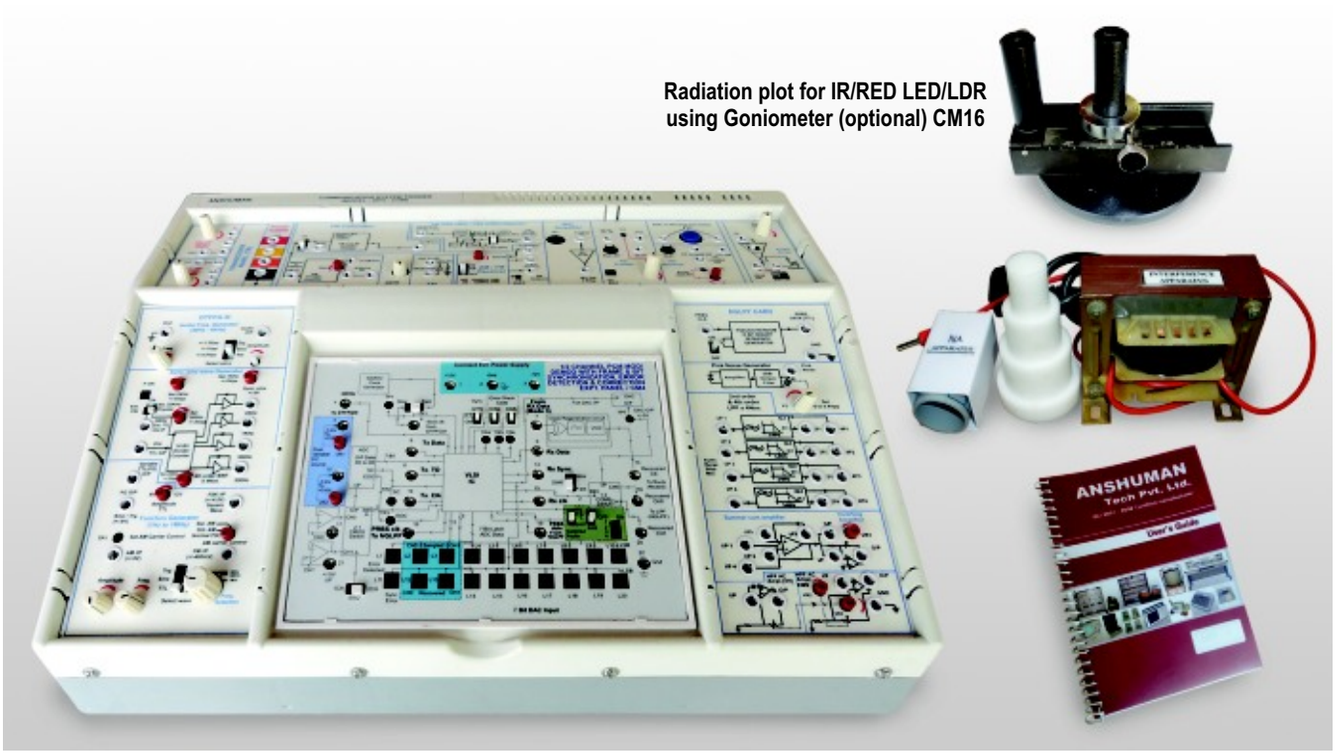
COMMUNICATION SYSTEM TRAINER (Model : XPO-COM)

Fiber Optic Communication Trainer



Radiation plot for IR/RED LED/LDR using Goniometer (optional) CM16

SALIENT FEATURES

- Can learn and experiment about variety of communication mediums (AM, FM, FO Wired) & methods (Modulation / Demodulation Analog/ Digital).
- Covers Analog communication, Digital communication, Fiber optics characteristics as well as communication, Wired communication through various modular experiment panels implemented using latest state of arts VLSI/CPLD's.
- Aesthetically designed injection molded electronic desk (master unit) carrying useful experiment resources like power supplies, Multi Fuction generators, FM/AM/FO/Transmitter/receiver, MIC and L/S amplifier, Butterworth Filter (BWF), Sync sine waves etc while central slot will hold various replaceable experiment panels. Order 10 MUs + 10 Panels sets or mu multiples.
- Can buy CM6,CM7,P19 as stand alone panels to save money.
- Connection through sturdy 4mm Banana sockets, patch cords, ST connectors, BNC Connectors.
- Student workbook & instructor's Guide provided

SPECIFICATIONS OF MASTER UNIT

- **Built in DC Power Supply :**

  5V/1A, ± 12V/500mA, 0 to -15V DC (Variable) / 100mA, 0 to15V DC (Variable)/100mA.

- **Waveform Generator :**

1. **Carrier Generator:**
   - Waveform : SINE / TRG / TTL / CMOS (settable)
   - Output Frequency : 1 Hz to 1 MHz
   - Output Voltage : 0-20 Vpp
   - Controls : Frequency & Amplitude control pots
   - Modulation : AM (std) -I/P volt - ±5V, 0V-No modulation AM (DSBSC)- I/P volt. 0-9.8 Vpp, o/p volt.0- 2.7, FM I/P volt. 400mV (±50% modulation), ASK- I/P upto 500Hz, ±5V Square wave, FSK-I/P upto 500Hz, ±4.5V Square wave.
2. **Audio Oscillator:**
   - Waveform : SINE / TRG / SQUARE
   - Output Frequency : 50 Hz to 5KHz
   - Output Voltage : Sine 0-2Vpp, Sq. 0-9 Vpp, TRG. 0-3Vpp
   - Controls : Freq & Amplitude control pots.
3. **Synchronized Sine Wave Generator :**
   - Input : 32 KHz TTL I/P to Generate 4 nos. of sync. sine O/P
   - Waveform : SINE
   - Output Frequency : 250 / 500 / 1000 / 2000 Hz
   - Output Voltage : 0-10 Vpp
   - Controls : Amplitude control pot
- Mic with Pre-Amp. Hand held Electret / dynamic microphone with preamplifier for audio range.
- Audio Amplifier : Variable Gain upto 20 for Audio range, Built in Loudspeaker - 8 ohm/500mW / earphone.
- Pink Noise Gen. : Frequency response of filter for audio range.
- Buffer/AC amplifier : NIV gain amplifier 2 Nos, Gain- 0-20, For Non sinusoidal Signal Generator cum INV buffer.
- BNC TO Banana Converter : Converts 1 BNC Socket to 2 Banana Sockets (4mm) & Vice Versa.
- Butter Worth Filter [LPF]: 4 Nos - 2 pole/4 pole butter worth filter cutoff freq 3.4 KHz Audio range.
- Pseudo Random Binary Sequence generator : Switch settable for on/off fix 15 bit PRBS Generator, will also function as input digital data stream generator.

- **Wireless Communication :**
- **1a. FM Transmitter (Transistorized) :**
- Carrier Tunable from 88 MHz to 108 MHz with built in FM [VCD]
- Modulating Signal : Amplitude - 5Vpp, Freq. - Audio Range
- Tx Power O/P : 50 to 100mW
- **1b. FM Receiver :** External 5 BS5 to connect to antenna, 2nd IF Input, 2nd IF Output, speaker & Audio amplifier, AM/FM Select switch, L/S impedance 8 ohm / 0.5 W.

- Controls (Manually) : Settable 88 to 108 MHz.
- Antenna / Transmission: Telescopic antenna [3 branch antenna] optional.

◆ **2a. AM Transmitter (Transistorized):**

- Carrier : 500KHz to 1.5MHz
- Modulating Signal: Amplitude - 5Vpp, Freq.- Audio Range.
- Tx Power Output : 50 to 100mW.

◆ **2b. AM Receiver :** External 5 BS5 to connect to antenna, 2nd IF Input, 2nd IF O/P, speaker & Audio amplifier, AM/FM Select switch, L/S impedance 8 ohm / 0.5 W.

- Controls (Manually) : Gain control settable from 0 to 4.5V.

◆ **3a. Fibre Optics Transmitter :**

- Data Input Bandwidth : 500KHz to 1.5MHz.
- Modulating Signal : Amplitude - 5Vpp, Freq.- Audio Range.
- Tx Power Output : 50 to 100mW.

◆ **3b. FO Receiver :** Detector (tr=8ms) separate BS5 socket for digital, AC coupled & TTL o/ps.

- Controls (Manually) : Transmitter bias control.
- Antenna / Transmission: 1m plastic fiber cable, CRT-1.492, NA- 0.5, λ– 660nm, step index, terminated with SMA connector.

Mechanical Dimensions :

(A) Master Unit : 460mm(W), 160mm(H), 350mm(D)
Net weight : 5 Kg. Gross Wt.: 7 Kg.

(B) Panel : 215mm(W), 165mm(H), 40mm(D)
Net weight : 700 gm approx.

(C) Operating Voltage : 220/240Vac switch settable ±10%, 50Hz/35VA.

List of Experiment on Master Unit (9): **1)** Voice link using mic & LS amplifier, **2)** Study of AM Xmitter / Receiver, **3)** Study of FM Xmitter / Receiver, **4)** Band determination of PLL as FM Detector **5) A)** PLL as FM Detector **B)** FSK (Frequency Shift Keying) Mod / Demod [Wired] **C)** FSK (Frequency Shift Keying) Mod / Demod [Through FO] **6)** A) Diode as AM Detector B) ASK (Amplitude Shift Keying) Mod / Demod [Wired] C) ASK (Amplitude Shift Keying) Mod / Demod [Through FO]

7) Fiber Optics Transmitter / Receiver **7.1)** Analog Bandwidth. **7.2)** Digital Bandwidth. **7.3)** Voice Communication using mic, speaker & Fiber optics **7.4)** Listening to AM/FM Radio through Fiber Optics link

8) Pseudo Random Binary Sequence Generator [PRBS] **9)** Study of active filters, Noise generation & elimination. **A)** Study of Pink Noise Generator **B)** Study of Signal To Noise Ratio of an Amplifier **C)** Study of active 2nd & 4th order Low Pass Filter **D)** Study of Frequency response of HPF / AC Amplifier [3H] E) Study of Frequency response of HPF / AC Amplifier [1.6K].

SA OPTION ◆ **Modular experiment panels : Following experiement panels normally work in conjuction with COM Master unit. However they can be ordered as standalone (SA) units with built in power supply, Mic amplifier, LS amplifier, Low Pass filter (Atleast select one or more panels).**

MU OPTION ◆ **Shares common resources like PS, Sync Sin Waves, Carrier generator, Audio Frequency Oscillator /Signal source from DTFFG-III, 2-P/4-P Low Pass filter from NGLPF Card, PRBS Generator, MIC Pre-Amplifier, Audio Amplifier from Master Unit (MU). etc.**

1) Plastic Fiber Optics Cable Expt. Panel (CM1)

(Provided with 16 banana + 2 TPs + 1 LED)

◆ **Fiber optic cable (plastic):** Core material : PMMA (polymethyl methacylate), Cladding material: fluorinated polymer, Fiber structure: step index type, Core cladding diameter: 90 /1000 microns, Core refractive index : 1.492, Cladding refractive index: 1.405 to 1.417, Numerical aperture : 0.5(typically), Acceptance angle: 55 to 60 degrees, Attenuation (60nm):0.3 dB/meter, Jacket material: polythene (black): 2.2 mm OD, LENGTH=1m, 5m

◆ **Transmitter: 4 nos. LASER (780nm), RED (660nm), BLUE (470nm), IR** SFH 485 **(850nm),** Reverse voltage: VR =5V, Forward Current: IF=100mA, Power dissipation: Ptot =200mW,Wave length at peak emission: λ peak = 880nm.

◆ **Receiver 1 No. PIN photo diode (SFH 203) :** Max wave length =850 nm, Rise time and Fall Time tr & tf=5ns, Reverse voltage: 50V, Total Power Dissipation: 100mW, Photo Current: 135(>/= 100µA).

◆ **Function Blocks:**

a] AC Amplifiers: 1 nos,**b]**Comparator : 1 nos **c]** Fibre Optic Driver with : Analog Bandwidth: 500KHz(except LASER) &1MHz for LASER, Digital Bandwidth: 1 MHz (except LASER) &2MHz for LASER **d]** Voice link: established using microphone & speaker (Master unit [MU]) **e]** PC –PC Communication: Using RS –232 interface 9 pin D – connector, Baud Rate: 2400**, f]** Switched faults: 4 in transmitter 4 in receiver**.**

◆ **Accessories**

N.A. APPARATUS, Bending radii stack (BR), fiber optic cable: 1m, 5m with SMA CONNECTOR, Electrical Interference Experiment Apparatus, Coupling loss apparatus, Speaker and MIC (from MU).

List of experiments (14) : DC Characteristics of transmitter diodes, SENSITIVITY of Optical Fiber, AC Frequency Response - Analog Link & BW, Digital Frequency Response - Digital Link & B.W, Numerical Aperture, Losses in cable- i) Bending loss ii) Transmission loss iii) Coupling loss. Immunity to Electrical Noise interference of optical fiber PC interface : Using RS 232, Signal transmission using Pulse Width Modulation & Demodulation, VOICE COMMUNICATION using direct transmission as well as modulated using PWM,Voice transmission using Amplitude Modulation & Demodulation, Signal transmission using Frequency Modulation & Demodulation, SWITCHED FAULTS.

◆ **Optional expansion module**

High speed digital link (B.W.=2MHz) with 1m FO cable.

- **Transmitter**

Forward input current (IFPK): 1000 mA (IFdc)=80 mA, Reverse input voltage: VBR= 5V, Peak wavelength emission: 660 nm, N.A.: 0.5, Rise time: 80 ns, Fall time: 40 ns.

- **Receiver**

Supply voltage: (max) 7V, O/p collector current: 25 mA, O/p collector power dissipation: 40 mW, O/P VOLTAGE: 18v, Fan out (TTL): 5

2) 1 channel Sampling & Reconstruction, 4 Channel TDM/PAM & PPM, PWM, PFM Expt. panel (CM2)

(Provided with 20 banana + 10 TPs + 10 Leds)

- Crystal Freq.-10 MHz.
- Switched faults : - 4 Nos.
- **1 channel Sampling/ Reconstruction & 4 Channel TDM/PAM & demodulation: -**

a) Modulator : Analog i/p channel: - 4 Nos, 10 Vpp, Bipolar. Settable Sampling Freq. (1of 7) : 64 / 32 / 16 / 8 / 4 / 2 / 1 KHz With Settable Duty Cycle 10-90 % in decade steps.

b) De-Modulator : Clock Regeneration using PLL, LPF, 1/2/3 Wire Communications

◆ **PWM / PPM**

a) Modulator : I/P freq Audio range (Sine) @ 0-8 Vpp , Carrier Freq - 64KHz (TRG) @ 8 Vpp O/P TTL.

b) De-Modulator : LPF (MU), PPM is converter into PWM then Demodulated.

◆ **PFM**

a) Modulator : Center Freq (64KHz / TTL) from Function Generator (MU) is FM modulated by audio signal generating PFM pulse train.

b) De-Modulator : PLL Detector followed by LPF from MU.

List of experiments (3) : Single channel PAM Sampling [1CH Signal Sampling & Reconstruction (1 CH SSRC)] i) Natural Sampling, ii) Flat Top Sampling (Sample Hold), Multichannel [4CH / 2CH for SA] PAM Sampling, multiplexing of data over single wire & demultiplexing of data at receiver to reconstruct 4 channels by various method 3 \ 2 \ 1 wires [mode 1, 2, 3 respectively., PWM \ PFM \ PPM Pulse modulation & demodulation as a methods of digital communication.

3) Carrier modulation/ Demodulation Expt. Panel (CM3)

(Provided with 38 banana + 3 Tps)

- **Carrier Sine wave**-500KHz, 250KHz(0° phase) & 250KHz(90° phase) with settable amplitude 0 to 2Vpp.
- 4 MHz Crystal Stabilized Clock.
- **On board Unipolar to Bi polar Converter, Data Squaring.**
- **Carrier Modulation Techniques** ASK, FSK, PSK & QPSK.
- **Carrier De-Modulation Techniques** ASK (Rectifier Detector), FSK (Phase Lock Loop Detector), PSK (Squaring loop Detector) and QPSK (Fourth power loop detector).
- **Low Pass Filter** 2 Nos with Cut off Frequency 340KHz.

List of experiments (4) : Amplitude Shift Keying [ASK] Modulation / Demodulation, Frequency Shift Keying [FSK] Modulation / Demodulation, Phase Shift Keying [PSK] Modulation / Demodulation, Quadrature Phase Shift Keying [QPSK] Modulation / Demodulation.

4) 2 Channel Pulse Code [TDM/ PCM] Modulation / Demodulation with frame & bit Error Detection & synchronization & Correction Expt. Panel (CM4)

(Provided with 22 banana + 6 TPs + 20 Leds)

- Switched faults: - 4 Nos. + 2 No Switches for bit error simulation
- 1 & 2 Ch TDM / PCM Mod - Demod: - 1/2/3 Wire Communications
  - **a) Modulator :** Analog i/p : - 2 Nos, 10 Vpp , onboard Two adjustable variable DC source, Sampling Freq. 16KHz per Channel for Fast mode & 0.106 Hz per Channel for Slow Mode, use of PRBS to generate frame marker useful to establish syc. in receiver during 1/2 wire communications.
  - **b) De-Modulator :**Synchronization is established by using Pseudo Random Binary Sequence, Clock Regeneration using PLL.
  - **c) Frame & bit Error Detection :**Use of PRBS for synchronization. Selectable Even, Odd parity (Binary cyclic) & Hamming (Linear Block code)
  - **d) Error Correction :**Single or Double Data bit error correction using Hamming code.
- Voice communication using wired PCM.
- Voice communication using Fiber optics (CM1) & PCM.

List of experiments (8) : Single channel Pulse Code Modulation & Demodulation by various method 3/2/1 wires [mode 1, 2, 3 respectively], Two channel TDM, PCM Modulation & Demodulation by various method 3/2/1 wires [mode 1, 2, 3 respectively],Use of PRBS for frame synchronization by adding a Bit (Marker) in 2 / 1 Wire (Mode 2, 3 respectively), Study of Error Code Check such as Even Parity, Odd Parity and 1 bit / 2 bit error simulation & correction by Hamming Code, Voice and Radio communication using PCM, Study of ADC / DAC [CODEC] by observing on Leds & by applying DC Levels at single or both i/ps, Switched Faults, Study of eye diagram, PC Communication using PCM.

5) Delta, adaptive delta, sigma delta modulation and demodulation Experiment Panel (CM5)

(Provided with 26 banana+ 5TPs.)

- Consisting of Voltage comparator, differential amplifier, TTL to Bipolar Converter.
- Switched faults. (4 Nos.)
- Delta, adaptive delta (CVSD), sigma modulation & demodulation, Adaptive control circuits 2Nos. each, provides 2 bit binary code, used to control gain of an integrator for adaptive delta modulation.
- **Companding** : Using compressor and expander function blocks, Study of Mu Law & A Law.

List of experiments (6) : Delta mod-demod, Adaptive (CVSD) delta mod demod, Sigma delta mod demod, Voice communication, Effect of companding on delta mod-demod, Switched faults.

6) AM modulation & demodulation Expt . panel (CM6)

(Provided with 26 banana)

- Consisting of 3 Nos. modulators, Ceramic BPF, envelope - diode detector, product detector. Built in LPF for standalone application.
- Switched faults - 4 Nos.
- **Modulator:** Balanced modulator (DSB SC) - 2Nos. and DSB - TC -1 No., SSB - SC - 1No.
- **Demodulator:** Envelope detector-1 No., Product detector -1 No.
- Frequency division multiplexing with 2 Nos. of DSB-SC AM channels (Use P19 for demod of **FDM - AM**), 2p LPF for stand alone application.

List of experiments (12) : DSB modulation with transmitted carrier (TC), DSB modulation with suppressed carrier (SC), Ceramic filter (BPF), SSB SC modulation (for upper/lower side band), DSB TC demodulation, DSB SC demodulation, SSB SC demodulation, ASK

Demodulation using synchronous detector, QAM mod demod,FDM-AM using P19(AM/FM receiver kit), Voice communication, Switched faults.

- **CBT (Optional) -** Proving theory of AM (DSB-SC, SSB-SC, FDM, QAM) using numerical method on PC (Excel Graphs)

7) AM demodulator cum AM-FM Receiver Expt. Panel (P19)

(Provided with 3 banana + 20TPs.)

Consisting of antenna, RF amplifier, IF amplifier, Local oscillator (455KHz), Mixer, Audio amplifier with L/S.

- AM demodulator - Diode Detector for DSB.
- Switched faults -16 Nos.
- Synthesized Superheterodyne Receiver - AM receiver cum tunner (450 to 1450KHz), FM receiver cum tunner (88 to 108MHz)

List of Experiment (8): **AM receiver (5) :** DSB TC demodulation using tuning of AM receiver, Sensitivity of radio receiver, Signal to noise ratio, Effect of AGC, Fidelity of Radio Receiver.

FM receiver (3): FM demod using tuning of FM receiver, Sensitivity of radio receiver, Selectivity of radio receiver.

FDM AM : Using CM6, Frequency Division Multiplexed channel recovery.

8) FM Modulation & Demodulation Expt. Panel (CM7)

(Provided with 28 banana + 3TPs.)

- Switched faults: - 8 Nos.
- **Modulator** : (With center freq. 455 KHz). Reactance Modulator, Varactor Modulator with center frequency adjustment, Phase modulator using varactor, Armstrong Modulator using PLL.
- **Demodulator** : Detuned resonant circuit detector, Quadrature detector, Foster-Seeley discriminators, Ratio detector, Phase-locked loop detector & determination of capture and lock range, Phase Demodulator using quadrature detector. 2P LPF for standalone application.
- Pre-emphasis & De-emphasis Block for flat frequency response.

List of experiments (12) : **Frequency modulation using :** Reactance modulator, Varactor modulator, Phase modulator using varactor, Frequency demodulation using : Detuned resonant detector, Foster Seeley/ratio detector, Study of PLL capture & lock range & its use as FM detector, Use of PLL as Armstrong Modulator, Quadrature detector, Phase demodulation using quadrature detector, Introduction of noise & its effects on frequency modulation, Voice communication, pre-emphasis & de-emphasis for flat frequency response, Switched faults.

- **CBT (Optional) -** Proving theory of FM, PM (using numerical method on PC (Excel Graphs)

9) Data Formatting / Reformatting Expt. Panel (CM8)

(Provided with 18 banana.)

- **Data Formatting and Reformatting Option** NRZ (L), NRZ (M), Polar RZ (AMI) & NRZ, Bipolar RZ & NRZ, Bi-phase Manchester, Bi-phase Mark, Differential Encoded Dibit (For use with QPSK).] -8 Nos. of encoders & 3 Nos. of bit decoders & 1 No. of dibit decoders.
- **Bi phase Clock Recovery -** By using Phase Lock Loop (PLL) with center frequency 250KHz & 32KHz selectable.

List of experiments (3) : Study of RZ, NRZ-L [Non Return To Zero - Level], NRZ-M [Non Return to Zero - Mark], Bi phase Mark, NRZ-S, Bi phase Manchester encoders & decoders) Study of RZ - AMI [Return To Zero - Alternate Mark Inversion] encoder & decoder, Study of differential DIBIT [MSB / LSB] Encoder & Decoder.

10) Fourier analysis cum synthesis expt. panel (FAS) (CM 9)

(Provided with 12 banana + 11 Tps.)

- Fundamental frequency 1KHz
- **Analysis** by Splitting 1KHz square wave into fundamental sin and 9 harmonics including DC component if any.
- **Synthesis** of 10 above components to generate original signal.
- Display frequency components on CRO using spectrum display controller in external trigger mode.
- Study of filters (LPF, HPF, BPF) and display characteristics curve on CRO (XY Mode) using FM sweep display.

List of experiments (5) : Fourier analysis, Fourier synthesis, Spectrum Analyzer cum Fourier component display on CRO, Study of filters, Switched faults.

- **CBT (Optional) -** Proving theory of Fourier Analysis & Synthesis [using numerical method on PC (Excel Graphs)]

11) Transmission Line Expt. Panel (CM10)

(Provided with 27 banana)

- Consisting of 50 ohm, 70 ohm simulated line, pulse generator, 50 ohm line driver, BNC to banana adaptor- 2nos, Impedance matching variable resistors-2 nos.
- Effect of pulse input, reactive termination, match termination, noise.
- Standing wave display on CRO in external trigger mode & VSWR determination.
- **Optional Coaxial cable (RG58)** x 50m(25m x 2 nos.) & terminating BNC,

  Calculation of delay, impedance, speed of light, standing wave ratio (VSWR).

  List of experiments (13) : Delay using a pulse input, Matching using pulse input, Reactive termination, Noise in communication, Matching and frequency response, Phase relationship, Standing wave ratio and Transformer matching, Standing waves, Low pass filter effect, 50 ohm line as an oscillator, Time domain reflectometry, Switched Faults, Experiments with actual RG 58 cable used in transmission line (optional).
- **Time domain experiments**

  a) Time domain measurements. b) time domain reflectometry. c) transmission delay when using pulse input d)effect of reactive termination frequency domain experiments e) sinusoidal study state in transmission.

12) DPCM / ADPCM Modulation / Demodulation Expt. Panel (CM11)

(Provided with 13 banana + 3 TPs. + 20 LEDs + 6 switches)

- Operation mode : Switch selectable - DPCM OR ADPCM
- Number of data bits in data frame switch selectable 3/4/5 bits.
- On-board Clock source @ 660 KHz.

a) **Modulator Function Blocks : -** 1 Analog Input- 10Vpp & Audio upto 2KHz, Onboard adjustable DC signal source, ADC Sampling Frequency @8.5 KHz, 7 Bit Comparator, Subtractor, Signed Adder, Parallel to Serial Converter.

b) **Demodulator Function Blocks : -** 1 Analog Output- 10Vpp & Audio upto 2KHz, Demodulated DPCM / ADPCM signal reconstructed using 7-bit DAC followed by passing through 2P/4P Butterworth filter on NGLPF Panel (MU), Serial to Parallel Converter, 7 Bit Signed Adder,

List of experiments (5) : DPCM - Modulation - Demodulation, ADPCM - Modulation - Demodulation, Slope Overload Error, Voice Communication using DPCM / ADPCM, Study of Eye Diagram.

13) 16 QAM Modulation / Demodulation Expt. Panel (CM12)

(Provided with 12 banana + 2 TPs.+ 12 LEDs + 5 switches)

- On-board Clock source @ 1.2 MHz.

a) **Modulator Function Blocks:-** 1 Analog Input- 10Vpp & Audio upto 300Hz [1KHz], Onboard adjustable DC signal source, ADC Sampling Frequency @ 1.5KHz, 7 Bit ADC, Signed Adder, Quadrature sine generator I, Q @ 55KHz, Mux and Latch.

b) **Demodulator Function Blocks :-** 1 Analog Output- 10Vpp & Audio upto 300Hz [1KHz], switch selectable DAC O/P either 16 QAM O/P or Demod O/P, original signal recovered by passing through 2P/4P Butterworth filter on NGLPF Panel (MU), 7 Bit DAC, Signed Adder, 7 Bit Amplitude & Phase comparator, Latch & Mux.

List of experiments (6) : Generate 16 QAM modulated sin output, Verify constancy of frequency but only phase angle and amplitude varies depending upon modulation bits, Draw constellation diagram for 16 QAM, Determine upper limit of data rate given a particular carrier frequency, Send and receive voice using 16 QAM, Cycle slip error

14) 4 Channel CDMA Modulation / Demodulation Expt. Panel (CM13)

(Provided with 12 banana + 7 LEDs + 2TPs + 5 switches)

- On-board Clock source @1. 2 MHz.

a) **Modulator Function Blocks :** High speed 7 bit ADC & 4 station data (sequence generator), 4 parallel in serial out (PISO) converter, 4 chip sequence (m=8) generators, signed digital adder, modulation control mode select switches, CDMA clock control logic.

b) **Demodulator Function Blocks :** Signed synchronous multiplier, station select mux, bipolar to unipolar converter, serial in parallel out (SIPO) and 7 bit DAC.

List of experiments (6) : Verification of CDMA modulation algorithm at o/p of DAC, Recovery of selected station data out of 4 stations, Upper frequency limit for recovery of voice frequency (Bandwidth determination), Voice communication, Study of ADC & DAC (Codec), Study of Eye Diagram.

15) LBC/BCC Encoder Decoder Expt. Panel (CM14)

(Provided with 14 banana + 16 LEDs + 3TPs + 5 switches)

- On-board Clock source @ 1.2 MHz.
- LBC or BCC selection Facility.

a) **Encoder Function Block**: High speed 7 bit ADC (10Vpp) & logic blocks for Latch, mux (2 Nos.) & 2 nos of separate Encoder combinational logic blocks, Encoder o/p LED indicators, provision to apply 4 bit data nibble either from switches or ADC o/p. **b) Error introducing logic**: Selective errors can inserted into transmitted code using error sockets (7 Nos.) with error LED indication.**c) Decoder Function Block:** High speed DAC Analog o/p (10Vpp) & audio up to 2 KHz BW, switch selectable voice (ADC) or 4 bit digital data, logic blocks for 4 bit upper & lower latches, 2:1 mux & 2 nos. Decoder combinational logic blocks and recovered o/p on LED's.

List of experiments (10): LBC / BCC encoder/ decoder o/p verification, LBC/BCC error detection and correction, upper limit on frequency components of incoming voice signal, voice communication, ADC & DAC (codec) testing.

16) Convolution Coding Encoder Decoder Expt. Panel (CM15)

(Provided with 15 banana + 20 LEDs + 3TPs + 5 switches)

- On-board Clock source @ 600KHz.

a) **Encoder Function Block :** High speed 7 bit ADC & logic blocks for Latch, mux (2 Nos.) & CC Encoder (2,1,4 scheme) built in PISO & SIPO function block, 14 bit Encoder o/p LED indicators, provision to apply 4 bit data nibble either from switches or ADC o/p.

b) **Error Introducing Logic :** Selective errors can inserted into transmitted code using error sockets (7+1 Nos.) with error LED indication.

c) **Decoder Function Block :** High speed DAC Analog o/p (10Vpp) & audio upto 2 KHz BWs switch selectable voice/ADC or 4 bit digital input data, logic blocks for 4 bit upper & 4 bit lower latch, mux & function block for CC (Viterbi) decoder based on lease distance calculator and recoered o/p on LED's.

List of experiments (6) : Convolution Encoder Decoder output verification, Convolution error detection and correction, upper limit on frequency components of incoming voice signal, voice communication, ADC & DAC (codec) testing.

17) Glass Fiber-Optics Cable Expt. Panel (CM16)

(Provided with 22 banana + 3 LEDs + 5TPs + 5 switches)

- **Transmitter (4 nos.):**
  1] 1310nm Laser: Output power=5mW, Threshold current=15mA, Forward voltage=1.2V, Operating current=25mA, Center wavelength=1310nm.
  2] 1550nm Laser: Output power=5mW, Threshold current=15mA, Forward voltage=1.2V, Operating current=25mA, Center wavelength=1550nm.
  3] RED Laser: O/P power=5mW, Wavelength=650nm, Polarization=Linear, Lifetime=5000 hours, Class=IIIa, Range=4000 ft in darkness.
  4] Red LED: Diameter=5mm, Forward voltage=2.0V, Operating current=20mA, Center wavelength=650nm, Operating temp.=-25-85^{0}C.
- **Receiver (3nos.):**
  1] 1310nm Photo diode : Detection Range=1100-1650nm, Rise/Fall Time=0.2ns, Monitor current=200uA/mW, Monitor dark current=200nA.
  2] 1550nm Photo diode: Detection Range=1100-1650nm,, Rise/Fall Time=0.2ns, Monitor current=200uA/mW, Monitor dark current=200nA.
  3] SFH213 PIN PD: Detection Range=450-900nm, Rise/Fall Time=5ns, Reverse Vol.=50V, Power Dissipation=100mW, Photo Current =135uA.
- **Glass Fiber Optic cable :**

  Cable type= Multi Mode Simplex, Cable length= 3meter, Connector type= ST/PC, Wavelength=Broadband, Core Dia=50µm, Cladding Dia=125µm, Coating Dia=2 or 3 mm, Maximum attenuation=0.4dB/km, Insertion loss=0.3dB, Return loss=20dB, Working Temperature=-40~+800C.
- **Panel Specifications / Functional Blocks**:
- Panel consists of 4 nos. of transmitters & 3 nos. of Receivers circuit blocks.
- Can transmit both DC/TTL and Analog signals using Glass FO cable.
- Biasing can be adjusted using POTs upto 60mA for different emitters.
- ACC & APC modes of operation illustrated using Red laser.
- Optionally plotting of LED Radiation Pattern using Goniometer interfaced through 5 pin DIN audio connector.

  PC-to-PC communication using RS-232 protocol using 9Pin DB connector.
- Facilitates WDM expt, for this use CM17 panel (OPTIONAL).

  List of Experiments to be performed (4): Study of characteristics of glass fiber using IR LASERs 1310nm and 1550nm, Study of Automatic Current Control (ACC) & Automatic Power Control (APC) operating modes using Red LASER, Free space communication using IR LED, Radiation plot for IR/RED LED using Goniometer (optional).

18) WDM Expt. Panel / CM17 : (Needs CM16 to perform WDM experiment)

The panel consists of two Fiber-optics plastic-molded modules viz. 2x1 coupler & WDM splitter with flying-leads ended into 4 nos. of ST connectors, joined in together by ST adaptor & displayed under transparent Perspex overlay. For performing WDM expt, connect those 4 nos. of ST connectors to CM16 panel.

- **2x1 Wavelength Coupler :**

  Operating wavelength= 1310nm & 1550nm(2 ports), Port ratio= 50/50%, Bandwidth= +/-40nm, Insertion loss= <8dB, Excess Loss= <0.2dB, Cable type= 3mm single mode, Connector type= ST/PC.
- **WDM splitter :**

  Operating wavelength= 1310nm & 1550nm (2 ports), Bandwidth= +/-15nm, Insertion loss= <0.2dB, Isolation= >17dB, Single mode 9/125um cable, Connector type= ST/PC.

  List of Experiments to be performed (3): Study of Wavelength Division Multiplexing (WDM), Measurement of isolation in WDM communication, Study of Non-linear effects in optical communications.

19) FHSS Experiment Panel (CM18) :

(Provided with 12 banana + 2 TPs.+ 12 LEDs + 5 switches)

- On-board Clock source @ 5MHz.

a) Modulator Function Blocks:- 1 Analog Input- 10Vpp & Audio upto 750Hz [1.5KHz], Onboard adjustable DC signal source, ADC Sampling Frequency @ 3.9KHz, 6 Bit ADC, Signed Adder, sine wave generator @ 208, 156, 125, 416, 312. 250 KHz, Mux and Latch, TTL reference @208KHz.

b) Demodulator Function Blocks :- 1 Analog Output- 10Vpp & Audio upto 750Hz [1.5KHz], switch selectable DAC O/P either FHSS O/P or Demod O/P, original signal recovered by passing through 2P/4P Butterworth filter on NGLPF Panel (MU), 6 Bit DAC, Signed Adder, 6 Bit Amplitude & Phase comparator, Latch & Mux.

List of experiments (5) : Generate FHSS modulated sin output, Verify constancy of amplitude but only frequency hoping varies depending upon modulation bits, Demodulation verification, Determine upper limit of data rate given a particular carrier frequency, Send and receive voice using FHSS.

20) OQPSK Experiment Panel (CM19) :

(Provided with 12 banana + 2 TPs.+ 12 LEDs + 5 switches)

- On-board Clock source @ 5MHz.

a) Modulator Function Blocks:- 1 Analog Input- 10Vpp & Audio upto 1.3KHz[2KHz], Onboard adjustable DC signal source, ADC Sampling Frequency @6.5KHz, 7 Bit ADC, Signed Adder, Quadrature sine generator I, Q @208KHz, Mux and Latch, TTL reference @208KHz.

b) Demodulator Function Blocks :- 1 Analog Output- 10Vpp & Audio upto 1KHz [2KHz], switch selectable DAC O/P either OQPSK O/P or Demod O/P, original signal recovered by passing through 2P/4P Butterworth filter on NGLPF Panel (MU), 7 Bit DAC, Signed Adder, 7 Bit Amplitude & Phase comparator, Latch & Mux.

List of experiments (5) : Generate OQPSK modulated sin output, Verify constancy of frequency & amplitude but only phase angle varies depending upon modulation bits, Draw constellation diagram for OQPSK, Demodulation verification, Determine upper limit of data rate given a particular carrier frequency, Send and receive voice using OQPSK.

21) Integrated DigiCom Expt. Panel (CM20) : [PSK, QPSK, 16 QAM, 8 QAM, 8 PSK, MSK differential mode & non- differential mode]

(Provided with 12 banana + 2 TPs.+ 12 LEDs + 5 switches)

- On-board Clock source @5MHz.

a) Mod/Demod Function Blocks:- Onboard adjustable DC signal source (+-5Vpp) ,7 Bit ADC with Sampling Frequency of 6.5 Khz, 4bit selectable digital i/p's using switches, Sine Adder, Sine Divider, Differentiator Block, Scheme selector block, Frequency selector block, Quadrature sine generator I, Q @208-416KHz, MUX 2:1, Latch, PISO, SIPO(1:2,1:3,1:4), on board 208 KHZ, TTL reference clock, Delayed clock for cycle slip error, 7 Bit DAC with single Analog Output- 10Vpp & Audio upto1.3KHz [2KHz can be tolerated], 7 Bit Amplitude & Phase comparator, Socket selectable DAC O/P either one of the Modulation O/P or Demodulation O/P, with differential or non differential mode and recovered signal by passing through 4P Butterworth filter on NGLPF Panel (MU).

List of experiments (6) : Generate PSK, QPSK, 16 QAM, 8 QAM, 8 PSK, MSK modulated digital sin output in-differential & non-differential mode, Verify variations in phase angle [if any], amplitude [if any] & frequency [if any], Depending upon modulation bits, Draw constellation diagram for PSK, QPSK, 16 QAM, 8 QAM, 8 PSK, Demod. verification in-differential & non-differential mode for all schemes, Determine upper limit of data rate given a particular carrier frequency, Send and receive voice using PSK, QPSK, 16 QAM, 8 QAM, 8 PSK, MSK, **Cycle slip error in 8PSK & 8QAM, Bit Error Ratio (BER).**