iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** XII **Month of publication:** December 2017

DOI:

Design of a Low Frequency RFID Reader

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Abstract: The objective of the present paper is to design and develop a low frequency (125 KHz) RFID Reader. The design requirements are imposed by the RFID specifications and the carrier wave for the transmission must have a frequency of 125 KHz in order to operate free band frequency. The data should be coded using a Manchester coding around the target frequency. The antenna that communicates using an inductive magnetic field. The received signal is connected to microcontroller which is decoded and then the data is sent to computer via serial communicator. In general, the low-frequency RFID Reader is used for applications such as animal tagging, vehicle parking, toll gates and vehicle identification, etc. because low frequency has a low radiation affect that gives less harm to the environment.
Keywords: low frequency RFID, Manchester coding, magnetic field, Antenna and radiation.

I. INTRODUCTION

RFID is a technology that uses electromagnetic waves in the radio frequency range to transmit the ID of objects, and can be thought of as a smart barcode system. It has not become popular until recently due to technological advancement in integrated circuits and radios that it's been feasible, mostly because of the size and cost going down considerably. This has made it useful on a large scale with enhanced interest from the industry and government has made the widespread popularity for it [1].
Radio frequency identification (RFID) is a wireless automatic object detection and data capture technology and it was used in the Second World War in Britain to recognize friendly aircraft. After a long time of invention, this technology is used in business and productive environments. The huge number of possible applications and the decreasing costs of Tags, this technology will certainly become global in the near future.

II. DESIGN STEPS

The design and development of low frequency (125 KHz) RFID Reader block diagram is shown in figure 1. The system mainly consists with the following units. They are

A. Oscillator (CD4060)
B. Modulator & amplifier
C. Antenna
D. Demodulator & amplifier
E. Atmega328p
F. USB to Serial converter (FT232R)
G. Personal computer

The detailed explanation for each individual unit is presented in the following sections.

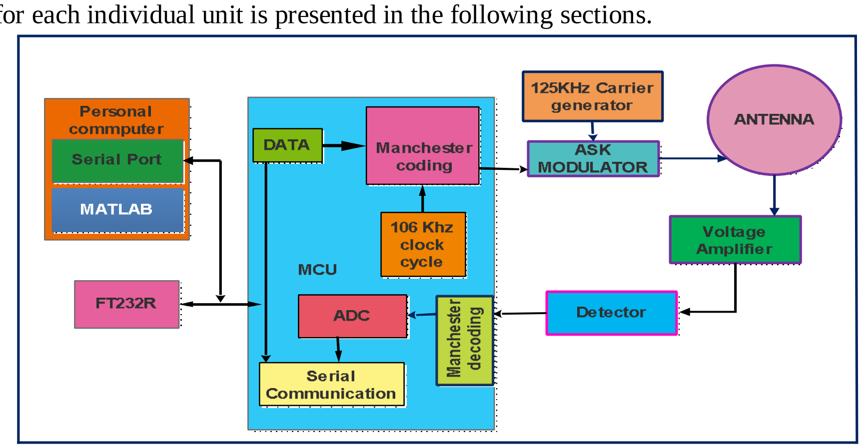

Figure 1: Block diagram of LF (125 KHz) RFID Reader.

H. Oscillator circuit (CD4060)

To generate the 125 KHz carrier frequency for the present work as per the RFID specifications. The IC CD4060 can be easily configured as an accurate timer, oscillator, flasher, clock generator, or sequential timer. The IC CD4060 consisting inbuilt oscillator stage helps to keep the component count around the IC to the minimum while designing frequency generators or oscillators. The internal oscillator stage is made operational simply through a network of resistors and a capacitor connected to the pins 8, 9, and 10. The IC pins of 10, 11 and 12 are the active inputs, pin 10 and 11 are connected with resistors. The resistor R1 at pin 11 can be considered as some sort of clamping or reference resistor whose value must be ideally 10 times more than the resistor connected to pin 10. Pin 12 is the reset input of the IC, which must be connected to the ground for enabling the IC to function. An 8 MHz crystal is connected to the 74HC4060 IC with the pins of 10 and 11. At the pin 4, the 8MHz clock is divided by 64 and the required output of 125 KHz is generated at the 4th pin as a square wave form.

In the present work encoding is a transition from low to high in encoded signal signifies a high signal in the original data and a transition from high to low in the Manchester signal signifies a low signal in the original data. However, one should only look at the transitions that occur on the falling edge of the transmission rate clock to determine the data for that clock period since according to the convention, the transitions occurring on the rising edge of the clock carry no meaning. The reason for Manchester encoding is to aid in the clock recovery process for the receiver, which is one of the primary strengths of the encoding scheme [2].

I. Modulator and Amplifier

The RFID are in general digitally modulated. In the present work a simple transistor is used for Amplitude shift keying (ASK). ASK modulation is used in the implanted part for its simplicity and low power consumption. In the present design, R5 is 22 KΩ and R6 is 12KΩ provided biasing for the transistor 2N2907 (Q1) which is acting as a switch as shown in figure 2[3].

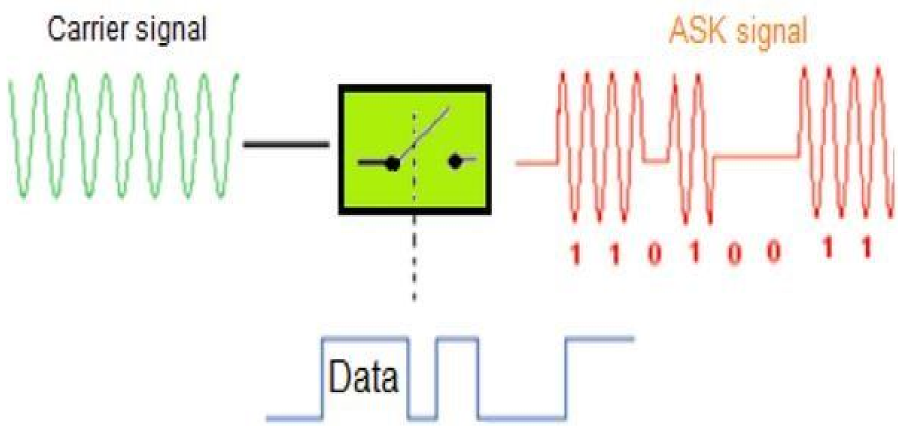

Figure 2: Switching action of ASK modulator

A digitally modulated signal is a stream of distinct symbols. A simple example with substantial relevance for RFID is ASK. The signal power is kept large (m = 1) to indicate a binary '1' and small or zero (m = 0) to represent a binary '0'. An example is shown in Figure 3. In ASK, each symbol is a period of fixed duration in which the signal power is either high or low.

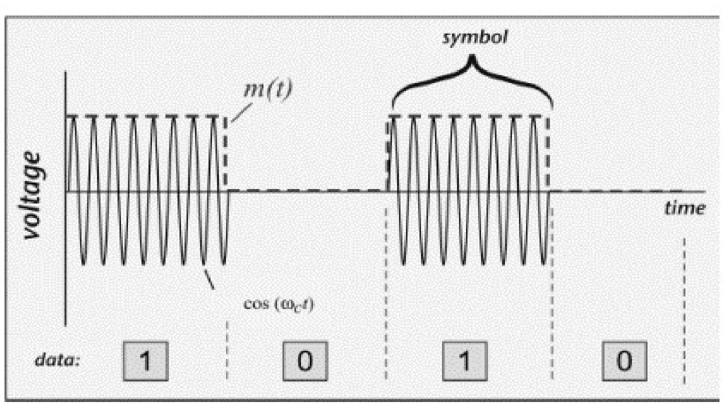

Figure 3: ASK Modulated signal

J. Antenna

The basic design of the antennas was subjected to various implementations. The RFID specifications were limited to use of small loop antennas. The size, shape and core of the antennas were dimensions that were allowed to specify ourselves, the L and C define the band pass center frequency. In the original implementation of the present design, the values of L and C was tuned to more or less exactly 125 kHz. The equation 1 is used to tune the 125 kHz frequency, wheref is the fundamental frequency is 125 KHz, L is inductance and C is capacitance (in Farads). To get this 125 KHz frequency 1nF ceramic capacitor and an inductance of 1.62milli Henry is calibrated.

In order to design antenna the coil that has selected a 24 gauge copper wire having 120 mm diameter with 58 turns, leave more copper wire for an additional 2-3 turns. [4]. A high Q-factor indicates that the antenna has a very narrow in frequency, which is highly selective. This is good in order to reject interfering signals so that exact signal is detected by the antenna.

K. Demodulator and amplifier

The first step is demodulating the backscattering signal obtained from the antenna, and the second step is detecting the frequency (or period) of the demodulated signal. The demodulation is accomplished by detecting the envelope of the carrier signal. The demodulator is simply removing the carrier frequency of 125 kHz which can be done by using the diode detector method. A half-wave capacitor-filtered rectifier circuit is used in the demodulation process. A diode detects the peak voltage of the backscattering signal and the voltage is then fed into an RC charging/discharging circuit. The RC time constant must be small enough to allow the voltage across C to fall fast enough to keep in step with the envelope. However, the time constant must not be so small as to introduce excessive ripple. The demodulated signal must then pass through a filter. [5].

The demodulated signal is then passed through a filter and signal shaping circuit before it is fed to the microcontroller. The half point of our supply voltage is grounded, a 5V single supply the half point is +2.5V. The circuit needs the output impedance of this supply low, so an OP-AMP to buffer the +2.5V point which is high impedance due to R5 and R6, and we get a low impedance output. The output of this reference voltage is given to the buffer amplifier which amplifies the signal so the controller can identify the receving signal.

The input signal to this op-amp is over the THRESHOLD it will output 5V if the input signal is below, it will output 0V. The RF amplitude signal has now been demodulated by the envelope detector, filtered and amplified through two stages of operational amplifiers, and at the end digitized using the saturation properties of op-amps. The last voltage divider has been added to reduce the voltage down to a level that is safe for the Atmega microcontroller. The next in this series will be in decoding the actual digital signal using an Atmel ATmega328p MCU.

L. Atmega 328p Microcontroller

In order to decode the demodulated signal, is then coded clock needs to be recovered. The code running on the MCU convert the ADC value after the conversion completes and determines whether it corresponds to the low end of a pulse or the high end of a pulse. The code then assigns the ADC value of either a binary ‘1’ or a binary ‘0’, effectively digitizing the signal. The threshold between a high and a low signal is determined by finding the halfway point between the max and the min of the ADC values. The max value is initialized to be the lowest possible voltage, and the minimum value is initialized to be the highest possible voltage. They are updated whenever a higher max or a lower min is found. The threshold is updated whenever a new max or min ADC value is found. This is a sophisticated solution to deal with indeterminate floating voltages of the ADC [6]. The code then takes the digitized ADC input and encodes it using Manchester encoding, following the IEEE 802.3 convention. The Manchester decoded signal is the digitized data signal XOR’d with a digital clock running on the MCU via timer 0 running at the target transmission frequency of 106 kHz. Which is chosen to the lowest possible data transmission rate, of 106kBd, for the rate because of pulse rate data is transmitting does not gain any accuracy given a higher transmission rate. This decoded output is then translated onto Port B. The Mega328P reads the voltage value and sends to the decoder on ADC0 which is set to PINB.0 and converts it to a digital value. The 8 most significant bits in the ADCH register are then printed out to the serial port at 9600 baud after each ADC conversion. Interrupt driven the serial communication which implemented a delay of 20ms between each ADC conversion, so send this data to serial port with data in MATLAB. The data is sent from MATLAB which is Manchester encoded to the controller pinB.1.

M. USB to Serial converter(FT232R)

The FT232R is used to convert USB to serial interfacing integrated circuit, which requires an integration of few external components which are sufficient. Ft232r has TX and Rx pins and these pins are connected to RX and TX pins of the microcontroller. The drivers activated corresponding port number is selected in the personal computer.

N. Personal Computer

The Atmega328p serial port to USB of the personal computer by using Ft232R is done. The device software as well as application software is developed successfully and the results are displayed on the display unit with graphical user interface (GUI) with MATLAB [7]. The display panel consists of a start button. When we press this button reader is activated and if the Tag is in the field corresponding UID number is placed as a label under UID. The STOP button is for deactivating the reader, CLOSE button is to close the entire GUI. To read/write data into the Tag, separate panels are placed. By using these panels we can read data if data already exist in the Tag or we can write data to place in the Tag. The software is implemented in MATLAB with a baud rate of 115200.

III. RESULTS AND DISCUSSION

The RFID Reader circuit is powered up a continuous carrier wave is emitted by an oscillator which will be radiated by the antenna by means of electromagnetic waves. If any Tag is present in the field of RFID Reader/Writer, corresponding identification is sent via inductive coupling as a signal (UID) received by the reader. This signal is demodulated and is further decoded by means of the Manchester encoded value retrieved by this method. This data is given in ADC ranges from 0-255 and data is calculated by counting how many times the peaks in the vector are greater than a threshold voltage of 2.5. Here we take the vector value as 10 which divide by the data and multiplied by the calibrated constant, the resultant value is the identification number displayed on MATLAB GUI under the tagline UID.

The signal which is radiated by the antenna is identified by the Tag and the corresponding data is sent to the RFID reader. Reader antenna reads the values which are coming from the Tag, these values are given to the diode detector to retrieve the data. This data is sent to the amplifier and then decoder, the decoded value is then is given to the internal ADC of Atmega1284p. This data is converted into pulse width modulation and then high-level conversion in the controller program. This converted data is sent to a serial port of the controller to the personal computer via FT232R of USB to Serial converter.

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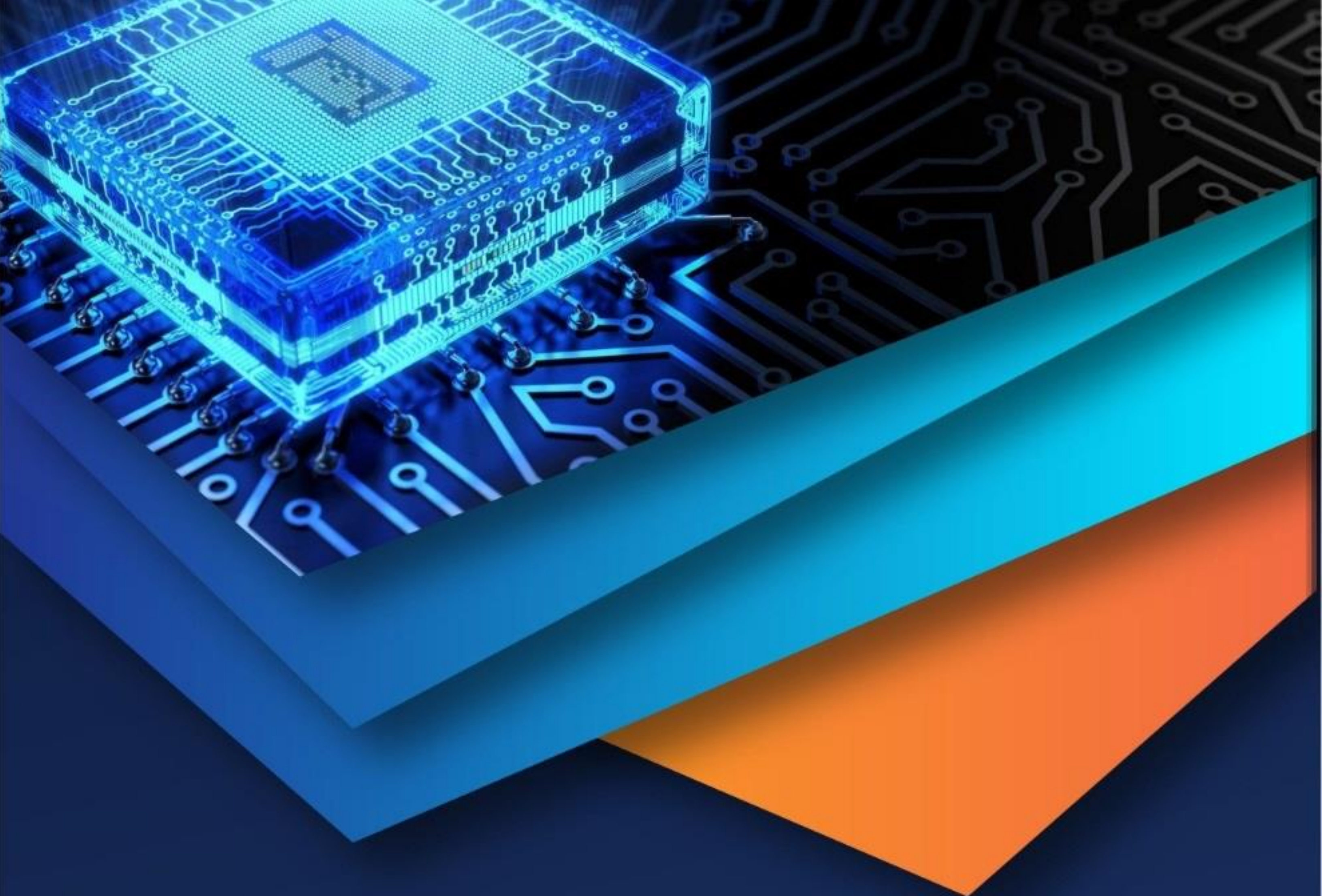

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