1. Input circuit model
2. Rectifier model
3. Tank model

by symmetry
- only odd harmonics

half-bridge
Tank $C_b$ 10µH

big to block DC

For $R_e > \sqrt{L/C}$

expect $\frac{V_o}{V_m}$

any effects of transformer?

$\sigma_C$ on $f$

$\sigma_b$ on $Q$
1. Analysis of a half-bridge dc–dc parallel resonant converter, operated above resonance. In Fig. 1, the elements $C_a$, $L_a$, and $C_r$ are large in value, and have negligible switching ripple. You may assume that all elements are ideal. You may use the sinusoidal approximation as appropriate.

(a) Construct an equivalent circuit for this converter, similar to Fig. 19.22, which models the fundamental components of the tank waveforms and the dc components of the converter input current and output voltage. Clearly label the values and/or give expressions for all elements in your model, as appropriate.

At rated (maximum) load, this converter produces $I = 20 \text{ A}$ at $V = 3.3 \text{ V}$.

(b) What is the converter switching frequency $f_s$ at rated load?

(c) What is the magnitude of the peak transistor current at rated load?

At minimum load, the converter produces $I = 2 \text{ A}$ at $V = 3.3 \text{ V}$.

(d) What is the converter switching frequency $f_s$ at minimum load?

(e) What is the magnitude of the peak transistor current at minimum load? Compare with your answer from part (c)—what happens to the conduction loss and efficiency at minimum load?

\[
\text{Vout fixed at 3.3 V}
\]

\[
2 \geq I_{\text{out}} \leq 20 \text{ A}
\]

As $V_g$ or $I_v$ change, $f$ requires $\text{V}_b$ to change to $\text{keep V}_b = 3.3 \text{ V}$.
makes $W \propto n$

familiar?

$Q_c = \frac{Re}{Z_0} = \frac{Re}{\sqrt{L/\frac{1}{n^2}C}} = \frac{nRe}{\sqrt{L/C}}$

$Q = f(ln(n))$

Expect qualitatively two

$\frac{V_{R1}}{V_{S1}}$

$V_{R1}$

$V_{S1}$

$Re = \infty$

$Re$ small
Analytically

\[ \frac{V_{R1}}{V_{S1}} = \frac{R_{El1} \frac{1}{S_C}}{\frac{S_L}{n^2} + R_{El1} \frac{1}{S_C}} = \frac{Z_{load}}{Z_{in}} \]

\[ \frac{R_{E} / S_C}{R_{E} + \frac{1}{S_C}} = \frac{R_{E}}{R_{E} C S + 1} \] from

\[ \left( \frac{R_{E} C S + 1}{S_L} \right) \frac{S_L}{n^2} + R_{E} \] \[ \frac{Z_{load}}{Z_{in}} = \left( \frac{R_{E} C S + 1}{S_L} \right) \frac{S_L}{n^2} + R_{E} \]

\[ \left[ \frac{S^2}{L C} + \frac{s L}{S R_{E} n^2} + 1 \right]^{-1} \]

\[ \frac{1}{n} = \frac{V_{R1}}{V_{S1}} \] from \( V_{S1} \)

\[ \frac{1}{n} = \frac{V_{R1}}{V_{S1}} \]

\[ \frac{S^2}{W_R^2} + \frac{s L}{Q W_{Rt}} + 1 \]
Quantitative

Selected values

Element values
- $L = 10 \mu H$
- $C = 1.5 \mu F$
- $n = 20$
- $V_Z = 160 V$
- $V = 3.3 V$

Operating points
- at $I = 20 A$
  - $R = 0.165 \Omega$
  - $R_e = 0.204 \Omega$
  - $f_0 = 821,873 Hz$
  - $Q_e = 1.58$
  - $f_c = 1,031,696 Hz$
- at $I = 2 A$
  - $R = 1.65 \Omega$
  - $R_e = 2.036 \Omega$
  - $f_0 = 821,873 Hz$
  - $Q_e = 15.77$
  - $f_c = 1,156,025 Hz$

For $V_0 = 3.3$

$R_e \approx \frac{\pi^2}{8} R$

![Diagram with frequency response and voltage levels]

$V_{out\ goal}$

20 A Load
- $R_L \rightarrow Q_T = 16$

20 A Load
- $R_L \rightarrow Q_T = 1.6$
Largest $i_{1n} = i_\alpha$ when $R_2 = \infty$

$R_2 = 0$

![Circuit diagram]

$R_2 = \infty$

![Circuit diagram]

Series resonance

$Z_i (R_2 = 0)$

$Z_i (R_2 = \infty)$

Biggest for $R_2 = \infty$
\[
\frac{V_{out}}{V_{in}} = \frac{\frac{1}{wC} \left| 1 \right| R \left\{ Z_{load} \right\}}{wL + \frac{1}{wC} \left| 1 \right| R \left\{ Z_{in} \right\}}
\]

Boost
Buck

Above Resonance