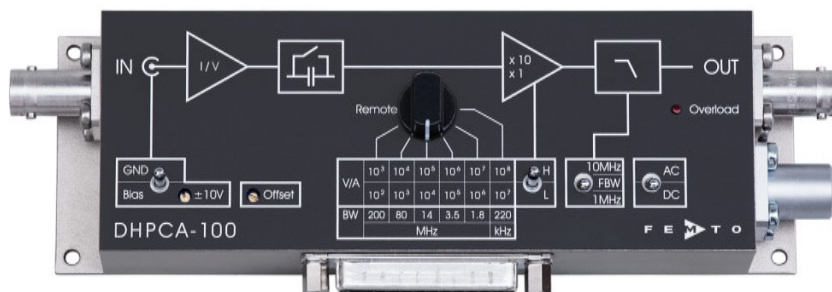


# Variable Gain High-Speed Current Amplifier



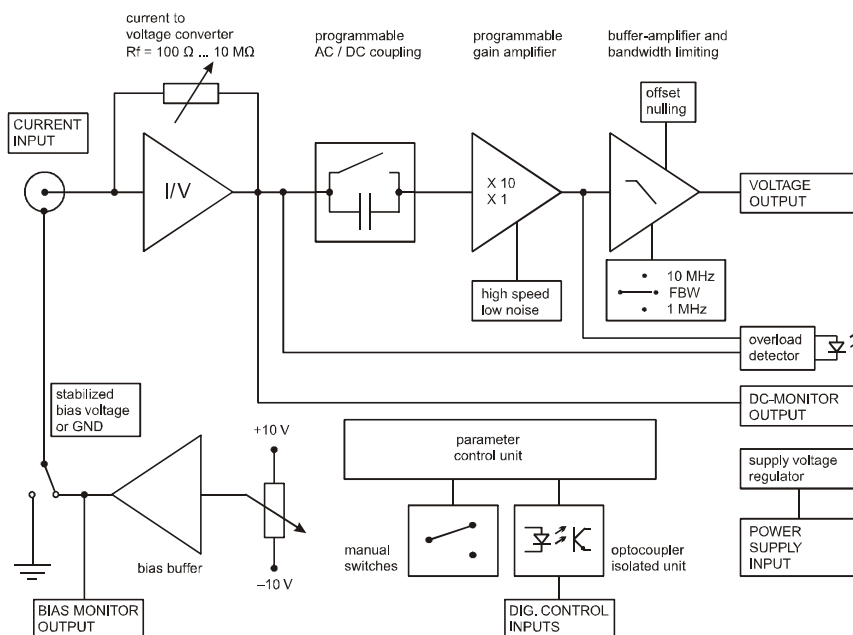
## Features

- Transimpedance (gain) switchable from  $1 \times 10^2$  to  $1 \times 10^8$  V/A
- Bandwidth from DC up to 200 MHz
- Upper cut-off frequency switchable to 1 MHz, 10 MHz or full bandwidth
- Switchable AC/DC coupling
- Adjustable bias voltage for use with external photo detectors
- Input protection against  $\pm 1.5$  kV transients
- Local and remote control of all main functions

## Applications

- Photodiode and photomultiplier amplifier
- Spectroscopy
- Beam monitoring for particle accelerators/synchrotrons
- Ionisation detectors
- Preamplifier for A/D converters, HF lock-ins, etc.

## Block Diagram



BS-DHPCA R6

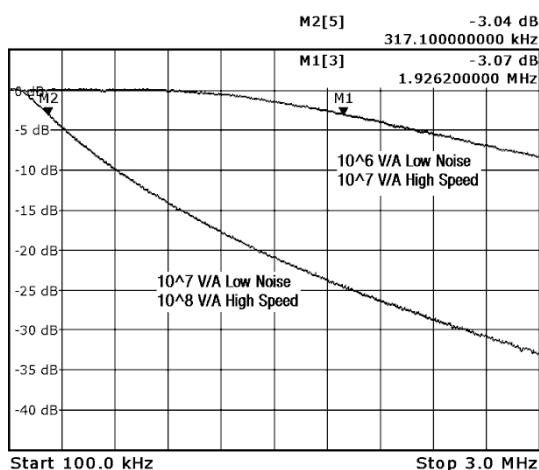
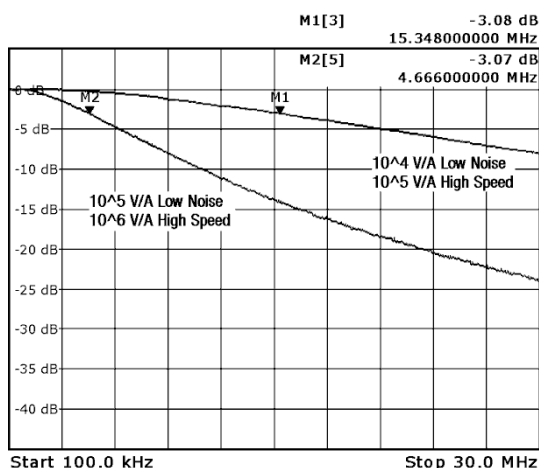
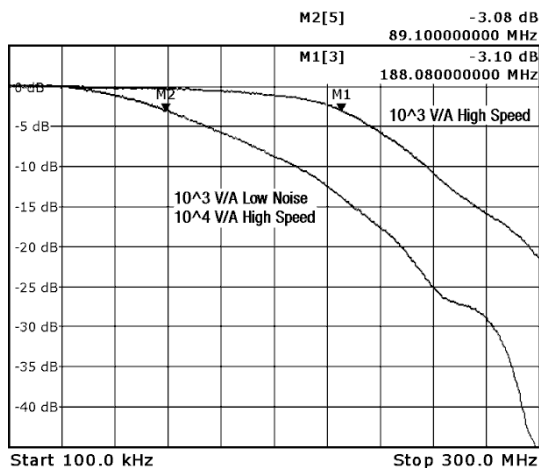
## Variable Gain High-Speed Current Amplifier

|                                       |                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                     |                    |                         |                          |                          |                          |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------|--------------------------|--------------------------|--------------------------|
| Specifications                        | Test conditions                                                                                                                                                                                                                                                                                                                                                                                                            | $V_s = \pm 15\text{ V}$ , $T_A = 25\text{ }^\circ\text{C}$ , load impedance = $50\text{ }\Omega$                    |                    |                         |                          |                          |                          |
| Gain                                  | Transimpedance                                                                                                                                                                                                                                                                                                                                                                                                             | $1 \times 10^2 \dots 1 \times 10^8\text{ V/A}$ @ $50\text{ }\Omega$ load                                            |                    |                         |                          |                          |                          |
|                                       | Gain accuracy                                                                                                                                                                                                                                                                                                                                                                                                              | $\pm 1\text{ }\%$                                                                                                   |                    |                         |                          |                          |                          |
| Frequency Response                    | Lower cut-off frequency                                                                                                                                                                                                                                                                                                                                                                                                    | DC / $100\text{ Hz}$ , switchable                                                                                   |                    |                         |                          |                          |                          |
|                                       | Upper cut-off frequency                                                                                                                                                                                                                                                                                                                                                                                                    | depending on gain setting up to $200\text{ MHz}$ (see table below), switchable to $10\text{ MHz}$ or $1\text{ MHz}$ |                    |                         |                          |                          |                          |
| Input                                 | Equ. input noise current                                                                                                                                                                                                                                                                                                                                                                                                   | see table below                                                                                                     |                    |                         |                          |                          |                          |
|                                       | Equ. input noise voltage                                                                                                                                                                                                                                                                                                                                                                                                   | typ. $2.8\text{ nV}/\sqrt{\text{Hz}}$                                                                               |                    |                         |                          |                          |                          |
|                                       | Input bias current                                                                                                                                                                                                                                                                                                                                                                                                         | typ. $20\text{ pA}$                                                                                                 |                    |                         |                          |                          |                          |
| Performance depending on Gain Setting | Gain setting (low noise) (V/A)                                                                                                                                                                                                                                                                                                                                                                                             | $10^2$                                                                                                              | $10^3$             | $10^4$                  | $10^5$                   | $10^6$                   | $10^7$                   |
|                                       | Upper cut-off frequency ( $-3\text{ dB}$ )                                                                                                                                                                                                                                                                                                                                                                                 | $200\text{ MHz}$                                                                                                    | $80\text{ MHz}$    | $14\text{ MHz}$         | $3.5\text{ MHz}$         | $1.8\text{ MHz}$         | $220\text{ kHz}$         |
|                                       | Rise/fall time ( $10\text{ }\%$ - $90\text{ }\%$ )                                                                                                                                                                                                                                                                                                                                                                         | $1.8\text{ ns}$                                                                                                     | $4.4\text{ ns}$    | $25\text{ ns}$          | $0.1\text{ }\mu\text{s}$ | $0.2\text{ }\mu\text{s}$ | $1.6\text{ }\mu\text{s}$ |
|                                       | Input noise current density ( $/\sqrt{\text{Hz}}$ )                                                                                                                                                                                                                                                                                                                                                                        | $180\text{ pA}$                                                                                                     | $11\text{ pA}$     | $1.8\text{ pA}$         | $480\text{ fA}$          | $140\text{ fA}$          | $45\text{ fA}$           |
|                                       | measured at                                                                                                                                                                                                                                                                                                                                                                                                                | $1\text{ MHz}$                                                                                                      | $1\text{ MHz}$     | $1\text{ MHz}$          | $10\text{ kHz}$          | $10\text{ kHz}$          | $10\text{ kHz}$          |
|                                       | Integr. input noise current (RMS)*                                                                                                                                                                                                                                                                                                                                                                                         | $2.5\text{ }\mu\text{A}$                                                                                            | $280\text{ nA}$    | $25\text{ nA}$          | $3.0\text{ nA}$          | $0.8\text{ nA}$          | $60\text{ pA}$           |
|                                       | Max. input current ( $\pm$ )                                                                                                                                                                                                                                                                                                                                                                                               | $10\text{ mA}$                                                                                                      | $1\text{ mA}$      | $0.1\text{ mA}$         | $10\text{ }\mu\text{A}$  | $1\text{ }\mu\text{A}$   | $0.1\text{ }\mu\text{A}$ |
|                                       | DC input impedance                                                                                                                                                                                                                                                                                                                                                                                                         | $50\text{ }\Omega$                                                                                                  | $50\text{ }\Omega$ | $60\text{ }\Omega$      | $100\text{ }\Omega$      | $1\text{ k}\Omega$       | $10\text{ k}\Omega$      |
|                                       | Gain setting (high speed) (V/A)                                                                                                                                                                                                                                                                                                                                                                                            | $10^3$                                                                                                              | $10^4$             | $10^5$                  | $10^6$                   | $10^7$                   | $10^8$                   |
|                                       | Upper cut-off frequency ( $-3\text{ dB}$ )                                                                                                                                                                                                                                                                                                                                                                                 | $175\text{ MHz}$                                                                                                    | $80\text{ MHz}$    | $14\text{ MHz}$         | $3.5\text{ MHz}$         | $1.8\text{ MHz}$         | $220\text{ kHz}$         |
|                                       | Rise/fall time ( $10\text{ }\%$ - $90\text{ }\%$ )                                                                                                                                                                                                                                                                                                                                                                         | $2.0\text{ ns}$                                                                                                     | $4.4\text{ ns}$    | $25\text{ ns}$          | $0.1\text{ }\mu\text{s}$ | $0.2\text{ }\mu\text{s}$ | $1.6\text{ }\mu\text{s}$ |
|                                       | Input noise current density ( $/\sqrt{\text{Hz}}$ )                                                                                                                                                                                                                                                                                                                                                                        | $155\text{ pA}$                                                                                                     | $5.8\text{ pA}$    | $1.5\text{ pA}$         | $440\text{ fA}$          | $140\text{ fA}$          | $45\text{ fA}$           |
|                                       | measured at                                                                                                                                                                                                                                                                                                                                                                                                                | $1\text{ MHz}$                                                                                                      | $1\text{ MHz}$     | $1\text{ MHz}$          | $10\text{ kHz}$          | $10\text{ kHz}$          | $10\text{ kHz}$          |
|                                       | Integr. input noise current (RMS)*                                                                                                                                                                                                                                                                                                                                                                                         | $1.9\text{ }\mu\text{A}$                                                                                            | $240\text{ nA}$    | $24\text{ nA}$          | $3.0\text{ nA}$          | $0.8\text{ nA}$          | $60\text{ pA}$           |
|                                       | Max. input current ( $\pm$ )                                                                                                                                                                                                                                                                                                                                                                                               | $1\text{ mA}$                                                                                                       | $0.1\text{ mA}$    | $10\text{ }\mu\text{A}$ | $1\text{ }\mu\text{A}$   | $0.1\text{ }\mu\text{A}$ | $10\text{ nA}$           |
|                                       | DC input impedance                                                                                                                                                                                                                                                                                                                                                                                                         | $50\text{ }\Omega$                                                                                                  | $50\text{ }\Omega$ | $60\text{ }\Omega$      | $100\text{ }\Omega$      | $1\text{ k}\Omega$       | $10\text{ k}\Omega$      |
|                                       | * The integrated input noise is measured with an open but shielded amplifier input in the full bandwidth ("FBW") setting. The measurement bandwidth is 3 x the upper cut-off frequency at the specific gain setting; filter slope is a 1st order roll-off.                                                                                                                                                                 |                                                                                                                     |                    |                         |                          |                          |                          |
|                                       | The peak-to-peak noise can be calculated from the RMS noise as follows:                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                     |                    |                         |                          |                          |                          |
|                                       | Input referred peak-to-peak noise:                                                                                                                                                                                                                                                                                                                                                                                         | $I_{pp} = I_{RMS} \times 6$                                                                                         |                    |                         |                          |                          |                          |
|                                       | Peak-to-peak output noise:                                                                                                                                                                                                                                                                                                                                                                                                 | $U_{pp} = I_{pp} \times \text{gain}$                                                                                |                    |                         |                          |                          |                          |
|                                       | Upper cut-off frequencies and equivalent input noise currents given in this table are typical values only which will depend on the source capacitance. Keep the source capacitance as low as possible by using short cables at the input to achieve best possible bandwidth and noise performance. For the dependence of the upper cut-off frequencies on the source capacitance please see the diagrams on the next page. |                                                                                                                     |                    |                         |                          |                          |                          |

# Variable Gain High-Speed Current Amplifier

Specifications (continued)

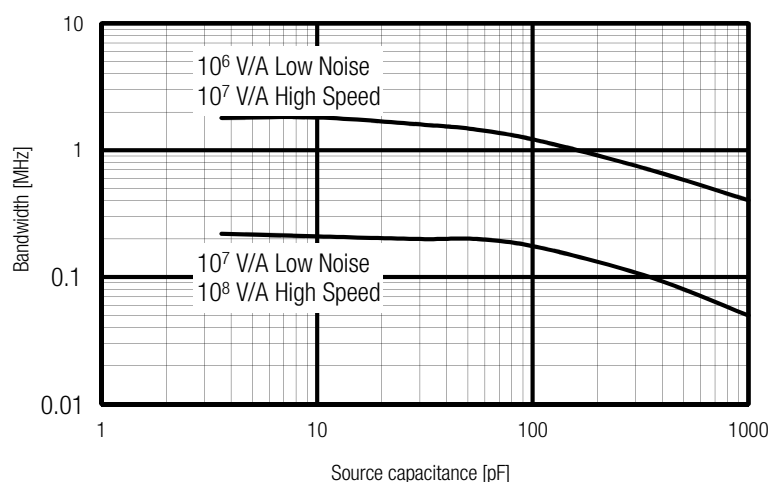
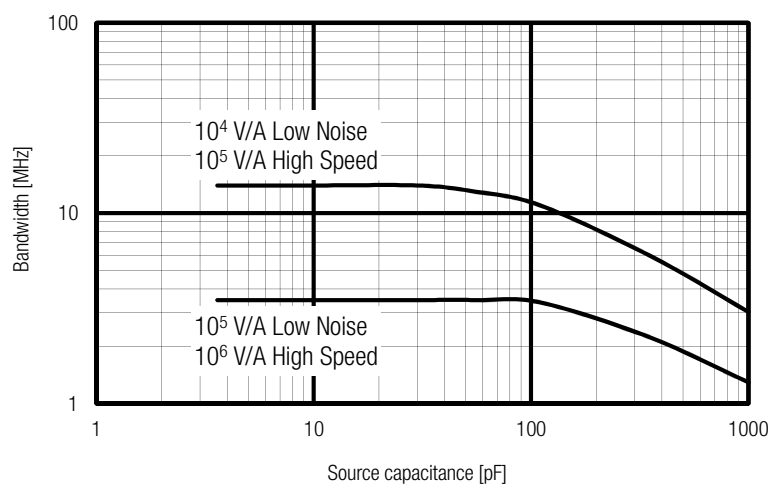
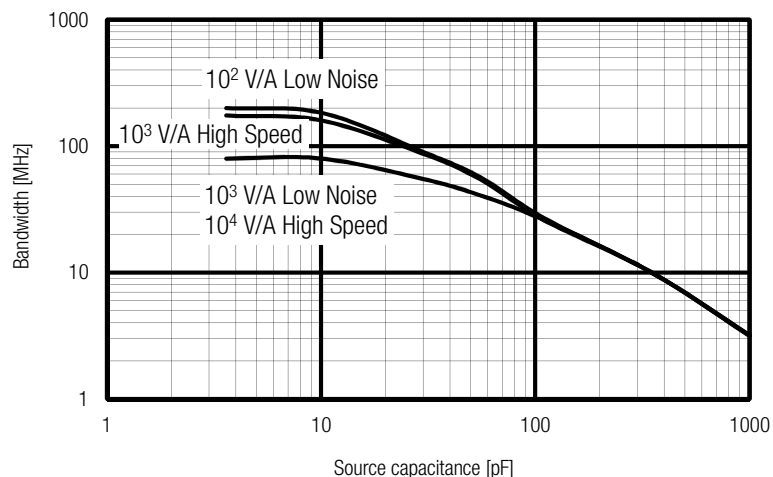
Frequency response plots



# Variable Gain High-Speed Current Amplifier

Specifications (continued)

Dependence of upper cut-off frequency on source capacitance

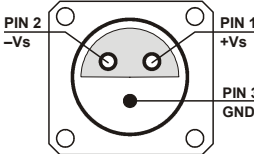


## Variable Gain High-Speed Current Amplifier

### Specifications (continued)

|                             |                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                               |
|-----------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| Output                      | Output voltage range<br>Output impedance<br>Slew rate<br>Max. output current<br>Output offset compensation | $\pm 1$ V (@ 50 $\Omega$ load), for linear amplification<br>50 $\Omega$ (designed for 50 $\Omega$ load)<br>1,000 V/ $\mu$ s<br>$\pm 40$ mA<br>adjustable by offset potentiometer and external control voltage, output offset compensation range min. $\pm 100$ mV                                                                                                                                                                  |                                                               |
| DC Monitor Output           | Monitor output gain                                                                                        | Mode                                                                                                                                                                                                                                                                                                                                                                                                                               | Monitor gain                                                  |
|                             |                                                                                                            | low noise<br>high speed                                                                                                                                                                                                                                                                                                                                                                                                            | gain setting divided by $-1$<br>gain setting divided by $-10$ |
|                             | Monitor output polarity                                                                                    | inverting                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                               |
|                             | Monitor output voltage range<br>Monitor output bandwidth<br>Monitor output impedance                       | $\pm 1$ V (@ $\geq 1$ M $\Omega$ load)<br>DC ... 1 kHz<br>1 k $\Omega$ (designed for $\geq 1$ M $\Omega$ load)                                                                                                                                                                                                                                                                                                                     |                                                               |
| Detector Bias               | Bias voltage range                                                                                         | $\pm 10$ V, max. 22 mA, connected to shield of BNC input socket, adjustable by potentiometer, switchable to GND                                                                                                                                                                                                                                                                                                                    |                                                               |
|                             | <b>Warning</b>                                                                                             | A bias current of 20 mA may destroy sensitive detectors. Please pay attention to the correct polarity and careful adjustment of the bias voltage to protect your detector. Put the bias switch to GND (ground) if you do not want to use the internal bias voltage. The positive and the negative supply voltage of the amplifier must be switched “on” and “off” simultaneously in order to avoid overvoltage at the bias output. |                                                               |
| Bias Voltage Monitor Output | Description                                                                                                | The signal at the bias voltage monitor output (pin 7 of the Sub-D control socket) is identical to the detector bias voltage present on the shield of the input BNC socket. By monitoring the signal on pin 7 the desired bias voltage can be adjusted through the bias potentiometer. Even if the bias switch is set to “GND”, the bias voltage can be monitored and set to the desired value.                                     |                                                               |
|                             | Monitor output polarity                                                                                    | non-inverting                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                               |
|                             | Monitor output voltage range<br>Monitor output impedance                                                   | $\pm 10$ V (@ $\geq 1$ M $\Omega$ load)<br>1 k $\Omega$ (designed for $\geq 1$ M $\Omega$ load)                                                                                                                                                                                                                                                                                                                                    |                                                               |
| Indicator LED               | Function                                                                                                   | overload                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                               |
| Digital Control             | Control input voltage range<br>Control input current<br>Overload output                                    | LOW bit: $-0.8$ V ... $+1.2$ V, HIGH bit: $+2.3$ V ... $+12$ V<br>0 mA @ 0 V, 1.5 mA @ $+5$ V, 4.5 mA @ $+12$ V<br>non active: $<0.4$ V @ 0 ... $-1$ mA<br>active: typ. 5 ... 5.1 V @ 0 ... 2 mA                                                                                                                                                                                                                                   |                                                               |
| Ext. Offset Control         | Control voltage range<br>Offset control input impedance                                                    | $\pm 10$ V<br>15 k $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                        |                                                               |
| Power Supply                | Supply voltage<br>Supply current                                                                           | $\pm 15$ V<br>typ. $+110$ / $-90$ mA (depends on operating conditions, recommended power supply capability min. $\pm 200$ mA)                                                                                                                                                                                                                                                                                                      |                                                               |
|                             | Stabilized power supply output                                                                             | $\pm 12$ V, max. 20 mA, $+5$ V, max. 50 mA                                                                                                                                                                                                                                                                                                                                                                                         |                                                               |

## Variable Gain High-Speed Current Amplifier

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Specifications (continued) | <div> <div>Case</div> <div>Weight</div> <div>Material</div> </div> <div> <div>320 g (0.74 lb.)</div> <div>AlMg4.5Mn, nickel-plated</div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Temperature Range          | <div> <div>Storage temperature</div> <div>Operating temperature</div> </div> <div> <div>−40 °C ... +100 °C</div> <div>0 °C ... +60 °C</div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Absolute Maximum Ratings   | <div> <div>Signal input voltage</div> <div>Transient input voltage</div> <div>Control input voltage</div> <div>Power supply voltage</div> </div> <div> <div>±5 V</div> <div>±1.5 kV (out of a 1 nF source)</div> <div>−5 V / +16 V</div> <div>±20 V</div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Connectors                 | <div> <div>Input</div> <div>Output</div> <div>Detector bias output</div> <div>Power supply</div> </div> <div> <div>BNC, isolated, jack (female)</div> <div>BNC, jack (female)</div> <div>shield of input BNC</div> <div> Lemo® series 1S, 3-pin fixed socket<br/> (mating plug type: FFA.1S.303.CLAC52)<br/> Pin 1: +15V<br/> Pin 2: −15V<br/> Pin 3: GND </div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                            | <div>Control port</div> <div> Sub-D 25-pin, female, qual. class 2<br/> Pin 1: +12 V (stabilized power supply output)<br/> Pin 2: −12 V (stabilized power supply output)<br/> Pin 3: AGND (analog ground)<br/> Pin 4: +5 V (stabilized power supply output)<br/> Pin 5: digital output: overload (referred to pin 3)<br/> Pin 6: DC monitor output<br/> Pin 7: bias monitor output<br/> Pin 8: output offset control voltage input<br/> Pin 9: DGND (ground for digital control pins 10 - 16)<br/> Pin 10: digital control input: gain, LSB<br/> Pin 11: digital control input: gain<br/> Pin 12: digital control input: gain, MSB<br/> Pin 13: digital control input: AC/DC<br/> Pin 14: digital control input: high speed / low noise<br/> Pin 15: upper cut-off frequency limit 10 MHz<br/> Pin 16: upper cut-off frequency limit 1 MHz<br/> Pin 17 - 25: NC </div> |

## Variable Gain High-Speed Current Amplifier

### Remote Control Operation

### General

Remote control input pins are opto-isolated and connected by a logical OR function to the local switch settings. For remote control set the corresponding local switches to "Remote", "DC", "L" (low noise mode) and "FBW", and select the desired setting via a bit code at the corresponding digital inputs.

Mixed operation, e.g. local AC/DC setting and remote controlled gain setting, is also possible.

Switch setting "Bias / GND" is not remote controllable.

### Gain setting

| low noise<br>Pin 14=LOW<br>gain (V/A) | high speed<br>Pin 14=HIGH<br>gain (V/A) | Pin 12<br>MSB | Pin 11 | Pin 10<br>LSB |
|---------------------------------------|-----------------------------------------|---------------|--------|---------------|
| $10^2$                                | $10^3$                                  | LOW           | LOW    | LOW           |
| $10^3$                                | $10^4$                                  | LOW           | LOW    | HIGH          |
| $10^4$                                | $10^5$                                  | LOW           | HIGH   | LOW           |
| $10^5$                                | $10^6$                                  | LOW           | HIGH   | HIGH          |
| $10^6$                                | $10^7$                                  | HIGH          | LOW    | LOW           |
| $10^7$                                | $10^8$                                  | HIGH          | LOW    | HIGH          |

### Gain settling time

<80 ms

### AC/DC setting

| coupling | Pin 13 |
|----------|--------|
| DC       | LOW    |
| AC       | HIGH   |

### Low pass filter setting

| upper cut-off frequ. limit | Pin 15 | Pin 16 |
|----------------------------|--------|--------|
| full bandwidth             | LOW    | LOW    |
| 10 MHz                     | HIGH   | LOW    |
| 1 MHz                      | LOW    | HIGH   |

### High speed / low noise setting

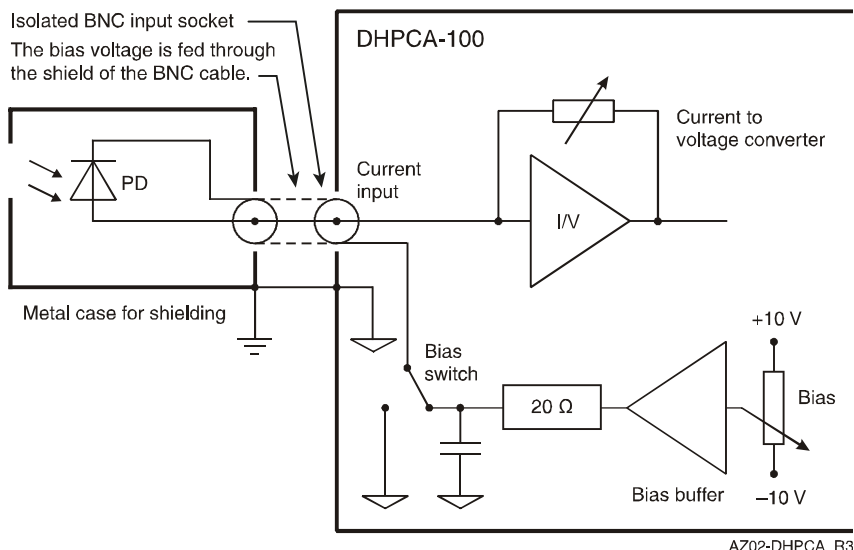
| mode            | Pin 14 |
|-----------------|--------|
| low noise mode  | LOW    |
| high speed mode | HIGH   |

# Variable Gain High-Speed Current Amplifier

## Application Diagrams

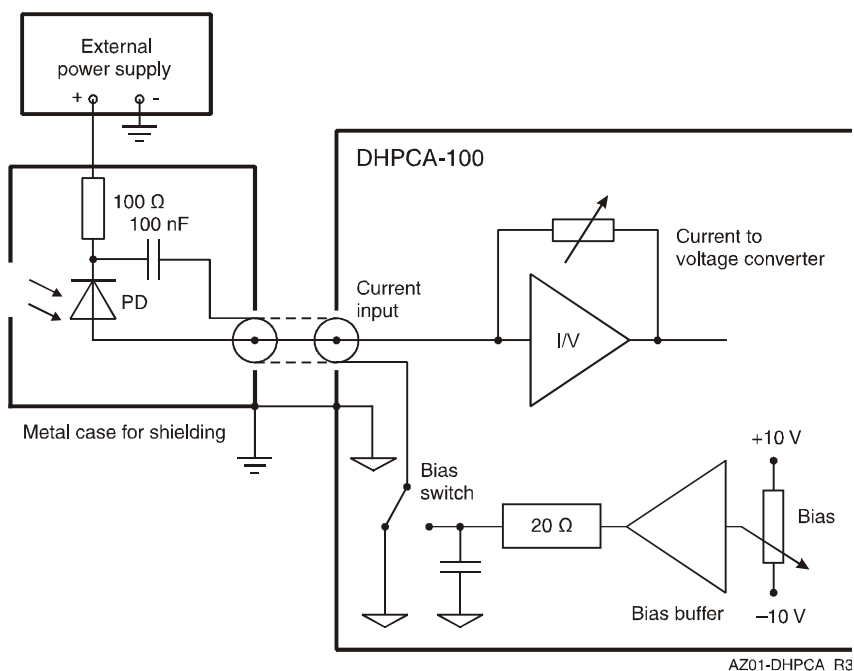
### Photo detector biasing through internal bias voltage source

Set bias switch to "Bias". The photodiode is biased through the amplifier with the bias voltage applied to the shield of the isolated BNC input socket. The photodiode should be mounted in a metal case. For optimum shielding the metal case has to be isolated from the photodiode but connected to the housing of the DHPCA-100.



### Photo detector biasing through external voltage source

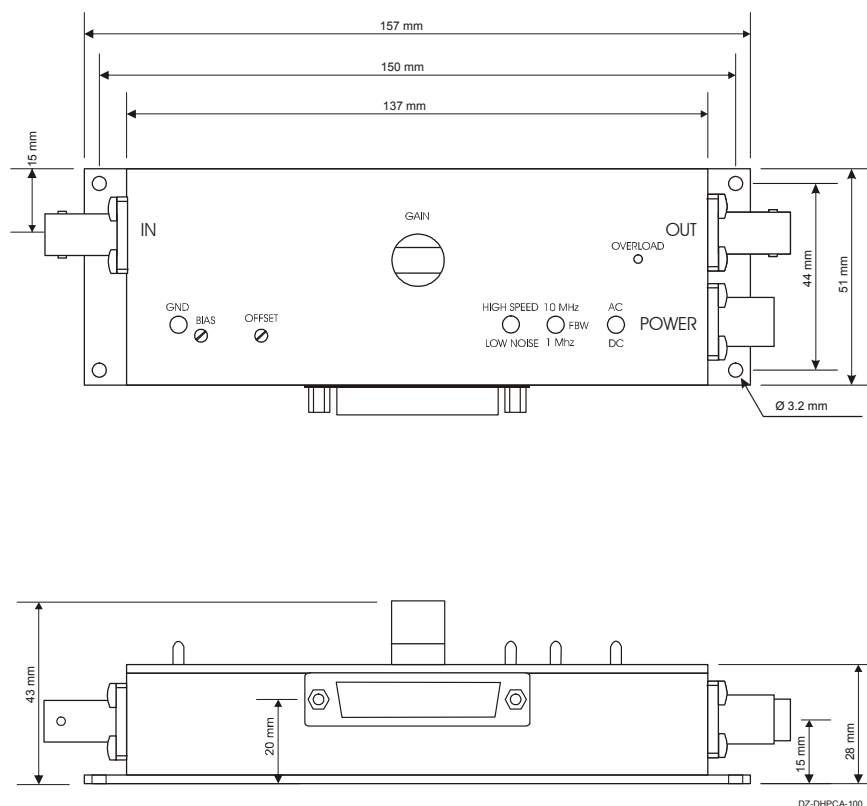
Set bias switch to "GND". The photodiode is biased through an external voltage source. The shield of the isolated BNC input socket is internally set to amplifier GND. The photodiode should be mounted in a metal case. For optimum shielding the metal case has to be isolated from the photodiode but connected to the housing of the DHPCA-100.





# Variable Gain High-Speed Current Amplifier

## Dimensions



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