Graphical Tester for Otoplastics

With Bluetooth® Low Energy (LE) Interface

Software Manual

Additional Manual for iOS and MacBook with Apple *silicon*

2024

TABLE OF CONTENTS **Page**

1 INTRODUCTION

1.1 Purpose

This paper walks you through the process of obtaining, installing and using the application software (*app*) to control the Bluetooth® LE leakage tester on **iOS** platforms. The *app* is called **OtoBLE** for each platform.
Find a brief explanation on how to download and install the *app* from the **Apple Store** in chapter 2.
It is assumed that the user is sufficient familiar with iOS and that the controlling *app* 'OtoBLE' already has been downloaded and installed.

1.2 Platforms

The *app* can run on three platforms:

- **Windows 10**, in the Universal Windows Platform (UWP), this platform is an exclusive part of W10 OS a.k.a. Universal App Platform (UAP), hardware: desktop, laptop and tablet
- **Android OS**, as of Android 6.0 (Marshmallow, API 23), hardware: tablet and smartphone
- **Apple iOS**, from: iPad model Air, iPhone model 6 (both iOS12.4) and MacBook equipped with Apple *silicon* (CPU ARM M1+)

The 'look and feel' of the *app* on the different platforms is much the same. For each platform, there is **no** need to run the classic Bluetooth® pairing procedure (one-time sign-up) for your Bluetooth® LE leakage tester.
In the upcoming chapters you will find a description on how to operate the Bluetooth® LE leakage tester with the *app* running on **iOS** smartphones and tablets.

2 INSTALLATION

2.1 Acquisition

To acquire the *app* OtoBLE to run on your iOS device you have to visit the Apple Store.
The *app* resides in "Productivity", the URL reads: https://apps.apple.com/us/app/otoble/id1569397180, or search for 'OtoBLE'. Assuming that you are logged in, tap **Get** and then tap **Install** in the *pup-up* window, after some time you can tap **Open**: the *app* OtoBLE will start and is now available in the *app* list:

OtoBLE

2.2 Procedure

Turn your Bluetooth® LE Leakage Tester on, wait for the beep, then start the OtoBLE *app*, in this order please.
If the iOS asks in the *app* whether the Bluetooth® radio should be turned on, turn it on (*§*2.3.2).
When there is more than one active BLE leakage tester within range of the iOS platform, then the *app* will connect to the tester that currently has the strongest Bluetooth® transmitter signal (RSSI).

For further information on the leakage tester's **hardware**, download the document **OTOmanualBLE_EN** from our website.

English version: OTOmanualBLE_EN.pdf, URL: https://www.cursorengineering.nl/en/documentation-ble/
Nederlandse versie: OTOmanualBLE_NL.pdf, URL: https://www.cursorengineering.nl/documentatie-ble/
Deutsche Version: OTOmanualBLE_DE.pdf, URL: https://www.cursorengineering.nl/de/dokumentation-ble/

2.3 Bluetooth® LE

2.3.1 version

The leakage tester is a Bluetooth® *Low Energy* (LE) device and it is necessary to have, *at least*, Bluetooth® v4.0 available on your platform. However, there is no need to worry about versions: during the installation of the *app*, it immediately becomes clear whether the *app* is suitable for the hardware you are using.
It is certain that all iOS platforms mentioned in §1.2 have the correct Bluetooth® version. Bluetooth® LE devices are always advertising their capabilities to their environment, this is why there is no explicit need to go through the so-called *pairing* procedure, which is common and necessary with *classic* Bluetooth®

2.3.2 switching via *Settings*

The Bluetooth® **radio** can be turned **Off**, but should be **On**. The *app* checks whether the Bluetooth® radio is **On** and will, if not, ask the user in a *pop-up* window, to turn on Bluetooth®, choice: *Settings* or *OK*. By tapping tapping on *Settings* you will be taken there and under >Bluetooth® > the slider can be moved to the right to activate the Bluetooth® radio. If the OtoBLE *app* is now activated again, the *app* will continue to search for BLE devices. However, if *OK* is chosen, this will be interpreted as a refusal and the *app* will wait patiently and eventually shut itself down.

2.3.3 switching via *Control Centre*

Bluetooth® radio can also be turned off to invalidate the possibility of making *new* connections, this is done by means of the *Control Centre*. If the *app* only reports in the status line that the Bluetooth® radio is powered off, but does not present a pop-up screen, then there is a ban on making new connections.
By *swiping* the *Control Panel* to the foreground and tapping the Bluetooth® logo, the *app* resumes and immediately starts searching for BLE devices.

3 MEASUREMENTS

3.1 Start off

Switch on the leakage tester and wait for a short beep, then activate the OtoBLE *app*, in this order.
In most cases however, only one leakage device is present (*paired* or not) and the *app* will to connect to that device straight away. After a successful connection the *app* shall look like the picture below, from this screen all measurements (*sessions*) will be performed. In the next chapter, all screen elements will be discussed.

Picture 3.1.1: the measurement screen on an iPad Air, ready to use

3.2 Screen legend

3.2.1 general

In the following sections, the functionality of the various screen elements shall be discussed.

3.2.2 buttons

- **Exit:** the *app* will be terminated and, if there was a connection present, the leakage tester on his turn will enter the '*sleep*' mode, this mode is discussed in §4.1.2
- **Save Graph:** the graph can be saved with a name of your choice plus date/time stamp, the procedure to save the graph is being treated in §4.2
- **Start Test:** a new measurement starts: the caption on the **Exit** button will change to **Stop Test**
- **Stop Test**: the running measurement will be aborted, after a short time the *app* returns to *READY*

3.2.3 graph

- **mB:** the y-axis indicates the relative pressure in millibar [mB] with respect to existing air pressure; measurements are always taken with a pressure of 5mB. The dotted lines above and below the 5mB value form the extreme limits within which a perfect measurement result has been or will be achieved (5mB ± 0.1mB). The orange line indicates the value (4mB) at which the measurement is still considered sufficient (the hearing care professional decides). SI unit for pressure: the Pascal [Pa] (5mB ≡ 500Pa).
- **sec.:** the x-axis represents the total measurement time in seconds. The measurement time can only start when an initial pressure of 5mB has been achieved.

3.2.4 status

The status line, displayed just above the graph, shows to the right of [STATUS:] the condition the leakage tester is in. At the end, the *progress bar*, indicating the duration of a changing status.
The leakage tester has a number of conditions, the most important of which will be discussed in chapter 5.
If only the user's attention is required, the background will turn orange, however, in the event of an error message, the background will turn red.
One status message has already passed: **Your BLE2400 is ready to go!**: the leakage tester is ready for the first session, you guessed it.

3.2.5 info panel

To the right of the graph, the data is visible with information about the course of a measurement:

- **test** : [number] : the number of measurements since the *app* was launched
  [*LED colour*] : *example*
  [light green] : the last measurement completed within specifications
  [dark blue] : measurement is running, not finished yet
  [red] : something went wrong: see status line for more information
  [orange] : last measurement completed, but outside the specifications
- **sample** : the current number of measurements (samples) during the total session time
- **pressure** : the current measured pressure, or the last measured pressure **(mB)**
- **time out** : the time [mm:ss] remaining before automatic *app* termination **and** putting the tester into '*sleep*' mode (max. 60 minutes)

3.2.6 battery icon

The battery icon shows the charge status of the batteries *in* the leakage tester. The value is only an indication, remember that a transitional situation can occur in which the tester will start normally, but may not have sufficient power to operate the pump and valve, or build up sufficient pressure. The state of charge (%) is derived from the voltage profile during discharge of a standard 1.5V AA Alkaline battery; the tester continues to work properly down to a charge condition far into the red zone.

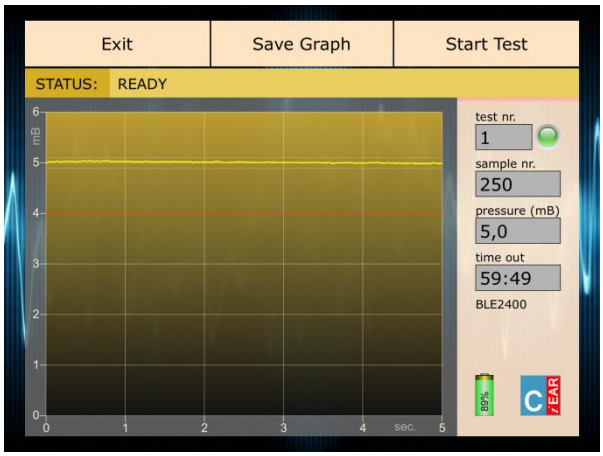
3.2.7 company logo

Tapping the logo (bottom right) offers two functions:

- it opens a pop-up pane with some information about the tester, software etc. for five seconds
- it can change the behaviour of the screen *'time out*' timer: the screen enters lock mode in sync with the time set by the user, or the screen stays on continuously; read §4.1.4 on how to use this function

3.3 Start measuring

To start a leakage test session, tap the **Start Test** button, the air pump in the tester will increase the pressure in the system in short time to a stable 5mB. When this pressure is reached and stable, the actual leak measurement will start and takes five seconds. During this period the graph is drawn *'real time*' and ideally the pressure should remain at 5mB. A margin of 4mB is adhered to indicate that a lower value is to be interpreted as an insufficient fitting of the earpiece, but as written before: the hearing care professional ultimately decides. The picture below shows an ideal result of a measurement; note that the **Save Graph** button is now clickable.



Picture 3.3.1: an ideal measurement result

A standard measurement procedure goes through a number of different stages:

SESSION START	:	just a very short notice
AIR IN	:	the air pump starts and brings the pressure to just above 5mB
STABILIZING PRESSURE	:	the pump stops, the air valve regulates the pressure to 5mB and closes the system
MEASURING PRESSURE	:	the test starts sampling with an initial pressure of 5mB; the graph will be plot
SESSION FINISHED	:	the last sample has been taken, the valve opens and the deflating procedure begins
READY	:	the system is ready for the next session

When the session is finished, the **Save Graph** button is enabled and after tapping it the user can save the recorded graph. This procedure is explained in paragraph 4.2.

4 MISCELLANEOUS

4.1 Modes

4.1.1 idle

This is the mode the system is in when it is waiting for the next session. The '*idle*' mode lasts sixty minutes and when the user does not take any action the timer counts down to zero: the *app* puts the tester into '*sleep*' mode and terminates itself. The down counter will be reset every time a session starts.

4.1.2 sleep

In order not unnecessarily shortening the lifespan of the batteries, the tester is powered down if it is not used for a certain period. The system has a so-called *countdown* timer for this purpose and is visible in the info panel (*time out*). The time to power-down is set to sixty minutes at the start. De tester is given one minute more so that it never switches itself off too soon.

4.1.3 standby

Before entering the '*sleep*' mode, which is irreversible by software, a warning is presented to the user on the status line: 'STANDBY MODE ENTERED!'. From this moment the system is de facto in '*standby*' mode and the user has fifteen minutes left to reset the *countdown* timer by doing a (dummy) test.

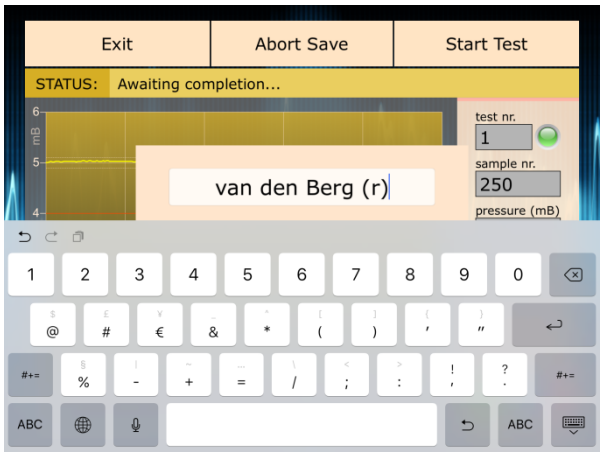
4.1.4 screen *'time out*'

Because the *standby* time has been extended to one hour, we have made the screen *time out* selectable: if nothing is done the *time out* will follow the time value set by the user (default).
After tapping the *Cursor* logo the information pane pops up, however, is the fingertip now held on the logo and moved to a place outside the logo (a *swipe* out), then the screen *time out* timer will stop (default) and the screen will remain active continuously until this action is repeated or the app shuts down.
The choice made is fed back to the user each time.

4.2 Archive

4.2.1 general

After each test, the user has the opportunity to save the resulting graph to a *file* for later use in documents.
Tapping the **Save Graph** button a window will pop up that allows you to enter a filename as shown below:



Picture 4.2.1: saving a graph

4.2.2 procedure

Click in the *pop-up* window on the so-called *placeholder* (filename[.png]) and enter the name; a maximum of 48 characters can be used, conclude with [**Done**]. Tapping the **Abort Save** button terminates the saving procedure, but can be restarted or continued by tapping **Save Graph** again until the saving procedure has been completed or until the next measurement starts. The graphic result of an ear measurement can only be saved once. A file is created with the representation of the graph just drawn. The average size of the file is somewhat dependent on the screen resolution and ranges from approx. 80kB to 450kB.
A 'name + date/time' stamp is always added at the bottom *inside* the graph.
The graphs will be stored in the so-called 'Portable Network Graphics' file format, therefore the *extension* name reads **.png**. One should not enter this extension name: the extension will be automatically added.

4.2.3 folder location

All *apps* from suppliers other than Apple run in a so-called *sandbox*, preventing them from accessing files stored by other apps or making changes to the device. So every saved graph ends up in the OtoBLE sandbox. From there you can edit the graphs, email them etc. or possibly transfer them to another platform where the reports will be processed. There are differences between iPhones/iPads and MacBooks (§*4.2.3.1* ff.)

4.2.3.1 on the iPhone and iPad

With the *app* **Files**, which is standard available on every iOS platform, you can view the OtoBLE graphs in the *sandbox*: open *Files* and tap '*On My iPhone/iPad',* tap on the *OtoBLE* folder and then the subfolder *graph map*.

4.2.3.2 on the MacBook

Graphs are stored, quite hidden, in the folder: Macintosh HD >Users >[username] >Library >Containers >OtoBLE >Data >Documents >graph map. Here is how to get there: open a **Finder** window and select **Go**, hold down the *option*-key and click *Library* which is now visible in the list and then click/scroll through to the aforementioned end location. Create a *Desktop Shortcut* if you want.

4.2.4 messages

Some common status messages during archiving:

- **Filename '*filename*' already exists**: the *filename* already exists, make up a different name
- **Filename cannot be empty**: the *filename* cannot not be empty
- **Character (x) not supported in filenames**: although strictly allowed, characters are banned from the range **x** = ["\", "/", "*", "?", ":", "<", ">", "\\", "|"] for compatibility reasons; these tokens are automatically deleted as you type
- **Graph not saved yet, press 'Save Graph' again to resume**: apparently **Abort Save** has been tapped and the text box disappeared: tap **Save Graph** again; characters already entered are retained
- **Graph has been saved**: the file '*filename*.png' has been stored in the *Library*; read §4.2.3 ff.

5 STATUS MESSAGES

5.1 During connection set-up

Immediately after launch, the *app* searches for available leakage testers nearby.
If a suitable device is found, the software tries to establish a Bluetooth® LE connection with the tester.
While setting up this connection several status messages will appear on screen: mostly it is progress information, occasionally user action is required.

An overview of the most important messages is shown on the next page:

- **Bluetooth powered OFF (swipe Control Centre):** Bluetooth® hardware is available, but is still switched off, read §2.3.2 on how to turn the Bluetooth® radio (back) on
- **Scanning for BLE Devices...**: the *app* explicitly searches for leakage testers of the type BLExxxx for approx. fifteen seconds, your tester should be turned on beforehand and preferably in '*idle*' mode
- **Could not connect to any Leakage Tester**: no tester was found in the immediate vicinity; your tester might be (still) switched off *
- **Connection to BLExxxx established, wait..**: a leakage tester was identified and the *app* will try to upload settings and exchange data
- **IDENTIFICATION OF BLExxxx FAILED**: unknown problem occurred; maybe tester was only switched on while the *app* was already running * (occasionally the *app* can get *back on track*)
- **Offset unstable, restart your BLExxxx** : the *ambient* air pressure which is a reference (0mB) for every measurement is not stable enough, in most cases the tester is not yet acclimatized enough; wait a few moments after this message and then start again *
- **Your BLExxxx is ready to go!**: the tester has passed all initial tests and the settings are implemented and checked; you can start measurements now

* leads to **Exit (only**), the *app* terminates automatically within two minutes

5.2 During measurements

The messages during a standard measurement procedure where already mentioned in section 3.3.
Here follows an addition for deviating cases:

- **TARGET PRESSURE NOT REACHED OR UNSTABLE**: the system looses so much air that the pressure cannot be increased sufficiently, but before drawing any conclusions, the system should be checked for leaks without an otoplastic and with the air hose sealed at the very end; check that the air pump operates and whether the otoplastic is properly attached to the ear, also test if air is coming out of the tester at all
- **PRESSURE DISCHARGE TOO SLOW**: when a measurement has finished the system should be depressurized in a few seconds, but when this procedure takes too long it indicates malfunction or contamination of the internal air valve; if this problem persists service is required
- **READY (BELOW REJECTION LEVEL)**: the session has finished, but during the inquiry the system pressure has been 4mB or below, at some point
- **READY (CRITICAL LOW BATTERY)**: the session has finished, but the batteries are exhausted (< 3.6V, 16%) and should be replaced; remember that a transitional situation can occur where the tester will start normally, but will not have sufficient power to operate the pump or valve

5.3 During *idle* time

While waiting for the next session, the system is '*inactive*'. Even during this '*idle*' mode, data is exchanged with the tester and notifications can come up from the *app*.

We will name a few:

- **CONNECTION WITH 'BLExxxx' LOST**: the existing Bluetooth® connection went down on either side; most common reason is a switched off device *
- **STANDBY MODE ENTERED!**: this is a warning initiated by the tester to inform the user that 75% of the '*idle*' time has passed and thus makes clear that the *countdown* timer should be reset

* leads to **Exit (only**), the *app* terminates automatically within two minutes