IMPROVEMENT OF POWER QUALITY IN SMART HOUSEHOULD WITH THE THSe ACTIVE FILTER

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Abstract

This paper we have explained the concept of how Multilevel- THSeAF a structure Transformer less Hybrid Series Active Filter planned to boost the facility quality of single-phase residential houses. It also covers improvement of power quality for contemporary single-phase system and stress integration system of a compensator. Important characteristics of the system include ability to clean the grid and correct the power factor simultaneously. It also enquires effect of harmonic assesses and compensates the impact of the controller's choice. The executed test cases on these systems have been validated properly.

Keywords: Multilevel- THSeAF, harmonic assesses, single-phase system, Transformer.

1. Introduction

In 1882 it was not possible to increase voltage for long distance transmission which was carried out using DC, so overcome this problem engineers introduced AC current and later on three phase power systems was developed. These traditional power systems were designed assuming ideal component with insignificant non-linearity behavior and that the power flows from the grid to consumers and not vice versa. The decision of investment on sustainable sources in the 20th century increased the desire to reduce usage of natural resources and decrease the pollutant emissions. However, there were certain rumors to extract power from these alternative resources like firstly these sources were not capable enough to produce constant power due to their energy characteristics and secondly their unpredictable behavior. Also, they have low commercial efficiency Furthermore they require more expensive and advanced components and controllers. The traditional power system faced the employment of distributed generation which was unable to manage power flow from multiple sources, which led to the introduction of smart grid concept.

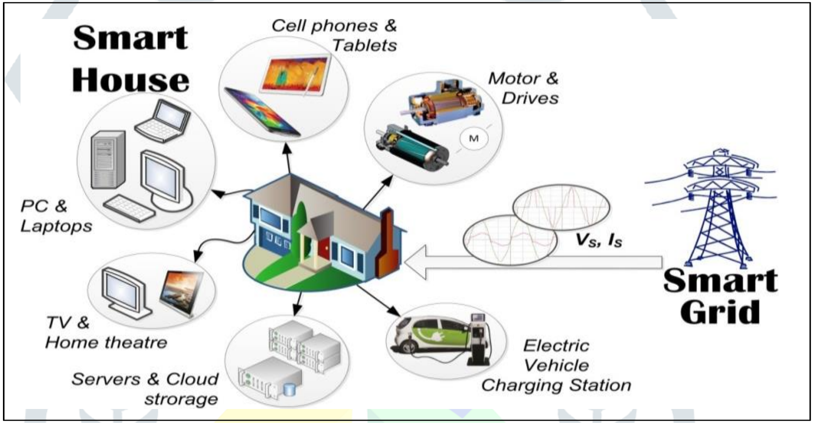


Fig.1 Pictogram of a smart residential consumer with common nonlinear electronic loads

2. Literature Survey

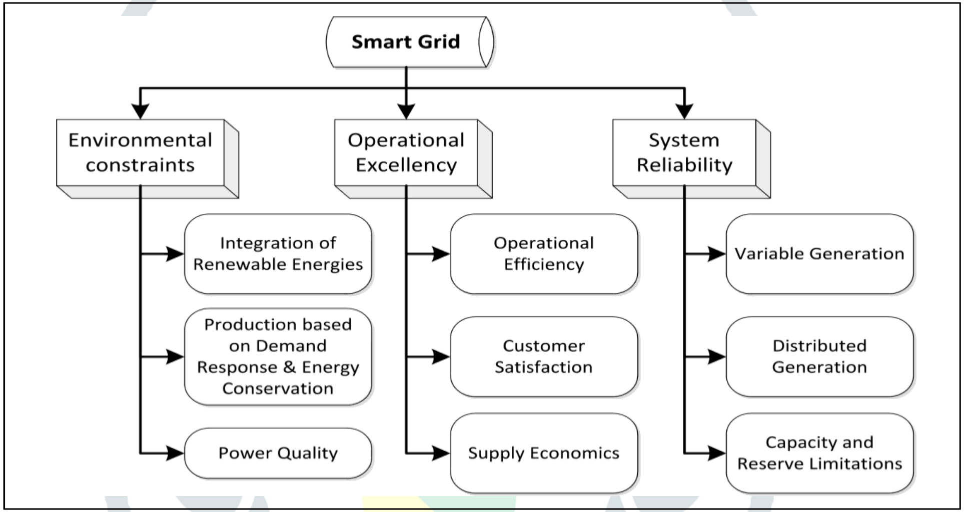


Fig.2 Overview of a smart grid operational flowchart

The growing concern in power quality can be explained using the below points

- The power quality of current gets deteriorated from nonlinear load because of current harmonic pollutions. This has created a concern for the power network.
- They inject undesired harmonics causing increase of the current magnitude, which indeed increases

the losses and overall heating. A low efficiency of the system and failure of the electrical equipment are some of multiple problems that current distortions may create if they are not appropriately compensated (Singh et al., 2005; Singh, Chandra et Al-Haddad, 2015; Zoabi, 2014);

- The solution to deliver a high reliable and high-quality electric power upsurge of more aware and stringent consumers power suppliers, this means they require a clean stable voltage and distortion free consumers terminals for this three phase system.

3. System Architecture

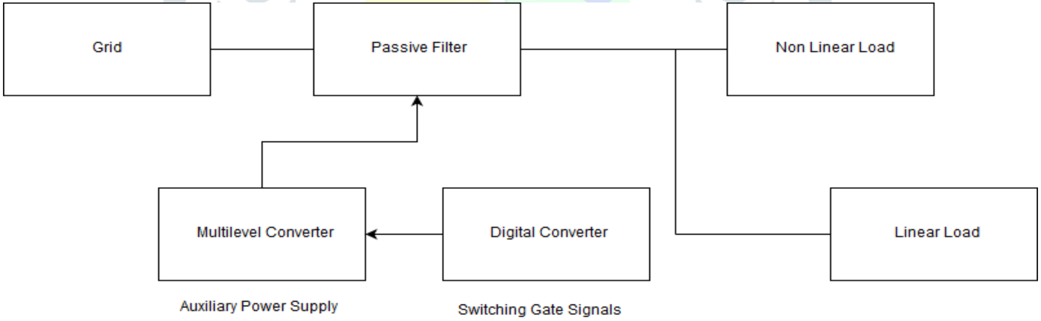


Fig 3. System Architecture

4. Proposed Algorithm

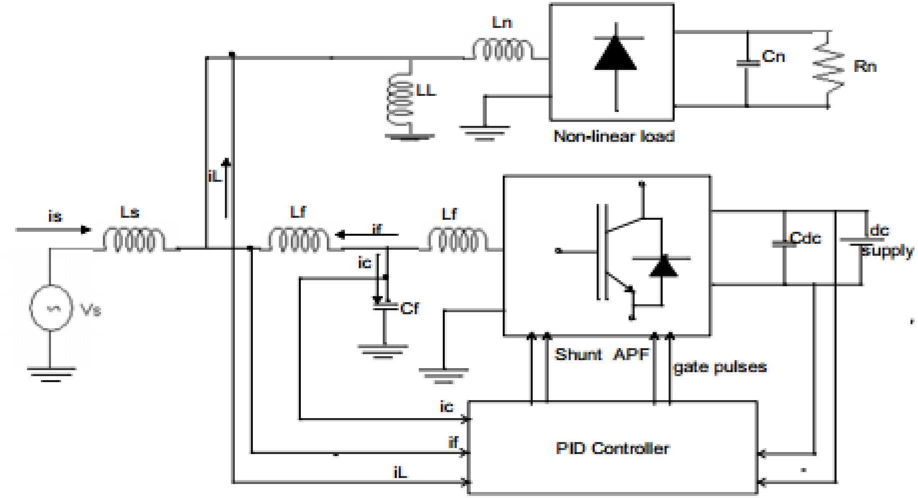
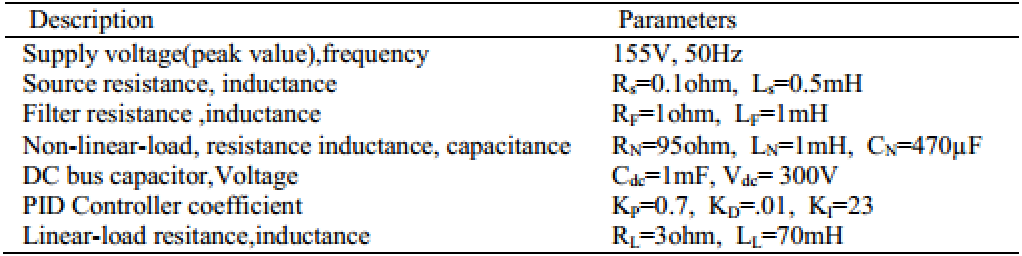


Figure 4 Block Diagram of Proposed Model

Above is the proposed block diagram of proposed model, it is used to reduce the hormonic inline current to convert it to sinusoidal having almost zero phase difference with supply voltage. it also improves the load power factor. For this we can connect a converter in shunt with the main converter so that it acts as nonlinear load. the shunt associated converter is a guarded rectifier having a semiconductor switching.

A separate dc power supply is provided to auxiliary converter connected in shunt with the non-linear load; this eliminates the requirement of transformer at supply end. Table 1 shows the values of configuration parameters that we consider as reference parameters for proposed circuit model.

Table1. Configuration Parameters



Description	Parameters
Supply voltage(peak value),frequency	155V, 50Hz
Source resistance, inductance	R_s=0.1ohm, L_s=0.5mH
Filter resistance ,inductance	R_F=1ohm, L_F=1mH
Non-linear-load, resistance inductance, capacitance	R_N=95ohm, L_N=1mH, C_N=470µF
DC bus capacitor,Voltage	C_{dc}=1mF, V_{dc}= 300V
PID Controller coefficient	K_P=0.7, K_D=.01, K_I=23
Linear-load resitance,inductance	R_L=3ohm, L_L=70mH

Here we have the overall mathematical analysis, describing the various current equations. The instantaneous equation of source current and source voltage is:

$$I_s'(t) = \sum_{n=1}^{\infty} I_n \mathrm{Sin}(n\omega t+\varphi_n) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$I_s'(t) = \underbrace{I_1 \mathrm{Sin}\,(\omega t+\varphi_1)}_{\text{Fundamental component}} + \underbrace{\sum_{n=2}^{\infty} I_n \mathrm{Sin}(n\omega t+\varphi_n)}_{\text{Harmonic component}} \;\ldots\ldots\ldots\ldots \quad (3)$$

$$I_s'(t) = \underbrace{I_1 \mathrm{Sin}\omega t \mathrm{Cos}\,\varphi_1}_{I_A(t)} + \underbrace{I_1 \mathrm{Sin}\omega t \mathrm{Sin}\varphi_1}_{I_R(t)} + \underbrace{\sum_{n=2}^{\infty} I_n \mathrm{Sin}(n\omega t+\varphi_n)}_{I_H(t)} \;\ldots\ldots\ldots \quad (4)$$

As this single-phase supply is connected to non-linear load (here diode bridge rectifier with R-L load), a non-sinusoidal line current is drawn from the supply with significant harmonic distortions, now supply current Is(t) becomes Is’(t), as explained by eqn 2-4

Hence now the supply current Is’(t) is phasor sum of active component (IA), reactive component (IR), and harmonic component (IH) of line current. Here our force approach is to atone IR and IH components from the line current by contraction of THD (total harmonic distortions). The power drawn by the non-linear load can be obtained by multiplying the source current given by equation 4 [Is’(t)] to source voltage given by Equation 1.

$$P_L(t) = I_s'(t) * V_s(t) \tag{5}$$

$$= V_m Sin\omega t\ [I_1 Sin\omega t Cos\ \varphi_1 + I_1 Sin\omega t Sin\varphi_1 + \sum_{n=2}^{\infty} I_n Sin(n\omega t+\varphi_n) \tag{6}$$

$$= V_m Sin\omega t\ I_1 Sin\omega t Cos\ \varphi_1 + V_m Sin\omega t\ I_1 Sin\omega t Sin\varphi_1 + V_m Sin\omega t \sum_{n=2}^{\infty} I_n Sin(n\omega t+\varphi_n \tag{7}$$

$$= P_F(t) + P_R(t) + P_H(t) \tag{8}$$

So, the all power drawn is phasor sum of principle power or active power PF(t), aware power PR(t) and harmonic power PH(t). If the gate pulse of IGBT, employed in VSI is applied in such a manner so that the harmonic power and reactive power is provided by the APF then only active power is drawn by the source, which is multiplication of IA(t) (given by eqn4) and Vs(t)

$$P_F(t) = V_s(t) * I_A\ (t) \tag{9}$$

Where IA(t) is the desired value of current Is’ ’drawn by the source so that the ac source is responsible only for active power PF (t)

$$P_F(t) = V_m Sin\omega t * I_1 Sin\omega t Cos\ \varphi_1 [17] = V_s(t) * I_A\ (t) \tag{10}$$

$$I''_s(t) = P_F(t)/ V_s(t) \tag{11}$$

$$I''_s(t) = V_m\ I_1 Sin^2\omega t\ Cos\ \varphi_1 / V_m Sin\omega t \tag{12}$$

$$I''_s(t) = I_1\ Cos\ \varphi_1\ Sin\omega t \tag{13}$$

$$I''_s(t) = I_{max}\ Sin\omega t \tag{14}$$

This is the sinusoidal current in phase with supply voltage. As it is clear from the block diagram (Figure 4) that two converters are connected in parallel, the out-put DC voltage of auxiliary converter is regulated with the help of controller in order to estimate the maximum value of supply current Imax and according to this value of reference current the gate pulse for IGBT’s are generated. As a result, the current injected by VSI is equal and opposite in phase with the harmonic component (I H) and reactive component (IR) of the line current.

$$I_F(t) = -I_R - I_H \qquad (15)$$

Let us apply Kirchhoff's current law at the junction point of common coupling PCC(13)

$$IL(t) = Is(t) + IF(t) \qquad (16)$$

The load current IL(t) is phasor sum of source current I S(t) and filter current IF(t). Here the out-put current of VSI is called as filter current as it is working as an Active Power Filter in combination with passive filter component Lf and Cf and a PID controller.

$$Is(t) = IL(t) - IF(t) \qquad (17)$$

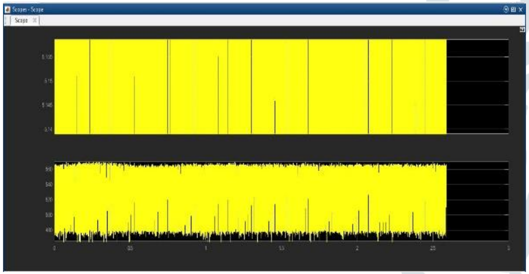
From Equation 4, 15 & 17, the load current IL= Imax Sinωt which in-tern is equal to the reference value of supply current.

5. Applications

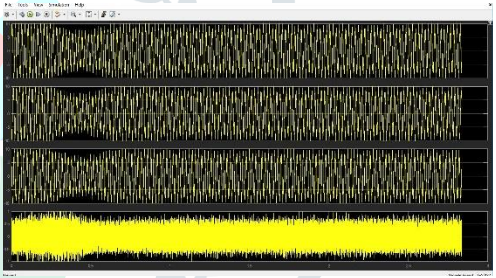
- Proposed model gives a very promising effect over the distortion introduced in harmonics as well as a significant improvement in total load power factor.
- This compensator eliminates supply harmonic currents and improves grid power quality with no have to be compelled to use the everyday large series electrical device.

- This proposed model may lead to the scope of a reliable and sustainable supply.
- This proposed model leads to improvement of power quality for a modern single-phase system and due to the integration of a compensator with energy storage capacity it provides a sustainable supply.

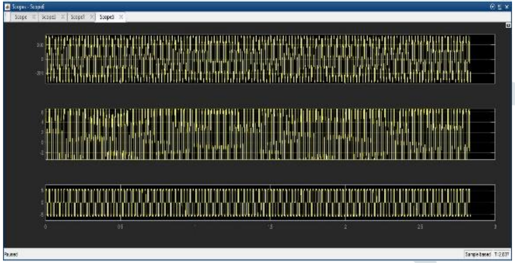
6. Simulation Results

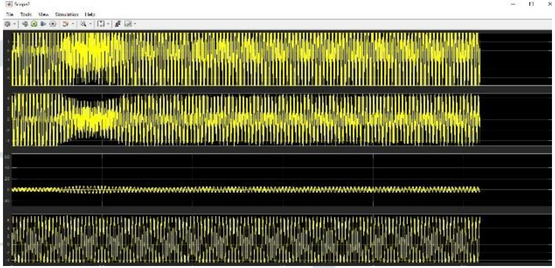


Current



Voltage





7. Conclusion

Renewable energy sources that are proliferating very rapidly are connected to the grid via resonant filters that may also interact with the grid impedances and can cause undesired EMI and resonance phenomenon. Therefore, the necessity of maintaining clean decoupled power is becoming an important issue since electric power quality is usually measured at generation, distribution and load levels. To improve power quality, a Multilevel-THSeAF was developed in this work based on the five-level NPC configuration. The key novelty of the proposed topology includes power quality improvement in a single residential building that may result to the enhancement of the global power system. Moreover, the configuration can regulate and improve the load voltage and when connected to a renewable auxiliary DC source, the topology is able to counteract actively to the power flow in the system similar to a UPS. Having a constant and distortion-free supply at load PCC, it was denoted that the active compensator responds well to source voltage variations. Furthermore, this compensator eliminates source harmonic currents and improves grid power quality with no need to use the typical bulky series transformer. It was established that this active compensator acknowledges properly to source voltage by giving a constant and distortion-free supply at load terminals. Furthermore, it eliminates source harmonic currents and improves power quality of the grid without the usual bulky and costly series transformer. The proposed transformer less configuration was simulated and experimentally validated.

8. References

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