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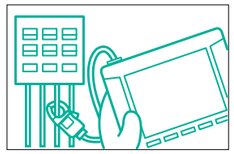
Realization of Power & Power Quality Management using a CW240

CASE 1 Get a view of energy consumption!

It is essential to measure energy and manage consumption of each sector such as facility and production line for your energy saving activities and to minimize loss.

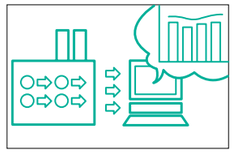


CASE 2 Contribute for improving productivity!

Constantly analyze productivity by managing unit consumption. Managing voltage, current, electric power and power factor makes for good maintenance of production facility.
Moreover, you can check operation management loss and enhance productivity.

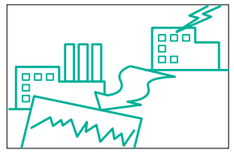
CASE 3 Discover of electric power waste!

Measure and collect data of electric power consumption by short period.
The CW240 can figure out load of production process, and has the ability to check wasteful time and current flow of standby load current.



CASE 4 Detect voltage fluctuation!

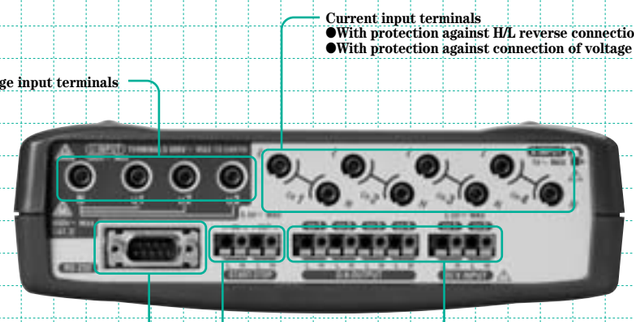
When trouble occurs on supply side of electric power, instantaneous voltage drop can affect quality of produced goods at the factory. The CW240 is useful for collecting data such as voltage fluctuation to prevent such problems.

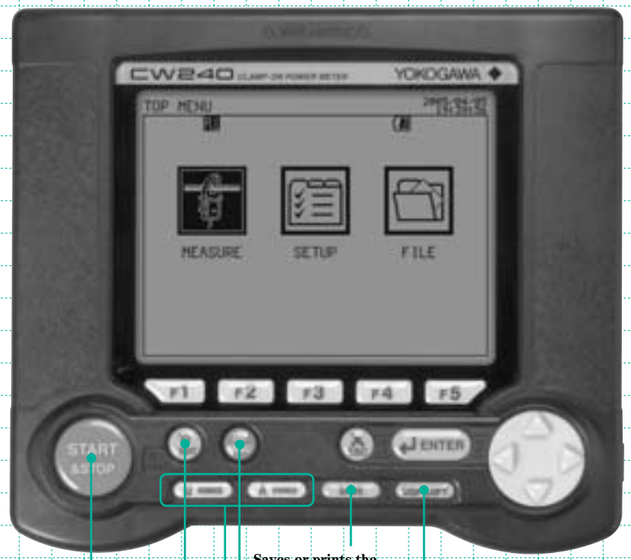


Characteristics of CW240

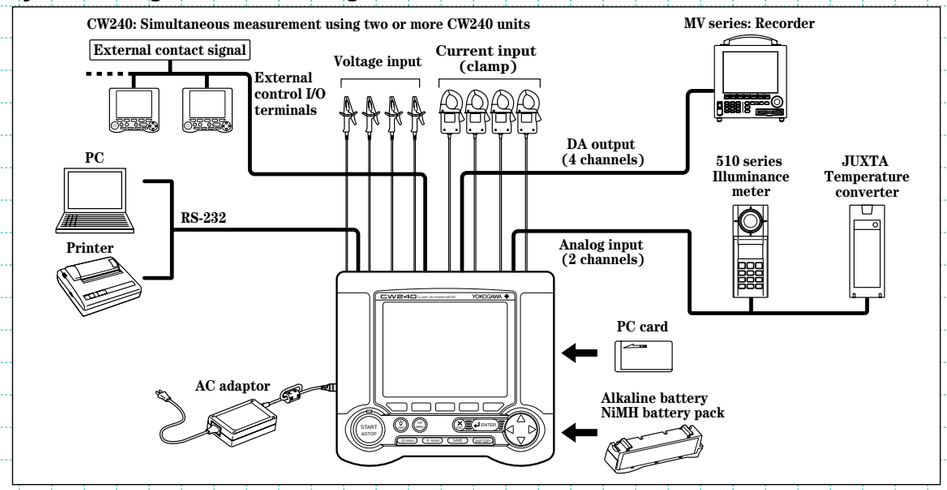
- Simultaneous measurement of instantaneous value, electric energy, demand, harmonics and voltage fluctuation.
- Simultaneous measurement of loads in 4 systems of up to 1P2W
  Simultaneous measurement of loads in 2 systems of up to 1P/3P3W
- Data saving interval can be set from 1 waveform (for instantaneous measurement) to 1 hour.
- Measure up to 50th order harmonics
- 4ch leakage current measurement using newly released clamp probe 96036
- Long time data logging by using compact flash memory.
- Multi language for the display (English, German, French, Italian, Spanish, Korean and Chinese)
- 2ch analog input (Optional)
  Equipped with 4ch analog output (recorder output)
- AC adaptor for power supply. NiMH rechargeable battery and alkaline battery for backup

CW240





System Configuration Block Diagram



510 series Illuminance meter
Product of Yokogawa M&C Corporation

MV series: Recorder and JUXTA
Product of Yokogawa Electric Corporation

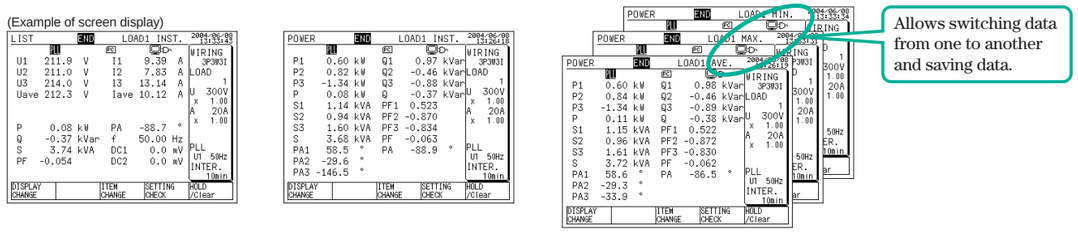
Power Investigation

Power Investigation Improves power Efficiency Through Detailed Data Coll ection.

Measurement of Instantaneous Value: For investigation of power consumption, maximum load factor and peak current

The CW240 can be used to carry out investigation regarding renewal of electric equipment such as transformers in building, check load factors and demand factors, and to check current/voltage fluctuation at motor start-up.

(Example of screen display)



Allows switching data from one to another and saving data.

- **Measurement elements :** Voltage/current/electric power (active, reactive, apparent)/power factor/phase angle of each phase, average/minimum/maximum values of each measurement element.
- **Data collection time :** 1/2/5/10/15/30 seconds, 1/2/5/10/15/30/60 minutes
  One cycle (waveform), 100/200/500 ms (short time interval)

Convenient functions

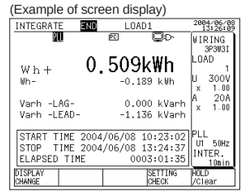
Use of the 3-wattmeter method enables display of instantaneous value of each measurement element.

Power Quantity Measurement: For Power-Saving Diagnosis and Data Collection for ISO14001

The CW240 can measure and display the power quantity consumed up to the specified time (from the start of integration until the end).

- **Measurement elements :** Active power quantity, regenerative power quantity, reactive power quantity (leading/lagging)
- **Data collection time :** 1/2/5/10/15/30 seconds, 1/2/5/10/15/30/60 minutes

(Example of screen display)



Convenient functions

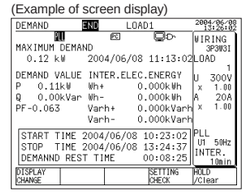
The number of display digits and display units can be selected.

- Standard (Voltage/current range is selected according to the phase)
- Arbitrary (Decimal point position and display unit can be specified)
- Auto (Decimal point position and display unit are selected automatically according to the integration result)

Demand Measurement: For Review and Investigation on Contract Demand

- **Measurement elements :** Maximum power demand required since the start of logging measurement and the time it occurs
  Active power, reactive power (lag), power factor
  Active power quantity (consumption, regeneration), reactive power quantity (lagging/leading)

(Example of screen display)



Convenient functions

Normally, the demand time limit is set to 30 minutes in the contract with a power company.
However, the CW240 allows you to set the desired demand time limit in units of seconds/minutes.
Demand time limit setting : 1/2/5/10/15/30 seconds, 1/2/5/10/15/30/60 minutes

- **Demand**
  Demand time limit : Length of time set to obtain the average power (normally 30 minutes)
  Demand power : Average power during the demand time limit

CW240 Solution

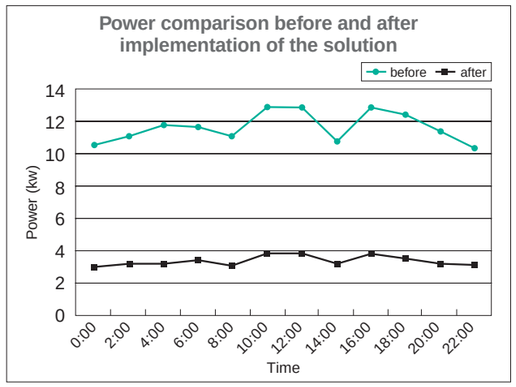
Investigation into Energy Saving at Factories and Buildings

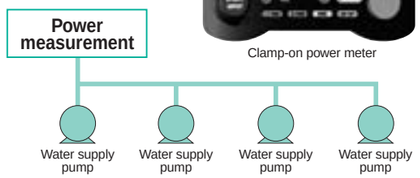
Food processing plant Facility investigated : Pumps

Purpose : To review the current power equipment, and replace it if necessary but with low investment cost

Solution 1 : Calculation of the amount of used water based on power consumption since flow meters are expensive

Solution 2 : Introduction of invert pump control





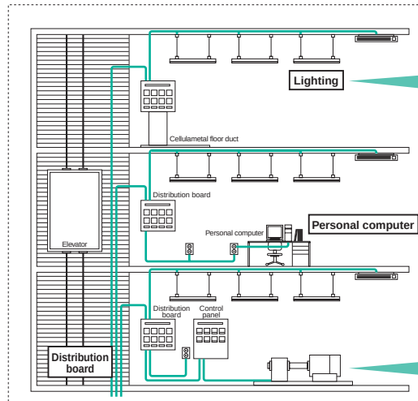
Clamp-on power meter

AP240 Suitable for Data Analysis!

Energy saving & Reduce electricity bill

CW240 Solution

Energy Saving and Maintenance for Electric Equipment at Factories and Buildings



Investigation at offices
- Air conditioning
- Lighting
- Office automation equipment
- Elevator

Investigation at production departments
- Power quantity
- Investigation of electric power consumption rate
- Production quantity
- Power factor

CW240 solution (building)
1. For energy investigation/control for each application and floor
2. For simple investigation for each shop and tenant
3. Diagnosis of operational status of equipment such as elevator and air conditioner
4. Diagnosis regarding renewal of electric equipment

CW240 solution (factory)
1. Diagnosis of operational status of equipment such as production equipment and air conditioner
2. For investigation of electric power consumption rate for each production line
3. For energy investigation/control for privately-owned electrical power facilities
4. For control of monthly target energy consumption

Power Supply Quality Control

Discovers Failures in Power Supply Lines.

Harmonic Measurement

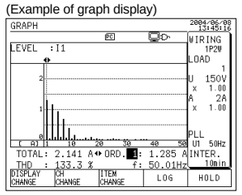
In many cases, inverter power supplies are used to drive air-conditioners and compressors. These power supplies cause distortions in voltages and currents, leading to malfunctions and power loss. Therefore, investigation and control of influences on the main power supplies by harmonics is necessary.

- **Harmonics for analysis** : 1st to 50th
- **Display data** : List, bar graph (linear/log), vector (inflow/outflow judgment)
- **Measurement elements** : Level, content, phase angle (voltage/current/electric power of each harmonic), aggregate value (voltage, current, electric power, power factor), aggregate harmonic distortion factors (THD-F or THD-R) of voltage/current
- **THD-F** : Distortion factor for the fundamental wave, THD-R: Distortion factor for all rms values voltage/current
- **Data collection time** : 1/2/5/10/15/30/60 minutes

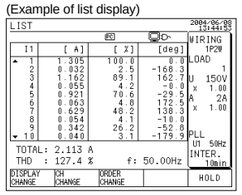
Convenient functions

The harmonic whose data is required to be saved can be selected. Inflow/outflow of harmonics can be checked.

(Example of graph display)



(Example of list display)



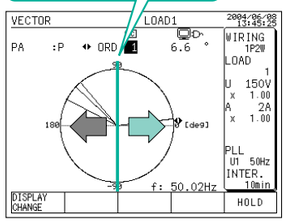
●THD-F

Distortion factor for the fundamental wave, THD-R: Distortion factor for all rms values

(Influences by harmonics)

Category	Device	Influence type
Power devices	Capacitor, reactor	Overheat, burn, vibration, noise due to excessive current
	Transformer	Overheat, noise, increase in core/copper loss
	Fuse, breaker	Blow-out, malfunction due to excessive current
	Induction motor	Periodic fluctuation of revolution speed, overheat, increase in loss
Electronic/electrical household appliances	Protective relay	Malfunction
	Electrical household appliances	Flickering, noise, malfunction, breakdown
	Fluorescent lamp, mercury-arc lamp	Burn of stabilizer/capacitor, flickering
	Computer	Malfunction, out of control, breakdown
	Electronics device	Malfunction of automatic control part

: Inflow of harmonic
: Outflow of harmonic



Explanation of vector diagram

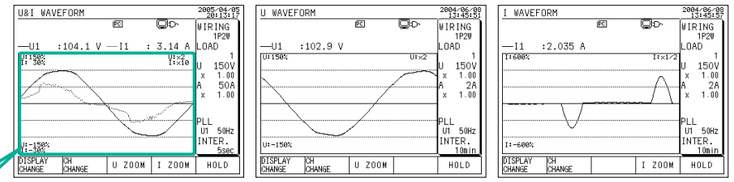
- Vector length indicates the apparent power of each harmonic in proportion to that of the fundamental harmonic.
- The horizontal axis shows active power and the vertical axis indicates reactive power. They are shown in a logarithm.
- Frequencies shown are those of the measurement element actually measured.

Waveform Measurement

- **Measurement elements :** Voltage of each phase, current of each phase Voltage and current of each phase
- **Data saving format :** Binary (can be converted to CSV format using a standard application program)

The scale of the vertical axis can be changed from x1/3 to x20.

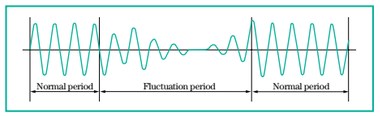
Easy to understand waveform distortion.



Voltage Fluctuation Measurement

The CW240 detects dates/times of when fluctuations occur, fluctuation type, channels where they occur, rms values, and periods between start and end. The voltage threshold is set, and fluctuations exceeding the threshold are detected.

- **Measurement element :** Voltage dip (voltage drop), voltage swell (voltage rise), instantaneous power failure
- **Data saving** : Detected based on the voltage rms value of one waveform. Up to 100 data sets can be saved.



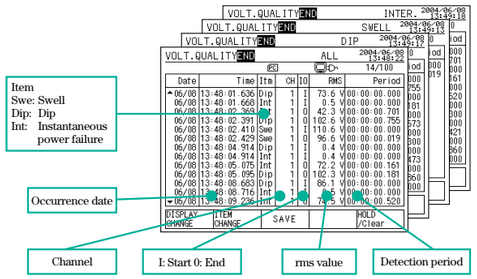
Measurement results

Convenient functions

It is possible to provide a voltage difference between start and end by setting a hysteresis.

Failures in power supply lines

Item	Phenomenon	Problem
Voltage dip (Sag, voltage drop)	A voltage drop occurs for a short time due to the occurrence of a large inrush current, for example, when a motor is started.	Decrease of power supply voltage may cause devices to stop or reset operations.
Voltage swell (Voltage rise)	Voltage increases instantaneously, for example, when lightning occurs or when a power line with a heavy load is turned ON/OFF.	Increase of power supply voltage may cause devices to stop or reset operations.
Instantaneous power failure (Instantaneous stop of power supply)	Power supply is stopped instantaneously or for a short/long time, for example, when a problem occurs in the power supply (suspension of power supply due to lightning, etc.) or due to the trip of a breaker caused by short circuits in the power supply, etc.	Instantaneous power failure may cause devices to stop or reset operations. Recently, various preventive measures have been taken for computers, thanks to widespread use of UPS (uninterruptible power source).



CW240 Solution — Improvement of Harmonic Measurement and Diagnosis

Printing plant

Purpose: To investigate the cause for periodic breakdown of printing machine

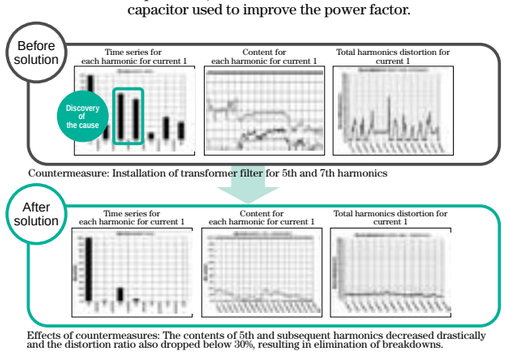
It may be caused by harmonics generated in the power lines.

Measurement: Advantages obtained by using the CW240

- Compact and easy to carry
- Measurement of up to the 50th harmonic
- Long-term data collection
- Vector diagram display

Result: Occurrence of harmonics in 5th and 7th was discovered!

In addition, it became clear that harmonics are generated due to loads inside the factory. In perticular, the 5th harmonic causes adverse effects such as burn-out of the serial reactor in the capacitor used to improve the power factor.

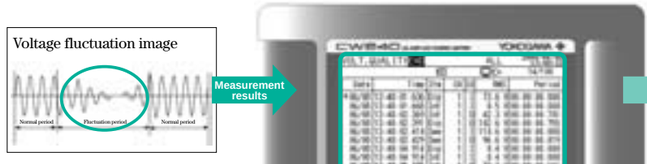


CW240 Solution — Power Supply Quality Check at Various Places

Quality check for power supplies used in semiconductor manufacturing equipment in accordance with the SEMI guidelines

Measure stability of the voltage of supplied power according to SEMI S2-0302 (Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment). If a sag (default: within 2%) occurs, the wafer is removed from the line for inspection so daily quality check for power supplies is necessary.

SEMI: Semiconductor Equipment and Materials International
SEMI guidelines are used at the time the contract is made, to evaluate the safety of semiconductor manufacturing equipment when exporting it from Japan to the USA.



Result:

Occurrence date/time of the sag can be reported so that semiconductor quality can be improved.

Other:

Verification of instantaneous power failure preventive measures implemented in semiconductor manufacturing equipment

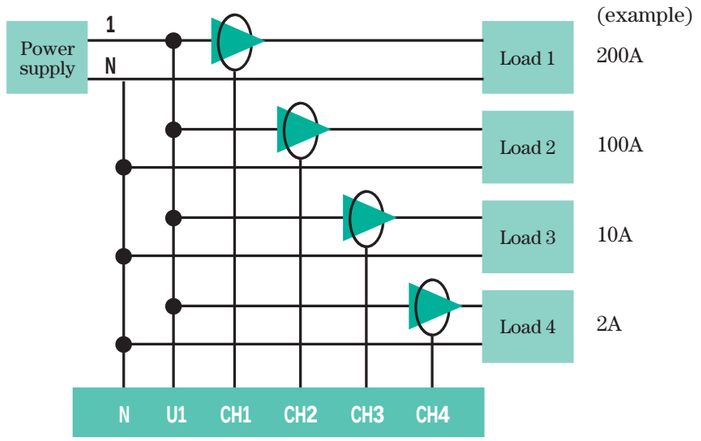
Advantages obtained by using the CW240
- Compact and easy to carry
- Detects voltage fluctuations in each cycle. Instantaneous power failures and voltage fluctuations are monitored continuously, and the occurrence and recovery times are reported.

Voltage level (100% as reference)	50% ~	70% ~	80% ~	90% ~ 110%	~ 120%
Fall (rise) time	Within 0.2 sec.	Within 0.5 sec.	Within 10 sec.	No limit	Within 0.5 sec.

Measures Loads in Four Systems Simultaneously.

The CW240 enables simultaneous measurement of loads in four systems in the case of the single-phase 2-wire system, and in two systems in the case of the single/three-phase 3-wire system (common to voltage).
Current clamp probe/range can be set for each system.

This allows measurement according to the current flowing in each load.

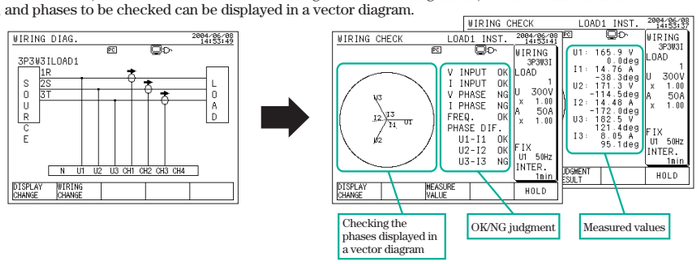


CW240 side Example of single-phase 2-wire system

Reduces Operation Errors at Work Site.

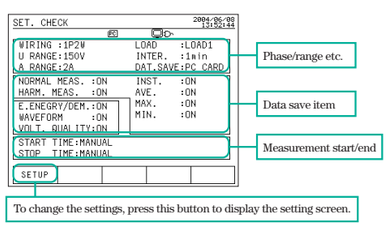
Wiring check function

Prior to start of measurement, the CW240 checks whether wiring is correct. Wiring errors, reverse connection of current clamps, and phases to be checked can be displayed in a vector diagram.



Setting check function

Settings made for data saving can be checked in the screen. This prevents data acquisition errors that may occur due to mistakes in voltage range setting, current clamp selection or data save item selection.



Saving a Large Amount of Data

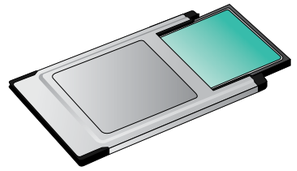
Use of an external memory card (compact flash) makes it possible to save a large amount of data. A memory card (*1) of up to 512 MB can be used, and the data is saved in CSV format. (*2)
In addition, the CW240 has a 1MB internal memory.

*1: Memory cards purchased from Yokogawa should be used.
*2: Data shorter than one second is saved in binary format.
Screen copies can be made in bitmap format.
Voltage fluctuation data is saved in text format.

●Storage period when PC card (64MB) and internal memory (1MB) are used

When storing all items of measured data, measured power quantity/demand data, and measured voltage fluctuation data

Wiring		1P2W 4 systems	1P3W 2 systems	1P3W31	3P3W21 2 systems	3P3W31, 3P4W	3P4W41	3P3W +1P3W
Number of storable data items		168	196	114	208	138	142	216
Recording medium	Interval time							
PC card (64MB)	1s	9 hrs	8 hrs	14 hrs	8 hrs	12 hrs	12 hrs	7 hrs
	1min	24 days	21 days	37 days	20 days	30 days	30 days	19 days
	60min	1471 days	1304 days	2223 days	1232 days	1852 days	1802 days	1188 days
Internal memory (1MB)	1s	8 min	7 min	12 min	7 min	10 min	10 min	6 min
	1min	8 hrs	7 hrs	12 hrs	7 hrs	10 hrs	10 hrs	6 hrs
	60min	21 days	18 days	32 days	17 days	26 days	26 days	17 days



When storing all items of measured data, measured power quantity/demand data, all items of measured harmonics data, waveform data and measured voltage fluctuation data

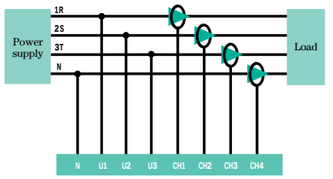
Wiring		1P2W 4 systems	1P3W 2 systems	1P3W31	3P3W21 2 systems	3P3W31, 3P4W	3P4W41	3P3W +1P3W
Number of storable data items		5642	5052	3758	6888	4390	5002	7504
Recording medium	Interval time							
PC card (64MB)	1min	17 hrs	19 hrs	26 hrs	14 hrs	22 hrs	19 hrs	13 hrs
	60min	44 days	49 days	65 days	35 days	56 days	49 days	32 days
Internal memory (1MB)	1min	12 min	13 min	19 min	8 min	16 min	13 min	7 min
	60min	12 min	13 hrs	19 hrs	8 hrs	16 hrs	13 hrs	7 hrs

Leakage Current Measurement

- External magnetic field effect is 0.002A or less, at 400A/m -

Yokogawa's proprietary technology has achieved a magnetic field impact amount of 30 ppm even in adjacent power lines. (At 100A)
Use of the 2A current clamp probe (96036) enables measurements with 200.0 mA range.

Current clamp probe 96036



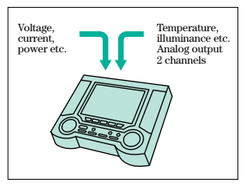
CW240 side Three-phase 4-wire 4-current

Analog Input/Output

- Besides power data -

Analog data such as temperature and illuminance data can be saved simultaneously with power data by using the analog input function (2 channels).
The available input ranges are 100 mV/1 V/5 V. In addition, the analog output function (4 channels) acquires data to an external recorder, allowing data duplexing. Output is ±1 VDC.
(The analog input/output function is optional.)

Digital illuminance meter 51001



Other Convenient Functions

Power supply backup
Besides the AC adapter, it is possible to use a NiMH battery pack (94004) or alkaline batteries (six AA batteries).
The CW240 will continue to operate even if supply of power is interrupted.

Multi-lingual support
The CW240 supports Japanese, English, German, French, Spanish and Italian (available in the near future).

Manual data saving
The data for the selected items can be saved or printed using the SAVE key.
However, it cannot be saved during integrating measurement (and during standby).

Screen hard copy
The currently displayed screen can be saved or printed using the DISP COPY key.
Files are saved in bitmap format.

Zoom function
The measured data for the selected five items can be zoomed in.
The items to be displayed can be selected from instantaneous value and measured power quantity data.

Specifications

CW240

■ Inputs

Item	Voltage	Current	
Input type	Resistive potential division	Clamp detection	
Rated value (range)	150.0 V 300.0 V 600.0 V 1000 V	Varies with the clamp and range used. 96036 (2A) 96033 (50A) 96030 (200A) 96031 (500A) 96032 (1000A) 96034 (3000A range) (2000A range) (1000A range) 96035 (3000A range) (300A range)	 200.0/500.0mA/1.000/2.000A 5.000/10.00/20.00/50.00 A 20.00/50.00/100.0/200.0 A 50.00/100.0/200.0/500.0 A 200.0/500.0 A/1.000 kA 300.0/750.0 A/1.500/3.000 kA 200.0/500.0 A/1.000/2.000 kA 100.0/200.0/500.0 A/1.000 kA 300.0/750.0 A/1.500/3.000 kA 30.00/75.00/150.0/300.0 A
Phase to be measured	Single-phase 2-wire, single-phase 3-wire, single-phase 3-wire 3-current (current in neutral line), three-phase 3-wire 2-current (2-power meter method), Three-phase 3-wire 3-current (3-power meter method), three-phase 4-wire, three-phase 4-wire 4-current (current in neutral line), Scott connection (three-phase 3-wire + single-phase 3-wire)		
Number of systems to be measured	With the same voltage Single-phase 2-wire: 4 systems, single-phase 3-wire: 2 systems, three-phase 3-wire 2-current: 2 systems		
Input resistance	Approx. 1.3MΩ	Approx. 100KΩ (CW240 main unit)	
Maximum allowed input (continuous)	1000 Vrms	96036 (2A) 96033 (50A) 96030 (200A) 96031 (500A) 96032 (1000A) 96034 (3000A range) (2,000A range) (1000A range) 96035 (3000A range) (300A range)	20Arms 130Arms 250Arms 625Arms 700Arms 2400 Arms (3600 Arms for 10 minutes) 2400Arms 1200 Arms 3600 Arms 360 Arms
A/D converter	Voltage/current input simultaneous conversion, PLL synchronized 128 samples/period, 16-bit resolution		

■ Measurement Functions

Item	Voltage	Current / Active power / Reactive power (reactive power meter method is used)	
Method	Digital sampling		
Frequency range	45 to 65Hz (Measurement element is selected from U1, U2 and U3)		
Crest factor	Rated input: 3 (however, 1.8 when 1000V range is used)		
Accuracy	±0.2%rdg. ±0.1%rng.	96030, 96031, 96033, 96036 96032, 96034, 96035	±0.6%rdg.±0.4%rng. ±1.0%rdg.±0.8%rng.
Power factor influence	—	96030 Other than 96030	±1.0%rng (45 to 65Hz, power factor =±0.5) ±2.0%rng (45 to 65Hz, power factor =±0.5)
Reactive factor influence	—	96030 Other than 96030	±1.0%rng. (45 to 65Hz, reactive factor =±0.5) ±2.0%rng (45 to 65Hz, reactive factor =±0.5)
Active input range	5 to 110% of each range (Max. 100% in the case of 1000V range)		
Display range	Voltage / current: 0.4 to 130% of each range (Zero suppression when below 0.4% of the range) Power (active, reactive, apparent): 0 to 130% of each range (Zero suppression when below 0.17% of the range rating). Harmonic level: 0 to 130% of each range Frequency: 40 to 70Hz		
Temperature coefficient	±0.03%rng/°C	±0.05%rng/°C	
Display updating interval	Approx. 0.5 seconds		

rdg: Reading rng: Range

■ Range Configuration for Active Power

For single-phase 2-wire system (X2 for single/three-phase 3-wire system, X3 for three-phase 4-wire system)

● When 96030 / 96031/ 96032 / 96033/ 96036 is used

Voltage range \ Current range												
									96032(1000A)			
								96031(500A)				
							96030(200A)					
	96036(2A)				96033(50A)							
	200.0 mA	500.0 mA	1.000 A	2.000 A	5.000 A	10.00 A	20.00 A	50.00 A	100.0 A	200.0 A	500.0 A	1.000 kA
150.0 V	30.00 W	75.00 W	150.0 W	300.0 W	750.0 W	1.500 kW	3.000 kW	7.500 kW	15.00 kW	30.00 kW	75.00 kW	150.0 kW
300.0 V	60.00 W	150.0 W	300.0 W	600.0 W	1.500 kW	3.000 kW	6.000 kW	15.00 kW	30.00 kW	60.00 kW	150.0 kW	300.0 kW
600.0 V	120.0 W	300.0 W	600.0 W	1.200 kW	3.000 kW	6.000 kW	12.00 kW	30.00 kW	60.00 kW	120.0 kW	300.0 kW	600.0 kW
1.000 kV	200.0 W	500.0 W	1.000 kW	2.000 kW	5.000 kW	10.00 kW	20.00 kW	50.00 kW	100.0 kW	200.0 kW	500.0 kW	1.000 MW

● When 96034 / 96035 is used

Voltage range \ Current range												
									96034_3(3000A)			
							96034_2(2000A)					
					96034_1(1000A)							
									96035_1(3000A)			
	96035_2(300A)											
	30.00 A	75.00 A	150.0 A	300.0 A	100.0 A	200.0 A	500.0 A	1.000 kA	2.000 kA	300.0 A	750.0 A	1.500 kA	3.000 kA
150.0 V	4.500 kW	11.25 kW	22.50 kW	45.00 kW	15.00 kW	30.00 kW	75.00 kW	150.0 kW	300.0 kW	45.00 kW	112.5 kW	225.0 kW	450.0 kW
300.0 V	9.000 kW	22.50 kW	45.0 kW	90.00 kW	30.00 kW	60.00 kW	150.0 kW	300.0 kW	600.0 kW	90.00 kW	225.0 kW	450.0 kW	900.0 kW
600.0 V	18.00 kW	45.00 kW	90.00 kW	180.0 kW	60.00 kW	120.0 kW	300.0 kW	600.0 kW	1.200 MW	180.0 kW	450.0 kW	900.0 kW	1.800 MW
1.000kV	30.00 kW	75.00 kW	150.0 kW	300.0 kW	100.0 kW	200.0 kW	500.0 kW	1.000 MW	2.000 MW	300.0 kW	750.0 kW	1.500 MW	3.000 MW

■ Equations

Active power, reactive power, apparent power, power factor and phase angle are measured for each phase.
The average, maximum and minimum values of those obtained during integrating measurement are calculated.

Voltage rms $U_{mrms} = \frac{1}{T}\int_0^T u_m(t)^2 dt = \frac{1}{T}\sum_{n=0}^{T} u_m(t)^2$

Current rms $I_{mrms} = \frac{1}{T}\int_0^T i_m(t)^2 dt = \frac{1}{T}\sum_{n=0}^{T} i_m(t)^2$

Active power $P_m = \frac{1}{T}\int_0^T \{u_m(t) \times i_m(t)\} dt = \frac{1}{T}\sum_{n=0}^{T} \{u_m(t) \times i_m(t)\}$

Reactive power 1 When the reactive power meter method is used

$Q_m = \frac{1}{T}\int_0^T \{u_m(t) \times i_m(t + \frac{T}{4})\} dt = \frac{1}{T}\sum_{n=0}^{T} \{u_m(t) \times i_m(t + \frac{T}{4})\}$

u(t): Voltage input signal
i(t) : Current input signal
T : One cycle of input signal
m : Each phase

■ Equations for Each Phase

Wiring / Measurement Items	Equation	Symbol	Single-phase 3-wire	Three-phase 3-wire 2-current *6	Three-phase 3-wire 3-current	Three-phase 4-wire
Average voltage	—	Uave	(U1 + U2)/2	(U1 + U2 + U3)/3 *1		
Average current	—	Iave	(I1 + I2)/2	(I1 + I2 + I3)/3 *2		
Active power	—	ΣP	P1 + P2	P1 + P3	P1 + P2 + P3 *4	
Reactive power 2 (*5)	$Q = \sqrt{S^2 - P^2}$	ΣQ	Q1 + Q2	$\sqrt{\Sigma S^2 - \Sigma P^2}$	Q1 + Q2 + Q3 *4	
Apparent power	S = U×I	ΣS	S1 + S2	$\frac{3}{2}$ (S1 + S3)	S1 + S2 + S3 *4	
Power factor	When the reactive power meter method is not used (*5)	ΣPF	$\Sigma PF = \frac{\Sigma P}{\Sigma S}$			
	When the reactive power meter method is used	ΣPF	$\Sigma PF = \frac{\Sigma P}{\sqrt{\Sigma P^2 + \Sigma Q^2}}$			
Phase angle (*5)	—	ΣPA	$\Sigma PA = \cos^{-1}\Sigma PF$			

In the case of distorted waves, there may be differences from other instruments that employ different measurement principles.

*1: Line voltage is measured in the case of 3-phase 3-wire system, and phase voltage in the case of 3-phase 4-wire system.
*2: I2 for three-phase 3-wire system (2-power meter method) is calculated by vector operation.
*3: This equation is applicable when the reactive power meter method is not used. Even in this case, the value is multiplied by the polarity of Q for each phase calculated by the reactive power meter method.
*4: In the case of three-phase 3-wire system, the phase voltage from the virtual neutral point is used to calculate each phase power.
*5: Multiplied by the polarity of Q for each phase calculated by the reactive power meter method.
*6: In the case of distorted waves and unbalanced inputs, there may be differences from other instruments that employ different measurement principles.
P1, P3, Q1, Q3, S1, S3, PF1 and PF3 are obtained during calculations carried out by the 2-power meter method, and do not exist as physical values.

■ Specifications of Each Function

● Frequency Measurement Function

Measurement input	Voltage input Selectable from U1, U2 and U3
Measurement frequency range	45 to 65 Hz
Display range	40.00 to 70.00 Hz
Accuracy	±0.1%rdg. ±1dgt For 10% to 130% sine wave input of voltage range
Low-pass filter function	Cutoff frequency: Approx. 300 Hz OFF/ON selectable

● Power Quantity Measurement Function

Measurement elements	Active power quantity, regenerative power quantity, reactive power quantity (lead/lag)
Measurement accuracy	Measurement accuracy of active power and reactive power ±1dgt (When STANDARD is selected for display digits)
Measurement range	Active power quantity Consumption 0.00000 mWh to 999999 GWh Regeneration -0.00000 mWh to -999999 GWh Reactive power quantity Lagging 0.00000 mvarh to 999999 GVarh Leading -0.00000 mvarh to -999999 GVarh
Display digits setting function	Selectable from automatic setting by rated power, minimum resolution setting, and minimum resolution shift by integrated value.
Integration time accuracy	±20 ppm (Typ., 23°C)

● Demand Measurement Function

Measurement elements	Active power (consumption), reactive power (lagging), power factor: Demand value within the interval time Active power quantity (consumption, regeneration), reactive power quantity (lagging), leading: Power quantity within the interval time Maximum demand (consumption power demand) required since the start of integrating measurement and the time it occurs
Measurement accuracy	Measurement accuracy of active power and reactive power ±1dgt (When STANDARD is selected as the standard number of display digits)

● Harmonic Measurement Function

Method	PLL synchronization
Measurement frequency range	Fundamental wave frequency 45 to 65 Hz
Harmonics for analysis	1st to 50th
Window width	1 cycle
Window type	Rectangular
Analysis data quantity	128 points
Analysis rate	1 sample/16 cycles
Analysis items	Harmonic level: Level of each harmonic of voltage, current and power Relative harmonic content: Content of each harmonic of voltage, current and power Harmonic phase angle: Phase angle of each harmonic of voltage, current and power For voltage and current, the phase angle of the fundamental wave or that of U1 can be selected as the reference. Total value: Total value of all the harmonics up to the 50th harmonic of voltage, current, power and power factor Total harmonic distortion rate: Voltage / current (THD-F or THD-R)
Accuracy	Harmonic level 1st to 20th: ±1.5%rdg. ±1.5%rng 21st to 30th: ±2.0%rdg. ±1.5%rng 31st to 50th: ±3.0%rdg. ±1.5%rng Relative harmonic content: Value calculated from harmonic level ±2dgt Harmonic phase angle The accuracy is guaranteed if both voltage and current levels for each harmonic are 5% of the range or higher. 1st to 20th: ±5° 20th to 50th: ±(0.3° X k+1°) k: Order The accuracy for current in relation to the fundamental wave is not specified.
Display data	List, bar graph (linear/log), vector

● Waveform Measurement Function

Measurement elements	Selectable from voltage/current waveform of same phase, all voltage waveforms, and all current waveforms.
Magnification change	x1/3 to x 20 in relation to the rating
Display data	1 waveform

● Voltage Fluctuation Measurement Function

Measurement elements	Voltage dip, voltage swell, instantaneous power failure
Measurement method	Detected based on voltage rms of one waveform.
Threshold/hysteresis	Can be set in percentage in relation to the reference voltage.
Accuracy	Same as voltage rms accuracy
Detection period	Time length during which the threshold is exceeded
Display data	Occurrence date (year, month, day), voltage rms, detection period
Number of events	100

● Display Function

Display	5.7-inch STN monochrome LCD display (320 dots x 240 dots) with backlight
Backlight	OFF/ON and auto OFF selectable
Contrast	Automatically adjusted according to the ambient temperature / Settable in 8 steps.
Display digits	Items other than power quantity: 4 digits Power quantity: 6 digits
Language	English, Japanese, German, French, Spanish, Italian, Korean and Chinese
Display average function	Moving average (Averaging count: selectable from 2, 5, 10 and 20)
Display hold	Hold / cancel

● Save/Print Function

Data can be saved/printed manually or automatically.

Storage media	Internal memory: 1MB or PC card
Printing	Dedicated printer (via RS-232)
Save/print data	Measured data, voltage variation data, waveform data, screen data, setting data
Saving format	Measured data: CSV format (Binary format if short-time interval is set) Voltage variation data: Text format Waveform data: Binary format Screen data: BMP format (bitmap) Setting data: Text format
Save/print interval	
Standard interval:	1/2/5/10/15/30 seconds, 1/2/5/10/15/30/60 minutes It is not possible to output/print measured harmonic and waveform data if the interval is shorter than 30 seconds.
Short-time interval:	0.1/0.2/0.5 seconds for each waveform Only instantaneous values can be input.

● Data storage time display

Unoccupied capacity in the storage destination
Data save items, calculated based on the interval time.

● File operation

Rename	File names in the internal memory and PC card can be changed.
Deletion	File names in the internal memory and PC card can be deleted.
Format	PC card and internal memory and can be initialized
Data copy	Files in the internal memory can be copied to the PC card.
Setting file	Setting file can be read, written, deleted and renamed.

● Communication Function

Electrical specifications	EIA RS-232
Synchronization system	Asynchronous communication
Baud rates	1200/2400/9600/19200/38400 bps
Connector	D-sub 9-pin

● PC card interface

Slot	PC card slot TYPE II (x1)
Compatible card	ATA flash memory card
Data format	MS-DOS format
Recording contents	Measured data, voltage fluctuation data, waveform data, screen data, setting data

● External control I/O terminals

Used to control start/end of integrating measurement.

Control input	TTL level or contact
Control output	TTL level

● Analog Input and DA Output Functions (Optional)

DA output	
Output voltage	±1VDC of the rated value for each range Power quantity depends on the output rate. X1, X10 and X100 can be set for harmonics. Frequency: 0.4 to 0.7V / 40 to 70 Hz
Number of output channels	4 channels
Output data (Four items can be selected)	Instantaneous value Voltage, current, average voltage, average current, active power, reactive power, apparent power, power factor, phase angle, frequency
Power quantity	Active power quantity (consumption, regeneration), reactive power quantity (lagging/leading)
Harmonic	Level, content, phase angle, total value, THD (THD-F or THD-R)
Accuracy	±(Measurement accuracy + 0.2%f.s.)
Resolution	Polarity + 11 bits
Updating interval	Other than harmonic measurement: 1 cycle of input signal Harmonic measurement: 16 cycles of input signal
Temperature coefficient	±0.02%f.s./°C or less
Output resistance	22Ω±5%
Power quantity output route	Selectable from 1V/1kWh, 1V/5kWh, 1V/10kWh, 1V/50kWh, 1V/100kWh, 1V/500kWh and 1V/1000kWh.
Analog input	
Input ranges	100mV/1V/5VDC
Number of inputs	2 channels
Accuracy	±0.5% f.s
Resolution	Polarity + 11 bits
Sampling rate	Approx. 20ms
Input resistance	Approx. 100kΩ

● Clock Function

Automatic calendar, automatic leap-year setting, 24-hour system	
Real-time accuracy	±20 ppm (Typ., 23°C)

● Wiring Check Function

Verification of validity of measurement of voltage/current input value, voltage/current phase difference, voltage-to-voltage phase difference, current-to-current phase difference and frequency
Verification of single-phase load (in the case of Scott connection)
Wiring diagram, vector diagram display

● Setting Check Window

Used to check data save items and start/end for integrating measurement.

● Other functions

VT ratio/CT ratio setting, ID number setting, NiMH (nickel hydride battery) charge, remaining battery voltage display, beep sound (key operation), key lock, system reset

● General specifications

Location for use:	Indoor, at an altitude of 2000 meters or less
Storage temperature and humidity ranges	-20 to 60°C, 90%RH (no condensation)
Operating temperature and humidity ranges	5 to 40°C, 5 to 80%RH (no condensation)
Insulating resistance	500 VDC, 50MΩ or greater Between voltage input terminals and case Between voltage input terminals and current input terminals / DC power terminals / external interface terminals
Insulating withstand voltage (50/60Hz, for one minute)	5.55 kVAC rms for one minute (Sensed current: 1mA) Between voltage input terminals and case 3.32 kVAC rms for one minute (Sensed current: 1mA) Between voltage input terminals and current input terminals / DC power terminals / external interface terminals
Power supply	AC adapter (standard accessory), 100 to 240 VAC, 50/60Hz
Backup battery (for power failure)	Six AA size alkaline batteries (standard accessory) One NiMH battery pack (optional)
Maximum rated power consumption	Main unit: Approx. 10W (normal operation), approx. 20W (during charging of NiMH battery pack) AC adaptor: Approx. 30VA (normal operation), approx. 60VA (during charging of NiMH battery pack)
External dimensions	Approx. 206 (W) × 184 (H) × 65 (D) mm (excluding projecting parts)
Weight	Approx. 1.2 kg (without batteries)

● Accuracy guarantee conditions

Warm-up time	30 minutes or more (within active input range, sine wave input, power factor=1, PLL synchronization)
Accuracy guarantee temperature and humidity ranges	23±5°C, 30 to 75%RH
Accuracy guarantee frequency range	45 to 65Hz
Accuracy warranty period	1 year