Solar Kart

Ajay
B.Tech Scholar
Department of Electrical Engineering
Amrita School of Engineering, Kollam

Adwait S Anand
B-Tech Scholar
Department of Electrical Engineering
Amrita School of Engineering, Kollam

Abstract—The conception and assembly of an experimental Electric Vehicle based on photovoltaic solar energy is presented in this manuscript. The vehicle has a battery for storing the energy. The applications aim is to achieve the lowest possible energy consumption for the vehicles movement, indicators with photovoltaic modules and battery as its electricity source.

Index Terms—Electric Vehicle, Solar Vehicle, Solar Electric Vehicle, Zero-Emission, Photovoltaic Solar Energy, Photo voltaic, Maximum Power Point Tracker.

I. INTRODUCTION

By switching out old fossil fuel burning engines for clean electric motors and solar panels, the power of the sun harnessed showcasing renewable energy .

The idea of an electric vehicle is not new and has a history of more than 100 years. Since more than a decade ago, the searching for developments of Zero-Emission Vehicles (ZEV), Electric Vehicles (EV), and Hybrid Electric Vehicles has taken a new impulse. These technologies can be observed in the consecutive auto shows around the world in the shape of conceptual designs. An incipient presence in the market is appreciated in the last years, basically with hybrid technology combining two or more energy systems. In accordance with the use of new and clean energy sources, the trend is to sup-plant internal combustion engines by traction through electric motors, thus solving a problem related with greenhouse gas (GHG) emissions.

The need to research for achieving practical zero emission in the source and consumption in addition to the challenge of linking the scientific-technological knowledge to the global interests of a sustainable planet, by means of the promotion of the use of alternative energies, makes evident the aim to initially possess an experimental prototype of SOLAR VEHICLE. In this sense, photovoltaic solar energy plays an essential role in the implementation of clean energies as main electricity source for EVs. A zero-emission solar vehicle is powered by photovoltaic solar energy by means of solar panels, with storage of electric energy in batteries, and the traction is obtained by an electric motor, this is the basic idea Nevertheless, solar energy for vehicle applications is not an obvious issue because several critical points must be care-fully analyzed, e.g., a) the efficiency and costs of photo-voltaic panels, b) how to maximize the solar radiation, and c) the energy management and control.

At present there are numerous solar vehicle projects around the world for multiple purposes. From the applied research point of view, interesting contributions have been presented in the last two years. A project involving battery powered electric vehicles charged by photovoltaic panels is being carried out with the aim to investigate the cleaner production of power hence reducing the use of diesel fuels in agriculture. On the other hand, solar vehicles are built around the world to participate of different solar races with the aim to test and investigate new technological advancements and its potential application in zero-emission vehicles.

The conception and construction of an experimental solar vehicle that uses photovoltaic and battery for storing the harnessed energy is presented. The applications aim is to achieve the lowest possible energy consumption for the vehicles movement, with photovoltaic modules as the main electricity source. The development of the solar vehicle is an initiative of students The main objectives of this work are the following ones:

a) To transfer the obtained knowledge on the new trends in transport, electric traction and renewable energy sources to the productive sector, b) To spread the use of alternative energies in all society sectors.

II. DESIGN OF THE SOLAR VEHICLE

An experimental solar vehicle prototype was built in the context of an interdisciplinary project called GARUDA for the Eco kart competition promoting the use of clean energies in multipurpose vehicles. This is a vehicle with a system based on photovoltaic solar energy which charges the battery which helps in movement and used for indicators. One of the most important points in the construction of the vehicle is closely related to the chassis design, with the purpose of achieving a structural optimized work, and ex-pressed in the lowest possible energy consumption for the vehicles movement. The

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design was conceived from a point of view of a high-efficiency, lightweight and stable transport, with reduced costs, and zero emission. The block diagram of a general SEV is as shown in the figure1 given below

A. General Design

The solar vehicle was made for only one rider in recumbent position. The high-efficiency electric traction is achieved by a 48V 3kW brushless dc motor

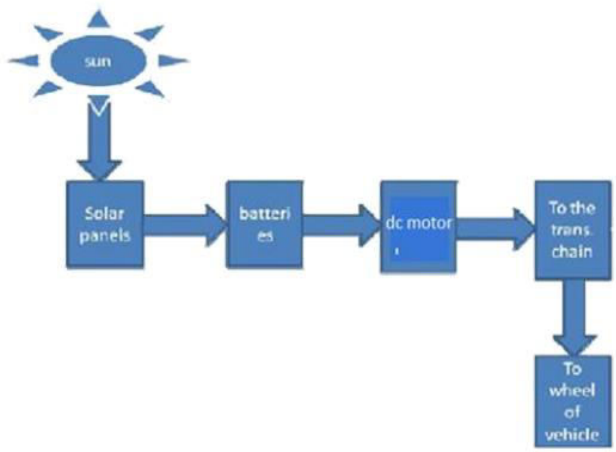

Fig. 1.Block Diagram of SEV

Fig. 2. BLDC Motor

a). Brushless DC (BLDC) Motors: BLDC are Preferred for Solar Cars because .

Improved speed vs. torque characteristics High dynamic response High efficiency Noiseless and interference-free operation Extended speed ranges Long operation life It is mounted on the wheel, the stator of the BLDC motor is made up of the silicon steel stampings with slots in the interior surface. The slots accommodate a closed distributed armature winding. The winding is to be wound for a specified number of poles. This winding is suitably connected to a DC supply through the power driver module which is controlled via PWM signals from the microcontroller PSC. Rotor made from forged steel accommodates permanent magnet. The figure 2 shows the BLDC hub motor used in SEV.Besides, it has an accommodation for the battery behind the seat, and a rear-mounted structure for accommodatingelectronics and controllers.

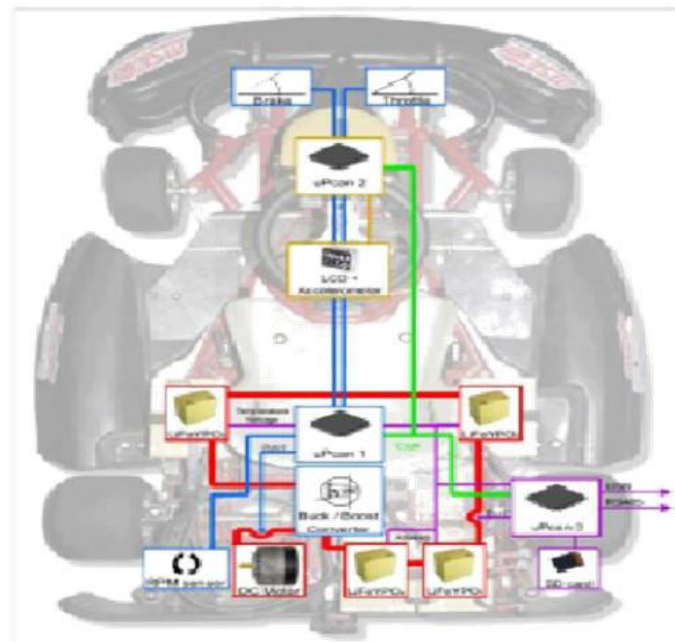

Fig. 3.Parts of Electric Vehicle

A solar roof comprised by a rectangular aluminum structure with ribs was assembled over the vehicle and covered by glass-fiber, for distributing and supporting the photovoltaic solar panels. The general parts of the vehicle are depicted in Fig. 3.

b). System Integration

In the design the solar panels are connected to battery assembly through solar charge controller. Figure4 represents the electrical system design of electrical solar vehicle. The independent MPPT circuitries are monitored and controlled centrally by a Microcontroller which has embedded MPPT algorithm. Due to the balance between the simplicity of design and overall efficiency Perturb and observe algorithm is selected for tracking the maximum power point of the panels. The microcontroller will compute the power and continually adjust the operating voltage based on the required battery charging mechanism. This process continues as long as the system is powered on.

III. WORKING

Solar panel works by allowing photons, or particles of light, to knock electrons free from atoms, generating a flow of electricity. Solar panels actually comprise many, smaller units called photovoltaic cells. (Photovoltaic simply means they convert sunlight into electricity.) Many cells linked together make up a solar panel. Each photovoltaic cell is basically a sandwich made up of two slices of semi-conducting material, usually silicon the same stuff used in microelectronics. Solar (or photovoltaic) cells convert the suns energy into electricity. Whether they're adorning your calculator or orbiting our planet on satellites, they rely on the photoelectric effect: the ability of matter to emit electrons when a light is shone on it. Silicon is what is known as a semi-conductor, meaning that it shares some of the properties of metals and some of those of an electrical insulator, making it a key ingredient in solar cell.

Sunlight is composed of miniscule particles called photons, which radiate from the sun. As these hit the silicon atoms.

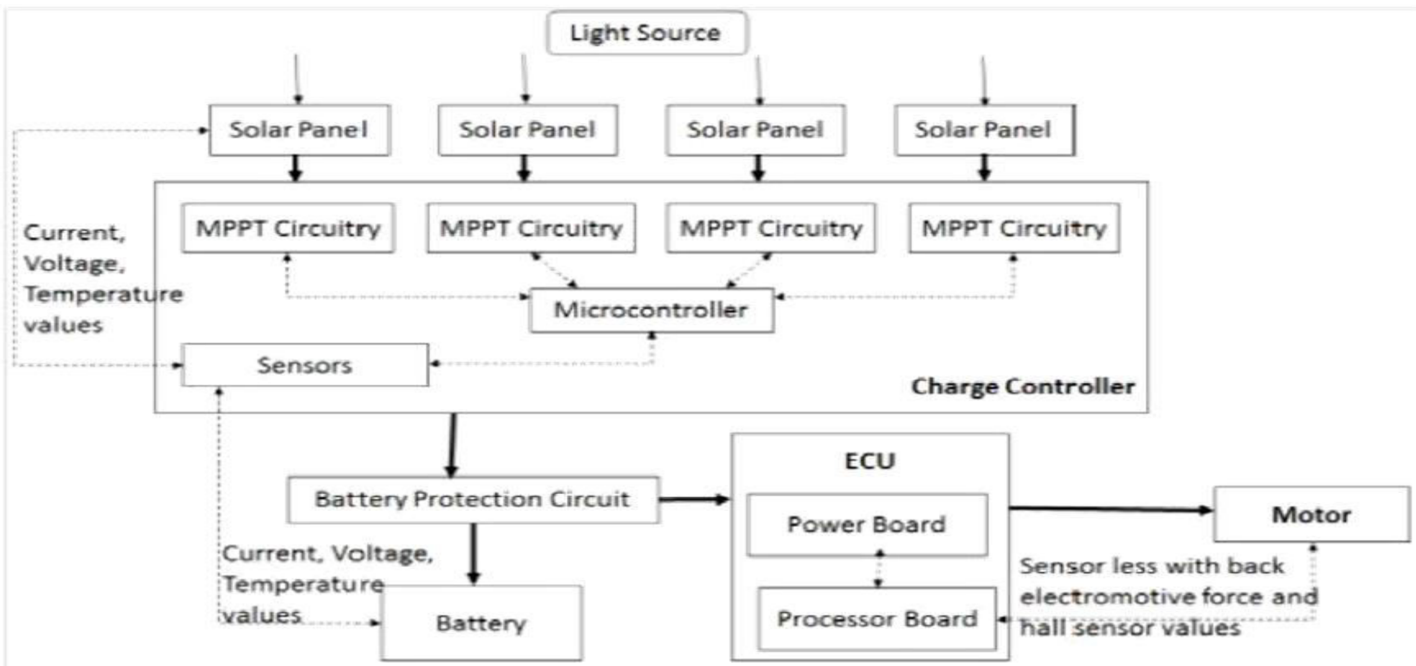

Fig. 4. Overall control Scheme

of the solar cell, they transfer their energy to lose electrons, knocking them clean off the atoms. The photons could be compared to the white ball in a game of pool, which passes on its energy to the colored balls it strikes. Freeing up electrons is however only half the work of a solar cell: it then needs to herd these stray electrons into an electric current. This involves creating an electrical imbalance within the cell, which acts a bit like a slope down which the electrons will flow in the same direction. Creating this imbalance is made possible by the internal organization of silicon. Silicon atoms are arranged together in a tightly bound structure. By squeezing small quantities of other elements into this structure, two different types of silicon are created: n-type, which has spare electrons, and p-type, which is missing electrons, leaving holes in their place. When these two materials are placed side by side inside a solar cell, the n-type silicones spare electrons jump over to fill the gaps in the p-type silicon. This means that the n-type silicon becomes positively charged, and the p-type silicon is negatively charged, creating an electric field across the cell. Because silicon is a semi-conductor, it can act like an insulator, maintaining this imbalance .As the photons smash the electrons off the silicon atoms, this field drives them along in an orderly manner, providing the electric current.

A. MPPT

To increase the maximum power output from the solar panel MPP tracking systems are used. Even though the temperature, irradiation and the load characteristics varies it helps in maintain the output of the solar PV panel constant. For high efficiency output from the PV panel buck converters are used for DC-DC power transmission. In standalone PV systems buck converters are effective in dc-dc step down operation and for battery storing operations.. For battery charging application step down converters gives high efficiency. The power output of PV module varies continuously with the variation of irradiation and temperature. The maximum power point tracking.

Fig. 5.Solar Panel

(MPPT) algorithm is used for extracting the maximum power from the solar PV module and transferring that power to the load. A DC-DC converter (Step down), serves the purpose of transferring maximum power from the PV module to the load and acts as an interface between the load and the module.

B. Solar Panels and Battery Design

Solar panels being available in many types we get options to select them as per our requirements. The type which we will be using is polycrystalline. Though Mono crystalline panels have more efficiency but according to the requirement and economy we considered polycrystalline panels to be used.

Mechanical: Type	Multi Crystalline
No of Cells in Series	60
Y-Axis Mounting Hole	946
X-Axis Mounting Hole	6.9
Area of one panel (m2)	0.567m2
Junction Box Cable	4 sq mm, with Plug-in
type connectors TUV certified	1000mm
Glass Type	High Transmission, Low Iron, Tempered, 4.0mm Electrical
Power Max (Pm)	250w
Open Circuit (Voc)	24.5V
Coefficient Power (Percentage/k)	(-0.45 percent / K) NOCT 46C +/- 2C
Coefficient Power (Percentage/k)	(-0.45 percent/ K)
Coefficient Voltage (Percentage/k)	(-0.31 percent / K)
Coefficient Current (Percentage/k	(+0.05 percent/ K)
Temperature Range	(-40C) to (85C)

Table 1: Panel Description

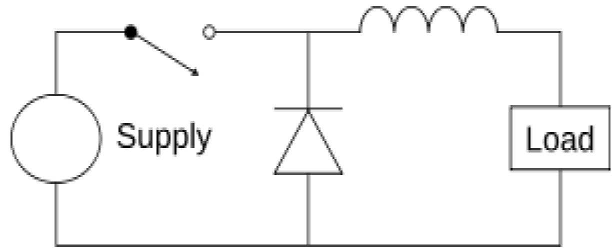

Fig.6. Buck Converter

IEC 61730-2 (ed.1)	
TUV Safety class II3.2b	
BATTERY	Type Lead acid
Capacity	35
Voltage	12v
Number of cells	4
Total Voltage	48v
Dimension	97m x129m x227m
Weight	10.4kg
Charging current	2.5A
Total Power	1680W

Table 2: Battery Specification

C. Buck Converter

It is also known as a dc- dc converter .A buck converter circuit has a transistor, inductor and, capacitor. The capacitor is connected parallel to the load. Buck converter continuously switches on and off at high frequency. To maintain a continuous output, the circuit uses the energy stored in the inductor, during the on periods of the switching transistor. The circuit diagram of buck converter is illustrated as given below: The required buck convertors are 48v-12v and 48v-5v . Power requirement Indicators and Warning lights- 12v,120w Data acquisition -12v 24w and 5v 20w cooling fan (bldc)-50w,12v.

D. MPPT Charge Controller

Maximum power point tracking (MPPT) is a technique that grid connected inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic modules. Photovoltaic solar cells have a complex relationship between solar irradiance (W/square meter), temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the

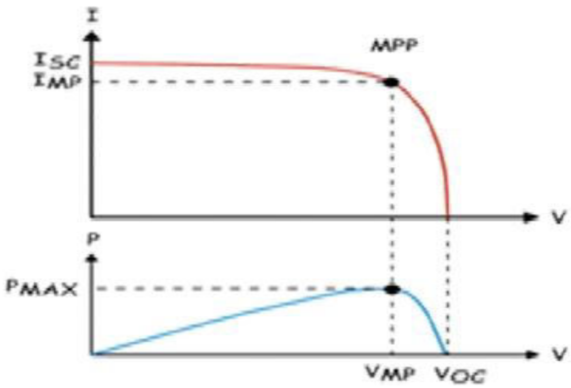

Fig. 7.Maximum Power Point Tracking

Output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental condition. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

E. MPPT Algorithm used

Perturb and observe in this method the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called perturb and observe method and is most common, although this method can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

F. TLP250 Mosfet Driver

TLP250 is more suitable for MOSFET and IGBT. The main difference between TLP250 and other MOSFET drivers is that TLP250 MOSFET driver is optically isolated. Its means input and output of TLP250 MOSFET driver is isolated from each other. It works like an opto-coupler. Input stage has a light emitting diode and output stage has photo diode. Whenever input stage LED light falls on output stage photo detector diode, output becomes high.

G. Capacitor

The bulk input capacitor, C, stores enough energy from the solar panel to power the load for the required duration and provides the charge for starting up the power supply.

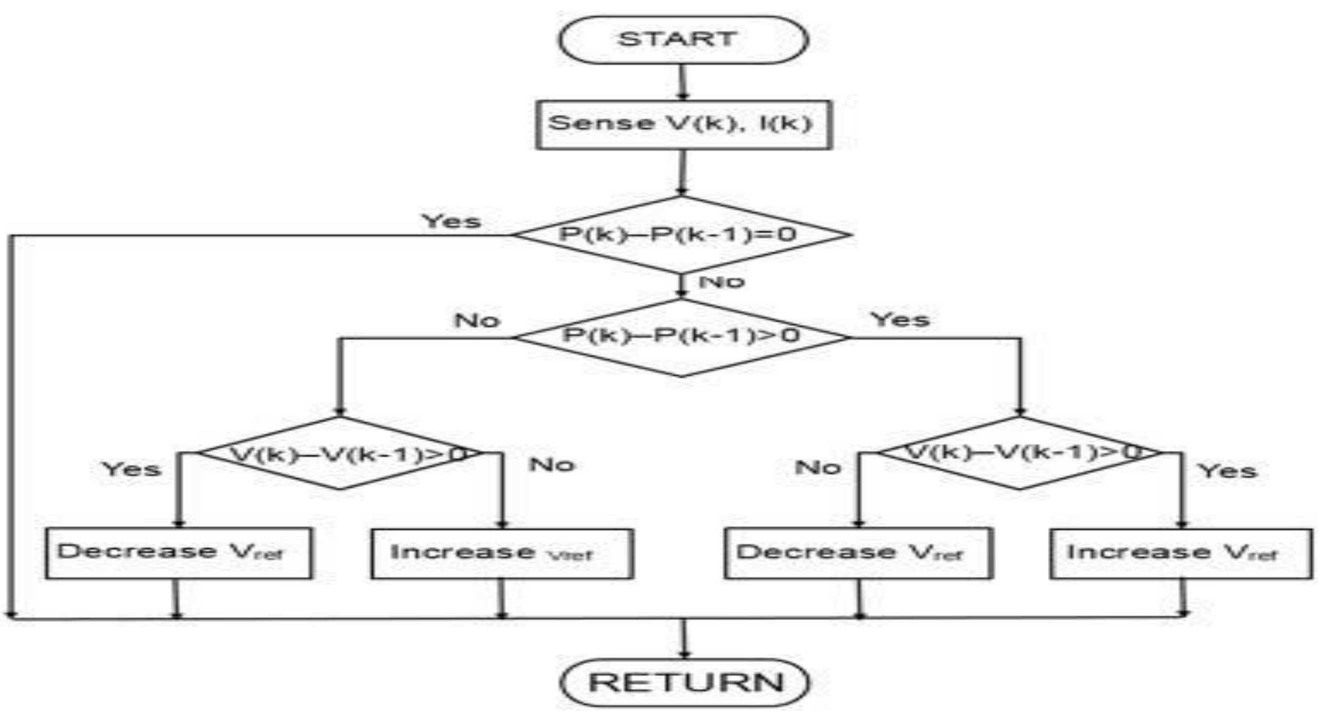

Fig. 8.Block Diagram of Perturb and Observe

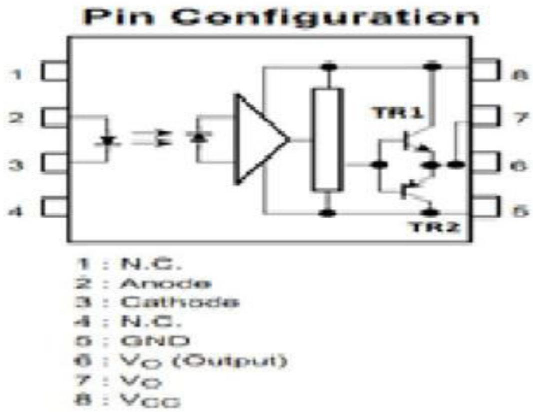

Fig.9. Pin Configuration of TLP250

The panel delivers a current corresponding to its voltage to either the power supply or C. When the power supply is off, the solar panel delivers its current to the capacitor. When the power supply is on, the capacitor and solar panel provide the necessary current to power the load. Since C merely stores energy and this energy is released over a relatively lengthy period of time, C can be a low cost electrolytic capacitor. The details given below gives the reason why we are using this capacitor. Given its use in wide range of temperature as given in figure 10.

H. MOSFET: IRF640N

N-Channel Power MOSFETs : 200V, 18A, 0.15
Features :Ultra Low On-Resistance

SERIES	FEATURES	OPERATING TEMPERATURE RANGE	WORKING VOLTAGE (VDC) CAPACITANCE (μ F) RANGE
SA	Radial lead Standard +85°C	-40°C to +85°C for WV ≤ 160V -25°C to +85°C for WV > 160V	6.3 ~ 450 V 0.1 ~ 22000 μF

Fig.10. Temperature Ranges

Specifications of IRF640NSPBF

Fet Type	MOSFET N-Channel, Metal Oxide	Fet Feature	Standard
Rds On (max) @ Id, Vgs	150 mOhm @ 11A, 10V	Drain To Source Voltage (vdss)	200V
Current - Continuous Drain (id) @ 25° C	18A	Vgs(th) (max) @ Id	4V @ 250µA
Gate Charge (qg) @ Vgs	67nC @ 10V	Input Capacitance (ciss) @ Vds	1160pF @ 25V
Power - Max	150W	Mounting Type	Surface Mount
Package / Case	D²Pak, TO-263 (2 leads + tab)	Channel Type	N
Current, Drain	18 A	Gate Charge, Total	67 nC
Package Type	D2Pak	Polarization	N-Channel
Power Dissipation	150 W	Resistance, Drain To Source On	0.15 Ohm
Resistance, Thermal, Junction To Case	1 °C/W	Temperature, Operating, Maximum	+175 °C
Temperature, Operating, Minimum	-55 °C	Time, Turn-off Delay	23 ns
Time, Turn-on Delay	10 ns	Transconductance, Forward	6.8 S
Voltage, Breakdown, Drain To Source	200 V	Voltage, Drain To Source	200 V
Voltage, Forward, Diode	1.3 V	Voltage, Gate To Source	±20 V
Lead Free Status / RoHS Status	Lead free / RoHS Compliant	Other names	*IRF640NSPBF

RDS(ON) = 0.102 (Typ), VGS = 10V

Fig.11. Specifications of MOSFT

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I. Diode: 1560G

Features: Ultrafast 35 and 60 Nanosecond Recovery Time 175C Operating Junction Temperature High Voltage Capability to 600 V Low Forward Drop Low Leakage Specified @150C Case Temperature Current Derating Specified Both Case and Ambient Temperatures

IV. APPLICATION

In the last years, there is an increasing awareness about the need to achieve a more sustainable mobility, allowing meet-inn the mobility needs of the present without compromising the ability of future generations to meet their needs (Kyoto Protocol, 1997). The most pressing arguments towards new solutions for personal mobility are the following: The CO2 generated by the combustion processes occurring in conventional thermal engines contributes to the greenhouse effects, with dangerous and maybe dramatic effects on global warming and climatic changes; The worldwide demand for personal mobility is rapidly growing, especially in China and India; as a consequence, energy consumption and CO2 emissions related to cars and transportation are expected to increase; Fossil fuels, largely used for car propulsion, are doomed to depletion; their price is still growing, and is subject to large and unpredictable fluctuations; renewable energy sources is one of the most effective solution to such problems. Is it therefore natural to wonder about possible use of solar energy for automotive applications. The conversion from light into direct current electricity is based on the researches performed at the Bell Laboratories in the 50s, where the principle discovered by the French physicist Alexander-Edmond Becquerel (1820-1891) was applied for the first time. The photovoltaic panels, working thanks to the semi conductive properties of silicon and other materials, were first used for space applications. The diffusion of this technology has been growing exponentially in recent years, due to the pressing need for a renewable and carbon-free energy. World solar PV installations were 2.826 gig watts peak (GWp) in 2007, and 5.95 gig watts in 2008, with a 110So with the application of solar vehicles people will be able to cope with current crisis. Moreover its a cleaner fuel can be tapped almost everywhere. These vehicles can overcome with the most important problem faced by the people that is depletion of oil reserves.

V. CONCLUSION

The students also learn about the different aspects of hybrid electric vehicles, covering subjects such as mechanical trans-missions, energy storage systems, circuit breakers, dimension-ing of electronic components and different power electronic circuits. This allows them to look beyond the boundaries of system specific problems limited to one module and gives them real-life experience in designing, dimensioning and controlling both specific system components as well as user-friendly end-products.

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