Test&Measurement

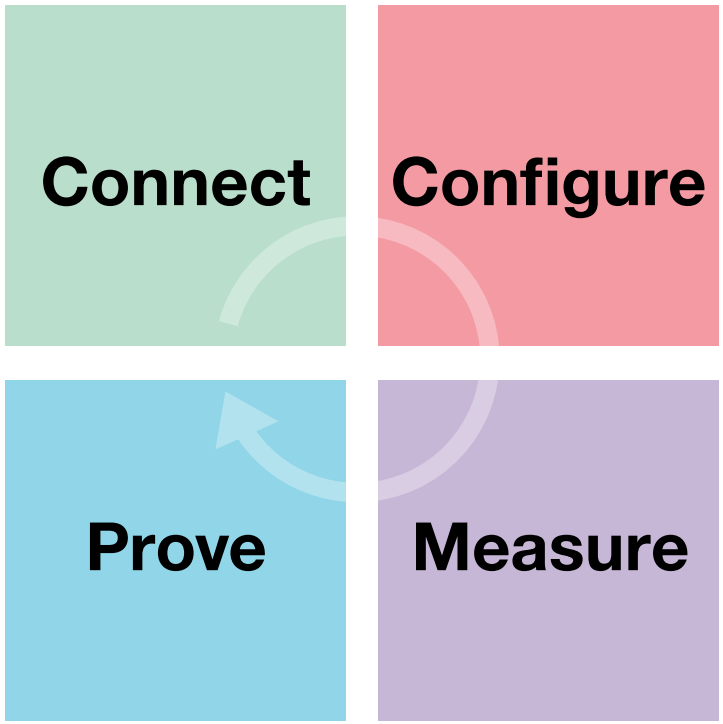
YOKOGAWA

Getting Started with Electrical Power Measurements

Energy efficiency directives from bodies like International Electro technical Commission (IEC), European commission, California Energy Commission (CEC) and others govern standards across various classes of electrical, electronic and mechatronic equipment.

This infographic provides a snapshot guide for making reliable power measurements across your product development lifecycle with particular emphasis on the high accuracy needs of compliance testing.

Scan the QR code to enter the Yokogawa VIP Suite for Power Measurements. On this page we have collected together the most updated Yokogawa Test & Measurement power measurement related articles, news and videos for your easy viewing.


Connect
Configure
Prove
Measure

1. Connect your application

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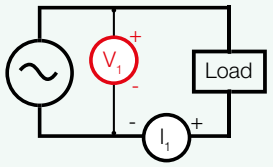
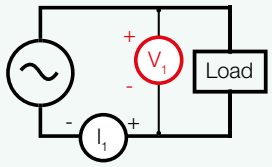
Choose the wiring configuration and connect the device under test to the voltage and current inputs of the instrument accordingly.

1P2W – Single phase two wire

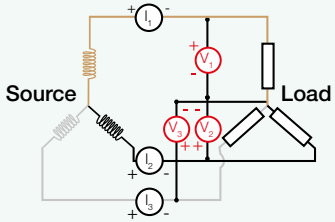


For low current loads

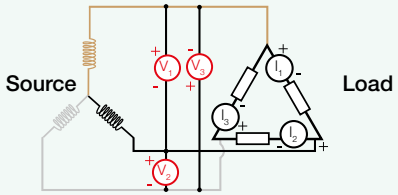


For lower voltages

3P3W – Three phase three wire



Star load



Delta load

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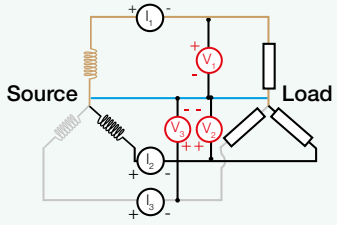
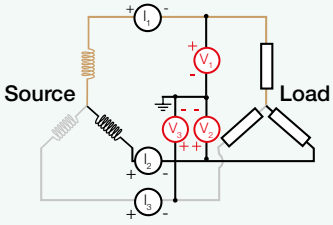
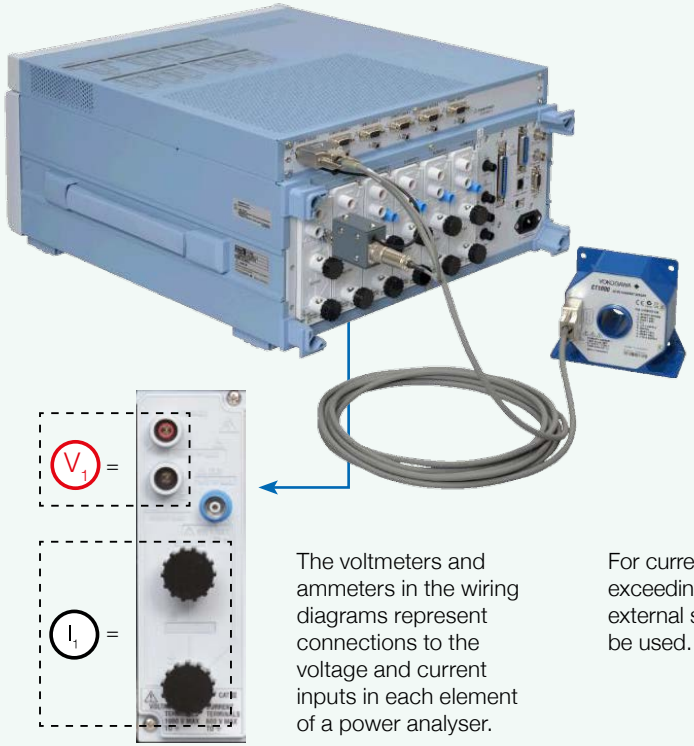


Ideal 4 wire connection for star load



Virtual Star Point when internal load connections are inaccesible

Connecting to a power measurement instrument*



The voltmeters and ammeters in the wiring diagrams represent connections to the voltage and current inputs in each element of a power analyser.

For currents or voltages exceeding input capacity, external sensors can be used.

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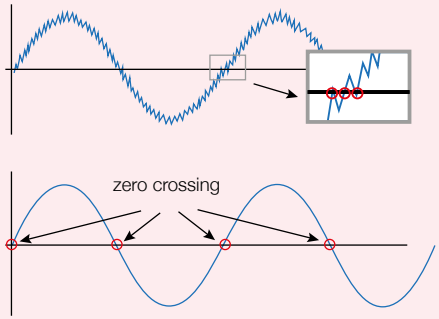


A frequency filter can remove noise from the chosen synchronisation signal for cleaner period detection

Select the measurement range

To ensure the best accuracy, pick the voltage and current ranges closest to the RMS value of the signal being measured.

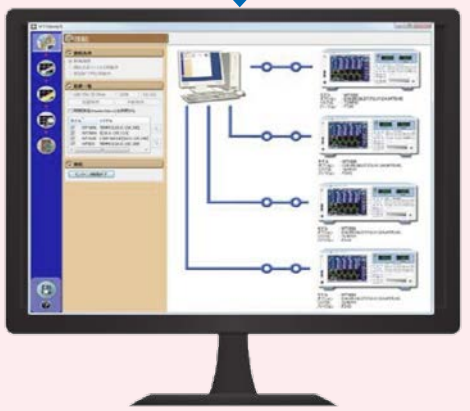
*Apply a Line filter if you need to remove unnecessary noise/high frequency components.

* Some measurement instruments offer measurement of electromechanical parameters such as torque, mechanical power, synchronous speed, slip, electrical angle, motor efficiency and total system efficiency from the analogue or pulse inputs of rotation and torque sensors.

Set the data update rate

The data update rate needs to be longer than 1 period of the measurement signal. Longer update rates help average out noise while shorter update rates are useful to detect / analyse inconsistencies. For fluctuating signals, the update rate may be set to change automatically based on changing input frequencies.

Connected to PC via Ethernet /USB GPIB / Modbus/ Webserver/TCP



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Customise your display to analyse multiple input signals in numeric, waveform, trend, vector or harmonic bar displays.

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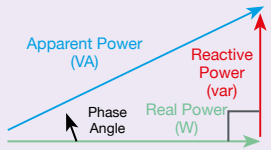
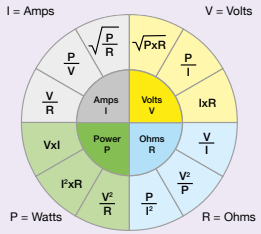
AC Power triangle





DC Power Parameters

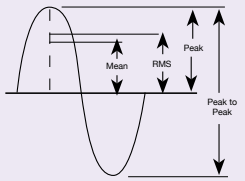
Power and Energy

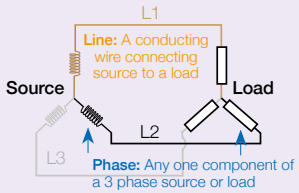
- **Power (P)** is the rate at which energy is generated or dissipated, measured in Watts. It is the average value over time of the instantaneous power of alternating current. It depends on voltage (V), current (I) and cosine Φ, 'Φ' being the angle of the phase difference between V and I.
- **Reactive Power (Q)** - Power stored and released as magnetic or electrostatic fields
- **Apparent Power (S)** - Total power in an AC circuit, both dissipated and absorbed/returned measured in Volt-Amps (VA).
- **Power Factor (λ)**- Ratio of true power to apparent power. Also expressed as cosΦ.
- **Energy** – The total energy consumed or generated over a defined period. (Watthours) Computed as power Integrated over specified time period
- **Efficiency**- Ratio of output power to input power

Impedance

Load type	Circuit	Voltage / Current waveform	Vector diagram
Resistance		Voltage (u) Current (i)	Voltage (u) Current (i)
Coil (inductor)		Lags by 90°	
Capacitor		Leads by 90°	

In addition to resistance, AC circuits may have inductive and capacitive loads that add reactance to the total circuit impedance and cause voltage and current to be out of phase by an angle Φ





Voltage and Current

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- **Peak value** of Voltage (Vpk) or current (Ipk) is the highest absolute value of the input signal
- **Mean Voltage** (Vmean) or current (Imean) is the average of all rectified instantaneous values over a defined period.
- **Line current:** Current through any one line between a three-phase source and load.
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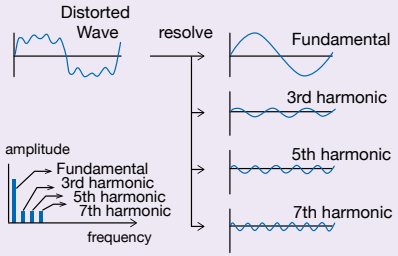
- **Phase current:** Current through any one component in a three-phase source or load.
- **Phase voltage:** Voltage across a load in a particular phase

Harmonics & Distortions



Total Harmonic Distortion THD

$$\frac{\textit{RMS value of all harmonics}}{\textit{RMS value of fundamental wave}}$$

Harmonic Distortion Factor

$$\frac{\textit{RMS value of nth harmonic}}{\textit{RMS value of fundamental wave}}$$

- Any complex waveform can be split into its constituent fundamental wave and higher order harmonics.
- While useful in applications such as VFDs, harmonics can cause noise, heating and unwanted vibrations when left unchecked and can pollute the electricity grid.
- Standards like IEC61000-3-2 place restrictions on harmonics across various classes of products in order to ensure reliable electrical systems.

4. Prove the accuracy

Manufacturers today have to meet a number of governmental and regulatory standards to ensure product efficiency, safety, comfort and productivity for consumers and businesses. Adherence to such standards often requires uncertainty specifications that are traceable to national and international calibration references. This section lists some of the factors influencing measurement uncertainty and how to achieve accurate measurements today and over the long term.

Measurement and uncertainty

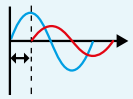
No measurement is complete unless its uncertainty is specified

	Magnitude of measurement	±	Uncertainty of measurement	Units
eg;	50	±	0.005	Watts

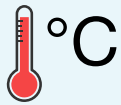
At power factor 1, Total Measurement Uncertainty is expressed as
Uncertainty of Reading + Uncertainty of Range.
In reality, there are more factors affecting total uncertainty which can be accounted for using the measurement instrument's specification sheet

Factors affecting Measurement Uncertainty

Selected voltage / current range

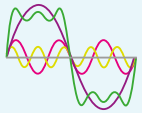

Internal Phase Shift

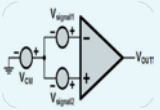
Frequency



Temperature


Instrument Crest factor


Wave shape



Common Mode Rejection


Sensor Uncertainties

Reliability of your measurement

How accurate is it today?

Refer to the instrument's accuracy specifications to account for the uncertainty of your readings from the factors listed above.

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ISO 9001 IEC EN CE EUROPEAN STANDARDS

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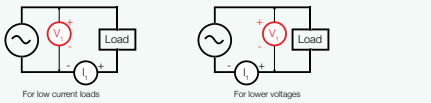

For low current loads — For lower voltages

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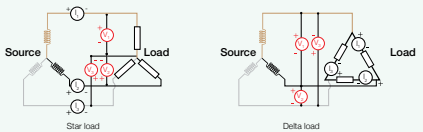

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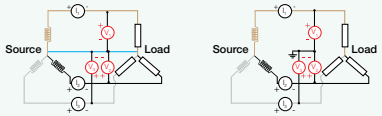

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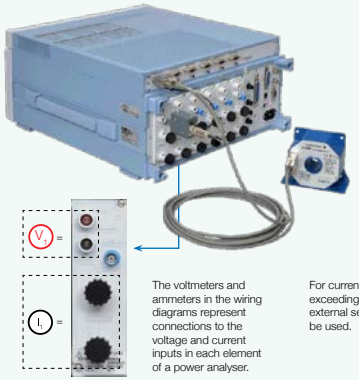

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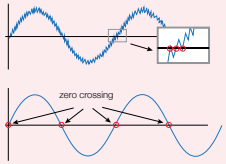

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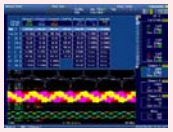

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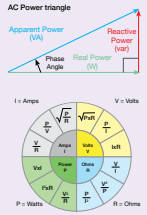

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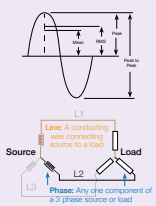

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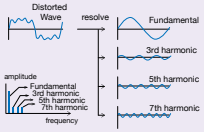
Harmonics & Distortions



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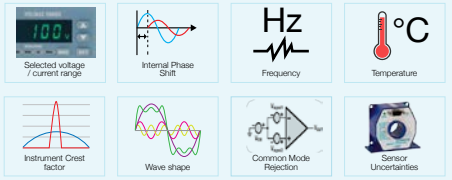

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ISO 17025 ACCREDITED LABORATORY

Precision Making

For more information: tmi.yokogawa.com