IntegraVision PA2200 Series Power Analyzers

PA2201A 2-Channel
PA2203A 4-Channel

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.

GREENTEST ®
TECHNOLOGIES

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 a touch interface

- Save space on your bench with a minimum-depth form factor.

Power converter test for:

- UPS and energy Storage.

- EV, HEV, PHEV

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

- Solar Inverters

- Satellites and Aero/Defense

Figure 1. PA2203A IntegraVision Power Analyzer 4 Power Channels, 3-Phase Analysis
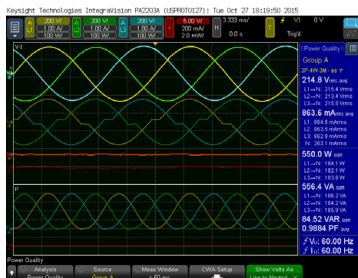
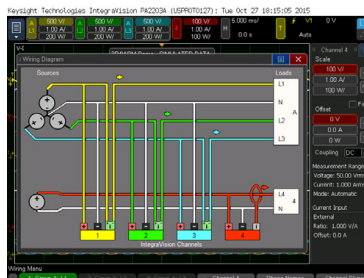Figure 2. Visualize 4 dynamic power channels simultaneously

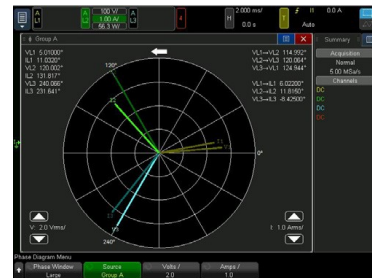Figure 3. Intuitive wiring configurator for faster insights

Figure 4. 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 the 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 the 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 the 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 give 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.

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. In order 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.

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 tests. 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.

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 types 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 a startup) 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 an event like startup, 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 i2t 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.

Data logger

- 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. (Rackmount 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.
- Easily upgrade firmware via front panel USB. Download the 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

Figure 5. 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.
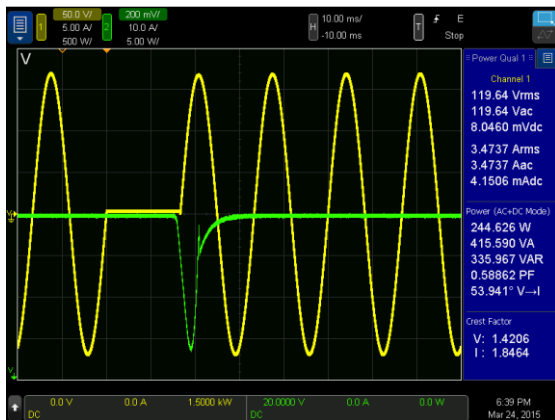

Figure 6. Transient measurement

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.
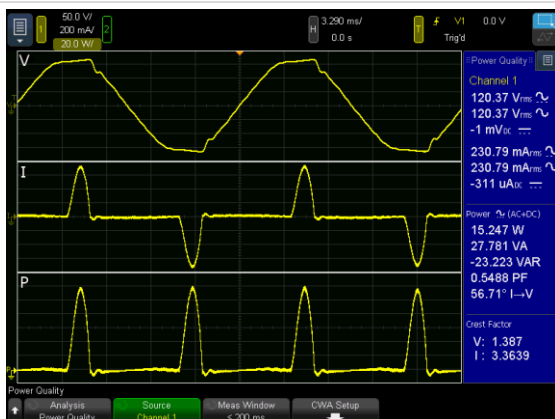

Figure 7. Power analysis panel

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
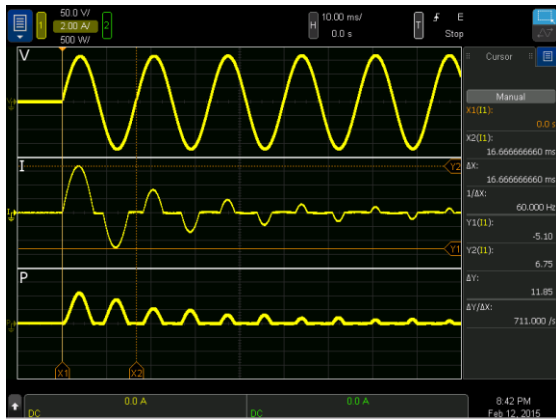
Figure 8. Measurement with cursors

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.

Figure 9. 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.
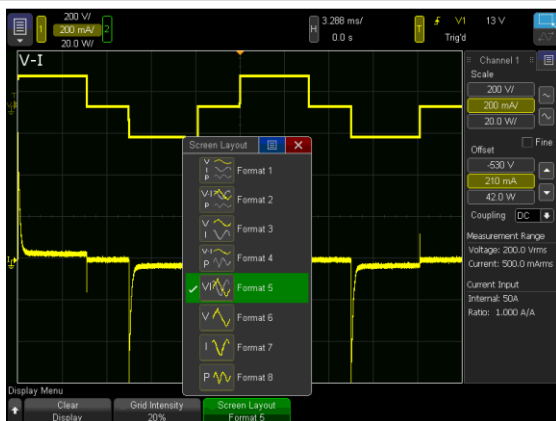
Figure 10. User selectable screen layouts

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

Figure 11. 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.

Figure 12. On-screen keyboard with touch

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

Front Panel PA2203A
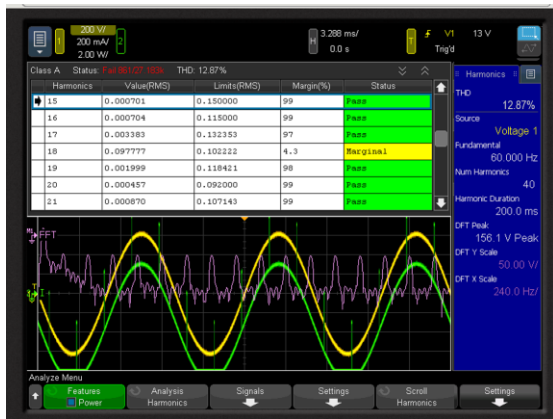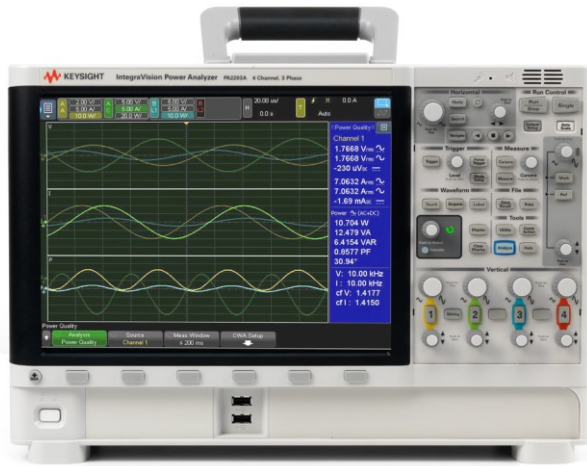

Figure 13. Front view of PA2203A

Rear Panel PA2203A

Figure 14. Rearview of PA2203A

Rear Panel PA2201A

Voltage inputs

Isolated BNC input for external current probes and transducers up to 10 V full scale

Integrated sliding safety cover

LAN

USB

Trigger in/out

Direct current input:
2 internal shunts for 2 arms and 50

Figure 16. Rearview of PA2201A

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

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

Figure 17. Direct current input connector

Key Applications

Electrical power conversion systems

Example:

- 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
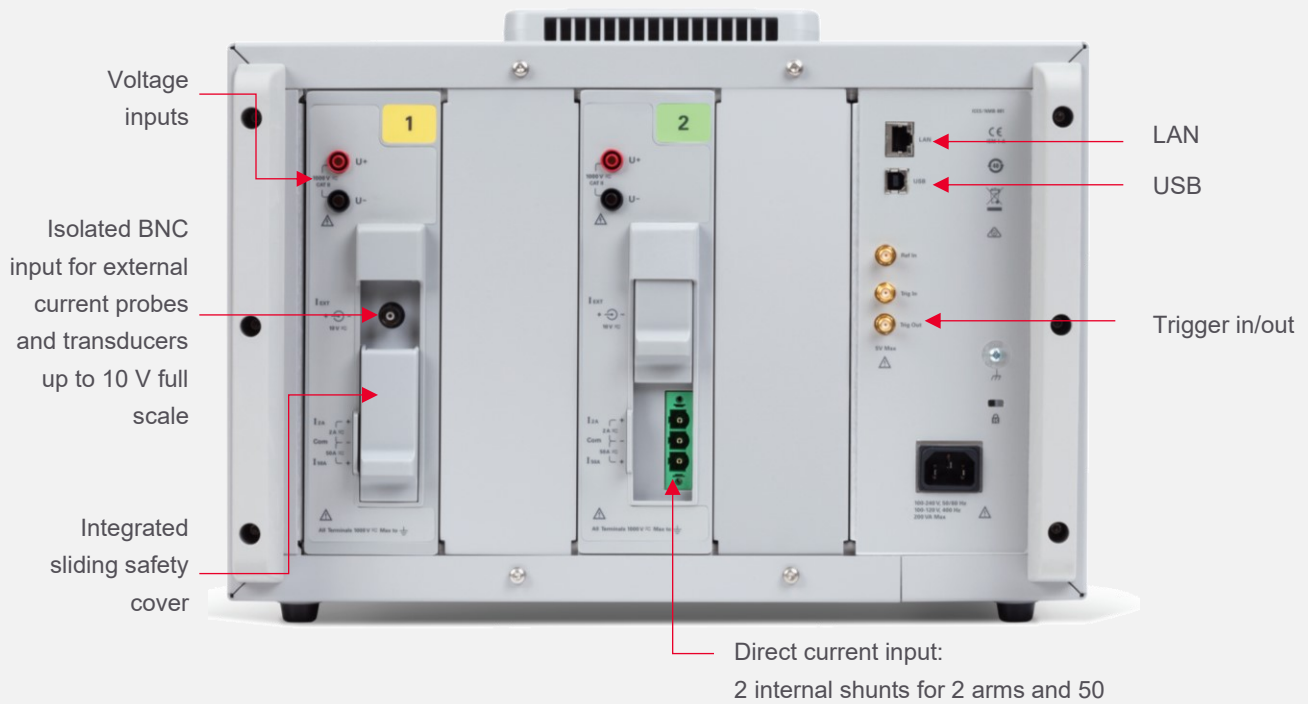
Important power converter measurements:

- 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 a startup, in-rush current and calculate i2t 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

Example:

- UPS
- Battery-powered backup and standby systems
- Battery chargers
- Charging stations
- Battery management systems
- Energy storage systems DC/AC inverters

Important energy storage measurements:

- Capacity
- Run-time
- 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 the 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.

Energy and electro-mechanical systems

Example:

- 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 lighting devices often involves the measurement of voltage waveforms, current waveforms, and THD because distortion in voltage and current waveforms are 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 [1]	Specified to 1MHz	
Current measurement (2 A or 50 A Input)	Specified to 100KHz	
Current measurement (External Input) [1]	Specified to 1MHz	
Maximum voltage	1000 V_{rms} (2000 V_{peak})	
Maximum current	Direct input:	2 Arms (6 A_{peak}) or 50 Arms (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 (voltages and current)		
Voltage	Connector	Safety Banana plug
	Maximum voltage	1000 V_{rms}, 2000 V_{peak} (peak not to exceed 25ms duration)
	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 Arms, 6 A peak or 50 Arms, 100 A peak (peak not to exceed 25ms duration)
	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 the 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 miswiring, but it should not be relied upon in situations where higher than 2 Arms 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, $ACrms$ - N Cycles, $ACrms$ - 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
	Auto scale	Yes
	Cursors	2X, 2Y, tracking or manual
	File storage	Save, Recall, Move, Print
Continuous Whole-Cycle Analysis (CWA)	Voltage	DC, ACrms, AC with DC_{rms}, Rectified Mean, Frequency, Maximum, Minimum, Crest Factor
	Current	DC, ACrms, 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 the fundamental frequency of 120 Hz)

Notes:
1. With anti-aliasing filter OFF, the -3 dB point of the analog measurement bandwidth occurs at or above 2.5 MHz
Per the accuracy specification table, Voltage measurement and Current (External Input) measurement accuracies are unwarranted for signals above 1 MHz

Accuracy

Accuracy specifications for V, I, P, Q, S, λ, phase: ± (% Reading + % Range + Fixed term) [1]

Valid for 1 year from calibration

Power factor (λ) Accuracy: $(0.005 + 0.0018*f) *\text{sqrt}(1-\lambda^2) + 0.0002*\lambda$ with f being frequency in kHz

Phase Accuracy: $(0.03 + 0.054*f)$ degrees with f being frequency in kHz. If using internal current the following adders may also be required. If using a low pass filter with Fc<1kHz, the following adders are not required. In the following equations, θ is phase angle and Irms is the rms current input level.

Input	If Irms	Spec adder
2A	< 100mA	$8E-7/((\theta+0.0006/Irms) *Irms^2)$
50A	< 2A	$0.0003/((\theta+0.012/Irms) *Irms^2)$

Frequency								
		DC 3 to 10 Hz	10 Hz to 40 Hz	40 Hz to 100 Hz	100 Hz to 1 kHz	1 kHz to 10 kHz	10 kHz to 100 kHz[2]	100 kHz to 1 MHz[2]
Voltage	%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	100µV						
Current [6,7] (directly connected 2A inputs)	%Reading + %Range (2A)	0.08 + 0.04	0.08 + 0.03	0.08 + 0.03	0.08 + 0.05	0.3 + 0.2	(0.02 x f) + 0.4	Unspecified
	Fixed term 2A	0.05mA*Ntrans						
Current [6,7] (directly connected 50A inputs)	%Reading + %Range (50A)	0.08 + 0.04	0.08 + 0.03	0.08 + 0.03	0.12 + 0.05	0.5 + 0.2	(0.05 x f) + 0.4	Unspecified
	Fixed 50A	1mA*Ntrans						
Power [7,8,9] (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	0.1mV * (1/Rtrans) * Voltage reading [4]						
Power [7,8,9] (directly connected current input)	%Reading + %Range (2A)	0.1 + 0.05	0.1 + 0.05	0.1 + 0.05	0.1 + 0.05	0.5 + 0.2	(0.05 x f) + 0.7	Unspecified
	Fixed 2A	0.05mA * Ntrans * Voltage reading [4]						
	%Reading + %Range (50A)	0.1 + 0.05	0.1 + 0.05	0.1 + 0.05	0.15 + 0.05	0.5 + 0.2	(0.05 x f) + 0.7	
	Fixed 50A	1mA * Ntrans * 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. Specs are valid for the 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 0V/A common mode, with a power factor of 1. The measurement technique must be Continuous Whole-Cycle Analysis (CWA) with an interval greater than or equal to 200ms. Specifications for inputs beyond 0.8x107 V*Hz are characteristics. Specifications for frequencies between DC to 10Hz and above 1MHz are characteristics. Internal current and power with internal current specifications above 10kHz are characteristics. Beyond 23+/- 5C, use the following temperature adder:

V, I	Temp coefficient	0.005 + 0.005	per degree beyond 23+/-5C
	DC temp coefficient	0.005 +0.020	per degree beyond 23+/-5C
P, Q, S	Temp coefficient	0.01 + 0.01	per degree beyond 23+/-5C
	DC temp coefficient	0.01 + 0.02	per degree beyond 23+/-5C

2. For measurements above 100kHz, the anti-aliasing (AA) filter must be turned off. If the AA filter is on, add an additional (00004 * f^2) * % of reading. For all specs dependent on frequency, use frequency (f) in kHz.
3. In order 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 the range.
4. Errors due to external transducer accuracy must be added to the above specifications. In the specifications above, R_{trans} is used as the transducer ratio.
5. Voltage and transducer input -3dB BW is greater than 2.5MHz, non-alias protected.
6. If current greater than 20Arms is applied to the 50A input, you must wait at least 10 minutes to get full accuracy below $20A_{rms}$. This is due to the self-heating of the shunt.
7. Common-mode signals applied to the current terminals can affect the accuracy of the measurement. To calculate the impact of the common-mode, multiply the AC_{rms} 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 U_{acrms}.

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

8. Use these specs for P, Q, and S. Range for power measurement are defined as Voltage Range * 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: $P_{err} = 0.1*f*sqrt(1-\lambda^2)$ % of Range and $Q_{err} = 0.1*f* \lambda$ % of Range with f being frequency in kHz

Continuous Whole-cycle Analysis (CWA) frequency measurements

Basic accuracy: 0.05% [1,2,3]

Measurement limits vs. CWA window length

CWA window length	Min measurable freq
50 ms	200 Hz
100 ms	100 Hz
200 ms (default)	45 Hz (default)
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

Notes:

1. For signals lower than the values in the following table, a filter with a cut-off frequency of less than 5x the minimum measurable frequency must be used. Otherwise, add 0.2% of reading.

External current input	10 mV$_{rms}$
2 A	20 mA$_{rms}$
50 A	500 mA$_{rms}$

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

CWA frequency measurements

1. Additional errors in the passband of low pass filter, where f is input frequency, and Fc is the specified cut off frequency of the filter, are $0.85*(1-sqrt(1/(1+(f/Fc)^2)))*100$.

Phasor diagram

1. The phasor diagram is limited to input frequencies between 12hz and 30kHz.

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/µs
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).
Measurement channel to earth capacitance	< 100 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 the 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 the rear panel
Web remote control	VNC Web interface (via major Web browsers)
10 MHz Reference Input	Earth referenced SMA connector on the rear panel. 0 to 3.3 V logic level (5 V Max.)
Trigger In	Earth referenced SMA connector on the rear panel. 0 to 3.3 V logic level (5 V Max.)
Trigger Out	Earth referenced SMA connector on the 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 61010-1:2012 Ed.3+R:19Jul2019,
	• CSA C22.2#61010-1-12:2012 Ed.3+U1; U2,
	• IEC 61010-1:2010,
	• AMD1:2016
	• IEC 61010-2-030: 2010, CAT II,
	• Pollution Degree 2
	Refer to Declaration of Conformity for the latest revisions of regulatory compliance at: www.keysight.com/go/conformity
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)