EE3014 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

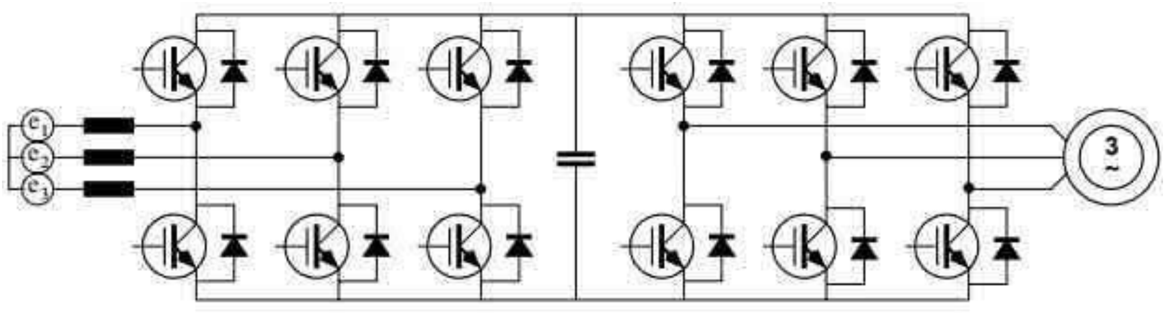
UNIT IV-POWERCONVERTERS FOR WIND SYSTEMS

4.2-AC-DC-AC CONVERTERS: UNCONTROLLED RECTIFIERS, PWM INVERTERS, GRID-INTERACTIVE INVERTERS - MATRIX CONVERTER

THREE PHASE AC-DC-AC CONVERTERS (THE BACK-TO-BACKCONVERTER)

The back-to-back converter is consists simply of a force-commutated rectifier and a force-commutated inverter connected with a common dc-link shown in figure. The properties of this combination are well known; the line-side converter may be operated to give sinusoidal line currents, for sinusoidal currents, the dc-link voltage must be higher than the peak main voltage, the dc-link voltage is regulated by controlling the power flow to the ac grid and, finally, the inverter operates on the boosted dc-link, making it possible to increase the output power of a connected machine over its rated power. Another advantage in certain applications is that braking energy can be fed back to the power grid instead of just wasting it in a braking resistor.

An important property of the back-to-back converter is the possibility of fast control of the power flow. By controlling the power flow to the grid, the dc-link voltage can be held constant. The presence of a fast control loop for the dc-link voltage makes it possible to reduce the size of the dc-link capacitor, without affecting inverter performance. In fact, the capacitor can be made small enough to be implemented with plastic film capacitors.



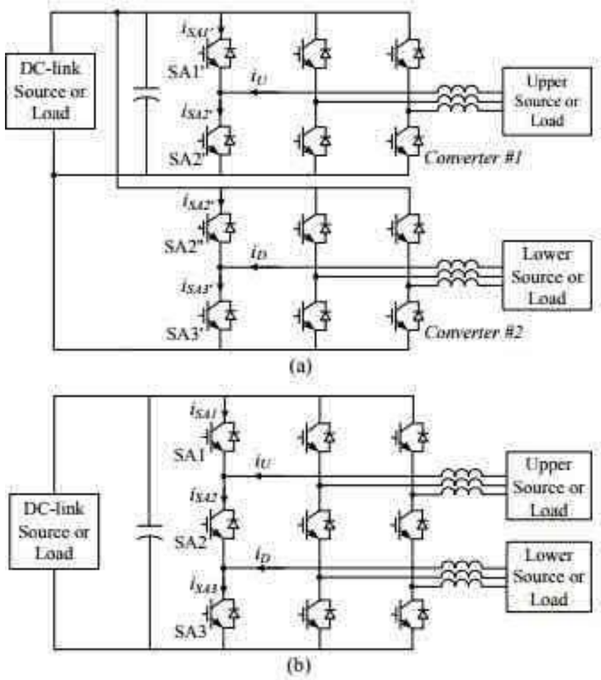
Back-to-back converter

Issues associated with a small DC-link capacitor

Smallest size of the dc-link capacitor is governed by the need to keep the switch-frequent ripple at acceptable (i.e. small) levels. Fluctuations in the load cannot be smoothed in the converter, but must be accommodated by other means. One alternative is to simply transfer such fluctuations to the power grid, but this may re-introduce the line-current harmonics the back to back converter is supposed to eliminate. However, load fluctuations will be random and thus relatively harmless compared to the in-phase harmonics generated by diode rectifiers. Another alternative is to use the load itself. In a typical drive, the mechanical energy stored in the drive is several orders of magnitude larger than the electrical energy stored in the DC-link capacitor in a back-to-back converter. If the application does not need servo-class performance, there is noreason why the rotational speed cannot be allowed to fluctuate slightly.

Application criteria for three-phase nine-switch converters

The nine-switch topology is derived from two converters connected back-to-back (BTB) shown in figure. Two phase legs from converter 1 and 2, respectively, are merged together to compose one phase leg of the nine switch converter, and meanwhile one switch is dismissed. Thus nine-switch converters have only three phase legs and each of them has only three switches.

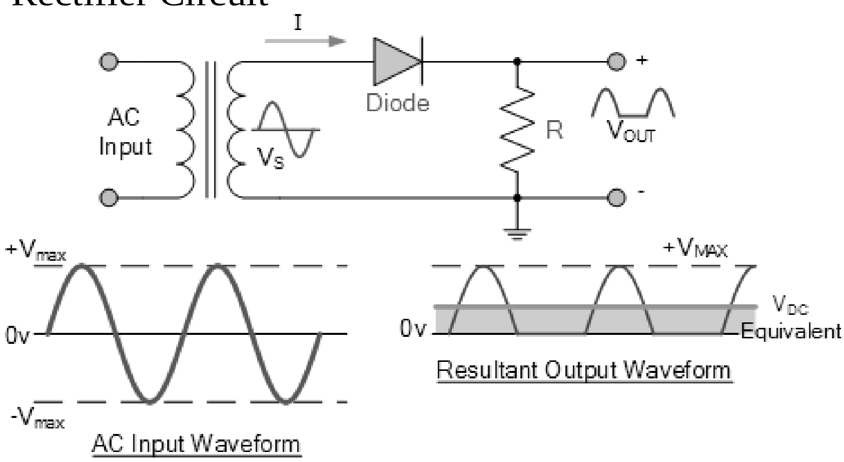


Nine-switch power converters

With such a topology, nine-switch converters retain the DC-link and can achieve all the functions of twelve-switch BTB even with three switches less.

UNCONTROLLED RECTIFIERS

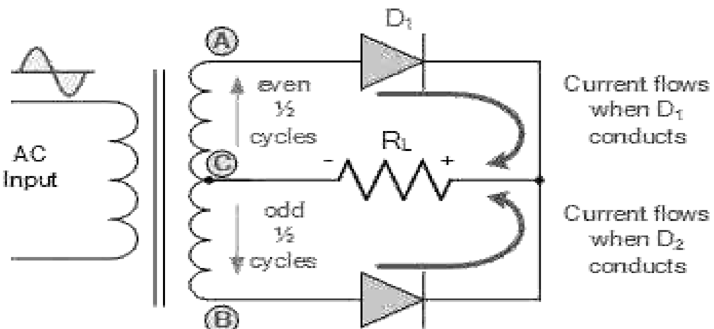
Half Wave Rectifier Circuit

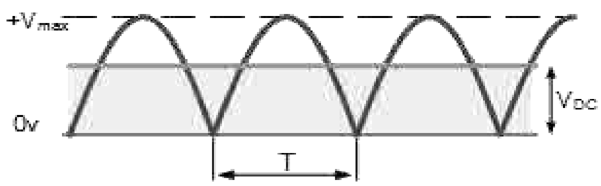


A rectifier is a circuit which converts the *Alternating Current* (AC) input power intoa *Direct Current* (DC) output power. The input power supply may be either a single-phase or a multi-phase supply with the simplest of all the rectifier circuits being that of the **Half Wave Rectifier.** The power diode in a half wave rectifier circuit passes just one half of each complete sine wave of the AC supply in order to convert it into a DC supply. Then this type of circuit is called a –half-wave‖ rectifier because it passes only half of the incoming AC power supply as shown below. During each –positive‖ half cycle of the AC sine wave, the diode is *forward biased* as the anode is positive with respect to the cathode resulting in current flowing through the diode. During each –negative‖ half cycle of the AC sinusoidal input waveform, the diode is *reverse biased* as the anode is negative with respect to the cathode.

Full Wave Rectifier Circuit

Like the half wave circuit, a full wave rectifier circuit produces an output voltage or current which is purely DC or has some specified DC component. Full wave rectifiers have some fundamental advantages over their half wave rectifier counterparts. The average (DC) output voltage is higher than for half wave, the output of the full wave rectifier has much less ripple than that of the half wave rectifier producing a smoother output waveform. In a **Full Wave Rectifier** circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection.



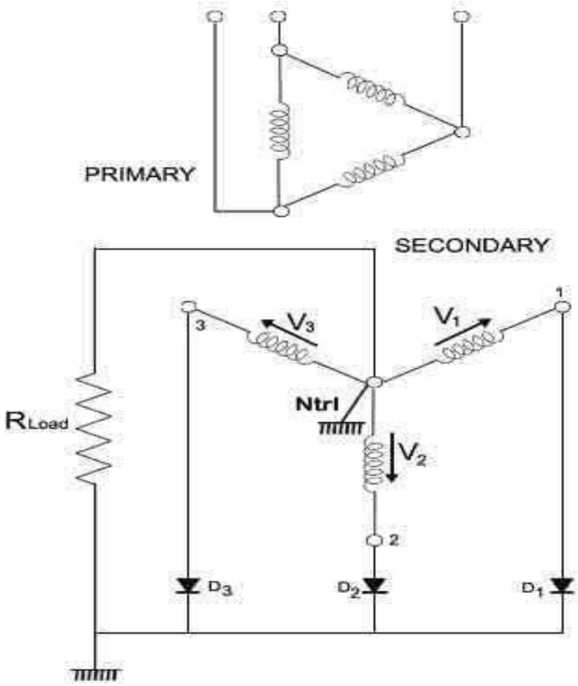


Resultant Output Waveform

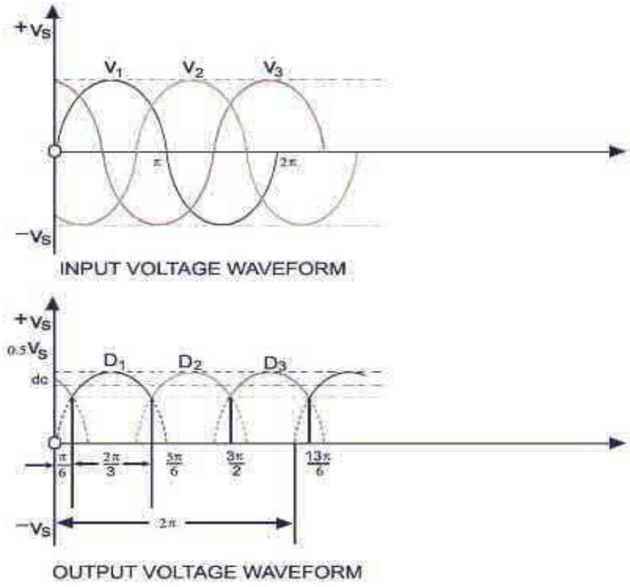
This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer centre point C producing an output during both half- cycles, twice that for the half wave rectifier so it is 100% efficient as shown below. The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformeris positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows. When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a ―bi- phase‖ circuit.

Three phase Half Wave Rectifier

A three phase half wave rectifier, as the name implies, consists of a three phasetransformer. Given below is a star connected secondary three phase transformer with threediodes connected to the three phases as shown in the figure. The neutral point ‗NTRL' of thesecondary is considered as the earth for the circuit and is given as the negative terminal for the load.

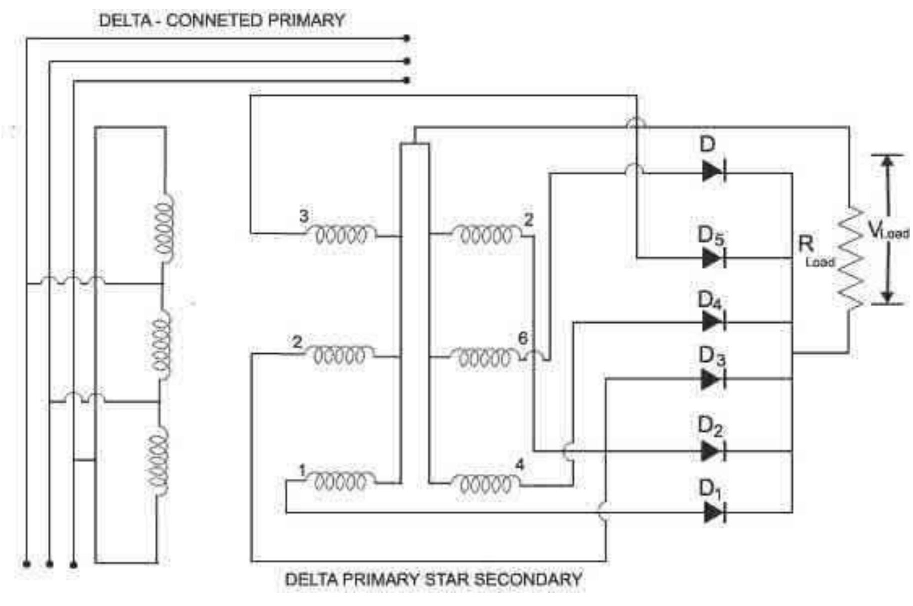


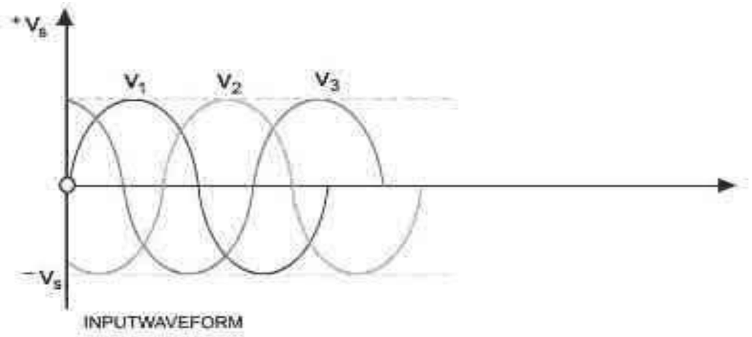
The input and the output wave forms for the circuit above is shown below. For each one- third of the cycle, each diode conducts. At the instant when one diode out of three is conducting, the other two are left inactive, at that instant their cathodes becomes positive with respect to the anodes. This process repeats for each of the three diodes.

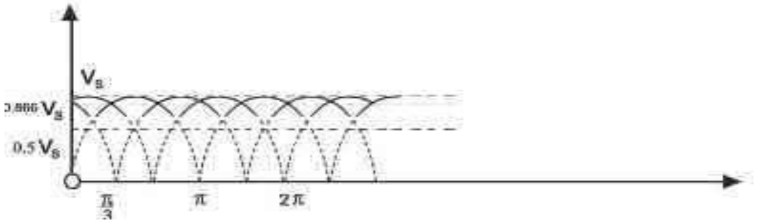


Three Phase Full Wave Rectifier

A three phase full wave rectifier can also be called a six wave half wave rectifier asshown in the figure. The diodes D_1 to D_6 will conduct only for $1/6^{th}$ of the period, with a periodof $\pi/3$. As shown in the output wave form, the fluctuation of dc voltage is less in a three phasecircuit. The variation lies between the maximum alternation voltage and 86.6% of this, with the average value being 0.955 times the maximum value.




+Vs
V1
V2
V3
-Vs
INPUTWAVEFORM


Vs
0.866 Vs
0.5 Vs
π/3
π
2π