Modular Multi-level Converter
1. Control response & controller design
2. Power system dynamics
   - have time constants in milliseconds or longer
3. Models & use simulations where easy
   - Non-switching equivalent
Harmonics

\[
\omega_s = 2\pi f
\]

\[
\int \frac{1}{2} L \frac{d^2 i(t)}{dt^2} + (i(t) + L) \frac{di(t)}{dt} + (v(t) + 6L i(t)) dt = 0
\]

For now

\[
\frac{d^2 i(t)}{dt^2} + (i(t) + L) \frac{di(t)}{dt} + (v(t) + 6L i(t)) = 0
\]

\[
\text{Assu}\_m e\_m \text{stance}
\]

Point of

\[
V_A = 45
\]

\[
V_A = 45
\]

\[
\text{Point of intersection}
\]

\[
2h
\]

\[
15
\]

\[
15
\]

\[
51
\]

\[
51
\]
condensed component \( \text{trace space averaged} \)

Nonlinear component

\[ 2 = \frac{\alpha c_0}{Q} + \frac{t_p}{2} \]

\( t \) harmonic behaviour

\[ \frac{a}{\alpha} = 2 + \frac{t_p}{2} \frac{7}{10} \]
Two independent control variables

Fung Shui

Theme

Architecture

Modularity

Function

N. Sci

Equation:

\[ M(t) = W \cdot \cos(\omega t + \phi) \]
\[
\frac{2}{V_{oc}} (P - 1) = \frac{2}{V_{oc}} P - \frac{2}{V_{oc}} = V(S) + V(S') = V_0
\]

\[
\frac{2}{V_{oc}} (P - 1) = V_{out} = V_0 + \frac{1}{D} V_{in} \Rightarrow V_{out} = V_0 + \frac{1}{D} V_{in}
\]

Diagram with various symbols and annotations.
\[ I_a = \frac{1}{V_{bc}} (Z_D - 1) \, I_{ac} \]

\[ I_c = \frac{2}{V_{bc}} (I_p - I_a) \]

A conduction loss

A conversion loss

A runaway switching losses

\[ S_y I_y = (1 - D) \, I_{ac} \]

\[ S_i I_p = D \cdot I_{ac} \]