Efficient Digital Control For Mppt And Output Voltage Regulation of Partially Shaded Pv Modules Using Sepic Converter

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Abstract- *In this project utilization of a modified Single Ended Primary Inductance Converter (SEPIC) for control of photovoltaic power using Maximum Power Point Tracking(MPPT) control Mechanism is presented. The main aim of this project is, SEPIC converter is to be used along with a Maximum Power Point Tracking control mechanism. The MPPT is liable for extracting the maximum possible power from the photovoltaic and feed it to the load via the SEPIC converter which steps up the voltage to the required level. Voltage multiplier technique is applied to the SEPIC converter. The multiplier technique provides new operation characteristics and a high static gain. The theoretical analysis, design procedure and simulation results are shown in this paper. GWO based global MPPT algorithm is used to track the Maximum power and three phase inverter voltage into AC voltage for load. The hardware is developed with DSPIC30F2010.*

I. INTRODUCTION

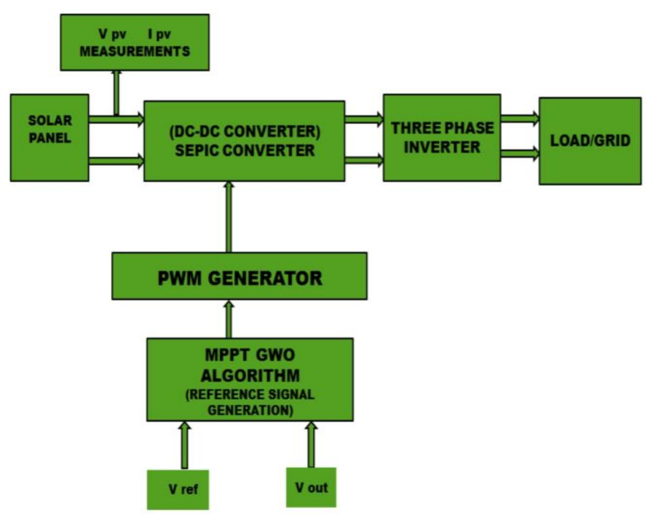
Renewable energy sources are noticed as a fast developing power generation system because of the availability in wide range. Electricity generation by PV systems causes no environmental pollution, no material depletion and has no rotating or moving parts. The output characteristics of PV system depend on the ambient temperature and the solar irradiance. Moreover, the PV system output provides single operating point, when the irradiance is uniform and the generated power is maximum (de Brito et al. 2003). Also the output power is affected by shading due to clouds, buildings, birds, plants and dusts. Hence the conversion efficiency and reliability are decreased. In order to increase the conversion efficiency, various tracking methods are developed to extract maximum power from the solar panels. Few of the most popular methods are perturb and observe, incremental conductance and hill climbing method. The simplicity, low cost and easy implementation of the conventional methods made them suitable for practical applications. But during power tracking process, there is a delay in reaching extract tracking direction. Therefore PV voltage and current are measured after a single sampling time using these methods. Also the change in atmospheric parameters will produce incorrect tracking direction before the tracking path is reached. Artificial intelligence (AI) methods and optimization algorithms are developed to overcome the drawbacks of conventional methods. AI technique uses FLC and ANN individually or as a hybrid method. The exact 2 operating point is obtained by these techniques without exact mathematical model. These techniques work depending on the system behavior and the PV characteristics. The operating point in the complete operating region is stable using these techniques. The PV panel power characteristics are affected under partially shaded operating condition. In order to optimize the global maxima evolutionary algorithms like GA, PSO, CS and FA are used. The tracking efficiency is reduced considerably due to the use of random variables in these algorithms. The uncertainty of solution is increased and hence the desired operating point cannot be reached. The power converter control variables such as voltage, current and duty cycle performance will change slowly with respect to the solution parameters of these algorithms. Recently deterministic way is used to neglect the drawbacks of these algorithms. Normally, by the MPPT method the PV system parameters are observed and the control signal to the DC-DC converter is produced. The power converters used in PV system acts as an interface between the DC source and the load so that the increase in power quality is achieved. Under varying temperature and irradiance, the PV panel operating point changes. This leads the maximum power point tracker to change the duty cycle of the converter and hence the converter operating point matches with the PV panel maximum power point. If the PV panel is directly coupled to the load, the intersection of I-V curve point will be the operating point and will not produce maximum power. Also with the change in panel temperature and irradiance, the MPP changes which leads to panel over sizing and increase in system cost. The different types of converters used in PV system are buck, boost, buck-boost, cuk and SEPIC converters. The 3 optimal performance can be achieved by interfacing PV module with DCDC converter. The AC output voltage from a DC input with desired frequency can be achieved by using a single phase PWM inverter. The controlled turn ON and OFF of the switching devices determine the inverter output frequency. The H-bridge inverters produce non-sinusoidal output voltage with some form of harmonics and is suitable for low and medium systems. Overheating of electrical components is caused by excessive harmonics. Low distorted sinusoidal output is required for high power systems. The multilevel inverter gives improved power quality, good electromagnetic compatibility from a medium input voltage and low rating devices. The output voltage waveform is better with reduced switching losses and increased number of voltage levels. Two-level inverter output is modified to get a smooth stepped output using a MLI. But the complexity of the circuit increased with more smooth output voltage. In order to reduce the complexity the reduced switch MLI is designed.

II.LITERATURE REVIEW

Natarajan et al [1] detailed PV array circuit modeling procedure. The characteristics of PV module are obtained by the experimental characteristics of the circuit model. The closed loop P &O MPPT algorithm is used for tracking maximum power point of the developed model and the duty cycle of the boost converter integrated with it is adjusted. Thus maximum power transfer is done by matching the source impedance with the load impedance. Ebtesam et al. [2] suggested that, to enhance the reliability and power shortage problems analysis of PV system by proper design equations is very important. The solar panel size, tilt angle, battery size, voltage regulator, inverter capacity are calculated according to the system requirement. It is also summarized that, for adequate, economical and reliable system design over and under sizing of each part of equipment should be avoided. Irwan et al. [3] used the PVSYST, software tool for the stand-alone photovoltaic [SAPV] system assessment. As the PV array is affected by the losses due to solar incidence, ambient temperature, wiring and manufacture mismatch the SAPV output energy is less than 100%. The room lighting system configuration and prediction of energy production are done through the PVSYST software. Hiren&Vivek [4] presented Modeling and simulation of PV array and described a method to obtain the I-V and P-V characteristics under 14 partial shading conditions for non-uniform insolation. Normally PV panel faces shading problem due to clouds, towers, buildings, trees, electric or telephone poles. The partial shading conditions affect the PV characteristics. Thus it is essential to extract the maximum power. For known shading pattern the optimum PV array configuration for the extraction of maximum power is designed by the simulink model. Testing is done by artificially generating the shading effect by covering the modules with partially transparent gelatin paper. The effectiveness of MPPT algorithms is investigated under non-uniform irradiance condition using this model. Measurements with and without blocking and bypass diodes are done. Huan-Liang et al. [5] used a Matlab / Simulink model to implement the PV cell, module and array. The I-V and P-V characteristics are analyzed with solar insolation and temperature as the input parameters. The tool Sim Power System is used for PV modeling which enables the simulation, analysis and optimization easier. Marcelo et al. [6] developed a method for the mathematical modeling and simulation of PV arrays. The PV model using single-diode with the parasitic series and parallel resistances are included to find the best non-linear I-V equation. The PV circuit model can be built with the adjusted I-V equation parameters using any circuit simulator. Other methods require virtual mathematical curve to extract the slope of I-V points by trial and error method. In this method of PV modeling a solution to obtain the parameters of practical PV array is presented. Interpolation and artificial intelligence techniques discussed by other authors are complicated and 15 requires more computation compared to this method. In those cases parasitic series and parallel resistances are neglected which leads to incorrect maximum power point extraction. The diode saturation current equation of this method effectively adjusts the I-V curve at the Voc for different temperatures. In this method the relation between Isc and Ipv replaces the assumption of Ipv ≈ Isc made in the previous works. The detailed equations presented constitute of a single-diode I-V model and the algorithm to calculate the parameters. Krismadinata et al. [7] implemented a circuit based PV cell simulation model using Matlab/Simulink platform. The PV cell characteristics for varying temperature and irradiance conditions are modeled. Datasheets of different PV modules are compared. The created model is less complex, easy to implement and compatible to different types of PV modules. Koray et al. [8] presented a new PV array reconfiguration method to increase the efficiency under non-uniform irradiance. Total cross-tiedtype array (TCT) is chosen because of the easy connection of adaptive part to the fixed part through switching matrix circuit. The configuration scanning algorithm determines the current variation index (CVI) value and hence the smallest value is searched. This method decides the configuration scheme that yields the maximum power. The presented algorithm increases the available power to 37.1% and can also be applied to arrays with different characteristics and power levels without any change in hardware and software. 16 Habbati et al. [9] have chosen a single-diode model considering series and parallel resistances to construct a detailed model of PV module using Matlab/Simulink platform. This model can be used for any type of PV module under different climatic conditions to obtain I-V and P-V characteristics. Computation of Rs and Rshand iterative adjustment is important even if the manufacturer specifies the value. Otherwise the computed and the experimental maximum power point will not be matching. Himanshu et al.

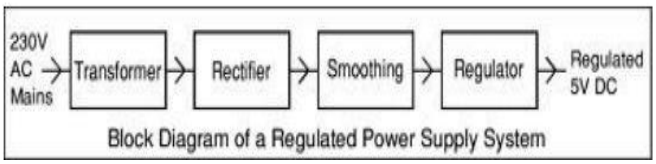
[10] presented a Matlab / Simulink model of stand-alone PV system considering solar irradiance and temperature. The IV and P-V characteristics under different ambient conditions are analyzed. The increase in temperature and Isc decreases the maximum output power. However increase in solar insolation, increases Isc. Maximum output power depends on solar irradiance whereas Isc is proportional to radiation intensity. The designed PV model is easy for Matlab/Simulink implementation. Sachin &Vivek et al [11] used a fast MPPT algorithm using variable step-size for initial approximation of maximum power point and hill-climbing or incremental conductance method for exact MPP tracking. This results in convergence with minimum number of iterations and faster tracking. The tracking efficiency is more, compared to conventional algorithm. The scheme is robust and fast controller can be implemented for tracking as it is suitable for various environmental conditions. Safe duty cycle limit can be achieved by taking great care. DC-DC boost converter is used with MPPT. Roberto Faranda et al [12] carried out performance evaluations of ten widely used MPPT algorithms by a comparative study. The ten methods 17 are constant voltage method [CV], short-current pulse [SC] method, open voltage method [OV], Perturb and observe methods such as classic P&O technique [P&O a], optimized P&O technique [P&O b],and three-point weight comparison method [P&O c], Incremental conductance methods like classic IC algorithm [IC a], and two-model MPPT control [IC b] algorithm, Temperature methods like temperature gradient [TG] algorithm and temperature parametric equation method [TP]. A cost comparison of the MPPT methods is proposed considering the costs of power components, sensors and microcontroller. The energy generated is more in the case of [P&O b] and [IC a] compared to other methods. It is suggested that further research can be focused on experimental comparison of these methods under shadow conditions. Jun Pan et al. [13] used a P&O based novel MPPT which improves the system accuracy speed and simplifies the structure. The DC-DC converter is assumed to be ideal without power loss and the output voltage is constant. Therefore the output current of the converter is proportional to the PV output power. Hence the output current of DC-DC converter is used with MPPT for varying the duty cycle. The proposed P&O method need one variable that is, the DC-DC output current and variable perturb step compared to traditional P&O. Also traditional P&O method has oscillation problem. The charging speed and the battery state of charge [SOC] are increased. Juan David et al. [14] classified and organized different MPPT approaches like Centralized MPPTs [CMPPT], Distributed MPPTs [DMPPT] and Reconfiguration MPPTs [RMPPT] under mismatching 18 operating conditions of PV system. Each architecture is described in a structured way with principles of operation hardware requirements, details of different approaches, advantages and disadvantages. The main characteristics and issues are highlighted for future research activities. But the designer should select the best MPPT solution for the specific application as it varies from one application to the other. The selection of MPPT solution affects the decision making process. To achieve final objective it should be considered as an important aspect. Hence it is necessary to develop guidelines and methodologies to choose best MPPT method for the specific application. Bidyadhar et al [15] used various MPPT techniques in different PV applications. The methods reviewed are Curve-Fitting technique, Fractional Short-circuit current [FSCI] technique, Fractional open-circuit voltage [FOCV] technique, Look-up table technique, One-cycle control [OCC] technique, Differentiation technique, Feedback voltage or current technique, Feedback of power variation with voltage technique, Perturbation and observation [P&O] and Hill-climbing technique, Incremental conductance [Inc-cond.] technique, Forced oscillation technique, Ripple correlation control [RCC] technique, Current Sweep technique, EstimatedPerturb-Perturb [EPP] technique, Parasitic capacitance technique, Load current / load voltage maximization technique, DC link capacitor droop control technique, Linearization-based MPPT technique, Intelligence MPPT techniques such as FLC, ANN and PSO, Sliding-mode based MPPT technique, Gauss-Newton technique, Analytic-Based MPPT technique, Hybrid MPPT techniques and MPPT techniques for mismatched conditions. 19 The classifications are based on control strategies, number of control variables, types of circuitry and cost..

III. BLOCK DIAGRAM



IV. HARDWARE IMPLEMENTATION

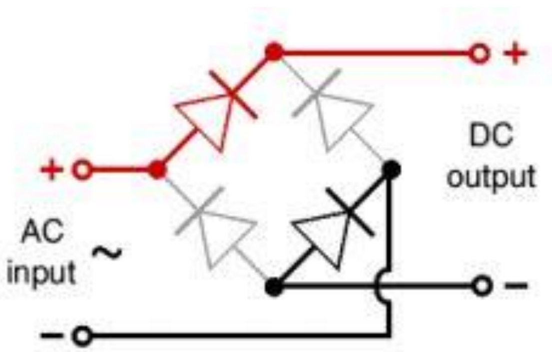
POWER SUPPLY There are many types of power supply. Most are designed to convert Voltage AC Mains electricity to a suitable low voltage supply for electronic Circuits and other Devices. A power supply can by broken down into a series of blocks, each of which performs a particular function.



• Transformer - steps down high voltage AC mains to low voltage AC
• Rectifier - converts AC to DC, but the DC output is varying.
• Smoothing - smoothes the DC from varying greatly to a small ripple.
• Regulator - eliminates ripple by setting DC output to a fixed voltage.

Here the AC supply main is given to the step down transformer. The transformer having the different voltages. The output from the transformer is given to the rectifier circuit. In this rectifier circuit the AC voltage is 62 converted to DC voltages. The rectified DC voltage is given to the regulator circuit. The output of the regulator is depends upon the regulator IC chosen in the circuit.

5.1.1.BRIDGE RECTIFIER:

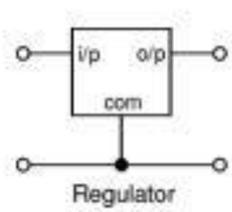


individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier. Smoothing is performed by a large value electrolytic capacitor connected across the DC Supply to act as a reservoir, supplying current to the output when the varying DC Voltage from the rectifier is falling. The diagram shows the unsmoothed DC (Dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the Peak ofthe varying DC, and then discharges as it supplies current to the output.

Note that smoothing significantly increases the average DC voltage to almost the peak Value (1.4-× RMS value). For example, 6V RMS AC is rectified to full wave DC of about 4.6V RMS (1.4V is lost in the bridge rectifier), with smoothing this increases to almost The peak value giving 1.4 × 4.6 = 6.4V smooth DC. Smoothing is not perfect due to the capacitor voltage falling a little as it discharges, Giving a small ripple voltage. For many circuits a ripple which is 10% of the supply Voltage is satisfactory and the equation below gives the required value for the Smoothing capacitor. A larger capacitor will give less ripple. The capacitor value must Be doubled when smoothing half-wave DC.

5.1.2.REGULATOR:

Voltage regulators ICs are available with fixed (typically 5, 12 and 15V) or variable Output voltages. They are also rated by the maximum current they can pass. Negative Voltage regulators are available, mainly for 64 use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and Overheating ('thermal protection').



Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, Such as the 7805 +5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary

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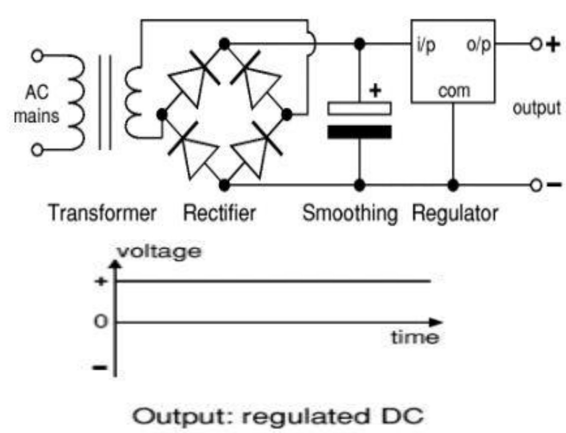


fig:rectifier circuit diagram and waveform

5.1.3.MOSFET:

• This N-Channel enhancement mode silicon gate power field effect transistor is an advanced power MOSFET designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation.

• The invention of the power MOSFET was partly driven by the limitations of bipolar power junction transistors (BJTs), which, until recently, was the device of choice in power electronics applications.

• All of these power MOSFETs are designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power.

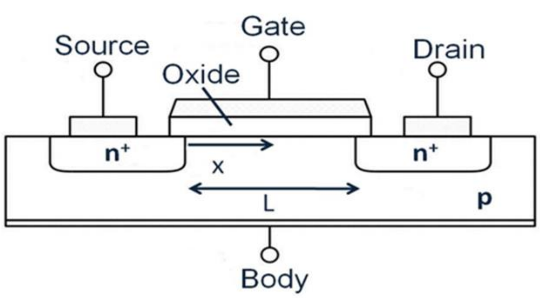
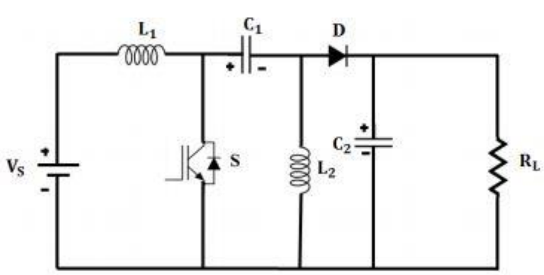


FIG: structure of MOSFET

V. SEPIC CONVERTER

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor.



A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output voltage is of the same polarity as the input voltage), the primary means of coupling energy from the input to the output is via a series capacitor, and true shutdown mode. Single-ended primary-inductor converter (SEPIC) is a type of DCDC converter that allows the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output voltage is of same polarity as the input voltage), the isolation between its input and output (provided by a capacitor in series), and 53 true shutdown mode when the switch is turned off, its output drops to 0 V. SEPICs are useful in applications in which a battery voltage can be above and below that of the regulator's intended output. For example, a single lithium ion battery typically discharges from 4.2 volts to 3 volts; if other components require 3.3 volts, then the SEPIC would be effective. The step-up and step-down static gain of the SEPIC converter is an interesting operation characteristic for a wide input voltage range application. However, as the switch voltage is equal the sum of the input and output voltage, this topology is not used for a universal input HPF rectifier. The voltage multiplier technique was presented in order to increase the static gain of single-phase and multiphase boost DC-DC converters. An adaptation of the voltage multiplier technique with the SEPIC converter is presented. The modification of the SEPIC converter is accomplished with the inclusion of the diode Dm and the capacitor Cm. Many operational characteristics of the classical SEPIC converter are changed with the proposed modification. The capacitor Cm is charged with the output voltage of the classical boost converter. Therefore, the voltage applied to the L2 inductor during the conduction of the power switch (S) is higher than in the classical SEPIC, increasing the static gain. The polarity of the voltage stored in the capacitor Cs is inverted in the proposed converter and the expressions of the capacitors voltages and others operation characteristics are presented in the theoretical analysis. The continuous conduction mode operation of the modified SEPIC converter presents two operation stages. 1) First Stage [t0, t1] - At the instant t1, switch S is turned-off and the energy stored in the input inductor L1 is transferred to the output through the Cs capacitor and output diode Do and also is transferred to the Cm capacitor through the 54 diode Dm. Therefore, the switch voltage is equal to the Cm capacitor voltage. The energy stored in the inductor L2 is transferred to the output through the diode. Second Stage [t1, t2] - At the instant t1, switch S is turnedon and the diodes Dm and Do are blocked and the inductors L1 and L2 store energy. The input voltage is applied to the input inductor L1 and the voltage Vcs-Vcm is applied to the inductor L2. The Vcm voltage is higher than the Vcs voltage. The voltage in all diodes and in the power switch is equal to the Cm capacitor voltage. The output voltage is equal to the sum of the Cs and Cm capacitors voltage. The average L1 inductor current is equal to the input current and the average L2 inductor current is equal to the output current.

VI.DSPIC 30F2010PIN CONFIGURATION:

Microchip Technology's Motor Control & Power Conversion family of dsPIC Digital Signal Controllers provides an easy-to-use solution for applications requiring motor control. Microchip Technology introduced 20 16-bit Flash micro controllers that provide the industry's highest performance. The dsPIC family of Digital Signal Controllers features a fullyimplemented digital signal processor (DSP) engine, 30 MIPS non-pipelined performance, C compiler friendly design, and a familiar Microcontroller architecture and design environment. The 20 new dsPIC30F2010 devices form three product families targeting motor control and power conversion, sensor, and general-purpose applications. The DSPIC core is a 16-bit (data) non-pipelined modified Harvard machine that combines the control advantages of a high-performance 16-bit Microcontroller with the high computation speed of a fully implemented DSP to produce a tightly coupled, single-chip single-instruction stream solution for embedded systems designs. The initial 20-dsPIC30F2010devices feature 12 Kbytes to 144 Kbytes of on-chip secure 69 Flash program memory space and up to eight Kbytes of data space Operating voltage appeals to many Microcontroller applications that remain at 5 volts, while many DSPs are restricted to 3.3-supply V maximum. Devices are planned in 40-pinpackage.

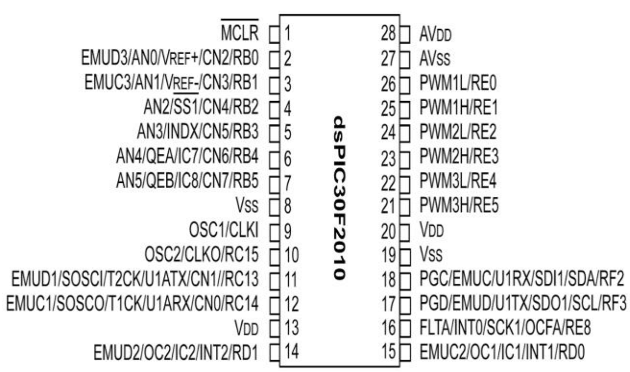


fig: DSPIC 30F2010pin Configuration

VII. CONCLUSION

It is observed that the individually photo voltaic module and SEPIC converter works properly for the designed parameter. The interfaced model of SEPIC-PV also gives the desired output result. The multiple peak point of I-V AND P-V characteristic graph solves so that the MPPT controller tracks the global point easily. The simulated model of PV, SEPIC and MPPT controller works properly during partial shading condition and give desired result.

REFERENCES

[1] Li WH, He XN (2011) Review of nonisolated high step-up DC/ DC converters in photovoltaic gridconnected applications. IEEE Trans Ind Electron 58(4):1239–1250

[2] Shahin A, Hinaje M, Martin JP et al (2010) High voltage ratio DC–DC converter for fuel-cell applications. IEEE Trans Ind Electron 57(12):3944– 3955

[3] A. Hakemi and M. Monfared, "Very high gain threephase indirect matrix converter with two Z-source networks in its structure," in IET Renewable Power Generation, vol. 11, no. 5, pp. 633-641, 4 12 2017.

[4] Yushan Liu; Haitham Abu-Rub; BaomingGe; FredeBlaabjerg; Omar Ellabban; Poh Chiang Loh, "Model Predictive Control of Impedance Source Inverter," in Impedance Source Power Electronic Converters, 1, Wiley-IEEE Press, 2016, pp.424