



QUANTUM COMPUTER

Low noise signal processing solution

Providing the optimal systems for controlling multi-qubits

- Multi-channel low noise arbitrary waveform generation system
- Multi-channel precision low noise DC voltage source
- Multi-channel low noise amplification system

Customized products

NF Corporation

QUANTUM COMPUTER

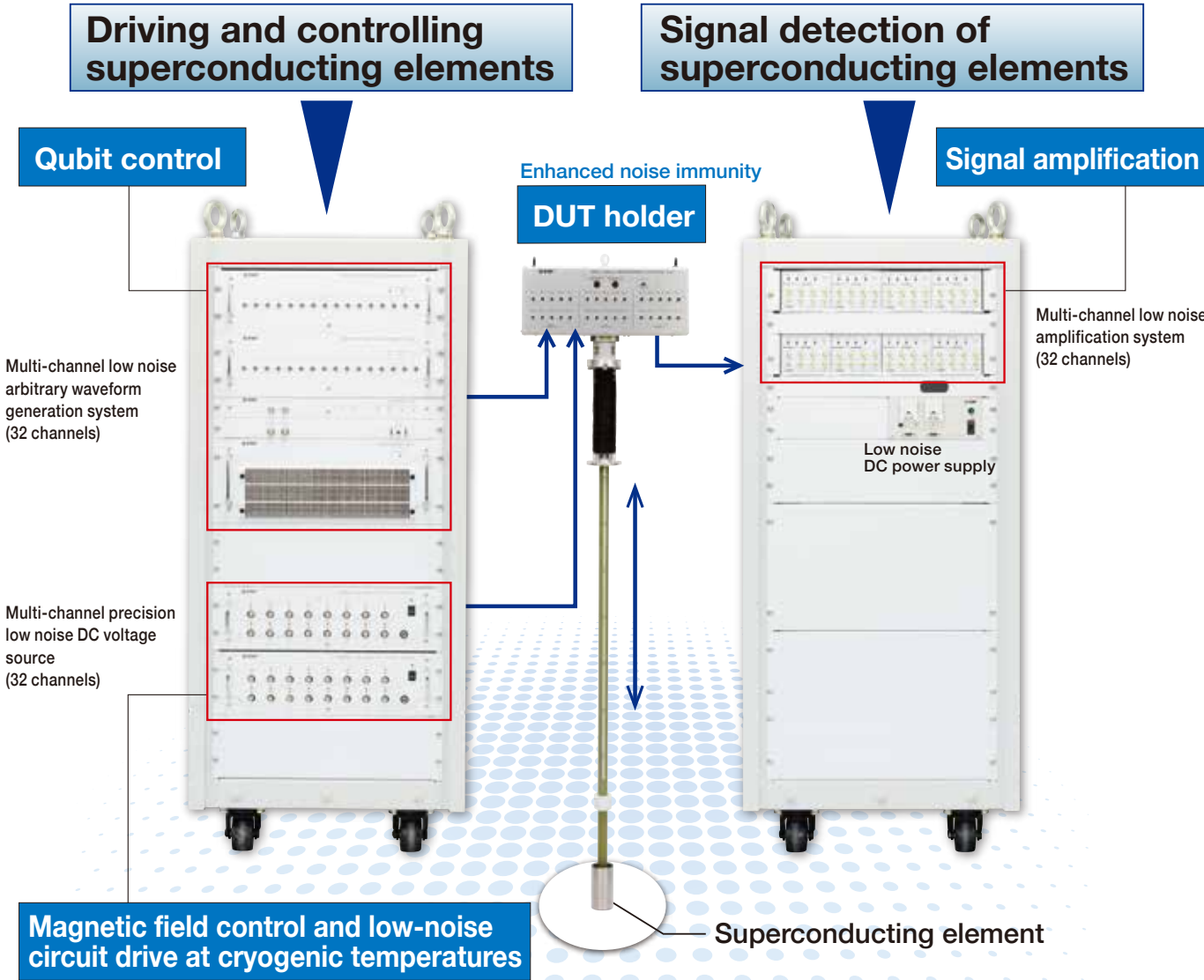
Low noise signal processing solution

Low noise&High stability

A low noise system required for control of superconducting elements and high-precision signal detection in quantum annealing computer equipment.

Multiple qubits

Multi-channel systems are suitable for evaluating multiple qubits.



Signal source for qubit control

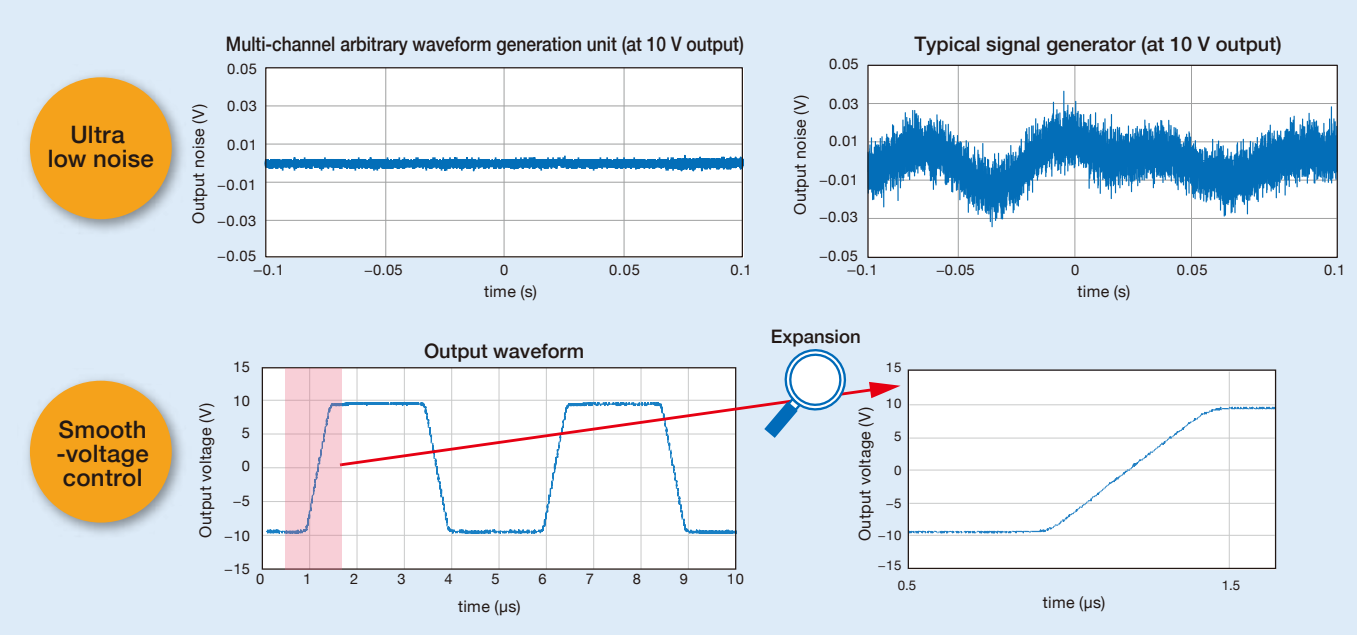
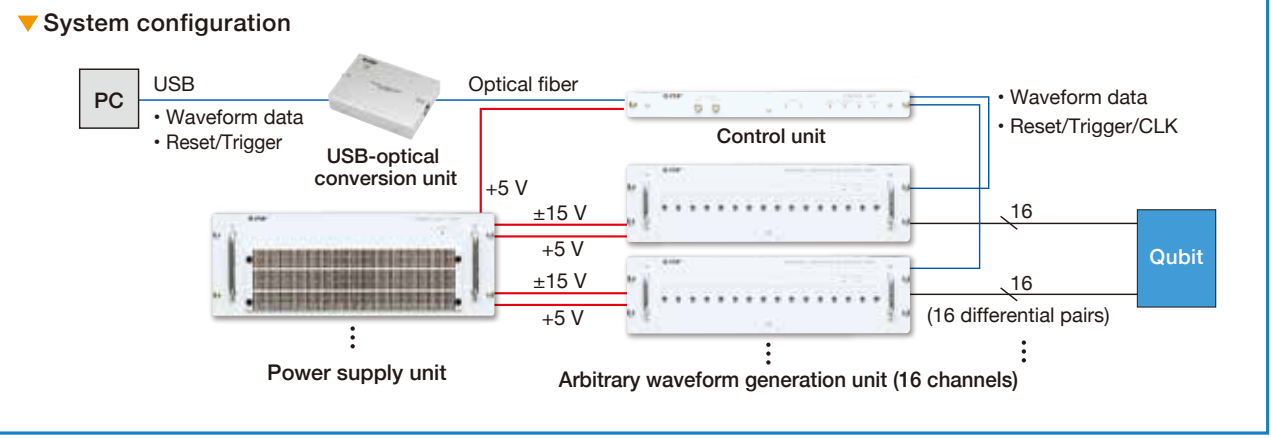
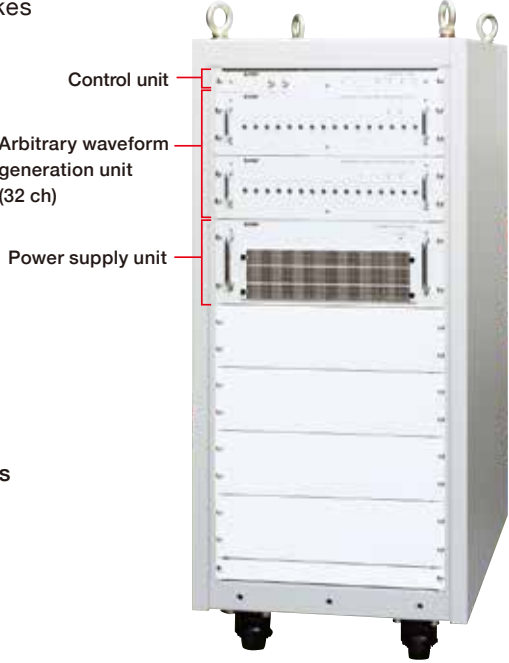
Multi-channel low noise arbitrary waveform generation system

Up to 1024 channels

This is a signal source designed for controlling qubits in a quantum annealing computer system. It features 16 channels per unit, allowing the construction of a system with up to 1024 channels. Its low noise level makes it highly suitable for controlling multiple qubits effectively.

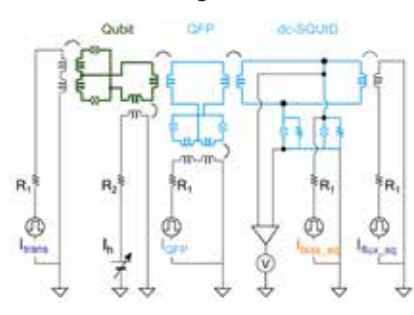
- Up to 1024 channels of differential sync output and arbitrary waveform output
- Arbitrary waveform can be set for each channel
- Less than 50 ns channel-to-channel skew
- High linearity achieved by analog linear interpolation circuit and underclock
- Low noise design with enhanced noise immunity
 - Reduction of common mode noise by differential signal output
 - Optical fiber communication cuts off noise via PC
 - Low noise linear power supply reduces noise pickup through the power supply
- A system is constructed by combining a control unit with up to 1024 channels an arbitrary waveform generation unit with 16 channels, and a low-noise linear power supply unit.

Specification examples are shown on page 6.

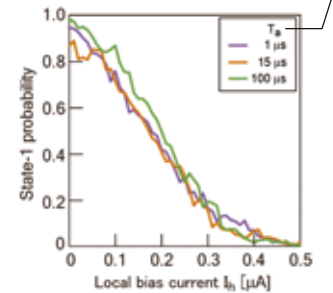


Measurement of superconducting flux qubits

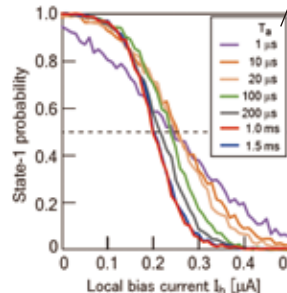
Quantum annealing circuit structure



Noise floor : pA/√Hz range (Equivalent to conventional system)



Noise floor : fA/√Hz range (Equivalent to NF system)



By using a low noise power supply and increasing the annealing time, the state transition occur in a narrow range

scientific reports "Supplementary Materials for Factorization by Quantum Annealing Using Superconducting Flux Qubits Implementing a Multiplier Hamiltonian", Daisuke SAIDA et al.

Magnetic field control and low noise circuit drive under cryogenic temperature

Multi-channel precision low noise DC Power source

This is the ultra low noise, high accuracy, and high stability multi-channel low noise DC power source. The system can be utilized to drive Josephson parametric amplifiers (JPAs) and HEMT amplifiers, thanks to its ability to minimize noise through the power supply when operating circuits at extremely low temperatures with minimal thermal noise. Moreover, its highly accurate and stable outputs make it well-suited for controlling the magnetic field of qubits and compensating for device characteristic variations. The multi-channel power supply system can be constructed by adding units as required.

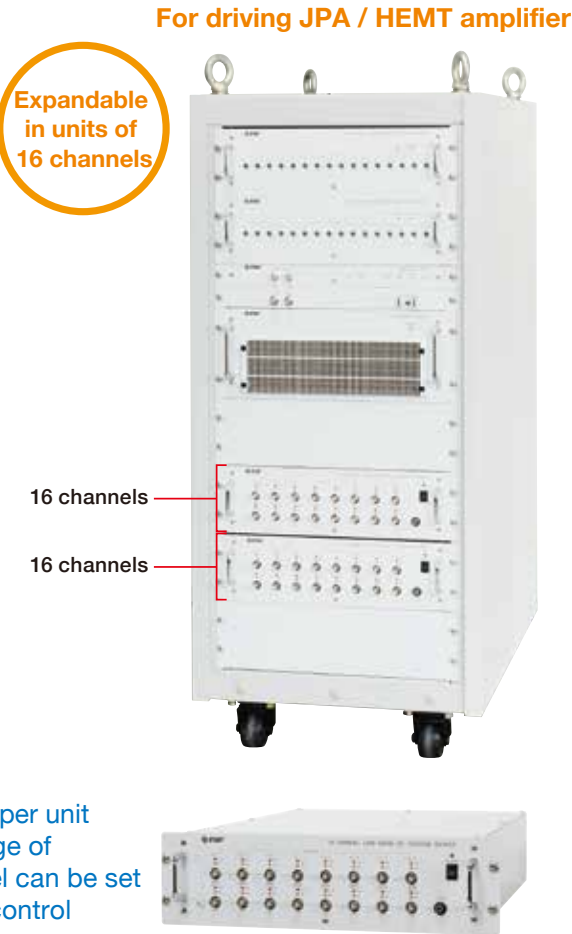
Voltage source

- Output noise voltage 2 μVrms (Bandwidth between 10 Hz and 1 MHz)
- Output voltage 0 to +16.1 V (unipolar output)
 ± 10 V (bipolar output)
- Setting resolution 500 μV (100 μV available)
- Setting accuracy $\pm (0.03 \% + 250 \mu\text{V})$
- Output stability $\pm 2 \text{ ppm}/^\circ\text{C}$
- Output current up to 15 mA per channel

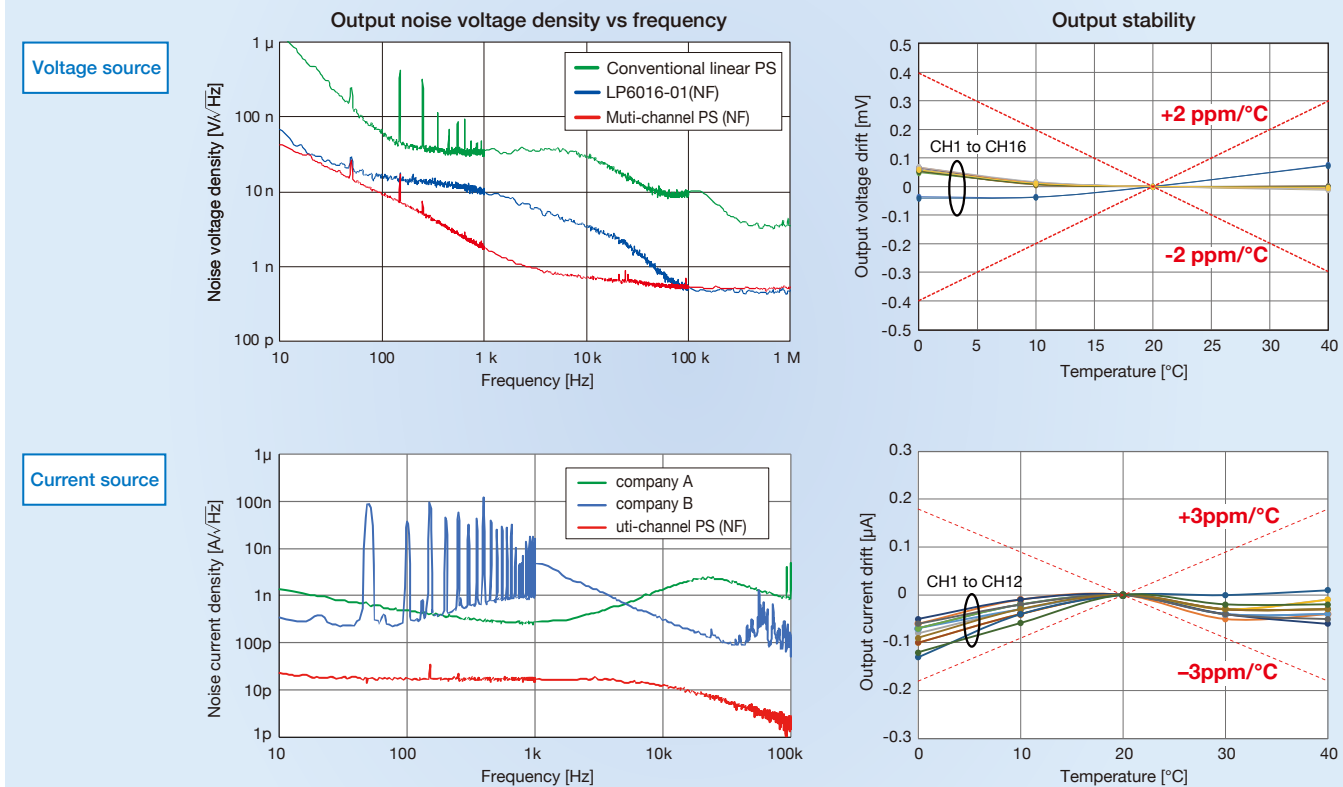
Current source

- Output current noise 0.01 $\mu\text{Ap-p}$ (BW10 kHz)
- Output current 0 to ± 3 mA (setting range changeable)
- Setting resolution 100 nA
- Output Accuracy $\pm (0.05 \% + 80 \text{ nA})$
- Output Stability $\pm 3 \text{ ppm}/^\circ\text{C}$

Specification examples are shown on page 6.



Output noise and output stability



Signal amplification

Multi-channel low noise amplification system

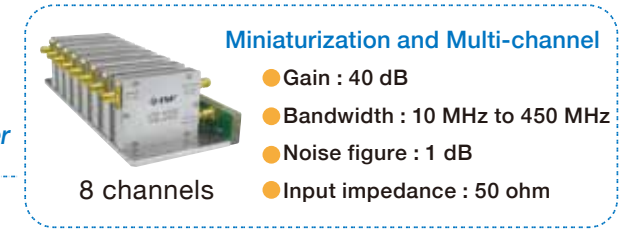
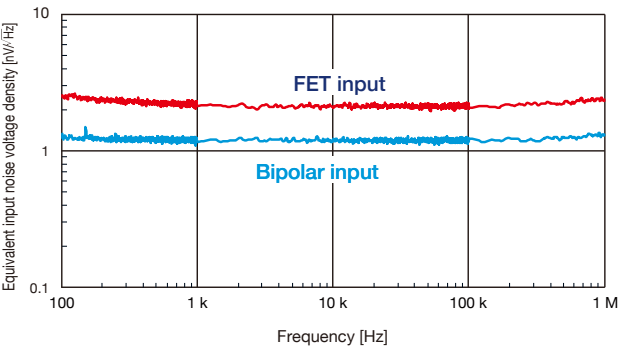
Expandable
in units of
4 channels

A signal amplification system suitable for low noise, number of channels and functions can be constructed. Ultra-low noise performance supports highly accurate measurements. Selectable according to sensor type: differential input (bipolar input, FET input), single-ended input (bipolar input, FET input) There are 4 channels per unit, and a multi-channel system is possible by increasing the number of units.

- Low noise 1.3 $\text{nV}/\sqrt{\text{Hz}}$ (bipolar input), 2.5 $\text{nV}/\sqrt{\text{Hz}}$ (FET input)
- Compact housing suitable for multi-channel applications
- Multifunctional
 - Input coupling selection DC/AC
 - Input mode selection Differential/Single-ended/GND
 - Low-pass filter selection THRU/LPF ON ($f_c=1 \text{ MHz}$)
 - Input conversion offset voltage adjustment range $\pm 100 \mu\text{V}$
 - Amplifier GND selection FLOAT/EXTERNAL

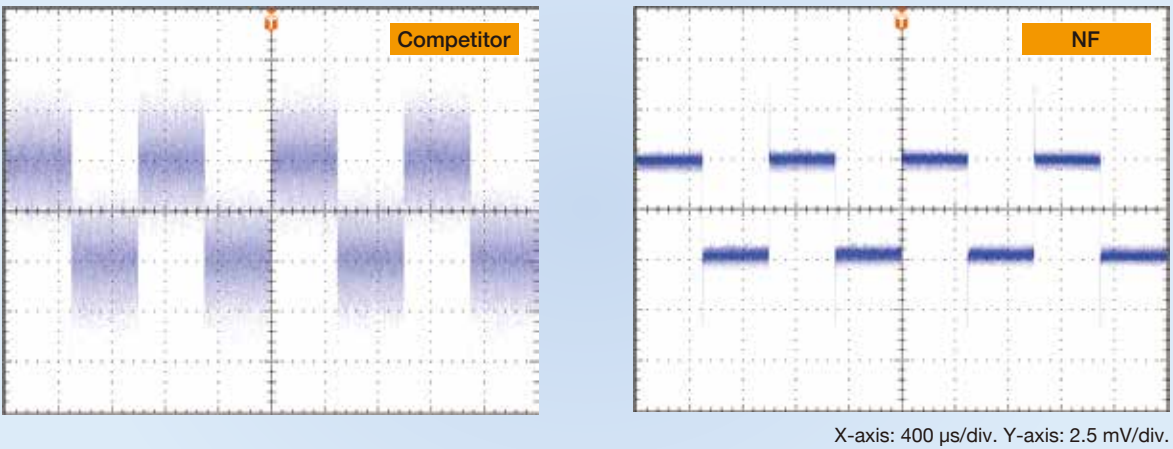
Specification examples are shown on page 6.

Ultra-low noise performance



- Gain : 40 dB
- Bandwidth : 10 MHz to 450 MHz
- Noise figure : 1 dB
- Input impedance : 50 ohm

Noise level comparison



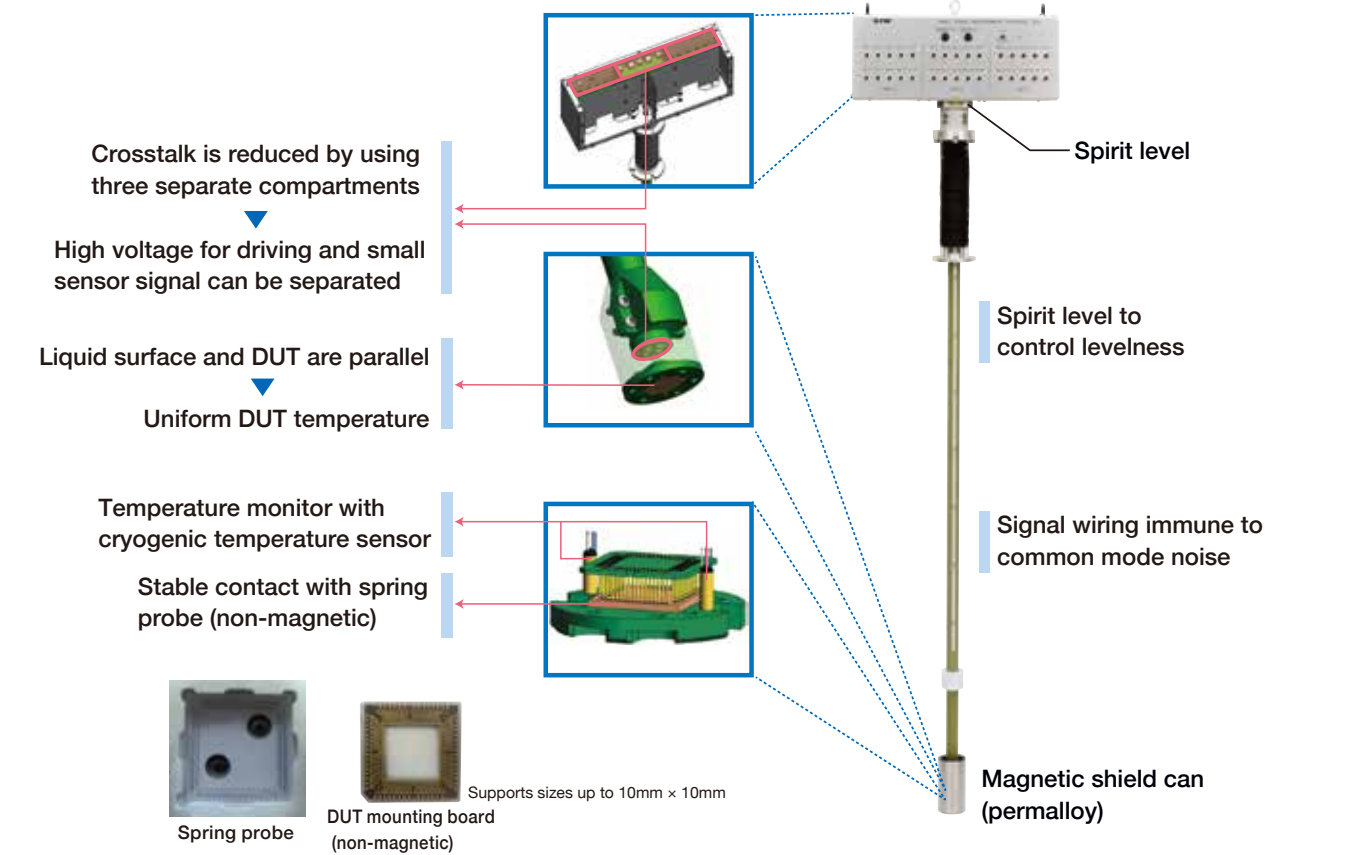
Low noise measurement under cryogenic temperature

Low noise DUT holder for cryostat



A rod for cooling and measuring superconducting elements such as Josephson elements with liquid helium (4.2 K). Supports stable measurement and evaluation with various measures to improve noise immunity.

- Signals 60 pins, differential 30 signals (can be changed by custom request)
- Special wiring to reduce common mode noise
- The internal structure is divided into three compartments, enabling use while suppressing crosstalk between wiring.
- The temperature of the DUT is uniform because the liquid surface and the DUT are horizontal.
- Spring probe provides stable contact and easy maintenance
- It is possible to insert a rod with levelness controlled using a spirit level.
- Magnetic shield can (ferromagnetic material: permalloy) can be attached
- Built-in temperature sensor (non-magnetic compatible)



Specifications (example)

Multi-channel low noise arbitrary waveform generation system

Unless otherwise specified: temperature 23±5°C, load 1MΩ, LPF THRU, ATT THRU, linear interpolation circuit ON

Output waveform		Arbitrary waveform
Maximum output voltage		±10 V (paired with COM; ±20 V differential)
Sampling rate		2 M S/s
Waveform length		10 words to 256 K words
Number of stored waveforms		16 waveforms stored in volatile memory
Output characteristics	Connectors	HR10-7R-4S
	Form	Differential output
	Maximum current	10 mA
	Impedance	50 Ω paired with COM
	Channel-to-channel skew	Within 50ns
	Noise	1.2 mVrms: linear interpolation circuit ON, bandwidth 20 MHz, paired with COM 0.1 mVrms: linear interpolator OFF, bandwidth 20 MHz, paired with COM
	Bandwidth	3 MHz: linear interpolation circuit ON, −3 dB typ. 1.6 kHz: linear interpolation circuit OFF −3 dB typ.
Linear interpolation		ON/OFF switching by PC
Other features		Sequence, external synchronization
Interface		USB2.0
USB optical conversion adapter	Input	Input connector: USB2.0 Type B female, Connect with PC, Communication: USB2.0 high speed
	Output	Output connector: optical connector,Communication: Dedicated optical serial signal
Power supply unit		Input voltage: AC 100 V ±10 %, frequency: 50/60 ±2 Hz, power consumption: 270 W or less (for 16 channels)

Multi-channel precision low noise DC power source

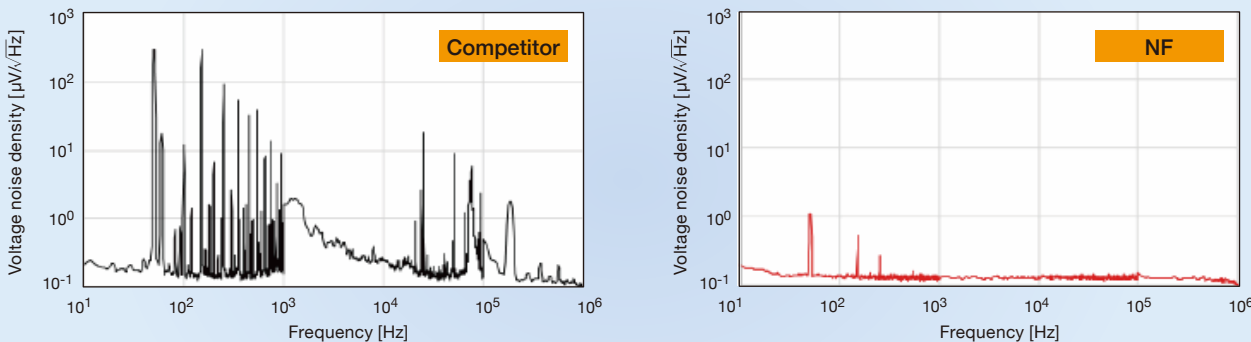
		Voltage source	Current source
Type		Series regulator type	-
Output characteristics	Number of outputs	16 channels	16 channels
	Connectors	BNC receptacle connectors	BNC receptacle connectors
	setting range	0 V to +16.1 V (unipolar output) / ±10 V (bipolar output) Configurable for each channel. Res: 500 μV (100 μV available)	±3 mA Configurable for each channel. Res: 100 nA
	setting control	External control	External control
	setting accuracy	±(0.03 % of setting + 125 μV), at 23 °C ±5 °C, no load	±(0.05 % of setting + 80 nA), at 23±5°C, no load
	Temperature coefficient	±2 ppm/°C	±3 ppm/°C
	Maximum output	15 mA for each channel	Compliance voltage: ±4 V
	Ripple noise	2 μVrms or less typ. , in a bandwidth of 10 Hz to 1 MHz	10 nAp-p or less typ. , in a bandwidth of 0.1 Hz to 10 kHz
Interface	Output ON/OFF	External control	External control
	Interface	USB2.0, 10BASE-T/100BASE-TX, TCP/IP	USB2.0, 10BASE-T/100BASE-TX, TCP/IP
Power supply		AC 100 V ±10%, 50/60 ±2 Hz	AC 100 V ±10%, 50/60 ±2 Hz

Multi-channel low noise amplification system (4 channels)

		Bipolar input	FET input
Input coupling		DC/AC	
Input mode		A-B/A-/B-/GND	
Input impedance		100 kΩ, coupling capacitance 1 μF	1 MΩ, coupling capacitance 0.1 μF
Equivalent Input Noise Voltage Density		1.3 nV/√Hz	2.5 nV/√Hz
Offset voltage referred to input		Adjustable to zero (input shorted, DC coupled, potentiometer setting)	
Input bias current		30 nA	30 pA
Input voltage range		Within ±0.1 V	
Maximum output voltage/current		±10 V, ±10 mA	
Slew rate		22 V/μs	600 V/μs
Output impedance		50 Ω	
Voltage gain		40 dB (f=1 kHz)	
Voltage gain frequency response		DC to 1 MHz (within +0.5 dB / -3.0 dB)	DC to 20 MHz (within +0.5 dB / -3.0 dB)
Low pass filter		fc = 1 MHz (Linear phase 3rd order)	
External dimensions (mm)		105 (W) × 88 (H) × 210 (D)	
Power supply*		±15 V, current consumption: ±240 mA (maximum)	

*NF low-noise DC power supply is recommended.

Noise level comparison



▶ Reduced voltage noise by 1/300 at 50 Hz and 1/500 at 150 Hz compared to competitor equipment

Application

- Superconducting devices
- Cryogenics and condensed matter physics

*Note: The contents of this catalog are current as of July 14th, 2023.
Product appearance and specifications are subject to change without notice.
Before purchase, contact us to confirm the latest specifications, pricing and delivery date.

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