CHAPTER 4

DESIGN OF SOLAR CHARGING CIRCUIT

This methodology in adopting solar charging is the supportive action for minimizing the charging time required for the designed hybrid electric vehicle. The batteries used are normally charged with any made plug-in variable charging unit available in the market, with input AC and output variable DC. Solar panels are used to convert photon energy into electrical energy. The word photovoltaic refers to “light electricity”. The application of these photovoltaic made solar panels and cells can be found in our daily life like usage in calculators, water heaters and watches.

4.1 DC-DC BOOST CONVERTER

As of fluctuations in sunlight because of angular changes with respect to direction of sunlight and other environmental factors, the output of the solar panel will not be constant. So it is required to design DC boost converter, which takes the output of the solar panel, boosts the voltage and maintains it constant.

A boost converter acts as step-up power converter. It takes the input voltage from the solar panel ranging from 4 Volts to 15 Volts and maintains the output of 60 Volts for charging the batteries.

TPS40210 EVM has the characteristics of taking in an input voltage of 9.6V to 13.2V and providing output voltage of 24V with maximum of 2 Amperes of current. This EVM has smaller area of construction and more feasible in utilizing in the designed vehicle. The battery pack used is five batteries set, each of 12 volts and 20 Ampere hours. By adding voltage doubler circuit, we can get output voltage of 60 Volts. The ORCAD PSpice was used for simulating the circuit. This EVM operates at 12 Volts to 26 Volts outputting 60 Volts constant voltage for charging of the batteries. The PSpice model utilized for simulation is shown in the Figure 4.1.
Figure 4.1: Texas Instruments EVM Circuit
4.2 DESIGN & RESULTS

The design would not have been completed without implementing hardware or software to the system. During the design process we used various simulation software to check the feasibility of each component that was used in system integration. We used Multisim 11 printed circuit board (PCB) layout and design tool that includes a graphical user interface (GUI) and various simulation interfaces. Many library components can be found in Multisim. These components are included in the GUI as virtual components. Although, many of the components are already included in component libraries, it was essential that we created the exact number of pins on any virtual components that we added. Moreover, the pin locations and sizes had to match the actual components. This process is known as creating a footprint. The footprints utilized in Multisim are later utilized with Utilboard for creating the PCB generation arrangement.

4.2.1 SOLAR PANEL MODELLING

Solar cells are nothing but p-n junction semiconductor fabricated in a thin wafer. When sunlight falls on it, a current proportional to the solar radiation is generated. The solar cell has current-voltage characteristics as similar to diode during the dark period.

A photovoltaic cell generates normally 0.5 Volt to 0.8 Volt depending on the solar intensity, type of material used for its construction. Normally the solar cells are connected in series as Solar-Array (36 cells to 72 cells) in getting required voltage.

The solar cell modeling which is discussed presents the effects of the variation of the solar radiation, the influence of temperature on the PV cell outputs are investigated, the effects of the series resistance. Figure 4.2 shows PV cells built using Matlab/ SIMULINK model.
Figure 4.2 : PV Cell Matlab/SIMULINK Model

Figure 4.3 shows the simulation results of the PV cell array model showing current rating (Ampere), voltage rating (Volt), Power Rating (Watts). It is seen that for an arrangement of 72 solar cells in series assuming constant irradiance it is seen to get a current of about 4.5 A with a voltage of about 14.5V together giving approximately 67 Watts of power.
Figure 4.3 Simulation Results Of A Solar Panel
It is shown for different cases of input voltage for LTSpice circuit for EVM is shown in Figure 4.4 with different cases of result from Figure 4.5 to 4.8. Also, the output voltage is a very 56 Volts at steady state, which nearly approximate to 60 Volts required for our battery to get charged.

Figure 4.4 LTSpice Circuit for the Linear Technology EVM
LTC3862 (buck boost convertor) RANGE: Vin: 5v-36v, Vout: 48v, 5A

Case 1:
For Vin: 15V, Vout: Increases gradually to reach 54V

![Graph showing voltage increasing linearly with respect to constant input voltage.]

Figure 4.5: Voltage Increasing (Boosted) Linearly with Respect to Constant Input Voltage

Case 2:
For Vin: 12V, Vout: reaches a constant 54 V after a suitable time.

![Graph showing output voltage reaching a constant value after it reaches 54 volts.]

Figure 4.6: Output Voltage reaching a Constant Value after it reaches 54 volts
Case 3:
For Vin:30V, Vout: 54 V

Figure 4.7: Output voltage remains Constant at 54V for various input Voltages

Figure 4.8: Output Current Waveforms
The physical model of the LT EVM is built which is shown in the Figure 4.9.

Figure 4.9 : Physical model of LT EVM circuit

The built physical model of LT EVM circuit is tested with solar panel for charging of the batteries used in the designed vehicle. We could easily charge four batteries completely by utilizing this technology as the output voltage of the circuit was approximately 56 Volts. The obtained simulation results are shown in Figures 4.5 to 4.8. So this technology can be utilized in charging the batteries utilized in the designed vehicle during the sunny days, which actually minimizes the charging time required, also saving the electrical power generated in the region.