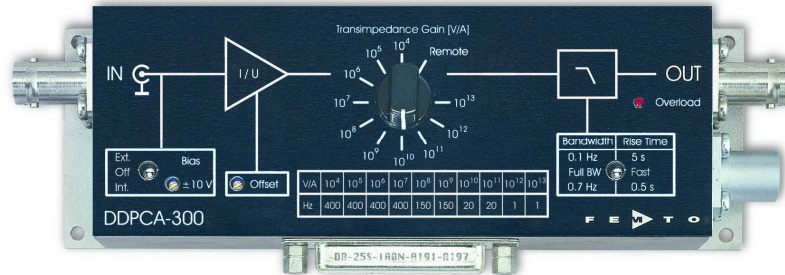


Variable Gain Sub Femto Ampere Current Amplifier



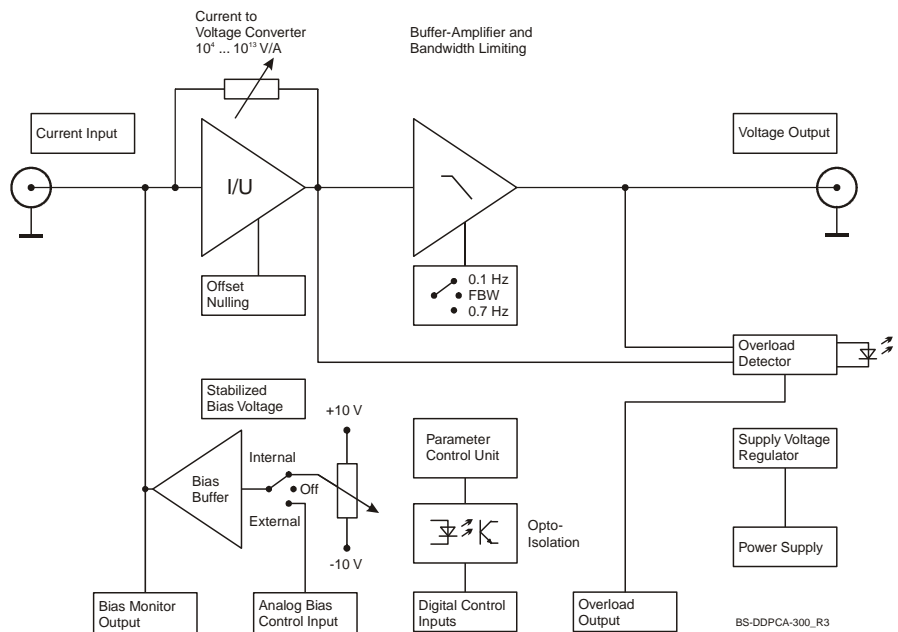
Features

- **0.4 fA Peak-Peak Noise**
- **Very High Dynamic Range: Sub-fA to 1 mA (> 240 dB)**
- **Transimpedance (Gain) Switchable from 1×10^4 to 1×10^{13} V/A**
- **Bandwidth up to 400 Hz, Rise Time Down to 0.8 ms - Independent of Source Capacitance (up to 10 nF)**
- **Adjustable Bias Voltage on Input Relative to Ground**
- **Compact Housing for Use Close to the Signal Source**
- **Local and Remote Control**
- **Easy to Use:**
Convert Your Standard Digital Voltmeter or DAQ Board to a High-End Digital Sub Femto Amperemeter

Applications

- **Photodetector Amplifier**
- **I/V Characterization of Small MOS Structures**
- **DC Measurements of Ultra Low Currents**
- **Ionization Detectors, Mass Spectrometry, Quantum and Biotech Experiments**
- **Characterization of High Impedance Nanomaterials**
- **Spectroscopy**
- **High Resistance Measurements**

Block Diagram



Variable Gain Sub Femto Ampere Current Amplifier

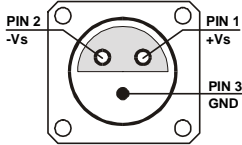
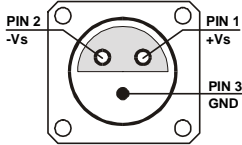
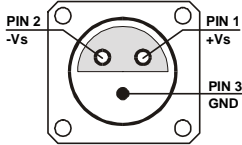
Specifications	<i>Test Conditions</i>	<i>V_s = ± 15 V, T_a = 25°C, Relative Humidity < 35 % Warm-up 20 minutes (min. 10 minutes recommended)</i>				
Gain	Transimpedance	1 x 10 ⁴ ... 1 x 10 ¹³ V/A				
	Gain Accuracy	± 1 %				
	Gain Drift	see table below				
Frequency Response	Lower Cut-Off Frequency	DC				
	Upper Cut-Off Frequency	up to 400 Hz (see table below)				
	Adjustable Low Pass Filter	switchable to 3 settings (full bandwidth, 0.7 Hz and 0.1 Hz)				
		<u>Upper Cut-Off</u>	<u>Rise Time</u>			
		Full BW (see table below)		Fast (see table below)		
		0.7 Hz	0.5 s			
		0.1 Hz	5 s			
		Setting the low pass filter to full bandwidth is recommended for high measurement speed. By setting the low pass filter to 0.7 Hz or 0.1 Hz the peak-peak noise performance can be improved but the signal settling time will be longer.				
Input	Equ. Input Noise Current	gain setting dependent, see table below minimum input noise is 0.4 fA peak-peak (at gain setting 10 ¹² or 10 ¹³ V/A with low pass filter switched to 0.1 Hz)				
	Input Bias Current	20 fA typ. / 30 fA max.				
	Input Bias Current Drift	factor 2 / 10 °C				
	Max. Input Current (Full Scale)	see table below (value for linear amplification)				
	Input Offset Compensation	adjustable by offset trimpot, ± 100 fA				
Performance Depending on Gain Setting	Gain Setting (V/A)	10 ⁴	10 ⁵	10 ⁶	10 ⁷	10 ⁸
	Upper Cut-Off Frequency (- 3 dB)*	400 Hz	400 Hz	400 Hz	400 Hz	150 Hz
	Rise / Fall Time (10 % - 90 %)*	0.8 ms	0.8 ms	0.8 ms	0.8 ms	2.3 ms
	Integrated Input Noise Current (Peak-Peak)*	7 nA	7 nA	70 pA	70 pA	1.2 pA
	Spectral Input Noise Current Density (√Hz)	45 pA	45 pA	0.45 pA	0.45 pA	15 fA
	Measured at	10 Hz	10 Hz	10 Hz	10 Hz	10 Hz
	Gain Drift (°C)	0.01 %	0.01 %	0.01 %	0.01 %	0.01 %
	Max. Input Current (± Full Scale)	1 mA	0.1 mA	10 µA	1 µA	0.1 µA
	DC Input Impedance (// 5 pF)	< 1 Ω	< 1 Ω	< 1 Ω	< 1 Ω	< 100 Ω
	Gain Setting (continued) (V/A)	10 ⁹	10 ¹⁰	10 ¹¹	10 ¹²	10 ¹³
	Upper Cut-Off Frequency (- 3 dB)*	150 Hz	20 Hz	20 Hz	1 Hz	1 Hz
	Rise / Fall Time (10 % - 90 %)*	2.3 ms	17 ms	17 ms	350 ms	350 ms
	Integrated Input Noise Current (Peak-Peak)*	1.2 pA	50 fA	50 fA	2 fA	2 fA
	Spectral Input Noise Current Density (√Hz)	15 fA	1.3 fA	1.3 fA	0.2 fA	0.2 fA
	Measured at	10 Hz	1 Hz	1 Hz	0.4 Hz	0.4 Hz
	Gain Drift (°C)	0.01 %	0.03 %	0.03 %	0.03 %	0.03 %
	Max. Input Current (± Full Scale)	10 nA	1 nA	0.1 nA	10 pA	1 pA
	DC Input Impedance (// 5 pF)	< 100 Ω	< 10 kΩ	< 10 kΩ	< 1 MΩ	< 1 MΩ
	* The values for upper cut-off frequency, rise / fall time and integrated input noise current stated in the table above are achieved with the low pass filter set to "Full BW / Fast" (full bandwidth / fast rise time). Lower peak-peak noise values can be achieved by setting the low pass filter to 0.7 Hz or 0.1 Hz. In that case the bandwidth will be lower and the signal rise / fall time will be longer though.					

Variable Gain Sub Femto Ampere Current Amplifier

Specifications (continued)

Output	Output Voltage Output Impedance Max. Output Current	$\pm 10\text{ V}$ (@ $\geq 1\text{ M}\Omega$ load) $50\ \Omega$ (terminate with $\geq 1\text{ M}\Omega$ load for best performance) $\pm 30\text{ mA}$
Adjustable Bias Voltage	General Bias Voltage Range Bias Current	An adjustable bias voltage is provided for directly biasing the device under test DUT (e.g. photodiode, high resistance semiconductor component). The bias voltage is connected to the inner conductor of the BNC input socket; the BNC-shield is always connected to analog ground. The bias voltage can be set either locally at the amplifier or through the remote interface. For measurements not requiring a bias voltage it can be fully disabled. $\pm 10\text{ V}$ at inner conductor of BNC input socket max. $\pm 10\text{ mA}$
Local Bias Adjustment	Bias Switch Setting Bias Adjustment	set bias switch to position "Int." adjust bias voltage by bias trimpot
Remote Bias Adjustment	Bias Switch Setting Bias Adjustment Input Impedance of Control Pin 8 Bias Control Voltage Range Bias Control Polarity Example:	set bias switch to position "Ext." adjust bias by analog control voltage fed to pin 8 of Sub-D connector (referred to AGND pin 3) $200\text{ k}\Omega$ $\pm 10\text{ V}$ at pin 8 (referred to AGND pin 3) inverting feeding a control voltage of $+ 2\text{ V}$ to pin 8 of the Sub-D connector leads to $- 2\text{ V}$ bias voltage at the inner conductor of the BNC input socket referred to BNC shield (analog ground, AGND)
Bias Deactivation	Bias Switch Setting	set bias switch to position "Off"
Bias Monitor Output	Range Connector Output Impedance	$\pm 10\text{ V}$, mirrors the adjusted bias voltage at the BNC input (inner conductor referred to AGND pin 3) pin 7 of Sub-D connector (referred to AGND pin 3) $50\ \Omega$ (terminate with $\geq 1\text{ M}\Omega$ load for best performance)
Overload Indication	LED Digital Output	lights when overload is detected active when overload is detected (non active: 0 V , max. -1 mA , active: 5.1 V , max. 7 mA ; referred to AGND pin 3)
Digital Control	Control Input Voltage Range Control Input Current	LOW bit: $- 0.8 \dots + 1.2\text{ V}$, HIGH bit: $+ 2.3 \dots + 12\text{ V}$ 0 mA @ 0 V ; 1.5 mA @ $+ 5\text{ V}$; 4.5 mA @ $+ 12\text{ V}$
Auxiliary Power Output	Voltage	$\pm 12\text{ VDC}$, stabilized, max. $\pm 50\text{ mA}$ (at Sub-D, may be used for supplying external devices up to $\pm 50\text{ mA}$)
Power Supply	Supply Voltage Supply Current	$\pm 15\text{ V}$ $+ 70\text{ mA} / -15\text{ mA}$ typ. (depends on operating conditions, recommended power supply capability minimum $\pm 150\text{ mA}$)
Case	Weight Material	320 g (0.74 lb.) AlMg4.5Mn, nickel-plated
Temperature Range	Storage Temperature Operating Temperature	$- 40 \dots + 100\text{ }^\circ\text{C}$ $0 \dots + 50\text{ }^\circ\text{C}$

Variable Gain Sub Femto Ampere Current Amplifier

Absolute Maximum Ratings	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Signal Input Voltage</td> <td style="padding: 2px;">± 15 V relative to bias</td> </tr> <tr> <td style="padding: 2px;">Transient Input Voltage</td> <td style="padding: 2px;">± 2 kV (discharge from 1 nF source)</td> </tr> <tr> <td style="padding: 2px;">Digital Control Input Voltage</td> <td style="padding: 2px;">- 5 V / + 16 V</td> </tr> <tr> <td style="padding: 2px;">Bias Control Input Voltage</td> <td style="padding: 2px;">± 12 V</td> </tr> <tr> <td style="padding: 2px;">Power Supply Voltage</td> <td style="padding: 2px;">± 20 V</td> </tr> </table>	Signal Input Voltage	± 15 V relative to bias	Transient Input Voltage	± 2 kV (discharge from 1 nF source)	Digital Control Input Voltage	- 5 V / + 16 V	Bias Control Input Voltage	± 12 V	Power Supply Voltage	± 20 V		
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Connectors	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Input</td> <td style="padding: 2px;">BNC</td> </tr> <tr> <td style="padding: 2px;">Output</td> <td style="padding: 2px;">BNC</td> </tr> <tr> <td style="padding: 2px;">Bias Voltage Output</td> <td style="padding: 2px;">center pin of BNC input socket</td> </tr> <tr> <td style="padding: 2px;">Power Supply</td> <td style="padding: 2px;"> LEMO series 1S, 3-pin fixed socket Pin 1: + 15V Pin 2: - 15V Pin 3: GND </td> </tr> <tr> <td style="padding: 2px; vertical-align: middle;"> <div style="text-align: center;">  </div> </td> <td></td> </tr> <tr> <td style="padding: 2px;">Control Port</td> <td style="padding: 2px;"> Sub-D 25-pin, female, qual. class 2 Pin 1: +12V (stabilized power supply output) Pin 2: -12V (stabilized power supply output) Pin 3: AGND (analog ground) Pin 4: NC Pin 5: overload output (refers to AGND) Pin 6: signal output (connected to BNC output connector) Pin 7: bias voltage monitor output (refers to AGND) Pin 8: bias control voltage input (refers to AGND) Pin 9: DGND (ground for digital control pins 10 - 13) Pin 10: digital control input: gain, LSB Pin 11: digital control input: gain Pin 12: digital control input: gain Pin 13: digital control input: gain, MSB Pin 14 - 25: NC </td> </tr> </table>	Input	BNC	Output	BNC	Bias Voltage Output	center pin of BNC input socket	Power Supply	LEMO series 1S, 3-pin fixed socket Pin 1: + 15V Pin 2: - 15V Pin 3: GND	<div style="text-align: center;">  </div>		Control Port	Sub-D 25-pin, female, qual. class 2 Pin 1: +12V (stabilized power supply output) Pin 2: -12V (stabilized power supply output) Pin 3: AGND (analog ground) Pin 4: NC Pin 5: overload output (refers to AGND) Pin 6: signal output (connected to BNC output connector) Pin 7: bias voltage monitor output (refers to AGND) Pin 8: bias control voltage input (refers to AGND) Pin 9: DGND (ground for digital control pins 10 - 13) Pin 10: digital control input: gain, LSB Pin 11: digital control input: gain Pin 12: digital control input: gain Pin 13: digital control input: gain, MSB Pin 14 - 25: NC
Input	BNC												
Output	BNC												
Bias Voltage Output	center pin of BNC input socket												
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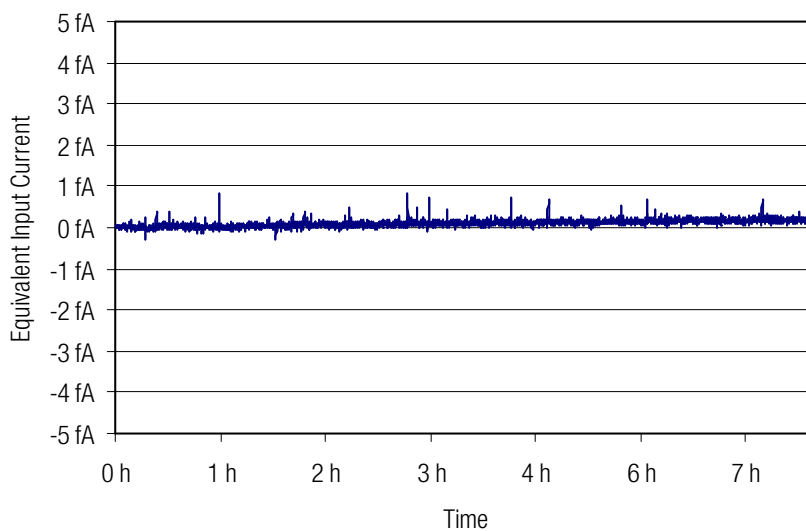
Variable Gain Sub Femto Ampere Current Amplifier

Remote Control Operation	General	<p>Remote control input bits are opto-isolated. For remote control operation set the rotary gain switch to the "Remote" position and select the desired gain setting via a bit code at the digital inputs.</p> <p>Switch settings "0.1 Hz / Full BW / 0.7 Hz" and "Bias Ext. / Off / Int." are not remote controllable.</p>				
	Gain Setting	Gain (V/A)	Pin 13 MSB	Pin 12	Pin 11	Pin 10 LSB
		10^4	LOW	LOW	LOW	LOW
		10^5	LOW	LOW	LOW	HIGH
		10^6	LOW	LOW	HIGH	LOW
		10^7	LOW	LOW	HIGH	HIGH
		10^8	LOW	HIGH	LOW	LOW
		10^9	LOW	HIGH	LOW	HIGH
		10^{10}	LOW	HIGH	HIGH	LOW
		10^{11}	LOW	HIGH	HIGH	HIGH
		10^{12}	HIGH	LOW	LOW	LOW
		10^{13}	HIGH	LOW	LOW	HIGH

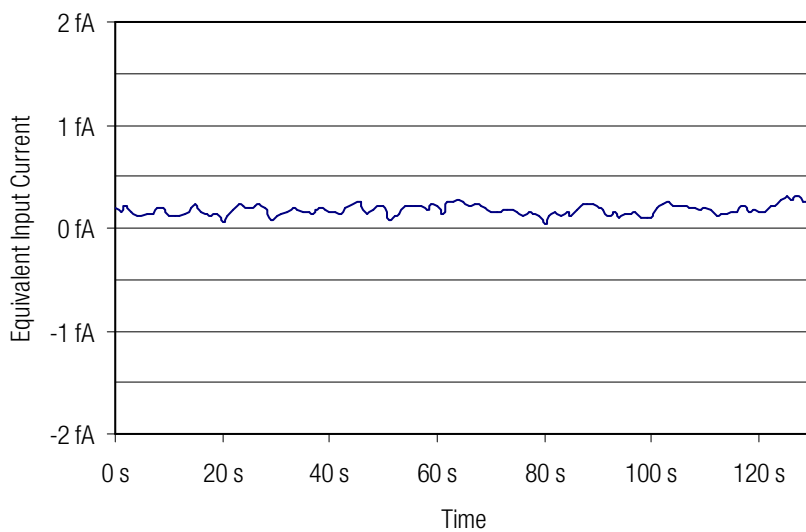
Variable Gain Sub Femto Ampere Current Amplifier

Typical Performance
Characteristics

Long Term Drift



Short Term Drift

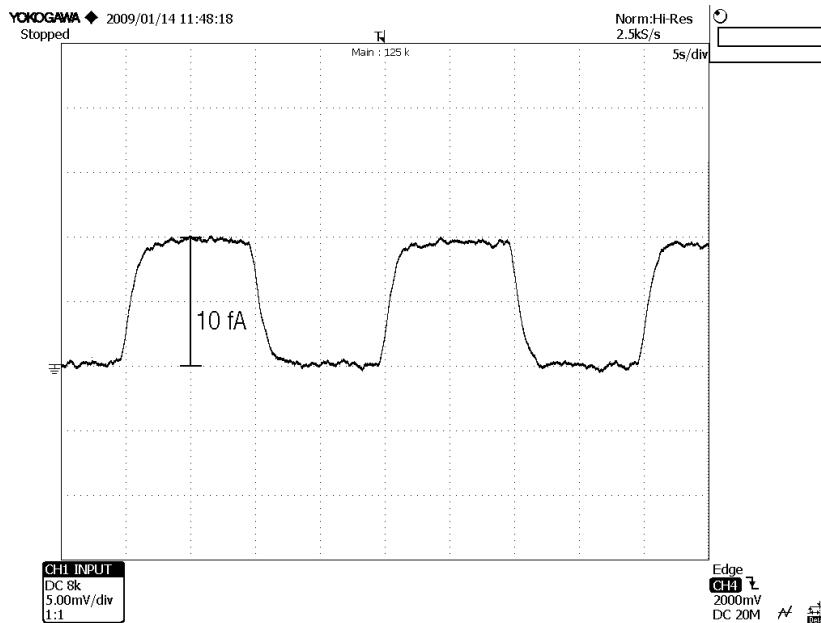


Both drift curves were recorded with shielded input in the gain setting 10^{12} V/A, filter setting 0.1 Hz (20 minutes warm-up before measurement).

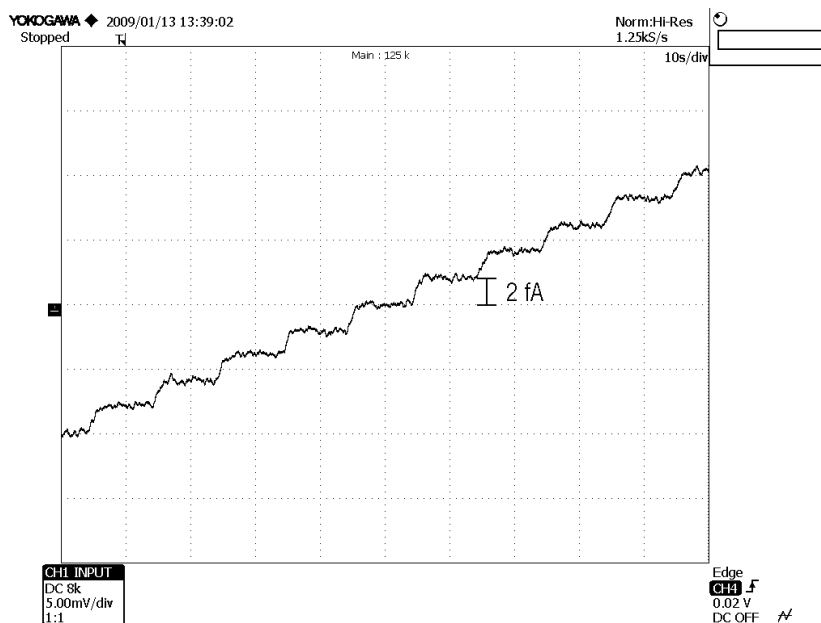
Variable Gain Sub Femto Ampere Current Amplifier

Typical Performance
Characteristics

10 fA square wave



2 fA step curve

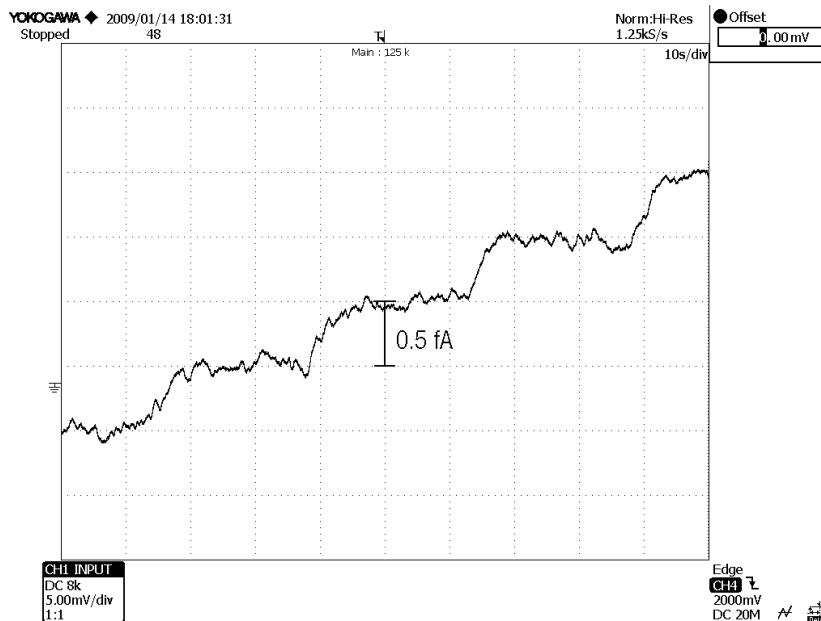


Both curves were recorded in the gain setting 10^{12} V/A, filter setting 0.7 Hz, no external averaging (20 minutes warm-up before measurement).

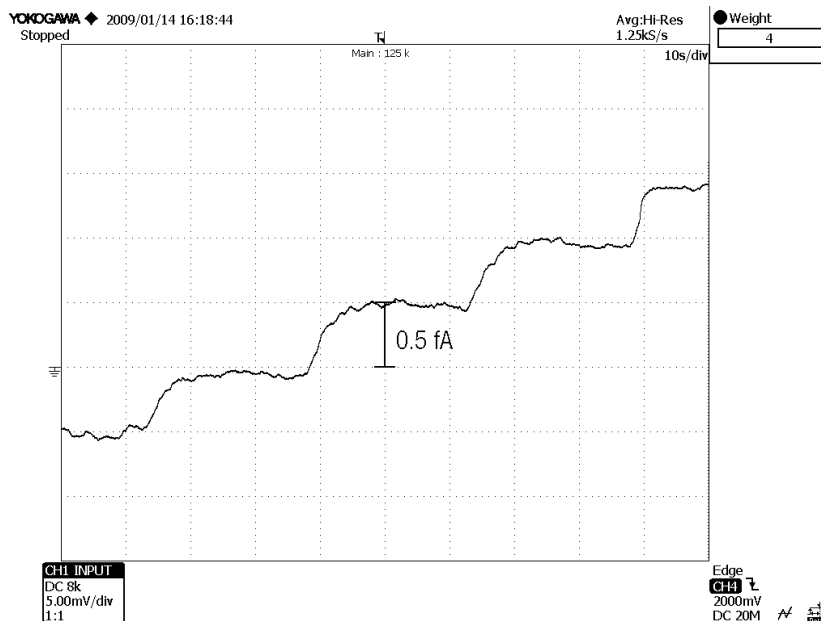
Variable Gain Sub Femto Ampere Current Amplifier

Typical Performance
Characteristics

0.5 fA step curve, no averaging



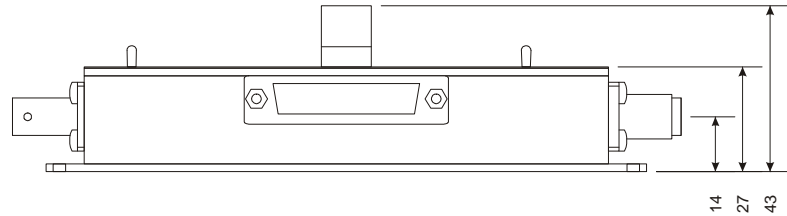
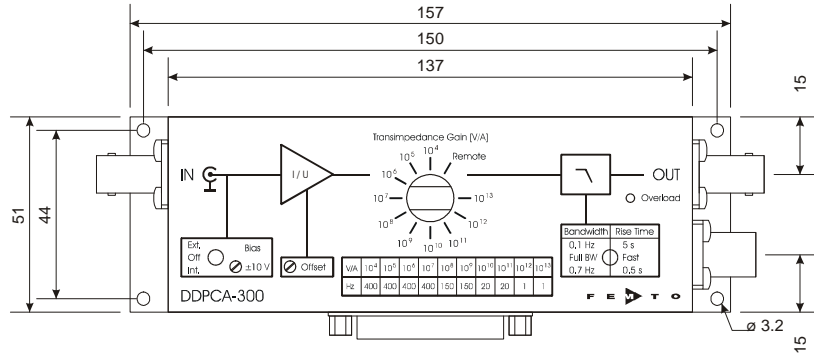
0.5 fA step curve, 4 times external averaging



Both curves were recorded in the gain setting 10^{13} V/A, filter setting 0.1 Hz (20 minutes warm-up before measurement).

Variable Gain Sub Femto Ampere Current Amplifier

Dimensions



all measures in mm unless otherwise noted

DZ-DDPCA-300_R3

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