Q.2a. Give classification of instruments. Explain in brief?

Answer:

Classification of Instrument

Instrument are classified in to two category-

1) Absolute instruments:-

This instrument gives the magnitude of the quantity under measurement in terms of physical constants of the instrument. The examples of this class of instruments are tangent galvanometer and Rayleigh's current balance

2) Secondary Instruments:-

These instruments are so constructed that the quantity being measured can only be measured by observing the output indicated by the instrument. These instruments are calibrated by comparison with absolute or other secondary instruments. Which has already been calibrated against absolute instruments?

Instruments can be further classified:

a) Deflection Type:
In deflection type, the deflection of the instrument provides a basis for determining the quantity under measurement.

b) Null Type:
In null type of instrument a zero or null indication leads to determination of the magnitude of measuring quantity.

Instruments can be classified as

i. Analog Mode
Signals that vary in a continuous fashion and take on infinite numbers of values in any given range are called analog signal. The device which produces these signals called analog devices.

ii. Digital Mode
The signals which vary in discrete steps and thus take up on only finite different values in a given range are called digitals signals. The devices that produce such signals are called digital devices.

Q2b. What are standards? Explain classification of standards.

Answer:

Standards and their Classification

A standard is a physical representation of a unit of measurement. The term 'standard' is applied to a piece of equipment having a non measure of physical quantity. They are used for the purposes of obtaining the values of the physical properties of other equipments by comparison method.

Standard of measurement can be classified by their function and application in the following category:

1) International Standard
2) Primary Standard
3) Secondary Standard
4) Working Standard

The international standards are defined on the basis of international agreement. They represent the units of measurements which are closest to the possible accuracy attainable with present day technological and scientific methods. International standards are checked and evaluated regularly against absolute measurement in terms of the fundamental units.

Primary standards are absolute standards of such high accuracy that they can be used as the Ultimate reference standards. These standards are maintained by national standards laboratory in different parts of the world.

The secondary standards are the basic references standards used in industrial measurement laboratories.
The responsibilities of maintenance and calibration of these standards lies with the particular industry involved.

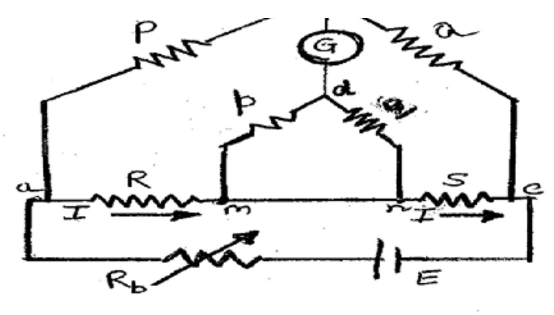
The working standard is the major tools of a measurement laboratory. These standards are used to cheek and calibrate general laboratory instrument for their accuracy and performance

Q 3a. Explain the Kelvin double bridge method of measurement of low resistance.

Answer:

Kelvin double bridge methods of measurement of low resistance:

The Kelvin double bridge incorporate the idea of a second set of ratio arms, hence the name double bridge and the use of four terminal resisters for the low resistance arms. Fig. below show the schematic diagram of the Kelvin double bridge.



The first of ratio arms is P & Q. The second set of ratio arms p & q is used to connect the galvanometer to a point d at the appropriate potentials between points m & n to eliminate the effect of connecting lead of resistance r between the known resistance R and the standard resistance S. The ratio p/q is made equal to P/Q under balance condition there is no current through the galvanometer which means that the voltage drop between a and b, E_{ab} is equal to the voltage drop E_{amd} between a and c

Now, E_{ab}= p/(P+Q) E_{ac} and E_{ac} =I[R+S+{(P+q)r/p+q+r}]

And E_{and}=I[R+(p/p+q){(p+q)r/p+q+r}]=I{R+(pr)/(p+q+r)}
For zero galvanometer deflection E_{ab}=E_{amd}
OR p/(P+Q) I[R+S+{(p+q)*r}/(p+q+r)]=I[R+(pr)/(p+q+r)]
OR R=(P/Q)*S+qr/(p+q+r)[P/Q –p/q] ……………………………………(i)
Now if P/Q=p/q equal (i) becomes R=P/Q*S………………………… (ii)
Equation (ii) is the usual working equation for the Kelvin bridge .It indicate that the resistance of connecting lead r has no effect on the measurement provided that the two sets of ratio arms have equal 'ratios'.

Q3b. A Kelvin double bridge each of the ratio arms P=Q=p=q =1000 ohms. The emf of the battery is 100V and a resistance of 5 ohms is included in the battery circuit. The galvanometer has a resistance of 500 ohms and the resistance of the link connecting the unknown resistance to the standard resistance may be neglected. The bridge is balanced when the standard resistance S = 0.001 ohms.

i. Determine the value of unknown resistance.
ii. Determine the current (approximate value) through the unknown resistance R at balance.

Answer:

i. At balance ,the value of unknown resistance
R=P/Q*S =1000/1000*0.001=0.001 ohm

ii. If we examine the Kelvin bridge circuit, we find the resistors P, Q and p, q are in parallel with the resistance of link r since r is negligible and P, Q, p and q have large values the effect of ratios arms can be neglected for the purpose of calculation of current.

Therefore current under balance conditions

I=E/R_b+R+S=100/5+0.0014+0.0001=20A

Where R_b = resistance in the battery circuit.

Q4a. Explain the effect of frequency on calibration?

Answer:

Effect of frequency on calibration

The frequency effect arise because of various factors such as

1. Skin effect
2. Non uniform distribution of current along the heater wires
3. Spurious capacitive currents

Skin Effect

The skin effect causes a higher reading at higher frequencies especially if the heater wire is small. A low current instrument with a circular cross-section, used in vacuum, may have a skin effect error of less than 1% at frequencies up to 30,000 MHz. Ribbon heaters are often used for large currents, but they have larger skin effects. Solid wire and better still hollow conductors are ideal with view to minimizing from the skin effect.

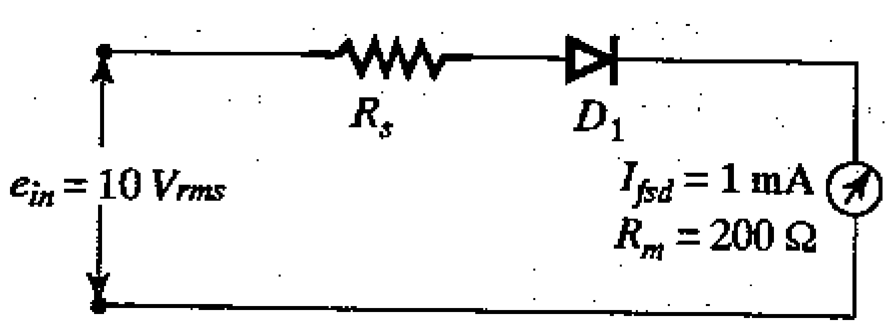
Non Uniform Distribution of current

This occurs at frequencies where the heater length is of the order of a fraction of a wave length (magnitude of one wavelength). The current distribution along the heater is not uniform and the meter indication is uncertain. Hence to avoid this heater length and its associated leads should be less than $1/10^{th}$ of a wave length.

Spurious capacitive currents

These occur when the thermocouple instrument is connected in such a manner that terminals are at a potential above ground. As the frequency is increased, a large current flows through the capacitance formed by the thermocouple leads, with the meter acting as one electrode as the other. To avoid this, proper shielding of the instrument should be provided.

Q4b. Calculate the value of the multiplier resistor for a 10V r m s range on the voltmeter as shown in fig



Answer:

$R_{S} = (0.45 \times E_{rms}) / 1mA - R_m$
$= (0.45 \times 10) / 1mA - 200$
$= 4.5\ k - 0.2\ k$
$= 4.3\ k\Omega$

Q5. What is electronic counter? What are the different modes of operation of electronics counter? Explain in brief.

Answer:
Electronic counter
The decade counter can be easily incorporated in a commercial test instrument called an electronic counter. A decade counter, by itself, behaves as a totaliser by totaling the pulses applied to it during the time interval that a gate pulse is present. Typical modes of operation are totalizing, frequency, period ratio, time interval and averaging.

Totalising
In the totalizing mode as shown in fig below, the input pulses are counted (totalized) by the decade counter as long as the switch is closed if the count pulse exceeds the capacity of the decade counter, the overflow indicator is activated and the counter starts counting again.

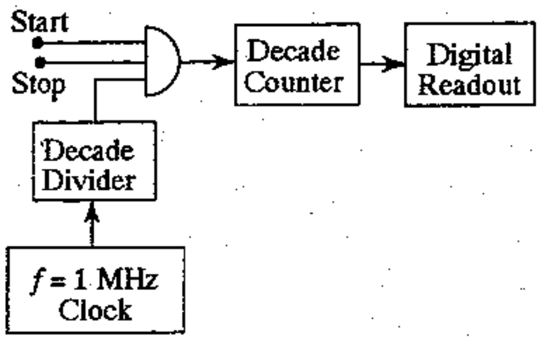


Fig: Block diagram of the totalizing mode of an Electronic counter

Frequency mode
If the time interval in which the pulses are being totalized is accurately controlled, the counter operates in the frequency mode. Accurate control of the time interval is achieved by applying a rectangular pulse of known duration to the AND gate, in place of the dc voltage source. This technique is referred to as gating the counter. The frequency of the input signal is computed as

$$F = N / t$$

Where f = frequency of the input signal
N = pulse counted
t = duration of the gate pulse

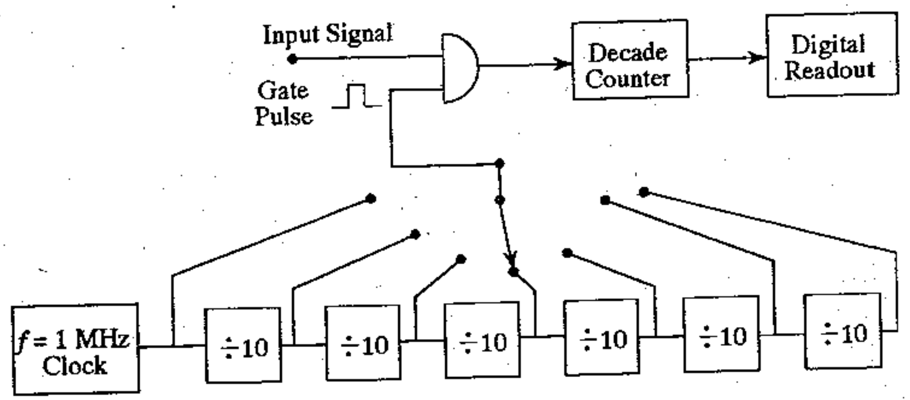


Fig: Block diagram of an Electronic counter Frequency mode

Ratio mode

The Ratio mode of operation simply displays the numerical value of the ratio of the frequency of the two signals

The low frequency signal is used in place of the clock to provide a gate pulse . the number of cycles of the high frequency signal, which are stored in the decade counter during the presence of an externally generated gate pulse, is read directly as a ratio of the frequency

Period Mode

In some applications, it is desirable to measure the period of the signal rather than its frequency. Since the period is the reciprocal of the frequency, it can easily be measured by using the input signal as a gating pulse and the counting the clock pulse. The period of the input signal is determined from the number of the pulses of known frequency or known time duration which are countered by the counter during the one cycle of the input signal.The period is computed as

$$T = N / f$$

Where N = pulse counted

f = frequency of the clock

Time Interval Mode

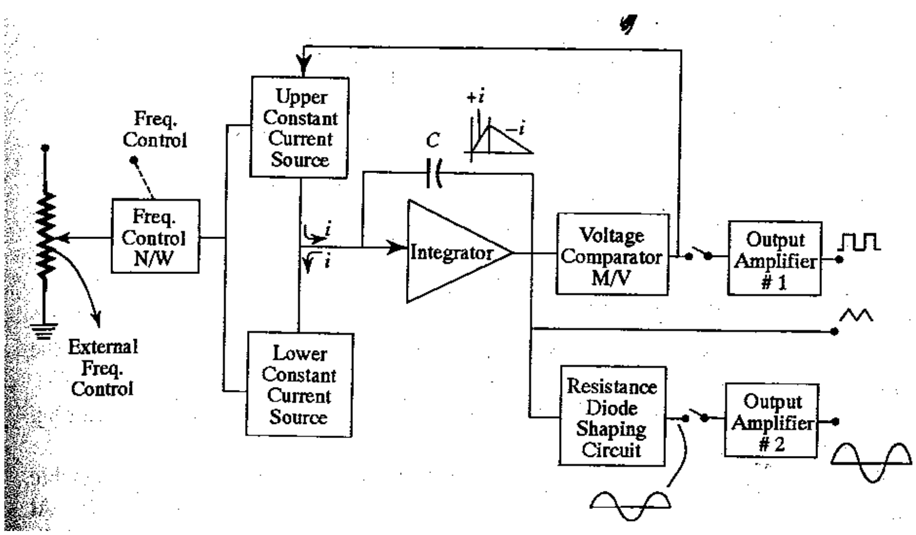
The Time interval mode of operation mearures the time elapsed between two events . the gate is controlled by two independent inputs, the start inputs, which enables the gates the stop inputs, which disables it.During the time interval between the start and stop signal, clock pulse accumulates in the register, thus providing an indication of the time interval between the start and stop of the event.

Q6a What is function generator? Explain its function with the help of block diagram

Answer:

A function generator produces different wave forms of adjustable frequency. The common output wave forms are thr sine, square, triangular and saw tooth wave. The frequency may be adjusted, from a fraction of a hertz to several hundred kHz.
The various outputs of the generator can be made available at the same time. For example, the generator
Can provide a square wave to test the linearity of an amplifier and simultaneously provide a saw tooth to drive the horizontal deflection amplifier of the CRO to provide a visual display.

Capability of phase lock
The function generator can be phase locked to an external source. one function generator can be used to lock a second function generator , and the two output signals can be displaced in phase by adjustable amount.
In addition, the fundamental frequency of one generator can be phase locked to a harmonic of another generator, by adjusting the amplitude and phase of the harmonic, almost any wave form can be generated by addition.
The function generator can also be phase locked to a frequency standard and all its output wave forms will then have the same accuracy and stability as the standard source.
The block diagram of a function generator is shown in fig below. Usually the frequency controlled by varying the capacitor in the LC or RC circuit. In this instrument the frequency is controlled by varying the magnitude of current which drives the integrator. The instrument produces sine square & triangular waves with a frequency range of 0.01 to 100kHz.



Block Diagram Of A Function Generator

Q6b. Draw the block diagram of sampling oscilloscope and explain its operation with the help of input and output waveforms.

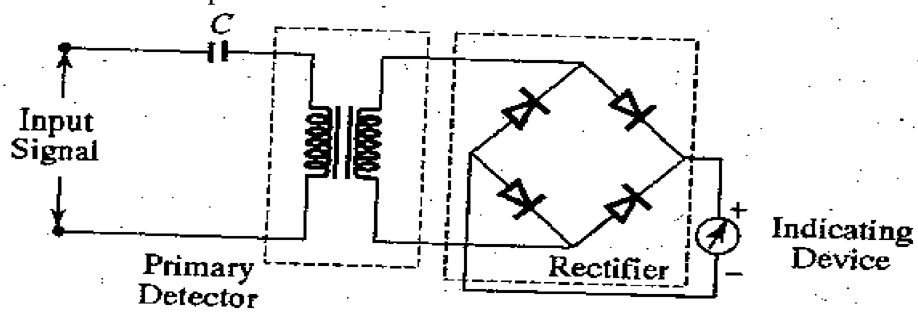
Answer: Page Number 189-190 of Text Book II

Q7a. What is basic wave analyzer? Explain with the help of circuit diagram.

Answer:

Basic wave analyzer

A basic wave analyzer is shown below. It consists of a primary detector, which is a simple LC circuit. This LC circuit is adjusted for resonance at the frequency of the particular harmonic component to be measured.



The intermediate stage is a full wave rectifier, to obtain the average value of the input signal. The indicating device is a simple dc voltmeter that is calibrated to read the peak value of the sinusoidal input voltage.
Since the LC circuit is turned to a single frequency, it passes only the frequency to which it is tuned and rejects all other frequencies. A number of tuned filters, connected to the indicating device through a selector switch, would be required for a useful wave analyzer.

Q7b. What is bolometer? Describe its functions.
Answer:
Bolometer
Bolometer measurements are based on the dissipation of the RF powering a small temperature sensitive element, called bolometer. This Bolometer may be a short ultra thin wire having a positive temperature coefficient (PTC) of resistance, called baretter, or a bead of semiconductor having a negative temperature coefficient (NTC) called Thermistor.
Both baretters and thermistors can measure small powers, of the order of a fraction of microwatts. They can also indicate or monitor large amounts of power by inserting a directional coupler.
The RF power to be measured heats the bolometer and causes a change in its electrical resistance, which serves as an indication of the magnitude of power.
The bolometer is generally used in a bridge network so that small changes in resistance can be easily detected and hence power can be measured.

Q8 a. What are the different types of null recorders? Describe the working of bridge type recorder.

Answer:

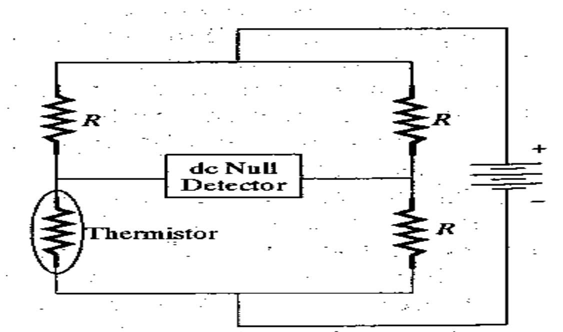
The different types of null recorders are as follows:

1. potentiometric recorders
2. Bridge recorders
3. LVDT recorders(Linear Variable Differential Transformer)

Bridge Type Recorders

When a non electrical quantity such as temperature is to be recorded, the the transducer converts the temperature changes in to corresponding electrical variations.

If a thermistor or resistance thermometer were used as the transducer, the changes in temperature would produce variations in the resistance of the transducer, rather than a change in voltage. In this case the thermister is made part of the bridge circuit as shown in fig. below.



The resistance changes in the termistor cause corresponding changes in the bridge output. These changes are applied to the detector. The bridge balance (null) can be restored by varying the resistance of another arm of the bridge, while recording in terms of current, voltage or temperature. Depending on the kind of voltage supplied to the bridge the output can be chosen to be dc or ac.

Q8b. What are the advantages of a magnetic recorder? What are the basic components of a tape recorder?

Answer:

Magnetic Tape Recorder

The major advantage of using a Magnetic Tape Recorder is the once the data is recorded, it can be replayed an almost indefinite number of times. The recording period may vary from few minutes to several days. Speed translation of the data captured can be provided, i.e. fast data can be slowed down and slow data speeded up by using different record and reproduce speeds.

The recorders described earlier have a poor high frequency response. Magnetic Tape Recorder, have a good response to high frequency, i.e. they can be used to record high frequency signals , hence, magnetic tape recorder are widely used in the instrumentation system.

Basic components of a Tape Recorder

A Magnetic Tape Recorder consists of the following basic components.

1. Recording head

2. Magnetic head
3. Reproducing head
4. Tape transport mechanism
5. Conditioning devices.

Q9a. Explain the working principle of Inductive transducer?

Answer:
Inductive Transducer

Inductive Transducer may be either of the self generating or the passive type. The self generating type utilizes the basic electrical generator principle, i.e a motion between a conductor and magnetic field induces a voltage in the conductor (generator action). This relative motion between the field and the conductor is supplied by changes in the measured. An Inductive electromechanical transducer is a device that converts physical motion (position change) into a change in inductance.

Transducer of the variable inductance type work upon one of the following principles.

1. Variation of self inductance.
2. Variation of mutual inductance.

Inductive transducers are mainly used for the measurement of displacement. The displacement to be measured is arranged to cause variance in any of three variables.

1. number of turns
2. Geometric configuration

Permeability of the magnetic material or magnetic circuits

An inductive transducer has N turns and a reluctance R. when a current I is pass through it, the flux is

$$\Phi = N i / R$$

$$\text{Therefore,} \quad d\Phi/dt = N/R \times di/dt = Ni/R^2 \times dR/dt$$

If the current varies very rapidly,

$$d\Phi/dt = N/R \times di/dt$$

but emf induced in the coil is given by $e = N \times d\Phi/dt$

$$\text{Therefore} \quad e = N \times N/R \times di/dt = N^2/R \times di/dt$$

Also the self inductance is given by $L = e / (di/dt) = N^2/R$

Therefore, the output from an inductive transducer can be in the form of either a change in voltage or a change in inductance.

Q9b. What are the objectives of Data Acquisition System (DAS)? Name the two methods of signal conditioning.

Answer:

Objective of a DAS

1. It must acquire the necessary data, at correct speed and at the correct time.
2. Use of all data efficiently to inform the operator about the state of the plant.
3. It must monitor the complete plant operation to maintain on line optimum and safe operations.
4. it must provide an effective human communication system and be able to identify problem areas, thereby minimizing unit availability and maximizing unit through point at minimum cost.
5. It must be able to collect, summarise and store data for diagnosis of operation and record purpose.
6. it must be able to compute unit performance indices using online, realtime data.
7. It must be flexible and capable of being expanded for future requirements.
8. it must be reliable, and not have a down time greater than 0.1%

Two methods of signal conditioning which are particularly applicable with advantage to data acquisition are (i) ratio metric conversion, and
ii) Logarithm conversion.

Text Books

I. A Course in Electrical and Electronic Measurements and Instrumentation, A.K Sawhney, Dhanpat Rai & Co., New Delhi, 18th Edition 2007.

II. Electronic Instrumentation, H.S Kalsi, Tata McGraw Hill, Second Edition 2004.