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Making Advanced Electronics for Sustainable Energy

The Solarized Grid

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Consumers continue to demonstrate their desire for solar power. Grid tied solar electric systems are being installed, in significant numbers, on consumers' homes and businesses. This growing demand for solar power is bringing together solar contractors, non-profits, utilities and government entities to deliver on the promise of solar renewable energy. Increasing political pressure for more environmental and sustainable energy resources and rising electricity prices continue to support a transition to a more reliable grid without more transmission. Even as the centralized power supply grid has provided excellent service, the grid of the future will have to incorporate higher levels of intermittent resources such as solar and wind, resources located locally with distributed local control of demand and generation. The time has come to rethink the home energy system, the role of the local utility, and the solutions to enable higher penetration levels of distributed local solar generation.

One way to think of it is building a system, piece by piece. Each building block adds additional functionality and benefits for the customer and for the utility grid operations. Individually, these pieces may be detrimental to grid operations but, properly configured the synergy created provides significant benefits for the utility. You can think of this like an orchestra. Each instrument provides a unique sound and individually may not necessarily seem interesting but, in combination and effectively orchestrated, the complete assembly is inspirational.

In the case of grid-tied rooftop solar, the customer benefits from simply installing a new smart inverter and some panels. He sees immediate benefit in the way of a lower monthly power bill. If local electric rates are above grid parity for solar (currently about 20 cents/kwh) his investment would provide a positive return over its operational lifetime. This is all well and good for the individual but, his investment has provided no benefit to the utility and may negatively impact its operation and in so doing, impact his neighbors as well.

Now, if batteries and a charge controller are added to the system, perhaps it can be configured to charge and discharge batteries to provide a number of benefits. Certainly the addition of batteries could provide the customer with some off-grid and off-peak hours of operation, but, can the functions of the smart inverter and those of the battery charge controller be orchestrated for utility grid benefit as well? What if the smart inverter and charge controller were combined into one device coordinated by a single intelligent process? In this case, we achieve even more benefits including:

1) Energy release into the grid can be controlled to more closely coincide with peak demand,
2) Reverse flow onto the grid during peak generation hours can be eliminated,
3) Solar irradiance variability (the cloud cover effect) can be mitigated, thus providing a smooth delivery of energy to the grid.

Finally, our orchestra is starting to sound like something everyone will enjoy. But, there could be more. Suppose we add Uninterruptable Power Supply (UPS) capabilities and the ability to dispatch heavy loads based on measurement of voltage and frequency locally on the grid? These capabilities, available today in the Heart Transverter System, provide the complete solution anticipated by all advocates of the Smart Grid.

HT2000 Power Module "The Orchestra"

The Transverter System provides many additional benefits not possible with today's simple offerings. These include:

1) Elimination of Transient Over Voltage conditions
2) Self-healing grid operations such as staggered reconnection/disconnection and transient ride-through
3) Critical load support with UPS providing ultra-high availability
4) Dynamic load curtailment triggered by system disturbances
5) Dynamic energy injection triggered by system disturbances
6) Ancillary services such as VAR compensation
7) Reduction of overall system losses
8) Reduced wear on distribution equipment
9) Higher customer reliability
10) Extended system life
11) Utility resilience to fuel cost shock
12) Long term stable electric rates for consumers
13) Simpler rate structures from smoother load profiles
14) Communication of distributed generation activity back to the utility for enhanced operations

What is needed to complete our orchestra is a conductor. The Transverter T13X fulfills this role. The T13X completes the Transverter System by monitoring the connected grid service at each home and also providing monitoring and control of up to six residential circuits which are usually large non-critical loads (like air-conditioning), water heaters, and the like. So, when the T13X "sees" that frequency is abnormal or that local voltages are well above nominal levels, it then communicates with the rest of the Transverter System (inverters, charge controller, UPS) to take one or more alternative actions.

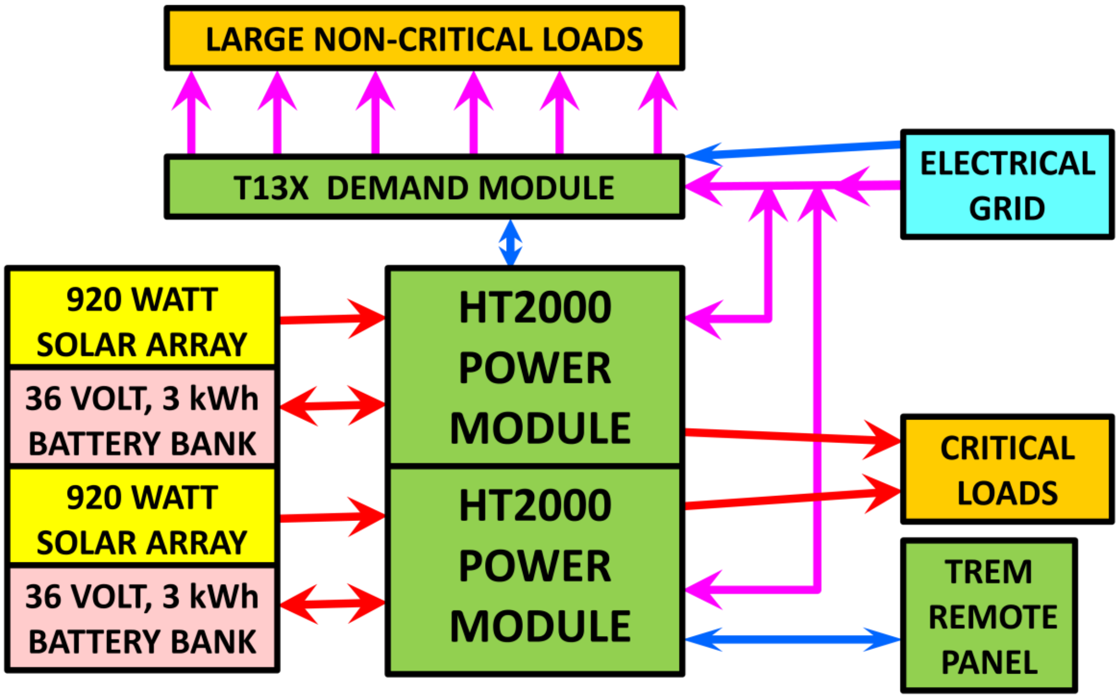
1) Loads that were previously disconnected by the T13X relays are allowed to reconnect and consume power,
2) Large loads are dispatched to disconnect from the grid,
3) Local generation is redirected to charge batteries,
4) The solar being generated at the residence is limited.

By taking these actions, singularly or in combinations in just a few cycles, the system dynamically balances every participating component in the system such that power never goes back into the grid. Since our T13X conductor and all the Transverter orchestra are communicating at very high rates, the actions taken can swing between the steps described here to deliver needed energy to support the grid. All these decisions are made continuously and autonomously based on what the Transverter System "sees" presented by the grid in the form of voltage and frequency. This all happens very quickly (within one 60 Hz wave shape) so the grid never sees this subtle fine tuning at each residence on the circuit.

T13X Demand Response Module "The Conductor"

The complete Transverter System provides both customers and utilities with new options that create a wide array of possibilities. The capability exists to provide enough local intelligence and autonomous control into high volumes of residential solar so that grid stability issues are eliminated and vastly improved customer service, reliability and grid flexibility are enabled.

What does a system like this look like? Here's an example. We take the typical American home, which has an average load of 1.7 kW, and equip it with 8 solar panels, 6 batteries and 4 kW of Transverter UPS power modules. This will provide approximately 1/3 of the home's total energy automatically and provide continuous power to the critical loads like the refrigerator, lights, fans and electronics, even in the event of a sustained grid blackout. The large non-critical loads are monitored and controlled by the Transverter T13X demand response module. This system can be configured so that it never pushes power back through the power meter and into the grid or it can be configured to help level out peak demand hours for the grid. Rather than have a few houses installed with large expensive hard to control systems it is far more effective, from a community viewpoint, to put in place large numbers of houses with moderate systems with the advanced capabilities discussed here. These eliminate the high solar integration stability issues that have really come to the surface in areas like Hawaii and Germany. This entire system can be installed for under $13,000.



A Transverter System as described above, allows you to integrate solar panels directly into the UPS system so that, during daylight hours, the solar is providing energy directly to the resident's UPS critical loads and recharging batteries.

It is conceivable that a distribution circuit installed with multiple Transverter Systems could generate enough solar energy at times that total circuit generation exceeds the critical loads and would back-feed this excess energy into the grid for use by all of the other, non-critical, loads on the circuit. However, if all of the loads on the circuit were less than solar energy available the grid would operate backwards. This circumstance is exactly what we do **not** want to occur because it is a major source of the grid instability issues. The Transverter System can help mitigate this issue when installed on a community scale.

You might be thinking "well, this is great for new additions of distributed generation but what about all the legacy solar systems connected to my grid? The T13X is smart enough that it can act as a conductor for non-Transverter systems as well. Granted, there are limitations to achieving all we've discussed thus far in managing existing legacy solar installations but, the T13X can be used to provide the following benefits at existing sites:

1) Situational awareness – knowing what is being generated moment to moment

2) Provide load management based on grid conditions
3) Provide generation management based on grid conditions
4) Provide staggered reconnection of dispatched loads and generation for smoother operations

The degree of distributed system control isn't as refined as what can be achieved by a complete Transverter System but, it's a significant advancement over existing operations.

The secret to making this a reality is everything is working in harmony. The orchestra is finely tuned, each player knows their part and the conductor is providing precise instructions on a continuous basis that is in sync with the overall dynamics of the electric grid. The solution we have described is the culmnination of years of development and deep knowledge of solar technology and the utility industry as it originally existed and what is possible today. By developing a fully integrated System, Heart Transverter SA has delivered a solution that addresses the weaknesses of high-penetration distributed solar generation and, at the same time, kept all the potential "Smart Grid" advantages intact.

LINKLIOGRAPHY

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