Learning the Basic Concepts of Capacitor Bank Switching

34.5-kV Per-Phase System

1 - Energization Inrush

CB1 and CB4 Closed, Close Switch S1.
Energization Inrush - First Bank $C_1$

$$i(t) = \frac{V(0)}{Z_0} \sin \omega_0 t$$

$$Z_0 = \frac{L}{\sqrt{C_1}}$$

$$\omega_0 = \frac{1}{\sqrt{LC_1}}$$

**Peak Current = 3041 Amps, Natural Frequency = 500 Hz**

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**Bus Voltage: Peak Voltage = 1.87 per unit**
CB1, CB4, S1 Closed. Close Switch S2.

(i(t) = \frac{V(0)}{Z_{01}} \sin \omega_0 t

Z_{01} = \sqrt{\frac{L_b}{C_{EQ}}}

\omega_0 = \frac{1}{\sqrt{L_b C_{EQ}}}

C_{EQ} = \frac{C_1 C_2}{C_1 + C_2}

Peak Current = 1400 Amps, Natural Frequency = 9.4 KHz
Back-to-Back Energization

\[ i(t) = \frac{V(0)}{Z_{01}} \sin \omega_0 t \]
\[ Z_{01} = \sqrt{\frac{L_b}{C_{EQ}}} \]
\[ \omega_0 = \frac{1}{\sqrt{L_b C_{EQ}}} \]
\[ C_{EQ} = \frac{C_1 C_2}{C_1 + C_2} \]

Peak Bus Voltage = 1400 Amps

3 - Outrush Transient

\[ i(t) = \frac{V(0)}{Z_{02}} \sin \omega_{02} t \]
\[ Z_{02} = \sqrt{\frac{L_F}{C_1}} \]
\[ \omega_{02} = \frac{1}{\sqrt{L_F C_1}} \]

CB1, CB3, CB4, S1 Closed. Fault on Feeder or Bus.
4 - Voltage Magnification

CB1, CB2, CB4 Closed. Close Switch S1 or S2.

Voltage Magnification

\[ \omega_0 = \frac{1}{\sqrt{L_2 C_{LV}}} = \frac{1}{\sqrt{L_1 C_1}} \]

Peak Distribution Bus Voltage = 1.76 per unit.
5 - Transient Recovery Voltage

CB1 Closed, Fault on Bus. Open CB1 to Clear Fault.

Transient Recovery Voltage

Oscillation between Circuit Breaker Bushing Capacitance and Source Inductance.

Peak Bus Voltage = 1.4 per unit, Frequency = 5 KHz.