Power Spectral Density of Dicode Pulse Position Modulation .

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ABSTRACT

Dicode pulse-position modulation is a new modulation format, which has been found that offers improved sensitivity over digital PPM and multiple PPM. The power spectral density of that format theory has been described with mathematic equation and graph of that have been taken. Software simulation has been programmed and hardware (coder, decoder) have been constructed for the Dicode PPM theory. Also DiPPM's window has been development for the proper use of the software spectral analyzer. The reliability of both power spectrum density results has been described. Although, previous equation and graph of the power spectrum density of DiPPM, have been proved for its faultiness. At last found that the DiPPM format gives output signal with increased power than that of the input signal.

Keywords DiPPM (dicode pulse-position modulation), PSD (power spectrum density), PRBS (pseudo-random binary sequence),

1 THE DICODE PULSE-POSITION MODULATION SYSTEM.

DiPPM (dicode pulse-position modulation) is a novel coding scheme for optical-fibre communication. Previous pulse position modulation schemes have been proposed such digital pulse-position modulation which operates with higher data rates than its pulse code modulation (PCM) counterparts. It does offer a better sensitivity, however, the final line rate can be very high and this limits its usefulness. An exception is multiple PPM which, although it can run at slower speeds than digital PPM, does require complex decoding logic and this limits its appeal [1]. Another technique magnetic recording is the dicode technique. There is some interest in using it in optical fibre links, as with this signaling format, only data transitions are sent and no signal is transmitted when data is constant. DiPPM is an original coding scheme that combines dicode and digital PPM to form dicode pulse-position modulation. Like digital PPM, this new scheme offers a better sensitivity than PCM. However, unlike digital PPM, the DiPPM system achieves this with only twofold increase in speed. Original theoretical results show that a simple, leading-edge, threshold-detection, dicode PPM system gives sensitivities slightly better than that of digital PPM at high fibre bandwidths, whereas for low fibre bandwidths, the sensitivity is significantly greater [2-3].

This paper describes the power spectral density (PSD) of DiPPM. Hardware (coder/decoder) and software simulation of DiPPM theory have been constructed and compared, to confirm the results. Also previous mathematical results [4] of the DiPPM power spectral density have been compared with and analyzed.

2 POWER SPECTRAL DENSITY OF DiPPM (RESULTS/COMPARISON).

Hardware circuit of DiPPM has been constructed (coder / decoder) and tested. The coder /decoder tested with BER to confirm correct operation, the PSD measurement with pseudo-random binary sequence input have been taken Fig 1. A software simulation of the DiPPM theory has been programmed. Although it satisfies the theory, the result did not match with the hardware's result. For that reason, measurement of PSD have been taken with input PCM same to a clock (1,0,1,0,1,0…..) Fig 2. Running the software with the same PCM input the results still did not much. The PSD did give the right power at the frequency of 60 MHz and its multiplied values by two, but it did not show any power at the frequencies of 120 MHz and its multiplied values by two. Comparison of the PSD with different spectral analyzers showed that the software program could not simulate exactly as a spectral analyzer. Solution of the problem was to construct a window (w) that simulate the software spectral analyzer as a real spectral analyzer do perform.

To estimate the power spectral density (PSD) of a signal, periodogram have to be used,

periodogram(x,[],'twosided', nfft,Fs); (1)

where x is the sequence, [] is a default rectangular window, 'twosided' converts the spectrum to a spectrum calculated over the whole Nyquist interval, nfft is the integer that specifies the length of the FFT and Fs specified as an integer in hertz (Hz) to compute the PSD vector and the corresponding vector of frequencies. The periodogram for a sequence [x1, ... , xn] is given by the following formula:

$$S(e^{j\omega}) = \frac{1}{n}\left|\sum_{l=1}^{n} x_l e^{-j\omega l}\right|^2 \tag{2}$$

The DiPPM window that gives the simulating performance of a spectral analyzer is:

w=(15/1)-((1/38)(cos(2*pi*f*Ts)))+((1/24)*(cos(4*pi*f*Ts)))-((1/16)*(cos(6*pi*f*Ts)))+((1/23)*(cos(8*pi*f*Ts)));*

The periodogram of (1) is going to be at the form of:

periodogram(dippm_signal_time,w,'onesided',1024,Sampling_frequency); (3)

Because even now there is problem with the values of the power (dB), (3) will be change to the form of:

*periodogram(dippm_signal_time*6000,w,'onesided',1024,Sampling_frequency);* (4)

DiPPM output signal has been multiplied by 6000 to reach the power that the graph of the spectral analyzer has. At that point, both PSD graphs (equipment’s and software’s) look the same. As the condition of the software spectral analyzer is the same with that of the real, PRBS input have been set to the software simulation. The graph that has been given is the same with the experiment’s result. Figure 3 shows the software PCM power spectral density and figure 4 PSD with PRBS input. The difference at the magnitude that can be seen at the graphs is not important as it can change through the software and the powers will remain the same. The periodogram of the weighed signal sequence by the window is equal to:

$$S(e^{j\omega}) = \frac{\frac{1}{n}\left|\sum_{l=1}^{n} w_l x_l e^{-j\omega l}\right|^2}{\frac{1}{n}\sum_{l=1}^{n} |w_l|^2} \tag{5}$$

3 POWER SPECTRAL DENSITY OF DiPPM (COMPARISON WITH PREVIOUS RESULTS).

Previous results have been shown the power spectrum density of the DiPPM format. Based on the signal processing theory and with a mathematical explanation the equation for PSD of the DiPPM has shown as:

x=(A^2)*(Ts)*((sin(pi*f*Ts)/(pi*f*Ts))^2)*(3/32)-((1/32)*(cos(2*pi*f*Ts)))+((1/32)*(cos(6*pi*f*Ts)))-((1/16)*(cos(8*pi*f*Ts)))+((1/32)*(cos(10*pi*f*Ts))); (6)

It's easy to understand the error by the view of the above equation (6), as it can not give the power at at the second harmonic if the input frequency. That happens because at this equation no continuity exists and no power of the 240 MHz (based the value of the experiment that section 2 describes with input 120 MHz) at the PSD graph is going to exists. Plot in shows the second harmonic, but the equation (6) can not produce it. Modification of the equation (6), based on the plot [4] gives the equation:

x=(A^2)*(Ts)*((sin(pi*f*Ts)/(pi*f*Ts))^2)*(3/32)-((1/32)*(cos(2*pi*f*Ts)))+((1/32)*(cos(4*pi*f*Ts)))-((1/16)*(cos(6*pi*f*Ts)))+((1/32)*(cos(8*pi*f*Ts))); (7)

Figure 5 shows the graph that has been result of the equation (7). Using the equation in the software simulation, gives the graph of the Fig.5 at nfft equal to 512 and the graph of Fig. 6 using at nfft equal to 1024. The result remains the same even with default window ([]) or with DiPPM window (w).

4 EXPERIMENTAL RESULTS.

DiPPM's power spectral density has been shown at section 2. Proof of its reliability, is the similarity of the results that gives the DIPPM software simulation and its hardware through measurements that have been taken. Although, the graphs of the figures 5 and 6, where are function of equation (6), do not agree with them. Equation 6 can not be accepted as DiPPM's equation that gives the power spectrum density, which its result is similar to PCM power spectrum density. The power of DiPPM increase as the frequency increases (Fig. 1-4)

5 CONCLUSIONS.

Coder and decoder of the theory have been constructed with low cost and simulation software has been programmed. For the first time, the power spectrum density of the new modulation format DiPPM has been shown. Also mathematical equation for the DiPPM window (w) have been described and used to mathematical software for the proper simulation of the theory.

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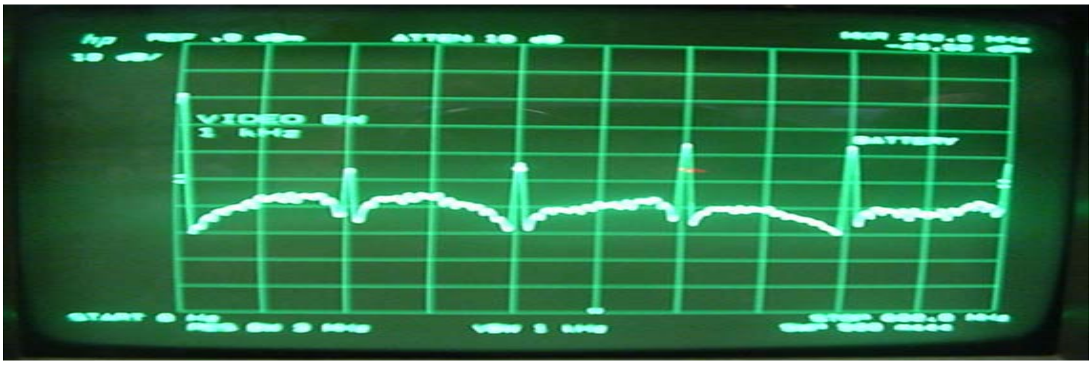

Fig. 1: PSD of PRBS DiPPM (Measurements)

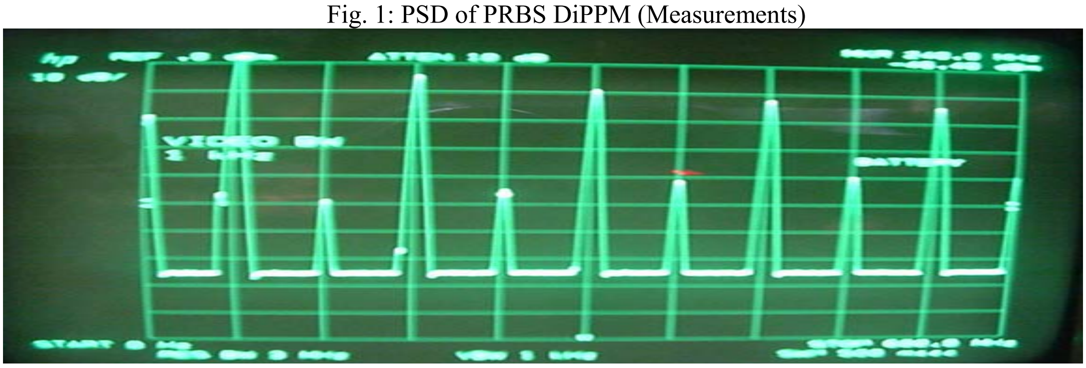

Fig.2: PSD of PCM {1,0,1,0,1,0,1,0,1…} (Measurements)

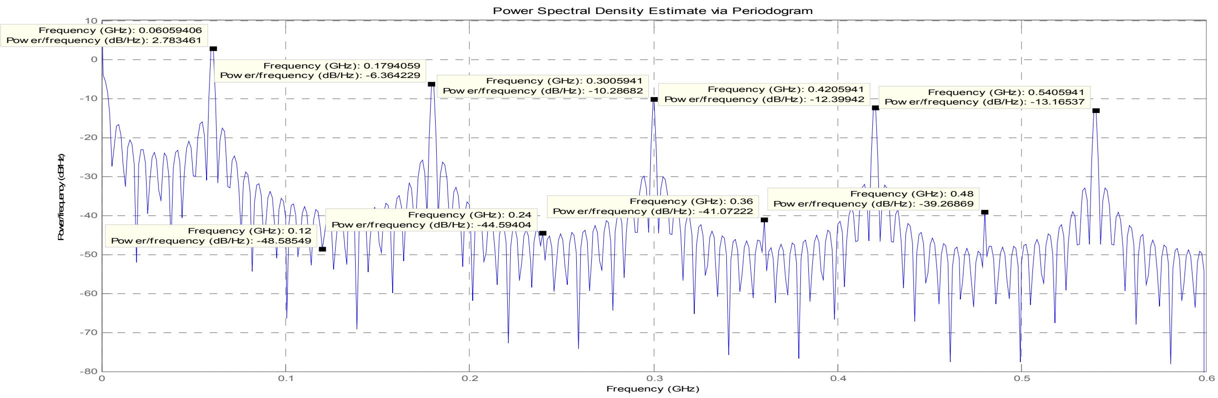

Fig 3.: PSD of PCM {1,0,1,0,1,0,1,0,1…} (Matlab)

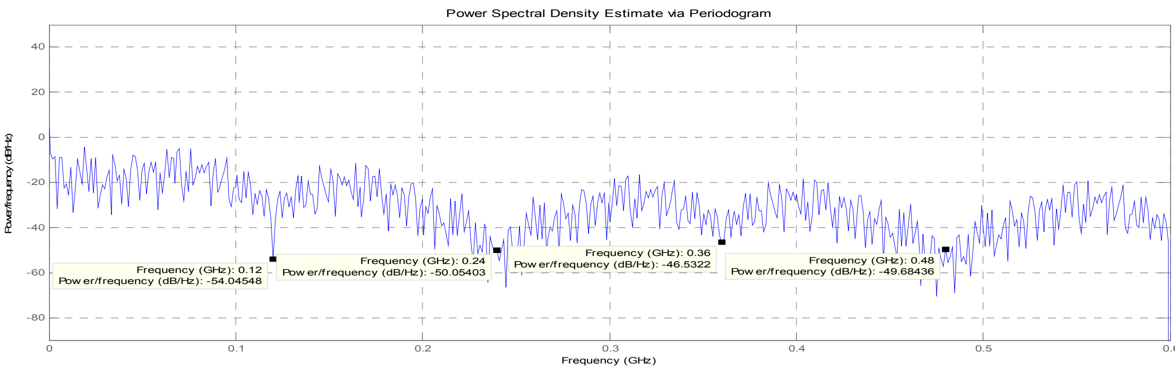

Fig.4: PSD of PRBS DiPPM (Matlab)

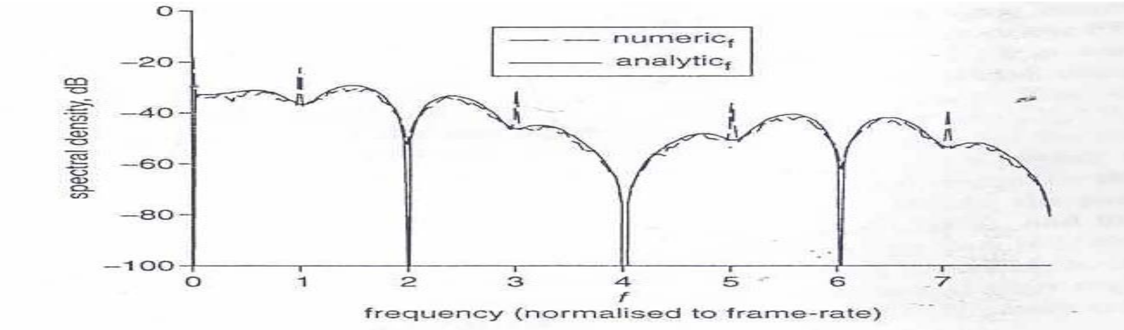

Fig.5: PSD of equation (6)

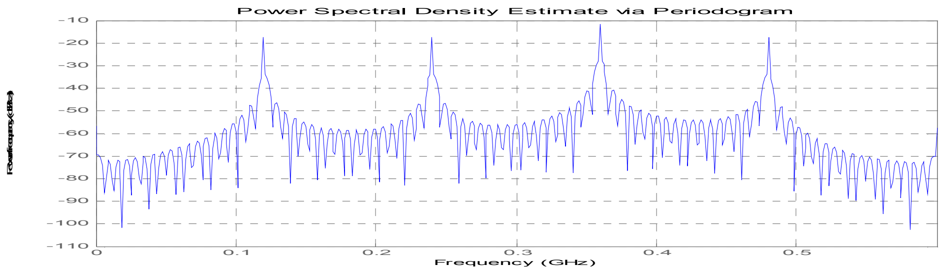

Fig.6: PSD of equation (6) (Matlab)