16BEEC702A MEASUREMENTS AND INSTRUMENTATION L T P C

3 0 0 3

INTENDED OUTCOMES:

- Basic measurement concepts
- Concepts of electronic measurements
- Importance of signal generators and signal analyzers in measurements
- Relevance of digital instruments in measurements
- The need for data acquisition systems
- Measurement techniques in optical domains.

UNIT-I BASIC MEASUREMENT CONCEPTS

Measurement systems – Static and dynamic characteristics – units and standards of measurements – error analysis – moving coil, moving iron meters – multimeters – True RMS meters – Bridge measurements – Maxwell, Hay, Schering, Anderson and Wien bridge.

UNIT-II BASIC ELECTRONIC MEASUREMENTS

Electronic multimeters – Cathode ray oscilloscopes – block schematic – applications – special oscilloscopes – Q meters – Vector meters – RF voltage and power measurements - Carbon microphone - Loud speaker.

UNIT-III SIGNAL GENERATORS AND ANALYZERS

Function generators – RF signal generators – Sweep generators – Frequency synthesizer – wave analyzer – Harmonic distortion analyzer – spectrum analyzer.

UNIT-IVDIGITAL INSTRUMENTS

Comparison of analog and digital techniques – digital voltmeter – multimeters – frequency counters – measurement of frequency and time interval – extension of frequency range – measurement errors.

UNIT-VDATA ACQUISITION SYSTEMS AND FIBER OPTIC MEASUREMENTS

Elements of a digital data acquisition system – interfacing of transducers – multiplexing – computer controlled instrumentation – IEEE 488 bus – fiber optic measurements for power and system loss – optical time domains reflect meter.

TEXT BOOKS:

S.NO.	**Author(s) Name**	**Title of the book**	**Publisher**	**Year of publication**
1	Albert D.Helfrick and William D.Cooper,	Modern Electronic Instrumentation and Measurement Techniques	Prentice Hall of India, New Delhi	2003
2	Joseph J.Carr	Elements of Electronics Instrumentation and Measurement	Pearson education, New Delhi	2003

REFERENCES:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Alan S Morris	Principles of Measurements and Instrumentation	Prentice Hall of India,New Delhi	2003
2	Ernest O. Doebelin	Measurement Systems-Application and Design	Tata McGraw-Hill,New Delhi	2004

WEBSITES:

http://mechatronics.mech.northwestern.edu/design_ref/tools/multimeter.html

http://www.radio-electronics.com/info/t_and_m/generators/radio-frequency-rf-signal-generator.php

www.physics.sc.edu/~hoskins/Demos/CathodeRay.html

KARPAGAM ACADEMY OF HIGHER EDUCATION
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FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

LECTURE PLAN

NAME OF THE STAFF : Mrs.A.MOHANARATHINAM

DESIGNATION : ASSISTANT PROFESSOR

CLASS : B.E-IV YEAR ECE

SUBJECT : MEASUREMENTS AND INSTRUMENTATION

SUBJECT CODE : 16BEEC702A

S.No	TOPICS TO BE COVERED	TIME DURATION	SUPPORTING MATERIALS	TEACHING AIDS
	UNIT-I BASIC MEASUREMENT CONCEPTS			
1	Measurement systems, Static and dynamic characteristics	01	T3- Page.no : 1-8	BB
2	units and standards of measurements	01	T1- Page.no :10-30, 32-45	BB
3	error analysis	01	T1 Page.no : 6-18	BB
4	moving coil, moving iron meters	01	T3- Page.no : 26-31, 31-38	BB
5	multimeters	01	T3 Page.no. 121-124	BB
6	True RMS meters	01	T3 page.no. 107-109	BB
7	Bridge measurements	01	T3 page.no.322	BB
8	Maxwell, Hay, Schering	01	T3 page.no.345-351	BB
9	Anderson and Wien bridge.	01	T3 page.no.351-354	BB
Total Lecture Hours		**09**		
Total Hours		**09**		

S.No	TOPICS TO BE COVERED	TIME DURATION	SUPPORTING MATERIALS	TEACHING AIDS
	UNIT-II BASIC ELECTRONIC MEASUREMENTS			
10	Electronic multimeters	01	T1 Page.no 140-144	PPT , BB
11	Cathode ray oscilloscopes	01	T1 Page.no 186-187	PPT , BB
12	block schematic – applications	01	T1 Page.no 187	PPT , BB
13	special oscilloscopes	01	T1 Page.no 227-244	PPT , BB
14	Q meters , Vector meters	01	T1 Page.no 265-173,174-177	PPT , BB
15	RF voltage measurements	01	T1 Page.no 181-184	PPT , BB
16	power measurements	01	T1 Page.no 181-184	PPT , BB
17	Carbon microphone	01	www.artsites.ucsc.edu	PPT , BB

18	Loud speaker	01	www.cemca.org.in	PPT , BB
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-III SIGNAL GENERATORS AND ANALYZERS				
19	Function generators	01	T1 Page.no.277-279	BB, PPT
20	RF signal generators	01	T1 Page.no.246-250	BB, PPT
21	Sweep generators	01	T1 Page.no.264-267	BB, PPT
22	Frequency synthesizer	02	T1 Page.no.257-260	BB
23	wave analyzer	01	T1 Page.no.283-286	BB
24	Harmonic distortion analyzer	02	T1 Page.no.286-291	BB
25	spectrum analyzer.	01	T1 Page.no.291	BB, PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-IV DIGITAL INSTRUMENTS				
26	Comparison of analog and digital techniques	01	T1 Page.no.144-146	BB
27	digital voltmeter	01	T1 Page.no 146-159	BB
28	multimeters	01	T1 Page.no 140-144	BB,PPT
29	frequency counters	01	T1 Page.no 315-326	BB,PPT
30	measurement of frequency and time interval	02	T1 Page.no 315-116	BB
31	extension of frequency range	01	T1 Page.no 330-334	BB
32	measurement errors.	02	T1 Page.no 327-334	BB
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-V DATA ACQUISITION SYSTEMS AND FIBER OPTIC MEASUREMENTS				
33	Elements of a digital data acquisition system	01	T1 Page.no 379-381	BB
34	interfacing of transducers	02	T1 Page.no 381-391	BB
35	multiplexing	01	T1 Page.no 391-398	BB
36	computer controlled instrumentation	01	T1 Page.no 406-411	BB
37	IEEE 488 bus	01	T1 Page.no 412-415	BB,PPT
38	fiber optic measurements for power	01	T1 Page.no 425-428	BB
39	fiber optic measurements for system loss	01	T1 Page.no 428-429	BB
40	optical time domains reflect meter	01	T1 Page.no 429-432	BB
Total Lecture Hours		**09**		
Total Hours		**09**		

Total No of Lecture Hours Planned: 45 Hrs

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TEXT BOOKS:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of the publication
1	Albert D.Helfrick and William D.Cooper,	Modern Electronic Instrumentation and Measurement Techniques	Prentice Hall of India, New Delhi	2003
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WEBSITES:

http://mechatronics.mech.northwestern.edu/design_ref/tools/multimeter.html

http://www.radio-electronics.com/info/t_and_m/generators/radio-frequency-rf-signal-generator.php

www.physics.sc.edu/~hoskins/Demos/CathodeRay.html

STAFF IN-CHARGE **HOD/ECE**

Subject code:16BEECE702A

Subject name:MEASUREMENTS AND INSTRUMENTATION
Unit I BASIC MEASUREMENT CONCEPTS

S.No	Questions	A
1	An instrument is defined as a device for determining ………… of the quantity or variable	Magnitude
2	The deviation from the true value of the measured variable is	Resolution
3	The degree of closeness or conformity to true value of the quantity under measurement is	Precision
4	Precision is composed of two characteristics namely	Accuracy & Conformity
5	The error which is proned due to human mistakes is	Systematic error
6	Systematic error is dealt with	Instruments
7	The other name of random error is	Environmental error
8	The Arithmetic mean is given by,	Sum of readings taken
9	The algebraic sum of all deviation must be	Large
10	The variance is given by,	Mean deviation
11	The basic type of units in science & engineering is	Fundamental & CGS units
12	The unit derived by assigning the value 1 to permeability of free space is	CGS System

13	The unit derived by assigning the value 1 to permittivity of free space is	CGS System
14	In MKS system, MKS stands for	Meter, Kilometer, Second
15	Universally accepted system is	SI System
16	Standard of measurement is classified as i. International, National ii .National, working iii International, working iv Primary, secondary	International, National & National, working
17	Primary standard is maintained by	International Standard Lab
18	The standard used in Industry is	International
19	The Principal tool of measurement lab is	International Standard
20	The system which is based on the rotation of earth about its axis is	Universal Time
21	In SI System, SI term stands for	System of International
22	PMMC stands for	Pole Magnet Moving Core
23	PMMC principle of operation is based on	D'Arsonoval Movement

24	The construction of magnet which provides Self- Shielding is	Horse Shoe
25	Sensitivity is the reciprocal of	Voltage
26	The ………… eliminates the possibility of having the meter in circuit without shunt.	Multirange Ammeter
27	Match the following : A. IEEE standard i.Thermometer B. Electrical standard ii.Doppler Shift C. Standard of temperature iii.Engineer D. Frequency standard iv.Ampere	A-iii ; B-iv ; C-i ;D-ii
28	The switch "S" used in Ayrton shunt is a multiposition ……. type	Make after break
29	The type of AC bridge is	Hay bridge
30	Match the following A. Ratio arm1 i. R3 B. Standard arm ii R1 C. Unknown arm iii R2 D. Ratio arm2 iv R4	A-ii; B-i; C-iv: D-iii
31	The bridge is said to be balanced if the potential difference across G is….	0v
32	The balanced equation of Wheatstone bridge is	R1R2=R3R4
33	Wheatstone bridge measures resistance from	2Ω to 4Ω

34	To overcome or suppress defects of Wheatstone bridge we go for	Hay Bridge
35	Match the following A. Kelvin's Bridge i. Unknown Capacitance B. Schering Bridge ii Unknown Resistance C. Hay's Bridge ii Unknown Inductance D. Maxwell's Bridge iv High Q Inductors	A-ii; B-iii; C-iv: D-i
36	The products of magnitude of the opposite arms must be equal	Z1Z2 = Z3Z4
37	The cosine of the phase angle of the circuit is given by	Dissipation factor
38	Vector voltmeter is useful in	UHF Application
39	The frequency range of Vector Voltmeter is given by	> 5MHz
40	The sampling pulse rate is controlled by a	Sampling Gate
41	The total Harmonic Distortion or Distortion factor is defined as	D22 +D32+D42+…………..
42	A wavemeter comes under the category of	Vector voltmeter
43	The electrical properties of coils & capacitors is measured using	Vector voltmeter
44	Vector voltmeter is used to measure the	Amplitude gain & Phase shift
45	RF voltage is measured by …. the alternating voltage & …. the resulting dc o/p.	Amplifying, Rectifying

46	The diodes not used to rectify the RF signal is	PN Junction diode
47	Pick out the circuit/meter which doesn't come under the category of Harmonic Distortion Analyzer.	Tuned Circuit
48	In the Wavemeter, the best selectivity is achieved by using, i. Quartz Crystal Filter Inverse Feedback Filter iii. Band Pass Filter iv. Band Reject Filter	Quartz Crystal Filter & Inverse Feedback Filter
49	Direct reading Instrument of the heterodyne type are sometimes called as	Time- Selective Ammeter
50	Match the following:	A-ii ; B-iii ; C-i ; D-iv
51	Attraction type & Repulsion type comes under the category of	Moving Coil
52	The methods for connecting unknown components to the test terminals of a Q-Meter are i. Direct ii. Indirect iii. Series iv. Parallel	i , ii, iii
53	The type of the transistor used in electronic multimeter is i. FET ii. UJT iii. BJT iv. MOSFET	Both i & ii
54	The limiting range to built Moving Iron instrument is up to	25A
55	The error caused due to external condition other than the	Gross Error

56	The error resulting in Moving Iron due to a.c. only is	Hysterisis Error
57	The error caused in Moving Iron due to d.c. only is i. Hysterisis Error ii. Temperature Error iii. Frequency Error iv. Stray Magnetic fields	i,ii,iv
58	Static characteristic included in the list below is	Speed
59	The types of forces required for satisfactory operation of any indicating instrument i. Deflecting ii.Controlling iii Damping iv Torsional	i,ii,iv
60	Dynamic characteristic included in the list below is a. Drift b. Reproducibility c. Fidelity d. Dead Zone	Drift

B	C	D
Sign	Design	Sensitivity
Error	Precision	Sensitivity
Sensitivity	Accuracy	Error
Degree of agreement & conformity.	No. of significant figures & Accuracy	Conformity & Significant figures
Random error	Gross error	Instrumental Error
Experiment	Experimenter	Observation
Residual error	Systematic error	Instrumental error
Sum of readings taken to number of readings	Sum of deviation taken	Sum of deviation taken to number of readings
Small	Infinite	Zero
Average deviation	Mean Square Deviation	Mean Average Deviation
Fundamental & Derived units	SI & derived units	Fundamental & SI units
CGS Electromagnetic System	CGS Absolute System	CGS Electrostatic System

CGS Electromagnetic System	CGS Absolute System	CGS Electrostatic System
Meter, Kilogram, Second	Mass, Kilometer, Second	Mass, Kilogram, Second
MKS System	CGS System	CGS Absolute System
National, working & international, working	international, working & Primary, secondary	Primary, secondary & International, National
National Standard Lab	International System Lab	National System Lab
Working	Primary	Secondary
Working Standard	Primary Standard	Secondary Standard
Solar Time	Seasonal Time	International Time
System Units International	Standard Units of International	International System of Units
Permanent Magnet Moving Coil	Permanent Magnet Moving Core	Pole Magnet Moving Coil.
Galvanometer Movement	Null detector movement	Pointer Movement

Core Magnet	Pole Magnet	Stray Magnet
Meter Movement	Voltage movement	Full scale deflection Current
Multirange Voltmeter	Ayrton meter	DC Ammeter.
A-ii; B-iv; C-i: D-iii	A-iii; B-iv; C-ii: D-i	A-iv; B-i; C-ii: D-iii
Make before break	Make break	Suppress break
Kelvin's bridge	Kelvin's Double bridge	Wheatstone bridge
A-i; B-iv; C-ii: D-iii	A-i; B-iii; C-iv: D-ii	A-iv; B-i; C-ii: D-iii
1v	>1v	<1v
R1R3=R2R4	R1R4=R2R3	R2R3=R1R4
1 Ω to low meg Ω	0 Ω to 1 Ω	1 Ω to 0.01 Ω

Maxwell's Bridge	Kelvin's bridge	Schering bridge
A-ii; B-i; C-iv: D-iii	A-iii; B-i; C-iv: D-ii	A-iv; B-i; C-ii: D-iii
θ1 θ2 = θ3 θ4	Z1 Z4 = Z2 Z3	θ1 θ4 = θ2 θ3
Current factor	Power factor	Voltage factor
HF Application	VHF Application	IF Application
1 MHz to GHz	20 KHz	20 KHz to 1 MHz
Voltage Tuned Oscillator	Sampling Pulse Generator	Automatic Phase Control
D12+D22 +D32+D42+…… ……..	Square root of D12+D22 +D32+D42+…… ……..	Square root of D22 +D32+D42+…………..
Harmonic Distortion Analyzer	RF Powermeter	Q-Meter
Harmonic Distortion Analyzer	RF Powermeter	Q-Meter
Filter transfer function	Impedance	RF voltage
Rectifying, Modifying	Modifying, Amplifying	Rectifying, Amplifying

Schottky diode	Point contact diode	Zener diode
Wavemeter	Vector Voltmeter	Fundamental Suppression
Inverse Feedback Filter & Band Pass Filter	Quartz Crystal Filter & Band Reject Filter	Quartz Crystal Filter & Band Pass Filter
Frequency Selective Voltmeter	Time Selective Voltmeter	Frequency Selective Ammeter
A-iv ; B-iii ; C-ii ; D-i	A-ii ; B-iii ; C-iv ; D-i	A-ii ; B-iv ; C-i ; D-iii
Moving Iron	PMMC	Galvanometer
i, iii, iv	ii, iii, iv	i ,ii, iv
Both i & iii	Both ii & iii	Both iii & iv
75A	50A	100A
Instrumental Error	Environmental error	Systematic error

Temperature Error	Frequency Error	Stray Magnetic fields
i,iii,iv	ii,iii,iv	i,ii,iii
Sensitivity	Fidelity	Dynamic Error
i,iii,iv	ii,iii,iv	i ,ii,iii
Reproducibility	Fidelity	Dead Zone

Answers
Magnitude
Error
Precision
Conformity & Significant figures
Gross error
Instruments
Residual error
Sum of readings taken to number of readings
Zero
Mean Square Deviation
Fundamental & Derived units
CGS Electromagnetic System

CGS Electrostatic System
Meter, Kilogram, Second
SI System
international, working & Primary, secondary
National Standard Lab
Secondary
Working Standard
Universal Time
International System of Units
Permanent Magnet Moving Coil
D’Arsonoval Movement

Core Magnet
Full scale deflection Current
Ayrton meter
A-iii ; B-iv ; C-i ;D-ii
Make before break
Hay bridge
A-ii; B-i; C-iv: D-iii
0v
R1R4=R2R3
1 Ω to low meg Ω

Kelvin's bridge
A-ii; B-i; C-iv: D-iii
Z1 Z4 = Z2 Z3
Power factor
VHF Application
1 MHz to GHz
Voltage Tuned Oscillator
Square root of D22 +D32+D42+…………..
Harmonic Distortion Analyzer
Q-Meter
Amplitude gain & Phase shift
Rectifying, Amplifying

Zener diode
Vector Voltmeter
Quartz Crystal Filter & Inverse Feedback Filter
Frequency Selective Voltmeter
A-ii ; B-iii ; C-iv ; D-i
Moving Iron
i , ii, iii
Both i & iii
50A
Environmental error

Frequency Error
i,ii,iv
Sensitivity
i ,ii,iii
Fidelity

S.No	Questions	A
1	Electronic multimeter consists of a _____________ to select the function.	hard-wired circuitry
2	Electronic multimeter is capable of measuring ____________________	only AC
3	Electronic multimeter is capable of measuring __________________	current only
4	Rectifier is used to convert_____ to _____	AC,DC
5	The unknown resistor value is found by using _________	ohm-meter
6	Bridges are divided in to__________	2
7	The arms of the AC bridges are denoted by__________	resistances.
8	Detector will deflects to show the _____________ of the circuits.	current
9	Quality factor is the ratio between _____________ and _____________	resistance, voltage
10	In ______________bridge we can measure inductance in comparison with capacitor.	Haye's
11	Common detector used in bridges are	galvanometers
12	The products of magnitude of the opposite arms must be equal	Z1Z2 = Z3Z4
13	Vector voltmeter is useful in	UHF Application
14	The frequency range of Vector Voltmeter is given by	> 5MHz
15	The sampling pulse rate is controlled by a	Sampling Gate
16	Vector voltmeter is used to measure the	Amplitude gain & Phase shift
17	RF voltage is measured by …. the alternating voltage & …. the resulting dc o/p.	Amplifying, Rectifying

18	The diodes not used to rectify the RF signal is	PN Junction diode
19	High Q-values can’t be measured in ______________	haye’s bridge.
20	______________ are lossless.	inductors.
21	External fields has less effects on _______________	resistors.
22	In ____________,one electron beam is used to generate two traces.	dual trace oscilloscope.
23	Two separate electron beams are needed in______________	Dual trace oscilloscope.
24	__________ Vertical amplifiers are needed in Dual trace oscilloscope.	1

B	C	D	Answers
range switch	function switch	manual switch	function switch
only DC	both AC and DC	none	both AC and DC
voltage only.	resistance only	all the above.	all the above.
DC,AC	complex ,simple	resistance,voltage	AC,DC
voltmeter	ampere meter	i ,ii	ohm-meter
3	4	none	2
impedances.	capcitances.	any other meters	impedances.
potential difference between two points.	phase	none	potential difference between two points.
voltage ,reactance	reactance, resistance	none	reactance, resistance
Maxwell's	wien	none	Maxwell's
voltage detectors.	phase detectors.	none	galvanometers
θ1 θ2 = θ3 θ4	Z1Z4 = Z2Z3	θ1 θ4 = θ2 θ3	Z1Z4 = Z2Z3
HF Application	VHF Application	IF Application	VHF Application
MHz to GHz	20 KHz	20 KHz to MHz	20 KHz to MHz
Voltage Tuned Oscillator	Sampling Pulse Generator	Automatic Phase Control	Voltage Tuned Oscillator
Filter transfer function	Impedance	RF voltage	Amplitude gain & Phase shift
Rectifying, Modifying	Modifying, Amplifying	Rectifying, Amplifying	Rectifying, Amplifying

Schottky diode	Point contact diode	Zener diode	Zener diode
Schering bridge	maxwell’s bridge.	Anderson bridge.	maxwell’s bridge.
resistors.	capacitors.	none.	capacitors.
capacitors.	inductors.	none.	capacitors.
dual beam oscilloscope.	sampling oscilloscope.	none	dual trace oscilloscope.
dual beam oscilloscope.	digital oscilloscope.	sampling oscilloscope.	dual beam oscilloscope.
2	3	none	1

UNIT III - SIGNAL GENERATORS AND ANALYZERS

	Questions	A	B
1	A instrument that delivers a choice of different waveforms whose frequencies are adjustable over a wide range is	Sweep generator	Spectrum analyzer
2	In function generator, the frequencies of the output waveforms may be adjusted from a fraction of a __________ to several ___________.	hertz, hundred hertz	hertz, hundred kilohertz
3	Any waveform can be generated by adjusting the ______ and _______ of the harmonics in the function generator. i. amplitude ii. Frequency iii. Phase iv. Current	i, ii	ii, iii
4	In function generator, the frequency control voltage regulates	Current sources	Voltage sources
5	The change of state in function generator is controlled by	Current sources	Resistance-diode shaping circuit
6	The output of the resistance-diode shaping circuit in a function generator is	Triangular wave	Sine wave
7	Match the following.Match the following. A. Integrator i. Sine wave B. Voltage comparator Multivibrator ii. Capability of the function generator C. Resistance diode shaping circuit iii. Triangular wave D. Phase lock iv. Square wave	A-ii, B-iv, C-i, D-iii	A-ii, B-iii, C-iv, D-i
8	Application of a RF signal generator	Testing a radio receiver and transmitters	Generate different wave forms
9	An instrument designed to measure the relative amplitude of single frequency components in a complex or distorted waveform	Function generator	RF signal generator
10	The instrument which has very narrow bandwidth	Heterodyne wave analyzer	Frequency selective Wave analyzer

11	In frequency selective wave analyzer, the filter consists of a cascaded arrangement of _________ resonant sections and __________ amplifier. i.RC ii.LC iii. Filter iv.Output	i, iv	ii, iii
12	_________ is tuned to tune the filter to any desired frequency within the selected pass band in wave analyzer.	Precision potentiometers	Polystyrene capacitors
13	In frequency selective wave analyzer, _________ can be used to drive a recorder or an electronic counter.	meter amplifier	driver amplifier
14	The wave analyzer which is used for the measurement at higher frequencies	Frequency selective wave analyzer	heterodyne wave analyzer
15	The information is centered on a ____ frequency in a heterodyne wave analyzer.	zero	18 MHz
16	Application of a wave analyzer	generate different wave forms	testing a radio receivers and transmitters
17	The harmonic distortion is the ratio of the amplitude of the _______ to that of the __________, expressed as a percentage. i. harmonic ii. fundamental frequency iii. harmonic frequency iv. desired frequency	i, ii	i, iii
18	In a tuned circuit harmonic analyzer, the series resonant circuit is tuned to a specific ________ frequency.	fundamental	harmonic
19	The variations in the amplifier gain is compensated by the _______ in the tuned circuit harmonic analyzer.	parallel resonant circuit	transformer
20	The difficulties of the tuned circuit are overcome in the heterodyne analyzer by using a highly selective, _________.	amplifier	attenuator
21	In wave meter, the mixer usually consists of	detector	amplifier

22	The advantages of the fundamental suppression harmonic distortion analyzer i.harmonic distortion generated within the instrument itself is very small ii. measures total harmonic distortion iii. selectivity requirements are not severe iv. needs very less components	i, iii, iv	i, ii, iv
24	Match the following. A. Fundamental suppression H.D.A i. Mixer B. Wave meter ii. Reverse current C. Lower current source iii. Rejection filter D. Wien bridge iv. Two modes of operation	A-iv, B-i, C-ii, D-iii	A-ii, B-iv, C-i, D-iii
25	In fundamental suppression harmonic distortion analyzer, the rejection amplifier consists of i. a buffer amplifier ii. a wien bridge iii. a preamplifier iv. a bridge amplifier	i, ii, iii	ii, iii, iv
26	The phase locked loop makes the frequency correction based on a	time measurement	amplitude measurement
27	Match the following. A. VCO i. Logic element B. Programmable divider ii. Provides an analog output C. Loop filter iii. Source of the output frequency D. Phase detector iv. Assure stable & noise free operation	A-ii, B-iv, C-i, D-iii	A-iv, B-iii, C-ii, D-i
28	The direct method of frequency synthesizer generates the desired frequency from a	reference frequency	radio frequency
29	A simple sweeping oscillator signal generator consists of i. VCO ii. Linearizing circuit iii. Sweep voltage generator iv. Attenuator	i, ii, iii	ii, iii, iv

30	In the linearizing circuit of a sweep generator, when the sweep voltage approaches	1+(Rf/Ra)	1+(Ra/Rf)
31	V_1, then the gain of the amplifier is increased to		
32	The automatic level control in wide band sweep generator maintains the resultant	frequency	amplitude
33	________ to within a few decibels.		
34	Which of the following can be used as a attenuator in sweep frequency generator?	PN junction diode	Zener diode
35	________ is used to determine the frequency response of the amplifier.	Function generator	Sweep frequency generator
36	The crystal detector in the sweep generator consists of	rectifier diode & amplifier	Amplifier & capacitor
37	The principle of spectrum analyzer is similar to	Audio receiver	Radio receiver
38	The VHF spectrum analyzer covers the range from __________.	20 Hz to 20 KHz	20 KHz to 50 KHZ
39	In the spectrum analyzer, the second local oscillator is tuned to	400 MHz	421.4 MHz
40	Two types of frequency instabilities present in spectrum analyzer are i. Short term instability ii. Frequency noise iii. Phase noise iv. Long term instability	i, ii	ii, iii
41	The frequency counter consists of ________ or ________ gate. i. AND ii. EX-OR iii. EX-NOR iv. OR	i, iv	i, ii
42	________ operates on the principle of gating the input frequency into the counter for a predetermined time.	Sweep frequency generator	frequency synthesizer
43	In the time interval measurement of frequency counter, one channel supplies the ______ pulse for the main gate and the other a ________ pulse. a. enabling, disenabling b. counting, triggering c. frequency, triggering d. disenabling, frequency	enabling, disenabling	counting, triggering

44	The slope selection feature must be present in the measurement of	ratio	time interval
45	A very useful and versatile laboratory instrument used for display, measurement and analysis of waveforms is	AFO	RFO
46	The heart of the CRO is	deflection plates	delay line
47	In CRO, the pre-accelerating anode and accelerating anode are connected to a common positive high voltage of about	1150 V	5000 V
48	The Electrostatic method of focusing is used in	CRO	TV
49	________ is usually a nickel cylinder, with a centrally located hole, co-axial with the CRT axis in CRO.	plates	Control grid
50	The secondary electrons are collected by an aqueous solution of graphite called	Aluminium coating	Phosphor coating
51	________ in a CRT screen converts electrical energy to light energy.	Copper	Aluminium
52	When sinusoidal voltages are simultaneously applied to horizontal and vertical plates, the patterns formed on the CRT screen are called	Rectangular pattern	Linear pattern
53	When two equal voltages of equal frequency but with 90 degree phase displacement are applied to a CRO, the trace on the screen is a	straight line	circle
54	When two equal voltages of equal frequency but with a phase shift (not equal to 0 or 90 degree) are applied to a CRO, we obtain an	straight line	circle
55	In CRO, the values of a current can be obtained by measuring the voltage drop across a _______ connected in the circuit.	Known resistance	Unknown resistance
56	The frequency ratio in CRO is given by	fy/fx	fx/fy
57	If the major axis of the ellipse lies in the first and third quadrant, the phase angle is either between ________ or between ________ . i. 0° to 90° ii. 90° to 180° iii.180° to 270° iv. 270° to 360°	i, ii	i, iii

58	Match the following. A. Lissajous pattern i. fy/fx B. Sin Φ ii. Voltage drop across a known resistance C. Current measurement iii. Measurement of phase and frequency D. Frequency ratio iv. Y1/Y2	A-ii, B-iv, C-i, D-iii	A-iv, B-iii, C-ii, D-i
59	In storage oscilloscope, the secondary emission ratio is defined as	Ip/Is	IsIp
60	Match the following. A. Storage CRTs i. written condition B. Upper stable point ii. Bistable tubes and half tone tubes C. Lower stable point iii. Shape flood beams D. Collimating electrodes iv. Erased condition	A-ii, B-iii, C-iv, D-i	A-ii, B-i, C-iv, D-iii

C	D	Answers
Harmonic distortion analyzer	Function generator	Function generator
hundred hertz, hundred mega hertz	hertz, hundred mega hertz	hertz, hundred kilohertz
i, iii	ii, iv	i, iii
Frequency sources	Power sources	Current sources
Integrator	Voltage comparator multivibrator	Voltage comparator multivibrator
Saw tooth wave	Square wave	Sine wave
A-iii, B-iv, C-i, D-ii	A-iii, B-i, C-iv, D-ii	A-iii, B-iv, C-i, D-ii
Sound and vibration analysis	Measures distortion	Testing a radio receiver and transmitters
Wave analyzer	Frequency	Wave analyzer
Heterodyne harmonic analyzer	Tuned circuit harmonic analyzer	Frequency selective Wave analyzer

ii, iv	i, iii	i, iii
Buffer amplifiers	Driver amplifiers	Precision potentiometers
buffer amplifier	filter amplifier	buffer amplifier
tuned circuit wave analyzer	Wave meter	heterodyne wave analyzer
30 MHz	48 MHz	zero
sound and vibration analysis	finds frequency response of the amplifiers	sound and vibration analysis
i, iv	ii, iii	i, ii
intermediate	audio	harmonic
series resonant circuit	amplifier	parallel resonant circuit
filter	output meter	filter
quartz crystal oscillator	balanced modulator	balanced modulator

i, ii, iii	i, ii, iii, iv	
A-iii, B-iv, C-ii, D-i	A-ii, B-i, C-iv, D-iii	A-iv, B-i, C-ii, D-iii
i, iii, iv	i, ii, iv	ii, iii, iv
frequency measurement	phase measurement	phase measurement
A-iii, B-i, C-iv, D-ii	A-iii, B-iv, C-i, D-ii	A-iii, B-i, C-iv, D-ii
intermediate frequency	oscillator frequency	reference frequency
i, iii, iv	i, ii, iv	i, iii, iv

1+(Ra/1+Rf)	1+(Rf/1+Ra)	1+(Rf/Ra)
phase	period	amplitude
Photo diode	PIN diode	PIN diode
Frequency synthesizer	Wave analyzer	Sweep frequency generator
rectifier diode & capacitor	resistor & capacitor	rectifier diode & capacitor
Super heterodyne receiver	Frequency receiver	Super heterodyne receiver
100 Hz to 100 KHz	10 KHZ to 300 MHz	10 KHZ to 300 MHz
431.4 MHz	442.8 MHz	421.4 MHz
iii, iv	i, iii	iii, iv
ii, iii	iii, iv	i, iv
Frequency selective voltmeter	Frequency counter	Frequency counter
frequency, triggering	disenabling, frequency	enabling, disenabling

period	frequency	time interval
CRO	HDA	CRO
amplifier	CRT	CRT
1550 V	1500 V	1500 V
Camera	Amplifier	CRO
Heater	Cathode	Control grid
Aquadag coating	Silicon coating	Aquadag coating
Sulphur	Phosphor	Phosphor
Lissajous pattern	Triangular pattern	Lissajous pattern
sine wave	ellipse	circle
sine wave	ellipse	ellipse
Known capacitance	Unknown capacitance	Known resistance
fxfy	fy/(1+fx)	fy/fx
i, iv	ii, iv	i, iv

A-iii, B-i, C-iv, D-ii	A-iii, B-iv, C-ii, D-i	A-iii, B-iv, C-ii, D-i
Is/Ip	Is/(1+Ip)	Is/Ip
A-iii, B-iv, C-i, D-ii	A-iv, B-iii, C-ii, D-i	A-ii, B-i, C-iv, D-iii

UNIT-IV **DIGITAL INSTRUMENTS**

1	**Questions**	**A**
2	By using a digital voltmeter ,we can measure _______________	Voltage
3	Linear method of finding the voltage comes under ______________	Potentiometertype
4	Servo method of finding digital values is a type of _______________	Potentiometertype
5	In potentiometer type ,the unknown voltage is compared with _________	anotherunknownvoltage
6	Potentiometric type is further divided into	servotype and successive approximationtype.
7	Servo type consists of comparator which produces	Squarewaveform.
8	Signal conditioner in non-integrating type is used for_________	ConvertingACtoDC
9	The variation in the Potentiometer will Produces a _________	voltage
10	The digital display in servo type potentiometer is driven by	servomotor.
11	The zero indicator is also known as_________	detector
12	DAC circuits are used to _________ from the digital counter.	enterthedatas
13	Attenuator circuits are used to produces_________	amplifiedsignal.
14	In successive approximation method _____________code is used.	16-8-4-2
15	Comparator circuit is used to compare two_____	unknownsignals.
16	Linear ramp type DVM consists of ____________ comparators.	1
17	Logic control circuits are used to drive ____________	digitaldisplays.
18	Local oscillator will produces a _________ voltage	stable
19	Crystal oscillator will produces __________voltage	fixedandstable
20	Ramp type DVM is used to measure	phase
21	The ramp signal may be	positive.
22	In linear ramp type DVM one of the comparator is being__________	appliedwithvoltage.

23	In dual slope DVM the slopes are.______________	VinandVout
24	In dual slope DVM the slopes are _________	unequal.
25	Digital signal are _____________ signals.	timevaryingsignals.
26	Digital multimeters can measure__________	phase
27	Flip flops in dual slope DVM are used to control the_________	counter
28	The flip flop in Dual Slope will ___________ when counter reaches the maximum.	resets.
29	Potentiometer is used to measure ______________	unknowncurrent
30	Potentiometer is also used to _____ of analog circuits.	reset
31	The potentiometer can be used either in _______ mode or_____________ mode	nullandequaldeflection
32	Logical zero is recognised by_____________	negativelevel
33	The binary counter forms the heart of ________digital implementations.	discretelogic.
34	Negative logic is represented by means of_________-	truelevel
35	Dual slope integrator is a __________	DACcircuit
36	Attenuator is used to_______________the signal.	strengthen
37	Staircase waveform is also known a ________________	quasramp.
38	Stepper technique in stepper-type DVM is used instead of using_____________	integrator.
39	The servo ADC circuit is also called as the________________	RampADCcircuit.
40	The servo ADC circuit is also known as __________________	binarycounter
41	Successive type is ___________________ than servo ADC.	slower
42	Successive type is ____times faster than Servo type ADC	30
43	Shift register is present in __________	ramptypeDVM.
44	Voltage to frequency converter is a _____________	VCO.
45	In voltage to frequency conveter the input voltage is represented by______________	outputvoltage.
46	Parallel ADC circuit is also called as_____________	serialADC
47	Digital techniques are_________-than analog techniques.	better

48	In voltage to frequency converter the GATE is opened for_________	5ms
49	The digital display, displays with ___________	LED’s
50	I to V converters converts input _________ to output_________	current,voltage.
51	Flip flops in dual slope DVM are used to control the_________	counter
52		
53		
54		
55		
56		
57		
58		
59		
60		

B	C	D	Answer
voltage and phase.	waveforms	voltage and current.	**Voltage**
Ramp type	staircase method	integrating type.	**Ramp type**
ramp type	integrating type	linear type.	**Potentiometertype**
internal reference voltage.	control voltage.	continuous voltage.	**internal reference voltage.**
potentiometric and ramp type.	linear and staircase method.	integrating method.	**servotypeandsuccessive approximationtype.**
triangular waveform.	ramp signal	sweep voltage.	**Squarewaveform.**
Converting DC to AC	To give ramp voltage	square output.	**ConvertingACtoDC**
current	Resistance	phase difference.	**voltage**
amplifier	comparator circuits.	reference voltage.	**servomotor.**
null detector	voltage detector	phase detector.	**null detector**
convert the analog signal to digital	read the content.	rectify the data.	**read the content.**
distorted signals	detected signals.	original signal.	**original signal.**
8-4-2-1	8-2-4-1	4-3-2-1	**8-2-4-1**
known signals.	known and a phase signal	unknown and a reference signal.	**unknown and a reference signal.**
2	3	4	**2**
oscillator circuits.	logic gates	counters.	**logic gates**
reference	variable	difference.	**variable**
variable	difference.	sweep.	**fixedandstable**
ramp voltage	voltage	time interval.	**time interval.**
negative	positive e or negative.	i,ii,iii.	**positive e or negative.**
applied with reference voltage.	ramp voltage.	grounded.	**grounded.**

Vin rise and Vin fall	Vin and Vref	Vin rise and Vout fall.	**Vin and Vref**
equal.	Fall time is 0.	i,ii.	**equal.**
discrete	continuous.	depends on input	**timevaryingsignals.**
frequency	inductance	conductance.	**conductance.**
integrator.	switch control circuits.	clock generators	**switch control circuits.**
sets	hold condition.	toggles.	**sets**
unknown potential.	unknown resistance.	i,ii	**unknown potential.**
auto-zero.	apply voltage	i,ii	**auto-zero.**
null and unequal deflection.	control and equal deflection	control and unequal deflection.	**nullandequaldeflection**
false level.	positive level.	switch off position.	**positive level.**
continuous logic	flip flop	all the above.	**discretelogic.**
switch on position	logical zero	all the above.	**logical zero**
ADC circuit.	Hard-wired circuit	i ,ii,iii	**ADC circuit.**
increase the amplitude.	reduce the amplitude.	i,ii,iii	**reduce the amplitude.**
ramp	square waveform.	sweep waveform	**quasramp.**
clock	counter	DAC	**integrator.**
staircase ADC circuit.	counter circuits	binary circuits	**RampADCcircuit.**
digital counter	servo DAC circuit		**binarycounter**
faster.	easier	costlier	**faster.**
45	20	28	**28**
Potentiometric type DVM.	successive type DVM.	integrator type DVM.	**successive type DVM.**
LO	Crystal osc.	ii,iii	**VCO.**
output frequency	output phase.	all the above.	**output frequency**
flash ADC	binary ADC	ramp ADC	**flash ADC**
cheaper	better and faster	iii	**better and faster**

0.5ms	0.1s	0.05s	**0.1s**
LCD’s	7-segment displays.	ii,iii	**ii,iii**
voltage, frequency	voltage ,current.	current to phase.	**current,voltage.**
integrator.	switch control circuits.	clock generators	**switch control circuits.**

Unit V DATA ACQUISITION SYSTEMS AND FIBER OPTIC MEASUREMENTS

S.No	Question	A
1	_______________ systems are used to measure and record the signals obtained from direct measurement and from transducers.	Instrumentation
2	Data acquisition systems are used to measure and record the signals originating from transducers, such as	Strain gages, Oscilloscopes
3	Instrumentation systems can be categorized into two major classes. What are they ? i. Analog systems ii.Communication systems iii.Electrical systems iv.Digital systems	i, iv
4	Match the following. A. Visual display devices i. Translates B. Signal conditioners ii. Stylus-and-ink C. Graphic recording instruments iii. Oscilloscopes D. Transducers iv. Amplify, Modify	A-iv, B-iii, C-i, D-ii
5	_____________is used for translating physical parameters into electrical signals.	a.Scanner
6	An analog data acquisition system typically consists of i.Transducers ii.Signal conditioners iii.Visual display devices iv.Magnetic tape instrumentation	i, iii
7	__________ is used for continuous monitoring of the input signals in analog data acquisition system.	a.Signal conditioners
8	_________ accepts multiple analog inputs and sequentially connects them to one measuring instrument.	Multiplexer
9	Elements of an analog data-acquisition system i. Transducers ii.Visual display devices iii.Digital recorder iv.Scanner	i, iii
10	Characteristics of an instrumentation amplifier i. Infinite gain ii.High impedance differential input iii. Finite gain iv.Low impedance differential input	i, ii

11	Multiplexer has	1 input & 2n outputs
12	In digital-to-analog conversion, a very common application of multiplexing is found in	Computer technology
13	__________ and __________ are the two ways to accomplish D/A multiplexing. i.Single D/A converter on each channel ii. Double D/A converter on each channel iii.Separate D/A converter for each channel iv.Triple D/A converter for each channel	i, ii
14	_________ and _________ circuits are used in separate D/A converter type multiplexing.	Gating, Analog
15	Sample and hold circuits are found in ________ type of multiplexing.	Separate D/A converter
16	In first method of multiplexing, ________ is made by gating clock pulses to the appropriate output channels.	Input selection
17	In the second method of multiplexing, the sequential selection of sample-hold circuits is made by	Gating and Control circuits
18	______ and _________ are required to operate the counter and sample the comparators in counter-type A/D converter.	Gating and Control circuits
19	One of the most valuable and powerful advances in the development of test equipment is ___________.	Advanced control equipment
20	Three components required for a computer-operated test system i.Computer compatible test equipment ii.Computer iii.Communication system iv.Automatic test equipment	i, iii, iv
21	In testing an audio amplifier, the computer is performing three tasks. What are they? i. increases the power ii.Supplies stimulus to the unit under test iii.Determines the response of the unit iv.Analyze and present the data	i, ii, iii
22	The response of the audio amplifier is determined by using	Spectrum analyzer
23	In testing a radio receiver, the audio output can be measured by	SINAD meter
24	The significant advantage of computer measurements is	Improved high frequency response

25	The most significant interface for computer-operated test equipment is	The Centronics parallel interface
26	The IEEE standard 488 bus is a	Dual interface for programmable instrumentation
27	The IEEE standard 488 is primarily suited for ________ microprocessor.	8-bit
28	The IEEE 488 standard is based on the transmission of _________-bit data words with a parallel _____-bit data bus.	8, 8
29	A ________ is a set of interconnecting wires shared by several pieces of test equipment.	Talker
30	Match the following. A. Radio receiver i. Controller B. Traffic cop ii. Gating and control circuits C. Audio amplifier iii. SINAD meter D. D/A multiplexer iv. Distortion analyzer	A-ii, B-iv, C-i, D-ii
31	The IEEE 488 bus interface is divided into two areas. What are they?	Address bus & Data bus
32	In IEEE 488 standard bus, _________ transmits the data necessary for the operation of the system.	Interface signal lines
33	Which one of the following is not comes under the data byte transfer control of IEEE 488 standard bus?	NRFD
34	Which one of the following is not comes under the general interface management?	IFC
35	In IEEE bus system, the interface clear(IFC) signal is used _________.	Only by the talker
36	In IEEE 488 bus system, the service request is used by __________.	The Listener
37	________ is used by the controller in IEEE 488 bus, to select between two alternative sources of device programming data.	REN
38	Which one of the following is not comes under the handshake lines of IEEE 488 bus system?	DAV
39	In IEEE 488 instrumentation bus, messages are passed from ________ to _________ under the control from the ________.	Talker, Controller, Listener

40	Match the following. A. Both Talker & listener i. Signal generator B. Talker ii. Frequency counter C. Controller iii. Voltmeter D. Listener iv. Attention.	A-iii, B-i, C-iv, D-ii
41	Which one of the following can be used as both talker & listener?	Frequency counter
42	Which one of the following can be used only as listeners?	Frequency counter
43	One of the easiest instruments to interface with the IEEE 488 bus is the	Signal generator
44	If the frequency of the generator is set via digital inputs from the bus, then the generator is called as	Function generator
45	The IEEE interface is intended for distances less than ______ total cable length.	20 m
46	Fiber optic transmission is made possible by a phenomenon called	Total internal refraction
47	Match the following. A. Critical angle i. 2 Sin-1(n1 Sin θc) B. Numerical aperture ii. Cos -1 (n2/n1) C. Acceptance angle iii. 20 log (NA1/NA2) D. Loss iv. Square root of (n22 - n12)	A-iii, B-iv, C-i, D-ii
48	The light source for a fiber optic communications system is either a _____ or a _________. i.LED ii.Avalanche photo diode iii.LASER diode iv.PIN photo diode	ii, iii
49	The two basic categories of fiber optic detectors are i.Light Emitting Diode ii.Avalanche photo diode iii.PIN photo diode iv.LASER diode	ii, iii
50	In the fiber optic measuring, _________ converts the diode current to a voltage.	Log converter
51	A very powerful tool in the maintenance and installation of a fiber optics system is _______.	Auto ranging power meter
52	A typical fiber has an index of refraction of about _________	0.5
53	Larger reflections in optical fiber are the indicators of	Breaks in the fiber

54	When the liquid in LCD is activated, the molecular turbulence causes light to be scattered in all directions and the cell appears to be bright. The phenomenon is called	Rayleigh scattering
55	The advantages of LCD's are i.Power consumption ii.Cost iii.Area iv.Life span	i, ii
56	Liquid crystal cells are of two types. What are they?	Transmittive type & Refractive type
57	Match the following. A. Fiber optic transmission i. Photo diode B. Light detector ii. Total internal reflection C. Light source iii. Dynamic Scattering D. Liquid Crystal Display iv. LASER diode	A-iv, B-iii, C-i, D-ii
58	In systems using digital recorders, the recorder axes are driven by powerful and positive	Accelerometers
59	The digitliser used in the data logging system is a _________.	Digital voltmeter
60	Match the following. A. Program pin board components i. Protects the different B. Multiplexer ii. Digital voltmeter C. Digitliser iii. Time controlled switch D. Limit detectors iv. Route the signals	A-iii, B-i, C-iv, D-ii

B	C	D	ANSWER
Electrical	Data acquisition	Electronic	**Data acquisition**
Strain gages, Thermocouples	Thermocouples, Multimeters	Oscilloscopes, Multimeters	**Strain gages, Thermocouples**
i, ii	i, iii	i, iii, iv	**i, iv**
A-ii, B-iv, C-i, D-iii	A-ii, B-iii, C-iv, D-I	A-iii, B-iv, C-ii, D-i	**A-iii, B-iv, C-ii, D-i**
b. Transducer	. Signal convert	d. Signal conditioner	**b. Transducer**
ii, iv	ii, iii, iv	i, ii, iii, iv	**i, ii, iii, iv**
b. Graphic recording instruments	c. Visual display devices	d. Transducers	**c. Visual display devices**
Converter	Auxiliary equipment	Signal conditioner	**Multiplexer**
ii, iii	i, ii	ii, iv	**i, ii**
ii, iii	i, iii	ii, iv	**ii, iii**

n inputs & 2n outputs	2n inputs & n outputs	2n inputs & 1 output	**2n inputs & 1 output**
Information technology	Digital technology	Analog technology	**Computer technology**
i, iii	ii, iii	ii, iv	**i, iii**
Analog, Digital	Gating, Control	Digital, Gating	**Gating, Control**
Single D/A converter	Double D/A converter	Triple D/A converter	**Single D/A converter**
Output selection	Converter selection	Channel selection	**Channel selection**
Sequential channel selector	Channel selection switches	Bus	**Gating and Control circuits**
Synchronization and Control circuitry	Synchronization and Gating circuitry	Channel selection switches and control circuitry	**Synchronization and Control circuitry**
Automatic control equipment	Automatic test equipment	Advanced test equipment	**Automatic test equipment**
ii, iii, iv	i, ii, iii	i, ii, iv	**i, ii, iii**
i, iii, iv	i, ii, iv	ii, iii, iv	**ii, iii, iv**
Distortion analyzer	Transducer	Instrumentation amplifier	**Distortion analyzer**
Wattmeter	Voltmeter	Ammeter	**SINAD meter**
Speed is high	Noise is less	High stability	**Speed is high**

RS-232 interface bus	The IEEE 488 bus	The IEEE 480 bus	**The IEEE 488 bus**
Dual interface for processor interconnection	Digital interface for processor interconnection	Digital interface for programmable instrumentation	**Digital interface for programmable instrumentation**
16-bit	24-bit	32-bit	**8-bit**
8, 16	16, 8	16, 16	**8, 8**
Signal lines	Bus	Listener	**Bus**
A-iii, B-i, C-iv, D-ii	A-iii, B-iv, C-i, D-ii	A-ii, B-iii, C-iv, D-i	**A-iii, B-i, C-iv, D-ii**
Data bus & Interface bus	Address bus & Control lines	Data bus & Control lines	**Data bus & Control lines**
Status lines	Control lines	Data lines	**Interface signal lines**
DAV	ATN	NDAC	**ATN**
DAV	REN	EOI	**DAV**
By any device	Only by the listener	By the controller	**By the controller**
The Talker	Any Device	The Controller	**Any Device**
EOI	IFC	SRQ	**REN**
REN	NRFD	NDAC	**REN**
Listener, Controller, Talker	Listener, Talker, Controller	Talker, Listener, Controller	**Talker, Listener, Controller**

A-ii, B-iv, C-i, D-iii	A-ii, B-iii, C-iv, D-i	A-iii, B-iv, C-i, D-ii	**A-ii, B-iii, C-iv, D-i**
Signal generator	Voltmeter	Decoder	**Frequency counter**
Signal generator	Voltmeter	Decoder	**Signal generator**
Voltmeter	Frequency counter	Decoder	**Frequency counter**
Wave generator	Sweep generator	Synthesized generator	**Synthesized generator**
25 m	12 m	2 m	**20 m**
Rayleigh scattering	Total internal reflection	Numerical aperture	**Total internal reflection**
A-ii, B-iv, C-i, D-iii	A-ii, B-i, C-iv, D-iii	A-iii, B-i, C-iv, D-ii	**A-ii, B-iv, C-i, D-iii**
ii, iv	i, ii	i, iii	**i, iii**
ii, iv	iii, iv	i, iv	**ii, iii**
Low pass filter	Transimpedence amplifier	Digital voltmeter	**Transimpedence amplifier**
Optical time-domain reflectometer	Optical power meter	Auto ranging time-domain power meter	**Optical time-domain reflectometer**
1.5	2.5	3.5	**1.5**
Impurities	Splice losses	Bending	**Splice losses**

Static scattering	Total internal reflection	Dynamic scattering	**Dynamic scattering**
i, iii	i, iv	ii, iv	**i, ii**
Transmittive type & Reflective type	Transformative type & Refractive type	Transformative type & Reflective type	**Transmittive type & Reflective type**
A-iii, B-iv, C-i, D-ii	A-ii, B-i, C-iv, D-iii	A-ii, B-iv, C-i, D-iii	**A-ii, B-i, C-iv, D-iii**
Relays	Servo motors	Stepping motors	**Stepping motors**
Transducer	Multiplexer	Lineariser	**Digital voltmeter**
A-iv, B-iii, C-ii, D-i	A-ii, B-iv, C-i, D-iii	A-ii, B-iii, C-iv, D-i	**A-iv, B-iii, C-ii, D-i**

COURSE MATERIAL

Measurements and Instrumentation

Unit I

BASIC ELECTRONIC MEASUREMENTS

1.1 Review of DC and AC voltmeters:

Generally AC electromechanical meters are based on two basic movements: those based on DC movement, and those designed for AC usealone.Permanentmagnet moving coil (PMMC) meter movement does not work correctly if it is directly connected to alternating current, because the direction of needle movement will change with each half-cycle of AC quantity. Figure 1.1 shows D'Arsonval meter movement causes useless flutter of the needle while ac is passing through this wire coil. Permanent-magnet meter is a device whose motion depends on the polarity of the applied voltage.

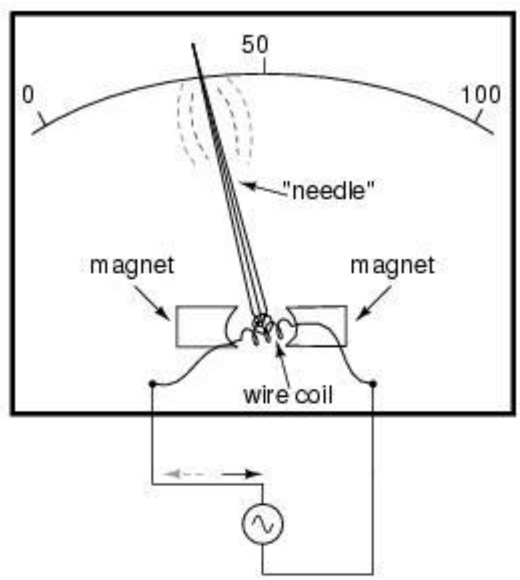


Figure 1.1.Passing AC through this D'Arsonval meter movement causes Useless flutter of the needle.

InD'Arsonval meter movement, initially the dc current must be rectified through diodes. Thediodes act like a one-way valve for electron flow: acting as a conductor for one polarity and an insulator for another. The arrowhead in each diode symbol points against the permitted direction of electron flow. Arranged in a bridge, four diodes serve to steer AC through the meter movement in a constant direction throughout all portions of the AC cycle shown in Figure 1.2.

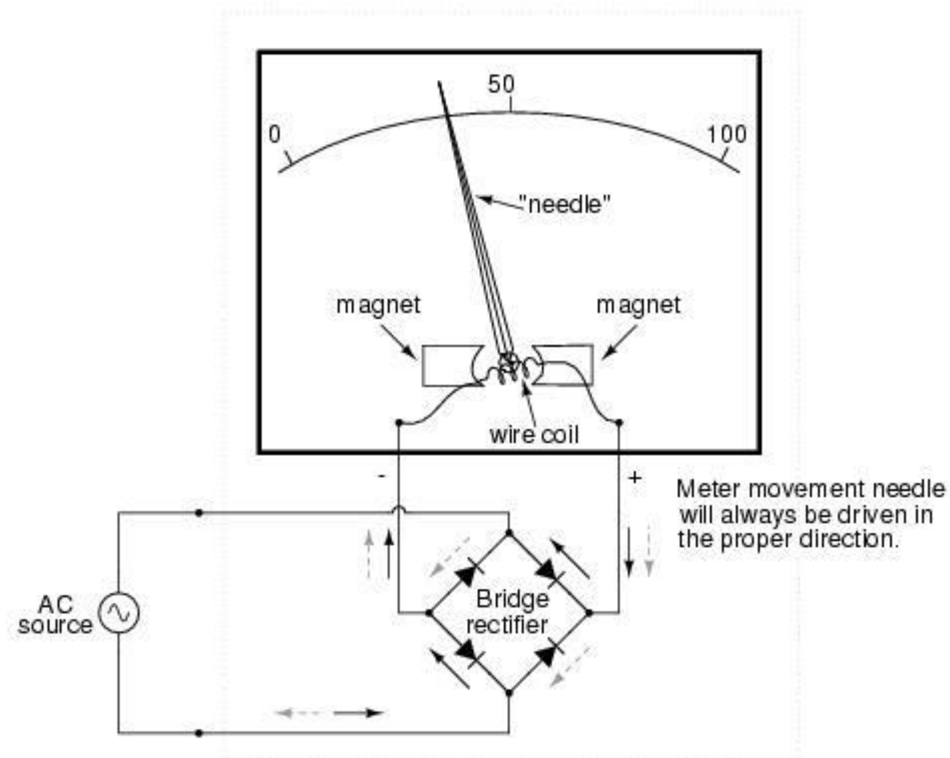


Figure 1.2 Passing AC through this rectified AC meter movement will drive it in one direction.

Another strategy for a practical AC meter movement is to redesign the movement without the inherent polarity sensitivity of DC types. This means avoiding the use of permanent magnets. The simplest design is to use a non-magnetized iron vane to move the needle against spring tension, the vane being attracted toward a stationary coil of wire energized by the AC quantity to be measured as in Figure 1.3 below.

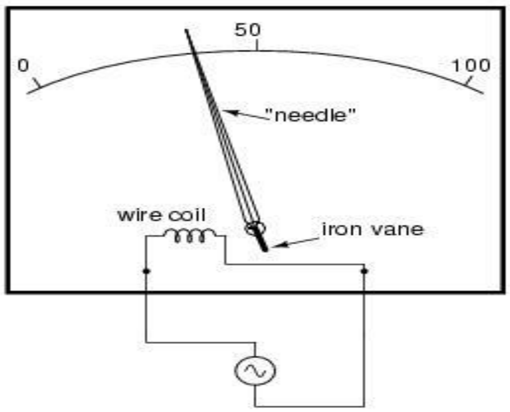


Figure 1.3 Iron-vane electromechanical meter movement

Electrostatic attraction between two metal plates separated by an air gap is an alternative method for generating a needle-moving force proportional to applied voltage. The forces involved are very small, much smaller than the magnetic attraction between an energized coil and an iron vane, and as such these “electrostatic” meter movements tend to be fragile and easily disturbed by physical movement. This technology possesses high input impedance, meaning that no current need be drawn from the circuit under test. Also, electrostatic meter movements are capable of measuring very high voltages without need for range resistors or other, external apparatus.

1.2 DC Voltmeter

The DC voltmeter mainly consists of a dc amplifier apart from the attenuator, as shown in Figure.1.4.

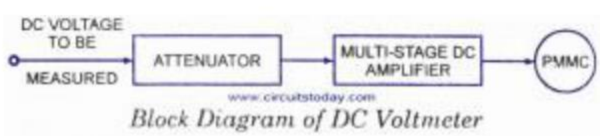


Figure 1.4 Block diagram of DC voltmeter

DC voltmeters can be divided into two categories.

1. Direct coupled amplifier DC Voltmeter.

2. Chopper type DC Voltmeter.

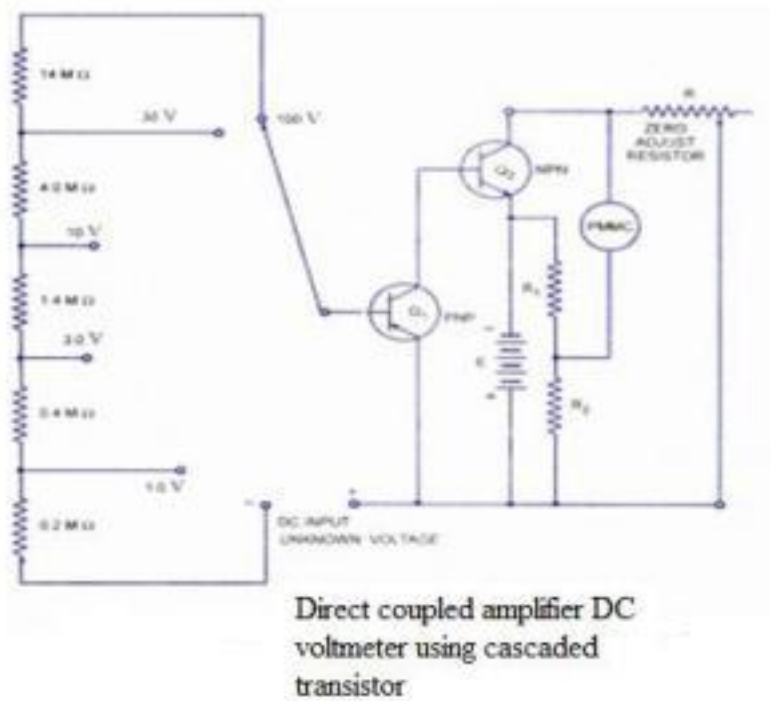


Figure 1.5Direct coupled amplifier DC voltmeter

This type of voltmeter is very common because of its low cost. This instrument is used only to measure voltages of the order of milli-volts owing to limited amplifier gain. The circuit diagram for a direct coupled amplifier dc voltmeter using cascaded transistors is shown in Figure 1.4. An attenuator is used in input stage to select voltage range. A transistor is a current controlled device so resistance is inserted in series with the transistor Q1 to select the voltage range. It can be seen from figure that sensitivity of voltmeter is 200 kilo ohms/volt neglecting small resistance offered by transistor Q1. Other values of range selecting resistors are so chosen that sensitivity remains same for all the ranges. So current drawn from the circuit is only 5micro Ampere.

Two transistors in cascaded connections are used instead of using a single transistor for amplification in order to increase the sensitivity of the circuit. Transistors Q1 and Q2 are taken complement to each other and are directly coupled to minimize the number of components in the circuit. They form a direct coupled amplifier. A variable resistance R is put in the circuit for zero adjustment of the PMMC. It controls the bucking current from the supply E to buck out the quiescent current. The draw-back of such a voltmeter is that it has to work under specified ambient temperature to get the required accuracy otherwise excessive drift problem occurs during operation.

1.2.1 DC Voltmeter using FET

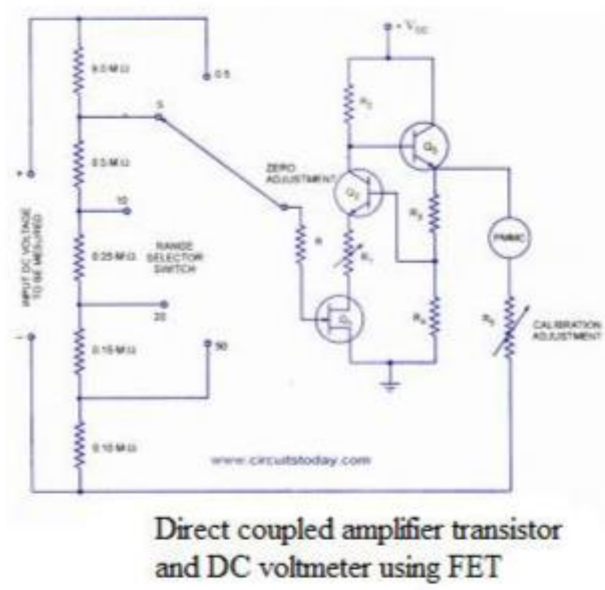


Figure 1.6Direct coupled amplifier DC voltmeter using FET

Another circuit diagram of a direct coupled amplifier dc voltmeter using FET in input stage is shown in Figure 1.6. In this voltmeter, voltage to be measured is firstly attenuated with range selector switch to keep the input voltage of amplifier within its level. FET is used in the input stage of amplifier because of its high input impedance so that is does not load the circuit of which voltage is to be measured and it also keeps the sensitivity of voltmeter very high. As FET is a voltage controlled device so resistance network of attenuator is put in shunt in the circuit. Transistors Q_2 and Q_3 form the direct coupled dc amplifier whose output is finally supplied to PMMC meter. When transistors work within their operating region, the deflection of meter remains proportional to the applied input voltage. This voltmeter can be used for measurement of voltages of the order of milli-volts because of sufficient gain of amplifier.

Apart from having high input impedance, this circuit has another advantage that when input voltage exceeds its limit, amplifier gets saturated which limits the current passing through the PMMC meter. So meter does not burn out.

1.2.2 Chopper Type DC Voltmeter

The simple block diagram of the chopper fed DC voltmeter is shown in Figure 1.7

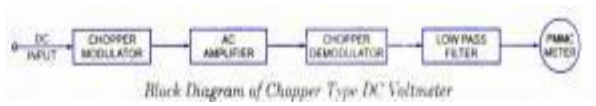


Figure 1.7 Block diagram of chopper type DC Voltmeter

Chopper type dc amplifier is used in highly sensitive dc electronic volt-meters. Its block diagram is shown in Figure 1.7. Firstly dc input voltage is converted into ac voltage by chopper modulator and then it is supplied to an ac amplifier, Output of amplifier is then demodulated to a dc voltage proportional to the original input voltage. Modulator chopper and demodulator chopper act in anti-synchronism.Chopper system may be either mechanical or electronic.

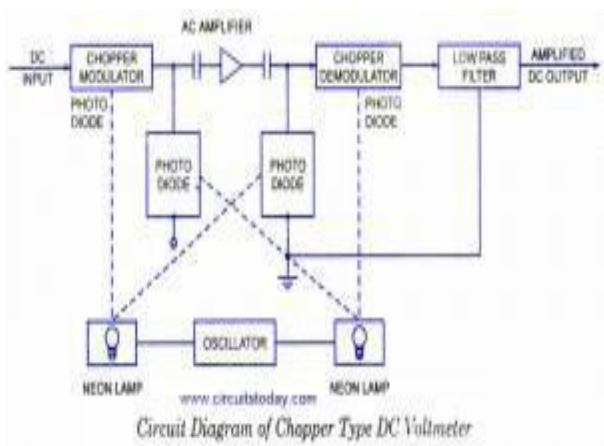


Figure 1.8 Choppertype DC voltmeter

Circuit diagram of an electronic chopper employing photo diodes is shown in Figure 1.8. Photo diodes change its resistance under different illumination conditions; this property of photo diode is used in chopper amplifier. Its resistance changes from the order of few mega-ohms to few hundred ohms when it is illuminated by a light source in the dark place.

Two neon lamps are used in this circuit which is supplied by an oscillator for alternate half cycles. Two photo diodes are used in input stage which acts as half-wave modulators because of its alternate switching action by the neon lamps at the frequency of oscillator.

Output of chopper modulator is a square wave voltage (proportional to the input signal) which is supplied to the ac amplifier through a capacitor. Amplified output is again passed through a capacitor and then fed to chopper demodulator. Capacitor is used to remove dc drift from the signal. Chopper demodulator gives a dc output voltage (proportional to the input voltage) which is passed through the low pass filter to remove any residual ac component. Now this dc output voltage is supplied to the PMMC meter for measurement of input voltage.

In chopper amplifier dc voltmeter, input impedance is of the order of hundred mega-ohms and it has sensitivity of one micro-volt per scale division.

1.3 AC Voltmeter

Sometimes signal is firstly amplified by ac amplifier and then rectified before supplying it to dc meter, as shown in Figure 1.9. In the former case the advantage is of economical amplifiers and the arrangement is usually used in low priced voltmeters.

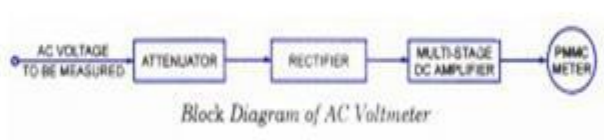


Figure 1.9Blockdiagram of AC voltmeter

Broadly ac voltmeters can be divided into three categories.

1. Average reading AC voltmeters using vacuum tube diode
2. Average reading AC voltmeters using semiconductor diode
3. Peak reading AC voltmeter

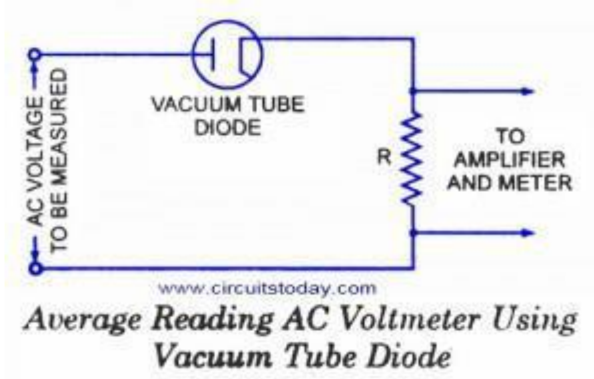


Figure 1.10 AC voltmeter using vacuum tube diode

Normally ac voltmeters are average responding type and the meter is calibrated in terms of rms values for a sine wave. Since most of the voltage measurements involve sinusoidal waveform so this method of measuring rms value of ac voltages works satisfactorily and is less expensive than true rms responding voltmeters. However, in case of measurement of non-sinusoidal waveform voltage, this meter will give high or low reading depending on the form factor of the waveform of the voltage to be measured.

The circuit diagram for an average reading voltmeter using a vacuum tube diode is shown in Figure 1.10. The arrangement requires a vacuum tube diode, an high resistance (of the order of 105 Q.) R and PMMC instrument, all connected in series, as shown in fig. Resistance R is used to limit the current and make the plate

The linear plate characteristics are essential in order to make the current directly proportional to voltage. Also because of high series resistance R, plate resistance of vacuum tube diode becomes negligible and therefore variations in plate resistance do not cause non-linearity in voltage-current characteristics. Thus, the scale of PMMC instrument is uniform and independent of variations of tube plate resistance. Voltage across the high resistance is fed to dc amplifier and output of the amplifier is fed to PMMC instrument. Circuit diagram of an average reading ac voltmeter using semi-conductor diode is shown in Figure 1.11.The diode conducts during the positive half cycle and does not conduct during the -ve half cycle, as shown in figure.

The average current through the meter will be given by the expression $I_{av}= V_{av} / 2R = 0.45 * [V_{rms}/R]$

V_{rms} is the effective or rms value of applied voltage and 1.11 is the form factor of sinusoidal wave. R is multiplied by 2 because the voltmeter operates on half-wave rectification. It is to be worthnoting that this instrument can be used to indicate dc voltages but in such a case the instrument readings will have to be multiplied by 2 x 1.11, that is, as the diode conducts all the time. Circuit diagram of an average reading ac voltmeter using semi-conductor diodes as a full-wave rectifier is shown in figure. In this case average current through the meter will be Vrms/ 1.11R. Main advantages associated with these voltmeters are that they are simple in construction, have high input impedance, low power consumption and uniform scale. Main disadvantage of these voltmeters is that these operate in audio-frequency range. In radio-frequency range, distributed capacitance of the high resistance R introduces error in the readings.

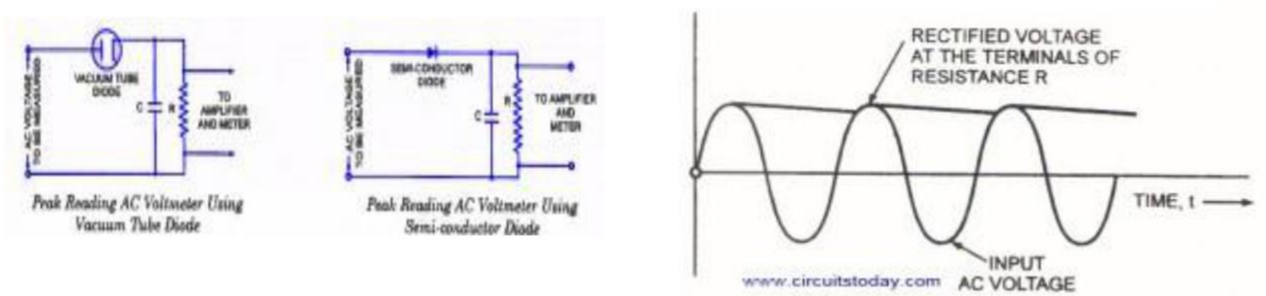
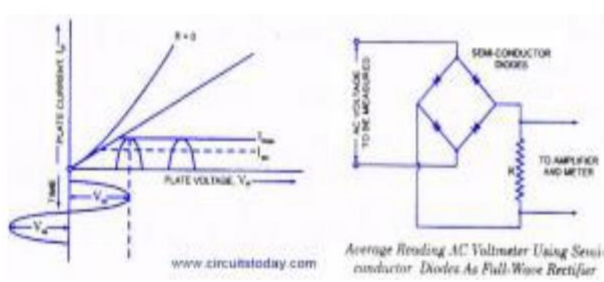


Figure 1.11ACvoltmeter using vacuum tube diode



Another disadvantage of such a voltmeter is that due to non-linear volt-ampere characteristic for lower voltage the readings of the voltmeter at lower voltage are not correct.

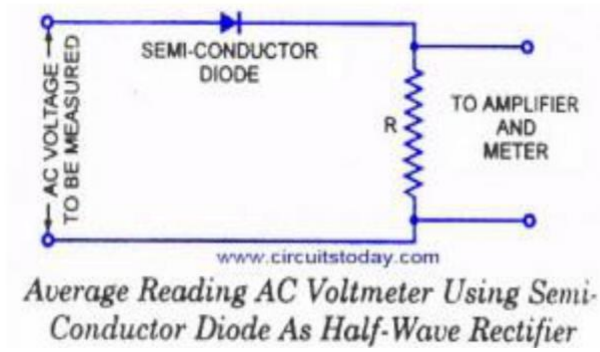


Figure 1.12 Peak reading AC Voltmeter and its waveform

The circuit diagram for peak reading voltmeter using vacuum tube and semi-conductor diode are shown in figures respectively.

In this type of voltmeters capacitor C is charged to the peak value of the applied voltage and capacitor is discharged through high resistance R between two peaks of the wave which results in a small fall in capacitor voltage. But this voltage is again built up during next peak of the wave, as shown in figure. So voltage across capacitor C and resistance R remains almost constant and equal to peak value of the applied voltage.

Either the average voltage across R or the average current through R, can be used to indicate the peak value of applied voltage. In case the vacuum tube diode (or semi-conductor diode), series resistance R shunted by capacitance C and PMMC are connected in series across the source of unknown voltage, the current through the PMMC will indicate the peak value of applied voltage.

In case, the circuit shown in figure making use of rectifying diode, series resistance R, dc amplifier and PMMC is employed, the average voltage across R will indicate the peak value of applied voltage. The high value input resistance also gives more linear relationship between peak applied voltage and the instrument indication. Also the performance of the diode with inputs consisting of pulses and modulated waves is improved.

The dc amplifier associated with the diode rectifier should be provided with stabilizing means in order to prevent drift in the indication of the output meter. Usually a voltage regulated supply combined with a compensating circuit is used.

The use of high series resistance R, associated with dc amplifier, no doubt results in a high input resistance but at the same time it implies that an applied voltage of sufficient amplitude is required so that the system acts as a peak voltage device. The main disadvantage of this system is with regards to measurement of low voltage. If the applied voltage is too small, then there is a flow of some current throughout the cycle of the voltage because of high velocity of emission of electrons, and the input resistance may be a few hundred ohms and it defeats the very purpose with which electronic instruments are used.

1.4 Electronic Multimeters

It is one of the most versatile general purpose instruments capable of measuring dc and ac voltages as well as current and resistances. The solid-state electronic millimeter (or VOM) generally consists of the following elements.

A balanced bridge dc amplifier and a PMMC meter.

An attenuator with an input stage to select proper voltage range.

A rectifier for converting of an ac input voltage to proportionate dc value.

An internal battery and additional circuitry for providing the capability of resistance measurement.

A function switch for selecting various measurement functions of the meter such as voltage, current or resistance.

In addition, the instrument is usually provided with a built-in power supply for operation on ac mains and, in most cases, one or more batteries for operation as a portable test instrument.

The multimeter is one of the most used devices in electronics,with determination and measuring electrical quantities functions. With the development of integrated circuits the digital multimeter appeared whose main difference from the analog display is how the result is displayed- in the liquid crystal display (LCD).

Measurable quantities with multimeter:

- Electrical resistance- measuring unit Ohm (Ω);
  - Voltage – volt (V)
  - Alternative voltage (~);
  - Continuousvoltage(=);
  - Intensity of electrical current – ampere (A);
  - Directcurrent (=);
  - Alternative current (~);

Besides these electrical quantities, multimeters also provide the opportunity to check the functions of some components like,

resistance (by direct measurement on ohmic scale);

semiconductor diode;

electrical capacitance;

bipolar transistors;

The schematic diagram of multimeter is shown in Figure 1.13.

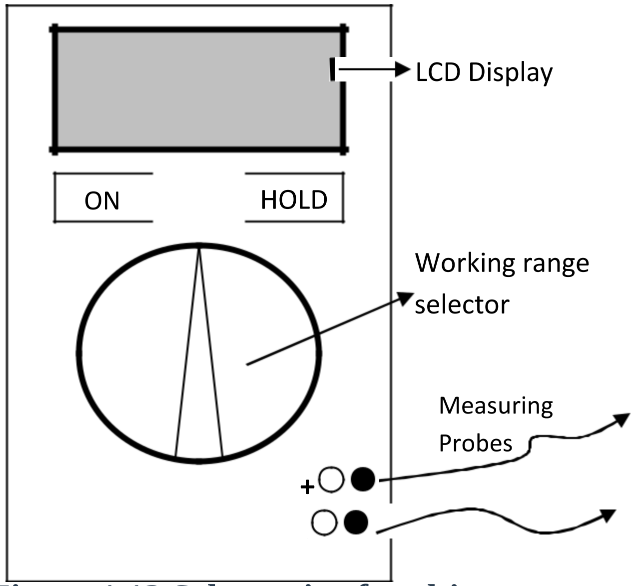


Figure 1.13 Schematic of multimeter

Button ON - allows to start/ close the multimeter

button HOLD - allows maintaining the value shown on the display until pressing the button (the measurement can’t be made with the button pressed);

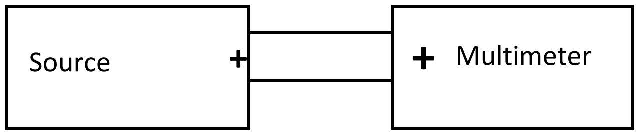
working range selector- allows to select the working mode of the device(measure quantities and determine the components) as well as the measuring range for electrical quantities.

Measurement circuits schemes using multimeter:

Voltages measurement:

To measure the voltage, the multimeter is connected as shown in Fig 1.14 between those two test points.

Example of connection:



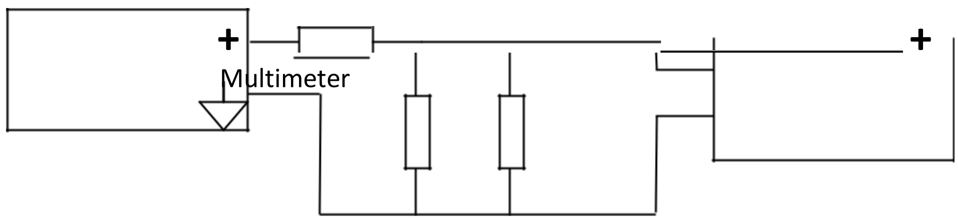


Figure 1.14 Measurement of voltage DC voltage measurements (symbol V=)

When the range selector is switched on one of the positions for DC voltage measurements. The selected inscription is the maximum amount which can be measured on that scale. The two cords must be connected the two points between which the voltage to be measured, red cord represents + and the black cord is -.

While reading from the display, if voltage value is greater than the maximum of that scale, on the display if it reads 1, the switching range on a scale with bigger valuesischanged. If the displayed value is negative then the polarity of the measured voltage is reversed to the voltage corresponding to + at the red cord and – at the black one. If the displayed value doesn't have sign, it means that the node where the red cord is connected will have bigger potential.

AC voltage measurements V~

When the range selector is set on AC voltage measurement positions, it represents the effective value of AC voltage measured.

Measurement of electrical currents

When measuring the electrical currents we must consider the following basic rules, before connecting the device:

- the red cord of the multimeter must be connected to the device' jack corresponding to the domain of measurement estimated.

- Always avoid shorting voltage sources with the multimeter. Current measurement is always made by inserting the resistance which determines the current, otherwise the multimeter will bedamaged(it burns!)

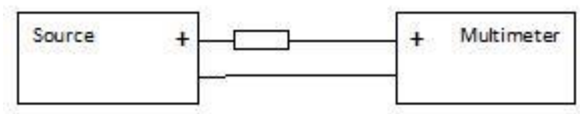


Figure 1.14Measurements of resistance

On this scale the multimeter measures the electrical resistance between two points of the circuit or the electrical resistance of a component. With the range selector on Ω position and the cord free the device indicates 1 (domain overflow, a normal thing considering that the electrical resistance between two wires in air is very big).

If the cords are shorted then the device must indicate 0, otherwise it means that the two probes are broken or the device battery is low.

Determine the functionality of semiconductor devices

Also on the positions "ohmetru" is the position for checking the diodes and bipolar transistors. In directsense,i.e. the red cord is on ANOD and the black cord on CATOD, the device indicates 0 or a small value, usually up to hundreds of ohms, and if it indicates 1, that is field overtaking.

Bipolar transistors verification is made as if there were two diodes (diode base- emitter and base- collector diode).

For example, at NPN transistors the red cord is connected to the base and we check the emitter and collector terminals to indicate a low resistance (hundreds of ohms). Put the black cord on base and the device must indicate a break at emitter and collector.

Determine the continuity of electrical paths

Also on the ohmmeter scales is the position, 'buzzer' used for checking the electrical continuity between two points. If short-circuit is made between the two cords of the device,a sound must be heard, in that moment we check only the device. Then the cords are positioned between the points and to check the electrical continuity, if the device becomes noisy it means that it has electrical continuity.

Continuity checking is always done in the absence of measuring circuit voltages, otherwise the device can be damaged!

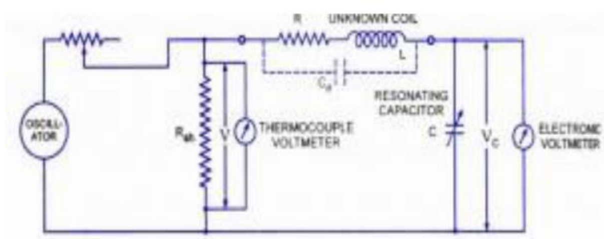
Capacity measurements at capacitors(F)

This function is found only on some digital multimeters, not being available on general paths.

1.5 Q-Meter

It is known that every inductor coil has a certain amount of resistance and the coil should have lowest possible resistance. The ratio of the inductive reactance to the effective resistance of the coil is called the quality factor or Q-factor of the coil.

So $Q = X_L / R = \omega L / R$



Circuit Diagram of a Q-meter

Figure 1.15 Q-metercircuitdiagrams

A high value of Q is always desirable as it means high inductive reactance and low resistance. A low value of Q indicates that the resistance component is relatively high and so there is a comparatively large loss of power. The effective resistance of the coil differs from its dc resistance because of eddy current and skin effects and varies in a highly complex manner with the frequency. For this reason Q is rarely computed by determination of R and L.

One possible way for determination of Q is by using the inductance bridge but such bridge circuits are rarely capable of giving accurate measurements, when Q is high. Special meters are used for the determination of Q accurately.

Q-meter is an instrument designed for the measurement of Q-factor of the coil as well as for the measurement of electrical properties of coils and capacitors. This instrument operates on the principle of series resonance i.e. at resonate condition of an ac series circuit voltage across the capacitor is equal to the applied voltage times of Q of the circuit. If the voltage applied across the circuit is keptconstant then voltmeter connected across the capacitor can be calibrated to indicate Q directly.

Circuit diagram of a Q-meter is shown is Figure 1.15. A wide-range oscillator with frequency range from 50 kHz to 50 MHz is used as a power supply to the circuit. The output of the oscillator is shorted by a low-value resistance, R_{sh} usually of the order of 0.02 ohm. So it introduces almost no resistance into the oscillatory circuit and represents a voltage source with a very small or of almost negligible internal resistance. The voltage across the low-value shunt resistance R_{sh}, V is measured by a thermo-couple meter and the voltage across the capacitor, V_c is measured by an electronic voltmeter.

For carrying out the measurement, the unknown coil is connected to the test terminals of the instrument, and the circuit is tuned to resonance either by varying the frequency of the oscillator or by varying the resonating capacitor C. Readings of voltages across capacitor C and shunt resistance R_{sh} are obtained and Q-factor of the coil is determined as follows :

By definition Q-factor of the coil,

$Q=X_L/R$

And when the circuit is under resonance condition, $X_L =$

X_C Or

$IX_L = IX_C = VC$

And the voltage applied to the circuit.

$V=IR$

So, $Q = X_L / R = IX_L / R = VC / V$

This Q-factor is called the circuit Q because this measurement includes the losses of the resonating capacitor, voltmeter and the shunt resistor R_{sh}. So, the actual Q-factor of the coil will be somewhat greater than the calculated Q-factor. This difference is usually very small and is neglectedexcept when the resistance of the coil under test is relatively small in comparison to the shunt resistance R_{sh}.

The inductance of the coil can also be computed from the known values of frequency f and resonating capacitor C as follows.

At resonance, $X_L = X_C$ or $2\pi fL = 1/2\pi fC$ or $L = 1/(2\pi f)^2$ Henry.

1.6True RMS voltmeter

RMS value of the sinusoidal waveform is measured by the average reading voltmeter of which scale is calibrated in terms of rms value. This method is quite simple and less expensive. But sometimes rms value of the non-sinusoidal waveform is required to be measured. For such a measurement a true rms reading voltmeter is required. True rms reading voltmeter gives a meter indication by sensing heating power of waveform which is proportional to the square of the rms value of the voltage.

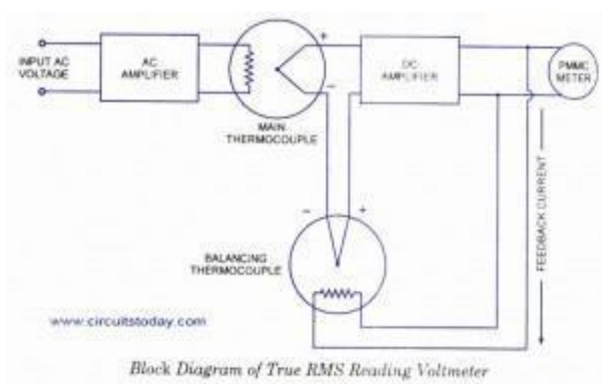


Figure 1.7 RMS Reading Voltmeter

AC waveform to be measured is applied to the heating element of the main thermocouple through an ac amplifier. Under absence of any input waveform, output of both thermo-couples are equal so error signal, which is input to dc amplifier, is zero and therefore indicating meter connected to the output of dc amplifier reads zero. But on the application of input waveform, output of main thermo-couple upsets the balance and an error signal is produced, which gets amplified by the dc amplifier and fedback to the heating element of the balancing thermo-couple.

This feedback current reduces the value of error signal and ultimately makes it zero to obtain the balanced bridge condition. In this balanced condition, feedback current supplied by the dc amplifier to the heating element of the balance thermo-couple is equal to the ac current flowing in the heating element of main thermo-couple. Hence this direct current is directly proportional to the rms value of the input ac voltage and is indicated by the meter connected in the output of the dc amplifier. The PMMC meter may be calibrated to read the rms voltage directly.

By this method, rms value of any voltage waveform can be measured provided that the peak excursions of the waveform do not exceed the dynamic range of the ac amplifier.

1.7 Differential voltmeter

The differential voltmeter can be used as a conventional Transistorized Electronic Voltmeter (TVM) and a Differential Null Voltmeter. It can also be used to measure variations of voltage near some known value (Null Detector), high resistance values (Meggometer), and for dBm measurements.

Meter Design Characteristics

The differential voltmeter is a solid-state instrument that provides the capability of making dc voltage measurements from +/- 10 microVolts to +/- 1,100 volts. AC voltages from 0.001 to 1,100 volts can be measured over a frequency range from 5 hertz to 100 kilohertz. Both of these measurements can be made without concern of loading the circuit. The differential voltmeter has four voltage readout dials that vary the resistance of the divider assembly as described above.

The differential voltmeter uses a built-in Null Detector to measure an unknown voltage. The meter circuitry compares the unknown voltage to a known, adjustable reference voltage supplied by the meter. The reference voltage is provided by a high-voltage dc power supply and decade resistor divider assembly strings that are set by voltage readout dials. In this way, the output from the high-voltage power supply can be precisely divided into increments as small as 10 microvolts. The readout dials are used to adjust the meter pointer to 0 and the unknown voltage is then read from the voltage dials.

A primary feature of the differential voltmeter is that it does not draw current from the unknown source for dc measurements when the measurement is obtained. Therefore, the determination of the unknown dc potential is independent of its source.

Front Panel Controls

The front panel of a typical differential voltmeter is shown in Figure 4.15. With a few differences, the controls and terminals are similar to those used on other differential voltmeters. The Null Sense switch selects the conventional TVM mode of operation and the various full-scale null detector sensitivity ranges when the instrument is operated in the differential mode of operation. The RANGE switch allows selection of the desired input voltage range, positions the readout dial decimal point, and selects the various ranges of the Null Sense switch. The readout dials provide a digital readout of the measured voltage when the instrument is in the differential mode.

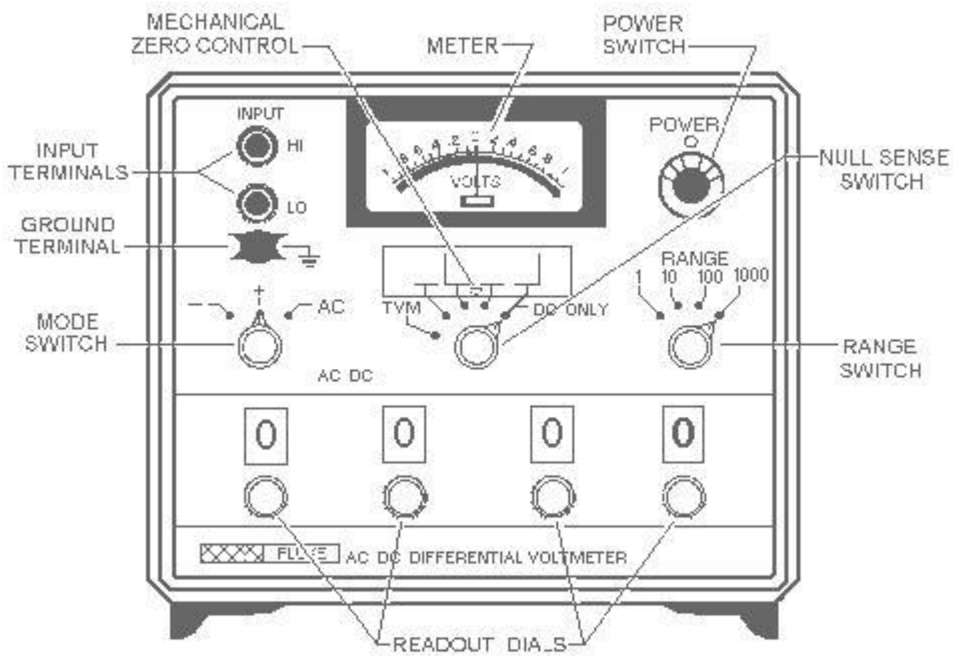


Figure 1.8 Controls, terminals, and indicators.

Modes of Operation

There are two primary modes of operation: the conventional transistorized voltmeter mode and the differential null mode. These modes are described in the next paragraphs.

Conventional Transistorized Voltmeter (TVM) Mode

When the instrument is used as a conventional transistorized dc voltmeter, the circuitry is connected as shown in Figure 1.8. The null detector drives the front panel meter and provides a full-scale meter deflection for any full-scale input. Positive or negative voltage measurements are made by reversing the meter terminals through the contacts of the MODE switch.

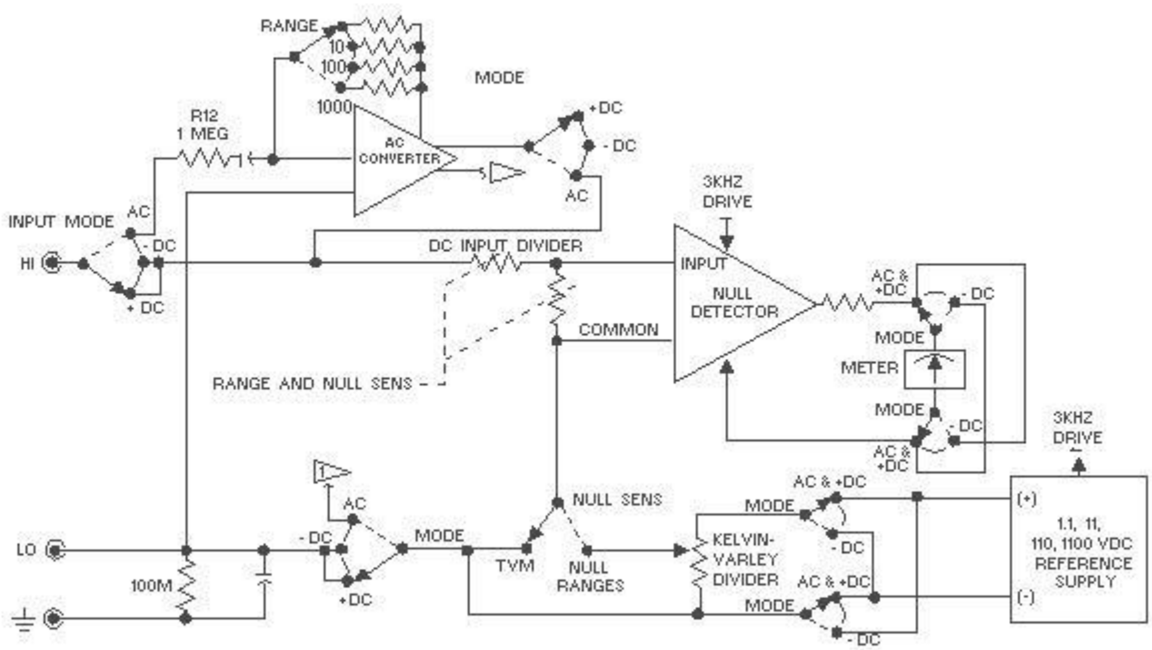


Figure 1.9 Block diagram of AC/DC differential voltmeter

Functional Block Diagram

Figure 1.9 is a functional block diagram of a differential voltmeter. The circuitry is made up of a reference supply, a resistive divider, a dc input divider, an ac converter, a null detector, and a meter. The circuitry is interconnected by various switching arrangements when you perform the desired ac or dc conventional or differential voltage measurements.

Placing the MODE switch in figure to the AC position connects the instrument circuitry as a conventional transistorized ac voltmeter. A full-scale input voltage at the input terminals of the instrument results in a voltage being applied to the input of the null detector. The null detector drives the front panel meter that indicates the value of the measured ac voltage.

Differential Null Mode

When the instrument is used as a dc differential voltmeter, the MODE and NULL SENS switches in figure 4-16 are placed to their respective +/- dc and desired full-scale meter sensitivity positions. In this mode of operation, the NULL SENS switch selects a suitable resistance value to determine the full-scale sensitivity of the meter. Thedc input voltage applied to the instrument is then compared with the null detector, and any resulting difference is used to drive themeter. The meter terminals can be reversed through the contacts of the MODE switch for +/- dc voltage measurements.

1.8 Vector Impedance Meter

Vector Impedance meter can be used to measure magnitude and phase angle of impedance.

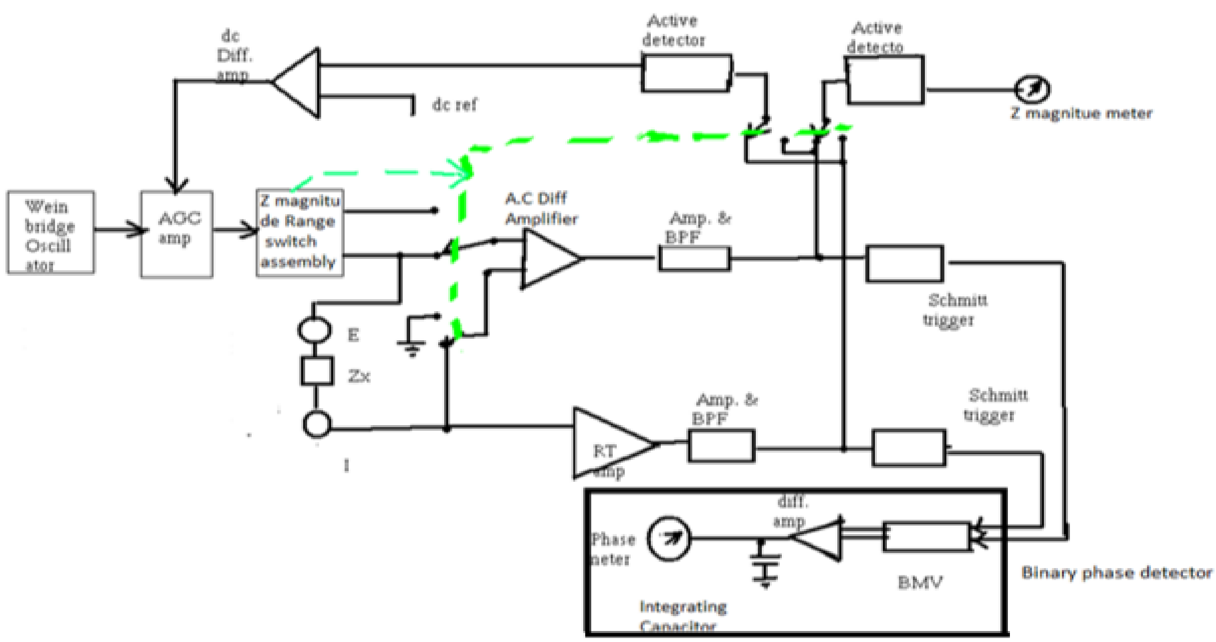


Figure 1.10Block diagram of vector impedance meter

The block diagram of vector impedance meter has been shown in Figure 1.10At low frequency there is no change, but to study about the component need to be analyze with wide frequency, covers 400 Khz to 110 Mhz.

Constant current mode- lower range

(X1, X10 and X100)

- Unknown component connected across the input of the differential amplifier. Current depends on range of impedance switch.

- Transresistance amplifier converts current through into voltage. (Op-

Amp) Constant voltage mode – (1k, X10K, 100K, 1M)

Schmitt trigger – positive spike -→ binary phase detector (Bistablemultivibrator, differential amp, integrating capacitor) – constant current channel sets the multivibrator, constant voltage channel resets the multivibrator.

The set and reset outputs are applied to the differential amp, which applies the difference voltage to an integrating capacitor. The capacitor voltage is directly proportional to the zero crossing intervals, which gives the phase difference between voltage and current waveforms.

1.9 Vector voltmeter

The advantages of vector voltmeter can be listed as follows.

- Amp gain and phase shift
- Complex insertion loss
- Filter transfer function.
- Two-port network parameters

The vector voltmeter block diagram is displayed in Figure 1.11. It consists of two RF to IF converters, automatic phase control section, phase meter circuit and the voltmeter circuits.

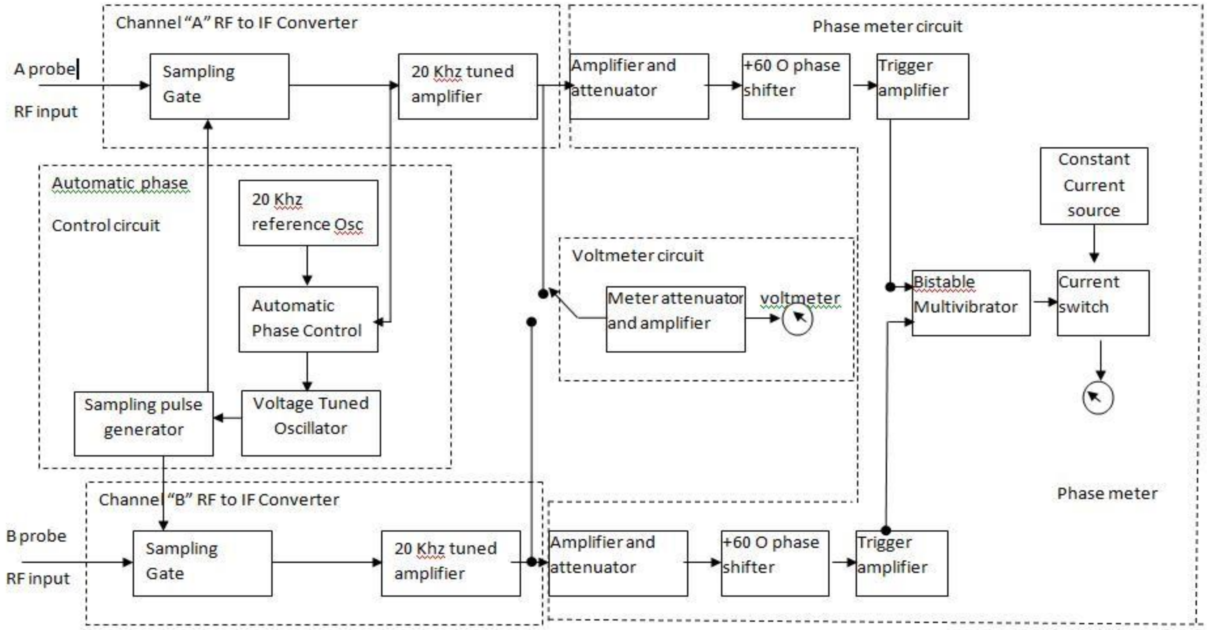


Figure 1.11Block diagram of vector voltmeter

Two RF signals of the same fundamental frequency to two IF signals with 20 KHz fundamental frequencies.These signals are having same amplitude and phase of Original RF waveform. Fundamental components are filtered from the IF signals, measured by voltmeter, and a phase meter.

RF to IF converters, Automatic phase control section produce 20 Khz.

1.10 RF voltage and power measurements

Measuring RF Voltages with VOM

Simple diode detectors can be constructed to enable ordinary VOMs to measure RF voltages ranging from a few hundred millivolts to the breakdown voltage of the diodes. Figure 1.12 shows two types of simple detectors, a series detector and a shunt detector. The choice is somewhat arbitrary but the shunt circuit is convenient when using microwave diodes designed to be directly connected to ground.

Construction is not critical but the components to the left of the dotted line should have short leads. A termination resistor (such as 50 ohms) may be added across the input for measuring the loaded output voltage of amplifiers and signal sources.

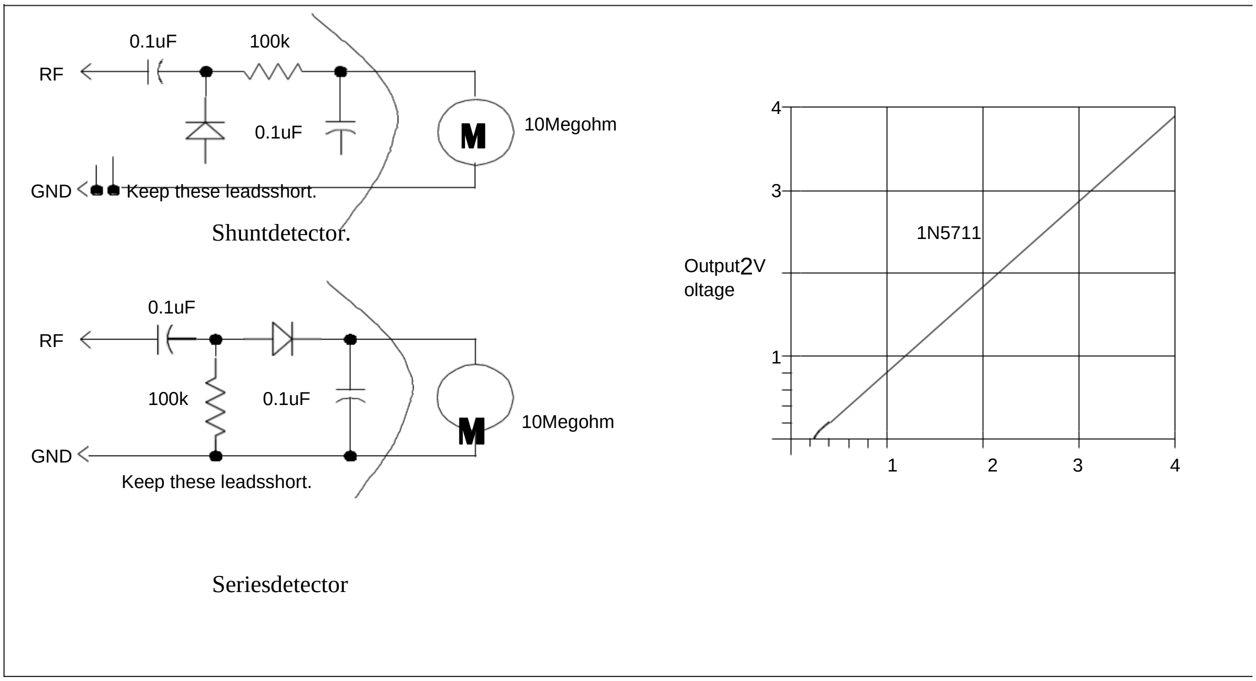


Figure 1.12 Simple Detectors

A small-signal Schottky diode such as the 1N5711 is probably the most readily available low barrier potential detector but germanium diodes such as the 1N60, 1N34, or even the 1N270 will also give excellent sensitivity. Ordinary silicon diodes such as the 1N914 may be used but the detector will exhibit an offset of about 300mV when measuring peak voltage. The 1N5711 offset is about 100mV and the germanium diodes' offset is about 60mV when measuring RF peak voltage. The voltage probe will read low by this offset when measuring large RF voltages and the probe will begin to exhibit significant error when measuring voltages below about twice this offset number. Figure 1.12 shows a simple technique to remove the offset so that the VOM will display the correct reading for voltages above a few hundred mill volts.

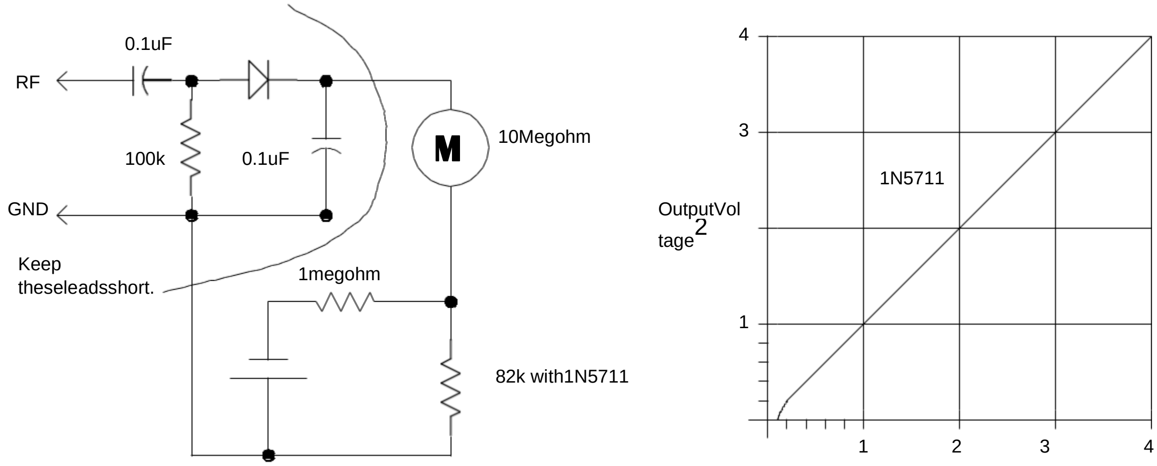


Fig2: Series detectr with offset correction. The 82k resistormaybe

Figure1.13 Series Detector with offset correction

Thebatteryandresistorsgenerateanegativevoltagenear100mVwhichisagoodvalue for the 1N5711.Other diode types may need a different offset correctionandthe82kvaluemaybevariedtogiveacorrectreadingwhenmeasuring aseveralvoltRFsignal.200kpotentiometermaybesubstitutedforthe82kresistorifanadju stableoffset is desired. If RMS readout is desired, add a 4.15 megohmresistorinserieswith the 10 megohm meter. (A 3.9 meg. in series with a 270k will workwell.)Figure1.13shows a differential versionsuitableformeasuringtheRFvoltageacrossacomponentinacircuit.Theprobesh ouldgivethesamereadingwhentheleadsare reversed.

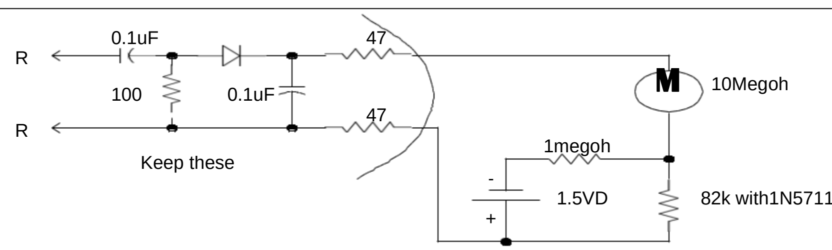


Figure 3: Differential-

Figure1.14Differential sensing

Measuring RF power

With everything today going wireless, RF power measurement is rapidly becoming a necessity. Many useful techniques for measuring RF signal levels accurately are in line to optimize the performance of these wireless systems.

RF signals can take many forms, from a single carrier continuous wave (CW) to that of a multi-carrier, QAM (Quadrature Amplitude Modulation) that contains high crest-factor wave shape. Measuring the power levels of these widely varying signals requires understanding their characteristics as well as the required measurement accuracy. If the signal is bursty, such as that in a TDD (Time Division Duplexing) system, it becomes more complicated as there are time domain measurement considerations. In any event, selecting the right detector type can help simplify the design task.

Measuring RF power using peak detection

Take the simplest case of a CW waveform measurement. Even if the amplitude can vary, as long as the signal is within a prescribed time interval during which the amplitude is relatively constant, accurate measurement can be made with a peak level detector, such as the LTC5532 from Linear Technology. This device is built with a very fast Schottky detector with on-chip temperature compensation and a 2 MHz bandwidth output buffer. The internal Schottky circuit peak-detects the incoming RF signal and performs a peak-hold filtering, producing a DC output voltage that is proportional to the RF input peak level.

LTC5532 is a very low power device that runs on 500 µA supply current in active mode. Yet its internal Schottky circuit is capable of detecting 7 GHz RF signals. A version of the part, the LTC5532EDC in a 6-lead, 2 mm x 2 mm plastic DFN package, offers low parasitic and can support operation to 12 GHz and higher.

Figure 1.15 shows this 12 GHz detector's RF input matched to 11.5 GHz – 12 GHz. So its input circuit can be connected to the coupled output of a directional coupler or an RF source. The detector output amplifier gain is externally set by the R2 and R3 resistors at 10k each closing the loop around the internal amplifier with a non-inverting gain of two. At 12 GHz frequency, the circuit board material can introduce circuit parasiticthat can affect the input impedance matching. However, acceptable performance can be achieved using standard FR-4 PC board material. The RF input matching consists of two 1.2 pF capacitors, C1 and C3. The C3 capacitor also serves the purpose of DC blocking because the device's RF input is internally DC biased. RF input matching may need to be re-optimized for each specific application layout or other operating frequencies. At 12 GHz the RF input Return Loss measured 10 dB. Figure 1.17n the next page shows a plot that depicts the detector's transfer characteristic when a 12 GHz RF input signal is swept from -24 dBm to 8 dBm, its useful detection range.

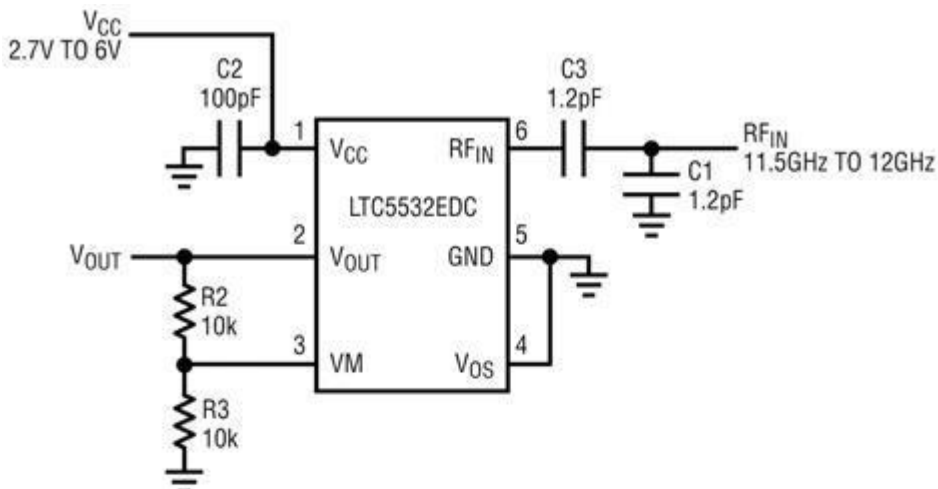


Figure 1.15 12 GHz-RF peak detector circuit.

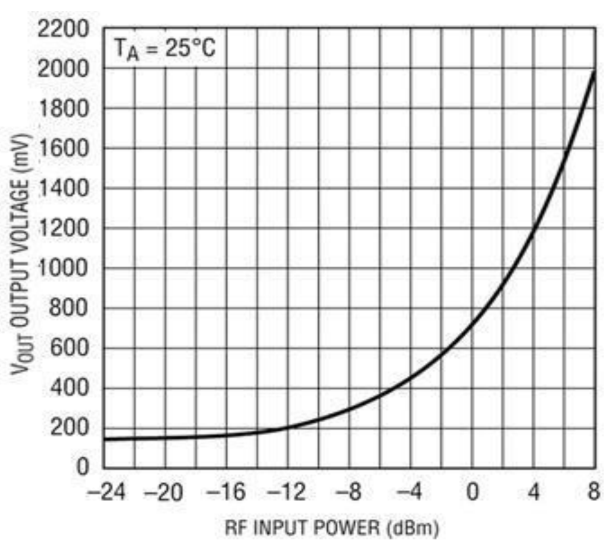


Figure 1.16 12 GHz detector characteristics.

Review Questions:

Part A

1. What do you mean by D'Arsonval movement?
2. What are the types of DC voltmeter?
3. What is called PMMC?
4. List the AC voltmeter types.
5. List a few factors for the selection of electronic voltmeters?
6. What is VOM?
7. How the polarities of diodes are found using multimeter?
8. What is Q meter?
9. State the condition for resonance.
10. What are the measurements possible with Q meter?
11. What do you mean by true RMS voltmeter?
12. What are the advantages of vector voltmeter?
13. What is the range of frequency vector impedance meter can operate?
14. What is TVM?
15. What is the frequency range of RF wave?
16. How the RF power measurement can be done?
17. What is QAM?

Part B

18. Explain in detail about the constructional features and working principle of direct coupled amplifier DC voltmeter using FET with a relevant diagram.
19. Describe about the average reading AC voltmeters using semiconductor diode. Draw suitable diagram and explain the same.
20. Write brief notes on Q meter.
21. Draw and explain the working of vector impedance meter different modes.
22. Describe vector voltmeter with its block diagram.
23. Explain briefly about RF voltage and power measurements.

Unit II

SIGNAL GENERATORS AND ANALYSERS

2.1 Signal Generators

Signal generators can be used to test frequency responses of loudspeakers. They are also a useful way of testing a Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters without the need of an external signal source.

2.2 Function Generator

A function generator is a signal source that has the capability of producing different types of waveforms as its output signal. The most common output waveforms are sine-waves, triangular waves, square waves, and sawtooth waves. The frequencies of such waveforms may be adjusted from a fraction of a hertz to several hundred kHz.

Actually the function generators are very versatile instruments as they are capable of producing a wide variety of waveforms and frequencies. In fact, each of the waveform they generate are particularly suitable for a different group of applications. The uses of sinusoidal outputs and square-wave outputs have already been described in the earlier Arts. The triangular-wave and sawtooth wave outputs of function generators are commonly used for those applications which need a signal that increases (or reduces) at a specific linear rate. They are also used in driving sweep oscillators in oscilloscopes and the X-axis of X-Y recorders.

Many function generators are also capable of generating two different waveforms simultaneously (from different output terminals, of course). This can be a useful feature when two generated signals are required for particular application. For instance, by providing a square wave for linearity measurements in an audio-system, a simultaneous saw tooth output may be used to drive the horizontal deflection amplifier of an oscilloscope, providing a visual display of the measurement result. For another example, a triangular-wave and a sine-wave of equal frequencies can be produced simultaneously. If the zero crossings of both the waves are made to occur at the same time, a linearly varying waveform is available which can be started at the point of zero phase of a sine-wave.

Another important feature of some function generators is their capability of phase-locking to an external signal source. One function generator may be used to phase lock a second function generator, and the two output signals can be displaced in phase by an adjustable amount. In addition, one function generator may be phase locked to a harmonic of the sine-wave of another function generator. By adjustment of the phase and the amplitude of theharmonics, almost any waveform may be produced by the summation of the fundamental frequency generated by one function generator and the harmonic generated by the other function generator. The function generator can also be phase locked to an accurate frequency standard, and all its output waveforms will have the same frequency, stability, and accuracy as the standard.

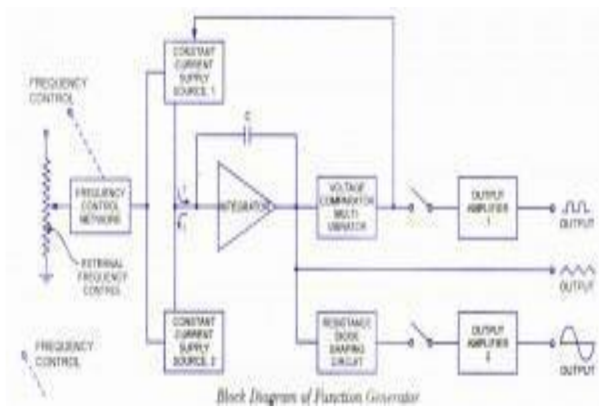


Figure 2.1 Block diagram of function generator

The block diagram of a function generator is given in Figure 2.1. In this instrument the frequency is controlled by varying the magnitude of current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.

The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a predetermined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.

2.3 RF signal Generators

A typical radio frequency signal generator contains, in addition to thenecessary power supply, three main sections; an oscillator circuit, a modulator,and an output control circuit.The internal modulator modulates the radiofrequency signal of the oscillator. In addition, most RF generators are providedwith connections through which an external source of modulation of any desiredwaveform may be applied to the generated signal.

Metal shielding surrounds theunit to prevent the entrance of signals from the oscillator into the circuit undertest by means other than through the output circuit of the generator.

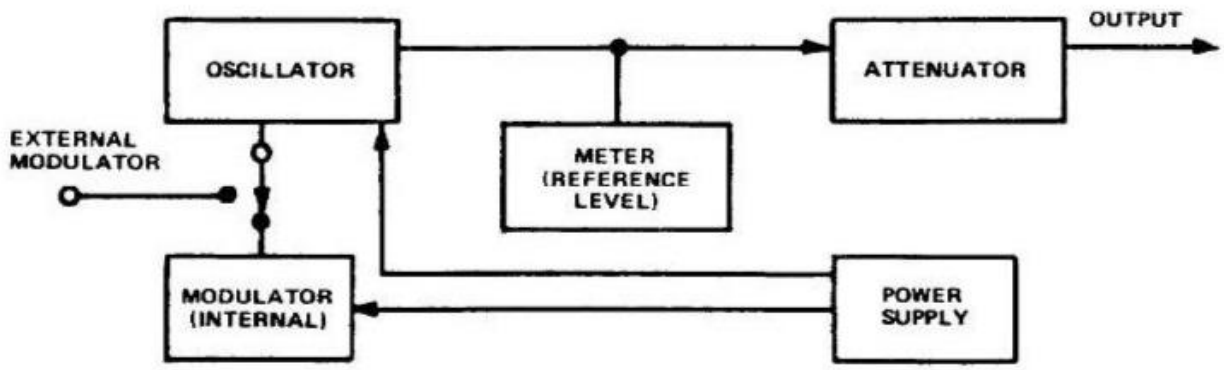


Figure 2.2 Block diagram of RF signal generator

A block diagram of a representative RF signal generator is shown in Figure 2.2.The function of the oscillator stage is to produce a signal which can be accurately set in frequency at any point in the range of the generator. The typeof oscillator circuit used depends on the range of the frequencies for which the generator is designed. In low frequency signal generators, the resonating circuit consists of a group of coils combined with a variable capacitor. One of the coils has a selector switch attached to the capacitor to provide an LC circuit that has the correct range of resonant frequencies.

The function of the modulating circuit is to produce audio (orvideo) voltage which can be superimposed on the RF signal produced by the oscillator.The modulating signal may be provided by an audio oscillator withinthe generator, or it may be derived from an external source.In some signalgenerators, either of these methods of modulation may be used.In addition, a means of disabling the modulator section is used whereby the pure un-modulatedsignal from the oscillator can be used when it is desired.

The type of modulation used depends on the application of the particularsignal generator. The modulating voltage may be either a sine wave, a square wave,or pulse of varying duration.

In some specialized generators, provision is madefor pulse modulation in which the RF signal can be pulsed over a wide range ofrepetition rates and at various pulse widths.

2.4 Sweep-Frequency Generator

The working of a sweep-frequency generator is explained in the article below. The working and block diagram of an electronically tuned sweep frequency generator and its different parameters are also explained.

A sweep frequency generator is a type of signal generator that is used to generate a sinusoidal output. Such an output will have its frequency automatically varied or swept between two selected frequencies. One complete cycle of the frequency variation is called a sweep. Depending on the design of a particular instrument, either linear or logarithmic variations can be introduced to the frequency rate. However, over the entire frequency range of the sweep, the amplitude of the signal output is designed to remain constant.

Sweep-frequency generators are primarily used for measuring the responses of amplifiers, filters, and electrical components over various frequency bands. The frequency range of a sweep-frequency generator usually extends over three bands, 0.001 Hz – 100 kHz (low frequency to audio), 100 kHz – 1,500 MHz (RF range), and 1-200 GHz (microwave range). It is really a hectic task to know the performance of measurement of bandwidth over a wide frequency range with a manually tuned oscillator. By using a sweep-frequency generator, a sinusoidal signal that is automatically swept between two chosen frequencies can be applied to the circuit under test and its response against frequency can be displayed on an oscilloscope or X-Y recorder.

Thus the measurement time and effort is considerably reduced. Sweep generators may also be employed for checking and repairing of amplifiers used in TV and radar receivers.

The block diagram of an **electronically tuned sweep frequency generator** is shown in the figure below

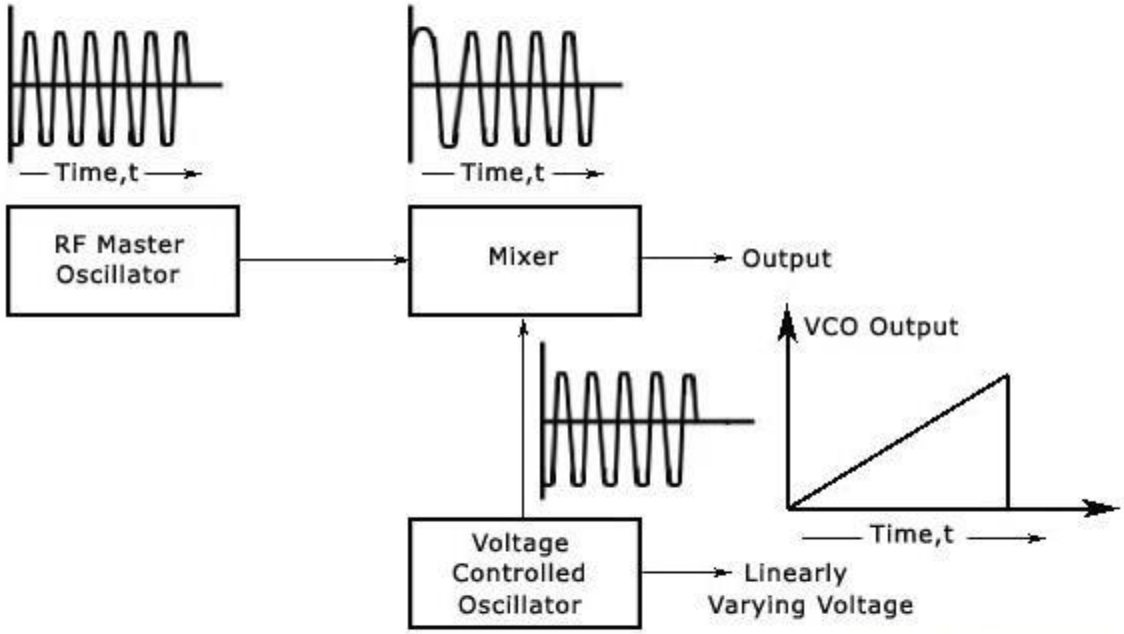


Figure 2.3 Electronically Tuned sweep generator

The most important component of a sweep-frequency generator is the master oscillator. It is mostly an RF type and has many operating ranges which are selected by a range switch. Either mechanical or electronic variations can be brought to the frequency of the output signal of the signal generator.

In the case of mechanically varied models, a motor driven capacitor is used to tune the of the output signal of the master oscillator.

In the case of electronically tuned models, two frequencies are used. One will be a constant frequency that is produced by the master oscillator. The other will be a varying frequency signal, which is produced by another oscillator, called the voltage controlled oscillator (VCO). The VCO contains an element whose capacitance depends upon the voltage applied across it. This element is used to vary the frequency of the sinusoidal output of the VCO. A special electronic device called a mixer is then used to combine the output of VCO and the output of the master oscillator. When both the signals are combined, the resulting output will be sinusoidal, and its frequency will depend on the difference of frequencies of the output signals of the master oscillator and VCO. For example, if the master oscillator frequency is fixed at 10.00 MHz and the variable frequency is varied between 10.01 MHz to 35 MHz, the mixer will give sinusoidal output whose frequency is swept from 10 KHz to 25 MHz.

Adjustments can be brought to the sweep rates in a sweep frequency generator and it normally can be varied from 100 to 0.01 seconds per sweep. The X-axis of an oscilloscope or X-Y recorder can be easily driven synchronously with a voltage that varies linearly or logarithmically. In the electronically tuned sweep generators, the same voltage which drives the VCO serves as this voltage.

When the frequency varies linearly or logarithmically, the values of the end frequencies can be used to find the frequency of various points along the frequency-response curve. Markers can be employed for more accuracy.

2.5 Frequency synthesizer

A frequency synthesizer is an instrument by which many discrete frequencies are generated from one or more fixed reference frequencies. The reference frequencies are stable and spectrally pure frequency typically generated from a piezoelectric crystal. Modern frequency synthesizers must provide much discrete output frequency so that it is impractical to generate the frequencies by having a reference frequency for each desired output frequency. The control input determines the value of the frequency synthesizer output frequency,

Frequency Multiplication or Frequency Synthesis

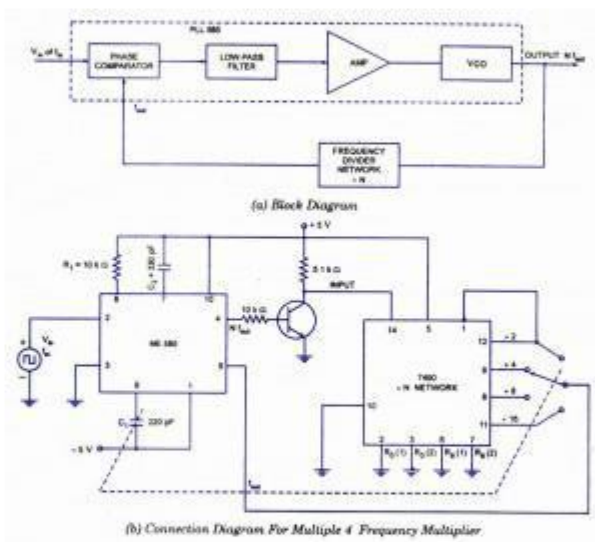


Figure 2.4 Frequency Multiplier

The block diagram of a frequency muliplier (or synthesizer) is shown in figure. In this circuit, a frequency divider is inserted between the output of the VCO and the phase comparator (PC) so that the loop signal to the PC is at frequency fOUT while the output of VCO is N fOUT. This output is a multiple of the input frequency as long as the loop is in lock. The desired amount of multiplication can be obtained by selecting a proper divide- by N network where N is an integer. Figure shows this function performed by a 7490 configured as a divide-by-4 circuit.

In this case the input Vin at frequency /in is compared with the output frequency f_{OUT} at pin 5. An output at N f_{OUT} (4 fOUT in this case) is connected through an inverter circuit to give an input at pin 14 of the 7490, which varies between 0 and + 5 V. Using the output at pin 9, which is one-fourth of that at the input to the 7490, the signal at pin 4 of the PLL is four times the input frequency as long as the loop remains in lock.

Since the VCO can be adjusted over a limited range from its centre frequency, it may become necessary to change the VCO frequency whenever the divider value is changed.

For verification of the circuit operation, one must determine the input frequency range and then adjust the free running fOUT of the VCO by means of R1 and C1 so that the output frequency of the 7490 divider is midway within the predetermined input frequency range. The output of VCO should now be equal to 4 f_{in}.

2.6 Harmonic distortion analyzer

Harmonic distortion in power amplifiers

Distortion is a serious problem faced in power amplifier design. In faithful amplification the output signal must be a scaled replica of the input signal and if there is any dissimilarity between the input and output waveform, then the output is said to be distorted. Unpleasant sound output coming from an audio system, which is no more the faithful reproduction of the original audio is mainly due to distortion. Other reasons for bad sound output are noise, clipping etc. The figure given below shows faithful amplification and distorted amplification.

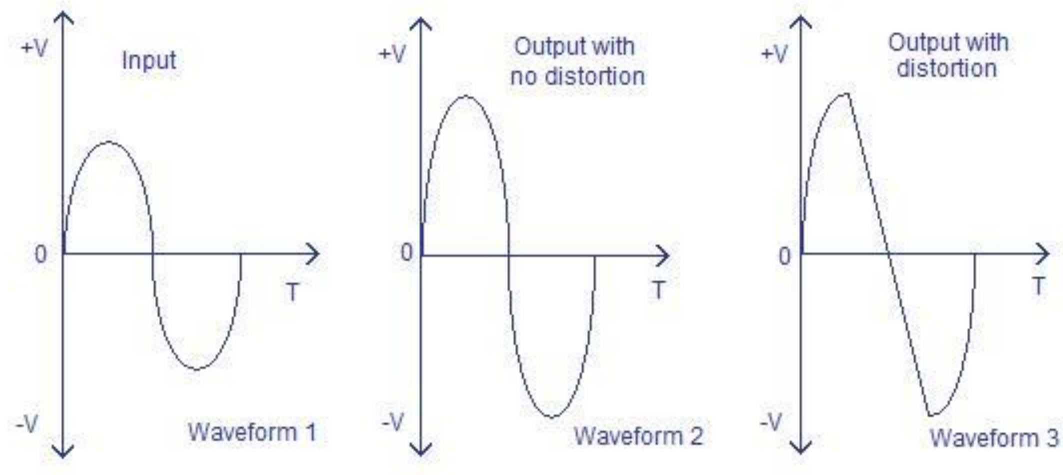


Figure 2.5 Distortioninpower amplifier

In the above figure, it is observed that every point in the input waveform (waveform1) is exactly reproduced in the non distorted output (waveform2) and the falling edges of the input waveform are unfaithfully reproduced in the distorted output (waveform 3).

Harmonic distortion can be explained as any distortion or corruption in the output waveform due to the generation of harmonics. The integer multiples of a fundamental frequency are called harmonics. In audio amplifier domain, the frequency of the input signal is taken as the fundamental frequency. For example, if “x” is the fundamental frequency then 1x,2x, 3x, 4x………nx are the harmonics.

Harmonic distortion in power amplifiers are mainly caused by the non linearities of the active elements (transistors). The active element used for amplification whether BJT, FET, MOSFET or anything like that may not equally amplify every point in the input waveform and this is the reason behind the non-linearity. In different amplifier configurations Class A has the highest linearity, then class AB, then Class B and finally Class C has the worst linearity.

How well designed the audio amplifier may be, its output might contain some distortion mainly in the form of even harmonics. Out of the even harmonics 2nd order harmonics will be generally the prominent one. Second order harmonic distortion is the amount of 2nd order harmonic content present in the output signal with respect to the fundamental frequency.

Total Harmonic Distortion or THD

Total harmonic distortion or THD is a very important parameter in the audio amplifier domain. THD is a measure of the amount of harmonic components present in a signal. It can be defined as the ratio of the sum of the powers of all the harmonic components to the power of the fundamental frequency. In audio amplifier applications the signals must be commonly of sine wave type and in this case the THD is defined as the ratio of the RMS amplitude of the higher order harmonic frequencies to the RMS amplitude of the fundamental frequency. THD is usually expressed in percentage .

If V1 is the amplitude of the fundamental frequency and V2, V3, V4……..Vn are the amplitudes of the higher order harmonic frequencies, then THD can be expressed as

$$THD = \sqrt{(V2^2+V3^2+V4^2\ldots\ldots\ldots+Vn^2)} / \sqrt{(V1^2)}$$

ie; $$\mathbf{THD = \{\sqrt{(V2^2+V3^2+V4^2\ldots\ldots\ldots+Vn^2)}\} / V1}$$

THD+N ratio.

THD+N is another scale used for expressing the sound quality of an audio power amplifier. It means total harmonic distortion plus noise. THD+N is very commonly used now a days and it covers almost every type of corruption present in the signal. THD+N can be defined as the ratio of the summation of all higher order harmonics plus summation of all noise components to the fundamental frequency. Since noise is also accounted in this scale it is better than the THD scale. The reason for the noise present in the amplifier output includes the power supply interference, RF interference, switching noises, thermal noise of the active elements etc.

THD+N is usually measured using a distortion analyzer. This is done by separating the fundamental frequency using a notch filter and then measuring what is left over. The left over usually consists of the harmonics plus all noise components. THD+N is also represented in percentage and the lower it is, better the sound quality of the amplifier.

Signal to noise ratio S/N or SNR

Signal to noise ratio or SNR or S/N is another important audio amplifier parameter. The SNR also has nothing to do with the harmonic distortion, but it deserves a short discussion here. Signal to noise ratio can be defined as the ratio of the useful signal power to the unwanted (noise) signal power. The SNR actually gives an estimate of the false-information present in a signal. A signal to noise ratio (SNR) more than one means the useful signal component will be larger than the noise components. SNR is usually expressed in decibel (dB).

Signal to noise ratio (SNR) is measured in two steps. Firstly the output signal level of the amplifier with input (usually sine wave) is measured. Then the input signal is removed and the output level is measured. No input signal doesn't mean that the input terminals of the amplifier are left open. The common approach is to connect it to a signal generator and voltage output of the signal generator is reduced to zero.That way the input of the amplifier gets connected to a low-impedance source with zero amplitude. Then both values are divided to get the SNR.

2.7 Spectrum Analyzers

The problems associated with non-real-time analysis in the frequency domain can be eliminated by using a spectrum analyzer. A spectrum analyzer is a real-time analyzer, which means that it simultaneously displays the amplitude of all the signals in the frequency range of the analyzer.

Spectrum analyzers, like wave analyzers, provide information about the voltage or energy of a signal as a function of frequency. Unlike wave analyzers.spectrum analyzers provide a graphical display on a CRT. A block diagram of an audio spectrum analyzer is shown in Fig.7.

The real-time or multi-channelanalyzer is basically a set of stagger-tuned bandpass filters connected through an electronic scan switch to a CRT. The composite amplitude of the signal within each filters bandwidth is displayed as a function of the overall frequency range of the filter.

Therefore, the frequency range of the instrument is limited by the number of filters and their bandwidth. The electronic switch sequentially connects the filter outputs to the CRT.

Horizontal deflection is obtained from the scan generator, which has a saw tooth output that is synchronized with the electronic switch.

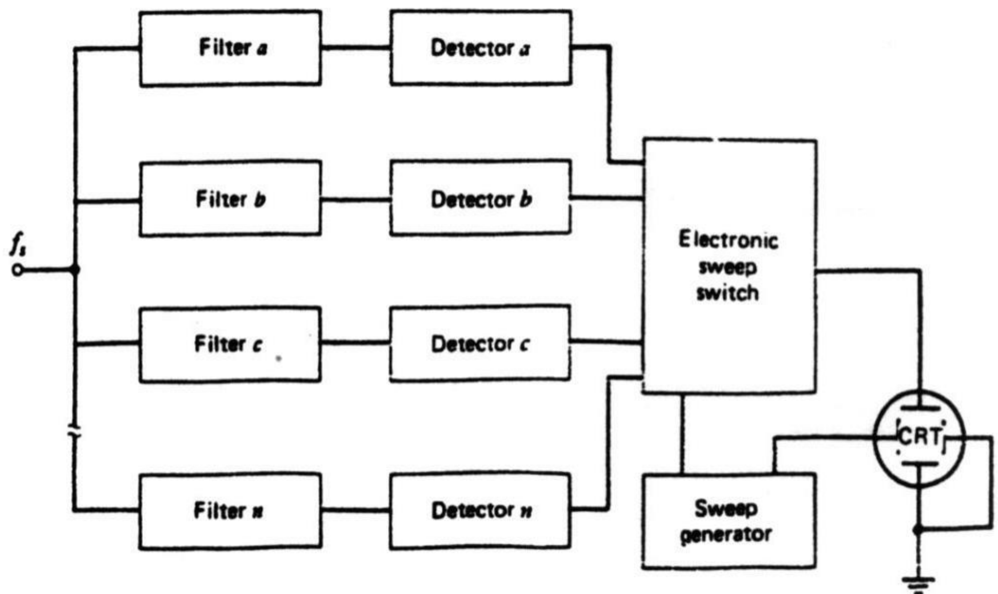


Figure 2.6 Block diagram of an audio spectrum analyzer

Such analyzers are usually restricted to audio-frequency applications and may employ as many as 32 filters. The bandwidth of each filter is generally made very narrow for good resolution.

The relationship between a time-domain presentation on the CRT of an oscilloscope and a frequency-domain presentation on the CRT of a spectrum analyzer is shown in the three-dimensional drawing in Fig 2.7.

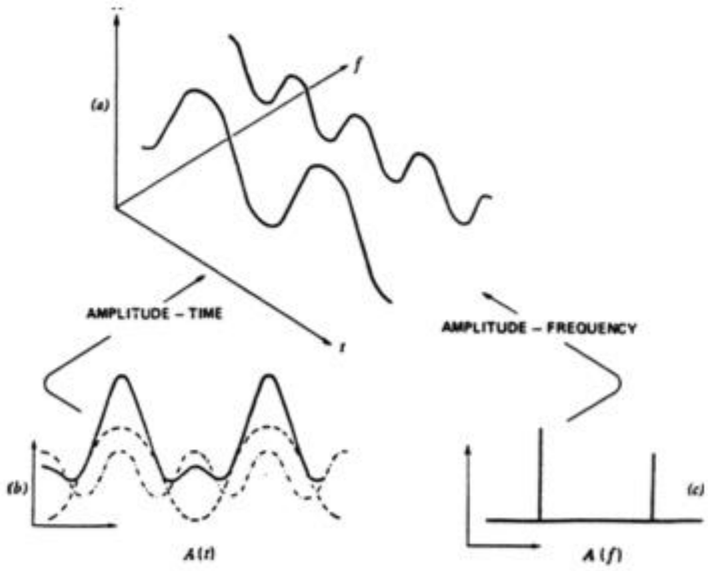


Figure 2.7 Three dimensional relationship between time, frequency and amplitude

After the waveform is applied to the amplifier, it got amplified further directly to the distortion analyzer which measures the total harmonic distortion.

In the field of microwave communications, in which pulsed oscillators are widely used. spectrum analyzers are an important tool. They also find wide application in analyzing the performance of AM and FM transmitters.

Spectrum analyzers and Fourier analyzers are widely used in applications requiring very low frequencies in the fields of biomedical electronics, geological surveying. and oceanography. They are also used in analyzing air and water pollution.

2.8 Noise Generator

A Noise generator is a circuit that produces electrical noise (i.e., a random signal). Noise generators are used to test signals for measuring noise figure, frequency response, and other parameters. Noise generators are also used for generating random numbers.

Noise can generally be grouped into two classes:

independent noise.
noise which is dependent on the image data.

Image independent noise can often be described by an additive noise model, where the recorded image *f(i,j)* is the sum of the *true* image *s(i,j)* and the noise *n(i,j)*:

$$f(i,j) = s(i,j) + n(i,j)$$

The noise *n(i,j)* is often *zero-mean* and described by its variance σ_n^2. The impact of the noise on the image is often described by the *signal to noise ratio* (SNR), which is given by

$$SNR = \frac{\sigma_s}{\sigma_n} = \sqrt{\frac{\sigma_f^2}{\sigma_n^2} - 1}$$

where σ_s^2 and σ_f^2 are the variances of the true image and the recorded image, respectively.

In many cases, additive noise is evenly distributed over the frequency domain (*i.e. white noise*), whereas an image contains mostly low frequency information. Hence, the noise is dominant for high frequencies and its effects can be reduced using some kind of lowpass filter. This can be done either with a frequency filter or with a spatial filter. (Often a spatial filter is preferable, as it is computationally less expensive than a frequency filter.)

In the second case of *data-dependent noise* (*e.g.* arising when monochromatic radiation is scattered from a surface whose roughness is of the order of a wavelength, causing wave interference which results in image *speckle*), it is possible to model noise with a multiplicative, or non-linear, model. These models are mathematically more complicated; hence, if possible, the noise is assumed to be data independent.

Detector Noise

One kind of noise which occurs in all recorded images to a certain extent is *detector noise*. This kind of noise is due to the discrete nature of radiation, *i.e.* the fact that each imaging system is recording an image by counting photons. Allowing some assumptions (which are valid for many applications) this noise can be modeled with an independent, additive model, where the noise *n(i,j)* has a zero-mean Gaussian distribution described by its standard deviation (σ), or variance. (The 1-D Gaussian distribution has the form shown in Figure 1.) This means that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value.

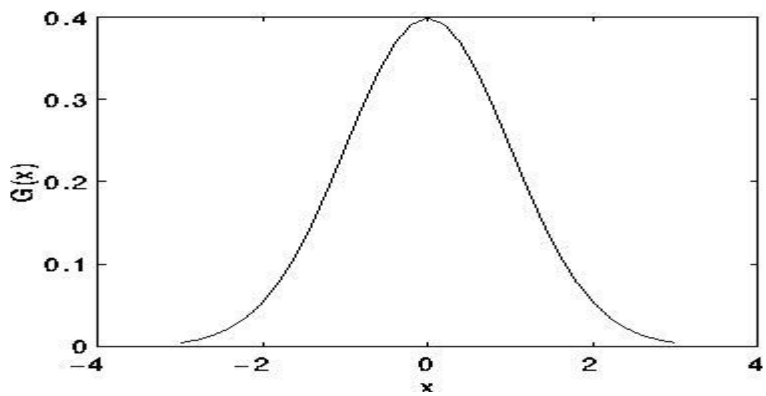


Figure 2.81-D Gaussian distribution with mean 0 and standard deviation 1

Salt and Pepper Noise

Another common form of noise is *data drop-out* noise (commonly referred to as *intensity spikes*, *speckle* or *salt and pepper noise*). Here, the noise is caused by errors in the data transmission. The corrupted pixels are either set to the maximum value (which looks like snow in the image) or have single bits flipped over. In some cases, single pixels are set alternatively to zero or to the maximum value, giving the image a `salt and pepper' like appearance. Unaffected pixels always remain unchanged. The noise is usually quantified by the percentage of pixels which are corrupted.

2.9 Pattern Generator

This is a multipurpose section which is primarily used to generate timing patterns used for synchronous detection gating, LED control, and for synchronizing the power supply. The heart of this system is the EPROM (Erasable Programmable ROM). Here preprogrammed bit patterns are stored and are cycled out through the counter, and are tapped off using certain address lines. Using the address the bit pattern is sent out and latched using an octal latch. There may be an additional latch used to deglitch the system, in which the last byte is held until the counter increments itself to the next address and the next pattern is obtained. Various patterns within the EPROM are used to select the sampling speeds of the LEDs or the synchronous detector pulse, the calibration patterns and diagnostic timing.

2.10 Wobbuloscope

A Wobbuloscope consists of a sweep generator, CRO and a marker generator, which can be tuned to frequencies corresponding to the vision carrier, associate of sound signal as well as the IF of the T.V. receiver

Review Questions:

Part A

1. What is called function generator?
2. What are all the types of signal generators?
3. List a few applications of frequency synthesizer?
4. What is called sweep generator?
5. What are the types of wave analyzer?
6. What are the applications of wave analyzer?
7. What do you meant by noise?
8. What is called THD?
9. Define THD+N ratio.
10. What is SNR?
11. What is Wobbuloscope?

Part B

1. Sketch and explain the block diagram of function generator and highlight at least three main features of it.
2. Explain RF signal generator with its block diagram.
3. Draw and explain the basics of sweep generator with suitable diagrams.
4. Explain the heterodyne sweep generator with relevant block diagram.
5. Explain the kind of circuit associated with a pattern generator.
6. Explain how noise is generated and how to rectify those noises?

Unit III

3.1 Basic Oscilloscope (CRO):

- The cathode-ray oscilloscope (CRO) is a multipurpose display instrument used for the observation, measurement, and analysis of waveforms by plotting amplitude along *y-axis and time along x-axis.*

- *CRO is generally* an *x-y plotter; on a single screen it can display different signals applied to different channels. It can measure* amplitude, frequencies and phase shift of various signals. Many physical quantities like temperature, pressureand strain can be converted into electrical signals by the use of transducers, and the signals can be displayed on the CRO.

- A moving luminous spot over the screen displays the signal. CROs are used to study waveforms, and other time-varying phenomena from very low to very high frequencies.

- The central unit of the oscilloscope is the cathode-ray tube (CRT), and the remaining part of the CRO consists of the circuitry required to operate the cathode-ray tube.

3.2 Block diagram of a cathode-ray oscilloscope:

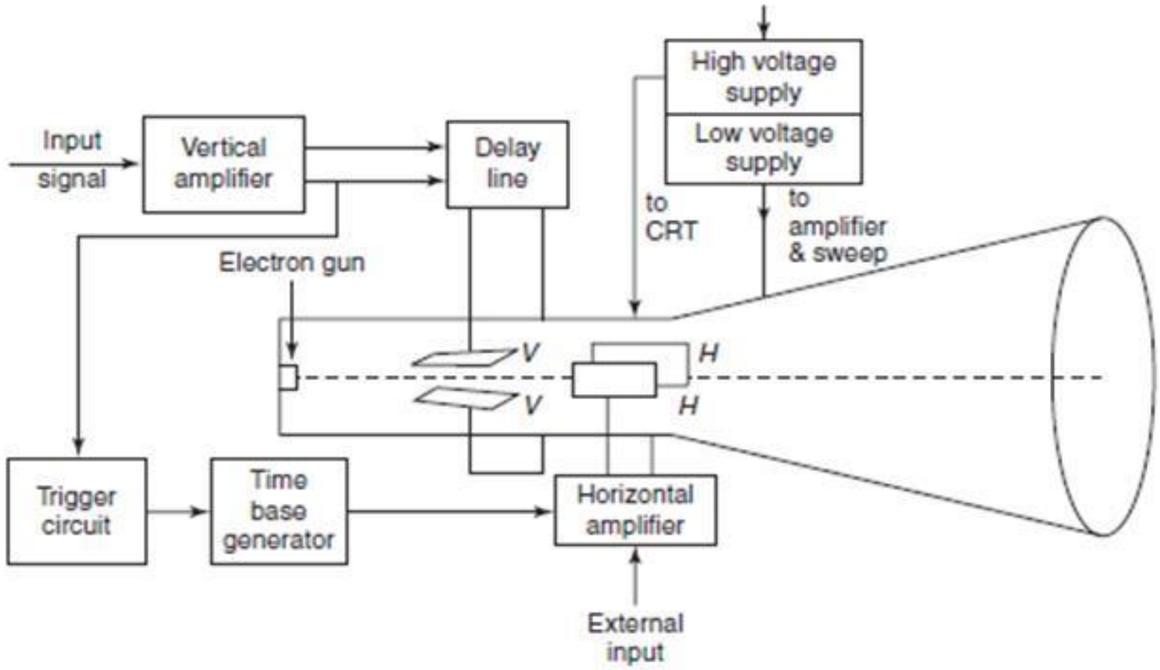


Figure 3.1 Block diagram of a cathode ray oscilloscope

Components of the cathode-ray oscilloscope:

(i) CRT

(ii) Vertical amplifier

(iii) Delay line

(iv) Horizontal amplifier

(v) Time-base generator

(vi) Triggering circuit

(vii) Power supply

Cathode-ray tube:

- The electron gun or electron emitter, the deflecting system and the fluorescent screen are the three major components of a general purpose CRT. A detailed diagram of the cathode-ray oscilloscope is given in Fig. 3.2.

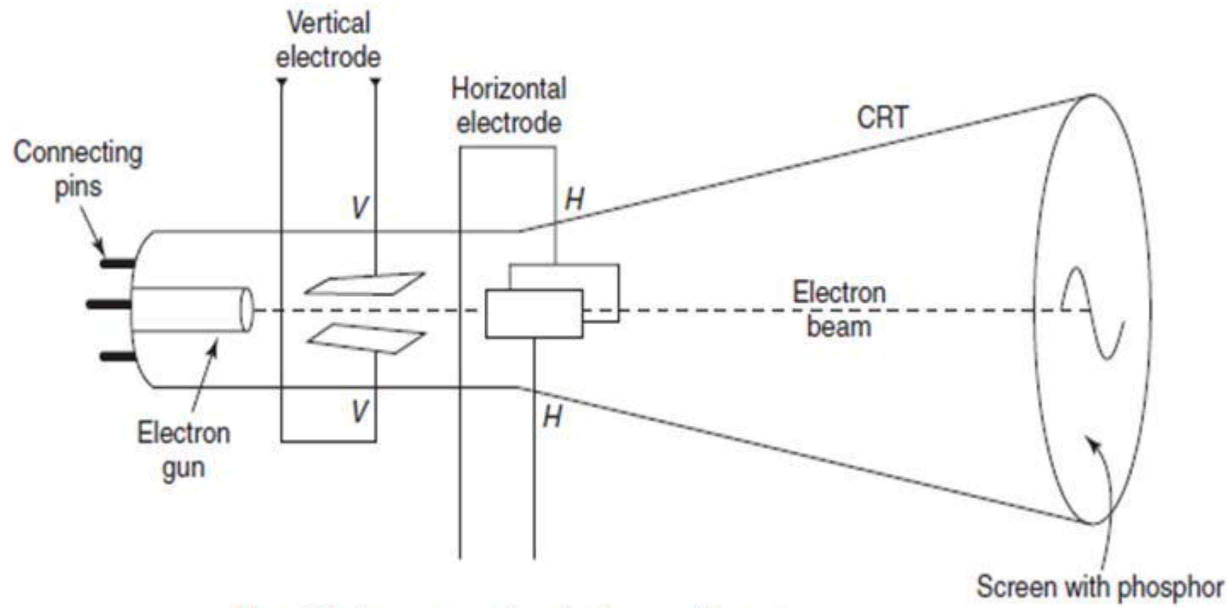


Figure 3.2 Components of a cathode ray oscilloscope

Electron gun:

- In the electron gun of the CRT, electrons are emitted, converted into a sharp beam and focused upon the fluorescent screen.
- The electron beam consists of an indirectly heated cathode, a control grid, an accelerating electrode and a focusing anode.
- The electrodes are connected to the base pins. The cathode emitting the electrons is surrounded by a control grid with a fine hole at its centre.
- The accelerated electron beam passes through the fine hole.
- The negative voltage at the control grid controls the flow of electrons in the electron beam, and consequently, the brightness of the spot on the CRO screen is controlled.
- Electrostatic deflection of an electron beam is used in a general purpose oscilloscope. The deflecting system consists of a pair of horizontal and vertical deflecting plates.

- Let us consider two parallel vertical deflecting plates P1 and P2. The beam is focused at point O on the screen in the absence of a deflecting plate voltage.

- If a positive voltage is applied to plate P1 with respect to plate P2, the negatively charged electrons are attracted towards the positive plate P1, and these electrons will come to focus at point Y1 on the fluorescent screen.

- The deflection is proportional to the deflecting voltage between the plates. If the polarity of the deflecting voltage is reversed, the spot appears at the point Y2, as shown in Fig. 3.3(a).

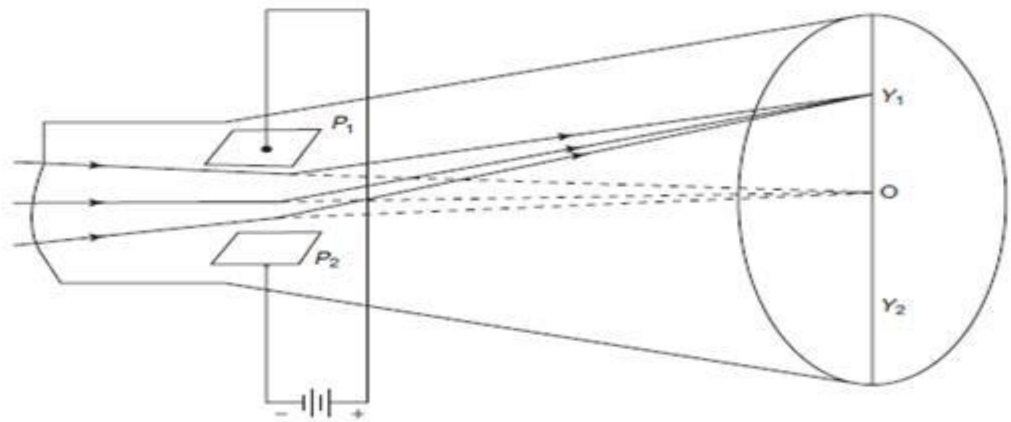


Figure 3.3a.Defection system using vertical plates

To deflect the beam horizontally, an alternating voltage is applied to the horizontal deflecting plates and the spot on the screen horizontally, as shown in Fig. 3.3(b).

- The electrons will focus at point X2. By changing the polarity of voltage, the beam will focus at point X1. Thus, the horizontal movement is controlled along X1OX2 line.

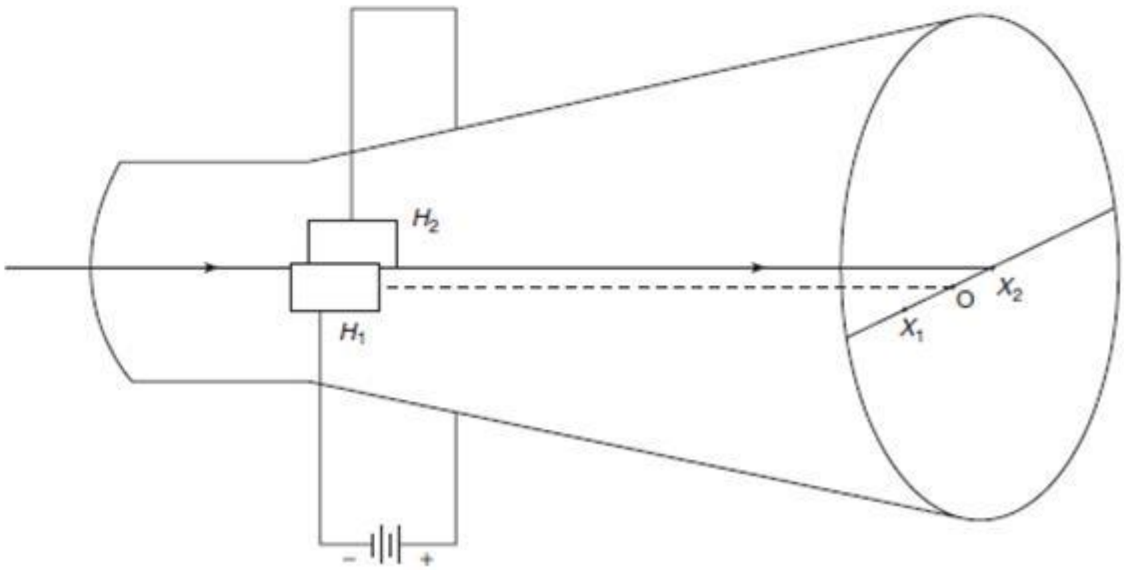


Figure 3.3 bDeflecting system using parallel horizontal plate

3.3 CRO Controls and Probes:

The controls available in most of the oscilloscopes provide a wide range of operating conditions and thus make the instrument especially versatile. Since many of these controls are common to most of the oscilloscopes a brief description of them is necessary.

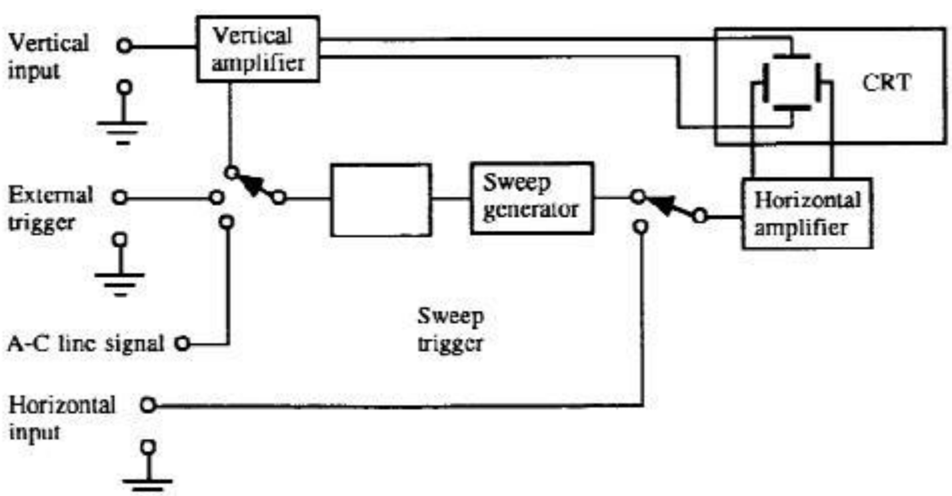


Figure 3.4 Typical blocks in CRT

Power and scale illumination: Turns the instrument on and controls illumination of the granules.

Focus: Focus the spot or trace on the screen.

Intensity: Regulates the brightness of the spot or trace.

Vertical Amplifier Section

Position: Controls vertical positioning of oscilloscope display.

Sensitivity: Selects the sensitivity of the vertical amplifier in calibrated steps.

Variable Sensitivity: Provides a continuous range of sensitivities between the calibrated steps. Normally the sensitivity is calibrated only when the variable knob is in the fully clockwise position.

AC-DC-GND: Selects desired coupling (ac or dc) for incoming signal applied to vertical amplifier, or grounds the amplifier input. Selecting dc couples the input directly to the amplifier; selecting ac sends the signal through a capacitor before going to the amplifier thus blocking any constant component.

HorizontalSweep Section

Sweep time/cm: Selects desired sweep rate from calibrated steps or admits external signal to horizontal amplifier.

Sweep time/cm Variable: Provides continuously variable sweep rates. Calibrated position is fully clockwise.

Position: Controls horizontal position of trace on screen.

Horizontal Variable: Controls the attenuation (reduction) of signal applied to horizontal amplifier through External Horizontal connector.

Trigger: The trigger selects the timing of the beginning of the horizontal sweep.

Slope: Selects whether triggering occurs on an increasing (+) or decreasing (-) portion of trigger signal.

Coupling: Selects whether triggering occurs at a specific dc or ac level.

Source: Selects the source of the triggering signal. INT - (internal) - from signal on vertical amplifier EXT - (external) - from an external signal inserted at the EXT. TRIG. INPUT

Trigger Level: Selects the voltage point on the triggering signal at which sweep is triggered. It also allows automatic (auto) triggering and allows sweep to run free (free run).

Connections for the Oscilloscope:

Vertical Input: A pair of jacks for connecting the signal under study is connected to the Y (or vertical) amplifier. The lower jack is grounded to the case.

Horizontal Input: A pair of jacks for connecting an external signal to the horizontal amplifier. The lower terminal is grounded to the case of the oscilloscope.

External Trigger Input: Input connector for external trigger signal.

Cal. Out: Provides amplitude calibrated square waves of 25 and 500 millivolts for calibrating the gain of the amplifiers. Accuracy of the vertical deflection is + 3%. Sensitivity is variable. Horizontal sweep should be accurate within 3%. Range of sweep is variable.

Operating Instructions:

Before plugging the oscilloscope into a wall receptacle, set the controls as follows: (a) Power switch at off (b) Intensity fully counter clockwise (c) Vertical centering in the center of range 62 (d) Horizontal centering in the center of range (e) Vertical at 0.2 (f) Sweep times 1 Plug line cord into a standard ac wall receptacle (nominally 118 V). Turn power on. Do not advance the Intensity Control.

Allow the scope to warm up for approximately two minutes, then turn the Intensity Control until the beam is visible on the screen.

Procedure:

1. Set the signal generator to a frequency of 1000 cycles per second. Connect the output from the generator to the vertical input of the oscilloscope. Establish a steady trace of this input signal on the scope.
2. Adjust (play with)all of the scope and signal generator controls until you become familiar with the functionof each. The purpose of such "playing" is to allow the student to become so familiar with the oscilloscope that it becomes an aid (tool) in making measurements in other experiments and not as a formidable obstacle.

Note: If the vertical gain is set too low, it may not be possible to obtain a Steady trace.

3. Measurements of voltage: Consider the circuit in Fig. 3.5. The signal generator is used to produce a 1000 hertz sine wave. The AC voltmeter and the leads to the vertical input of the oscilloscope are connected across the generator's output. By adjusting the Horizontal Sweep time/cm and trigger, a steady trace of the sine wave may be displayed on the screen.

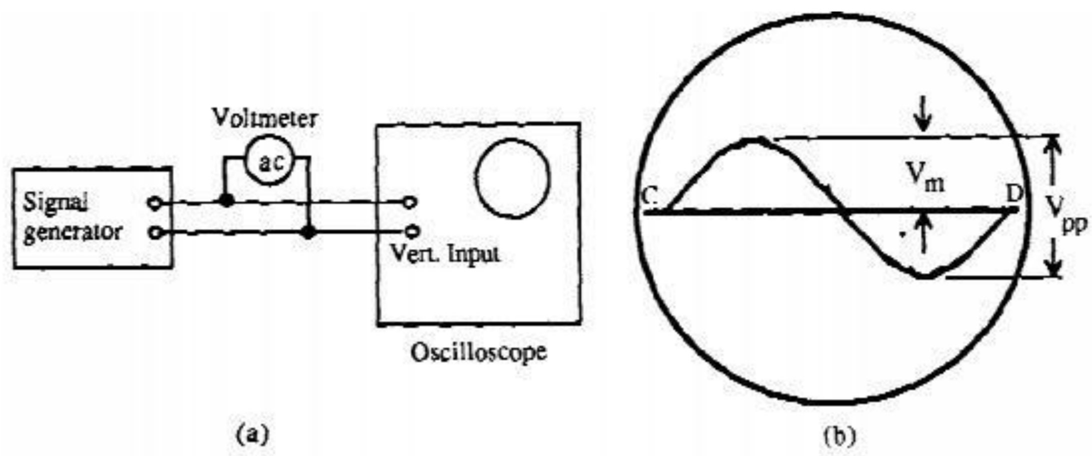


Figure 3.5 (a)Test circuit (b)Trace on CRO screen

The trace represents a plot of voltage vs. time, where the vertical deflection of the trace about the line of symmetry CD is proportional to the magnitude of the voltage at any instant of time. To determine the size of the voltage signal appearing at the output of terminals of the signal generator, an AC (Alternating Current) voltmeter is connected in parallel across these terminals (Fig. 3.5 a). The AC voltmeter is designed to read the dc "effective value" of the voltage. This effective value is also known as the "Root Mean Square value" (RMS) value of the voltage.The peak or maximum voltage seen on the scope face (Fig. 3.5 b) is Vm volts and is represented by the distance from the symmetry line CD to the maximum deflection.

The relationship between the magnitude of the peak voltage displayed on the scope and the effective or RMS voltage (VRMS) read on the AC voltmeter is VRMS = 0.707 Vm (for a sine or cosine wave). Thus an agreement is expected between the voltage reading of the multimeter and that of the oscilloscope. For a symmetric wave (sine or cosine) the value of V_m may be taken as 1/2 the peak to peak signal Vpp.The variable sensitivity control a signal may be used to adjust the display to fill a convenient range of the scope face. In this position, the trace is no longer calibrated so that it cannot be just read the size of the signal by counting the number of divisions and multiplying by the scale factor.

Caution: The mathematical prescription given for RMS signals is valid only for sinusoidal signals. The meter will not indicate the correct voltage when used to measure non-sinusoidal signals.

4. Frequency Measurements:

When the horizontal sweep voltage is applied, voltage measurements can still be taken from the vertical deflection. Moreover, the signal is displayed as a function of time. If the time base (i.e. sweep) is calibrated, such measurements as pulse duration or signal period can be made. Frequencies can be determined as reciprocal of the periods.Set the oscillator to 1000 Hz. Display the signal on the CRO and measure the period of the oscillations. Use the horizontal distance between two points such as C to D in Fig. 3.5 b and set the horizontal gain so that only one complete wave form is displayed. Then reset the horizontal amplifier until 5 waves are seen. Keep the time base control in a calibrated position. Measure the distance (and 64 hence time) for 5 complete cycles and calculate the frequency from this measurement. Compare the result with the value determined above. Repeat the measurements for other frequencies of 150 Hz, 5 kHz, 50 kHz as set on the signal generator.

5. Lissajous Figures:

When sine-wave signals of different frequencies are input to the horizontal and vertical amplifiers a stationary pattern is formed on the CRT when the ratio of the two frequencies is an integral fraction such as 1/2, 2/3, 4/3, 1/5, etc. These stationary y patterns are known as Lissajous figures and can be used for comparison measurement of frequencies. Use two oscillators to generate some simple Lissajous figures like those shown in Fig. 3.6.

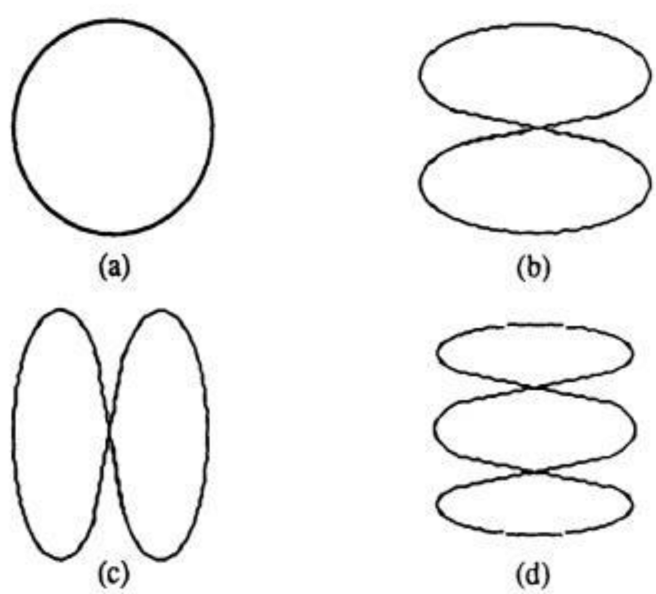


Figure 3.6 Lissajous patterns for horizontal to vertical frequency ratio of (a) 1:1(b)2:1(c)1:2(d)3:1

It is difficult to maintain Lissajous figures in a fixed configuration because the two oscillators are not phase and frequency locked. Their frequencies and phase drift slowly causing the two different signals to change slightly with respect to each other.

Testing is learnt: Examine the input to the circuit and output of the circuit using your oscilloscope. Measure such quantities as the voltage and frequency of the signals Specify if they are sinusoidal or of some other wave character.If square wave, measure the frequency of the wave. Also, for square waves, measure the on time (when the voltage is high) and off time (when it is low).

<u>Technical Information on CRO:</u>

Some technical parameters:

Bandwidth: 0 –20 MHz to 0 –few GHz

High input impedance

Sensitivity: From µVcm-1to few 100 Vcm-1

Basic Classification: Manual Programmable Automatic Averaging

CLASSIFICATION

Storage Oscilloscope

Sampling Oscilloscope

Digital Oscilloscope

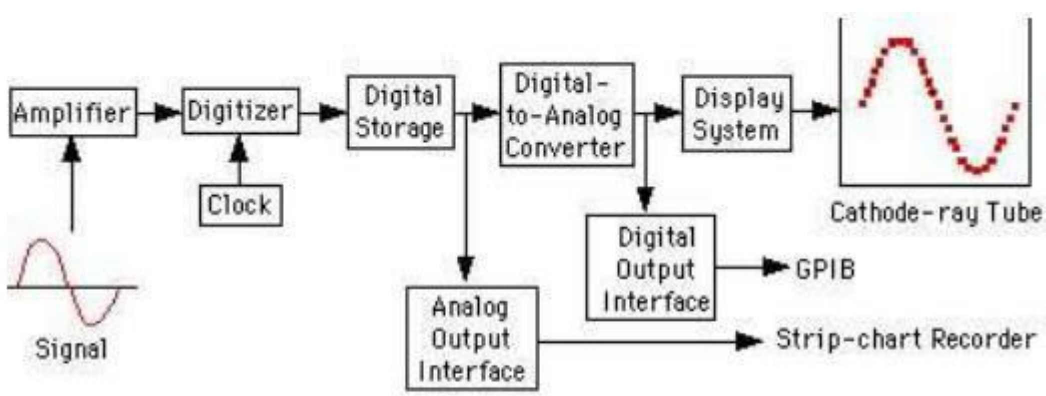


Figure 3.7 Block diagram of Digital Storage Oscilloscope

Storage Oscilloscope: Special CRT which can store a waveform Used to capture and examine non-repetitive signals Used to store signals with low frequencies (10Hz) Highest frequency that can be recorded: 0.1MHz

Sampling Oscilloscope: Used in the case of repetitive waveforms

Equivalent Sampling: One sample is taken from every period

Shape of signal is acquired when displayed sequentially

Frequency limit: 10-50GHz Sensitive to noise

Random Sampling: Samples of signal and time base are taken randomly Samples are displayed randomly rather in sequence No frequency limitation (theoretically) Digital Oscilloscope: Contain memory facility for storage or precision measurement Uses input signal sampling, A to D conversion or DSP Plotters can be attached to oscilloscopes to obtain hard copies of recorded signal instrumentation interfaces can be used for interconnected measurements.

Review Questions:

Part A

1. What are the main parts of CRT?
2. Define deflection sensitivity of CRO.
3. What is the purpose of a Post Deflection Acceleration (PDA) in a CRT?
4. Differentiate between LED and LCD.
5. What for delay line is used in CRO? Which are the two types of delay lines?
6. What are the classifications of encoder?
7. What is the need of sample and hold circuit in A/D converter?
8. What is the principle of sampling oscilloscope?
9. What are called Lissajous figures?
10. What are different types of oscilloscopes?

Part B

1. Sketch and explain the essential parts of CRO.
2. State and explain the various front panel controls of asimple CRO.
3. Draw and explain the digital storage oscilloscope.

Unit IV

4.1Comparison of analog and digital techniques

An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous quantity to a discrete digital number. The reverse operation is performed by a digital-to-analog converter (DAC). Typically, an ADC is an electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current. However, some non-electronic or only partially electronic devices, such as rotary encoders, can also be considered ADCs. The digital output may use different coding schemes. Typically the digital output will be a two's complement binary number that is proportional to the input, but there are other possibilities. An encoder, for example, might output a Gray code. An ADC might be used to make an isolated measurement.

ADCs are also used to quantize time-varying signals by turning them into a sequence of digital samples. The result is quantized in both time and value.

4.2 Digital multimeter

Multimeter:

Multimeter or a multi-tester, also known as a volt/ohm meter or VOM, is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits analog multimeters and digital multimeters (often abbreviated DMM or DVOM.) Analog instruments are usually based on a micro-ammeter whose pointer moves over a scale calibration for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length.

<u>Basic Circuit:</u>

(i) Block Diagram

(ii) Circuit

A multimeter can be a hand-held device useful for basic fault finding and field service work or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems. Quantities measured:

Contemporary multimeters can measure many quantities. The common ones are: Voltage, alternating and direct, in volts. Current, alternating and direct, in amperes. The frequency range for which AC measurements are accurate must be specified. Resistance in ohms.

Additionally, some multimeters measure:

Capacitance in farads

Conductance in siemens

Decibels

Duty cycle as a percentage

Frequency in hertz.

Inductance in henrys.

Temperature in degrees.

Celsius or Fahrenheit, with an appropriate temperature test probe, often a thermocouple.

Digital multimeters may also include circuits for: Continuity; beeps when a circuit conducts. Diodes (measuring forward drop of diode junctions, i.e., diodes and transistor junctions) and transistors (measuring current gain and other parameters).Battery checking for simple 1.5 volt and 9 volt batteries. This is a current loaded voltage scale. Battery checking (ignoring internal resistance, which increases as the battery is depleted), is less accurate when using a DC voltage scale.

Various sensors can be attached to multimeters to take measurements such as: Light level Acidity/Alkalinity (pH) Wind speed, Relative humidity, Resolution, Digital, The resolution of a multimeter is often specified in "digits" of resolution. For example, the term 5½ digit refers to the number of digits displayed on the display of a multimeter. By convention, a half digit can display either a zero or a one, while a three quarters digit can display a numeral higher than a one but not nine. Commonly, a three-quarters digit refers to a maximum value of 3 or 5. The fractional digit is always the most significant digit in the displayed value. A 5½ digit multimeter would have five full digits that display values from 0 to 9 and one half digits that could only display 0 or 1.

Such a meter could show positive or negative values from 0 to 199,999. A 3¾ digit meter can display a quantity from 0 to 3,999 or 5,999, depending on the manufacturer. While a digital display can easily be extended in precision, the extra digits are of no value, if not accompanied by care in the design and calibration of the analog portions of the multimeter. Meaningful high-resolution measurements require a good understanding of the instrument specifications, good control of the measurement conditions, and traceability of calibration of the instrument. Specifying "display counts" is another way to specify the resolution.

Display counts give the largest number, or the largest number plus one (so the count number looks nicer) the multimeter's display can show, ignoring a decimal separator. For example, a 5½ digit multimeter can also be specified as a 199999 display count or 200000 display count multimeter. Often the display count is just called the count in multimeter specifications.

In the digital multimeter the quantity measured by the meter is displayed by using 7 segment LED displays, alphanumeric displays or liquid crystal displays

(LCDs), in the digital converters and other digital processing circuits. The digital multimeter is an instrument which is capable of measuring AC voltages, DC voltages, AC and DC currents and resistance over several ranges. The current is converted to voltage by passing it through low shunt resistance. The AC quantities are converted to DC by employing various rectifiers and filtering circuits. While for the resistance measurements the meter consists of a precision low current source that is applied across the unknown resistance. All quantities are digitalized using analog to digital converter and displayed in the digital form on the display. The analog multimeters require no power supply and they suffer less from electric noise and isolation problems but still the digital multimeters have the following advantages over analog multimeters. Accuracy is very high. The input impedance is very high hence there is no loading effect. An unambiguous reading at greater viewing distances is obtained. The output available is electrical which can be used for interfacing with external equipment. The prices are going down. Small in size.

4.3 Digital voltmeter

A digital voltmeter, or DVM, is used to take highly accurate voltage measurements. These instruments measure the electrical potential difference between two conductors in a circuit. DVMs are electric voltmeters, and the preferred standard, as they offer several benefits over their analog counterparts. Voltmeters are used to measure the gain or loss of voltage between two points in a circuit. The leads are connected in parallel on each side of the circuit being tested. The positive terminal of the meter should be connected closest to the power supply. In turn, the negative terminal would be connected after the circuit being tested. The analog dial or digital display will exhibit the voltage measurement. A digital voltmeter typically consists of an analog to digital converter (A/D) with a digital display. The analog signal is converted into a digital code proportionate to the magnitude of the signal. Voltages from picovolts to megavolts are measurable, though the scale usually graduates in millivolts, volts, or kilovolts. Frequencies between zero and several megahertz may also be measured.

DVMs measure both alternating current (AC) and direct current (DC) in electronics. Common laboratory and commercial applications involve electromechanical machinery with a current flowing through wires and circuits. Often, a digital voltmeter is used to monitor a unit, such as a generator. Portable or handheld devices, such as the digital multimeter (DMM), for example, may combine several functions into one instrument measuring voltage, current, and resistance. This is the preferred tool of an electrician. Many DVMs integrate outputs for monitoring, controlling, transmitting, and printing of data. Advanced systems are often connected to computers, allowing for automation, optimization of processes, and prevention of malfunctions and critical failure safeties. Chemical plants can convert measurements to voltage, and control and monitor temperature, pressure, level, or flow. Medical equipments such as x-ray machines, may use a digital voltmeter to make sure the voltage of the equipment is in the proper range.

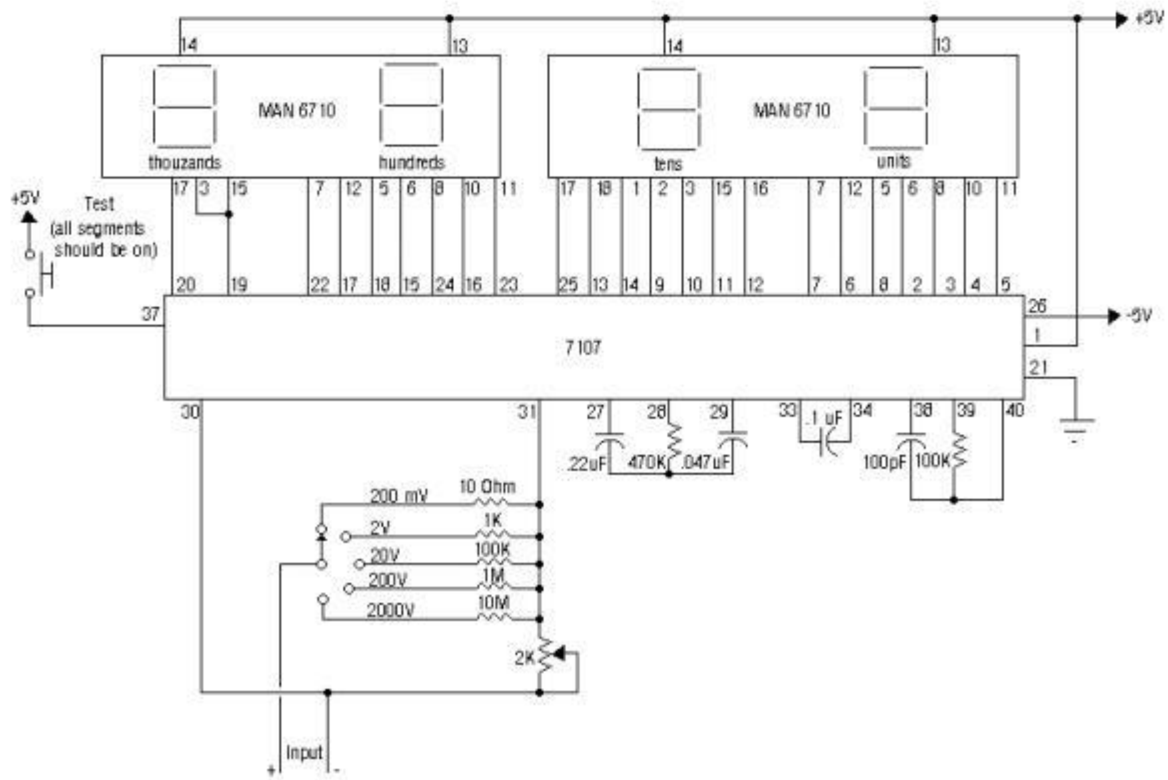


Figure 4.1 Digital Voltmeter Classification of Digital Voltmeters:

The digital voltmeters are classified mainly based on the technique used for the analog to digital conversion. Depending on this, the digital voltmeters are mainly classified as, i) Non-integrating type and ii) Integrating type

The non-integrating type digital voltmeters are further classified as,

a) Potentiometric type: These are sub-classified as, 1) Servo Potentiometric type 2) Successive approximation type 3) Null balance type

b) Ramp type : These are sub-classified as, 1) Linear type 2) Staircase type

The integrating type digital voltmeters are classified as :

a) Voltage to frequency converter type

b) Potentiometric type

c) Dual slope integrating type

d) Ramp type DVM

It uses a linear ramp technique or staircase ramp technique. The stair case ramp technique is simpler than the linear ramp technique.

Successive approximation type DVM

The potentiometer used in the servo balancing type DVM is a linear divider but in successive approximation type a digital divider is used. The digital divider is nothing but a digital to analog (D/A) converter. The servomotor is replaced by an electronic logic. The basic principle of measurement by this method is similar to the simple example of determination of weight of the object. The object is placed on one side of the balance and the approximate weight is placed on other side. If weight placed is more, the weight is removed and smaller weight is placed. If this weight is smaller than the object, another small weight is added, to the weight present.

Likewise, if the total the measurable quantities like voltage, current and power measurement weight is higher than the object, the added weight is removed and smaller weight is added. Thus by such successive procedure of adding and removing, the weight of the object is determined. The successive approximation type DVM works exactly on the same principle.

In successive approximation type DVM, the comparator compares the output of digital to analog converter with the unknown voltage. Accordingly, the comparator provides logic high or low signals. The digital to analog converter successively generates the set pattern of signals. The procedure continues till the output of the digital to analog converter becomes equal to the unknown voltage. Fig. 4.2 shows the block diagram of successive approximation type DVM.

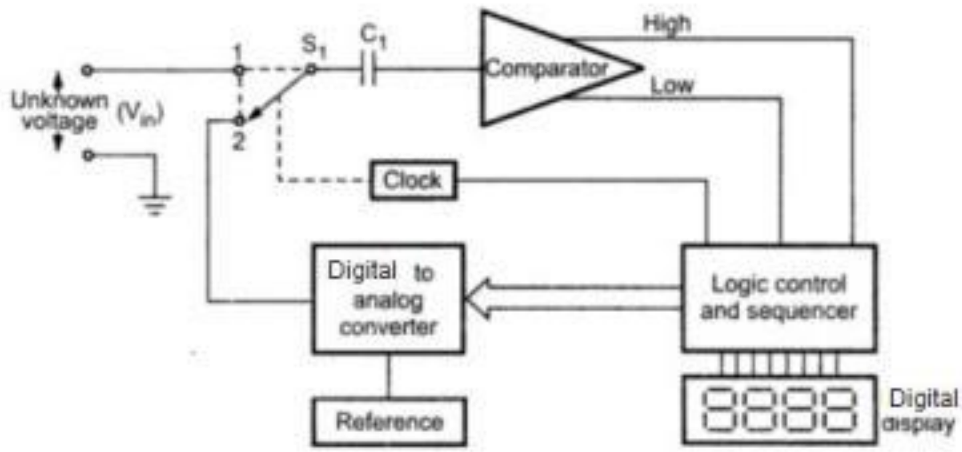


Figure 4.2Successive approximation type DVM

Consider the voltage to be measured is 3.7924 V. The set pattern of digital to analog converter is say 8-4-2-1. At the start, the converter generates 8 V and switch is at the position 2. The capacitor C_1 charges to 8 V. The dock is used to change the switch position. So during next time interval, switch position is 1 and unknown input is applied to the capacitor. As capacitor is charged to 8 V which is more than the input voltage 3.7924 V, the comparator sends HIGH signal to the logic control and sequencer circuit. This HIGH signal resets the digital to analog converter which generates its next step of 4 V. This again generates HIGH signal. This again resets the converter to generate the next step of 2 V. Now 2 V is less than the input voltage. The comparator generates LOW signal and sends it to logic control and sequence circuit. During the generation of LOW signal, the generated signal by the converter is retained. Thus the 2 V step gets stored in the converter. In addition to this, next step of 1 V is generated. Thus the total voltage level becomes, stored 2 + generated 1 i.e. 3 V. This is again less than the input and generates LOW signal. Due to low signal, this gets stored. After this 0.8 V step is generated for the second digit approximation. Thus the process of successive approximation continues till the converter generates 3.7924 V. This voltage is then displayed on the digital display. At each low signal, there is an incremental change in the output of the digital to analog converter. This output voltage approaches the value of the unknown voltage.

Linear ramp technique:

The basic principle of such measurement is based on the measurement of the time taken by linear ramp to rise from 0 V to the level of the input voltage or to decrease from the level of the input voltage to zero. The time measured with the help of electronic time interval counter and the count is displayed in the numeric form with the help of digital display.

Block Diagram:

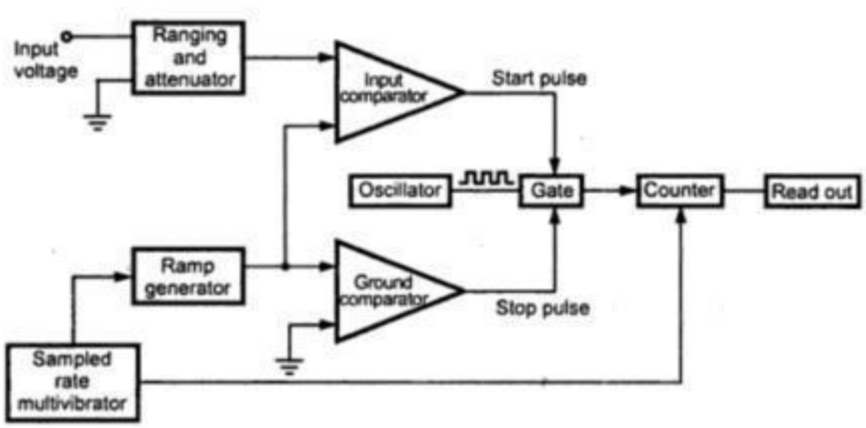


Figure 4.3 Linear ramp type DVM

Properly attenuated input signal is applied as one input to the input comparator. The ramp generator generates a proper linear ramp signal which is applied to both the comparators. The input comparator is used to send the start pulse while the ground comparator is used to send the stop pulse. When the input ramp are applied to the input comparator and at the point when negative going ramp becomes equal to input voltages the comparator sends the start pulse due to which gate opens. The oscillator drives the counter. The counter starts counting the pulses received from the oscillator. Now the input ramp is applied to the ground comparator and it is decreasing.

Thus when ramp becomes zero, both the inputs of ground comparator becomes zero and send it the stop pulse due to which gate closed. The sample rate multivibartor determines the rate at which the measurement cycles are initiated.

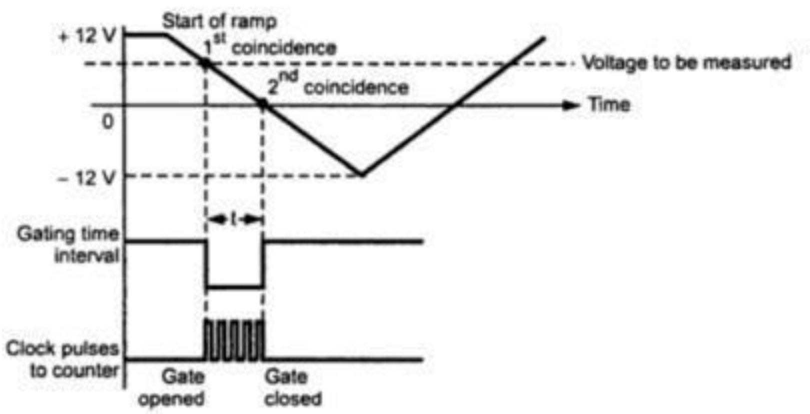


Figure 4.4 Voltage to time conversion

Dual Slope Integrating Type DVM;

This is the most popular method of analog to digital conversion. In the ramp techniques, the noise can cause large errors but in dual slope method the noise is averaged out by the positive and negative ramps using the process of integration. The basic principle of this method is that the input signal is integrated for a fixed interval of time. And then the same integrator is used to integrate the reference voltage with reverse slope. Hence the name given to the technique is dual slope integration technique. The block diagram of dual slope integrating type DVM is shown in the Fig. 4.5.

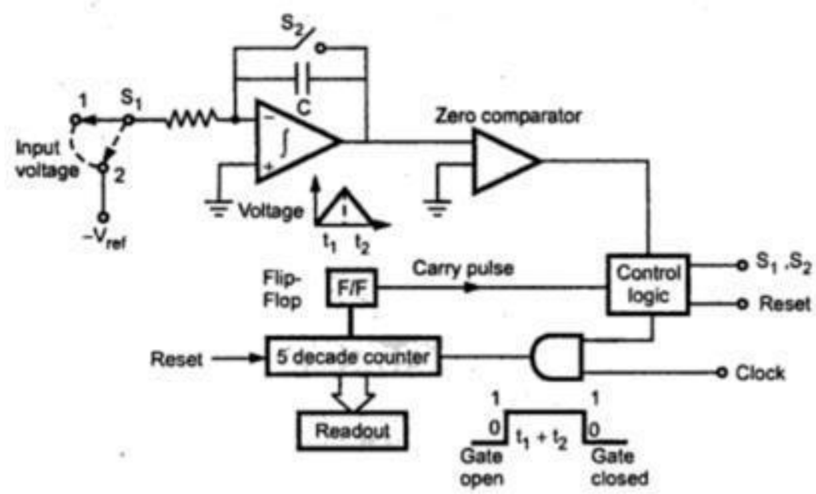


Figure 4.5 Dual slope integrating type DVM

It consists of five blocks, an op-amp used as an integrator, a zero comparator, dock pulse generator, a set of decimal counters and a block of control logic. When the switch SI is in position 1, the capacitor C starts charging from zero level. The rate of charging is proportional to the input voltage level. The output of the op-amp is given by,

$$V_{out} = \frac{1}{R_1 C}\int_0^{t1} V_{in}\,dt$$

Where, t_1 = Time for which capacitor is charged

V_{in}= Input voltage

R1 = Series resistance

C = Capacitor in feedback path

After the interval t_1,the input voltage is disconnected and a negative voltage Vref is connected by throwing the switch SI in position 2. In this position, the output of the op-amp is given by,

$$V_{out} \quad \frac{1}{R_1 C}\int_0^{t1} V_{ref}\,dt$$

$$V_{out} \quad \frac{V_{ref}\,t_2}{R_1 C}$$

$$V_{in}\ \frac{V_{ref}\,t_2}{t_1}$$

4.4 Frequency Counter

A frequency counter is an electronic instrument, or component of one, that is used for measuring frequency. Frequency is defined as the number of events of a particular sort occurring in a set period of time. Frequency counters usually measure the number of oscillations or pulses per second in a repetitive electronic signal.

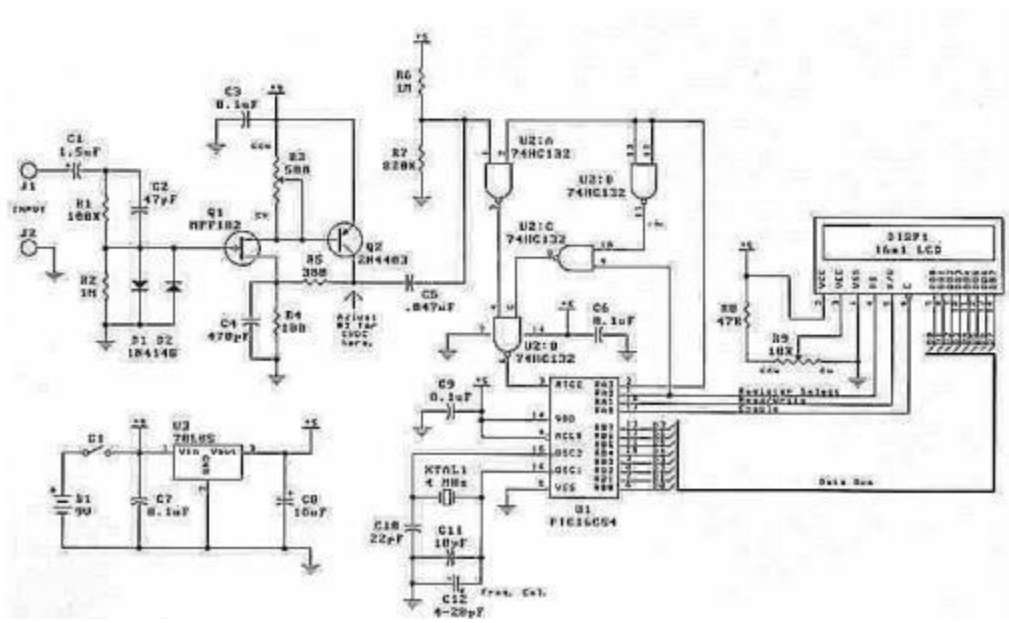


Figure 4.6 Frequency counter

Operating principle:

Most frequency counters work by using a counter which accumulates the number of events occurring within a specific period of time. After a preset period (1 second, for example), the value in the counter is transferred to a display and the counter is reset to zero. If the event being measured repeats itself with sufficient stability and the frequency is considerably lower than that of the clock oscillator being used, the resolution of the measurement is greatly improved by measuring the time required for an entire number of cycles, rather than counting the number of entire cycles observed for a pre-set duration (often referred to as the reciprocal technique). The internal oscillator which provides the time signals is called the time base and must be calibrated very accurately. More complex signals may need some conditioning to make them suitable for counting. Most general purpose frequency counters include some form of amplifier, filtering and shaping circuitry at the input. DSP technology, sensitivity control and hysteresis are other techniques to improve its performance.

Frequency counters designed for radio frequencies (RF) are also common and operate on the same principles as lower frequency counters. Often, they have more range before they overflow. For very high (microwave) frequencies, many designs use a high-speed prescaler to bring the signal frequency down to a point where normal digital circuitry can operate.

Microwave frequency counters can currently measure frequencies up to almost 100 GHz. Above these frequencies the signal to be measured is combined in a mixer with the signal from a local oscillator, producing a signal at the difference frequency, which is low enough to be measured directly.

Accuracy: The accuracy of a frequency counter is strongly dependent on the stability of its time base. Highly accurate circuits are used to generate this for instrumentation purposes, usually using a quartz crystal oscillatorwithin a sealed temperature-controlled chamber known as a crystal oven or OCXO (oven controlled crystal oscillator). For higher accuracy measurements, an external frequency reference tied to a very high stability oscillator such as a GPS disciplined rubidium oscillator may be used. Where the frequency does not need to be known to such a high degree of accuracy, simpler oscillators can be used. It is also possible to measure frequency using the same techniques in software in an embedded system. A CPU for example, can be arranged to measure its own frequency of operation provided it has some reference time base to compare with.

<u>I/O Interfaces</u>: I/O interfaces allow the user to send information to the frequency counter and receive information from the frequency counter. Commonly-used interfaces include RS232, USB, GPIB and Ethernet. Besides sending measurement results, a counter can notify the user when user-defined measurement limits are exceeded. Common to many counters are the SCPI commands used to control them. A new development is built-in LAN based control via Ethernet complete with GUI's. This allows one computer to control one or several instruments and eliminates the need to write SCPI commands any time.

The basic block diagram of digital frequency counter is as shown in Fig. 4.7

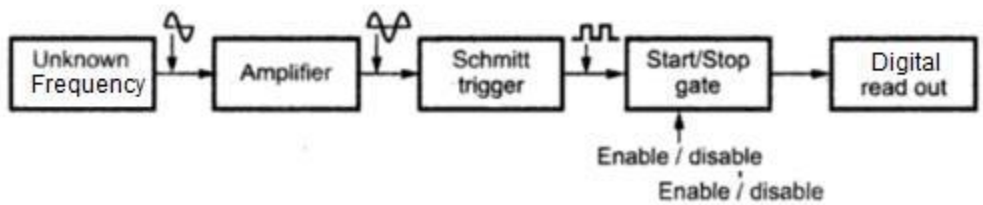


Fig.4.7 Block diagram of digital frequency counter

The signal waveform whose frequency is to be measured is first amplified. Then the amplified signal is applied to the Schmitt trigger which converts input signal into a square wave with fast rise and fall times. This square wave is then differentiated and clipped. As a result, the output from the Schmitt trigger is the train of pulses for each cycle of the signal. The output pulses from the Schmitt trigger are fed to a START/STOP gate. When this gate is enabled, the input pulses pass through this gate and are fed directly to the electronic counter, which counts the number of pulses. When this gate is disabled, the counter stops counting the incoming pulses. The counter displays the number of pulses that have passed through it in the time interval between start and stop. If this interval is known, the unknown frequency can be measured.

For the unknown frequency measurements the digital frequency counter is the most accurate and reliable instrument available. Having highest accuracy in digital frequency counters, the accuracy upto the atomic time standards can be achieved. As most of the events now a days can be converted into an electrical signal consisting train of pulses, the digital frequency counter can be used for counting heart beats, passing of radioactive particles, revolutions of motor shaft, light flashes etc. The block diagram of digital frequency counter is as shown in the Fig. 4.8. The major components of the digital frequency counter are as given below. (1) Input signal conditioning circuit (2) Time base generator (3) Gating circuit (4) Decimal counter and display unit. Let us study each block of the digital frequency counter one by one.

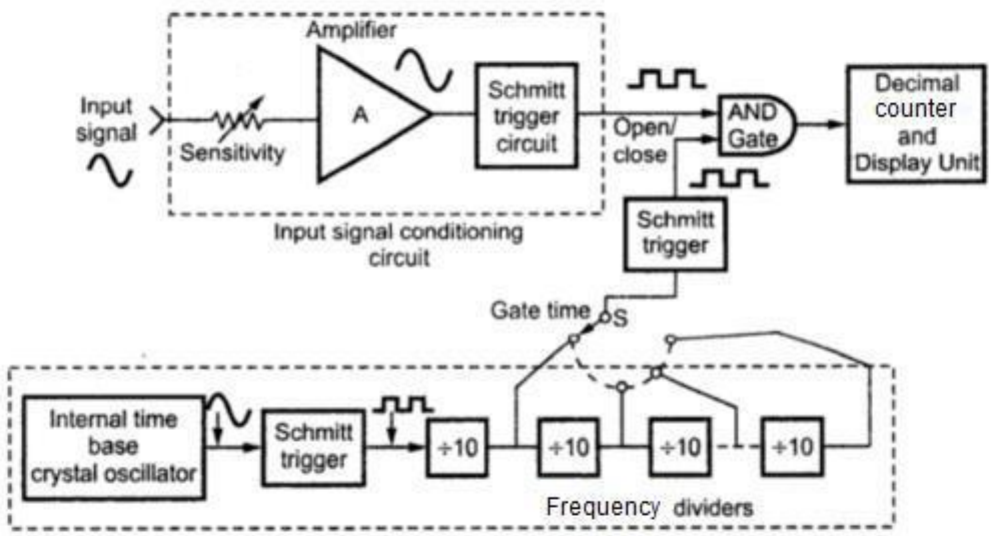


Fig.4.8 Elaborated version of digital frequency counter

(i) Input signal conditioning circuit:

In this circuit, an amplifier and Schmitt trigger are included. The threshold voltage of the Schmitt trigger can be controlled by sensitivity control on the control panel. First of all the input signal of unknown frequency is fed into input signal conditioning circuit. There the signal is amplified and then it is convened into square wave by Schmitt trigger circuit.

(ii)Time base generator:

The crystal oscillator produces a signal of 1 MHz or 100 MHz depending upon the requirement. In general, the accuracy of the digital frequency counter depends on the accuracy of the time base signals produced, thus the temperature compensated crystal oscillator is used. Then output of the oscillator is passed through another Schmitt trigger circuit producing square wave output. Then it is fed to frequency dividers connected in cascade. Thus a train of pulses are obtained after each frequency divider section.

Using time base selector switch S the Gate Time can be adjusted.

(iii)Gating circuit:

The gating circuit consists of AND gate. When the enable signal is provided to the AND gate, it allows a train of pulses to pass through the gate for the time period selected by the time base circuit. The pulses are counted and then the second pulse generated from the time base generator disables AND gate and thus closes it.

(iv)Decimal counter and display unit:

In this unit, decade counters are connected in the cascade. The output of the AND gate is connected to the clock input of the first decade counter. Then the output of this counter to the clock input of next and so on. Using these counters the number of pulses are counted and are displayed by the display unit. As the numbers of pulses counted are proportional to the input signal frequency, the final display is proportional to the unknown frequency of the input signal.

Period measurement

Using the frequency counter, the period measurement is possible.

We know that, time period T = 1/f. So if the frequency to be measured is low, then the accuracy of the frequency counter decreases as less number of pulses are connected to the gating circuit. Thus in low frequency region it is better to measure period rather than frequency. The block diagram for the period mode of digital frequency counter is shown in Fig. 4.9. The main difference is in the frequency mode and period mode of the digital frequency counter is that the unknown input signal controls the gate time of gating circuit while the time base frequency is counted in the decade counter assembly. During the period mode, the input signal conditioning circuit produces a train of pulses. So the positive going zero crossing pulses are used as trigger pulses for opening and closing of AND gate in the gating circuit. The main advantage of period mode is that the accuracy is greater for low frequency input signals.

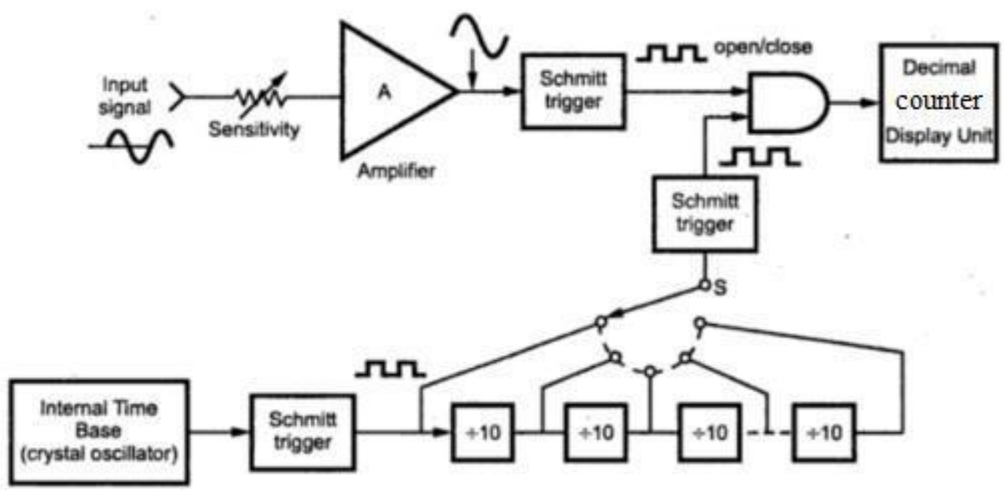


Fig.4.9 Period measurement Time interval measurement

In this measurement mode, two inputs are used to start and stop the counting. Here similar to the period measurement, the internal frequency pulses generated by time base generator circuits are counted. The start and stop signals are derived from two inputs. The AND gate is enabled with the external input 1 applied. The counting of the pulses starts at this instant. The AND gate is disabled with the input 2 applied. Thus pulses are counted in the time interval which is proportional to the time interval between application of inputs 1 and 2.

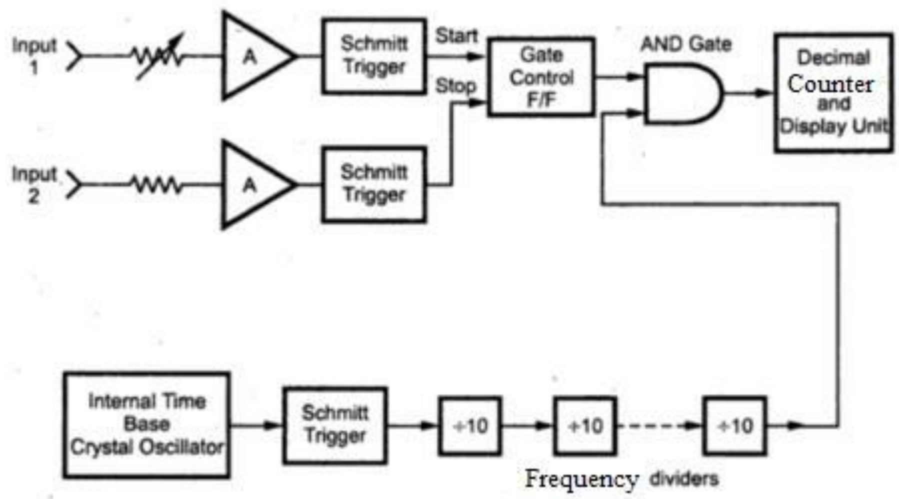


Fig.4.8 Time interval measurement

4.5 Measurement errors

The true score theory is a good simple model for measurement, but it may not always be an accurate reflection of reality. In particular, it assumes that any observation is composed of true value plus some random error value. One way to deal with this notion is to revise the simple true score model by dividing the error component into two subcomponents, random error and systematic error. Here, the differences between these two types of errors and the main sources of error are discussed here.

Random error is caused by any factors that randomly affect measurement of the variable across the sample. For instance, each person's mood can inflate or deflate their performance on any occasion. If mood affects their performance on the measure, it may artificially inflate the observed scores for some children and artificially deflate them for others. The important thing about random error is that it does not have any consistent effects across the entire sample.

Instead, it pushes observed scores up or down randomly. The important property of random error is that it adds variability to the data but does not affect average performance for the group. Because of this, random error is sometimes considered noise. Systematic error is caused by any factors that systematically affect measurement of the variable across the sample. Unlike random error, systematic errors tend to be consistently either positive or negative because of this, systematic error is sometimes considered as bias in the measurement. Types of Errors:

The static error is defined earlier as the difference between the true value of the variable and the value indicated by the instrument. The static error may arise due to number of reasons. The static errors are classified as

1) Gross errors 2) Systematic errors 3) Random errors

Gross Errors:

The gross errors mainly occur due to carelessness or lack of experience of a human being. These cover human mistakes in readings, recordings and calculating results. These errors also occur due to incorrect adjustments of instruments. These errors cannot be treated mathematically. These errors are also called personal errors. Some gross errors are easily detected while others are very difficult to detect.

The complete elimination of gross errors is not possible, but can be minimized.

(i) Taking great care while taking the reading, recording the reading and calculating the result.

(ii) Not dependent on only one reading. At least three or even more readings must be taken and preferably by different persons and also under the conditions in which the instruments can be switched on and off.

The systematic errors occur due to the shortcomings of the instrument and the characteristics of the material used in the instrument, such as defective or worn parts, ageing effects, environmental effects, etc. A constant uniform deviation of the operation of an instrument is known as a systematic error. There are three types of systematic errors as:- 1) Instrumental errors 2) Environmental errors 3) Observational errors

Instrumental errors:

These errors are due to the following three reasons:

a) Shortcomings of instruments: These are because of the mechanical structure of the instruments. For example, friction in the bearings of various moving parts, irregular spring tensions, reduction in tension due to improper handling, hysteresis, gear backlash, stretching of spring, variation in air gap, etc. These errors can be avoided by the following methods

(i) Selecting a proper instrument and planning the proper procedure for the measurement. (ii) Recognizing the effect of such errors and applying the proper correction factors. (iii) Calibrating the instrument carefully against a standard.

b) Misuse of Instruments: A good instrument if used in abnormal way gives misleading results. Poor initial adjustments, improper zero setting, using leads of high resistance etc. are the examples of misusing a good instrument. Such things do not cause permanent damage to the instruments but definitely cause serious errors.

c) Loading Effects: Loading effect due to improper way of using the instrument cause the serious errors. The best example of such loading effect error is connecting a well calibrated voltmeter across the two points of high resistance circuit. The same voltmeter connected in a low resistance circuit gives accurate reading. Thus, the errors due to the loading effect can be avoided by using an instrument intelligently and correctly.

Environmental errors:

These errors are due to the conditions external to the measuring instrument. The various factors causing these environmental errors are temperature changes, pressure changes, thermal e.m.f., stray capacitance, cross capacitance, effect of external fields, ageing of equipment and frequency sensitivity of an instrument. The various methods which can be used to reduce these errors are:

(i)Using the proper correction factors and using the information supplied by the manufacturer of the instrument.

(ii) Using the arrangements which will keep the surrounding conditions constant. This includes the use of air conditioning, temperature control enclosures etc.

(iii)Reducing the effect of dust, humidity on the components by hermetically sealing the components in the instruments.

(iv)The effects of external fields can be minimized by using the magnetic or electrostatic shields or screens.

(v)Using the equipment which is immune to such environmental effects. For Using the equipment which is immune to such environmental effects. For example, in environment having lot of temperature variations, use of an instrument in which resistance material having a very low resistance temperature coefficient is appropriate.

Observational errors:

These are the errors introduced by the observer. There are many sources of observational errors such as parallax error while reading a meter, wrong scale selection, the habits of individual observers etc. To eliminate such observational errors, one should use the instruments with mirrors, knife edged pointers, etc. Now days, the instruments with digital display are available which can largely eliminate such observational errors. The systematic errors can be subdivided as static and dynamic errors. The static error are caused by the limitations of the measuring device while the dynamic errors are caused by the instrument not responding fast enough to follow the changes in measured variable.

Random errors:

Some errors still exist, though the systematic and instrumental errors are reduced or at least accounted for. The causes of such errors are unknown and hence, the errors are called random errors. These errors cannot be determined in the ordinary process of taking the measurements. These errors are generally due to the accumulation of large number of the small effects. These errors are generally small. Hence, these errors are of real concern only when the high degree of accuracy is required. The random errors follow the laws of probability and hence, these errors can be analyzed statically and treated mathematically. These errors cannot be corrected by any method of calibration or other known method of control as the causes of such errors are unknown.

The only way to reduce these errors is by increasing the number of observations and using the statistical methods to obtain the best approximation of the reading.

Review Questions:

Part A

1. What is the difference between analog and digital instruments?
2. What is digital voltmeter?
3. Give classification of digital voltmeters.
4. What is the principle of ramp type digital voltmeter?
5. What are the essential parts of the ramp type DVM?

SICX1005-Electronic Measurements and Instrumentation

6. What are the advantages of digital instruments?
7. What is the principle involved in successive approximation type DVM?
8. Why period mode is preferred for measurement of very low frequency in a frequency counter?
9. What is the importance of gate time in frequency counter?
10. How can be trigger time error reduced?
11. What is called random error?
12. What is systematic error?
13. How can the measurement errors be reduced?

Part B

14. Explain with a neat block diagram, the operation of ramp type digital voltmeter.
15. Explain with a neat block diagram, the operation of successive approximation type digital voltmeter.
16. Explain with a neat block diagram, the operation of dual slope integrating type digital voltmeter.
17. Explain with a neat block diagram, the operation of servo potentio-metric type digital voltmeter.
18. Describe DMM with a help of block diagram and explain its working.
19. Explain the principle used in the digital frequency counter and working of DFC.
20. Brief on measurement errors in instrument systems.

Unit V

Recorders

5.1 XY recorder

A strip chart recorder records the variations of a quantity with respect to time while X-Y recorder is an instrument which gives a graphic record of the relationship between two variables. In strip chart recorders, usually self-balancing potentiometers are used. These self-balancing potentiometers plot the emf as a function of time. The X-Y recorder, an emf is plotted as a function of another emf. This is done by having self-balancing potentiometer control the position of the rolls while another self-balancing potentiometer controls then position of the recording pen. In some XY recorder, one self-balancing potentiometer circuit moves a recording pen in the X direction while another self-balancing potentiometer circuit moves the recording pen in the Y direction at right angles to the X directions, while the paper remains stationary. They are many variations of XY recorders.

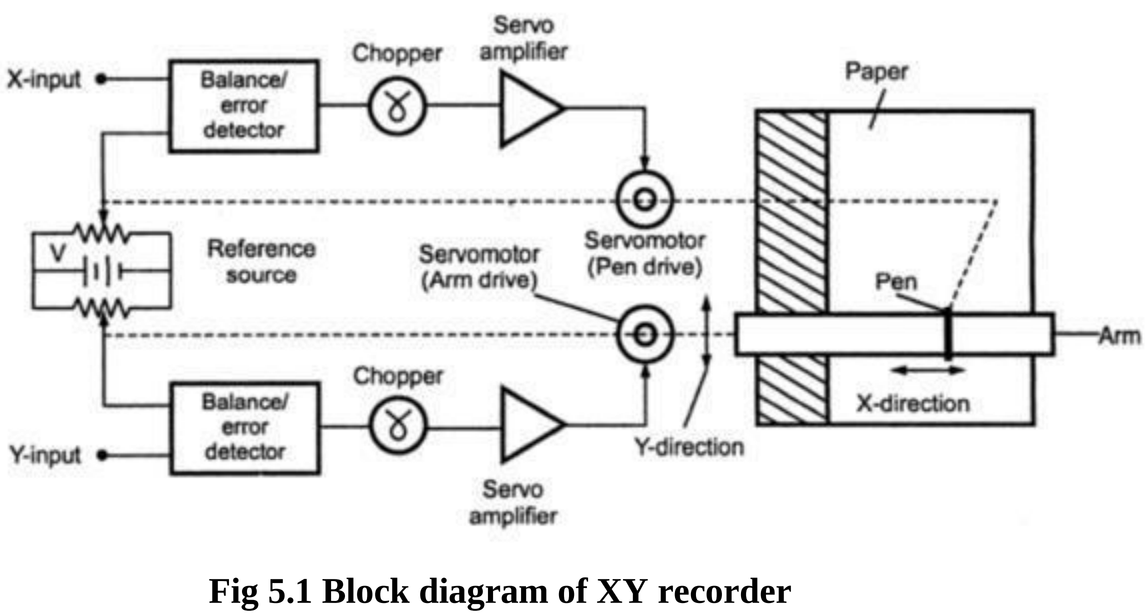


Fig 5.1 Block diagram of XY recorder

The emf, for operation of XY recorders, may not necessarily measure only voltages. The measured emf may be the output of a transducer that may measure displacement force, pressure, strain, light intensity or any other physical quantity. Thus with the help of XY recorders and appropriate transducers, a physical quantity may be plotted against another physical quantity. Hence an XY recorder consists of a pair of serve system, driving a recording pen in two axes through a proper sliding pen and moving arm arrangement, with reference to a stationary paper chart. A signal enters each of the two channels. The signal are attenuated to the inherent full scale range of the recorder, the signal then passes to a balance circuit where it is compared with an internal reference voltage.

5.2 Magnetic recorder

Principle of magnetic tape recorders:

The principle of the magnetic tape recording is as follows. When a magnetic tape is passed through a recording head, the signal to be recorded appears as some magnetic pattern on the tape. This magnetic pattern is in accordance with the variations of original recording current. The recorded signal can be reproduced back by passing the same tape through a reproducing head where the voltage is induced corresponding to the magnetic pattern on the tape. When the tape is passed through the reproducing head, the head detects the changes in the magnetic pattern i.e. magnetization. The change in magnetization of particles produces change in the reluctance of the magnetic circuit of the reproducing head, inducing a voltage in its winding.

The induced voltage depends on the direction of magnetization and its magnitude on the tape. The emf., thus induced is proportional to the rate of change of magnitude of magnetization i.e. $e_a = N\,(d\varphi / di)$. where N = Number of turns of the winding on reproducing head. φ = Magnetic flux produced. Suppose the signal to be recorded is V sin wt.

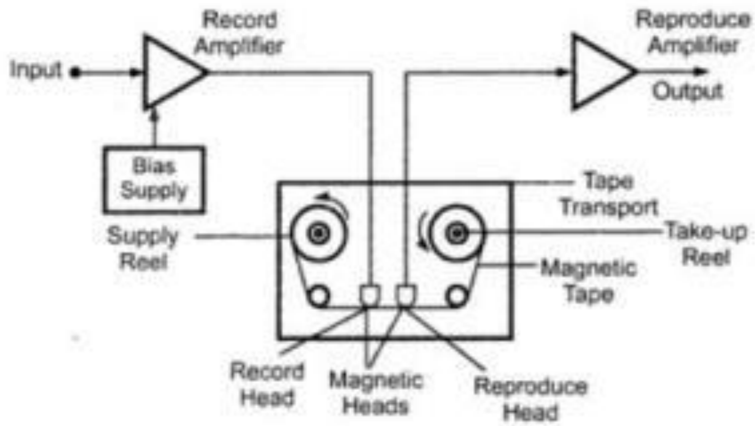


Fig 5.2 Basic block diagram of magnetic recorder

Thus, the current in the recording head and flux induced will be proportional to this voltage. It is given by, Ki.Vm sin cut, where K, = constant. Above pattern of flux is recorded on the tape. Now, when this tape is passed through the reproducing head, above pattern is regenerated by inducing voltage in the reproducing head winding.

5.3 Strip chart recorder:

The physical quantity to be recorded is given as input to the range selector. The range selector switch keeps data within acceptable limits. Whatever may be the input data, the stylus is to be moved along the calibrated scale in accordance with input data. So it is necessary to monitor and condition the input data to be recorded. To get proper record of input data, signal conditioning block is used which gives proper input signal along the calibrated scale. Most of the strip chart recorders use a servo feedback system which controls the displacement of stylus across the chart paper. The position of stylus is measured using potentiometer system. The chart paper moves vertically at a uniform speed. This movement is generally controlled by stepper motor. The speed selector switch enables user to select required speed for movement of chart paper. Many times, a pointer is attached at the tip of stylus, so that we can get directly instantaneous value of input data on calibrated scale.

Operation:

The input data can be recorded on the chart paper by various methods.

Pen and Ink Stylus: The ink is filled in the stylus using gravity of capillary action. In general, red colour is used to record the input data. One can use any colour to record data as per standard colour coding adopted. The stylus moves across chart paper which is properly scaled, in accordance with the variations in input signal. The advantage of this system is that even we can use an ordinary paper to record input signal which reduces cost. The good quality chart paper hardly offers friction to the stylus tip.

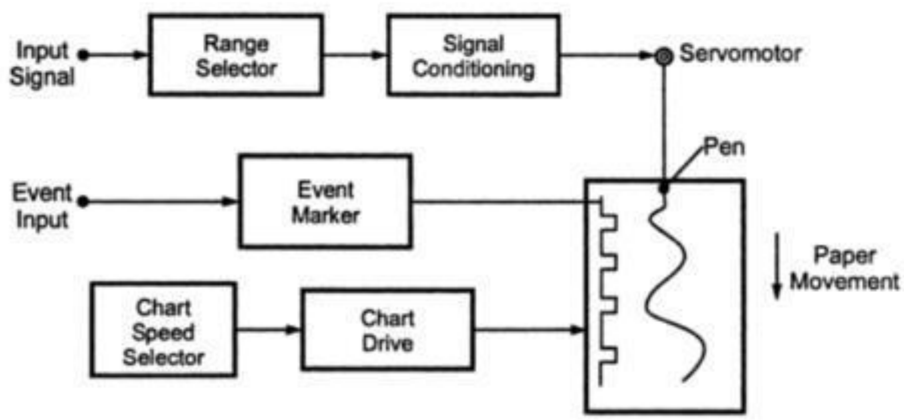


Fig 5.3 Block diagram of strip chart recorder

The disadvantages of the system are clogging of ink at rest condition and splattering of ink at higher speeds. Because of this there is a restriction on the higher speed. With this system, frequency range covered is of few Hz. The modem technology offers disposable fiber tip pens and multiplexing of pens to record maximum of 6 data at an instant.

5.4 Inductive interference with neighboring circuits:

In practice it is observed that the power lines and the communication lines run along the same path. Sometimes it can also be seen that both these lines run on same supports along the same route. The transmission lines transmit bulk power with relatively high voltage. Electromagnetic and electrostatic fields are produced by these lines having sufficient magnitude. Because of these fields, voltages and currents are induced in the neighboring communication lines. Thus it gives rise to interference of power line with communication circuit.

Due to electromagnetic effect, currents are induced which is superimposed on speech current of the neighboring communication line which results into distortion. The potential of the communication circuit as a whole is raised because of electrostatic effect and the communication apparatus and the equipments may get damaged due to extraneous voltages. In the worst situation, the faithful transmission of message becomes impossible due to effect of these fields. Also the potential of the apparatus is raised above the ground to such an extent that the handling of telephone receiver becomes extremely dangerous. The electromagnetic and the electrostatic effects mainly depend on what is the distance between power and communication circuits and the length of the route over which they are parallel. Thus it can be noted that if the distortion effect and potential rise effect are within permissible limits then the communication will be proper. The unacceptable disturbance which is produced in the telephone communication because of power lines is called Telephone Interference. There are various factors influencing the telephone interference.

These factors are as follows i) Because of harmonics in power circuit, their frequency range and magnitudes. ii) Electromagnetic coupling between power and telephone conductor. The electric coupling is in the form of capacitive coupling between power and telephone conductor whereas the magnetic coupling is through space and is generally expressed in terms of mutual inductance at harmonic frequencies. (iii) Due to unbalance in power circuits and in telephone circuits. (iv) type of return telephone circuit i.e. either metallic or ground return. (v) Screening effects.

5.6 Multiple earth loops:

In an electrical system, a ground loop or earth loop is equipment and wiring configuration in which there are multiple paths for electricity to flow to ground. The multiple paths form a loop which can pick up stray current through electromagnetic induction which results in unwanted current in a conductor connecting two points that are supposed to be at the same electric potential, often, but are actually at different potentials.

Ground loops are a major cause of noise, hum, and interference in audio, video, and computer systems. They do not in themselves create an electric shock hazard; however the inappropriate connections that cause a ground loop often result in poor electrical bonding, which is explicitly required by safety regulations in certain circumstances. In any case the voltage difference between the ground terminals of each item of equipment is small. A severe risk of electric shock occurs when equipment grounds are improperly removed in an attempt to cure the problems thought to be caused by ground loops.

Conducted and Radiated Electromagnetic Interference (EMI):

The emissions due to currents which are carried by the metallic or conducting paths are called conducted emissions. These emissions are carried by the metallic paths which are placed on common network. They cause interference with other devices present in a common network. While the emissions which are electric fields radiated by a device or equipment in network are called radiated emissions. The radiated emissions in the form of radiated electric fields cause interference in other devices.

Grounding techniques:

The guidelines to be followed while employing different grounding techniques.

The single point ground system should be employed when low level signals are involved in case of an analog subsystem.

In case of a digital system, multipoint ground technique should be employed using a large ground plane or number of alternate ground paths in parallel.

The signal conductors should be placed in close vicinity of ground returns to reduce area of the ground loop formed.

A combination of single point and multipoint grounding should be employed where frequency selectivity is desired. Such combination is called hybrid ground technique.

In any system, multiple ground loops should be avoided. If it is not possible to avoid loop totally, then the loop area should be kept as small as possible.

The concept of grounding is the circuit concept.

Analogous to this the physical concept for grounding is termed as bonding which connects two metal surfaces through a low impedance path. The bonding makes a whole structure homogeneous with respect to current flow. This avoids development of potentials in metal parts thus EMI is avoided. The bonding protects system from electrical shock and current return paths. There are two types of bonding namely direct bonding and indirect bonding. The direct bonding exists between metallic parts of elements while indirect bonding is the contact established through jumpers indirectly. The quality of bond is represented by the dc resistance of the bond.

5.7 Analog and digital data acquisition

In the last few years, industrial PC I/O interface products have become increasingly reliable, accurate and affordable. PC-based data acquisition and control systems are widely used in industrial and laboratory applications like monitoring, control, data acquisition and automated testing.

Selecting and building a DA&C (Data Acquisition and Control) system that actually does what you want it to do requires some knowledge of electrical and computer engineering.

- Transducers and actuators
- Signal conditioning
- Data acquisition and control hardware
- Computer systems software
    - Analog signals can be represented by :
        - Continuous, expressed in decimal system
        - No limitation on the maximum/minimum value
        - Cannot be processed by computer
        - Digital signals: binary number system
        - All numbers are expressed by a combination of 1 & 0
        - The maximum value is limited by # of bits available

DAQ systems capture, measure, and analyze physical phenomena from the real world.

Light, temperature and pressure are examples of the different types of signals that a DAQ system can measure.

Data acquisition is the process of collecting and measuring electrical signals and sending them to a computer for processing.

An electrical signal comes from Transducers. The simple blocks constituting data acquisition are

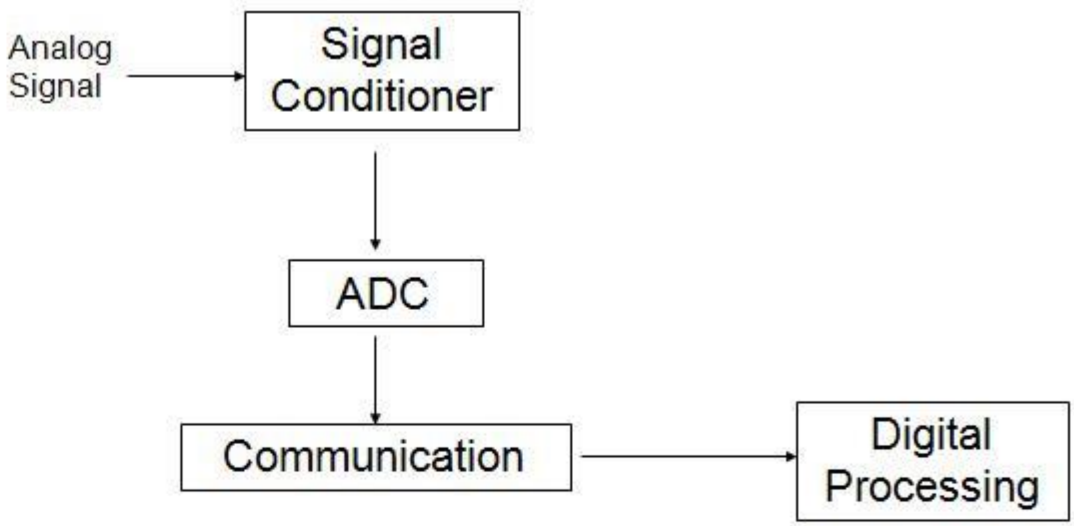


Fig 5.4 Block diagram of DAQ

One of the most common signal conditioning functions is amplification.

For maximum resolution, the voltage range of the input signals should be approximately equal to the maximum input range of the A/D converter. Amplification expands the range of the transducer signals so that they match the input range of the A/D converter. For example, x10 amplifier maps transducer signals which range from 0 to 1 V into the range 0 to 10 V before they go into the A/D converter.

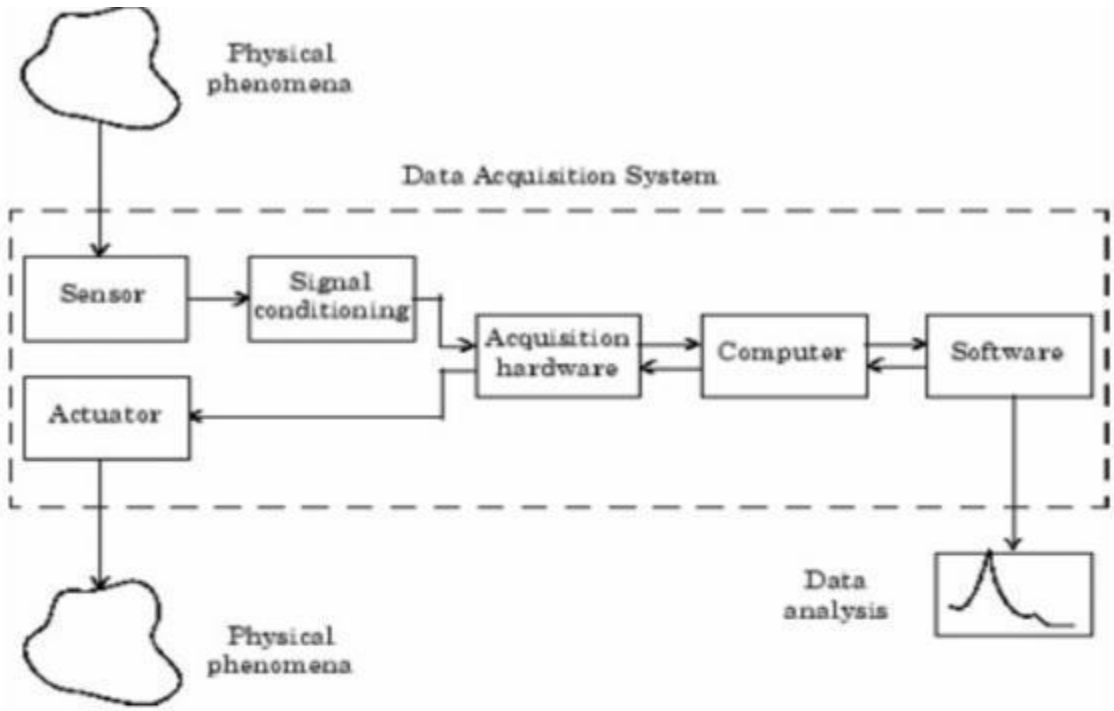


Fig 5.5 Elaborated version of DAQ

Data Loggers

A data logger is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors. They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors.

Different types of data loggers and their operation

The differences between various data loggers are based on the way that data is recorded and stored. The basic difference between the two data logger types is that one type allows the data to be stored in a memory, to be retrieved at a later time, while the other type automatically records the data on paper, for immediate viewing and analysis. Many data loggers combine these two functions, usually unequally, with the emphasis on either the ability to transfer the data or to provide a printout of it.

Interfacing Transducers to Electronic Control and Measuring Systems

The output voltages and currents from many transducers are very small signals. In addition to the low levels, it is often necessary to transmit the transducer output some distance to the data collection or control equipment. Also in an industrial environment, where there is large electrical machinery, the electrical noise present can cause serious difficulties in low-level circuits. These noises can be either radiated as an electromagnetic field or induce in the wiring of the plant as ground loops, and induced spikes on the ac power supply. Regardless of the source of noise, low-level signals must be transmitted from place to place with care.

One effective method of combating noise is to increase the strength of low level signals before transmission through wires. This is often done with an amplifier called an instrumentation amplifier. There are several characteristics of an instrumentation amplifier that set them apart from operational amplifiers. The features of a Three Op-Amp Differential topology of an instrumentation amplifier are:

Combination of inverting and non-inverting topologies, the output signal is an amplified version of the difference between the two input signals;

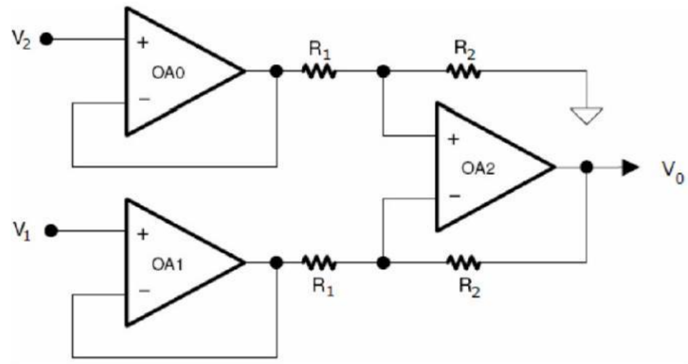


Fig. Instrumentation Amplifier

Fig 5.6 Instrumentation amplifier

When interfacing TSI Transducers with data acquisition boards many problems can be encountered. In this application note, we attempt to explain the requirements and help the user to set up their system.

When interfacing the transducers to a data acquisition board fully differential input works the best. This means that each channel has its own (+) input and (-) input. The (-) inputs are not grounded, but are separate from ground.

Single-Ended Inputs

Single-ended input cards have only a (+) input. All the (-) inputs are connected to ground. These single ended input cards have only one advantage: they give you more input channels for less money. This is because there is only one electronic switch for each channel (the (+) input).

Unless all of the sensors you attach to your data acquisition card are current loop powered, it is difficult to wire a single-ended data acquisition card without introducing zero errors into the measurement. TSI air velocity transducers cannot be loop powered because they require too much current.

Computer controlled instrumentation:

In general, most of the test equipments or test instruments require some sort of modifications in the form of use of some special circuits so as to interface them with a computer. Depending upon the nature of test equipments, the modifications may be very simple as in case of some equipment or may be very significant in other equipments. For example the measuring instruments using any sort of mechanical device for the effective measurement are not suitable in computer controlled test systems. The meter movement in instruments or resistors and capacitors used in bridge are not suitable for computer controlled measurement systems.

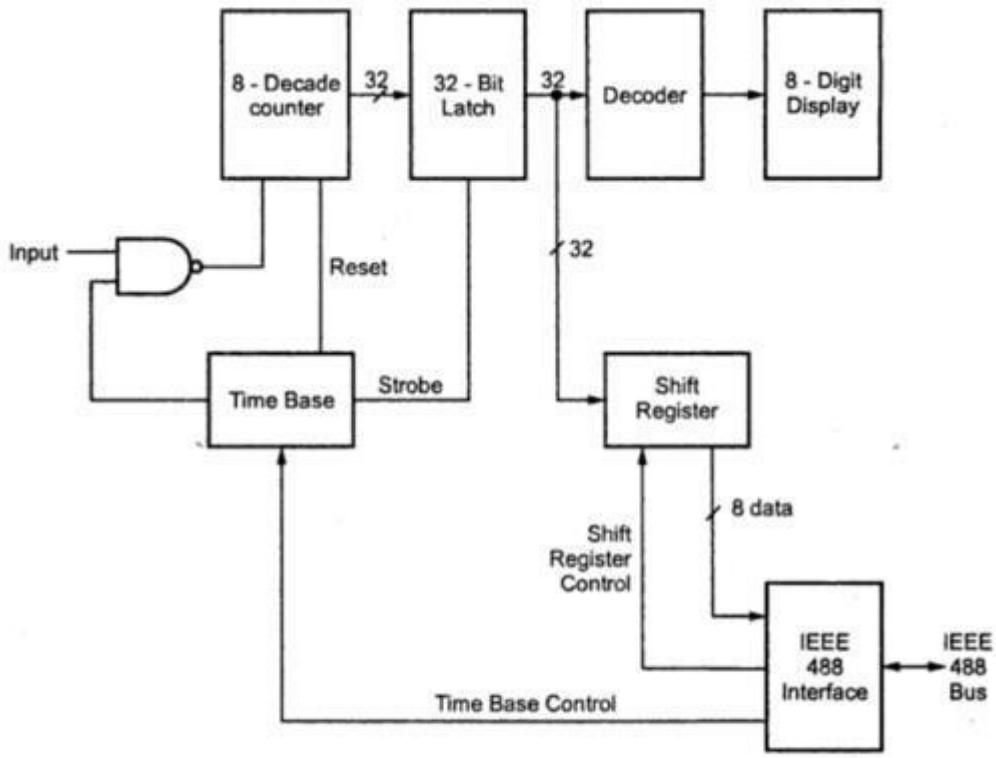


Fig 5.6 Digital frequency counter with IEEE 488

Such instruments need certain modification such that they can be used in computer controlled measurement system. Generally all the mechanical devices are replaced by purely electronic equivalents. In general, the instruments used in the computer controlled instrumentation are, i) Digital frequency counter ii) Synthesized signal generator iii) Relay switched attenuator iv) Computer controlled spectrum, analyzer v) Adjustable a.c. power supply A digital frequency counter to, interface with IEEE 488 bus is as shown in the Fig. 5.7. As frequency counter is a digital instrument, it is comparatively simple to interface. The data is placed on a bus a digit at a time. The data is connected to display unit through decoder.

For this either a shift register or multiplexer along with interface circuits are used to fulfill the electrical requirements of the bus. As the frequency counter can be used either as a listener or a talker. In other words it requires appropriate additional circuitry such as data generating circuit and data receiving circuit. In addition to this it requires a correct method of switching between data generating and data receiving circuits. The controlling computer sends messages which are decoded and then accordingly the frequency counter is selected as either a listener or a talker.

Review Questions:

Part A

1. What is difference between x-y and x-t recorder?
2. What are the disadvantages of magnetic tape recorder?
3. Name a few digital recorders.
4. What is called ground loop?
5. What the difference is between conducted and radiated electromagnetic interference?
6. What do you mean by data logger?
7. What are single ended inputs?

Part B

1. Write short notes on grounding techniques.
2. Draw and explain XY recorder with the relevant block diagram.
3. Explain the principle and working of magnetic tape recorder?

4. Explain briefly about the analog and digital data acquisition systems.
5. Explain the functions of IEEE488 bus with a suitable example.

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