Chapter 20

Quasi-Resonant Converters

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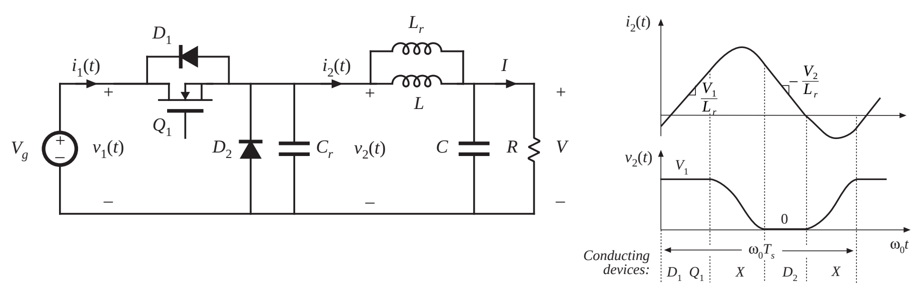
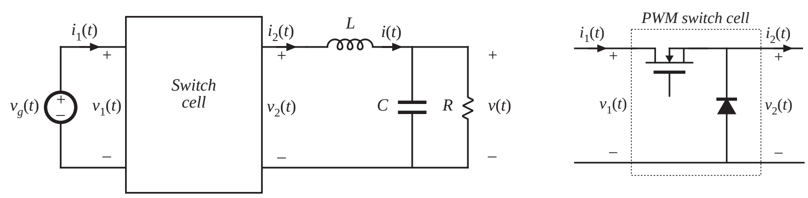
A quasi-square-wave ZVS buck



- Peak transistor voltage is equal to peak transistor voltage of PWM cell
- Peak transistor current is increased
- Zero-voltage switching in all semiconductor devices

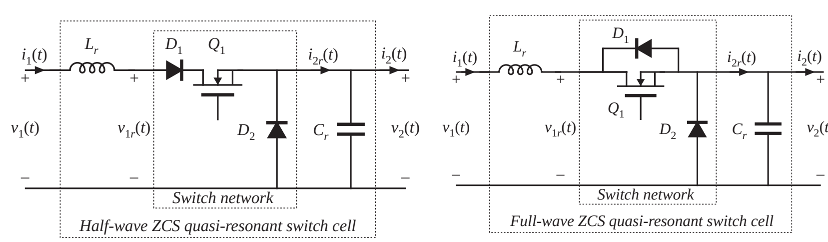
The resonant switch concept

- A quite general idea:
- 1. PWM switch network is replaced by a resonant switch network
- 2. This leads to a quasi-resonant version of the original PWM converter

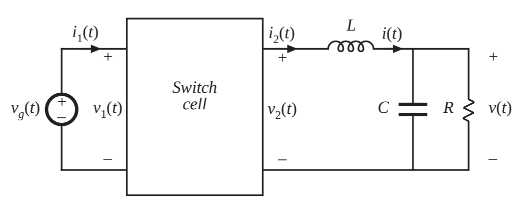


Example: realization of the switch cell in the buck converter

Two quasi-resonant switch cells



Insert either of the above switch cells into the buck converter, to obtain a ZCS quasi-resonant version of the buck converter. L_r and C_r are small in value, and their resonant frequency f_0 is greater than the switching frequency f_s.



20.1 The zero-current-switching quasi-resonant switch cell

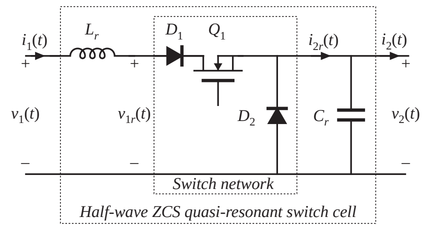
Tank inductor L_r in series with transistor: transistor switches at zero crossings of inductor current waveform

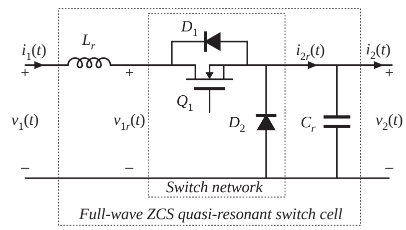
Tank capacitor C_r in parallel with diode D_2 : diode switches at zero crossings of capacitor voltage waveform

Two-quadrant switch is required:

> *Half-wave:* Q_1 and D_1 in series, transistor turns off at first zero crossing of current waveform
>
> *Full-wave:* Q_1 and D_1 in parallel, transistor turns off at second zero crossing of current waveform

Performances of half-wave and full-wave cells differ significantly.





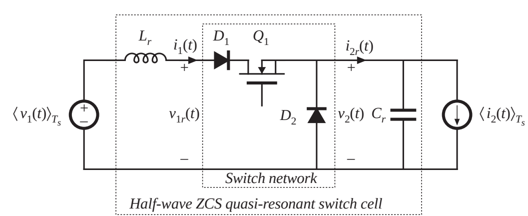
The switch conversion ratio μ

A generalization of the duty cycle $d(t)$

The switch conversion ratio μ is the ratio of the average terminal voltages of the switch network. It can be applied to non-PWM switch networks. For the CCM PWM case, $\mu = d$.

If $V/V_g = M(d)$ for a PWM CCM converter, then $V/V_g = M(\mu)$ for the same converter with a switch network having conversion ratio μ.

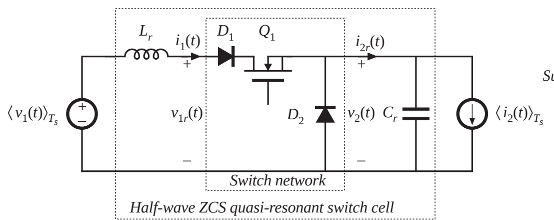
Generalized switch averaging, and μ, are defined and discussed in Section 10.3.



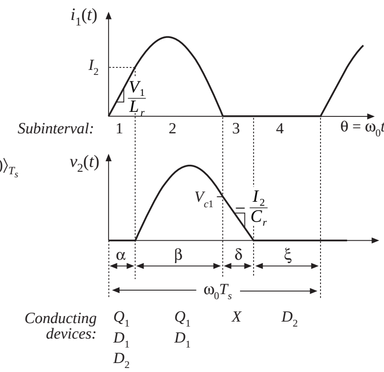
20.1.1 Waveforms of the

half-wave ZCS quasi-resonant switch cell

The half-wave ZCS quasi-resonant switch cell, driven by the terminal quantities $\langle v_1(t) \rangle_{Ts}$ and $\langle i_2(t) \rangle_{Ts}$.



Waveforms:

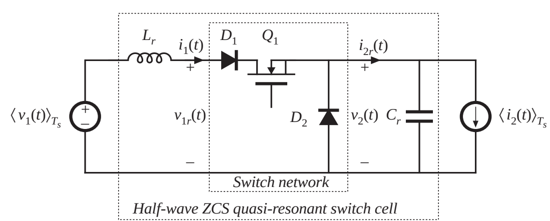


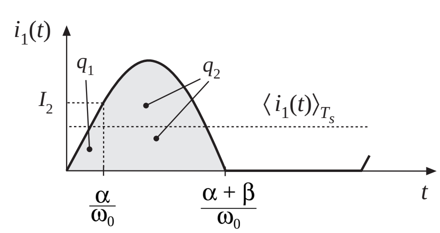
Each switching period contains four subintervals

Boundary of zero current switching

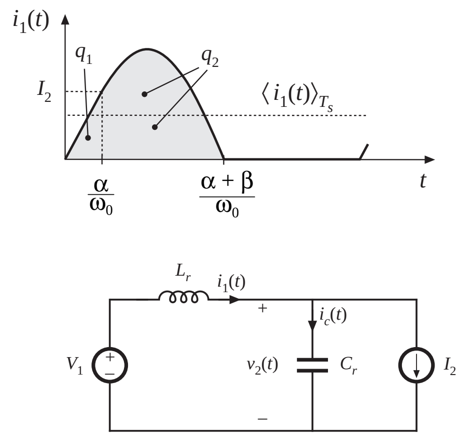
20.1.2 The average terminal Waveforms

Averaged switch modeling: we need to determine the average values of $i_1(t)$ and $v_2(t)$.





Charge arguments: computation of q_2



Circuit during subinterval 2

Switch conversion ratio μ

Analysis result: switch conversion ratio μ