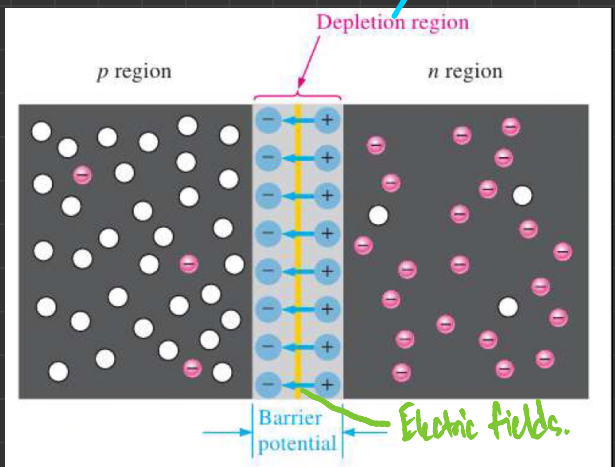
DIODES AND APPLICATIONS.

① [The PN Junction].

N-type. → major : free e^-
minor : hole

P-type. → major : hole
minor : free e^-



- n region losing free electrons, as they diffuses across the junction
- p region losing hole as the free e^- and holes combine.

พาหะ P → N , พาหะ N → P.

Note! ความหนาแน่นก่อนต่อ.

$Density_P \simeq Density_N$.

- ในการเคลื่อนที่ e^- ผ่าน Depletion region จะต้องใช้พลังงานภายนอกมาช่วยเพื่อจะทำให้ e^- ผ่านเขตนี้ไปได้.

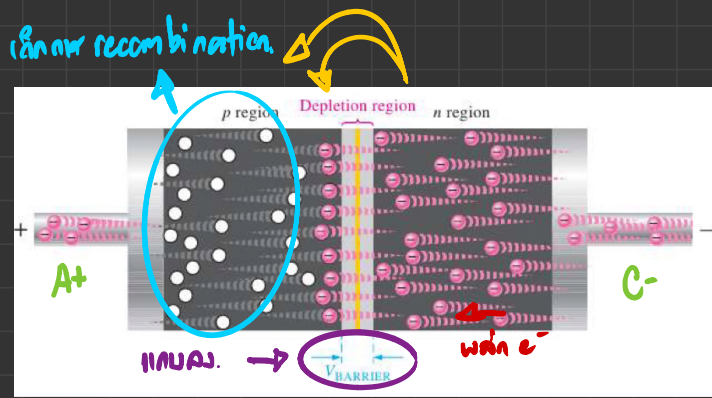
The typical Barrier Potential is 0.7 V (for silicon)
0.3 V (for germanium) → 25 °C

② [Diode Operation].

Semiconductor (Silicon ≃ 0.7 V)

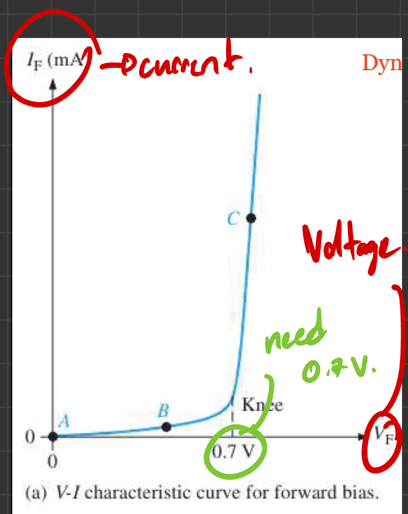
[2.1] Forward Bias. (ไบอัสตรง)

↳ the condition that permits current through a pn junction.



Note! Vbias ต้อง > 0.7 V. (Si)

V-I Characteristic for (Forward Bias) → graph expo.



(a) V-I characteristic curve for forward bias.

!! proof V. = 0.7 for conductance.

Exponential Diode

The exponential diode model represents the following relationship between the diode current I and the diode voltage V:

$$I = IS \cdot \left(e^{\frac{qV}{NkT_{m1}}} - 1\right) \qquad V > -BV$$

$$I = -IS \cdot \left(e^{\frac{-q(V+Vz)}{kT_{m1}}} - e^{\frac{qV}{NkT_{m1}}}\right) \qquad V \le -BV$$

where:

- q is the elementary charge on an electron (1.602176e–19 coulombs).
- k is the Boltzmann constant (1.3806503e–23 J/K).
- BV is the **Reverse breakdown voltage** parameter value.
- N is the emission coefficient.
- IS is the saturation current.
- T_{m1} is the temperature at which the diode parameters are specified, as defined by the **Measurement temperature** parameter value.

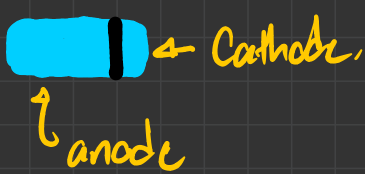
When $(qV / NkT_{m1}) > 80$, the block replaces $e^{\frac{qV}{NkT_{m1}}}$ with $(qV / NkT_{m1} - 79)e^{80}$, which matches the gradient of the diode current at $(qV / NkT_{m1}) = 80$ and extrapolates linearly. When $(qV / NkT_{m1}) < -79$, the block replaces $e^{\frac{qV}{NkT_{m1}}}$ with $(qV / NkT_{m1} + 80)e^{-79}$, which also matches the gradient and extrapolates linearly. Typical electrical circuits do not reach these extreme values. The block provides this linear extrapolation to help convergence when solving for the constraints during simulation.

↳ ใช้ simulator พิสูจน์.

- Vbias > 0.7 V (Si) ใน Semiconductor จะช่วยนำกระแสไฟฟ้าไหลง่ายขึ้น.

Note!

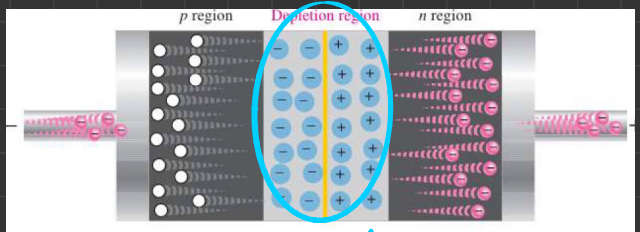
Symbol.



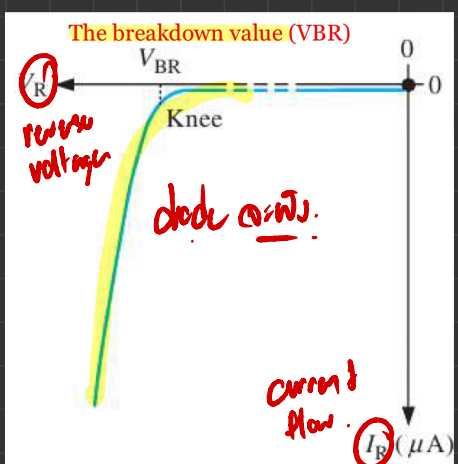
[2.2] Reverse Bias (ไบอัสย้อนกลับ)

Is the condition that prevents current through the pn junction.

Note! * Reverse current can be produced by minority carries *.
(small current)

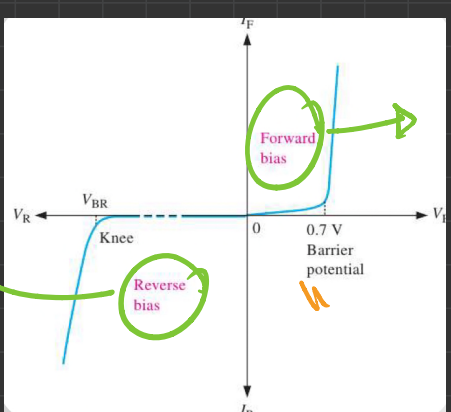


เป็นกลับขั้น. (กระแสไม่ไหล)



- กระแสไฟย้อนกลับสูงมาก
  ไดโอดเสีย.
- typical rectifier diode
  a breakdown voltage around.

V_B > 50V.	Some are $5V_B$.

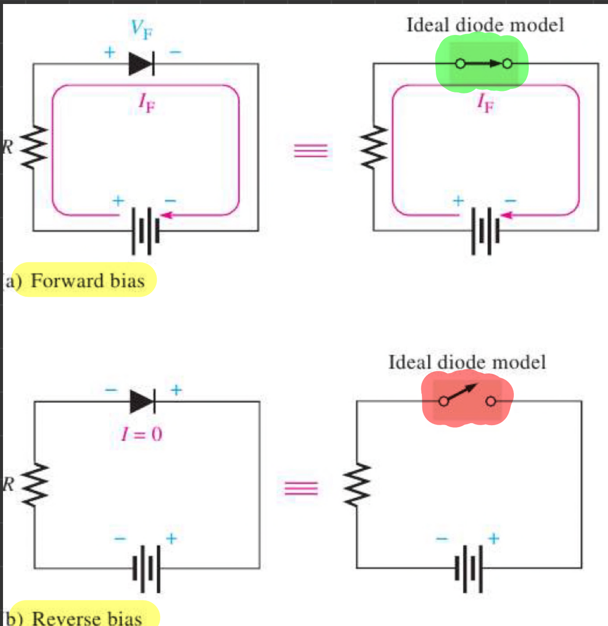


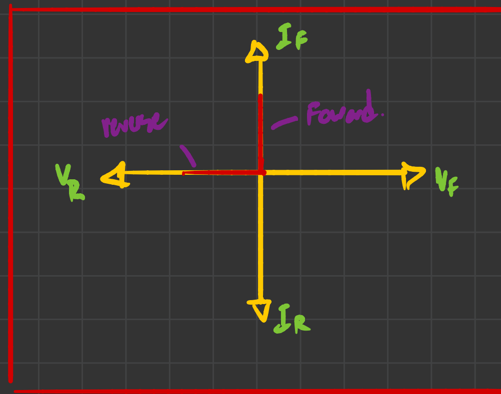
on.

off.

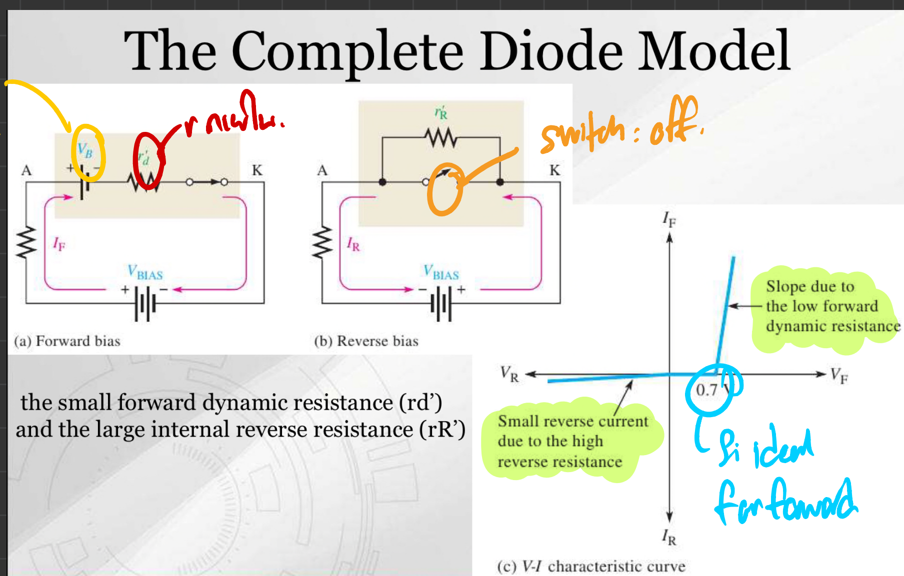
[2.3]. Ideals and Application.

- Diode จะต่อเมื่อมีแรงดันตกอยู่ภายในเท่านั้น.
- ในอุดมคติ
  - forward bias, → switch : ON.
  - reverse bias. → switch : OFF.





Barrier Potential



③ [Half-wave rectifiers] → แปลง AC เป็น DC.

discharge เร็ว

C น้อย

C มาก

discharge ไว (กราฟเป็น linear)

(reverse) Diode: off — K, A

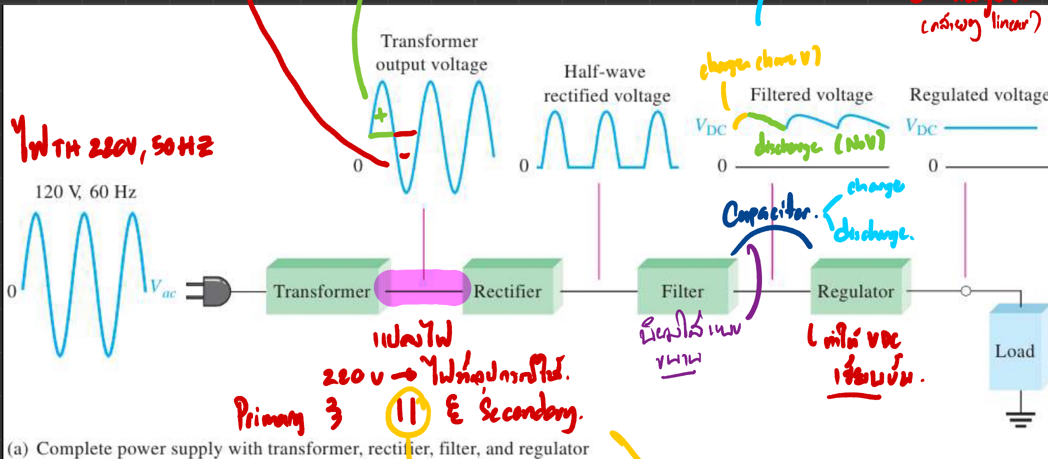
(forward) Diode: ON — A, K

ไฟไทย 220V, 50Hz

charge (ขึ้น V)

discharge (ลง V)

Capacitor. { charge, discharge.



(a) Complete power supply with transformer, rectifier, filter, and regulator

แปลงไฟ 220V → ไฟที่อุปกรณ์ใช้.

Primary 3 11 ε Secondary.

220V. แกนเหล็ก. 12V.

ปรับให้เรียบ

ให้ได้ VDC เรียบเนียน.

ขึ้นอยู่กับขดลวด.

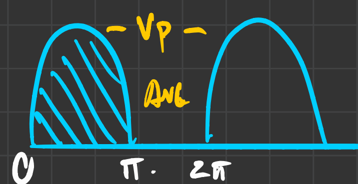
Turns Ratio.

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = n$$

volt, coils.

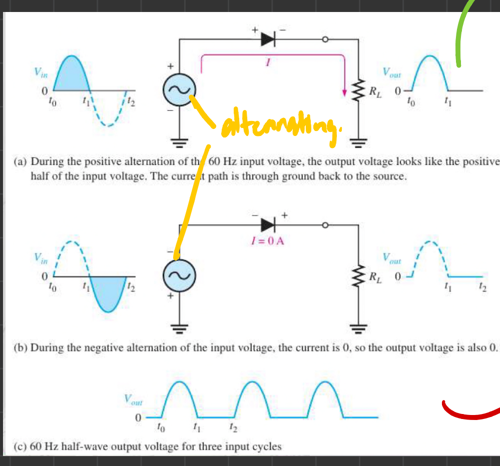
if $V_P > V_S$ (step up)

if $V_P < V_S$ (step down)



[3.1] Half-wave cal.

Diode: ON. (forward)



(a) During the positive alternation of the 60 Hz input voltage, the output voltage looks like the positive half of the input voltage. The current path is through ground back to the source.

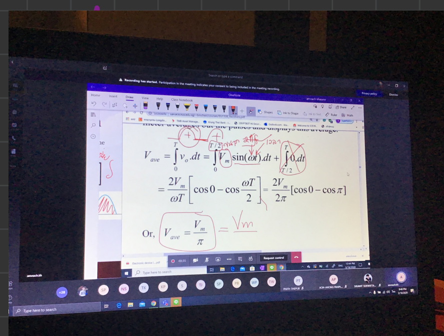
(b) During the negative alternation of the input voltage, the current is 0, so the output voltage is also 0.

(c) 60 Hz half-wave output voltage for three input cycles

alternating.

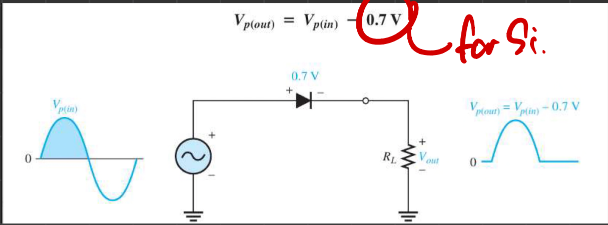
proof.

(Reverse) Diode: off.

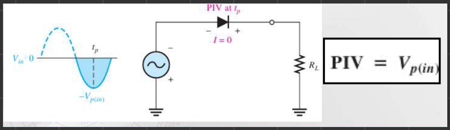


$$V_{AVG} = V_P / \pi.$$

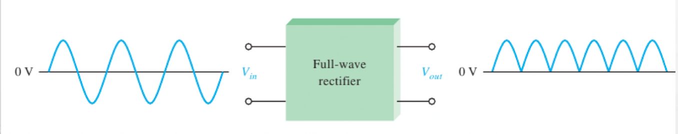
Effect of Barrier Potential. (specific rectifier)



Peak Inverse Voltage.



4 [Full-wave rectifier].



$$V_{AVG} = \frac{2V_p}{\pi}$$

• ใช้ได้ดีกว่า half wave.

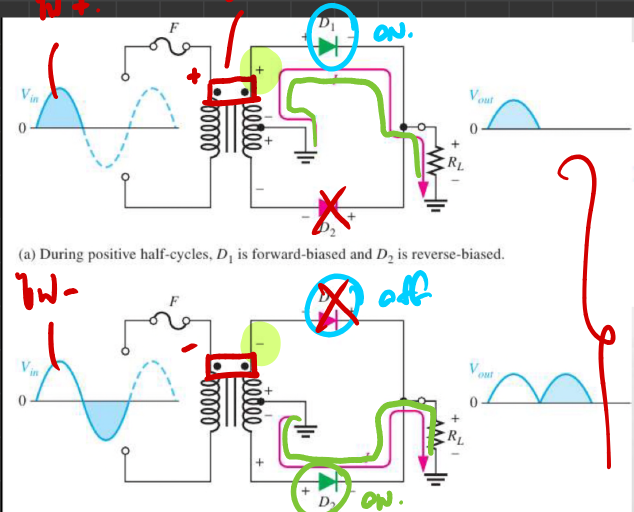
Ex: 31.8%. → 63.6%.

[4.1] Center tapped full wave.

Note! ระวัง effect ratio.

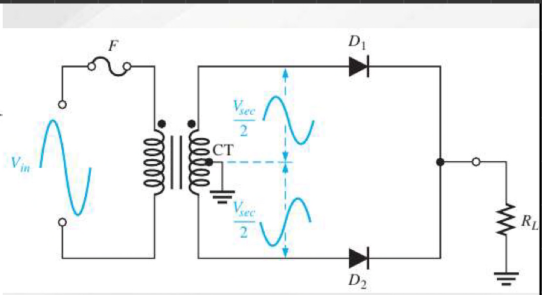
ratio 1 → $\frac{V_{p(pri)}}{2} - 0.7V$.

← หมายความว่า $V_{in}-$ → $V_{out}-$
dot. $V_{in}+$ → $V_{out}+$



(a) During positive half-cycles, D_1 is forward-biased and D_2 is reverse-biased.

(b) During negative half-cycles, D_2 is forward-biased and D_1 is reverse-biased.

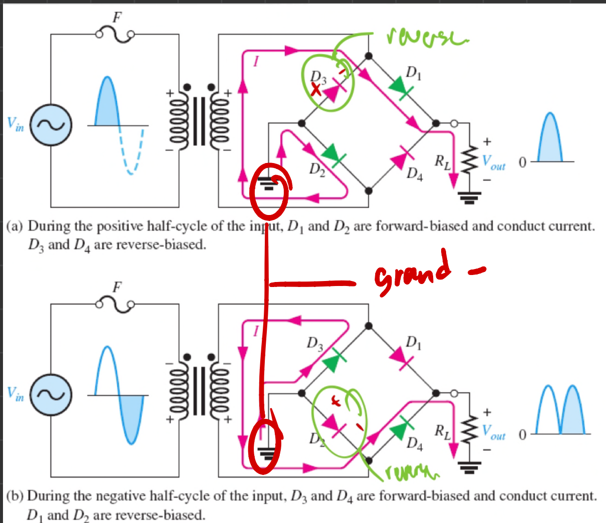


A center-tapped full-wave rectifier.

ก็คือ = full wave.

ratio 2 → $\left(\frac{V_{p(pri)}}{2} \times 2\right) - 0.7V$

(5) [full bridge Operation]

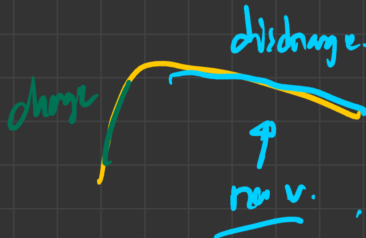


(a) During the positive half-cycle of the input, D_1 and D_2 are forward-biased and conduct current. D_3 and D_4 are reverse-biased.

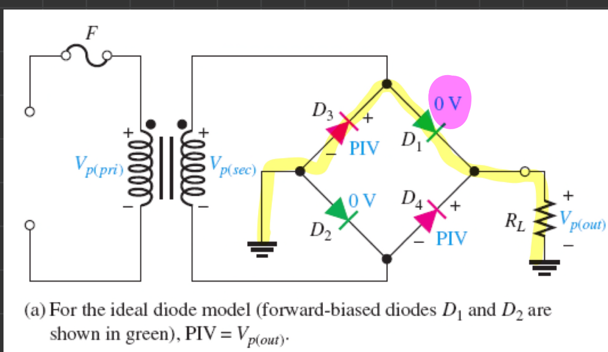
(b) During the negative half-cycle of the input, D_3 and D_4 are forward-biased and conduct current. D_1 and D_2 are reverse-biased.

2 diodes = 0.7 x 2

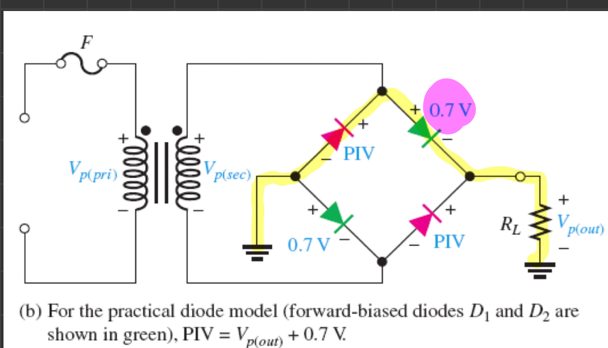
$V_{p(out)} = V_{p(sec)} - 1.4$ V.



Peak Inverse Voltage.



(a) For the ideal diode model (forward-biased diodes D_1 and D_2 are shown in green), PIV = $V_{p(out)}$.

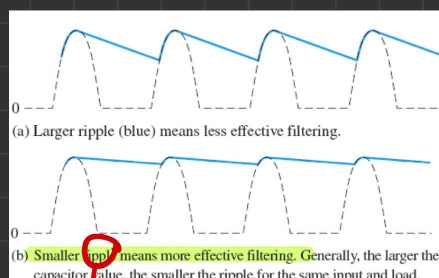


(b) For the practical diode model (forward-biased diodes D_1 and D_2 are shown in green), PIV = $V_{p(out)}$ + 0.7 V.

[5.1] Ripple filters

C ค่าสะดุดของ Capacitor

สะดุดน้อย = ดี



(a) Larger ripple (blue) means less effective filtering.

(b) Smaller ripple means more effective filtering. Generally, the larger the capacitor value, the smaller the ripple for the same input and load.

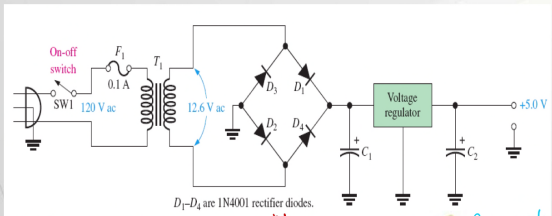
สะดุด

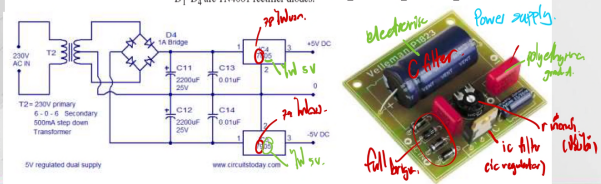
$r = V_{r(pp)} / V_{DC}$.

R, L, C Increase then V_r decrease and V_{DC} increase.

6. Regulated Power supply.

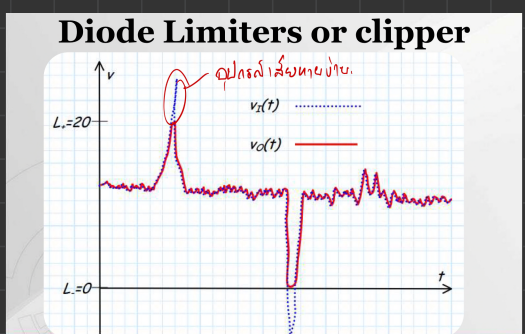
Regulated power supply



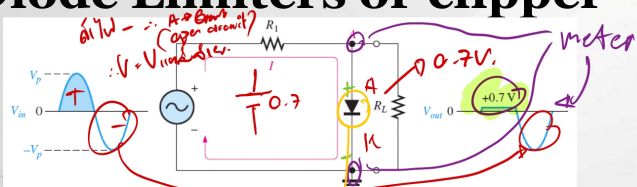


7. Clippers and Limiters

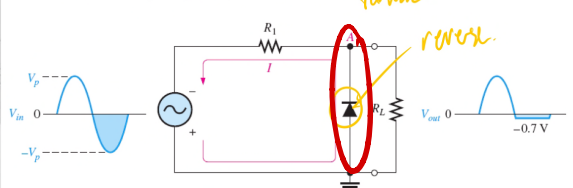
Diode Limiters or clipper



Diode Limiters or clipper



(a) Limiting of the positive alternation. The diode is forward-biased during the positive alternation (above 0.7 V) and reverse-biased during the negative alternation.



(b) Limiting of the negative alternation. The diode is forward-biased during the negative alternation (below −0.7 V) and reverse-biased during the positive alternation.