CHAPTER 5

DC-DC CONVERTER

As the current trend is to go green research in automobile industry is on a focus to reduce pollution. In this regard fuel cells are gaining prominence and this technology is advancing day by day. This technology is a fine combination of mechatronics. As the automobile with a hydrogen fuel cell demands a higher voltage than that is generated by a fuel cell, the voltage from fuel cell has to be boosted for its vehicular applications. Thus different type of dc/dc converters is being designed. The challenge is to achieve a higher voltage with minimum DC input and minimum components. The current AC inverters are designed to get a less voltage DC source, for example the battery charger in a vehicle and providing a one twenty volts ac source moving at 60 Hz. This introduces generous amounts of sound into the circuits which is extremely disagreeable with audio set up. To solve the difficulty, an exact sinusoidal signal must be produced from the source of DC but this has a high cost associated with them. In an attempt to lower costs, a method of producing a sine wave by way of PWM and with a dc source are being implemented, One stipulation being that the supply potential be greater than the output voltage. This leads to a necessity for a dc/dc converter that is able to offer the inverter with an elevated voltage from a low voltage source that is adopted for fuel cell applications.

5.1 Advantages & Disadvantages of DC-DC Converters

A dc/dc converter is an electronic circuit and it is employed to modify DC electrical circuit from one potential difference stage to an added potential difference level. It is a voltage regulator that uses switches, inductor and capacitor for power conversion and is broadly used in steady switch-mode dc power supply application. DC-DC converter is used for the following three basic reasons

1) To simplify power supply systems.

2) To isolate primary and secondary circuit.

3) To match the loads to the power supply
Advantages of dc/dc converters:

- DC/DC converters provide a technique to extend potential from a partly reduced cell potential thus decreasing place as a replacement for using several batteries.
- DC/DC converters are now on hand as switches need nominal additional components. They are also obtainable as a whole hybrid circuit element, which can be used within an electronic assembly.
- Most of the dc/dc choppers regulate the V (voltage). But only some special cases incorporate more LED energy sources. A sort of dc/dc converter is a type that regulates simple charge pumps and current through the LEDs which increases the output voltage.
- DC/DC converters constructed to make best use of the energy yield for photovoltaic systems and for switch called rather than as power optimizers.
- An isolated dc/dc converter has more efficiency transformer on condition of the barrier. This barrier can bear up 100V to 1000V as it is requisite for medicinal approach.
- Output from isolated converter is organised to be negative or positive.
- The foremost inadequacy of the choppers is unsteady supply of V and I. But these troubles are solved from assorted control schemes employed by grouping of these choppers.

Disadvantage of dc/dc Converter:

Switching converters have complication, noise problem and to a more price, but this has let-down with further design of chip.

Depending upon the application the dc/dc converters are divided into different number of types. One classification is depending on the isolation between input and output circuits and those which do not have isolation. Also depending on power transfer i.e. energy flow from the supply side through magnetic to the output simultaneously or energy saved in the magnetic field to be let free next to load. Accordingly dc/dc converters are classified as

1) Isolated dc/dc converters
2) Non-isolated dc/dc converters

Advantage of isolated converter over non-isolated converter is it will have high frequency transformer providing a barrier by withstanding a hundred volts to some thousand volts. The choice of dc/dc converter depends on several factors such as
- Input Voltage and Output voltage (low, high, inverted etc)
- Output power (some converters are limited in power)
- Safety (Isolated or Non-isolated converter)
- Cost (depending on number of power devices)

5.2 Types of DC-DC Converters

Isolated type of dc/dc converter is chosen here. Types of isolated dc/dc converters are

1) Fly-back
2) Forward
3) Half-bridge
4) Full-bridge
5) Push-pull

1) Fly-back

Fly back is a buck boost chopper with isolated division to configure a transformer. With additional advantage of isolation, the voltage ratio is multiplied. It is used in both alternating to direct and direct to direct transfer with galvanic separation between output and input. The fly back circuit is as shown in Fig: 5.1. It can present single or multiple isolated output voltages and will activate above extensive scope of input voltage deviation. With regard to efficiency and energy, fly-back power supplies are substandard than several switched mode power supply circuits but it is easy technique and because of less rate makes it accepted in small output power range. Efficiency is typically 75% to 80% and Power rating is from 1 Watt to 50 Watts.

![Fig: 5.1 Fly back converter.](image)
Advantages:

- The main gain is the output filter inductors vital for all forward topologies which is not obligatory for fly back. This is because of the transformer in the fly back acts as an inductor and not as a transformer.
- In many situations an LC filter is added in load side of fly back regulator for condensing output voltage ripples.
- Voltage rating on secondary components is low

Disadvantages:

- More EMI since of the gap.
- More ripple current.
- More output and input capacitance.
- Higher losses
- Right half pole in compensation loop.

2) Forward

Fig: 5.2 Forward converter.

A forward converter as shown in Fig: 5.2 is a form of dc/dc converter similar to a fly back and HB converters it can deliver an output voltage whichever more or less in reference to input voltage and present electrical isolation. The single transistor forward converter is commonly used for off-line supplies in the power range below 200 W. Because of its simplicity and low component count makes it a viable alternative to the Fly back, whenever galvanic isolation is required. It is as well used to step up or step down the potential. The Forward is
usually a good choice when high output current is required. The transformer magnetizing I at the closing stages of every cycle must be reset to zero. These converters produce symmetrical ac waveforms across the first section winding of the transformer. Therefore, core flux is excited bidirectionally, follow-on a better employment of magnetic core and results in increased power rating.

Advantages:

- Better transformer utilization: Forward converter transfers energy instantly across the transformer and does not rely on energy storage. The resulting lower peak currents in primary as well as secondary means lower copper losses compared to fly back. The transformer can be made more ideal with much higher magnetizing inductance and no air gap.
- Filtered output: Energy storage is mainly in the output inductor and the output capacitor can be made fairly small with a much lower ripple current rating. The output inductor and freewheeling diode keeps the output current fairly constant and the secondary ripple current is dramatically reduced and its main purpose is to reduce output voltage ripple.
- Due to much larger magnetizing inductance lower active device peak current.

Disadvantages:

- Increased cost: the additional output electrical device and freewheeling diode is needed.
- Minimum load requirements: significantly with multiple outputs, the gain dramatically changes if device goes into DCM operation (at lightweight loads).
- Higher voltage demand for the MOSFET, which frequently discourages use in off-line applications that has got to work on 230V grids.

3. Half-bridge

This converter given in Fig: 5.3 is a sort of dc/dc converter like fly back and forward choppers, which can furnish an output voltage more or less compared to input voltage and provide electrical separation by means of a transformer. It is more composite than a fly back or forward types. The HB chopper design will give large output energy and it will make use of unit that are lesser and reduced pricey. The HB Control chopper has been newly used as a small output voltage conversion as a result of its excellent features where there efficiency is more or
less ninety percent at less output voltage. From this converter statics and dynamics characteristics can be achieved. Where the dc voltage transfer proportion takes place in both discontinuous and continuous conduction form, where the margin among both modes & level of current in the transformer can also be achieved.

![Half-bridge converter diagram]

**Fig: 5.3 Half-bridge converter.**

**Advantages:**

- Magnetic cores are small.
- No gap of magnetic path.
- Less stray magnetic field.

**Disadvantages:**

- They are functioning at 1/2 the supply potential where the switching transistors are operational two times the collector current as in comparison with the basic push-pull scheme.
- It is not suitable for current mode control.

4) Full-bridge

The FB can be adapted as an efficient converter known as the Zero Voltage Switching Phase shift converter where each side of the bridge is driven by essentially a square wave and the relative phase shift of the square waves is adjusted to control the transferred power. The FBZVS
is the most trendy dc/dc chopper due to low circulating reactive energy, moderate device stresses, ZVS operation, high efficiency and fixed switching frequency. By connecting in series a dc blocking capacitor and a storable inductor with primary winding, during the free-wheeling interval the current on the primary can be reduced to nil. The circuit diagram is as shown in Fig: 5.4.

Advantages:

- FB is used in application of high voltage requirement
- FB has slightly more voltage ripple than the half-bridge.
- FB uses four diodes, in its place of just clipping off half the wave, it changes the polarity of half wave.

Disadvantages:

- FB has an efficiency of 95% and the half-bridge an efficiency of 99% and therefore it is slightly more efficient than the full-bridge.
- FB electrical converter is analogous to the HB inverter, however it's an extra segment to attach the ground point to the load.
- FB would have larger losses and noise than the HB as a result of the FB having more switching elements.

5) Front-end
Active front end handle two power stages, it is used to lessen the total of harmonic disturbances reflected to power grid by insisting sine wave current from the power. Grade six pulse rectifier used in so many drives that can generate twenty to ninety percent distortion of current. The active rectifier in AFE (active front end) drives leads to neutralizing harmonics that in point of fact eliminates those, that are created in a grade six pulse drive. Several applications may have need of an immediate halt of the drive that gives up energy which is typically altered into heat by braking resistors. This surplus power can be fed back to the ac line like a ac current by means of ac to dc regenerative part universally named AFE. It is fully regenerative combination of a PWM (pulse width modulation) IGBT converter with a clean power filter. This provides a range of unique features.

Advantages:

- Active Front End rectifier is regenerative.
- It has energy saving, compact sizes and low heat release.
- It has sinusoidal line current.

Disadvantages:

- Active Front end drive is claimed to produce near sinusoidal output under all load.
- Very high switching frequency.
- High cost.

6) Push-pull

It is a converter circuit that uses push type and pull type device. Push-Pull is a term associated with two switches where each switch is connected to positive or negative leg of the dc power supply. Push-Pull is a dc/dc chopper that is very widespread by reason of more that is calculated by power lost at the terminals of push-pull device.

Features of Push pull converter-

- Push-pull converter grades in easy and compact gating requisite. It has merely two devices in the first section with supply to common ground.
- Push–pull converters make a reduced amount of sound on line at input, have steady input
I and are more □ in higher energy approaches.

- HF transformer separation with converter is favoured to acquire more steps up ratio and the galvanic separation between utility and modules.
- Voltage fed schemes, employs noticeably outsized electrolytic capacitor too curb the big input I ripple leading to large volume, more priced and concise duration of PV system.
- Current-fed schemes demonstrate subsequent advantages compared to voltage-fed topologies: 1) lesser input I ripple 2) minor turns-ratio of transformer 3) output capacitive filter 4) nil imbalance problem of flux.
- Current-fed chopper suffers from elevated peaks in voltage crossways the switches during switch off. Passive RCD snubber is employed to take up the spike in voltage owing to less efficiency. A non-dissipative snubber is planned to recycle the absorbed power, this amplifies the complexity.
- Active clamping is popularly used due to high efficiency and achieves ZVZCS of the devices at the same time
- To lessen the quantity of the transformer turns ratio and switches voltage doubler is chosen.

Advantages:

- To drive MOSFETs push pull does not necessitate an isolated power supply
- Peak current sensing is required so that core does not drift into saturation.
- Push-Pull is used for far-away access latch release cables and security break cables.
- 7V nineteen cables are extremely flexible making them ideal for pull assemblies.
- Push pull converter is of low cost.
- Transformer rating required is smaller than the forward converter.

Disadvantages:

- Push pull uses two switches which are not widely used in flux walking phenomena.
- Central tap transformer is used is one of the main disadvantages.