Grid Connected Solar PV System with SEPIC Converter Based MPPT

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Abstract – This paper discusses the design of SEPIC's single-faced core induction transformer and how it's proposed to be used with PV systems. (PV). The PV system consists of solar panels and DC/DC converters to upgrade and reduce the solar panel's output so that the network is connected to the required effort, reflecting a ripple-free PVC effort. A DC/DC converter should be used with high efficiency and responsiveness. The best of these transformers is the SEPIC Converter. The PV system has been connected to the network in reverse to export the energy produced from the PV system as well as feed some electrical loads. The PVS and the DC/DC converter (SEPIC) were designed and simulated using the matlab, and the MPPT tracking system was used to the maximum extent. The output (DC/DC converter (SEPIC) produced on Vdc = 600 v) has been set, where the income effort of SEPIC can vary to 298 v continuous currents, and this system can be released to the network up to 50 kw. This system has been designed and simulated using canals at several different stages. SEPIC's response to solar radiation changes has been tested, and the high response has been demonstrated in maintaining the required chilling effort to connect to the electrical grid.

Keywords—SEPIC; Home solar PV; DC/DC converter

I. INTRODUCTION

Solar photovoltaic technology has emerged as the most preferred form of electricity generating among many renewable energy sources. As an investment option that prioritizes usable cleanliness and safety, this solution offers potential benefits for both households and enterprises. By adopting this approach, individuals may effectively lower their power expenses, attain a degree of energy self-sufficiency, and contribute to the mitigation of global emissions. Solar panels consist of photovoltaic (PV) cells that are designed to catch photons, which are particles of sunshine. The photovoltaic cells employ a semiconductor material, such as silicon, to transform the collected energy into direct current (DC) power. Subsequently, a DC/DC converter is employed to elevate the DC voltage to a predetermined level, followed by its conversion into useable AC power by an inverter. There exist five fundamental processes involved in the use of solar energy for everyday applications. These are.

- Solar Panel
- Combiner
- DC/DC Converter
- DC/AC Inverter
- Utility Switch

A collection of photovoltaic (PV) cells is arranged to create a PV module, while a grouping of PV modules is assembled to make a PV array. This PV array is designed to provide the necessary electricity to meet the stipulated demands of the grid. Often, solar photovoltaic (PV) modules are interconnected in a series configuration to enhance the overall PV output voltage. This is due to the fact that individual PV modules often provide a relatively low direct current (DC) output voltage, typically ranging from 100 volts to 298 volts. Hence, it is vital to employ a suitable power electronic DC-DC converter in order to transform the low DC output to the desired utilisation voltage level. In addition to this, the direct current (DC) output voltage produced by the photovoltaic (PV) panel exhibits significant variation due to factors such as solar irradiance, shadowing effects, ambient temperature, PV module mismatches, and the condition of the PV module surface. Furthermore, the careful choice of an appropriate DC-DC converter topology has greater significance in effectively harnessing solar energy derived from solar photovoltaic (PV) arrays.

Hence, it is imperative to develop a highly efficient DC-DC converter in order to manage the low and fluctuating DC output voltage derived from the photovoltaic arrays. The converters now available on the market exhibit a high cost yet have a poor level of efficiency. In order to address the aforementioned requirements, this study introduces the design and simulation of a single-ended primary inductance converter (SEPIC) using the MATLAB/Simulink software platform. The SEPIC converter incorporates an MPPT controller in order to maintain a consistent and controlled voltage output from a solar photovoltaic (PV) array, even when subjected to varying levels of irradiance. Additionally, an inverter is implemented and linked to the SEPIC converter in order to transform direct current (DC) electricity into alternating current (AC) power, which is then sent to the grid. Additionally, an analysis of the converter's performance is conducted, and potential enhancements to the design are also deliberated.A collection of photovoltaic (PV) cells is organised into a PV module, and a grouping of PV modules is assembled into a PV array in order to produce the necessary electricity for designated loads.

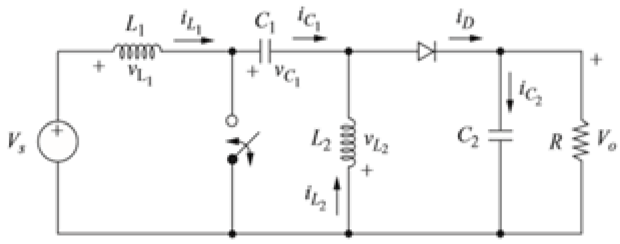
II. SEPIC CONVVERTER

Due to the adaptability of its output gain, the single ended primary inductor converter (SEPIC) functions as a buck boost DC-DC converter with non-inverting polarity output voltage, where its output voltage varies based on its duty cycle [1]. Unlike DC-DC buck and boost converters, the maximum power point tracking (MPPT) region of the SEPIC is unbounded [2]. The switch control terminal of the SEPIC is advantageously connected to ground; this simplifies the gate-drive circuitry [3]. In contrast to buck-boost and Cuk DC-DC converters, its non-inverting polarity output voltage eliminates the need for a splitting power supply or opto- coupler and associated circuit for negative voltage feedback sensing, which added complexity and slowed the system's response [4]. The input inductor of the SEPIC reduces the input current pulsation, resulting in a high degree of MPPT precision [5]. SEPIC is one of the most important types of DC/DC converters (Buck _ Boost) that can be used with solar PVC. The use of SEPIC in MPPT-based applications is also preferable, such as equipment shipped with PVC and autonomous PV systems [5.6]. In this research, the network is connected to an effort of 600 volts to export an electrical power of up to 50 kilowatts and is used by SEPIC to raise or reduce the electrical effort produced from solar panels to obtain the electrical connection effort with the network. The reflector is used to convert the exterior effort from SEPIC from a continuous current to a frequency current. To eliminate the waves in the wave of effort from the reflection, filters are used to get a pocket vector to connect to the electrical grid.

III. ANALYSIS OF SEPIC CONVERTER

a. Operational Principle

SEPIC has advantages in converting its internal effort, as it can lift or reduce the effort, such as the Buck Reinforcement Transformer, as well as keeping the polarity without reflection, and is therefore considered suitable for most applications. Intensified energy storage and maintenance of current traffic [6,12] in the existing circle There are two different cases of operation of the existing circle in form Fig.1. : first, in the case of the switch open, and second, in the case of the switch closed.



1) State1 Circuit- (Switch closed)

Fig .2. shows the status of SEPIC's operation when the IGBT switch is closed, so the current runs through the L1 file and is shipped through Vs. L2 is shipped with a C1 capacitor.

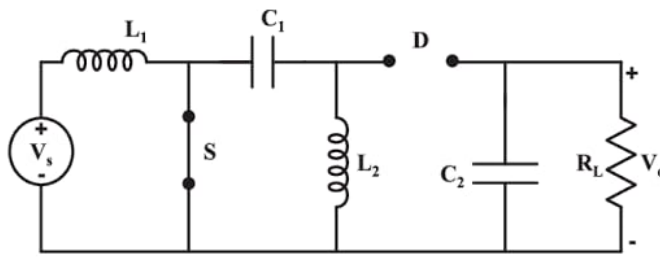


Fig.2. State1 Circuit operation (Switch closed)

2) State1 Circuit- (Switch open)

Fig .3. shows When the IGPT is open, the inductor output through the diode to the load and the capacitors are charged. In this mode output voltage will be more because the inductors charge are longer.

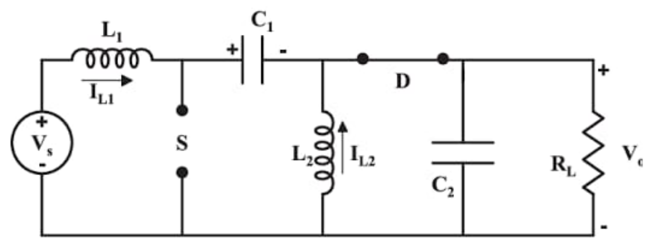


Fig.3. State2 Circuit operation (Switch open)

IV. DESIGN OF THE PROPOSED SYSTEM

In this research, the vectors were designed at several different stages with different operating conditions and with different control systems, where PID control systems were used in the design of SEPIC and then in the case of a

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reverse connection. The MPPT control system was used when linking SEPIC to solar PVC panels and the electrical grid. In the following, all different situations will be clarified for the whole system.

For the converter to operate more efficiently, precise determination of circuit elements is required. Using the following formulas, component parameters are calculated when CCM operation is assumed: V is the ripple voltage, where D is the duty cycle, IL is the ripple current, and Fs is the switching frequency.

$$D = \frac{V_{out}}{V_{in} + V_{out}}$$

$$L_1 = \frac{D * V_{in}}{\Delta IL_1 * F_S}$$

$$L_2 = \frac{D * V_{in}}{\Delta IL_2 * F_S}$$

$$C_1 > \frac{D * I_{OUT}}{\Delta V_{C1} * F_S}$$

$$C_2 > \frac{D * I_{OUT}}{\Delta V_{C2} * F_S}$$

$$D_{max} = \frac{V_{OUT} + V_D}{V_{in} + V_{out} + V_D} \equiv \frac{600 + 0.5}{298 + 600 + .5} \equiv 0.66$$

Values of Calculated Components:

TABLE1

Selected Components for SEPIC converter

Component	Calculated Values
Diode _ D	0.6243
C1	$1.7921 * 10^{\wedge} - 4$
C2	$2.9785 * 10^{\wedge} - 4$
L1	$2.2048 * 10^{\wedge} - 5$
L2	$2.2048 * 10^{\wedge} - 5$

V. MODELLING & SIMULATION

A. Model of the SEPIC Converter Simulink

Modelling the SEPIC converter using MATLAB/ Simulink software. Initially, the input voltage of the converter is assumed to be fixed, and it will subsequently be adapted to a variable source input voltage (solar PV array block). Since the greatest output voltage of the PV array is considered to be 298 volts, 100 to 298 volts DC is used as the input source voltage. The frequency (F) and duty ratio (D) of the pulse generator are set to 25 kHz and 0.66 (66%), respectively. The simulation model of the fixed input SEPIC converter is depicted in Fig .4.

.4.

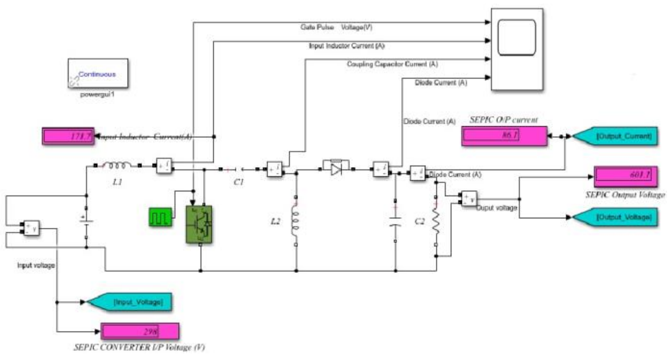

Fig..4. Model of the SEPIC Converter Simulink (Fixed Input)

The model of the SEPIC converter depicted in Fig.4. is simulated using the MATLAB/Simulink program. The input voltage, VI, ranges between 100 and 298 V, while the output voltage, Vo, is 600 V. Experiments are conducted using a resistive load of 65. Consequently, the load current, IL, is nearly 86.6 A shows in Fig.6. . In this adhesive, it uses a pulse generator to give a pulse to the IGBT portal to operate and stop, and one of the defects of this vector is that it does not contain a control system to obtain the values of the output effort that is required and therefore cannot be controlled by the output effort. Therefore, an appropriate digital controller with the SEPIC Converter must be used to obtain a fixed voltage product. The driver used in SEPIC will be explained in the following directions.

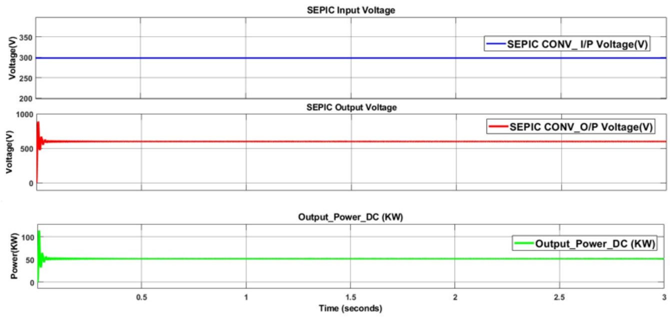

Fig .5. shows the output and input voltage FOR SEPIC Converter

Fig.5. shows three values: the first curve, the constant income effort representing solar panels, and the value of 300 volts of continuous current. The second curve is SEPIC's 600-volt flow effort, and we note that SEPIC has increased BOOST's income effort over time to 3 seconds without changing the value of the output effort. The effort required to connect to the network is 600 volts of frequency current, and therefore SEPIC shows a high response when scaling up the effort. The third curve shows a 50-kkilowatt withdrawal or excretion from SEPIC, which is constant over time.

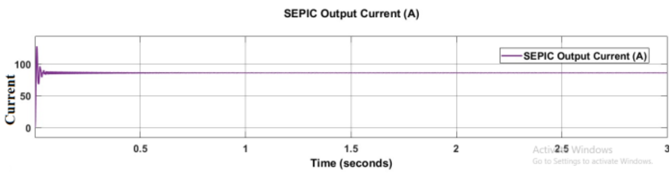

Fig .6. shows SEPIC the output Current (A)

a. Controller Design

Fig.7. shows To accomplish enhanced voltage regulation (constant voltage output), a simple PID (Proportional, Integral, and Derivative) controller has been applied to the SEPIC converter. The proposed closed loop controller maintains constant output voltage regardless of variations in input voltage and reduces overshoot significantly, thereby enhancing the converter's efficiency. With the aid of PID Controller operation, a desired control signal is generated and enhanced by a closed loop control circuit that continuously compares feedback voltage with a set reference voltage. Controller corrects the difference between the measured value and the required set point value, thereby adjusting the entire process to enhance dynamic response and reduce steady-state error.

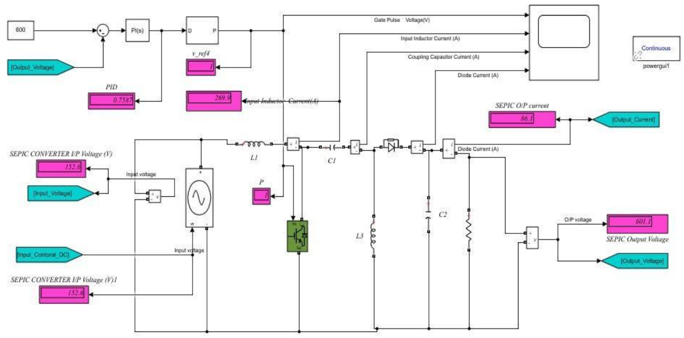

Fig.7. SEPIC converter with PID controller

The trial-and-error method is used to determine the gain values KP, KD, and KI of the PID controller, and the following gain values are derived for optimal performance: (KP = 0.08, KD = 0.001, KI = 120.0).

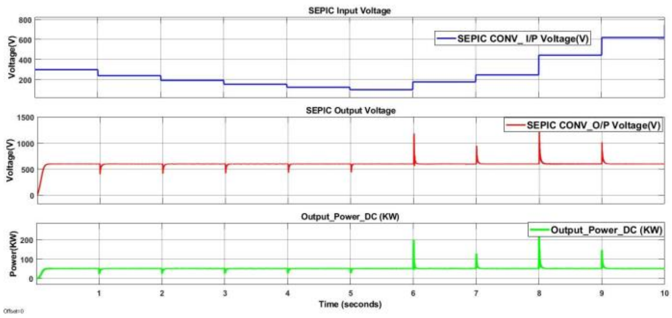

Fig.8. shows the response of the control system to different effort values.

Fig.8. It shows a relationship between SEPIC's income effort and the output effort and the exterior capacity of SEPIC. We note that SEPIC's income effort was variable over time. When it started, it was 300 volts and lasted until 1 seconds. The effort was reduced to 220 to 2 seconds. After the second six, the income effort gradually increased to 200 volts and continued until the second seven. It increased again to 410 volts by the second nine. It increased to 610 volts. We note that, despite changes in the income effort, the output effort is constant at the desired value of 600 volts and also the output capacity from SEPIC is constant. This demonstrates the strength and speed of the SEPIC response to control a fixed output effort under any circumstances using PID.

b. Connecting Solar PV Array and grid with Converter

Fig.9. illustrates the modeling and simulation of the entire tidal system by linking the PV arrays to the electrical grid by SEPIC Converter to maintain the tying effort using the MPPT server and using an inverse to convert the output effort from a controlled continuous current to a frequency

current. A filter is used to convert the output wave from the reflector from a square wave to a pocket wave to complete the network connection. We also note that the system used feeds some of the electrical loads, whether they're continuous or frequent.

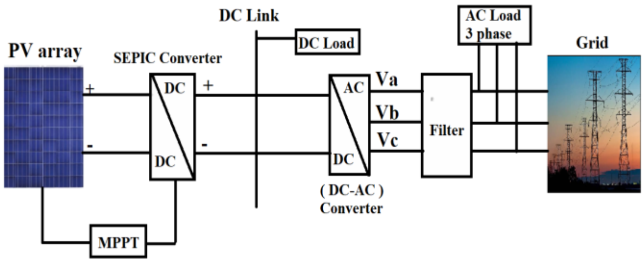

Fig. 9. Solar PV array and grid connected to SEPIC converter

C. Maximum Power Point Tracking (MPPT)

The essential stage for photovoltaic arrays is to track the PV array's maximum peak power in order to produce the most electricity. During the design of the PV system, the optimal procedure should be followed, and numerous MPPT methods can ensure this [8]. It is contingent on irradiance and temperature. Each strategy contains multiple levels. Application characteristics, including those of the most famous, the hill climbing technique on the resilience of two points, can have a significant impact on the selection of MPPT control systems, such as sensor complexity, the number of digital or analog applications, rapid convergence traceability, and financial impact. P(k), p (k-1) Start comparing MPPT and MPP side-by-side. The primary advantage of strategic is that it is inexpensive, easy to implement, does not require a control scheme or microcontroller, and requires only one voltage sensor [9]. This method is effective [10-11] so long as the daily variation in solar radiation is not excessive. As shown in Figure 10, the proposed MPPT algorithm is perturbative and uses feedback to regulate the dc-dc converter. An increase converter It raises the voltage value at the expense of the current value, deals exclusively with constant current, and compares the voltage of a solar cell Vpv to the voltage inside the inverter Vref.

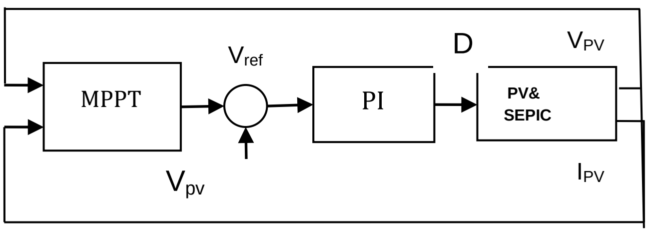

Fig.10. Schematic diagram of boost converter control.

VI. RESULTS AND DISCUSSION:

A MATLAB/SIMULINCMATLAB/SIMULINCthe system is illustrated in Fig. 9. The SEPIC Converter was to be used to link the PVC to the grid as well as feed some loads, whether a frequency current load, through filters[13], reflectors, or continuous current loads, through the tangent current line. The results of the system will be explained, a comparison will be made between solar radiation and its effect on SEPIC, and a study will be made of when SEPIC responds to changes in solar radiation and how long the network effort is maintained.

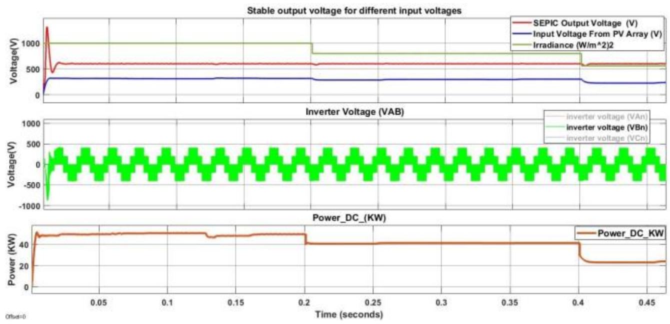

Fig .11. shows the output voltage FOR SEPIC Converte and Inverter

Fig.11. shows three curves in the first curve. A comparison is made between the value of the change in solar radiation, the effect on the output of the PVP, and the effect on the SEPIC output. We note that the value of solar radiation was 1000 W/M2 and lasted for 0.2 seconds. Solar panels were fixed at 290 volts, while SEPIC was fixed at 600 volts, which is the effort to maintain them. In the second 0.2, solar radiation changed and fell to 800 W/M squared. This is therefore reflected in the low efficiency of PV cells. SEPIC shows a high response to the changes and also the strength of the MPPT system to maintain a constant output effort where SEPIC's output is not altered. At the second 0.4, solar radiation dropped to 600 W/M squared, and so the PV effort declined with the SEPIC output effort constant. This is evidence of the reliability of the SEPIC converter with PV cells and its high response to changes in solar radiation. The second curve illustrates the effort to get out of the reflection as a facial effort, and we note that the effort to get out between VAB is a square wave, and therefore this wave should be converted by using a filter to get a pocket wave to feed the electrical loads and connect with the grid.

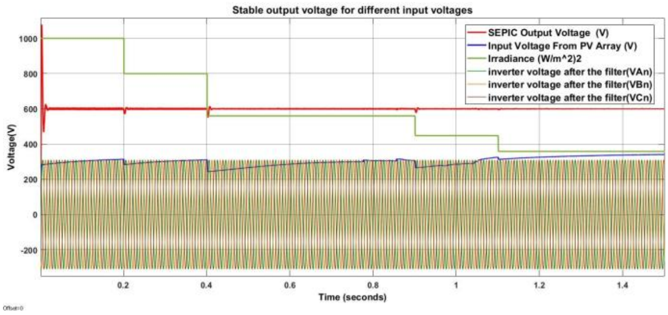

Fig .12. Stable output Voltage For different input Voltages

Fig.12. shows the effect of the change in solar radiation on SEPIC's output and the output of the PVC, as well as the shape of the wave after the filter and its transformation into a pocket vector. We note that solar radiation has fallen to very large values, from 100 W/M2 to 350 W/M2. Despite that significant change, SEPIC and the MPPT system have given a high response to these changes and maintain an output effort of 600 volts. We note that the filter with the square wave filter comes out of the reflection and turns it into a pocket wave, and in the following form, the pocket wave will be clearly presented to the three faces.

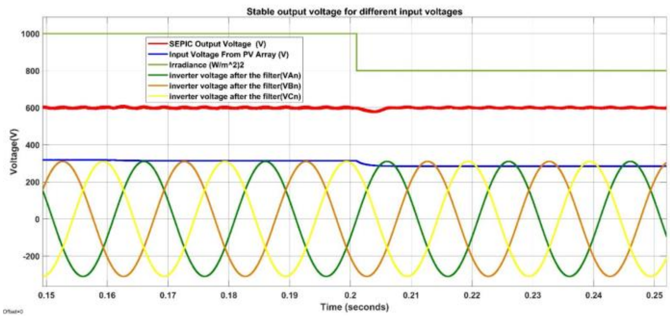

Fig .13. Inverter Voltage After the Filter (VABC)

Fig.13. The corresponding shapes of three wavelengths after reflection, filter, and face effort value are 300 volts of variable current and metabolism, showing variable values of solar radiation and output effort value. SEPIC

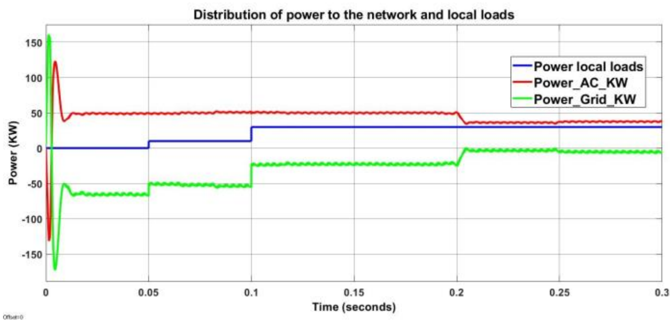

Fig .14. Distribution of power to the network and local loads

Fig. 14 illustrates the relationship between load capacity, system capacity, and network exporting capacity as loads are entered into the system at different times. Studying the impact of loads on the system's ability and Grid.

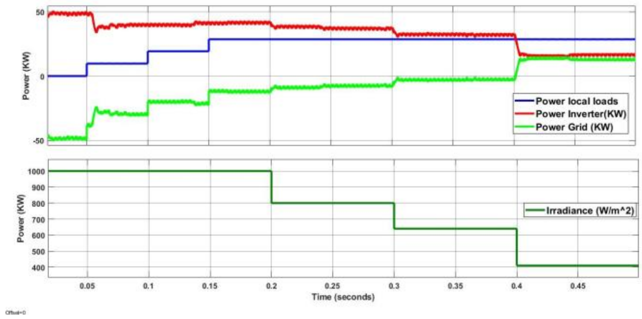

Fig .15. Distribution of power to the network and local loads

Fig.15. illustrates the effect of solar radiation on the power of PV cells, the carrying capacity, and the power of the network. We note that the value of solar radiation was 1000 w/m2 during the time period of 0:0.2 seconds, so the system produces a capacity of 20 kW and thus feeds the loads and exports the residual capacity of the network. We note that three loads are attached to different values at different times. At the time of 0:0.05 seconds, there was no load; at the time of 0:05:0.1 seconds, the first load was entered at a value of 10 kW. In the period of 0.1–0.15 seconds, the second load is entered at a value of 20 kW. At the time of 0.15 seconds, the third load is entered at a value of 30 kw gross loads, which is less than the capacity produced by the solar system, and the loads are fed and the power is exported to the network. This is with the persistence of solar radiation at 1000 w/m2 and within a time period of 0:0.02. When solar radiation falls to 800 W/M squared at 0.2 seconds, we note that the power of the solar system (PV) falls to 35 KW, and therefore loads are fed and exported to the network at approximately 3.5 KW. When solar radiation drops to 600 W/M squared over the 0.3 second time period, solar panels are reduced to 32 KW, and thus loads are fed and exported to 2 KW. When solar radiation drops to 400 W/M squared, PV power falls to 25 KW and is exported to the network to get the loads out of coverage. The curves illustrate the ability and response of the system to changes in solar radiation and the system's ability to distribute load capacity and electrical grids.

VII. Conclusion

• In this article, a simulation was made to connect a SEPIC transformer with more than one module and more than one different control method under different operating conditions. It is concluded from the results that the high response of the SEPIC module and the control system used.

• A comparison was made between two control methods, namely PID and MPPT, and a control system was chosen to track the maximum power (MPPP) in the photovoltaic system..

• The efficiency of the photovoltaic system based on the SEPIC Converter was studied by connecting it to some loads, whether DC or AC loads, in addition to connecting to the electrical network to export the power produced by the photovoltaic system.

Some electrical equations for SEPIC components were applied and their effect on the output was studied, whether by lowering or raising the output voltage..

• The whole system was simulated and the results were derived using the MATLAB simulation program.

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