24.01.2022

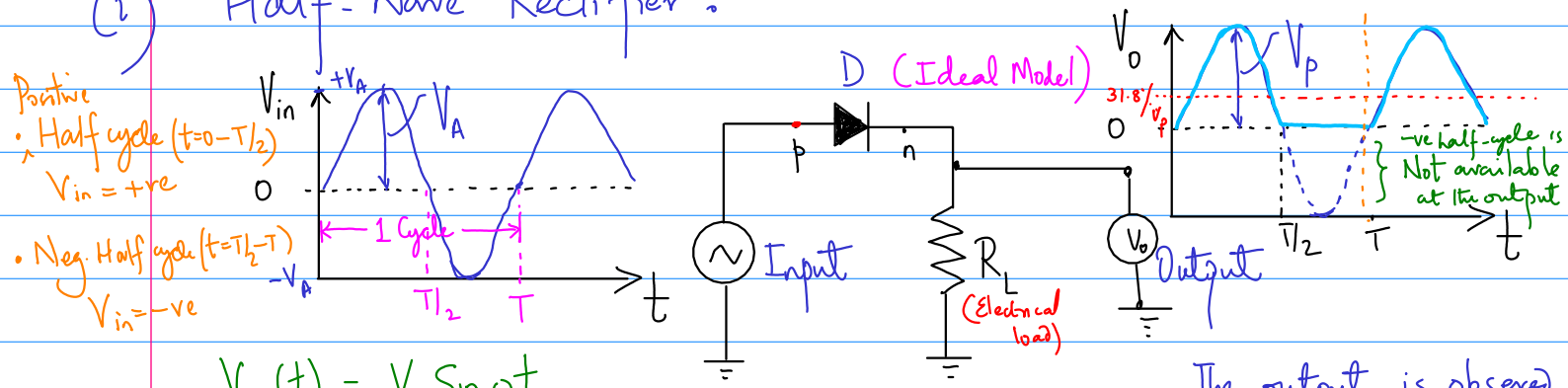
p-n Diode : Applications

Since p-n diodes are unidirectional element, meaning it has ability to conduct current in one direction and block in other direction.

- Diodes are used in circuits called rectifiers that convert ac voltage into dc voltage.
- Rectifier ckt. are found in all dc power supply that operates from an ac source.

A) Rectifier Operation :

(i) Half-Wave Rectifier :



$V_{in}(t) = V_A \sin \omega t$

The output is observed on the scope/simulator

What would be voltage across R_L when a DC voltmeter is connected across it?

- It measures the average value of the output signal.

Mathematically, it is the area under the output signal over a full (one) cycle and then divided by 2π, the number of radians in a full cycle.

$$V_{ave.} = \frac{1}{2\pi}\int_{t=0}^{t=T/2} V_p \sin\omega t \, d(\omega t) + \frac{1}{2\pi}\int_{t=T/2}^{t=T} V_p \sin\omega t \, d\omega t$$

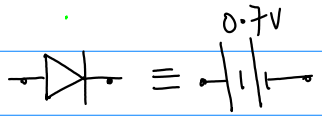
(+ve half-cycle; −ve half-cycle = 0)

$$\Rightarrow \boxed{V_{ave.} = \frac{V_p}{\pi}} \approx 31.8\% \text{ of } V_p$$

In order to incorporate the effect of barrier potential in p-n diode on half-wave rectifier,

We use "Modified Ideal Diode Model":

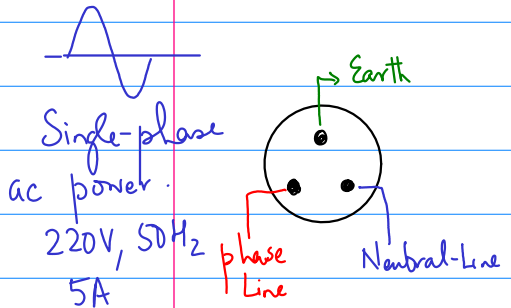
For practical pn diode:



$$V_p = V_{in} - 0.7V$$

$$\boxed{V_{ave} = \frac{V_p}{\pi} = \frac{(V_{in} - 0.7V)}{\pi}}$$

V_{in} = Amplitude of the input signal.

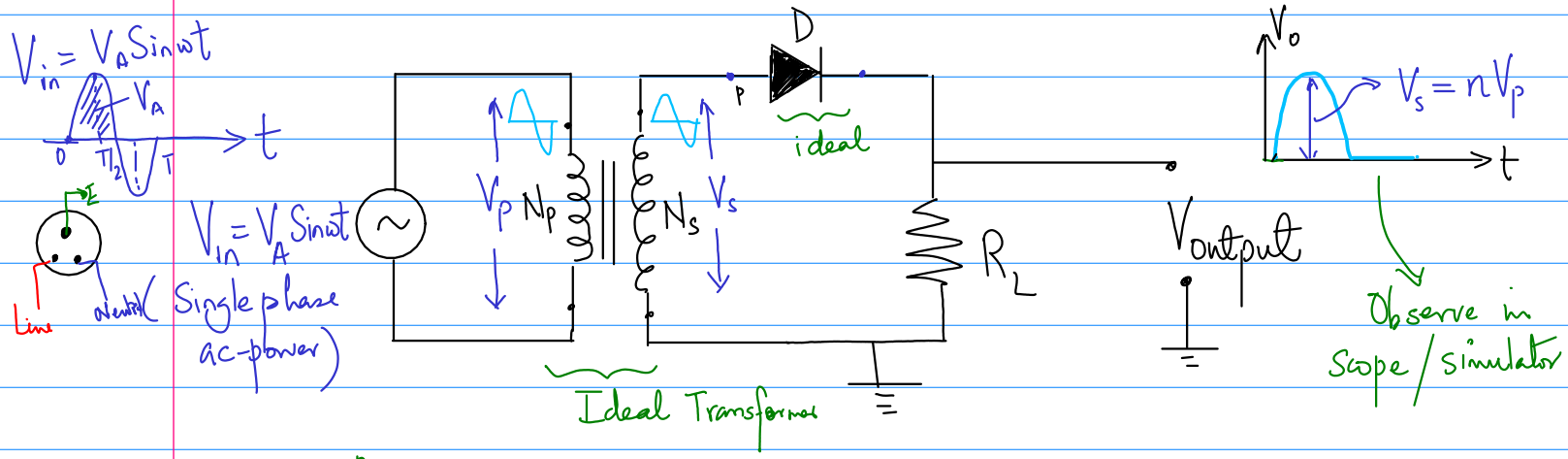


In practice, the rectifier ckt is connected with the step-down transformer at the input terminal.

Advantages:

i) Allows the source voltage to step-down

ii) Prevents rectifier ckt. with any electrical hazard.



In transformer, we define

Turn ratio, $n = \frac{N_s}{N_p}$ (N_s: Number of turns in the secondary coil; N_p: # turns in the primary coil)

$n > 1$: step-up transformer

$n < 1$: step-down transformer

$$V_s = n V_p$$

If you connect dc voltmeter across the R_L

$$V_{ave} = \frac{V_s}{\pi} = \frac{nV_p}{\pi} = \frac{n V_{in}}{\pi}$$

$$(V_{ave.})_{\text{Transformer Coupled Rectifier}} = \frac{n V_{in}}{\pi}$$

n = turn-ratio of the transformer.

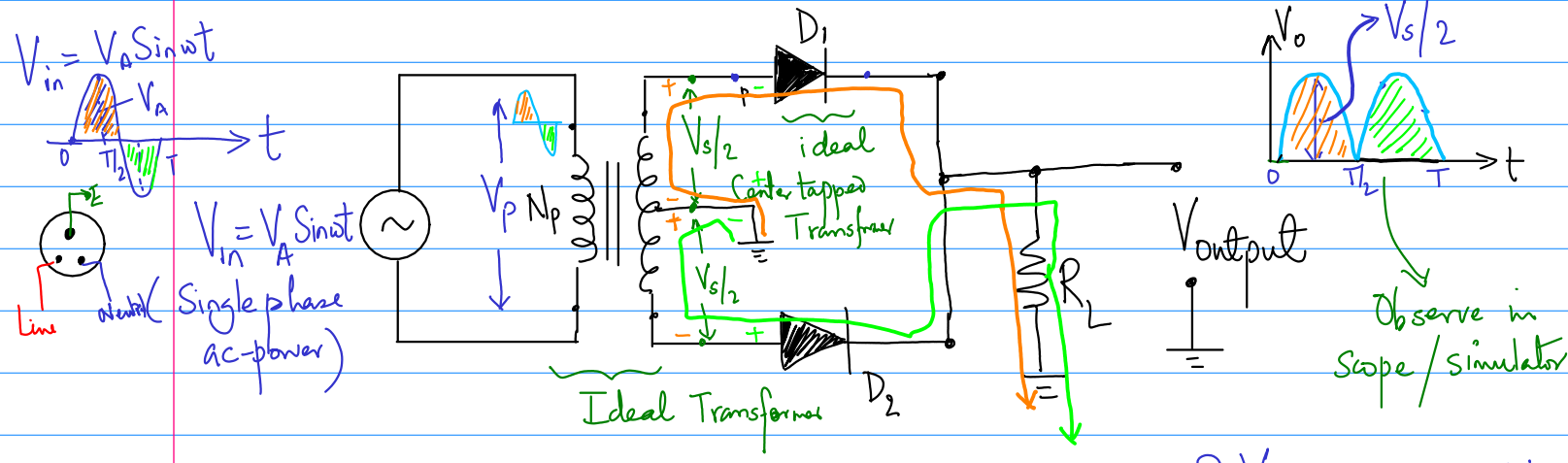
V_{in} = Amplitude of the input voltage.

For practical diodes:

$$(V_{ave.})_{\text{Tran. Couples}} = \frac{n V_{in} - 0.7V}{\pi}$$

V_{in} = amplitude of the input voltage.

Full-Wave Rectifier:



$$V_{p,out} = V_s/2 \quad ; \quad V_{ave.} = \frac{2V_{p,out}}{\pi} = \frac{2 \cdot V_s/2}{\pi}$$