Analysis of Cascaded H-Bridge Multilevel Inverter for Effectiveness of APF with Integration Control

G.Nageswara Rao,

Abstract: ***An growth in non-linear hundreds that are recognised to generate harmonics inside the supply cutting-edge of an electrical network. to overcome this trouble, in place of the usage of passive filters, energetic power filters (apf) had been introduced to inject harmonic currents of the same amplitude and inside the opposite order of the segment present day harmonics in the load into the network. in an try to enhance the effectiveness of apf in source cutting-edge harmonics reimbursement, this paper affords the overall performance evaluation on the use of cascaded h-bridge multilevel inverter (chmi) with unified consistent-frequency integration (uci) as an apf in a single-phase machine. a simulation take a look at conducted the usage of matlab/simulink at the apf has shown advanced source contemporary overall harmonic distortion (thd) because the chmi number of output voltage ranges is multiplied..***

Index Terms*: *Active Power Filter (APF), Cascaded H-bridge Multilevel Inverter (CHMI), Unified Constant- Frequency Integration (UCI) Control.

I. INTRODUCTION

These days, the burden of electricity electronics-primarily based equipment which produces non-linear load is inevitable. the usage of rectifiers, uninterruptable energy components, motor speed manage and so forth. motive the occurrences of interference within the major electrical distribution device. these strength electronics gadgets produce harmonics or distortion of the deliver modern-day despite the fact that the efficiency and the reliability of the machine is expanded through various process control or utility gear[1]. to overcome the harmonic-associated problems, active energy filters (apf) were added [2] and used within the utility and commercial energy systems [3]. the apf is added to replace conventional passive filters (pf) in many programs due to the drawbacks of the latter while running with non-linear hundreds in particular under 1 mw [4]. The primary blessings of apf are the functionality of dealing with harmonics ranging between fluctuating frequencies and may be operated at a lower order harmonic. the apf will inject harmonic currents of the equal amplitude and inside the opposite order of the segment present day harmonics in the load into the electricity machine. as a result, the apf compensates both reactive power and harmonic currents drawn by means of the non-linear masses very correctly. the shunt configuration is the maximum popular in apf programs due to its functionality to compensate reactive power [5]. some product manufacturer refers apf as a power line conditioning. This paper provides the performance evaluation on the usage of cascaded h-bridge multilevel inverter (chmi) with unified steady-frequency integration (uci) as an apf in a single-segment device. a simulation examine is carried out using matlab/simulink on the apf and the consequences are shown to signify the overall performance before drawing a end.

II. MULTILEVEL INVERTER

The primary multilevel inverter become brought in 1981 [6]. the topologies of multilevel inverters may be categorized as cascaded h-bridge multilevel inverter (chmi), diode clamped multilevel inverter (dcmi) and flying capacitor multilevel inverter (fcmi). multilevel inverters in apf application has proven better performance while as compared to using the traditional three-degree inverters [7]. in trendy, the full harmonic distortion (thd) of a multilevel inverter output voltage decreases as the ranges are elevated [8]. the maximum popular multilevel inverter topology is the chmi because of its strong production and reliability. numerous modified chmi-based multilevel inverter topologies had been brought [9]-[12]. with such topologies, the output voltage degrees remain the same as the authentic chmi but the wide variety of energy switches used is substantially reduced.

A. *Unified Constant frequency Integration Control*

The unified steady-frequency integration (uci) control has been brought to improve the overall performance of an apf by means of imparting a low fee circuitry development and fast switching control loop. the apf with uci controller is based totally on the one-cycle manage (occ) principle [13]. by way of using the occ manipulate approach, most of the traditional voltage sensors and the multipliers in the manipulate loop are extinguished and the control circuitry will become simple and sturdy. essentially, a uci controller requires handiest principal sensing elements which location current and voltage sensor.

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The employment of an integrator with reset is the main element. the components including comparators, clocks and turn-flops are a part of the circuit that controls the output of the inverter in the apf. the output of the inverter draws the other signal of the reactive modern-day that is produced by means of the non-linear loads.In this example, many complicated measurements and calculations in the traditional apf have been abolished which includes the era of a cutting-edge reference, multipliers and size of the ac line voltage. determine 1 suggests the simple structure of a uci controller for the control of an apf in a single-segment gadget. The main goal of the h-bridge inverter in an apf is to supply the reactive and harmonic contemporary in reverse order as required by way of the non-linear load. as a end result, the net present day drawn from the ac source is continually basically sinusoidal with a fundamental lively electricity furnished to the non-linear load. determine 2 depicts the basic single-section complete-bridge shunt apf which consists of hands. arm a consists of switches s1 and s2 whilst arm b includes switch s3 and s4. all electricity switches in both arms are connected in series. c1 is a dc capacitor that acts as a dc source to the apf. it'll be charged through the supply at some point of the operation of the inverter electricity switches. referring to discern 1, r1 and r2 are the voltage divider that measures the voltage difference in capacitor c1 and sends the remarks signal to the uci controller whilst the charging procedure of c1 is modified. the voltage throughout c1 fluctuates consistent with the modifications inside the source modern-day. this is because of the non-linear load function that influences the perfectness of the source contemporary waveform in the gadget.

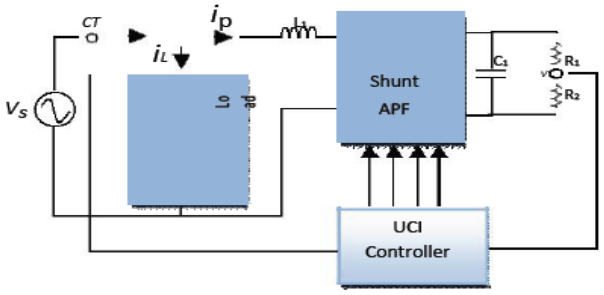

Figure 1: Basic structure of UCI in a single-phase shunt APF

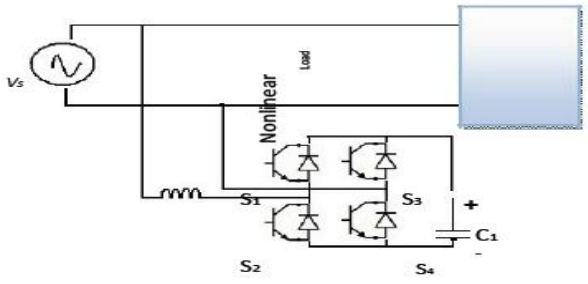

Figure 2: Single-phase full-bridge shunt APF

III. CONTROL IN A SINGLE PHASE APF SYSTEM

The application of uci manipulate in energetic power filtering has drastically been studied as provided in [14]. in a unmarried-segment apf system, uci manage has proven appropriate overall performance and is capable of operate in regular-state and dynamic conditions [15]. in a unmarried-section system, the primary configuration that utilizes a complete-bridge inverter connected in parallel with series resistors is as proven in figure 1. the difference inside the charging voltage in c1 is due to the occurrences of harmonic within the closed loop system. in brief, for the primary unmarried-phase machine, the uci control only calls for a unmarried current sensor to experience the main cutting-edge and a voltage sensor on the output aspect to degree the distinction inside the price of the capacitor voltage vc. figure three depicts the equal circuit of a single-section apf system. in this case, is is the source modern-day and rs is a current sensing resistor. re is the equivalent resistor that is used to emulate the non-linear load with the apf for important supply cutting-edge.

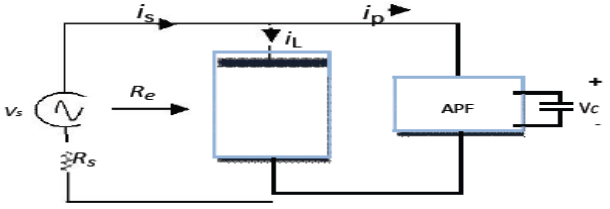

Figure 3: The equivalent circuit with resistor Re

From the equivalent model for inductor current and voltage waveform as explained in [15], the relationship between V_s and V_c are given as follows;

$$V_c = \frac{1}{1-2D} . V_s \qquad (1)$$

The control goal of the APF is supposed to be;

$$V_s = R_e * i_s \qquad (2)$$

Where $D = T_{on} / T_s$ is the duty ratio, $T_s = 1/f_s$ is the switching period and f_s is the H bridge inverter switching frequency.

Figure 4 shows the schematic diagram of a uci manipulate for an apf in a single-section machine. vc is the voltage distinction at the apf capacitor. the motive of the pi controller is to preserve the dc voltage value which has been saved within the capacitor and produce the output mistakes voltage, vm. the error vm is then included and the output is compared with the vm - rs* is cost. all switches sw1, sw2, sw3 and sw4 are turned on and rancid while the clock pulse is fed to the flip-flop as a set s signal. the switching procedure repeats in every switching cycle within the responsibility ratio d. the overall manage procedure satisfies the manage intention of an apf as follows

$$2DV_m = V_m - R_s * i_s \qquad (3)$$

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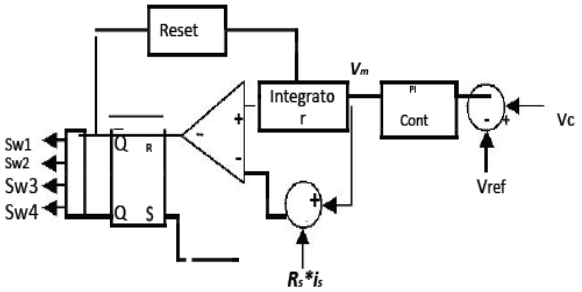


Figure 4: The structure of UCI in single-phase shunt APF

IV. METHODOLOGY

In this paintings, a chmi-based totally apf with uci control in a unmarried-segment electric community has been designed. the apf should produce a nearly sinusoidal deliver modern-day with the lowest possible percentage thd. to gain the objective of the work, the methodology of the paintings has been designed with 3 principal tasks. the first challenge is to research the imperfectness of the source contemporary waveform which is drawn through standard non-linear masses in a single-segment electricity device. as in determine five, the non-linear load taken into consideration on this paintings is an rc load that's coupled with a rectifier. the principle ac source is set to 240 vrms. determine 6 depicts the matlab/simulink model of a single-phase system feeding the non-linear load. the second mission involves the improvement of the simulation model of the traditional 3-stage h-bridge inverter followed by the 5-degree and seven-level chmi. the third segment pertains to the layout and development of the uci switching manage method. parent 7 indicates the simulation model of a five-degree chmi apf with uci manipulate. parent eight specifically indicates the uci control structure for the five-degree chmi apf.

Figure 5: The non-linear load representation

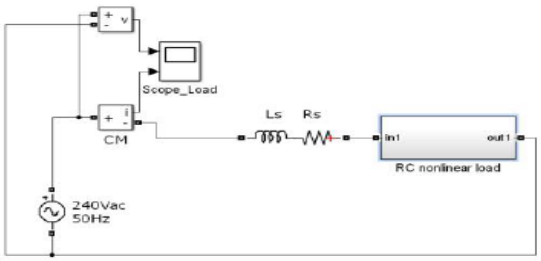


Figure 6: A single-phase system with non-linear load

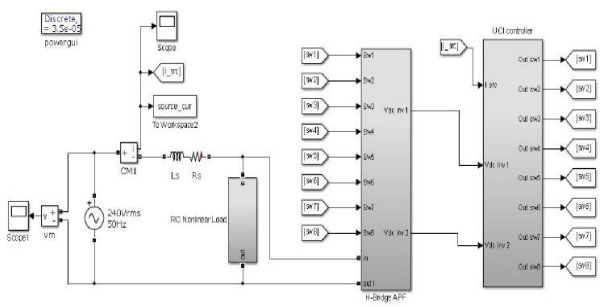


Figure 7: Simulation model of a single-phase 5-level CHMI APF with UCI control

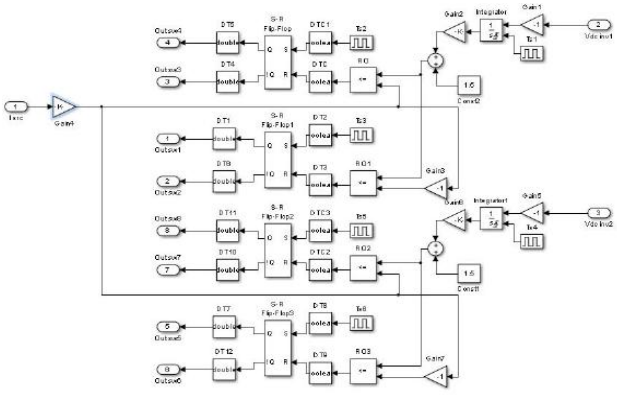


Figure 8: UCI control structure for the 5-level CHMI APF

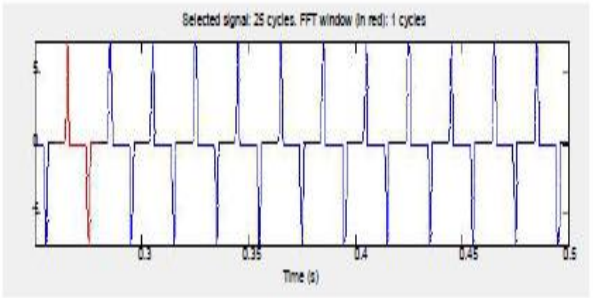
V. EDITORIAL POLICY

The submitting author is responsible for obtaining agreement of all coauthors and any consent required from sponsors before submitting a paper. It is the obligation of the authors to cite relevant prior work.

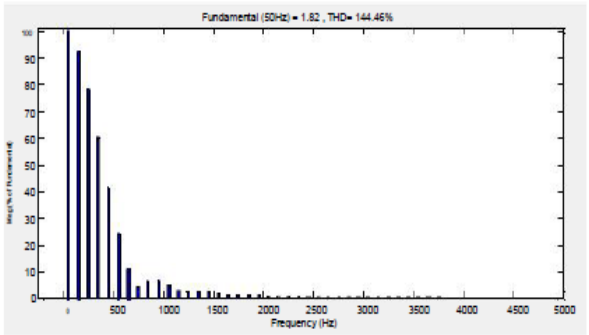
Authors of rejected papers may revise and resubmit them to the journal again.

VI. RESULTS AND DISCUSSION

Figure 9(a) and (b) depict the source current waveform and its harmonic spectra respectively for a single-phase system feeding non-linear loads. The THD of the source current is 144.46%, as indicated by Figure 9(b).



(a)



(b)

Figure 9: Single-phase system feeding non-liner loads (a) Source current (b) Harmonic spectrum

Desk 1 is derived from the simulation take a look at performed on three exclusive inverter configurations as lively energy filters with uci control. for comparison functions, three exclusive configurations are taken into consideration particularly the conventional 3-degree h-bridge inverter and the non-conventional five- degree and 7-stage chmi. the use of the three-degree h-bridge inverter as an apf, the deliver contemporary has surprisingly decreased from 144.46% (with out filter) to fourteen.88%. this contain using 4 electricity switches. by doubling the range of strength switches with the five-level chmi configuration, similarly reduction of about four% is finished within the supply modern-day thd. with the 7-level chmi, although the range of strength devices has accelerated from four to 12, the supply contemporary thd is reduced by approximately 7%. this suggests that with the aid of growing the range of output voltage stages inside the chmi, the supply current thd may be reduced. in different phrases, even though the supply voltage is feeding a non-linear load, the deliver present day can stay as a sinusoid.Table 1: Performance comparison on different APF inverter configurations

APF	Number of power switches	Number of DC Capacitors	Source current THD
3-level H-bridge	4	1	14.88%
5-level CHMI	8	2	10.90%
7-level CHMI	12	3	7.63%

VII. CONCLUSION

This paper has presented a performance analysis on the use of cascaded H-bridge multilevel inverter (CHMI) with Unified Constant-Frequency Integration (UCI) as an APF in a singlephase system. Based on the results obtained from the simulation study conducted, the 5- level and 7-level CHMI with UCI control is found to improve the APF performance in terms of effectiveness in source current harmonics compensation. This is confirmed by the reduction in the source current THD as the CHMI number of output voltage levels is increased in comparison to the use of the conventional 3-level H-bridge inverter. However, by using the CHMI configuration, the power switches count is increased which in turn can increase the size and cost of the overall APF system. The concept of increasing the inverter output voltage in improving the performance of an APF can be further explored to include the utilization of circuits with manageable number of power switches.

Ethical clearance - Not required

Source of funding- Self

Conflict of Interest - **Effectiveness of APF with Integration Control**

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