3. Clippers and Clampers

3.1. Clippers

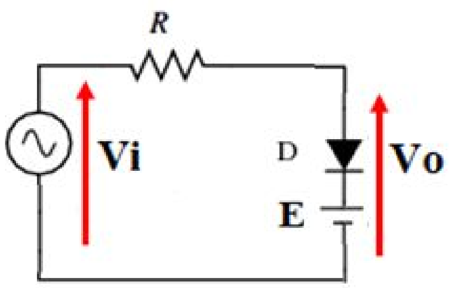
A Clipper is a circuit which removes the peak of a waveform. There are two types of clippers:

- ✓ **Series clippers**, where the diode is in series with the output voltage.
- ✓ **Parallel clippers**, where the diode is in parallel with the output voltage.

Example: Half ware rectifier is a clipper.

Application 1 :

Positive Clipper Circuit (ideal diode)
This is a parallel clipper with positive bias E
With : E < Vip



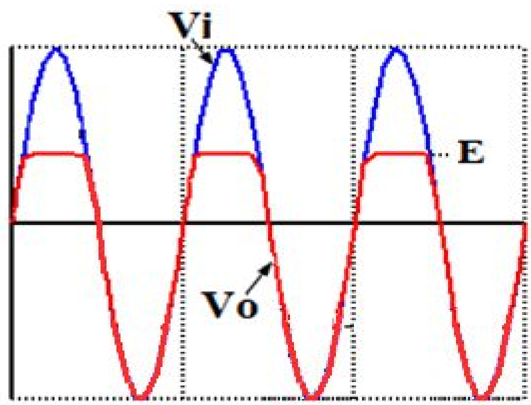


Fig.2.12.1. Positive Clipper Circuit

D is **ON** if Va-Vk > 0

Vi-E>0 $\Rightarrow$ **Vi>E**

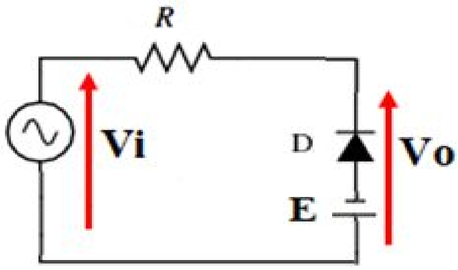
Vo =E

D is **OFF** if **Vi< E**

Vo =Vi

Application 2 :

Negative Clipper Circuit (ideal diode)
This is a parallel clipper with negative bias -E
With : E < Vip



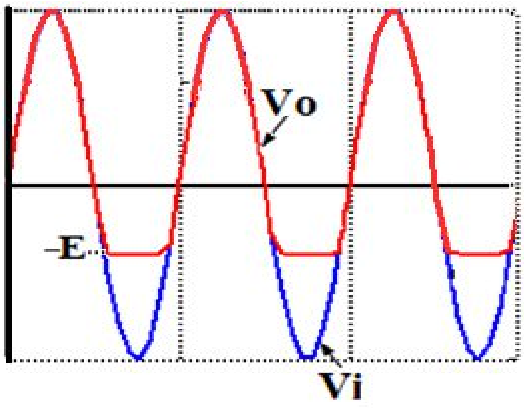


Fig.2.12.2. Negative Clipper Circuit

D is **ON** if Va-Vk > 0
-E-Vi>0 $\Rightarrow$ **Vi<-E**

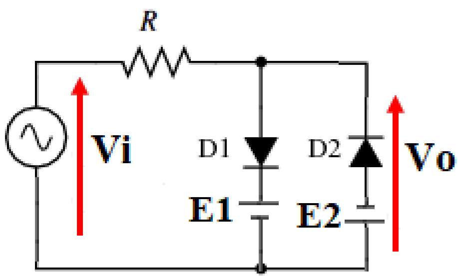
Vo = -E

D is **OFF** if **Vi >-E2**

Vo =Vi

Application 3:

Positive and negative Clipper Circuit (ideal diodes)
E1 and E2 are both < Vip



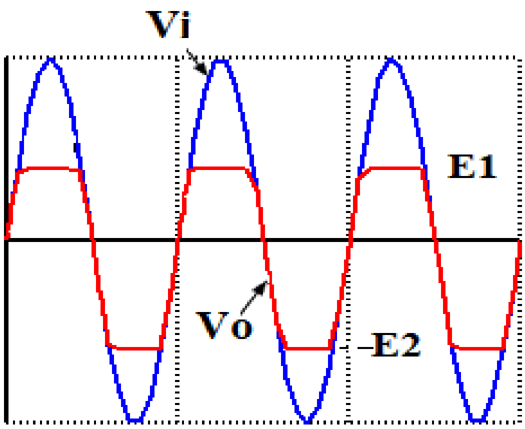


Fig.2.12.3. Positive and Negative Clipper Circuit

D1 is **ON** if Va-Vk > 0
Vi-E1>0 $\Rightarrow$ **Vi>E1**

Vo =E1

D2 is **ON** if Va-Vk > 0
-E2-Vi>0 $\Rightarrow$ **Vi<-E2**

Vo = -E2

D1 and D2 are **OFF** if **-E2< Vi< E1**
Vo =Vi

> ***Note:***
> ***There is also a Zener diode clipper circuit in the "Zener diode" section. A Zener diode replaces both the diode and the DC voltage source.***

3.2. Clampers

A clamper is a network constructed of a diode, a resistor and a capacitor that shifts a waveform to a different dc level without changing the appearance of the applied signal.

Application 1:

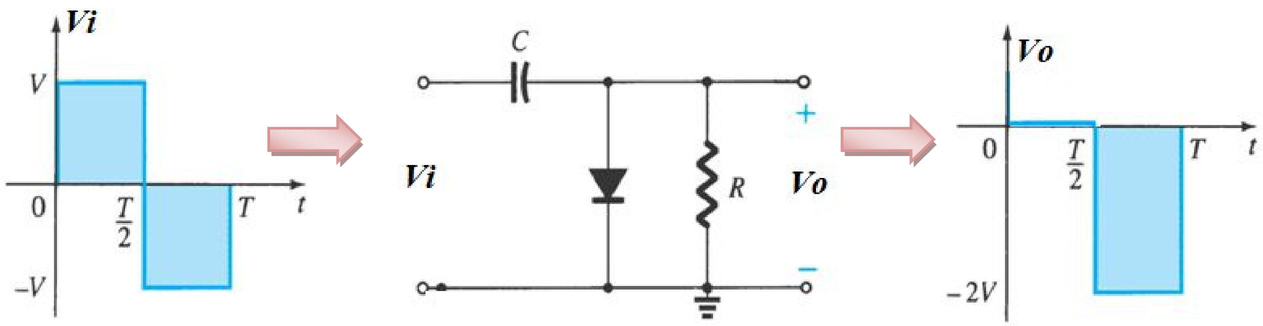
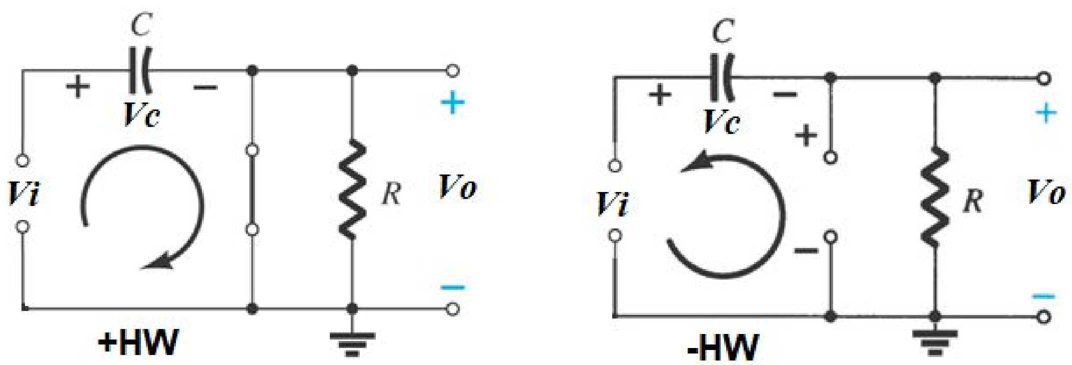


Fig.2.13.1. Clamper Circuit

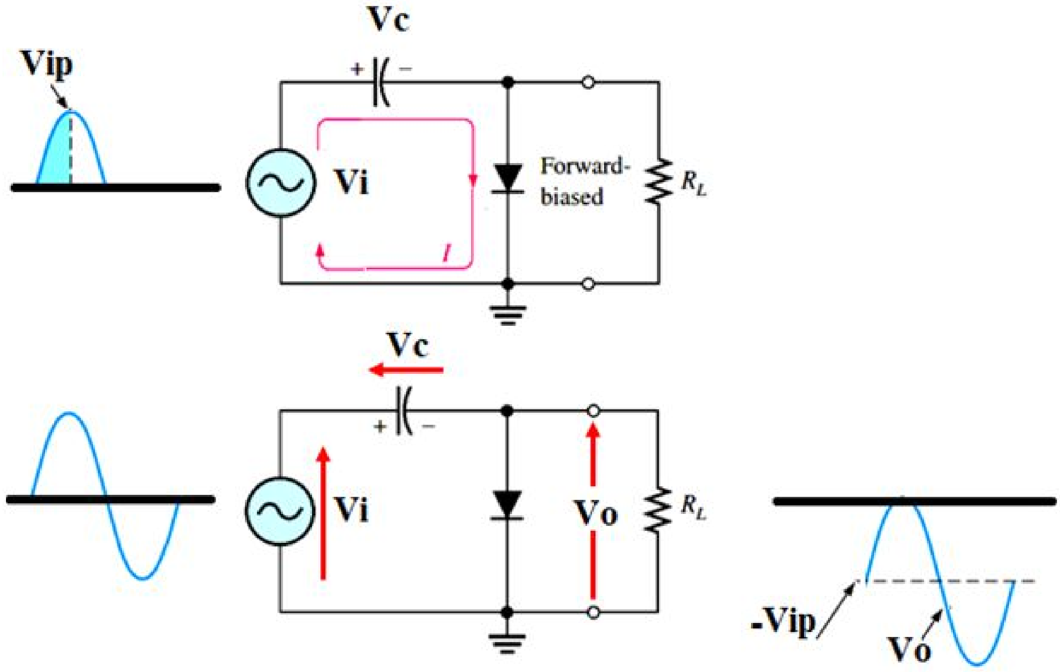
Analysis (ideal diode)

Operation at forward biased (Vi>0), the diode is short circuited (ON). The voltage will be:
Vo=0
Since the current is shorted through the diode and the capacitor is charged up to a voltage **Vc=Vi(peak).**
During reverse biased (Vi<0), the diode is open circuited (OFF). The voltage across R will be: **Vo = Vi- Vc= Vi- Vi(peak)**

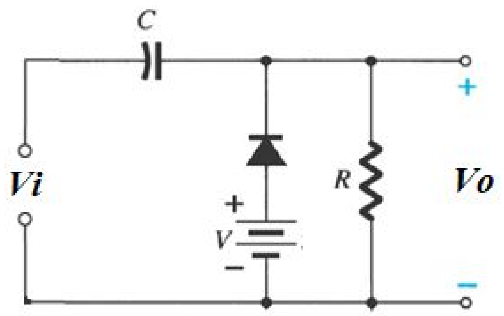


Application 2: Clampers with sin signal.

When the input voltage initially goes positive, the diode is forward biased, allowing the capacitor to charge to near the peak of the input (Vip). Just after the positive peak, the diode is reverse-biased. This is because the anode is held near (-Vip) by the charge on the capacitor. The capacitor can only discharge through the resistance RL. So, from the peak of one positive half-cycle to the next, the capacitor discharges very little.



Application 3:



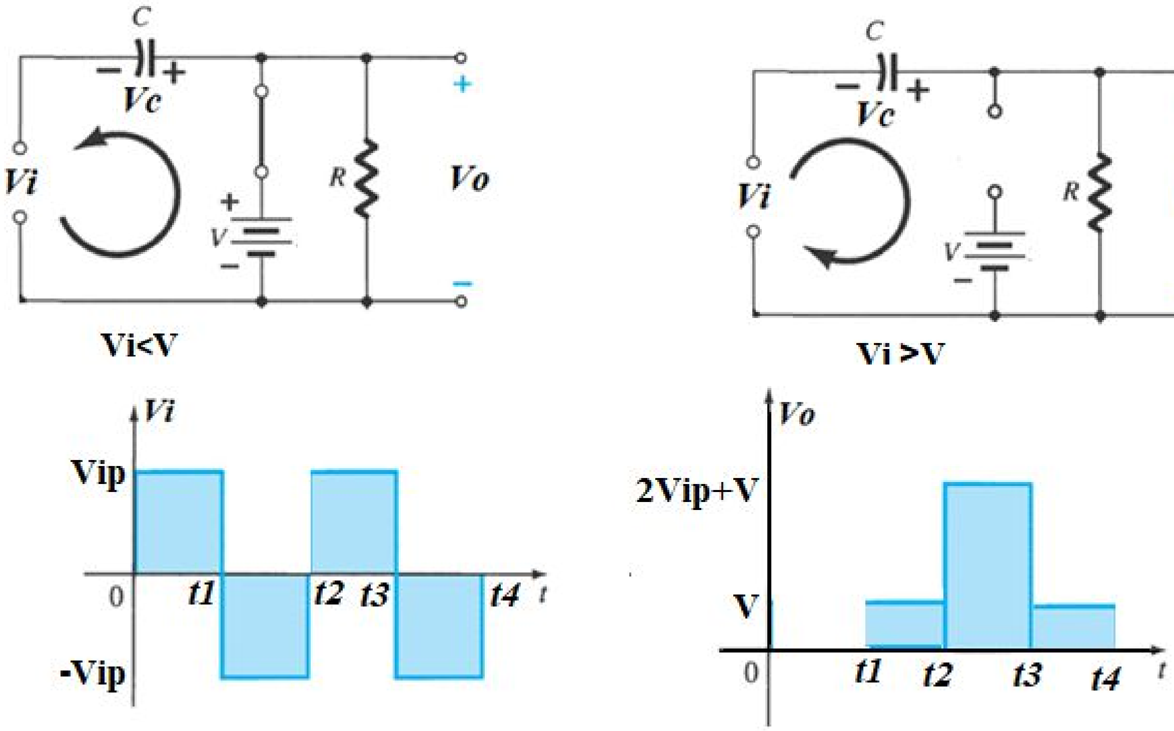
Operation at forward biased (**Vi<V**), the diode is short circuited (**ON**). The voltage will be:

Vo =V

The capacitor is charged up to a voltage:

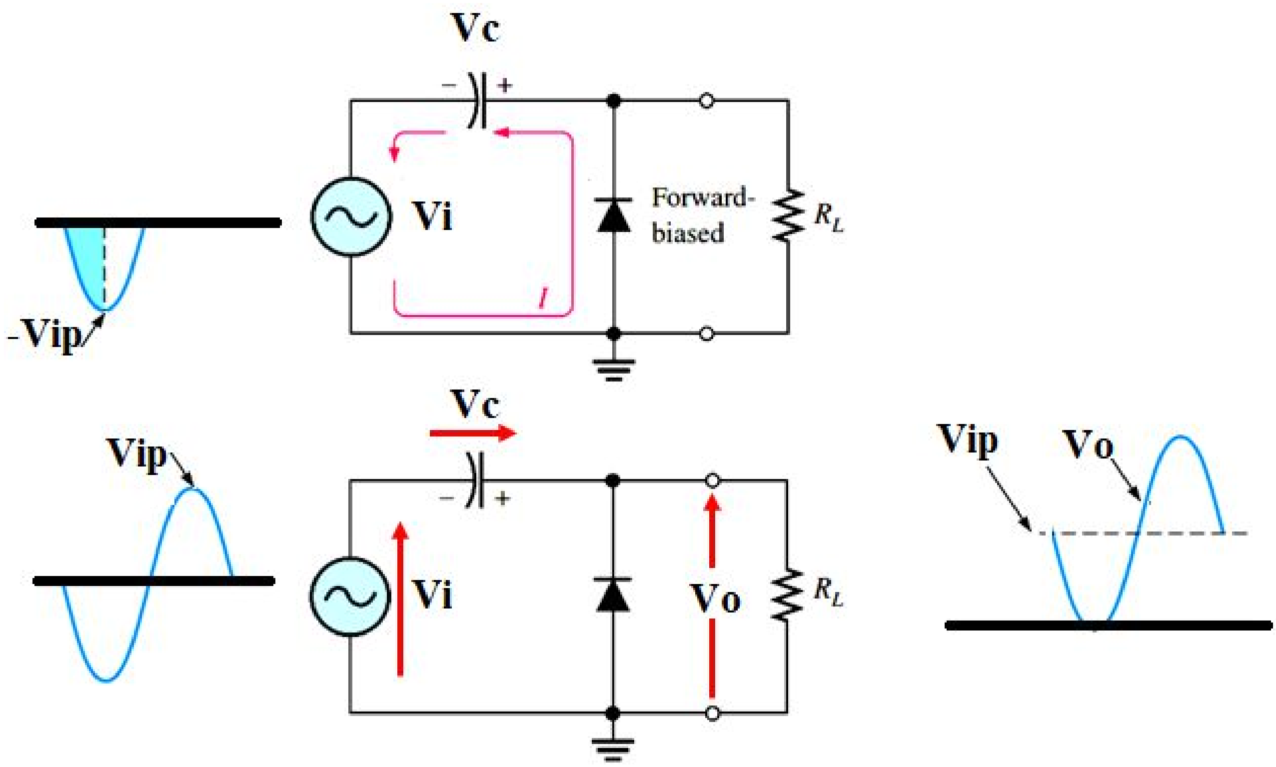
Vc= -Vi +V =Vi(peak) +V

During reverse biased (**Vi>V**), the diode is open circuited (**OFF**). The voltage across R will be: **Vo = Vi+ Vc= Vi+ Vi(peak)+V**



Application 4: Clampers with sin signal.

When the input voltage initially goes negative, the diode is forward biased, allowing the capacitor to charge to near the peak of the input (Vip).



Just after the negative peak, the diode is reverse-biased. This is because the cathode is held near (Vip) by the charge on the capacitor.

The capacitor can only discharge through the resistance RL. So, from the peak of one negative half-cycle to the next, the capacitor discharges very little. The amount that is discharged, of course, depends on the value of RL and C.

All clamper circuits:

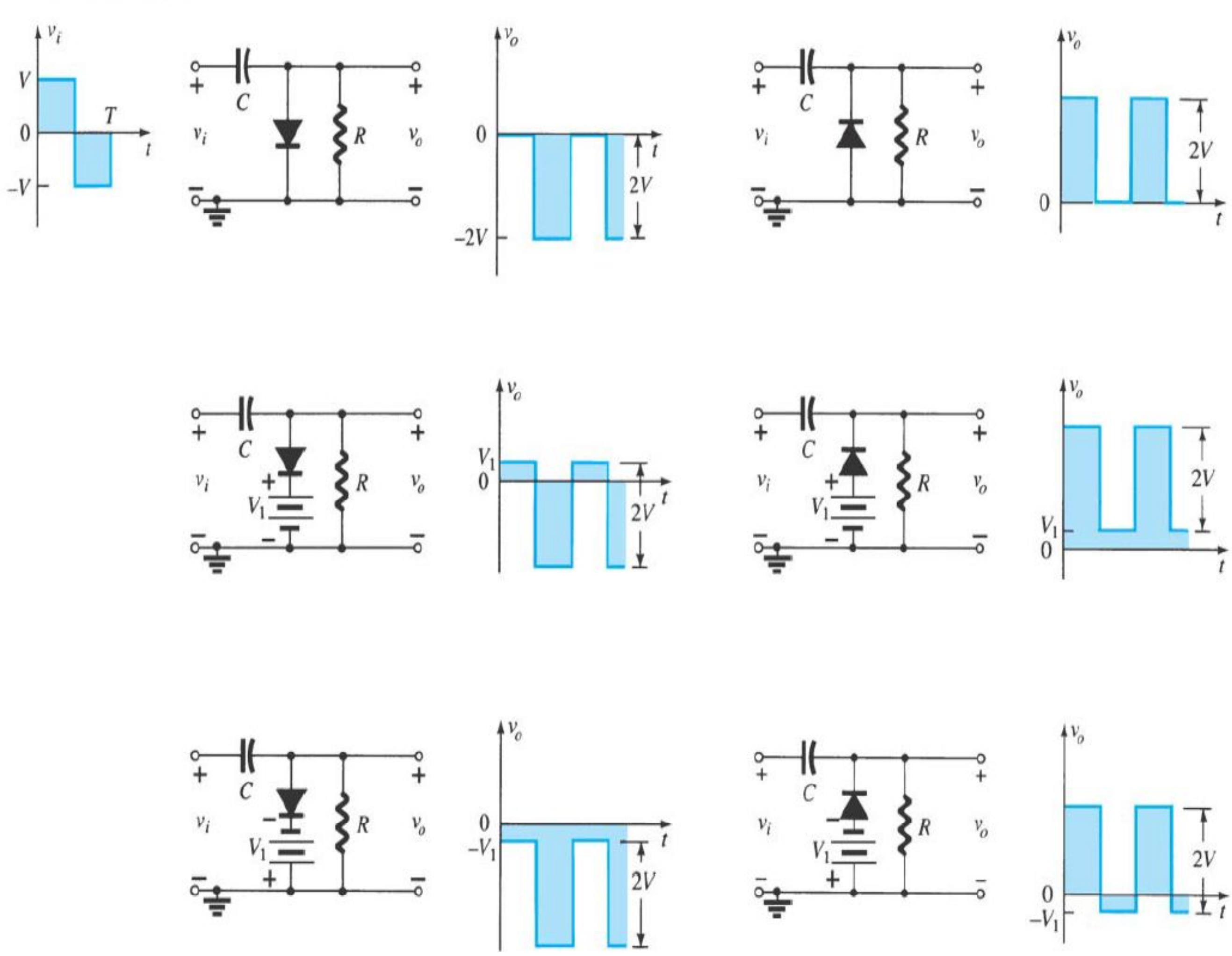
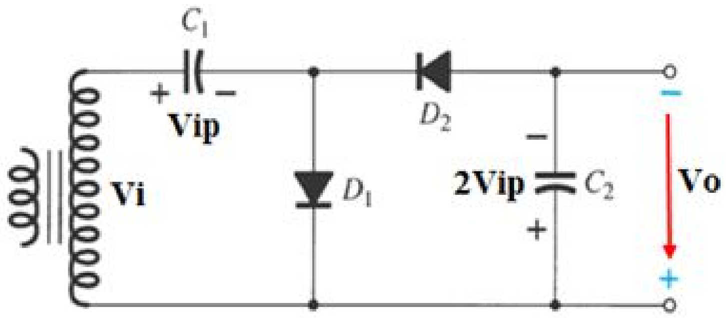


Fig.2.13.2. Clamper Circuits

4. Voltage multiplier circuits

A *voltage multiplier* is a specialized rectifier circuit producing an output which is theoretically an integer times the AC peak input, for example, 2, 3, or 4 times the AC peak input. Thus, it is possible to get 200V(DC) from a 100 Vpeak (AC) source using a doubler, 400V(DC) from a quadrupler. Any load in a practical circuit will lower these voltages.

4.1. Half-Wave Voltage Doubler



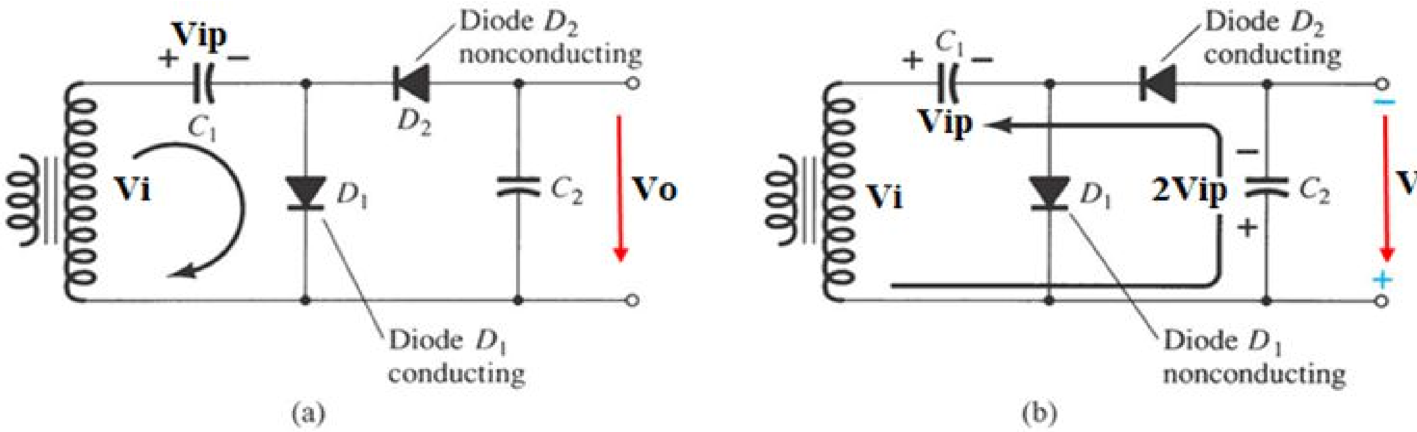
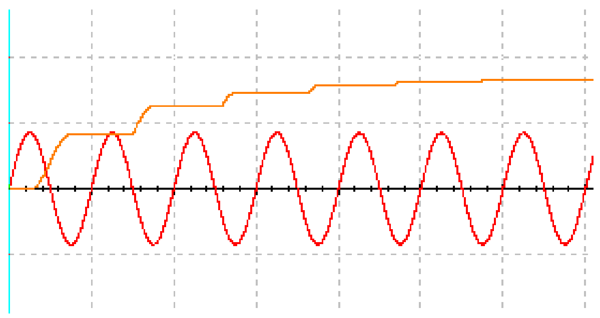


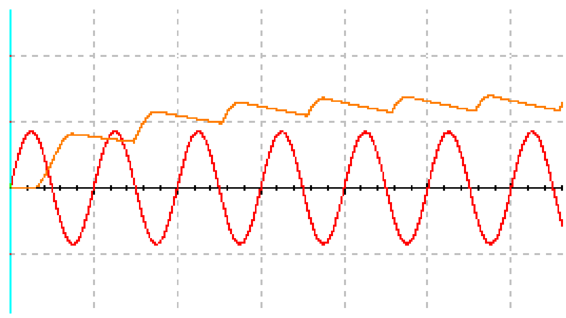
Fig.2.14.1. Half-Wave Voltage Doubler

a) During the positive half-cycle across the transformer, the diode D1 conducts and D2 is cut off. The capacitor C1 charge-up to peak rectified voltage **Vip**.

b) Second half cycle, D2 conducts and D1 is cut-off. Now the capacitor C2 is charged up with **Vip+ VC = Vip+Vip = 2Vip**



Half wave doubler (Vo)



Half wave doubler (with load R// Vo)

4.2. Full-Wave Voltage Doubler

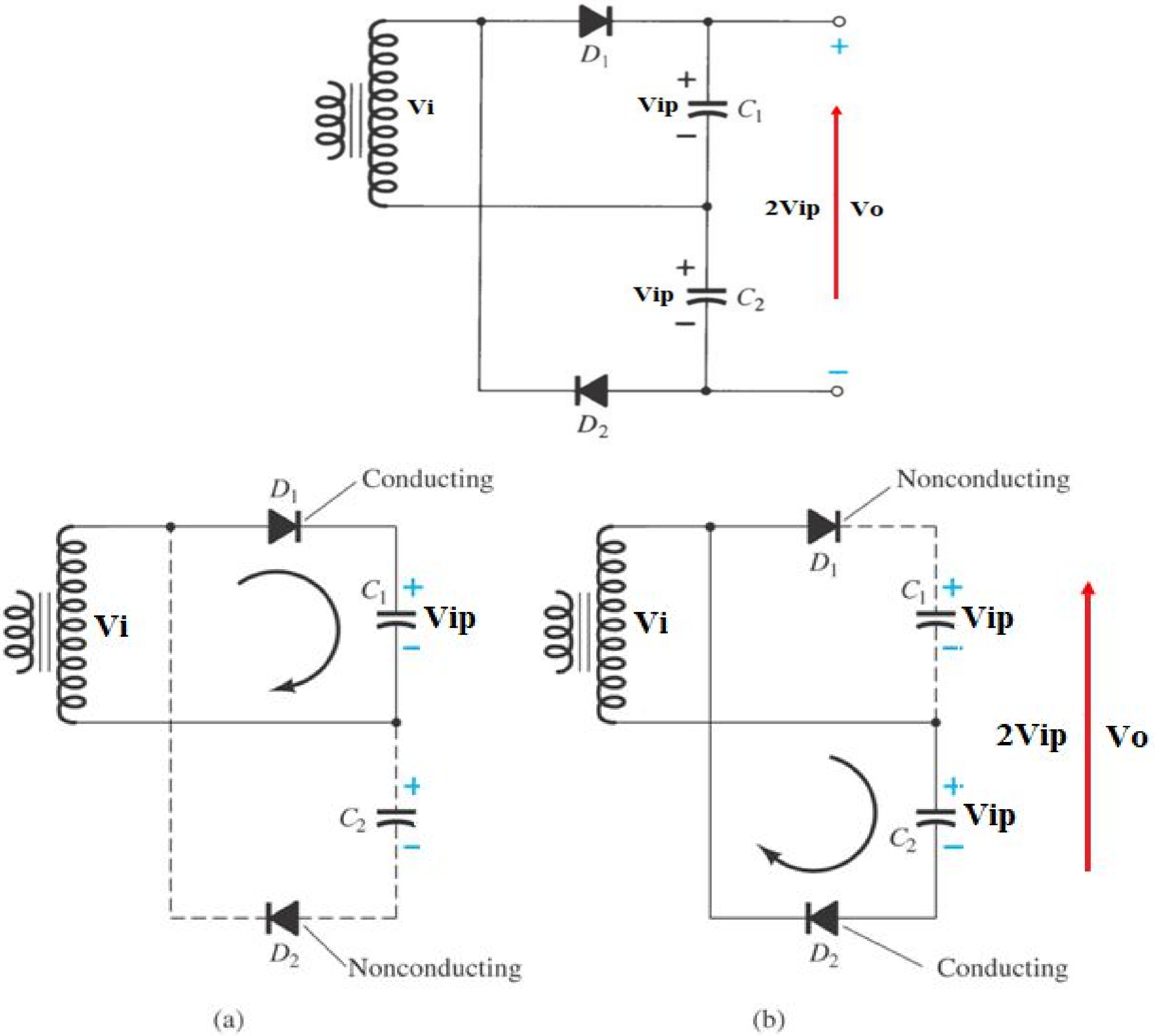
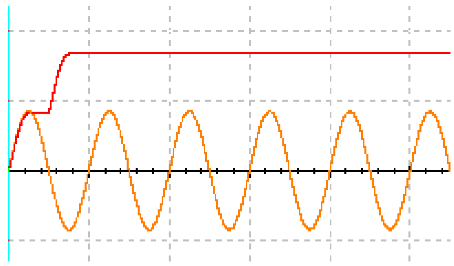


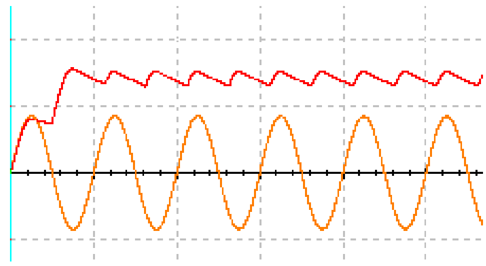
Fig.2.14.2. Full-Wave Voltage Doubler

a) Positive cycle, D1 is conducting, thus charging C1 to Vip. D2 is not conducting ⇒ No charging of the capacitor C2.

b) Negative cycle, D2 is conducting, thus charging C2 to Vip. D1 is not conducting ⇒ C1 still maintain the charging voltage Vip.



Full wave doubler (Vo)



Full wave doubler (with load R// Vo)

4.3. Half-Wave Doubler, Tripler and Quadrupler

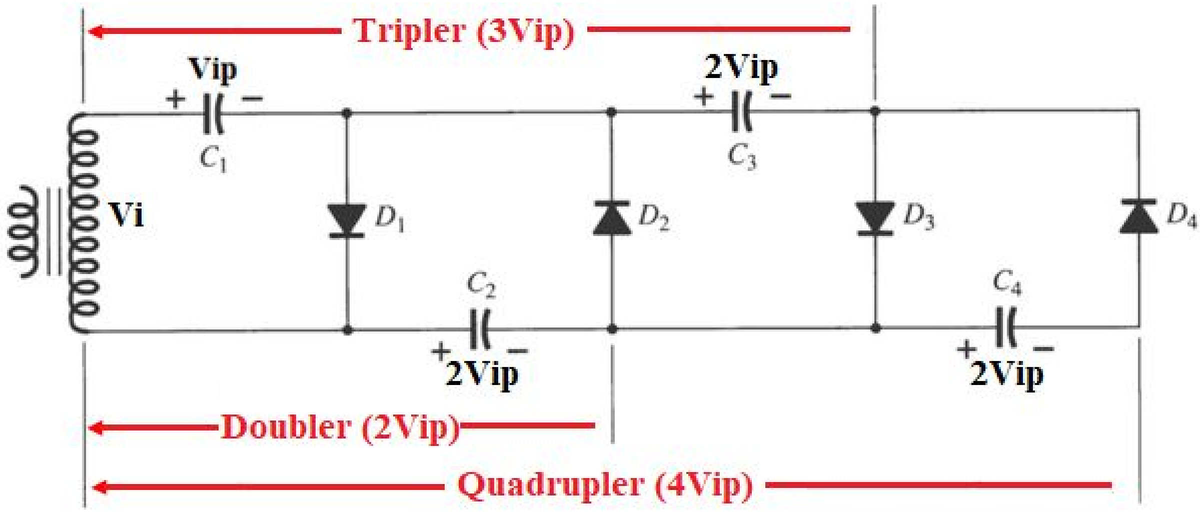


Fig.2.14.3. Voltage Multiplier circuit

By arranging alternately capacitor and diode, we are able to obtain voltage **doubler**, **tripler** and **quadrupler**.
C1 plus transformer will charge C2. C2 will charge C3 and C3 will charge C4.

5. Peak detector

A *peak detector* is a series connection of a diode and a capacitor outputting a DC voltage equal to the peak value of the applied AC signal (The circuit is shown in the following Figure).
An AC voltage source applied to the peak detector, charges the capacitor to the peak of the input. The diode conducts positive “half cycles,” charging the capacitor to the waveform peak. When the input waveform falls below the DC “peak” stored on the capacitor, the diode is reverse biased, blocking current flow from capacitor back to the source. Thus, the capacitor retains the peak value even as the waveform drops to zero.

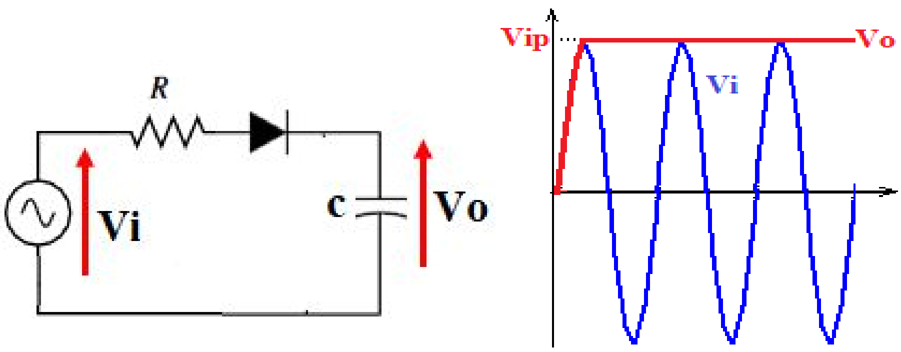


Fig.2.15. Peak detector circuit