Total Harmonic Distortion (THD) compensation via UPQC using PID Controller

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Abstract - *This paper proposes in novel approach for Unified Power Quality Conditioner. The main purpose of UPQC is to compensate harmonics, voltage flicker/imbalance and reactive power. It is used to enhance the power quality at distribution levels. In general, the power structure of 3-phase 3 wire UPQC consist of 2 back to back connected 6-switch inverters. PID controllers are widely applicable and can be set up easily and operate optimally for enhanced productivity, improved quality and reduced maintenance requirements. The proposed topology of UPQC is to compensate THD by PID controller in voltages and currents parameter.*

***Key Words*: UPQC, PID controller, THD, power quality (PQ), voltage source inverter (VSI), DC link etc.**

1. INTRODUCTION

The term *power quality* refers to a wide variety of electromagnetic phenomena that characterize the voltage and current at a given time and at a given location on the power system. The increasing application of electronic equipment that can cause electromagnetic disturbances, or which can be sensitive to these phenomena, has heightened the interest in power quality in recent years [4]. UPQC enhances the power quality of the power system.

1.1 Unified Power Quality Conditioner

A UPQC generally consists of two voltage source inverters (VSI), connected in shunt and series configuration with the grid, at the point of common coupling (PCC) and share a common dc link capacitor. The series VSI protects the downstream loads from sags/swells in the PCC voltage where as the shunt VSI reduces the upstream line losses by compensating the harmonic distortion and reactive component of the load current. When the voltage at PCC is distorted, the series VSI can be additionally controlled to mitigate and prevent the voltage harmonics from reaching the load [2]. The key components of this system are as follows:

1) Two inverters—one connected across the load which acts as a shunt APF and other connected in series with the line as that of series APF.

2) Shunt coupling inductor is used to interface the shunt inverter to the network. It also helps in smoothing the current wave shape. Sometimes an isolation transformer is utilized to electrically isolate the inverter from the network.

3) A common dc link that can be formed by using a capacitor or an inductor. In Fig.1, the dc link is realized using a capacitor which interconnects the two inverters and also maintains a constant self-supporting dc bus voltage across it. An *LC* filter that serves as a passive low-pass filter (LPF) and helps to eliminate high frequency switching ripples on generated inverter output voltage.

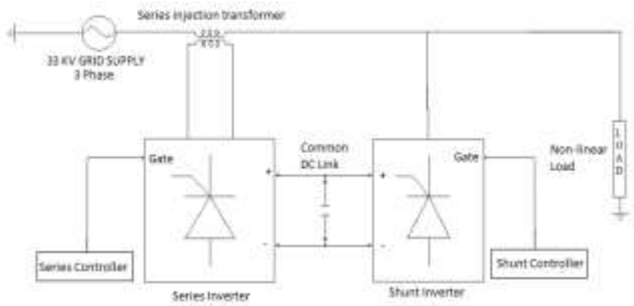

Fig.1: UPQC general block diagram

4) Series injection transformer that is used to connect the series inverter in the network. A suitable turn ratio is often considered to reduce the current or voltage rating of the series inverter [3].

1.2 Operation strategy of UPQC

Loads, such as, diode bridge rectifier or a thyristor bridge feeding a highly inductive load, presenting themselves as current source at point of common coupling (PCC), can be effectively compensated by connecting an APF in shunt with the load. On the other hand, there are loads, such as Diode Bridge having a high dc link capacitive filter. These types of loads are gaining more and more importance mainly in forms of AC to DC power supplies and front end AC to DC converters for AC motor drives. For these types of loads APF has to be connected in series with the load. The voltage injected in series with the load by series APF is made to follow a control law such that the sum of this injected voltage and the input voltage is sinusoidal [1].

1.3 PID CONTROLLER

A Proportional-Integral-Differential (PID) Controller is a genetic control loop feedback controller. It calculates an “error” value as the difference between a measured process variable and a desired set point and also attempts to minimize the error by adjusting the process control inputs. The PID controller calculation (algorithm) involves three separate constant parameters, and is accordingly sometimes called **three-term control**: the proportional (P), the integral (I) and derivative (D) values. These values can be interpreted in terms of time: P depends on the present error, I on accumulation of past errors, and D is a prediction of future errors, based on current rate of change. These three terms are added together to produce a control signal that is applied to the system being controlled. The “three-term” functionalities are highlighted by the following:

The proportional term- providing an overall control action proportional to the error signal through the all-pass gain factor.

The integral term- reducing steady-state errors through low-frequency compensation by an integrator.

The derivative term- improving transient response through high-frequency compensation by a differentiator.

2. METHEDOLOGY

In this mechanism we are using PID controller. Voltage and current series and shunt parameters are given by the ref value and compared to the values given by the abc to dq block which gives resultant output to the controller used. This proposed controller uses two types of input i.e. inverting input and non-inverting input.

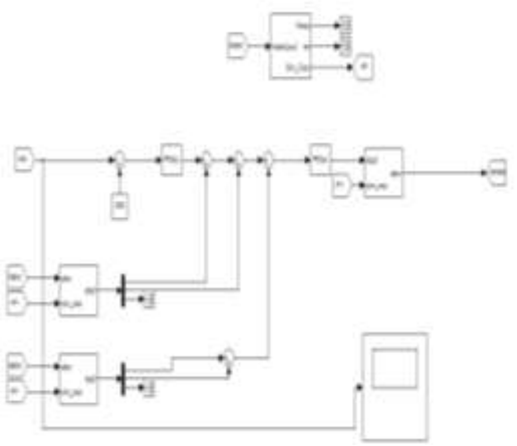

Fig. 2: UPQC simulation model using PID controller

In this scheme, load current and source current reference inputs are given to the abc to dq0 block and via multiplexer these are given to the PID output which is the compared value of V_{dc} with the standard 230 volts and then after comparing values again it is given to dq0 to abc block which gives voltage shunt values for all the phases abc.

3. RESULT AND DISCUSSION

Unified Power Quality Conditioner (UPQC) is used in the power system for power quality improvement and reduction of harmonics.

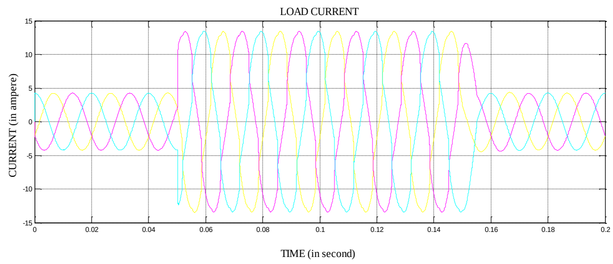

Fig.3: Load Current with PID controller

Fig. 3 shows the load current of all the three phases I.e. phase a, phase b, phase c using PID controller. Here distortion arises between 0.05 to 0.15 seconds.

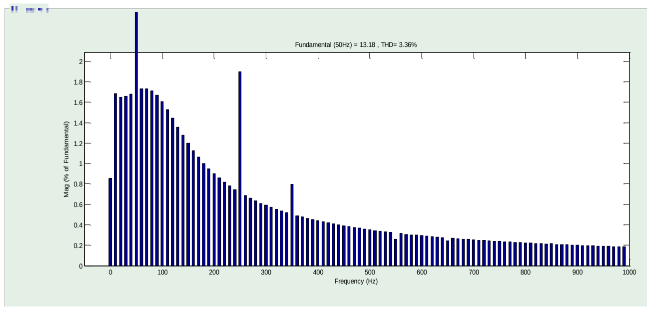

Fig.4: THD spectrum of Source Current of phase- A with PID controller

Fig. 4 shows the Total Harmonic Distortion (THD) of source current of Phase-A with PID controller and value obtained is 3.36% fundamental Frequency (50Hz).

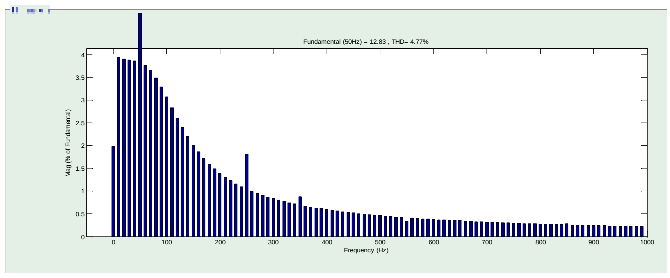

Fig. 5: THD spectrum of Source Current of phase- C with PID controller

Fig. 5 shows the Total Harmonic Distortion (THD) of source current of Phase-C with PID controller and value obtained is 4.77% fundamental Frequency (50Hz).

4. CONCLUSION

PID controller is mostly used control technique which is simple and easily understandable technique but the optimum transient response is difficult of optimize hence PID controller is combined with another software computing technique. The result of the above paper work shows that the UPQC gives good performance for compensation of THD in current parameters based on PID controller. The THD output of current parameter of UPQC has been obtained.

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