ASSESSMENT OF LOAD INFORMATION OF 2.5 KVA POWER INVERTER AND 5.0 KVA OPERATIONAL CAPACITY OF PHOTOVOLTAIC INVERTER

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ABSTRACT

An inverter is a motor control that varies and influences the speed of an Alternating Current induction motor. This is achieved by varying the frequency produced by an AC power to the motor. The study looked at the assessment of load information of 2.5 kVA power inverter and 5.0 KVA operational capacity of photovoltaic inverter. The analysis of 5KVA inverter reveals that V_{out} (converter) has a required voltage of 48.0 V and yielded an output of 100 V which is 48% voltage difference. V_{out} (inverter) has a required voltage of 220 V and yielded an output of 220 V which is 100% voltage produced. P_{out} (converter) has a required power of 700mW and yielded an output of 0.15Mw which is 0.021% less in power difference. P_{out} (inverter) has a required power of 5kVA and yielded an output of 2.09kVA which is 41.8% less in power difference. I_{out} (inverter) required is 22.7 A and current output yielded is 9.53 A this also show a percentage difference of 42%. The voltage production of household items is blender, bread toaster, electric iron and energy saver lamp has voltage range of 330, 330, 550 and 110 respectively. It would be concluded from the study that 5KVA has a higher operational ability to accommodate more load than a 2.5 KVA voltaic cell. Also, can effectively be used for domestic consumption since it can comfortably carry most domestic appliances. Finally, it was recommended amongst others that 5KVA power inverter should be applied for environment that demands the use of higher power and voltage supply.

KEYWORDS: Load Information, Power Inverter, and Photovoltaic Inverter

INTRODUCTION

An inverter is a motor control that varies and influences the speed of an Alternating Current induction motor. This is achieved by varying the frequency produced by an AC power to the motor. An inverter controls voltage attached to the motor. This process takes place by using some intricate electronic circuitry that controls six separate power devices. They switch on and off to create a simulated triple phase AC voltage. This switching process is also called inverting DC bus voltage and current into the AC wave forms that are applied to the motor. This led to the name "inverter". For the rest of this discussion, the term "inverter" will be used in place of adjustable speed drive.

The world need for electrical energy is predominantly increasing and regular energy resources are diminishing and even threatened to be depleted. With the increasing popularity of other renewable energy such as solar and wind, the need for static inverters to convert dc energy stored in batteries to regular alternating current form has increased substantially. This conversion can either be achieved by transistors or by SCRs (silicon controlled rectifiers). For lower and medium power outputs, transistorized inverters are suitable but for high power outputs, SCRs should be used. Transistor inverters are significant in wide variety of applications. They provide power to the complicated electronic systems of orbiting satellites and cool astronaut suits. With the development of electronic devices and circuits, modern equipment often have converters that allow the user to change the voltage and frequency applied to the equipment. Power electronics also supply the industries with better methods to save energy and improve performance (Sen, 2002).

Most inverters are built with variable voltage, variable frequency design. They consist of a converter section, a bus capacitor section and an inverting section. The converter section uses semiconductor devices to rectify (convert) the incoming fixed voltage, fixed frequency 3-phase AC power to DC voltage which is stored in the bus capacitor bank. There it becomes a steady source of current for the power devices which are located in what is known as the inverting section. The inverting section absorbs power from the DC bus cap bank, inverts it back to simulated 3-Phase AC sine waves of different voltage and varying frequency that are typically used to vary the speed of a 3-phase induction motor.

Photovoltaic inverters are inverters systems, and are either used for day system only or for day and night periods accordingly. The latter describe the ones that have battery backup for use when the sun is down or cloudy. The simplest and least expensive photovoltaic system is the day use and consists of module wired directly to an appliance with no storage device. When sun shines on the modules, the appliance consumes the electricity generated. Higher isolation (sunshine) levels results in increased power output and greater load capacity.

Hybrid describes system with battery storage. The battery is used as a backup power to the inverter connected to it during periods of less isolation and at night. Most of the batteries are usually charged during sunny period with PV modules or alternate source to keep it ready for use during the night. Another hybrid system approach is a PV system integrated with a wind turbine. The inclusion of a wind turbine is significant in the location

where the wind blows when the sun shine ability is weak. In this situation, consecutive days of cloudy weather are not a problem so long as the wind turbine is spinning. Some of these power systems can be integrated to make general supply of electricity. These forms of inverters are available in the market to drive light loads in the range of 500 to 1000watts. Greater wattages are achieved by calculating the entire household total electrical load and sizing the entire system (inverter, PV array and battery) to meet such loads. It is this aspect that roused our design and construction interest.

Different methods exist for sizing a system output for optimum performance. One of such methods utilizes solar calculator where all electrical loads are manually calculated and uploaded to the calculator for sizing. Alternatively, data of energy consumption provided by an electric utility industry such as Enugu Electricity Distribution Company (EEDC) electric bill can be made available and uploaded for sizing. Manual sizing can be obtained by the use of work sheet.

The challenges faced as a result of shortage of power supply in the country, back-up power system market is constantly growing with advanced technologies and methodologies being incorporated and implemented. Country such as India and other developing countries that are faced with electricity challenges are constantly developing and patronizing alternative power back up systems. Indian UPS market is a steadily growing market with both Indian and multinational manufacturers contending for a major chunk of market share. The Indian inverter market consists of several organized and unorganized players jostling for space. Let us look into major driving factors for this industry.

UPS AND INVERTER INDUSTRY

The UPS and inverter industry have in recent times existed in Nigeria for some period. All industry experts conceptualize that a major factor driving growth for inverters and UPS in industrial and private sectors is a need for uninterrupted power supply to run basic infrastructure. Most industries in this situation based on the sensitivity of their business would want to prevent any form of power blackout. The widening gap between demand and supply of electricity in India is a key factor driving growth in this market. Statistically speaking, according to George Mathew, research analyst, Net scribes shares, "With an 8.7 per cent average energy deficit and a 9 percent peak deficit in 2012-13, the demand for power backup solutions is considerably increasing. This is particularly true for south India which faced a shortage of 7.2GW in 2012-13." Inverter is basically a backup power device whereas UPS is used for backup power as well as power conditioning.

There are critical nature of processes carried out which cannot afford a millisecond of power disruption. This is one sector where UPS really suits in and which is driving growth in the UPS sector.

Lack of an Efficient Power Grid

In considering the efficiency of power supply system in different countries in the world, observation show that power delivery output vary based on technological standards and

government support. The India power system does not have a grid that is efficient or sufficient enough for its people. Not only is there a lack of power compared to what is required, the power that we do receive is not efficient power and it thus incurs huge losses. Sameer R. Shanghvi, managing director, Barr Electronics says, "If these losses were to be rectified, there would be a huge surge in the percentage of power available to us". Insufficient power supply capacity and inefficiency of grid for distribution are factors that are driving our UPS and inverter industry today. Power quality and reliability have been (and remain) a concerning issue until today in India. From industrial and commercial sectors, the power requirement has increased, and this demand and supply gap is forcing establishments to opt for inverters and UPS systems to address this requirement. Vikas Chola, MCU application manager North India, Texas Instruments (India) informs, "Furthermore, to maintain technology, inverters and UPS have become an integral part to address power fluctuations and prevent wear and tear to expensive electronics and industrial equipment." Change in rural attitude. Aside from higher purchasing power of Indian households, another reason fueling growing popularity of this sector is an adjustment of rural consumers. A comparative index indicates that rural consumers who would previously easily withstand a 7-8-hourlong power cut are no longer willing to withstand power cuts of more than 4-5 hours. This change in attitude has created the rural markets as a growing avenue for power backup systems.

The market for inverters and UPS in India and most underdeveloped nations is influenced by a pronounced presence of the unorganized sector, informs Mathew. However, the market for these products in India is extensive enough for both organized and unorganized sectors to exist side by side, since they essentially cater for different sets of consumers. He presumes that while the unorganized sector mobilizes to the price-oriented consumers, organized players mostly target the brand-conscious consumers.

However, the low prices given by the unorganized players are now compelling the organized players to reduce their prices to effectively maintain their competitive edge in the market. Although Shanghvi believes organized players are some of the major manufacturers in the inverter industry in India and world. He says that "There is a massive potential for growth for both the sectors."

Effect of grid parity on this industry

Today, the cost of power is on a constant rise and, at the same time, the cost of buying a solar solution is declining. As manufacturers in this industry increase, so does the awareness of solar causing the prices to go down. Shanghvi said, "If we look at the last five years and consider per watt cost, it must have gone down at least by 50 per cent, if not more. And the trend is, the cost is continuously going down but our power requirement and power price is going up. So the situation is coming to something called grid parity."

In illustrating grid parity, he adds, "It means the power we pay for and the power we extract, in terms of capital expenditure (CAPEX) and operational expenditure (OPEX), respectively, will be the same because of rising prices of fossil fuels and traditional methods of supplying power, and the fact that the price of photovoltaic module, which are made from the abundantly-available, easily extractable silicon, is going down." He emphasized that this

point of intersection is called grid parity. In the future, the solar industry would definitely be in a very strong position to expand rapidly. Once grid parity is realized, the payback period comes down drastically. If for instance, generator is utilized, have a grid tie inverter extracting sunlight and using it as power, your payback period can come down to as low as 1.6 years. This will result in making the purchase decision an easier one. Market and business trends extensive research by market research agencies on power backup systems market across rural and urban sectors brings up a number of trends.

In Nigeria, inverter systems are mostly used in small business operation center, homes and so on. As a result of the expensive nature of the purchasing power of battery and other components in the inverter system, it is difficult for most people to purchase. The study therefore focuses on the assessment of operational capacity of 2.5 KVA power inverter and 5.0 KVA photovoltaic inverter.

Purpose of the study

The study looked at the assessment of operational capacity of 2.5 kVA power inverter and 5.0 kVA photovoltaic inverter. Specifically, the study sought to:

1. Determine the requirement for comparison in output voltage from the simulation.
2. Determine the sizing of the PV panel.
3. Determine the electrical load information when using the 2.5 kVA power inverter.

Methods

The design topology which was adopted is used in two stages boost converter and half-bridge inverter, and their controls.

Comparison in output voltage simulation 5 KVA Power Inverter.

S/N	Parameter	Required	Achieved
1	V_{out}(converter)	48.0 V	100V
2	V_{out}(inverter)	220V	220V
3	P_{out}(converter)	700mW	0.15W
4	P_{out}(inverter)	5kVA	2.09kVA
5	Converter wave form	Modulated	Modulate
6	Inverter wave form	Modified Sine wave	Square wave with Distortion
7	I_{out}(inverter)	22.7 A	9.53A
8	I_{Lpk}	330mA	185.32mA
9	Inverter Freq.	50Hz	48.6Hz
10	Converter Freq.	25kHz	24.6kHz

The result show a variable figure of voltage needed and voltage achieved after completion of inverter production.

Sizing of the PV panel

Many methods exist for sizing a system output for optimum performance. One method makes use of "solar calculator" where all electrical loads are manually calculated and uploaded to the calculator for sizing. Alternatively, data of energy consumption provided by an electric utility company like Enugu Electricity Distribution Company (EEDC) electric bill can be uploaded for sizing.

Manual sizing as used in this design is also possible. This is achieved by use of worksheet to calculate loads for consumption. The format followed is listed below:

- List all of the electrical appliances to be powered by the system.
- Record the operating wattage of each item following the previous step.
- Specify the numbers of hours per day each item may be used.
- Multiply the first three columns to determine watt hour usage per day.
- Enter the number of days per week that each item will be used to determine the total watt hour per week each item will require.
- For equipment ratings, check the label of equipment and record their values accordingly, otherwise check with local appliance dealers or product manufacturers for information.

Electrical Load Information when using 2.5 VA Power Inverter

Individual Loads	AC Usage (volt)
Washing machine	330
TV	110
DVD player	110
Refrigerator	220
Blender	330
Bread toaster	330
Electric iron	550
Energy saver lamp	110

Discussion

The analysis of 5KVA inverter reveals that V_{out} (converter) has a required voltage of 48.0 V and yielded an output of 100 V which is 48% voltage difference.V_{out} (inverter) has a required voltage of 220 V and yielded an output of 220 V which is 100% voltage produced. P_{out} (converter) has a required power of 700mW and yielded an output of 0.15Mw which is 0.021% less in power difference. P_{out} (inverter) has a required power of 5kVA and yielded an output of 2.09kVA which is 41.8% less in power difference. I_{out} (inverter) required is 22.7 A and current output yielded is 9.53 A, this also show a percentage difference of 42%.

The voltage consumption of a washing machine on daily use is 330 volt. Television has 110V, DVD player has 110 volts and refrigerator has 220. Other household items such as blender, bread toaster, electric iron and energy saver lamp have voltage range of 330, 330, 550 and 110 respectively. The voltage consumption rate using the 2.5 kVA voltaic inverter can be managed depending on the usage.

Conclusion

Based on the assessment of the operational capacity of 5KVA power inverter and 2.5 KVA voltaic inverter, it would be concluded that 5KVA has a higher operational ability to accommodate more load than a 2.5 KVA voltaic cell. Also, can effectively be used for domestic consumption since it can comfortably carry most domestic appliances.

Recommendations

The following recommendations were made:

1. The 5KVA power inverter should be applied for environment that demands the use of higher power and voltage supply.
2. On the use of 2.5 KVA voltaic cell inverter, constant charging should be done to keep the battery running.
3. In addition, to save more power, rationing of power usage among appliances in the household should be carried out.

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