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# Hybrid Filter for Harmonic Mitigation in Medium Voltage Motor Drive

Mariamma Baby
*M-Tech,(Power Electronics),Electrical and Electronics Engineering Department,Mar Athanasius College Of Engineering,Kothamangalam*

Prof. Daisykutty Abraham
*Electrical and Electronics Engineering Department,Mar Athanasius College Of Engineering,Kothamangalam*

## Abstract

***Hybrid filter can be used for the mitigation of line-side harmonic currents of a three-phase 12-pulse diode rectifier used as the front end of a medium-voltage high-power motor drive. This hybrid filter consists of series connection of a simple LC filter tuned to the 11th-harmonic frequency with a small-rated active filter using a three-level neutral-point clamped NPC PWM converter. The active filter used in the hybrid filter is much smaller in converter capacity than the pure active filter. The simple single-tuned LC filter used in the hybrid filter is much smaller in size, lower in cost and weight, than the traditional passive filter. This paper presents the analysis of medium voltage motor drive with and without hybrid filters using MATLAB software.***

***Keywords - Active filters, harmonic distortion, motor drives, passive filters, rectifiers***



## 1.Introduction

Three-phase six-pulse diode rectifier can be used as the front end of the medium-voltage motor drive. However, the diode rectifier produces a large amount of harmonic current at the line side. When high-power equipment or apparatus is installed on an industrial power system, a line frequency transformer is required to achieve voltage matching and galvanic isolation between the power system and the equipment. The combination of a three-phase 12-pulse diode rectifier with a multiwinding, phase-shift transformer is often adopted as the front end of a medium-voltage high-power motor drive without regenerative braking, in order to comply with harmonic guidelines or regulations. The transformers are vulnerable to winding and voltage imbalances that produce a bad effect on cancelling out the 11th, and/or 13th-harmonic currents at the line side.

This paper presents a hybrid filter [2] for the mitigation of line-side harmonic currents of a three-phase 12-pulse diode rectifier used as the front end of a medium-voltage high power motor drive. This hybrid filter consists of series connection of a simple *LC* filter tuned to the 11th-harmonic frequency with a small-rated active filter using a three-level neutral-point clamped NPC PWM converter. The hybrid filter has the following advantages over a pure active filter and a traditional passive filter consisting of multiple-tuned *LC* filters and a highpass filter: the active filter taking part in the hybrid filter is much smaller in converter capacity than the pure active filter. The simple single-tuned *LC* filter used in the hybrid filter is much smaller in size, lower in cost and weight, than the traditional passive filter.

## 2.Medium voltage motor drive

The functional block diagram of a medium voltage motor drive is shown in fig.1.

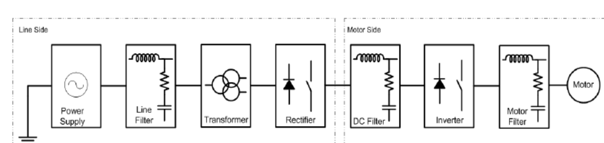


**Fig.1.Functional block diagram**

Depending on the system requirements and the type of the converters employed, the line- and motor-side filters are optional. A phase shifting transformer with multiple secondary windings is often used mainly for the reduction of line current distortion. The rectifier converts the AC utility supply to a DC level with a fixed or adjustable magnitude. The commonly used rectifier topologies include multipulse diode rectifiers, multipulse SCR rectifiers or pulse-width-modulated (PWM) rectifiers. The DC filter can simply be a capacitor that provides a stiff DC voltage in voltage source drives or an inductor that smoothes the DC current in current source drives.

The inverter can generally be classified into voltage source inverter (VSI) and current source inverter (CSI). The VSI converts the DC voltage to a three-phase AC voltage with adjustable magnitude and frequency whereas the CSI converts the DC current to an adjustable three phase AC current.

## 3. Hybrid filter

This hybrid filter consists of series connection of a simple *LC* filter tuned to the 11th-harmonic frequency with a small-rated active filter using a three-level neutral-point clamped NPC PWM converter. The hybrid active filter has the following advantages over a pure active filter and a traditional passive filter consisting of multiple-tuned *LC* filters and a high pass filter: the active filter taking part in the hybrid filter is much smaller in converter capacity than the pure active filter. The simple single-tuned *LC* filter used in the hybrid filter is much smaller in size, lower in cost and weight, than the traditional passive filter.

### 3.1 Tuned Harmonic Filters

A tuned harmonic filter is a device with two basic elements: inductive and capacitive. These reactive elements are connected in series to form a tuned LC circuit. The tuned harmonic filter is a resonant circuit at the tuning frequency so its impedance is very low for the tuned harmonic. Due to its low impedance at the tuned harmonic frequency, the tuned filter now becomes the source of the tuned frequency harmonic energy demanded by the loads, rather than the utility.

### 3.2 Active filters

Active filtering techniques can be applied either as a standalone harmonic filter or by incorporating the technology into the rectifier stage of a drive, UPS or other power electronics equipment. Active filters will monitor the load currents, filter out the fundamental frequency currents, analyze the frequency and magnitude content of the remainder, and then inject the appropriate inverse currents to cancel the individual harmonics.Active filters utilize power electronics circuitry and therefore maintenance requirements can be higher than for passive solutions and may be similar to that for a variable frequency drive. The losses associated with active filters also tend to be higher than for passive solutions.

## 4. Medium voltage motor drive systems with a hybrid filter

Motor drive equipped with a hybrid active filter uses a three-winding (Δ-Δ-Y) transformer for the 12-pulse diode rectifier. The hybrid filter is connected to the secondary of the step-down transformer. The system configurations have the advantage of a low cost hybrid filter because the ratings of the *LC* filter and the active filter are 8% and 0.8% of the motor rating. Fig.1 shows a motor drive system using a hybrid filter.

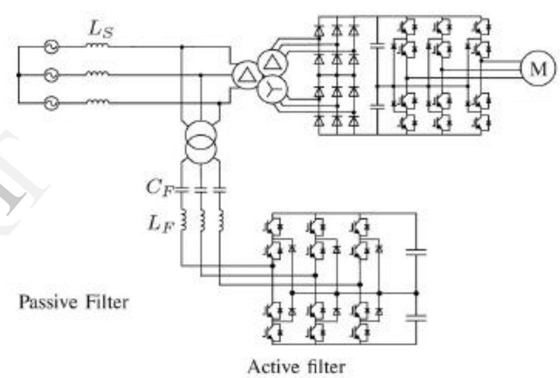


**Fig.2. Motor drive system equipped with a hybrid filter**

## 5. Simulation & Results

Simulation is done in MATLAB and the results obtained are shown. Simulation of the motor drive system equipped with and without hybrid filter is performed. The final speed of the system without hybrid filter and with hybrid filter is shown in fig.3.a & 3.b respectively.

## 6. Conclusion

In this paper a motor drive system employing a hybrid filter is analysed and compared with a system without a hybrid filter. Harmonics present in the two systems are compared using the speed of the two systems obtained by the simulation in MATLAB.

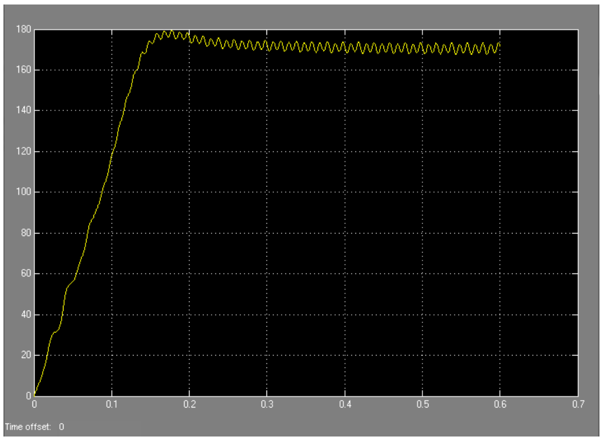


**Fig.3.a.Speed waveform of system without hybrid filter**

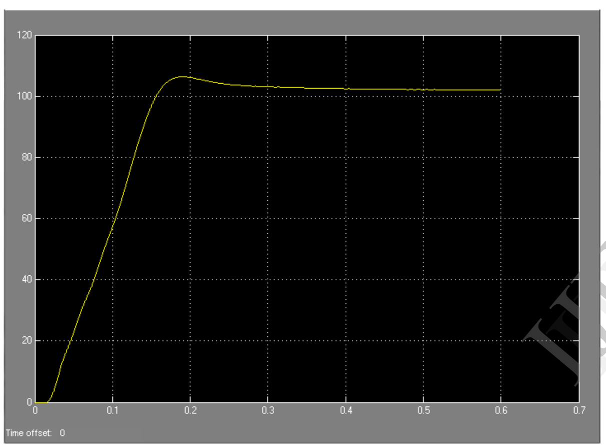


**Fig.3.b.Speed waveform of system with hybrid filter**



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