Q523

Example 3.20. *A base load station having a capacity of 18 MW and a standby station having a capacity of 20 MW share a common load. Find the annual load factors and plant capacity factors of two power stations from the following data :*

Annual standby station output	$= 7{\cdot}35 \times 10^6$ *kWh*
Annual base load station output	$= 101{\cdot}35 \times 10^6$ *kWh*
Peak load on standby station	$= 12$ *MW*
Hours of use by standby station/year	$= 2190$ *hours*

Solution.

Q524

Example 3.22. *The annual load duration curve for a typical heavy load being served by a steam station, a run-of-river station and a reservoir hydro-electric station is as shown in Fig. 3.16. The ratio of number of units supplied by these stations is as follows :*

Q525

it is the fundamental method in making economy studies.

Example 4.1. *A transformer costing Rs 90,000 has a useful life of 20 years. Determine the annual depreciation charge using straight line method. Assume the salvage value of the equipment to be Rs 10,000.*

Q526

Example 4.2. *A distribution transformer costs Rs 2,00,000 and has a useful life of 20 years. If the salvage value is Rs 10,000 and rate of annual compound interest is 8%, calculate the amount to be saved annually for replacement of the transformer after the end of 20 years by sinking fund method.*

Q527

Example 4.3. *The equipment in a power station costs Rs 15,60,000 and has a salvage value of Rs 60,000 at the end of 25 years. Determine the depreciated value of the equipment at the end of 20 years on the following methods :*

(*i*) Straight line method ;

(*ii*) Diminishing value method ;

(*iii*) Sinking fund method at 5% compound interest annually.

Q528

Example 4.4. *A generating station has a maximum demand of 50,000 kW. Calculate the cost per unit generated from the following data :*

Capital cost = Rs 95×10^6 ;	*Annual load factor* = 40%
Annual cost of fuel and oil = Rs 9×10^6 ;	*Taxes, wages and salaries etc.* = Rs $7{\cdot}5 \times 10^6$
Interest and depreciation = 12%	

Q529

Example 4.5. *A generating station has an installed capacity of 50,000 kW and delivers 220 × 10^6 units per annum. If the annual fixed charges are Rs 160 per kW installed capacity and running charges are 4 paise per kWh, determine the cost per unit generated.*

Q534

Example 6.2 *A single phase motor connected to 400 V, 50 Hz supply takes 31·7A at a power factor of 0·7 lagging. Calculate the capacitance required in parallel with the motor to raise the power factor to 0·9 lagging.*

Q536

Example 6.4 *A 3-phase, 5 kW induction motor has a p.f. of 0·75 lagging. A bank of capacitors is connected in delta across the supply terminals and p.f. raised to 0·9 lagging. Determine the kVAR rating of the capacitors connected in each phase.*

Q538

Example 8.1. *In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self-capacitance of each insulator, find (i) the distribution of voltage over 3 insulators and (ii) string efficiency.*

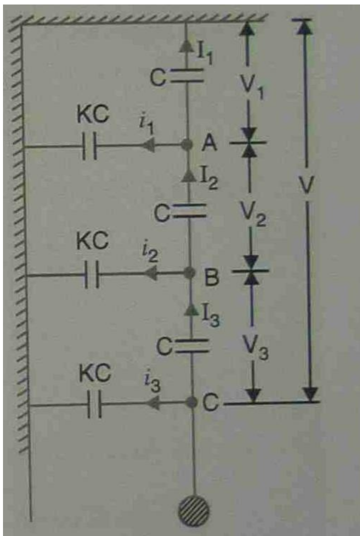


Fig. 8.14

Q539

Example 8.2. *A 3-phase transmission line is being supported by three disc insulators. The potentials across top unit (i.e., near to the tower) and middle unit are 8 kV and 11 kV respectively. Calculate (i) the ratio of capacitance between pin and earth to the self-capacitance of each unit (ii)the line voltage and (iii) string efficiency.*

Q540

Example 8.3. *Each line of a 3-phase system is suspended by a string of 3 similar insulators. If the voltage across the line unit is 17·5 kV, calculate the line to neutral voltage. Assume that the shunt capacitance betwen each insulator and earth is 1/8th of the capacitance of the insulator itself. Also find the string efficiency.*

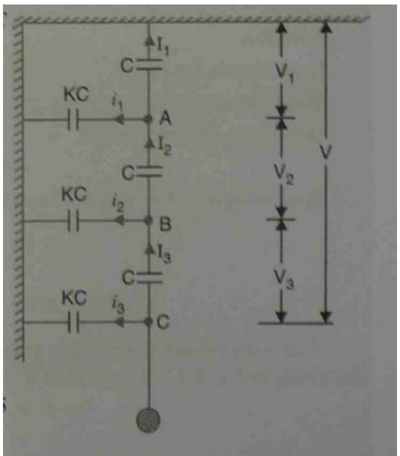


Fig. 8.15

Q541

Example 8.17. *A 132 kV transmission line has the following data :*

Wt. of conductor = 680 kg/km ; *Length of span = 260 m*

Ultimate strength = 3100 kg ; *Safety factor = 2*

Calculate the height above ground at which the conductor should be supported. Ground clearance required is 10 metres.

Q542

Example 8.18. *A transmission line has a span of 150 m between level supports. The conductor has a cross-sectional area of 2 cm^2. The tension in the conductor is 2000 kg. If the specific gravity of the conductor material is 9·9 gm/cm^3 and wind pressure is 1·5 kg/m length, calculate the sag. What is the vertical sag?*

Q543

Example 9.1. *A single phase line has two parallel conductors 2 metres apart. The diameter of each conductor is 1·2 cm. Calculate the loop inductance per km of the line.*

Q544

Example 9.2. *A single phase transmission line has two parallel conductors 3 m apart, the radius of each conductor being 1 cm. Calculate the loop inductance per km length of the line if the material of the conductor is (i) copper (ii) steel with relative permeability of 100.*

Q545

Example 10.1. *A single phase overhead transmission line delivers 1100 kW at 33 kV at 0·8 p.f. lagging. The total resistance and inductive reactance of the line are 10 Ω and 15 Ω respectively. Determine : (i) sending end voltage (ii) sending end power factor and (iii) transmission efficiency.*

Q546

Example 10.2. *What is the maximum length in km for a 1-phase transmission line having copper conductor of 0·775 cm^2 cross-section over which 200 kW at unity power factor and at 3300V are to be delivered ? The efficiecny of transmission is 90%. Take specific resistance as 1.725 μ Ω cm.*

Q547

Example 10.3. *An overhead 3-phase transmission line delivers 5000 kW at 22 kV at 0·8 p.f. lagging. The resistance and reactance of each conductor is 4 Ω and 6 Ω respectively. Determine : (i) sending end voltage (ii) percentage regulation (iii) transmission efficiency.*

Q548

Example 10.16. *A balanced 3-phase load of 30 MW is supplied at 132 kV, 50 Hz and 0·85 p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20 + j52) ohms and the total phase-neutral admittance is 315×10^{-6} siemen. Using nominal T method, determine: (i) the A, B, C and D constants of the line (ii) sending end voltage (iii) regulation of the line.*

Q549

Example 10.18. *Find the following for a single circuit transmission line delivering a load of 50 MVA at 110 kV and p.f. 0·8 lagging :*

(i) sending end voltage (ii) sending end current (iii) sending end power (iv) efficiency of transmission. Given A = D = 0·98 ∠3°; B = 110 ∠75° ohm ; C = 0·0005 ∠80° siemen.

Q552

Example 11.17. *The capacitance per kilometre of a 3-phase belted cable is 0·3 μ F between the two cores with the third core connected to the lead sheath. Calculate the charging current taken by five kilometres of this cable when connected to a 3-phase, 50 Hz, 11 kV supply.*

Q553

Example 11.18. *The capacitances of a 3-phase belted cable are 12·6 μF between the three cores bunched together and the lead sheath and 7·4 μF between one core and the other two connected to sheath. Find the charging current drawn by the cable when connected to 66 kV, 50 Hz supply.*

Q554

Example 11.19. *The capacitance per kilometre of a 3-phase belted cable is 0·18 μF between two cores with the third core connected to sheath. Calculate the kVA taken by 20 km long cable when connected to 3-phase, 50 Hz, 3300 V supply.*

Q556

Example 13.1. *A 2-wire d.c. distributor cable AB is 2 km long and supplies loads of 100A, 150A,200A and 50A situated 500 m, 1000 m, 1600 m and 2000 m from the feeding point A. Each conductor has a resistance of 0·01 Ω per 1000 m. Calculate the p.d. at each load point if a p.d. of 300 V is maintained at point A.*

Q557

Example 13.28. *A 3-wire 500/250 V d.c. system has a load of 35 kW between the positive lead and the middle wire and a load of 20 kW between the negative lead and the middle wire. If there is a break in the middle wire, calculate the voltage between the outers and the middle wire.*

Q558

Example 13.29. *A 3-wire, 500/250 V distributor is loaded as shown in Fig. 13.54. The resistance of each section is given in ohm. Find the voltage across each load point.*

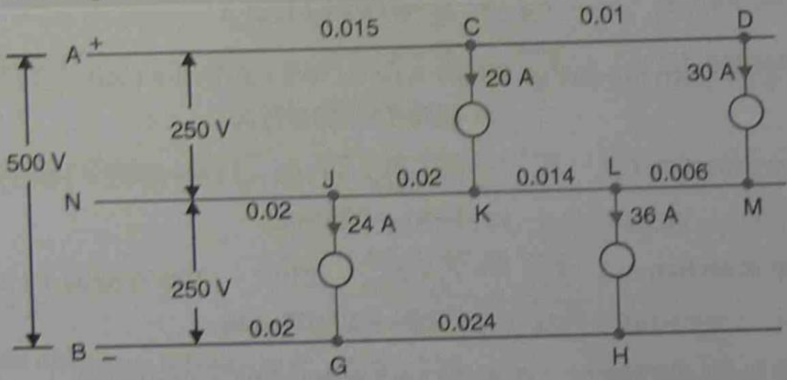


Fig. 13.54

Q559

Example 14.3. *A single phase distributor one km long has resistance and reactance per conductor of 0·1 Ω and 0·15 Ω respectively. At the far end, the voltage V_B = 200 V and the current is 100 A at a p.f. of 0·8 lagging. At the mid-point M of the distributor, a current of 100 A is tapped at a p.f.*

Q589

An isolated 75 MVA synchronous generator feeds its own load and operates initially at no-load at 3000 r.p.m., 50 Hz. A 20 MW load is suddenly applied and the steam valves to the turbine commence to open after 0.5 s due to the time-lag in the governor system. Calculate the frequency to which the generated voltage drops before the steam flow meets the new load. The stored energy for the machine is 4 kW-s per kVA of generator capacity.

Q590

Two synchronous generators operate in parallel and supply a total load of 200 MW. The capacities of the machines are 100 MW and 200 MW and both have governor droop characteristics of 4 per cent from no load to full load. Calculate the load taken by each machine, assuming free governor action.

Q591

A 132 kV line is fed through an 11/132 kV transformer from a constant 11 kV supply. At the load end of the line the voltage is reduced by another transformer of nominal ratio 132/11 kV. The total impedance of the line and transformers at 132 kV is (25 + j66) Ω. Both transformers are equipped with tap-changing facilities which are arranged so that the product of the two off-nominal settings is unity. If the load on the system is 100 MW at 0.9 p.f. lagging, calculate the settings of the tap-changers required to maintain the voltage of the load busbar at 11 kV. Use a base of 100 MVA.

Q592

An 11.8 kV busbar is fed from three synchronous generators having the following ratings and reactances,

20 MVA, X' 0.08 p.u.; 60 MVA, X' 0.1 p.u.; 20 MVA, X' 0.09 p.u.

Calculate the fault current and MVA if a three-phase symmetrical fault occurs on the busbars. Resistance may be neglected. The voltage base will be taken as 11.8 kV and the VA base as 60 MVA.

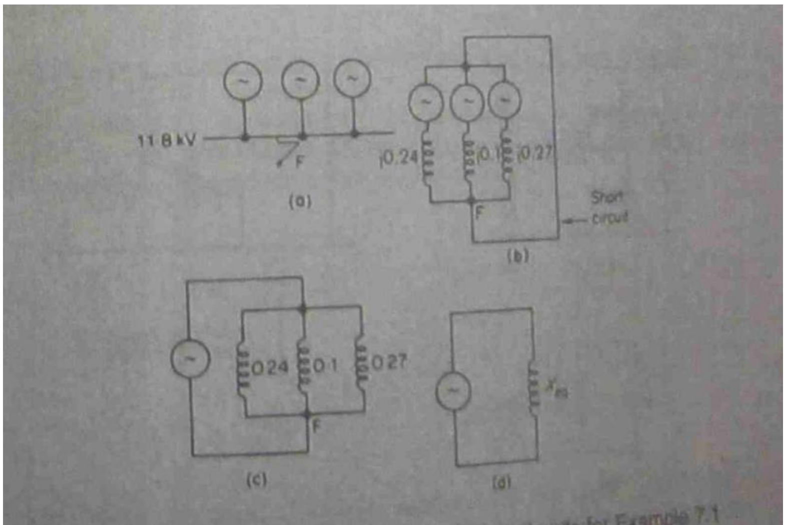


Figure 7.3 Line diagram and equivalent circuits for Example 7.1

Q593

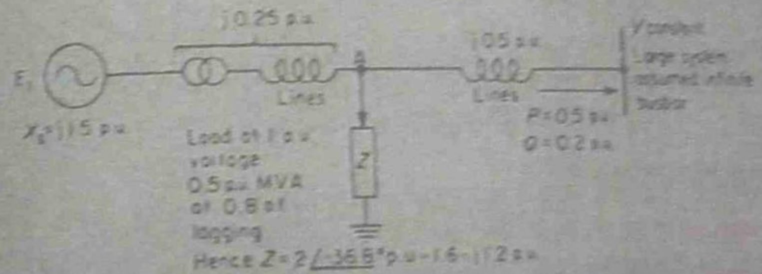
In the network shown in Figure 7.4, a three-phase fault occurs at point F. Calculate the fault MVA at F. The per unit values of reactance all refer to a base of 100 MVA. Resistance may be neglected.

Q594

A synchronous generator of reactance 1.5 p.u. is connected to an infinite busbar system (V = 1 p.u.) through a line and transformers of total reactance 0.5 p.u. The no-load voltage of the generator is 1.1 p.u. and the inertia constant H = 5 MW-s per MVA. All per unit values are expressed on the same base; resistance and damping may be neglected. Calculate the frequency of the oscillations set up when the generator operates at a load angle of 60° and is subjected to a small disturbance. The system frequency is 50 Hz.

Q595

For the system shown in Figure 8.3, investigate the steady-state stability



(a) Line diagram of system for Example 8.2

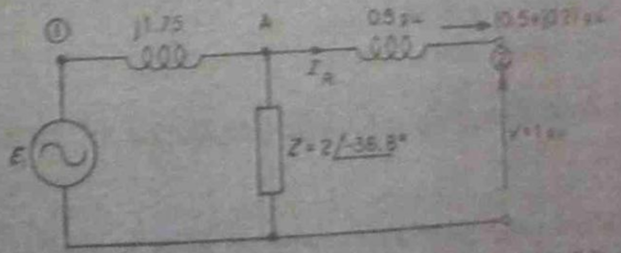


Figure 8.3 (b) Equivalent circuit for Example 8.2

Q596

Determine the relative attenuation occurring in 5 cycles in the overvoltage surge set up on a 66 kV cable fed through an air-blast circuit breaker when the breaker opens on a system short circuit. The breaker incorporates resistance switching, i.e. an optimum resistance switched in across the contact gap on opening. The network parameters are as follows:

$R = 7.8\,\Omega \quad L = 6.4\,\text{mH} \quad C = 0.0495\,\mu\text{F}$

Q597

Determine the time of operation of a 1 A, 3 s overcurrent relay having a plug setting of 125 per cent and a time multiplier of 0.6. The supplying CT is rated 400 : 1 A and the fault current is 4000 A.

Q612

EXAMPLE 6-1. Determine voltage condition on a system of the type shown in Fig. 6-7, assuming that

$V_x = 5000$ V

$P_1 = 600$ kW 0.8 power-factor lag

$Z_1 = 4 \angle 70° \ \Omega$

$P_2 = 400$ kW 0.707 power-factor lag

$Z_2 = 2.5 \angle 60° \ \Omega$

Q613

EXAMPLE 6-3. Refer to Example 6-2. Consider that network 1 is connected in parallel with network 2. Determine the equivalent *ABCD* constants.

Solution.

By Eq. (6-13),

Q639

2. It was thought that $2^p - 1$ was prime when p is a prime. Shown that this is not true when $p = 11$
3. Find the gcd for 3096 and 1234.
4. Write the following decimal numbers in binary
   (a) 256_{10}
   (b) $2^4 - 1$
   (c) 549
   (d) 12.34

Q641

Prove that the sum of the first n natural numbers is given by this formula:

$$S_n = 1 + 2 + 3 + \ldots + n = n(n+1)/2$$

Q642

prove that $8^n - 3^n$ is divisible by 5 for all $n \in \mathbb{N}$.

Q643

1. $\{1,2,3,4\} \cap \{3,4,5,6,7\} = \{3,4\}$. Notice $3 \in \{3,4\}$ while $1 \notin \{3,4\}$.
2. $\{1,2,3,4\} \cap \{13,14,15,16,27\} = \emptyset$.
3. {Abergail, Ann, Blodwin, Bronwin, Clair,}∩ { Abergail, Bronwin, Gareth, Ian} = {Abergail, Bronwin, }.
4. In figure 4.2 we see $A \cap \bar{A} = \emptyset$ so A and $\bar{A}$ have nothing in common.
5. $A \cap B \subset B$ and $A \cap B \subset A$

Union:

Q644

Let S be the set of all outcomes when two dice (one blue ; one green) are thrown. Let A be the subset of outcomes in which both dice are odd, and let B be the subset of outcomes in which both dice are even. We write C for the set of outcomes when the two dice have the same number showing.

How many elements are there in the following sets?

It is useful to have the set S set out as below

Q645

Find

the number of ways of picking 5 students from a group of 19

Q646

Expand

$(2+x)^5$

Q647

1. Suppose $f(x) = x^2$ and $g(y) = 1/y$ then $g(f(x)) = 1/x^2$. We of course have to take care about the definition if the range and the domain to avoid $x = 0$
2. When $f(x) = x^2$ and $g(x) = x^{1/2}$ g is the inverse function when f is defined on the positive reals.

Q649+Q650

Write the substitute equation for

System 1:

$$x'_F = A_F x_F + B_F u$$
$$y_F = C_F x_F + D_F u$$

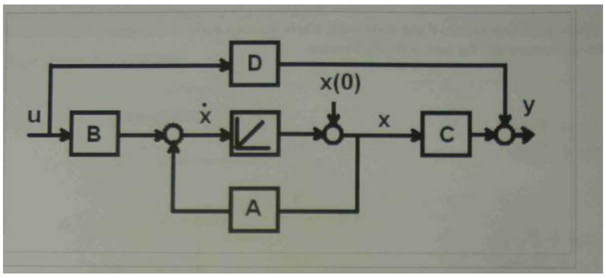
System 2:

$$X'_G = A_G x_G + B_G y_F$$
$$Y_G = C_G x_G + D_G y_F$$

And we can write substitute these equations together form the complete response of system H, that has input u, and output y_G:

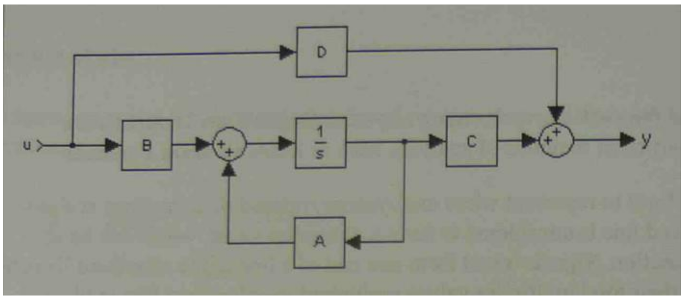
Q651+Q652

Find the state space model of the following system.



Q653

Find the state space equation



Q665

Find the root-locus of the closed-loop system:

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

Q685

Example 1.5.1. Spring–Mass–Damper System

The linear case of the classical system in Fig. 1.6 is considered in Example 2.2.1. The differential equation (2.2) that describes the position $x(t)$ of the mass m in response to an external force $f(t)$ is

$$m\ddot{x} + c\dot{x} + kx = f$$

As discussed in Section 2.2, $-kx$ is the spring force on m, with spring constant k, and $-c\dot{x}$ the damping force, with damping coefficient c. In the linear case k and c are constant, and weight mg does not occur in the equation if $x = 0$ is chosen at the position of static equilibrium, where the weight is counterbalanced by a spring force.

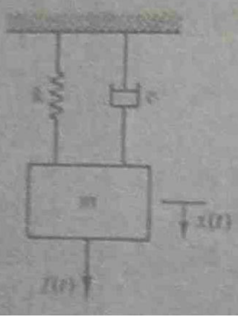


Figure 1.6 Spring–mass–damper system.

Q686

Example 1.7.1

Determine the response to initial conditions $c(0) = 1$, $\dot{c}(0) = 2$ of the system

$$\ddot{c} + 7\dot{c} + 6c = r \qquad (1.30)$$

Q687

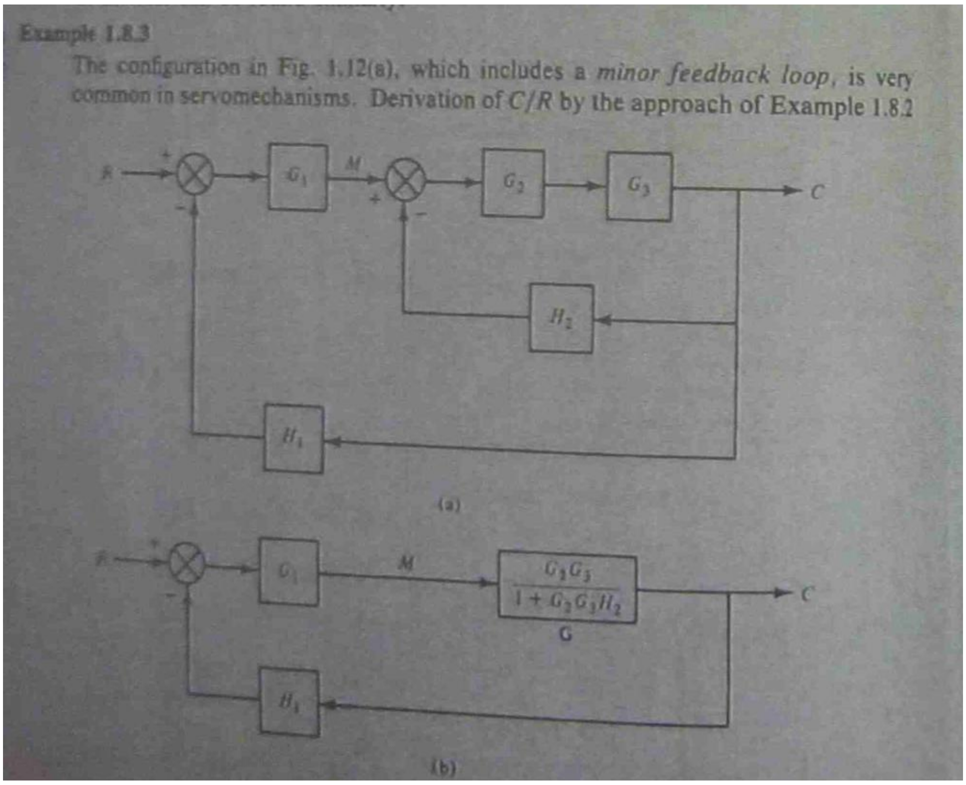
Example 1.7.2

Find the response $c(t)$ of a system with transfer function

$$G(s) = \frac{2(s+3)}{(s+1)(s+6)}$$

Q688

Drive the equation

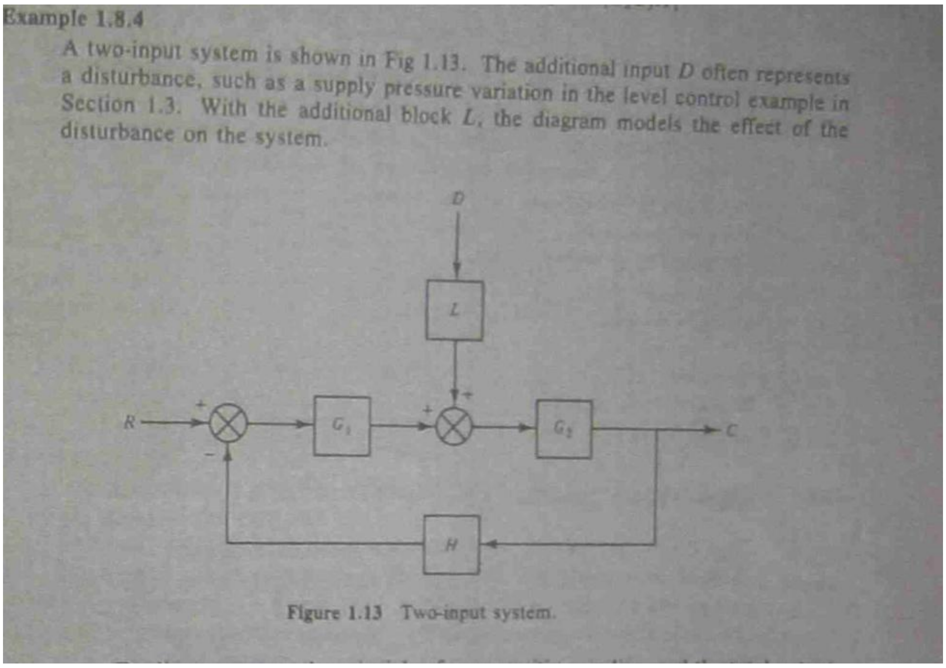


Example 1.8.3

The configuration in Fig. 1.12(a), which includes a *minor feedback loop*, is very common in servomechanisms. Derivation of C/R by the approach of Example 1.8.2

Q689

Drive the equation



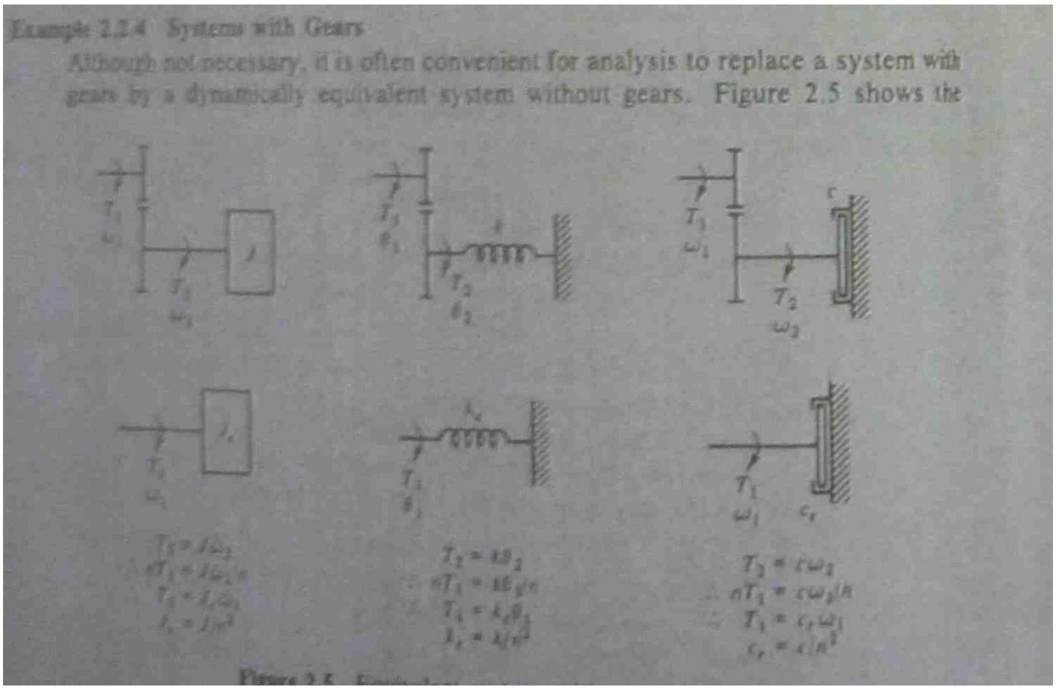
Example 1.8.4

A two-input system is shown in Fig 1.13. The additional input D often represents a disturbance, such as a supply pressure variation in the level control example in Section 1.3. With the additional block L, the diagram models the effect of the disturbance on the system.

Figure 1.13 Two-input system.

Q692

Drive the equation

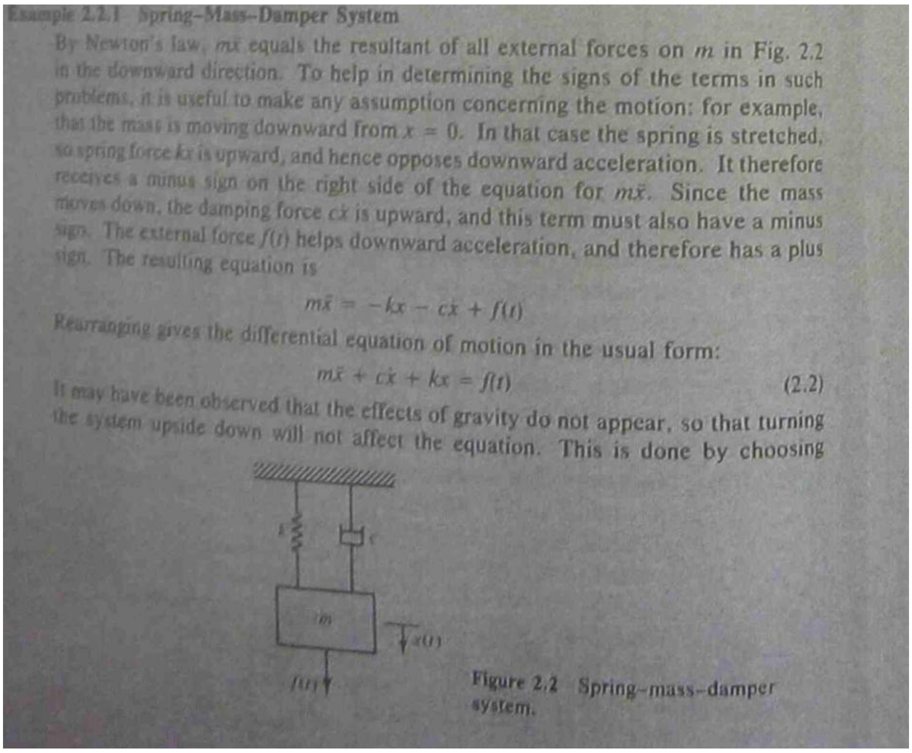


Example 2.2.4 Systems with Gears

Although not necessary, it is often convenient for analysis to replace a system with gears by a dynamically equivalent system without gears. Figure 2.5 shows the

Q690

Drive the equation



Example 2.2.1 Spring–Mass–Damper System

By Newton's law, $m\ddot{x}$ equals the resultant of all external forces on m in Fig. 2.2 in the downward direction. To help in determining the signs of the terms in such problems, it is useful to make any assumption concerning the motion: for example, that the mass is moving downward from $x = 0$. In that case the spring is stretched, so spring force kx is upward, and hence opposes downward acceleration. It therefore receives a minus sign on the right side of the equation for $m\ddot{x}$. Since the mass moves down, the damping force $c\dot{x}$ is upward, and this term must also have a minus sign. The external force $f(t)$ helps downward acceleration, and therefore has a plus sign. The resulting equation is

$$m\ddot{x} = -kx - c\dot{x} + f(t)$$

Rearranging gives the differential equation of motion in the usual form:

$$m\ddot{x} + c\dot{x} + kx = f(t) \quad (2.2)$$

It may have been observed that the effects of gravity do not appear, so that turning the system upside down will not affect the equation. This is done by choosing

Figure 2.2 Spring–mass–damper system.

Q691

Drive the equation

Example 2.2.2 Two-Mass System

The system in Fig. 2.3 can represent a dynamic absorber, where a relatively small mass m_1 is attached to a main mass m via spring k_1 and damper c_1 to reduce vibrations x due to force f. Assume, say, that m and m_1 both move to the right from the zero positions, m farther and faster than m_1. Then spring force $k_1(x - x_1)$ "opposes" m and "helps" m_1, and damper force $c_1(\dot{x} - \dot{x}_1)$ has the same effect. Hence the differential equations of motion become

$$m\ddot{x} = -kx - k_1(x - x_1) - c_1(\dot{x} - \dot{x}_1) + f$$

$$m_1\ddot{x}_1 = k_1(x - x_1) + c_1(\dot{x} - \dot{x}_1)$$

or

$$m\ddot{x} + c_1\dot{x} + (k + k_1)x = c_1\dot{x}_1 + k_1x_1 + f \qquad (2.4)$$

$$m_1\ddot{x}_1 + c_1\dot{x}_1 + k_1x_1 = c_1\dot{x} + k_1x$$

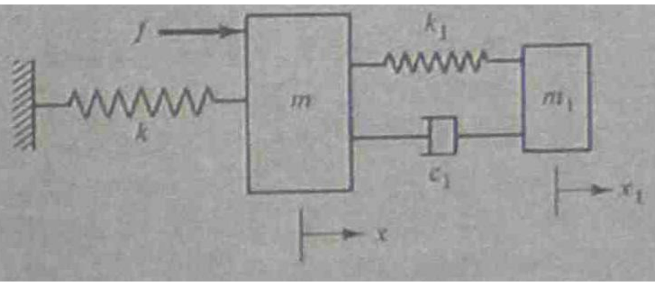


Figure 2.3 Dynamic absorber.

Q693

Drive the equation

Example 2.3.2 Bridged-T Network [Fig. 2.8(f)]

This network is often used in ac control systems, that is, systems in which signals are represented by modulation of an ac carrier. With e_o occurring inside a loop, it may be seen that the voltage-divider approach used above does not apply in equally straightforward fashion. But E_o/E_i can be obtained by the use of Kirchhoff's laws in Fig. 2.7(c), which could also have been used in Example 2.3.1. E_o/E_i will be derived by both the loop and node methods.

(a) *Loop method*: Kirchhoff voltage equations are written for each closed loop in terms of loop current variables:

Q694

Drive the equation

Example 2.4.2 Armature-Controlled DC Motor [Fig. 2.9(b)]

The armature loop is described by

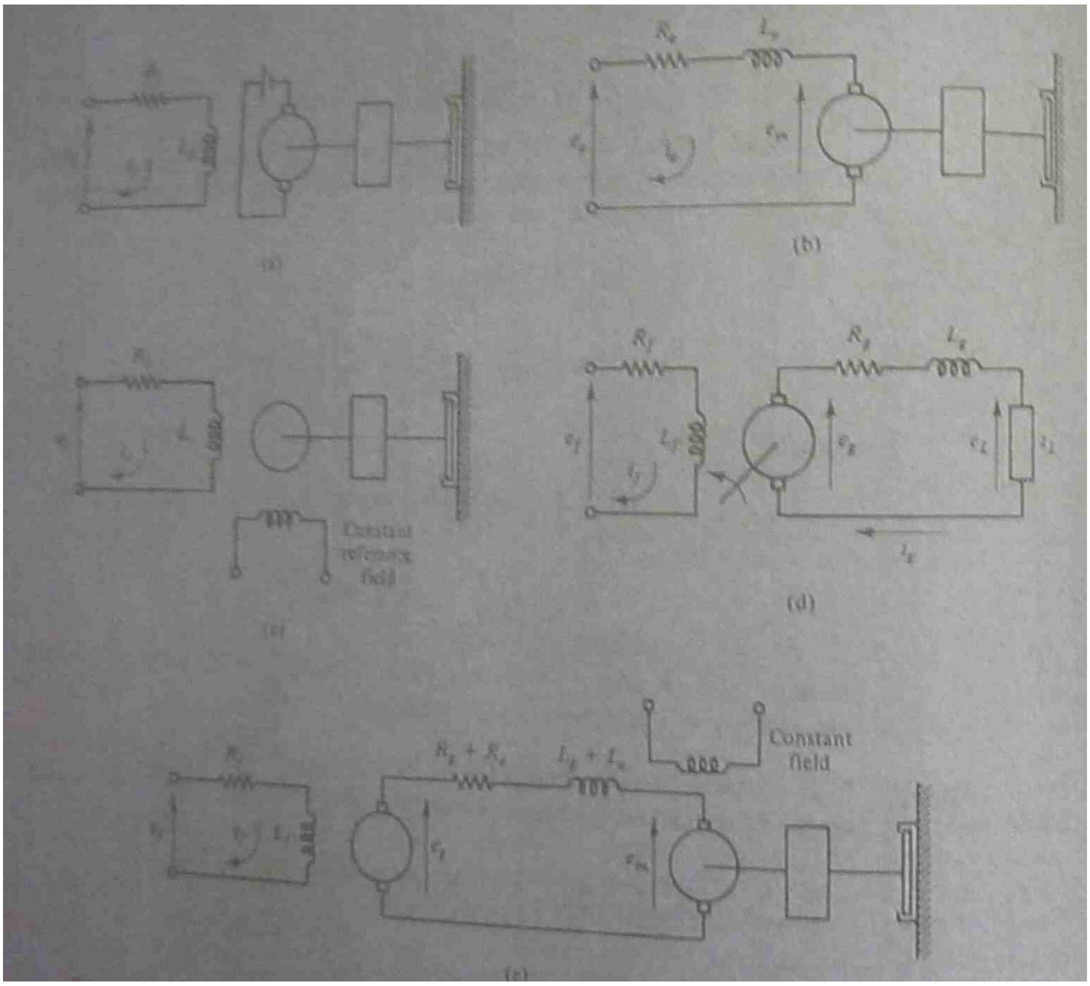
$$e_a = R_a i_a + L_a \dot{i}_a + e_m \qquad E_a = (R_a + L_a s)I_a + E_m$$

Here the counter emf (electromotive force) voltage can be taken to be proportional to shaft speed,

$$e_m = K_v \dot{\theta} \qquad E_m = K_v s\Theta$$

and the developed torque proportional to current i_a,

$$T = K_t i_a \qquad T = K_t I_a$$



Q695

Drive the equation

Figure 2.10 AC motor characteristics.

Example 2.4.8 DC Generator [Fig 2.9(d)]

The field loop equation is

$$e_f = R_f i_f + L_f \dot{i}_f \qquad E_f = (R_f + L_f s) I_f$$

The developed generator voltage e_g can be assumed to be proportional to field current:

$$e_g = K_g i_f \qquad E_g = K_g I_f$$

The voltage e_L across the load is given by

$$E_L = Z_L I_g \qquad Z_L = \text{load impedance}$$

and the generator loop is described by

$$e_g = R_g i_g + L_g \dot{i}_g + e_L \qquad E_g = (L_g s + R_g + Z_L) I_g$$

Q696

Drive the equation

$$T(s) \quad (V/f)s + 1 \qquad (2.21)$$

Example 2.5.1 Space Heating

In Fig 2.15, let T be the difference with a constant ambient temperature. By (2.18), the heat loss q_o to ambient can be modeled by $q_o = T/R_t$, where R_t is the thermal resistance. If q is the heat inflow rate from an electrical heater, the net inflow $(q - T/R_t)$ must equal $C_t \dot{T}$, where C_t is the thermal capacitance. Hence the behavior is modeled by the differential equation

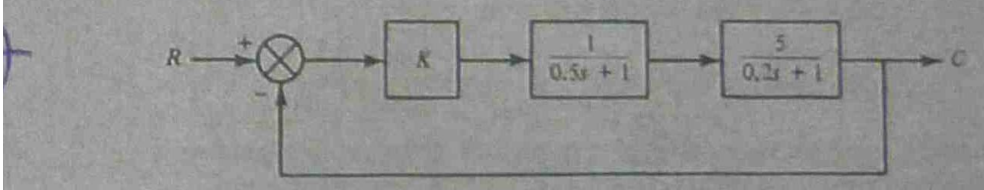
$$R_t C_t \dot{T} + T = R_t q \qquad (2.22)$$

Q697

Drive the equation

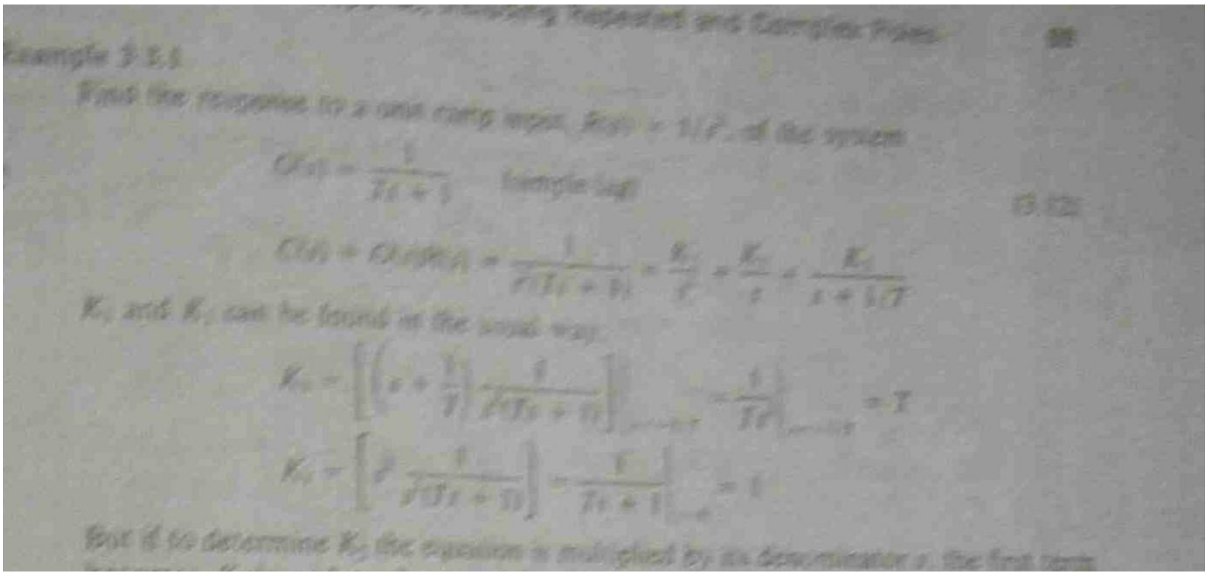
Example 3.2.1

Figure 3.3(a) models a level control system of which the process consists of the two-tank system with control valve in Figs. 2.19 and 2.20 and the level in the second



Q698

Drive the equation


Example 3.3.1

Find the response to a unit ramp input, $R(s) = 1/s^2$, of the system

$$G(s) = \frac{1}{Ts + 1} \qquad (3.12)$$

$$C(s) = G(s)R(s) = \frac{1}{s^2(Ts + 1)} = \frac{K_1}{s^2} + \frac{K_2}{s} + \frac{K_3}{s + 1/T}$$

K_1 and K_3 can be found in the usual way.

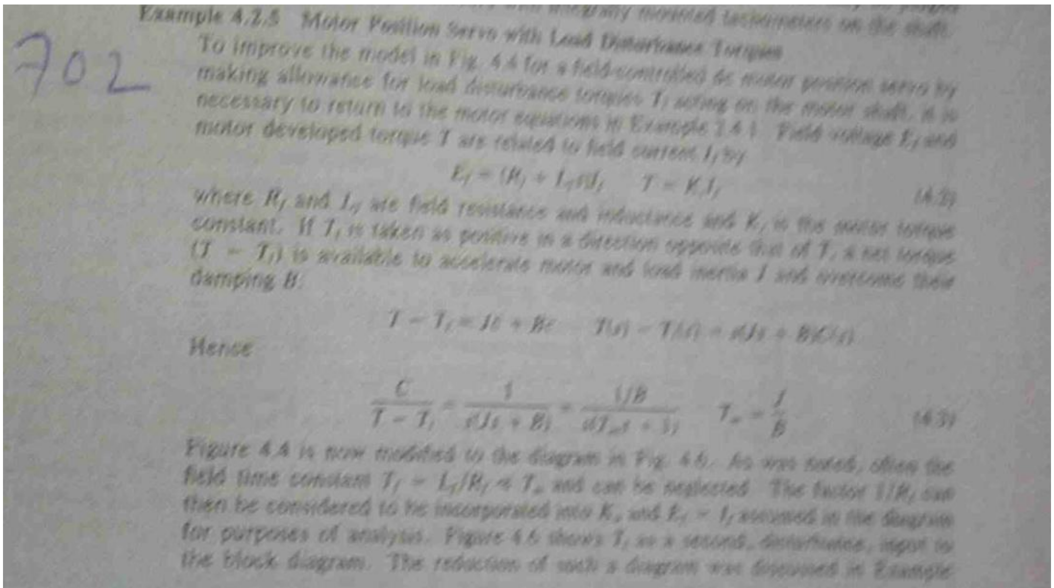
$$K_3 = \left[\left(s + \frac{1}{T}\right)\frac{1}{s^2(Ts + 1)}\right]_{s=-1/T} = \frac{1}{Ts^2}\Big|_{s=-1/T} = T$$

$$K_1 = \left[s^2\frac{1}{s^2(Ts + 1)}\right] = \frac{1}{Ts + 1}\Big|_{s=0} = 1$$

But if to determine K_2 the equation is multiplied by its denominator s, the first term

Q702

Drive the equation


702

Example 4.2.5 Motor Position Servo with Load Disturbance Torques

To improve the model in Fig. 4.4 for a field-controlled dc motor position servo by making allowance for load disturbance torques T_l acting on the motor shaft, it is necessary to return to the motor equations in Example 2.4.1. Field voltage E_f and motor developed torque T are related to field current I_f by

$$E_f = (R_f + L_f s)I_f \qquad T = K_t I_f \qquad (4.2)$$

where R_f and L_f are field resistance and inductance and K_t is the motor torque constant. If T_l is taken as positive in a direction opposite that of T, a net torque $(T - T_l)$ is available to accelerate motor and load inertia J and overcome their damping B:

$$T - T_l = J\ddot{c} + B\dot{c} \qquad T(s) - T_l(s) = s(Js + B)C(s)$$

Hence

$$\frac{C}{T - T_l} = \frac{1}{s(Js + B)} = \frac{1/B}{s(T_m s + 1)} \qquad T_m = \frac{J}{B} \qquad (4.3)$$

Figure 4.4 is now modified to the diagram in Fig. 4.6. As was noted, often the field time constant $T_f = L_f/R_f \ll T_m$ and can be neglected. The factor $1/R_f$ can then be considered to be incorporated into K_t and $E_f = I_f$ assumed in the diagram for purposes of analysis. Figure 4.6 shows T_l as a second, disturbance, input to the block diagram. The reduction of such a diagram was discussed in Example

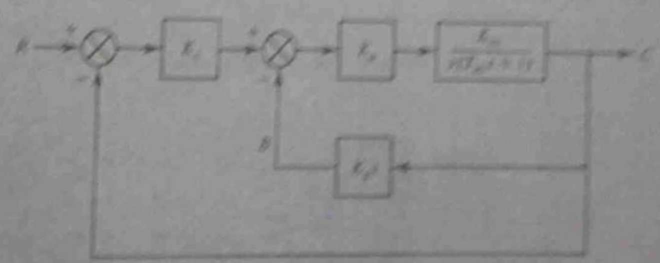


Figure 4.5 Servo with velocity feedback

Q703

Drive the equation

703 **Example 4.3.2 Motor with IR-Drop Compensation**

Figure 4.9 shows the armature-controlled dc motor of Fig. 2.9(b) (Example 2.4.2) with a resistance R added in the armature loop, the voltage across which is fed

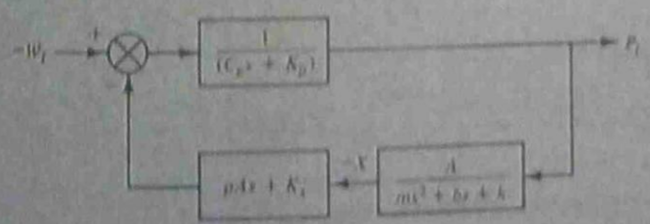


Figure 4.8 Block diagram for Fig. 4.7.

Q704

Drive the equation

Example 5.3.1 PI Control of Simple Lag Plant

In Fig. 5.1(a) let

$$G(s) = \frac{1}{s+1} \qquad G_c(s) = \frac{K_c(s+z)}{s} \tag{5.5}$$

The integral of the error as well as the error itself is used for control. The loop gain function

$$G_cG = \frac{K_c(s+z)}{s(s+1)}$$

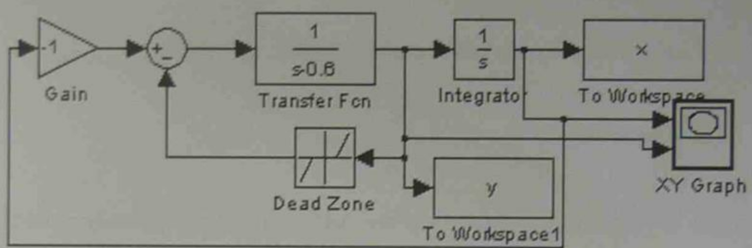
shows immediately the essential improvement due to the addition of ...

Q712

Drive the equation.

Nonlinear Output Derivative Feedback

$s^2 + (K - 0.6)s + 1 = 0$



Q713

Drive the equation.

Relay Position Control

Q714

Position Control with Torque Saturation

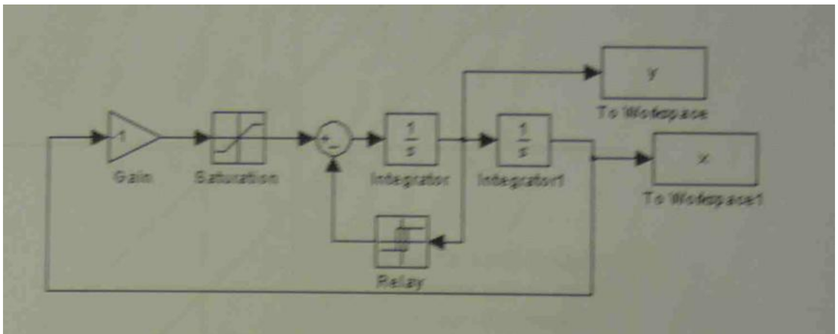


Figure 2.16 Simulink diagram of control system for Example 3

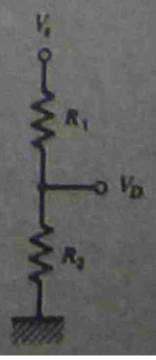
Q715

An amplifier outputs a voltage that is ten times the voltage on its input terminals. It has an input resistance of 10 kΩ. A sensor outputs a voltage proportional to temperature with a transfer function of 20 mV/°C. The sensor has an output resistance of 5.0 kΩ. If the temperature is 50°C, find the amplifier output.

Q716

The divider of Figure 2.4 has $R_1 = 10.0$ kΩ and $V_s = 5.00$ V. Suppose R_2 is a sensor whose resistance varies from 4.00 to 12.0 kΩ as some dynamic variable varies over a range. Then find (a) the minimum and maximum of V_D, (b) the range of output impedance, and (c) the range of power dissipated by R_2.

FIGURE 2.4
The simple voltage divider can often be used to convert resistance variation into voltage variation.



Q717

A 2-kHz data signal is contaminated by 60 Hz of noise. Compare a single-stage and a two-stage *RC* high-pass filter for reducing the noise by 60 dB. What effect does each have on the data signal?

Q718

Design a high-impedance amplifier with a voltage gain of 42.

Q719

Temperature is to be measured in the range of 250°C to 450°C with an accuracy of ±2°C. The sensor is a resistance that varies linearly from 280 Ω to 1060 Ω for this temperature range. Power dissipated in the sensor must be kept below 5 mW. Develop analog signal conditioning that provides a voltage varying linearly from −5 to +5 V for this temperature range. The load is a high-impedance recorder.

Q720

Find the binary equivalent of the base 10 number 47.

Q721

Develop a digital circuit using AND/OR gates that implements the equation developed in Section 3.2.3.

Q722

A sensor converts the liquid level in a tank to voltage according to the transfer function (20 mV/cm). A comparator is supposed to go high (5 V) whenever the level becomes 50 cm. Splashing causes the level to fluctuate by ±3 cm. Develop a hysteresis comparator to protect against the effects of splashing.

Q723

The input to a 10-bit ADC with a 2.500-V reference is 1.45 V. What is the hex output? Suppose the output was found to be 1B4H. What is the voltage input?

Q724

A 4-bit digital word is intended to control the setting of a 2-Ω dc resistive heater. Heat output varies as a 0–24 V input to the heater. Using a 10-V DAC followed by an amplifier and a unity gain high-current amplifier, calculate (a) the settings from minimum to maximum heat dissipation, and (b) how the power varies with LSB changes.

Q725

An SCR with a 4.0-V trigger is used in the circuit of Figure 7.11 as a light-dimmer control. What resistance, R, should be used to provide approximately 10% to 90% on time?

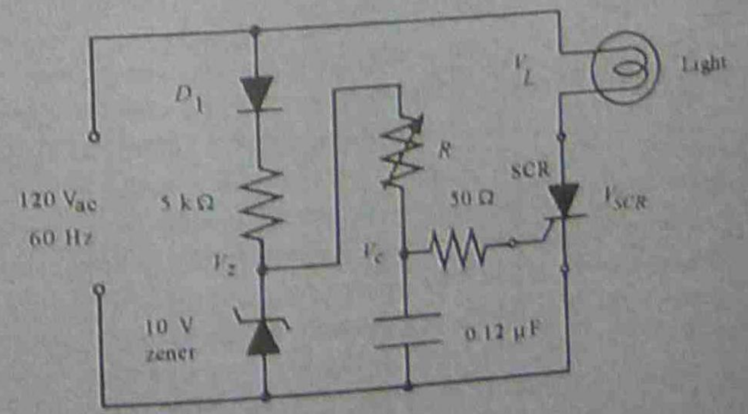


FIGURE 7.11
Circuit for Example 7.3.

Q726

A DIAC is available that has a 28-V breakover voltage, V_L. Show how this can be used to make the light dimmer of Example 7.3 using a TRIAC. Again, we want approximately a 10% to 90% range of adjustment using R, with $C = 0.12\ \mu F$.

Q727

Study the pictorial process of Figure 8.7. Identify the input and output devices and the characteristics of each device.

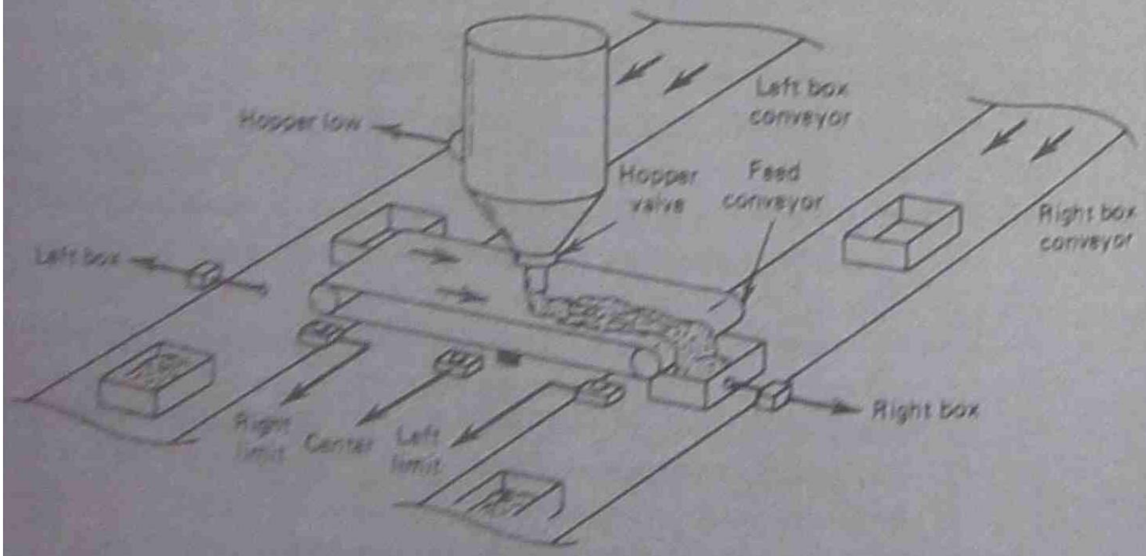


FIGURE 8.7
A discrete-control process.

Q728

Construct a narrative statement outline of the event sequence for the system shown in Figure 8.5. The objective is to fill bottles moving on a conveyor.

Q729

A controller outputs a 4–20-mA signal to control motor speed from 140–600 rpm with a linear dependence. Calculate (a) current corresponding to 310 rpm and (b) the value of (a) expressed as the percent of control output.

Q730

A liquid-level control system linearly converts a displacement of 2–3 m into a 4–20-mA control signal. A relay serves as the two-position controller to open or close an inlet valve. The relay closes at 12 mA and opens at 10 mA. Find (a) the relation between displacement level and current, and (b) the neutral zone or displacement gap in meters.

Q731

Suppose a process error lies within the neutral zone with $p = 25\%$. At $t = 0$, the error falls below the neutral zone. If $K = +2\%$ per second, find the time when the output saturates.

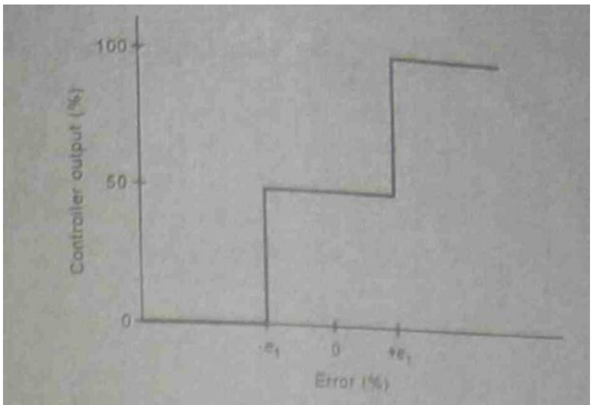


FIGURE 9.5
Three-position controller action.

Q732

Let us combine everything and see how the error of Figure 9.22a produces an output in the three-mode controller with $K_P = 5$, $K_I = 0.7\ s^{-1}$, $K_D = 0.5$ s, and $p_I(0) = 20\%$. Draw a plot of the controller output.

Q733

Level measurement in a sump tank is provided by a transducer scaled as 0.2 V/m. A pump is to be turned on by application of +5 V when the sump level exceeds 2.0 m. The pump is to be turned back off when the sump level drops to 1.5 m. Develop a two-position controller.

Q734

A control signal varies from 0–5 V. A floating controller, such as that in Figure 10.10, has trip voltages of 2 V and 4 V, and a three-position controller has outputs of 0 and ±2 V. The integrator consists of a 1-MΩ resistor and a 1-μF capacitor. Plot the controller output in response to the input of Figure 10.11a.

Q735

An integral control system will have a measurement range of 0.4 to 2.0 V and an output range of 0 to 6.8 V. Design an op amp integral controller to implement a gain of K_I = 4%/(%-min). Specify the values of G, R, and C.

Q738

Pressure from 50 to 400 psi is converted to voltage by the relation

$$V = 0.385[p]^{1/2} - 2.722$$

This is input to an ADC with a 5.0-V reference, which provides 00H to FFH over the pressure range. An HLL uses an instruction $DV = UDF(1)$ to input the data from the ADC as a base 10 number DV that varies from 0 to 255 over the pressure range. Develop a linearization equation to give a quantity p in the program that is equal to the actual pressure

Q739

In a compound control system, the ratio between two variables is to be maintained at 3.5 to 1. If each has been converted to a 0–5 V range signal, devise a signal conditioning system that will output a zero signal to the controller when the ratio is correct.

Q740

A process requires adjustment of setpoints to increase production. A particular sequence must be followed to provide the increase. SP1, SP2, and SP3 are the setpoints, P and PCR are the pressure and a critical pressure, respectively, and T and TCR are the temperature and critical temperature, respectively. Develop a flowchart that increases the setpoints as follows:

1. Increase SP1 by 1%.
2. Wait 10 s, test for pressure compared to critical.
3. If the pressure is less than critical, then
   a. decrease SP2 by [illegible]%
   b. increase SP3 by [illegible]%
   c. wait for T < TCR
   d. increase SP2 by 1%
   e. go to step 1
4. If the pressure is above critical,
   a. decrease SP1 by [illegible]%
   b. decrease SP2 by [illegible]%
   c. go to step 2

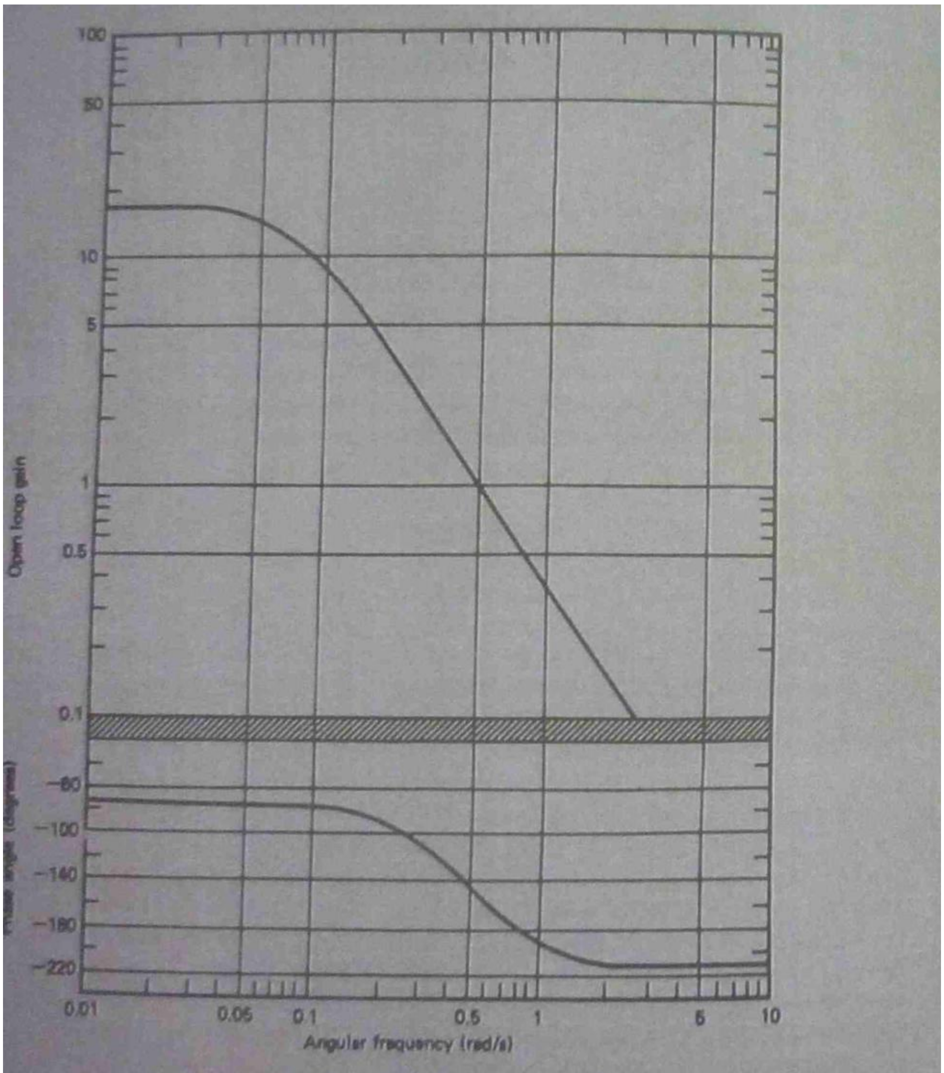
26

Q741

Suppose the deviation following a step-function disturbance is a 4.7% error in the controlled variable. If a quarter-amplitude criterion is used to evaluate the response, find the error of the second and third peak.

Q742

Determine whether the system of Figure 12.16 is stable according to the rules given earlier.



IGURE 12.16

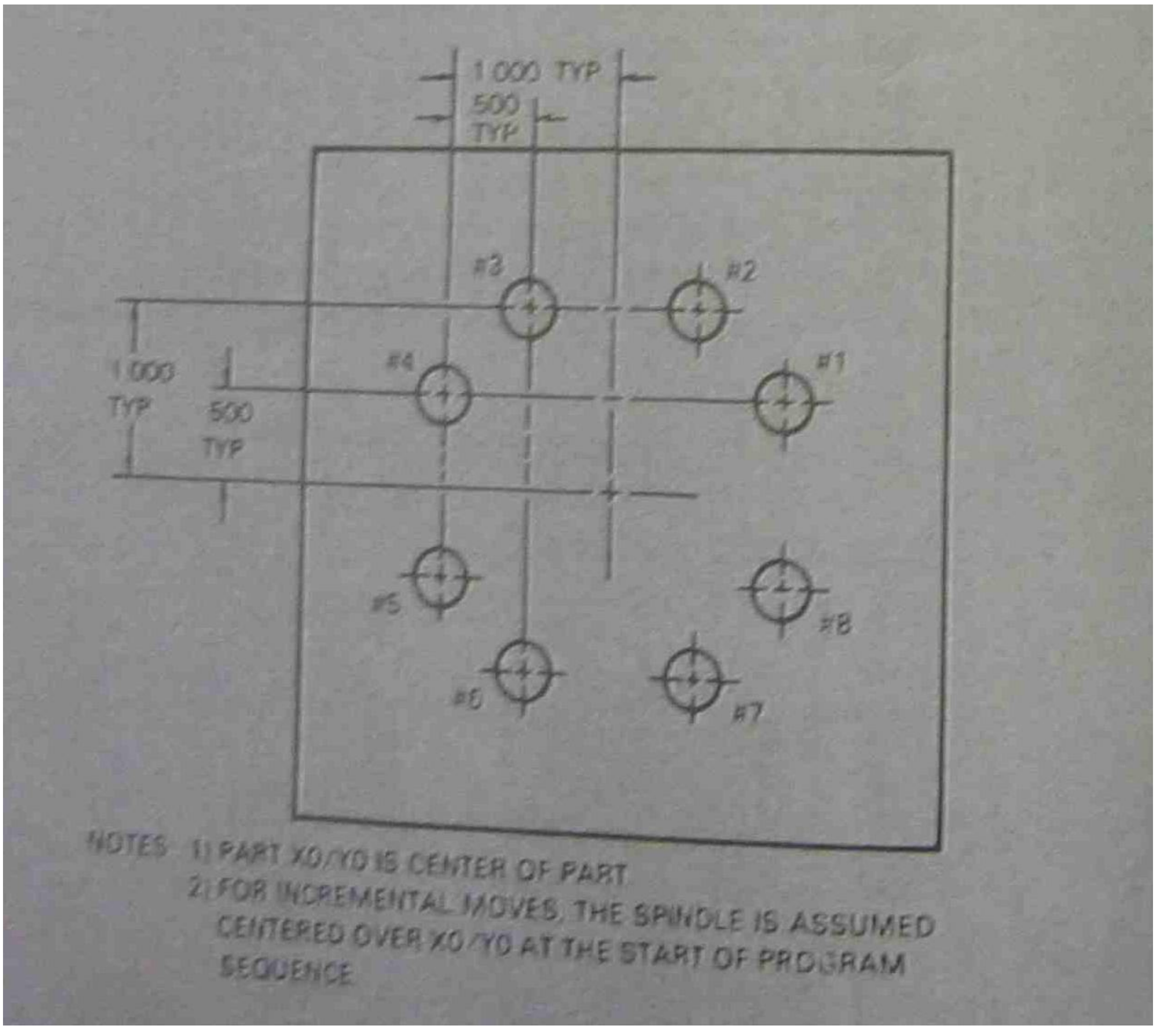
Bode plot shows the open-loop gain and phase versus frequency of an applied sinusoid

Q743

A transient disturbance test is run on a process loop. The results of a 9% controlling variable change give a process-reaction graph as shown in Figure 12.16. Find settings for three-mode action.

Q746

Determine the positions of the holes



Q748

Explain the following program

```
48 Z3 RA
49 X-3.26 Y2.26 RA          REM:RAPID TO #18
50 Z0 RA                    REM:RAPID TO BUFFER
51 Z-.62 FA                 REM:FEED TO DEPTH
52 Y-2.26 FA                REM:FEED TO #19
53 Z3 RA
54 X3.26 RA                 REM:RAPID TO #20
55 Z0 RA                    REM:RAPID TO BUFFER
56 Z-.62 FA                 REM:FEED TO DEPTH
57 Y2.26 FA                 REM:FEED TO #21
58 Z3 RA
59 X-3.26 RA                REM:RAPID TO #18
60 Z0 RA                    REM:RAPID TO BUFFER
61 Z-.62 FA                 REM:FEED TO DEPTH
62 X-3.25 Y2.25 FA          REM:FEED TO #22
63 Y-2.25 FA                REM:FEED TO #23
64 Z3 RA
65 X3.25 RA                 REM:RAPID TO #24
66 Z0 RA                    REM:RAPID TO BUFFER
67 Z-.62 FA                 REM:FEED TO DEPTH
68 Y2.25 FA                 REM:FEED TO #25
69 TOOL 0                   REM:CANCEL OFFSET
70 Z0 RA                    REM:RETRACT QUILL
71 X-12 Y8 RA               REM:TCH
72 END
```

Q749

Explain the following program

```
X0/Y0 = CENTER OF PART
TOOL CHANGE = X-300 Y200
TOOLS LIST;
TOOL 1 = 8mm COMB. DRILL
TOOL 2 = 25mm 4 FLUTE END MILL
TOOL 3 = 10mm 4 FLUTE END MILL
BUFFER HEIGHT;  TOP OF PART FOR TOOL 1,2.54mm FOR
TOOLS 2 AND 3
CLEARANCE OVER CLAMPS;  75mm

 1 TOOL 1001
 2 Z100 A
 3 TOOL 1002
 4 Z75  A
 5 TOOL 1003
 6 Z87.5 A
 7 X-300 Y200 RA
 8 TOOL 1
 9 V20 216                         REM:8mm DRILL 1066 RPM
10 V21 2.54
11 G81
12 X-60 Y40 Z-13 RA                REM:DRILL #1
13 Z75 RA                          REM:RETRACT SPNDL
14 X60 RA                          REM:DRILL #2
15 Y-40 RA                         REM:DRILL #3
16 X0 Y0 RA                        REM:DRILL #4
17 X-60 Y-40 RA                    REM:DRILL #5
18 G80
19 TOOL 0                          REM:CANCEL OFFSET
20 Z0 RA                           REM:RETRACT SPNDL
21 X-300 Y200 RA                   REM:TCH
22 TOOL 2                          REM:25mm E/M 425 RPM
23 FEED 172.5
24 X0 Y0 RA                        REM:RAPID TO #6
25 Z0 RA
26 Z-13 FA                         REM:FEED TO DEPTH
27 Y12.25 FA                       REM:FEED TO #7
28 X37.25 FA                       REM:FEED TO #8
29 Y-12.25 FA                      REM:FEED TO #9
30 X-37.25 FA                      REM:FEED TO #10
31 Y12.25 FA                       REM:FEED TO #11
32 X0 FA                           REM:FEED TO #7
33 TOOL 0                          REM:CANCEL OFFSET
34 Z0 RA                           REM:RETRACT SPNDL
35 X-300 Y200 RA                   REM:TCH
36 TOOL 3                          REM:10.0 E/M 800 RPM
37 FEED 325.1
38 X0 Y0 RA                        REM:RAPID TO #6
39 Z0 RA                           REM:RAPID TO BUFFER
40 Z-13 FA                         REM:FEED TO DEPTH
41 Y20 FA                          REM:FEED TO #13
42 X45 FA                          REM:FEED TO #14
43 Y-20 FA                         REM:FEED TO #15
44 X-45 FA                         REM:FEED TO #16
45 Y20 FA                          REM:FEED TO #17
46 X0 FA                           REM:FEED TO #13
47 Y44.75 FA
48 Z75 RA
```

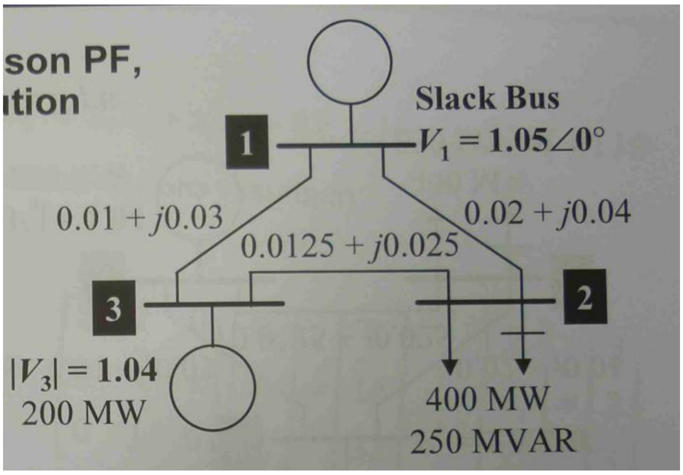
Q750

REVIEW QUESTIONS

1. What is the sine of an angle? The cosine? The tangent?
2. What are the sine, cosine, and tangent of the triangle in Figure 8–11? What is angle B?
3. What are the coordinates of the holes in the part in Figure 8–12, assuming that the center is X0/Y0?
4. What are the coordinates of the four cutter locations indicated in Figure 8–13?

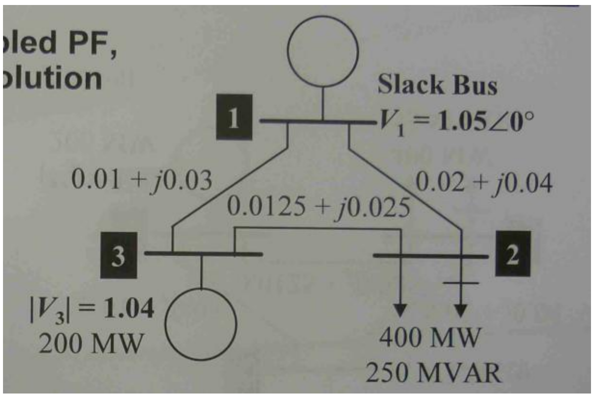
Q760

Using the Newton-Raphson PF, find the power flow solution



Q761

Using the fast decoupled PF, find the power flow solution



Q762/763

- **Find the minimum of**

  $f(x_1, x_2, x_3) = x_1^2 + 2x_2^2 + 3x_3^2 + x_1x_2 + x_2x_3 - 8x_1 - 16x_2 - 32x_3 + 110$

  - evaluating the first derivatives to zero results in

Q764

Use the Kuhn-Tucker method to determine the minimum distance from the origin of the x-y plane to a circle described by

$$(x-8)^2 + (y-6)^2 = 25 \quad or$$

$$g(x, y) = (x-8)^2 + (y-6)^2 - 25$$

Q765

- **Solve for the time-domain solution of the current**
  - for a faulted generator having the following characteristics

    $R = 0.125\ \Omega \qquad L = 10\ \text{mH} \qquad v(t) = 151 \sin(377\,t + \alpha)$
  - which will give

    (a) zero dc offset current,

    (b) maximum dc offset current

Q766

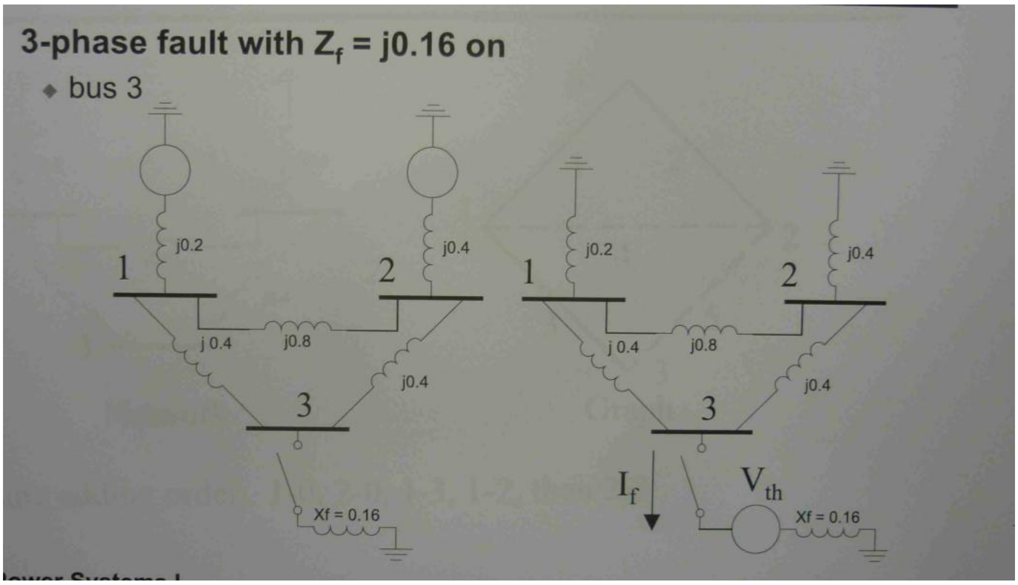
Consider a 500 MVA, 30 kV generator with no load and a constant excitation voltage of 400 V. A three-phase short circuit occurs at the terminals. Obtain the transient waveforms for the current in each phase and the field winding

Q767

- A generator operating at no load, is set to deliver a terminal voltage of 1.0 pu
- The generator is subjected to a fault on the terminals when phase a is at a voltage peak
- Peak values of the current are recorded at the following times:
  - 0.0042 s : I = 8.7569
  - 0.0208 s : I = 6.7363
  - 0.3208 s : I = 2.8893
  - 0.3375 s : I = 2.8608
  - 5.0000 s : I = 1.1785
- Determine the reactances and time constants

Q768

Find the fault current.



Q769

Obtain the symmetrical components of a set of unbalanced currents

$$I_a = 1.6\angle 25^\circ$$

$$I_b = 1.0\angle 180^\circ$$

$$I_c = 0.9\angle 132^\circ$$

Q789

Example 3.1. *A 750 kV transmission line section has a series impedance of 0.00072 + j0.0175 p.u., a total shunt impedance of 8.775 p.u., a voltage magnitude at the terminal buses of 0.984 p.u. and 0.962 p.u., and a voltage angle difference of 22°. Calculate the active and reactive power flows.*

Q790

Example 3.2. *A 500/750 kV transformer with a tap ratio of 1.050:1.0 on the 500 kV side, see Figure 2.4, has negligible series resistance and a leakage reactance of 0.00623 p.u., terminal voltage magnitudes of 1.023 p.u. and 0.968 p.u., and an angle spread of 5.3°. Calculate the active and reactive power flows in the transformer.*

Q791

Example 3.3. *A Δ-Y, 230/138 kV transformer presents a 30° phase angle shift. Series resistance is neglected and series reactance is 0.0997 p.u. Terminal voltage magnitudes are 0.882 p.u. and 0.989 p.u., and the total angle difference is −16.6°. Calculate the active and reactive power flows in the transformer.*

Q792

Example 5.1. *Figure 5.1 shows a 5-bus network with four transmission lines and two transformers. Generators, with voltage control, are connected at buses 1, 3, and 5, and loads are connected at buses 4 and 5, and at bus 4 a shunt is also connected. Classify the buses according to the bus types PU, PQ and $U\theta$.*

Q793

Example 5.2. *Consider again the 5-bus in Figure 5.1. Formulate the equality constraints of the system and the inequality constraints for the generator buses.*

Q794

Example 6.1. *A 750 kV transmission line has 0.0175 p.u. series reactance (the series resistance and the shunt admittance are ignored in this example). The terminal bus voltage magnitudes are 0.984 and 0.962 p.u. and the angle difference is 10°. Calculate the sensitivities of the active and reactive power flows with respect to voltage magnitude and phase angle.*

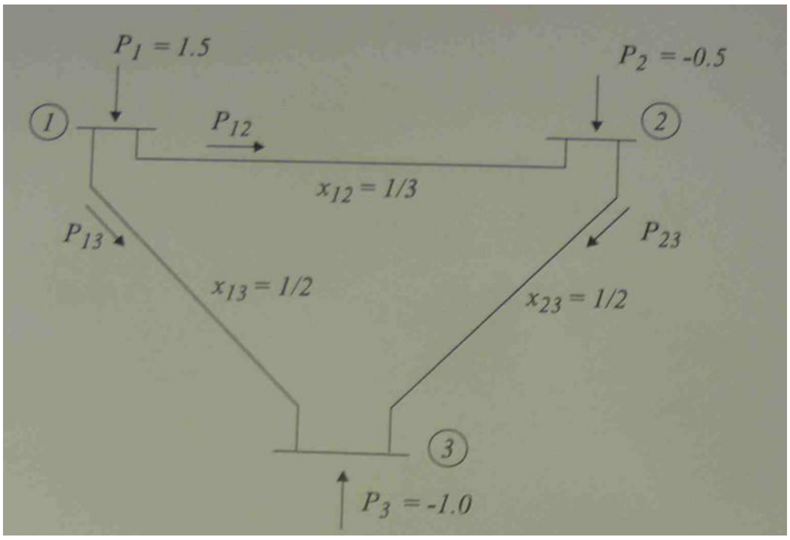
Q795

Example 6.2. *Consider the network given in Figure 6.7 in which the reference angle is $\theta_1 = 0$. Use the dc power flow method to calculate the power flows in the lines.*

Q796

Example 7.1. *The whole procedure shall be demonstrated in single steps on the sample network given in Figure 7.17. With the arbitrarily chosen node numbering the admittance matrix* **Y** *has the following structure.*

$$\mathbf{Y} = \begin{bmatrix} y_{11} & y_{12} & 0 & 0 & y_{15} \\ y_{21} & y_{22} & y_{23} & 0 & 0 \\ 0 & y_{32} & y_{33} & y_{34} & y_{35} \\ 0 & 0 & y_{43} & y_{44} & y_{45} \\ y_{51} & 0 & y_{53} & y_{54} & y_{55} \end{bmatrix} \qquad (7.37)$$



Q802

Example 2.1

The test example for power flow calculation, which is shown in Figure 2.1, is taken from reference [2].

The parameters of the branches are as follows:

$z_{12} = 0.10 + j0.40$
$y_{120} = y_{210} = j0.01528$
$z_{13} = j0.30, k = 1.1$
$z_{14} = 0.12 + j0.50$
$y_{140} = y_{410} = j0.01920$
$z_{24} = 0.08 + j0.40$
$y_{240} = y_{420} = j0.01413$

Q803

Example 2.2

For the same system as in Example 2.1, the Newton method with the rectangle coordinate system is used to solve power flow.

The bus admittance matrix is the same as in Example 2.1. Given the initial values of bus voltages:

$$e_1^0 = e_2^0 = e_3^0 = 1.0,$$
$$f_1^0 = f_2^0 = f_3^0 = 0.0,$$
$$e_4^0 = 1.05, \quad f_4^0 = 0.0$$

Q804

Example 2.3

In this example we solve the system in Example 2.1 with the decoupled PQ method.

Q805

Compute the fuel consumption.

Example 4.1

We collected some statistical data for a generating unit in one power plant. The capacity limits of the generator are

$$150 \le P_G \le 200$$

Four data samples of unit fuel consumption are selected, i.e., 0.405, 0.379, 0.368, and 0.399 (Btu/MW·h), which correspond to power output of 150, 170, 185, and 200 (MW), respectively. The corresponding fuel consumptions are computed and listed in Table 4.1.

Q812

Compute the fuel consumption.

Example 5.1

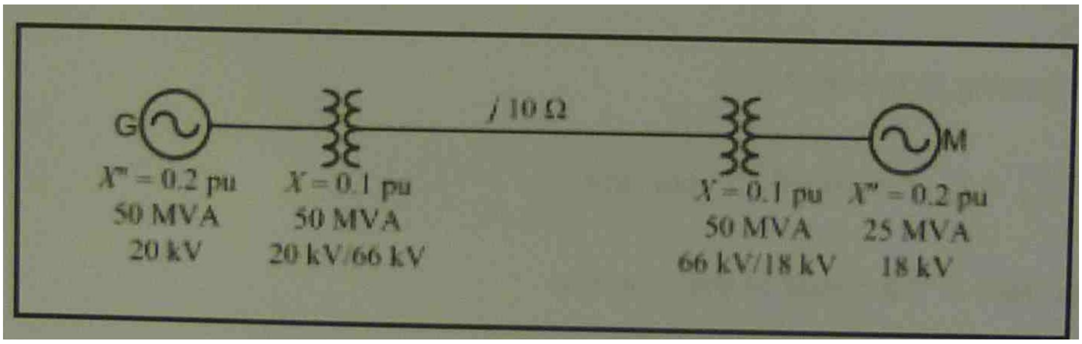
The test example is the IEEE 30-bus system with some data change. The modified 30 bus system consists of 5 generation units, 21 loads, 41 transmission lines and transformers.

The fuel consumption functions of the generators are quadratic curves and are shown in Table 5.24. The two-stage economic dispatch results are shown in Tables 5.25 and 5.26.

Q821

Calculate the fault current.

Consider the power system of Fig. 6.8 in which a synchronous generator supplies a synchronous motor. The motor is operating at rated voltage and rated MVA while drawing a load current at a power factor of 0.9 (lagging) when a three phase symmetrical short circuit occurs at its terminals. We shall calculate the fault current that flow from both the generator and the motor.



Q826

Calculate the fault current.

Consider the power system of Fig. 6.8 in which a synchronous generator supplies a synchronous motor. The motor is operating at rated voltage and rated MVA while drawing a load current at a power factor of 0.9 (lagging) when a three phase symmetrical short circuit occurs at its terminals. We shall calculate the fault current that flow from both the generator and the motor.

Q832

Calculate the fault current.

Consider the network shown in Fig. 8.10. The system parameters are given below

Generator G : 50 MVA, 20 kV, $X'' = X_1 = X_2 = 20\%$, $X_0 = 7.5\%$

Motor M : 40 MVA, 20 kV, $X'' = X_1 = X_2 = 20\%$, $X_0 = 10\%$, $X_n = 5\%$

Transformer T_1 : 50 MVA, 20 kV Δ /110 kVY, $X = 10\%$

Transformer T_2 : 50 MVA, 20 kV Δ /110 kVY, $X = 10\%$

Transmission line: $X_1 = X_2 = 24.2\ \Omega$, $X_0 = 60.5\ \Omega$

We shall find the fault current for when a (a) 1LG, (b) LL and (c) 2LG fault occurs at bus-2.

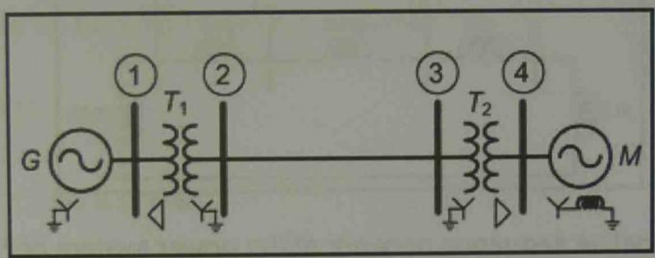


Fig. 8.10 Radial power system of Example 8.4.

Q881

A silicon abrupt p-n junction has a p-type region of $2\text{x}10^{16}$ cm^{-3} acceptors and an n-type region containing $2\text{x}10^{16}$ cm^{-3} acceptors in addition to 10^{17} cm^{-3} donors.

Calculate

i. the thermal equilibrium density of electrons and holes in the p-type region, and both densities in the n-type region

ii. the built-in potential of the p-n junction at room temperature

iii. the built-in potential of the p-n junction at 400K, assuming the intrinsic concentration increases 300 fold over that at 300K

Q882

Example 2.3: ***Using the pwl junction diode model***

An approximation to the forward I-V characteristic of the diode shown in figure 2.4a, is given by $V_F(I_F) = 1.0 + 0.01\,I_F$. For a constant current of 45A for ⅔ of a cycle, calculate the diode

i. on-state voltage;

ii. mean power loss; and

iii. rms current.

Q883

A Schottky diode is used to half-wave rectify a square wave ±15V source in series with a 1Ω load resistor. If the diode model shown in figure 2.4b is modelled with R_o = 0.01 Ω, E_o = 0.2V, R_i = 1000Ω, and V_b = 30V, determine:

- *i.* the diode model forward and reverse bias operating point equations for the series circuit
- *ii.* the load current and diode voltage
- *iii.* the rectifier losses (neglecting any recovery effects) and the load power dissipation
- *iv.* estimate the power dissipated in the load if the source is ac with the same fundamental component as the square wave
- v. what is the non-fundamental power dissipated with the square wave source?

Q884

Example 2.5: ***Space charge layer parameter values***

A 10μm thick p-type 2×10^{16} /cc silicon epitaxial layer is grown on an n^- - type 1×10^{14} /cc silicon substrate, of area 1 cm^2, to form an abrupt pn junction.

Calculate the following PSpice parameter values, at room temperature:

- *i.* zero bias junction potential, Φ;
- *ii.* zero bias scl width, maximum electric field, charge, and junction capacitance, W_o, ξ_o, Q_o, C_{jo}; and
- *iii.* avalanche breakdown voltage, V_b.

If the substrate is 150μm thick, for a 1000V reverse bias, calculate:

- *iv.* scl width and penetration depth each side of the junction, W, x_n, x_p;
- v. charge each side of the junction, maximum electric field, and the capacitance, Q, ξ_j, C_j.

Q890

Example 10.1: ***Series device connection – static balancing***

Ten, 200 V reverse-blocking, ultra fast 35 ns reverse recovery diodes are to be employed in series in a 1500 V peak, string voltage application. If the maximum device reverse leakage current is 10 mA calculate the sharing factor, and for worst case conditions, the maximum value of sharing resistance and power dissipation.

- If 10 per cent tolerance resistors are employed, what is the maximum sharing resistance and its associated power rating?
- If a further allowance for supply voltage tolerance of ±5% is incorporated, what is the maximum sharing resistance and its associated power rating?

Q891

Example 10.2: ***Series device connection – dynamic balancing***

The string of ten, 200 V diodes in worked example 10.1 is to incorporate capacitive reverse recovery transient sharing. Using the data in chapter 5, figure 5.9, specify a suitable sharing capacitance based on zero capacitance and supply tolerances (a = b = 0), ± 10 per cent capacitance tolerances (a = 0.1, b = 0), ± 5 per cent supply tolerance (a = 0, b = 0.05), then both tolerances (a = 0.1, b = 0.05). Estimate in each case the energy loss due to capacitor discharge.

Q892

Example 10.3: *Resistive parallel current sharing - static balancing*
For the two diodes shown in figure 10.6, with $\hat{I} = 100A$, what derating result when they are parallel connected, without any external sharing circuits?
The maximum current rating for each device is I_{av} 100A; hence with suitable forced sharing a 190A combination should be possible. Using the network in figure 10.7 for current sharing, it is required that 100A flows through D_1 and 90A through D_2. Specify the per cent overall derating, the necessary sharing resistors and their worse case losses.

Q893

Example 10.5: *AC circuit fuse design*

A fast acting fuse is connected in series with a thyristor in a 415 V ac, 50 Hz ac application. The average current in the thyristor is 30 A at a maximum ambient temperature of 45°C. The ratings of the thyristor are

$I_{T(AV)} = 45$ A @ $T_c = 85$°C
$I_{TRMS} = 80$ A
$I^2t = 5$ k A²s for 10 ms @ 125°C
$I^2t = 20$ k A²√s
$I_{TSM} = 1000$ A for 10 ms @ 125°C and $V_{RRM} = 0$

The fault circuit inductance is 1.32 mH and the resistance is negligible. Using the figures 10.12 to 10.17, select a suitable fuse.

Q894

Example 10.6: *Non-linear voltage clamp*

Evaluate the current of a 1mA @ 250 V Zener diode when used to clamp at 340V dc. Calculate the percentage decrease in voltage-dependent resistance and the per unit increase in power dissipation, assuming $\alpha = 30$.

Q895

Example 13.1: *DC chopper with load back emf (first quadrant)*

A first-quadrant dc-to-dc chopper feeds an inductive load of 10 ohms resistance, 50mH inductance, and back emf of 55V dc, from a 340V dc source. If the chopper is operated at 200Hz with a 25% on-state duty cycle, determine, with and without (rotor standstill) the back emf

i. the load average and rms voltages;
ii. the rms ripple voltage, hence ripple factor;
iii. the maximum and minimum output current, hence the peak-to-peak output ripple in the current;
iv. the current in the time domain;
v. the average load output current, average switch current, and average diode current;
vi. the input power, hence output power and rms output current;
vii. effective input impedance, (and electromagnetic efficiency for $E > 0$);
viii. sketch the output current and voltage waveforms.

Q896

Example 13.3: *DC chopper with load back emf – discontinuous conduction*

A first-quadrant dc-to-dc chopper feeds an inductive load of 10 ohms resistance, 50mH inductance, and back emf of 100V dc, from a 340V dc source. If the chopper is operated at 200Hz with a 25% on-state duty cycle, determine:

i. the load average and rms voltages;
ii. the rms ripple voltage, hence ripple factor;
iii. the maximum and minimum output current, hence the peak-to-peak output ripple in the current;

Q898

Example 13.2: *DC chopper with load back emf*
- verge of discontinuous conduction

A first-quadrant dc-to-dc chopper feeds an inductive load of 10 ohms resistance, 50mH inductance, and back emf of 55V dc, from a 340V dc source. If the chopper is operated at 200Hz with a 25% on-state duty cycle, determine:

i. the maximum back emf before discontinuous load current conduction commences with $\delta = ¼$;
ii. with 55V back emf, what is the minimum duty cycle before discontinuous load current conduction; and
iii. minimum switching frequency at E=55V and t_T = 1.25ms before discontinuous conduction.

Q899

Example 13.4: ***Second-quadrant DC chopper – continuous conduction***

A dc-to-dc chopper capable of second-quadrant operation is used in a 200V dc battery electric vehicle. The machine armature has 1 ohm resistance and 1mH inductance.

i. The machine is used for regenerative braking. At a constant speed downhill, the back emf is 150V, which results in a 10A braking current. What is the switch on-state duty cycle if the machine is delivering continuous output current? What is the minimum chopping frequency for these conditions?

Q900

Example 17.2: ***Temperature effect on inductance***

The gapped pot core in example 17.1 is specified by a relative temperature coefficient of 1×10^{-6}/K. What is the expected inductance variation over the temperature range 25-55°C?

Q901

Example 17.1: ***Inductance variation with time***

A pot ferrite core with an effective permeability of 100 (A_L = 250) and a disaccommodation factor $df < 35 \times 10^{-6}$ has been in satisfactory operation for five weeks after production. What is the expected inductance variation after 10 years?

Table 17.3. Factors affecting the disaccommodation factor

			ρ(Ω cm)	
		10^5	500	≈ 20
μ_i		11-250	800-2000	4000
T_c	°C	450-300	250-170	145
df × 10^{-6}		50-10	20-2	3

Q902

Example 17.3: ***Inductor design with Hanna curves***

A 20 μH, 10 A choke is required for a forward converter. The inductance must be constant for unidirectional currents to 10 A. An available E-core pair has the following effective parameters

$\ell_e = 0.11$ m, $A_e = 175 \times 10^{-6}$ m^2, $V_e = 19.3 \times 10^{-6}$ m^3

and

$\mu_r = 2500$ @ 25°C and 3000 @ 100°C (from figure 17.7)

i. At a core temperature of 25°C, determine the required air gap and turns. Allow a 5 per cent decrease in inductance at rated conditions.
ii. Estimate the inductance at 20A dc.
iii. Calculate the inductance at 10A and 20A dc, both at 100°C.

Q903

Example 17.6: ***Ferrite voltage transformer design***

Consider the design requirements for the split rail push-pull smps shown in figure 15.7b, which is specified as follows

$V_o = 5$ V	$V_{ac} = 48$ V ± 15 per cent
$I_o = 4$A	$f = 20$kHz
$P_o = 20$ W	$T_a = 25$°C, $\Delta T \le 35$ K
	$\eta = 97$ per cent

Q942

Find the period of 60HZ

Q943

The period of a signal is 100 ms. What is its frequency in kilohertz?

Q944

A sine wave is offset 1/6 cycle with respect to time 0. What is its phase in degrees and radians?

Q945

Explain frequency domain by using sine waves.

Q946

Explain how to decompose signal.

Q947

A nonperiodic composite signal has a bandwidth of 200 kHz, with a middle frequency of 140 kHz and peak amplitude of 20 V. The two extreme frequencies have an amplitude of 0. Draw the frequency domain of the signal.

Q986

An amplifier operating over a 4 MHz band width has a 100Ω input resistance. It is operating at 27°C has a voltage gain of 200, and has an input signal of 5 μV rms. Determine the rms output signals (desired & noise) assuming external noise can be disregarded.

Q987

A transistor amplifier has a measured S/N of 10 at its input and 5 at its output. Calculate the transisto NF

Q988

Two resistors 5 kΩ and 20 kΩ are at 27°C. calculate for a 10 KHz band width the thermal noise power and voltage.

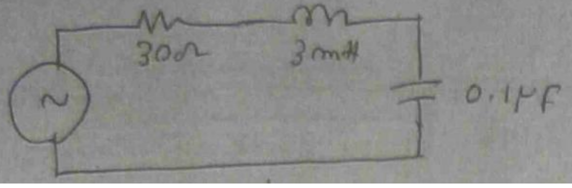
(a) For each resistor

(b) For their series combination

(c) For their parallel combination

Q989

Determine the resonant frequency for the circuit shown in Fig 1.14 calculate its impedance when f = 12 KHz



Q990

Determine f_r for the circuit shown in figure when $R_1 = 20\Omega$, $R_2 = 1\Omega$ L = 1mH, C = 0.4 µF, e_{in} = 50mV. Calculate e_{out} at f_r and 12 kHz

Q992

Ex Determine %m for the following conditions if the unmodulated carrier is 80V peak to peak (P-P)

	maximum P-P carrier (V)	minimum P-P carrier (V)
(a)	100	60
(b)	125	35
(c)	160	0
(d)	180	0
(e)	135	35

Q996

Ex A TRF receiver is to be designed with a single tuned circuit using a 10 μH inductor.

(a) Calculate the capacitance range of the variable capacitor required to tune from 550 to 1550 kHz

(b) The ideal 10 kHz BW is to occur at 1100 kHz. Determine the required Q.

(c) Calculate the BW of this receiver at 550 kHz and 1550 kHz.

Q1000

Pb An FM signal has a center frequency of 100 MHz but is swinging between 100,001 MHz and 99,999 MHz at a rate of 100 times per second.

Determine

(a) The Intelligence frequency f_i

(b) The intelligence amplitude

(c) What happened to the intelligence amplitude if the frequency deviation changed to between 100,002 and 99,998 MHz.

Q1004

Pb An AM broadcast receiver has two identical tuned cercuits. The Q of these circuits is 60 and the IF frequency is 455 kHz and the receiver is tuned to a station at 680 kHz. Calculate the amount of frequency rejection.

Desired signal (f_s)

Q1009

Pb

A digital transmission has an error probability of 10^{-4} and is 10^{8} bits long. Calculate the expected number of error bits.

Q1013

Pb (1)

A commonly used coaxial cable RG 8A/U has a capacitance of 29.5 pF / ft and inductance of 73.75 mH / ft. Determine its characteristic impedence for a 1 ft section and for a length of 1 mile.

Q1014

Determine the characteristic impedence of

(a) A parallel wire line with D/d = 2 with air dielectric

(b) An air dielectric coaxial line with D/d = 2.35

Pb 3

Determine the amount of delay and the velocity of propagation introduced by a 1 ft section of RG 8A/U coaxial cable used as a delay line.

Q1015

Pb 5

Determine the wave length of a 100 MHz signal in free space and while travelling through an RG 8A/U coaxial cable.

Q1022

pb calculate the power received at satellite given the following conditions

1. The power gain of the transmitting parabolic dish antenna is 30,000
2. The transmitter drives 2 kW of power into antenna at carrier frequency 6.2 GHz
3. The satellite receiving antenna has power gain 30
4. The transmission path is 45000 km.

Q1017

pb 2 It is desired to build a $\lambda/2$ dipole to receive a 100 MHz broadcast. Determine the optimum length of the dipole.

Q1024

pb (5) Calculate the optical power 50 km from a 0.1 mW source on a single mode fiber that has 0.25 dB/km loss.

Q1025

pb (6) make a power budget analysis for a fiber optic system with the following characteristics.

Losses		Specifications	
LED to fiber connection	5 dB	LED power output	0.1 mW
3 connectors	1.5 dB each	Detector sensitivity	2 μW
six splices	0.5 dB each	max. bit rate	5 mb/s
10 km of fiber	0.6 dB/km		
fiber to detector	6 dB		

Total fiber dispersion 4 ns/km

Q1066

EXAMPLE 5.7. A residence in Springfield, Illinois, has a total heat loss rate *UA* of 544 Btu/h·°F and a balance point temperature of 55 F. It will have an induced draft, natural gas forced-air furnace, for which k = 0.8. For Springfield, DD55 = 3434. The average annual energy used for space heating is

Q1074

EXAMPLE 18.1. A 40-W, 430-mA (milliampere) 48-in. [122 cm] fluorescent tube produces 3200 lm. What is the illuminance on the floor of a 10-by-10 ft. room assuming 40% overall efficiency and uniform illumination?

Q1076

EXAMPLE 20.1. It is suggested that the reader photocopy Fig. 20.39 and fill it in as the solution progresses.

Given. Classroom: 6 m × 8 m × 3.70 m height, elementary school. Initial reflectances: ceiling 80%, entire wall 50%, floor 20%. (Note that the sketch on Fig. 20.39 can accommodate different reflectances for the upper, center, and lower wall sections.) Provide adequate lighting using fluorescent lamp fixtures. Assume yearly