CHAPTER - III

FUNCTIONAL BLOCKS, CONSTRUCTION AND WORKING OF TEMPERATURE TELEMETRY

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3.1 INTRODUCTION

In second chapter we have defined the problem and seen the design consideration and requirement of Radio Telemetry, for measurement and control of temperature.

A number of ICs used as temperature sensors, voltage to frequency converters discussed in preceeding chapter. These Ics can be successfully utilized to construct the present telemetry system, which works satisfactory over a temperature range 0°C to + 150°C with great accuracy.

This chapter consist three major sections.

i) Functional Block diagram

ii) Construction and

iii) Working of telemetry

BLOCK DIAGRAM OF TELEMETRY

The present telemetry system is closed - loop feed back control type. The functional block diagram is divided in to two parts.

a) Block diagram of remote station and

b) Block diagram of Base station

3.1.1 BLOCK DIAGRAM OF REMOTE STATION

Functional block diagram of a remote station is shown in fig. 3.1, which consists of temperature sensor for sensing temperature V/F converter FM transmitter, FM receiver, F/V converter and control circuit.

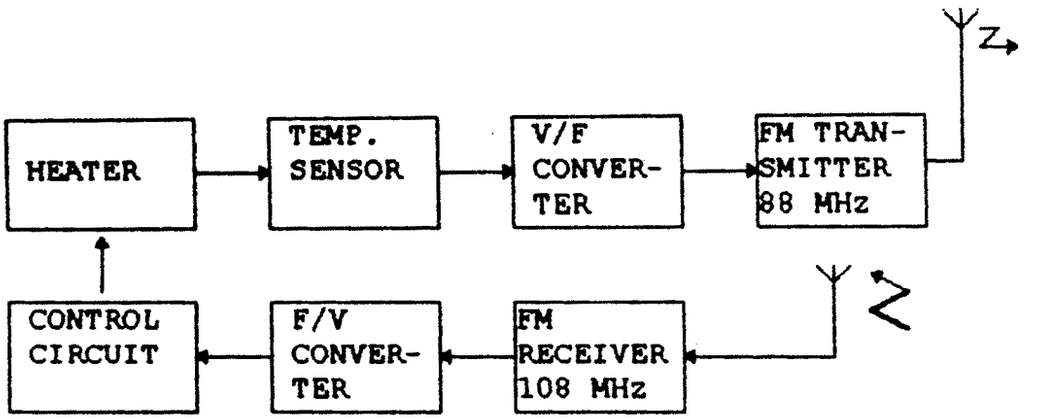


Fig. 3.1 Block diagram of remote Station

The principle of the system can be very well understood from the block diagram shown in fig. 3.1. A description of the different blocks involved and their functions are as follows

3.1.2 TEMPERATURE SENSOR

Temperature sensor forms the heart of the telemetry system. System uses semiconductor temperature sensor IC LM 35 (National semiconductor), whose output voltage is linearly proportional to the Celsius (centigrade)

temperature. As already explained LM 35 does not require any external calibration.

The basic centigrade temperature sensor is shown in fig. 3.2 used to measure temperature over the range of 0°C to +150°C.

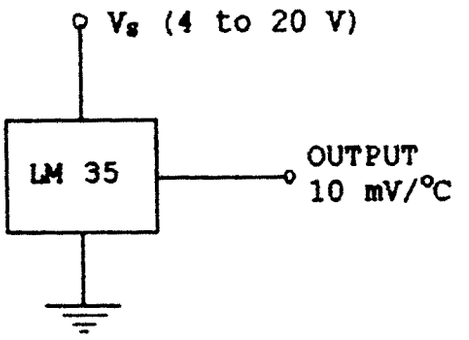


Fig. 3.2 Basic Centigrade Temperature Sensor

From above discussion it is clear that LM 35 is the most suitable for our telemetry system. Output of the LM 35 is equal to +10 mV/°C. This out put is connected to the input of voltage - to - frequency.

3.1.3 VOLTAGE TO FREQUENCY CONVERTER

The LM 331 voltage to frequency converter is ideally suited for the use in simple low cost circuits. The out put when used as a voltage to frequency converter is a pulse train at a frequency precisely proportional to the applied input voltage.

Following fig. 3.3 shows simple V/F converter

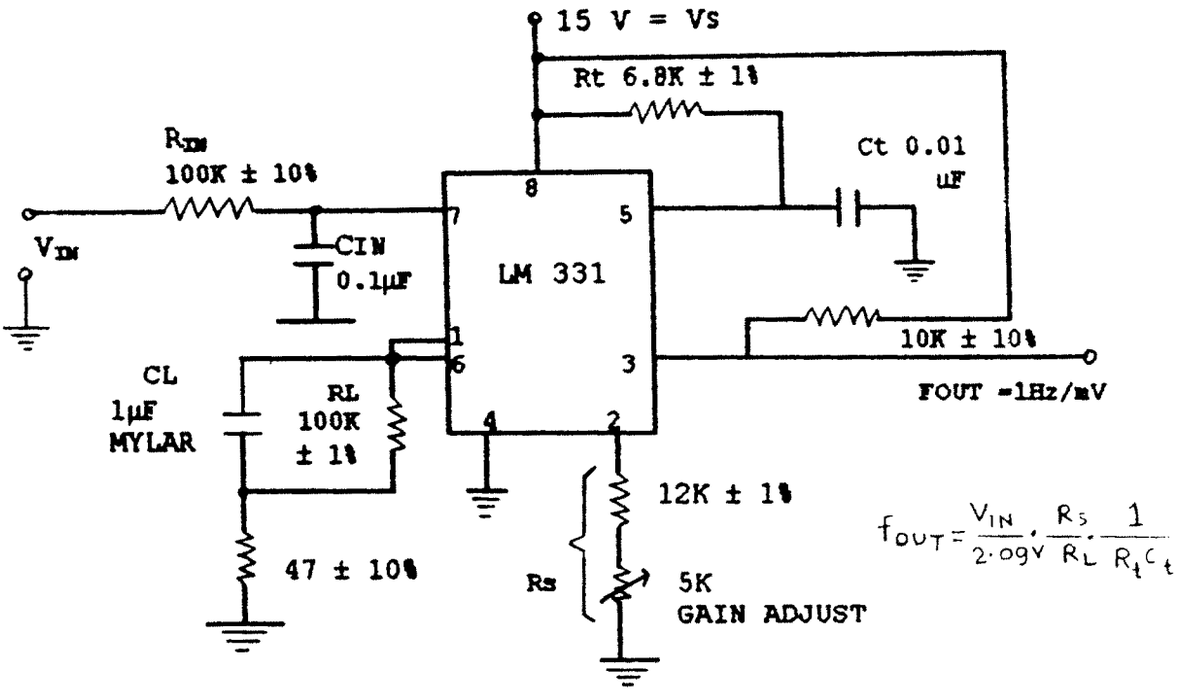


Fig. 3.3 Simple Voltage - to - frequency converter

(f = 10 Hz to 11 KHz)

OPERATION

A resistor, R_{IN} = 100KΩ± 10%, has been added in the path to Pin 7, so that the bias current at Pin 7 will cancel the effect of the bias current at Pin 6 and helps to provide minimum frequency offset. The resistance R_s at Pin 2 is made up of a 12 KΩ fixed resistor plus a 5 KΩ (cremet, preferably) gain adjust rheostat. The function of this adjustment is to trim out the gain tolerance of the LM 331, and the tolerance of R_t, R_L and C_t. For best results, all the

components should be stable low temperature - coefficient components, such as metal - film resistors.

The capacitor should have low dielectric obsorption, depending on the temperature characteristic desired, NPO ceramic, Polystyrene, Teflon are best suited. A capacitor C_{IN} is added from Pin 7 to ground to act as a filter for Vin.

The out put frequency of the V/F converter using LM 331 is 1Hz/mV. when the output of temperature sensor LM 35 is applied as a input to the V/F converter, constructed using the LM 331. The output frequency of V/F converter is 10Hz/°C. This output frequency here after called as temperature signal.

This temperature signal is applied as input modulating signal to FM modulator cum transmitter.

3.1.4 FM TRANSMITTER

To transmit temperature signal from remote station to the base station where it is to be measured, FM transmitter is used. Fig. 3.4 shows a circuit diagram of the FM transmitter stage commonly used in telemetry system.

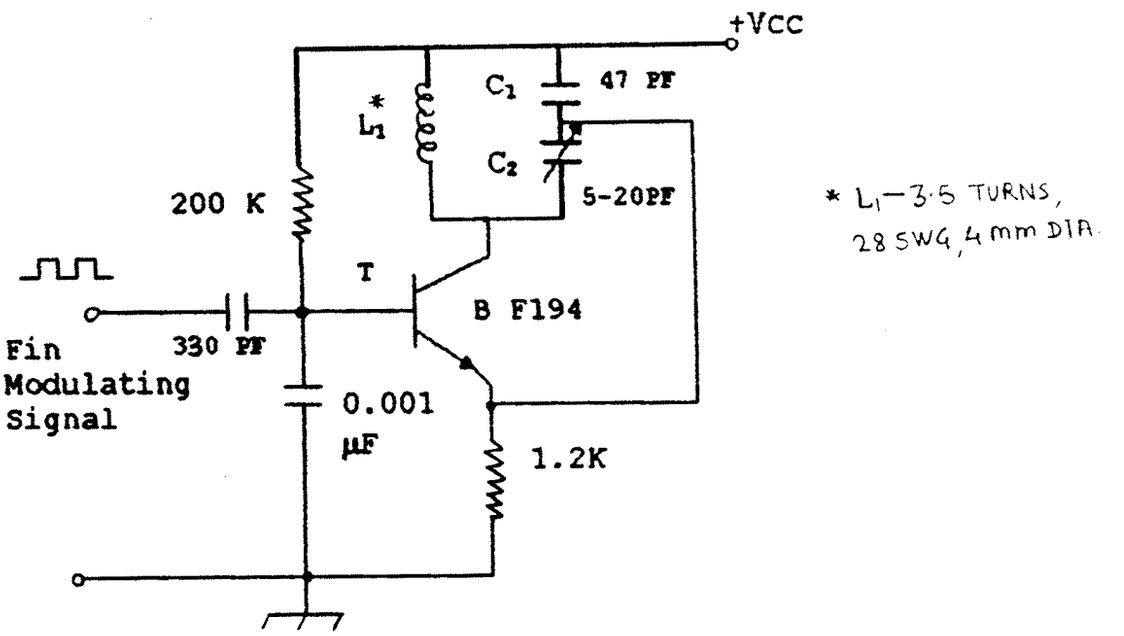


Fig. 3.4 Circuit diagram of FM Telemetry Transmitter

The transistor T acts in a grounded base Colpitts RF oscillator with L_1 and C_1 and C_2 as the tank circuit. The positive feed back to the emitter is provided from a capacitive devider in the collector circuit formed by C_1 and C_2. Inductor L_1 functions both as a tuning coil and a transmitting antenna. Trim capacitor C_2 adjusted to precisely set the transmission frequency at the desired point. In this case, it is with in the standard FM broadcast band from 88 to 108 MHz. Frequency modulation is achieved by variation in the operating point of the transistor, which inturn varies its collector capacitance, thus changing the resonant frequency of the tank circuit. The operating point is changed by the modulating input. Thus the transmitter

output consists of an RF signal, tuned in the FM broadcast band and frequency modulated by the subcarrier. Which in turn is frequency modulated by the physical signal (temperature). Maximum frequency deviation allowed for above transmitter is ± 7.5 KHz, and center frequency 88 MHz.

3.1.5 FM RECEIVER

The FM receiver used in present telemetry is the standard FM broadcast receiver which makes design of transmitter and receiver simple and inexpensive. FM receiver are easily available in market, with a sensitivity of 1μV.

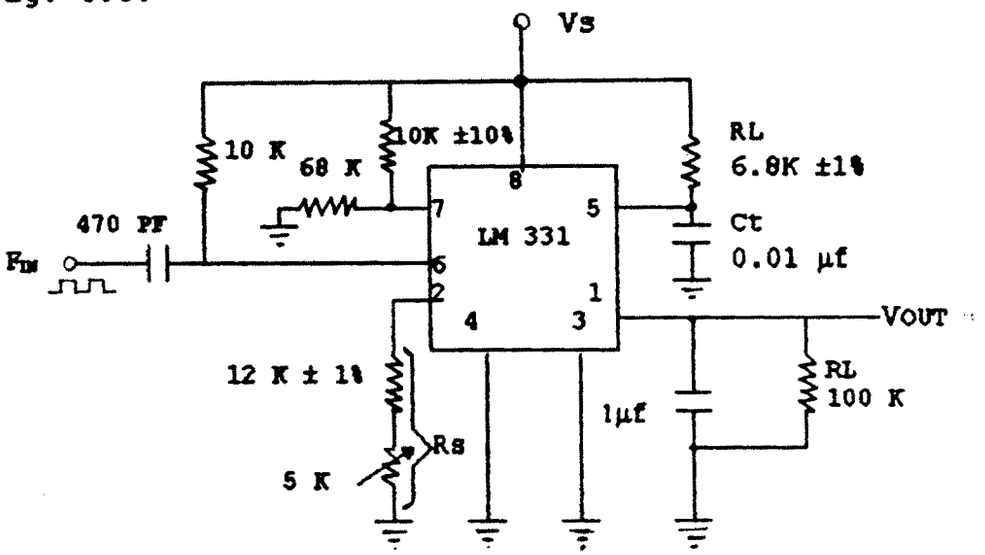
The FM receiver perform following function

It receives incoming FM signal and amplify it into r.f. unit. The output of H.F. unit of the receiver is fed to the subdemodulator to extract the modulating signal. in FM/FM system the subdemodulator first convert the FM signal in to an AM signal. This is followed by a AM detector which demodulate the newly created AM wave form.

The FM receiver used in remote system receives the control signal transmitted by the base station. The receiver is tuned to 108 MHz frequency, since base station transmitter is tuned to 108 MHz. Control signal detected by receiver of remote system is a 4 KHz fixed frequency signal.

3.1.6 FREQUENCY - TO - VOLTAGE CONVERTER

Control signal of a 4 KHz fixed frequency is applied to the input of F/V converter; shown in following fig. 3.5.



$V_{OUT} = F_{IN} \times 2.09V \times \frac{R_L}{R_s} \times (R_t\ C_t)$

Fig 3.5 Simple Frequency - to - Voltage converter.

A pulse input at F_{IN} is differentiated by C-R network and the negative going edge at Pin 6 causes the input comparator to trigger the timer circuit. Just as with a V/F converter, the average current flowing out of Pin 1 is

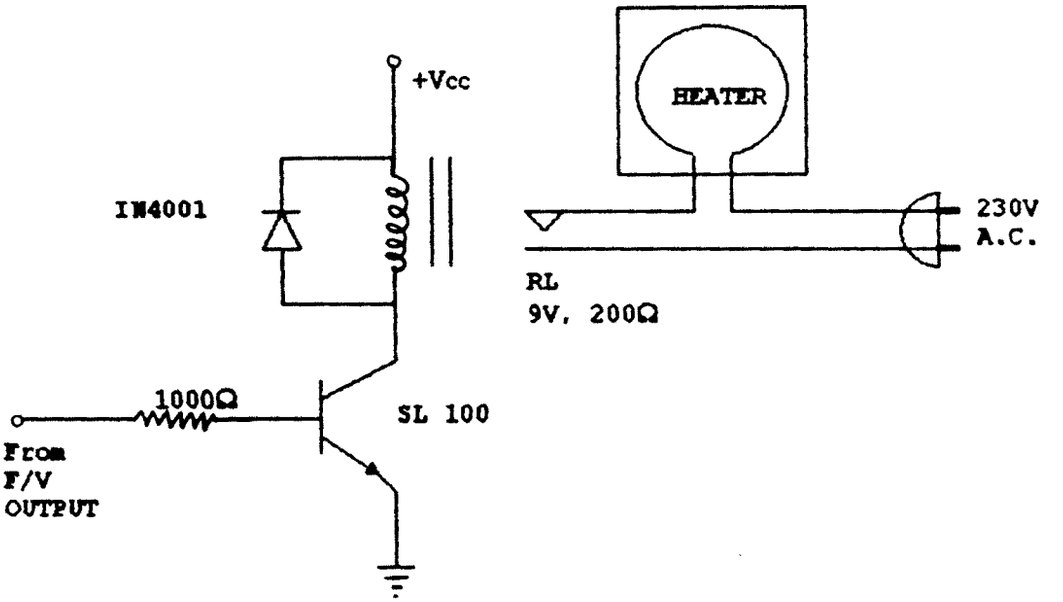
$$I_{AVE} = I \times (1.1\ R_t\ C_t) \times F.$$

This current is filtered in the network R_L - 100KΩ and 1 µF. The ripple will be less than 10 mV peak, but the response will be slow, with a 0.1 second time constant and

setting of 0.7 second to 0.1 % accuracy. VOUT of above F/V converter is applied as input to the relay control circuit.

3.1.7 HEATER CONTROL CIRCUIT

Output of the F/V converter is applied to the input of heater control circuit. Circuit diagram of the simple heater control circuit is shown in fig. 3.6.



When control signal of 4 KHz is received by remote station, Frequency to voltage circuit produces proportional voltage at the output. This output of F/V converter control the relay drive circuit ON. When no control signal is received by remote station it make relay OFF.

3.2 BLOCK DIAGRAM OF BASE STATION

The block diagram of a base station is shown in fig. 3.7, which consist FM receiver, Buffer, Microprocessor and FM transmitter.

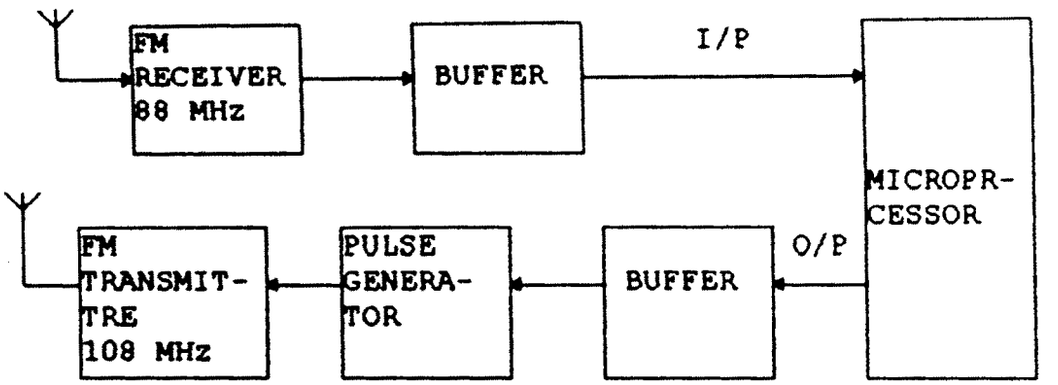


Fig. 3.7 Block diagram of base station.

The function of each block involved in base station block diagram is as follows.

3.2.1 FM RECEIVER

It receives temperature signal transmitted by FM transmitter of remote system. It is tuned to 88 MHz frequency. It receives FM signal, demodulate and extract the temperature signal. Out put of the FM receiver is applied to Buffer block.

3.2.2 THE BUFFER

Buffer block not only isolate FM receiver and microprocessor but also provides TTL compatible output. This output of the buffer can be connected as input to the microprocessor. A TTL IC 7407 is used as buffer.

3.2.3 MICROPROCESSOR

This is a brain of the telemetry system, and used as programmable controller. It measure the incoming frequency of the temperature signal (Calibrated as 10Hz/°C); and display it in the form of temperature in degree Celsius. Connection to the microprocessor is shown in fig. 3.8.

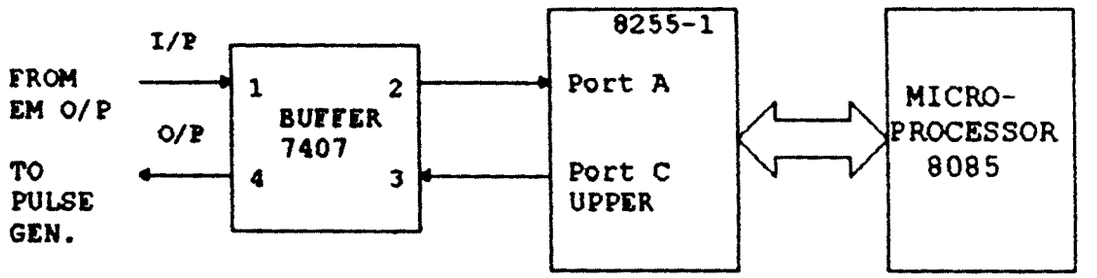


Fig. 3.8 Interfacing of 7407 to microprocessor.

Upper port 8255-1 is used as I/O port. The input temperature signal is applied to P_{A0} (i.e. Pin 21 of J_1 front end FRC connector). Microprocessor measure the frequency of incoming temperature signal and display it on seven segment displays. At the same time the incoming temperature is compared with

set point temperature value. When the incoming temperature exceeds the set point temperature, the microprocessor sends a low out put at PC6 (Pin - 23 of J_1). When incoming temperature decreases below set point temperature, microprocessor sends a high output at PC_6. The output of the PC6 is used as control signal.

The microprocessor is used in temperature telemetry as programmable controller. If is necessary to develop appropriate program which can perform assigned job to the microprocessor. The development of program is discussed in chapter IV.

3.2.4 PULSE GENERATOR

The pulse generator generates 4KHz rectangular pulses. These pulses are transmitted from base station and received at remote station. These pulses are used as control signal, to turn ON or OFF heater.

The IC 555 used as astable multivibrator to produce fixed 4KHz pulses is shown in fig. 3.9.

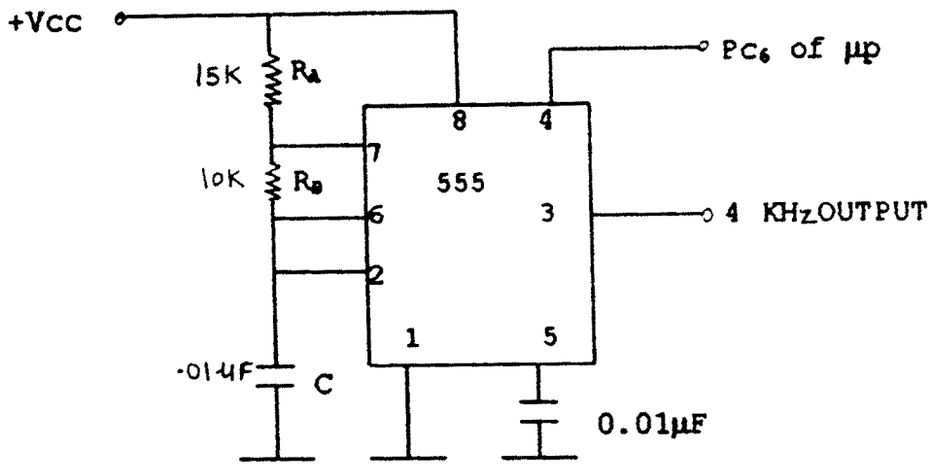


Fig. 3.9 Astable multivibrator

Here Pin 4 of the IC 555 is connected to Pc6 of µp. When PC_6 is at logic '0' circuit is reset and will not produce pulses. When Pc6 goes high (logic '1') the circuit is enabled (i.e. will produce pulses). The output of the above circuit is applied as modulating signal to the FM transmitter of base station. This FM transmitter transmit frequency modulated signal to receiver of remote system.

The frequency of this transmitter is 108 MHz.

3.3 WORKING OF TELEMETRY CIRCUIT

Circuit diagram of complete telemetry system is shown in fig. 3.10 A and fig. 3.10 B. Working of the circuit is as follows.

1. The LM 35 temperature sensor, sense the temperature and produces output 10mV/°C; over a temperature range 0°C to

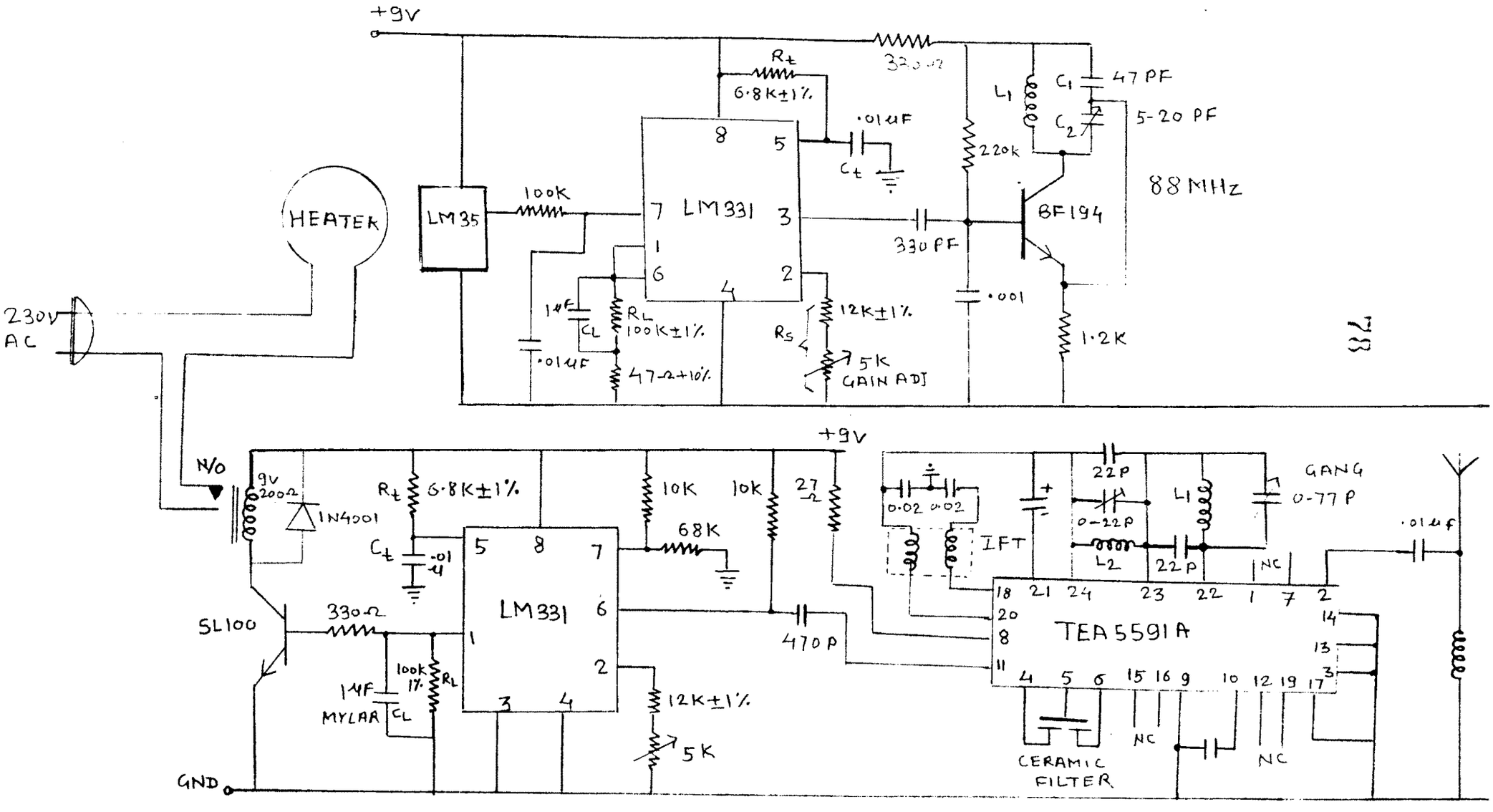


Fig. 3.10 A.Circuit diagram of remote system.

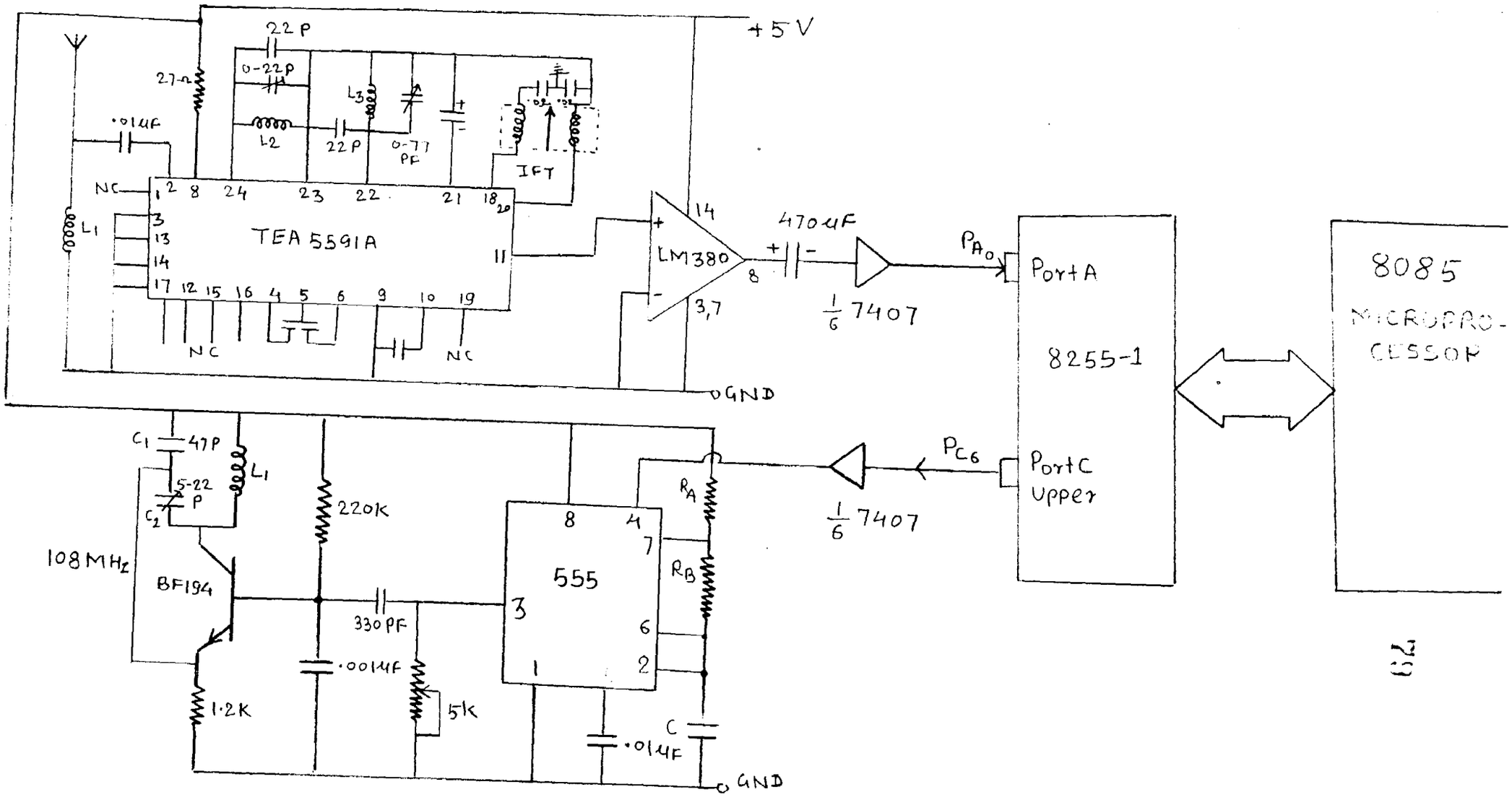


Fig. 3.10 B. Circuit diagram of base system

+150°C. Output of the LM 35 is applied as input to the V/F converter.

2. The LM 331 voltage to frequency converter convert input voltage (Which is the output of LM 35) in to frequency. The output of LM 331 V/F converter is 10 Hz/10mV. Therefore LM 35 and LM331 wired together produces 10Hz/°C. This 10Hz/°C output is called temperature signal. This temperature signal is applied to FM transmitter, which transmit this to base or control system.

3. At the control or base station FM receiver (tuned to 88 MHz) receives, FM modulated temperature signal transmitted by remote station, demodulates and recover original temperature signal. This signal is applied to microprocessor through buffer 7407.

4. Microprocessor measure the temperature of incoming signal (actually microprocessor is used to measure frequency but the frequency is calibrated interms of temperature.) and display the temperature in Celsius. At the same time microprocessor compare incoming temperature with set point temperature. When incoming temperature exceeds the set point temperature, it produces low out put control signal. When incoming temperature decreases bellow set point temperature, microprocessor produces high output signal. This is used as control signal to control the temperature.

5. Control signal from microprocessor is applied to the pulse generator. Control signal is connected to the reset control (Pin 4) of IC 555, connected in astable mode. When control Signal goes high IC 555 will produce pulses of 4 KHz. When control signal goes low IC 555 is disabled. The output of 555 is applied to control station transmitter.

6. Control station FM transmitter operates at 108 MHz transmit control signal to the remote station.

7. The remote station receiver tuned to 108 MHz receives FM modulated control signal, after demodulation, 4KHz control signal is applied to F/V converter.

8. F/V converter constructed using LM 331 convert 4KHz control signal in to voltage (approx 4V). This voltage is called control voltage, which is applied to relay control circuit. Only when temperature of heater goes bellow set point temperature, F/V converter will receive 4 KHz control signal and turns ON heater. When the temperature of heater exceeds set point temperature, no control signal of 4 KHz is received, hence heater is turned OFF. In this way the system measure and control the temperature.

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