Optical Encephalography

Model: Spectratech OEG-SpO2

User's Manual - Technical Edition Rev 1.0

Pre-information for usage

As this equipment was developed for **research purpose**, you are kindly requested not to use it for other purposes. Please carefully read this manual before use because it is a very precise measuring equipment.

Spectratech Inc.

Version	Date of issue	Remarks
V 1.0	October 1, 2011	First version

Greeting message

The equipment is just one that captures a change of blood flow rate in the frontal lobe if it is simply said. It is an indispensable equipment for a brain researcher to challenge the issue of brain function measurement of which importance has risen more and more in the 21st century. However, it also has a possibility in which the examinee may suppose that his/her heart was unwillingly looked into different from the researcher's intention unless it arranges an enough explanation, and carefully considered experimental environment and experimental issues for him/her before the experiment. We strongly hope you to understand and consider the issue when this equipment is used.

If the 20th century is assumed to be the age of shape diagnostics representing CT and MRI, the 21st century may be called the age of functional diagnostics with the equipments such as PET, fMRI, and fNIRS (Near- infrared reflectance spectrometry: Our device is a kind of fNIRS). However, it is said that the functional diagnostics still have a lot of issues to be researched. Understanding such historical background, we developed the Optical Encephalography Spectratech OEG-SpO2 to be of some help for broadening the base of the research.

We agree that there still are a lot of issues that should be improved as an equipment. So, we will welcome the pep talks from you, the brain researchers.

We wish you, the brain researchers the best success in your researches.

Mitsu Ohashi, President
Spectratech, Inc.

Thank you for your purchasing our Spectratech OEG-SpO2.

This equipment consists of the following components.

- Spectratech OEG-SpO2 Main unit ····· 1 set
- Spectratech OEG-SpO2-01 Head module ····· 1 set
- Spectratech OEG-SpO2-03 Carrying bag ····· 1 set
- Spectratech OEG-SpO2-07 Install software in CD-ROM ····· 1 set
- Spectratech OEG-16-02 Phantom power supply ····· 1 set
- Spectratech OEG-16-04 BNC cable for external signal input ····· 2 sets
- Spectratech OEG-16-05 Box for manual event trigger input ····· 1 set
- Spectratech OEG-16-06 USB cable for PC connection ····· 1 set
- AC adaptor(+5v,2A output, Medical grade) ····· 1 set
- User's Manual ····· 1 set

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§1 Brief overview

The equipment is designed to simultaneously measure the **Hb change** and the **Apparent arterial oxygen saturation** in each in vivo part not so deep in by the multi-channel (up to 16 channels) method utilizing the light absorption characteristics in the neighborhood of near infrared to red light that changes with the bonding state of the in vivo hemoglobin (Hb) with oxygen. The spread spectrum modulation method that is the latest digital technique and originally developed by our company is adopted for the optical modem technology that underlies the equipment. It has achieved great reduction in costs, downsizing, and high performance compared with the conventional technologies. It is assumed that the equipment is used mainly on the frontal lobe part that has few hairs. So, a simple and non-invasive measurement is possible, and it is also considered to use it for a battery-powered mobile measurement system, and simultaneous measurements for multiple examinees.

In addition, the equipment has been developed consistently for research purpose, so you are kindly requested not to use it for other purposes.

The equipment can be used in stand-alone mode, or by connecting with PC with a USB port and Microsoft Windows XP, Windows VISTA, or Windows 7 installed.

Change of hemoglobin:

The change of blood amount conventionally called **concentration change length** of hemoglobin shall be called **Hemoglobin change (Hb change)**, to be exact **The product of change in the apparent Hb concentration and the optical pathlength** from now on. Please refer to **Paragraph Acquisition principle in §3 Acquisition principle of biological information** for the details.

Development purpose of Spectratech OEG-SpO2:

There is EEG information widely known for the pulse oximeter besides **Hb change** as one of the biological information acquired by NIRS (Near-Infrared Spectroscopy) associated with the change of extinction characteristics of hemoglobin. Conventionally, in the world of optical brain function imaging, the research has progressed focusing on the Hb change in brain localization. The pulse wave signal in a brain localization is very weak compared with Hb change and a good SNR (signal to noise ratio) has not been obtained, therefore it has not been used in spite of a possibly useful information.

Spectratech has newly worked on this subject. All the basic parts are newly designed further enhancing our own technology of the spectrum spread modulation. Furthermore, the **"Ultrahigh SNR technology"** was established in addition to the functions of the existing Spectratech OEG-16. It could reach a level at which even a multi-channel analysis of ultraweak pulse wave of a brain localization is possible.

Spectratech offers the new index of **Apprent SpO2** (Apparent arterial oxygen saturation) this time so that it will be of some help for the researches still more deeply from cerebral circulation/metabolism to brain function. Of course, it is a state where the measuring equipment is just prepared as a foundation now. It is hoped that the brain function research will be deepened further by measuring **Apparent SpO2** and the pulse wave change simultaneously besides the conventional hemoglobin change as well as you, the researchers will research from various angles, and kindly advise us.

§2 Features

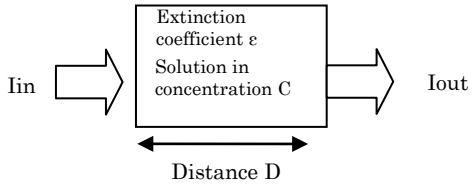
(1) It is possible to measure hemoglobin change and apparent arterial oxygen saturation in a brain localization simultaneously at multiple points.
(2) The head module is as very light as about 250g. It does not make examinees tired so easily even for a long-time measurement.
(3) The main unit is as small as about a half of notebook PC, and easy to move it when measuring.
(4) Specially designed to be used on the frontal lobe.
(5) The spread spectrum modulation method, that is the latest light modulation technique is adopted.
(6) It equips 6 light injection points, 6 optical light-receiving points, and 16-channel measure points.
(7) Event-related measurement, and block design measurement are possible.
(8) Synchronized operation with other measurement equipments (TTL input) is possible.
(9) Event input can be input from external device, network, or by manual operation.
(10) Effective bandwidth of biological signal is prepared for two kinds of 6.1 Hz (Fast Mode) and 0.76 Hz (Fine Mode).
(11) It is connected with PC via USB port. When measured using PC connected, real-time measurements are displayed.
(12) It operates with AC input or the battery (6 x AA battery).
(13) It can continuously measure only with the battery for up to one hour while measuring where no AC power supply is available during moving, or outdoors.
(14) With AC power supply, it can measure continuously for up to ten hours.
(15) Wearable bag is provided for mobile measurement (detachable). (Fine Mode)
(16) Multiple, simultaneous measurements is possible for up to five equipments with the optional distributor (Hyper-Scanning).

§3 Acquisition principle of biological information

The acquisition principle of biological information under the equipment is explained as follows.

1) Acquisition principle of biological information

Based on the Beer-Lambert law, assuming that the incident light to a solution in a certain density is **Iin**, and the light that got through the solution is **Iout**, it is known that the following expression is true.



-Log (**Iout/Iin**) = Extinction coefficient (**ε**) of solution x Concentration of solution (**C**) x Distance (**D**)

That is, if an extinction coefficient **ε** of the solution in a specific wavelength was obtained beforehand, the concentration **C** of the solution can be obtained by measuring **Iin**, **Iout**, and **D**.

The following is the modified Beer-Lambert Law, that is applied to a medium with scattering by extending the Beer-Lambert Law.

$$-\mathrm{Log}\,(\Delta \mathrm{Iout}\,/\mathrm{Iin}) = \varepsilon \times \Delta C \times D + \Delta S$$

Here, ΔIout means a change in amount of transmissive light, ΔC for concentration change, D for average length of light path, and ΔS for effect change by scattering.

Assuming that the incident light to live body in a specific wavelength is Iin (λ), change in amount of the light that returned ex vivo by being effected by in-vivo absorption and scattering is ΔIout (λ), the extinction coefficient of oxyhemoglobin (OxyHb) is ε oxy (λ), deoxyhemoglobin (DeoxyHb) is ε deoxy (λ), the concentration change of OxyHb is ΔCoxy, and the concentration change of DecoxyHb is Δdecoxy, this equipment is designed presuming that the following expression is true.

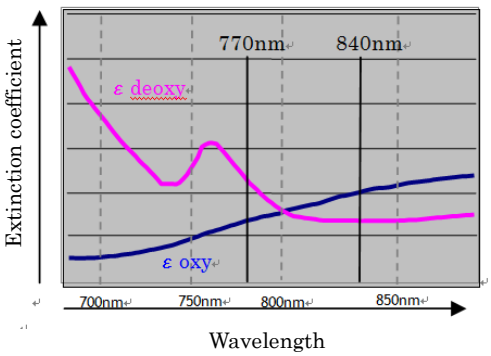
$$-\mathrm{Log}\,(\Delta \mathrm{Iout}\,(\lambda)/\mathrm{Iin}\,(\lambda)) = (\varepsilon\ \mathrm{oxy}\,(\lambda) \times \Delta \mathrm{Coxy} + \varepsilon\ \mathrm{deoxy}\,(\lambda) \times D + \Delta S$$

From this expression, the concentration change of OxyHb ΔCoxy and the concentration change of DeoxyHb ΔCdeoxy are obtained.

Here, there are two variables to be obtained such as ΔCoxy, ΔCdeoxy, therefore the equipment obtains them using the near-infrared extinction coefficient in two wavelengths such as 770 nm and 840 nm shown below.

$$-\mathrm{Log}\,(\Delta \mathrm{Iout}\,(\lambda 840)/\mathrm{Iin}(\lambda 840)) = (\varepsilon\ \mathrm{oxy}\,(\lambda 840) \times \Delta \mathrm{Coxy} + \varepsilon\ \mathrm{deoxy}\,(\lambda 840) \times \Delta \mathrm{Cdeoxy}) \times D + \Delta S$$

$$-\mathrm{Log}(\Delta\ \mathrm{Iout}\,(\lambda 770)/\mathrm{Iin}(\lambda 770)) = (\varepsilon\ \mathrm{oxy}\,(\lambda 770) \times \Delta \mathrm{Coxy} + \varepsilon\ \mathrm{deoxy}\,(\lambda 770) \times \Delta \mathrm{Cdeoxy}) \times D + \Delta S$$



And, from D x ΔCoxy, D x ΔCdeoxy obtained from the above expressions,

$$D \times \Delta \mathrm{Coxy} + D \times \Delta \mathrm{Cdeoxy} = D \times \Delta \mathrm{Ctotal}$$

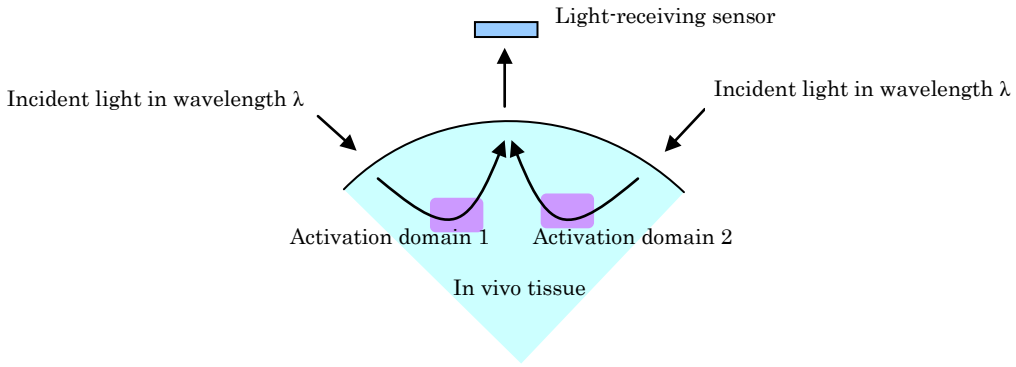
as calculated above, it is assumed to be a total Hb change (D x ΔCtotal).

As for the unit of Hb change[Note 1] (D x ΔCoxy, D x ΔCdeoxy, and D x ΔCtotal), it uses mM·cm (millimolar centimeter) or mM·mm (millimolar millimeter) that still contains a light path length because it cannot be specified.

Note 1: From now on, D x ΔCoxy, D x ΔCdeoxy, and D x ΔCtotal shall be called **Hemoglobin change (Hb change)**, to be exact **The product of change in the apparent Hb concentration and the optical pathlength**. As the simplified symbol representations, ΔCoxy·L, ΔCdeoxy·L, and ΔCtotal·L, or ΔCo·L, ΔCd·L, and ΔC·L are used respectively.

2) Light modulation

When being tried to obtain the multipoint biological information at the same time, it can separate off where the light that reached a sensor came from. There, the light modulation technology is used. The equipment has adopted the spread spectrum multi-modulation method for the light modulation, that is one of the latest digital technologies.



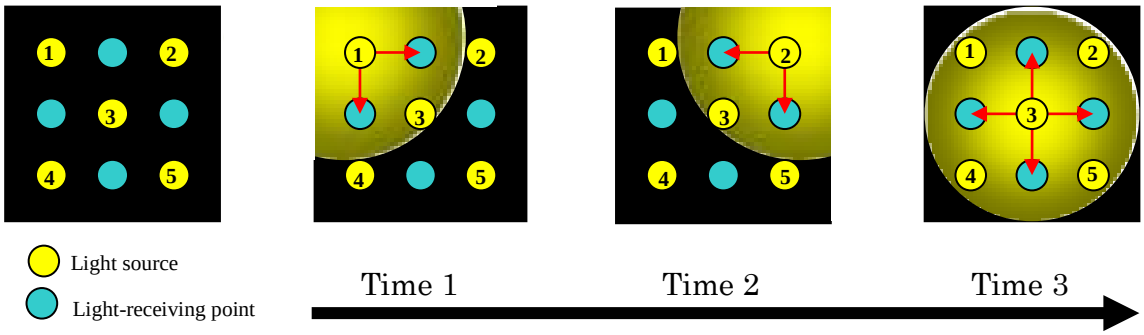
On the other hand, CDMA (Code Division Multiple Access), that is, the spread spectrum modulation is one of the most advanced modulation technologies, that is used for the recent mobile phones or GPS of car navigation systems. It is a modulation method that uses random numbers. Though it is rather difficult to understand the essential theory, it has the advantages in less influenced by turbulence light, simultaneous measurement, no big problem for multiple channels, and the actual circuit scale won't be so large. So, NIRS (Near Infrared Reflectance Spectroscopy) including our equipment generally use the near-infrared ray in continuous wave (CW: Continuous wave) as a light source. TDMA (Time Division Multiple Access) or FDMA (Frequency Division Multiple Access) has been known as optical multi-modulation method in CW. This equipment has adopted CDMA (Code Division Multiple Access) that is quite different from the technique. CDMA is generally called spread spectrum modulation method from the principle. TDMA (Time Division Multiple Access) or FDMA (Frequency Division Multiple Access) has been known as optical multi-modulation method in CW. The equipment has adopted CDMA (Code Division Multiple Access) quite different from the conventional technique. CDMA is generally called spread spectrum modulation method from the principle.

TDMA is a method that controls each light source at the micro level, and a light source in a specific place emits a light at a certain moment. The sensor side where a light was received can separate off the light that came from a specific point by controlling the time. Though it is extremely advantageous in easy-to-use as a modulation method, it still has the disadvantages in easily influenced by turbulence light, and limitation to the biological signal bandwidth for multiple channels.

FDMA method light-modulates the light of each source at individual frequency to emit it. The sensor side where lights were received can separate off the lights that came from each point by separating them off with a frequency-dependent filter after changing the optical composite signal from each point into an electrical signal. It becomes less influenced by the turbulence light compared with TDMA, and is advantageous in its simultaneous measurement. Though it has the disadvantage in necessity of designing a precise frequency-dependent filter, complex circuit scale, and extreme difficulty for supporting multiple channels when exceeding a certain scale, it still is a light modulation technology with good prospects.

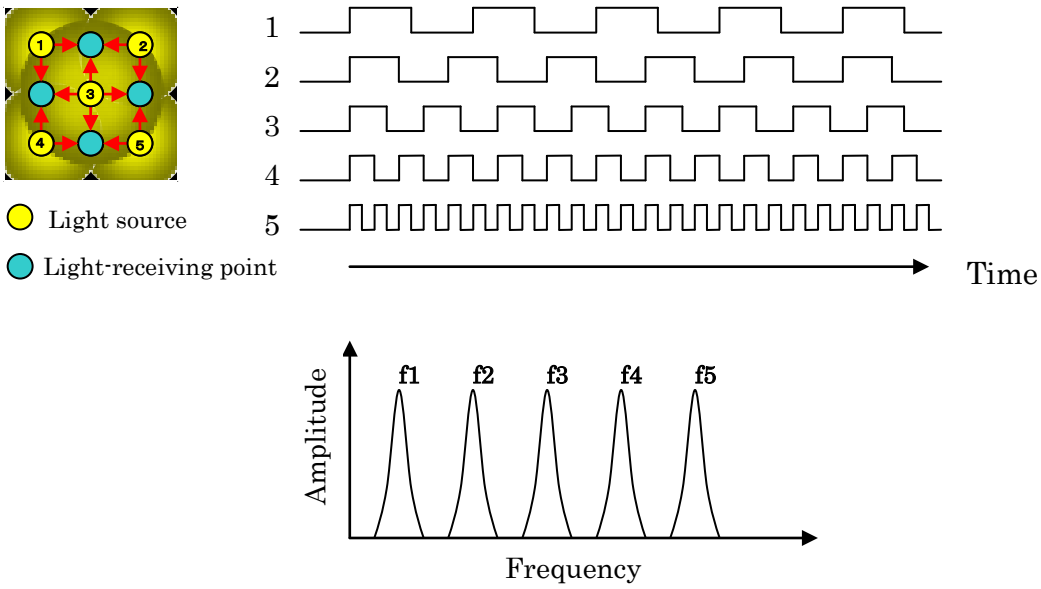
Overview of TDMA method

In the figure below, only the light source 1 lights up at the time 1, and the light is received at each receiving point It is the method to light up sequentially with time such as the light source 2 at the time 2, the light source 3 at the time 3, and so on in the same way.



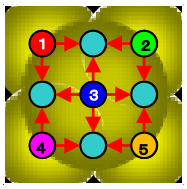
Overview of FDMA method

In the figure below, the light sources 1~5 repeat lighting up at the same time at different modulation frequency. It is a method to specify the point and the optical signal strength at each receiving point by utilizing the different modulation frequency of a light signal from each light source even if each light source lights up at the same time.



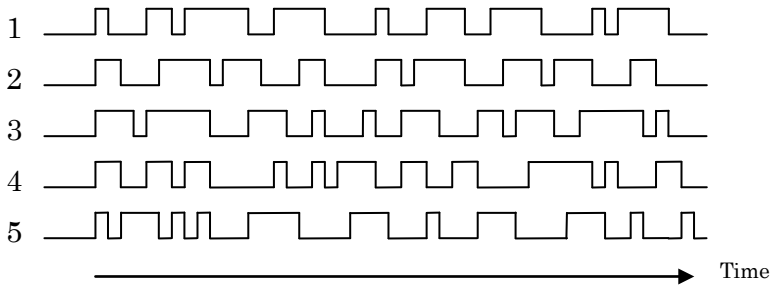
Overview of CDMA (Spread spectrum modulation) method

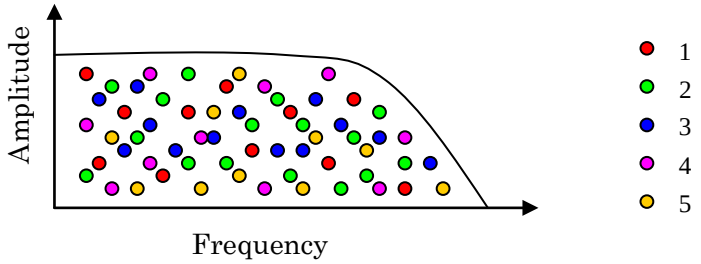
In the figure below, the light sources 1~5 modulate with different random numbers, and repeat lighting up. The method is to specify the point and the optical signal strength at each receiving point by utilizing the difference in random number code of the optical signal from each light source even if each light source lights up at the same time.



Light source

Light-receiving point





Feature of each method (Use for light measurement)

Light modulation method	TDMA (Time Division Multiple Access)	FDMA(Frequency Division Multiple Access)	CDMA (Code Division Multiple Access)
Principle	Simple	Complex	Difficult
Simultaneous measurement	△	◎	◎
Multi channels	△	○	◎
High SN ratio	Limited bandwidth	Limited bandwidth	Available in various methods
Influence by disturbance noise	Large (Depending on modulation method)	Little	Very little
MODEM circuit	Simple/Small size	Complex/Large scale	Simple/Small scale
Practical application	Transmission packet of Internet	Terrestrial digital broadcasting (13-segment OFDM (Orthogonal Frequency Division Multiplexing))	Mobile phone GPS (Used for car navigation system)

3) Ultrahigh SNR technology

In order to catch an ultraweak light, the high-sensitivity and high SNR (Signal to Noise Ratio) optical sensor technologies are required. Generally, SNR is decided almost by the optical sensor itself and the performance of the first-stage amplifier mounted immediately after it. For the sensor of Spectratech OEG-16, the SNR is enhanced to the ultimate by the critically-examined parts and mounting method on the orthodox practice. It demonstrates a sufficient performance to measure the hemoglobin (Hb) changes in the frontal lobe.

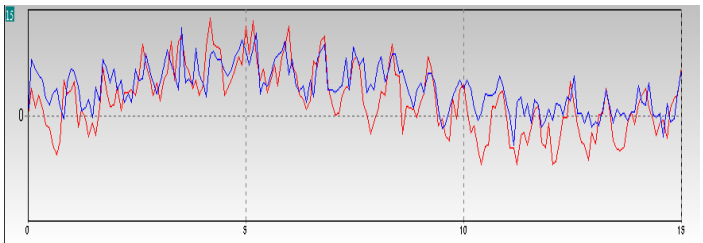
As for Spectratech OEG-SpO2, the performance required for the optical sensor became severe much more, and further high-sensitivity and high SNR were required. A significant improvement in SNR was realized by adopting our own super-high SNR technology that had advanced the spread spectrum light modulation circuits and the sensor circuits. As the result, it is improved by 9 dB in SNR or more in spite of its performance being 2 times in gain, and 8 times in speed compared with SpectratechOEG-16.

Sensor part for Specrtaetch OEG-SpO2

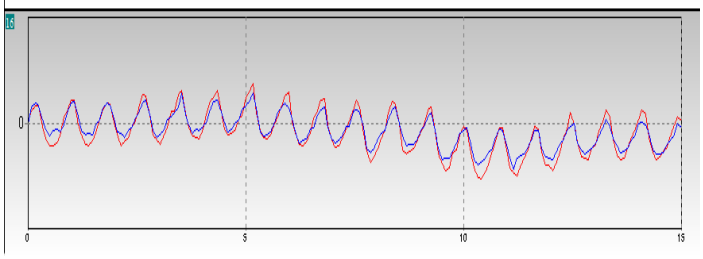
Sensor part for Spectratech OEG-16

Measurement example of pulse wave signal

(Measurement in frontal lobe, 3cm in distance between light source part and light-receiving part, multichannel measurement, and sampling rate of 0.081sec)



In case of ultrahigh SNR technology not used
(Bandwidth is enough, but SNR is bad)



In case of ultrahigh SNR technology used
(Bandwidth is enough, and SNR is very good)

Red: 840nm wavelength signal

Blue: 770nm wavelength signal

4）Apparent SpO2 (Apparent arterial oxygen saturation)

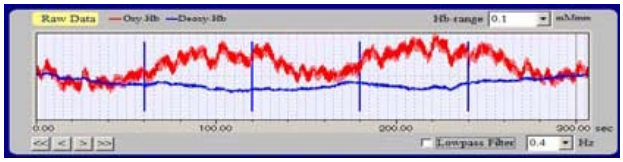
Spectratech OEG-SpO2 has become to be able to measure the pulse wave component of blood flow changes at a fairly good SNR. Then, it obtained the pulsatile Oxy-Hb and Deoxy-Hb components, and calculates the oxygen saturation following the principle below. Since it differed from the formula used by pulse oximeter, Apparent SpO2 (Apparent oxygen saturation) was named.

It is expected that the argument about the change of arterial oxygen saturation in a brain localization can be probably advanced while it has not been really discussed in fNIRS environment due to the poor SNR of pulse wave signals. However, ApparentSpO2 is displayed in %, but it is not a calibrated value like a pulse oximeter. At this moment, it has not reached the level at which the accuracy and the correctness can be discussed.

As a value, you may still use it as a mere standard, and please make use of it within understanding whether ApparentSpO2 tends to increase or to decrease at a specific time.

Principle

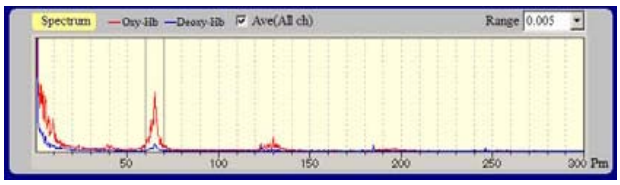
STEP1



First, it obtains Hb changes (Red: ΔCoxy·L, Blue: ΔCdeoxy·L) from the wavelength signals measured in a broadband that includes enough pulse waves.

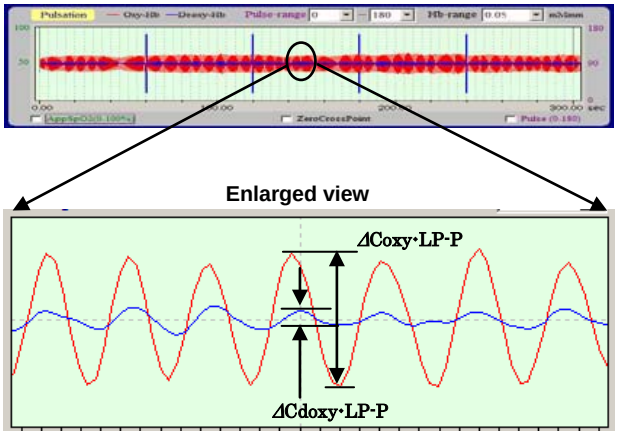
Biological signal bandwidth of SpectratechOEG-SpO2 is 6.1Hz.

STEP2



It obtains the power spectrum of the Hb change signals, and checks the frequency of the pulse wave.

STEP3

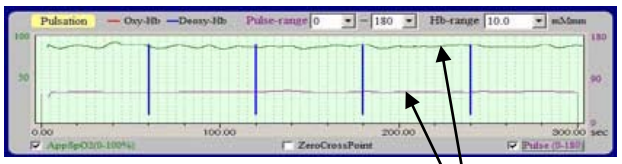


It processes the Hb change signals with the bandpass filter that has it pass through the frequency bandwidth confirmed at STEP2.

It obtains the maximum amplitude in a pulse wave of the Hb change (ΔCoxy·L, ΔCdeoxy·L) signals obtained, and calculate the following.

Apparent SpO2 = ΔCoxy·LP-P / (ΔCoxy·LP-P + ΔCdeoxy·LP-P)

STEP4



It displays ApparentSpO2 obtained by the calculation and the pulse rate changes obtained as by-products as graphs.

Apparent SpO2

Change in pulse rate

Precaution: Although the SNR has become good enough, there is a limit. Generally in the brain localization near the hair outside of the prefrontal area, the required SNR may not be obtained. In such case, with the present algorithm, the indicated value of ApparentSpO2 gets close to 50%. Please understand it, which will be improved further in the future.

§4 Specification

Spectratech OEG-SpO2-01 Head Module

1) Light emitting part

Six units equipped

Built-in type LED with two waves (Wavelength 1: 840nm 2: 770nm)

Output power: 3.8mW/770nm, 3.4mW/840nm max. on surface of light emitting part

Safety of laser products (IEC 60825-1): Exempted

Reference: It was decided to exempt LED from IEC 60825-1 at IEC/TC 76 (Optical radiation safety and laser equipment) conference on October 11~15, 2004.

2007-03 IEC 60825-1 から抜粋

NORME INTERNATIONALE / INTERNATIONAL STANDARD

CEI IEC 60825-1

Deuxième édition Second edition 2007-03

PUBLICATION GROUPÉE DE SÉCURITÉ GROUP SAFETY PUBLICATION

Light emitting diodes (LEDs) have been removed from the scope of this part of IEC 60825, but may still be included in other parts.

In previous editions, LEDs were included in the scope of IEC 60825-1, and they may be still included in other parts of the IEC 60825 series. However, with the development of lamp safety standards, optical radiation safety of LEDs in general can be more appropriately addressed by lamp safety standards. The removal of LEDs from the scope of this Part 1 does not preclude other standards from including LEDs whenever they refer to lasers. CIE S009 may be applied to determine the risk group class of an LED or product incorporating one or more LEDs.

2) Light-receiving part

Six units equipped

Si PIN photo diode with visible light cutoff filter

3) Number of simultaneous measurement channels

16 channels

4) Distance between light injection part and optical light-receiving part

3cm

Note: The head module is assumed to use on the frontal lobe part that has few hairs. It is not recommended to use it on other part. In addition, even if it is measured on the frontal lobe with little hairs, the device's sensor may not sense because some of the examinees might have extremely weak signals. Please be forewarned.

Spectratech OEG-SpO2 Main unit

1) Measuring method of biological signal

Based on the modified Beer-Lambert Law

Hb change (ΔCoxy·L, ΔCdeoxy·L, ΔCtotal·L) Unit: mMol·mm

Apparent SpO2 (Apparent arterial oxygen saturation) Unit: %

2) Optical multi-modulation method

Modulation method: Spread spectrum modulation DS (Direct Sequence) method[Note 1]

PN CODE: M-sequence code (Code length: 65535 bits (Max))

Effective bandwidth of biological signal:

Fine Mode: 0.76 Hz (Sampling interval: 0.65535sec)

Fast Mode: 6.10 Hz (Sampling interval: 0. 08192sec)

3) Event input function

It can input an event trigger manually at an appropriate time using the accessory box (Spectratech OEG-16-05 with entry acknowledge LED).

4) External trigger input function

(1) It equips two systems of the photo-isolated "external trigger input block" to work cooperatively with external devices. It is connected with external devices via BNC cable for external signal input (Spectratech OEG-16-04 accessory). It accepts the usage in both the external event trigger and external measurement/record start trigger.

Input condition: TTL level (Isolated by photo-coupler in the main unit) Note 2

(2) Possible to input from other PC via Network (Use of UDP protocol)

Details of how to use from Network are described in **§6 and §7 in Applied Technology Edition**.

5) Measurement time

(1) AC power supply Continuous measurement: Up to about 10 hours (Fine Mode)
Up to about 2 hours (Fast Mode)

(2) Battery operation Continuous measurement for up to about 1 hour

6) Connection with PC

It is connected with PC with a USB port, and Windows XP, Windows VISTA or Windows 7 (32Bit OS or 64Bit OS) via the USB cable for PC connection (Spectratech OEG-16-06 accessory). And, Installation software (Spectratech OEG-SpO2-07 accessory) is installed so that PC can output various commands, and record or display the measurement data received. **As for PC performance, Intel I5 CPU or above, and 4GB main memory or above are required.**

7) Built-in battery

For main part of Main unit:

4 x AA battery (Continuous operation for about 1 hour)

For photo isolation part:

2 x AA battery (Continuous operation for about 6 months)

For internal clock:

CR2032 Lithium battery (Continuous operation for about 3~5 years)

8) The latest firmware can be downloaded from our website as needed.

Note 1:
The DS (Direct Sequence) method is one of the spread spectrum signal generation methods, called direct diffusion method as well, and modulates by using the random numbers called spread code sequence (PN sequence). In addition, there is FH method (Frequency Hopping) method.

Note 2:
TTL input means +3~+5V digital signal input at high impedance.

§5 Configuration

This equipment consists of the following components.

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2) Spectratech OEG-SpO2-01 Head module	1 set
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9) AC adaptor(+5v,2A output, Medical grade)	1 set
10) User's Manual	1 set

※ The component of which product No. starts with Spectratech OEG-16- is commonly used for Spectratech OEG-16.

1) Spectratech OEG-SpO2 Main unit ····· **1 set**

Front side of Main unit

POWER: It is the power switch. Pushing the upper part turns it ON. When the power is supplied by either of AC adaptor or battery and it is ready to operate, LED on the button lights up.

START: It is the button to start measurement/recording. Pushing the button will start measurement/recording, and LED on the button lights up to indicate starting operation. Pushing the button cannot start operation unless an in vivo calibration was done with CAL button, and CAL LED lights up. If START button is pushed again during a measurement/recording (LED lighting up), it restarts another measurement/recording from the point when it was pushed again after deleting the recorded data till then. It is useful when a recording is started in spite of insufficient preparation when starting a measurement, which may often happen.

STOP: It is the button to stop measurement/recording. Pushing the button will stop the measurement/recording. Green LED in the button lights up to indicate the confirmation of the stop. When not connected with PC, multiple tasks can be measured and recorded by repeating START/STOP. Recording time of the record memory in Main unit is about two hours for Fast Mode, and about ten hours for Fine Mode. Even if START button was pushed, it doesn't begin to record when the memory is full. When the memory became full, please send off the data to PC once for processing the memory to be cleared.

EVENT: The button is pushed when an event trigger is input manually from the front side of Main unit. It corresponds only when it is being measured. The manual event trigger input is prepared also on the rear side of Main unit.

CAL: It is the button for the in-vivo calibration. In case of AUTO mode being described in the separate Software Edition, please push the button once before beginning a measurement after installing the head module to a live body. The LED blinks during the calibration, and becomes in lighting-up state when the calibration ended, then it is possible to measure. It always lights up in case of MANUAL mode, and it can start a recording at any time without performing the calibration process.
In addition, the LED is blinking a little bit faster during the calibration. If it still blinks slowly after the calibration, it warns that some channels are out of the specified signal range. Please confirm the mounting condition of the sensors to the live body. Even under such condition, a measurement/recording can begin.

BATT: It lights up (Red) when the capacity of the battery (4 x AA battery) for the main part of Main unit fell to less than the rated value, it lights up (Red). In case of battery operation, please exchange the battery with charged one soon when the LED lighted up. Continuous operating time of the battery is limited in one hour. This LED may warn in the blinking state besides the lighting on. For the details, please refer to **Appendix 3 Important error display** in this User's Manual.

Rear side of Main unit

SENSOR L: Cable L for SpectratechOEG-SpO2-01 Head module is connected to.

SENSOR R: Cable R for SpectratechOEG-SpO2-01 Head module is connected to.

EXT-EVENT-IN 1: It is used for the measurement/recording start input or the event trigger input from external devices via Spectratech OEG-16-04 BNC cable for external signal input. It is necessary to have mounted 2xAA dry cell to use this input.
It can be used also by connecting the accessory BOX for Spectratech OEG-16-05 manual event trigger input (however, LED on BOX does not carry out lighting operation).

EXT-EVENT-IN 2: It is used for the event trigger input from external devices via Spectratech OEG-16-04 BNC cable for external signal input. It is necessary to have mounted 2xAA dry cell to use this input.
It can be used also by connecting the accessory BOX for Spectratech OEG-16-05 manual event trigger input (however, LED on BOX does not carry out lighting operation).

REMOTE: Cable from Spectratech OEG-16-05 Box for manual event trigger input is connected to. An event trigger can be input manually from this Box besides EVENT switch on the front side of Main unit. Green LED on the Box lights up when an event trigger was accepted.

USB: It is connected to PC with Spectratech OEG-16-06 USB cable for PC connection when various commands are given to Spectratech OEG-SpO2 Main unit from USB, or PC receives measurement data from Main unit.

DC-IN: Cable from the attached AC adaptor is connected to. It is used when operating by connecting to PC, or the battery operation is not wanted despite an independent operation by Main unit.

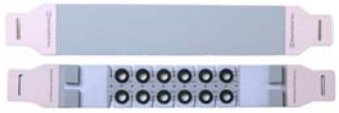
Battery 4 x AA: For main part of Main unit Battery

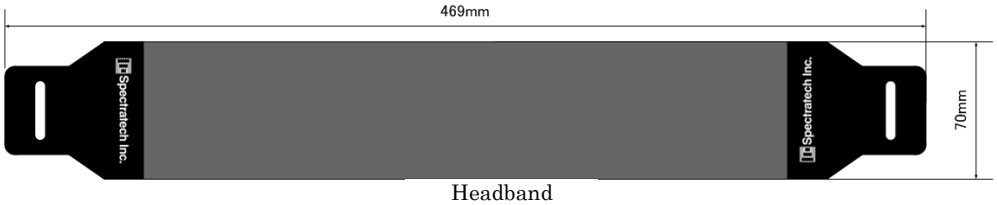
Please equip the battery set in case of battery-powered operation of Spectratech OEG-SpO2 Main unit. It consists of four AA batteries. It is capable of continuous operation for about 1 hour. When the capacity becomes insufficient, BATT-LED on the front side of Main unit lights up (Red) to warn it. When the LED lighted up, please exchange the battery set with charged one soon. When the LED turned on during a measurement/recording, the recording is automatically ended, the data is saved, and it is put into halt state.

Battery 2 x AA: For photo isolation part

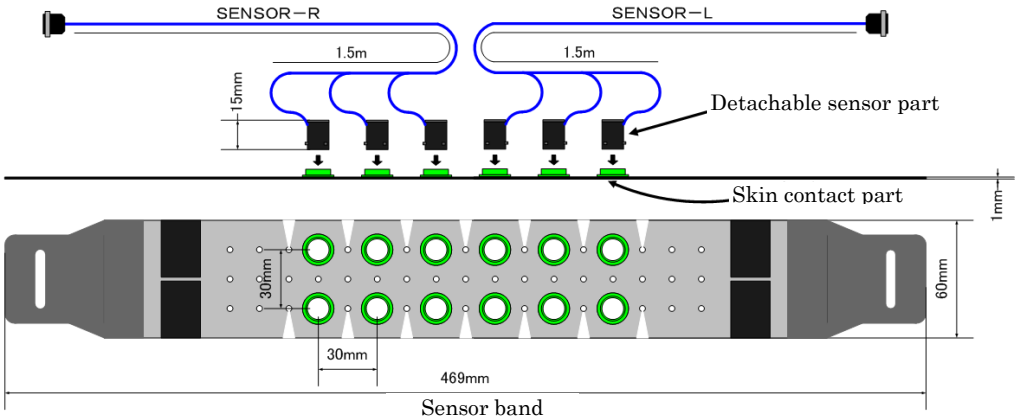
The battery set is used when EXT-EVENT-IN 1 or EXT-EVENT-IN 2 of Spectratech OEG-SpO2 Main unit is connected to external device. It consists of two AA batteries. Since use of this battery makes a complete optical isolation between an external device and Main unit, external devices can be connected safely. It can be used continuously for about 6 months. When EXT-EVENT-IN1 or 2 is not used, this battery need not be equipped.

2) Spectratech OEG-SpO2-01 Head module · 1 set





Headband



Sensor band

It is the high-sensitivity part that is attached to the head to obtain biological information. It consists of the precisely made optical components. Please handle it carefully.
The signal lines from each sensor part of the head module are concentrated into the two connectors. Please connect the connector of Cable L to SENSOR L, and that of Cable R to SENSOR R on the rear side of Main unit. In addition, it is recommended to wipe off oil and dust, etc. on the sensor part with rubbing alcohol before it is installed to the live body.

3) Spectratech OEG-SpO2-03 Carrying bag ····· **1 set**

This bag is an accessory to take along Spectratech OEG-SpO2 Main unit for performing a mobile biological measurement. It is possible to take along it on his/her back like a rucksack, by putting it on his/her shoulder, or wrapping it around his/her waist. In addition, it is not a situation in which an optical mobile measurement of the brain function can be performed practically under the present situation. However, our company, in the situation where even mobile experiment has not been able to be done up to now dared to produce it so that the researchers may do various research experiments to put it to practical use in the future.



4) Spectratech OEG-SpO2-07 Install software in CD-ROM ····· **1 set**

Installing this CD-ROM software on PC makes it possible to use the application software for Main unit. PC with a USB port, and Windows XP, Windows VISTA or Windows 7 (32Bit OS or 64Bit OS) installed is required. **For PC performance, Intel I5 CPU or above, and 4GB main memory or above are required.**

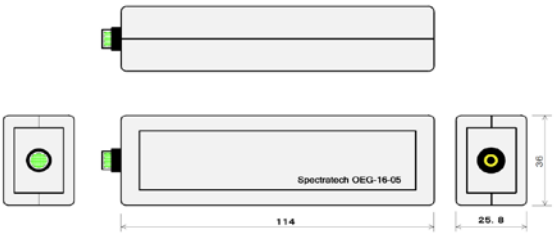
5) Spectratech OEG-16-02 Phantom power supply ····· **1 set**

This phantom power supply is used to confirm that each light-emitting part/light-receiving part of the head module part works properly. The confirmation method is described in **3) Confirmation by phantom power supply** in **§10 Calibration operation**.

6) Spectratech OEG-16-04 BNC cable for external signal input (1.5m) ····· **2 sets**

The two BNC cables are used to start a measurement/recording by Main unit or to input Event trigger from external devices. One end of the BNC cable is connected to EVENT-IN 1 or 2 on the rear side of Main unit, and the other one is connected to the output terminal of the external device with BNC connector that can be used for measurement/recording start or Event trigger. The Main unit corresponds to TTL output from the external devices. When the output specification of the external device does not meet TTL output, please contact us, or our Sales agency/Dustributor without forcibly connecting it.

7) Spectratech OEG-16-05 Box for manual event trigger input (3m cable attached) · · · · · 1 set



This Box assumes to be use when it is required to input an Event input manually a little distance away from Main unit during a measurement/recording. Connector on the cable end of this BOX is connected to REMOTE terminal on the rear side of Main unit. When the button of this Box is pushed during a measurement/recording, it is input as an Event trigger, and when it was acknowledged by Main unit, LED on the button lights up to indicate it.

The BOX can also be used being attached to EXT-EVENT-1 or 2 (however, LED on the BOX button does not carry out the lighting operation).

8) Spectratech OEG-16-06 USB cable for PC connection · · · · · · · · · · 1 set

When various commands are given to SpectratechOEG-16 Main unit from PC, or PC obtains measurement data from Main unit, this cable is used to connect Main unit with PC.

9) AC adaptor (+5V,2A output , Medical grade) · 1 set

When Spectratech OEG-SpO2 Main unit is not operated with the battery, the DC output cable of this adaptor is connected to DC-IN on the rear side of Main unit.

10) User's Manual · 1 set

It includes various instructions for this equipment. User's Manual is also stored in PDF format in the CD-ROM of Spectratech OEG- SpO2-07 Installation software.

*** AA battery ·Not include**

SpectratechOEG-SpO2 Main unit has two storage spaces on the side to store the batteries. One can house four AA Batteries, and the other does two AA batteries.

The set of four batteries is necessary for battery-powered operation of Main unit. A new set is capable of a continuous operation of Main unit for about 1 hour. When the capacity becomes insufficient, BATT-LED on the front side of Main unit lights up (Red) to warn it. When the LED lights up, please exchange the batteries with charged ones.

When the LED lights up during a measurement/recording, the recording is automatically ended, the data is saved, and it is put into halt state.

The other battery set (2 x AA) is used when an external device is connected. Since use of this battery set makes a complete optical isolation between the external device and Main unit, the external devices can be connected safely. It can be used continuously for about 6 months. When EXT-EVENT-IN1 or 2 is not used, this battery set need not be equipped.

§6 Usage environment and utility form

Usage environment

The usage environment should be at ordinary temperature inside the room.
Temperature of usage environment: 5°C~30°C
Humidity of usage environment: 20%~70% (Not condensed)
Waiting time to measurement: Please start a measurement **15 minutes at least** after installing the sensor to the live body. It takes time until temperature of the sensor becomes equal to the body temperature.

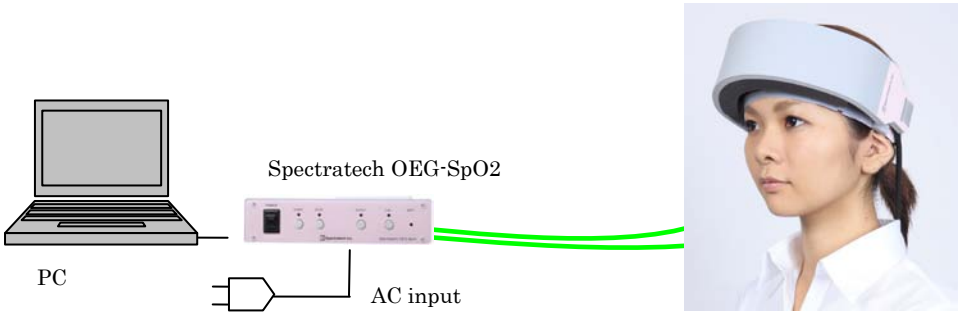
Utility form

Spectratech OEG-SpO2 has the following utility forms.

1) PC-Online 1 (Real-time waveform is displayed on PC while measuring. AC input operation.)
2) PC-Online 2 (Real-time waveform is displayed on PC while measuring. 2 units operate simultaneously. AC input operation.)
3) PC-Offline 1 (Measuring only with Spectratech OEG-SpO2 with battery. Waveform is displayed on PC connected after measurement.)
4) PC-Offline 2 (Measuring only with Spectratech OEG-SpO2 with AC 100V. Waveform is displayed on PC connected after measurement.)

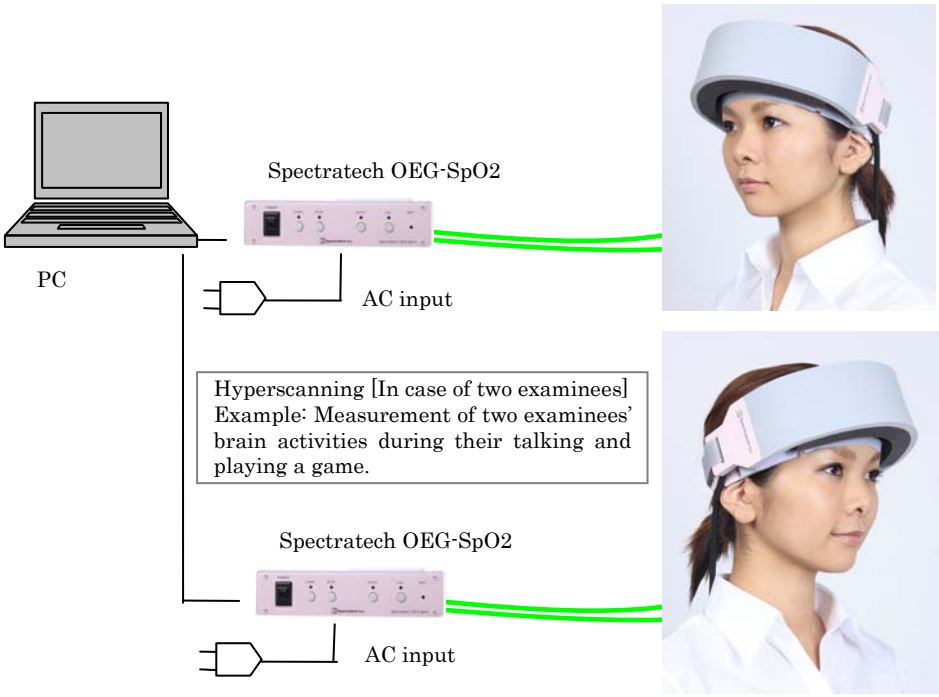
1) PC-Online 1 (Real-time waveform is displayed on PC while measuring. AC input operation.)

It is the most popular utility form. A measurement/recording is processed by one Spectratech OEG-SpO2 connected to PC as the measurement result is being monitored in real time.



2) PC-Online 2 (Real-time waveform is displayed on PC while measuring. Two units operate simultaneously. AC input operation.)

Two Spectratech OEG-SpO2,s are concurrently connected to one PC, and measurement/recording of two examinees is performed simultaneously, and the work is processed while monitoring the measuring process in real time. PC should have two USB ports or more in this case.

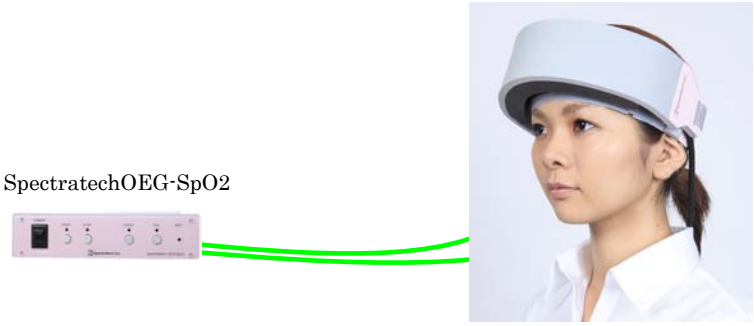


3) PC-Offline 1 (Measuring only with Spectratech OEG-SpO2 with battery. Waveform is displayed on PC connected after measurement.)

The examinee can move freely while measuring because of battery-powered operation. It can continuously measure/record for up to one hour. However, please refrain from strenuous movement because of a cause of artifact (Artifact: Irrelevant noise to the biological signal, movement of the head, for instance).

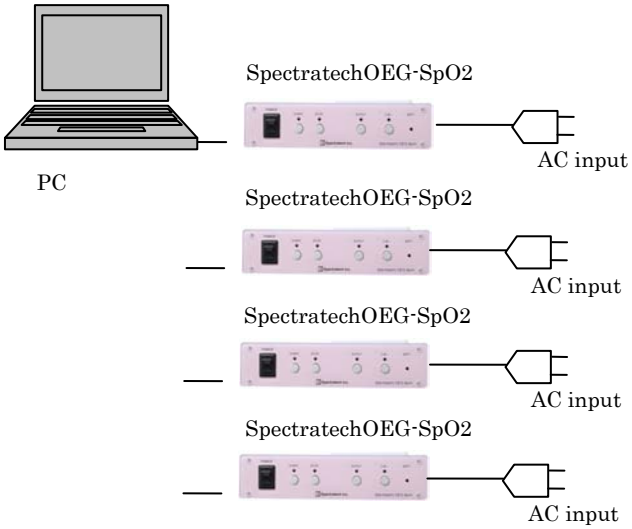
In addition, it is not a situation in which an optical mobile measurement of the brain function can be performed practically under the present situation. However, our company, in the situation where even mobile experiment has not been able to be done up to now dared to produce it so that the researchers may do various research experiments to put it to practical use in the future.

First stage When measuring ------- (Moving freely with battery) -------



Second stage DATA collection + Wave shape display ----------

It can collect from multiple Spectratech OEG-SpO2 units.

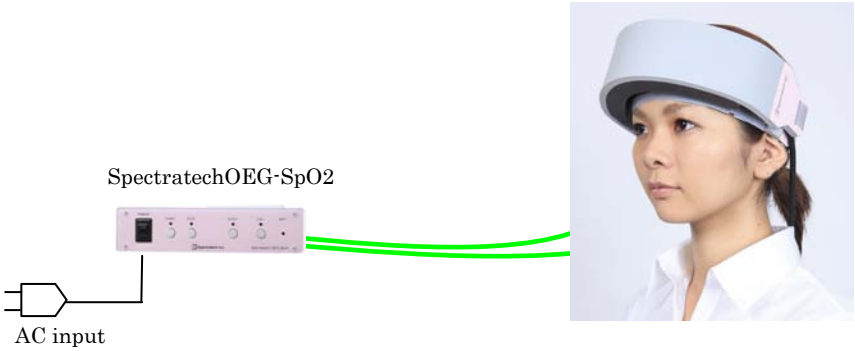


Hyperscanning:
Simultaneous measurement of four examinees
Example: Measurement of the brain activities while a group of four examinees are acting in class.

4) PC-Offline 2 (Measuring only with Spectratech OEG-SpO2 with AC input. Waveform is displayed on PC connected after measurement.)

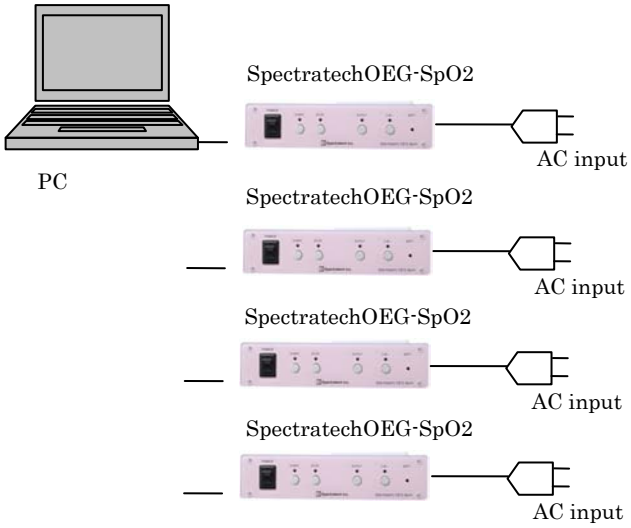
It is convenient when collecting the data that do not move. It is possible to measure/record continuously for up to 10 hours (Fine Mode).

First stage When measuring ---------- (Only Main unit with AC input) ----------



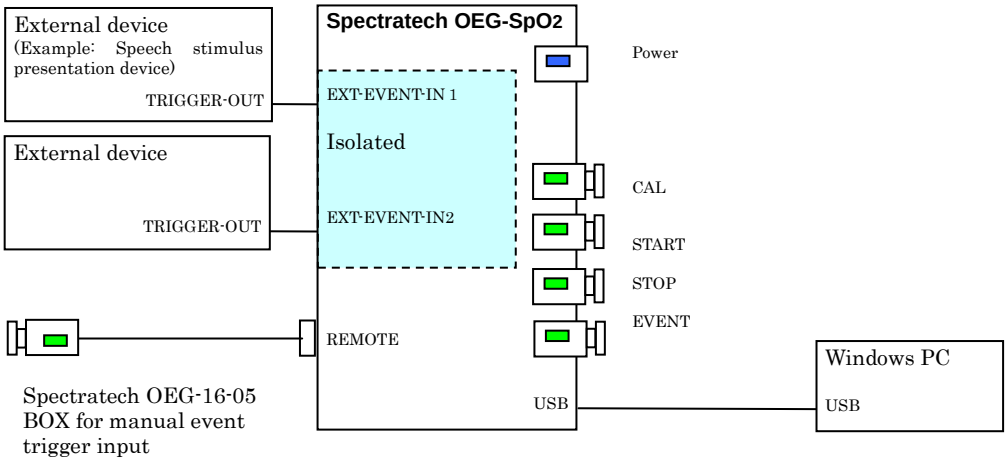
Second stage DATA collection + Wave shape display ----------

It can collect from multiple Spectratech OEG-SpO2 units.



§7 Connection condition for external devices

In general, Spectratech OEG-SpO2 receives a trigger signal of an external device for a simultaneous measurement, for example and starts a measurement synchronous with the external device (EXT-EVENT-IN1). If the measurement is a block design measurement (after-mentioned), for example, Spectratech OEG-SpO2 automatically receives the event start information at the starting point of speech stimulation by a speech stimulus presentation device, and the event (EXT-EVENT-IN2) is captured. In addition, the following connection condition is provided, for example when an event that a measurer wanted to mark occurred the measurer occasionally pushes the switch (Spectratech OEG-16-05 Box for manual event trigger input) in hand to input the event (At this time, Main unit informs the measurer that it was confirmed to have accepted the event by blinking the LED of the switch in hand.), and uses it when processing the measurement data afterwards.



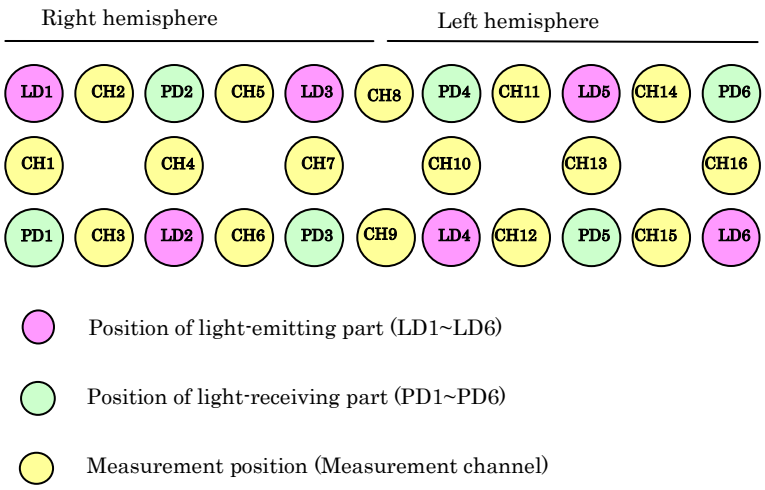
EXT-EVENT-IN1 can be switched by setting from PC when OEG-SpO2 starts a measurement/record and an event trigger is input. EXT-EVENT-IN2 is only for the event trigger input. Therefore, it can operate connecting an external device that causes an event trigger to both IN1 and IN2. As the event input information is individually recorded in Main unit including manual event input from REMOTE, EVENT input on front side of Main unit, and icon click on PC, PC can separately display when which event was input afterward. display is good which event at which time input when PC displays them later.

In addition, as EXT-EVENT-IN1 and IN2 are photo-isolated, the external devices can be connected safely. Please surely load the two batteries in Battery2 (Power supply for the photo isolation) on the side of Main unit when EXT-EVENT-IN1 and IN2 are used. It can be used continuously for about half a year in normal use.

§8 Definition of measurement channel

The measurement channels are defined on this equipment as follows.

When the head module is installed as the above figure, the position is defined as CH1~CH16 in sequence from the right edge toward each measurement position in yellow shown in the figure below.



§9 EVENT input and AUTO-EVENT

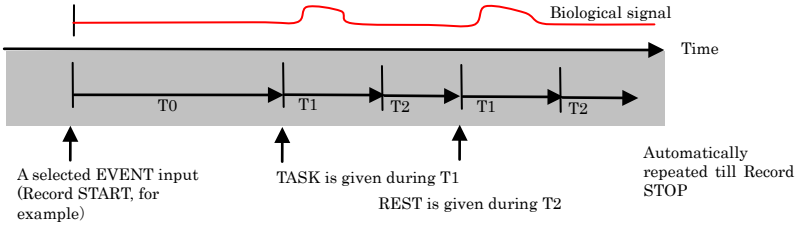
For this equipment, the event input (EVENT input) having been described in up to the preceding chapter and AUTO-EVENT to be explained in this chapter are understood and operate as follows.

1) EVENT input

It is the time signal that was informed to this equipment by an external device or a manual operation. It can be used to judge how the measured/recorded biological signal changed when which event was input as a guide by displaying it together with the biological signal on PC. It is possible to input/record it into the equipment at any time during the measurement/recording by the UDP input from Network (described in User's Manual - Applied Technology Edition in detail), or the mouse instruction on PC when performing measurement/recording by EXT-EVENT-IN1, EXT-EVENT-IN2, and REMOTE on the rear side of Main unit, EVENT on the front side of Main unit, and connecting with PC.

2) AUTO-EVENT

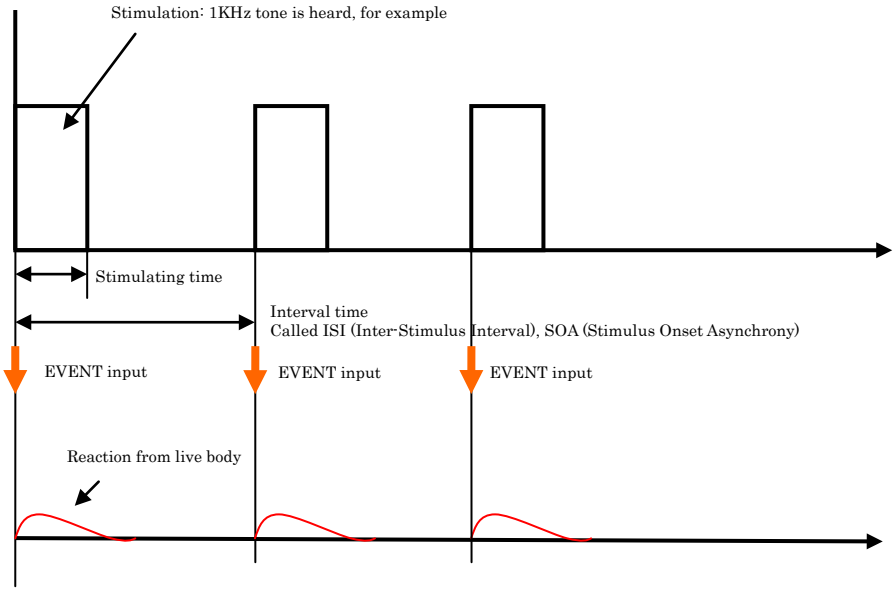
It is the time signal that is automatically displayed additively at regular intervals by this equipment being selected optionally from each EVENT input above 1) or the record start (START) input. It is convenient when describing it watching on PC screen when an automatic stimulation device, etc. is not used, that is, in case of verbal stimulation instruction, for instance. Three kinds of T0, T1, and T2 of time setting can be done for AUTO-EVENT. It is assumed to use each time frame as T0 is the initial beginning time from AUTO-EVENT cause, T1 for TASK time to give stimulation, and T2 for REST time not to give stimulation.



Concept of the general event input is shown in the following.

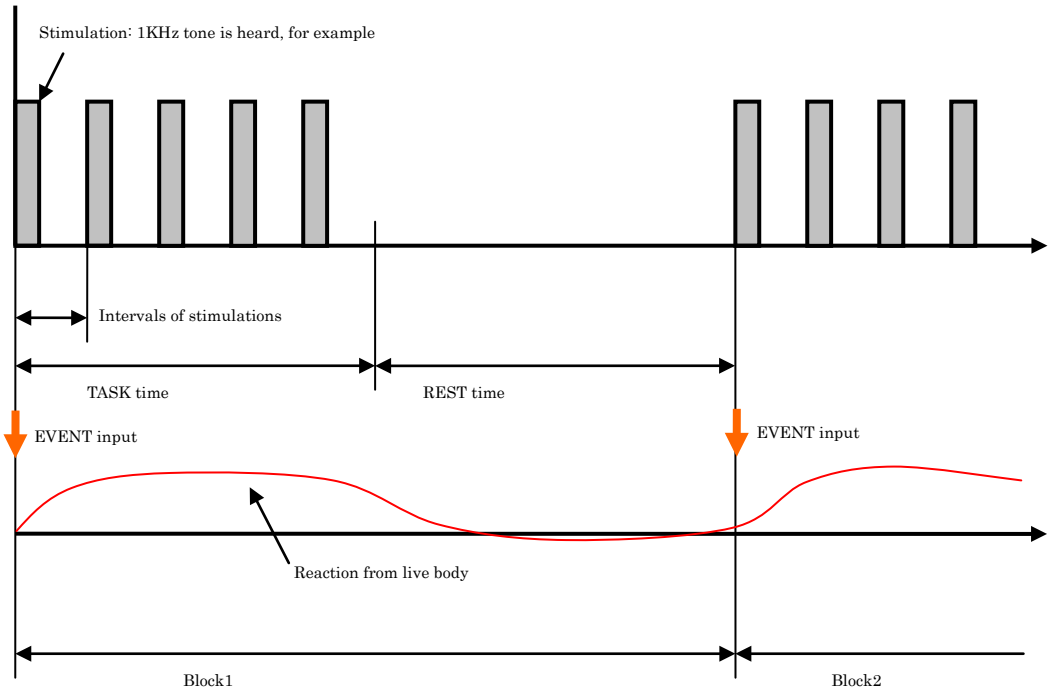
1) Basic concept of Event-Related operation

When some stimulation is begun from a stimulation device a trigger signal is issued, and the equipment accepts the signal as an event input. The live body reacts with beginning of stimulation, and the situation is continuously measured/recorded by the equipment.



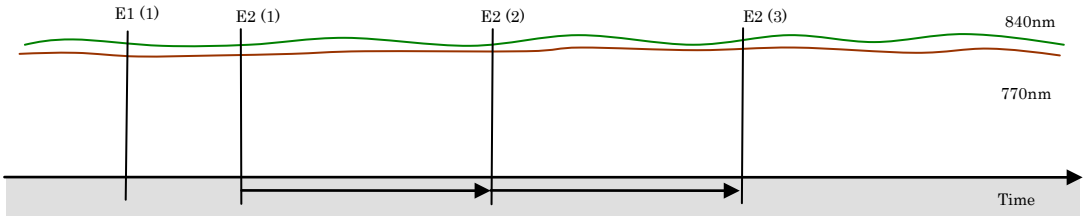
2) Basic concept of Block-Design operation

When some multiple stimulations are begun from a stimulation device a trigger signal is generated, and the equipment accepts the signal as an event input. The live body reacts with beginning of stimulation, and the situation is continuously measured/recorded by the equipment.



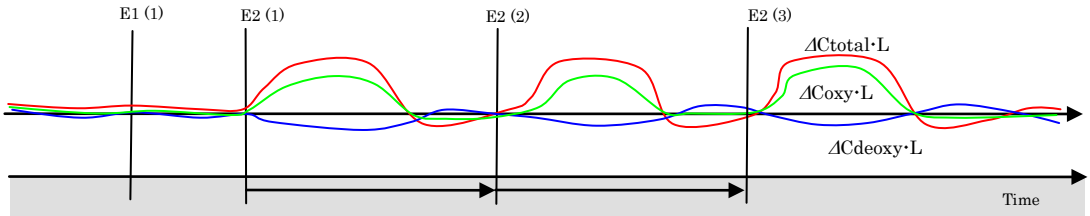
Each signal of EVENT input and AUTO-EVENT can be displayed together with the biological signal on the application software screen of PC. It is possible for any display type of 1) Wavelength display, and 2) Hb change (ΔCoxy·L, ΔCdeoxy·L, ΔCtotal·L) or ApparentSpO2 display. The outline is illustrated below.

1) In case of wavelength display



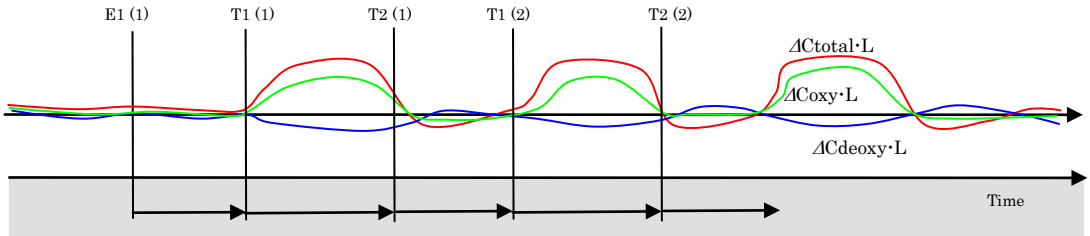
The first Event1 input at time E1 (1)
The first Event2 input at time E2 (1)
The second Event2 input at time E2 (2)
The third Event2 input at time E2 (3)

2) In case of Hb change (ΔCoxy·L, ΔCdeoxy·L, ΔCtotal·L) display



The first Event1 input at time E1 (1)
The first Event2 input at time E2 (1)
The second Event2 input at time E2 (2)
The third Event2 input at time E2 (3)

3) In case of Hb change (ΔCoxy·L, ΔCdeoxy·L, ΔCtotal·L) display by AUTO-EVENT



AUTO-EVENT start input by EVENT1 at time E1 (1).
The first automatic description of AUTO-EVENT-T1 at time T1 (1)
The first automatic description of AUTO-EVENT-T2 at time T2 (1)
The second automatic description of AUTO-EVENT-T1 at time T1 (2)
The second automatic description of AUTO-EVENT-T2 at time T2 (2)

§10 Calibration operation

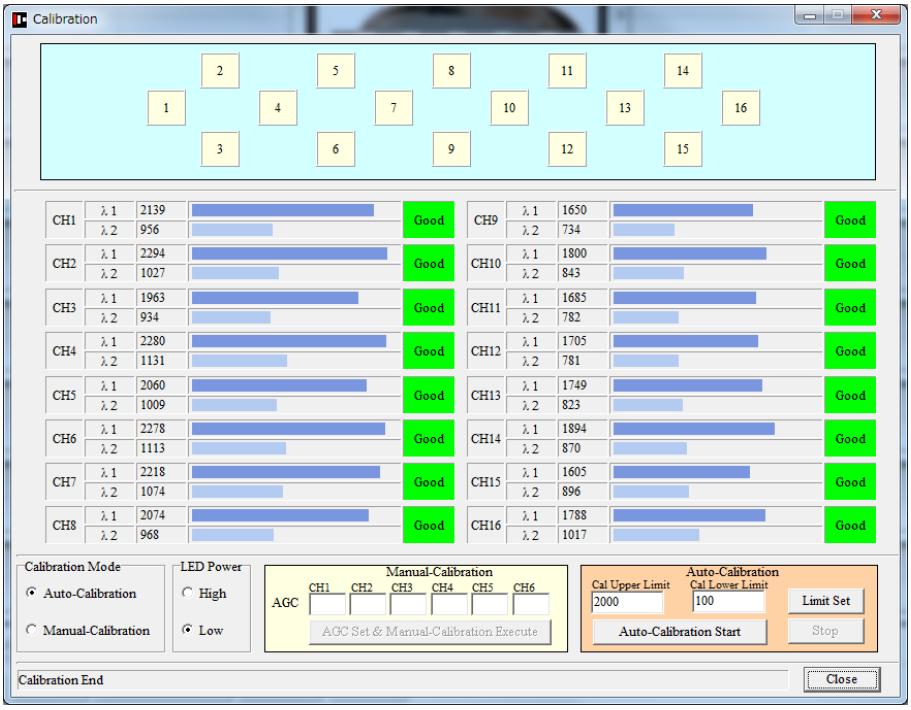
A calibration work should be done before the biological measurement with Spectratech OEG-SpO2 equipment.

1) Biological calibration

Under the condition where the head module of this equipment was mounted to the live body, it means the work to perform an automatic gain adjustment/correction of each sensor in the head module that has variations due to the mounting situation. It is recommended to perform the calibration work at the time of not only mounted to the live body but also starting each measurement. Please note that this operation is for AUTO mode explained in the separate Software Edition. The calibration is not necessary for MANUAL mode. CAL-LED of the equipment always lights up in MANUAL mode.

The biological calibration can be done for the stand-alone equipment as well as when it is connected with PC. Under the condition where the head module was mounted to the live body, (1) click the biological calibration icon (CAL) on the application software when it is connected with PC, or (2) press CAL button on the front side of the equipment when it is not connected with PC. LED on CAL button of the equipment blinks "fast" to inform that it is being calibrated. LED on CAL button of the equipment lights up if the calibration was judged to be able to measure normally. When some signals are weak or too strong, the LED blinks "slowly" and informs the result.

Detailed information in the figure below is shown for the calibration when PC is connected.



It cannot know the details as shown in the above figure at a calibration only by the equipment. However, please try to make it possible to measure by adjusting the mounting condition of the head module, and pushing CAL button again watching the LED status. A measurement/recording can start even if the LED lights up or blinks unless it is turned off.

2) Auto calibration and manual calibration

It can select a calibration method from the two of auto calibration and manual calibration.

Auto Calibration

It is recommended to use this calibration method usually. The auto calibration is a method for OEG-SpO2 to automatically check the biological input signal strength to each sensor for setting the best gain.

CAL Upper Limit

It is the value to direct how much the maximum signal of each measurement channel is set when OEG-SpO2 performs an auto calibration. **2,000** is the recommended value when it is used in a room of usual brightness. When disturbance light is strong (Right under a very bright fluorescent lamp or outdoor, for instance), please try to adjust by reducing it to 2,000, for example as the turbulence light interferes as light energy. On the other hand, when it is used in a very dark room the light energy emitted by OEG-SpO2 itself can be put into the sensor at a maximum because there is almost no cumbersome light energy by the turbulence light. In such case, please try to adjust with 3,000 or 3,500, etc. Then, the gain may go up, and clean biological signal will be obtained. However, if the value is raised too much, the sensor may become saturated and impossible to obtain correct biological signals. Please be careful about it.

CAL Lower Limit

It is the value to direct the minimum signal strength to be measured and displayed on PC screen when OEG-SpO2 performs an auto calibration. If it is below the value, it cannot be an object. However, it was obtained as measured data, and exists on the measured data which the application software puts out to the file. So, it will be used for analysis, etc. afterward. Around **100** is the recommended value. Please also note that the biological signals around 0~200 may include a lot of noises, and it is not easy to see it considerably on a graphical display. An appropriate value may be selected depending on the experiment objective.

Manual Calibration

Manual calibration is a method of the user's specifying the gain of each sensor.

AGC--CH1-CH2-CH3-CH4-CH5-CH6

OEG-SpO2 equips six sensors. It can set the gain of each sensor (PD1, PD2, PD3, PD4, PD5, and PD6 in the gain (AGC) range of 0~255 times individually.

Since Hb change (ΔCoxy･L, ΔCdeoxy･L) is a relative value, even if the gains of each sensor differs it is the world in which no problem is taken at all. However, the wavelength data obtained by OEG-SpO2 being based on it has been acquired as absolute value. When it conducts some comparison experiments with the wavelength data in absolute value, etc., it is convenient to fix the gain of all the sensors by the manual calibration. Please use the manual calibration for such experiment.

LED HighPower and LowPower

Light-emitting part of OEG-SpO2 has a power control part that can emit the two-staged light energy such as High Power and Low Power. Please note that it does not control individual light-emitting part, and common to all the light-emitting parts. The user can select either one of the two on the calibration screen.

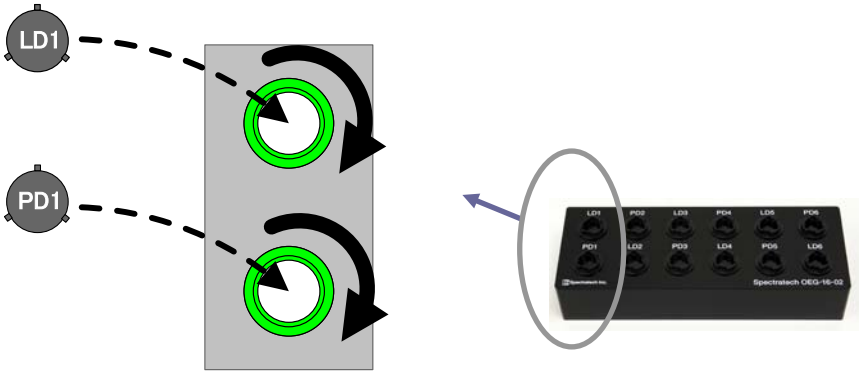
Please use it with Low Power usually as it may influence the lifetime. In addition, Low Power is recommended for battery-powered operation because it influences the power consumption. High Power should be used only when the sensitivity is insufficient with Low Power.

3) Confirmation by phantom power supply

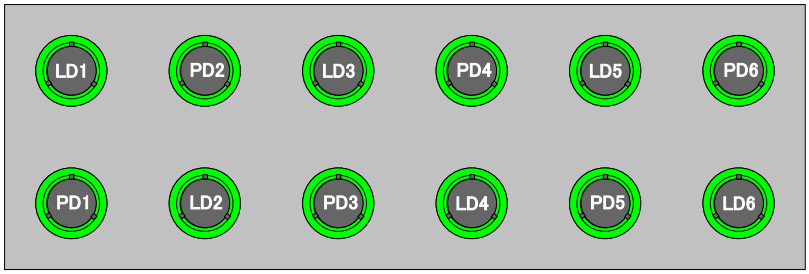
Please confirm the sensor operation by using the bundled SpectratechOEG-16-02 Phantom power supply if there is suspicion that the bioinstrumentation data is doubtful or the sensor does not work normally at the calibration.

Mounting method to phantom power supply

Each detachable sensor part of SENSEO-R and SENSOR-L of the head module is mounted in each specified position on Phantom power supply following the black dash line in the figure below. And, it is rotated in the direction of the black solid line arrow to fix it.



Please arrange each detachable sensor on Phantom power supply as shown in the figure below.



How to confirm sensor operation

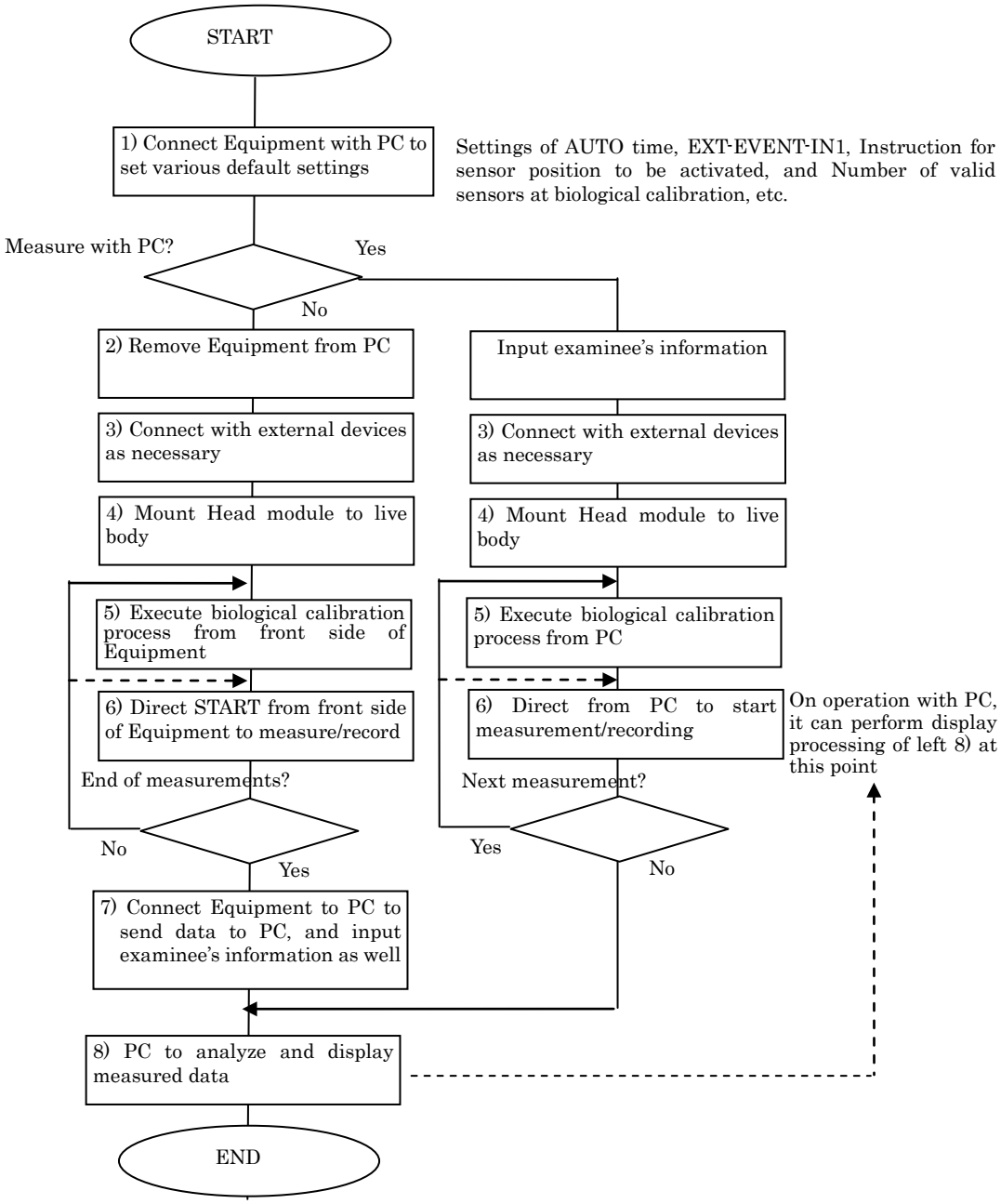
When the mounting to Phantom power supply was completed, the biological calibration (CAL) is done from the application program on PC. The screen shown in the figure below appears when the calibration was completed.

Supposing that **2000** is assigned to Cal Upper Limit, if the value of each λ1 remains in about **2000±40%**, it can be judged that those sensors are normal. In addition, though the value of λ2 indicates half the value compared with λ1, it is no problem because of the characteristic of ND filter in Phantom power supply.

§11 Flow of measurement and recording operation

Flow in outline

Flow of the equipment's measurement/recording is outlined as follows.



1) To connect Equipment with PC to do various default settings

A) Attach the head module to the equipment.
B) Connect the equipment with PC using the accessory USB cable.
C) Turn on the equipment and PC.
D) Boot up the application software on PC.
E) Set the various setting items on MAIN screen and in each window.
(Details are described in the separate Software Edition.)

2) To remove Equipment from PC

A) Turn off the equipment.
B) Remove USB cables from PC and the equipment.

3) To connect with external devices as necessary

A) External device is connected to EXT-EVENT-IN1 or IN2 on the rear side of the equipment using Spectratech OEG-16-04 BNC cable for external I/O signals as necessary. The equipment accepts TTL level input. It should be connected after confirming that the output of the external device has TTL output. When EXT-EVENT 1 or 2 is used, it is necessary to load two AA batteries into the Battery 2xAA space. It should be checked to have loaded two AA batteries in sufficient capacity before measurement. The battery can be used continuously for about half a year. If an event input from the external device is not accepted, the battery might be weak. In that case, the battery should be checked.
B) When an event input by manual operation is necessary, Spectratech OEG-16-05 BOX for manual event trigger input is connected to REMOTE on the rear side of the equipment.
C) It is necessary to load four AA batteries in sufficient capacity into the Battery 4xAA when the equipment operates in stand-alone mode with the batteries.
D) When the equipment operates with AC input, the bundled AC adaptor is connected to the commercial power, and the cable end of this adaptor is connected to DC-IN on the rear side of the equipment.
E) Turn on the equipment after the above-mentioned preparation was completed.

4) To mount Head module to live body

Spectratech OEG-SpO2-01 Head module is mounted to the live body. All of the six light-emitting parts and the six light-receiving parts (sensor) must be carefully mounted to the live body in close contact.

5) To process biological calibration from front side of Equipment, or to do it from PC

A) It is confirmed that STOP-LED on front side of the equipment lights up. In that condition, the biological calibration can be done.
B) CAL button on the front side of the equipment is pressed, or CAL icon on the application window is clicked when connecting with PC. Then, the calibration of the equipment is begun, and LED on the CAL button of the equipment lights up if it can be judged to measure it almost normally.
C) Detailed information shown in the figure below is displayed for the calibration when PC is connected.

D) It cannot know the details as shown in the above figure at a calibration only by the equipment. However, please try to make it possible to measure by adjusting the mounting condition of the head module, and pushing CAL button again watching the LED status. A measurement/recording can start even if the LED lights up or blinks unless it is turned off. The calibration is not necessary in the MANUAL mode. The LED always lights up in MANUAL mode.
E) Here, please wait for about 15 minutes until the sensor becomes to fit in the live body temperature for the first measurement after turning on the power supply, or the one when the examinee was replaced.

6) To direct START from front side of Equipment to measure/record, or to direct PC to start measurement/recording

A) It can start a measurement/recording when CAL-LED lights up or blinks "slowly".

B) It starts a measurement/recording to press START button on the front side of the equipment, or to click START icon in the application window on PC.

C) When a recording started, the LED on START button lights up, and the LED on STOP button turns off.

D) After a measurement/recording started, pressing START button again (Note 1) is acknowledged as restart, and it deletes the measured/recorded data up to now, and starts a measurement/recording again from the restart point. It is convenient for starting an experiment over again, etc.

E) When a necessary measurement time passed, it presses STOP button on the front side of the equipment, or clicks STOP icon in the application window on PC. It is informed that the measurement/recording was stopped by the lighting-up of STOP-LED on the front side of the equipment.

7) To connect Equipment with PC to send data in Equipment to PC, and to input examinee's information as well

A) When a measurement ended, the power supply of the equipment is turned off first.

B) The equipment is connected with PC with the bundled USB cable.

C) Turn on the power supply of the equipment.

D) Click LOAD icon in the application window on PC.

E) PC obtains the measured/recorded data in the equipment. It rather takes a time to obtain a data measured for one hour.

8) PC to analyze and display measured data

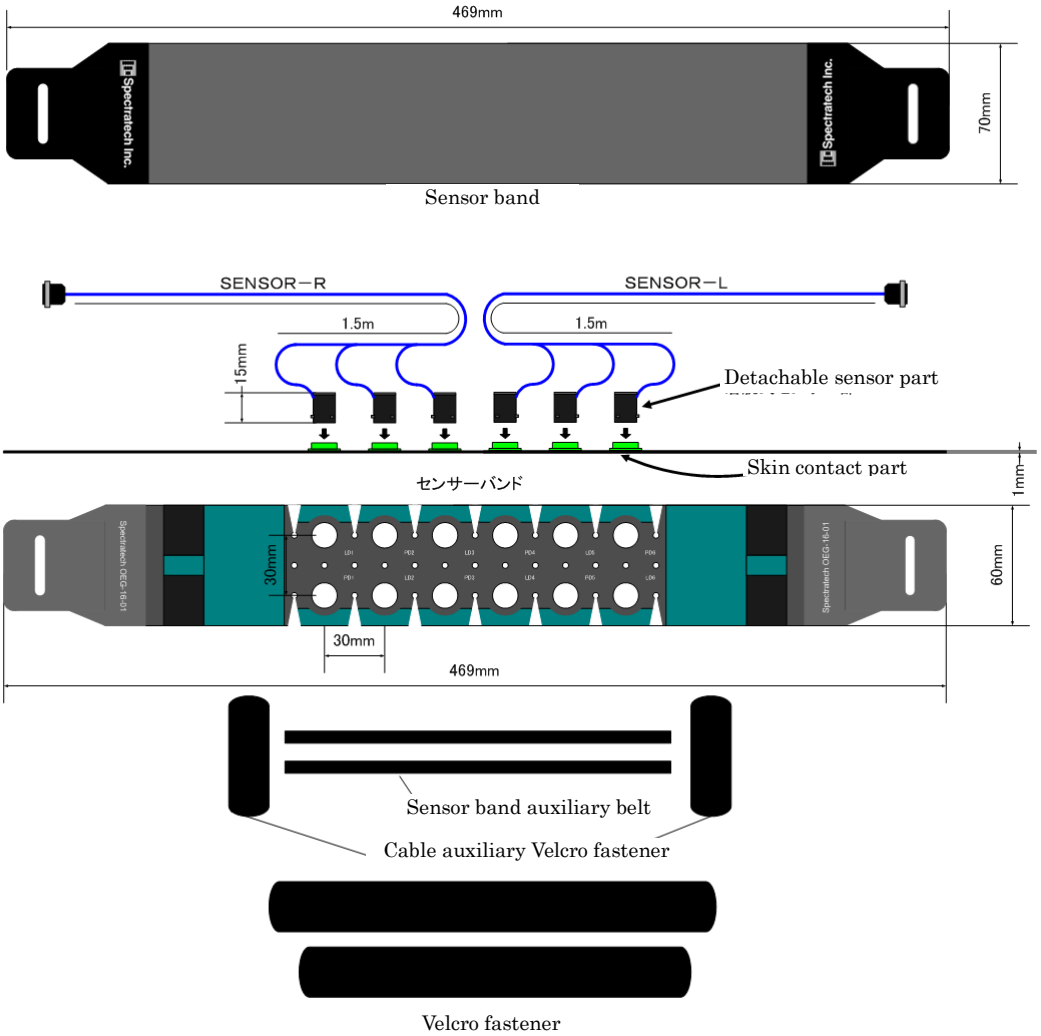
Various filtering processes are given to the obtained data to remove the noises, and the data can be displayed with wavelength or Hb change (⊿Coxy･L, ⊿Cdeoxy･L) together with the event input information. When operating with PC, the result can be displayed in real time while measuring it. (The details are explained in the separate Software Edition.)

Note 1: To avoid the operational error, it can set how long to push each button of START, STOP, and CAL on PC optionally between one and three seconds beforehand for actually acknowledged as ON. For the details, please refer to the **Paragraph SW Time in §15 ® OEG-16 Devie Control (Sensor Config) in Software Edition I**.

§12 Handling method of head module

SpectratechOEG-SpO2-01Head module consists of the following items.

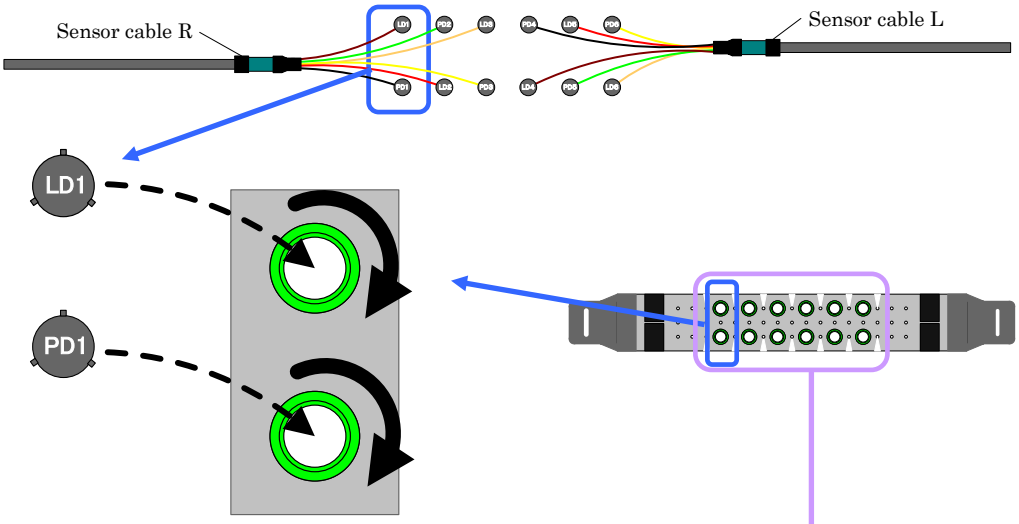
1) Headband ····· 1set
2) Sensor band ····· 1set
3) Velcro fastener ····· 2 sets
4) Cable auxiliary Velcro fastener ····· 2 sets
5) Sensor band auxiliary belt ····· 2 sets
6) Detachable sensor part SENSOR-R ····· 1 set
7) Detachable sensor part SENSOR-L ····· 1 set



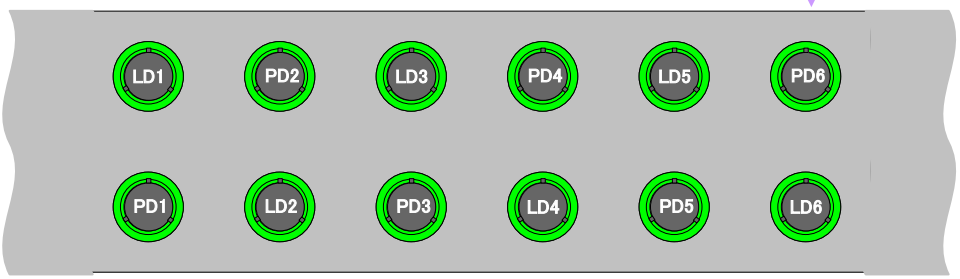
Mounting method to live body

STEP 1

Each detachable sensor part of the sensor cables SENSEO-R and SENSOR-L are inserted into each skin contact part on the sensor band following the black dash line shown in the figure below, and it is rotated in the direction of the black solid line arrow to fix it.

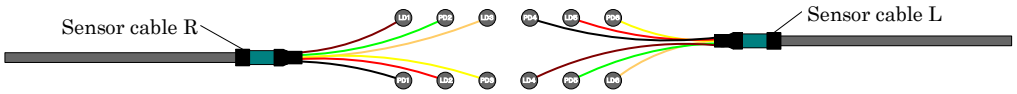


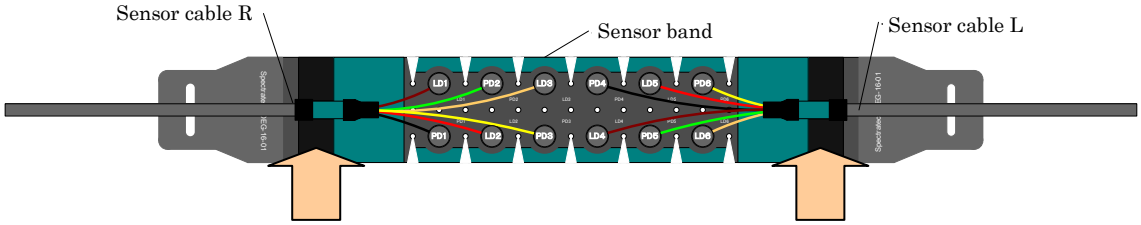
Each detachable sensor of SENSEO-R, SENSOR-L is arranged like the figure below.



STEP 2

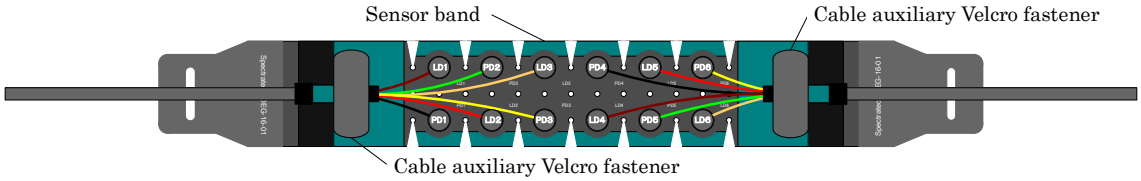
The Velcro fastener part on the sensor cable is mounted to the Velcro fastener part on the sensor band firmly after mounting the sensors. (The part marked by the arrow in orange color.)





STEP 3

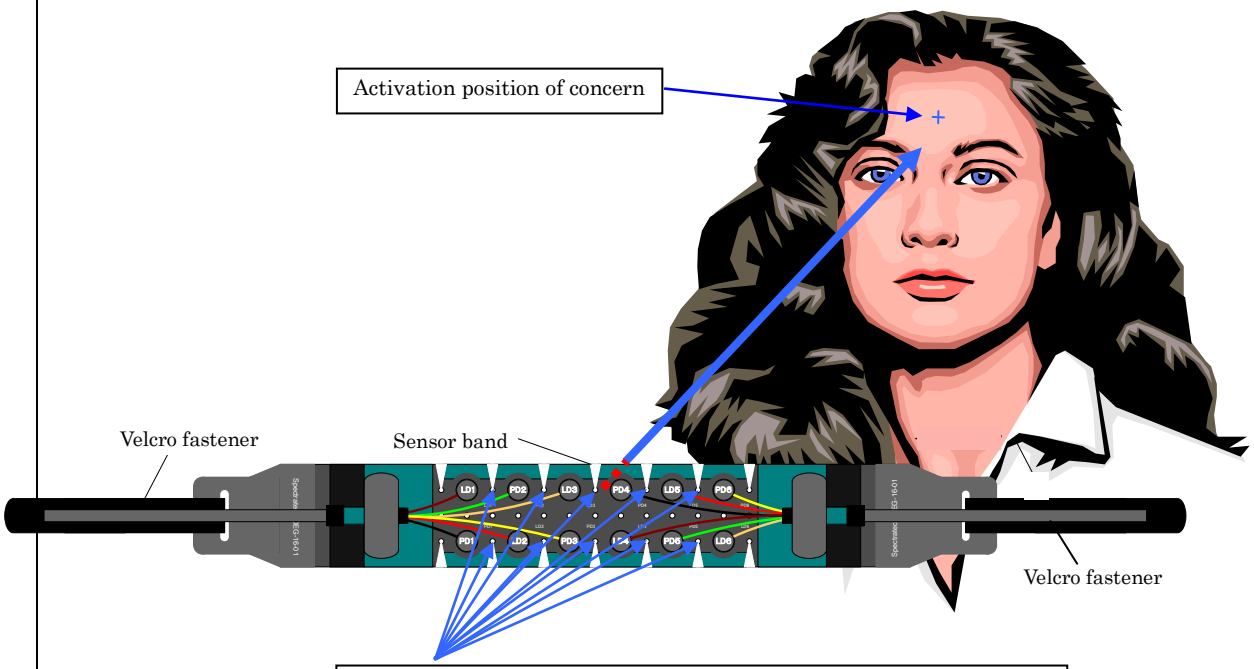
Though it is absolutely no problem to use it in STEP2 condition, it is recommended to hold further with the cable auxiliary Velcro fastener as shown in the figure below when it is wanted to mount the cable more firmly.



STEP 4

First, the Velcro fastener is passed through both ends of the sensor band.

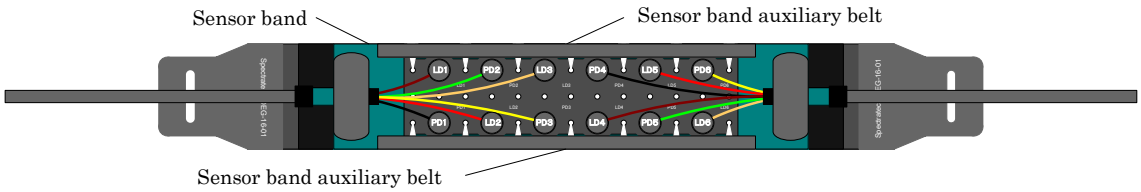
Since an indication hole is prepared at the activation position on the sensor band, it mounts the sensor band on the concern position of the live body using the indication hole, and fixes it with the Velcro fastener behind the head.



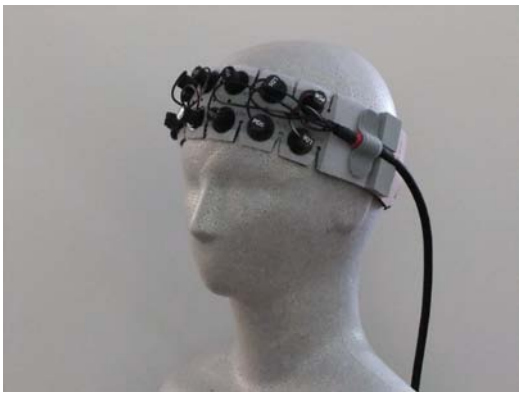
The position of each hole in 3mmΦ, which is provided in the center of each light-emitting part and light-receiving part corresponds to the activation position. Please use it for the indication when mounting it to the live body.

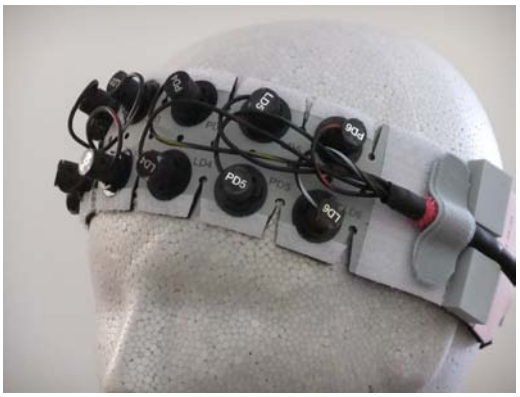
STEP 5

Depending on the live body, the sensor might float somewhat from the live body due to the curvature of the frontal lobe even if it is held with the headband. In such case, the sensor band auxiliary belt is used to stabilize it. While the sensor band is mounted to the live body, the sensor band auxiliary belt is mounted from the edge of the auxiliary belt to each Velcro fastener part of the sensor band side in order as pulling the belt a little. The two sensor band auxiliary belts are provided, which can be mounted to both upper and lower side of the sensor band. Generally, even only the upper side produces an appreciable effect.

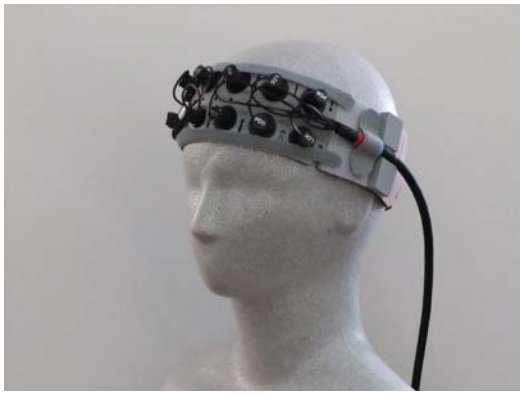


Before sensor band auxiliary belt mounted





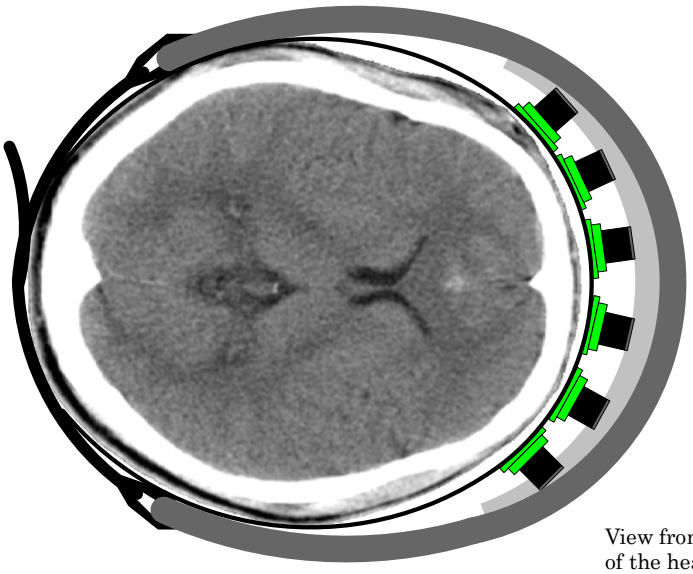
After sensor band auxiliary belt mounted



STEP 6

The Velcro fastener is mounted to the headband as well as the sensor band, and it is mounted onto the sensor band already mounted to the live body as covering the sensor band with it. At this time, it must be carefully done so that the soft urethane sponge part inside the headband holds all the detachable sensors, and the skin contact face of the detachable sensor contacts the live body with no gap.

Headband



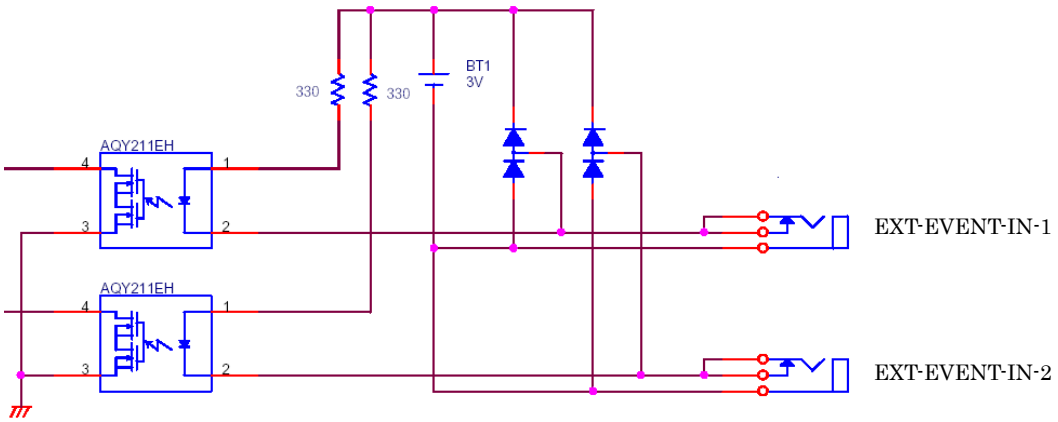
View from vertex of the head

Appendix 1 Input specification of EXT-EVENT-IN-1 and -2

Input specification of EXT-EVENT-IN1 and EXT-EVENT-IN2 is as follows.

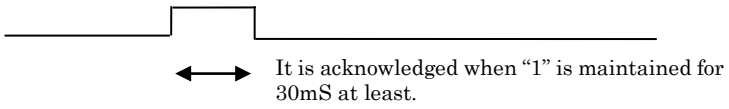
Input specification: TTL input. It is judged as "1" for 2~5V, and "0" for 0.8V or less.
Polarity: Both the negative polarity and the positive polarity can correspond by setting from PC.

Equivalent circuit schematic:

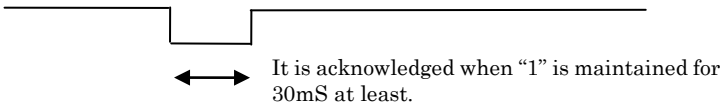


Timing specification:

1) In case of positive logic



2) In case of negative logic



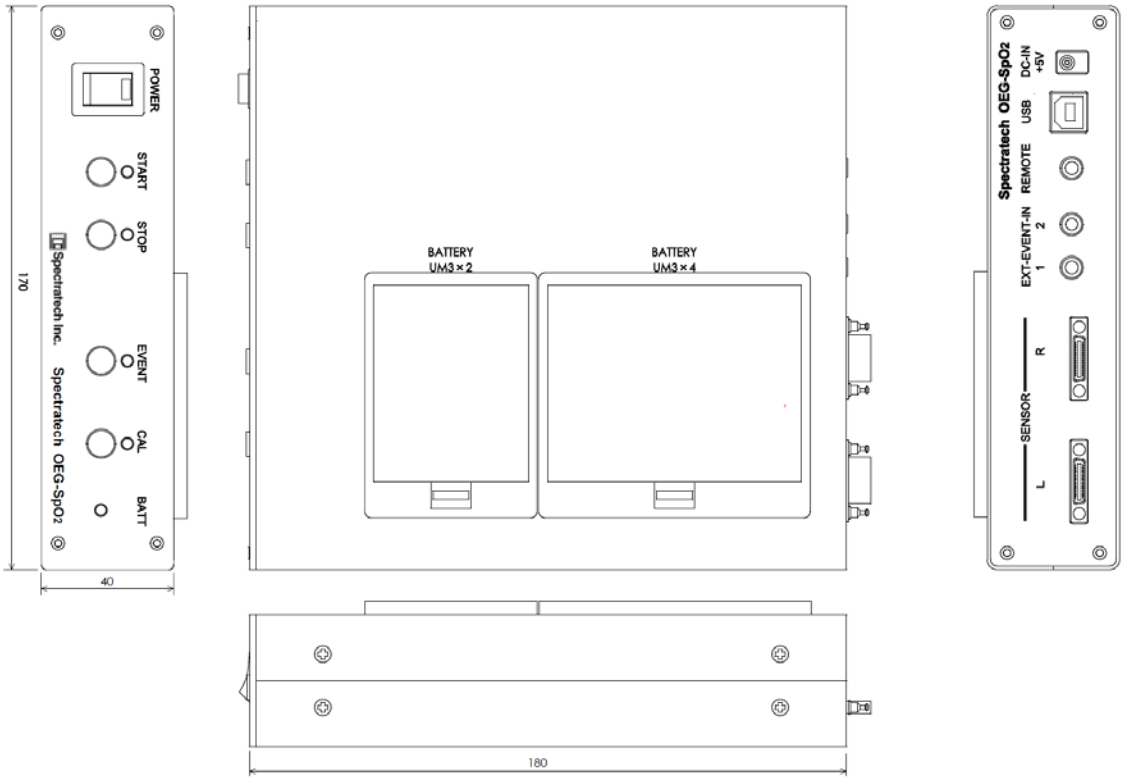
Precaution:

The dry batteries loaded in the Battery 2xAA are used for the power supply for optical isolation of EXT-EVENT-IN1 and EXT-EVENT-IN2. When it is connected with an external device with positive logic, the power energy must be consumed as long as the external device is connected. It is recommended to remove the pertinent cables when the measurement/recording was finished for making the batteries last long.

Appendix 2 Outline dimensional drawing

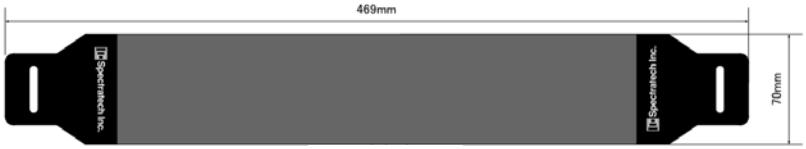
Spectratech OEG-SpO2 Outline dimensional drawing of Main unit

Dimension: 40mm (H) x 170mm (W) x 180mm (D)
Material: Aluminum
Weight: Approx. 600g (Without batteries loaded)
Approx. 750g (Six batteries loaded)

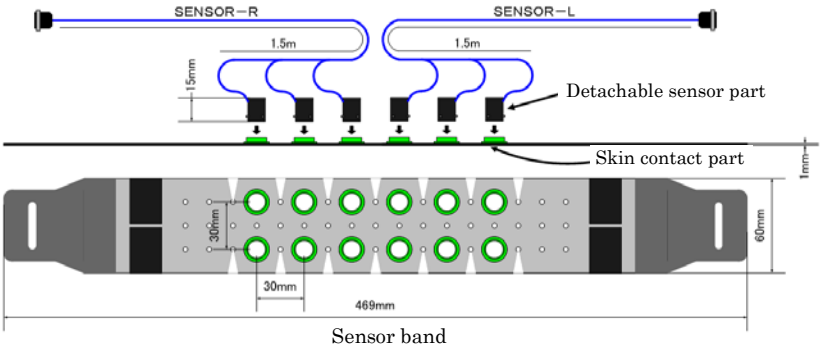


Spectratech OEG-SpO2-01 Head module Outline dimensional drawing:

Dimension:	Headband	70mm (H) x 469mm (W) x 29mm (D)
	Sensor band	60mm (H) x 469mm (W) x 1mm (D)
	Detachable sensor part	15mm (H) x 11mm (Φ)
Material:	Headband	Neoprene sponge (outside), urethane sponge (inside)
	Sensor band	PE (Polyester) 100%
	Detachable sensor part	POM (Polyoxymethylene)
Weight:	Approx. 250g	



Headband



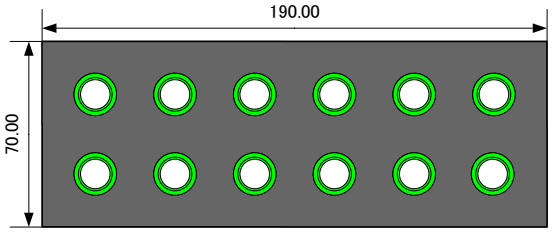
Sensor band

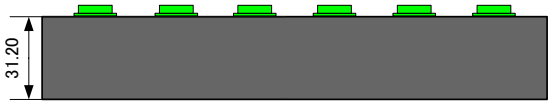
Spectratech OEG-SpO2-03 Carrying bag external dimensions

Dimension:	55mm (H) x 190mm (W) x 205mm (D)
Material:	Fabric cloth
Weight:	250g

Spectratech OEG-16-02 Phantom power supply

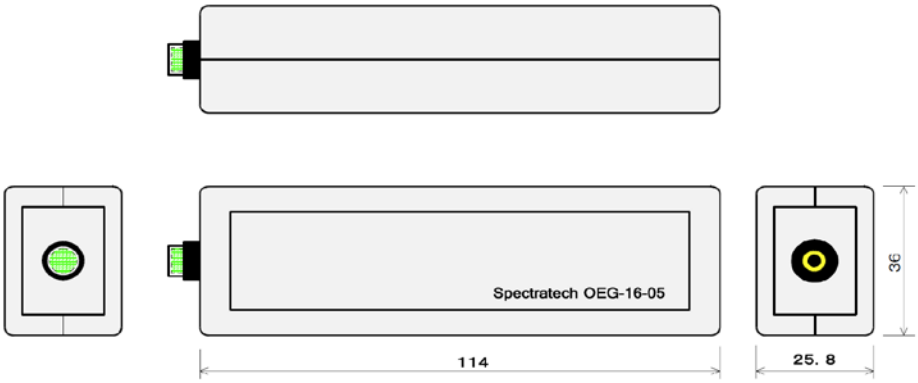
Dimension: 31.2mm (H) x 190mm (W) x 70mm (D)
Material: ABS resin in black
Weight: 480g





Spectratech OEG-16-05 BOX for manual event trigger input Outline dimensional drawing

Dimension: 25.8mm (H) x 36mm (W) x 114mm (D)
Material: ABS resin



Appendix 3 Important error display

1) RTC ERROR (Real Time Clock ERROR)

Spectratech OEG-SpO2 Main unit equips a clock inside, for which a small battery is also equipped. The lifetime is roughly 3~5 years in calculation. If this battery was burned out, the date information in the measured data becomes an unexpected value. Therefore, when Spectratech OEG-SpO2 Main unit detected the battery burned out at starting a measurement, it stops all the usual operations, and blinks BATT-LED (Red) on front side of Main unit to warn you.

Action: If BATT-LED **"blinks fast"** at starting a measurement, open the cover of Main unit loosening the screws to check the battery in the 10 yen coin size. Then, replace it with a new one, and reset the clock from the application software on PC. How to reset the clock is described in **Paragraph SW Time** in **§15 ® OEG-16 Devie Control (Sensor Config) in Software Edition I**.

Model of battery: CR2032 Lithium battery (It's easily obtained at a convenient store, etc.)

2) DATA ROM ERROR

When Spectratech OEG-SpO2 Main unit is operated in PC-Offline1 Mode, that is, a measurement/record operation is done with the battery the measured data will be stored in DATA-ROM in Main unit. Usually, a work proceeds normally by deleting the pertinent recorded data after connecting it with PC later, and completing acquisition of the data using LOAD icon. However, DATA-ROM will be full with the recorded data for about 10 hours (Fine Mode) if it was not deleted for too long a time. If it still tries to start a recording in PC-Offline1 Mode, BATT-LED on the front side of Spectratech OEG-SpO2 Main unit blinks to warn you. Of course, it cannot record anymore.

Action: "Slow blinking" of BATT-LED means that DATA-ROM is full. Please delete the data in Spectratech OEG-SpO2 Main unit to secure the space by connecting it with PC, starting up OEG16.exe application, and using the data erase icon in LOAD icon on the main screen.

3) Definition of BATT-LED

BATT-LED on the front side of SpectratechO OEG-SpO2 Main unit provides three kinds of the following error expressions.

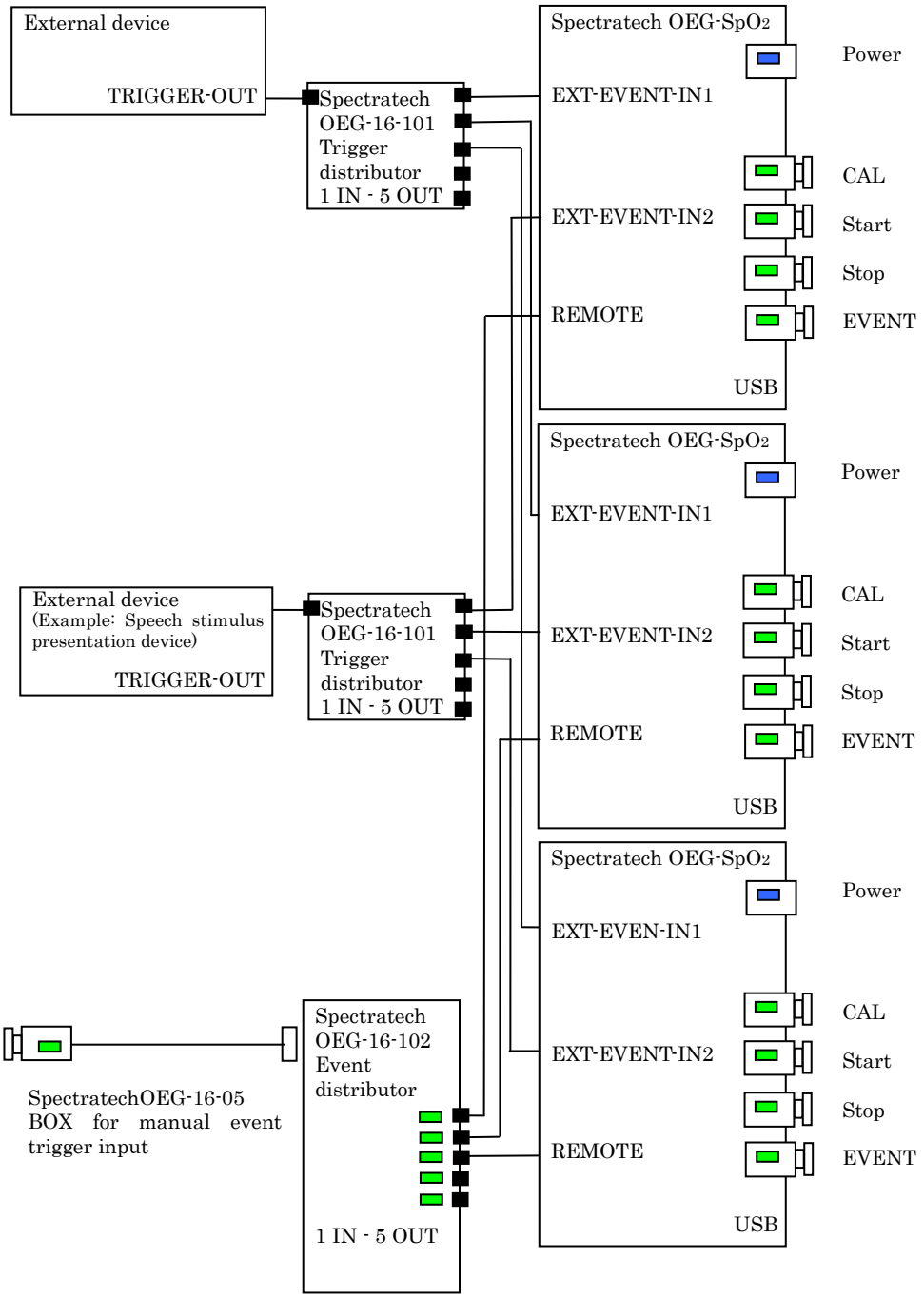
Lighting-up: It lights up when Spectratech OEG-SpO2 is being operated, that is, in PC-Offline1 Mode, the capacity of the battery (a block of four AA batteries) for the main part of Main unit falls less the defined value.

Fast blinking: It blinks when the above RTC ERROR occurred. The indication of the estimate is the same as the blinking speed during CAL (Calibration).

Slow blinking: It blinks when a DATA ROM ERROR occurred. The indication of the estimate is the same as the warning blinking speed when the signal is too weak after finishing CAL.

Appendix 4 Synchronous operation of multiple OEG-SpO2 equipments with external event input

When multiple OEG-SpO2's operate with one Trigger factor/Event factor, the following connection is possible using the optional Spectratech OEG-16-101 and Spectratech OEG-16-102. Though the figure below shows a simultaneous connection diagram for up to 5 sets, the operation by six or more sets is also possible with the cascade connection of Spectratech OEG-16-101 and 102.

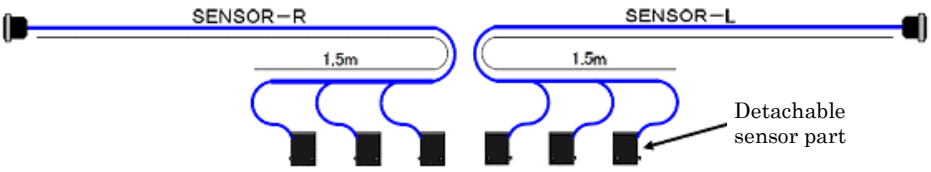


Appendix 5 List of model numbers for order

Item	Product name	Model number for order	Remarks (Minimum order)
Main unit	Optical Encephalography	Spectratech OEG-SpO2	1 set
Maintenance supplies	Sensor part (L, R) 1.5m	Spectratech OEG-SpO2-01-0115	1 each of L, R Cable length 1.5m
Consumables	Sensor band	Spectratech OEG-SpO2-01-02	1 pc (1 pc preattached to Main unit)
Consumables	Headband	Spectratech OEG-SpO2-01-03	1 pc (1 pc preattached to Main unit)
Maintenance supplies	Carrying bag	Spectratech OEG-SpO2-03	1 pc (1 pc preattached to Main unit)
Consumables	Adhesion pad	Spectratech OEG-16-01-04	6 sheets (6 sheets preattached to Main unit)
Maintenance supplies	Sensor cover	Spectratech OEG-16-01-05	12 pcs (12 pcs preattached to Main unit)
Maintenance supplies	Sensor adaptor	Spectratech OEG-16-01-06	12 pcs (When attaching to the live body by oneself)
Maintenance supplies	Phantom power supply	Spectratech OEG-16-02	1 pc (1 pc preattached to Main unit)
Maintenance supplies	BNC cable for external signal input	Spectratech OEG-16-04	2 pcs (2 pcs preattached to Main unit)
Maintenance supplies	BOX for manual event trigger input	Spectratech OEG-16-05	1 pc (1 pc preattached to Main unit)
Option	Velcro tape kit	Spectratech OEG-SpO2-01-0101	6 different-length Velcro tapes
Option	Trigger distributor 1IN 5OUT	Spectratech OEG-16-101	1 pc (Common to Spectratech OEG-16)
Option	Event distributor 1IN5OUT	Spectratech OEG-16-102	1 pc (Common to Spectratech OEG-16)
Option	Carrying case	Spectratech OEG-16-201	1 pc (Common to Spectratech OEG-16)

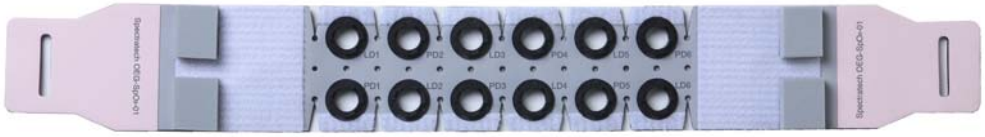
Spectratech OEG-SpO2-01-0115 Sensor part (L, R) 1.5m

It is the same as the sensor preattached to Spectratech OEG-SpO2 Main unit. The cable length is 1.5 m. (The connector is not compatible with the sensor for Spectratech OEG-16).



Spectratech OEG-SpO2-01-02 Sensor band

The sensor band is a part to touch the live body directly. When it has become dirty with sweat, etc., please use a new sensor band.



Spectratech OEG-16-01-03 Headband

The headband is made of a very soft material (Neo Plain) so that a strain may not be applied as much as possible to the live body. If it is used carefully, it can be used for a long time, however please understand it as consumables.

Spectratech OEG-16-01-04 Adhesion pad

Without using Spectratech OEG-16-01 head module, it can experiments by making it adhere to a concerned portion of the live body using this adhesion pad. Since the adhesibility is the same material as the adhesion pad used for an electrocardiograph, it is not so strong. When it is used in the frontal lobe, please press it down firmly with SpectratechOEG-SpO2-01-03 headband after being mounted. Although it is not so practical, a possibility to be able to experiment even in an environment of a little intense movement may become higher since it adheres to the live body. It is possible to use it also when conducting a metering experiment on the belly, and the arm, etc.

Appearance when adhesion pads are attached to sensors

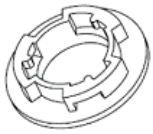
Spectratech OEG-16-01-05 Sensor cover

It is a cover to protect the optical surface of the sensor of Spectratech OEG-SpO2-01. If the sensor cover has been mounted when not using the sensor, the optical surface (light-receiving part, emitting part) is safely managed. Although the required covers are preattached to Main unit, please order it when it was lost, etc.

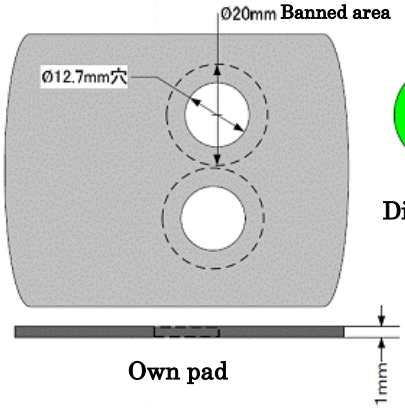
Spectratech OEG-16-01-06 Sensor adaptor

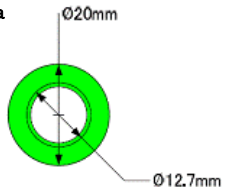
You may use this sensor adapter when you experiment by mounting Spectratech OEG-SpO2-01 sensor to your own pad, etc. The sensor adapter can be mounted in a 12.7-mm hole being made at your own pad side. About 1 mm in thickness is suitable for the pad.

Aron alpha in the general mark, etc. can adhere the sensor adaptor to your own pad though it may depend on the material in the pad side. (Material of the sensor adaptor is ABS resin.)



Creation indication of own pad

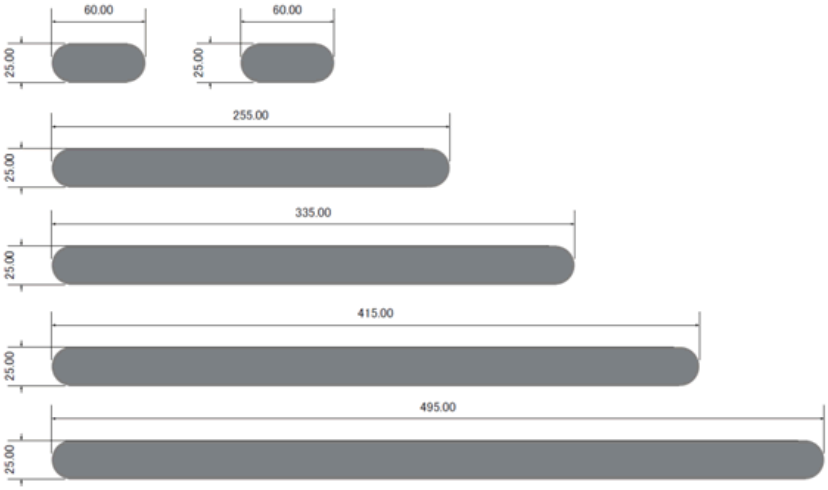




Dimension of sensor adaptor

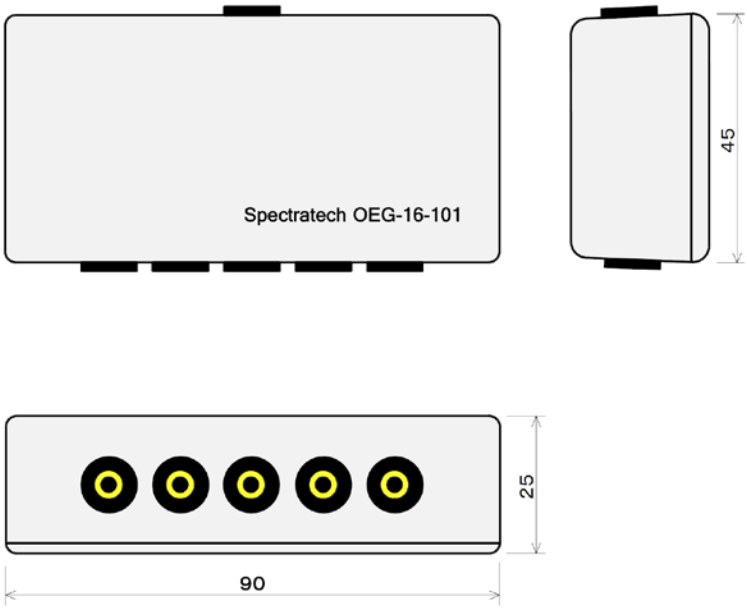
Spectratech OEG-SpO2-01-0101 Velcro tape kit

It is a set of 6 Velcro tapes. It can be used it for both the sensor band and the headband. Please use it according to the size of subject's head.



Spectratech OEG-16-101 Trigger distributor 1IN 5OUT

It is used to give a trigger simultaneously to multiple OEG-SpO2 Main units with one external trigger factor. 5 connecting cables (3m each) come with it.



Spectratech OEG-16-102 Event distributor 1IN 5OUT

It used to give an event simultaneously to multiple OEG-SpO2 Main units from a BOX for manual operation event trigger input (Spectratech OEG-16-05). 5 connecting cables (3 m each) come with it.