MITIGATION OF SWITCHING FREQUENCY BY UTILIZING SINGLE-STAGE ACTIVE POWER FILTER WITH A DOUBLE BAND HYSTERESIS CONTROL

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ABSTRACT - The main objective of this paper is mitigation of switching frequency by utilizing single stage active power filter with a Double band hysteresis control. For harmonic elimination and enhancement of power factor various control procedures have been presented for single-stage APFs. Among the current-control procedures, the traditional single-band hysteresis current control (SBHCC) has gotten much consideration because of its significant favorable circumstances. Notwithstanding the advantages, the SBHCC has major disadvantages that switching frequency is very high and more switching losses. These losses can be diminished by expanding the hysteresis band, to the detriment of diminishing the switching frequency. In this proposal, a double band hysteresis current-control (DBHCC) approach is presented for single-stage shunt active filters. It is additionally worth to take note of that the DBHCC It is additionally worth to take note of that the DBHCC conspire offers a little total harmonic distortion (THD) of the source current for little hysteresis band values. The steady state and transient execution of the proposed control conspire has been studied through simulations under a diode connect rectifier load, a diode connect rectifier with RL load and a triac-controlled resistive load. At that point, it is simulated by utilizing SIMULINK/MATLAB.

Keywords: Hysteresis Current Control Strategy, Active Power filter, SBHCC, DBHCC

1. INTRODUCTION

In a perfect power framework, electrical energy ought to be exchanged from the source to the load with the sinusoidal voltage and flow in settled frequency. Be that as it may presences of nonlinear components, particularly control electronic gadgets, in the different parts of the framework render this unimaginable. The harmonic current [1-4] mitigation on the power framework is expanding attributable to the basic utilization of intensity hardware in household, modern and business hardware. It is well realized that the distorted source current prompts poor power factor, expanded warming problems, and unsafe unsettling influence to different burdens which are tied at the point of common coupling (PCC). Although LC filters can be used for disposing of the undesirable harmonics and enhancing the power factor, they display many draw backs like resonance, fixed compensation capacity, and substantial size. Filter parameters may change because of temperature. As a solution for this, APFs are broadly utilized for wiping out the undesirable current harmonics and making strides the power factor. The shunt APF [5-23] is required to inject compensating current flows into the PCC for each stage. With the end goal to have the capacity to acquire sinusoidal supply flows which have no stage distinction with the supply voltages, the injected compensating currents must have a similar adequacy and 180^0 stage contrast to those of the load current harmonics.

The control techniques introduced [5,6] depend on PI control which requires four gains for effective task. The control strategy introduced has two separate parts, one for single-stage sinusoidal waveform generation and the other for the current-control which makes utilization of the HCC strategy [7-11]. Among the current-control procedures, the ordinary single band hysteresis current-control (SBHCC) plot offers higher accuracy, quick powerful reaction, robustness and simplicity in execution [12-16]. In spite of these points of interest, the SBHCC has a major disadvantage that the switching frequency is high at lower balance list which expands the switching losses. In standard, high changing frequency prompts a greatly improved waveform for the compensating current reference. These problems can be diminished by expanding the hysteresis band, to the detriment of diminishing the switching losses. In this way, the hysteresis band is to be made a tradeoff between switching losses and switching frequency of the APF [17-20].

Adaptive hysteresis current control (AHCC) approach defeats this issue by evolving the hysteresis band as a component of reference compensating current variations in order to keep the switching frequency about steady[24,25]. Despite the fact that this methodology gives palatable outcome, a settled switching frequency is obtained at the expense of additional signal processing and control complexity requirements. In this paper, a DBHCC technique for single stage shunt APFs is proposed. The DBHCC technique keeps up the benefits of single-band hysteresis control and at a similar time offers extra advantages such as reduced switching frequency and losses[24-25].The execution of the DBHCC procedure under semi square-wave stack flows is researched by PC recreations by utilizing Simulink of Matlab.

2. SURVEY OF EXISTING SYSTEMS

In this segment the techniques for controlling APFs. At that point, the principle technique of single-band hysteresis control strategy will be presented. APFs can be sorted into two general classifications, for example open loop and closed loop, in view of the control strategies. In open-loop frameworks, the load current and its harmonics are detected and APFs produce the compensating current and after that, inject it into the framework. Notice that this sort of frameworks would not have the capacity to check whether compensation methodology is successful or not. Closed loop frameworks can deal with this assignment with more accuracy by including an input loop into the framework and they incidentally utilize DSPs. The dominant part of new control strategies have been considered subdivisions of closed loop frameworks. Closed loop frameworks can be subdivided into five different methods as pursues:

- Constant-capacitor-voltage procedure
- Constant-inductor-current procedure
- Optimization procedure
- Linear-voltage-control procedure
- Other procedures

The above methods having lot of disadvantages like high switching losses and low accuracy. Consequently, we present the upgraded hysteresis control strategy double band hysteresis to beat this issue.

3. BLOCK DIAGRAM OF THE SYSTEM

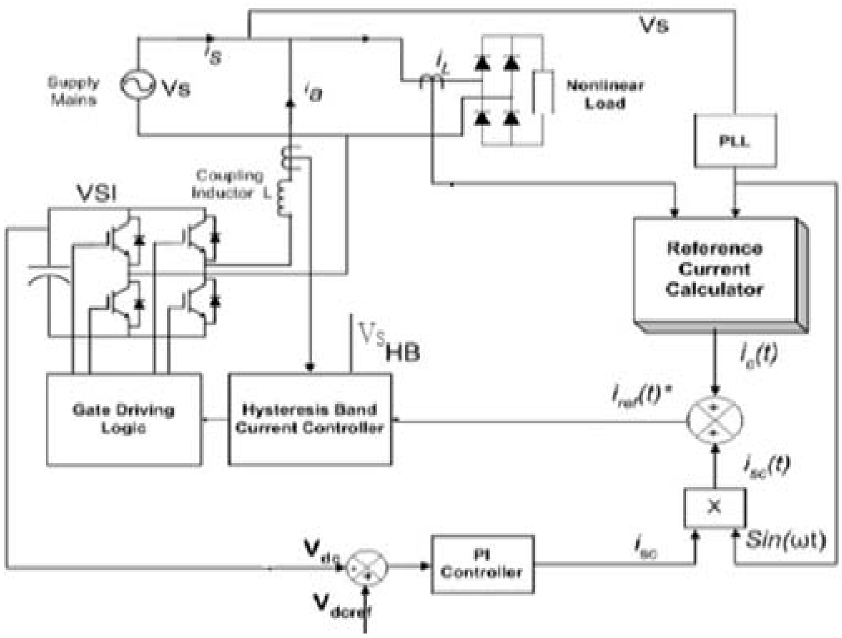

Fig.1. Block diagram of proposed single stage shunt APF.

Fig.1 shows a single-stage shunt APF design. It very well may be seen that the APF is associated with PCC which makes it shunt with the nonlinear load and mains supply. The active filter makes utilization of a voltage-source inverter (VSI) and DC link capacitor. The fundamental goal of the active power filter is to inject single-stage flows (i_{Fa}) into the PCC to accomplish sinusoidal supply flows (i_{sa}) at solidarity control factor which are disintegrated by the non-straight load flows (i_{La}). For a substantial activity of the framework, it is necessitated that i_{sa} is sinusoidal and have no stage contrast with e_{sa}. Activity of the single-stage shunt APF can be portrayed by the accompanying conditions.

4. SINGLE BAND HYSTERESIS CURRENT CONTROL

Single-band hysteresis current control strategy is one of the basic current control techniques where the real current is compelled to follow its reference current. In fact, this strategy confines the real current between two limits similarly displaced from the reference. It doesn't let the real current to leave the band between the limits by turning the switches ON and OFF [26]. The essential topology of hysteresis-band control is appeared in Fig.2.

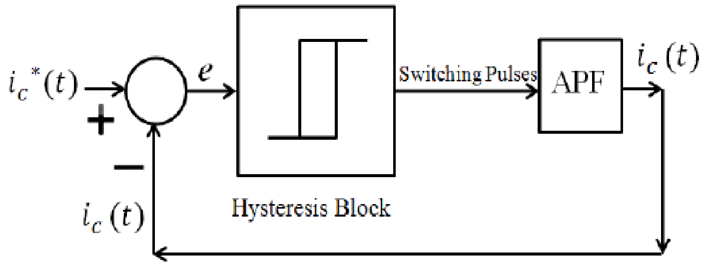

Fig.2. Hysteresis Band Basic Topology

Where, the reference current i_c^* is compared and the real current in the hysteresis band. At the point when the real current will in general diminishing accordingly, the pulse generator ought to produce $+Vdc$ when the incline is certain and $-Vdc$ when the slope is negative. As a result of this reason this procedure is named the two-level hysteresis control, and is represented in Fig.3.

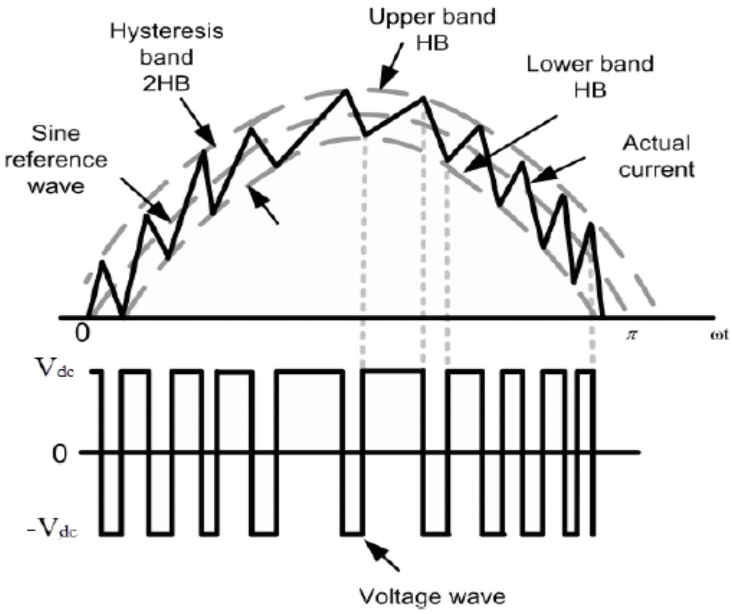

Fig.3. Two-level Hysteresis Band Operation

Note that, regardless of the higher accuracy, quick powerful reaction, and simplicity in usage, which are considered significant favorable circumstances of single-band current control, it has a disadvantage for example, high switching frequencies which gives rise to high switching losses. In this manner, we present the advanced hysteresis control technique (double band hysteresis) to defeat this issue.

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5. PROPOSED DOUBLE-BAND HYSTERESIS CURRENT-CONTROL

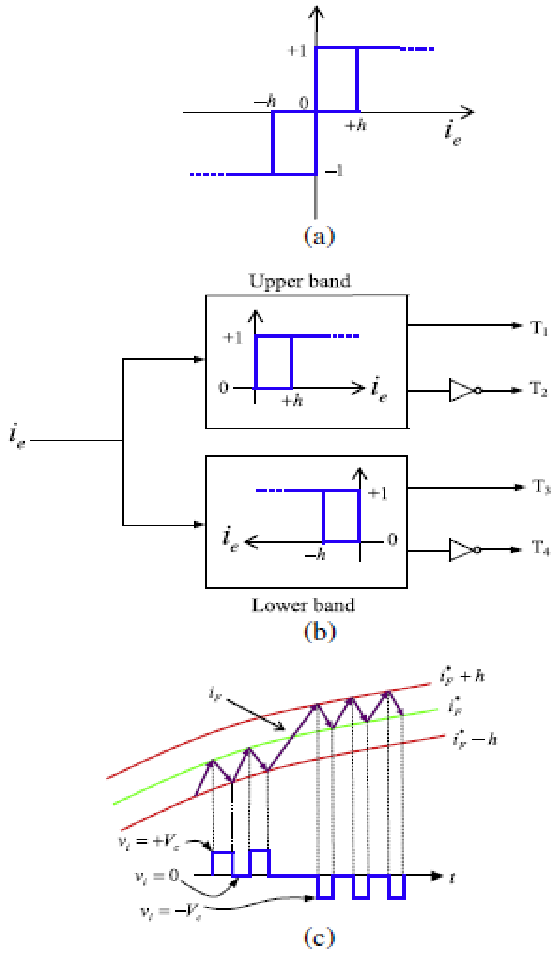

Fig.4. Double band hysteresis current control scheme (a) Double-band hysteresis function. (b) Two-level hysteresis functions. (c) Hysteresis switching.

As found in Fig.4, the reference current ic is contrasted and the real current in the double band hysteresis like single-band, yet there is a little distinction. It implies that the task of the double band hysteresis straightforwardly relies upon the mistake conditions as follows: When the error value is positive and the genuine current surpasses the recommended first upper hysteresis limit, first upper turn would be turned off and the first lower switch is turned ON as of now and when the real current passes the first lower limit while it diminishes, first upper switch would be turned ON and the first lower turn is turned OFF. It implies that the real current is limited by first upper and first lower limits, where the error value is positive. At the point when error value is negative and the real current tends to increment past the second upper limit, second upper turn would be turned OFF and second lower switch will be turned ON. At the point when the real current tends to decrease below the second lower limit, second lower turn will be set for keep this decent. In this circumstance the error is changing between second lower and second upper limits. Then again, single-band task is connected for both negative and positive blunder independently. Note that, the zero value can't be chosen for first lower and second upper limit values, in light of the fact that by choosing zero value, the dead-band space (the hole between first lower and second upper) will be expelled and it might turn the three-level activity to two-level. Thus, when the positive, negative and positive slope will likewise show up and the pulse generator ought to create $+Vdc$ and 0 where the slope is sure and negative separately. At the point when the mistake is negative, 0 and $-Vdc$ ought to be created for the positive and negative inclines separately.the belpow figure.5 shows the operation of **Double Hysteresis Band**

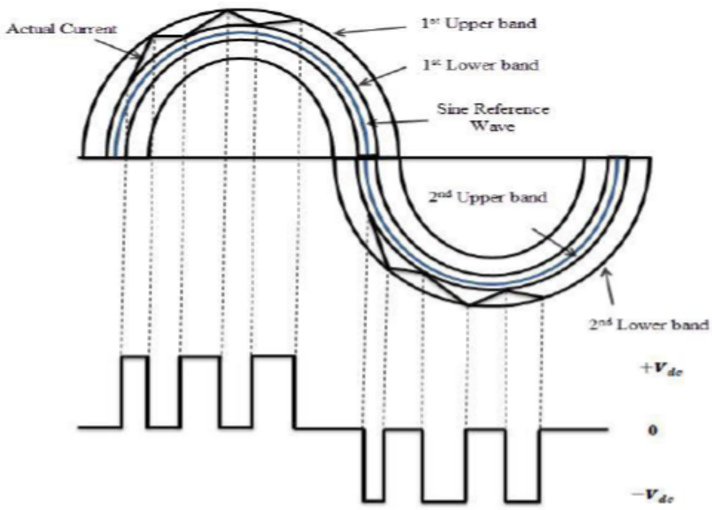

Figure 5: Double Hysteresis Band Operation

At the point when a comparative examination is performed to determine the statement of the on time of T1 (Ton), the accompanying expression can be acquired

$T_{on}= \frac{hL}{Vc-Vi}$ ……………………………………………1

At the point when active filter current mistake hits the lower hysteresis band at point I^*_f -h, T_1 is turned off and v_i =0. Substituting v_i =0 , gives question 2

$\frac{d\Delta iF}{dt} = \frac{1}{L} V_I$ ………………………………………………2

Amid the off period, the active filter current error changes from -h to 0 with a positive slope. Again, from the geometry of Fig. 4(c) and we can discount the time of T_1 as

$T_{off}= \frac{hL}{Vi}$………………………………..3

The exchanging time frame amid the positive half-cycle is gotten as

$T_s= T_{on}+T_{off}= \frac{hL}{(Vc-Vi)Vi}$ ……………..4

It ought to be noticed that the switching time frame got is for T1 and T2 in the half-cycle in which T3 is off and T4 is continuously on. Subsequently, the general switching time of the inverter in one cycle is twice of the period. Along these lines, the switching frequency amid one cycle is ascertained to be

$f_s^{2B}= \frac{Vc}{2hL}(msin\theta - m^2sin^2\theta)$……………5

The normal switching frequency more than one central period is acquired as eqn.6

$f_s^{2B}= \frac{Vc}{2hL}(\frac{2}{\pi}m - \frac{1}{2}m^2)$…………………………6

Unmistakably, the normal switching frequency winds up zero when the modulation index is zero.

6. SIMULATION RESULTS

I) EXISTING SYSTEM SIMULATION RESULTS

The execution of the DBHCC conspire has been assessed by utilizing the SimPowerSystems tool compartment of Simulink. The block diagram of the reenactment demonstrate with a diode connect rectifier load is appeared in Fig. 6.

The block named "activating" executes the double band hysteresis work as two separate capacities from which the exchanging control signals for the switching components are directly determined. The proposed DBHCC plan and its viability in relieving the switching frequency under various burdens, three nonlinear load types are considered: (I) diode connect rectifier load, (ii) diode connect rectifier with RL load, and (iii) triac-controlled resistive load. The diode connect rectifier load is worked by an arrangement resistor (Rs) with a diode connect rectifier associated with a capacitor (CL) in parallel with a resistor (RL).Fig.6. Shows the conventional double band hysteresis controller.

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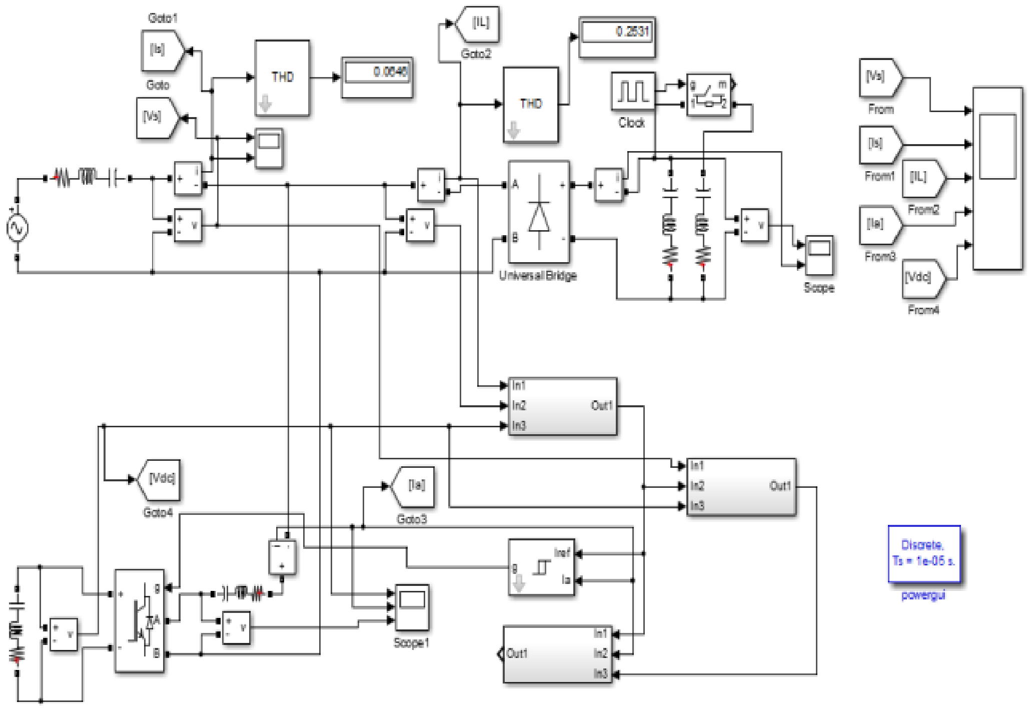

Fig.6. MATLAB/SIMULINK diagram of existing system

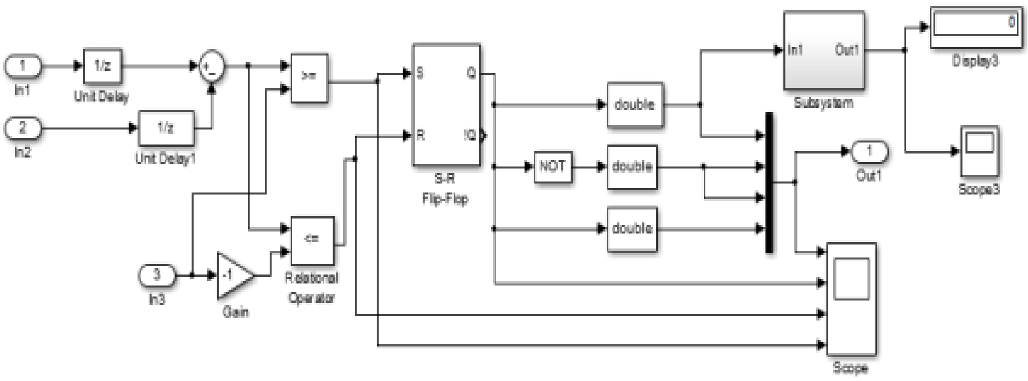

Fig.7. Subsystem of double band hysteresis of current controller

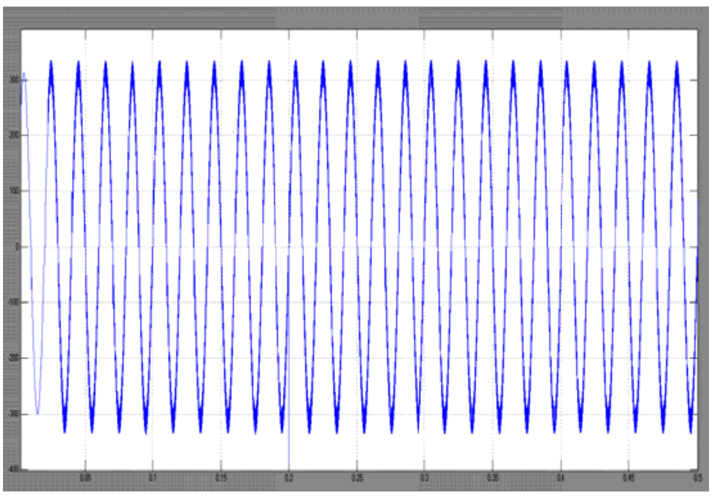

Fig.8. Waveforms of the source voltage (v_s)

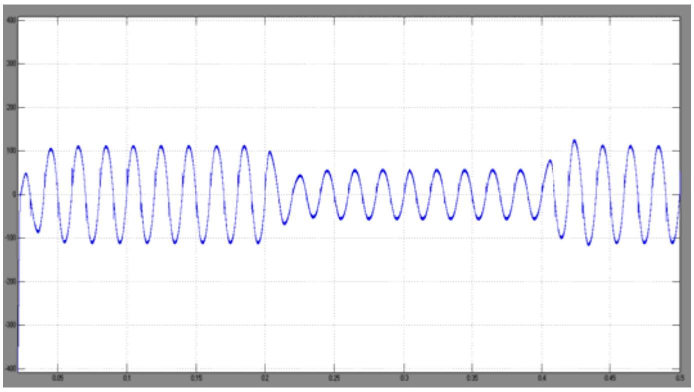

Fig.9. Waveforms of source current (i_s)

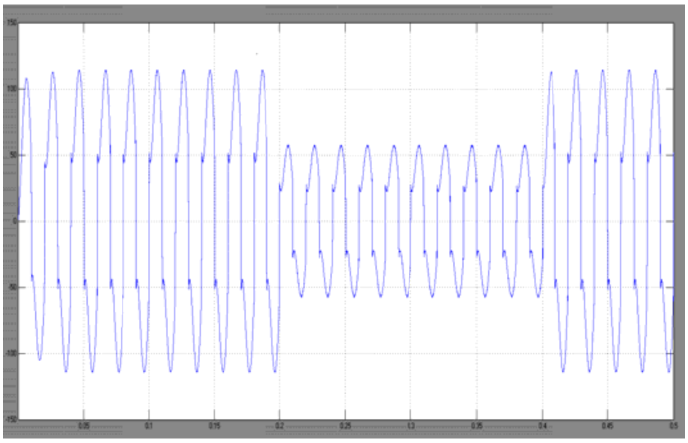

Fig.10. Waveforms of load current (i_L)

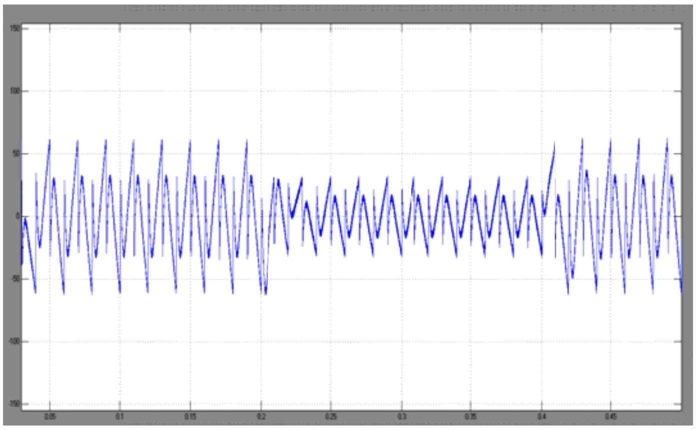

Fig.11. Waveforms of active filter current (i_F)

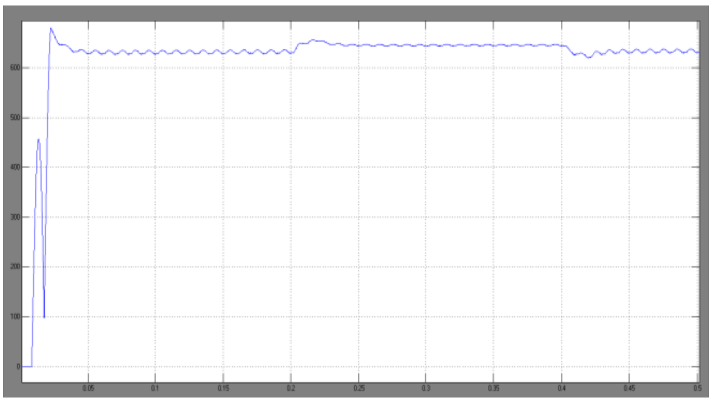

Fig.12. Waveforms of dc link voltage obtained by the DBHCC scheme for a diode bridge rectifier load with 0.1 to 0.3 sec

Fig.8 demonstrates the source voltage, Fig.9 demonstrates source current, Fig.10 demonstrates load current and Fig.11 demonstrates the active filter current gotten by utilizing the DBHCC conspire for the equivalent diode connect rectifier load. In spite of the non-sinusoidal load current, the APF framework effectively delivers a sinusoidal source current with unity power factor by controlling the active filter current. Note that the amplitude of ripple on the source current has been reduced impressively compared with that of acquired by the SBHCC plot. Looking at the registered THD s of the two methods for a similar diode connect rectifier load, the THD of source current gotten by the DBHCC method apparently is marginally smaller than that acquired by the SBHCC conspire. The primary reason of this difference comes from the distortions around the zero intersections of the current error in the DBHCC plot. The THD ranges source current is 11.45% shown in Fig.13 and The THD ranges load current is 26.40% shown in Fig.14

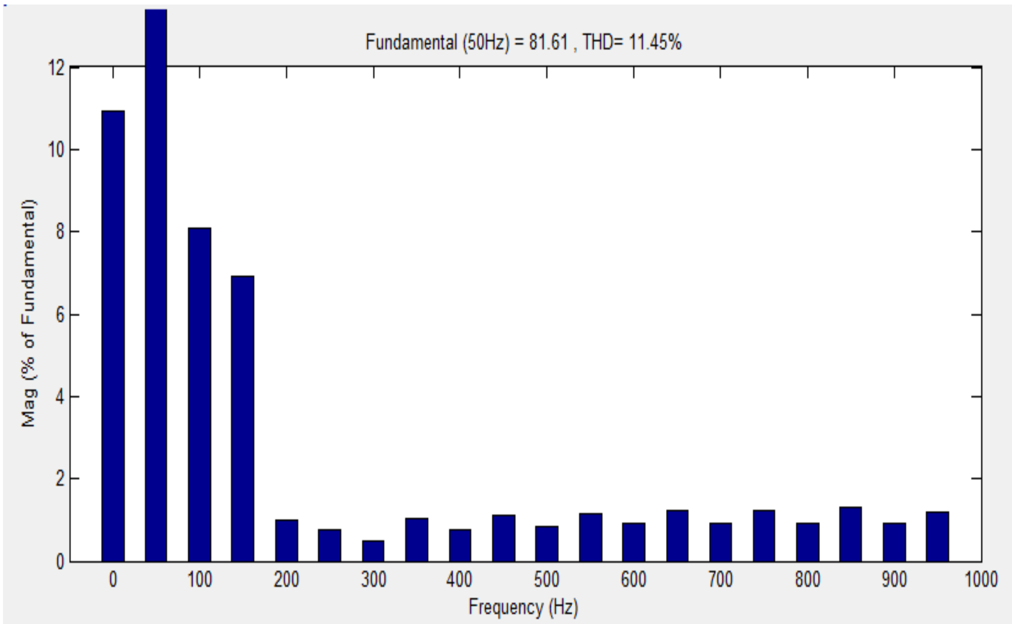

Fig.13. Harmonic spectrums of the source current correspond to the nonlinear load

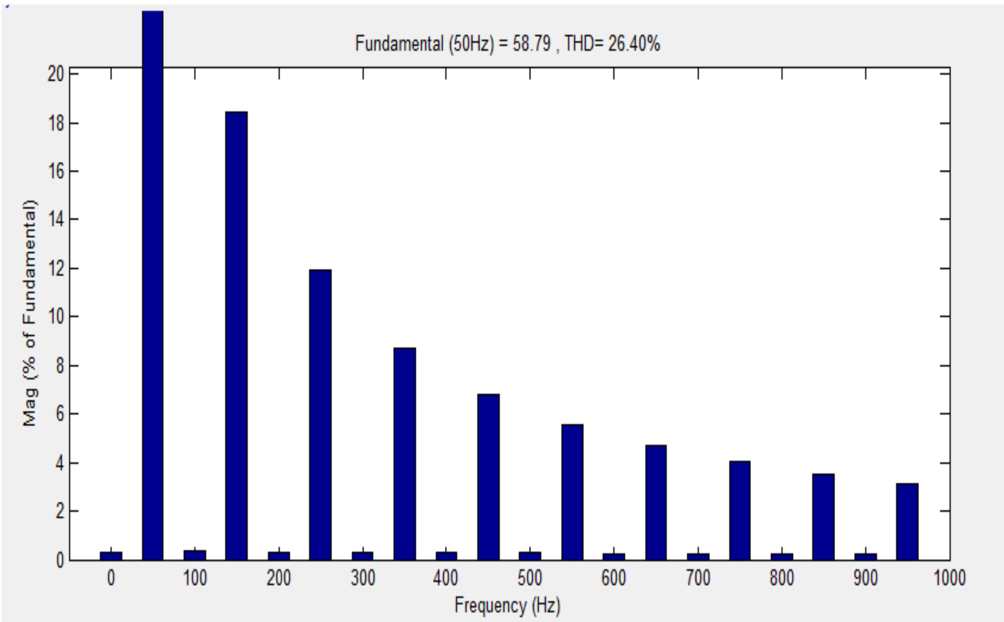

Fig.14. Harmonic spectrums of the load current correspond to the nonlinear load

II) PROPOSED SYSTEM SIMULATION RESULTS

Fig.15 shows the simulink model of DBHCC. The proposed system uses logic operators. So we can get the efficient results compared to existing system. Fig.16 shows DBHCC controller with logic operators like flip flops and Boolean expressions.

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Fig.17 shows the source voltage, Fig.18 shows source current,Fig.19 shows load current and the Fig.20 shows active filter current gotten by utilizing the DBHCC conspire for the equivalent diode connect rectifier load. Compare to existing model proposed model source current give less THD. The THD of source current is 2.01% [16,18]shown in fig.22 and The THD ranges load current is 25.91% shown in Fig.23

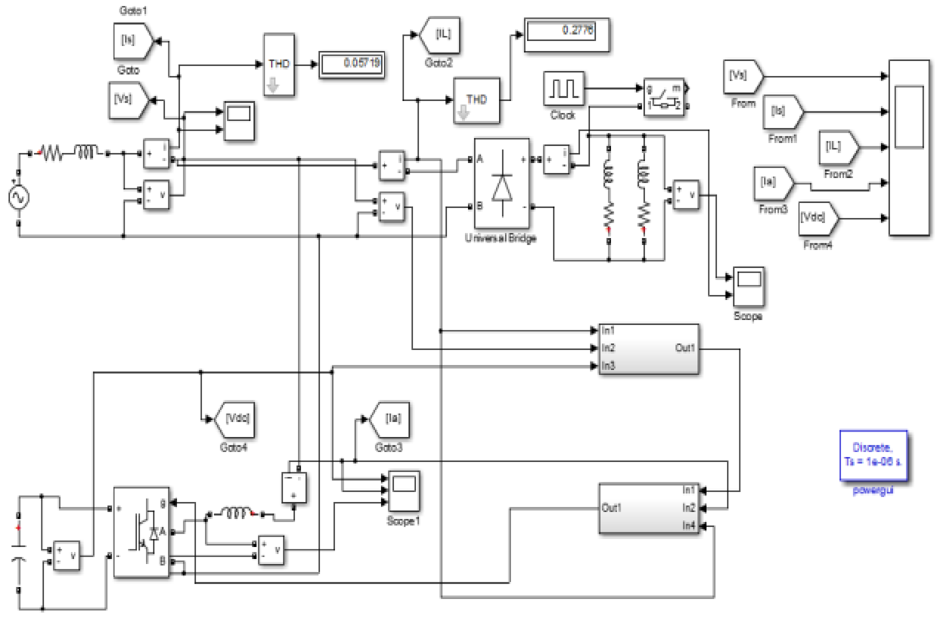

Fig.15. MATLAB/SIMULINK diagram of proposed system

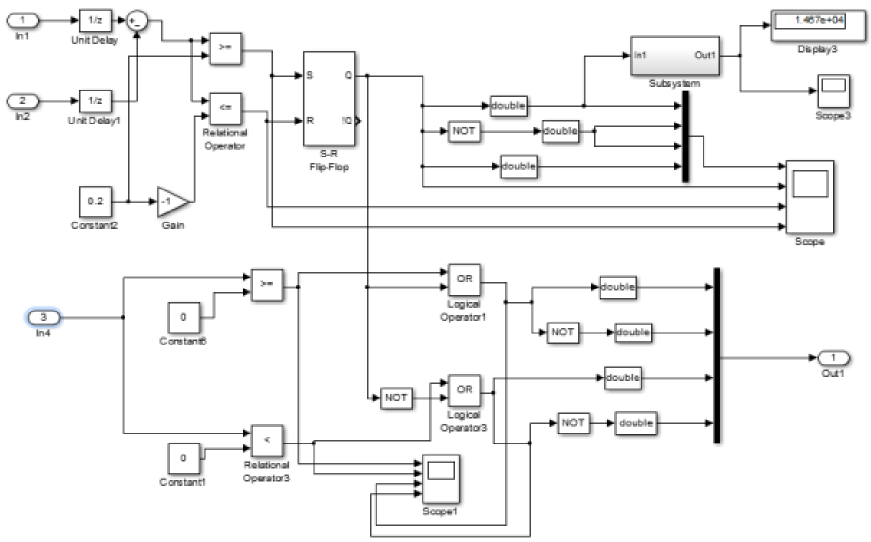

Fig.16. Subsystem of double band hysteresis of current controller

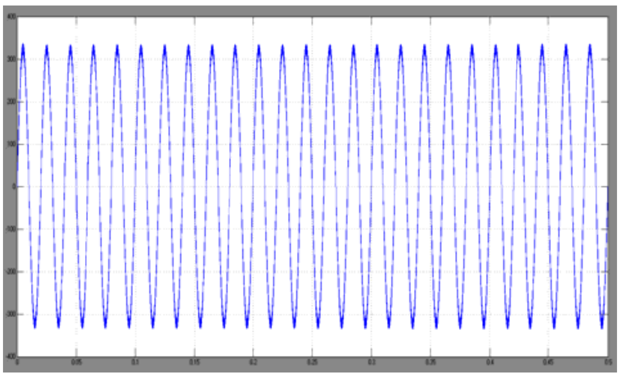

Fig.17. Waveforms of the source voltage (v_s)

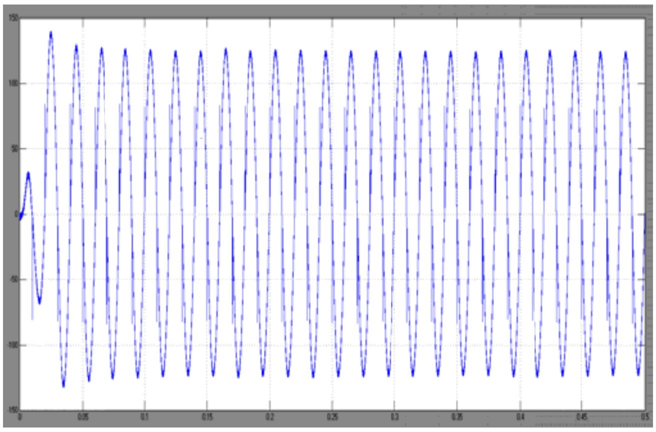

Fig 18.Waveforms of the source current (i_s)

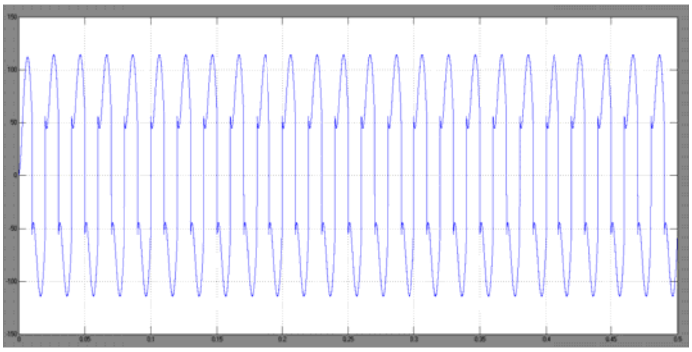

Fig 19.Waveforms of the load current (i_L)

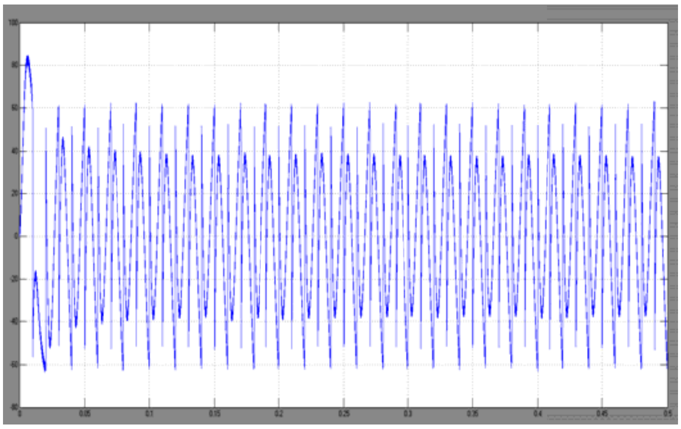

Fig 20.Waveforms of the active filter current (i_F)

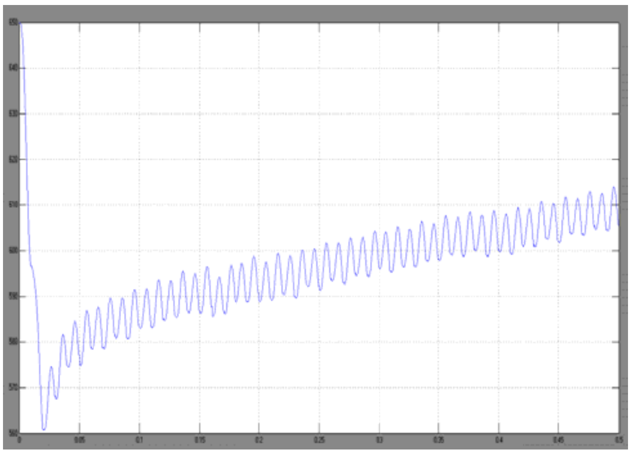

Fig 21.Waveforms of the dc link voltage obtained by the DBHCC scheme

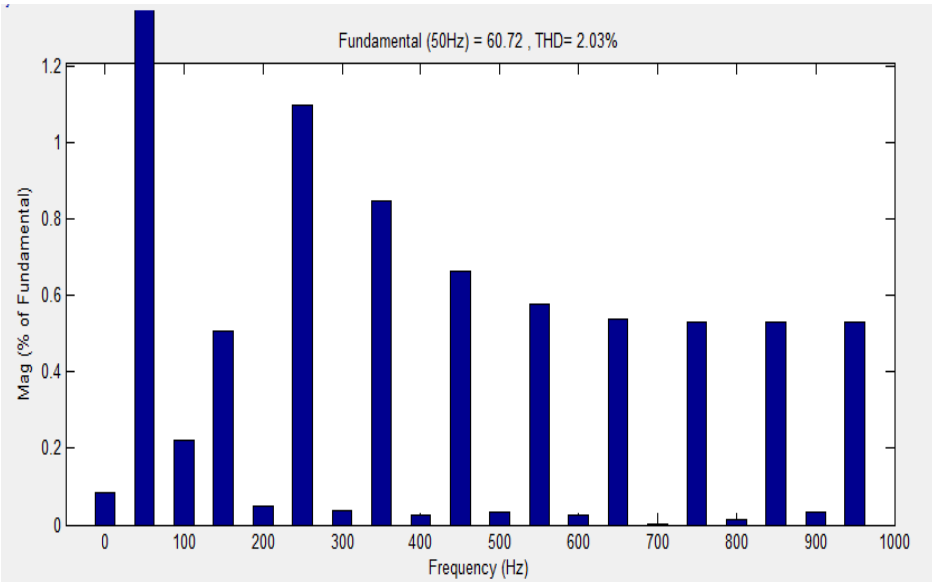

Fig.22. Harmonic spectrums of the source current correspond to the nonlinear load

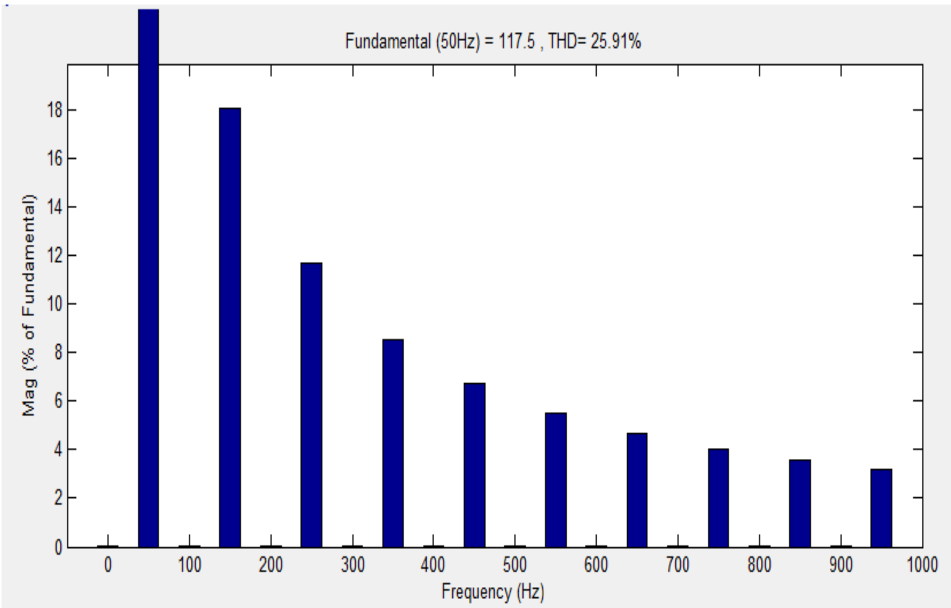

Fig.23. Harmonic spectrums of the load current correspond to the nonlinear load

Fig.24 demonstrates the simulated switching frequencies of the conventional DBHCC method for the diode connect rectifier with RL load. Fig.25. Demonstrates the switching frequencies proposed DBHCC current controllers. Switching frequency for the proposed DBHCC plot is very small than that of conventional DBHCC plot.

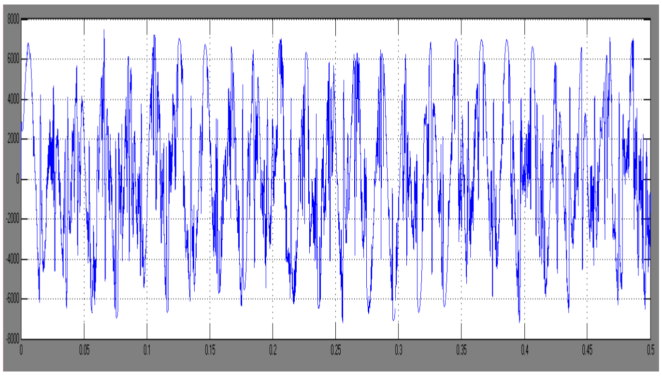

Fig.24. Wave forms of switching frequencies of conventional DBHCC schemes

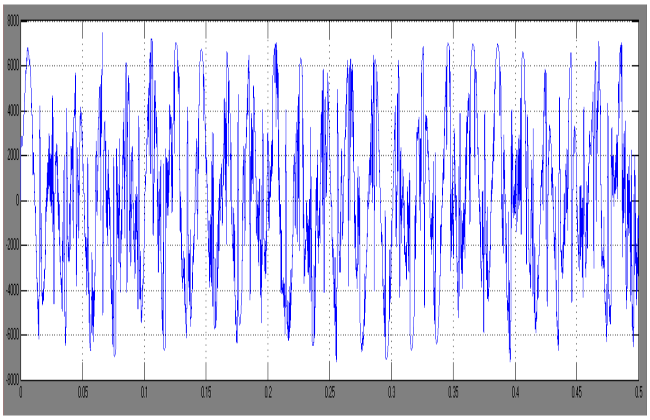

Fig.25. Wave forms of switching frequencies of Proposed DBHCC schemes

The proposed system parameters show in Table

Table.1 System parameters

System parameters	Values
Supply Voltage , V_s	325V
Supply Frequency	50Hz
DC Bus voltage, V_d	650V
Coupling Inductor, L	0.3mH
DC side capacitor	5000uf
Inductance of rectifier load	10mH
Resistance of rectifier load	5ohms

The below table shows the THD% conventional and proposed system

Table.2 THD% difference between conventional and proposed system

Hysteresis band	DBHCC Conventional (THD %)	DBHCC Proposed (THD %)
0.1	5.61	1.86
0.2	11.45	2.03
0.3	5.19	1.96
0.4	10.32	2.02

7. CONCLUSION AND FUTURE SCOPE:

The higher accuracy, quick powerful reaction, and simplicity in usage, which are considered significant favorable circumstances of single-band current control, it has a disadvantage for example, high switching frequency which gives rise to high switching losses. In this manner, we present the advanced hysteresis control technique (double band hysteresis) to defeat this issue.

The reference current generator and the double band hysteresis current controller are performed attractively. This work includes a basic procedure of multiplying the load current with the sinusoidal reference created by PLL is utilized in producing the instantaneous active component. The double band hysteresis adding machine powerfully modifies the hysteresis transmission capacity with the goal of steady constant switching recurrence. The source current waveform is in stage with the utility voltage and free from harmonic components. We can see that THD on source side has decreased from 11.45% to 2.01%. In this manner results demonstrate DBHC with conventional control effectively compensates both reactive power and harmonics. The switching frequency is additionally kept up almost steady and furthermore keeping up the benefits of the ordinary system.

As a future work, this proposed control technique is relied upon to be enhanced in not so distant future or it may be upgraded by changing the switching calculations and by applying different controller strategy for making currents able to follow their references as quick as could be expected under the circumstances. Likewise, there is a tremendous probability to decrease the settling time and making DC voltage steady in most limited time by enhancing PI-controller.

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