

Serial No.

16488

A-FTF-J-FFA

## ELECTRICAL ENGINEERING

Paper—I

(Conventional)

Time Allowed : Three Hours

Maximum Marks : 200

### INSTRUCTIONS

*Candidates should attempt SIX questions, selecting TWO questions from Part—A, ONE from Part—B, ONE from Part—C and TWO from Part—D.*

*The number of marks carried by each question is indicated at the end of the question.*

*Answers must be written in ENGLISH.*

*Assume suitable data, if necessary, and indicate the same clearly.*

*Wherever a question is attempted, all its subdivisions must be attempted.*

*Unless otherwise indicated, symbols and notations have their usual meanings.*

### PART—A

1. (a) A certain linear, homogeneous, isotropic dielectric material has a relative permittivity of 1.8. If the applied voltage in the material is—4000 volts in

the y-axis direction, determine Electric field intensity  $\vec{E}$ , Electric flux density  $\vec{D}$  and polarization  $\vec{P}$ . Also find the volume charge density  $\rho_v$ . 12

(b) Find the magnitude of the magnetic flux density in a material for which :

(i) the magnetization is 2.8 A/m and magnetic susceptibility is 0.0025;

(ii) the magnetic field intensity is 1300 A/m and the relative permeability is 1.006;

(iii) there are  $8.2 \times 10^{28}$  atoms per cubic meter, each having a dipole moment of  $3 \times 10^{-30}$  A.m<sup>2</sup> in the same direction, and the magnetic susceptibility is  $2 \times 10^{-4}$ . 10

(c) Show that in a source-free region ( $\vec{J} = 0, \rho_v = 0$ ), Maxwell's equations can be reduced to two. Identify the two all-embracing equations. 10

2. (a) The block diagram of a unity feedback control system is given in Fig. 2 (a).

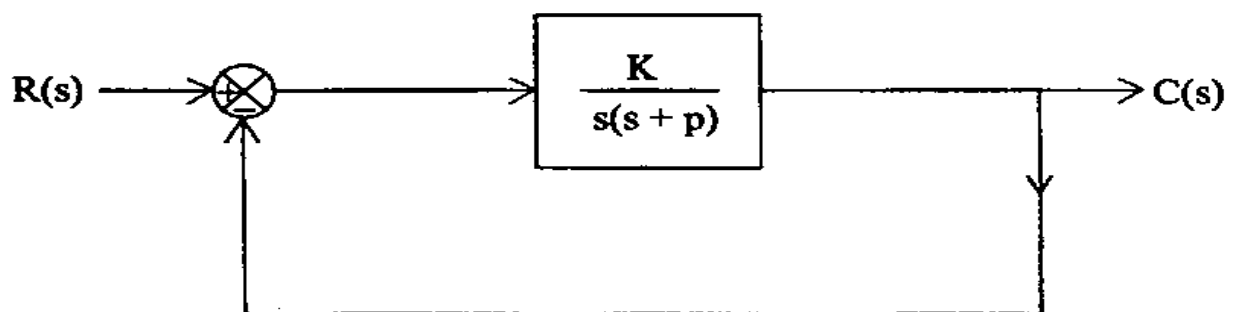


Fig. 2 (a)

The parameters  $K$  and  $p$  are both greater than zero.

Determine the values of ' $K$ ' and ' $p$ ' to satisfy the following frequency domain specifications :

$$\text{Resonant peak } M_p = 1.04$$

$$\text{Resonant frequency} = 11.55 \text{ rad/sec.} \quad 12$$

- (b) For the Fig. 2 (c), find the expression of the closed loop transfer function. 10
- (c) For the feedback control system shown in Fig. 2 (c) find the range of  $K$  for the stability of closed loop system.

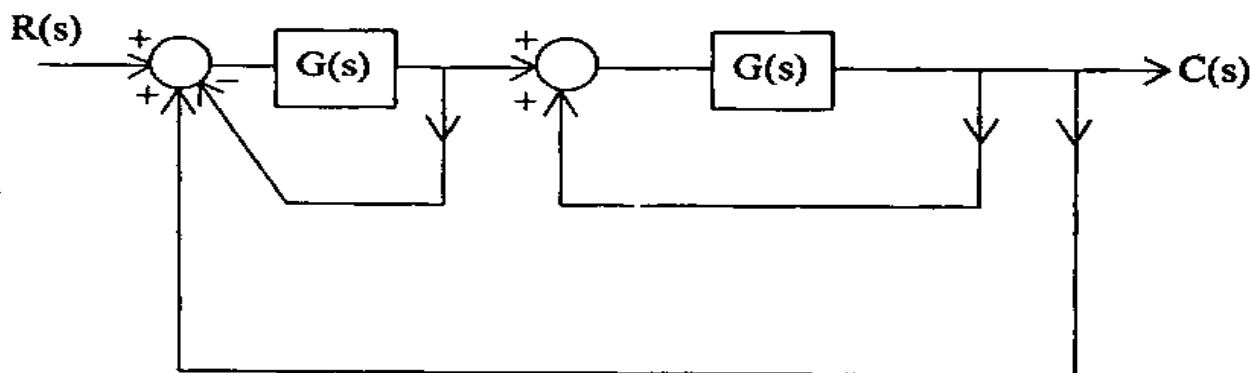


Fig. 2 (c)

Given :

$$G(s) = \frac{K}{(s+4)(s+5)} \quad 10$$

3. (a) The Nyquist plot of an all-pole second order open-loop system is shown in Fig. 3 (a). Obtain the transfer function of the system. 12

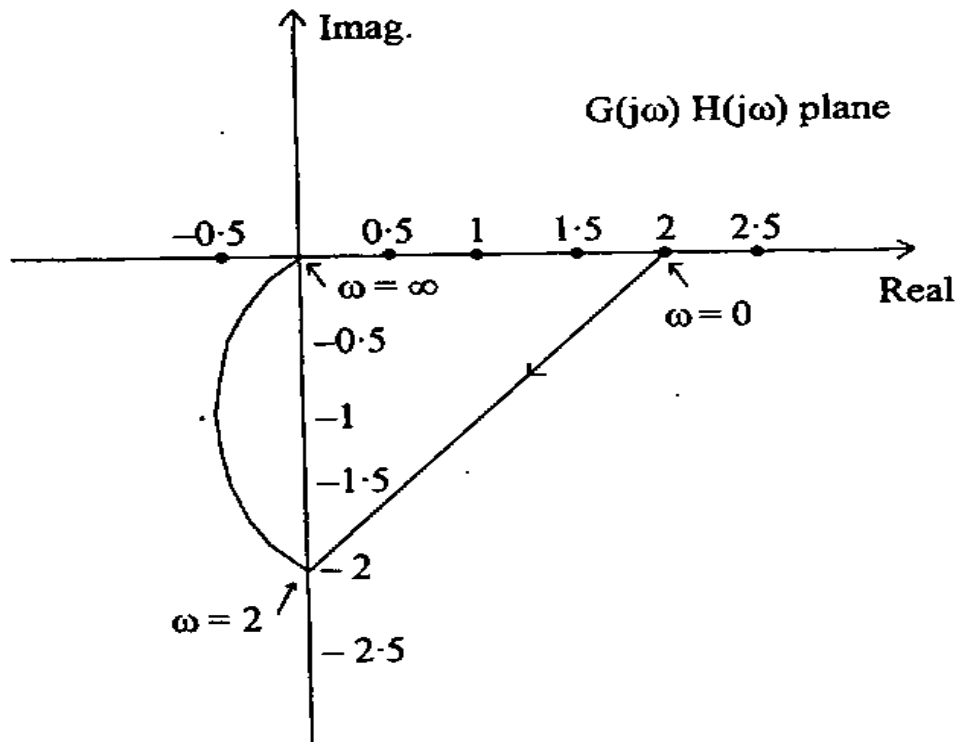


Fig. 3 (a)

- (b) For the system shown in Fig. 3 (b) find using Nyquist stability criterion the range of values of  $T$  so that the closed-loop system is stable. 10

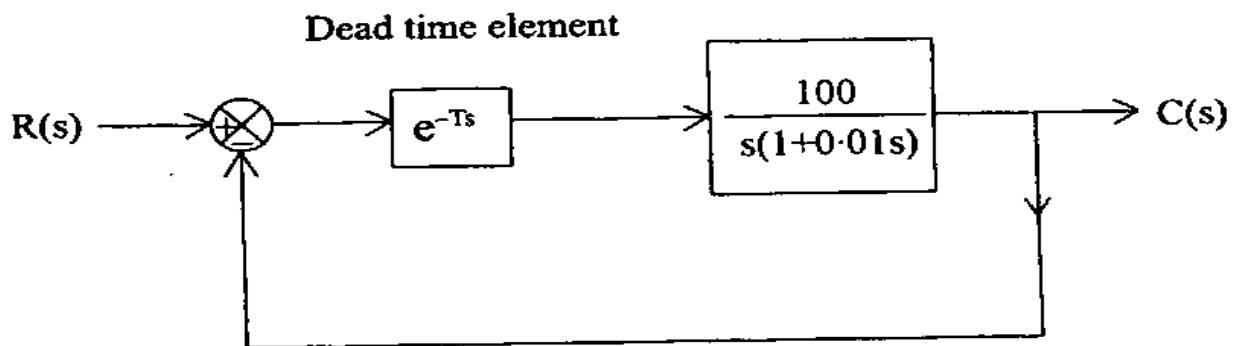


Fig. 3 (b)

- (c) The unit step response of a linear control system is shown in Fig. 3 (c). Find the transfer function of a second order prototype system to model the system. 10

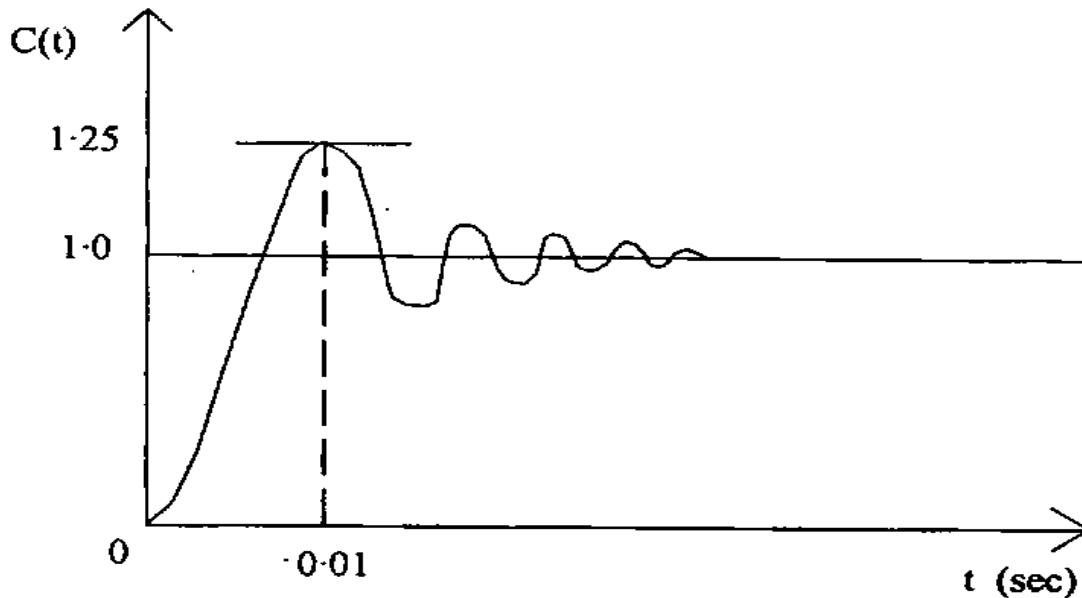


Fig. 3 (c)

**PART—B**

4. (a) Distinguish between 'hard' and 'soft' magnetic materials. List the properties and applications of 'hard' magnetic materials, giving 2 examples of such materials. 12
- (b) A solid dielectric specimen has a dielectric constant of 4.8, and  $\tan \delta = 0.001$  at a frequency of 100 Hz. If it is subjected to an alternating field of 60 kV/cm, calculate the dielectric loss of the specimen. 12

- (c) Write down the properties and the types of insulating materials used in the construction of power and distribution transformers. 12
5. (a) Comment on the statement that “Hall effect” is observed in all metals but is very much prominent in semiconductor materials.”

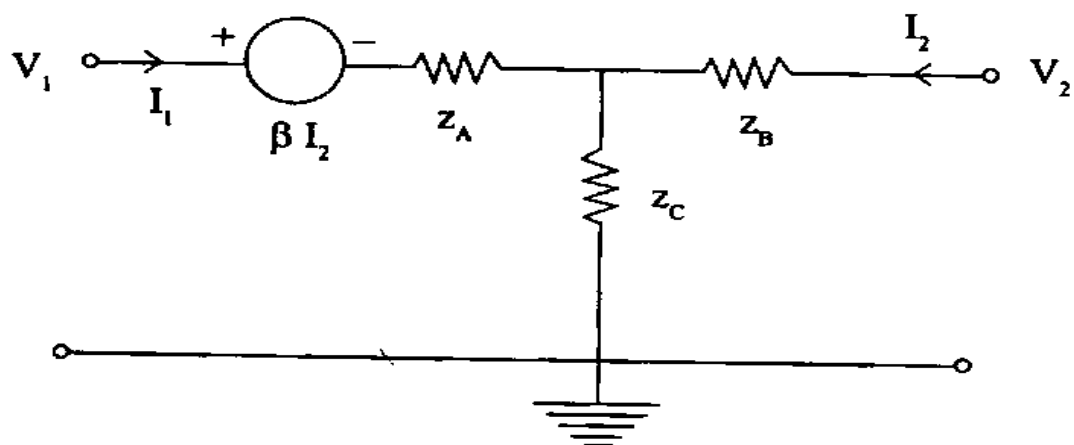
Explain the Hall effect with a neat sketch.

12

- (b) List the different groups into which semiconducting materials can be classified. Name at least one material from each group. 12
- (c) The magnetic susceptibility of  $\text{Fe}_2\text{O}_3$  is  $1.4 \times 10^{-3}$ . Calculate the flux density and magnetization when it is subjected to a magnetic field of  $10^6$  A/m. 12

### PART—C

6. (a) A 2-port network has z-parameters  $z_{11}$ ,  $z_{12}$ ,  $z_{21}$ ,  $z_{22}$ . It is to be represented by the equivalent circuit shown in the figure. Determine the values of  $z_A$ ,  $z_B$ ,  $z_C$  and  $\beta$ . 12



{6}

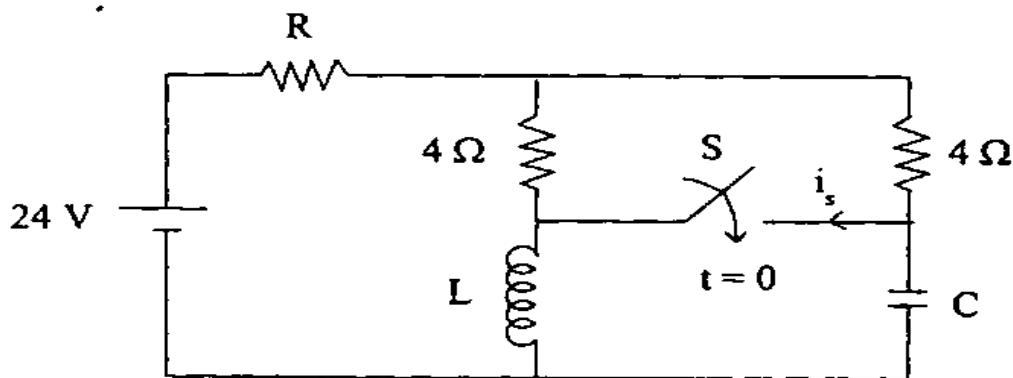
(Contd.)

- (b) The circuit shown in the figure is in steady-state with switch S open. The switch is closed at time  $t = 0$ .

Determine the value of R so that the current  $i_s(0^+)$  through the switch is 1.2 A.

Determine  $i_s(\infty)$ .

12



- (c) A system has a transfer function

$$T(s) = \frac{s^2 - 2s + 1}{s^2 + 2s + 1}$$

Sketch the magnitude and phase responses of the system.

Sketch the polar-plot of  $T(j\omega)$  as a function of  $\omega$ .

Find poles and zeros of  $T(s)$ .

12

7. (a) State 'Voltage to current source transformation' theorem.

It is required to replace network N in Fig. (a) by a suitable equivalent network. Which of the networks of Fig. (b) could be valid equivalent network(s) ?

12

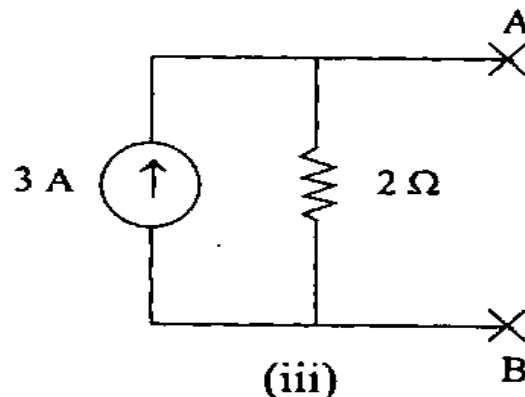
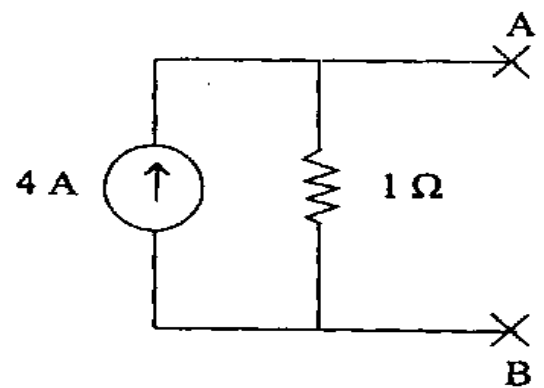
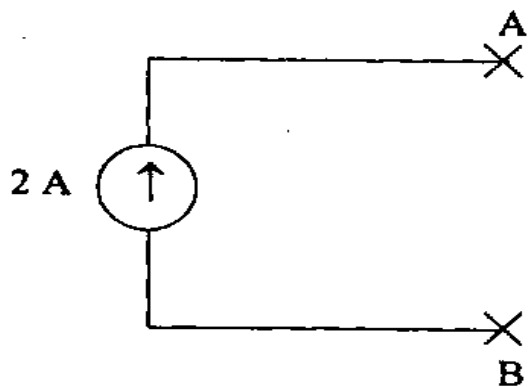
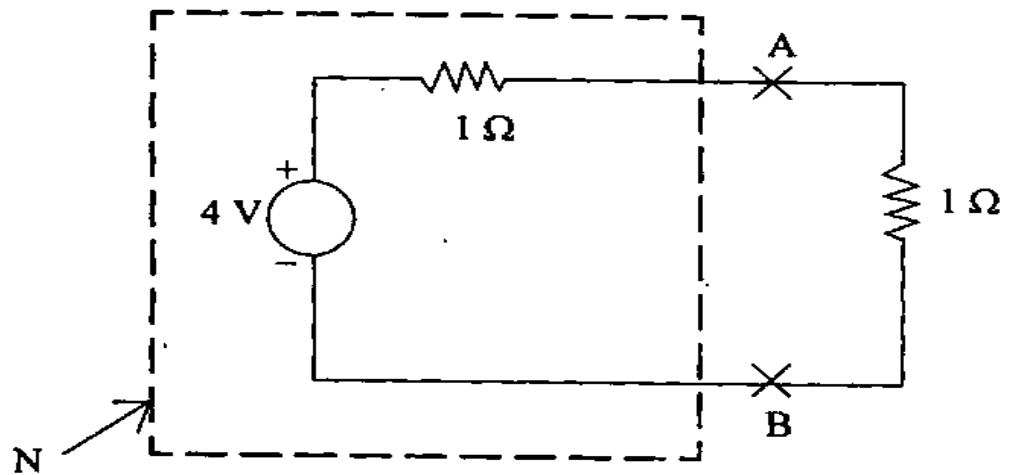


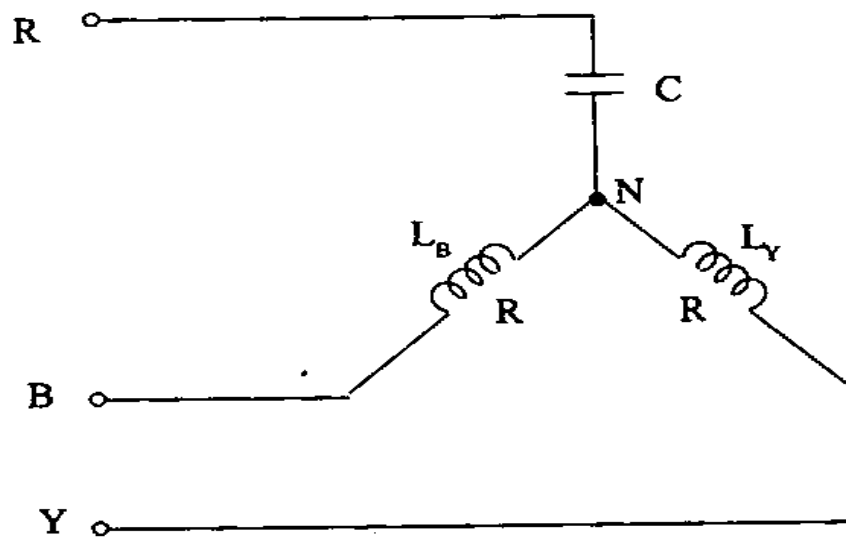
Fig. (b)

{8}

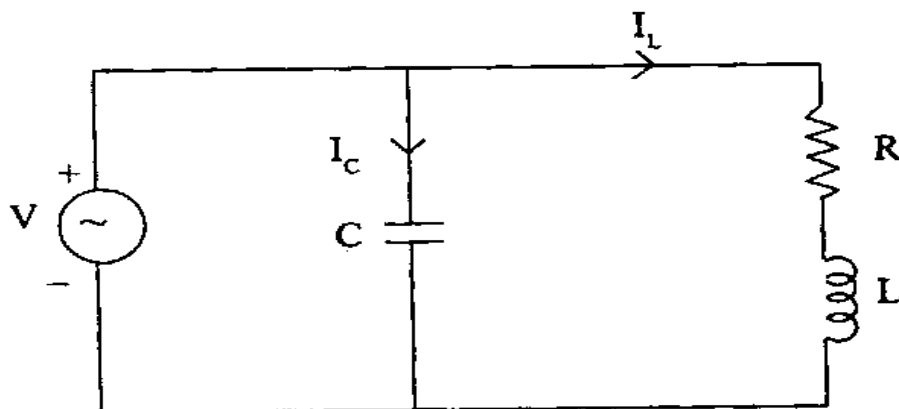
(Contd.)



- (b) A star-connected load is connected across a 3-phase balanced a-c supply as shown in the figure. The lamps  $L_B$  and  $L_Y$  have equal resistances. If the phase-sequence is  $\overline{RYB}$ , draw a neat phasor diagram with  $V_{YB}$  as the reference phasor, and hence find out which lamp will glow brighter. 12



- (c) For the parallel circuit shown in the figure draw a neat phasor diagram and determine an expression for the value of the capacitor C for the circuit to exhibit the unity power factor. 8+4=12



## PART—D

8. (a) (i) Describe with the help of a block diagram a multi-channel data acquisition system (DAS). 6
- (ii) Explain the construction of a shunt multiplier. 4
- (b) Explain with the help of a circuit diagram, the working of a digital voltmeter. Why is it considered to be accurate ? 10
- (c) Draw the circuit of Anderson bridge. Derive the null conditions. Show that Maxwell bridge is the special case of this bridge. 12
9. (a) A moving coil ammeter has a fixed shunt of  $0.02 \Omega$  with a coil circuit resistance of  $R = 1 \text{ k}\Omega$  and needs potential difference of  $0.5 \text{ V}$  across it for full scale deflection.
- (i) Calculate the current it corresponds to;
- (ii) Find the value of shunt when the total current is 10 Amperes. 12.
- (b) The inductive reactance of the pressure-coil circuit of a dynamometer wattmeter is  $0.4\%$  of its resistance at normal frequency ( $50 \text{ Hz}$ ) and the capacitance is negligible.
- Calculate the percentage error and correction factor due to the reactance for load at  $0.707 \text{ p.f. lagging}$ . 10

- (c) Draw an electrodynamic type frequency meter circuit and explain its working. 10
10. (a) (i) Discuss the difference between the construction of PMMC and dynamometer instruments. 4
- (ii) Draw the circuit of a Kelvin double ratio arm bridge and show how the effect of lead resistance is eliminated. 8
- (b) Calculate the gauge factor of a strain gauge if a 1.5 mm-diameter conductor that is 24 mm long changes length by 1 mm and diameter by 0.02 mm under a compression force. 10
- (c) Is tachometer a transducer ? Give a circuit to measure d.c. output from ac tachometer. 10

