A Review on Power Switching and Converter

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***Abstract:** In this paper Power electronic converters are switch-mode circuits that process power between two electrical systems using power semiconductor switches. The electrical systems can be either DC or AC. Therefore, there are four possible types of converters; namely DC/DC, DC to AC, AC to DC, and AC to AC.*

***Index Terms:** Converter, DIODE, MOSFET and THYRISTOR*

I. INTRODUCTION

An Few Electronic switches capable of handling high voltage and current operations at high frequency (HF) are the most important devices needed in the design of energy conversion systems that use PE. For the purposes of this discussion we will define the concept of an ideal switch. An ideal power electronic switch can be represented as a three terminals device as shown in Fig. 1.1. The input, the output, and a control terminal that imposes ON/OFF conditions on the switch. A switch is considered ‘‘ideal’’ when it is open, it has zero-current through it and can handle infinite voltage. When the switch is closed it has zero-voltage across it and can carry infinite current. Also, an ideal switch changes condition instantly, which means that it takes zero-time to switch from ON-to-OFF or OFF-to-ON. Additional characteristics of an ideal switch include that it exhibits zero-power dissipation, carries bidirectional current, and can support bidirectional voltage. If we plot the switch current (i) with respect to its voltage (v) we define four quadrants that are often referred to as the v-i plane and are shown in Fig. 1.1. By definition, an ideal switch can operate in all four quadrants.

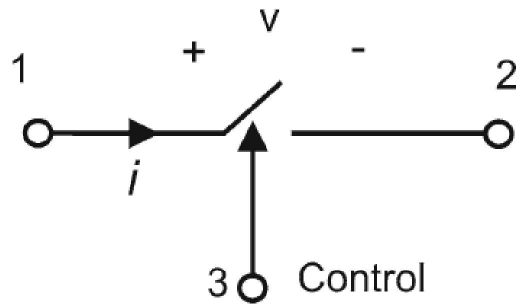

Fig 1.1(a): Ideal Switch

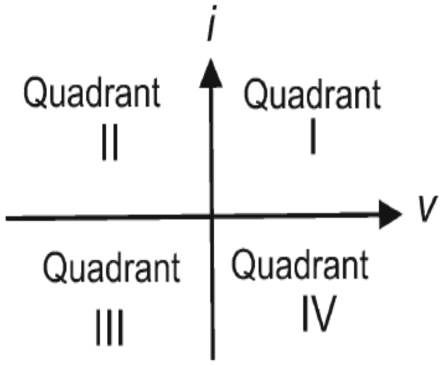

Figure 1. 1: 4-Quadrant Switch V-I Characteristics

Practical or real switches do have their limitations in all of the characteristics explained in an ideal switch. For example, when a switch is on, it has some voltage across it, known as the on-voltage and it carries a finite current. During the off stage, it may carry a small current known as the leakage current while supporting a finite voltage. The switching from ON-to-OFF and vice versa does not happen instantaneously. Of course, all actual switching devices take times to switch and we define these characteristics as the delay, rise, storage, and fall times. As a consequence of the above two non-ideal cases, there is voltage and current across the switch at all times, which will result in two types of losses. The first loss occurs during the on and off-states and is defined as the ‘‘conduction loss’’. The second loss is defined as the ‘‘switching loss’’ which occurs just as the switch changes state as either opening or closing. The switch losses result in raising the overall switch temperature. Further, the ON/OFF-state of the power switch must be controlled though an external signal.

II. POWER ELECTRONIC CONVERTER

On Power electronic converters are switch-mode circuits that process power between two electrical systems using power semiconductor switches. The electrical systems can be either DC or AC. Therefore, there are four possible types of converters; namely DC/DC, DC to AC, AC to DC, and AC to AC. The four converter types are described below:

DC to DC Converter: is also known as ‘‘Switching Regulator’’. The circuit will change the level voltage available from a DC source such as a battery, solar cell, or a fuel cell to another DC level, either to supply a DC load or to be used as an intermediate voltage for an adjacent power electronic conversion such as a DC to AC converter. DC to DC converters coupled together with AC/DC converters enable the use of high voltage DC (HVDC) transmission which has been adopted in transmission lines throughout the world.

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DC to AC Converter: Also described as ‘‘Inverter’’ is a circuit that converts a DC source into a sinusoidal AC voltage to supply AC loads, control AC motors, or even connect DC devices that are connected to the grid. Similar to a DC to DC converter, the input to an inverter can be a stiff source such as battery, solar cell, or fuel cell or can be from an intermediate DC link that can be supplied from an AC source.

AC to DC Converter: This type of converter is also known as ‘‘Rectifier’’. Usually the AC input to the circuit is a sinusoidal voltage source that operates at 120 V, 60 Hz or a 230 V, 50 Hz, which are used for power distribution applications. The AC voltage is rectified into a unidirectional DC voltage, which can be used directly to supply power to a DC resistive load or control a DC motor. In some applications the DC voltage is subjected to further conversion using a DC to DC or DC to AC converter. A rectifier is typically used as a front-end circuit in many power system applications. If not applied correctly, rectifiers can cause harmonics and low power factor when they are connected to the power grid.

AC/AC Converter: This circuit is more complicated than the previous converters because AC conversion requires change of voltage, frequency, and bipolar voltage blocking capabilities, which usually requires complex device topologies. Converters that have the same fundamental input and output frequencies are called ‘‘AC controllers’’. The conversion is from a fixed voltage fixed frequency (FVFF) to a variable voltage fixed frequency (VVFF). Applications include: light dimmers and control of single-phase AC motors that are typically used in home appliances. When both voltage and frequency are changed, the circuits are called ‘‘Cycloconverters’’, which convert a FVFF to variable voltage variable frequency (VVVF) and when fully controlled switches are used, this class of circuit is called ‘‘Matrix Converter’’. Another way of achieving AC to AC conversion is by using AC to DC and DC to AC through an intermediate DC link. This type of combined converter approach can be complex as the correct control approach must be implemented including simultaneous regulation of the DC link, injection of power with a prescribed power factor and bidirectional control of energy flow.

III. LITERATURE REVIEW

1. Aa **Hemant Kumar et. al. [2018]** In this paper, the modeling and implements of a three phase full wave controlled rectifier has been modeled on MATLAB SIMULINK software version 7.10.0.449[R2010a]. It is also deals with the simulation analysis of three phase full wave controlled rectifier by obtaining various waveforms. For large power dc loads, three phase ac to dc converters are commonly used. Three phase half wave converter is rarely used because it introduces dc component in the supply current. Some years back ac to dc power conversion was achieved using motor generator sets, mercury arc rectifiers, and thyratorn tubes. The modern ac to dc power converters are designed using high power, high current thyristors and presently most of the ac-dc power converters are thyristorised power converters. This paper also presents that how a full wave controller works for different firing angles at a given time and waveforms were obtain for verification. implementation in Simulation model for three phase full wave rectifier (convertor) has been introduced. This paper also shows the working methodology of three phase full wave (convertor) rectifier at different firing angle at a given time. Various waveforms were obtaining to compare with the actual waveform of three phase rectifier which gives useful result whereas three phase’s rectifier is required.
2. **Anand K Pandey et. al. [2017]** This research paper presents the complete modelling and simulation of single phase step-down cycloconverter. Basically single phase cycloconverter generates double, triple and fourth times of the output frequency. A Cycloconverter is a device that converts AC, power at one frequency into AC power of an adjustable but lower frequency without any direct current, or DC, stage in between. It can also be considered as a static frequency changer and typically contains silicon-controlled rectifiers. The FFT analysis of output current waveform has also been discussed in this paper. The cycloconverter circuits are designed and simulated and desired results are obtained. Cycloconverters are widely used in industry for ac-to-ac conversion. With recent device advances, newer forms of cyclo conversion are being developed. These newer forms are drawing more research interest. In this article, the most commonly known cycloconverter scheme is introduced, and its operation principle is discussed. For more detailed information, the following references can be used.
3. **Neha et. al. [2017]** This paper modeling and simulation of multipulse method using diode and thyristor bridge rectifier presents to reduce the harmonics contents from the device through the method of multi pulse technique. These harmonics produced in the data c For reduce the total harmo,48 are checked to make the particular constellation cost-effective for high power application in power industry. By using MATLAB/SIMULINK these modeling are done. Multi-pulse reactifier provides effective solution for harmonic reduction. This provides the 12-pulse, 18-pulse and various topologies provides the effective solution for Total Harmonic Distortion(THD) for input current and power factor. These constellation provides the cost effective solvent for high power constellation in power industry.
4. **D. Pylarinos et. al. [2016]** This paper describes an education scenario for a first course in power electronics based on a MATLAB/SIMULINK approach. This scenario was followed in the Electrical Engineering Department of the TEI of Crete in 2014 and students were asked to fill in a questionnaire after completing the class. The scenario was based on thyristor-based rectification and AC control, as prior approaches were based on the use of hardware and/or the simulation of such circuits in Or CAD/PS pice. Fourier/harmonic analysis through the use of MATLAB was added and

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Students were encouraged to undertake projects focused on simulating other types of converters in SIMULINK to receive a passing grade. The course's syllabus, the general teaching approach and the questionnaire's results are briefly presented and discussed in the paper. This paper describes the education scenario followed in the Electrical Engineering Department of the Technological Educational Institute for Crete in 2014 for teaching a first course in power electronics, based on a MATLAB/SIMULINK approach. The syllabus and general teaching approach for the course is briefly described. A 60 questions questionnaire was handed to the students after the completion of the course and results are also briefly described in this paper.

5. **Anand Panchbhai et. al. [2015],** Multi-pulse converters are developed for ac dc conversion with reduced harmonic currents and reactive power burden, low EMI, RFI at input ac mains and good quality low rippled dc output. Diode rectifier and phase controlled thyristor rectifiers are popular in several industrial applications such as chemical processes, DC arc furnaces, HVDC transmission systems etc. In this paper the simulation and hardware of closed loop control of 24-pulse converter is presented. The special phase shift transformers are designed to get required phase displacement. This 24 pulse rectifier has been designed for high voltage / current application by connecting them in series/parallel respectively. Here the entire closed loop approach is explained which can be utilized for HVDC transmission.
6. **G.Dyana Godwin et. al. [2015]**, This Paper deals with the adaptable control characteristics of DC motor including with Comparison of open loop and closed loop controlled full Convener fed DC drive. Fixed AC is converted in to Variable DC using a full Converter. The speed of DC Motor is controlled by directing the armature voltage and also by using different single phase AC/DC converter the armature current is controlled unreliable delay of firing angle. The open loop and the closed loop Systems are modeled and the Corresponding results are obtained by using MATLAB simulation. Open loop and closed loop controlled full Converter fed D.C drive systems are designed and simulated successfully using matlab. The error in speed is regulated using PI and PID Controller. The simulation results are in line with the theoretical results. Closed loop systems using PI and PID Controller is estimated mat lab. The Simulation with fuzzy controller will be done in future
7. **P.Manikandan et. al. [2013],** Three-phase controlled rectifiers have a wide range of applications such as motor control in industries, dc drives, cycloconverters etc. They are used for electro-chemical process, many kinds of motor drives, traction equipment, controlled power supplies, and many other applications. The main aim of this paper is to design the three phase PWM rectifier and analyze its performance. The rectifier is designed to convert input ac power into intermediate dc power. This power conversion is done at unity power factor viewed from the supply mains. The advantage of this system is it also improves the power quality. This improved power factor improves/modifies the wave shape of line current close to sinusoidal and reduces the line amplitude of line current to reduces the line loss and hence to improve the power quality. In this paper three phase PWM rectifier was designed and its performance has been analyzed using Simulink/MATLAB package program. Simulation results have been given for power quality improvement by means of making qudrature axis voltage zero. If the quadrature axis voltage zero means the reactive power output from the source will be zero. This will lead to the system voltage and current within phase. If the voltage and current are in phase means the power factor will be unity. It was done in this paper. This will help in many industrial and drive applications
8. **M. Sasi kumar et. al. [2012]** In The bi-directional AC/DC power converter is studied, implemented and the design perfor mance is validated with simulated results . It has the advantages of the proposed converter which can be operated with unity power factor for bi-directional power flow conditions. The direction of the current flow in the inductor is the same under both motoring and regenerating mode. This proposed model makes the current control simple.
9. **Sudeep Pyakuryal, et. al. [2012]** Silicon diodes are widely used for converting ac power into dc power. Diodes start conducting when they are forward biased and start producing dc voltage at the output but the output voltage is uncontrolled. With the use of a thyristor, instead of a diode, the output voltage can be controlled to a desired level. A thyristor needs a triggering pulse at the gate, when forward biased, to conduct. By controlling the triggering (firing) angle, the output dc voltage can be controlled effectively. A single phase full-wave controlled bridge ac to dc converter, rectifier, using thyristors is presented in this paper. Behavior of rectifier feeding different kinds of loads is investigated. To obtain the voltage and current waveforms, a program called ATP, Alternative Transients Program, has been utilized. ATP is world's most widely used electro-magnetic transients program and is available for use to the licensed users free of charge. In this paper, for a phase- controlled thyristor based rectifier, it has been shown that the average value of dc output voltage is controllable and is a function of triggering angle. Single-phase full-wave controlled bridge rectifier with thyristor was implemented successfully in ATP. It was noted that the average value of output voltage is a function of firing angle. Thus, by controlling the firing angle, the output voltage can be controlled effectively. This research will help seniors, graduate students, and design engineers to understand the modeling and working principle of ac to dc converters i.e. rectifiers.

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IV. CONCLUSION

The concept of the ideal switch is important when evaluating circuit topologies. Assumptions of zero-voltage drop, zero-leakage current and instantaneous transitions make it easier to simulate and model the behavior of various electrical designs

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