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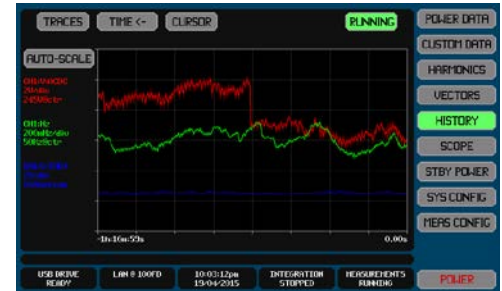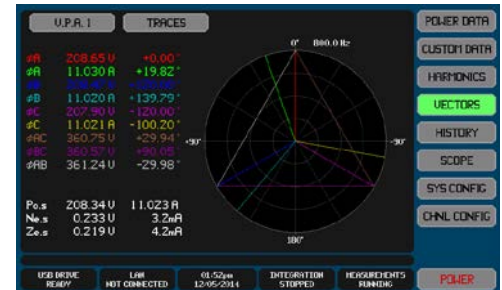
PA2640 Precision Multi-Channel Power Analyzer

PA2640 Precision Multi-Channel Power Analyzer

The PA2640 is actually three power analyzers in a single chassis with a single user interface. These are called Virtual Power Analyzers (VPA) or Channels. The PA2640 may have up to 4 channels installed, which may be any combination of channel cards and with any combination of available current input options.

Channels may be configured in any one (or none) of the 3 virtual power analyzers. Each virtual power analyzer may be configured for up to all channels installed.

Each VPA is independently configured for multi-channel wiring configuration, signal filtering, default measurement coupling, display results smoothing and significant digits, VA/VAR combine method, and efficiency grouping. VPAs may optionally be configured to be synchronized to each other.

Powertek, is the premier source of precision power testing and measuring equipment for industrial and consumer product development and manufacturing. Powertek's sophisticated technology provides companies the edge in design verification and product manufacturability. Powertek is ISO9001- 2008 certified.

History Displays

Vector Diagrams

Harmonics Displays with Limits

Oscilloscope Displays
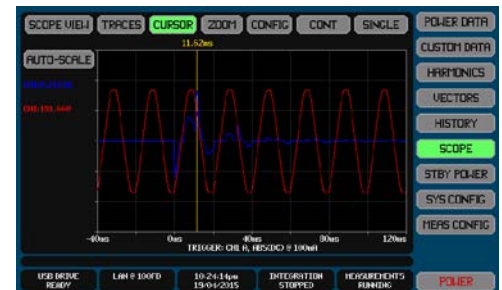
XVIEW Software

While all Powertek precision test equipment is designed to be used in a completely stand-alone manner, there are times when external tools can aid or enhance the operation of an instrument. XView software tools and drivers are designed to help easily configure an instrument from a single screen, or are used to view a complete set of measurements in a single screen. Other XView tools are designed for data collection where results can be recorded in an Excel-compatible file for post-processing, insertion into reports, or simply for archival purposes.

1 DIMENSIONAL, ENVIRONMENTAL AND POWER SUPPLY SPECIFICATIONS

1.1 DIMENSIONAL

Nominal Dimensions   137mmH x 248mmW x 284mmD (5.4" x 9.75" x 11.2") with feet not extended

Nominal Weight   3.2kg (7lb) net, 5kg (11lb) shipping

1.2 ENVIRONMENTAL

Storage Environment   -20 to 75C (-4 to 167F) (non-condensing)

Operating Environment   0 to 40C (32 to 104F), <85% RH (non-condensing), Pollution Degree 2

Operating Altitude   0 to 2000m (6560ft) ASL

1.3 POWER SUPPLY

Line Power   Installation Category II; 85-264Vrms, 45 to 65Hz, 40VA max.
Internally fused with a non-user serviceable fuse

2 ELECTRICAL CHANNEL INPUT AND ACCURACY SPECIFICATIONS

Note:

     All percentages are % of reading unless otherwise described.

2.1 INPUT ISOLATION SPECIFICATIONS

Valid for any V terminal to PA2640 chassis ground; any A terminal to PA2640 chassis ground; and between any V and any A terminal.

Impedance $>1G\Omega \;||\; <30pF$

Max. Voltage $4500V_{PK}$ max without damage
$2500V_{RMS}$ max for <1s without damage
$1000V_{RMS}$ max continuous rated working voltage (CAT I/II)
$600V_{RMS}$ max continuous rated working voltage (CAT III)
$300V_{RMS}$ max continuous rated working voltage (CAT IV)
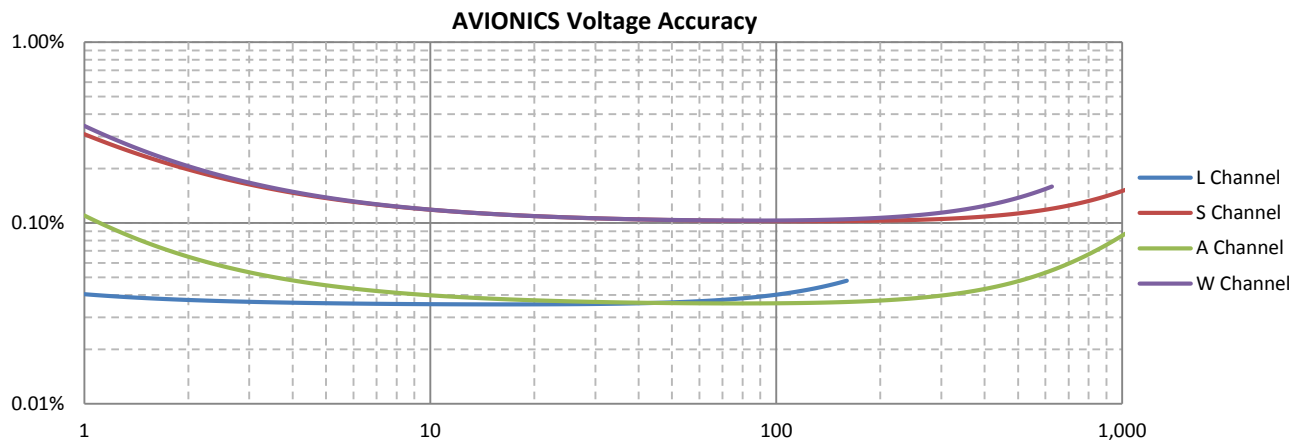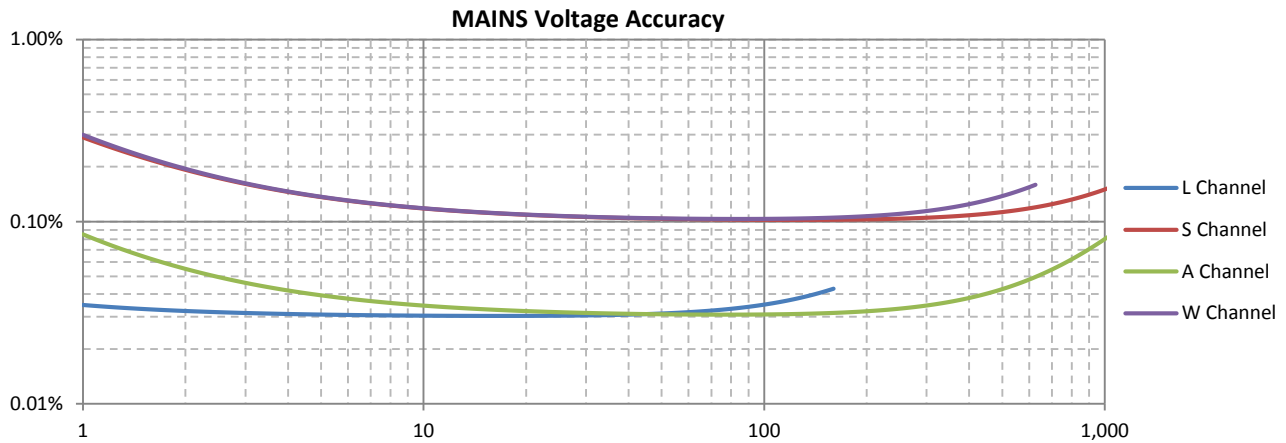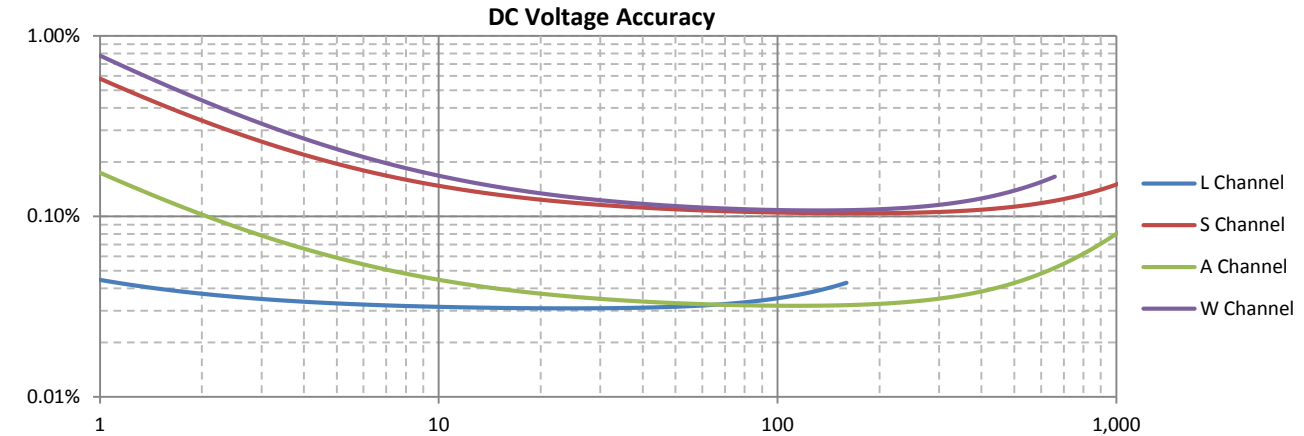
2.2 VOLTAGE MEASUREMENT SPECIFICATIONS

The specifications for voltage are independent of the current input option installed in the respective channel.
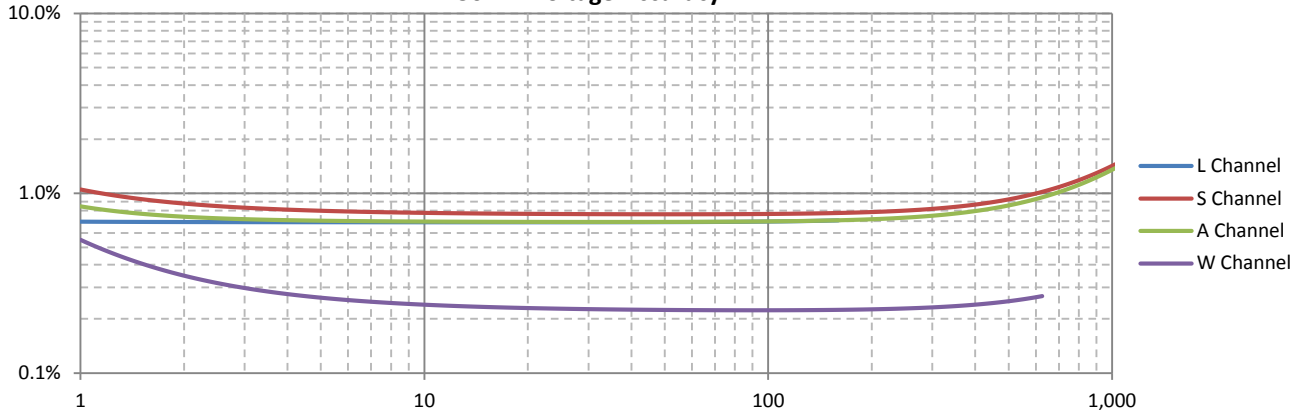
2.2.1 VOLTAGE INPUT CAPABILITY AND CHARACTERISTICS

Specification		S Channel Type	A Channel Type	L Channel Type	W Channel Type
No Damage Voltage Range	<1ms	$<3000V_{RMS}$ and V_{PK}		$<500V_{RMS}$ and $3000V_{PK}$	$<3000V_{RMS}$ and V_{PK}
	<100ms	$<2000V_{RMS}$		$<300V_{RMS}$	$<1500V_{RMS}$
	<5s	$<1500V_{RMS}$		$<250V_{RMS}$	$<1000V_{RMS}$
	Continuous PA2640	$<1000V_{RMS}$		$<160V_{RMS}$	$<650V_{RMS}$
	Unpowered	As above			
Measurable Voltage Range		$<1803V_{RMS}$ and V_{PK}		$<182.3V_{RMS}$ and V_{PK}	$<1803V_{RMS}$ and V_{PK}
Specified Voltage Range		$<1000V_{RMS}$ and $<1750V_{PK}$		$<160V_{RMS}$ and $<175V_{PK}$	$<650V_{RMS}$ and $<1750V_{PK}$
Impedance Burden		$1.201M\Omega \pm 0.25\%$		$121k\Omega \pm 0.25\%$	$399.5k\Omega \pm 0.25\%$
3dB Bandwidth (typical)		900kHz			3MHz

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2.2.2 VOLTAGE MEASUREMENT ACCURACY

The charts below show guaranteed maximum voltage errors for DC, MAINS, AVIONICS, and 50kHz throughout a 1V to 1000V range of applied voltages expressed as % of reading and are valid within ±5C of the calibration temperature (add 0.005% per C beyond this) and where no significant common-mode is present. Following the charts is a table which can be used to calculate the guaranteed accuracies for applications other than shown in the charts and also for the computation of numerical errors.

DC Voltage Accuracy

MAINS Voltage Accuracy

AVIONICS Voltage Accuracy

50kHz Voltage Accuracy

Chart: 50kHz Voltage Accuracy. Y-axis from 0.1% to 10.0%, X-axis from 1 to 1,000. Curves: L Channel, S Channel, A Channel, W Channel.

2.2.2.1   PRIMARY VOLTAGE MEASUREMENT ACCURACY TABLE

Add relevant errors from the table below for the maximum error in primary voltage measurements (e.g. DC, AC, AC+DC, Rectified, Peak, Valley, Peak-Valley).

MAXIMUM SCALING ERRORS				
Apply to all results as shown below as a percentage of the reading If signal contains significant levels at multiple frequencies, apply to each level & frequency				
Specification		**S Channel Type**	**A Channel Type**	**L Channel Type**	**W Channel Type**
Base Scaling Error Apply to all results		0.1%	0.03%		0.1% (0.2% if 2ms LF/PERIOD)
Frequency Dependent Scaling Error Apply to all results other than DC or MAINS	AVIONICS	None	0.005%		None
	LF or VLF	0.01%			0.05%
	<10kHz	$F*0.005\%$			$F*0.002\%$
	10k-40kHz	$0.05\%+(F-10)*0.012\%$			
	40k-100kHz	$0.41\%+(F-40)*0.025\%$			$0.08\%+(F-40)*0.004\%$
	100k-1MHz	Typically $(F/1000)^2*100\%$			$0.32\%+(F-100)*0.013\%$
	>1MHz	Not specified			Typically $(F/3500)^2*100\%$
Self-Heating Scaling Error Apply to all results (only significant at higher voltages) 1 minute nominal time constant		$0.05\%*(V_{AC+DC}/1000)^2$		$0.5\%*(V_{AC+DC}/1000)^2$	$0.15\%*(V_{AC+DC}/1000)^2$
Temperature Scaling Error Apply to all results if outside of ±5C from calibration temperature		0.005% per C outside of ±5C from calibration temperature			
Bandwidth Limit Scaling Error Apply if using USER bandwidth setting		$10\%*(F/F_{BW})^2$, unspecified for $F > 0.3*F_{BW}$			
MAXIMUM FLOOR ERRORS				
Apply to all results as shown below in Volts (generally only significant at low input levels)				
Specification		**S Channel Type**	**A Channel Type**	**L Channel Type**	**W Channel Type**
Base Floor Error Apply to all results		1.8mV	450µV	45µV	1.8mV
DC Floor Error Apply to DC and RECTIFIED results Apply to AC+DC results after multiplying by V_{DC}/V_{AC+DC}		3mV	1mV	100µV	5mV
AC Floor Error Apply to AC, AC+DC, and RECTIFIED results	MAINS, LF, VLF & F_{BW}≤10kHz	$100µV/V_{RDG}$	$100µV/V_{RDG}$	$4µV/V_{RDG}$	$200µV/V_{RDG}$
	AVIONICS & F_{BW}≤50kHz	$300µV/V_{RDG}$	$300µV/V_{RDG}$	$8µV/V_{RDG}$	$650µV/V_{RDG}$
	Otherwise	$1.1mV/V_{RDG}$	$1.1mV/V_{RDG}$	$11µV/V_{RDG}$	$1.5mV/V_{RDG}$
Peak Floor Error Apply to PK, VLY and PK-VLY results	MAINS, LF, VLF & F_{BW}≤10kHz	40mV	40mV	8mV	60mV
	AVIONICS & F_{BW}≤50kHz	75mV	75mV	11mV	125mV
	Otherwise	125mV	125mV	17mV	175mV
Common Mode Error Apply to AC, AC+DC, and RECTIFIED results Apply using voltage on V LO terminal relative to chassis ground. Error has 90° phase shift to common-mode voltage		1µV per V.Hz (11.5mV@230V/50Hz)		100nV per V.Hz (1.15mV@230V/50Hz)	700nV per V.Hz (8.05mV@230V/50Hz)
Adjacent Channel Error Apply to AC, AC+DC, and RECTIFIED results Apply using adjacent channel A LO or V LO terminal voltage relative to chassis ground. Error has 90° phase shift to adjacent channel voltage		300nV per V.Hz (3.45mV@230V/50Hz)		30nV per V.Hz (345µV@230V/50Hz)	210nV per V.Hz (2.415mV@230V/50Hz)

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2.2.2.2 SECONDARY VOLTAGE MEASUREMENT ACCURACY TABLE

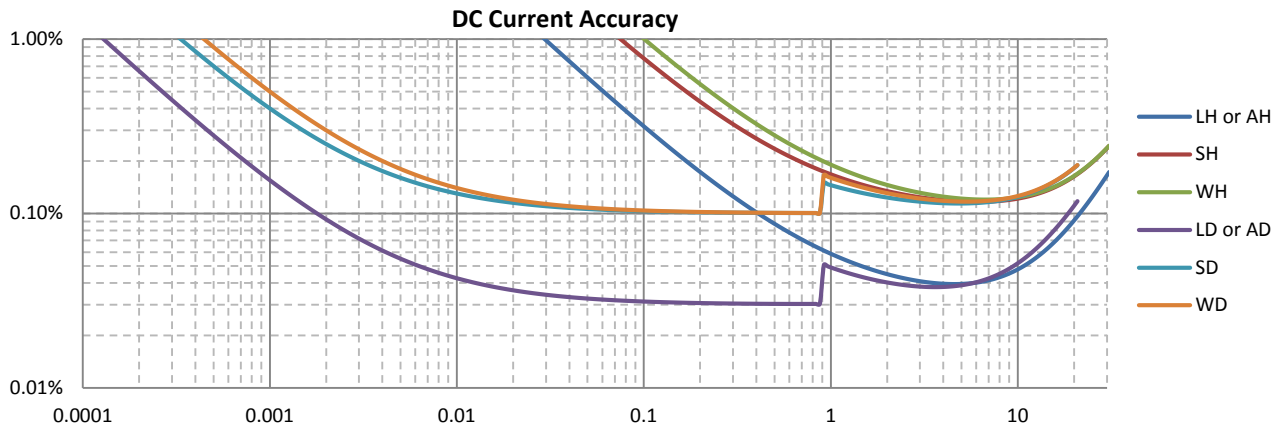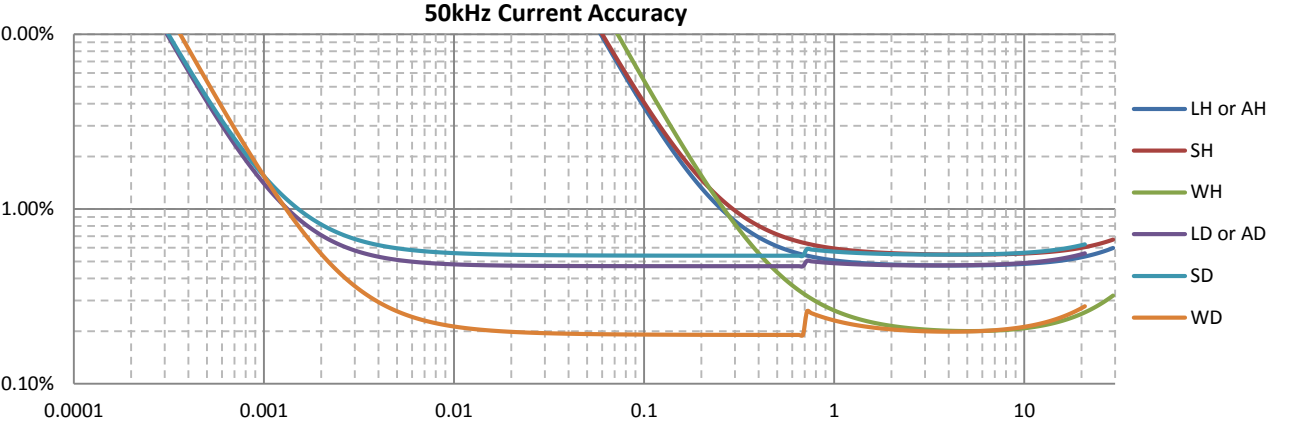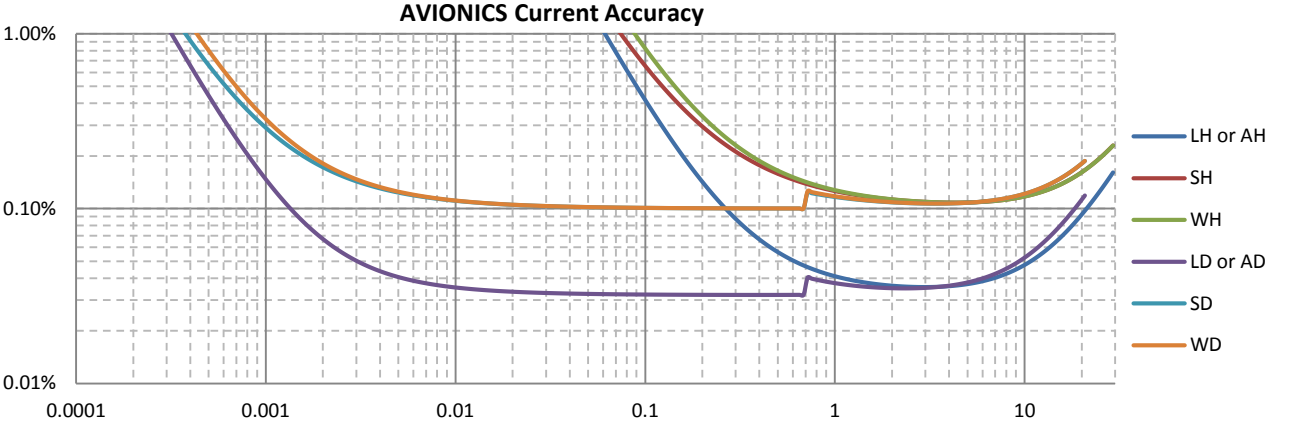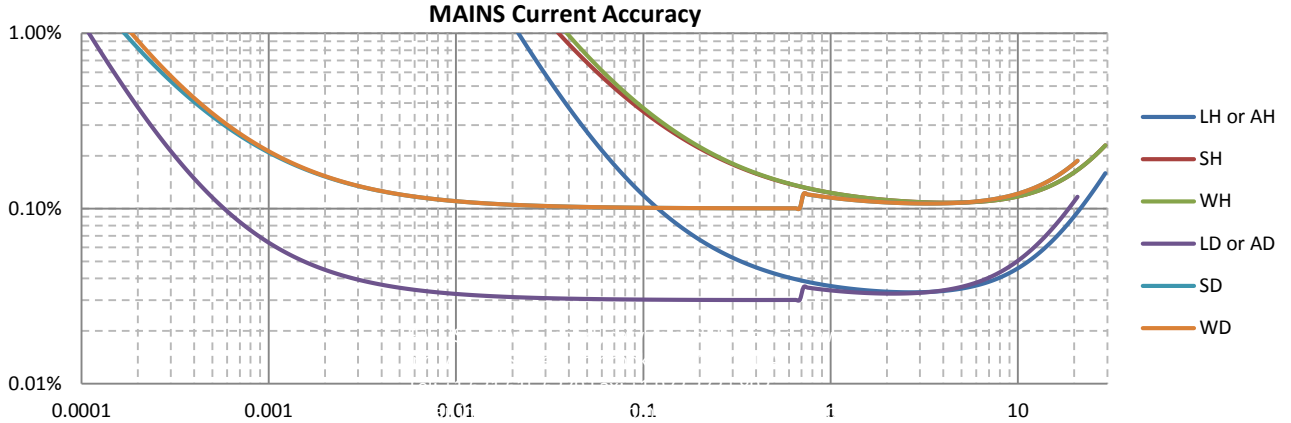| Specification	S Channel Type	A Channel Type	L Channel Type	W Channel Type
Crest Factor Error	(Total Floor Error from preceding table for PK results) / V_{AC}			
Form Factor Error	(Total Floor Error from preceding table for AC+DC results) / $V_{RECTIFIED}$			
Inter-Channel Error For 120° between equal amplitudes	(Relevant Voltage Errors from preceding table at the inter-channel voltage) + 0.0015%*F			
Harmonic or Spectrum Error	AC Voltage Errors from preceding table at V and F of the harmonic or spectrum point + $(H/N)^2$*0.3% of reading + (if not fundamental) from below using the frequency of the harmonic or spectrum point			
<10kHz	0.01% of V_{AC+DC}	0.006% of V_{AC+DC}		0.015% of V_{AC+DC}
10k-115kHz	0.05% of V_{AC+DC}			0.03% of V_{AC+DC}
115k-435kHz	Not Available			0.08% of V_{AC+DC}
Inter-Channel Fundamental Phase Error	0.02°+0.15°*F			0.01°+0.07°*F
Harmonic-Fundamental Phase Error (typical, BANDWIDTH configured as UNFILTERED)	0.02°+0.1°*F+0.001°*H			0.02°+0.03°*F+0.001°*H
%THD Error Errors shown are all expressed in %THD units	$(0.005+0.000025*N)$*%THD+0.00005*N*$\sqrt{N}$ + from below using the frequency of highest included harmonic			
<10kHz	0.025+1.25/V_{AC}	0.015+1/V_{AC}	0.015+0.2/V_{AC}	0.03+1.5/V_{AC}
10k-115kHz	0.15+3.5/V_{AC}		0.15+0.35/V_{AC}	0.06+4/V_{AC}
115k-435kHz	Not Available			0.15+4/V_{AC}

2.3 CURRENT MEASUREMENT SPECIFICATIONS
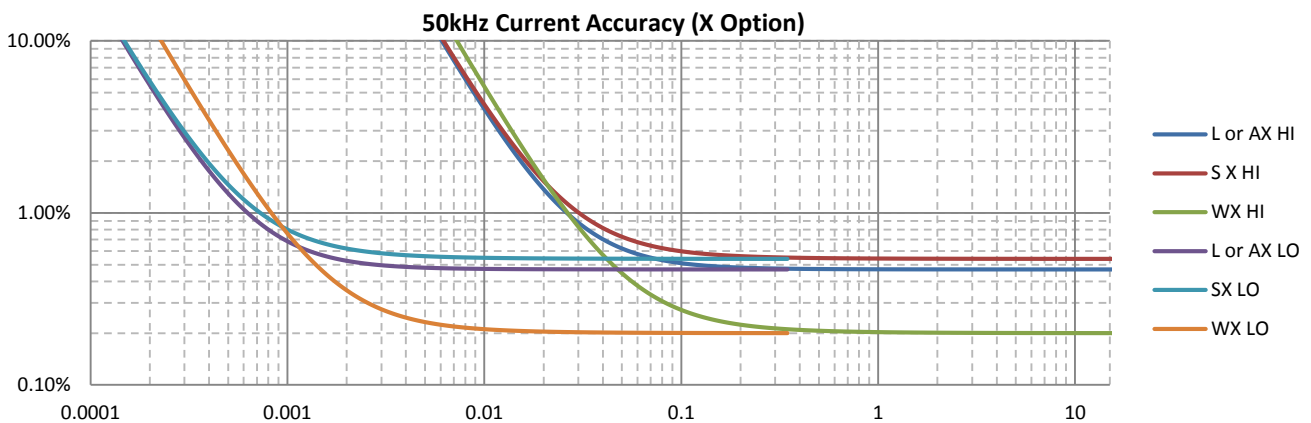
2.3.1 CURRENT INPUT CAPABILITY AND CHARACTERISTICS
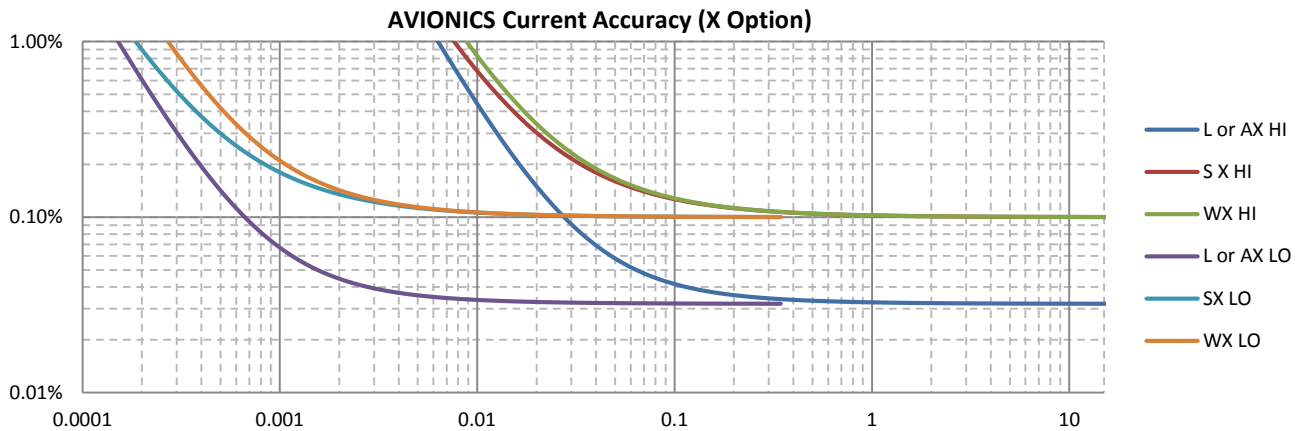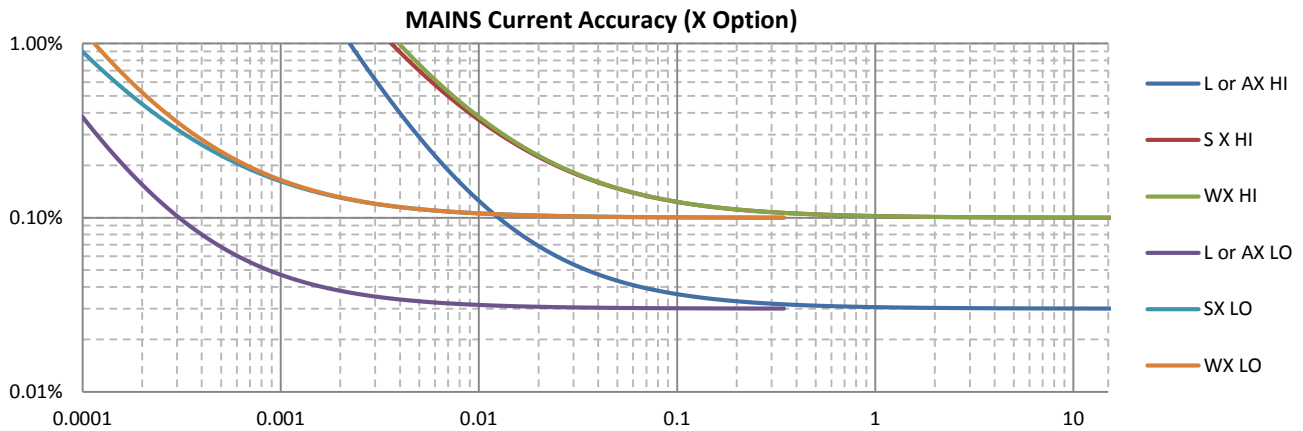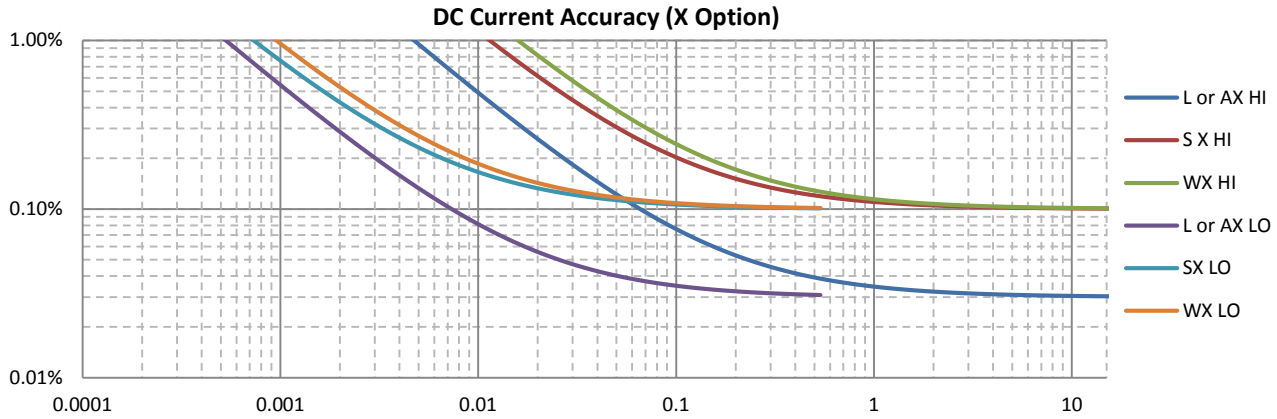
Specification	Channel Type	Option H	Option D HI Range or Auto-Range when on HI Range	Option D LO Range or Auto-Range when on LO Range	Option X HI Range	Option X LO Range
No Damage Current Range <8ms	All	<200A_{RMS} and <300A_{PK}	<150A_{RMS} and <250A_{PK}	<60A_{RMS} and <150A_{PK}	<200V_{RMS} and <300V_{PK}	<20V_{RMS} and <30V_{PK}
<40ms	All	<75A_{RMS}	<50A_{RMS}	<40A_{RMS}	<50V_{RMS}	<10V_{RMS}
<1s	All	<50A_{RMS}	<30A_{RMS}	<5A_{RMS}	<30V_{RMS}	<5V_{RMS}
Continuous	All	<30A_{RMS}	<20A_{RMS}	<2A_{RMS}	<25V_{RMS} and V_{PK}	<5V_{RMS} and V_{PK}
PA2640 Unpowered	All	As Above	<2A_{RMS} and <150A_{PK}		<25V_{RMS} and <300V_{PK}	
Measurable Current Range	All	<225A_{RMS} and A_{PK}	<150A_{RMS} and A_{PK}	<1.02A_{RMS} and A_{PK}	<23.1V_{RMS} and V_{PK}	<0.576V_{RMS} and V_{PK}
Specified Current Range	All	<30A_{RMS} and <200A_{PK}	<20A_{RMS} and <140A_{PK}	<1A_{RMS} and A_{PK}	<15V_{RMS} and <20V_{PK}	<0.55V_{RMS} and V_{PK}
Impedance Burden	All	2.5mΩ to 7mΩ	4mΩ to 12mΩ	0.562Ω ± 0.75%	20.5kΩ ± 0.25%	10.25kΩ ± 0.25%
3dB Bandwidth (typical)	S, A or L	1.25MHz				
	W	5MHz			3MHz	

2.3.2 CURRENT MEASUREMENT ACCURACY

The charts below show guaranteed maximum current errors for DC, MAINS, AVIONICS, and 50kHz throughout a 100µA to 30A range of applied currents expressed as % of reading and are valid within ±5C of the calibration temperature (add 0.005% per C beyond this) and where no significant common-mode is present. Following the charts is a table which can be used to calculate the guaranteed accuracies for applications other than shown in the charts and also for the computation of numerical errors.

DC Current Accuracy

Legend: LH or AH; SH; WH; LD or AD; SD; WD

Y-axis: 1.00%, 0.10%, 0.01%
X-axis: 0.0001, 0.001, 0.01, 0.1, 1, 10

MAINS Current Accuracy

Legend: LH or AH, SH, WH, LD or AD, SD, WD

AVIONICS Current Accuracy

Legend: LH or AH, SH, WH, LD or AD, SD, WD

50kHz Current Accuracy

Legend: LH or AH, SH, WH, LD or AD, SD, WD

DC Current Accuracy (X Option)

Legend:
- L or AX HI
- S X HI
- WX HI
- L or AX LO
- SX LO
- WX LO

MAINS Current Accuracy (X Option)

Legend:
- L or AX HI
- S X HI
- WX HI
- L or AX LO
- SX LO
- WX LO

AVIONICS Current Accuracy (X Option)

Legend:
- L or AX HI
- S X HI
- WX HI
- L or AX LO
- SX LO
- WX LO

50kHz Current Accuracy (X Option)

Legend:
- L or AX HI
- S X HI
- WX HI
- L or AX LO
- SX LO
- WX LO

2.3.2.1 PRIMARY CURRENT MEASUREMENT ACCURACY TABLE

Add relevant errors from the table below for the maximum error in primary current measurements (e.g. DC, AC, AC+DC, Rectified, Peak, Valley, Peak-Valley).

MAXIMUM SCALING ERRORS						
Apply to all results as shown below as a percentage of the reading If signal contains significant levels at multiple frequencies, apply to each level & frequency						
Specification	**Channel Type**	**Option H**	**Option D HI Range**	**Option D LO Range**	**Option X HI Range**	**Option X LO Range**
Base Scaling Error Apply to all results	A or L	0.03%				
	S or W	0.1% (0.2% if 2ms LF/PERIOD)				
Frequency Dependent Scaling Error Apply to all results other than DC or MAINS	LF or VLF — S, A or L	0.01%				
	LF or VLF — W	0.05%				
	AVIONICS — A or L	0.002%				
	AVIONICS — S or W	None				
	<10kHz — S, A or L	F*0.003%				
	<10kHz — W	F*0.0015%				
	10k-40kHz — S, A or L	0.03%+(F-10)*0.007%				
	10k-40kHz — W	F*0.0015%				
	40k-100kHz — S, A or L	0.24%+(F-40)*0.02%				
	40k-100kHz — W	0.06%+(F-40)*0.003%			0.06%+(F-40)*0.004%	
	100k-1MHz — S, A or L	Typically (F/1250)²*100%				
	100k-1MHz — W	0.24%+(F-100)*0.012%			0.3%+(F-100)*0.015%	
	>1MHz — W	Typically (F/5000)²*100%			Typically (F/3000)²*100%	
Self-Heating Scaling Error Apply to all results (only significant at higher currents) 3 minute nominal time constant	All	$0.00015\%*A_{AC+DC}^2$	$0.0002\%*A_{AC+DC}^2$	None		
Temperature Scaling Error Apply to all results if outside of ±5C from calibration temperature	All	0.005% per C outside of ±5C from calibration temperature				
Bandwidth Limit Scaling Error Apply if using USER bandwidth setting	All	$10\%*(F/F_{BW})^2$, unspecified above $0.3*F_{BW}$				

MAXIMUM FLOOR ERRORS						
Apply to all results as shown below in Amps (generally only significant at low input levels)						
Specification	**Channel Type**	**Option H**	**Option D HI Range**	**Option D LO Range**	**Option X HI Range**	**Option X LO Range**
Base Floor Error Apply to all results	A or L	56μA	38μA	250nA	6μV	150nV
	S or W	225μA	150μA	1μA	23μV	600nV
DC Floor Error Apply to DC and RECTIFIED results Apply to AC+DC results after multiplying by A_{DC}/A_{AC+DC}	A or L	0.23mA	0.15mA	1μA	40μV	5μV
	S	0.45mA	0.3mA	2μA	80μV	6μV
	W	0.68mA	0.45mA	3μA	120μV	8μV
AC Floor Error Apply to AC, AC+DC, and RECTIFIED results	MAINS, LF, VLF & $F_{BW}\leq10kHz$ — S, A or L	$3.3\mu A/A_{RDG}$	$1.5\mu A/A_{RDG}$	$90pA/A_{RDG}$	$35nV/A_{RDG}$	$20pV/A_{RDG}$
	MAINS, LF, VLF & $F_{BW}\leq10kHz$ — W	$5\mu A/A_{RDG}$	$2.5\mu A/A_{RDG}$	$125pA/A_{RDG}$	$50nV/A_{RDG}$	$50pV/A_{RDG}$
	AVIONICS & $F_{BW}\leq50kHz$ — S, A or L	$33\mu A/A_{RDG}$	$15\mu A/A_{RDG}$	$0.9nA/A_{RDG}$	$350nV/A_{RDG}$	$200pV/A_{RDG}$
	AVIONICS & $F_{BW}\leq50kHz$ — W	$50\mu A/A_{RDG}$	$25\mu A/A_{RDG}$	$1.25nA/A_{RDG}$	$500nV/A_{RDG}$	$500pV/A_{RDG}$
	Otherwise — S, A or L	$330\mu A/A_{RDG}$	$150\mu A/A_{RDG}$	$9nA/A_{RDG}$	$3.5\mu V/A_{RDG}$	$2nV/A_{RDG}$
	Otherwise — W	$500\mu A/A_{RDG}$	$250\mu A/A_{RDG}$	$12.5nA/A_{RDG}$	$5\mu V/A_{RDG}$	$5nV/A_{RDG}$
Peak Floor Error Apply to PK, VLY and PK-VLY results	MAINS, LF, VLF & $F_{BW}\leq10kHz$ — S, A or L	8mA	5mA	40μA	0.75mV	25μV
	MAINS, LF, VLF & $F_{BW}\leq10kHz$ — W	10mA	6.5mA	50μA	0.9mV	30μV
	AVIONICS & $F_{BW}\leq50kHz$ — S, A or L	25mA	17mA	125μA	2.5mV	65μV
	AVIONICS & $F_{BW}\leq50kHz$ — W	30mA	20mA	150μA	3mV	80μV
	Otherwise — S, A or L	75mA	50mA	400μA	7.5mV	200μV
	Otherwise — W	90mA	60mA	500μA	10mV	250μV
Common Mode Error Apply to all results Apply using voltage on A LO terminal relative to chassis ground. Error has 90° phase shift to common-mode voltage	All	500pA per V.Hz (5.75μA@230V/50Hz)	400pA per V.Hz (4.6μA@230V/50Hz)	20pA per V.Hz (0.23μA@230V/50Hz)	15nV per V.Hz (0.172mV@230V/50Hz)	0.5nV per V.Hz (5.75μV@230V/50Hz)
Adjacent Channel Error Apply to all results Apply using adjacent channel A LO or V LO terminal voltage relative to chassis ground. Error has 90° phase shift to adjacent channel voltage	All	150pA per V.Hz (1.725μA@230V/50Hz)	120pA per V.Hz (1.38μA@230V/50Hz)	7pA per V.Hz (80.5nA@230V/50Hz)	7nV per V.Hz (80.5μV@230V/50Hz)	0.2nV per V.Hz (2.3μV@230V/50Hz)

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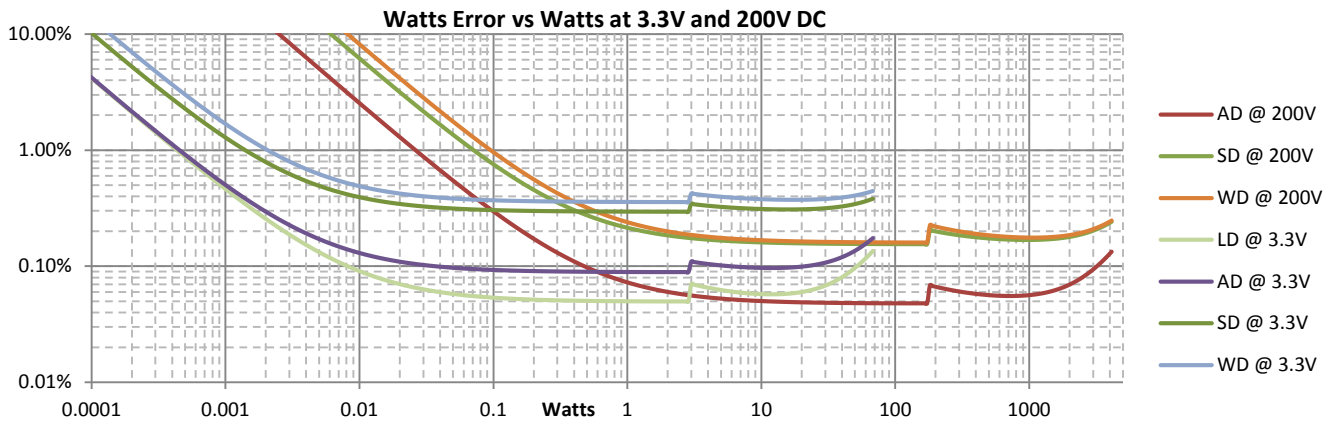Email info@powertekus.com www.powertekus.com

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2.3.2.2 SECONDARY CURRENT MEASUREMENT ACCURACY TABLE

Specification	Channel Type	Option H	Option D HI Range	Option D LO Range	Option X HI Range	Option X LO Range
Crest Factor Error	All	(Total Current Floor Error from preceding table for PK results) / A_{AC}				
Form Factor Error	All	(Total Current Floor Error from preceding table for AC+DC results) / $A_{RECTIFIED}$				
Multi-Channel Error For similar current level and phase in each phase.	A_N (2ø3w)	All	Relevant Current Errors from preceding table for $A_{øA}$ + Relevant Current Errors from preceding table for $A_{øB}$ + 0.0005% of $(A_{øA} + A_{øB})*F$			
	$A_{øC}$ (3ø3w 2ch)	All	Relevant Current Errors from preceding table for $A_{øA}$ + Relevant Current Errors from preceding table for $A_{øB}$ + 0.0015% of $(A_{øA} + A_{øB})*F$			
	A_N (3ø4w)	All	Relevant Current Errors from preceding table for $A_{øA}$ + Relevant Current Errors from preceding table for $A_{øB}$ + Relevant Current Errors from preceding table for $A_{øC}$ + 0.0015% of $(A_{øA} + A_{øB} + A_{øC})*F$			
Harmonic or Spectrum Error		All	AC Current Errors from preceding table at A and F of the harmonic or spectrum point + $(H/N)^2*0.3\%$ of reading + (if not fundamental) from below using the frequency of the harmonic or spectrum point			
	<10kHz	A or L	0.006% of A_{AC+DC}			
	10k-115kHz		0.05% of A_{AC+DC}			
	<10kHz	S	0.01% of A_{AC+DC}			
	10k-115kHz		0.05% of A_{AC+DC}			
	<10kHz	W	0.015% of A_{AC+DC}			
	10k-115kHz		0.03% of A_{AC+DC}			
	115k-435kHz		0.08% of A_{AC+DC}			
Current-Voltage Fundamental Phase Error	S, A or L	0.005° + 0.015°*F				
	W	0.005° + 0.007°*F				
Harmonic-Fundamental Phase Error (typical, BANDWIDTH configured as UNFILTERED)	S, A or L	0.02°+0.1°*F+0.001°*H				
	W	0.02°+0.03°*F+0.001°*H				
%THD Error Errors shown are all expressed in %THD units.		All	$(0.005+0.000025*N)*\%THD+0.00005*N*\sqrt{N}$ + from below using the frequency of highest included harmonic			
	<10kHz	A or L	0.015+0.2/A_{AC}	0.015+0.15/A_{AC}	0.015+0.001/A_{AC}	0.015+0.025/A_{AC}	0.015+0.0006/A_{AC}
	10k-115kHz		0.15+2/A_{AC}	0.15+1.5/A_{AC}	0.15+0.01/A_{AC}	0.15+0.25/A_{AC}	0.15+0.006/A_{AC}
	<10kHz	S	0.025+0.2/A_{AC}	0.025+0.15/A_{AC}	0.025+0.001/A_{AC}	0.025+0.025/A_{AC}	0.025+0.0006/A_{AC}
	10k-115kHz		0.15+2/A_{AC}	0.15+1.5/A_{AC}	0.15+0.01/A_{AC}	0.15+0.25/A_{AC}	0.15+0.006/A_{AC}
	<10kHz	W	0.03+0.25/A_{AC}	0.03+0.18/A_{AC}	0.03+0.0012/A_{AC}	0.03+0.03/A_{AC}	0.03+0.001/A_{AC}
	10k-115kHz		0.06+2.5/A_{AC}	0.06+1.8/A_{AC}	0.06+0.012/A_{AC}	0.06+0.3/A_{AC}	0.06+0.01/A_{AC}
	115k-435kHz		0.15+2.5/A_{AC}	0.15+1.8/A_{AC}	0.15+0.012/A_{AC}	0.15+0.3/A_{AC}	0.15+0.01/A_{AC}

2.4 WATTS, VAR AND VA MEASUREMENT SPECIFICATIONS

The charts below show guaranteed maximum Watts errors for DC, MAINS, AVIONICS, and 50kHz from 100µW up to the highest available using a D option current measurement (H and X option current accuracies are similar within their respective range of currents and are not shown for clarity), expressed as % of Watts reading and are valid within ±5C of the calibration temperature (add 0.005% per C beyond this) and where no significant common-mode is present. Following the charts is a table which can be used to calculate the guaranteed accuracies for applications other than shown in the charts and also for the computation of numerical errors.

Watts Error vs Watts at 3.3V and 200V DC

Legend: AD @ 200V, SD @ 200V, WD @ 200V, LD @ 3.3V, AD @ 3.3V, SD @ 3.3V, WD @ 3.3V

Watts Error vs Watts at 115V and 240V MAINS or AVIONICS (PF=1)

SD and WD plots are indistinguishable
Add 0.005% to AD plots for AVIONICS

Legend:
- AD @ 240V
- SD @ 240V
- WD @ 240V
- AD @ 115V
- SD @ 115V
- WD @ 115V
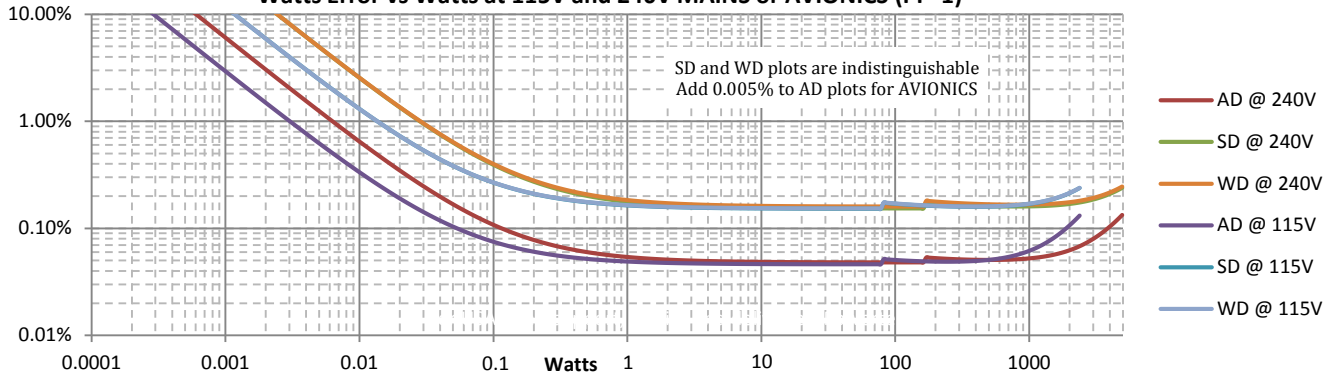
Watts Error vs Watts at 115V and 240V 50kHz(PF=1)

Legend:
- AD @ 240V
- SD @ 240V
- WD @ 240V
- AD @ 115V
- SD @ 115V
- WD @ 115V
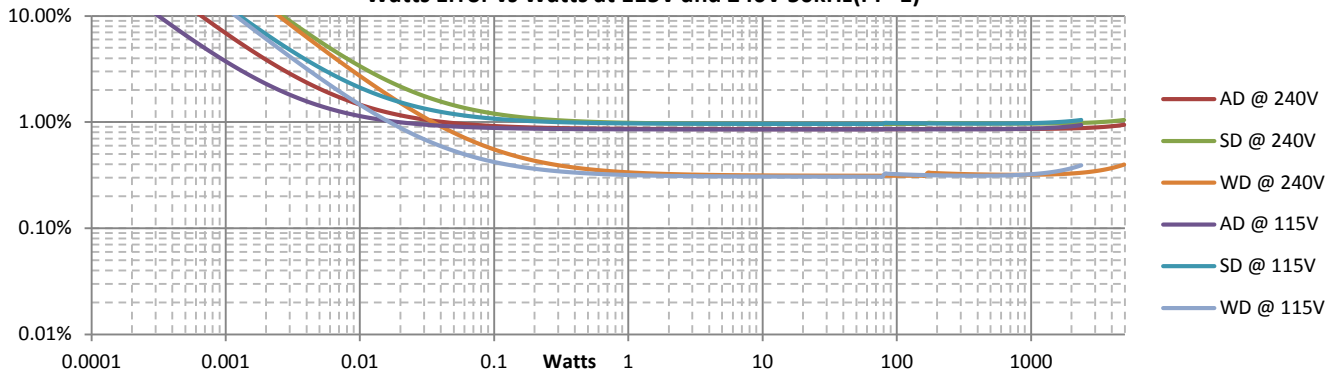
Watts Error vs Frequency @ 240V,1A (PF=0.3 and 1), D or H options

Legend:
- A (PF=1)
- S (PF=1)
- W (PF=1)
- A (PF=0.3)
- S (PF=0.3)
- W (PF=0.3)
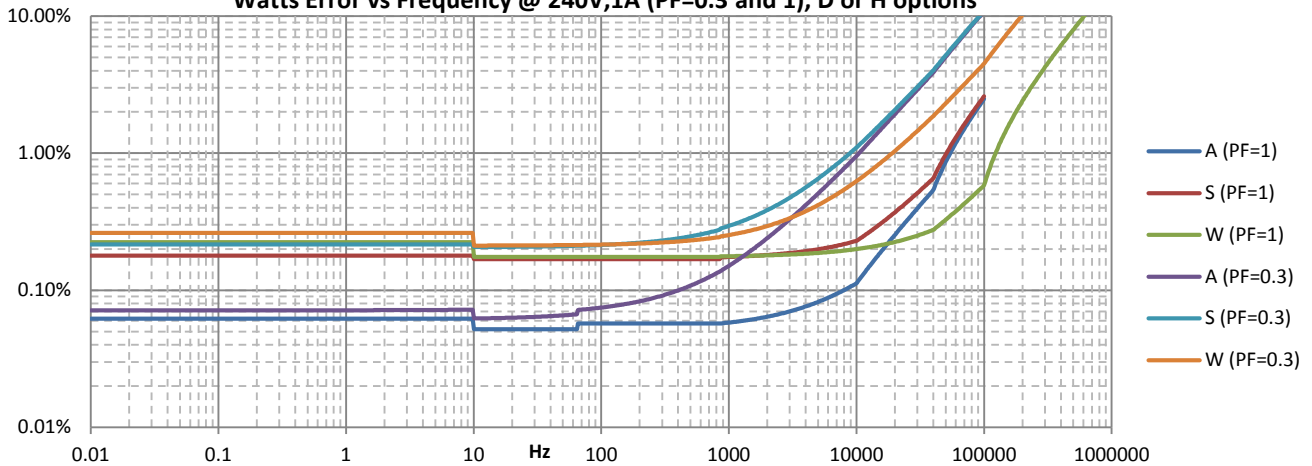
2.4.1 WATTS, VAR AND VA MEASUREMENT SPECIFICATIONS

2.4.1.1 PRIMARY WATTS, VAR AND VA MEASUREMENT ACCURACY TABLE

Add relevant errors from the table below for the maximum error in all Watts, VA and VAR measurements except harmonic Watts. Note that by definition DC Watts and DC VA are identical, and DC VAR is zero.

MAXIMUM SCALING ERRORS						
Apply to all results as shown below as a percentage of the reading If signal contains significant levels at multiple frequencies, apply to each level & frequency						
Specification	**Channel Type**	**Option H**	**Option D HI Range**	**Option D LO Range**	**Option X HI Range**	**Option X LO Range**
Base Scaling Error Apply to all results	A or L	0.045%				
	S or W	0.15% (0.3% if 2ms LF/PERIOD)				
Frequency Dependent Scaling Error Apply to AC component of all results other than DC or MAINS	LF or VLF — S, A or L	0.01%				
	LF or VLF — W	0.05%				
	AVIONICS — A or L	0.005%				
	AVIONICS — S or W	None				
	<10kHz — S, A or L	F*0.006%				
	<10kHz — W	F*0.0025%				
	10k-40kHz — S, A or L	0.06%+(F-10)*0.014%				
	10k-40kHz — W	F*0.0025%				
	40k-100kHz — S, A or L	0.48%+(F-40)*0.032%				
	40k-100kHz — W	0.1%+(F-40)*0.005%			0.1%+(F-40)*0.0055%	
	100k-1MHz — S, A or L	Typically $(F/1100)^2$*150%				
	100k-1MHz — W	0.4%+(F-100)*0.018%			0.43%+(F-100)*0.02%	
	>1MHz — W	Typically $(F/5000)^2$*150%			Typically $(F/3000)^2$*150%	
Self-Heating Scaling Error Apply as % of Power reading to all results using voltage and current Self-Heating Errors from previous tables	All	Add Voltage and Current Self-Heating Errors				
Temperature Scaling Error Apply to all results if outside of ±5C from calibration temperature	All	0.005% per C outside of ±5C from calibration temperature				
Bandwidth Limit Scaling Error Apply to AC component of all results if using USER bandwidth setting	All	$20\%*(F/F_{BW})^2$, unspecified above $0.3*F_{BW}$				
MAXIMUM FLOOR ERRORS						
Apply to all results as shown below in Watts, VA or VAR as applicable (generally only significant at low input levels)						
Specification	**Channel Type**	**Option H**	**Option D HI Range**	**Option D LO Range**	**Option X HI Range**	**Option X LO Range**
Base Floor Error Apply to all results	L	$(V_{AC+DC}*56\mu A)$ + $(A_{AC+DC}*45\mu V)$	$(V_{AC+DC}*38\mu A)$ + $(A_{AC+DC}*45\mu V)$	$(V_{AC+DC}*250nA)$ + $(A_{AC+DC}*45\mu V)$	$(V_{AC+DC}*6\mu A)$ + $(A_{AC+DC}*45\mu V)$	$(V_{AC+DC}*0.15\mu A)$ + $(A_{AC+DC}*45\mu V)$
	A	$(V_{AC+DC}*56\mu A)$ + $(A_{AC+DC}*450\mu V)$	$(V_{AC+DC}*38\mu A)$ + $(A_{AC+DC}*450\mu V)$	$(V_{AC+DC}*250nA)$ + $(A_{AC+DC}*450\mu V)$	$(V_{AC+DC}*6\mu A)$ + $(A_{AC+DC}*450\mu V)$	$(V_{AC+DC}*0.15\mu A)$ + $(A_{AC+DC}*450\mu V)$
	S or W	$(V_{AC+DC}*225\mu A)$ + $(A_{AC+DC}*1.8mV)$	$(V_{AC+DC}*150\mu A)$ + $(A_{AC+DC}*1.8mV)$	$(V_{AC+DC}*1\mu A)$ + $(A_{AC+DC}*1.8mV)$	$(V_{AC+DC}*23\mu A)$ + $(A_{AC+DC}*1.8mV)$	$(V_{AC+DC}*0.6\mu A)$ + $(A_{AC+DC}*1.8mV)$
DC Floor Error Apply to DC and AC+DC results using the Voltage and Current DC Floor Errors from previous tables	All	$(V_{DC}*$Current DC Floor Error$)$ + $(A_{DC}*$Voltage DC Floor Error$)$ + (Current DC Floor Error*Voltage DC Floor Error)				
AC Floor Error (VA and VAR only) Apply to AC and AC+DC VA & VAR results using voltage and current AC Floor Errors from previous tables	All	$(V_{AC}*$Current AC Floor Error$)$ + $(A_{AC}*$Voltage AC Floor Error$)$				
Common Mode Error (VA and VAR only) Apply to AC component of VA and VAR results using the Voltage and Current Common Mode Errors from previous tables.	All	$(V_{AC}*$Current Common Mode Error$)$ + $(A_{AC}*$Voltage Common Mode Error$)$				
Common Mode Error (Watts only) Apply to AC component of Watts results using the Voltage Common Mode Error from previous table	All	$(A_{AC}*$Voltage Common Mode Error$)$				
Adjacent Channel Error Apply to AC component of all results using the Voltage and Current Adjacent Channel Errors from previous tables	All	$(V_{AC}*$Current Adjacent Channel Error$)$ + $(A_{AC}*$Voltage Adjacent Channel Error$)$				
Phase Floor Error (Watts only) Apply to AC and AC+DC Watts results	S, A or L	$VA_{FUND}*(PF_{FUND} - \cos(\cos^{-1}(PF_{FUND}) + 0.015°*F))$ Alternately, as a worst case (at PF=0) this can expressed as F*0.028% of VA				
	W	$VA_{FUND}*(PF_{FUND} - \cos(\cos^{-1}(PF_{FUND}) + 0.007°*F))$ Alternately, as a worst case (at PF=0) this can expressed as F*0.013% of VA				

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2.4.1.2   HARMONIC WATTS MEASUREMENT ACCURACY TABLE

Specification	Channel Type	Option H	Option D HI Range	Option D LO Range	Option X HI Range	Option X LO Range
Harmonic or Spectrum Watts Error	All	AC Watts Errors other than Phase Floor Error from preceding table at levels and F of the harmonic or spectrum point + $(H/N)^2$*0.5% of reading + from below using the frequency of the harmonic or spectrum point				
	<10kHz / A or L	0.006% + (0.004%+0.028%*F)/PF				
	10k-115kHz / A or L	0.05% + (0.004%+0.028%*F)/PF				
	<10kHz / S	0.01% + (0.004%+0.028%*F)/PF				
	10k-115kHz / S	0.05% + (0.004%+0.028%*F)/PF				
	<10kHz / W	0.015% + (0.004%+0.013%*F)/PF				
	10k-115kHz / W	0.03% + (0.004%+0.013%*F)/PF				
	115k-435kHz / W	0.08% + (0.004%+0.013%*F)/PF				

2.5   POWER FACTOR MEASUREMENT SPECIFICATIONS

2.5.1   PF MEASUREMENT ACCURACY TABLE

Add relevant errors from the table below for the maximum error in PF measurements. For PF_{FUND} apply only the Base Floor and Phase Errors.

Note:

DC PF is 1.0 by definition and has no error; the table below applies to AC, AC+DC and FUND PF results.

Specification	Channel Type	Option H	Option D HI Range	Option D LO Range	Option X HI Range	Option X LO Range
Base Floor Error Apply to all PF results	L	$(56\mu A/A_{AC+DC})$ + $(45\mu V/V_{AC+DC})$	$(38\mu A/A_{AC+DC})$ + $(45\mu V/V_{AC+DC})$	$(250nA/A_{AC+DC})$ + $(45\mu V/V_{AC+DC})$	$(6\mu A/A_{AC+DC})$ + $(45\mu V/V_{AC+DC})$	$(0.15\mu A/A_{AC+DC})$ + $(45\mu V/V_{AC+DC})$
	A	$(56\mu A/A_{AC+DC})$ + $(450\mu V/V_{AC+DC})$	$(38\mu A/A_{AC+DC})$ + $(450\mu V/V_{AC+DC})$	$(250nA/A_{AC+DC})$ + $(450\mu V/V_{AC+DC})$	$(6\mu A/A_{AC+DC})$ + $(450\mu V/V_{AC+DC})$	$(0.15\mu A/A_{AC+DC})$ + $(450\mu V/V_{AC+DC})$
	S or W	$(225\mu A/A_{AC+DC})$ + $(1.8mV/V_{AC+DC})$	$(150\mu A/A_{AC+DC})$ + $(1.8mV/V_{AC+DC})$	$(1\mu A/A_{AC+DC})$ + $(1.8mV/V_{AC+DC})$	$(23\mu A/A_{AC+DC})$ + $(1.8mV/V_{AC+DC})$	$(0.6\mu A/A_{AC+DC})$ + $(1.8mV/V_{AC+DC})$
AC Floor Error Apply to all PF results using voltage and current AC Floor Error from previous tables, this error always causes a reduced PF reading	All	$-PF_{RDG}$*((Current AC Floor Error/A_{RDG}) + (Voltage AC Floor Error/V_{RDG}))				
DC Floor Error Apply to AC+DC PF result after multiplying by (1-PF)	L	$(0.23mA/A_{AC+DC})$ + $(0.1mV/V_{AC+DC})$	$(0.15mA/A_{AC+DC})$ + $(0.1mV/V_{AC+DC})$	$(1\mu A/A_{AC+DC})$ + $(0.1mV/V_{AC+DC})$	$(40\mu A/A_{AC+DC})$ + $(0.1mV/V_{AC+DC})$	$(5\mu A/A_{AC+DC})$ + $(0.1mV/V_{AC+DC})$
	A	$(0.23mA/A_{AC+DC})$ + $(1mV/V_{AC+DC})$	$(0.15mA/A_{AC+DC})$ + $(1mV/V_{AC+DC})$	$(1\mu A/A_{AC+DC})$ + $(1mV/V_{AC+DC})$	$(40\mu A/A_{AC+DC})$ + $(1mV/V_{AC+DC})$	$(5\mu A/A_{AC+DC})$ + $(1mV/V_{AC+DC})$
	S	$(0.45mA/A_{AC+DC})$ + $(3mV/V_{AC+DC})$	$(0.3mA/A_{AC+DC})$ + $(3mV/V_{AC+DC})$	$(2\mu A/A_{AC+DC})$ + $(3mV/V_{AC+DC})$	$(80\mu A/A_{AC+DC})$ + $(3mV/V_{AC+DC})$	$(6\mu A/A_{AC+DC})$ + $(3mV/V_{AC+DC})$
	W	$(0.68mA/A_{AC+DC})$ + $(5mV/V_{AC+DC})$	$(0.45mA/A_{AC+DC})$ + $(5mV/V_{AC+DC})$	$(3\mu A/A_{AC+DC})$ + $(5mV/V_{AC+DC})$	$(120\mu A/A_{AC+DC})$ + $(5mV/V_{AC+DC})$	$(8\mu A/A_{AC+DC})$ + $(5mV/V_{AC+DC})$
Phase Error Apply to all PF results	S, A or L	$(PF_{FUND} - \cos(\cos^{-1}(PF_{FUND}) \pm 0.015°*F))$ Alternately, as a worst case (at PF=0) this can expressed as F*0.00028				
	W	$(PF_{FUND} - \cos(\cos^{-1}(PF_{FUND}) \pm 0.007°*F))$ Alternately, as a worst case (at PF=0) this can expressed as F*0.00013				

2.6   FREQUENCY MEASUREMENT SPECIFICATIONS

Frequency Range	FUND setting of MAINS: 45Hz to 65Hz FUND setting of AVIONICS: 300Hz to 900Hz Otherwise- LF/PERIOD setting of VLF: 0.0099Hz to 65Hz LF/PERIOD setting of LF: 0.19Hz to 1kHz LF/PERIOD setting of 300ms period: 9Hz to 305kHz (W channel type) or 80kHz (other channel types) LF/PERIOD setting of 100ms period: 19Hz to 305kHz (W channel type) or 80kHz (other channel types) LF/PERIOD setting of 20ms period: 44Hz to 305kHz (W channel type) or 80kHz (other channel types) LF/PERIOD setting of 10ms period: 145Hz to 305kHz (W channel type) or 80kHz (other channel types) LF/PERIOD setting of 2ms period: 495Hz to 305kHz (W channel type) or 80kHz (other channel types) If BANDWIDTH set to USER setting then upper limit is 0.5*setting
DC Level	DC offset is automatically eliminated
Min. Input (typical)	Voltage: 0.5Vrms (W, S or A channel type) or 75mVrms (L channel type) at fundamental Current, H option: 0.05Arms at fundamental Current, D option: 0.04Arms (HI range) or 0.3mArms (LO range) at fundamental Current, X option: 5mVrms (HI range) or 150μVrms (LO range) at fundamental
Min. Pulse Width (typical)	Greater of - 1.25μs (W channel type) or 5μs (other channel types) 0.001% of measurement period 10% of signal period
Update Period (nominal)	As shown below for FREQ SPEED settings of FAST/NORMAL/SLOW respectively - LF/PERIOD setting of VLF: greater of 1/2/15s or 1 cycle LF/PERIOD setting of LF: greater of 1/1/5s or 1 cycle LF/PERIOD setting of 300ms period: 0.25s/0.75s/2s LF/PERIOD setting of 100ms period: 55ms/250ms/1s LF/PERIOD setting of 20ms period: 25ms/200ms/700ms LF/PERIOD setting of 10ms period: 10ms/100ms/300ms LF/PERIOD setting of 2ms period: 2ms/50ms/150ms
Resolution (nominal)	W Channel Type: 0.000125%/Update Period in seconds Otherwise: 0.0005%/Update Period in seconds
Maximum Error	0.01% + Resolution
Settling Time (nominal)	Greater of (x2 if significant DC content) - a) 2 amplitude periods b) 2 frequency measurement periods c) 4 cycles of the signal

3   MECHANICAL CHANNEL INPUT AND ACCURACY SPECIFICATIONS (MT TYPE)

3.1   INPUT CAPABILITIES AND CHARACTERISTICS

Input Terminals	SPD (Speed) : BNC (isolated from PA2640 chassis), configurable as analog or digital input
	TRQ (Torque) : BNC (isolated from PA2640 chassis), configurable as analog or digital input
	DIR (Direction) : BNC (isolated from PA2640 chassis), digital input
Input Common-Mode	Up to -15Vpk to +15Vpk specified
	Up to -30Vpk to +30Vpk with no damage
Analog Input Range	Up to -12Vdc to +12Vdc specified
	Up to -15Vpk to +15Vpk specified
	Up to -30Vpk to +30Vpk with no damage
Digital Input Range	LO: <0.8V (nominal)
	HI: >2V (nominal)
	Up to -30Vpk to +30Vpk with no damage
Input Impedance	Each input nominally 150kΩ to PA2640 chassis ground

3.2   DIGITAL INPUT MEASUREMENT SPECIFICATIONS

Digital Frequency Timing	Signal must be LO for >500ns
	Signal must be HI for >500ns
	Frequency measurement up to 500kHz (typically 900kHz)
	Minimum measurable frequency limited by user set measurement period
DIR Setup/Hold Timing	DIR must be stable for >550ns prior to and after active edge of SPD input
Maximum Frequency Error	Measurement Period >10ms: 0.01%
	Measurement Period ≤10ms: 0.015%

3.3   ANALOG INPUT MEASUREMENT SPECIFICATIONS

Maximum Input Error	0.05% + 1mV
	Add (0.005% + 50µV) per C outside of ±5C from calibration temperature

4 ANALYSIS SPECIFICATIONS

4.1 INTEGRATION SPECIFICATIONS

Start Delay Time	Zero to 99 days, 99 hours, 99 minutes, 99 seconds (1 second resolution) 0.01% + 8ms maximum error
Integration Time	Manual (unrestricted period of time), or 1 second to 99 days, 99 hours, 99 minutes, 99 seconds 0.01% + 1ms maximum error
Maximum Data Error	(0.01% + 1ms) (not for integrated average data) + (0.03/measurement period in seconds)% per year

4.2 HARMONIC ANALYSIS SPECIFICATIONS

Method	DFT performed at each frequency on same set of sampled signals (there is no discontinuity throughout the analysed frequency range)
Window	F > (2/measurement period): Hann (also called Hanning) Otherwise: Rectangular
Maximum Harmonic	The smaller of - a) A frequency of 435kHz (W type channels) or 115kHz (otherwise) b) 500th (harmonics over the 100th requires option H500) c) HARMONICS setting d) If BANDWIDTH set to USER: 0.5*setting/fundamental frequency
Harmonic Bandwidth	Nominally the greater of- a) The smaller of fundamental frequency or 2/(LF/PERIOD measurement period) b) If FUND set to AVIONICS: 20Hz c) (Fundamental Frequency*Maximum Harmonic/2250)
Measurement Period	Nominally (1/Harmonic Bandwidth)
Update Interval	Nominally the greater of - a) LF/PERIOD measurement period b) Harmonic Measurement Period (from above) c) 0.25ms x Σ(Maximum Harmonic for each channel configured for harmonics)
Data Available	Volts, Amps and Watts amplitudes for each configured harmonic Volts and Amps as a percentage of the fundamental of the same signal Volts and Amps THD as a percentage of the fundamental of the same signal Volts and Amps THD as a percentage of the AC+DC amplitude of the same signal V and A Phase of fundamental relative to the voltage fundamental of the lowest numbered channel in the VPA V and A Phase of each non-fundamental harmonic relative to the fundamental of the same signal
Accuracy	See relevant Voltage, Current and Watts accuracy specifications

4.3 SPECTRUM ANALYSIS SPECIFICATIONS

Method	DFT performed at each frequency on same set of sampled signals (there is no discontinuity throughout the analysed frequency range)
Window	Hann (also called Hanning)
Frequency Resolution	0.01Hz to 1kHz
Measurement Period	Nominally (1/ Frequency Resolution)
Maximum Frequency	Minimum is 100 x Frequency Resolution Maximum is the lowest of nominally - a) 16384 x Frequency Resolution (under some circumstances as low as 8192 x Frequency Resolution) b) 435kHz (W type channels) or 115kHz (otherwise)
Data Available	Volts, Amps and Watts amplitudes for each configured spectrum frequency
Accuracy	See relevant Voltage, Current and Watts accuracy specifications

4.4 CYCLE VIEW SPECIFICATIONS

Signal Range	As specifications for Voltage and Current

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Cycle Period	From 2.3us (W type channels), 8.7us (otherwise) up to 100 seconds
Time Resolution	1/512th of a cycle
Method	Mean cycle formed by asynchronously sampling all cycles within measurement period
Maximum Error	As Voltage and Current Specifications for PK data (Watts = multiplication of V and A waveforms)

4.5   SCOPE SPECIFICATIONS

Signal Range	As specifications for Voltage and Current
Timebase	1/2/5 settings from 5us/div to 20s/div
Capture Depth	Up to 32k points per signal
Capture Resolution	<0.00005% of specified maximum measurable peak Voltage or Current
Sampling Period (nominal)	Greater of - 1.1μs (W type channels) or 4.1μs (otherwise) 0.03% of timebase setting
Maximum Error	As Voltage and Current Specifications for PK data (Watts = multiplication of V and A waveforms)

4.6   HISTORICAL DATA COLLECTION SPECIFICATIONS

Collection Time	Automatically continuously variable between 1 measurement period and 584.5 million years (collection is automatically stopped after this time has elapsed but this is untested at the time of writing)
Time Resolution	Note: this is the resolution by which you can determine when an event occurred, not that of the PA2640 detecting events. All events are captured. The greater of- a) 1 pixel of displayed data (front panel) or 1 increment of the requested time interval (interface) b) 1 measurement period of the data being recorded c) A maximum of 1/4096th of the elapsed historical data collection time (typically 1/8192th).
Data Capture	Every measurement is included in the maximum, average and minimum data for each increment of the time resolution interval regardless of the time resolution.

4.7   DATA LOGGING SPECIFICATIONS

Logged Measurements	Up to 16 measurement data per record (each of which can be 1 measurement or up to 500 harmonic measurements)
Data per Record	Up to 8003 data per record
Internal FIFO Buffer	32Mbyte (always in binary format, 4 bytes per data)
Internal Memory	≥2Gbyte (always in binary format, 4 bytes per data) non-volatile Typically 5Mbytes/sec maximum sustained mean write rate
External Data File Format	ASCII (CSV, scientific format) or Binary
Timestamp	Record number + optional date and time (1 second resolution)
Maximum File Size	4Gbyte
Maximum Records	Only limited by maximum file size
Start Delay Time	Zero to 99 days, 99 hours, 99 minutes, 99 seconds (1 second resolution) 0.01% + 8ms maximum error
Run Time	Manual (unrestricted period of time), or 1 second to 99 days, 99 hours, 99 minutes, 99 seconds (1 second resolution) 0.01% + 8ms maximum error
Log Interval	0.002 second, or 0.01 second to 99 hours, 99 minutes, 99.99 seconds (0.01 second resolution) 0.01% maximum error ± 2ms non-accumulating error