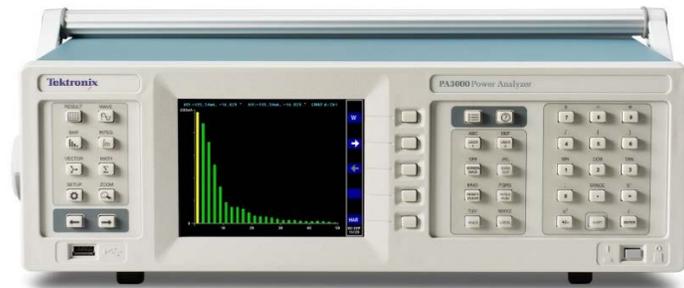## SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the Model PA3000 Power Analyzer. Specifications are the standards against which the Model PA3000 is tested. Upon leaving the factory, the Model PA3000 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23 °C, and are provided solely as useful information.

Source and measurement accuracies are specified at the Model PA3000 terminals under these conditions:

1. 23 °C ± 5 °C, < 70 percent relative humidity
2. After a one-hour warm-up period
3. A/D autozero enabled
4. Averaging set to 10
5. Calibration period: One year

MEASUREMENT CHANNELS

Voltage connections	▪ Measurements to 600 V_{rms}, DC to 1 MHz, continuous ▪ Measurements to 2000 V_{pk}, maximum crest factor of 10
30 A current connection[1]	▪ Measurements to 30 A_{rms}, DC to 1 MHz, continuous ▪ Measurements to 200 A_{pk}, maximum crest factor of 10 ▪ Measurements to 75 A_{rms} for 1 s non-repetitive
1 A current connection	▪ Measurements to 1 A_{rms}, DC to 1 MHz, continuous ▪ Measurements to 5 A_{pk}, maximum crest factor of 10 ▪ Measurements to 2 A_{rms} for 1 s non-repetitive
External current connection	▪ Measurements to 20 V_{pk}, DC to 1 MHz, continuous ▪ Measurements to 50 V_{pk} for 1 s
Analog card power supply outputs	▪ ± 15 V supply ▪ ± 15 V ± 5%, 250 mA max (protected) per analog card output

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[1] 30 A DC for 30 minutes maximum. 20 A DC indefinitely

Specifications are subject to change without notice

ACCURACY SPECIFICATIONS[2,3,4]

Current accuracy	**Accuracy A$_{rms}$ (45 Hz – 850 Hz):**[5,6,7]
	▪ **1 A shunt:** ± 0.04% reading ± 0.04% range
	▪ **30 A shunt:** ± 0.04% reading ± 0.04% range
	▪ **External shunt:** ± 0.1% reading ± 0.04% range
	Accuracy A$_{rms}$ (10 Hz – 45 Hz, 850 Hz – 1 MHz):[8,9,10]
	▪ **1 A shunt:** ± (0.05 + 2×10^{-5} × f)% reading ± 0.05% range ± 40 µA
	▪ **30 A shunt:** ± (0.05 + 2×10^{-5} × f)% reading ± 0.05% range ± 4 mA
	▪ **External shunt:** ± (0.1 + 2×10^{-5} × f)% reading ± 0.05% range ± 1.1 mV[11,12]
	Accuracy A$_{dc}$:
	▪ **1 A shunt:** ± 0.05% reading ± 0.1% range ± 100 µA
	▪ **30 A shunt:** ± 0.05% reading ± 0.1% range ± 10 mA
	▪ **External A shunt:** ± 0.1% reading ± 0.1% range ± 1.1 mV
	Ranges (peak):
	▪ **1 A shunt:** 12.5 mA, 25 mA, 50 mA, 125 mA, 250 mA, 500 mA, 1.25 A, 2.5 A, 5 A
	▪ **30 A shunt:** 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, 50 A, 100 A, 200 A
	▪ **External A shunt:** 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V, 20 V
Voltage accuracy	**Accuracy V$_{rms}$ (45 Hz – 850 Hz):**[5,7,13]
	▪ ± 0.04% reading ± 0.04% range
	Accuracy V$_{rms}$ (10 Hz – 45 Hz, 850 Hz – 1 MHz):[8,9,10]
	▪ ± (0.05 + 1×10^{-5} × f)% reading ± 0.05% range ± 20 mV
	Accuracy V$_{dc}$:
	▪ ± 0.05% reading ± 0.1% Range ± 50 mV
	Ranges (peak):
	▪ 5 V, 10 V, 20 V, 50 V, 100 V, 200 V, 500 V, 1000 V, 2000 V

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[2] Temperature coefficient: ±0.02 % of reading per °C, 0 °C to 18 °C and 28 °C to 40 °C

[3] To meet specifications in Integration Mode, the unit must be in a fixed range with autozero off

[4] External shunt impedance is ≤ 10 Ω

[5] Low Bandwidth is on for accuracy specifications < 850 Hz, if High Bandwidth is on then add 0.1 % of range to the specification

[6] If autozero is off, then add 85 µA of offset for the 1 A Shunt, 8.5 mA for the 30 A Shunt, or 360 µV/Zext for the external shunt

[7] Specifications are valid only when applicable voltage and current inputs are > 1 % of range

[8] Typical performance

[9] Signal level of the frequency source over 50 kHz must be > 25 % of range, otherwise results will show as zero

[10] High Bandwidth is on for accuracy specifications > 850 Hz

[11] External shunt limited to ≤ 100 kHz

[12] Typical Spec. Measurement should be > 75% of full scale. To optimize performance on the 50 mV range for external shunt, turn the filter on

[13] If autozero is off, then add 20 mV of offset

Specifications are subject to change without notice

SUPPLEMENTAL CHARACTERISTICS

The following specifications are supplemental characteristics that provide additional information about instrument functions and performance. These characteristics are nonwarranted specifications; they describe the typical performance of the PA3000.

MEASUREMENT CHARACTERISTICS

Voltage harmonics accuracy[14,15]	$\pm (0.08 + 2 \times 10^{-5} \times f_{hn})$% reading ± 0.08% range ± 0.02V
Voltage harmonics phase[15,16]	**With current as phase reference:** ■ $\pm 0.05° \pm (0.014 \times V_{range}/V_{reading_{hn}})° \pm (7.4 \times 10^{-4} \times f_{hn})°$ **With voltage as phase reference:** ■ $\pm 0.05° \pm (0.014 \times V_{range}/V_{reading_{hn}})° \pm (3.7 \times 10^{-4} \times f_{hn})°$
Current harmonics accuracy[14,15]	**1 A shunt:** ■ $\pm (0.08 + 2 \times 10^{-5} \times f_{hn})$% reading ± 0.08% range ± 40 µA **30 A shunt:** ■ $\pm (0.08 + 2 \times 10^{-5} \times f_{hn})$% reading ± 0.08% range ± 4 mA **External shunt:** ■ $\pm (0.08 + 2 \times 10^{-5} \times f_{hn})$% reading ± 0.08% range ± 1.1 mV
Current harmonics phase[15,16]	**With voltage as phase reference:** ■ $\pm 0.05° \pm (0.014 \times A_{range}/A_{reading_{hn}})° \pm (7.4 \times 10^{-4} \times f_{hn})°$ **With current as phase reference:** ■ $\pm 0.05° \pm (0.014 \times A_{range}/A_{reading_{hn}})° \pm (3.7 \times 10^{-4} \times f_{hn})°$
Voltage peak accuracy	$\pm (0.1 + 2 \times 10^{-5} \times f)$% reading ± 0.15% range ± 80 mV
Current peak accuracy	■ **1 A shunt:** $\pm (0.1 + 2 \times 10^{-5} \times f)$% reading ± 0.2% range ± 400 µA ■ **30 A shunt:** $\pm (0.1 + 2 \times 10^{-5} \times f)$% reading ± 0.2% range ± 30 mA ■ **External shunt:** $\pm (0.15 + 2 \times 10^{-5} \times f)$% reading ± 0.2% range ± 3 mV
Voltage accuracy V_{rmn}	$\pm (0.2 + 2.5 \times 10^{-5} \times f)$% reading ± 0.1 % range ± 0.1 V
Current accuracy I_{rmn}	■ **1 A shunt:** $\pm (0.2 + 2 \times 10^{-5} \times f)$% reading ± 0.1% range ± 200 µA ■ **30 A shunt:** $\pm (0.2 + 2 \times 10^{-5} \times f)$% reading ± 0.1% range ± 20 mA ■ **External A shunt:** $\pm (0.2 + 2 \times 10^{-5} \times f)$% reading ± 0.1% range ± 100 µV/Z_{ext}
Hour accuracy[17]	± 0.0125 %
Watts accuracy (45 Hz – 850 Hz)[18]	$\pm (V_{rms}acc \times A_{rms}) \pm (A_{rms}acc \times V_{rms})$
Watt hour accuracy	$\pm (Watt_{acc} + Hour_{acc})$
VA accuracy (45 Hz – 850 Hz)	$\pm (V_{rms}acc \times A_{rms}) \pm (A_{rms}acc \times V_{rms})$
PF accuracy	W_{acc} / VA

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[14] High Bandwidth is on for harmonic measurements > 1 kHz

[15] Harmonics are valid when the magnitude of the harmonic is > 2 % of range

[16] Specification is with High Bandwidth on. If Low Bandwidth is on add $0.0002° \times f_{hn}$ to the phase error

[17] To meet specifications in Integration Mode, the unit must be in a fixed range with autozero off

[18] Accuracy specification is for PF =1. For PF ≠ 1, see the W Accuracy equation under *Accuracy equations* in the user manual

Specifications are subject to change without notice

Frequency accuracy[19]	**0.1 Hz – 10 Hz:** ▪ 0.1 % of reading **10 Hz – 1 MHz:** ▪ 0.05 % of reading
Effect of common mode	**Voltage:** ▪ 600 V, 60 Hz < 10 mV ▪ 100 V, 100 kHz < 65 mV **Current:** ▪ 600 V, 60 Hz, 30 A shunt < 1 mA ▪ 100 V, 100 kHz, 30 A shunt < 25 mA ▪ 600 V, 60 Hz, 1 A shunt < 25 µA ▪ 100 V, 100 kHz, 1 A shunt < 500 µA ▪ 600 V, 60 Hz, external shunt < 1 mV ▪ 100 V, 100 kHz, external shunt < 20 mV
Input impedance	**Voltage:** ▪ Differential input impedance: 1 MΩ || 13 pF ▪ High and low impedance to ground: 30 pF **30 A current connections:** ▪ Shunt Impedance: 5 mΩ ▪ High and low impedance to ground: 45 pF **1 A current connections:** ▪ Shunt Impedance: 500 mΩ ▪ High and low impedance to ground: 45 pF **External current connections:** ▪ High and low impedance to ground: 45 pF ▪ External Shunt Impedance (Z_{ext}): ≤ 10 Ω
Analog inputs	**Ranges:** ▪ 10 Vdc range: ± 1 V to ± 10 V ▪ 1 Vdc range: ± 0.1 V to ± 1V **Accuracy:** ▪ ±0.2% of reading ± 0.2% of range ± 0.005 V **Sample rate:** ▪ 1000 samples per second

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[19] For steady state frequency. If frequency has changed, then allow 3x the update rate for an accurate frequency measurement. See *Update rate* in the user manual

Specifications are subject to change without notice

AVALAILABLE MEASUREMENTS[20]

V_{rms} – Volts RMS	V_{cf} – Volts crest factor[21]	PF_{av} – Average power factor
A_{rms} – Amps RMS	A_{cf} – Amps crest factor[21]	CVA_r – Correction VAr
Watt – Watts[21]	V_{thd} – Volts total harmonic distortion[21]	VAH_f – Fundamental VA hours
VA – Volt-Amps[21]	V_{df} – Volts distortion factor[21]	VA_rH_f – Fundamental VAr hours
VA_r – Reactive power[21]	V_{tif} – Volts telephone influence factor[21]	V_f – Fundamental volts rms
Freq – Frequency	A_{thd} – Amps total harmonic distortion[21]	A_f – Fundamental amps rms
PF – Power factor[21]	A_{df} – Amps distortion factor[21]	W_f – Fundamental power[21]
V_{pk+} – Volts peak (positive)	A_{tif} – Amps telephone influence factor[21]	VA_f – Fundamental apparent power[21]
V_{pk-} – Volts peak (negative)	Z – Impedance[21]	VA_{rf} – Fundamental reactive power[21]
A_{pk+} – Amps peak (positive)	R – Resistance[21]	PF_f – Fundamental power[21]
A_{pk-} – Amps peak (negative)	X – Reactance[21]	V_{rng} – Voltage range
V_{dc} – DC Volts	Hr – Hour	A_{rng} – Amps range
A_{dc} – DC Amps	WHr – Watt hours	V_{ll} – Voltage Line-to-Line
V_{rmn} – Volts rectified mean	VAHr – VA hours	V_{ln} – Voltage Line-to-Neutral
A_{rmn} – Amps rectified mean	VA_rHr – VAr hours	A_n – Neural amps
V_{cmn} – Volts corrected rectified mean	AHr – Amp hours	V Harmonics – Voltage harmonic n
A_{cmn} – Amps corrected rectified mean	W_{av} – Average watts	A Harmonics – Current harmonic n
		W Harmonics – Watts harmonic n

GENERAL SPECIFICATIONS

IEEE-488 (optional)	IEEE Std 488.1 compliant.
RS-232	- Baud rates from 9600 bps, 19200 bps (default), and 38400 bps 8 bit, No parity, 1 stop bit, hardware flow control 9 pin male D-type connector
Ethernet	- IEEE 802.3 compatible, 10Base-T - RJ-45 connector with Link and Activity indicators - TCP/IP connection on port 5025
USB device	- USB 2.0 compatible - Full speed (12 Mbits/sec)

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[20] Definitional equations available in the user manual
[21] Accuracy equations available in the user manual

Specifications are subject to change without notice

USB host	▪ USB flash drive must be formatted with FAT12, FAT16 or FAT32 file ▪ Rear panel USB does not support USB flash drives ▪ Sector size must be 512 bytes. Cluster size up to 32 kB ▪ Only Bulk Only Mass Storage (BOMS) devices which support the SCSI or AT command sets are supported ▪ 250 mA, +5 V supply per port
Auxiliary inputs/outputs	**Analog inputs:** +10 V to -10 V signal on each analog input ▪ Pin 1 – Pin 4 : Analog input 1 through Analog input 4 **Digital outputs:** Each digital output is +5 V TTL with 10 kΩ output impedance ▪ Pin 5 – Pin 8 : Digital output 1 through digital output 4 **Counter inputs:** +10 V to -10V signal on each counter input ▪ Pin 9 – Pin 10: Counter input 1 through counter input 2 ▪ Signal must be less than 0.5 V to be a zero ▪ Signal must be greater than 1.5 V to be a one ▪ Duty cycle must be between 20 % and 80 % **Ground:** ▪ Pin 11 – Pin 22: Connected to ground ▪ Pin 23 – Pin 25: Have no connection
Transducer power supply	± 15 V, Max current 250 mA per analog card
Power supply	100 V to 240 V AC, 50 Hz or 60 Hz, 120 VA maximum
Warranty	3 years
EMC	Conforms to European Union EMC Directive
Safety	NRTL listed to UL61010-1 and UL61010-2-30 Conforms to European Union Low Voltage Directive
Environment	**Altitude:** Maximum 2000 m (6562 ft) above sea level **Operating:** 0 °C to 40 °C, 70 % relative humidity up to 31 °C, Decreasing linearly to 50 % relative humidity at 40 °C **Storage:** -25 °C to 65 °C
Dielectric strength	▪ Mains supply inlet (Live + Neutral to earth): 1.5 kVAC ▪ Voltage measurement inputs : 2 kV_{pk} to earth ▪ Current measurement inputs : 2 kV_{pk} to earth
Dimensions	**With handle and feet:** 14.6 cm high × 45 cm wide × 33.5 cm deep (5.75" × 17.75" × 13.2") **Without handle and feet:** 13.2 cm high × 42 cm wide × 33.5 cm deep (5.2" × 16.5" × 13.2")
Weight	9.5 kg (20.9 lb.) – 4 channel instrument with GPIB option installed

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