AS – 2797

B.Sc. V Semester Examination, 2013

Electronics, Paper – III

Electronic Instrumentation and Digital Signal Processing

Section – A

Ans.1 (i) (b), (ii) (c), (iii) (d), (iv) (a), (v) (b), (vi) (b), (vii) (d), (viii) (b), (ix) (b), (x) (a)

Section – B

Ans.2 (a) Q-meter – Q-meter is an instrument designed to measure some of the electrical properties of coils and capacitors. The principle of the Q-meter is based on series resonance. The voltage drop across the coil or capacitor is Q times the applied voltage.

$$Q = \frac{X_L}{R}$$

where, X_L = Inductive reactance

R = Resistance of coil

If a fixed voltage is applied to the circuit, a voltmeter across the capacitor can be calibrated to read the value of Q directly.

At resonance,

$X_L = X_C$ and

$$E_L = I X_L$$
$$E_C = I X_C$$
$$E = IR$$

where,

E = applied voltage
E_C = capacitor voltage
E_L = Inductive voltage
X_L = Inductive reactance
X_C = Capacitive reactance
I = circuit current

So,

$$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{X_C}{R}$$

$$Q = \frac{E_C}{E}$$

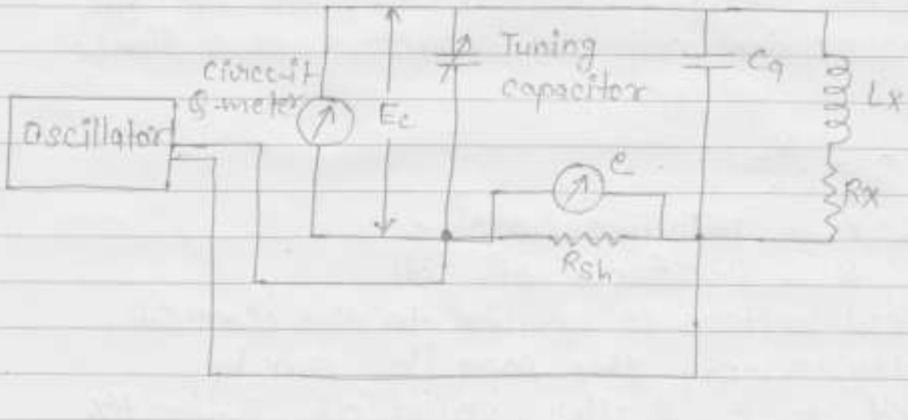
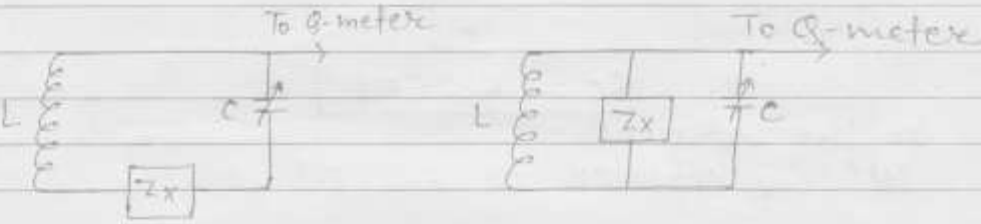


Fig: circuit diagram of Q-meter

* Applications of Q-meter

(1) Impedance measurement — An unknown impedance can be measured using a Q-meter ; either by series or shunt substitution method.
It can be determined by individually determining its components R_x and L_x.

(2) Measurement of characteristic Impedance of a Transmission Line using Q-meter —



Fig(a) Series substitution   Fig(b) Shunt substitution

Ans (2)(b) — Given that,

$f_1 = 2MHz$, $f_2 = 6MHz$

$C_1 = 500pf$, $C_2 = 50pf$

so, $f_2 = 3 f_1$

$$\frac{1}{2\pi\sqrt{L(C_2+C_s)}} = \frac{3}{2\pi\sqrt{L(C_1+C_s)}}$$

(keeping square of both sides)

$$L(C_1+C_s) = (3\times3)\,L(C_2+C_s)$$

$$C_1 + C_s = 9C_2 + 9C_s$$

$$C_1 - 9C_2 = 9C_S - C_S$$

$$C_1 - 9C_2 = 8C_S$$

So, $$C_S = \frac{C_1 - 9C_2}{8}$$

$$C_S = \frac{500pf - 9(50pf)}{8}$$

$$C_S = \frac{500pf - 450pf}{8}$$

$$= \frac{50pf}{8}$$

$$\boxed{C_S = 6.25\,pf}$$

So the value of self capacitance is 6.25pf.

Ans. 3 – Signal Generator – A signal generator is an instrument that provides a controlled output waveform or signal for use in testing, aligning or in measurements on other circuits or equipments.

Characteristic features of signal generators –

(i) The frequency of the signal should be well known and stable.
(ii) The amplitude of the output signal should be controllable, from very low to relatively large values.

(3) The signal should be free from distortion.

Applications of signal generator

(1) To provide appropriate signal for calibration, testing and trouble shooting of the amplifier circuits which are used in communications, electronics such as radio and television amplifiers.

(2) They can be used as power source for the measurement of gain, bandwidth, signal to noise ratio and standing wave radio and other properties of circuits.

(3) To measure the characteristics of antennas and transmission lines.

Ans. 4 Function generator - A Function generator is an instrument that has the capability of producing different types of waveforms as its output signal such as sine waves, Triangular waves, square waves, sawtooth waves and frequency range for these waves vary from a fraction of a hertz to several hundred KHz.

One function generator can be phase locked with second function generator this is a useful features of the function generator.

When a function generator is phase locked to a standard frequency of the source, then all the output waveforms of the generator have same accuracy and stability as that of a standard source.

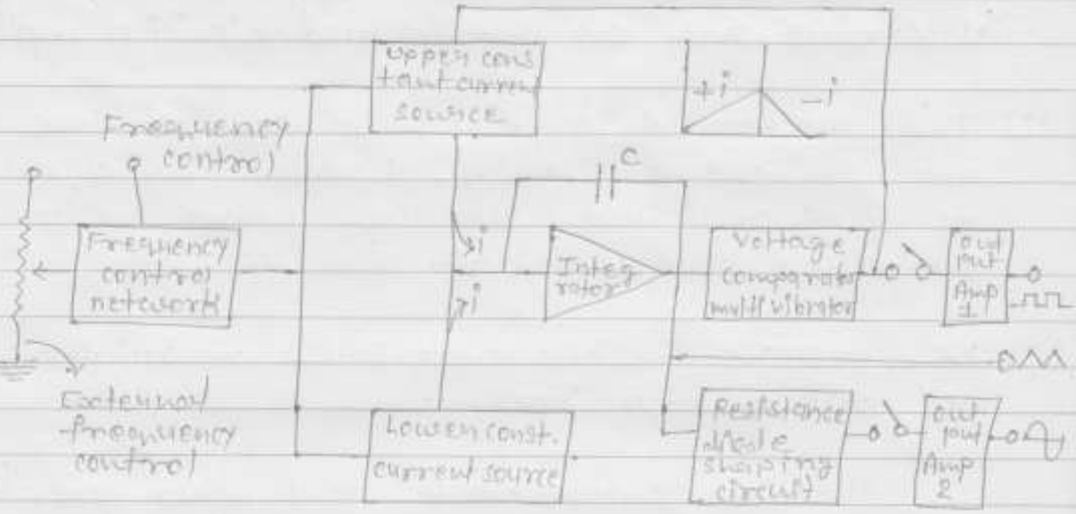


Fig: Block diagram of Function Generator

In this generator the frequency is controlled by varying the magnitude of current, that drives the integrator. The frequency controlled voltage regulates two current supply sources. The upper current supply source supplies constant current to the integrator whose voltage rises linearly with time. An increase or decrease in the current increases or decreases the slope of the output

Voltage and 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 the upper supply source and switches to the lower supply source. Lower supply source supplies a reverse current to the integrator so output drops linearly with time. After reaching a predetermined level the voltage comparator again changes state and switch 'ON' to upper supply source.

Triangular waves are obtained at the output of integrator, whose frequency depends on the upper constant current source. The voltage comparator gives square waves. The triangular wave is synthesized into sine wave using diode resistance network. In this resistance diode shaping circuit the shape of triangular wave is changed as its amplitude changes, and sine wave, with less than 1 percent distortion are obtained at the output.

Ans. 5 Active and Passive probes –

(i) Active Probes – A Probe is a device used to connect the input of a measurement instrument for ex. oscilloscope or electronic voltmeter, to a point in the circuit where the measurement is made.

Active probes contain active components, such as: transistors, for their operation.

In some cases where extremely low capacitance and wide bandwidth are required for high frequency measurements, an active probe is used. An active probe has a small wide band amplifier built into it near the tip of the probe which is designed to have very little capacitance on its input.

Active probes require a power source for the active circuit. This power may be supplied from the scope probe interface or from an external power supply box.

(ii) Passive Probes – Passive probe is also known as Non intrusive Monitoring and as oscilloscope probes. They have low cost and lack of the performance in comparison to the active probes, but they provide the ruggedness and wide dynamic range suitable for visualizing signals over a broad range of applications.

Passive probes are constructed of wires and connectors. There are no active components such as transistors or amplifiers in the probe and thus no need to supply power to the probe. They are easy to use and most widely used probes. High quality passive probes are rarely simple to design. They are available with various attenuation factors – 1X, 10X and 100X; for different voltage ranges.

Ans :- 6 Shielded Cables — Shielded wire is a conductor that is surrounded by and insulated from another conductor, which is a braided cylinder. Coaxial cables are used as shielded cables.

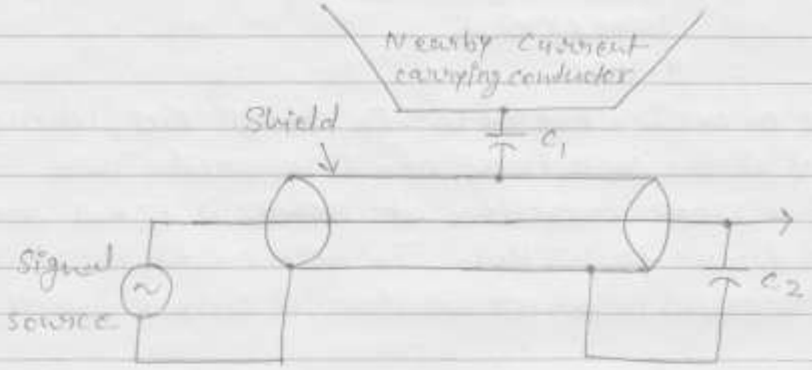


Fig: shielded test lead

where C_1 & C_2 are capacitors.
C_1 is the capacitance between the shield and a nearby current carrying conductor, which represents a path for interfering currents. C_2 represents the capacitance between the inner conductor and the shield. This shielding can reduce the coupling due to the fact that C_1 and C_2 are in series, so the total capacitance is less than either capacitance alone.

Problems with shielded cables —

$C_t = C_1 + C_2$
$= 30 + 90$
$= 120pF$

fig: Equivalent instrument input circuit with shielded cables

This circuit will be arithmatic simplex if E=10 V & error due to voltage division is negligible.

$$E_o = \frac{ER_t}{R_t+R} = \frac{(10V)(1\times10^6 \Omega)}{[(1\times10^6)+(6\times10^2)]\Omega}$$

$$= \frac{1\times10^6 V}{1.0006\times10^6}$$

$$= 9.99V$$

so error is ~0.1% ; but at higher frequencies, where the reactance of the capacitors can't ignored. The reactance of a 120pF capacitor at 100kHz is 13 kΩ, and at 1 mHz it drops to 1.3 kΩ. In both cases the reactance of the capacitor will be predominate and output voltage will reduce

$$\text{At } 1mHz,\ E_o = \frac{(10V)(1300\Omega)}{(1300+600)\Omega} = \frac{(10V)(1300)}{(1900)}$$

$$= 6.84V$$

Because of this voltage drop there is a phase shift of the signal.

$$\theta = \arctan(R_s/X_c)$$

$$= \arctan(600/1300) = \arctan(0.46)$$

$$\simeq 24.7^\circ$$

These errors are not important for sine wave measurements, but in measurements to any nonsinusoidal waveform, these problems becomes acute. They become more acute if rise-time of the waveform is faster. The solution to these problems is the use of a low capacitance probe.

Ans. 7 Signals — A function of one or more independent variables, which contains some information is called a signal. In electrical form signals may be voltage or current. In our daily life we use several electric signals such as radio signals, T.V. signal, computer signal etc.

Digital signal is a type of signal which is also called discrete time signals. When signals are in the form of digital or numeric form they are known as digital signals. They can be used for digital signal processing system

* Applications of Digital signal Processing (DSP) -

There are various applications of DSP due to the availability of high resolution spectral analysis. Some are listed below -

1. Speech Processing — Speech is a one dimensional signal. Digital processing of speech is applied to a wide range of speech problems such as speech spectrum analysis, channel vocoders etc. It is applied to speech coding, speech enhancement, speech analysis and synthesis, speech recognition and speaker recognition.

2. Image Processing — Any two dimensional signal is called an image. Digital processing of images requires two dimensional DSP tools such as Discrete Fourier Transform (DFT),

Fast Fourier Transform (FFT) algorithms and Z-transforms. Image formation and recording image compression, image restoration, image reconstruction and image enhancement.

(3) Radar Signal Processing – Radar means Radio Detection and Ranging.
Radar systems consists of transmit-receive antenna, digital processing system and control unit.

(4) Digital communications – DSP is used in digital communication such as telecommunication, echo control and digital tape recorders.

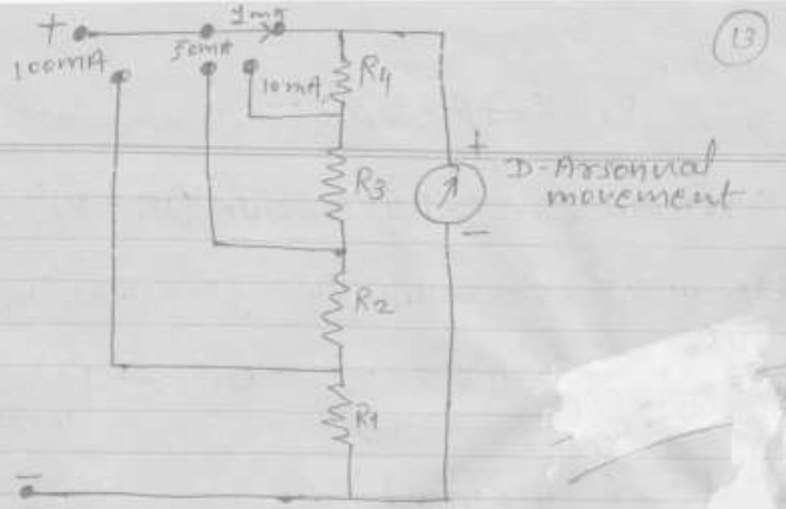
Ans. 8 Ayrton shunt – The Ayrton shunt eliminates the possibility of having the meter in the circuit without a shunt. Ayrton shunt uses make before break switch to protect the system from full scale deflection current. It provides protection to the circuit.

Given that :

$R_m = 100\Omega$, $I_m = 50 \mu A$

(i) For, 0-1 mA range

$\because I_{sh} R_{sh} = I_m R_m$



$\therefore\ 950\,\mu A (R_1+R_2+R_3+R_4) = 50\,\mu A \times 100$

$\therefore\ R_1+R_2+R_3+R_4 = \frac{50\,\mu A \times 100}{950\,\mu A} = \frac{5000}{950}$

$= 5.26\,\Omega$ —— (1)

For, 0-10mA.

$9950\,\mu A (R_1+R_2+R_3) = 50\,\mu A \cdot (100+R_4)$ —— (ii)

For, 0 – 50mA

$49950\,\mu A (R_1+R_2) = 50\,\mu A (100+R_3+R_4)$ —— (iii)

For, 0 – 100mA.

$99950\,\mu A (R_1) = 50\,\mu A (100+R_2+R_3+R_4)$ —— (4)

But, from eqn. (ii)

$R_1 + R_2 + R_3 = 5.26 - R_4$

$9950\,\mu A\,(5.26 - R_4) = 50\,\mu A\,(100 + R_4)$ [from eqn (ii)]

$9950\,\mu A \times 5.26 - 9950\,\mu A \times R_4 = 5000\,\mu A + 50\,\mu A R_4$

So, $R_4 = \frac{9950\,\mu A \times 5.26 - 5000\,\mu A}{10\,mA} = \frac{47337}{10\,mA}$

$\boxed{R_4 = 4.74\,\Omega}$

from eqn. (i)

$R_1 + R_2 + R_3 = 5.26 - 4.74 = 0.52$

$\therefore R_1 + R_2 = 0.52 - R_3$

from eqn. (iii)

$49950\,\mu A\,(0.52 - R_3) = 50\,\mu A\,(R_3 + 4.74 + 100)$

$49950\,\mu A \times 0.52 - 49950\,\mu A \times R_3$

$= 50\,\mu A \times R_3 + 50\,\mu A \times 4.74 + 50\,\mu A \times 100$

$49950\,\mu A \times 0.52 - 50\,\mu A \times 4.74$

$= 49950\,\mu A \times R_3 + 50\,\mu A \times R_3 + 5000\,\mu A$

$(25974 - 237)\,\mu A = 50\,mA \times R_3 + 5000\,\mu A$

(15)

$$25737\mu A = 50\,mA \times R_3 + 5000\mu A$$

$$R_3 = \frac{25737\mu A - 5000\mu A}{50\,mA} = \frac{20737\mu A}{50\,mA}$$

$$R_3 = 0.4147 = 0.42\,\Omega$$

But,

$$R_1 + R_2 = 0.52 - R_3$$

$$\therefore\ R_1 + R_2 = 0.52 - 0.4147 = 0.10526$$

So, $R_2 = 0.10526 - R_1$ —— (5)

from eqn. (4)

$$99950\mu A\,(R_1) = 50\mu A \times (100 + R_2 + R_3 + R_4)$$

But,

$$R_2 + R_3 + R_4 = 5.26 - R_1$$ —— [from (1) eqn]

Substitute in eqn. (4)

$$99950\mu A \times R_1 = 50\mu A \times (100 + 5.26 - R_1)$$

$$99950\mu A \times R_1 = 5000\mu A + (50\mu A \times 5.26) - (R_1 \times 50\mu A)$$

$$(99950\mu A + 50\mu A)\,R_1 = 5000\mu A + 263\mu A$$

$$100\,mA \times R_1 = 5263\mu A$$

$$R_1 = \frac{5263\mu A}{100\,mA} = 0.05263\,\Omega$$

from eqn. (V)

(16)

$R_2 = 0.10526 - R_1$

$= 0.10526 - 0.05263$

$R_2 = 0.05263\Omega$

So Shunts values are

$R_1 = 0.05263\Omega$, $R_2 = 0.05263\Omega$

$R_3 = 0.4147\Omega$, $R_4 = 4.74\Omega$ ——.

⟹ Ans.