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Design and Construction of Wireless Thermometer

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Abstract
The importance of the measurement of body temperature cannot be overemphasis. A person body temperature says a lot about their health conditions. Most of the diseases or infections can be detected by a change in body temperature. The most common form of increased body temperature is fever. The effectiveness of treatment given to the patience can be known through measuring of temperature. It is that accompanying, every 1℃ rise in system temperature is a 10% rise in the enzymes – control chemical reaction. At temperature of 43℃ and above, enzymes denatured, provoking death a certainty. Therefore, the temperature of a body needs to be measured regularly using a thermometer. The liquid in glass thermometer applications has several limitations, such as limited temperature range and precision. Hence the need to develop a high precision wireless thermometer that can provide more accurate measurements. The wireless thermometer consists of two parts, the transmitter and the receiver. The transmitter senses the temperature rise through its sensor connected to it and sends it to the receiver to display it on the LCD (liquid crystal display).

Keywords: thermometer, temperature, wireless, transmitter, receiver.

Introduction
A thermometer can be defined scientifically as a device that gauges temperature by measuring a temperature-dependent property, such as the expansion of a liquid in a sealed tube. Thermometers measure temperature or temperature gradient, using a variety of different principles. The word thermometer is derived from two smaller word fragments: *thermo* from the Greek for heat and *meter* from Greek, meaning to measure. A thermometer has two

important elements, the temperature sensor (e.g. the bulb on a mercury thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a value (e.g. the scale on a mercury thermometer)[1]. As with many aspects of scientific or technological knowledge, the idea of the thermometer appeared in ancient times, but was never developed. Again, like so many other intellectual phenomena, it lay dormant during the medieval period, only to be resurrected at the beginning of the modern era. The Greco-Roman physician Galen (c. 129-216) was among the first thinkers to envision a scale for measuring temperature. Of course, what he conceived of as "temperature" was closer to the everyday meaning of that term, not its more precise scientific definition: the ideas of molecular motion, heat, and temperature discussed in this essay emerged only in the period beginning about 1750. In any case, Galen proposed that equal amounts of boiling water and ice be combined to establish a "neutral" temperature, with four units of warmth above it and four degrees of cold [2]

A thermometer has different application it can be applied in industry, in laboratory, in home and for whether forecast

The way an industrial thermometer works depends upon the type of temperature sensor it uses. Sensor options include bimetal, liquid or gas-filled, electronic, or infrared (IR). **Liquid or gas-filled** thermometers use a gas or liquid as the temperature-sensing element. The liquid expands as the temperature rises in the tube and indicates the temperature. **Bimetal or bi-metallic** thermometers use a bimetal spring as the temperature-sensing element. This coil spring is made of two different types of metals that are welded or fastened together. Choices include copper, steel and brass - as long as one metal has low heat sensitivity and the other metal has high heat sensitivity. Whenever the welded strip is heated, the two metals change length based on their individual rates of thermal expansion. Since the two metals expand to different lengths, the bimetallic strip is forced to bend or curl towards the side with a lower coefficient of thermal expansion. The movement of the strip is used to deflect a pointer over a calibrated scale, which then indicates temperature to the user. **Electronic devices** such as thermistors measure changes in electrical resistance and convert them to changes in temperature. **Infrared thermometers** are non-contact devices that convert infrared (IR) energy to an electrical signal that can be displayed in units of temperature. [3]

The types of thermometer used in the laboratory include partial immersion, total immersion liquid filled (mercury, spirit filled, or nontoxic liquid) or dial thermometer and digital thermometer. Partial immersion have a mark on stem of the thermometer indicating a length that need to be inserted or immersed in the object being monitored, e.g. liquid, water bath, or heat block. Total immersion thermometer are considered

more accurate than partial immersion because the thermometer is totally immersed in the environment that is being monitored, e.g. refrigerator or freezer and these thermometer are not affected by external factors. [4] The way a laboratory thermometer works depends upon its type. They are generally a liquid-in-glass device, a bimetallic strip, an electronic thermistor thermometer, or infrared (IR) device. Several types of laboratory thermometers are commonly available including; **Liquid-in-glass** thermometers are made of sealed glass and contain a fluid, usually mercury or red alcohol, whose volume changes relative to its temperature. The liquid expands as the temperature rises, rising in the tube and indicating the temperature. **Bimetallic strip** thermometers include two different metals that are bonded together and expand at different rates as they warm up. Since the two metals expand to different lengths, the bimetallic strip is forced to bend or curl towards the side with a lower coefficient of thermal expansion. The movement of the strip is used to deflect a pointer over a calibrated scale which then indicates temperature to the user. Often, long bimetallic strips are wound into a coil and used with a dial. **Electronic devices** such as thermistors measure changes in electrical resistance and convert them to changes in temperature. **Infrared thermometers** are non-contact devices that convert infrared (IR) energy to an electrical signal that can be displayed in units of temperature [5].

In many cases, the temperature of food can be checked using a probe thermometer. Ideally, a hand-held digital thermometer should be used when probing foods and checking air temperatures. This may be supplemented by additional "in-place" thermometers which may be located in refrigerators, chills, cold displays and freezers. Temperature control is important because harmful bacteria are a hazard present in many of the foods handled in catering businesses. They also tend to multiply rapidly at room temperature. As bacteria are invisible to the naked eye and cannot be physically removed from food, all we can do is control their numbers. [6]

Medical devices and medical electronic are areas that had little to offer 100years ago. However, there were three important existing technologies that lead to many further development over the following 100years. These are the stethoscope, electrocardiography and x-ray medical imaging. Although these technology had been described and were available to some extent when the proceedings of the IEEE (institute of electrical and electronics engineering) pages first appeared, they had yet to achieve the widespread use that they have today. The development of modern technology is known to be making a revolution in bio-medical engineering. In medicine, modern technology has been applied to travail and almost impossible task. Medical electronics instrumentation can revealed advances due to every known disease and malfunction and this has continue to excite engineering with the challenge

to reduce the profile of morbidity and mortality. If we look at the development of the past and imagine ourselves with challenge 100years ago, we know that none of us could have predicted the advances in medical devices and medical electronics that we enjoy today. However these equipment are becoming complex and expensive for the developing nations in addition to their weak infrastructure that makes the equipment impracticable for used [7]. Due to the recent advancement in science and technology many sophisticated and high precision measurement devices and system were developed. Among the device developed, those for measurement of temperature are essential because of the role of temperature in virtually all aspect of life [8]

There are several types of thermometer in used today these are;

i. The Liquid in Glass Thermometer
ii. The mercury in glass thermometer:
iii. The alcohol in glass thermometer:
iv. The resistance thermometer
v. Typical thermocouple
vi. The Constant Volume Gas Thermometer
vii. Radiation thermometry/Pyrometry [ ]
viii. Digital thermometer

The type of thermometer that is going to be considered in this research work is wireless thermometer. In order to ensure flexibility, convenience and ease of temperature measurement. Wireless thermometer enables nurses and clinicians to monitor a patient's temperature continuously without disturbing the patient, enhancing patients comfort and mobility. It also enable reading to be automatically stored, retrieved and analyze for trends, saving time and minimizing errors associated with mercury-in-glass thermometer. The feature of the wireless thermometer discussed here includes;

i. It is a digital instrument
ii. The transmitter is separated from the receiver, thus it is wireless device
iii. It is microcontroller based

The principle of operation of this instrument is based on the fact that, the temperature sensor which is connected to the transmitter will sense the temperature and send it to the receiver which is going to display it on the LCD.

It is of great important to measure body temperature; the reason is that a number of diseases are accompanied by characteristic changes in body temperature. Likewise, the course of certain disease can be monitored by measuring body temperature, and the efficiency of a treatment initiated can be evaluated by the physician. Fever is a

reaction to disease-specific stimuli where the set point of the temperature control centre is varied to promote the body's defence against the disease process. Fever is the most common form of pathological (disease-related) elevation on body temperature. [9] Measurement (from old French) is the assignment of numbers to object or event. It is a cornerstone of most natural sciences, technology, economics and quantitative research in other social sciences [10] Measurement plays an important role in nature and human existence. It is a broad discipline in both engineering and science encompassing the area of detection, acquisition, control and analysis of different data. Measurement provide means of describing natural, human and artificial activities in quantitative terms. It comprises the precise and accurate and recording of physical and nonphysical parameters that play a vital role in every branch of scientific research and industrial processes Temperature is the degree of hotness or coldness of a body. Precisely it is a potential for heat transfer. In qualitative manner, we can describe the temperature of an object as that which determine the sensation of warmth or coldness felt from it. It is easy to demonstrate that when two item of the same material are place together (physicist say when they are put in thermal contact), the object with higher temperature cools while the cooler object become warmer until a point is reached after which no more changes occurs, and our senses, they feel the same. When the thermal changes have stopped, we say that the two object (physicist defined them more rigorously as system) are in thermal equilibrium. We can then define the temperature of the system by saying that the temperature is that quantity which is the same for both system when they are in thermal equilibrium. If we experiment further with more than two system, we find that many system can be brought into thermal equilibrium with each other, thermal equilibrium does not depend on the kind of object used, put more precisely. If two system are separately in thermal equilibrium with a third. Then they must also be in thermal equilibrium with each other [11]

It is estimated that accompanying every 1˚C rise in body temperature is a 10% rise in the rate of enzymes-controlled chemical reaction. At 43˚C and above, cell are irreparably damaged and enzymes denatured, rendering death a certainty [12] some people have lower baseline body temperature, even their body temperatures have raised during infection, the body temperature may still be within the reference range. These changes can only be identified when their usual body temperature are monitored with a thermometer on a regular basis. The use of liquid-in-glass thermometers have several limitations, such as limited temperature range and precision. Thus there is a need to develop a high precision wireless thermometer to provide more accurate measurements.

The purpose of this research work is to design and construct a wireless thermometer that can measure the body temperature of a patient. The complete system should be capable of measuring, processing and analyzing temperature. The output will give an indication of the state of health of the patient. Another important objective of designing this instrument is to achieve a reliable instrument that works effectively and efficiently without uncertainty in recording result. Sometimes when a doctor is using a mercury in glass, it may likely to break and the mercury is a persistent, bio-accumulative, toxic material that can harm the brain, heart, kidney, lungs and immune system of people of all ages. (U.S. EPA). This is eliminated with wireless thermometer.

Body temperature is an important physiological parameter used routinely in the clinical management of critically ill patient. For both children and adults, it is usually measured manually using rectal, ear, oral or auxiliary method [13] in patient with fever, body temperature is assessed frequently, causing constant disturbance to the patient and increasing nursing workload. The mercury-in-glass it has a number of drawbacks and risks. Some of the important features of wireless thermometer include

1. It provides a multi-disciplinary research works that cuts across engineering and medicine
2. The research work adds to the body of knowledge on more efficient and accurate method of designing thermometers

The instrument has found application in areas such as:-

i. Hospital: where it is being used by medical doctor nurses and other medical personnel
ii. School and colleges: where medical student use it for research and studies
iii. Homes: where individual may use it in monitoring their body temperature from time to time.

In order to ensure portability, the device will use a battery. The project will be constructed to work wirelessly, the transmitter is separate from the receiver, the thermometer is connected to the patient body and the receiver is kept somewhere around. It can measure the temperature manually, but it cannot measure the temperature automatically. The intended application of the device is monitoring of human body temperature. Thus only positive temperature will be measured and displayed.

DESIGN AND CONSTRUCTIONS

The design of the system consist of the transmitter and receiver, the transmitter comprises of the power supply which supply the require voltage to the device, the

temperature sensor which senses the temperature, microcontroller unit the RF receiver and the display unit. The receiver comprises of power supply, the RF receiver, microcontroller unit and the display unit.

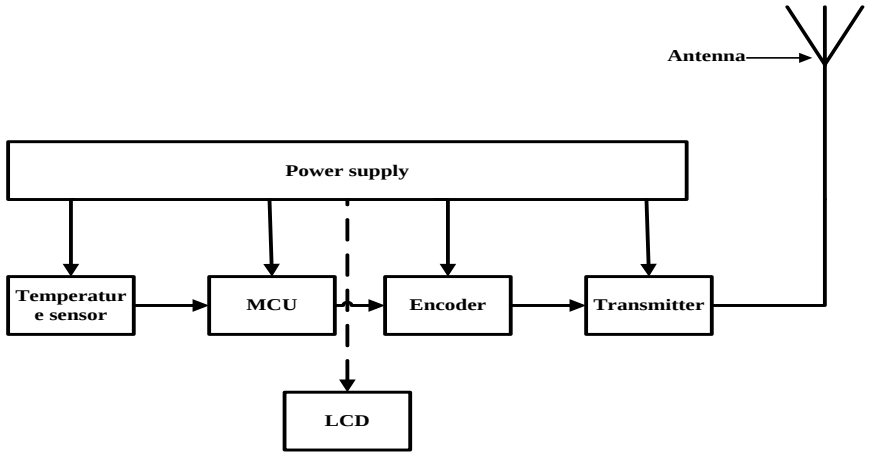


Fig: 1. Block diagram of wireless transmitter

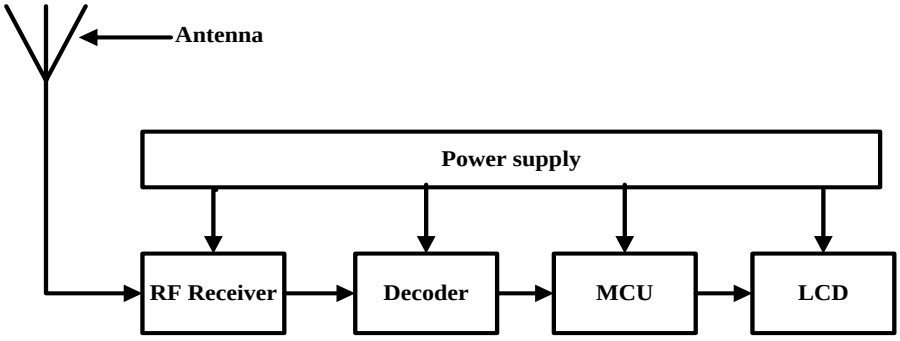


Fig: 2. Block diagram of wireless receiver

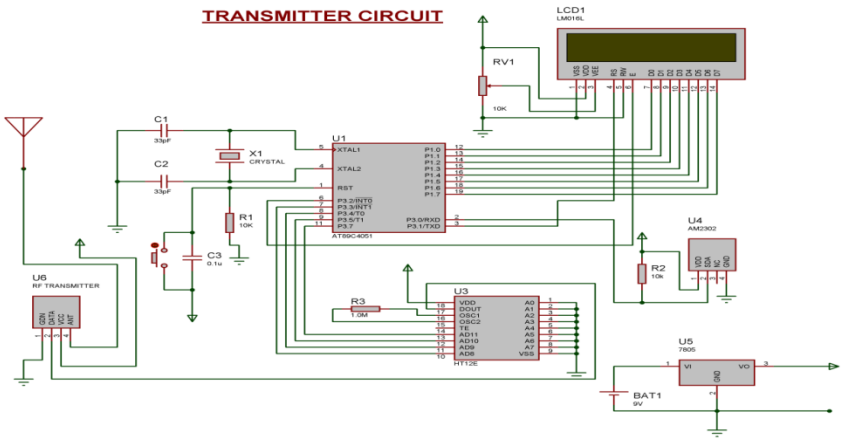


Fig. 3. Transmitter circuit

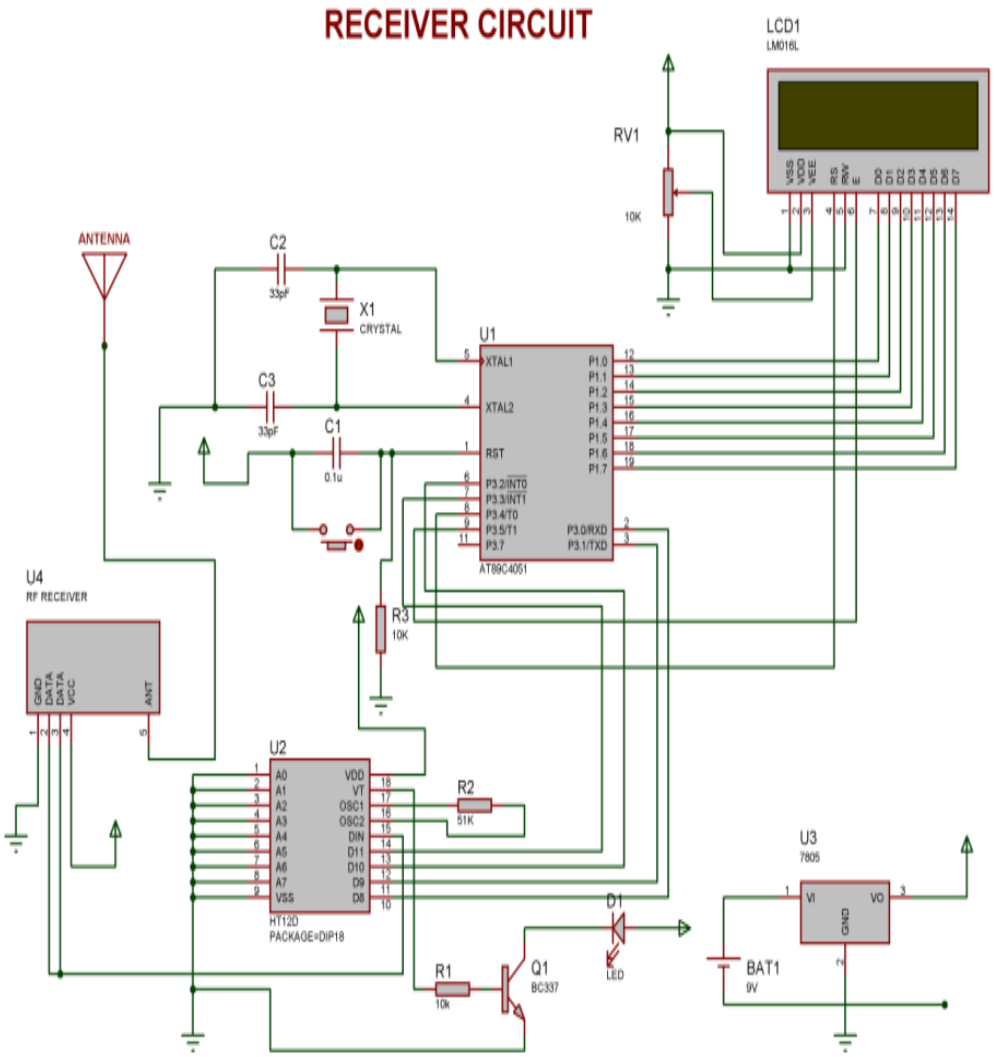


Fig. 4. Receiver circuit

Software Design

The software design started with testing the temperature sensor by writing a control program in assembly language, to enable the sensor sense temperature. Assembly language is a low-level, pseudo-English representation of the microcontrollers machine language. Each assembly language instruction has a one-to-one relation to one of the microcontroller's machine-level instructions. Assembly language is converted into executable machine code by a utility program referred to as an assembler; the conversion process is referred to as assembly, or assembling the code. Assembly language uses a mnemonic to represent each low-level machine instruction or operation. The design consist of a flowchart which was drawn as a guide to understand the working principle of a device as shown below.

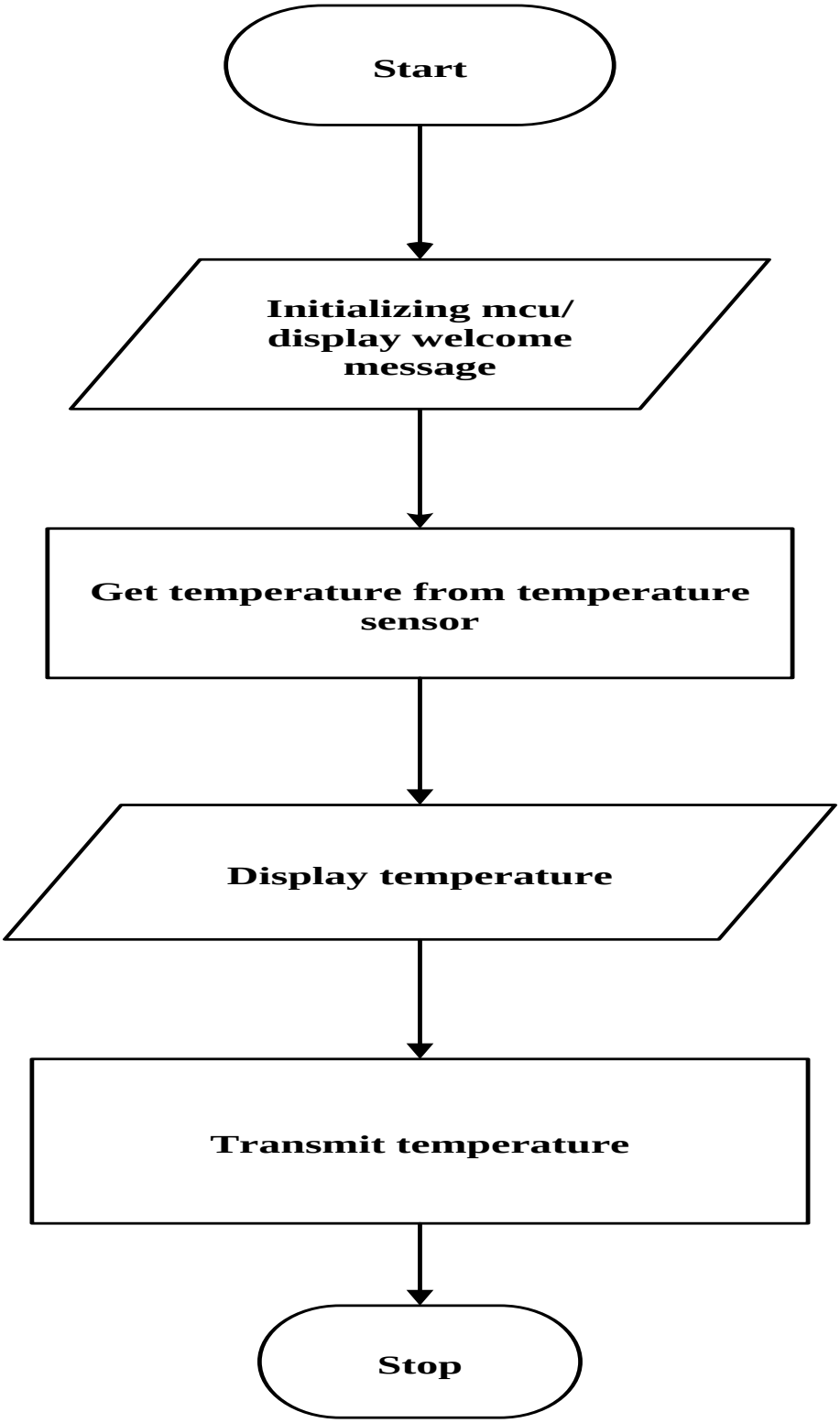


Fig:3.13 Transmitter flow chart

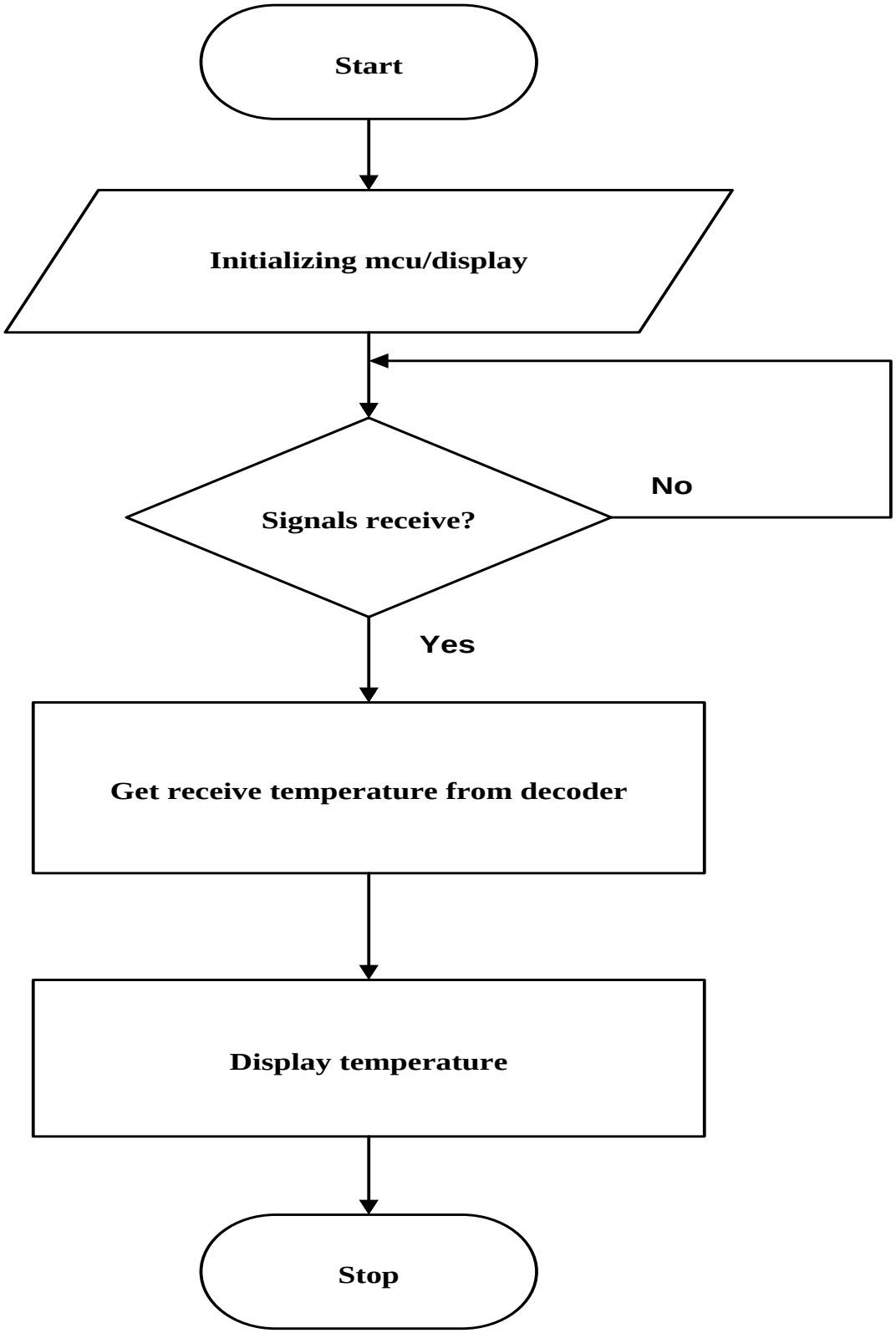


Fig: 3.14 Receiver block diagram

PERFORMANCE

This chapter provides the performance evaluation of the system. The wireless thermometer was used to measure the body temperature of several persons. The result are presented in tabular form. The device was also used to determine the ambient temperature over time. A graphical representation of temperature over time is provided.

Test Result

Name	Temperature (˚C)	Time (s)
Samson visa	35.5	14
	35.8	32
	35.9	38
Clifford	35.4	25
	35.6	33
	36.2	35
Mahmud	34.5	36
	34.9	24
	34.5	26
Nurudeen	35.6	35
	35.9	32
	36.1	37

Table 4.1 temperature of different people

TEMPERATURE OF THE ENVIROMENT

S/N	Time (minutes)	Temperature (˚C)	
		11:00AM - 1:40PM	5:30 PM – 7:10PM
1	1	31.5	31.4
2	2	31.6	31.5
3	3	31.7	31.3
4	4	31.8	31.3
5	5	31.8	31.4
6	6	31.7	31.3
7	7	31.6	31.3
8	8	32.6	31.3
9	9	31.9	31.3
10	10	31.9	31.2
11	11	30.2	31.3
12	12	31.9	31.3

13	13	31.9	31.1
14	14	31.8	31.1
15	15	31.9	31.0
16	16	31.9	31.0
17	17	31.9	31.1
18	18	32.0	31.1
19	19	32.0	31.1
20	20	31.9	31.2
21	21	31.9	31.1
22	22	31.9	31.1
23	23	32.0	31.1
24	24	31.9	31.1
25	25	32.1	31.0
26	26	32.1	31.0
27	27	32.2	30.9
28	28	32.3	30.9
29	29	32.3	30.9
30	30	32.3	30.8
31	31	32.4	30.8
32	32	32.3	30.8
33	33	32.1	30.8
34	34	32.1	30.8
35	35	32.1	30.8
36	36	32.1	30.8
37	37	32.1	30.8
38	38	32.2	30.5
39	39	32.1	30.3
40	40	32.4	30.2
41	41	32.5	30.1
42	42	32.5	30.1
43	43	32.6	30.1
44	44	32.6	30.0
45	45	32.6	30.0
46	46	32.6	30.1
47	47	32.6	29.9
48	48	32.6	29.7
49	49	32.6	29.8
50	50	33.0	30.0

51	51	32.9	29.9
52	52	32.9	29.9
53	53	32.9	29.9
54	54	33.0	29.7
55	55	32.9	29.7
56	56	32.8	29.8
57	57	32.9	29.7
58	58	32.9	29.8
59	59	33.0	30.0
60	60	33.2	30.1
61	61	33.2	30.0
62	62	33.3	30.0
63	63	33.2	30.1
64	64	33.2	30.1
65	65	33.1	29.9
66	66	33.0	30.1
67	67	33.1	30.1
68	68	33.3	30.2
69	69	33.3	30.2
70	70	33.3	30.1
71	71	33.4	30.1
72	72	33.3	30.1
73	73	33.3	30.0
74	74	33.0	30.0
75	75	33.1	30.1
76	76	33.3	30.0
77	77	33.5	30.1
78	78	33.4	30.0
79	79	33.5	30.0
80	80	33.5	30.1
81	81	33.5	30.1
82	82	33.6	30.0
83	83	33.6	29.9
84	84	33.6	29.9
85	85	33.5	30.0
86	86	33.6	29.9
87	87	33.6	29.9
88	88	33.7	29.8

89	89	33.7	29.8
90	90	33.6	29.9
91	91	33.6	29.8
92	92	33.5	29.7
93	93	33.6	29.8
94	94	33.8	29.8
95	95	33.9	29.7
96	96	33.9	29.8
97	97	34.0	29.8
98	98	34.1	29.7
99	99	34.0	29.7
100	100	34.0	29.7

Table 4.2 temperature of the environment

Graph of temperature against time

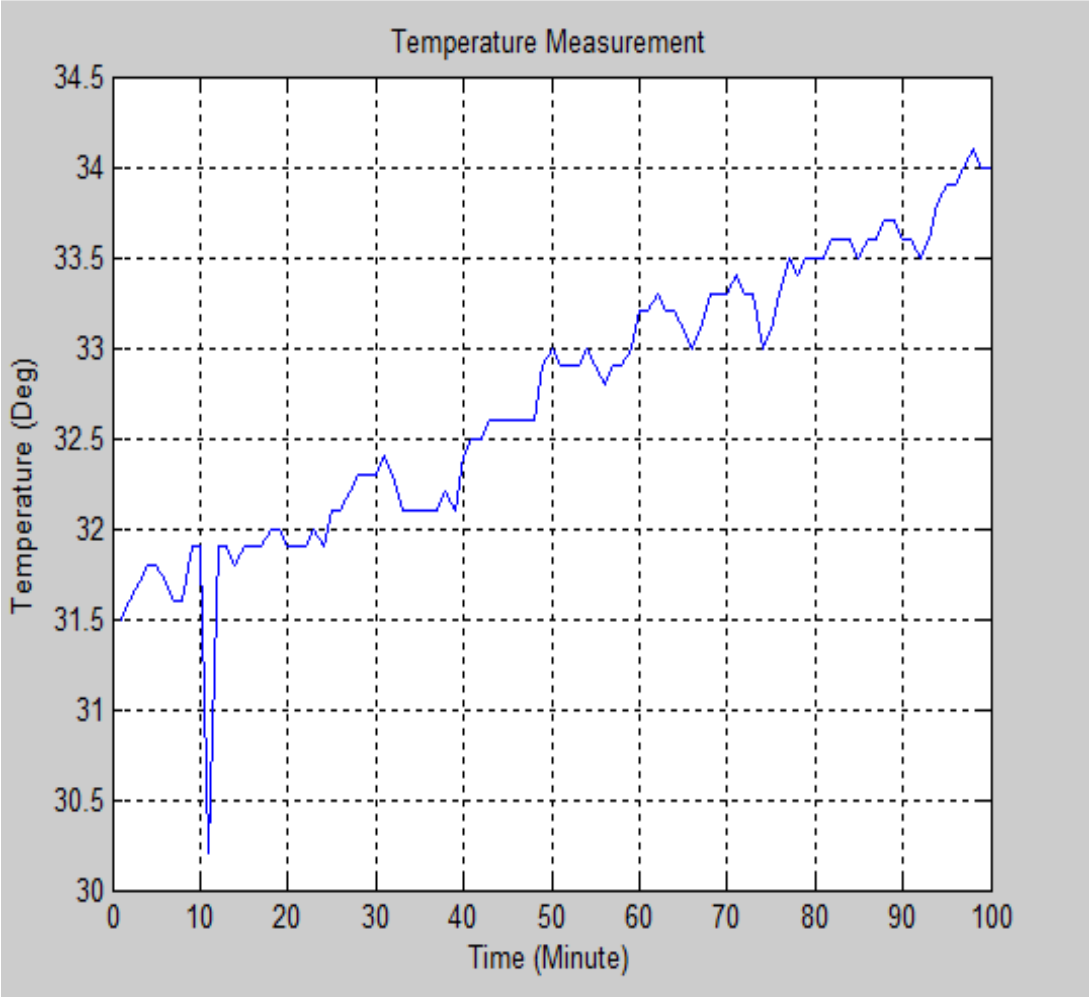


Fig: 4.1 graph of afternoon temperature against time

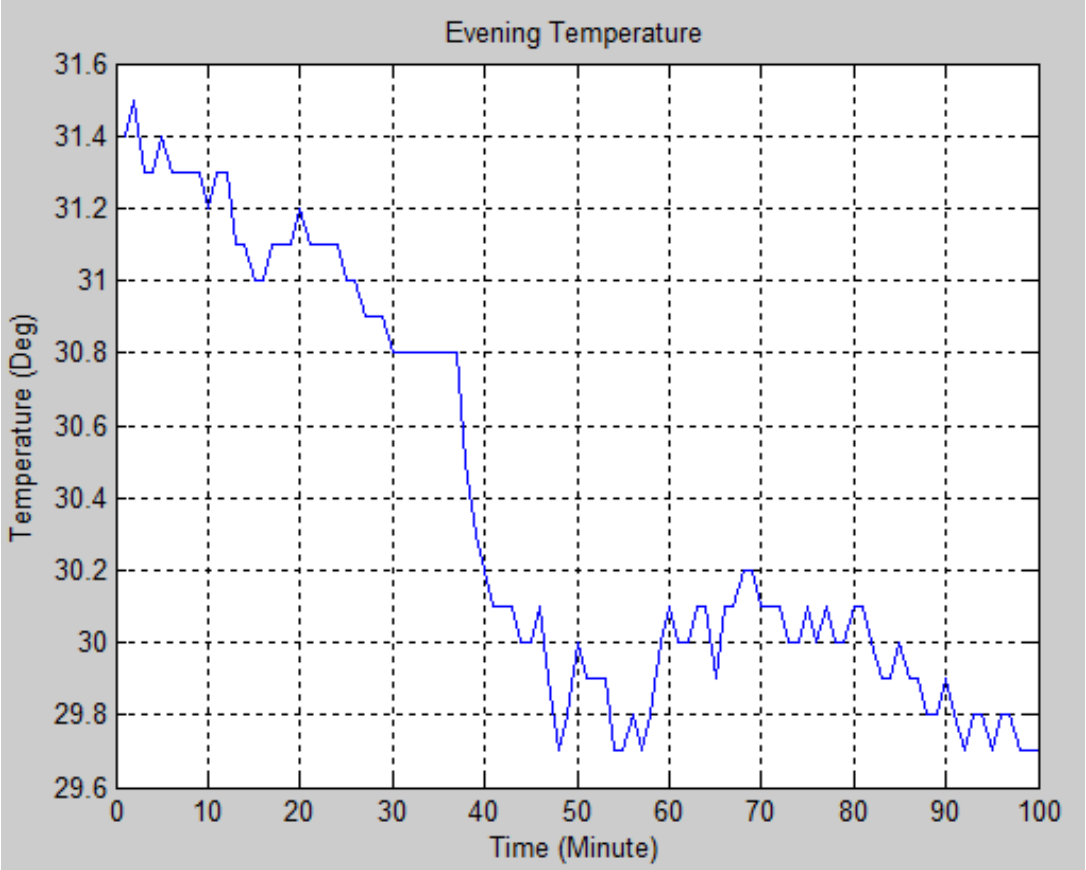


Fig: 4.2 Graph of evening temperature against time

Discussion

Graphical representation of results obtained using the wireless thermometer are given in Fig. 4.1 and 4.2. the of Fig. 4.1 shows an increase in temperature over time. This increase is due to the fact that the temperature values were measure in the afternoon between 11:00 AM and 1:40 PM. Similarly, the temperature values for evening time through the night tend to decrease over time. These result shows that the device is capable of gauging real-time temperature values accurately.

Conclusion

It was concluded that the design and construction of wireless thermometer were successfully done and the temperature of a human body is being able to measure using this device. ATMEL 89C4051 microcontroller is used in the design work as chief component. Other component used in the design work, their features and calculations associated with them are all stated, analysis of the components used troubleshooting approach in case of any malfunction, recommendation for further research and improvement are all included in this work. The general testing done before

casing/packaging confirm that wireless thermometer with LCD display is reliable and offers relief to human effort as a modern day system in hospital, clinic, homes and offices etc.

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