Design and Development of a Prototype Signal-based Hospital Communication System

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Abstract

The signal based hospital communication system is focused at enhancing effective communication and monitoring of patients by the health officer within the premises of the hospital. It is simple in design, effective and serviceable with the wired logic approach while the use of radio waves for the final link was avoided because of the inherent danger to human health. The various units consisting of power supply, multivibrators, logic gates and indicating system for lighting were designed to specification putting in mind the relevance and availability of parts. The prototype was constructed and testing was made contiguous to the hospital situation.

Keywords: Communication system; Flip flop; Astable; Hospital; Prototype.

Introduction

In the most fundamental sense, communication involves implicitly the transmission of information from one point to another through a succession of process which involves:

1.   The generation of a message signal: voice, music, picture, or computer data

2.   The description of that message signal with a certain measure of precision, by a set of symbols: electrical, aural, or visual

3.   The encoding of these symbols in a form that is suitable for transmission over a physical medium of interest

4.   The transmission of the encoded symbols to the desired destination

5.   The decoding and reproduction of the original symbols

6.   The re-creation of the original message signal, with a definable degradation in quality; the degradation is caused by imperfections in the system [1,2]

Communication systems transfer information using signals which are functions of time that convey information from the transmitter to the receiver at the other end of the transmission medium [3]. In electrical communication systems, signals take the form of electromagnetic waves that can be transmitted over wired or wireless media. Examples of wired media include twisted wire pair, coaxial cable, and optical fiber in which the signal energy is contained and guided within the medium. In wireless media, on the other hand, the signal energy propagates in the form of unguided electromagnetic waves [4,5]. Radio, microwave, and infrared are examples of wireless media.

Rescue of life through communication medium that is void of Radio Frequency (RF) is essential in the hospital/clinic because of the effects of RF to human health [6]. We designed and developed an emergency system that will be of help in the hospital and clinic as a medium of communication between the Patient and the health officer on duty. This communication medium is predominantly signaled that does not require voice. Hospital is a place where patient does not need noise or disturbance; this was put into consideration when designing the system.

This paper design and develop a communication system that is signal based. In section 4 the methodology of the system was discussed; section 4.1 develop the design calculations and specifications, while the mode of operation, assembling and testing was discussed in sections 5 and 1.4 respectively. The conclusion and recommendation drawn from the work was presented in section 1.5.

Methodology

In designing and developing this system, every stage was designed to specification taking into consideration the design calculations. The stages involved are: the power supply, the astable, the flip flop, the indicator and the gate. The technique involved is a one way signal communication.
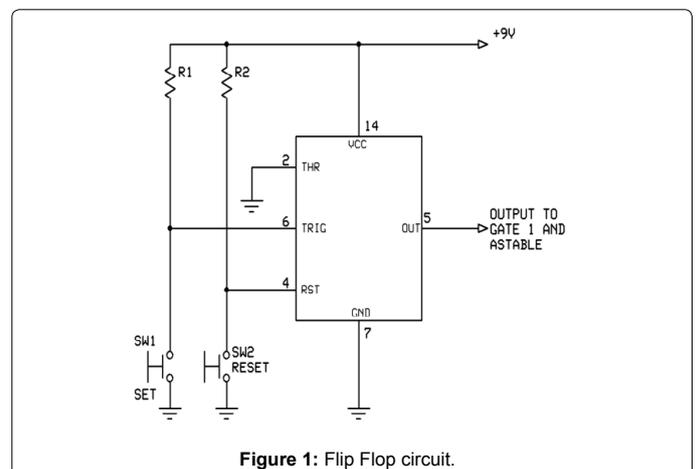
In Figure 1, S1 and S2 is NOMP (Normally Open Momentary

Figure 1: Flip Flop circuit.

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Push) Switch, where S1 is used for setting the alarm while S2 is for resetting the alarm. R1 and R2 (often called pull-up resistors) are required to keep the set and reset voltage levels high. It can be selected anywhere between 1KΩ to 100KΩ as preferred by the designer. When S1 is pressed, the flip-flop change its output state to high and remains there even after the switch has been released. Its output will only go low at the press of the reset button. The astable chops down the signal from the flip-flops to pulses that is use to drive the indicators, which is light emitting diode (Figure 2).

The calculations for the resistors of indicator 1, 2, 3 and LED indicator are the same. It is so because R7, R37 and R67 are used as current limiting resistor for the same kind of loads where R5 and R36 is base resistor for same circuitry (Figure 3).

Design calculation and specifications

R3, R4 and C2 determine the frequency of the astable circuit (Figure 2)

$$F = \frac{1.44}{(R3 + 2R4)C2}$$

$$\therefore F = \frac{1.44}{10000 + 2 \times 47000) \times 10 \times 10^{-6}}$$

$$F \cong 1.4 Hz$$

Basic design parameters of 8050/8550 transistor:

Vcc(max) = 45V, Ic (max) = 1.5A, Hfe = 100, V_{BE} = 0.7V

Basic design parameters of the LED:

Forward voltage = 2V, Forward current = 15mA
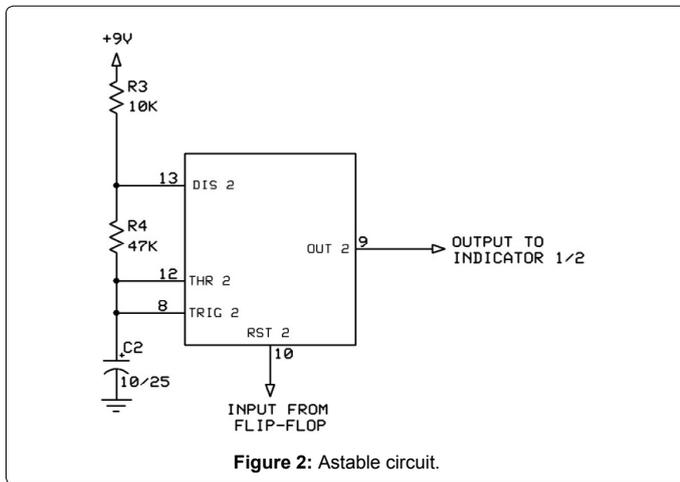

Figure 2: Astable circuit.

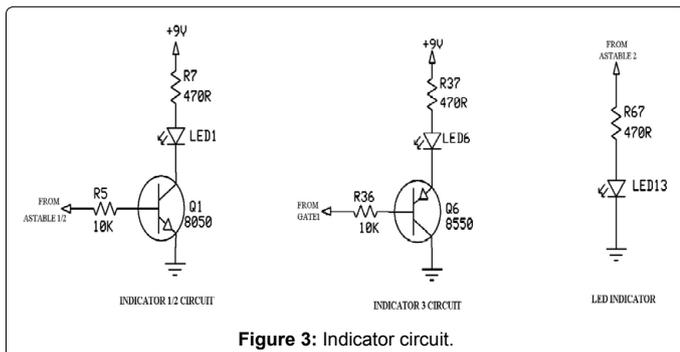**Figure 3:** Indicator circuit.

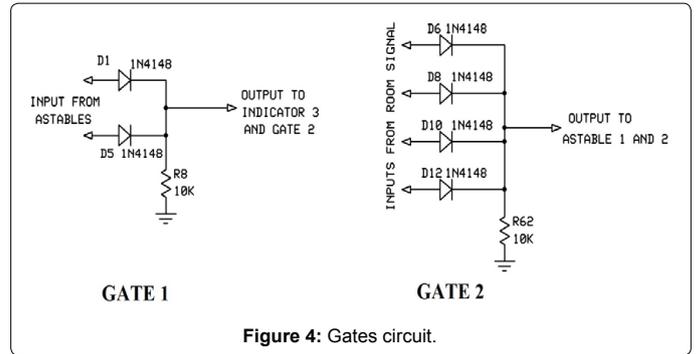**Figure 4:** Gates circuit.

For Vcc = 9V;

$$R7 = R37 = R67 = \frac{Vcc - V_{LED}}{I_{LED}}$$

$$= \frac{9 - 2}{15 \times 10^{-3}}$$

$$\cong 470 \Omega$$

$$I_B = \frac{I_C}{H_{FE}}$$

$$I_{BQ} = \frac{15 \times 10^{-3}}{100}$$

$$I_{BQ} = 0.15 mA$$

Base current, I_{BQ} is multiplied by a constant value to ensure that the transistor is saturated. Let this constant value be 5. Therefore,

$$I_B = 5 \times 0.15 \times 10^{-3}$$

$$I_B = 0.75 mA$$

$$R6 = R35 = \frac{Vcc - V_{BE}}{I_B}$$

$$= \frac{9 - 0.7}{0.75 \times 10^{-3}}$$

$$= 11,066 \Omega$$

$$= 10K \Omega$$

The two gates (namely gate 1 and gate 2) in Figure 4 are the Diode Resistor Implementation of an OR logic gate. The resistors R8 and R62 are pull down resistors which are to ensure that the outputs of the gates are not floating. The value is chosen to be fairly high. Also a range of 4.7KΩ to 100KΩ is good.

Calculations of astable 1 in Figure 5; R63, R64, and C2 are the frequency determining component of the circuit. The frequency is calculated thus;

$$F = \frac{1.44}{(R_{63} + 2R_{64}) \times C_{15}}$$

$$F = \frac{1.44}{(47000 + 2 \times 47000) \times 10 \times 10^{-3}}$$

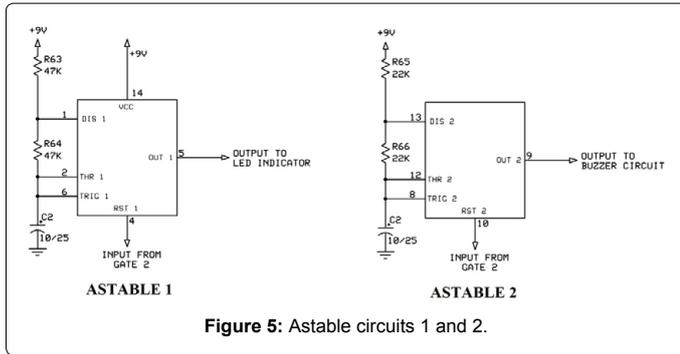$$F \cong 1 Hz$$

Calculations of astable 2:
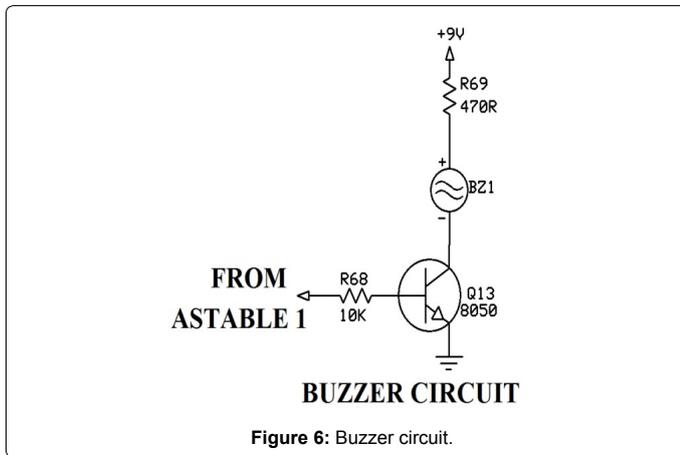
Figure 5: Astable circuits 1 and 2.

Figure 6: Buzzer circuit.

R65, R66 and C16 are the frequency determining circuit of astable 2. The frequency is calculated thus;

$$F = \frac{1.44}{(R_{65} + 2R_{65}) \times C_{16}}$$

$$F = \frac{1.44}{(22000 + 2 \times 22000) \times 10 \times 10^{-3}}$$

$$F = 2.2 Hz$$

The calculation for the buzzer is the same as the indicator circuit. The circuit in Figure 6 is use to drive the buzzer. The buzzer requires almost 30mA in which if the IC is use to drive the buzzer directly, it may stress the IC. The resistor R69 is use to limit the forward current that is flowing through the buzzer.

The power supply has no special calculation. The 4-bridge rectifier diodes are selected to have a Peak Inverse Voltage (PIV) greater than the maximum peak voltage of the AC being rectified. At 12V AC, the maximum voltage is;

$$V_{MAX} = \sqrt{2} \times V_{RMS}$$

$$V_{MAX} = 12\sqrt{2}$$

$$V_{MAX} = 17 Volts$$

The peak-to-peak voltage V_{PP} is calculated thus;

$$V_{PP} = 2 \times V_{MAX}$$

$$V_{PP} = 2 \times 17$$

$$V_{PP} = 34 Volts$$

The PIV of the 1N4007 diode is 1000V which much greater than 34volts. This means that the diodes are able to operate at its safe operating area. The capacitors C17 and C18 are decoupling capacitors. There values are not critical because the 7809 takes charge of the load difference which would have make the capacitors value critical.

Mode of Operation

The basic idea behind the work is to send a signal whenever any of the set button is pressed. The set buttons are: SW1-SW8. They trigger there corresponding flip flop into operation when pressed. The flip flops are built around U1-U8. It makes sure the output is high when and after the set is pressed. The outputs of the flip flop are used to drive the reset pin of the astable multivibrator. When the reset pin of a 555 operated astable is high, it produces a pulsed signal, which is only used to drive the LED1, 5, 7, 9 and 11. In short the astable is used to produce a blinking effect. The outputs of the entire flip flop altogether are ORed i.e., connected together to the input of an OR logic gate, this ensure that all the set buttons can operate the central alarm at any time. The alarm is driven by an astable built around U9. The block diagram of the system is shown in Figure 7. The design also include a reset button, SW10, which when pressed, resets all activated alarm. The system is driven by 9volts regulated power supply o increase stability.

Assembling and testing

The components use in Table 1 was assembled on a board as shown in Figure 8. Each stages were tested okay given the required
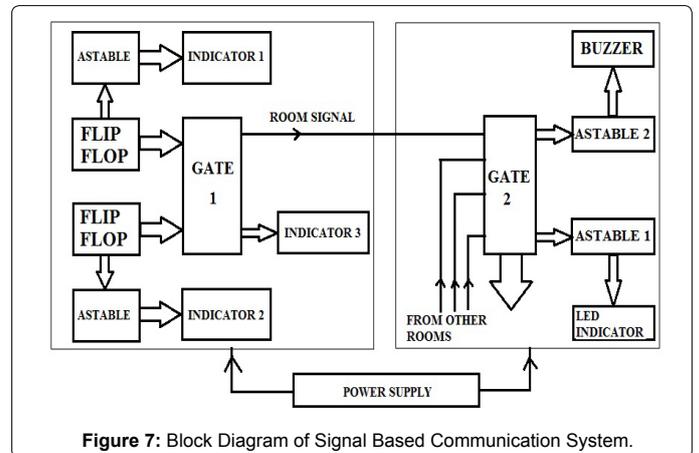

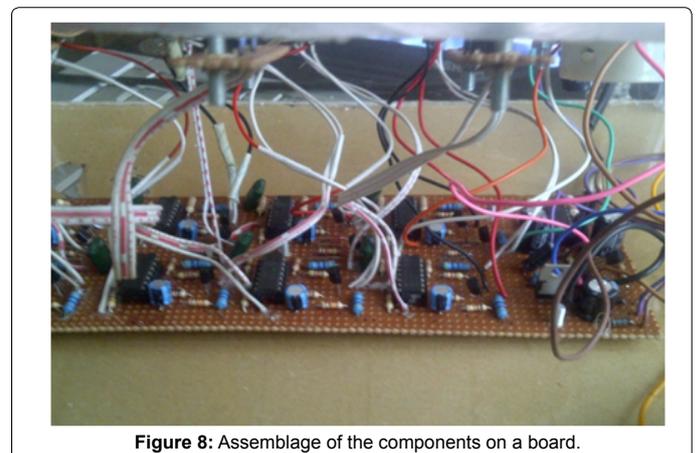**Figure 7:** Block Diagram of Signal Based Communication System.

Figure 8: Assemblage of the components on a board.

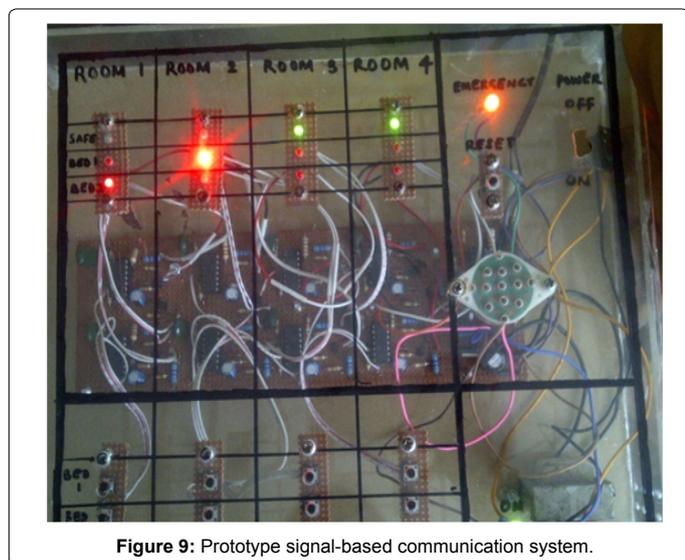| Quantity		Designation	Description	Part No.
9		R1,R2, R9, R16, R23,R30, R38, R46, R54	Resistor	1KΩ, 0.25 Watts
26		R3, R5, R8, R10, R12, R15, R17, R19, R22, R24, R26, R29, R31, R33, R36, R39, R41, R44, R47, R49, R52, R55, R57, R60, R62, R68	Resistor	10KΩ, 0.25 Watts
11		R4, R11, R18,R25, R32, R40, R48, R56, R58, R63, R64	Resistor	47KΩ, 0.25 Watts
7		R6,R13, R20, R27, R34, R42, R50	Resistor	4.7KΩ, 0.25 Watts
15		R7,R14, R21, R28, R35, R37, R43, R45, R51, R53, R59, R61, R67, R69, R70	Resistor	470Ω, 0.25 Watts
2		R65, R66	Resistor	22KΩ, 0.25Watts
8		C1, C3, C5, C6, C7, C9, C11, C13	Capacitor	100nF Paper Capacitor
12		C2, C4, C6, C8, C10, C12, C14, C15, C16, C17, C19, C20	Capacitor	10uF, 25V Electrolytic Capacitor
1		C18	Capacitor	470uF, 25V Electrolytic Capacitor
9		Q1-Q5, Q7, Q9, Q11, Q13	Transistor	8050 NPN Switching Transistor
4		Q6, Q8, Q10, Q12	Transistor	8550 PNP Switching Transistor
12		D1-D12	Diode	1N4148 Signal Diode
4		D13-D16	Diode	1N4007 Signal Diode
9		LED1-LED5, LED7, LED9, LED11, LED14	Light Emitting Diode	3mm RED LED
5		LED6, LED8, LED10, LED12, LED14	Light Emitting Diode	3mm GREEN LED
		LED13	Light Emitting Diode	3mm ORANGE LED
9		U1-U9	Semiconductor	NE556
1		U10	Semiconductor	LM7809 Voltage Regulator
8		SW1-SW8	Switch	Nomp Switch
1		SW9	SWIT Switch CH	Spst Slide Switch
1		BZ1	Piezoelectric Buzzer	-
1	T1	Transformer		220/12V 500mA

Table 1: List Of Components.

Figure 9: Prototype signal-based communication system.

signal needed. When a patient needs attention of any medical officer, he/she will initialize a button which will trigger on the buzzer and LED simultaneously and continuously until reset button is pressed by the receiver (the buzzer maybe put on silent mode). The officer in-charge will easily know the particular room and bed that need his/her attention; example is illustrated in Figure 9 where the patient in room 2 bed 1 needs a medical attention.

Conclusion and Recommendation

The circuit for the signal communication was designed and developed. The designed calculations for each stages of the design and specifications was carried out, the overall performance of the system was tested and certified okay. It was observed that most of the hospitals if not all in Nigeria and other developing nations lack this system, this system, if installed in the hospitals and clinics will save some lives and make the work of the medical personnel easier in terms of knowing when the patient need their attention. The option of wired logic was chosen because of easy maintenance and cost effective, it was designed in such a way that any hospital/clinic can afford. Communication industries can work on this prototype system and market it to the appropriate quarters. The system is therefore recommended for use in the hospitals and clinics in Nigeria and other developing countries.

References

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