# Construction of Frequency-Hopping System Using RF Communications Trainer

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***Abstract*—To clearly understand wireless communication technology for education purposes, an inexpensive wireless modulation and demodulation system is required. A radio frequency (RF) communications trainer can generate RF-modulated signals and carrier waves. A spectrum analyzer can seek the peak frequency and be controlled by a PC. Therefore, a frequency-hopping wireless modulation and demodulation system can be constructed by using an RF communications trainer and a spectrum analyzer. In this study, we constructed a frequency-hopping transmission system using the RF communications trainer, GRF-1300, and the spectrum analyzer, GSP -730. To validate this system, we evaluated the peak frequency detection probability and compared it with theoretical values. Results show that, when the hopping time interval was larger than or equal to 2000 ms, the peak frequency detection probability almost coincided with the theoretical values.**

***Keywords*—RF communications trainer, Spectrum analyzer, Frequency-hopping, Peak frequency detection probability.**

## I. INTRODUCTION

A radio frequency (RF) communications trainer helps wireless communication engineers and students to understand wireless communication technology. An RF communications trainer can generate RF-modulated signals or carrier signals. To clearly understand wireless communication technology for education purposes, a demodulation system is also required. A general-purpose vector signal analyzer [1]-[3] can demodulate modulated signals; however, such vector signal analyzers are very expensive. On the other hand, a spectrum analyzer can seek peak frequencies and be controlled by a PC; therefore, a frequency-hopping [4] wireless modulation and demodulation system can be constructed by using an RF communications trainer and a spectrum analyzer.

In this study, we constructed a frequency-hopping transmission system in the radio frequency band using the RF communications trainer, GRF-1300 [5], and the spectrum analyzer, GSP-730 [6]. To validate the system, we evaluated the peak frequency detection probability and compared it with theoretical values.

## II. CONSTRUCTED FREQUENCY-HOPPING SYSTEM

Figure 1 shows the configuration of our constructed frequency-hopping transmission system. The RF communications trainer, GRF-1300, and the spectrum analyzer, GSP-730, were connected to controller PCs with USB cables. The GRF-1300 can generate carrier waves within a frequency range between 870 MHz and 918 MHz.

A random frequency-hopping sequence can be generated as follows: first, 49 uniformly distributed random variables are generated and ranked in order of increasing frequency. Then, a hopping-frequency sequence with a transmission frequency (MHz) is created by adding 869 to the abovementioned ranking number. The frequency-hopping sequence is transmitted from the transmitting controller PC to the RF communications trainer, GRF-1300. The transmission period of the controller PC command sequence corresponds to the hopping time interval, $T$.

Table 1 shows the configurations of the spectrum analyzer, GSP-730. A command to search for the peak frequency and send it back is transmitted from the receiving controller PC to the GSP-730. The transmission period of the receiving command sentence corresponds to the peak frequency detection period, $\tau$.

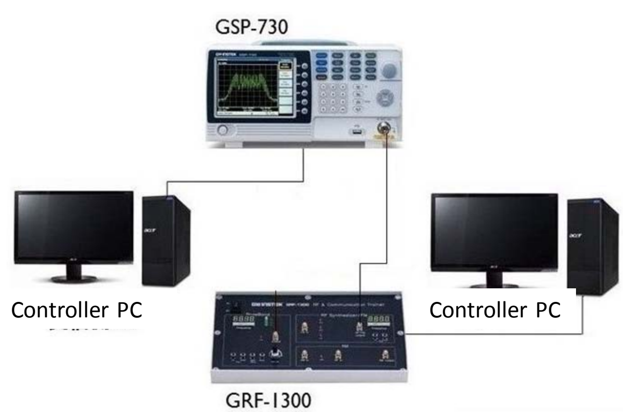


Figure 1. Frequency-hopping transmission system

Table 1. Configuration of GSP-730

| | |
|---|---|
| Center frequency | 894 MHz |
| Span | 50 MHz |
| Sweep Time | 400 ms |
| RBW | 300 kHz |

## III. Performance Evaluation

The ideal peak frequency detection probability, $p$, can be expressed as equation (1), assuming that the peak frequency detection period is $\tau$ and the hopping time interval is $T$.

$$p = \begin{cases} 1 & (T \geq \tau) \\ \dfrac{T}{\tau} & (T < \tau) \end{cases} \tag{1}$$

We evaluated the peak frequency detection probability, assuming the allowable frequency detection error of $\pm 0.2$ MHz. Figure 2 shows the relationship between the peak frequency detection probability, $p$, and the peak frequency detection period, $\tau$, as parameters of the hopping time interval, $T$. For further comparison, a hopping frequency increasing from 870 MHz to 918 MHz at constant frequency intervals of 1 MHz was also plotted. It can be seen from this figure that the peak frequency detection probability in the cases of increasing the frequency by 1 MHz intervals and random sequence frequency hopping almost coincided with the theoretical values when the hopping time interval was equal to or larger than 2000 ms. However, when the hopping frequency interval shortened, the peak frequency detection probability decreased. This is seemingly because it became difficult to detect the peak frequency when the hopping time interval approached the sweep time of the spectrum analyzer. Furthermore, for the random sequence, the peak frequency detection probability was only about 0.9, even if the peak frequency detection period was sufficiently short, which was smaller than the theoretical value.

To clarify the abovementioned supposed reason, we evaluated the effects of the hopping frequency intervals on the peak frequency detection probability. Figure 3 shows the peak frequency detection probability by the hopping frequency interval for increasing frequency hopping as a parameter for a $T$ of 500 ms. This figure shows that, as the hopping frequency intervals increased, the peak frequency detection probability decreased. It also decreased when the hopping frequency interval was 8 MHz. Furthermore, we can see that the performance of the 8-MHz hopping frequency interval was almost identical to that of the random frequency-hopping sequence. In the random sequence frequency hopping, hopping with a large frequency-hopping interval may occur, in which case the frequency detection probability decreases.

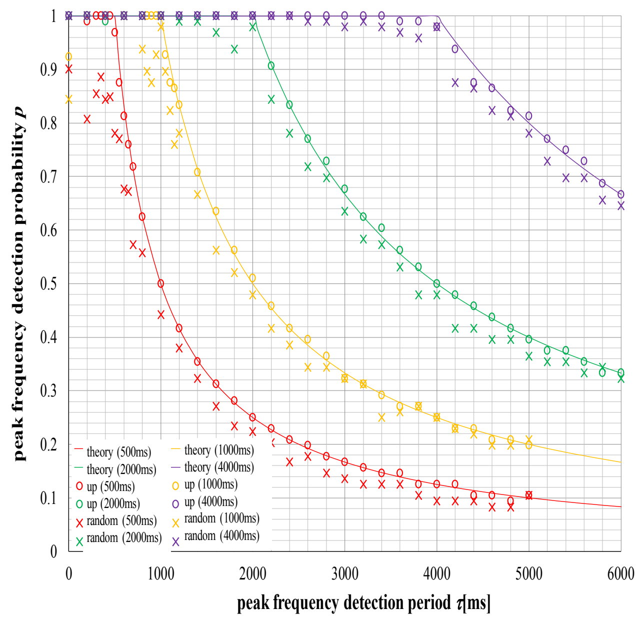


Figure 2. Relationship between peak frequency detection probability and peak frequency detection period as parameter of hopping time interval

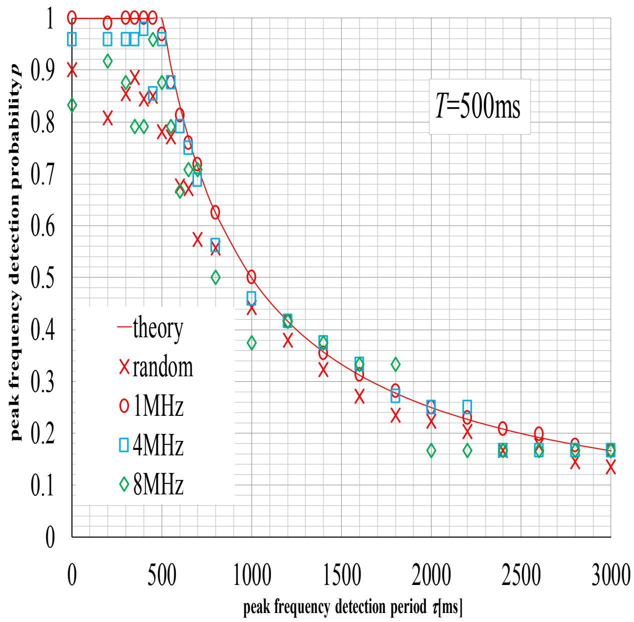


Figure 3. Peak frequency detection probability by hopping frequency interval for increasing frequency hopping as a parameter

## IV. CONCLUSION

In this study, we constructed a frequency-hopping transmission system using an RF communications trainer, the GRF-1300, and the spectrum analyzer, GSP-700. The results show that, when the hopping time interval was larger than or equal to 2000 ms, the peak frequency detection probability almost coincided with the theoretical values. However, when the peak frequency detection period approached the sweep time of the spectrum analyzer, it became difficult to detect the peak frequency, so the peak frequency detection probability decreased.

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