AC Coupling of Inverters:

Forming Mini-grids with Xantrex™ XW Hybrid Inverter/Chargers and GT Inverters

Application Note

Xantrex XW Series Hybrid Inverter/ Chargers and GT Single-Phase Inverters

976-0240-01-01 Rev A

This Application Note is in addition to, and incorporates by reference, the relevant product manuals for Schneider Electric Xantrex XW Series Hybrid Inverter/Chargers and GT Single-Phase Inverters. Before reviewing this Application Note you must read the product manuals.

This Application Note outlines how Xantrex XW Series Hybrid Inverter/Chargers and GT Single-Phase Inverters (Xantrex XWs and GT Inverters) can be interconnected to form an AC mini-grid.

This Application Note contains the following sections:

Scope

This Application Note provides safety guidelines as well as planning and setup information. It provides procedures for forming an AC mini-grid. For information on particular brands of photovoltaic (PV) panels, consult your PV manufacturer.

Schneider Electric

Audience

This Application Note is intended for qualified installers creating an AC mini-grid. To design and install a system that is safe and will operate correctly, qualified installers must have training and experience in solar power systems to safely and correctly follow these instructions and the applicable electrical and building codes. Qualified installers have an awareness of the hazards involved in performing electrical installation work and how to reduce those hazards. Only qualified personnel should perform the instructions contained in this Application Note.

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Xantrex XW Series Hybrid Inverter/Chargers and GT Single-Phase Inverters contain no user-serviceable parts. Attempting to service the inverters yourself may result in a risk of electrical shock or fire and will void your warranty. Internal capacitors remain charged after all power is disconnected.

To reduce the risk of electrical shock, authorized service personnel must disconnect both AC and DC power from Xantrex XW Series Hybrid Inverter/ Chargers and GT Single-Phase Inverters before attempting any maintenance or cleaning or working on any circuits connected to them. Putting the inverter in Standby mode will not reduce this risk.

To reduce the chance of short-circuits, authorized service personnel must use insulated tools when installing or working with this equipment

Failure to follow these instructions will result in death or serious injury.

Introduction

A residential or light industrial AC-centric system is one where all the energy sources and loads are connected directly to the AC bus. The benefits of an AC-centric system over a DC-centric system are:

- DC infrastructure is kept to a minimum by using small gauge wire for high-voltage (< 600 V) string PV arrays and reducing heavy gauge battery interconnects. Thus, installation is easier and less expensive since wire sizes and conduits can be smaller.
- Improved array-to-grid efficiency due to the removal of a conversion step. In an AC-centric system, the array is connected directly to the grid through a grid-tie inverter: DC (array) → AC (grid). In a DC-centric system, the array is connected to the battery bank through a charge controller, which is then connected to the grid through an inverter/charger: DC (array) → DC (battery) → AC (grid).
- Improved array-to-load efficiency if demand occurs at the same time as solar production.

The weaknesses of an AC-centric system over a DC-centric system are:

- Lower array-to-load efficiency if demand does not occur at the same time as solar production, since energy cannot be stored in the battery for later use: DC (array) → AC (load) → DC (battery) → AC (load).
- Grid-tie inverters are more expensive than solar charge controllers.

Overview

Each GT Inverter requires its own AC breaker in the sub-panel and is connected to the AC Load (Output) of the Xantrex XW. Although there is room to add breakers for the GT Inverters directly into the Xantrex XW Power Distribution Panel (Xantrex XW PDP), it is more straightforward to install the GT Inverter breakers in the AC sub-panel which must be installed according to the installation guide for the Xantrex XWs. This sub-panel may also contain load breakers. See Figure 1 on page 3.

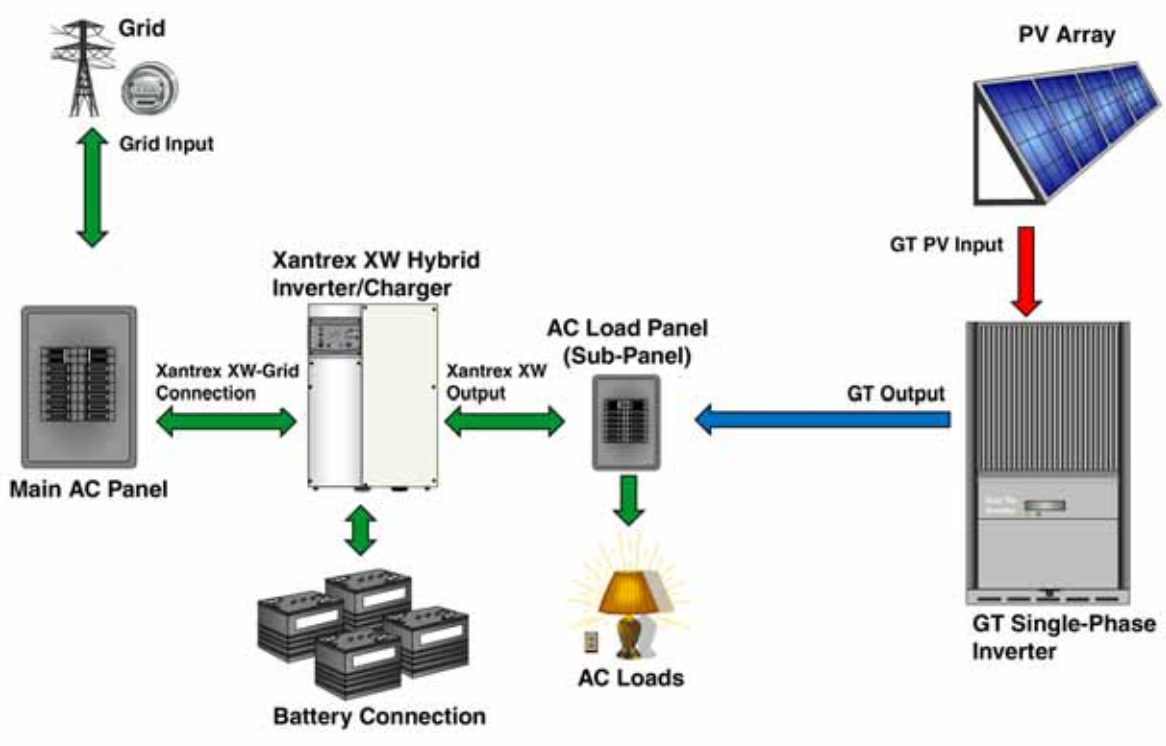

Figure 1 AC-Coupled System – Current Flows

Operation While Grid Connected

On each of its two AC inputs, the Xantrex XW is equipped with an input relay that closes only when the AC source is qualified (i.e., within the user-adjustable range). Closing the input relay connects the AC source directly to the AC output terminals of the Xantrex XW. In this pass-through mode, the Xantrex XW essentially behaves like any other load as it charges the battery bank. If the AC voltage and frequency are within limits per UL1741 and CSA C22.2 No. 107.1, then—after a five minute delay—the GT Inverter will harvest the solar energy from the array. This energy will be consumed by the local loads (including what is needed to recharge the battery bank), and any excess will be exported to the grid (either through the Xantrex XW or through a separate transfer switch connection, depending on the applicable regulations within the jurisdiction where the system is installed).

The Xantrex XW continuously monitors the input voltage and frequency. If the voltage or frequency move beyond the acceptable ranges—for example, during a power surge or outage—the Xantrex XW opens its input relay, disconnecting both Xantrex XWs and GT Inverters from the grid and forcing them to stop selling power to the utility grid. As soon as the relay opens, the Xantrex XW transfers from charge mode to invert mode to provide power to the local loads. The GT Inverter may detect the temporary loss of AC during this transfer and stop harvesting until it detects a stable AC output for a minimum of five minutes.

During utility outages or instability, the system becomes an off-grid system.

Stand-alone (Off-grid) Systems

When the grid is not present and the Xantrex XW is inverting, the inverter/charger acts as a voltage source, providing tightly controlled voltage and frequency on its AC output. The GT Inverter and AC loads are connected to this AC voltage through the installed sub-panel. The GT Inverter will qualify and connect to the provided AC voltage just like it would to the utility grid.

When the Xantrex XW is in invert mode, electrical current is free to flow in either direction through it. This means if the GT Inverter is providing more power on the AC bus than the loads can consume, current will flow back through the Xantrex XW to charge the battery bank.

Unlike its behavior when in charge mode, the Xantrex XW does not regulate charging when power is flowing from its AC output to the battery. This is not a problem if the battery is sufficiently discharged. However, if the battery is already full and there is not enough load on the AC system, and if the GT Inverters continue feeding power to the AC bus, the battery voltage could potentially rise until an over voltage fault condition (High Batt Cut Out setting) is reached. This will cause the Xantrex XW and the entire system to shut down, including the AC loads. This could also damage the battery if High Batt Cut Out is set too high for the battery. However, the Xantrex XW has integrated protection (described in the next section) to prevent this from happening when the correct firmware version is used.

Important: To prevent battery damage in a mini-grid AC system, use only firmware which has the AC coupling feature implemented. Use the firmware version (or higher) listed in Table 1 for your model. For firmware upgrade instructions, see the Xantrex XW Config User's Guide (Document Part Number 975-0365-01-01) available on www.schneider-electric.com.

Table 1 Firmware Versions and Part Numbers

Model	Firmware Version	Firmware Part Number[a]
Xantrex XW6048 120/240 60	1.05	150-0175-01-05
Xantrex XW4548 120/240 60	1.04	150-0176-01-04
Xantrex XW4024 120/240 60	1.04	150-0177-01-04
Xantrex XW6048 230 50	1.05	150-0218-01-05
Xantrex XW4548 230 50	1.05	150-0219-01-05
Xantrex XW4024 230 50	1.05	150-0220-01-05

a.The last two fields are the same as the firmware version. Make sure your firmware's part number matches or is higher than (based on the last two fields) what is listed in the table.

AC Coupling Module with Line Frequency Variation Pattern

The AC Coupling Module is a control strategy that varies the line frequency according to a predetermined pattern to cause a grid-tie inverter to cease producing power to avoid overcharging the system battery. The Xantrex XW executes a pattern generator algorithm that varies the line frequency linearly to avoid overload.

Figure 2 on page 6 shows the effect of the frequency generation function where the Xantrex XW changes the mini-grid frequency with a linear rate of change of 0.4Hz/s. When the charge bulk voltage is exceeded, the frequency linearly decreases until the GT Inverters cease converting power to the AC mini-grid.

While the Xantrex XW and GT Inverter are in AC connected/coupling mode, the Xantrex XW changes the frequency only when the Charge Bulk Voltage setting is exceeded. This setting is user-adjustable in Custom battery mode.

The internal maximum frequency adjustment range when the Charge Bulk Voltage setting is exceeded is:

- North American models: f_{LINE}=[60-55]Hz
- European models: f_{LINE}=[50-45]Hz

The Xantrex XW can be connected in parallel or in three-phase configuration based on the power demand of the AC loads. The GT Inverter's rated power should not exceed the Xantrex XW's rated power and AC current, and it must match the phase configuration. For example, if the grid configuration is three

phase, and you want to install three GT4.0 inverters for a total of 12kW in three-phase configuration, you should use three Xantrex XW4024s configured for three phase.

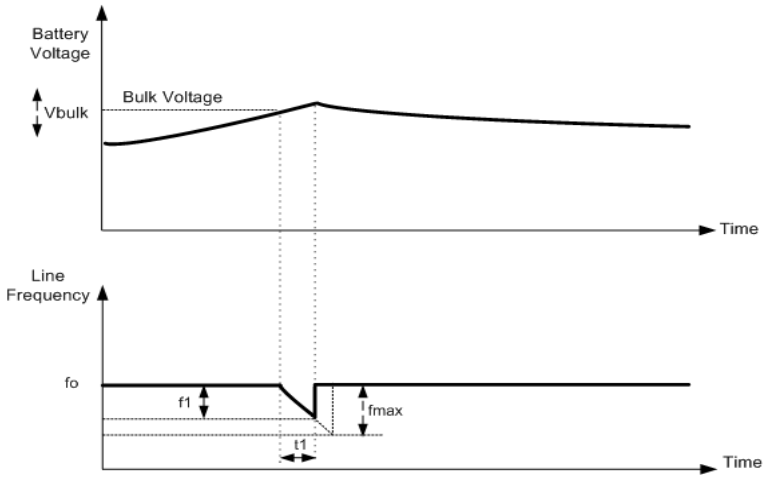

Figure 2 Results in Off-grid Islanded Mode[a]

a.The Xantrex XW linearly decreases the mini-grid frequency (f, 1Hz/div) when the DC voltage (VDC, 1 V/div) exceeds the set point limit. The GT Inverter is disconnected and DC charging current (IDC, 5 A/div) is reduced to zero.
b.fo is the nominal line frequency at 60 Hz or 50 Hz.
c. If fo is 60 Hz: fmax = 5 Hz
d. If fo is 50 Hz: fmax = 5 Hz
e. Vbulk set point = [50...64] V

Renewable Feed-In-Tariff (FIT)

If a GT system is connected to the grid according to a FIT program, then it can be converted to an AC backup system by using a Xantrex XW and an AC transfer switch. The output from the GT Inverter is connected to the common point on the AC transfer switch. The normally closed contacts are wired to the sub panel of the Xantrex XW. The normally open contacts are wired to the utility grid supply.

The external AC transfer switch can be driven as follows:

- Use the Xantrex XW AUX port (12 V/0.25 Amax)

Or

- Use an AC transfer switch with an AC coil type energized from utility grid line-to-neutral voltage.

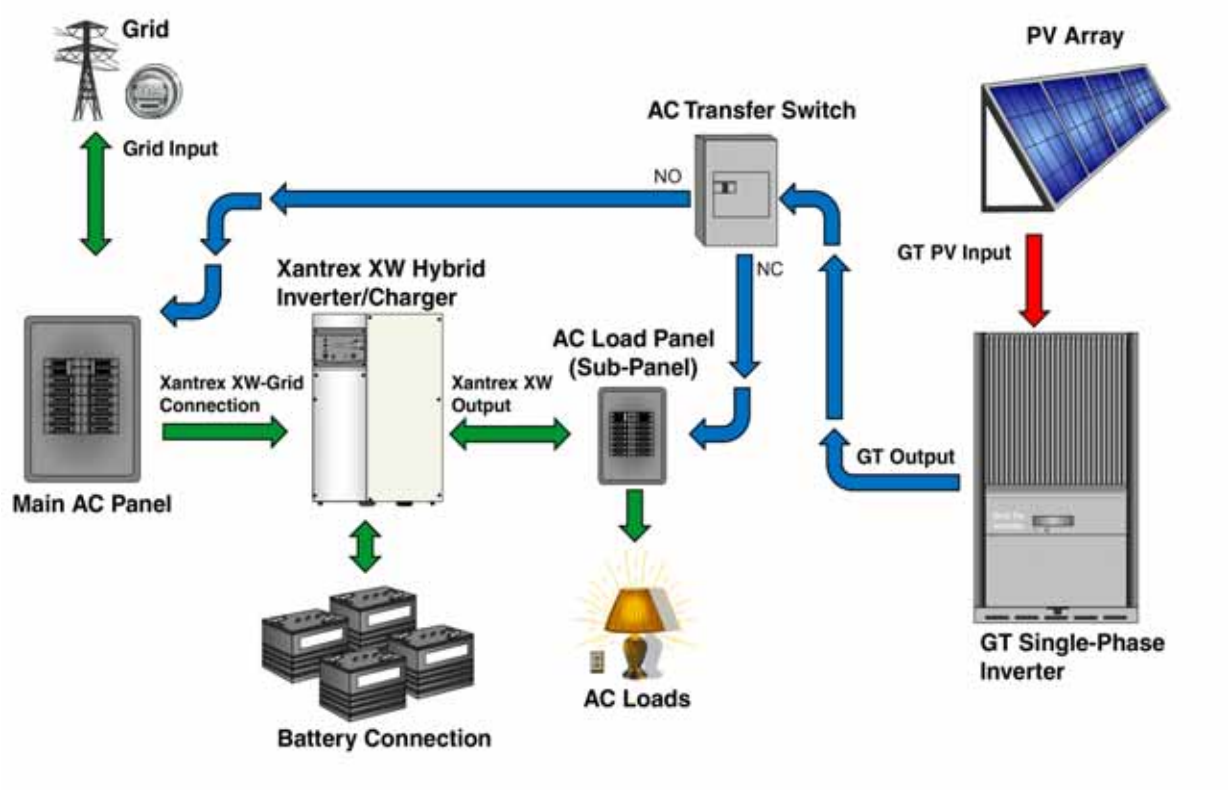

Figure 3 AC-Coupled System with a Renewable Feed-In Tariff

Installation Procedure

1. Install one or more Xantrex XWs according to the procedures outlined in the *Xantrex XW Power System Installation Guide* (Document Part Number 975-0239-01-01).
2. Install one or more GT Inverters according to its installation guide, with the following exception: instead of connecting the GT Inverter's AC output to the main service panel, connect these lines to the AC transfer switch (as shown in Figure 3) and the Xantrex XW's AC Load Panel (sub-panel).

Table 2 Recommended Settings for the Xantrex XW Installation

Search	Disabled
Grid Support	Enabled

For all other settings, see the *Xantrex XW Power System Installation Guide* (Document Part Number 975-0239-01-01) and the *Xantrex XW Series Hybrid Inverter/Charger Operation Guide* (Document Part Number 975-0240-01-01).

Limitations

This system has not been tested with a generator as an AC source to the Xantrex XW. If you must use a generator, turn off the GT Inverters to make sure they do not backfeed the generator. In addition, a normally open (NO) disconnect switch can be installed between the generator output and the AC2 (gen) input.

The power metering on the Xantrex XW may not work reliably when the inverter/charger is in voltage source invert mode and power is flowing back into the batteries.

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Contact Information
www.schneider-electric.com

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North America	1 650 351 8237 1 866 519 1470	1 925 245 1022	re.techsupport@schneider-electric.com
France	0 825 012 999		fr-re-techsupport@fr.schneider-electric.com
Deutschland	+49 (0) 180 575 3 575	+49 (0) 2102 404 7101	pv-service@de.schneider-electric.com
España	+34 902 101 813	+34 933 055 026	es-sat@es.schneider-electric.com
L'Italia	+39 035 4151111	+39 035415 3200	IT-pronto-contatto@it.schneider-electric.com

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