DESIGN AND SIMULATION OF ALTERNATIVE POWER SUPPLY SYSTEM FOR TELECOM TOWERS

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ABSTRACT – Telecommunication towers are critical infrastructure supporting the global connectivity network, necessitating uninterrupted power supply for seamless operations. However, traditional power sources often face challenges such as reliability, environmental impact, and cost inefficiency. This study explores the design and simulation of an alternative power supply system tailored for telecom towers to address these challenges. The research employs a comprehensive approach, integrating renewable energy sources, energy storage technologies, and efficient power management strategies to develop a robust and sustainable solution. Through simulation models and optimization algorithms, the proposed system's performance is evaluated under various scenarios, considering factors like geographic location, energy demand patterns, and weather conditions. Results indicate significant improvements in reliability, cost-effectiveness and environmental sustainability compared to conventional power systems. This study contributes valuable insights into the development of alternative power supply solutions for telecom infrastructure, facilitating enhanced operational efficiency and resilience in the telecommunication industry.

Keywords – Power Supply, Telecommunications, Efficiency.

I. INTRODUCTION

The usage of mobile phones has significantly increased with the growth of technology. However, cellular networks need to be improved to provide uninterrupted connections to their users. To achieve this goal, more research and advanced devices are required. Our project focuses on implementing renewable energy sources in the field of mobile networks, which predominantly rely on traditional methods. We chose[1]solar energy as the renewable energy source due to its recent advancements and availability in every corner of the country. We understand that the supply from the grid is not always available, causing network issues for users. This problem can cause users to lose hope in their network provider. To solve this, we have come up with an alternative power supply system that is reliable and emits fewer pollutants into the air than the present traditional methods. We used Matlab simulation software to test different controllers and algorithms that go into this project. This simulation can simulate controllers without practical testing, allowing us to get an overview of the controller's performance. We can also simulate solar panels, which are quite costly. The primary source of power for this alternative system is Photo Voltaic Arrays (PV arrays). We have focused on both AC and DC loads of the telecom towers. To compensate for the lower voltage output of solar panels, we use [5]Boost Converters. To convert the DC power generated by the panels into AC power, we utilize an[6] inverter. To minimize losses from the inverter, we incorporate an [7]LCL filter which results in a pure AC voltage output. Generally, most [3]telecom towers use 40V DC for electronic devices such as transmitters, receivers, and filters, while the AC supply is used for the surrounding area of the towers, such as lights and other AC applications. The PV system can only provide power during the availability of sunlight. When it's absent, there is no voltage from the PV system. To overcome this, we use a [1] battery with controllers to charge the battery during sunlight and use the battery when there is no radiation from the sun. The maximum irradiation from the sun is seen in March, and the power rating according to the month is as follows: Jan (64,500 kWh), Feb (68,000 kWh), Mar (71,500 kWh), Apr (65,500 kWh), May (62,500 kWh), June (61,000 kWh), July (54,500 kWh), Aug (57,500 kWh), Sept (57,000 kWh), Oct (50,500 kWh), Nov (47,500 kWh), Dec (43,500 kWh). However, we cannot estimate the power delivery from the PV system for the entire year using this data. The peak sun energy is in March, with 71,500kWh. The months and respective solar radiation is shown in the figure below

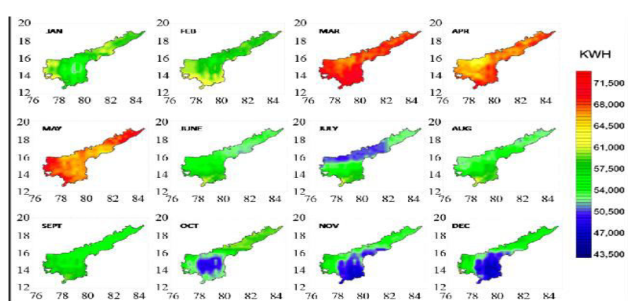

Figure 1: solar irradiance of Andhra Pradesh in a year

Alternative Power Supply System for Telecom Towers:

This system is comprised of several components, including PV modules, DC-DC converters, batteries, bi-directional converters, inverters, DC loads, and AC loads. Its primary function is to convert solar irradiance into usable AC and DC voltage. During the day, the PV modules generate voltage to power the tower, while on overcast days and at night, the system relies on charged batteries. The power flow begins with the conversion of solar irradiance into electricity via solar panels. The voltage generated is initially low and requires boosting with a boost converter. Additionally, the load requires less voltage than the generated voltage, necessitating a buck converter to reduce the voltage level. The obtained voltage is DC, so it must be converted to AC to use with AC applications. This is where the inverter comes in. The battery is also used, so a bi-directional converter is necessary to charge and supply power. All of these components are illustrated in the block diagram.

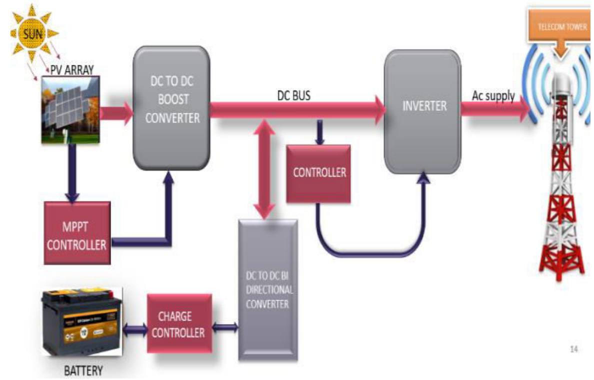

Figure 2: Block diagram of the system

II. LITERATURE SURVEY

This system is designed to provide an alternative power source to the BTS or telecom tower during power outages. It is composed of several components, including PV modules, a DC-DC converter, batteries, a charge controller, and a DC load. The system's efficient operation relies on converting solar irradiation into electrical signals using PV cluster modules. During the day, the PV modules supply the load through the DC-DC converter and charge the batteries through the charge controller. At night and on overcast days, the batteries supply the load with the required power.

The battery string size is significant enough to cover the night and some shady days, ensuring that the system remains operational throughout. A block diagram of the standalone system is shown in Figure 2, which is a mix of solar PV exhibit modules that generate direct current (DC), a controller and MPPT which control charging and releasing the battery string, and a BTS load that includes all DC loads.

In addition to DC loads, the system can also power applications that require AC by introducing an inverter into the system. The inverter converts the DC from the boost converter into AC for the AC loads. The overall system consists of a boost converter, inverter, inverter filter, buck converter, bi-directional converter, and battery, all of which combine to provide a seamless and reliable power supply to the BTS or telecom tower.

To set up the system, one must first obtain data on the total solar irradiance in Andhra Pradesh to predict the amount of power that can be generated each month.

a) Motivation of the Project

Telecom towers play an essential role in connecting us to the world around us through cellular networks. However, these towers require a continuous power supply to operate without disruption. Relying solely on the main grid power supply is not practical as it is impossible to predict when the grid might fail. When this happens, the mobile base transceiver stations (BTS) connected to the telecom towers experience complete shutdowns due to power outages.

To address this challenge, traditional backup power supplies such as diesel generators have been used. However, these generators require fuel to run and contribute to air pollution. As a result, there has been a growing need to implement renewable energy sources into the system. Solar energy is becoming increasingly popular as an alternative power source for telecom towers. By harnessing the sun's energy, we can ensure the uninterrupted operation of the telecom towers without relying on the main grid power supply.

The implementation of solar power in the telecom industry has several benefits. Firstly, it reduces the carbon footprint and greenhouse gas emissions associated with diesel generators. Secondly, it reduces operational costs by eliminating the need to purchase fuel for backup power. In addition, solar energy is a clean and sustainable source of power that can help to conserve the environment. In conclusion, the integration of renewable energy sources such as solar power in the telecom industry is a significant step towards ensuring the uninterrupted connectivity of the world. By adopting sustainable energy sources, we can contribute to the conservation of the environment while also reducing operational costs.

III. ALTERNATIVE POWER SUPPLIES IN TELECOM

a) MPPT Controller

Solar energy has emerged as a promising renewable energy source, with photovoltaic (PV) systems being widely adopted for power generation. However, the efficiency of solar panels can be significantly affected by varying environmental conditions such as sunlight intensity, temperature, and shading. Maximum Power Point Tracking (MPPT) technology addresses this challenge by dynamically adjusting the operating point of the PV system to maximize power output. MPPT algorithms continuously monitor the voltage and current characteristics of the solar panel and determine the point at which maximum power is extracted from the panel, known as the Maximum Power Point (MPP). By operating the PV system at the MPP, MPPT ensures optimal energy conversion and enhances the overall efficiency of the solar power generation process. The Maximum Power Point Tracking (MPPT) controller plays a crucial role in optimizing the performance of solar panels. It receives electrical power from the photovoltaic (PV) array and feeds it to the switches of the boost converter. This process ensures that the solar panels can generate maximum power at any time of the day by continuously adjusting the voltage and current supplied to them. The MPPT controller is essentially a smart device that tracks the maximum power point of the solar panels and adjusts the voltage and current accordingly, allowing the panels to operate at their highest efficiency. By doing so, it improves the overall performance of the solar system, reduces energy losses, and maximizes the output.

The Perturb and Observe algorithm has been widely used in the control of solar panels due to its less complexity and better efficiency. It is a highly effective method that constantly monitors the irradiance and temperature of the solar panel and adjusts the duty ratio accordingly. This process allows for maximum power output to be achieved from the solar panels at any instant in time.

In essence, the Perturb and Observe algorithm works by perturbing the operating point of the solar panel and observing its response. Based on this observation, the algorithm adjusts the duty ratio to achieve the maximum power output. This technique is particularly beneficial in cases where the solar panel parameters are unknown or constantly changing, as it adapts to changes in the environment and maintains optimal performance.

b) Inverters

Semiconductor devices are increasingly being used in the electrical field. Power semiconductors are the heart of modern power electronics and are mainly used to convert power from one form to another. Inverters are circuits that convert Direct Current (DC) to Alternating Current (AC). The main objective of an inverter is to use a DC voltage source to supply a load requiring AC. The quality of AC output is an important factor to consider. The input of an inverter is taken from various DC sources such as batteries, photovoltaics, fuel cells, alternators, etc. There are two types of circuits used in single-phase inverter circuits; half-bridge and full-bridge configurations. Inverters are widely used for various applications, from small switched power supplies for computers to large electric utility applications for transporting bulk power.

The most common technique used for inverter circuits is Sinusoidal Pulse Width Modulation (SPWM). This technique is based on comparing a triangular carrier signal with a sinusoidal reference waveform. The advantages of unipolar SPWM are that it only requires a small filter to produce a sine wave and reduces Total Harmonic Distortion (THD).

Thus, the purpose of this project is to compare and analyze the results of THD between the bipolar SPWM and unipolar SPWM switching techniques. Furthermore, a hardware prototype of the inverter using unipolar SPWM was developed to verify the simulation results. The microcontroller used for this project is the Arduino Uno.

c) Bi-Directional Converter

A bidirectional DC-to-DC converter stands as a cornerstone in contemporary power electronics, boasting the remarkable capability to fluidly transform DC power between distinct voltage levels in either direction. Operating in both buck and boost modes, these converters wield unparalleled versatility, accommodating the conversion from higher to lower voltages and vice versa with equal efficiency. Beyond their technical prowess, bidirectional DC to DC converters serve as linchpins in a myriad of critical applications, including energy storage systems, electric vehicles, and renewable energy infrastructures.

By facilitating bidirectional power flow, they enable seamless integration between various energy storage devices and the larger electrical grid, thereby fostering enhanced efficiency, reliability, and sustainability in our evolving energy landscape. A bi-directional DC to DC converter is an electronic device capable of converting DC power from one voltage level to another bidirectionally. Unlike traditional converters that operate unidirectionally (either stepping up or stepping down voltage), bi-directional converters can facilitate power flow in both directions. This bidirectional capability is particularly useful in applications where energy needs to be efficiently transferred between two DC sources or loads bi-directionally.

d) Battery Charge Controller

The battery charge controller is a crucial component in any photovoltaic (PV) system, as it ensures that the battery is efficiently charged from the PV array voltage. Essentially, the battery charge controller acts as a charger for the battery, connecting it to the system and regulating the amount of terminal voltage required to charge it. This voltage is typically less than the overall system voltage, which is why a bidirectional converter is used to reduce the voltage.

The bidirectional converter has two switches that need gate pulses to operate. By operating the duty cycles of the converter, the controller can control the operation of the converter, whether it operates in boost or buck operation. This is important because it allows the controller to regulate the amount of voltage that is being delivered to the battery, ensuring that it is charged efficiently and effectively.

To determine whether the converter should operate in boost or buck mode, the battery charger controller uses a function to give the signal to the switches of the converter. Two inputs are taken into account: the reference battery current, which is the amount of current that the battery should receive, and the measured battery current, which is the actual amount of current that the battery is receiving. These inputs allow the controller to monitor the charging process and make adjustments as needed to ensure that the battery is charged properly.

Overall, the battery charge controller is a critical component in any PV system, as it ensures that the battery is charged safely, efficiently, and effectively. With the help of the diagram, the process of charging the battery can be easily understood, and the benefits of using a battery charge controller become clear.

IV. RESULTS

In this simulation we will consider two cases based on battery charging state they are

Case(I) :- While Battery Is Discharging

Case(II) :- While the Battery Is Charging

a) Case(I) :- While Battery Is Discharging

In this case, we should set the battery reference current to +10A to allow for discharge.

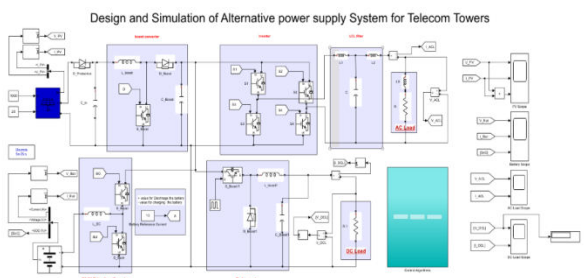

Fig. 3: Simulink Model of Alternative Power Supply System For Telecom Towers

The following figure shows the output of solar panels when its fully functioning and there is enough sunlight.

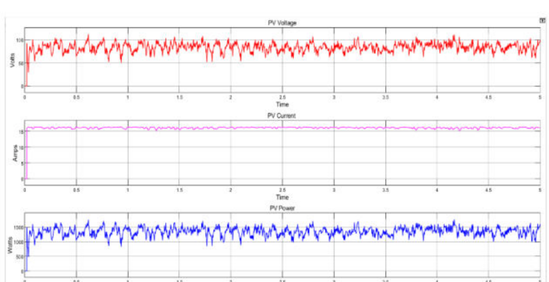

Fig. 4: Voltage, Current and power of the PV array

The Following Figure Shows the AC output of the overall system designed while the battery is discharging.

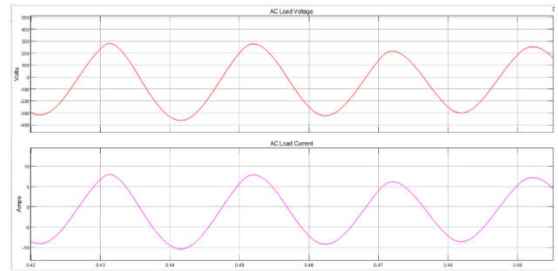

Fig. 5: AC Voltage and current output of the designed system

b) Case(I) :- While Battery Is Charging

In this case, we should set the battery reference current to -10A to allow for Charging.

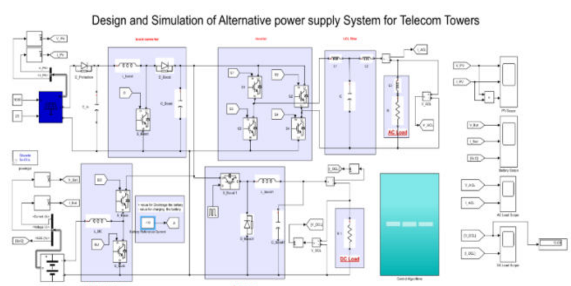

Fig. 6: Simulink Model of Alternative Power Supply System for Telecom Towers

The Figure below shows the AC Output of the overall system while the battery is charging

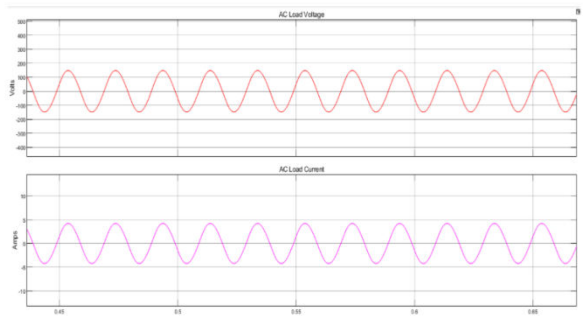

Fig. 7: AC output Voltage and Current While the battery is charging.

The Simulation is conducted to test the performance of the system so that an alternative power supply system can be developed for the telecom towers The battery's initial SOC is set to 50 percent. This value is chosen to ensure that the battery can receive or supply power when necessary. The below table shows the measured battery current can follow the reference battery current throughout the simulation process. This shows that the design and analysis of the Alternative Power Supply system for telecom has successfully provided enough voltage and power to run the Tower.

Table. 1: The reference current, voltage, SOC AND DC voltage values of the system

Mode of operation	SOC	AC VOLTAGE	AC CURRENT	DC VOLTAGE
While Battery Is Charging	50%(increasing)	149.4 V	4.87 A	13.72V
While Battery Is discharging	50%(decreasing)	247.2V	8.72 A	40.72V

V. CONCLUSION

The project aims to develop an alternative power supply system for telecom towers that utilize renewable energy sources, particularly solar energy, due to its clean operation and better efficiency. The system is designed to power the telecom towers in the absence of the main grid power supply. The hardware topology and MPPT algorithms presented in this project are validated through computer simulations using MATLAB software. All the components that are developed in Simulink are tested during simulations.

The MPPT algorithm used in the system can help in achieving better efficiency from the solar panels. Currently, most of the telecom towers are powered by diesel generators as their backup power source, which is less efficient and releases pollutants into the atmosphere. The system developed in this project aims to replace diesel generators completely and produce clean energy, thereby reducing the operational and maintenance costs of the tower. It is possible to change the output of the system by configuring the PV parameters and obtaining higher values of voltages and powers.

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