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Technical Note 13: Sine Wave Series PWM – Phase Angle Adjustments

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September 7, 2001

Overview

This tech note is to mitigate Sine Wave (SW) Series product damage caused by tampering with and improperly setting the PWM phase angle (located in the SW Series technical menu).

SW Series products are specifically designed to utilize and convert renewable energy from photovoltaic, wind, hydro, fuel cells, batteries, or other DC sources into usable AC current that is used for primary power (off-grid), or backup power (grid connected). Other features include charger capabilities from the utility or an engine generator, and the ability to sell excess renewable energy back to the utility (grid tie).

SW Series History

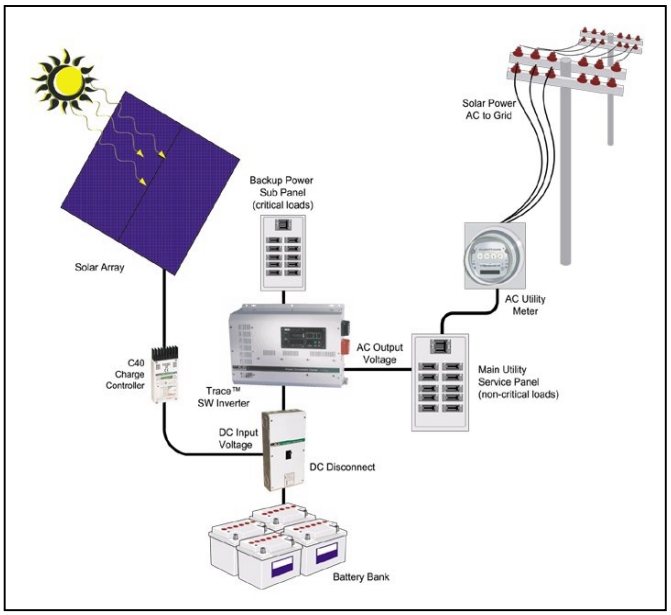
SW Series products are based on high efficiency step wave PWM modulation using H-Bridge inverter configurations. This unit utilizes the same inverter module to provide both the DC to AC inverter process and charging capabilities from utility AC line power (or generator).

SW Series Power Panel (can be individual units)

Applications

SW Series products are designed to provide flexibility for a wide range of applications:

1. **Off Grid as Primary Power:** The inverter charger uses renewable energy to charge the batteries and becomes the sole AC power source to the home. Backup charging sources include an engine generator or other recharging source.
2. **On Grid with Backup Power:** The inverter charger uses renewable energy or utility power for charging the batteries. When utility power is lost, the inverter functions as a backup power supply by using batteries during the utility outage.
3. **Grid Tie (Utility Interactive) with Backup Power:** The inverter charger utilizes renewable or utility power to charge the batteries. At the same time, renewable energy is used to supply the load with excess power sold back to the utility grid.



Basic Inverter Block Diagram

P/N 970-0063-01-01 Rev A

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PWM Phase Angle

SW Series products are a flexible and versatile platform used in multiple applications. Access to the phase angle adjustment is required to properly correct the inverter's output voltage zero crossing and the utility voltage zero crossing point.

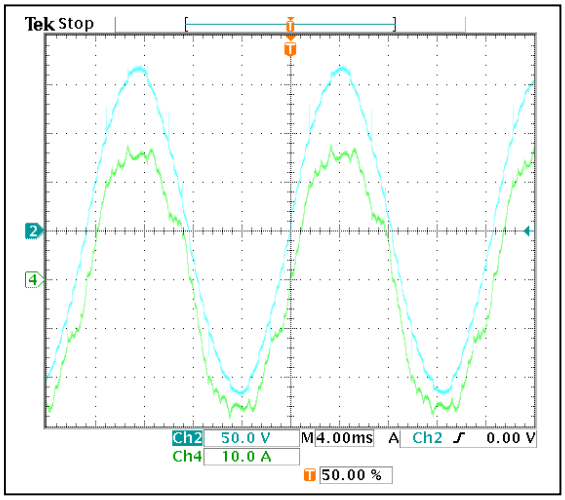
The "PWM phase angle adjustment" is located in a key-code protected, factory only tech menu. The PWM phase angle is set as default in firmware and is not accessible by the end user.

☞ **Note**: The PWM phase angle should not be adjusted in the field unless by fully authorized, trained personnel.

Special test equipment is typically used to measure phase shift and power factor when adjustments are needed to solve a local issue. The PWM setting is only used by qualified technicians under the supervision of Xantrex Technology Inc.'s Technical Support group or Applications Engineering.

Testing Examples:

The examples below are pictures of phase angles between current and voltage and the effects of wave shape.



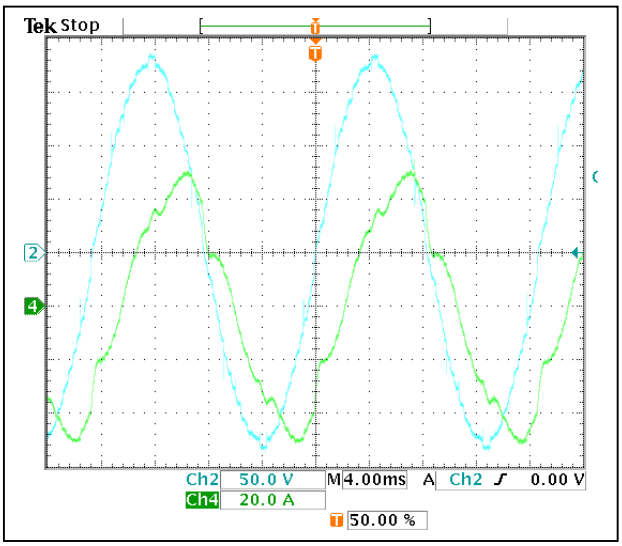
In Phase - PWM Adjustment

PWM Angle Set to Zero Shift:

On resistive loads, phase angle is measured at the 125 setting (zero degrees shift) with no noticeable change in reactive current between the default setting of 128 (5 degrees current lags voltage) and 125 (0 degrees as shown above).

Phase Angle Set to Max Shift:

If the PWM phase angle is set to 134 (improperly set - maximum setting of 45 degrees shift between lagging current and voltage zero cross), the inductive reactive current increases to over 13 amps. The external resistive loads are still consuming the same amount of current and power, but the resultant phase shift causes the inverter's reactive current to circulate within the inverter itself.



Out of Phase - PWM Adjustment

"PWM Angle" to correct Power Factor:

If the SW PWM angle is set to provide displaced power factor correction [Ref 1, pp 10-113, par 263] for local loads (instead of using PFC caps), when those loads turn off, the reactive loads are removed. The voltage to current relationship becomes offset, thus increasing the reactive power circulating within the inverter. The inverter should not be used to perform this function. To properly correct power factor, external PFC capacitors should be utilized.

Sell and Charger Mode Issues:

Other effects of incorrectly adjusted PWM angle are increased harmonics caused by the out of phase current and voltage from the source of generation (i.e., the inverter output grid power).

Anti-Islanding Software Issues:

Firmware controls are a safety feature to prevent an island condition per the IEEE929-2000 [Ref 3] and UL1741-2000. Adjustments of the phase angle may cause the unit to disqualify and disconnect the line in sell mode as the zero-cross is beyond acceptable limits. This will cause frequent sell mode disconnects, or failure to reconnect to the grid at all.

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Local Reactive Loads

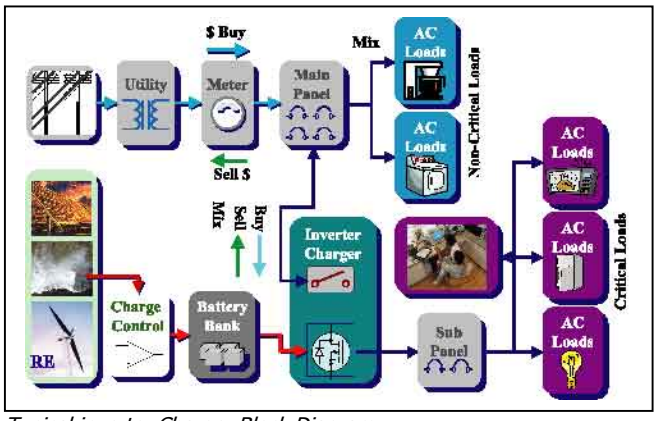
Displaced power factor is a dynamic condition that changes in respect to load or conditions on the grid such as:

Grid displaced power factor (caused by lack of power factor correction)
Local grid power factor correction devices switched into or off the grid (changes the grid reactance)
Residential inductive or capacitive reactive loads

Motor run capacitors can be utilized as AC filters or to provide small capacitive reactive displacement because they are designed for continuous connection to the line (with proper current limiting protection). It is assumed that adding AC filter capacitors is only needed when power factor issues create a problem.

The SW Series produces output power in relationship to the utility line and is typically not affected by power factor. The output power of the inverter is only affected when the unit is in the sell mode, injecting power back into the grid (on the inverter's "input power connections" as shown below).

In sell mode, the inverter supplies power to the loads and utility at one common point. If excessive amounts of displaced power factor are present (on the line side), reactive loads may reduce the real power sold to the utility.



Typical inverter Charger Block Diagram

The end result is the utility NET power meter may read a lower return rate than expected. Typically, when power factor correction is required, the utility power company will add PFC caps at the utility's high voltage side (for large displaced loads > 10Kvars). Locally, the end user can add smaller AC filter caps at the inverter charger (typically < 2Kvars) to reduce inductive reactance.

AC motor run filter capacitors are typically hard wired to the circuit breaker side of the inverter (line input) to displace inductive reactance power factor.

50uF 370VAC Motor Run Cap

Some AC motor run capacitors may only be rated for 15 amp circuits. The SW input AC connection is rated at 60 amps, thus each added capacitor should be series fused to provide overcurrent protection should the caps internally fail. Bussmann(type SB or GC, 15 amp 250 VAC, series fuse (and holder) for each 50-100 uF capacitor should provide the overcurrent protection required.

For larger capacitor banks, a fuse link for capacitor protection should be capable of continuously carrying 135% of the rated capacitor current, and must withstand, without damage, the normal transient current during bank energization or de-energization. [Ref 1, pp 10-114, par 268].

Conclusion

SW Series inverter chargers are designed to produce power in reference to the utility line voltage. The inverter is not intended for use as a power factor correction device. Proper PFC capacitor or motor run capacitors should also be utilized as described above.

The tech menu PWM Phase Angle should not be used in the field, unless authorized by the Technical Support Group, or Applications Engineering department from Xantrex. Any other changes within the tech menu could result in poor performance, inverter damage, and a voided warranty.

References

[1] Fink, Donald., Beaty H., 1987, Standard Handbook for Electrical Engineers, 12th Edition, McGraw-Hill Book Company, New York, NY.
[2] Trace Engineering, 4/2/1999, Technical Note #11, Power Factor. Xantrex Technology Inc., Arlington WA. http://www.traceengineering.com/technical/tech_notes/index.html
[3] IEEE929 Std 929-2000, IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems, Institute of Electrical and Electronics Engineers, Inc., New York, NY.
[4] UL1741, Std 1741, Static Inverter and Charge Controllers for Use in Photovoltaic Systems, Underwriters Laboratories Inc, North Brook, ILL

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