



PV – 10208, 15208 & 20208 POWER CONVERSION SYSTEM FOR GRID – TIED PHOTOVOLTAIC APPLICATIONS

TECHNICAL DESCRIPTION



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1.0 General System Overview

This document describes the Trace Technologies 10, 15 and 20 – kW Power Conversion Systems for grid-connected photovoltaic applications. The inverter incorporates the advanced, insulated gate bipolar transistor (IGBT) based power electronics technology developed by Trace Technologies. The power conversion system consists of a three-phase, 208 VAC pulse-width-modulated inverter, for isolation and protection of the connected AC and DC power systems and an isolation transformer (also, optionally supplied by Trace). The following technical specifications and diagram detail the components, operation, and interconnection of the system.

2.0 Inverter

Trace Technologies manufactures a patented insulated gate bipolar transistor (IGBT) based power electronic inverter. There is presently over 1800 MW of installed capacity of Trace Technologies inverters throughout the world in wind, solar photovoltaic, battery energy storage, industrial drive and stand-alone hybrid power system applications.

2.1 Inverter Hardware

The inverter is detailed on the attached block diagram at the end of this document. Descriptions of operation of the components are as follow.

2.1.1 Inverter Circuit and Capacitor Bank

The inverter matrix utilizes IGBT technology as the main power semiconductor-switching device. This technology exhibits both the high power levels and low conduction losses associated with bipolar devices, as well as the low switching losses and high switching frequencies associated with MOSFET devices. In addition Trace Technologies employ IPM (Intelligent Power Module) switching Technology. Together the IGBT and IPM offer protection logic for short circuit, over temperature, DC over voltage and AC over/under voltage conditions.

2.1.2 Integrated Bus Board

The integrated bus board receives logic level timing signals from the digital signal processor (DSP) board and converts these signals to IGBT switching states.

Additionally, the integrated bus board monitors the condition of the IGBT's and reports fault condition to the DSP controller. The DSP is plugged directly into the integrated bus board and is designed to the industry standard specification PC – 104.

2.1.3 Digital Signal Processor (DSP) Board

The DSP Board utilizes a state of the art Texas Instruments digital signal processor integrated chip to implement control and system monitoring functions. The DSP software implements the peak power tracker function for optimizing the power delivery from the PV array. The DSP commands the integrated bus board to issue the appropriate gating signal to the IGBTs, as determined from the digitized current and voltage waveforms at the inverter input and output, and by the control commands received through the operator interface. The DSP based control board communicates with the operator interface board via PC – 104 bus.

2.1.4 AC Line Filter

The AC line filter removes harmonic currents at the utility power system interface. Due the high switching frequency and the pulse-width-modulation (PWM) technique used with the inverter, the filter is modest in size, and need only remove high frequency harmonic current components.

2.1.5 Operator Interface ** (Optional)

Access to metering, control and status functions (DC voltage, kVA, ground current, kVAR's and AC voltage) is provided via an operator interface on the front of the inverter enclosure. The interface consists of a rugged, weather-resistant liquid crystal display and membrane keypad. Menu driven displays allow the operator to interrogate the inverter for status and metering functions, with local control also available through this interface. (**Operator Interface available 3rd QTR 2000). The standard configuration operates through an enable/disable (E-Stop) switch located on the front door.

2.2 Power Quality

The state-of-the-art technology used in the Trace Technologies inverter results in exceptional power quality. The use of IGBT devices allows for high switching frequencies. The combination of the high switching frequencies and AC line filter produces high fidelity waveforms which are well below the IEEE-519 recommended limits for total harmonic current distortion. Unlike line-commutated inverters, the Trace Technologies inverter allows power factor to be regulated precisely at unity, eliminating the need for external reactive power compensation.

2.3 Self-Protective Features

The inverter has many built-in protective features to prevent or limit damage to the photovoltaic system, the inverter, and the utility distribution system in the event of system-level malfunction or failure. These features provide for orderly system shut - down without the need for many external protective devices. Among the features are:

2.3.1 IGBT Device Protection

Sensing DC overvoltage, overcurrent and overtemperature of the device protects the IGBTs. Set points for these functions are fixed at the time of factory test, and can only be changed through the diagnostic port on the microprocessor controller inside the enclosure.

2.3.2 Utility Islanding Protection

Detection of islanding from the utility grid is achieved via a frequency shift approach together with over/under-voltage and over/under-frequency sensing. Set points and definite time delays for these functions are factory set according to Underwriters Laboratories (UL) requirement 1741.

2.3.3 Standards

The Trace family of photovoltaic inverters; PV – 10208, 15208 and 20208 are all in compliance with IEEE 519 and 929, Underwriters Laboratories (UL – 1741) and the National Electric Code (NEC). Our facility has been Registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9000 Series Standards for quality.

2.4. Summary of PV10208, 15208 & 20208 Inverter Specifications:

| AC Line Interface | | | |
|---|---|---|------------|
| Maximum Continuous Power | 10 – kW | 15 – kW | 20 – kW |
| Full Load Efficiency | > 95% (see figure in section 6.0) | | |
| Nominal Line Frequency | 60 Hz | | |
| Nominal Line Voltage | 208vac, 3 phase | | |
| Min/Max AC Line Voltage | 183/220VAC - (nominal 208, +6%, -12%) | | |
| Line Current (max) | 30.84A rms. | 46.3A rms. | 61.7A rms. |
| Power Factor | Unity +/- 0.02 | | |
| AC Current Distortion | < 5% per IEEE 519 | | |
| PV Array Interface | | | |
| PV Array Configuration | Monopole, Negative Grounded or bipolar neutral ground | | |
| Max Open Circuit Voltage | 600VDC | | |
| Max Array Current (inverter input) | 31.9 ADC | 47.8 ADC | 63. 8 ADC |
| Power Tracking Voltage Window | 300/480 VDC | | |
| PV Ripple Current | 1.6A rms. (5% of max at full load) | | |
| **Operator Interface (optional) | | | |
| Input Device | 20 key keypad | | |
| Serial Interface | RS – 232 or 422 for computer access/control | | |
| Display Device | 4-Line x 20 char. LCD, Backlit | | |
| Display Parameters | AC Line Voltage (L – L) AC Output Current (per phase) Ground fault current PV Reference Voltage KVA Var. | PV Voltage AC kW Fault Codes Protective Function Target Inverter Status | |
| User Settable Parameters | PV Start Voltage PV Shutdown Power | | |
| Protective Functions | | | |
| AC Line Over/Under Voltage | E – Stop | DC Over voltage | |
| AC Line AC Over Current Protecting AC Line Over/Under frequency | Inverter Over temperature | Active Anti – Islanding | |
| Environmental | | | |
| Temperature | -20 to +50°C | | |
| Relative humidity | 95% non-condensing | | |
| Elevation | Derated above 6,600 feet | | |
| Enclosure rating | NEMA 4 | | |
| Cooling | Fan forced air | | |
| Dimensions | 25 ^{1/2} "H x 18"W x 10 ^{1/4} "D (dimensions w/mounting tabs) | 29 ^{1/2} "H x 25"W x 13 ^{3/4} "D (dimensions w/mounting tabs) | |
| Weight | Approx. 75 lbs. | Approx. 175 lbs. | |
| Third Party Certifications | | | |
| UL certified 1741 | | | |

3.0 Control and Instrumentation

3.1 Operating Mode

The inverter utilizes Trace Technologies' unique power tracking algorithm to operate in a power maximization mode at all times there is sufficient irradiance to overcome inverter tare losses. Inverter wakeup is triggered when the open circuit DC input voltage rises above the preset minimum operating voltage. The inverter transitions back to the idle state for nightly shutdown when tare losses exceed input power for a predetermined time period.

The power-tracking algorithm includes the intelligence and rapid response time necessary to limit the DC input power to its design value. Cloud enhancement effects are handled within the algorithm by moving off of the maximum power point, and seeking the design input power point. This eliminates the need for the source circuit dumping contactors, crowbar circuits and similar unreliable schemes used to protect other types of inverters.

3.2 Local Control

Local control is implemented through an emergency stop (E-Stop) enable/disable button and operator interface keypad (Optional) located on the door of the enclosure.

3.3 Remote Control/Instrumentation

The microprocessor control unit has provisions for installation of an RS-232 or 422 for computer access/control - communication link, should future remote control and monitoring capability (via personal computer) be desired.

All parameters, status indicators and targets accessible through the local operator interface may be accessed remotely through these ports

4.0 Isolation Transformer (Required; Can be Supplied by Trace or User)

An isolation transformer is required to allow grounding of the DC system per NEC Article 690, and to match the utilization voltage. Due to the low level of harmonic distortion produced by the inverter, a general-purpose dry type transformer is suitable for this application. The isolation transformer is rated for a 208V to 208/120VAC, three phase, Δ -Y connected, 80°C temperature rise, 60Hz, dry type device, housed in a Nema 3R outdoor enclosure – wall or floor mounted.

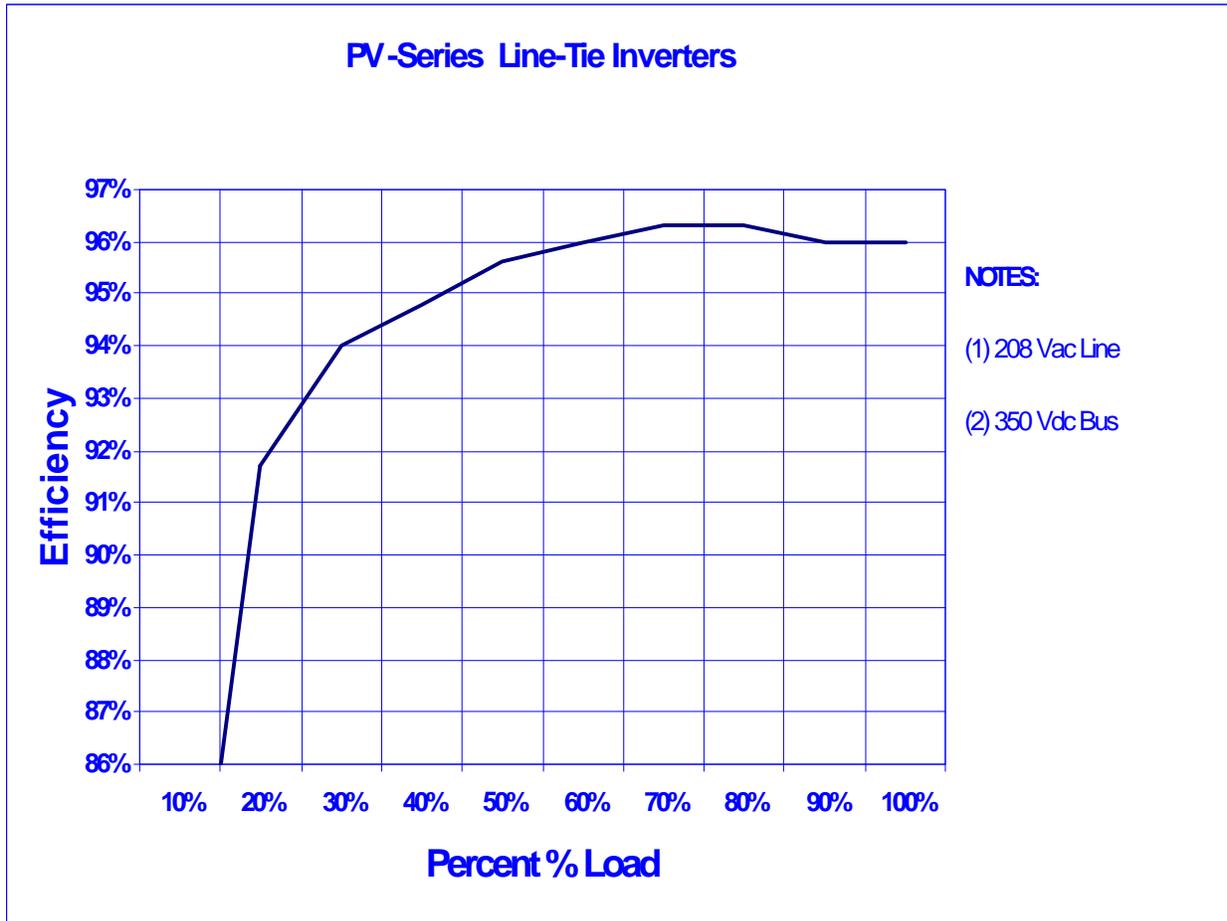
Also provided is an enclosed, molded-case, thermal-magnetic circuit breaker that can be mounted on the side of the transformer enclosure or wall mounted for overcurrent protection. This breaker can also serve as a service - disconnect.

| kW | Inverter Wt. (lbs.) | Isolation Transformer (Inches) | Transformer Wt. (lbs.) |
|----|---------------------|--------------------------------|------------------------|
| 10 | 75 | 24H x 22.5W x 22D | 220 |
| 15 | 115 | 24H x 22.5W x 22D | 300 |
| 20 | 180 | 24H x 22.5W x 22D | 350 |

5.0 Maintenance Requirements

Routine maintenance requirements are minimal, consisting only of periodic inspection of the cooling fans, enclosure seals and external electrical connections.

6.0 Efficiency Graph

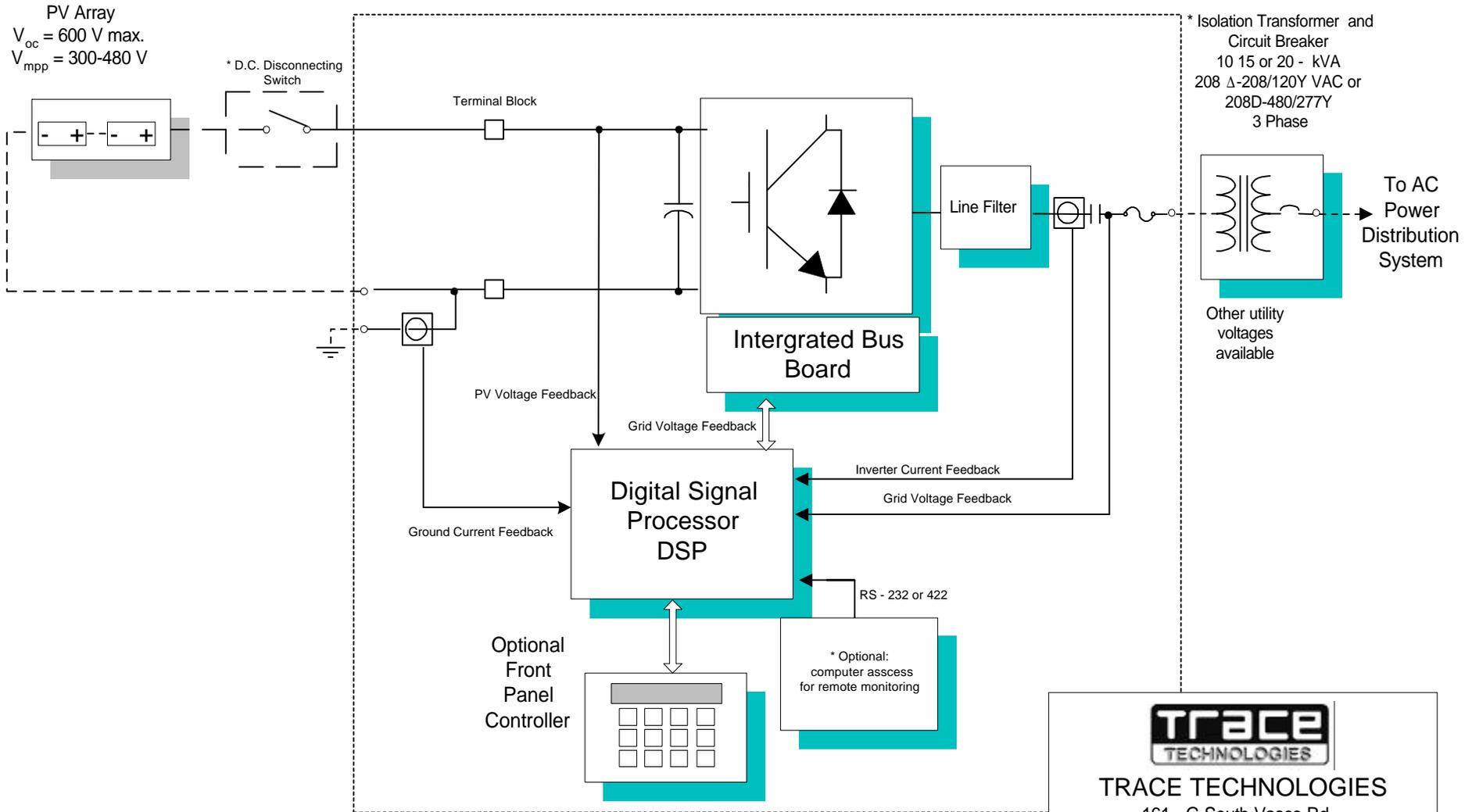


Attachments:

7.1 Inverter Schematic Block Diagram (next page)

Power Conversion System for Grid-Tied Photovoltaic Application

Electrical and Control Block Diagram Grid Interface Inverter



* Notes :

1. The Isolation transformer DC disconnect switch, DC combiner box(not shown) laptop computer and AC circuit breaker may be supplied by customer or by Trace.

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