The Shunt Active Power Filter to Compensate Reactive Power and Optimized THD with Improved Power by PI Controller in a 3 Phase 3 Wire Distribution Network

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ABSTRACT

Three phase induction motors are the most common and frequently encountered machines in industry. This type of machines has simple in design and easy to maintain. This project deals with study and analysis of performance of induction motor and study and implementation of various possible controllers using vector control scheme. The PI and PID controller has been discussed and literature survey has been carried out. On the basis of literature survey PI and PID control system are developed here.

Keywords: Active Power Filter, threshold harmonics distortions, quality factor, transfer function, hysteresis etc.

I. INTRODUCTION

The use of induction motors has increased tremendously since the day of its invention. They are being used as actuators in various industrial processes, robotics, house appliances (generally single phase) and other similar applications. The reason for its day by day increasing popularity can be primarily attributed to its robust construction, simplicity in design and cost effectiveness. These have also proved to be more reliable than DC motors. Apart from these advantages, they have some unfavorable features like their time varying and non-linear dynamics. Three phase induction motors are the most common and frequently encountered machines in industry, because this type of machines has a simple design and easy

II. INDUCTION MOTOR SPEED CONTROL

An easy way to comply with the conference for speed control of induction motor different controllers such

as conventional PI and PID controllers are used. When the load is applied on the motor the motor speed decreases. This decreased speed will be feedback to the summation block .The summation block consist of two inputs, that is the feedback speed and the reference speed. The error signal is developed from both this inputs which is fed to the PI, PID controller where all these controllers acts and brings back the speed to the reference value. From here throughout the process the speed remains constant for a constant load applied on it. So the advantage of using different controller is that even if load is applied on a motor the reference speed can be obtained which cannot be obtained in open loop system. Therefore the closed loop system using PI, PID controller has been achieved in this paper. After getting the speed response for different controllers, the results are compared.

Speed control techniques for induction motor drive which we are using in this Paper is

1. Speed response of induction motor in open loop System.
2. Speed control of induction motor in closed loop system using PI Controller.
3. Speed control of induction motor in closed loop system using PID Controller.

III. POWER QUALITY

The PQ issue is defined as "any occurrence manifested in voltage, current, or frequency deviations that results in damage, upset, failure, or mis-operation of end-use equipment." Almost all PQ issues are closely related with PE in almost every

aspect of commercial, domestic, and industrial application. Equipment using power electronic devise are residential appliances like TVs, PCs etc. business and office equipment like copiers, printers etc. industrial equipment like programmable logic controllers (PLCs), adjustable speed drives (ASDs), rectifiers, inverters, CNC tools and so on. The Power Quality (PQ) problem can be detected from one of the following several symptoms depending on the type of issue involved.

IV. HARMONIC POWER FILTERS

The steady increase in non-linear loads on the power supply network raises question about power quality and reliability. The challenge knows how to select and deploy harmonic filters correctly to achieve satisfactory performance. In this chapter we discuss about different non-linear loads and what kind of filters must be used to effectively mitigate harmonics in the system.

4.1. Current source non-linear load

Thyristor converters are a common and typical source of harmonic currents. Fig. 2.1(a) shows a thyristor rectifier where a sufficient dc inductance produces a dc current. Therefore, it is called a current-source nonlinear load and represented as a current source shown in Fig. 2.1(b). Similarly, diode rectifiers with a sufficient dc inductance, a highly inductive load with silicon-controlled rectifier (SCR) ac power control, etc., are current-source nonlinear loads.

4.2. Voltage source non-linear load

Another common type of harmonic source is a diode rectifier with smoothing dc capacitors, as shown in Fig. 2.2(a). Therefore, the diode rectifiers behave like a voltage source, rather than a current source. Fig. 2.2(b) shows the equivalent circuit of the diode rectifier system where the diode rectifier is represented as a harmonic voltage source or voltage-source nonlinear load.

V. Types of power filter

There are different types of power filter analyzing the current situation power filters widely classified into three categories; Fig 4.1 shows these categories of power filters
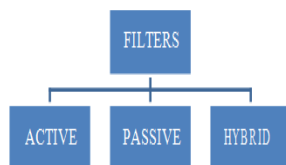

Figure 4.1 Types of power filters

VI. SHUNT ACTIVE POWER FILTER

The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase-shifted by 180°.
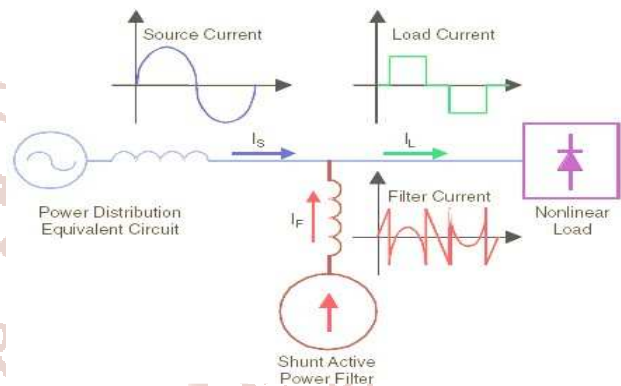

Figure 6.1 shows how the active filter works to compensate the load harmonic currents.

Figure 6.1 shows the connection of a shunt active power filter and Figure 3.2shows how the active filter works to compensate the load harmonic currents.

VII. PI CONTROL SCHEME
- ➤ Dc voltage control loop
- ➤ Transfer function of PWM converter
- ➤ Selection of PI controller parameters

The complete schematic diagram of the shunt active power filter is shown in figure 6.1 while figure 7.1 gives the control scheme realization. The actual capacitor voltage is compared with a set reference value.
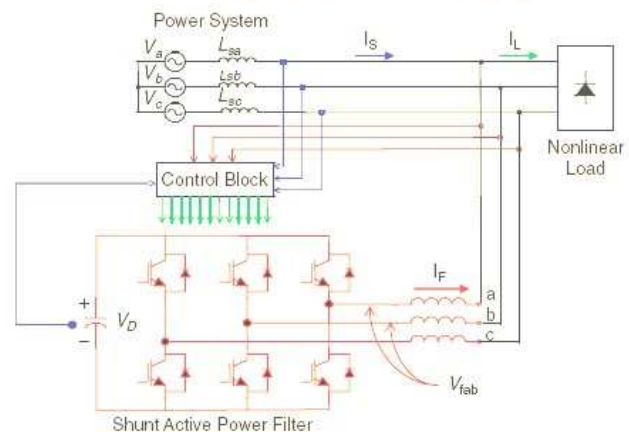

Figure7.1. Schematic diagram of shunt active filter

The error signal is fed to PI controller. The output of PI controller has been considered as peak value of the reference current. It is further multiplied by the unit sine vectors (usa, usb, and usc) in phase with the source voltages to obtain the reference currents (isa*, isb*, and isc*). These reference currents and actual currents are given to a hysteresis based, carrier less PWM current controller to generate switching signals of the PWM converter [2]. The difference of reference current template and actual current decides the operation of switches. To increase current of particular phase, the lower switch of the PWM converter of that particular phase is switched on, while to decrease the current the upper switch of the particular phase is switched on. These switching signals after proper isolation and amplification are given to the switching devices. Due to these switching actions current flows through the filter inductor Lc, to compensate the harmonic current and reactive power of the load, so that only active power drawn from the source.

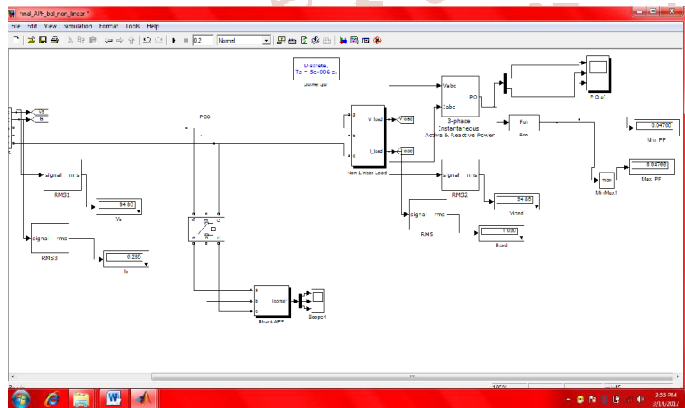## VIII. SIMULATION MODELS AND RESULTS ANALYSIS
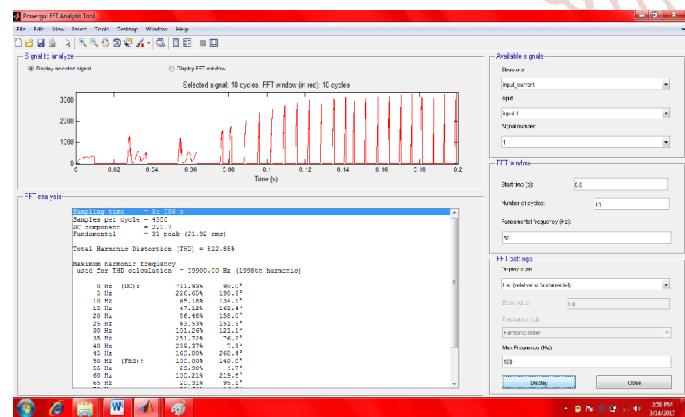

Figure 8.1 For 250 PI constant unbalanced loads RC

Figure 8.2 THD value for 250 PI constant Unbalanced load RC

XV. RESULTS

Table-1 Result of Balanced load for different PI constant

PI constant	VS	IS	VL	IL	P.F	THD
150	10.4	7.4	54.4	2.5	1	3.14%
170	51.8	5.8	51.8	1.4	0.93	3.16%
190	43.5	6.5	43.5	2.4	0.92	3.70%
210	35.9	6.8	35.9	2.0	0.90	2.35%
230	37.9	6.4	37.9	2.1	.92	5.53%
250	91.9	6.0	91.9	1.8	-0.57	8.60%

Table-2 Result of Unbalanced RC load for different PI constant.

PI constant	VS	IS	VL	IL	P.F	THD
50	10.4	7.4	10.4	1.9	0.93	2.70%
170	10.4	7.4	10.4	1.9	0.90	2.65%
190	43.5	6.5	43.5	2.4	0.92	3.70%
210	35.9	6.8	35.9	2.0	0.98	2.31%
230	78.8	6.1	78.8	1.6	0.80	4.39&
250	94.8	6.2	94.86	1.6	0.04	8.22%

Table-3 Result of Unbalanced RC load for different PI constant

PI constant	VS	IS	VL	IL	P.F	THD
150	10.4	7.4	10.4	1.9	0.93	2.70%
170	10.4	7.4	10.4	1.9	0.90	2.67%
190	10.4	7.4	10.4	1.9	0.90	2.62%
210	9.6	7.4	9.6	1.7	0.90	2.61%
230	9.8	7.4	9.8	1.8	0.90	2.61&
250	10.2	7.4	10.2	1.9	0.89	2.6%

Table-4 Result of Unbalanced RC load for different PI constant

PI constant	VS	IS	VL	IL	P.F	THD
150	53.1	3.76	53.1	2.58	0.9	3.60%
170	52.3	5.86	52.3	1.82	0.9	3.60%
190	34.0	6.15	34.0	2.34	0.9	6.75%
210	37.7	5.84	37.7	2.23	0.9	2.20%
230	33.4	6..25	33.4	1.85	0.9	4.16%
250	84.0	5.21	84.0	2.04	-0.9	6.91%

X. CONCLUSION

Presence of constant instantaneous active power is due to the positive sequence current and only in case of purely resistive loan but may be unbalance.

The presence of constant instantaneous imaginary power is due to the positive sequence current and only in the case of pure inductive load but may be unbalance

The presence of oscillations in both of instantaneous powers is due to the negative sequence current whether a load is purely resistive or inductive

From FFT analysis and table 1 to 4 seems that the proposed shunt-APF system with optimized PI system along constant 210 outperform for balanced and unbalanced configuration load (R,RC,RL and RLC) for unique power factor.

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