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Energy Management and Power Control of a solar panel for Distributed Power Generation and Grid Integration

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Abstract:

The main objective of the system is proposed a number of integrated energy systems based on a compact converter topology. DISTRIBUTED generation (DG) by local green energy sources has gained worldwide attention because of the ever-growing energy demand, gradual depletion of fossil fuels, and environmental concerns linked to the burning of fossil fuels.

This interest is an equally demanding attempt to energy storages device like batteries, ultra capacitors, etc. Almost always, these entities have the power converters for grid interfacing and energy processing. Having they individual power converters has advantages like more flexible character control and simple in design but does not encourage functionality integration. Reducing of semiconductors to arrive at a more compact integrated designing is not possible.

In This project total systems can be able to connect for single phase or three phase depending on the types of sources using, storages, and loads assembled. They can operate in the grid-tied or stand-alone mode with no compromise in performances expected, when compared with other solutions using more switches. The proposed systems are shown to output equally good terminal waveform quality while yet gaining advantages like reduced switch count and compactness.

In this extension concept the input is we are using is PV in existing system so input changing in place of PV with MPPT and in place of ultra capacitor changing to super capacitor. Through proper design, the proposed systems are shown to output equally good terminal waveform quality while yet gaining advantages like reduced switch count and compactness. Having they individual power converters has advantages like more flexible character control and simple in design but does not encourage functionality integration. Reducing of semi conductors to arrive at a more compact integrated designing is not possible. In This project total systems can be able to connect for single phase or three phases depending on the types of sources using, storages, and loads assembled. The simulation work has been done in MATLAB/SIMULINK framework.

Key words:
Distributed generation (DG), energy storages, energy systems, Microgrids, Pulsewidth-modulated converters.

Introduction:

IN THE PAST, centralized power generation was promoted. the facility generation units were typically engineered aloof from the inhabited areas however near the sites wherever the fuel (i.e., fossil fuel) was accessible. This unbroken the transportation value (of the fuel) to a minimum and eliminated the likelihood of pollution in inhabited areas. Such schemes remained quite in style till recently despite drawbacks like resistance unit (i2R) losses (due to transmission of electricity through cables over long distances), the voltage regulation issues, power quality problems, and enlargement limitations.

With the facility demand increasing systematically, a stage has return once these centralized power generation units is stressed no any. As a result, the main focus has been shifted to generation (and consumption) of electrical power "locally" resulting in "distributed power generation systems" (DGS).At a constant time, redoubled awareness regarding the importance of a clean surroundings and also the quickly vanishing fuel have given impetus to the idea of local power

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generation using nonconventional energy (NCE) sources (e.g.,photovoltaic (PV) cells, fuel cells (FC), wind energy, etc.), which may suit a particular region and provide power at various load centres along with the main power grid. Most of these sources are pollution-free and are abundant. Unfortunately, they are not so reliable. For example, the Photovoltaic source is not available during the nights and during cloudy conditions.

Wind energy may or may not be available but it can provide the more voltage than the solar and fuel energy but it takes many losses to the grid interconnection. Other sources, such as fuel cells may be more reliable, but have monetary issues associated with them. Because of this, two or more non- conventional sources arrequired to ensure a reliable and cost- effective power solution. Such that the integration of different types of energy sources into a DG system is called a hybrid distributed generation system (HDGS).

For larger controllability, energy storages seem to be inescapable although their capacities are often reduced if there area unit additional supply varieties within the systems. The put in energy storages conjointly needn't be of an equivalent kind. They must instead be designed with a range, as an example, a mix of ultra capacitors and batteries for fulfilling the facility and energy density needs of the thought of system. In short, which means a typical comprehensive energy system would unlikely be a single-source system.

Rather, it might embody several entities required for meeting the native generation, storage, utilization, and grid-tied needs. nearly always, these entities would have their own power converters for process energy to a type appropriate for storage or consumption. this is often little doubt the foremost versatile arrangement, that actually is a plus. Alternative blessings may be thought of, except for sure, together with too several individual converters to a system may every now and then introduce an excessive amount of pricey redundancy.

This can be the case for renewable systems, whose energy generations area unit typically intermittent. Power converters connected to them may thus operate below their rated capacities for a large amount of your time. It would thus be of interest to perform some integration instead of use multiple individual converters as per existing observe.

For that, variety of integrated energy systems victimization twenty fifth lesser semiconductors area unit planned here for decigram. in operation principles and blessings of the systems planned area unit 1st processed before considering their possible performance tradeoffs. These tradeoffs can not be avoided by most (if not all) reduced semiconductor topologies however will certainly be decreased for the systems planned. Relevant clarification is often found during a later section, at the side of experimental results for proving the practicalities of the systems planned.

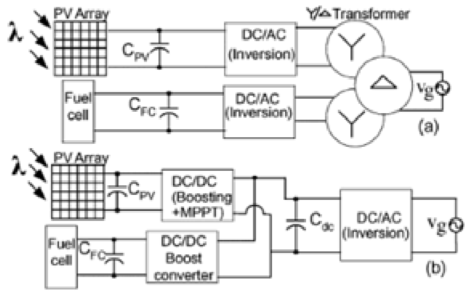

Fig 1: a) Conventional, multistage topology using two H-bridge inverters (b) Modified topology with only one H-bridge inverter

Energy generation systems with nonintegrated power converters:

Fig 2 shows the everyday block illustration of a standard alternative energy generation system drawn here for instance. Every supply or storage enclosed is in the middle of its own dc–dc boost or charging device tied to a standard dc link. The controlled energy is then forwarded to a dc–ac electrical converter for acquisition before channeling it to the grid.

The electrical converter will either be single or 3 part, although the latter is expressly drawn within the diagram. It's additionally not necessary for the dc–ac electrical converter to tie to the grid if the energy generated is supposed for immediate load consumption in an islanded native microgrid.

The dc–ac electrical device is an islanded microgrid may get replaced by a dc–dc converter if the hundreds are dc naturally. DC network is definitely clear stage, however supported gift advancement; ac output would in all probability still dominate for several years.

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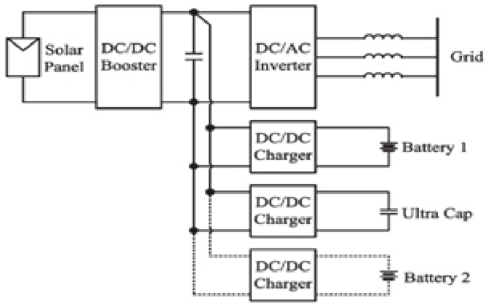

Fig `2: Block diagram

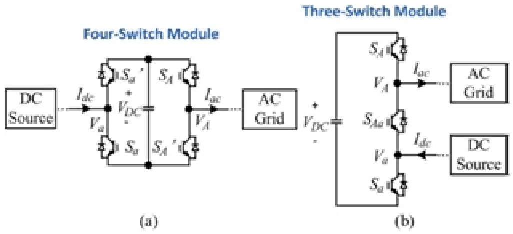

Fig 3: Illustration of (a) nonintegrated four-switch and (b) integrated threeswitch topologies.

INTEGRATED ENERGY GENERATION SYSTEMS:

The integration principles are better explained by referring first to the nonintegrated energy system shown in Fig. 3(b). For easier viewing, two of its phase legs with switches {SA, SA,, Sa’, Sa} are drawn separately, as shown in Fig. 3(a). For each of the illustrated phase legs, its two switches must be switched in complement, meaning that, when one switch is on, the other must be off. Terminal voltage of the considered phase leg can then produce two discrete values identified as Vdc and 0 V.

The same applies to the other phase leg shown in Fig. 3(a). Terminal voltages of the two phase legs can then be any of the four sets of values indicated in Table I. Instead of two independent phase legs, the switches can be rearranged as shown in Fig. 3(b) while still providing two terminal voltages. Instead of four switches, only three switches labeled as {SA, SAa, Sa} are used. That represents a saving of 25%, which can be sizable if more switches are considered. Among the three switches, two of them will be turned on to tie the terminal voltages to either the same or different dc rails at any instant. The three possibilities are summarized in Table II, which, when compared with Table I, tells a constraint faced by the three-switch topology.

To be more precise, the terminal voltages of the three-switch topology cannot produce the fourth combination of VA = 0 V and Va = Vdc, which certainly is a tradeoff incurred by saving one switch. The overall system design should therefore be planned such that influences from Simulation results this tradeoff on the terminal voltages are kept to a minimum. Discussion on this issue can be found in the next section.

Applying the same integration to the remaining two pairs of phase legs with switches {SB, SB’, Sb’, Sb} and {SC, SC’,S’c, Sc} then results in the integrated energy system shown in Fig. 3. The system in Fig. 4 uses nine switches as compared to 12 for the nonintegrated system shown in Fig. 3. The same six terminal voltages are retained with the upper three produced by the dc–ac inverter formed by the upper three switches {SA, SAa, Sa} and middle three switches {SB, SBb, Sb}. On the other hand, the lower three voltages are produced by three dc–dc converters formed by the middle three switches {SB, SBb, Sb} and lower three switches {SC, SCc, Sc}.

The middle three switches are obviously shared by the inverter and converters, which will surely introduce some constraints as already identified (fourth combination of VA = 0 V and Va = Vdc cannot be produced). Before progressing forward, it is appropriate to share here that the same nine-switch topology has earlier been used as an ac–ac converter for dual motor drives, rectifier-inverter systems, and uninterruptible power supplies. In those attempts, the six converter terminals are organized as either two sets of three-phase ac outputs or one set of three-phase ac input and one set of three-phase ac output.

They have so far been proven fine, but with serious limitations imposed. The limitations can be summarized as either a very limited phase shift between the two sets of ac terminals or a doubling of dc link voltage caused by strict amplitude sharing. These constraints would make the 25% saving in semiconductors not so attractive. Methods for minimizing them are therefore of interest and are discussed here in the context of energy systems.

Concentrating on energy systems also has the merit of merging ac and dc circuits using the nine-switch topology, which so far has not been tried by other researchers.

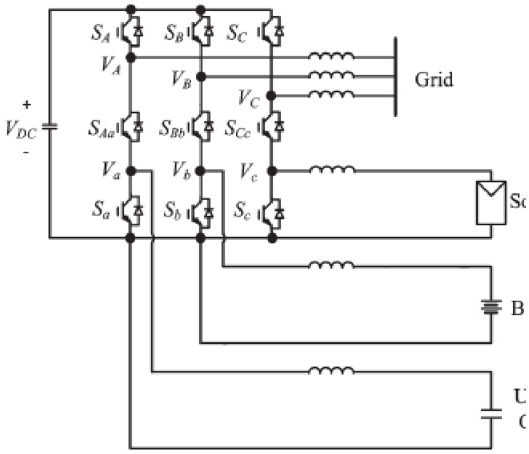

Fig 4: Integrated three-phase energy system with multiple sources and storages.

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PV Module Characteristics :

The equivalent circuit diagram of an PV module is shown in fig.5,

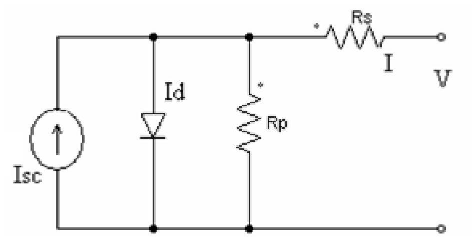

Fig. 5 Equivalent circuit diagram of a solar cell PV module

The above figure is PV module circuit diagram, the current source represents the current is generated by light photons and its output is constant under constant temperature and constant irradiance. The diode shunted with the current source determines the characteristics of I-V of an solar cell. There is a series of resistance in a current path through the semiconductor material, the metal grid, contacts, and a current collecting bus. These resistive losses are lumped together as a series resistor (Rs). Its effect becomes very noteworthy in a PV module. The loss associated with a small leakage of current through a resistive path in parallel with the intrinsic device is represented by a parallel resistor (Rp). Its effect is much less noteworthy in a PV module compared to the series resistance, and it will only become noticeable when a number of PV modules are connected in parallel for a larger system. The characteristic equation which represents the I-V characteristic of a practical photovoltaic module is given below

$$I = I_{pv} - I_o\left[\exp\left(\frac{V+IR_s}{V_t n}\right)-1\right] - \frac{V+IR_s}{R_p} \quad (1)$$

Where I is current and V is voltage are the PV cell current and voltage respectively, IPV is the photovoltaic current, Io is the reverse saturation current of diode, Vt = NskT/q is the thermal voltage of the array with Ns cells connected in series, k is the Boltzmann constant, T is the temperature of the p-n junction, q is the electron charge and n is the diode ideality constant. IPV and Io are given as follows.

$$I_{pv} = \{[1+a(T-T_{ref})]\, I_{sc}\}\left[\frac{G}{1000}\right] \quad (2)$$

$$I_o = I_o(T_{ref})\left[\frac{T}{T_{ref}}\right]^{\frac{3}{n}} e^{\frac{qE_g}{nk}\left[\frac{1}{T_{ref}}-\frac{1}{T}\right]} \quad (3)$$

Where “a” is temperature coefficient of Isc, G is the given irradiance in W/m2 and Eg is the band gap energy. The intensity of solar irradiance is the most dominant environmental factor which is strongly affecting the electrical characteristics of solar panel ac- cording to the Equation (1).

The effect of the irradiance on the voltage-current (V-I) and voltage-power (V-P) characteristics.the PV cell produces higher output currents because the light generated current is proportionally generated by the flux of photons.

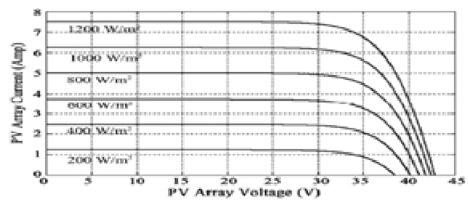

Fig.6 I-V characteristics of the solar PV array

It measures the PV array voltage and current, and then perturbs the operating point of PV generator to encounter the change direction. The maximum point is reached when . There are many varieties, from simple to complex.

If the power increases due to the perturbation then the next perturbation of the operating voltage is continued in the same direction.

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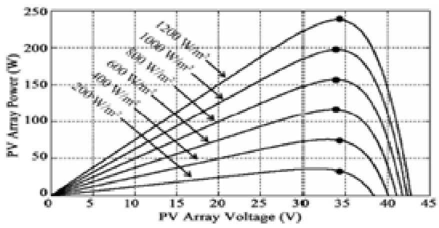

Fig.7 P-V characteristics of the solar PV array

The maximum power point (MPP) decreases with decreasing irradiance and this is indicated on each (V-P) curve.

INCREMENTAL-CONDUCTANCE MPPT ALGORITHM:

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called „maximum power point (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery. MPPT algorithm can be applied to both buck and boost power converter depending on system design.

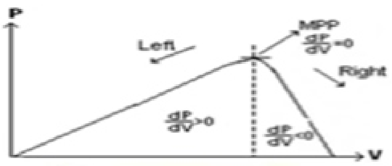

Fig.8 Basic Concept of Incremental Conductance on a PV Curve.

The basic concept of Incremental conductance on a PV curve of a solar module is shown in figure 8. The slope of the P-V module power curve is zero at The MPP, increasing on the left of the MPP and decreasing on the Right hand side of the MPP. The basic equations of this method are as follows.

dP/dV=0 at MPP
dP/dV>0 left of MPP
dP/dV<0 right of MPP
dP/dV = d(VI)/d(V)= I + V*dI/dV

The dP/dV is defined as Maximum power point identifier factor. By utilizing this factor, the IC method is proposed to effectively track the MPP of PV array. The following definitions are considered to track the MPP.

ΔI/ΔV =-I/V at MPP, ΔVn=0 ΔI/ΔV >-I/V left of MPP, ΔVn= + δ

ΔI/ΔV <-I/V right of MPP, ΔVn= -δ

The MPPT regulates the PWM control signal of the dc to dc power converter until the condition: (dI/dV) + (I/V) = 0 is satisfied. Consider the nth iteration of the algorithm as a reference, and then n+1 iteration process can be determined by using the above equations. The Flow chart of incremental conductance MPPT is shown in figure 9. The output control signal of the IC method is used to adjust the voltage reference of PV array by increasing or decreasing a constant value (ΔV=δ) to the previous reference voltage. In this method the tracking of MPP is accomplished by a fixed step size (+ δ) regardless to the gap between the operating point of PV and MPP location. In this method the peak power of the module lies at above 97% of its incremental conductance.

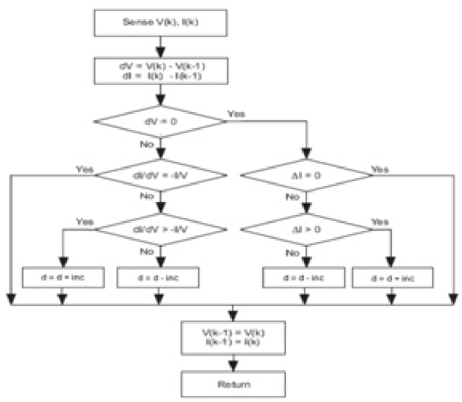

Fig 9: MPPT flowchart

Simulation results:

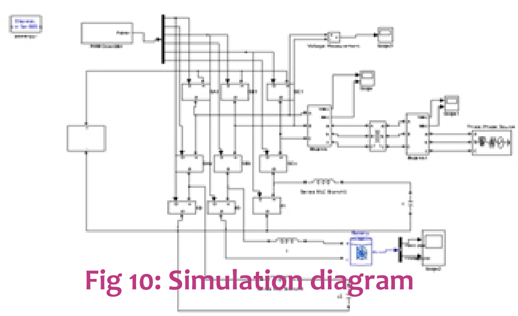

Fig 10: Simulation diagram

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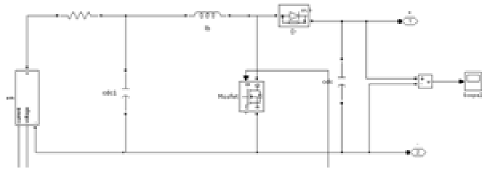

Fig 11: Solar with boost converter without MPPT

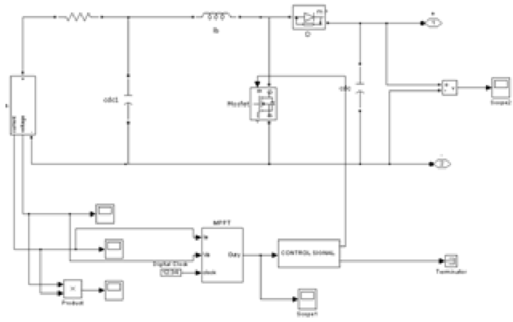

Fig 12: Solar with boost converter with MPPT

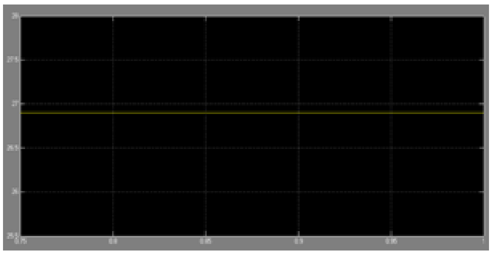

Fig13: PV voltage

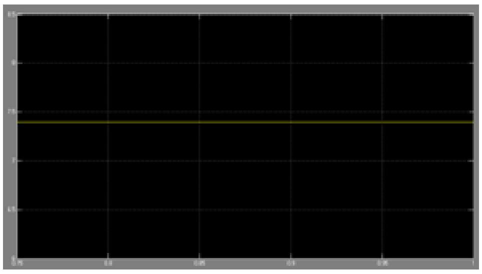

Fig14: PV current

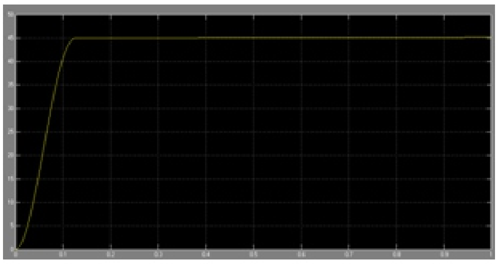

Fig 15: Boost converter

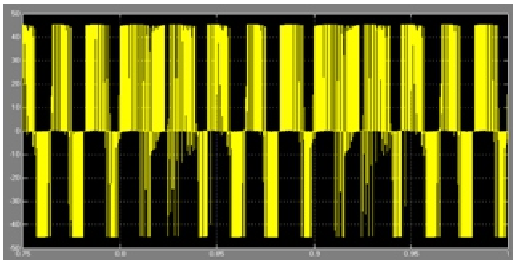

Fig16: Inverter voltage

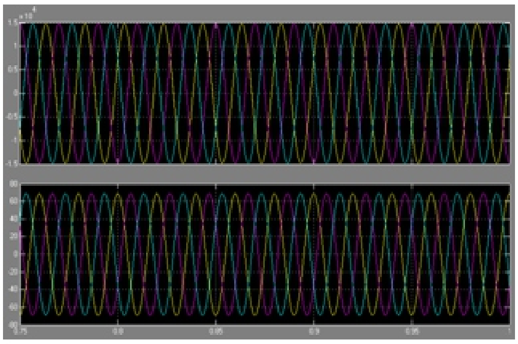

Fig 17: Grid voltage and current

CONCLUSION:

This paper has proposed a number of integrated energy systems based on a compact converter topology with the MPPT technology.

Through proper design, the proposed systems are shown to output equally good terminal waveform quality while yet gaining advantages like reduced switch count and compactness.

Surely, some tradeoffs cannot be avoided but can be minimized through the s proper modulation planning and, hence, do not constitute a major problem. The simulation of the PV system with Incremental conductance MPPT algorithm has been successfully implemented in the Matlab/Simulink.

So that it forces the PV module to operate at close to maximum power operation point to draw maximum available power.

Simulation has already confirmed that their conceptual validity and practicality, regardless of whether it is implemented in single- or three-phase form.

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