EEE 224/227

Solutions to Tutorial Sheet 2

1. Total transmitted power = 5kW

$= \quad P_c\,(1 + m^2/2)$

$\therefore \quad$ If m = 0.6

$P_c = 5/(1 + 0.18)$

$\therefore \ \underline{P_c = 4.237\ \text{kW}}$

Hence, power in each sideband

$= \tfrac{1}{2}(5 - 4.24) = \underline{0.38\ \text{kW}}$

2. (a) $m = 3/10 = 0.3$

(b) $f_1 = f_c + f_m = 1.001$ MHz

$f_2 = f_c - f_m = 0.999$ MHz

(c) Sideband amplitude $= E_m/2 = 3/2 = 1.5$ V

(d) Sideband power $= \dfrac{2.(3/2)^2}{10^2 + 2.(3/2)^2} \equiv \underline{4.3}\%$

3. $P_{total} = P_c \ 1 + m^2/2$

(a) For $m = 0.707 \qquad P_t = P_c\,(1 + \tfrac{1}{4})$

$\therefore \ P_t = \tfrac{5}{4}\ P_c = \tfrac{5}{4} \times 40 = \underline{50\ \text{kW}}$

(b) Transmission efficiency $\equiv \dfrac{\text{power in s.b.}}{\text{total power}}$

$$\equiv \frac{m^2}{2+m^2} = \frac{0.5}{2+0.5} = \underline{20\%}$$

3. (c) $P_c \equiv \frac{V^2}{2R}$ $\therefore$ $V^2 = 2RP_c = 2 \text{ x } 50 \text{ x } 4 \text{ x } 10^4$

$\therefore$ $V = 2 \text{ x } 10^3$

$\therefore$ Peak output voltage $= V(1 + m)$

$= 1.707 \text{ x } 2 \text{ x } 10^3$

$= \underline{3414V}$

4. (a) Sideband amplitude $= m/2 = 40\%$
$\therefore$ $m = 80\%$

(b) $P_c = 1000W = \frac{Vc^2}{2R} = \frac{Vc^2}{2 \times 50}$
$\therefore$ $Vc = \sqrt{10}.100$

$\therefore$ $V_{LSB} = \frac{m}{2} Vc = 0.4 \sqrt{10}.100 = \underline{126.5V}$

(c) $\frac{\text{sideband power}}{\text{carrier power}} = \frac{m^2}{2} = \frac{0.64}{2} = \underline{0.32}$

(d) Total o/p power $= 1000(1 + m^2/2)$
$= 1000(1 + 0.32) \equiv \underline{1.32 \text{ kW}}$

(e) m now $80 \text{ x } ⅘ = 64\%$
$\therefore$ o/p power $= 1000(1 + 0.64^2/2) \equiv \underline{1.2 \text{ kW}}$

5. (a) total power $= (1 + m^2/2)P_c$

carrier power

$m = 1$

$\therefore$ $24 \text{ x } 10^3 = (1 + ½) P_c$

$\therefore$ $\underline{P_c \equiv 16 \text{ kW}}$

(b) 60% modulation $m = 0.6$

5. (b) $\therefore$ Power in one sideband $= \dfrac{m^2 P_c}{4}$

$= 0.36 \text{ x } 16 \text{ x } 10^3/4 = 1440 \text{ W}$

If P_{RC} = power in the reduced carrier

$$10 \log_{10} \frac{P_c}{P_{RC}} = 26$$

$$\frac{P_c}{P_{RC}} = 398 \quad \therefore \; P_{RC} = \frac{16 \times 10^3}{398} = 40 \text{ W}$$

$\therefore$ Total power output $= 1440 + 40 = \underline{1480 \text{ W}}$

6. (a) $P_t = P_c (1 + m^2/2) = P_c (1 + 1^2/2)$

$= 1.5 P_c$

$P_{SB} = P_c m^2/4 = P_c 1^2/4 = 0.25 P_c$

$$\therefore \text{ Saving } = \frac{1.5 - 0.25}{1.5} = \underline{83.3\%}$$

(b) $P_t = P_c (1 + 0.5^2/2) = 1.125 P_c$

$P_{SB} = P_c 0.5^2/4 = 0.0625 P_c$

$$\therefore \text{ Saving } = \frac{1.125 - 0.0625}{1.125} = \underline{94.4\%}$$

7. For a square low detector

$$\frac{\text{2nd harmonic term}}{\text{fundamental}} = \frac{m}{4}$$

$\therefore$ For 10% distortion $\underline{m = 40}$

See Connor "Modulation" Chapter 6.

8. Diode input voltage is

$$v = 5\sqrt{2} \sin\left(2\pi \times 10^6 t\right) + 2\sqrt{2} \sin\left(2\pi \times 10^3 t\right)$$

$$i = 5 + v + 0.05\, v^2$$

$$\therefore\ i = 5 + 5\sqrt{2} \sin\left(2\pi \times 10^6 t\right) + 2\sqrt{2} \sin\left(2\pi \times 10^3 t\right)$$

$$+ 0.05 \left[50 \sin^2\left(2\pi \times 10^6 t\right) + 40 \sin\left(2\pi \times 10^6 t\right) \sin\left(2\pi \times 10^3 t\right) + 8 \sin^2\left(2\pi \times 10^3 t\right) \right]$$

The 1 MHz carrier is AM′ ed by the 1 kHz.

i.e. AM signal is

$$5\sqrt{2} \sin\left(2\pi \times 10^6 t\right) \left[1 + \frac{\sqrt{2}}{5} \sin\left(2\pi \times 10^3 t\right)\right]$$

i.e. $m = \frac{\sqrt{2}}{5} \times 100 = \underline{28.2\%}$

Frequencies present in diode current are

d.c.	1 kHz	1 MHz
	0.999 MHz	1.001 MHz
	2 kHz	2 MHz