# **Research and Simulation of DPSK Modulation**

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**Abstract.** This paper presents the modulation and implementation of DPSK (Differential Phase Shift Keying) modulation mode. And system simulation diagram is built by the software of Optisystem, which gets different time domain graphs and frequency spectrograms with different DPSK signals. Then we make a comparison according to the simulation results.

Keywords: Communication, DPSK modulation, Optisystem, frequency spectrogram.

# 1. Introduction

Today is in the era of information that grows explosively, large-capacity communication technology support will be needed urgently. DPSK modulation is gradually applied to the high-speed optic-fiber transmission systems due to its advantages of small channel spacing, strong anti-jamming capability, high band utilization and so on.

# 2. DPSK Modulation

In DPSK modulation mode, digital information is carried through the relative value of the phase before and after the information symbols. Assuming the phase difference between before and after the information symbols is represented by  $\Delta \varphi$ , when  $\Delta \varphi = 0$ , it means that the original digital code is 0. And when  $\Delta \varphi = 1$ , it means that the original digital code is 1. This modulation uses differential encoding and phase modulation in emission part while balance detection method in the receiving part, which shows the advantages that the optical signal to noise ratio is low, and the fluctuation tolerance of the reception signal power is large.

#### 3. Implementation of DPSK modulation

There are many ways to realize the DPSK modulation. The RZ-DPSK and CSRZ-DPSK are two modulation schemes most widely used at present. In the RZ-DPSK modulation format, the phase difference between the code 1 and code 0 is  $\pi$ . The difference between CSRZ-DPSK and RZ-DPSK modulation format is that the former superposes phase inverting features of adjacent pulses on the basis of the original signal, which can achieve the goal of more uniform and reasonable distribution of the signal phase.

The two modulation formats described above can be achieved by two-stage modulation mode. The generation schematic of RZ-DPSK and CSRZ-DPSK is shown as Fig.1.

Fig.1 shows the signal sent to the optic-fiber to transmit is produced by laser then forms modulation signal through two-stage MZ modulation. The first MZ is used to load data, the other is used to generate the clock signal pulse sequence. For the second stage modulator, if the bias voltage and cp signal are set differently, the duty cycle of RZ-DPSK signal will be different.

It should be noted that although the RZ-DPSK and CSRZ-DPSK signal are both DPSK modulation, the phase of both output signals is different. Because the bias value of CSRZ on MZ transfer curve is zero when CSRZ signal generated, which leads the phase between adjacent code elements appear alternating changes. So the two are somewhat different on the phase.



Fig.1. Generation block diagram of RZ-DPSK and CSRZ-DPSK

# 4. Simulation of DPSK signal

The system simulation block diagram (Fig.2) is built by the software of Optisystem, of which the modulation rate is 10Gbit/s.



Fig.2. Simulation block diagram of RZ DPSK and CSRZ modulation signal

Now input a NRZ signal of 10Gbit/s, when the parameters of sinusoidal clock signal generator and MZ2 modulator are set differently according to the modulation principle of DPSK signal, we can get simulation of DPSK (that is NRZ-DPSK), RZ-DPSK and CSRZ-DPSK signal. The output time-domain graphs and frequency spectrograms are relatively shown as Fig. 3.



(a) Output time domain diagram and frequency spectrogram of NRZ-DPSK signal





(c) Output time domain diagram and frequency spectrogram of 50% RZ-DPSK signal

![](_page_2_Figure_5.jpeg)

(d) Output time domain diagram and frequency spectrogram of 66% RZ-DPSK signal (CSRZ signal ) Fig.3. Simulation results of DPSK modulation

It can be seen that DPSK modulation signal has obvious advantages from the simulation diagrams above.

(1) Observing the frequency spectrograms, we can find that DPSK modulation signal has constant envelope characteristic, the power is pulled up at zero frequency, and the impact of sidelobes are reduced.

(2) The power spectrums of DPSK signal are all continuous spectrum rather than discrete spectrums components, so demodulation can be completed by means of the detection method of heterodyne balance. This way helps to improve the reception sensitivity and transmission power needed by system is relatively smaller. Meanwhile the decision threshold level of the receiver is 0, so that the receiver can keep the best working state.

(3) The nonlinear resistance ability of DPSK signal is stronger, but not ideal enough. RZ-DPSK signal and CSRZ-DPSK signal are two modified modulation signals mentioned above that have different duty cycles, which can improve the nonlinear tolerance of the signal significantly.

Compared with RZ-DPSK modulation signal, CSRZ-DPSK modulation signal has advantages as follows.

(1) Observing the frequency spectrogram, we can find that CSRZ-DPSK signal spectrum is narrower than that of RZ-DPSK signal, which makes the system enhance the ability to restrain high order PMD effect.

(2) CSRZ-DPSK modulation signal has better ability to restrain carrier components, and reduces sideband spectral interval, as CSRZ-DPSK can achieve  $\pi$  phase transition accurately. CSRZ-DPSK signal not only keeps the advantage of the RZ-DPSK on transmission performance, moreover it has better nonlinear redundancy and higher spectrum efficiency, mainly because the spectrum interval between the two main peaks is the same size as modulation rate.

(3) The crosstalk between channels when CSRZ-DPSK code transmitted is lower than that of RZ-DPSK.

It can be seen from the simulation results, DPSK modulation format has advantages in inhibiting nonlinear tolerance, channel crosstalk, PMD tolerance and so on, which determines it occupies an important place in the coherent optical communication system of high-speed, long-distance, large-capacity.

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