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Design and Analysis of Series Connected H-Bridge Multilevel DC/AC Converter for Enhancing Attributes of Power

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***Abstract*—This paper deliberates a series connected H-Bridge Multilevel dc/ac converter topology for power quality enhancement. A Modified Second Order Adaptive Notch Filter (SOAF) is intended for reference current extraction that provides acceptable results in stable and distorted source situations. The phase shifted pulse width modulation produce switching signals with matching reference which delivers equivalent power among the modules. The suggested controller can accomplish substantial harmonic rejection even at unstable and disturbed supply voltage state. MLI is planned for compelling use of Distributed Energy Resources likewise to give ceaseless supply still on denied Power Quality circumstances. The Modified SOAF is actualized for multipurpose control, adaptability to circumvent the loss appeared and for its improved disturbance elimination potential. The THD of the input flow of electrons after enhancement are observed to be with in the threshold as fixed by IEEE 519 standard. Thus the distributed micro grid system is able to provide constant, perfect and stable power supply and is confirmed by MATLAB simulation.**

Keywords*— Grid connected inverter, harmonic distortion, multifunctional converter, second order adaptive filter, power quality

I. INTRODUCTION

Modern environmental policies plus increased requirements of energy paved way to massive employment of renewable source utilizations. Consuming renewable energies however, is not always free of challenges. Major problems that arise due to addition of renewable power to grid are voltage and frequency fluctuations, harmonics [1]. Several learning was made intended for unfailing combination plus proper positioning of the distributed supplies that concluded in micro grid introduction. These revisions primarily seeks on micro grid incidence forecast means, control design followed by the unquestionable branch, grid synchronization methods. The chief aim of such learning is to aid the micro grid as well as distributed supplies to travel in the course of the miniature disturbances in grid attached also islanded modes. Turbulence and unexpected alteration of micro grid end in voltage plus frequency wave distortions. These wave distortions might include unhelpful effects on power devices. As a result, the usage of a forceful plus unfailing controller and synchronizer is a necessity in micro grids [13].

Different control techniques have been introduced for efficient operation of grid connected inverter [12-13]. Variable compensation Control of power converters with low-voltage distorted power systems only improves current based PQ in single phase systems [2]. Capability of series and shunt active power filters depends a lot in grid inductance along with the position of compensator [3]. The Z-source inverter is proposed as it provides buck and boost operations by varying Modulation index (M) or Boost factor (B) which controls the speed of the motor [24].The study on such concern paved way for cascaded H-bridge multilevel inverter (CHBMLI). This provides effective interface of distributive energy resources and micro grids. It also acts as power quality conditioner and proved to be cost effective [17]. The problems related with these two dimension inverters that they work on greater exchanging recurrence which prompts greater exchanging misfortune and because of large direct current-interface voltage the rate of change of voltage worry over the switches are great. The power overseeing capacity of these inverters is less, hence anything but a fitting decision for large power application, consequently restricted to less power applications [15]. It seems that Multi-Level Inverter (MLI) works with smaller exchanging recurrence and the consonant end ability seems to be very great contrasted with these two dimension dc/ac converters. So MLI's are desirable over work as a SAF and expand successful execution in large energy applications [16]. Further this is been normally perceived by analysts and people from industry. Hence MLI's discovers its

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implementation for photovoltaic networks, MV drives, APF's and FACTS.

Essentially more than one sorts of MLI are seen, which are fell MLI, nonpartisan point cinched and flying capacitor based. Be that as it may, the last two endures potential difference adjusting cum complex exchanging problem. In addition, amidst the distinctive configurations of staggered dc/ac converters, fell H-connect staggered dc/ac converters (CHBMLI) needs less components for producing specific voltage value, particular structure, delicate exchanging capacity and it doesn't require voltage adjusting capacitors. Subsequently it's an ideal exchange in medium-voltage extend control framework applications [18]. The measured design of the CHBMLI empowers it to work with indistinguishable control system and amid blame in a segment; that specific broken segment perhaps surrogated easily. Notwithstanding, the issue related with CHBMLI is it need isolated DC hotspot for every part, while the quantity of DC energy builds, it's regulation unpredictability load increments alongside high number of sensor prerequisites. In any case, mechanical application does not favor more amounts of sensors to be incorporated in the framework. Dependability of framework perchance influenced because of specific management of DC supplies and the general expense likewise increment. In any case, the previously mentioned issues can be successfully annihilated when CHBMLI works using solitary DC supply [19]. In existing proposition a fell transformer was attached to yield of every element to create staggered wave. Intended for a viable utilization of SAF, controller strategy is appropriate to produce essential remuneration supply amid perfect and other condition. Earlier, numerous writings were tended to concentrating on different techniques for drawing out the reference signal and noteworthy consonant end [20]. The complete consonant twisting (THD) in inverter structure is diminished by lessening the switches and sources utilizing nearest level control and this will not influence the RMS rate [22].

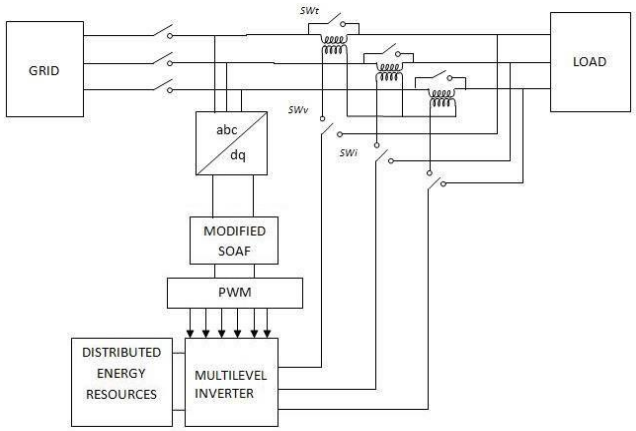

Fig. 1. The proposed system of MLI with modified SOAF structure

Modeling of PLL method for second order generalized integrator meant for good performance shows limited capability in rejecting grid disturbance and oscillatory faults along with sub- harmonics and DC offset [4]. The multipurpose control of grid connected inverter is achieved by using adaptive notch filter (ANF). It acts as frequency adaptive sequence components extractor. Also it performs multiple tasks and avoids the usage of PLL [5]. It suits best for grid synchronization, act as barrier to harmonics and other disturbances in grid signal [6]. Amongst various available synchronization procedures together with adaptive techniques, the modified second order adaptive filter (SOAF) is chosen for SSS configured MLI that possess high disturbance rejection capability. Modified SOAF removes essential component present in deformed grid signal during grid disturbances [7]. The proposal is given in favor of voltage plus frequency fixation in both grid conditions furthermore to make sure the power production adequacy. The quick and perfect synchronization procedure is chosen along with rapid reacting control structure Because of the various operation and advantages of adaptive filters it has many applications [8-11]. The modified SOAF supported micro grid system is designed using SIMULINK/MATLAB. The outcome illustrates the precision of the control method confirms balanced three phase voltages with constant frequency.

II. PROPOSED SYSTEM ORGANISATION

The 7-level adjusted CHBMLI utilizing toroidal center transformer at the yield of every H- spans was proposed. Such system overwhelms weakness of conventional CHBMLI. The displayed topology utilizes a solitary DC-connect capacitor, in this manner limiting the quantity of controller and sensors. In addition, equivalent voltage was encouraged towards every unit that keeps away from imbalanced power dispersion in those units. Additional element with series transformers was galvanic confinement capacity, consonant decrease feature because of the spillage reactance, expanded unwavering quality of the framework and diminished electromagnetic obstruction issues. Additionally the inverter works at low exchanging recurrence. Within the suggested system, seven dimension voltages was created through three associating H-connect during every stage, in which yield was combined using one stage toroidal center transformer. At this point every H-connect speaks to a unit, guaranteeing similar setup also through associating transformers, this empowers less demanding link toward lattice incorporated frameworks and consumer interconnecting uses. Now every unit develops positive, zero and negative energies. Lastly every voltage was included by series transformers, coming about seven stage ventured wave. Meanwhile game plan conveys a seven stage yield energy containing three similar units, every unit develop measure till power that was included by series transformers. Here, the yield energy value created by amount using necessary H-connect was given by,

$$V0 = 2n + 1$$

Where, n demonstrates single stage H-connected association of framework. Hence, in seven stage yield power, three H-spans were associated during every stage.

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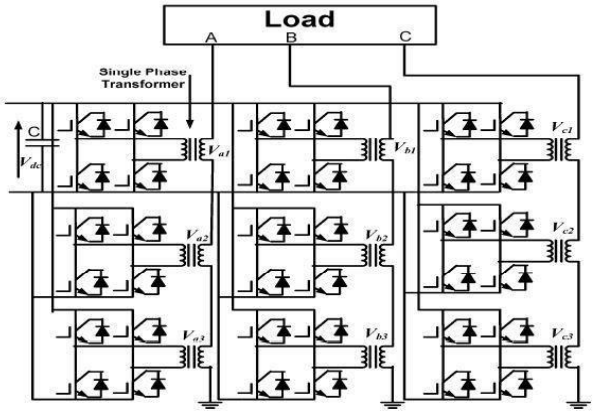

Fig. 2. The Cascaded H-Bridge MLI Structure.

III. MODIFIED SECOND ORDER ADAPTIVE FILTER

In this paper the modified second order adaptive filter (SOAF) based synchronization method is implemented for extraction of harmonic components from the grid signals in grid connected distributed energy system. SOAF also aids in decrement of THD thus provide power quality enhancement which is affected by the presence of non-linear loads. The feedback signal for the suggested modified SOAF is the required frequency that is generated from the fundamental component extracted. Its behavior and performance by the complete analysis proves to have high disturbance rejection capability in the system and very low settling time followed by satisfactory transient performance and hence found to be effective for fundamental component extraction in comparison with other grid synchronization techniques. The SOAF is modified so as to advance the computational time and for further reduction of total harmonic reduction and the focus of the modification is to suit it for the application of DER's with power grid along with power quality improvement.

A. Second-Order Adaptive Filter(SOAF)

In SOAF, the algorithm is adaptive where the reference for it is the essential frequency extracted with interest ω. The frequency that is extracted is actually two sinusoidal signals that is each ninety degree shifted. The combination of sine and cosine blocks is developed with least mean square algorithm that is put into operation as discrete forward integrators. Using SOAF the harmonic component is extracted with required frequency of interest by the use of determined essential positive sequence frequency of SRF-PLL. The conversion period of the SOAF is based upon the gain and the required essential element is achieved followed by the removal of harmonic part from the distorted waveform. The raise in bandwidth is achieved with enhance of gain thus reduces the settling time of the filter and its reduction is achieved by boosting the frequency. The exact data of essential frequency is acquired by the usage of SRF-PLL, in view of the fact that simply positive sequence essential part of impartial distorted grid waveform is introduce as its input.

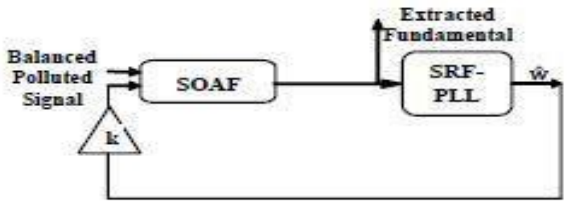

Fig. 3. Representation of conventional second order adaptive filter.

The most important harmonic components are of 5th and 7th orders in general for the period of non-linear load or grid fault. The total reduction of superior order harmonics is accomplished by appropriate choice of the bandwidth of SRF-PLL. The SOAF transfer function is given as,

$$\kappa = g_1 \varepsilon_v,$$

Where, g1= gain of error signal ε_v

The scheme consists of two transfer functions of second order namely adaptive band pass filer (ABPF) and adaptive notch filter (ANF). Damping factor and settling time (for fundamental) is given as,

$$\zeta_1 = g_1/2\omega \ ; T_{s1} = 9.2/g_1$$

Thus the observations on SOAF filter shows that enhancement of gain results in rise of bandwidth of filter which provides the advantage of settling time reduction conversely the system stability is affected thus proves that this system is not the satisfactory selection for grid system which has inconsistent frequency conditions.

B. Modified Second-Order Adaptive Filter(Modified SOAF)

The chief negative aspect of any power grid system is that only for the period of balanced and undistorted operating conditions, the grid signal parameters have their sinusoidal waveform of essential component. But the grid signal turns out to be unbalanced or include distortions with occurrence of harmonics all through faulty conditions and by reason of the non-linear load. During such deformed grid signals or frequency deviations the SOAF function fails. Thus a novel means of conversion of second order adaptive filter is proposed in this section to overcome the difficulty mentioned above. Through this alteration, the SOAF performance was prepared to be autonomous of the frequency of the system. As the advancement of this alteration the SOAF will be found trouble free to dig out the fundamental element from the affected signal that is applied as the reference for the PLL block. The alteration made in the conventional SOAF is multiplication of the frequency to be filtered ω with $g3\epsilon v$. From the above said conversions the conventional SOAF was made best suitable for applications of micro grid with DER integration without disturbing the stability of the system. Intended for the over said compensation come to pass, the subsequent alterations have been done.

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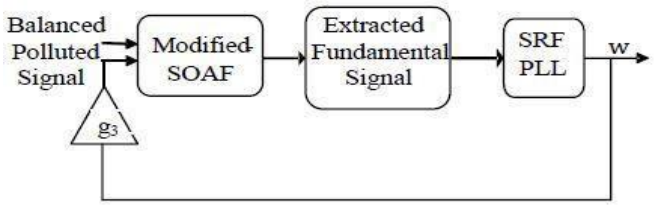

Fig. 4. Representation of modified second order adaptive filter.

Whose transfer function was modified as,

$$k = g_3\omega\,\epsilon_v$$

Transfer function of input to output is adaptive band pass filter and the transfer function of input to error is a notch filter.

$$ABPF_1(\Sigma) = AF_1(\Sigma)/1 + AF_1(\Sigma);\ ANF_1(\Sigma) = 1 - ABPF_1(\Sigma)$$

Resolving period of the proposed second-order system is calculated as, $T_{s1} = 4.6\tau_1$, here τ_1 is the time constant. The damping factor, fundamental time constant, settling time for given modified-SOAF is calculated from the below equation,

$$\zeta_1 = g_3/2;\ \tau_1 = 2/g_3\omega\ ;\ T_{s1} = 9.2/g_3\omega$$

From reference it is clear that the modified-SOAF reaction is quicker in times of high gain values which are used for the estimation of the proposed SOAF bandwidth. Even at small gain values, the capability of filtering is found to be more than satisfactory however it takes relatively high settling period. Accordingly, conciliation has to be done among the gain rate as well as bandwidth of the proposed SOAF on the way to obtain the finest outcome. Subsequently it proves that bandwidth is solitarily based upon gain ($g3$) besides just like the conventional filter it is no more a function of frequency and gain, this turns it to be suitable in favour of the implementation for variable-frequency power systems.

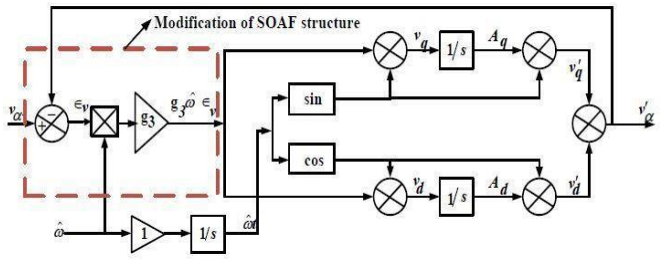

Fig. 5. Block diagram of modified second order adaptive filter.

IV. SIMULATION RESULTS

The control scheme with suggested MLI is validated with MATLAB Simulink. Voltage quality issue on grid voltage is justified here. The simulation of the proposed MLI is done to check the performance. The compensated PCC voltage reference is brought into line for pre-fault voltage. The MLI real power supplies load and grid. Grid supplies reactive power for load thus the compensating current is injected. Voltage regulation is done by negative sequence current of MLI. However, complete compensation at PCC is not achieved and grid current is unbalanced. That is, the real and reactive power of MLI is oscillating because of the negative sequence current. For this, the reference signal must be aligned to achieve zero averaged active power. Thus, requisite positive plus negative sequence voltage is injected that mitigates the voltage quality issue which is non-tackled alongside the PCC voltage stays controlled. As a result, with less reactive power consumed both grid and load voltage are balanced and sinusoidal.

However, the frequency response analysis demonstrates that filtering performance is better with low gain value and damping factor but the dynamic response is slower. Following this, the gain must be less than 0.5 for required filtering capability and dynamic performance. So the implementation of modified-SOAF filter is found to be the perfect choice for effective operation and for achieving low total harmonic distortion. The simulation results for such a system of MLI with SOAF are shown below. The output shows the intentional voltage disturbance between time period of 0-1 and 1.5-2 at grid voltage even for which the output load voltage is undisturbed sinusoidal and balanced thus the THD at load side reduces.

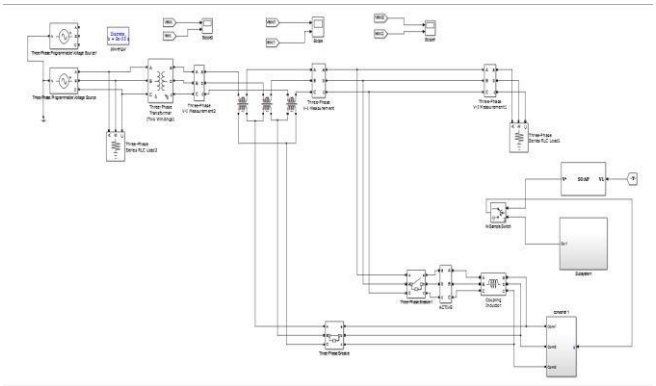

Fig. 6. Simulation circuit diagram.

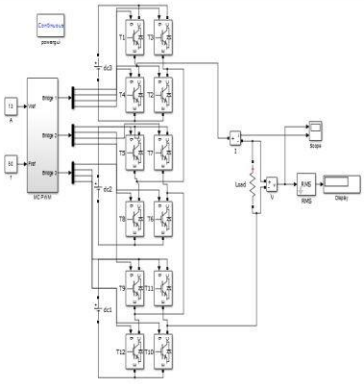

Fig. 7. Cascaded H-Bridge multilevel inverter.

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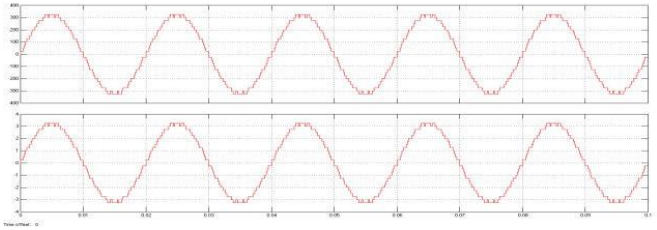

Fig. 8. Multilevel inverter output

V. CONCLUSION

Inverters in distribution systems with misshaped grid voltage certainly produce elevated amounts of current harmonics. In MG the voltage and frequency oscillations happen because of accidental changes and disturbances which have critical effect. A series transformer tied multilevel inverter that provides harmonic lessening during various source fundamental conditions is suggested. The modules receive similar power among the inverter modules using single DC- link capacitor operation. The total design of created topology was explained alongside of controller operation. Aimed at current harmonic extraction an SOAF centered controller is connected to separate the essential burden current that aids in assessing the reference signal. The switching pulses were produced with phase shifted PWM technique by relating the reference. At last the introduced control procedure connected to the created topology of MLI adaptively mitigates harmonic currents without compromising stability even when the grid is extremely weak and purely reactive and is verified by simulation.

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