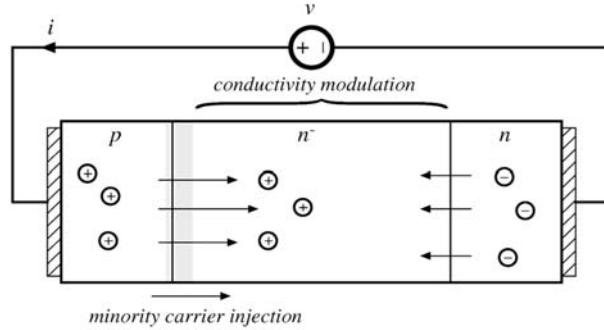


Forward Biased Diode



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Diode Stored Charge

The diode equation:

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

Charge control equation:

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

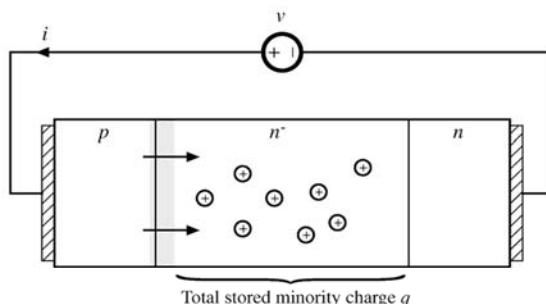
With:

$\lambda = 1/(26 \text{ mV})$ at 300 K

τ_L = minority carrier lifetime

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

Fundamentals of Power Electronics

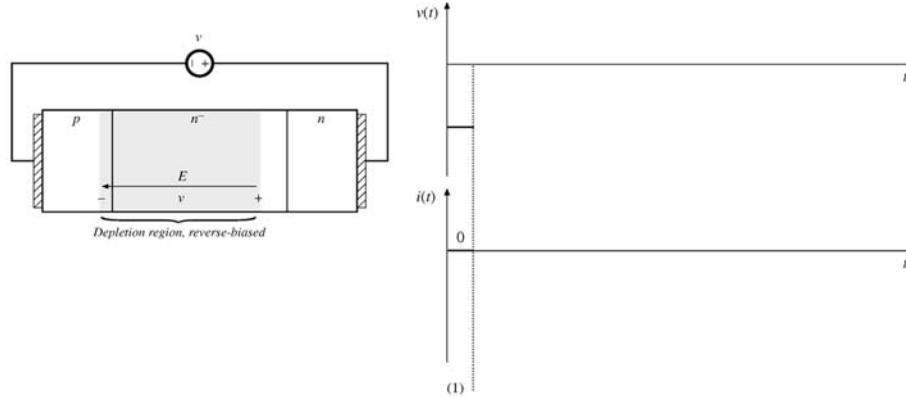


In equilibrium: $dq/dt = 0$, and hence

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

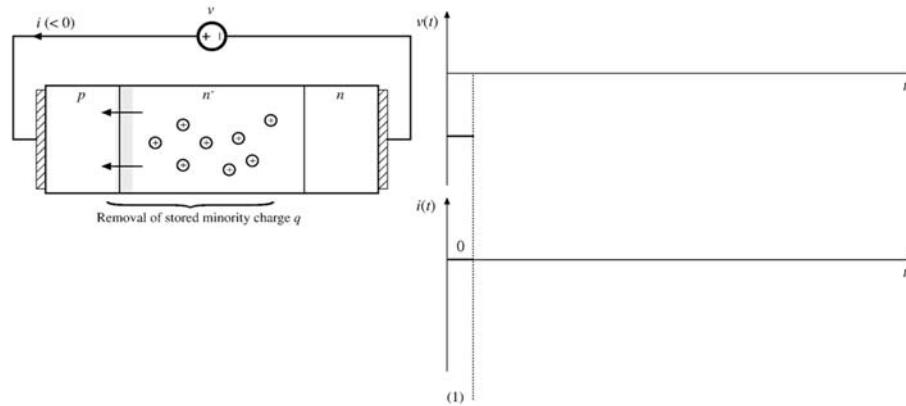
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Diode Turn-On



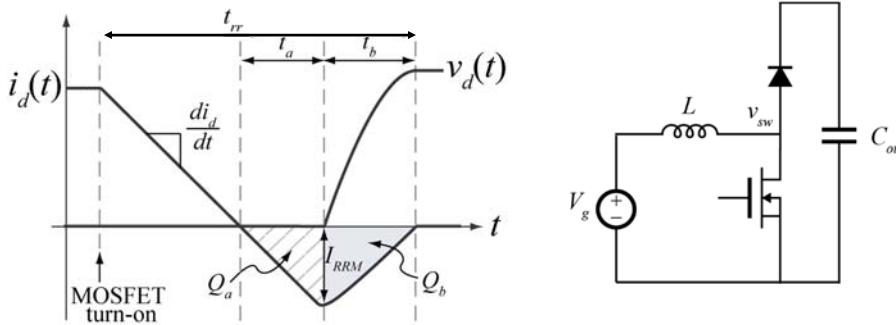
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Diode Turn-Off



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Diode Reverse Recovery



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Datasheet RR Characteristics

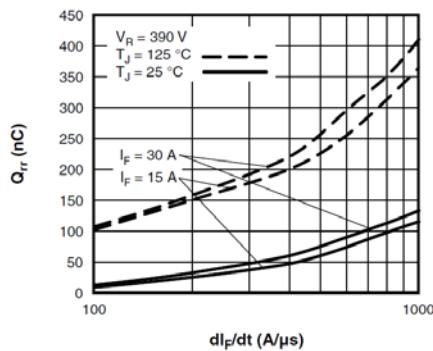


Fig. 10 - Typical Stored Charge vs. dI_F/dt

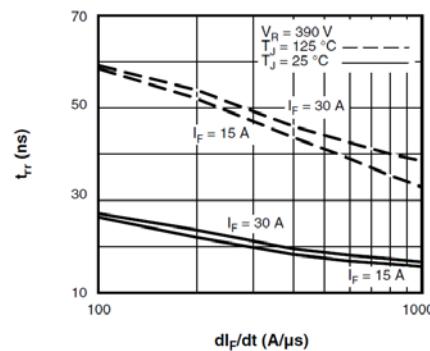


Fig. 9 - Typical Reverse Recovery Time vs. dI_F/dt

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Types of Power Diodes

Standard recovery

Reverse recovery time not specified, intended for 50/60Hz

Fast recovery and ultra-fast recovery

Reverse recovery time and recovered charge specified

Intended for converter applications

Schottky diode

A majority carrier device

Essentially no recovered charge

Model with equilibrium i - v characteristic, in parallel with depletion region capacitance

Restricted to low voltage (few devices can block 100V or more)

Paralleling Diodes

Attempts to parallel diodes, and share the current so that $i_1 = i_2 = i/2$, generally don't work.

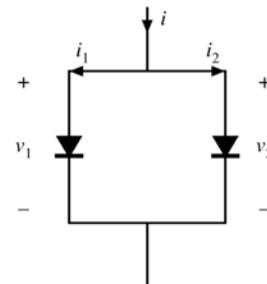
Reason: thermal instability caused by temperature dependence of the diode equation.

Increased temperature leads to increased current, or reduced voltage.

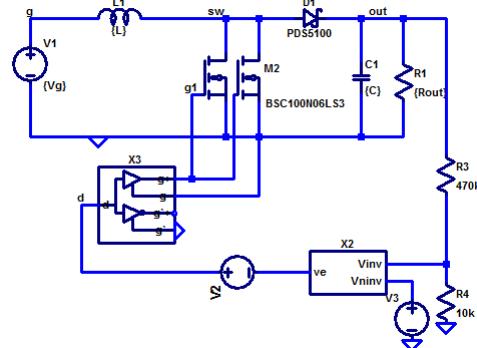
One diode will hog the current.

To get the diodes to share the current, heroic measures are required:

- Select matched devices
- Package on common thermal substrate
- Build external circuitry that forces the currents to balance



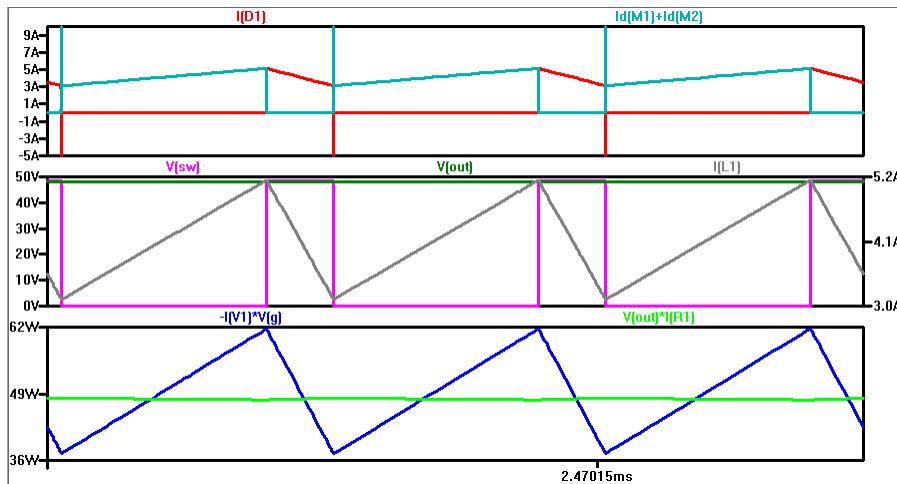
Schottky Diode



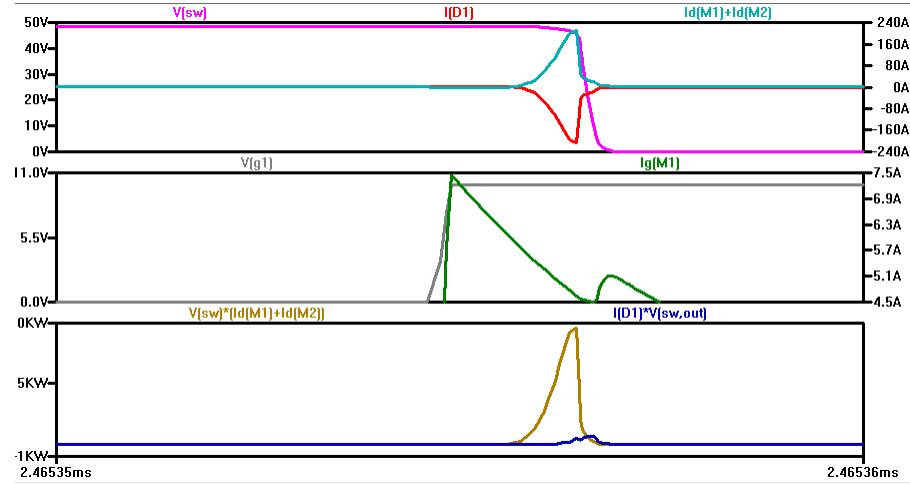
L	C_{out}	f_s	Diode	η (Sim)
22uH	22uF	202k	Si (FR)	93.9%
22uH	22uF	202k	Si Schottky	96.9%



Simulation Waveforms

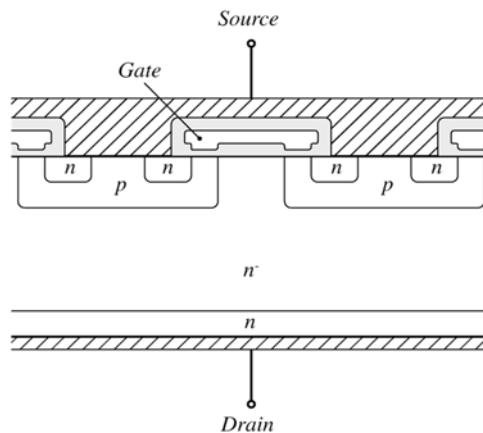


Switching Transition



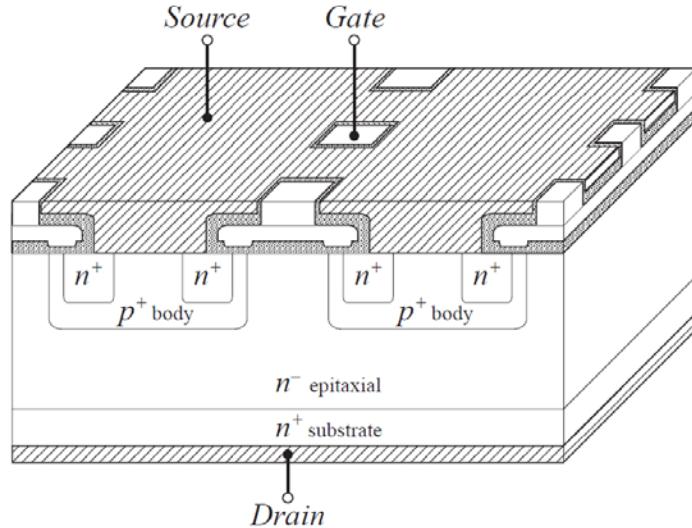
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Power MOSFET



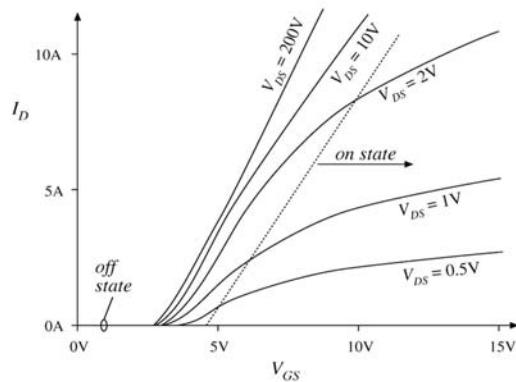
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MOSFET Cross Section



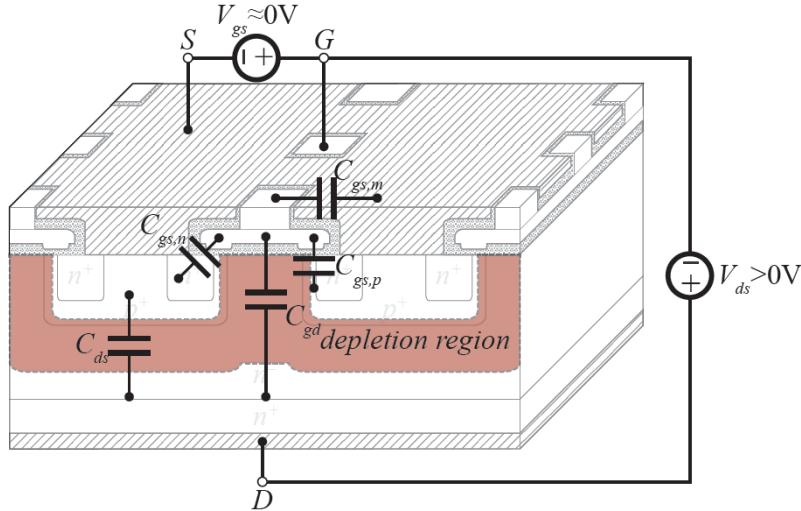
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MOSFET Static Characteristics



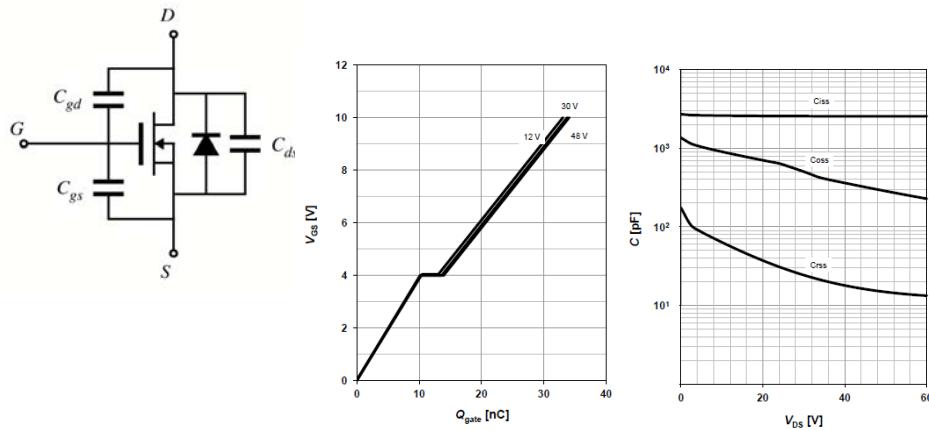
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MOSFET Depletion capacitance



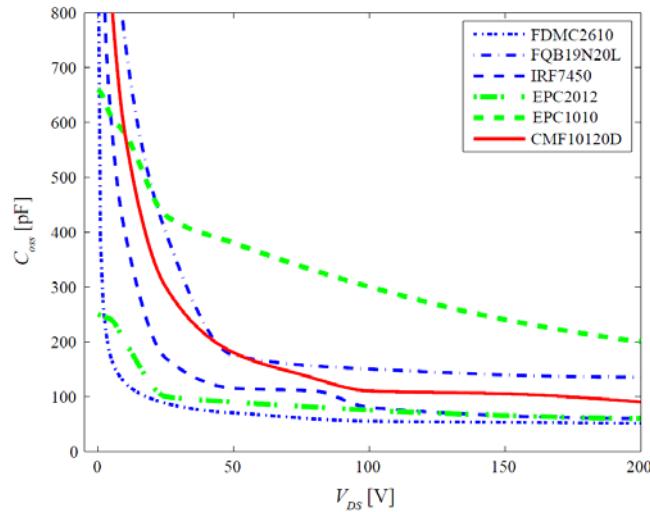
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MOSFET Equivalent Circuit



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Nonlinear Coss



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Power MOSFET: Conclusions

- A majority-carrier device: fast switching speed
- Typical switching frequencies: tens and hundreds of kHz
- On-resistance increases rapidly with rated blocking voltage
- Easy to drive
- The device of choice for blocking voltages less than 500V
- 1000V devices are available, but are useful only at low power levels (100W)
- Part number is selected on the basis of on-resistance rather than current rating