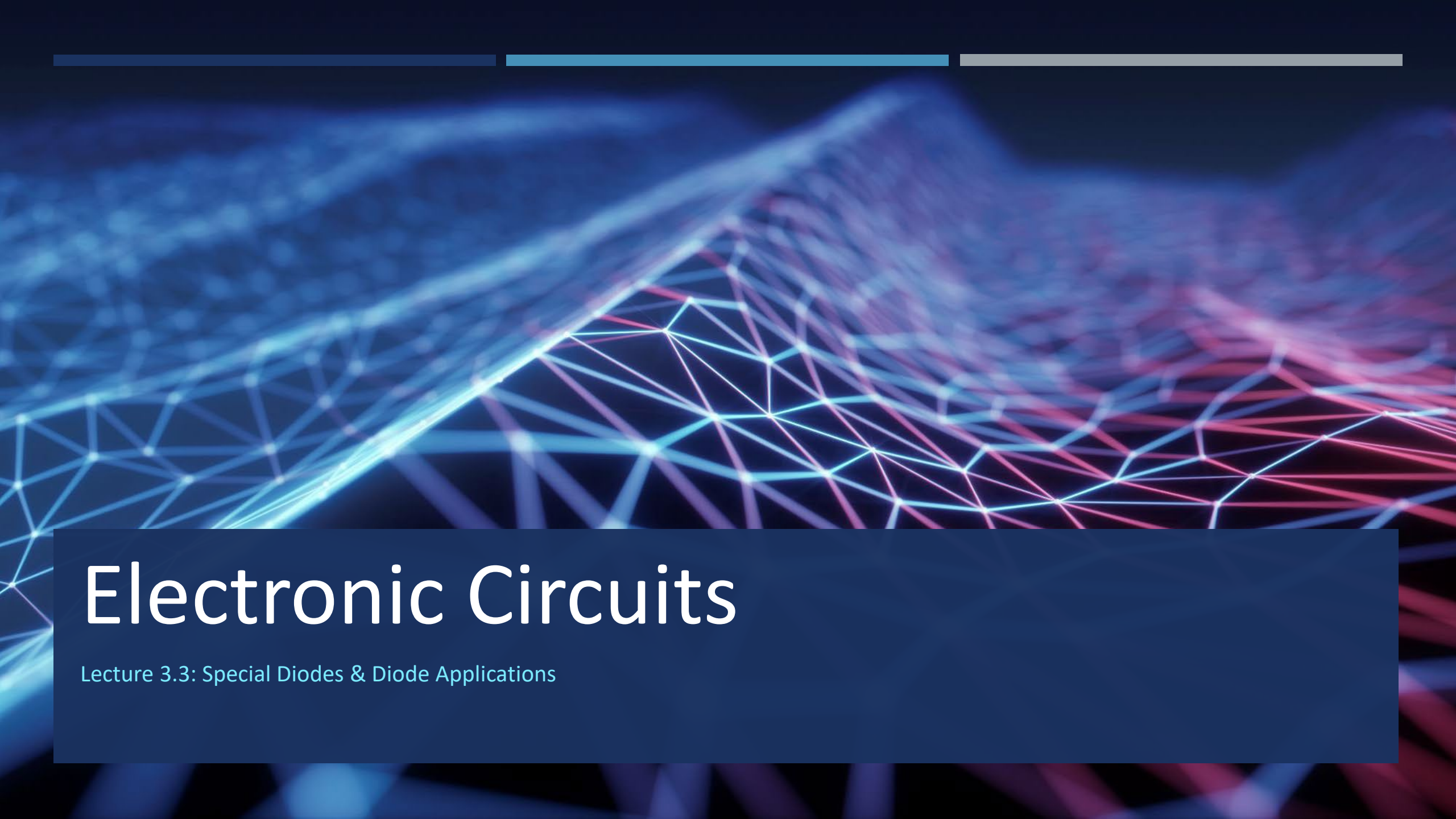


Electronic Circuits

Lecture 3.3: Special Diodes & Diode Applications

Diode Specifications

- Peak Inverse Voltage
  - In reverse biasing, the maximum diode voltage. Over this value, the diode is corrupted.
- Maximum Forward Current
  - In forward biasing, the maximum diode current. Over this value, the diode is corrupted.
- Zener Voltage
  - The maximum reverse voltage to break the diode. After this voltage, zener conducts the current. This is less than the peak inverse voltage.
- Diode Capacitance
  - Since there are two adjacent layers with opposite charges separated by the depletion layer, a diode can have a significant capacitance in pF levels.
- Response Time
  - Because of the diode capacitance, any resistor connected to the diode circuit forms RC time constant, which results in a time delay in response.

Special Diodes (1)

Table 6.2 Some specialty diodes

Schematic	Name	Brief description
	Zener diode	Designed to be used at the reverse breakdown voltage as a limiter or voltage reference. Reverse break-down current is limited by power considerations
	Light emitting diode (LED)	A semiconductor diode optimized to emit light due to electron-hole recombination when the diode is conducting in the forward direction. Electrically similar to other semiconductor diodes, but usually with a larger turn-on voltage (Can be used in reverse as a light detector)
	Photodiode	A semiconductor diode optimized to detect incident light. The diode is used in series with a resistor and with reverse bias. Incident light creates electron-hole pairs and increases the conductivity of the diode
	Varactor diode	Designed to use the inherent capacitance of a semiconductor diode due to the depletion region. By varying a DC biasing voltage in the reverse direction, the size of the depletion region, and hence the capacitance, can be adjusted

Special Diodes (2)

Table 6.2 Some specialty diodes

Schematic	Name	Brief description
	Schottky diode	Generally has a smaller turn-on voltage and a very rapid turn-on time compared to other semiconductor diodes. Used when either of those parameters is a significant issue. Relies on a metal-semiconductor junction. Also known as a barrier diode or a hot-carrier diode. Not to be confused with the four-layer Shockley diode
	Tunnel diode	Based on quantum mechanical tunneling, and has the unusual property that for some operating conditions the dynamic resistance is negative—that is, the current decreases when the voltage across it increases
	Laser diode	As its name implies, a laser diode is constructed to produce laser light. Usually based on a p-i-n layer structure. The laser light arises from the area near the junction. Often represented in a circuit using the simple diode schematic, without the arrow
	Vacuum tube diode	A diode based on vacuum tube technology. Largely obsolete except for novelty use and for very high-voltage and/or very high power devices. Otherwise, used like other diodes

Zener Diode

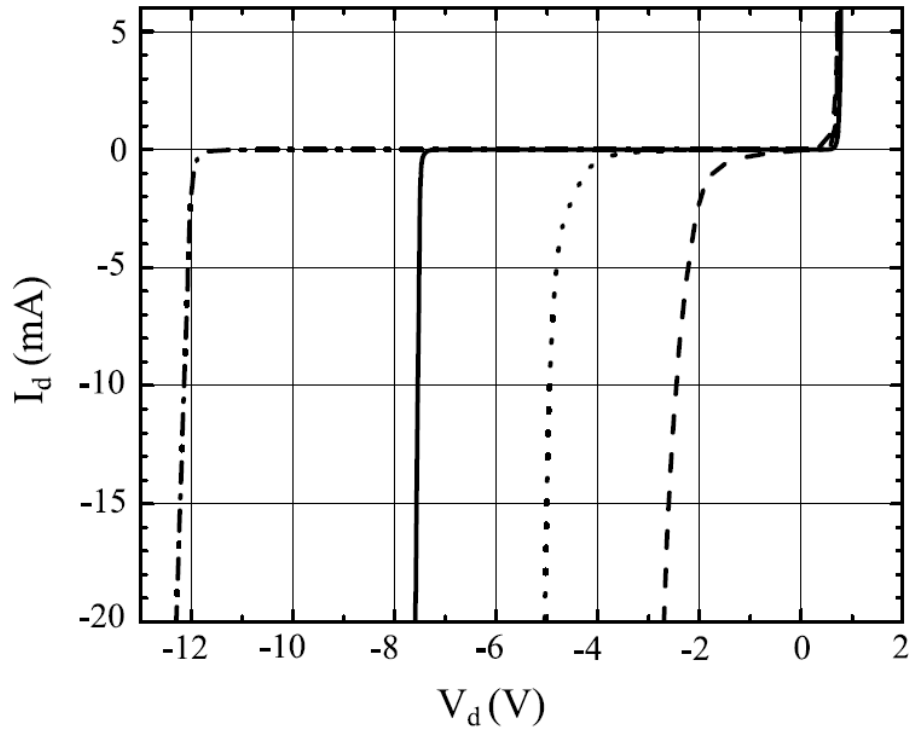
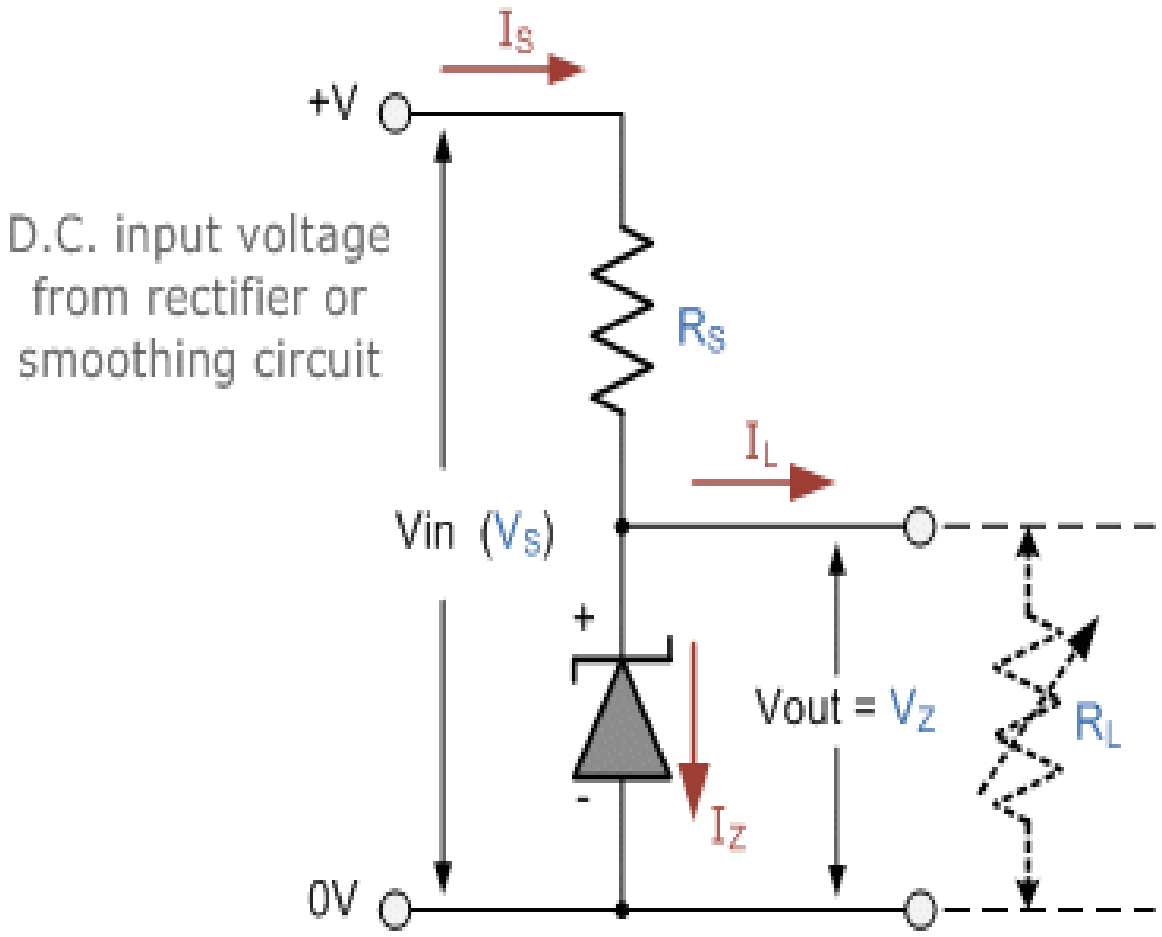


Fig. 6.17 The measured (d.c.) characteristic curves for 3.3 V (dashed), 5.1 V (dotted), 7.5 V (solid), and 12 V (dot-dash) Zener diodes

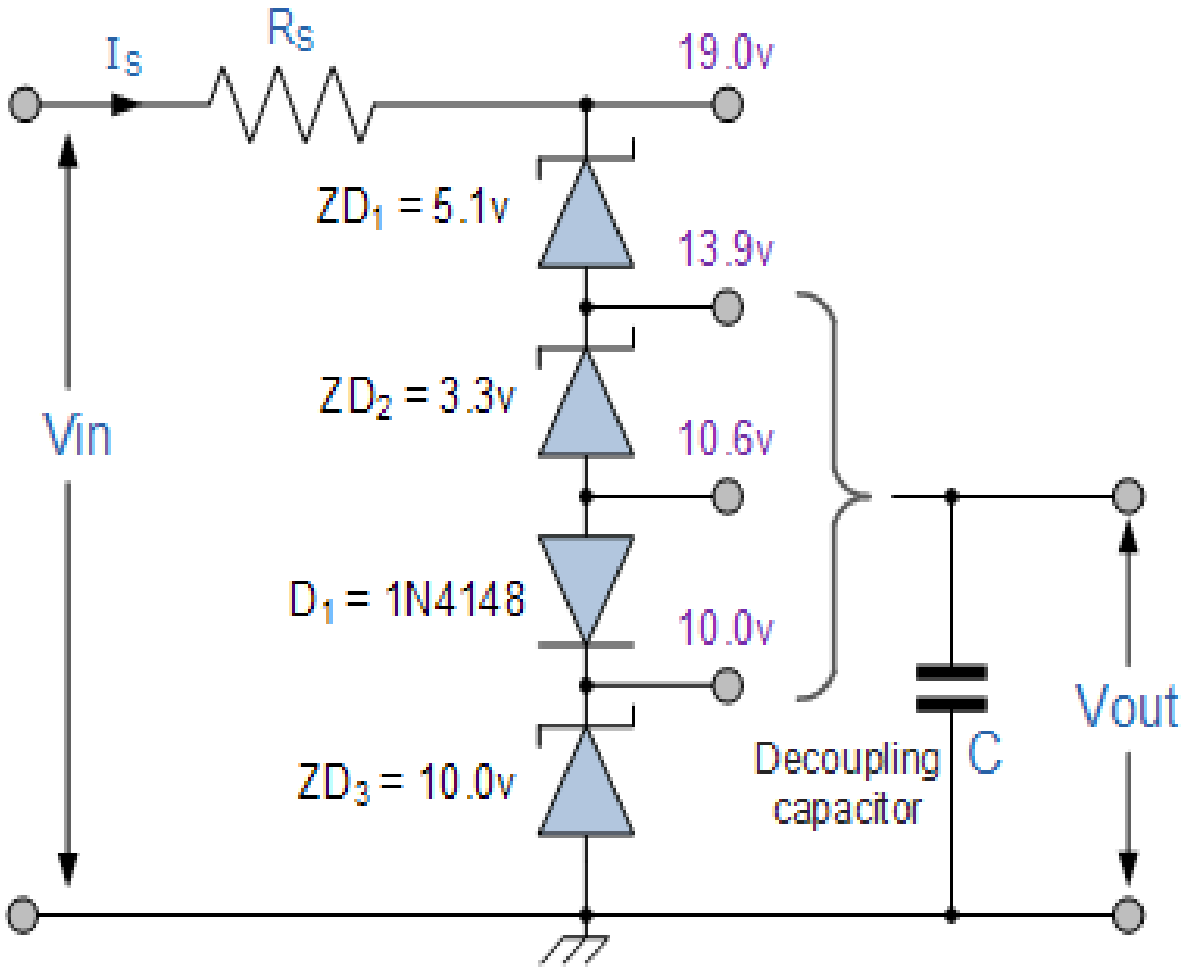
- Zener diodes are used for
  - Two zener in series but opposite connection to limit the voltage.
  - Reverse connection as a voltage regulator.

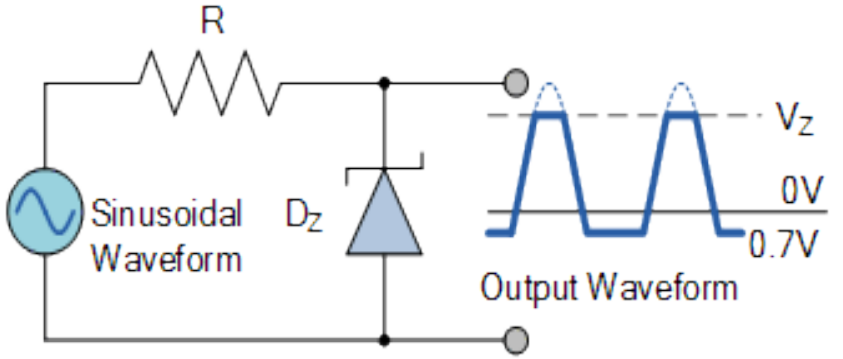
Zener Diode Application (1)



- By considering R_L and R_s voltage divider rule and Ohm's Law restriction to the current:
  - If V > Vz, then Vout = Vz
  - If V <= Vz, then Vout = Vz = V
- Vz = 5.0 V, +V = 12 V, the maximum power of the zener is 2 W. Then,
  - $I_{Z,max} = \frac{P_{Z,max}}{V_Z} = \frac{2W}{5V} = 400mA$
  - $R_{s,min} = \frac{V_s - V_Z}{I_Z} = \frac{12-5\ V}{0.4\ A} = 17.5\ ohms$
  - $I_L = \frac{V_Z}{R_L} = \frac{5\ V}{1000\ ohms} = 5\ mA$ if 1kOhm resistor is connected as the load.
  - $I_Z = I_s - I_L = 400\ mA\ - 5\ mA = 395\ mA$
  - $P_Z = V_Z * I_Z = 5\ V\ * 395\ mA = 1.975\ mW$

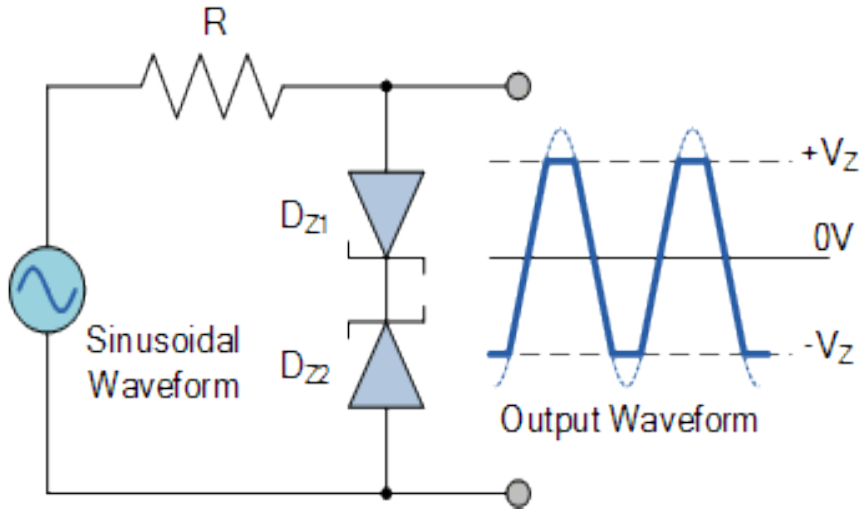
Zener Diode Application (2)





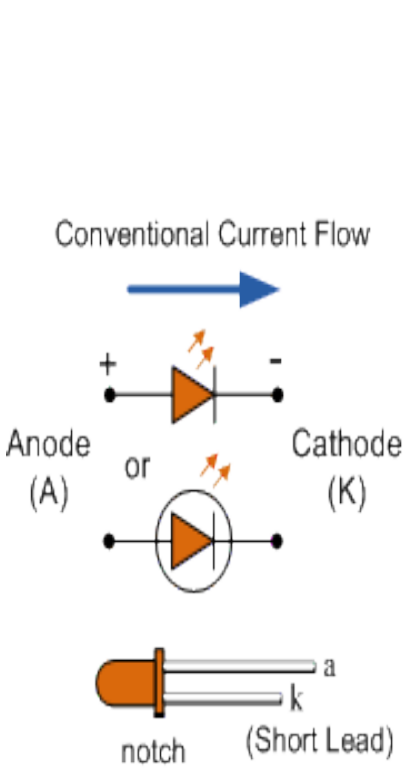
Single Zener Diode Clipping

Double Zener Diode Clipping

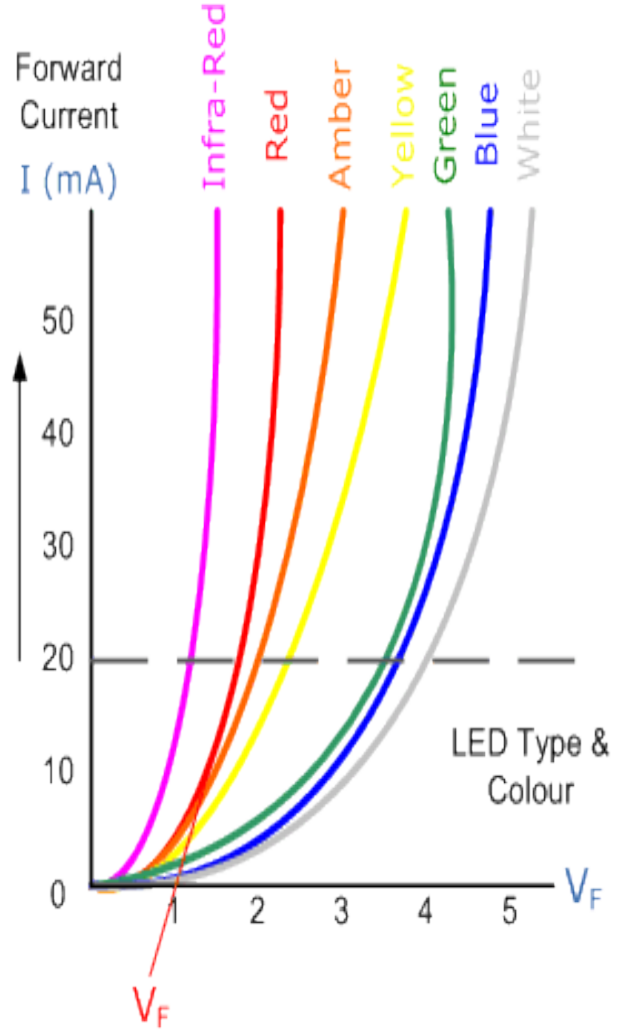


LED: Light-Emitting Diode Characteristics

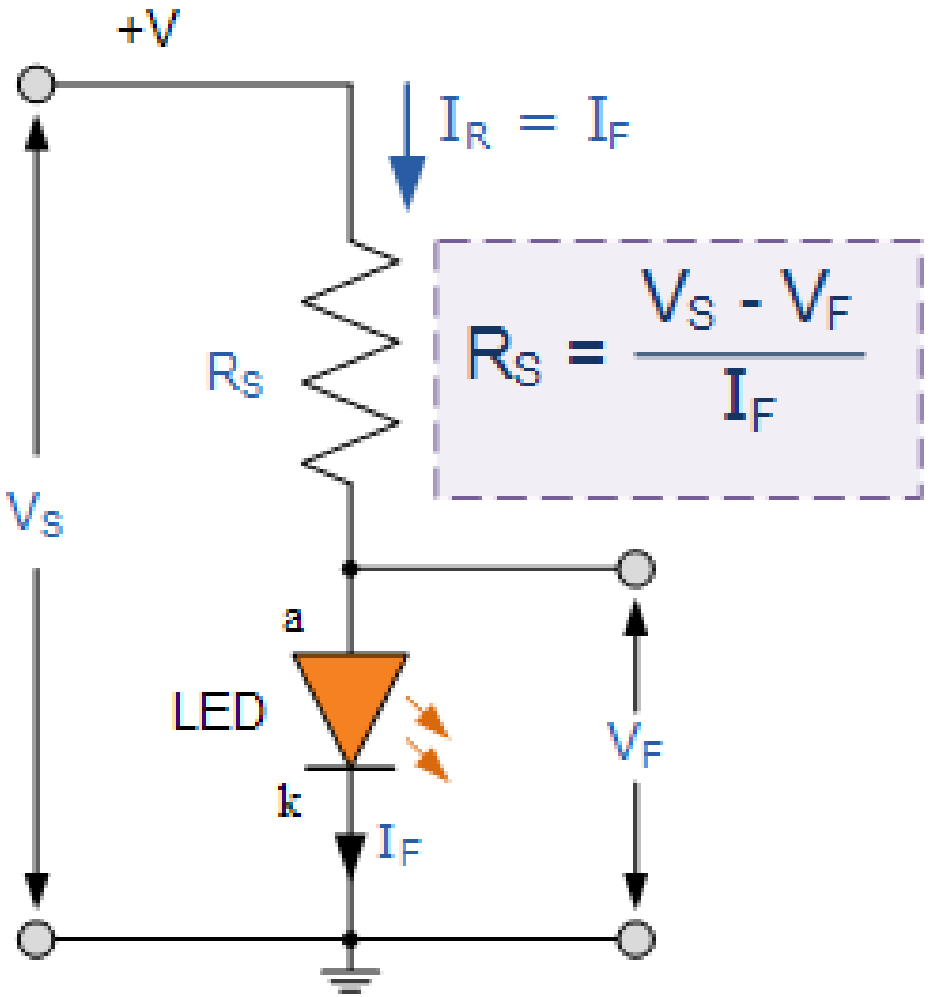
Typical LED Characteristics			
Semiconductor Material	Wavelength	Colour	V_F @ 20mA
GaAs	850-940nm	Infra-Red	1.2v
GaAsP	630-660nm	Red	1.8v
GaAsP	605-620nm	Amber	2.0v
GaAsP:N	585-595nm	Yellow	2.2v
AlGaP	550-570nm	Green	3.5v
SiC	430-505nm	Blue	3.6v
GaInN	450nm	White	4.0v

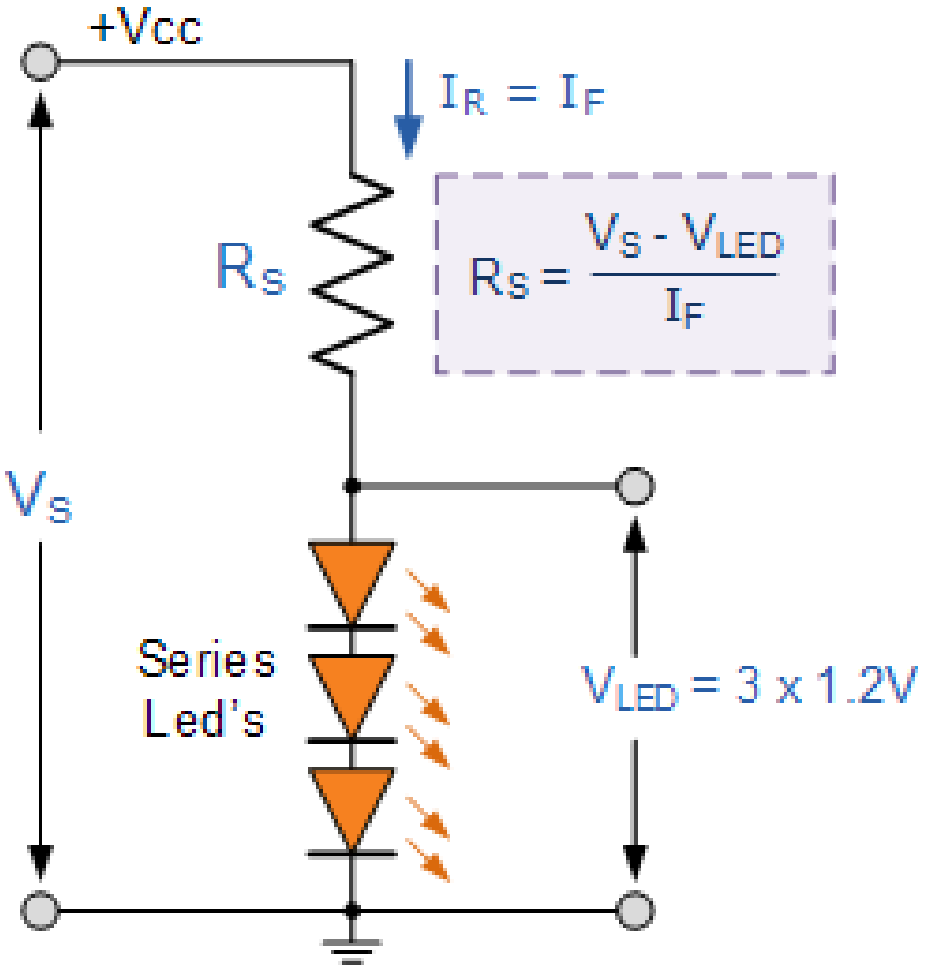


LED and its
I-V Characteristics

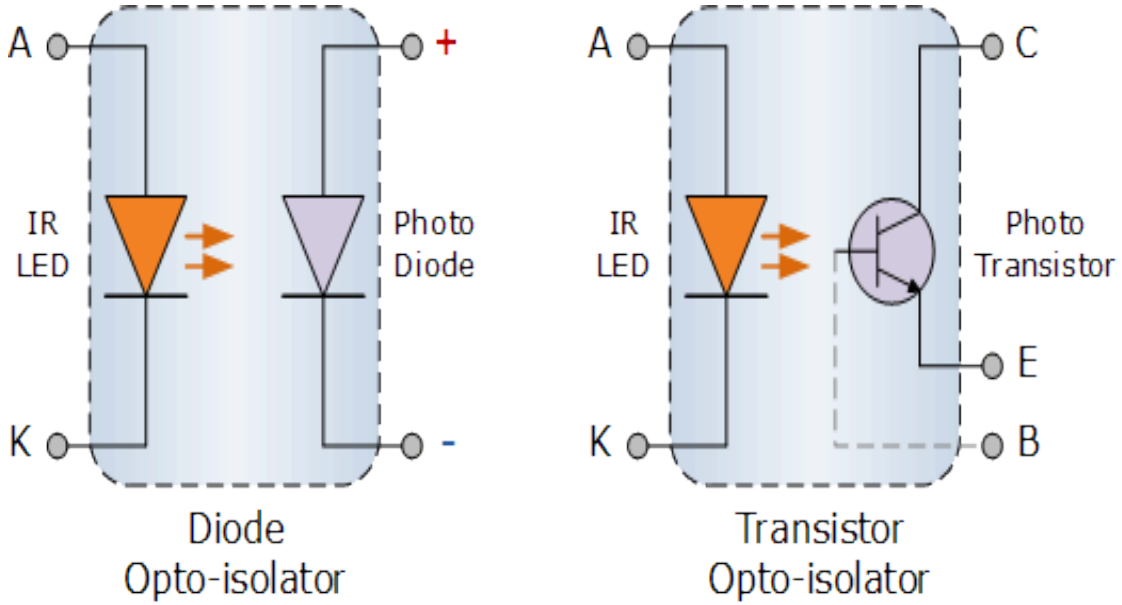


LED Application



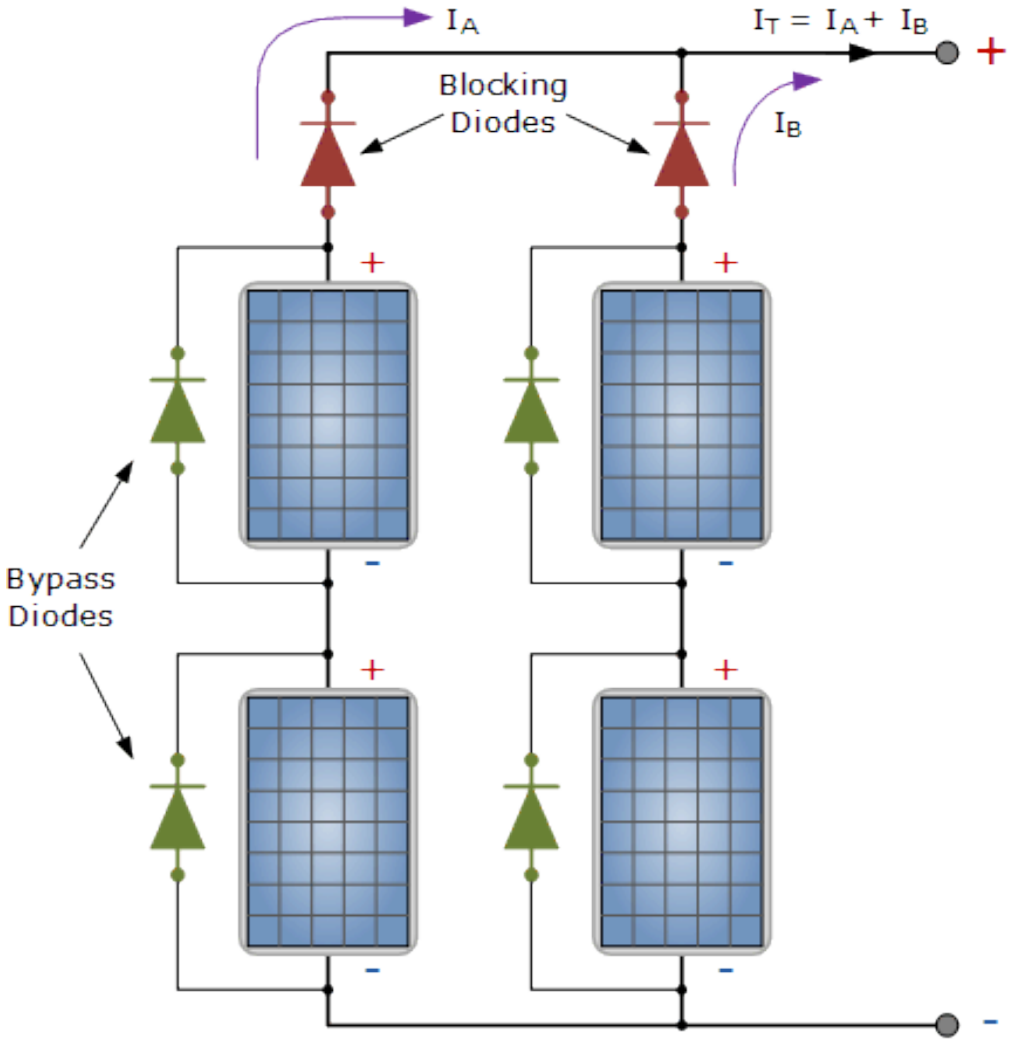


Opto-coupler (Opto-isolator)



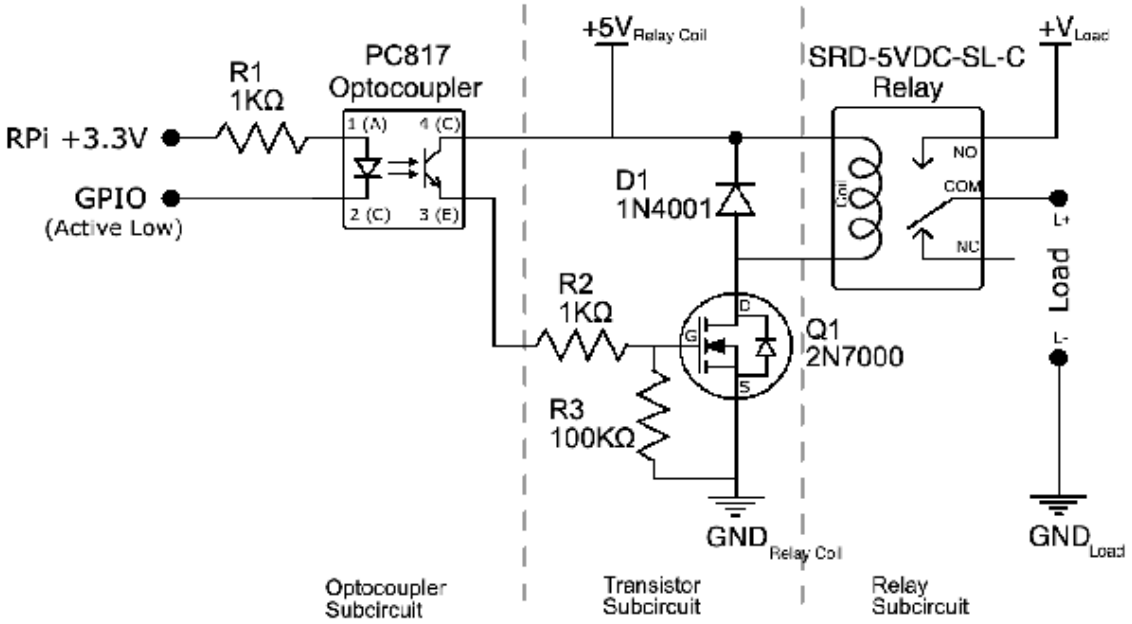
- Opto-isolators are digital or switching devices, so they transfer either “ON-OFF” control signals or digital data. Analogue signals can be transferred by means of frequency or pulse-width modulation.
- This allows information to be transferred between circuits without an electrical connection or common ground potential.

Bypass & Blockade



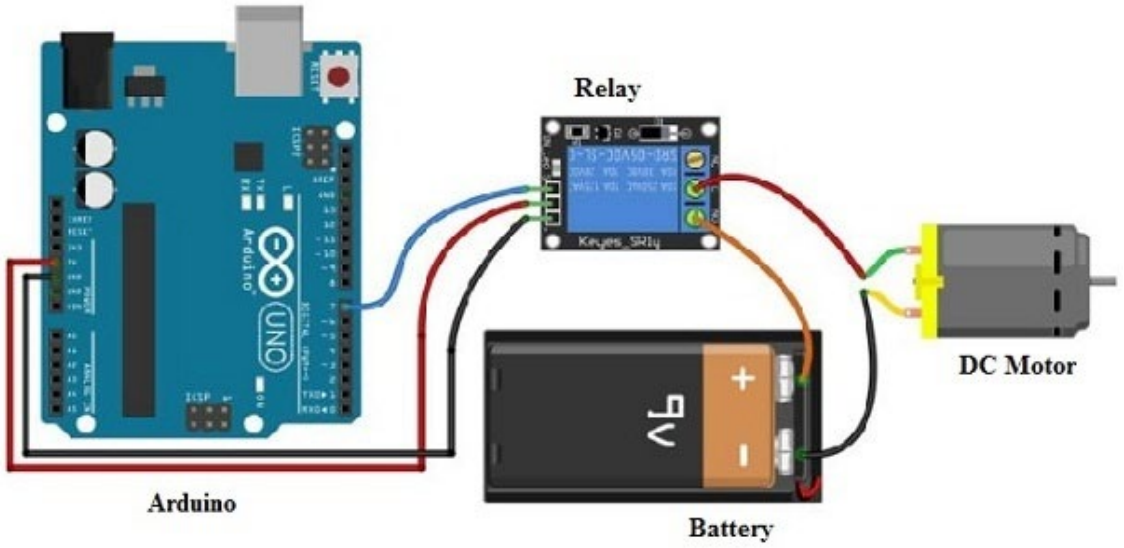
- PV Module Application:
  - Diodes are devices that allow current to flow in one direction only.
  - Diodes colored green above are “bypass diodes”, one in parallel with each solar panel to provide a low resistance path. Bypass diodes in solar panels and arrays need to be able to safely carry this short circuit current.
  - Diodes colored red are referred to as the “blocking diodes”, also called a series diode or isolation diode, ensure that the electrical current only flows in one direction “OUT” of the series array to the external load, controller or batteries.

Bypass for Relays (1)



- Diode (D_1) is reversely connected to the coil of the relay via MOSFET (Q_1).
- Practical optocoupler and relay connection. Using a Raspberry Pi board (or any other microcontroller) to control very-high-voltage devices via digital input/output voltages.

Bypass for Relays (2)



- Practical simple relay module. Using an Arduino Uno R3 board (or any other microcontroller) to control high-voltage devices (upto a 220-V lamp, or similar) via digital input/output voltages.
  - A diode (1N4007) is reversely connected to the coil of the relay via NPN transistor (BC547).
  - VCC: Relay input voltage
  - GND: Relay ground voltage reference
  - Signal: Digital control signal
  - Common Contact: Power to the external device
  - Normally Closed: Common contact is connected when the signal is LOW ; otherwise, disconnected.
  - Normally Open: Common contact is connected when the signal is HIGH; otherwise, disconnected.

LTS: Left to Students (Voltage Doubler)

Download and install relay models into the software via:

https://forum.allaboutcircuits.com/threads/ltspice-modified-relay-models.188250/

Then, analyze all the circuit given in this lecture using LTspice!

Thanks for listening ☺

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