

# Development of Temperature Monitoring System via F. M. Transmission and Reception in Hospitals

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## ABSTRACT

*The monitoring and controlling of temperature is imperative to many applications both in engineering generally and in an industrial process. In most cases, the use of thermometer as the primary sensing element is inappropriate and this gives way to the discovery of transducers that can actually measure physical variables and correspondingly converted them into a form suitable for most industrial and engineering application. In some industrial processes like determining the temperature of a pasteurizer (a high temperature cubicle in Breweries, where Beer is de-natured) is mostly determined by a Thermocouple or Thermopile but it has limitation due to its poor sensitivity arising from the non-linear response of its two dis-similar metals to temperature change. Thermistor are particularly best suited for measuring temperature and produce a change in resistance proportional to the temperature change. This paper however discovered that the location of the measured object in relation to the location of the observer determines the best medium that will enable easy reading and analysis of the measured temperature. However, to allow for flexibility and ease of location, air as a medium of communication is preferred over cable which is the major pre-occupation of this paper. This paper extensively discussed the method of employing an electronic thermometer embedded with a very sensitive temperature sensor as transmitter placed with the measurand and a highly sensitive detecting element as receiver with the receptionist. The idea of this paper would be best applied in the hospital where the measurand is the patient on the sick bed and the receptionist is the medical doctor.*

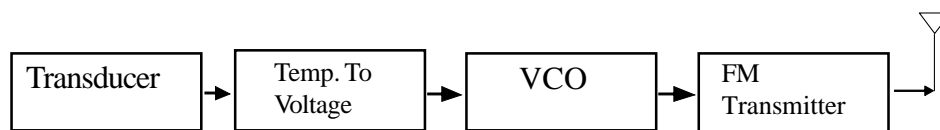
**Keywords:** *Temperature Monitoring System, F. M. Transmission, Reception, Hospitals*

## INTRODUCTION

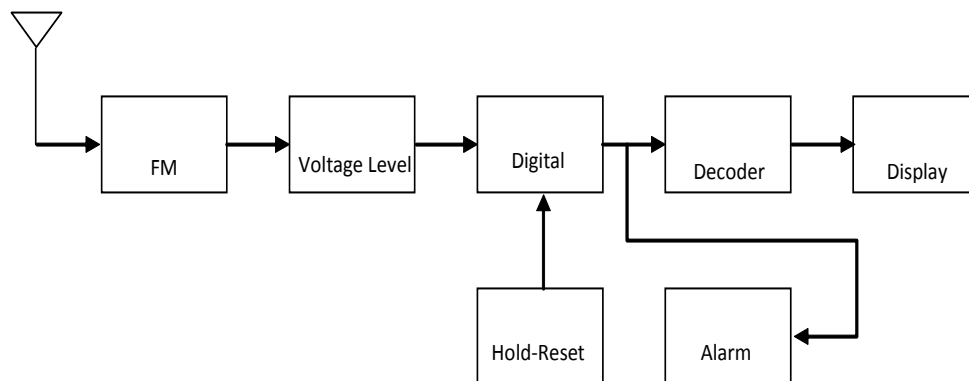
World is currently experiencing a paradigm shift from obsolete or traditionally based approach to technical issues to digitally or modern based information exchange owing to increase in modern civilization. By the motive of this paper, the field of medicine has been a major beneficiary of this technology with the current spate of rise in innovation being introduced into its equipment. One of such discoveries is this electronic temperature monitoring device, which is adaptable for measuring the temperature of a patient in the hospital. The advent of this technology has gradually phased out and faulted many temperatures measuring device which has been in

existence for an age. Typical example of these temperatures measuring device is the mercury-in-glass thermometer (clinical thermometer) for measuring temperature, it operates on the principle of the change in volume of mercury in a calibrated glass column with temperature. Its shortcoming is the error which it normally introduced into measurement as a result of difference in expansion between mercury and glass to the same level of temperature, otherwise refers to as non-linear error. Another temperature measuring device of interest in this category is ‘thermometer’ which uses the characteristic change in length of some selected dissimilar metals with temperature. It has a major disadvantage of low sensitivity to small change in temperature. These errors are eliminated by this electronic thermometer embedded with a very sensitive temperature sensor circuit to convert temperature to measurable electrical analog and also capable of presenting clear and distinct digital readouts.

The aspiration of this paper is based chiefly on the development that a Doctor will be able to monitor the temperature of his patient right from his consulting room or some distance away from the patient sick bed. This paper essentially consists of sensitive temperature sensor circuit as Transmitter placed with the measurand and another of highly sensitive detecting element as Reception. The block diagram of the system is as shown below (Olatunbosun, 2002).



**Fig. 1A:** Block Diagram of the System: The Transmitting Side



**Fig. 1B:** Block Diagram of the System: The Reception Side

**Transducer:** This senses the temperature and produces a change in resistance proportional to the change in temperature.

**Temperature to Voltage:** The change in resistance of the transducer is converted to a change of voltage.

**Voltage Controlled Oscillator (VCO):** This converts the varying voltage to a varying frequency of a pulse waveform.

**FM Transmitter:** In this device, the output of the voltage – controlled oscillator is used to modulate a high frequency signal using FM modulation scheme, and the modulated signal is transmitted through the antenna into the air. At the reception side, the signal is received and processed to be displayed on a digital readout.

**FM Receiver:** The transmitted modulated signal is received through the antenna into the FM receiver circuit for demodulation and our desired signal is obtained.

**Voltage Level Detector:** The zero-level detector converts the output of the FM receiver to a purely digital waveform by acting as a comparator, setting a signal level that corresponds to a high and a low values for another stages.

**Counter:** The digital counter circuit counts the frequency of the digital signal and sends the output to the decoder.

**Decoder:** The decoder block made up of a BCD (Binary Coded Decimal) to seven-segment decoder counts the binary codes from the counter output into the seven-segment representing ON and OFF that feed the different segments of the display.

**Display:** This gives an actual numerical representation of the temperature being measured.

**Alarm Circuit:** This is a comparator that responds to a predetermined condition by sending an output signal when this condition is satisfied. This is designed to trigger-off when the temperature being sensed rises above or falls below certain pre-determined values.

## POWER SUPPLY

A 12V direct current (dc) voltage is suitable for this system and could be generated from the 50Hz, 220Vac main. Hence, the block diagram of the power supply suitable to drive the different modules that constitutes this temperature – monitoring device is as shown below(Alan S. Morris, 1993).

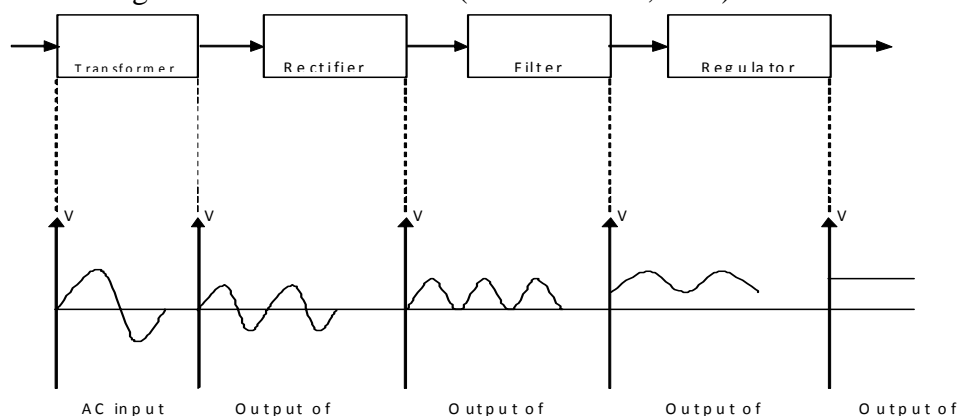


Fig. 2: Block diagram of the Power Supply stages and the Waveforms at each output stage

**Rectifier:** The conversion of the ac voltage to a pulsated dc voltage is achieved by rectified circuit which is accomplished by the bridge arrangement of diodes. It is however pertinent to note that, the current rating of the diode should exceed the secondary current of the transformer.

**Filter:** The output of the rectifier still contains ripples due to presence of little or infinitesimal ac components. The capacitors filter the signal to remove ac ripple. The dc voltage output of the capacitor is

$$V_{dc} = V_{max} \dots\dots\dots(1)$$

And  $V_{max}$  is the peak value of the transformer secondary voltage.

**Regulator:** Voltage regulation is necessary to keep the same dc value at the output, even if the input dc voltage varies or the load connected to the output dc changes. This is essentially achieved by a regulator IC unit which contains the reference source, the comparator, amplifier circuit, control devices and overload protection embedded in a single IC chip.

The objective of this research are:

- (a) To convert temperature to a suitable form for wireless transmission.
- (b) To transmit the signal through Frequency Modulation (FM) transmission scheme
- (c) To capture the signal at the receiving end using frequency modulation (FM) reception scheme.
- (d) To display the temperature on a digital readout.
- (e) To make an alarm to sound when temperature exceeds or falls below some pre-determine values.

## METHOD

This paper focuses its research attention on three major aspects of electronic engineering as; instrumentation, telecommunication and digital electronics. The simplified block diagram that shows the various parts of this temperature monitoring system is as depicted in figure 1, divided into two modules as transmission side and the reception side. The transmission side is the module that will be with the patient for sensing and transmitting the temperature dependent signal. The reception module will allow the doctor to have a digital representation of the patient's body temperature.

### **SENSING AND TRANSMISSION**

**Transducer:** As it has been previously elucidated in figure 1, a suitable transducer here is the temperature sensing transducer, which has some aspect of its properties changing with temperature. Transducer adapts a signal to another signal which is then processed to give an output. A sensor is available which behaves as a transducer

that provides input to a system while the embedded actuator provides output from a system. It is however worth of mention that an active transducer needs a power supply for its operation (previously provided) while a passive one does not require a power supply. A transducer is considered to be efficient provided it possessed the following qualities (Olatunbosun, 2002): sensitivity – it gives an indication of the speed of response of the transducer and system; Linearity – a measure of the degree of the output due to the relationship between the input fed into a particular transducer and the output from it. Reliability – a measure of the period or time during which the transducer operates accurately or satisfactorily.

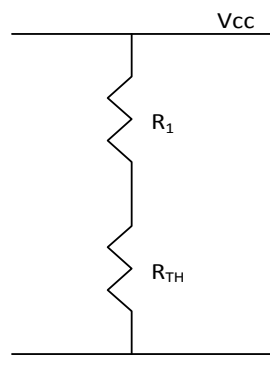
Hence, a transducer should be able to generate identical response to the same input stimulus over its entire working life. Temperature sensing transducers are of different types. They differ in the range of temperatures to which they respond, their different levels of sensitivity and stability. To be able to overcome some inadequacies presented by some transducers, I have chosen to use a thermistor as the sensing device in this paper since its resistance changes with temperature non-linearly and above all, it has very good sensitivity and measures a wide range of temperature.

**Thermistor:** The resistance – temperature relationship of a Thermistor is approximated by the relation:

$$R = Ae^{B/T} \dots\dots\dots (2) \text{ (Green, 1998).}$$

Where: R is the resistance at temperature  
T Kelvin. A and B are constants for a specific thermistor.

Thermistor are made in the form of very small beads and due to its small size, it can be inserted into regions where other larger temperature sensing devices might not fit. A resistance is connected in series with the thermistor to limit the current through it as indicated thus;

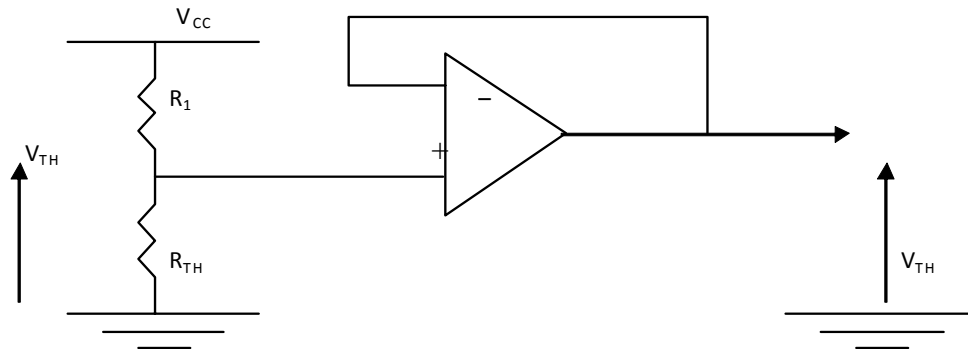


**Figure 4:** A Simple Thermistor Potentiometer

However, voltage across the thermistor at a particular temperature is expressed.

$$V_{TH} = \frac{R_{TH}}{R_{TH} + R_1} V_{CC} \dots\dots\dots(3)$$

Temperature to Voltage Conversion: The arrangement below as you can see is a potential divider connected to an operational amplifier in a “voltage – follower” mode to convert the resistance changes of a thermistor (temperature) to voltage change ( $V_{TH}$ ).



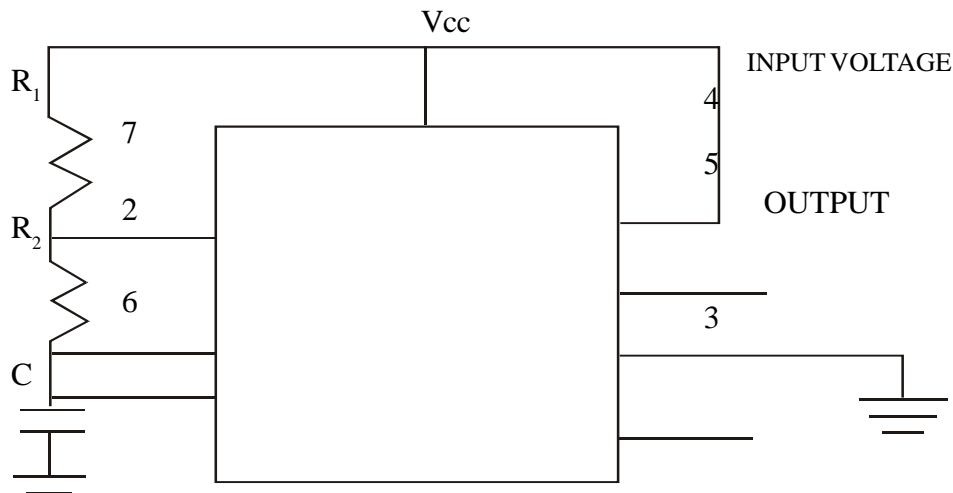
**Figure 5:** Temperature to Voltage Conversion Circuit Diagram

The voltage developed is fed into the voltage controlled Oscillator (VCO) circuit in such a manner that the voltage change is not affected by the VCO since the op-amp has prevented it from loading and drawing too much current from the potential divider circuit (James and Robert, 1989).

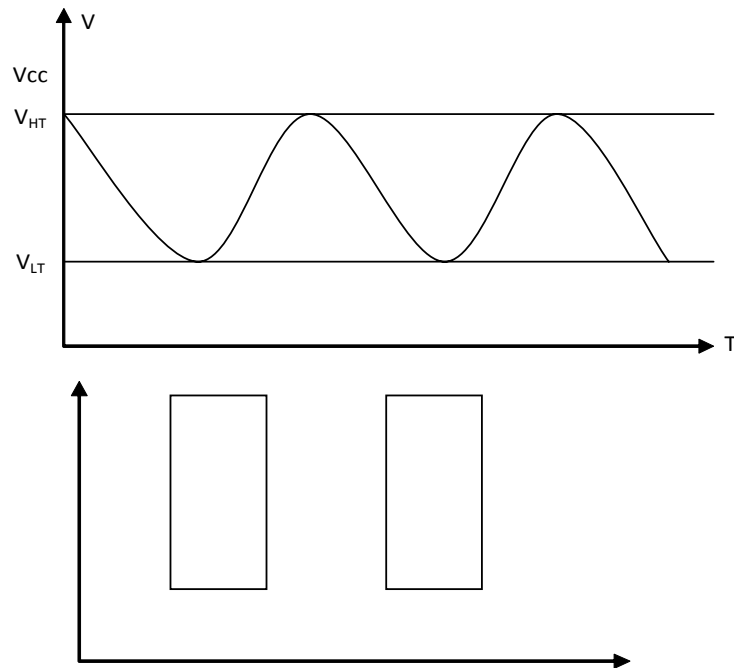
**Voltage Controlled Oscillator:** In order to efficiently convert the voltage output of the thermistor into pulses that is more suitable for radio transmission, we used VCO. Here, the frequency of the output waveform varies with the applied voltage. There are different types of oscillator circuits for generating different types of signal waveform. For the purpose of this paper, a pulse waveform generator is required since a digital input is needed at the output end. The circuit employed for this is built around the classical 555IC chip (James Bignell, Robert Donovan, 1989).

**555 Timer IC as a VCO:** This is a functional block that contains two comparators, two transistors, two resistors of equal rating, a flip-flop and an output stage. The series connection of the three resistors was used as a voltage divider, that sets the reference voltage level at the two comparators as threshold level and trigger level of voltages. A typical 555 TIMER IC for this implementation is shown below (James Bignell, Robert Donovan, 1989).

**Waveform Characteristics of 555 Timer IC:** When power was applied, Capacitor C charges through  $R_1$  and  $R_2$  towards  $V_{cc}$ . As the voltage across C goes above the threshold level, the output of comparator 1 becomes “high” the flip flop is reset to reduce the output. When the flip flop is set, the output of capacitor 2 becomes high and the discharge transistor is turned off. In this behaviour, the capacitor charges towards  $V_{cc}$  again and the cycle continue.



**Figure 6:** 555 TIMER IC AS VCO

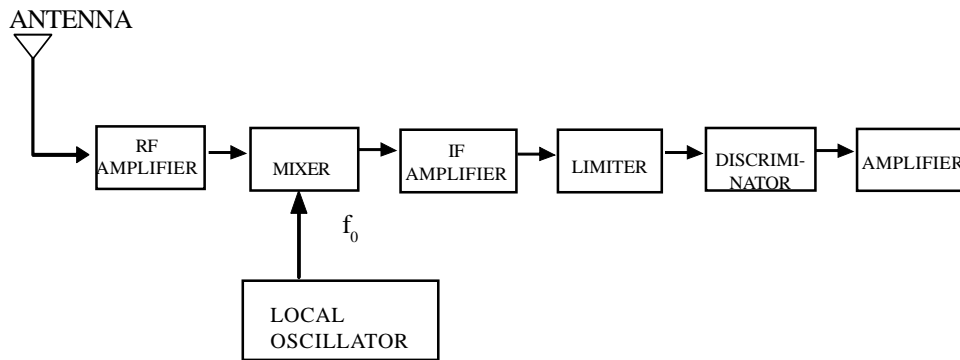


**Figure 7:** Output Waveform of the VCO

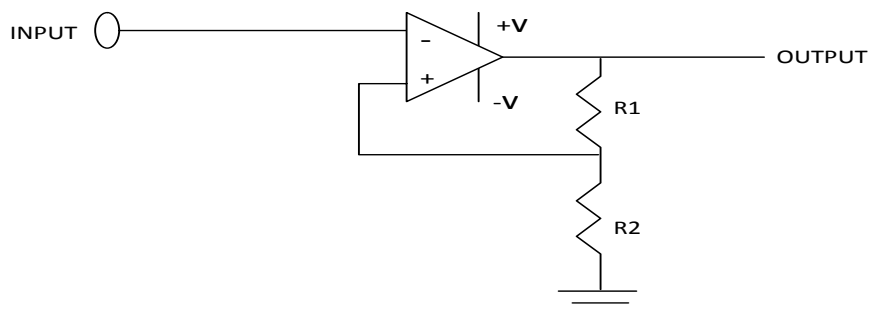
### RECEPTION SIDE

**Frequency Modulation Receiver (FM Receiver):** The FM receiver here captured the air-born signal transmitted with its antenna. Radio Frequency Amplifier (RF Amp) tuned this signal to the carrier frequency of the transmitter. The mixer mixed this signal with the signal from another oscillator called local oscillator. Intermediate frequency is the output of the inner which was subsequently fed into the limiter to give constant amplitude of the input and is consequently amplified as it can be seen in the block diagram below in accordance with Simon Haykin, (1989).

**Voltage Level Detector:** As we had known that the output of FM receiver might have been corrupted with noise due to transmission through the air, hence, voltage level detector used in this research is a comparator OP-AMP which is a highly digitalized device (an extract of Paul Hurowitt and Winfield Hill, 1989).



**Figure 8:** Block Diagram of an FM Receiver



**Figure 9:** Voltage Level Detector

**Counter Hold And Reset:** The digital output of our comparator is next to pass to the counter. There is available NOR gate that reset the counter to zero before start counting afresh for a new temperature reading. The counter counts the frequency output of the zero level detector and presents it in a binary form. We consider the use of JK flip-flop as the building element of the counter in this research and with its description in brief (Ronald, 1985). Since, a flip-flop is a memory device whose output depends on its inputs combination, hence, the reason for the choice of JK flip-flop because of its efficient counter implementation.

CLOCK	J	K	OUTPUT
!	0	0	NO CHANGE
!	0	1	1
!	1	0	0
!	1	1	TOGGLE

**Figure 9:** JK FLIP-FLOP

**Table 1:** Truth Table of JK Flip-Flop



**Display Unit:** The signal at this level is presented to the seven-segment LED display, appropriately quantified and displayed in decimal digits. The counter, the BCD to seven-segment decoder and the seven-segment display are used to achieve this feat.

**Alarm Control Circuit:** The main aspiration of this research is to enable a doctor to monitor the temperature of the patient. In order to ensure a proper monitoring process when the doctor loses concentration on the digital display, an alarm circuit is incorporated to sound when the temperature rises to a critical value.

The results obtained from the test shows that as temperature changes, the counter and display responded promptly with very little delay. A HOT PLATE and A METAL ROD was used to carry out the test where A HOT PLATE was used to generate heat which is equivalent to temperature rise. A METAL ROD was used to produce a cooling effect. The thermistor (the primary sensor) was brought near the hot plate for a short period of time, say 10 seconds. The response was noticed, and then the thermistor was allowed to make contact with the Metal Rod for the same period of time. The thermistor was again allowed to heat up for a longer period of time, up to 60 seconds and also made to cool down for the same length of time. The response of the system was observed. The thermistor was then allowed to remain at room temperature and the response of the system was also observed for changes. It was observed that the system responded quickly to sudden changes in temperature, and at relatively constant temperature, the counter held almost the same values within  $+1^{\circ}\text{C}$ . At room temperature, the counter holds a temperature value of  $25^{\circ}\text{C}$  within a  $+1^{\circ}\text{C}$  variation.

## CONCLUSION AND RECOMMENDATIONS

Temperature monitoring is a major discovery in many applications ranging from industrial process monitoring system to a clinical or medical application (which is the target of this research). It is so pellucid that the proper functioning and performance of a system (be it human or machine) can easily be assessed and analysed based on its temperature characteristic over-time. Remote operations and management of systems is made possible by the ability to transmit this relevant temperature readings to a location where it can be monitored, analysed and recorded to give a true picture of the characteristics of the system being observed. However, it is recommendable that this finding should be properly funded and universally accepted as the most efficient means of monitoring or measuring temperature since some properties errors or shortcomings introduced by some old temperature measuring devices have been eliminated. Hence, this research serves as a rich foundation upon which sophisticated data-acquisition, analysis and storage applications can be developed. Further improvement can be incorporated by making it possible for the device to monitor more than one system (be it human or machine) at a time, by implementing a cpu or microprocessor and memory in the design.

This will greatly increase the speed of operation of the device and the accuracy of the temperature reading obtained.

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