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SOLAR SMART LED STREET LIGHTING SYSTEM

Prof. Bhargav B Patel, Prajapati Kinjal, Gupta Vinnie, Patel Deval

Electronics and Communication Dept., Madhuben&Bhanubhai Women's Institute of Engineering for Studies & Research in Computer and Communication Technology, New V.V. Nagar, Anand

Abstract: *This paper proposes the design and implementation of a technologically advanced, cost effective and smart LED street light with the use of MPPT(Maximum Power Point Tracking)algorithm, and the latest microcontroller LPC800 max board. The basic buildingblocks for the street light design include microcontroller of the ARM family, battery for power supply and MPPT boostconverter. All the design configurations have been made with the LPC800 board which has ARM cortex M0+ controller. The MPPT algorithm is used to extract maximum power from the solar panels.The MPPT boost converter circuit will boost the voltage and store it in the battery which will be consumed by the power LED bank at night. I2C bus has been configured for the communication betweenmicrocontroller and ADC for obtaining voltage and current samples which is primary need for designing MPPT. RTC is implemented for automatic switching on and off the street lights. Microcontroller keeps monitoring the overall performance of the system and feedback mechanism is also introduced to prevent the battery from getting overcharged.*

Keywords: Embedded system, Solar Panel, MPPT controller, battery & LEDs.

I.INTRODUCTION

Since last many decades we are consuming non-renewable energy sources even after knowing about its hazardous effects on the environment. But, now its high time to switch over to renewable energy sources due to its many advantage limited existence of non-renewable sources.

There is a desperate need for high-quality, technologically advanced, affordable and reliable Lighting systems at sites where the electricity grid is either non- existent or unstable (for applications such as road lighting, residential lighting, area lighting and security lighting).

The solar cells receive the solar energy and operate on the photo-electric energy by using solar cells principle. The energy from the photovoltaic cells is used to switch on the lights. At present solar electric power generation systems are having fixed solar panels whose efficiency of generation is less. But by setting proper MPPT(Maximum Power Point Tracking) algorithm, we can increase the efficiency of solar panels from 20% to 80% so the benefits are obvious. Also, Pulse width modulation required for MPPT algorithm is designed with the STATE CONFIGURABLE TIMER and Real Time Clock is with SYSTEM TICK TIMER.

II.GENERAL OVERVIEW OF PROPOSED SYSTEM

Figure 1 shows the block diagram of solar smart street LED lighting system. The major blocks are solar panel, microcontroller, battery. The dc power generated by the solar panel is provided to the MPPTboost converter circuit. It boosts the solar panel output to charge the battery sufficiently. The voltage and current samples are given to the ADC (Analog to Digital Converter) which is connected to the microcontroller via I2C (Inter Integrated Circuit) serial bus interface. A switch is connected to the LEDs to control the switching of them. There should be a safety feedback mechanism which protects the whole circuit. For this, a pair of resistor is connected before the load which prevents the whole circuit from very high boosted voltage and also protects battery from overcharging.

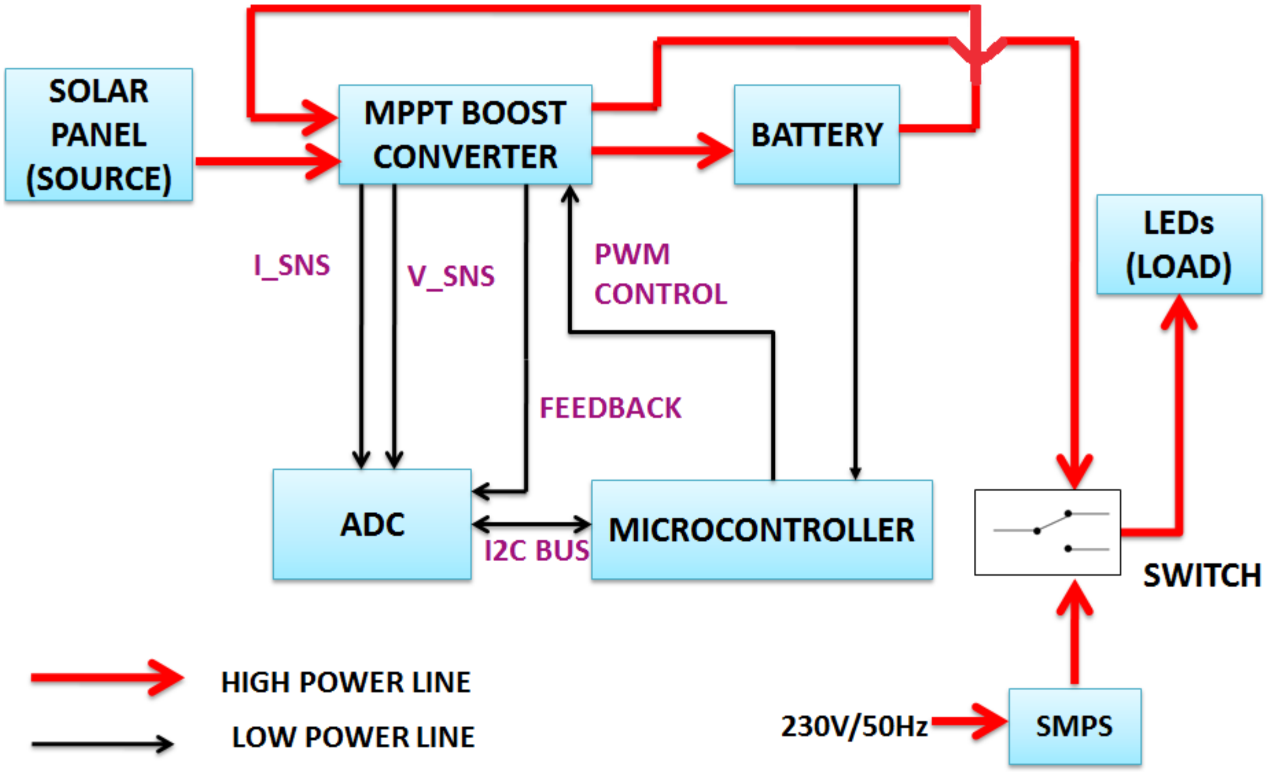


Figure 1. Block diagram

A. Solar Panel:

The solar panel we used as a source is of 20W having 17.32V open circuit voltage and 1.37A short circuit current.

B. LPC800 max Microcontroller:

This is basically NXP developed 32 bit ARM cortex M0+ processor running with 12MHz crystal frequency. Its main features are built-in Nested Vectored Interrupt Controller (NVIC), 3.3V and 5V external power supply, Serial Wire Debug (SWD) and Flash In-Application Programming (IAP) and In-System Programming (ISP).

C. MPPT boost converter:

This boost converter has 4.5mh inductor, TIP122 power transistor and C1815 simple transistor,IN4007 shot key diode and a network of resistors and capacitors. This network boosts the input voltage which can drive the LEDs sufficiently.

D. Battery:

We have used the lead acid battery which stores the charge given by solar panel is of 12V and is having initial maximum 3A current. It is having 120 Vah. The maximum current that can handle by this battery is 10A and its maximum voltage rating is up to 13.8V.

E. LED bank:

We have connected total 27 POWER LEDs as our street light circuit. There are 9 LEDs connected in series and such 3 strings are connected in parallel. These power LEDs have 0.3W Power consumption. They operate at 3v and draw 100 mA current. Practically, this LED load takes 24V draws 250mA and consumes 6W.

III. HARDWARE and SOFTWARE IMPLEMENTATION

3.1. Hardware Implementation

The schematic of the project is shown below:

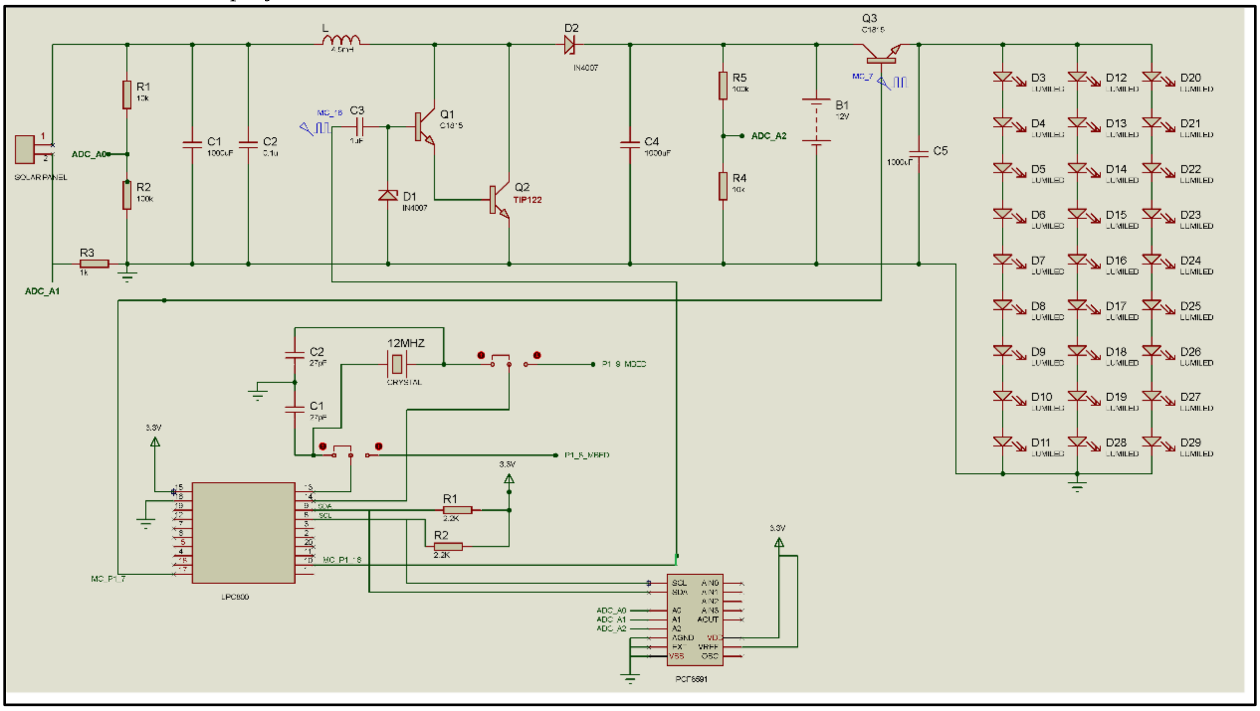


Figure 2.Complete hardware schematic

There are two section of the project hardware:

1. ADC interfacing.
2. MPPT boost converter interfacing.

The ADC chip PCF8591T is configured by selecting the value of read byte(0x9E), control byte(0x45) and write byte (0x9F). This ADC is connected to microcontroller (LPC800 max board) via I2C (inter integrated circuit) serial bus interface. The port pins 10(SDA) and 11(SCL) of microcontroller are connected with the port pins 9(SDA) and 10(SCL) of ADC. As the microcontroller is 32bit and ADC chip is 8 bit, the standard mode of operation of I2C is selected. The configuration value (0x45) is selected because we need four channels of ADC. The microcontroller stores the ADC readings and processes it.

The DC power from solar panel is fed to the MPPT boost converter. The voltage and current samples are given to the ADC channel A0, A1 and A2 via R1, R2 & R3 respectively. These readings are given to the ADC of the microcontroller so as to have maximum power point tracking algorithm. The input capacitors gets charged by the solar panel but the point that is to be noted is that the discharging time of them is higher than the charging time. These capacitors are kept to get ripple free voltage of the panel and to remove the spikes of the solar current and voltage waveforms so that a steady value of voltage and current sensors can be given to the ADC.

The inductor kept between the input capacitors and darlington pair of transistors, serves the purpose of delivering the charge to the output capacitor when transistor gets ON. The darlington pair of transistors increases the current gain. Here, we have used first simple low power NPN transistor C1815 and second is NPN power transistor TIP122.

When the input voltage is applied, inductor stores the charge and current flows through the diode. So there is voltage drop of0.7V and this voltage appears at output capacitor. As the current passes through the capacitor, it gets charged. This is the condition when transistor is switched off. Now, when it is switched ON, the voltage across it is same as input as it acts as a short circuit. If the transistor is switched off suddenly, then inductor releases its energy which charges the output capacitor. At that time, the voltage across transistor is summation of input voltage and voltage across inductor.

Generally, inductor is introduced when an alternating current is flowing. This MPPT boost network is based on dc supply still inductor is used.This is because switching ON and OFF the transistor is pulsating dc which is same as ac.

3.2. Software Implementation

- We have used the software LPCXPRESSO version 7.5.0_254.

- It is a low-cost development tool platform, available directly from NXP, that provides a quick way to develop advanced applications using NXP's highly efficient and low-power LPC microcontrollers. It includes everything to take end users from evaluation to final production.
- The salient features of the software are described below:
- Low-cost development tool platform for LPC MCUs
- Eclipse-based IDE
- Low-cost target board
- Integrated debug probe (separate debug probe not required)

3.3. Project flow chart

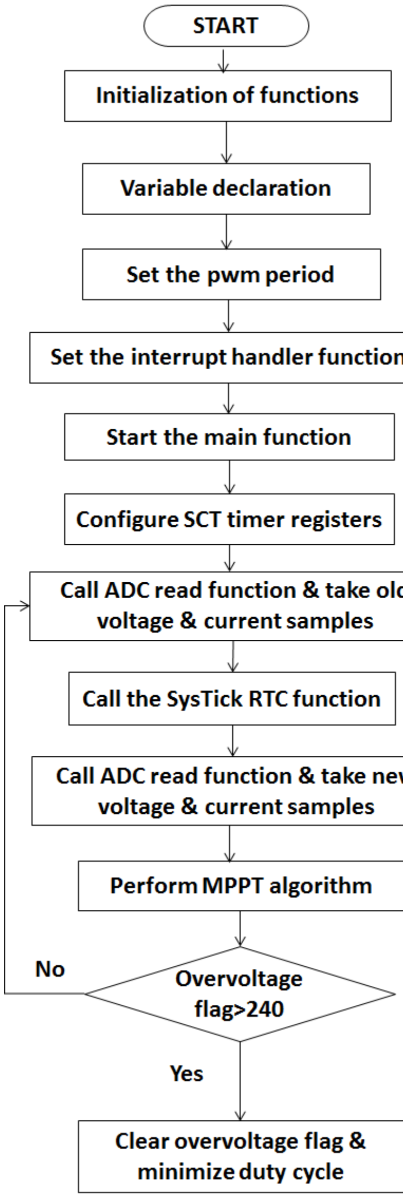


Figure 3.Flow chart

IV. RESULT ANAYSIS

Figures shown below illustrate the results observed on DSO while testing different portions of the system hardware circuit. Figure 4 shows the ADC readings waveform with the configuration of I2C bus. The waveform shows the reading (76,0,255) which is completely visualized by the upper waveform. The yellow line represents SDA line and red line represents SCL line.

The Figure 5 shows the complete project output waveform. Here, the red line shows the output of the systick timer and yellow line shows the output of SCT timer with MPPT algorithm.

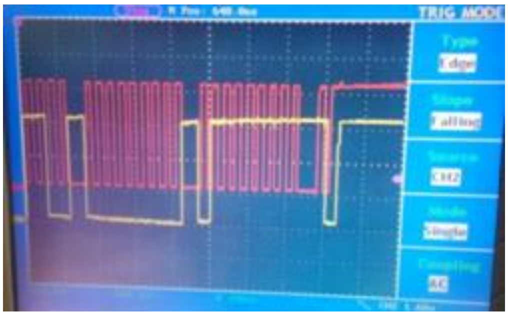
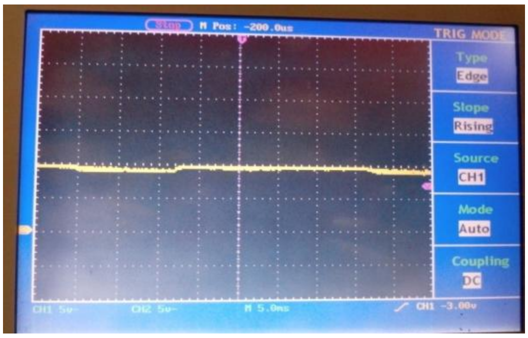


Figure 4.I2Cconfiguration with ADC readings

Figure 5. Complete software output



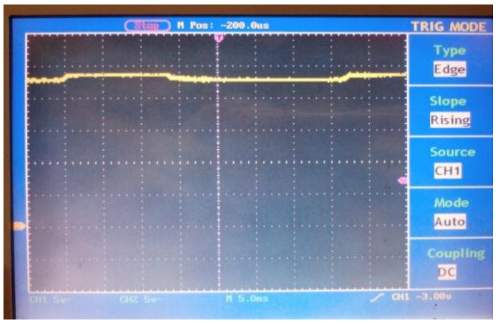


Figure 6. MPPT boost converter Input voltage

Figure 7. MPPT boost converter output voltage

Figure 6 and 7 shows the boosted value of MPPT boost converter circuit. The input supply is 10V and the boosted output voltage is 23V. Both the waveforms are captured across input and output capacitor.

V. CONCLUSION

India is blessed with vast renewable resource i.e. solar energy but still we are not properly making use of it due to lack of public domain knowledge about the advantages of using renewable energy rather than consuming non-renewable energy. Initial installation cost is higher but is very much cost effective if we concentrate on long term plans. So, we designed a system which is easy to install at rural as well as urban places which should be implemented so that every village can get the facility of street lights. System is made from very basic components & with the use of latest demand of LEDs.

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