

- **1-Axis Precision Gradient Amplifier**
- **300 VDC, 100 Arms, 200 Apk**
- **Digital Tuning and Set-up**
- **Advanced Diagnostics & iDSO™**
- **Programmable Load Protection**



## Description

The GA301 Gradient Amplifier from Performance Controls, Inc. (PCI) is a single axis pulse width modulated amplifier. It is rated at 300 VDC, 100 Arms, 200 Apk and operates from a DC power source. The GA301's exceptionally low output noise, extremely high bandwidth and excellent stability make it ideally suited for demanding power amplifier tasks found in laboratory and medical applications.

The GA301 is backward compatible with the GA300 gradient amplifier it replaces. Utilizing advanced hybrid digital and analog control architecture, the GA301 provides a host of powerful features. These include digital tuning, digital set-up, diagnostic tools, programmable protection for loads, and more. One such feature is the Integrated Digital Storage Oscilloscope (iDSO™). These features are easily accessible with the companion InSight™ software toolkit.

## Applications

- MRI gradient magnetic field control systems
- High power, voice coil based shock and vibration test systems
- Magnet-based particle beam steering systems
- Any inductive/resistive load requiring precise control of high current over a wide frequency range

## Features and Benefits

<b>Digital Tuning and Set-up</b>	Tuning and set-up parameters set digitally via USB or RS-485 serial ports: offers maximum repeatability and easy configuration replication.
<b>Current Control Compensation</b>	Easy DIP switch selection from among eight factory-defined or user-defined tuning settings for error-free matching to various loads.
<b>Advanced Diagnostics, Monitoring, and iDSO™</b>	Extensive array of tools for optimizing system performance and for troubleshooting problems at the amplifier and system level.
<b>Ultra High Reliability</b>	Member of the proven, world-class "GA" family of PCI amplifiers, with over 300,000 hours MTBF.
<b>Low Audible Noise</b>	Automatic adjustment of fan speed for acoustic noise reduction during operation: perfect for ergonomic or noise sensitive applications.
<b>InSight™ Software Toolkit</b> (see separate data sheet)	Single, easy-to-use graphical user interface for all amplifier functions.
<b>Voltage Loop Control (optional)</b>	For applications needing voltage loop control instead of current loop control, such as driving voice coil actuators.
<b>Parallel Operation (optional)</b>	Ability to operate multiple amplifiers in parallel, for driving loads requiring very high current levels.

## Specifications

Parameter	Value
<b>Power Supply Input Voltage and Current</b>	
Input voltage range	100 to 300 VDC
Input current rating	40 A, external fusing required
System input - continuous power	≤12 kVA (load dependent)
System input - peak power	≤60 kVA (load dependent)
Internal DC Bus Capacitance	11,500 uF
<b>Amplifier Output Voltage and Current</b>	
Output voltage, with Vbus = 330 VDC	+/- 300 Vpk delivered to load (load dependent)
Output current:	
• Continuous RMS, at 0 Amps DC	100 Arms
• Continuous DC, at 0 Amps AC and T <sub>HEATSINK</sub> ≤ 25°C	80 ADC, derated linearly as temp increases to:
• Continuous DC, at 0 Amps AC and T <sub>HEATSINK</sub> = 85°C	50 ADC
• Absolute peak	200 Apk (consult with PCI for 400 Apk option)
<b>Load Specifications</b>	
Inductance range, standard	60 μH to 1 mH
Inductance range, non-standard	Consult with PCI
Resistance range	0 Ω to Open
Maximum external capacitance, output to ground	1.0 μF
Maximum external capacitance, output to output	1.0 μF
<b>Load/Application Protection</b>	
Following conditions can be monitored for disabling amplifier output:	
• RMS current	User programmable
• Peak current clamping	User programmable
<b>Small Signal Bandwidth</b>	
Small signal bandwidth, with 500 uH load at 300 VDC bus	-3 dB at 7 kHz
<b>Output Current Noise Spectrum</b>	
Output current noise, 1 Hz to 1.0 kHz	< 500 μArms
Output current noise, 2 Hz to 100 kHz	< 10 mArms
<b>Total Harmonic Distortion (THD)</b>	
THD, at 200 Hz and 70 Arms	< 0.2%
<b>DC Stability</b>	
Self-heating drift, at 85 A	< 60 mA / 10 min
Current offset vs. ambient temperature	< 4 mA / °C
Scale factor	< 30 ppm / °C
<b>Command Signal Processing</b>	
Input voltage	+/- 10V differential +/- 5V each signal of complementary pair
Differential input impedance	50 kΩ
CMRR (circuit performance), at 1.0 kHz	> 70 dB
<b>Command Scaling (Gain Adjustment)</b>	
Scaling adjustment range	0 to >20 A / V

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Parameter	Value
<b>Output Offset (Offset Adjustment)</b>	
Output offset adjustment range	+/- 0.3 A
<b>Current Loop: Tuning / Gain Adjust</b>	
The current control compensation network is configurable via a DIP switch which allows selection from among eight alternate tuning configurations for matching of amplifier to load. Each of the eight settings is pre-defined at the factory and all are user-configurable for specific load impedances and performance requirements. Each setting specifies a set of three control parameters (P, I, and D), used to compensate the current control loop.	
<b>Pulse Width Modulation Technique</b>	
Base switching frequency	51 kHz +/- 5% (user-settable in this range)
Effective switching frequency	102 kHz +/- 5% (user-settable in this range)
<b>Clock Synchronization</b>	
Qualified clock sync signal type	TTL level square wave
Frequency range, user selectable	51 kHz +/- 5% (user-settable in this range), or 102 kHz +/- 5% (user-settable in this range)
Duty cycle range	50 +/- 5%
<b>Communications</b>	
RS485 serial communications	Via rear panel (Modular Jack)
USB serial communications	Via rear panel (USB Type B)
<b>Signal Monitoring</b>	
Programmable DAC for monitoring wide range of signals	Via rear panel (dedicated test point or P1)
Current error signal (4A/V)	Via rear panel (dedicated test point)
Current monitor	Via rear panel (P1)
Voltage monitor	Via rear panel (P1)
Multiple internal and system control signals	Via integrated Digital Storage Oscilloscope (iDSO™)
<b>Mechanical</b>	
Front panel outer dimensions:	
• Width	19 inch   483 mm
• Height	5.1 inch   130 mm (3U)
Front panel mounting holes:	
• Horizontal position from side edges	0.43 inch   11 mm
• Vertical position from top and bottom edges	0.85 inch   22 mm
Enclosure outer dimensions:	
• Width	17 inch   432 mm
• Depth	24 inch   610 mm
• Height	5.0 inch   127 mm
Weight, without packaging	48.0 lb   21.8 kg
<b>Environmental</b>	
Operating temperature range	+59 to +95 °F   +15 to +35 °C
Storage and transportation temperature range	-22 to +158 °F   -30 to +70 °C
Maximum relative humidity, non-condensing for operating, storage and transportation	≤ 95%
Maximum non-operating shock and vibration, no packaging	1 g
Maximum non-operating shock and vibration, with approved PCI packaging	10 g

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Parameter	Value
<b>Thermal Management, Power Dissipation</b>	
The power semiconductors are mounted to an air cooled heat sink. Three DC fans provide forced air cooling. The fans are powered from an internal power supply (external 24V supply not required). Fan speed is governed by power history and thermal conditions within the amplifier, resulting in low audible noise across much of the power spectrum.	
Power dissipation, at 0 Amps	150 Watts (application dependent)
Power dissipation, at 50 Amps	600 Watts (application dependent)
Power dissipation, at 100 Amps	1250 Watts (application dependent)
<b>Electrical Isolation</b>	
Control signals are isolated from the DC bus with reinforced insulation. The GA301 has its negative DC bus terminal tied to the amplifier chassis (Earth ground).	

## Digital Tuning and Set-up

All GA301 tuning and set-up parameters are set digitally via its serial interface or via DIP switches.

Communication with the GA301 can be performed with third-party terminal software or with PCI's InSight™ software toolkit.

## Advanced Diagnostics and Monitoring

The GA301 provides an extensive array of tools and information for diagnosing and monitoring amplifier-level and system-level performance. The functionality below is supported by PCI's InSight™ software toolkit; please refer to its data sheet for more information.

- Programmable DAC output - Rear panel test point can output: current error, bus voltage, output current, heat sink temperature, power transistor junction temperature, and other signals.
- Fault and warning logs - Records last 50 faults and last 50 warnings.
- Fault and warning context data – Records associated peak values showing state of amplifier during each event
- Power Utilization Monitor (PUM) - A real-time monitoring system for ensuring system design margins are achieved while maximizing performance of the system. Refer to separate InSight™ data sheet for details.
- Integrated Digital Storage Oscilloscope (iDSO™) - A 4-channel embedded digital oscilloscope is provided for convenient access to internal signals.

## Fault Protection

Faults disable the power stage upon the conditions below and set the appropriate front panel status LED indication.

Fault Name	Condition
Over Current, Peak	Output current exceeds amplifier's peak current rating.
Over-Current, RMS	RMS value of the output current exceeds either of two internal set-points. A third, user configurable RMS current threshold and time constant are available if specific RMS protection of the load is desired.
Over-Current, Average	Average (DC) value of output current (positive or negative) is exceeded.

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Fault Name	Condition
Bridge Fault	Detected if an internal fault occurs.
Thermal, Heatsink	Heat sink temperature is out of range (too high or low).
Thermal, Filter	Amplifier output filter temperature limit is exceeded.
Thermal, $T_{jmax}$	Power stage transistor junction temperature limit is exceeded.
Sync Lost	Loss of valid synchronization signal. This fault is both optional and user configurable.
Brownout	Partial loss and recovery of DC bus power.
Over-Voltage Condition	Bus voltage is too high. (Not a latching fault. Power stage is disabled only while the condition persists.)
Under-Voltage Condition	Bus voltage is too low, (Not a latching fault. Power stage is disabled only while the condition persists.)

## Front Panel Indicator

A single STATUS LED indicates amplifier status. The LED indicates GREEN when enabled and YELLOW when disabled. Faults are indicated by flashing YELLOW where the number of flashes indicates general fault type; a serial port query provides additional fault details and fault context data.

## Rear Panel Switches and Potentiometers

Name	Function
Tuning Configuration Switches	DIP switch positions 0, 1, 2 select one of eight current loop tuning configurations.
Sync Clock Source/Receive	DIP switch position 3 selects sync clock source or receive mode
Scale Pot	Adjusts current command gain/scaling.
Offset Pot	Adjusts current command offset.

## Rear Panel Connectors

Name	Connection Type	Function(s)
HV / GND	Terminal Block	High Voltage DC bus input
OUT(-) / OUT (+)	Bus Bars	Output Terminals (load connections)
GND	Bolt and wing-nut	Functional Earth / Chassis ground
GND	Test Point (PCB mount)	Reference point for TUN measurements
TUN (ERROR)	Test Point (PCB mount)	Tuning monitor test point
GND	Test Point (PCB mount)	Reference point for DAC measurements

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Name	Connection Type	Function(s)
DAC	Test Point (PCB mount)	Programmable test point
P1	15-pin D-sub (male)	Analog / Digital I/O signals (Command, Enable, Reset, Fault, etc.)
RS-485	Modular Jack	Digital/Serial comm. (control and monitor)
USB	USB Type B	Digital/Serial comm. (control and monitor)
SYNC	BNC (PCB mount)	Clock I/O – Source/Receive configurable

## Quality Assurance

### Reliability

- MTBF (Mean Time Between Failures) demonstrated to be greater than 300,000 hours.
- Life Time: The GA301 is designed to have a usable life of ten years.

### Quality Program

The GA301 is designed and manufactured in accordance with an ISO 9001 compliant and audited quality program.

## Certifications and Standards

- Complies with UL Medical Requirement of ANSI/AAMI ES60601-1:2005/(R)2012, CSA CAN/CSA-C22.2 NO. 60601-1:14 and IEC 60601-1 Edition 3.1 (2012)
- CE marked in accordance with Low Voltage Directive (2006/95/EC), the EMC Directive (2004/108/EC) and the CE Marking Directive (93/68/EEC).

## Options and Customizations

PCI offers the following standard options for the GA301. Beyond the options described below, PCI is able to provide customizations to meet your special requirements and welcomes your inquiries.

### GA301-P

The GA301-P provides the ability to parallel multiple amplifiers to drive a common load. With equal load current sharing, each amplifier is able to deliver its own full rated output current to the load.

### GA301-VP

The GA301-VP provides voltage loop control, extended peak current capability of 400 Apk, and the ability to parallel multiple amplifiers to drive a common load requiring very high current levels.

### Full galvanic isolation to chassis

Consult with PCI if isolation is required.

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*Performance Controls, Inc. (PCI) designs and manufactures high performance PWM (pulse width modulated) amplifiers and motor drives. We specialize in amplifiers characterized by high precision, high power, wide bandwidth, and ruggedized construction. You can select from one of our standard products, have a product customized, or work with us to develop a custom solution that exactly satisfies your application.*

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