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Characteristics of AM and PM Signals in Multi-Carrier Polar Transmitter

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Abstract

Polar transmitter can support multi-band and multi-mode operation. The efficiency of frequency usage can be increased if polar transmitters can transmit multi-carrier signals. In this paper the configuration of polar transmitters is investigated to generate multi-carrier signals. Spectrum and CCDF Simulation results of two-carrier signals generated by the polar transmitter can be used to design of PM and AM path in a polar transmitter.

***Keywords**: Multi-carrier, Amplitude Modulation, Phase Modulation, CCDF(Complementary Cumulative Distribution Function), Peak to Average Power Ratio, Polar Transmitter*

1. Introduction

A lot of research and development is in progress to increase frequency utilization efficiency and to transmit information seamless. If a transceiver can monitor the frequency environment around the transceiver and use an unused frequency, frequency utilization efficiency is increased and provide seamless service more easily. In general, unused frequency bands exist discretely, and in order to effectively use such unused frequency bands, a multi-band, multi-carrier transmitter is required. The multi-carrier transmitter is useful when the amount of information to be transmitted is large. Frequency utilization efficiency can be increased by searching for and using an unoccupied frequency that is not occupied by other transmitters in the frequency band allocated at the moment when the information is to be transmitted.

As a structure of a transmitter to support multi-band and multi-mode, a polar transmitter is known as one of the most suitable structures [1,2,3]. The structure of the polar transmitter is shown in Figure 1. As shown in Figure 1, the polar transmitter has a small number of components compared to other transmitters and does not use analog up-conversion using a mixer. Therefore, there is an advantage in that it is easy to broaden the

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bandwidth of all elements except for the power amplifier among the constituent elements of the polar transmitter [4]. As the name indicates, the polar transmitter divides the information of the original signal into magnitude (AM component) and phase (PM component) and processes it. If PAPR(peak to average power ratio) is not maintained while the AM and PM signals pass through the AM and PM paths, respectively, distortion occurs in the transmission signal, and the distortion of the transmission signal means information loss. Therefore, in order to properly design a polar transmitter, it is necessary to know the CCDF characteristics of PAPR of signals processed in the AM path and PM path constituting the polarity transmitter.

In this paper, a method for generating multi-carriers using a polar transmitter with a structure capable of wideband and multi-mode operation is presented. The characteristics of frequency spectrum and CCDF of AM and PM signals in the AM and PM path in the polar transmitter when generating a multi-carrier signal are described.

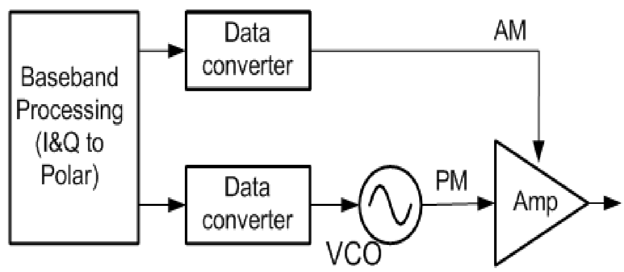


Figure 1. Configuration of polar transmitter

2. Simulation

In order for the polar transmitter as shown in Figure 1 to accommodate multiple carriers, it uses a Digital Complex Quadrature Modulator (DCQM) and a Digital Quadrature Modulator (DQM) to remove the image signal and up-modulate the signal to the desired band. In Figure 1, the base band processing that changes I & Q signal to a polar signal can be implemented as shown in Figure 2. As can be seen from the structure of Figure 2, DCQM is used to effectively generate two carriers. The structure of Figure 2 shows the structure of a polar transmitter generating two carriers. As shown in Figure 2, two digital complex quadrature modulators are used to generate two carriers. And since the data rate of the output signal of the digital complex modulator may be different from each other, the data rate is adjusted at the output terminal of the digital complex orthogonal modulator. In addition, the CORDIC algorithm is used to generate AM data and PM data required by the polar transmitter.

The feasibility of the implementation of Figure 2 is simulated using ADS (Advanced Design System). For the convenience of simulation, two carriers were set to have 2 MHz and 1 MHz bandwidths, respectively. The separation of the center frequency between carriers is of 4 MHz. The frequency simulation results of PM signal, AM signal and the output signal of 2-carrier polar transmitter is shown figure 3. Figure 4 and Figure 5 show the result of measuring the output spectrum after implementing it in FPGA. It can be seen that Figure 4 and 5 are similar to Figure 3, which is the simulation result. Figure 5 shows the output spectrum of a 2-carrier polar transmitter in which a signal of 2 MHz bandwidth and a signal of 1 MHz bandwidth are separated by 4 MHz.

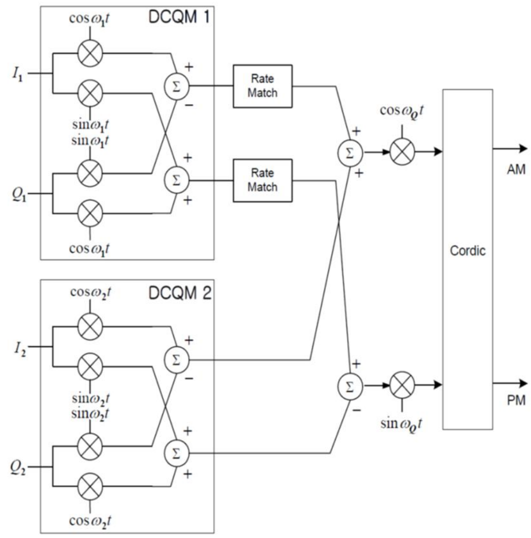


Figure 2. Simple block diagram of 2-carrier polar transmitter using DCQM

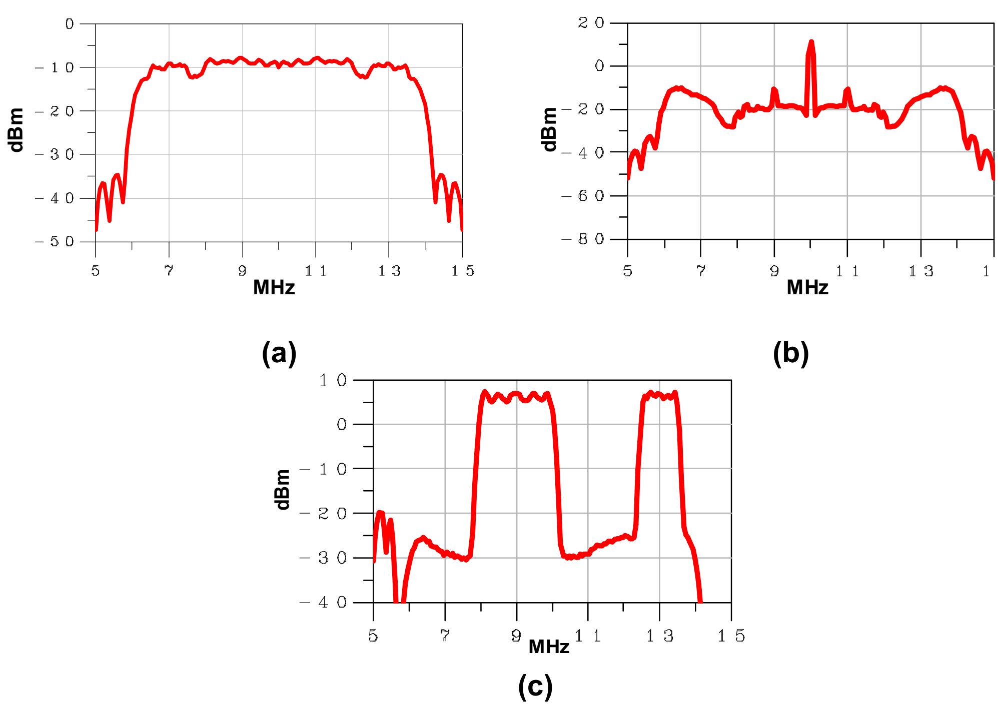
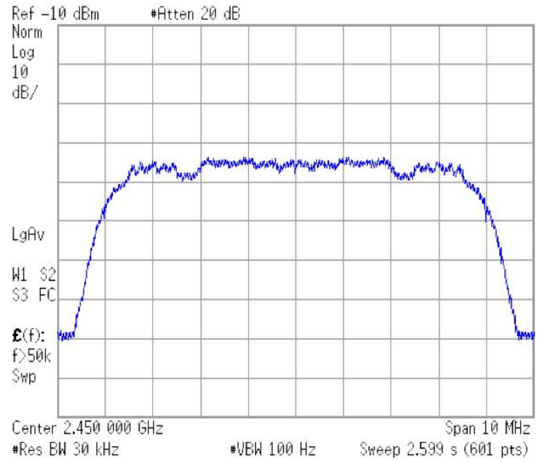
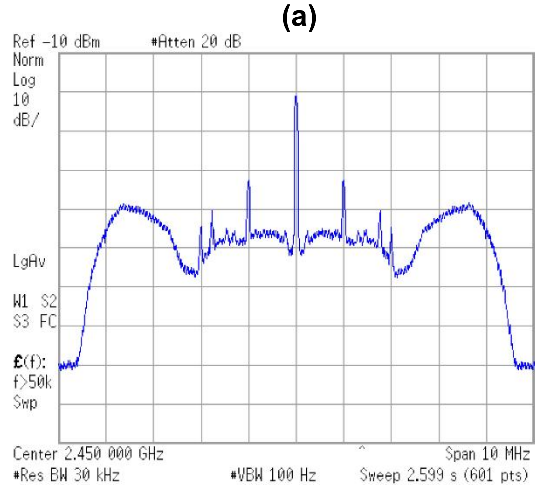


Figure 3. Spectrum of 2-Carrier Polar Transmitter in ADS, (a) PM Spectrum, (b) AM Spectrum, and (c) Output Spectrum of 2-Carrier



(a)



(b)

Figure 4. AM and PM Spectrum of 2-carrier polar transmitter in FPGA, (a) PM Spectrum of 2-carrier polar transmitter, (b) AM Spectrum of 2-carrier polar transmitter

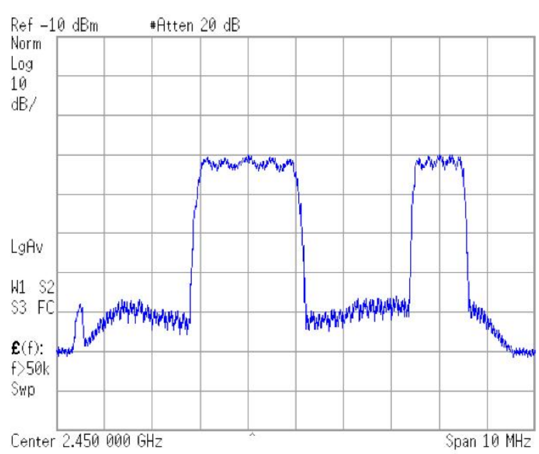


Figure 5. Spectrum of the output signal of 2-carrier polar transmitter

From the AM spectrum and PM spectrum in Figure 4, it can be seen that the bandwidth of the original spectrum is considerably wider than that of the original spectrum. Figure 6 shows the CCDF of PAPR of 1MHz, 2MHz and 2-carrier signals. From Figure 6, the CCDF of signals with bandwidths of 1MHz and 2MHz does not show much difference, but 2-carrier signals show that the CCDF is increased by about 1dB. The CCDF of the 2MHz single carrier signal shows a different trend from the CCDF of other signals, and the PAPR increases abruptly at 6×10^{-4} and becomes 7.5dB at 1×10^{-4}. Figure 7 shows CCDF for 2-carrier signal and AM signal of polar transmitter. From Figure 7, it can be seen that the CCDF of 2-carrier signal and the CCDF of the AM signal of the polar transmitter are almost the same. Figure 8 shows CCDF of AM signal and PM signal of polar transmitter. Since the frequency spectrum of the AM signal is more irregular than that of the PM signal, it is considered that the CCDF of the AM signal is larger than the CCDF of the PM signal. However, it is necessary to investigate the statistical characteristics of the signal because it may have characteristics different from the shape of the spectrum. Figure 8 shows that the CCDF of the PM signal is larger than the CCDF of the AM signal.

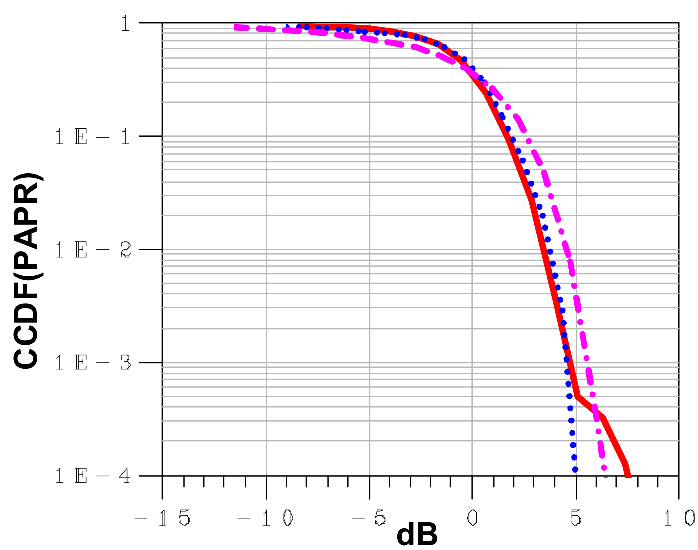


Figure 6. CCDF of 1MHz, 2MHz Single Carrier Signal and 2-Carrier Signal (dot: 1MHz single carrier, line: 2MHz single carrier, line-dot: 2-carrier signal)

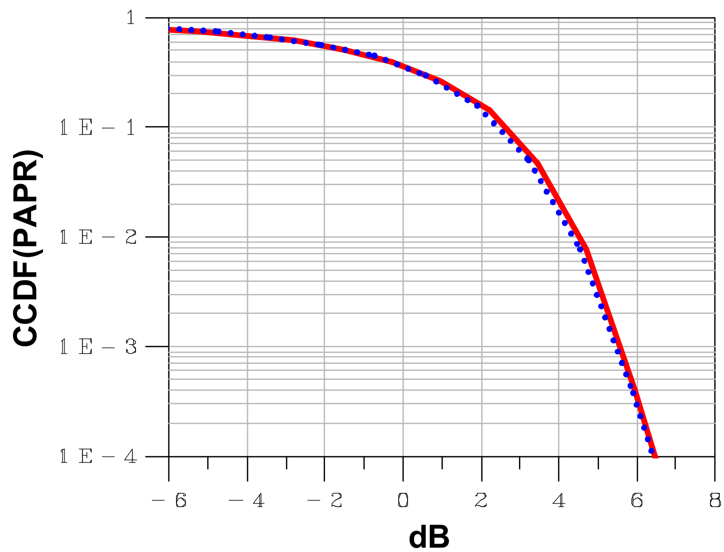


Figure 7. CCDF of 2-Carrier Signal and AM Signal of Polar Transmitter (dot: AM signal of polar transmitter, line: 2-carrier carrier)

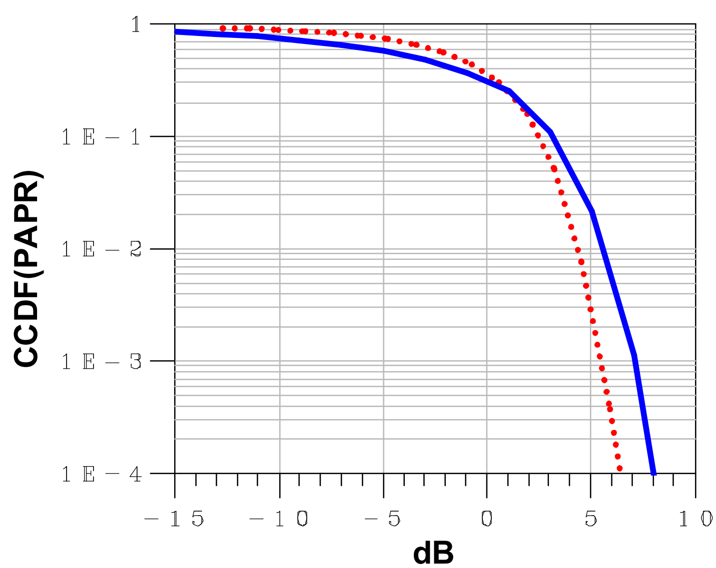


Figure 8. CCDF of AM and PM Signals of 2-Carrier Polar Transmitter (dot: AM signal, line: PM signal)

3. Conclusions

In this paper, the structure of a polar transmitter for generating two carriers has been examined. In the case of a polar transmitter generating two carriers, it can be seen that the bandwidth of the AM signal and the PM signal is significantly wider than the bandwidth of the individual signal. In addition, it can be seen that the CCDF of the PM signal is generally larger than the CCDF of the AM signal, and the CCDF of the 2-carrier signal is almost similar to the AM signal of the polar transmission signal. The results of this paper can be usefully used to design AM and PM paths of polar transmitters.

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