Tank Input Impedance

\[ \text{SRC example} \]
\[ Z_{\text{in}} = sC_r + \frac{1}{2\pi f R_C} \]

\[ H(s) = \frac{Z_C}{Z_{\text{in}}} \]

\[ C_{eq} : H(s)|_{s=0} = \text{odd for all } R_C \]
- as \( R_C \to \infty \), \( Z_{\text{in}} \to \infty \)
- cannot tolerate output short circuit
- \( Z_{\text{in}} \) is resistive

\[ Z_{\text{in}} \] is capacity ≤
\[ Z_{\text{VS}} \] not possible
\[ Z_{\text{CS}} \] may be possible

\[ to = \frac{1}{\text{inductor}} \]
\[ Z_{\text{VS}} \] may be possible
\[ Z_{\text{CS}} \] not possible

\[ \text{as } R_C \uparrow, Z_{\text{in}} \uparrow \rightarrow D_{\text{cond}} \uparrow \]
\[ R_{\text{out}} \downarrow \rightarrow \text{Conduction losses decrease at light load} \]
Series Resonant Tank
Parallel Resonant Converter
PRC Tank Input Impedance

\[ Z_{in} = \frac{1}{sL} + \frac{1}{sC_p} || R_c \]

\[ H(s) = \frac{\frac{1}{sC_p} || R_c}{Z_{in}} \]
PRC Tank

Textbook Theorem 1

- 19.4.2 in 2nd Edition
- 22.4 in 3rd Edition

• If tank is purely reactive $||Z_i(j\omega)||$ is a purely monotonic function of $R_e$

• Only need to look at $Z_{i\infty} = Z_i|_{R_e \to \infty}$ and $Z_{i0} = Z_i|_{R_e \to 0}$; all other curves are monotonically decreasing/increasing in between
LCC
LLC

[Diagram of an electrical circuit with components labeled L_s, C, Z_i, and Z_o.]

[Graph showing plots with axes labeled F, |Z|, and |H|, with annotations indicating high current at short-circuit and low current at open-circuit.]
Tank Summary (1/2)
Tank Summary (2/2)

**LCC**

\[ Z_i \rightarrow L \rightarrow C_s \rightarrow Z_0 \]

\[ Z_i \rightarrow C_p \rightarrow Z_0 \]

**LLC**

\[ Z_i \rightarrow L_s \rightarrow C \rightarrow L_p \rightarrow Z_0 \]
Series Resonant Tank – Subharmonic Modes
Subharmonic Modes - High Q

\( f_0 \) to \( f_0 \)

\( F = 1 \)

\( f_s = f_0 \)

Normal sinusoidal approx @ \( f_s \)

Sinusoidal approx @ 2f_0

@ 7f_s
Subharmonic Modes – Low Q
SRC Control Plane

\[ F = \frac{f_s}{f_0} \]

\[ M = \frac{V}{V_0} \]

\[ Q = 0.2 \]

\[ Q = 0.35 \]

\[ Q = 0.5 \]

\[ Q = 0.75 \]

\[ Q = 1 \]

\[ Q = 1.5 \]

\[ Q = 2 \]

\[ Q = 3.5 \]

\[ Q = 5 \]

\[ Q = 10 \]

\[ Q = 20 \]

Fundamentals of Power Electronics 47 Chapter 19: Resonant Conversion
SRC Mode Boundaries

Fundamentals of Power Electronics 48 Chapter 19: Resonant Conversion