ECE 529

UTILITY APPLICATIONS OF POWER ELECTRONICS

SESSION no. 33
Harmonic filters

\[ V_n \]

Load harmonic behavior

Most harmonic producing loads
- Power converters that is drawing current - regulated or unregulated
- controlled cases depend on sinusoidal voltage

Diagram:

- Battery
- Rectifier
- Diode

No other legible text or symbols present in the image.
- Reducing current harmonics

1) Filters
   - Passive
   - Active

5th, 7th, 10th
(2) Series active filters

Each phase

(3) Hybrid Active filters

A

B

Load
(4) Harmonic Cancellation

- more cost effective with high power applications than lower power

\[ I_n = (n \cdot p + 1) \]

\( p = \text{pulse} \)

\( n = 0, 1, 2 \ldots \)

\( I_1, I_3, I_5 \)

\( Z_{sec} \)

\( m, M \)

\( V_{TH2} \)

\( I_{1y}, I_{3y}, I_{5y, 10} \)

\( I_1, I_3, I_5 \)

\( V', V'_{L-30^\circ}, V_{L-30^\circ} \)

\( I_1 | L-30^\circ \text{ pos seq} \)

\( I_5 | L-150^\circ \text{ neg seq} \)

\( I_{1y} | L-210^\circ \text{ pos seq} \)

\( \text{Conversion configuration} \)

\( V_{DC} \)
can also do

18 pulse
24 pulse
48 pulse
etc

require more complicated transformers
- conventional winding
  with a zig-zag winding

\[ V_{BC} \]

\[ \theta = 15^\circ \]
Voltage harmonics

- much more challenging to filter passively

VSC

V_{AB}

V_{NG}

360 Hz
L acts as low pass...
Solutions

1. 12 pulse, 24 pulse, 48 pulse

   → 1990's - VSC based FACTS devices
      - Westinghouse largely
      - Transformer connecting
      - Plus phase shift between bridges

2. Pulse width modulation
   - raising switch freq
3. Multi-level converters