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TRIMODE POWER CONVERTER OPTIMIZES PV, DIESEL AND BATTERY ENERGY SOURCES

George O'Sullivan, Abacus Controls Inc
Russell Bonn and Ward Bower, Sandia National Laboratories

Conservatively, there are 100,000 localities in the world waiting for the benefits that electricity can provide, and many of these are in climates where sunshine is plentiful. With these locations in mind a prototype 30 kW hybrid system has been assembled at Sandia to prove the reliability and economics of photovoltaic, diesel and battery energy sources managed by an autonomous power converter.

In the Trimode Power Converter the same power parts, four IGBT's with an isolation transformer and filter components, serve as rectifier and charger to charge the battery from the diesel; as a stand-alone inverter to convert PV and battery energy to AC; and, as a parallel inverter with the diesel-generator to accommodate loads larger than the rating of the diesel. Whenever the diesel is supplying the load, an algorithm assures that the diesel is running at maximum efficiency by regulating the battery charger operating point.

Given the profile of anticipated solar energy, the cost of transporting diesel fuel to a remote location and a five year projection of load demand, a method to size the PV array, battery and diesel for least cost is developed.

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Designated Author

George O'Sullivan
Abacus Controls Inc
P.O. Box 893
Somerville, NJ 08876-0893
U S A

phone 908 526 6010
fax 908 526 6866

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TRIMODE POWER CONVERTER OPTIMIZES PV, DIESEL AND BATTERY ENERGY SOURCES

George O'Sullivan, Abacus Controls Inc - Senior Member IEEE
Russell Bonn, Sandia National Laboratories
Ward Bower, Sandia National Laboratories

Conservatively, there are 100,000 localities in the world waiting for the benefits that electricity can provide, and many of these are in climates where sunshine is plentiful. With these locations in mind a prototype 30 kW hybrid system has been assembled at Sandia to prove the reliability and economics of photovoltaic, diesel and battery energy sources managed by an autonomous power converter.

Cost effective applications of hybrid systems include remote facility power, remote home and village power, and power for dedicated loads such as communications. The hybrid system market is anticipated to be one of the most important growth opportunities for PV for the rest of the decade.

Hybrid design is bounded by economics, electrical performance goals and predetermined needs. Reducing diesel fuel consumption and engine run time is an economic necessity in countries where oil importation is a critical drain on financial resources.

POWER CONVERTER

In Figure 1, a block diagram of the TRIMODE Power Converter, power flow is shown with solid lines, control with dashed lines, and the open arrows show the direction of power transfer. The 480 VAC three phase grid can be serviced either from the diesel engine generator, the three phase TRIMODE power processor, or both sources.

Interfacing between the PV array and the battery is a DC - DC Max Power Tracker (MPT) whose function is to operate the photovoltaic array at its maximum power point whenever the battery can take the power, and to operate as a constant voltage DC power supply at the battery float voltage whenever the battery is fully charged.

The upper solid state relay is used in the control of diesel-generator power to the load, synchronizing the inverter with the diesel-generator, and battery charging from the generator. During these operations, the lower solid state relay is ON.

With the diesel operating and an overload condition sensed over a few cycles, the TRIMODE will add power to the grid through the lower solid state relay. This relay serves as the safety device for the battery voltage, diesel voltage, loss of phase lock, and excessive current demand from the TRIMODE. The algorithm that determines how much current to add to the diesel-generator current will be the load current less the diesel generator rated current on a per phase basis.

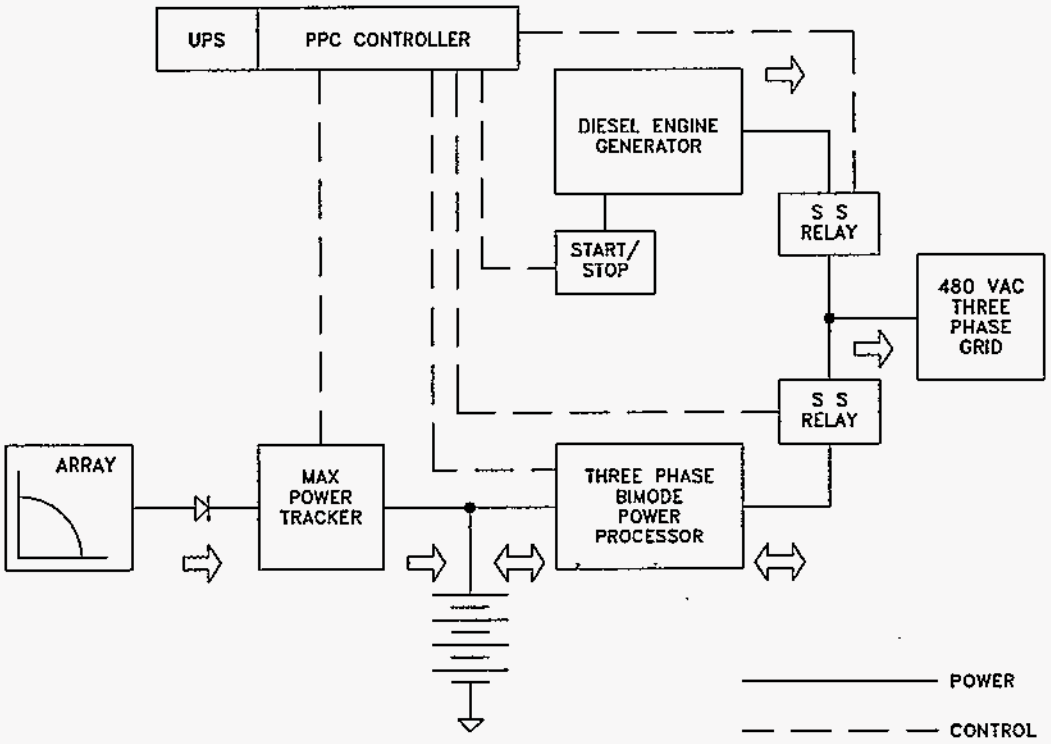

FIGURE 1
TRIMODE POWER CONVERTER

Operating on a per phase basis has significant advantages in remote village applications since there is a reasonable probability that one phase may become overloaded while another phase is underutilized. With the TRIMODE design, the underutilized phase will be charging the battery while the overloaded phase will be using battery power; thus load will be synthetically transferred from one phase to another. The desirable end result will be load balancing among the phases whenever one or two phases is in an overload condition.

TEST PROGRAM

The laboratory testing program at Sandia is designed to improve standards and test guide lines, establish benchmarking, assist manufacturers by conducting tests too costly for factory testing, and provide a government test bed for acceptance testing. The tests discussed in the paper are the Sandia standard tests for hybrid PV systems. The hybrid test configuration includes a 25 kW polycrystalline PV array, 300 kW hours of batteries, a 50 kW diesel engine generator, and resistive, reactive and non-linear loads.

ECONOMICS

Given the profile of anticipated solar energy, the cost of transporting diesel fuel to a remote location and a five year projection of load demand, a method to size the PV array, battery and diesel for least cost is developed.