

CONTENTS

Introduction2

1. FX Power Monitor Features.....3

2. About CTs and VTs5

3. CT and VT Connection and Configuration8

4. Application Examples 15

5. Terminology and FAQ 17

Revision Information 19

Introduction

This document describes the power monitor function for the FX1000.

■ Notice

- The contents of this manual are subject to change without notice as a result of continuing improvements to the instrument's performance and functions.
- Every effort has been made to ensure accuracy in the preparation of this manual. Should any errors or omissions come to your attention, however, please inform Yokogawa Electric's sales office or sales representative.
- Under no circumstances may the contents of this manual, in part or in whole, be transcribed or copied without our permission.

■ Trademarks

- Our product names or brand names mentioned in this manual are the trademarks or registered trademarks of Yokogawa Electric Corporation (hereinafter referred to as YOKOGAWA).
- Ethernet is a registered trademark of XEROX Corporation in the United States.
- We do not use the TM or ® mark to indicate these trademarks or registered trademarks in this user's manual.
- All other product names mentioned in this user's manual are trademarks or registered trademarks of their respective companies.



❖ Benefit about FX1000's Power Monitor Function

- ❖ Power measurement using the FX1000 by itself
 - Less wiring (less wiring work) and less space
- ❖ A variety of monitor displays on the LCD
 - Stacked bar graph that displays integrated power
 - Trend graph that displays change in power
 - Historical trend that displays past data
- ❖ Display and recording of power data along with other measurements
 - Check the relationship between power and other measurements at a glance

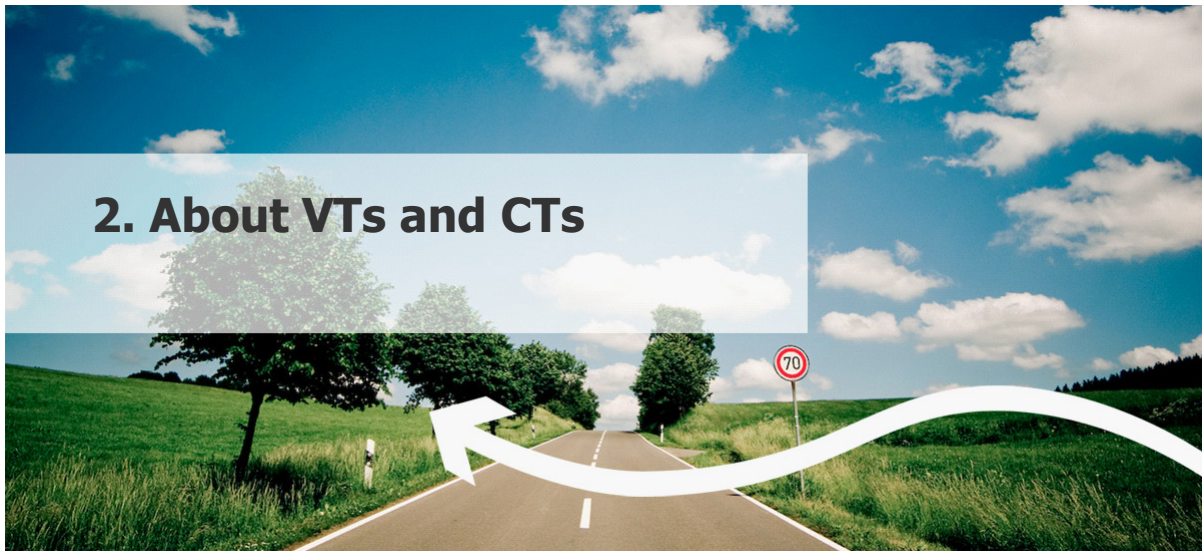


Comparison of Power Measurement Instruments (1)

Item		FX1000/(PWR)	PR300	WT210/WT230
Input	Phase and Wiring system	1P2W, 1P3W, 3P3W	1P2W, 1P3W, 3P3W, or 1P2W, 1P3W, 3P3W, 3P4W	WT210: 1P2W WT230: 1P2W, 1P3W, 3P3W, 3P4W
	Rated voltage (allowable input voltage)	120V range: 120V (150V) 240V range: 240V (300V)	150V range: 110V (150V) 300V range: 220V (300V) 600V range: 440V (600V)	WT210/230: 15, 30, 60, 150, 300, 600V, etc. External Input (option)
	Rated current (allowable input current)	1A (1.2A)	1A range: 1A (1.2A) 5A range: 5A (6.0A)	WT210 only: 5m, 10m, 20m, 50m, 100m, 200mA WT210/230: 0.5, 1, 2, 5, 10, 20A
	Universal	Universal circuit (phase and wiring system) Universal voltage	Universal circuit (phase and wiring system) Universal voltage	Universal circuit (phase and wiring system) Universal voltage Universal current
Accuracy rating	Current and Voltage	±1.0% of Range	±0.25% of F.S.	±(0.1% of rdg + 0.1% of mg)(45~66Hz)
	Active power	±1.0% of Range	±0.5% of F.S.	±(0.1% of rdg + 0.1% of mg)(45~66Hz)
Measurement range	Frequency	45 to 65Hz	45 to 65Hz	0.5 to 100kHz (inverter measurements possible)
	Power factor	(LEAD)0.5~1~(LAG)0.5	(LEAD)0.5~1~(LAG)0.5	-1.0000~1.0000
Measurement element	Voltage	Yes	Yes	Yes
	Current	Yes	Yes	Yes
	Active power	Yes	Yes	Yes
	Reactive power	Yes	Yes	Yes
	Apparent power	Yes	Yes	Yes
	Active energy	Yes	Yes	Yes
	Reactive energy	Yes	Yes	Yes
	Regenerative energy	Yes	Yes	Yes
	Apparent energy	Yes	Yes	Yes
	Option power integration	-	Yes	-
	Power factor	Yes	Yes	Yes
	Frequency	Yes	Yes	Yes
	Demand current and power	-	Yes (option)	-
Insertion loss	Harmonics	-	-	Yes (option)
	Voltage	1P2W: 120Vrange:0.2VA, 240Vrange:0.4VA 1P3W: 0.2VA/ph 3P3W: 120Vrange:0.2VA/ph, 240Vrange:0.4VA/ph	1P2W 150Vrange:0.2VA, 300Vrange:0.4VA, 600Vrange:0.8VA 1P3W 300Vrange: 0.2VA/ph 3P3W/3P4W: 150Vrange:0.2VA/ph, 300Vrange:0.4VA/ph, 600Vrange:0.8VA/ph	
Display	Current	1P2W: 0.2VA 1P3W/3P3W/3P4W: 0.2VA/ph	1P2W: 0.2VA 1P3W/3P3W/3P4W: 0.2VA/ph	
	Display device	5.7-inch TFT color LCD (240 × 320 dots)	Red 7-segment LED 5 digits (3 rows)	Red 7-segment LED 5 digits (3 rows)
	Trend display and recording	Yes	-	-
	Stacked bar graph display and report function	Hourly and monthly reports of active energy	-	-

Comparison of Power Measurement Instruments (2)

Item		FX1000/(PWR)	PR300	WT210/WT230
Output	Analog output	-	1point (option)	WT210: 4points (option*) WT230: 12points (option*) *Select analog output or digital output
	Integrated pulse output	-	1point (option)	4points (option*)
	Digital output	12points max. 1 FAIL point (note the possible combination of options)	1point (option)	*Select analog output or digital output
	Communication function	RS-232 or RS422/485 (option) Ethernet (option)	RS-485 (standard) Ethernet (option)	GP-IB or RS-232-C (option)
Miscellaneous	Operating temperature range	0 to 50°C	0 to 50°C	5 to 40°C
	Power supply	90 to 132, 180 to 250VAC	100 to 240VAC ±10% or 130 to 300VDC ±15%	100 to 240VAC
Dimensions	W × H × D	144 × 144 × 183.9	JIS110: 110 × 110 × 128 DIN96: 96 × 96 × 126	WT210: 250 × 107 × 382 WT230: 228 × 153 × 384
	Control functions	-	DI 1point (optional power integration)	DIO 6points (integration start, stop, etc. option)
Other functions	USB/F	keyboard, flash memory (option)	-	-



◆ Instrument Transformers (VTs and CTs)

- ◆ To measure power on actual high-voltage and high-current AC circuits, voltage and current must be transformed to low values that measuring instruments can receive.

Instrument transformers are used for this purpose.

- Voltage Transformers (VTs) transform voltage.
- Current Transformers (CTs) transform current.
 - Clamp-on CTs are easy to attach to already laid power cables.



Example of VT



Example of CT



Example of clamp-on CT
(CTW Series)

❖ Selecting a CT

- ❖ Check the voltage of the circuit.
 - Check the voltage of the circuit to be tested, then select a CT that support that voltage.
- ❖ Check the rated primary current.
 - Choose a CT with a rated primary current that is slightly larger than the maximum current that will be measured.
(Generally, the rated primary current is about 1.5 times larger than maximum current.)
- ❖ Choose the rated secondary current.
 - Input current range of FX1000 is 1A. Choose a 1A CT.
 - 1A CTs are useful for long-distance wiring.
- ❖ Check the rated load.
 - The load should be checked because it affects the wiring distance and other factors.
See, "Operating a CT."
- ❖ Ampere-turn:
 - If the primary current is a few amperes, winding the primary cable around the CT several times will cause the secondary current to be multiplied by just the number of times the cable is wound, allowing you to extract it.
Example; If you wind a cable once around a 100A/1A CT, two turns of the cable will pass through the center of the CT resulting in a 50A/1A ratio.
- ❖ Other:
 - To prevent accidents when the secondary circuit is open, it is safest to use a CT with a built-in voltage restraint.



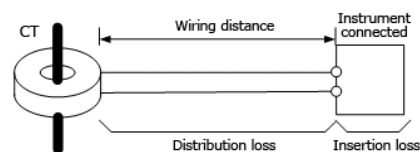
vigilantplant.
The clear path to operational excellence

YOKOGAWA ◆

❖ Operating a CT

- ❖ Rated Load:
 - The rated load is the sum of the distribution loss between the CT and instrument connected to the secondary side, and the insertion loss at the instrument connected to the secondary side.

$$\text{CT rated load} \geq \text{insertion loss at secondary side} + \text{distribution loss}$$



- ❖ Check the wiring distance and material.
 - Loss grows proportionally larger with the wiring distance.
 - The total length of the wiring materials is the distance both ways.

Approx. Resistance in Wiring Material

Nominal cross-sectional area: 1.25mm² = Approx. 18 Ω/km

Nominal cross-sectional area: 2.0mm² = Approx. 10 Ω/km

vigilantplant.
The clear path to operational excellence

YOKOGAWA ◆

❖ Operating a CT

❖ Examples (rough calculation)

CT: rated primary current/rated secondary current = 100A/1A
CT's rated load: 0.5VA

- When using wiring material with a nominal cross-sectional area of 1.25mm²
 - Wiring resistance $R = 18 \Omega/\text{km} \times 0.015\text{km} \times 2$ (both ways) = 0.54Ω
 - Distribution loss = $I^2R = (\text{rated secondary current})^2 \times \text{wiring resistance} = 1 \times 1 \times 0.54 = 0.54\text{VA}$
 - Condition: CT rated load > distribution loss + insertion loss of the instrument connected to the secondary side
 - This results in $0.5 > 0.54 + 0.2 = 0.74$, which is false (the condition is not met).
- When using wiring material with a nominal cross-sectional area of 2.0mm²
 - Wiring resistance $R = 10 \Omega/\text{km} \times 0.015\text{km} \times 2$ (both ways) = 0.3Ω
 - Distribution loss = $I^2R = (\text{rated secondary current})^2 \times \text{wiring resistance} = 1 \times 1 \times 0.3 = 0.3\text{VA}$
 - Condition: CT rated load > distribution loss + insertion loss of the instrument connected to the secondary side
 - This results in $0.5 \geq 0.3 + 0.2 = 0.5$, which is true (the condition is met).
- In the examples above, wiring with a nominal cross-sectional area of 2.00mm² is required.

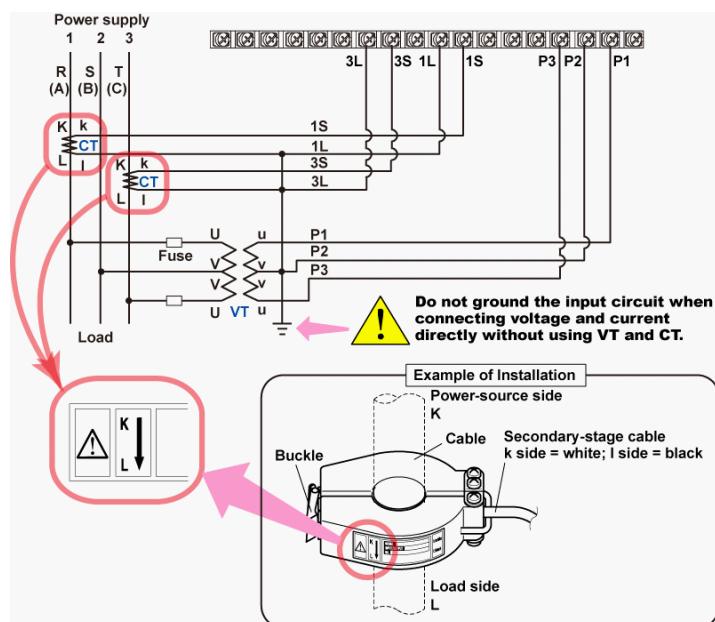
❖ Precautions Regarding Installing CTs

- ❖ Never open the secondary circuits of CTs.
 - Never open the secondary circuit while current is flowing through the primary circuit.
 - If you do, high voltage will appear at the secondary terminals and will lead to malfunction or burnout.
 - Some CTs have devices for suppressing hazardous voltage even when the secondary circuit is opened.
(The CTW series have such devices.)
- ❖ Pay attention to the CT installation direction and polarity.
 - On both the primary and secondary circuits, pay attention to the installation polarity and direction of K and k (power source side) and L and l (load side).



◆ Connection that uses a VT and CTs

◆ Connection that uses a VT and CTs Three-phase three-wire system

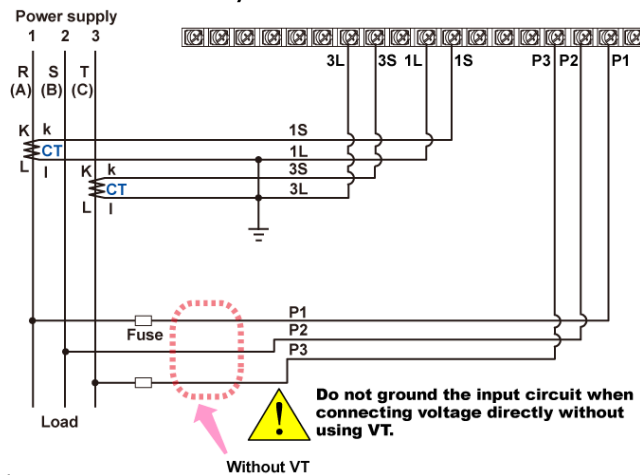


Connection for Power Measurement

❖ Connection that does not use a VT

- Low voltage such as 100V and 200V can be measured without a VT if the voltage is within the allowable input voltage range of the FX1000. (If you are not using a VT, be sure to use a fuse for protection.)

Three-phase three-wire system



vigilantplant.
The clear path to operational excellence

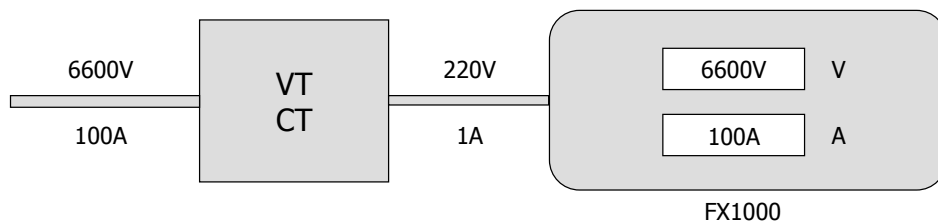
YOKOGAWA ◆

Setting the VT and CT Ratios

❖ What are VT and CT ratios?

- When using instrument transformers (VTs and CTs), you have to set the VT and CT ratios. The ratios are used to convert the measured values to voltage and current values on the primary circuits of the instrument transformers.
 - VT ratio: VT's primary circuit voltage rating/secondary circuit voltage rating
Example: VT ratio = 6600V/220V = 30
 - CT ratio: CT's primary circuit current rating/secondary circuit current rating
Example: CT ratio = 100A/1A = 100
 - If you don't use instrument transformers (VTs and CTs), the VT and CT ratios are 1.

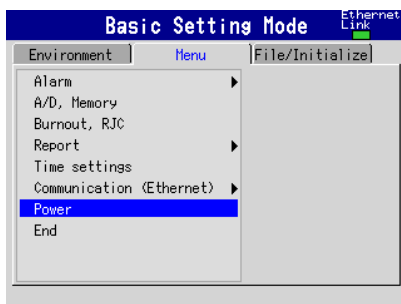
Setting: VT ratio = 30, CT ratio = 100



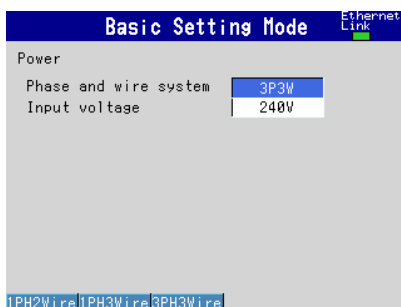
vigilantplant.
The clear path to operational excellence

YOKOGAWA ◆

Power Setting: Basic Setting Mode



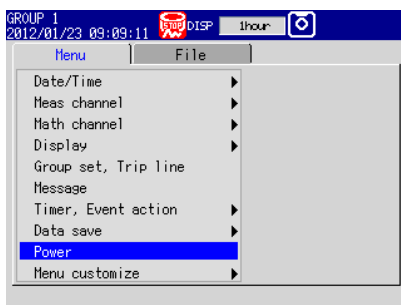
- ❖ Press MENU and hold down FUNC for 3 seconds (to switch to Basic setting mode)
- ❖ Select [Power]



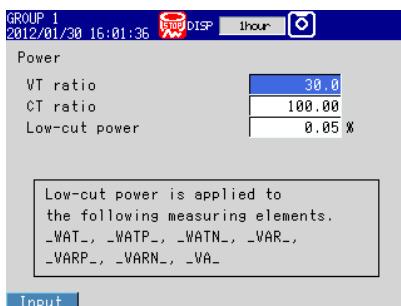
- ❖ Set the parameter for Power
 - 1PH2Wire or 1PH3Wire or 3PH3Wire
 - 120V or 240V

- For example: 3P3W and 120V

Power Setting: Set-up Mode



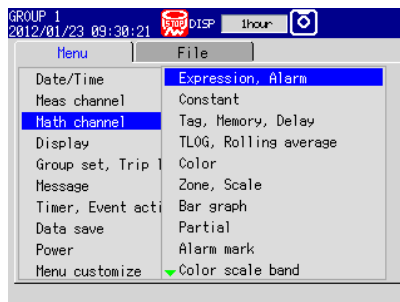
- ❖ Press MENU (to switch to setting mode)
- ❖ Select [Power]



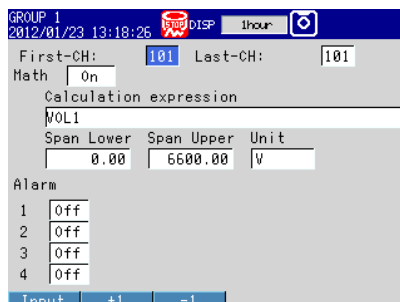
- ❖ Set the VT/CT ratio
 - VT: 1.0 to 6000.0
 - CT: 0.05 to 999.99/1000.0 to 9999.9/10000 to 32000

- For example: VT=30.0/CT=100.00

❖ Power Setting: Parameters on Math 1

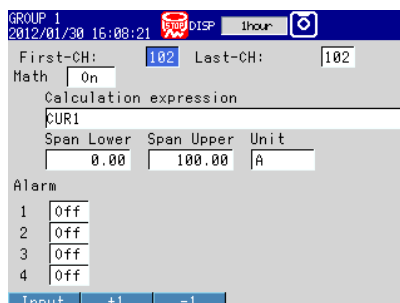


- ❖ Press MENU
(to switch to setting mode)
- ❖ Select [Math channel]-
[Expression, Alarm]

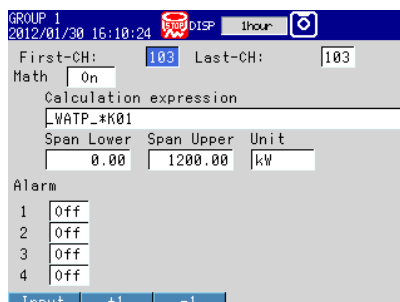


- ❖ Set Math CH
 - Set the followings for Voltage
 - Expression: VOL1
 - Span: 0.00-6600.00 V

❖ Power Setting: Parameters on Math 2

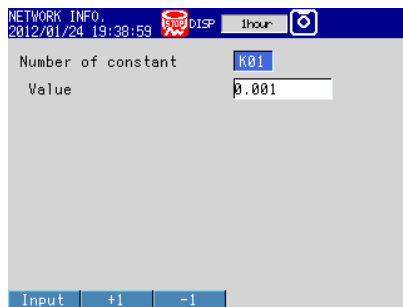


- ❖ Set Math CH
 - Set the followings for Current
 - Expression: CUR1
 - Span: 0.00-100.00 A



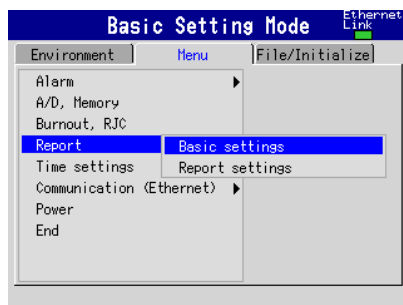
- ❖ Set Math CH
 - Set the followings for Active Power
 - Expression: _WATP_*K01
 - Span: 0.00-1200.00 kW

Power Setting: Parameters on Math 3

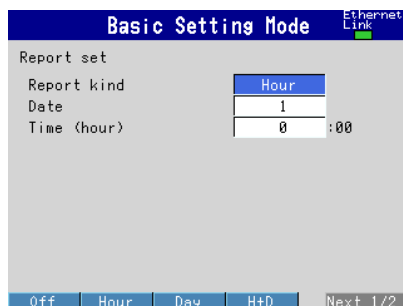


- ❖ Set Constant for kW unit
 - Set the K01
 - K01: 0.001

Power Setting: Basic Setting Mode for Report

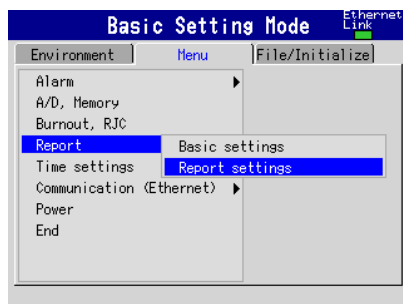


- ❖ Press MENU and hold down FUNC for 3 seconds
(to switch to Basic setting mode)
- ❖ Select [Report]-[Basic setting]

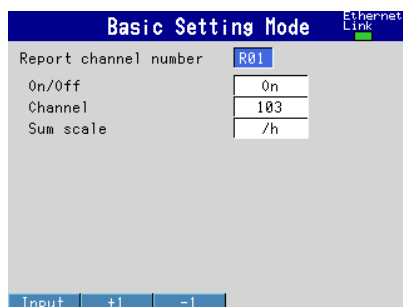


- ❖ Set the report settings as follows
 - Report kind: Hour
 - Date: 1
 - Time: 0:00

❖ Power Setting: Basic Setting Mode for Report

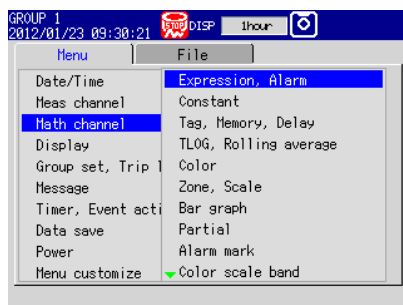


- ❖ Press MENU and hold down FUNC for 3 seconds (to switch to Basic setting mode)
- ❖ Select [Report]-[Report setting]

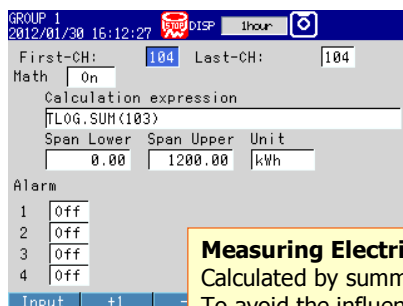


- ❖ Set the report settings as follows
 - Report channel number: R01
 - On/Off: On
 - Channel: 103
 - Sum scale: /h

❖ Power Setting: Parameters for Active Energy



- ❖ Press MENU (to switch to setting mode)
- ❖ Select [Math channel]-[Expression, Alarm]

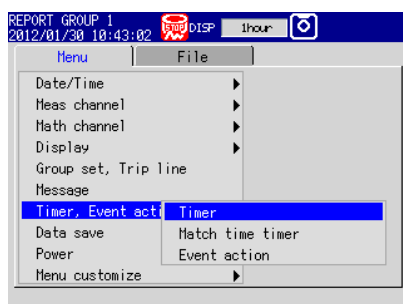


- ❖ Set Math CH
 - Set the followings for Active Energy
 - Expression: TLOG.SUM(103)
 - Span: 0.00-1200.00 kWh

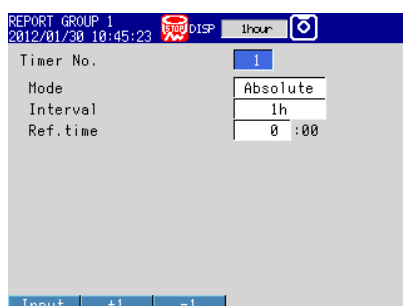
Measuring Electric Energy

Calculated by summing the measured values of the power measurement channels.
To avoid the influence of noise, use low-cut function:
(_WAT_, _WATP_, _WATN_, _VAR_, _VARP_, _VARN_, and _VA_)

Event Action Setting for Demand Alarm

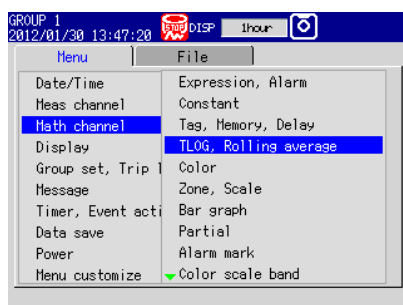


- ❖ Press MENU
(to switch to setting mode)
- ❖ Select [Timer, Event action]-
[Timer]

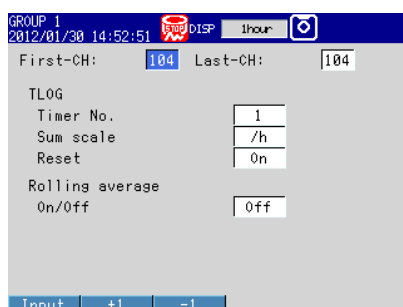


- ❖ Set the followings for Timer No.1
 - Mode: Absolute
 - Interval: 1h
 - Ref.time: 0:00

Event Action Setting for Demand Alarm



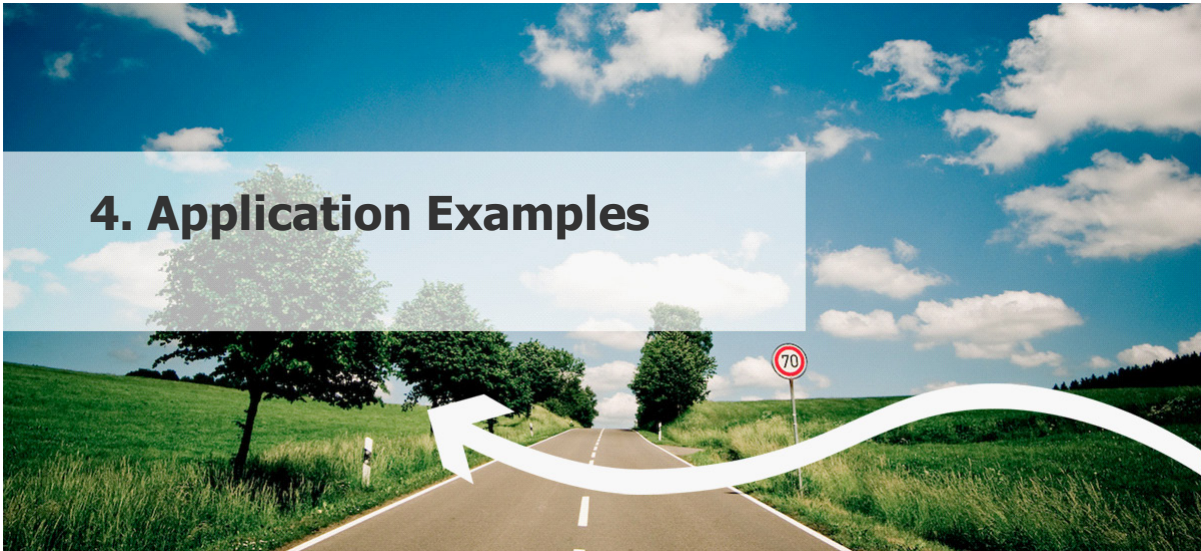
- ❖ Press MENU
(to switch to setting mode)
- ❖ Select [Math channel]-
[TLOG, Rolling average]



- ❖ Set the followings
 - TLOG
 - Timer No.: 1
 - Sum scale: /h
 - Reset: On
 - Rolling average
 - On/Off: Off

After Math ch ON and 1 hour, Math data can be reset

4. Application Examples



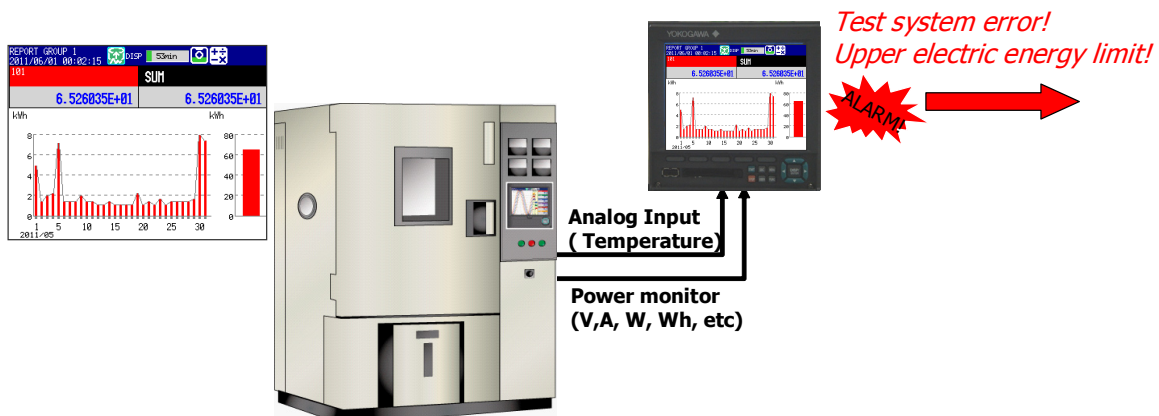
vigilantplant®
The clear path to operational excellence

YOKOGAWA 

❖ Power Monitor Application

❖ Remote monitoring of environmental testing systems

- Monitor the temperature, humidity, and integrated power of thermostatic chambers
- Transmit the system's self diagnosis and integrated-power alarm data via email
- Offer improved maintainability for test system manufacturers



vigilantplant®
The clear path to operational excellence

YOKOGAWA 

Target application

Customer	Application		
	Facility	Application	Current proposal
Thermo bath maker	Thermo bath	energy monitoring	FX100+ PR300
Freezer maker	Compressor (Freezer)	energy monitoring failure diagnosis	FX100+ UPM
Building air conditioning & evaluation	Freezer	performance testing (synchronized data of Temp, Press and Power)	DXA+ UPM
Automobile parts maker	Production line	energy monitoring	MW100+ UPM
Industrial machine maker	Press machine	energy monitoring	PC+ PR300
Industrial furnace maker	Electrical furnace	energy monitoring	DXA+ UPM
Heat treatment facility maker	Heat treatment facility	energy monitoring	DXA+ PR300
Freezer maker	Compressor (Freezer)	energy monitoring facility maintenance	DXA+ PR300
Tire maker	Vulcanizer	energy monitoring	DXA+ PR300

We can expect new market by FX1000





Terminology

Explanations are given for 3-phase 3-wire systems.

❖ Active power:

- The actual power (energy) that the load is consuming. [Unit: W]
- It is determined by the following formula (with balanced load):

$$P = \sqrt{3} EI \cos \theta$$
(E: rms voltage, I: rms current, θ : phase)
- $\cos \theta$ represents the phase angle of voltage and current, it is the power factor.

❖ Reactive power:

- If the inductive load is large, the transmission current also becomes large even if the same active power is consumed. This makes the efficiency of the power facility poor. Reactive power is that component of power that cannot be used as energy even when current flows. [Unit: Var]
- It is determined by the following formula (with balanced load):

$$Q = \sqrt{3} EI \sin \theta$$

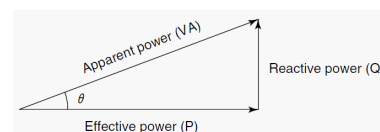
❖ Apparent power:

- A simple totalized value of the rated voltage and rated current. It is used to express the capacity of power equipment. [Unit: VA]
- It is determined by the following formula (with balanced load):

$$VA = \sqrt{3} EI$$

❖ Power factor

- Indicates the degree of apparent power consumed as active power in $\cos \theta$.



Terminology

❖ Balanced load:

- A load in which all the phase currents are equal in a 1-phase 3-wire distribution system or 3-phase 3-wire distribution system.

❖ Crest factor:

- The crest factor is the ratio of the waveform peak value to the rms value. For DC, it is 1. For a sine wave, it is $\sqrt{2}$ (1.414...).
- To make AC voltage measurements in which the crest factor is greater than that of the FX1000 specifications, you have to increase the range (decrease the sensitivity).

❖ Harmonics

- Harmonics are component frequencies that are integer multiples of the fundamental frequency (50/60Hz).
- The fundamental frequency is the first harmonic, and the frequency n times the fundamental ($1/n$ the wavelength) is called the n -th harmonic.
- AC voltage from a power plant is transmitted at a specified frequency. These days, current is controlled due to a wide use of thyristors, which generate distortion (an abnormality) in the voltage wave. This voltage waveform containing distortion is harmonics. It contains a frequency higher than the normal frequency and can adversely affect electrical appliances, resulting in problems such as over-current.

FAQ

❖ Can harmonics be measured?

- No. Please use a WT.

❖ Can power be measured even when there are harmonics?

- It can be measured as an rms value.
However, the amount of harmonics that can be tolerated is unknown.

❖ Can CTs that output 5A be used if the actual output current is 1A or less?

- Logically yes.
But, protective measures must be applied to the power line of the measured device (such as by inserting a breaker) so that the FX1000 input current does not exceed 1A.

Revision Information

Title : FX1000 Power Monitor Function
Manual number : TI 04L21B01-02EN

Jan. 2012/1st Edition
Newly published

Written by Yokogawa Electric Corporation
Published by Yokogawa Electric Corporation
2-9-32 Nakacho, Musashino-shi, Tokyo 180-8750, JAPAN



YOKOGAWA ELECTRIC CORPORATION

Headquarters

2-9-32, Nakacho, Musashino-shi, Tokyo, 180-8750 JAPAN

Branch Sales Offices

Nagoya, Osaka, Hiroshima, Fukuoka, Sendai, Ichihara, Toyota, Kanazawa, and Kitakyusyu.

YOKOGAWA CORPORATION OF AMERICA

2 Dart Road, Newnan, Georgia 30265-1094, U.S.A.

Phone : 1-800-888-6400

Fax : 1-770-254-0928

YOKOGAWA EUROPE B. V.

Euroweg 2, 3825 HD Amersfoort, THE NETHERLANDS

Phone : 31-88-4641000 Fax : 31-88-4641111

Branch Sales Offices / Wien (Austria), Zaventem (Belgium), Ratingen (Germany), Madrid (Spain), Runcorn (United Kingdom), Milano (Italy), Velizy-Villacoublay (France), Budapest (Hungary), Stockholm (Sweden), Sola (Norway), Warszawa (Poland), Vila Nova de Gaia (Portugal), Bucharest (Romania), Dublin (Ireland)

YOKOGAWA AMERICA DO SUL LTDA.

Praca Acapulco, 31 - Santo Amaro. Sao Paulo/SP - BRAZIL

Phone : 55-11-5681-2400 Fax : 55-11-5681-4434

YOKOGAWA ENGINEERING ASIA PTE. LTD.

5 Bedok South Road, 469270 SINGAPORE

Phone : 65-6241-9933 Fax : 65-6241-2606

YOKOGAWA ELECTRIC KOREA CO., LTD.

14-1, Yangpyongdong-4Ga, Youngdeungpo-Gu, Seoul, 150-866 KOREA

Phone : 82-2-2628-6000 Fax : 82-2-2628-6400

YOKOGAWA AUSTRALIA PTY. LTD.

Tower A, 112-118 Talavera Road, Macquarie Park, N.S.W.2113, AUSTRALIA

Phone : 61-2-8870-1100 Fax : 61-2-8870-1111

YOKOGAWA INDIA LTD.

Plot No.96 Electronic City Complex, Hosur Road, Bangalore 560100, INDIA

Phone : 91-80-4158-6000 Fax : 91-80-2852-1442

YOKOGAWA CHINA CO., LTD.

3F TowerD Cartelo Crocodile Building

No.568 West Tianshan Road, Shanghai 200335, CHINA

Phone : 86-21-62396262 Fax : 86-21-62387866