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A Review on Active Power Factor Correction Schemes

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ABSTRACT

Generally transformation of ac to dc voltages has been commanded by stage controlled or diode rectifiers. The non-perfect character of the input current drawn by these rectifiers makes number of issues like increment in reactive power, high input current sounds and low input power factor, lower rectifier effectiveness, extensive input voltage contortion and so on. To make up for the higher reactive power request by the converters at high power transfer levels, power factor correction ends up required. Stage controlled converters are broadly utilized on the grounds that these converters are basic, more affordable, solid, and don't require any recompense circuit. Be that as it may, the SPF in stage controlled converters is low when the output voltage is not exactly the maximum, that is, the point at which the terminating edge is substantial. As the terminating edge expands, the removal edge between the supply voltage and current increments and the converter draws additionally slacking reactive power, in this manner diminishing the PF. Semi-converter systems give preferred PF over full-converter systems, despite the fact that the enhancement isn't wonderful. This poor PF activity is a noteworthy worry in factor speed drives and in high power applications. Better electrical usage and productivity can be accomplished with the utilization of PF enhancement framework.

Keywords : Power Factor Correction (PFC), Active Power Factor correction (APFC), Pulse Width Modulation (PWM), Programmable Logic Controllers (PLC), Neural Network (NN), Field Programmable Gate Array (FPGA), Discontinuous Inductor Current Mode (DICM)

I. INTRODUCTION

The non-sinusoidal kind of the info flows lined by the rectifier cause a development in the information current music, responsive power and info voltage distortion. There are a couple of hindrances of the uninvolved power factor update strategies. These join tremendous output dc voltage swell, upgrade in the power factor for thin working area and colossal size of responsive parts [1]. These bothers are overpowered by using dynamic current wave framing strategies that further improve the execution of rectifiers. Use of several switches with variable on time and predictable switch recurrence outline the introduce of the movement of broken method of conduction [8,9]. Each exchanging period in EAC should give a vague area to the broken current heartbeats from that of the zone under reference input current. Chance to contrast turn-on time is the clarification behind the model giving more precision to single stage rectifiers [10]. The best in class joined circuits for dedicated power factor controller fuse Microlinear'sML4812 [11] and Unitrode UC2854 [12]. Zheren Lai had proposed different predictable exchanging recurrence Pulse Width Modulated controllers for power factor rectification (PFC), which uses constant conduction mode [13-15].

Single-stage rectifier features have been illuminated and separated by Gerry Moschopoulos and Praveen K. Jain [16] to join nearly solidarity control factor assignment, fragile exchanging ability and negligible exertion. They furthermore give illumination about

the control technique that ensures enduring on time and variable off-time framework, along with unity control factor assignment. The options open for the structure of different PWM systems incorporate Sinusoidal, Regular-examined, Square-Wave, the Regular-Sampled Harmonic-Elimination PWM and consonant end PWM.A suitable PWM scheme is picked, dependent upon the essentials. For consonant end for the inverters output, PWM frameworks are used that in the meantime achieve the output voltage control [17].

By using DSP, the drawbacks of this PFC designs can be endure. Use of digital signal processor (DSPs) is in playing out the figuring of the commitment cycles early which is nesses to achieve solidarity control factor in a half line period. One of the essential purposes of enthusiasm, for utilization of digital control power factor amendment (PFC) in light of the control strategy, is that high exchanging recurrence of action is possible. The speed of assignment of DSP isn't a factor responsible for this. Pre-learned commitment cycles are used to control a lift converter that along these lines can achieve sinusoidal current waveform [18].

The execution and assurance of judicious calculation which is significant in digital power factor redress (PFC) relies upon lift topology. The commitment cycles age is required to achieve solidarity control factor in a half line period. It is performed early. The insignificant exertion DSP can help in execution of PFC working at higher exchanging recurrence. The achievement of 0.99 PF can be under goes the wide output control conditions and info voltage ranges. The sinusoidal current waveform in transient state is required for step stack change and info voltage change; the control procedure can achieve PFC [1]. The topological necessities and key principles shape a starting stage for a bit of the speculative parts of PFC circuit. Fundamental dc to dc converters can be made to give PFC. A fundamental designs accept an occupation to choose the total efficiency of a PFC voltage controller. The relationship of theoretical efficiencies of principal setups is fundamentally required to choose the whole profitability of a PFC voltage controller. The likelihood of a diminished abundance control getting ready power factor remedy (PFC) voltage controller begins here [2]. The fundamental setup of converters required in achieving PFC and voltage control, has been cleared up in [3] giving idea for power stream. Deliberate advancement of PFC controllers can be performed, from a plan of sixteen possible surmised designs. The improvement in overall capability is possible given that the power arranged by one converter isn't reprocessed absolutely by the other converter inside the power factor redress (PFC) controller. The indistinguishable circuit in stationary state has been used in one exchanging cycle for PFC application in lift converter. Examination of the Buck converter with a LC input direct working in broken capacitor voltage mode and predictable inductor current mode which gives an average cognizance of the good conditions and insults of the system. A strong arrangement instrument has been addressed by the logical results, which was not available as of now. An examination and illumination of fourth request (fourth request) topology with galvanic separation is worked in the two modes [4]. The confirmation of exchanging clamor immunity is given by the new turning edge-examining calculation which is deduced [5]. The typical information current is used for control. It is important that the gotten tests decisively reflect the typical info current. This licenses exact extent of the ordinary information current. In the event that there ought to be an event of discrete current control mode algorithm [6], this performs high power factor redress for a lift converter. The controller beats get self-synchronized with the stage and recurrence of info voltage. As the controller works in reference stationary edge, the customary stage catapulted circle isn't required. For the equivalent single stage support rectifiers, two decoupled settled recurrence current mode controllers deliver the exchanging moments.

Using direct model Jian Sun proposed the power factor revision (PFC) technique by ZCD of lift single

stage cooling to dc converters where the fundamental period of the information current and the nonattendance of essential damping in the current loop is analyzed. To restricted or taking out the zero-crossing point bending, the showed method relies upon a clear stage pay framework [19]. To perform ZCS in the switches and zero-voltage-exchanging (ZVS) in the diodes, the zero current switching pulse code regulation (ZCS-PWM) aide circuit is structured in the displayed ZCS-PWM rectifier. The portrayal of seven change states for clearing up the direct of the ZCS-PWM rectifier in one exchanging period has been given. To foresee the structure execution, the beat width alteration switch demonstrate is used [20]. The power factor revision has been given by the zero request converter circuit. To make converter circuits that can achieve power factor amendment (PFC), the duality rule is associated. The mix of reasonable circuits is another issue is which gives power factor amendment and output control [21].

There is a framework of the particular techniques used for PF improvement. There are central focuses and hindrances of each strategy. One needs to pick a method, dependent upon the application close by and the cost. By the latest progressions like neural in the composition, further these controls can be superseded [7-8].

There is an extension in receptive U.power, input current music and info voltage curving due to the non-sinusoidal nature of the information current drawn by the rectifiers. In electrical systems, an examination of uninvolved symphonious channels arrangement to confine consonant turning caused by symphonious sources and reimburse control factor, has been performed. The weights of the dormant power factor cure frameworks are colossal size of receptive parts, power factor (PF) improvement for a thin working zone, broad output dc voltage swell [1]. Using two or three switches, the uncontrollable method of conduction works with predictable exchanging recurrence and variable turn-on-time [2, 3]. The bothers have been overpowered by using dynamic current wave framing strategies and upgrade the execution of rectifiers. It should output an unclear area for the irregular current heartbeat from that of the locale under reference input current in each exchanging period in EAC. Since it has a chance to change the turn on time, the measure gives more essential exactness to single stage rectifiers [4]. Before long there are a couple of submitted PF controller is accessible, for instance, Microlinear's [5] and Unitrode [6]. For power factor alteration, Zheren Lai proposed a gathering of relentless exchanging recurrence Pulse-Width-Modulated controllers, which uses steady conduction mode [7-9].

The examination and illumination of the features of single-stage rectifier has been given by Gerry Moschopoulos and Praveen K. Jain [10]. These features fuse nearly solidarity power factor undertaking, fragile exchanging ability and simplicity. The illumination of the methodology for control used to ensure solidarity power factor movement a consistent on time, factor off-time technique has furthermore been given. For the engineer, particular PWM methods, similar to Square-Wave, Sinusoidal, Regular-in spected, consonant transfer PWM and the ordinary Sampled Harmonic-Elimination PWM are the open choices. In perspective of the necessities, the PWM plan is picked. The Pulse-width-Modulation systems are used, for consonant end at the output of the inverter and at the same time achieving the output voltage control [11]. By using DSP PFC plot, standard gear control plan for different stages, extraordinary commotion opposition, versatile structure changes, and effortlessness of use of cutting edge control calculations, less vulnerability to developing and environmental assortments to meet a specific customer need can be endure. By using digital signal processors (DSPs), the commitment cycles required to achieve solidarity control factor in one half line period are figured early. The action at a high exchanging recurrence which isn't explicitly expose to the getting ready rate of DSP is one of the essential positive conditions of the computerized control PFC use reliant on this control framework. Sinusoidal current

waveform can be practiced using the lift converter controlled by these prev by these prev processed obligation cycles [12].

In light of lift topology, a perceptive calculation for computerized control factor alteration (PFC) has been proposed by Zangetal [13]. For variable obligation cycles, to achieve solidarity control factor in a half line period are made. For step stack change and information voltage change, the control methodology can achieve PFC for sinusoidal current waveform in transient state. A diminished redundant power-preparing PFC voltage controller is proposed by Tse [14].

In light of a power flow thought, converters for achieving PFC and voltage direction are clarified in [15]. If the power taken care of by one converter isn't re-arranged totally by the other converter inside the PFC controller, the general capability can be upgraded [16]. For PFC application in lift converter for one exchanging cycle, the stationary state equivalent circuit is used. By using these working modes, the examination of the Buck converter with a LC input channel working in uncontrollable capacitor voltage mode and relentless inductor current mode that gives a conventional understanding of the central focuses and weights has been promoted. A strong plan instrument has been addressed by the consistent results, which was not open in advance. Guaranteeing exchanging commotion insusceptibility, the turning edge-sampling algorithm is induced in [17]. It is imperative that the procured models unequivocally reflect the normal info current, the normal information current is used for control. Exact extent of the normal info current has been permitted along these lines. Since exchanging beats get self-synchronized with the stage and recurrence of input voltage, discrete current mode control algorithm proposed by Souvik, Chattopadhay, Ramnarayanan [18] that performs high PF remedy for a lift converter, the controller input voltage detecting isn't required. One needs to pick the procedure, dependent upon the application close by and the cost. There can be further substitution of these controls by the latest developments like neural which are open in the composing [19-21]. Using a cross breed display with two multi-circle controllers to control the power arrange, the quality of a lift power factor correction(PFC) circuit is proposed by Muzumder, Nayfeh [22]. The exchanging frequency approaching boundlessness is the one and the other for which it is finite but far reaching. The overall nearness of a smooth hyper surface for the lift PFC circuit isn't possible, using thoughts of intermittent systems. The structure drenches, if the headings don't accomplish the sliding surface. The strength of the period-one circle is lost everything considered. The onset of the speedy scale flimsiness happens when the inductor current procedures zero, using the conditions for nearness and the possibility of corresponding control, shows why, for the second closed circle structure. An answer that leaves the sliding surface (if nearness tumbles) everything considered can't stabilize in the splashed region. For an AC to DC power converter the power factor control circuit fuses an inductor getting AC redressed power elaborated by Joorabian, Seysossadat, Zamani in [23]. By an exchanging circuit reliant on an examination between a DC transport voltage and a settled reference voltage, the charging time of the inductor is controlled. Without an AC altered line detecting framework, and without a current-detecting resistor related with the wellspring of the MOSFET switch, the circuit works. In light of powerfactor remedy (PFC) and strategy used for examination, the structure and execution of two basic sorts of shunt consonant channels is discussed and an algorithm is presented for each in [24]. For consonant camouflage in AC side of a precedent six-beat HVDC converter, the procedure is used. For responsive power pay, stack modifying, symphonious pay and unbiased current pay and upgrading the supply side PF, the four-leg active power filter is used by [25]. There is a relationship of the dynamic PF to a stack that can be unbalanced and may in like manner draw consonant flows.

The illumination of the info channel necessities for a power factor alteration sort out reliant on a Boost

converter working in Discontinuous Inductor Current Mode (DICM), focusing on the relationship between the PFC orchestrate and the information channel is given in [1]. The PFC organize is possible to make sense of it. It has diverse characteristics. The info current with reduced high recurrence is used to restrict the information current separating necessities. The intrinsic power factor redress property is used to unravel the control circuit. The movement down characteristics are used to gain an output voltage lower than the abundancy of the changed sinusoid input voltage. To upgrade the capability of the PFC by bringing down the exchanging adversities or possibly conduction hardships there are circuit systems. By having less switches in the power path, or possibly by reducing their normal and RMS flows, PFC stage can be diminished and conduction hardships in the joined diode interface.

There is a phase down change extent for the Buck converter showed up in Fig 2.b.It is thusly possible to get an output voltage V2 lower than the plentifulness V1 of the input voltage. Right when the quick information voltage v1 is higher than the output voltage V2, the converter can work. The info current of the converter is broken, as depicted in Fig 2.b.Therefore the line current of a PFC subject to a Buck converter has half and half bends. For sure, even in CICM, in this way, the info current must be sifted through that has a significant high recurrence part [2-4].

Fig 2.c shows the Boost converter. Since the output voltage V2 is always higher than the abundancy V1 of the input voltage, it has a phase up change extent. The info current does not have cross breed turns, since errand is possible all through the line-cycle. Since the inductor is placed in course of action at the contribution, as appeared in Fig 2.d. the information current is steady. While working in CICM, thusly an input current with reduced high-recurrence substance can be gotten. The Boost converter working in CICM is extensively used for PFC in perspective of these reasons [3].

The Buck-Boost converter can work as either a phase down or a stage up converter, as showed up in Fig 2.e. The open door in deciding the output voltage has been given in light of the way that the output voltage V2 can be higher or lower than the adequacy V1 of the input voltage. A sinusoidal line current can be gotten and undertaking is possible all through the line-cycle. The output voltage is a changed that converts into higher voltage stress for the switch. The information current with altogether high-recurrence content are uncontrollable, similar to the Buck converter, as appeared in Fig 2.f. Table 1 shortens the topology-specific traits.

The two-switch Buck + Boost Converter [5] is a captivating game plan, despite these major converters. Exactly when the input voltage is lower than the output voltage, as a Boost converter and when the input voltage is higher than the output voltage, it fills in as a Buck converter. In a way like the Buck-Boost converter, in this way assignment is possible from first to last line-cycle and the output voltage can be changed in a wide range. At any rate this topology has an extended number of switches that prompts higher conduction incidents and cost. Because of its non-adjusted output, the voltage worry of the switches is lower than in a Buck-Boost converter, which is its positive part.

The inductor current in the midst of one exchanging cycle there is constantly imperativeness secured in the inductor since it never accomplishes zero, in this working mode. By constantly changing the obligation cycle of the converter using an appropriate control method, the volt seconds associated with the inductor which must be balanced all through the line cycle.

Case Of control plot is showed up in fig.3. To keep the output voltage of the PFC arranges reliable and to give the screw up flag the low-data transfer capacity external loop with trademark is used. To control the information current, the high-data transfer capacity internal loop with trademark is used. To give a reference, which is corresponding to the error flag , a multiplier is used. It has a changing sign with the

pined for shape for the input current. The most broadly perceived situation has been showed up in Fig. 3, where the tweaking signal is the rectified sinusoid input voltage. It is useful to use as an altering signal the complexity between the output voltage and the input voltage, dependent upon the topology of the PFC sort out [7].

The control circuit can be enhanced by abstaining from the multiplier and detecting of the line voltage. Since is the control signal from the low data transfer capacity output voltage controller, for this circumstance, the tweaking signal is equal and it is essentially unfaltering for the each line cycle. Subsequently, the info current is propped to a regard relative with and its shape approaches a square waveform. Consistence with the standard can be obtained up to generally 230Vrms input voltage and 500W power, as the revisions of the control circuit prompts a more damaged line current. if the edges of the line current waveform are loose, consistence up to a couple of kW can be gotten then trapezoidal waveform gained [8]. In the subsequent work, the related research work is tended to [10-14].

Low information PF and infusion of music into the utility lines is seen due to these set up converters that draw non sinusoidal info cooling flows. Single-stage switch mode cooling dc converters are being used as front-end rectifiers in perspective of the upsides of high capability and power thickness, in a grouping of applications. In light of stringent power quality control and strict limits on total consonant twisting (THD) of input current put by benchmarks, for instance, IEEE 519-19922 and IEC 61000-3-2, analyze in upgraded power quality utility interface.

For power quality improvement, distinctive investigators present the diverse procedures. For info current wave forming examination into dynamic and inert strategies has featured their common inconveniences. Resonation, enormous size and settled compensation are the awful signs of the detached channels while as a result of control multifaceted nature and included cost, the usage of dynamic converter is obliged.

Because of the closeness of lift inductor, the converter still experienced high voltage weight on the capacity capacitor. Semiconductor devices, like diodes, transistors, etc. with high voltage rating, should be used appropriately in wide input voltage applications; this moreover limits the helpful usage of SSPFC. Organize power exchange thought has been exhibited starting late in which an extra winding is implanted in parallel with coupled to the boost inductor and the output [28-30]. Through this coupled winding, a piece of info vitality set away in the boost inductor will be diverted to the output explicitly. At whatever point load and line moves then the voltage stresses and the voltage swing on the capacity capacitor are both decreased. The capacity capacitor voltage can't plunge under the apex line input voltage in view of the wandering up of input voltage by the boost inductor.

A high PF single switch forward AC-DC converter (SSFC) with low stockpiling capacitor voltage is presented in [29]. A heap up voltage source is familiar with discard the dead edge of info current over the considered input voltage transformer discretionary in the midst of the turn on time of power switch. Despite when the contemplated changed input voltage discretionary is lower than the output voltage, thusly the input power can even now trade to output (i.e., stimulating the output inductor). The DC voltage included over the reviewed input voltage is used to invigorate the lift inductor, in [29]. The capacity capacitor gets all the vitality set away in the lift inductor. Along these lines the capacity capacitor voltage is high and can't plunge under the apex input voltage. The reflected input voltage and the heap up voltage notwithstanding for the proposed SSFC are used to invigorate the output inductor clearly. Stood out from that of a boost inductor, the capacity capacitor is continued by the reset smaller vitality of transformer. In view of the nonattendance of lift inductor putting at the front end of the proposed circuit, the voltage on the widely appealing capacity capacitor keeps commonly low.

The computerized control fly back PFC framework is proposed [31, 32].Three power factor change

converters are shown [33], [34], [35], [36] and [37]. There is a discourse on the single switch forward dc-dc converter. For the transformer of the forward converter four dormant and one dynamic reset procedures are shown and the fittingness of the reset circuits for self-impelled synchronous revision is assessed. With dynamic secure reset circuit and with self-moved synchronous rectifiers, further the establishment information on forward converter is showed. The dynamic catch forward converter is proposed [38-41].

Inlight of lift topology, an insightful calculation for digital power factor remedy (PFC) is executed and construed. To achieve solidarity power factor in a half line period all required obligation cycles are made early. To execute PFC working at higher exchanging recurrence, a minimal effort DSP can be used. Under wide input voltage and output power conditions, the power factor of 0.99 can be practiced. For sinusoidal current waveform in transient state for step stack change and input voltage change, the control method can achieve PFC [1]. Starting from basic benchmarks and topological necessities having recognized the behavior by which essential dc to dc converters can be made to give PFC, the theoretical parts of PFC circuit is illuminated. A crucial activity is played by the examination of speculative efficiencies of essential arrangements, in which the power is taken care of, in choosing the general profitability of a PFC voltage controller. The likelihood of a diminished dreary power-handling PFC voltage controller is the aftereffect of this [2]. In light of a powerflow thought, the essential design of converters for achieving PFC and voltage direction is elucidated in [3]. Productive advancement of PFC controllers can be performed by deciding sixteen possible designs. On the off chance that the power arranged by one converter isn't re-dealt with totally by the other converter inside the PFC controller, the general capability can be advanced. For PFC voltage in boost converter for one switching cycle, the stationary state rise to circuit is used. A not too bad cognizance of the central focuses and hindrances is offered by examination of the Buck converter with a LC input channel working in discontinuous capacitor voltage mode and relentless inductor current mode. A solid design instrument has been addressed by the explanatory results, which was not open heretofore.

The clarification and examination of the fourth-arrange topology with galvanic partition, working in the two modes has been given [4]. Guaranteeing exchanging clamor invulnerability, the trading edge-examining algorithm has been resolved in[5]. For control the normal info current is used. It is important that the obtained models unequivocally reflect the average input current. Exact extent of the average input current is possible along these lines. Since exchanging beats get self-synchronized with the period of information voltage and recurrence of info, the controller input voltage sensing isn't required for the discrete current mode control algorithm [6] that performs high power factor amendment for a boost converter. As the controller works in stationary reference layout, customary PLL isn't required. For the equivalent single stage help rectifiers, two decoupled settled recurrence current mode controllers make the exchanging minutes. By using the latest advances like neural in the composing [7-8], further these controls can be displaced. For dynamic power factor review the work done is in the writing [9-13].

Due to modernization in contraptions field and immediately extended amounts of electronic hardware, power hardware and high voltage power structure, the power quality of the AC system has transformed into a mind blowing concern. PFC investigate has transformed into a fervently discussed issue, improve transmission profitability and with the true objective to lessen consonant sullying in electrical cables. The plan and enhancement of 3φ power factor corrector using PIC (Programmable Interface Circuit) little scale controlling chip has been displayed. Using real algorithm to choose and trigger satisfactory exchanging capacitors with the ultimate objective to reimburse extraordinary responsive parts. Using PIC and sensors, there is detecting and estimation of the power factor a motivator from the

heap. As such PF near solidarity has been cultivated. Along these lines, it shows signs of improvement quality AC output. Upon their applications specifically fragments, distinctive power factor cure techniques will moreover be analyzed.

II. CONCLUSION

Semi-converter systems give preferred PF over full-converter systems, despite the fact that the enhancement isn't wonderful. This poor PF activity is a noteworthy worry in factor speed drives and in high power applications. Better electrical usage and productivity can be accomplished with the utilization of PF enhancement framework.

III. REFERENCES

[1]. Sam Ben-Yaakov and Ilya Zeltser, "Toward a Plug-and-Play Approach for Active Power Factor Correction," Published in Power Electronics EUROPE, Issue 1, 2004.

[2]. Osama A. Al-Naseem and Ahmad Kh. Adi, "Impact of Power Factor Correction on the Electrical Distribution Network of Kuwait – A Case Study," Journal on Power and Energy Engineering (OJPEE)Vol. 2, No. 1,pp173-176.

[3]. Mahmoud S. Abd El-Moniem, Haitham Z. Azazi and Sabry A. Mahmoud, "A single-stage voltage sensorless power factor correction converter for LED lamp driver," Alexandria Engineering Journal, Production and hosting by Elsevier, 2013,pp 643–653.

[4]. Anant Kumar Tiwari, Durga Sharma and Vijay Kumar Sharma, "Automatic Power Factor Correction Using Capacitive Bank," Int. Journal of Engineering Research and Applications, Vol. 4, Issue 2(Version 1), February 2014, pp.393-395.

[5]. Chih-Lung Shen and Yong-Xian Ko, "Hybrid-input power supply with PFC (power factor corrector) and MPPT (maximum power point tracking) features for battery charging and HB-LED driving," Science Direct, Journal of Energy, Vol. 72, August 2014, pp 501-509.

[6]. Wanfeng Zhang, GuangFeng and Yan-Fei Liu, "A New Predictive Control Strategy for Power Factor Correction," Published in Eighteenth Annual IEEE Applied Power Electronics Conference and Exposition, (APEC'03), February 2003, pp403-409.

[7]. LopamudraMitra and C.K.Pangrahi, "Power Factor Improvement Using Active Power Factor Correction Methods," International Journal of Electrical Engineering and Technology (IJEET), Vol. 1,No. 1, May - June (2010), pp32-46.

[8]. N. K. Poon, M. H. Pong and Chi K. Tse, "A Constant-Power Battery Charger with Inherent Soft Switching and Power Factor Correction," IEEE Transactions on Power Electronics, Vol. 18, No. 6, November 2003, pp 1262- 1269.

[9]. Chi K. Tse, Martin, H. L. Chowand Martin K. H. Cheung, "A Family of PFC Voltage Regulator Configurations with Reduced Redundant Power Processing," IEEE Transactions on Power Electronics, Vol. 16, No. 6, November 2001, pp794-802.

[10]. AshishPandeya, Dwarka P. Kotharia, Ashok K. Mukerjeea and BhimSinghb, "Modelling and simulation of power factor corrected AC–DC converters," International Journal of Electrical Engineering Education, Vol. 41, Issue 3, July 2004, pp 244-264.

[11]. C. K. Tse, "Circuit theory of power factor correction in switching converters," International Journal of Circuit Theory and Applications, Vol.31, Issue 2,March/April 2003,pp 157–198.

[12]. Do-Hyun Jang, Gyu-Ha Choe and MehrdadEhsani, "Asymmetrical PWM Technique with Harmonic Elimination and Power Factor Control in AC Choppers," IEEE Transactions on Power Electronics, Vol. 10, No. 2, March 1995, pp175 – 184.

[13]. Amar Bouafassa, LazharRahmaniand SaadMekhilef , "Design and real time implementation of single phase boost power factor correction converter," ISA Transactions Published by Elsevier, Vol. 55, March 2015, pp267-274.

[14]. H.Z.Azazi, E. E. EL-Kholy, S.A.Mahmoud and S.S.Shokralla, "Review of Passive and Active Circuits for Power Factor Correction in Single Phase, Low Power ACDC Converters," Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10), December 2010, pp 19-21.

[15]. Nabil A. Ahmed, Kenji Amei and Masaaki Sakui, "AC chopper voltage controller-fed single-phase induction motor employing symmetrical PWM control technique," Electric Power Systems Research by Elsevier, Vol. 55, Issue 1, July 2000, pp 15-25.

[16]. Salvador Alepuz, Sergio Busquets-Monge, JosepBordonau, Juan A. Martínez-Velasco, César A. Silva, Jorge Pontt and José Rodríguez, "Control Strategies Based on Symmetrical Components for Grid-Connected Converters Under Voltage Dips," IEEE Transactions On Industrial Electronics, Vol. 56, No. 6, June 2009, pp 2162- 2173.

[17]. V. S. Fating, S.V. Jadhav, R.T. Ugale, and B.N. Chaudhari, "Direct Torque Control of Symmetrical and Asymmetrical Single Phase Induction Motor," Joint International Conference on Power System Technology and IEEE Power India Conference, 2008(POWERCON 2008), January 2009, pp 12-15.

[18]. G.M. Hashem and M.K. Darwish "Generalized Symmetrical Angle PWM Technique for A.C. Voltage Controller,"39th International Universities Power Engineering Conference, 2004,(UPEC 2004) source IEEE Xplore, August 2005, pp 1-4.

[19]. R. Itoh and K. lshizaka, "Series connected PWM GTO current/source convertor with symmetrical phase angle control," IEE Proceedings, Vol. 137, No. 4, July 1990, pp 205-212.

[20]. H.Hussin, A.Saparon, M. Muhamadand M.D. Risin, "Sinusoidal Pulse Width Modulation (SPWM) Design and Implementation by Focusing on Reducing Harmonic Content," Fourth Asia International Conference on Mathematical/Analytical Modelling and Computer Simulation, 2010 IEEE, pp 620-623.

[21]. Andreas Lindemann and Johann W. Kolar, "Single and Three Phase Rectifiers with Active Power Factor Correction for Enhanced Mains Power Quality," PCIM Conference on Power Quality, 2001, pp 1-7.

[22]. R. Karthigaivel, N. Kumaresan, N.Ammasaigounden, G. Meena Devi and M. Subbiah, "Identification and Analysis of Operating Modes of Single-Phase Semi-Converter Fed Battery Charging Circuits Using Symmetrical Angle Control Scheme - A Monograph,"2010 International Conference on Intelligent and Advanced Systems (ICIAS), February 2011, pp 1-6.

[23]. Mostafa I. Marei, Ehab F. El-Saadanyand Magdy M. A. Salama, "A New Approach to Control DVR Based on Symmetrical Components Estimation," IEEE Transactions on Power Delivery, Vol. 22, No. 4, October 2007. pp 2017- 2024.

[24]. Mansour Mohseni, Syed M. Islam and Mohammad A. S. Masoum, "Impacts of Symmetrical and Asymmetrical Voltage Sags on DFIG-Based Wind Turbines Considering Phase-Angle Jump, Voltage Recovery, and Sag Parameters," IEEE Transactions on Power Electronics, Vol. 26, No. 5, May 2011, pp 1587- 1597.

[25]. AnandRaghunathan, SujitDey and Niraj K. Jha, "Register-Transfer Level Estimation Techniques for Switching Activity and Power Consumption,"1996 IEEE/ACM International Conference on Computer-Aided Design, 1996. ICCAD-96, August 2002, pp 158-165.

[26]. Khalid Rustom and IssaBatarseh, "Recent Advances in Single-Stage Power Factor Correction," IEEE International Conference on Industrial Technology, Dec. 2003, pp 1089- 1095.

[27]. Sang-Hun Lee, Feel-soon Kang, Sung-Jun Park, Su Eog Cho and Man Hyung Lee, "Single-stage power-factor-corrected converter for switched reluctance motor drive," Electric Power Systems Research Published by Elsevier B.V, 2005, pp 1-7.

[28]. Mopidevi.subbarao, Ch.saibabu and S. Satyanarayana,"Charge Current Controlled Single Phase Integrated Switched Mode Power factor Correction Converter,"1st International Conference on Power Engineering, Computing and CONtrol (PECCON-2017), March 2017, VIT University, Chennai Campus, Energy Procedia 117 (2017), pp 71-78.

[29]. Aresh C. Sen and S. R. Doradla, "Symmetrical and Extinction Angle Control of Solid-State Series Motor Drive," IEEE Transactions on Industrial Electronics and Control Instrumentation, Vol. 23, No. 1, february1976, pp 31-38.

[30]. A. Pandey, B. Singh and D. P. Kothari," Comparative Evaluation of Single-phase Unity Power Factor ac-dc Boost Converter Topologies ," IE (I) Journal—EL ,Vol. 85, September 2004, pp 102- 109.

[31]. Darwin Rivas, Luis Morán, Senior Member, IEEE, Juan W. Dixon, Senior Member, IEEE, and José R. Espinoza, "Improving Passive Filter Compensation Performance With Active Techniques," IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 50, NO. 1, FEBRUARY 2003, pp 161-170.

[32]. SuriyaKaewarsa, "An Improved Zero-Voltage-Transition Technique in a Single-Phase Active Power Factor Correction Circuit,"Vol. 8,No.4, 2008, pp 207-214.

[33]. S. Ramamoorthy, "Improved Three Phase AC-DC Converter with Power Factor and Harmonics Correction," Middle-East Journal of Scientific Research, 2014, pp 1597-1604.

[34]. Mukeshkumar, Gautam Kumar Panda and Pradip Kumar Saha, "Power Factor Correction of Three Phase Rectifier with Interleaved Boost Converter," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 4, Issue 5, May 2015, pp4115-4120.

[35]. Abhijit D. Pathak, Ralph E. Locher and Himanshu S. Mazumdar, "3-Phase Power Factor Correction, Using Vienna Rectifier Approach and Modular Construction for Improved Overall Performance, Efficiency and Reliability," presented at the 2003 Power Electronics Conference in Long Beach, CA. pp 1-13.

[36]. Yungtaek Jangand Robert W. Erickson, "New Single-Switch Three-Phase High-Power-Factor Rectifiers Using Multiresonant Zero-Current Switching," IEEE Transactions on Power Electronics, Vol. 13, No. 1, January 1998, pp 194-201.

[37]. Jain Sandesh, Thakur Shivendra Singh and Phulambrikar S.P, "Improve Power Factor and Reduce the Harmonics Distortion of the System," Research Journal of Engineering Sciences, Vol. 1(5), November 2012, pp31-36.

[38]. Mazen Abdel-Salam, Adel Ahmed and Mohamed Abdel-Sater, "Ramptime Current -Controlled APF for Harmonic Mitigation, Power Factor Correction and Load Balancing," Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010, pp 144-150.

[39]. Alfredo R. Munozand Thomas A. Lipo, "On-Line Dead-Time Compensation Technique for Open-Loop PWM-VSI Drives," IEEE Transactions on Power Electronics, Vol. 14, No. 4, July 1999, pp 683-689.

[40]. Yan-Fei Liuand Paresh C. Sen, "Large-Signal Modeling of Hysteretic Current-Programmed Converters," IEEE Transactions on Power Electronics, Vol. 11, No. 3, May 1996, pp 423- 430.

[41]. Luis A. Moran, Luciano Fernandez, Juan W. Dixonand Rogel Wallace, "A Simple and Low-Cost Control Strategy for Active Power Filters Connected in Cascade," IEEE Transactions On Industrial Electronics, Vol. 44, No. 5, October 1997, pp 621-629.

[42]. Oscar Garcıa , Jose A. Cobos, Roberto Prieto, Pedro Alou, and Javier Uceda, "An Alternative to Supply DC Voltages with High Power Factor," IEEE Transactions on Industrial Electronics, Vol. 46, No. 4, August 1999, pp 703-709