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# Encrypted Wireless Communication System on UHF Frequency Based on Text Messages

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**Abstract**.

*Communication is a habitual thing for every human, whether it's communicating directly or indirectly. When a natural disaster happens, problems can occur on communication systems. These problems can lead to information being not received properly, so the two parties communicating didn't know the content of the message. In this situation, a two-way radio device is the best solution that can be used to communicate. A two-way radio device enables the user to communicate without any cellular network or internet, because the radio can be both a transceiver or a receiver in its own frequency. A common two-way radio device uses UHF frequency range (400 MHz - 520 MHz) because of the characteristics of this frequency range that can penetrate buildings or vegetation that usually interfere with the radio signal. However, a two-way radio device has a broadcast and unencrypted characteristic, so that every conversation that is happening between the radio users can be heard by other users. In an emergency situation such as a natural disaster, important and confidential information shouldn't be heard by an unauthorized person. So in this project, the writers have a goal to design an encrypted text based communication system that works on the UHF frequency band.*

**Keyword**: *Radio, UHF, Encryption*

## 1. Introduction

Since the beginning of human mankind, communication is the common way for humans to interact with each other. There are two ways of communication, direct communication and indirect communication. Based on research which has been done by the World Bank, 36% of Indonesian citizens use Internet connection to communicate. Unfortunately, when the disaster strikes, the communication system and transfer of information could be disrupted. Modern communication systems such as cellular service and the Internet are highly dependent on several supporting elements. Some of the supporting elements are electricity, cellular tower, broadcast station, and human resources. When disaster occurs, these supporting factors are likely to be interrupted. This interference that happens on the communication system cause trouble to someone. Crucial information such as disaster reports, or general information about the current situation of family and friends would be unknown. In this disaster situation, two-way radio is the most reliable form of communication because the two-way radio are independent and can be utilized without any supporting elements such as cell tower and Internet [1].

Based on KM 773 regulation, there are 3 categories of radio system, broadcasting radio, public radio, and community radio. These 3 types of radio are highly regulated by the government with each category has different frequency allocation and coverage area [2]. The



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most common radio frequencies are split into 3 types, High Frequency (HF) 3 MHz - 30 MHz, Very High Frequency (VHF) 30 MHz - 300 MHz, dan Ultra
High Frequency (UHF) 300 MHz - 1 GHz [3]. This frequency range has its own uses and advantages. For the amateur radio operator, UHF are the chosen and the most popular for everyday use. UHF can pass through obstructions such as buildings, terrain, and vegetation. But, UHF has a low propagation, which means the transmission range is inferior compared with HF and VHF [4]. Two-way radio with UHF capabilities are widely used for short range communication by police department, warehouse worker, or community without any license or proper certification. But, two-way radio has broadcast capability and un- encrypted transmission, which means it can be heard by anyone on the same frequency. This problem can cause important and confidential information become vulnerable. Encryption method on two-way radio can be achieved only with digital radio. The supported radio applied frequency shifting method or FSK (Frequency Shift Keying). This frequency shifting involved a unique code. This unique code was inserted into the frequency, so that other users on the same frequency unable hear it. Digital radio has a special component that is used to differentiate with an analog radio. The component is called ADC or Analog to Digital Converter.

ADC converts sinusoidal signal into digital form such as 1 and 0. In this paper, ADC needs Goertzel algorithm to evaluate discrete signal on certain frequency and convert the signal into digital form. Nowadays, in digital communication, there are several types of general encryption used, one of them is Caesar Encryption. This encryption method is similar to FSK which is using a certain code that cause the message sent unable to be understood by the other people. If the FSK method using unique code to shift transmission frequencies, the unique code on Caesar Encryption used to shift the alphabet order [5]. Caesar methods for encryption are the simplest form of encryption but quite effective.

This paper discusses about encrypted text messages transmission in UHF radio. The text is transmitted with in a form of morse code tone. Caesar encryption are applied on transmitted UHF signal.

## 2. Theory

The common radio frequency can be used to transmit data with or without encryption. On the LF range (3KHz – 300KHz) the encrypted data transmission could be achieved with Caesar Chiper encryption on RF Module [6]. Besides the encrypted data transmission, additional code can be emmbeded into original data using AES algorithm [7]. This system design consists on 3 main components. There are Analog to Digital Converter, Goertzel Algorithm, and Caesar Cipher. Figure 1 represents the block diagram for the system. The plain text is typed by keyboard and then encrypted with Caesar Chiper. The encrypted message was converted to audio tone based on the morse code and sent to the radio receiver with the radio transmitter. The received messages on the radio receiver were converted to digital binary form using Goertzel Algorithm and were decrypted.



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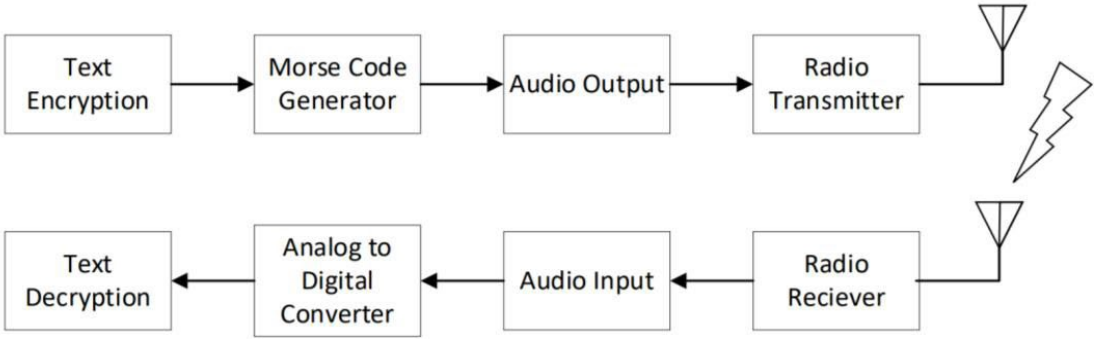


**Figure 1**. Block Diagram System Design of Encrypted Emergency Text Based Wireless Communication on UHF Frequency Band

**ADC (Analog to Digital Converter)**

ADC is a tool used for transforming analog signals into digital signals. The purpose of turning the signal from an analog form into a digital form is because the signal around the world is an analog signal, but data transmission in the modern world uses digital signals more [7]. ADC works by making the analog signals to be a discrete signal form (the highest value of a signal based on time), then the discrete signal is quantified based on the value of the quantization level that is dependent on the discrete signal level. From those levels, the signal is coded into a digital signal. The higher the quantization level, the higher resolution of the digital signal created.

**Goertzel Algorithm**

Goertzel Algorithm is a technique used in digital signal processing to evaluate discrete signals on a certain frequency [8]. Goertzel Algorithm is usually used to detect frequencies in dual-tone multi frequency signaling (DTMF), in which the frequency is recognized based on two frequencies that exist simultaneously. The Goertzel Algorithm is used because it is more efficient and more accurate than the Fast Fourier Transform (FFT) Algorithm.

This System Design uses Goertzel Algorithm to quickly recognize and efficiently the frequency that is set in the program, so that morse code can be recognized even though there are noise in the signal that is received by the processing module.

**Caesar Cipher**

Caesar Cipher is a simple text encryption method that is used to shift the order of the alphabet. Caesar Cipher has a mathematical equation of [9]. Equation 1 represents the mathematical equation of Caesar Chiper.

$$= + s m 26 \quad (1)$$

c = cipher result
p = alphabet character
order s = value to shift
the words



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The encryption method is based on modulo 26 to asure the integer value wraped around the alphabetical number [10]. Alphabet shifting can be calculated numerically one by one then translated into text based on alphabetical order. Caesar Cipher is used in this design to encrypt text that are transmitted so unauthorized person unable to understand the plain text that is transmitted.

## 3. Results and discussion

This research was carried out at telecommunication laboratory of Electrical Engineering Department. The test consists of alphabetical and numerical transmission with two sets of transceiver, decoder, encoder, and 2 display modules. Each text was obtained 10 times in 3 frequency band. The received text would be compared with the transmitted plain text.

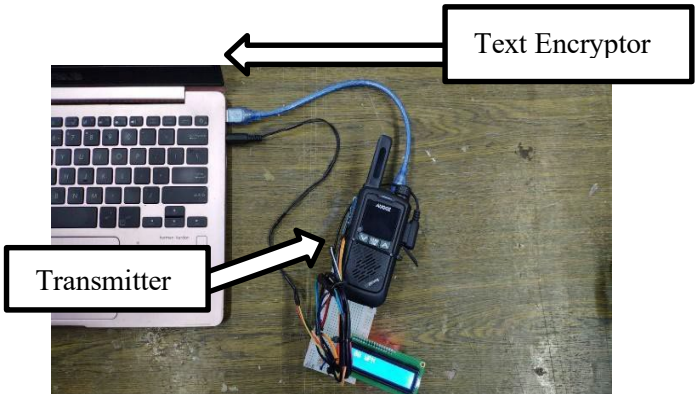


**Figure 3**. Radio Transmitter Module and Text Encryption

**Figure 3.** shows transmitter device. This device encrypted the text input and converted to morse code. The morse code then transformed into audio format and sent to the receiver with transmitter.

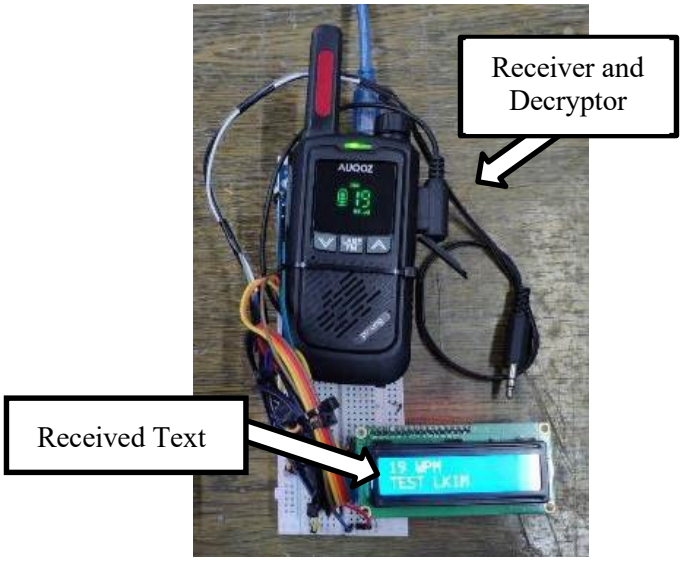


**Figure 4**. Radio Receiver Module and Text Decryption



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**Figure 4.** shows receiver device. This device decrypted received morse code based on the unique code. The result of the decryption shown on the display with alphabetical or numerical format.

**Table 1**. Numerical Encryption and Decryption Results

| No | Plain Text | Code | Encrypted Text | Received Text | | |
|---|---|---|---|---|---|---|
| | | | | Frequency 1 | Frequency 2 | Frequency 3 |
| 1 | 1223 4144 | 1 | LMMNNOLOO | 1223 4444 | 1223 4444 | 1222 4444 |
| 2 | 4375 1847 | 1 | ONRPPLSOR | 4375 1847 | 4375 1847 | 4375 1847 |
| 3 | 9485 6728 | 1 | TOSPPQRMS | 9485 6728 | 9485 6728 | 9485 6728 |
| 4 | 7362 5347 | 1 | RNQMMPNOR | 7362 5447 | 7362 5347 | 7362 5347 |
| 5 | 9384 6133 | 1 | TNSOOQLNN | 9384 6133 | 9384 6133 | 9384 6133 |
| 6 | 1827 3674 | 1 | LSMRRNQRO | 1827 3572 | 1827 3672 | 1827 3672 |
| 7 | 9826 3467 | 1 | TSMQQNOQR | 9826 3467 | 9826 4466 | 9826 3467 |
| 8 | 9837 4512 | 1 | TSNRROPLM | 9837 4512 | 9837 4512 | 9837 4512 |
| 9 | 2837 4638 | 1 | MSNRROQNS | 2837 4638 | 2837 4638 | 2837 4638 |
| 10 | 9283 4678 | 1 | TMSNNOQRS | 9283 4678 | 9283 4578 | 9283 4678 |

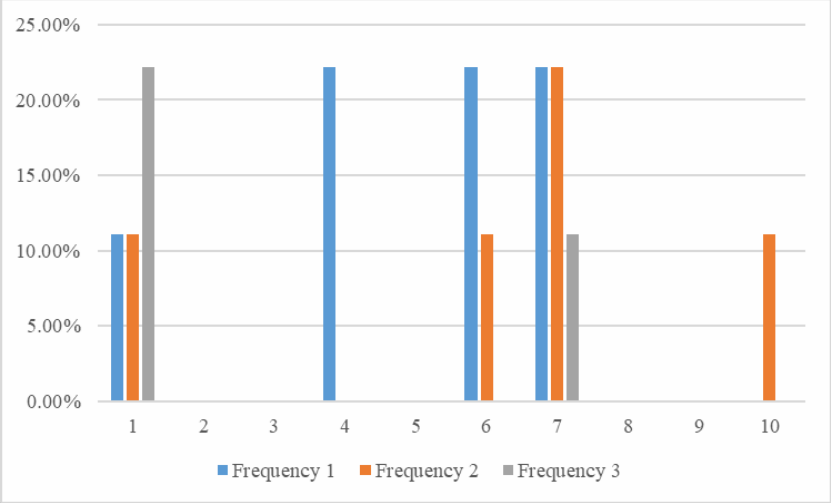


**Figure 5**. Error Rate of Numeric Text Decryption

**Table 1.** shows the encrypted and decrypted that consists of 9-digit random numbers text message. Each text is encrypted with the same unique code. Overall, 10 out of 30 data has a difference on 1 or 2 digit numbers. Table 1 shows that the data transmission could be sucessfully sent on different frequencies.

Based on Figure 5, it could be concluded that 66.6% perfect transmission occured with the 0.048% average percentage of error. While the data been obtained, it was found that the first letter of the transmitted morse code consists of minor static signals that interference the overall text. The noise reduction algorithm is necessary to avoid unwanted or misreading.



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**Table 2**. Alphabetical Encryption and Decryption Results

| No | Plain Text | Code | Encrypted Text | Received Text | | |
|---|---|---|---|---|---|---|
| | | | | Frequency 1 | Frequency 2 | Frequency 2 |
| 1 | TEST LKIM | 1 | UFTUUMLJN | TEST LKIM | TETT LKIM | TEST LKIM |
| 2 | TEST LKIM | 2 | VGUVVNMKO | TEST LKIM | TEST LKIM | TEST LKIM |
| 3 | TEST LKIM | 3 | WHVWWONLP | TEST LKIM | TEST LKIM | TEST LKIM |
| 4 | TEST LKIM | 4 | XIWXXPOMQ | TEST LKIM | TEST LKIM | TEST LKIM |
| 5 | TEST LKIM | 5 | YJXYYQPNR | TEST LKIM | TEST LKIM | TEST LKIM |
| 6 | TEST LKIM | 6 | ZKYZZRQOS | TTST LKIM | TTST LKIM | TTST LKIM |
| 7 | TEST LKIM | 7 | ALZA[SRPT | TTST LTIM | TEST LTIM | TEST LKIM |
| 8 | TEST LKIM | 8 | BMAB\TSQU | TEST LKIM | TEST LKIM | TEST LKIM |
| 9 | TEST LKIM | 9 | CNBC]UTRV | TEST LKII | TEST LKIM | TEST LKIM |
| 10 | TEST LKIM | 10 | DOCD^VUSW | TEST LKIM | TEST LKIM | TETT LKIM |

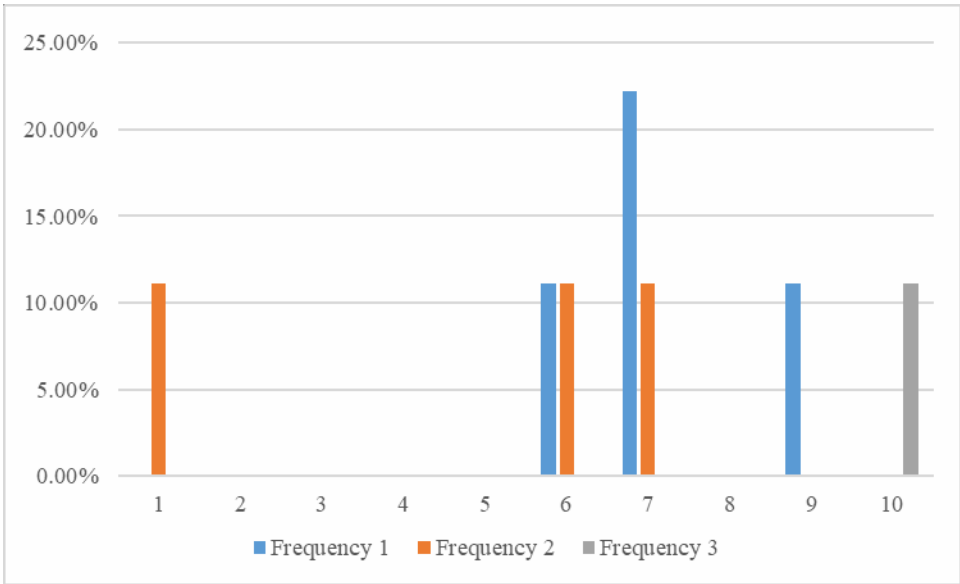


**Figure 6**. Result of Alphabetical Text Transmission

**Table 2.** shows the encrypted and decrypted that consists of 9-digit predetermined alphabets with the encryption and noise reduction enabled. Each text is encrypted with the difference unique code. Overall, 7 out of 30 test has a difference between 1 or 2-digit alphabet. Table 2 shows that the data transmission could be sucessfully sent on different frequencies. Based on Figure 6, it could be concluded that 76.6% perfect transmission occured with the 0.029% average percentage of error. While data been obtained, it was found that noise reduction algoritm could reduce the unwanted static signals.

## 4. Conclusion

The making of UHF based wireless encrypted text messages is built successfully. The Goertzl Algoritm could detemine the desired audio tone frequency and convert into digital form. The Caesar Chiper could encrypt the transmitted text and decrypt the received text. The encrypted



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text in the form of morse code
could be decoded with the average percentage of error were 0.048% and 0.029% for numerical transmission and alphabetical transmission. The noise reduction algoritm could reduce the chance of misreading of the received morse code.

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