Energy Maximizer for PV fed DC-DC Boost Converter

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Abstract —
This work presents a novel energy maximizing unit (EMU) using Texas Instruments microcontroller TMS320F28027 for a stand-alone or grid connected PV plant. One of the essential requirements in any PV plant is to extract the maximum power from the PV arrays under varying weather conditions for which normally an MPPT (Maximum Power point tracking) controller is employed. The MPPT controller is employed at a system level or macro level which is spread across huge area. Under such conditions, shading and mismatching of different panels prohibits the MPPT to extract the maximum power. Hence the upcoming trend is to employ the MPPT controller at micro level for each panel or a small group of panels which eliminates shading and mismatch losses. The product presented in this paper works at micro level for a small group of panel. In such applications the controller requires to extract the maximum power as well maintain the voltage within a desired range. This feature has been demonstrated and validated. The validation and field results are presented in this paper.

Keywords—PV, MPPT

1. INTRODUCTION

Solar power generation is currently considered as one of the most useful renewable energy sources, as it is relatively less polluted and maintenance free. The main hindrance of solar energy going widespread is the initial high capital cost of solar modules. The disadvantage of solar energy production is that the power generation is not constant throughout the day, as it changes with weather conditions. Furthermore, the efficiency of solar energy conversion to electrical energy is very low, which is only in the range of 9–17% in low irradiation regions. This means that a fairly vast amount of surface area is required to produce high power. Therefore, maximum power point tracking is an essential part of the photovoltaic system to ensure that the power converters operate at the maximum power point (MPP) of the solar array. Various MPPT algorithms have been developed. These algorithms differ from each other in terms of number of the sensors used, complexity, and cost to implement the algorithm. The main objectives of all these MPPT algorithms are to achieve faster and accurate tracking performance and reduce the oscillations around MPP.

Each algorithm can be categorized based on the type of the control variable it uses: 1) voltage; 2) current; or 3) duty cycle. Among different algorithms, much focus has been on perturb and observe (P&O). The P&O method involves a perturbation in the operating voltage of the solar array. This MPPT algorithm is implemented in boost converter. Control of output voltage is done by the *TMS320F28027* piccolo device. It provides the fast and flexible control. The various quantity can be programmed and controlled to it's specify limit range.

2. PROPOSED SOLUTION

- The EMU is proposed to replace eliminate the problem of partial shading and mismatching losses.
- The EMU addresses both maximum power extraction as well as voltage regulation of the PV fed boost converter.
- The power circuit of the proposed solution is shown in Fig. 1a and the functional block diagram of the EMU is shown in Fig. 1b.
- Functional features of EMU – 1.Provide output voltage regulation 2. MPPT of PV at micro level.

Experimental Setup :

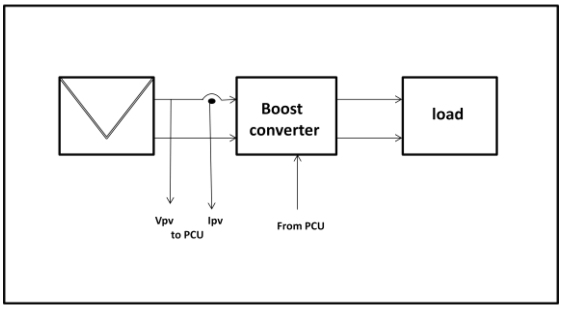


Fig.1a. Power Circuit Diagram of EMU

Fig.1a. shows the experimental setup of the project with all parts is described in more detail later in this report. The testing of different components in this setup was carried out with the use of a power supply, a signal generator, a multimeter and an oscilloscope in the Laboratories of the college.

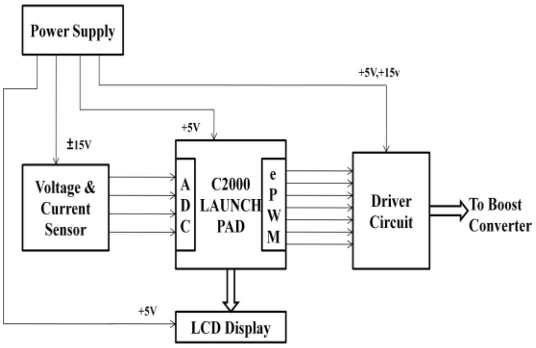


Fig.1b. Functional Block Diagram of the EMU

3. IMPLEMENTATION

3.1 Hardware Implementation

Data sheets for all hardware components give operational data as well as limitations of the products and best conditions at which the product operates. The data sheets were very important reference to ensure circuits were being setup correctly.

3.1.1. *TMS320F28027* Processor:

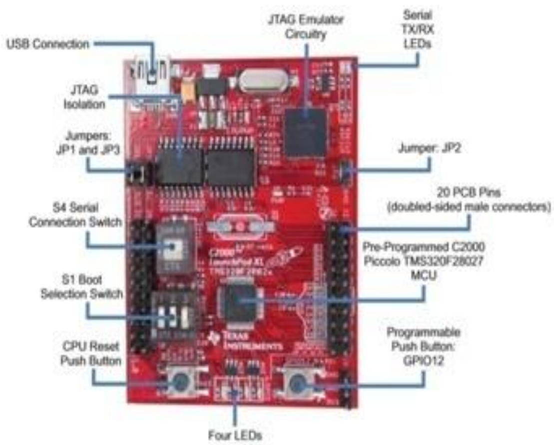


Fig. 1. LAUNCHXL – F28027 Board Overview

LAUNCHXL-F28027 Piccolo texas device is used to control the output voltage of the EMU. Among the 16 ADC channels of the F28027 device, A4 and A2 channels is configured for voltage sensor and current sensor respectively. The sampling period of ADC is taken as 0.2ms (1/5000Hz). With this sampling period, SOC is configured and ADC process starts. Then the digital value is converted into the respective analog value of voltage and current. This value is fed as the input to the P&O algorithm. As the output of the algorithm the compare register value of ePWM is configured. Among the 4 channels of ePWM module of Piccolo device the first channel (1a & 1b) is configured and given as the input to the driver circuit of boost converter.

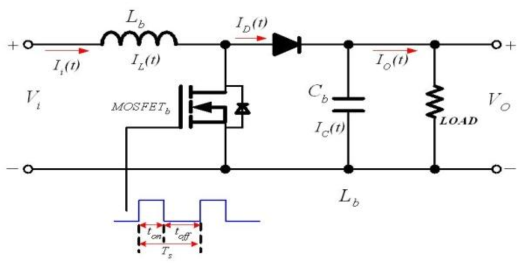
3.2.Voltage sensor:

The voltage sensor LA 20-P is a simple voltage divider that steps down the voltage that can be fed into one of the analog inputs of *TMS320F28027* piccolo device.

3.3. Current sensor:

The LA 55-P current sensor is used in our project. This will measure the current provided by the solar panel.This voltage from measure pin is then fed into an analog pin of *TMS320F28027* piccolo device. The +15V and -15V supply is supplied from the power source 47247 ta 60/B.

3.4. Design of boost converter:



V_o = 48V ; V_{in} = 25-35V ;
Power P =125W ; Duty Cycle D= 50 % ;
Assume V_{in} = 25 V ; $I_o = P/V_o$= 2.6 A
$V_o/V_{in} = I_{in}/I_o$; I_{in}= 5A ; $I_{in} = I_L$
I_L = 5A ; I_L = 4.5 to 5.5 A ; ΔI_L = 1 A
ΔV_{rip} = 48 x 0.02 =0.96V
$L = (V_{in} \times D)/(F_s \times \Delta I_L)$ = 3.5mH
The output capacitor is designed for 1% output voltage ripple (ΔV_{rip})
$C= (I_o \times D)/(F_s \times \Delta V_{rip})$ = 135μF

The practical value of capacitance available to support the output voltage of 50V is 220μF, 200V.

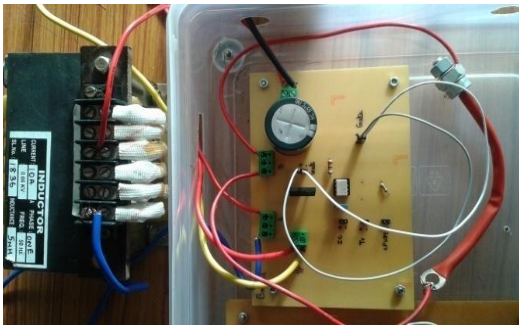
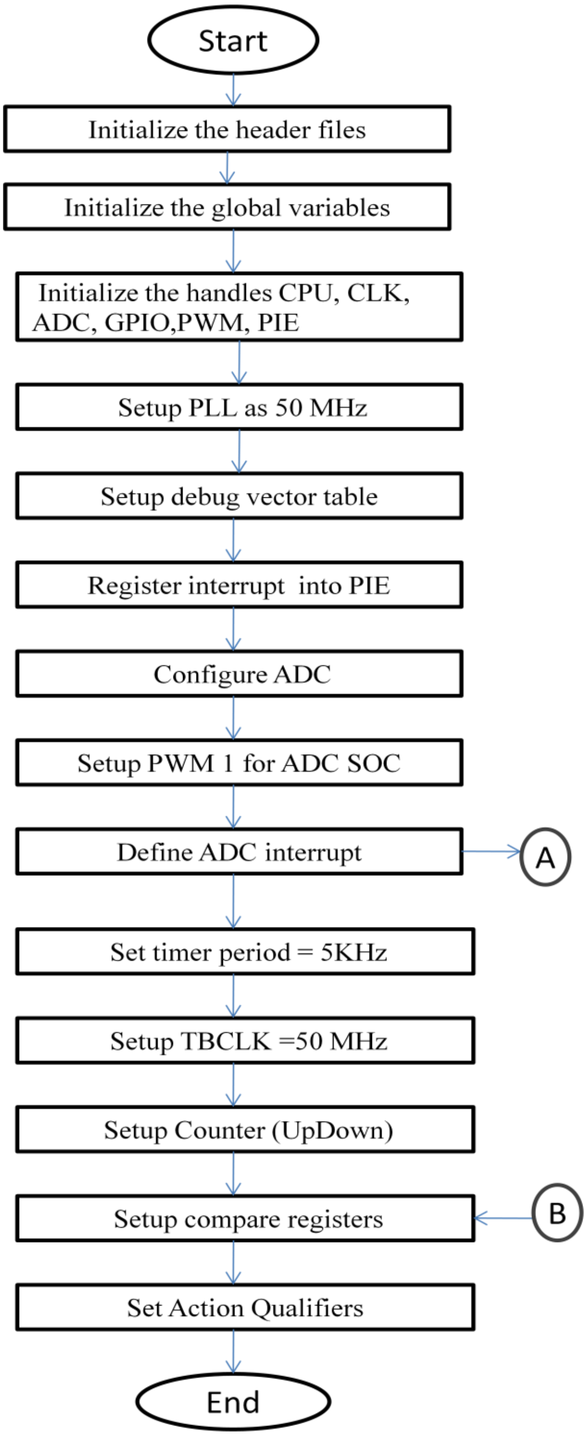


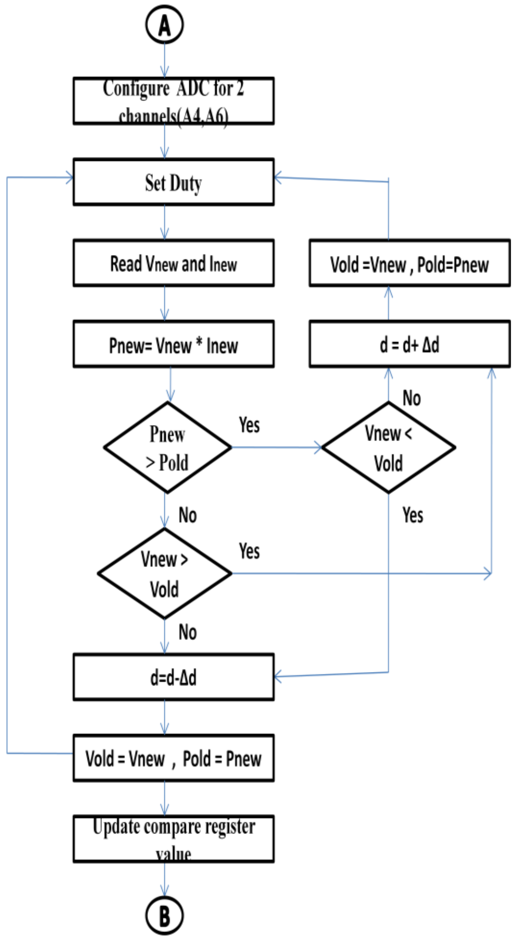
Fig. 2b. Experimental setup of Boost Converter

For low power application MOSFET is a suitable device and also for frequency 5 kHz, switching losses in MOSFET is not much higher.

3.5 Software Implementation

Code Composer Studio version 5 is used to develop the firmware for the processor All the system simulations have been performed using MATLAB.





4. RESULTS

Simulation Results :

Simulation of boost converter with calculated values of inductor and capacitor to get output voltage of 48V is carried out using MATLAB. The results are shown in Fig .3a & 3b.

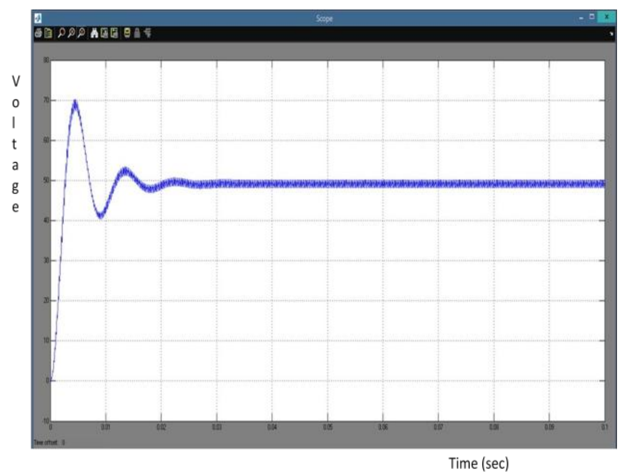


Fig.3a Output Voltage

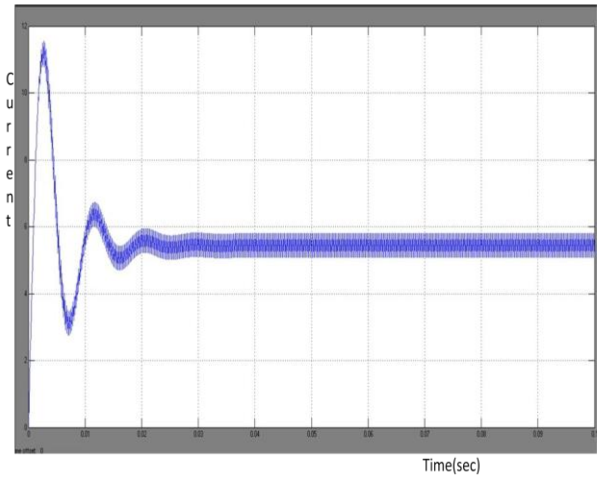


Fig.3b. Inductor Current

Open loop test of power circuit:

Input PV voltage	Duty cycle (%)	Boost converter output voltage
21	10	34
26	20	33
22	30	32
16	40	46
10	50	20

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The above table shows the output voltage of the power circuit under open loop control.

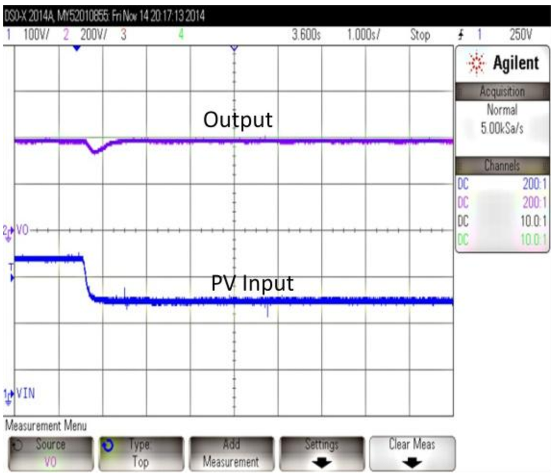

Fig.4a. Output Voltage-Validation Result-1

The above figures show the constant output voltage of the power circuit irrespective to PV input voltage variation.

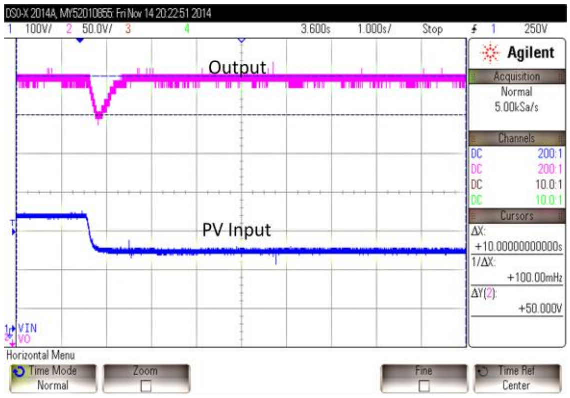

Fig.4b. Output Voltage-Validation Result-2

5. CONCLUSION

This EMU is employed at micro level for each panel which Eliminates shading and mismatch losses. The proposed EMU will increase the power output of a PV plant and hence it will reduce the break even period of the investment in PV plants, this will in turn improve the availability of power in remote areas where PV is employed due to non availability of utility grid.

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