2015/2016 SEMESTER 2 EXAMINATION

Diploma in Aerospace Electronics (DASE)
Diploma in Energy Systems Management (DESM)
Diploma in Computer Engineering (DCPE)
Diploma in Electrical & Electronic Engineering (DEEE)
Common Engineering Programme (DCEP)
Diploma in Engineering with Business (DEB)
1st Year and 2nd Year FT

PRINCIPLES OF ELECTRICAL & ELECTRONIC ENGINEERING II

Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **TWO** sections:
   Section A - 10 Multiple Choice Questions, 2 marks each.
   Section B - 8 Short Questions, 10 marks each.

3. **ALL** questions are **COMPULSORY**.

4. **All questions are to be answered in the answer booklet**.

5. **Start** each question in Section B on a **new page**.

6. Fill in the Question Numbers, in the order that they were answered, in the boxes found on the front cover of the answer booklet under the column "Questions Answered".

7. This paper contains **10** pages, inclusive of formulae sheets.

SECTION A

MULTIPLE CHOICE QUESTIONS (20 marks)

1. Please **tick** your answers in the **MCQ box** on the inside of the front cover of the answer booklet.
2. No marks will be deducted for incorrect answers.

A1. An n-type semiconductor is produced by__________

(a) Adding pentavalent impurities to the intrinsic material via doping process
(b) Adding trivalent impurities to the intrinsic material via doping process
(c) Adding electrons to the intrinsic material via diffusion process
(d) Removing holes from the intrinsic material via diffusion process

A2. The phasor diagram in Figure A2 shows two phasors $\mathbf{V_A}$ and $\mathbf{V_B}$:

Which one of the following statements is **false**?

(a) $\mathbf{V_A}$ lags $\mathbf{V_B}$ by 40°
(b) $\mathbf{V_A}$ leads $\mathbf{V_B}$ by 40°
(c) $\mathbf{V_B}$ lags $\mathbf{V_A}$ by 40°
(d) $\mathbf{V_B}$ leads $\mathbf{V_A}$ by 320°

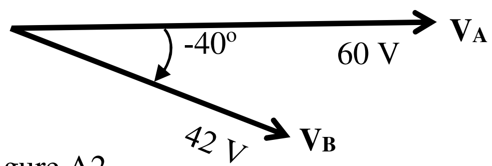


Figure A2

A3. A parallel RLC circuit has the following conductance and susceptances:

$G = 20$ mS, $B_L = 50$ mS, $B_C = 30$ mS

What is the impedance $\mathbf{Z}$ of this circuit in rectangular form?

(a) $\mathbf{Z} = (20 - j20)\ \Omega$ (b) $\mathbf{Z} = (25 + j25)\ \Omega$
(c) $\mathbf{Z} = (20 + j20)\ \Omega$ (d) $\mathbf{Z} = (25 - j25)\ \Omega$

A4. An electrical appliance consisting of a coil and resistance consumed 4.8 kW of true power (P). If an apparent power (S) of 5 kVA is measured, what is the power factor?

(a) 0.96 lagging (b) 0.28 lagging (c) 0.96 leading (d) 0.28 leading

A5. For the circuit shown in Figure A5, calculate the current flowing through the impedance Z?

(a) $0.5\ \angle 60°$ A
(b) $2\ \angle 60°$ A
(c) $0.5\ \angle -60°$ A
(d) $2\ \angle -60°$ A

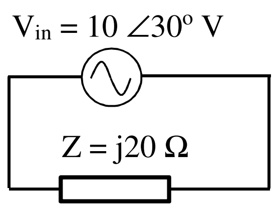


Figure A5

A6. In Figure A6, the value of $\bar{I}_T$ is:

(a) -6 A
(b) 6 A
(c) –j6 A
(d) j6 A

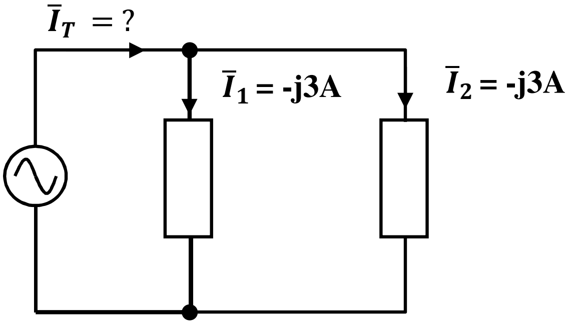


Figure A6

A7. Which one of the following devices is best suited to detect temperature change?

(a) Photodiode (b) Light dependent resistor (LDR)
(c) Thermistor (d) Moisture sensor

A8. Which one of the following statements best describes the purpose of the relay coil shown in Figure A8?

(a) To amplify the voltage across the relay coil
(b) To eliminate the use of collector resistor
(c) To function as an electronic switch
(d) To activate the relay contact

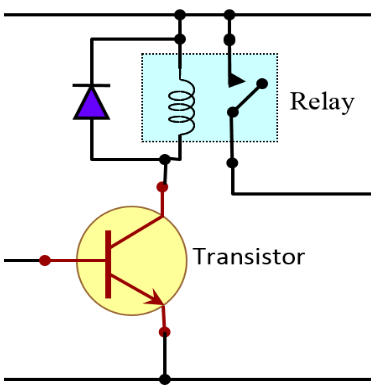


Figure A8

A9. Which one of the following steps is unlikely to drive the output of an operational amplifier with negative feedback into its saturated states ($\pm V_{sat}$)?

(a) Increase the value of its feedback resistor
(b) Remove the negative feedback and operate the amplifier in the open loop mode
(c) Increase the input signal to a large value
(d) Reduce the input signal to a very small value

A10. Which one of the following op amp configurations in Figure A10 will satisfy the equation $\mathbf{V_{out} = 2V_{in}}$?

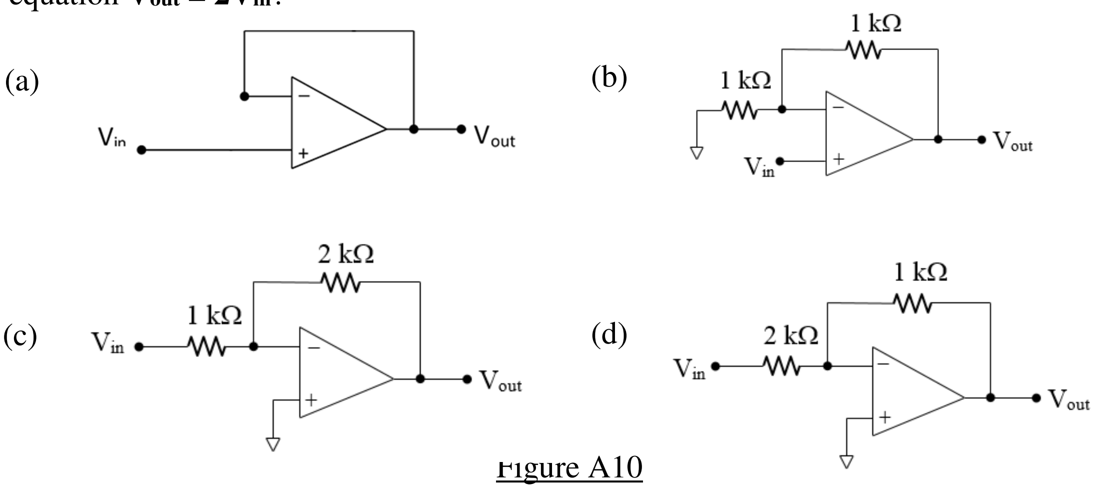


Figure A10

SECTION B

SHORT QUESTIONS (80 marks)

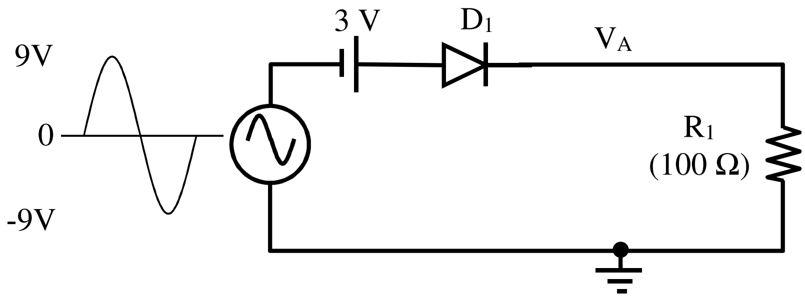
B1. (a) What type of dopants (pentavalent or trivalent) is used to produce p-type silicon? What are the majority carriers in p-type silicon? Explain how they are produced by the dopant. (5 marks)

(b) For the silicon diode circuit shown in Figure B1, the forward voltage drop of the diode D_1 is 0.7 V. Determine:

(i) The maximum voltage of V_A during the positive half cycle; (2 marks)

(ii) The peak inverse voltage (PIV) of diode D_1. (3 marks)

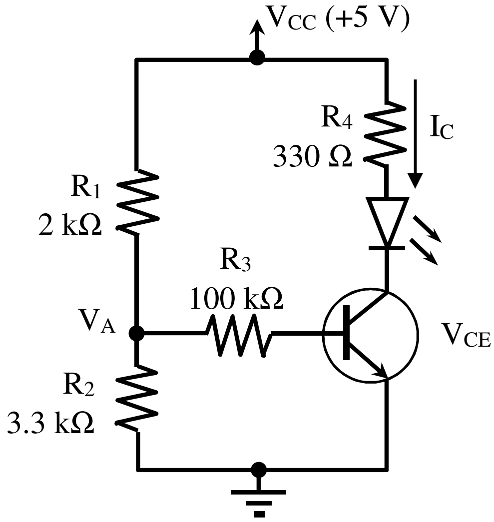
Figure B1



B2. In Figure B2, the transistor circuit is biased so that the LED lights up whenever the supply power is switched on.
Given that: V_{LED} is 2.0 V when forward-biased, $\beta = 220$ when transistor is operating in active region, $V_{BE} = 0.7$ V when forward biased and $V_{CE(sat)} = 0.2$ V in saturation mode. You may assume that:

$$V_A = \frac{R_2}{R_1 + R_2} \times V_{CC}$$

Figure B2



(a) Determine V_A, and hence the current in R_3; (4 marks)

(b) Calculate I_C and V_{CE}; (2 marks)

(c) Is the transistor is operating in the active or saturation mode? Give a reason for your answer. (2 marks)

(d) If R_4 is increased to 560 Ω, will the transistor operate in saturation mode? Give a reason for your answer. (2 marks)

B3. Figure B3-A illustrates a thermistor application in detecting ambient temperature shift. Given that $R_1 = R_2 = R_3 = 10\ k\Omega$. The thermistor ($R_{TH}$) has a resistance of 16 kΩ at 0ºC and 5 kΩ at 25ºC.

(a) Determine V_{AB} at 0ºC and at 25ºC. (6 marks)

(b) Now two LEDs (Green and Red) are inserted into the circuit across terminals A and B as shown in Figure B3-B. Both the Red and Green LEDs have a forward biased voltage of 1.7 V.

(i) Which LED will light up at 0ºC? Give a reason for your answer. (2 marks)

(ii) Which LED will light up at 25ºC? Give a reason for your answer. (2 marks)

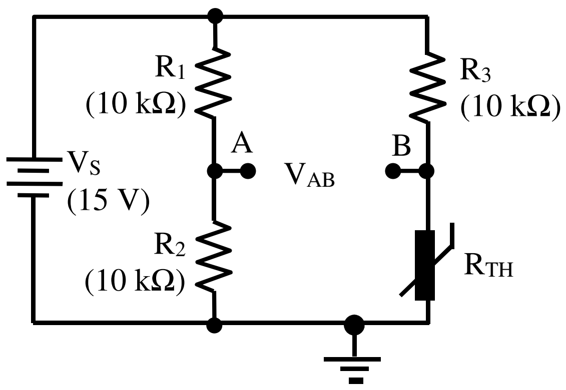


Figure B3-A

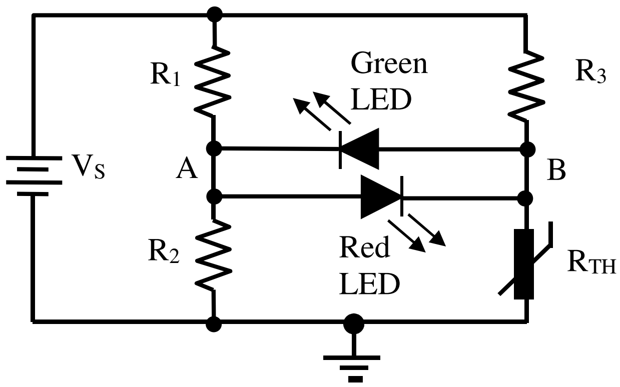


Figure B3-B

B4. Two 200 Hz sinusoidal ac voltage sources are connected in series as shown in Figure B4. The expressions for the two sources are respectively:

$v_{S1}(t) = 72 \sin(\omega t + 45^{o})$ V

$v_{S2}(t) = 28 \sin(\omega t - 45^{o})$ V

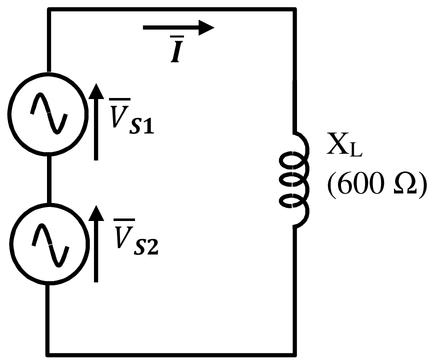


Figure B4

(a) Express $\overline{\boldsymbol{V}}_{\boldsymbol{S1}}$ and $\overline{\boldsymbol{V}}_{\boldsymbol{S2}}$ as phasors in polar form, with the voltage magnitudes expressed in their rms values. (2 marks)

(b) Calculate the resultant rms source voltage ($\overline{\boldsymbol{V}}_{\boldsymbol{T}}$) in polar form. (2 marks)

(c) Draw the phasor diagram for $\overline{\boldsymbol{V}}_{\boldsymbol{S1}}$, $\overline{\boldsymbol{V}}_{\boldsymbol{S2}}$ and $\overline{\boldsymbol{V}}_{\boldsymbol{T}}$. Indicate their magnitudes and phase angles in your diagram. (3 marks)

(d) Write down the time-domain sinusoidal expression for the circuit current. (3 marks)

B5. (a) For the circuit in Figure B5, find the total admittance ($\bar{Y}_T$), total current ($\bar{I}_T$), and the branch currents through the resistor ($\bar{I}_R$), inductor ($\bar{I}_L$) and capacitor ($\bar{I}_C$). Express all answers in polar form. (6 marks)

(b) Sketch the phasor diagram of the currents $\bar{I}_T$, $\bar{I}_R$, $\bar{I}_L$ and $\bar{I}_C$ obtained in part (a). Use supply voltage $\bar{V}_S$ as reference phasor. (4 marks)

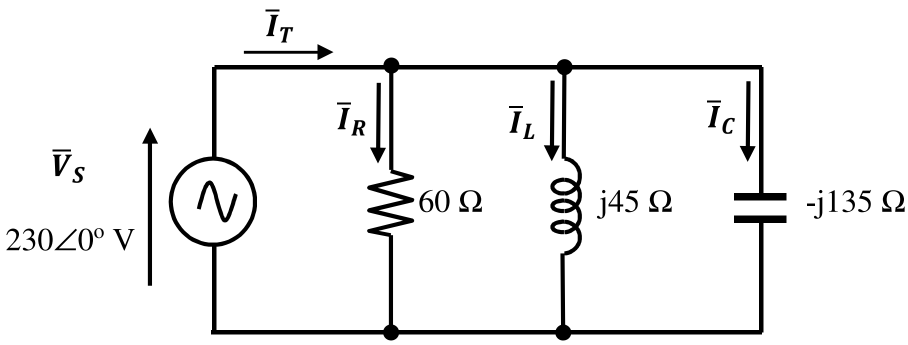


Figure B5

B6. The supply voltage, $\bar{V}_S$, is to be used as the reference phasor in analysing the series RLC circuit shown in Figure B6.

(a) Calculate the total impedance, $\bar{Z}_T$. (4 marks)

(b) Calculate the circuit current, $\bar{I}_T$, in polar form. (2 marks)

(c) What is the power factor of the circuit? Is it leading or lagging? (2 marks)

(d) Calculate the real power **P** delivered. (2 marks)

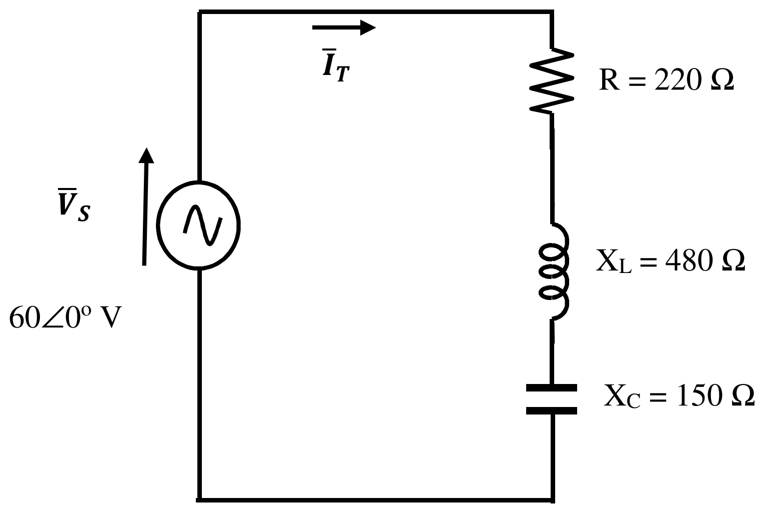


Figure B6

B7. Figure B7 shows the configuration of an op amp circuit which has three input terminals V_{in1}, V_{in2} and V_{in3}; and an output terminal V_{out1}.

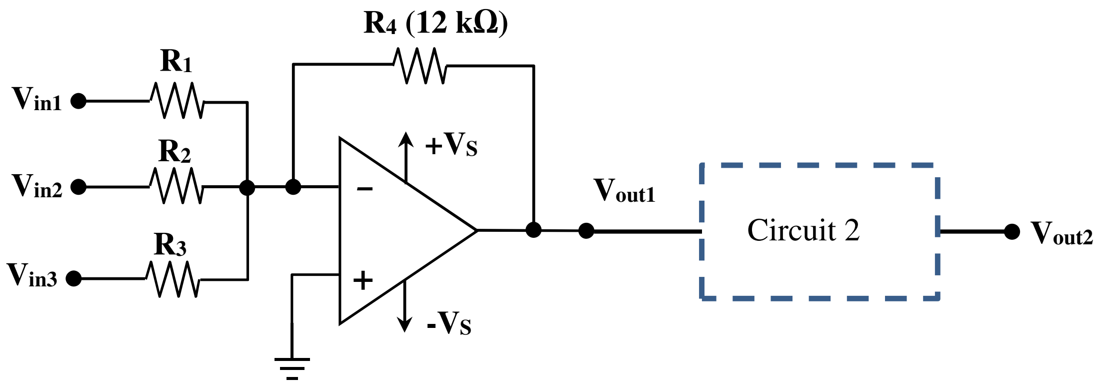


Figure B7

(a) Design a multichannel scaling circuit using the configuration of Figure B7 by selecting the appropriate resistors for R_1, R_2, and R_3 so that it satisfies the equation:

$$V_{out1} = -\left\{10V_{in1} + V_{in2} + \frac{1}{4}V_{in3}\right\}$$

Draw your circuit in your answer booklet and label the resistance values.

(6 marks)

(b) If $V_{in1} = 0.6$ V, $V_{in2} = -4$ V, and $V_{in3} = 12$ V, determine V_{out1} (indicate sign).

(2 marks)

(c) Design and draw a circuit (Circuit 2) such that the entire circuit in Figure B7 can produce an output voltage V_{out2} given by:

$$V_{out2} = -\{\,2V_{out1}\}$$

Label all resistance values of this circuit. (2 marks)

B8. For the Op Amp circuit given in Figure B8:

(a) Determine the voltages: V_1, V_2, and V_3; (3 marks)

(b) State the type of amplifier configuration implemented for U1, U2 and U3 respectively; (3 marks)

(c) Determine the output voltages: V_A, V_B, and V_C.

(4 marks)

The supply voltages to the **R_1-R_4 network** and all operational amplifiers are **± 15 V**. Assume **$+V_{sat}$ = + 14V** and **$-V_{sat}$ = - 13V** for all op amps.

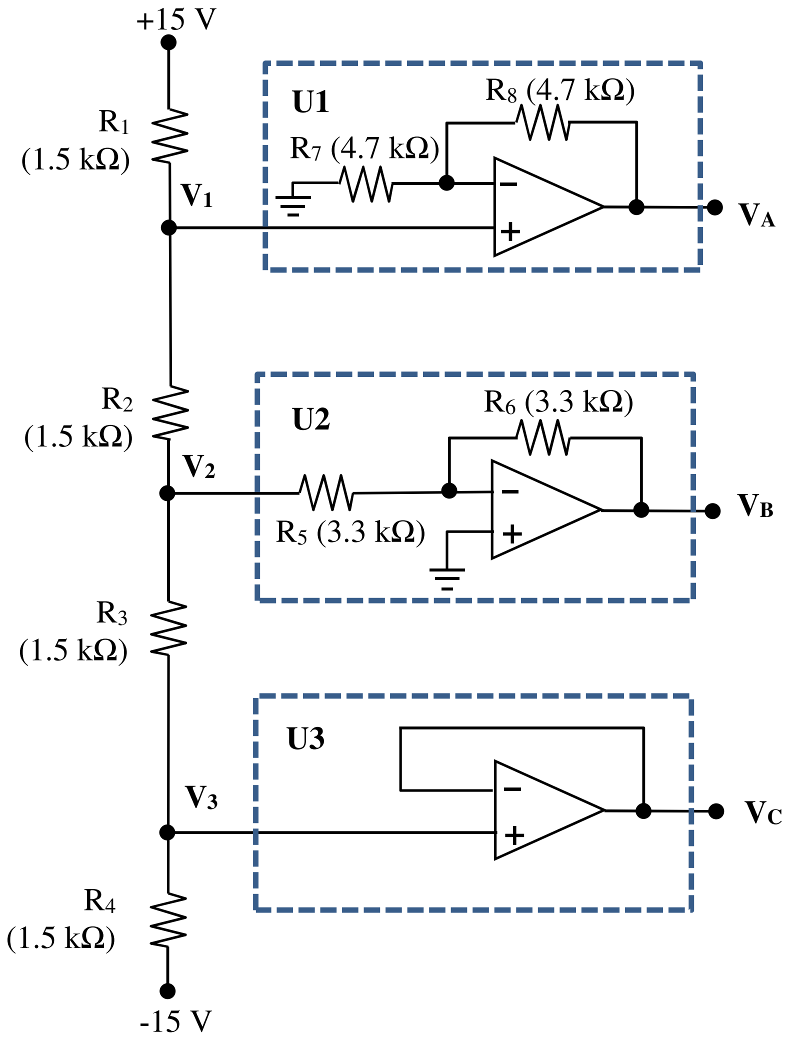


Figure B8

- End of Paper -

Formulae List

Number of electrons in a shell (band) = $2N^2$

6.25×10^{18} electrons ➔ 1C of negative charge

Ohm's Law for ac:

$$\overline{V} = \overline{I}\overline{Z} \qquad \overline{I} = \frac{\overline{V}}{\overline{Z}} = \overline{V}\overline{Y} \qquad \overline{Z} = \frac{\overline{V}}{\overline{I}}$$

Capacitors:

Capacitive reactance, $X_C = \dfrac{1}{2\pi fC}$ in ohms

Inductors:

Inductive reactance, $X_L = 2\pi fL$ in ohms

AC Voltages and Currents:

$I_{rms} = I_p / \sqrt{2} = 0.7071\ I_p$ $\qquad I_{p\text{-}p} = 2I_p$ $\qquad I_{av} = 2I_p / \pi = 0.637 I_p$

$V_{rms} = V_p / \sqrt{2} = 0.7071\ V_p$ $\qquad V_{p\text{-}p} = 2V_p$ $\qquad V_{av} = 2V_p / \pi = 0.637 V_p$

AC Impedance/Admittance:

Series circuit,

$$\overline{Z}_R = R \qquad \overline{Z}_C = -jX_C = -j\frac{1}{\omega C} = \frac{1}{\omega C}\angle -90^o \qquad \overline{Z}_L = jX_L = j\omega L = \omega L\angle 90^o \qquad \omega = 2\pi f$$

$$\overline{Z} = \overline{Z}_1 + \overline{Z}_2 + \overline{Z}_3 + \ldots\ldots\ldots \qquad \phi = \angle\overline{Z} = \angle\overline{I} = \tan^{-1}\frac{X_{tot}}{R_{tot}}$$

Parallel circuit,

$$\overline{Y}_R = G \qquad \overline{Y}_C = jB_C = j\omega C = \omega C\angle 90^o \qquad \overline{Y}_L = -jB_L = -j\frac{1}{\omega L} = \frac{1}{\omega L}\angle -90^o \qquad \omega = 2\pi f$$

$$\overline{Y} = \overline{Y}_1 + \overline{Y}_2 + \overline{Y}_3 + \ldots\ldots\ldots \qquad \phi = \angle\overline{Y} = \angle\overline{V}_S = \tan^{-1}\frac{B_{tot}}{G_{tot}}$$

AC Power:

$$S = V_S I = I^2 Z \qquad P = V_S I\cos\phi \qquad Q = V_S I\sin\phi \qquad \cos\phi = \frac{P}{S}$$

Diodes:

Forward voltage drop is 0.7 V for silicon diode and 0.3 V for germanium diode

Zener impedance $Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z}$

Half-Wave Rectifier:

$V_{p(out)} = V_{p(\sec)} - 0.7\,V \quad V_{AVG} = \dfrac{V_{p(out)}}{\pi} \quad PIV = V_{p(\sec)}$

Centre-Tapped Full-Wave Rectifier:

$V_{p(out)} = \dfrac{V_{p(\sec)}}{2} - 0.7V \quad V_{AVG} = \dfrac{2V_{p(out)}}{\pi} \quad PIV = 2V_{p(out)} + 0.7V$

Bridge Full-Wave Rectifier:

$V_{p(out)} = V_{p(\sec)} - 1.4\ V \quad V_{AVG} = \dfrac{2V_{P(out)}}{\pi} \quad PIV = V_{p(out)} + 0.7\ V$

Ripple Factor:

$r = \dfrac{V_{r(rms)}}{V_{DC}}$ where $V_{r(rms)} = \dfrac{V_{r(p-p)}}{2\sqrt{3}}$

Line Regulation = $\left(\dfrac{\Delta V_{OUT}}{\Delta V_{IN}}\right)100\ \%$ **Load Regulation =** $\left(\dfrac{V_{NL} - V_{FL}}{V_{FL}}\right)100\ \%$

Transistors:

$I_E = I_C + I_B \quad \beta_{DC} = \dfrac{I_C}{I_B} \quad \alpha_{DC} = \dfrac{I_C}{I_E} \quad \beta_{DC} = \dfrac{\alpha_{DC}}{1-\alpha_{DC}}$

$V_{BE} = 0.7V \quad V_{BB} = V_{BE} + I_B R_B \quad V_{CE} = V_{CB} + V_{BE}$

Operational Amplifiers

Voltage Gain of Inverting Amplifier: $-\dfrac{R_f}{R_i}$

Voltage Gain of Non-inverting Amplifier: $1 + \dfrac{R_f}{R_i}$

Output voltage of summing amplifier:

$V_O = -\left(\dfrac{R_f}{R_1}V_1 + \dfrac{R_f}{R_2}V_2 + \dfrac{R_f}{R_3}V_3 + ... + \dfrac{R_f}{R_n}V_n\right)$ for “n” inputs

Threshold Voltages for comparator with positive feedback:

Upper Trigger Point (UTP) = $\dfrac{R_2}{R_1 + R_2}(+V_{O[max]})$

Lower Trigger Point (LTP) = $\dfrac{R_2}{R_1 + R_2}(-V_{O[max]})$