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Improvement in Sensitivity in Immediate Frequency Receiver Using Semi-Wave Voltage Impacts

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ABSTRACT

IFM receivers play important roles in electronic wars. They have been created as instruments for rapid identification of any kind of threat and generally finding danger frequency. Moreover, they are better than receivers because they are less costly, they occupy less volume, they have average separation ability and even good separation ability in environments without wave interference. The main restriction of traditional IFM receivers is their limited bandwidth. Optical microwave IFMs were investigated but the main problem with their implementation is their prices. The present research tries to investigate optical IFMs with higher sensitivity. The recommended methods are based on optical integration use for conversion of RF optical signals into DC. In general, in a RADAR receiver, we need an IFM bank. An increase in the number for IFMs results in an increase in the number of optical detectors. Consequently, if detectors with low frequency and low price are used, network system price will be decreased considerably. In the present paper, we first investigate sensitivity of implementation system and then some solutions are provided for increasing the sensitivity.
KEYWORDS: IFM receiver, electronic war, bandwidth

INTRODUCTION

Electronic war is an art and science for protection of friendly use of electromagnetic spectrum in addition to prevention form hostile use of it. Electronic war includes a complete spectrum of radio frequency of infrared, optical and ultraviolet. Immediate frequency measurement (IFM) receiver was first introduced by Irep in 1948. The output of the first receivers was indicated on a scope in polar coordinates. The angle of this polar display indicated the frequency of input signal and its size indicated the strength of input signal. In general, it can be said that an immediate frequency receiver makes use of interference technique and calculates frequency of input signals. To put it more exactly, the input RF signal is received and is converted into two lines with and without delays with a known wavelength. Figure 1 (in the final section) shows diagram for an immediate frequency receiver. A normal immediate frequency receiver is a radio frequency receiver in radar which is used in a war. Its main duty is to measure signals frequency radiated from enemy radar. Although modern IFM receivers still follow the past performance principles, input signal frequency is usually indicated digitally. Study of broadband IFM in Microwave bands started in 1950s in laboratories of England and America in quest for solutions for measurement of detection frequency and appropriate broadband. The first step was taken by Robinson and Godard [1] and Robinson [2] in 1955 on hybrid of phase reversing ring. It was built for "Porker" regal navy. The second step of development was Robinson's invention [3] in 1975, i.e. vertical phase detector in response to Porker's needs. Porker identified ability to measure broadband frequency for Porker. In 1980, digital immediate frequency receivers (DIFM) were designed by MEL Company to cover frequency band from 1 to 18 giga hertz. In 1990-2000, the position of DIFM was challenged as digital circuits with gigahertz pulse clocks and Sample and Hold circuits and Analog-to-digital (ADC) circuits were developed. These rapid digital advancements pave the way for direct digitalization of RF and process with IFM algorithm or spectrum analysis technique of fast Fourier transform (FFT) [4-8].

RESEARCH METHODOLOGY

The present research tries to investigate sensitivity in immediate receiver and helps with selecting a system close to ideal system. The main goal of the present research is to achieve an immediate frequency receiver with maximum possible sensitivity. To this end, subsidiary goals include use of optical measurement system instead of simple measurement systems and investigation of the impact of V_πParameter variations on system sensitivity. Furthermore, simulation was conducted in MATLAB software in order to acquire a relatively simple and optimum design. Optimization was done in order to increase receiver's sensitivity. We increased sensitivity by calculating an appropriate value for $V_\pi$parameter (mid-wave frequency).

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Statement of problem

Figure 2 indicates the status of a high-frequency compound IFM. Because we have considerable mortality in frequencies above 10 gigahertz, the optical path and RF cable were shortened as far as possible. RF wave is produced by an RF producer and is divided into two parallel parts by a Wilkinson power divider with two arms. These two parts are called "optical path" and "RF path". RF wave in optical path is MAM1[7] input which has been biased in 1/4. An optical carrier is modulated by MZM1, then this modulated carrier travels fiber path cable and optical delay is exerted on it. The second part of RF wave enters RF path and is delayed by coaxial cable.

The delayed RF signal will be MZM2 input (1/4 bias) which modulates the optical carrier for the second time. Then, the signal which has been modulated two times is detected by a detector. The output of detector is transferred from the lower filter and is calculated by a digital DC voltmeter. Correlation 1 indicates this voltage.

$$G = eG_{PD}L_1L_2 \quad (1)$$

$$V_{DC} = \frac{1}{4} G Z_{PD} P_0 [1 + \frac{\pi^2 (1+M^2) Z_{in} P_{RF}}{4V_\pi^2} + \frac{\pi^2}{V_\pi^2} M Z_{in} P_{RF} COS\phi] \quad (2)$$

In this correlation, φ is phase response, M is range response, Z_{PD} and Z_{in} are output impedances of detector and input impedance of MZMs, P_o and P_{RF} are optical powers and RF, V_π is mid-wave voltage of MZMs, G_{PD} is quotient of detector and L_1 and L_2 are lost MZMs. Now, we can change V_π and optimize V_{DC} value. As we change mid-wave voltage range from 3 to 10 microvolt, output diagrams for V_{DC} are equal to figures 3 and 4 and 5 and 6. As it can be seen, as V_π is reduced, V_{DC} is increased. Therefore, we had better reduce V_π as it is possible.

CONCLUSION AND DISCUSSION

In this paper, we introduced a new technique for acquiring an optical IFM receiver which makes use of cheap DC detectors. Using combination concept, this optical system was able to indicate frequency of DC output. These high-frequency measurements make use of inexpensive detectors. The importance of this design is determined when we want to use a bank of IFMs for designation of enemy's multiple signals separately and eliminate enemy's threats with a high precision in bandwidth. Furthermore, we obtained different voltages by selecting different values for V_π and we concluded that as V_π is reduced, fixed voltage will be increased.

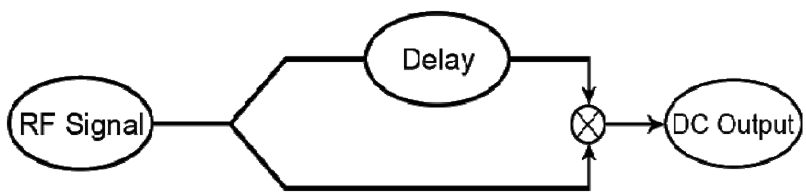

Figure 1.diagram for an immediate frequency receiver

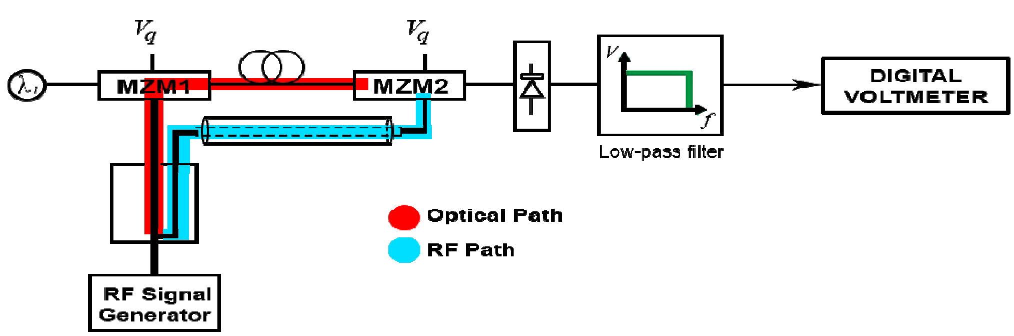

Figure 2.diagram for a high-frequency IFM

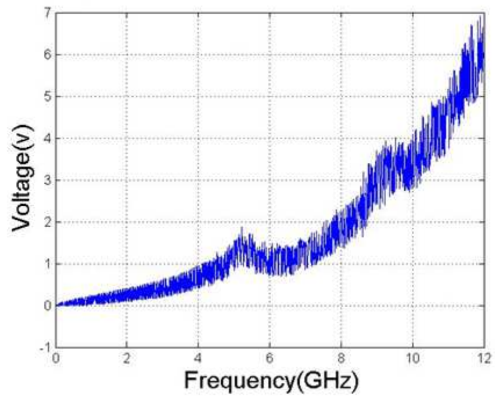

Figure 4.voltage-frequency diagram in V_{π}=5

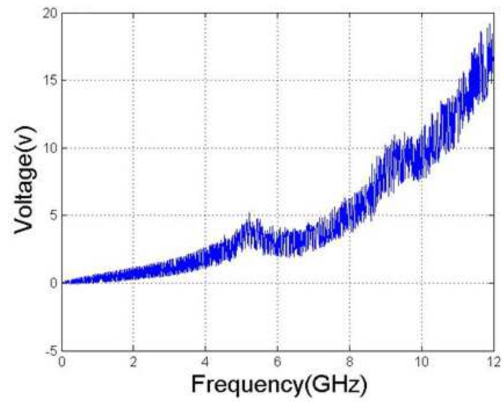

Figure 3.voltage-frequencydiagram in V_{π}=3

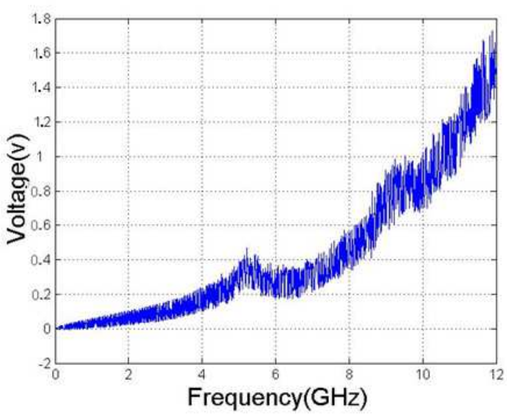

Figure 6.voltage-frequency diagram in V_{π}= 10

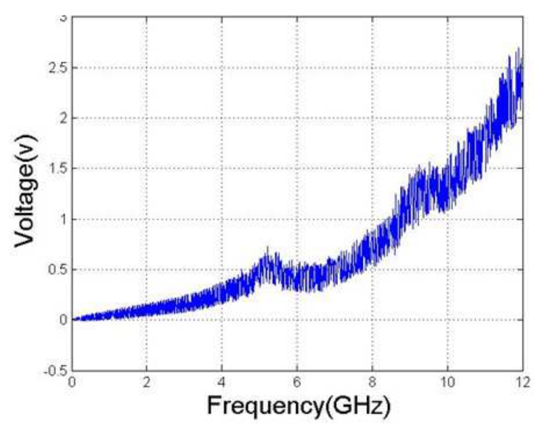

Figure 5.voltage-frequency diagram in V_{π}= 8

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