Solar PV Based Wireless Remote Airfield Lighting System

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Abstract— Many remote airfields requires power for the lighting of airfield runway lights because power grid are not connected to the runway lights. It is challenging and necessary requirement to provide the adequate lighting facility. The findings of a Remote Airfield Lighting System research Centre gives a light with low power consumption and a color/intensity is obtained for identification of airfield and landing. This paper has added a new function along with the lights for the operational test with automatic switching of lights and batteries smart charging using solar panels with microcontroller and low cost pilot controlled lighting. The improvement is that RALS can be conveniently used at a low cost.

Keywords: Runway lighting, Solar charging, Remote control, Pilot-controlled lighting

I. Introduction

Many remote communities depend on air transport for business and emergency needs. There are numerous small, remote communities which do not have paved road access, around the world. Vital lifetimes for these communities are remote airfields which are mainly used for provisional supply functions and occasional emergency. The Adequate lights are necessary for the pilots to identify the runway of the airfields for safety landing during night time. Hundreds of Thousands of dollars costs for a traditional airfield lighting system but due to inadequate lighting system power supply, it is unusable

The Remote Airfield Lighting System (RALS) [1] team contracted Far Light LLC to produce runway corner lights for customized general purpose. LED is not required by the specifications as the light source but text fixture used LEDs due to the requirement of light time usage and battery power. Operational tests are necessary, before wide spread applications of RALS. In the operational test, to the runway corner lights new functions are added including smart charging of the batteries and Switching on/off the lights using solar panels as microcontroller as the controlling device. At the low cost, the functions that are added to the existing system can greatly show the improvement in the lighting system convenience. A lighting configuration is identified by the RALS research. It consists of four corner lights, so that location and orientation is identified by pilots at a distance of 5 miles from the air field and as an edge light a number of retro reflective panels are used, safety landing on the runway can be assisted by the panels. RALS team found the corner lights requirements after various research and field testing. Requirements for the corner lights (CL) are:

- At night time, for best visual perception Aviation Green CL1 of wavelength $\lambda \approx 500$ nm is used
- The emission of CL2 is Omni directional with photonic candelas of number 10 in the vertical plane of degree minimum from 0 to 10, so that the pilots can perceive lights from 5 miles away.
- CL3 synchronized 2 Hz, 40% duty cycle flashing of the 4 corner lights is necessary to facilitate pilots' identification of the airfield in the presence of light.

Solar energy [2] is a convenient source of charging for the batteries of the LED corner lights and green environment can be maintained. The 'smart' charger is needed as Li-Ion batteries cannot be trickle-charged.

The smart charger starts charging when the output voltage of solar panel is higher and lower than the preset threshold.

The charging will stop when the threshold is higher than charging current. At the unregulated terminal, Li-Ion battery pack nominal voltage is 7.4V and in full charged condition, the maximum voltage allowed is 8.4 V. If boost DC-DC converter is used in switching type, under the sunshine the solar panel provide the output voltage not less than 10V. If the voltage of the solar panel will be waste if the output is high. For example, in a linear type regulator heat is generated due to the excessive voltage which is wastage of solar panel output. In buck DC-DC converter of switching type, during duty cycle off period the converter will not draw current from solar panel. Under the sunshine condition, the off-the-shelf 6V solar produces 10V and 12V provide 20V. For Application, 12V batteries are not used as voltage is too high from 12V SLA (sealed lead acid) batteries. Hence 6V batteries are chosen. To have the charging margin, Solar panels power not less than 6W are chosen in the case of few consecutive rainy/overcast days.

II. Mathematical Modelling

The ASI (Approach slope indicator) units provide the visual guidance for aircraft to land at the threshold area while clearing all obstacles on the approach. The approaching angle for an aircraft is $3^{o.}$ The angle of elevation of the aircraft approaching the land is shown in Fig.2.1.

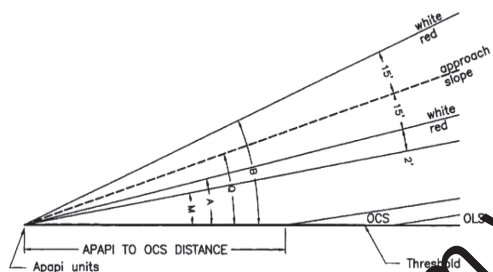

Fig.2.1. Angle of Elevation

The recommended practice for siting of APAPI units based on numerical calculation is as follows.

- Approach slope angle Q

$$Q = 3° \quad (1)$$

- The lower boundary of the on-slope indication.

$$A = Q - 15' \quad (2)$$

$$A = 3° - 15' = 2°45' \quad (3)$$

- Angle M - Angle M is related to the lowest height at which the pilot will perceive an on-slope indication over the threshold.

$$M = A - 2' \quad (4)$$

$$M = 2°45'-2' = 2°43' \quad (5)$$

- Maximum eye to wheel height (EWH) of the critical aircraft.

EWH = 3m minimum

- Minimum wheel clearance over the threshold. This distance shall be not less than:
  a) for a PAPI system - 9m where the code number is 3 or 4 .
  b) for a PAPI system where the code number is 1 or 2.

APAPI system - 3m or the aircraft eye-to-wheel height in the approach altitude, whichever is greater.

- The minimum eye height over the threshold (MEHT)

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MEHT = EWH + minimum wheel clearance over threshold
MEHT = 3m + 3m = 6m minimum

- The optimum location for APAPI wing bar as follows:

D1 - distance of APAPI from threshold

$$\text{MEHT} = D1 \times \tan (M) \quad (6)$$

$$\text{Example: } 6m = D1 \times \tan (2°43') \quad (7)$$

D1 = 126m

- The Obstacle Clearance Surface (OCS)

$$\text{OCS} = M - 1° \quad (8)$$

$$\text{OCS} = 2°43' - 1° = 1°43' \quad (9)$$

Point of origin for runway where the code number is 2 shall be 60m downwind of the units, i.e. the distance from threshold is:
126m - 60m = 66m

- Obstacle limitation surface (OLS) and ensure that OCS is not penetrated by any object within approach divergence angle.

III. Implementation

Fig.3.1 shows the block diagram of wireless remote airfield lighting system. When aircraft reaches the altitude of 25000 feet, the receiver present in the remote airfield receives the signal and the same is sent to the controller which turns on the runway light. The battery is the source for the runway light which gets charged by solar panel.

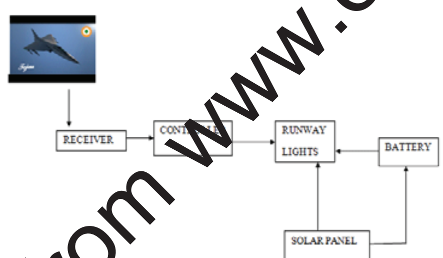

Fig.3.1 Block diagram for wireless remote airfield lighting system.

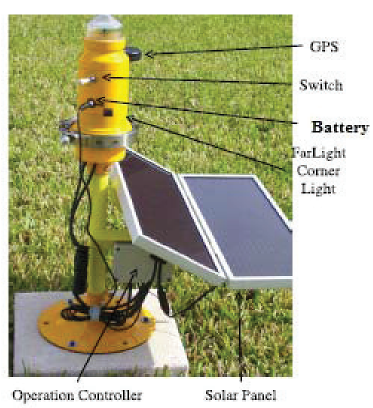

Fig3.2 Picture of the LED runway corner light

The Fig3.2 shows the picture of the LED runway corner light. 315 MHz working wireless remote control like is by wireless garage openers to automatically switch off/on LED runway corner lights.

By replacing the retro reflective panels with simple LED edge lights, the electronic devices and solar panels cost can be lowered. ZigBee wireless networking functions are used in the edge lights along with a microcontroller board for providing control and routing for wireless networking. A radio beacon transmitter transits a non-directional signal with low and medium frequency and when a aircraft is properly equipped with receiver, pilot can determine bearings and home on the station. The operating frequency band is of 190 to 535 kilohertz (kHz), according to ICAO Annex 10 the frequency range for NDBs is between 190 and 1750 kHz, and transmits a continuous carrier with either 400 or 1020 hertz (Hz) modulation. During voice transmission, except compass locators all radio beacons will transmit a continuous three letter identification in code. Compass locator is the conjunction of radio beacon and Instrument Landing System markers. Radio beacons makes voice transmission unless the class designator includes "W" (without voice). Disturbance resulting from factors like lighting, precipitation etc. causes erroneous bearing information in radio beacons. At night, radio beacons are vulnerable to interference from distant stations. The disturbance that affects the facility's identification also affects the Automatic Direction Finder (ADF) bearing. When the ADF needle is erratic, noisy identification occurs. When the erroneous bearing information is heard, ADF receivers don't have flag to indicate warning so that pilot has to continuously monitor the NDB's identification.

IV. Simulation

Fig.4.1 represents the interleaved DC-DC Boost converter-open which is used for charging battery using solar panel. The battery supplies power to the runway light and in turn it gets charged form the solar panel. Fig 4.2 represents the output voltage of the solar panel and load and also current of inductor and resistor of the interleaved DC-DC Boost converter.

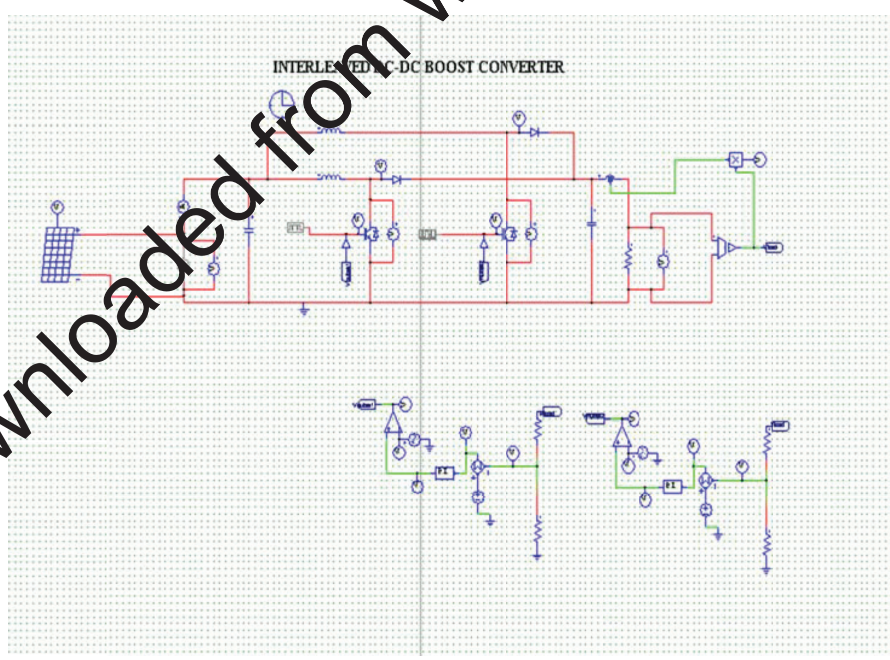

Fig.4.1 Interleaved DC-DC Boost converter

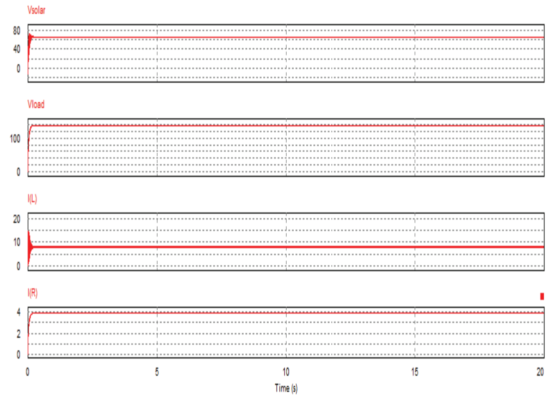

Fig.4 .2 Output for interleaved DC-DC Boost converter.

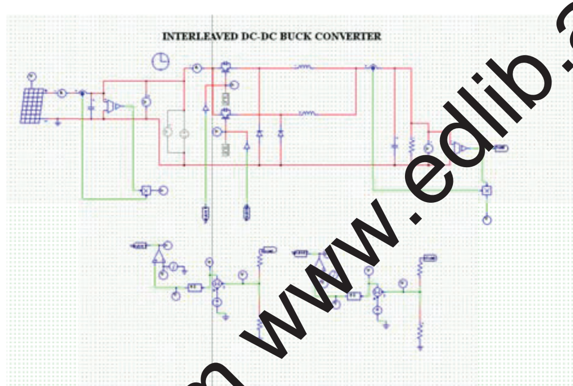

Fig 4.3 Interleaved DC-DC buck convertor

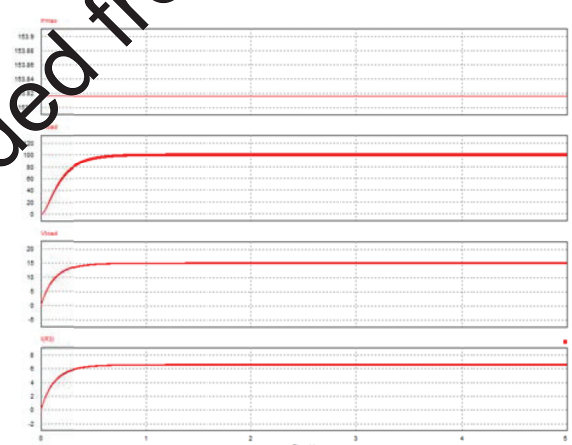

Fig 4.4 output for Interleaved DC-DC buck converter

Fig4.3 represents the closed loop system DC-DC Boost converter which is used for charging battery using solar panel. Fig 4.4 represents the output voltage of the solar panel and load and also current of inductor and resistor of the open loop system DC-DC Boost converter.

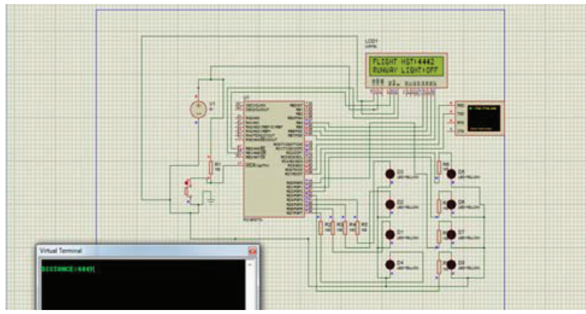

Fig.4.5 Runway lights when the flight is above 2500 feet.

Fig 4.5 shows the simulation model made in Proteus and this gives the result when the flight is above 2500 Ft. of sea level. The above shows the output that the runway light is not turned on till the flight reaches 2500 Ft.

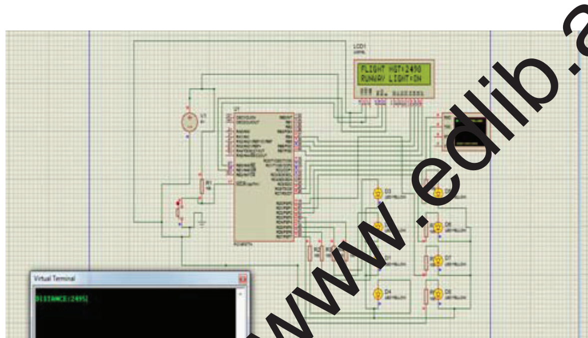

Fig.4.6 Runway lights when the flight is below 2500 feet.

Fig 4.6 shows the simulation model made in Proteus and this gives the result when the flight is reached below 2500 Ft. of sea level. The above shows the output that the runway light is turned on after descending 2500 Ft. of sea level.

V Conclusion

The automatically switching on/off the lights and smart charging of the batteries using solar panels under the control of a microcontroller and low cost pilot controlled lighting has been analyzed.

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