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Analogy between PWM and Controlled Rectifier

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ABSTRACT

AC/DC converters are widely employed to get regulated power supply, battery charging and DC motor speed control. SCR converters are preferred in the field of high-voltage DC energy transmission(HVDC), superconductor magnetic energy storage,etc. However, these converters have low power factor and also result in harmonic pollution. The first option is to use input LC passive filters. Other possibilities include the use of pulse width modulation (PWM) type converters.The advantage of PWM over other methods is that it does not require bulky and costly LC components. When PWM is employed, SCR's are not preferred as switching elements, since additional commutation circuits are required; instead ,power Mosfets, Power transistors and insulated gate bipolar transistors (IGBTs) are often used. The number of harmonics eliminated with these techniques is linked to the number of switching angles. In comparison with the phase controlled rectifier ,it can be controlled to consume nearly sinusoidal current with power factor equal to unity.Another advantage is its capability of energy recuperation .

Keywords: PWM Rectifier, Thyristor rectifier, THD, Power Factor.

I. INTRODUCTION

Modern electric devices are usually fed by diode or thyristor rectifiers. These rectifiers have simple construction,easy control algorithms and are cheap to produce but on the other side they load supply network with higher harmonics and with reactive power. Grid disturbances may result in malfunction or damage of other electrical devices [1-3]. Therefore many methods for reduction or elimination of harmonics pollution in the power system are investigated and developed. Phase control and commutation of semiconducting devices impact the phase displacement between the first harmonics of the consumed current and the first harmonics of the supply voltage. This displacement leads to power factor degradation and to reactive power consumption. The consumed current harmonics cause non-sinusoidal voltage drops on the supply network impedances and lead to supply voltage deformation [9-12]. This may cause malfunctions of other devices that are sensible to the sinusoidal shape of the supply voltage (e.g. measurement apparatuses, communication and control systems). The reactive power rises with longer control angle delays, so the rectifier acts as a time variable impedance that is nonlinear and causes deformed current consumption [4]. In order to suppress these negative phenomena caused by the power rectifiers, use is made of rectifiers with a more sophisticated control algorithm. Such rectifiers are realized by semiconductors that can be switched off IGBT transistors. The rectifier is controlled by pulse width modulation. A rectifier controlled in this way consumes current of required shape, which is mostly sinusoidal. It works with a given phase displacement between the consumed current and the supply voltage. The power factor can also be controlled and there are minimal effects on the supply network [5-8]. PWM rectifiers can be divided into two groups according to power circuit connection – the current and the voltage type. For proper function of current a type rectifier, the

maximum value of the supply voltage must be higher than the value of the rectified voltage. The main advantage is that the rectified voltage is regulated from zero. They are suitable for work with DC loads (DC motors, current inverters) For proper function voltage type rectifiers require higher voltage on the DC side than the maximum value of the supply voltage [13]. The rectified voltage on the output is smoother than the output voltage of the current type rectifier. they also require a more powerful microprocessor for their control [14-16]. Output voltage lower than the voltage on input side can be obtained only with increased reactive power consumption [17].

II. PHASE CONTROLLED RECTIFIER

The phase controlled thyristor rectifiers belong to the category of worst electrical network polluters. The phase control and the commutation of semiconductor devices impact on the phase displacement between the first harmonics of consumed current and supply voltage. This displacement leads to power factor degradation. The consumed current harmonics cause the non-sinusoidal voltage drops on the supply network impedances and the supply voltage deformation which may cause the malfunction of the other devices that are sensible on the supply voltage sinusoidal shape. To reduce these side effects the rectifiers are being supplemented by filters and compensators. The major disadvantage is that additional circuits raise the cost and requirements on the material and space needed for the converter are increased.

Figure 1(a) shows controlled rectifier circuit.Figure.1(b)shows input and output waveform of this rectifier. Input is given to the rectifier circuit by means of centre tapped transformer. SCR switch is triggered by means of pulse generator. In the positive half cycle thyristorT1 conducts and during negative thyristor T2 conducts. A rectified output will given to the load.

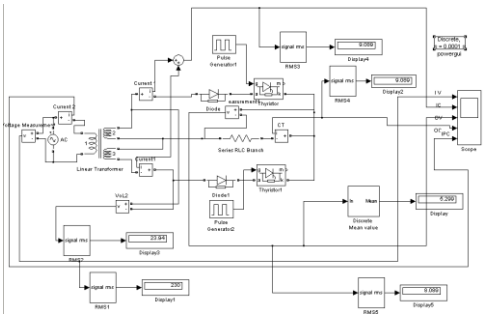

Figure 1(a). Controlled Rectifier circuit

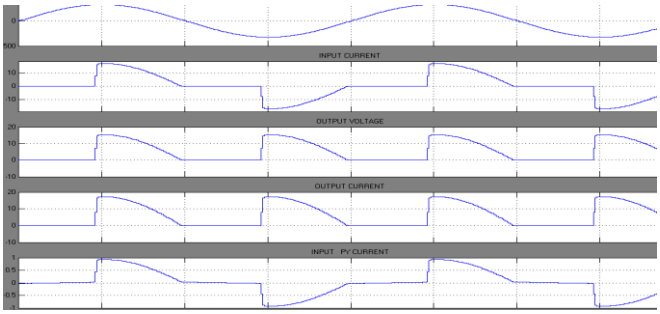

Figure 1(b). Wave forms

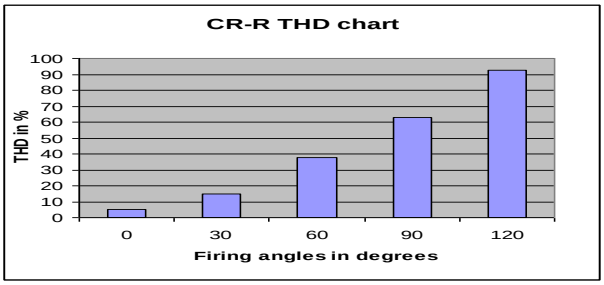

Figure 1(c). Firing angle

After the triggering angle the output follows the input voltage. Since resistive load, the current and voltage are in phase.

III. PWM RECTIFIER

This rectifier is realized by semiconductor devices that are switched off (MOSFET). The rectifier is controlled by pulse width modulation .Rectifier controlled in this way consumes current with demanded waveform that is mostly sinusoidal.It works with given phase displacement between consumed current and supply voltage,enables control of power factor, and has minimal effects on the supply network.

Main features of PWM rectifiers are:bi-directional power flow,nearly sinusoidal input current,regulation of input power factor to unity,low harmonic

distortion of line current,adjustment and stabilization of DC link voltage,reduced capacitor size due to continuous current.Two techniques of PWM are employed to get reduced harmonics. They are multiple pulsewidth and sinusoidal PWM. Figure 1(a) shows PWM rectifier circuit.Figure 1(b)shows input and output waveform of this rectifier

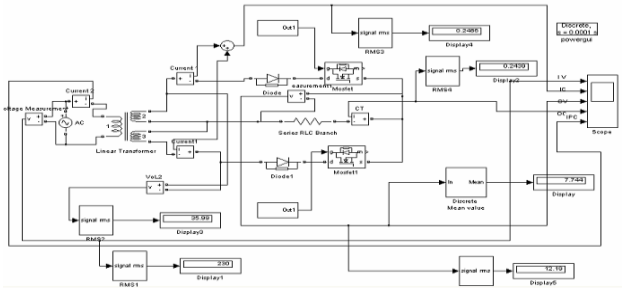

Figure 2(a). PWM Rectifier circuit

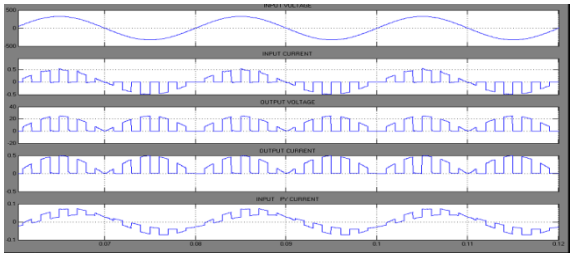

Figure 2(b). Wave forms

The triggering pulse is generated by means of this circuit.

The constant DC voltage and a triangular pulse is compared

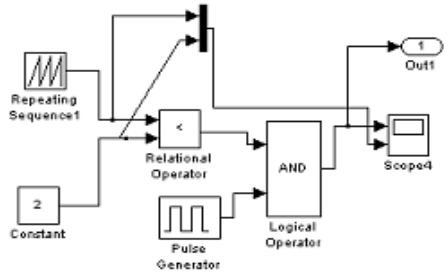

Figure 2(c). Gate triggering circuit

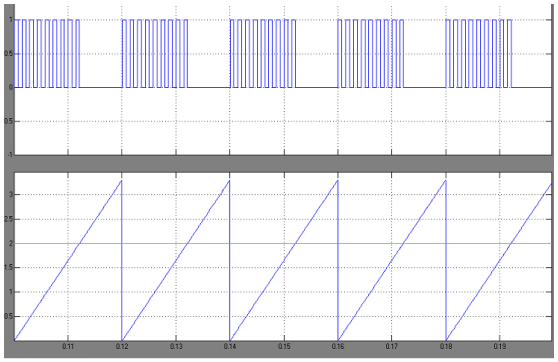

Figure 2(d). Gate triggering waveform

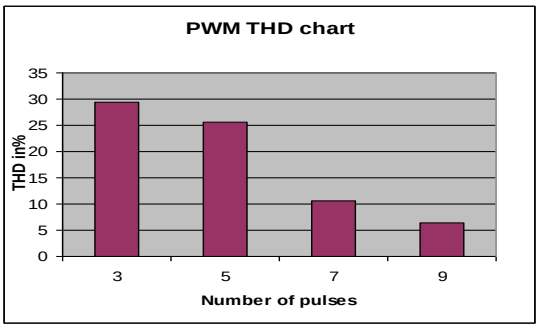

Figure 3. THD chart

Simulation

Table 1. Firing Angle variations

Controlled Rectifier		
A	Output voltage	THD
90	5	62.57%

Table 2. Pulse variations

PWM Rectifier		
No.of Pulses	Output voltage	THD
3	5	27.86%
5	5	25.12%
7	5	9.92%
9	5	6.32%

Practical Controlled Rectifier

Table 1a. Firing Angle variations

A	Output voltage	THD	PF	DPF
92	5	65.6%	0.561	0.856

Pwm Rectifier

Table 2a. Pulse variations

No.of Pulses	Output voltage	THD	PF	DPF
3	5	29.5%	0.696	0.999
5	5	25.6%	0.710	1
7	5	10.7%	0.718	1
9	5	6.5%	0.725	1

Simulation

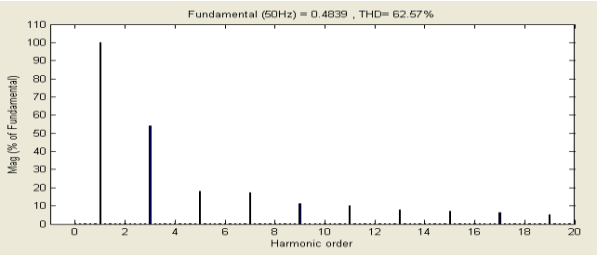

Figure 4. FFT analysis of controlled rectifier

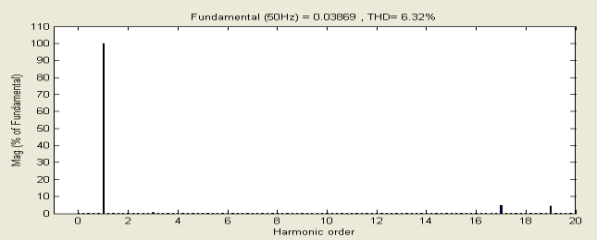

Figure 5. FFT analysis of PWM rectifier

Practical:

Controlled Rectifier THD Chart

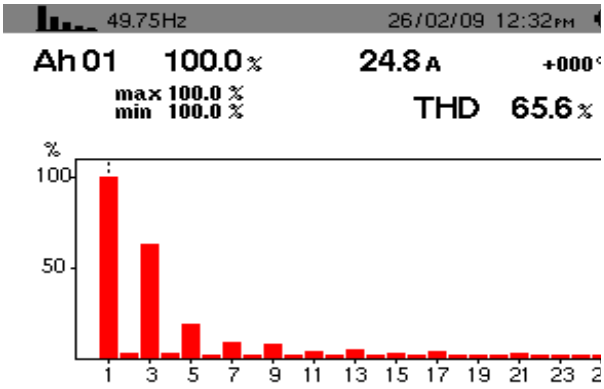

Figure 5a. FFT analysis of controlled rectifier

PWM Rectifier THD Chart

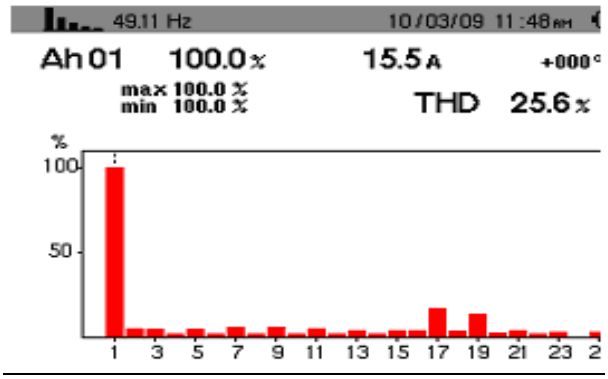

Figure 5b. FFT analysis of PWM rectifier

IV. CONCLUSION

Thus utilization of PWM rectifiers eliminates the problems caused by phase controlled rectifiers.The thyristor rectifiers overload the supply network with higher harmonics and reactive power consumption .These side effects of the controlled rectifiers can't be ignored.So the PWM rectifiers in which there will be no consumption of reactive power and hence the harmonics are reduced.

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