KYAMBOGO UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

BACHELOR OF ENGINEERING IN TELECOMMUNICATIONS ENGINEERING

PROJECT TITLE: Design and construction of an RF Transmitter and GSM based anti- baby theft system for Hospitals

CASE STUDY: Mulago National Referral Hospital Labour Ward, Kawempe General Referral Hospital

BY

MUHANGUZI TOBIAS

15/U/7774/ETE/PE

SUPERVISOR: MR MBIIKA CERIANO

A REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS FOR THE PARTIAL FULFILLMENT OF THE AWARD OF BACHELOR OF ENGINEERING IN TELECOMMUNICATION ENGINEERING

20th AUGUST 2018

DECLARATION

I declare to the best of my knowledge that this Compilation is my original work and no part of it has been submitted in Kyambogo University or elsewhere for a Degree or any other academic award in any University or institution of Learning".

Sign:______________________ Date______________________

Muhanguzi Tobias

APPROVAL

I confirm that the project titled "Design and construction of an RF Transmitter and GSM based anti- baby theft system for hospitals" has been carried out by the candidate under my supervision and has been approved for meeting the requirements governing the award of a Bachelor of Engineering in Telecommunication Engineering of Kyambogo University, for the completion of third year project.

Sign:______________________ Date______________________

Mr Mbiika Ceriano

(PROJECT SUPERVISOR)

DEDICATION

I dedicate this project to my late father and mother Mr Kwatotyo Edward Kareireho RIP and Mrs Kwatotyo Tumwiine Marydovika RIP who gave me the inspiration to achieve my goals during this project period, To my friend, lecturer, Mr Mbiika Ceriano (PROJECT SUPERVISOR) for being a good guide throughout the project process and Dr Mugoya Sam of Mulago National Referral Hospital who provided us with the necessary data and information during our group research.

I also dedicate this project to my Aunt Mrs Semambo Angella Kemirembe who passed on early this year RIP, was a dedicated mother when I had none.

May the almighty God bless you all!

ACKNOWLEDGMENT

I humbly thank the almighty God for granting me with life, knowledge and wisdom to accomplish my project and compile this report.

My sincere thanks go to our project supervisor Mr. Mbiika Ceriano for all the knowledge and advice he has put in us during this period, Dr Mugoya Sam for providing us with the necessary data and information during our group research.

May the living God bless you abundantly!

LIST OF ACRONYMS

LCD ……………………………………………………………………......... Liquid Crystal Display
LED …….…………………………………………………….……………......... Light Emitting Diode
MCU …….……………………………………………………….…………......... Microcontroller
BJT …………………………………………………………..…......... Bipolar Junction Transistor
SWR ………………………..………………………………………….…......... Standing Wave Ratio
UART ……………………………………….......... Universal Asynchronous Receiver Transmitter
TTL …………………………………..………………………......... Transistor Transistor Logic
CCTV ……………………………………………………………......... Closed Circuit Televisions
IWA …………………………….…………...………….......... Indian Women Association Uganda
SMS ……………………………………………...………………………......... Short Messages
GSM …………………..……………………………......... Global System for Mobile Communication
RF ………………………………………………………………………………......... Radio Frequency
RFID ……………………………………….……………......... Radio Frequency Identification

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF TABLES

TABLE OF CONTENTS

ABSTRACT

The design and construction of a system that monitors the location of a newly born baby for hospitals, using RF transmitters and additional visual indication LEDs for the deaf, the system is implemented using Arduino development boards, atmega328 microcontroller and GSM for mobile communication to the care taker.

The system consists of:-

- The Microcontroller Unit (MCU) that controls the activities of the different units within the systems on both the mother's side and the baby's side.
- The display unit that is made up of the Liquid Crystal Display (LCD) that displays messages that are sent to the mother or any other person that is responsible for monitoring the baby.
- The indictor unit consists of the light emitting diodes and buzzers that are used to show the status of the system, the parameters measured are; - the distance of the baby from the mother, or whether the RFID tag is removed, or whether the system is powered off.

CHAPTER ONE

1.0 Introduction

Babies are one of the most vulnerable patients in a hospital. Ensuring infant security is critical to not only the reputation of the hospital, but also to the peace of mind of everyone there, from nursing staff to new moms. The most effective infant protection solution should provide accurate newborn location information along with 24/7 abduction attempt alerts The best step a healthcare facility can take for newborns and their families is integrating a state-of-the-art baby tracking system [1].

1.1 Background of the Study

Wireless RF transmitter, RFID and GSM Technologies have gained variety of application in different devices, because they have low power consumption, permit device mobility, and been developed for enhanced functionality, we choose GSM-800 because it has already existing infrastructure, making implementation easy, LCD display was used to indicate the name of the baby and error messages, In case of the implementation without GSM, which could eliminate the need for the LCD display, by sending message to a mobile phone.

1.2 The Problem Statement

Most hospitals in Uganda especially Mulago hospital, have had cases of theft/kidnap/swapping of newly born babies by strangers or people who impersonate the relatives of the baby's mother. Therefore, This project led us to the design, construction and modification of a prototype system that was able to locate the position of the baby and alert the mother and a next of kin, in case the distance between the baby and the mother increases beyond limit, the system was able to alert the mother by triggering an alarm, visual indication for deaf mothers, and sending an SMS on the GSM network to the care taker, hence the baby would be quickly rescued by any authorities in the hospital.

On a personal note, I (Muhanguzi Tobias Newman) volunteer with IWA-Indian Women Association Uganda, and this would be of great interest to the Association [2].

1.3 Objectives

1.3.1 Main Objective

To Design and Construct an RF Transmitter and GSM based anti-baby theft system for hospitals.

1.3.2 Specific Objectives

To carry out formal or informal research on the wireless tracking systems.

To analyze the current system and develop a circuit that could solve the defined problems, with some achievable considerations and specifications.

To design the firmware, program the microcontroller and test it with the circuit designed.

To test and validate the overall constructed system/simulation.

1.4 Project Justification

- In most Ugandan hospitals especially Mulago hospital, are using Closed circuit televisions (CCTV) cameras to monitor the movements of people within the hospitals. From the visit, it was found out that the CCTV cameras available are either not functioning or are too old and obsolete thus from this observation, there is actually no proper system in place that is capable of tracking down the position of a newly born baby.

- We designed an RF- GSM based system that was able to track the position of the baby from its mother which in turn triggers an alarm at the mother's end (buzzer and LEDs) hence she would be able to take necessary action to intercept the stranger before he/she disappears and hence the baby will be rescued.

1.5 Project Significance

The safety of babies and their mothers in hospitals is a priority in accordance to the medical ethics. This project aims at minimizing the kidnap and theft/swap of babies in hospitals. This will make hospitals more secure and comfortable for both newly born babies and mothers. In addition, more so in case the baby is stolen, some people cannot afford DNA test fees.

1.6 Scope of the Study

1.6.1 Content Scope

This project led to the construction of a breadboard prototype implemented using two Arduino UNO development boards and microcontroller Atmega328, RF transmitters, and GSM module as major components, the project did not lead to a final deployable system, but the prototype was enough evidence that the actual system could be developed and could work properly, effectively and efficiently.

1.6.2 Time Scope

Depending on the scope of the content, the project consumed 5 months from start (documentation), through design, implementation and testing.

1.6.3 Geographical

The research under taken is only considering Mulago National Referal Hospital Labour ward and Kawempe General Referal hospital, which are both, located in Kampala district.

1.7 Methodology

In this chapter, I present the research design, the target population, the sample and sampling procedures and data collection instruments that I used in the study. The validity and reliability of the data collection instruments, data analysis procedures and ethical considerations in respect of the study are also presented in this chapter.

1.8 Summary Table for Methodology

Table 1: Summary of methodology

OBJECTIVE	**METHOD**	**DESCRIPTION**
To carry out formal or informal research on the wireless tracking systems.	Internet surfing, use of Questionnaires, and interviews	Interviews were I designed a set of interview questions and these questions were to guide me during the interview. The required information that was obtained involve extensive research on the security of babies in hospitals. This involved analysis of the history of child theft and kidnap/swapping in hospitals especially Mulago hospital. Dr Mugoya Sam, Gynecologist, was interviewed on this issue.
To analyze the current system and develop a circuit that could solve the defined problems, with some achievable considerations and specifications.	Internet surfing	This involved studying and analyzing of the current security system used for monitoring, and the similar products on market for tracking newly born babies in the hospitals mostly at Mulago Hospital.
To design the firmware, program the microcontroller unit and test it with the circuit designed.	Proteus professional, trial version, Integrated Development Environment (IDE) for Arduino	Proteus professional, trial version 8 was be used to construct the three circuit diagrams; it is a software tool used for designing electronic circuits as well as simulating. The program (sketch) added to the microcontroller was written in an Integrated Development Environment (IDE) for Arduino.
To test and validate the overall constructed system/simulation	Simulation and physical testing	The different error parameters where tested and are presented in the proceeding chapters.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

This chapter defines facts and findings on newborn monitoring as discovered from the research made in articles, books, websites or journals that are related to the system.

The system was implemented after carrying out elaborate research about the security system that was available in the hospitals. These security systems were mainly Closed Circuit Televisions (CCTV), which were being used to monitor the movements of people within the hospital premises. The research about the new system that was developed involved the acquisition of components that were used for its implementation. The following list of components were used for the implementation of the system.

2.2 Newborn Monitoring Systems Popular In Hospitals:

Baby safety and security with active RFID system is very popular in modern hospitals.

Using RFID technology, baby tagging security systems from harland Simon prevent the unauthorised removal of an infant from a ward providing 24/7 security and peace of mind for mothers and staff.

Using the lightest, smallest and most comfortable baby tag on the market, the system accurately monitors real-time location. Designed specifically for use on maternity, neonatal and paediatric wards, it can automatically trigger an alarm, lock a door or turn on a camera if an infant is moved beyond a defined 'secure area'. [3]

2.3 Current Systems on Market in Uganda:

"We have surveillance cameras. But they are few," Dr Baterana Byarugaba, Mulago's executive director, said while receiving the cameras from the Speaker of Parliament, Ms Rebecca Kadaga, at the hospital, furthermore, we were told that the baby is attached a plastic tag, bear its name and the mothers details as a precaution.

2.4 Components used in project:

The components include; Power supplies, Arduino development boards, Crystal oscillators, GSM modules for Arduino, LCDs, LEDs, Zennar diodes, Resistors, Variable resistors,

2.5 Power Supply

For this system, most components that are used are powered by using the 5V. The input that was provided was between 9V and 12V the Arduino board has an in-built regulator to achieve the constant voltage of +5V, irrespective of the changes in the input voltage, which varied

2.6 The Arduino Development Board and Software

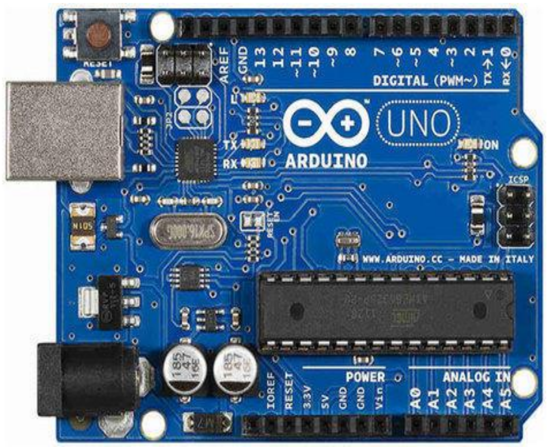


Figure 1 : Arduino UNO

The Arduino UNO is a widely used open-source microcontroller board based on the **ATmega328P** microcontroller and developed by **Arduino.cc**. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board features 14 Digital pins and 6 Analog pins. It is programmable with the **Arduino IDE** (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0.The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform The ATmega328 on the Arduino Uno comes preprogrammed with a **bootloader** that allows uploading new code to it without the use of an external hardware programmer.-It communicates using the original STK500 protocol.-The Arduino UNO is generally considered the most user-friendly and popular board,-with boards being sold worldwide for less than 5$.

2.6.1 Special Pin Functions

Each of the 14 digital pins and 6 Analog pins on the Uno can be used as an input or output, using **pinMode()**, **digitalWrite()**, and **digitalRead()** functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the **analogReference()** function.

2.6.2 Communication

The Arduino/Genuino Uno has a number of facilities for communicating with a computer, another Arduino/Genuino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .ino file is required. The Arduino Software (IDE) includes a serial monitor, which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows serial communication on any of the Uno's digital pins.

2.6.3 Technical Specifications

- Microcontroller: ATmega328P
- Operating Voltage: 5v
- Input Voltage: 7-20v
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by **bootloader**
- SRAM: 2 KB
- EEPROM: 1 KB

- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

2.7 Microcontroller Unit

A microcontroller is an Integrated Circuit chip that executes programs for controlling other devices or machines. It is a micro device (small size as it is an integrated Circuit chip) device, which is used for control of other devices and machines that is why it is called a Microcontroller. It is a Microprocessor having RAM, ROM and input or output ports (I/O ports).

2.7.1 How a Microcontroller Works

A Microcontroller is a very fast device and so every instruction in the microcontroller is executed at a very fast speed. It's functioning is given below;

When the power supply is turned ON, the quartz oscillator being enabled by Control Logic Register. In the first few milliseconds, while the first preparations are in progress, the parasite capacitors are being charged. When the voltage level reaches its maximum value and frequency of the quartz Oscillator becomes stable, the process of writing bits on special function registers (SFRs) started. Everything occurs according to the clock of the oscillator and over all electronics starts working. All this takes very few nano seconds. The PC or Program Counter is reset to zero address of the program memory. Then the address of the instructions is sent to Instruction Decoder, which decodes the instructions and thus executes them. After execution of one instruction, the address of the program counter is incremented by 1 and thus sending the address of the next instruction-to-instruction decoder and executes the next instructions.

This is the intelligent part of the system. It does the necessary logic, storage, processing of the input data to give destined output. The higher the frequency of operation, the more the power consumption of the Microcontroller. At 20 MHZ, the system consumes more power than at lower frequencies. This microcontroller is commonly used at 16MHZ and at an operating voltage of 5V.

2.7.2 The MCU Used Atmega328

ATmega328 is an eight (8) bit micro-controller. It can handle the data sized of up to eight (8) bits. It is an AVR based micro-controller. Its built-in internal memory is around 32KB. It operates ranging from 3.3V to 5V. It has an ability to store the data even when the electrical supply is removed from its biasing terminals. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, and real timer counter with separate oscillator. ATmega-328 is shown in the figure given below.

Figure 2 : ATmega 328

2.8 Crystal Oscillator

A crystal Oscillator is an electronic circuit or electronic device that is used to generate periodically oscillating electronic signal. The electronic signal produced by an oscillator is typically a sine wave or a square wave. An electronic oscillator converts the direct current signal into an alternating current signal. A Quartz crystal oscillator is used to generate electrical signal of a precise frequency by utilizing the vibrating crystal's mechanical resonance made of piezoelectric material.

2.8.1 Crystal Oscillator Circuit Diagram

The quartz crystal Oscillator circuit diagram can be represented as follows.

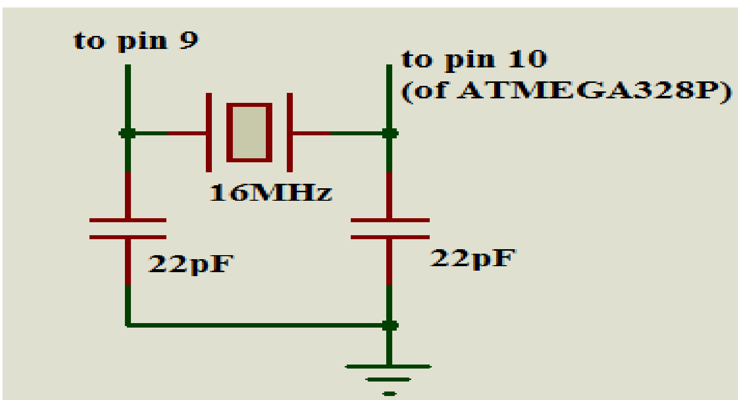


Figure 3: Proteus circuit diagram of a crystal oscillator

Figure 4: crystall oscillator

2.8.2 Crystal Oscillator Working

The atoms, molecules, ions are packed in an order in three spatial dimensions with repeating pattern to form a solid that can be called as a crystal. The crystal can be made by almost any object that is made of elastic material by using appropriate electrical transducers. As every object consists of natural resonant frequency of vibration, steel consists of high speed of sound and is very elastic. Thus, steel is frequently used instead of quartz in mechanical filters. This resonant frequency depends on different parameters such as size, elasticity, speed of sound, and shape of the crystal. In general, the shape of high frequency crystals is simple rectangular plate and the shape of low frequency crystals is tuning fork shape as shown in the figure below.

Crystal Oscillator circuit works on the principle of the inverse piezoelectric effect or mechanical deformation produced by applying an electric field across certain materials. Thus, it utilizes the vibrating crystal's mechanical resonance, which is made up of a Piezo electric material for generating an electrical signal of a specific frequency.

2.8.3 Liquid Crystal Display (LCD)

LCDs are used for characters while others are used for the graphics. However, the type of Liquid Crystal Displays that is being used for this project is the one that is used for characters; to be specific it is used for alphanumeric characters. For this project, the type of Liquid Crystal Display being used has been identified as JHD162A

2.8.4 Interfacing LCD with Arduino Uno

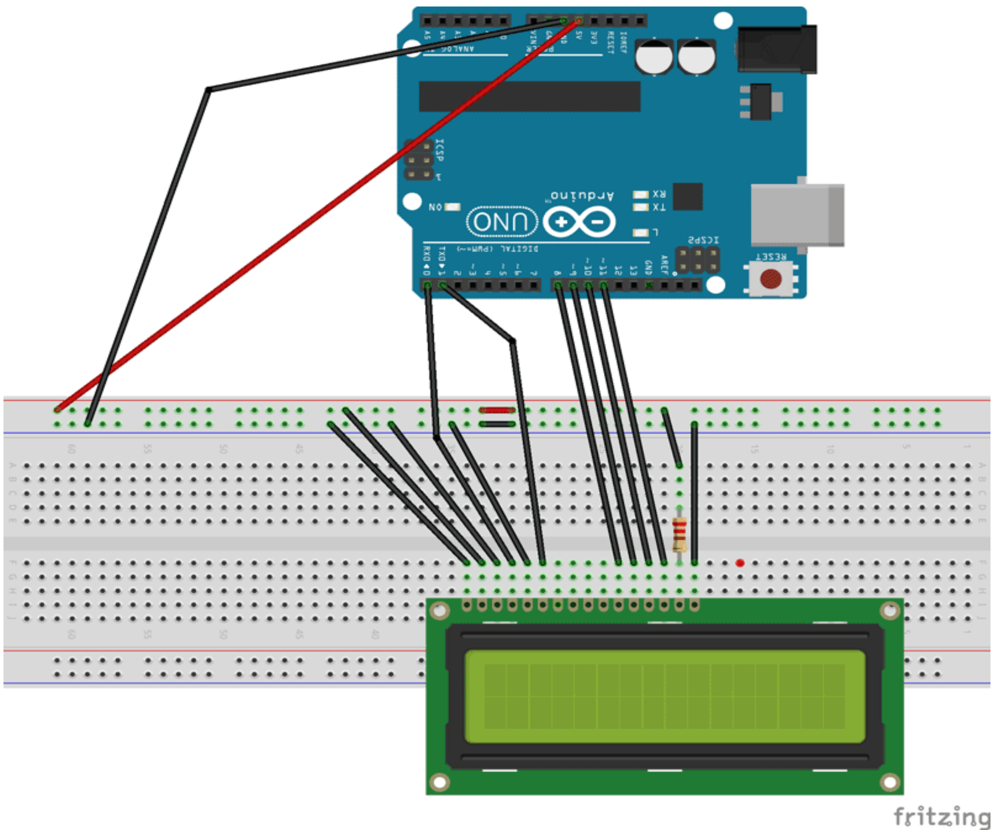


Figure 5: Arduino-LCD-Circuit

The above figure shows the circuit diagram of 16x2 LCD connected to ARDUINO UNO.

Source: https://circuitdigest.com/fullimage?i=circuitdiagram_mic/Arduino-LCD-Circuit.gif

1.1.1 Working

To interface a LCD to the ARDUINO UNO, we need to know a few things.

1. #include <LiquidCrystal.h>
2. lcd.begin(16, 2);
3. LiquidCrystal lcd(0, 1, 8, 9, 10, 11);
4. lcd.print("hello, world!");

As by the above table we only need to look at these four lines for establishing a communication between an ARDUINO and LCD.

First we need to enable the header file (‘#include <LiquidCrystal.h>’), this header file has instructions written in it, which enables the user to interface an LCD to UNO in 4 bit mode without any fuzz. With this header file we need not have to send data to LCD bit by bit, this will all be taken care of and we don’t have to write a program for sending data or a command to LCD bit by bit.

Second we need to tell the board which type of LCD we are using here. Since we have so many different types of LCD (like 20x4, 16x2, 16x1 etc.). Here we are going to interface a 16x2 LCD to the UNO so we get ‘lcd.begin(16, 2);’. For 16x1 we get ‘lcd.begin(16, 1);’.

In this instruction we are going to tell the board where we connected the pins. The pins which are connected need to be represented in order as “RS, En, D4, D5, D6, D7”. These pins are to be represented correctly. Since we have connected RS to PIN0 and so on as show in the circuit diagram, we represent the pin number to board as “LiquidCrystal lcd(0, 1, 8, 9, 10, 11);”. The data which needs to be displayed in LCD should be written as “ cd.print("hello, world!");”. With this command the LCD displays ‘hello, world!’.

As you can see we need not to worry about any thing else, we just have to initialize and the UNO will be ready to display data. We don’t have to write a program loop to send the data BYTE by BYTE here.

2.8.5 LCD Initialization

The steps that have to be followed for initializing the LCD display is given below and these steps are common for almost all applications.

Send 38(hexadecimal [h]) to the 8 bit data line for initialization.

Send OFh for making LCD ON, Cursor ON and Cursor blinking ON.

Send 06h for incrementing cursor position.

Send 01b for clearing the display and return the cursor.

Sending data to the LCD

The steps for sending data to the LCD module are given below.

Make R/W low [Because we only need to write.]

Make RS=0 if data byte is a command and make RS=1 if the data byte is a data to be displayed.

Place data byte on the data register.

Pulse E from high to low.

“Repeat above steps for sending another data.”

2.9 RF Wireless Transmitter & Receiver Module 433 MHz for Arduino

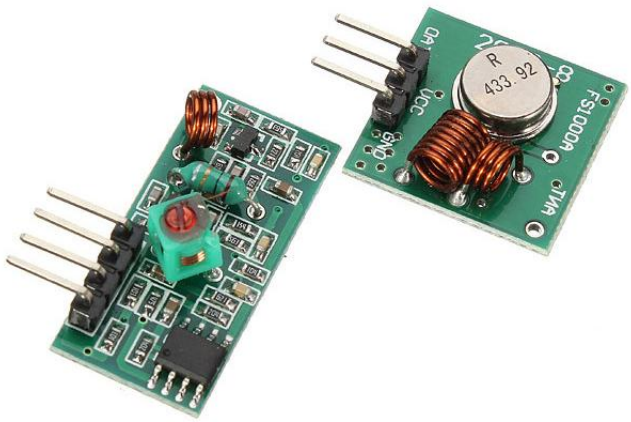


Figure 6: RF transmitter and Receiver

2.9.1 Specifications

2.9.1.1 Transmitter:

Working voltage: 3V - 12V for max.power use 12V

Working current: max Less than 40mA max , and min 9mA

Resonance mode: (SAW)

Modulation mode: ASK

Working frequency: 433MHz

Transmission power: 25mW (315MHz at 12V)

Frequency error: +150kHz (max)

Velocity: less than 10Kbps so this module will transmit up to 90m in open area.

2.9.1.2 Receiver:

Working voltage: 5.0VDC +0.5V

Working current: ≤5.5mA max

Working method: OOK/ASK

Working frequency: 315MHz-433.92MHz

Bandwidth: 2MHz Sensitivity: excel –100dBm (50Ω)

Transmitting velocity: <9.6Kbps (at 315MHz and -95dBm) the use of an optional antenna will increase the effectiveness of your wireless communication.

2.10 Buzzer Arduino Connection

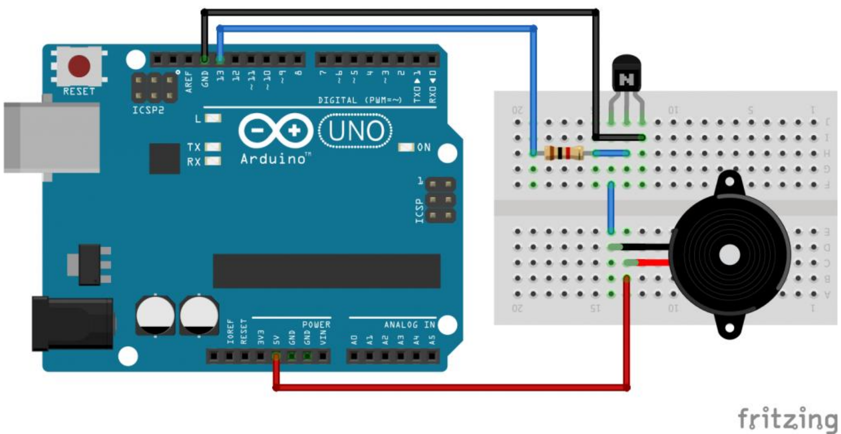


Figure 7: Buzzer integration with Arduino

We are connecting the buzzer to the VCC and collector of the transistor BC548. Here transistor works as a switch and by applying a high signal to its base triggers the buzzer to beep.

2.10.1 Buzzer Arduino Code

We simply need a high signal to the transistor base. For that, we use digitalWrite(13, HIGH). Once we are getting the signal high from the pin 13 piezo buzzer will produce sound beep till the signal is high. In addition, by applying the digitalWrite(13, LOW), the buzzer will be off. [4]

```
void setup() {          // the setup function runs once when you press reset or power the board

  pinMode(13, OUTPUT);    // initialize digital pin 13 as an output.

  digitalWrite(13, HIGH);  // turn the buzzer on (HIGH is the voltage level)
```

```
}
```

2.11 Resistors

A resistor is an electrical component that limits or regulates the flow of electrical current in an electronic circuit. Resistors can also be used to provide a specific voltage for an active device such as a transistor.

2.12 Variable Resistor

A variable resistor is a resistor whose resistance can be altered. Its maximum and minimum- (if any) resistances and the parameter that alters its resistance characterize it. Examples of variable resistors include Light Dependent Resistors, Potentiometers and many more. Some sensors are actually variable resistors. Resistors are used to control the amount of current through components like Light Emitting Diodes, Buzzers, Seven Segment Displays, and Motors among others.

2.13 Light Emitting Diodes (LEDs)

An LED is a diode that emits energy in form of light. A diode is an electronic component that permits current to flow in a certain direction and forbid flow in the reverse direction. An LED further emits light when it is conducting. The intensity of the produced light is proportional to the flowing current. Like shown above, the cathode pin is usually shorter than the anode pin. While inside the LED itself, the anode plate is actually too smaller than the cathode plate. The Like in the lower diagram, the cathode side is flattened. If a Pd is connected in such a direction where current should flow (cathode made less positive than anode), that is called forward biasing and the reverse is called reverse biasing. During forward biasing, a certain minimum voltage Vd depends a lot on the color and manufacturer of the diode but the following values are common. By convention, can only flow from the anode (positive end) to the cathode (ground or negative end). When the LED is on, there is a 1.9 voltage drop across it (The voltage drop varies with the type of LED). This means that if the positive leg is connected to the 5Volts, the negative leg will be at 3.1 volts. Current is what determines how bright an LED is. More current means more light. LED current should typically be around 10 to 20mA. When current flows through the LED, a forward voltage drop of about 1.6V will develop between its pins, depending on the current. Therefore, this resistor acts as a valve – reduce it to increase the LED brightness, or increase it to limit wasted power in the circuit. Consider an LED at maximum brightness. To achieve this, a typical LED current is required. Now we need to calculate the forward voltage drop across this diode with this current. Forward Voltage drop is not just a function of current, but also LED color and temperature (because of the different LED chemistries) as shown in the table below.

2.13.1 LED Color-Pd Definition

Table 2: LED Forward Voltages

LED color	Potential difference/V
Infrared	1.6 V
Red	1.8 V to 2.1
Orange	2.2 V
Yellow	2.4 V
Green	2.6 V
Blue	3.0 V to 3.5 V
White	3.0 V to 3.5 V
Ultraviolet	3.5 V

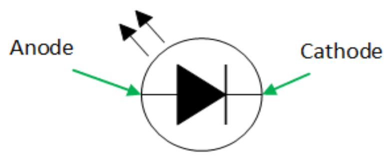


Figure 9: schematic symbol of a diode

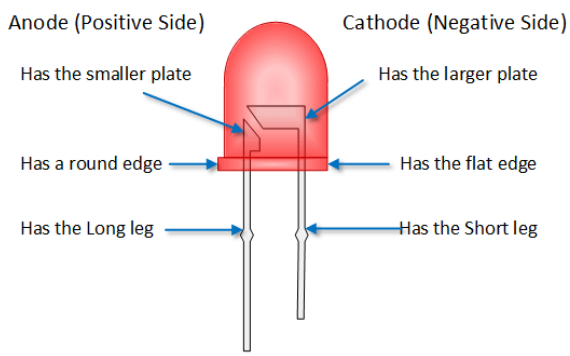


Figure 8: used for normal

Figure 10: parts of a diode

There are two great points of consideration. Recommended current (I) for clear visible light is

10mA to 20mA. Therefore, it is better to take the average that is 15mA. Vd depends on the colour of the LED and the manufacturer of the LED. Vcc of 5V regulator has been in this system. Using Ohm's law, the following equation applies:
(Voltage applied –Forward Voltage drop)/Forward current = Resistor value.

2.14 Capacitors

Figure 11: diagram of an electrolytic capacitor used

So the capacitor can store charge, electrostatically in an electric field" and it can release the charge when needed.

2.15 Connecting GSM Module to Arduino

The problem with this connection is that, while programming Arduino uses serial ports to load program from the Arduino IDE. If these pins are used in wiring, the program will not be loaded successfully to Arduino. Therefore, you have to disconnect wiring in Rx and Tx each time you burn the program to Arduino. Once the program is loaded successfully, you can reconnect these pins and have the system working

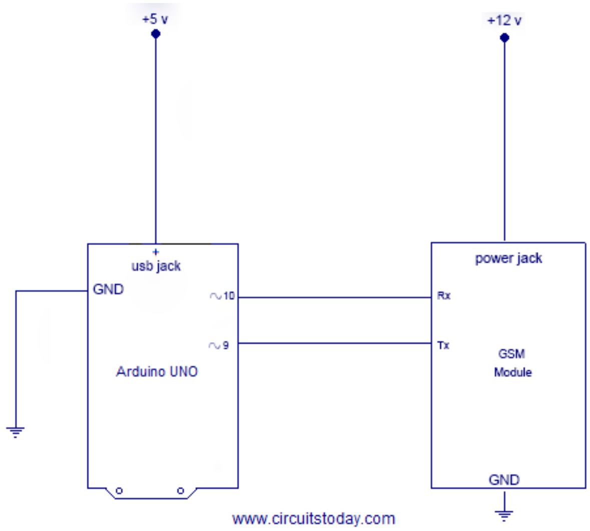


Figure 12: GSM Module integration with Arduino

Source/ Find code at http://www.circuitstoday.com/wp-content/uploads/2015/03/Interfacing-GSM-Module-and-Arduino.png

The basic functions **SendMessage() with commands** AT+CMGF=1 and AT+CMGS=\"+256xxxxxxxxxx\"\r and **RecieveMessage()with commands** AT+CNMI=2,2,0,0,0 and AT+CMGL=\"ALL\"\r **are used,**

2.16 The Arduino IDE basics:

The program (sketch) added to the microcontroller are written in an Integrated Development Environment (IDE) for Arduino. This IDE produces .ino Files and other files in fact it can also load the machine code from the hex file onto a microcontroller connected to the computer, the IDE converts embedded c to machine language which is the uploaded to the microcontroller.

CHAPTER THREE

3 RESEARCH DESIGN AND SYSTEM DESIGN

3.1 RESEARCH DESIGN

According to Creswell and Clark (2007, p. 33) "the combination of qualitative and quantitative data provides a more complete picture by noting trends and generalizations as well as in-depth knowledge of participants' perspectives."

The triangulation-validating-quantitative-data design was preferred whereby one form of data (qualitative) is used to validate the other form of data (quantitative).

In this study, Quantitative and qualitative data were collected concurrently from legitimate staff of Mulago hospital and kawempe hospital

3.2 Sample and Sampling Procedures

In experimental studies, the procedure of selecting a sample for investigation may be done using probability or non-probability sampling (Bryman, 2008). The choice of whether to use probability or non-probability sampling is based on the type of design chosen for the study, which can be qualitative, quantitative or mixed. This study used a mixed methods approach and the research focused on health facilities.

In a phenomenological study criterion-based sampling according to (Creswell, 1998), selected participants had to meet two major criteria namely; the experience of the phenomenon under study and the ability to articulate their live experiences.

3.3 Description of Data Collection Instruments

A questionnaire takes a quantitative approach to measuring perceptions and provides data upon which generalizations can be made on the views of a given population on a particular phenomenon.

The self-administered questionnaire was preferred in this study given that the targeted respondents are literates who can read, write, fill out the questionnaire appropriately without any assistance, and express themselves effectively.

3.3.1 Questionnaires for Mothers

A questionnaire for mothers was designed for this study to collect both quantitative and qualitative data. The questionnaire consisted of two sections labeled A to B. Section A of the questionnaire was capturing biographic data from the participants including their age, marital status, professional qualifications, and reason for choice of hospital.

Section B of the questionnaire consisted of items concerning the security, professionalism of Midwives, health around the hospital, kindness of nurses to them, how expensive is the medical fairs, The participants offered their responses on a five option scale including strongly agree, agree, uncertain, disagree and strongly disagree. “Refer to the appendix for Questionnaire”

3.3.2 Questionnaire for Midwives

A questionnaire for Midwives was designed for this study to collect quantitative and qualitative data to capture their professional ethics, in addition their perceptions on the effectiveness and health concerns of our system “refer to the attached appendix”

3.4 Validity of Instruments

Alden (2007) observes that the quality of an instrument refers to the degree to which the resulting score truly represents the factor to be measured. Alden further notes that the instruments must be tested for face validity, content validity and concurrent validity.

Content validity is concerned with the extent to which instruments measure what they were designed to measure and the extent to which they cover the variables.

3.5 Incremental Model for System Design/ Waterfall Model

The system was composed of three circuits, each of which was designed and built separately. This allowed partial utilization of product and avoid a long development time. The series of releases are known as increments, with each increment providing more functionality to the system. The model combines the elements of the waterfall model with the iterative philosophy of prototyping [4] [5]

3.6 SYSTEM ANALYSIS AND DESIGN

3.6.1 System Operation /Description

It is worth mentioning that in most hospitals in Uganda, the security mechanisms that are available for monitoring newly born babies especially Mulago hospital are Closed Circuit Televisions (CCTV) cameras. The system that has been designed and implemented is able to send messages or information about the baby‘s location or position to the mother or other people who might be in charge of security in the hospital premises and also it is able to alert the mother and other people around by triggering of an alarm through the buzzer and LEDs, the system consists of the display unit that is made up of the Liquid Crystal Display (LCD) that displays messages that are sent to the mother or any other person that is responsible for monitoring the baby. The mother circuit in turn sends an SMS, which is an error message to the caretaker's phone using GSM. The Microcontroller Unit that controls the activities of the different units within the systems on both the mother's side and the baby's side. The indicator unit consists of the light emitting diodes, and buzzer that are used to show the status of the system as it is being operated. The Radio frequency transmitter and receiver unit used to send and receive information about the position of the baby, the status of the battery whether it is on or off. On the child's side, the system consists of the Micro controller Unit that controls the operation of the other system units like the buzzer, indicator, transmitter and receiver unit by sending instructions to them depending on the position of the baby. The indicator consists of the light emitting diodes that show the status of the system when it is sending information about the baby, RED for danger, GREEN for Normal operation parameters. The buzzer is triggered when the **baby is very far from the mothe**r or when the **belt is removed** or the system is **powered off** (those are the parameters monitored).

The variables that were used during the design of the flowchart of the system were t**he location or distance of the baby from the mother, the power supplied to the child's end of the system**, **the belt found on the child's end of the system**. The location of the baby from the mother was used to ensure that the baby was always located within the **15m radius** Beyond the 15m radius the microcontroller would be able to trigger the buzzer so that it was able to alert the mother and at the same time send a message to the mother that the baby was very far from her. In addition, send a message on the GSM Network to the caretaker's phone, Removal of the battery powering the child's side of the system would trigger the system to send a message to the mother's side alerting her about the system being switched off by removing the battery. During the design phase of the system, parameter calculations were made in order to determine the different sizes of components and their current and voltage ratings that were to be used during the implementation of the system. The flow chart for the system consisted of different blocks that were used to illustrate the operation of the actual system that was to be constructed. The blocks of the flow chart included a block that operated in accordance to the location of the baby, a block that operated according to the presence of power at the baby's end of the system, while the last block of the flow chart checked the presence of the belt tied on the baby. The flow chart of the system was designed using software called Microsoft Visio, which is a Microsoft office package.

3.6.1.1 The system flow diagram

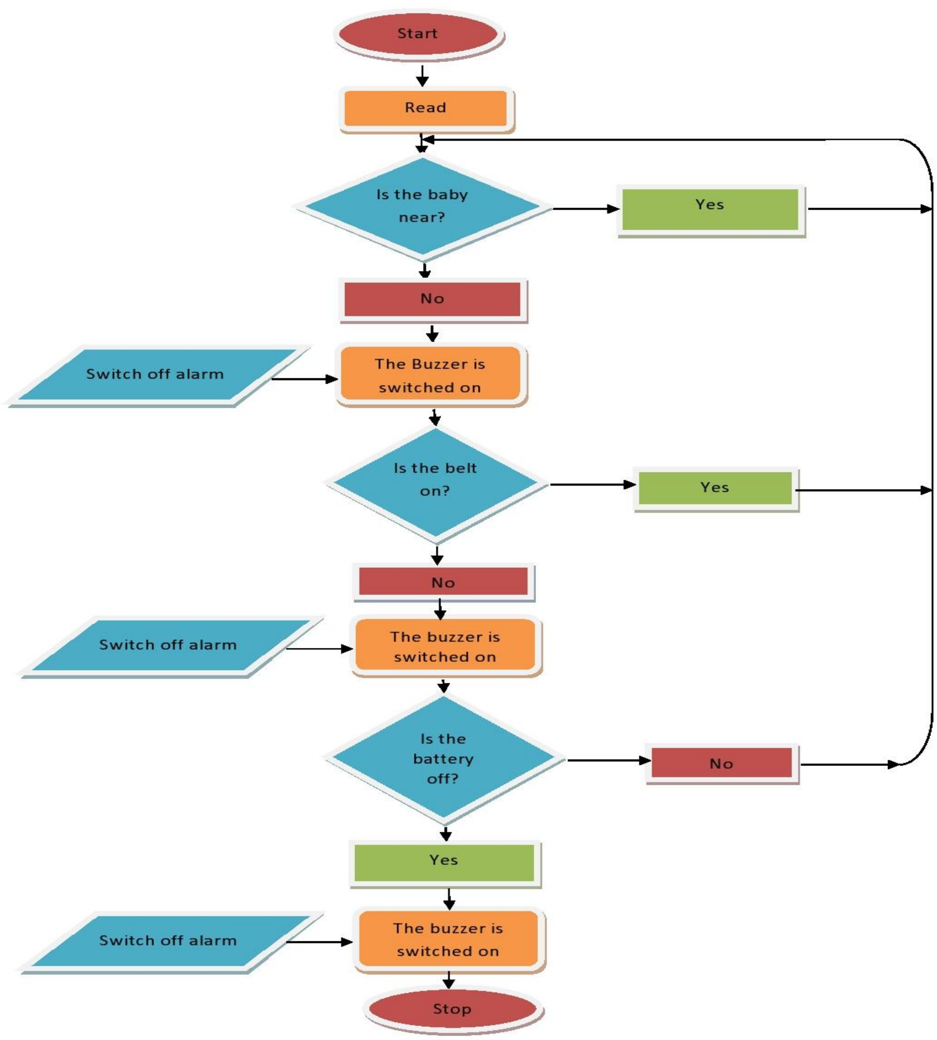


Figure 13: system flow diagram

During the design phase of the system, programming language was used help in the programming of the microcontroller unit is embedded C++.

Calculations of the resistance values and capacitance values necessary for the construction of the system were carried out using different formulae, which included

Potential divider rule given by

Equation 1: calculation of Vx

$Vx = \frac{Rak}{(Ra+Rb)k}\ x\ Vin$,

$Vx = \frac{18k}{(47+18)k} x\ Vin$ Where Vx is the required voltage a cross the 18k resistor, V_{in} is the supply voltage and $Vx$is 3.7v, and 3.2v for Vin of 12v and 9v, the zenner is a comparator, which ensures that for any supply the Arduino takes 5v, to avoid damage.

While the capacitance values were calculated using the formula

Equation 2: calculation of capacitance

$C = \frac{Q}{V}$ Where $C$the capacitance in μFarady, Q the charge of the Capacitor in coulombs, and finally V the voltage across the capacitor in volts.

$C = 4700\mu F$ Was used to store the charge for the circuit of the baby to enable it to send the error when power is off.

For the resistors, the resistance values of the system were calculated using the following formula

Equation 3: calculation of resistance

$R = \frac{V}{I}$ where $R$the resistance value in ohms, V is the voltage in volts across the resistor and I is the current. Suitable resistors have been chosen to achieve the expected V_x and as external pull down for grounding the different components.

In this phase of design, the circuit diagram of the system was also designed using the proteus software. This involved analysing the behaviour and performance of different components that were to be used in the construction of the system. The outcome of each circuit designed was observed and the parameters like the voltages, current rating and voltage ratings of the components were taken into consideration. The design of the circuit was first carried out on the baby's end of the system where the different components required were analysed and their behaviour was recorded. These included the transmitter system, capacitors, resistors and the diodes. The final circuit for the baby's side of the system was designed and tested using the proteus software until it was found to give out the required results which were, being able to send messages to the mother about the location of the baby, it was also able to report the shortage of power at the baby's side of the system to the mother's side of the system. The second design of the circuit was carried out on the mother's end of the system. This involved analysing the components required for the implementation of the system, which were among others the Receiver system, capacitors, transistors and the diodes. The frequency at which the receiver system would operate were tested during the circuit design using the proteus software and it was found out that the best frequency for the operation of the system was 16MHZ. Therefore, this frequency was used for the system. The distance of operation of the system was analysed, calculated, and finally tested in the proteus software to ensure that it was the correct distance at which the system would be able to function as required.

3.6.1.2 Equations used during the transmitter distance calculations

During the calculations of the transmitting distance, the transmitting power, the following equations were used. For calculating the transmitting distance,

Equation 4: field strength

$E = \frac{\sqrt{30pt}}{d}$ where E is the field strength in V/m and Pt is the total transmitter power. When the radio transmitter sensitivity was known, the equation was transposed to

Equation 5: range/ effective radius

$d = \frac{\sqrt{30pt}}{E}$ where d is the distance of transmission or the distance between the baby and the mother, E is the field strength and Pt is the transmitter power

Equation 6: transmitter power

Pt = VIcosØ where V is the voltage of the transmitter, I is the current through the transmitter and Ø is the phase angle of the current.

The problem involved in the measurement of high frequency RF Voltages or currents was that at high frequencies, the values obtained during the measurements were inaccurate and they were only estimates an therefore a given range of values was used during the design and construction of the system.

3.6.1.3 System Block Diagram:

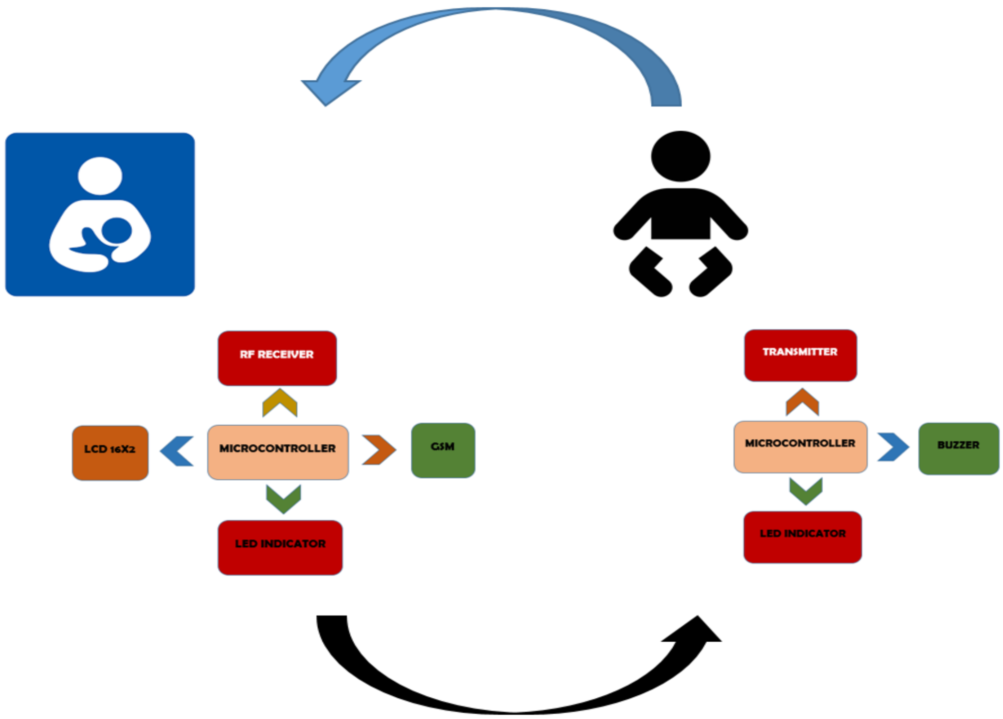


Figure 14: system block diagram

3.6.1.4 Detailed baby's side circuit Design

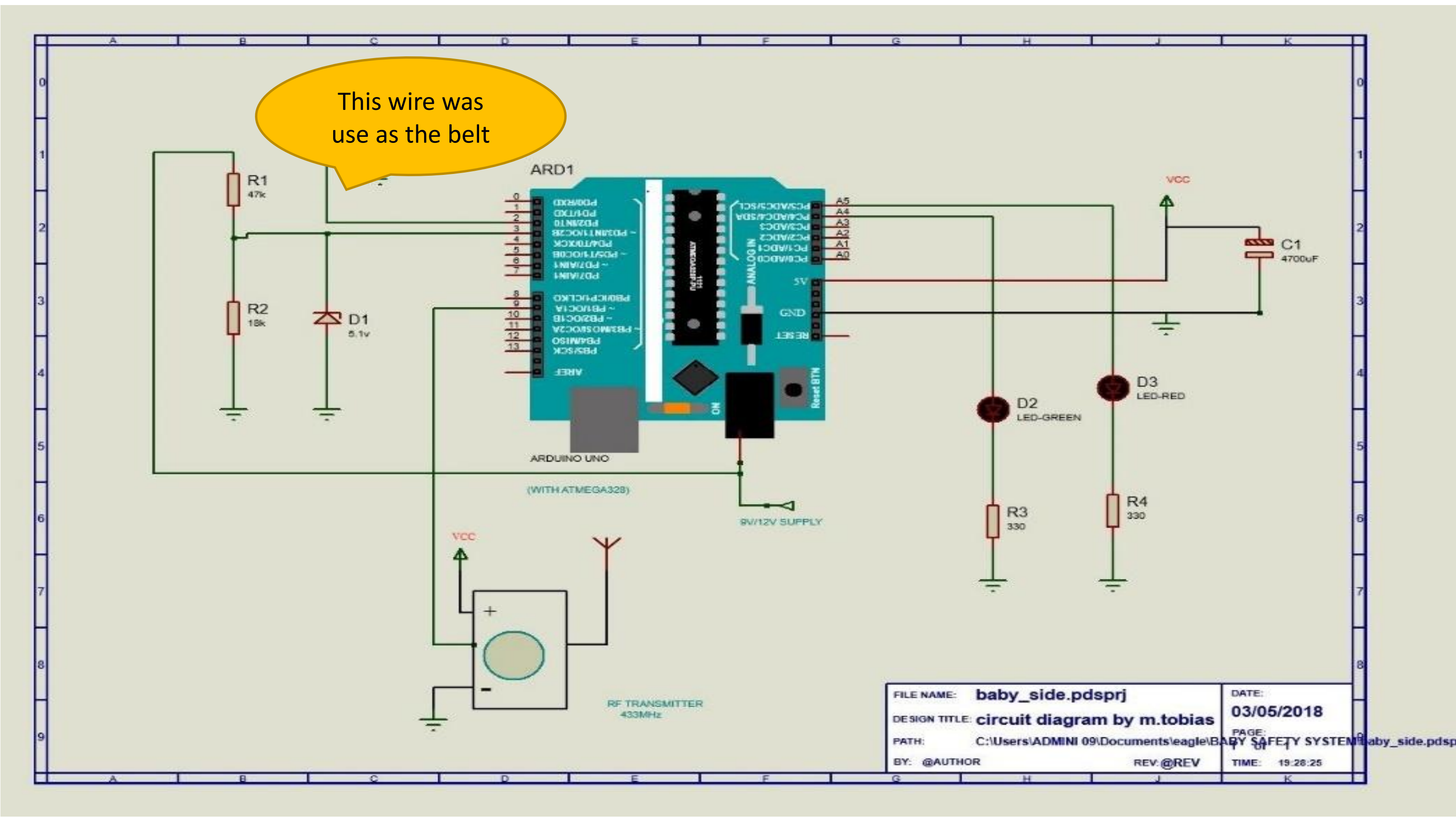


Figure 15: circuit diagram of the baby's side in normal operation

Once the system was powered, the system unit on the child's side was constantly and regularly sending information to the system unit found on the mother's side using RF modules. The system was able to send information about the position of the baby. If the baby was located near the mother, the system will be able to send a message to the system unit at the mother's side. In case the mother's side does not receive any message in the set period of 3 seconds, it confirms that the baby is not seen or it will indicate that the baby is very far. The child's system was able to report when the belt was untied from the baby; it also was able to report when the battery was removed to the mother. The system on the mother's side was also able to indicate the range at which the baby was located. For the sake of implementation of this project, the microcontroller unit of the system was programmed so that it was only able to allow the baby to be within the range of 15m radius. Beyond the 15m radius, the microcontroller would trigger the alarm to alert the mother about the disappearance of the baby. When the baby was within the 15m radius, the system was able to report that the baby was within this radius and the alarm was not triggered. However, beyond the 15m radius, the alarm was triggered and the sound of the alarm increased with an increase in the distance from the mother. The system used to alert the mother about the disappearance of the baby was audio.

When the baby was within the 15m radius, there was no alarm since it was within the required range. However, when the baby was moved beyond the 15m radius the system triggered an alarm and it can be seen that the alarm becomes louder beyond the 15m radius.

Although the system was only working at the 15m radius, it should be noted that the distance of operation could be adjusted as required in case the system was to be deployed for commercial purposes in various hospitals. If the distance from the mother to child was increased, it means the range of operation of the system would also be increased to ensure that the system operated properly in the range.

The alarm notification did not only occur when the baby was moved beyond the 15m radius but it also occurred when the power was switched off or when the belt was removed from the child. However, the most fundamental reason for the alarm was to alert the mother about the baby being out of range from her or vary far away from her so that something could be done to rescue the baby before it became impossible for it to be traced by the authorities.

The graph shows the variation of the distance of the baby from the mother and the increase in the alarm.

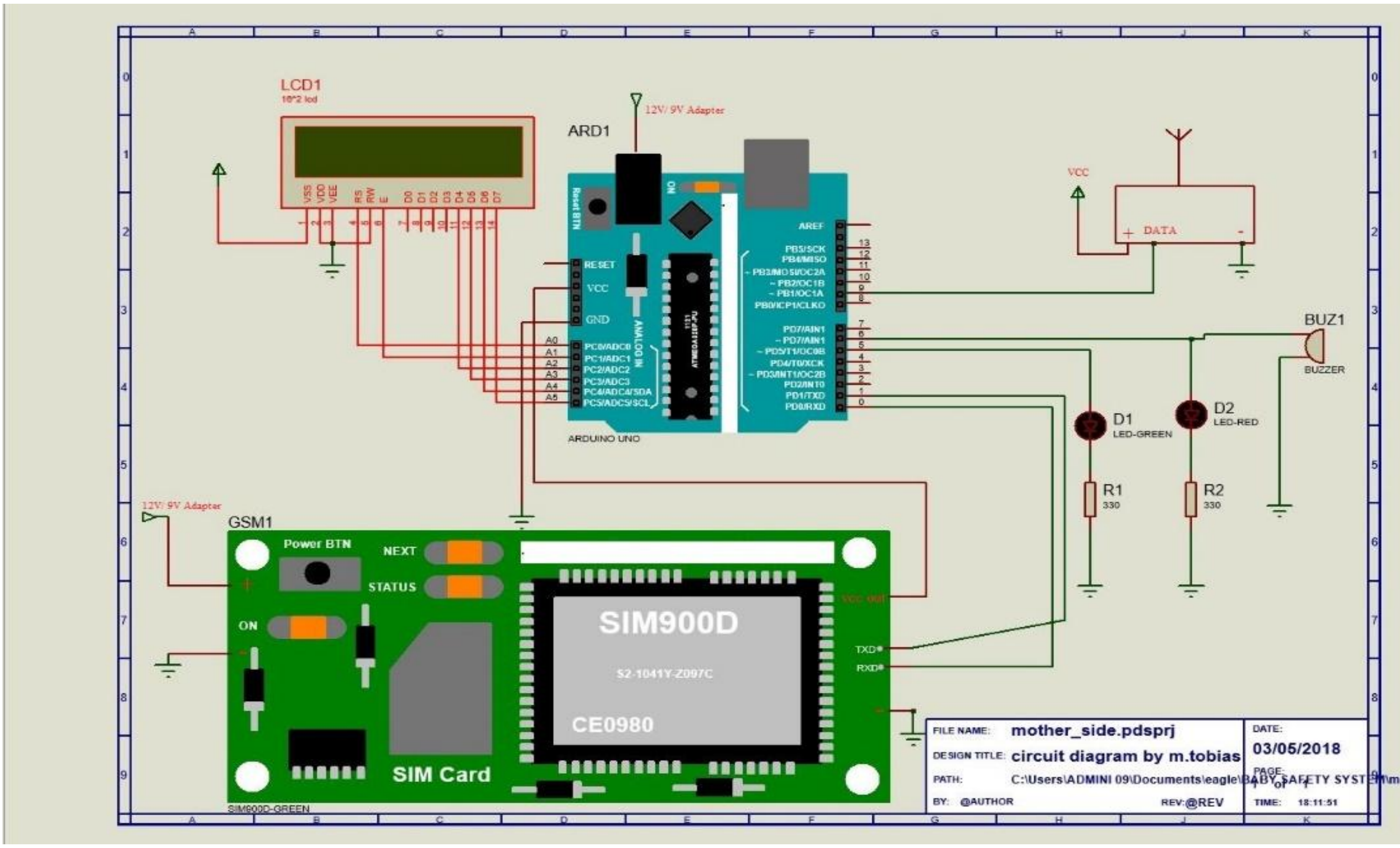


Figure 16: circuit diagram of the mothers' side in normal operation

The system on the mother's side was designed to be able to report information about the location of the baby so that the mother is well informed about the baby's location. The system that was constructed was able to display information about the availability of power source, which was a 9V battery.

The system was also able to inform the mother whether the baby was within the 15m radius or not. The system was also able to show if the belt was removed from the baby or not. The system was able to display all these messages on to the LCD screen. Depending on the location of the baby and whatever was happening on the baby's side, the system was able to report the required information about the availability of power, location of the baby and whether the belt was removed or not.

When the baby was within the 15m radius, the system on the baby's side was able to send information about the location of the baby within that radius. Here is how the information was displayed when the baby was within the 15m radius. The LCD displayed that the baby was within the 15m radius to the mother.

3.6.1.6 GSM circuit diagrams

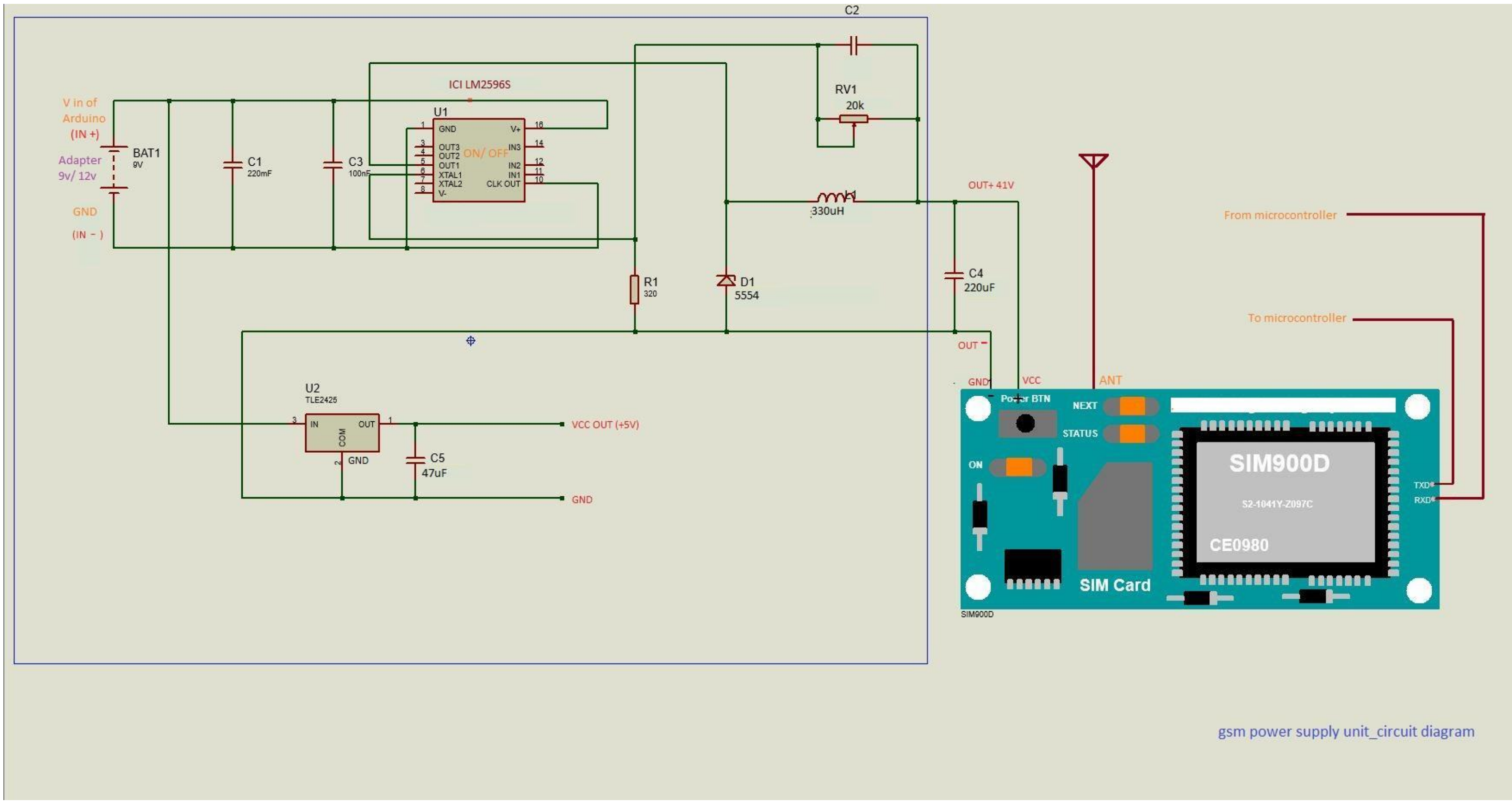


Figure 17: GSM regulator circuit diagram

3.6.2 Assumptions That Were Taken Into Consideration

The following assumptions were taken into consideration during the design of the system.

i) **System operating range**: It was assumed that the mother was located within the 15m radius and therefore the system was designed to ensure that it only functioned within that range.

ii) **System stability**: The system was assumed independent of interferences from the outside, which could be interferences from other electronic transmitting devices.

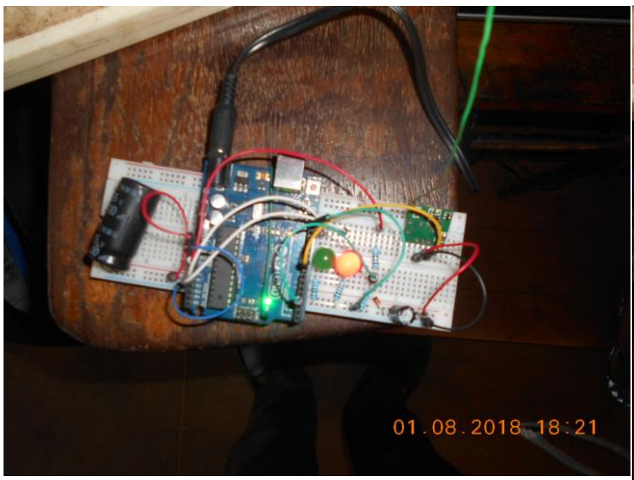
iii) **System safety:** It was also assumed that there was no **radiation effects of the system on the child** on whom the system was being attached and **the nearby biomedical machines** in the hospitals.

CHAPTER FOUR

4 RESULTS OF IMPLEMENTATION, TESTING AND VALIDATION

4.1 Introduction

The contents of this chapter are the results of implementation, testing and validation of the system of choice that the researcher decided to come up with and in this case



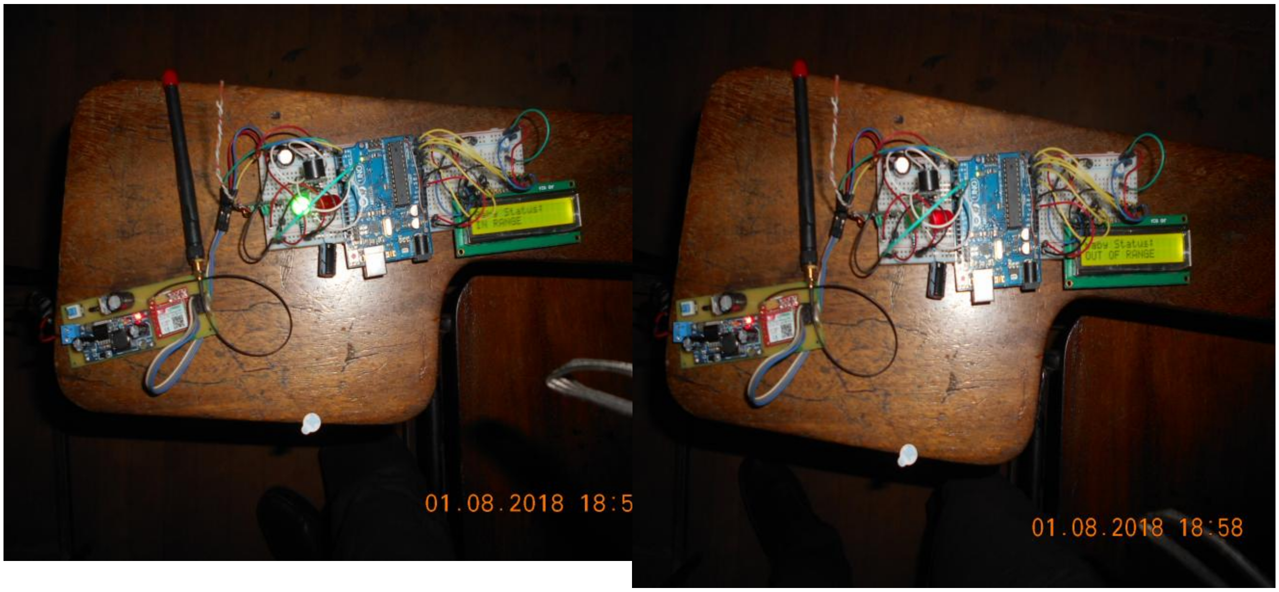


Figure 18: System setup Displays

Figure 19: LCD error messages

Figure 20: GSM error messages displayed

4.2 Project Schedule

The following Gantt chart was used as a timeline reference for the development process of the system expected towards the end of the project tasks.

Table 3: Gantt chart for the schedule

	2017/2018												
	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug
RA													
Proposal writing													
SD													
TSS													
I &ST													
Report Writing													
Presentation													

Table 4: key to the schedule

RA	Requirement Analysis
SD	Subsystems Design
TSS	Testing of Subsystem
I &ST	Integration and System Testing

4.3 Expenditure

The following table shows how money was utilized during the process of carrying out the project. Although the values here appear to be high, it is because the items were purchased in quite small quantities and it is worth noting that if many of such systems were to be constructed, the overall cost of each of the system would be much less than the multiple. [6]

Table 5: Implementation Costs

Quantity	Name	Specification/ Part Number	Unit Price	Amount
2	Microcontrollers	ATMEGA128	12,000/=	24,000/=
2	Development boards	Arduino UNO	60,000/=	120,000/=
10	Colour LED	BLB-1.5V	1,000/= @3	4,000/=
1	Arduino Connector Pack		15,000/=	15,000/=
2	LCD	JHD162A	20,000/=	40,000/=
2	Crystal oscillator	16MHz	3,000/=	6,000/=
2	Temperature Sensor	LM35	5,000/=	10,000/=
1	DC Adapter	12V DC	25,000/=	25,000/=
2	Voltage Regulator	LM7805	1,000/=	2,000/=
2	Circuit Boards	Bread-Board	13,000/=	26,000/=
2	Prototyping boards		3,000/=	6,000/=
2	RF Sender & Receiver		25,000/=	50,000/=
2	RF Transceiver		40,000/=	80,000/=
2	buzzer		1,000/=	2,000/=
2	RFID Module		24,000/=	48,000/=
		Assorted items		100,000/=
		Estimated total cost		600,000/=

CHAPTER FIVE

5 CONCLUSIONS, CHALLENGES &RECOMMENDATIONS

This chapter is the presentation of the conclusion basing on SO and EST analysis, challenges Faced during the project development and recommendations. SO stands for Strength, Opportunities, while EST represents Economic, Sociological and Technological.

5.1 Conclusion

Babies are one of the most vulnerable patients in a hospital. Ensuring infant security is Critical to not only the reputation of the hospital, but also to the peace of mind of everyone there, from nursing staff to new moms. The most effective infant protection solution should provide accurate newborn location information along with 24/7 abduction attempt alerts The best step a healthcare facility can take for newborns and their families is integrating a state-of-the-art baby tracking system. [1]

5.2 Challenges and Limitations

Data collection was hectic due to lack of enough and relevant text books in the libraries.
Accessing the relevant authorities in the medical sector in the time of collecting data and information was a difficult problem.
Design of the circuit and simulation was very difficult and we had to use trial versions, of proteus, which had many limitations in its functionality.

5.2.1 Strength

The project process made me more equitable with practical knowledge and skills in the areas of system development, and wireless technologies.

5.2.2 Opportunities

I had the opportunity to achieve something tangible developed by the group members and myself, this made me proud of myself, and increased my esteem and team spirit.

5.2.3 Economical

I was able to utilize the available limited time and resources in order to come up with positive results having all qualities, we had hoped to use GSM 900, but it was expensive and we opted for

GSM 800, which did the work, not to the expected limit

5.2.4 Sociological

Skills of teamwork and planning are universally desired since they increase the efficiency of any project in terms of time and money. Furthermore, during the project development I grew my leadership skills. More to that, I learnt teamwork, working as a group or part of a group.

5.2.5 Technological

I was exposed to different modern wireless technologies as well as new advances while in the Industry of monitoring and security systems like RFID Tags, and GSM.

5.3 Recommendations

Like it has been stated before, the current developed prototype is not a deployable system, I therefore recommend that the University, companies and other interested parties join me and support in the further development of the system to be deployed

The hospitals and other medical practitioners should improve the security of babies in hospitals by carrying out more research on the safety and comfort of babies.

All hospital employees like doctors and the nurses should be vetted before being employed in order to know their behaviours and whether they have any criminal backgrounds. This will help to minimize the theft of babies in the hospitals.

More security personnel should be provided at the medical facilities in order to minimize the problem of theft of babies within hospitals.

To a technical point, it could be made in such a way, when contact between the transmitter and receiver in the room and hallway is lost, all exit doors are slammed shut and the elevators are disabled, leaving the only way to take a newborn out of the maternity ward to be the windows, and so the maternity ward should be about 50 feet off the ground on the third floor. [7]

REFERENCES

[1] CenTrak, "https://www.centrak.com/newbaby-infant-protection/," [Online].

[2] IWA, [Online]. Available: http://iwauganda.org/. [Accessed Friday August 2018 (EAT)].

[3] rfiddiscovery, "Baby safety and security with active RFID system," rfiddiscovery, [Online]. Available: https://rfiddiscovery.com/rfid-discovery-solutions/baby-tagging/. [Accessed August 2018].

[4] "SDLC - Waterfall Model," tutorialspoint, [Online]. Available: https://www.tutorialspoint.com/sdlc/sdlc_waterfall_model.htm. [Accessed Friday January 2017].

[5] "Waterfall model," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Waterfall_model. [Accessed Saturday JAnuary 2017].

[6] "component pricing," Innovex, [Online]. Available: http://www.innovex.org/. [Accessed Friday Febuary 2017].

[7] [Online]. Available: https://www.geek.com/news/hi-tech-baby-tracking-at-hospitals-543807/. [Accessed Friday March 2017].

[10] "Liquid-crystal display," Monday March 2017. [Online]. Available: https://en.wikipedia.org/wiki/Liquid-crystal_display.

[11] "Arduino UNO," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Arduino#_blank. [Accessed Tuesday May 2017].

APPENDICES

RESISTOR CODE SHEET A1

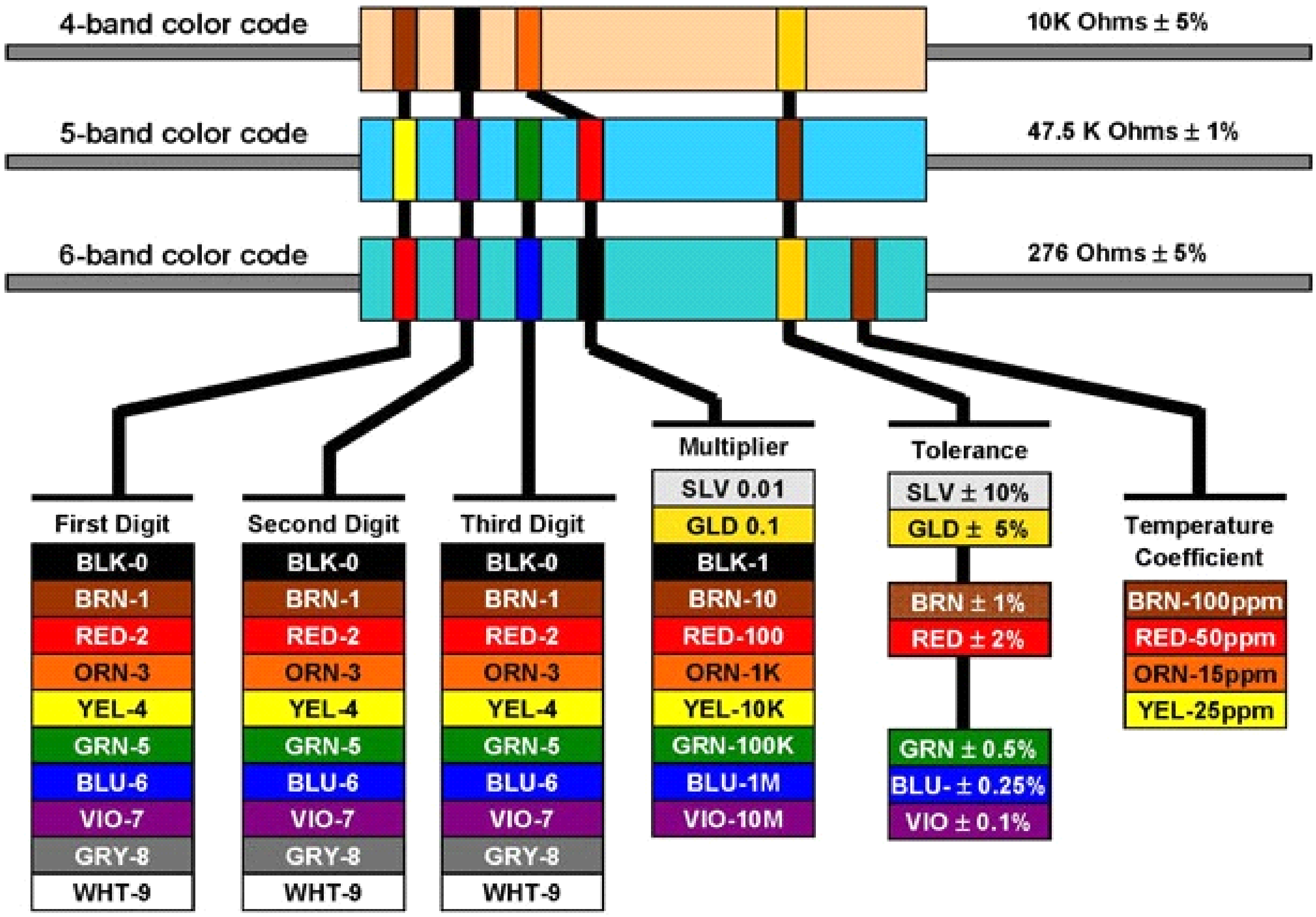


Figure 21: Resistor Code Sheet

ATMEGA 328 PIN SHEET A2

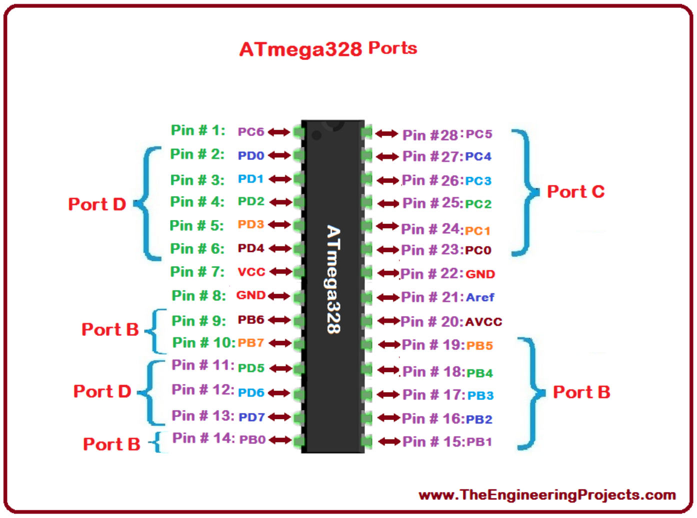


Figure 22: ATmega 328 Pin Sheet

Source, https://www.theengineeringprojects.com/2017/08/introduction-to-atmega328.html

VCC is a digital voltage supply.

AVCC is a supply voltage pin for analog to digital converter.

GND denotes Ground and it has a 0V.

Port A consists of the pins from PA0 to PA7. These pins serve as analog input to analog to digital converters. If analog to digital converter is not used, port acts as an eight (8) bit bidirectional input/output port.

Port B consists of the pins from PB0 to PB7. This port is an 8-bit bidirectional port having an internal pull-up resistor.

Port C consists of the pins from PC0 to PC7. The output buffers of port C has symmetrical drive characteristics with source capability as well high sink.

Port D consists of the pins from PD0 to PD7. It is also an 8-bit input/output port having an internal pull-up resistor.

Rest: The first pin up is used for Reset (RST). It is active low. When the voltage on this pin is low then the microcontroller is restarted. This pin should be kept with a high voltage. A 10-kilo ohm resistor is recommended to connect this pin to Vcc to give a high constant voltage. The 10-kilo ohm resistor is connected to control the current entering the microcontroller from Vcc. A push button may or may not be added to the pin to link it to the ground such that restarting is achieved by pressing this button.

QUESTIONNAIRE A3

Questionnaire:

1. What is your name? (respondent)

Dr. Mugoya Sam

2. We require your full job tittle at Mulago National Referral Hospital Labour Ward-12, duration at the hospital?

Gynacologist

15 years, Mulago Hospital

3. We require your email address to send you our project, details, and phone number?

mugoya@gmail.com
Tel. 0714421823

[Qn. 2 and 3 can be postponed to come last]

4. How many babies are born in Mulago National Referral Hospital Labour Ward-12 on a daily basis, for the past week?

On average 200 babies are born.

5. What security is provided to the newly born babies after birth against impersonators, thieves, who may want to swap babies, steal the babies or those who connive with some nurses to swap babies?

We use physical security which include: Putting Name tags on the new born babies, Registering them in our books, Plus security guard at check points.

6. How many babies have been stolen per year in the past two years to present?

On average two (2) per year.

Figure 23: Questionnaire

7. How many have been recovered?

We have recovered quite a number but the statistic can be got from the police, where the cases are always reported.

Figure 24: Questionnaire pg2

CODE FOR THE MOTHER'S SIDE:

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(A0, A1, A2, A3, A4, A5);
#include <VirtualWire.h>
String error_msg = "";
const int RCVD_INDICATOR = 5;
const int BUZZER = 6;
const int FAULTY = 2, IN_RANGE = 1, OFF_RANGE = 0;
int last_state = -1;


void initVW(byte pin, long rate)
{
 // Initialise the IO and ISR
  vw_set_ptt_inverted(true); // Required for DR3100
  vw_setup(rate);   // Bits per sec
  vw_set_rx_pin(pin);
  vw_rx_start();       // Start the receiver PLL running
}
String readVW()
{
 String ret = "";
 uint8_t buf[VW_MAX_MESSAGE_LEN];
  uint8_t buflen = VW_MAX_MESSAGE_LEN;
  if (vw_get_message(buf, &buflen)) // Non-blocking
  {
    for (int i = 0; i < buflen; i++)
     {
```

```
        ret = ret + (char)buf[i] ;//lcd.print((char)buf[i]);
      }
  }
  while( vw_get_message(buf, &buflen) ){} //read remaining bytes
  ret.trim();
  if( ret.startsWith("BABY ") ){  ret = ret.substring(5, ret.length() ); }
  else{ ret=""; }
  return ret;
}

void ignoreResponse()
{
  while(!Serial.available()){} delay(1000);
  while(Serial.available()){Serial.read();}
}
boolean initModem()
{
  Serial.begin(19200); delay(500);
  Serial.println("AT"); delay(500);
  String tt=""; while(Serial.available()){ tt = tt + (char)Serial.read(); }
  if( !(tt.indexOf("OK")>-1) ){ initModem(); }
  else
  {
    delay(3000);
    Serial.println("AT+IPR=19200");  delay(500);
    Serial.println("AT+CSMP=17,167,0,16\r");
    ignoreResponse();
  }
}

void send_sms()
```

```
{

  //send tpo second number
    Serial.println("\r");delay(500);
    while(Serial.available()){ Serial.read();}
    Serial.println("AT+CMGF=1\r"); delay(500);
    Serial.println("AT+CMGS=\"+256753215106\"\r");
    delay(500);
    Serial.print(error_msg);
    delay(500); Serial.println("\r"); delay(500);
    Serial.write(26); ignoreResponse();
}

void setup()
{
   lcd.begin(16, 2);
   lcd.print("BABY SAFETY");
   pinMode(RCVD_INDICATOR,OUTPUT);
   digitalWrite(RCVD_INDICATOR, LOW);
   pinMode(BUZZER,OUTPUT);
   digitalWrite(BUZZER, LOW);
   delay(1000);
   initVW(9, 4000);
   delay(1000);

  lcd.clear(); lcd.print("Network Search");
  initModem(); //wait for _gsm to power up
  lcd.clear(); lcd.print("System ON");
}
int get_state()
{
```

```
  error_msg = "";
  long startT = millis();
  while(  (millis()-startT)<1500 )//check for 3 sec
  {
    String val = readVW();
    if(val!="")
    {
      digitalWrite(RCVD_INDICATOR, HIGH);
      delay(50);
      digitalWrite(RCVD_INDICATOR, LOW);

      if(val.startsWith("NEAR") || val.startsWith("FAR") ){
        return IN_RANGE;
      }
      else if(val.startsWith("BELT") || val.startsWith("POWER") ){
       error_msg = val;
       return FAULTY;
     }
    }
  }
  return OFF_RANGE;
}
void loop()
{
   int state = get_state();
   if(last_state!=state){
    lcd.clear(); lcd.print("Baby Status:");
    lcd.setCursor(0,1);
    if(state==FAULTY)
    {
       digitalWrite(BUZZER, HIGH);
```

```
      lcd.print(error_msg);
      send_sms();
    }
    else if(state==IN_RANGE)
    {
      digitalWrite(BUZZER, LOW);
      error_msg = "IN RANGE";
      lcd.print(error_msg);
      send_sms();
    }
    else if(state==OFF_RANGE){
      digitalWrite(BUZZER, HIGH);
      error_msg = "OUT OF RANGE";
      lcd.print(error_msg);
      send_sms();
    }
  }
  delay(1000);
  last_state=state;
}
```

CODE FOR THE BABY'S SIDE:

```
//simple Tx on pin D12
#include <VirtualWire.h>
//char *controller;
const int BELT = 2; //whether belt is still connected
const int PWR = 3;//whether system is still powered
const int RED = A1;//red led AND buzzer, IN CATASTROPHE
const int GREEN = A0;//GREED LED on ehen state os OK
const int PWR12 = 10;//Pin that enables high power transmission

void initVWrireTx(byte pin, long rate)
{
vw_set_ptt_inverted(true); //
vw_set_tx_pin(pin);//pin where transmitter is connected
vw_setup(rate);// speed of data transfer Kbps
}
void sendVW(char *txt)
{
vw_send((uint8_t *)txt, strlen(txt));
vw_wait_tx(); // Wait until the whole message is gone

}
void myDelay(long tym)
{
tym /= 10;
while(tym--)
{
delay(10);
if((digitalRead(BELT)==HIGH )&&(digitalRead(PWR)==LOW ))
{
sendVW("BABY BELT&PWR OFF");
```

```
}
else if(digitalRead(BELT)==HIGH ){ sendVW("BABY BELT OFF");  }
else if(digitalRead(PWR)==LOW ){ sendVW("BABY POWER OFF"); }
if((digitalRead(BELT)==HIGH )||(digitalRead(PWR)==LOW ))
{
digitalWrite(RED, HIGH);
digitalWrite(GREEN, LOW);
}
else
{
digitalWrite(RED, LOW);
digitalWrite(GREEN, HIGH);
}
}
}
void setup()
{
pinMode(BELT, INPUT_PULLUP);
pinMode(PWR, INPUT);
pinMode(RED, OUTPUT);
pinMode(GREEN, OUTPUT);
pinMode(PWR12, OUTPUT);
digitalWrite(PWR12, LOW);
digitalWrite(RED, HIGH);
delay(200);
digitalWrite(GREEN, HIGH);
delay(200);
digitalWrite(RED, LOW);
initVWrireTx(9, 4000);
}
```

```
void loop()
{
//digitalWrite(PWR12, LOW);
myDelay(1000);
sendVW("BABY NEAR");
//digitalWrite(PWR12, HIGH);
//myDelay(500);
//sendVW("BABY FAR");

}
```