

FCスタック インピーダンス測定システム

FC stack Impedance Measurement System

100kWを超える燃料電池フルスタックシステムの厳しいノイズ環境下で安定したインピーダンス測定を実現

Realizes stable impedance measurement under severe noise environment of fuel cell full stack system exceeding 100 kW

高精度

High precision measurement

最大14ch同時測定

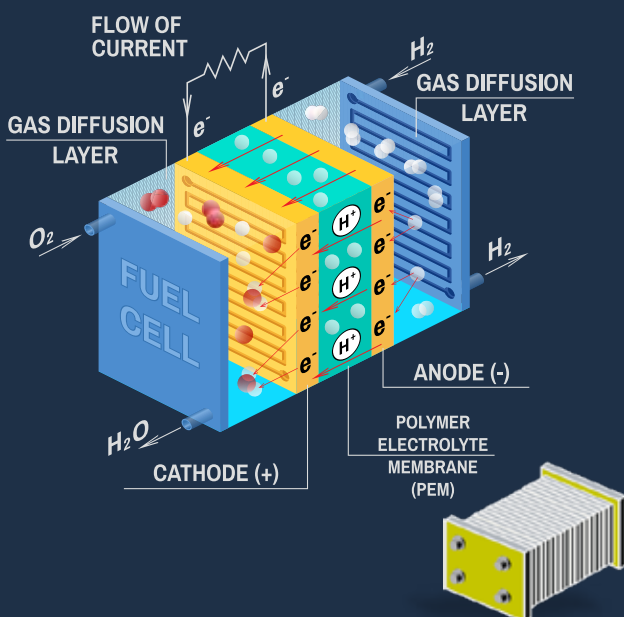
Simultaneous measurement of up to 14 channels

最大400V、1000A

Supports up to 400V, 1000A

0.01Hz~10kHz、周波数スイープ/固定周波測定

0.01Hz to 10kHz, freq sweep / fixed freq measurement



Fuel Cell full stack system

FC stack Impedance Measurement system

FCスタックの開発評価では、スタックの状態変化を把握するために内部インピーダンスのモニタが欠かせません。一方、高電圧、大電流を扱うFCフルスタックベンチは厳しいノイズ環境のため、微小信号のインピーダンスを正確に測定することが非常に困難でした。

「FCスタック インピーダンス計測システム」は、耐ノイズ性に優れた計測フロントエンドと信号処理技術により、厳しいノイズ環境下で高精度で安定したインピーダンス測定を実現しました。

In the evaluation of FC stack development, monitoring the internal impedance is indispensable in order to understand the state of the stack. On the other hand, FC full-stack benches that handle low voltage and high current made it extremely difficult to accurately measure the impedance of small signals due to high noise level.

The "FC Stack Impedance Measurement System" achieves high-precision and stable impedance measurement in high noise environments by using a measurement front end with excellent noise resistance and signal processing technology.

✓ **高精度 ... 耐ノイズ性を確保**

Highly accurate measurement (noise immunity)

フロントエンドと信号処理で、高電圧、大電流を扱うノイズ環境の厳しいFCフルスタックベンチで高精度で安定した測定を実現

✓ **高電圧、大電流対応 ... 測定レンジ最大400V、1000A**

Supports up to 400V, 1000A measurement

高電圧、大容量化が進むFCフルスタックに対応

✓ **多チャンネル・同時測定 ... 最大14ch同時測定**

Simultaneous measurement of up to 14ch(Cell and Stack)

スタックと同時にセルのインピーダンスを同時に測定することでスタック内の状態の違いを把握することが可能

✓ **最大250kWの回生負荷に対応 ... 50kW毎の容量拡張**

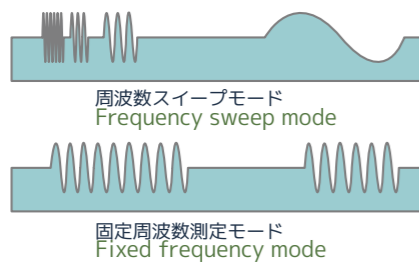
Supports regenerative loads up to 250kW

負荷容量50kW~250kW、350V/750V/1500Vの3つ電圧から選択可能

✓ **周波数スイープ測定と固定周波測定機能をサポート**

Supports frequency sweep and fixed frequency measurement, as well as two measurement functions

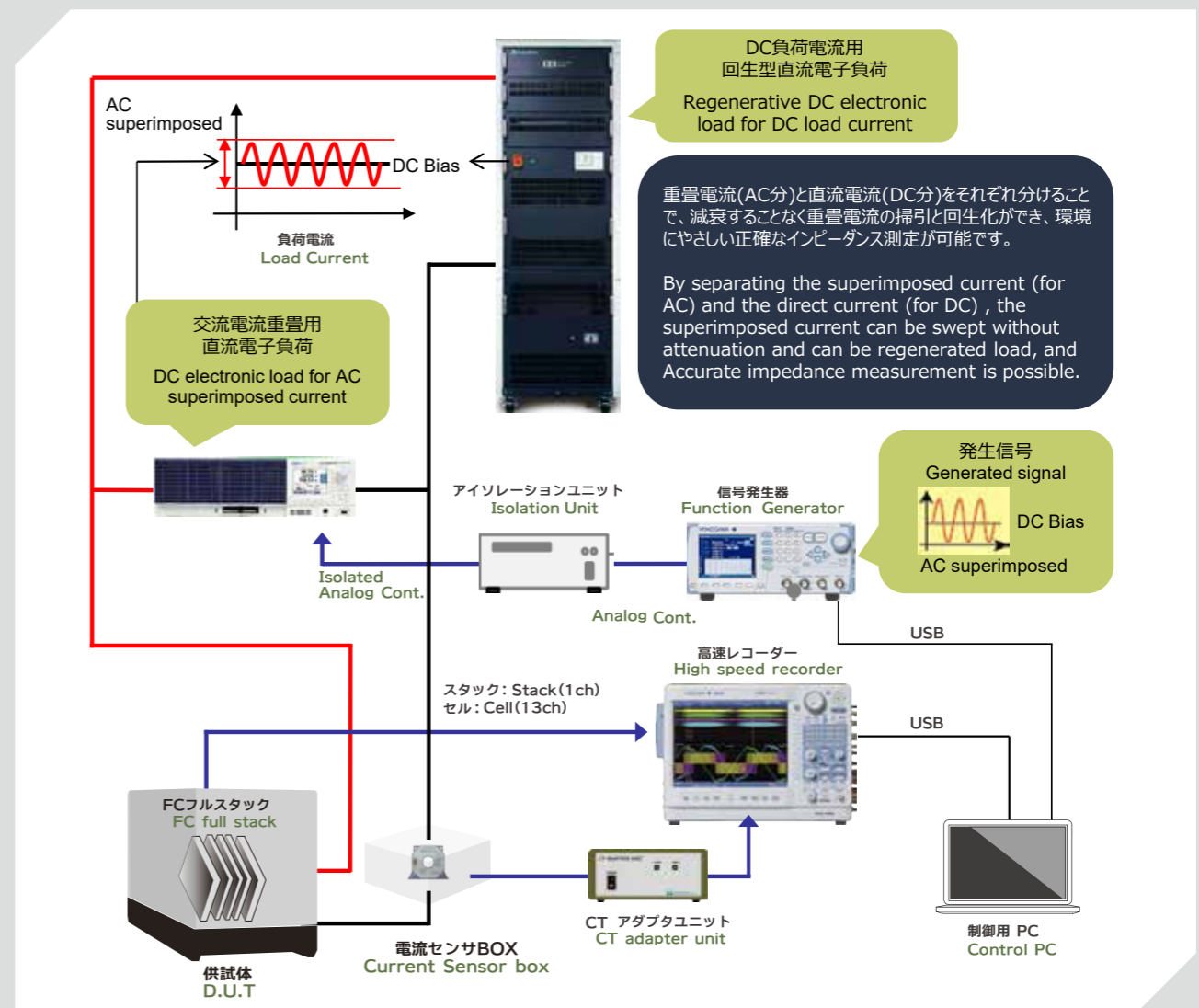
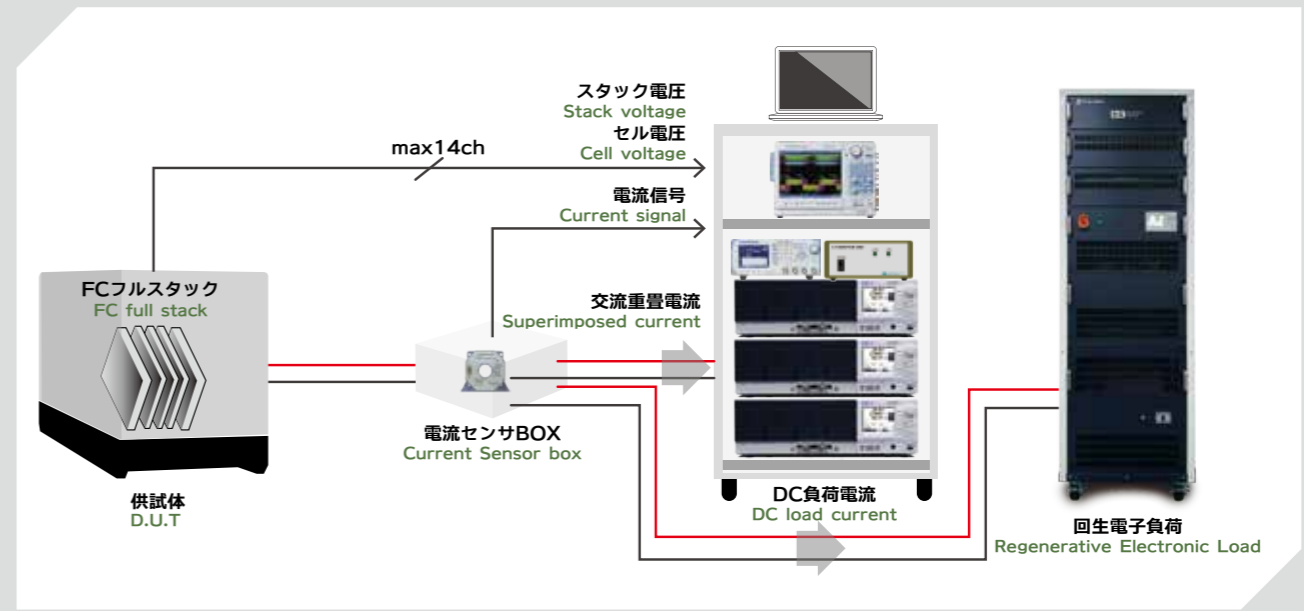
周波数スイープによるCole-Coleプロットの他に、FCスタックの状態モニタ用に固定周波数のインピーダンスを連続測定するモードをご用意



✓ **柔軟性 ... カスタマイズ対応**

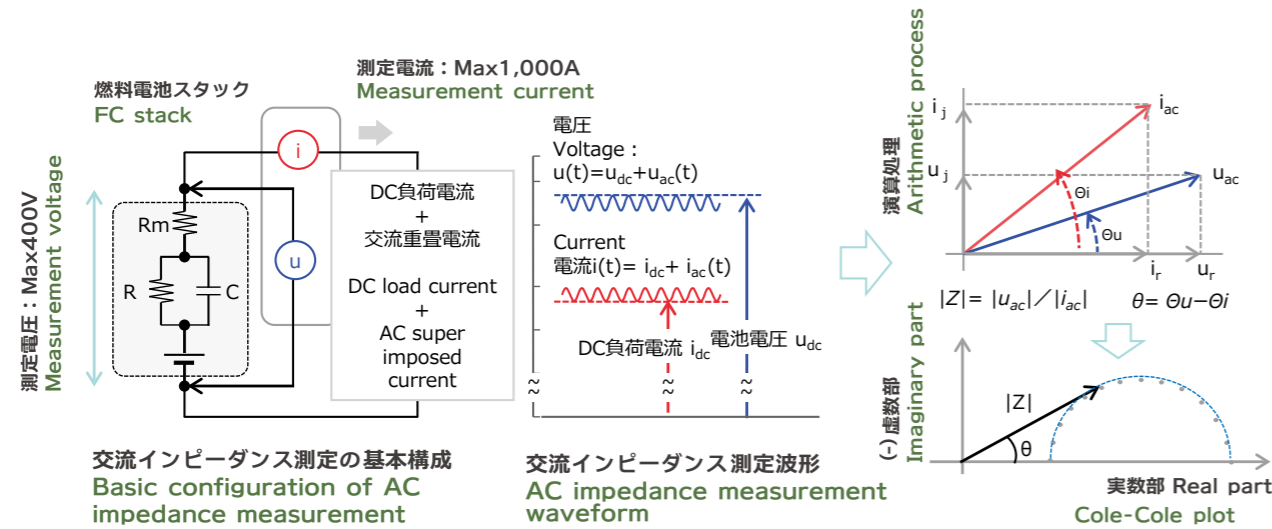
Flexibility and Software customizable

ソフトウェアのカスタマイズで各種FCスタックベンチに柔軟に対応



交流インピーダンス法は、発電状態の燃料電池のDC負荷電流に微小の交流電流を重畳させ、その時の電流、電圧波形に含まれる交流成分(振幅、位相)を演算処理で求め、インピーダンス値に換算します。

In the AC impedance method, a small amount of AC current is superimposed on the DC load current of the fuel cell in the power generation state, and the AC components (amplitude and phase) included in the current and voltage waveforms at that time are calculated and converted to impedance.

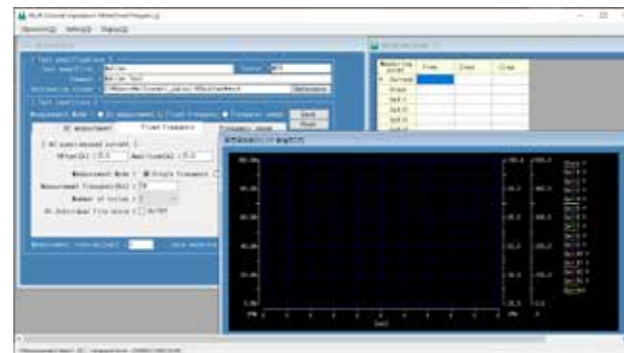


「FCスタックインピーダンス計測システム」は、交流重畳電流の周波数をスイープさせてCole-Coleプロットを表示する「周波数スイープモード」とユーザー指定の固定周波数で繰り返し測定した結果をトレンドグラフで表示する「固定周波数モード」を用意しました。Cole-ColeプロットでFCスタック全体の状態を把握し、着目する周波数のインピーダンスの変化を「固定周波数モード」でトレンドグラフに表示させことでFCスタック内部の状態をモニタすることができます。例えば、電解質膜抵抗(Rm)に対応した周波数(例えば1kHzなど)を「固定周波数モード」で測定することで、FCスタックの運転状態を変えた時の電解質膜抵抗の変化を把握することができます。

The "FC stack impedance measurement system" has "frequency sweep mode" and "fixed frequency mode". In the "frequency sweep mode", the frequency of the AC superimposed current is swept to display the Cole-Cole plot, and in the "fixed frequency mode", the result of repeated measurement at the fixed frequency specified by the user is displayed in the trend graph. The state of the entire FC stack can be grasped by the Cole-Cole plot, and the internal change of the FC stack can be monitored by displaying the change in the impedance of the frequency of interest on the trend graph in the "fixed frequency mode". For example, by measuring the frequency (for example, 1 kHz) corresponding to the electrolyte membrane resistance (Rm) in the fixed frequency mode, it is possible to grasp the change in the electrolyte membrane resistance when the operating state of the FC stack is changed.



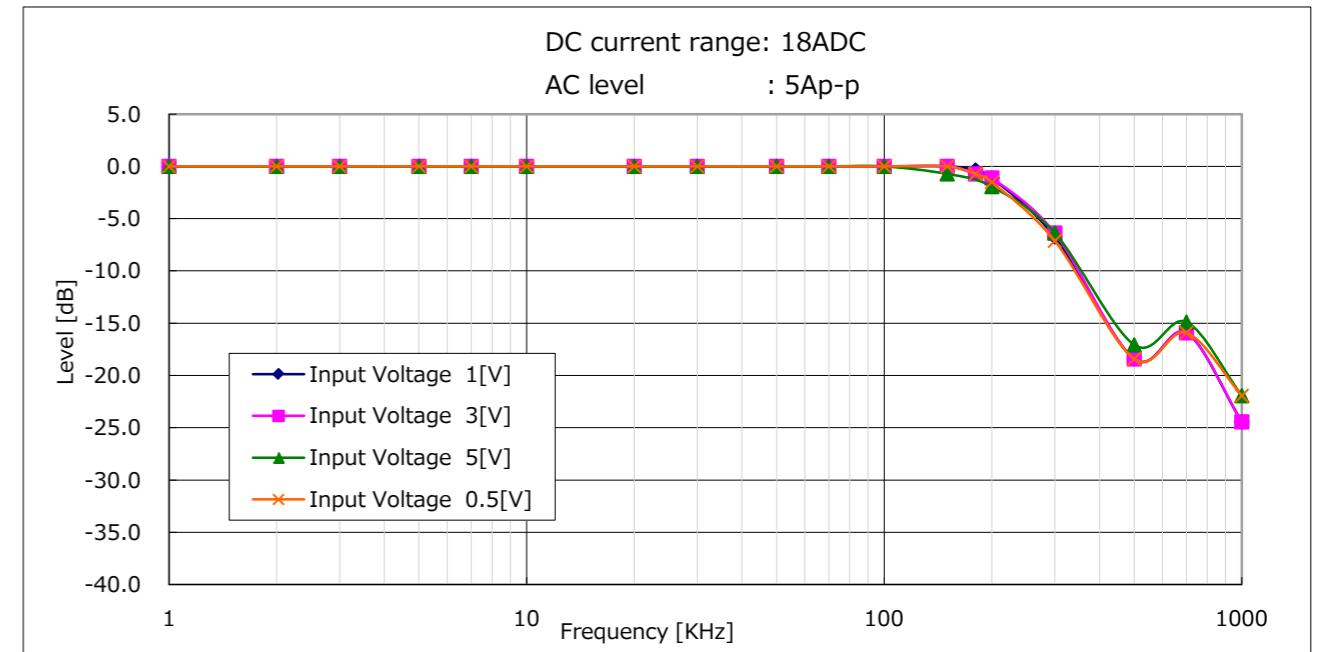
周波数スイープモード
Frequency sweep mode



固定周波数測定モード
Fixed frequency mode

「FCスタック インピーダンス計測システム」に採用している交流重畳用電子負荷(Load station series)は、周波数特性が100kHzと高周波帯域までカバーしており、より正確にインピーダンス測定を実施することが可能です。

The electronic load for AC superposition (Load station series) used in this measurement system can measure impedance more accurately because its frequency characteristic covers up to a high frequency band of 100 kHz.



ハイエンド多機能電子負荷 High-end multi-functional Electronic Load Load Station series(300W/1000W)

- オシロライクなインターフェース
"Revolutionary UI" Oscilloscope like operation
- 最小動作電圧の概念がない「まるで電子抵抗」動作
"No minimum operation voltage" requirement. It works just like a resistive load.
- 高速電流制御テクノロジーによる「電流のマジシャン」
"High speed current control technology" . [Like a magic of current]
- 1μsからの電流立ち上がり/立ち下り応答時間を独立して設定可能 (ダイナミックモードCC動作時)
Independent Rise time and Fall time setting from "1us" (When in the dynamic CC mode.)

Ordering information

Ordering No. (Model)	Detail
LN-300A	Electronic load 120V, 60A, 300W, 20A/μs
LN-300C	Electronic load 500V, 12A, 300W, 1A/μs
LN-1000A	Electronic load 120V, 180A, 1kW, 30A/μs
LN-1000C	Electronic load 500V, 36A, 1kW, 3A/μs
LN-xxx(*1)/REC	Test data of the electronic load
LX-OP01	GP-IB/DIDO option
LX-OP03	Master/slave connection cable
LX-RK-EIA	EIA Rack mount kit for LN300/1000
LX-BP	Rack mount kit blank panel for LN-300
RC-02A	Ripple and noise meas. module (Factory option)
RC-02A/REC	Test data of RC-02A

(*1)xxx : Name of the electronic load (*2) Factory option only



「FCスタック インピーダンス計測システム」に採用している回生型直流電子負荷(Ene-phant series)は、50kWから250kWの大容量に対応しております。トランス絶縁方式を採用しており電力系統ノイズの影響を受けず、正確なインピーダンス測定を実施することが可能です。また回生電力ノイズはClassAに準拠しています。回生電力ノイズにより他のデバイスに影響を与えないように設計されています。

The regenerative DC electronic load (Ene-phant series) used in the "FC stack impedance measurement system" is compatible with large capacity from 50kW to 250kW. The transformer insulation method is adopted therefore it is possible to carry out accurate impedance measurement without being affected by system grid noise.

Regenerative power noise conforms to Class-A. Designed so that it does not affect other devices due to regenerative power noise.

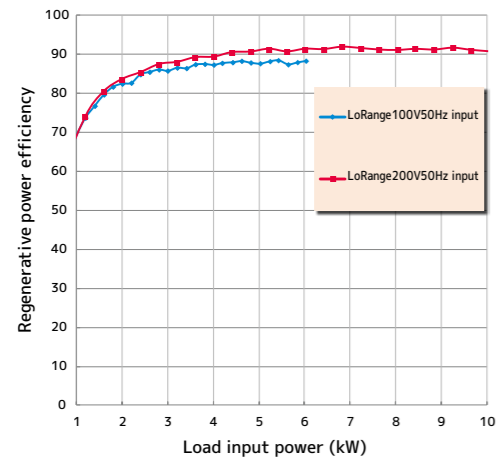
■ 90% 以上の回生効率
Over 90% regenerative efficiency

90% 以上（定格負荷時）と高効率を実現。

さらに定格電力の 15% 以上であれば 80% 以上の回生効率を実現。

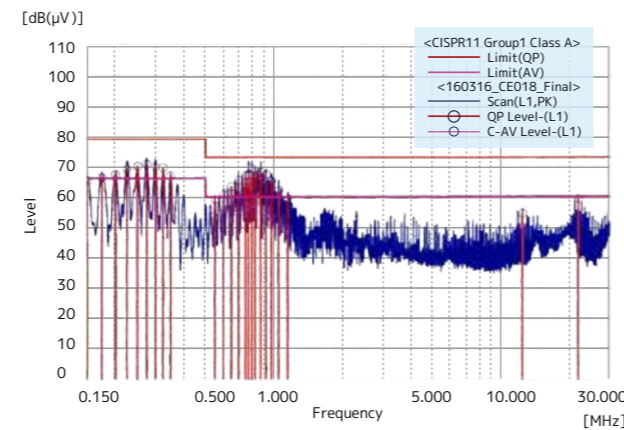
Realized over 90% high efficiency. (at rated loading)

Regenerating efficiency of 80% is achieved for 15% or above loading.



NT-AA-10KE-L Load input - Regenerative power efficiency characteristics

■ 回生電力ノイズCISPR の ClassA に準拠
Conforming to CISPR Class A



■ トランスを用いた電気絶縁を採用
Isolated by the transformer

The load and grid are isolated by transformer.



回生型直流電子負荷 Regenerative DC Electronic Load
Ene-phant series(50kW~250kW)

- オシロライクなインターフェース
"Revolutionary UI" Oscilloscope like operation
- 最大定格1500V
Supports up to 1500 V by connecting in series.
(2 units max. *Neutral point to be connected to the earth)
- 系統連系規定に準拠
Conforming to the grid regulation and provided over.
- 多彩なインターフェース RS-232C,LAN,DIDO を標準装備
RS-232C, LAN, DIDO are standard.
- 拡張容量最大250kW(マスタースレーブ接続5台まで)
Expanded up to 250kW can be expanded by combining five units.



50kW~250kW DC Models
15 models

■ Ordering information

Model	Description
NT-AD-50KO-L	1500V DC regenerative electronic load (Single phase 50kW)
NT-AD-50KH-L	750V DC regenerative electronic load (Single phase 50kW)
NT-AD-50KD-L	350V DC regenerative electronic load (Single phase 50kW)

High-end multi-function electronic load basic specifications

Model	LN-300A	LN-300C	LN-1000A	LN-1000C
Max rate	120V, 60A, 300W	500V, 12A, 300W	120V, 180A, 1kW	500V, 36A, 1kW
Min operating voltage	1V @60A 0.5V@30A 0.2V@12A	3V@12A 1.5V@6A 0.7V@2.8A	1V@180A 0.5V@90A 0.2V@36A	3V@36A 1.5V@18A 0.7V@8.4A
Loading mode	CC, CR, CV, CP, EXT, Dynamic, Short			
Slew rate	20A/us	1A/us	30A/us	3A/us
Min response time	> 500ns			
Parallel operation	1 master unit can control multiple slave units.(Max 10 units) Those loads to be in same voltage rating. (When the master is LN-300A, then the slaves are either LN-300A or LN-1000A)			
Measurement mode	DCV, DCA, Power(Calculated), Ripple voltage(Option: RC-02A)			
Interface	USB & EXT analog input: Standard. GPIB & DIDO: Optional			
Trigger output	0 to 5V (Photo-coupler output)			
Current monitor output	DC 0 to 5V (Not isolated)			
Parallel connection(Master/Slave)	10 sets			
Protection & Alarm	OCP, OPP, OV-alarm, Over Temp Protector and Reverse connection alarm			
Power requirement	AC85 to 264V, 50/60Hz			
Dimensions: W x H x D mm	215 x 129 x 420		430 x 129 x 450	
Weight	Approx: 6.5kg		Approx. 13kg	

Note: The specifications are subject to change without prior notice.

回生型直流電子負荷基本仕様

Regenerative DC electronic load basic specifications

Model	NT-AD-50KO-K	NT-AD-50KH-L	NT-AD-50KD-L
Max rate	1500V 100A 50kW	750V 200A 50kW	350V 300A 50kW
Operating range (Power curve)			
Loading mode	CC, CV, CP, CC+CV, CP+CV, MPPT		
Regeneration efficiency	Max. 90% or over (when in rated input/output)		
Ripple current	4Ap-p or less (switching freq.)		
CCmode	Setting / Resolution	0.0A ~ 100.0A / 0.125A	0.0A ~ 200.0A / 0.25A
CVmode	Setting / Resolution	20V ~ 1500v / 2V	20V ~ 750v / 1V
CPmode	Setting / Resolution	0kW ~ ± 50kW / 20W	
MPPT mode	Hill climbing method(factory option)		
CC+CVmode	Setting range, resolution, accuracy: Same as CC mode & CV mode		
CP+CVmode	Setting range, resolution, accuracy: Same as CP mode & CV mode		
Protection	Protection	Emergency stop, internal over voltage, internal over heat, over current, over voltage, low voltage, over power, DC side reverse connection	
	System protection function	"Over current, over voltage, low voltage, over frequency, low frequency, passive islanding detection, active islanding detection"	
Interface	Standard	RS-232C, LAN	
	Option	None	
External control	DI	Photo coupler input (DC12 ~ 24V/8mA)	
	DO	Photo coupler output open collector (DC24V/10mA, 1mA recommended)	
	AI	0 ~ 10V (CC, CC limit, CV, CV limit, CP, CP limit)	
Monitor output	Voltage	0 ~ 10V / 0 ~ F.S.of Voltage BNC/50 Ω /Insulated output	
	Current	0 ~ 10V / 0 ~ F.S.of Current BNC/50 Ω /Insulated output	
Parallel connection(Master/Slave)	5 sets		
General	Input Voltage	"System side input: 3-phase, 3-wire, 400 ± 40V, 50/60Hz *1	
	Power consumption	800VA 以下	
	Operating temp/humi	0 ~ 40°C、 20 ~ 85%RH (no dew, no corrosive gas.)	
	W x H x D (mm)	W600 x H1977.5 x D900mm	
Weight	780kg or less		

*1: The system voltage can be changed to 3-phase, 4-wire 380V or 400V at the time of shipment from the factory upon customer request.

FCスタック インピーダンス計測システム基本仕様

FC stack impedance measurement system basic specifications

Classification	Item	Content	Remarks
Stack voltage Signal input	No. of ch	1ch	
	Input range	200 mV ~2000V	Max. input 1000Vrms(≤ 1kHz)
	Common-mode input voltage	Max. 800V	
Cell voltage Signal input	No. of ch	Max. 13ch	
	Input range	10mV~200V	Max. input 140V (DC + AC peak)
	Common-mode input voltage	Max. 400V	
Current Signal input	Current sensor	DC-CT	
	Detect current	Max. 1000A	Attenuation 1500:1/Shunt R:3 Ω
Voltage, current signal measurement functions	A/D resolution	16bit	
	Sampling rate	Max. 1MS/s	
	Freq. bandwidth	300kHz	
	BW limit (LPF)	400Hz/4kHz/40kHz/Full	
Impedance measurement section	Measurement mode	· Frequency sweep mode	Fixed Freq. : Single / Two freq.
		· Fixed freq. meas mode	
		· DC measurement mode	
	Freq. range	0.01Hz~10kHz	<10Hz: DC coupled ≥ 10Hz: AC coupled
	Freq. setting resolution	Max. 20 step / decade	
	No. of cycles	1/2/4/8cycles	10 times of setting freq over 1kHz.
	Sampling rate	Over 1000 times of measurement frequency.	
	Measurement accuracy	1%	When the AC signal level is 20% or more of the measurement range and a resistive load (phase difference = 0)
	Meas interval for fixed Freq. mode	Within 1 second	1kHz fixed., 1ch measurement
AC superimposing control signal	± 10V	Electronic load control for AC superposition	
General	Frequency	47Hz~63Hz	
	Rate voltage	100/220VAC ± 10%	Set at factory prior to shipment
	Operating temperature range	5~40°C	
Others	Emergency stop function	No	To be prepared by the customer when necessary

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