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POWER QUALITY IMPROVEMENT IN AC-DC CONVERTER BASED ON PID CONTROLLER AND SPWM

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Abstract: Power quality management is major issue today. Power conversion ac-dc and power quality suffers from operating problems of poor power factor, injection of harmonics into the ac mains, variations in dc link voltage of input ac supply, equipment overheating. In power system harmonic cause is normal problem that is increase losses and stability of electric system. Due to ac-dc conversion is harmonic current absorption, voltage distortion due to the voltage drop caused by harmonic currents flowing through system impedances. Here is proposed 3 Leg ac-dc converters, which are improved power quality ac- dc converters. Proposed system is control output dc voltage by varying the modulation index. Here used PID controller based control system which control voltage and current variation through inject 3rd Harmonic Injection. The main emphasis of this investigation has been on a compactness of configurations, simplicity in control, reduction in rating of components, thus finally leading to saving in overall cost. In this is based on varying R load. For bidirectional power flow applications, the current source converter is designed and simulated with R load. Proposed model is simulated MATLAB environment and optimized power quality.

Keywords: Power quality improvement, PID Controller, SPwm, AC-Dc Converter, # leg Converter, Harmonic Reduction

I. INTRODUCTION

Electrical power is one of the growing factors in our community. Power generation, transmission, distribution and usage were accepted for important changes that influence on electrical quality and performance requirements of our current century industry. Quick consumption of fuel holds, regularly expanding vitality request and contemplations over worldwide environmental change move control age from sustainable power sources. An electrical system that includes multiple loads and distributed energy resources that can be operated in parallel with in the border utility grid is called micro grid. Many countries generate electricity in large centralized facilities; these plants have excellent economies of scale, but usually transmit electricity long distances and can negatively affect the environment. Distributed generation allows collection of energy from many sources and may give lower environmental impacts and improved security of supply. Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in the same building. This also reduces the size and number of power lines that must be constructed. Voltage drops, voltage swells, transient over-voltages, harmonics and grounding related troubles are the most common PQ criticisms among the American customers (Sandesh Jain et al. 2012). In 2001, the European Copper Institute has completed a PQ review casing 1,400 places in 8 countries of Europe. It is predicted that harmonic alteration, power supply dependability, voltage drops and electromagnetic compatibility are the most significant subjects for the countries of the European Union (EU) (Sakshi Bangia et al. 2013). In earliest days, to reduce harmonic distortion they used passive filters. To conquer the disadvantage of conventional passive filters the power system engineers predicted active filters to shrink the enlarged harmonic distortion in electric power networks. For current and voltage interruption in power distribution system, active filters play an essential role in power problems. One of the standard complimentary conditions of utilizing an active filter over the passive filter is that it can be utilized to decrease the effects of harmonics. In such circumstances, it is attainable to make use of the active device relatively than passive ones with a precise end goal to give self-motivated compensation and power factor enhancement (Pedro Rodriguez et al. 2009). Intelligent controllers are used to activate the power electronics devices (Insulated Gate Bipolar Transistor) present within the shunt active power filter (SAPF) for dropping the existence of harmonics within the system and to enhance power factor (George & Agarwal 2005).

In this thesis, the efficient closed loop controller to optimized power system is implemented with different load conditions for three phase source and intelligent controller were used to alter the current harmonics and to progress the power factor. According to IEEE Standard, “Power quality is the idea of powering and training responsive equipment”. The power is essential for all the electrical components. For proper working of the electrical components, the power quality must be retained. If the power quality is reduced, the equipment could get spoiled or it can break down even in a standard conditions. The other types of power problems are because of the exceeding are power factor alteration, capacitor crash, circuit breakers for non-visible reason, computer nonfunctional, communication breakdown, conductor failure owing to heating, electronic equipment shutting down, sparkling of fluorescent lights, fuses carried without reason, motor defective and overheating, unbiased conductor and terminal breakdown, overheating of metal attachment, power intrusion on voice communication and transformer malfunctions on overheating. The power quality issues are voltage drops, harmonic distortion and small power factor. Voltage drop come into the wire line when the lines are jammed. Harmonic distortion is produced due to the intrusion of noise and non-linearity of power electronic strategies. Low power factor is the consequences of inductive loads. In olden days electrical components were considered to meet exclusive issues like over loads, short circuits and lightning. In the order to improve the phase, power electronic devices were initiated. Hence the electrical components cannot be calculated with equal features. The most important problem with power systems is non-linearity caused by components like inductors and transformers. The power electronic devices are tremendously nonlinear and they turn to produce switching losses continuously (Sandesh Jain et al. 2012).

The main emphasis of the investigation has been on compactness of configurations, simplicity in control, reduction in rating of components, thus finally leading to saving in overall cost. Based on these considerations, a wide range of configurations of power quality mitigators are developed for providing a detailed exposure to the design engineer in selection of a particular configuration for a specific application under the given constraints of economy and the desired performance. Fig 1 Block diagram 3 phases AC-DC Converter.

Electricity is that the most advantageous sort of vitality for modern, rural, business and local exercises; it's the key contribution for the monetary and mechanical improvement of a rural. As of late, nations wherever the planet have fixated fabricate, transport, correspondence still as robotization goes ahead huge scale and to deal with moderate development they need a property power offer to understand their natural procedure objectives However, this state of affairs is sort of dismal because of the subsequent challenges [16]. Hybrid systems arise once the continual and therefore the separate meet. Consolidate Continuous and separate information sources, yields, states, or elements, and you have a half and half framework. Prominently, half and half frameworks emerge from the work of limited state rationale to administer nonstop physical procedures (as in installed administration frameworks) or from topological and arrange imperatives interfacing with constant administration (as in organized control frameworks) [17] sunlight based photovoltaic and twist sources due to their eco-pleasing nature and Cost practicality. The fundamental innate disadvantage of star photovoltaic and wind systems area unit their irregular nature [8].

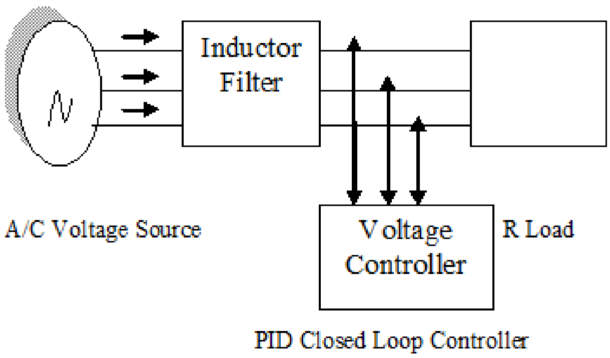


Fig. 1: Block diagram 3 phase AC-DC Converter

II. PROPOSED METHOD

In modern years, increased use of power electronics in manufacturing companies and economic processes ends up in harmonics enhancement and less power factor to the electrical power system (Suresh Kumar et al. 2011). Traditionally, in order to overcome this kind of problems, passive R-L-C filters have been utilized. Basically Harmonics in power distribution system is overviewed as harmonic current or harmonic voltage which is a multiple of total number of system frequencies or fundamental frequencies. Harmonic Order in the electrical system has different list of harmonics based on the function of order. Harmonic order or harmonic number is a correlation to the frequency of the harmonic element (Ahmad Z Albanna and Constantine J Hatziadoniu 2010).

$$F_h = (h) * \text{fundamental frequency or line frequency} \quad (1)$$

Where h = Integer value

For illustration purpose, first order harmonics of the system will be equal to the line frequency. The 3rd harmonic of a system can be represented by above given formula. Assume system frequency as 50 Hz.

$$F_3 = 3 * 50 = 150 \text{ Hz} \quad (2)$$

Fifth harmonic is almost given by

$$F_5 = 2 * 50 = 250 \text{ Hz} \quad (3)$$

Harmonics are the main reasons for power supply contamination. Due to this reduction of power factor and enhancement in electrical losses will occur. The influence of harmonic results in premature faults and joint catholicity the reason for need of apparatus in high rating. The voltage distortion generated in the system is the main problem with the harmonics diffusion. There are different kinds of harmonics in the system. From that the triplen harmonics produces serious impacts.

A. Synchronous Reference Frame (SRF)

Real currents are changed into a synchronous orientation frame during this method. The reference frame is coordinated with the AC mains voltage and it is revolving at an equal frequency. In this scheme, the reference currents are imitative straight from the real load currents though it does not permit for the supply voltages, which signify the most essential features of this system. The generation of the reference signals is not plagued with distortion or voltage disturb, consequently swelling the benefit hardihood and enactment (Tanrioven and Alam 2006).

The synchronous reference frame theory or d-q theory is based on time-domain reference signal estimation techniques. It performs the operation in steady-state or transient state as well as for generic voltage and current waveforms. It allows controlling the active power filters in real time system. Another important characteristic of this theory is the simplicity of the calculations, which involves only algebraic calculation. The basic structure of SRF controller consists of direct (d-q) and inverse (d-q)-1 park transformations as shown in fig.2. These can useful for the evaluation of a specific harmonic component of the input signal The reference frame transformation is formulated from a three-phase a-b-c stationary system to the direct axis

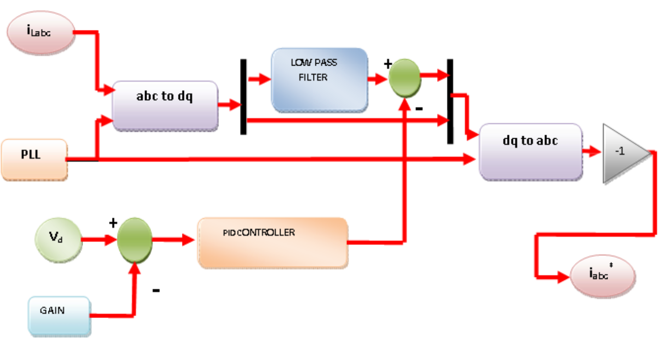


Fig.2 Synchronous d-q-0 reference frame based compensation algorithm

(d) and quadratic axis (q) rotating co-ordinate system. In a-b-c, stationary axes are separated from each other by 1200 as shown in fig. 3 The instantaneous space vectors, Va and ia are set on the a-axis, Vb and ib are on the b-axis, similarly Vc and ic are on the c-axis.

These three phase space vectors stationary coordinates are easily transformed into two axis d-q rotating reference frame transformation.

The LPF is a second order Butterworth filter, whose cut off frequency is selected to be 50 Hz for eliminating the higher order harmonics. The PID controller is used to eliminate the

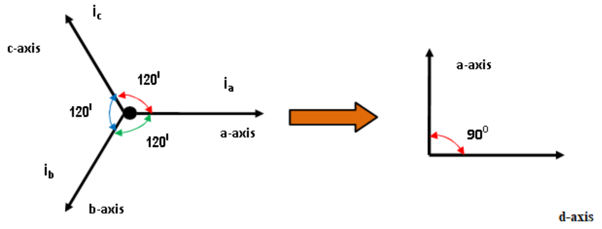


Fig.3 A-b-c to d-q-0 transformation

Steady-state error of the DC component of the d-axis reference signals. Furthermore, it maintains the capacitor voltage nearly constant. The DC side capacitor voltage of PWM-voltage source inverter is sensed and compared with desired reference voltage for calculating the error voltage. This error voltage is passed through P-I controller whose propagation gain (KP) and integral gain (KI) is 0.1 and 1 respectively.

B. Modeling and Design of PID Controller

The first evolution of the PID controller was developed in 1911 by Elmer Sperry. However, it wasn't until 1933 that the Taylor Instrumental Company (TIC) introduced the first pneumatic controller with a fully tunable proportional controller. A few years later, control engineers went eliminate the steady state error found in proportional controllers by resetting the point to some artificial value as long as the error wasn't zero. This resetting "integrated" the error and became known as the proportional-Integral controller. Then, in 1940, TIC developed the first PID pneumatic controller with a derivative action, which reduced overshooting issues. However, it wasn't until 1942, when Ziegler and Nichols tuning rules were introduced that engineers were able to find and set the appropriate parameters of PID controllers. Often these two requirements conflict with each other and cannot be satisfied in the single-degree-of-freedom case. By increasing the degrees of freedom, it can be reach up to the satisfaction of both. Finally, a very powerful computational approach with MATLAB to search optimal sets of parameter values to satisfy given transient response specifications(such as that the maximum overshoot in the response to the unit-step reference input be less than a specified value and the settling time be less than a specified value). This approach can be directly applied to the design of high- performance control systems.

The PID controller is widely employed because it is very understandable and because it is quite effective. One attraction of the PID controller is that all engineers understand conceptually differentiation and integration, so they can implement the control system even without a deep understanding of control theory. Further, even though the compensator is simple, it is quite sophisticated in that it captures the history of the system (through integration) and anticipates the future behavior of the system (through differentiation).

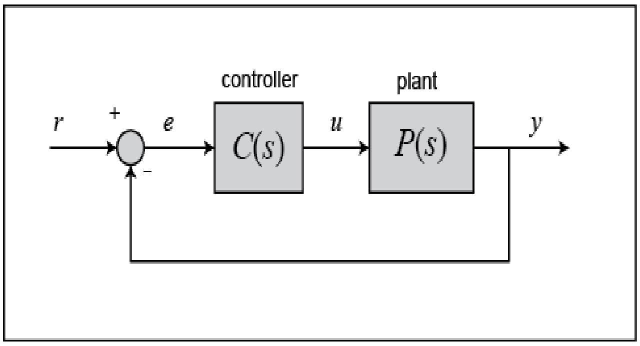


Fig 4 Block PID Controller

The output of a PID controller, which is equal to the control input to the plant, is calculated in the time domain from the feedback error as follows:

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_p \frac{de}{dt} \quad (4)$$

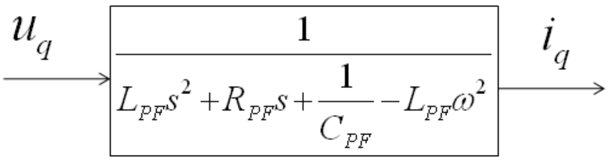
First, let's take a look at how the PID controller works in a closed-loop system using the schematic shown above. The variable (e) represents the tracking error, the difference between the desired output (r) and the actual output (y). This error signal (e) is fed to the PID controller, and the controller computes both the derivative and the integral of this error signal with respect to time. The control signal (u) to the plant is equal to the proportional gain (K_p) times the magnitude of the error plus the integral gain (K_i) times the integral of the error plus the derivative gain (K_d) times the derivative of the error.

This control signal (u) is fed to the plant and the new output (y) is obtained. The new output (y) is then fed back and compared to the reference to find the new error signal (e). The controller takes this new error signal and computes an update of the control input. This process continues while the controller is in effect.

The transfer function of a PID controller is found by taking the Laplace transform of Equation (1).

$$K_p + \frac{K_i}{s} + K_d s = \frac{K_d s^2 + K_p s + K_i}{s} \quad (5)$$

where K_p = proportional gain, K_i = integral gain, and K_d = derivative gain.



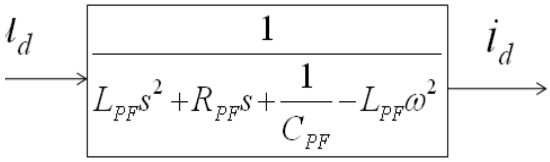


Fig.5 Block diagram of the closed loop system

III. Simulation Results

The simulation results are obtained through Power System toolboxes in SIMULINK by taking system parameter as given below.

A. System Parameters

The system parameters considered for proposed system which is used input and output section is given below in Table 1.

Components	Specifications
AC Source	V_s=230vrms, f=50 Hz
Nonlinear Load	R_L=2-10(Ω)
Passive Filter	L_{PF}=1(mH),R_{PF}=0.1(Ω),
Output	800v Dc

B. MATLAB Based Modelling and Simulation

To demonstrate the performance of these passive filters feeding a three-phase converter with R load, these passive filters are modeled in MATLAB environment along with SIMULINK and power system block set toolboxes. Different components of these converters such as low pass filter with R load are simulated in MATLAB/SIMULINK. Fig. shows the MATLAB model of a inductor filter based six pulse ac-dc converters with R load. Depending on the harmonic spectrum of the supply current, the passive filters designed

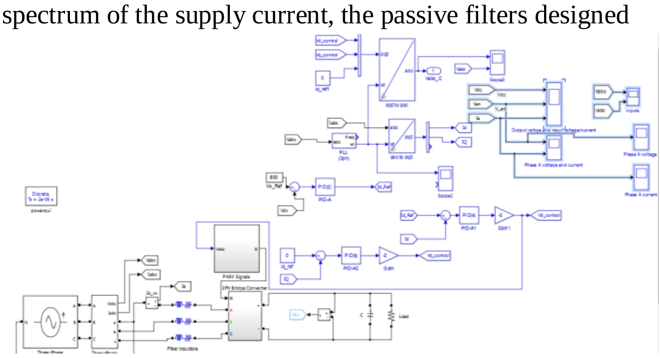


Fig.6 MATLAB based model of a six pulse ac-dc converter R load with filter

are low pass filter tuned for 3th order harmonic frequency. Based on the design carried out the filter component values are L=1mH, R=0.1Ω.

C. Results and Discussion

The configuration of proposed model has been simulated and developed for six pulse ac-dc converter with R load. The performance of proposed model based converter with R load is shown in below Fig.

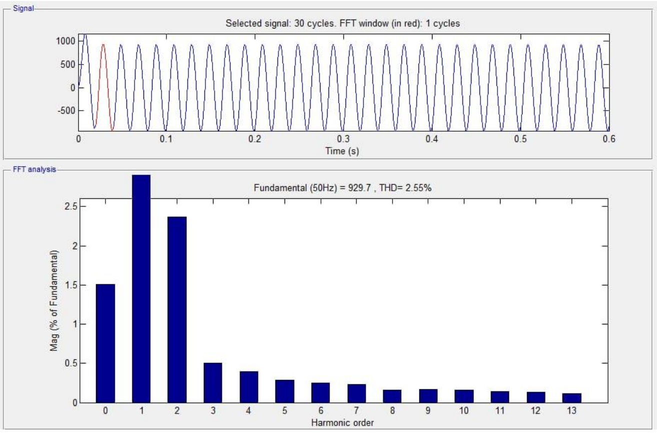


Fig. 7 Current THD analysis with 20% load

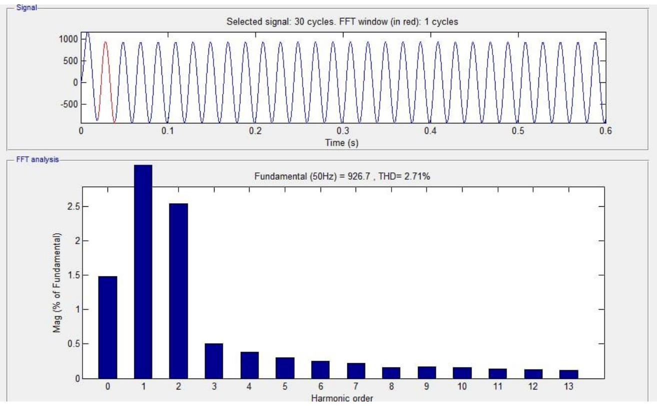


Fig. 8 Current THD analysis with 100% load

Figure 7 and 8 is show current total harmonic distortion based on different load. When we change load power facture also change as we see on figure.

TABLE 2 Compare table based on THD

Load	^{V}THD	^{V}THD (Proposed)	^{I}THD	^{I}THD (Proposed)
20	1.2	0	5.2	2.55
40	1.5	0	4.9	2.65
60	1.8	0	4.5	2.68
80	2.1	0	4.1	2.70
100	2.4	0	3.6	2.71

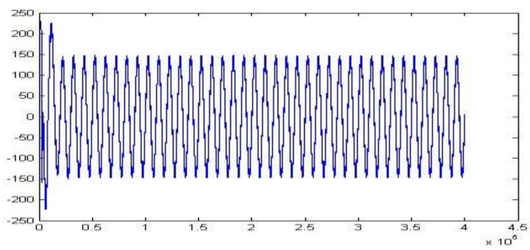


Fig 9 Current

IV. CONCLUSION

The main objective of this proposed model to optimized power quality ac-dc circuit with different load capacity and investigation has been to evolve different power quality improvement techniques for improving various power quality indices at ac mains as well as on dc bus in ac-dc converter with R load. It has also intended to determine factor that is direct and indirect involves to generate harmonic and eliminated that to optimized power. This research work has been on developing configurations suitable for retrofit applications, where presently a six pulse diode bridge rectifier is being used. The obtained results of various circuit configurations of front end ac-dc converters is show previous chapter and have demonstrated successfully fulfilling these objectives.

The effect of load variation and corresponding variation of power quality study.

- Optimized power quality with load varying capacity in ac-dc circuit.
- Proposed efficient converter which optimized power quality.
- Closed loop controller is used to controller voltage and current variation.
- The system represented by linear models at each harmonic frequency.
- The precise evaluation of harmonic distortion must have accurate load modeling.
- Hence developed 3 leg, 3 phase 3 level ac-dc converter to optimized power quality.

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