Performance Improved Topology of Front End Converters

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Abstract— This paper contains a basic topology of static rectifier like diode rectifier, phase controlled rectifier, chopper based rectifier, multipulse rectifier & pulse width modulated rectifier to overcome problems like poor power factor, higher distortion in input current & ripple in output voltage is more. The simulation of all rectifier is carried with medium voltage application.

Key words: Improved Quality Converters, Pulse Width Modulation (PWM), AC/DC Boost Converters, Total Harmonic Distortion (THD)

I. INTRODUCTION

AC/DC power converters are extensively used in various applications like power supplies, dc motor drives, and front-end converters in adjustable-speed ac drives, HVDC transmission, SMPS, utility interface with non-conventional energy sources, in process technology like welding, power supplies for telecommunications systems, and aerospace, military environment and so on. Traditionally, ac–dc power conversion has been dominated by diode or phase-controlled rectifiers which act as non-linear loads on the power systems and draw input currents which are rich in harmonics and have poor supply power factor, thus creating the power quality problem for the power distribution network and for other electrical systems in the vicinity of rectifier. The other associated problems with these converters include:

- Large reactive power drawn by the rectifiers from the power system which requires that the distribution equipment handle large power, thus increasing its volt-ampere ratings;
- Voltage drops at the buses;
- Higher input current harmonics resulting in the distorted line current which tends to distort the line voltage waveform. This often creates problems in the reliable operation of sensitive equipment operating on the same bus;
- increased losses in the equipment's (due to harmonics) such as transformers and motors connected to the utility;
- electromagnetic interference with the nearby communications circuits;
- blown-fuses on power factor correction capacitors due to high voltages and currents from resonance with line impedance and capacitor bank failures;
- Damaging dielectric heating in cables and so on.

Thus the reliable operation of a power system is greatly influenced by the widespread use of ac/dc converters in different applications. In view of this, regulatory agencies have issued several strict standards such as IEEE-519, IEC-1000, and IEC 61000-3-2, etc. and are being enforced on the consumers.

IEEE-519-1992 Recommended Practices and Requirements for Harmonic control in Electrical Power Systems provide guidelines for determining what the acceptable limits are. To meet these standards and improve the power quality, use of passive filters, active filters and hybrid filters has been made along with conventional rectifiers, especially in high power rating and already existing installations. The fixed compensation, bulkiness of the components, series and parallel resonance phenomena in passive filters and large rating and complexity of active power filters are the greatest drawbacks with these compensation techniques. To overcome these drawbacks, power quality improvement ac/dc converters are included as an inherent part of the ac–dc conversion system which produces higher efficiency, reduced size, and well regulated dc output. The output voltage in these converters is regulated even under the fluctuations of the input voltage and changes in the load. Since the converter output voltage remains constant even under the supply voltage fluctuations, the power quality improvement converters can solve the supply brownout problem. This new breed of rectifiers has been made possible mainly because of the use of modern solid-state, self-commutating power semi-conducting devices such as power MOSFETs, IGBTs, GTOs, etc. and are specifically known as switched mode rectifiers (SMRs), power factor correction converters (PFCs), high power factor converters (HPFCs) and PWM rectifiers. The single-phase power quality improvement converters are already in common practice and the industrial applications of three-phase converters have also emerged. It can be said that for medium to high power applications, the input rectifier is fed from a three-phase ac source.

II. TYPE OF CONVERTERS

These converters are classified as follows ways:

- Diode Rectifier
- Phase Controlled Rectifier
- Chopper Based Rectifier
- Multipulse Rectifier
- PWM Rectifier

A. Diode Rectifier

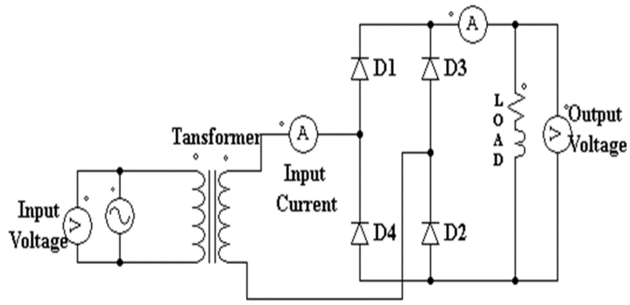

Fig. 1: Diode rectifier

During the positive half-cycle of the input voltage, the power is supplied to the load through diodes D1 and D2.During the negative cycle of the input voltage, diodes D3 and D4 conduct.

B. Phase Controlled Rectifier

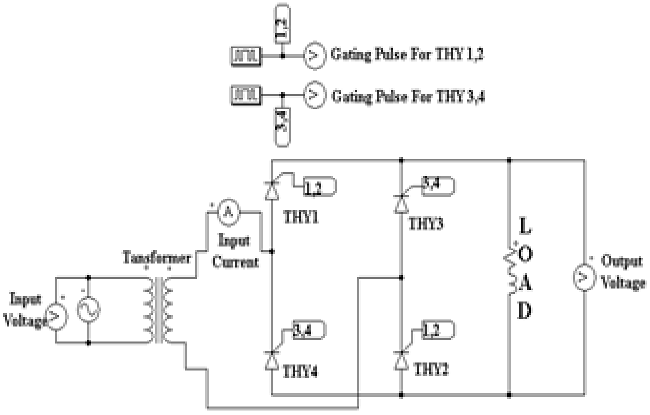

Fig. 2: Phase Controlled Rectifier

During the positive half-cycle, Thyristor T1 and T2 are forward biased and when these Thyristor are fired simultaneously after delay angle the load is connected to the input supply through T1 and T2.Due to the inductive load, Thyristor T1 and T2 continue to conduct beyond the next cycle start, even though the input voltage is already negative. During the negative half-cycle of the input voltage, Thyristor T3 and T4 are forward biased and firing of Thyristor T3, and T4 applies the supply voltage across Thyristor T1 and T2 as reverse blocking voltage.

C. Chopper Based Rectifier

Boost Chopper converter consists of a diode rectifier cascaded with a PWM boost chopper, as shown in Fig.3 for a single-phase supply.

The boost chopper has essentially two functions:

1) It controls the line current to be sinusoidal at unity power factor.
2) It regulates the capacitor voltage Vd, which should always be higher than the peak line voltage

In this circuit, for the operation in the positive half-cycle of supply voltage, considering a small time segment when can be represented by a dc voltage then at the time when IGBT is turned on, the current will flow in diode through the boost inductor.

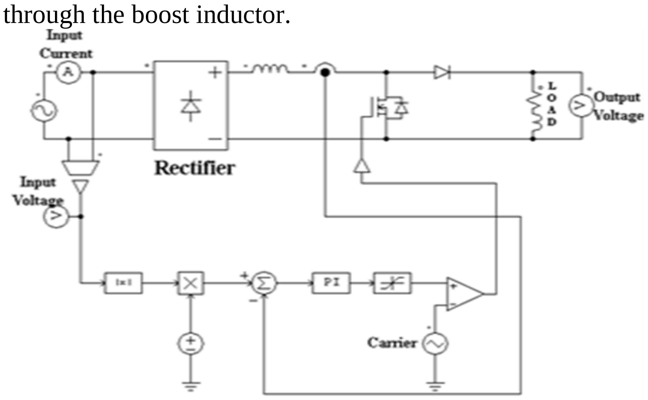

Fig. 3: Chopper Based Rectifier

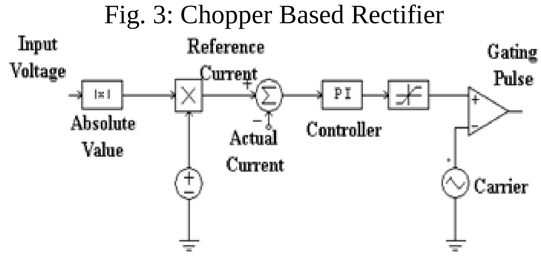

Fig. 4: Single-phase diode rectifier with boost chopper

The control block diagram of control circuit is shown in Fig.4 the Absolute Value of Input current is find & multiply with fixed Direct Current. Then that will be a reference current & that will compared with actual current & error is generated. The error is given to controller. Several types of controller are available & here P-I Controller will be used for controller & that output of P-I is given to Comparator in which it will compared with Carrier wave. That will generate a gating pulse for IGBT.

D. Multipulse Rectifier

The 3 phase rectifier have an more advantage of that it will be connected with different combination like 6-pulse,12-pulse,18-pulse & 24-pulse by connecting them in different configuration get more reduction in DC O/P & also an improvement in power factor.

1) 6-Pulse Rectifier

The Fig.5 shows a diagram for a 6-pulse converter. Here in this for an each phase 2 pulse & in final o/p DC will have a 6-pulse.here for this pulse converter the diode bridge rectifier will be used & also an controlled devices also be used for a pulse converter. So from this arrangement there will be less ripple in o/p & smooth current at source side.

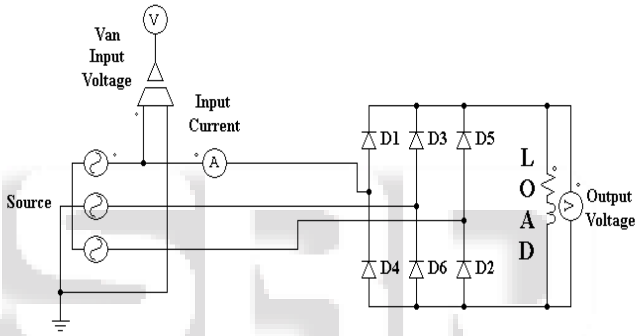

Fig. 5: six-pulse converter

2) 12-pulse converter

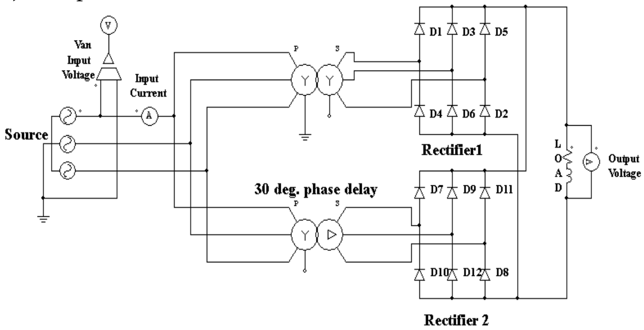

Fig. 6: Twelve -Pulse Converer

The Fig.6 shows a diagram for a 12-pulse converter. Here in this converter combine two 6-pulse converter & by adding the o/p of both 6-pulse converter with some phase delay, in o/p 12-pulse.The source current is more smoother compared to six pulse converter.

3) PWM Rectifier

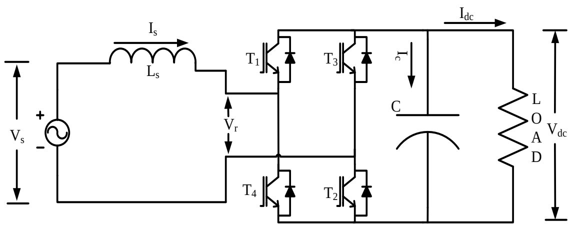

Fig. 7: PWM Rectifier

As shown in Figure7 the rectifier consists of 4 IGBT transistors, which form a full bridge, the input inductance and the capacitor at the output. It is controlled by pulse width modulation.

There are basically three mode for operation of rectifier shown as follows:

1) Switch T1 and T2 are in ON state and T3 and T4 and are in OFF state, Fig.8 (a).
2) Switch T3 and T4 are in ON state and T1 and T2 and are in OFF state, Fig.8 (b).
3) Switch T1 and T3 are in ON state and T2 and T4 are in OFF state or Switch T1 and T3 are in OFF state and T2 and T4 are in ON state, Fig.8(c).

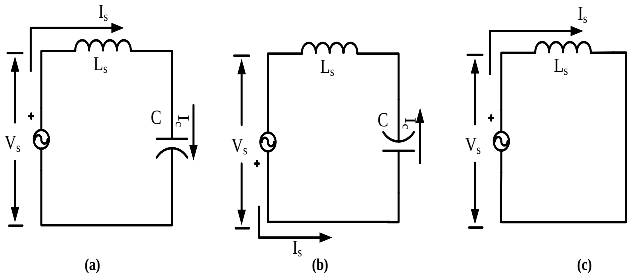

Fig. 8: Equivalent circuit for different switching

III. SIMULATION RESULT & COMPARISON OF PERFORMANCE PARAMETERS

A. *Diode Rectifier*

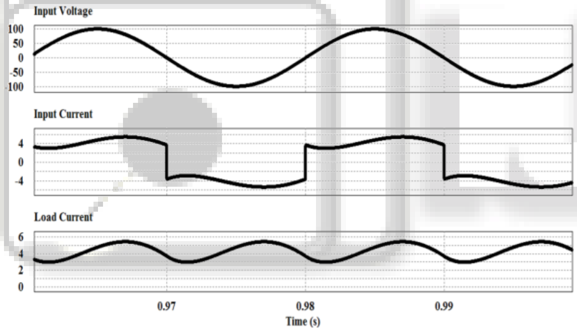

Fig. 9: Result of diode rectifier

B. *Phase Controlled Rectifier*

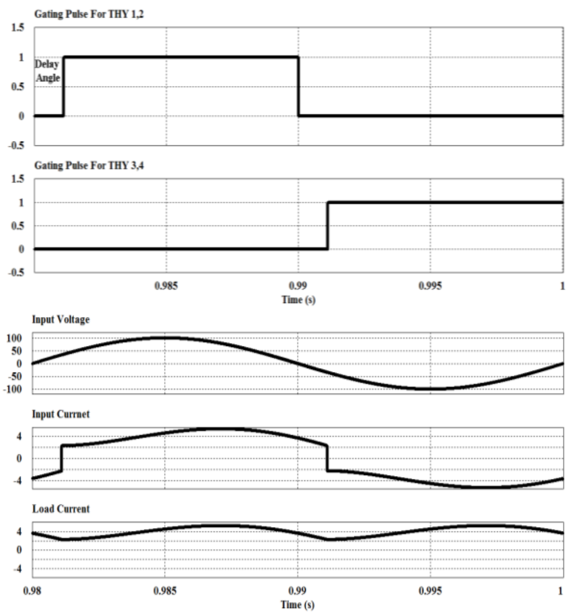

Fig. 10: Result of phase controlled rectifier

C. *Chopper Based Rectifier*

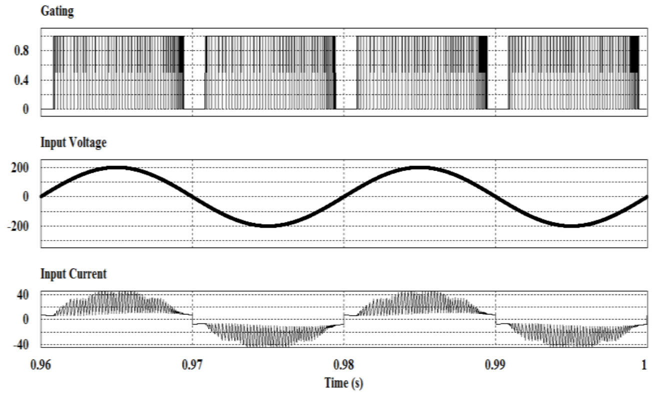

Fig. 11: Result of chopper based rectifier

D. *Multipulse Rectifier*

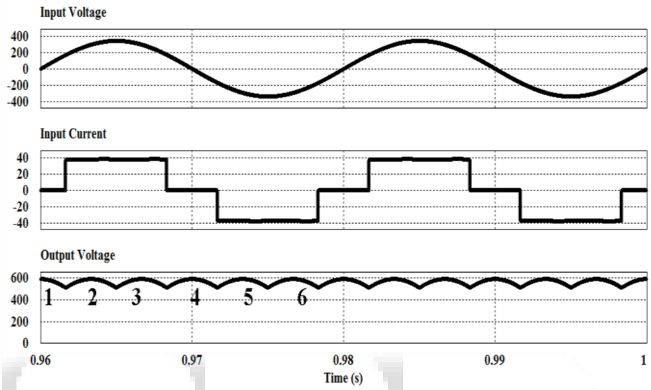

Fig. 12: Result of six-pulse rectifier

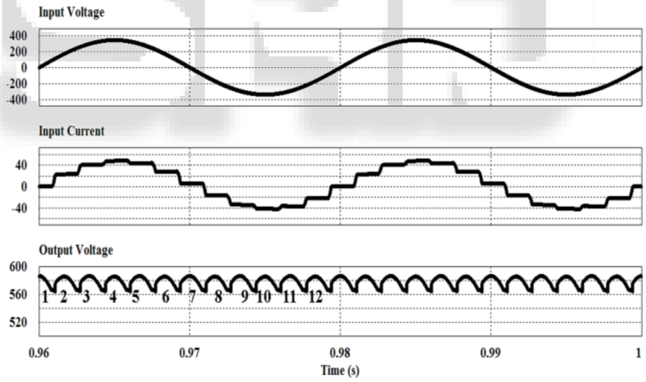

Fig. 13.result of twelve pulse rectifier

E. *PWM Rectifier*

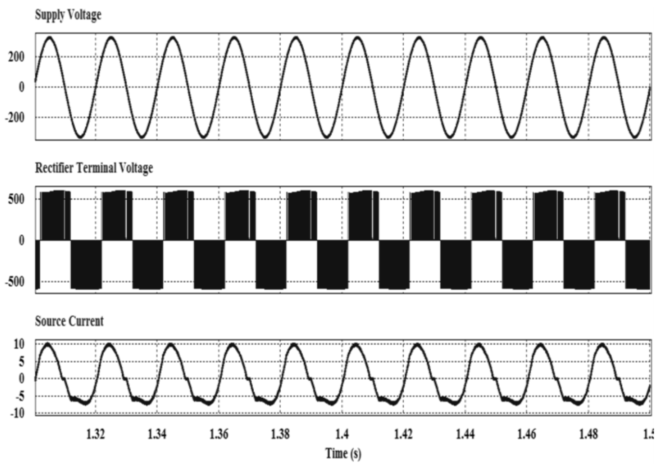

Fig. 14.result of PWM rectifier

F. Source Currnet Comparision

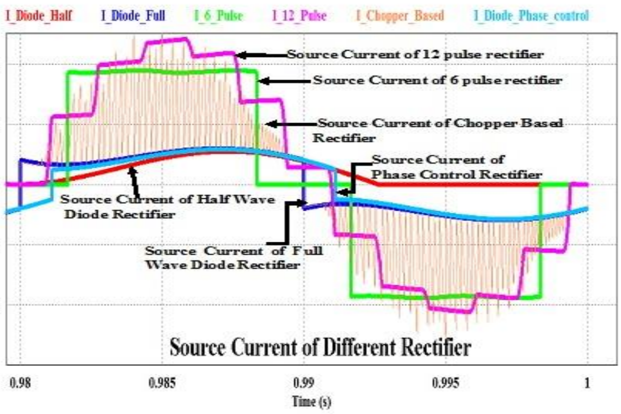

Fig. 15: Source current of different rectifier

G. Performance Comparision

Type of Rectifier	Max. Used rating	Semiconductor Device for conversion	Technical Parameters		
			Input PF	Input Current THD	Conversion Efficiency
Single Phase	Used in smaller equipment upto 10 kVA	Thyristor	0.5	80%	75%
		MOSFET / IGBT	0.95	<10%	94 TO 95%
Three Phase 6 pulse Rectifier	Used in UPS upto 300-400 kVA	Thyristor	0.85 to 0.93	30 to 50%	96 to 98%
Three Phase 12 pulse Rectifier	Used in UPSs above 200 kVA	Thyristor	0.9 to 0.96	10 to 15%	97%
PWM Rectifier	Upto 250 kVA	IGBT	0.98 to 0.99	<3 to 5%	96%

Fig. 16: Performance comparision

IV. SELECTION CONSIDERATIONS

A. For Specific Applications

Selection of converters for a particular application is an important decision for application engineers. The following are a few factors responsible for selection of right converter configuration for specific applications:

- required level of power quality in input (permitted PF, CF, THD);
- Type of output dc voltage (constant, variable, etc.);
- power flow (unidirectional and bidirectional);
- number of quadrants (one, two, or four);
- nature of dc output (isolated, non-isolated);
- requirement of dc output (buck, boost, and buck–boost);
- required level of power quality in dc output (voltage ripple, voltage regulation, sag and swell);
- Type of dc loads (linear, nonlinear, etc.);
- cost;
- size;
- weight;
- efficiency;
- Noise level (EMI, RFI, etc.);
- Rating (W, kW, MW, etc.);
- reliability;
- number of dc outputs;
- Environment (ambient temperature, altitude, pollution level, humidity, types of cooling, etc.).

Moreover, these are only a few factors. There are some other considerations such as comparative features of other options of power quality improvement, types of device, magnetic components, protection, etc., in the selection of best converter for a specific application.

V. CONCLUSION

This paper includes a basic static rectifier arrangement like controlled rectifier & uncontrolled rectifier. The uncontrolled rectifier will contains diode as conduction devices & controlled will consist of THYRISTOR, IGBT, MOSFET & GTO etc. from thyristor & transistor family as a conduction switch. The PWM rectifier will provide a best performance for unidirectional & bi-directional application.

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