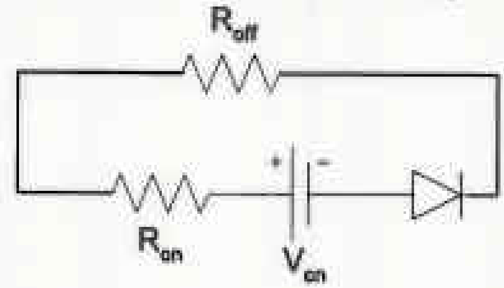
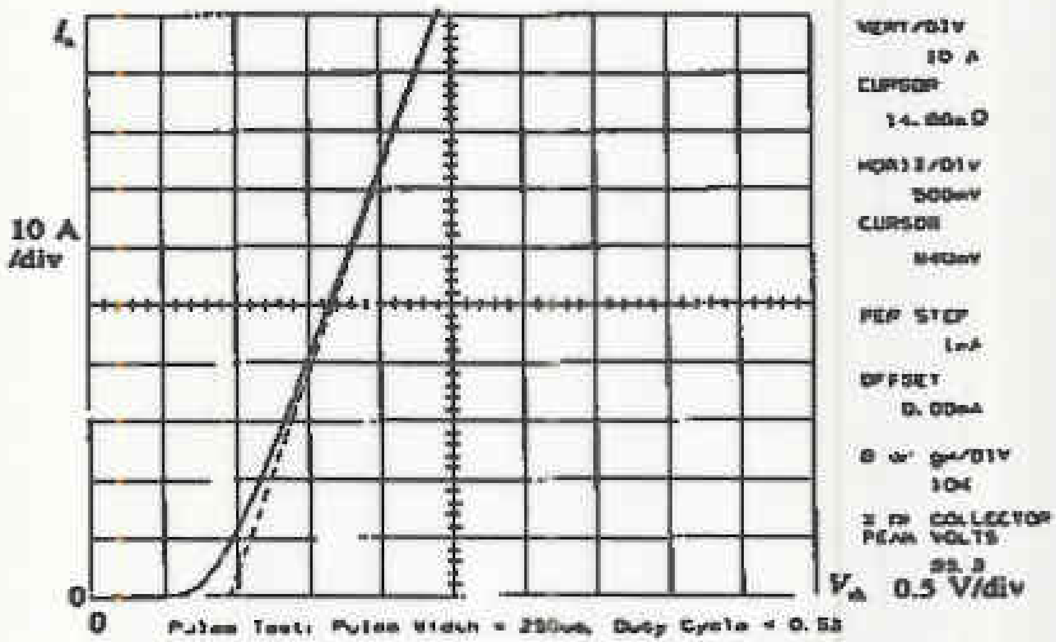
DC Parameters from I-V curve tracer

Static models of diodes involve the following:



For HW #4 from the MUR3040PT diode data book for practice obtain all three values: R_{on} = 0.015, R_{off} = 40 mΩ, and V_{on} = 0.94 V.



Forward current vs. forward voltage for MUR3040PT fast diode.

Static characteristics do not tell the full story of any device. Like people the dynamic characteristics may reveal new and unexpected behavior. For example, the V_{on} for the diode above does have a brief voltage overshoot when driven by a constant current source to turn it on. This needs to be accounted for in any dynamic model of diode operation as the dynamic I-V is unique.

Paralleling diodes

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

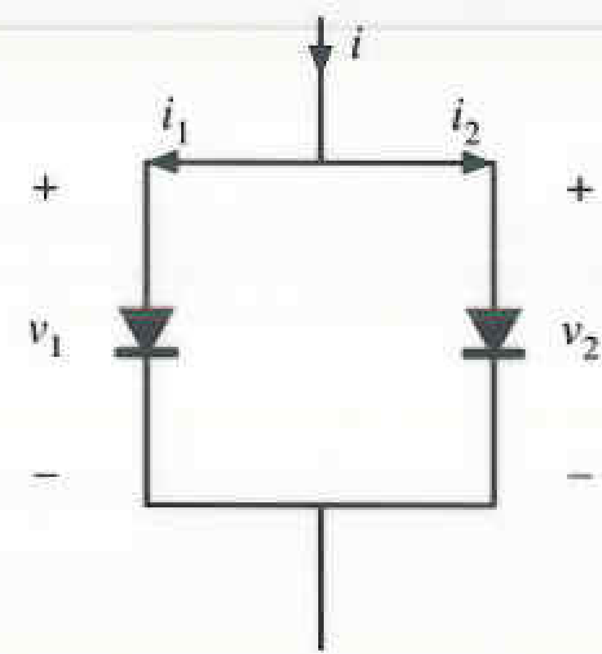
Reason: thermal instability caused by temperature dependence of the diode equation.

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

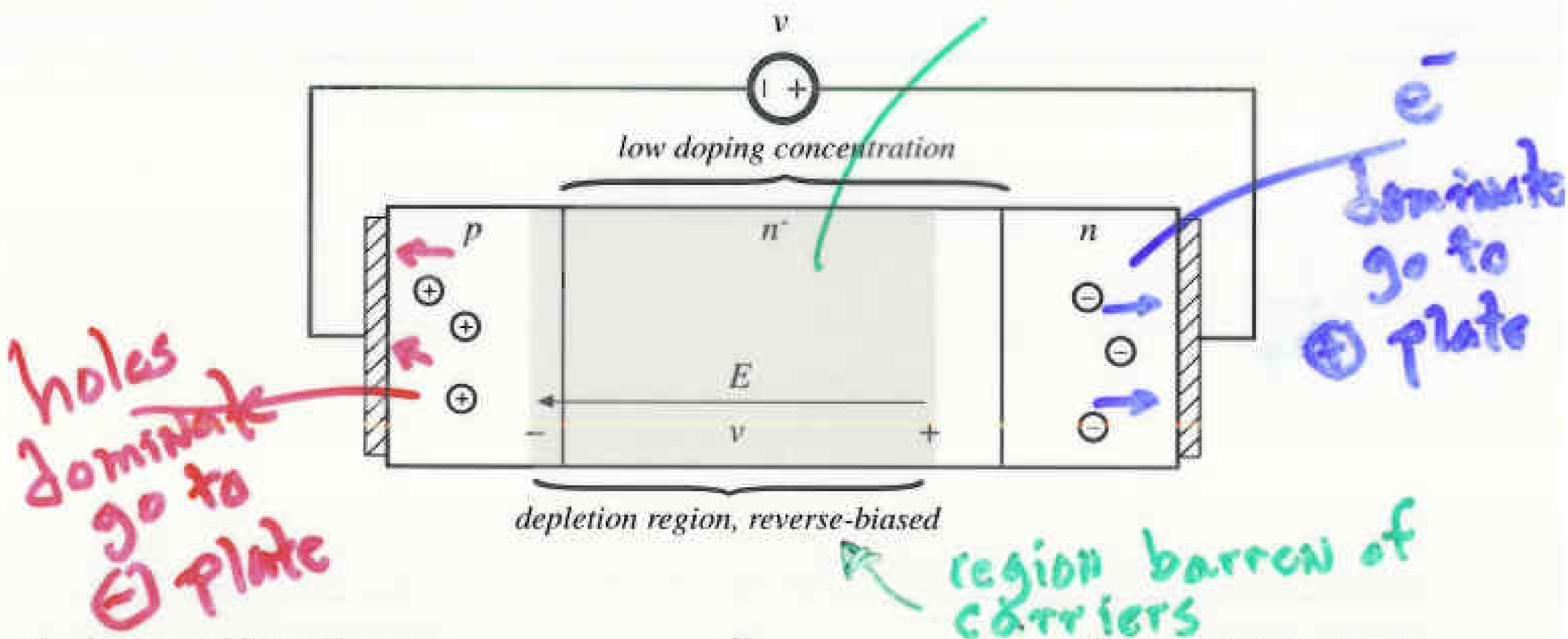


V_{off} (max) ↑ vs R_{ON} ↓ V_{ON} ↓

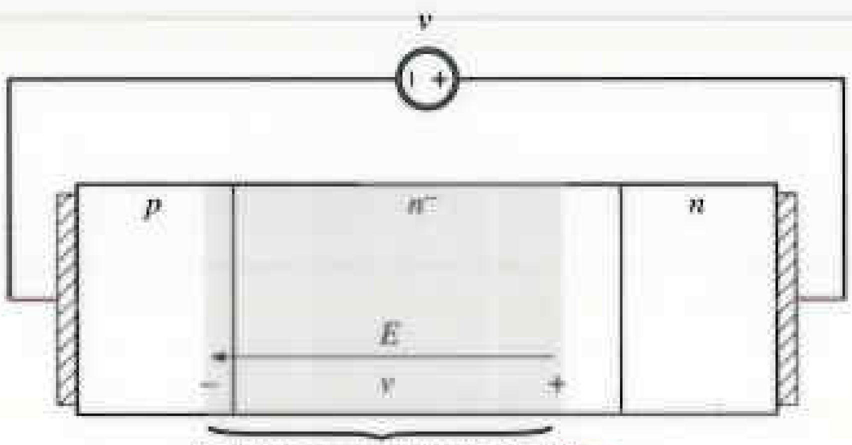
4.2.1. Power diodes

PIN Structure

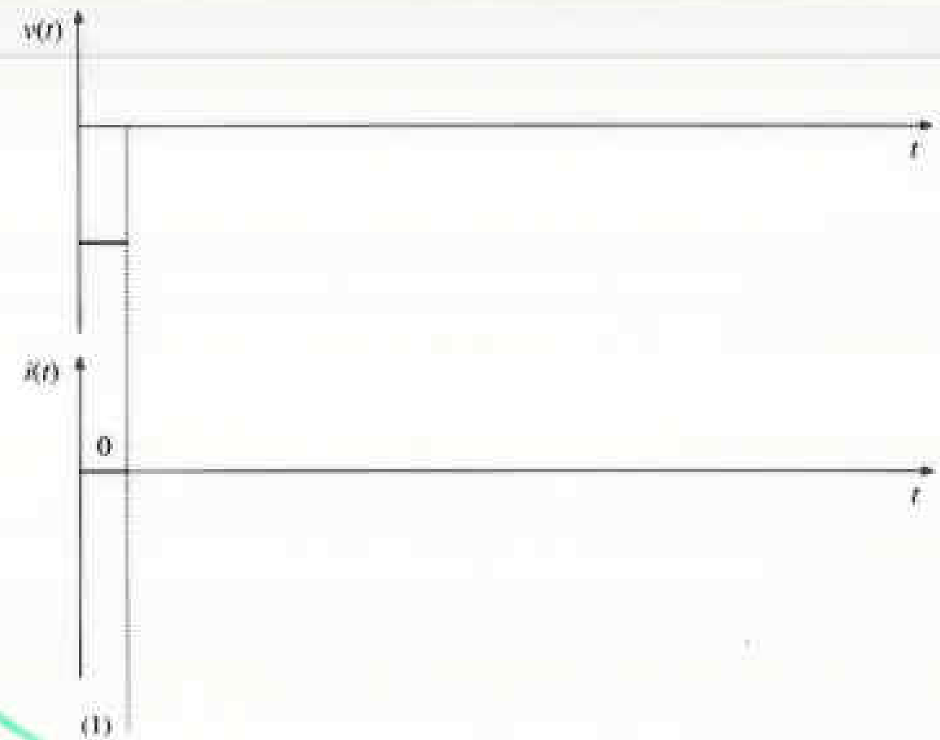
A power diode, under reverse-biased conditions:



Diode in OFF state: reversed-biased, blocking voltage



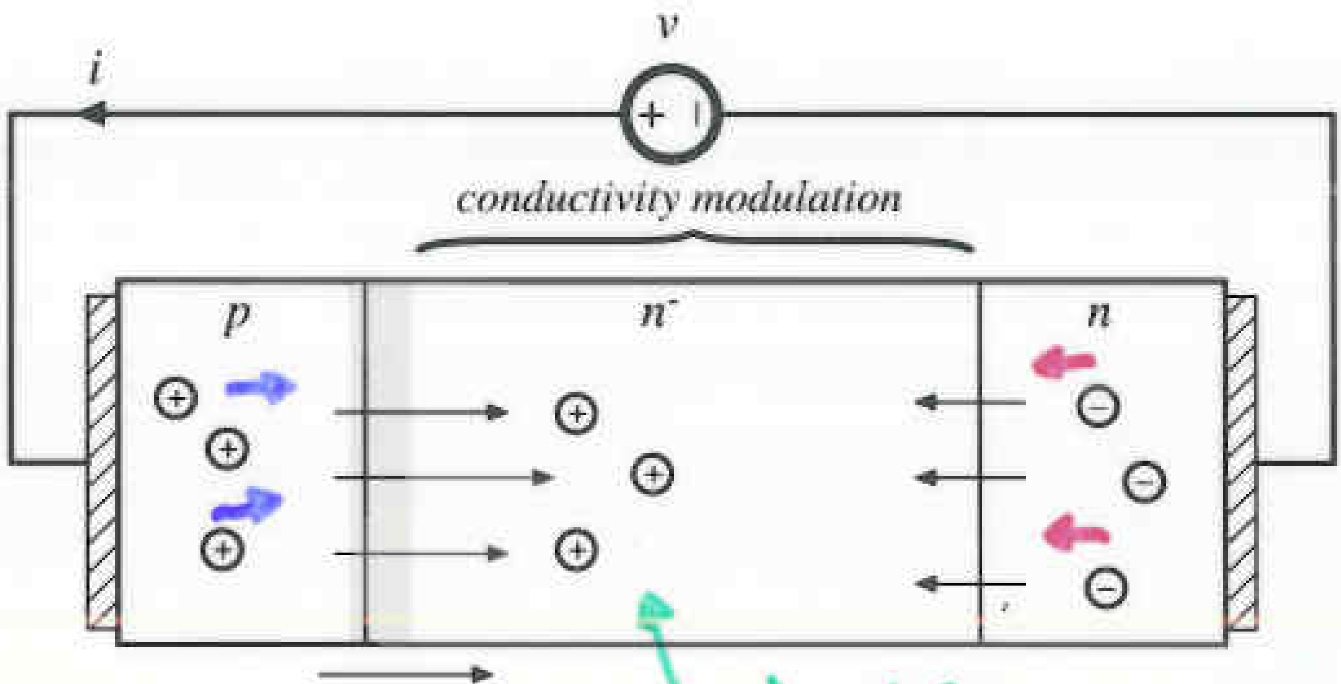
Depletion region, reverse-biased



- Diode is reverse-biased
- No stored minority charge: $q = 0$
- Depletion region blocks applied reverse voltage; charge is stored in capacitance of depletion region

depletion region size expands with reverse bias

Forward-biased power diode



depletion region size SHRINKS with forward bias

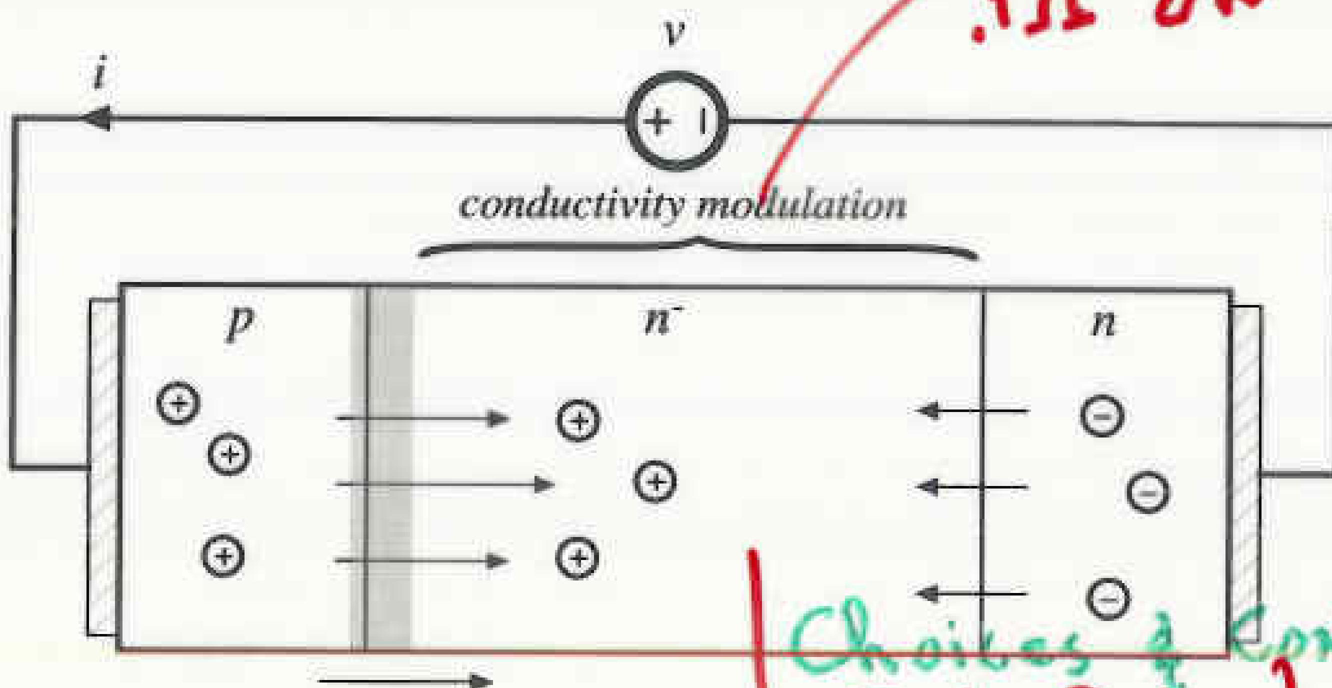
$i = ?$

PIN Diode

Forward-biased power diode

MΩ off

.1Ω on



Choices & Consequences!

$R_D(on)$ is larger for PIN structure

But ? is higher

Charge-controlled behavior of the diode

equilibrum

The diode equation:

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

Charge control equation:

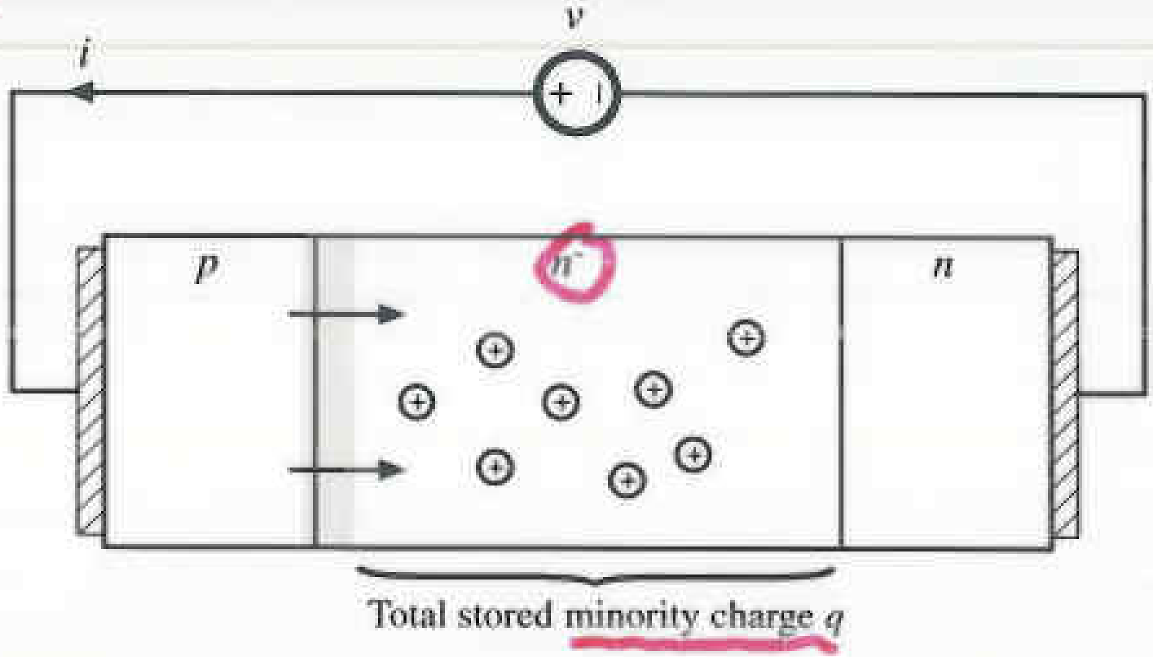
$$\frac{dq(t)}{dt} = i(t) - \frac{q(t)}{\tau_L}$$

With:

λ= 1/(26 mV) at 300 K

τ_L = minority carrier lifetime

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



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

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