

# OPERATING INSTRUCTIONS AND SYSTEM DESCRIPTION FOR THE

## ISO-STIM 01D

### STIMULUS ISOLATION UNIT

$\pm 100$  V /  $\pm 10$  mA, bipolar output



VERSION 3.2

npi 2010

npi electronic GmbH, Hauptstrasse 96, D-71732 Tamm, Germany  
Phone +49 (0)7141-9730230; Fax: +49 (0)7141-9730240  
support@npielectronic.com; <http://www.npielectronic.com>

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## 1. Safety Regulations

**VERY IMPORTANT: Instruments and components supplied by npí electronic are NOT intended for clinical use or medical purposes (e.g. for diagnosis or treatment of humans) or for any other life-supporting system. npí electronic disclaims any warranties for such purpose. Equipment supplied by npí electronic must be operated only by selected, trained and adequately instructed personnel. For details please consult the GENERAL TERMS OF DELIVERY AND CONDITIONS OF BUSINESS of npí electronic, D-71732 Tamm, Germany.**

- 1) **GENERAL:** This system is designed for use in scientific laboratories and must be operated by trained staff only. General safety regulations for operating electrical devices should be followed.
- 2) **AC MAINS CONNECTION:** While working with the npí systems, always adhere to the appropriate safety measures for handling electronic devices. Before using any device, please read manuals and instructions carefully.  
The device is to be operated only at 115/230 Volt 60/50 Hz AC. Please check for appropriate line voltage before connecting any system to mains.  
Always use a three-wire line cord and a mains power-plug with a protection contact connected to ground (protective earth).  
Before opening the cabinet, unplug the instrument.  
Unplug the instrument when replacing the fuse or changing line voltage. Replace fuse only with an appropriate specified type.
- 3) **STATIC ELECTRICITY:** Electronic equipment is sensitive to static discharges. Some devices such as sensor inputs are equipped with very sensitive FET amplifiers, which can be damaged by electrostatic charge and must therefore be handled with care. Electrostatic discharge can be avoided by touching a grounded metal surface when changing or adjusting sensors. **Always turn power off when adding or removing modules, connecting or disconnecting sensors, headstages or other components from the instrument or 19" cabinet.**
- 4) **TEMPERATURE DRIFT / WARM-UP TIME:** All analog electronic systems are sensitive to temperature changes. Therefore, all electronic instruments containing analog circuits should be used only in a warmed-up condition (i.e. after internal temperature has reached steady-state values). In most cases a warm-up period of 20-30 minutes is sufficient.
- 5) **HANDLING:** Please protect the device from moisture, heat, radiation and corrosive chemicals.
- 6) **POWER SUPPLY:** Do **not connect more than two** ISO STIM 01D to a single power supply. The power supplies are designed to work with maximal two stimulators. Use only the power supply shipped with the instrument.

## 2. Special Safety Notice for High Voltage Instruments



**HIGH VOLTAGE!!  
RISK OF ELECTROCUTION!!**

**Observe extreme caution when working with this instrument!!!**

- 1) Always connect high voltage power supplies to protective earth!!
- 2) Do not touch connections unless the instrument is turned off and the capacitance of both the load and power supply are earthed!!
- 3) Allow adequate time for discharge of internal capacitance of the power supply!!
- 4) Do not ground yourself or work under wet or damp conditions!!
- 5) Servicing should be only done by qualified personnel aware of the hazards!!
- 6) If in doubt, return to supplier for servicing!!

### 3. ISO-STIM 01D Stimulus Isolation Unit

#### 3.1. System Description

The ISO-STIM 01D stimulus isolation unit is designed for application of extracellular stimuli, e.g. in brain slices.

The output signal is optically isolated from ground and can either be a constant voltage up to  $\pm 100$  V or a constant current up to  $\pm 10$  mA. The ISO-STIM 01D has a build-in timing unit with adjustable pulse length, amplitude and polarity.

The ISO-STIM 01D has three modes of operation:

In the DIRECT input mode the output signal follows exactly the input signal.

In the GATE TTL input mode the output signal is generated by the build-in timing unit and triggered either by a TTL trigger at the GATE TTL connector or manually with the MANUAL TRIGGER switch.

In the ANALOG input mode the output signal follows – like in direct mode – the input signal but is triggered by the input signal itself and the duration of the output stimulus is set at the ISO-STIM 01D.

The ISO-STIM 01D has two LEDs to indicate if the amplifier is 10% below its positive or negative limit, and one LED to indicate the application of a voltage or current stimulus.

The stimulus output can be monopolar or bipolar selected by a switch.

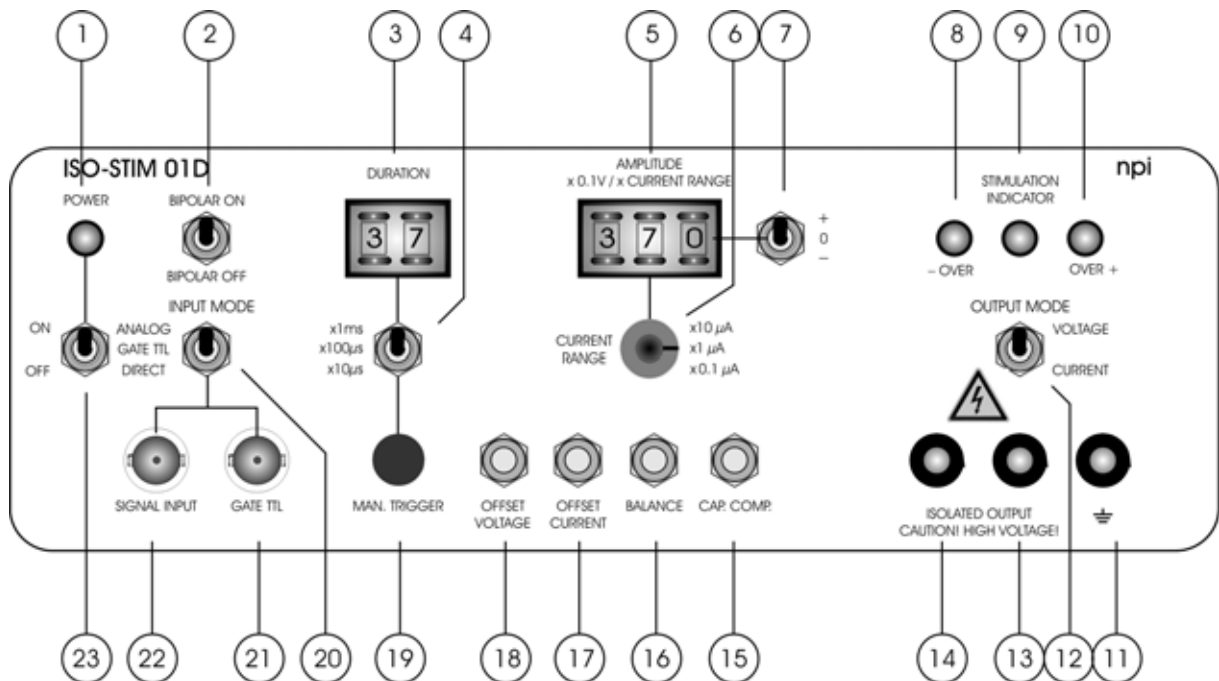


Figure 1: ISO-STIM 01D front panel view

### 3.2. Description of the Front Panel

(1) POWER LED



LED indicating that the ISO-STIM 01D is powered on

(2) BIPOLAR ON/ BIPOLAR OFF switch



Switch that selects the stimulus mode. Switching to BIPOLAR ON results in a stimulus with the same amplitude in positive and negative direction without any delay. Amplitude and duration settings are dependent on the mode of operation and/or the settings at the front panel or at the external stimulus generator

(3) DURATION potentiometer



Potentiometer that sets the duration of the stimulus (multiplied with the duration range factor) generated by the build-in timing unit (ANALOG INPUT MODE, GATE TTL MODE). The duration range factor is set by switch #4

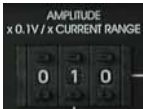
(4) DURATION range switch



Switch for setting the DURATION range factor (x10µs, x100µs, x1ms)

**Note:** Setting of 00 as duration is **not** defined and should **not** be set!!

(5) AMPLITUDE x0.1V / x CURRENT RANGE potentiometer



Potentiometer that sets the amplitude of the stimulus generated by the internal timing unit (GATE TTL MODE). In VOLTAGE output mode the setting is multiplied by 0.1 V. In CURRENT output mode the setting is multiplied by the setting of the CURRENT RANGE switch (#6). Switch #7 sets the polarity of the stimulus

(6) CURRENT RANGE switch



Switch for setting the CURRENT RANGE factor (x0.1 µA, x1 µA, x10 µA)

(7) +/- switch



Switch for setting the polarity of the stimulus. In "0" position the internal stimulus generation is disabled

**(8, 10) OVER LEDs**

LED indicating that the amplifier is 10% below its negative limit (limit is  $\pm 100\text{V}$  in VOLTAGE OUTPUT MODE). In CURRENT OUTPUT MODE the limit ( $\pm 100\text{ V}$ ) is set by the corresponding voltage at the electrode due to Ohm's Law [ $V = I \cdot R$ ], i.e. this control indicates during an experiment in CURRENT OUTPUT MODE that the electrode resistance increases and the amplifier is not be able to provide the current which is set if the electrode resistance increases further.

**(9) STIMULATION INDICATOR LED**

LED indicating the application of a voltage or current stimulus

**(11) Chassis connector**

Banana plug for connecting the chassis of the ISO-STIM 01D, e.g. to ground

**(12) OUTPUT MODE switch**

The output signal can be either a voltage (OUTPUT MODE switch set to VOLTAGE) or a current (OUTPUT MODE switch set to CURRENT). The polarity of the output signal is set by switch #7

***Important:*** If the CAP.COMP. (#15) is overcompensated in CURRENT MODE the stimulus isolator will ring and not work properly!

**(13, 14) OUTPUT plugs**

The ISOLATED OUTPUT signal is available at two plugs (red and black). The polarity of the input or the +,0,- switch respectively is not changed, i.e. the red plug is positive (+) if the output polarity switch is set to + or the analog input signal is positive. This signal is completely isolated from earth.

***Caution:*** These plugs can provide HIGH VOLTAGE !!!

**(15) CAP. COMP. trim pot**

The CAP.COMP. potentiometer compensates for the input capacitances in isolated CURRENT output operation only. Capacity compensation is achieved by turning the potentiometer with a small screw driver clockwise, until the current signal at the oscilloscope is as square as possible.

***Important:*** If the CAP.COMP. is overcompensated in CURRENT MODE the stimulus isolator will ring and not work properly!

**(16) BALANCE trim pots**

Trim-pot for setting the baseline of the stimulus pulse. Even if no stimulus is applied in DIRECT MODE or the stimulus AMPLITUDE is set to zero in GATE (TTL) MODE, the stimulus isolator may generate a stimulus pulse due to the properties of it's isolation amplifiers. Using this trim pot the stimulus output can be balanced to zero (see below).

**(17) OFFSET CURRENT trim pot**

Trim-pot to compensate for the CURRENT OFFSET of the stimulating electrode. It is recommended to compensate the offsets only in a completely warmed up condition i.e. after 30 minutes warm-up time (see below).

**(18) OFFSET VOLTAGE trim pot**

Trim-pot to compensate for the VOLTAGE OFFSET of the stimulating electrode. It is recommended to compensate the offsets only in a completely warmed up condition i.e. after 30 minutes warm-up time. Compensation procedure is the same for current and voltage in the respective stimulation mode (see below).

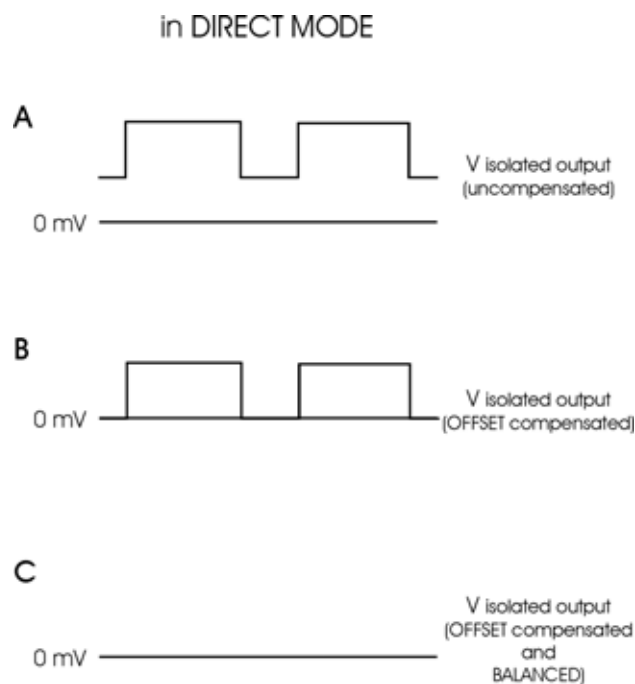


Figure 2: Compensation of the isolated stimulus output

Figure 2 shows how to compensate the stimulus output using OFFSET and BALANCE trim pots, here in DIRECT MODE. This procedure can also be done in GATE TTL mode. In both modes the stimulus AMPLITUDE has to be set to zero.

First, the voltage source OFFSET is compensated using the VOLTAGE OFFSET trim pot #18 (A). If the baseline is set, the isolation amplifiers may still produce a signal during stimulus application (B). This signal is balanced to zero using the BALANCE trim pot (C).

The same procedure is repeated for current source OFFSET if the ISO-STIM 01D is in CURRENT mode using the CURRENT OFFSET trim pot #17.

(19) MANUAL TRIGGER button



Button for triggering the ISO-STIM 01D manually

(20) INPUT MODE switch



Switch for selecting the INPUT MODE (see Chapter 4.3).

(21) GATE TTL connector



BNC connector for the input of a GATE signal in GATE TTL mode (see also Chapter 4.3)

(22) SIGNAL INPUT connector



BNC connector for the input of an analog signal in ANALOG or DIRECT mode (see also Chapter 4.3)

(23) ON / OFF switch



Switch to turn POWER of the ISO-STIM 01D ON or OFF, respectively

## 4. Operation

### 4.1. Connections – Noise Reduction

The ISO-STIM 01D comes with a power supply (13.8 V, DC) with two outputs which are connected to the stimulus isolation device by two cables with banana plugs. The corresponding jacks at the ISO-STIM 01D are located at the rear panel. The polarity doesn't matter. If you experience unusual high noise try to change the polarity, e.g. switch the banana plugs, or use the FILTERED/UNFILTERED switch (see also chapter 4.2).

***Important:*** In most cases the noise level is substantially reduced, if the black cable from the power supply is connected additionally to ground!!

***Note:*** You can use one power supply with maximal two ISO-STIM 01D! Use only the power supply shipped with the ISO-STIM 01D!

The stimulation electrode is connected to isolated output (see Figure 1). We recommend to use a bipolar electrode for stimulating nerve bundles. This will produce only a short stimulation artifact at the beginning.

***Remember:*** If unipolar electrodes are used the whole slice will be stimulated resulting in a DC shift of the whole slice.

#### **4.2. FILTERED/UNFILTERED switch (rear panel)**

There is a switch at the rear panel of the ISO-STIM 01D labeled ISOLATED OUTPUT GROUND. In most configurations of the setup switch to FILTERED can reduce the noise, but this depends on several factors, especially grounding of the whole setup. Therefore, it is unpredictable whether switching from UNFILTERED to FILTERED substantially improves the signal-to-noise ratio.

#### **4.3. Modes of Operation**

##### *GATE TTL INPUT MODE:*

In this mode the output signal is generated by the build-in timing unit. It is triggered either manually via the MANUAL TRIGGER switch or via a TTL pulse at the GATE TTL BNC connector. The duration of the pulse is set at the DURATION thumb wheel switch and the 3-position range switch below. The duration time is determined by reading of the thumb wheel switch multiplied by the factor set via the range switch. The minimum duration is 10  $\mu$ s, the maximum is 99 ms.

The amplitude of the pulse is set by the AMPLITUDE thumb wheel switch. The reading of this switch is multiplied by 0.1 V in VOLTAGE OUTPUT MODE. In CURRENT OUTPUT MODE the reading is multiplied by the factor set with the CURRENT RANGE switch. For example, 250 at the thumb wheel switch will give 25 V or 250  $\mu$ A (CURRENT RANGE switch in position x1  $\mu$ A) at the output plugs depending on the setting at the OUTPUT MODE switch. If the CURRENT RANGE switch is in position x10  $\mu$ A, 250 at the thumb wheel switch will give 2.5 mA at the output plugs.

##### *DIRECT INPUT MODE:*

The signal fed into the SIGNAL INPUT connector is transformed into the isolated output signal and amplified by a factor of ten (OUTPUT MODE: VOLTAGE), i.e. an input of 1 V will lead to an output stimulus of 10 V. In CURRENT OUTPUT MODE the amplitude of the output stimulus is again dependent on the setting the CURRENT RANGE switch. With the CURRENT RANGE switch in position x1  $\mu$ A, an input voltage of 1 V will result in an output stimulus of 100  $\mu$ A, and with the CURRENT RANGE switch in position x10  $\mu$ A the output current will be 1 mA.

The polarity switch must be in 0 position! The frequency of the input signal should not exceed 5 kHz.

***ANALOG INPUT MODE:***

The signal fed into the SIGNAL INPUT connector will be isolated from earth and amplified (OUTPUT MODE: voltage) as in the DIRECT INPUT MODE. The trigger level is set to 300 mV, i.e. the input signal must have an amplitude of 300 mV or more. If the trigger level is exceeded the input signal is transformed to the isolated output plugs, and the output stimulus follows the input signal as long as set by the DURATION thumb wheel.

Figure 3 gives some examples how the different input modes work.

**Please note that this figure does not show original recorded data. It's for illustration only**

***BIPOLAR***

The isolator is capable to generate biphasic stimuli by switching the stimulus mode switch to BIPOLAR ON. In this mode, the stimulus that is set by the user, will be followed by a second stimulus with the same amplitude and duration, but with reverse polarity. There is no delay between first and second part of the stimulus. For instance, if the user sets a positive stimulus of +1 V amplitude and 100  $\mu$ s duration, this stimulus will be followed immediately by a negative stimulus of -1 V and 100  $\mu$ s duration.

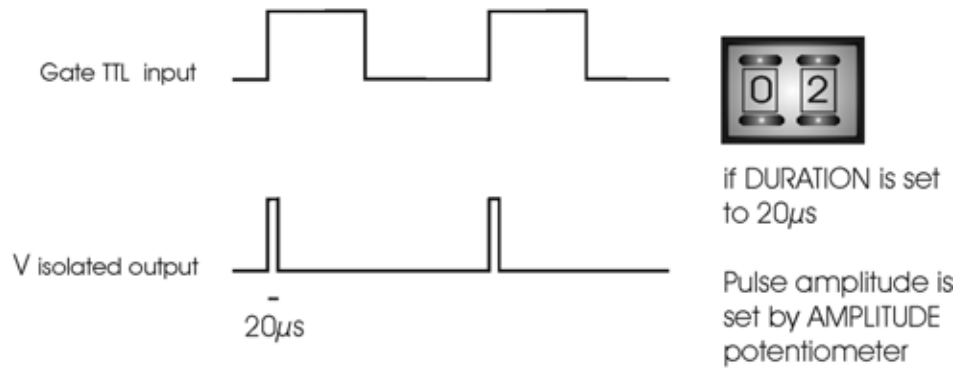
***OPERATION IN THE 10 mA (max.) RANGE***

According to Ohm's law, with 100 V voltage 10 mA current can be achieved **only** if the resistance of the stimulus electrode is not higher than 10 k $\Omega$ . Otherwise the current will be less.

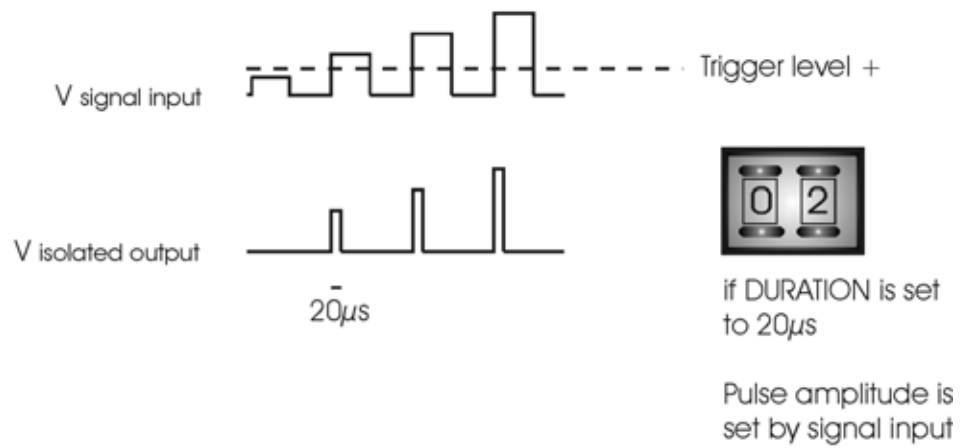
The output is short-circuit protected with a 1 k $\Omega$  resistor. This implicates that when using low resistance stimulation electrodes with high current flow, there is a voltage drop at this resistor.

**CAUTION:** This means that in voltage operation mode the output swing is reduced due to the voltage divider between the electrode resistance and the protection resistor.

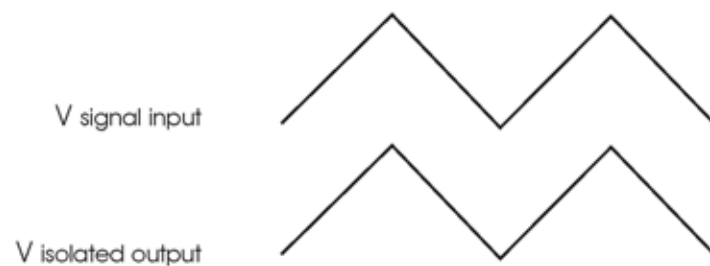
Gate TTL mode (input at GATE TTL BNC)



Analog input mode (input at SIGNAL INPUT BNC)



Direct mode (input at SIGNAL INPUT BNC)



amplification of the output signal is not shown

Figure 3: Modes of operation (illustration only)

## 5. Test Procedures

For the following test procedures a function generator is required. The frequency for testing should be around 100 Hz, waveform is triangle. The value of the test pulse amplitude is always described detailed in each of the following steps. In this test condition a load resistor of 100 k $\Omega$  is connected to the output plugs (red and black plugs).

### 5.1. *DIRECT mode*

*Settings:* INPUT MODE switch is in position DIRECT, OUTPUT MODE switch in position VOLTAGE. Analog input voltage from a function generator is  $\pm 2$  V and connected to the SIGNAL INPUT BNC. Max. output voltage has to be  $\pm 20$  V.

**Caution:** If you measure the output signal with an oscilloscope take care that the function generator has not the same ground connection because of the isolation of the output. It is important to realize that a connection is also possible through the protective ground connections between oscilloscope and function generator (most mains supplied oscilloscopes have a connection between ground and protective earth)! Thus, we recommend to use a battery driven oscilloscope for test measurements to avoid unwanted grounding!

Now the OUTPUT MODE switch is set in position CURRENT (CURRENT RANGE switch set to  $\times 1$   $\mu$ A) and the amplitude of the input signal is  $\pm 2$ V. The max. signal at the isolated output plugs has to be  $\pm 20$  V according to the current of  $\pm 200$   $\mu$ A flowing through the load resistance of 100 k $\Omega$ .

### 5.2. *TTL trigger mode*

*Settings:* INPUT MODE switch is in position GATE TTL, OUTPUT MODE switch in position VOLTAGE. The TTL output of the function generator has to be connected to the GATE TTL BNC, the SIGNAL INPUT BNC is not connected. The output voltage will be preset from the value dialed at the AMPLITUDE potentiometer and the polarity from the position of the corresponding toggle switch. Remember at any time Ohm's law to realize what potentials should be generated theoretically; the maximum output voltage of the system is  $\pm 100$ V.

### 5.3. *ANALOG trigger mode*

*Settings:* INPUT MODE switch is in position ANALOG TRIG, OUTPUT MODE switch in position VOLTAGE. Toggle switch for DURATION range in position 100  $\mu$ s, TIME potentiometer dialed on value 3. Input voltage from a function generator has to be positive referring to ground, value 5 V and connected to the ANALOG INPUT BNC. Output voltage will occur if the input voltage is higher than 300 mV (this is the internal analog trigger level) and only for the desired time (here 300  $\mu$ s). The output signal can be varied by using other input amplitude values and / or several time settings.

**Caution:** If you are working in CURRENT MODE realize that the input resistance of an oscilloscope is normally 1 M $\Omega$ , e.g. an oscilloscope connected to the outputs is a 1 M $\Omega$  load for the current source producing an output signal that is measured.

## 6. Technical Data

|                          |  |
|--------------------------|--|
| Input operating modes:   | DIRECT, ANALOG TRIGGER, TTL TRIGGER<br>selectable with toggle switch   |
| Function modes:          | voltage source, current source<br>selectable with toggle switch  |
| Source ranges:           | $\pm 100 \mu\text{A}$ , $\pm 1 \text{ mA}$ , $\pm 10 \text{ mA}$ (current source), selectable with 3-<br>position rotary switch<br>$\pm 100 \text{ V}$ (voltage source)                |
| Time range factor:       | $\times 10 \mu\text{s}$ , $\times 100 \mu\text{s}$ , $\times 1 \text{ ms}$<br>selectable with toggle switch, time range up to 99 ms  |
| Amplitude potentiometer: | 3 digits, $\pm 10 \text{ V}$ , amplified internally with gain of 10 (voltage<br>source) or scaled with source range switch (current source);<br>polarity selectable with toggle switch |
| Time potentiometer:      | 2 digits, 0 – 99 as multiplication factor selectable   |
| Input voltage range:     | $\pm 10 \text{ V}$ , amplified internally with gain of 10  |
| Input impedance:         | 10 k $\Omega$  |
| Output:                  | monopolar or bipolar, selected by toggle switch  |
| Output voltage:          | $\pm 100 \text{ V}$ max., isolated   |
| Output current:          | $\pm 10 \text{ mA}$ max., isolated   |
| Dimensions:              | 245 x 260 x 90 mm  |