Introduction of Chopper

Many industrial applications require a variable DC voltage source; therefore it is necessary to convert fixed voltage into a variable voltage. This variable voltage can be obtained either from AC supply voltage or from a fixed DC voltage. A variable DC output voltage can be obtained either by an AC link choppers or as a DC chopper.

In AC link chopper, a fixed DC input is first converted into an AC by an inverter then the output of the inverter is stepped-up or stepped-down by a transformer which is then converted back by an uncontrolled rectifier. However in DC chopper direct DC-to-DC conversion is done. Thus, a chopper can be used as a stepped-down or stepped-up DC input voltage. If we compare both the choppers AC link & DC choppers, design of DC chopper is efficient, smaller in size, & low in cost because of the single stage conversion. Therefore, it is widely used in regulated Switched Mode Power Supplies.

Control Strategies:

As it is clear that, the average value of output voltage, E_o can be controlled by periodic opening & closing of the switches. The two ways of control strategies for operating the switches are employed in DC Choppers, they are:

1. Time-Ratio Control (TRC)
2. Current Limit Control

Time-Ratio Control (TRC):

In the Time-Ratio Control the value of T_{on}/T is varied which is affected in two ways. They are constant frequency and variable frequency operations.

Constant Frequency System: In this type of control strategy, the on time T_{on} is varied but the chopping frequency f is kept constant. This control strategy is also called 'Pulse Width Modulation Control'. The following figure shows the pulse width modulation. From figure it is clear that the chopping period T is constant. The output voltage E_o can be varied by varying the on time T_{on}.

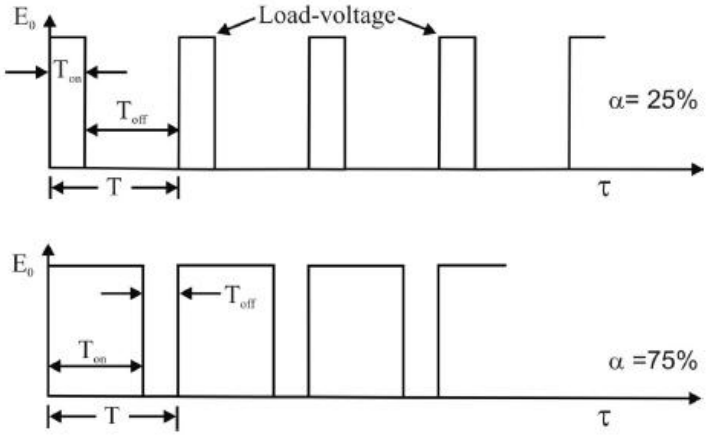

Figure 1

Variable Frequency System:

In this type of control strategy, the chopping frequency f is varied and either on time T_{on} is kept constant or off time T_{off} is kept constant. This type of control is also called as Frequency Modulation Control. The following figure shows the principle of frequency modulation. From the figure 2(a) it is clear that the chopping period T is varied but on-time T_{on} is kept constant. The output voltage waveforms are shown for two different duty cycles.

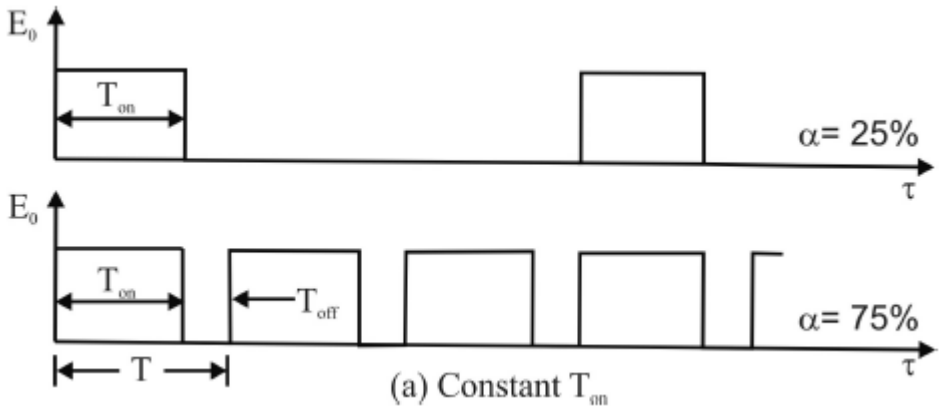

Figure 2 (a)

From the figure 2 (b) it is clear that the chopping period T is varied but on time T_{on} is kept constant.

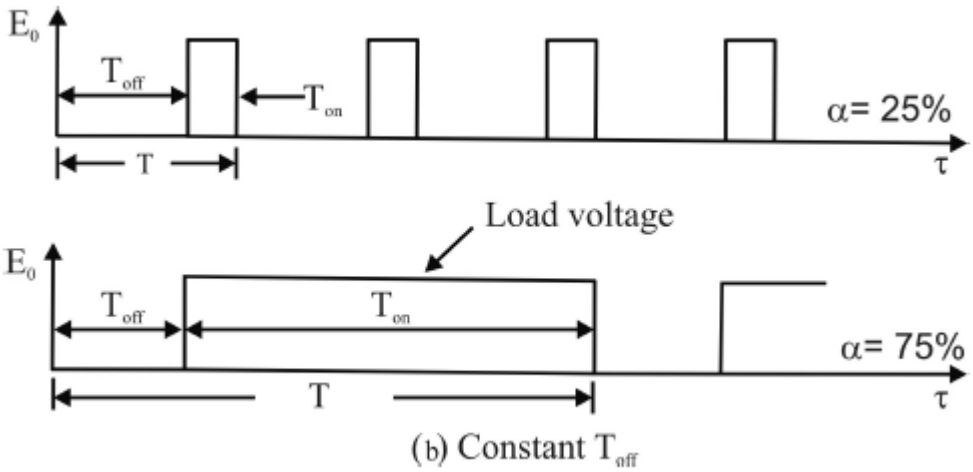

Figure 2 (b)

Frequency modulation control strategy has the following major disadvantages compared to Pulse- Width Modulation Control.

1. The chopping frequency has to be varied over a wide range for the control of output voltage. In Frequency Modulation, Filter design for such wide frequency variation is therefore quite difficult.

2. For the control of duty cycle, frequency variation would be wide. As, there is a possibility of interference with signaling & telephone lines in frequency modulation technique.
3. The large “off” time in Frequency Modulation technique may result in the discontinuities in the load current, which is undesirable.

Thus, the constant frequency system (PWM) is the preferred scheme for chopper drives.

Current Limit Control:

In current limit control strategy, the chopper is switched ‘On’ & ‘Off’ so that the current in the load is maintained between two limits. When the current exceeds the upper limit, the chopper is off. During off period, the load current falls & decreases exponential. When it reaches the lower limit, the chopper is switched ‘On’. Current limit control is possible either with constant frequency or with constant T_{on}. The current limit control is used only when the load has energy storage elements. The reference values are the load current or load voltage. The following figure shows the principle of current limit control.

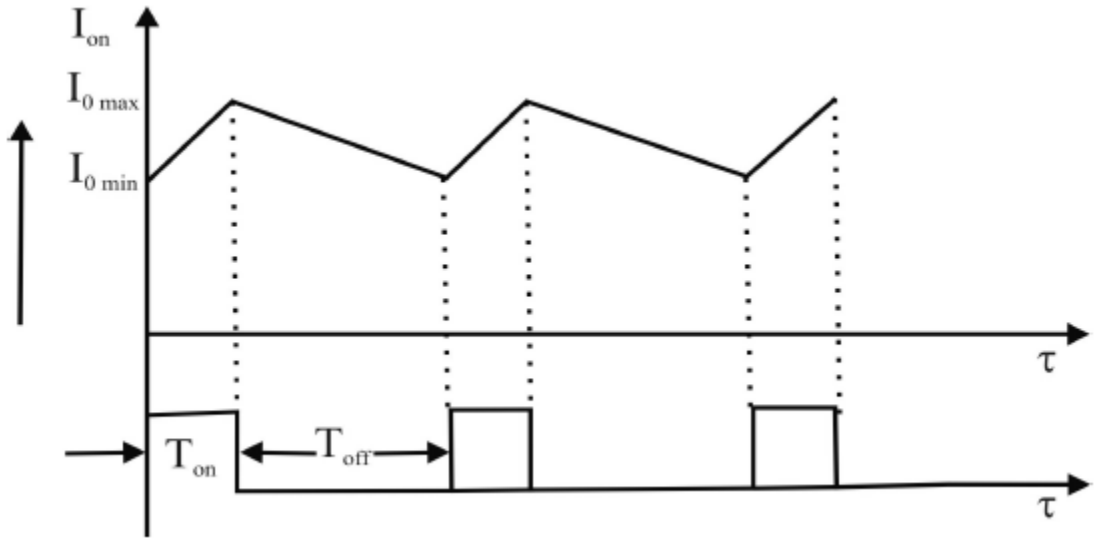

Figure 3

Since the chopper operates between prescribed current limits, discontinuity cannot occur. The difference between I_{omax} & I_{omin}, decides the switching frequency. The ripple in the load current can be reduced if the difference between the I_{omax} & I_{omin} limits is the largest. This in turn increases chopper frequency thereby increasing the switching losses.