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Design of Intelligent Charger for Electric Vehicles

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Abstract - *For providing power from Vehicle to grid, the role of intelligent charger comes in to the action. The intelligent charger for vehicle to grid power flow comprises of AC-DC PWM converter and bidirectional converter. During the on-peak load condition, intelligent charger transfers electrical energy from vehicle to grid and during off-peak load condition, the charger charges the vehicle-battery.*

***Key Words*: Battery Charger; Solar Panel; Electric Vehicle; Vehicle to grid; energy storage system, V2G Operation**

1.INTRODUCTION

In recent years, the researches on effective use of battery energy have been increased according to the market expansion of electric vehicle (EV) using batteries as energy source. Due to the increasing needs for electric power in EVs, battery energy conditioning systems are required for charge and discharge control of the batteries [1].The peak-load condition could be occurred in day- time from 10 a.m. to 12 p.m. or from 4 p.m. to 6 p.m. when is swamped with electric power demand in factories or buildings. Because of the quantity of power demand depends on the power consumption of loads, the utility grid has to secure a supply of electric energy is larger than the required power consumption under peak load-condition. It means that the waste of electric power could will be light at the other time than peak-load period.
In this paper, rapid-charger system which has a function of load compensation at the peak-load condition is proposed [1].

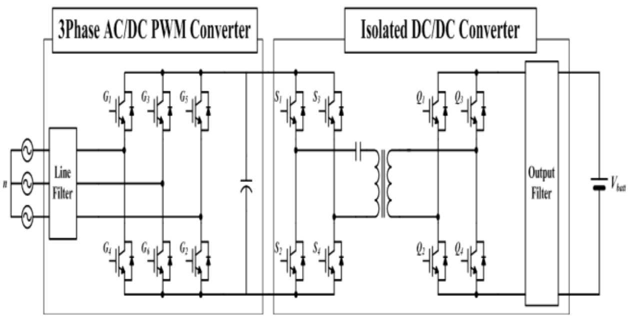


Fig - 1 : Intelligent-charger system schematic diagram.

At the peak-load condition, the intelligent charger passing charged energy in the battery of electric vehicle to the grid (V2G).).
As shown in Fig. 1, propose rapid-charger system the well-known two-stage power converter which is composed of AC-DC PWM converter and an isolated bidirectional DC-DC converter [1].

2. CONFIGURATION OF SYSTEM

Fig. 2 shows a diagram of the grid-connected electric vehicles charger station system. The proposed system is composed of battery bank, bi-direction DC/DC converter, and bi-directional DC/AC inverter. The bi-directional DC/DC converter is able to transfer power between the battery bank and the bi-directional DC/AC inverter in both directions, either in battery charging mode or in battery discharging mode. The three phase's bi-directional DC/AC inverter is synchronized and connected to the grid. The inverter controls DC-link voltage desired level of 650V [2].

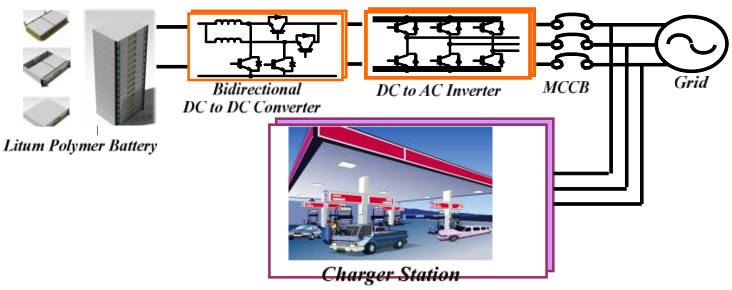


Fig – 2: Grid-connected electric vehicle charger station systems

3. Source of Intelligent Charger

3.1 Battery

PROPOSED CHARGING-DISCHARGING SEQUENCE
Fig 3 shows the proposed power flow determination algorithm for 10kW rapid-charger system including V2G mode. At the peak-load condition, the system controller checks the rapid-charger operational state (i.e. charging or discharging). Fig 4 shows the each mode of operations [1].

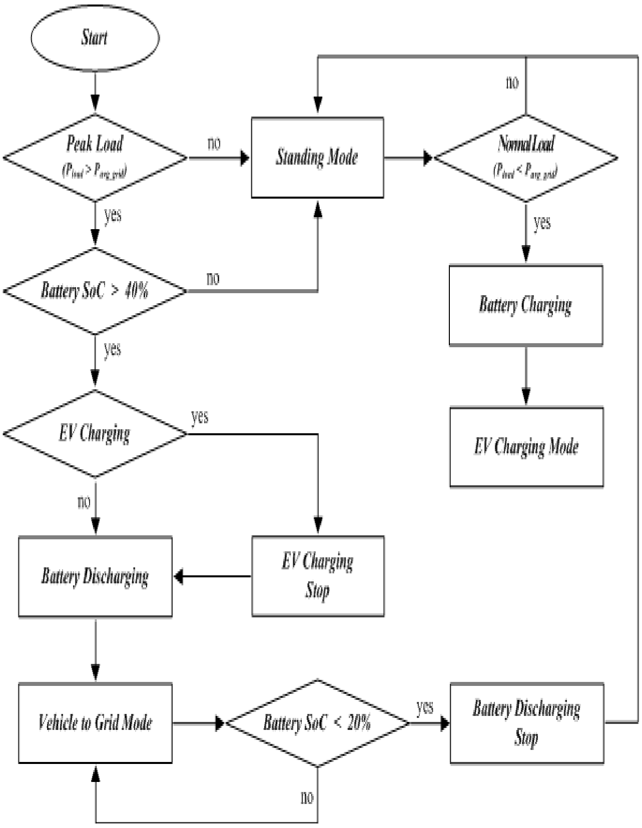


Fig - 3 : 10kW rapid-charger system algorithm flowchart

V2G mode (Discharging mode) — When the peak-load condition is recognized, the battery state of charge (SOC) is detected by the system controller. In the proposed sequence shown in Fig. 3, the rapid charger starts to operate the V2G mode when the battery SOC is above 40%. V2G mode continues until 20% of SOC, and the rapid charger is operated under the standing mode below 20% of the battery SOC.

Standing mode (Sleep mode) — At the beginning of peak load condition, if the battery SOC detected by the system controller is below 40%, the rapid charger operates under the standing mode. During the peak-load condition, both of the charging and discharging operation is not performed.

Charging mode — after the peak-load condition (i.e. normal-load condition), the battery charging operation can be performed. When battery SOC is below 40% and grid power is larger than load power demand, the rapid-charger operates under the charging mode.

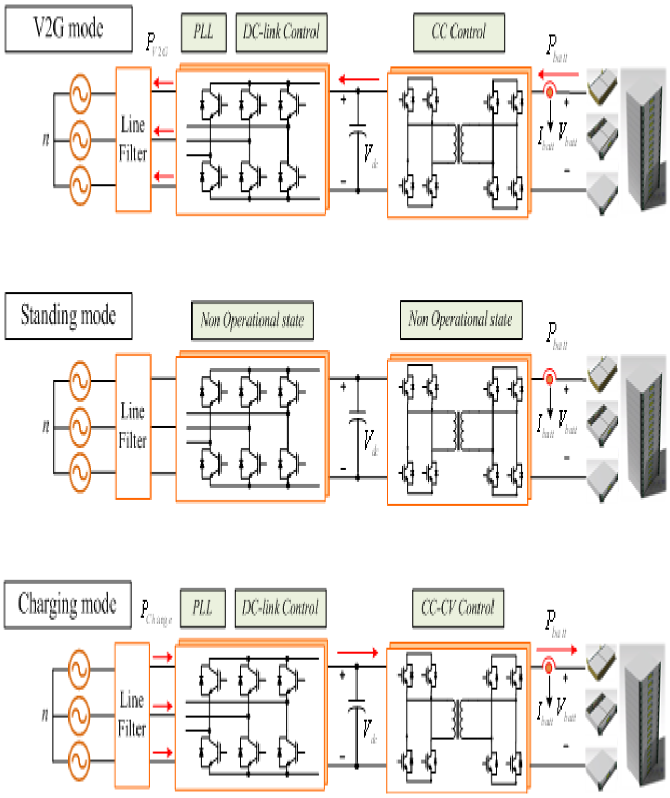


Fig - 4 : Each mode of operations in 10kW rapid-charger system

The Relationship between Generated Power and Battery Power according to the Load Power

According to the increasing power consumption, more power generation is needed at the peak- load. When the power demand for loads is smaller than generated power from the utility grid, the excess power of grid charges the battery. In case of the power demand is larger than generated power, such as the peak-load condition, the rapid charger transfer the energy stored in batteries to the utility grid to share the power demand for loads. During the peak-load condition, the relationship between the load power, P_{load}, and the averaged grid power, Pavg_grid, can be represented as [1].

$$P_{load} > P_{avg}\_grid \quad (1)$$

The maximum required power of V2G mode, PV2G, during the peak-load condition is shown in (2). The PV2Gcan be expressed as the capacity of the battery, P_{batt}, in kWh divided by the time interval of peak-load condition, tpk, as [1].

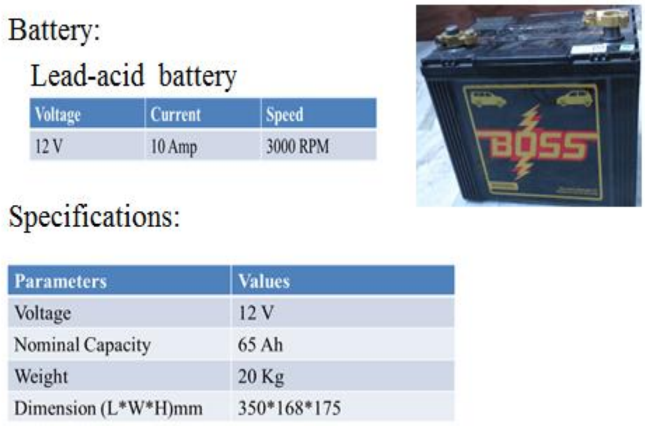
$$PV2G = P_{load} \_ P_{avg}\_grid \quad (2)$$

$$P_{V2G} = \frac{P_{batt}}{tpk} \quad (3)$$

When the averaged grid power is larger than load power demand as expressed in (4), the rapid charger operates under the charging mode. The possible charging power, P_{charge}, can be written as [1]

P_{avg} _ Grid> P_{load} (4)

$P_{charge} \leq P_{avg}$ _ grid - P load (5)


Battery:

Lead-acid battery

Voltage	Current	Speed
12 V	10 Amp	3000 RPM

Specifications:

Parameters	Values
Voltage	12 V
Nominal Capacity	65 Ah
Weight	20 Kg
Dimension (L*W*H)mm	350*168*175

3.2 Solar Panel

Solar power generation system and maximum power generation system

In this chapter, we mention about the necessity (maximum power generation logic) that the operation condition of conversion circuits must be changed, and basic idea of our proposal.

Necessity of maximum power generation method

Fig. 5 shows equivalent circuit of solar power conversion circuit [3].

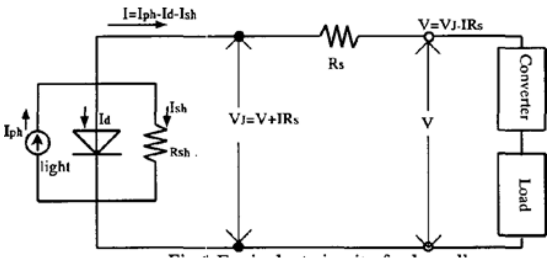


Figure: 5 Equivalent circuit of solar cell

Current induced by solar power.(Arrow signal encircled)

Id Diode current followed by operating voltage

$$I_d = I_o\left\{\exp\frac{qV_J}{nkT} - 1\right\}$$

Leakage curren in part of pn junction which is not completely formed

R_{sh} = Leakage resistance (shunt resistance)

$$I_{sh} = \frac{Vi}{Ish}$$

Rs Sum of electric resistance for semiconductor of solar cell and resistance of electrode, etc.

As mentioned above, general formula of solar cell characteristics is defined by following equation.

$$I = I_{ph} - I_o\left\{\exp\frac{q(V + IR_s)}{nkT} - 1\right\} - \frac{V + IR_s}{R_{sh}} \quad (6)$$

Operating voltage defined Vs, and characteristics of PWM converter, this relation is defined by next equation.

$$v = \exp\{-\alpha(Vs - Vso)\} \quad (7)$$

By these equations (6) and (7), optimum operating voltage Vs can be certainly obtained according to the change of solar energy level measured frequently. Fig.7 shows schematic diagram of calculation. In this figure, upper left shows the characteristics of solar cell, lower left patt shows characteristics of PWM inverter circuit, and lower right shows optimal operating voltage related with solar power. For easy implementation, curve of optimal operating voltage could be approximated by third order polynomials.

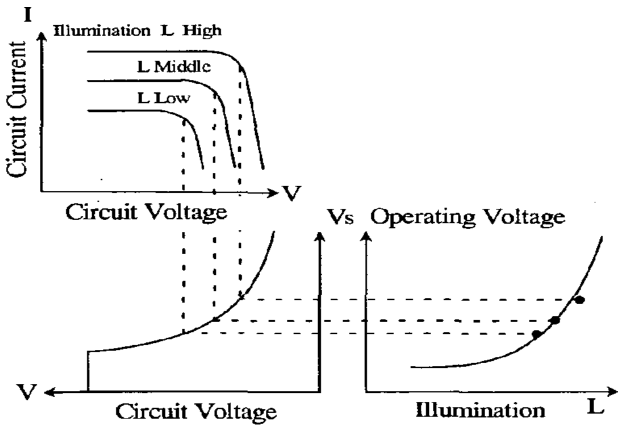


Figure: 7 Relationship between circuit and operating voltage

It becomes clear that optimum operating point for maximum power exists in one point in this figure.According to solar energy level (shown by L), this power curve change toward the horizontal and vertical axis. In addition, characteristics of solar cell are certainlyvariedaccording to operating condition such astemperature.Therefore the new learning method, which can absorb characteristic changes, is necessary [3].

Solar Panel :

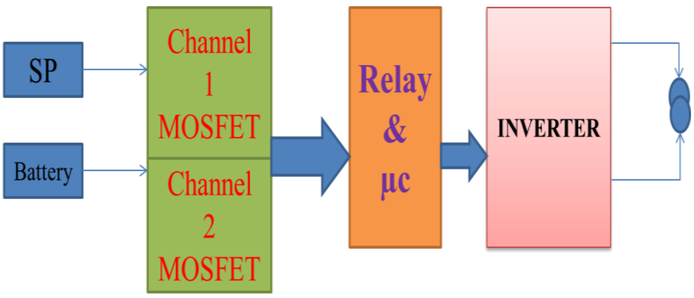
Company Name – Trinasolar
Smart Energy Together
Module – TSM-290 PC/PA14

Solar Panel

Specifications :

Parameter	Ratings
Maximum Power (P max)	300 W
Maximum Power Voltage (Vmax)	36.9 V
Maximum Power Current (Imax)	8.13 A
Open Circuit Voltage	45.3 V
Short Circuit Current	8.60 A
Module Application	Class A
Irradiance	1000 W/m²

4. BLOCK DIAGRAM OF THE SYSTEM



5. COMPONENTS OF THE SYSTEM

5.1 INVERTER

600 VA 12 V DC to 230 V AC pure sine wave Inverter
Features:
High efficiency
Temperature controlled cooling fan – reduces energy consumption
Low interference Wide operating DC input range: 10.5 - 16.5 VDC
LED indicators for power and protections
Detachable cable with 12V plug adapter

5.2 BI-DIRECTIONAL METER

The bidirectional meter installed for Net Metering customers records the flow of power in two directions.
It measures how much electricity you use from PGE and how much electricity your system supplies to the PGE grid.

INSTRUCTIONS FOR READING BIDIRECTIONAL METERS

A bidirectional meter cycles through a series of three screens. These screens display information registering your meter's status, the power delivered from PGE and the power you have delivered to PGE. These screens change at a regular interval, typically every five seconds, or repeat continuously. The first screen shows all 8s. These indicate the meter's display is working properly.
The second screen shows a 01 on the left-hand side, indicating power delivered to the customer.
The third screen shows a 02 on the left-hand side, indicating power exported to PGE.
If left-to-right, then systems are drawing power from PGE.
If right-to-left, then systems are sending power to PGE.

3. WORKING AND CONTROL SCHEME OF INTELLIGENT CHARGER

Future scope
For Proposed topology, role of single car becomes insignificant. Presumption required for 2020
Total Electric Vehicles= 1 Lakh
solar Powered Electric vehicles=30,000
Single Electric Vehicle =408 watts
Total : 30,000 x 408 = 12.24 Mw

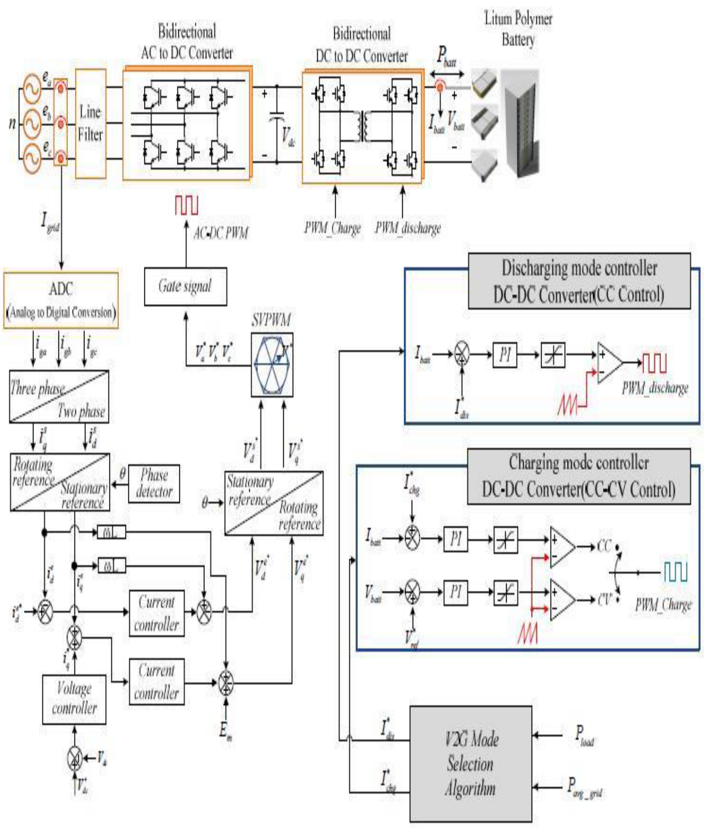


Fig. Intelligent charger Charging-Discharging Control Block Diagram

4. CONCLUSION

In this paper, for electric vehicle considering vehicle to grid is presented. Under the peak-load condition, the sequence and the control method of battery charging and discharging for the rapid-charger is proposed. Now days, Vehicle to Grid energy Transactions are picking up. The scheme proposed is supposed to support the Grid.

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