PRODUCT TRAINING

TOF3D – NEUROMUSCULAR MONITOR

HOMINUM SALUTI MEDICINAM EXERCENS ®

MIPM

mipm.com

Internal Training, December 2021

PREPARATION

Make sure to have the TOF3D simulator installed on your computer or have a monitor available

In addition to that training you should read the user manual.

Contact MIPM if you have any questions. https://www.mipm.com/en/contact

TOF 3D

NEUROMUSCULAR MONITORING

From the creators of Watch*

HOMINUM SALUTI MEDICINAM EXERCENS ®

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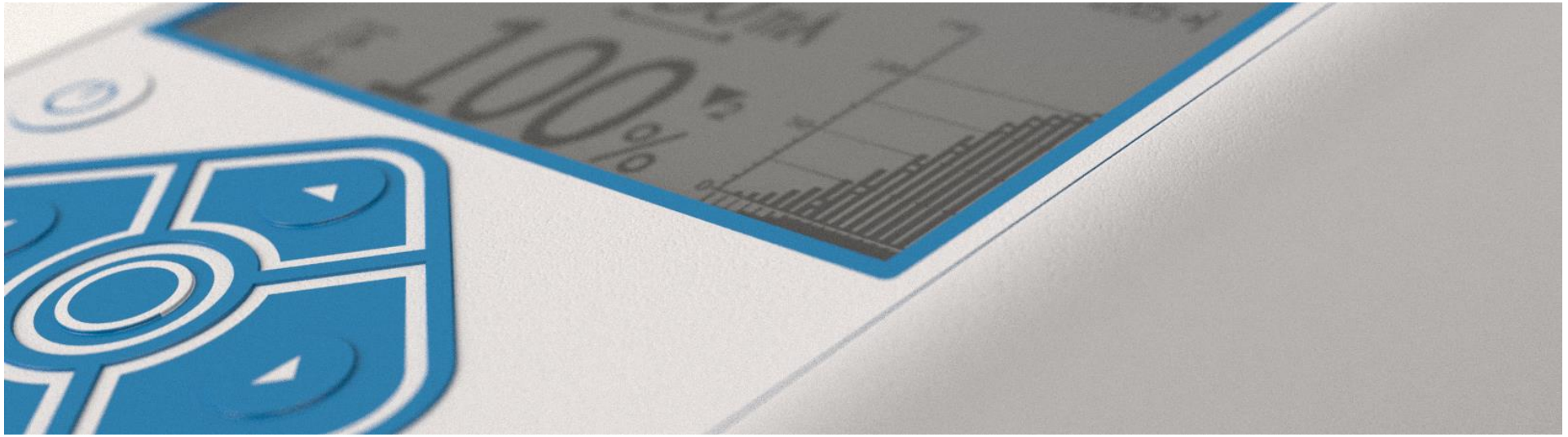
*TOF Watch is a registered trademark of Merck Sharp & Dohme B.V.

AGENDA

- How muscles contract (brief reminder)
- Why relaxation of the muscles?
- Neuromuscular Transmission Monitoring (NMTM) in Clinical Practice
- TOF3D
- Trouble shooting
- Hands on
- Q&A

TERMS

- Acetylcholine (ACh): Neurotransmitter responsible for stimulus transmission in the synaptic cleft
- NMBA: Neuromuscular Blocking Agent
- Paralysis: relaxation of muscles due to application of NMBA
- TOF: Train of Four
- PTC: Post Tetanic Count
- AMG: Acceleromyography
- MMG: Mechanomyography
- EMG: Electromyography

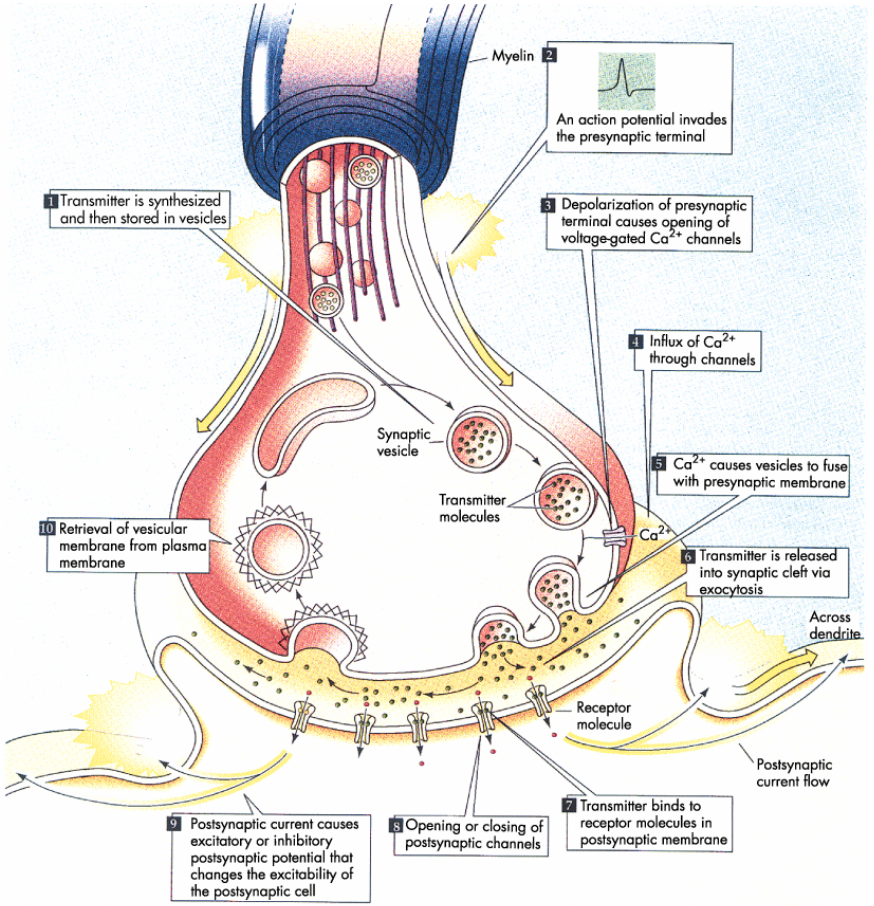


NEUROMUSCULAR JUNCTION

HOW MUSCLES CONTRACT

- A nerve is stimulated by impulses coming from the brain (or "artificial" electrical impulse)
- At the motor end plate Acetylcholine is emitted from the neuron in the synaptic cleft. ACh attaches to receptors at the muscle cell and enables contraction of the muscle
- ACh is consumed and must be reproduced in the nerve
- If a receptor is blocked (by NMBA) ACh cannot attach to that receptor
    - Muscle cannot contract
    - Muscle is relaxed
- NMBA concentration in the synaptic cleft fades over time
    - Relaxation of the muscle decreases until complete recovery

Only after complete recovery the muscle is fully functional!



NEUROMUSCULAR MONITORING

WHY RELAXATION?

1. Intubation

2. Required condition during surgery
   - During several surgery procedures surgeon needs the patient's muscles to be paralyzed to optimize surgical conditions.

3. Improve compliance during ventilation on the ICU

NEUROMUSCULAR MONITORING

WHY NMT MONITORING?

Residual paralysis may lead to severe complications for the patient.

- Pharyngeal dysfunction
- Increased risk for aspiration and pneumonia
- Acute respiratory events
- Residual paralysis increases patient's post operative discomfort in general

NMT Monitoring is used to determine the level of neuromuscular blockade.

- Safe tracheal extubation only if TOF ratio >0,9 (90%)
- Effective management of NMBA administration
  - Economic reason for NMT monitoring
  - Maintain muscle relaxation to ensure proper surgical condition

NEUROMUSCULAR MONITORING

AVAILABLE METHODS

+ Electromyography - EMG
+ Mechanomyography (Clinical reference) – MMG
+ Acceleromyography (Clinical practicability) - AMG

NEUROMUSCULAR MONITORING

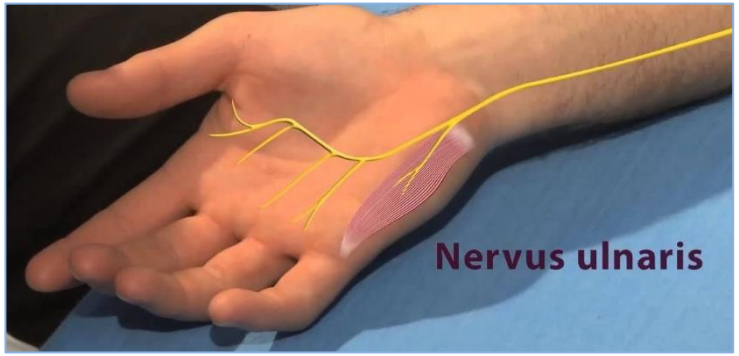
NMT MONITORING IN CLINICAL PRACTICE

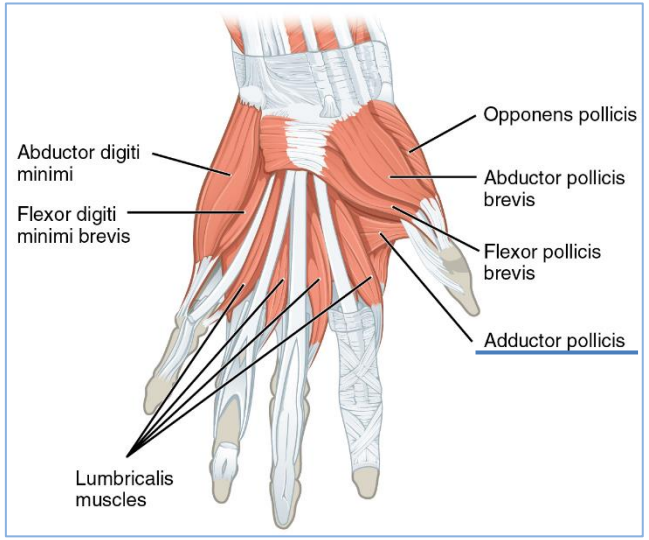
- TOF (Train Of Four) as reference for muscular paralysis and recovery condition of the patient
- PTC (Post Tetanic Count) for monitoring of deep muscular blockade
- Subjective neuromuscular monitoring with peripheral nerve stimulator (Subjective!! Based on personal perception)

NEUROMUSCULAR MONITORING

TOF STIMULATION – TOF RATIO / TOF COUNT

- Nervus ulnaris is innervated with 4 impulses
- Depending on neuromuscular block, 0-4 responses of Musculus Adductor Pollicis are received by TOF Monitor
- TOF Ratio = T4/T1
- TOF Ratio can only be calculated if 4 responses are detected.
  - T1 must be >20% compared to base line (Individual 100% answer)
  - T2, T3, T4 must be >3%
- Otherwise TOF Count 0 – 4
- If 4 responses are detected TOF Ratio is shown as “percentage of recovery”





NEUROMUSCULAR MONITORING

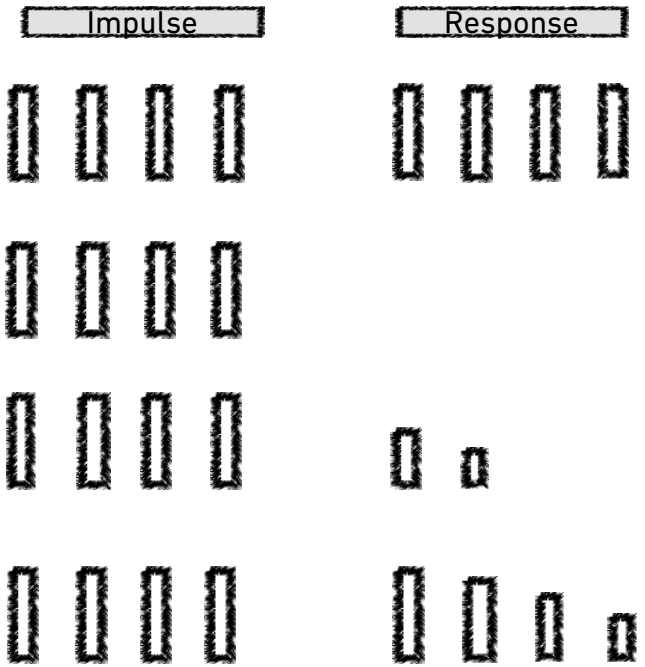
TOF RATIO / TOF COUNT - EXAMPLES

+ Non relaxed patient / full recovery

+ Complete neuromuscular block

+ Recovery: early stadium - (e.g. TOF count 2)

+ Recovery: medium stadium - (e.g. TOF ratio 50%)



NEUROMUSCULAR MONITORING

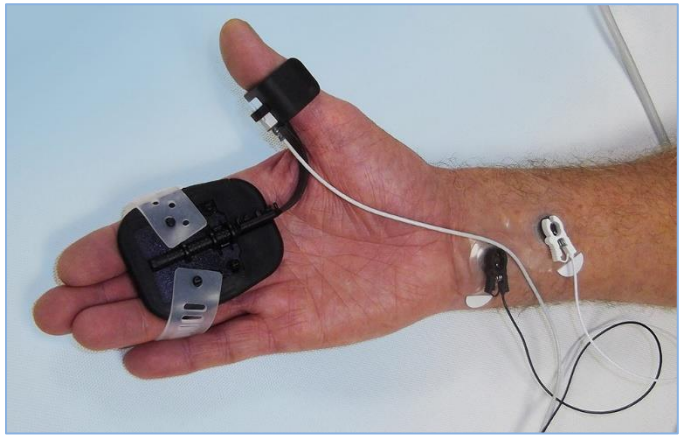
BASICS

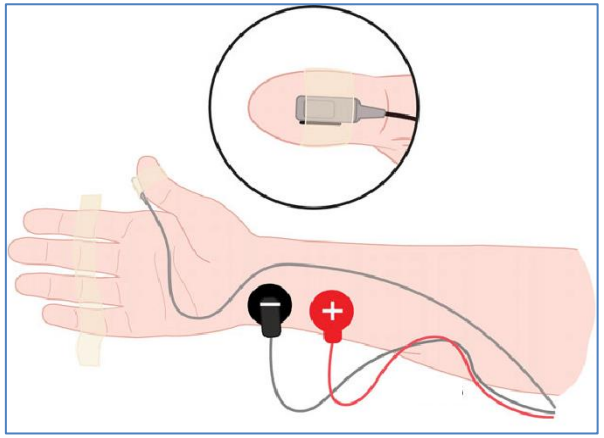
It all starts with the correct setup of stimulation electrodes and acceleration sensor! The hand should be fixed to the OR table or the hand adapter should be used.

Use small (pediatric) electrodes to ensure proper placement and skin contact.

Observe polarization of the stimulation cables.

+ Positive (White) cable: Proximal
+ Negative (Black) cable: Distal





NEUROMUSCULAR MONITORING

BASICS

The more distal the acceleration sensor is placed on the thumb, the stronger the acceleration signal. This effect can be used to adjust the signal strength.

NEUROMUSCULAR MONITORING

BASICS

The shortcoming of AMG technology is that the observed muscle (e.g. adductor pollicis) requires space to move.

Only the movement (acceleration) of the muscles can be picked up by the sensor.

If hands are tucked to the body in an unfavorable way or if the free movement of the muscle is blocked by blankets or surgical drapes AMG will not work!

Using the hand adapter improves the performance by holding up the thumb providing space to move.

If the monitor cannot be used on adductor pollicis (thumb) you may try different setups:

NEUROMUSCULAR MONITORING

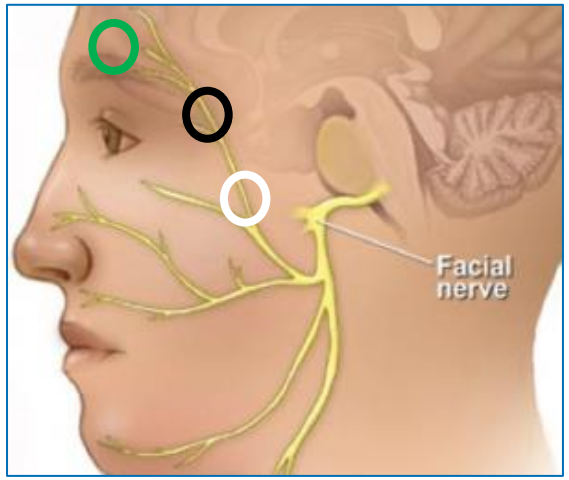
ALTERNATIVE STIMULATION SETUPS

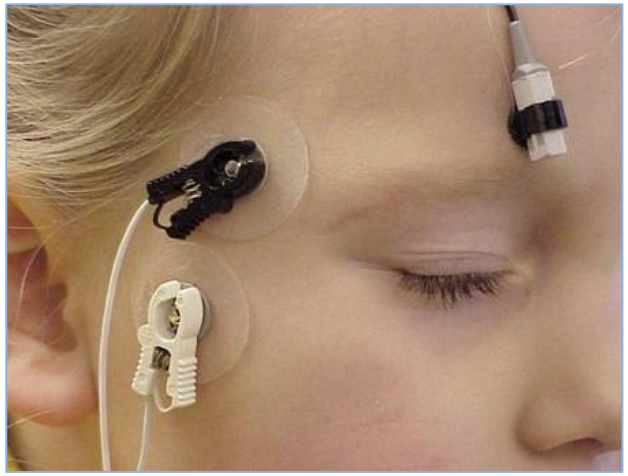
Stimulation: Facial nerve

Place positive electrode (white) near ear lobe and the negative electrode (black) 2 cm's from the eyebrow (along facial nerve inferior and lateral to the eye)

Response:
Orbicularis occuli muscle – Eyebrow twitching

Use the Eye adapter to fix the acceleration transducer to the eyebrow





NEUROMUSCULAR MONITORING

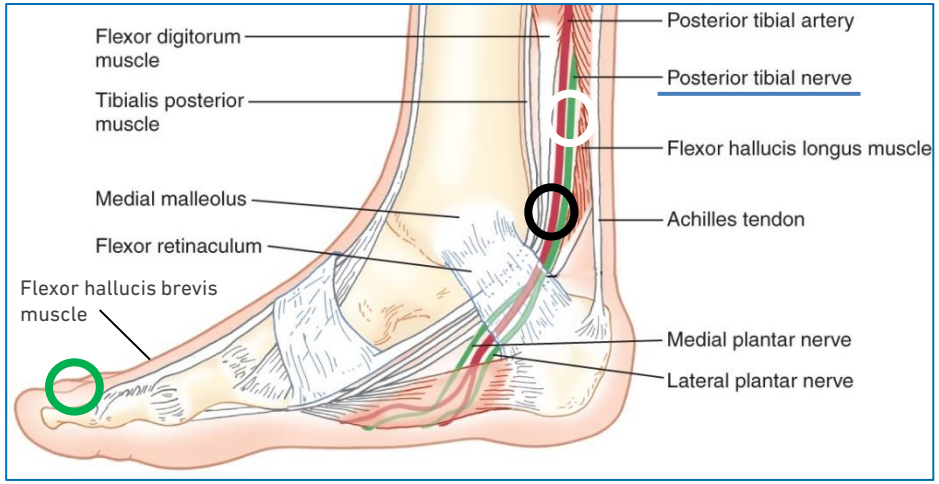
ALTERNATIVE STIMULATION SETUPS

Stimulation: Posterior tibial nerve

Place the negative electrode (black) over inferolateral aspect of medial malleolus (palpate posterior tibial pulse and place electrode there) and positive electrode (white) 2 – 3 cm proximal to the negative electrode.

Response:
Flexor hallucis brevis muscle – planter flexion of big toe

Use the Thumb adapter or plaster to fix the acceleration transducer to the toe.



NEUROMUSCULAR MONITORING

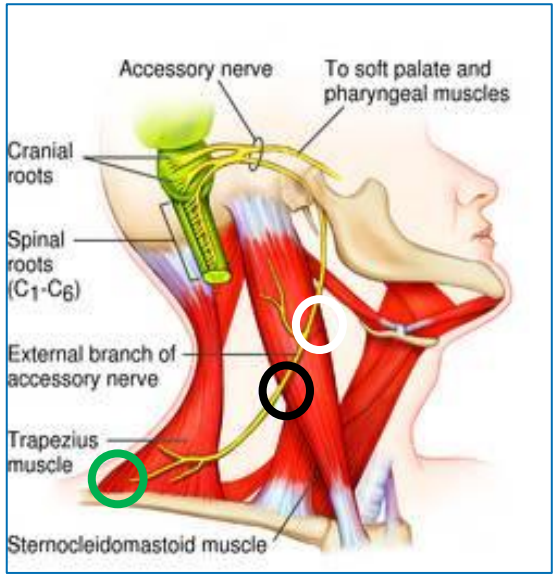
ALTERNATIVE STIMULATION SETUPS

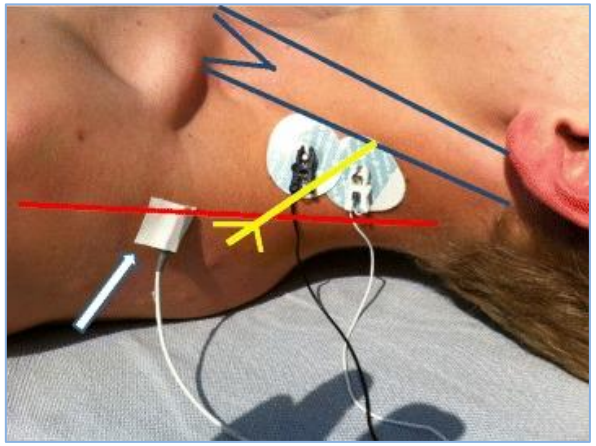
A study conducted by Dormagen hospital in Germany showed a good correlation between using a setup at the trapezius muscle and using the adductor pollicis setup.

In this setup the Accessory nerve is stimulated provoking a shrug.

Fix the acceleration sensor with tape to the patient's shoulder.

There is no known literature or different studies available about this method.
It should <u>not</u> be recommended as a standard method.

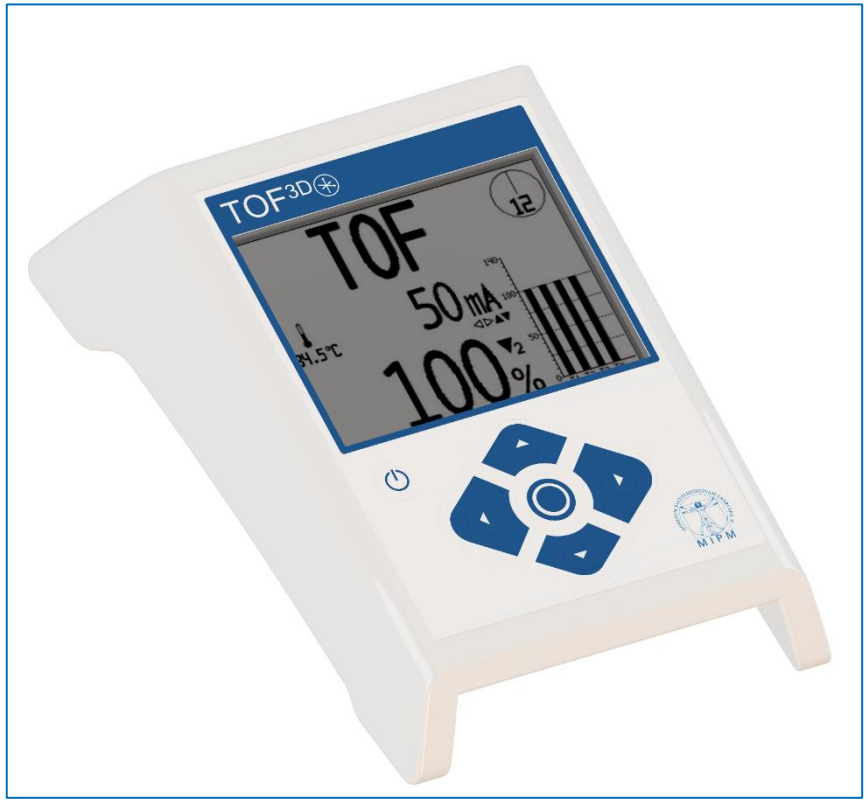




NEUROMUSCULAR MONITORING

TOF3D

- Compact design
- Various stimulation modes
  - TOF, PTC, Tet, DBS, Single Twitch
- Big clearly arranged display
- Adjustable continuous measurement
- Calibration Mode



NMT MONITORING IN CLINICAL PRACTICE

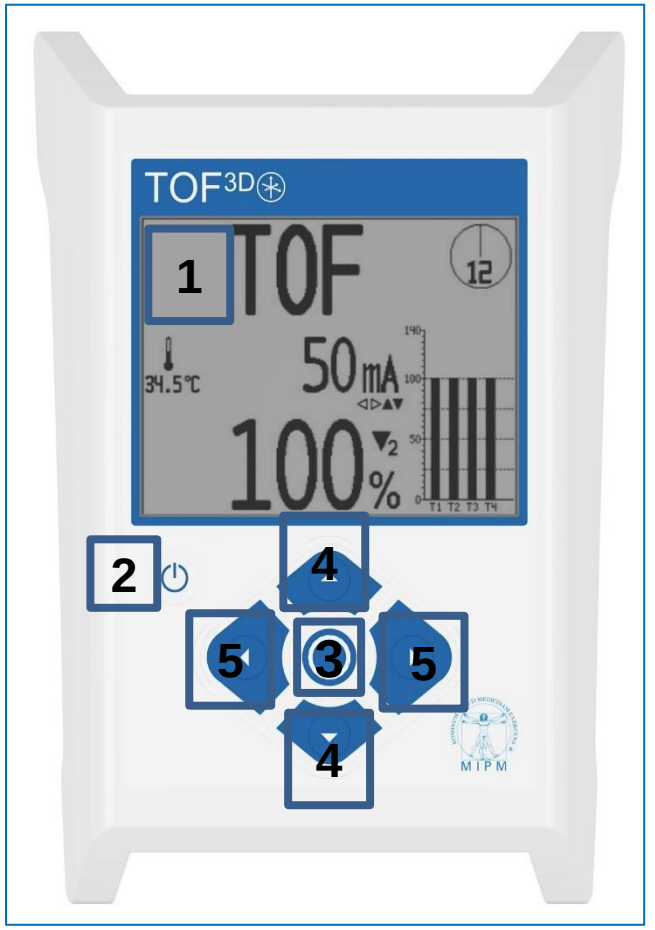
TOF3D

- Using TOF3D is an easy method to monitor the degree of neuromuscular blockade
- AMG: a piezo crystal produces an impulse if accelerated by contraction of the Musculus adductor pollicis (thumb). Impulses are processed and displayed as TOF ratio or single impulse response
- More reliable than subjective monitoring!
  - Reproducible!
  - Objective!
  - Calibration function normalizes signal amplification and electric stimulus to the respective patient.

TOF3D® IN DETAIL

FRONT VIEW

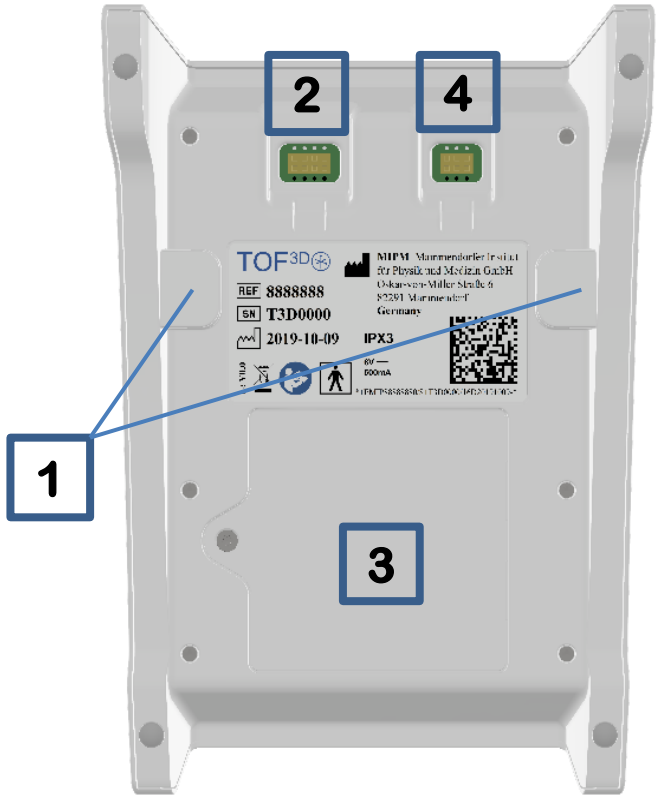
1. Display
2. On / Off key
3. Center Key
4. Up / Down keys
5. Right / Left keys



TOF3D® IN DETAIL

BACK

1. Adapter for IV pole holder
2. Socket for Patient cable
3. Battery Compartment
4. USB Interface

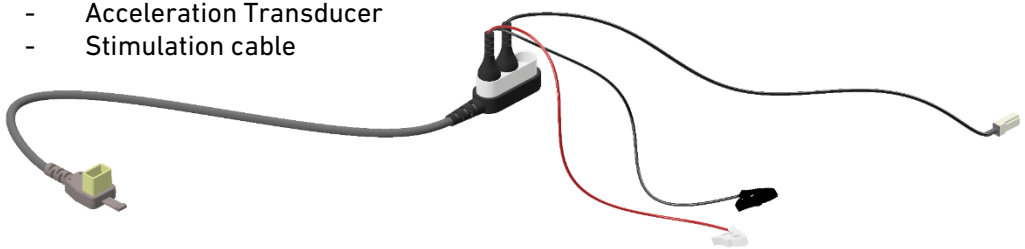


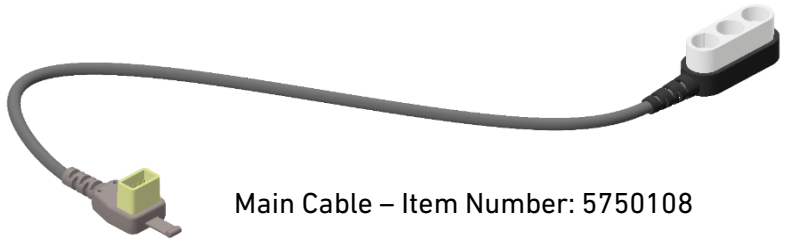
TOF3D® IN DETAIL

ACCESSORIES

Complete Patient Cable – Item Number: 5750104

Including:
- Main cable
- Acceleration Transducer
- Stimulation cable

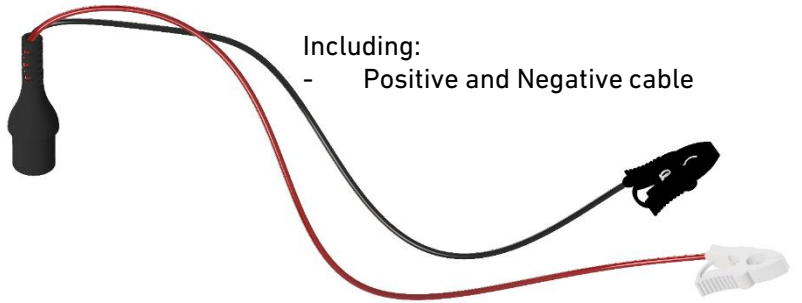




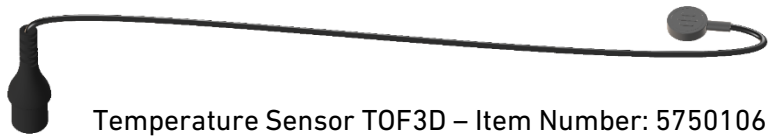
Main Cable – Item Number: 5750108

Stimulation Cable – Item Number: 5750107

Including:
- Positive and Negative cable



Acceleration Sensor TOF3D – Item Number: 5750105



Temperature Sensor TOF3D – Item Number: 5750106

TOF3D® IN DETAIL

ACCESSORIES

Hand Adapter TOF3D – Item Number: 5750100

Data Interface Plug TOF3D – Item Number: 5750109

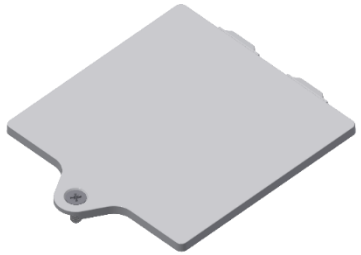
Thumb Adapter TOF3D – Item Number: 5750101

Eye Adapter TOF3D – Item Number: 5750102

TOF3D IN DETAIL

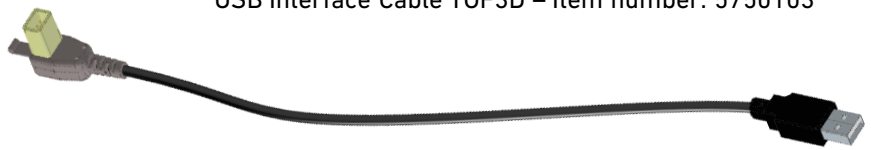
ACCESSORIES

Battery Lid TOF3D– Item number: 5750111

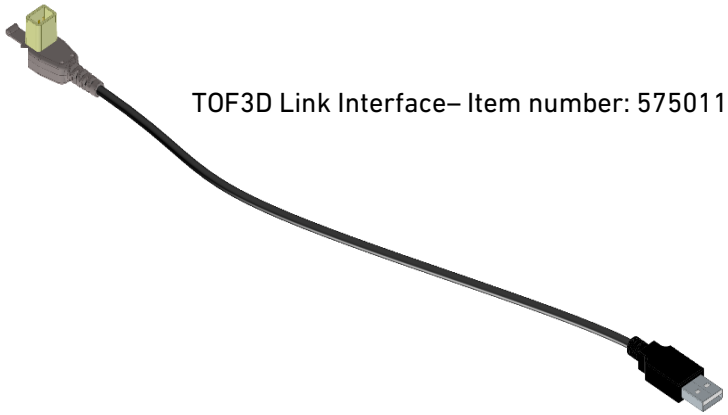


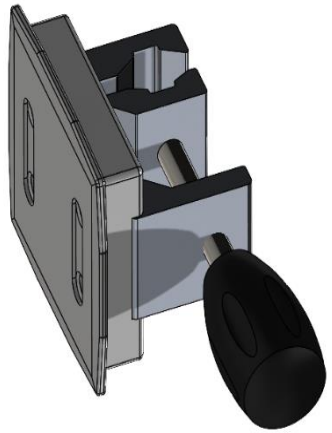
Split connector sealing plug TOF3D– Item number: 5750116

USB Interface Cable TOF3D – Item number: 5750103



TOF3D Link Interface– Item number: 5750117





IV-pole holder TOF3D – Item number: 5750110

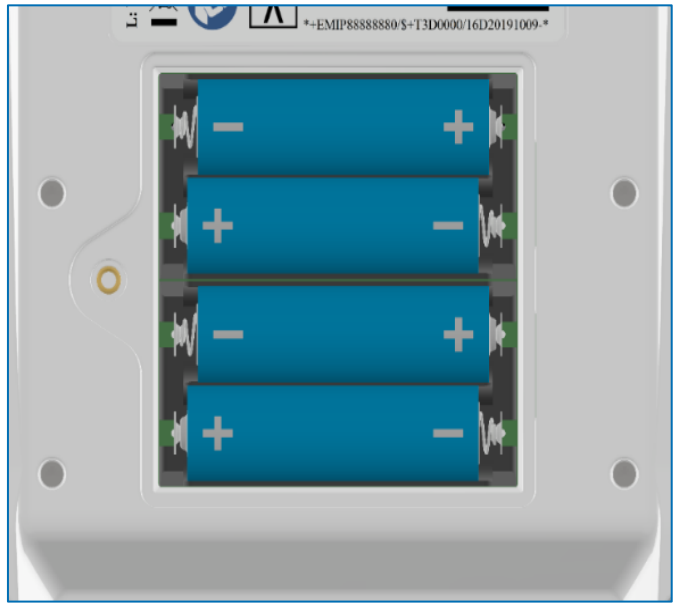
TOF3D IN DETAIL

THE TOF3D IS BATTERY POWERED

Open the battery lid using a cross tip screwdriver.

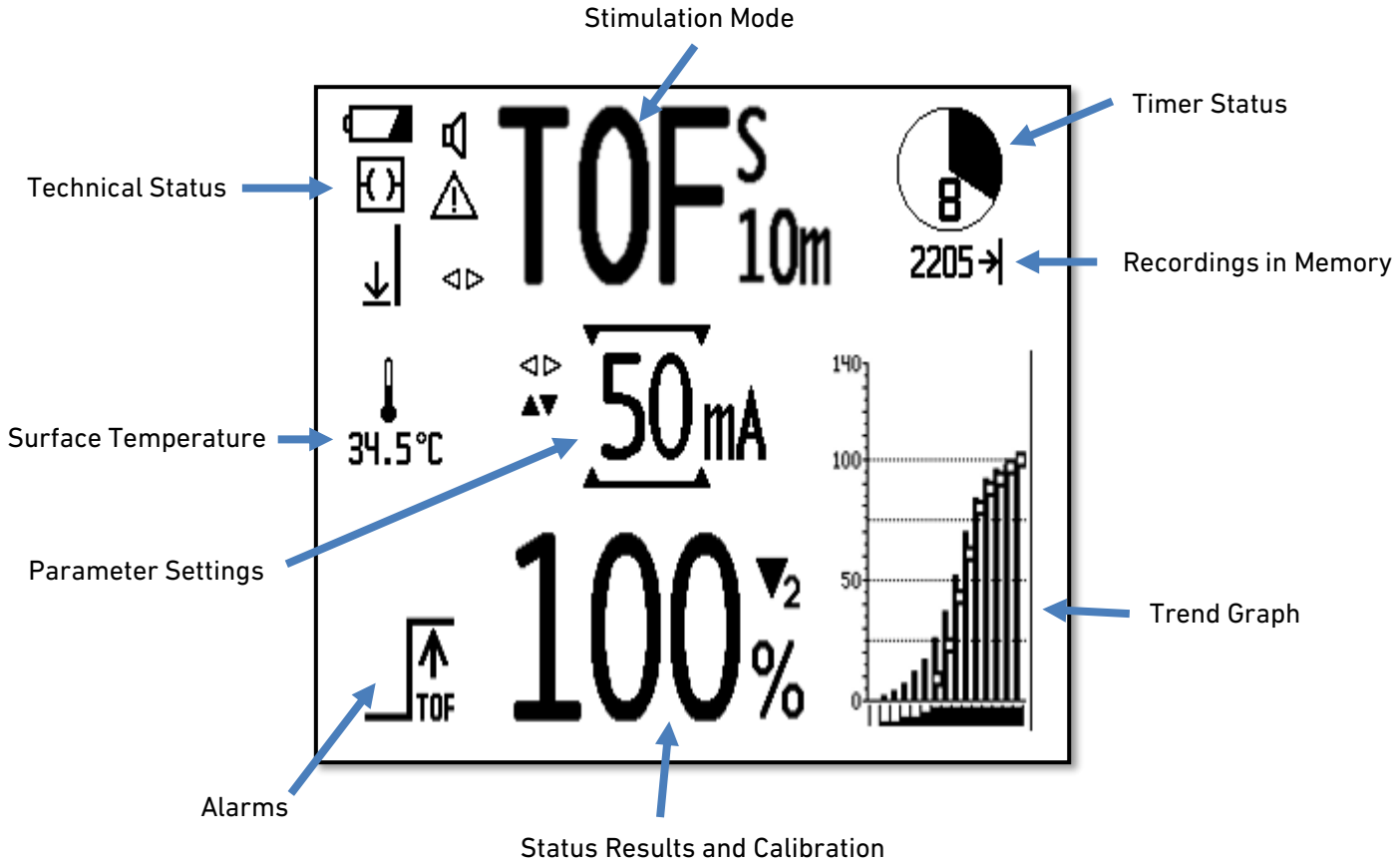
Insert 4 AA batteries as shown on the picture.

Fully charged batteries will give you up to 1500 hours of continuous stimulation.



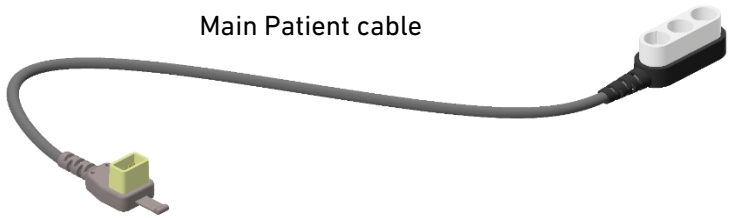
TOF3D IN DETAIL

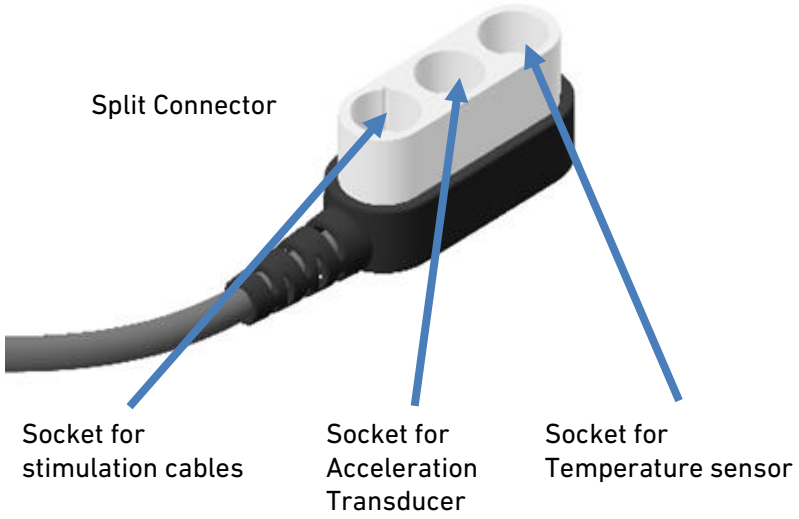
THE DISPLAY



TOF3D IN DETAIL

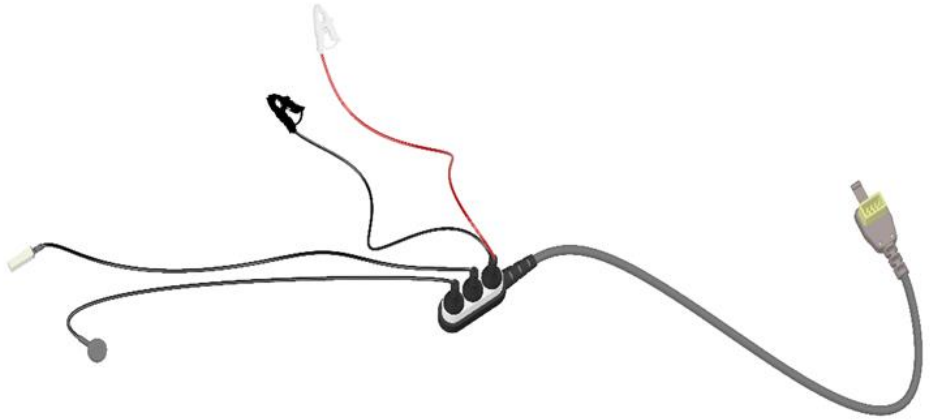
CABLE CONNECTION





Acceleration Transducer, Stimulation cables and temperature sensors need to be connected to the split connector.

Each connector port is mechanically coded to make sure that the cables only fit in their respective position.



TOF3D® IN DETAIL

CABLE CONNECTION

Connect the patient cable to the patient cable socket on the back side of the monitor.

TOF3D IN DETAIL

QUICK GUIDE - CALIBRATION

The monitor must be calibrated before application of NMBA!
The calibration procedure determines the individual patient's muscle response.

This ensures accurate measurements.

CAL 1: The monitor determines the base line (muscle response in the absence of NMBA) for the respective patient.

CAL 2: The monitor determines the base line (muscle response in the absence of NMBA) for the respective patient as well as the supra-maximal stimulation current.

Select CAL1 or CAL2 in the Settings menu.

If patient is already relaxed do not calibrate device as this leads to wrong results!
Since amplification of the signal and stimulus strength haven't been normalized by calibration process TOF ratio may be above 100%.

TOF3D® IN DETAIL

QUICK GUIDE

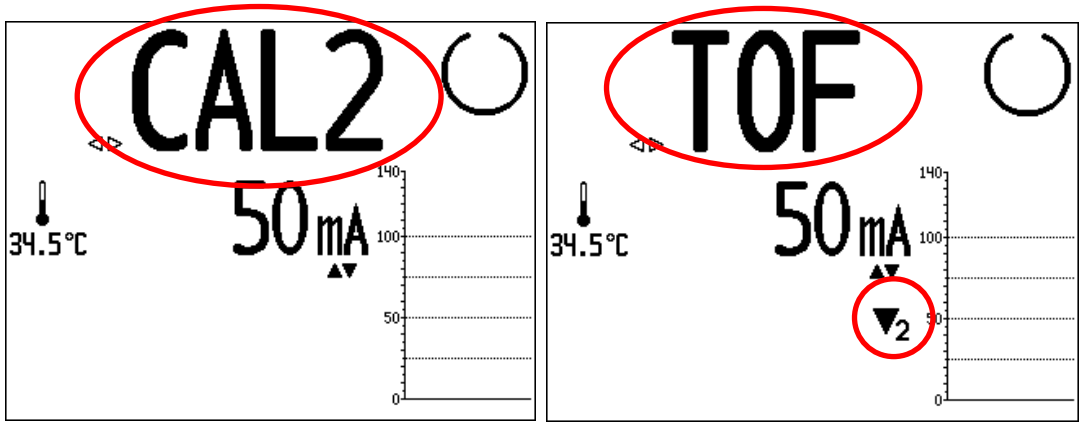
Place the stimulation electrodes and acceleration sensor to the patient as explained before.
Turn ON the monitor.
After a completed self test the monitor automatically goes to CAL Mode.

1. Inject sedative (wait for appropriate sedation)
2. Calibrate TOF3D.

   Press and hold the center key for at least 1 second to initiate Calibration.

   Wait until monitor returns to TOF mode and

   “calibration successful” is displayed



3. Inject blocking agent (NMBA)
4. Start single TOF stimulation by pressing the Center Key once

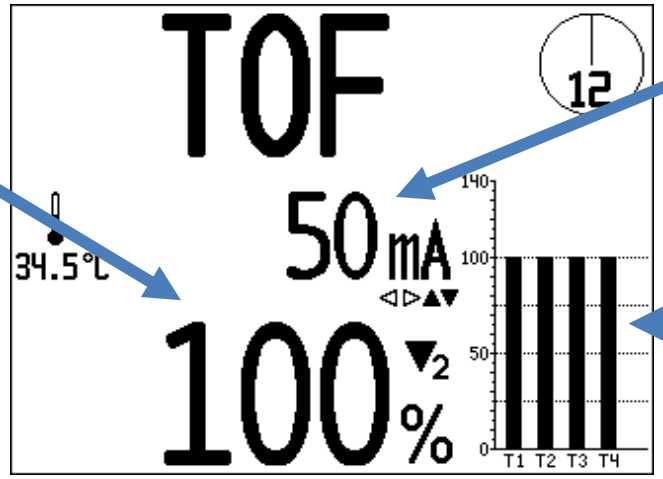
   (Start continuous TOF stimulation by pressing the Center Key for more than one second)

TOF3D IN DETAIL

QUICK GUIDE

After a successful TOF measurement you will see:

TOF Ratio or TOF Count



Applied stimulation current

Number and height of twitches

After 15 seconds the twitch responses are faded out and the trend graph is shown.

TOF3D IN DETAIL

QUICK GUIDE

If TOF count = 0 - Use PTC to monitor deep muscular blockade.

- Select PTC Mode using the Right – Left Keys
- Press and hold (>1 sec) Center Key to activate PTC
  - The monitor performs a response test (PrePTC - 15 impulses at 1 Hz)
    - If more than 5 impulses > 3% are detected PTC is not carried out
  - If PrePTC is successful tetanic stimulus starts (5 seconds)
  - After tetanic stimulus – 15 impulses (1 Hz)
- TOF 3D displays number of responses (max. 15)
- Monitor goes back to TOF mode
- **PTC may only be used every 2 minutes!**

TOF3D IN DETAIL

QUICK GUIDE

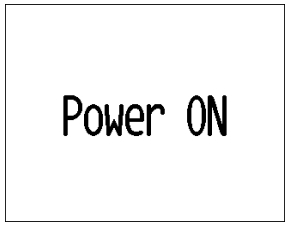
TOF3D offers a variety of functions.

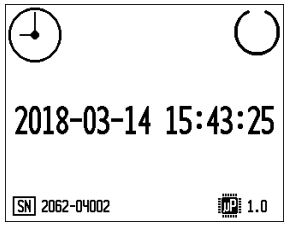
TOF3D can be used for single twitch stimulus and different other stimulation modes.

However the most common function is TOF stimulation. TOF has biggest practical evidence.

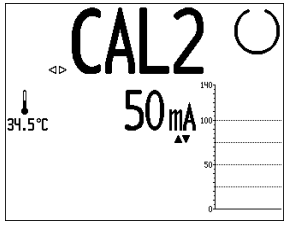
TOF3D IN DETAIL

QUICK GUIDE – A TYPICAL TOF SESSION

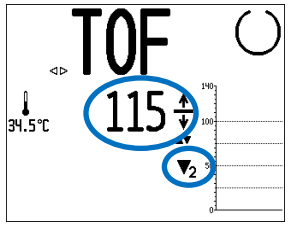




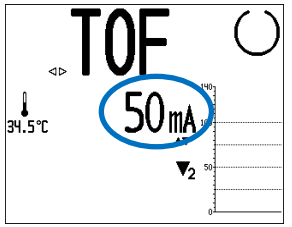
Self Test
Verify Date/Time



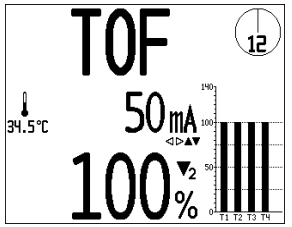
Initiate Calibration with Center Key >1 sec.



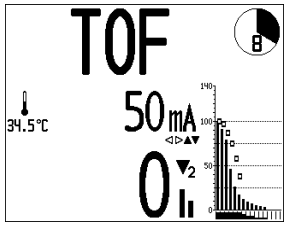
Base line adjustment and CAL confirmation are displayed



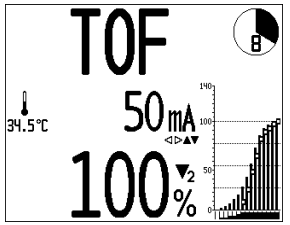
Stimulation current is displayed



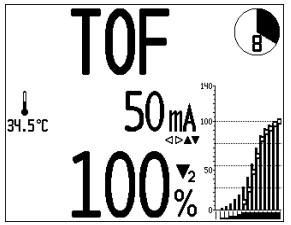
Start continuous TOF Measurement using Center Key > 1 sec.



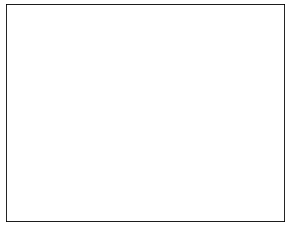
Observe effect of NMBA Bolus



Observe recovery until TOF>90%



Stop TOF measurement using Center Key



Turn Off Device

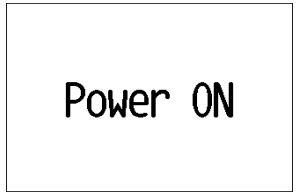
If unit is turned on again within two hours (from last measurement) you can add new data to the patient. If more than two hours have elapsed the patient has to be released and stored data must be transmitted via interface or deleted.

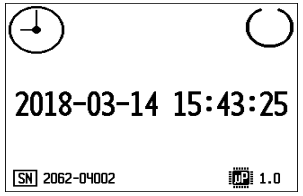
TOF3D IN DETAIL

QUICK GUIDE – DATA MANAGEMENT

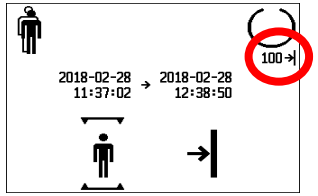
The TOF3D has an integrated memory. If data logging is active the start up procedure may be different depending on if there is still data in the memory.

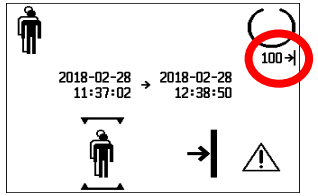
There are 100 logs in the memory.





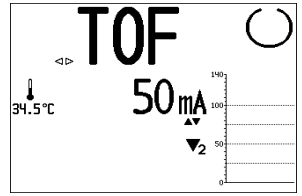
If the data is less than 2 hours old, you may add new data to the existing patient

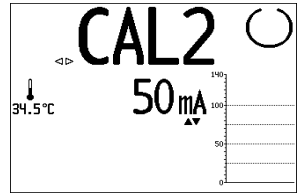




If the data is older than 2 hours, or you want to clear the memory the old patient will be replaced by a new one

If the monitor was calibrated and the existing patient was selected TOF3D goes to TOF mode



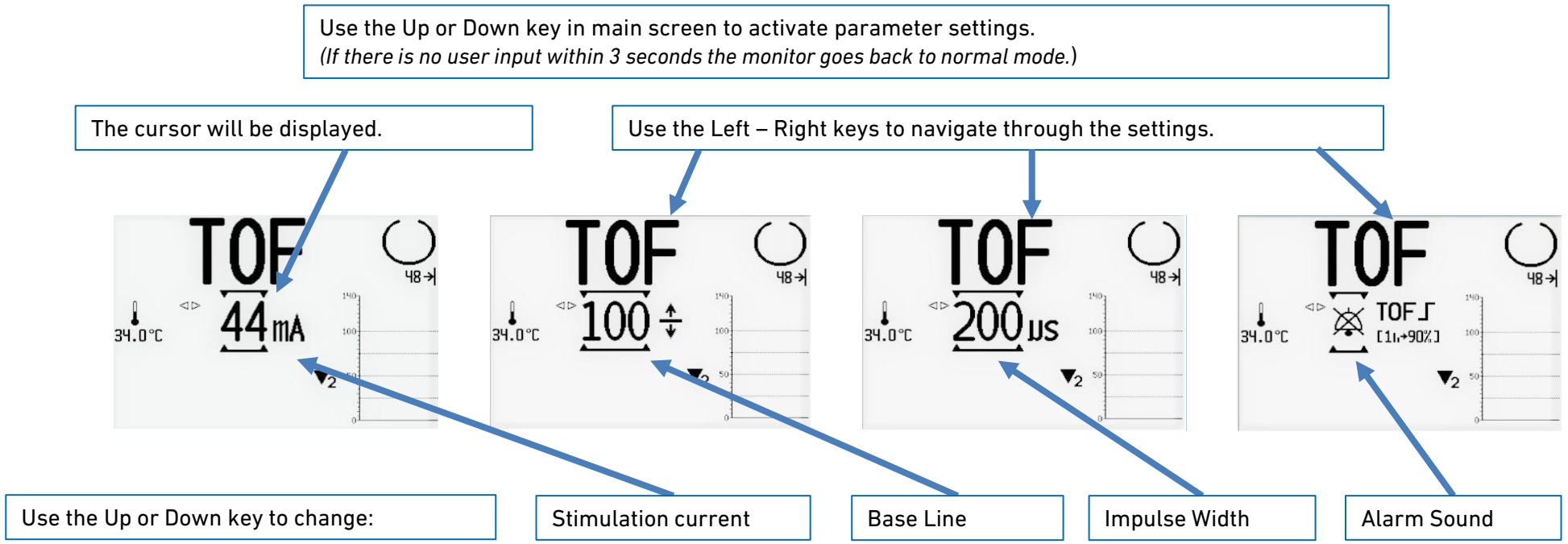


If new patient was selected or the monitor wasn't calibrated TOF3D goes to CAL mode

TOF3D IN DETAIL

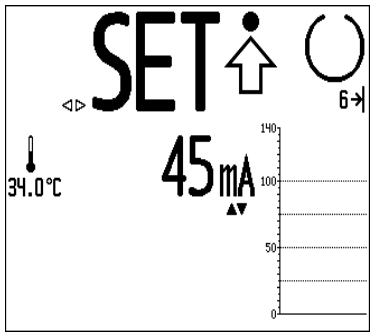
QUICK GUIDE – PARAMETER SETTINGS IN THE MAIN SCREEN

During normal operation you can always have a look at or change certain parameter settings.
Be aware; if the monitor was calibrated and parameter settings are changed manually, the calibration patterns are lost.

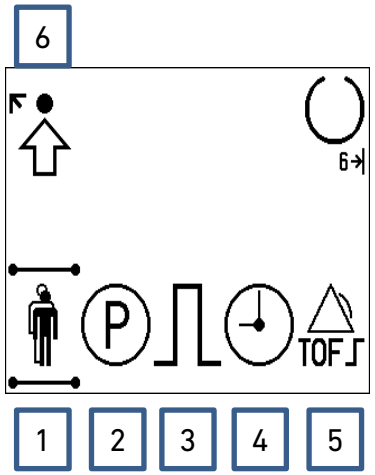


TOF3D® IN DETAIL

QUICK GUIDE – SETUP MENU



Go to Setup Menu using the Left – Right Keys

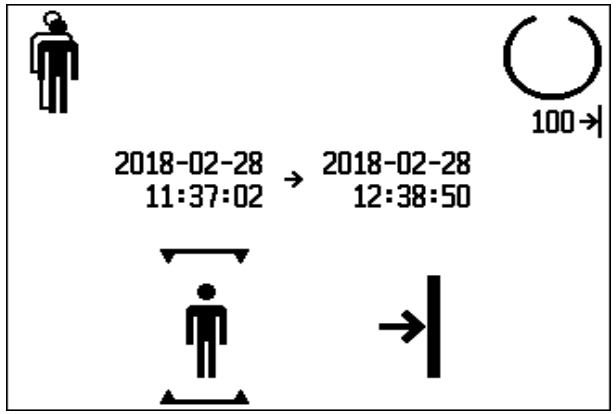


1. Data Management
2. Parameter Menu
3. Stimulation settings
4. Date / Time Settings
5. TOF Alarm Settings
6. Exit Setup Menu

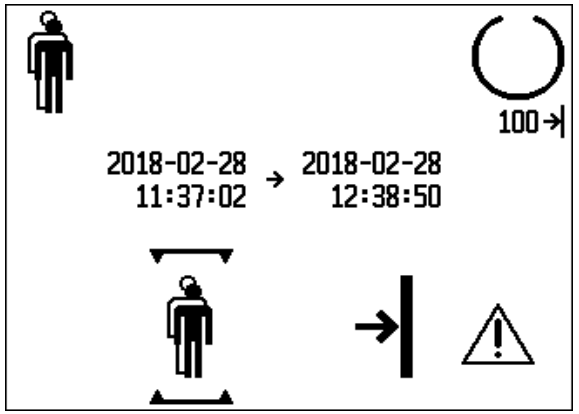
Use Left – Right Keys to navigate in the menu and Up – Down Keys to change settings. Use Center Key to enter or exit menus.

TOF3D IN DETAIL

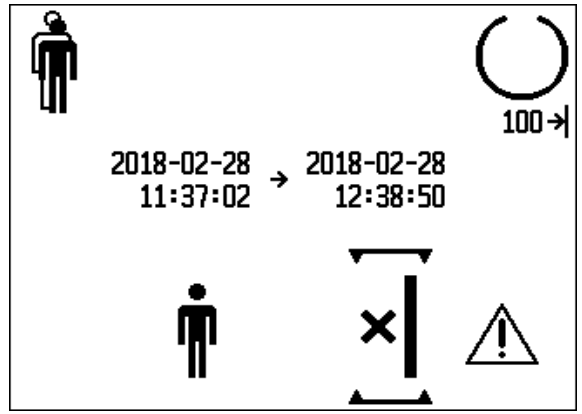
QUICK GUIDE – DATA MANAGEMENT



New Data will be added to data in memory



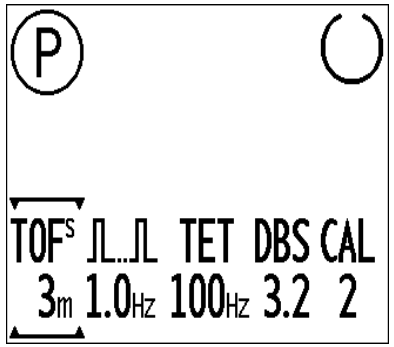
Existing Data will be erased – New Patient



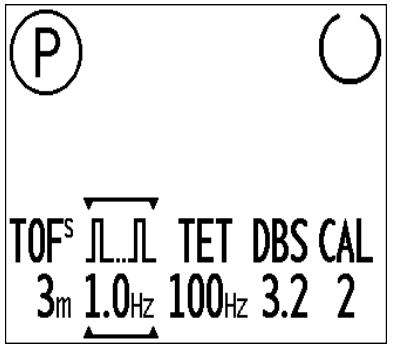
Activate / Deactivate data logging

TOF3D IN DETAIL

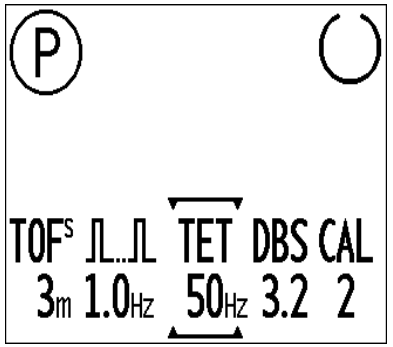
QUICK GUIDE - PARAMETER MENU



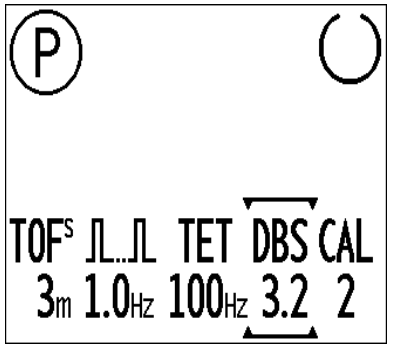
Select interval for continuous TOF Measurement in minutes.



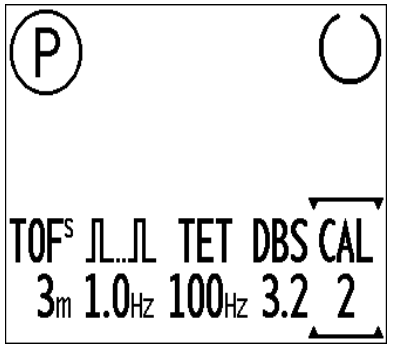
Select frequency for single twitch stimulation



Select frequency for tetanic stimulation



Select between Double Burst 3.2 and 3.3



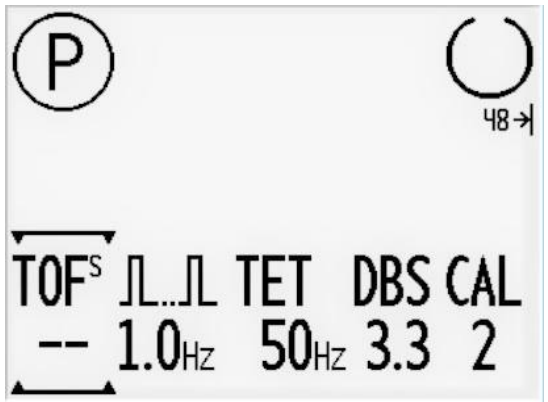
Select CAL 1 or CAL2

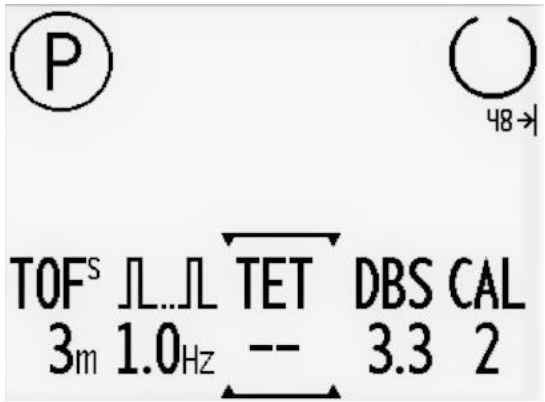
TOF3D IN DETAIL

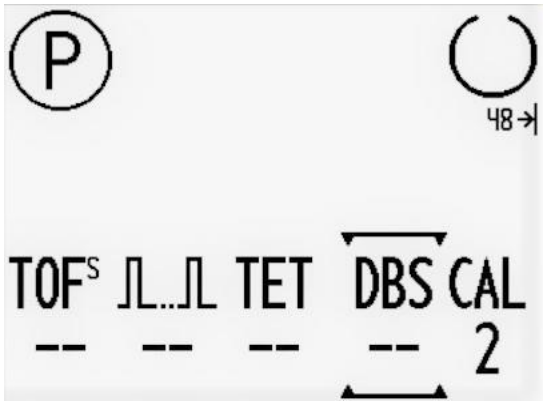
QUICK GUIDE – PARAMETER MENU

It is possible to eliminate stimulation modes from the menu. This will customize the monitor if stimulation modes are not used by customers.

If you want to eliminate a stimulation mode from the menu use the Left – Right Key to select the stimulation mode. Then use the Down key until -- is shown. Repeat this for all stimulation modes you want to eliminate.



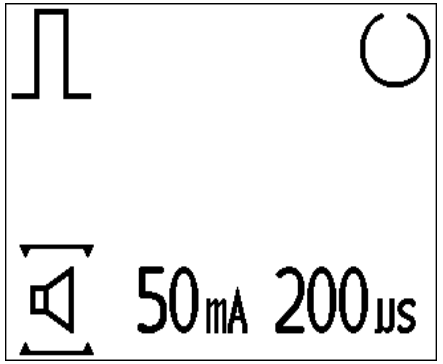




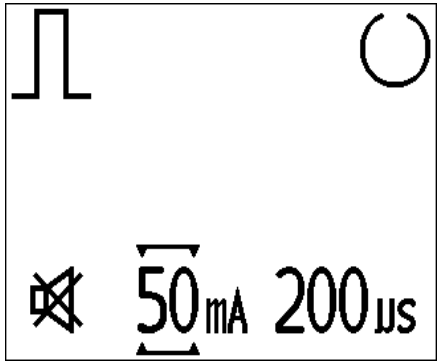
To reactivate eliminated stimulation modes go to the parameter menu again and use the Up Key.

TOF3D IN DETAIL

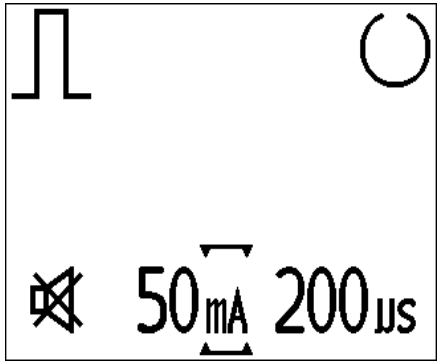
QUICK GUIDE – STIMULATION SETTINGS



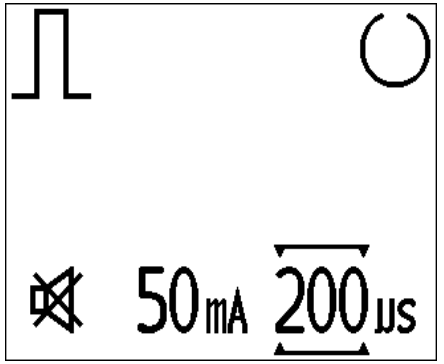
Activate or deactivate stimulation Beep.



Change default stimulation current



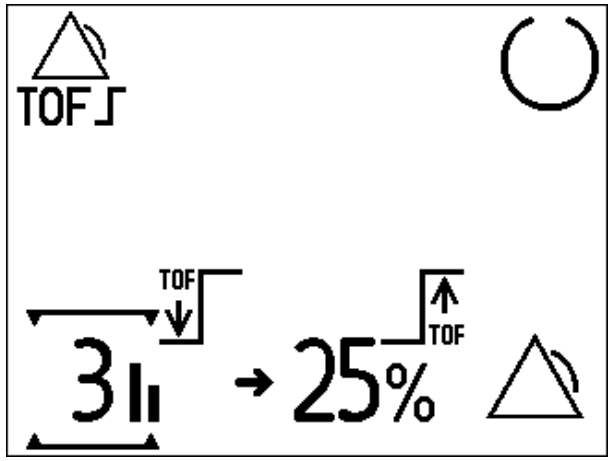
Change measurement unit for stimulation current. mA / µC



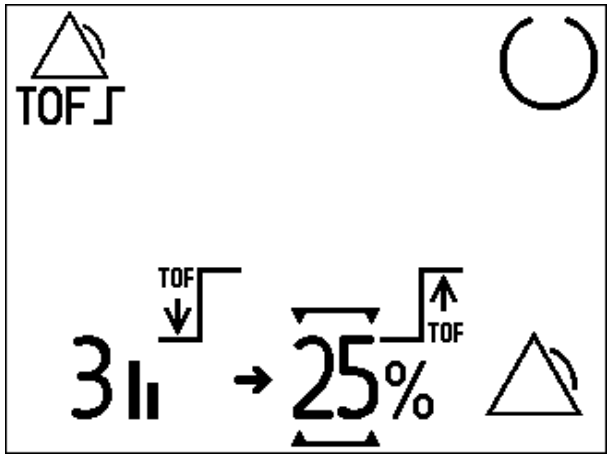
Chose stimulation pulse width. 200/300 µs.

TOF3D® IN DETAIL

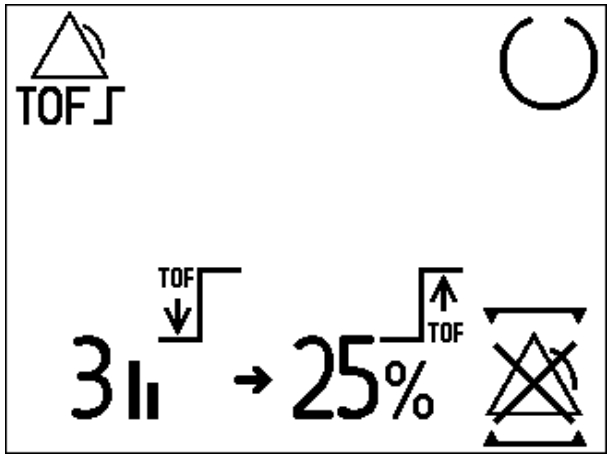
QUICK GUIDE – ALARM SETTINGS



Set Lower Alarm Limit



Set Upper Alarm Limit



Activate / Deactivate
TOF Alarm sound.

TOF3D® IN DETAIL

SPECS

Technical Specifications	
Device Dimensions	Height : 62,5 mm Width : 141 mm Depth : 202 mm
Display	Size: 4,4‘‘ – 90 x 67 mm Type: LCD Resolution: 240 x 320
Battery	Technology: Alkaline or NiCd/NiMH Type: 4 x 1,5V AA Operating Time: ≈ 1500 hours of constant TOF monitoring
Electrical Specification	Internally powered handheld device – Type BF Continuous operation IPX3 Operating Voltage: 4 – 6 Volt Max. current: 330 mA Power consumption: max. 2,5 Watt
Stimulation	Waveform: Monophasic rectangular wave Pulse width: 200 µs or 300 µs Constant Current: 0 – 60 mA Load: 100 Ω – 5kΩ
Data Storage	Online Data dump: Yes Data storage in device: Yes Memory capacity: ≈ 45,000 records (e.g. 180 hours of TOF recording)

TOF3D COMPETITORS

AMG

StimPod
Xavant

TOFscan
Idmed / Dräger

TOF3D COMPETITORS

AMG

Both competitors offer all available stimulation modes.

TOF 3D offers highest resolution display – better readability from greater distances

Alarm Management - Set Alarm Limits for upper and lower TOF Rates.

Competitors claim: No calibration needed.
This is not true!

Modern sensors can compensate variations in the sensitivity (connected to acceleration sensor placement). However the major part of variations in measurement comes from the different patient responses (patient variation). To overcome the variation in patients' responses and ensure correct measurement TOF monitors should always be calibrated.

TOF3D COMPETITORS

EMG

There are 2 EMG based handheld systems on the market.

TetraGraph
Senzime

TwitchView
Blink DC

EMG devices offer one big advantage compared to AMG based devices.
EMG technology does not depend on free moving muscles as they pick up the muscle's electric potential that is generated independent of the muscle's movements.

However EMG is linked to extremely high cost since the monitors can only be used with a special single use electrode.
A comparison between cost of AMG based monitoring and EMG based monitoring showed that using EMG increases cost for neuromuscular monitoring up to **2.000%** p.a. depending on the number of cases.

Moreover EMG is susceptive to RF noise coming from various devices used in the OR.

TROUBLE SHOOTING

Calibration didn't work.

- Check placement of acceleration sensor and stimulation electrodes
  - Maybe the acceleration sensor isn't placed correctly
  - Maybe the electrodes are not placed over Nervus ulnaris

- Maybe the skin resistance is too high
  - Observe messages in display
  - Clean skin with an abrasive gel or isopropyl alcohol solution

TOF3D

TROUBLE SHOOTING

PTC doesn't start

- Before TOF3D starts the Post Tetanic Count an additional check for muscle relaxation is performed.
  - If the check gives a stimulus response the PTC is not carried out.

- Has PTC been performed within the last 2 minutes?

TOF3D

TROUBLE SHOOTING

Calibration worked but TOF is not displayed.

+ check if patients' hand is still fixed
+ check if the thumb is free to move
+ check if stimulation cables are still connected to the electrodes
+ check if transducer is still positioned correctly

TOF3D

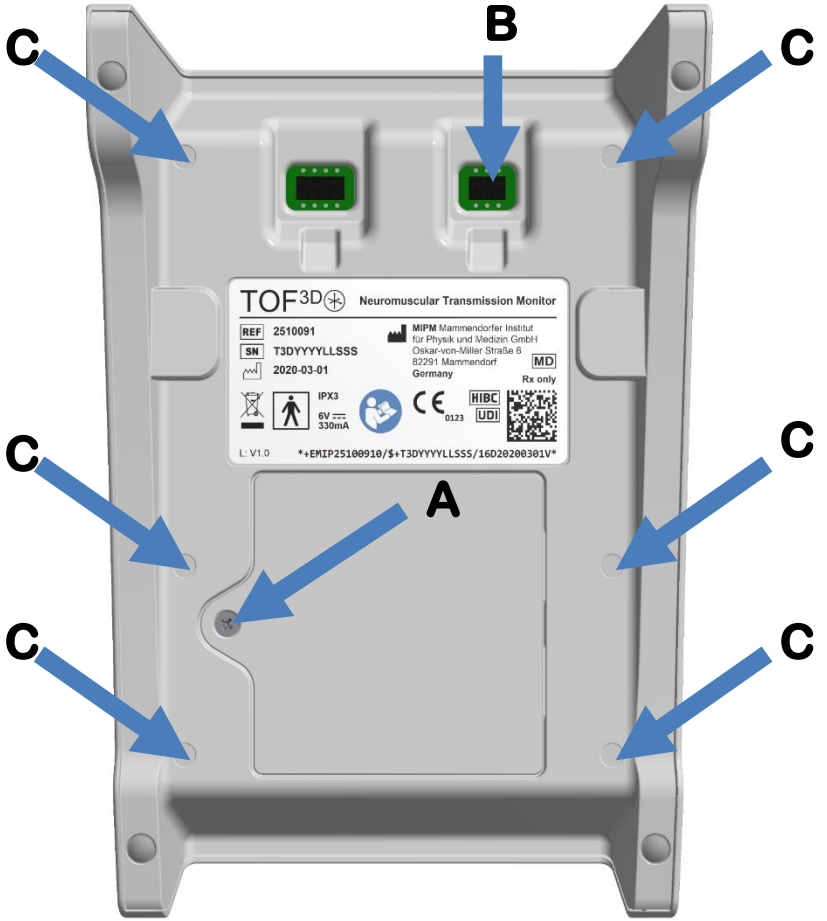
HANDS ON – TRY TO PERFORM THE FOLLOWING TASKS

1. Setup TOF3D for monitoring at Adductor pollicis muscle. Use the hand adapter.
2. Make TOF3D ready for Use. Initiate continuous TOF measurement
3. Set TOF Time Interval to 5 minutes and upper TOF alarm level to 90%.
   + Initiate TOF interval measurement
4. Delete Patient Memory
5. Set Calibration mode to CAL2
6. Set Stimulation pulse width to 300 µs
7. Initiate PTC
8. Connect patient cable with all necessary components.
9. Customize the monitor. Remove Single Twitch, TET and DB from the menu.
10. Replace batteries of the unit.

TOF3D

SERVICE - REPAIR

+ Remove Battery lid (marker A)
+ Remove the four batteries
+ Remove the sealing plug (marker B)
+ Remove the silicone plugs and the screws below (marker C)
+ Remove lower shell

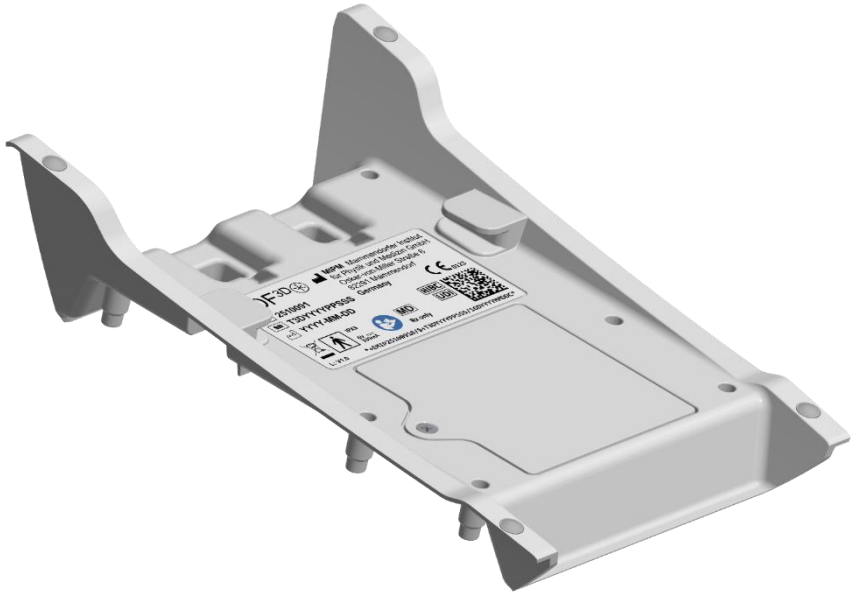


TOF3D

SPARE PARTS

Housing TOF3D top shell
Partnumber: 5750114

Housing TOF3D lower shell
Partnumber: 5750115



TOF3D

TECHNICAL SAFETY CHECK

- Visual Inspection
  - Check overall condition of TOF3D (Housing / Display / Keys) and Accessories
- Functional Check
  - Measure Voltage of Batteries
  - Check Peak to Peak Voltage on Oscilloscope for correct measurement
  - Check Transducer functionality
- Electrical Safety Check
  - Measure Patient leakage current

- Technical Safety check needs to be performed on annual basis
- Batteries only need to be replaced if indicated
- Detailed Information are provided in the Service Manual and the Technical Safety check protocol
- In case of any technical questions, please get in contact with service@mipm.com