Multi-Input and Multi-Output Converter Using Renewable Energy Sources

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Abstract **- The futuristic technologies and new dimensions of the digital world make a perfect combination to increase the power demand which makes people move towards advancement in the field of research in power converters. The concern over energy availability is based on the rapid building of organizations and development in people's population. These factors that influence renewable energy sources in industries and commercial have become more important today. Thus people started moving towards renewable energy resources due to the merit of renewable energy sources over conventional energy resources. It also causes less amount of pollution when compared to conventional energy resources. The role of an energy converter in an electrical system is to make the availability, based on the requirement, and have control over the power generation depending upon the rate of change of demand in the consumer sideload. Nowadays the application of energy converters is in a wide range, which covers the majority of field applications and the advancement in the semiconductive materials. The intermittency issues occurring have been solved with the help of multiport converters. Our proposed project is implemented based on a variable multiple-input multiple-output converter which delivers continuous DC-DC and DC-AC power supply to the loads using multi-input renewable sources such as solar, wind turbine, etc**.

Index Terms – MIMO converter, digital potentiometer, buck converter

I. INTRODUCTION

India's power generation development is expanding rapidly. The Indian economy faces significant challenges in meeting its energy demands over the following decade. The necessity for energy in India continues to rise, which cannot be met by non-renewable resources. The entire capacity installed in India is about 367,280.54 MW, as stated on 2/01/2020 (CEA 20192020).

The indigenous existence of renewable resources gives credibility to the economy and tends to create energy independence worthwhile. The economy relies on imports of fossil fuels leads to subjection to the supplier nation's short-term political and economic goals, which may hinder energy security. Recent advances in renewable energy-based power systems, hybrid vehicles, aerospace systems, smart grids, and portable handheld devices have developed challenges within the design of recent power conversion systems. The necessity for clean and far more efficient sources of energy also has significant implications for conventional electricity transmission and distribution networks. Renewable energy sources that are most evolving, e.g., .solar energy, wind energy systems, and fuel cells, should be ready to upload renewable energy to the grid and be ready to supply different applications. Power electronic converters significantly improve the system performance of renewable energy conversion to

function effectively at available power. This power conversion allows for an efficient interconnection between renewable energy systems and loads. Growing numbers of those power generating sources would force new methods and techniques to sustain electricity control within the integrated energy system. The power electronic interface can handle the transfer and control of power using switch mode power converters. The event of secure and low-cost electronic devices will mitigate or reduce most of the issues caused by the proliferation of renewable energy sources.

In the existing system several single input and single output converters has been cascaded into a single system, where multiple accessing of multi input sources are not available simultaneously which in turn considered to be a main disadvantage of this existing system. Some of the disadvantage of existing system are that the existing system works only on the single input source at a time and when any failure occurs it switch on to the next supply. The efficiency of the conventional device system can be reduced due to the factors. The current system is also complex to construct and highly cost-effective. Pulse width modulation is the strategy for a decision to control present-day power electronics circuits. The essential thought is to the administration the duty cycle of a switch with the end goal that a load sees a controllable standard voltage. To accomplish this, the switching frequency is picked sufficiently high that the charge can't take after the particular exchanging occasions. Pulse width modulation systems utilized as a part of a traditional inverter can be altered to use in multilevel converters.

In this paper, Multiple Input Multiple Output converter is proposed that is powered using multiple renewable energy sources like solar, wind turbine, etc. The proposed methodology is to provide continuous and efficient power supply to the loads by means of multiple input sources.

II. Multi-Input and Multi-Output Converter Using Renewable Energy Sources

The proposed methodology is to provide continuous and efficient power supply to the loads by means of multi input sources such as solar, battery etc. The input side may consist of solar panel, wind turbine, piezoelectric such renewable resources and the power generation mechanism by means of multiple inputs can be observed and its output DC or AC voltage indicate that system stability has been maintained.

In this paper solar panel, wind turbine and piezoelectric have been connected to the battery with the charge controller. The battery is the storage of the entire system. A 12V adapter is also connected to the battery for the usage of backup power from the grid.

The system consist of the digital potentiometer and buck converter that is located in the output section of the proposed system. The microcontroller ESP32 controls the system. All the sensors and converter works on 5V, thus a 5V power is regulated from the battery and through microcontroller given to all sensors.

The proposed system consist of:

- Microcontroller (ESP32) □ Solar panels
- Charge controller □ Battery
- Relay module
- High rpm Motor
- High Current Buck Converter □ LCD with 12C Module
- DC Voltmeter
- AC Voltmeter
- Adapter
- Inverter
- Digital Potentiometer

When the user gives the require value of the output voltage to the microcontroller through the keypad enabled at the microcontroller which the keypad is works using the matrix system to give the required value and to change the different mode of the system, the LCD displays the entered value and from the microcontroller the signal is given to the digital potentiometer.

In the digital potentiometer by the input signal from the microcontroller it creates an output value which is the given to the input if the buck converter. It is this input value of the buck converter that determines the output voltage of the proposed system. When the input value is received from the potentiometer the 12V power from the battery is step downed to the required output voltage. In case of the AC socket an inverter is placed at the output

to convert the DC to AC output. A voltage sensor is placed to sense the flow of the output voltage and to turn of the system if over flow of power to the socket is sensed.

The relay is connected to the system to turn off and on the flow of the power to the device. Thus their will continues flow of power from the source to the connected device.

The objective of proposed system is to increases the complete productivity of the power converter system and to offer continuous energy supply to the numerous system load. Multi input / output converter will be more efficient than the single input dc-dc converter. It is used to provide the continuous power supply to the multiple dc and AC loads. It is primarily designed for a cost efficient approach to hybrid power systems for energy generation and dispatch. Also the system uses fewer parts, better control, greater reliability and lower system losses.

III. HARDWARE IMPLEMENTATION

1. ESP32 Microcontroller

ESP32 is a very popular chip used for IoT applications. The main part of this module is the ESP32D0WDQ6 chip. It has 48 pins, but not all pins are available for use. It consists of an on-chip module and Bluetooth. Due to these features, it can be used for many embedded system applications. It consists of two cores and each core can be controlled separately. It can operate in a variable frequency range from 80 MHz to 240 MHz It has 18 integrated analog to digital converters. Each ADC is based on 12-bit SAR technology two digital to analog DACs. Integrates nine touch sensors. For communication, it has 2 UART communication channels, 2 i2c communication interfaces, two I2C interfaces and a CAN communication interface. It has 16 pulse width modulation channels. It also has a cryptographic hardware acceleration module for various cryptographic algorithms such as RSA, AES Digital input GPIO pins. It has six GPIO pins that can only be used as digital input pins. They cannot be configured as digital output pins.

2. Solar panels (12V 20W)

This 20W 12V Solar Panel is the best quality solar panel we found in a comparative market with excellent performance even weak sunlight. It is Durable anti-eye enough to make a unique processing panel, set convenient enough. It consists of unique technology to prevent water freeze deformation frame with elegant picture Small portable size and easy to carry.

DC OUTPUT VOLTAGE (V)	12
MAX. OUTPUT CURRENT (AMP)	1.03 1.4
MAX POWER OUTPUT	20
WEIGHT (gm)	2880
MATERIAL	POLYCRYSTALLINE SILICON
OPEN CIRCUIT VOLTAGE (VOC)	23.1
VOLTAGE MAXIMUM POWER (Vm(v))	17.5
SHORT CIRCUIT CURRENT (ISC) (Amps)	1.44
DIMENSION	740 X 350 X 25 MM (L X B X THICKNESS)

3. Charge Controller

A solar charge controller is used to keep the battery from overcharging by regulating the voltage and current coming from the solar panel to the battery. It is programmed at 15-A/200-W unit and uses MPPT (maximum power point tracking) to accelerate solar charging of the battery up to 30% per day. MPPT checks the output of the solar panel compares it to the battery voltage and adjusts it to the best voltage in order to get maximum current in to the battery. The solar charge controller uses a 25-A circuit breaker to protect it against overcurrent and has a baseline of continuous power consumption of 35 mA. The 12-V DC power is accessible via a female cigarette lighter socket that is implanted in a sidewall of the hard case, and is protected against overcurrent by the internal circuitry of the solar charge controller.

4. 12V Battery

A 12V lithium-ion battery is connected in series by three or four lithium-ion batteries. The capacity of the battery pack depends on the capacity of a single cell, or the capacity of the batteries in parallel. It is a new kind of safe and environmental protection battery. There is no standard capacity. It is determined according to the specific requirements of electrical appliances or equipment. The general capacity is: 2200mAh, 5Ah, 10Ah. Some electric

vehicles can reach 20Ah, or 50Ah. The more batteries are connected in parallel, the larger the capacity is. 2V lithium battery volume depends on the battery capacity, and it has no uniform specification. The bigger the battery, the larger the volume is. Nowadays, a lot of equipment needs a large capacity, light weight lithium battery. Take electric cars for example, they used to use lead-acid batteries, but now many electric cars change into lithium batteries because of the large capacity, light weight and small volume. The charging and discharging current of a lithium battery is determined by the power of the device. On the basis of constant voltage, the more power the device has, the more current it needs to output.

5. High Current Buck Converter

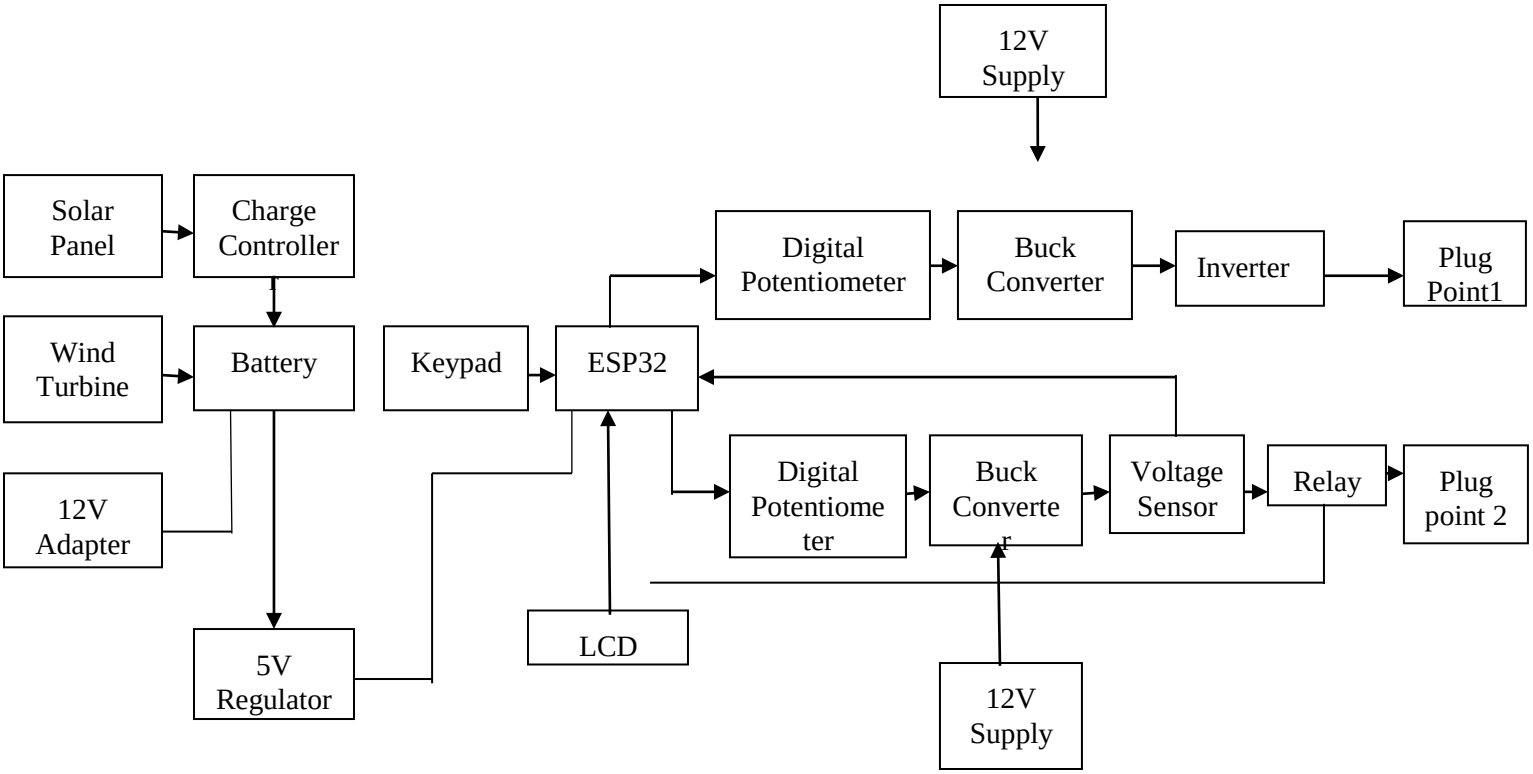
A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while drawing less average current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element, a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). It is called a buck converter because the voltage across the inductor "bucks" or opposes the supply voltage. Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that lower voltages by dissipating power as heat, but do not step up output current.

6. Digital Potentiometer

A digital potentiometer (also called a resistive digital-to-analog converter or informally a digipot) is a digitally-controlled electronic component that mimics the analog functions of a potentiometer. It is often used for trimming and scaling analog signals by microcontrollers. A digital potentiometer is built either from a resistor ladder integrated circuit or a digital-to-analog converter although a resistor ladder construction is the more common. Every step on the resistor ladder has its own switch which can connect this step to the output terminal of the potentiometer. The selected step on the ladder determines the resistance ratio of the digital potentiometer. The number of steps is normally indicated with a bit value e.g. 8 bits equals 256 steps; 8 bits is the most common, but resolutions between 5 and 10 bits (32 to 1024 steps) are available. A digital potentiometer uses digital protocols like I^2C or Serial Peripheral Interface Bus for signalling; some use simpler up/down protocols. Some typical uses of digital potentiometers are in circuits requiring gain control of amplifiers (frequently instrumentation amplifiers), small-signal audio-balancing, and offset adjustment.

Most digital potentiometers use only volatile memory, which means they forget their position when they are powered down (on power up they will report a default value, often their midpoint value) - when these are used, their last position may be stored by the microcontroller or FPGA to which they are interfaced. Some digipots do include their own non-volatile storage, so their default reading on power up will be the same as they showed before they were powered down.

Fig.1 Block Diagram of the proposed system



The components and their quantity used in prototype are listed in the table below.

Table 1. Hardware Specifications

ITEMS	QUANTITY
ESP32 MICROCONTROLLER	1
12V 20W SOLAR PANEL	1
CHARGE CONTROLLER	1
HIGH RPM MOTOR 12V	1
12V LI-ION BATTERY	1
HIGH CURRENT BUCK CONVERTER	2
LCD WITH 12C MODULE	1

DC VOLTMETER	1
AC VOLTMETER	1
DIGITAL POTENTIOMETER	2

IV. CONCLUSION

For the requirement of Low maintenance applications, the proposed MIMO DC-DC converter will provide high efficiency at the time it is associated to the expected system. Also, the cost of conventional power form converter is also very high compared to the proposed MIMO converter. Consistent and constant power supply to the loads are provided by the proposed converter. The Reliability and life time of the converter is very high since converter is using power semiconductors. The manufacturing cost is also less due to usage of power semiconductors which occupies less volume. The proposed system finds applications in many Industrial areas like Micro grid system, Electric cars, residential low power electric appliances, HVDC system and DC to DC charger. The input to the proposed system is extracted from various resources like Solar, Wind,
Micro grid and Fuel cell resource systems. Due to Multi Input and Multi Output converters low manufacturing cost it is utilized by various energy management resources and energy supplier. Analysing and monitoring the power is also better when compared to the conventional converter. These type of converters finds many applications in the field of research and Industry. MIMO converters can have different attributes such as Multi- directional power flow, lesser volume, soft switching, isolation between input and output, battery charging control, Hybrid switching, less noise.

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