International Journal of Engineering & Technology, 7 (4.30) (2018) 149-151

SPC

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

GPS Tracker Through HF Radio Using FSK Method

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Abstract

A GPS tracker through HF radio using FSK method for Blue Force Tracking (BFT) application was developed. The project aims to transmit and receive the location information which is obtained from the GPS data. The system used frequency range of 500 Hz to 2000 Hz for modulating and demodulating the GPS data using FSK method. The smallest frequency gap between characters without affecting the accuracy of the output is 100 Hz, but the transmission time per character must be set to 100 ms. The transmission speed was investigated to find the optimum speed of the system by varying the delay command in the program. The system can accurately transmit and receive the location data in 1350 ms per coordinate. In general, the developed system successfully maintains the performance of transmitting and receiving the location information which can be applied for the future advancement of the BFT.

Keywords: *BFT application; FSK method; GPS tracker; HF radio.*

1. Introduction

Blue Force Tracking (BFT) is the military term for a GPS-enabled system that provides military commanders and forces with location information about friendly military forces [1]. In military, blue typically denotes friendly forces while red denotes enemy forces. The system provides a common picture of the location of friendly forces and therefore is referred to as the "Blue Force" tracker. BFT is an essential element to any tactical environment given its ability to contribute to situational awareness at all levels.
In battlefield soldiers are often used friendly identities known as Combat Identification (CID). CID is the ability to quickly identify friendly, enemy, and neutral troops; managing and controlling battles; and optimum use of weapons and armies [2]. CID failure can cause a friendly fire by failing to identify the enemy or friend [3]. CID system failure can lead to fratricide (involvement of a soldier or unsuitable friendship unit), neutricide (erroneously involving a neutral touch), and endanger themselves by failing to identify the enemy. According to previous studies [3] [4], most incidents can be attributed to loss of situational awareness (SA), misidentification of the target, or both. SA and target identification, along with tactics, techniques, and procedures, are considered the basic elements of CID.
One approach to improving CID's performance is to support SA by providing the BFT system, for example, the XXI Military Team Brigade Command and the Under-Blue Tracking System (FBCB2-BFT) [5]. The FBCB2-BFT system consists of computers, satellite antennas, and GPS receivers that are connected by remote radios and commercial L-band satellites. These systems form multi-storey architecture using land, air, and over-the-horizon relay to keep track of their friendly and organized positions, which are sent to the friendly units. FBCB2-BFT delivers pictures of tactical and operating levels, including friendly units positioning each other [5].
One of the mediums used for BFT is at Very High Frequency (VHF). VHF's tactical radio network provides low bandwidth but long-distance communication services for military deployment. This network is mainly related to voice traffic, but the range of services available for packet-based radio is very broad. Situational awareness is one of the critical services available in highly desirable strategic networks for tactical networks used. One of the key issues for tactical networks is that even though strategic networks have a lot of Mbps, the tactical network that uses the VHF band can now support 64 kbps. Another issue is that even though strategic networks have reliable infrastructure, tactical networks must be able to operate with ever-changing topologies and frequent loss of connectivity [6].
The Spanish army had used HF and VHF as their transmission medium for BFT. These BFTs have been tested on their vehicles with 97% passing tests and 3% have been completed in the following months [7].

2. Methodology

In this project, the device operational system starts by receiving the GPS coordinates. After that the data is modulated using FSK method. The transmitter will broadcast the signal wirelessly through HF radio. The receiver will receive the data and feed into the microcontroller. The microcontroller will demodulate the modulated signal. The recovered data will be shown on serial monitor and also on an application.
The raw GPS data is being decoded by u-blox NEO 6Q and only the latitude and longitude are utilised in this project. Arduino Uno was used as the controller of the process involving modulation, demodulation and transferring the data using serial communication to the PC. The GPS data is modulated by the Arduino Uno into different tone by assigning different frequency for each character. The range of frequency is between 500 Hz and 2000 Hz. The use of this range is because the noise appears in the range

below 500 Hz and will affect the performance of the detection of frequency at the receiver side. The received signal will be demodulated by the second Arduino Uno at the receiver side and the binary data is compared to the array in the program. The matched data will be converted into characters, which are numbers 0-9, '.' and ';'.

Serial monitor is a separate pop-up window from the Arduino IDE that acts as a separate terminal that communicates with the microcontroller by receiving and sending serial data. Serial data is sent over a single wire on USB and consists of a series of 1's and 0's sent over the wire. The application (named as BFT Malaysia application) is the Graphical User Interface (GUI) for interpreting the demodulated GPS data to the Google Map for mapping. This application read the data from the serial communication on selected port.

The signal is transmitted wirelessly through a pair of military grade HF radio, Sapura Thales TRC 3700. This HF radio employs Digital Signal Processing (DSP) technique to significantly improve the quality of received and transmitted signals including extensive user-adjustable digital and analog filtering functions for combating all forms of received interference. The radio transmission test was carried out at SOFI Lab Sapura Defence Sdn. Bhd., Wangsa Maju. Since the frequencies being used involve values below 1000 Hz, the squelch setting at the receiver is set to off. The frequency channel was set to 6.00 MHz. The PTT on the transmitting side has to be triggered by using relay as it is only operating as a switch. The Arduino Uno will turn on the PTT on the radio in order to broadcast the modulated signal. At the receiving side, the modulated signal will be received and feed to the Arduino Uno for the demodulation of the signal.

3. Results and Discussions

The frequencies for each character at the transmitter and the receiver sides are compared as shown in Table 1. From the table, the maximum deviation of the received frequencies from the transmitted ones is 6 Hz. This is still within the tolerable range of the frequency-identification algorithm at the receiver.

Table 1: Measurement of the transmitted and received frequency

Character	Transmitted Frequency (Hz)	Received Frequency (Hz)	Difference (Hz)
0	500	499	-1
1	600	600	0
2	700	702.1	+2.1
3	800	801.2	+1.2
4	900	906.0	+6
5	1000	1000	0
6	1100	1101	+1
7	1200	1196	-4
8	1300	1302	+2
9	1400	1405	+5
.	1500	1506	+6
;	2000	1999	-1

The transmission time per character is varied to find the shortest transmission time per coordinate possible without affecting the accuracy of the output. The frequency gap between frequency values representing each character is set to 100 Hz. The result of the experiment is shown in Table 2. It can be concluded that the shortest transmission time per coordinate possible without affecting the accuracy of the output is 1350 ms per coordinate, which is 90 ms per character.

One of the probable factor of the instability or inaccuracy of the output data when the transmission time per character is lower than 90 ms is the difference in code runtime in transmitter and receiver. The number of lines of code in the transmitter program is more than in the receiver. This means, for each character transmission, the program at transmitter goes through more code lines contributing to more transmission delay compared to the program at receiver. This causes the transmission to be out of sync, thus affecting the stability and accuracy of the output. The shortest transmission time per coordinate possible in radio transmission test is at 1350 ms per coordinate. The inability for the receiver to accurately identify the incoming signal at 900 ms per coordinate is probably caused by signal loss during wireless transmission, and since the signal representing each character is not repeated long enough (small transmission time per character), the data is lost, which then results inaccurate output.

Table 2: Varying the transmission time per character

Transmission time per character (ms)	40	50	60	70	80	90	100
Transmission time per coordinate (ms)	600	750	900	1050	1200	1350	1500
Output state (Accurate (A) /Inaccurate (IA))	IA	IA	IA	IA	IA	A	A

The frequency gap between characters is varied to find the smallest frequency gap possible without affecting the accuracy of the output. The result of the experiment is shown in Table 3. From the recorded data, it can be concluded that the smallest frequency gap possible without affecting the accuracy of the output is 100 Hz. It is also proven that the increment of transmission time per character does not affect or enable frequency gap smaller than 100 Hz to deliver accurate output.

Table 3: Varying the frequency gap and the transmission time per character

Transmission time per character (ms)	50			70			100		
Frequency gap (Hz)	50	70	100	50	70	100	50	70	100
Output state (Accurate (A)/ Inaccurate (IA))	IA	IA	IA	IA	IA	IA	IA	IA	A

A possible cause of the inaccuracy of output data when the frequency gap between characters is lower than 100 Hz is the receiver's limited ability in identifying frequency. The algorithm at the transmitter captures incoming signal and identify the frequency in time-domain, which can cause inaccurate signal amplitude reading and output calculated frequency wrongly.

The computer was installed with the BFT Malaysia application to show the exact location of the transmitter. The application monitors the data on the serial communication of the receiver to capture the received GPS data and pin point the location as shown in Figure 1. The port COM8 was being selected as the demodulator was connected to the port. The result shows the exact location of the transmitter by interpreting the GPS data into two types which is in text and in mapping. The port must be correctly selected to avoid data lost during the extraction data.

4. Concluding Remarks

The BFT system has been optimised with respect to the time taken for the GPS data to be transferred from transmitter to receiver. The system can successfully transmit and receive coordinates every 1350 ms. The receiver is unable to accurately identify the incoming signal when transmission time per coordinate is below 1350 ms. This is probably caused by signal loss during wireless transmission, and since the signal representing each character is not repeated long enough (small transmission time per character), the data is lost, thus resulting inaccurate output. In addition, the frequency gap between characters needs to be set more than 100 Hz to be accurately received. In future, our system will be improved not only to be able to send the BFT information but can simultaneously send voice and message without any disturbance. This project will benefit many agencies and organizations in our country, including the Military, Maritime Enforcement Agency, and Department of Fisheries.

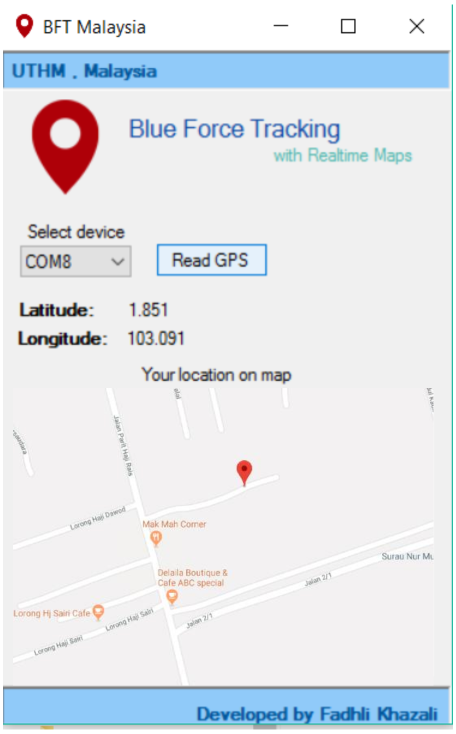

Fig. 1: The BFT Malaysia application with pin point transmitter location.

Acknowledgement

The authors would like to express their gratitude to Sapura Defence Sdn Bhd for letting us use the HF radio equipment.

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