A HIGH-GAIN-SOFT SWITCHING LUO CONVERTER WITH A VARIABLE P&O MPPT FOR PV APPLICATIONS

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ABSTRACT:

This work proposes a novel Luo based DC-DC converter with Variable Step Size Perturb and Observe MPPT algorithm for photovoltaic (PV) applications. LUO converter is used for this DC-DC conversion with larger output voltage and high-power density. Solar energy is one of the renewable and clean energy sources which generate power without any pollution. The PV module can be connected to load through a LUO converter. MPPT controller is implemented to track the maximum power with respect to the variations in the weather circumstances to efficiently operate the solar Photovoltaic (PV) system. This work proposed a Variable MPPT algorithm to extract a maximum power from the solar. To verify the performance of this converter with MPPT, MATLAB simulation has been carried out.

I. INTRODUCTION

Global warming and energy policies have become a hot topic on the international agenda in the last years. Developed countries are trying to reduce their greenhouse gas emissions. The only emissions associated with PV power generation are those from the production of its components. After their installation they generate electricity from the solar irradiation without emitting greenhouse gases. In their lifetime, which is around 25 years, PV panels produce more energy than that for their manufacturing. Also they can be installed in places with no other use, such as roofs and deserts, or they can produce electricity for remote locations, where there is no electricity network. The latter type of installations is known as off-grid facilities and sometimes they are the most economical alternative to provide electricity in isolated areas. However, most of the PV power generation comes from grid-connected installations, where the power is fed in the electricity network.

Increasing the efficiency in PV plants so the power generated increases is a key aspect, as it will increase the incomes, reducing consequently the cost of the power generated so it will approach the cost of the power produced from other sources. The efficiency of a PV plant is affected mainly by three factors: the efficiency of the PV panel (in commercial PV panels it is between 8-15%), the efficiency of the inverter (95-98 %) and the efficiency of the maximum power point tracking (MPPT) algorithm (which is over 98%). Improving the efficiency of the PV panel and the inverter is not easy as it depends on the technology available, it may require better components, which can increase drastically the cost of the installation. Instead, improving the tracking of the maximum power point (MPP) with new control algorithms is easier, not expensive and can be done even in plants which are already in use by updating their control algorithms, which would lead to an immediate increase in PV power generation and consequently a reduction in its price.

MPPT algorithms are necessary because PV arrays have a non linear voltage-current characteristic with a unique point where the power produced is maximum. This point depends on the temperature of the panels and on the irradiance conditions. Both conditions change during the day and are also different depending on the season of the year. Furthermore, irradiation can change rapidly due to changing atmospheric conditions such as clouds. It is very important to track the MPP accurately under all possible conditions so that the maximum available power is always obtained.

In the past years numerous MPPT algorithms have been published. They differ in many aspects such as complexity, sensors required, cost or efficiency. However, it is pointless to use a more expensive or more complicated method if with a simpler and less expensive one similar results can be obtained. This is the reason why some of the proposed techniques are not used.

The MPPT algorithm is to maximize the charging current in every type of dynamic conditions. Around 95% voltage of the voltage rating is maintained by battery and slight voltage variation as well as current maximization is taken into the account by MPPT algorithm, so the combined results reach the MPP. It means, the overall responsibility of maximizing the charging current or reaching the MPP, is on the shoulder of MPPT algorithm. Therefore, in this project, a new algorithm is proposed for MPPT

II. RELATED WORK

Ariya et al [1] performed tests on a commercial PV inverter to explore inter-harmonic generation and more important investigates the mechanism of inter-harmonic emission. The investigation reveals that the perturbation of the Maximum Power Point Tracking (MPPT) algorithm is one of the sources that induce inter-harmonics in the grid current, especially at low-power operating conditions.

Sangwongwanich et al [2] explored the generation mechanisms of inter-harmonics in PV systems and the characteristics. The exploration reveals that the perturbation from the maximum power point tracking (MPPT) algorithm is one of the origins of inter-harmonics appearing in the grid current.

R. Langella et al [3] presented the results of experimental evaluation of inter-harmonics produced by PV inverters (PV Inv) for a range of different operating conditions. First, intrinsic inter-harmonic generation due to Maximum Power Point Tracking (MPPT) control is analysed. Finally, the paper investigates inter-harmonic currents produced by PV Inverters when harmonics and inter-harmonics are superimposed to the fundamental supply voltages.

III. SYSTEM IMPLEMENTATION

This paper proposes a novel Luo based DC-DC converter with Variable Step Size Perturb and Observe MPPT algorithm for photovoltaic (PV) applications.

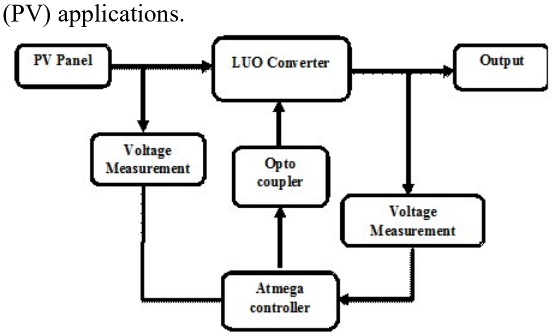

Fig.1 Proposed system architecture

In fig.1, Photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. PV panel is connected to a LUO converter, via a controller, and then connected to the load. voltage measurements are fed into the controller. It is used to measure the voltage and current from PV panel. The output is given to controller. In this project we used Atmega controller. ATMEGA 328 microcontroller, which acts as a processor. Nearly it consists of 28 pins. The inputs can be controlled by transmitting and receiving the inputs to the external device. It also consists of pulse width modulation (PWM). These PWM are used to transmit the entire signal in a pulse modulation. Controller output is given to opto coupler. An opto coupler is analogous to a relay which isolates two circuits magnetically. It is connected to LUO converter. A LUO converter is an electronic circuit or electromechanical device that converts a source of direct current (DC) from one voltage level to another. It is a type of electric power converter. DC-DC converter voltage is fed to controller.

1. LUO CONVERTER

The DC-DC converter enables the energy transfer between the high voltage side and low voltage side giving tremendous advantages in terms of low cost, flexible, reliable and efficient, increased due to the possible constraints of easy to make synchronous rectification and implementation. The features include resonant clamping circuit implementation in the boost mode and soft-switching operation, due to phase shift operation, in the buck mode, without need additional devices, and provide high efficiency and easy to control. Power electronic converters and new semiconductor devices are key components to meet the targets of extended mileage range and reduced pollution. The rapidly efficient DC-DC converters must be used to provide appropriate voltage levels and the power management between different energy level sources and storage elements. The proposed developed DC-DC converter is Luo converter it overcomes the parasitic problems present in the classical dcdcconverter . Fig shows the circuit diagram for developed dc-dc luo converter. The harmonics Levels present in the luo converter less compared to the classical buck converter.

The circuit diagram of the Buck - output Luo converter is shown in Fig.2 In the circuit, S is the power switch and D is the freewheeling diode. The energy storage passive elements are inductors

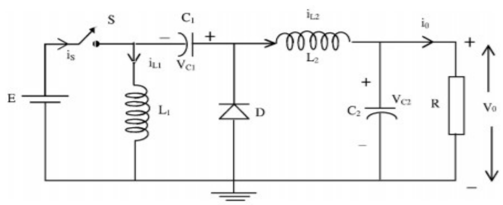

Fig.2 LUO converter

L1, L2 and capacitors C1, C2, R is the load resistance. To analyse the operation of the Luo converter, the circuit can be divided into two modes. When the switch is ON, the inductor L1 is charged by the supply voltage E. At the same time, the inductor L2 absorbs the energy from source and the capacitor C1. The load is supplied by the capacitor C2. The equivalent circuit of Luo converter in mode 1 operation is shown in (a). During switch is in OFF state, and hence, the current is drawn from the source becomes zero, as shown in (b). Current iL1 flows through the freewheeling diode to charge the capacitor C1. Current iL2 flows through C2 –R circuit and the freewheeling diode D to keep itself continuous. If adding additional filter components like inductor and capacitor to reduce the harmonic levels of the output voltage

Modes of operation

Mode 1: when the switch is ON, the inductor L1 is charged by the supply voltage E. At the same time, the inductor L2 absorbs the energy from source and the capacitor C1. The load is supplied by the capacitor C2. The equivalent circuit of Luo converter in mode 1 operation is shown in (a).

Mode 2: switch is in OFF state, and hence, the current is drawn from the source becomes zero, as shown in (b). Current iL1 flows through the freewheeling diode to charge the capacitor C1. Current iL2 flows through C2 –R circuit and the freewheeling diode D to keep itself continuous.

2. VARIABLE STEP SIZE P&O MPPT ALGORITHM

The maximum power output obtained from a PV module varies due to change in cell temperature and solar irradiation. In order to obtain the maximum peak point during the variable conditions an MPPT algorithm is employed in SPV system. The P&O method works by increase / decrease the module voltage to find maximum output power. If dPpv /dVpv is positive, which is to the left side of the MPP, the voltage is increased to reach the MPP. When dPpv/dVpv is negative, the voltage is decreased to reach the MPP. The step size of a conventional P&O MPPT is a fixed value (dD = 0.01). The algorithm increase/decrease the duty cycle in steps until the MPP is reached. The step size is changed based on the output of the previous perturbation. If the output power increases due to the last perturbation then, the next perturbation follows the same direction. If the output power decreases due to the last perturbation then, the next perturbation follows the opposite direction. P&O algorithm is the simplest algorithm and the implementation is also very easy. But, the algorithm is not suitable for rapidly varying weather condition due to the slow tracking with step size. The output voltage and current signals oscillate at the steady state

A variable step size P&O is proposed to overcome the drawbacks of P&O algorithm. The proposed algorithm increases the tracking speed and also to reduce the oscillation. In this algorithm dP/dV is compared with an error and depending on the value of error corresponding step is given. If the operating point is far away from the MPP, the algorithm gives large step value and a small step value is given by the algorithm when the operating point is close to the MPP.

The proposed work deals with the distributed adaptive control approach for dual mode SPEGS integrated to the local three phase grid. The proposed technique works for two modes. In first mode, when sunlight is available, it harnesses the maximum power from the solar PV source and feeds that power in to three phase grid as well as connected load. Additionally, in this mode, the same system configuration is also utilized for power quality improvement of the distribution network. In second mode, when sunlight is not present, it solely behaves as a DSTATCOM for mitigating the power quality issues of three phase grid with same VSC, which is used in first mode. So, in this way, power electronics devices are utilized to their maximum capacity and consequently, the payback time of proposed system is also reduced. The proposed algorithm potential to multitask such as mitigation of harmonics,

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improvement of power factor, load balancing along with unity power factor mode (UPF). Modelling and simulation of this control, are done in MATLAB platform.

Two different cases are considered. A VSS P&O MPPT is operated at different set of duty cycle values and the performance is studied by simulation. VSS P&O Type1 has duty cycle values of dDbig = 0.025 and dDsmall = 0.005. Type2 variable step size P&O has dDbig = 0.02 and dDsmall = 0.005. dDbig helps to reach to reach the peak power point quickly and dDsmall reduces the oscillation around the peak power point when compared with conventional P&O algorithm. Fig.3 illustrates the flow chart of the variable step size P&O algorithm.

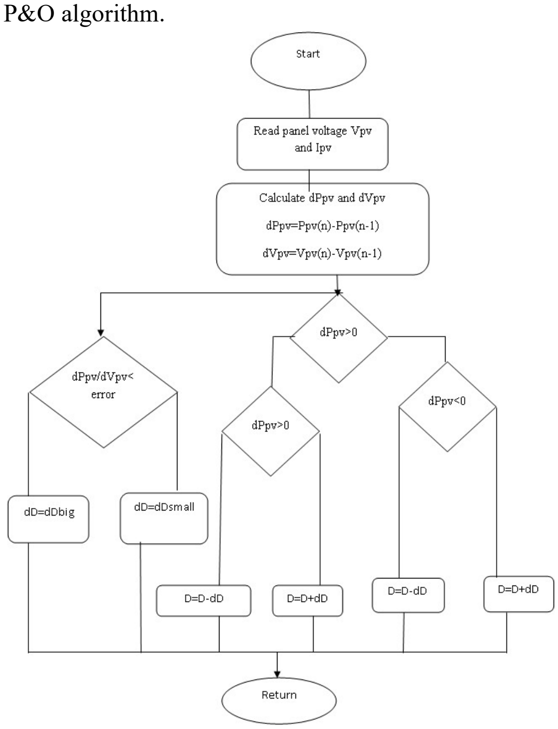

Fig.3 proposed flow chart

3. HARDWARE IMPLEMENTATION

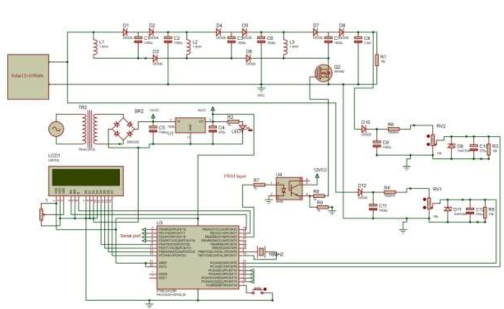

Fig.4 Circuit diagram

In fig.4, Power supply gives supply to all components. It is used to convert AC voltage into DC voltage. Transformer used to convert 230V into 12V AC.12V AC is given to diode. Diode range is 1N4007, which is used to convert AC voltage into DC voltage. AC capacitor used to charge AC components and discharge on ground. LM 7805 regulator is used to maintain voltage as constant. Then signal will be given to next capacitor, which is used to filter unwanted AC component. Load will be LED and resister. LED voltage is 1.75V.if voltage is above level beyond the limit, and then it will be dropped on resister. Solar panel is converts the energy of light directly into electricity by the photovoltaic effect. Solar panel voltage is measured by voltage measurement unit. The output of voltage measurement is connected to controller port A0 and A1. Reset switch is connected to controller port 1. Controller output is given to buffer IC4050. The output of buffer is connected to opto coupler. Opto coupler output is connected to LUO converter port of MOSFET (IRF840).

a) ATMEGA328:

The Atmega328 has 28 pins. It has 14 digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins. These I/O pins account for 20 of the pins. The Pinout for the Atmega328 is shown below.

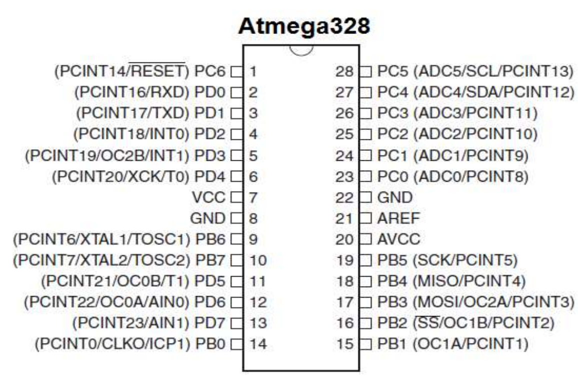

Fig.5 Atmega 328-pinout

b) OPTO COUPLER

In electronics, an **opto-isolator**, also called an **optocoupler**, **photocoupler**, or **optical isolator**, is "an electronic device designed to transfer electrical signals by utilizing light waves to provide coupling with electrical isolation between its input and output". The main purpose of an opto-isolator is "to prevent high voltages or rapidly changing voltages on one side of the circuit from damaging components or distorting transmissions on the other side."

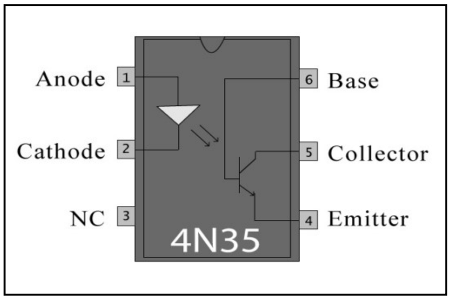

Fig.6 Pin Diagram – 4N35

c) IRF840

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.

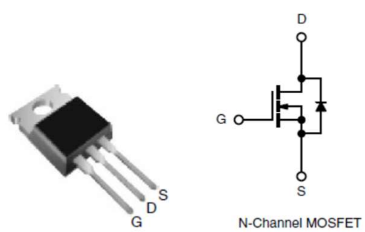

Fig.7 MOSFET Symbol

IV. RESULTS & DISCUSSIONS

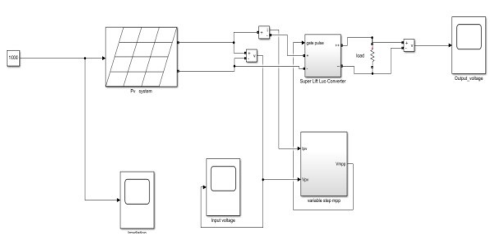

Figure 8: Overall Simulink model

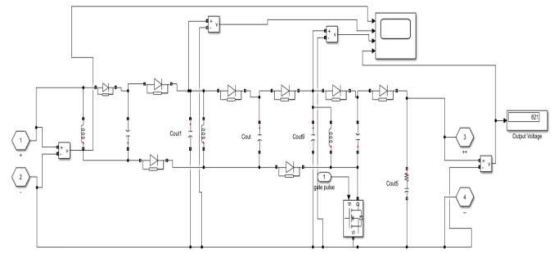

Figure 9: Luo converter stage

```
function y = MYMPP(u,i,uo,io,D)
m=0;
du=u-uo;
di=i-io;
dp=(u*i)-(uo*io);
d=0.00001*(abs(dp/du));
if du==0
    if di==0
    m=D;
    else
        if di>0
            m=D-d;
        else m=D+d;
        end
    end
else
    if di/du== -(i/u)
    m=D;
    else
        if di/du> -(i/u)
```

Figure 10: Variable MPPT

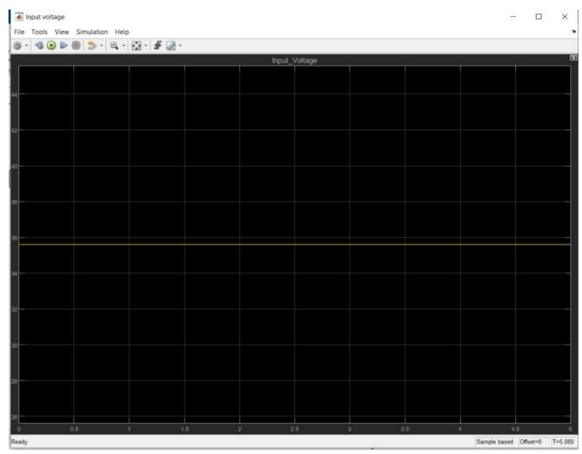

Figure 11: Input voltage

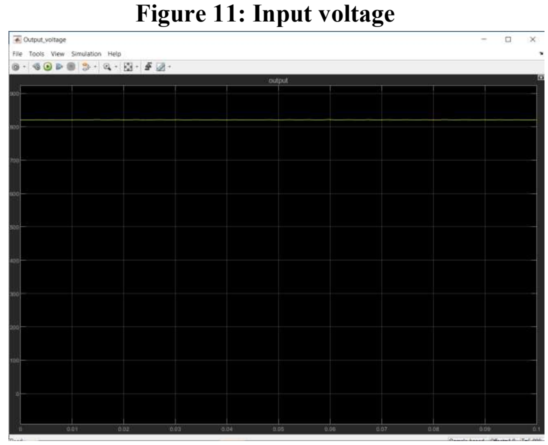

Figure 12: Output voltage

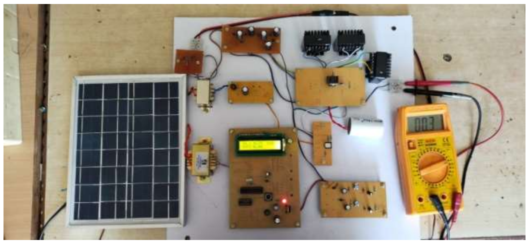

Fig.13 Hardware implementation

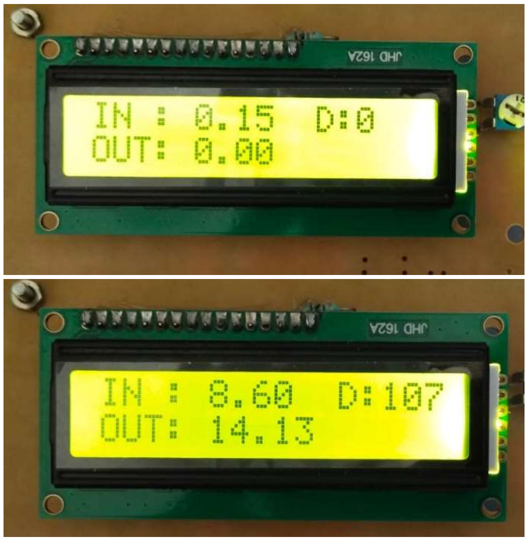

Fig.14 Output

V. CONCLUSION

A variable step size P&O algorithm is proposed in this paper. The proposed algorithm has two cases and operated at different values of duty cycles. PV module and MPPT algorithms are simulated in MATLAB/Simulink is tested at varying irradiation and temperature. A comparison between the conventional and the proposed P&O algorithm is done. Conventional P&O algorithm is not much effective under varying weather condition to obtain the maximum output power due to its slower response at fixed duty cycle. It is noted that the tracking speed is increased and oscillation is reduced at MPP in the case of a variable step size P&O algorithm.

Future Enhancement

- In future, we will propose a three-dimensional duty cycle control method to achieve steady state in between MPPT updates.

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