

Motion Studio
BY APDM

USER GUIDE

WELCOME

TO MOTION STUDIO

Motion Studio provides an easy way to collect data with your Opal wearable sensors. Features include advanced configuration, recording, data management, calibration, and real-time visualization.

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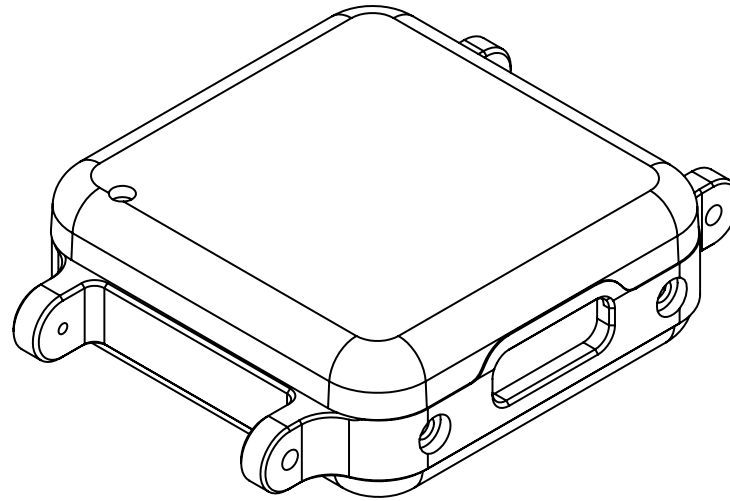
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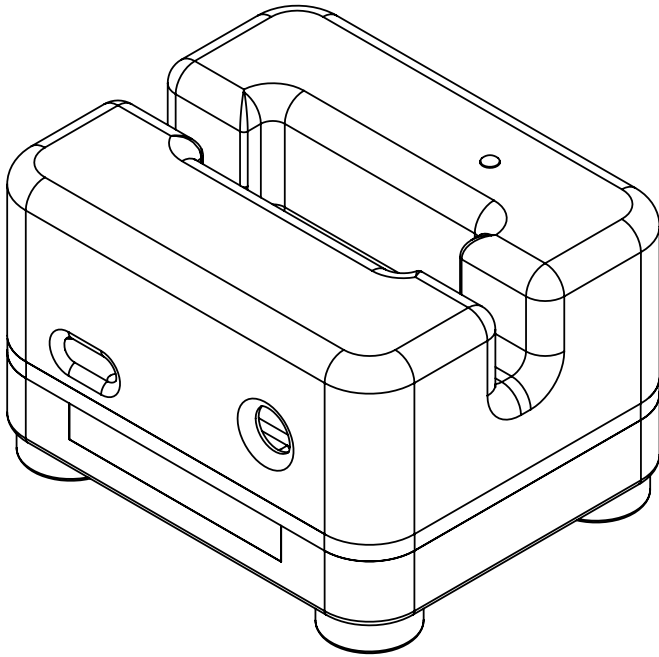
PARTS





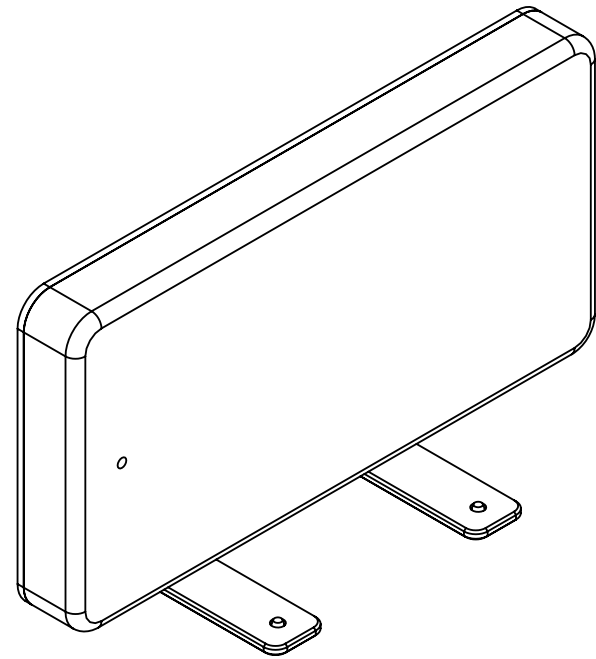
OPALS

The Opal movement sensors precisely record movement with triaxial accelerometers, gyroscopes, and magnetometers.



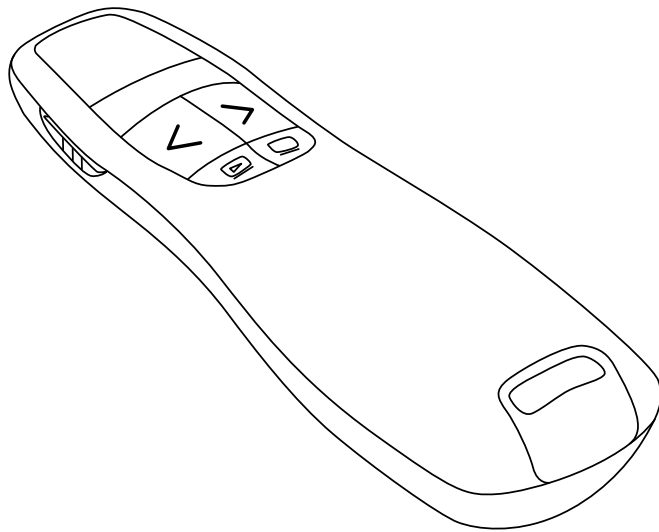
DOCKING STATION

The Docking Station is used to charge and configure the Opal movement sensors. Depending on your configuration, up to 6 Docking Stations may be chained together into a single unit.



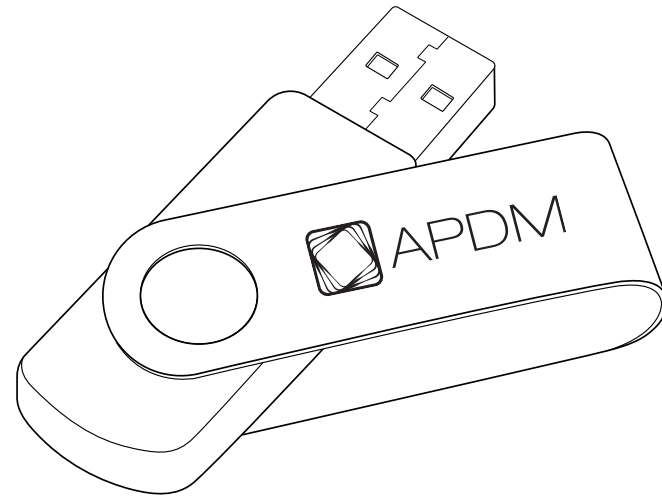
ACCESS POINT

The wireless Access Control Point allows for wireless communication between the host computer and Opal movement sensors. A single Access Point can support up to 6 Opals.



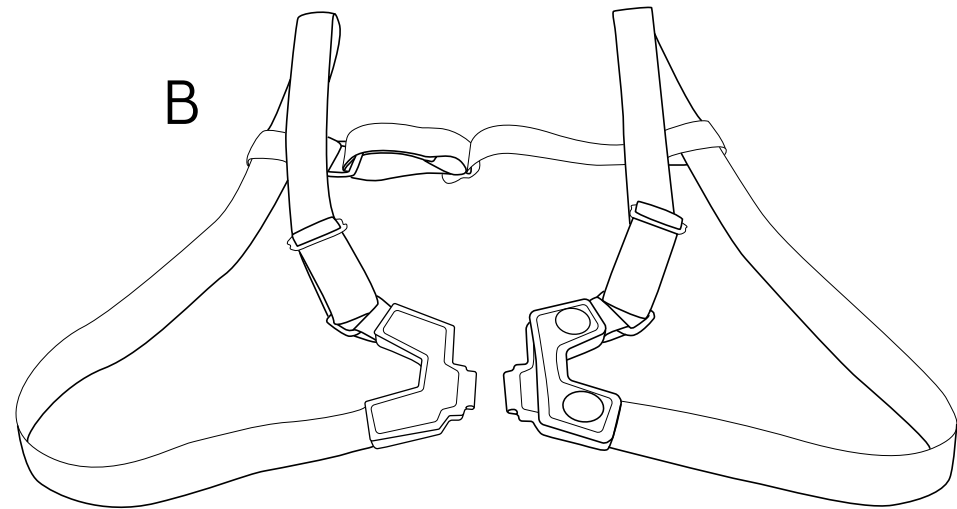
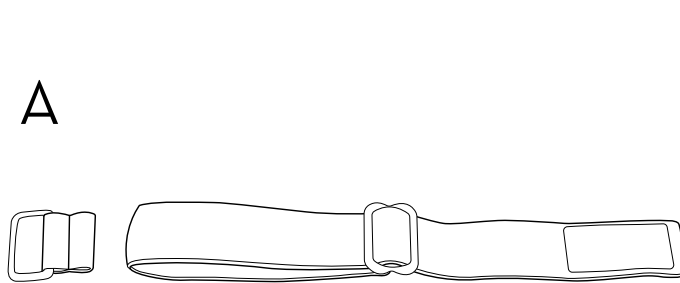
WIRELESS REMOTE

The Motion Studio software supports the use of a remote control to aid while collecting data. This functionality makes it possible for a single attendant to collect data while following or assisting the subject.



USB DRIVE

The USB drive contains the Motion Studio software for data collection.

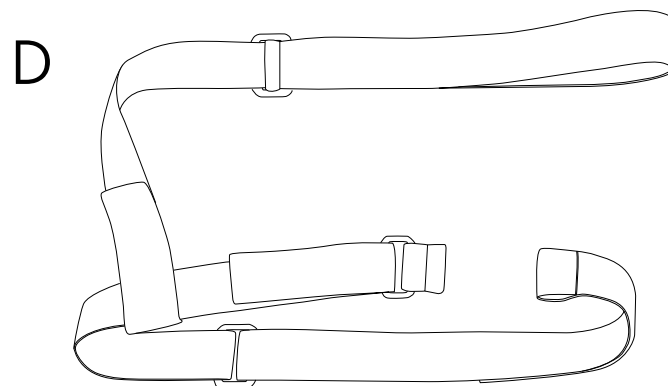
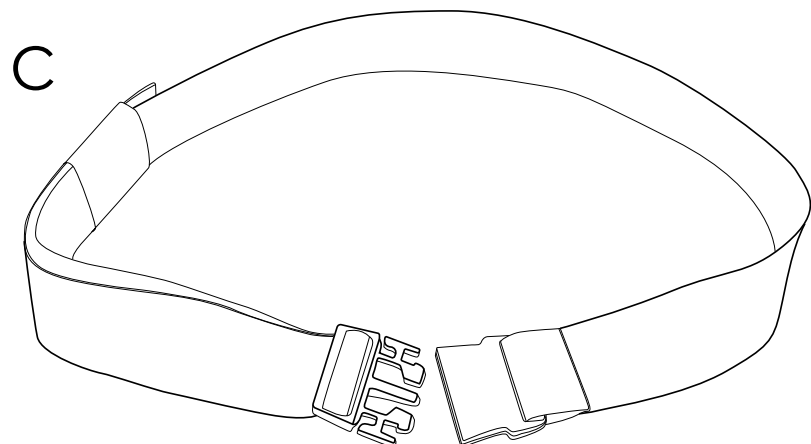


STRAPS

There are a number of options for securing the sensors on subjects using a selection of straps.

A. Wrist and Foot strap

B. Sternum strap



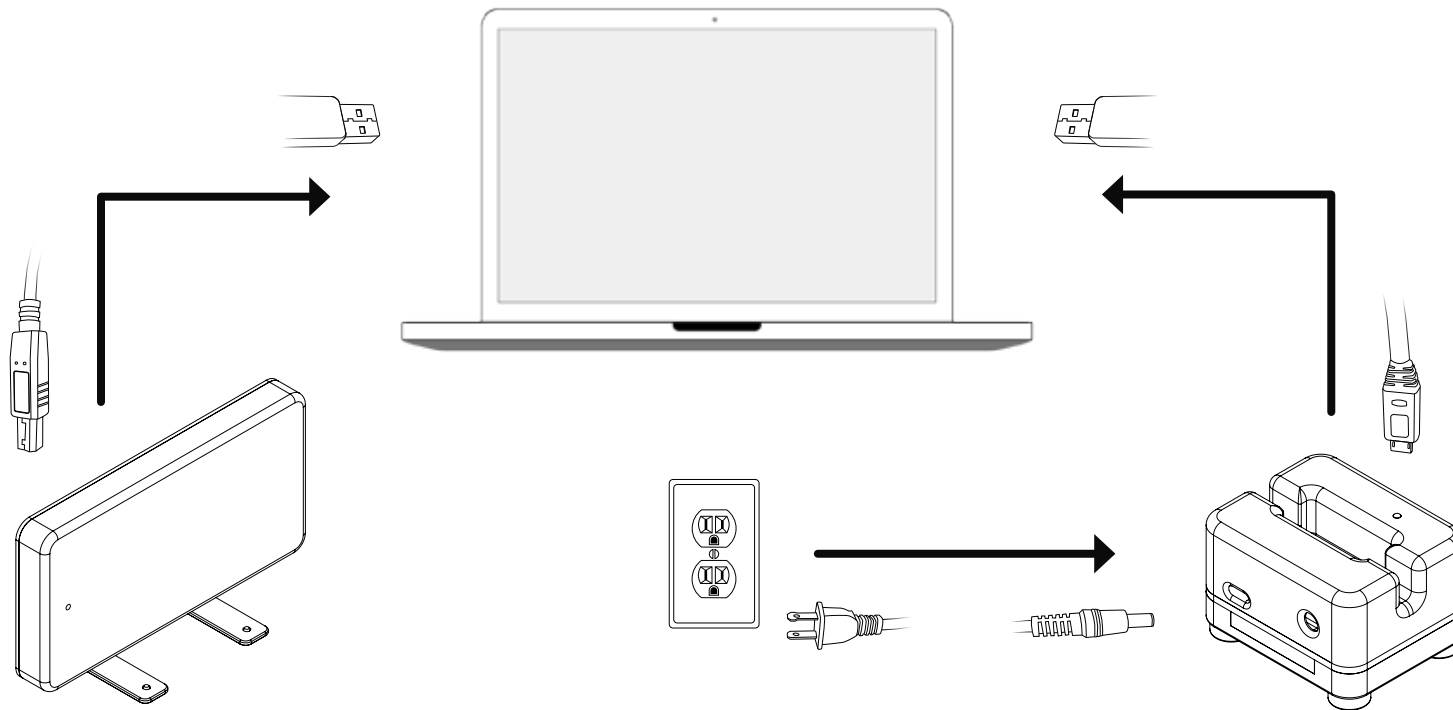
C. Lumbar strap

D. Thigh strap

E. Head strap

SETUP





SETUP

1. Connect the Access Point to your computer using the Type-B USB cable provided.
2. Connect the external power adapter to the Docking Station, and plug it in.
3. Connect the Docking Station to your computer using the Micro USB cable provided.
4. Plug the Opal(s) into the Docking Station.

SOFTWARE INSTALLATION





Requirements

Operating System

Windows 7 (64-bit) or later.

(Make sure you have Internet Explorer 10 or later installed.)

OSX Mountain Lion or later.

RAM

4GB+

Processor

Intel Core i3 or better.

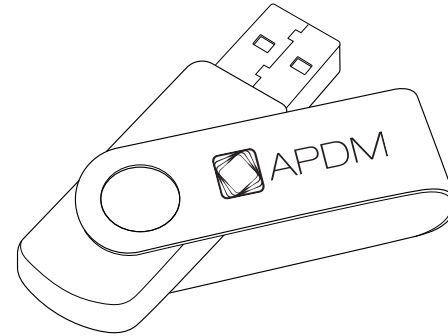
Recommended Intel Core i5 or i7.

Drive Space

500MB for installation.

Recommended 100GB+ for ample recording storage.

Installation



Macintosh OSX

- Insert the provided USB drive into your computer. Double click the MotionStudio_Mac64.dmg file. Drag the Motion Studio icon into the Applications folder to install.

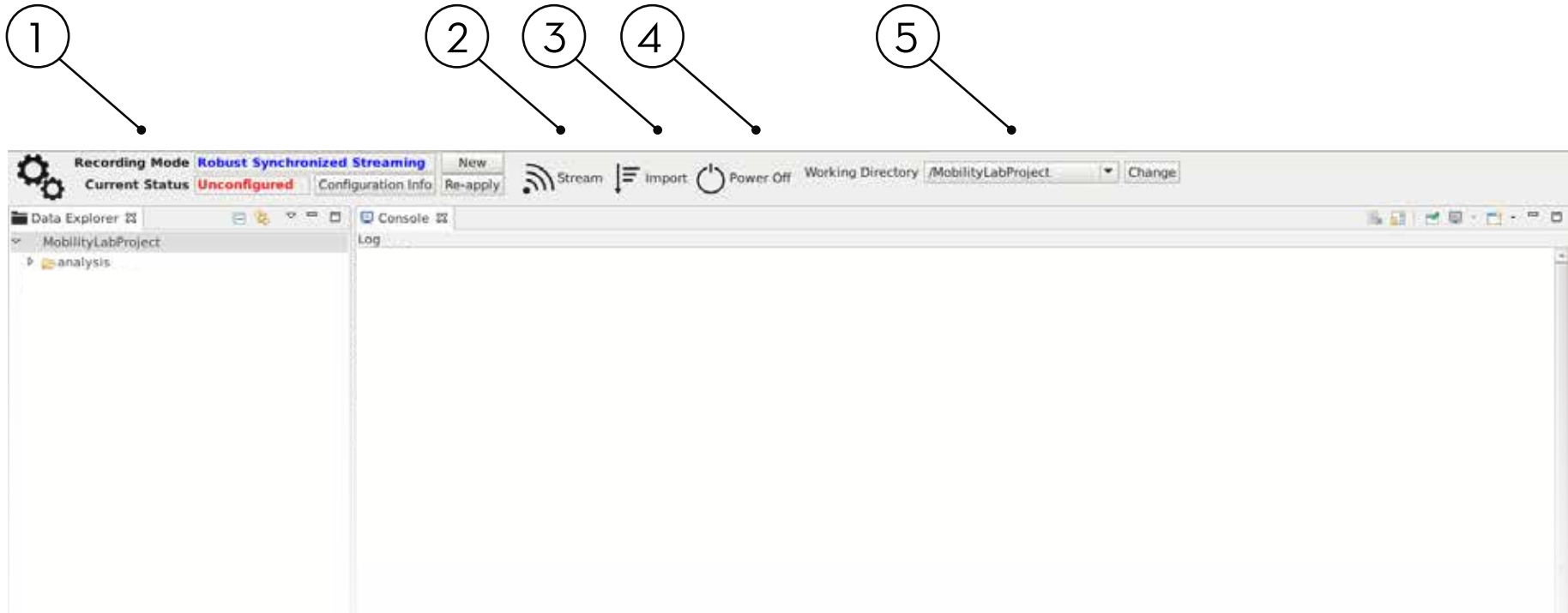
Windows

- Insert the provided USB drive into your computer. Double click on the setup file. This will guide you through the installation process.

You may also visit share.apdm.com/motion_studio

USING YOUR SOFTWARE





MENU

1. **Recording Mode**

The Recording Mode shows whether you are configured to stream or log data. This can be changed in the configuration menu.

2. **Stream**

The Stream button allows you to stream data wirelessly from your sensors. This button will not show in logging mode.

3. **Import**

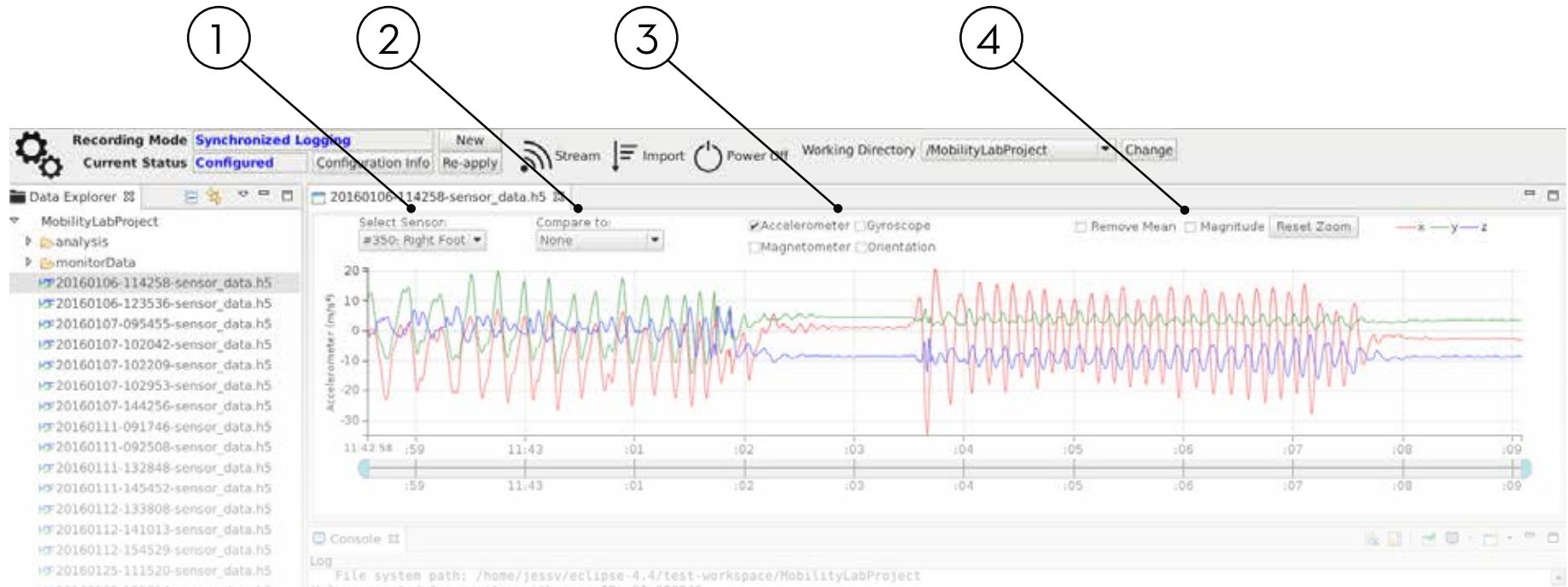
The Import button allows you to import raw data from your sensors.

4. **Power Off Sensors**

The Power Off Sensors tab turns off any docked sensors for storage.

5. **Working Directory**

The Working Directory shows the project and folder that recorded data will be saved to.



VIEWING YOUR DATA

1. **Select Sensor**

The Select Sensor dropdown allows you to see data from each sensor.

2. **Compare To**

The Compare To dropdown allows you to see data from one sensor compared to another sensor.

3. **Component Selections**

The Component Selections allow you to select which sensor components to display below.

4. **Other Selections**

Use the Other Selections to Remove Mean, show Magnitude, and Reset Zoom. Use the time scrubbing bar below to zoom in and out on the data plot.



Synchronized Streaming Modes

If one of the synchronized streaming modes (robust or rapid) is selected in the configuration dialogue, you can stream data from multiple synchronized sensors directly to a computer.

Starting a Streaming session

Press the “Stream” button in the menu. The stream dialogue will enable you to configure how you view and record streaming data from the Opals.

Record Duration

Fixed Duration - Specify the number of hours, minutes, and seconds for each recording. Press the “Stop” button to stop your recording before the specified duration has lapsed.

Indeterminate - The recording will continue until the “Stop” button is pressed.

External Sync - The “Record” button will be disabled and the system will wait for external synchronization events to start and stop recording.

Save Options

HDF5 - An open format for storing structured, binary data. Files are compact, and can be opened in a number of analysis software packages, including Matlab.

CSV - A plain-text format that can be opened in spreadsheet applications such as Excel in addition to most analysis software.



Statistics

Latency - The current latency between the time data is recorded to the time it is received by the computer. This may increase with poor wireless reception or sensors that are occluded from the Access Point (e.g. against a metal chair, around a corner). Additional latency will be incurred by the plotting of the data to the screen.

Dropped Samples - The number of samples dropped since the current streaming session was started. In the event that data is dropped, all of the recorded data will be present on the sensor's on-board memory and can be recovered manually using the Import Manager after the sensor is docked.

Annotations

Use the Annotation buttons to add annotations to an ongoing recording. When the button is clicked, a timestamped marker will be added to the recorded file. Add custom text about the marker in the text box. The remote may also be used to annotate data from a distance.

Real Time Chart

Use the "Select Sensor" combo box to view the real-time data from different sensors (subject to wireless and plotting latency). The real-time chart allows you to view the data streaming from your sensors. There are a number of visualizations:

Strip chart - Shows the calibrated data from all activated sensors.

Orientation - Shows the estimated orientation of the sensor as a rendered 3D model. To initialize the visualization, hold the sensor so the port is facing you and press the "Center" button.

2D - Shows one of the axes of an individual accelerometer or gyroscope versus one of the other axes. For example, "Y vs. Z Accelerometer" or "X vs. Y Gyroscope."



Remote Control

Motion Studio supports the use of a remote control to aid while recording in the Synchronized Streaming mode. This functionality makes it possible to start and stop recording away from the computer.

Supported Remotes - Motion Studio has been designed to use a standard presentation remote. Other presentation remotes will most likely assume the same functionality.

Enabling the Remote - Enabling and disabling the remote can be performed in the streaming dialogue by clicking on the “Enable Remote” checkbox. When the remote is enabled, on-screen buttons that are mapped to remote functionality will have their standard icons either overlaid or replaced by special remote icons.

The “Start” and “Stop” buttons are mapped to the “Next” and “Previous” slide buttons on the remote. The “Annotation” buttons are mapped to the “Start” and “Stop” presentation buttons on the remote.





Synchronized Logging Mode

In the synchronized logging mode, multiple sensors can be wirelessly synchronized with each other. Each sensor's data will be recorded to the on-board flash memory.

To Start Recording

Undock the sensors after configuration. After a few seconds, they will start recording to their flash memory. When within wireless contact with each other, they will synchronize their clocks. To start an additional recording in a separate file, connect and disconnect the sensors from their cables or Docking Stations. No re-configuration is necessary.

To Import Recorded Data

Dock the sensor(s). Click on the "Import Data" button in the toolbar.

Low Power Logging Mode

In the low power logging mode, each sensor's radio is turned off to save power. The sensor's will be synchronized at the start of recording, but they will not be actively synchronized while logging and some level of clock drift will occur during long recordings.

To Start Recording

Undock the sensors after configuration. The sensors will stop recording once they are docked again. No re-configuration is necessary.

To Import Recorded Data

Dock the sensor(s). Click on the "Import Data" button in the toolbar.



External Button Event Handling

APDM offers an optional button that fits into the data port of an undocked sensor. The button allows for additional functionality while recording including inserting event markers into the data stream, and stopping and starting recording.

Enabling the Button

The button is enabled via the Sensor tab in the configuration dialogue box. After undocking a sensor with button handling enabled, you must insert the button into the data port on the sensor. The button must be removed before the sensor can be docked.

Event Markers

The external button provides the ability to record the time of external events directly into the data stream for offline analysis. Pressing the button will insert the button state (up/down) into the data stream of the sensor the button is connected to. A maximum of one button transition (on/off or off/on) can be recorded every 10ms. The button state is stored on a sample-by-sample basis in the output file. Both CSV and HDF file formats support the storage of the button state. A value of 1 indicates that the button is pressed, while a value of 0 indicates that the button is not pressed. If you are using one of the streaming modes, the current button state is indicated in the “Button State” field in the Stream Dialogue (make sure you have selected the correct sensor in the “Select Sensor” drop-down when viewing the button state). This is a good way to test that the functionality is working.

Starting and Stopping Recordings

If the button is held down for at least 3 seconds, the sensor will transition into a “hold” mode where recording is halted. The LED will indicate this mode by a slow blue blink pattern. If the button is released and held for another 3 seconds while halted, the sensor will start running again and a new recording will be started. If one sensor is in hold mode, any other sensors will continue to record. The sensors will remain powered up. The external button is best used for starting and stopping recordings when using a single monitor in the low power logging mode.



Import and Conversion Manager

The Import and Conversion Manager enables you to import the data saved on the sensors and convert it to a format that can be read by a number of software analysis packages. Click the “Import” button in the toolbar to open the Import and Conversion Manager. When opened, the data from all currently docked sensors is moved to your local computer. These raw data files are displayed in the Recordings Ready for Conversion table.

Selecting Data for Import

In the Recordings Ready for Conversion table, you can select data for conversion by using the checkboxes. When you click on a file in the table, any other files that have overlapping recording times will be highlighted. This functionality aids in the finding and merging of data that was recorded on multiple monitors synchronously.

Conversion Options

HDF5 - An open format for storing structured, binary data. Files are compact, and can be opened in a number of analysis software packages, including Matlab.

CSV - A plain-text format that can be opened in spreadsheet applications such as Excel in addition to most analysis software.

Include Raw Data - Include raw sensor data in the converted file. This is the raw sensor data that has not been processed or converted to SI units.

Compress Data - Compress the data when importing into an HDF5 file. The resulting file will be significantly smaller, but it will take longer to perform the conversion.



File Naming Options

Base File Name - The name of the file the data is being converted into.

Include Sensor ID - The case ID of the sensor being converted will be embedded in the file name.

Include Sensor Label - The label of the sensor being converted will be embedded in the file name.

Prepend Date - The date and time of the start of the recording is added to the beginning of the file name.

Import Options

Merge Selections into One File - All selections will be merged into a single HDF file after conversion. Multiple selections from the same sensor cannot be merged into a single HDF file.

Convert Selections into Separate Files - Each selection will be converted into a separate file.

After Import

Converted data will show in your current working directory. Right click and select “Plot” to plot the data to the screen.



Managing Data

The Data Explorer shows a hierarchical view of your projects and folders. Projects are the top level containers in the Data Explorer, and can hold any number of folders. Folders hold other folders or data files. The projects and folders that are visible in the Data Explorer are called your Workspace.

Working Directory

The Working Directory Tool is displayed in the application's toolbar. You can change your Working Directory by clicking on the "Change" button and selecting a different project or folder. Whenever data is recorded through the streaming interface or imported from your sensors, it will appear in the current Working Directory.

Creating New Projects

1. Right-click in the Data Explorer and select "New > Project"
2. Select the "Project" option from the New Project Wizard
3. Specify the project name
4. By default, the project and all contained files will be placed in Motion Studio's workspace directory, which is indicated in the console when Motion Studio is launched. If you wish to specify a different location on your hard drive to create the project, uncheck the "Use default location" box and choose the location of the new directory.
5. Click "Finish"
6. To make this your current working directory, click on the "Change" button in the Working Directory Tool and choose the new project.



Creating New Folders in Projects

1. Right-click in the Data Explorer and select “New > Folder”
2. Select the parent project or folder for the folder you wish to create
3. Specify the folder name
4. By default, the folder will be created in the project’s directory structure on your hard drive. It is possible, however, to associate the folder with a project but to store the data in a different location. If you wish to specify a different location on your hard drive to create the folder, click the “Advanced” button, select the “Link to alternate location (Linked Folder)” option, and specify the folder on your hard drive that you wish to store this folder’s data in.
5. Click “Finish”
6. To make this your current working directory, click on the “Change” button in the Working Directory Tool and choose the new folder.

Plotting

To plot a recorded file, either double-click on the file in the Data Explorer, or right-click on the file and select the “Plot” option. The plot dialogue enables you to specify the monitor to plot.



Powering Sensors On and Off

Docking Sensors

In most situations, it is sufficient to simply dock the sensors when not in use. When docked, the sensors stop recording, stop broadcasting, and start charging their batteries. Once fully charged, the batteries will enter a trickle charge mode to keep them topped off.

Power Off

For transport or storage, it is often desirable to power off all system components. This can be done by docking the sensors and clicking on the “Power Off” button in the toolbar. When this option is chosen, the sensors will power down the next time they are undocked.

Power On

From a powered off state, the sensors can be powered on either by configuring them through the configuration dialogue, or by docking them and pressing the “Power On” button.

Note: Reconfiguration is required for synchronized streaming modes if the Access Point was also powered down or suspended.

Storage

In most situations, it is sufficient to simply dock your sensors when not in use. When docked, sensors stop recording, stop broadcasting, and charge batteries. ***Do not leave sensors docked in a Docking Station that is not plugged into a power outlet.***

For transport and storage, it is best to power off all system components. This can be done by docking the sensors and clicking the “Power Off” button in the Mobility Lab menu. The sensors will power down the next time they are undocked.



Sensor Reference

Charging

Sensors charge any time they are connected to a Docking Station. It is recommended that sensors be charged for 1 to 3 hours to provide a peak charge to the battery. The sensor uses a Lithium battery that charges best in 5-35°C or 40-95°F.

Data Storage

The sensors will utilize a flash card to store data while logging. This data can be downloaded by using a docking station to dock the sensor. When the sensor is docked, it finishes writing to the internal flash card and then releases it to the Docking Station. At this time, the Docking Station indicates to the PC that there is a new read-only removable drive to be mounted. Using your file browser, you can navigate to the removable drive and copy the files off of it. The files are in a proprietary raw format and need to be converted to either a HDF5 or CSV format that will provide data in calibrated SI units. This conversion happens automatically if Motion Studio is used to import the data. Alternately, there are functions in the SDK to do this conversion programmatically.

Cleaning

Clean the Opal sensors with a rubbing alcohol or other cleaning wipe. Do not use methyl alcohol, as it will cause degradation of the plastic over time.

The sensors and other system components should not be submerged in any liquids or subjected to any high temperatures.

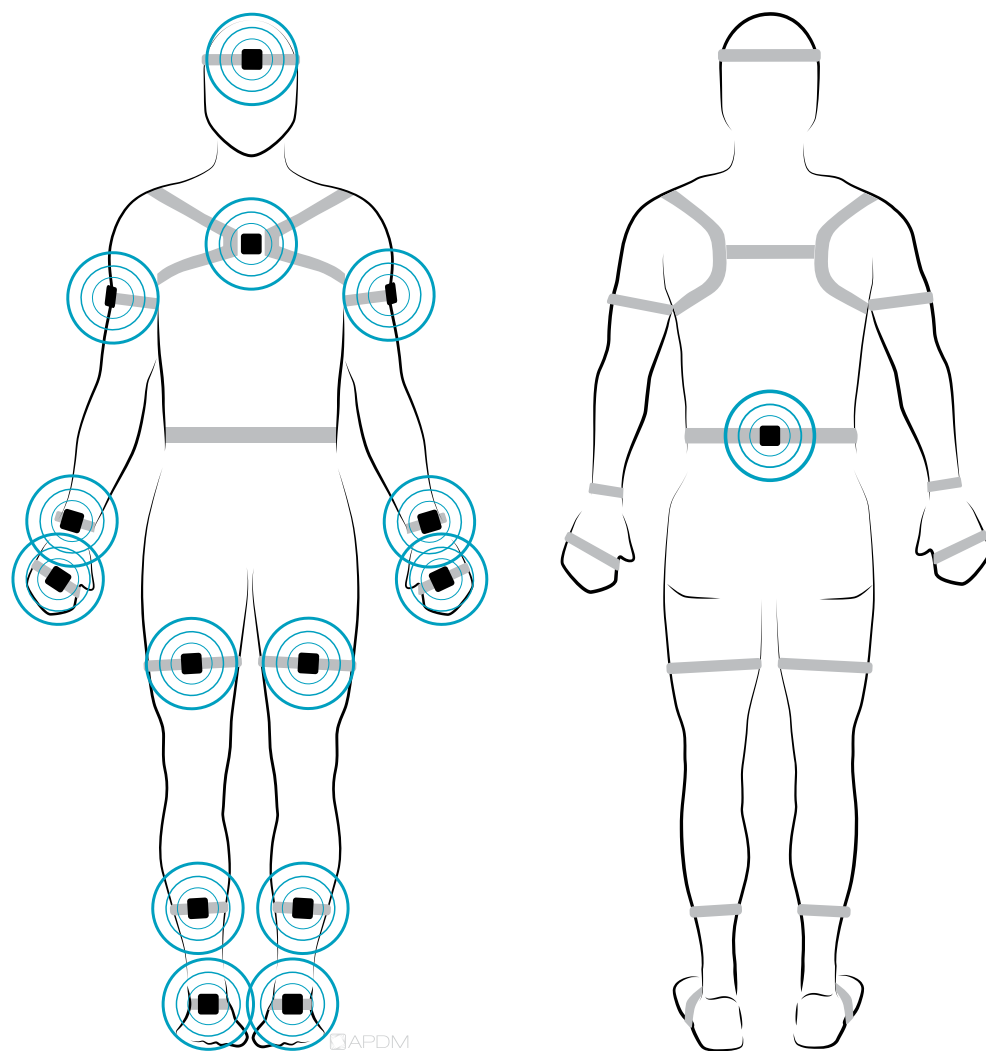
The sensor straps can be removed and washed separately using mild soap and water.

TIPS





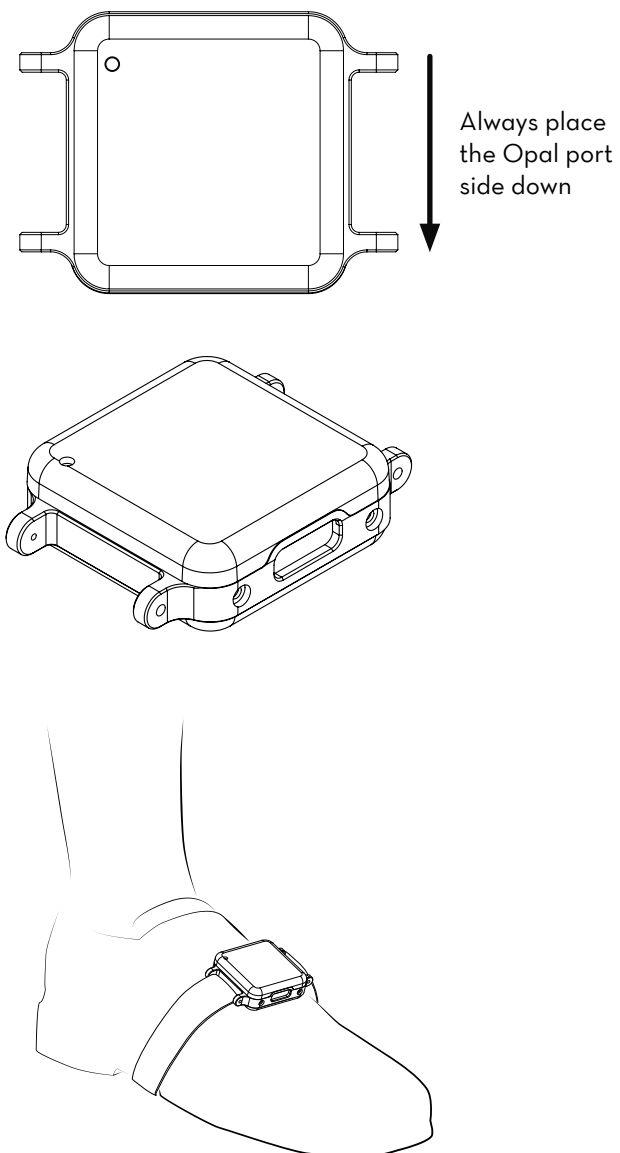
Sensor Placement



Your APDM sensor system comes with all or some of the sensors shown.

To upgrade your system, contact us at 888-988-APDM (2736) or info@apdm.com.

Orientation



TROUBLESHOOTING

APDM is pleased to assist you with any questions you may have about your hardware, software, or the use of the technology for your application.

Please contact us at:

web: support.apdm.com

email: support@apdm.com





LED Colors

○ White ● Red ● Yellow ● Green ● Cyan ● Blue ● Magenta

LED Patterns and Error Messages

The LED on the Access Point and sensors provides important information about the operating state of the hardware. The table below lists the LED flashing patterns associated with these states, which can be useful in troubleshooting issues encountered with the hardware.

	Pattern	State
Startup Mode	● Yellow	Startup wait (5 sec) v1.0, bootloader v1
	● Magenta	Startup wait (5 sec) v1.1, bootloader v2
	● Red	Failed to load firmware
	○ White	Bootloader Mode
Firmware Mode	● Blue ● Yellow	Docked Mode (pre-charging - very low battery)
	● Blue ● Green fast	Docked Mode (bulk charging - low battery)
	● Blue ● Green slow	Docked Mode (trickle charging - 80-100% charge)
	● Blue	Docked Mode (full charge)
	● Red ● Blue	Docked Mode (battery error)



Firmware Mode

	Docked Mode (wait)
	Docked Mode (error)
	Reset Mode
	Transitioning into standby or powering off
	Hold Mode
	Run Mode (battery level 4, full)
	Run Mode (battery level 3)
	Run Mode (battery level 2)
	Run Mode (battery level 1, low)
	Run Mode (battery very low)
	Run Mode (clock unset, battery level 4, full)
	Run Mode (clock unset, battery level 3)
	Run Mode (clock unset, battery level 2)
	Run Mode (clock unset, battery level 1, low)
	Run Mode (clock unset, battery very low)
	Run Mode (no sync-lock, battery level 4, full)
	Run Mode (no sync-lock, battery level 3)
	Run Mode (no sync-lock, battery level 2)
	Run Mode (no sync-lock, battery level 1, low)
	Run Mode (no sync-lock, battery very low)



Firmware Mode		Run Mode (clock unset, no sync-lock, battery level 4, full)
		Run Mode (clock unset, no sync-lock, battery level 3)
		Run Mode (clock unset, no sync-lock, battery level 2)
		Run Mode (clock unset, no sync-lock, battery level 1, low)
		Run Mode (clock unset, no sync-lock, battery very low)
Error Mode		Error Mode (default)
		Error Mode (configuration)
		Error Mode (system)
		Error Mode (data buffer)
		Error Mode (SD buffer)
		Error Mode (SD I/O)
Wireless Streaming Debug Mode		Card is full
		Normal
		CPU limited
		Sync bad
		CPU limited, Sync bad
		Missed sync > 0
		Missed sync > 0, CPU limited
		Missed sync > 0, Sync bad
		Missed sync > 0, CPU limited, Sync bad

INFORMATION

FCC

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions.

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

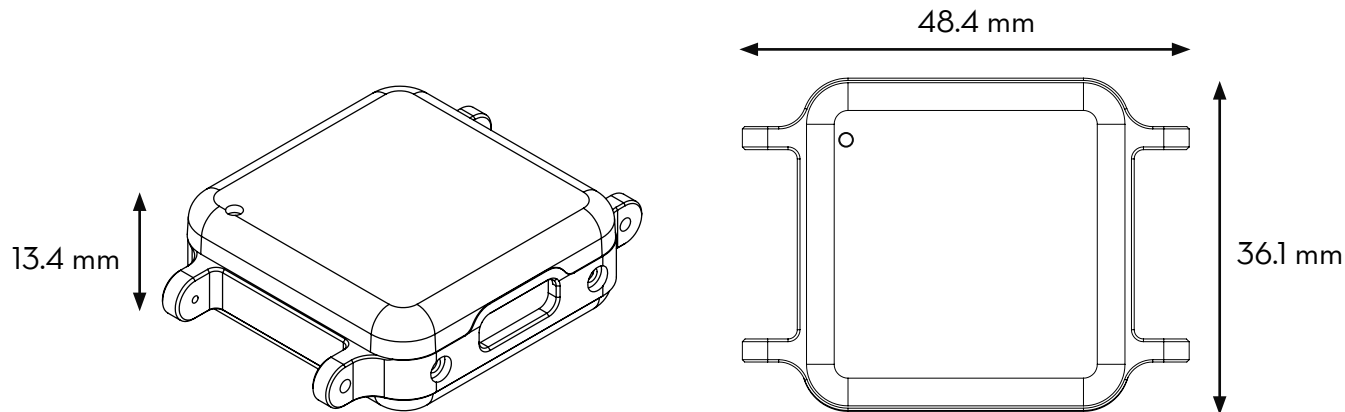
Changes or modifications not expressly approved by APDM could void the user's authority to operate the equipment.

FCC ID: 2AHZD-OPAL-V1

FCC ID: 2AHZD-AP-V1

For complete sensor information, please visit www.apdm.com





Material	6061 anodized Aluminum, ABS plastic
Weight	<22 grams (with battery)
Battery Life	Wireless Streaming (8h), Synchronous Logging (12h), Asynchronous Logging (16h)
Wireless Radio	Nordic Semiconductor nRFLO1+ radio, ultra-low power
Frequency Band	2.40-2.48GHz ISM band, adjustable
Data Rate	2Mbps on-air data-rate
Latency	300ms (typical) with data buffer, 30ms (typical) without data buffer
Transmission Range	30m line of sight, 10m indoors
Data Buffer	8Gb (~720 hours)
Synchronization	≤1ms difference, up to 24 Opals

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