

ABSTRACT

PORTABLE EMERGENCY BACKUP GENERATORS BE CAREFUL WHAT YOU PLUG INTO THEM

1. AN ***'INVERTER'*** TYPE PORTABLE ELECTRIC GENERATOR IS THE BETTER CHOICE, PARTICULARLY IF USED DURING AN EMERGENCY UTILITY POWER OUTAGE (SUCH AS BAD WEATHER), TO POWER SENSITIVE ELECTRONIC EQUIPMENT (SUCH AS COMPUTERS, MODEMS, ROUTERS, CHARGERS, ETC). WHY? BECAUSE AN INVERTER GENERATOR PRODUCES 'CLEANER' POWER THAT IS LESS LIKELY TO HARM SENSITIVE ELECTRONIC EQUIPMENT.
2. A ***'NON-INVERTER'***- PORTABLE GENERATOR POWER 'DIRTINESS' CAN BE IMPROVED (MADE CLEANER) BY USING A 'POWER CONDITIONER', (SUCH AS A POWERWORX CPS-E3-N3, RESIDENTIAL CLEAN POWER SYSTEM).
 - a. CAN IMPROVE TOTAL HARMONIC DISTORTION, POWER FACTOR AND 'WORBBLENESS' OF VOLTAGE, CURRENT AND POWER WAVEFORMS
3. 'CLEANLINESS' OF ELECTRICITY GENERATED BY A PORTABLE GENERATOR, WITH AND WITHOUT A POWER CONDITIONER, CAN BE DETERMINED AND COMPARED, BY USE OF AN OSCILLOSCOPE, TO MEASURE:
 - a. HOW ERRATIC (THE 'WOBBLE') IS THE ALTERNATING (AC) VOLTAGE, CURRENT AND POWER ELECTRIC WAVE FORMS PRODUCED BY THE GENERATOR. THE LESS 'WOBBLE', THE CLEANER THE POWER.
 - b. TOTAL HARMONIC DISTORTION (THD, A MEASURE OF CLEAN POWER) SHOULD BE AS LOW AS POSSIBLE. INVERTER PORTABLE GENERATORS (AND UTILITY POWER) GENERALLY PRODUCE LESS THAN <5% THD. NON-INVERTER GENERATORS GENERALLY PRODUCE >5% THD (NOT UNCOMMON >12% TO >20%). SENSITIVE ELECTRONIC EQUIPMENT IDEALLY PREFER <5% AND CAN BE DAMAGED BY TOO HIGH THD. MANY POWER CONDITIONERS ARE DESIGNED TO IMPROVE (REDUCE) THD.
 - c. POWER FACTOR (PF, A MEASURE OF CLEANER POWER – EFFICIENCY OF POWER USED, YOU DON'T WANT TO PAY FOR WHAT YOU DON'T USE -WASTE ENERGY), SHOULD BE AS HIGH AS POSSIBLE. THE IDEAL POWER FACTOR (PF=100%) IS WHEN ALL THE POWER YOU PAY FOR IS THEN USED TO PRODUCE USEFUL WORK. ANY POWER THAT IS WASTED – NOT USED TO PRODUCE USEFUL WORK (SUCH AS BY UNWANTED HEAT, VIBRATION, AC VOLTAGE AND CURRENT WAVE FORMS BEING OUT OF PHASE WITH ONE ANOTHER, ETC), MEANS THE POWER FACTOR IS LESS THAN 100% AND SOME OF THE POWER PAID FOR IS WASTED.
 - i. DIRTY POWER PRODUCED BY NON-INVERTER PORTABLE GENERATORS, AFFECTS THE POWER FACTOR, RESULTING IN LESS EFFICIENT, COSTLIER POWER (REQUIRES MORE FUEL, SUCH AS GASOLINE, LPG OR NATURAL GAS, TO PRODUCE THE POWER YOU NEED). MANY POWER CONDITIONERS ARE DESIGNED TO CLEAN UP THE POWER RESULTING IN IMPROVED (INCREASED) POWER FACTOR AND LESS COSTILIER POWER (LESS FUEL IS REQUIRED TO PRODUCE THE ELECTRICITY USED).

Before you purchase a portable power generator, inquire about the expected Total Harmonic Distortion and Power Factor and 'wobbliness' of the voltage-current-power wave form specifications from the manufacturer. If such specifications are not available, the better practice is to assume the power is *dirty* and its Total Harmonic Distortion is greater than 5% and its wave forms are wobbly. If you plan to power sensitive electronic equipment (such as computers, routers, modems and chargers, or any other equipment sensitive to Total Harmonic Distortion) with the generator and the generator's Total Harmonic Distortion is expected to be above 5%, consider installing power conditioning equipment, such as the PowerwoRx Residential Clean Power System (other conditioners are discussed in the report), to condition the power to lower and less harmful Total Harmonic Distortion, and improved Power Factor values (and less wobbliness in the voltage-current-power wave forms).

Many portable backup generators generally produce 'dirty' power, the quality of which could damage sensitive electronic equipment. In contrast, utility electrical suppliers are regulated by State utility commissions and generally obligated to provide 'clean' power to its customers, safe to power sensitive electronic equipment.

A technical report with test measurement results (using an oscilloscope) was prepared by a Registered Professional (Texas) engineer, independent of and unaffiliated with any third party, regarding use of a tri-fuel, gasoline/natural gas/LPG fueled portable power generator, available for residential home emergency backup power supply during temporary utility mains outages (bad weather events), to power certain electrical circuits and sensitive electronic equipment in the home.

The report includes discussions on:

- Protecting sensitive electronic equipment when powering such equipment with a portable generator, such as by selecting the better generator type or use of power conditioners,
- Power Factor,
- Total Harmonic Distortion,
- Wobbliness of voltage-current-power wave forms,
- and Oscilloscope testing operating procedures

as well as the author's independent test results (for Power Factor and Total Harmonic Distortion and voltage-current wave form patterns) which consumers can use as a selection guide, who desire to use a backup portable generator to power certain systems in their home or place of business, and be better informed of various methods to protect sensitive electronic equipment from harm that can be caused by dirty power produced by portable generators.

Risk of damage to sensitive electronic equipment can greatly be reduced by:

- Assessing the power supplied by a portable backup generator to such equipment has a Total Harmonic Distortion value (measure of the 'dirtiness' of power) as low as possible. Many portable backup generators can produce Total Harmonic Distortion in excess of 10%-20%.
- Assessing the voltage and current wave form phase, and how much they overlap each other (measure of the efficiency of the power used or Power Factor, ideally the peaks of the voltage and current wave forms should occur at the same time giving a Power Factor of ~100%). Many portable backup generators can produce 'wobbly', widely spaced non-overlapping voltage and current wave forms, resulting in lower Power Factor (and higher Total Harmonic Distortion) and wasted energy (using more fuel – which costs more - to produce a desired amount of electricity).

The author's tested utility main power and unconditioned portable generator observations indicated:

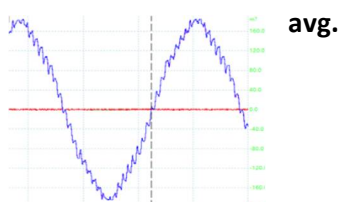
• Utility Main

- **No load Total Harmonic Distortion less**
- **Power Factor for two test loads:**
 - **Oscillating Fan: 54%-65% (59.5%**
 - **Hair Dryer: 93%-99% (>96%**
- **Wave form 'wobble': Essentially none**



• Unconditioned Portable Generator

- **No load Total Harmonic Distortion 19.4%**
- **Power Factor**
 - **Oscillating Fan: 62% avg.**
 - **Hair Dryer: 99% avg.**



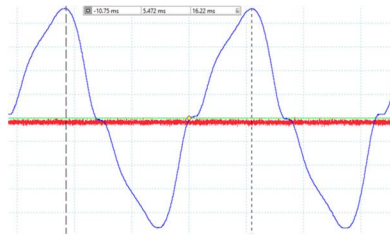
- Wave form ‘wobble’: Yes

The author installed a PowerwoRx CPS-E3-N3, Residential Clean Power System, to test its effects on conditioning (making cleaner) the power generated by the test portable generator.

(Power conditioners also provide other functions such as increased protection of electrical circuits from power surges such as from lightening strikes).

- **Conditioned Portable Generator**

- **No load Total Harmonic Distortion 16.2% avg.**
 - **16%-20% improvement¹**
- **Power Factor**
 - **Oscillating Fan: 82%-75% range (manual phase angle measurement) - 63.8% (oscilloscope integration);**
 - **3% to 24% improvement²**
 - **Hair Dryer: 99.5% avg.**
 - **Since Power Factor is already close to 100% without a conditioner, accuracy of test equipment and test procedure was unable to confirm a difference in Power Factor.³**
- **Wave form ‘wobble’: Very little**
 - **Much reduced wobble in wave forms.**



OVERALL OBSERVATIONS – NON-INVERTER PORTABLE GENERATOR

- ✓ **Was the Total Harmonic Distortion improved with a power conditioner – YES**
- ✓ **Was the Power Factor improved with a power conditioner – YES**
- ✓ **Was the wobbliness of voltage-current-power wave forms improved with a power conditioner – YES**

Consequently, a correctly sized (the right start-up and run wattage) non-inverter portable generator, used during an emergency incident to provide electric power, associated with an appropriate power conditioner (which may include a PowerwoRx , Residential Clean Power System), is unlikely to harm sensitive electronic equipment, such as computers, modems, routers and chargers, when powered by such generator.

¹ 19.4%-16.2% = 3.2%; 3.2%/19.4%=16%; 3.2%/16.2%=20%

² 63.8%-62.3%=1.5%; 1.5%/62.3%~0.02 or 2%; 82%-62.3%=19.7%; 19.7%/82%=24%

³ Some internet references cite that power conditioners do not provide the benefits claimed (i.e., they do not produce higher Power Factor and therefore do not result in reduced electric bill) but in regard to the independent tests performed by the author, his Power Factor, contrary to such references, indicated improvement (increased).