Design and Implementation of Microcontroller-Based R-F Remote Controlled safe with Digital Code Lock and Indicator

BY

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Abstract

The paper work presents a brief history and evolution of key locks, as well as the various key types and key locks. Also, the basic concepts of telecommunications and modern digital systems are elucidated. The system architecture of a microcontroller-based radio frequency remote controlled lock and indicator is showcased with the attendant description of the operational details. The paper further describes the system implementation. Finally, tests were performed in stages and the results obtained were then used to conclude that an elegant Microcontroller-Based Code Lock System has been achieved.

Keywords**:** Microcontroller, Radio-Frequency, Key-locks, Digital systems, Code Lock.

Introduction

In this present age of digital technology, the concept of a digital revolution carries the ramifications of paradigm shift from traditional to new ways of doing thing in real-time this has given rise to revolutionary trends that has orchestrated industrialization in the world today, and consequently improved the socio-economic, political and technological base of many countries and the world in general. Also, the recent technological advancement in management information systems and sharing of information across nations and amongst the international community has also reshaped our society to a great extent, this has no doubt been made possible by the efforts of various technologies advancements in micro-electronics, devices, machines and micro-controller-based systems with most at times computer interface which has yielded an information technology society where a successful and dynamic relationship between engineering and societal needs meet.

After the industrial revolution, the world directed towards the information age with the development of computers during the 1950's. This was followed by the invention of Integrated Circuits (ICs) in the 1980's which led the electronics world to the peak by its compact size, weight, and cost with an attendant increased quality and reliability in real-time as well as the launching of communication satellite in 1962. The world converted into a global village such that we are not only able to use the products of engineering, but also have been challenged to study about existing technologies with a view to creating our own idea with a view to solving contemporary problems.

This work is aimed at considering the possibility of designing a Microcontroller-Based gate opener with Digital Code Lock through a Radio Frequency (RF) Remote Controller which can enhance Security in homes, offices, etc. This of course is an indispensable concept in industrial electronics. More so, The value of security to man is applicable to the facilities used by him. Most gates in industrial settings are fortified with automation. This microcontroller based project for safeguarding a house or office focuses on the use of RF remote to control the entrance and exit from a gate with an embedded personalized code lock.

Brief Historical backgrounds of Locks

Security is the concern of people around the world. Beyond hiding object or constantly guarding them, the most frequently used option is to secure them with a device.

Locks are the most widely employed security devices. They are found on anything to which access must be controlled, such as vehicles, storage containers, doors, gates and windows. The security of any property or facility relies heavily on locking devices. Locks merely deter or delay entry and should be supplemented with other protection devices when a proper balance of physical security is needed. And assessment of all hardware including door frames and jams, should be included in any physical security survey. Locking devices vary greatly in appearance as well as function and application, as written in a book by Sandra Kay Miller (1996).

In 1778, English man Robert Barron patented a completely new kind of lock, the lever tumbler lock, which originally only uses two tumblers along with traditional wards – obstructions for key bit. The idea of building tumblers into the lock itself was completely revolutionary, and represented the first "modern" door lock. The Barron lock was manufactured completely by hand and was pricey for its day. Part of Barron lock was soon copied and was used and developed by competitors in his country.

Jeremiah Chubb of Portsmouth, England, invented a detected lock, a type of lever tumbler that instantly stopped working if the wrong key was used. Only the original key or a special regular key would activate the lock again. Chubb invented the lock in 1818 in response to a government – sponsored context to develop an unpick able lock. The Chubb lock had a spring –loaded bolt which was held in closed position by four oblong perforated brass lever tumblers. The tumblers were placed one on top of the other and locked on one end with a dowel. The other end of the tumblers was lifted by the bit of the key, which was shaped like a sort of stair case, each step corresponding to one of the levers.

In 1824, Charles patented an improved version that didn't need a regulator key to reset the lock. The original lock had four lever tumblers,

Another locksmith, American Alfred Charles Hobbs, invented the protector lock. Hobbs became famous as the first man to be able to pick the Chubb detector lock at the 1851world fair in London (The Great Exhibition), but in 1947 Charles and his son john increased the number to six. They later invented another device that made it impossible for a lock – picker to detect the additional tumbler. In 1984 Chubb and Sons Lock & safe Co Ltd became a part of the Racal Electronic group, making the Chubb lock group one of the largest in its field in the world. Another company, Williams Holdings, brought Chubb Security in 1997; but sold it on to in 2000 after poor sales figure.

In his book on locks, Allen Palms (1999) stated that, in the 15th to 16th century, sacristies were added on Swedish church on the north side of the building outside the sanctuary. They were built with sturdy stone walls and arched stone or brick ceilings, and the windows are protected by sturdy iron bars. Between the sanctuary and the sacristy was a heavy wooden door with wrought- iron hinges. It often had iron fittings or iron stripes riveted on. The door was locked with a wooden block lock, a smith tumbler lock, or in the 18th century, with a large rot iron rim lock.

A time lock is a part of a locking mechanism commonly found in bank vault and other high- security container. The lock is a timer designed to prevent the opening of the safe or vault until it reaches zero, even if the correct combination(s) are known. Most safes or vaults utilize at least two independent clock mechanism as a fail –safe system to guarantee the unlocking of the safe peradventure one of the timers (called movement) fails. Only one needs to reach zero in order for the safe to be opened. Time locks can typically be set from 15minutes to 144hours (6days).

Time locks were originally created to prevent criminals from kidnapping and torturing the person(s) who knows the combination, and the using the extracted information to later burgle the safe of vault.

There is also the time delay combination lock which will open at anytime with the correct combination, but will not actually unlock until a set delay period elapses, usually less than one hour. Modern time locks are electronic but otherwise serve the same function as the old mechanical wind- up time lock, however, when the battery dies, the time lock unlocks.

Materials and Methods.

This electronic system is designed with an 89C51 of the 8051 microcontroller family. An electromagnetic relay driven by a transistor static switch is interfaced to the microcontroller. Also four light emitting diodes (LEDs), red, yellow, green and blue serve as a form of indicators (LED indicator) when the remote is in use, presence of an RF signal, when the gate is open and closed respectively and an interfaced soft coding key pad.

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by be signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and retransmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

The system components were all assembled and placed together in modules. They were tested individually and then placed on a bread board. The system was tested, and when proved to be working, they were replaced on a Vero board. The components were soldered on the Vero board using soldering lead and soldering iron. After the entire system had been tested it was packaged in a casing for better presentation.

A type of relay that can handle the high power required to directly drive an electric motor is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called protective relays.

When electromagnetic radiation interacts with single atoms and molecules, its behavior also depends on the amount of energy per quantum (photon) it comes.

Basic Theory; Electromagnetic Spectrum

The electromagnetic spectrum is the range of all possible frequencies of the electromagnetic radiation. The electromagnetic spectrum of an object is the characteristic distribution of electromagnetic radiation emitted or absorbed by that particular object. The electromagnetic spectrum extends from low frequencies used for modern radio to gamma radiation at the short wave-length end, covering wavelengths from thousands of kilometers down to a fraction of the size of an atom. The long wavelength limit is the size of the universe itself, while it is thought that the short wavelength limit is in the vicinity of the Planck length, In principle the spectrum is infinite and continuous.

Electromagnetic waves are typically described by any of the following three physical properties: the frequency f, wavelengthλ, or photon energy E. The frequencies range from 24×10^{23} Hz (1 GeV gamma rays) down to the local plasma frequency of the ionized interstellar medium (-1 kHz). Wavelength is inversely proportional to the wave frequency, so gamma rays have very short wavelengths that are fractions of the size of atoms, whereas wavelengths can be as long as the universe. Photon energy is directly proportional to the wave frequency, so gamma rays have the highest energy and radio waves have very low energy.

These relations are illustrated by the following equations:

$f = c/\lambda$, or $f = E/h$, or $E = hc/\lambda$……………………………(1)

Where: c = 299.792,458 m/s is the speed of light in vacuum and

$h = 6.62606896(33) \times 10^{-34}\ J\text{s} = 4.13566733(10) \times 10^{-15}$ eV is Planck's constant.

Generally, electromagnetic radiation is classified by wavelength into radio wave, microwave, infrared, the visible region we perceive as light, ultraviolet. X- Rays and

Radio frequency (RF) , is a rate of oscillation in the range of about 30 kHz to 300 GHz, which corresponds o the frequency of electrical signals normally used to produce and detect radio waves. RF usually refers to electrical rather than mechanical oscillations, although mechanical oscillations do exist.

The communication is done through a resonator, a circuit with a capacitor and an inductor forming a tuned circuit. The resonator amplifies the oscillations within a particular frequency band, while reducing oscillations at other frequencies outside the band. The conductor or the capacitor of the tuned circuit is adjustable allowing the user to change the frequencies at which it resonates. The resonant frequency of a tuned circuit is given by the formula

$f_0 = 1/2\pi\sqrt{LC}$ ………………………………….(2)

Where f_0 is the frequency in Hertz, L is inductance in henries, and C is capacitance in farads.

Special Properties of RF Electrical Signals

An electrical current that oscillates at RF has unique characteristics, one of such property is the ability to ionize air thus, creating a conductive path through it. This property is exploited by 'high frequency' units used in electric arc wielding, although strictly speaking, these machines do not typically employ frequencies within the HF band. Another special property is that RF current cannot penetrate deeply into electrical conductors but flows along the surface of conductors; this is known as the skin effect. Another property is the ability to appear to flow through paths that contain insulating materials, like the dielectric insulator of a conductor. The degree of effects of these properties depends on the frequency of the signals.

Bands

The band is a small section of the spectrum of radio communication frequencies, in which channels are usually used or set aside for the same purpose. Above 300 GHz, the absorption of electromagnetic radiation by earth's atmosphere is so great that the atmosphere is effectively opaque, until it becomes transparent again in the infrared and optical window frequency ranges.

To prevent interfaces and allow for efficient use of the radio spectrum, similar services are allocated in bands. Each of these bands has a basic band-plan which dictates how it is to be used and shared, to avoid interfaces and to set protocol for the compatibility of transmitters and receiver.

Bands are divided at wavelengths of 10^{th} meters, or frequencies of 3×10^{11} hertz**.**

Table 1. Radio Frequency Bands.

BAND NAME	ITU BAND	FREQUENCY AND WAVELENGTH IN AIR
Sub-hertz	0	<3 Hz > 10,000km
Extremely low frequencies	1	3 - 30 HZ 100,000 km – 10,000 km
Super low frequency	2	30 - 300 Hz 10,000 km – 1000 km
Ultra low frequency	3	300 - 3000 Hz 1000 km – 100 km
Very low frequency	4	3 - 30 kHz 1000 km – 100 km
Low frequency	5	30 - 300 kHz 10 km – 1 km
Medium frequency	6	300 – 3000 kHz 1 km – 100 m
High frequency	7	3 - 30 MHz 10m – 1m
Very high frequency	8	30 - 300 MHz 10m – 1m
Ultra high frequency	9	300 – 3000 MHz 100mm – 10mm
Super high frequency	10	3 – 30 GHz 100mm – 10mm
Extremely high frequency	11	30 – 300 GHz 10mm – 1mm
Terahertz	12	300 – 3000 GHz 1mm - 100µm

SYSTEMS SCHEMANTIC BLOCK DIAGRAM

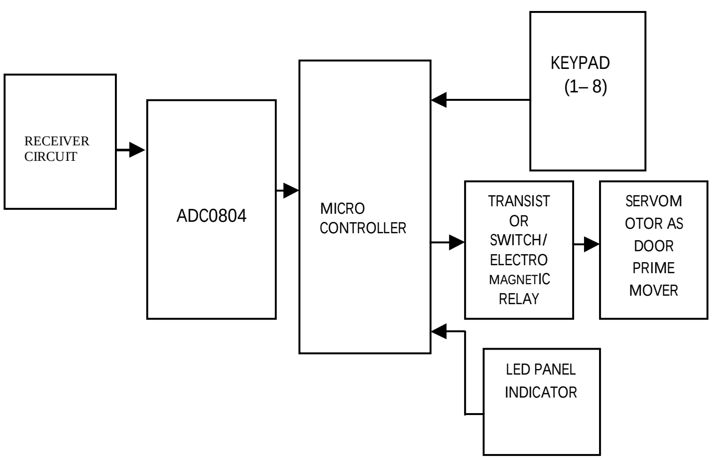


FIG.1, The System Schematic Block Diagram.

Basic Features of a Microcontoller Layout.

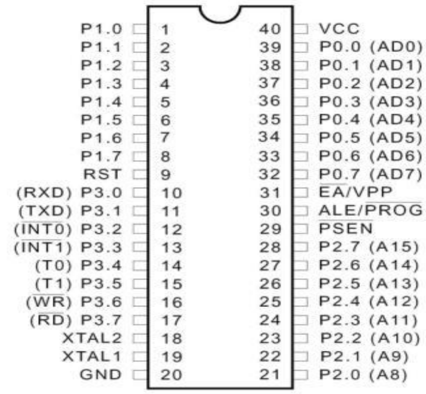


FIG.2, MICROCONTROLLER PIN LAYOUTS

A microcontroller can be considered a self- contained system with a processor, memory and peripherals and can be used as an embedded system. The majority of microcontroller in used today is embedded in other machinery, such as automobiles, telephones, appliances and peripherals for computer systems. These are called embedded systems. While some embedded systems are very sophisticated, many have minimal requirements for memory and program length, with no operating system, and low software complexity. Typical input and output devices include switches, relays, solenoids, LEDs, small or custom LCD displays, radio frequency devices, and sensors for data such as temperature, humility, light level etc. Embedded systems usually have no keyboard, screen, disks, printers, or other recognizable I/O devices of a personal computer, and may lack human interaction devices of any kind.

Programs: Microcontroller programs must fit in the available on –chip program memory, since it would be costly to provide a system with external, expandable, memory. Compliers and assemblers are used to convert high- level language codes into a compact machine code for storage in the microcontroller's memory. Depending on the device, the program memory may be permanent, read –only memory that can be programmed at the factory, or program may be field- alterable flash or erasable read – only memory.

Interrupt: microcontrollers must provide real time (predictable, though not necessarily fast) response to events in the embedded system they are controlling. When certain events occur, an interrupt system can signal the processor to suspend processing the current instruction sequence and to begin an interrupt service routine (ISR, or "interrupt handler"). The ISR will perform any processing required based on the source of the interrupt before returning to the original instruction sequence. Possible interrupt sources are device dependent, and often include events such as an internal timer overflow, completing an analog to digital conversion, a logic level change on an input such as from a button be pressed, and data received on a communication link. Where power consumption is important as in battery operated devices, interrupts may also wake a microcontroller from a low power sleep state where the processor is halted until required to do something by a peripheral event. Etc.

Systems Circuit Diagram

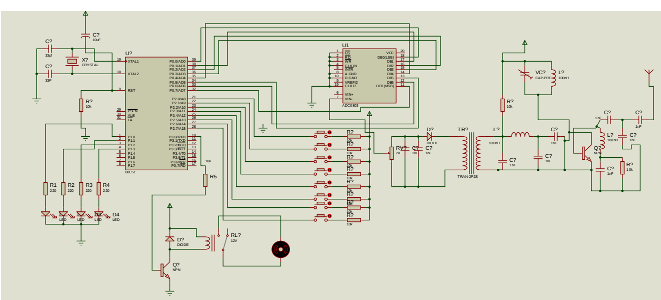
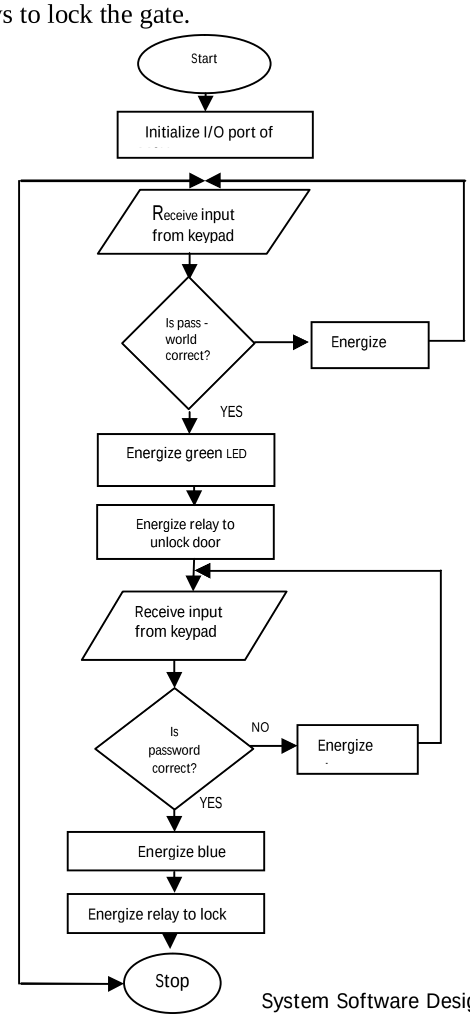


FIG.3, SYSTEMS CIRCUIT DIAGRAM.

System Design and Implementation

The microcontroller based RF remote controller gate opener with digital code lock is designed with a digital keypad introduced at port two of the microcontroller. The keypad is designed to communicate with the gate. The pull up resistors, R1 to R8 ensure that the switches of the keypad do not float. A power reset realized using RC network is connected to the pin 9 of the microcontroller to enhance automatic reset. Pins 18 and 19 of the microcontroller is connected to a 12MHz quart crystal in order to avoid frequency drift, that is, t ensures that there is frequency stability at the microcontroller where the controlling software is stored is designed to read the input data in the form of a handshake from the keypad.

When a correct password is entered through the keypad, the data is fed into the microcontroller and the RAM writes the data in the form of machine language which is then outputted. An electromagnetic relay is connected at the common collector of the transistor, such that whenever the connection is driven to saturation, the relay is energized and the normally closed contact of the relay opens while the normally open contact closes. When this happens, the gate unlocks. This electromagnetic relay is connected to drive the servomotor which energizes the gate. The servomotor must confirm to the following; 12v AC maximum of 3Amp and coil resistance of 600ohms and 300watt maximum power output. A green LED at he indicator panel glows when the correct password is entered on the keypad to unlock the gate while a blue light glows to lock the gate.



System Software Design Flow Chart

System Tests and Result.

Each unit was tested individually using a multi-meter. Some malfunctioned and were replaced with those of appropriate values.

After assembling each module in the breadboard, a visual inspection was carried out. Each module was re- tested before being transferred to the Vero board. The components were then soldered and the Vero board re-tested.

The system was re- inspected to ensure that the wired circuit was properly built before powering the system (continuity test). After the system was coupled, it was tested using a power source and it worked in accordance with the system design objective. That is, the red light glows to signify power, the yellow light glows when there is the presence of an Radio Frequency signal, the green light glows when the gate is open, while the blue comes up when the gate it is locked.

System Maintenance Considerations

Every working system must be carefully monitored to ensure that its initial objectives are still being met.

Maintenance, therefore should involve all activities and precautions taken to ensure optimal performance of a system. It also involves correction of faults or errors created in the cause of using the system

To prevent system failure, it is necessary to advice on the following;

- Ensure that a system operated under specification
- Ensure proper training of persons that are to use the system
- Avoid contact with liquids which could cause the system to malfunction.
- Keep a maintenance log book as this will help to keep track of possible faults or problems that arise as the system is being used, in other to assist future improvements.

The reasons that satisfy the need for system evaluation and maintenance include;

- To confirm that the initial objectives of the system are constantly being met.
- To deal with unforeseen problems arising from operation.
- To ensure that the system is able to cope with changing requirements of its operational site.

Suggestions for Further Improvements.

The system can be improved upon by applying some Artificial Intelligence Techniques to make it a more complex and robust and result oriented system , thereby enhancing its capacity to perform the various set functions in real-time.

Summary and Conclusion

This project was actualized by the design, construction and implementation of a microcontroller- based RF remote control gate opener with digital code lock. It should be noted that the system has been designed in such a way that it can be modified with respect to change in the future, as regard technological growth.

Furthermore, it is evident to say that the project so conceptualized, designed and produced has shown the effectiveness and efficiency in improving comfort and security, conserving energy and most especially saving time.

Also it is worthy to note that the work pattern of any organization may be affected by the introduction of a new system. The change from an old system to a new one is usually not easy until the detail of the essence of the new system is properly communicated to the users within the environment.

References

Alan Muinford (1993): The IT Manager: Security And Training, Prentice-Hall, Inc. New Jersey.

Alan Pritchard (1997) A Guide To Computer Literature: An Introductory Survey Of The Sources Of Information, Clive Bingley Ltd, United kingdom.

Allen Palms (1999): Lock: Locks and locked, Time square, United Kingdom.

Anderson, F. (1998): Computer In Agriculture, Acta-Hall, United kingdom.

Assa Abloy (1997): Door Opening Solutions, Whispering fuse, Maryland.

Baker C, R. (1999): An Analysis Of Fraud On Locking Devices, Spectra Inc, New York.

Boxus, P. (1998): Multiple-Cycle Micro propagation Control, Specks Publishers, London.

Carter G.N (1963): An Input-Output Analysis Of The Nigerian Economy Cambridge press, London.

Dennis Roddy and John Coolen (2002): The Small World Of Microcontrol, Computer Prints, New York.

Freeman, R. and Meed J. (1993): How To Study Effectively, Collins Educational, London.

Irving Gottlied (1973): Basic Electronics Procedures, Foulsham-Tab Limited, USA.

Jeffrey Whirtten, and Lanni Bentley, (2001): System Analysis And Design, (Fifth Edition), Mc Graw Hill Publisher, New York.

Kevin Dittmam (1987): Dictionary Of Computer Information Processing Telecommunication (second Edition), Mc-Graw Hill Inc.

Loveday, R. (1964): A First Course In Statistics, Newman Books, New York.

Michaelson, H. B. (1990): How To Write And Publish Research Engineerring Paper And Reports, (Third Edition): Phoenix Az, Oryx.

Morris Mano and Charles Kime (1991): Logic And Computer Design Fundamentals, Space Design Inc. Arkansas.

Osy Igweonyia (2002): Standard Methods In Business Research (Millennium Edition), New Generation Books, Enugu.

Sandra kay Miller (1996): How to analyze security Needs 2010 Penton Media, Inc.

http://en.wikpedia.org/wiki/time.lock