# FREQUENCY RESPONSE ANALYZERS

## FRA series

## Measures frequency responses with high accuracy.

Function and performance further improved.

### FRA 5097 15 MHz

**0.1mHz to 15MHz, Impedance display**

### FRA 5087 10 MHz

**0.1mHz to 10MHz, Multifunction**

### FRA 5022 100 kHz CE

**0.1mHz to100kHz, High C/P model**

**As FRA servo analyzers, they are useful for a wide range of measurement applications.**

| SWPS | DCPS | | | | | EDLC | etc. |
|---|---|---|---|---|---|---|---|
| Loop response for switching power supplies | Ripple rejection ratio for series regulators | Servo response for magnetic and optical disks | Resonance response for piezo-electric components | Impedance of electronic components | AC impedance of fuel cells | Internal resistance for electric double layer capacitors | For other measurement applications |

## NF Corporation

# FRA5097 (15 MHz) / FRA5087 (10 MHz)

## The high accuracy and functionality unique to frequency response analyzers which allow them to achieve sure measurements are dramatically enhanced to make our FRAs even more convenient and useful!

NF Corporation's frequency response analyzers utilize the excellent noise eliminating feature of Fourier transformations to accurately measure frequency response characteristics. Equipped with floating input circuitry and auto ranging functions for constantly optimizing input ranges, our FRAs allow dynamically changing frequency responses to be quickly measured with high accuracy, without the need to be concerned with input signal levels or the ground potential of the device being tested; moreover, operation is quite simple. Experience first-hand just how excellent are accuracy, functions, and operability of our FRAs.

### ●Amplitude accuracy : ±0.05 dB
### Phase accuracy : ±0.3°

Digital Fourier transforms and a self calibration function assure that measurements will always be highly accurate.

### ●Built-in printer

A printer for outputting hard copies of on-screen images onto thermosensitive paper is built-in, which makes saving measurements and creating reports convenient.

### ●Dynamic range : 140dB

Auto ranging which optimizes the measurement range at every measurement point and a high resolution A/D converter secure a wider dynamic range. Measurement is secured if a great change occurs during measurement.

### ●Auto ranging

Input range is switched automatically according to the input signal level, so setup of voltage sensitivity is not necessary for the frequency response analyzer.

### ●Excellent functions are built-in

An auto-integration function which suppresses the effects of external disturbances and variations of measured results by automatically setting an optimum number of integration times is built-in. In addition, the following functions are available to secure measurements.

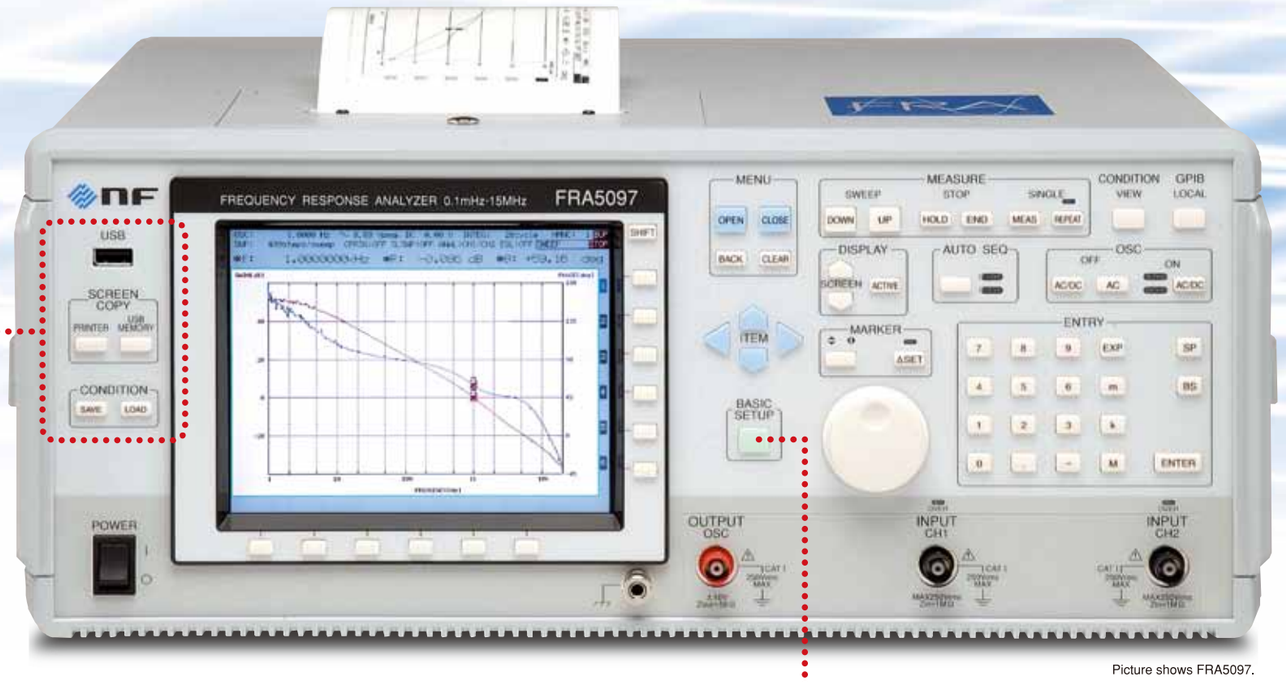
(See page 3 for the major ratings of each.)

- **Frequency axis high-density sweep**
- **Amplitude compression**
- **Delay**
- **Equalize**
- **Auto integration**
- **Operation**

### ●Frequency range
### 0.1mHz to 10MHz*／15MHz*

From ultra low frequency to high frequency.
High density measurements of up to 20,000 points at one sweep are possible.
Logarithmic equal interval setting and auto-magnification in sections where values greatly change are possible.
Resolution is 0.1mHz.

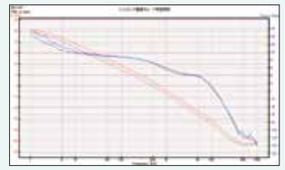
* FRA5087 : 0.1mHz to 10MHz, FRA5097 : 0.1mHz to 15MHz




Picture shows FRA5097.

### ●Date display software

Data stored in the USB memory can be read out to a personal computer for graphic display and saving in a CSV format.



(This software can be downloaded from the NF Corporation Web site.)

### ●GPIB and USB equipped

Measuring conditions can be set via an external personal computer and measured data can be read out to it via GPIB and USB.

## Easy saving and reading by USB memory

### ●USB

Measured data can be stored and loaded into a USB memory device. Furthermore, the following functions are available.

### ●Screen copy

A screen can be output to the USB memory and printer by the press of a key.

### ●Conditions

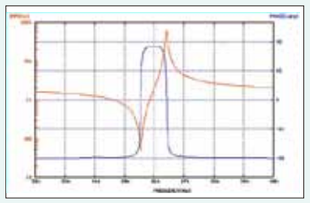
Setup conditions can be saved into and loaded from the USB memory by the press of a key.

### ●Various graphic outputs

Bode, Nyquist, Nicols, and Cole-Cole plots can be displayed. Following measurement, interconversion is also available.

### ●Impedance display function (optional for FRA5087)

Impedance can be accurately measured and displayed. Moreover, open-short correction, maximum and minimum value displays, and screen image storage can be done.



### ●Isolation

Oscillator output 2-channel and analysis inputs are isolated from the cabinet by 250Vrms. In this way, the instrument can be protected from damage by an erroneous signal connection.

### ●Color TFT LCD

A frequency response graph and setup menu for measuring conditions can be displayed on a crisp color LCD.

### ●Battery backup

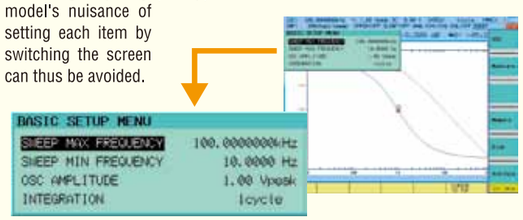
The contents of the setup and measured data stored in the memory before turning off power are held if power is turned off.

## A basic setup screen can be displayed by one touch.

A special key is provided to facilitate setting procedure.

### ●Basic setup

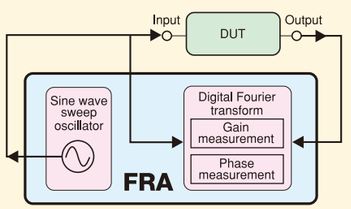
A basic setup screen is displayed simply by pressing the basic setup key. The upper lower limits, amplitude, and number of integrations for measuring frequency (sweep) can be set on one screen. The conventional model's nuisance of setting each item by switching the screen can thus be avoided.




## Frequency response analyzer mechanism

Frequency response analyzers consist of a sweep oscillator, voltmeter, and phase meter. Digital Fourier transform calculations allow voltage and phase to be obtained simultaneously and with high accuracy, with the oscillator as the reference(Note). When measurement at a frequency ends, the frequency is switched to the next frequency. Thus, an identical measurement is automatically repeated. This is similar to the operations which are performed by using an independent oscillator and phase meter. In this way, setting on the frequency response analyzer is easy. Furthermore, since the range of the voltmeter can be changed for each measuring point, a high dynamic range measurement far beyond the limit of bits of the A/D converter can be done.

**Note: Fourier transform calculations**
The products of measured values and a reference (sine wave signal) are integrated. This is similar to operations for obtaining the basic waves of a Fourier series. An asynchronous element such as an external disturbance attenuates in proportion to the square root of integration time.



# FRA5097 15 MHz / FRA5087 10 MHz

## ■Major specifications

### ◆Oscillator section

| | |
|---|---|
| Output waveform | ∿ Sine wave, ⊓ Square wave, △ Triangular wave |
| Frequency range | ∿ : **FRA5087** 0.1mHz to 10MHz<br>**FRA5097** 0.1mHz to 15MHz<br>⊓ △ : 0.1mHz to 100kHz<br>Setting resolution : 0.1mHz<br>Accuracy : ±10ppm |
| AC amplitude | 0V to 10Vpeak (no load)<br>Setting resolution : Three digits or 0.01mVpeak, whichever is greater |
| DC bias | −10V to 10V (no load)<br>Resolution : 10mV |
| Output control | Quick : Goes to a set voltage or 0V instantaneously.<br>Slow : Goes to a set voltage or 0V slowly.<br>Phase control : Sets the start and stop phases of oscillation in 1° steps.<br>AC/DC simultaneous ON/OFF and AC only OFF possible. |
| Frequency sweep | Logarithmic sweep : 3 to 20,000 steps/sweep or 1 to 20,000 steps/decade (3 steps/sweep minimum ; 20,000 steps/sweep maximum).<br>Linear sweep : 3 to 20,000 steps/sweep or 0.1mHz to 10MHz/step (**FRA5087**), 0.1mHz to 15MHz/step (**FRA5097**) (where, 3 steps/sweep minimum and 20,000 steps/sweep maximum).<br>Frequency axis high density sweep : When measured data changes greatly, sweep density is made higher around the frequency area automatically for accurate measurement. |
| Isolation | Withstand voltage : 250Vrms (to chassis, to analysis section input)<br>Measurement category : I |

### ◆Analysis section input

| | |
|---|---|
| Number of input channels | Two (CH1 and CH2) |
| Isolation | 250Vrms (signal and ground to oscillator section and analysis section input channel)<br>Measurement category : I |
| Maximum input voltage | ±350Vpeak (AC+DC) |
| Maximum measuring voltage | 250Vrms |
| Dynamic range | 140dB typ. (10Hz to 1MHz) |
| Measuring mode | REPEAT, SINGLE, SWEEP |
| Analysis mode | Ratio : CH1/CH2, CH2/CH1<br>Level : CH1, CH2 |
| Harmonic measurement | 2nd to 10th order<br>(up to 10MHz for **FRA5087** and 15MHz for **FRA5097**) |
| Harmonic wave and noise rejection ratio | Normal mode DC : 60dB or greater<br>Wide band white noise : 50dB or greater (noise band width 500kHz)<br>Harmonic (10th or less) : 60dB or greater (100kHz or less)<br>40dB or greater (100kHz or greater) |
| Auto ranging function | Switches the input range according to the input signal level. |
| Delay function | Delays time until a start of measurement following switching the frequency. 0 to 9,999 seconds or 0 to 9,999 cycles. |
| Integration function | Integrates data for measurement, eliminating the noise. 0 to 9,999 seconds or 0 to 9,999 cycles. |
| Auto integration function | Repeats integration until a certain reliability is obtained. 0 to 9,999 seconds or 2 to 9,999 cycles. |
| Amplitude compression function | Controls the level of oscillation so that the amplitude level of DUT may stay at a certain value in order to keep the DUT from saturation and damage. |
| Equalize function | Measures the frequency characteristics of measuring systems such as the sensors and cables beforehand and then removes the error of the system in measurement to obtain the characteristics of the DUT only. |
| Operation function | Arithmetic operation (data to data, data to logarithmic value, value to value), differentiation of data, second differentiation, integration, second integration, open-loop to closed-loop conversion, closed-loop to open-loop conversion. |

### ◆Measurement error

| CH1/CH2 or CH2/CH1 | ≦20kHz | ≦500kHz | ≦2.2MHz | >2.2MHz |
|---|---|---|---|---|
| a, b, R | ±0.5% | ±1% | ±10% | ±25% |
| dBR | ±0.05dB | ±0.1dB | ±1dB | ±2dB |
| Phase (deg.) | ±0.3° | ±0.5° | ±2° | ±5° |

In case analysis input voltage is 100mVpeak to 10Vpeak (2Vpeak maximum when exceeding 2.2MHz) immediately after calibration

### ◆Display section

| | |
|---|---|
| Display | 6.5 inches, color TFT LCD |
| Graph display | Bode, Nyquist, Nicols, and Cole-Cole plots<br>Interconversion is also available.<br>(reading and auto-scale are available with use of the cursor) |
| Measured data display | Gain (linear, logarithmic), phase enlarged display possible |
| Other functions | Auto scaling as well as marker, measurement condition, title, date and time displays |

### ◆External memory

| | |
|---|---|
| Media | USB memory (USB 1.1 or USB 2.0) |
| Connector | Front panel, USB-A connector |
| File format | FAT (compatible with Windows 98SE or later, compatible with IBM PC/AT) |
| Recorded contents | Setting conditions, measured data, screen data (bit map format) |
| File operation function | Directory, rename, delete, save, load |

### ◆External I/O

| | |
|---|---|
| Interface | GPIB : Condition setting, condition and data inquiry, operation command<br>USB : USB 1.1 (low speed, full speed), TMC rear panel, USB-B connector |
| Thermosensitive printer | Takes hard copy of LCD screen image on the internally stored thermosensitive paper |
| DC power supply output | 5055 connector (optional), ±24V, 100mA maximum |

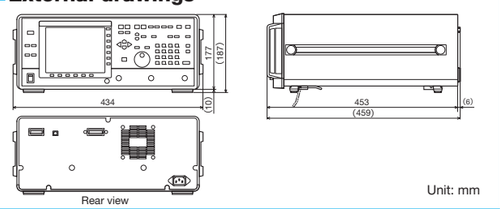
### ◆Impedance display function (optional for **FRA5087**)

| | |
|---|---|
| Display items | Impedance, resistance, reactance, admittance, conductance, and susceptance are displayed on linear and logarithmic graphs. |
| Current shunt input convert coefficient | 0 to 1.0E+6 (five digit resolution or 0.01E-9), phase inversion function |
| Open/short correction functions | Sets the open and short correction memories and displays a graph with open/short correction at measurement. |
| Maximum, minimum search functions | Searches the maximum and minimum values of vertical axis parameters on a bode diagram, moves the marker, and displays the calculated values. |

### ◆Other

| | |
|---|---|
| Power supply | AC 100V/120V/230V ±10%<br>Where, 250V or less and 50Hz/60Hz ±2Hz |
| Power consumption | 100 VA maximum |
| Guaranteed temperature and humidity ranges | +5 to +35° C, 5 to 85% relative humidity<br>(Absolute humidity of 1 to 25g/m3 with no condensation) |
| Dimensions | 434(W)×177(H)×453(D)mm (not including projections) |
| Weight | Approx. 12kg |
| Accessories | 1 instruction manual, 1 GPIB/USB instruction manual,<br>1 power supply cable (3-pin, 2m), 3 signal cables (BNC-BNC),<br>1 T-type divider, 1 roll of thermosensitive paper |

### ■External drawings




Unit: mm

※A rack mount bracket kit is available.





# FRA5022 100 kHz

The FRA5022 is a frequency response analyzer (FRA) for measurement frequencies of 0.1 mHz to 100 kHz. With a slim, space-efficient case design and simple operation for ease of use, it is well suited for integration into production lines and systems.

### ●Gain accuracy: ±0.05 dB, Phase accuracy: ±0.3°

Digital Fourier transforms and a self calibration function always achieve highly accurate measurements.

### ●Frequency range: 0.1 mHz to 100 kHz

The FRA5022 covers the frequency range best suited for electrochemicals measurement and mechanical servo analysis, allowing for support of a wide range of applications.

### ●Dynamic range: 120 dB or wider

Auto ranging and a high resolution A/D converter secure a wider dynamic range. Measurement is secured even if a drastic change occurs during measurement.

### ●Isolation

Oscillator output and each input are isolated from the case, allowing for easy signal injection during servo loop measurement, thus protecting the instrument from being damaged and preventing errors.

### ●Quick switching of settings

Multiple presettings can be switched with "one touch".
This stresses the importance of ease of use on production lines.

### ●Data display software

Software for loading measurement data onto a PC and displaying graphs is included as standard. Besides display in graphs, measurement data can also be saved in CSV format.

### ◆Oscillator section

| | |
|---|---|
| Output waveform | Sine wave |
| Frequency range | Setting range: 0.1 mHz to 100 kHz<br>Setting resolution: 5 digits or 0.01 mHz, whichever greater |
| AC amplitude | Setting range: 0 to 10 Vpk or 0 to 7.07 Vrms<br>Setting resolution:<br>0.01 Vpk (amplitude ≧ 1 Vpk), 0.001 Vpk (amplitude < 1 Vpk)<br>or 0.01 Vrms (amplitude ≧ 1 Vrms), 0.001 Vrms (amplitude < 1 Vrms) |
| DC bias | Setting range: 10 V to +10 V<br>Setting resolution: 0.01 V |
| Maximum output (AC + DC) | Voltage: ±10 V (no load)<br>Current: ±100 mA |
| Output impedance | 50Ω, unbalanced |
| Output control | Both AC and DC on, both AC and DC off, only AC off,<br>SLOW control that gradually changes AC and DC |
| Isolation | Withstand voltage: 42 Vpk or 30 Vrms<br>Electrostatic capacitance against casing: 250 pF or less |

### ◆Analysis input section

| | |
|---|---|
| Number of input channels | 2 |
| Input impedance | 1 MΩ, 60 pF in parallel |
| Frequency range | 0.1 mHz to 100 kHz |
| Maximum input voltage | Measurement range: ±10 V |
| Over-detection level | Setting range: 0.01 to 19.99 Vrms |
| Measurement range | Automatic switching (autoranging) |
| IMRR | 120 dB or more |
| Dynamic range | 120 dB or more |
| Isolation | Withstand voltage: 42 Vpk or 30 Vrms<br>Electrostatic capacitance against casing: 300 pF or less |

### ◆Analysis processing section

| | |
|---|---|
| Measuring mode | CH2/CH1, CH2/OSC |
| Integration time | Cycle setting range: 1 to 999<br>Time setting range: 0.01 to 999.99 s |
| Ratio accuracy | 0.1 Hz to 20 kHz: Gain ±0.05 dB (±0.5%), phase ±0.3°<br>Outside the range above: Gain ±0.15 dB (±15%), phase ±1°<br>(Input signal levels of both channels: 10 mVrms or higher) |

### ◆Measurement processing section

| | |
|---|---|
| Measuring operation | Sweep measurement/graph display<br>Spot measurement/numeric display<br>Scan measurement (Up to ten spots are measured in sequence.) |
| Sweep control | Frequency axes: Linear/logarithmic<br>Sweep operations: Up, down, hold, stop<br>Delay time setting range: 0.00 to 999.99 s |

### ◆Display section

| | |
|---|---|
| Graph display | Bode plots (gain dB, phase vs. frequency split display)<br>Orthogonal coordinate display: Numeric display of the value of a + jb |
| Spot display | Numeric display of frequency, gain, phase, and amplitude<br>GO/NO-GO judgment based on the range specification of gain and phase |
| Numeric display of measurement values | Gain: ±199.99 dB when dB<br>0, ±(1.0000E - 9 to 9.9999E + 9) when linear<br>Phase: Any 360° in ±360.00°<br>a, b: 0, ±(1.0000E - 9 to 9.9999E + 9)<br>Amplitude: 0.000 mVrms to 19.99 Vrms |
| Measured data memory | Memory units: 2<br>Memory capacity: up to 1,000 points (per memory unit) |
| Memory display mode | A, B, A & B (overlapping), A/B (vector ratio) |

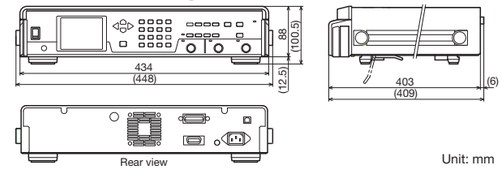
### ◆Other

| | |
|---|---|
| Setting memory | 10 |
| Interface | GPIB, USB: USBTMC |
| DC power supply output | Connector for 5055 (sold separately), ±24 V |
| Memory backup | The settings immediately before power-off and measured data are retained. |
| Power supply | AC 100 V to AC 230 V ±10% (AC 250 V or lower) 50 Hz/60 Hz ±2 Hz |
| Power consumption | 55 VA max. |
| Overvoltage category | II |
| Temperature and humidity for guarantee | +5 to +35°C, 5 to 85% relative humidity<br>(Absolute humidity of 1 to 25 g/m3 with no condensation) |
| Dimensions | 434(W)×88(H)×403(D) (not including projections) |
| Weight | About 6.8 kg |
| Accessories | 1 instruction manual, 1 power supply cable, 1 CD-ROM<br>(data display software, LabVIEW driver, sample program) |

### ◆Data display software

| | |
|---|---|
| Data capture | Measured data loaded from FRA to PC |
| Data save | Measured data stored in CSV format |
| Graph display | Bode, Nyquist, Nicols, and Cole-Cole plots |
| Parameter setting | Main FRA parameters are set and controlled. |

### ■External drawings



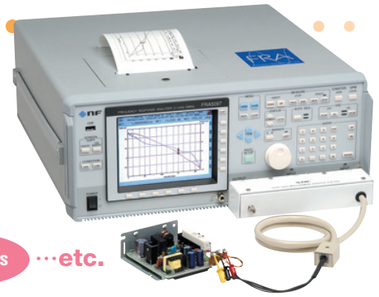

Unit: mm

※A rack mount bracket kit is available.

# Reliable FRA that offers excellent performance in various situations. Highly accurate measurement meets the greater demands of customers.

## Measurement applications

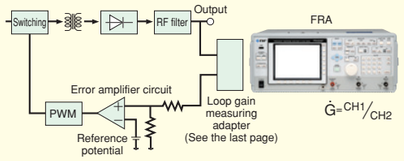
Frequency response analyzers providing consistently high-quality measurements with excellent accuracy and functions are often used for measuring the stability of servo systems, so they are sometimes called "FRA servo analyzers" and for many years have lent powerful support to state-of-the-art technology measurements. The range of applications is broad, covering various fields from electronic circuitry, parts, and materials to electrochemistry, machinery, and vibrations.

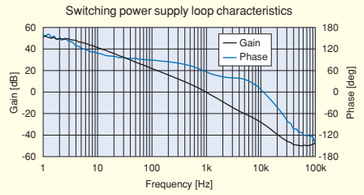


Electronic circuits | Electronic components | Electronic materials | Electrochemistry | Machinery | Vibrations ···etc.

### Loop characteristics of switching power supplies

Evaluate the dynamic stability (gain margin, phase margin) of a switching power supply. Since the signal source and measured terminal are mutually isolated, unrestricted connection is made possible, even with portions having overlapping direct current. The effect of a phase correction circuit can be measured clearly.




### Servo response for magnetic and optical disks

Measure transfer functions of servo systems which control the pick-ups of magnetic disk optical disks, and measure open loop response in a normal operating status. It can also measure the phase of a high gain area in a stabilized condition because of its higher noise eliminating capacity, with measurement in a dynamic range of more than 140dB, by using the auto ranging operation at every measuring frequency.

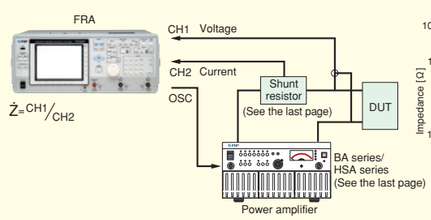


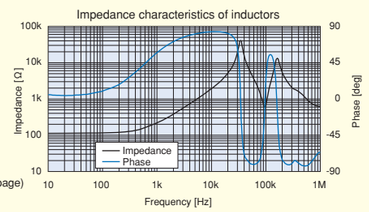




### Impedance of electronic components

Measure the impedance of inductors or capacitors. The frequency response analyzer can provide the impedance characteristics of DUT. Since it can perform measurements under a high voltage or large current in combination with a power amplifier, which cannot be done by an LCR meter, impedance can be measured in a condition closer to an actual state of use.



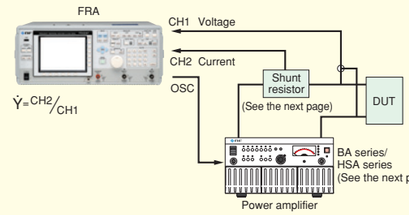

**Other applications...**

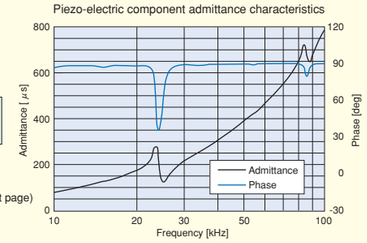
- Characteristics evaluation for vibration-proofing materials
- Frequency response measurement for filters
- Contact resistance measurement for EV connectors
- Testing for hydraulic equipment such as large vibration benches and fatigue testers
- CMRR PSRR measurements for OP amplifiers
- Internal temperature elevation measurements for transformers
- Characteristics measurements for ultrasonic motors
- Chemical impedance measurements



### Resonance characteristics of piezo-electric components

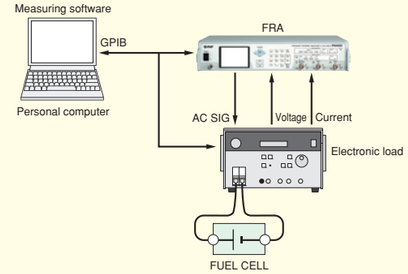
Measure the electric resonance of piezo-electric components such as those used for piezo-electric actuators. The frequency response analyzer can provide high frequency resolution of a specified frequency range, which differs from FFTs, and then detailed characteristics near the resonance point can be known because of high phase accuracy, ±0.3°. By combination with the power amplifier, a large amplitude response can also be measured, not only the small amplitude response.

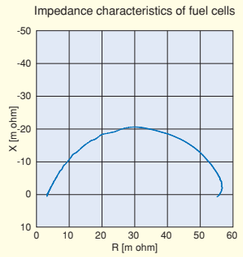



### AC impedance of fuel cells

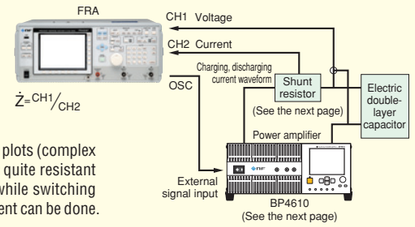
Measure the AC impedance of fuel cells with an electronic load. Since the frequency response analyzer is not affected by direct current, impedance can be measured accurately with any output current from the fuel cell. Furthermore, measurement at a very low frequency 0.1mHz (almost DC) can be done. Moreover, it can be developed into a system which calculates the parameters (parasitic resistance, reactive resistance, double layer capacity) of an equivalent circuit from the results of measurement.

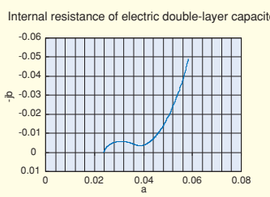



### Internal resistance of electric double-layer capacitors

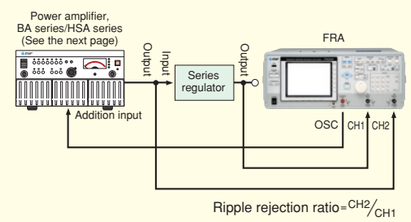
Measure the internal resistance of an electric double layer capacitor placed intermediately between a capacitor and cell. The frequency response analyzer can perform measurements with a high resolution of up to 0.1mHz. It can also analyze Faraday impedance with Cole-Cole plots (complex impedance display). Moreover, since it is quite resistant to external disturbances, measurement while switching charging and discharging with a large current can be done.

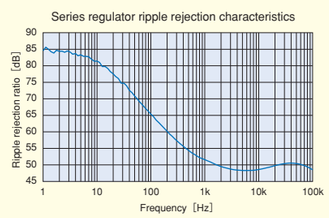



### Ripple rejection ratios of series regulators

Measure ripple rejection ratios for series regulators. The ripple rejection ratio characteristics are a major feature of a series regulator. Since the frequency response analyzer automatically removes a DC component of up to ±200V, it can measure a high voltage output of the series regulator with a high dynamic range of up to 140dB in combination with a power amplifier (HSA series).



## Peripheral Equipment

### Impedance Measuring Adapter
**PA-001-0368** optional

For FRA5087 and FRA5097

An adapter to measure the frequency response of impedance for electronic components. The shunt resistors for current detection (1Ω,10Ω,100Ω) are built-in.

### Loop Gain Measuring Adapter
**PA-001-0369** optional

For FRA5087 and FRA5097

An adapter to measure the loop gain of a negative feedback circuit in operation. (Clip cable can be replaced: PC-007-1922)

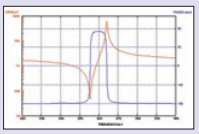
### High Power Impedance Measurement Adapter
**PA-001-1840 (1Ω)**
**PA-001-1841 (100Ω)** optional

Combine with a bipolar amplifier to measure impedance.
- Built-in shunt resistor
- Max. input voltage: 250Vrms
- Max. input current: 1Arms(1Ω), 0.1Arms(100Ω)

### Shunt Resistor
**PA-001-0370** optional

A shunt resistor incorporating a 1Ω 4-terminal resistor, used to detect a current (1Arms maximum) flowing through a DUT. It can be used for all FRA models.

### Impedance Display Function
**PA-001-1231** optional



For FRA5087

Measures and displays impedance. It can also perform open/short correction, maximum and minimum values displays, and screen image storage. (Standard with FRA5097.)

### Signal Injector Probe
**5055**

An auxiliary unit to measure the loop response of a servo system or the like with closed loops. It can be used for all FRA models.

## Related Production

Boosts up power of FRA's oscillator output.

### High Speed Bipolar Amplifier
**BA series**

BA4850

- BA4825: DC to 2MHz 100Vrms (300vp-p), 0.5Arms
- BA4850: DC to 50MHz ±20V, ±1A
- Four-quadrant output

### High Speed Bipolar Amplifier
**HSA series**

HSA4012 (DC to 1MHz)

- Six models line up
- DC to 500kHz/1MHz/10MHz
- 150Vp-p/300Vp-p/147Vp-p
- 1Arms/2Arms/4Arms/±1.4A
- Four-quadrant output

### Bipolar Power Supply
**BP series**

BP4610

- ±60V, DC to 150kHz, CV/CC mode
- BP4610 : ±10A (30Ap-p)
  BP4620 : ±20A (60Ap-p)
- Four-quadrant output

## Optional accessories

### High withstand voltage clip set (3 per set)
**PA-001-0419**

### High withstand voltage alligator clip cable set (small) (3 per set)
**PA-001-0420**

### High withstand voltage alligator clip cable set (large) (3 per set)
**PA-001-0421**

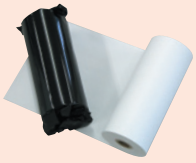
### Alligator clip cable set (3 per set)
**PA-001-0422**

### High withstand voltage BNC adapter (T-branch)
**PC-001-4503**

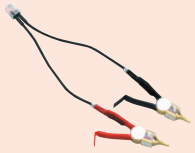
### High withstand voltage BNC cable
**PC-002-3347**

### High withstand voltage extension BNC cable
**PC-007-0364**

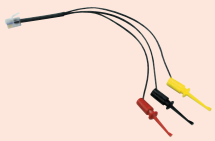
### Replacement printer paper (ten rolls)
**PC-007-0382**



### Impedance measuring adapter kelvin clip cable (for replacement)
**PC-007-1490**



### Loop gain measuring adapter clip cable (for replacement)
**PC-007-1922**



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