Winter – 2019 Examinations

Model Answers

Subject & Code: Electrical & Electronic Measurements (22325)

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

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Model Answers
Subject & Code: Electrical & Electronic Measurements (22325)

1 Attempt any FIVE of the following: **10**

1 a) State the meaning of 'Absolute standard' and 'Secondary standard'.
Ans:
Absolute Standard: An Absolute standard is the one that does not require any other reference for calibration. 1 Mark
Secondary Standard: The secondary standard is that which must be compared periodically to a reference i.e primary standard, depending on the accuracy required. 1 Mark

1 b) State the working principle of PMMC Analog instrument.
Ans:
Working Principal of PMMC Analog Instrument:
When current carrying conductor is placed in a magnetic field, it experiences mechanical force. 1 Mark
In PMMC instrument, when current flows through a coil placed in the gap between the poles, force is produced on the coil. The coil rotates and pointer attached to the coil shows deflection proportional to the current magnitude. 1 Mark

1 c) Calculate the resistance of shunt required to make a milliammeter which gives maximum deflection for a current of 15 mA and which has a resistance of 5 Ω; read up to 10 Amp.
Ans:
Given: Full scale deflection current I_G = 15 mA .
Resistance of moving coil instrument R_G = 5 Ω.
Shunt resistance R_{sh} :
For full scale deflection when the arrangement carries current of I = 10 A, using the principle of equal voltage across parallel resistances of R_G and R_{sh}, 1 Mark
$I_G.R_G = (I – I_G) R_{sh}$
$R_{sh} = I_G.R_G/(I – I_G) = 15 \times 10^{-3} \times 5/(10 – 15 \times 10^{-3})$
$R_{sh} = 7.51 \times 10^{-3}$ ohms 1 Mark

1 d) State the purpose of four quadrant meter.
Ans:
Purpose of four quadrant meter:
Four-quadrant meter is basically a bidirectional energy-meter with additional measurement facility. The purposes of four-quadrant meter are:
1) **Measurement of energy/power under following conditions:** 1 Mark for each of any two purposes = 2 Marks
Quadrant I: Import of active power and Import of lagging reactive power.
Both active & lagging reactive powers flow positively.
Both are delivered to the consumer load.
Quadrant II: Export of active power and Import of lagging reactive power.
The active power flow negatively & lagging reactive power flows positively. The active power is delivered to supply system.
The lagging reactive power is delivered to load.
Quadrant III: Export of active power and Export of lagging reactive power.
Both active & lagging reactive powers flow negatively.

Both active & lagging reactive powers are delivered to supply system.

Quadrant IV: Import of active power and Export of lagging reactive power.
The active power flows positively & lagging reactive powers flow negatively.
The active power is delivered to load & lagging reactive power is delivered to supply system.

2) **Measurement of Maximum demand (MD)** for each type of power i.e kW, kVA and kVARh
3) **Time-of-use metering:**
Bidirectional consumption and demand.

1 e) A single phase wattmeter rated for 500 V; 5A is having full scale deflection of 1000 watt. What is multiplying factor of the wattmeter?

Ans:

Multiplying factor = $\frac{Voltage\ Range \times Current\ Range \times PF}{FSD}$ — 1 Mark

Multiplying factor = $\frac{500\times5\times1}{1000} = 2.5$ (P.F is assumed as 1) — 1 Mark

1 f) List the errors occuring in single phase electronic energy meter.

Ans:

Errors in Single Phase Electronic Energy Meter:

1) Error due to wrong sensor opeartion.
2) Error due to temperature.
3) Error due to wrong CT opeartion.
4) Error due to wrong PT opeartion.
5) Error due to wrong opeartion of scaling network.
6) Error due to wrong ADC opeartion.
7) Error due to wrong Display.

1 Mark for each of any two errors = 2 Marks

OR Equivalent Answer

1 g) State the advantages of electronic energy meter.

Ans:

Advantages of Electronic Energy Meter:

1) Low cost.
2) High accuracy.
3) More flexibility.
4) High sensitivity
5) No frictional losses.
6) Less loading effect.
7) High frequency range.
8) Power consumption is less.
9) High resolution.
10) No requirement for external adjustment.
11) Low load, full load, power factor and creeping adjustments are not required.

1 Mark for each of any two advantages = 2 Marks

2 Attempt any THREE of the following: 12

2 a) Compare analog instrument to digital instrument on the basis of accuracy, resolution, power required and portability.

Ans:

Comparison between Analog instruments & Digital instruments:

Particulars	Analog Instruments	Digital Instruments
Accuracy	The accuracy of analog instrument is comparatively less. e.g Class 0.5, class 1	The accuracy of digital instrument is comparatively more. e.g Class 0.1
Resolution	The resolution of analog instruments is less.	The resolution of digital instruments is more.
Power required	More power is required for working of analog instruments.	Less power is required for working of digital instruments.
Portability	Analog instruments are extremely portable.	Digital instruments are not easily portable.

1 Mark for each point = 4 Marks

2 b) List the types of systematic errors and state the reasons due to which these errors occur.

Ans:

Systematic Error:

i) Instrumental Error: These errors are caused due to the mechanical structure of measuring instrument such as:

a) Inherent shortcomings of instruments: Instrument may read too low or too high.

b) Improper use of instruments: Improper handling e.g. overloading, overheating, failure to adjust zero, use of high resistance leads.

c) Loading effect: Cause distortion in original signal.

2 Marks for errors

ii) Environmental Error: These are because of surrounding conditions such as temperature, pressure, humidity, dust, vibrations, or external magnetic fields or electrostatic fields.

2 Marks for reasons

iii) Observational Error: Parallax errors, incorrect multiplying factor.

2 c) State the purpose of calibration of measuring instruments. Explain the procedure of calibration of D.C. voltmeter by using D.C. potentiometer.

Ans:

Purpose of calibration:

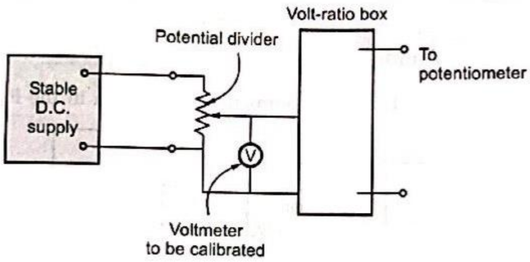
Calibration is the process of evaluating and adjusting the precision and accuracy of measuring equipment. Proper calibration of an instrument allows people to have a safe working environment and produce valid data for future reference.

1 Mark for purpose

- Precision is the degree to which repeated measurements under unchanged conditions show the same result
- Accuracy is the degree of closeness of measurements of a quantity to its actual true value.

For calibration, reference standards with known values for selected points covering the range of interest are measured with the instrument in question. Then a functional relationship in terms of error is established between the values of the standards (true value) and the corresponding measurements.

Calibration of D.C. voltmeter by using D.C. potentiometer:



1 Mark for diagram

For calibration of voltmeter using DC potentiomter, a volt-ratio box is required which consists of 50Ω to 100kΩ variable resistors and the arrangement steps down the input voltage so that it can be safely measured by DC potentiometer.

2 Marks for explanation

- Potentiometer is standardized before measurement.
- The circuit is connected as shown in the figure. With the help of potential divider the reading of voltmeter is set to the certain value.
- Let the reading of votlmeter is the measured voltage 'V_m' and the voltage measured by DC potentiometer is 'V_p'.
- The true value of the voltage 'V_t' is found out by multiplying the reading of potentiometer 'V_p' by corresponding ratio of the volt-ratio box.
- Calculate the relative error in the voltmeter for each reading.

$$\%\, error = \frac{(Measured\ value - true\ value)}{true\ value} \times 100 = \frac{V_m - V_t}{V_t} \times 100$$

- A calibration curve can be drawn by plotting the percentage error against the measured voltages.

2 d) A permanent magnet moving coil instrument gives full scale deflection of 25mA when a voltage of 75mV is applied across it. Calculate:

(i) Resistance of shunt required for full scale deflection of 150 A.
(ii) Series resistance for full scale deflection of 500 V.

Ans:

Given:

Full scale deflection current I_m = 25mA = 25 x 10^{-3} A
Required full scale deflection current I = 150 A.
Full scale deflection Voltage V_m = 75 mV = 75 x 10^{-3} V
Required full scale deflection Voltage V = 500 V.

Shunt resistance R_{sh} :

$R_m = V_m / I_m = 75 \times 10^{-3} / 25 \times 10^{-3}$ — 1 Mark
$= 3\ \Omega$

Now, $\mathbf{R_{sh}} = I_m.R_m / (I - I_m)$ — ½ Mark
$= 25 \times 10^{-3} \times 3 / (150 - 25 \times 10^{-3})$
$= 0.075 / 149.975$ — 1 Mark

= **0.0005 Ω**

Series Resistance R_{se}:

R_{se} = (V / I_m) - R_m ½ Mark

= (500 / 25 x 10^{-3}) – 3

= 20000 – 3 1 Mark

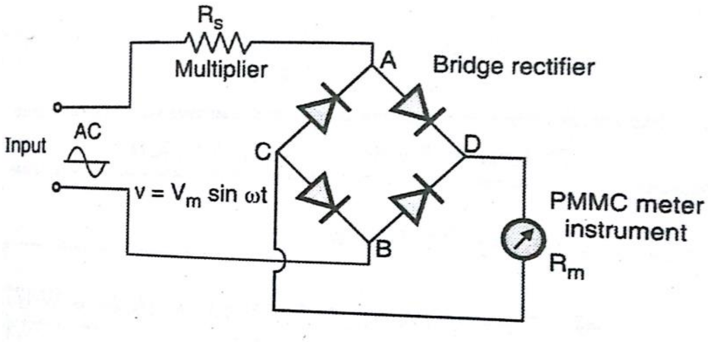
= **19997 Ω**

3 Attempt any THREE of the following: 12

3 a) Explain with neat sketch, the working of full wave rectifier voltmeter.

Ans:

Full Wave Rectifier Type Voltmeter:



2 Marks for Diagram

Working of full wave rectifier type A. C. Voltmeter

Referring to the circuit diagram, for rectification, a full wave bridge circuit (ABCD) is used. Input is given across A and B in series with R_S (multiplier). Ultimately d.c. is available as output voltage from points C and D to which PMMC meter is connected. Now the current passing through meter is given as, $I_M = \frac{Vdc}{Rm+Rs}$ which causes full scale deflection of the meter.

2 Marks for Working

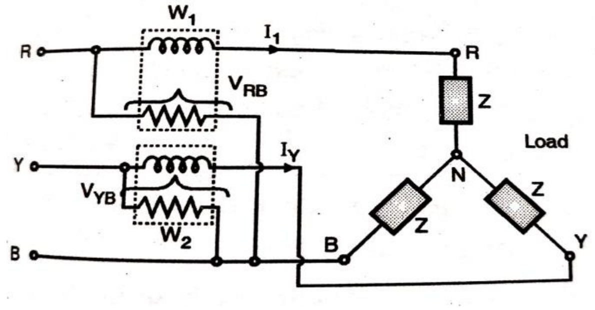
3 b) Draw the circuit diagram for:-

i) Measurement of active power in 3-phase load circuit using two wattmeter.

ii) Measurement of reactive power in 3-phase load circuit using one wattmeter.

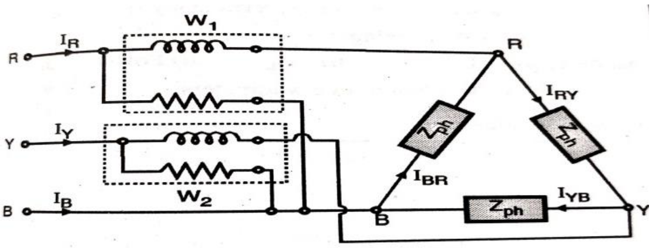
Ans:

(i) Measurement of active power in 3- phase load circuit using two- wattmeter:



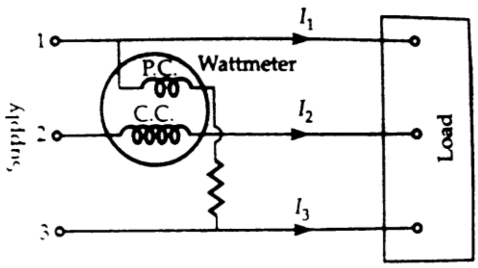
2 Marks for labeled circuit diagram

OR



(ii) Measurement of reactive power in 3- phase load circuit using one wattmeter

2 Marks for labeled circuit diagram

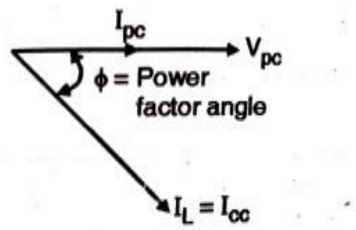


3 c) Explain the error occurred due to pressure coil inductance of electrodynamometer type wattmeter. How this error is compensated?

Ans:

For power measurement assume that the pressure coil of wattmeter is purely restitive. Hence current taken by pressure coil I_{pc} is in phase with voltage across the pressure coil V_{pc}

2 Marks for error

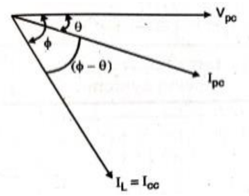


Depending upon the power factor of connected load, current coil takes current, I_{cc} at appropriate phase angle with respect to the load voltage (Pressure coil voltage) V_{pc}. For inductive load, power factor is lagging. Therefore wattmeter reading is equal to

$$W = V_{pc} I_{pc} \cos \phi$$

But in practical cases, the pressure coil possesses small inductance. Due to this, I_{pc} lags behind V_{pc} by small angle θ. Therefore wattmeter reading is equal to

$$W = V_{pc} I_{pc} \cos (\phi - \theta)$$



The phase difference between I_{cc} and I_{pc} decreases and $\cos(\phi - \theta)$ increases .

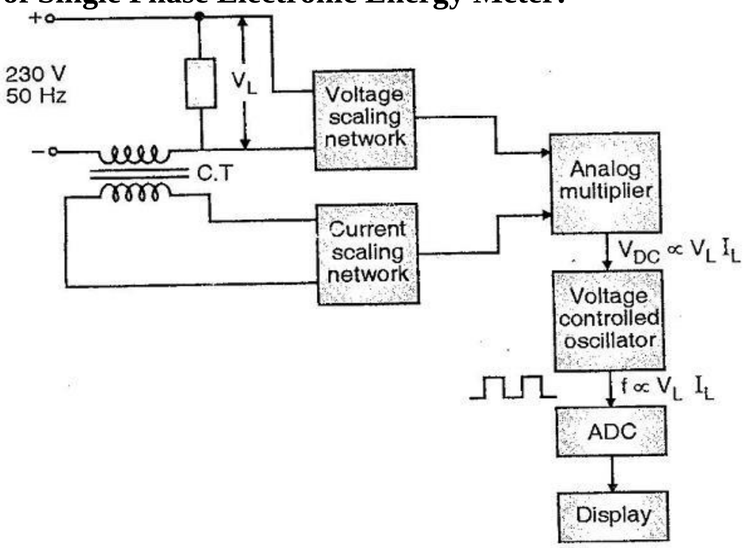
Hence the wattmeter reads more power than the actual power consumed by the load. The error occurred due to pressure coil inductance of electrodynamometer type wattmeter can be compensated as follows: — 2 Marks for compensation

To reduce this error, capacitance is connected in parellel with pressure coil of the wattmeter. By making the value of capacitive reactance X_c equal to inductive reactance X_L the pressure coil circuit is made purely resistive and the error is eliminated.

3 d) Describe with block diagram; the construction of single phase electronic energy meter.

Ans:

Construction of Single Phase Electronic Energy Meter:



2 Marks for Diagram

OR Any other equivalent layout diagram

1. CT reduces current to reasonable value for current scaling network.
2. Voltage & current scaling networks reduce proportionally the voltage & current to values suitable for the analog multiplier.
3. Analog multiplier gives a dc voltage proportional to the product of the voltage and current drawn from supply that is the power drawn.
4. The voltage controlled oscillator gives a frequency proportional to its input (which is proportional to the power).
5. The ADC converts the square wave frequency analog output to display the energy in Watt-hour.

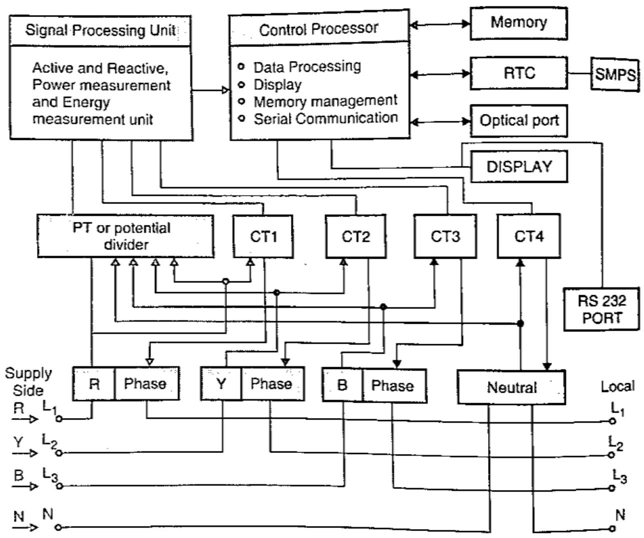
2 Marks for Description

4 Attempt any THREE of the following: 12

4 a) Draw a neat labeled block diagram of 3-phase Electronic Energy meter.

Ans:

Labeled diagram of 3-phase electronic energy meter:



OR Any other equivalent diagram

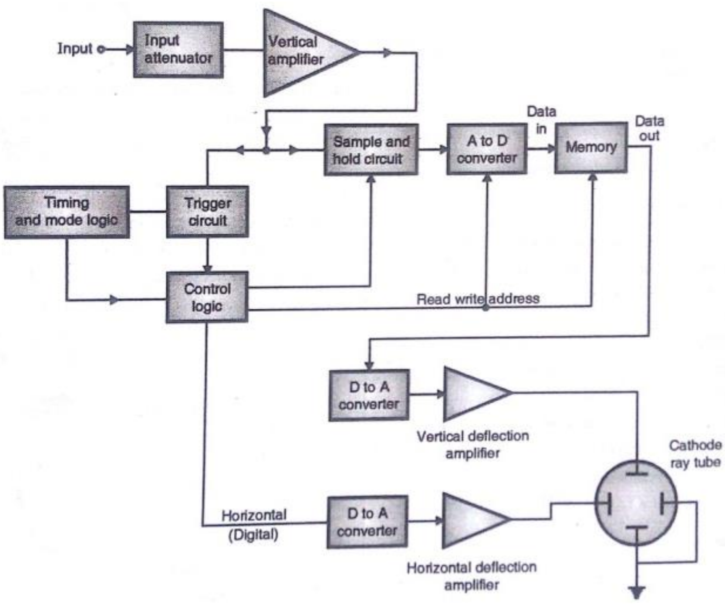
4 marks for labeled diagram,

3 marks for partially labeled diagram,

2 marks for unlabeled diagram

4 b) Describe with block diagram; the principle of operation of digital storage oscilloscope.

Ans:



2 Marks for block diagram

Fig: Block diagram of digital storage oscilloscope OR Any equivalent diagram

The block diagram of DSO is shown above. Sampling rate may be as high as 1,00,000 samples per sencod. For such high sampling rates, a fast conversion ADC is requried. Flash ADC convertor are used at the cost of decresed resolution with increase in sampling rate.

2 Marks for description

The memory size is related to the amount of horizontal segment of the trace that can be

divided into one sweep of the time base.
If the 10 bit ADC is used then the frequency response of 25khz is obtained.The total memory storage capacity is 4096 for single channel, 2048 for two channels and 1024 for 4 channels each.
The selection of sampling rate and memory size depends on the type of waveform being recorded.
A continuous storage oscilloscope consist of feature called "Pre-Trigger view".
This mode is useful when failure occurred.
The DSO has three modes of Operation:

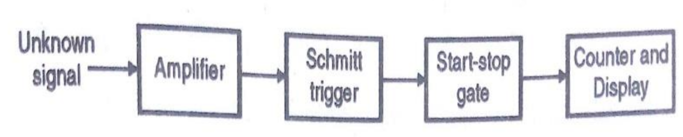
i) Roll mode
ii) Store mode
iii) Hold or save mode

i) **Roll mode :**This mode is used to observe the fast varying signal.In this mode input signal is not trigger at all.The stored signal is rolled across the screen from right to left.
ii) **Store mode:**This mode is most commonly used it called as refresh mode.Once trigger pulse is obtained the memory write cycle is initiated ADC converts input signal to digital code and fed to memory.When memory is full the memory write cycle stops.The digitally stored signal is converted back to the analog using DAC.When the next trigger is received , the memory is refreshed with the next signal.
iii) **Hold and save mode:**The modern DSO operate on automatic refresh system.When a new sweep signal from the time base circuit is received. Then the new contents are over written on the old contents.If it is required to retain the particular signal in the memory then overwritting should be stopped.This obtained by using Hold and Save button.

4 c) Describe with block diagram the working of digital frequency meter.

Ans:

Digital frequency meter:



1 Mark for Diagram

Fig: Block diagram of digital frequency meter OR Any equivalent diagram

Amplifier:
The signal whose frequency is to be measured is first amplified and supplied to the schmitt trigger.

Schmitt Trigger:
The schmitt trigger convert the signal into square wave having fast rise and fall time.The square wave is then differentiated and clipped. Each pulse is proportional to each cycle of unknown signal

3 Marks for explanation

Start – Stop gate:
When the gate is open input pulses are allowed to pass through it.The counter is now

start counting the pulses.
When gate is closed input pulses are not allowed to pass through it.The counter is now stop counting the pulses.

Counter and display:

The number of pulses during the period gate is open are counted by counter.If the interval between start and stop condition is known the freuency of unknown signal is measured.

$$F = \frac{N}{t}$$

Where, F = unknown frequency
N = No. count displayed on counter
t = time interval between start and stop condition of the gate

4 d) Describe with suitable example; frequency measurement by Lissajous patterns on CRO.

Ans:

- Initially the unknown frequency signal is connected to vertical deflection plates of CRO.
- Now switch of the internal sweep generator of the horizontal deflecting system.
- A standard source of frequency is applied to the horizontal deflection plates.
- The frequency of standard source is adjusted now until a circular or elliptical pattern appears on CRT screen. 2 Marks for description
- When such pattern is observed on a screen, it indicates that two frequencies are equal.
- Practically, it is not possible to adjust the standard frequency exactly equal to unknown frequency. Hence the standard frequency is adjusted to be a multiple or submultiple of unknown frequency.

Vertical input Frequency measurement by Lissajous patterns on CRO can be explain by following example:
Assume horizontal input frequency is 10 kHz for following pattern

2 Marks for any one suitable example

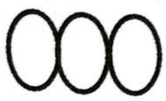


Fig: Lissajous patterns observed on CRO

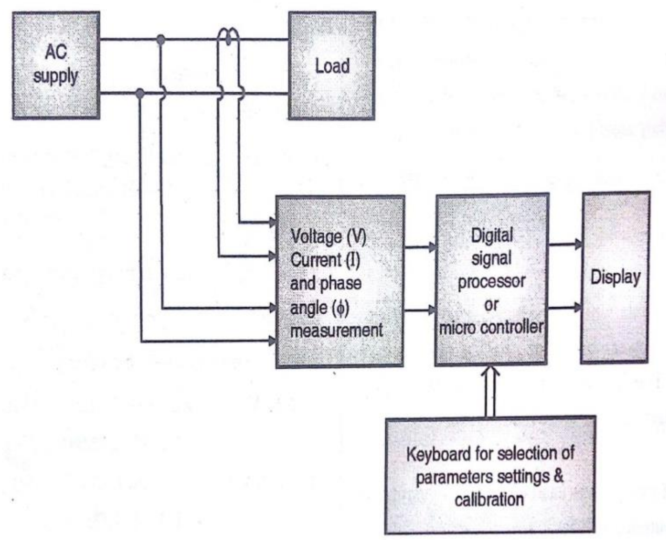
Vertical input Frequency $= \frac{Number\ of\ Horizontal\ tangencies}{Number\ of\ vertical\ tangencies}\ x\ Horizontal\ input\ frequency$

$$= \frac{3}{1} \times 10\ kHz$$

Vertical input Frequency = 30 kHz.

4 e) Draw the block diagram of tri-vector meter. State the various measurements possible from tri-vector meter.

Ans:



2 Marks for Diagram

Fig: Block diagram of tri-vector meter

OR Any euivalent diagram

Various measurements possible from tri-vector meter are:

Tri-vector meter is a measuring instrument which measures the kWh, kVArh, the kVAh of a power line. Tri-vector meter is an energy meter which accurately measures all the parameters of supply such as voltage, current, power factor, active load, reactive load, apparent load etc.

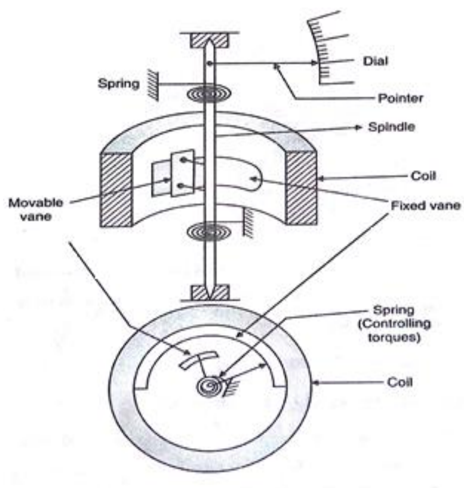
2 Marks for quantities

5 Attempt any TWO of the following: 12

5 a) Explain with neat sketch; the construction and working principle of Repulsion type moving iron instrument**.**

Ans:

Repulsion Type Moving Iron Instrument:



3 Marks for Diagram

Construction:

It consist of fixed cylinder hollow coil which carries operating current inside the coil there are two soft iron pieces. One of which is fixed other is movable. The fixed iron piece is attached to the coil whereas the movable iron piece is attached to the pointer.

2 Mark for construction

Under the action of deflecting torque the pointer attached to the moving system moves over the scale. The controlling torque is provided by spring control and damping torque is provided by air friction.

Working Principle:

When two iron pieces are magnetized with same polarity a repulsive force act on them and moving iron piece gets deflected. — 1 Mark for principle

5 b) Explain the effect of power factor on wattmeter reading in two wattmeter method for power measurement.

Ans:

Effect of P.F. on Reading of Wattmeter in Two Wattmeter Method:

In two wattmeter method the readings of two wattmeter are given by equations:

W_1=V I cos (30°+ø) and W_2=V I cos (30°-ø)

We will consider following cases of power factors

1. If power factor is unity i.e. p.f.=1 (ø=0)

W_1=V I cos (30°+0) and W_2=V I cos (30°- 0)

W_1=V I cos 30° and also W_2=V I cos 30° — 2 Marks

Thus both the wattmeter reads equal readings and each wattmeter reads half of the total power

2. If power factor is 0.5 i.e. ø = 60°

W_1=V I cos(30°+60°) and W_2=V I cos(30° – 60°)

W_1= VIcos(90°) = 0 and W_2= V I cos(-30°) = 0.866 VI — 2 Marks

Thus one wattmeter reads zero and other one shows positive reading.

3. If power factor is 0 i.e. ø =90°

W_1=V I cos(30°+90°) and W_2=V I cos(30°-90°) — 2 Marks

W_1=V I cos120° and W_2=V I cos(-60°)

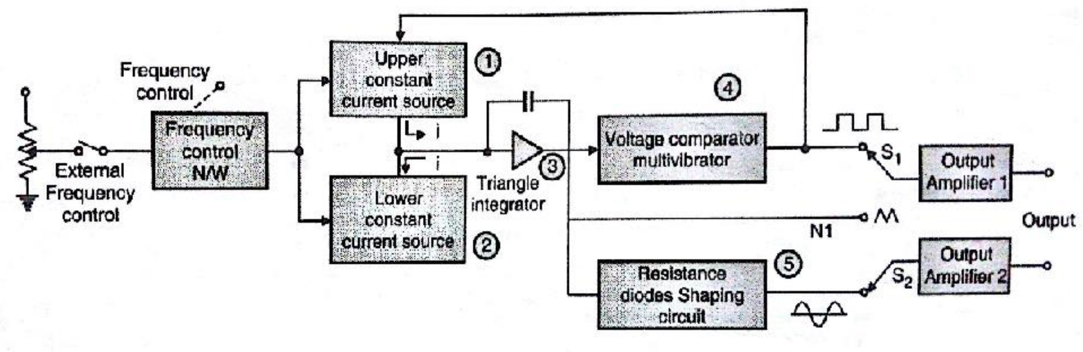
W_1= - 0.5 VI and W_2= 0.5V I

Thus both the wattmeter reads equal but opposite power.

5 c) Draw block diagram of function generator and state the function of each block.

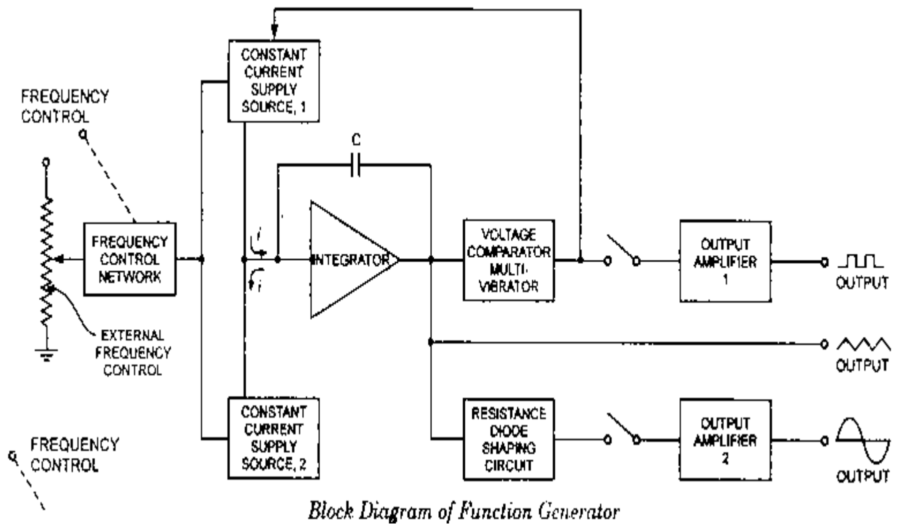
Ans:

Block Diagram of Function Generator:



3 Marks for Diagram

OR



Block Diagram of Function Generator

Working of Function Generator :

- This instrument can deliver sine, triangular & square waves with frequency range of 0.01 Hz to 100 kHz.
- The frequency control network is governed by a frequency dial on the front panel of the instrument
- The frequency control voltage regulates two current sources.
- The upper current source supplies a constant current to the integrator whose output voltage increases with time.
- The voltage comparator multi-vibrator changes state at a predetermined level on the positive slope of the integrator's output voltage.
- The lower current source supplies a reverse current to the integrator so that its output voltage reaches a predetermined level on the negative slope of the integrator's output voltage.
- The lower current source supplies a reverse current to the integrator so that its output voltage reaches a predetermined level on the negative slope of the integrator's output voltage.

3 Marks for functions

6 Attempt any <u>TWO</u> of the following: **12**

6 a) Explain the calibration of single phase electronic energy meter using direct loading.

Ans:

Calibration of Single-phase Electronic Energy Meter by Direct Loading Method:

The following figure shows the arrangement of calibration for single phase electronic energy meter. A phase shifter is connected for changing power factor of circuit.

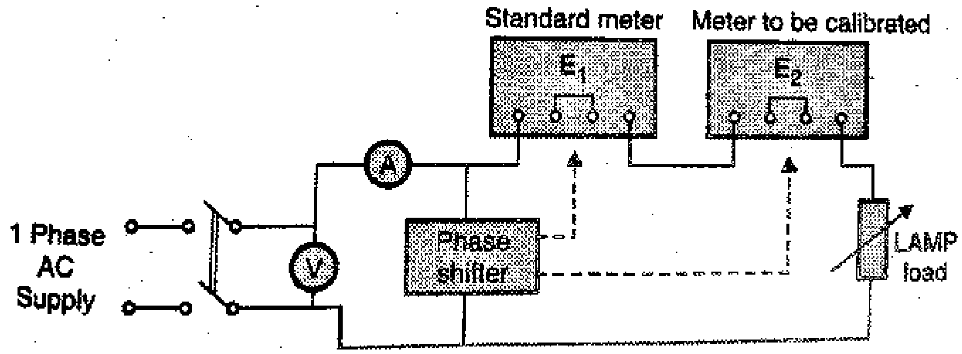
The energy readings are taken for different values of current at different power factors.

3 Marks for explanation

Let D = Registration of meter under calibration in kWh &

Ds = Registration of standard meter in kWh

Then % error = $[(D - D_S)/D_S] \times 100$

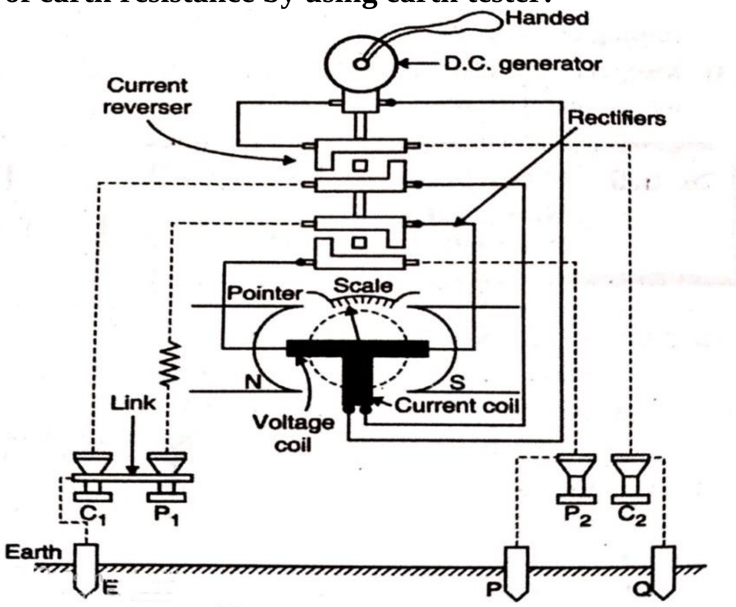


3 Marks for circuit diagram

6 b) Describe the procedure for the measurement of earth resistance by using earth tester.

Ans:

Measurement of earth resistance by using earth tester:



3 Marks for labeled Diagram

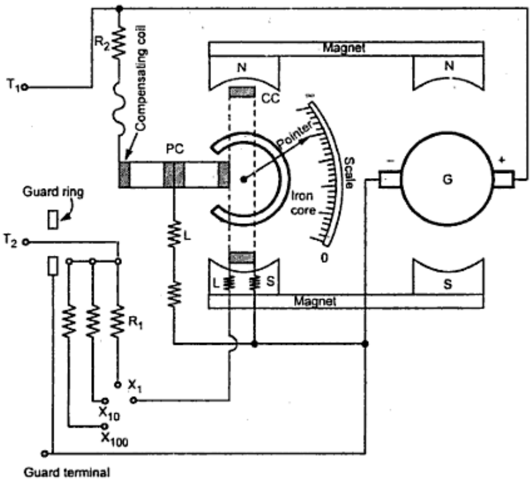
- It is connected to earth electrode E, whose resistance is to be measured, and the other spike P and R, as shown in the figure.
- When handle is rotated the D.C. flows from the generator through the current coil of the movement to the current reverser, and alternating current from the reverser through the soil between the electrode E and R .
- This voltage drop between electrode P and E is rectified by the rectifier and fed to the potential coil of the meter.
- As the indication of the meter depends upon the ratio of the potential across its potential coil, and current passing through its current coil, the deflection of the pointer will indicate directly resistance in ohm of the earth electrode under test.

3 Marks for procedure

6 c) Explain with neat sketch the construction and working principle of megger.

Ans:

Megger:



3 Marks for diagram

Construction of Megger :

Two coils: the current coil and pressure coil are mounted at an angle on the same spindle and form the part of the moving system.

These coils are connected to a small hand driven generator, with polarities such that torque produced by them will act in opposition to each other.

2 Marks for construction

The coils being placed in the air gap of a permanent magnet will move in it, the potential coil is connected in series with a fixed control resistance and the current coil is in series with a resistance to control the current flowing through it and the resistance under test.

When the resistance under test is infinity no current flows through the current coil, the pressure coil will therefore set itself perpendicular to the magnetic axis, and the pointer indicates infinity on dial.

If the resistance under test is very low, the high current will flow through the current coil, it makes the pressure coil; to lie in the direction of axis of permanent magnet, as the effect of pressure coil will be negligible, the position of the pointer in this case is marked as zero.

For value in between the pointer will indicate values in between zero and infinity.

The dial is marked with values of resistances in mega ohms by calibration. When the instrument is not working the pointer may rest at any position on the dial.

Working principle of Megger:

It works on the principle of electromagnetic attraction. When a current-carrying primary coil is placed under the influence of a magnetic field it experiences a force. This force produces a torque that is used to deflect the pointer of the device which gives some reading.

1 Mark for working principle