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Improvement of Power Quality in a Matrix Converter using Hybrid Filters

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ABSTRACT: In recent years, the use of nonlinear devices either for residential or industrial applications has increased exponentially. Hence the power distribution system is polluted with harmonics. The important harmonic source is AC/DC converters and inverters. The Matrix converter is a special converter which produces higher order harmonics. Due to the discontinuous input current, the matrix converter behaves as a source of current harmonics, which are injected back into the AC mains. The solution to overcome this problem is to filter out these harmonics. The harmonic compensation for matrix converter using passive, active and hybrid filters is designed and implemented through simulation. The results are compared and shown that hybrid filter provides better compensation compared to passive and active filters.

KEYWORDS: Single phase Matrix converter(SPMC), harmonics, rectifier, passive filter, active filter, hybrid filter.

I.INTRODUCTION

The Matrix Converter is an array of bidirectional switches as the main power elements, which interconnects directly with the Input supply to the load, without using any dc-link or large energy storage elements. Matrix converter is also called direct energy converter. The term power quality became most prominent in the power sector and both the electric power supply company and the end users are concerned about it. The quality of power delivered to the consumers depends on the voltage and frequency ranges of the power. If there is any deviation in the voltage and frequency of the electric power delivered from that of the standard values then the quality of power delivered is affected.

Now-a-days with the advancement in technology there is a drastic improvement in the semi-conductor devices. With this development and advantages, the semi-conductor devices got a permanent place in the power sector helping to ease the control of overall system. Moreover, most of the loads are also semi-conductor based equipment. But the semi-conductor devices are non-linear in nature and draws non-linear current from the source. And also the semi-conductor devices are involved in power conversion, which is either AC to DC or from DC to AC. This power conversion contains lot of switching operations which may introduce discontinuity in the current. Due to this discontinuity and non-linearity, harmonics are present which affect the quality of power delivered to the end user. The main affect caused by these problems is the production of harmonics. Harmonics is the serious disadvantages of power electronic systems that it injects considerable harmonics both the sides, to the connected load side and to the power source side. The presence of harmonics deteriorates the quality of power and may damage the end user equipment. These harmonics causes the heating of underground cables, insulation failure, reduces the life-time of the equipment, increases the losses etc.

II.SOLUTIONS TO POWER QUALITY PROBLEMS

The most effective solution to improve the power quality is the use of filters to reduce harmonics. There are different filter topologies in the literature such as- active, passive, hybrid. The passive power filters are used to filter out a particular order harmonics and has the problem of parallel resonance. The other solution is the use of Active Power Filter (APF). There are different types of APF like series APF, shunt APF. The shunt APF is costly and is not used for large systems. The series APF works as a harmonic isolator and used to reduce the negative-sequence voltage. There is another filter topology which is a combination of passive filter and APF known as Hybrid Filter.

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III. SINGLE PHASE MATRIX CONVERTER

For different types of conversion different circuits are used. But in certain applications like uninterruptable power supply which converts AC into DCfor charging the batteries using rectifiers and then converts the stored energy again into Ac using inverter, requires two conversion circuits. Also in traction different types of motors are employed such as DC shunt, DC series and AC series which require conversion of supply.A number of conversion kits are required in laboratories. This increases the total cost and also the space requirement. Single phase matrix converter is capable of performing all these conversions. The use of matrix converter in the future reduces the need for learning many varying converter topologies and that is now the subjects of current research. The matrix converter requires a bidirectional switch capable of blocking voltage and conducting current in both directions.

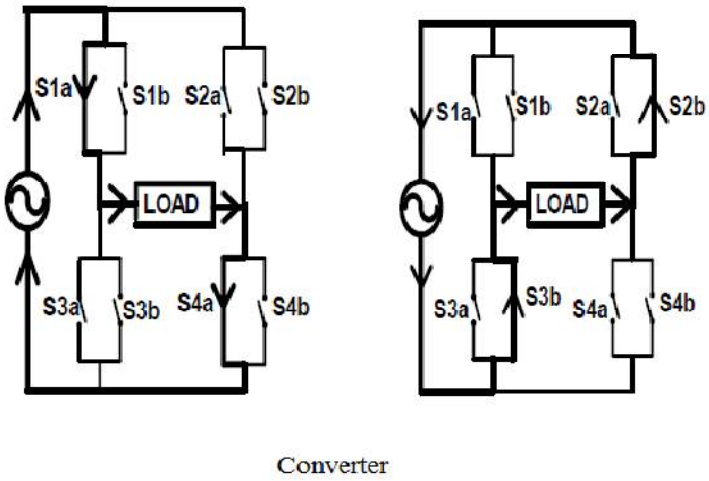

Figure 1 SPMC as Rectifier

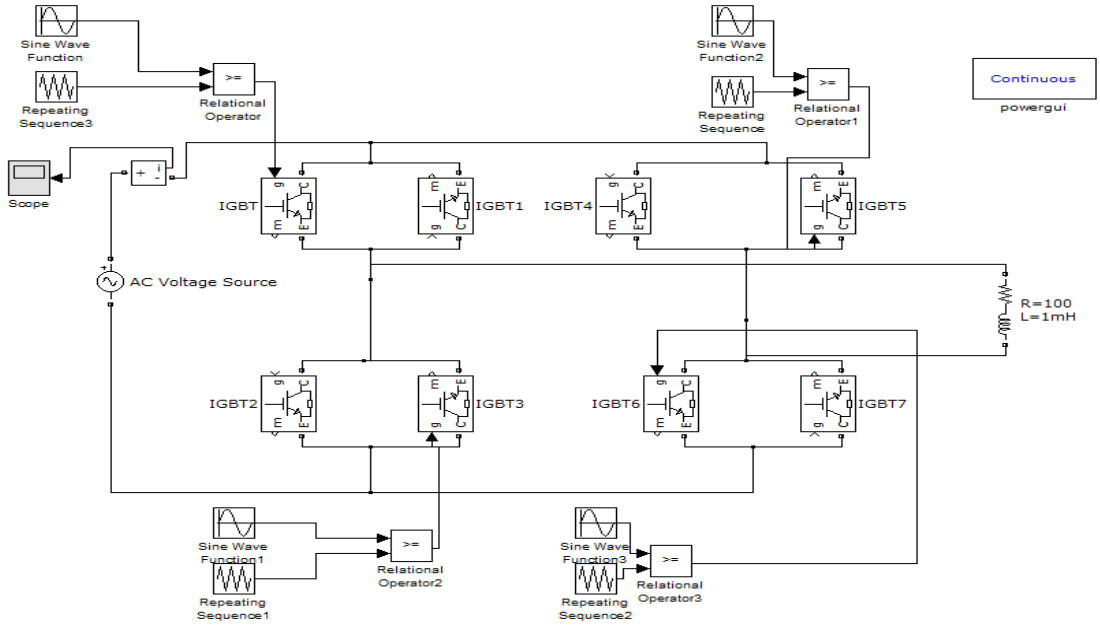

Figure 2 Simulink Model of SPMC as Rectifier

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The matrix converter can be used as a rectifier, inverter, cycloconverter and as a chopper by changing the switching combinations accordingly. In this project we are considering matrix converter as a rectifier for analysing the harmonics. Filters are designed for this converter to reduce the harmonics produced by them. The input and output waveforms and the total harmonic distortion are observed for different filters used and are compared. The block diagram showing switching action of matrix converter as rectifier is shown in figure1. Simulation of matrix converter as rectifier is shown in figure 2.The input voltage of the rectifier is AC voltage of 240V, 50Hz.

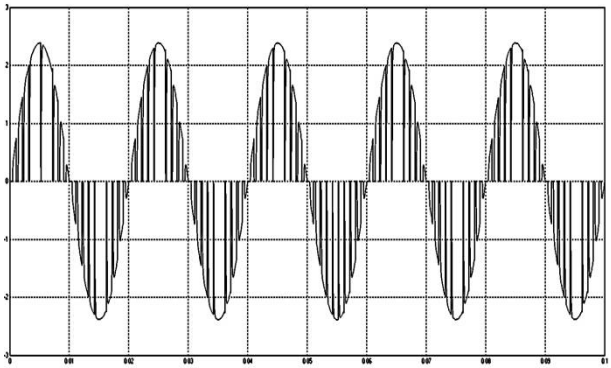

Figure 3 Input current of the Rectifier without filter versus time

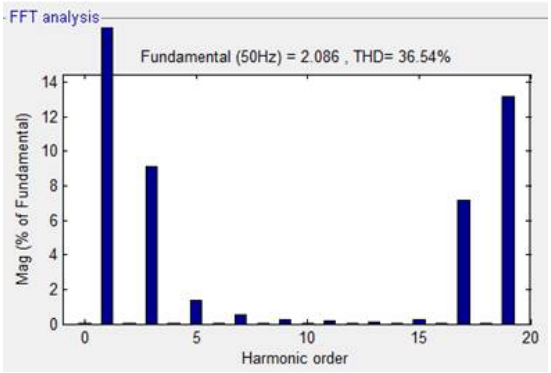

Figure 4 THD of SPMC as Rectifier

The Total Harmonic Distortion is found for the input current waveform of Rectifier without filter by FFT Analysis. Figure 4 shows the total harmonic distortion of the circuit and it is 36.54%.

IV.SPMC AS RECTIFIER WITH PASSIVE FILTER

The MATLAB/Simulink model of SPMC as Rectifier with Passive filter is as shown in Figure 5. The designed L and C values of the passive filter are L=75e-3H and C=135.1e-6F.

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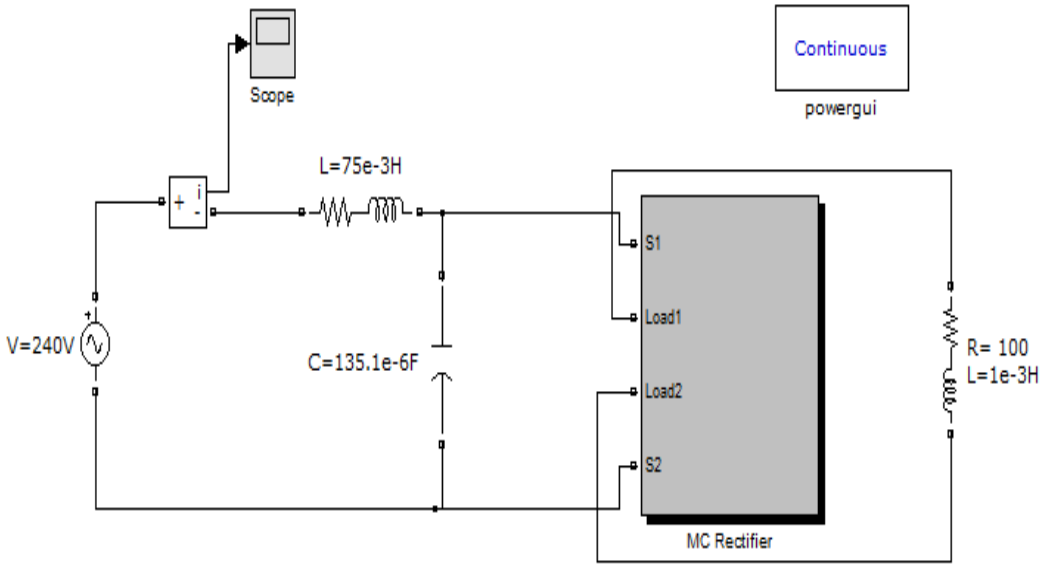

Figure 5 Rectifier with Passive Filter

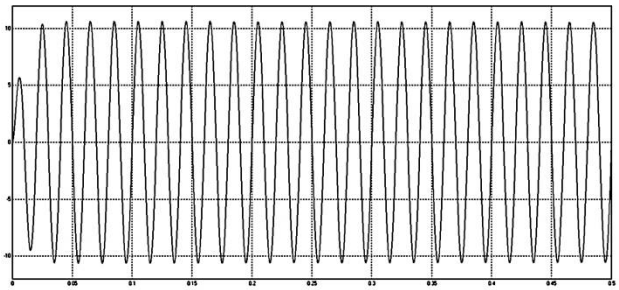

Figure **Error! No text of specified style in document.** Input current of Rectifier with Passive filter versus time.

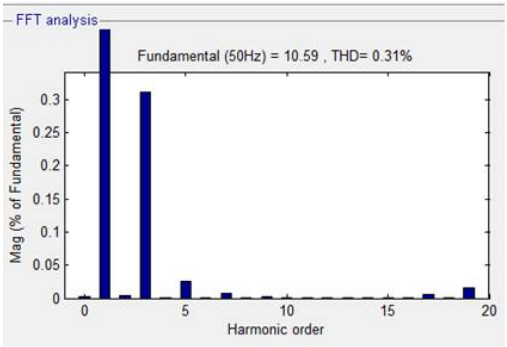

Figure 7 THD of Rectifier with Passive Filter

The Total Harmonic Distortion is found for the input current waveform of Rectifier with Passive filter by FFT Analysis. Figure 7 shows the total harmonic distortion of the circuit and it is 0.31%.

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IV.SPMC AS RECTIFIER WITH ACTIVE FILTER

The MATLAB/Simulink model of SPMC as Rectifier with designed values of Active Filter is as shown in Figure 8.

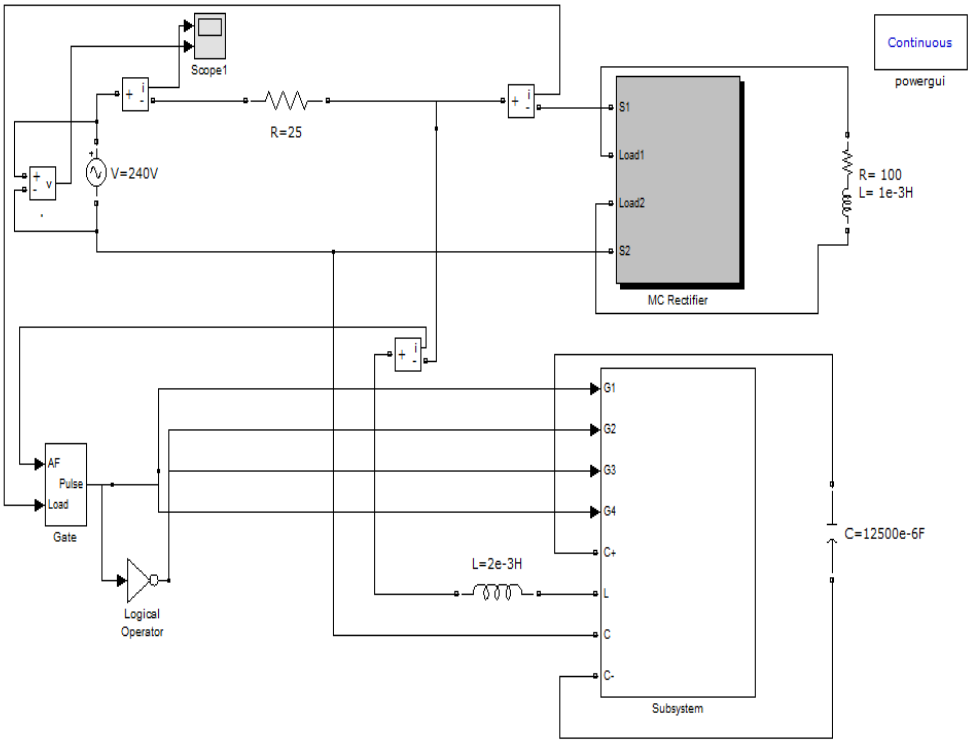

Figure 8 Simulink Model of Rectifier with Active Filter

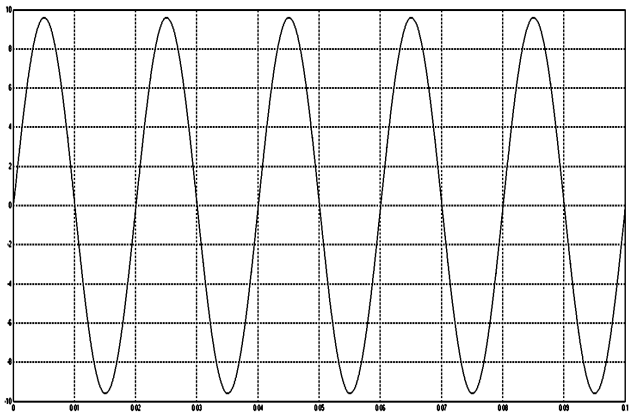

Figure 9 Input Current of Rectifier with Active filter verses time

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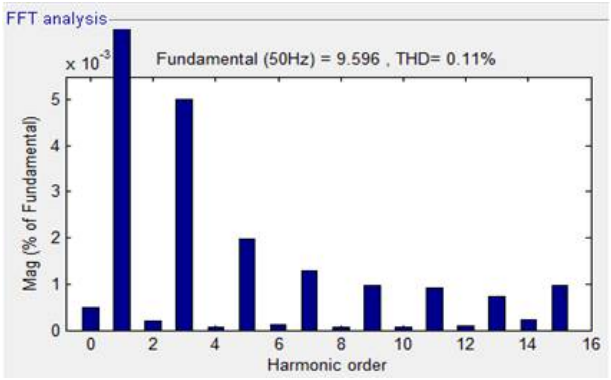

Figure 10 1THD of Rectifier with ActiveFilter

The Total Harmonic Distortion is found for the input current waveform of Rectifier with active filter by FFT Analysis. Figure 10 shows the total harmonic distortion of the circuit and it is 0.11%.

IV.SPMC AS RECTIFIER WITH HYBRID FILTER

The MATLAB/Simulink model of SPMC as Rectifier with Hybrid Filter is as shown in Figure 11.

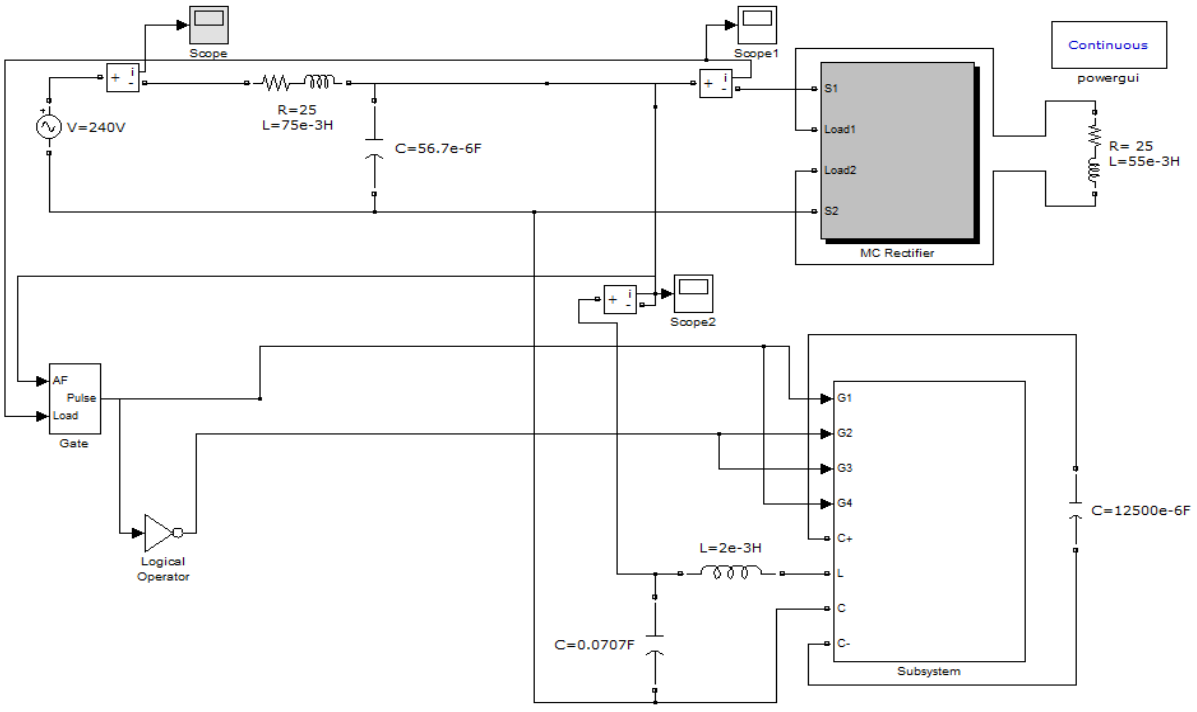

Figure 11 Simulink Model of Rectifier with Hybrid Filter

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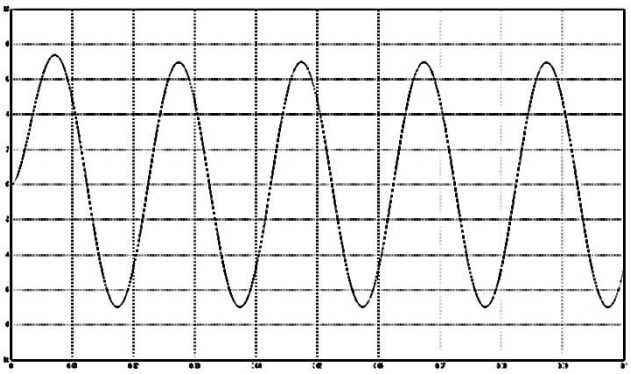

Figure 12 Input Current of Rectifier with Hybrid Filter verses time

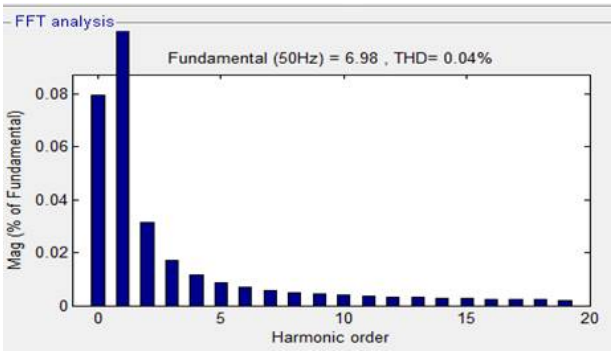

Figure 13 THD of Rectifier with Hybrid Filter

The Total Harmonic Distortion is found for the input current waveform of Rectifier with Hybrid filter by FFT Analysis. Figure 13 shows the total harmonic distortion of the circuit and it is 0.04%.

V. RESULTS

Matrix Converter as a Rectifier is simulated without any filter, with passive, active and hybrid filters. The total harmonic distortion found in each of the circuit is as shown in Table 1.

TYPE OF FILTER	RECTIFIER
NO FILTER	36.54%
PASSIVE FILTER	0.31%
ACTIVE FILTER	0.11%
HYBRID FILTER	0.04%

Table 1 comparison of THD values for different filters

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VI.CONCLUSION

A single phase matrix converter can be analyzed for different power electronic converter circuits using appropriate switching devices. Inthis case IGBT is used as the main power switching device. PWM technique is employed to generate the pulses. The input and output waveforms are analyzed and the simulated results are compared. The matrix converter as a rectifier is a source of current harmonics. The passive, active and hybrid filters are designed to reduce the harmonics in the matrix converter.The designed model was implemented in a MATLAB/SIMULINK and the results were tabulated.The results were compared and it was found that the use of hybrid filter was the most effective one in reducing the harmonics.

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