Scientech 2804

4-Channel TDM-PCM Modulator and Demodulator

Product Tutorials

Ver. 1.1

Designed & Manufactured in India by-
An ISO 9001:2008 company

Scientech Technologies Pvt. Ltd.

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4-Channel TDM-PCM Modulator and Demodulator

Scientech 2804

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Safety Instructions

Read the following safety instructions carefully before operating the product.

To avoid any personal injury, or damage to the product, or any products connected to it;

Do not operate the instrument if you suspect any damage within.

The instrument should be serviced by qualified personnel only.

For your Safety:

Use proper Mains cord : Use only the mains cord designed for this product. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This product is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

Use only the proper Fuse : Use the fuse type and rating specified for this product.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Features

- **Modulator and Demodulator on same board**
- **On-board four DDS Signal Generator for Standard and Arbitrary signals**
- **Selectable Sampling frequencies**
- **On board four 2nd order Butterworth Low Pass filter**
- **SMD LED indicators**
- **Compact and Light Weight**
- **Can be issued just like a book for hands-on learning**

Technical Specifications

Modulation & Demodulation Techniques	:	Two channel TDM-PCM. Four channel TDM-PCM.
Internal Signal Generator	:	Four dedicated Direct Digital Synthesizer Generators for each channel.
Types of Signal	:	Sine, Square, Arbitrary signal.
Frequency	:	500 Hz, 1 KHz, 1.5 KHz, 2 KHz, 3 KHz.
SMD LED Indicators	:	54 nos. for DDS signal selection. DDS signal frequency selection. Sampling selection. Technique selection. Interconnect path.
Crystal Frequency	:	8 MHz.
Sampling Frequencies	:	8 KHz, 16 KHz, 32 KHz.
Selection Mode	:	Push switches.
Number of Test Points	:	40 nos.
Low Pass Filter	:	4nos. Cut-off frequency-5 KHz.
Dimensions (mm)	:	W 326 x D 252 x H 52.
Power Supply	:	110V - 260V AC, 50/60Hz.
Weight	:	1.5kg (Approximately).
Operating Conditions	:	0-40^0 C, 85% RH.
Included accessory	:	2mm Patch cord - 2nos. TechBook Power Supply-1no.

TDM-PCM Modulation and Demodulation

Introduction:

What is TDM PCM?

Time Division Multiplexing (TDM), transmissions from multiple sources occur on the same facility but not at the same time. Transmission from various sources is interleaved in the time domain PCM is the most prevalent encoding technique used for TDM digital signals. With a PCM- TDM system, two or more voice channels are sampled, converted to PCM codes, and then time-division-multiplied onto a single metallic or optical fiber cable.

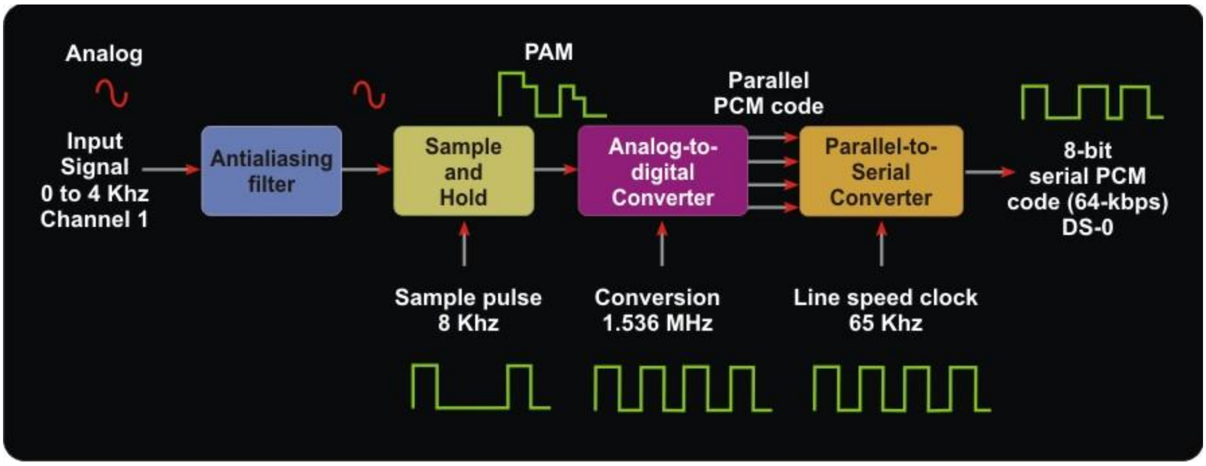


Figure shows the simplified block diagram for a single-channel PCM system. As figure shows single channel using an 8 KHz sample rate and an eight-bit PCM code, which produces a 64 kbps PCM line speed:

$$Line\ Speed = \frac{8000\ samples}{second} * \frac{8\ bits}{sample}$$

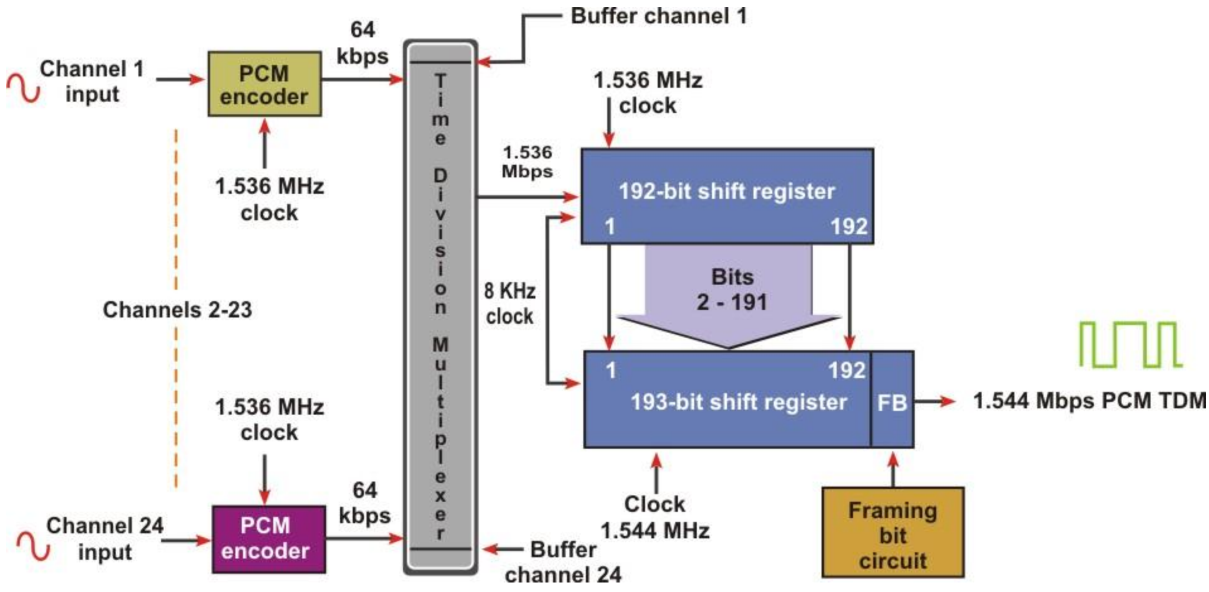
$$= 64{,}000\ bps$$

Generalized formula for line speed:

$$line\ speed = \frac{no.of\ channel}{frame} * \frac{8000\ frames}{second} * \frac{8\ bits}{channel}$$

How TDM-PCM works?

A digital carrier system is a communications system that uses digital pulse rather than analog signals to encode information. Figure given below shows the block diagram for T1 digital carrier system. T1 stands for transmission one and specifies a digital carrier system using PCM-encoded analog signals. A T1 carrier system time-division multiplexes PCM-encoded samples from 24 voice-band channels for transmission over a single metallic wire pair or optical fiber transmission line. Each voice-band channel has a bandwidth of approximately 300 Hz to 3000 Hz. Again, the multiplexer is simply a digital switch with 24 independent inputs and one time-division multiplexed output. The PCM output signals from the 24 Voice band channels are sequentially selected and connected through the multiplexer to the Trans- mission line.



With a T1 carrier system, D-type channel banks perform the sampling, encoding, and multiplexing of 24 voice-band channels. Each channel contains an eight-bit PCM code and is sampled 8000 times a second. Each channel is sampled at the same rate but not necessarily at the same time. Each channel's sample is offset from the previous channel's sample by 1/24 of the total frame time. Therefore, one 64 kbps PCM-encoded sample is transmitted for each voice-band channel during each frame (a frame time of 1/8000= 125 μS). The line speed is calculated as follows:

$$24\frac{channels}{frame} * 8\frac{bits}{channel} = 192\ bits\ per\ frame$$

Thus,

$$192\frac{bits}{frame} * 8000\frac{frames}{second} = 1.536\ Mbps$$

Later, an additional bit (called the framing bit) is added to each frame. The framing bit occurs once per frame (8000-bps rate) and is recovered in the receiver, where it is used to maintain frame and sample synchronization between the TDM transmitter and receiver. As a result, each frame contains 193 bits, and the line speed for a T1 digital carrier system is:

$$193\frac{bits}{frame} * 8000\frac{frames}{second} = 1.544\ Mbps$$

Two Channel TDM-PCM

A two channel system, one sample is taken from each channel during each frame, and the time allocated to transmit the PCM bits from each channel is equal to one-half the total frame time. Figure shows the TDM frame allocation for a two channel two-channel PCM system with an 8 KHz sample rate. Therefore, eight bits from each channel must be transmitted during each frame. Thus, the line speed at the output of the multiplexer is

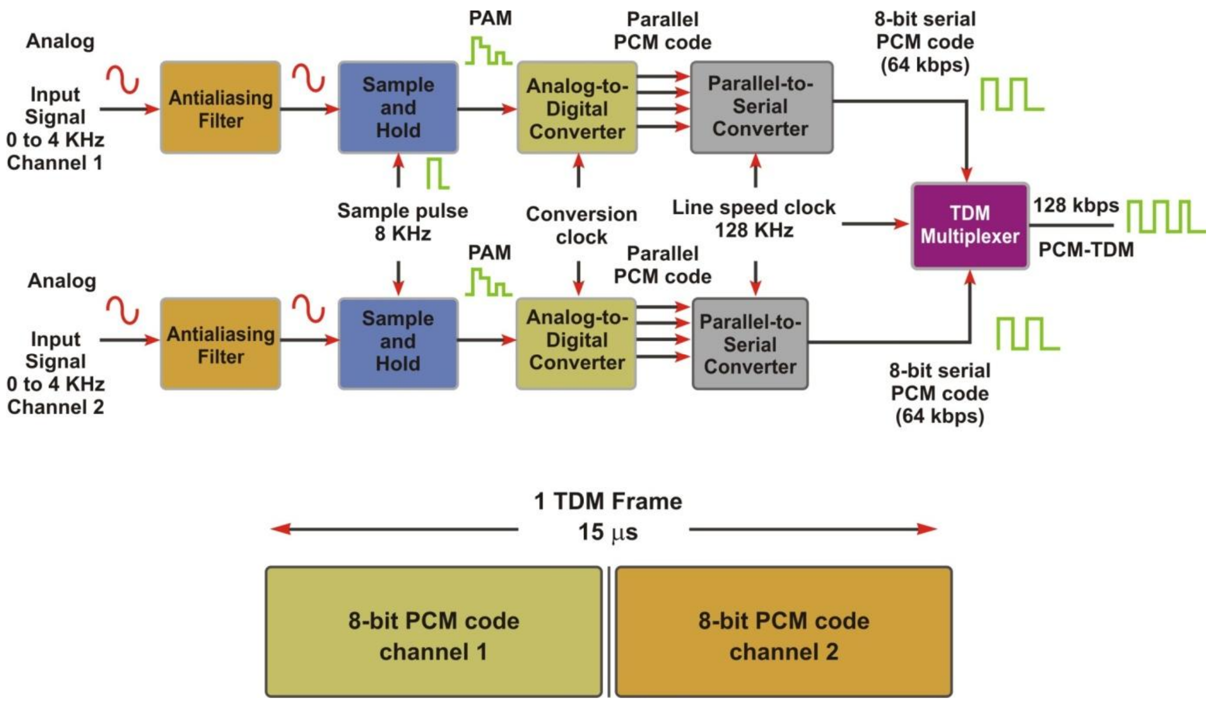
$$\frac{2\ channel}{frame} * 8000\frac{frames}{second} * 8\frac{bits}{channel} = 128\ kbps$$

For 2-channel each frame contains 16-bits so line speed will be

$$16\frac{bits}{channel} * \frac{channel}{frame} * 8000\frac{frames}{second} = 128\ kbps$$

Then, after adding single bit (total 17-bit) bit rate will be

$$17\frac{bits}{channel} * \frac{channel}{frame} * 8000\frac{frames}{second} = 136\ kbps$$



Experiment 1

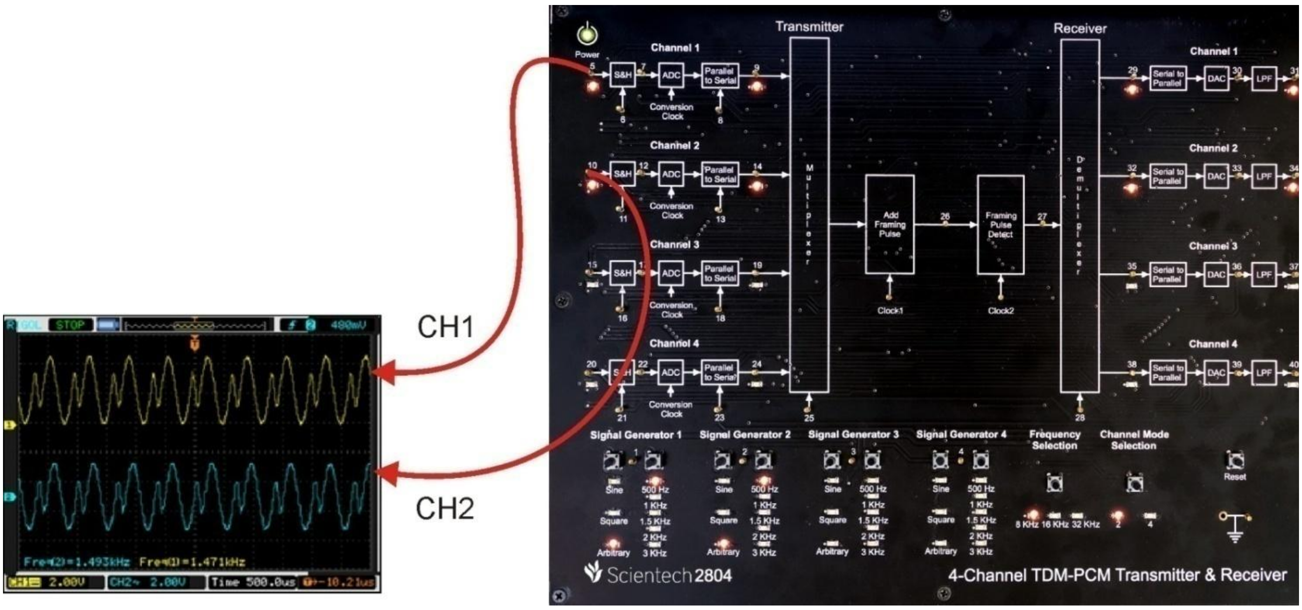
Objective:

- Observe Input signal by the following Signal frequency
  - 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz.
- Observe the sample and hold signal by varying the sampling clock i.e.
  - 8 KHZ, 16 KHZ, 32 KHZ.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

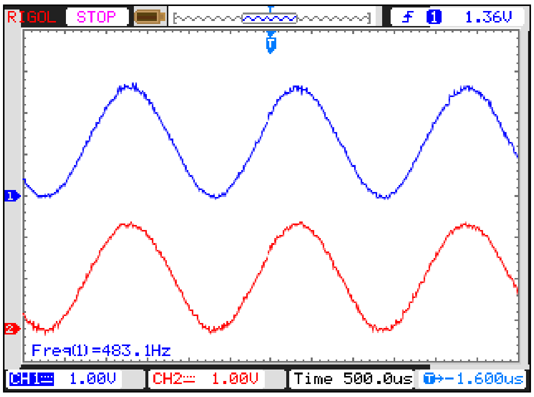
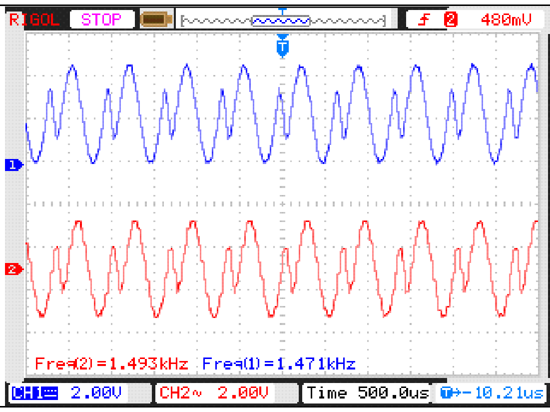
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

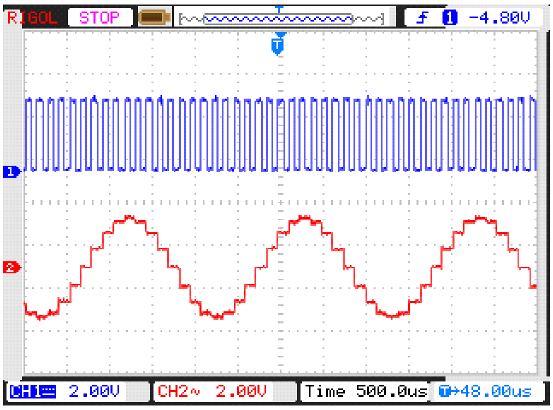
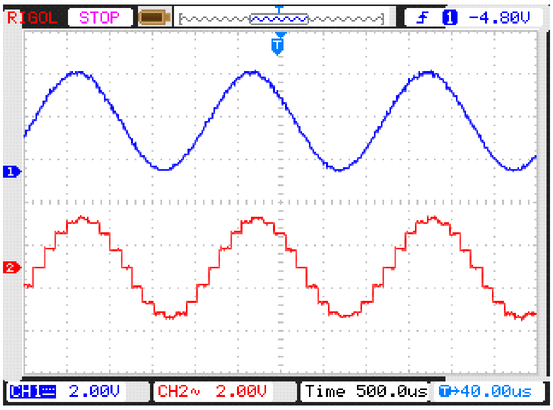
Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2.* And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHZ and 32 KHZ. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Output Waveforms
Sine/500 Hz	Channel1	-	 CH1: Input Signal (TP1), CH2: Channel1 Input(TP5)
Arbitrary /1.5 KHz	Channel2	-	

			CH1: Input Signal (TP2), CH2: Channel1 Input (TP10)
Sine/500 Hz	Channel1	8 KHz	 CH1: Sampling Clock(TP6), CH2: Sampled Output(TP7)
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Sampled Output(TP7)

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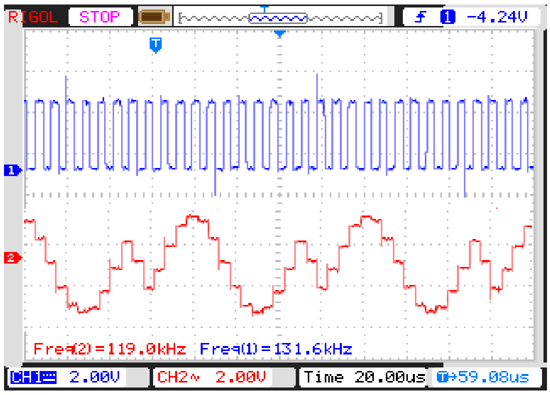
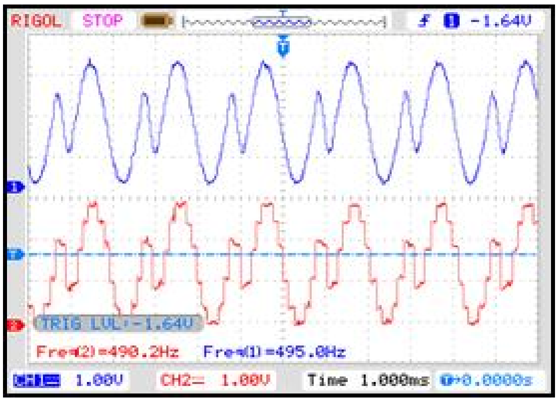
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP11), CH2: Sampled Output(TP12)
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP10), CH2: Sampled Output(TP12)

Experiment 2

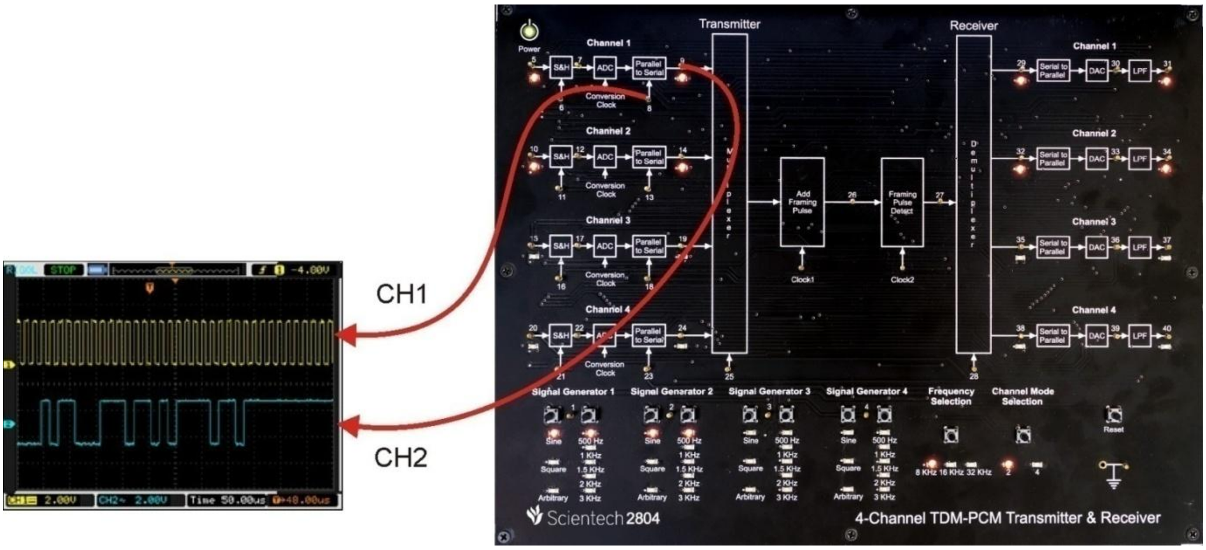
Objective:

Observe the PCM clock and PCM output by varying the line speed frequency.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

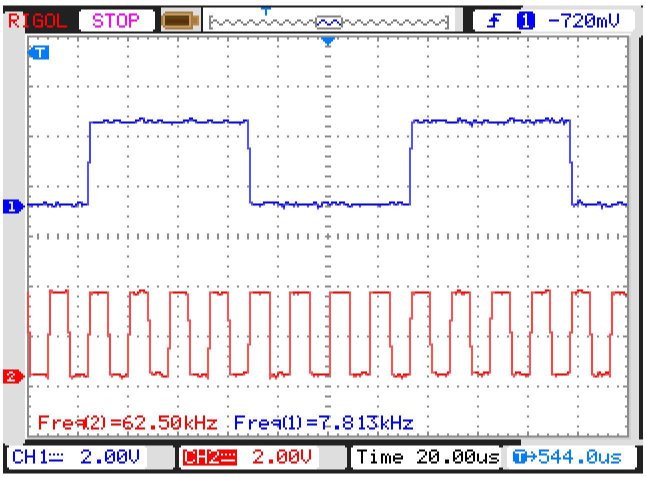
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

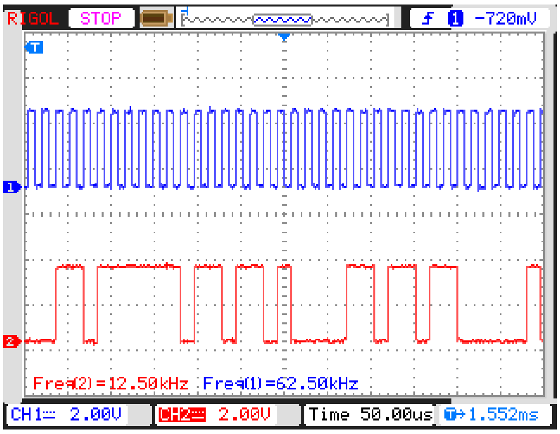
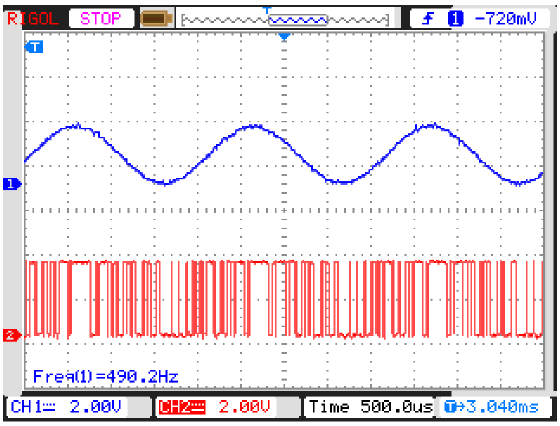
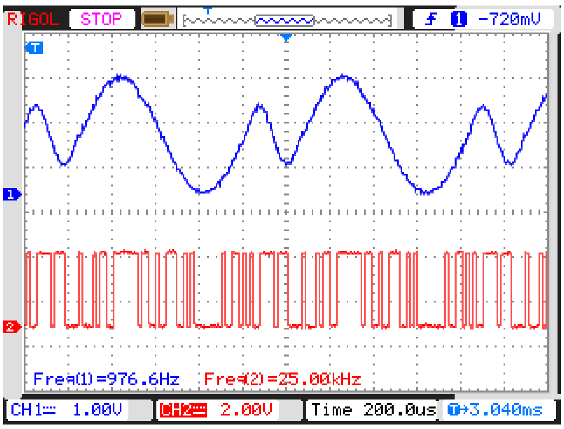
Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8 & TP13 and PCM output at TP9 & TP14.



CH1: Sampling Clock (TP6/TP11), CH2: Line Speed Clock (TP8/TP13)

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: PCM Clock (TP8), CH2: PCM Output (TP9)
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: PCM Output (TP9)
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP10), CH2: PCM Output (TP14)

Experiment 3

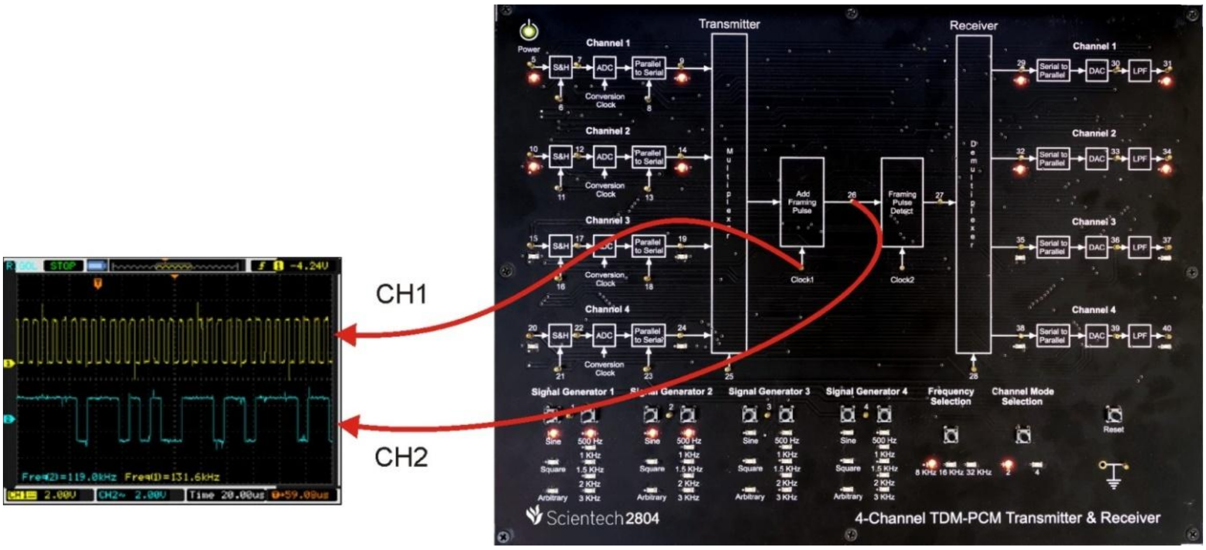
Objective:

Observe the 17 bit frame of multiplexed output with added framing pulse.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

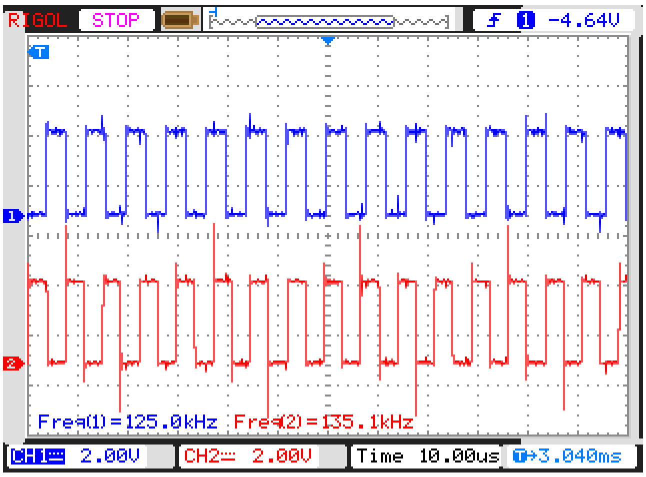
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2.* And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

1. Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
2. Observe the same input signal at TP5 and TP10.
3. Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
4. Observe the line speed clock at TP8 & TP13 and PCM output at TP9 & TP14.
5. Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.

I/P Signal Type/ Freq.	Sampling Freq.	Sampled Output
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP25), CH2:Clock for 17 bits frame (TP clock1)

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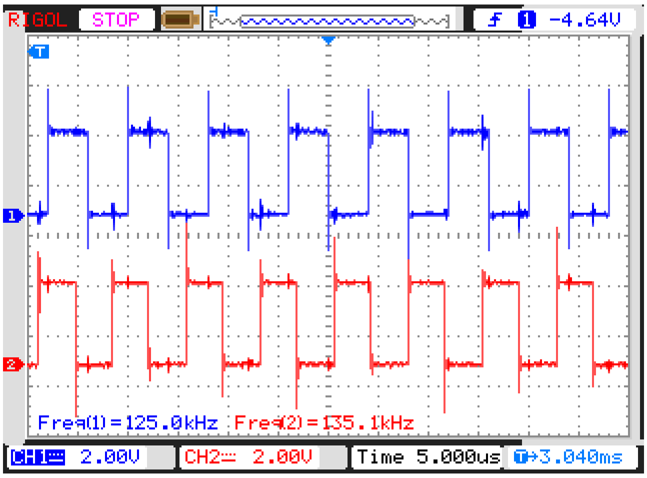
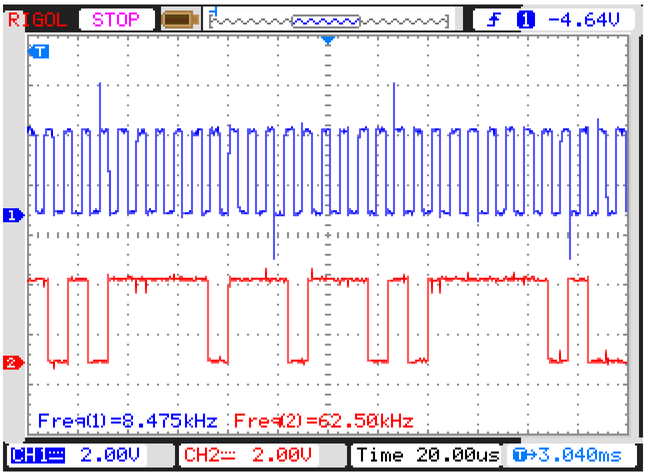
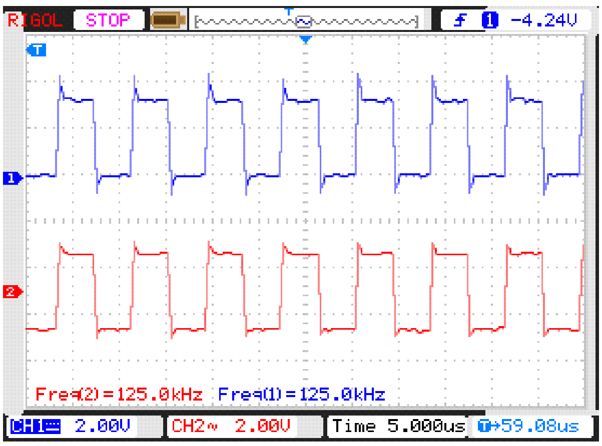
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP25), CH2: Clock for 17 bits frame (TP clock1)
Sine/500 Hz	8 KHz	 CH1: Clock for 17 bits frame (TP clock1), CH2: 17 bits frame (TP 26)
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP25), CH2: Clock at detecting Frame bit(TP clock2)

Experiment 4

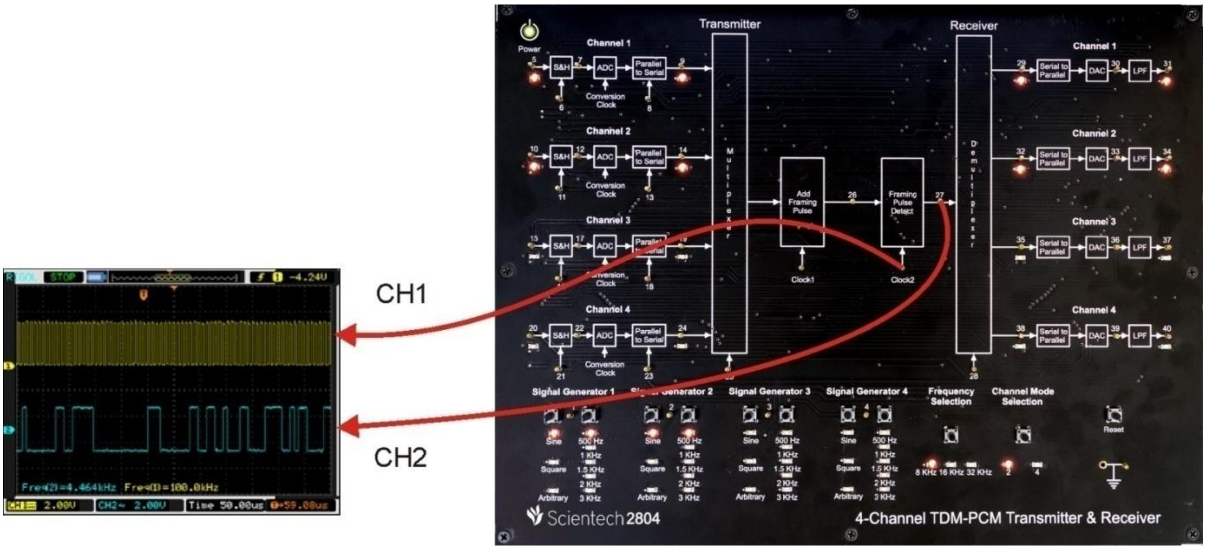
Objective:

Observe the 16 bit frame output after detecting framing pulse.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

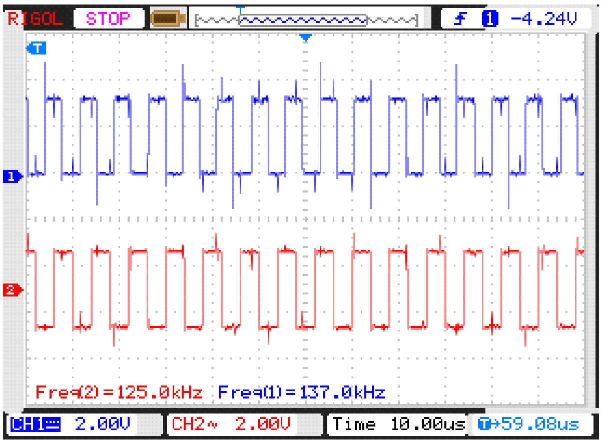
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2.* And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8 & TP13 and PCM output at TP9 & TP14.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.

I/P Signal Type/ Freq.	Sampling Freq.	Sampled Output
Sine/500 Hz	8 KHz	 CH1: Clock for 17 bits frame (TP clock1), CH2: Clock at detecting Frame bit(TP clock2)

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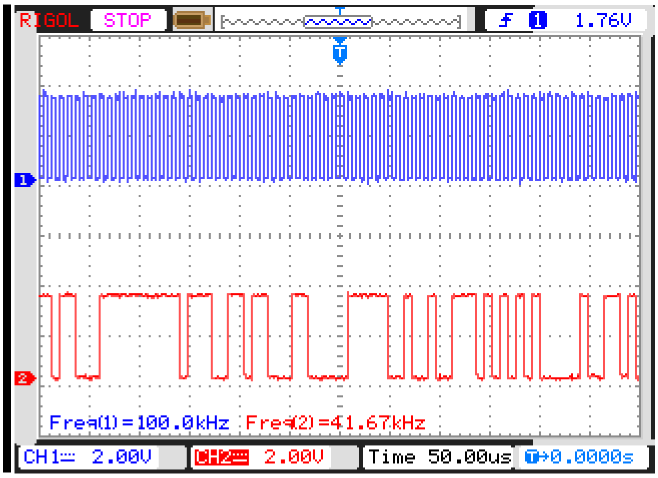
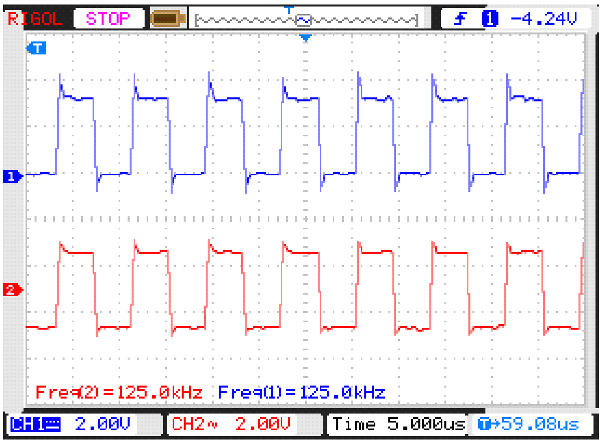
Sine/500 Hz	8 KHz	 CH1: Clock at detecting Frame bit(TP clock2) CH2: 16 bit PCM Frame (TP 27)
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP 25), CH2: Clock at detecting Frame bit(TP clock2)

Experiment 5

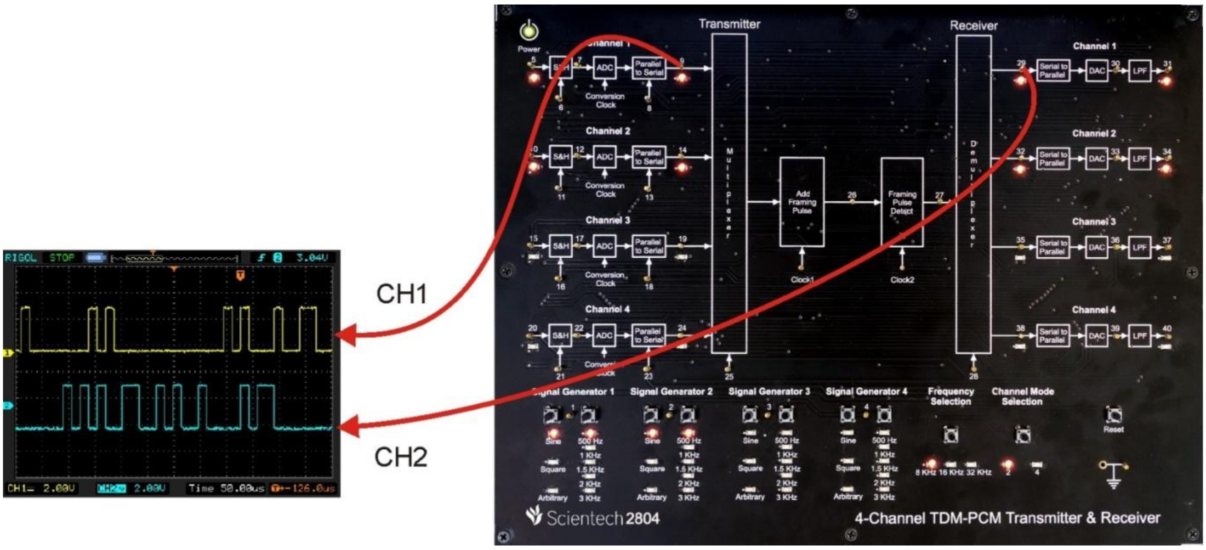
Objective:

Observe the demultiplexed output.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

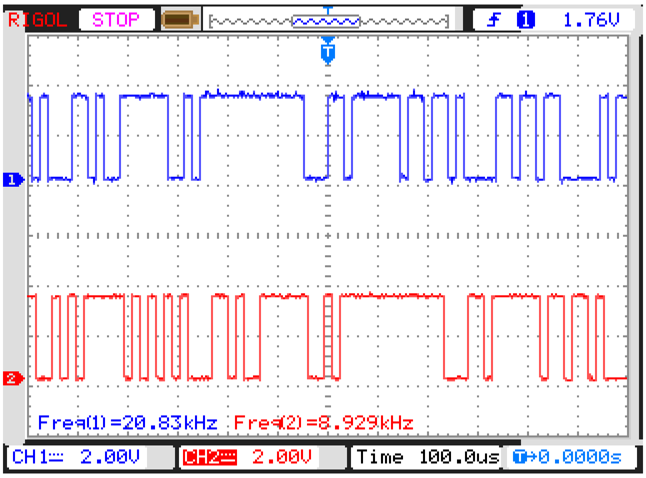
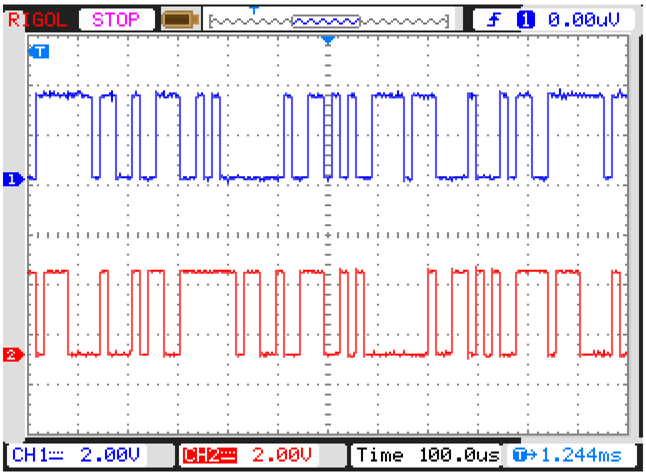
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2.* And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8 & TP13 and PCM output at TP9 & TP14.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29 and TP32.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: PCM output (TP9), CH2:PCM Output after Demultiplexer (TP29)
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: PCM Output (TP14), CH2:PCM Output after Demultiplexer (TP32)

Experiment 6

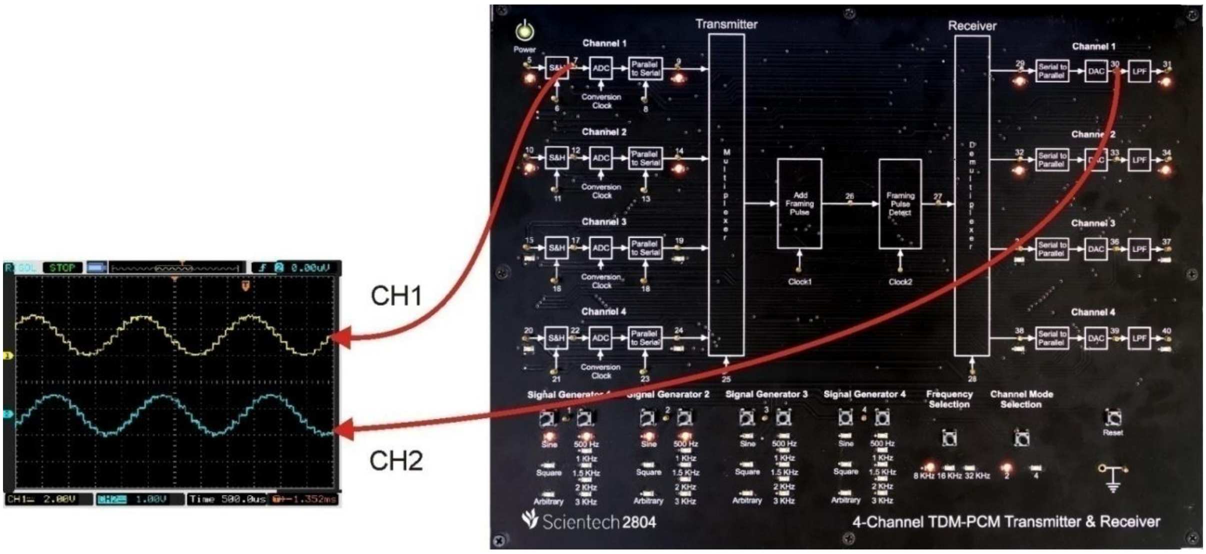
Objective:

Observe the Demodulated output of 2-Channel TDM-PCM.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

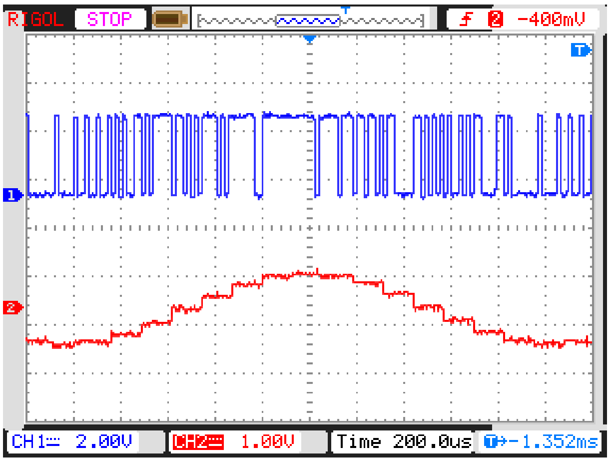
Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

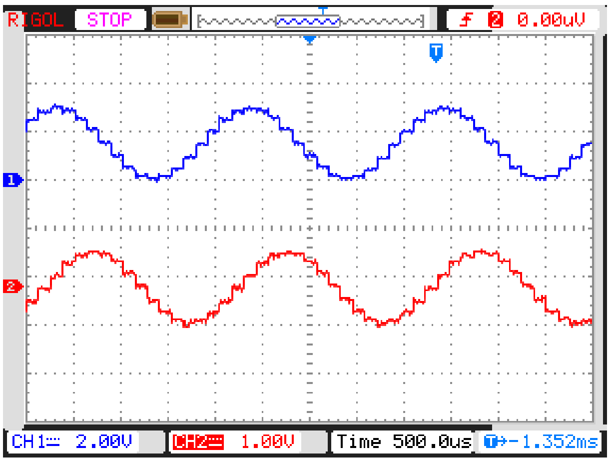
Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8 & TP13 and PCM output at TP9 & TP14.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29 and TP32.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: PCM Output (TP29), CH2: Demodulated Output (TP30)

- Observe the Demodulated output at TP30 and TP33.

Sine/500 Hz	Channel1	8 KHz	 CH1: Sampled Signal (TP7), CH2: Demodulated Output (TP30)

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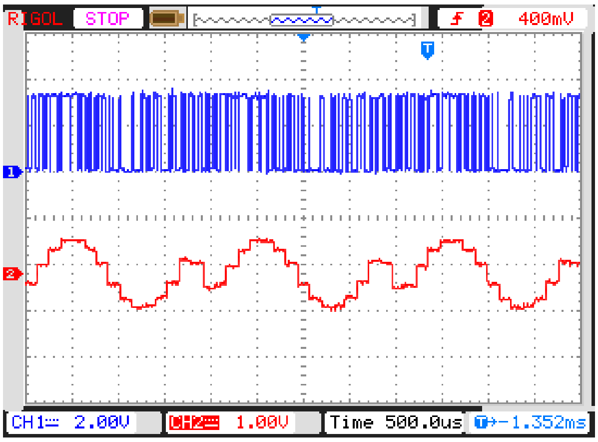
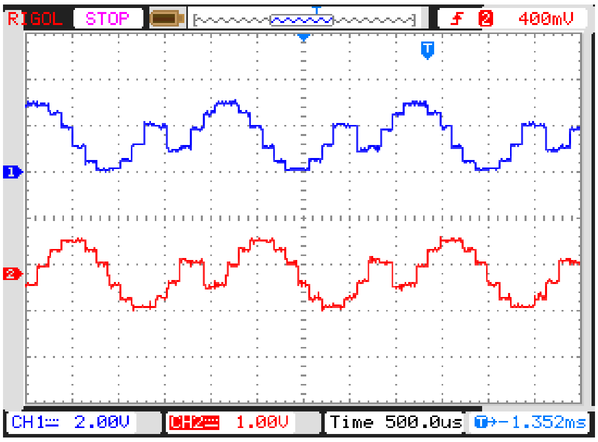
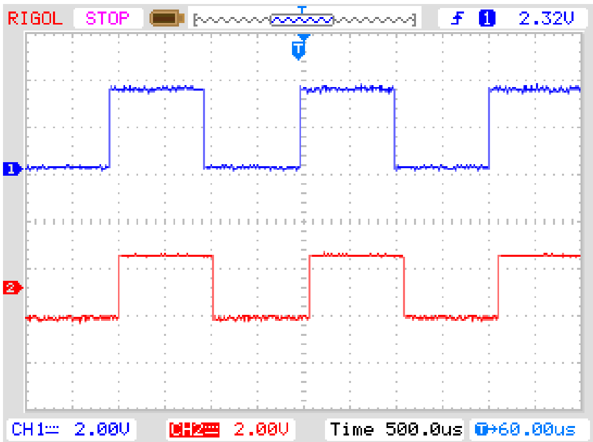
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: PCM Output (TP32), CH2: Demodulated Output (TP33)
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Sampled Signal (TP12), CH2: Demodulated Output (TP33)

Square/500 Hz	Channel1	32 KHz	 CH1: PCM Output (TP29), CH2: Demodulated Output (TP30)

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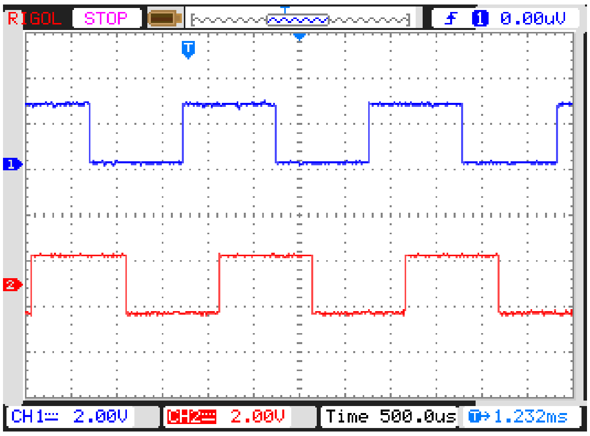
Square/500 Hz	Channel1	32 KHz	 CH1: Sampled Signal (TP7), CH2: Demodulated Output (TP30)

Experiment 7

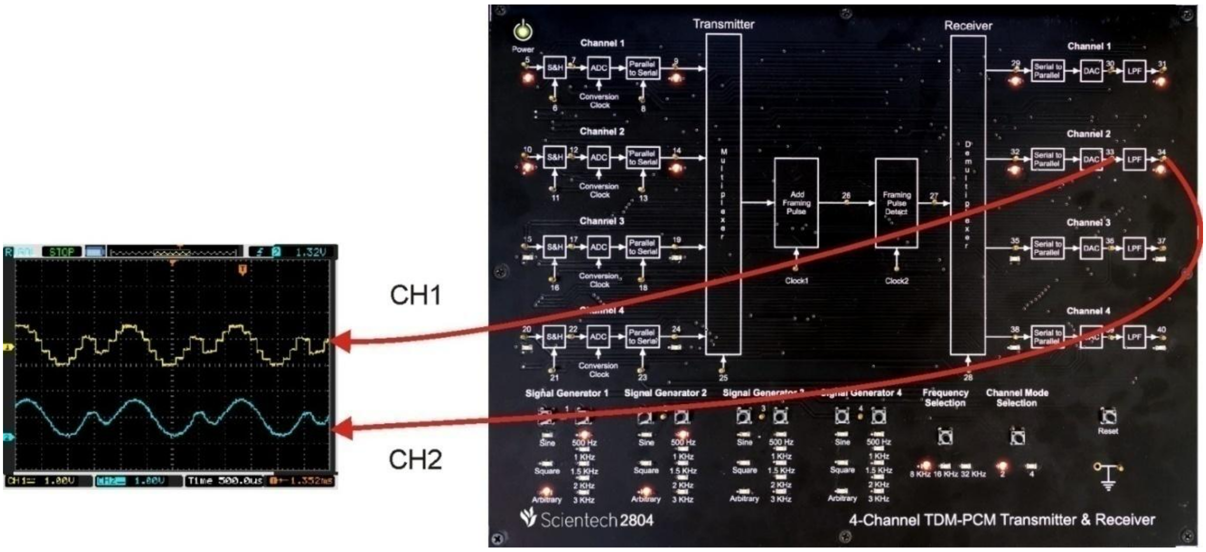
Objective:

Observe the Low Pass Filter output of Demodulated signal of 2-Channel TDM-PCM.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: 2-channel TDM-PCM is selected by default and LEDs of Channel1 and Channel2 will glow when user switch on the power.

Step 3: Select input *signal type* of channel 1 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the input signal on test point (TP1).

Step 4: Select input *signal frequency* of channel 1 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 1*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP1).

Step 5: Select input *signal type* of channel 2 using push button i.e. Sine, Square and Arbitrary, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the input signal on test point (TP2).

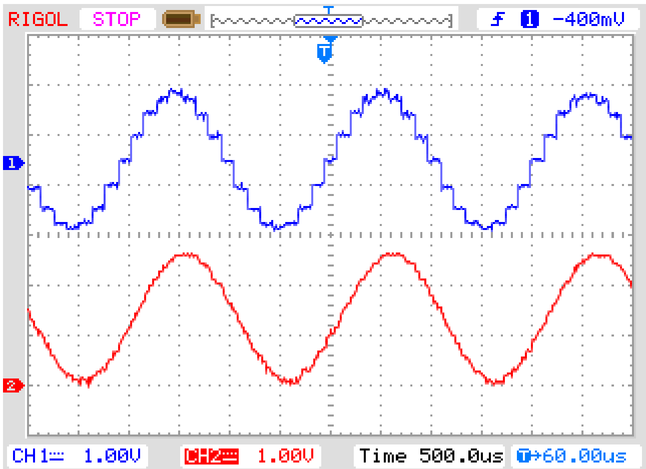
Step 6: Select input *signal frequency* of channel 2 using push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at *Signal Generator 2*. And respective LED will glow according to the selection. Observe the change in frequency on test point (TP2).

Step 7: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1 and TP2 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5 and TP10.
- Observe the sampled clock at TP6 & TP11 and sampled signal at TP7 & TP12 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8 & TP13 and PCM output at TP9 & TP14.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29 and TP32.
- Observe the Demodulated output at TP30 and TP33.

Observe the Low Pass Filter output of demodulated signal at TP31 and TP34.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: Demodulated Output (TP30), CH2: Low Pass Filter Output (TP31)

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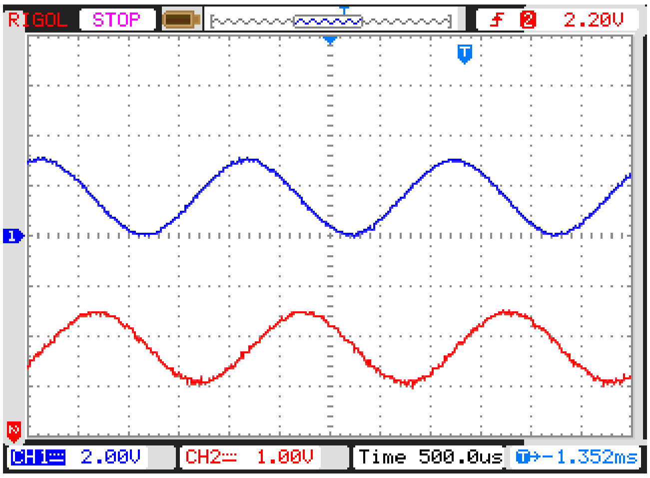
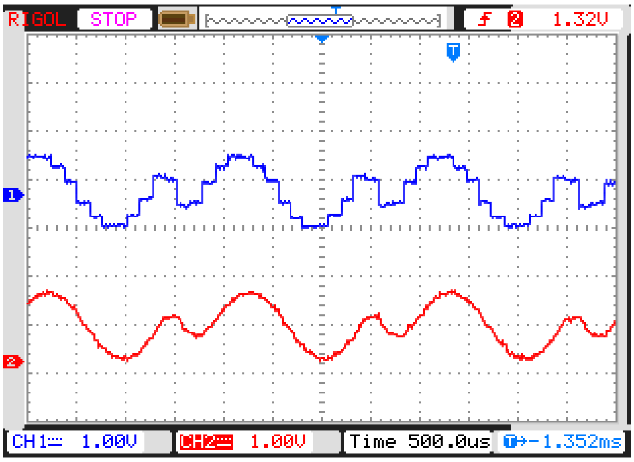
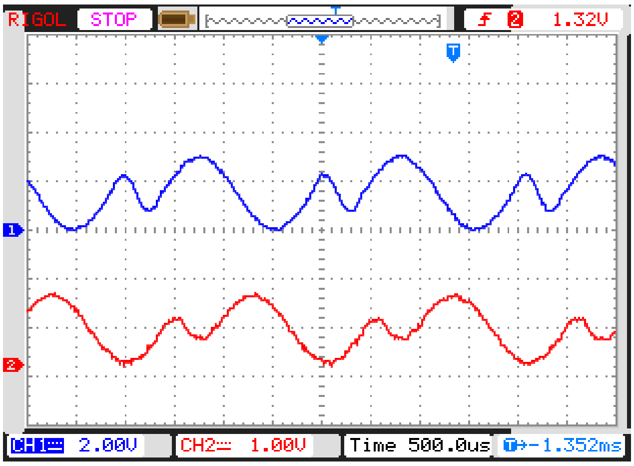
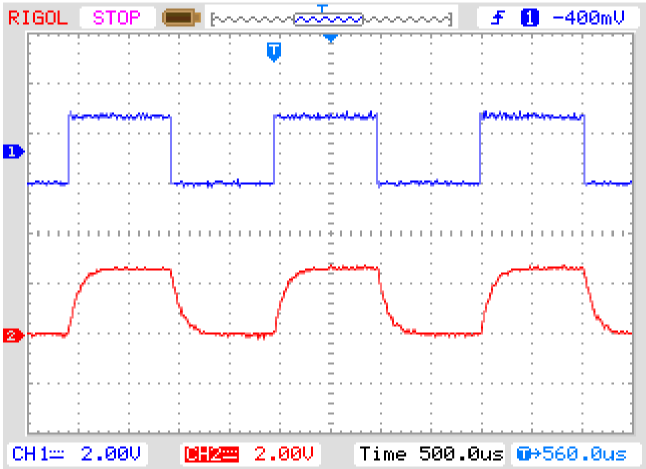
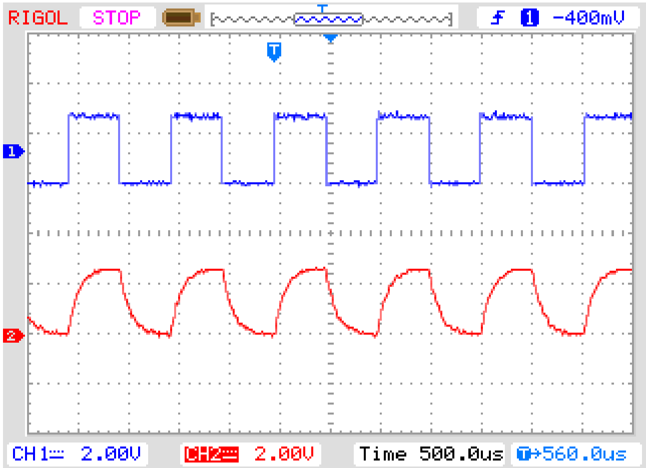
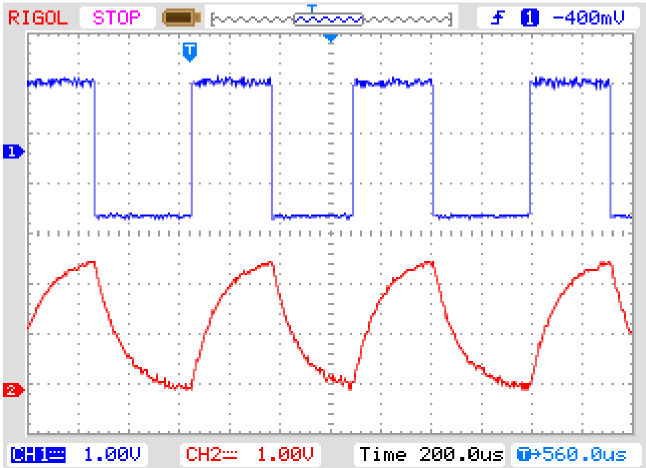
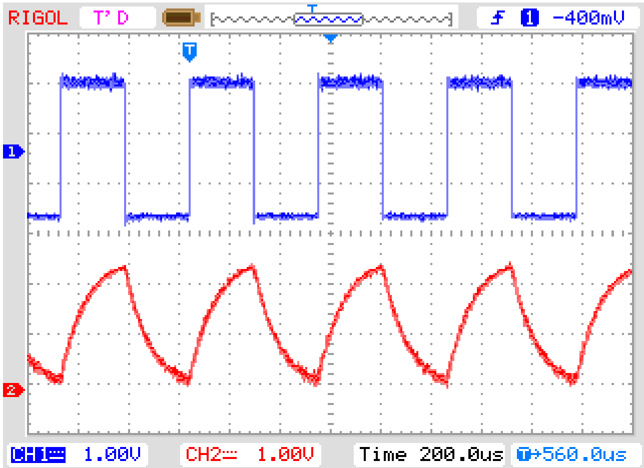
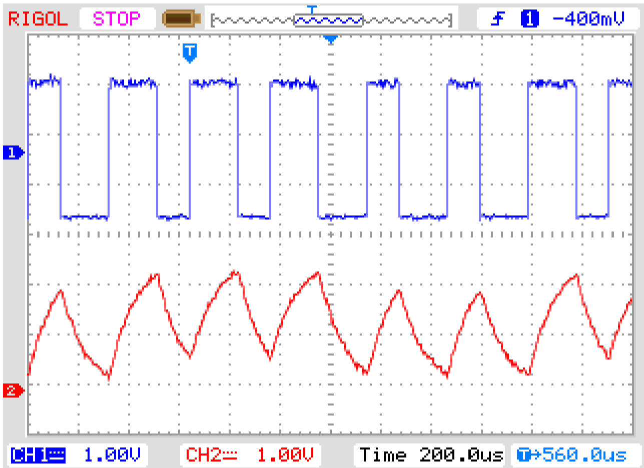
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)

Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Demodulated Output (TP33), CH2: Low Pass Filter Output (TP34)
Arbitrary /500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP10), CH2: Low Pass Filter Output (TP34)

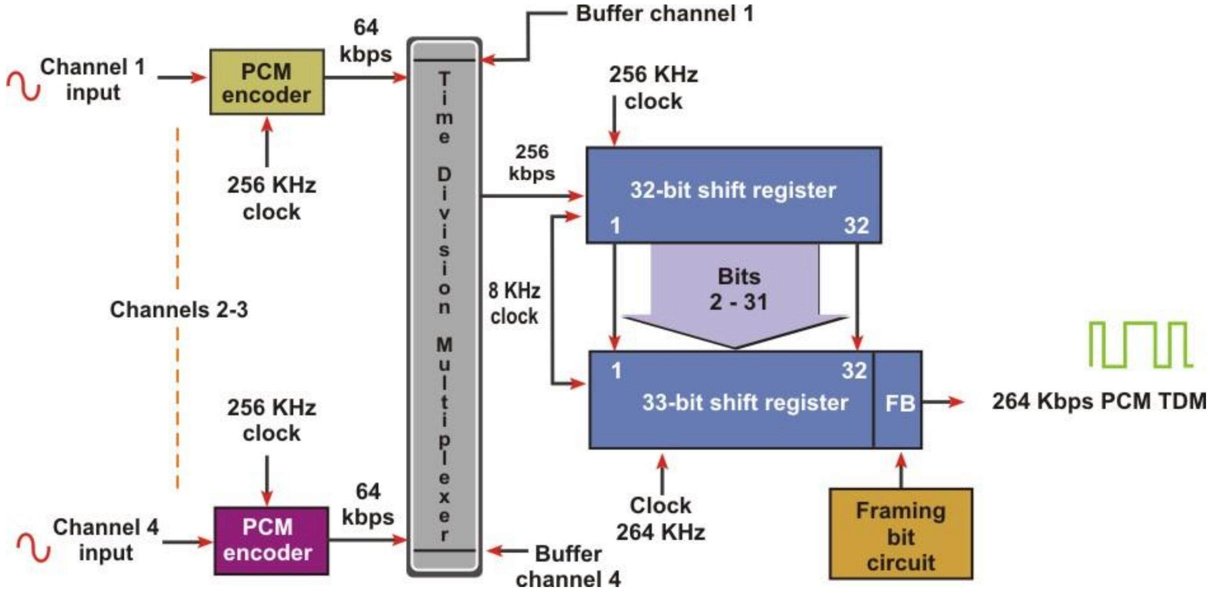
Square / 500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP30), CH2: Low Pass Filter Output (TP31)
Square / 1 KHz	Channel1	8 KHz	 CH1: Input Signal (TP30), CH2: Low Pass Filter Output (TP31)
Square / 1.5 KHz	Channel1	8 KHz	 CH1: Input Signal (TP30),

			CH2: Low Pass Filter Output (TP31)
Square / 2 KHz	Channel1	8 KHz	 CH1: Input Signal (TP30), CH2: Low Pass Filter Output (TP31)
Square / 3 KHz	Channel1	8 KHz	 CH1: Input Signal (TP30), CH2: Low Pass Filter Output (TP31)

Note :- Above results are shown filter effects of square wave w.r.t frequency . Type of low-pass filter at the receiver end is 2nd order butterworth active filter with 3-db, cut-off frequency 5 KHz. If you observe the signal at the output of the DAC i.e. input of the filter, you will see the proper square wave. As we have used low-pass filter with cut-off frequency 5 KHz so you are getting curved shape square wave due to the RC effect of the filter at maximum input frequency option i.e. 3 KHz.

Four Channel TDM-PCM: A four channel system, one example is taken from each channel during each frame, and the time allocated to transmit the PCM bits from each channel is equal to one-half the total frame time. Figure shows the TDM frame allocation for a four channel two-channel PCM system with an 8 KHz sample rate. Therefore, eight bits from each channel must be transmitted during each frame. Thus, the line speed at the output of the multiplexer is

$$\frac{4\ channel}{frame} * 8000\frac{frames}{second} * 8\frac{bits}{channel} = 256\ kbps$$



Later on an additional bit (called framing bit) is added to each frame. The framing bit occurs at 8000 bps rate and is recovered in the receiver, where it is used to maintain frame and sample synchronization between TDM transmitter and receiver. Here what we are discussing about 4-Channel TDM-PCM, using 8 KHz sampling frequency for all calculation.

For 4-channel each frame contains 32-bits so line speed will be

$$32\frac{bits}{channel} * \frac{channel}{frame} * 8000\frac{frames}{second} = 256\ kbps$$

Then, after adding single bit (total 33-bit) bit rate will be

$$33\frac{bits}{channel} * \frac{channel}{frame} * 8000\frac{frames}{second} = 264s\ kbps$$

Experiment 8

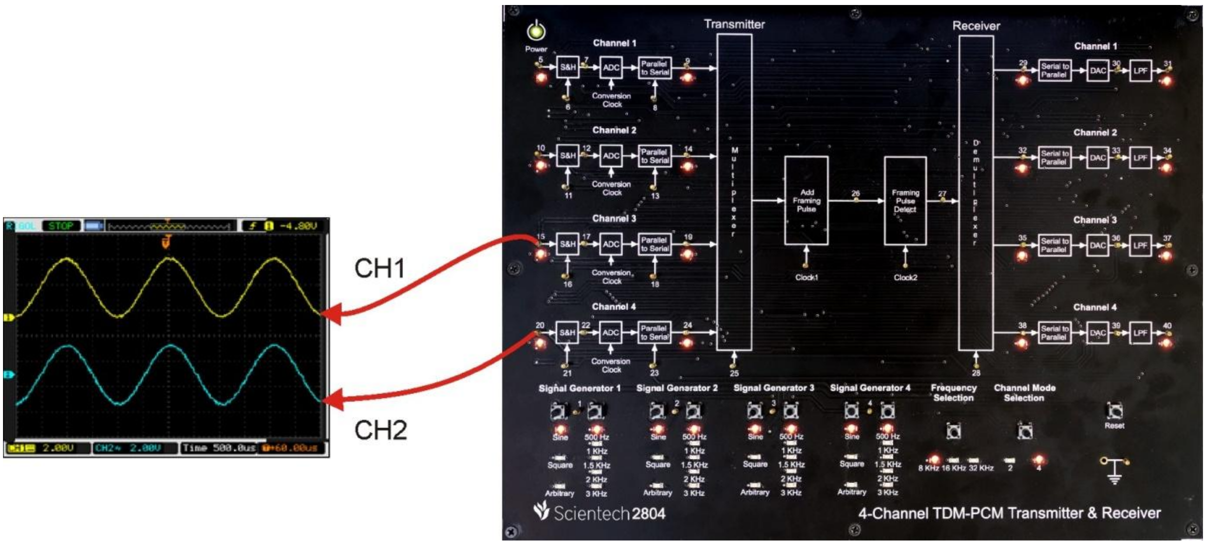
Objective:

- Observe Input signal by the following Signal frequency
    - 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz.
- Observe the sample and hold signal by varying the sampling clock i.e.
    - 8 KHz, 16 KHz, 32 KHz.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

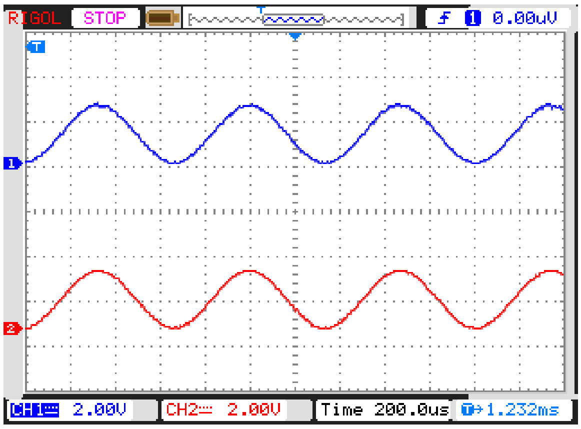
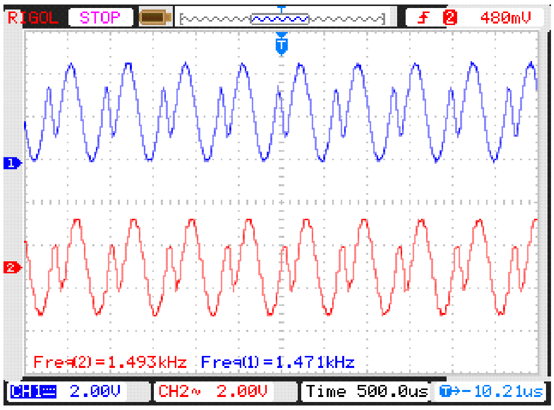
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

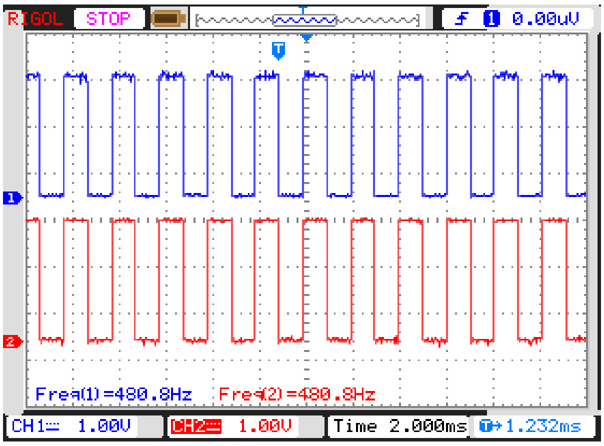
Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

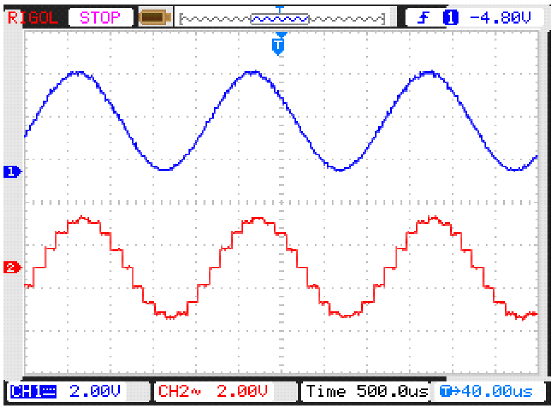
Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

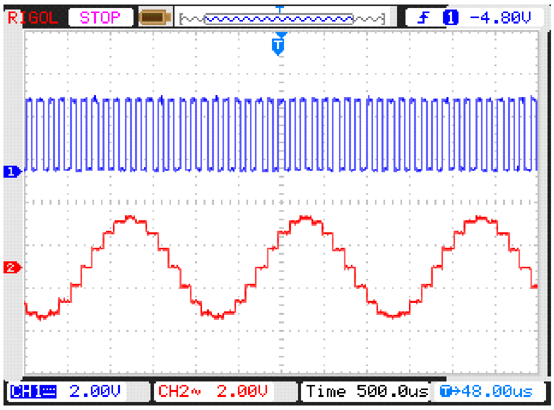
Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	-	 CH1: Input Signal (TP1), CH2: Channel1 input(TP5)
Arbitrary /1.5 KHz	Channel2	-	 CH1: Input Signal (TP2), CH2: Channel1 input(TP10)

<table>
<tr>
<td>Square /500 Hz</td>
<td>Channel3</td>
<td>-</td>
<td>

CH1: Input Signal (TP3),
CH2: Channel1 input(TP15)</td>
</tr>
<tr>
<td>Sine/500 Hz</td>
<td>Channel1</td>
<td>8 KHz</td>
<td>

CH1: Input Signal (TP5),
CH2: Sampled Output(TP7)</td>
</tr>
<tr>
<td>Sine/500 Hz</td>
<td>Channel1</td>
<td>8 KHz</td>
<td>

CH1: Input Signal (TP6),
CH2: Sampled Output(TP7)</td>
</tr>
</table>

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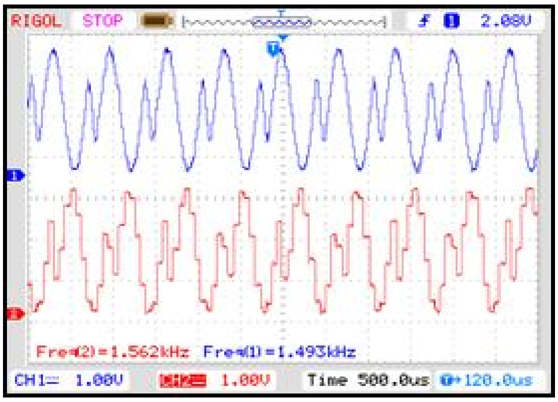
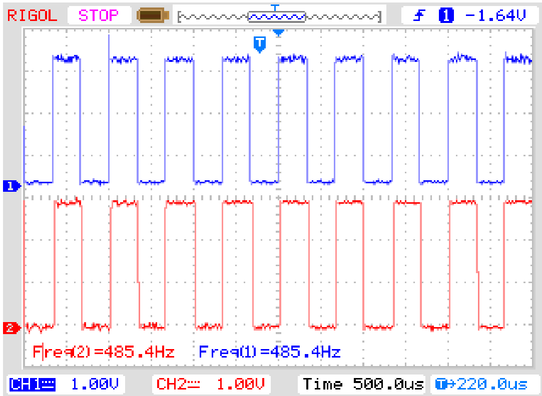
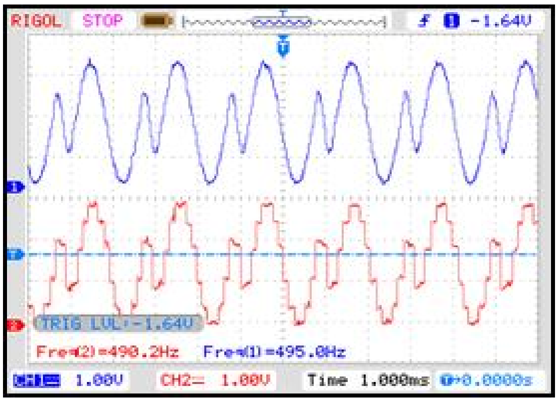
Arbitrary /1.5KHz	Channel2	16 KHz	 CH1: Input Signal (TP2), CH2: Sampled Output(TP12)
Square/500 Hz	Channel3	8 KHz	 CH1: Input Signal (TP3), CH2: Sampled Output(TP17)

Arbitrary /1.5KHz	Channel4	8 KHz	 CH1: Input Signal (TP4), CH2: Sampled Output(TP22)

Experiment 9

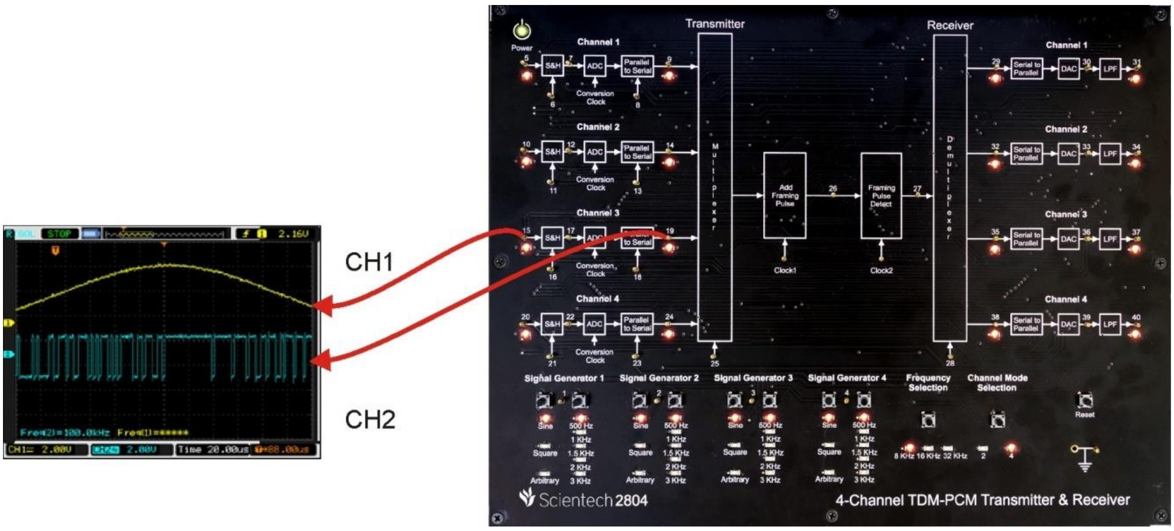
Objective:

Observe the PCM clock and PCM output by varying the line speed frequency.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

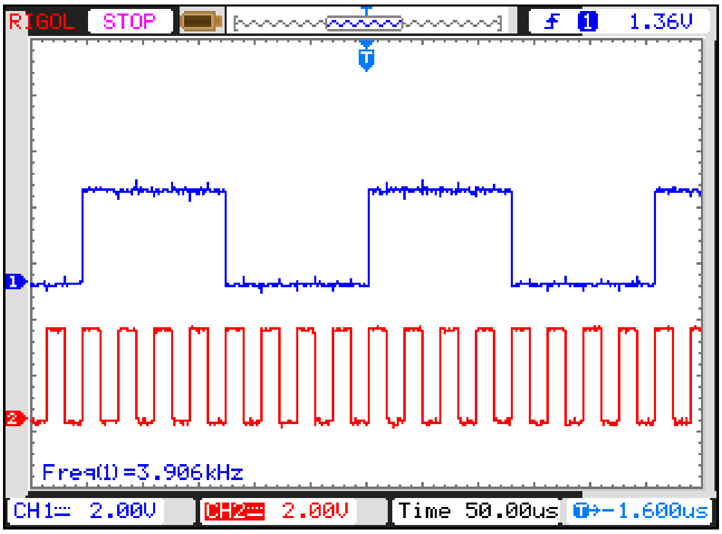
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

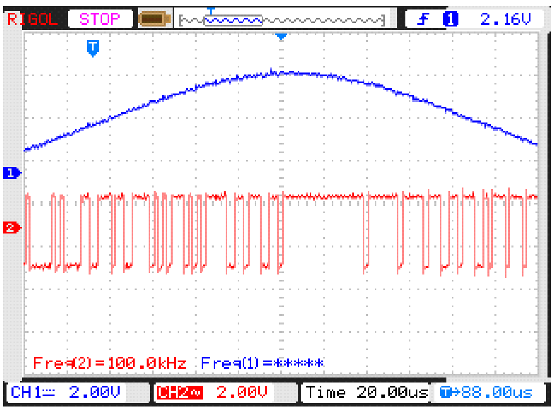
Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.



CH1: Sampling Clock (TP6/TP11/TP16/TP21), CH2: Line Speed Clock (TP8/TP13/TP18/TP23)

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: PCM Output (TP9)

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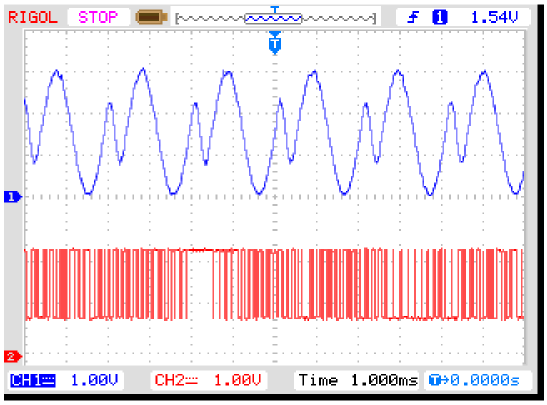
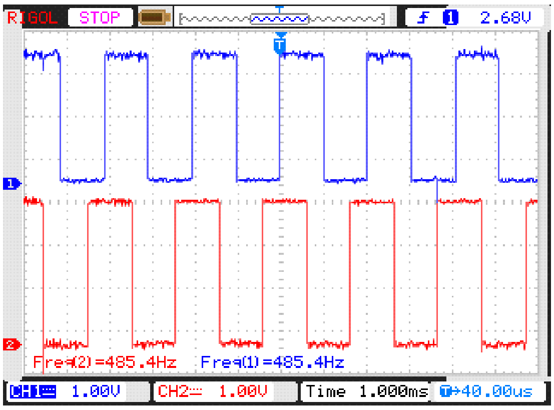
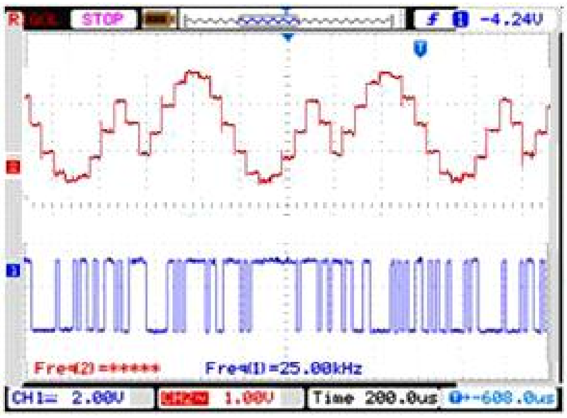
Arbitrary/ 500Hz	Channel2	8 KHz	 CH1: Input Signal (TP10), CH2: PCM Output (TP14)
Square/500 Hz	Channel3	8 KHz	 CH1: Input Signal (TP15), CH2: PCM Output (TP19)
Arbitrary /1.0KHz	Channel4	16 KHz	 CH1: PCM Output (TP22), CH2: Sampled Signal (TP24)

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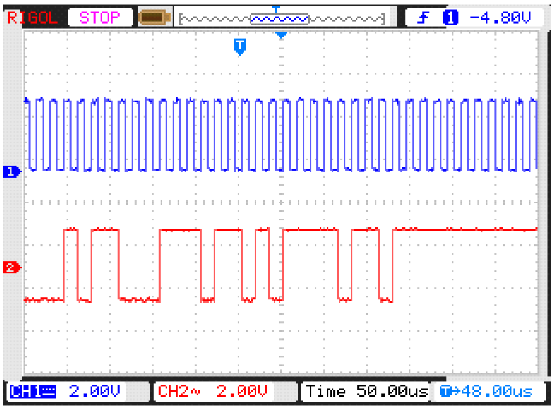
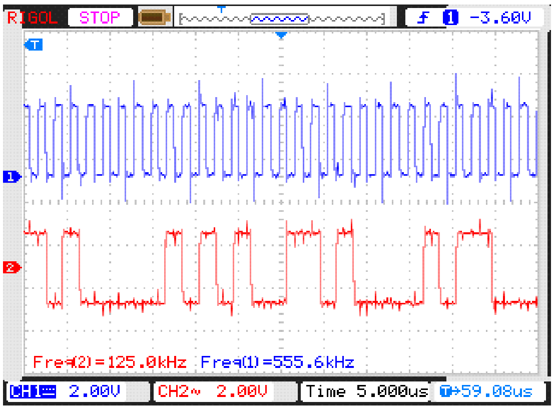
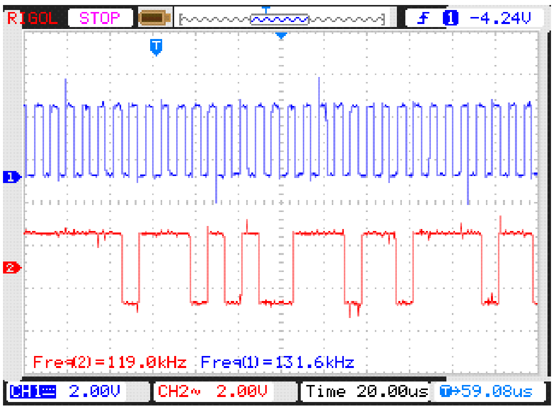
Sine/500 Hz	Channel1	8 KHz	 CH1: Line speed (TP8), CH2: PCM Output (TP9)
Sine/1.5 KHz	Channel2	8 KHz	 CH1: Line speed (TP13), CH2: PCM Output (TP14)
Sine/500 Hz	Channel3	8 KHz	 CH1: Line speed (TP18), CH2: PCM Output (TP19)

Experiment 10

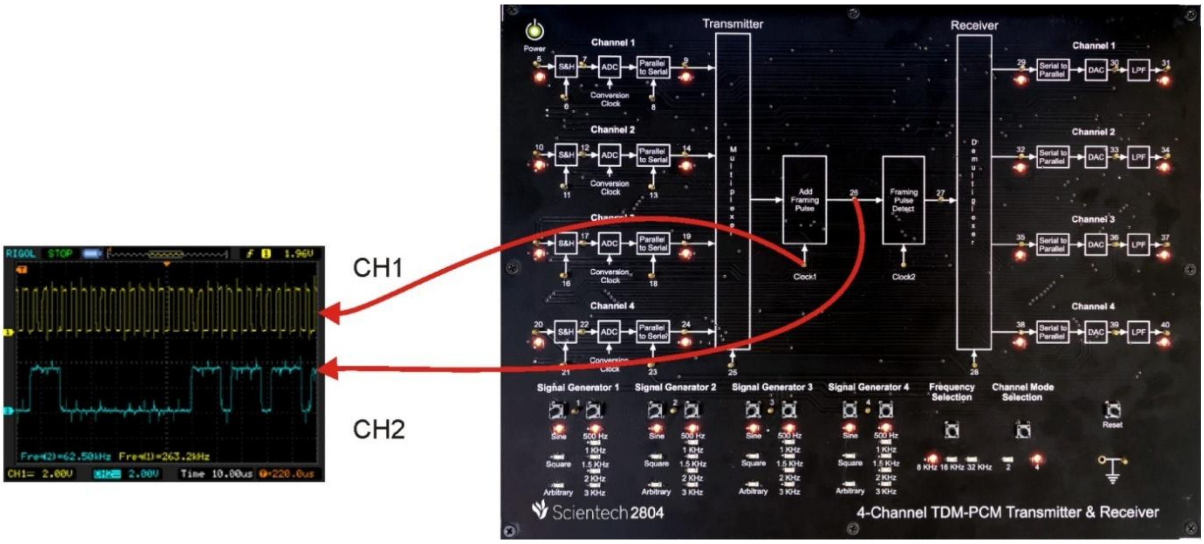
Objective:

Observe the 33 bit frame of multiplexed output with added framing pulse.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

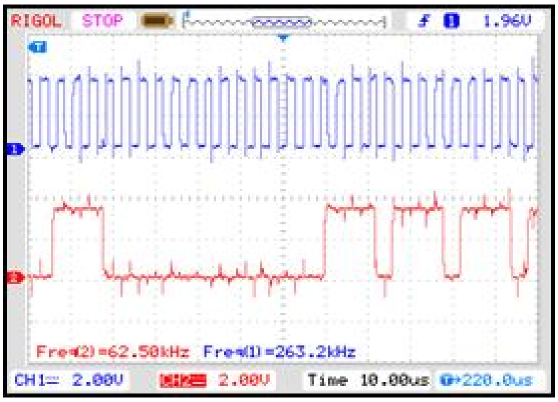
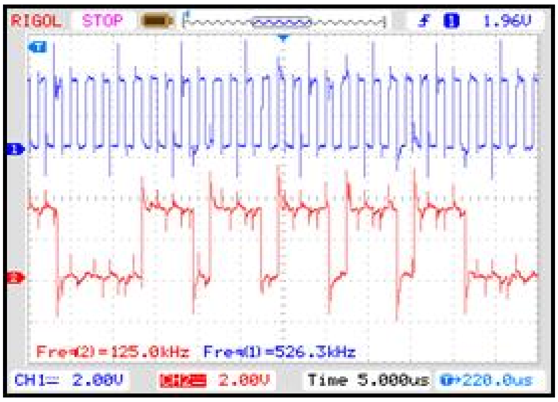
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.

I/P Signal Type/ Freq.	Sampling Freq.	Sampled Output
Sine/500 Hz	8 KHz	 CH1: Clock for 33 bits frame(TP clock1), CH2: 33 bits frame (TP 26)
Sine/500 Hz	16 KHz	 CH1: Clock for 33 bits frame (TP clock1), CH2: 33 bits frame (TP 26)

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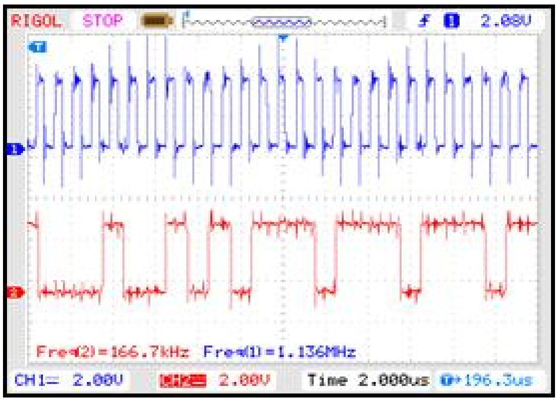
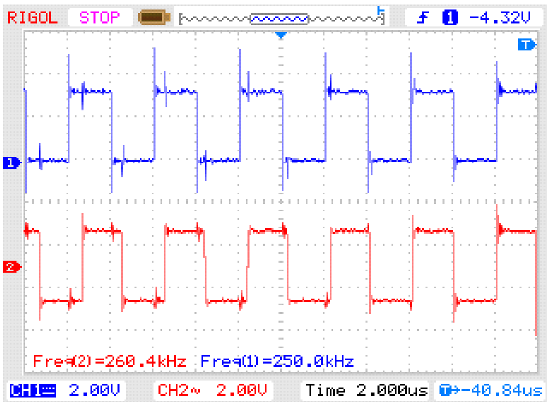
Sine/500 Hz	32 KHz	 CH1: Clock for 33 bits frame (TP clock1), CH2: 33 bits frame (TP 26)
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP25), CH2:Clock for 33 bits frame (TP clock1)

Experiment 11

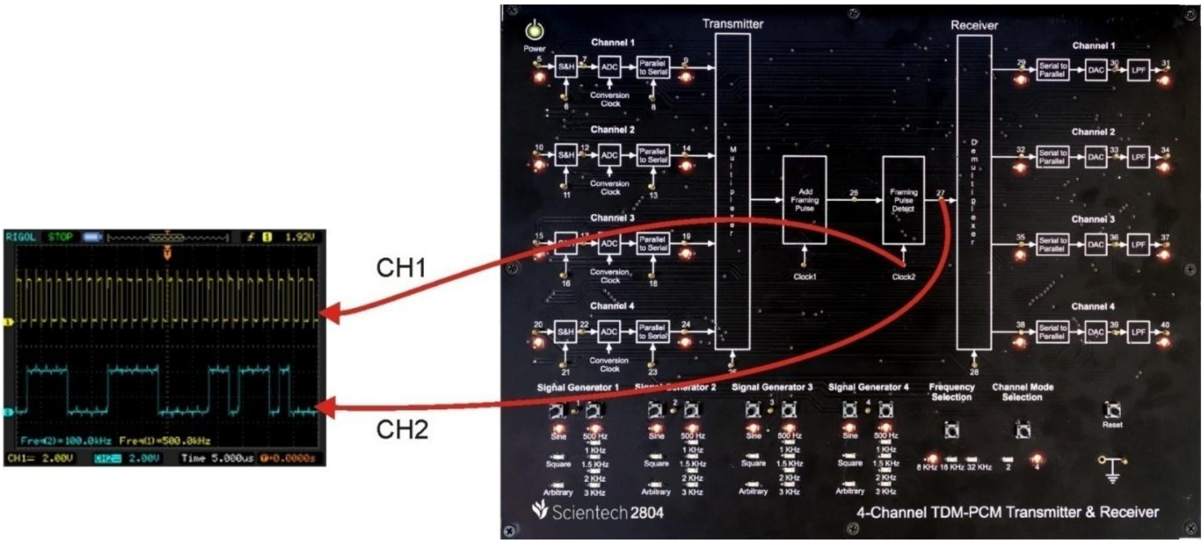
Objective:

Observe the 32 bit frame output after detecting framing pulse.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the Power Supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

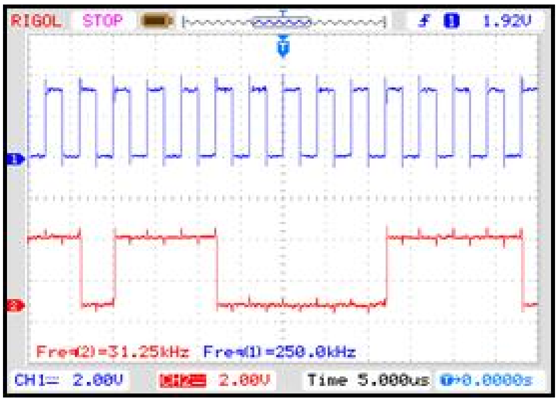
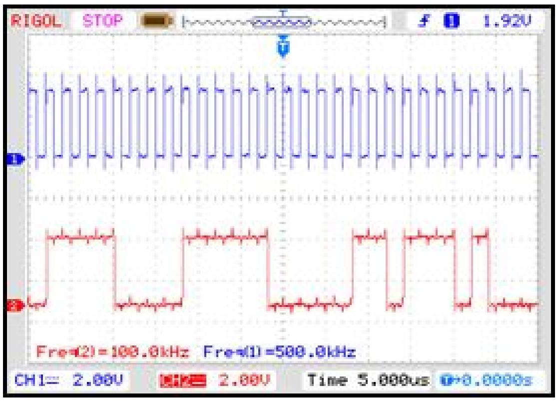
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.

I/P Signal Type/ Freq.	Sampling Freq.	Sampled Output
Sine/500 Hz	8 KHz	 CH1: Clock for 32 bits frame (TP clock2) CH2: 32 bit Frame (TP 27)
Sine/500 Hz	16 KHz	 CH1: Clock for 32 bits frame (TP clock2) CH2: 32 bit Frame (TP 27)

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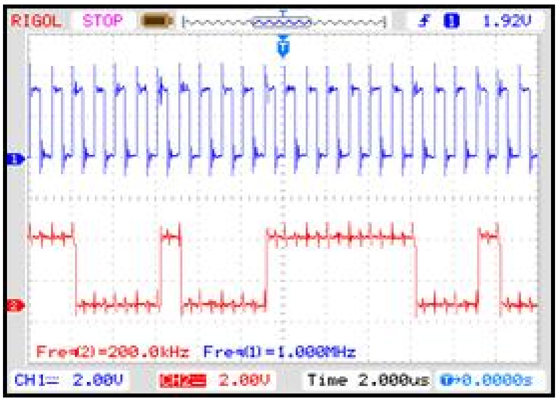
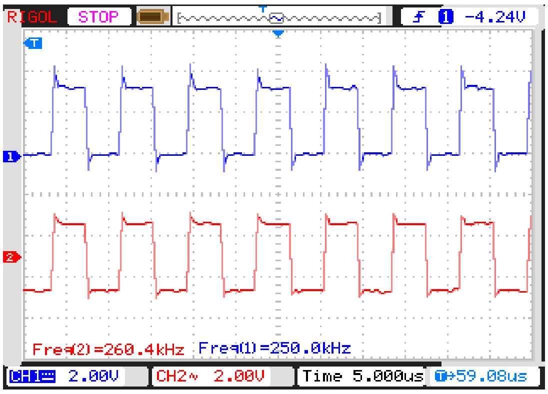
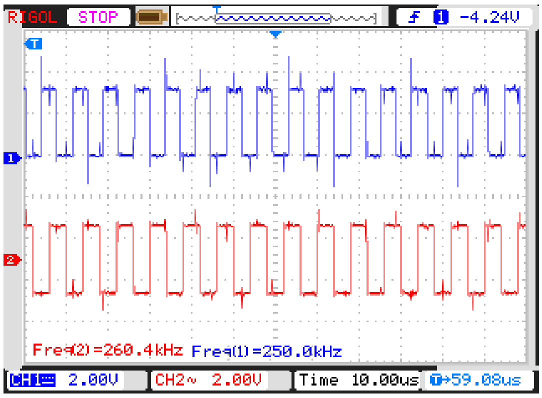
Sine/500 Hz	32 KHz	 CH1: Clock for 32 bits frame (TP clock2) CH2: 32 bit Frame (TP 27)
Sine/500 Hz	8 KHz	 CH1: Multiplexer Clock (TP25) CH2: Clock for 32 bits frame (TP clock2)
Sine/500 Hz	8 KHz	 CH1: Clock for 33 bits frame (TP clock1) CH2: Clock for 32 bits frame (TP clock2)

Experiment 12

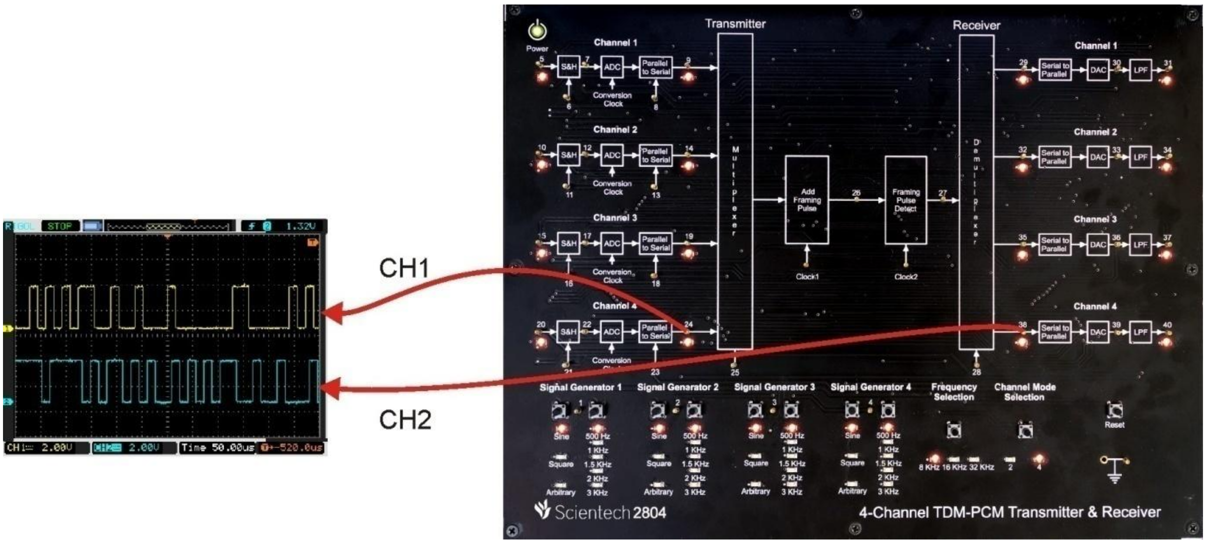
Objective:

Observe the Demultiplexed Output.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

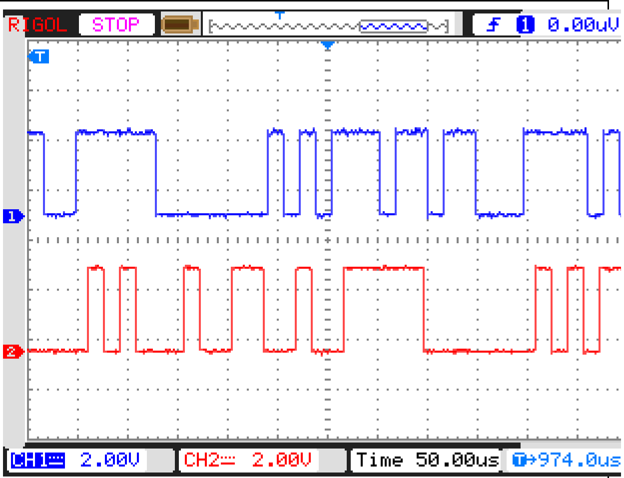
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29, TP32, TP35 and TP38.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: PCM Output (TP9), CH2:PCM Output after Demultiplexer (TP29)

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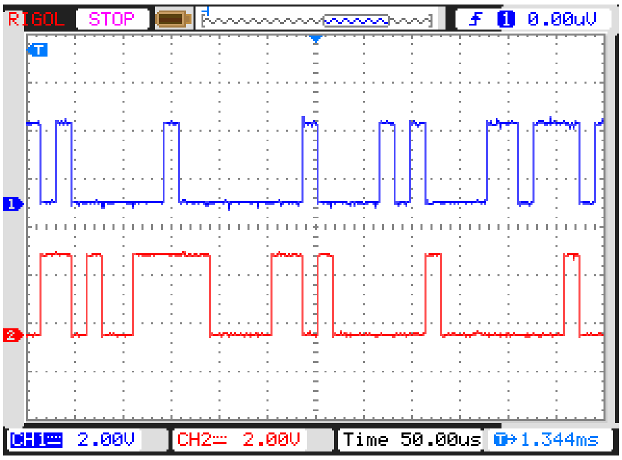
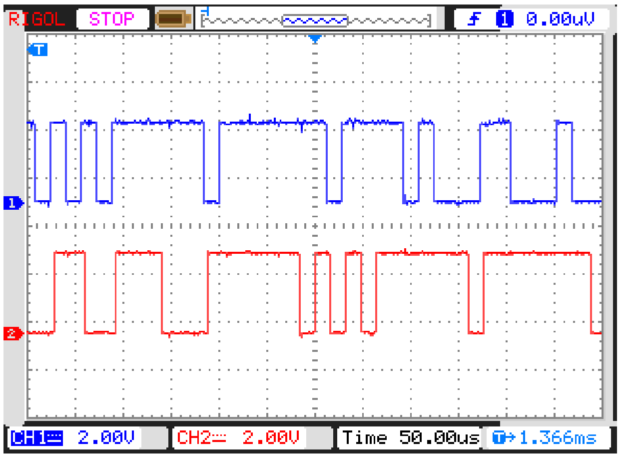
Sine/500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP14), CH2:PCM Output after Demultiplexer (TP32)
Sine/500 Hz	Channel3	8 KHz	 CH1: Input Signal (TP19), CH2:PCM Output after Demultiplexer (TP35)

Experiment 13

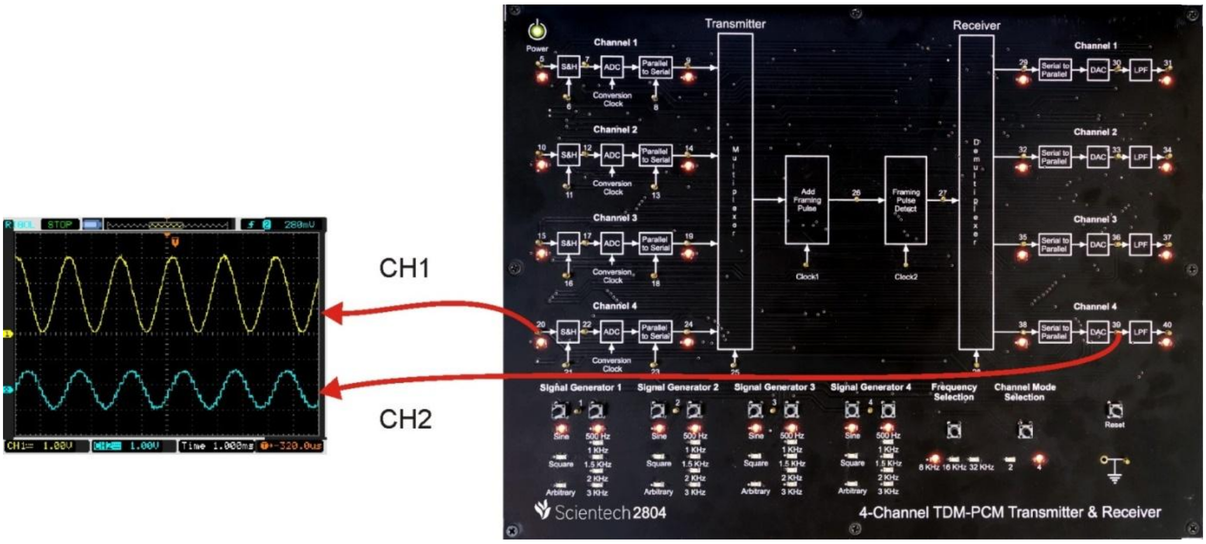
Objective:

Observe the Demodulated output of 4-Channel TDM-PCM.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

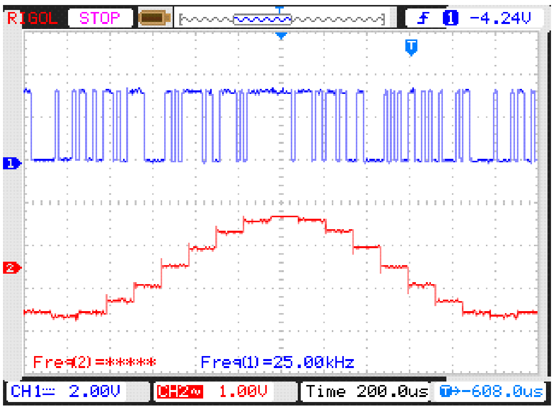
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29, TP32, TP35 and TP38.
- Observe the Demodulated output at TP30, TP33, TP36 and TP39.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP29), CH2: PCM Output (TP30)

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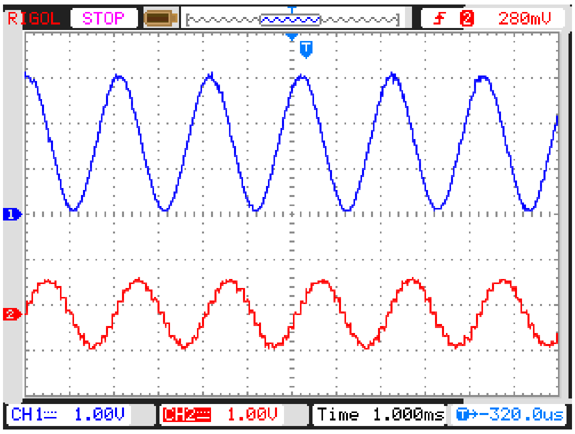
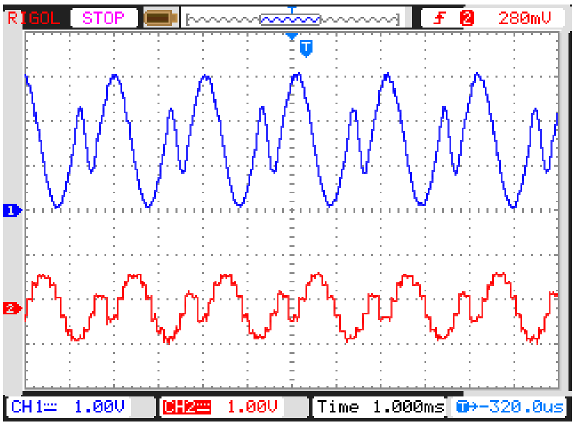
Sine/500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Demodulated Output (TP30)
Arbitrary/500 Hz	Channel2	8 KHz	 CH1: Input Signal (TP10), CH2: Demodulated Output (TP33)

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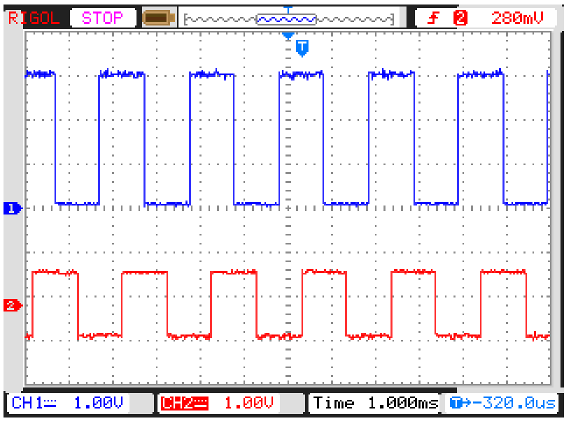
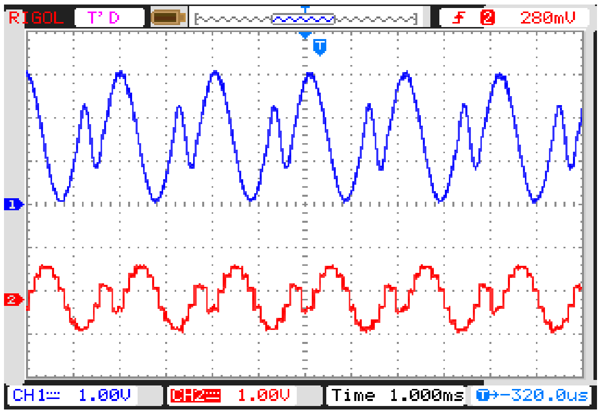
Square/500 Hz	Channel3	8 KHz	 CH1: Input Signal (TP15), CH2: Demodulated Output (TP36)
Arbitrary/500 Hz	Channel4	8 KHz	 CH1: Input Signal (TP20), CH2: PCM Output (TP39)

Experiment 14

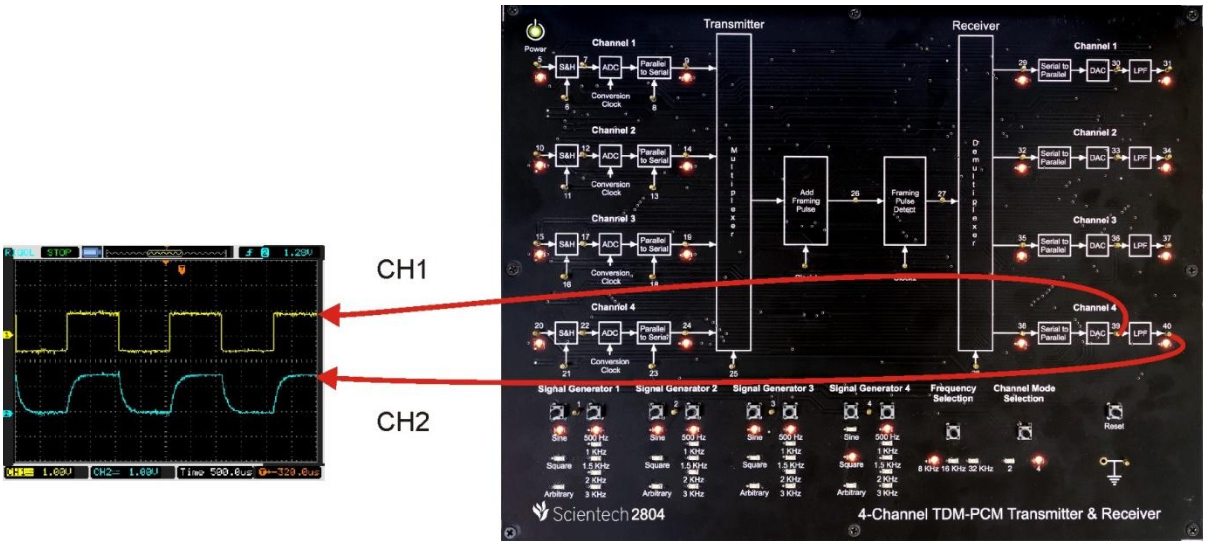
Objective:

Observe the Low Pass Filter output of Demodulated signal of 2-Channel TDM-PCM.

Setup:

- TechBook Scientech 2804
- Power Supply
- Oscilloscope/DSO
- Test probe

Connection Diagram:



Procedure:

Step 1: Connect and switch on the power supply of Scientech 2804.

Step 2: Select 4 channel TDM-PCM using push button and LEDs of Channel 1, Channel 2, Channel 3 and Channel 4 will glow.

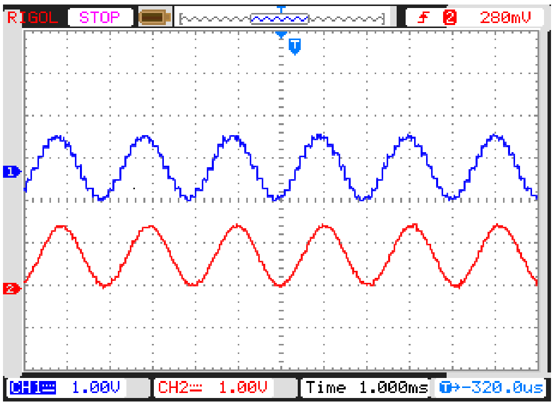
Step 3: Select input *signal type* of channel1, channel2, channel3 and channel4 using respective push button i.e. Sine, Square and Arbitrary, given at respective *Signal Generators*. And respective LED will glow according to the selection of channel. Observe the input signal on test points (TP1, TP2, TP3 and TP4).

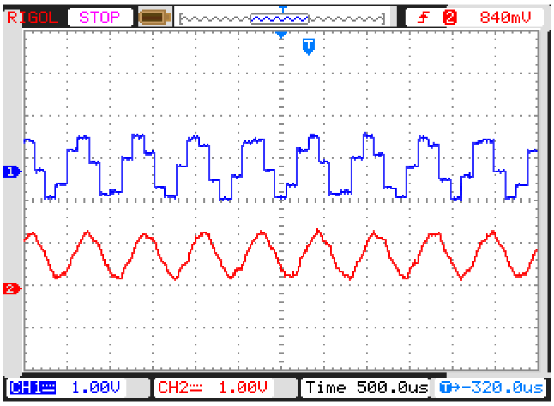
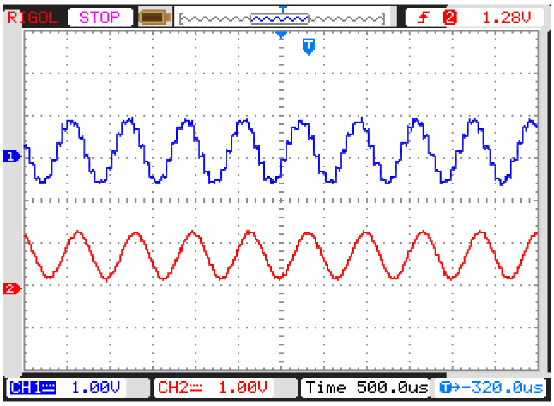
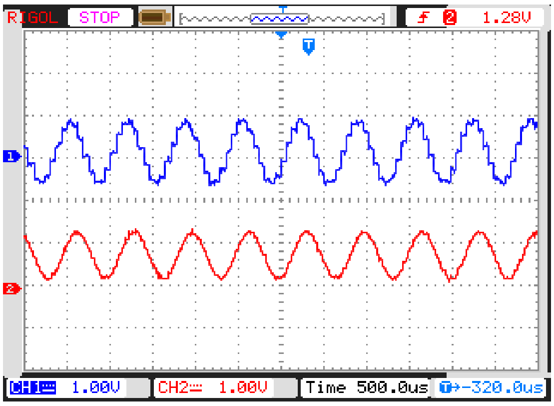
Step 4: Select input *signal frequency* of channel1, channel2, channel3 and channel4 using respective push button i.e. 500 Hz, 1 KHz, 1.5 KHz, 2 KHz and 3 KHz, given at respective *Signal Generators*. And respective LED will glow according to the selection. Observe the change in frequency on test points (TP1, TP2, TP3 and TP4).

Step 5: Select *sampling frequency* using push button i.e. 8 KHz, 16 KHz and 32 KHz. And respective LED will glow according to the selection.

Observation:

- Observe the input signal at TP1, TP2, TP3 and TP4 by varying input signal type and frequency on the oscilloscope screen.
- Observe the same input signal at TP5, TP10, TP15 and TP20.
- Observe the sampled clock at TP6, TP11, TP16 and TP21 & sampled signal at TP7, TP12, TP17 and TP22 by varying sampling frequency using push button.
- Observe the line Speed clock at TP8, TP13, TP18 and TP23 & PCM output at TP9, TP14, TP19 and TP24.
- Observe the multiplexed output with added framing pulse at TP26 and its clock at Clock1.
- Observe the 16 bit frame output after detecting framing pulse at TP27 and its clock at Clock2.
- Observe the PCM output at individual channel after demultiplexing at TP29, TP32, TP35 and TP38.
- Observe the Demodulated output at TP30, TP33, TP36 and TP39.
- Observe the Low Pass Filter output of demodulated signal at TP31, TP34, TP37 and TP40.

I/P Signal Type/ Freq.	Channel	Sampling Freq.	Sampled Output
Sine/500 Hz	Channel1	8 KHz	 CH1: Demodulated Output (TP30), CH2: Low Pass Filter Output (TP31)

Sine/1.5 KHz	Channel1	8 KHz	 CH1: Demodulated Output (TP30), CH2: Low Pass Filter Output (TP31)
Sine/1.5 KHz	Channel2	8 KHz	 CH1: Demodulated Output (TP33), CH2: Low Pass Filter Output (TP34)
Sine/1.5 Hz	Channel2	16 KHz	 CH1: Demodulated Output (TP33), CH2: Low Pass Filter Output (TP34)

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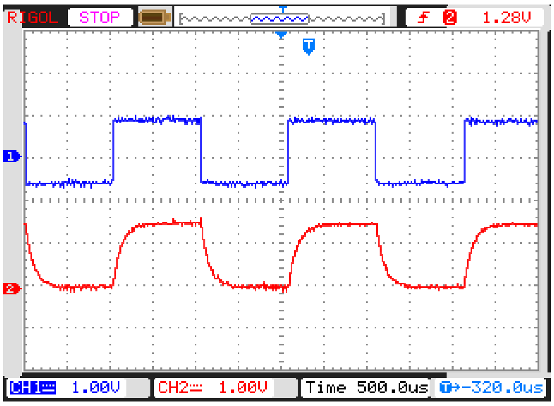
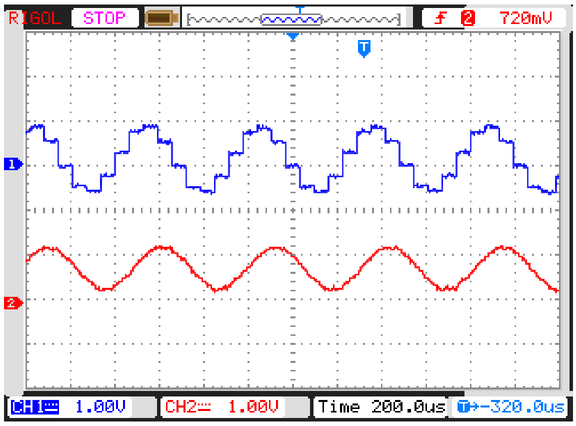
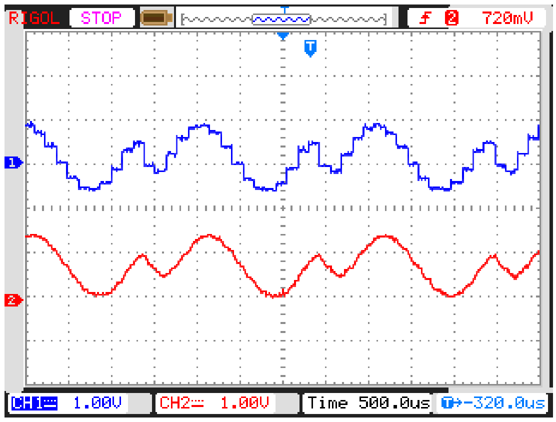
Square/500 Hz	Channel3	8 KHz	 CH1: Demodulated Output (TP36), CH2: Low Pass Filter Output (TP37)

Sine/1.5 KHz	Channel3	8 KHz	 CH1: Demodulated Output (TP36), CH2: Low Pass Filter Output (TP37)
Arbitrary/500 Hz	Channel4	8 KHz	 CH1: Demodulated Output (TP39), CH2: Low Pass Filter Output (TP40)

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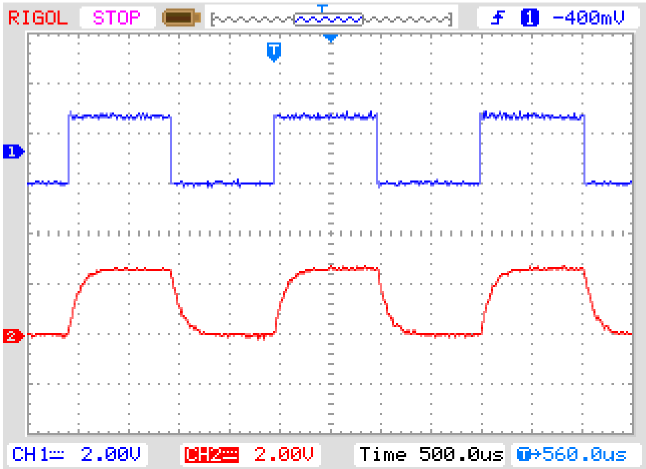
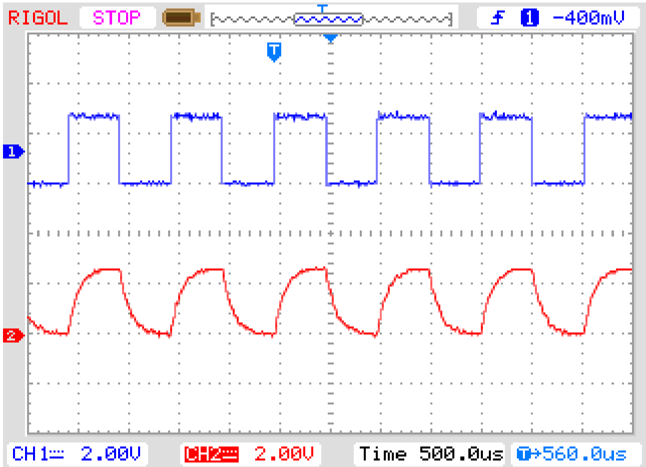
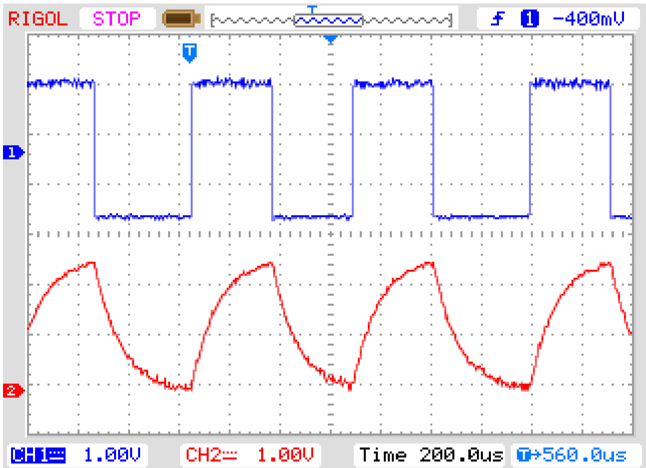
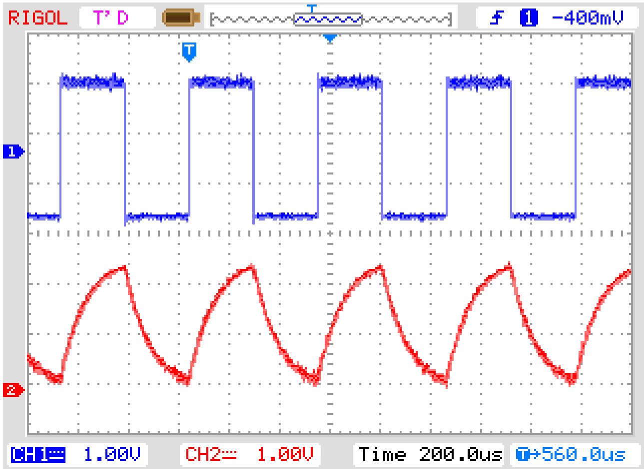
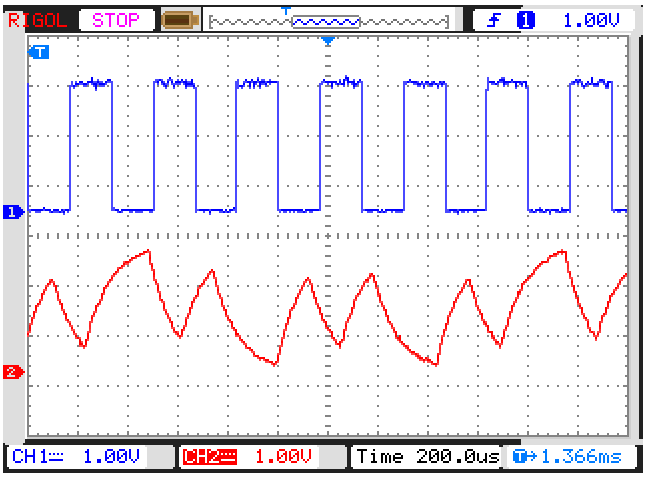
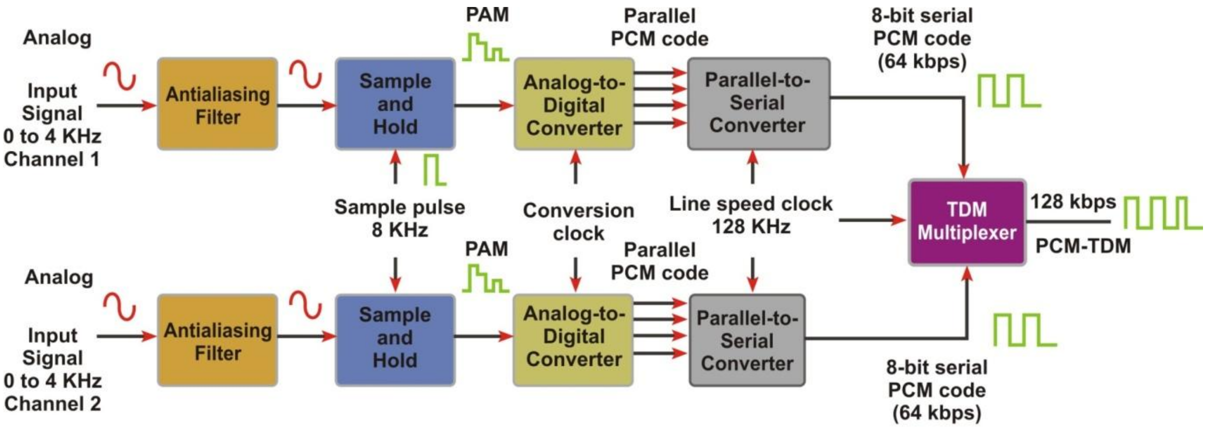
Square / 500 Hz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)
Square / 1 KHz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)
Square / 1.5 KHz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)

Square / 2 KHz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)
Square / 3 KHz	Channel1	8 KHz	 CH1: Input Signal (TP5), CH2: Low Pass Filter Output (TP31)

Note :- Above results are shown filter effects of square wave w.r.t frequency . Type of low-pass filter at the receiver end is 2nd order butterworth active filter with 3-db, cut-off frequency 5 KHz. If you observe the signal at the output of the DAC i.e. input of the filter, you will see the proper square wave. As we have used low-pass filter with cut-off frequency 5 KHz so you are getting curved shape square wave due to the RC effect of the filter at maximum input frequency option i.e. 3 KHz.

Case Study

2-Channel TDM-PCM



Specifications:

Input Signal type of Channel1: Sine

Input Frequency of Channel1: 500 Hz

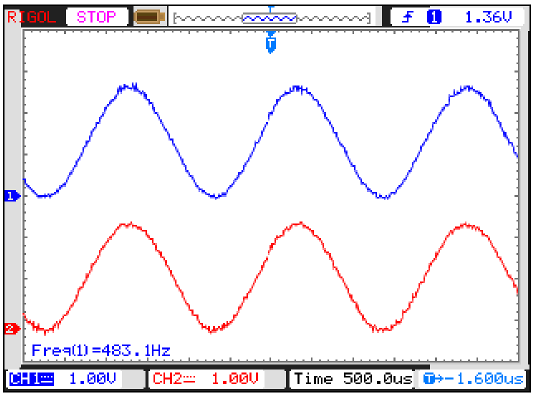
Input Signal type of Channel2: Arbitrary

Input Frequency of Channel2: 1.5 KHz

Sampling Frequency: 8 KHz

Observations:

Channel 1: TP1 & Channel 2: TP5



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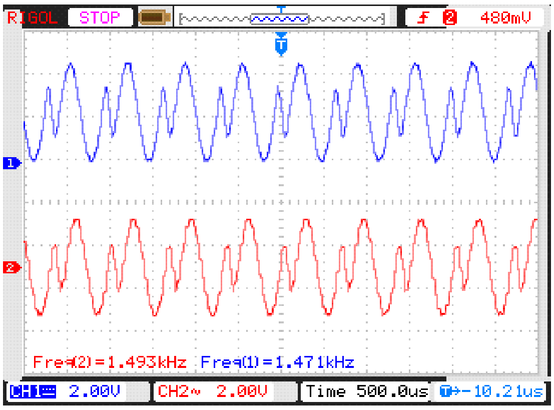
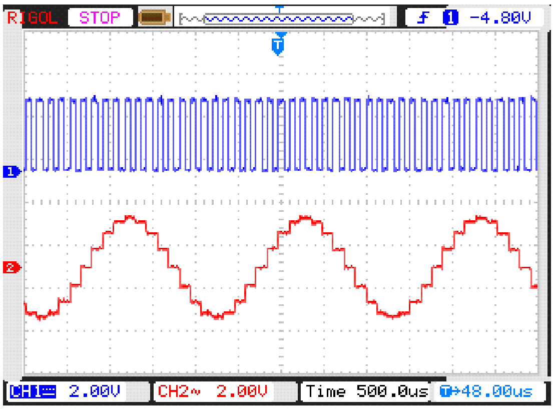
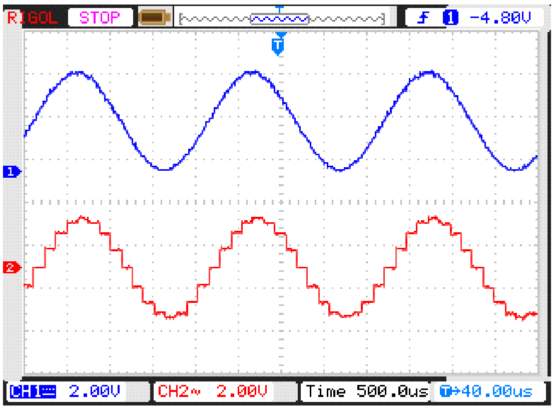
Channel 1: TP2 & Channel 2: TP10



Channel 1: TP6 & Channel 2: TP7



Channel 1: TP5 & Channel 2: TP7



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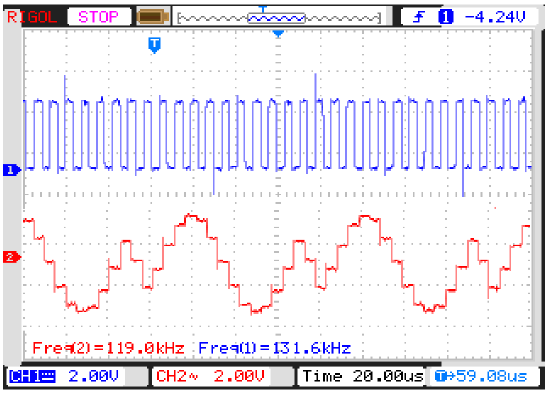
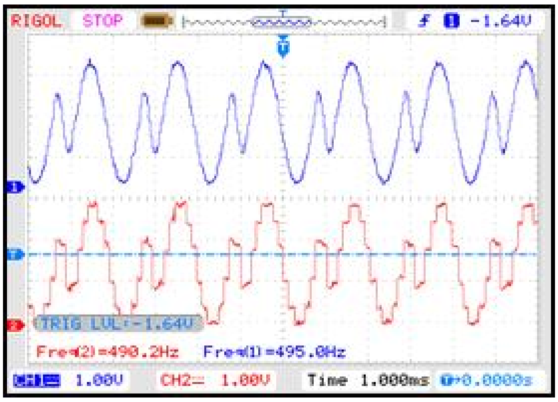
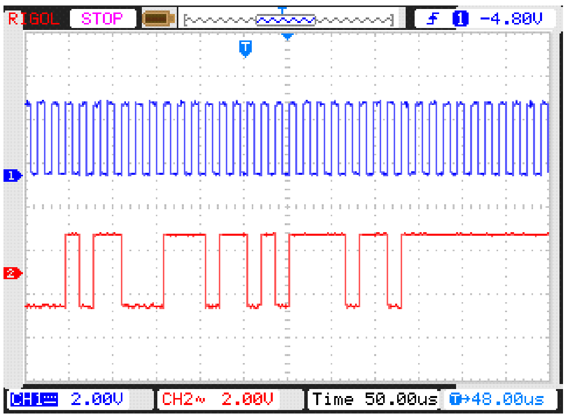
Channel 1: TP11 & Channel 2: TP12



Channel 1: TP10 & Channel 2: TP12



Channel 1: TP8 & Channel 2: TP9



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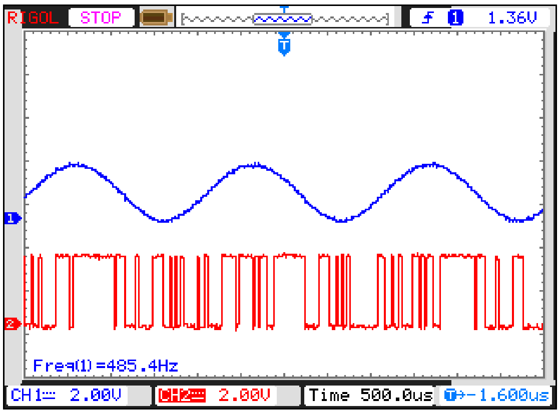
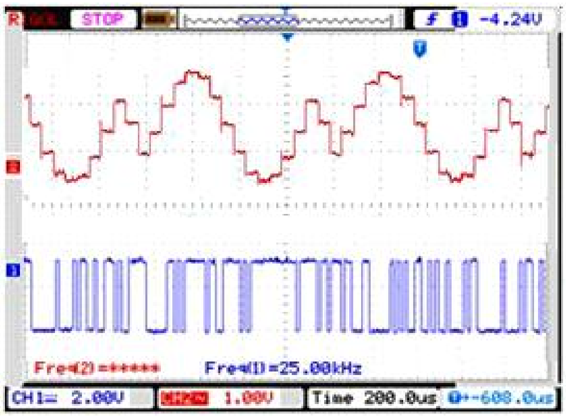
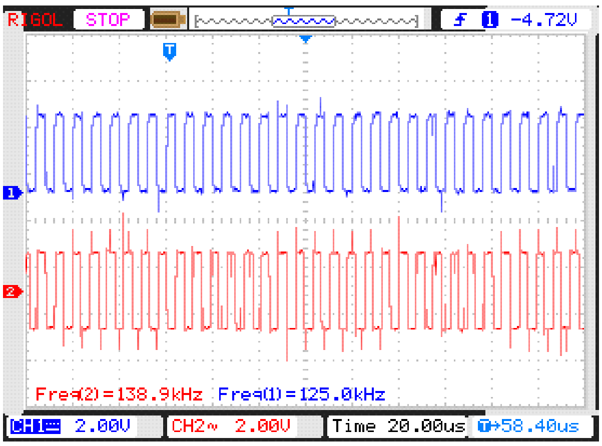
Channel 1: TP5 & Channel 2: TP9



Channel 2: TP12 & Channel 1: TP14



Channel 1: TP25 & Channel 2: TP clock1



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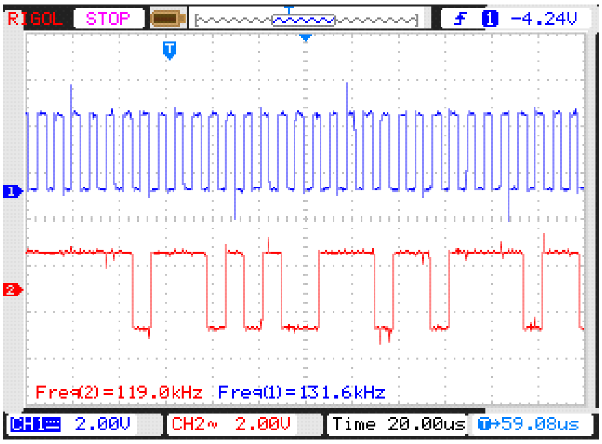
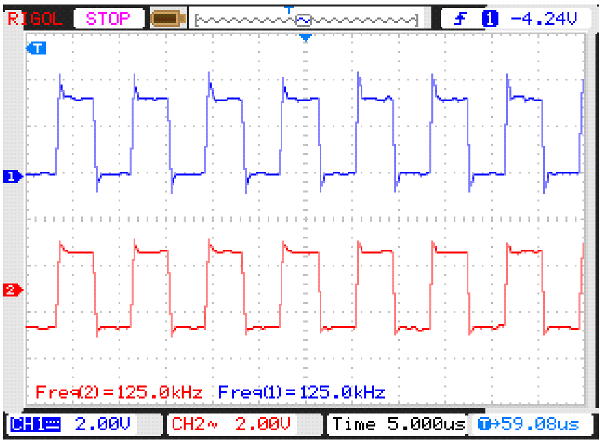
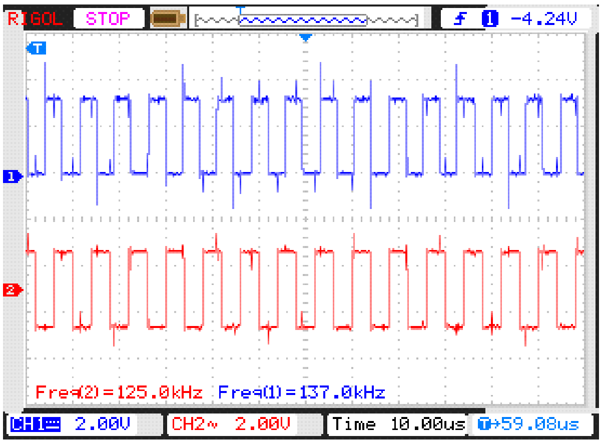
Channel 1: TP clock1 & Channel 2: TP 26



Channel 1: TP25 & Channel 2: TP clock2



Channel 1: TP clock1 & Channel 2: TP clock2



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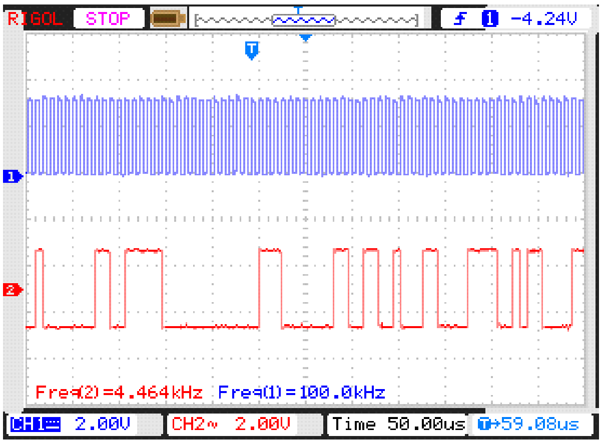
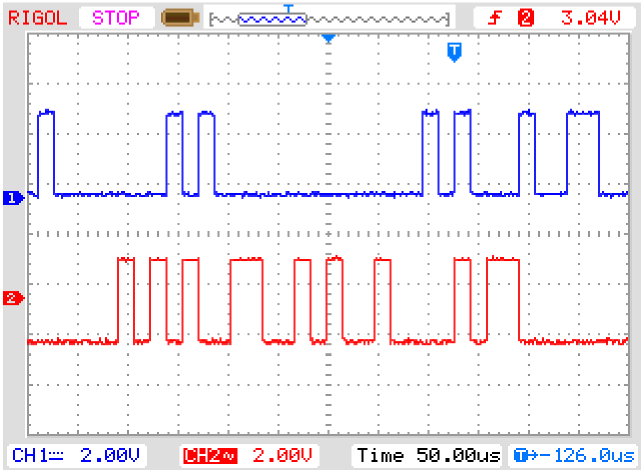
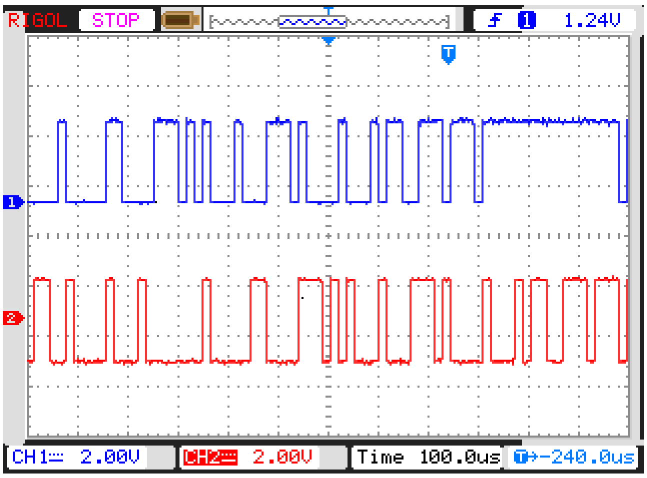
Channel 1: TP clock2 & Channel 2: TP 27



Channel 1: TP 9 & Channel 2: TP 29



Channel 1: TP 14 & Channel 2: TP 32



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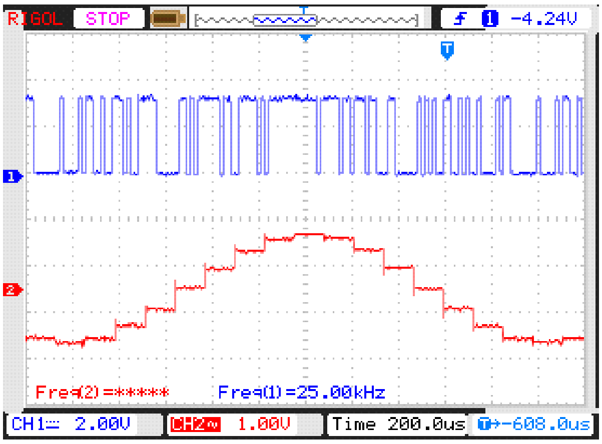
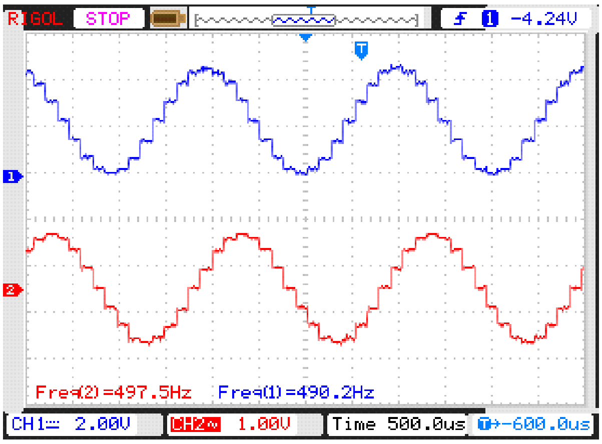
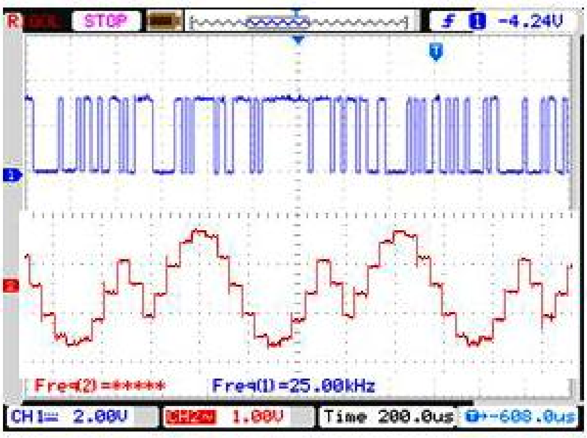
Channel 1: TP 29 & Channel 2: TP 30



Channel 1: TP 7 & Channel 2: TP 30



Channel 1: TP 32 & Channel 2: TP 33



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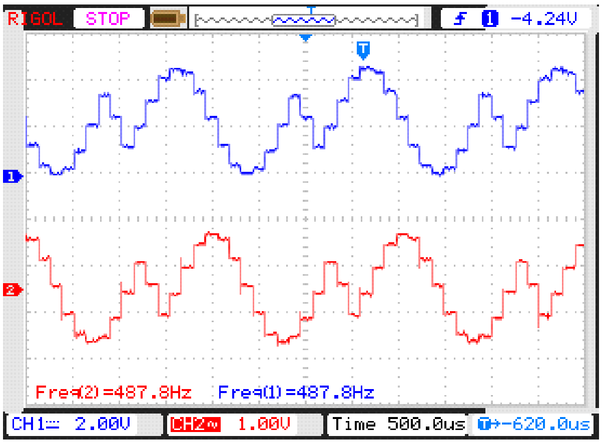
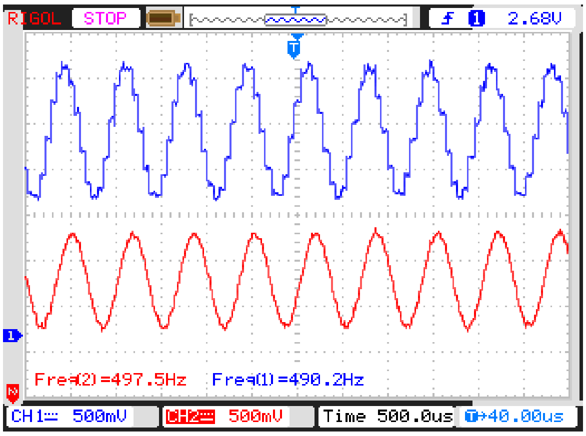
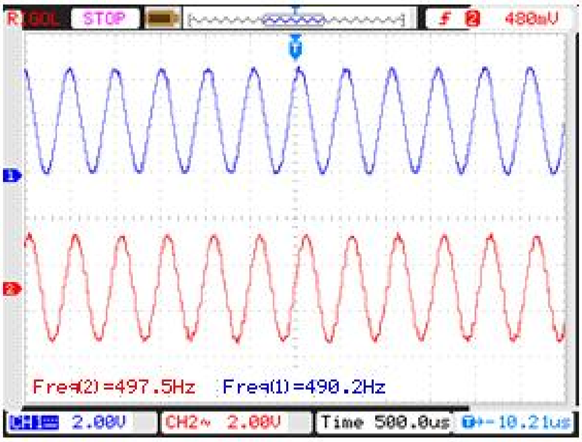


Channel 1: TP 30 & Channel 2: TP 31



Channel 1: TP 5 & Channel 2: TP 31



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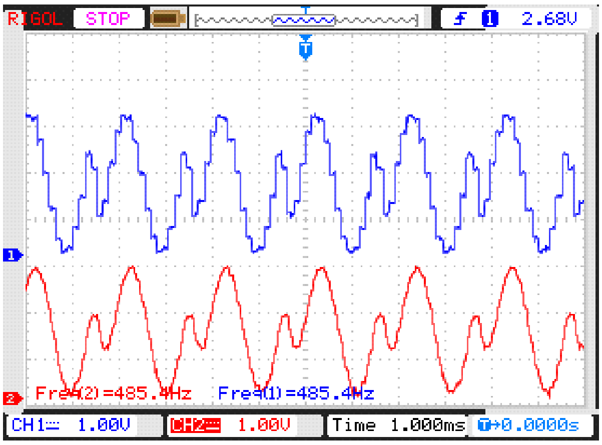
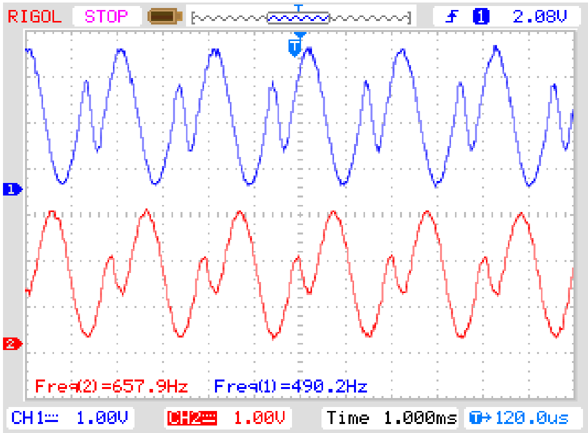
Channel 1: TP 33 & Channel 2: TP 34



Channel 1: TP 10 & Channel 2: TP 34



Glossary

Bandwidth: The carrying capacity or size of a communication channel; usually expressed in hertz (Cycles Per Second) for analog circuits or in bits per second (BPS) for digital circuits.

Baud: A unit of signaling speed equivalent to the number of signaling elements per second. Modems that transmit faster than 1800 BPS send multiple bits per baud. For example, 9600 BPS modems transmit 4 bits per baud.

Bipolar Return to Zero (BRZ): A bipolar signal in which each pulse returns to zero amplitude before its time period ends. This prevents the buildup of DC current on the signal line.

Bipolar Violation (BPV): Occurrence of two successive pulses of the same polarity in a bipolar signal.

Bit: Originally a contraction of "Binary digit." A bit is the basic unit in data communications and the smallest element of information in the digital system. An individual bit is either a 1 or a 0.

Bit Error Ratio (BER): The ratio of bits with errors to the total number of bits detected, usually expressed as a number with an exponent to a power of ten. Used to measure the quality of a signal path.

Byte: Set of eight bits that is used to represent information such as a number, letter, or character.

Circuit Switching: A switching method whereby a dedicated path is established between transmitter and receiver.

Communication: Communication (from Latin "Communis", meaning to share) is the activity of conveying information through the exchange of thoughts, messages, or information, as by speech, visuals, signals, writing, or behavior.

Communication Ports: Paths into or out of a Computer that provide the means to link the computer with external devices, such as terminals and printers.

Demodulation: Conversion of a modulated signal to an unmodulated “baseband” signal.

Digital signal: Representation of physical signals using numbers, usually called “samples," to represent amplitude or intensity.

Full Duplex: Full-duplex communication means that data can be simultaneously transmitted and received across a communication channel.

Half Duplex: Half-duplex communication means that data can be alternately transmitted and received across a communication channel.

Hertz: Frequency measurement unit. 1 Hertz = 1 cycle per second.

Inverse Multiplexing: Taking a single high-bandwidth stream and dividing it into multiple channels for transmission over a wide area in separate 56 or 64 Kbps switched digital circuits.

Mbps: Megabits Per Second. One megabit is 1,048,576 bits.

Modem: Combination of Modulator/Demodulator. A device that converts digital data to/from analog signals for transmission over analog lines.

Modulation: Process of varying one or more properties of a high frequency periodic waveform, called the carrier signal, with respect to a modulating signal.

Multiplexer: Commonly referred to as a "MUX." It is a device used to combine multiple parallel information streams into a single channel.

Multiplexing: Simultaneous transmission of several messages along a single channel of communication.

Pulse Code Modulation: Pulse Modulation Technique in which the amplitude of an analog signal is converted to a binary value and is represented as a series of pulses.

Pulse Modulation: Method of varying the amplitude, frequency or phase of information-bearing signals into a series of pulses.

Frequency Modulation: A method of transmitting information on radio waves by encoding the information as a change in frequency or number of cycles per second.

Sampling: Foremost process in analog to digital conversion. In it, a continuous time signal is converted into discrete time signal by measuring the signal at periodic instants of time.

Signal: An electrical quantity (voltage or current or field strength) whose modulation represents coded information about the source from which it comes.

Synchronous transmission: Data transmission that is synchronized by timing signals and usually transmitted in blocks rather than individual characters. This type of transmission is more efficient than asynchronous transmission.

TDM: TDM is a communication process that transmits two or more streaming digital signals over a common channel. In TDM, incoming signals are divided into equal time slots.

Frequently Asked Questions

Q1. What is Communication?

Ans. Communication means transferring of message from one place to another place.

Q2. What are the different types of communication? Explain.

Ans. Two types of communication are there:

- Analog Communication
- Digital Communication.

As a technology, analog is the process of taking an audio or video signal (the human voice) and translating it into electronic pulses. Digital on the other hand is breaking the signal into a binary format where the audio or video data is represented by a series of "1"s and "0"s. Both the types of communication occur according to the corresponding signal used.

Q3. What is Sampling?

Ans. The process of obtaining a set of samples from a continuous function of time x(t) is referred to as Sampling.

Q4. State Sampling theorem.

Ans. It states that, while taking the samples of a continuous signal, sampling rate should be equal to or greater than twice the cut off frequency so that the original signal can be recovered properly and the minimum sampling rate is known as the Nyquist rate.

Q5. What is Cut-off frequency?

Ans. The frequency at which the response is -3dB with respect to the maximum response is referred to as Cut-off Frequency.

Q6. What is Passband?

Ans. Passband is the range of frequencies or wavelengths that can pass through a filter without being attenuated.

Q7. What is Stopband?

Ans. Stopband is a band of frequencies, between specified limits, in which a circuit, such as a filter or telephone circuit, does not let signals pass through, or the attenuation is above the required Stopband attenuation level.

Q8. What is Demodulation?

Ans. Demodulation is the act of removing the modulation from an analog signal to get the original baseband signal back. Demodulation is necessary because the receiver system receives a modulated signal with specific characteristics and it is required to turn it to baseband.

Q9. Name the modulation techniques.

Ans. Analog modulation techniques - AM, SSB, FM, PM and SM

Digital modulation techniques - OOK, FSK, ASK, PSK, QAM, MSK, CPM, PPM, TCM, OFDM.

Q10. What is Multiplexing?

Ans. Multiplexing (known as Muxing) is a term used to refer to a process where multiple analog message signals or digital data streams are combined into one signal over a shared medium. The aim is to share an expensive resource. For example, in telecommunications, several phone calls may be transferred using one wire.

Q11. Explain Full Duplex and Half Duplex.

Ans. Full duplex refers to the transmission of data in two directions simultaneously. For example, telephone is a full-duplex device because both parties can talk at once. In contrast, a Walkie-Talkie is a half-duplex device because only one party can transmit at a time. Most modems have a switch that allows choosing between full-duplex and half-duplex modes.

Q12. Define encoder and decoder.

Ans. Encoder is a digital electronics device that converts the information in complex code (binary numbers) of predefined format, which is further converted in the original form by the device called decoder.

Q13. What is the Nyquist sampling rate?

A. Nyquist sampling rate states that, the minimum sampling rate is equal to twice the highest audio input frequency

Q14. What is the principle of pulse modulation?

A. Pulse modulation consists essentially of sampling analog information signal and then converting those discrete pulses and transporting the pulses from a source to a destination over a physical transmission medium.

Q15. What is idle channel noise

A. When there is no analog input signal, the only input to PAM sampler is random, thermal noise. This noise is called idle channel noise.

Q16. Define quantization error?

A. Quantization is the value of which equals the difference between the output and input values of quantizer.

Warranty

1. We guarantee this product against all manufacturing defects for **12 months** from the date of sale by us or through our dealers.
2. The guarantee will become void, if
   a. The product is not operated as per the instruction given in the Learning Material.
   b. The agreed payment terms and other conditions of sale are not followed.
   c. The customer resells the instrument to another party.
   d. Any attempt is made to service and modify the instrument.
3. The non-working of the product is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type, serial number of the product and date of purchase etc.
4. The repair work will be carried out, provided the product is dispatched securely packed and insured. The transportation charges shall be borne by the customer.

Hope you enjoy the Scientech Experience.

List of Accessories

1. Patch Cord 16"(Black) ....2 Nos.
2. Mains Cord ....1 No.
3. TechBook Power Supply ....1 No.