Switch conversion ratio μ

$$\langle i_1 \rangle = \frac{1}{T_s}\left[\frac{1}{2}\frac{\alpha}{\omega_0} I_2 + C_r V_{c1} + \frac{\beta}{\omega_0} I_2\right]$$

$$\mu = \frac{\langle i_1 \rangle}{I_2} = \frac{1}{T_s}\left[\frac{1}{2}\frac{\alpha}{\omega_0} + \frac{C_r V_{c1}}{I_2} + \frac{\beta}{\omega_0}\right]$$

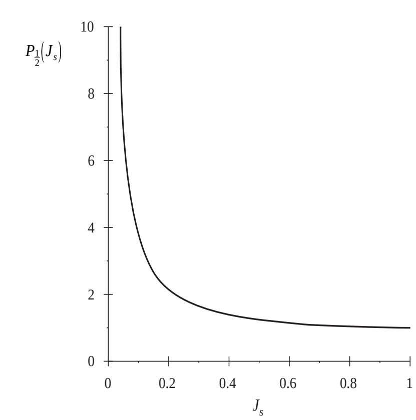
$$\mu = \frac{F}{2\pi}\left[\frac{\alpha}{2} + \beta + \frac{M_{c1}}{J_2}\right]$$

$$\mu = F \frac{1}{2\pi}\left[\frac{J_2}{2} + \pi + \sin^{-1}(J_2) + \frac{\sqrt{1-J_2^2}+1}{J_2}\right]$$

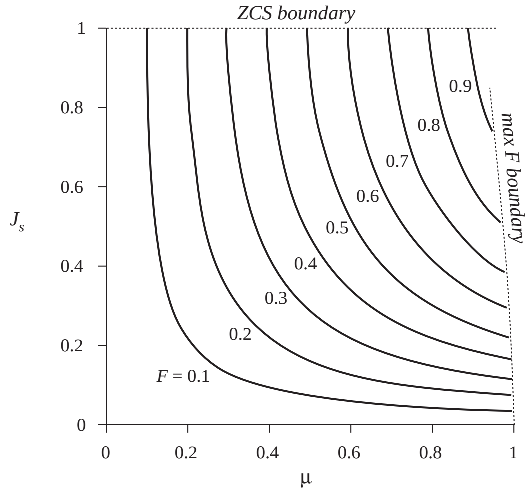
$$\mu = F\, P_{1/2}(J_2)$$

where $P_{1/2}(J_2)$ is the bracketed term (from book (20.43))

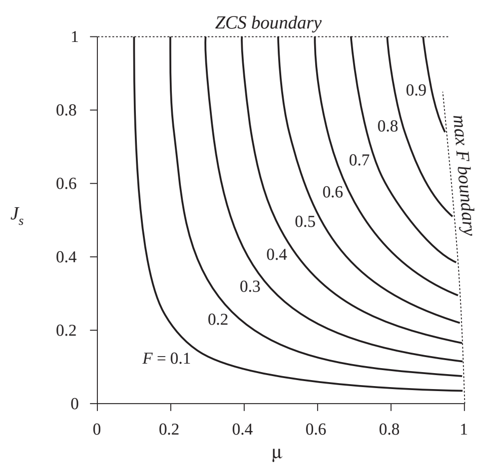
Analysis result: switch conversion ratio μ



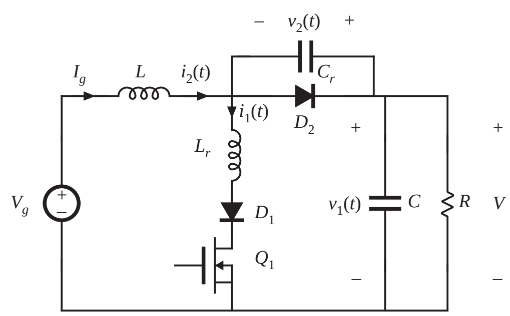
Characteristics of the half-wave ZCS resonant switch



Buck converter containing half-wave ZCS quasi-resonant switch

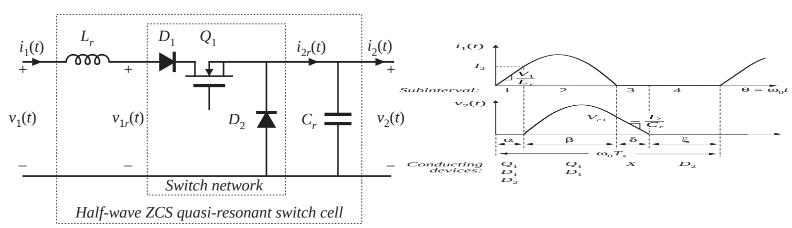


Boost converter example

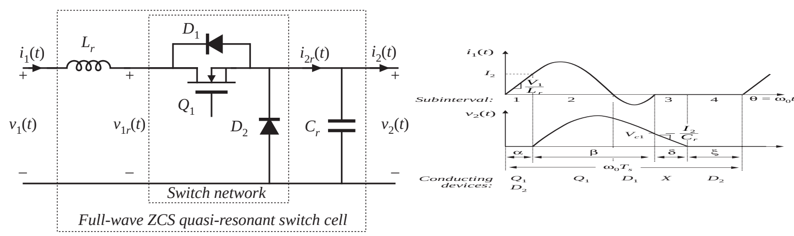


20.1.3 The full-wave ZCS quasi-resonant switch cell

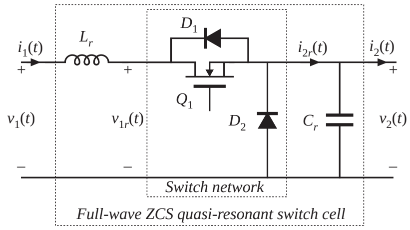
Half wave

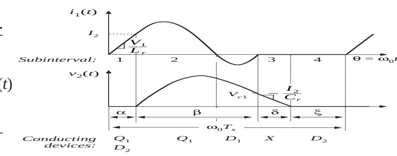


Full wave

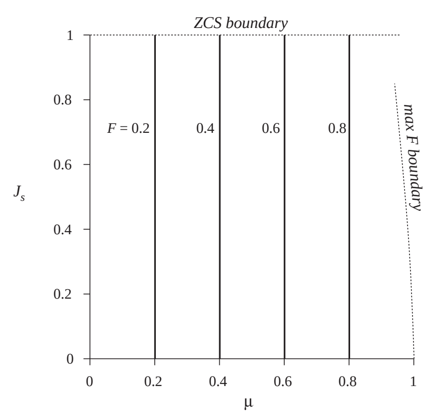


Analysis: full-wave ZCS



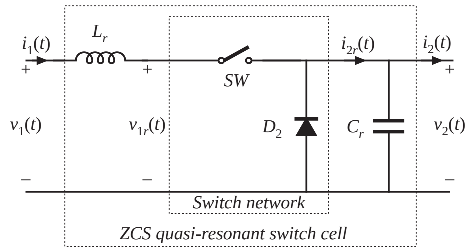


Full-wave cell: switch conversion ratio μ



20.2 Resonant switch topologies

Basic ZCS switch cell:



SPST switch SW:

- Voltage-bidirectional two-quadrant switch for half-wave cell
- Current-bidirectional two-quadrant switch for full-wave cell

Connection of resonant elements:

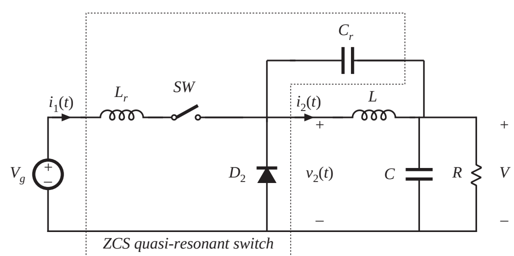
Can be connected in other ways that preserve high-frequency components of tank waveforms

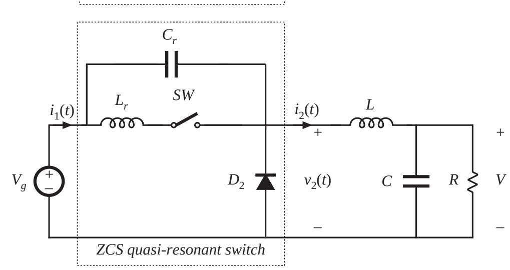
Connection of tank capacitor

Connection of tank capacitor to two other points at ac ground.

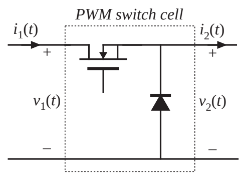
This simply changes the dc component of tank capacitor voltage.

The ac high-frequency components of the tank waveforms are unchanged.



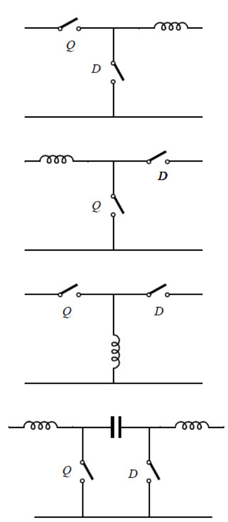


PWM switch cell topology: HF (ac) view

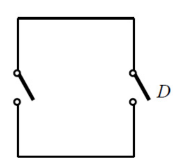


PWM Switch Cell of PWM Converters

Converter examples



High-frequency view of the switch network



Basic switch implementation options

Q: single-quadrant (transistor)
D: single-quadrant (diode)

Q: current-bidirectional (e.g. MOSFET)
D: current-bidirectional synchronous rectifier (e.g. MOSFET)

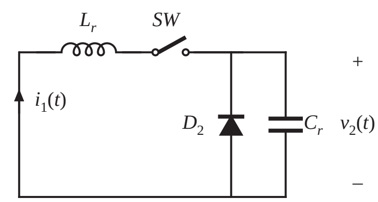
A test to determine the topology of a resonant switch network

Replace converter elements by their high-frequency equivalents:

- Independent voltage source V_g: short circuit
- Filter capacitors: short circuits
- Filter inductors: open circuits

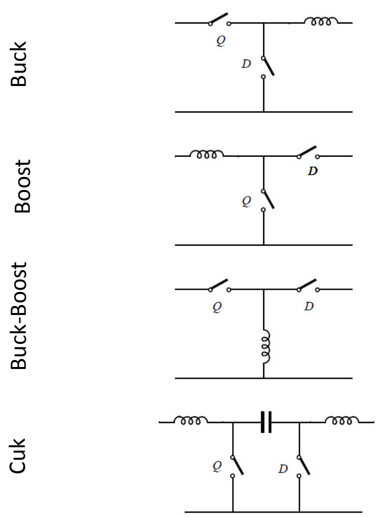
The resonant switch network remains.

If the converter contains a ZCS quasi-resonant switch, then the result of these operations is

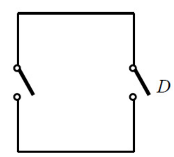


ZCS-QR

Converter examples



High-frequency view of the switch network



Basic switch implementation options

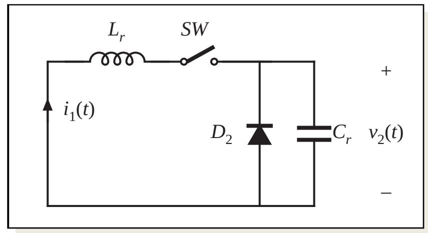
Q: single-quadrant (transistor)
D: single-quadrant (diode)

Q: current-bidirectional (e.g. MOSFET)
D: current-bidirectional synchronous rectifier (e.g. MOSFET)

Zero-current and zero-voltage switching

ZCS quasi-resonant switch:

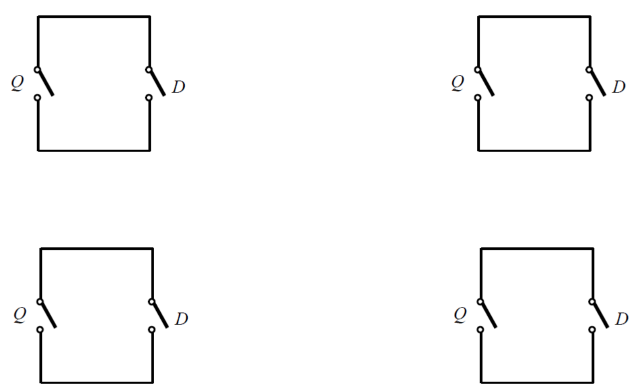
- Tank inductor is in series with switch; hence SW switches at zero current
- Tank capacitor is in parallel with diode D_2; hence D_2 switches at zero voltage



Discussion

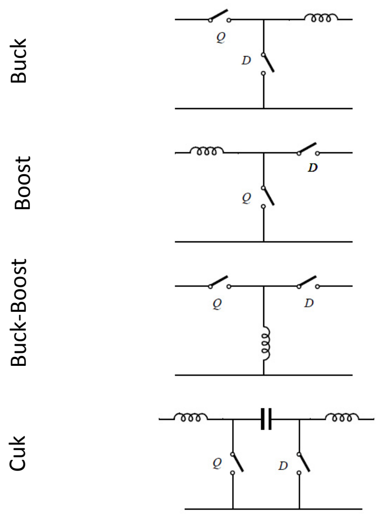
- Zero voltage switching of D_2 eliminates switching loss arising from D_2 stored charge.
- Zero current switching of SW: device Q_1 and D_1 output capacitances lead to switching loss. In full-wave case, stored charge of diode D_1 leads to switching loss.
- Peak transistor current is $(1 + J_s)\ V_g/R_0$, or more than twice the PWM value.

Classification of Resonant-Switch Converters

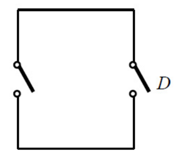


ZVS-QR

Converter examples



High-frequency view of the switch network



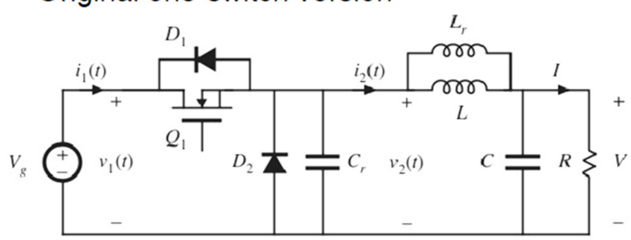
Basic switch implementation options

Q: single-quadrant (transistor)
D: single-quadrant (diode)

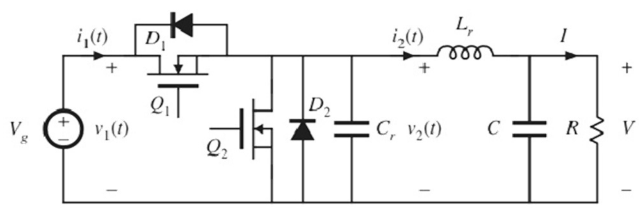
Q: current-bidirectional (e.g. MOSFET)
D: current-bidirectional synchronous rectifier
(e.g. MOSFET)

ZVS QSW Converters: Already Studied

Original one-switch version

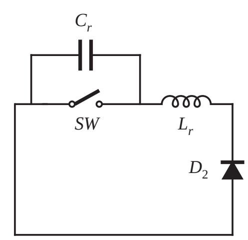


Add synchronous rectifier



20.2.1 The zero-voltage-switching quasi-resonant switch cell

When the previously-described operations are followed, then the converter reduces to



A full-wave version based on the PWM buck converter: