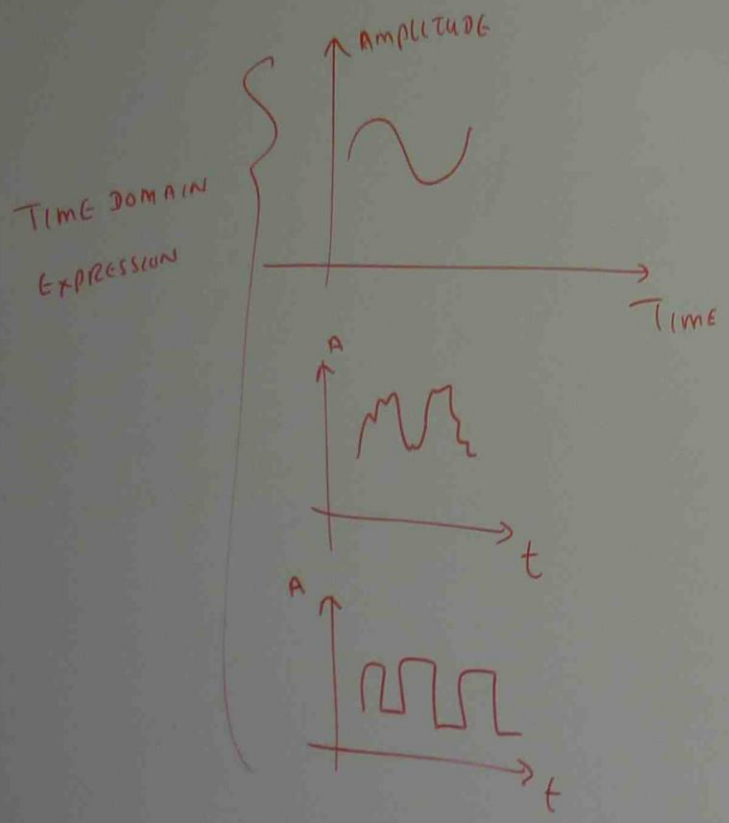
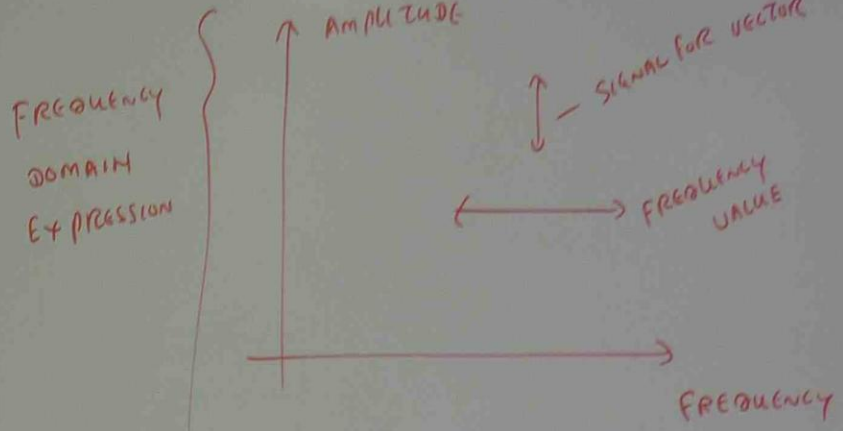
APPLICATION OF PERIODIC WAVE FUNCTION IN POWER ENGINEERING



$f(t) = A \sin \omega t \pm \phi$ ← TRANSIENT CALCULATIONS



$F(z) = A \angle \pm \phi$

↑ STEADY STATE CALCULATION.

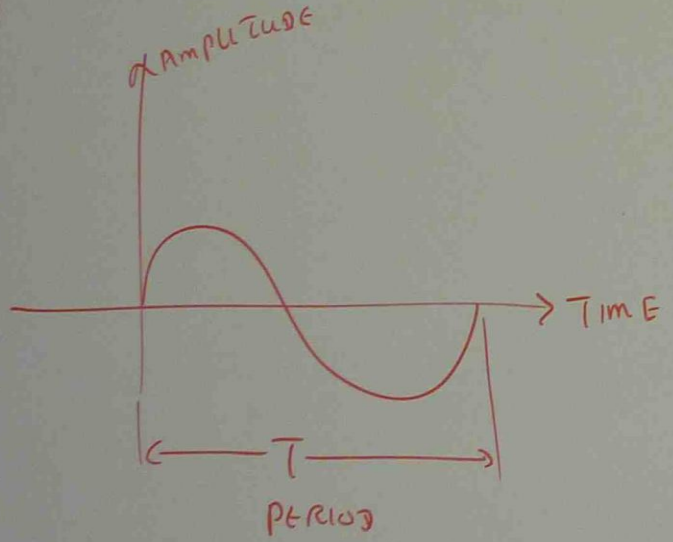
HARMONICS

MULTIPLE FACTOR OF FUNDAMENTAL FREQUENCY

FUNDAMENTAL $f_0 = 50Hz$

SECOND HARMONIC $f_2 = 2 \times 50Hz = 100Hz$

THIRD HARMONIC $f_3 = 3 \times 50Hz = 150Hz$



$$f = \frac{1}{T}$$

f = FREQUENCY

T = PERIOD

pb

A WAVE FORM HAS A PERIOD $T = 40ms$. CALCULATE THE FREQUENCY OF THE FUNDAMENTAL, THE SECOND AND THIRD HARMONICS.

FUNDAMENTAL FREQUENCY $f = \frac{1}{T} = \frac{1}{40ms} = \frac{1}{40 \times 10^{-3}}$

$$= \frac{10^3}{40} = 25Hz$$

SECOND HARMONICS $= 2f = 2 \times 25Hz = 50Hz$

THIRD HARMONICS $= 3f = 3 \times 25Hz = 75Hz$

FOURTH HARMONICS $= 4f = 4 \times 25Hz = 100Hz$

Pb

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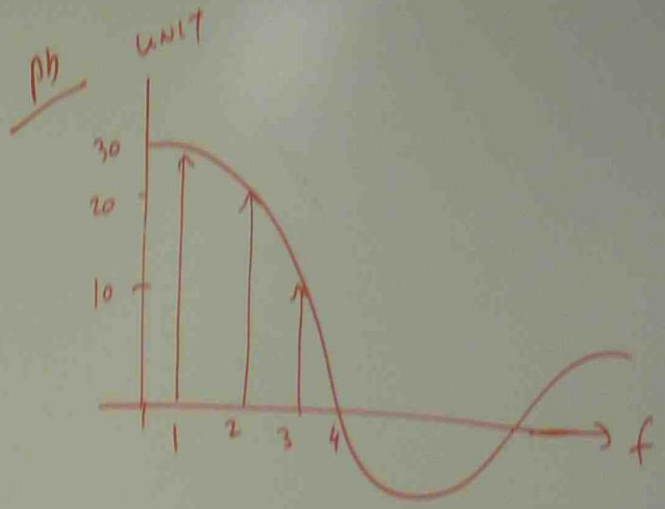


FIND 1st, 2nd, 3rd AND 4th HARMONICS AMPLITUDES OF GIVEN WAVE FORM.

1st = FUNDAMENTAL = 30 UNIT

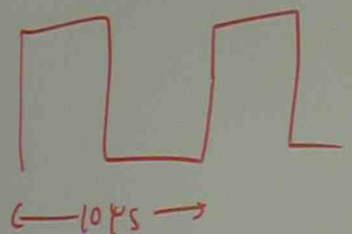
2nd = HARMONICS = 20 UNIT

3rd = HARMONICS = 10 UNIT

CALCULATE THE FREQUENCIES

p7

(a)



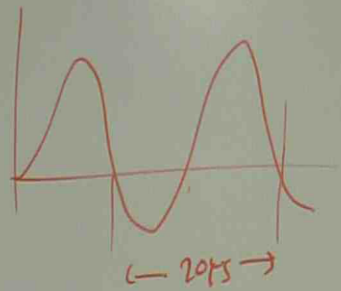
$$f = \frac{1}{T} = \frac{1}{10 \times 10^{-6}}$$

$$= \frac{10^6}{10}$$

$$= 10^5 \text{ Hz}$$

$$= 100 \text{ kHz}$$

(b)



$$f = \frac{1}{T}$$

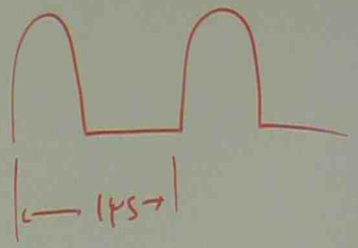
$$= \frac{1}{20 \times 10^{-6}}$$

$$= \frac{10^6}{20}$$

$$= \frac{1000 \times 10^3}{20}$$

$$= 50 \text{ kHz}$$

(c)



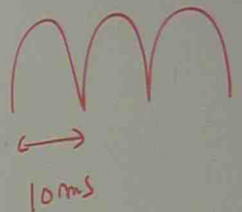
$$f = \frac{1}{T}$$

$$= \frac{1}{1 \times 10^{-6}}$$

$$= 10^6 \text{ Hz}$$

$$= 1 \text{ MHz}$$

(d)



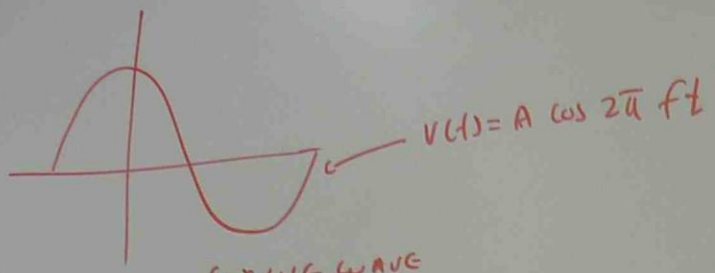
$$f = \frac{1}{T}$$

$$= \frac{1}{10 \times 10^{-3}}$$

$$= \frac{10^3}{10}$$

$$= 100 \text{ Hz}$$

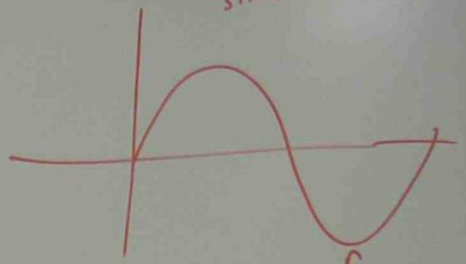
MATHEMATICAL EXPRESSION OF HARMONICS WAVE FORMS



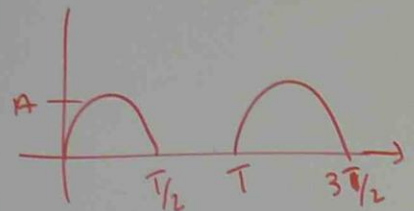
$V(t) = A \cos 2\pi ft$

COSINE WAVE

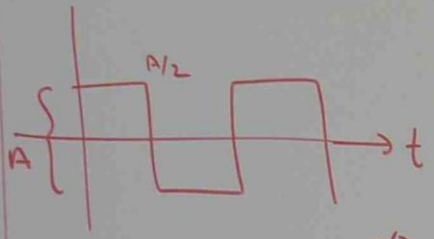
SINE WAVE



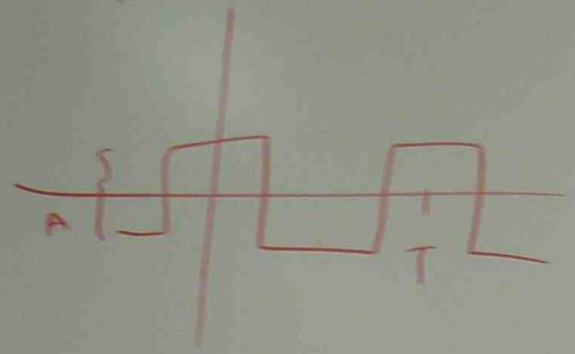
$V(t) = A \sin 2\pi ft$



$$V(t) = \frac{A}{2} + \frac{A}{2} \sin 2\pi f_0 t + \sum_{n=2}^{\infty} \frac{A\left[1 + (-1)^n\right]}{\pi (1 - n^2)} \cos 2\pi (n f_0) t$$



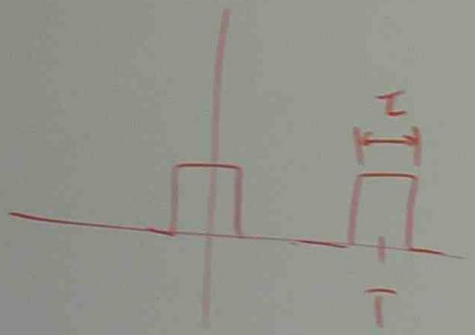
$$V(t) = \sum_{n=0}^{\infty} \frac{2A}{n\pi} \sin 2\pi n f_0 t$$



$$V(t) = \sum_{n=\text{odd}}^{\infty} \left(A \frac{\sin \frac{n\pi}{2}}{\frac{n\pi}{2}} \right) \cos 2\pi (n f_0) t$$

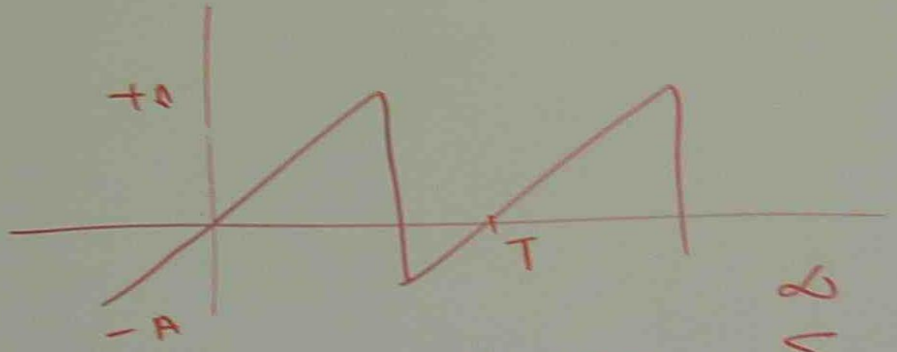
ODD = 1, 3, 5, 7

EVEN = 2, 4, 6, 8



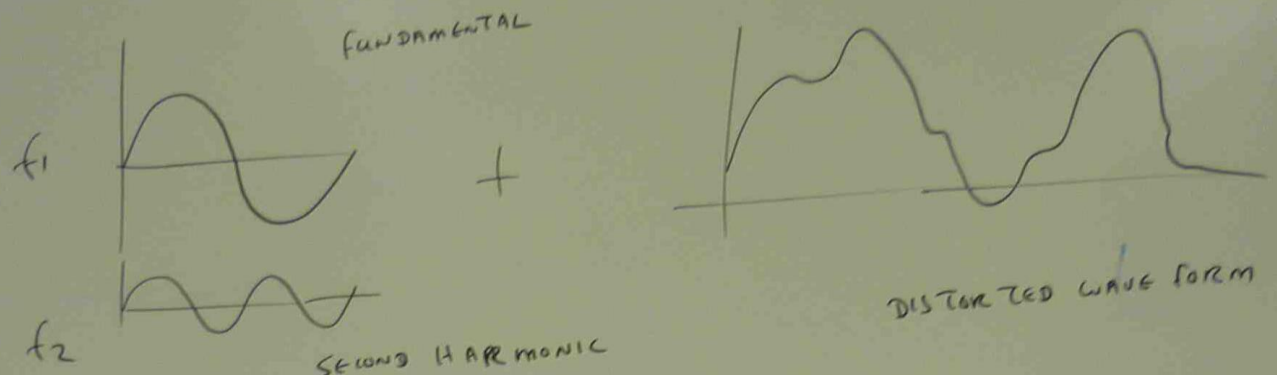
$$V(t) = \frac{A\tau}{T} + \sum_{n=3}^{\infty} \left(2A \frac{\tau}{T} \right) \left(\frac{\sin n\pi \tau/T}{2\pi \tau/T} \right) \cos 2\pi (n f_0) t$$

$$V(t) = \sum_{n=\text{odd}}^{\infty} \frac{8A}{(n\pi)^2} \cos 2\pi (n f_0) t$$



$$V(t) = \sum_{n=1}^{\infty} (-1)^{n+1} \left(\frac{2A}{n\pi}\right) \sin 2\pi (n f_0) t$$

HARMONICS



$$f(t) = A_1 \sin \omega t + A_2 \sin(2\omega t \pm \phi_1) + A_3 \sin(3\omega t \pm \phi_2) + \cdots$$

P_t = TOTAL POWER = $P_{1m} + P_{3m} + P_{5m} + \cdots$

$$V = \sqrt{\frac{U_{1m}^2 + U_{3m}^2 + U_{5m}^2}{2}}$$

$$I_m = \sqrt{\frac{I_{1m}^2 + I_{3m}^2 + I_{5m}^2}{2}}$$

Ph A VOLTAGE IS GIVEN BY

$e = 30 \sin \omega t + 20 \sin (3\omega t + 30^\circ) + 10 \sin (5\omega t - 90^\circ)$

VOLT IS APPLIED TO A CIRCUIT AND THE RESULTING CURRENT IS GIVEN BY

$i = 0.5 \sin (\omega t - 17) + 0.1 \sin (3\omega t - 15) + 0.09 \sin (5\omega t - 150)$

Amp.

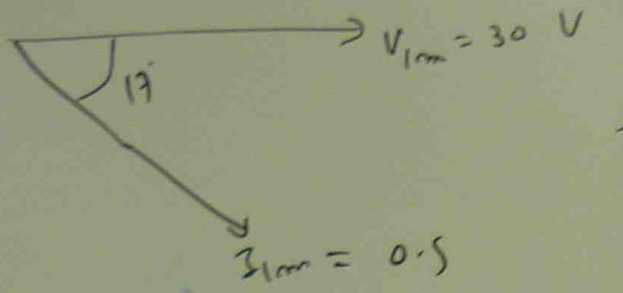
FIND TOTAL POWER APPLIED AND OVER ALL POWER FACTOR

$$P_m = \frac{V_m I_m}{2} \cos \theta^{V_m}_{I_m}$$

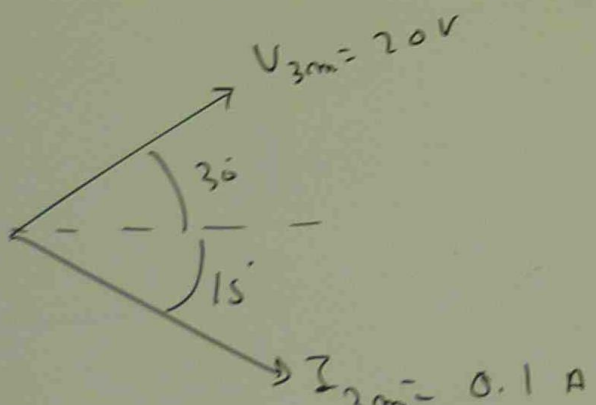
$$P_{1m} = \frac{V_{1m} I_{1m}}{2} \cos \theta^{V_{1m}}_{I_{1m}}$$

$$P_{3m} = \frac{V_{3m} I_{3m}}{2} \cos \theta^{V_{3m}}_{I_{3m}}$$

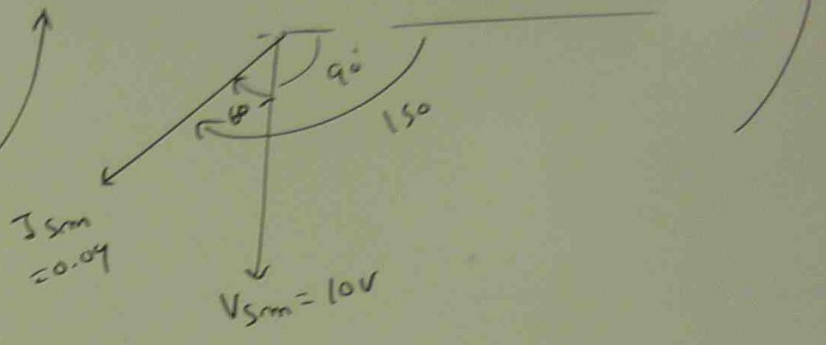
$$P_{5m} = \frac{V_{5m} I_{5m}}{2} \cos \theta^{V_{5m}}_{I_{5m}}$$



$$P_{1m} = \frac{30 \times 0.5}{2} \cos 17 = 7.1\,W$$



$$P_{3m} = \frac{20 \times 0.1}{2} \cos 45 = 0.7\,W$$



$$P_{5m} = \frac{10 \times 0.04}{2} \cos 60$$

$$= 0.23\,W$$

$$P_T = P_{1m} + P_{3m} + P_{5m}$$

$$= 7.1 + 0.7 + 0.23$$

$$= 8.03\,W$$

$$V_{rms} = \sqrt{\frac{V_{1m}^2 + V_{3m}^2 + V_{5m}^2}{2}} = \sqrt{\frac{30^2 + 20^2 + 10^2}{2}} = 18.7\,V$$

$$I_{rms} = \sqrt{\frac{I_{1m}^2 + I_{3m}^2 + I_{5m}^2}{2}} = \sqrt{\frac{0.5^2 + 0.1^2 + 0.04^2}{2}} = 1.5\ \text{Amp.}$$

$$\text{TOTAL V.A} = V_{rms}\, I_{rms}$$

$$= 18.7 \times 1.5 = 28.06\ \text{V.A}$$

$$PF = \frac{P_T}{\text{TOTAL V.A}} = \frac{8.03}{28.06} = 0.281$$