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# Sensors and Utilities

## ***Instructions for use V1.14.00***

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## Table of Contents

<b>1</b>	<b>Welcome .....</b>	<b>3</b>
1.1	How to contact g.tec.....	3
1.2	About this document .....	4
1.3	Important information for using a sensor or utility.....	4
1.4	Cleaning and storage of sensors and utilities .....	4
1.5	Connecting sensors to amplifier inputs .....	4
<b>2</b>	<b>Sensors .....</b>	<b>8</b>
2.1	g.PULSEsensor .....	8
2.2	g.TEMPsensor .....	9
2.3	g.GSRsensor.....	10
2.4	g.Gsensor.....	11
2.5	Respiration Airflow Sensor.....	12
2.6	Respiration Effort Sensor.....	13
2.7	g.SNORINGSensor.....	14
2.8	g.LIMBSensor .....	15
2.9	g.SpO2sensor .....	16
2.10	g.CNAPadapter .....	17
<b>3</b>	<b>Utilities.....</b>	<b>18</b>
3.1	g.SIGgen .....	18
3.2	g.Zcheck.....	19
3.3	g.TRIGbox.....	20
3.4	Trigger cables .....	22
3.4.1	Trigger cable for g.USBamp to be used with g.TRIGbox.....	22
3.4.2	Trigger cable to be used with E-Prime or Presentation stimulation software .....	22

# 1 Welcome

## 1.1 How to contact g.tec:



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## 1.2 About this document

g.tec provides utilities and various sensors for physiological and physical signals. All sensors are designed to be connected to the input channels of g.tec amplifiers to enable synchronous and simultaneous recording of many electrophysiological data (including EEG, ECG, EMG, EOG and ECoG). This manual describes how to use different sensors in a correct and safe way to assure best data quality for research. The technical principles of the sensor functions are explained and recommendations for the amplifier configuration are given. The manual also shows the correct application of the sensors and provides procedures to test functions. Mandatory safety measures, technical data and specifications are listed.

## 1.3 Important information for using a sensor or utility

Any user of our sensors, utilities and amplifiers is responsible for the correct application and safe operation. Before use, please carefully read these instructions and any documents that may be packed together with some sensors. g.tec's sensors and utilities are no certified medical devices and are not intended to be used as medical devices. Use g.tec's sensors and utilities for research applications only. Please contact g.tec with any additional questions or other support.

## 1.4 Cleaning and storage of sensors and utilities

Unless otherwise stated in the manufacturer's documents (which may come packaged together with some sensors), please note the following instructions. Use only a damp cloth when cleaning devices, cables and connectors. Use alcohol (70%) with a soft tissue for disinfection purposes if required. Ensure that any liquids do not enter the device or connectors. Make sure that all components are completely dry before storing the device. If applicable, remove all batteries from the device before storage or if the device will not be used for at least 2 weeks. Store the device in a dry place between -10°C and +50°C. In case the device was stored at lower temperatures, wait until all condensed water disappears before using it (wait at least 1 hour in a heated room).

## 1.5 Connecting sensors to amplifier inputs

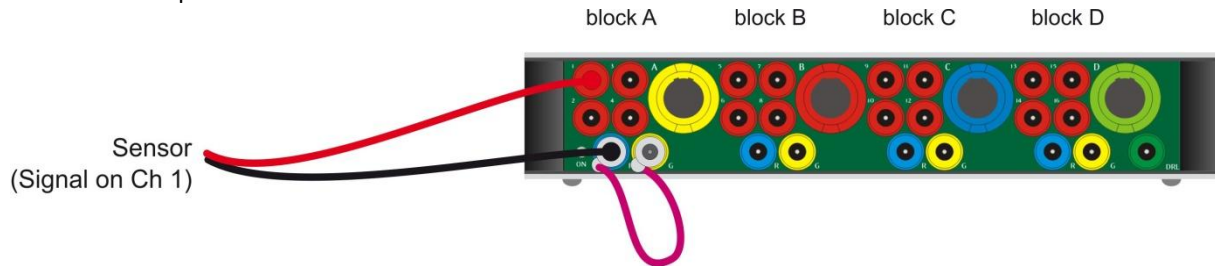
All sensors provided by g.tec can be connected directly to the input channels of our biosignal amplifiers. Make sure that sensors are not connected to any other electrical devices, power supplies or charging devices. Do not connect the output leads of a sensor to electrodes or to other electrical devices. Patient safety is provided by the biosignal amplifier's applied part or medical data acquisition system. Using a sensor connected to an unsafe recording system may result in electric shocks and other injuries of the subject or other persons.

Sensors may be equipped with two or three output leads terminated with 1.5-mm touchproof safety connectors which fit into the amplifier's input connectors. Please connect the sensors as follows, depending on the sensors and amplifiers:

**g.USBamp**

Sensors with two leads:

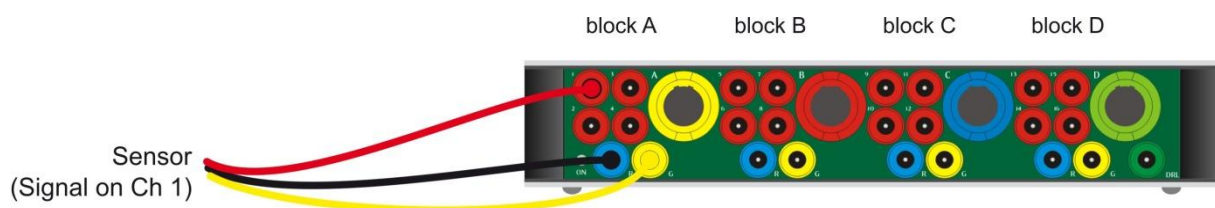
Connect one lead (black, if applicable) to the REF input of g.USBamp (blue) and the other lead (red, if applicable) to an input channel of g.USBamp (red). Use a jumper cable to shortcut the REF and GND of the used block of the amplifier.



Sensors with three leads:

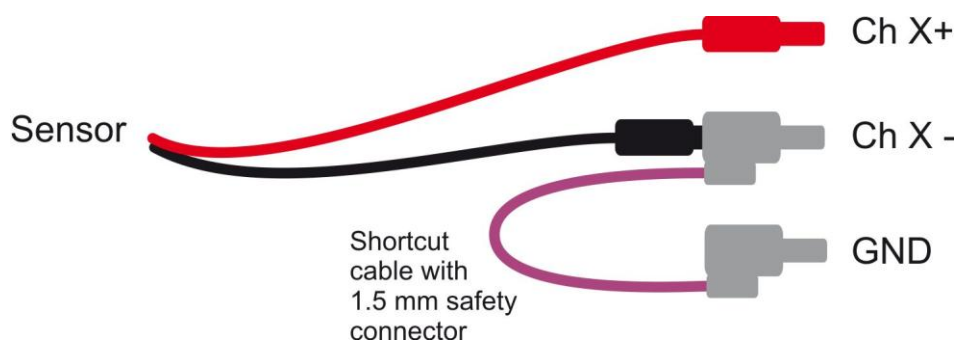
Plug the yellow connector into the GND socket (yellow). Plug the blue (or black) connector into the REF socket (blue). Plug the red connector into an input channel socket of g.USBamp (red). In this case, the sensor output cable shorts REF and GND of the used input block of g.USBamp.

Note: Do not use other input channels of the used block for electrophysiological recordings (EEG, ECoG, EMG, ECG, EOG, etc) because the shortcut between GND and REF may reduce the quality of such signals. Do not use the "Common REF" functions for this block to avoid interference with other input blocks.

**g.MOBilab+**

Sensors with two leads:

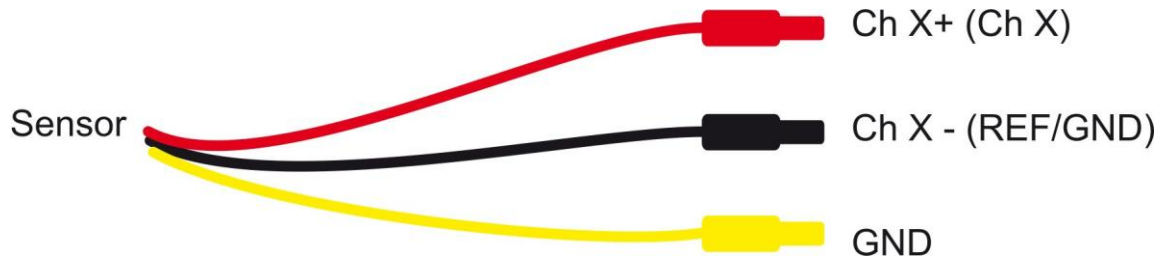
For bipolar input channels connect one lead (black, if applicable) to the "Ch X-" socket (black) and use a jumper cable to short it with the GND socket. Connect the other lead (red, if applicable) to the "Ch X+" socket.



When using the analog input connector box (Ch 7, Ch 8), connect one lead (black, if applicable) to "REF/GND" and the other lead (red, if applicable) to "Ch X". In this case no jumper is required.

Sensors with three leads:

Plug the yellow connector into the GND socket. Plug the black (or blue) connector into the “Ch X-” socket (for bipolar inputs) or into the GND/REF socket (analog input box). Plug the red connector into the “Ch X+” (bipolar inputs) or “Ch X” (analog input box) socket.



#### **g.HIamp**

Use a 64-channel passive electrode connector box or a 16-channel passive electrode connector box for g.HIamp.

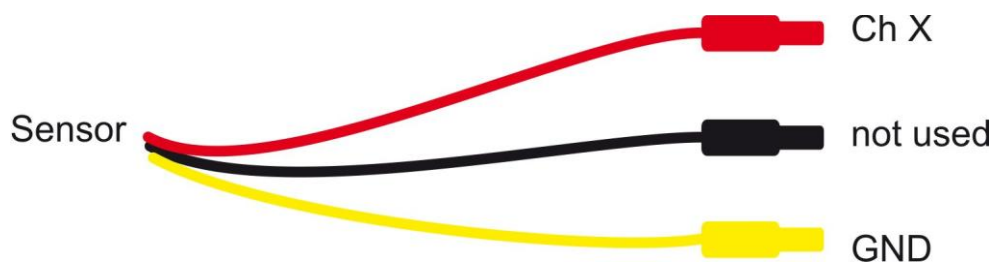
Sensors with two leads:

Connect one lead (black, if applicable) to the GND socket (yellow) and connect the other lead (red, if applicable) to an input channel socket (red).



Sensors with three leads:

Plug the yellow connector into the GND socket (yellow) and plug the red connector into an input channel socket (red). The blue (or black) connector remains unused in this case.

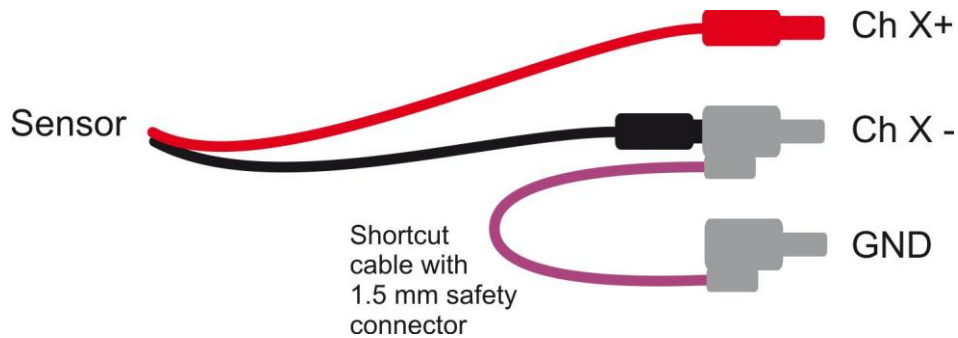


**g.BSamp**

Note that some sensors are unsuitable for use with this amplifier, due to AC-coupling and the limited input voltage range of g.BSamp.

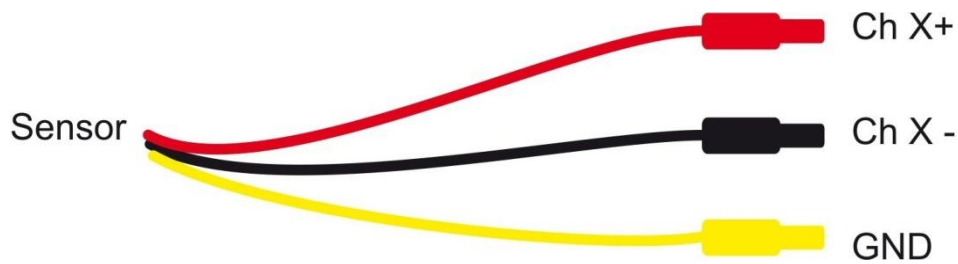
Sensors with two leads:

Connect one lead (black, if applicable) to the “Ch X-” socket (black), and use a jumper cable to short it with the GND socket (yellow or green). Connect the other lead (red, if applicable) to the “Ch X+” socket.



Sensors with three leads:

Plug the yellow connector into the GND socket (yellow or green). Plug the black (or blue) connector into the “Ch X-” socket and plug the red connector into the “Ch X+” socket of g.BSamp.



## 2 Sensors

### 2.1 g.PULSEsensor



#### What can be measured?

The g.PULSEsensor measures the pulse plethysmogram, which displays the volumetric change of blood in the vessels. Each heartbeat increases the blood pressure, which dilates and increases blood to the capillaries. The pulse signal shows these changes beat-by-beat over time.

#### How does the sensor work?

The sensor itself consists of an infrared light source (LED) with a certain wavelength and a phototransistor that measures the amount of reflected light. It can be placed on a finger tip or earlobe. The light is sent through the skin into the tissue underneath, and the amount of reflected light depends on the perfusion of the tissue.

#### Recommended amplifier configuration

Bandpass filter 0.1 Hz – 30 Hz, notch filter 50/60 Hz on

#### Correct application and testing

Place the sensor on the finger tip or earlobe (depending on type) and make sure that the LED sits smoothly on the skin with little pressure. Try to prevent the sensor from moving over the skin, and lay the cable without tension. Turn on the interface box and start viewing the signal. You should see a clear plethysmogram for at least 30 seconds before starting the experiment.

#### Safety measures

Use 9V alkaline batteries or rechargeable batteries only. Do not connect the sensor to any power supply or charging device!

#### Technical data and specifications

Power supply: 9V alkaline battery or rechargeable battery

Current consumption: < 20 mA

Output signal range: +/- 1 mV (typical)

Emitter/detector wavelength: 950 nm

g.PULSEsensor is not a certified medical device. The product is not intended to be used as a medical device.



## 2.2 g.TEMPsensor



### What can be measured?

The g.TEMPsensor is designed to measure the skin temperature within a range of 20 – 45 °C. The skin temperature depends on skin perfusion, which is influenced by physiological and psychological parameters.

### How does the sensor work?

The sensor is equipped with a high-accuracy YSI-400 thermosensor to be applied directly on the skin. Changes of the skin temperature are transformed into a proportional voltage output signal. The sensor is already calibrated, and 0 V output voltage corresponds to 20°C. A temperature increase of 1°C adds 8 mV to the output signal, so that 45°C will yield an output voltage of 200 mV.

### Recommended amplifier configuration

This sensor requires a DC-coupled amplifier (no highpass filter!), lowpass filter 30 Hz, notch filter 50/60 Hz on

### Correct application and testing

Place the sensor on the skin (e.g. on the finger, forehead or cheek) and fix it with tape or with an elastic band. Make sure that the sensor sits smoothly on the skin with little pressure. Note that high accuracy skin temperature recording requires a room with constant temperature and humidity, and the subject needs to adapt to these conditions for 30 – 60 minutes prior to the experiment. Make sure that the interface box is turned on, and replace the battery if the green indicator LED is not brightly lit.

### Safety measures

Use 9V alkaline batteries or rechargeable batteries only. Do not connect the sensor to any power supply or charging device!

### Technical data and specifications

Power supply: 9V alkaline battery or rechargeable battery

Current consumption: < 10 mA

Output signal range: 0 – 200 mV (calibrated for 20 – 45°C)

Accuracy: 0.2°C

g.TEMPsensor is not a certified medical device. The product is not intended to be used as a medical device.

## 2.3 g.GSRsensor



### What can be measured?

The g.GSRsensor measures the electrical conductivity of the skin, also known as galvanic skin response (GSR) or electro-dermal activity (EDA), which depends on perspiration. Psychological and physiological stress and emotional responses activate sweat glands, thereby increasing perspiration and skin conductivity. The signal can change quickly, such as in response to stimulation, or slowly, such as an adaptation to the environment or to a general stress level.

### How does the sensor work?

A small constant DC voltage is applied to a pair of special finger electrodes and the current is measured by the sensor. The output signal is proportional to the skin conductivity in a range of 0 – 30  $\mu\text{S}/\mu\text{Mho}$  (micro Siemens/micro Mho). The sensor is equipped with an internal isolation barrier to rule out influences between GSR electrodes and other electrophysiological recordings.

### Recommended amplifier configuration

This sensor requires a DC-coupled amplifier to record conductivity levels and slow changes (no highpass filter!), lowpass filter 30 Hz, and notch filter at 50 or 60 Hz. To record only quick responses, an additional highpass filter (e.g. 0.05 or 0.1 Hz) can be used.

### Correct application and testing

Place the electrodes on two fingers of the same hand (electrode contacts on the opposite side of the fingernail) and close the Velcro straps with a little tension. Turn on the device and replace the battery if the green indicator LED is not brightly lit. Watch the signal and wait for a few minutes till the electrodes have adapted. Short hyperventilation (heavy breathing) will cause an immediate increase of skin conductivity in most subjects. Note that GSR signals can be very individual. Some subjects show high fluctuations and responses even without any obvious stimulus, while others will show only very small changes over a long time. Pressing the calibration button adds +1  $\mu\text{S}$  to the current value and results in a +6.7 mV signal step for testing purposes.

### Safety measures

Use 9V alkaline batteries or rechargeable batteries only. Do not connect the sensor to any power supply or charging device!

### Technical data and specifications

Power supply: 9V alkaline battery or rechargeable battery

Current consumption: < 40 mA

Output signal range: 0 – 200 mV (corresponding to 0 – 30  $\mu\text{S}/\mu\text{Mho}$ )

Electrode voltage: approx. 400 mV DC

Isolation barrier: 500 V RMS between electrodes and output signal

g.GSRsensor is not a certified medical device. The product is not intended to be used as a medical device.

## 2.4 g.Gsensor



### What can be measured?

The g.Gsensor measures G-forces in 3 directions (X/Y/Z) in a range of  $\pm 3$  g. It can be used to record acceleration or vibration values of up to 80 Hz. When attached to the subject's body, the sensor measures changes of position or physical activity (such as walking, running or jumping). The g.Gsensor can also measure acceleration and vibration when mounted on an object (vehicle, aircraft, simulator, etc.)

### How does the sensor work?

The internal sensing element measures G-forces of the orthogonal X-, Y- and Z-axes independently. For each axis, an output signal is provided, and +1 g equals an output voltage of +66 mV.

### Recommended amplifier configuration

For position recordings and slow changes the sensor requires a DC-coupled amplifier (no highpass filter!), lowpass filter 30 – 100 Hz, and notch filter at 50 or 60 Hz. To record faster movements such as vibration, the filters may be set according to the expected activity and may include a highpass filter.

### Correct application and testing

Attached to the body: Use the belt clip or other suitable materials to position the sensor on an appropriate location.

Fixed to an object: Make sure that the sensor is securely mounted and cannot move.

Shake the sensor and turn it around the X-, Y- and Z-axes to check all signals. The directions of the axes are indicated on the device. Replace the battery if the green indicator LED is not brightly lit.

### Safety measures

Use 9V alkaline batteries or rechargeable batteries only. Do not connect the sensor to any power supply or charging device!

### Technical data and specifications

Power supply: 9V alkaline battery or rechargeable battery

Current consumption: < 10 mA

Output signal range: -200 to +200 mV (equals -3 g to +3g)

Shock resistance: max. 10 g

Accuracy: 5%

Nonlinearity: <0.3 %

g.Gsensor is not a certified medical device. The product is not intended to be used as a medical device.

## 2.5 Respiration Airflow Sensor



### What can be measured?

The Respiration Airflow Sensor measures breathing activity through mouth and nose. The output signal voltage rises during inhalation and drops during exhalation.

### How does the sensor work?

The sensor measures the air temperature right in front of the nose and mouth. As exhaled air is normally warmer than the air in the room, the temperature changes reflect respiratory activity.

### Recommended amplifier configuration

Bandpass filter 0.1 Hz – 30 Hz, notch filter 50/60 Hz on

### Correct application and testing

The sensor is placed on the upper lip, below the subject's nostrils. Bend the two nasal prongs forward to prevent them from entering the nostrils. Put the sensor wires on each side of the sensor over the patient's ears and secure them with tape. Then, lay the wires under the chin and close the lock. Connect the sensor to the interface box and check the signal.

### Safety measures

Please refer to the manufacturer's instructions for use, which are packed together with the sensor.

### Technical data and specifications

Power supply: internal battery in the interface box with a minimum life time of 1 year. Replace the interface box when the battery is empty and the sensor stops working.

Sensor type: Thermistor

Output signal range: +/- 0.5 to 1 mV (typical)

The Respiration Airflow Sensor is not a certified medical device. The product is not intended to be used as a medical device. Please also read the manufacturer's instructions for use, which are packed with the sensor.

## 2.6 Respiration Effort Sensor



### What can be measured?

The Respiration Effort Sensor measures changes of the circumference of the torso related to breathing activity. It can be applied around the chest or abdomen, or on both of these areas to compare abdominal and chest respiratory activity.

### How does the sensor work?

The sensor measures the tension of an elastic band using a piezo-electric element. Changes of the tension cause a voltage output indicating changes of the torso's circumference.

### Recommended amplifier configuration

Bandpass filter 0.1 Hz – 30 Hz, notch filter 50/60 Hz on

### Correct application and testing

The sensor element is connected to the elastic band with two snap locks. The length of the band should be adjusted to provide some tension when attached around the torso. Place the sensor element at a position where it will not be touched accidentally to avoid artifacts. Movements of the sensor element and the cables may cause large artifacts in the signal.

### Safety measures

Please refer to the manufacturer's instructions for use, which are packaged together with the sensor.

### Technical data and specifications

Sensor type: Piezo-electric tension sensor

Output signal range: +/- 1 mV (typical)

The Respiration Effort Sensor is not a certified medical device. The product is not intended to be used as a medical device. Please also read the manufacturer's instructions for use, which are packaged together with the sensor.

## 2.7 g.SNORINGSensor



### What can be measured?

The g.SNORINGSensor records tracheal sound and is predominantly used in sleep research to detect snoring in sleeping subjects.

### How does the sensor work?

The sensor uses a piezo-electric element which picks up vibrations and low frequency sound from the skin surface.

### Recommended amplifier configuration

Bandpass filter 5 Hz – 100 Hz or higher, notch filter 50/60 Hz on

### Correct application and testing

The sensor is attached to the skin with adhesive tape. Place the sensor on the subject's neck close to the trachea or larynx. For sleep research make sure that the wires can move freely with the subject.

### Safety measures

Please refer to the manufacturer's instructions for use, which are packaged together with the sensor.

### Technical data and specifications

Sensor type: Piezo-electric sensor

Output signal range: +/- 0.5 to 5 mV (typical)

g.SNORINGSensor is not a certified medical device. The product is not intended to be used as a medical device.

Please also read the manufacturer's instructions for use, which are packaged together with the sensor.

## 2.8 g.LIMBsensor



### What can be measured?

The g.LIMBsensor is used to identify sudden movements of the legs or hands during sleep (e.g. in patients suffering from restless legs syndrome). The sensor provides a clear signal indicating each movement, which allows investigation of the frequency of movements during the night.

### How does the sensor work?

The sensor uses a piezo-electric element, which is attached to an elastic Velcro holster band. The sensor is fixed at the ankle or wrist and generates a voltage output signal corresponding to movement related changes of tension of the holster band.

### Recommended amplifier configuration

Bandpass filter 0.1 Hz – 60 Hz or higher, notch filter 50/60 Hz on

### Correct application and testing

Apply the sensor with the elastic Velcro holster band at the ankle or wrist. Close the band with a little tension and test the signal output. Please also see the manufacturer's instructions in the manual.

### Safety measures

Please refer to the manufacturer's instructions for use, which are packaged together with the sensor.

### Technical data and specifications

Sensor type: Piezo-electric sensor

Output signal range: +/- 0.5 to 5 mV (typical)

g.LIMBsensor is not a certified medical device. The product is not intended to be used as a medical device. Please also read the manufacturer's instructions for use, which are packaged together with the sensor.

## 2.9 g.SpO2sensor



### What can be measured?

The g.SpO2sensor measures the oxygen saturation of the peripheral blood in percent. The pulse frequency (0 – 300 bpm) and the plethysmogram (autoscaled) can also be recorded.

### How does the sensor work?

The sensor sends infrared light (LED) into the tissue and measures the amount of reflected light at different wavelengths. Since the color of blood depends on the amount of solute oxygen, the percentage concentration (SpO2) can be computed. All signals are delivered as analog voltage signals.

### Recommended amplifier configuration

SpO2-signal (pin 1, red connector): DC required! (0 Hz), Lowpass: 30 Hz, notch filter 50/60 Hz on

Pulse frequency (pin 2, black connector): DC required! (0 Hz), Lowpass: 30 Hz, notch filter 50/60 Hz on

Plethysmogram (pin 3, white connector): 0.1 – 30 Hz, notch filter 50/60 Hz on

### Correct application and testing

The finger sensor should be placed on the index finger of the right or left hand with the LED on the opposite side of the fingernail. Turn on the device by pressing the “ON/OFF” button. Immediately after turning on the device, a calibration signal will be delivered on the SpO2 and the pulse frequency outputs for a few seconds. These rectangular signals alternate between 0% and 100% (SpO2) and between 0 bpm and 300 bpm (Pulse frequency), respectively. After some seconds, the “SIG OK” indicator should turn on permanently. The LED for “BAT OK” indicates proper battery voltage.

### Safety measures

Use 2 x 1.5V alkaline batteries (AA) only. Do not connect the sensor to any power supply or charging device!

### Technical data and specifications

Output signal range: approx. 0 – 200 mV

Power supply: 2 x 1.5 V (AA) alkaline batteries, internal fuse: 500 mA

Current consumption: < 60 mA

BAT OK voltage: >2.4 V      SIG OK: quality > 90 %

g.SpO2sensor is not a certified medical device. The product is not intended to be used as a medical device.



## 2.10 g.CNAPadapter



### What can be measured?

The g.CNAPadapter is a signal interface box to provide an analog voltage signal of the continuous non-invasive arterial blood pressure measured by the CNAP monitor (CNSystems Medizintechnik AG, Austria).

### How does the sensor work?

The CNAP monitor provides access to the internal measurement bridge used with the pressure sensor. A reference voltage is applied to the bridge circuit via the “BP wave out” interface of the device. The output signal of the bridge is an analog voltage proportional to the continuous blood pressure.

### Recommended amplifier configuration

DC-coupled input required, lowpass filter 30 Hz – 60 Hz, notch filter 50/60 Hz on

### Correct application and testing

Please read the manufacturer’s manuals of the CNAP monitor (delivered with the device) before using the device. Plug the “BP wave out” connector into the “BP wave out” socket on the right side of the CNAP monitor. Turn on the g.CNAPadapter and connect the output leads to the inputs of the amplifier. The green “BAT OK” LED indicates a proper battery voltage (above 7 V); replace the battery when this LED is off. The recorded signal should look quite similar (depending on filter settings) to the one displayed on the CNAP monitor screen. A blood pressure change of 1 mmHg equals to an output voltage change of 1 mV.

<b>Note: The analog output signal is only provided after the CNAP monitor has finished the initialization and calibration procedure, which takes several minutes, please see the CNAP monitor manual!</b>
---

<b>Note: The analog output signal contains an offset voltage that must be determined by the user. This offset voltage level is stable and can be used for offset correction of the raw signal during data preprocessing or analysis! Check the offset voltage before data recording! Please use the “zeroing” function of the CNAP monitor (see CNAP monitor manual) for offset determination.</b>
--

### Safety measures

Use 9-V alkaline batteries or rechargeable batteries only. Never connect a power supply or charging device to the g.CNAPadapter.

### Technical data and specifications

Power supply: 9-V alkaline batteries or rechargeable battery

Output signal: 1 mmHg = 1 mV (+ constant bridge offset voltage, to be determined by the user)

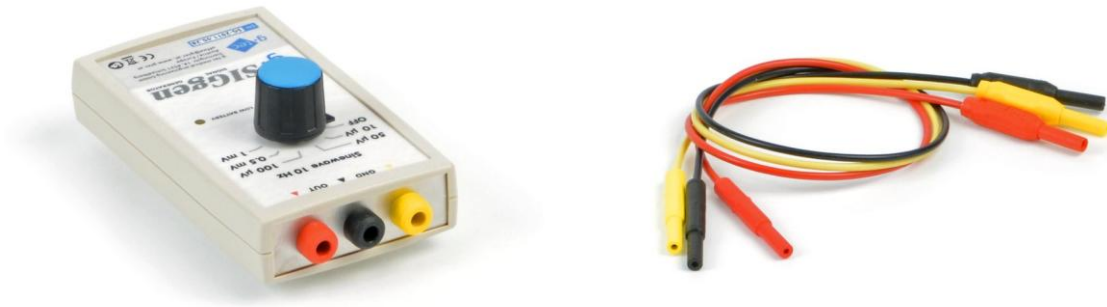
Internal voltage gain: 40

Current consumption: < 15 mA

g.CNAPadapter is not a certified medical device. The product is not intended to be used as a medical device.

## 3 Utilities

### 3.1 g.SIGgen



#### What is g.SIGgen?

The g.SIGgen test signal generator is a simple tool to test amplifiers, data acquisition systems and software components. The device provides a 10-Hz sinusoidal test signal, which can be fed right into the biosignal amplifier's inputs. The peak-to-peak amplitude of the output signal can be adjusted ( $\pm 10 \mu\text{V}_{\text{pp}}$ ,  $\pm 50 \mu\text{V}_{\text{pp}}$ ,  $\pm 100 \mu\text{V}_{\text{pp}}$ ,  $\pm 0.5 \text{ mV}_{\text{pp}}$ ,  $\pm 1 \text{ mV}_{\text{pp}}$ ).

#### Correct application and testing

Use the genuine cables with 1.5-mm safety connectors to connect the device to the amplifier input sockets. Connect the GND wire (yellow) first. The yellow and the black socket have the same potential (internal connection). Connect the black output to the REF input or to the inverted input (for bipolar inputs) and connect the red output to the signal input or to the non-inverted input (for bipolar inputs) of the amplifier. Turn on the device by selecting an output amplitude. The LOW BATTERY indicator turns on when the battery needs to be replaced. Note that the filter settings of the amplifier may influence the amplitude of the recorded test signal.

#### Safety measures

Use 9-V alkaline or rechargeable batteries only. Never connect a power supply or charging device to g.SIGgen. Never connect electrodes to the device's output sockets. Do not use the device during recordings with subjects.

#### Technical data and specifications

Power supply: 9V alkaline or rechargeable battery

Current consumption: < 10 mA

Output signal frequency: 10 Hz

Output signal amplitudes:  $\pm 10 \mu\text{V}_{\text{pp}}$ ,  $\pm 50 \mu\text{V}_{\text{pp}}$ ,  $\pm 100 \mu\text{V}_{\text{pp}}$ ,  $\pm 0.5 \text{ mV}_{\text{pp}}$ ,  $\pm 1 \text{ mV}_{\text{pp}}$

g.SIGgen is not a certified medical device. The product is not intended to be used as a medical device.

### 3.2 g.Zcheck



#### What is g.Zcheck?

The g.Zcheck electrode impedance measurement system is designed to measure the impedance of already applied passive electrodes for electrophysiological recordings (e.g. EEG). The system uses a 10-Hz sinusoidal test signal to determine the electrode impedance. g.Zcheck displays the impedance measured with a pair of electrodes plugged into the device. The LEDs on the device indicate the impedance value within a few seconds after pressing the CHECK-button (blue). The green range (<2.5 kOhm to 5 kOhm) indicates a “good” impedance for EEG recordings. The yellow range (6 kOhm to 9 kOhm) shows medium impedance, and the red range (10 kOhm to infinite) reflects unacceptably high impedance.

#### Correct application and testing

Use electrodes of the same material only. Connect the GND electrode to the black socket and test all other electrodes against this electrode by connecting them to the red socket one at a time. Press the blue CHECK button for at least 3 seconds until the LED indicator stops moving to get a stable result. In case all values are in the medium or bad range, abrade the skin again at the GND position (with abrasive gel) to assure low impedance at this electrode. The LOW BATTERY indicator turns on when the battery needs to be replaced. To test the device, press both buttons at the same time for at least 5 seconds with no electrodes connected. The indicated value should be 5 kOhm.

#### Safety measures

Use 9-V alkaline or rechargeable batteries only. Never connect a power supply or charging device to g.Zcheck.

#### Technical data and specifications

Power supply: 9V alkaline or rechargeable battery

Current consumption: < 40 mA

Test signal frequency: 10 Hz

g.Zcheck is not a certified medical device. The product is not intended to be used as a medical device.

### 3.3 g.TRIGbox



#### What is g.TRIGbox?

The g.TRIGbox is a tool to generate precise bounce-free trigger pulses from various sensor or digital input signals. Input and output lines are isolated from each other. The trigger outputs can be connected to a data acquisition system, to the trigger inputs or to the analog input channels of biosignal amplifiers. Output trigger pulses have a length of at least 20 ms to ensure secure trigger detection of the recording system, even at low sampling frequencies. Four trigger outputs are available, and each output can be controlled via three different types of input signals:

- 1) Low level input signals in the range of  $\pm 0.5$  mV to  $\pm 200$  mV  
(e.g. dynamic microphones, inductive sensors, piezo sensors, sound card output signals, ...)
- 2) High level input signals in the range of  $\pm 100$  mV to  $\pm 5$  V  
(e.g. optional push buttons or digital outputs from various devices with CMOS or TTL logic levels)
- 3) Optical sensor signals  
(optional highspeed phototransistor sensors to detect changes of light intensity, e.g. on a computer screen, on LEDs, flash lamps and other light sources)

Each channel has a separate threshold level adjustment and a trigger output indicator LED. The trigger output signals are provided at two different voltage levels: 5 V (for TTL or CMOS logic inputs) and 200 mV (for the connection to analog unfiltered amplifier inputs). In addition to the single trigger output signals, an encoded 4-bit analog output signal can be used to record all 16 possible output combinations in one analog channel.

#### Correct application and testing

Connect a trigger source to an appropriate input channel of the g.TRIGbox and turn on the device. The LOW BATT indicator LED will flash for about half a second. If the LED remains on or does not flash at all, the battery needs to be replaced. Then, activate the trigger source and adjust the threshold for reliable and secure trigger detection. The trigger output LED indicates a HI output signal. When using analog trigger sources or optical sensors, the accurate adjustment of the threshold is very important. Identify the lower detection threshold (output trigger remains LO) and the upper detection threshold (output trigger always HI) by turning the adjustment knob counter-clockwise and clockwise, respectively. Remember the knob positions and adjust the knob then about to the middle in between these two positions. Connect the trigger output cable to the input channel of the amplifier and check the trigger signal or marker.

#### Safety measures

Use 9-V alkaline batteries or the optional safety power supply only. Do not connect g.TRIGbox to any charging devices or 3<sup>rd</sup>-party power supplies.

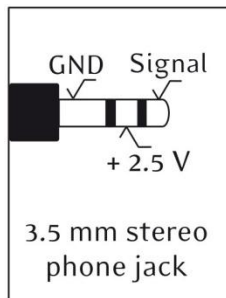
#### Technical data and specifications

Power supply: 9V alkaline battery or optional safety power supply.

Current consumption: < 60 mA

Isolation voltage between inputs and outputs: 4 kV

g.TRIGbox is not a certified medical device. The product is not intended to be used as a medical device.



connect optical sensors to detect screen markers, flash lamps, LED indicators, slide projectors etc.

connect high level trigger sources like TTL signals, other logic signals, push-buttons

adjust threshold, set threshold level about to the middle between upper and lower limit

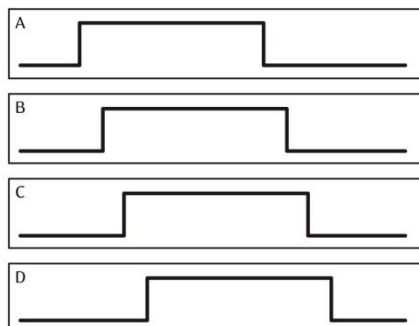
connect low level trigger sources such as microphones, sound card, piezo sensors, inductive sensors, ...

low battery indicator: short flash when switching -> OK remaining on -> replace battery

switch on/off

<- external safety power supply

<- trigger output indicators



encoded trigger:  
trigger A - least significant bit  
trigger D - most significant bit

output voltage steps:  
12.5 mV (for g.USBamp, 200 mV BSL output)

#### PIN ASSIGNMENT TTL:

pin1 ... GND  
pin2 ... OUTPUT A (5V)  
pin3 ... OUTPUT B (5V)  
pin4 ... OUTPUT C (5V)  
pin5 ... OUTPUT D (5V)  
pin8 ... encoded output (5V)

#### BSL:

pin 1 ... GND  
pin 9 ... OUTPUT A (200 mV)  
pin10 ... OUTPUT B (200 mV)  
pin 11 ... OUTPUT C (200 mV)  
pin12 ... OUTPUT D (200 mV)  
pin15 ... encoded output (200 mV)

### 3.4 Trigger cables

For g.USBamp and for g.HIamp special trigger cables enable access to the digital trigger inputs, which are sampled synchronously with the recorded signals. Trigger cables with open leads allow mounting customer-specific connectors for various trigger sources.

#### 3.4.1 Trigger cable for g.USBamp to be used with g.TRIGbox

This cable connects the output socket of g.TRIGbox (15-pin SUB-D) to the DIG I/O 1 or DIG I/O 2 digital input socket of g.USBamp (3.0).

##### *Pin-assignment and digital channels*

<b>g.TRIGbox output</b>	<b>15-pin SUB-D connector</b>	<b>connected to DIG I/O 1</b>	<b>connected to DIG I/O 2</b>
Trigger output A	pin 2	digital input 0	digital input 4
Trigger output B	pin 3	digital input 1	digital input 5
Trigger output C	pin 4	digital input 2	digital input 6
Trigger output D	pin 5	digital input 3	digital input 7
GND	pin 1	GND	GND

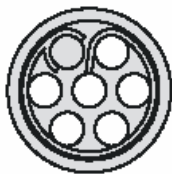
#### 3.4.2 Trigger cable to be used with E-Prime or Presentation stimulation software

To use 3<sup>rd</sup>-party stimulation software such as E-Prime or Presentation, trigger cables with 25-pin SUB-D connectors are provided to be plugged into the PC's parallel port socket.

##### **Hardware setup:**

For g.USBamp (version 3.0) plug the DIG I/O 1 and the DIG I/O 2 connector of the trigger cable into the corresponding sockets at the rear side of the amplifier.

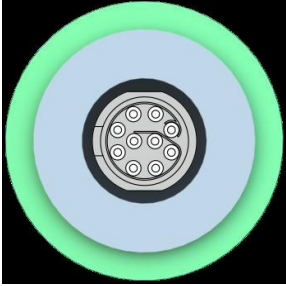
##### *Pin-assignment for the 7 pin socket DIG I/O 1 and DIG I/O 2 of g.USBamp (3.0):*

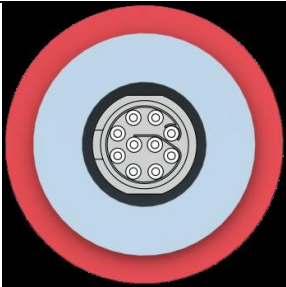


- Pin 1    digital input 0 (DIG I/O 1) resp. digital input 4 (DIG I/O 2)
- Pin 2    digital input 1 (DIG I/O 1) resp. digital input 5 (DIG I/O 2)
- Pin 3    digital input 2 (DIG I/O 1) resp. digital input 6 (DIG I/O 2)
- Pin 4    digital input 3 (DIG I/O 1) resp. digital input 7 (DIG I/O 2)
- Pin 5    digital output 0 (DIG I/O 1) resp. digital output 2 (DIG I/O 2)
- Pin 6    digital output 1 (DIG I/O 1) resp. digital output 3 (DIG I/O 2)
- Pin 7    ground digital

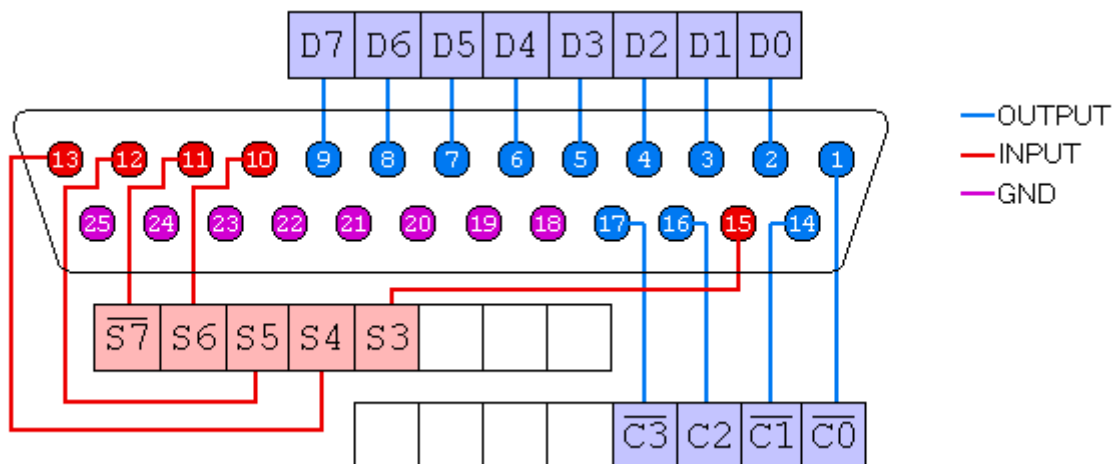
For g.Hlamp, plug the connector of the trigger cable into the DIG IN 1 or to the DIG IN 2 socket. DIG IN 1 supports digital input channels 1 to 8 and DIG IN 2 supports digital input channels 9 to 16 of g.Hlamp.

**Pin-assignment for the 10-pin socket DIG IN 1 and DIG IN 2 of g.Hlamp**

 DIG IN 1	Pin	Direction	Function
	1	I	Digital In 1
	2	I	Digital In 2
	3	I	Digital In 3
	4	I	Digital In 4
	5	I	Digital In 5
	6	I	Digital In 6
	7	I	Digital In 7
	8	I	Digital In 8
	9	Pas	Digital GND
	10	O	Vcc (3.3V)

 DIG IN 2	Pin	Direction	Function
	1	I	Digital In 9
	2	I	Digital In 10
	3	I	Digital In 11
	4	I	Digital In 12
	5	I	Digital In 13
	6	I	Digital In 14
	7	I	Digital In 15
	8	I	Digital In 16
	9	Pas	Digital GND
	10	O	Vcc (3.3V)

**Pin-assignment for the 25-pin connector (parallel port)**



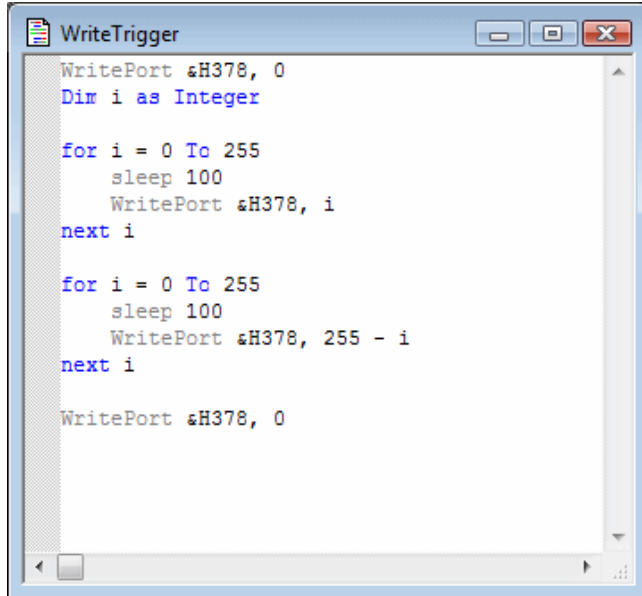
**Pin-assignment for the 25-pin connector (trigger cable for g.USBamp 3.0, 0276A)**

<b>Pin DSUB25</b> (Plug, male pins)	<b>DSUB</b> Function	<b>LEMO</b> Plug, male pins	<b>g.USBamp function</b> (V3.0, counting from 0)
1	----	----	----
2	D0	D I/O1 - 1	digital inputs 0
3	D1	D I/O1 - 2	digital inputs 1
4	D2	D I/O1 - 3	digital inputs 2
5	D3	D I/O1 - 4	digital inputs 3
6	D4	D I/O2 - 1	digital inputs 4
7	D5	D I/O2 - 2	digital inputs 5
8	D6	D I/O2 - 3	digital inputs 6
9	D7	D I/O2 - 4	digital inputs 7
10	S6	D I/O1 - 5	digital out 0
11	----	----	----
12	S5	D I/O1 - 6	digital out 1
13	S4	D I/O2 - 5	digital out 2
14	----	----	----
15	S3	D I/O2 - 6	digital out 3
16	----	----	----
17	----	----	----
18	----	----	----
19	----	----	----
20	----	----	----
21	----	----	----
22	----	----	----
23	----	----	----
24	GND	Dig I/O1 - 7	GND
25	GND	Dig I/O2 - 7	GND



**Software:**

Example for E-Prime: In E-Prime, the parallel port can be used with the Basic programmable InLine object. The sample code below shows how to write values from 0 to 255 and back from 255 to 0 to the parallel port, with a 100 millisecond delay in each iteration, and then reset the port value to 0.



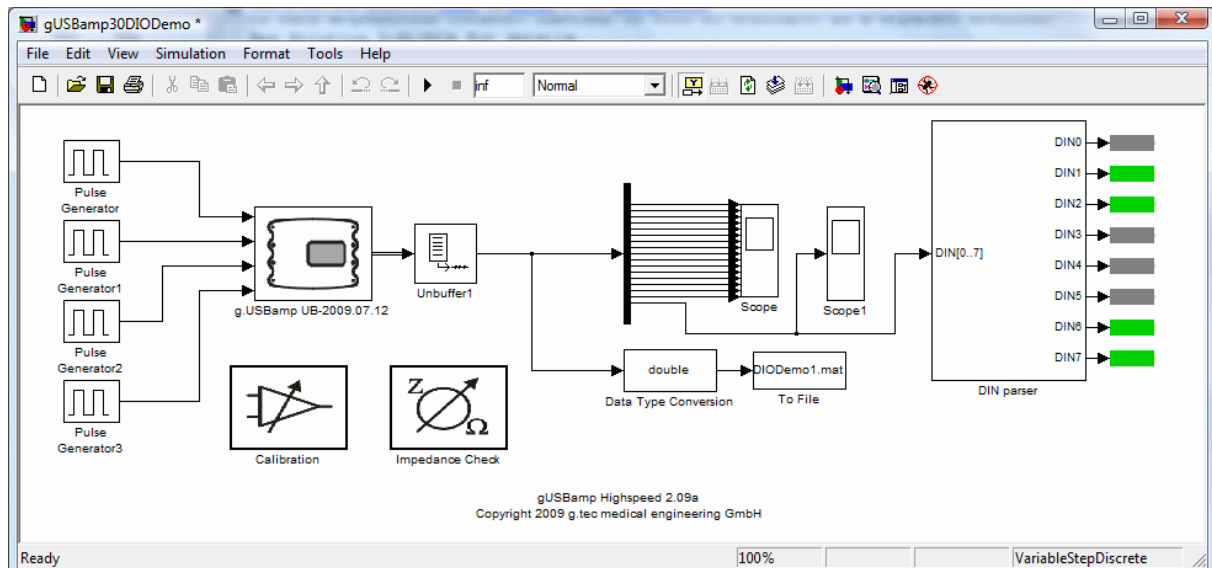
```
WritePort &H378, 0
Dim i as Integer

for i = 0 To 255
    sleep 100
    WritePort &H378, i
next i

for i = 0 To 255
    sleep 100
    WritePort &H378, 255 - i
next i

WritePort &H378, 0
```

In MATLAB Simulink, the signal can be recorded with the g.USBamp Simulink Highspeed model "gUSBamp30DIODemo.mdl". This model is part of the g.tec Highspeed On-Line Processing for Simulink package. The data from the digital I/O is output as 17<sup>th</sup> channel of g.USBamp ranging from 0 to 255. The current state of each line is indicated in the model in grey for 0 or green for 1 for **DINO** to **DIN7**. In the figure below, the current value of the digital input is 198 (binary 11000110).



For g.Hlamp, use the g.Hlamp Simulink Highspeed model "gHlampDIODemo.mdl". This model is part of the g.tec Highspeed On-Line Processing for Simulink package. The data of the digital I/O is output as an additional analog channel of g.Hlamp, ranging from 0 to 65535. The current state of each line is indicated in the model in grey for 0 or green for 1 for **DIN1** to **DIN16**.

