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Grid Connected PV System with MPPT Controller using ANFIS Algorithm

S. Shobana Saravanan[1], A. Ibrahim Basha[2], S. Lokesh[3], V. Vijay[4]
Prathyusha Engineering College, Chennai, India

Abstract:
This paper proposes the presents analysis of a grid-connected PV system with Maximum Power Point Tracking (MPPT) control. ANFIS algorithm based MPPT Technique is used for tracking maximum power point. The single-ended primary-inductor converter **(SEPIC)** is a type of DC/DC 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. ANFIS is used to provide a constant output, the output is not dependent on input. Even if any variation occurred in input the SEPIC converter is step up the input and maintains the output constanly. Simulations are performed to test the controller's capability of tracking the MPP when sudden variations in weather conditions occur. Experimental measurements are going to be in hardware system and its validated with the simulation.

Keywords: Components; Renewable, MPPT, SEPIC, Grid, ANFIS

I. INTRODUCTION

Micro-inverter topologies for photovoltaic (PV) power generation are classified into three major groups: the single-stage, the two-stage, and the multi-stage types. The multistage micro-inverters are usually comprised of a step-up dc–dc converter front stage, under maximum power point tracking (MPPT) control, an intermediate high-frequency dc– dc converter stage, used to attain a rectified-sine waveform, and a low frequency unfolding stage to interconnect to the grid. However, the multi-stage power train and the associated high component count result in a costly product. The two-stage micro-inverter can be designed cascading a MPPT-controlled step-up dc–dc converter and a grid-tied high-frequency inverter, whereas the single-stage topology has to perform the voltage step-up, the MPP tracking, and the dc–ac inversion functions all in one stage.

II. OBJECTIVE

To design and Implement Inverter for Photovoltaic applications

- Achieve high voltage boosting.
- Without bulky transformer.
- With less number of switches.
- With reduced switching stress.
- With reduced filter size.

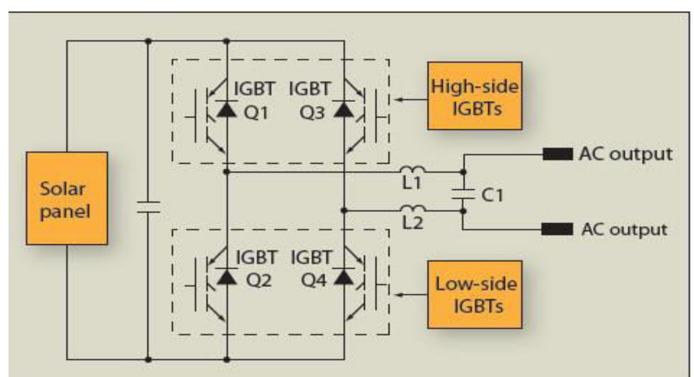
CONVENTIONAL METHODS

TRANSFORMERLESS PV SYSTEMS

The efficiency of the whole PV system can be increased with an extra 1%–2% in case the transformer is omitted. Transformer less inverters have higher efficiency and smaller weight and size than their counterparts with galvanic separation.

III. ISSUE IN TRANSFORMERLESS PV INVERTERS

The ground leakage current is very high. In case the transformer is omitted, the generated common-mode behavior of the inverter topology greatly influences the ground leakage current through the parasitic capacitance of the PV. In order to minimize the ground leakage current through the parasitic capacitance of the PV array, several techniques have been used**.**



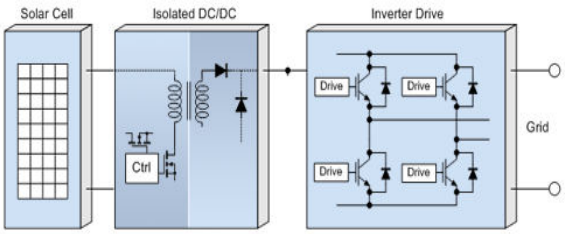
TOPOLOGIES

There are two main topology groups used in the case of grid-connected PV systems, namely,

- WITH GALVANIC ISOLATION
- WITHOUT GALVANIC ISOLATION

GALVANIC ISOLATION

Galvanic isolation can be on the dc side in the form of a high frequency dc–dc transformer or on the grid side in the form of a big bulky ac transformer. Both of these solutions offer the safety and advantage of galvanic isolation, but the efficiency of the whole system is decreased due to power losses in these extra components.



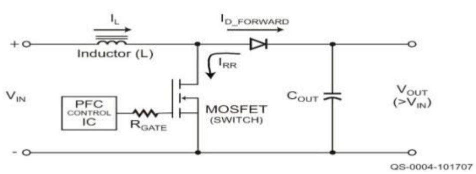
Drawbacks

- Limited dc step-up gain.
- Complicated control.
- More conversion Losses.
- Costly.

More number of switches.

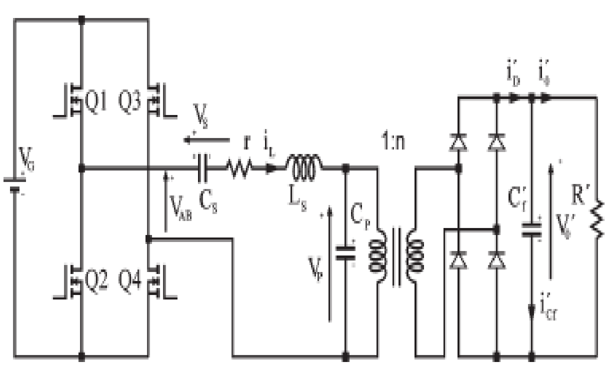
CONVENTIONAL METHOD 1

- A DC–DC BOOST converter with a high step-up voltage gain is used for many applications.
- Theoretically, a dc–dc boost converter can achieve a high step up voltage gain with an extremely high duty ratio.
- However, in practice, the step-up voltage gain is limited due to the effect of power switches, rectifier diodes, and the equivalent series resistance (ESR) of inductors and capacitors.
- Moreover, the extremely high duty-ratio operation will result in a serious reverse-recovery problem.



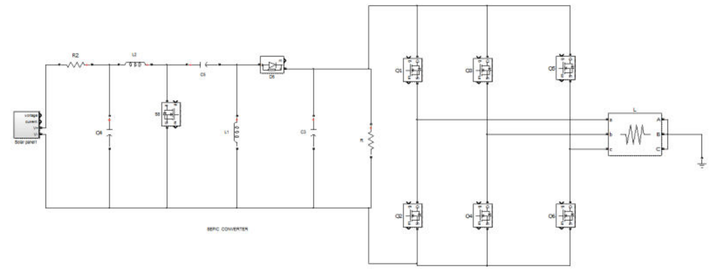
CONVENTIONAL METHODS 2

A dc–dc ISOLATED converter is a very simple structure with a high step-up voltage gain and an electrical isolation, but the active switch of this converter will suffer a high voltage stress due to the leakage inductance of the transformer.



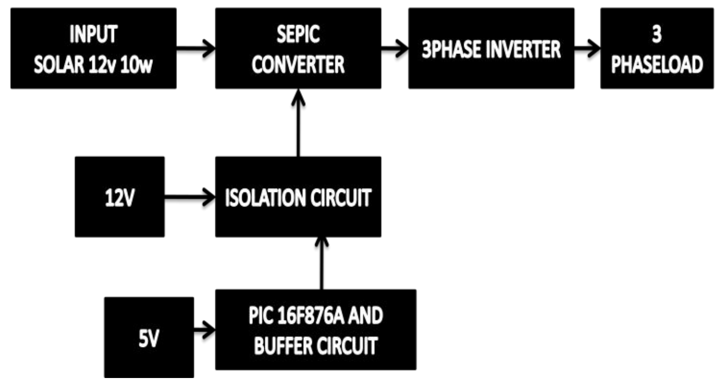
PROPOSED CIRCUIT

Attains high-quality ac output regardless of low frequency ripple across the dc link.



This is the simulation model done in MATLAB Simulink software.

BLOCK DIAGRAM

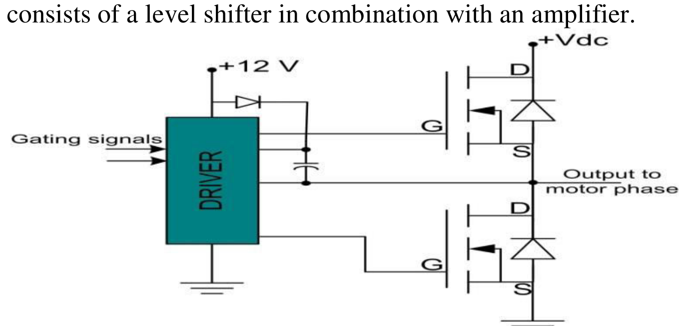


MAIN COMPONENTS

- Gate Driver (fan7392n)
- Isolation Circuit
- Diode (1N4007)
- Power MOSFET (IRF840)
- Voltage Regulator (LM7805)
- PIC 16F877A

GATE DRIVER (FAN7392n)

A gate driver is a power amplifier that accepts a low-power input from a controller IC and produces a high-current drive input for the gate of a high-power transistor such as an IGBT or power MOSFET. Gate drivers can be provided either on-chip or as a discrete module. In essence, a gate driver consists of a level shifter in combination with an amplifier.



The FAN7392 is a monolithic high- and low-side gate drive IC, that can drive high-speed MOSFETs and IGBTs that operate up to +600V. It has a buffered output stage with all NMOS transistors designed for high pulse current driving capability and minimum cross-conduction. Fairchild's high-voltage process and common-mode noise canceling techniques provide stable operation of the high-side driver under high dv/dt noise circumstances. An advanced level-shift circuit offers high-side gate driver operation up to VS=-9.8V (typical) for VBS=15V. Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The UVLO circuit prevents malfunction when VCC and VBS are lower than the specified threshold voltage. The high-current and low-output voltage drop feature makes this device suitable for halfand full-bridge inverters, like switching-mode power supply and high-power DC-DC converter applications.

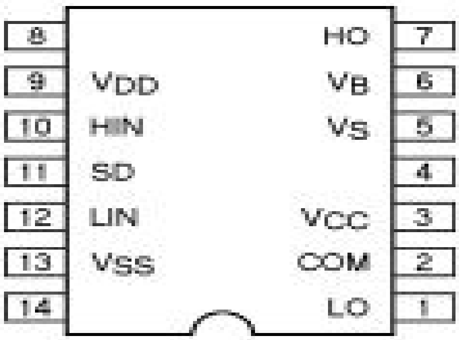


Figure.FAN7392

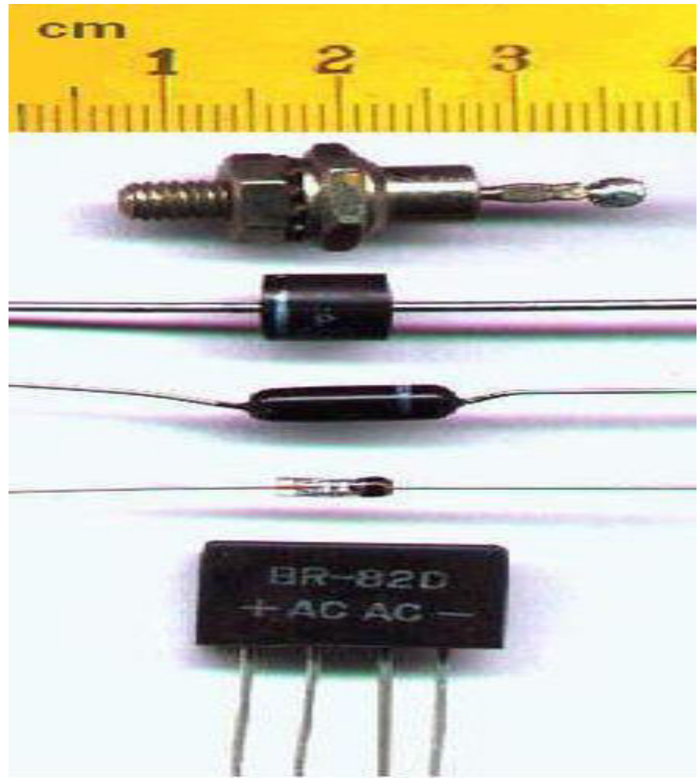
PIN SPECIFICATION

VDD-Logic supply
HIN-Logic input for high side gate driver output (HO), in phase
SD- Logic input for shutdown
LIN-Logic input for low side gate driver output (LO),in phase
VSS-Logic ground
HO-High side gate driver output
VB-High side floating supply
VS- High side floating supply return
VCC-Low side supply
COM-Low side return
LO-Low side gate driver output

FEATURES
3.3V Logic Compatible
Separate Logic Supply (V_{DD}) Range from 3.3V to 20V
Under-Voltage Lockout for V_{CC} and V_{BS}
Cycle-by-Cycle Edge-Triggered Shutdown Logic
Matched Propagation Delay for Both Channels

ISOLATION CIRCUIT
Isolation circuits are specially designed circuits to isolate the power circuit and controller circuit. these circuits are used to provide ground. ics are usually used to provide this isolation.

DIODE (1N4007)
In electronics, a diode is a two-terminal electronic component with asymmetric conductance; it has low (ideally zero) resistance to current in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. A vacuum tube diode has two electrodes, a plate (anode) and a heated cathode. Semiconductor diodes were the first semiconductor electronic devices. The discovery of crystals' rectifying abilities was made by German physicist Ferdinand Braun in 1874. The first semiconductor diodes, called cat's whisker diodes, developed around 1906, were made of mineral crystals such as galena. Today, most diodes are made of silicon, but other semiconductors such as selenium or germanium are sometimes used.



FEATURES

- Low forward voltage drop
- High current capability
- High reliability
- High surge current capability
- Exceeds environmental standards of MIL-S-19500/228

IV. MECHANICAL DATA

Case: Molded plastic , DO-41
Epoxy: UL 94V-O rate flame retardant
Lead: Axial leads, solderable per MIL-STD-202,Method 208 guaranteed
Polarity: Color band denotes cathode end
Mounting Position: Any
Weight: 0.012 ounce, 0.3 gram.

POWER MOSFET (IRF840)
The MOSFET, or Metal-Oxide-Semiconductor, Field-Effect Transistor is by far the most common field effect transistor in both digital and analog circuits. The MOSFET is composed of a channel of n-type or p-type semiconductor material, and is accordingly called an NMOSFET or a PMOSFET. Unfortunately, many semiconductors with better electrical properties than silicon, such as gallium arsenide, do not form good gate oxides and thus are not suitable for MOSFETs. The gate terminal is a layer of polysilicon (polycrystalline silicon) or aluminum placed over the channel, but separated from the channel by a thin layer of insulating silicon dioxide.

FEATURES

- Power MOSFET has lower switching losses but its on-resistance and conduction losses are more.
- MOSFET is a voltage-controlled device.
- MOSFET has positive temperature co-efficient for resistance. This makes parallel operation of MOSFET easy. If a MOSFET shares increased current initially, it heats up faster its resistance rises and this increased resistance causes this current to shift to other devices in parallel
- In MOSFET secondary break down does not occur, because it has positive temperature co-efficient.

VOLTAGE REGULATOR (LM7805)

A **voltage regulator** is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the *xx* is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx line are positive voltage regulators: they produce a voltage that is positive relative to a common ground.

PIC 16F877A

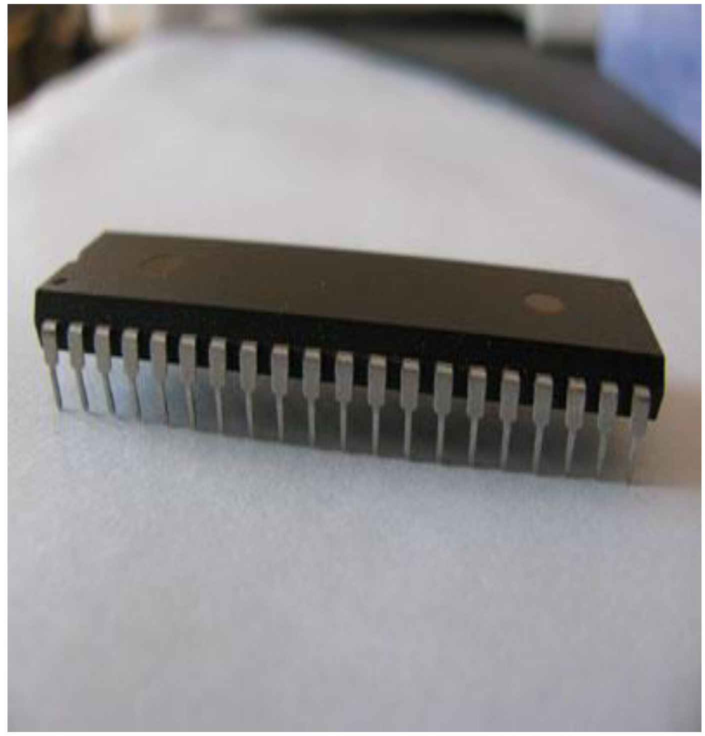
POWER SUPPLY DESIGN

Driver circuit needs 12V and 5V. Microcontroller need 5V supply, so we convert 230V AC supply is first step down in to 15V by using step down transformer. Then this 15V AC is converted in to DC by using Full bridge rectifier which has high efficiency than all other methods. This 15V DC is converting into 12V DC and 5v DC by using 7812 and 7805 regulator respectively. The capacitor is used to provide smooth variation in voltage. For indication purpose we used LED with 1K resistor to limit current flow to the LED. The following figure shows the regulated power supply.

PIC 16F877A

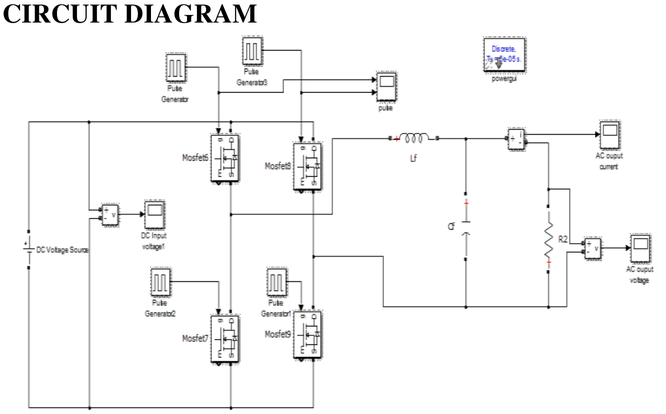
The microcontrollers played revolutionary role in embedded industry after the invention of Intel 8051. The steady and progressive research in this field gave the industry more efficient, high-performance and low-power consumption microcontrollers. The AVR, PIC and ARM are the prime examples. The new age microcontrollers are getting smarter and richer by including latest communication protocols like USB, I2C, SPI, Ethernet, CAN etc.

PIC MICROCONTROLLER



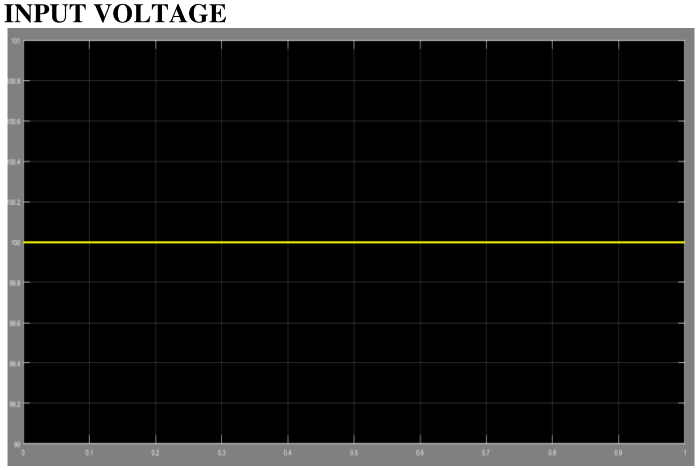
SINGLE PHASE INVERTER

CIRCUIT DIAGRAM

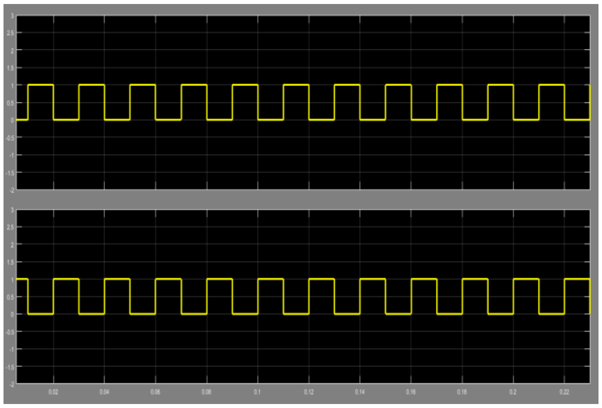


Simulation model of single phase inverter using MATLAB Simulink Software.

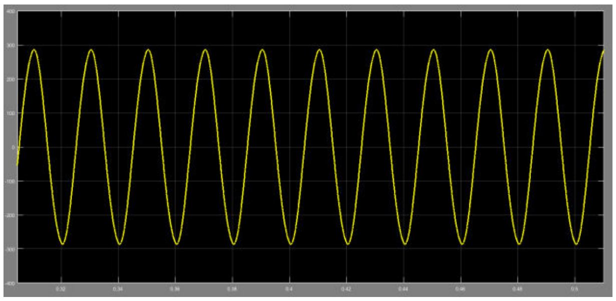
INPUT VOLTAGE



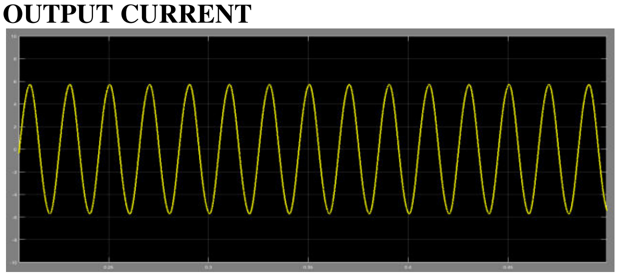
INVERTED PULSE



OUTPUT VOLTAGE



OUTPUT CURRENT



WORKING OF THE SYSTEM

- PIC microcontroller use to give triggering pulses for the mosfet switches.
- Buffer is used to amplify the current gain.
- Isolation circuit is used to prevent the controller from power circuit.
- 12 v supply is for ISOLATION CIRCUIT and 5 v supply is for microcontroller.
- According to ANFIS algorithm the switch is triggered and the maximum power is produced in output.
- SEPIC converter is used to boost the voltage upto 10 times of input voltage.
- Inverter converts the DC supply to AC supply and given to the load.
- This system provide a sufficient voltage irrespective of whether condition.
- There is a gate driver circuit for every switch to operate according to the ANFIS command and for the protection purpose.
- By this constant output, we can connect this system to the grid.

APPLICATIONS

- PV applications.
- Alternative energy generation applications.
- Drives application.

V. CONCLUSION

This paper presented real time simulation of grid connected PV system with efficient adaptive neuro fuzzy and MPPT controller. The generated DC power is connected to the grid using a voltage source inverter. The proposed ANFIS based MPPT controller is very efficient than other PV system. The results shows that the controllers are efficient in delivering the maximum power from the PV panel to the grid.

Table.1. PV panel Parameter

Parameter	Value
Open Circuit Voltage	21.7 V
Short circuit current	3.35 A
Voltage at P_{MAX}	17.4 V
Current at P_{MAX}	3.05 A
Series connected modules(N_{SS})	50
Parallel connected modules(N_{PP})	20
Number of PV cells in each model	36
Ideality factor of PV diode, *a*	1.5
Temperature Dependancy factor	3
Reference Temperature	25^{o}c
Temperature Coefficient of I_{SC}	0.065
Reference solar intensity	1000 W/m^2
Coupling inductance L	1.35mH
DC link capacitor C_{DC}	80mF
C1	10mF
L1	5 mH
Converter switching frequency	5 kHz

VI. REFERENCES

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