# Power Analyzer

## PA4000 Datasheet

Tektronix PA4000 Power Analyzers deliver highly accurate, multi-channel power, energy, and efficiency measurements. Precisely-matched inputs, unique Spiral Shunt™ technology, and advanced signal processing deliver high accuracy even with highly modulated waveforms and crest factors as high as 10. The versatile PA4000 offers comprehensive power measurements. Dual current shunts provide optimal resolution from microwatts to kilowatts. Harmonics analysis up to the 100th harmonic, and motor analysis with torque and speed inputs are included in the standard instrument. Every PA4000 comes with multiple PC interfaces, PC software, and USB flash drive support to help you collect and analyze data.

### Key features

- 1 to 4 Input Modules allows several configurations to match your application
- High measurement accuracy of 0.04% (basic voltage & current accuracy) for demanding test requirements
- Dual internal current shunts for each module maximize accuracy for high- and low-current measurements
- Unique Spiral Shunt™ design maintains stability over variations in current, temperature, etc. (patent applied for)
- Proprietary frequency detection algorithms ensure rock-solid frequency tracking even on noisy waveforms
- Application-specific test modes simplify instrument setup and reduce the likelihood of user error
- Easy data export to USB flash drive or remote PC software, for reporting and/or remote control
- Many standard features such as comm ports and harmonic analysis eliminate costly upgrade options

### Applications

- Power conversion
- Power generation
- Inverters
- Motor drives
- Electrical propulsion
- UPS
- Frequency converters
- Electric and hybrid vehicle
- High-efficiency lighting
- Consumer electronics
- Standby power

## Flexible voltage and current input choices to fit your application

The PA4000 is the only instrument of its kind to feature both high- and low-range internal current shunts in each input module. The 30-Amp shunt is perfect for many applications and can accept up to 200 A peak; but for measuring low-current devices the 1 A shunt provides increased resolution and accuracy for measurements down into the microamp range. For measuring currents over 30 Amps, a selection of matching external current transducers are available in several styles, including high-accuracy transducers up to 1000 A.

The PA4000's voltage inputs can accept up to 1000 $V_{RMS}$, 2000 $V_{peak}$, continuous.


PA4000 Rear Panel - Input Modules

Tektronix®

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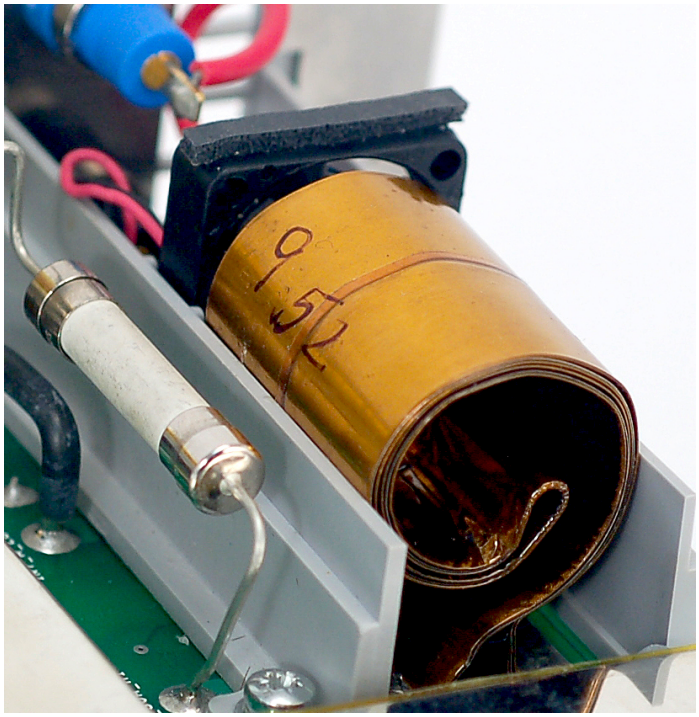
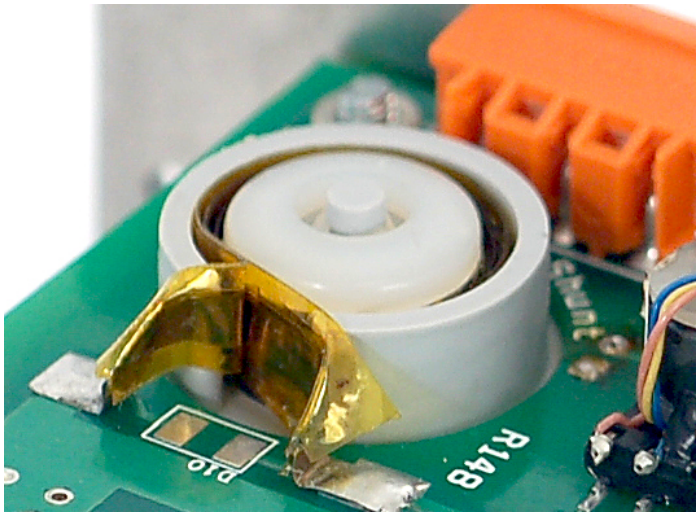
## Unique Spiral Shunt™ technology (patent applied for)

The PA4000 employs an innovative Spiral Shunt design that ensures stable, linear response over a wide range of input current levels, ambient temperatures, crest factors, and other variables. This new design is superior to other shunt technologies and contributes to the instrument's reliable accuracy and repeatability over a wide range of signal conditions common in today's power conversion technologies. The spiral construction not only minimizes stray inductance (for optimum high frequency performance) but also provides for high overload capability and improved thermal stability.



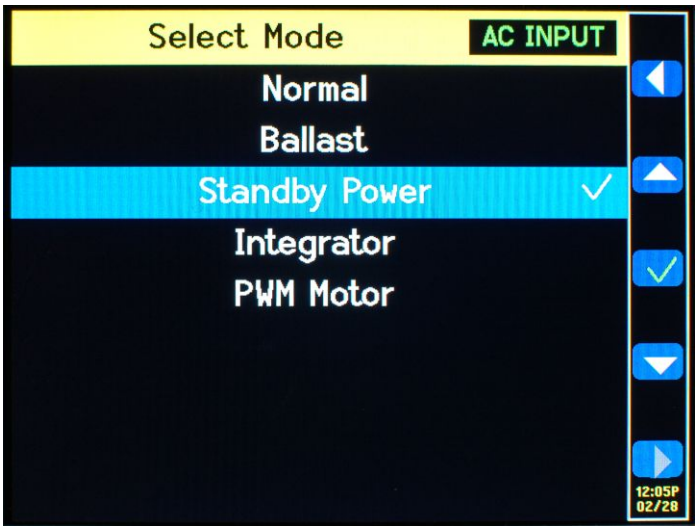
Spiral Shunt for 30 A input



Spiral Shunt for 1 A input

## Application-specific test modes

Some applications require special instrument settings to ensure proper measurements. The PA4000 simplifies setup for these applications by automatically choosing instrument settings and parameters that are optimized for each type of measurement application, resulting in more reliable measurement results with less opportunity for user setup error.




Selection of application-specific test modes.

### PWM motor drive mode

PWM motor mode is designed to overcome the difficulties associated with making measurements on the complex waveforms commonly found on the motor drives. High frequency sampling is combined with digital filtering to reject the carrier frequency and extract the motor frequency while still using prefiltered data for power parameters

### Standby power mode

Driven by consumer demand and energy efficiency regulations (such as ENERGY STAR), there is an ever-increasing need to measure power consumption of products while they are in standby mode. One of the most widely used standards for measurement is IEC 62301. Part of this standard requires the measurement of power over a prolonged period of time without missing any short duration power events. The PA4000 standby power mode provides continuous sampling of voltage and current to produce an accurate Watts measurement over the user specified period.

### Ballast mode

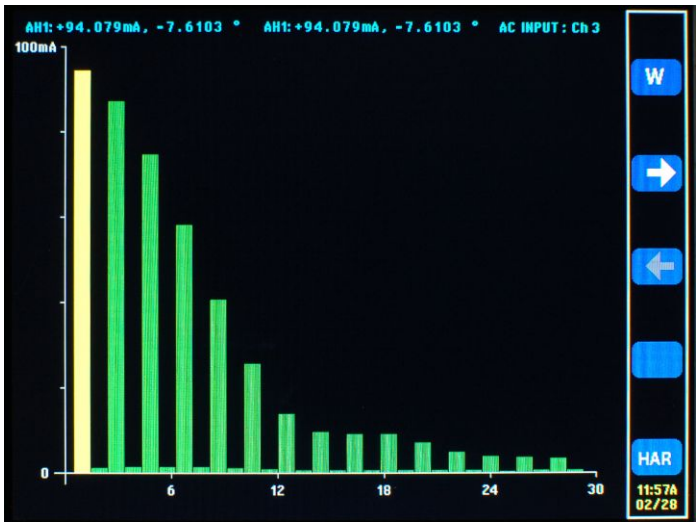
Ballast mode synchronizes measurements for highly modulated electronic ballast waveforms. In modern electronic lighting ballasts, it is often difficult to make accurate measurements because the output signals are high frequency waveforms that are heavily modulated by the power frequency. Ballast mode provides a way of locking the measurement period to the power frequency.

### Integrator mode

Integrator mode is used to provide measurements for determining energy consumption (Watt-hours, Ampere-hours, etc.). In addition, for certain parameters, average values are also available.

## Standard harmonics analysis

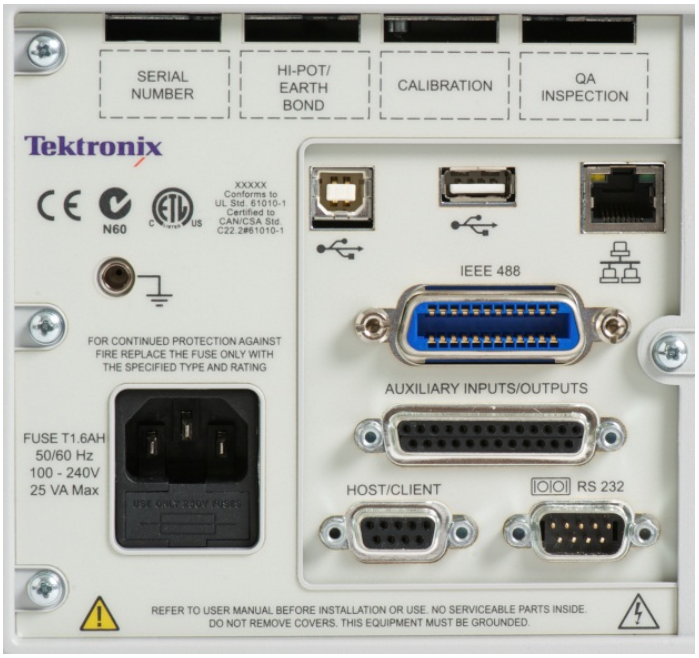
The PA4000 features harmonics analysis to the 100th harmonic as a standard feature. Harmonics, THD, and related measurements can all be analyzed simultaneously with other power parameters. Accurate measurement of harmonic amplitude, phase, and harmonic power are included, which are critical to the analysis of losses in rotating machinery.




Harmonics bar chart display mode.

## Standard communication ports

The PA4000 comes standard with USB, Ethernet, and RS-232 communication ports, plus a front-mounted USB port for data export to a flash drive. GPIB is available as a factory-installed option.




PA4000 rear panel, with communication ports

# Specifications

## Measurements

**Available measurements**

| | |
|---|---|
| $V_{RMS}$ - Volts RMS | VDF - Volts Distortion Factor |
| $A_{RMS}$ - Amps RMS | VTIF - Volts Telephone Influence Factor |
| WATT - Watts | ATHD - Amps Total Harmonic Distortion |
| VA - Volt-Amps | ADF - Amps Distortion Factor |
| VAR - Volt-Amps Reactive | ATIF - Amps Telephone Influence Factor |
| FRQ - Frequency | VF - Fundamental Volts rms |
| PF - Power factor | AF - Fundamental Amps rms |
| VPK+ - Volts peak (positive) | IMP - Impedance |
| VPK- - Volts peak (negative) | RES - Resistance |
| APK+ - Amps peak (positive) | REA - Reactance |
| APK- - Amps peak (negative) | HR - Integrator time |
| VDC - Volts DC | WHR - Watt Hours |
| ADC - Amps DC | VAH - VA Hours |
| VRMN - Volts rectified mean | VRH - VAr Hours |
| ARMN - Amps rectified mean | AHR - Amp Hours |
| VCF - Voltage crest factor | WAV - Average Watts |
| ACF - Current crest factor | PFAV - Average Power Factor |
| VTHD - Volts Total Harmonic Distortion | CVAR - Correction VArs |

**Voltage and current ranges**

| | |
|---|---|
| **Voltage Ranges** | 2000 $V_{peak}$, 1000 $V_{peak}$, 500 $V_{peak}$, 200 $V_{peak}$, 100 $V_{peak}$, 50 $V_{peak}$, 20 $V_{peak}$, 5 $V_{peak}$, 2 $V_{peak}$ |
| **Current Ranges (30 A Shunt)** | 200 $A_{peak}$, 100 $A_{peak}$, 50 $A_{peak}$, 20 $A_{peak}$, 10 $A_{peak}$, 5 $A_{peak}$, 2 $A_{peak}$, 1 $A_{peak}$, 0.5 $A_{peak}$, 0.2 $A_{peak}$, 0.1 $A_{peak}$ |
| **Current Ranges (1 A Shunt)** | 5 $A_{peak}$, 2 $A_{peak}$, 1 $A_{peak}$, 0.5 $A_{peak}$, 0.2 $A_{peak}$, 0.1 $A_{peak}$, 0.25 $A_{peak}$, 0.0125 $A_{peak}$, 0.005 $A_{peak}$, 0.0025 $A_{peak}$ |
| **Current Ranges (External Shunt)** | 3 $V_{peak}$, 1.5 $V_{peak}$, 0.75 $V_{peak}$, 0.3 $V_{peak}$, 0.15 $V_{peak}$, 0.075 $V_{peak}$, 0.03 $V_{peak}$, 0.015 $V_{peak}$, 0.0075 $V_{peak}$ |

**Measurement accuracy - voltage and current**

| | |
|---|---|
| **Voltage Accuracy, $V_{RMS}$ ( 45 Hz - 850 Hz )** | ± 0.04% of Reading ± 0.04% of Range ± 0.02 V |
| **Voltage Accuracy, $V_{RMS}$ ( 10 Hz - 45 Hz, 850 Hz - 1 MHz )** | ± 0.05% of Reading ± 0.05% of Range ± (0.02*F)% of Reading ± 0.02 V (typical) |
| **Voltage Accuracy, DC** | ± 0.05% of Reading ± 0.1% of Range ± 0.05 V |
| **Voltage Accuracy, $V_{rmn}$** | ± 0.2% of Reading ± 0.1% of Range ± 0.1 V |
| **Effect of Common Mode (Typical)** | 1000 V, 60 Hz < 10 mV<br>100 V, 100 kHz < 50 mV |
| **Current Accuracy, $A_{RMS}$ ( 45 Hz - 850 Hz )** | ± 0.04% of Reading ± 0.04% of Range ± (20 µV/$Z_{ext}$) |
| **Current Accuracy, $A_{RMS}$ ( 10 Hz - 45 Hz, 850 Hz - 1 MHz )** | ± 0.05% of Reading ± 0.05% of Range ± (0.02*F)% of Reading ± (20 µV/$Z_{ext}$) (typical) |
| **Current Accuracy, DC** | ± 0.05% of Reading ± 0.1% of Range ± (50 µV/$Z_{ext}$) |
| **Current Accuracy, $A_{RMS}$** | ± 0.2% of Reading ± 0.1% of Range ± (100 µV/$Z_{ext}$) |

**Measurement accuracy - power**

| | |
|---|---|
| **Watts Accuracy** | $(V_{RMS}$ acc. x $A_{RMS}$ x PF) ± ($A_{RMS}$ acc. x $V_{RMS}$ x PF) ± ($V_{RMS}$ x $A_{RMS}$ x cos θ -cos { θ± ($Vh1_{ph.err.}$ ± $Ah1_{ph.err.}$)}) |
| **VA Accuracy** | ($V_{RMS}$ acc. x $A_{RMS}$) ± ($A_{RMS}$ acc. x $V_{RMS}$ ) |
| **VAR Accuracy** | $\sqrt{\left(VA^2 - [W \pm Wacc.]^2\right)} - \sqrt{(VA^2 - W^2)}$ |
| **PF Accuracy** | Cos θ -cos [ θ± ( $Vh1_{ph.err}$± $Ah1_{ph.err}$)] ± 0.001 |

**Measurement accuracy - Harmonic magnitude and phase** [1]

| | |
|---|---|
| **Voltage Harmonics (45 Hz - 850 Hz) (Typical for 10 Hz to 45 Hz and 850 Hz to 1 MHz)** | ± 0.08% of Reading ± 0.08% of Range ± (0.02*F)% of Reading ± 0.02 V |
| **Voltage Harmonics Phase (45 Hz - 850 Hz) (Typical for 10 Hz to 45 Hz and 850 Hz to 1 MHz)** | 0.025 ± [ 0.005 * $V_{range}$ / $V_{reading}$ )] ± (0.1 / $V_{range}$) ± ( 0.002 *F ) |
| **Current Harmonics (45 Hz - 850 Hz) (Typical for 10 Hz to 45 Hz and 850 Hz to 1 MHz)** | ± 0.08% of Reading ± 0.08% of Range ± (0.02*F)% of Reading ± (20 µV /$Z_{ext}$) |
| **Current Harmonics Phase (45 Hz - 850 Hz) (Typical for 10 Hz to 45 Hz and 850 Hz to 1 MHz)** | 0.025 ± [0.005 * $A_{range}$ / $A_{reading}$)] ± (0.001 / $A_{range}$ * $Z_{ext}$)) ± (0.002 *F) |

## Physical characteristics

**Dimensions**

| | | |
|---|---|---|
| Height | 13.2 cm. | 5.2 in. |
| Width | 42 cm. | 16.5 in. |
| Depth | 31 cm. | 12.5 in. |

**Weight**

| | | |
|---|---|---|
| Net (without lead set) | 8.8 kg | 19.5 lb. |

**Temperature**

| | |
|---|---|
| Storage | -20 ° C to +60 ° C |
| Operating | 0 ° C to +40 ° C |

1 F is the frequency measured in kHz. In the case of harmonics, F is the harmonic frequency.

$Z_{ext}$ is the shunt impedance (0.6 Ω for 1 A shunt, 9.375 mΩ for 30 A shunt). It is assumed that the waveform measured is a sine wave.

Measurement conditions during calibration: Instrument default settings unless otherwise stated, Sine waves applied to V and I inputs, 30 minute warm-up, Temperature 23 °C ±5 °C.

# Ordering information

## PA4000 models

A PA4000 must be ordered with one of the following options:

| | |
|---|---|
| **Opt. 1CH** | One input module installed |
| **Opt. 2CH** | Two input modules installed |
| **Opt. 3CH** | Three input modules installed |
| **Opt. 4CH** | Four input modules installed |

## Standard accessories

### Accessories

| | |
|---|---|
| **--** | Voltage Lead Set (one per input module) |
| **--** | country-specific power cord |
| **063-4498-xx** | CD containing all relevant documentation and translated user manuals |
| **--** | USB Host - to - Device interface cable |
| **--** | certificate of calibration documenting traceability to National Metrology Institute(s) and ISO9001 Quality System Registration |
| **--** | Three year product warranty. |

## Instrument options

| | |
|---|---|
| **Opt. GPIB** | GPIB Interface |
| **Opt. 15V** | Power Output for External Current Transducers |
| **Language options** | No Language Options - Standard documentation CD includes user manual in English, French, German, Spanish, Japanese, Portuguese, Simplified Chinese, Traditional Chinese, Korean, and Russian. |

### Power cord options

| | |
|---|---|
| **Opt. A0** | North America power plug (115 V, 60 Hz) |
| **Opt. A1** | Universal Euro power plug (220 V, 50 Hz) |
| **Opt. A2** | United Kingdom power plug (240 V, 50 Hz) |
| **Opt. A3** | Australia power plug (240 V, 50 Hz) |
| **Opt. A4** | North America power plug (240 V, 50 Hz) |
| **Opt. A5** | Switzerland power plug (220 V, 50 Hz) |
| **Opt. A6** | Japan power plug (100 V, 110/120 V, 60 Hz) |
| **Opt. A10** | China power plug (50 Hz) |
| **Opt. A11** | India power plug (50 Hz) |
| **Opt. A12** | Brazil power plug (60 Hz) |
| **Opt. A99** | No power cord |

### Service options

| | |
|---|---|
| **Opt. C3** | Calibration Service 3 Years |
| **Opt. C5** | Calibration Service 5 Years |
| **Opt. D1** | Calibration Data Report |
| **Opt. D3** | Calibration Data Report 3 Years (with Opt. C3) |
| **Opt. D5** | Calibration Data Report 5 Years (with Opt. C5) |
| **Opt. G3** | Complete Care 3 Years (includes loaner, scheduled calibration, and more) |
| **Opt. G5** | Complete Care 5 Years (includes loaner, scheduled calibration, and more) |
| **Opt. R5** | Repair Service 5 Years (including warranty) |
| **Opt. R5DW** | Repair Service Coverage 5 Years (includes product warranty period). 5-year period starts at time of instrument purchase |

## Recommended accessories

| | |
|---|---|
| **CT-60-S** | Fixed-core current transducer, high accuracy, up to 60 A |
| **CT-200-S** | Fixed-core current transducer, high accuracy, up to 200 A |
| **CT-400-S** | Fixed-core current transducer, high accuracy, up to 400 A |
| **CT-1000-S** | Fixed-core current transducer, high accuracy, up to 1000 A |
| **CT-100-M** | Fixed-core current transducer, Hall effect, up to 100 A |
| **CT-200-M** | Fixed-core current transducer, Hall effect, up to 200 A |
| **CT-500-M** | Fixed-core current transducer, Hall effect, up to 500 A |
| **CT-1000-M** | Fixed-core current transducer, Hall effect, up to 1000 A |
| **CL200** | Current clamp, 1 A - 200 A, for Tektronix Power Analyzers |
| **CL1200** | Current clamp, 0.1 A - 1200 A, for Tektronix Power Analyzers |
| **PA-LEADSET** | Replacement lead set for Tektronix Power Analyzers (One channel lead set) |

CE

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

GPIB IEEE-488

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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Updated 10 February 2011

**For Further Information.** Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tektronix.com.



08 Apr 2013

55W-28940-0

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