Utility Applications of Power Electronics

Session 12
Half Bridge - Voltage Source Converter (VSC)

\[ V_a = d \frac{V_{dc}}{2} \]  
\[ V_a = (1-d) \frac{V_{dc}}{2} \]

This is an instantaneous value

"Instantaneous" accurate per switching cycle
The diagram illustrates a carrier wave with a switching frequency. The carrier wave is depicted with a series of peaks and valleys, indicating its oscillatory nature. The diagram also includes a notation for the switching frequency, which is labeled as $T_s$, and a waveform that varies at this frequency. The text below the diagram reads: 

$T_0 \geq T_p \geq \frac{1}{f_s}$

Where $T_0$, $T_p$, and $f_s$ are parameters related to the carrier wave and its switching characteristics.
DC to AC converter (bidirectional power flow)

\[ v \rightarrow \text{pos or neg} \rightarrow \text{sinusoid} \]
\[ i \rightarrow \text{pos or neg} \]

modify carrier

replace d with m

\[ -1 \leq m \leq 1 \]

\[ m(t) \rightarrow \text{modulating function} \]

\[ \text{at any instant in time have an instantaneous } m \text{ (just like } d) \]
\[ V_a(t) = \bar{V}_{at}(t) + \sum_{h=2}^{\infty} \bar{V}_h(t) \]

Low freq
- essentially 60Hz

\[ = \bar{V}_{as1}(t) + \bar{V}_{asy}(t) \]

\[ = d \frac{V_{dc}}{2} + (1-d)\left(-\frac{V_{dc}}{2}\right) \]

\[ = (2d - 1) \frac{V_{dc}}{2} \]

\[ M \rightarrow \text{instantaneous} \rightarrow \text{then modulation function} \]
over a 60 Hz cycle or longer

\[ V_a(t) = m(t) \frac{V_{dc}}{2} \]

\[ m(t) = M \cos(\omega t + \theta) \]

peak amplitude

\[ V_m = M \frac{V_{dc}}{2} \]

phase angle (relative to point of interconnect)
Open-Loop DC/AC Half Bridge Converter

Power Circuit

- Now have grounded midpoint on DC link
- Both switches need to be bidirectional

Gate Controls

- Updated son
Create sinsoidal \( m(t) \) function

\[
m(t) = 1 \cos(\omega t + \phi)
\]

2. \( \omega t \cdot \text{deg} \)

(file Halfbridge DC AC.plt; x-var T; M)
AC voltage between the two inductors compared to AC source

![Voltage Waveform]

AC current

![Current Waveform]
Zoomed current

Current in switch 1