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Design and Simulation of Pulse Code Modulation Multiplexing (PCMM) and De-Multiplexing Technique in MATLAB

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Abstract --- Pulse Code Modulation Multiplexing PCMM is a part of transmitting multi analog signals through single channel, PCM Can be implanted by passing information signals through Quantizer using MATLAB simulink and recovered (De-multiplexing) the information with the use of multi low pass filters LPF according to each frequency signal that been sent, Auto correlation and cross correlation tests were applied on the multi input signal to improve the inequality and no interference between multi input signal, delay time at the receiver is overcoming by reducing the order of LBFs and using delay block from Simulink library.

Keywords-- PCMM, Multiplexing techniques, PCM with MATLAB, PCMM simulation.

I. INTRODUCTION

Pulse Code Modulation Multiplexing (PCMM) is a system where multiple analog signals can be encoded as part of transmitting process without interfering between information frequencies. Each signal waveform is quantized and represented to sufficient accuracy by an appropriate code character. Each code character is composed of a specified number of code elements. The code elements can be chosen as two-level, or binary; three-level, or ternary; or *n*-ary. However, general practice is to use binary, since it is not affected as much by interference introduced by the required increased bandwidth. This binary stream code which represents the multi input information signals is transmitted over signal channel then de-multiplexed at the receiver according to each frequency signal [1,2]. The motivation behind modern PCM is that improved implementation techniques of solid-state circuitry allow extremely fast quantization of samples and translation to complex codes with reasonable equipment constraints [3]. PCM is an attractive way to trade bandwidth for signal-to-noise and has the additional advantage of transmission through regenerative repeaters with a signal-to-noise ratio that is substantially independent of the number of repeaters [1,2].

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II. PULSE CODE MODULATION MULTIBLEXING AND DEMULTIPLEXING MODEL

There are three steps in the development of a PCM signal from that analog model [1]:

1. Sampling;
2. Quantization; and
3. Coding.

As is illustrated in Figure 1 and 2, PCM multiplexing is carried out with the sampling process, sampling the analog sources sequentially. These sources may be the nominal 4-kHz voice channels or other information sources that have a 4-kHz bandwidth, such as data or freeze-frame video. The final result of the sampling and subsequent quantization and coding is a series of electrical pulses, a serial bit stream of 1s and 0s (1s and zeros are the binary translation of quantizer levels according to table 1[1]) that requires some identification or indication of the beginning of a sampling sequence, This identification is necessary so that the far-end receiver know exactly when the sampling sequence starts. Once the receiver receives the "indication," it knows a priori (in the case of DS1) that 24 eight-bit slots follow. It synchronizes the receiver. Such identification is carried out by a *framing bit*, and one full sequence or cycle of samples is called a *frame* in PCM terminology [1, 4].

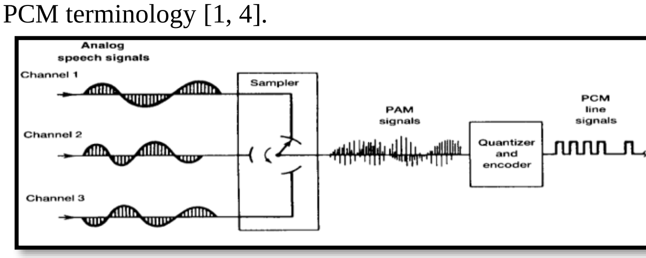

Figure 1 : pulse code modulation multiplexer (PCMM)

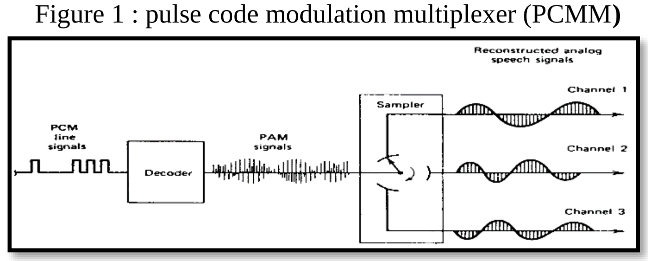

Figure 2 : pulse code modulation De-multiplexer (PCMM)

Table 1

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Quantizer level	CODE	Quantizer level	CODE
0	0000	8	1000
1	0001	9	1001
2	0010	10	1010
3	0011	11	1011
4	0100	12	1100
5	0101	13	1101
6	0110	14	1110
7	0111	15	1111

III. PULSE CODE MODULATION MULTIBLEXING PCMM SIMULATION

Pulse code modulation multiplexing transmitter is illustrated in figure 3. Where MATLAB Simulink 2012 is used [5]:

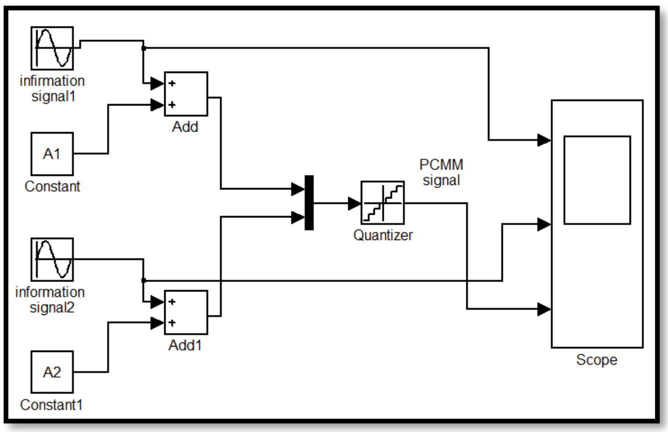

Figure 3 : PCMM transmitter

In figure above set the time of simulation to (5) ,Information signals are first shifted by its amplitude above zero axes and then multiplexed to Quantizer which representing the analog signals of the amplitude by a finite set of levels. It converts a continuous-amplitude signal to a continuous -amplitude sample.

Input and Output PCMM transmitter signals are shown in figure 4,

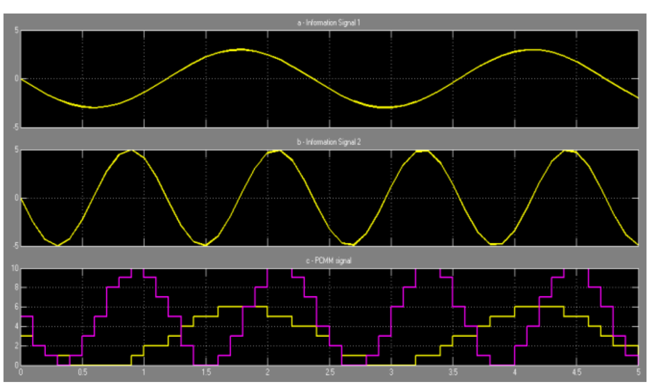

Figure 4 : a – information signal 1, b- information signal 2, c- PCMM signal

PCMM signal as mentioned above is converted to a serial binary code that called digital pulse code modulation D-PCM signal as shown in figure 5 and 6. Where signal 1 converted to 3-bit for each level of quantized signal, while signal 2 converted to 4-bit for each level of quantized signal.

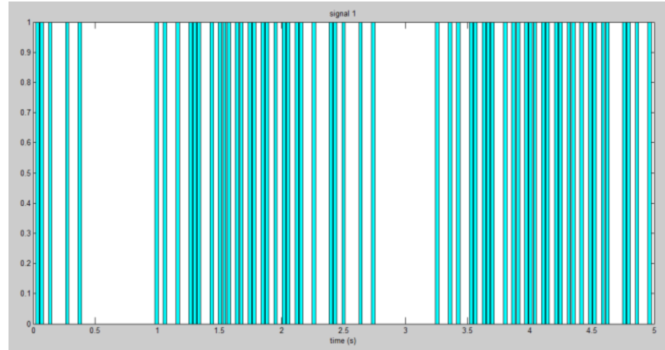

Figure 5: Signal 1 binary waveform.

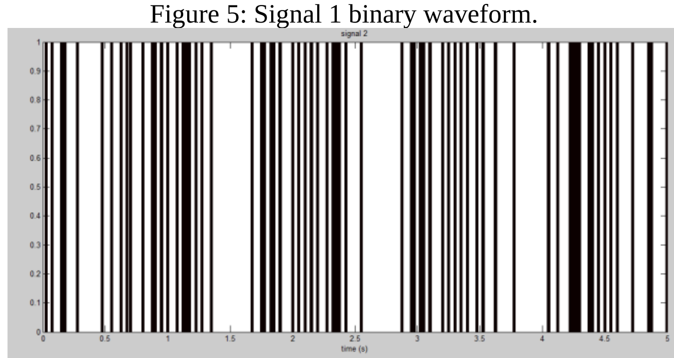

Figure 6: Signal 2 binary waveform.

Auto correlation test is applied on both binary signals as shown in figure 7 and 8. Where those figures shows main loop at the zero and side loops less than the threshold axes of 0.2, this prove the inequality between input signals[6].

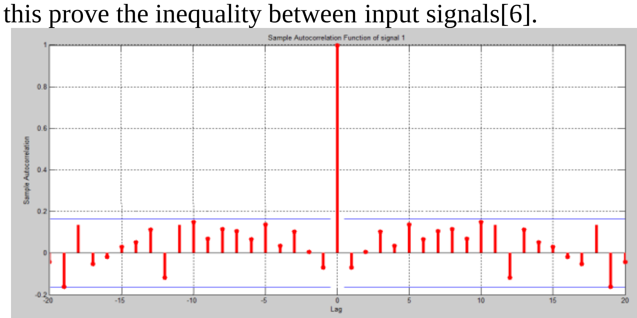

Figure (7) Autocorrelation test on signal 1

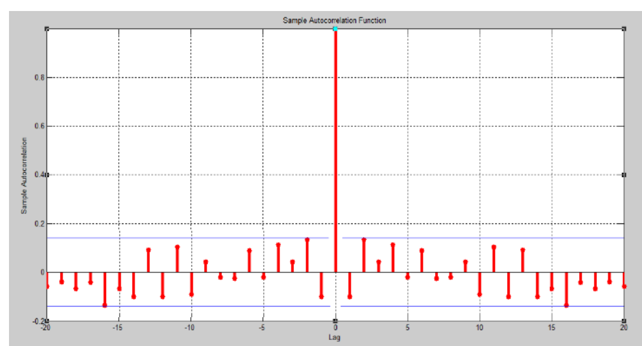

Figure (8) Autocorrelation test on signal 2

Cross correlation between binary signal 1 and binary signal 2 shown in figure 9, the test shows cross correlation (crosstalk) between signals less than 0.1, so quantization of input signals reduces the crosstalk between input signals [7].

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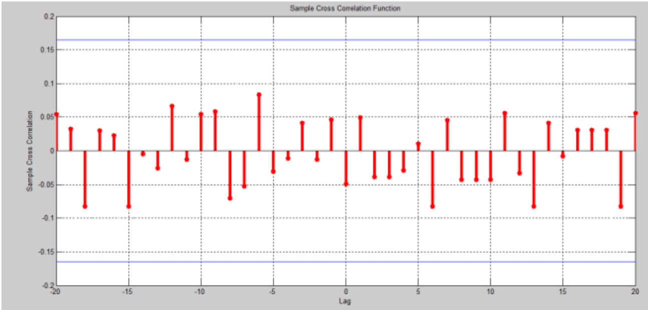

Figure (9) Cross correlation test between signal 1 and signal 2

IV.PULS CODE MODULATION DE- MULTIPLEXING SIMULATION

Transmitted digital signals in section 2 are de-multiplexed in figure 10, where multi Low pass filter are used to re-cover the input signal, then re-shifted by its amplitude A_1, A_2 and amplified by K.

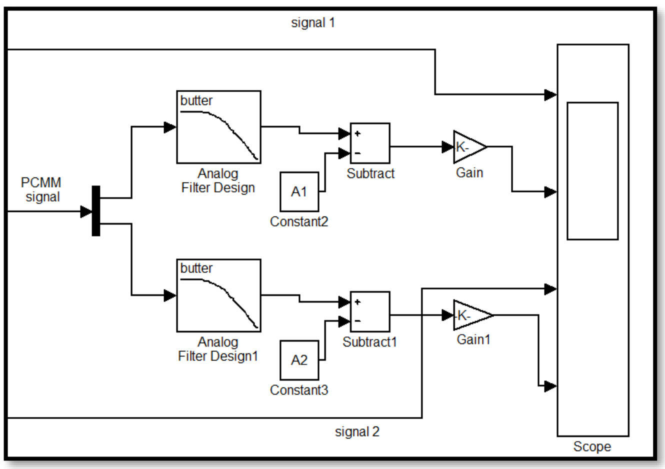

Figure 10: PCM De-Multiplexing

Waveforms at the scope can be shown in figure 11.

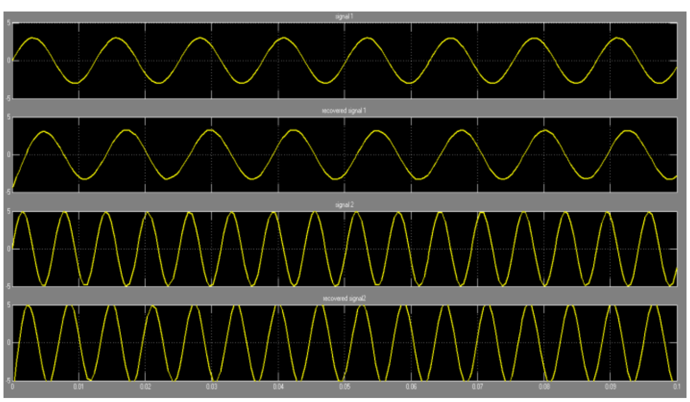

Figure 11 : a. Signal 1, b. Signal 2, c. Recovered signal 1, d.Recovered signal2

From this figure it could be shown that the recovered signal had a delay time. Delay time τ of signal 1 is 0.002s and signal2 $\tau = 0.001$s. since $f_1 < f_2$ so $\tau_1 > \tau_2$.

To overcome the delay time τ on the recovered signal, two methods are used:

1. Reduce the order of low pass filter[8,9].
2. Using the delay block in the simulation model as shown in fig 10[8,9].

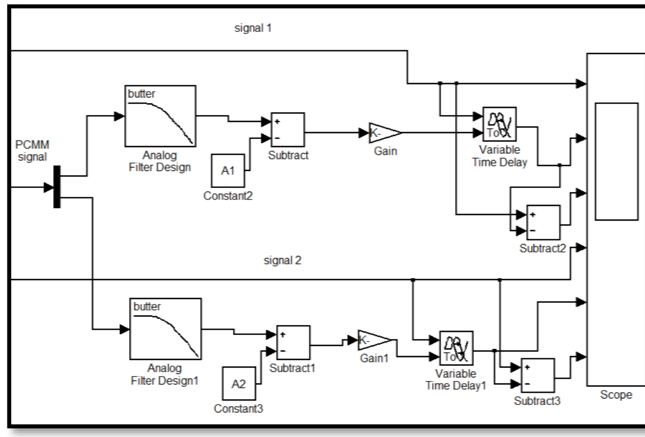

Figure 12: PCMM De-multiplexing with time delay cancelation.

Output signals of figure 12 are shown in figure 13, where the delay time in recovered signals canceled.

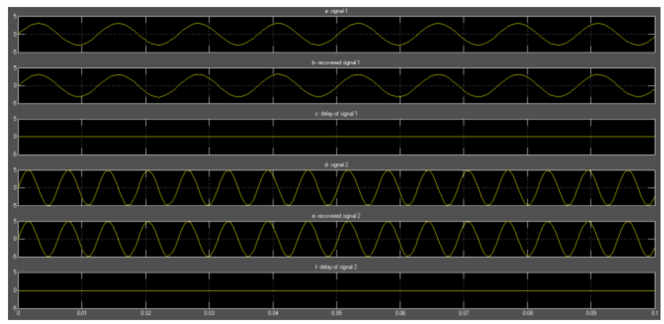

Figure 13 : a. Signal 1, b. Recovered signal 1, c. delay of signal 1 d. Signal 2, e. Recovered signal2 , f. delay of signal 2

V.CONCLUSION

Pulse code modulation multiplexing and de-multiplexing was implemented in Matlab Simulink with high performance in both autocorrelation and cross correlation on the transmitting multi input signals which mean high inequality and no interference between input signal , at the receiver time delay had overcame by reducing order of the low pass filter and delay block in Matlab Simulink laibrary.

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