Electronic Instruments for the Life Sciences

made to measure

OPERATING INSTRUCTIONS AND SYSTEM DESCRIPTION FOR THE

ISO-STIM-II

STIMULUS ISOLATION UNIT

±100 V / ±10 mA, bipolar output

VERSION 1.1
npi 2022

npi electronic GmbH, Bauhofring 16, D-71732 Tamm, Germany
Phone +49 (0)7141-9730230; Fax: +49 (0)7141-9730240
support@npielectronic.com; http://www.npielectronic.com

Table of Contents

1. Safety Regulations

VERY IMPORTANT: **Instruments and components supplied by npi 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. npi electronic disclaims any warranties for such purpose. Equipment supplied by npi 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 npi 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 npi 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 one** ISO-STIM-II to a single power supply. The power supplies are designed to work with one stimulator only. 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-II Stimulus Isolation Unit

3.1. System Description

The ISO-STIM-II stimulus isolation unit is designed for application of extracellular stimuli, e.g., in brain slices. The stimulator is modular, i.e., not all options have to be purchased or must be installed. The following description applies to the version with all options.

The output signal is optically isolated from ground. It is a constant current with up to ±10 mA (voltage output option is not installed in this system). The ISO-STIM-II has a built-in timing unit with adjustable pulse length, amplitude and polarity.

The ISO-STIM-II has three modes of operation:

- In the **TIMED** input mode, the output signal is generated by the built-in timing unit and triggered either by a TTL trigger at the INPUT connector or manually with the MANUAL pushbutton.
- In the **GATED** input mode, the output signal is generated only while the INPUT connector receives a TTL HIGH input signal.
- In the **DIRECT** input mode, the output signal follows exactly the input signal with the selected scaling (not installed in this system).
- In the **TIMED DIRECT** 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-II (not installed in this system).

The ISO-STIM-II 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.

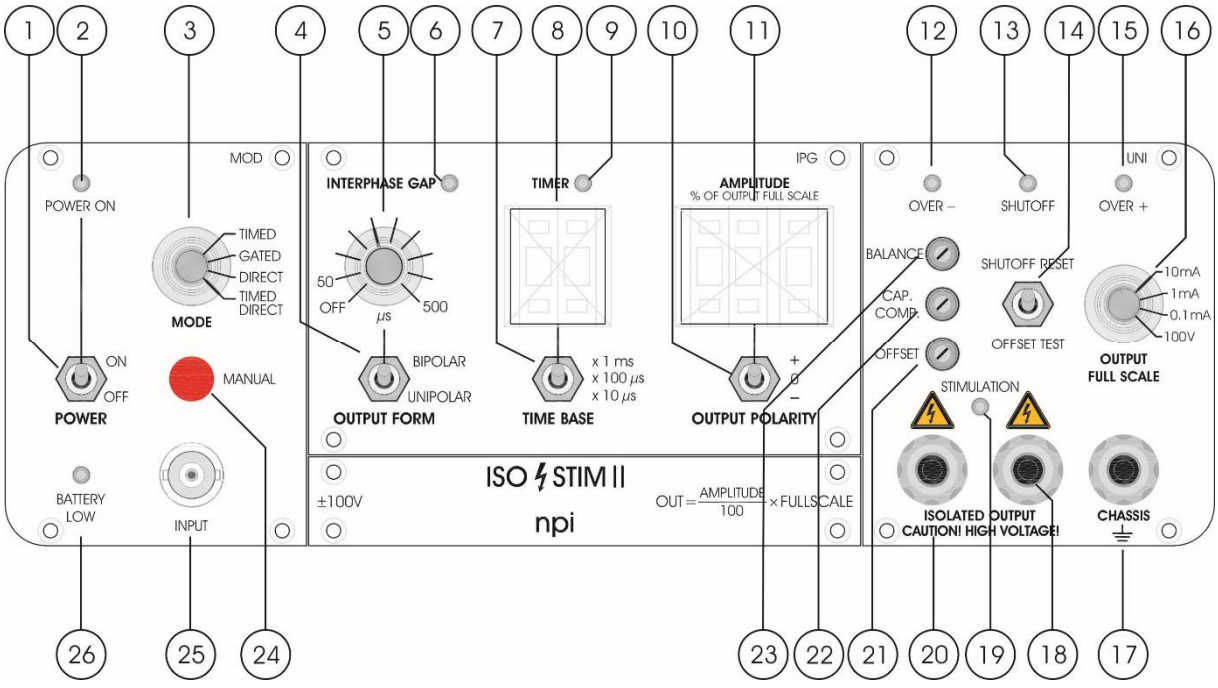


Figure 1: ISO-STIM-II front panel view

3.2. Description of the Front Panel

In the following description of the front panel elements each element has a number (in bold) that is related to that in Figure 1. The number is followed by the name (in uppercase letters) written on the front panel and the type of the element (in lowercase letters). Then, a short description of the element is given.

(1) POWER switch

Switch to power the ISO-STIM-II on or off.

(2) POWER ON LED

LED indicating that the ISO-STIM-II is powered on

(3) MODE switch

Switch for selecting the INPUT MODE (see Chapter 4.1).
(In this system, the MODE switch only has two positions: GATED and TIMED).

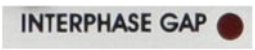
(4) BIPOLAR / UNIPOLAR switch

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
BIPOLAR stimulus mode is only functional in TIMED or GATED mode.

(5) INTERPHASE GAP potentiometer

Potentiometer to select the interphase gap time (IPG) in bipolar stimulation mode (see 4.2). IPG is turned off in the leftmost position (switch).

(6) INTERPHASE GAP LED



LED indicating that the INTERPHASE GAP can be used in the current operation mode.

(7) TIME BASE switch

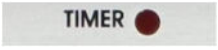
Switch for setting the TIME BASE factor (x10 µs, x 100µs, x1 ms) for the TIMER potentiometer (**#8**).

(8) TIMER digital potentiometer

Potentiometer that sets the duration of the stimulus generated by the built-in timing unit (TIMED mode and TIMED DIRECT mode).
The set time is determined by the value of this potentiometer multiplied by the factor set via TIME BASE switch (**#7**). The minimum duration is 10 µs, the maximum is 99 ms.

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

(9) TIMER LED

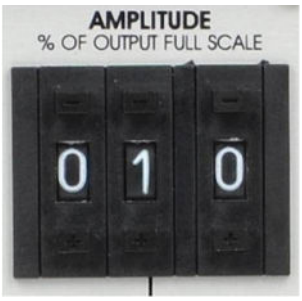


LED indicating that the TIMER can be used in the current operation mode.

(10) OUTPUT POLARITY switch

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

(11) AMPLITUDE digital potentiometer



Potentiometer that sets the amplitude of the stimulus generated by the internal timing unit (TIMED mode or GATED mode).
The potentiometer sets the output as percentage (XX.X%) of the OUTPUT FULL SCALE (**#16**), e.g. OUTPUT FULL SCALE set to 1 mA, AMPLITUDE set to 50.0 results in an output of 0.5 mA.
Polarity is defined by switch **#10**.

(12) OVER – LED

LED indicating that the amplifier is 10% below its negative limit (limit is ±100 V in VOLTAGE OUTPUT MODE). In CURRENT OUTPUT MODE the limit (±100 V) is set by the corresponding voltage at the electrode due to Ohm's Law [V = I*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. In this mode the LEDs have white color indication.
The OVER LEDs are also used in OFFSET TEST mode (see chapter 4.4). Here the LEDs have red color indication.

(13) SHUTOFF LED

LED indicating that the amplifier is in SHUTOFF. All outputs are disabled in this state.

For detailed information on SHUTOFF function see chapter 4.4.

(14) SHUTOFF RESET / OFFSET TEST switch

This switch has a pushbutton function in upper position to reset the stimulator if the SHUTOFF has been activated (see chapter 4.4).

In lower position the stimulator goes in OFFSET TEST mode. This is a simple way of adjusting large offsets without the need for an oscilloscope (see chapter 4.5).

(15) OVER + LED

See **#12.**
The OVER LEDs are also used in OFFSET TEST mode (see chapter 4.4).

(16) OUTPUT FULL SCALE switch

Switch for setting the FULL SCALE of the output. Total output is the product of the setting of this switch and the percentage set at the AMPLITUDE potentiometer (**#11**).

(17) CHASSIS connector

Jack linked to the CHASSIS. The green banana connector of the ISO-CAB-D cable is connected here.

(18) – ISOLATED OUTPUT connector

The ISOLATED OUTPUT signal is available at two plugs (red and black). The polarity of the input or the OUTPUT POLARITY 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/ground. The black jack serves as reference point for the isolated output signal. The black banana connector of the ISO-CAB-D cable is connected here.

Caution: THIS INSTRUMENT HAS A HIGH VOLTAGE OUTPUT (UP TO ±100 V)!!! Do not touch these pins or bare wires connected to these pins. Always turn power off if you manipulate devices connected to these pins.

(19) STIMULATION LED

LED indicating the application of a current stimulus. Independent of the stimulus length the LED lights up for 40 ms at the beginning of each pulse.

(20) + ISOLATED OUTPUT connector

See **#18**. The red banana connector of the ISO-CAB-D cable is connected here.

Caution: THIS INSTRUMENT HAS A HIGH VOLTAGE OUTPUT (UP TO ±100 V)!!! Do not touch these pins or bare wires connected to these pins. Always turn power off if you manipulate devices connected to these pins.

***Note*:** To adjust the trim potentiometers mentioned below, best use a small flat screwdriver (1.5 - 2 mm).

(21) OFFSET potentiometer

Trim-pot to compensate for the OFFSET of the stimulating electrode in TIMED or GATED mode. It is recommended to compensate the offsets only in a completely warmed up condition i.e. after 30 minutes warm-up time.

(22) CAP. COMP. potentiometer

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 screwdriver 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 generate huge artefacts is therefore not working properly!

(23) BALANCE potentiometer (**not installed in this system)**

Trim-pot for compensating for baseline differences of the stimulus when switching from DIRECT to GATE TTL mode or vice versa. Even if no stimulus is applied in DIRECT MODE or ANALOG MODE, the baseline of the stimulus isolator may not be zero. Using this trim-pot the stimulus output can be balanced to zero (see below).
(Not installed in this system)

***Note*:** For further details on OFFSET, BALANCE or CAP.COMP adjustment see Chapter 4.4

(24) MANUAL pushbutton

Button for triggering the ISO-STIM-II manually. This works in TIMED mode only.

(25) INPUT connector

BNC connector for the input of a GATE signal in GATE TTL mode (see also Chapter 4.1)
BNC connector for the input of an analog signal in ANALOG or DIRECT mode (see also Chapter 4.1)

(26) BATTERY LOW LED

For protection of the battery, the ISO-STIM-II has a special circuitry built-in: whenever the battery reaches a certain low threshold voltage (10% above absolute minimum), the BATTERY LOW LED will light up in red. At 1% above absolute minimum, the LED will start flashing and shortly after this. Now at the latest the ISO-STIM-II must be switched off.

Important: Deep discharge of the battery threatens if the ISO-STIM II is not switched off when the LED starts flashing!!

Note: The BATTERY LOW LED is functional only if the ISO-STIM II is operated with batteries.

The type of battery can be selected with a rotary switch from the rear panel of the ISO-STIM-II and the threshold voltage will be set accordingly.

(Not installed in this system)

3.3. Description of the Rear Panel

Figure 2 shows the rear panel of the ISO-STIM-II. The rear panel elements are described below.

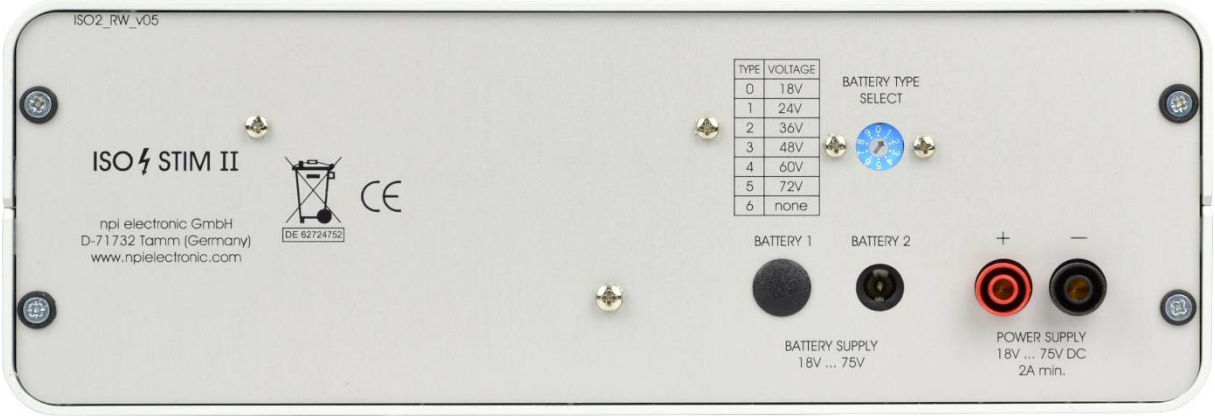
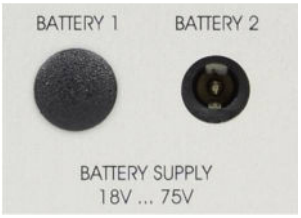


Figure 2: ISO-STIM-II rear panel view

POWER SUPPLY connector

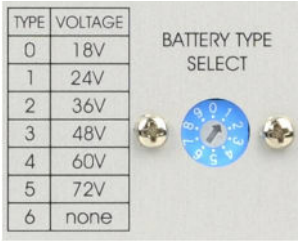
The power supply that has been delivered with the ISO-STIM-II is connected here.

BATTERY 1 (or 2) connector



These connectors can be used to connect the rechargeable battery (available as option). Please contact npi for further information.
In order to provide continuous supply power, batteries can be exchanged by hot swap: first, connect the new battery, then disconnect the old battery.

BATTERY TYPE SELECT rotary switch



This rotary switch is used to select the voltage of the battery in use. This has an effect only on the BATTERY LOW LED (**#26** front panel) and the automatic shutoff.

(Not installed in this system)

4. Operation

4.1. Modes of Operation

All modes of operation are shown as example graphics in Figure 3.

TIMED MODE:

In this mode the output signal is generated by the built-in timing unit. It is triggered either manually via the MANUAL pushbutton switch or via a TTL pulse at the INPUT BNC connector. The duration of the pulse is set at the DURATION potentiometer and the 3-position TIME BASE switch below. The duration time is determined by the value of the potentiometer multiplied by the factor set via the range switch. The minimum duration is 10 µs, the maximum is 99 ms.
The amplitude of the pulse is set by the AMPLITUDE potentiometer. The reading of this switch is always in XX.X% of the OUTPUT FULL SCALE switch.
For example, 25.0 at the AMPLITUDE potentiometer and 100 V at the OUTPUT FULL SCALE switch will give 25 V at the output plugs, for 0.1 mA at the OUTPUT FULL SCALE switch this will give 25 µA.

GATED MODE:

In this mode the output signal is generated only while the INPUT connector receives a TTL HIGH input signal. The amplitude of the pulse is set by the AMPLITUDE potentiometer (see above).

DIRECT MODE (not installed in this system):

The signal fed into the SIGNAL INPUT connector is transformed into the isolated output signal and scaled as specified in Table 1below.

Table 1: Output scaling in DIRECT mode

OUTPUT FULL SCALE	Scaling	example (@ 8 V input)
10 mA	1 mA/V	8 mA
1 mA	0.1 mA/V	800 µA
0.1 mA	10 µA/V	80 µA

TIMED DIRECT MODE (not installed in this system):

The signal fed into the INPUT connector will be isolated from earth and amplified (OUTPUT MODE: voltage) as in the DIRECT 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 TIMER. Scaling is as described in Table 1above.

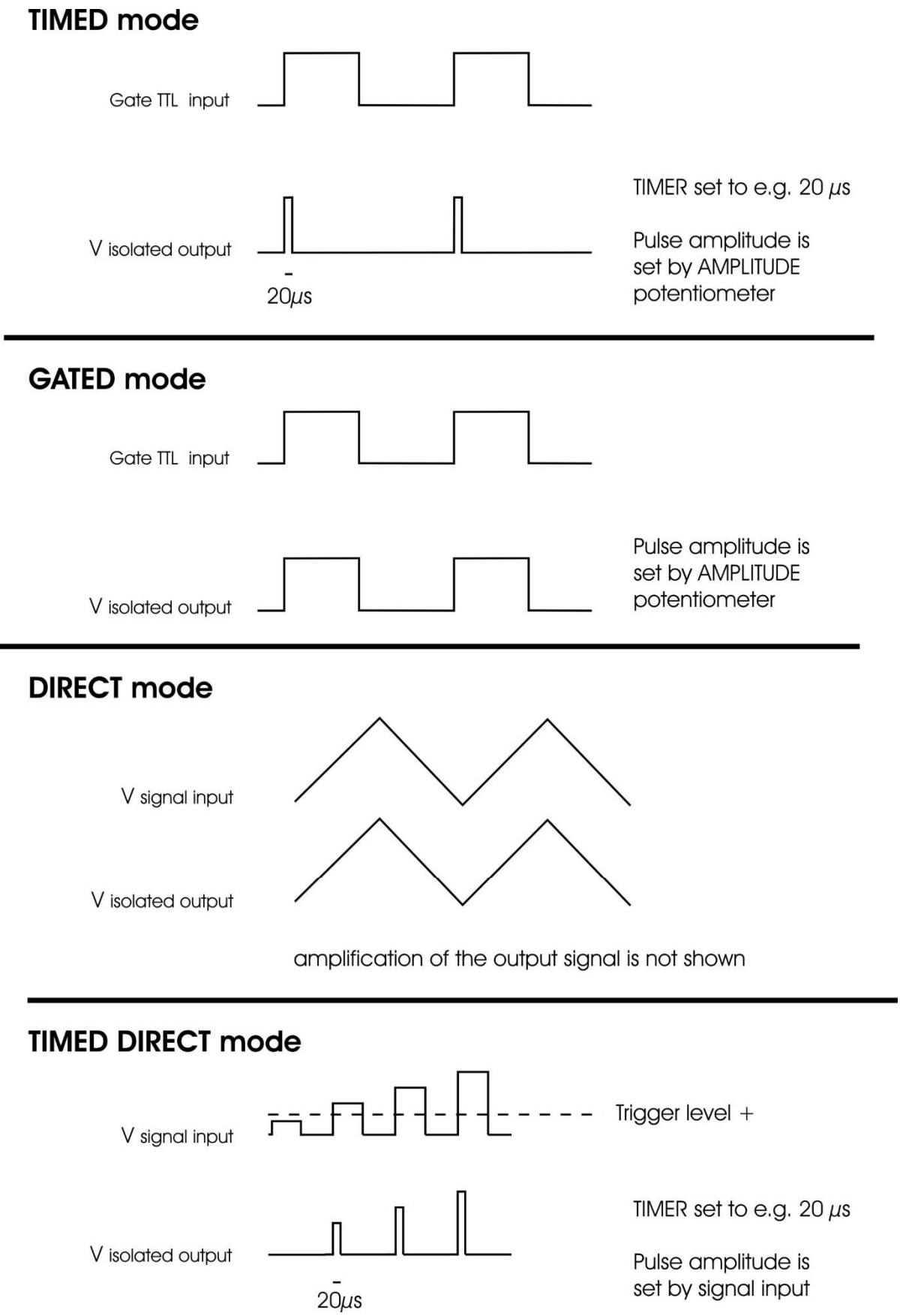


Figure 3: Modes of operation (illustration only)

4.2. BIPOLAR (only functional in TIMED or GATED mode)

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 (except IPG is active, see below). For instance, if the user sets a positive stimulus of +1 V amplitude and 100 µs duration, this stimulus will be followed immediately by a negative stimulus of –1 V and 100 µs duration.

BIPOLAR with IPG:

In bipolar mode, a delay between the first and the second, inverse stimulus can be inserted, the interphase gap (IPG, see Figure 3; IPG time is set by INTERPHASE GAP potentiometer (#**5**)

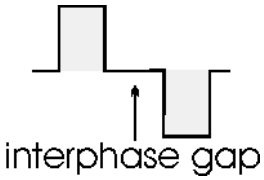


Figure 4: Interphase gap (IPG)

4.3. 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 kΩ. Otherwise, the current will be less.

The output is short-circuit protected, the current is limited internally to 25 mA.

4.4. SHUTOFF

Automatic SHUTOFF is activated in CURRENT output mode by the ISO-STIM-II in two ways:

The output voltage exceeds a certain limit (82 V):

> If the resistance of the stimulation electrode increases over time (or is accidentally disconnected), the stimulator must increase the output voltage to maintain the set current.
> This will only work as long as the output voltage is below the maximum possible output voltage (100 V). To minimize risk of damage to the tissue or electrode, the ISO-STIM-II will go into shutoff and the SHUTOFF LED (**#13**) will light up.

An output current is generated although there is no command signal:

> This may happen if the OFFSET and/or the BALANCE is not correctly adjusted. To avoid accidental stimulation or damage to the tissue, the ISO-STIM-II will go into shutoff and the SHUTOFF LED (**#13**) will light up.

The ISO-STIM-II can be reset from SHUTOFF by using the SHUTOFF RESET switch (**#14**). Before doing so, the issue that causes the SHUTOFF has to be eliminated (see above or chapter 4.5)

***Note*:** The whole SHUTOFF function can be deactivated by setting a jumper inside the ISO-STIM-II housing. Please ask npi electronic for further information.

4.5. OFFSET/BALANCE adjustment

Coarse offset adjustment using the OFFSET TEST

- Switch ISO-STIM-II to OFFSET TEST mode (**#14**). This will disconnect the high voltage outputs and internally connect a 100 kΩ resistor instead.
- The OVER LEDs (**#12** and **#15**) will indicate whether the output has an offset in the positive (**#15** lights up) or negative range (**#12** lights up).
- The offset can be adjusted with the OFFSET trim potentiometer (**#21**) using a small screwdriver, until both OVER LEDs are off.

Fine OFFSET adjustment

- Connect an oscilloscope to the HIGH VOLTAGE OUTPUTS (**#18** and **#20**) of the ISO-STIM-II.
- Set the MODE switch (**#3**) to TIMED or GATED.
- Set the AMPLITUDE to 0 using the OUTPUT POLARITY switch (**#10**).
- The output should now read "0" at the oscilloscope. Use a small screwdriver at the OFFSET trim potentiometer (**#21**) to adjust this if necessary.

***Note*:** OFFSET might have to be re-adjusted when changing the OUTPUT FULL SCALE settings.

*Balance adjustment **(not installed in this system)***

- Make sure that the OFFSET has been correctly adjusted (see above).
- Keep the oscilloscope connected to the HIGH VOLTAGE OUTPUTS (**#18** and **#20**).
- Set the MODE switch (**#3**) to DIRECT mode.
- Disconnect any input from the INPUT BNC (**#25**).
- The output should now read "0" at the oscilloscope. Use a small screwdriver at the BALANCE trim potentiometer (**#23**) to adjust this if necessary.

***Note*:** BALANCE might have to be re-adjusted when changing the OUTPUT FULL SCALE settings.

4.6. Capacity Compensation adjustment

During application of fast current pulses, the electric capacity of the electrode and the connection cable will form a low pass filter together with the electrode resistance which will result in a rounded signal. This capacity can be compensated with the CAP.COMP. potentiometer (**#22**).
To do this, connect an oscilloscope to the isolated outputs while the electrode and the connection cable are connected. Apply a series of square pulses to the electrode and observe the shape of the signal with the oscilloscope. Start from the leftmost position and increase the setting, until the signal appears as square shaped as possible. Be careful not to overcompensate, as the output will then have the tendency to ring (oscillate).

***Note*:** Setting the capacity compensation can be trained without an electrode when using the model cell (ISO.MOD). See also user manual of the model cell, chapter 3.

4.7. ISO-CAB-D (optional accessory)

npi provides an optional shielded cable for connection of stimulation electrodes. One end is equipped with three color coded 4 mm connectors. The red and black connector are connected to the ISOLATED OUTPUT connectors on the front panel of the ISO-STIM-II. Each of these stimulation lines has a shield which is connected to the common green SHIELD connector. To reduce noise during recordings, this connector can be connected to the CHASSIS connector at the ISO-STIM-II front panel

The other end of the cable provides open wires, to which different connector types can be soldered by the user. The red cable is +STIM, the yellow cable is –STIM. The shield is present as bare wire. Usually, these shield wires are left unconnected on this end of the cable.

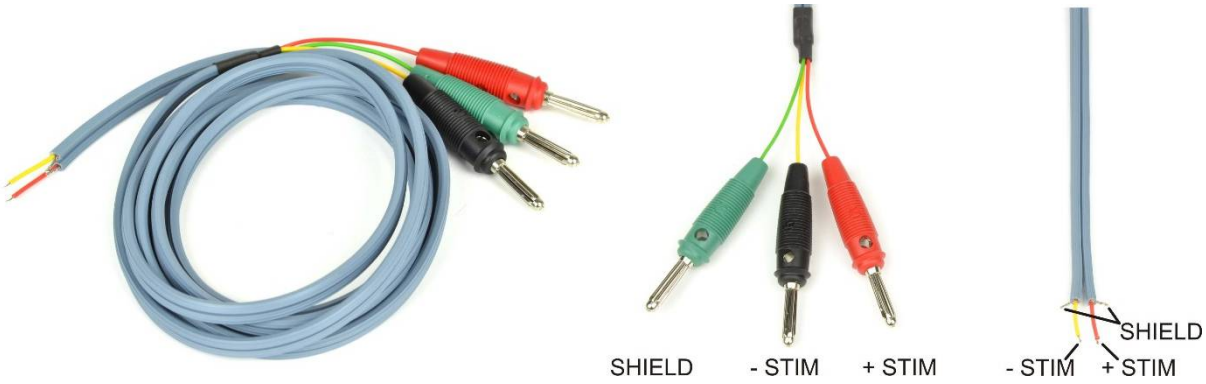


Figure 5: ISO-CAB - shielded cable for connection of stimulation electrodes.

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 in detail for each of the following steps. In this test condition a load resistor of 100 kΩ is connected to the output plugs (red and black plugs).

5.1. TIMED MODE and GATED MODE

Settings: MODE switch is in position TIMED (or GATED), OUTPUT FULL SCALE switch in position 1 mA. The TTL output of the function generator must be connected to the INPUT BNC. 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 ±100 V.

5.2. DIRECT INPUT MODE

Settings: MODE switch is in position DIRECT, OUTPUT FULL SCALE switch in position 1 mA. Analog input voltage from a function generator is ±2 V and connected to the INPUT BNC. Max. output current must be ±0.2 mA.

***Caution**:* If you measure the output signal with an oscilloscope make sure 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 using a battery driven oscilloscope for test measurements to avoid unwanted grounding!

Now the OUTPUT FULL SCALE switch is set in position 1 mA and the amplitude of the input signal is still ±2 V. The max. signal at the isolated output plugs must be ±20 V according to the current of ±200 µA flowing through the load resistance of 100 kΩ.

$$U = R * I = 100\ k\Omega * 200\ \mu A = 20\ V$$

5.3. TIMED DIRECT MODE

Settings: MODE switch is in position TIMED DIRECT, OUTPUT MODE switch in position VOLTAGE. Toggle switch for TIME BASE in position 100 µs, TIMER potentiometer dialed on value "03". Input voltage from a function generator must be positive referring to ground, value 5 V and connected to the 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 µs). The output signal can be varied by using other input amplitude values and / or several time settings.

***Caution**:* If you are working in current output mode (OUTPUT FULL SCALE to 10 mA, 1 mA or 0.1 mA) realize that the input resistance of an oscilloscope is normally 1 MΩ, e.g., an oscilloscope connected to the outputs is a 1 MΩ load for the current source producing an output signal that is measured.

***Note**:* We recommend to use the model cell ISO-MOD! Please see also user manual of the model cell.

6. Technical Data

Input (operation) modes:	TIMED, GATED (DIRECT and TIMED DIRECT not installed in this system) selectable with toggle switch
Output modes:	current source range selectable with 3-position switch
Source ranges:	±100 µA, ±1 mA, ±10 mA (current source) or ±100 V (voltage source), selectable with 4-position rotary switch
Amplitude potentiometer:	3 digits, XX.X% of the OUTPUT FULL SCALE; polarity selectable with toggle switch
Time base factor:	x10 µs, x100 µs, x1 ms selectable with toggle switch, time range up to 99 ms
Timer potentiometer:	2 digits, 0 – 99 as multiplication factor selectable
Input voltage range:	±10 V
Input impedance:	10 kΩ
Output:	monopolar or bipolar, selected by toggle switch
Output current:	±10 mA max., isolated (max. 100 V)
Output Impedance:	< 50 Ω
Dimensions:	245 x 260 x 90 mm^3