Keysight Technologies

IntegraVision PA2200 Series Power Analyzers

PA2201A 2-Channel

PA2203A 4-Channel

Data Sheet



KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

See it, measure it, prove it

The Keysight IntegraVision power analyzer is an intuitive combination of accurate power measurements and touch-driven oscilloscope visualization. Within a single instrument, it delivers the dynamic views you need to see, measure and prove the performance of your design.

Make all of your critical power measurements with one instrument

- Achieve power analyzer accuracies and scope-like waveform visualization with reduced setup time
- Address multiple test scenarios with the flexibility of wide-ranging, isolated inputs
- Visualize transients, in-rush currents and state changes with a high-speed digitizer that captures voltage, current and power in real-time
- Analyze voltage, current and power in the time and frequency domains
- Explore your design and gain new insights through the 12.1" / 310 mm high-resolution display with touch interface
- Save space on your bench with minimum-depth form factor



PA2203A IntegraVision Power Analyzer 4 Power Channels, 3-Phase Analysis

Power converter test for:



UPS and Energy Storage



EV, HEV, PHEV



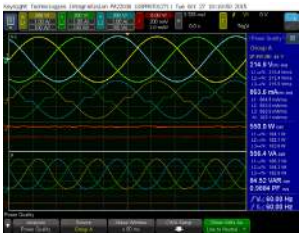
AC/DC, DC/AC, DC/DC Converters



Solar Inverters



Satellites and Aero/Defense



Visualize 4 dynamic power channels simultaneously



Intuitive wiring configurator for faster insights



Phasor diagram for phase relationship analysis

Goal: Optimize power

In today's world of ever-increasing focus on energy and power efficiency, engineers are under pressure to find every possible way to reduce power consumption and improve efficiency in their electronic power conversion systems (such as AC/DC power supplies, DC/DC converters, DC/AC inverters, solar inverters, battery management systems, electric vehicle power control systems, satellite power systems and general aerospace/defense applications) and for devices that draw power from an AC line. To achieve energy-efficient designs, R&D engineers need to make measurements to ensure their designs meet established goals, operate efficiently and behave properly under transient conditions without creating noise or power quality problems.

Traditional power measurement instruments cannot provide accurate dynamic measurements or measurements on power that vary vs time and oscilloscopes are not designed to measure power with high accuracy.

Tough power-related challenges facing engineers today

- How can we improve efficiency and performance of energy conversion systems?
- How can we efficiently use renewable energy sources, like solar inverters?
- How can we see incremental improvements made when optimizing high-efficiency power converters?
- How can we achieve stable, repeatable power and efficiency measurements?
- How can we characterize the efficiency and performance of complex power systems that switch modes from sleep mode to full power mode?
- How can we characterize performance of power conversions systems under dynamic or transient conditions?

The Keysight IntegraVision Power Analyzer is the solution

The Keysight IntegraVision power analyzer is ideal for R&D engineers who want to quickly and interactively measure AC and DC power consumption, power conversion efficiency, operational response to stimulus and common AC power parameters such as frequency, phase and harmonics – all with 0.05 % basic accuracy and 16-bit resolution. The power analyzer enables engineers to characterize power consumption under highly dynamic conditions with 5 million samples per second digitizing speed and 2.5 MHz bandwidth.

Insight – Precision power measurement and real-time waveform visualization gives true insights into energy consumption and performance.

Familiarity – Thanks to a user interface based on a familiar oscilloscope use model, you experience a short learning curve; if you can use an oscilloscope, you can use a Keysight IntegraVision power analyzer.

Ease of Connection – All inputs are isolated from each other and from the chassis ground, allowing for ease of connection without the need for differential probes or the danger associated with floating a ground-referenced instrument.

Simultaneous power calculation

The Keysight IntegraVision power analyzer simultaneously captures voltage and current on all channels, and then provides point-by-point multiplication to give real-time instantaneous power waveform display and power measurement.

Power converter test for:



UPS and Energy Storage



EV, HEV, PHEV



AC/DC, DC/AC, DC/DC Converters



Solar Inverters



Satellites and Aero/Defense

Measuring power: Power analyzer or oscilloscope?

Engineers working on electronic power conversion systems need high-accuracy measurements to identify and characterize incremental efficiency improvements in devices such as power inverters or converters, uninterruptible power supplies, battery management systems, vehicle and aircraft power systems, lighting systems/electronic ballasts and appliances. While some of today's power analyzers offer adequate measurement accuracy, they are cumbersome to use and lack the ability to characterize power consumption under dynamic conditions. Previously, engineers needed a power analyzer to make accurate measurements and an oscilloscope to visualize repetitive and single-shot events such as turn-on and occurrences of transients. Eliminating a separate oscilloscope in the measurement setup decreases test complexity and reduces configuration time.

Precision power analyzers offer high accuracy and ease of connection to the DUT, making them ideal for steady-state measurements of power consumption, efficiency and power quality. For these measurements, the accuracy of the power analyzer gives R&D engineers the measurement integrity they need. With floating inputs and directly connected measurements, precision power analyzers make it easy for engineers to connect to their DUTs.

Traditionally, only oscilloscopes offer the single-shot measurement capability necessary for dynamic measurements during functional test. Furthermore, by offering a visual picture of what is happening, oscilloscopes allow engineers to gain insight into their DUTs and to identify issues. However, their lower accuracy means that making critical efficiency measurements on high-efficiency converters may not be possible. Because oscilloscopes have ground-referenced, non-isolated front ends, probes are required for floating and current measurements. Probes further reduce measurement accuracy and make oscilloscopes harder to connect to the DUT for high-accuracy, power-related measurements.

R&D engineers, therefore, are forced to switch between these two instruments depending on the type of measurement they need to make: They use a power analyzer to make accurate measurements and an oscilloscope to visualize repetitive and single-shot events such as turn-on and occurrences of transients. Switching between instruments is time consuming and makes it difficult to get consistent, reproducible results.

Specific time-period measurement

The Keysight IntegraVision power analyzer supports the capture of voltage, current and power waveforms over specific periods of time, with measurements made based on cursors placed on the captured waveforms. This is particularly useful for examining transient phenomena and in the design of periodically controlled equipment. To ensure that your DUT complies with energy standards, for instance, it is vital to measure power consumption across a range of different modes from sleep to full activity – and all the transient states in between.

Capturing sudden or irregular phenomena

Abnormal phenomena can often be hard to isolate, disappearing from the screen almost as soon as they appear. Like a traditional oscilloscope, the Keysight IntegraVision power analyzer can be setup to make single-shot measurements to capture and measure transient phenomena, including in-rush, cycle dropouts, blackouts/brownouts, and other line disturbances.

Continuous Whole-Cycle Analysis

Power analyzers use mathematical transformations to analyze signals. For precision, the measurement window cannot have any discontinuities or gaps. Continuous Whole-Cycle Analysis (CWA) used by the PA2000 Series is a gapless measurement technique that always performs measurements on a positive integer number of signal cycles.

Keysight IntegraVision Power Analyzer overview

General



- Operates like an oscilloscope, but makes measurements like a power analyzer.
- Achieve 0.05% basic accuracy for superior measurement integrity.
- The PA2201A comes with 2 power channels for single phase measurements and analysis. The PA2203 has 4 power channels for 3-phase measurement and analysis.
- Provides isolated inputs for easy and safe connections.
- Capture waveforms with 5 M sample/second digitizer.
- Visualize voltage, current and power waveforms in real-time to gain insight into your device.
- Save space with a small footprint.
- Clearly see waveform details on a large gesture-enabled touchscreen.

Channel connections for voltage and current inputs

- Simultaneously digitize voltage and current with voltage inputs and current inputs on every channel.
- Connect via floating voltage and current inputs that are isolated to 1000 V from each other and from the chassis ground, allowing for ease of connection without the need for differential probes or the danger associated with floating a ground-referenced instrument.
- Measure voltage using connections via commonly-available shrouded banana plugs.
- Directly measure current up to 2 A and up to 50 A using built-in current shunts with fully specified and calibrated performance.
- Always have the measurement capability you need with both 2 A and 50 A on all channels unlike other power analyzers where you have to choose between low current and high current inputs.
- Use a clamp-on probe or other type of current probes when your testing requires greater than 50 A or wider than 100 kHz bandwidth. Use your favorite probe or any transducer with up to 10 V full-scale output. The external current measurement is provided on every channel. Probes connect via a floating BNC connector. The power analyzer also supports Keysight current probe models 11488, N2780B, N2781B, N2782B or N2783B.
- Current transformers on both the 2 A and 50 A current measurement inputs enable you to apply custom ampere-to-ampere scale factors to current signals.
- The PA2201A comes with 2 power channels for single phase measurements and analysis. The PA2203 has 4 power channels for 3-phase measurement and analysis.

Transients

- Capture one-time events (like start-up) or transient events (like cycle dropout) to visualize and perform analyses right on your power analyzer that before were only possible using an oscilloscope.
- Use edge triggering on voltage, current or power signals for easy synchronization with event like start-up, in-rush or spikes.
- Use external trigger-in to synchronize with an AC source to easily capture the response of your device to simulated AC line disturbances.
- Use external trigger-out to synchronize with other instruments on your bench.
- The 10 MHz Reference input and the Trigger input and output are 0 to 3.3 V logic level (5 V max).
- The Trigger-out connection has a 50 Ω output impedance.
- These are SMA connectors for safety to avoid accidental misconnection of high voltage or floating power signals onto ground-referenced low voltage trigger and clock lines.

Measurements

- Simplify configuration and purchase with all measurement functions included, unlike other power analyzers where you must configure your power analyzer from a long and confusing set of options.
- Choose from 29 pre-defined cursor measurements on waveforms including peak-to-peak, rise time, frequency, and area under waveform.
- Display up to 10 automatic measurements at a time along with measurement statistics.
- Gate measurements by manually placing the cursors on the waveform or by auto select, where cursors track the waveform.
- Measure true rms values of voltage and current, even if your waveform is non-sinusoidal and has DC offsets.
- Measure power quality: Watts, VA, VAR, power factor, phase angle, voltage crest factor, and current crest factor.
- Measure power and efficiency.
- Perform frequency domain analysis using FFT and harmonic measurements.
- Measure voltage harmonics, current harmonics, and power harmonics up to 250 orders.
- Simultaneously view harmonic data and capture/display time domain signal data for voltage, current or power.
- Display harmonics as a table of exact order values and as a bar chart to visualize the relative size of the harmonics.
- Measure total harmonic distortion (THD) following the IEC method.
- Check harmonics with IEC 61000-3-2 Class A, B, C, and D limits.
- Use math functions to operate on captured waveforms to create new user-defined measurements, such as i^2t to calculate thermal energy to properly size a fuse.
- Use the operators on math functions (can nest math functions):
  - Add, subtract, multiply, divide
  - Differentiate, integrate
  - FFT
  - Ax + B
  - Squared, square root
  - Absolute value
  - Common logarithm, natural logarithm
  - Exponential, base 10 exponential
- Perform integrated energy measurements of Ampere-Hours (AH) and Watt-Hours (WH) to determine total AC and DC energy consumption in order to analyze energy consumed from the grid or energy associated with battery charging/discharging operations.
- Compare live waveforms with reference waveforms for up to four reference waveforms that you can capture and store in nonvolatile reference waveform memory.

User interface

- Use pinch, zoom, scroll ☐ the same intuitive actions found on tablets and smartphones – on the large gesture-enabled touchscreen.
- Disable touch and use hardkeys/softkeys when operation via touch is not preferred.
- Select from eight different display formats to visually highlight the information you need to gain fast insights.
- Create custom waveform labels and screen annotations to make documentation easier.
- Save states and recall them later for fast jumps to commonly used setups.
- Quickly find signals and automatically configure display settings with Autoscale button.
- Easily save data and screen images on a USB flash drive connected via the convenient USB port on the front panel.
- Press and hold any button for context sensitive help. A full user manual is built-in as well.

Datalogger

- Capture data for off-line analysis and test archival.
- Set logging interval from 50ms to 1 day
- Set logging duration from 1s to 1 year

Remote IO

- Communicate remotely over your choice of USB and LAN interfaces. Both are standard for simplified ordering with nothing extra to buy.
- Control remotely over LAN via a standard web browser. The IntegraVision power analyzer contains a web server that provides a webpage containing a graphical front panel representation of the PA2201A/PA2203A front panel. The WebGUI operation is identical to operating the real front panel on the PA2201A/PA2203A.

Safety, installation and support

- Operate with safe connections provided by an integrated safety cover on current connections.
- Access direct current measurements made via removable connector (Keysight part number 5067-6088 or Phoenix connector type PC 16/ 3-STF-10,16, Phoenix part number 1967469).
- CAT II inputs are rated to 1000 V.
- Provides NISPOM compliant data sanitization.
- Universal AC input including 400 Hz AC operation.
- Mount in standard test rack. (Rack mount kit coming summer of 2015 – check www.keysight.com/find/PA2200Series for availability and for ordering information).
- Calibrate once per year, unlike other power analyzers whose published specs are for 6 months and for operation beyond 6 months, require adjustment of specs.
- Protected with 3 year warranty.
- Easily upgrade firmware via front panel USB. Download latest firmware files from www.keysight.com/find/PA2200Series. Simply save the firmware update file on a USB drive and use the utility menu to update your IntegraVision power analyzer.

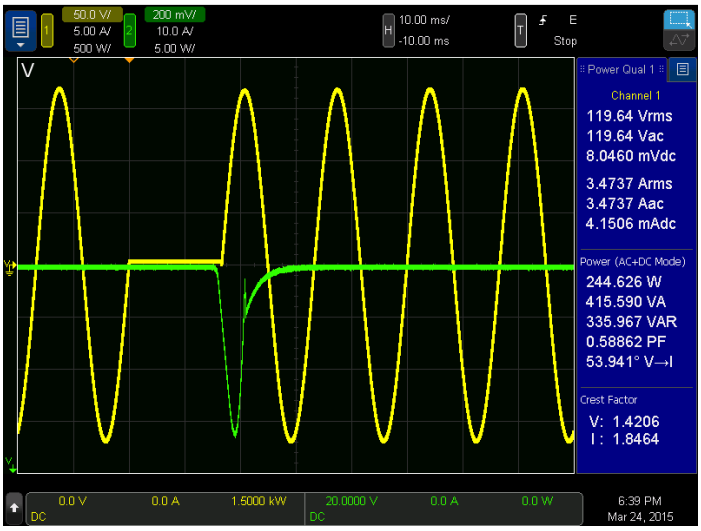
See it, measure it, prove it.

Main screen



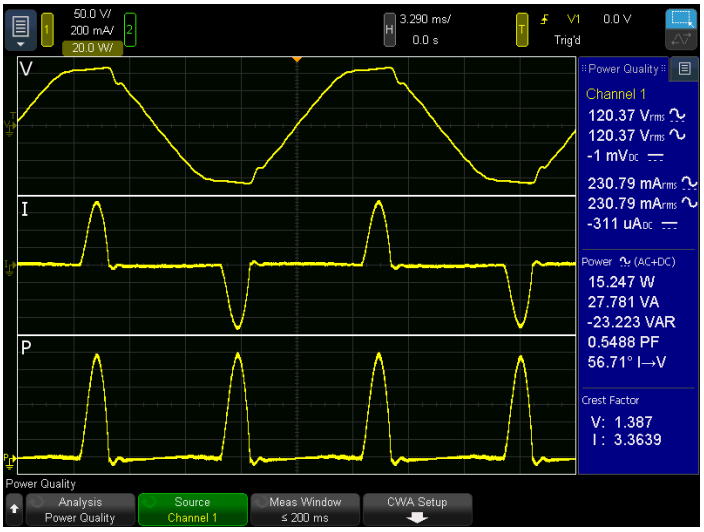
See real-time voltage, current and power on all channels simultaneously, with each parameter on its own grid (the default screen layout). Screen layout and functions are the same as a traditional oscilloscope.

Transient measurements



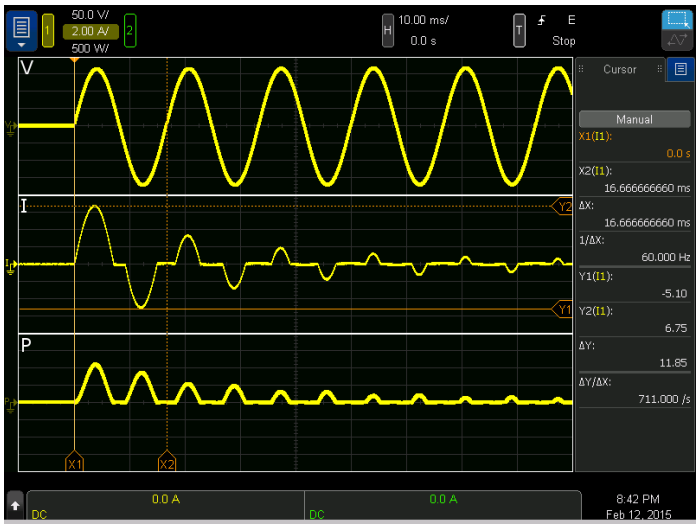
Use single-shot measurement mode to analyze power transients. Here the Keysight IntegraVision power analyzer displays an AC line voltage full-cycle dropout on one channel (yellow trace) and the corresponding response of a DC power supply output on the other channel (green trace). Thanks to single-shot measurement and visualization, you can easily see that the 20 V DC output drops about 0.6 V and then recovers in 10 ms.

Power analysis panel



Press the [Analyze] key to view power quality measurements, shown in the blue Power Quality analysis panel. While displaying live power quality measurements, you can also view real-time voltage, current and power waveforms.

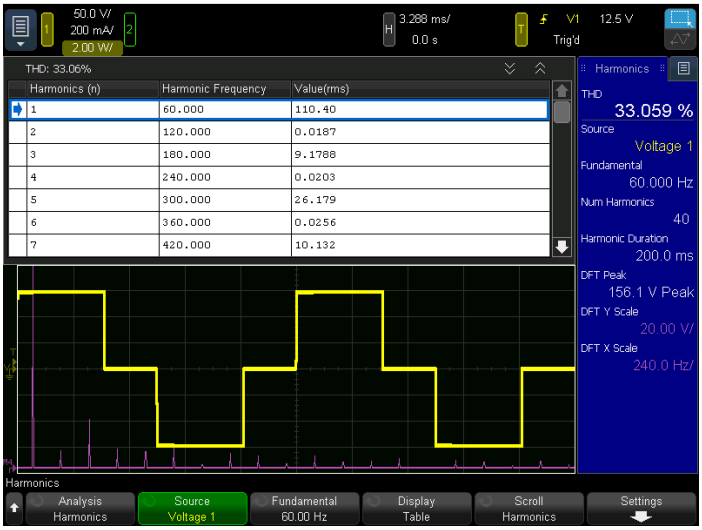
Measurement with cursors



Use cursors to make common measurements, shown in the right side panel. Here, the Keysight IntegraVision power analyzer displays in-rush current (middle current trace) and power (bottom power trace) following an AC line input voltage turn-on (top voltage trace). The cursors show a peak of 6.75 A during the first cycle.

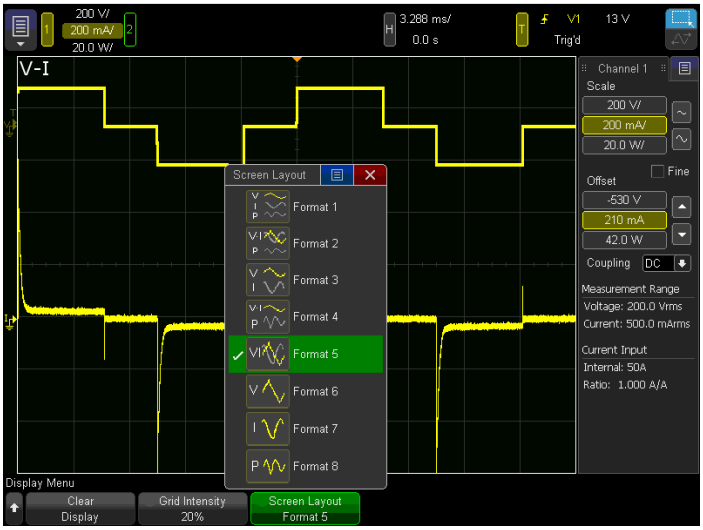
See it, measure it, prove it.

Harmonic measurements with graph



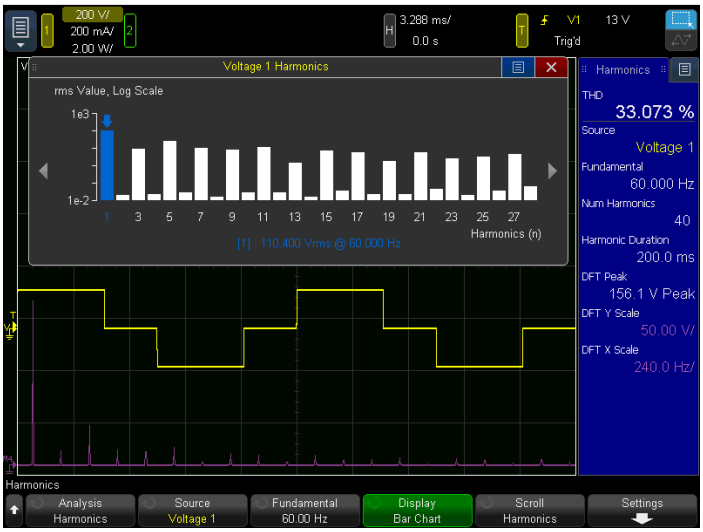
Perform harmonic analysis on voltage or current. Both the time domain waveform (yellow trace) and the harmonic table are simultaneously displayed.

User selectable screen layouts



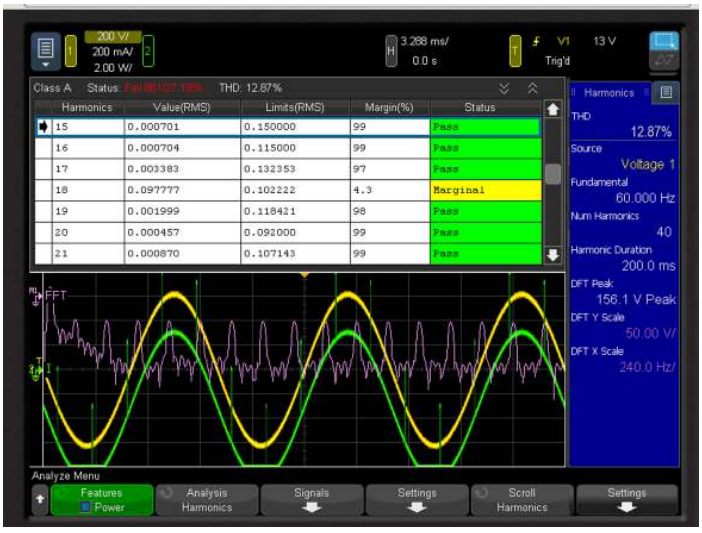
Choose from 8 different screen layouts of the voltage, current and power waveforms. Here, the Keysight IntegraVision power analyzer is displaying an enlarged view of voltage and current on the same grid to highlight the time relationship between voltage and current.

Harmonic measurements with bar graph



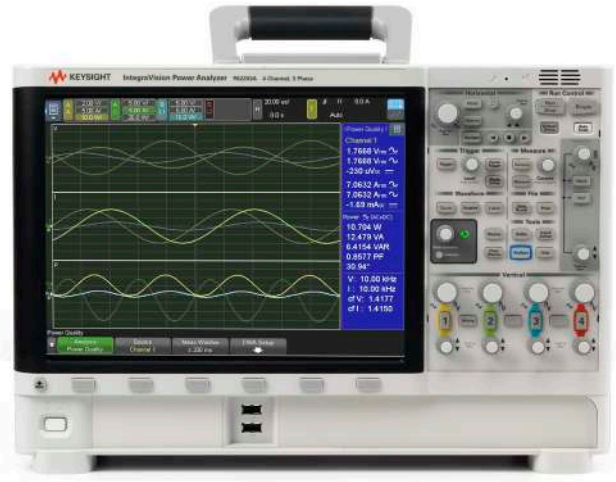
In addition to the harmonics table, simultaneously view a bar graph of the harmonic orders to visually identify high value harmonics.

On-screen keyboard with touch



Quickly check harmonics with IEC 61000-3-2 limits (Classes A, B, C, and D)

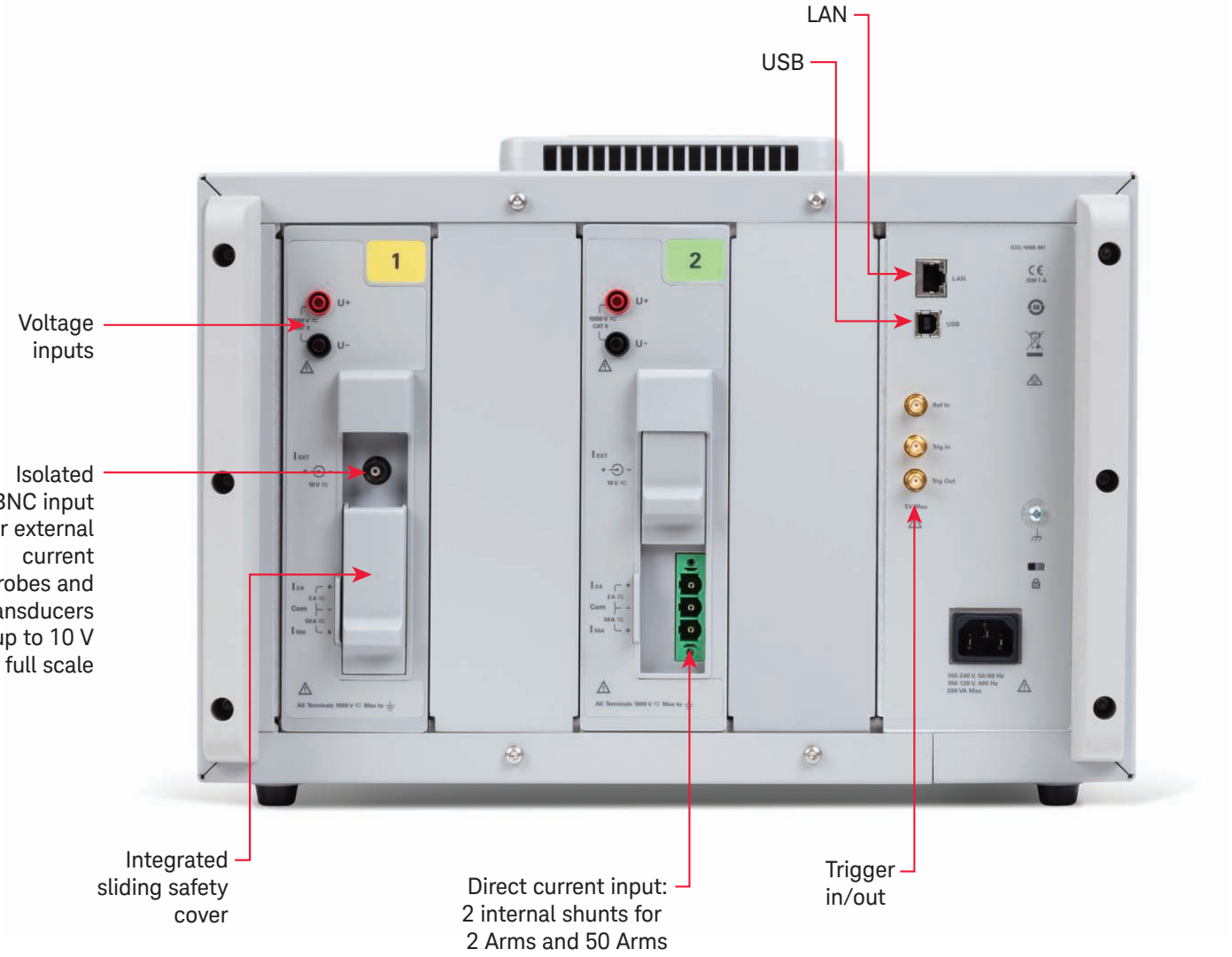
Front Panel PA2203A



Rear Panel PA2203A



Rear Panel PA2201A



When measuring current with the direct current input, wiring to the DUT is connected on a removable connector, allowing you to quickly remove the wires for fast reconfiguration.

The wires are inserted into the removable side of the connector and screws secure the wires inside of the connector.



Key Applications

Electrical Power Conversion Systems

Examples:
- AC/DC power supplies
- DC/AC inverters
- DC/DC converters
- Solar inverters
- Hybrid Electric Vehicles (HEV), Electric Vehicles (EV), and Plug-in Hybrid Electric Vehicles (PHEV) inverters

Important power converter measurements:
- Power consumption
- Efficiency
- Harmonics and THD
- Response to dynamic conditions
- Startup characterization

Like traditional power analyzers, IntegraVision can provide you with fast and accurate measurement of common parameters like power consumption and efficiency and harmonics.

Visualizing and measuring dynamic conditions is important due to the increasing complexity of control systems. IntegraVision can capture voltage, current and power waveforms over specific periods of time. Placing cursors on the captured waveforms will enable you to visualize and measure power consumption across a wide range of modes, from sleep to full activity, and all the transient states in between.

IntegraVision's single-shot measurement capability simultaneously captures voltage and current, so you can visualize and measure critical one-time events, like the response of your device to dynamic conditions, such as an unstable AC line. Using trigger-in, you can synchronize your AC source with IntegraVision and capture power converter response to cycle dropouts, line spikes, sag/surge and other AC line distortions. Similarly, you can capture your DUT's response to other time-varying events, like a step change in load or other dynamic loading conditions. You can also visualize and measure events like start-up, in-rush current, and calculate i^2t for fuse sizing. IntegraVision's direct high-accuracy measurement of your converter's output allows you to visualize and measure transient response, settling time, and other power supply performance characteristics. These measurements pose challenges for ground-referenced 8-bit or 10-bit scopes which don't have enough vertical accuracy or resolution to measure load regulation or to resolve narrow settling bands.

Energy Storage

Examples:
- UPS
- Battery powered backup and standby systems
- Battery chargers
- Charging stations
- Battery management systems
- Energy storage systems

Important energy storage measurements:
- Capacity
- Runtime
- Cross over time
- Accumulated energy in/out

IntegraVision measures instantaneous positive and negative values of current flowing into and out of the DUT. Data is captured at up to 5 M samples/second and values are integrated to accumulate amp-hours and watt-hours. This high speed integration function makes it possible to more accurately measure the power consumption of devices for which power usage and power direction of flow fluctuates greatly. Thus, battery capacity can be calculated and battery run-time can be determined based on real loading conditions as you observe current flow, power flow, and energy increase/decrease in the storage devices.

For UPS and battery backup systems, thanks to IntegraVision's single-shot measurement capability, single events and cross-over time from AC line to battery backup can be captured and analyzed.

Electrical and Electro-Mechanical Systems

Examples:
- Lighting
- Appliances
- Industrial machines
- Robotics

Important measurements for electrical/electro-mechanical systems:
- Instantaneous and peak power
- Power consumption
- Harmonics and THD
- Transients and dynamic current consumption

Testing of lighting devices often involves measurement voltage waveforms, current waveforms and THD, because distortion in voltage and current waveforms is becoming more prevalent due to the increasing complexity of control systems.

For appliances and industrial machines, you need to measure dynamic current and power over individual actions (such as a cycle on a machine or a single motion of a robot). During actual operating conditions, the time to accelerate/decelerate motors or to activate sub-systems can range from several hundred milliseconds to several seconds. IntegraVision gives you insight into power consumption and DUT behavior for short events (milliseconds) or over longer power cycles (seconds, minutes, hours or even days).

Overview

Basic accuracy (50/60 Hz)		0.05% of reading	
Best power accuracy (50/60 Hz)		0.1% of reading	
Power Channels (Voltage and Current)		PA2201A: 2 Channels, PA2203A: 4 Channels	
Voltage Measurement Bandwidth (-3 dB)		2.5 MHz (-3 dB)	
Current Measurement Bandwidth (2 A or 50 A Input)		100 kHz (-3 dB)	
Current Measurement Bandwidth (External Input)		2.5 MHz (-3 dB)	
Maximum Voltage		1000 V_{rms} (2000 V peak)	
Maximum Current		Direct input:	2 A_{rms} (6 A peak) or 50 A_{rms} (100 A peak)
		External transducer:	10 V_{rms} (30 V peak)
Record Size		Maximum 1.5 M points on each waveform simultaneously	
Digitizing Speed		Maximum 5 M samples/second at 16 bits on each waveform simultaneously	
Display size and type		12.1- inch capacitive multi-touch/gesture enabled display	
Power Channels (Voltage and Current)			
Voltage		Connector	Safety Banana Plug
		Maximum Voltage	1000 V_{rms}, 2000 Vpeak
		Input Impedance	2 M Ω || 12.5 pF
		Ranges	5 V, 10 V, 20 V, 50 V, 100 V, 200 V, 500 V, 1000 V
Current	Directly Connected	Connector	Pluggable Terminal Block, Phoenix Contact PN: 1967469
		Maximum Current	2 A_{rms}, 6 A peak or 50 A_{rms}, 100 A peak
		Input Impedance	2 A input: 60 mΩ + 0.10 µH
			50 A input: 6 mΩ + 0.06 µH
		Ranges	2 A input: 10 mA, 20 mA, 50 mA, 100 mA, 200 mA, 500 mA, 1 A, 2 A
			50 A input: 200 mA, 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, 50 A
	External Transducer	Connector	Isolated BNC
		Maximum Input Voltage	10 V_{rms}, 30 V peak
		Input Impedance	100 kΩ || 100 pF
		Ranges	50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V
Crest Factor		3 at full-scale (Unless in conflict with maximum input ratings) Maximum Crest Factor of 30 at 10% of full scale	
Current Input Protection		Internal current shunt measurement paths are not fused. Current limit protection (fuse or breaker) and appropriate wire sizing should be provided by the user. Currents in excess of 140% of the rated rms currents may cause permanent damage to the current measurement shunts. An internal protection mechanism is provided for the 2A shunt to avoid damage due to mis-wiring, but it should not be relied upon in situations where higher than 2 A_{rms} currents are expected.	
Isolation		Voltage and current terminals are isolated from earth ground to 1000 V CAT II rating. Voltage is isolated from current with 1000 V CAT II rating	

Measurement Capability		
Basic	Voltage, Current, Power, Math	Peak to Peak, Minimum, Maximum, Amplitude, Top, Base, Overshoot, Preshoot, Average - N Cycles, Average - Full Screen, DC_{rms} - N Cycles, DC_{rms} - Full Screen, AC_{rms} - N Cycles, AC_{rms} - Full Screen (Std. Deviation), DC
	Time	Period, Frequency, +Duty Cycle, -Duty Cycle, Rise Time, Fall Time, Delay, Phase, X at min Y, X at max Y, Area - N Cycles, Area - Full Screen
	Math	4 waveforms: Addition, Subtraction, Multiplication, Derivative, Integral, FFT, Mx+B, x^2, Square Root
	Reference	4 waveforms
	Triggering	Auto, Wait for Trigger, Force Trigger, Source (V, I, P, External, Line), Edge (Rising, Falling, Either), Noise Reject
	AutoScale	Yes
	Cursors	2X, 2Y, tracking or manual
	File Storage	Save, Recall, Move, Print
Continuous Whole-Cycle Analysis (CWA)	Voltage	DC, AC_{rms}, AC with DC_{rms}, Rectified Mean, Frequency, Maximum, Minimum, Crest Factor
	Current	DC, AC_{rms}, AC with DC_{rms}, Rectified Mean, Frequency, Maximum, Minimum, Crest Factor
	Power	Real Power AC, Real Power AC+DC, Real Power DC, Apparent Power AC, Apparent Power AC+DC, Reactive Power AC, Reactive Power AC+DC, Power Factor AC, Power Factor AC + DC, Power Angle AC, Power Angle AC+DC
Harmonics	Type	Voltage or Current
	Maximum frequency of any order	<30 kHz for any order
	Frequency content between 30 kHz and 2.5 MHz can be displayed using the internal Math FFT	
	Maximum harmonic order	250 orders (attainable below fundamental frequency of 120 Hz)

Accuracy

Accuracy Specifications for V, I, P, Q, S, λ, phase: ± (% Reading + % Range + Fixed Term)[1]
Valid for 1 year from calibration

		Frequency						
		DC[3] - 10 Hz	10 Hz-40 Hz	40 Hz-100 Hz	100 Hz-1 kHz	1 kHz-10 kHz	10 kHz-100 kHz[2]	100 kHz-1 MHz[2]
Voltage[4]	%Reading + %Range	0.05 + 0.05	0.06 + 0.05	0.05 + 0.05	0.05 + 0.05	0.1 + 0.05	0.8 + 0.4	0.008 x f + 0.5
	Fixed Term	100 µV						
Current[4] (External Input)	%Reading + %Range	0.05 + 0.05	0.06 + 0.05	0.05 + 0.05	0.05 + 0.05	0.1 + 0.05	0.8 + 0.4	0.008 x f + 0.5
	Fixed Term	$100\ \mu V \bullet (1/R_{trans})$						
Current[6,7] (Directly Connected 2 A and 50 A Inputs)	%Reading + %Range	0.08 + 0.04	0.08 + 0.03	0.08 + 0.03	0.1 + 0.05	0.5 + 0.2	(0.05 x f) + 0.4	Unspecified
	Fixed Term 2 A	0.05 mA						
	Fixed Term 50 A	1 mA						
Power[8,9] (External Current Input)	%Reading + %Range	0.08 + 0.08	0.08 + 0.08	0.08 + 0.08	0.08 + 0.08	0.15 + 0.08	1.6 + 0.7	Unspecified
	Fixed Term	$100\ \mu V \bullet R_{trans} \bullet$ Voltage Reading[4]						
Power[8,9] (Directly Connected Current Input)	%Reading + %Range	0.1 + 0.05	0.1 + 0.05	0.1 + 0.05	0.1 + 0.05	0.5 + 0.05	(0.05 x f) + 0.7	Unspecified
	Fixed Term 2 A	$0.05\ mA \bullet R_{trans} \bullet$ Voltage Reading[4]						
	Fixed Term 50 A	$1\ mA \bullet R_{trans} \bullet$ Voltage Reading[4]						

Notes:

For all specs dependent on frequency, use frequency (f) in kHz.

Ranges: Voltage: 5 V, 10 V, 20 V, 50 V, 100 V, 200 V, 500 V, 1000 V
2 A input: 10 mA, 20 mA, 50 mA, 100 mA, 200 mA, 500 mA, 1 A, 2 A
50 A input: 200 mA, 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, 50 A
External Transducer input: 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V

1. Specifications are valid for operating temperature of 23 ±5C, Humidity of 20 to 80% RH with at least 60 minutes of warm-up. Valid for 1 year from calibration. Input must be sinusoidal with amplitude between 10% to 110% of range with no common mode signal, with a power factor of 1. Measurement technique must be Continuous Whole-Cycle Analysis (CWA) with interval greater than or equal to 200 ms. Specifications for inputs beyond $0.8 x 10^7 V \square Hz$ are characteristics. Specifications for frequencies between DC to 10 Hz and above 1 MHz are characteristics. Internal current and power with internal current specifications above 10 kHz are characteristics. Outside of 23 ± 5C, use the following % of Reading + % of Range specification adder.

V, I	Temp Coefficient	0.005 + 0.005	Per degree outside of 23 ± 5C
	DC Temp Coefficient	0.005 + 0.020	Per degree outside of 23 ± 5C
P, Q, S	Temp Coefficient	0.01 + 0.01	Per degree outside of 23 ± 5C
	DC Temp Coefficient	0.01 + 0.02	Per degree outside of 23 ± 5C

2. For measurements above 100 kHz, anti-aliasing (AA) filter must be turned off. If AA filter is on, add an additional $(0.0004 \square f^2)$ times % of Reading . For all specifications dependent on frequency, use frequency (f) in kHz.
3. To meet the DC accuracy in the table, a zero compensation process must have occurred within the past hour, or within 2 C ambient temperature change. A zero compensation process happens automatically any time the range is changed, or when a zero process is explicitly requested via the user interface. Otherwise, add 0.1% of range.
4. In the specification above, R_{trans} is equal to the Voltage per Ampere transducer gain, and N_{trans} is the Ampere per Ampere turns ratio of the current transformer. Voltage Reading term is the RMS voltage measurement from the same power channel.
5. The -3 dB BW of voltage and transducer inputs is 2.5 MHz anti-aliasing is off.
6. If current greater than 20 A_{rms} is applied to the 50 A input, you must wait at least 10 minutes to get full accuracy below 20 A_{rms}. This is due to self heating of the shunt.
7. Common mode signal applied to the current terminals can affect the accuracy of the measurement. To calculate the impact of the common mode, multiply the ACrms common mode voltage by the frequency of the common mode signal and then multiply by the spec adder below. For the effects on power accuracy, multiply this error term by M_{acrms}.

2 A	2 nA / VHz
50 A	10 nA / VHz

8. Use these specs for P, Q and S. Range for a power measurement is defined as (Voltage Range) x (Current Range).
9. Apply this error to power P and reactive power Q. For power Factor (λ) in between 0 and 1, use the formula:
   $P_{err} = 0.1 f \square \sqrt{1-\lambda^2}$ % Range and $Q_{err} = 0.1 f \square \lambda$ times % of Range
10. Power factor Accuracy: $(0.005+0.0018 \square f)\sqrt{1-\lambda^2}$
11. Phase Accuracy: $(0.03+0.054 \square f)$ degrees

Continuous Whole-cycle Analysis (CWA) Frequency Measurements

Accuracy: 0.05%

Measurement Limits vs CWA Window Length:

CWA Window Length	Min Measurable Freq
50 ms	200 Hz
100 ms	100 Hz
200 ms	45 Hz
500 ms	20 Hz
1 s	10 Hz
2 s	5 Hz
5 s	2 Hz
10 s	1 Hz
20 s	0.5 Hz

1. For signals lower than the values following table, add 0.2%

External Current Input	10 mV
2 A	20 mA
50 A	500 mA

2. For current below 5 mA on the 2 A input and 100 mA on the 50 A input, frequency measurement accuracy is unspecified below 10x the minimum measurable frequency listed above.
3. The above specifications are valid for sinusoidal input signals larger than 10% of range using CWA frequency measurement.

Measurement Characteristics	
THD	-75 dBc at full scale for all inputs (<10 kHz)
dV/dt Common Mode relative to earth without resetting instrument	>25 kV/ms
Trigger Jitter	±100 ns Input and Output
Noise Floor	1% of range. On directly connected current inputs, add 5 mA (2 A connection) and 50 mA (50 A connection).
Voltage measurement capacitance to earth:	<130 pF
Current measurement capacitance to ground:	<130 pF
Display Characteristics	
Display	12.1-inch capacitive multi-touch/gesture enabled
Resolution	800 (H) x 600 (V) pixel format (screen area)
Intensity gradation	256 intensity levels
Display format	Configurable
Connectivity	
USB 2.0 hi-speed host port	Two USB 2.0 hi-speed host ports on front panel for memory devices and peripherals (e.g. keyboard, mouse, printer)
USB 2.0 hi-speed device port	One USB 2.0 hi-speed device port on rear panel. USB Test & Measurement Class (USBTMC) compatible.
LAN port	10/100/1000 Base-T port on rear panel
Web remote control	VNC Web interface (via major Web browsers)
10 MHz Reference Input	Earth referenced SMA connector on rear panel. 0 to 3.3 V logic level (5 V Max.)
Trigger In	Earth referenced SMA connector on rear panel. 0 to 3.3 V logic level (5 V Max.)
Trigger Out	Earth referenced SMA connector on rear panel. 0 to 3.3 V logic level, 50 Ω output impedance.

General environmental characteristics		
Power line consumption		Maximum 180 VA
Power voltage range		100-240 V, 50/60 Hz ±10%; 100-120 V, 50/60/400 Hz; auto-ranging
Temperature	Operating	0 to +40 °C
	Non-operating	-40 to +70 °C
Humidity	Operating	80% RH (non-condensing) at 40 °C
Altitude	Operating	Up to 3,000 m (15,000 ft)
	Non-operating	Up to 15,300 m (50,000 ft)
Acoustic power		Typical < 40 dBa, worst case noise <56 dBa
Warm-up Time		60 minutes
Electromagnetic compatibility		Compliant with EMC Directive (2004/108/EC),
		IEC 61326-1:2012/EN 61326-1:2013 Group 1 Class A
		Canada: ICES-001:2004
		Australia/New Zealand: AS/NZS
		South Korea KC mark
Safety		UL 61010-1 3rd edition, CAN/CSA_22.2 No.61010-1-12, IEC 61010-1:2010 3 rd edition
		IEC 61010-2-030: 2010, CAT II
Vibration		Based on IEC 60068
Shock		Based on IEC 60068
Dimensions		426 mm W x 308 mm H x 272.8 mm D (16.8 in W x 12.1 in H x 10.7 in D)
Weight		PA2201A: Net: 11.4 kg (25.2 lbs), Shipping: 12.8 kg (28.3 lbs)
		PA2203A: Net: 12.3 kg (27.2 lbs), Shipping: 13.7 kg (30.3 lbs)

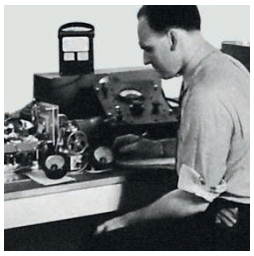
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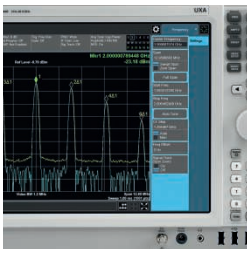
PA2201A for 2 power channels (single phase measurements and analysis)
PA2203A for 4 power channels (3-phase measurements and analysis).

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