Method of leakage current measurement

Broadly speaking, there are two methods of leakage current measurement. One is designed to measure leakage current by directly clamping on an earthing conductor and the other is intended to measure leakage current by clamping on two-way wires together. Please refer to Fig.1 for respective measurement methods. The principle of measurement involving the clamping of two-way wires together is meant to find out the difference of current flowing between the incoming wire and outgoing wire and display the result. If there is no leakage on the load side, the instrument display reads zero. If the leakage occurs on the load side, the leakage current will flow back into the power supply through earth, resulting in the difference of current flowing between the two-way wires which will then be displayed on the instrument as a value of leakage current.

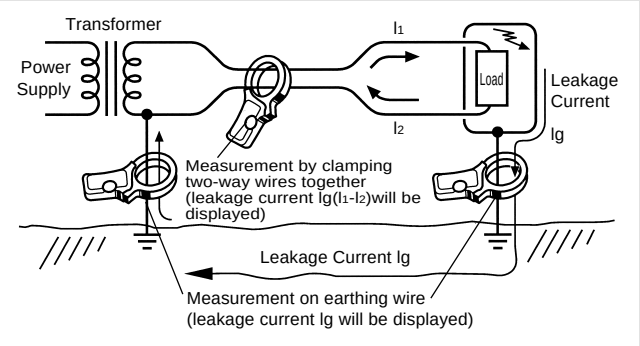

Fig.1 Method of leakage current measurement.

Features

- Least affected by external stray magnetic field.
  2mA AC approx. in proximity to a 15mm-dia conductor carrying 100A AC (2432) 10mA AC approx. in proximity to a 15mm-dia conductor carrying 100A AC (2433)
- Frequency Selector Switch to eliminate the effect of harmonics.
- Three AC current ranges:4mA/40mA/100A (2432)
  40mA/400mA/400A (2433).
- Data hold function.
- Peak hold function.
- Sleep function to save battery.
- Designed to international safety standard IEC61010-1 CAT. Ⅲ 300V

Selection Guide

MODEL	2432	2433
AC A	● 100A	● 400A
Data Hold	●	●
Peak Hold	●	●
Freg. Select	●	●

MODEL 2432

CE

High Sensitive Model

ϕ40 | MAX AC 100A | Resolution 0.001mA

Filter | PEAK 10ms

MODEL 2433

CE

ϕ40 | MAX AC 400A | Resolution 0.01mA

Filter | PEAK 10ms

Specifications

MODEL	Model 2432	Model 2433
AC A (50/60Hz)	4/40mA/100A ±1%rdg±5dgt(4/40mA) ±1%rdg±5dgt(0～80A) ±5%rdg(80.1～100A)	40/400mA/400A ±1%rdg±5dgt(40/400mA) ±1%rdg±5dgt(0～350A) ±2%rdg(350.1～399.9A)
AC A (WIDE)	4/40mA/100A ±2.5%rdg±10dgt[20～1kHz] , ±1%rdg±5dgt[50/60Hz](4/40mA) ±2.5%rdg±10dgt[40～1kHz] , ±1%rdg±5dgt[50/60Hz](0～80A) ±10%rdg[40～1kHz] , ±5%rdg[50/60Hz](80.1～100A)	40/400mA/400A ±2.5%rdg±10dgt[20～1kHz] , ±1%rdg±5dgt[50/60Hz](40/400mA) ±2.5%rdg±10dgt[40～1kHz] , ±1%rdg±5dgt[50/60Hz](0～350A) ±5%rdg[40～1kHz] , ±2%rdg[50/60Hz](350.1～399.9A)
Frequency Response	20Hz～1kHz(40Hz～1kHz:100A)	20Hz～1kHz(40Hz～1kHz:400A)
Maximum Circuit Voltage	600V AC/DC (between line/neutral) 300V AC/DC (against earth)	
Conductor Size	ϕ 40mm max.	
Safety Standard	IEC61010-1 CAT. Ⅲ 300V Pollution Degree 2 IEC61010-2-032	
Effect of External Stray Magnetic Field	2mA AC approx. in proximity to a 15mm-dia conductor carrying 100A AC	10mA AC approx. in proximity to a 15mm-dia conductor carrying 100A AC
Withstand Voltage	3700V AC for 1 minute	
Response Time	Approx. 2 seconds	
Power Source	Two R03 or equivalent (DC1.5V) batteries	
Dimensions	185(L)×81(W)×32(D)mm	
Weight	290g approx.	270g approx.
Accessories	9052 (Carrying Case) R03(1.5V)×2 Instruction Manual	
Optional	8004/8008 (Multi-Tran) These Multi-Trans can not be used for leakage current measurement	

KEW LEAKAGE CLAMP METERS

This is a full range of our leakage clamp meters.
Use of highly sensitive transformer jaws permits AC current measurements in the order of milliamps. These instruments can measure not only earth leakage current but also leakage current flowing in live conductors of single and three phase systems by directly clamping them together.
The most outstanding feature of the Kyoritsu leakage clamp meters is that all models have a frequency selector switch to check for the harmonic content of the current under test.

Selection Guide

MODEL	2414/15	2413F	2431	2412	2417	2434
AC A	● 100A	● 1000A	● 200A	● 500A	● 500A	● 100A
AC V	● 500V			● 600V		
Ω				● 200Ω		
Data Hold	●	●	●	●	●	●
Peak Hold		●				
Output		● AC/DC		● DC		
Freq.Select	●	●	●	●	●	●
True RMS					●	

MODEL 2414/2415

ϕ30 | MAX AC 100A | Resolution 0.01mA | AC V | Filter

- Compact, truly portable, high performance digital leakage current clamp meter.
- 200mA range with a minimum resolution of 0.01mA.
- Frequency filter switch to eliminate the effect of harmonics.

MODEL 2413F

CE

ϕ68 | MAX AC 1000A | Resolution 0.1mA | OUT PUT | PEAK 10/100ms | Filter

- Extra wide transformer jaws are best suited for clamping on all three or four wires (3 phases) together for leakage current measurement.
- Frequency filter switch to eliminate the effect of harmonics.
- Peak hold function.
- Analogue output terminal.

MODEL 2431

CE

ϕ24 | MAX AC 200A | Resolution 0.01mA | Filter

- Frequency Selector Switch to eliminate the effect of harmonics.
- Three AC current ranges 20mA/200mA/200A.
- 20mA range with a minimum resolution of 0.01mA.
- Auto power-off function (automatically turns off in about 10 minutes).
- Rotary switch for easy one finger power-on and range selection.

MODEL 2417

CE

ϕ40 | MAX AC 500A | RMS | Resolution 0.1mA | Filter | WP

- Water and dust proof construction. The instrument is protected against water and dust.
- True RMS for accurate measurement of non-sinusoidal waveform current.
- Selectable frequency response of 50/60Hz only or up to 1KHz.
- Automatically turns power off in about 30 minutes to conserve battery life.

MODEL 2412

ϕ40 | MAX AC 500A | Resolution 0.01mA | AC V | Ω | OUT PUT | Filter | External Power Supply

- Digital clamp meter with tear drop shaped, medium size transformer jaws specially designed for leakage current measurement.
- Frequency filter switch to eliminate the effect of harmonics.
- Output terminal for connection to recorders and facility to operate from external power supply permit continuous leakage current monitoring.

MODEL 2434

CE

ϕ28 | MAX AC 100A | Resolution 0.1mA | Filter

- Least affected by external stray magnetic field.
  20mA AC max. in proximity to a 15mm-dia conductor carrying 100A AC
- Frequency Selector Switch to eliminate the effect of harmonics.
- Data hold function
- Sleep function to save battery

Specifications

MODEL	Model 2414/2415	Model 2413F	Model 2431	Model 2412	Model 2417	Model 2434
AC A (50/60Hz)	20/200mA/100A(M-2414) 20mA/2/100A(M-2415) ±1.5%rdg±2dgt(20/200mA/2A) ±2%rdg±5dgt(100A)	200mA/2/20/200A/1000A ±1.5%rdg±2dgt(200mA/2/20A) ±2%rdg±2dgt(200A 0～500A) ±5.5%rdg(501～1000A)	20/200mA/200A ±3%rdg±5dgt(20/200mA/100A) ±5%rdg±5dgt(200A)	20/200mA/2/20/200/500A ±1.5%rdg±5dgt(20/200mA/2A) ±2%rdg±5dgt(20/200A) ±2.5%rdg±5dgt(500A)	200/2000mA/20/200/500A (True RMS) ±1.5%rdg±6dgt(20/2000mA) ±2%rdg±6dgt(20/200A) ±2.5%rdg±6dgt(500A)	400mA/4/100A ±2%rdg±4dgt
AC A (WIDE)	20/200mA/100A(M-2414) 20mA/2/100A(M-2415) ±1.5%rdg±2dgt(20/200mA/2A) ±2%rdg±5dgt(100A)	200mA/2/20/200A/1000A ±1%rdg±2dgt (200mA/2/20A)(50/60Hz) ±2%rdg±2dgt(200A 0～500A) ±5.5%rdg(501～1000A)	20/200mA/200A ±2%rdg±4dgt(20/200mA/100A) (50/60Hz) ±5%rdg±6dgt(20/200mA/100A) (40～400Hz) ±5%rdg±4dgt(200A) (50/60Hz)	20/200mA/2/20/200/500A ±1%rdg±3dgt(50/60Hz) (20/200mA/2A) ±1.5%rdg±3dgt (50/60Hz)(20/200A) ±2%rdg±3dgt(50/60Hz)(500A)	200/2000mA/20/200/500A (True RMS) ±3%rdg±4dgt(200mA/2/20A) (50/60Hz) ±3.5%rdg±4dgt(200A 0～500A) ±4%rdg±4dgt(500A)	400mA/4/100A ±2%rdg±4dgt (50/60Hz) ±3%rdg±5dgt (40-400Hz)
AC V	500V ±1.5%rdg±2dgt(50/60Hz) ±2%rdg±5dgt(40Hz～1kHz)	——	——	600V ±2%rdg±5dgt(50/60Hz) ±3.5%rdg±5dgt(40Hz～1kHz)	——	——
Ω	——	——	——	200Ω ±1.5%rdg±5dgt	——	——
Conductor Size	ϕ 30mm max.	ϕ 68mm max.	ϕ 24mm max.	ϕ 40mm max.		ϕ 28mm max.
Safety Standard	——	IEC61010-1 CAT. Ⅲ 300V IEC61010-2-032	IEC61010-1 CAT. Ⅲ 300V IEC61010-2-032	——	IEC61010-1 CAT. Ⅲ 300V IEC61010-2-032	IEC61010-1 CAT. Ⅲ 300V IEC61010-2-032
Effect of External Stray Magnetic Field ϕ15mm 100A	7mA AC max.	10mA AC max.	10mA AC max.	10mA AC max.	10mA AC max.	20mA AC max.
Frequency Response	40Hz～1kHz	40Hz～1kHz	40～400Hz	40Hz～1kHz		40～400Hz
Output	——	AC/DC200mV against 2000 count	——	DC200mV against 2000 count	——	——
Withstand Voltage	2200V AC for 1 minute	3000V AC for 1 minute	1000V AC for 1 minute	3700V AC for 1 minute		
Power Source	R6P(AA)(1.5V)×2	6F22(9V)×1	LR-44(1.5V)×2	6F22(9V)×1 or AC Adaptor	6F22(9V)×1	R03(AAA) (1.5V) × 2
Dimensions	173(L)×80(W)×32(D)mm	250(L)×130(W)×50(D)mm	149(L)×60(W)×26(D)mm	209(L)×96(W)×45(D)mm		169(L)×75(W)×40(D)mm
Weight	210g approx.	570g approx.	120g approx.	450g approx.		220g approx.
Accessories	7053(Test Leads) 9052(Carrying Case) R6P(AA)×2 Instruction Manual	9064(Carrying Case) 6F22×1 Instruction Manual	9090(Carrying Case) LR-44×2 Instruction Manual	7066(Test Leads) 9072(Carrying Case) 8025(Plug for Output Jack) 6F22×1 Instruction Manual	9079(Carrying Case) 6F22×1 Instruction Manual	Carrying Case R03×2 Instruction Manual
Optional	8004/8008(Multi-Tran)※ 8021(Energizer)	7073(2WAY Output Cord)	8004/8008(Multi-Tran)※ 8021(Energizer)	8004/8008(Multi-Tran)※ 8022(AC Adaptor)(110V) 8023(AC Adaptor)(220V) 7014(Output Probe)	8004/8008(Multi-Tran)※	8004/8008(Multi-Tran)※

※These Multi-Trans can not be used for leakege current measurement.

High frequency selector switch

This switch is designed to select "WIDE" or "50/60Hz" range. "WIDE" range covers a wide frequency band of 40Hz to 1kHz. AC current having a fundamental waveform and harmonics can be measured over this range. "50/60Hz" is restricted to a frequency response of 40Hz to 100Hz and therefore permits measurement of AC current of fundamental frequency only by filtering harmonic content. When in doubt as to the presence of harmonics you can identify it by using this frequency selector switch. To give an example, the following shows the results of AC current measurement on an earthing wire within a switchbox where there is an inverter based airconditioner is connected at summertime. Model 2414 reads 56mA AC with the frequency selector switch set at the "WIDE" position as shown, while it displays 3mA at the "50/60Hz" switch position. The difference between the two readings (56mA - 3mA = 53mA) is considered leakage current caused by harmonics. The test also found that this leakage current is flowing into single phase, 3-wire circuits other than those connected with the inverters in the building inspected.

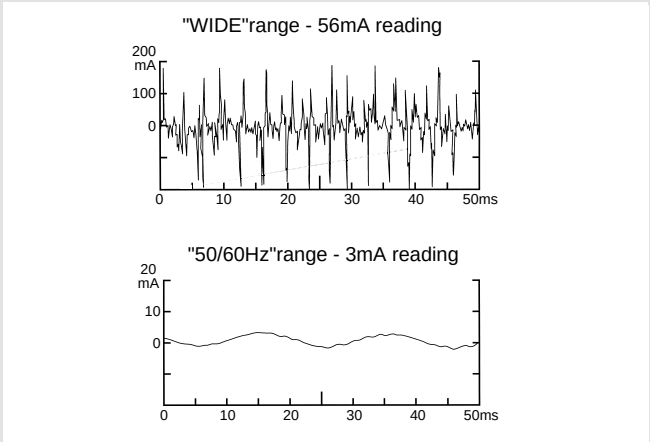

Fig. Results of AC current measurement on earthing wire within switchbox by using Model 2414 on the 200mA range.

True RMS value

Most alternating currents and voltages are expressed in effective values, which are also referred to as RMS(Root-Mean-Square)values. The effective value is the square root of the average of the square of alternating current or voltage values.
Many clamp meters with rectifier type circuits have scales that are calibrated in RMS values for AC measurements. But, they actually measure the average value of input voltage or current, assuming the voltage or current to be a sine wave.
The conversion factor for a sine wave, which is obtained by dividing the effective value by the average value, is 1.1. These instruments are in error if the input voltage or current has some other shape than a sine wave.

Waveform	Effective value V rms	Average value V avg	Conversion factor V rms/V avg	Reading errors for average sensing Instruments	Crest factor CF
A, 0	$\frac{1}{\sqrt{2}}A$ ≒ 0.707	$\frac{2}{\pi}A$ ≒ 0.637	$\frac{\pi}{2\sqrt{2}}$ ≒ 1.111	0%	$\sqrt{2}$ ≒ 1.414
A, 0	A	A	1	$\frac{A\times1.111-A}{A}\times100$ = 11.1%	1
A, 0	$\frac{1}{\sqrt{3}}A$	0.5 A	$\frac{2}{\sqrt{3}}$ ≒ 1.155	$\frac{0.5A\times1.111-\frac{A}{\sqrt{3}}}{\frac{A}{\sqrt{3}}}\times100=-3.8\%$	$\sqrt{3}$ ≒ 1.732
A, 0, T, f, D=f/T	$A\sqrt{D}$	$A\frac{f}{T}=A\cdot D$	$\frac{A\sqrt{D}}{AD}=\frac{1}{\sqrt{D}}$	$(1.111\sqrt{D}-1)\times100\%$	$\frac{A}{\sqrt{AD}}=\frac{1}{\sqrt{D}}$

CF: Crest Factor=Peak value/RMS value
DC=1
Sine wave=1.414