MODULE: 3

DC chopper

Chopper is a converter to convert fixed DC to Variable DC converter (simply DC to DC converter)

Step down (or step up) chopper

working:

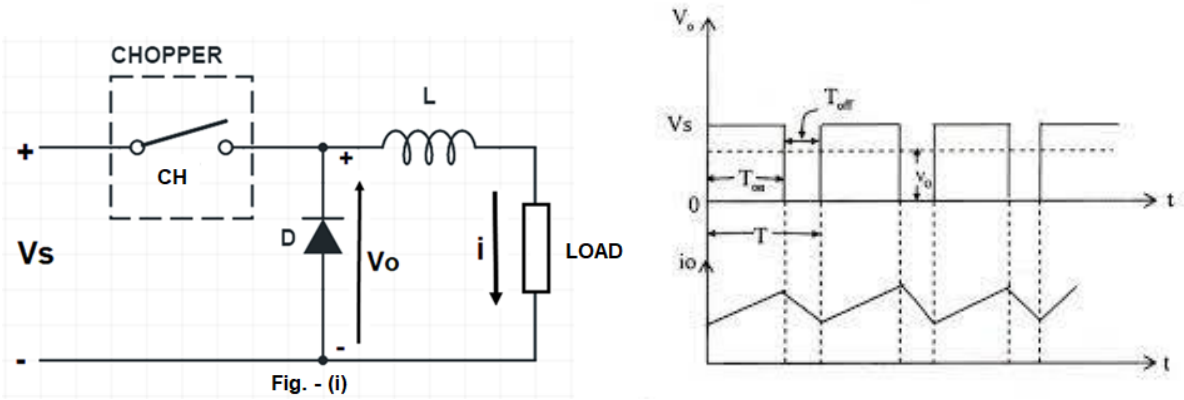


Fig. - (i)

- Switch is ON, current flows through the inductor and load.
- Switch is OFF, the stored energy in the inductor discharged through the load and the freewheeling diode.
- Hence output voltage is less than the input voltage and it is called a step-down Chopper.
- Duty cycle, α=Ton/T
- T = T_{ON} + T_{OFF}
- Output voltage V_0 = D.V_{in}

Problems

1. A step-up chopper has input voltage of 220V and output voltage of 660V. If the total time period of thyristor-chopper is 300μs, then compute its duty cycle (α) and turn ON time (TON).

   Solution

   Vin=220V

   Vo=660V

   T=300μs

   V_o = Vin/(1-α)

   660 = 220/(1-α)

   660-220 =660α

Solving α =440/660 = ⅔

TON=αT

Solving TON = 2/3 x 300 = 200μs

2. A step-down chopper has input voltage of 440V and output voltage of 220V. If the total time period of thyristor-chopper is 300μs, then compute its duty cycle (D) and turn ON time (TON)

Solution

Vin =440V

Vo=220V

T=300 μs

Vo=DVin

Duty ratio, D = Vo/Vin=220/440 = 0.5

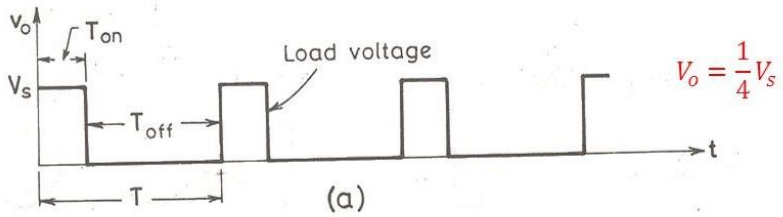
On time TON = DT = 0.5x300 μs = 150 μs

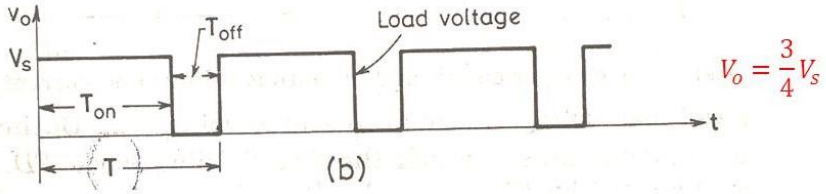
Chopper control strategies

Output of dc voltage can be controlled by 2 methods

(a)Constant frequency method

- In this method, ON time T_{ON} is varied keeping chopping frequency constant(ie, T is constant because T= 1/f).
- It is also called pulse width modulation scheme.
- Variation of T_{ON} means adjust the pulse width.

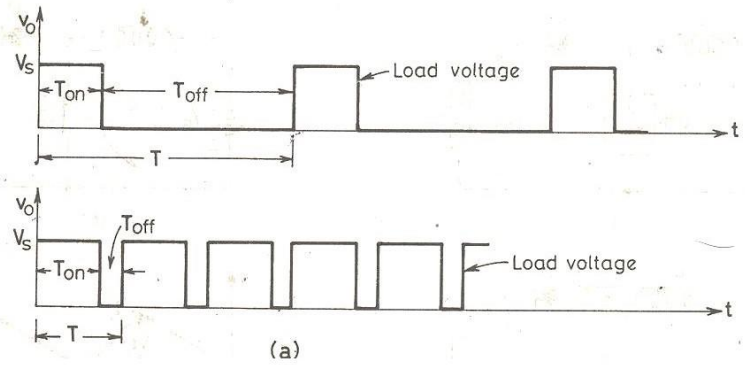




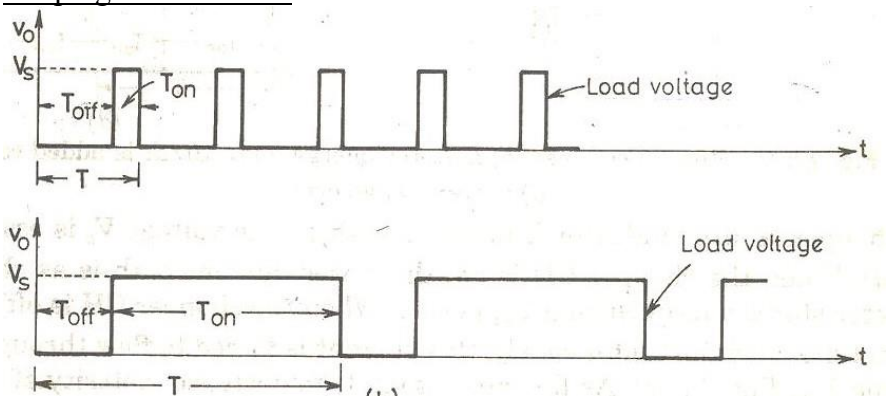
(b) Variable frequency method

- In this method, the chopping frequency is varied (ie, T is varied)
- It is also called frequency modulation scheme.

Keeping Ton constant



Keeping Toff constant

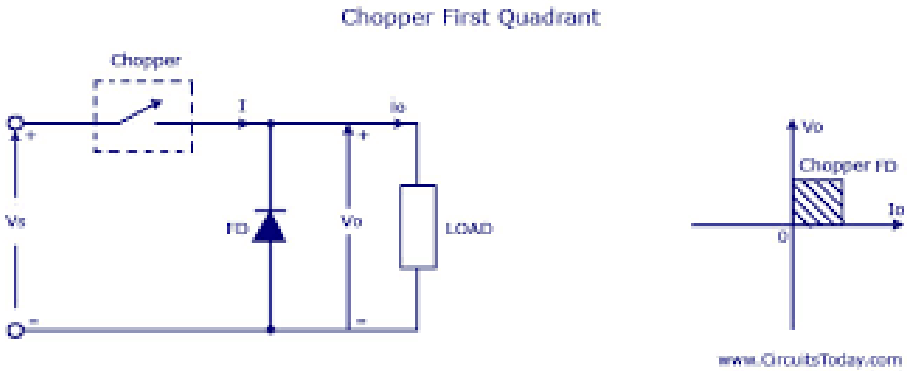


Types of choppers

Chopper is classified as follows,

1. Type A chopper or First quadrant chopper
2. Type B chopper or second quadrant chopper
3. Type C chopper or Two quadrant type A chopper
4. Type D chopper or Two quadrant type B chopper
5. Type E chopper or Fourth quadrant chopper

Type A chopper



- Type A chopper works in the first quadrant.
- In this chopper, the voltage and current both are positive and flows in the same direction.

- When CH is on,$V_0 = V_s$ and current I_0 flows from source to load.
- When CH is on,$V_0 = 0$ but current I_0 flowing in the same direction through freewheeling diode.
- Power from source to load and the average output voltage is less than input DC voltage.

Type B chopper

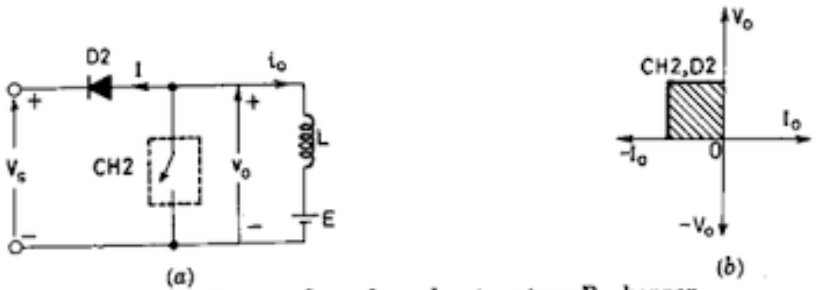
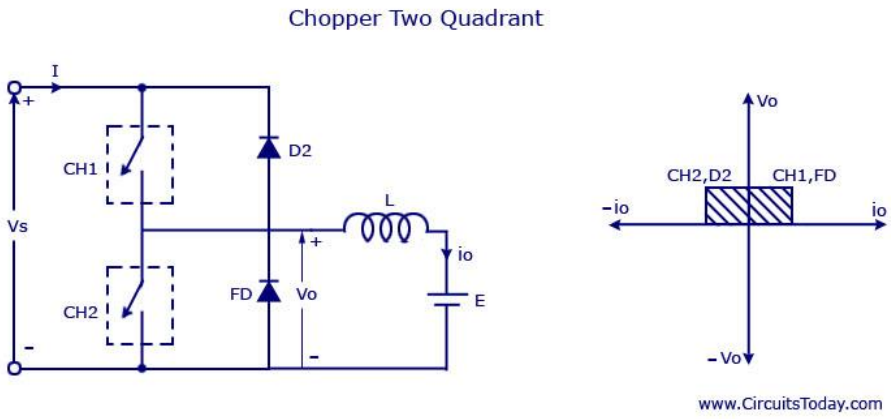


Fig. . Second-quadrant, or type-B, chopper.

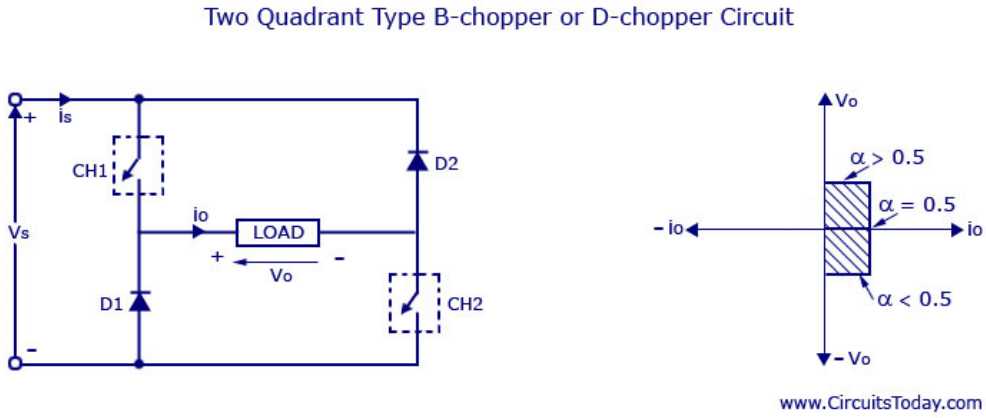
- Type B chopper operates in second quadrant
- The load must always contain a dc source E.
- When the chopper is on, V_0 is zero but the load voltage E drives the current through the inductor L and the chopper. L stores energy
- Output current $I_{0\ is}$ negative.
- When the chopper is off, $V_0 = E + V_L$
- The load voltage will be more than the voltage V_s
- Since V_O positive and the current I_0 negative. Power is negative
- Power flow will be from load to source.

Type C chopper



- It is the parallel combination of type A and type B chopper.
- It is a two-quadrant chopper.
- Type A operates in first quadrant. Power flows from source to load
- Type B operates in second quadrant. Power flows from load to source
- V_s – CH1-FD- Load (L&E) forms Type A chopper

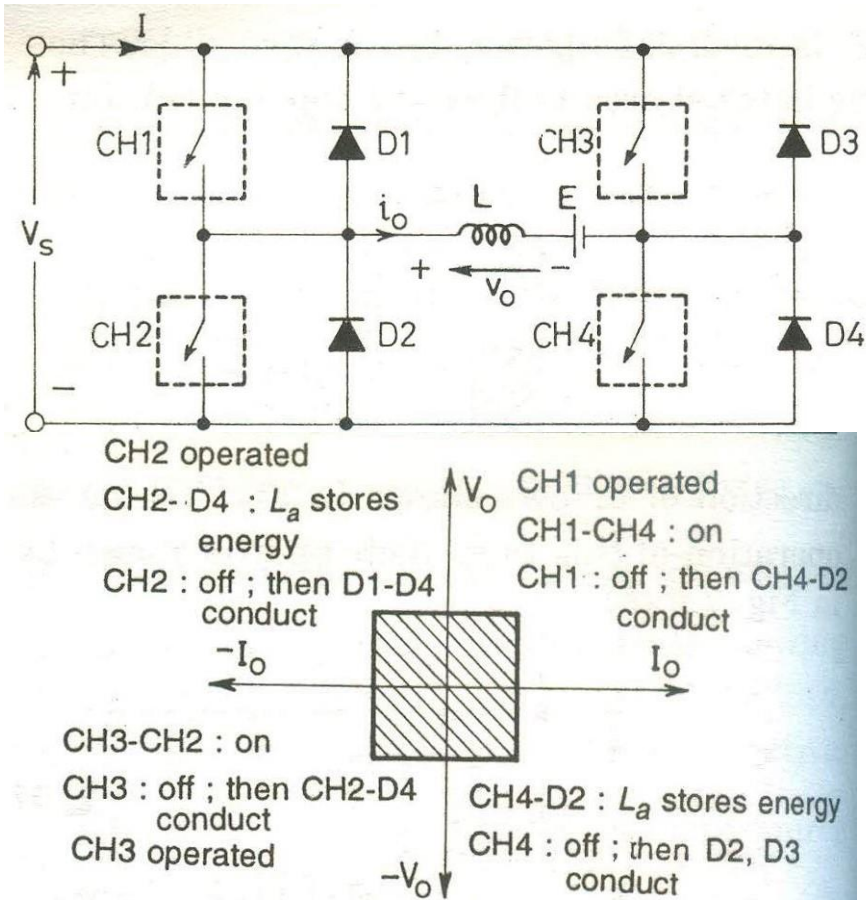
- V_s – D2- CH2- Load (L&E) forms Type B chopper
- V_O =0 when CH2 on and FD (freewheeling diode conducts)
- V_O=V_s when CH1 on and D2 conducts
- I_0 = positive when CH1 on and FD conducts
- I_0 = negative when CH2 on and D2 conducts
- **Type D chopper**



- Two quadrant chopper.
- Operates in first and fourth quadrants.
- When CH1 and CH2 are on, current flows through V_s $-CH1-load-CH2-V_S$
- Output voltage V_O=V_s is positive and I_O is positive
- When both choppers are off D1 & D2 conducts due to inductor in the load section. Output voltage is negative
- Current flows from load to source D1-V_s-D2-Load. I_O is positive

Type E chopper

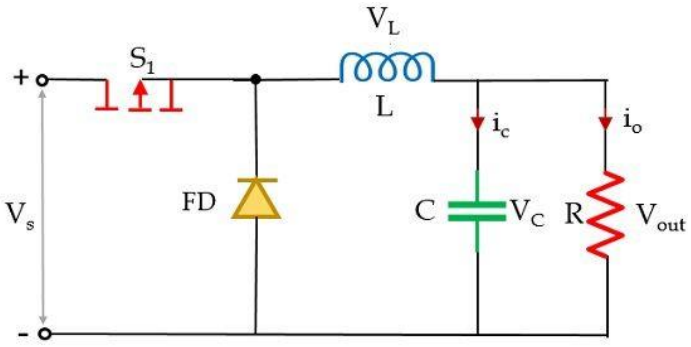
- The type E chopper is a four quadrant chopper.
- The type E chopper is parallel combination of two type C chopper.
- chopper CH1, chopper CH2, diode D1 and diode D2 makes one type C chopper
- chopper CH3, chopper CH4, diode D3 and diode D4 forms the other type C chopper.



Applications of chopper

- Switched mode power supplies, including DC to DC converters.
- Speed controllers for DC motors
- Driving brushless DC torque motors or stepper motors in actuators
- Class D electronic amplifiers
- Switched capacitor filters
- Variable-frequency drives
- D.C. voltage boosting
- Battery-operated electric cars
- Battery chargers
- Railway traction
- Lighting and lamp control

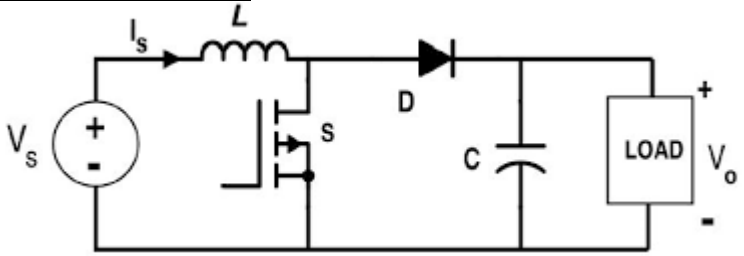
Buck converter



Buck Converter

- It is a dc to dc converter.
- o/p voltage is less than input voltage.
- Power mosfet or IGBT is used as the controller switch.
- 2 modes of operation.
    - **Mode:1(switch S1 is closed)**
    - ✓ Current flows through voltage source, s1,inductor L and load R
    - ✓ Power delivered to load
    - ✓ Inductor stores energy
    - ✓ This period is called ON time (Ton) of buck converter
    - **Mode :2 (switch S1 is open)**
    - ✓ Energy stored in L delivered to load
    - ✓ Continous current is obtained through freewheeling diode.
    - ✓ Capacitor smoothens the o/p current.
    - ✓ This period is called Off (Toff) time.

Boost Converter



- It is a dc to dc converter
- o/p voltage is less than input voltage.
- Vs is connected in series with inductor
- 2 modes of operation.
    - **Mode 1 (S is closed)**
    - Source is directly connected to inductor L
    - L offer zero resistance to current
    - Current flows through Vs- L-S-Vs
    - Inductor stores energy
    - This period of operation is called Ton time
    - **Mode 2 (S is open)**

- Diode forward biased
- Current flows through Vs-L-D-load-Vs
- Input voltage Vs and energy stored in L obtained across load as o/p voltage

Comparison of Buck and Boost converter

Sl.No	Buck converter	Boost converter
1	o/p voltage is less than i/p voltage	o/p voltage is higher than i/p voltage
2	Large filters are required	Small filters are required
3	Poor power factor correction	High power factor correction
4	Also called step down converter	Also called step up converter
5	The input current is discontinuous in nature	the input current is continuous in nature
6	Not suited for PV cells	Suited for PV cells
7	Used in self-regulating power supplies, advanced telecommunication and data communication systems	They are used in regulated power supplies, regenerative braking of DC motor and portable device applications

Cycloconverters

- Cycloconverters convert AC power of fixed frequency to AC power of variable frequency.
- It is an AC to AC converter without using dc link.

Types of cycloconverter

I. Based on output frequency
   - Step up cycloconverter (o/p frequency > i/p frequency)
   - Step down cycloconverter(o/p frequency < i/p frequency)

II. Based on no.of phases
   - 1ϕ to 1ϕ
   - 3ϕ to 3ϕ
   - 3ϕ to 1ϕ

Single phase step up cycloconverter

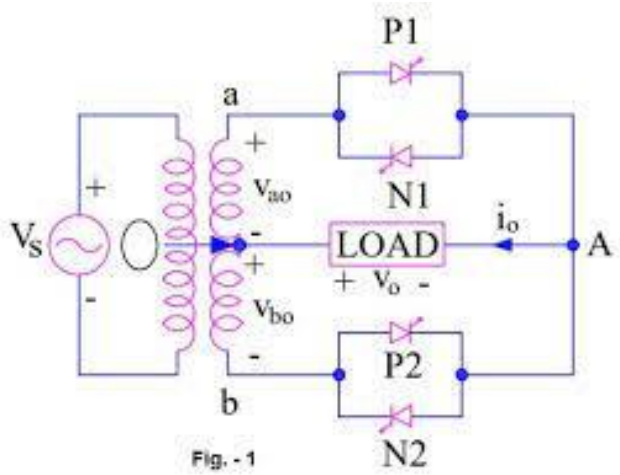


Fig. - 1

- During the positive half cycle, positive group thyristors P1 & N2 are forward biased for ωt = 0 to ωt = π.
- SCR P1 is fired to turn it.
- Load voltage is positive with terminal A positive and O negative.
- At ωt = ωt1, P1 is force commutated and the forward biased thyristor N2 is fired to turn it ON.
- During the period N2 conducts, the load voltage is negative because O is positive & this time.
- At ωt = ωt2, N2 is force commutated and P1 is turned ON.
- The load voltage is now positive.
- At ωt = π, terminal "b" is positive with respect to terminal "a"; both SCRs P2 & N1 are therefore forward biased from ωt = π to ωt = 2π.
- When P2 is turned on, the load voltage is positive
- To make the load voltage negative P2 is force commutated and N1 is triggered
- This process is repeated in the negative half cycle
- The frequency of output wave form is greater than input voltage and it is determined by proper switching of SCRs

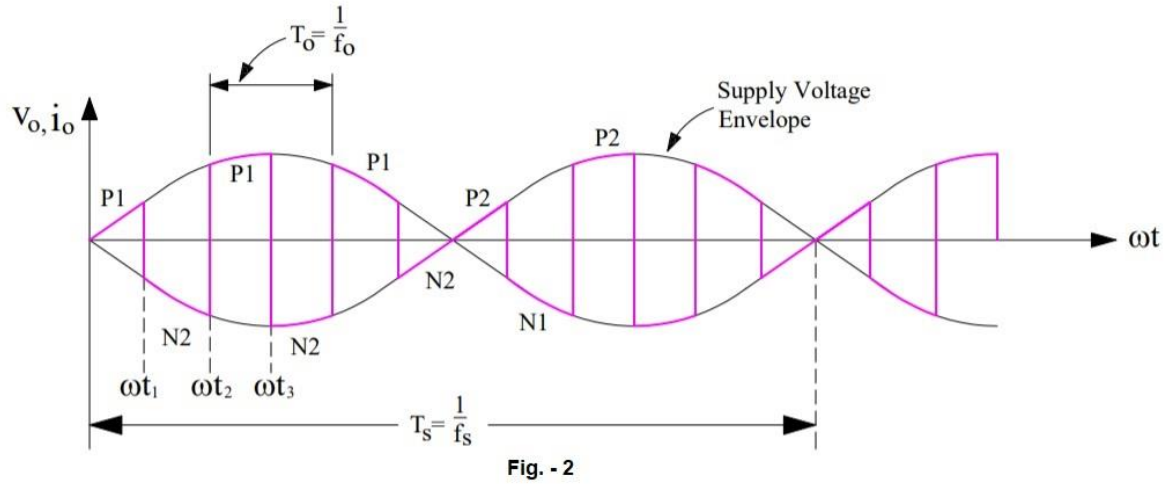


Fig. - 2