Survey-Project based analysis of traditional inverters compatibility with Solar

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Abstract:

Considering the price statistics of emerging consumption of solar inverters, the design and development of affordable, feasible 'Low Cost Solar Inverter' appears to be the primary need of a local man. Industries need to develop market statistics on ever increasing solar market and provide the solution to meet the desired needs and demands of the market. As per the surveys made in cities across Pakistan namely Karachi, Hyderabad, Khairpur Mir's and Sukkur, it was observed that there is a need low cost inverter through converting the traditional inverters compatible with Solar at low installation cost, hence making the traditional inverters to retain their state from losing their value as scrap.

Keyword: Inverter, survey, compatibility, design, development

1. Literature Review:

As per the literature reviewed for the data available on internet and meeting with the local market staff and learning more about the actual working of inverters. This system comprises of simple components that are normally used in the daily life that includes transformer, relays, fuse system, electrical switches, inverter circuits, charging, overcharging, Battery, Maximum power point transactions and Load.

MPPT stands for maximum power point tracker, which is an electronic system designed for optimizing/utilizing the varying power output from a solar panel module case , in our such that the connected battery exploits the maximum available power from the solar Panel for the efficient working[6].

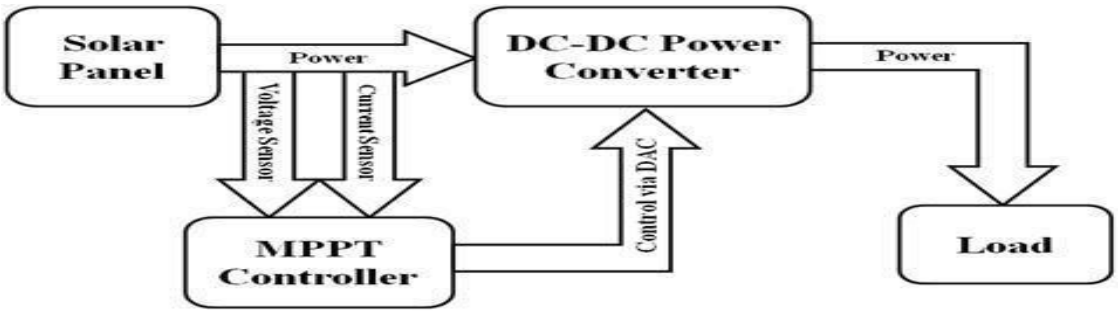


Fig1. The Typical Solar System

We know that the output from a solar panel is directly proportional to the degree of the incident sunlight, and also the ambient temperature. When the sun rays are perpendicular to the solar panel, it generates the maximum amount of voltage, and deteriorates as the angle shifts away from

90 degrees the atmospheric temperature around the panel also affects the efficiency of the panel, which falls with increase in the temperature.

Therefore we may conclude that when the sun rays are near to 90 degrees over the panel and when the temperature is around 30 degrees, the efficiency of the panel is toward maximum, the rate decreases as the above two parameters drift away from their rated values.

The above voltage is generally used for charging a battery, a lead acid battery, which in turn is used for operating an inverter. However just as the solar panel have its own operating criteria, the battery too is no less and offers some strict conditions for getting optimally charged.

Assuming a fully discharged 12V battery, with a voltage anywhere around 11.5V, may be charged at around C/2 rate initially (C=AH of the battery), this will start filling the battery relatively quickly and will pull its voltage to may be around 13V within a couple of hours. Finally when the battery voltage reaches around 14.3V, the process may be reduced to a C/50 rate which almost stops the charging process yet restricts the charge from falling to lower levels.
The entire process charges a deep discharged battery within a span of 6 hours without affecting the life of the battery. An MPPT is employed exactly for ensuring that the above procedure is extracted optimally from a particular solar panel. However in an event of an inefficient overload, such as a mismatched battery or a high current battery, the solar panel voltage tends to get pulled down by the load, when this happens pin2 voltage also begins dropping, however due to the presence of the 10uF capacitor at pin3, the potential stays solid and does not respond to the above drop. When the above situation is triggered, instantly causes pin3 to go high than pin2, which in turn toggles pin6 high, switching ON the BJT BC547.BC547 now immediately disables LM338 cutting off the voltage to the battery, the cycle keeps switching at a rapid pace depending upon the IC's rated speed. The above operations make sure that the solar panel voltage never drops or gets pulled down by the load, maintaining an MPPT like condition throughout. Since a linear IC LM338 is used, the remedy is to replace the LM338 stage with a buck converter. That would make the design extremely versatile and comparable to a true MPPT. According to the figure 1 attached above in the column of table of figures, it gives a brief introduction of the flowchart working of an inverter that is usually used in the market, or that is the old traditional flowchart of electrical inverters. The working of an inverter is quite simple and that represents to the basic principles in the electronics. Electronic inverters can be used to produce this kind of smoothly varying AC output from a DC input. They use electronic components called inductors and capacitors to make the output current rise and fall more gradually than the abrupt, on/off- switching square wave output you get with a basic inverter.[7]

Inverters can also be used with transformers to change a certain DC input voltage into a completely different AC output voltage (either higher or lower) but the output power must always be less than the input power: it follows from the conservation of energy that an inverter and transformer can't give out more power than they take in and some energy is bound to be lost as heat as electricity flows through the various electrical and electronic components.

The system normally comprises of Charging circuit and Discharging circuit, the first is the charging circuit where the input of normal 220/230V is given, which is firstly utilized in conversion from
220/24V in order to make the voltage operative for the electronic components. Then after the assembly of transistor is connected in order to provide a proper biasing and charging execution to the supply and then with the help of assembly, the charging and discharging switches are

connected in order to provide charging and overcharging safety to the inverter. Just after that the battery is connected which actually charges with the pulses/signal received from the transistor biasing assembly. Once, the charging circuit is completed, there appears a transaction of relay, if the supply has stopped, it switches the transaction to discharging circuit where in the same sequence is followed but in the reverse direction. With the help of the transformer, the potential is converted so as to provide a proper transaction to the working appliances that takes up 220/230 volts. The working of the transistor biasing and the inverter circuit remains reverse and hence they provide the smooth transaction to the system.[8]

The impact of maximum power point was also concerned, after finding the proper circuits available and checking their functionalities, almost 4 tried of 10 went unsuccessful that resulted in failure of desired results, but with the consultation, the proper circuit was notified which made us have proper results according to the needs, indeed that improved the charging in a very effective manner with corresponding values dependent on the various time periods of the sun rise.

Study was also carried taking care of the factors that actually affect the efficiency of the Solar Panel.[5] In the above consideration, after the several research experiments conducted across resulted a drastic change in the efficiency of solar panel when it is subjected to particular humidity range of about 60-
70%, specific of Karachi. Additional the effect of efficiency was also notified taking the altitude department where in it also revealed a dominant change in the efficiency of solar panel charging as the presence of masses also at times contribute to the lowering of the efficiency when it comes to utilizing the Solar Energy properly.

2. Project Introduction:

The increasing population in the current era and usage of fossil fuel especially coal and oil is expected to end soon which creates a big question mark on provision of affordable and reliable source of energy that should be under reach of a common man. While looking at Pakistan energy scene in the current era, the renewable energy appears to be the ultimate solution.

Earth's atmosphere receives power amounting to thousands of watt every day and only
30% of that energy reaches earth and the rest is absorbed by clouds, oceans and other sources. The range of solar light that reaches earth mostly lay in near-infrared region with

small amount of near-ultraviolet region. If we see the table below, it provides the detailed information about solar flux and energy consumption [1].

Solar	3,850,000EJ
Wind	2,250 EJ
Biomass potential	100–300 EJ
Primary energy use (2010)	539 EJ
Electricity (2010)	66.5 EJ

Fig.1. Comparison of energy content. Exajoule (EJ) is 10^{18} Joules or 278 billion kilowatt-hours (kW·h) [2].

The energy obtained from sun is received in a year ultimately is almost the double the nonrenewable energies can produce which include production from fossil fuels. The solar energy can be utilized according to the distance it appears from the equatorial scale and can be utilized accordingly of the irradiations received on the earth's crust.[3]

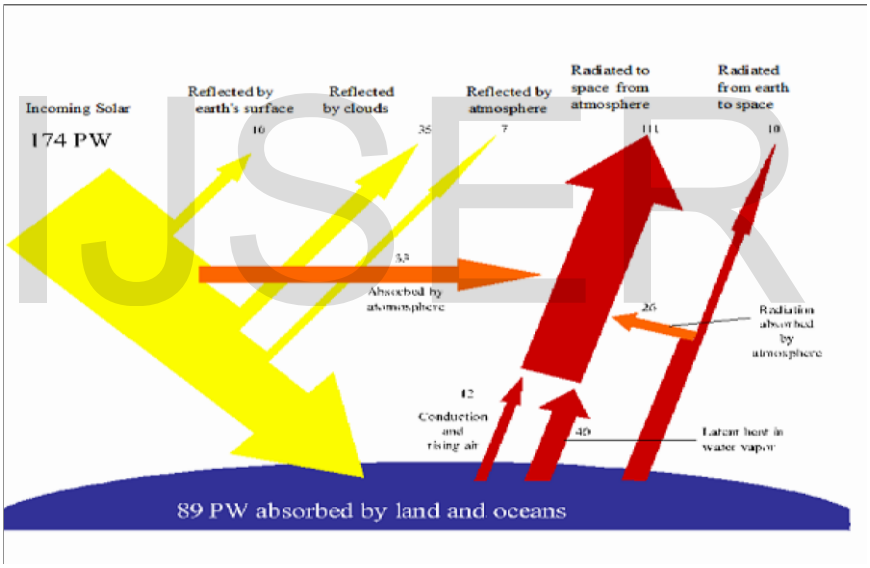


Fig.2: Breakdown of incoming solar energy
[3]

2.1 Solar Energy in Pakistan:

The Utilization of Solar Energy in Pakistan is hardly utilized anywhere, even Pakistan just stepped in inaugurating the first ever solar power on-grid power plant in Islamabad. The Project titled "Introduction of Clean Energy by Solar Electricity Generation System" is a special grant aid project of Japan International Cooperation Agency (JICA) under Cool Earth Partnership. This project includes the installation of 178.08 kW Photovoltaic (PV) Solar Systems each at the premises of Planning Commission and Pakistan Engineering Council, Islamabad .

Figure 1.2: Annual solar radiation in Pakistan

Pakistan can utilize the intensity of solar irradiations specifically in Sindh and Baluchistan for catering the need of the power generation and provision of the generation to local people of that territory which would benefit them in covering the socio-economic issues. As we all know that Pakistan, even being the Nuclear State, faces the Power crises where in the Production of Electricity and usage is mostly dependent on the Hydro Power and supporting with the Oil based and few much on the nuclear back. There is a great need of finding ways where in the state can address the power shortage within specified period of time as; the population of Pakistan keeps rising. Due to presence of Power crises, usage of inverters has risen on peak and most of the people install it as their backup in the time where there appears no electricity. Though the presence of inverter cannot match the statistics of normal power supply provided from the particular agencies of WAPDA, but at least helps in catering minimum needs of the people.

2.2. Inverter:

Inverter basically, is an electronic device which inverts the Direct Current (DC) to corresponding Alternating Current (AC) and opposite. When it comes to inverter, according to the circuitry defined, it can produce up a square wave, sine wave and modified sine wave considerations. The circuitry used in our project was modified sine, as the usage of pure sine wave was costing us high and additionally was holding complex circuitry

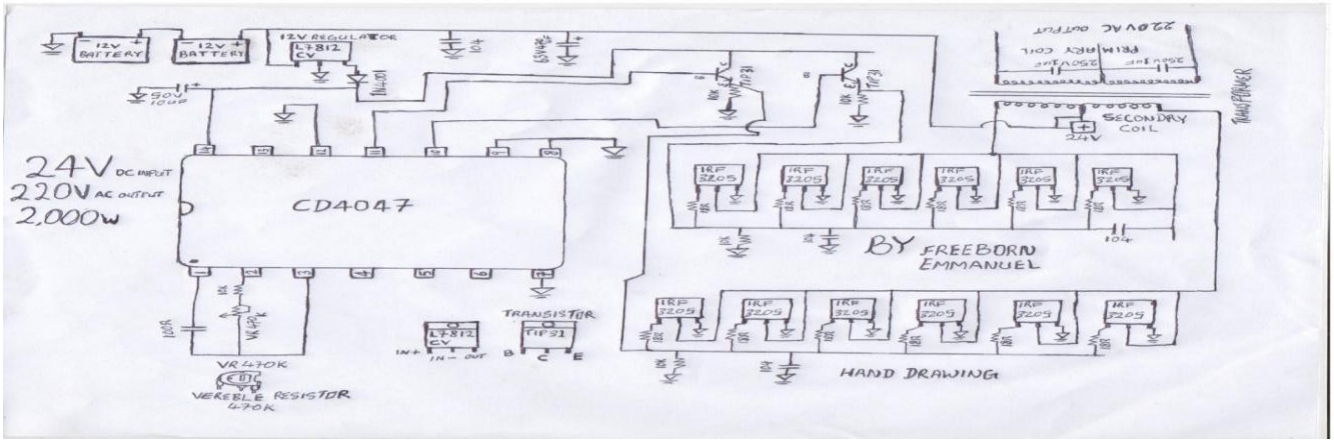
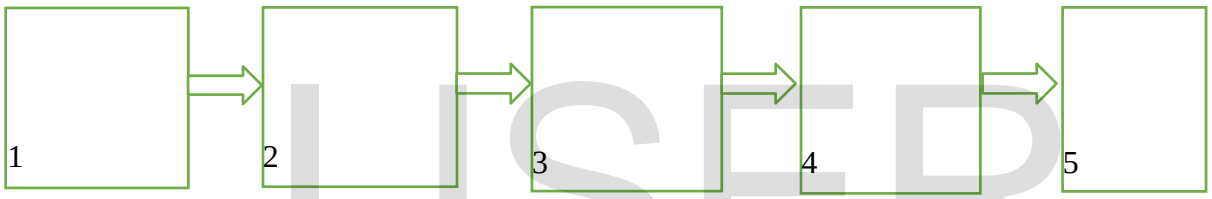


Fig.3 Inverter Circuit design

Charging Circuit:

←----------**Inverter**----------→

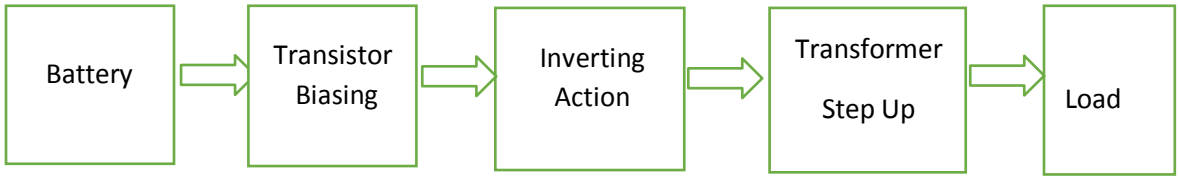


1. Input 220/230V
2. Transform/Step Down
3. Inverter Circuit
4. Transistor Biasing
5. Battery

Fig.4 The alternator block diagram

Discharging Circuit:

←----------**Inverter**----------→



Coming over the aspect of Solar Inverter, Solar inverter inputs the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.

Addressing the Power Shortage and advancing technology, the usage of Solar Inverter has increased but has not covered the on ground stats as the normal person cannot afford Inverter, as the range of the solar inverter appears to be above their pocket. Industries , needs to work very hard , specifically , to address the issue of the cost analysis as if considering Pakistan , there appears to millions living their lives under the poverty line and millions living their days on hunger .

2.3. Survey:

2.3.1. Residential survey:

Table 1. Comparison chart

City	Houses	E.Inverter	E.I Percent	New/Mod	%
Khairpur	**220**	**62**	**28%**	**Modify**	**53 (85%)**
Hyderabad	**250**	**78**	**31%**	**Modify**	**71(91%)**
Sukkur	**180**	**34**	**19%**	**Modify**	**30(88%)**
Karachi	**260**	**44**	**(17%)**	**Modify**	**37(84%)**

After having a brief project survey in Karachi, Hyderabad, Khairpur Mir's and Sukkur, with the specified door to door, and meet up with person to person, revealed that there appears almost 28% of the normal people in Khairpur Mir's City, use Electrical Inverters where in 17% of the people make use of Generators at their end to cater their electrical needs in almost 8-10 hours normal load shedding and rest remained waiting for time to clock down. The range appeared as 31% Electrical Inverter users and corresponding 16% dependent on the Generators in Hyderabad, corresponding 19% Electrical Inverter users, 23 % dependant on Generators in Sukkur, and corresponding 17% Electrical Inverters and 9% Generator dependency in Karachi (Gulshan). The survey was based on optimum of 200-250 houses and the percentages were calculated accordingly Survey was conducted in various areas that included Khairpur Mir's (Jeelani Muhalla), Sukkur (Gurdwara Chock) , Hyderabad (Qasimabad) and Karachi (Gulshan) .

2.3.2. Business Survey:

Table2: Comparison Table

City	# Shops	E.Inverter	E.I Percent	OP.Time	New/Mod	%
Khairpur	**100**	**26**	**26%**	**11am-9pm**	**Modify**	**65%**
Hyderabad	**130**	**37**	**28.4%**	**10am-7pm**	**Modify**	**78%**
Sukkur	**75**	**21**	**28%**	**11am-8pm**	**Modify**	**33%**
Karachi	**100**	**65**	**65%**	**10am-9pm**	**Modify**	**82%**

Additional there was a survey which was conducted to keep business community on the board and addressing their needs and demands , the same questions were asked from their visiting their door to door business and looking after the load they actually use in their shops . The survey suggests that there were almost 26% of users in Khairpur , 28.4% of users in Hyderabad ,28 % of users in Sukkur and 65% users of Karachi were user of electrical/traditional based inverter and out of them there were 78% of users in Hyderabad , 33% of users in Sukkur , 65% of users in Khairpur and 82% users of Karachi who showed their interest in developing the modification in their traditional system so that they could address their problems within their pocket , and indirectly helping them have less operational cost , as the major amount of time is usually when the Sun is on the top.

The business community statistics showed a great difference between the demands of Residential consumers and the business consumers, as the range of the Percentage differ from an average of 80% to some average in 60%.

Specifically, to the users of Electrical Inverters ,they were asked whether they would prefer buying a low cost Solar inverter , which can help cater their needs and save a bit of their pocket when in operation , there were almost 87% people of the 100% who showed their interest in building the systems which can make use of their current traditional Electrical Inverters , and not spending enough money more on buying the whole system again , 5 % showed interest in buying new and rest 8% dint bother to ponder over the core of survey.

Studying a survey of a non-governmental agency, it revealed that the usage of inverter is increasing day by day in rural population as compared with the urban population. They revealed that the basic reason behind that was the awareness factor.

Finding the current need of market and addressing their needs and demands, indeed providing solution to the market needs appears the core objective of any industry specially operating the specific department.

If any industry, which basically aims at finding the solutions/in fact takes engineers, needs to address the markets needs else than just introducing the related product in the market which, in fact appears not benefiting the market and public as whole. After considerations, a brief study was carried based on the market needs revealed that there needs to be minimal changes in the system where in their traditional Inverters can be easily made operative with the minimal finance.

2.4. Project Description:

A system was introduced which comprises a Solar Inverter 200W , Maximum Power Point Tracking Circuit , few switches where people can just Push/Pull with their needs . Additionally the need of digital system was not governed as most people wanted the system to be cheap, giving less considerations to the expense of Digital displaying and indeed being dependent on the normal lights , Green Red and Yellow for the indications of Charging (Green), Full Charging(Red) , Main Supply(Red) ,Solar Supply(Yellow) .

As it can be seen that normal inverter, when talking about Electrical needs an input that require almost 220/230 volts, and it accompanies the usage of a transformer, that in fact step down the required voltage to desired voltage of about 24.The circuitry of inverter is then governed, and after the usage of MOSFET drivers, and after the biasing of the particular voltage needed, the potential is then used for the charging of the battery.

Then it consists of a battery that needs to be charged from the potential output from MPPT tracker, simultaneously addressing the load required, until and unless there appears a particular voltage around. Once the Solar compatibility is overturned , the same inverter can be effective used for charging the battery from normal input of WAPDA and then can be used the same traditional way as it is used in previous years. Due to the presence of Islanding effect and neglecting it, usage of different switches is governed in order to secure the working of the circuit, be more efficient and simple.[4]

As we know that , islanding effect can cause problem to the system , so to make sure , introduction of switches from the panel side appears to be from the Panel side , in order to make sure smooth working of Inverter at all conditions.

Normal Inverter was successfully converted on the Solar with their on-grid functionality where they can make use of Solar Energy in the day time and corresponding Water and Power Development Authority, WAPDA, supply for the charging at Night time. The corresponding finance included the rate of Charging wires, Solar Panel, MPPT Circuit Switches and Connectors.

As per the statistics covered, the normal Inverter was converted on Solar with the expense of almost 16 Thousands which appeared to be a success story of introducing a low cost solar panel based inverter with considering solution towards the market need.

Additionally, According to the intensity of Solar Energy, and Solar irradiations in Hyderabad, Khairpur and Sukkur, revealed that the energy can better be utilized as the effect of humidity is also lowered with corresponding increase in the solar irradiation, indeed making the solar panel work better and efficient. Additional the temperature ranges from 18-32^{0}C in winters and 42-49^0 C in summers.

2.5. Price Statistics:

As per the statistics covered in the experiments, the induction of a proper Solar Panel(Mono) 150W, which appears to be available in the market from the range in 12,000. The additional circuitry required hardly 2000-4000 for covering the MPPT specifications. The whole system modification is going to cost us near 16000 to get the traditional system modified to Solar Energy with effective means.

Solar Panel specification is stated below:

Power: 150w (Mono) Power Tolerance: + - 3% Open Circuit Voltage: 21.5v Max Power Voltage: 17.5v Short Circuit Current: 8.3A Max Power Current: 7.8.A

3. Methodology:

The methodology was almost kept the same but there were few changes that were made in the structure and the experiments were conducted in order to ponder over the results, and validating either the methodology can easily be implemented by using these techniques on the industrial scale. As discussed earlier, the minor changes were made, that were in shape of introducing the Solar panel (150W), usage of Maximum Power Point tracking, few manual switches and few connections using the connecting wires. The method concludes the working of the inverter in 2 transactions which base the normal inverters to get compatible on the solar working.

3.1. Solar Based Working:

In the day time, when there appears Sunlight, the panel would charge the battery and simultaneously it would work, if there appears a Power cut, else the whole solar energy would be utilized in charging the battery.

Usual transaction when it comes to morning is governed probably after 9, if we keep the business community in mind. The normal shops usually open after 9, so keeping the fact, the solar energy utilization, the battery would easily have 1-2 hours of governing the charging process of the battery. With the help of manual transaction and usage of switches, the charging process can be overturned to Electrical supply if there appears need after the sun-set.

3.2. Electrical Transactions:

The normal Electrical transaction would be operational once there appears Solar Energy under the potential of charging the battery, and with the help of just manual switch, the operation can be overturned to the Electrical system, hence making it compatible on both the Solar and corresponding Electrical system.

The above specified methodologies can easily be governed with just the usage of manually switching and hence require the minimal input of the masses. Due to the illiteracy rate of the most people specifically in rural Sindh that includes Sukkur , Khairpur and few parts of Hyderabad , the digital system was not introduced and the usage of normal lights , that includes Green Red and Yellow , for their easy understanding and helping lowering the production cost of the modified system.

4. Experiments:

Experiment was conducted in the city Khairpur Mir's where a working Electrical inverter was converted to work on a compatible Solar Energy. As there appears several projects in interior Sindh and with no eye over the maintenance, hundreds of the panels which were installed on the roads, are now either are lying useless, or hundreds of panels are sold on scrap value.

The results were noted and it appeared to formulate almost 15.4V and corresponding 6.23A while it was striking the terminals of the battery. According to the picture that was taken then battery, the bubbles were continuously appearing which showed that the battery was charging when it was connected.

5. Results:

The results were in the favor of the theory and hence the system was successfully modified to work on the Solar Energy and corresponding Electrical systems. The experiments were conducted on both, Solar based and normal electrical based working and the results were functional and operational. The battery was also tasted according to the installation of MPPT circuit with the Solar panel, and it was beneficial for the battery, as it was charging the battery with effective charging. The results suggested that the technique can widely be employed in order to cater the normal needs of normal public.

6. Discussion:

The industries at times need to provide solution of the basic problems , on the grass root level , else than production , as most of the times , the grass root statistics doesn't require the new production but at times the solution of their current problems with respective less modification cost . The approach needs to be developed at student level, so that the students, when they go professional can actually address the grass root problems, else than introducing costly solution to the current problems. Survey based projects should be introduced, where in the normal public demands are easily answered and indirectly that brings respective learning of an engineer and have him an experience of the market. Additional, there needs to career guiding, where the students should be taught how actually to execute the plans in order to solve the basic problems of the public. This approach not only broadens the aspect of Engineers but also, would help them interact with the market and creating opportunities for themselves and also for their fellow engineering.

7. Challenges:

Considering the basic problem associated with on-grid battery backup inverters, is nothing but the factor called Islanding Protection. Islanding refers to the condition in which a distributed generator (DG) continues to power a location even though electrical grid power from the electric utility is no longer present. Islanding can be dangerous to utility workers, who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices. For that reason, distributed generators must detect islanding and immediately stop producing power; this is referred to as anti-islanding.

The common example of islanding is a grid supply line that has solar panels attached to it. In the case of a blackout, the solar panels will continue to deliver power as long as irradiance is sufficient. In this case, the supply line becomes an "island" with power surrounded by a "sea" of unpowered lines. For this reason, solar inverters that are designed to supply power to the grid are generally required to have some sort of automatic anti-islanding circuitry in them. For understanding the basics of the Islanding Protection; we need to look over the core reason for the

above mentioned effect. Electrical are devices that convert direct current (DC) to alternating current (AC). Grid-interactive inverters have the additional requirement that they produce AC power that matches the existing power presented on the grid. In particularly, a grid-interactive inverter must match the voltage, frequency and phase of the power line it connects to. There are numerous technical requirements to the accuracy of this tracking.

Considering a case of a house with an array of solar panels on the roof, the inverter is attached to the panels convert the varying DC current provided by the panels into AC power that matches the grid supply. If the grid is disconnected, the voltage on the grid line might be expected to drop to zero, a clear indication of a service interruption. However, consider the case when the house's load exactly matches the output of the panels at the instant of the grid interruption. In this case the panels can continue supplying power, which is used up by the house's load. In this case there is no obvious indication that an interruption has occurred. Typically, islanding is not a desirable operating condition. There are hazards to utility workers if power lines remain energized when the utility interconnection is lost. Additionally, voltage and frequency may fall outside acceptable levels, resulting in poor power quality for utility customers. Lastly, the DG must disconnect from the system faster than the automatic reclosing time that the utility uses. If it is not fast enough, damage to equipment may result when synchronism check is not present. IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems provides technical specifications and requirements for DG interconnections [1]. At this time, most utilities do not allow islanded operation of DG.

8. Conclusions:

The Low cost solar inverter was made in order to address the normal queries of the public, in keeping their interest on the peak and their respective demand was fulfilled. The system was also functional and gives the best solution to the market needs. Additional Usage of MPPT Circuit also increased the efficiency of system and helped the system to be more efficient with the usage of limited resources. Comparing the market statistics, there appears to be a major difference between the cost of a new solar inverter, and by bringing few changes up in the traditional inverters, respective goals can be easily achieved. This also suggests, that the experiment analysis shows a great demand to be addressed, and also suggests that the technique employed here can be used on a larger scale public to address the needs of a local man.

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