Chapter 23 : Electronics

1. Multimeters read AC/DC voltage and current, resistance and conductivity, frequency, diode conductance and capacitance. Ammeters read current and voltmeters read voltage. A cathode ray oscilloscope can be used to study AC and DC voltage waveforms.

2. Decreasing the sweep time of the CRO will make the peaks further apart. By increasing the vertical gain control the peak to peak of the waveform is increased.

3. $\sqrt{2}\ V_{RMS} = V_p$ $\quad \sqrt{2} \times 2\ V_{RMS} = V_{pp}$

$2\ V_p = V_{pp}$ $\quad \sqrt{2} \times 2 \times 15.6 = V_{pp}$

$V_{pp} = \underline{44 \text{ volts}}$

4. $P = VI = I^2 R$

$= (0.25)^2 \times 470 = 29\ W$

$\therefore$ Power rating $= \underline{30\ W}$ Resistor colour $= \underline{\text{yellow, violet, brown}}$

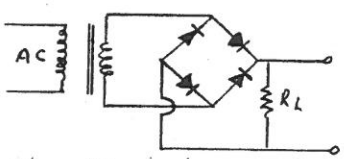
5. The capacitance, C, of a system is defined as the amount of charge, in coulombs, stored on each plate when the potential difference across the plates is 1 Volt.
A $0.01\ \mu F$, 240 V capacitor holds 0.01 μcoulombs per volt and has a maximum working voltage of 240 volts

6. Common types of capacitor are plastic-film capacitors (green caps), ceramic capacitors, electrolytic capacitors and variable capacitors.

Leave out 7, 8, 9

10. Intrinsic conduction occurs in a semi-conductor in the pure state. Intrinsic conduction does not give good conductivity under normal circumstances. Extrinsic conduction occurs in semiconductors which have doping. The extra electrons or holes the doping gives, makes extrinsic semiconductors good conductors.

11.



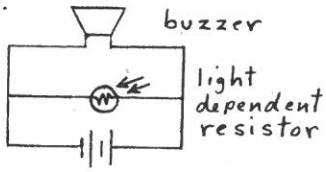
input = 12 V AC

output = 12 V − 2 × 0.7 (0.7 for each diode)

= $\underline{10.6\ V}$

The AC ripple can be reduced by the addition of a capacitor in parallel with the load resistor R_L. The charging and discharging of the capacitor holds the voltage output of the rectifyer at a relatively high value from one pulse to the next.

12.



At high levels of light intensity current mostly flows through the low resistance LDR.

The LDR has a low resistance in high levels of light. As light intensity drops, resistance of the LDR increases. At low levels of light, the resistance of the LDR is high. Current now travels through the buzzer, not the LDR.

13. (a) $V_p = \underline{20\ V}$ (from 0 to peak of curve)

(b) $V_{pp} = 2\ V_p = \underline{40\ V}$

(c) $V_{av} = \underline{0}$ (half of the waveform is above the zero line, half above)

(d) $V_{RMS} = \frac{V_p}{\sqrt{2}} = \underline{14\ V}$

(e) Frequency $= \underline{25\ Hz} = \frac{1}{T} = \frac{1}{0.04}$

14. Leave out

15. (a) brown, red, brown, gold (c) brown, green, red, silver
(b) orange, orange, brown, gold (f) yellow, violet, yellow, silver
(c) green, blue, green, gold (g) brown, grey, green, silver
(d) red, red, red, gold (h) brown, black, red, silver

16. $P = VI = \frac{V^2}{R}$

(i) $\therefore V = \sqrt{PR} = \sqrt{1 \times 5600}$

$= \underline{75\ V}$

$V = IR \therefore I = \frac{V}{R} = \frac{75}{5600}$

$= \underline{13\ mA}$

17. This is a voltage divider.

$V = IR$

$\therefore I = \frac{V}{R} = \frac{10 \text{ volts}}{(5600 + 8200)\ \Omega} = \underline{0.72\ mA}$

$V_1 = IR_1 = 0.72 \times 10^{-3} \times 5600 = \underline{4.0\ V}$

$V_2 = IR_2 = 0.72 \times 10^{-3} \times 8200 = \underline{5.9\ V}$

18. Leave out (b), (d), (f), (g)

(a) A voltage divider uses resistors in series (or a variable resistor) to split a supply voltage into separate voltages. Care must be taken to ensure that any device connected to any output of the divider does not draw a large current compared to that flowing around the divider circuit, otherwise the output voltage will not be stable.

(c) The dielectric is the insulating material which lies between the capacitor's conducting plates

(e) The Farad is the unit of capacitance. $1F = 1C/V$. A microfarad is 10^{-6} of a farad

(h) This type of capacitor uses aluminium oxide as the dielectric. It is polarized: it must be connected into the circuit the right way around.

19. Electrolytic capacitors are polarised and must be connected into the circuit with one end positive and the other negative. Reversing the polarity allows DC conduction and heating which leads to explosive breakdown.

20. Leave out.

21(a) N-type doping involves adding small amounts of Group V elements to the silicon crystal lattice. The Group V atoms replace silicon in the lattice and add extra electrons for conduction, since Group V atoms have one more valence electron than silicon. In N-type semiconductors, electrons are referred to as majority charge carriers, since most of the current is carried by electrons. There are still holes available for conduction and the holes are referred to as minority charge carriers.

(b) The barrier potential in a silicon diode is 0.7 V. This is the voltage needed to overcome the effects of the depletion layer.

(c) An AC wave form has a regularly fluctuating voltage and current. Since diodes only conduct in one direction, they can be used to convert AC to DC. This is called rectification. With half-wave rectification a single diode is used in the circuit. The diode will only conduct when the voltage is positive and above 0.7 V. Full-wave rectification involves arranging four diodes in a bridge formation. The diodes combine in pairs to allow conduction through the load resistor during both +ve and -ve phases of the input sine wave. Since two diodes are involved in each conduction cycle $V_{out} = V_{in} - 1.4$ V

(d) A zener diode is designed to work in reverse bias mode. When this diode conducts in reverse bias, the voltage drop across it remains almost constant even when there is a large variation in the current flowing through it. This makes a zener diode a useful voltage regulator.

22. $\left.\begin{array}{l} V = 0.7\text{ V} \\ I = 4.5\text{ A} \end{array}\right\}$ $P = VI = 4.5 \times 0.7 \approx$ 3 Watts

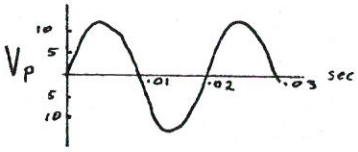
23. (i) $V_{OUT} = V_P - 1.4 = \frac{V_{PP}}{2} - 1.4$
$= 6.1$ volts

(ii) leave out average voltage V_{av}

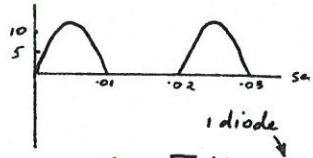
24. If the current drawn from the resistor is small, there is little AC ripple. Decreasing the resistance, increases I_{OUT}, thus increasing AC ripple.

25. Diodes: used in rectifyers.

26. (a) At A:



At B:



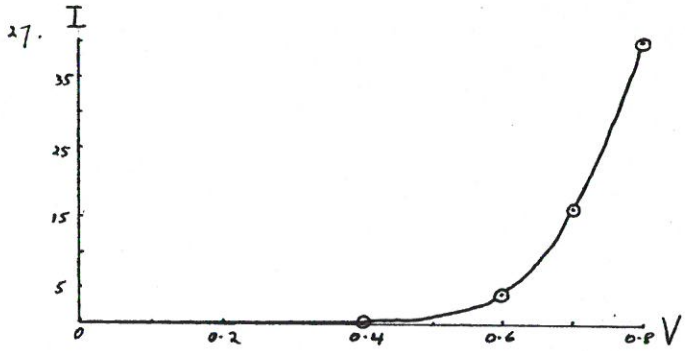
1 diode

$V_P = \sqrt{2}\, V_{RMS}$
$= \sqrt{2} \times 9 = 12.7$ V

$V_P = \sqrt{2}\, V_{RMS} - 0.7$
$= 12$ V

(b) At A: no change. At B: a capacitor would produce some smoothing, but there would be still quite some ripple.

27.



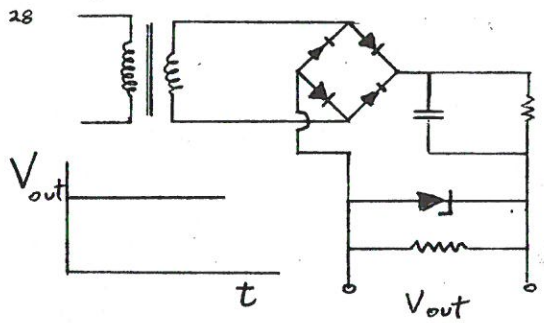
(a) This is the IV graph for a junction diode.

(b) 0.6 – 0.7 V

(c) $V = IR \therefore R = \frac{V}{I} = \frac{1}{\text{gradient}}$
at 1.0 Volts the gradient is vertical
$\therefore \frac{1}{\text{gradient}} = 0$ ie R is 0

(d) zero

28



29. Leave out

30. (a) $I = I_L + I_z$ (b) $V_{in} = V_R + V_z$

(c) $V_{in} = (I_L + I_z)R + V_z$
$\therefore R = \frac{V_{in} - V_z}{(I_L + I_z)}$

(d) $1000 = \frac{15.2 - 8.2}{I} \therefore I = 7 \times 10^{-3}$ A
$\therefore \max I_z = 7 \times 10^{-3}$ A
$\max P = VI = 8.2 \times 7 \times 10^{-3} = 5.7 \times 10^{-2}$ W

(e) $I_c = I - I_z = 7 \times 10^{-3} - 3 \times 10^{-3}$
$= 4 \times 10^{-3}$

(f) $R = \frac{V_{in} - V_z}{I_z + I_z} = \frac{15.2 - 8.2}{(10+3) \times 10^{-3}}$
$= 538\ \Omega$