AIJREAS VOLUME 3, ISSUE 5(2018, MAY) (ISSN-2455-6300) ONLINE
ANVESHANA'S INTERNATIONAL JOURNAL OF RESEARCH IN ENGINEERING AND APPLIED SCIENCES

CLOSED LOOP CONTROL OF ZVS/ZCS DC-DC CONVERTER WITH HIGH OUTPUT VOLTAGE FOR PHOTOVOLTAIC APPLICATION

M.Swathi
Department of EEE
Moghal College of Engineering

ABSTRACT

This project presents a non isolated, high boost ratio dc–dc converter with the application for photovoltaic (PV) modules. The proposed converter utilizes a hybrid transformer to incorporate the resonant operation mode into a traditional high boost ratio active-clamp coupled-inductor pulse-width-modulation dc– dc converter, achieving zero-voltage-switching (ZVS) turn-on of active switches and zero-current-switching turn-off of diodes. As a result of the inductive and capacitive energy being transferred simultaneously within the whole switching period, power device utilization (PDU) is improved and magnetic utilization (MU) is optimized. The improved PDU allows reduction of the silicon area required to realize the power devices of the converter. The optimized MU reduces the dc-bias of magnetizing current in the magnetic core, leading to smaller sized magnetics. Since the magnetizing current has low dc-bias, the ripple magnetizing current can be utilized to assist ZVS of main switch, while maintaining low rootmean- square (RMS) conduction loss. The voltage stresses on the active switches and diodes are maintained at a low level and are independent of the wide changing PV voltages as a result of the resonant capacitor in series in the energy transfer loop.

1. INTRODUCTION

The PV energy generated from sunlight is captured by dc PV modules. The power generated by these modules is integrated into the existing ac power distribution infrastructure through the power conditioners, which can adopt two-stage or single stage system configurations. Compared to single-stage systems, the two-stage single-phase architecture can use the high-voltage dc-bus as double-line ripple power buffer to avoid failure-prone electrolyte capacitors. In two-stage PV power conditioners, high boost ratio dc–dc converters are used to increase the low PV voltage to a high dc voltage to interface the PV modules with either a low-power individual inverter or a high power centralized grid-connected inverter. Since galvanic insulation is not mandatory in code, this high boost ratio dc–dc converter can be isolated or non isolated

SCOPE OF THE PROJECT

This project presents the performance analysis of hybrid transformer zvs/zcs dc-dc Converter with optimized magnetic and improved power devices utilization for photovoltaic module application.

2. LITERATURE SURVEY

J.-S. Lai (2009) this article provides an overview of PCS architectures and circuit topologies for low-voltage energy source in single-phase grid-tie applications. The discussion was focused on those relatively new but practical system architectures and circuit topologies including dc-dc converters and dc-ac inverters.

H. Hu, S. Harb, N. Kutkut, I. Batarseh, and Z. Shen (2013) The reliability of the micro inverter is a very important feature that will determine the reliability of the ac-module photovoltaic (PV) system. Recently, many topologies and techniques have been proposed to improve its reliability. This paper presents a thorough study for different power decoupling techniques in single-phase micro inverters for grid-tie PV applications. These power decoupling techniques are categorized into three groups in terms of the decoupling capacitor locations: 1) PV-side decoupling; 2) dc-link decoupling; and 3) ac-side decoupling. Various techniques and topologies are presented, compared, and scrutinized in scope of the size of decoupling capacitor, efficiency, and control complexity. Also, a systematic performance comparison is presented for potential power decoupling topologies and techniques.

S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg (2005) this review focuses on inverter technologies for connecting photovoltaic (PV) modules to a single-phase grid. The inverters are categorized into four classifications: 1) the number of power processing stages in cascade; 2) the type of power decoupling between the PV module(s) and the single-phase grid; 3) whether they utilizes a transformer (either line or high frequency) or not; and 4) the type of grid-connected power stage. Various inverter topologies are presented, compared, and evaluated against demands, lifetime, component ratings, and cost. Finally, some of the topologies are pointed out as the best candidates for either single PV module or multiple PV module applications.

B. Gu, J. Dominic, and J.-S. Lai (2013) this paper derives the small-signal model and designs the controller for a high boost ratio dc-dc converter with the application for PV modules. A voltage controller with proportional-integral (PI) cascaded quasi-resonant (QR) controllers is presented for an inner PV voltage loop of maximum power point tracking (MPPT) control. Here, PI controller provides fast-tracking of voltage reference and maintains zero steady-state error, while QR controller with resonant frequency equal to double grid-line (DGL) frequency provides high rejection capability of DGL oscillation of PV module voltage. As a result, the MPPT control algorithm can be free from DGL ripple oscillation and the MPPT efficiency can be improved. Experimental results based on a 250W prototype board confirm the effectiveness of the modeling and the proposed control method.

OPERATION MODES

t0–t1: At t0 , S2 is turned off. The negative magnetizing current iLm starts to charge Cj . Due to the voltage potential change of the drain node of S1, a parasitic minor resonant loop composed of secondary side of HT, Llk, Cr, Cs , and Cj starts to resonate until Dr is forward-biased.

t1–t2: At t1 , vds1 is reduced to zero. is1, which is equal to the sum of ip and niCr, flows through the body diode of S1. This provides a ZVS condition for S1 .Vinis applied on Lm and iLmis linearly increased. Meanwhile, the secondary-reflected input voltage nVin along with VCc charge Cr in a resonant manner through the resonant loop including secondary side of HT, Llk ,Cr , Dr , Cc and body diode of S1 .

t2–t3: At t2 , S1 is turned on with ZVS. t3–t4: At t3 , iDr resonates back to zero so Dr turns off with ZCS. Vin continues to linearly charge Lm. t4–t5: At t4, S1 is turned off. iLm starts to discharge Cj .Due to the voltage potential change of the drain node of S1, a parasitic minor resonant loop composed of secondary side of HT, Llk , Cr , Cs , and Cj starts to resonate.

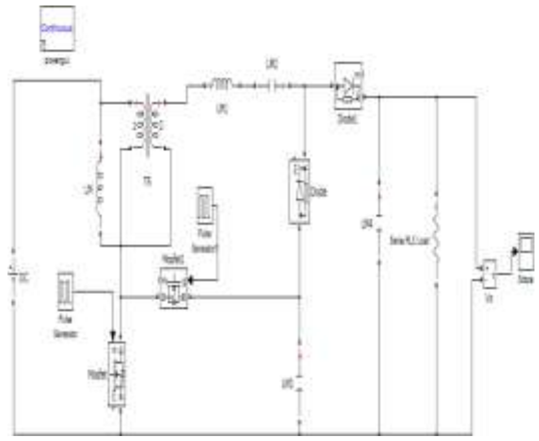
t5–t6: At t5 , Cs is discharged to the point where the anti parallel diode of S2 starts to conduct. This provides ZVS turn-on of S2. Also, the voltage potential of anode of Do increases high enough leading Do to be forward-biased.

t6–t7: At t6 , S2 is turned on with ZVS. Since it takes along time interval before iLm reduces to zero, ZVS of S2 is easily achieved. The energy is transferred to the output with the resonant current iDo .and Co is normally much higher than Cr, so we haveCeq2 ≈ Cr.

T7–t8: At t8, iDo resonates to zero, Do turns off with ZCS. From t5 to t8, the voltage applied on Lm is Vin–VCc, which decreases iLm to a negative valley to provide a ZVS turn-on condition of S1. Assuming the switching transition periods of t0–t1 and t4–t5are negligibly short, the boost ratio Mb can be derived by three flux balance criteria in the steady state. The first flux balance equation which governs the circuit is from the flux balance of Lm during the whole switching period.

SIMULATION RESULTS

4.1 SIMULATIONS PROPOSED CIRCUIT:



OUTPUT WAVEFORM

HARDWARE DESCRIPTION

The hardware system of the proposed converter is implemented using a PIC micro-controller. The software system like Proteus, Mplab, and Micropro is used for the system design for coding the pulses in to the PIC controller. The power supply circuit is designed that will control the PIC and driver circuit to drive the pulses to the MOSFET.

SOFTWARE UNIT

- **MICROPRO**

SPECIFICATIONS

- Auto detection of programmer by software
- Regulated Power supply 5,13.5V
- Auto Flash upgrades through serial port
- 16 MHz crystal Oscillator
- Built in RS232 connector
- ZIF socket for easy programming
- External ICSP Interface for on board programming
- Programmable configuration and ID
- Selective Erase and programming for supported PIC Devices
- Manual / Auto Reset
- Configurable COM Port.
- Program, Read, Verify and Blank check Modes
- Hex Code Editor
- Program & Verify fly Window
- Switchable to MPLAB software
- Extensive Integrated Help
- Debug vector Read & write
- Oscal value read & program (for selected chips)

MPLAB Integrated Development Environment (IDE) is a free, integrated toolset for the development of embedded applications on Microchip's PIC and dsPIC microcontrollers.

5.2.1 CONTROLLER UNIT

A Microcontroller (sometimes abbreviated µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

The PIC architecture is characterized by its multiple attributes:

1. Separate code and data spaces (Harvard architecture) for devices other than PIC32, which has Von Neumann architecture.
2. A small number of fixed length instructions. Most instructions are single cycle execution (2 clock cycles, or 4 clock cycles in 8-bit models), with one delay cycle on branches and skips.
3. One accumulator (W0), the use of which (as source operand) is implied. (i.e. is not encoded in the opcode)
4. All RAM locations function as registers as both source and/or destination of math and other functions.
5. A hardware stack for storing return addresses and fairly small amount of addressable data space (typically 256 bytes), extended through banking.

Data space mapped CPU, port, and peripheral registers.
The program counter is also mapped into the data space and writable. (This is used to implement indirect jumps)
Universal Asynchronous Receiver/Transmitter (UART) block makes it possible to receive and transmit data over a serial line with very little load on the CPU. Dedicated on-chip hardware also often includes capabilities to communicate with other devices (chips) in digital formats such as I²C and Serial Peripheral Interface (SPI).

FEATURES

- Floating channel designed for bootstrap operation
- Fully operational to +600V
- Tolerant to negative transient voltage dv/dt immune
- Gate drive supply range from 10 to 20V
- Under-voltage lockout for both channels
- 3.3V logic compatible
- Separate logic supply range from 3.3V to 20V
- Logic and power ground ±5V offset
- CMOS Schmitt-triggered inputs with pull-down
- Cycle by cycle edge-triggered shutdown logic
- Matched propagation delay for both channels
- Outputs in phase with inputs

Analog Applications:
10-bit, up to 8-channel Analog-to-Digital Converter (A/D), Brown-out Reset (BOR), Analog Comparator module with, Two analog comparators Programmable on-chip voltage reference (VREF) module, Programmable input multiplexing from device inputs and internal voltage reference, Comparator outputs are externally accessible
High-Performance RISC CPU:
Only 35 single-word instructions to learn, All single-cycle instructions except for program branches, which are two-cycle, Operating speed: DC – 20 MHz clock input DC – 200 ns instruction cycle, Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory, Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

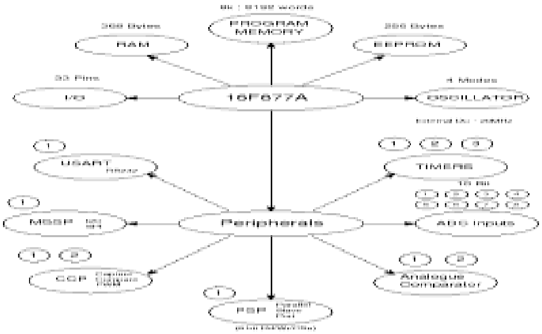


Fig.3.1. Micro-controller Peripherals
Peripheral Details:
Timer0: 8-bit timer/counter with 8-bit prescaler, Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock, Timer2: 8-bit timer/counter with 8-bit period register, prescaler and post scaler, Two Capture, Compare, PWM modules, Capture is 16-bit max, resolution is 12.5 ns Compare is 16-bit max, resolution is 200 ns, PWM max, resolution is 10-bit Synchronous Serial Port (SSP) with SPI (Master mode) and I2C (Master/Slave), Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection, Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only), Brown-out detection circuitry for Brown-out Reset (BOR).
Special Microcontroller Applications:
100,000 erase/write cycle Enhanced Flash program memory typical, 1,000,000 erase/write cycle Data EEPROM memory typical, Data EEPROM Retention > 40 years, Self-reprogrammable under software control, In-Circuit Serial Programming via two pins, Single-supply 5V In-Circuit Serial Programming Watch dog Timer (WDT) with its own on-chip

RC oscillator for reliable operation Programmable code protection, Power saving Sleep mode, Selectable oscillator options, In-Circuit Debug (ICD) via two pins. CMOS Technology: Low-power, high-speed Flash/EEPROM technology, fully static design, Wide operating voltage range (2.0V to 5.5V), Commercial and Industrial temperature ranges, Low-power consumption.

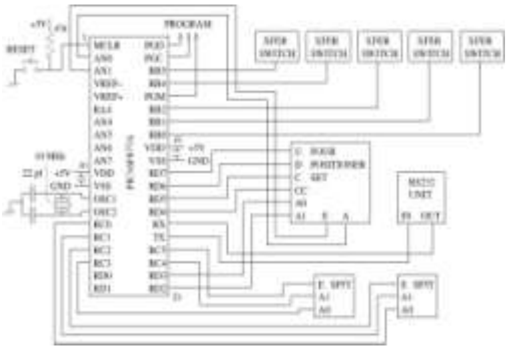


Fig.3.2. Microcontroller PIC16F877A

REQUIREMENTS (HARDWARE PART)

MOSFET GATE DRIVER

The High And Low Side Driver (IR2112) is a high voltage; high speed power MOSFET and IGBT driver with independent high and low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard CMOS or LSTTL outputs, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration which operates up to 600 volts.

The driver circuit is used to drive the bi-directional converter switches where in this project the converter acts as a shunt active filter (2-quadrant) for unity power factor operation and the dc voltage regulation. Here two BJT's (n-type and p-type) are used for amplification.

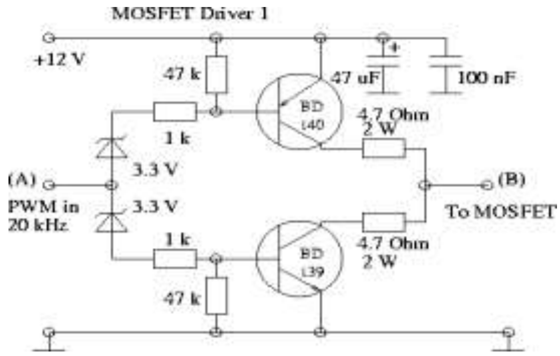


Fig.3.3. DRIVER CKT IR2110

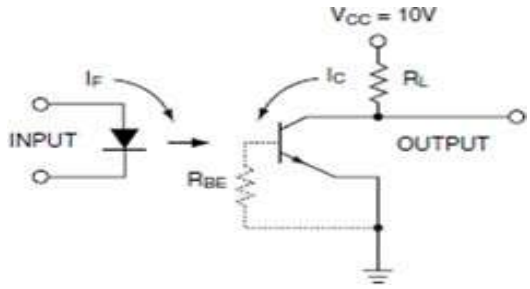


Fig.3.4. Operation of the MOSFET gate driver

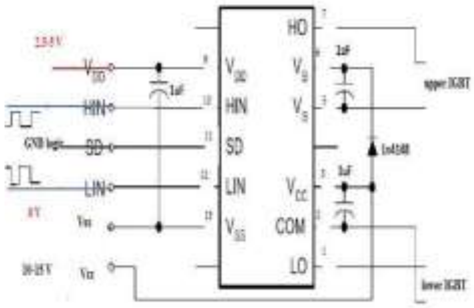


Fig.3.5. Driver Circuit operation

Fig.3.6. IR2110 Driver

FEATURES

- Floating channel designed for bootstrap operation
- Fully operational to +500V or +600V
- Tolerant to negative transient voltage & dV/dt immune

- Gate drive supply range from 10 to 20V
- Under voltage lockout for both channels
- 3.3V logic compatible
- Separate logic supply range from 3.3V to 20V
- Logic and power ground ±5V offset
- CMOS Schmitt-triggered inputs with pull-down
- Cycle by cycle edge-triggered shutdown logic
- Matched propagation delay for both channels
- Outputs in phase with inputs

The IR2110/IR2113 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration which operates up to 500 or 600 volts.

MOSFET

A cross section through an n-MOSFET when the gate voltage V_{GS} is below the threshold for making a conductive channel; there is little or no conduction between the terminals source and drain; the switch is off. When the gate is more positive, it attracts electrons, inducing an n-type conductive channel in the substrate below the oxide, which allows electrons to flow between the n-doped terminals; the switch is on.

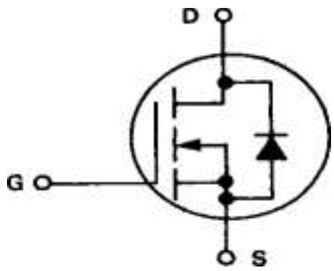


Fig.3.8. MOSFET

ADVANTAGES

- Silicon gate for fast switching speeds.
- Low R_{ds}(on) to minimize On-losses, specified at elevated temperature.
- Rugged---SOA is power dissipation limited.
- Source to drain diode characterized for use with inductive loads.
- Dynamic dv/dt rating
- Repetitive avalanche rated
- Fast switching
- Ease of paralleling
- Simple drive requirements

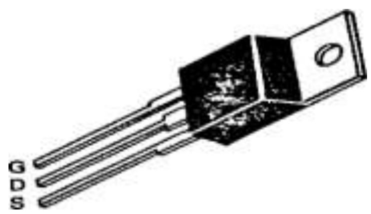


Fig.3.9. IRF840

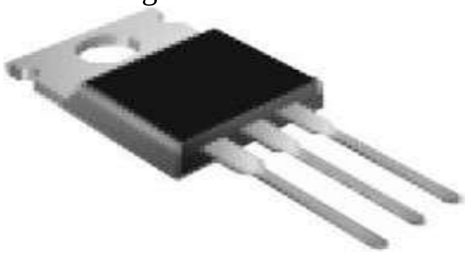


Fig.3.9. IRF840

PRODUCT SUMMARY		
V_{DS} (V)	500	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.85
Q_g (Max.) (nC)	63	
Q_{gs} (nC)	9.3	
Q_{gd} (nC)	32	
Configuration	Single	

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness. The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

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. 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. These types can be operated directly from integrated circuits.

FEATURES

- Ids= 8A; Vds=500V ;Rds(on)= 0.850Ω
- Single Pulse Avalanche Energy Rated
- SOA is Power Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance

DIODE

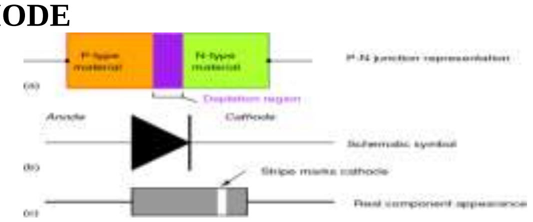


Fig.3.10. Diode

In electronics, a diode is a type of two-terminalelectronic component with nonlinear resistance and conductance (i.e., a nonlinear current–voltage characteristic), distinguishing it from components such as two-terminal linear resistors which obey Ohm's law. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material connected to two electrical terminals. A vacuum tube diode (now rarely used except in some high-power technologies) is a vacuum tube with two electrodes: a plate and a cathode. The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking current in the opposite direction (the reverse direction). Thus, the diode can be thought of as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, and to extract modulation from radio signals in radio receivers—these diodes are forms of rectifiers.

However, diodes can have more complicated behavior than this simple on–off action. Semiconductor diodes do not begin conducting electricity until a certain threshold voltage is present in the forward direction (a state in which the diode is said to be forward-biased). The voltage drop across a forward-biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or voltage reference.

INDUCTOR

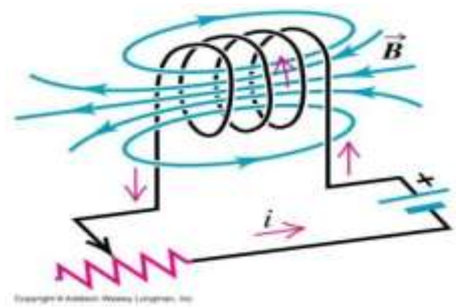


Fig.3.11 Inductor

An inductor (or reactor or coil) is a passivetwo-terminalelectrical component used to stored energy in a magnetic field. Any conductor has inductance although the conductor is typically wound in loops to reinforce the magnetic field. Due to the time-varying magnetic field inside the coil, a voltage is induced, according to Faraday's law of electromagnetic induction, which by Lenz's law opposes the change in current that created it. Inductors are one of the basic components used in electronics where current and voltage change with time, due to the ability of inductors to delay and reshape alternating currents. Inductors called chokes are used as parts of filters in power supplies or can be used to block AC signals from passing through a circuit.

CAPACITOR

A capacitor (formerly known as condenser) is a passivetwo-terminalelectrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices. When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

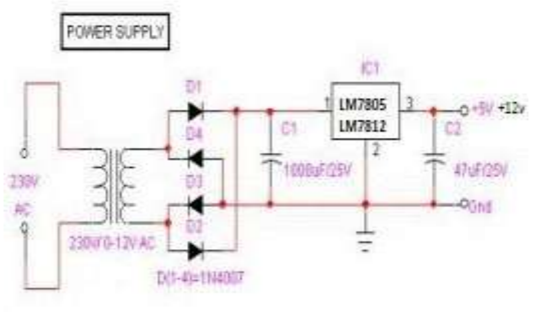


Fig.3.13. Power Supply Unit

The power supply section is the important one. It should deliver constant output regulated power supply for successful working of the project. A 0-12V/1mA transformer is used for this purpose. The primary of this transformer is connected in to main supply through on/off switch& fuse for protecting from overload and short circuit protection. The secondary is connected to the diodes to convert 12V AC to 12V DC voltage. And filtered by the capacitors, which is further regulated to +5v, by using IC 7805 and +12v by using IC7812.

5.11 Regulator IC's

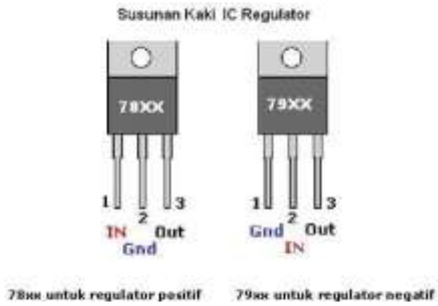
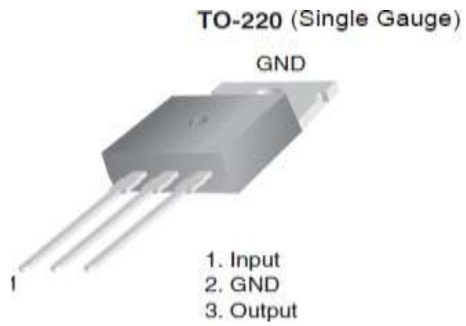
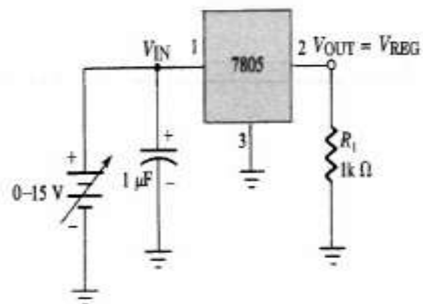


Fig.3.14. Regulators Unit





In electronics, a linear regulator is a component used to maintain a steady voltage. The resistance of the regulator varies in accordance with the load resulting in a constant output voltage. In contrast, the switching regulator is nothing more than just a simple switch. This switch goes on and off at a fixed rate usually between 50 kHz to 100 kHz as set by the circuit. The regulating device is made to act like a variable resistor, continuously adjusting a voltage divider network to maintain a constant output voltage. The primary advantage of a switching regulator over linear regulator is very high efficiency, a lot less heat and smaller size.

6. APPLICATIONS & FUTURE SCOPE

APPLICATION

A. Used in solar cells

FUTURE SCOPE

- The project will be divided in to modules and it will be elaborated.
- The literature reviews of the conventional papers will be discussed.
- The input and output values of the presented design will be listed.
- The simulation will be designed in MATLAB-SIMULINK and the system is verified based on power factor calculations.
- The hardware circuit is implemented using PIC microcontroller.

REFERENCES

[1] J.-S. Lai, "Power conditioning circuit topologies," IEEE Ind. Electron.Mag., vol. 3, no. 2, pp. 24–34, Jun. 2009.

[2] H. Hu, S. Harb, N. Kutkut, I. Batarseh, and Z. Shen, "A review of powerdecoupling techniques for microinverters with three different decouplingcapacitor locations in PV systems," IEEE Trans. Power Electron., vol. 28,no. 6, pp. 2711–2726, Jun. 2013.

[3] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of singlephasegrid-connected inverters for photovoltaic modules," IEEE Trans.Ind. Appl., vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.

[4] B. Gu, J. Dominic, and J.-S. Lai, "Modeling and control of a high boostratio PV module DC–DC converter with double grid-line ripple rejection,"inProc. IEEE 14thWorkshop ControlModeling for Power Electron., 2013,pp. 1–4.

[5] B. Gu, J. Dominic, and J.-S. Lai, "Control of electrolyte-free microinverterwith improved MPPT performance and grid current quality,"inProc. IEEE 29th Annu. Appl. Power Electron. Conf., 2014,pp. 1788–1792.

Author Details

***CHINNA YALAMANDA B** graduated in EEE from JNT University Hyderabad in 2009. He worked as senior engineer (electrical) for cement manufacturing company for five years in telangana state .pursuing M.tech degree in the steam of power electronics and electrical drives for 2016-18 in anurag engineering college*

PROJECT GUIDE:

***MUDUSU.SRINU**graduated in EEE from JNT University Hyderabad in 2006.He received M.Tech degree in the stream of Power and Industrial Drives in JNT University Kakinada in 2011,presently working as Assistant Professor in Anurag Engineering College*

HOD DETAILS:

***SCHANDRASEKHAR** received his B.Tech degree in electrical & electronics engineering from RVR&JC college of engineering Guntur in 2001, M.Tech (high voltage engineering) degreein electrical & electronics Engineering from university college of engineering jntu kakinad a in 2004. He is pursuing Ph.D at KL university. Presently he is working as associate professor and Head of the Department of EEE. He is presented a paper on MICRO GRID FAULT ANALYSIS in WSEAS International conference at INDONESIA On 7,8,9, MAY 2016. He is guiding a both undergraduate and post graduate student projects. his area of interest includes Micro Grids, High voltage transmission and Power systems.*