Review :

1) No. of pulses : odd multiples of 3 for synchronization (no sub harmonics)

$\frac{1}{2}$ wave symmetry (no even harmonics)

& 3-Φ symmetry

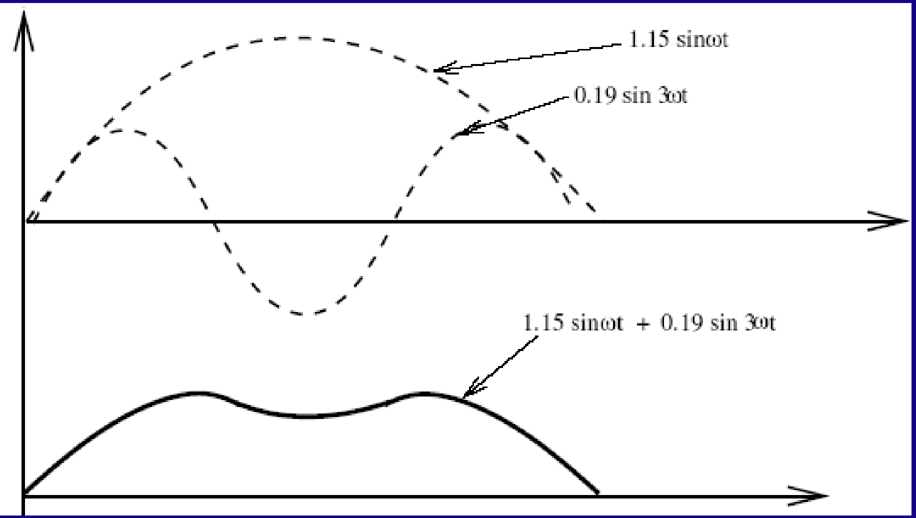
2) In sinusoidal PWM technique,

Predominant harmonic =

$$45\ F_{Sine} \pm 2\ F_{Sine} \ldots \text{for } F_N = 45$$

3) DC utilization poor (Peak of the fundamental component of $\text{Line} - \text{line} = \frac{V_{dc}}{2}\sqrt{3}$)

4) Can be improved by adding 3rd harmonic component to the modualting wave.



Expression for modulating wave = 1.15 sinωt + 0.19 sin3ωt

∴ Peak fundamental component of $V_{L\text{-}L} = (1.15)\sqrt{3}\ \dfrac{V_{dc}}{2} = \underline{V_{dc}}$

Harmonic elimination Techniques

Undesirable harmonics can be eliminated and fundamental can be controlled by creating notches at pre-determined angles

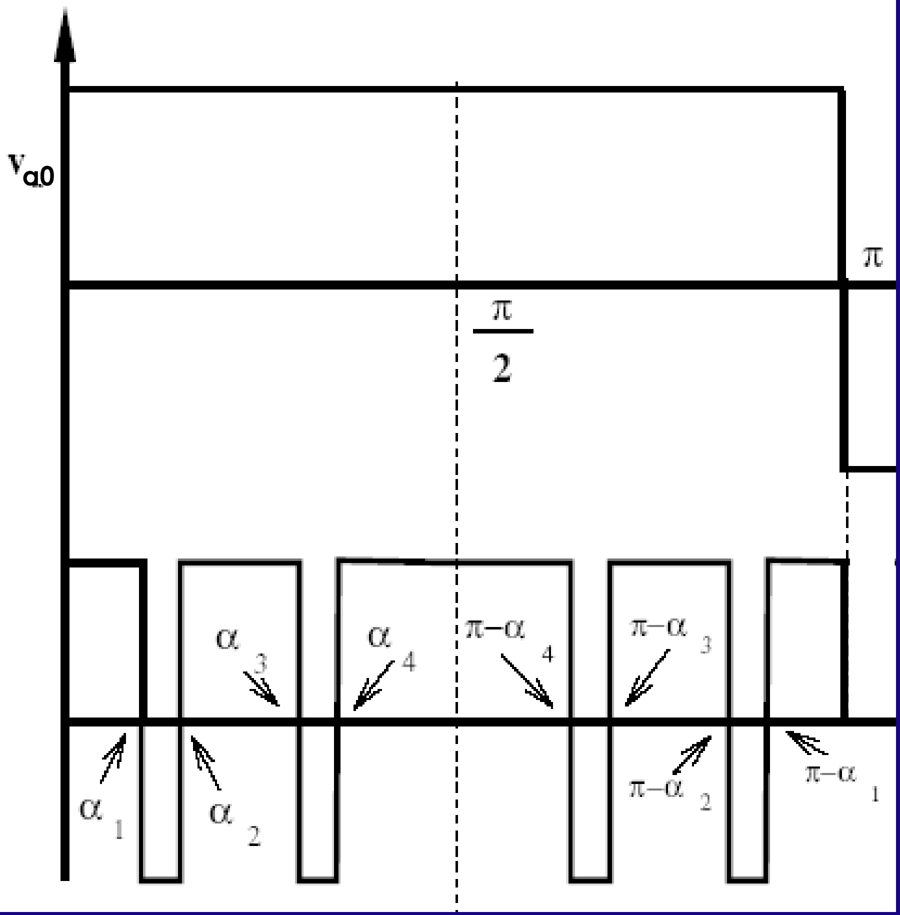
$\Rightarrow$ If 'n' switchings/ $\frac{1}{4}$ cycle

$\Rightarrow$ (n-1) harmonics are eliminated & magnitude of fundamental can be controlled

$\Rightarrow$ 4 switchings/$(1/4)$ cycle

$(\alpha_1, \alpha_2, \alpha_3, \alpha_4)$

$$\alpha_1 < \alpha_2 < \alpha_3 < \alpha_4 < \frac{\pi}{2}$$



- $\Rightarrow$ 3 significant harmonics = 0
- $\Rightarrow$ fundamental can be controlled
- $\Rightarrow$ square wave has quarter wave odd symmetry
- $\Rightarrow$ Coefficient of the fundamental & harmonic components are given by

$$b_n = \frac{4}{n\pi}\left\{1 + 2\sum_{k=1}^{m}(-1)^k \cos(n\,\alpha_k)\right\}$$

Assume that there are 5 switchings/$\frac{1}{4}$ cycle

$\Rightarrow$ 4 harmonics can be made zero

$\Rightarrow$ In 3 phase, 3 wire system, triple harmonics can be ignored.

So harmonics to be eliminated are 5^{th}, 7^{th}, 11^{th} and 13^{th}.

$$b_1 = \frac{4}{\pi}\{1-2\cos\alpha_1+2\cos\alpha_2-2\cos\alpha_3+2\cos\alpha_4 -2\cos\alpha_5\}$$

$$b_5 = \frac{4}{5\pi}\{1-2\cos 5\alpha_1+2\cos 5\alpha_2-2\cos 5\alpha_3+2\cos 5\alpha_4$$

$$-2\cos 5\alpha_5\} = 0$$

$$b_7 = \frac{4}{7\pi}\{1-2\cos 7\alpha_1+2\cos 7\alpha_2-2\cos 7\alpha_3$$

$$+2\cos 7\alpha_4-2\cos 7\alpha_5\} = 0$$

$$b_{11} = \frac{4}{11\pi}\{1-2\cos 11\alpha_1+2\cos 11\alpha_2\ldots\ldots\ldots\ldots$$

$$-2\cos 11\alpha_5\} = 0$$

$$b_{13} = \frac{4}{13\pi}\{1-2\cos 13\alpha_1+2\cos 13\alpha_2\ldots\ldots\ldots\ldots$$

$$-2\cos 13\alpha_5\} = 0$$

$\Rightarrow$ Non – linear transcedental equations

$\Rightarrow$ Solve numerically

$\Rightarrow$ choose required value for b_1

$\rightarrow$ fundamental component

$\alpha_1 = 10.514$, $\alpha_2 = 23.228$

$\alpha_3 = 29.289$, $\alpha_4 = 46.421$

$\alpha_5 = 50.157$

$b_1 = 0.986$ p.u.

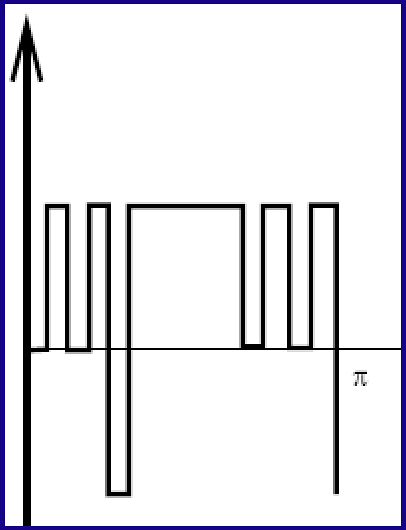
$\Rightarrow$ Immediate Dominant Harmonic

'V' gets AMPLIFIED

A well designed PWM strategy should have the following:

1) No pulse of opposite polarity in $\frac{1}{2}$ cycle of line-line voltage waveform

$\Rightarrow$ large ripple current



2) Sub-harmonics=0 (PWM waveform must be synchronized with its own fundamental)

$\Rightarrow$ Pulse No. = integer

$\Rightarrow$ $\frac{1}{2}$ wave, $\frac{1}{4}$ wave, 3-Φ symmetry

$\Rightarrow$ Do not allow different phases to switch simultaneously

⇒ The PWM inverter can be thought of as 3 separate driver stages which creates each phase waveform independently.

⇒ At any given instant, 1,2,3 devices may be either turned ON/OFF.

Using space vector PWM technique, it is proposed to achieve the above.