A LAB MANUAL ON
ADVANCED COMMUNICATION LAB

Subject Code: 06ECL67
(As per VTU Syllabus)

PREPARED BY
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LIST OF EXPERIMENTS

1) TDM of two band limited signals.
2) ASK and FSK generation and detection
3) PSK Generation & Detection.
4) DPSK Generation and detection
5) QPSK Generation and detection
6) PCM generation and detection using a CODEC chip.
7) Measurement of losses in a given Optical fiber (Propagation loss, Bending loss) and numerical aperture.
8) Analog and Digital (with TDM) communication link using optical fiber
9) Measurement of Frequency, Guide Wavelength, power, VSWR and Attenuation in a microwave test bench.
10) Measurement of Directivity and Gain of antennas: Standard Dipole (or printed Dipole), microstrip patch antenna and Yagi Antenna (printed)
11) Determination of coupling and Isolation characteristics of a stripline (or microstrip) directional coupler
12) (a) Measurement of resonance characteristics of a microstrip ring resonator and determination of dielectric constant of the substrate.
    (b) Measurement of power division and isolation characteristics of a microstrip 3 dB power divider.
01 - AMPLITUDE SHIFT KEYING (GENERATION AND DETECTION)

AIM:
To design and study the working of ASK modulation and demodulation system with the help of suitable circuit.

COMPONENTS REQUIRED:
2 Signal generators, resisters 39K-2, 3.3K-2, SL 100 transistor-1, CRO & probes.

Circuit Diagram: (Modulation)

![Circuit Diagram](image)

DESIGN:

\[ V_{BE} = 0.7 \text{ V}, \ V_{CE} (\text{Sat}) = 0.3 \text{ V} \]
\[ I_c = 1 \text{ mA}, \ \beta = 50, \ I_E = I_C \]

Applying KVL to O/P:
\[ V_{C\text{Peak}} - V_{CE} - R_E \cdot I_E = 0 \Rightarrow 2 - 0.3 - (1 \times 10^{-3})R_E = 0 \]

\[ R_E = 1.7k\Omega \approx 1.8k\Omega \]

Applying KVL to O/P, \( V_{m(\text{peak})} = 3\text{ V} \)
\[ V_{m(\text{Peak})} - I_B R_B - V_{BE} - I_E R_E = 0, \text{ Where } I_E R_E = (1 \times 10^{-3}) \times 1.8k\Omega \]
\[ 3 - 1 \times 10^{-3} \times R_B - 0.7 - 1.7 = 0 \]

\[ R_B = 30 \text{ K}\Omega \approx 39 \text{ K}\Omega \]

Design Demodulation
\[ \frac{1}{W_c} < R_1C_1 < \frac{1}{W}, \text{ Let } c = 0.01 \mu F; \ R_1C_1 = 1\text{ ms}; \ R_1 = 100k\Omega \]
**Demodulation Circuit:**

![Circuit Diagram]

**THEORY:**

**Introduction**

The transmission of digital signals is increasing at a rapid rate. Low-frequency analog signals are often converted to digital format (PAM) before transmission. The source signals are generally referred to as baseband signals. We can send analog and digital signals directly over a medium. From electro-magnetic theory, for efficient radiation of electrical energy from an antenna it must be at least in the order of magnitude of a wavelength in size; \( c = f\lambda \), where \( c \) is the velocity of light, \( f \) is the signal frequency and \( \lambda \) is the wavelength. For a 1kHz audio signal, the wavelength is 300 km. An antenna of this size is not practical for efficient transmission. The low-frequency signal is often frequency-translated to a higher frequency range for efficient transmission. The process is called modulation. The use of a higher frequency range reduces antenna size.

**ASK**

Amplitude shift keying - ASK - in the context of digital communications is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message.

For a binary message sequence there are two levels, one of which is typically zero. Thus the modulated waveform consists of bursts of a sinusoid.

A binary ASK (BASK) wave is obtained by multiplying the message signal with the carrier. The B-ASK signal has two levels ‘1’ and ‘0’ representing the presence and absence of the sinusoid respectively. This can be shown in the waveform below. The message signal must be represented in NZR uni polar format only. Binary ASK system has the largest probability of bit error when compared to FSK and PSK systems.

There are sharp discontinuities shown at the transition points. These result in the signal having an unnecessarily wide bandwidth. Band limiting is generally introduced before transmission, in which case these discontinuities would be ‘rounded off’. The band limiting may be applied to the digital message, or the modulated signal itself.
One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing (e.g., power amplification) more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector.

**PROCEDURE:**

1) The circuit connections are made as per the circuit diagram.
2) A message signal with frequency about ______ Hz and amplitude of about ______ volts is fed to the transistor and carrier is fed to the collector (nearly ______ volts).
3) ASK output is now drawn at the collector.
4) This ASK output is fed to the demodulator circuit and the message signal at the output is obtained.
5) The modulated and the modulating signal are drawn on a graph.
02 FREQUENCY SHIFT KEYING (MODULATION AND DEMODULATION)

AIM:

To design and study the working of FSK modulation and demodulation with the help of a suitable circuit.

THEORY:

As its name suggests, a frequency shift keyed transmitter has its frequency shifted by the message. Although there could be more than two frequencies involved in an FSK signal, in this experiment the message will be a binary bit stream, and so only two frequencies will be involved. The word "keyed" suggests that the message is of the ‘on-off’ (mark-space) variety, such as one (historically) generated by a morse key, or more likely in the present context, a binary sequence.

Conceptually, and in fact, the transmitter could consist of two oscillators (on frequencies f1 and f2), with only one being connected to the output at any one time.

Unless there are special relationships between the two oscillator frequencies and the bit clock there will be abrupt phase discontinuities of the output waveform during transitions of the message.

Bandwidth:

Practice is for the tones f1 and f2 to bear special inter-relationships, and to be integer multiples of the bit rate. This leads to the possibility of continuous phase, which offers advantages, especially with respect to bandwidth control.

FSK signals can be generated at baseband, and transmitted over telephone lines (for example). In this case, both f1 and f2 (of Figure 2) would be audio frequencies. Alternatively, this signal could be translated to a higher frequency. Yet again, it may be generated directly at ‘carrier’ frequencies.

Other forms of FSK

Minimum-shift keying

Minimum frequency-shift keying or minimum-shift keying (MSK) is a particularly spectrally efficient form of coherent FSK. In MSK the difference between the higher and lower frequency is identical to half the bit rate. Consequently, the waveforms used to represent a 0 and a 1 bit differ by exactly half a carrier period. This is the smallest FSK modulation index that can be chosen such that the waveforms for 0 and 1 are orthogonal. A variant of MSK called GMSK is used in the GSM mobile phone standard.

FSK is commonly used in Caller ID and remote metering applications

Audio frequency-shift keying (AFSK) is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone. Normally, the transmitted audio alternates between two tones: one, the "mark", represents a binary one; the other, the "space", represents a binary zero.

AFSK differs from regular frequency-shift keying in performing the modulation at baseband frequencies. In radio applications, the AFSK-modulated signal normally is being used to modulate an RF carrier (using a conventional technique, such as AM or FM) for transmission.
AFSK is not always used for high-speed data communications, since it is far less efficient in both power and bandwidth than most other modulation modes. In addition to its simplicity, however, AFSK has the advantage that encoded signals will pass through AC-coupled links, including most equipment originally designed to carry music or speech.

**MODULATION CIRCUIT:**

DESIGN:

Let $I_C = 1mA$, $\beta = 30$, $V_{CESat} = 0.2V$, $V_{BE} = 0.7V$

Applying KVL to collector loop:

$V_{CESat} + V_{RE} + I_E R_E = 5/2$  
$= 0.2V + 0.7V + I_E R_E = 3.5V$

i.e., $I_E R_E = 3.5 - 0.2 - 0.7$

$R_E = 3.3k\Omega$

Therefore, $R_E = 3.3k\Omega$

KVL to the emitter loop results in the equation

$I_B R_B + V_{BE} + V_{RE} = 5/2$

Therefore, $R_B = 22k\Omega$

$2\pi R_C C_1 = 1m,$

If $C_1 = 0.1\mu F$

$R_1 = 1.59k\Omega$
PROCEDURE:

1) The connections are made as per the circuit diagram.
2) Message signal of amplitude 5v and frequency 150 Hz is applied to the base of the transistor
3) Carrier \( C_1(t) \) of 200Hz and 7v is applied at the collector of the NPN transistor.
4) Another carrier \( C_2(t) \) of 2 kHz and 7v is applied at the Collector of the PNP transistor.
5) After getting the FSK output waveform, calculate 
   \[ t_{\text{max}} \text{ and } t_{\text{min}} \cdot \text{Therefore } f_{\text{max}} = \frac{1}{t_{\text{max}}} \text{ and } f_{\text{min}} = \frac{1}{t_{\text{min}}}. \]
6) Calculate the frequency deviation as \( \Delta f = f_{\text{max}} - f_{\text{min}} \)
7) Calculate the modulation index, \( \beta = \frac{\Delta f}{f_m} \).
8) Then apply the FSK output to the input of the Demodulation circuits and gets the demodulated output.

DEMODULATION CIRCUIT DIAGRAM:

![Demodulation Circuit Diagram]

DESIGN:

PROCEDURE:

1) Connections are made as shown in the demodulation circuit diagram above.
2) The FSK output is fed as the input to the demodulator circuit.
3) The DRB/POT are slowly tuned to obtain the desired demodulated waveform which is the square wave message signal.

Note:-
1) Please not that the tuning of the potentiometer/DRB has to be gradual.
2) The signal generators of carriers also can be varied gradually within the limits of the design for amplitude or frequency.
3) **WAVE FORMS:**

- **Msg signal**
  - 150Hz, 5V

- **Carrier Signal**
  - 2 KHz (C (t1))

- **Carrier Signal**
  - 1 KHz (C (t2))

- **Modulated O/P**

- **Demodulated O/P**
03 PHASE SHIFT KEYING
(MODULATION AND DEMODULATION)

AIM: To design and study the working of PSK circuit and to demodulate the above signal with a suitable circuit.

THEORY:
Phase shift keying is one of the most efficient digital modulation techniques. It is used for very high bit rates. In PSK, the phase of the carrier is modulated to represent Binary values. In BPSK, the carrier phase is used to switch the phase between 0° and 180° by digital polar format. Hence it is also known as phase reversal keying. The modulated carrier is given by:

- Binary 1: \( S(t) = A_{\text{max}} \cos(2\pi ft) \)
- Binary 0: \( S(t) = A_{\text{max}} \cos(2\pi ft + 180) = -A_{\text{max}} \cos(2\pi ft) \)

MODULATION CIRCUIT
PROCEDURE:

1) The connections are made as per the circuit diagram.
2) A sine wave of amplitude 5v and 2kHz is fed to the Collector of the transistor as carrier.
3) The message signal, a square wave of amplitude 5V and 150Hz is fed to the base of the transistor.
4) The BPSK wave is observed at pin 6 of the op-amp IC 741.
5) The demodulation circuit is also connected.
6) BPSK wave obtained is fed as input to the demodulation circuit.
7) The demodulated waveform is observed
8) All the required waveform to be plotted.

DEMODULATION CIRCUIT
Carrier Signal 3 KHz, 5v

Message Signal 150Hz, 5V

Modulated O/P

Demodulated O/P
04 QPSK MODULATION AND DEMODULATION

AIM: To generate a QPSK for a given binary digital signal and Observe. Demodulate the same QPSK to get back the Original digital signal, using carrier receiving circuit and Demodulator

COMPONENTS REQUIRED: Patch chords, signal generator, CRO, probes.

THEORY:
The figure shows the block diagram of a QPSK system. The input binary sequence is converted to binary NRZ Type of signal. This signal is called b(t). “1” is represented by +1v and “0” is represented by −1v. The demultiplexer divides b(t) into two separate bit streams of odd numbered and even numbered bits. The even bit stream modulates √Ps sin 2πfo t carrier and b0(t) modulates √Ps cos 2πfo t.

The modulated signals are:

S_e = b_e(t) √Ps sin 2πfo t
S_o = b_o(t) √Ps cos 2πfo t

The output of the adder is:

S(t) = S_e(t) + S_o(t).
S(t) = be(t) √Ps sin (2πfo t) + b_o(t) √Ps Cos. (2πfo t)

Modulation and Demodulation Circuit
PROCEDURE:

1) Refer to the block diagram & carry out the following connections and switch settings
2) Connect power supply in proper polarity to the kit.
3) Select data pattern of simulated data using switch SW1
4) Connect SDATA generated in DATA IN to NRZ-L CODER.
5) Connect the coded data NRZ-L DATA to the DATA IN of the DIBIT CONVERSION
6) Connect SCLOCK to CLK IN of DIBIT CONVERSION
7) Connect the dibit data I bit to control input C1 of CARRIER MODULATION
8) Connect the dibit data Q bit to control input C2 of CARRIER MODULATION
9) Connect the carrier component to input of CARRIER MODULATOR as follows
   a. SIN1 to IN1
   b. SIN2 to IN2
   c. SIN3 to IN3
   d. SIN4 to IN4
10) Connect the QPSK MOD OUT to MOD IN of the QPSK DEMODULATOR
11) Observe the output of the first squarer at the SQUARER1
12) Observe the output of the second squarer at SQUARER2
13) Observe the four sampling clocks at the output of the SAMPLING CLOCK GENERATOR
14) Observe the output of ADDER1
15) Observe the output of ADDER2
16) Observe the recovered data bit I at the output of the ENVELOPE DETECTOR 1
17) Observe the recovered data bit Q at the output of the ENVELOPE DETECTOR 2
18) Connect I BIT, Q BIT & CLK OUT of QPSK demodulator to I BIT IN & Q BIT IN & CLK IN posts of data decoder respectively.

19) Observe the recovered NRZ-L data from I and Q bits at the output of the DATA DECODER.

20) Use RESET switch if delay occurs at data out post and use PHASE SYNC switch if there is mismatch in the patterns of data at output with respect to the transmitter data.
05 - DPSK MODULATOR AND DEMODULATOR

**AIM:**
To generate a DPSK for a given binary (digital) signal and observe. Demodulate the same DPSK to get back the original digital signal, using carrier-receiving circuit & Demodulator.

**THEORY:**
In BPSK communication system, the demodulation is made by comparing the instant phase of the BPSK signal to an absolute reference phase locally generated in the receiver. The modulation is called in this case BPSK absolute. The greatest difficulty of these systems lies in the need to keep the phase of the regenerated carrier always constant. This problem is solved with the PSK differential modulation, as the information is not contained in the absolute phase of the modulated carrier but in the phase difference between two next modulation intervals.

In the block diagram (Fig.) 1 and 2 shows the DPSK modulation and demodulation system. The coding is obtained by comparing the output of an EXOR, delayed of a bit interval, with the current data bits (for detailed explanation see experiment no.2). As a result of operation, the DPSK signal across the output of the modulator contains 180-degree phase variation at each data bit 1. The demodulation is made by a normal BPSK demodulator, followed by a decision device supplying a bit 1 each time there is a variation of the logic level across its input.

The DPSK system explained above has a clear advantage over the BPSK system in that the former avoids the need for complicated circuitry used to generate a local carrier at the receiver. To see the relative disadvantage of DPSK in comparison with PSK, consider that during some bit interval the received signal is so contaminated by noise that in a PSK system an error would be made in the determination of whether the transmitted bit was a 1 or 0. In DPSK a bit determination is made on the basis of the signal received in two successive bit intervals. Hence noise in one bit interval may cause errors to two-bit determination. The error rate in DPSK is therefore greater than in PSK, and, as a matter of fact, there is a tendency for bit errors to occur in pairs. It is not inevitable however that errors occur in pairs. Single errors are still possible.

**Modulation and Demodulation Circuit:**

![Block Diagram for Differential Phase Shift Keying Modulation Technique](image-url)
PROCEDURE:
1. Refer to Block Diagram & Carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kit ADCL-01 and switch it on.
4. Connect SDATA generated to DATA IN of NRZ-L CODER.
5. Connect the NRZ-L DATA output to the DATA IN of the DIFFERENTIAL ENCODER.
6. Connect the clock generated SCLOCK to CLK IN of the DIFFERENTIAL ENCODER
7. Connect differentially encoded data to control input C1 of CARRIER MODULATOR
   a. Connect Carrier COMPONENT SIN1 to IN1 of carrier modulating logic
   b. Connect Carrier COMPONENT SIN2 to IN2 of carrier modulating logic
8. Connect DPSK modulated signal MOD OUT to MOD IN of the BPSK DEMODULATOR
9. Connect output of the BPSK DEMODULATOR b(t) OUT to input of DELAY SECTION b(t) IN and one input b(t) IN of decision device.
10. Connect the output delay section b(t-Tb) OUT to the input b(t-Tb) IN of decision device.
11. Compare the DPSK decoded data at DATA OUT with respect to input SDATA.
12. Use RESET switch for clear observation of data output, if recovered data mismatches with respect to transmitter data.
13. Input NRZ-L data at DATA IN of DIFFERENTIAL ENCODER.
14. Differential encoded data at DATA OUT of DIFFERENTIAL ENCODER
15. DPSK modulated output at MOD OUT
16. DPSK DEMODULATED signal at b(t) OUT of BPSK DEMODULATOR
17. Delay data by one bit interval at b(t-Tb) OUT of DELAY SECTION
18. DPSK decoded data at DATA OUT of DPSK DECODER.

RESULT: DPSK for the given binary signal was generated and demodulated
06 - TIME DIVISION MULTIPLEXING

Aim:
To design and demonstrate the working of time division (for) multiplexing for Pulse Amplitude Modulated Signals using discreet components.

Components Required:
Resisters 22K-2, 1k- 2, transistor SL 00 – 2, IC 4051-2

THEORY:
Time-division multiplexing (TDM) is a type of digital or (rarely) analog multiplexing in which two or more signals or bit streams are transferred apparently simultaneously as sub-channels in one communication channel, but are physically taking turns on the channel. The time domain is divided into several recurrent timeslots of fixed length, one for each sub-channel. A sample byte or data block of sub-channel 1 is transmitted during timeslot 1, sub-channel 2 during timeslot 2, etc. One TDM frame consists of one timeslot per sub-channel. After the last sub-channel the cycle starts all over again with a new frame, starting with the second sample, byte or data block from sub-channel 1, etc.

Application examples

- The plesiochronous digital hierarchy (PDH) system, also known as the PCM system, for digital transmission of several telephone calls over the same four-wire copper cable (T-carrier or E-carrier) or fiber cable in the circuit switched digital telephone network
- The SDH and synchronous optical networking (SONET) network transmission standards, that have surpassed PDH.
- The RIFF (WAV) audio standard interleaves left and right stereo signals on a per-sample basis
- The left-right channel splitting in use for stereoscopic liquid crystal shutter glasses

TDM can be further extended into the time division multiple access (TDMA) scheme, where several stations connected to the same physical medium, for example sharing the same frequency channel, can communicate. Application examples include:

- The GSM telephone system
Circuit Diagram: (for PAM Signal)

10V, 1 KHz
Square wave

5V, 200Hz
(Sine wave)

3V, 200Hz
(Sine Wave)

R_B1 22kΩ

R_B2 22kΩ

1kΩ

M0 o/p

M1 O/P
PROCEDURE:

1. Rig up the circuit with input of 1 KHz Square wave of 5V amplitude as per the circuit diagram make the connections carefully.
2. Signal generator inputs 5V, 3V & 200Hz frequency is provided to collectors of T1 & T2 respectively.
3. Sampled signals M0 & M1 is obtained at the emitter of T1 & T2, which is provided as inputs to pin 13 and pin 14 of IC -4051 Mux circuit
4. TDM output is fed as input to Pin 3 of Demux circuit. The signals M0 and M1 are retrieved back at pin 13 and Pin 14.

RESULT:
The circuit to demonstrate the working of TDM for PAM signals was designed and the output waveforms were verified.
07 – Measurement of frequency, guide wavelength, power, VSWR, attenuation in a microwave test bench.

AIM:-
To plot the V-I characteristics of Gunn diode and to measure the Guide wavelength and operating frequency and VSWR of a Gunn Diode.

COMPONENTS REQUIRED
1. Gunn Power supply
2. Gunn oscillator
3. Isolator
4. Pin modulator
5. Variable Attenuator
6. frequency meter
7. Slotted probe carriage
8. Tunable detector
9. VSWR meter
10. CRO

BLOCK DIAGRAM:-

THEORY:-
In 1963, J.B. Gunn discovered the bulk TRANSFERRED ELECTRON EFFECT in Gallium Arsenide which is a semiconductor material. Si & Ge are called INDIRECT GAP semiconductors because the bottom of the conduction band does not lie directly above the top of the valence band. In GaAs the conduction band lies directly above the top of the valence band. The lowest energy conduction band in GaAs is called as PRIMARY VALLEY. Gunn while measuring the current density J as a function of electric field E in a Gallium Arsenide n-type specimen discovered that after a threshold field E_th is reached, the current in the specimen suddenly becomes oscillatory w.r.t. time and these oscillations are in the microwave frequency range. This effect is called “GUNN EFFECT”.

Gunn diodes are operated in two modes:-
1. The Gunn mode or the transit time mode
2. The LSA mode (or limited space charge accumulation)

The Gunn diode is a bulk device i.e. it does not contain any junction but it is a slice of n-type GaAs. Hence it is a reversible device and can be operated in both directions.
PROCEDURE:-

(a) TO FIND V-I CHARACTERISTICS

1. Set the Gunn diode oscillator micrometer screw for a suitable frequency to get a square wave.
2. Bias the Gunn diode and Pin modulator from Gunn power supply.
3. Select the internal modulation in Gunn power supply.
4. Set modulating frequency and pin bias knobs to approximately half.
5. Change Gunn Bias in steps of 0.5v from 0 to 7v and note down the corresponding current.
6. Plot V-I characteristic graph and find Threshold Voltage from the graph.

(b) TO FIND GUIDE WAVELENGTH ($\lambda_g$) and OPERATING FREQUENCY ($f_o$)

2. Set the gunn bias in such a way that the diode operates in Negative Resistance region.
3. Tune the crystal detector such that the demodulated square wave o/p is maximum.
4. Short circuit the load end of the slotted line and calculate the count of the slotted line scale.
5. Without disturbing the gunn bias, rotate the frequency meter till a dip in square wave is observed on CRO.
6. At that point read the Frequency meter to obtain the operating frequency of the gunn diode ($f_o$).
7. The above steps are called as frequency determination using the direct method.
8. Locate a maxima on the CRO. This is also called a node.
9. Move the slotted line carriage to any node or antinode and note down the first reading as $X_1$.
10. Move the slotted section to the immediate next node or antinode and note down the 2nd reading $X_2$.
11. Guide wavelength ($\lambda_g$) is twice the difference of $X_1$ and $X_2$ i.e. $\lambda_g = 2(X_2 - X_1)$

Calculation

$\Lambda_c = 2a, \frac{1}{\lambda_0^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$

The value ‘a’ is the width of the waveguide known to us as 2.3cm, therefore $\lambda_c = 2 \times 2.3 = 4.6$ cms

(c) TO FIND VSWR :-

(i) Direct method:

1. Set the gunn diode in the negative resistance region
2. Locate any Maxima in the slotted line $V_{max}$.
3. Adjust the gain control knob of VSWR meter so that the pointer reads VSWR = 1 dB
4. Move the carriage to $V_{min}$ position
5. Move the slotted line section in any direction until the pointer deflects suddenly kicks back from the value which is the VSWR.
6. The VSWR meter reading at the kick back point gives the VSWR.

(ii) Double Minima method:

1. Measure $\lambda_g$ following appropriate procedure.
2. Locate any minima and note down the corresponding power in db.
3. Move the slotted line section to the right till power increases by 3 dB ($X_1$) and bring it back.
4. Move slotted line section to the left till power decreases by 3 dB ($X_2$)
5. If distance between two points is d, then $VSWR = \frac{\lambda_g}{\pi d}$, where $d = (X_2 - X_1)$.

RESULT:

- Frequency, $f_0 =$
- Guide wavelength, $\lambda_g$
- VSWR (direct method)
- VSWR (double minima method)
**TABULAR COLUMN**

<table>
<thead>
<tr>
<th>GUNN VOLTAGE (Volts)</th>
<th>GUNN CURRENT (Amps)</th>
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**CALCULATION:**

Measurement of \( \lambda_g \) and \( f_o \):

\[
X_2 = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.}
\]

\[
X_1 = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.}
\]

Now, \( \lambda_g = 2 (X_2 - X_1) = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.} \)

Now, \( \lambda_c = 2a \) where \( a \rightarrow \) Broad wall dimension of wave guide

So, \( \lambda_c = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.} \)

Hence, \( \frac{1}{\lambda o^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2} \)

\( \lambda o = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.} \)

So, \( f_o = C/\lambda o = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots GHz.} \)

Measurement of VSWR:

(i) Direct Method:

\[
\text{VSWR} = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.}
\]

(ii) Double Minima method:

\[
X_1 = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.} \text{ (minima position)}
\]

\[
X_2 = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.} \text{ (next minima position)}
\]

\[
D = (X_2 - X_1) = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots cm.}
\]

\[
\text{VSWR} = \frac{\lambda_c}{\pi d}
\]

\[
\text{VSWR} = \text{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.}
\]

**RESULT:**

The Gunn diode characteristics as well as guide wavelength, operating frequency and VSWR is found correctly.
**08 – Determination of coupling and isolation characteristics of a strip-line directional coupler.**

**AIM OF THE EXPERIMENT:** To determine the coupling and isolation characteristics of a stripline (or microstrip) Directional coupler.

**COMPONENTS REQUIRED:**

1. Power Supply
2. VCO
3. 50 ohm Transmission line
4. Branch line coupler
5. Parallel line in coupler
6. 50 ohm terminations
7. Cables with SMA connector
8. Oscilloscope / VSWR meter / Power Meter

**BLOCK DIAGRAM:**

```
  Power supply
    |                |                |
    VCO             6DB  6DB                |
    |                |                |
    |                |                |
    6DB attenuator  Microstrip           Detector
    |                | Directional Coupler |
    |                |                |
    |                |                |
    |                |                |
    |                |                |
    6DB attenuator                                          |
    |                |                |
    |                |                |
    |                |                |
    Power supply
```

**THEORY:**

A two stub branch line coupler is a fundamental direct coupled structure in which the main line is directly bridged to the secondary line by means of two shunt branches. The length of each branch and their spacing are all quarter wavelength in the transmission medium at the center frequency $f_0$.

In a parallel coupled directional coupler the main length “l” of the coupled line section is quarter wavelength in the transmission medium at the center frequency $f_0$. All inputs and outputs lines have the same characteristic impedance.
PROCEDURE:

1. Set up the system as shown in the block diagram
2. Keeping the tuning voltage at minimum and gain control at max, switch on the microwave signal source.
3. Insert a 50 ohm transmission line and check for the output at the end of the system using a CRO/VSWR meter/ RF power meter.
4. Vary the tuning voltage and check for power supply level using a CRO/VSWR meter.
5. Note the output for different VCO frequencies.
6. Replace the transmission line with a directional coupler.
7. Check the output at ports 2 (through port), measure power output 3 (coupled output), and power output at port 4 (isolated port).
8. Calculated insertion loss, coupling factor and isolation using the formula given.

CALCULATIONS:

WITH OSCILLOSCOPE:-

Insertion loss (dB) = \(\frac{1}{20} \log \frac{V_1}{V_2}\)

Coupling factor (dB) at port 2 = \(\frac{20}{\log_{10}} \frac{V_1}{V_3}\)

Isolation (dB) = \(\frac{20}{\log_{10}} \frac{V_1}{V_4}\)

WITH VSWR METER:

Coupling factor (dB) = power at port 1 \(P_1\) - power at port 3 \(P_3\)

Isolation (dB) = power at port 3 \(P_3\) - power at port 4 \(P_4\)

Directivity(dB) = power at port 1 \(P_1\) - power at port 4 \(P_4\)

Insertion Loss(dB) = power at port 1 \(P_1\) - power at port 2 \(P_2\)

TABULATION:-

<table>
<thead>
<tr>
<th>I/P At port 1</th>
<th>O/P at port 2</th>
<th>O/P at port 3</th>
<th>O/P at port 4</th>
<th>Isolation(dB)</th>
<th>Directivity(dB)</th>
<th>Coupling Factor(dB)</th>
<th>Insertion Loss(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

CONCLUSION:-

The coupling and Isolation characteristic of a stripline directional coupler is tested and verified and found out the values of the coupling factors at port’s 2 and 3 and the isolation factor between ports 2 and 3.
09 - DIRECTIVITY & GAIN OF ANTENNAS

AIM: Measurement of directivity & gain of antennas : Standard dipole (or printed dipole), microstrip patch antenna and Yagi antenna (printed).

Components Required : Power supply, VCO, 50 ohm transmission line, dipole antenna, patch antenna, yagi antenna, oscilloscope or VSWR meter.

Theory: The simplest practical antenna is the half wave dipole. In its original form it consists of two thin straight wires, each \( \lambda/4 \) in lengths, by a small gap. For this simple antenna, under fairly realistic approximations, closed form expressions are available for radiated fields, power, directivity etc.

The important feature of Yagi antenna is that it is an end-fire antenna, ie the direction of maximum radiation is tangential to the plane formed by the parallel antenna elements.

The design of a rectangular microstrip patch antenna begins with (a) choice of a substrate, (b) selecting the feed mechanism, (c) determining patch length \( L \), (d) determining patch width \( w \) and (e) selecting the feed location.

Procedure:

- Setup the system as shown in the figure for a standard dipole antenna.
- Keeping the voltage at min, switch on the power supply and keeping the gain control knob maximum, switch on VCO.
- Vary the tuning voltage and check the output for different VCO frequencies.
- Keeping at the resonant frequency calculate and keep the min distance for field between the transmitting & receiving antennas using the formula
  \[
  S = \frac{2d^2}{\lambda_0}
  \]
  where \( d \) is the length of the dipole and \( \lambda = c/f = 6\text{cm} \). The calculated value is 2.25cm. where \( L \) is the length of the dipole.
- Keeping the line of sight properly (0 degree at the turn table)
- Note the readings on the CRO, convert the voltage reading reading into dB by using the formula 20 log \((V/V_0)\) where \( V_0 = \) voltage at zero degree.
Rotate the turn table in clockwise & anti-clockwise for different angle of deflection & tabulate the output for every angle (Eφ).

Plot a graph : angle vs output.

Take a reading in the E and H planes.

Find the half power beam width (HPBW) from the points where the power becomes half (3db points or 0.707V points)

Directivity of the antenna can be calculated using the formula:

\[
D = \frac{41253}{(2 \times \text{HPBW})} \quad \text{or} \quad \sum \frac{72}{E_m^2} \left[ \frac{E_m}{E_\phi} \right]^2
\]

where HPBW is the half power beam width in degrees,
Find out two HPBW in two planes one principal plane and the other orthogonal plane.
Em & Eφ are the output signals at the receiving antenna for 0 degree and for different angles respectively.

Gain of the antenna can be calculated using the formula:

\[
G = \frac{4\pi S}{\lambda} \left[ \frac{P_r}{P_t} \right] = \frac{4\pi S}{\lambda} \left[ \frac{E_r}{E_t} \right]^2
\]

Gain in dB =10 log G
Where Et and Er are the signal strength measured using an oscilloscope at the transmitting end at the receiving end respectively, when the line of sight is proper. S is the actual distance kept between the antennas and \( \lambda \) is the wavelength found using the formula \( \lambda = \frac{c}{f} \) (f = frequency of operation)

Repeat the experiment for patch antenna and a yagi antenna.

Note: For microstrip antenna \( \lambda = \frac{\lambda_0}{\sqrt{\varepsilon_r}} \)
Table 1

<table>
<thead>
<tr>
<th>Angle (°)</th>
<th>Output on oscilloscope or VSWR meter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output (R)</td>
</tr>
<tr>
<td>0°</td>
<td></td>
</tr>
<tr>
<td>5°</td>
<td></td>
</tr>
<tr>
<td>10°</td>
<td></td>
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<tr>
<td>15°</td>
<td></td>
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<tr>
<td>20°</td>
<td></td>
</tr>
<tr>
<td>25°</td>
<td></td>
</tr>
<tr>
<td>30°</td>
<td></td>
</tr>
<tr>
<td>35°</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**: Directivity and gain of the given antennas are properly measured.
10A – Measurement of resonance characteristics of a microstrip ring resonator and determination of dielectric constant of the substrate.

(A) Aim: Measurement of resonance characteristics of a micro strip ring resonator and determination of dielectric constant of the substrate.

Components Required: power supply, VCO, 50 ohm transmission line, ring resonator, 50 ohm terminations, cables with Oscilloscope/VSWR meter/power meter.

Theory:
The ring resonator is known as a simple printed resonator that is useful for making approximate measurement of dielectric constant. It is also used in filters, and in antennas.

Ring resonators can be analyzed in two ways. Looking at a ring resonator in isolation, it may appear that the field would be in the form of a wave circulating around either direction, but in reality, the coupling structure plays an important role.

Block Diagram:-
Procedure:

Part (a)

- Set up the system as shown in figure.
- Keeping the voltage at minimum, switch on the power supply.
- Insert a 50 ohm transmission line and check for the output at the end of the system using a CRO/VSWR meter/RF power meter.
- Vary the power supply voltage and check the output for different VCO frequencies.
- Replace the 50 ohm transmission line with ring resonator.
- Vary the supply voltage, tabulate VCO frequency Vs output.
- Plot a graph frequency and find the resonant frequency.

Tabulation:

Part (b)

- Select a VCO frequency (say f1) where there is a measurable output. Note down the magnitude/power level of the output.
- Place the unknown dielectric material on top of the ring resonator. Ensure that there is no air gap between the dielectric piece and the resonator surface.
- Observe the change in the magnitude/power level at the output.
- Now reduce the supply voltage till maximum power level (before inserting the dielectric) is achieved. This is the new resonance condition due to the insertion of new dielectric material (eg: teflon).
- Note down the VCO frequency (say f2).
- Calculate the dielectric constant of the unknown material by using formula.
- Experiment may be repeated with different unknown material or with same material but for different height of the material.

Calculation:

\[
\lambda_1 = \frac{c}{f_1} \quad (1) \quad \lambda_2 = \frac{c}{f_2} \quad (2)
\]

The effective dielectric constant of any material can be found using the formula:
\[ \varepsilon_{\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left( 1 + \frac{12h}{w} \right)^{\frac{1}{2}} \]  \hspace{1cm} (3)

Where \( h \) = height of the known sample (substrate used for ring resonator)
\( w \)=width of the transmission line

knowing the dielectric constant of the substrate used for the ring resonator, the effective dielectric constant can be found using equation (3). Now the effective dielectric constant of the unknown material can be found using the relation,

\[ \pi d_m = \frac{\lambda_1}{\varepsilon_1} = \frac{\lambda_2}{\varepsilon_2} \]  \hspace{1cm} (4)

Where \( d_m \) = diameter of the ring resonator
\( \varepsilon_1 \)=effective dielectric constant of the known material
\( \varepsilon_2 \)= effective dielectric constant of the unknown material

now using equation (3), find the dielectric \( \varepsilon_r \) of the unknown material.

**Sample Calculation** :

For the known material :

\( f_1=5 \text{GHz}, h = 0.762 \text{mm}, w=1.836 \text{mm}, \varepsilon_{r1} = 3.2 \) (RT duroid)

\[ \lambda_1 = \frac{c}{f_1} = \frac{3 \times 10^{10}}{5 \times 10^9} = 6 \text{cm} \]

using equation (3) it can be found that effective dielectric constant of the material

\[ \varepsilon_{\text{eff1}} = \varepsilon_1 = \frac{3.2 + 1}{2} + \frac{3.2 - 1}{2} \left( 1 + \frac{12 \times 0.762}{1.836} \right)^{\frac{1}{2}} = 2.717 \]
For the unknown material:

\[ f_2 = 4.8 \text{GHz}, \ h = 0.762 \text{mm}, \ w = 1.836 \text{mm}, \ \varepsilon_{r2} = ? \]

\[ \lambda_2 = \frac{c}{f_2} = \frac{3 \times 10^8}{4.6 \times 10^9} = 6.25 \text{cm} \]

using the values of \( \lambda_1 \) and \( \lambda_2 \) in equation (4), we can find the effective dielectric constant of the unknown material.

That is,

\[ \frac{\lambda_1}{\varepsilon_1} = \frac{\lambda_2}{\varepsilon_2} \]

\[ \frac{6}{2.717} = \frac{6.25}{\varepsilon_2} \]

\[ \varepsilon_2 = \frac{6.25 \times 2.717}{6} = 2.83 \]

Using this value in equation (3),

\[ \varepsilon_{eff2} = \varepsilon_2 = 2.83 = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + \frac{12 \times 0.762}{1.836} \right]^{-\frac{1}{2}} \]

rearranging and calculating, we find that the dielectric constant of the unknown material \( \varepsilon_{r2} = 3.6 \)
Tabulation:

Table 2

<table>
<thead>
<tr>
<th>f1</th>
<th>( \lambda_1 )</th>
<th>f2</th>
<th>( \lambda_2 )</th>
<th>Height of the Unknown sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

Conclusion: Measurement of resonance characteristics of a micro strip ring resonator and determination of dielectric constant of the substrate is achieved successfully.
11) 3 dB POWER DIVISION AND ISOLATION CHARACTERISTICS

(B) Aim: Measurement of power division and isolation characteristics of a microstrip 3dB power divider.

Components Required:-

1. Power Supply
2. VCO
3. 50 ohm Transmission line
4. Branch line coupler
5. Parallel line in coupler
6. 50 ohm terminations
7. Cables with SMA connector
8. Oscilloscope / VSWR meter / Power Meter

Theory:

Power divider is a 3 port device in which one input port and two output ports. When the power is fed at input port 1, power will emerge from the other two ports 2 and 3. It is impossible to match all the ports of power divider.

In order to match all the three ports, an isolation resistance of $2Z_0$ is added between ports 2 and 3. With this, the proper isolation is provided between ports 2 and 3.

Block Diagram:-

Procedure:-

![Microstrip power divider circuit with resistor in the test](image_url)
1. Set up the system
2. Keeping the voltage at minimum, switch on the power supply.
3. Insert a 50 ohm transmission line and check for the output at the end of the system using a CRO/VSWR meter/ RF power meter.
4. Vary the power supply voltage and check the output for different VCO frequencies.
5. Keep the VCO frequency constant, note down the output. This value can be taken as the input to the power divider.
6. Replace the 50 ohm transmission line with the Wilkinson power divider.
7. Tabulate the output at Ports 2 and 3.
8. Calculate Insertion loss and coupling factor in each coupled arm.
9. Calculate the isolation between ports 2 and 3 by feeding the input to port 2 and measure output at port 3 by terminating port 1.
10. Repeat the experiment for different VCO frequencies.

**With RF Power meter:**

- Isolation (dB) = 10 log \(P_2/P_3\)
- Power division (dB) at arm3 = 10 log \(P_3/P_1\)
- Power division (dB) at arm2 = 10 log \(P_2/P_1\)

**With VSWR meter:**

- Isolation (dB) = \(R_2-P_2\)
- Power division (dB) at arm3 = \(P_1-P_3\)
- Power division (dB) at arm2 = \(P_1-P_2\)

**With Oscilloscope:**

- Isolation between port 2 and 3 = 20 log \(V_3/V_2\)
- Coupling factor at arm 3 (dB) = 20 log \(V_3/V_1\)
- Coupling factor at arm 2 (dB) = 20 log \(V_2/V_1\)

**Conclusion:** Measurement of power division and isolation characteristics of a microstrip 3dB power divider is achieved successfully.
12 - SETTING UP A FIBRE OPTIC ANALOG LINK.

AIM:
The objective of this experiment is to study a 950nm-fiber analog Link and to study the frequency response of the phototransistor at Various load conditions.

THEORY:
Fiber optic links can be used for transmission of digital as well as analog signals. Basically a fiber optic link contains three main elements transmitter and optical fiber & a receiver. The transmitter module takes the input signal in electrical form and then transforms it into optical (light) energy containing the same information. The optical fiber is the medium, which carries this energy to the receiver. At the receiver, Light is converted back into electrical form with the same pattern as originally fed to the transmitter.

BLOCK DIAGRAM
PROCEDURE:
1. Slightly unscrew the cap of IR LED SFH 756V (950 nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and tighten it.
3. Keep pr10 Optical power control pot at its maximum position (Anti clockwise direction)
4. Connect the power chord to the kit & switch on the power supply.
5. Feed about 2V(p-p) sinusoidal signal at 1KHz from the function generator to connector labeled as EXT-ANALOG OUTPUT using connecting cables provided with the kit.
6. Connect the other end of the Fiber to detector SFH 350V (Analog detector) very carefully as per the instructions in step 1.
7. The transistor photo detector output is available at the connector labeled as ANALOG OUT. Observe the o/p signal on CRO. Adjust pr10 & pr9 (gain control pot) so that you receive signal of 2V (p-p) amplitude.

CONCLUSION
13 - SETTING UP OF FIBER OPTIC “DIGITAL LINK”

AIM:
The objective of this experiment is to study a 950-nm Fiber optic Digital Link.

THEORY:
Transmitter: -LED and digital DC coupled transmitters are one of the most popular varieties due to their ease of fabrication. We have used a standard TTL gate to drive a NPN transistor, which modulates the LED SFH 450V source.
Receiver: - SFH-551V is a digital opt detector. It delivers a digital output, which can be processed directly with little additional external circuitry. The integrated circuit inside the SFH 551V opt detector comprises the photo diode device, a Trans impedance amplifier, a comparator and a level shifter. The photo diode converts the detector light in to the photo current. With the aid of an integrated lens the light emanating from the plastic fiber is almost entirely focused on the surface of the diode. At the next page the Tran impedance amplifier converts the photo current into a voltage. In the comparator the voltage is compared to a reference voltage. In over to ensure good synchronism between the reference and the transimpedance output voltage, the former is derived from a second circuit of a similar kind, which incorporates a blind photo diode. The comparator derives a level shifter with an open collector output stage. Here a catch diode prevents the saturation of the output transistor, thus limiting the output voltage to the supply voltage.

BLOCK DIAGRAM
PROCEDURE

1. Slightly unscrew the cap of IR LED SFH 450 V (950nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap.
3. Connect the power chord to the kit, switch on the power supply.
4. Feed the TTL signal of about 1 KHz from the function generator to connector labeled as EXT-TTL using connecting cables provided with the kit.
5. Connect the other end of the Fiber to detector SFH 551V (digital detector) very carefully.
6. Observe the received signal on CRO at TP 22. The transmitted signal and the received signal are same except for a slight delay in the received signal due to transmission through fiber.
7. Vary the frequency of the received signal & observe the output response. Determine the max. Bit rate that can be transmitted on the digital link.
8. Slightly unscrew the cap of IR LED SFH756V (660nm) and insert the fiber optic cable.
10. Feed the TTL signal of about 1 KHz from the function generator to connector labeled as EXT-TTL using connecting cables provided with the kit.
11. Connect the other end of the Fiber to detector SFH 551V (digital detector) very carefully.
12. Observe the received signal on CRO at TP 22. The transmitted signal and the received signal are same except for a slight delay in the received signal due to transmission through fiber.
13. Vary the frequency of the received signal & observe the output response. Determine the max. Bit rate that can be transmitted on the digital link.

CONCLUSION:-
14 - STUDY OF LOSSES IN OPTICAL FIBER

AIM:
The objective of this experiment is to measure the propagation loss for two different wave lengths’ and bending loss in plastic fiber provided in the kit.

APPARATUS:
Fiber optic kit, CRO, Signal generator, 1m & 3m plastic fiber.

THEORY:
Optical fibers are available in different materials they are selected by considering the absorption characteristics for different wavelengths of light. Losses are introduced in the fiber due to a variety of reasons. As light propagates from one end of the fiber to other end, part of it absorbed in the material exhibiting absorption loss. Part of the light is reflected back or in some other direction from the impurity loss of the signal at the other end of the fiber. This phenomenon is called propagation loss.
Whenever the condition for angle of incidence of the incident light is violated, the losses are introduced due to refraction of light. This occurs when fiber is subjected for bending.

BLOCK DIAGRAM:-

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PROCEDURE:

1. Set up the analog link as shown in the block diagram.
2. Use an optical fiber link of length 1 meter and note down the output voltage V1 Volts.
3. Use an optical fiber link of length 3 meters and note down the output voltage say V2 Volts.
4. If $\alpha$ is the attenuation of the fiber,
   \[ P1/P2 = V1/V2 = e^{[\alpha(L1+L2)]} \]
   Where $\alpha$= nepers/meter
   L1=fiber length V1
   L2=fiber length for V2

This $\alpha$ is peak wavelength of 950 nm.

MEASUREMENT OF BENDING LOSS:

1) Set up an analog link using 1 meter cable as shown in
   The block diagram.
2) Apply 2V (p-p) sinusoidal signal of 1kHz at EXT-ANALOG
   Terminal.
3) Observe the received signal at ANALOG-OUT.
4) Bend the fiber in a loop. Measure the received signal
   Amplitude (Vo).
5) Go on decreasing the diameter of the loop and note down
   the output voltage
6) Plot the graph of loop diameter vs Vo.

CONCLUSION:-
15 - STUDY OF NUMERICAL APERTURE OF OPTICAL FIBER

AIM:
The objective of this experiment is to measure the numerical aperture of the plastic fiber provided with the kit using 660nm wavelength LED.

APPARATUS:
Fiber optic kit, CRO, Signal generator, 1m & 3m plastic fiber.

THEORY:
Numerical aperture refers to the maximum angle at which a light incident on the fiber end is totally internally reflected and is transmitted properly along with the fiber. The cone found by the rotation of this angle along with the axis of the fiber is the cone of acceptance of the fiber. The light ray should strike the fiber end within its cone of acceptance; else it is reflected out of the fiber core.

CONSIDERATION IN A MEASUREMENT:-
1. It is very important that the source should be properly aligned with the cable & the distance from the launched point & the cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.
2. This experiment is best performed in a less illuminated room.

BLOCK DIAGRAM:-
PROCEDURE:

1) Slightly unscrew the cap of IR LED SFH 756V (660nm) Do not remove the cap from the connector. Once the cap is loosened insert the fiber into the cap and tighten it.
2) Short the jumpers.
3) Connect the power chord to the kit, switch on the power supply.
4) Apply TTL high input to the LED from EXT-TTL Terminal.
5) Insert the other end of the fiber into numerical aperture measurement jig.
6) Hold white sheet facing the fiber end. Adjust the fiber such that its cut face is perpendicular to the axis of the fiber. Keep the distance of 5mm between fiber tip and screen, and then gently tighten the screw.
7) Observe the illuminated circular patch of light on the screen.
8) Measure the distance “d” also measure vertical and horizontal diameters MR and PN as shown in the diagram.
9) Mean radius is calculated using the formula,
   \[ r = \frac{(MR + PN)}{4}. \]
10) Find numerical aperture using the formula;
    \[ NA = \sin(\theta_{\text{max}}) = \frac{r}{\sqrt{d^2 + r^2}} \]
    Where \( \theta_{\text{max}} \) is the maximum angle at which the light incident is properly transmitted through the fiber.

CONCLUSION:
TO STUDY THE TECHNIQUE GENERATION OF TDM DATA

AIM:- The aim of the experiment is to study the technique of generation of TDM data.

THEORY:-
The TDM transmission consists of three basic clock and timing signals on the basis of TX channel & information.

1. Data clock: Determines maximum data rate of channels
2. Mux clock: Determines time slot for each channel.
3. Frame Clock: Determines no of channels to be multiplexed

MARKER IN TDM:-
Marker used in TDM is a unique bit pattern placed at some fixed position in the frame & is used to determine the start of the frame at the receiver.

BLOCK DIAGRAM:-
WAVE FORMS:-

OBSERVATIONS:-

1. Setup the circuit as shown in the circuit above.
2. Observe and measure the frequencies for DATA CLK, MUX CLK & FRM CLK as shown in the waveform below.
3. Observe the marker at the test point MRTX1 on the channel & frame clock on te CRO channel
4. Observe the second marker MRTX2 and frame clock similarly at the output of OR gate.
5. Now observe the test point of marker at channel 1 w.r.t the MRTX1 and MRTX2 and plot the waveform.
6. The channel-1 signal needs to be measured w.r.t the frame clock.
SWITCHING FAULTS

1. Put switch in SF1 to ON. This will open the Tx-marker signal at input U9.
2. This means that the channel one is removed at the mux section.
3. No marker is transmitted and hence the receiver synchronization is disturbed.

STUDY OF CHANNEL INPUTS & PCM DATA IN TDM

1. Once the frame is formed and marker is inserted for synchronization in the first channel the remaining next 15 time slots are free for data information.
2. On the trainer kit we use channel 2-9 as 8 ON/OFF switches.
3. Switches 10 & 11 are kept blank.
4. In 12th time slot PCM data for codec-1 is inserted
5. 13th slot is again kept 0.
6. In the 14th PCM data of codec-2 is inserted
7. The 15th and 16th slots are kept 0.

OBSERVATIONS:

a. Observe the test points of TDM OUT w.r.t the frame clock on the CRO.
b. Put the channel in ON/OFF and observe the position of each channel in the frame.
c. Also observe that the frame repeats at regular intervals.
d. Markers MRTX1 & MRTX2 w.r.t the frame data are observed to be transmitted as alternate frames.
e. Also observe that the PCM coded voice data at PCM OUT test points of CODEC-1 & CODEC-2 w.r.t the frame clock and also w.r.t the TDM OUT test point.
STUDY OF PCM VOICE CODING AND CODEC FREQUENCY RESPONSE.

AIM:- The aim of this experiment is to study the linearized A-Law PCM coding. The analog and digital conversion as well as the reverse process and the filtering characteristics of the CODEC chip 145502 used in the OFC kit.

THEORY:-
Present techniques of voice communication use standards such as A-Law / U-law companded PCM voice coding at 64kbits/sec. When the analog speech signal is converted to pulse code modulation, it first is filtered using a low pass filter with a cut-off at about 3.4KHz. The analog signal is sampled at 8kHz as per the Nyquist Criteria. Each sample is quantized and coded into eight bits per sample.

Voice signal has a varying amplitude range that varies from one conversion to another. If the quantization levels are uniformly spaced then it certainly creates problems such as,

1. If the amplitude of the signal is small, quantization levels have to be closely spaced. This gives proper resolution.
2. If the signal amplitudes are large then this fine resolution will result in increasing the no of code bits.
3. Normally, unequal spacing of quantization levels are used.

The digital data output is in PCM form. The codec chip used exhibits both A-law and U-law companding techniques.

BLOCK DIAGRAM:-

![Diagram of PCM Voice Coding and Codec Frequency Response](image-url)
WAVEFORMS:

PROCEDURE:-
1. Make connections as shown in the block diagram.
2. Voice communication can be carried out between the two kits using telephone handsets.
3. We can observe the effects of the voice at various test points.
4. Keep SW6 towards SINE IN position.
5. Feed a sinusoidal signal of 1kHz 2vP-P to SINE 1 & SINE 2 input terminals.
6. This gives an analog input to both the CODEC chips.
7. The reconstructed wave forms can be observed at the CODEC 1 RX and CODEC II RX pins.
8. At various test points the signal changes.
9. Measure the amplitude of the CODEC O/P at various frequencies which gives the bandwidth of the CODEC.
10. As the codec works in the audio range the bandwidth needs to be 3.4kHz.

CONCLUSION:-
VIVA QUESTIONS FOR ADVANCED COMMUNICATION LAB

1. State different types of Digital modulation techniques?
2. What is shift keying?
3. What is a binary modulation technique?
4. Define ASK?
5. Define FSK?
6. Define PSK?
7. Define QPSK and DPSK?
8. Why QPSK is called quadrature shift keying?
9. Define TDMA?
10. What are applications of shift keying?
11. Define FDM?
12. State the applications of multiplexing?
13. State the principle of PLL?
14. State coherent detection?
15. State non-coherent detection?
16. Differentiate between DPSK and QPSK?
17. What is an M-Array data transmission?
18. What is a standing wave?
19. Define reflection and transmission co-efficient?
20. State different types of losses in transmission lines?
21. State some applications of smith chart?
22. Define modes?
23. Differentiate between TE and TM waves?
24. What is the range of microwaves?
25. What is the advantage of waveguides?
26. State the principle of quarter wave transformer?
27. Define VSWR?
28. Define properties of S-Matrix?
29. What are waveguide tees?
30. State properties of E-plane tees and H-plane tees?
31. State the properties of magic tee?
32. Define Isolator?
33. What is the principle of Directional coupler?
34. State different types of Directional couplers?
35. What is a Klystron?
36. State the classification of microwave tubes?
37. What are O-type and M-type tubes?
38. State application of klystron?
39. State the mechanism of oscillation in klystron?
40. How modulation occurs in reflex klystron?
41. State the principle of operation of TWT?
42. State the principle of operation of Magnetron?
43. State the applications of Magnetron?
44. What is PIN diode?
45. State some application of PIN diode?
46. State different modes of operation of GUNN diode?
47. What is an IMPATT, BARITT, TRAPATT diodes?
48. State two methods to find VSWR?
49. Define the principle of tunable detector?
50. Define the principle of slotted line carriage?
51. Differentiate between normal and expanded SWR?
52. What type of frequency meter is used in Laboratory?
53. Define directivity, radiation efficiency, beamwidth and bandwidth of an antenna?
54. What are the radiation patterns for Horn antenna, parabolic antenna?
55. State the formula to find directivity for an antenna?
56. What are the advantages of using optical fibers?
57. What is the principle of operation of OFC?
58. State the difference between step-index and graded index fiber?
59. State the formula to find the numerical Aperture?
60. What are the different types of losses in OFCS?