AJ's Technical Tips: Inverters in Small Solar PV Systems

Simon Nyukuri wrote me recently with two important questions. The first question is about the use of inverters with small solar PV systems. He wrote:

I earlier had installed a solar system that included an 80W module, a 75 amp-hour battery, and a Sollatek SPCC6 charge controller. It really did well. Then recently the owner decided to convert the system to AC. He bought a Trace DR 2424 inverter from where he knows himself. I added it on the system, then we latter noticed that the system had some interference when he tuned in to FM radio stations. Could the inverter be affecting the frequency radio waves? Also, since inverters are often located inside the houses, is there any possible health hazard to be considered?

First, it is, of course, important to install the inverters following safe electrical installation practices, but there are no safety or health issues associated with inverters beyond the normal issues related to working with AC electricity.

The interference that Simon's customer got when he tuned in FM radio stations is a common problem with a type of inverter that is called a "modified sine wave" inverter. The Trace DR 2424 inverter is of this "modified sine wave" type, and it is definitely the cause of the interference. It is possible to get a "true sine wave" inverter that will not cause this problem, but this type of inverter is more expensive. I will explain a bit more about the different types of inverters below.

First, however, I will say that my recommendation about the use of inverters with small off-grid solar electric systems is that you should never use an inverter unless it is absolutely necessary. If possible, it is always best to use DC appliances. An inverter should only be used if the appliance that is to be used in a system is only available for use with AC power.

I try to avoid the use of AC appliances and inverters in small solar PV systems for several reasons. First, inverters introduce inefficiency into the system and this wastes some of the precious electricity generated by the solar PV system. Second, adding an inverter makes the system more complicated, and this is one more component that can break and cause a problem. Third, some types of inverters - the modified sine wave type - cause interference problems like the one that Simon's customer experienced.

I know that in this case the customer went and purchased the inverter on his own without consulting with Simon. In such a case there is nothing that you can do except help the customer to the best of your ability. However, if a customer does ask about adding an inverter, my first question is to ask if there is any way to do the job with a DC appliance instead of an AC one. Sometimes it takes an extra effort to find a DC appliance that will work, but if you can stick with DC it is almost always worth the effort.

If it is absolutely necessary to use an inverter in a small solar PV system, then here are my recommendations for selecting an inverter. I will discuss nine different factors that you should consider in selecting an inverter. These are (1) input voltage, (2) output voltage, (3) rated power output, (4) surge capacity, (5) standby power use, (6) efficiency, (7) inverter wave form, (8) brand name, and (9) price.

Before I discuss these points, I will begin by explaining that an inverter is a device that converts DC (direct current) electricity into AC (alternating current) electricity. DC electricity is the type of electricity that is produced by solar modules and is stored in batteries. AC electricity is the type of electricity that is used with the electrical grid. Most appliances are made for use with AC power, but many are also available for use with DC electricity. Appliances that are commonly available for use with DC power include lights (both bulbs and fluorescent types), black and white TV sets, radios, and mobile phone chargers. Some other appliances, such as color TVs, refrigerators, and others, are also made for use with DC power, but they can be hard to find. This is one big reason that people sometimes choose to use an inverter.

Now, back to the main things that you should consider when purchasing an inverter:

Input Voltage: The input voltage for the inverter must match the voltage of the battery bank in the system. Most small systems are wired for 12 volts, but some larger systems use 24 or 48 volt configurations. If you have a 12 volt battery bank then you need an inverter that accepts a 12 volt input voltage. If you have two or more batteries that are wired in parallel so that you have a 24 volt battery bank, then you need a 24 volt inverter, et cetera.

Output Voltage: The other voltage to consider is the output voltage of the inverter. Most AC appliances used in Kenya require 240 volt AC electricity at a frequency of 50 Hertz. This is almost always the type of inverter that you want to use. Inverters sold for use in the United States and some other countries have 120 volt AC output at a frequency of 60 Hertz. These generally are not sold in Kenya, but if you get an appliance that requires 120 VAC, 60 Hertz power you may need to order one.

Rated Power Output: This is the maximum amount of power that the inverter can deliver **continuously**. You should select an inverter that has a rated power output that is high enough to meet the power requirements of all of the AC appliances that will be connected to the inverter at one time. For example, let us say that you want to select an inverter to power a 21" color TV that uses 70 Watts of AC power when it is on and a small refrigerator that uses 100 Watts of AC power when it is on. This is a total of 170 Watts of continuous power when both the TV and the refrigerator are on. This means that you should get an inverter that is rated for at least 170 Watts of continuous power output. In practice you may want to get one that is even a bit larger (for example, 200 or 300 Watts) in case other appliances are added to the system. You definitely do not want to get an inverter that is too small to run the two loads, because an under-sized inverter can be damaged by overheating that happens when the appliances need more power than the inverter can deliver.

Surge Capacity: The surge capacity is the maximum amount of power that the inverter can deliver for a very short period of time - for example, one second. The surge capacity should be listed along with the rated power on the inverter specifications. The surge capacity is always higher than the rated power. The surge capacity is important because some appliances draw a lot of power for a very short time when they are first turned on.

For example, electric motors often use 5 to 7 times more power when they first start up than under normal operation, while TV sets often draw up to twice as much power at startup than during normal operation. The inverter that you choose should have enough surge capacity to start the appliances that you want to use with it. In the example that we used above, the refrigerator might draw 600 Watts during startup, while the TV set might draw 140 Watts. If both the TV and the refrigerator start at the same time then the surge power could be 740 Watts in this example. This means that you should buy an inverter that has surge capacity of 740 Watts or more. In order to avoid damage to the inverter it is always important to make sure that the startup power required by the appliances is not higher than the surge capacity for the inverter!

Standby Power Use: Inverters use a small amount of power when they are turned on even if no AC appliances are in use. Some inverters draw a few Watts when they are in standby, while others draw 10 Watts or more. You want to select an inverter that has the smallest standby power use possible in order to avoid wasting electricity.

In addition, you should always advise your customers to turn the inverter off when no AC

appliances are in use. An inverter that uses 5 Watts of standby power can use up 120 Watt hours of electricity in one day if it is left on continuously! This is a waste of energy that can be avoided if people are careful about turning off the inverter when it is not in use.

Efficiency: Inverters also use some electricity in the process of converting DC electricity into AC power. The efficiency of the inverter is the ratio between the AC output power and the DC input power. For example, let us say that we have a 200 Watt inverter that is used to run a 21" color TV set that uses 70 Watts of AC power. In this example the inverter that we are using is 75% efficient. This means that the AC output (70 Watts) divided by the DC input is 0.75. This would mean that the DC input would be 93 Watts. This comes from 70 Watts ÷ 0.75 = 93 Watts. The 93 Watts is the amount of power that the solar system must provide to run the TV.

Small inverters usually have a lower DC to AC conversion efficiency than larger inverters, and low quality inverters of any size can also have a low efficiency. High quality inverters that are larger than 1000 Watts often have a DC to AC conversion efficiency of 80% to 90%. Smaller inverters are often 60% to 80% efficient, although low quality units can have efficiencies as low as 50%. You want to get an inverter in your price range that is as efficient as possible.

Inverter Wave Form: I started this article by talking about a "modified sine wave" inverter that was causing an interference problem with an FM radio. I also said that a "true sine wave" inverter would not cause this problem. These two types of inverters - "modified sine wave" and "true sine wave" - have different types of "wave forms". The wave form refers to the quality of the AC output signal from the inverter. There are actually three main types of wave forms for inverters. These are (a) square wave, (b) modified sine wave (sometimes called "modified square wave"), and (c) true sine wave (sometimes called "pure sine wave").

Square wave inverters are generally low quality and I do not recommend their use in most applications. Modified sine wave inverters are appropriate for use with a number of appliances, including lights, TV sets, computers, electric motors, and many other common appliances. They are the most common type of inverter used with small solar electric systems, and they are less expensive than true sine wave inverters. However, they do cause interference problems with FM radios (this can be true even if the FM radio runs on DC power and is not connected directly to the inverter!). They can also damage certain types of sensitive electronic equipment.

True sine wave inverters have an AC wave form that is more or less the same as the wave form for electricity from the electrical grid. These inverters can be used with any type of appliance, and some types of sensitive electronic equipment require their use instead of a modified sine wave inverter (for example, laser printers, CD players for stereos, and others). They also often have a higher DC to AC conversion efficiency than modified sine wave inverters. Unfortunately, they can be significantly more expensive than modified sine wave inverters, so they usually only get used when they are necessary.

Inverter Brands: There are a number of different brands of inverters, and some are better than others. High quality inverter brands include Trace, Xantrex, Hart, Exeltech, and ProWatt. When buying an inverter I usually try to stick to the high quality brand names that I list here, but there are some other brands of inverters that are available in Kenya that may also work well (I have not tested some of these other brands so I cannot give a recommendation based on my experience). In addition, there are a few *Jua Kali* electronics technicians in Kenya who also make reasonably good inverters. If you are unsure if the brand you are considering is good quality, I recommend that you ask around to see if it has a good reputation. As always, I am more than happy to get letters asking about the quality of a particular brand. I will do my best to answer any questions as quickly as possible!

Inverter Price: The price of the inverter is an important consideration when selecting one for purchase. However, the lowest priced inverters are not always the best ones to choose. If it is possible to use a good quality brand name modified sine wave inverter instead of a true sine wave inverter this can help keep the cost down. However, sometimes it is necessary to go for a more expensive true sine wave inverter in order to avoid FM radio interference issues or other problems.

These are some of the main factors that you should consider when purchasing an inverter. I will also give a few tips to keep in mind during installation. First, you should ALWAYS install a DC fuse between the inverter and the battery. The amperage of the fuse should be small enough to protect the inverter, but large enough to allow the surge capacity current to pass through without blowing the fuse.

Second, you should be especially careful not to reverse the polarity between the positive and the negative terminals for the DC input voltage when you are connecting the inverter. If you reverse the connection even for a brief instant you can permanently damage the inverter. Many manufacturers will not replace inverters under warranty if they are damaged in this way, so you can lose a lot of money in just one second by making an incorrect connection!

Third, you should be careful not to install an inverter in the same enclosure as the battery unless the space has good ventilation. The acid fumes from the battery can damage the electronic circuits in the inverter. Inverters should be installed in a well ventilated space that is at least a meter away from the battery.

Fourth, you should be sure to observe safe AC wiring practices when you install an inverter. 240 volt AC electricity is considerably more dangerous than 12 volt DC electricity, and you should always follow safe wiring practices when working with inverters.

As a final note on inverters, I will again emphasize that it is much better to use DC appliances with small solar PV systems whenever possible. You should only use an inverter if it is absolutely necessary!

To close, I will return to the second part of Simon Nyukuri's question (you will remember that his question had two parts). In the second part of the question he asked

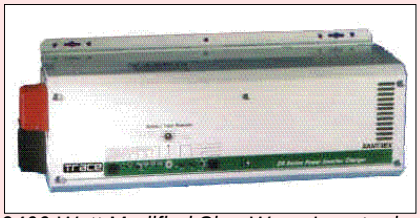
I would like to know if there is any special possible position for mounting a solar panel for best sunshine harvest despite the fact that most of us just mount depending with the roofing direction.

I discussed this point in one of my earlier Solarnet articles (Solarnet Vol. 4, No. 1 - January to May, 2002). As I said in that article, for most locations in Kenya (and other places close to the equator) it is usually best to mount the solar panel so that it is almost flat, with just enough tilt for rainwater to run off of the panel. When the panel is mounted so that it is almost flat the direction that the panel is facing is not so important. The main thing is to install it so that it is almost flat.

I thank Simon for sending in these excellent questions, and I encourage the rest of you to write to me as well. As always, I hope that this information is useful to you all, and I look forward to writing again in the next issue of Solarnet. Until then, *kwaherini*!

250 Watt Modified Sine Wave Inverter by ProWatt

1100 Watt True Sine Wave Inverter by Exeltech



2400 Watt Modified Sine Wave Inverter by Trace Engineering. This inverter is similar to the one that Simon Nyukuri asked about in his letter.