

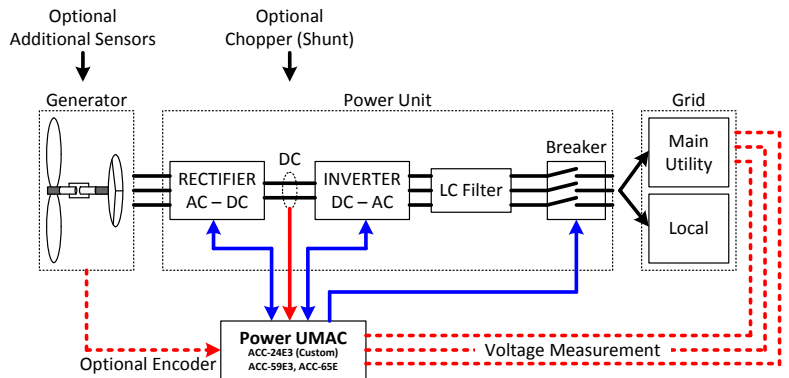


# Power Generation with Power PMAC

Delta Tau offers an integrated controls solution for power generation. This control scheme can be integrated with virtually any type of kinetic energy source such as wind, water, or high speed gas turbines. The mechanical speed does not need to be synchronous with the AC line Frequency to be created. Two electrical modes of operation have been developed:

1. Power generation into a main utility grid with an auto-adjusting frequency and a programmable voltage level output.
2. Power generation to an "isolated" local network with a user specified voltage and frequency.

**Theory of Operation:** The rotor or turbine spun by the power source is mechanically coupled (geared or gearless) to a large three-phase electric motor. This combination is often called Generator. The electric motor – generator – is tied to a power amplifier, called the Rectifier, which converts the variable frequency AC voltage into a continuous DC bus voltage. The DC bus is tied directly to another power amplifier, called the Inverter, which converts the DC bus into AC voltage and feeds it back "synchronously" into the main utility grid or isolated local grid. **The Power PMAC controls both the Rectifier and Inverter.**



**The Rectifier** treats the generator like a traditional digitally commutated three-phase brushless motor controlled in "open-loop" torque mode. A sensorless control algorithm has been developed so that the motor can operate with or without a feedback device. The latter is often desired in sensitive operating environments. A constant or variable (user configurable) torque opposite to the spinning direction of the rotor is commanded to build up the DC bus voltage.

**The Inverter** treats the AC grid lines like a three-phase digitally commutated brushless motor.

- In the synchronous generation mode, the phase position is computed in real-time from the utility grid voltages which are sampled at a very high rate (20 MHz). This maintains complete synchronicity with the main utility grid.
- In the standalone isolated generation mode, the phase position is arbitrary. Power PMAC's phase capture counter of an unused channel can be conveniently used for this purpose.

In either mode, the Inverter is commanded to hold "position" in closed-loop by maintaining the DC bus voltage to a specified threshold (equal or greater than the main utility grid in synchronous generation mode), hence harvesting the increased DC bus voltage created by the Rectifier as the current is fed to the load.

**Harmonics Suppression:** The output voltage from the Inverter and filtering circuitry is, by architecture, a perfect sine waveform which when superimposed on imperfect (in some cases) utility grid voltage, significantly reduces the efficiency of the overall system. These utility grid imperfections are often referred to as harmonics, most notably the 5<sup>th</sup>, 7<sup>th</sup>, and 11<sup>th</sup>. The Power PMAC can detect and quantify these harmonics on-the-fly, and introduce identical characteristics into its voltage output to match the utility grid's waveform. This allows the smooth flow of current and optimizes the efficiency of the plant.

## The Power PMAC Difference

- Operational power generation modes; into a utility grid, or into an isolated local grid.
- High speed computation for safety logic and grid shorts.
- Bidirectional sensorless control algorithm allowing automatic operation in whichever direction the rotor/turbine is spun.
- Ability to control the motor generator with or without a gear. Electronic gearing.
- Harmonics suppression for high efficiency.
- Automatic detection and sampling of grid voltages (can be wired in any order).
- Automatic reporting of grid RMS voltage and rotor speed.
- User programmable power curve(s) based on the kinetic energy data.
- Hardware flexibility and support for fiber distributed control in large structures.
- Large memory and high speed data logging (phase rate) and sharing.
- Full automation of plant, general purpose digital and analog I/Os. Control of breakers, shunt resistors, coolant etc...
- Built-in web browser, ideal for remote troubleshooting.