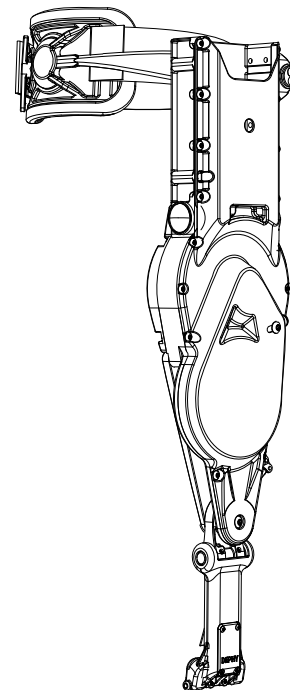


EB60 ExoBoot User Guide

KEY FEATURES

- High-performance, lightweight, autonomous ankle exoskeleton
- Replicate published experiments, improve on them, test, and repeat
- Same hardware can be used to:
 - Write your own controller using our API
 - Conduct studies with our walking controller
 - Conduct studies using a customized walking controller
- Includes a Direct Drive ActPack 4.1:
 - Fully integrated brushless motor (BLDC), power electronics and control logic
 - Built-in high-performance controllers: voltage, current, position, and impedance
 - Built-in sensors and interfaces: 6-axis IMU, voltage, current, temperature, strain gauge amplifier, expansion port, etc.
 - Communication: Bluetooth Classic EDR (BLE coming soon), USB, RS-485, SPI, UART, and I2C
 - Safety features: battery I²t, motor I²t, voltage limits, temperature
- Designed to use Dephy's BA30 LiPo Battery
- High-precision ankle angle sensor (plantarflexion)
- Cross-platform GUI and full suite of C/C++, Python, and MATLAB demo scripts



COMPLIANCE

- Contains FCC ID: QQQBT121
- The EB60 uses an ActPack 4.1 Direct Drive module. Please refer to the [ActPack 4.1 Datasheet](#) for more compliance information.

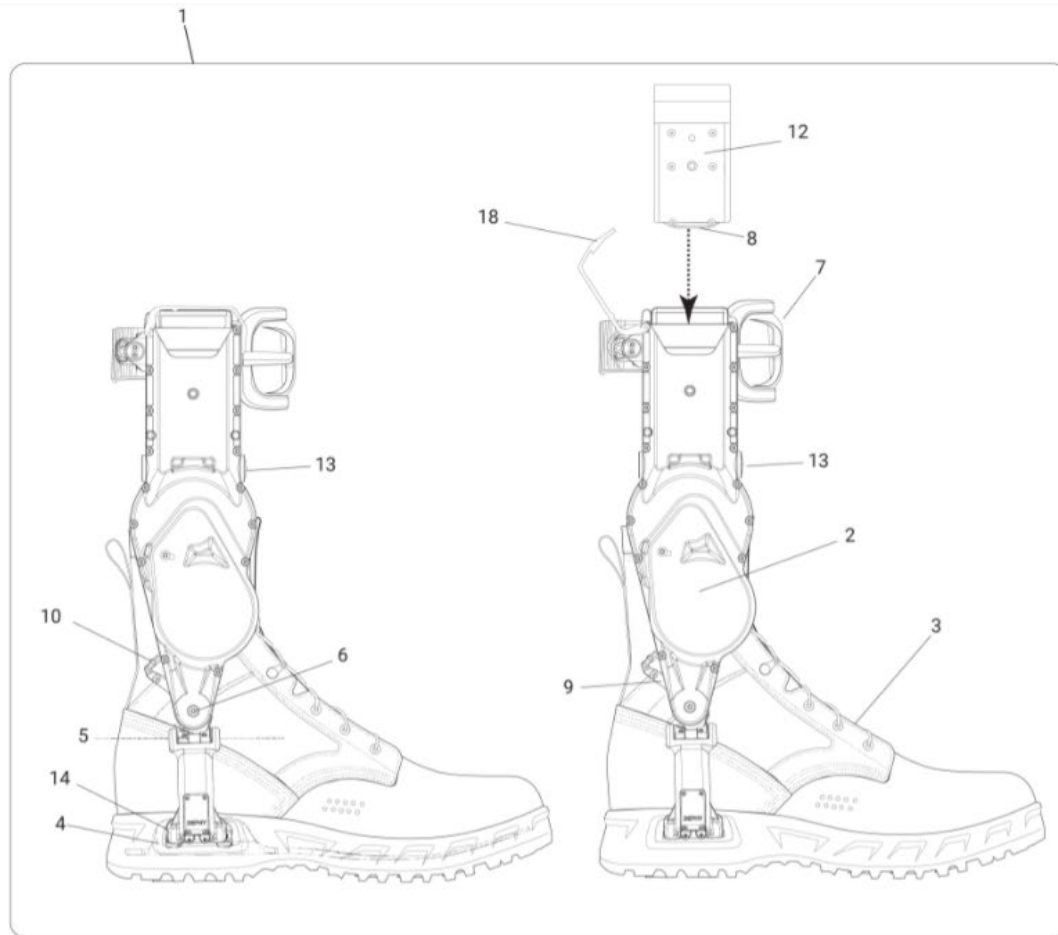
SAFETY

- Before using your EB60 ExoBoot, make sure to read and understand the safety information in this guide and at dephy.com/safety!

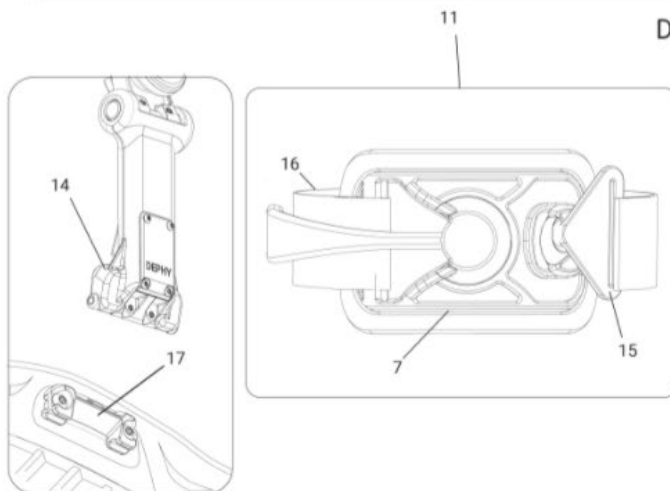
Table of Contents

Terminology	3
Data Streams	4
Safety	5
Don & Doff	6
Quick Disconnect (QD) On	6
Shlever Alignment	7
Quick Disconnect (QD) Off	8
Fit Adjustments	9
Shin Pad Height	9
Strap	9
Power	11
Battery Insertion and Retainer Clip	11
Power Button	11
FAQ	12
Reference Documents	14

Terminology



DEPHY EB60 ExoBoot terminology



1. EB60 ExoBoot
2. Actuator module
3. Boot (McRae T2 hot weather)
4. Carbon composite insert
5. Eversion/inversion axis
6. Ankle joint
7. Shin pad
8. Power connector
9. Actuator lever arm
10. Actuator chain
11. Shin pad assembly
12. BA30 LiPo battery
13. Power button
14. Quick disconnect boot/Exo
15. Medial clasp (Primary closure)
16. Adjustable elastic strap
17. Boot cleat
18. Battery retainer clip

The Dephy ExoBoot System has four main parts:

1. **The ExoBoot:** Dephy's powered lower limb exoskeleton platform.
2. **User Interface:** Custom Dephy software to interact with the ExoBoot and enable data logging.
3. **The Battery:** Dephy's safety tested custom BA30 LiPo battery solution. Datasheet.
4. **Footwear:** Custom carbon fiber insert shoe worn by the test subject that is capable of being attached to the ExoBoot.

Data Streams

Sensors onboard the ExoBoot include: a 6-axis IMU, motor encoder, and custom ankle joint sensor. By combining these data streams, metrics listed in the table below are calculated by the system and can be streamed to Dephy's user interface.

Variable	Full Name	Description	Units
State_time	Internal time	Embedded system timer	ms
Sys_time	System Time	Computer system timer	ms
Accel X, Y, Z	Accelerometer, 3 channels	Accelerometer output in X- (anterior/posterior), Y- (medial/lateral), and Z-directions (up/down)	m/s ²
Gyro X, Y, Z	Gyroscope, 3 channels	Gyroscope output in X- (anterior/posterior), Y- (medial/lateral), and Z-directions (up/down)	bits
Mot_ang	Motor Angle		ticks
Mot_vel	Motor Velocity		deg/s
Mot_acc	Motor Acceleration		rad/s ²
Mot_curr	Motor Current		mA
Mot_volt	Motor Voltage		mV
Batt_volt	Battery Voltage	Filtered battery voltage	mV
Batt_curr	Battery Current	Filtered battery current	mA
Temp	Temperature	System temperature	°C
Ank_torque	Ankle Torque	ExoBoot torque approximation	mNm
Ank_ang	Ankle Angle		deg * 100
Ank_vel	Ankle Velocity		deg/s * 10
Gait_state	Gait State	Dimensionless variable that returns 1 if user is in stance	
Step_energy	Step Energy	Approximate augmentation energy experienced by the user during current step	mJ
Step_time	Step Time	A time counter beginning at heel strike and resetting to 0 at the subsequent heel strike	ms
Speed	Speed	Approximate speed of the user defined using proprietary sensor calculations	mph
Incline	Incline	Approximate incline of the user defined using proprietary sensor calculations	% grade

Safety

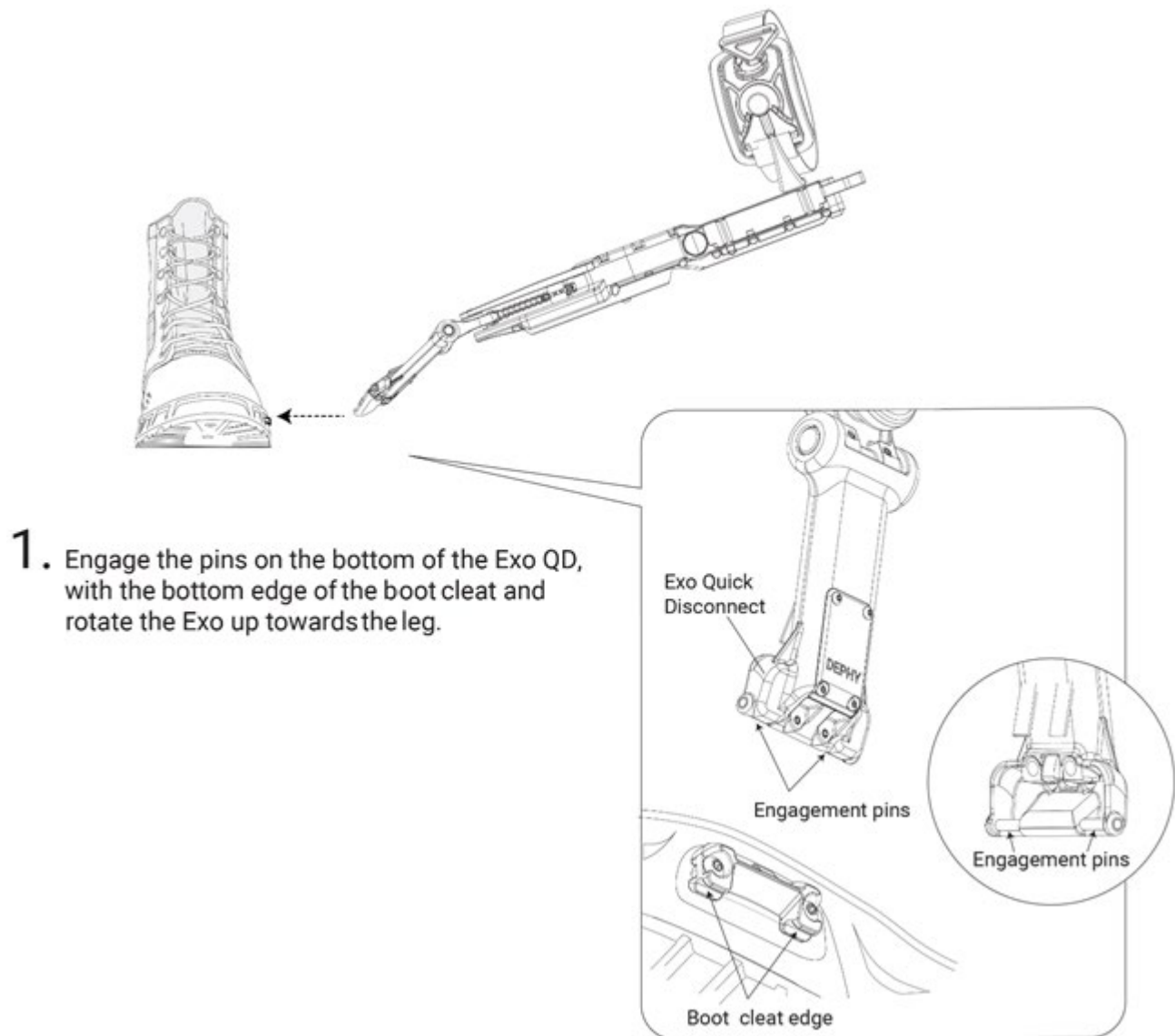
For general product safety information please refer to: dephy.com/safety

- ExoBoot users must follow guidelines set forth in this user guide and accompanying manuals.
- The ExoBoot equipment changes your footprint and adds distal mass. Be aware of how the ExoBoot components may impact or interact with the environment.
- The ExoBoot may apply torque about the ankle joint in a manner that the user is not expecting. If the disturbance is great enough, it may cause the user to trip and fall. The control algorithm is designed to only apply power when it can accurately sense the gait pattern. When unsure of the gait, the device defaults to applying zero torque. Users are instructed to exercise caution during changes in terrain such as descending stairs.
- Users should select a boot size that fits comfortably to avoid discomfort or blisters.
- ExoBoot users are required to wear socks while operating the device.
- Due to the possibility of skin irritation after an extended use period, pants that extend past the calves of a user are recommended to minimize irritation.
- If the device is subjected to blunt impact (e.g., hit against an object while walking), be sure to inspect for damage before continued use.
- Inspect after each use for signs of wear, discontinue use if you see signs of wear or damage.
- Keep the mechanism free of obstructions and appendages as it poses a significant pinching hazard.
- Protect from water exposure.
- The ExoBoot housing may heat up during use. Use caution when handling after extended use.
- Read and follow battery charging and use instructions:
Dephy_DS_SmartDock_C_0002_DS_0003_V02_SMARTDOCK. Charge only under supervision and contact Dephy if the battery exhibits a very fast red blinking pattern.
- Handle with care after extended exposure to sunlight as the device may heat up.
- User adaptation to device augmentation for extended periods may result in uneasy gait after doffing the device or turning off augmentation.
- Use Dephy approved cleaning methods and materials. See **C_0001_PR_0004_V01_EXORETURN** reference document for details.
- Device to be stored between -10 and 60 degrees Celsius.
- Contact Dephy for proper handling during shipping and transportation.
- Read this guide carefully and contact engineering@dephy.com if you have any questions or concerns.

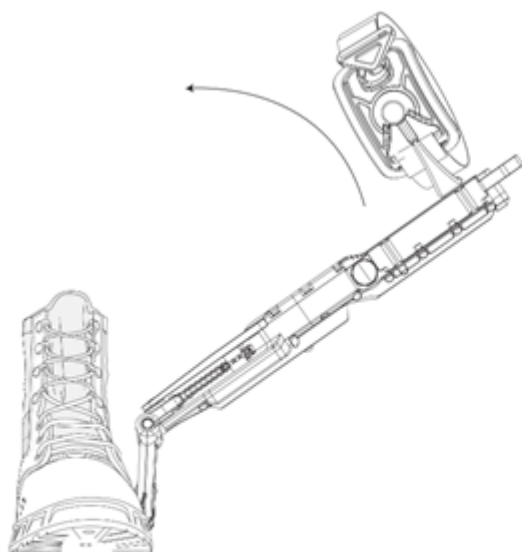
Don & Doff

Quick Disconnect (QD) On

Noting the metal pin at the bottom of the Dephy device, hook that pin under the recess at the bottom of the cleat on the Dephy footwear.



Making sure the bottom pin is seated, gently rock the device onto the cleat (about the anteroposterior axis through the cleat) so that the ExoBoot is vertical.



2. Swing Exo upright into locked position

Secure clasp and strap around calf



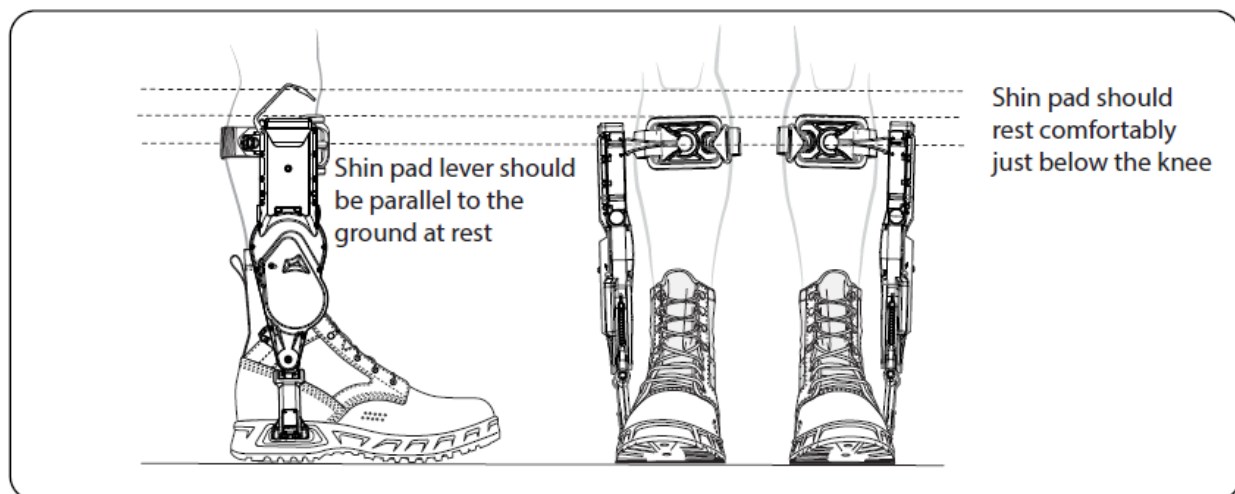
NOTE:
An audible feedback "click" will be heard when the Exo is upright in the locked position.

3. Secure calf strap by wrapping the strap around the widest part of the calf and sliding the clasp peg into the slot on the shin pad. The strap should be secure, but not too tight.

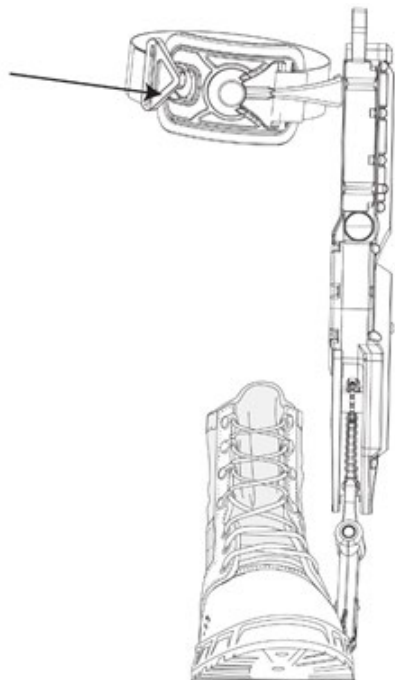
If successful, the device will be attached to the cleat, if not, the device will be free to move about the frontal axis on the cleat. Re-attempt until the device is seated.

Shlever Alignment

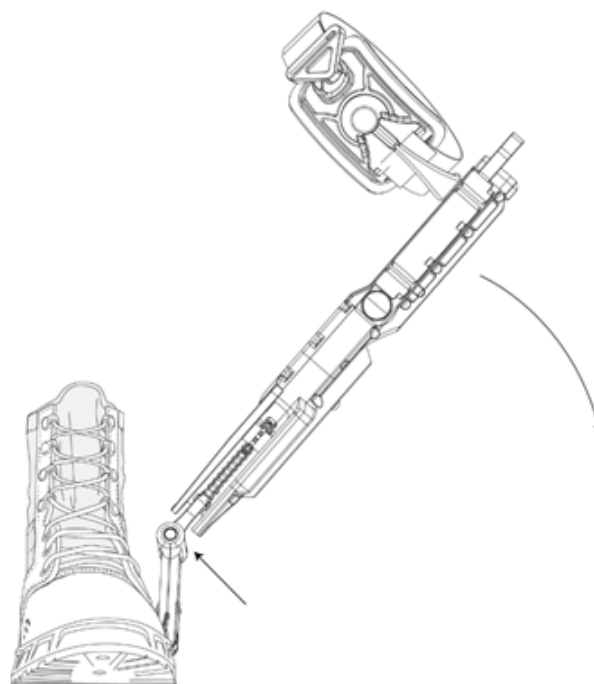
The shlever (a portmanteau of shin pad and lever) is the physical interface between the ExoBoot armature and the body. Align the shinpad to be just above the widest part of your calf and the bar connecting to the device is parallel with the ground. Ideal alignment is depicted in the image below. If the height of the shin pad restricts proper alignment, please adjust according to the section "Shin Pad Height" in this guide. Do not operate the device until the shin pad is properly attached to the body.



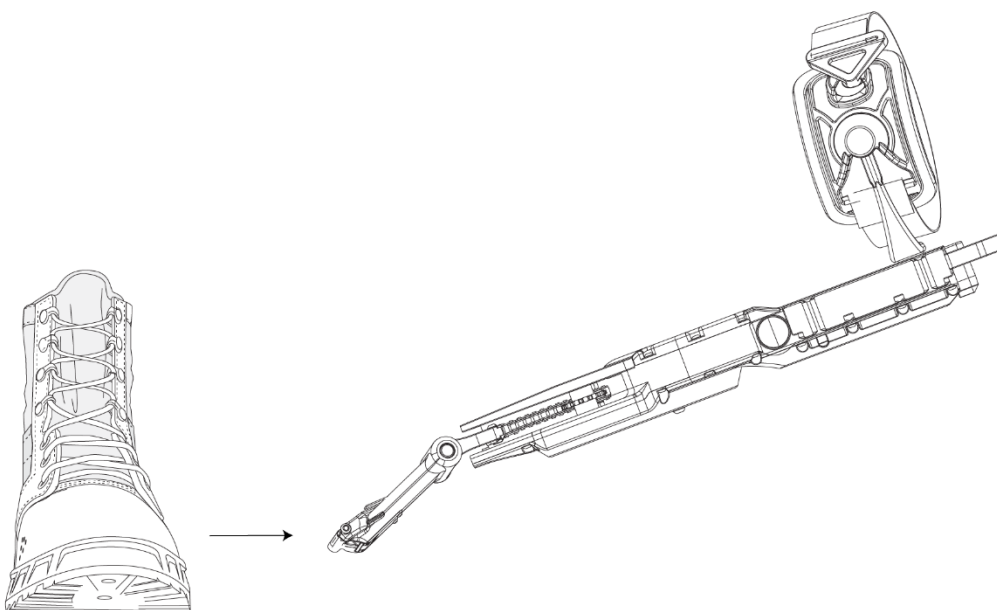
Quick Disconnect (QD) Off



1. Unfasten calf strap



2. Rotate exo away from the leg while pushing the Exo hinge section towards the boot until the QD disengages from the boot cleat.



3. Pull Exo away from the leg.

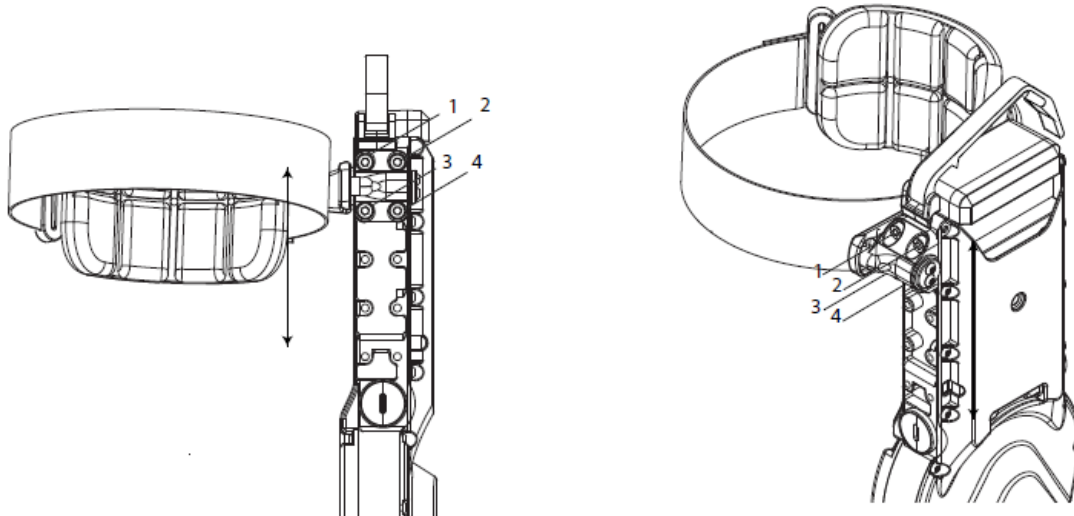
When removing the system, first unfasten the shin strap while holding on to the system to ensure the system does not crash to the ground. Slowly rotate the system away from the body laterally until the quick disconnect disengages. Then pull the system away from the boot.

Fit Adjustments

Please complete the following adjustments the first time a user wears the ExoBoot. Repeating these steps is only necessary if a different user operates the ExoBoot.

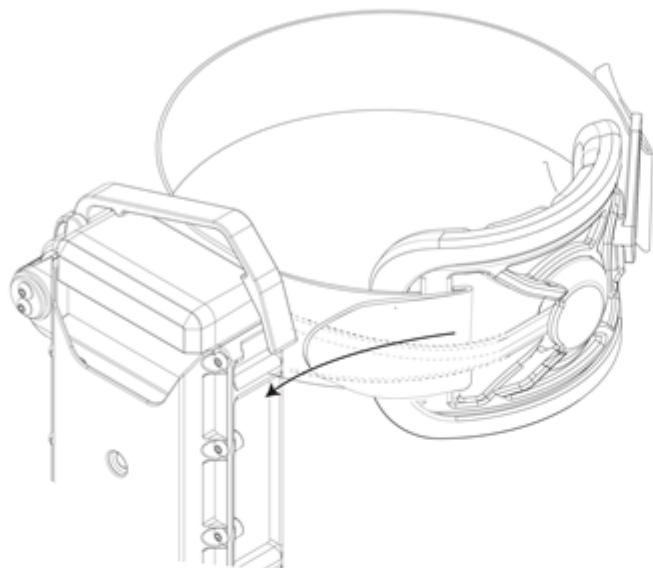
Shin Pad Height

Adjust the shin pad height using the supplied 3 Nm torque screwdriver as necessary. Remove the 4 screws that hold the shin pad level mount to the ExoBoot. Move mount to the desired position. Screws should be torqued to 3 Nm with supplied torque screwdriver.



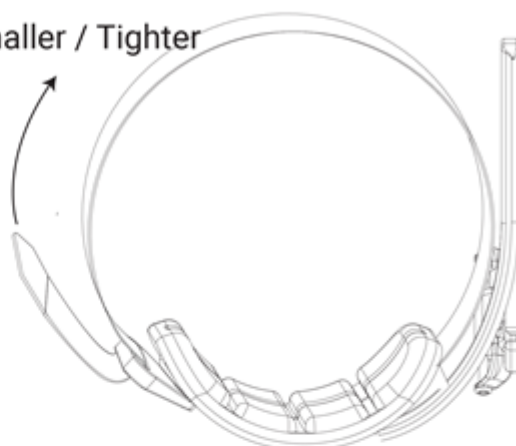
Strap

The fit of the shin strap can be adjusted to improve user comfort according to the diagram below.



For initial set up, adjust the lateral shin-pad "strap fold-over" point to desired length.

Smaller / Tighter

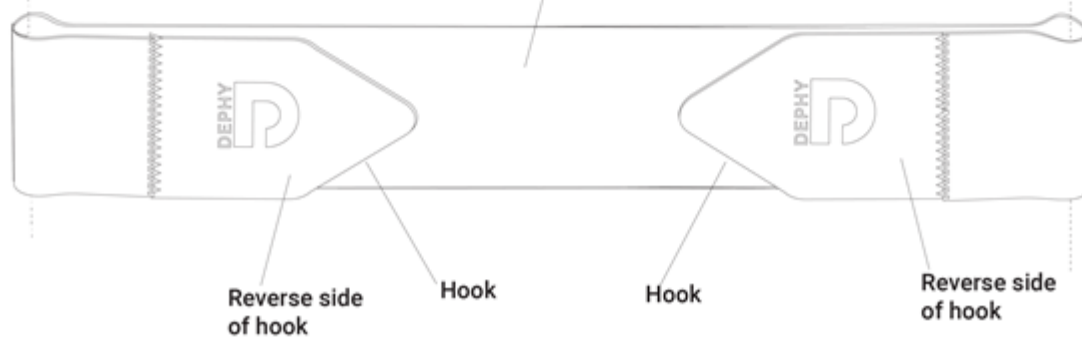


For subsequent smaller adjustments, the medial "clasp fold-over" point can be adjusted to comfortably fit around the leg.

Fold around medial clasp
or shin-pad

Stretch loop

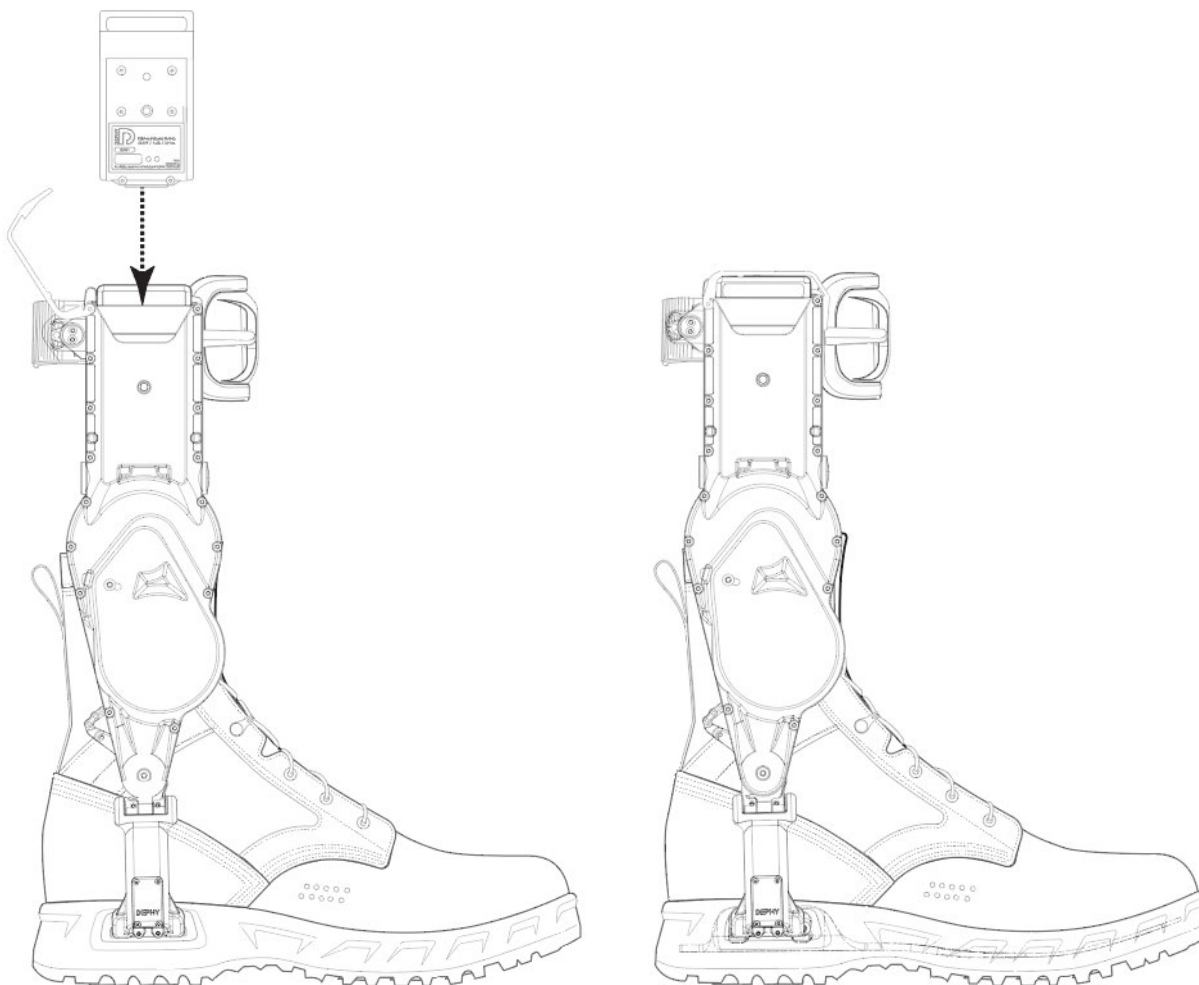
Fold around medial clasp
or shin-pad



Power

Battery Insertion and Retainer Clip

Ensure the battery clip is not engaged before installing the battery. Slide the battery into the receptacle. Swing the clip in the anterior direction and snap it into place. An audible click should be heard when the clip is properly engaged.



Power Button

Power On: To turn the device on, press the button for a brief moment (around 200ms). If you keep pressing, the LED will flash to indicate that you can now release the button.

- **Normal operation:** When the button is released the LED will enter glowing mode. Note, if you requested Stealth Mode, after 6 seconds, the LED will turn off but the ExoBoot will remain powered.
- **Fault detected:** The system will power off as soon as the button is released.

Power Off: To turn the device off, press and hold the button for more than 2 seconds. The LED will fade off. When the LED is off you can release the button. The device will be off.

Detect Power State: By quickly clicking the button, the LED glowing pattern will be briefly altered. You can use that to know if the device is on or not if the device was programmed in Stealth Mode.

FAQ

Is the ExoBoot system on?

- The ExoBoot System LED should be green if the system is on. If the ExoBoot is programmed with Stealth Mode the LED will not remain on past the initial 6s the device is on. You can quickly press the LED to see if it flashes, confirming the device is on.

Do I have to have internet connection to operate the ExoBoot?

- The device running the user interface does not need to be connected to the internet to work properly. No connection to site IT is needed.

Bluetooth is not connecting or streaming is slow.

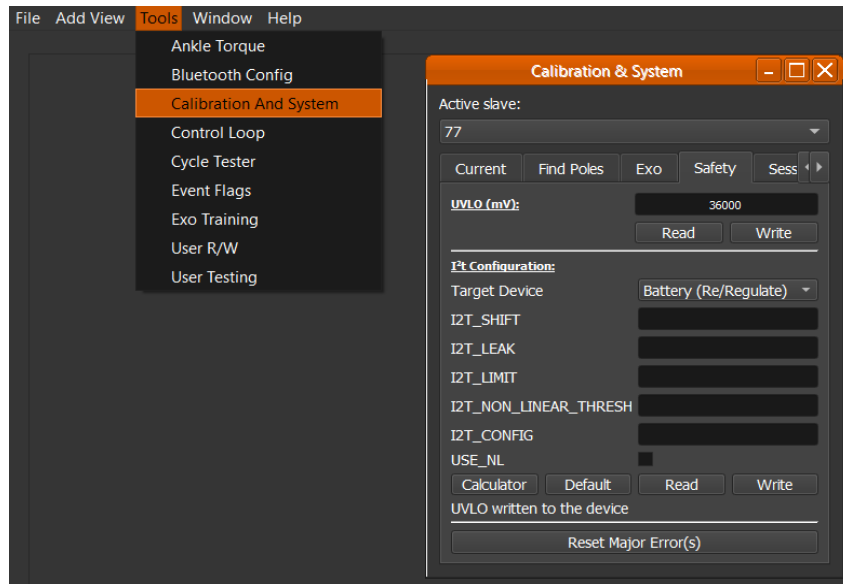
- Try unpairing and then repairing your device.
- Are too many Bluetooth devices connected to your Windows device? We recommend having only your ExoBoots paired to a device to ensure connection quality. Do not use a Bluetooth mouse or Bluetooth headphones while using the exoskeleton.

Device turned off while I was walking.

- Are your batteries blinking red? Batteries will work for a short time while the LED on the battery is blinking red. To maximize system stability, charge your batteries when they blink red.
- Ensure batteries are secure using retainer clips to prevent accidental disconnection during movement.

Device LED blinks when I try to turn it on but does not stay on.

- The ExoBoot will only turn on if the battery is above the minimal charge level, and all the sensors report correct values.
 - The BA30 LiPo Battery LED will indicate its state of charge. When red, please charge before using.
 - If the battery is charged, and the section below does not apply, reach out to Dephy.
- Have you recently changed ExoBoot firmware? Incompatible firmware versions or improper initialization of new firmware may prevent the device from turning on.
 - This is usually caused by not properly resetting the undervoltage lockout (UVLO) value. This can be done by connecting your ExoBoot (without the battery) to the Plan GUI via USB.
 - Go to: Tools > Calibration and System > Safety
 - Write the value 27,500 mV to UVLO. We recommend power cycling the ExoBoot and re-writing the value of 27,500 mV to ensure the new value is written to the system memory. This menu is depicted in the image below.



Other fault?

- Contact Dephy: engineering@dephy.com

Reference Documents

- Safety Guide: dephy.com/safety
- Software Guide: dephy.com/start
- EB60 Data Sheet: C_0001_DS_0001_V02_EB60DATA
- BA30 Data Sheet: [C_0002_DS_0001_V03_BA30DATA](#)
- SmartDock Data Sheet: Dephy_DS_SmartDock_C_0002_DS_0003_V01_SMARTDOCK
- Cleaning: C_0001_PR_0004_V01_EXORETURN

Date	May 25, 2021
Revision	C_0001_UG_0001_V01_EB60GUIDE
Created by	Jonathan Kaplan
Reviewed by	JF Duval
Approved by	Luke Mooney  <small>Luke Mooney (May 25, 2021 12:28 EDT)</small>
Purpose	User guide for the EB60 that has been reviewed and approved for release


C_0001_UG_0001_V01_EB60GUIDE

Final Audit Report

2021-05-25

Created:	2021-05-25
By:	Matt Mooney (mmooney@dephy.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAw7okiSOnJGdlEDLQE9tGRAYi5fFRgeSD

"C_0001_UG_0001_V01_EB60GUIDE" History

-  Document created by Matt Mooney (mmooney@dephy.com)
2021-05-25 - 3:28:54 PM GMT- IP address: 73.69.178.3
-  Document emailed to Luke Mooney (lmooney@dephy.com) for signature
2021-05-25 - 3:29:27 PM GMT
-  Email viewed by Luke Mooney (lmooney@dephy.com)
2021-05-25 - 4:27:32 PM GMT- IP address: 66.102.8.101
-  Document e-signed by Luke Mooney (lmooney@dephy.com)
Signature Date: 2021-05-25 - 4:28:01 PM GMT - Time Source: server- IP address: 73.69.178.3
-  Agreement completed.
2021-05-25 - 4:28:01 PM GMT