Application Note Inverter/charger Generator Sizing

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Introduction

Most generator manufacturers measure and rate the power output of their units using a resistive load such as a bank of heating elements. This is the ideal load to use to achieve the highest possible rating value. The power rating is specified in either watts (W), or volt/amps (VA). These ratings are often expressed as kilowatts (kW) or kVA where "k" = 1000. Watts is a measure of "real power," while VA is a measure of "apparent power".

The formula for watts is volts x amps x PF (PF is power factor). The formula for volt/amps is simply volts x amps and does not take into account power factor and therefore is referred to as apparent power. Power factor is a correction factor used to compensate for phase shifts between voltage and current when inductive or capacitive loads are involved. Most loads that are typically used with generators in boat and RV applications are inductive, not resistive in nature. This causes a major de-rating of the actual output power that you can expect the generator to produce in real world applications. This de-rating can be as much as 60% depending on the nature of the load.

This de-rating is necessary due to an electrical property called power factor. Resistive loads have a power factor of 1.0, so when resistive loads are used, watts and volt/amps have the same value. Inductive loads have a power factor between 0.3 to 0.8, typically. Using the above formula for watts, that with an inductive load, a generator producing the same voltage and current will actually produce a fraction of the real power that would be available with a resistive load. For example, consider a 1200 watt 120 volt generator driving either a 10 amp resistive load or a 10 amp inductive load with a power factor of 0.5:

Formula: volts x amps x PF = watts

Resistive load example: 120 V x 10 A x 1.0 PF = 1200 watts (1.2 kW)

Inductive load example: 120 V x 10 A x 0.5 PF = 600 watts (0.6 kW)

In boats, RVs and alternative energy applications, resistive loads include water heaters, stoves, space heaters, and incandescent lamps. Inductive loads include all motors, transformers, air conditioners, microwave ovens, battery chargers, converters, electronic equipment, and fluorescent lights.

Therefore, when sizing a generator for a particular application, it is necessary to take into account the nature of the loads, not just the total load in watts or VA.

The charger in a Freedom inverter/charger presents a large, highly inductive load (0.7 PF) for a generator. In addition, the charger relies on a high and stable peak source voltage, and not just an average voltage to perform properly. For example, 120 Vac power has a peak voltage of 170 volts. Small generators often have trouble maintaining high peak voltage under load while their average voltage may only drop slightly. For a generator to be able to support the power factor requirement and maintain a high peak voltage, it needs to be much larger than one would first think.

The following table shows the AC input current needed to produce the maximum DC output current from a charger. It also shows the minimum generator size in kW necessary to get near full performance out of the charger when taking into account the power factor, peak voltage and practical field experience. Generators running at 1800 RPM perform better then those that run at 3600 RPM. This chart assumes that no loads other than the charger are on the generator.

Freedom Model	**AC Input Amps**	**DC Output Amps**	**Minimum Generator Size**	
			120V	**120/240V**
Freedom 7/12v	5.5	25	2 k W	4 kW
Freedom 10/12v	11	50	3.5 kW	7 kW
Freedom 10/24v	11	25	3.5 kW	7 kW
Freedom 15/12v	16.5	75	5.0 kW	10 kW
Freedom 20/12v	22	100	6.5 kW	12 kW
Freedom 20/24v	22	50	6.5 kW	12 kW
Freedom 25/12v	27	130	8.0 kW	15 kW
Freedom 25/24v	27	65	8.0 kW	15 kW

When operating the charger from a light duty generator, the output current from the charger can be increased by correcting the power factor, or bringing the power factor closer to a value of 1.0. This will improve the output characteristics of the generator, restore some of its peak voltage, and allow the charger to perform better. This can be done by adding a resistive load to the generator (several hundred watts of light bulbs or a small heater) or by adding a capacitive load to the generator output. This capacitor should be what is called a "motor run" capacitor with a value of 50 MFD / 270 Vac, and should be wired permanently between the hot and neutral wires at the output of the generator.

The minimum generator size necessary to get any acceptable DC output performance from the charger is about 1200 watts. It is necessary to limit the amount of current that the charger will attempt to draw from this size generator by setting the power sharing feature in the inverter/charger to 5 amps. This will help prevent the charger from bringing the generator to its knees and thereby distorting its output to the point where the charger would reject the power and drop out. Again, the charger would need to be the only inductive load on the generator.

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