Payload Transmitter Unit

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in partial fulfillment for the requirements of a B.E Degree in Telecom Engineering

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Abstract

The payload transmitter unit is primarily the living brain of a satellite and comprises of several small modules. Initially, it was accepted as part of PNSS-1 from SUPARCO but, due to delay in funding instead of space/military grade components, normal off the shelf low cost components have been utilized to achieve almost the same results as envisaged through PNSS-1. It consists of transceiver and is capable of receiving the control signal from ground station transmitter on the basis of which it transmits all telemetry information i.e. temperature, current and humidity to ground station employing BPSK modulation at data rate of 256Kbps. In addition it is capable of receiving frequency modulated voice/audio signal from ground station and retransmit at another frequency of 110MHz to the ground station. In order to incorporate the telemetry information in the payload transmitter, only temperature sensor and one humidity sensor are being used along with current sensing design, interfaced through PIC microcontroller 16F877A. Arrangements have been made to display the received information on LCD device.

It is hereby certified that the contents and form of the project report entitled “Payload transmitter unit”, submitted by the syndicate of

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have been found satisfactory as per the requirement of the B.E. Degree in Electrical (Telecom) Engineering.

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DECLARATION

We hereby declare that no content of work presented in this thesis has been submitted in support of another award of qualification or degree either in this institution or anywhere else.

DEDICATED TO

Almighty Allah,

Faculty for their help

And our parents for their support

ACKNOWLEDGEMENT

Nothing happens without the will of Allah Almighty. We thank Allah Almighty for giving us knowledge and strength to accomplish this task successfully.

We would like to thank our project supervisor, Asst Prof Engr Fazal Ahmed, and our advisor, Lt Col Dr Adnan Ahmad Khan, without their support and encouragement; it would not have been possible to complete this project.

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We would also like to thank and our colleagues for helping in developing the project and people who have willingly helped us with their abilities.

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List of Abbreviations:

BPSK	Binary Phase Shift Keying
FM	Frequency Modulation
FSK	Frequency Shift keying
LCD	Liquid Crystal Display
PLT	Payload transmitter
PPU	Payload Processing Unit
RF	Radio Frequency
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission
TTCS	Telemetry Telecommand and Control System
TDM	Time Division Multiplexing
TTL	Transistor Transistor Logic
VSWR	Voltage Standing Wave Ratio

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Chapter 1

1.1 Introduction:

1.1.1 Background

This project forms the basis of the satellite project which is the requirement of SUPARCO. This project lays the foundation for the mega project, first of its kind, which is to be completed in December 2016.

The motivation behind the project is that we will be able to know about all the techniques that are being implemented in order to build this huge project. Secondly, we will be able to obtain knowledge about the different modules that are being utilized for this project. The enthusiasm to learn more and improve our skills as engineers was the motivation behind choosing this project.

1.1.2 Problem Statement

"Preliminary Design and Prototype Development of Payload Data Transmitter for Pakistan National Student Satellite-1"

1.2 Project Description

The payload transmitter unit consists of several different portions that are the requirement of SUPARCO but due to significant delay in the budget we had to move from space grade components to non space grade components. By doing this, our cost reduced and we ended up with a prototype that will form the basis for SUPARCO's project.

In this project, we are providing the efficient communication of audio signal as well as integrating telemetry which gives us information about the health of the satellite. We are receiving two different types of signals from the ground station transmitter. One is the voice signal which is being received after frequency modulation [1] with uplink frequency of 114 MHz. This is then forwarded towards the receiver at the downlink frequency of 110 MHz. Other signal is that for telemetry, whenever ground station requires telemetry information, it will send a signal which is being recognized at the receiver with the help of BPSK demodulation. After receiving the signal, temperature, humidity and current are being measured and this information is being transmitted with the help of BPSK modulation to the transmitter. In order to know whether the correct information is being received at receiver we are also displaying the measured information on an LCD.

1.3 Prospective Application Area

1. Use of frequency modulation is widely used by the broadcasting industry as it is resilient to noise. As most noise is amplitude based, this can be removed by running the signal through a limiter so that only frequency variations appear.
2. It can help in animal tracking. RF transmitters are attached to the legs of birds or animals and signals are continuously sent to a satellite in order to track the location of an animal.
3. FM is used in mobile applications as it can withstand signal level variations.
4. Due to FM, transmitter efficiency level will be higher as non-linear amplifiers will be used.
5. The RF generator in a microwave oven, electro surgery and induction heating are similar in design of RF transmitters.
6. All the telemetry information can be monitored on the ground station and satellite can be made to remain within its orbital window.
7. Temperature, Humidity and current can be adjusted within the range with the help of information collected from the satellite.
8. BPSK finds its application in many different fields of mobile and satellite communication.

1.4 Scope, Objectives, Specifications and Deliverables:

1.4.1 Scope and Objective:

The basic scope of the project is to achieve the following objectives:

1. Understanding and designing of the payload transmitter unit
2. Simulation of various blocks in different software
3. Implementation with help of microcontroller
4. Interfacing different blocks efficiently
5. BPSK modulation for sending telemetry information
6. FM for the voice signal transmission

Following are the goals of the project:

1. Maximum utilization of existing heritage
2. Modularity in design
3. Optimizing the design for a specific frequency and output power
4. Innovative product
5. Power efficient
6. Efficient communication of audio signals
7. Communication of Telemetry information

1.4.2 Specifications:

PARAMETERS	DESIRED
INPUT VOLTAGE	+5/12 VOLTS
INPUT MAX POWER	3 WATTS
TRANSMITTING FREQUENCY	110-114 MHz
MAX MASS	2.5 KILOGRAMS
OUTPUT POWER	27dBm ~ 501.18mW
VSWR	≥1.3:1
D/L FREQUENCY	433.9MHz
MODULATION	BPSK/FM
MULTIPLETING SCHEME	TDM

Figure 1: Specifications of the project [2]

1.4.3 Deliverables:

1. Transmitter and receiver of the voice channel with the help of FM
2. Receiver for the control signal and transmitter for sending telemetry information with the help of BPSK
3. Temperature sensor for measuring the temperature of payload segment
4. Humidity sensor
5. Current sensing with help of circuit designed
6. LCD interfacing
7. PIC microcontroller

Chapter 2

2.1 Literature Review:

2.1.1 Overview of existing literature:

Payload data transmitter unit is responsible for transmission of payload data to the ground station. Main functions of payload transmitter are as follows:

1. Reception of data from Ground station Transmitter
2. BPSK modulation
3. Transmission of payload data to transmit antenna of TTCS for onward transmission to ground.
4. Signal conditioning of its own telemetries
5. Measuring temperature, current and humidity from different sensors
6. Interfacing these sensors to a specific microcontroller
7. Displaying this telemetry information on an LCD

Payload transmitter is responsible for transmission of payload data to ground station with the help of transmit antenna of TTCS. It receives the data from ground station transmitter in NRZ format and after BPSK demodulation it will extract the information. These bit streams will indicate that the ground station demands for the telemetry information.

This data will be interpreted with help of PIC microcontroller [3]. Microcontroller will gather the data from different sensors and then display it on LCD. This information will then be transmitted to the ground station with the help of BPSK modulation. Hence, the ground station will be made aware regarding the health of the satellite.

The second portion of the project is the voice signal transmission with help of Frequency Modulation. In this portion of the project the signal is transmitted on two different frequencies i.e. one for the uplink and one for the downlink. With help of this portion we will be able to know the basics of FM and also get the knowledge of transmitting the signal at different frequencies.

2.2 Problem Formulation:

Payload Transmitter Unit is one of the most important portions of a satellite. In order to achieve the objectives and overcome the fore mentioned problem, we will proceed in an easy and effective manner. Payload transmitter unit shall be able to receive the data from ground station with help of Quadruple Differential Line Receiver. BPSK demodulator will then be used for extracting the information. The NRZ bit stream is being interpreted for having the knowledge about the signal received from ground station receiver. On the basis of this signal Microcontroller is being used to get the information about temperature, current and humidity. This data will then be displayed on the LCD which will then be transmitted towards the ground station with the help of BPSK modulation.

2.3 Background Study:

Initially this project was being supervised by SUPARCO, which had certain features that needed to be incorporated.

Payload transmitter is a major portion of satellite. Payload transmitter is responsible for transmission of payload data to ground station with the help of transmit antenna of TTCS. It receives data from the PPU and after sub carrier and carrier modulation it transmits the payload data to TTCS for onward transmission. Payload transmitter is also responsible for processing the telemetries of its own and transmitting them to DHU through CAN bus.

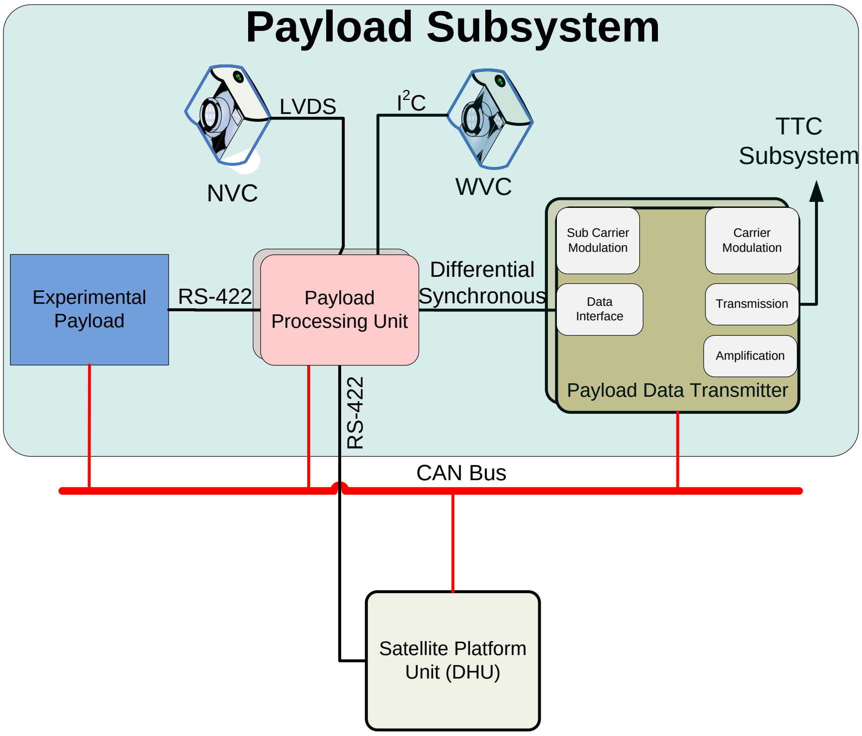

Figure 2: Initial diagram of the project [4]

Initially the basic design approach of this project was that the payload transmitter unit would receive 4 different data rates from **PPU**. For that purpose, Quadruple Differential Line Receiver is being used which will give a 4 state output. The output voltage will be -6V and +6V according to RS 422 standard. A converter will be used to convert signals from RS 422 to TTL format i.e. 0-5V. BPSK modulation will be implemented by following any of the two proposed design approaches:

1. Sub Carrier Modulation
2. Direct Modulation

For Sub carrier modulation approach, Band Pass Filter will be used at IF frequency of 1 MHz and frequency mixer will be employed for up converting to RF at 433.9 MHz as stated in our requirement.

For direct modulation approach, band pass filter will be deployed at RF frequency of 433.9 MHz. This band limited RF output will be passed to High Power Amplifier (HPA) for providing a power output of 27 dBm. HPA will amplify the RF signal before transmitting it to the antenna. For Tele-commands and Telemetry information, Microcontroller will take input from sensors and send the required data through CAN bus to DHU [5].

We had started our project by focusing on the guidelines that were being provided by SUPARCO but due to significant delay in the procedure, time limitations of our final year project and constraints of the budget we were not able to carry forward our initial project so we moved from space grade components to non space components. This reduced the cost and thus we implemented and designed a prototype for the actual project of SUPARCO.

Chapter 3

3.1 Detailed Design:

The project consists of different modules that must be implemented individually and then these modules must be interfaced together in order to achieve a payload transmitter unit that is the desired requirement.

The project consists of two different channels. One for the voice signal transmission and the other for the control signal. The voice signal is being transmitted with the help of frequency modulation. First the ground station will send the voice signal at a particular frequency and then this signal will be transmitted on another frequency via downlink channel to the receiver.

The second task is that we receive a control signal which gives the information that ground station requires pertaining to the health of the satellite. This received bit is demodulated at the receiver to get knowledge of the information being sent. Third task is to measure the current, humidity and temperature with help of sensors for which we have used a microcontroller. The fourth task is to make a transmitter which will be helpful for transmitting that telemetry information to the receiver segment. There will be two modules which will work as a BPSK encoder, modulator and BPSK decoder and demodulator. But, this will only be used for the telemetry portion and not for the audio signal transmission.

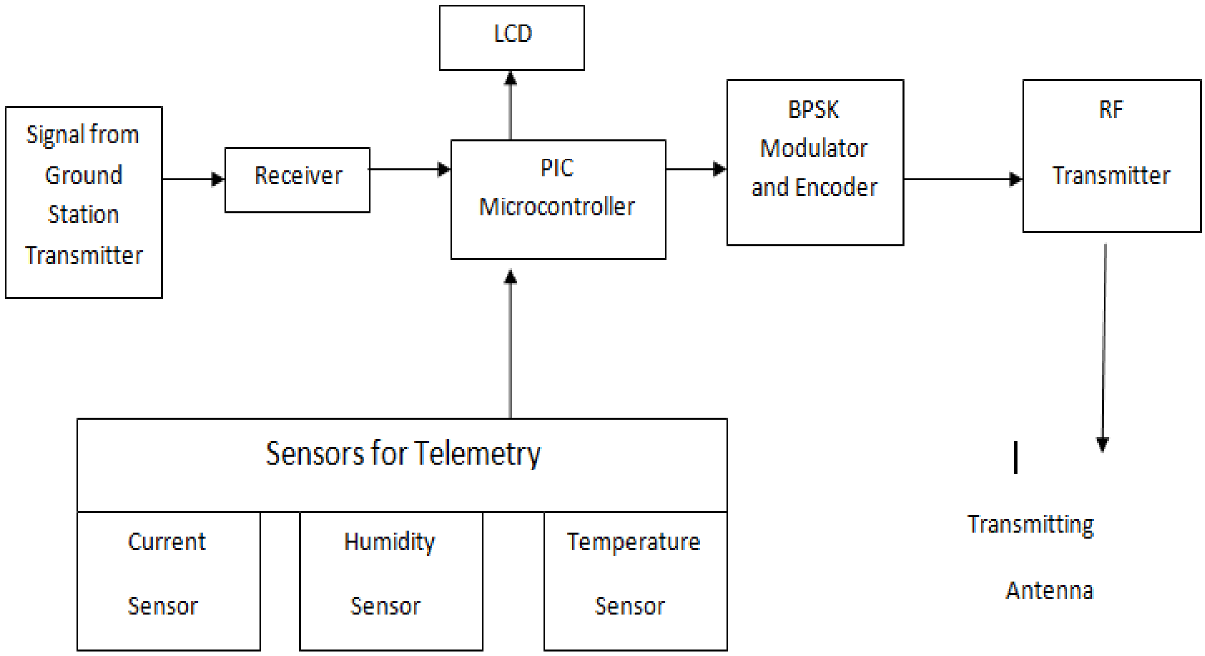

Figure 3: Payload transmitter prototype block diagram [6]

3.2 Modules Description and Design

We have approached the project by first designing the frequency modulator circuit and after that we have designed a transmitter and a receiver for the voice channel. Next step is to measure the telemetry information with the help of PIC 16F877A. Temperature and humidity are being measured with the help of different sensors, while for measuring the current we have designed a circuit. This information is then transmitted with the help of BPSK modulation to the ground station receiver.

3.2.1 FM / FSK Modulator

This is the first task that has been completed. During long transmission, the high frequency part of the digital signal will easily attenuate and cause distortion. Therefore, the signal has to be modulated before transmission, and for that purpose we are using FSK. FSK technique is to modulate the data signal at two different frequencies to achieve effective transmission. At the receiver, the data signal will be recovered based on the two different frequencies of the received signal. The relation of FSK signal and data signal is shown in the figure below.

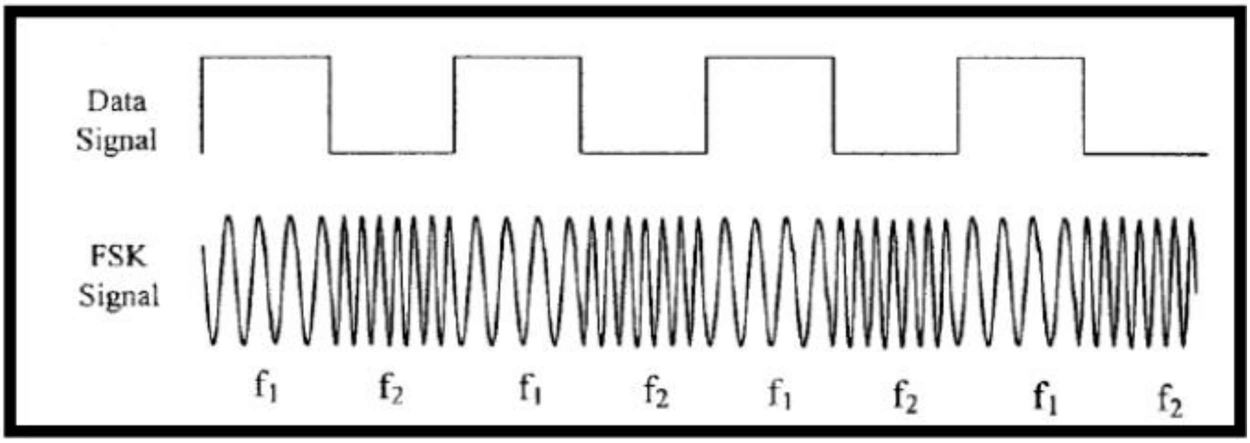

Figure 4: The signal waveforms of FSK modulation [7].

In order to achieve this FSK modulation we have used 2206 IC, which is a waveform generator. The circuit diagram of the FSK modulator by using 2206 IC is shown and being implemented.

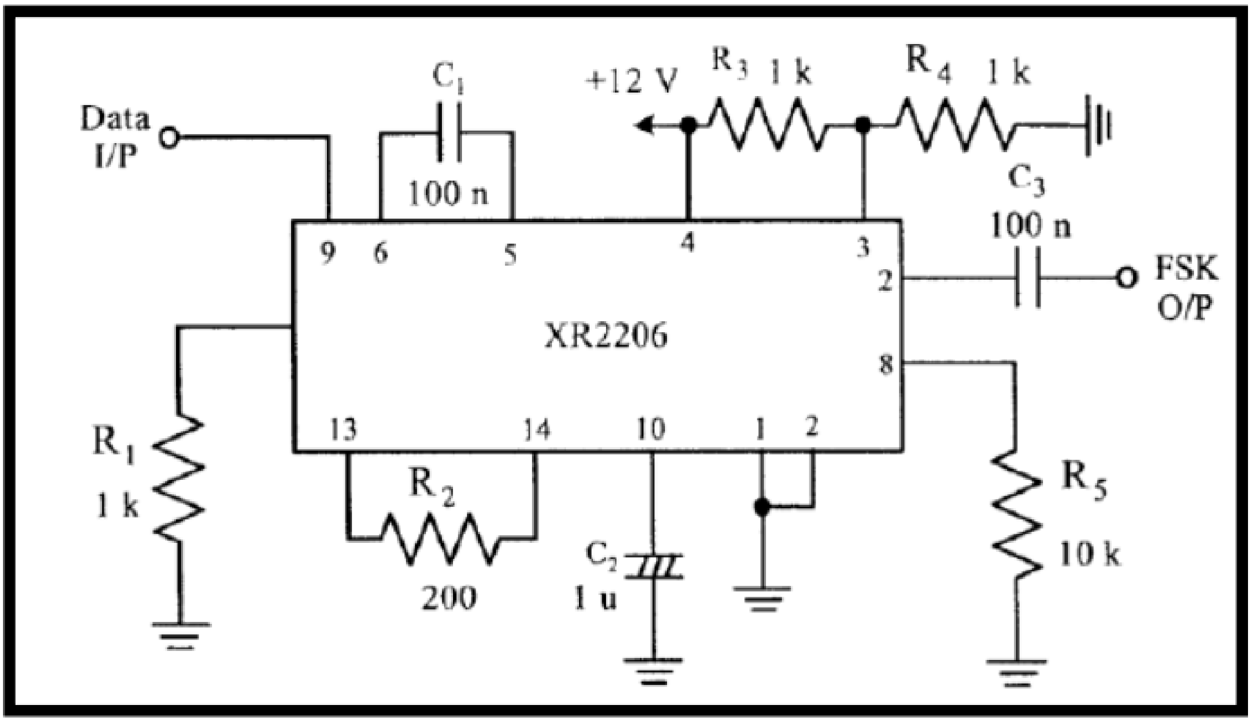

Figure 5: Circuit diagram of FSK modulator by using 2206 IC [8]

In this figure, resistors R3 and R4 comprise of a voltage divider circuit. The main function of the voltage divided circuit is to let the negative voltage waveform of the 2206 IC operate normally. The oscillation frequency of 2206 IC is determined by resistors R1 and R5. Its oscillation frequencies are

$$f_1 = \frac{1}{2\pi\sqrt{R_1 C_1}}$$

$$f_2 = \frac{1}{2\pi\sqrt{R_5 C_1}}$$

There is an internal comparator in 2206 IC. Assume that when the input is 5V, the output frequency is f1, and when the input is 0V, the output frequency is f2. We can utilize the TTL signal at pin 9 to control the output frequency to be f1 or f2. By using the variable resistor, we can adjust the frequency according to our desired requirement. In our case f1 is 1200 Hz and f2 is 2200Hz.

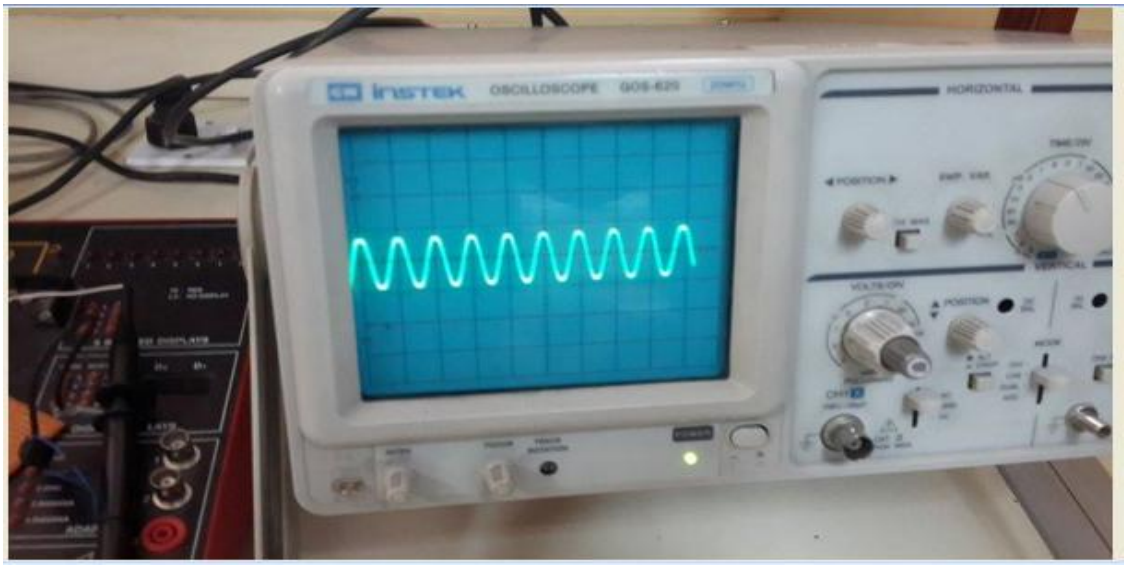

Figure 6: FSK modulated output when input is 0V

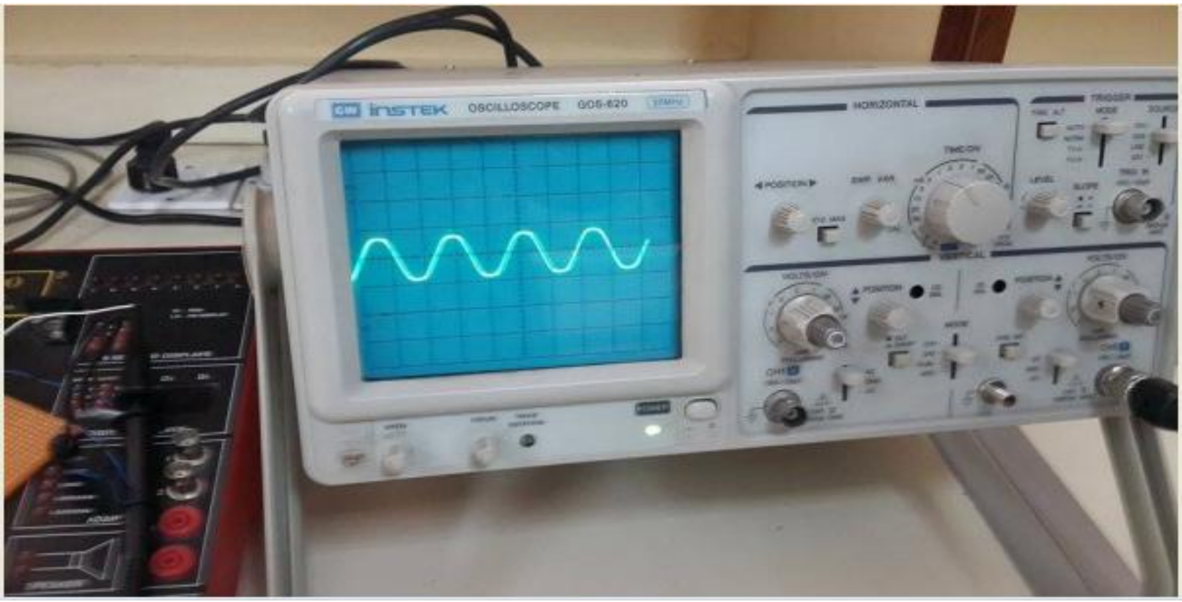

Figure 7: FSK modulated output when input is 5V

As well as implementing FSK, we have also approached the problem of transmission of voice signal with help of frequency modulation (FM).This is being achieved with help of Colpitts Oscillator [9].

3.2.2 Temperature sensor:

This is the second task that we have completed for the project. Transducer converts the physical data such as temperature into electrical signal. Depending on the transducer, the output produced is in the form of voltage, current or resistance etc. In our case we have the output in the form of voltage.

The temperature sensor that we have used is LM35[10]. It is easily available and is widely used. Secondly, it is a linear temperature sensor for which code is easily available. The LM35 series sensors are precision integrated- circuit temperature sensors whose output voltage is linearly proportional to Celsius temperature. The LM35 requires no external calibration because it is internally calibrated. The microcontroller we have used is PIC[11].

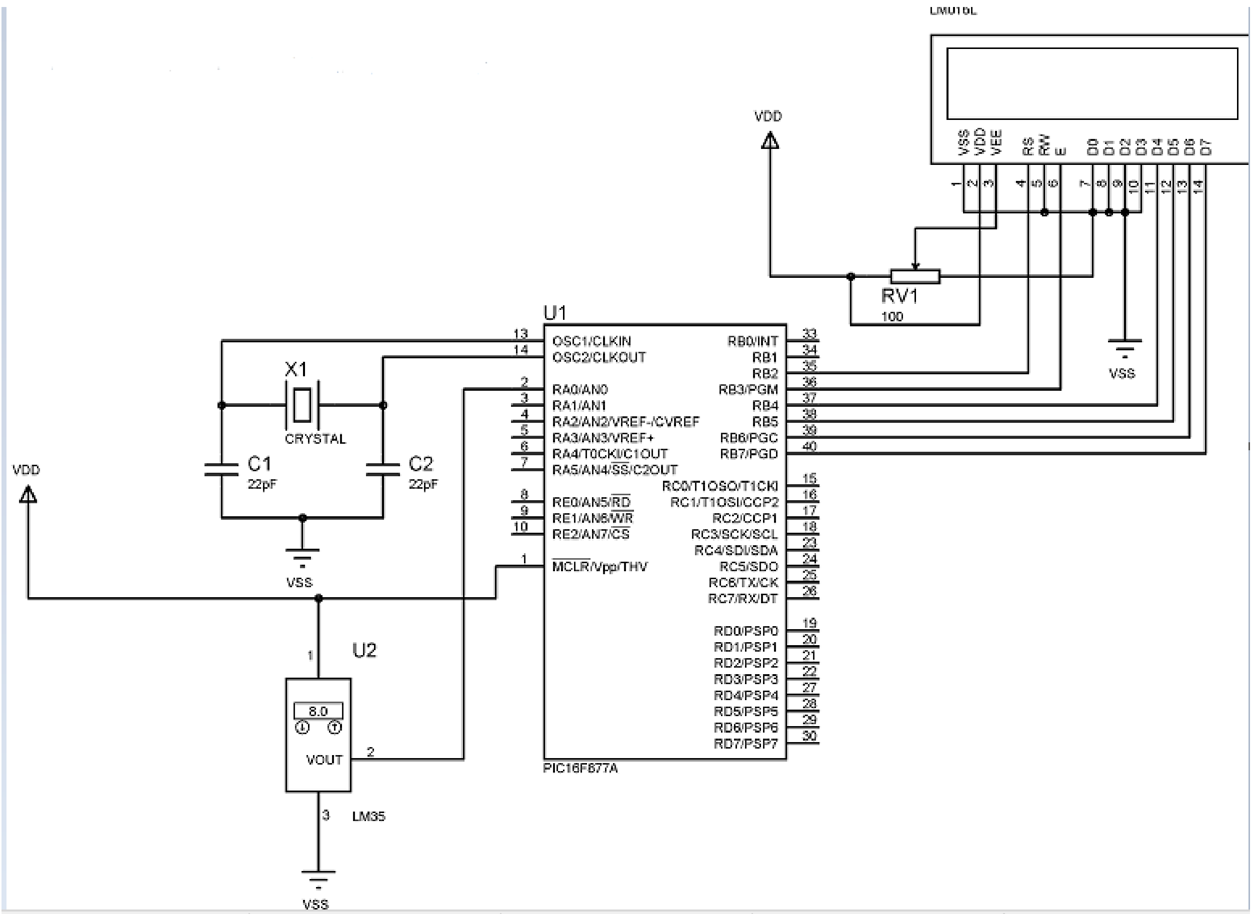

Figure 8: Circuit diagram for temperature sensor

3.2.3 Humidity sensor:

The next task that is being completed is humidity sensing with help of 555 timer ICs. Digital humidity sensor with LCD display is used to measure relative percentage of water vapors in the air. HS1101[12] is a capacitive humidity sensor and is interfaced with PIC 16F877A to measure humidity. Capacitive humidity sensor changes its capacitance with respect to a change in the sensing parameter which, in our case, is the amount of water vapor in air.

HS1101 is a capacitive humidity sensor and can be used with 555 timer ICs to generate square waves of different frequencies. It is not possible for a microcontroller to read the changing capacitance directly. That is why we used a circuit to convert changing the capacitance of HS1101 into a square wave whose frequency changes according to a change in capacitance.

With the help of this, we can measure the square wave frequency with the microcontroller. There is a proper relationship between humidity and frequency with the help of which we can determine the humidity.

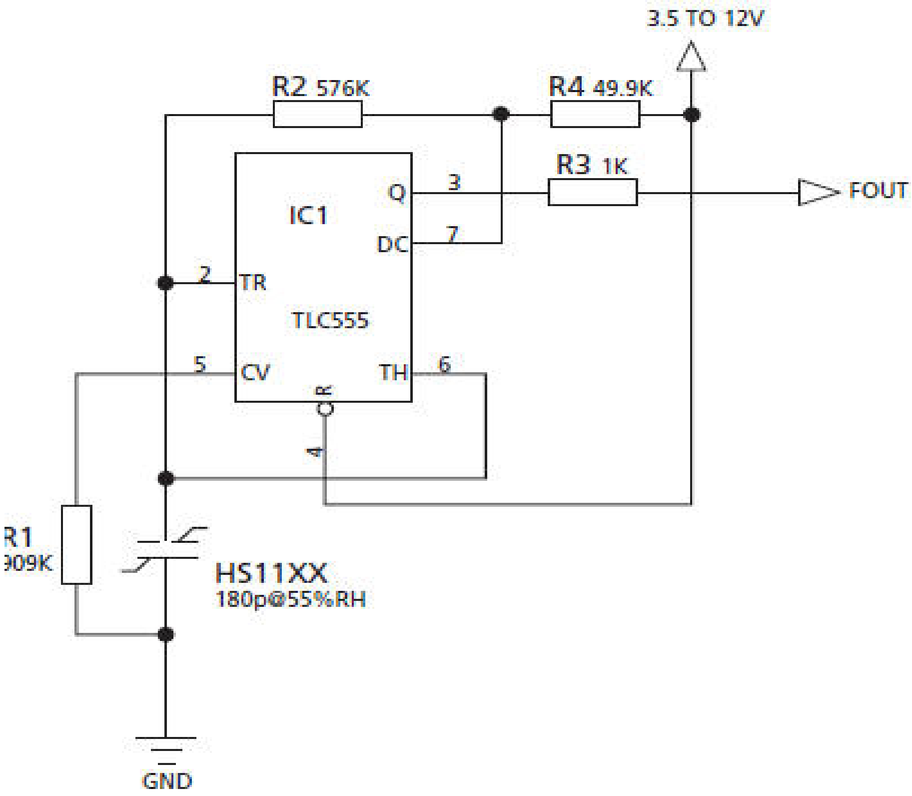

Figure 9: Circuit diagram for humidity sensor

3.2.4 Current Sensor:

There is a simple circuit that is being used to measure the current in a circuit.

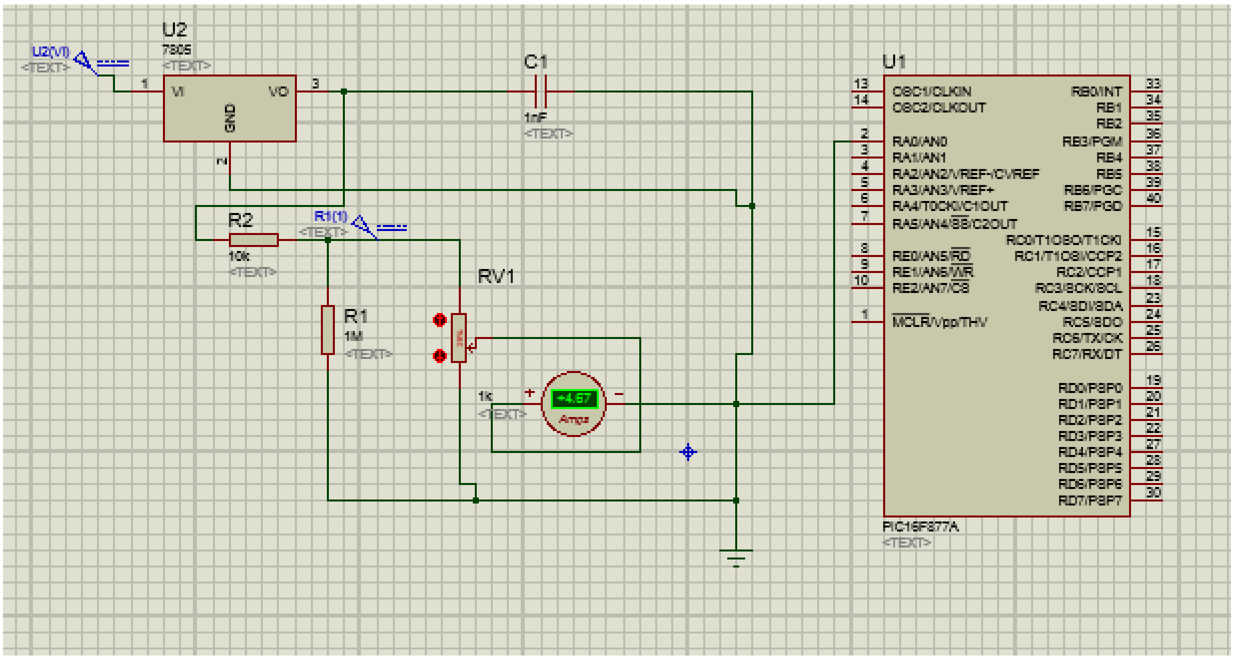

Figure 10: Proteus simulation for current sensing

3.2.5 BPSK encoder and modulator:

Since we are required to have a modulator with frequency of up to 433.9 MHz so we have to order that specific BPSK modulator and encoder that will serve our desired purpose.

However, we implemented the simulation of this modulator in MATLAB, which satisfied our requirement.

For that purpose we have used a modulator from Synergy Microwave Corporation Model MK-702S[13] which has a frequency range of 10-900 MHz.

Specifications

Product Category	QPSK Modulators and BPSK Modulators
Modulator Type	BPSK
Package Type	Connectorized
Connector Type	SMA
Carrier Frequency	10 to 900 MHz
Insertion Loss	2.5 dB
Unbalances	
Amplitude Unbalance	0.4000 dB
Phase Unbalance	2 degrees
VSWR	2 :1

Fig 11: BPSK Modulator MK-702S Specification

3.2.6 Transmitter and Receiver:

In order to forward the modulated signal for transmission we have used RF transmitter.

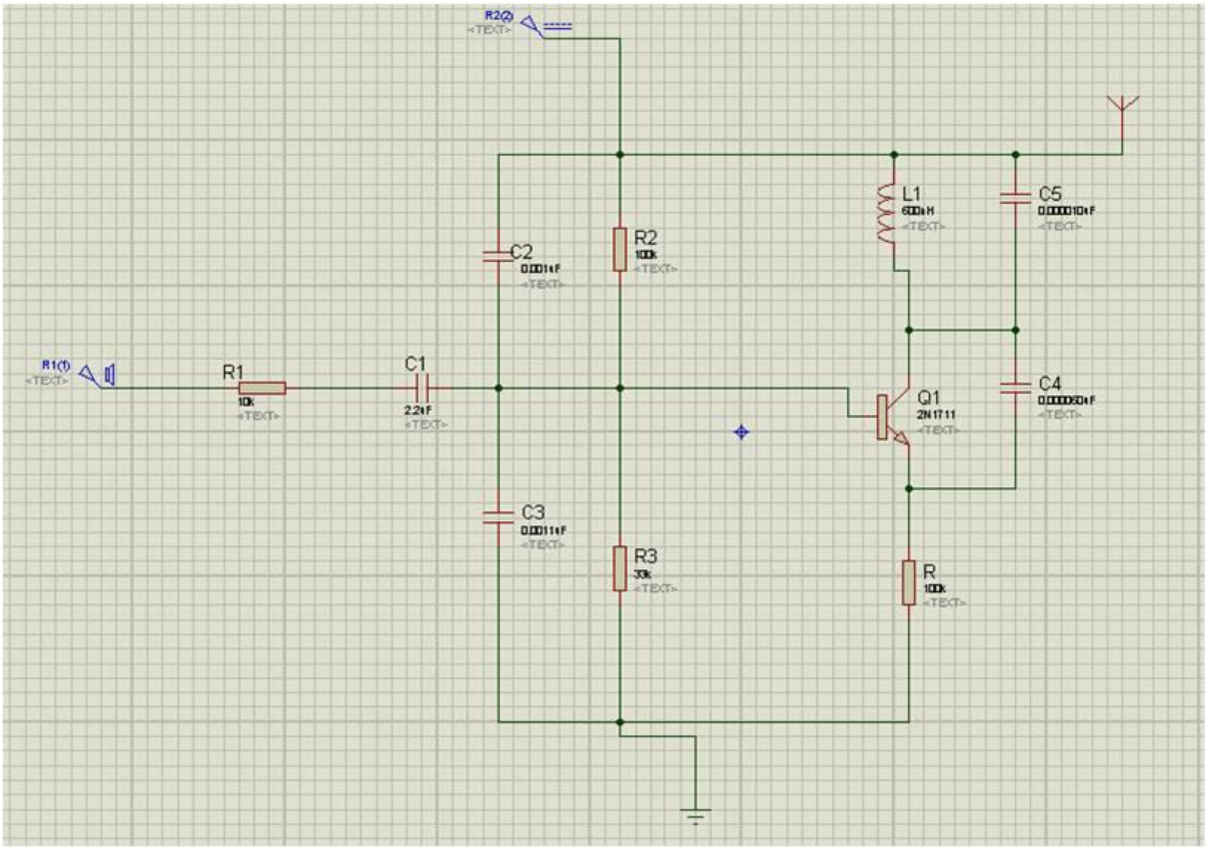

Figure 12: In this figure the circuit diagram of RF transmitter is shown

For the receiver we will use a receiver kit. The receiver is designed to receive the signal from the ground station transmitter unit which has been done by ground station group. The frequency range for that would be 110 MHz for downlink and 114 MHz for uplink.

Chapter 4

4.1 Project Analysis and Evaluation

All the results and simulations related to the modulator and sensors have been demonstrated below.

<u>Simulation for crystal oscillator interfacing with PIC16F877A</u>

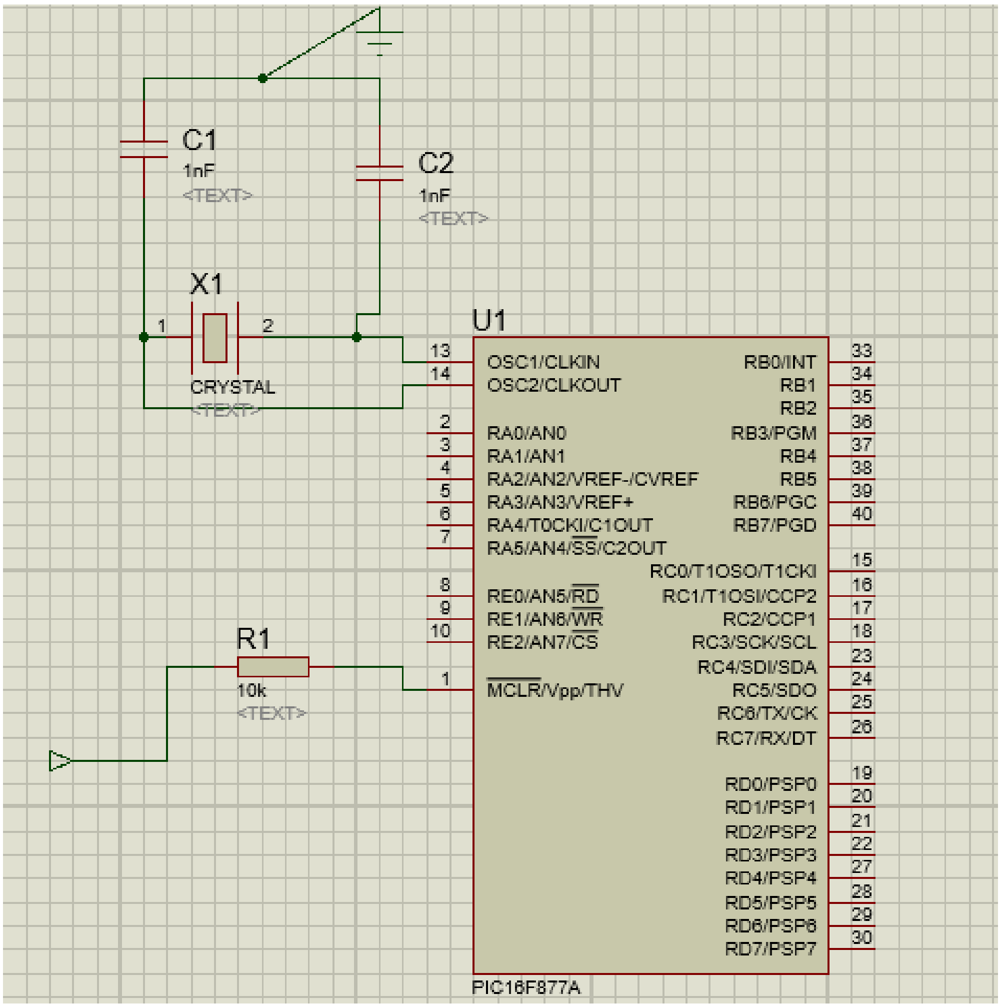

Figure 13: Proteus simulation for crystal oscillator

Simulation for crystal oscillator interfacing with PIC16F877A

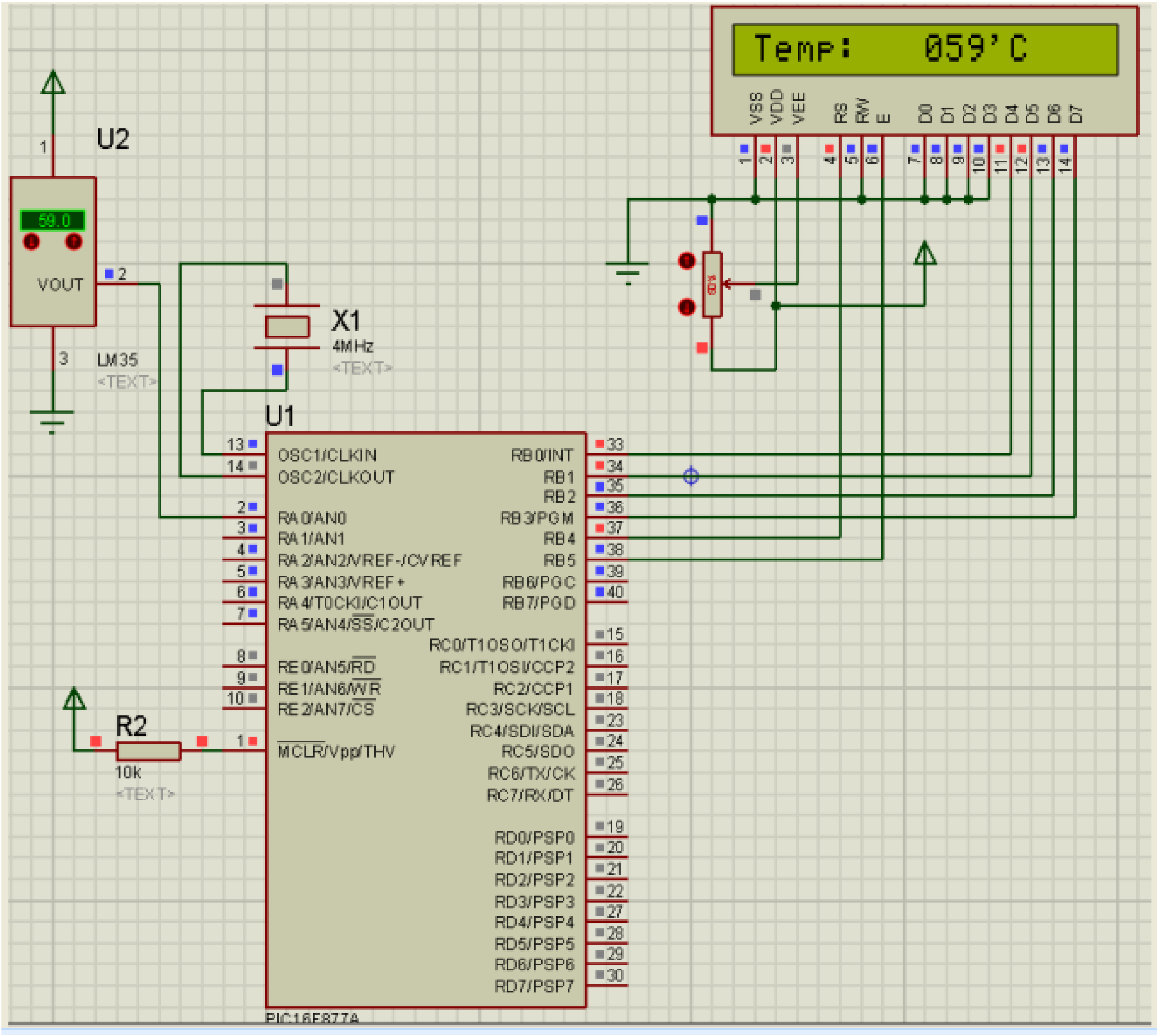

Figure 14: Proteus simulation for temperature sensor

__**For interfacing current sensor designed circuit with PIC16F877A**__

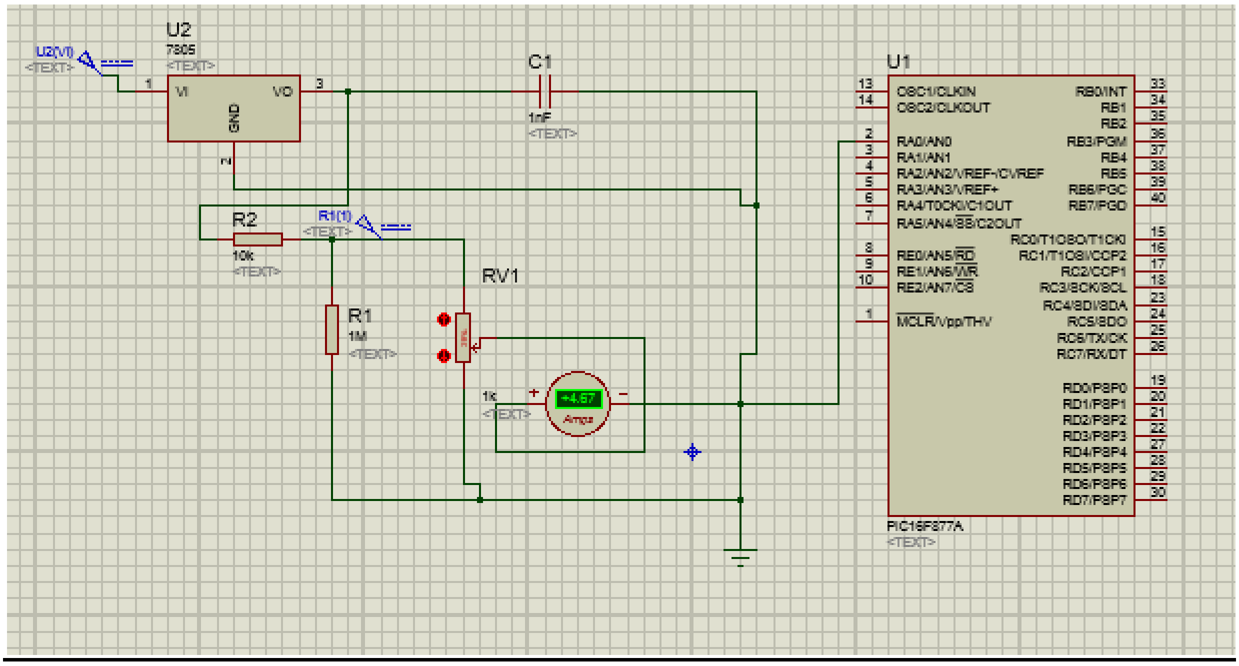

Figure 15: Proteus simulation for current sensing

__For interfacing humidity sensor and LCD__

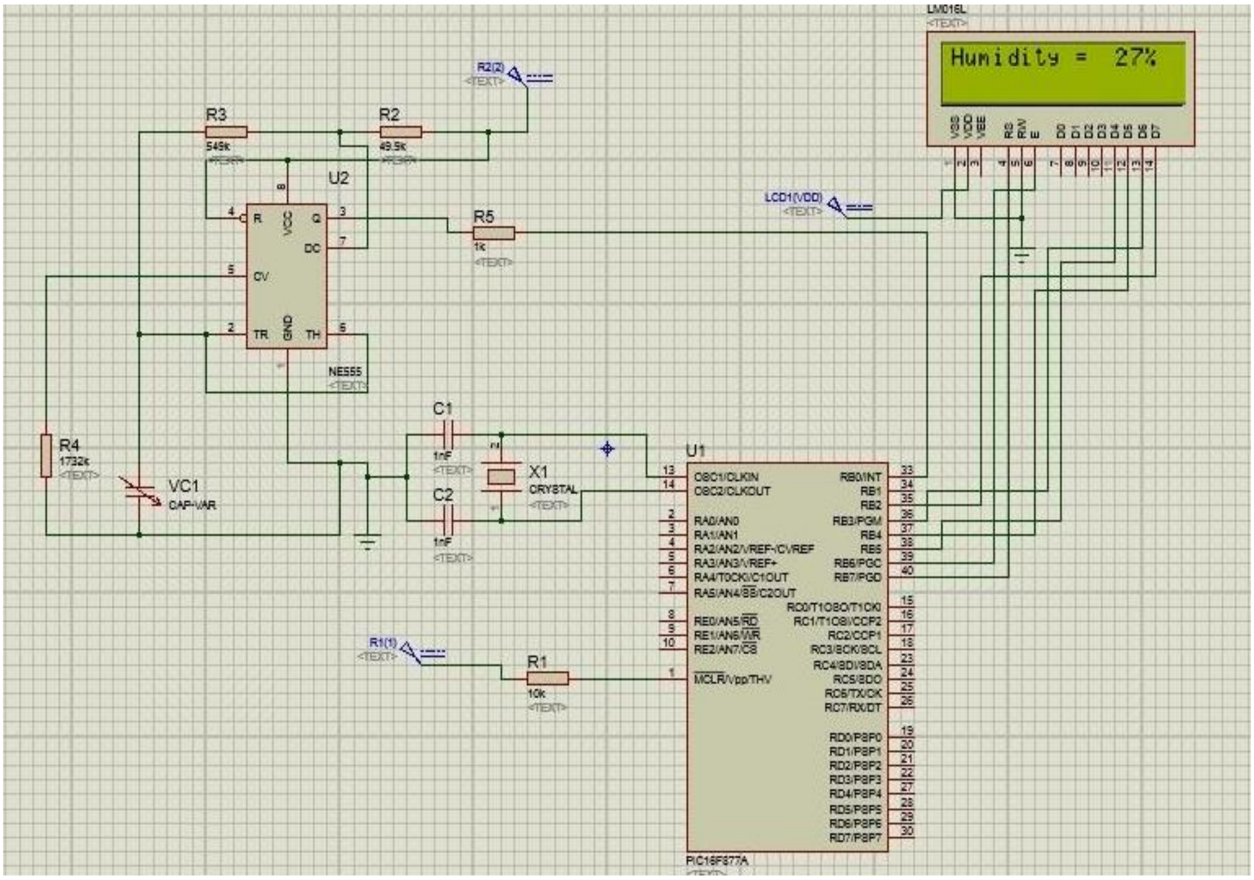

Figure 16: Proteus simulation for humidity sensor

Chapter 5

5.1 Recommendations for future work

This project forms the basis of the satellite project which is the requirement of SUPARCO. This project lays the foundation for the project which is to be completed in 2016. It will be a good development for Pakistan, enhancing the economy and will open job opportunities.
This long-term program has been envisioned to involve, train and impart knowledge to university students in the high-tech and sophisticated domain of satellite technology. Pakistan National Student Satellite Program (PNSSP) comprises a series of satellites which will be designed and developed by young and vibrant students of the motherland. The proposed program is a way forward for sustainable and progressive student satellite developments under the umbrella of SUPARCO.

This project is one of the most integral parts SUPARCO's project. This project serves as the backbone for the ultimate objective, i.e. SUPARCO and selected institutes collaboratively design, develop, manufacture and launch the first ever Pakistan National Student Satellite-1. This will help achieve the much needed industrial growth and enhance our national economy. SUPARCO also regularly organizes a satellite equipment design competition, finance development/ manufacturing of winning designs.

With help of this project, not only the students will take interest but it will be very helpful for different industries as well. Most of the industries will start to focus on this vast area of development that was hitherto unexplored and will definitely show their interest for the prosperity of the country which is the ultimate goal.

In order to extend this project and make some sort of improvement, different other sensors can be introduced that can be used as telemetry information like voltage sensor, pressure sensor and heat sensor etc. GPS modules can also be introduced in this project. With help of these coordinates, exact position of the satellite can be known and this will also be helpful to know whether satellite is revolving in its orbital window or not. In case it drifts away from its orbital window, necessary commands can be transmitted so that it moves back in its original position.

Chapter 6

6.1 Conclusion

The payload transmitter unit is a prototype development of the mega project consisting of several small modules which is the requirement of SUPARCO. However, this project is not totally based on the guidelines of SUPARCO, yet it will provide a fruitful result which can serve as a prototype for the original design. This payload unit is able to serve several different purposes. It receives the signal from ground station transmitter on the basis of which it transmits all telemetry information i.e. temperature, current and humidity to ground station receiver with help of BPSK modulation. It can also receive voice signal from ground station transmitter with the help of FM, and then forward this signal to the ground station receiver. The uplink and downlink frequencies are 114 MHz and 110Mhz.In order to incorporate the telemetry information in payload transmitter, temperature sensor along with a microcontroller are used. Similar approach was done for humidity and current. This telemetry information is being displayed on LCD in order to show that correct information is being received at receiver segment.

Following objectives are being achieved:

7. Understanding and designing of the payload transmitter unit
8. Simulation of various blocks in different software
9. Implementation with help of microcontroller
10. Interfacing different blocks efficiently
11. BPSK modulation for sending telemetry information
12. FM for the voice signal transmission

First limitation of the project is that redundancy must be provided at those portions where there is need of it like in case if one sensor is not able to get the data than other can work instead of it.

Secondly, if HPA and driver amplifiers are used than transmission range can be increased but due to non-availability of these amplifiers they are not being used for this particular project.

Chapter 7

7.1 Demonstration Outline

All the result and simulation related to modulator and different sensor have been demonstrated in the report. These are the basic outline of demonstration:

1. FM/FSK modulator
2. Temperature sensor
3. Humidity sensor
4. Current sensing circuit
5. BPSK modulator and encoder
6. Transmitter and receiver for audio signal

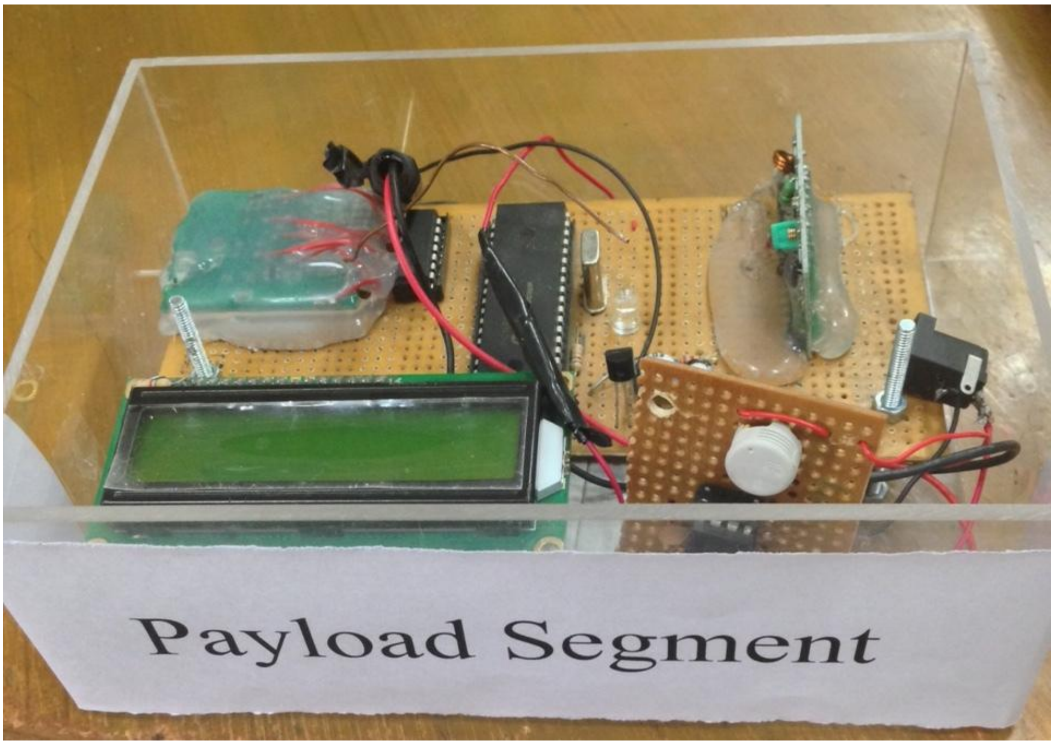

Fig 17: Payload telemetry transmission unit switched off

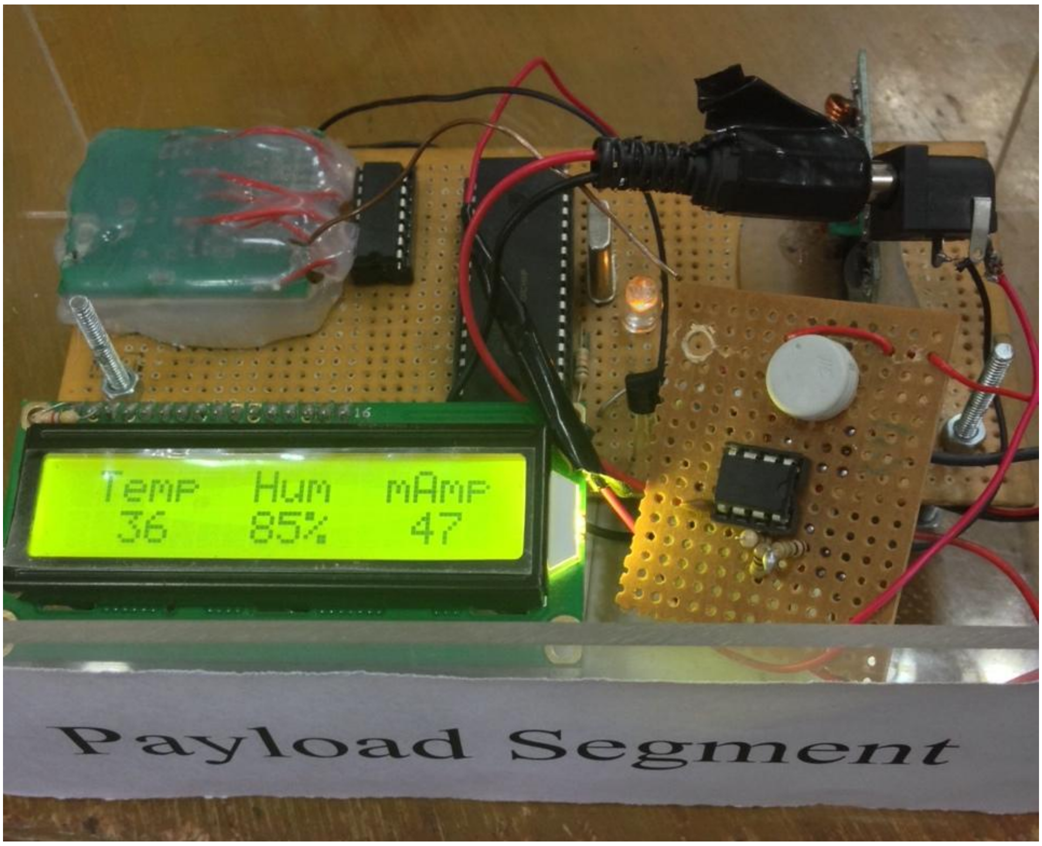

Fig 18: Payload telemetry transmission unit switched on

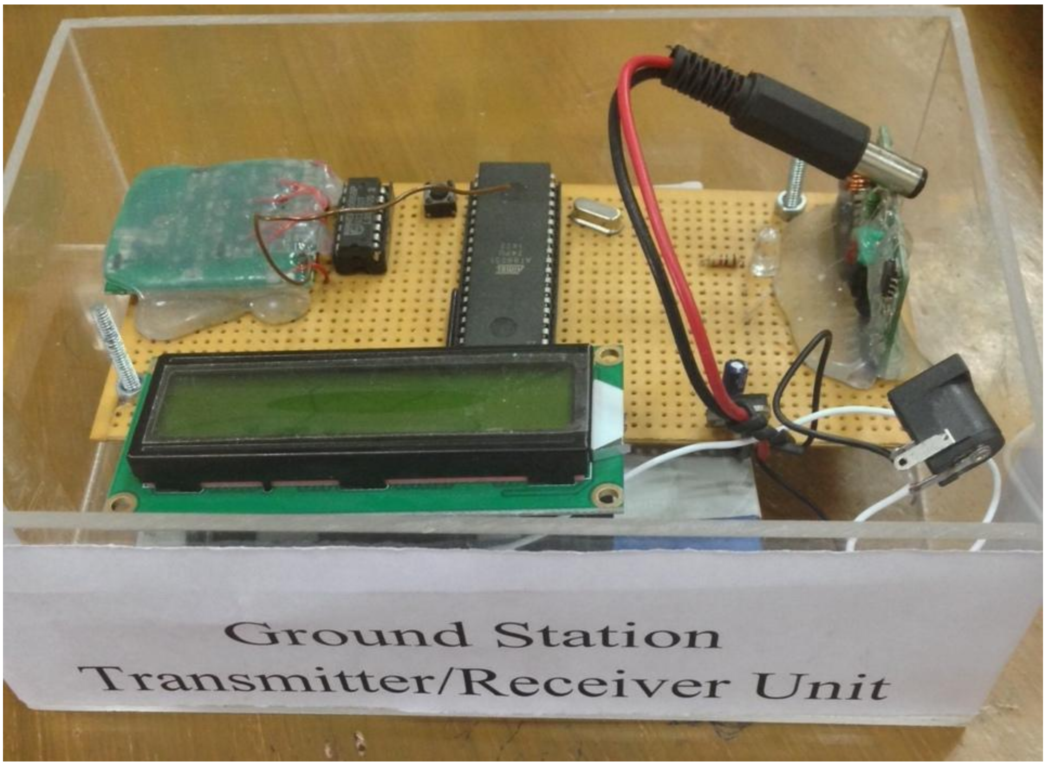

Fig 19: Ground station transmitter/receiver unit switched off

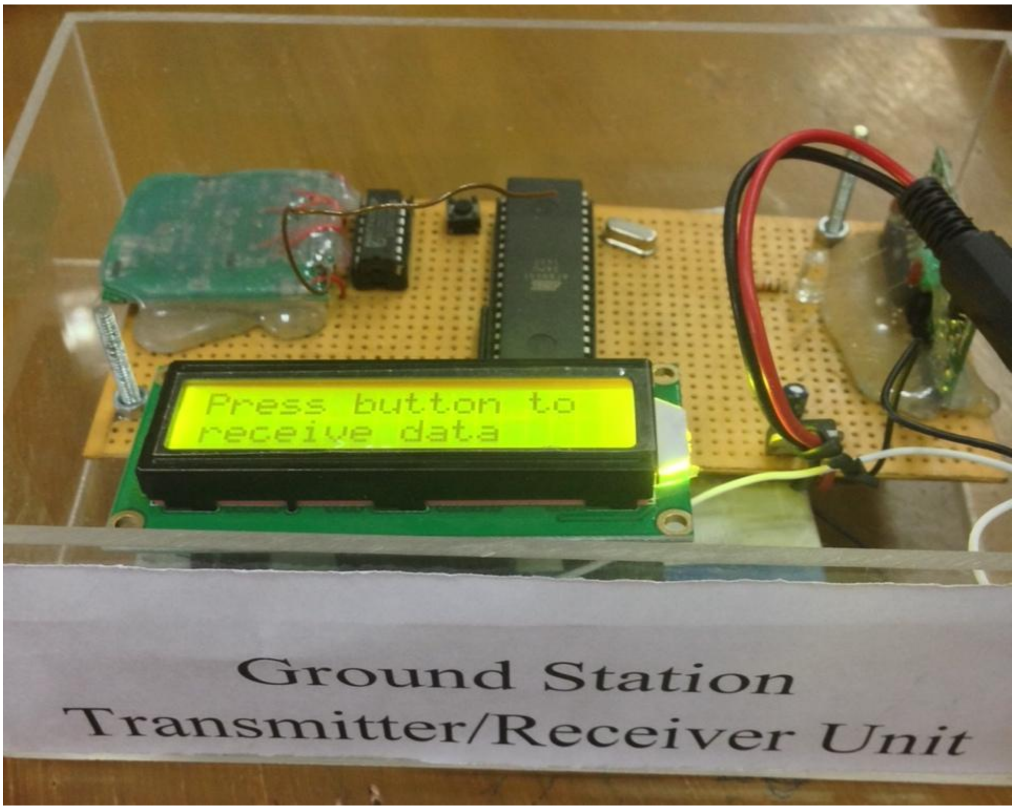

Fig 20: Ground station transmitter/receiver unit awaiting command

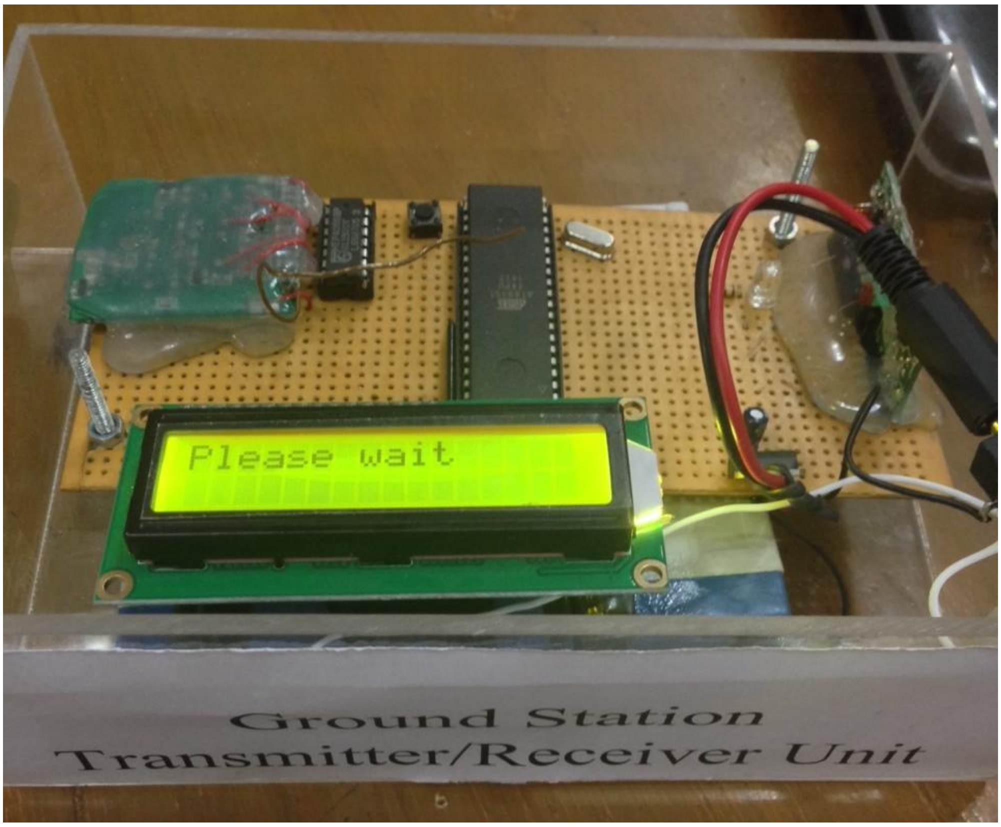

Fig 21: Ground station transmitter/receiver unit processing received data from payload segment

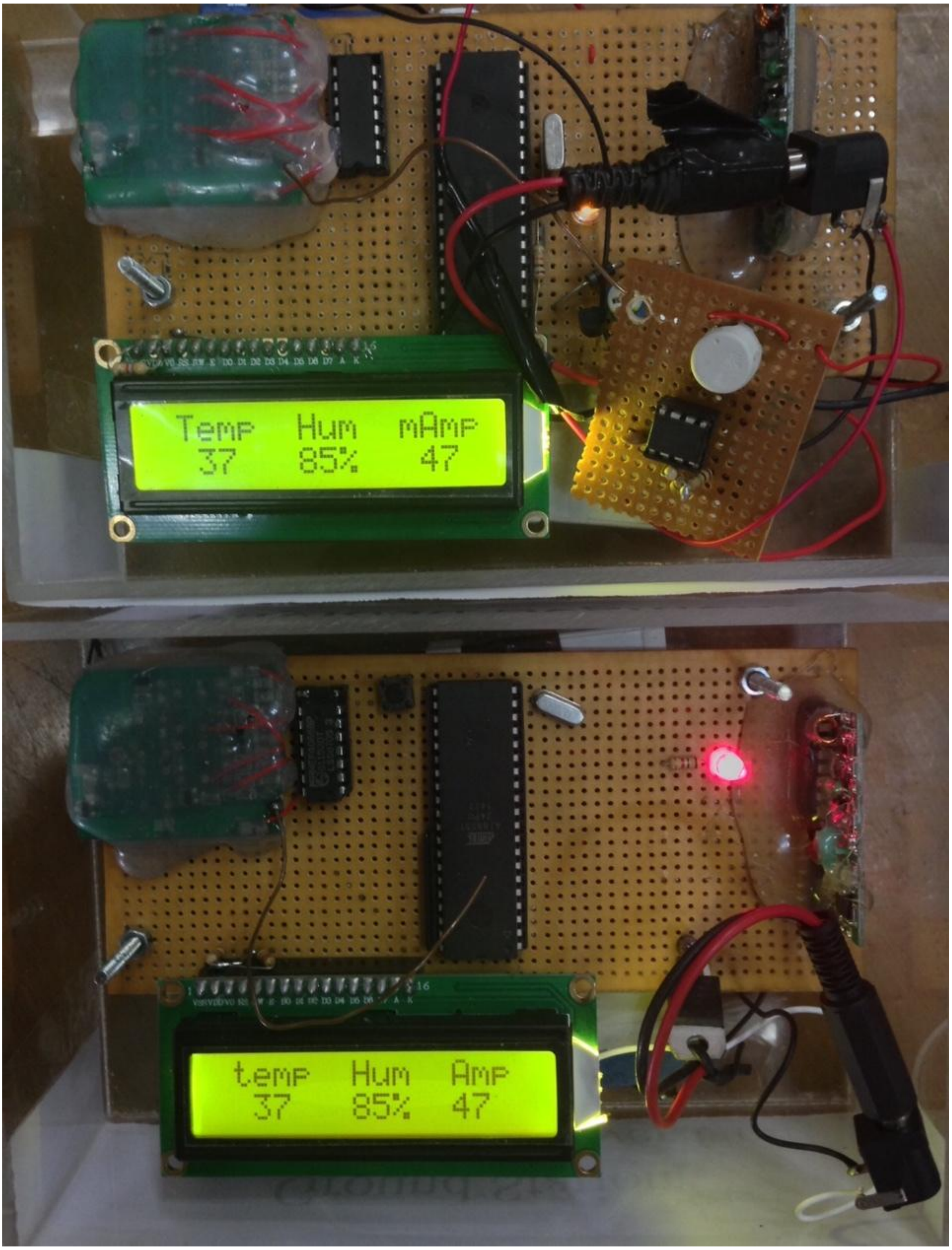

Fig 22: Ground station transmitter/receiver displaying telemetry information sent by payload segment

References

Many institutions and companies working on the satellite projects have done this type of work. Some references of these works are as follows:

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[3] *PIC Microcontroller Using Assembly and C*; Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi; 792 pages; 2010;

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[13] Couch, Leon W. II (1997). *Digital and Analog Communications*. Upper Saddle River, NJ: Prentice-Hall

Appendix A

PAYLOAD TRANSMITTER UNIT

Extended Title:

Preliminary Design and Prototype Development of Payload Data Transmitter for PNSS-1

Brief Description of The Project / Thesis with Salient Specs:

This proposal defines the broad requirements for Payload Transmitter Unit of PNSS-1 satellite. Payload transmitter unit shall be able to transmit payload data to antenna for onward transmission to ground. Payload transmitter unit shall be able to receive and modulate payload data from Payload Processing Unit (PPU). Payload transmitter unit shall be able to process and transmit its own telemetry to Data Handling Unit (DHU) through Controller Area Network (CAN). Payload transmitter unit shall be able to receive and process telecommand from DHU through CAN. Payload transmitter unit shall operate at voltage level of +5V and +12VDC.

Scope of Work :

- Understanding and designing of the payload transmitter unit.
- Simulation in MATLAB of different blocks.
- Implementation with help of microcontroller.

Academic Objectives :

- Scalability
- Simulation in MATLAB/ proteus, Lab view.
- Implementation of different techniques to ensure maximum efficiency/ data rates
- Modularity
- Interfacing various modules while ensuring power efficiency
- Clock generation and its transmission

Application / End Goal Objectives :

- Maximum Utilization of existing heritage
- Modularity in design
- Achieving variable data rates
- Optimize the design for an output level of at least 130 dBm
- Cost effective and innovative product

Previous Work Done on The Subject :

Many institutions and companies working on the satellite projects have done this type of work. Some references of these works are as follows:

- M. Zoyo & al., "X-band 22 W SSPA for earth observation satellite", in proceedings of GAAS'99 Conference, pp. 190-193.
- V. Lahr, B. Hespeler, H. Lienhart, K. Schieber, "High data rate QPSK modulator", in proceedings of ESA 3rd international workshop on Tracking, Telemetry and Command systems for space application, Darmstadt, pp 241-246, September 2004.

Material Resources Required : Various materials related to these Blocks are requirement of the

project : • Payload Processing unit (PPU) • VHF data transmitter, LO, • Narrow View Camera • BPSK Modulator • High Power Amplifier(FET) • Wide View Camera • Experimental Payload
No of Students Required : 3
Special Skills Required : • High Frequency Structure Simulator (HFSS) • Advanced System design (ADS) • MATLAB simulation • Use of microcontroller • Proteus • Model simulation • Lab View

Appendix B

Code used for the project

```
#include <16F877A.h>

#device adc=10

#FUSES NOWDT                    //No Watch Dog Timer

#FUSES HS                       //High speed Osc (> 4mhz)

#FUSES NOPUT                    //No Power Up Timer

#FUSES NOPROTECT                //Code not protected from reading

#FUSES NODEBUG                  //No Debug mode for ICD

#FUSES NOBROWNOUT               //No brownout reset

#FUSES NOLVP                    //No low voltage prgming, B3(PIC16) or B5(PIC18) used for I/O

#FUSES NOCPD                    //No EE protection

#FUSES WRT_50%                  //Lower half of Program Memory is Write Protected


#use delay(clock=12000000)

#use rs232(baud=2400,parity=N,xmit=PIN_C6,rcv=PIN_C7,bits=8)

#include <stdio.h>

#include <lcd.c>

int16 temp = 0;

int16 hum = 0;

int16 amps = 0;

int8 i = 0;

int8 comm = 0;

bit rx = 0;

void serial(void)

{comm =

        if(comm == '@')

        {       rx = 1;

        }}

void display(void)

{
```

```
            lcd_putc(" Temp  Hum  mAmp ");
            lcd_putc(temp, hum, amps);
}
void main(void)
{
   setup_port_a( ALL_ANALOG );
   setup_adc( ADC_CLOCK_INTERNAL );
            lcd_putc(" Please Wait... ");
            delay_ms(2000);
            while(1)
            {
              set_adc_channel( 0 );
                        temp = Read_ADC( );
                         temp = temp / 2;
            set_adc_channel( 1 );
                        current = Read_ADC( );
              set_adc_channel( 2 );
                        hum = Read_ADC( ); hum = hum / 11;
              display();
            if(rx == 1)
            {           putc(temp);
                        delay_ms(1000);
                        putc(hum);
                        delay_ms(1000);
                        putc(amps);
                        delay_ms(1000);
}}}
```

Appendix C

MATLAB code of BPSK modulator and its output:

```
nS=100;
nSym=20000;
M=2;
SNR=.1;
Tb=1e-6;
fc=1e6;
att = 1;

s=randi([0 M-1], nSym, 1);
s_mod=pskmod(s,M,pi);
s_mod=rectpulse(s_mod, nS);
%stem(0:nS*nSym-1, s_mod(1:nS*nSym));
h1=scatterplot(s_mod);
t=0:(Tb/(nS)):nSym*Tb-(Tb/(nS));
t=transpose(t);

figure(3);plot(t,s_mod);
axis([0 (10*Tb-(Tb/(nS))) -1.2 1.2]);
title('Input Bit Stream After NRZ Encoded')
xlabel('Time (sec)')
ylabel('Amp')
s_tx_nn=s_mod.*cos(2*pi*fc*t);

figure(4); plot(t,s_tx_nn);
axis([0 (10*Tb-(Tb/(nS))) -1 1]);
title('BPSK mod wave')
xlabel('Time (sec)')
ylabel('Amp')
```

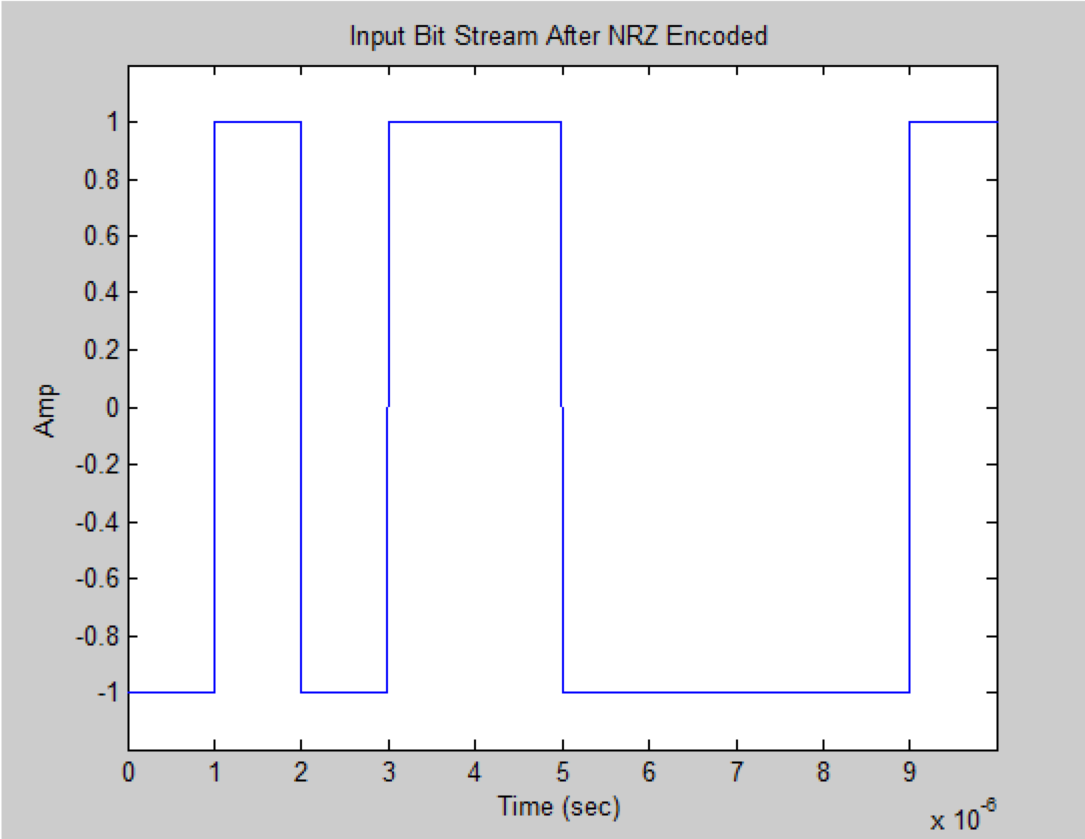

Figure App C1: Input NRZ bit stream

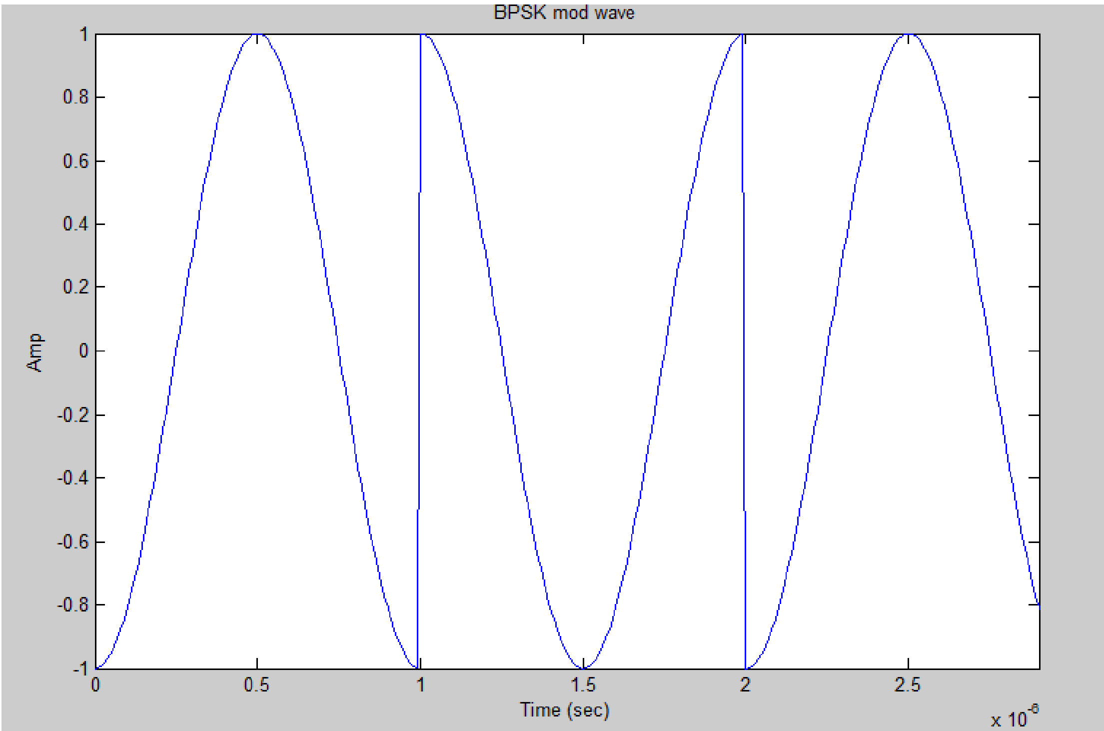

Figure App C2: Output of BPSK modulation Code

Appendix D

Timeline

TIMELINE

Payload Transmitter Unit

TASKS	% of Work	% Completion	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Project approval														
Literature Review														
Familiarization with different blocks														
Simulation of design along with analysis														
Implementation of modulator along with coding	30%	30%												
Implementation of temperature sensor	20%	20%												
Current sensing and humidity sensor implementation	15%	15%												
Transmitter and Receiver module	15%	10%												
Interfacing different modules	10%	10%												
Integrating audio and control signal on separate channel	5%	5%												
Testing & Final project display	5%													
	100%	95%												

Appendix E

Cost Breakdown

Estimated cost for described project is Rs 27950

Name of Component	No of Units	Unit Price	Total Price
HS-1101	4	Rs 800	Rs 3200
LM 35	5	Rs 50	Rs 250
Crystal Oscillator	4	Rs 50	Rs 200
LCD	8	Rs 100	Rs 800
7805	5	Rs 100	Rs 400
MK-702S	3	Rs 2500	Rs 7500
4066 Quad Bilateral switch	4	Rs 600	Rs 2400
Connectors		Rs 200	Rs 200
Misc Components (Resistors , Capacitors, inductors etc)			Rs 4000
Vero board			Rs 2000
PIC Microcontroller			Rs 2000
Miscellaneous			Rs 5000
GRAND TOAL			Rs 27950