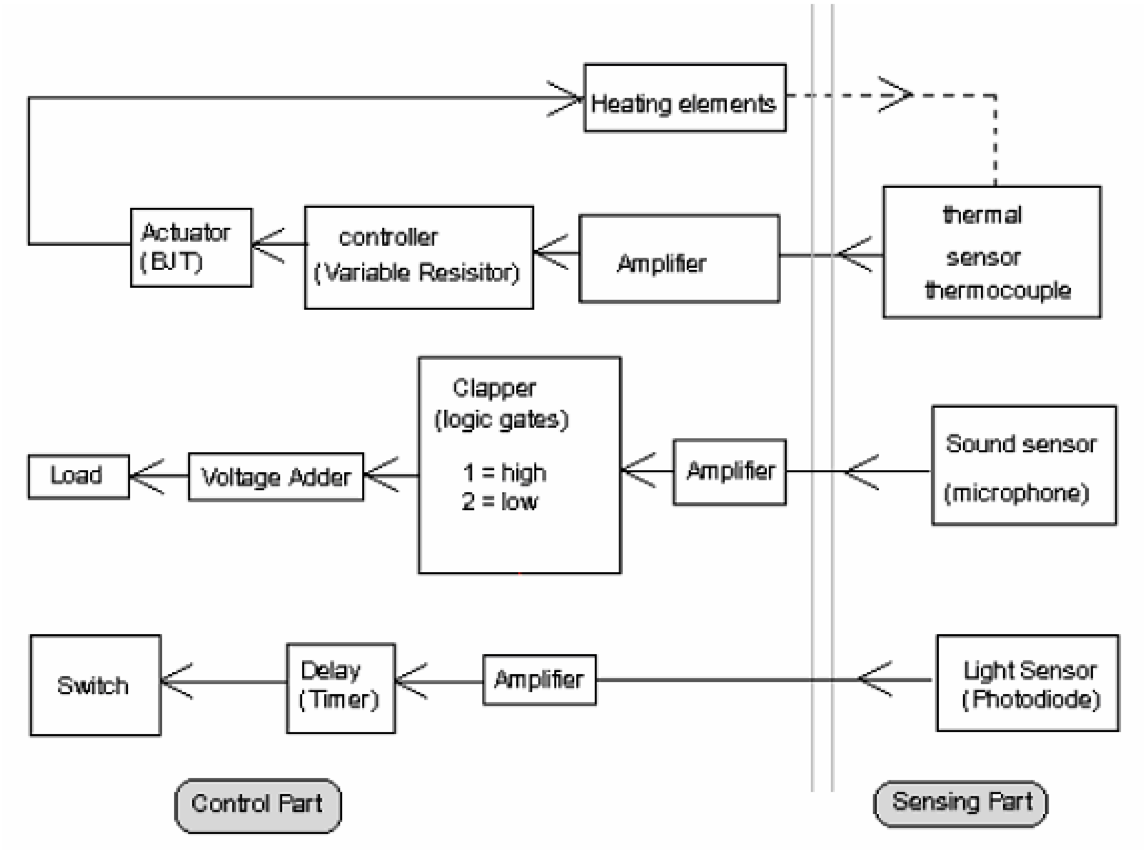
Thermal:
- Set fan or air conditioning on/off automatically for room
- Automatic control of cooling systems for industries
- Automatic control of exhaust fans in kitchen
- Can also be used to control cooling system of computer or other house appliances

Light:
- Outdoor control, turning on/off lights depending on darkness
- Automatic control of light at outdoor stadium or fields.
- It can be set to go off for a shadow passing over it, which combined with an alarm can be used as an impostor alarm system
- Indoor control, turning on/off lights of rooms depending on darkness

Sound:
- Turning on/off lights by clapping
- Can be set as automatic sound detecting impostor alarm
- Automatic control of lights in dark rooms like basements (Lights turn on when you walk in)

The cost estimated for the whole project is around A$37.00.

3.0 Design

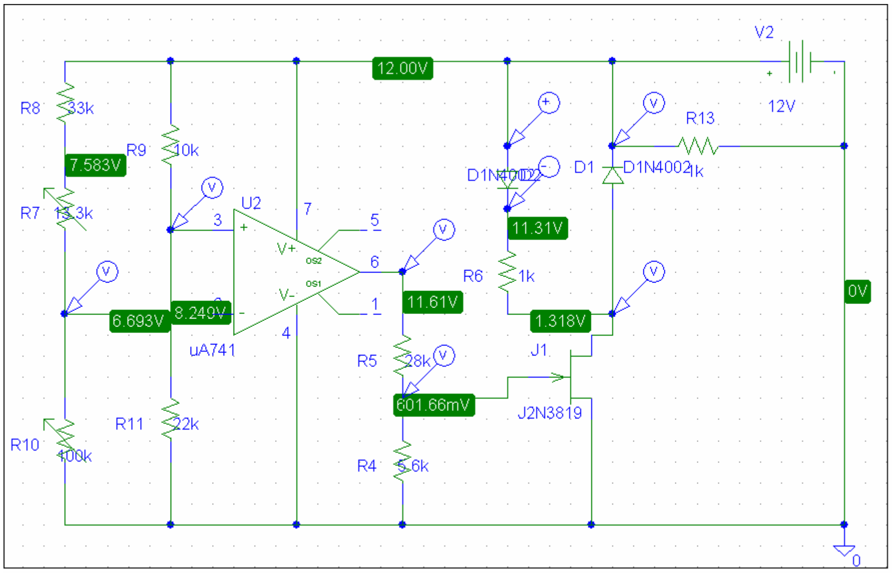


3.1 Thermal Control Unit

The thermal control unit works on the basic principle of a comparator. When one input has higher potential than the other, the comparator outputs a saturated voltage depending on the input terminal characteristic. A high potential at non-inverting input terminal produces positive saturation, whereas high potential at the inverting input terminal produces negative saturation. The comparator output connecting to the transistor base is then turning the transistor on or off.

The thermistor is connected to the circuit as a voltage divider. When the thermistor resistance varies with temperature, the voltage at the inverting input also varies.

When temperature is high, resistance of thermistor is lowered and the output is high.



When temperature is low, resistance of thermistor is lowered and the output is low.

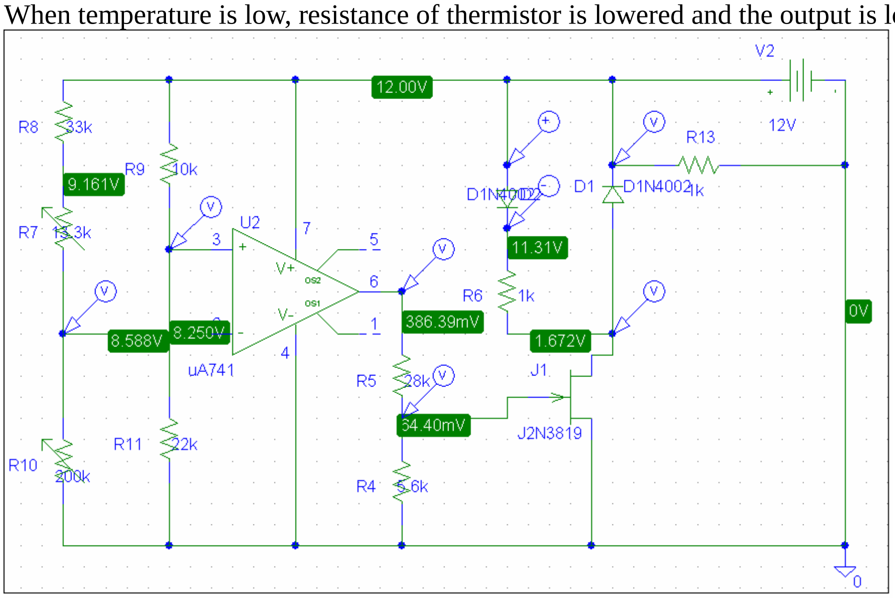


Fig 3.1.1 Schematic diagram for thermal control unit at different temperature

3.2 Light Sensing Unit

The light sensing unit is similar to the thermal control unit except that a light dependent resistor(LDR) is in place of the thermistor. Initially it was sought to have a photodiode to detect photons and trigger the circuit. However, a photodiode could be expensive. With the idea of low cost design in mind, it eventually came up a design using LDR which is twenty times cheaper.

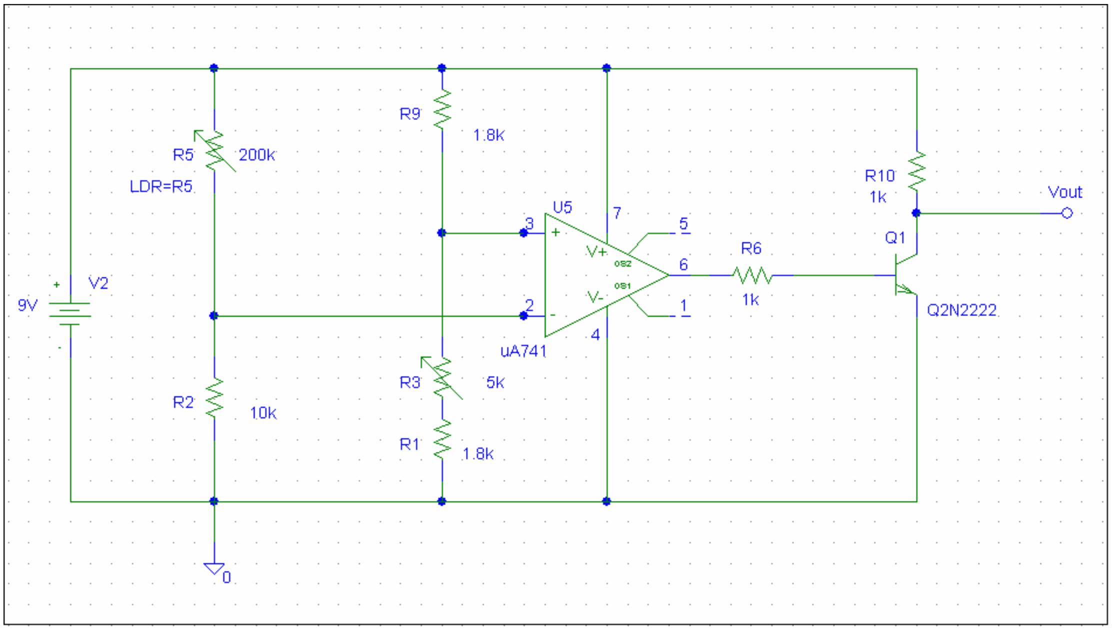


Fig. 3.2.1 Circuit diagram of light sensing control

3.3 Sound Detector

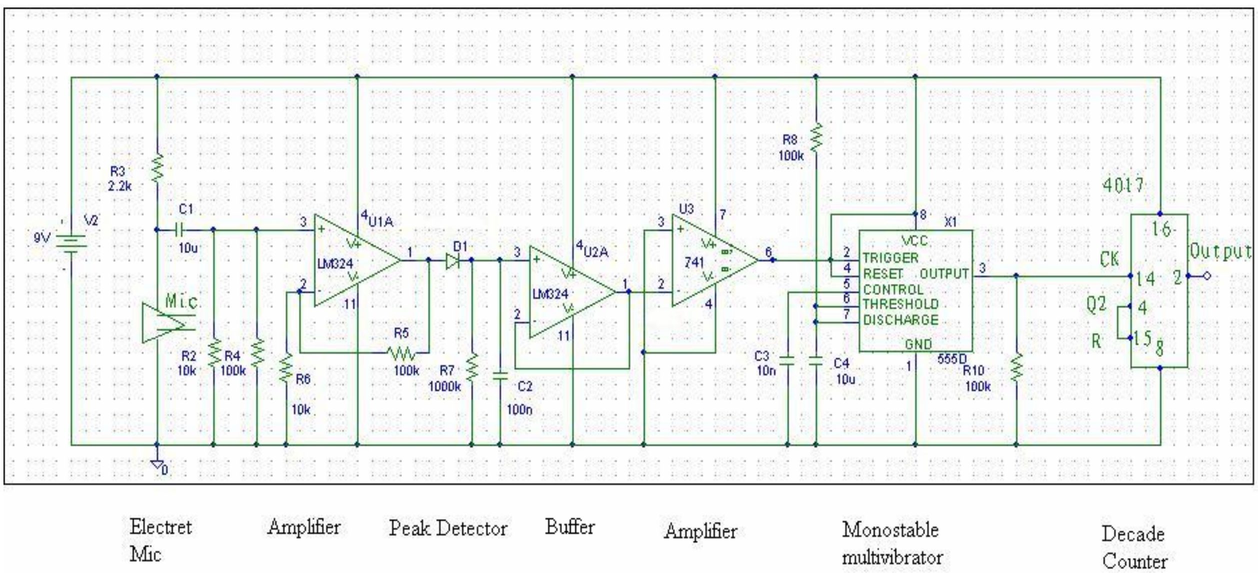


Fig. 3.3.1 Circuit diagram of Sound sensing

The Electret microphone provides the sound input to an amplifier, peak detector, buffer, and then further amplified to drive the 555 time which is set as a monostable multivibrator. A clap near the microphone will generate a voltage signal just large enough to trigger the circuit, causing the 555 timer to produce a pulse to clock the 4017 decade counter. Since the second output of the decade counter is connected to its reset, each pulse applied at pin 14 changes the output state at pin 2. The high output in pin can drive a relay or transistor for external loads.

4.0 Implementation

4.1 Thermal Control Unit

The goal of the thermal circuit is to detect the changes in temperature that can automatically switch on or off home application for the comfort and security of the new age home. To achieve the goal, the following design had been first tested.

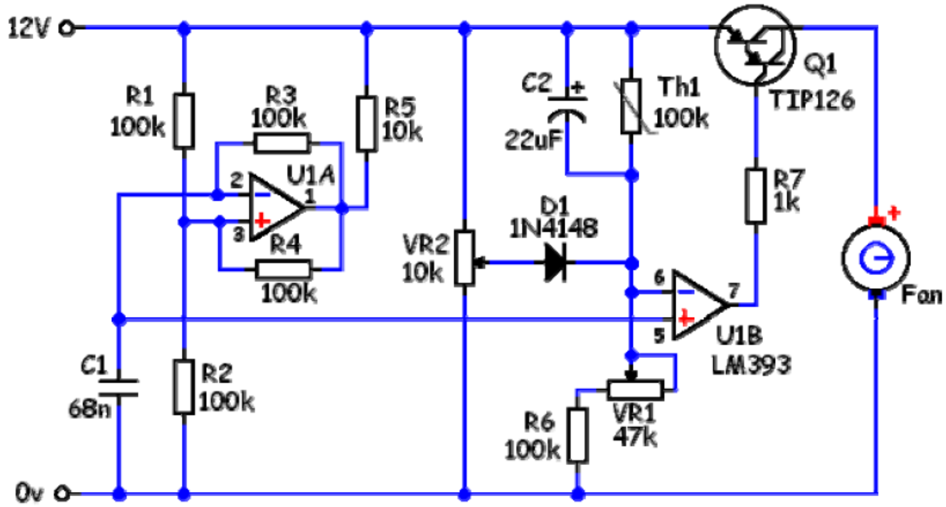


Fig 4.1.1 First design of the thermal control unit

In the thermal sensing device, the LM393 dual ICs are comparators with 8-pinpackage which will be used to implement both operator amplifiers and comparator theories. For example, the first comparator will generate a wave that switches capacitor C1 between charge and discharge cycles as the capacitor voltage hits the levels set by the resistor potential dividers, formed by R1-R5 at approximately 1/3 and 2/3. A second comparator compares the voltage signal with the temperature from the thermistor-resistor potential divider Th1, R6. When the voltage level goes above reference the power transistor is switched off, as it comes back to below reference it is switched on, allowing pulses of power to the fan.

The capacitors should be checked carefully on their polarities as there was a blown up of capacitor during experiment. This happened after the capacitor had been wrongly connected for about twenty minutes. The design requires a Darlington configuration (TIP126) which was not available. It was tried to replace the TIP126 by BJTs but the output was very low.

After the failure of the first design, the group worked on an alternative design which uses a single 741 op-amp and easy-to-find 2N2222 Transistor. The second design is being used in many applications. It can be used in many parts of household appliances such as fire detector. It acts as protective device, which turns the switch off when the appliance is heated up over a certain temperature.

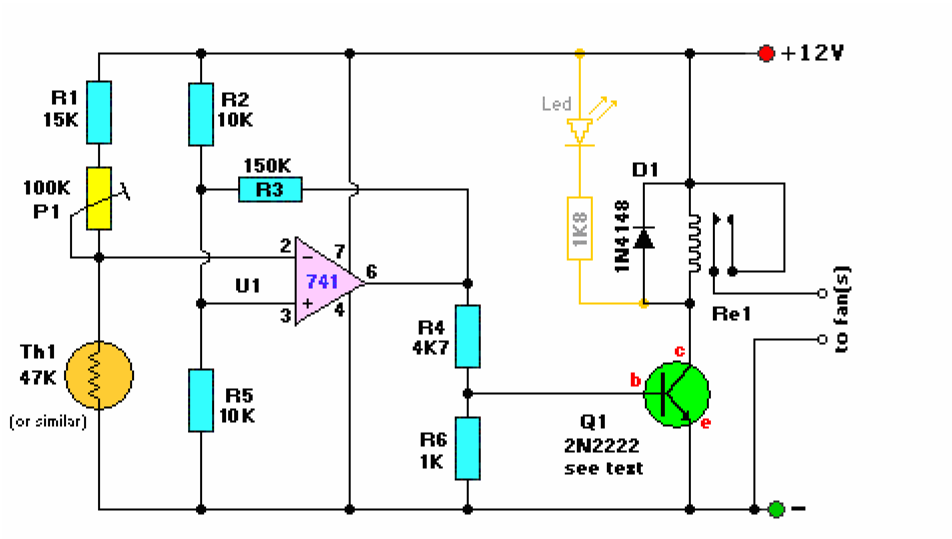


Fig 4.1.2 Second design of thermal control unit

Parts List:

R2, R5 = 10K R4 = 4K7
R1 = 15K R3 = 150K
R6 = 1K P1 = 50K ($1)
Th1 = Thermistor ($1) U1 = LM741 ($1)
D1 = 1N4001 ($0.25) Q1 = 2N2219 ($2.50)
Ry = Relay ($2)

4.2 Light Sensing Unit

The light sensing and control part of the system was the easiest to implement. The team decided to use a LDR instead of a photodiode, except for that other parts of the circuit was reasonably easy to implement. The circuit works in almost identical symmetry with the thermal control system.

Parts List:

R1, R4 = 10K R2, R3 = 470
R5 = 1K P1 = 10K ($1)
LDR1 = Light Dependent Resistor ($9)
U1 = LM741 ($1)
D1 = 1N4001($0.25)
Q1 = NTE128 ($2.50)
Ry = Relay ($2)

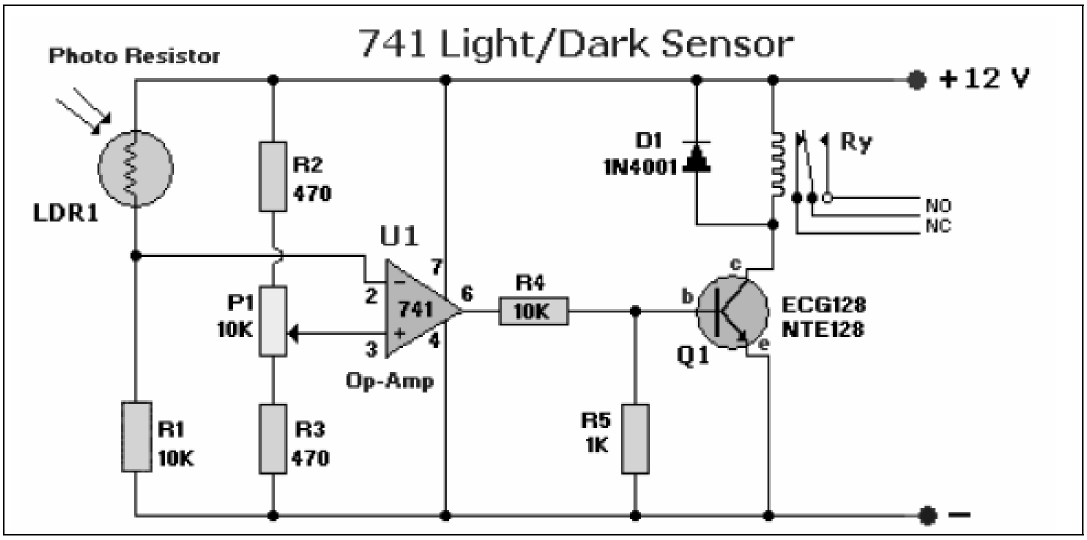


Fig. 4.2.1: Circuit diagram for light unit

The P1 can be tuned to various points to set the reference voltage. Depending on this the light intensity required to turn the LED on/off is also changed.

4.3 Sound Detector

It took quite a long time to figure out how the AM4011 Electret microphone insert works. At the beginning the microphone was placed in series with a 10kohm resistor and supplied +9V for testing. Observed from the oscilloscope, a clap merely produced about 10mV rise. After several trials of different set up, the microphone was best observed to produce close to 0.3V rise when connected with a shunt 10uF capacitor and 10kohm resistor.

It may notice that there are two amplifiers in the circuit. The 741 op-amp was not in the initial design. It was added because the LM324 alone could not provide enough power.

The monostable multivibrator was first tested with a single short pulse and its output period of “High” state was recorded. The “High” state should stay long enough to clock the decade counter. The decade counter was also tested for its sequential output using LEDs.

Finally the Sound Detector was integrated with the Light Sensing Unit for a combined application. It is simply feeding the Light Sensing Unit’s output to the power supply of the Sound Detector. This together forms the home auto lighting system. When the light intensity is high, the sound detector will not function as no power supply from the light detector. When the light intensity decrease gradually, the light detector powers the sound detector, and the first pulse leads to a high output of the 4017 decade counter—the light is turned on!! And the light hence may be turn off or on again by clapping. Each clap changes the state of the output.

5.0 Results

5.1 Thermal Control Unit

	Resistance across the variable resistor	**Minimum Resistance (1Kohm)**	**Maximum Resistance (50Kohm)**	**Our Setting Resistance (13.3Kohm)**
Voltage across components				
56Kohm		11.7V	1.86V	2.5V
5.6Kohm (Base of the BJT transistor)		1.3V(on)	0.19V(off)	0.68(close to on)
Diode		11.7V	1.05V	1.35V
LED lights		1.7V(on)	0.87V(off)	1.67V (close to on)
Positive Pin		8.5V	8.5V	8.5V
Negative Pin		6.8V	9.35V	8.55V

5.2 Light Sensing Unit

The dynamic tuning of this part was not possible to record as we didn't have access to a light intensity meter. But the part worked properly and we were able to tune P1 to various points to set the reference voltage. This changed the light intensity required to turn the LED on/off.

Resistance across the variable resistor	**Resistance at LDR**	**LED**	**Light Intensity**
9.8K	9.9K	On	Complete Darkness
6K	6.4K	On	Still shadow for 10s
4.2K	3.1K	Off	Quick Shadow
1K	1.5K	On	Quick Shadow

5.3 Sound Detector

Microphone Output(with clapping): 0.2 – 0.5 V
Output stay "High" period approx. 1.5 Sec
Decade Counter Output: 8.75V

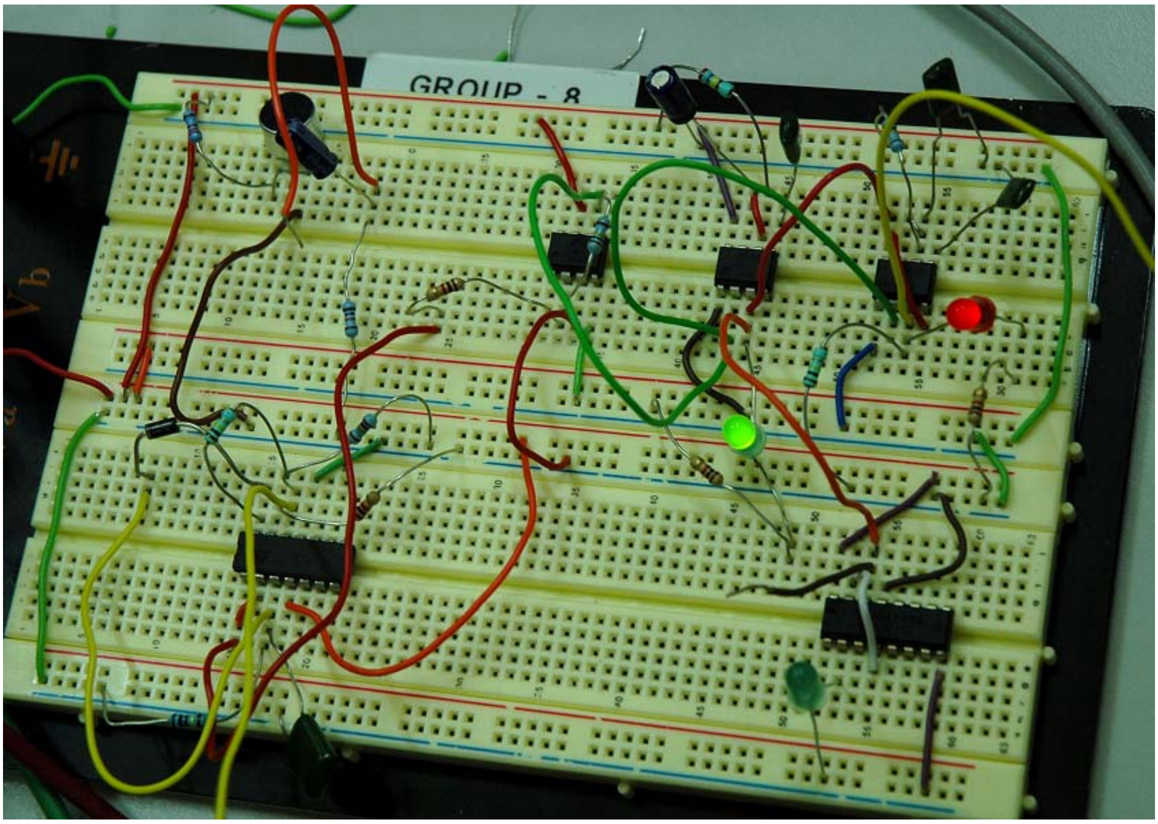
6.0 Conclusion

The whole automation system is consisted of three individual parts including a thermal control unit, a light sensing unit and a sound detector. Each unit may work separately to drive a load or circuit. Alternatively, they may be used to power the other unit(s) to provide conditional control, which largely increases their possible applications. The light sensing unit, other than turning on lights when the atmosphere is too dim, could also be used as a security system. The thermal control unit may also detect fire. The thermal control unit and sound detector have low level of sensitivity due to the use of low quality components. The thermal sensitivity could be improved by replacing the thermistor with thermal couple. The sound detector could also be improved using a more sensitive microphone. To be concluded, the project has been successfully accomplished.

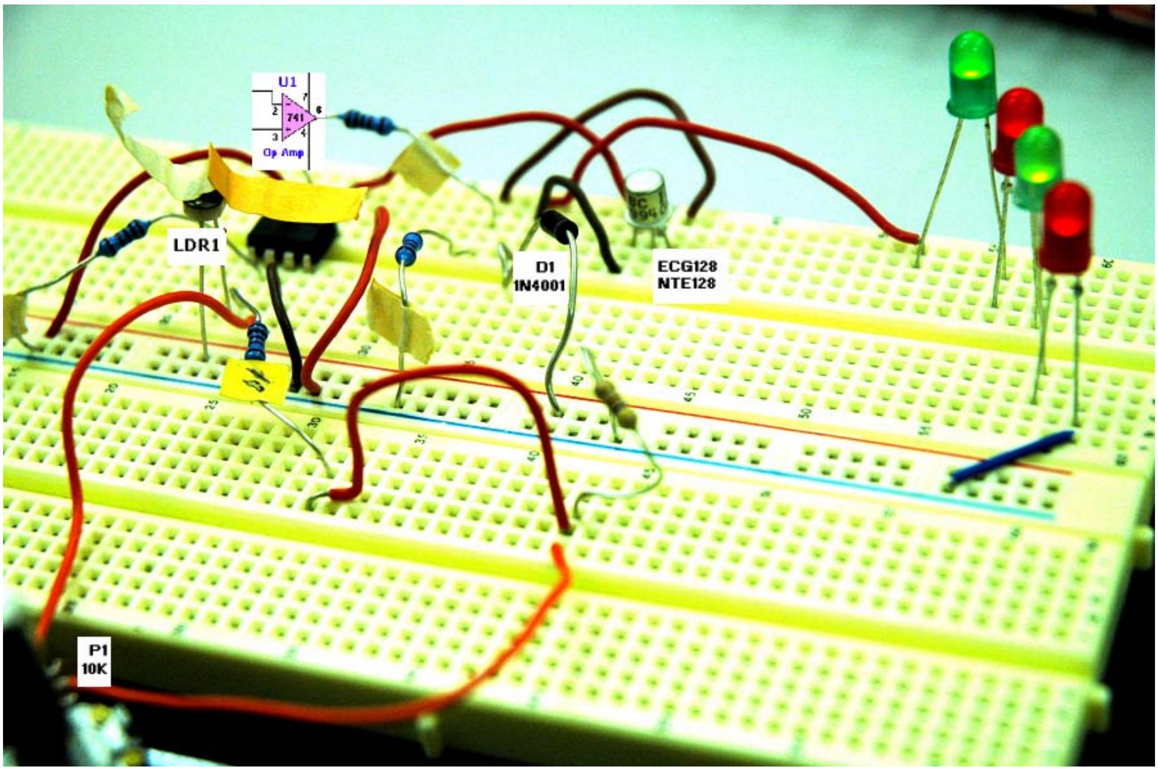
REFERENCES

[1] Thermal Control; http://www.cpemma.co.uk/thermal.html
[2] Sound Sensor; http://www.uoguelph.ca/~antoon/circ/
[3] Dark/Light Sensor; http://www.uoguelph.ca/~antoon/circ/sensor2
[4] Electronics for you; http://www.electronicsforu.com/electronicsforu/lab/

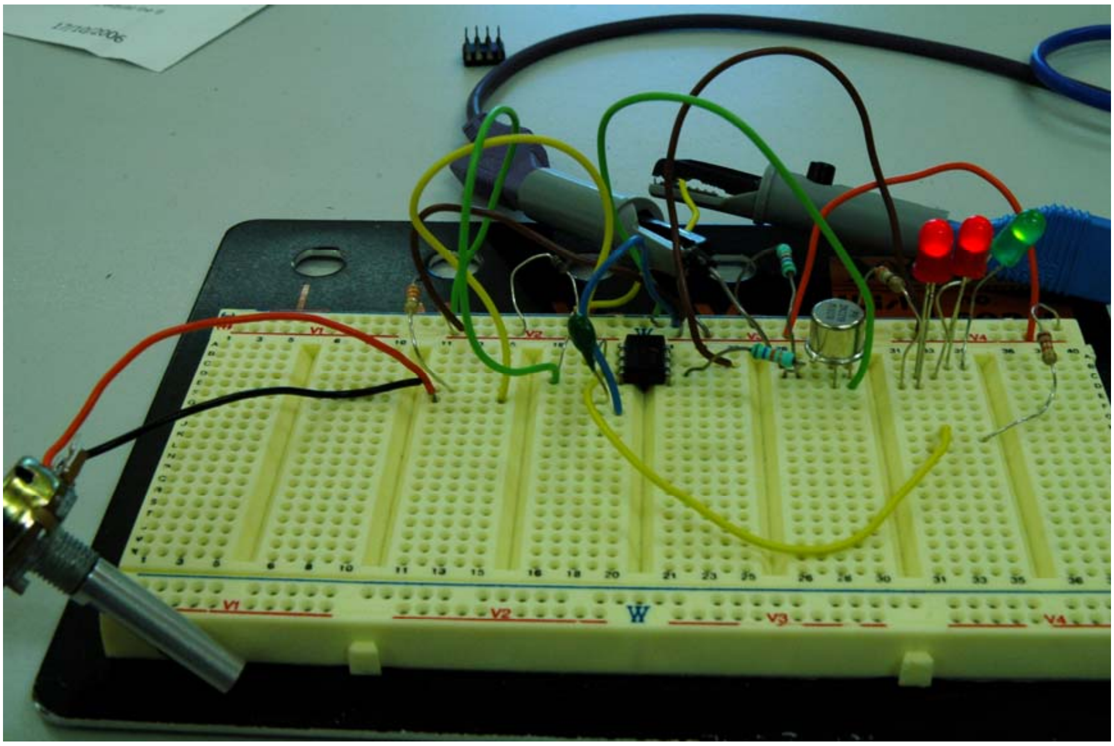
Appendix A: **Labelled photographs of assembled breadboard and PCB circuit.**



Sound Detector



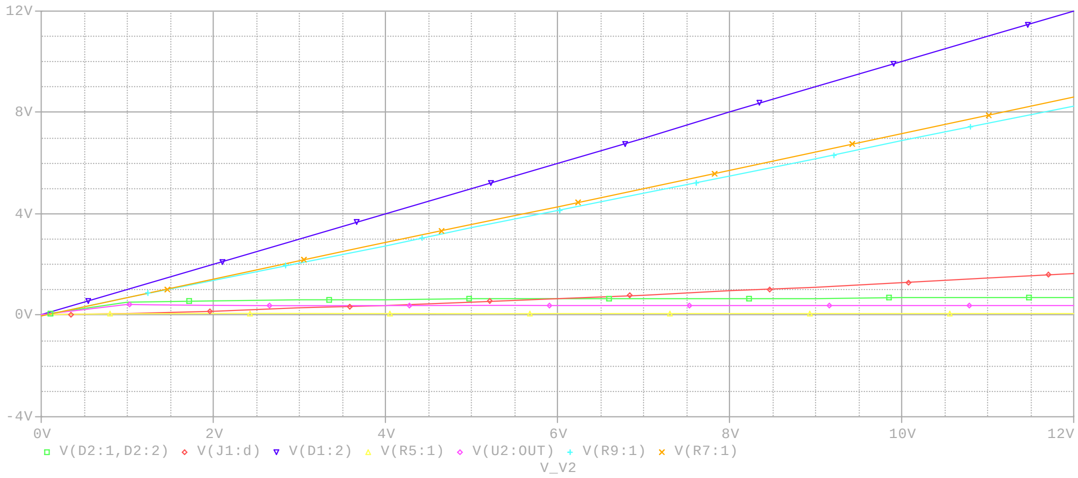
Light Sensor



Thermal Sensor

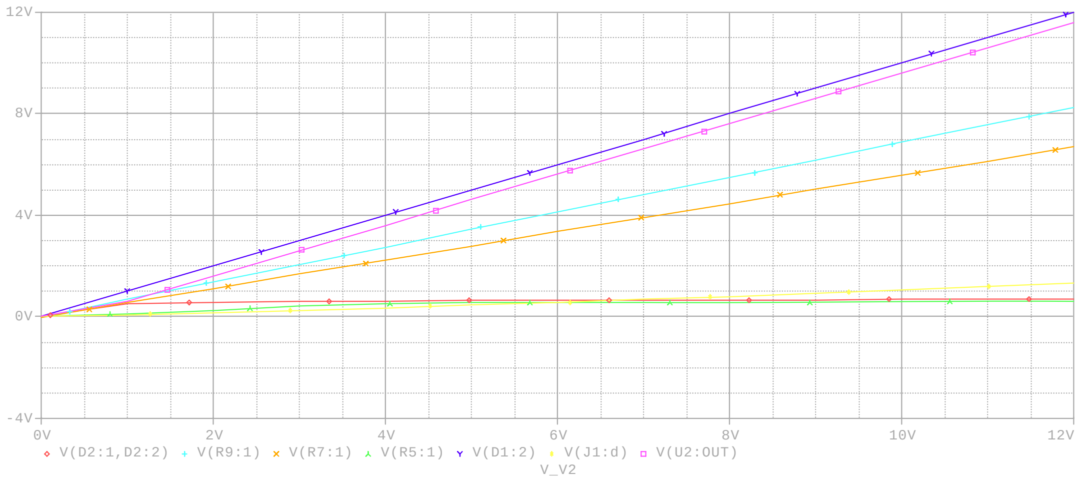
Thermal Sensor

When is thermal sensor turned off,



Note: This graph shows the relationship of the input voltage(x-axis) and the output voltage(y-axis) of the components. The green line is the voltage across the LED(replaced by diode as it couldn't be found in Pspice), the yellow line is the voltage at the base of BJT transistor, the blue line is the voltage at the collector of the BJT transistor, the orange line is the voltage at the positive pin, the light blue line is the voltage at the negative pin, the yellow line is the voltage at the output pin and the red line is the voltage at the output(if a fan is connected instead).

When is thermal sensor turned on,



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