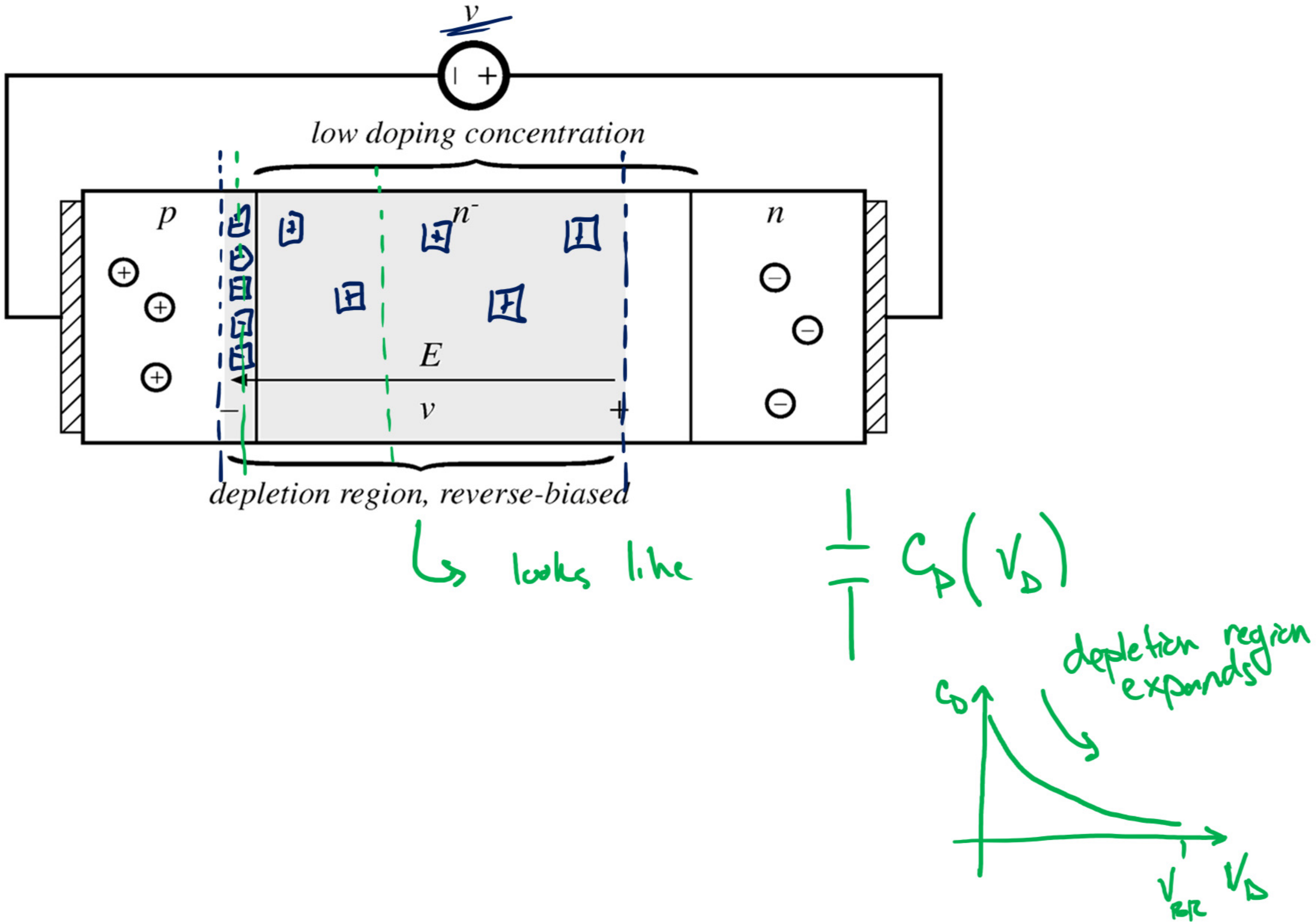
Reverse Biased Diode



Diode Stored Charge

The diode equation:

$$q(t) = Q_0\left(e^{\lambda v(t)} - 1\right)$$

Charge control equation:

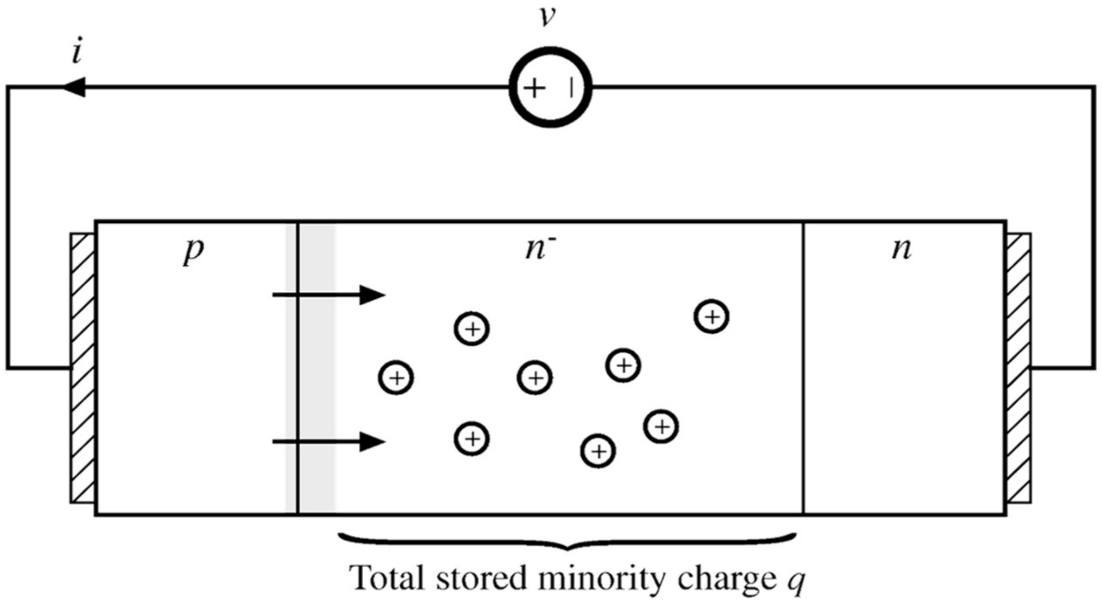
$$\frac{dq(t)}{dt} = i(t) - \frac{q(t)}{\tau_L}$$

With:

λ= 1/(26 mV) at 300 K

τ_L = minority carrier lifetime ≈ms

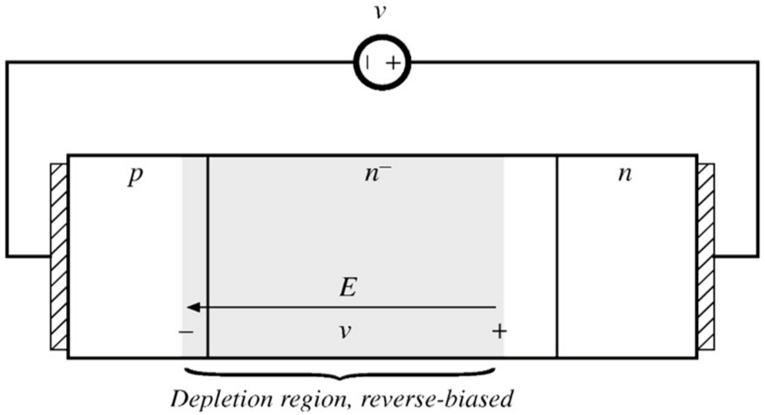
(above equations don't include current that charges depletion region capacitance)

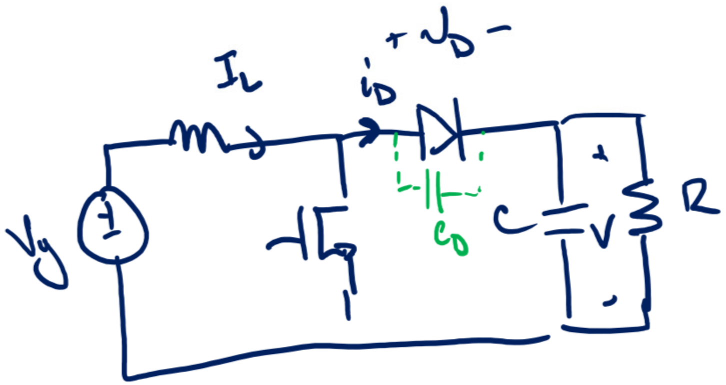


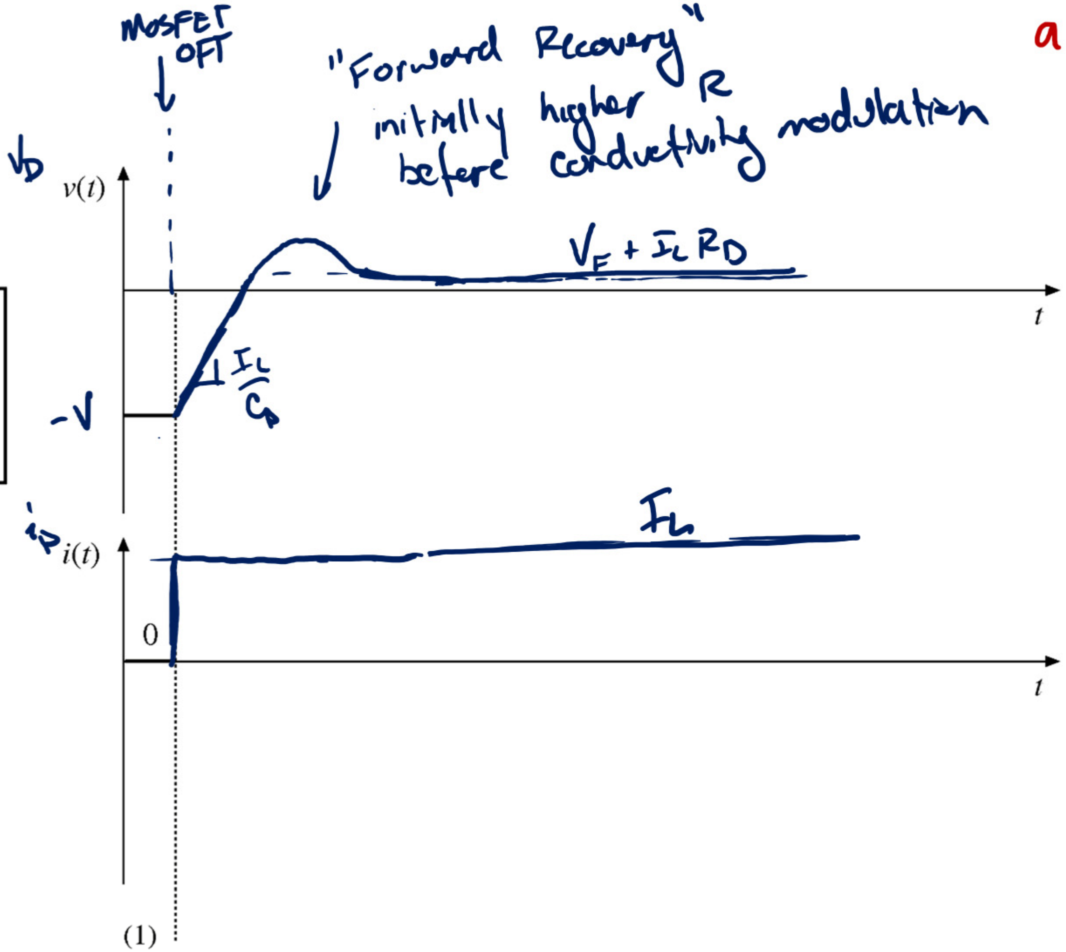
In equilibrium: $dq/dt = 0$, and hence

$$i(t) = \frac{q(t)}{\tau_L} = \frac{Q_0}{\tau_L}\left(e^{\lambda v(t)} - 1\right) = I_0\left(e^{\lambda v(t)} - 1\right)$$

Diode Turn-On

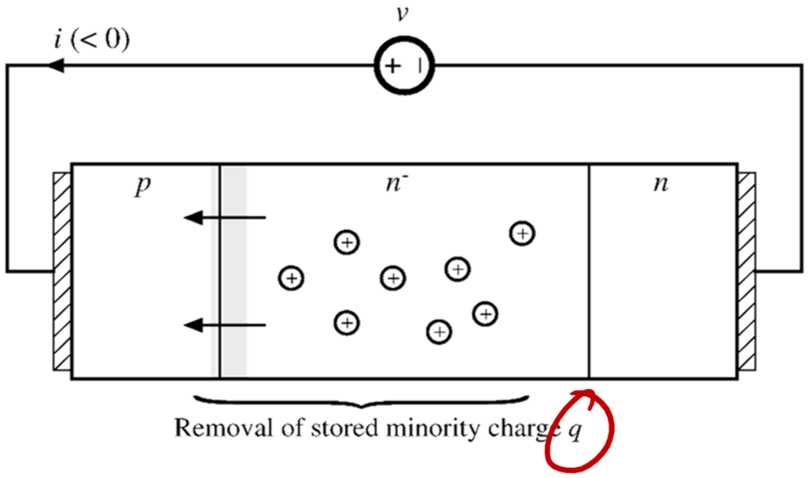


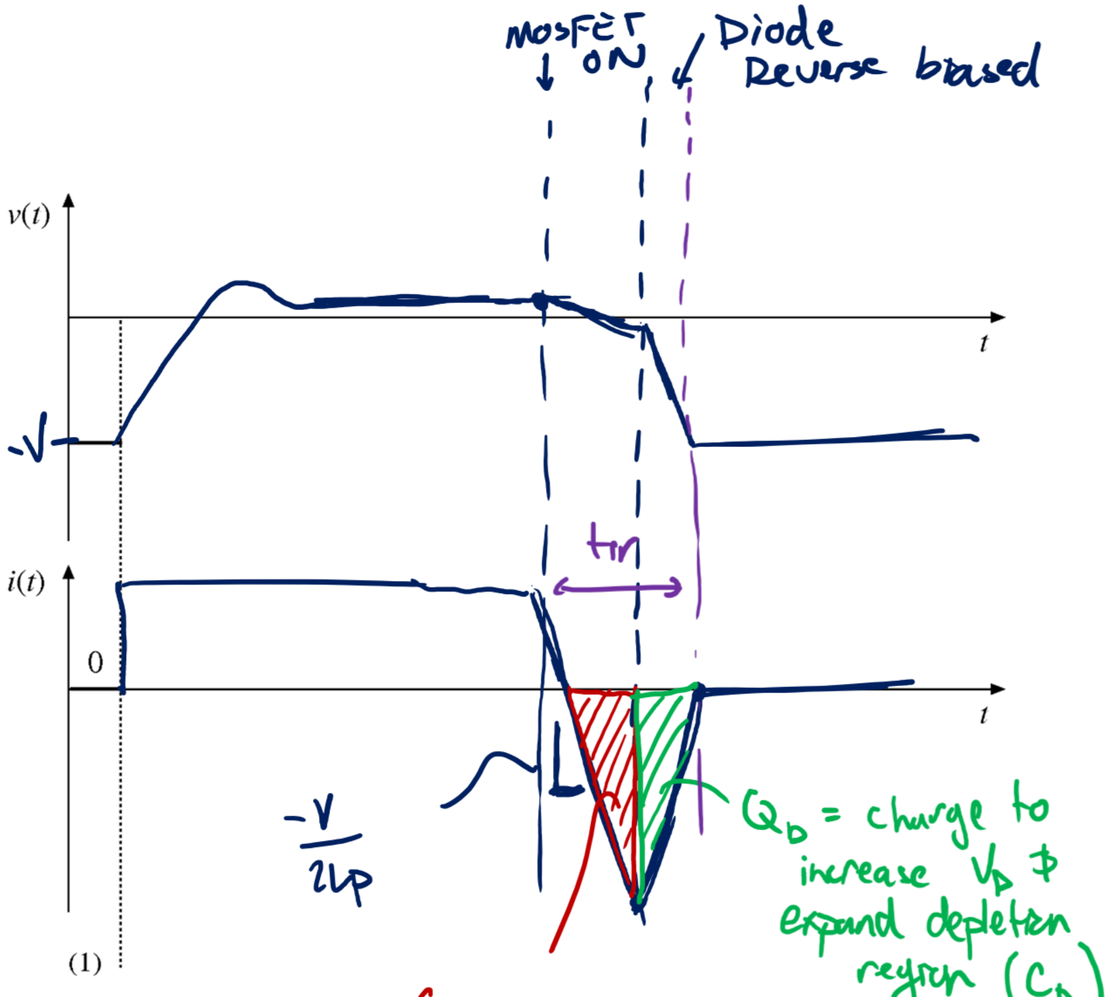


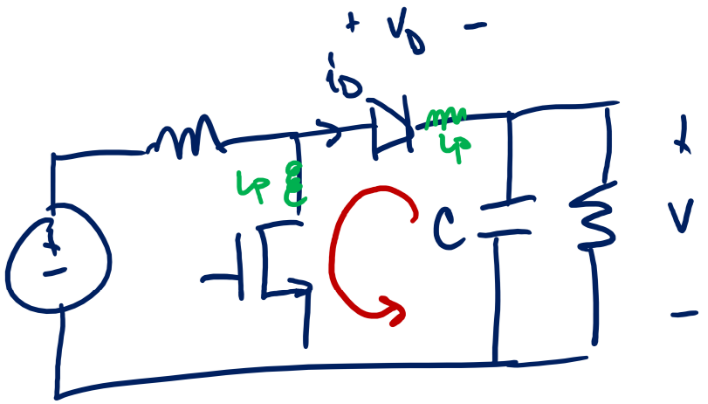


almost always neglected

Diode Turn-Off



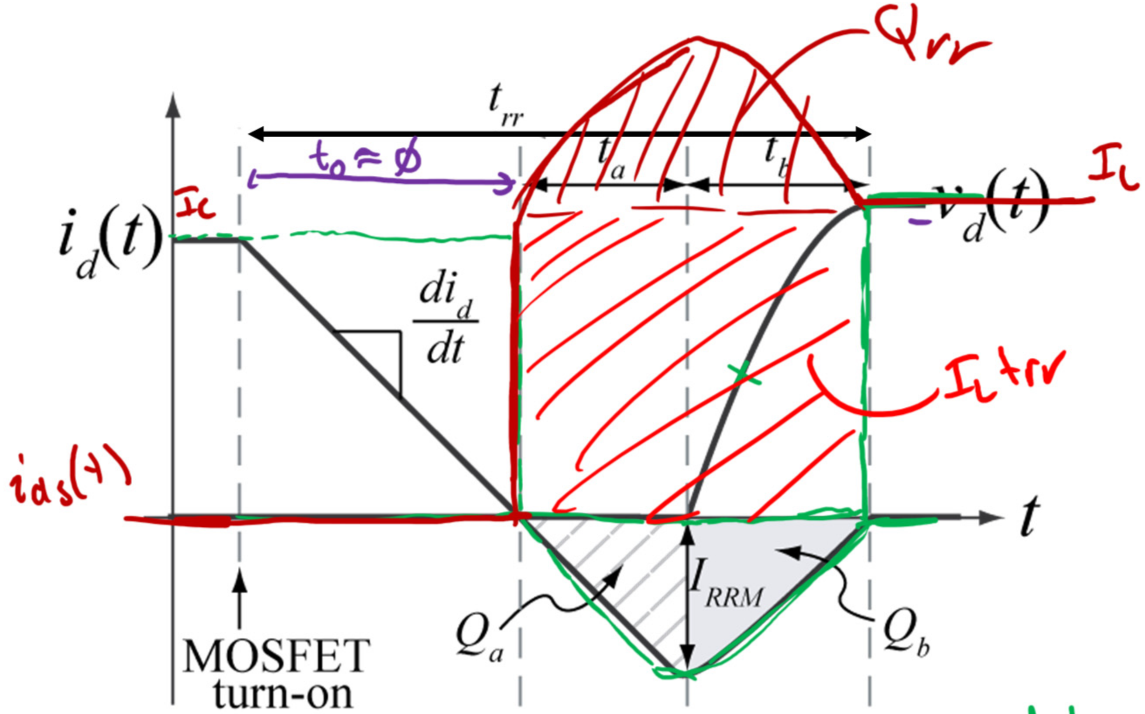


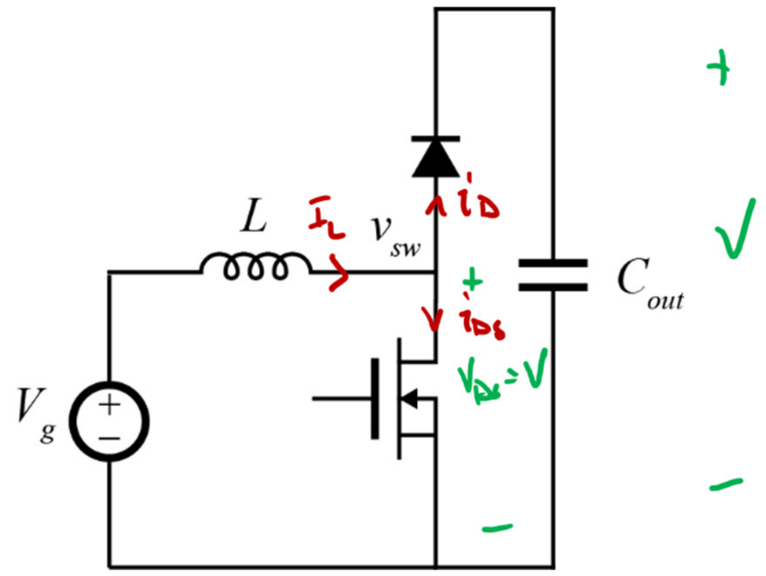


$Q_a = q =$ minority stored charge

$Q_{rr} = Q_a + Q_b$

Diode Reverse Recovery





Assume $t_0 = \phi$
& diode voltage during fwd bias is negligible w.r.t V

Under approximated waveforms

$$E_D = \int v_D i_D \, dt = \phi$$

$$E_T = \int v_{DS} i_{DS} \, dt = V(I_L t_{rr} + Q_{rr})$$

$$P_T = E_T f_s$$

Datasheet RR Characteristics

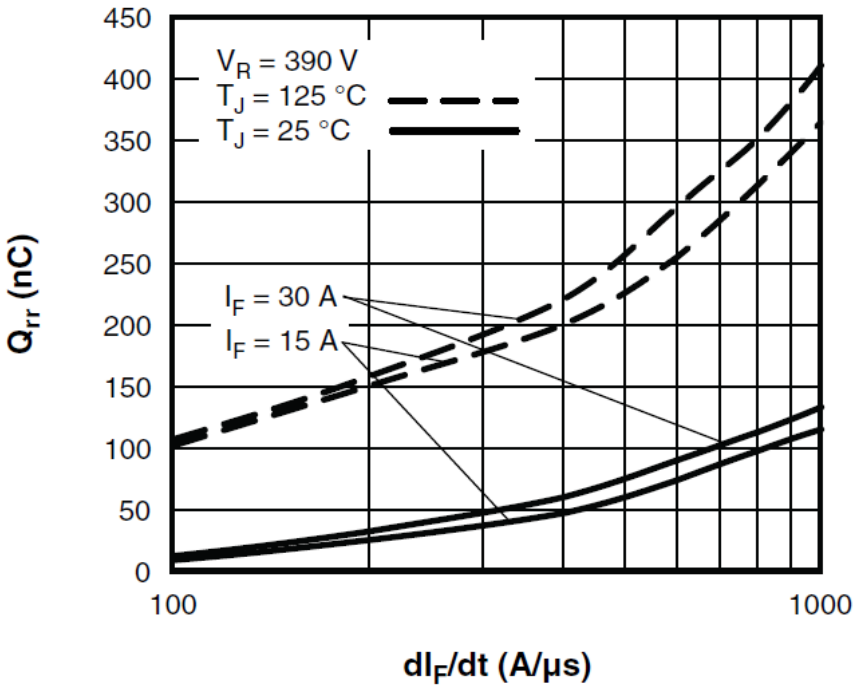


Fig. 10 - Typical Stored Charge vs. dI_F/dt

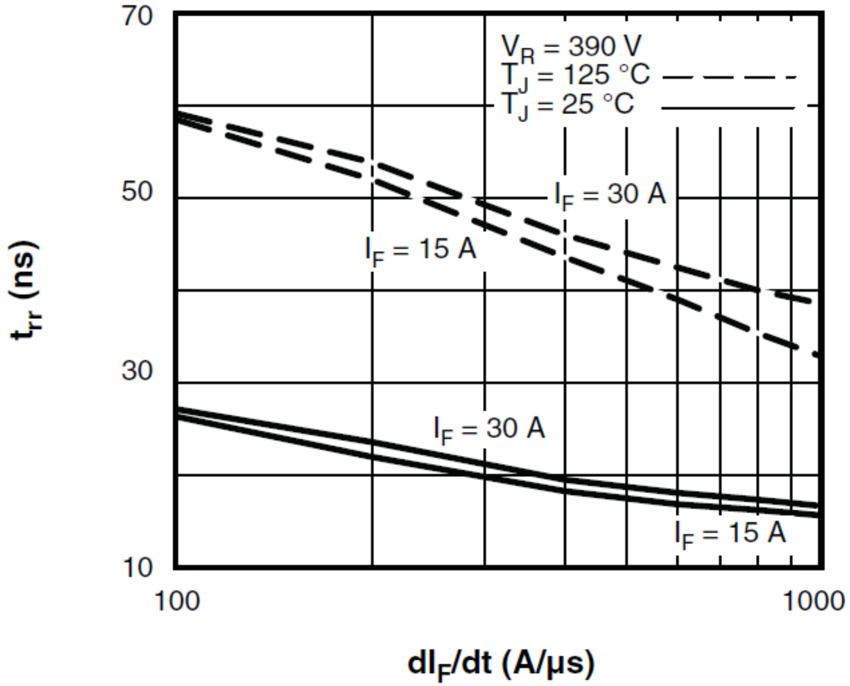
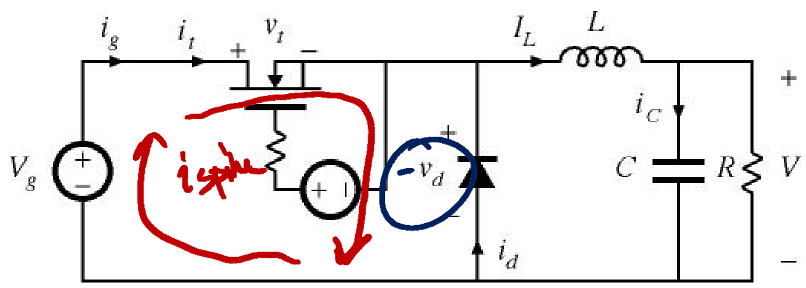
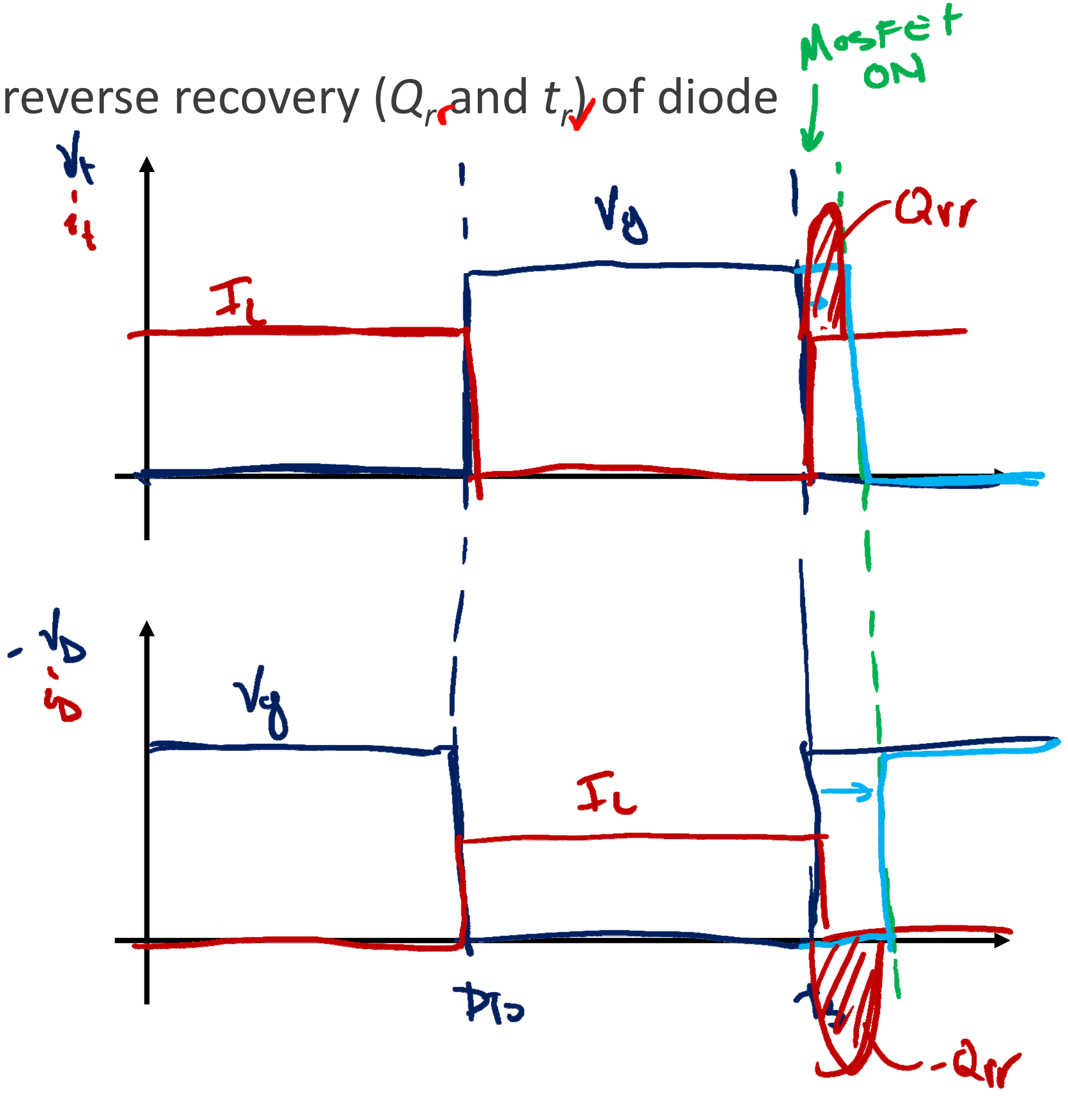


Fig. 9 - Typical Reverse Recovery Time vs. dI_F/dt

Buck Converter Example

- All elements ideal except for reverse recovery (Q_r and t_r) of diode





Buck Average Model with RR

$\langle i_g \rangle = I_g =$

$D I_L + \frac{1}{T_s}\left[t_{rr} I_L + Q_{rr}\right]$

$\langle v_L \rangle = 0 = D V_g - V$

$\langle i_C \rangle = 0 = I_L - \frac{V}{R}$