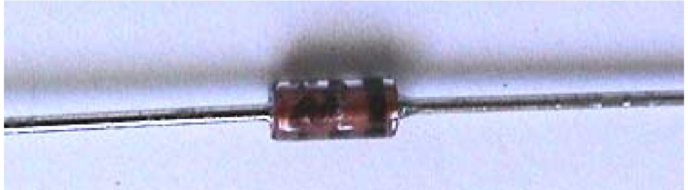
Midterm this Week

- Midterm in lab.
- Duration: 1 hour (2-3pm).
- Material on midterm:
  - Everything from first 4 weeks of class.
  - Thévenin's Theorem & Source Impedance.
  - Impedance of resistors, capacitors, and inductors.
  - Filters (RC,RL,RLC,low-pass,high-pass, bandpass, notch, Chebyshev, Butterworth, etc …).
  - Basic oscilloscope use, resistor code, etc...
- Midterm will cover design exercises and lab exercises.
- The purpose of the midterm is to consolidate passive analog linear circuitry before we move onto non-linear devices.

Diodes

a non-linear circuit element



- 2-terminal **quantum** device
- ***A diode only conducts in one direction !!!***
- **Non-linear** → ***Ohm's Law*** doesn't apply !

  → There is no simple Z_{diode} **formula !**

  → ***Thevenin's theorem*** doesn't apply !

- **Calculus:** you can linearize a function/system in the vicinity of some V_0 or I_0.

  → ***Ohm's law***, Z_{diode}, and ***Thevenin's theorem*** can only be used locally around some value of V_0 and I_0.

  → i.e. you can still write down a differential equation for your circuit (i.e. Kirchhoff's loop and junction laws are still valid).

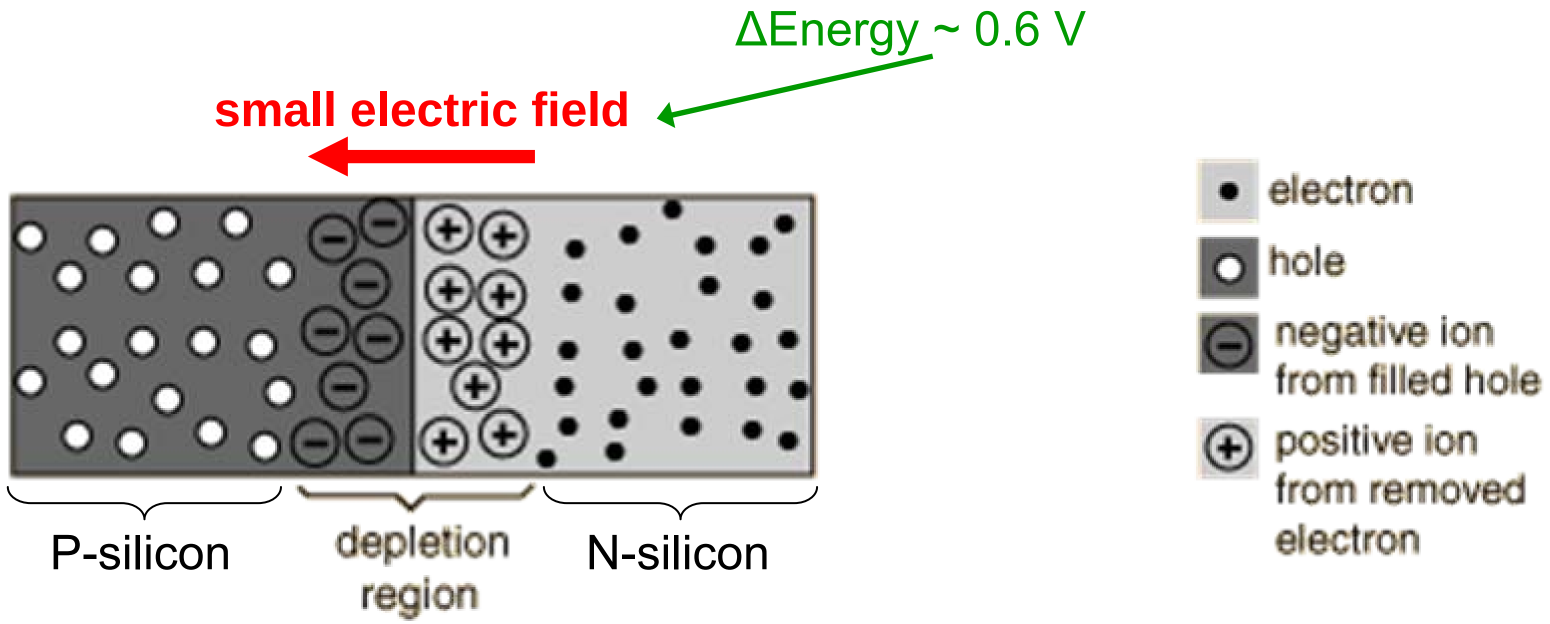
Intro to Semiconductors

Material	Resistivity
Copper	1.70x10-8 Ω.m
Silicon	6400 Ω.m
Rubber	~10^{13} Ω.m

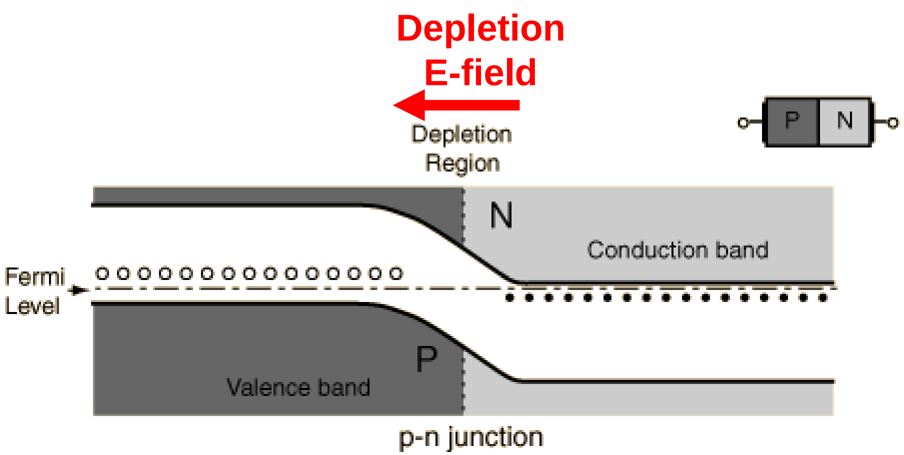
- Semiconductors have a modest resistivity:
- Normally we think of electrons moving in a circuit
- In a semiconductor things are a little different
  → We think of either holes or electrons.
    - Holes (+ charge)
    - Electrons (- charge)

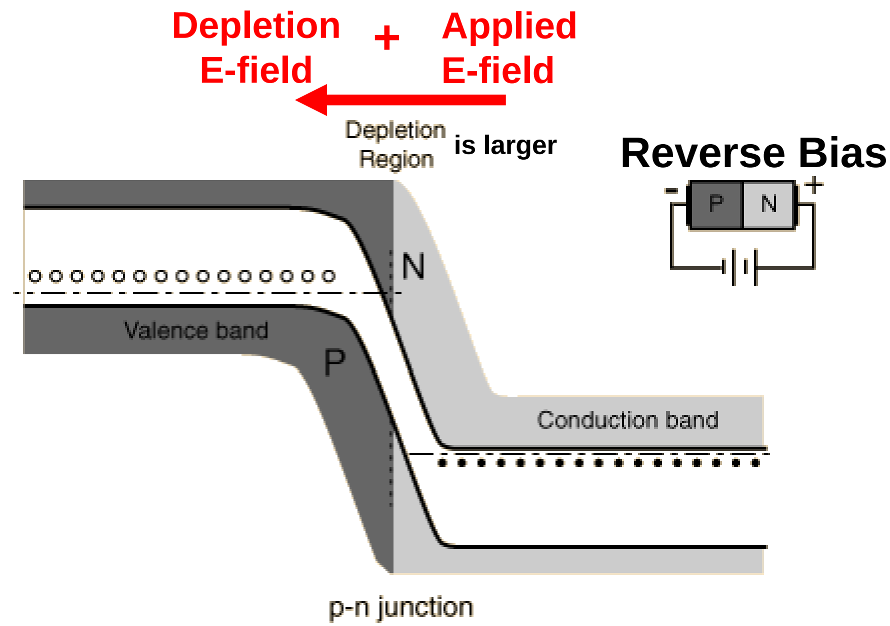
The PN junction

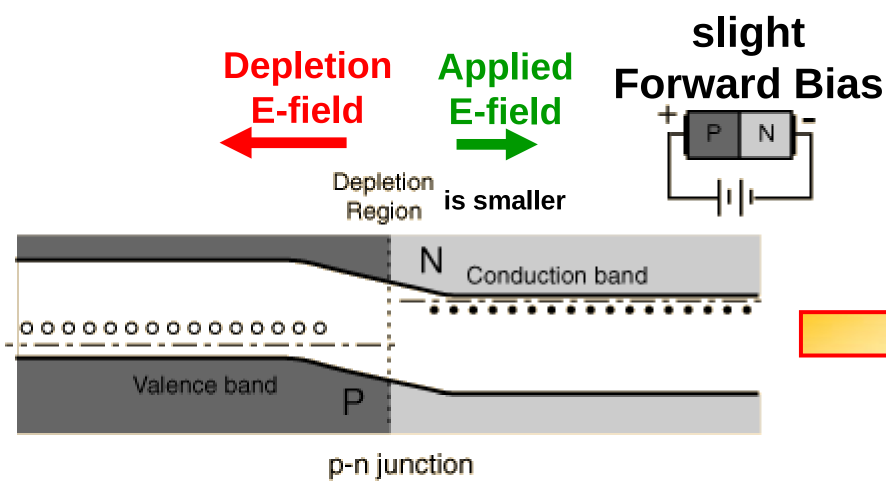
- Made from differently doped silicon
  - → N region has more electrons
  - → P region had more holes
- At the **PN junction** the holes & electrons recombine to form a small insulating **depletion region**.

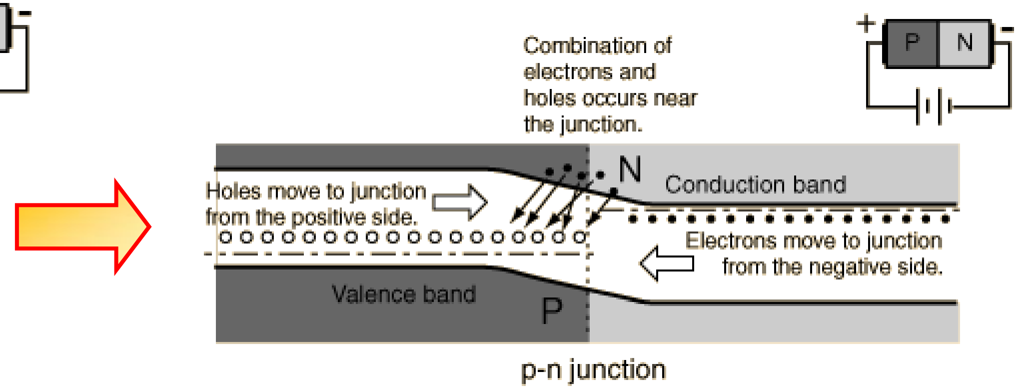


How a diode works

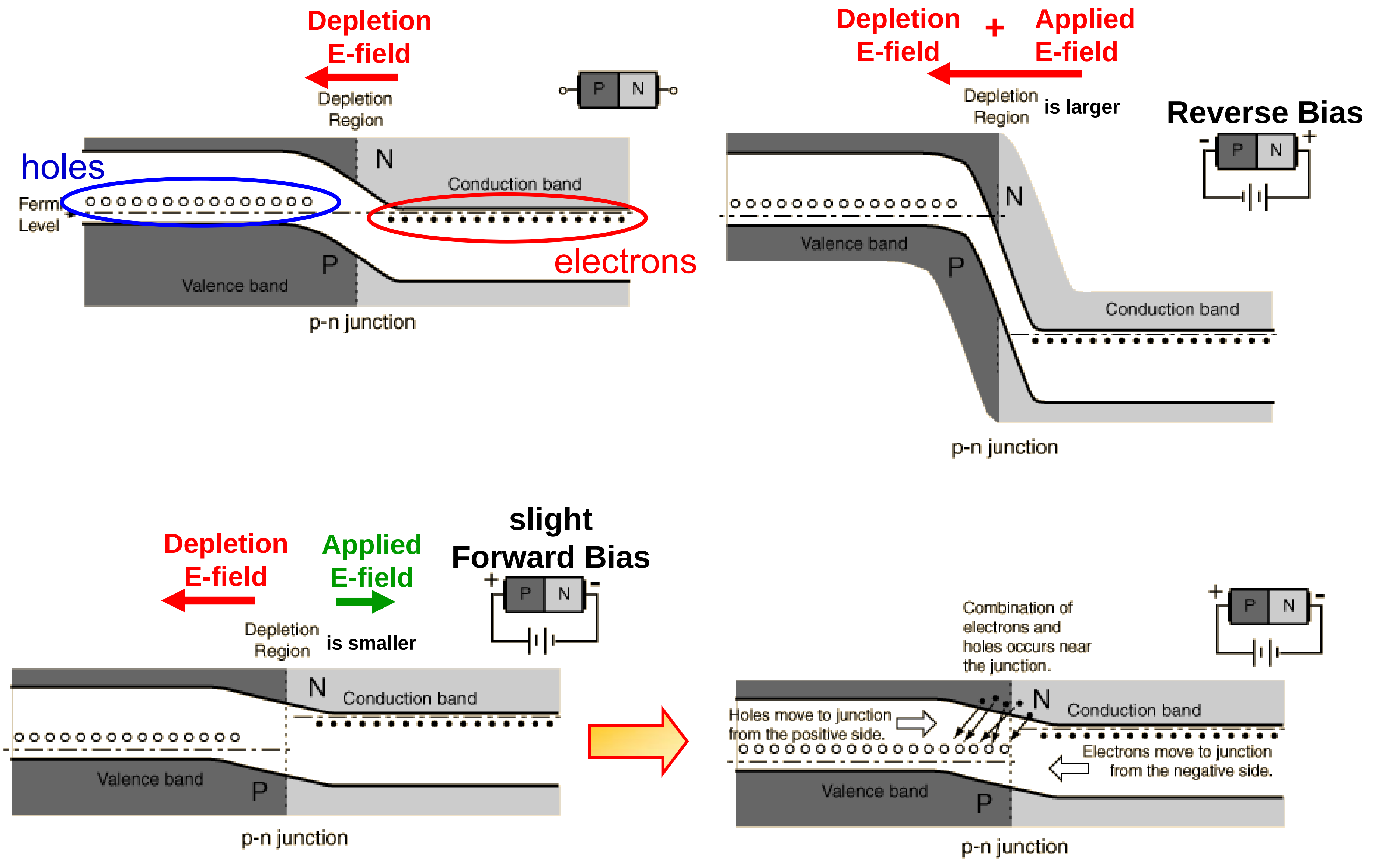




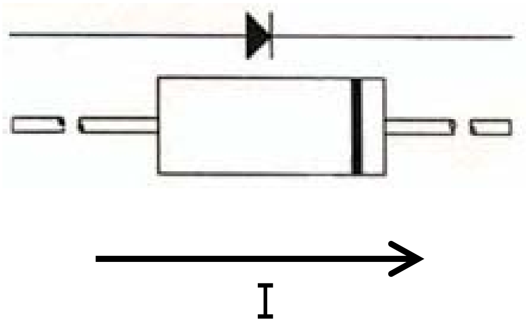


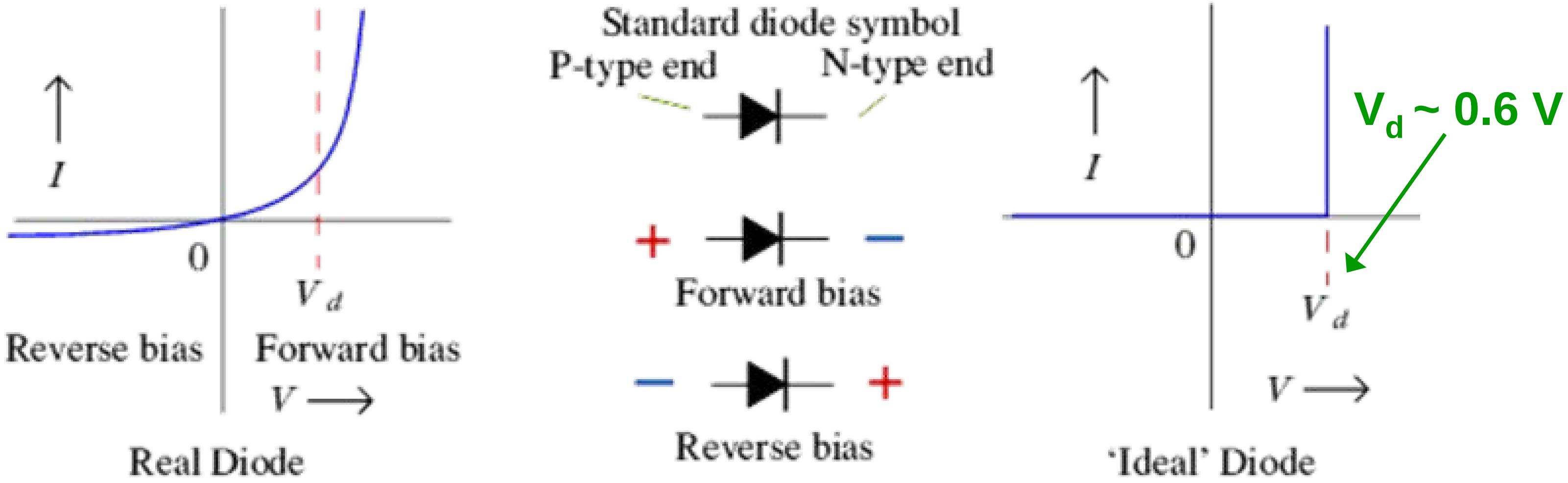


How a diode works



Diode: I-V characteristic curve I

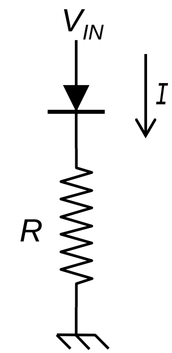




[image from *www.mtmi.vu.lt*]

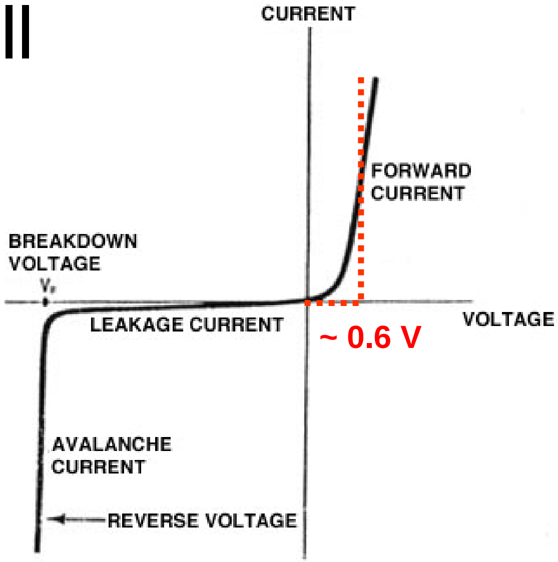
Diode: I-V characteristic curve II

- ***Simple model***
  - → Current can only flow in one direction.
  - → A 0.6V "diode drop" when conducting.
  - → $IR = V_{IN} - 0.6$ V
  - → Useful for designing circuits.



Current only flows in the direction of the arrow.

- More complete model: Ebers-Moll equation.
  - → Not so useful for designing circuits.



- A little negative is OK

  A lot is "bad" → smoke!!!!

Diode Spec Sheet

FAIRCHILD SEMICONDUCTOR®

January 2007

1N/FDLL 914/A/B / 916/A/B / 4148 / 4448

Small Signal Diode

DO-35
Cathode is denoted with a black band

LL-34
THE PLACEMENT OF THE EXPANSION GAP HAS NO RELATIONSHIP TO THE LOCATION OF THE CATHODE TERMINAL

LL-34 COLOR BAND MARKING

DEVICE	1ST BAND	2ND BAND
FDLL914	BLACK	BROWN
FDLL914A	BLACK	GRAY
FDLL914B	BROWN	BLACK
FDLL916	BLACK	RED
FDLL916A	BLACK	WHITE
FDLL916B	BROWN	BROWN
FDLL4148	BLACK	BROWN
FDLL4448	BROWN	BLACK

-1st band denotes cathode terminal and has wider width

Absolute Maximum Ratings* T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{RRM}	Maximum Repetitive Reverse Voltage	100	V
I_O	Average Rectified Forward Current	200	mA
I_F	DC Forward Current	300	mA
I_f	Recurrent Peak Forward Current	400	mA
I_{FSM}	Non-repetitive Peak Forward Surge Current Pulse Width = 1.0 second Pulse Width = 1.0 microsecond	 1.0 4.0	 A A
T_{STG}	Storage Temperature Range	-65 to +200	°C
T_J	Operating Junction Temperature	175	°C

* These ratings are limiting values above which the serviceability of the diode may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 200 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics

Symbol	Parameter	Max.	Units
		1N/FDLL 914/A/B / 4148 / 4448	
P_D	Power Dissipation	500	mW
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	300	°C/W

1N/FDLL 914/A/B / 916/A/B / 4148 / 4448 Small Signal Diode

Diode Spec Sheet

Electrical Characteristics* T_A=25°C unless otherwise noted

Symbol	Parameter		Test Conditions	Min.	Max.	Units
V_R	Breakdown Voltage		I_R = 100µA	100		V
			I_R = 5.0µA	75		V
V_F	Forward Voltage	1N914B/4448	I_F = 5.0mA	620	720	mV
		1N916B	I_F = 5.0mA	630	730	mV
		1N914/916/4148	I_F = 10mA		1.0	V
		1N914A/916A	I_F = 20mA		1.0	V
		1N916B	I_F = 20mA		1.0	V
		1N914B/4448	I_F = 100mA		1.0	V
I_R	Reverse Leakage		V_R = 20V		25	nA
			V_R = 20V, T_A = 150°C		50	µA
			V_R = 75V		5.0	µA
C_T	Total Capacitance					
	1N916A/B/4448		V_R = 0, f = 1.0MHz		2.0	pF
	1N914A/B/4148		V_R = 0, f = 1.0MHz		4.0	pF
t_{rr}	Reverse Recovery Time		I_F = 10mA, V_R = 6.0V (600mA)		4.0	ns
			I_{rr} = 1.0mA, R_L = 100Ω			

* Non-recurrent square wave PW = 8.3ms

Typical Characteristics

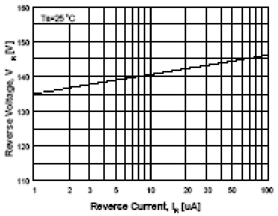
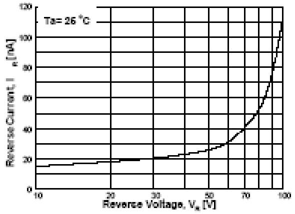


Figure 1. Reverse Voltage vs Reverse Current
BV - 1.0 to 100µA



GENERAL RULE: The Reverse Current of a diode will approximately double for every ten (10) Degree C Increase in Temperature

Figure 2. Reverse Current vs Reverse Voltage
IR - 10 to 100V

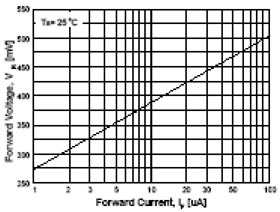


Figure 3. Forward Voltage vs Forward Current
VF - 1 to 100µA

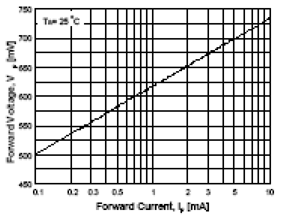


Figure 4. Forward Voltage vs Forward Current
VF - 0.1 to 10mA

Diode Spec Sheet

Typical Characteristics (Continued)

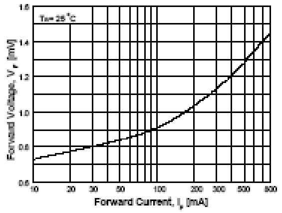


Figure 5. Forward Voltage vs Forward Current
VF - 10 to 800mA

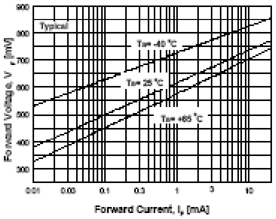


Figure 6. Forward Voltage vs Ambient Temperature
VF - 0.01 - 20 mA (- 40 to +65°C)

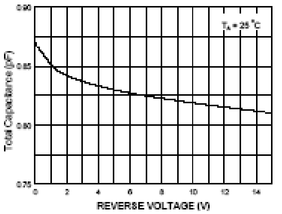
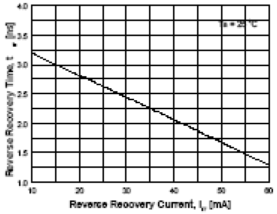


Figure 7. Total Capacitance



IF = 10mA , IRR = 1.0 mA , Rloop = 100 Ohms
Figure 8. Reverse Recovery Time vs
Reverse Recovery Current

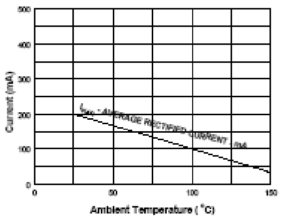


Figure 9. Average Rectified Current ($I_{F(AV)}$)
vs Ambient Temperature (T_A)

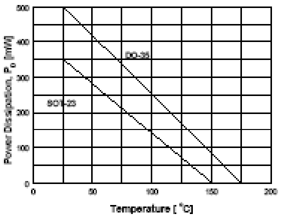


Figure 10. Power Derating Curve

Diode Spec Sheet

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Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

Rev. I22

Applications

- Circuit Protection
- Rectification
  - → half wave rectifier
  - → full wave rectifier
  - → Power Supplies
- Frequency manipulation
  - → Frequency multiplier
  - → Mixers

Fourier Transform (FFT)

of Full Wave Rectifier