



User Manual v1.1

DuePro

The first smart EMG system



Read this manual carefully before using DuePro.

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1 GENERAL DESCRIPTION

The DuePro device is an instrument consisting of 7 wireless probes (Due), a charging and storing probes base (DueStation) and a wireless cinematic probe (DueBio). So, the 8 sampling probes are designed as follows: seven probes are identical to each other and are designed to pick up the surface electromyographic signal (sEMG - two channels per probe), one probe, called biomechanical probe, is used for the collection of biomechanical quantities (two channels too). All 8 probes are able to transfer the data collected to a PC/Tablet/SmartPhone. The DuePro system was designed for the detection of surface electromyographic signals produced by skeletal muscles, using surface electrodes and for the collection of two biomechanical quantities using sensors integrated into the dedicated probe.

The information collected from the electrodes is conditioned and transferred to the PC via wireless communication. Data visualization, acquisition and processing can be done through OT BioLab+ software (in the case of acquisition via PC), or through ad-hoc Android applications (e.g. Due). The OT BioLab+ software is supplied with the device or alternatively it can be downloaded free of charge at www.otbioelettronica.it in the Download section. Android applications are available for free on the Google Playstore.

2 DUEPRO KIT CONTENT

- 7 Due probes;
- 1 DueBio probe;
- 1 DueDongle;
- 1 DueStation;
- 1 DueStation DC power supply;
- 2 Due-Belt Small, for arms;
- 2 Due-Belt Medium, for arms;
- 2 Due-Belt Large, for arms;
- 1 Due-Belt Body, for chest;
- 1 peek CDE-C;
- 1 DuePro User Manual.

3 END USER

DuePro is intended to be used as a surface electromyographic system in order to monitor the skeletal muscles myoelectric activity up to a maximum of 12 muscles simultaneously (sEMG signals) and 2 biomechanical signals. As a consequence, it is intended to be used primarily as a laboratory device, secondly it can be used in an outpatient physiotherapy to evaluate in qualitative and quantitative way muscle activity.

The user profile is a specialized operator:

- a) Knowledge: Minimum, basic concepts of the human body.
- b) Understanding of the language: Italian and / or English.
- c) Experience: Minimum, minimum training for the use of the device.
- d) Eligible disablements:
 - 40% maximum hearing reduction with 60% residual hearing;
 - reduction of the sight of 40% with a residual view at 60%.

Patient profile:

- a) Age: > 15 years.
- b) Weight: not relevant.
- c) Health: free of cardiological problems and not a pacemaker.
- d) Nationality: different.

3.1 Contraindications

DuePro is a battery-powered device (in the parts in contact with the patient) and has no particular contraindications.

3.2 Side effects

When collecting sEMG or biomechanical signals, there is no side effect. All the materials used for the construction of the parts that can come into contact with the patient are biocompatible. Possible allergic skin reactions (e.g. reddening of the skin) are reduced to a minimum by reducing the acquisition protocol duration. No form of energy is released to the human body. The DuePro system has the sole purpose of picking up electrical signals coming from the muscles. The device is not for diagnostic purposes, but only for exercise guidance, assessment of the degree of muscle activation and comparison of the degree of muscle activation in different temporal moments.

4 SAFETY CAUTIONS

The use of the DuePro system is prohibited under the following conditions:

- Simultaneous or near use of electrosurgery systems, a shortwave or microwave therapy device;
- From people unable to understand and/ or want;
- When the system is visibly damaged;
- In the presence of flammable anesthetic mixtures in contact with air, oxygen or nitrous oxide;
- On subjects with pacemakers;
- Contact the manufacturer immediately if foreign materials enter the device (liquids, etc.). In the event of strong impact of the DuePro device (falling on the floor, etc.), check the integrity of the device after the impact. In case of doubt, please contact the manufacturer;
- The DuePro device may be sensitive to electromagnetic interference from other devices that could alter the electromyographic measurements and consequently the physiological variables calculated on the basis of the information collected. We recommend that you do not use DuePro in the vicinity of devices that could cause the problems described above such as mobile phones, instrumentation with large transformers, etc.);
- The operator must make sure that the batteries of the DuePro equipment have been completely recharged, as indicated in this user manual, before its use;
- DO NOT leave the appliance within reach of children or incapable persons without supervision;
- DO NOT clean both the charging base and the single ones using acetone, ether, freon, petroleum derivatives or other solvents;
- DO NOT use soap or water on the probe pins;
- DO NOT clean the DuePro (in any of its parts) by immersion, autoclave or steam cleaning.



The device must not be used in any other way than indicated in these instructions.







5 SYMBOLS USED ON DUEPRO AND IN THE USER MANUAL



Serial number



Device is double insulated, usually with an external cover. This could minimize the risk of electric shock

-  BF class for the components applied to the patient
-  Carefully read the instructions before use
-  Manufacturer
-  Do not dispose of this product as non-differentiated waste. Prepare the re-use or separate collection of the product in accordance with the provisions of Directive 2002/96 / EC of the European Parliament and of the Council of the European Union on the disposal of electrical and electronic equipment
-  CE Marking - Device in compliance with applicable Community directives
-  Read the instruction

6 TECHNICAL SPECIFICATIONS

DuePro is a battery-powered device designed to ensure a high level of safety for patient and operator in all operating conditions. The isolation between DuePro and PC, for displaying and storing data in real time, is intrinsically achieved by wireless data transfer and communication. The charging of the wireless battery of all the probes that make up the DuePro device is obtained through the use of a DueStation. When the Due or DueBio probes are charging, it is physically impossible to connect the electrodes, thus avoiding the possibility of replenishing Due or DueBio from an external source when they are connected to the patient.

The signals picked up and amplified by the two individual probes are transferred to the DueStation base and then to the PC or from the sampling probes directly to the Tablet or Smartphone.

The connection must be carried out in accordance with the European standard EN 60601-1-1 on medical devices. Table 1 shows the list of available adapters and their connections. Additional adapters can be made at the user's request to interface other types of electrodes or sensors. Table 1 shows the technical specifications of the DuePro system and all the devices (Due, DueBio and DueStation) that compose it.

Model	DuePro
Number of Channels	14 wireless channels (Due o Due-Bio)
Maximum Due probes number	7
Due-Bio probes number	1
Accessories	Due
Class	II
Number and type of Channels	2 segnali sEMG
Gain	200 V/V
Bandwidth	10 ÷ 500Hz
Input noise	< 2 μ V _{RMS}
CMRR	>100 dB
Sampling frequency	2048 Hz
A/D converter resolution	16 bit
Input range	+/- 8mV (RTI= Referred to Input)
Receiver	PC, Smartphone, Tablet (Android)
Wireless transmission protocol	Bluetooth 4.0
Power supply	Batteria LiPo da 3,7V ricaricabile a induzione
Battery lifetime during continuous transmission	13 ore (full charge)
Weight	12g
Size	Raggio 21mm x 11mm spessore
Accessories	DueBio
Classe	II
Numero di canali	2
Conditional Channels	
Number of Channels	2
Bandwidth	0 ÷ 100Hz

Input noise	< 2 μV_{RMS}
CMRR	>100 dB
Sampling frequency	2048 Hz
IMU	
Number and type of Channels	1 channel, show 9 signals: <ul style="list-style-type: none"> • Triaxial accelerometer (+/- 8g) • Triaxial Gyroscope • Triaxial magnetometer
Sampling frequency	100 Hz
No-Conditional Channels	
Number of Channels	2
Sampling frequency	2048 Hz
For all Channels	
Power supply on output connectors	0V ÷ 3.3V
A/D converter resolution	16 bit
Gain	<ul style="list-style-type: none"> • Range input signal 3,3 V not amplified • Range input signal 33mV amplified with Gain 102 V/V
Receiver	PC, Smartphone, Tablet (Android)
Wireless transmission protocol	Bluetooth 4.0
Power supply	LiPo 3,7V rechargeable induction battery
Battery lifetime during continuous transmission	13 ore (full charge)
Weight	12g
Size	(Radius) 21mm x 11mm (thickness)
Accessories	DueStation
Functions	Due and DueBio probes inductively charges, receives data simultaneously from seven probes and converts input data to analogic output by dedicate connector.
Charging functionality	Inductively charges 8 probes simultaneously
PC communication	Wired with USB cable

Input signals	Up to 14 signals generated by 7 probes
Output signals	14 analog signals on a dedicated connector
Power supply	12 V, 24VA supplied with system
Accessories	DueDongle
Receiver	Receives data from seven probes Due or DueBio (14 signals) and communicates with the PC.
Wireless transmission protocol	USB 2.0 or higher
D/A converter	Digital to Analog conversion of received signals
D/A converter resolution	16 bits
D/A output range	0V-5V (14 analog output)
Power supply	12 V, 24 VA DC supplied by the manufacturer

TAB. 6.1: *DuePro technical specifications.*

7 DETAILED DESCRIPTION

DuePro is a battery-powered portable device for surface EMG acquisition. Signals can be transferred to a PC, smartphone or tablet for viewing and recording in real time. The device can connect directly to a smartphone or tablet with an Android operating system or to a personal computer using the DueStation or DueDongle devices. Data can be acquired using the Due or DueBio probes. The communication protocol is available for custom development together with the Matlab demonstration code. See Section 8.6 - Design of custom software applications and USB communication for further details. The following sections describe in detail the Due, Due-Bio, DueStation and DueDongle devices that make up the DuePro system.

The DuePro system consists of 8 Due probes arranged in the charging base as shown in Figure 7.1.

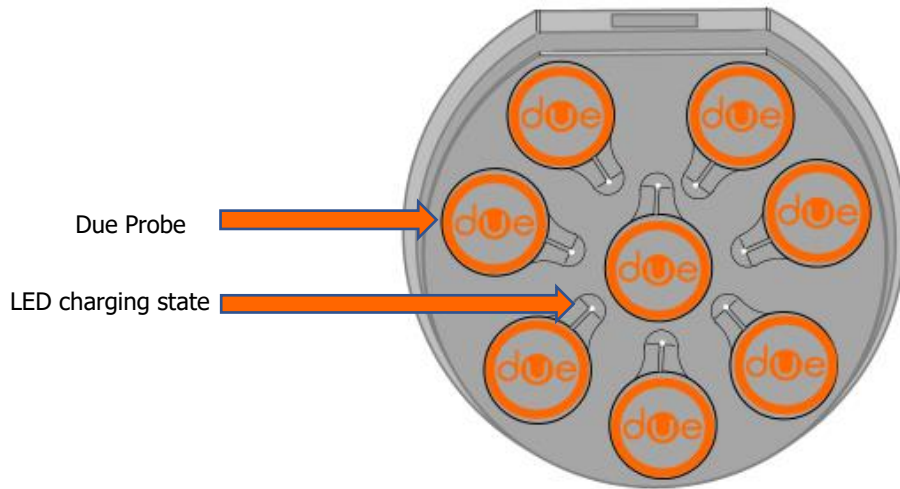


FIG. 7.1: Charging base of the 8 Due probes of the DuePro system.

7.1 Due probe

The Due probe is a device designed to acquire up to two surface EMG signals through two pairs of bipolar electrodes (CDE - Bipolar electrodes with a diameter of 15mm, with concentric connector). Figures 7.2 and 7.3 show the different views of the single Due probe. In the bottom view, you can see a velcro pad used to attach the Due probe to the subject, through the DuaStrap belts.

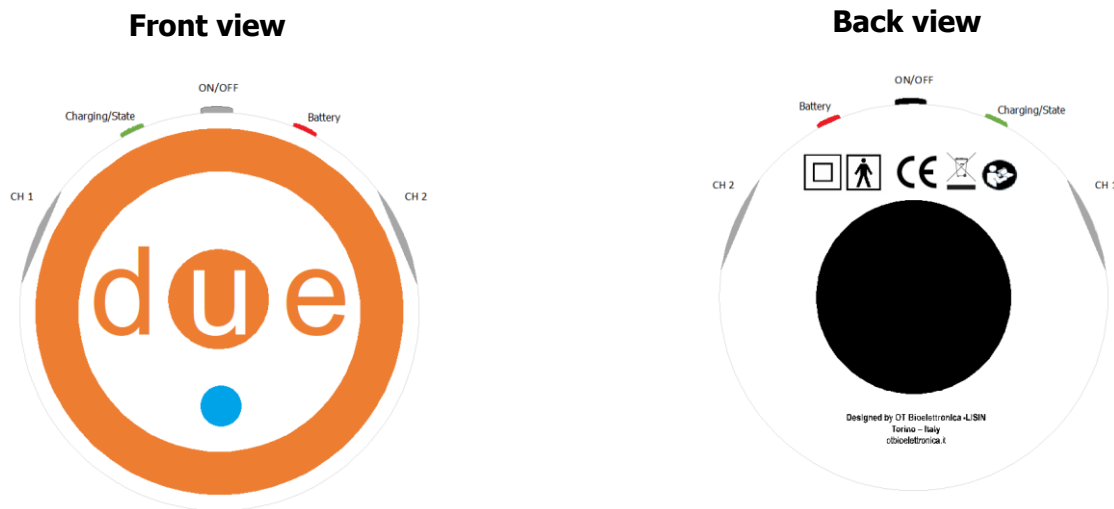


FIG. 7.2: Front and back view of the Due probe.

Side view

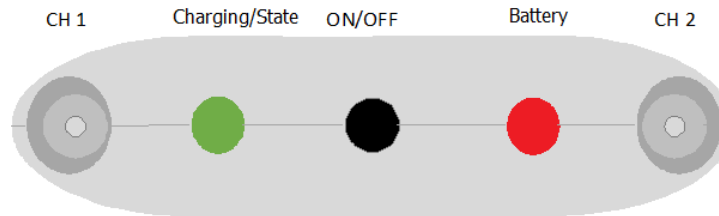


FIG. 7.3: Vista laterale della sonda Due.

7.1.1 Controls, indicators and connectors

The following is a description of the controls, indicators and connectors shown in figures 7.2 and 7.3:

- **Connectors:**

- **CH1:** Concentric connector used to connect electromyographic signal pick-up electrodes (channel 1).
- **CH2:** Concentric connector used to connect the signal pick-up electrodes elettromiografico (channel 2).

If it is necessary to acquire a single sEMG signal, it is strongly recommended to use the connector next to the green LED (channel 1) to minimize input noise and reduce the interference of the power line.

- **Indicators:**

- **LED Indicators:**

- **Battery:** red LED, it is normally off, it turns on steady when the remaining battery power is below 10%, flashes every 2 seconds when the remaining charge is less than or equal to 20%.
- **Status:** green LED, flashes every 2 seconds when the system is working properly. The device automatically tries to establish a connection with 1) a PC connected to DueStation or DueDongle; 2) a smartphone or tablet associated with the DuePro application running. When a connection is established, the device starts sending data automatically. In the event of an error, the system automatically resets and the green LED starts flashing simultaneously with the red LED.

- **Color coding:**

The colored dot on the front panel of the Due probe represents the color code that identifies the probe when the probe is connected to the OT BioLab+ visualization software (see Table 7.1).

Color	Red	Green	Blue	Yellow	Pink	Orange	Black
Number of probe	1	2	3	4	5	6	7

- **ON/OFF switch:**

Each Due probe of DuePro system turns on and off using the ON/OFF button (when the system is on, the Status LED flashes). When the system is on, pressing the ON/OFF button for 30 seconds or longer will restore the system configuration to the default state (standard name and connection settings). It is not recommended to restore the system. Consult the User Manual of the DueProgrammer App to reconfigure the probe or contact OT Bioelettronica for further details and assistance.

7.2 DueBio probe

DueBio is the probe for the collection of biomechanical or kinematic signals (for example force or angular position). It is identical in size and shape to the Due probes, but it allows to pick up biomechanical signals through the dedicated connectors, connecting sensors and transducers to the analogue inputs DueBio. The acquisition of kinematic signals can be performed using the inertial measurement unit (IMU) integrated into the system.

Figure 7.4 shows the front, back and side view of the DueBio probe. In the bottom view, you can see a velcro pad used to attach the DueBio probe to the subject, through the DuaStrap belts.



FIG. 7.4: Front, back and side view of DueBio probe.

7.2.1 Controls, indicators and connectors

• Connectors:

The DueBio probe has two audio jack connectors (female - 4-pole - 3.5 mm) to connect the analog input channels. For specific configurations, refer to section 7.2.2 (Hardware configuration and setup). The regulated 3.3 V DC power output lines are provided in each input connector to directly power connected sensors without using external power. The pinout of the connectors is shown in Figure 7.5.

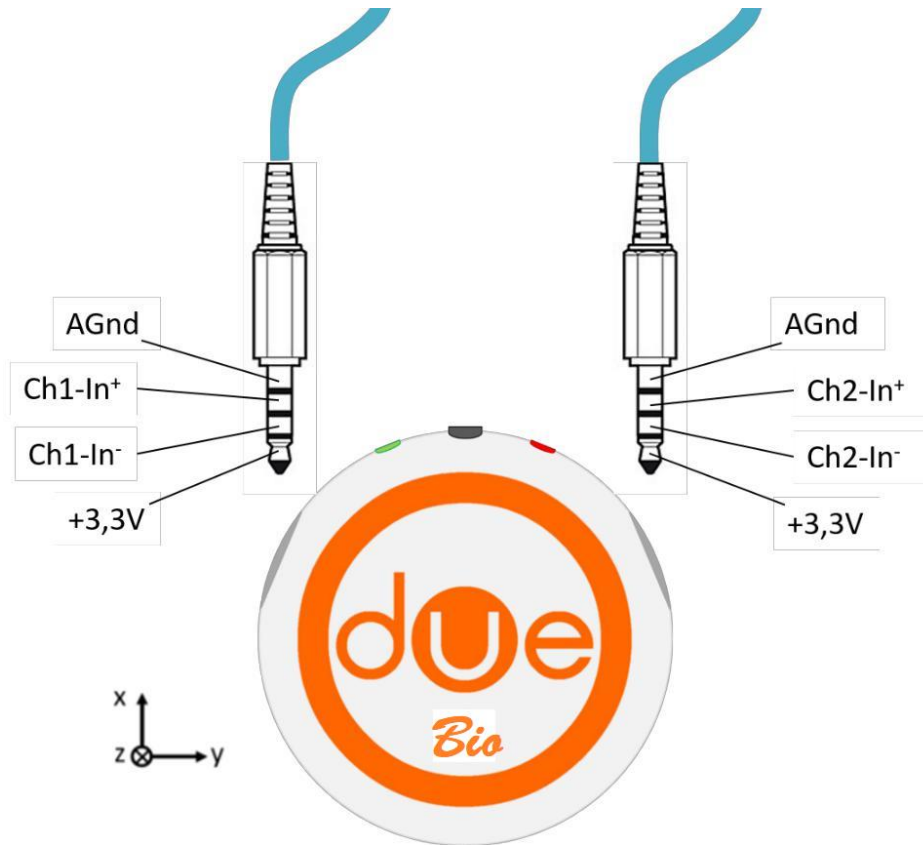


FIG. 7.5: Pinout connectors of DueBio probe.

- **Indicators:**

- **LED Indicators:**

Two LEDs are used to identify the status of the DueBio probe. Each of them reflects a different status of the device:

- **Battery:** red LED, it is normally off, it turns on steady when the remaining battery power is below 10%, flashes every 2 seconds when the remaining charge is less than or equal to 20%.
 - **Status:** green LED, flashes every 2 seconds when the system is operating correctly. The device automatically tries to establish a connection with 1) a PC connected to DueStation or DueDongle; 2) a smartphone or tablet associated with the DuePro application running. When a connection is established, the device starts sending data automatically. In the event of an error, the system automatically resets and the green LED starts flashing simultaneously with the red LED.

- **Coding:**

As for the Due probes, an identifier of this probe was also placed on the DueBio probe, in this case the word "Bio" was written on the front panel. When the probe is connected to the OT BioLab+ software it is displayed in position n° 7, consequently the black color is assigned to it.

- **ON/OFF switch:**

The probe switches on and off using the ON/OFF button (when the system is on, the Status LED flashes). When the system is on, pressing the ON/OFF button for 30 seconds or longer will restore the system configuration to the default state (standard name and connection settings). It is not recommended to restore the system. Consult the User Manual of the DueProgrammer App to reconfigure the probe or contact OT Bioelectronics for further details and assistance.

7.2.2 Hardware configuration and setup

The DueBio probe can be configured to acquire signals from different sensors as listed below:

- **Conditional signals:** conditional input for differential input signals (see Section 6 - TECHNICAL SPECIFICATIONS for details). For example, to condition and capture signals from a load cell, connect the differential outputs of the sensor to the input of the Chx-In + and Chx-In DueBio probe.
- **Unconditional signals (direct connection to A/D):** unconditional input for Single-ended signals (see Section 6 - TECHNICAL SPECIFICATIONS for details). To acquire this type of signal, connect the single ended sensor output to Chx-In + and AGnd of the DueBio probe input.

- **IMU:** inertial measurement unit on board. It is possible to acquire inertial data (triaxial accelerometer, triaxial gyroscope and triaxial magnetometer) with a sampling frequency of 100 Hz and a resolution of 16 bits. See Section 6 - TECHNICAL SPECIFICATIONS for details. The IMU is embedded in the board, so no connection is required to acquire these types of signals. See Figure 7.5 to find out how the Cartesian IMU axes are oriented relative to the center of the DueBio probe.

To configure the DueBio probe, it is necessary to restore the original factory configuration, the recovery procedure is as follows (see Section 7.2.1 - Controls, indicators and connectors). Once DueBio has been restored to its original factory configuration, it is possible to choose, using the DueProgrammer App, one of the configurations listed in Table 7.2.

The Code column in Table 7.2 refers to the chosen DueBio configuration (high nibble) and to the protocol version (less significant nibble).

CODE	Signal CH1	Signal CH2
0x8C	Conditioned	Direct A/D
0x9C	Direct A/D	Direct A/D
0xAC	Conditioned	IMU
0xBC	Direct A/D	IMU
0xCC	Conditioned	Conditioned

TAB. 7.2: Possible configurations for the acquisition of two signals with the DueBio probe.

7.3 Due-Station

The DuePro device is equipped with a charging base called DueStation, shown in Figure 7.6. Due-Station is able to charge up to 8 probes simultaneously via wireless induction charging. Next to the housing, in the DueStation, of each Due or DueBio probe, there is a LED (see Fig. 7.6) that indicates the recharging status. The DueBio probe is usually housed in the central position, but can be placed anywhere in the 8 charging slots. The DueStation base, in addition to constituting the charging platform for the individual probes, performs the following functions:

- Converts the digital signals received from the probes into analog signals making them available on the C1 connector (Figure 7.6).
- Allows the hardware synchronization of the probes by pressing button P1 (Figure 7.6).
- It allows to transfer data to PC in real-time through a special USB connector (Figure 7.6).



Ricaricare il dispositivo per almeno 2 ore prima del suo utilizzo.



FIG. 7.6: Top and Back view of DueStation.

7.3.1 Controls, indicators and connectors

- **Connectors:**

There are two connectors on the side panel:

- **Power connector:** DueStation must be powered using the available DC power supply (12V DC - 3A / 40W). DueStation is powered directly when the power jack is connected; ON/OFF switch is not present.
- **Analog Output (C1):** DueStation is designed to provide an analog signal converted to output in real time. Analogue signals are available on connector C1 on the side panel (20-pin micro D Sub - Part number 3M-10220-6212PL). An input trigger line is also available on the same connector to synchronize the output signal with the external acquisition system.

- **Indicators:**

To show the battery level, there is a LED next to each probe housing. The LED flashes green when the probe is charging, the LED is solid green when the probe is charged or the slot is empty, the LED is red when there is a recharging problem (contact OT Bioelettronica for further details and assistance).

- **Controls:**

- **Hardware Sync:** DueStation was developed for probes hardware synchronization. To synchronize the probes, just press the hardware synchronization button (P1) once.

7.4 DueDongle

DueDongle (Figure 7.7) is a device that can be used as a Bluetooth receiver. It is a Plug & Play device required to transfer data in real time from up to seven Due or DueBio probes to a Windows PC when it is not possible or necessary to use DueStation. It can be used as an alternative to DueStation. The specifications of the USB communication protocol are identical to those used for the DueStation.



FIG. 7.7: DueDongle.

7.5 DuaStrap

Due and DueBio can be worn using different belts, shown in table 7.3.

Belt	Description
DuaStrap-S	Support belt size S (arti)
DuaStrap-M	Support belt size M (arti)
DuaStrap-L	Support belt size L (arti)
DuaStrap-B	Support belt for chest

TAB. 7.3: DuaStrap.

8 USE OF DUEPRO

Each probe that makes up the DuePro system can be connected to a Personal Computer (PC) or a Smartphone/Tablet with the Android Operating System. Software is available to view, capture and record received signals: 1) The OTBiolab+ software must be used to acquire data with Windows PC; 2) The DuePro App must be used to acquire data with an Android smartphone or tablet. In case of using the DuePro system with Windows PC or Android Smartphone/Tablet, a first start-up procedure is required.

The OT Biolab+ software can be downloaded free of charge from the web page www.otbioelettronica.it while the DuePro App is available for free on Google Playstore.

8.1 Using DuePro with windows PC

The DuePro can be interfaced to any computer with a USB 2.0 interface (or higher) and with a Windows operating system (Windows 7 or later is recommended). This section refers to the use of DuePro together with the Windows PC and OT BioLab+ software. If a different operating system is used or if the user interface needs to be customized, several examples of Matlab/Octave are available. Please contact OT Bioelettronica to receive further manuals and examples.

To use the DuePro system with a Windows PC, you need to use the DueDongle or DueStation as a Bluetooth receiver.

8.1.1 First time start-up procedure

The following procedure must be performed when using the DuePro system for the first time:


1. Install the OTBiolab+ software on the PC (see OT Biolab+ v1.2 Manual Section 2);
2. Install the Due drivers (see OT Biolab+ v1.2 Manual Section 3.2);
3. Follow section 8.1.2 (Normal start-up procedure).


8.1.2 Normal start-up procedure


In case of a normal startup procedure, make sure that the OT Biolab+ software and the DueBio drivers are installed correctly on the Windows PC where you want to start the acquisition.

1. Connect the DueDongle or DueStation to a free USB 2.0 port on the PC. The DueStation connection requires a mini-USB cable. We strongly recommend that you avoid connecting the DueStation/DueDongle devices to a USB hub. In this case, data loss may occur depending on the USB hub used. It is forbidden to simultaneously connect the DueDongle and DueStation devices. In this case, unpredictable behavior of the OTBiolab+ software may occur. Pay attention: DueStation must be powered using the available DC power supply.
2. Run OT Biolab+;
3. Create the acquisition setting (see OT Biolab+ v1.2 Manual Section 6).
4. Start display.
5. Activate the Due or DueBio probes configured in the configuration. It is advisable to switch on the probes one at a time, verifying the correct display of the signals on the PC;
6. Choose the preferred synchronization method. See Section 8.3 (Hardware and Software Synchronization) for further details;

7. Connect the bipolar electrodes to the Due probes and, possibly, other sensors to the DueBio probe depending on the experimental setting;
8. Apply the electrodes on the skin. Clean the skin before applying the electrodes; use DuaStrap to fix the probes to the body;
9. Record the acquired signals as described in the OTBiolab+ User Manual.

 The probes must be activated once and for all. Wait for a probe connection before turning on the next one. If a probe does not connect to the DueDongle/DueStation, try turning it on again.

 The electrodes are single use. Do not reuse them.

 The DueBio probe will always be displayed instead of the probe n° 7, so if one of the seven probes connected to the PC is the DueBio probe, this will always be displayed in the last position.

8.2 Using DuePro with smartphone or tablet

You can receive signals acquired with DuePro via a mobile device (eg.. smartphone or tablet) with the Android operating system and a SmartReady Bluetooth 4.0 interface. A first start-up procedure (pairing) is required to enable communication with the Due/DueBio probes. The use of DuePro with mobile devices requires neither DueDongle nor DueStation.

8.2.1 First time start-up procedure

The following startup procedure is required when one or more probes must be used in combination with a new mobile device. This procedure is only needed the first time you use DuePro with a new mobile device:

- Open the Wireless and network settings on your mobile device;
- Select the settings relating to Bluetooth connectivity (Figure 8.1);

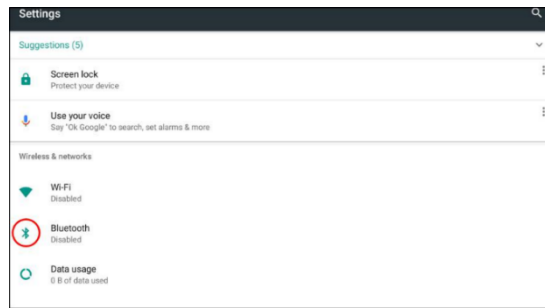


FIG. 8.1: Bluetooth icon in Settings page – Wireless & Network.

- Activate the Bluetooth connectivity on the device (Figure 8.2); make sure that the visibility of the remote device is active;

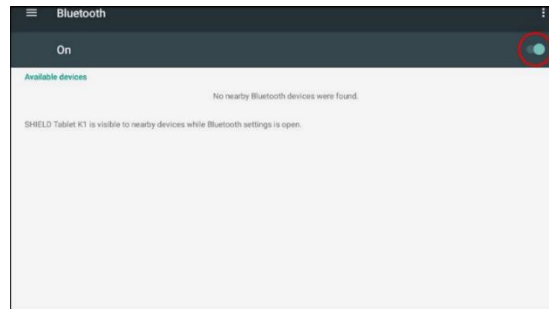


FIG. 8.2: Toolbar Bluetooth shows is switched on (red circle).

- Turn on the probe (Due or DueBio) that you want to pair;
- Press the search button to get a list of devices that can be connected to the mobile device. A list of unpaired devices is displayed (Figure 8.3). See Section 8.9 (Nomenclature of Probes) for the DuePro naming convention;

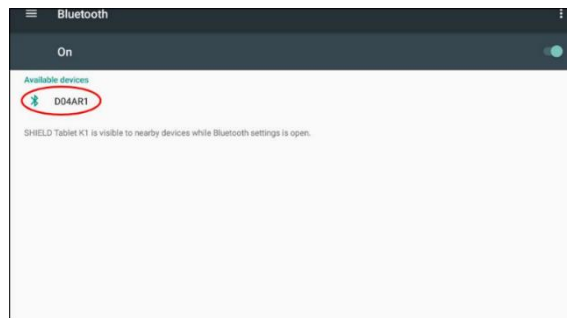


FIG. 8.3: Unpaired devices list that is displayed when the search button is selected (red circle). In this case the Due probe (D04AR1).

- Select the probe (Due or DueBio) you want to pair with. A pop-up window similar to the one in the figure 8.4 appears;

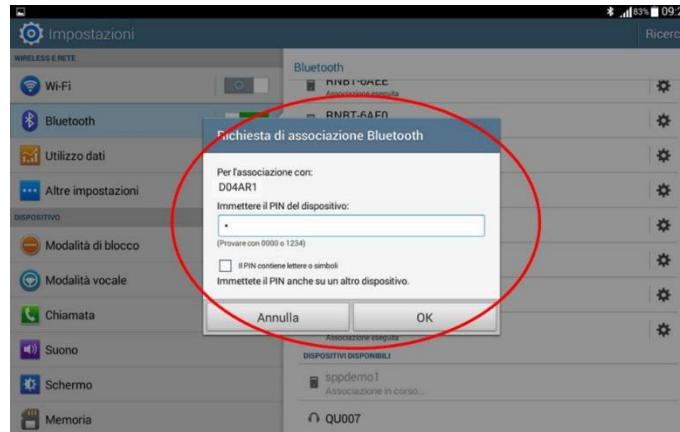


FIG. 8.4: Devices list that is required to pair (red circle).

- Insert "0" as password and press OK. The pairing password is "0" for all Due or DueBio probes;
- Once the selected Due or DueBio probe is correctly paired, you can view it in the Associated Devices list (Figure 8.5). Repeat this operation for all the sensors you want to associate;

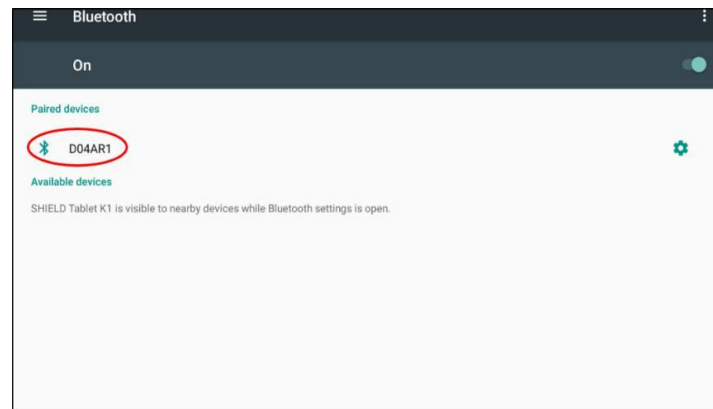


FIG. 8.5: Successfully paired devices, Due probe (D04AR1).

- Run the DuePro App on the mobile device;
- Press the "connection options" button (Figure 8.6, red circle).

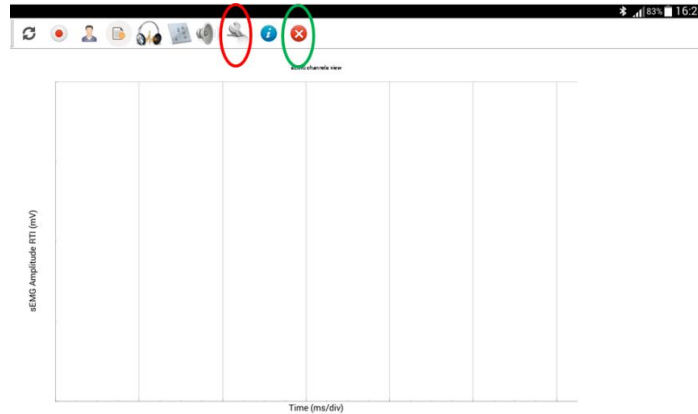


FIG. 8.6: DuePro App, connection options (red circle) and end acquisition (green circle).

- Select the UUID following the diagram below (Figure 8.7, red circle):
- UUID 1: 8a3362e1-7688-4a7f-9574-f6284c582f99
- UUID 2: e8e10f95-1a70-4b27-9ccf-02010264e9c8
- For each probe used, enter the name as shown in Figure 8.7 (blue circle). Press the Save button (Figure 8.7, green circle) and close the program (Figure 8.6, green circle);



The screenshot shows the 'BT Settings' screen. A red circle highlights the first UUID: 'e8e10f95-1a70-4b27-9ccf-02010264e9c8'. Below it is a table for probe names and a 'Save' button at the bottom, which is circled in green.

BT Settings	
UUID 1	e8e10f95-1a70-4b27-9ccf-02010264e9c8
UUID 2	8a3362e1-7688-4a7f-9574-f6284c582f99
Probes name	
Sensor Name	Number of channels
Sensor Unit 1: D03001	2
Sensor Unit 2: D03002	2
Sensor Unit 3: D03003	2
Sensor Unit 4: D03004	2
Sensor Unit 5: D03005	2
Sensor Unit 6: D03006	2
Sensor Unit 7: D03007	2
Save	

FIG. 8.7: Form for the connection options, UUID list (red circle) indicates the UUID used to connect the probes, name of the probes (blue circle), save button (green circle).

8.2.2 Normal start-up procedure

Follow the steps below to acquire signals from the Due or DueBio probes using a Smartphone or Tablet. The mobile device must have the DuePro application installed. You can download the DuePro App using the Google Play Store or by contacting OT Bioelettronica.

1. Start the DuePro App;
2. Activate all the Due or DueBio probes you want to connect. It is advisable to turn on the probes one at a time, verifying the correct display of the signals on the mobile device;
3. The Due or DueBio probes automatically connect to the mobile device. Wait until all the probes are connected. It is possible to observe the connection status in the register window of the App (Figure 8.8, red circle);
4. Use the DuePro App to capture and record signals. (Refer to the DuePro App User Manual).

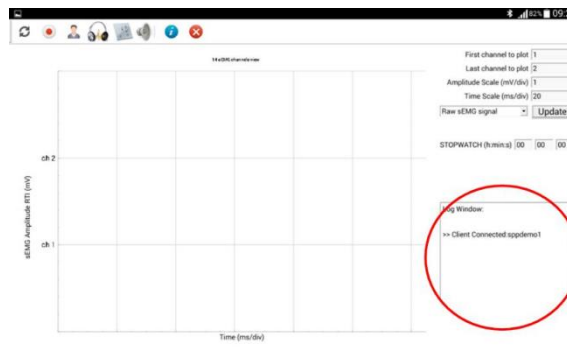


FIG. 8.8: New sensor connected. The red circle indicates the connection status with the probe.

8.3 Hardware and Software synchronization

Each probe of the DuePro system, being physically disconnected from the others, has a time delay of a few milliseconds compared to the other probes in the system. To decrease or cancel this problem it is necessary, every time the system is used, to perform the synchronization operation. There are two different synchronization modes: Software (SW) and Hardware (HW). **Software Synchronization (SW)** allows to have maximum dissynchronisms of 50 ms (about 7ms per probe) and is indicated in case in which there is a feedback of the subject (for example biofeedback).

To synchronize the system in SW mode, you must perform the following operations:

1. Start the OT BioLab+ (on PC) or DuePro capture software (on Android mobile devices or PC MAC);
2. Turn on all the probes you want to use and wait for the acquisition software to recognize that the probes have been connected;

3. Press the Sync button on the acquisition software.

Hardware Synchronization (HW) allows a maximum dissynchronism between all the probes of the DuePro system to be equal to 500 microseconds (just one sample) and is particularly useful in case it is necessary to study particularly close muscular activation models (such as in the case of perturbations sudden upright posture) or electromechanical delays.

To synchronize the system in HW mode, you must perform the following steps:

1. Start the OT BioLab+ (on PC) or DuePro capture software (on Android mobile devices or PC MAC);
2. Turn on all the probes you want to use and wait for the acquisition software to recognize that the probes have been connected;
3. Place the probes you want to use in the DueStation charging base (which in turn must be turned on). Check by means of the status LEDs on the charging base that all the probes are charging;
4. Press the P1 button on the DueStation charging base. Verify that each probe has started to transmit the acquired signals.

8.4 Charging Due and DueBio probes

The Due or DueBio probes can be loaded inductively using the DueStation. Up to 8 probes can be loaded at the same time. The central slot is assigned to the DueBio probe charge while the Due probes can be loaded into any free slot. The probes can be loaded even if they are switched on. Turn off the probes to speed up the charging process.

Follow these instructions to load the probes that make up the DuePro system:

1. Power up the DueStation by connecting the available 12V DC power supply;
2. Remove the cover that covers the DueStation;
3. When a charging slot on the DueStation is free, the associated charge LED is green and does not flash; this indicates that the slot is ready to accept a probe to be loaded;
4. Insert the probe into a free slot to load a Due or DueBio probe. The LED of the associated charge status is green and flashes for one second. This indicates that the Due or DueBio probe is in charge;
5. At the end of the charging process, the status LED stops blinking and remains lit;
6. If an error occurs with the charging process, the associated status LED turns red and the charging process stops.

8.5 Analog output

Using the DueStation as a receiver, up to 14 signals received from the probes via Bluetooth can be converted from digital to analog. It is not necessary to enable the analogue output function, the signals are directly available on the side panel of the

DueStation via the analogue output (C1, see Fig. 8.9). The C1 connector as a trigger input signal (0 V - 3.3 V) can be used to synchronize DuePro with other devices. Contact OT Bioelectronica for further details and assistance if custom adapters are required. The dynamics of the analogue output signals is between 0 V and 5 V. The EMG signals from the Due probes have a baseline set to + 2.5 V to provide a signal range of ± 2.5 V (referred to 'Exit'). You can set the analog output gain (x1, x2, x4, x8) using the OTBiolab+ software.

Connector C1 accepts a digital trigger input signal (0 V - + 3.3 V) that can be used to trigger acquisition from external devices that require synchronization with DuePro.

To enable Trigger mode, remove all probes from the DueStation slots and press Hardware Sync (P1) for 3 seconds. Once the Trigger mode is enabled, the signals change on the rising edge of the Trigger Input signal (Figure 8.10, arrows and green dots). The signals are sampled by the external device on the falling edge of the trigger input signal (Figure 8.10, arrows and purple dots).

Trigger (Input)

Gnd
Gnd
Gnd
Ch16
Ch15
Ch14
Ch13
Ch12
Ch11



Ch1
Ch2
Ch3
Ch4
Ch5
Ch6
Ch7
Ch8
Ch9
Ch10

FIG. 8.9: Connector C1, Analog output and Trigger input (micro D Sub 20 poli – N. 3M-10220-6212PL).

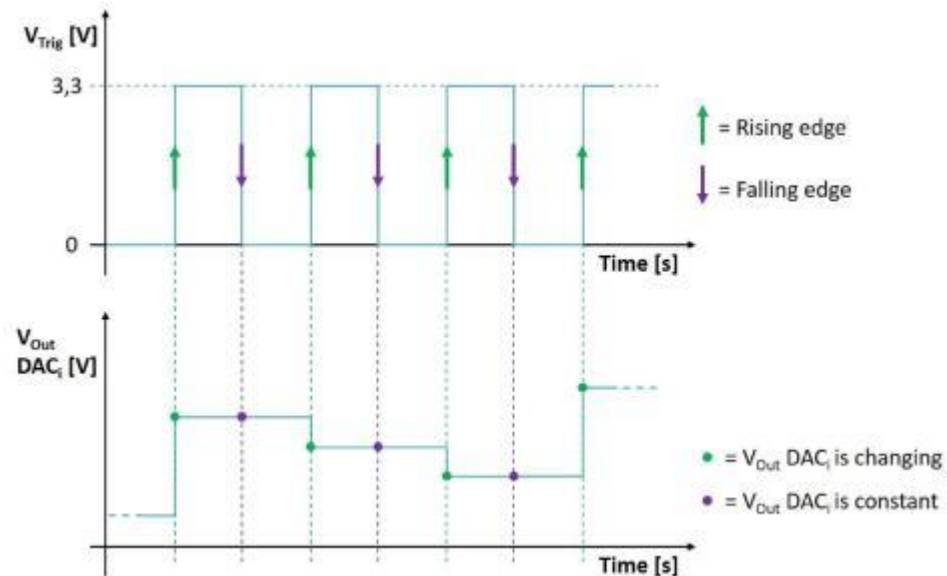


FIG. 8.10: DueStation operates in Trigger mode, the rising edge of the trigger input signal (arrows and green dots). The signals are sampled by the external device on the falling edge of the trigger input signal (arrows and purple dots).

8.6 Design of custom software application and USB communication

With DuePro it is possible to develop customized software compatible with PC or Tablet. The following sections describe the USB configuration required to connect the DueStation or DueDongle with custom software and the communication protocol required to correctly interpret data packets from Due or DueBio.

8.6.1 USB setup

The DueStation or DueDongle create a virtual COM port to communicate with a Personal Computer. The virtual COM port has the following settings:

- Baud Rate 921600 bps;
- Data Length 8 bit;
- Parity None;
- Stop Bit 1 bit;
- Flow Control None;

The PC initiates communication with DueStation or DueDongle by opening a virtual COM port and sending the character 0x80.

8.6.2 Data packet composition

The Due or DueBio probes transmit the data package organized as shown in Figure 8.11. Each data packet consists of a 4-byte long header, 128 bytes of long data and 5 bytes of termination. The header consists of a constant sequence of four bytes (255, 255, 0, 0) and is used to identify the beginning of a new data packet.

The data are arranged in Round-Robin mode (i.e. the sampled signals are multiplexed). Each sample consists of one word (2 bytes). The package queue consists of 5 different bytes listed below:

- SysID: it represents the type of probe (Due or DueBio) and the configuration (only for DueBio);
- PID represents the identification code of the probe (this value ranges from 1 to 7);
- Ramp is an incremental counter used to know if packets are lost during transmission;
- DC1 is a byte reserved for future use and set to 0 up to now;
- DC2 is a byte reserved for future use and set to 0 up to now;

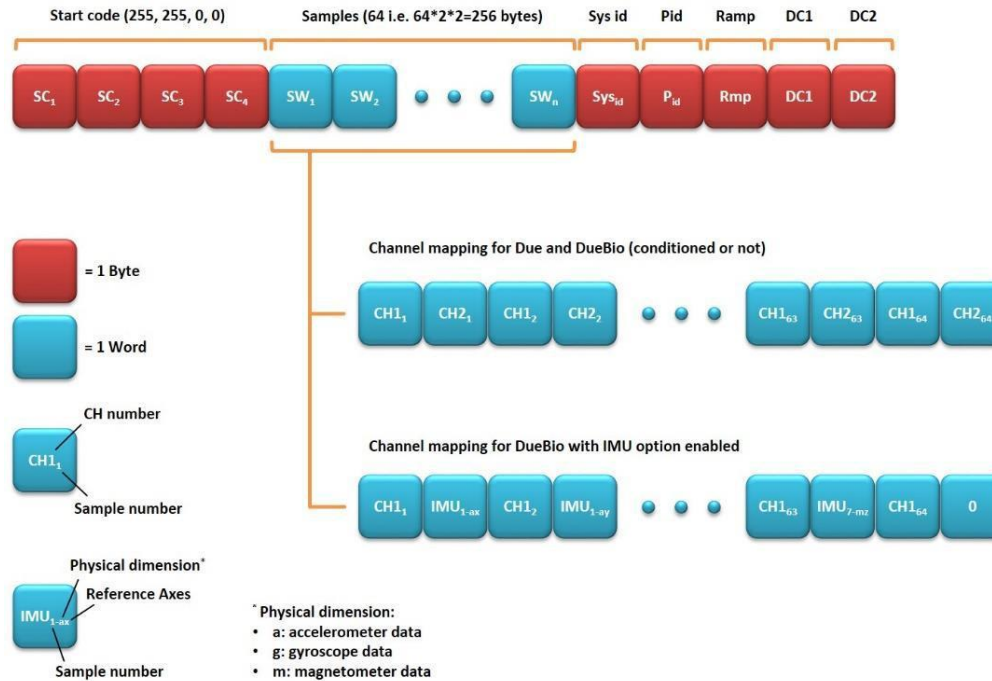


FIG. 8.11: USB and Bluetooth data packet composition.

The **Samples** section consists of 64 words per channel (big-endian); two methods are used to organize the words according to the configuration of the probes:

1. When the Due or DueBio probes are used to acquire data from an external signal (direct or conditional channels), the samples section is organized in 64 words for Ch1 and 64 words for Ch2, alternating the first with the second channel;
2. When the DueBio probe is used with the IMU option enabled, the samples section is organized in 64 words for Ch1 and 63 for the samples acquired by the internal IMU; the last word of the sample section is set to 0. The 63 words from the internal IMU are organized by sequentially sorting the samples from the accelerometer, the gyroscope and the magnetometer for each axis in sequence (X, Y and Z).

8.7 Signals

The resolution of the Due/DueBio probe is 16 bits obtained by sampling the signals with an A/D SAR converter. The other stages in the Due/DueBio probe allow to amplify and filter the EMG signals with a fixed gain of 200 V/V and a bandwidth between 10 Hz and 500 Hz.

Two separate single-channel A/D converters are used for all 2 channels that make up the Due or DueBio probes. The dynamics of the input of the A/D converter is $0 \div +3.3 \text{ V}$, considering the amplification gain that reflects a resolution referred to the input equal to: $\text{LSBRTI} = \text{ADCRANGE}/\text{Gain}/216 = 244 \text{ nV}$, which is absolutely inferior to the intrinsic noise generated by the electrode-skin contact, which allows the detection of the least possible EMG activity.

8.8 Electrodes

As accessories to be used with the DuePro device, but not supplied as standard, we find the adhesive electrodes, shown in Figure 8.12.

- CoDe adhesive concentric electrode - CODE 401500 - 501500
- Bipolar adhesive electrode - CDE



FIG. 8.12: Bipolar electrodes CDE 15x15mm with concentric connector.

8.9 Probes naming convection

All the devices that make up the DuePro system can be recognized by means of a specific identification code. Figure 8.13 illustrates the naming convention for the Due (red) probe related to the DuePro "AA" system updated to the protocol number "04". The Due or DueBio probes that make up the DuePro system are identified by an alphanumeric code of 6 characters. The first character identifies the device name (D stands for Due, B for DueBio etc. See Figure 8.13 for details). The Protocol ID field consists of two digits representing the system version. The system ID is a two-character alphanumeric code representing the identifier of the DuePro system. It goes from A0 to ZZ. The most recent field is a number that indicates the number and color of the probe (see Figure 8.13 for details). Only the Due or DueBio probes have this field.

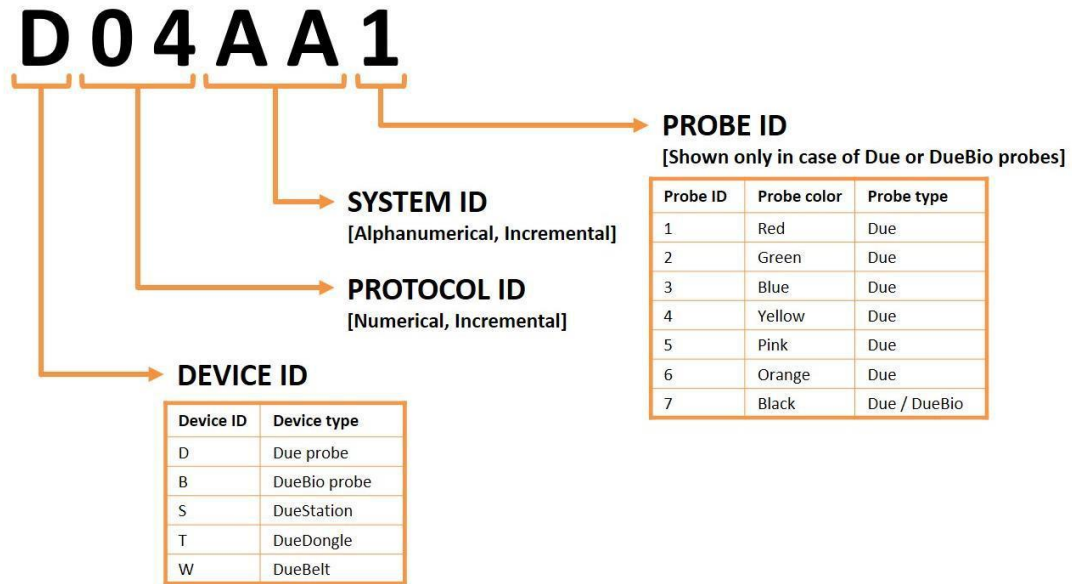


FIG: 8.13: *DuePro identification code.*

9 TROUBLESHOOTING

This section describes the most common problems that can be found by the users of the DuePro, with some suggestions to solve them. For problems not described in this section, contact the technical support service of OT Bioelettronica.

GENERAL PROBLEMS		
Problem	Possible causes	Solution
Bluetooth connection doesn't work.	Battery level.	Check the battery level by looking at the probe LED. If the battery level is more than 10%, restart the probe.
Due probe doesn't turn on.	Discharge probe.	Charge the probe for at least 20 minutes.
Hardware synchronization doesn't work.	DueStation off.	Check that the DueStation is turned on.

TAB. 9.1: Solving general problems that can occur using the DuePro.

10 MAINTENANCE AND STORAGE

DuePro must be used in the following environmental conditions:

Temperature:	from 0 ° C to + 40 ° C
Maximum relative humidity:	75%
Atmospheric pressure:	from 700 hPa to 1060 hPa

We recommend turning off the DuePro at the end of each measurement session and removing all cables and connections. The DuePro should be stored with all accessories included on a secure desk away from all situations listed in the Warnings section. Make sure the probes are turned off before storing the system.

DuePro must be stored in the following environmental conditions:

Temperature:	from -20 ° C to + 40 ° C
Maximum relative humidity:	75%
Atmospheric pressure:	from 700 hPa to 1060 hPa

DuePro and its accessories must be stored in a safe area and under the conditions listed in the Warning section of this manual. DuePro does not require specific maintenance procedures to maintain its performance. To maintain battery performance, recharge the batteries before each use. Check the battery performance regularly.

If the battery life is less than 1 hour during use and after charging, contact the manufacturer to check the batteries.

Cleaning: use only a dry cloth to clean the device.

It is advisable to schedule a device check with the manufacturer every 24 months. The DuePro should only be repaired by the manufacturer. Any repairs performed by unauthorized personnel will be considered as a violation of the device and will invalidate the manufacturer's warranty.

Disposal

The device and accessories must be disposed of in compliance with the relevant regulations in special equipped areas or with special waste. The DuePro contains electronic components that must be disposed of as electronic waste. Dispose of the device and accessories according to local regulations. Follow the regulations regarding the disposal of your country to ensure the

correct disposal of DuePro and its accessories. For more information on disposal of this device, contact the Environment Department and local authorities.



Warning: Do not dispose of this product as unsorted municipal waste. Collection of such waste separately for special treatment of the necessary, following Directive 2002/96/EC of the European Parliament and of the European Council on waste electrical and electronic equipment. (WEEE). The regulation is not valid in case of damaged product.

Life span of the device

The DuePro system is manufactured to last if the use and maintenance conditions indicated in this User Manual are followed. The life of the device is determined by the battery life (5 years). After this period, it is advisable to bring the device to the manufacturer every two years.

11 RISK ANALYSIS

11.1 General Requirement for basic safety and essential performance CEI EN 60601-1-2

Manufacturer's declaration and guidelines - electromagnetic emissions – Due probe	
Phenomenon	Professional healthcare environment
RF radiated emissions	EN 55011:2009 + A1:2010
Voltage fluctuations and flicker	IEC 61000-3-3

TAB. 11.1: Tests carried out and passed by the Due probe for compliance with the regulations on electromagnetic emissions

Manufacturer's declaration and guidelines - electromagnetic immunity – Due probe		
Phenomenon	EMC reference standard or test method	Immunity test levels - Professional healthcare environment
Electrostatic Discharges	IEC 61000-4-2	+/- 8 kV at contact +/- 8 kV e +/- 15 kV in air
Radiated RF EM fields	IEC 61000-4-3	3 V/m 80 MHz – 2.7 GHz 80% AM a 1 kHz
Radiated RF EM fields and proximity wireless fields	IEC 61000-4-3	28 V/m 450 MHz, 810 MHz - 2.45 GHz at 217 Hz 27 V/m 385 MHz at 18 Hz 9 V/m 710 MHz – 780 MHz, 5.24 GHz – 5.785 GHz at 217 Hz

TAB. 11.2: Tests carried out and passed by the Due probe for compliance with the regulations in force on electromagnetic immunity

Manufacturer's declaration and guidelines - electromagnetic emissions – DueBio	
Phenomenon	Professional healthcare environment
RF radiated emissions	EN 55011:2009 + A1:2010
Voltage fluctuations and flicker	IEC 61000-3-3

TAB. 11.3: Tests carried out and passed by the DueBio probe for compliance with the regulations on electromagnetic emissions

Manufacturer's declaration and guidelines - electromagnetic immunity – DueBio		
Phenomenon	EMC reference standard or test method	Immunity test levels - Professional healthcare environment
Electrostatic Discharges	IEC 61000-4-2	+/- 8 kV at contact +/- 8 kV e +/- 15 kV in air
Radiated RF EM fields	IEC 61000-4-3	3 V/m 80 MHz – 2.7 GHz 80% AM a 1 kHz
Radiated RF EM fields and proximity wireless fields	IEC 61000-4-3	28 V/m 450 MHz, 810 MHz - 2.45 GHz at 217 Hz 27 V/m 385 MHz at 18 Hz 9 V/m 710 MHz – 780 MHz, 5.24 GHz – 5.785 GHz at 217 Hz

TAB. 11.4: Tests carried out and passed by the DueBio probe for compliance with current regulations on electromagnetic immunity

12 TECHNICAL CHARACTERISTICS

Model: DuePro

Risk Class: I in accordance with the 93/42/CEE standards.

Insulation Class: Type BF with applied parts, in accordance with the European standards EN 60601-1.

Classification:

- class II, regarding protection against indirect contacts.
- IP20, based on the penetration of liquids and dust; unprotected device.

Container: Painted rigid polyurethane foam.

Power Supply: Rechargeable Internal Battery Li-Po 3.7 V

Average consumption: 0.6 W

Limitations: Device not suitable for use in environments with high concentrations of oxygen and/or flammable gases; do not use with electrosurgery or short wave or microwave therapy equipment.

Operation: Device adapted for continuous operation.

Dimensions: 96 x 60 x 20 mm

Weight: 110 g

13 WARRANTY

DuePro is covered by a 24-month warranty starting from the date of purchase on the electronic parts. The connection cables are covered by a 24-month warranty. The guarantee lapses in case of tampering with the appliance and in case of intervention on the same by unauthorized personnel. The warranty conditions are those described in the "Warranty Conditions".

13.1 Warranty conditions

1. The warranty period is 24 months on the electronic parts. The guarantee is provided by the manufacturer.
2. The warranty only covers damage to the product which causes it to malfunction. The guaranteed product must have the serial number equal to that indicated on the certificate of sale, otherwise the guarantee will be invalid.
3. A warranty is understood to be solely the repair or free replacement of components recognized as faulty in manufacturing or in the material, including labor.
4. The warranty does not apply in the case of: damage caused by negligence, use not in accordance with the instructions provided, damage caused by interventions by unauthorized persons, damage due to accidental causes or negligence of the purchaser (particular reference to external parts).
5. The warranty does not apply to damage caused to the appliance by unforeseen power supplies.
6. Parts subject to wear due to use are excluded from the warranty.
7. The warranty does not include transport costs that will be borne by the purchaser in relation to the transport methods and times.
8. The warranty expires after 24 months. In this case the assistance interventions will be performed by debiting the replaced parts, labor costs and transport costs according to the rates in force.

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