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A simulation of quadrature modulation/demodulation system for plasma diagnostics

プラズマ診断のためのIQ変調/復調システムのシミュレーション

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Based on quadrature signal theory, Agilent Technologies' Advanced Design System (ADS) software is introduced to simulate quadrature modulation/demodulation system in this paper. ADS provides easy-to-use interface, miscellaneous microwave components and quick simulation integration. As a consequence, it could be expected for new plasma diagnostics system design and simulation.

1. Introduction

In this paper, based on quadrature signal theory, conventional IQ modulation and demodulation simulations are presented in this paper. Both matlab and Advanced Design System (ADS) [1] simulations are shown and verified. This paper shows that: ADS software provides easy-to-use interface, miscellaneous microwave components and quick simulation integration; as a consequence, it is cost-effective and timely achievement software for new plasma diagnostics system design and simulation.

2. Quadrature Signal Theory

A quadrature signal (also called *complex signals*) is a two-dimentional signal whose value at some instant in time can be specified by a single *complex number* having two parts; what we call the *real* part and the *imaginary* part. Communications engineers use the terms *in-phase* and *quadrature* phase.

$$e^{j2\pi f_0} = \cos(2\pi f_0 t) + j\sin(2\pi f_0 t) \qquad (1)$$

Mathematical expression is shown in equation (1), where $\cos(2\pi f_0 t)$ is *real* part and $\sin(2\pi f_0 t)$ is *imaginary* part, their 3-D quadrature signal in time domain is shown in Fig. 1. As time increased, quadrature signal rotates in counter-clockwise direction on the complex plane.

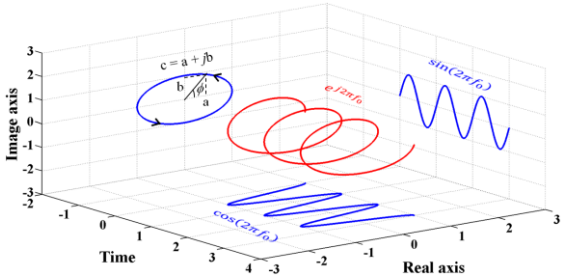


Fig. 1. 3-D quadrature signal (Matlab simulation).

3. IQ Modulation

The topology of IQ modulation is shown in Fig. 2. Mathematical expression of I and Q signals are shown in (2) and (3), respectively, and the 3-D IQ modulation signal in time domain is shown in Fig. 3. The front panel of ADS software and its simulation results are shown in Fig. 4 (a) and (b), respectively. Due to only the signal in real axis can be measured, the measurement signal is shown in Fig. 4 (b), and it is matched with that in matlab simulation.

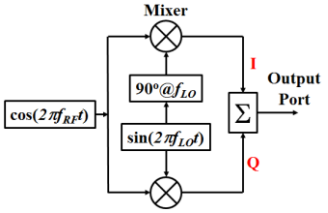


Fig. 2. Topology of IQ modulation.

I: $\cos(2\pi f_{RF}t)\times\cos(2\pi f_{LO}t)=$

$0.5\cos[2\pi(f_{LO}+f_{RF})t]+0.5\cos[2\pi(f_{LO}-f_{RF})t]$ (2)

Q: $\cos(2\pi f_{RF}t)\times\sin(2\pi f_{LO}t)=$

$0.5\sin[2\pi(f_{LO}+f_{RF})t]+0.5\sin[2\pi(f_{LO}-f_{RF})t]$ (3)

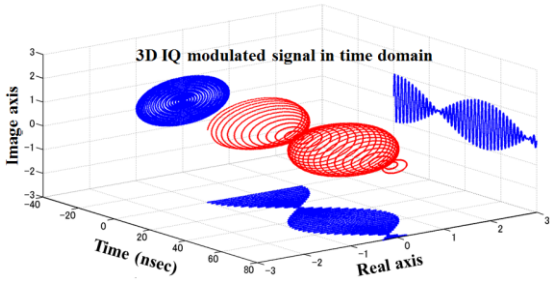
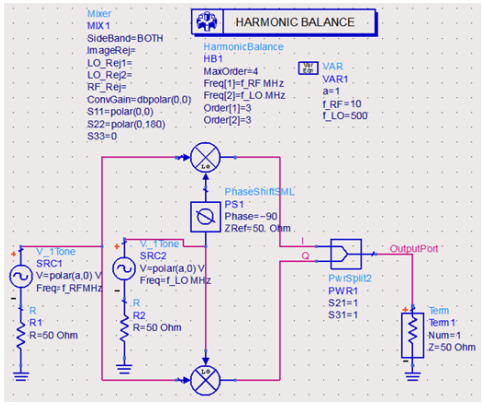
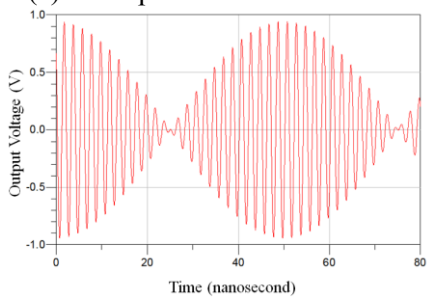


Fig. 3. IQ modulation signal (Matlab simulation).



(a) Front panel of ADS software



(b) Simulation result at output port

Fig. 4. ADS simulation of IQ modulation system.

4. IQ Demodulation

The topology of IQ modulation is shown in Fig. 5; its 3-D IQ demodulation signal in time domain is shown in Fig. 6, and ADS simulation is shown in Fig. 7. Two simulations are matched with each other very well.

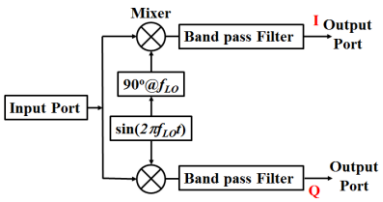


Fig. 5. Topology of IQ demodulation.

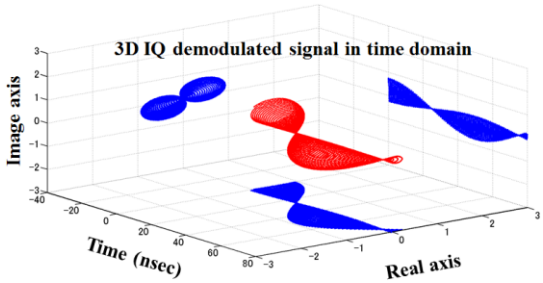
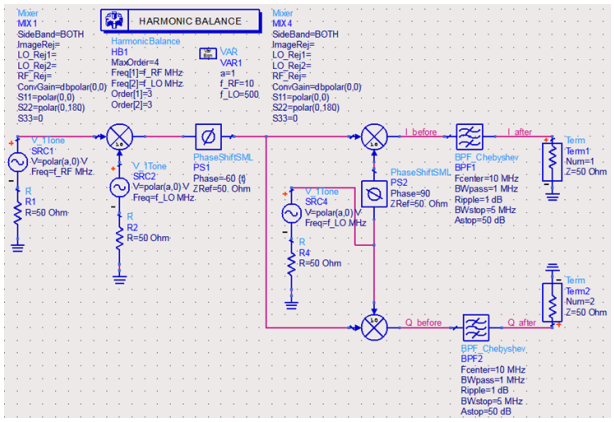
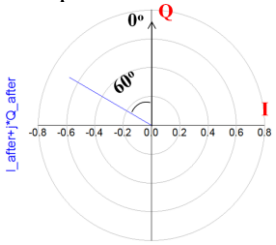


Fig. 5. IQ demodulation signal (Matlab simulation).



(a) Front panel of ADS software



(b) IQ signals at two output ports

Fig. 6. ADS simulation of IQ demodulation system.

5. Summary

Advanced Design System (ADS) software is introduced to simulate quadrature modulation/demodulation system in this paper. Matlab simulation and ADS simulation are matched with each other very well. Therefore, ADS could provide a quick and easy design method for new diagnostics applications.

Acknowledgments

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[1] Agilent Technologies Application "Agilent EEsof EDA Advanced Design System Circuit Design Cookbook".