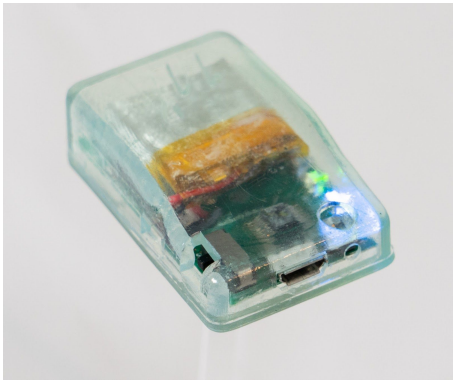
MUGIC™ Users Guide

MUGIC™ is a small, versatile prototype WIFI motion sensor system for Enhancing Expression



Please read before proceeding

MUGIC™ is a prototype device, not designed for mass-production. Please handle it with care. MUGIC™ is encased in a 3D-printed resin box with top and bottom parts; it is fragile.

DO NOT:

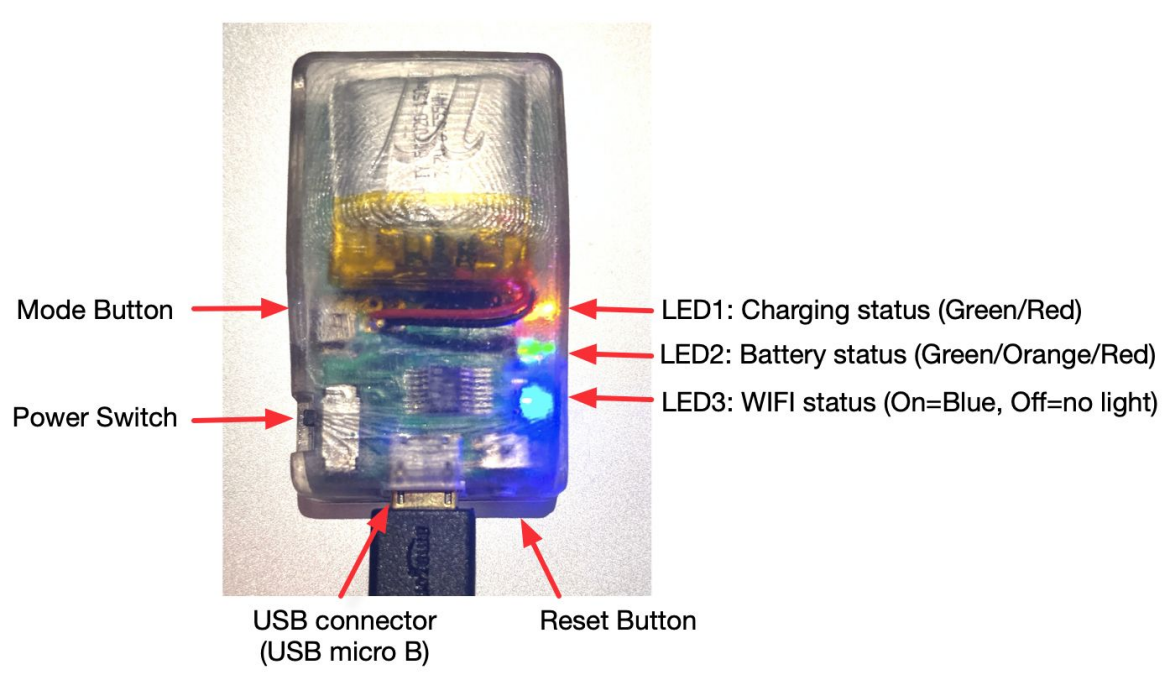
- Attempt to open the case
- Apply any liquid
- Store in hot (above 88F/31C), or humid conditions

NOTE: Avoid attaching MUGIC™ directly onto the skin for a long period of time.

A. What you need to know about MUGIC™

First, go to Silicon Labs site, and download and install the USB driver, CP210x USB to UART Bridge VCP Drivers (there are both Windows and Mac drivers here)
https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

Topography of MUGIC™



USB connector: We recommend to charge MUGIC™ before use (this will take approximately 1 hour). MUGIC™ will immediately begin charging when plugged into a USB power source supplying **5V with at least 500mA.** The device requires at least 5 minutes of charging before being able to be powered on, if the power is critically low.

Power Switch: Move up to turn ON (away from the USB connector), move down to turn OFF.

Reset Button: When pressed, MUGIC™ will reset to factory defaults.

Mode Button: When pressed, MUGIC™ will switch between WIFI mode (default) and USB mode. If you see the LED 3 in (Blue) blinks every 1 second, WIFI is active.

LED 1: Red light indicates that the device is charging when connected to USB.

LED 2: Green/Orange/Red indicates the status of the battery
(Green:80+% power remaining, Orange: more than 40%, and Red: less than 40%)
(Blinking red: less than 10% power remaining)

LED 3: Blue light blinking every 1 second means MUGIC™ is transmitting data over WIFI. While establishing the WIFI network, the blue light will blink as twice as fast.

B. Quick Start Guide - you just received your MUGIC™

Network Name and Password: Every MUGIC™ comes with its own unique 6-digits numbers. Turn the power on; MUGIC™ will automatically start in WIFI mode. The blue light (LED 3) will blink fast, then slows down to blinking every 1 second, which means MUGIC™ successfully created a WIFI network. Find:

- **Network Name:** The default network name is "MugicConnectXXXXXX" ('XXXXXX' means 6 digits. For example, it will look like "MugicConnect123876"). Join the network.
- **Password:** Enter the default password "mugicXXXXXX" (case sensitive, followed by the 6 digits in the network name. Using the above example, the password would be mugic123876.)

Note: you can change the network name and password. See page 7-10.

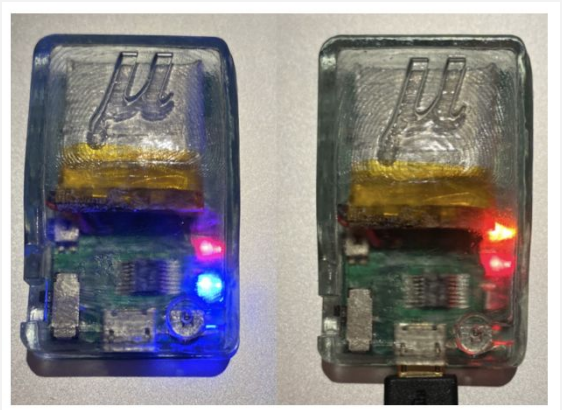
Troubleshooting: If the WIFI network name doesn't show up in your computer WIFI, turn your WIFI off, wait for 15+ seconds and turn back on. It should usually come up immediately, but it might take a few tries and eventually, it should show up.

WIFI mode and USB mode

- **WIFI mode:** MUGIC™ is set to **WIFI mode** as default. You can also charge MUGIC™ connected to an electric outlet via USB cable, so you won't run out of power while in WIFI mode.
- **USB mode:** MUGIC™ also works in **USB mode,** connecting to the computer via a USB cable. In case you need to connect to the internet via WIFI, MUGIC™ can also keep working via USB mode.

A few ways to switch between WIFI and USB modes

1) Max and Ableton Users can switch between WIFI and USB from the softwares. Go to www.mugicmotion.com/download
2) MUGIC™ App will let you switch between WIFI and USB modes from the app.
3) Push the **Mode Button** (above the Power Switch) with a thin, hard object like a pin. The blue blinking light will indicate which mode you are in.



WIFI mode
(Blue flickering light)

USB mode
(No Blue light)

"Shake it all about"

Now you are ready.

Before use, it is helpful to ***shake*** MUGIC™ for a few seconds; this is for sensor's calibration purposes. Shake them mimicking the movements of cocktail shakers, with quite fast motions. Try to also shake in different directions, twisting your wrist. Just a few seconds is enough.

Note: Please be careful not to throw or drop MUGIC™! The resin casing is fragile and can easily crack if you drop onto a hard surface.

You can now download apps and demos / Max patches from the http://www.mugicmotion.com web site to use the data sent by MUGIC™.

Start creating your projects!

Once you want to create your own Max patches or apps using MUGIC™, you can find in the next section more details about interfacing with MUGIC™.

Download the MUGIC™ App:

For configuring your MUGIC™ device, it is recommended to download the **MUGIC™ app** (available for Windows or MacOS users from the http://www.mugicmotion.com web site). The app offers menus for doing all of the operations in the next section, and will be updated over time for all your MUGIC™ device management needs.

C. Basic MUGIC™ Usage - Now what?

MUGIC™ in default mode

MUGIC™ is in **AP (Access Point) mode** as default, which means MUGIC™ creates its own wireless network. You are now receiving data via UDP (User Datagram Protocol) over the **default port, which is set to 4000.** (You can always return to this initial state by pressing the **RESET button** or turning off/on your device.)

Troubleshooting:
If you joined the MUGIC™ConnectXXXXXX network, but are not receiving any data:
Check your local IP (in your computer's settings or system preferences, network configuration). It should be 192.168.4.2 (the device should have the IP address 192.168.4.1). If this is not the case, you may not be the only computer or device to join the access point. Try turning off the device and back on, then join again. Alternatively, in a browser, **while MUGIC™ is on WIFI**, visit URL http://192.168.4.1/set?udp_ip=192.168.4.X where 192.168.4.X is your local IP address. (It's possible that the WiFi network be 10.0.0.1 or something else. In that case, use the router address of your WIFI network instead of 192.168.4.1.)

Data API

Once your computer receives the data over either WIFI using port 4000, or over USB, you will receive datagrams with the given format:

- Over WIFI: UDP network packet addressed to computer IP over port 4000.
  Contents: OSC Message **"/mugicdata AX AY AZ EX EY EZ GX GY GZ MX MY MZ QW QX QY QZ Battery SysStatus GyroStatus AccelStatus MagStatus Secs SeqNum"** ("A"=accelerometer, so AX AY AZ means the acceleration of X, Y and Z angles. See page 6 "MUGIC™ Datagram and description")

- Over USB: discard any line on the serial port not beginning with "mugicdata" (or pipe it into a log, since they consist of logging/debugging information indicating state transitions and other operations of the MUGIC™ device). The lines containing data have the format: **"mugicdata AX AY AZ EX EY EZ GX GY GZ MX MY MZ QW QX QY QZ Battery SysStatus GyroStatus AccelStatus MagStatus Secs SeqNum"**

(Note: Depending on the flags, some of these data may be 0. They are all on by default.)

The values are provided by the on-board BNO055 integrated sensor, whose full documentation is provided on the vendor's website. The most useful values for the average user are acceleration and quaternion orientations.

MUGIC™ Datagram and description

FIELD	Index	Meaning / unit
Accelerometer AX AY AZ	1 2 3	Acceleration: measured by the on-board accelerometer, in the local device frame, in m/s^2
Euler Angles EX EY EZ	4 5 6	Euler angles: computed by the on-board sensor from the quaternion, in (fixed) Earth-related frame, in degrees.
Gyrometer GX GY GZ	7 8 9	Gyrometer: angular velocity in the local device frame, in degrees per second.
Magnetometer MX MY MZ	10 11 12	Magnetometer: measures the components of the Earth magnetic field in the local device frame, in μT.
Quaternion QW QX QY QZ	13 14 15 16	Quaternion: provides an alternate measurement (different from Euler angles) of the rotation between the local frame and the Earth-related frame.
Battery	17	Battery level in percent.
Sensor status (Accelerometer, Gyrometer, m (continues)	18 19 20 21	Calibration status (0=N/A, 1=weak, 2=good, 3=excellent). In general, data is not reliable and should not be used when the corresponding status is 0. Note: It is possible to calibrate the device by a sequence of movements / positions systematically exploring every orientation, until every status is at least 1, preferably 2 or 3.
Seconds	22	Seconds elapsed since the last restart of the MUGIC™ device.[1]
SeqNum	23	Sequence number of data message: first message has sequence number 0, and subsequent messages increment this sequence number by 1.

These values are read from the device in native resolution of 100Hz (every 10ms), however it is not possible for the on-board software to read and publish this data at this rate over USB. The current reading and publishing frequency is set at a default of 40Hz, i.e. loop_delay of 25ms.[2,3]

[1] With a reasonably steady rate, should be spaced every 25ms per consecutive messages, but can vary depending on various interactions and activity in the device (e.g. network activity). Can be regulated through the loop_delay parameter (see next section).

[2] The most efficient way to publish data we have come about is over OSC messages, via WIFI, and turning off any non-essential measurements (which would then be published as 0) as indicated by the flags section in the next section. Using this we can achieve a consistent 15ms loop-delay, and with occasional fluctuations even 10ms (but some measurements might occasionally be spaced apart by more than 10ms).

[3] We are currently researching the possibility of publishing “raw” non-OSC messages, but this would likely be a non-portable non-standard modification - please contact us if you need this level of accuracy and publishing frequency.

Technical Details on Configuring your MUGIC™

The state of your device is stored in RAM while the device is running, and can be written to EEPROM (a more permanent storage that will keep its contents even if the device is powered off). Upon powering on, the state is loaded into RAM from EEPROM.

All commands below modify the RAM state; these changes will be lost if the device is powered off, or if the configuration is reloaded from EEPROM using the *reload* command. They can be saved into the EEPROM by using the *commit* command. The *reset* command will erase the state of the EEPROM and overwrite with the default / factory settings, similar to what can be obtained from pressing the RESET button.

The state of your device consists of the following main parameters with the following values:

Name	Where is it stored?	Meaning	Default values
name	EEPROM+RAM	This is the name of your device.	MUGIC™XXXXXX
ap_ssid ap_pwd ap_port	EEPROM+RAM	SSID (network name) and PWD (password) for the wireless network in AP mode.	MUGIC™ConnectXXXXXX mugicXXXXXX 4000
wifi_ssid wifi_pwd wifi_ip wifi_port	EEPROM+RAM	SSID (network name) and PWD (password) of the wireless network joined while in Client mode.	MUGIC™NetworkXXXXXX mugicXXXXXX 192.168.4.1 4000
udp_ip upd_port	RAM		192.168.4.2 4000
loop_delay	EEPROM+RAM		25ms (40Hz)

Using the MUGIC™ app

Download the MUGIC™ app from www.mugicmotion.com, and follow the instructions in the app. It leverages the WIFI and USB interfaces, and sends the appropriate commands depending on the context. If you don't have access to the app, or are curious, you can read on.

Over WIFI

Assuming the IP address of the mugic device is **192.168.4.1**, open that URL in a browser by entering the IP address in the browser's address bar. For example, you should see:

etc.

This page tells you about the configuration of your device. You can visit it any time to check on your changes. You can modify any of the parameters by visiting e.g. http://192.168.4.1/set?name=MyMUGIC, for instance, to change the name of your device from Mugic469106 (in the example) to MyMUGIC.
Note: special characters like ' and (space) need to be encoded like http://192.168.4.1/set?name=Mari%27s%20MUGIC™ to set the name to "Mari's MUGIC™". The same goes for any other parameter (like ap_ssid and wifi_ssid). The MUGIC™ app does that for you.

You can switch between WIFI mode and USB mode, by visiting the commands http://192.168.4.1/wifimode or http://192.168.4.1/usbmode.

Note: For a finer control of the device output, you can visit http://192.168.4.1/set?wifi=server, http://192.168.4.1/set?wifi=server or http://192.168.4.1/set?wifi=client or http://192.168.4.1/set?wifi=0.
You can turn USB data on or off by visiting http://192.168.4.1/set?usb=0 or 1, independently of the wifi mode.

Please remember that all these modifications affect the values stored in RAM. To save these values to EEPROM, visit http://192.168.4.1/commit. To discard your changes, visit http://192.168.4.1/reload. To reset the MUGIC™ device to factory settings, visit http://192.168.4.1/reset. For further info, visit http://192.168.4.1/help.

Over USB

You will need a program such as Minicom, Putty, or the Arduino IDE, to access the port (typically COM[0123] on Windows, SLAB_USBtoUART on MacOS). In that terminal, enter commands such as “print” to see the configuration state, or “name:MyMUGIC™” to change the name of your device.

Available commands and their arguments include (do not type the surrounding quotes, and change the ALL CAPS values to the values you desire):

- “print” to see the state of your device (it is recommended to turn “usb:0” to avoid the print statements to be drowned in MUGIC™Data messages)
- “name:NAME OF YOUR DEVICE” to name your device
- “wifimode” or “usbmode” to switch between WIFI mode or USB mode.

- “ap_ssid:NAME OF YOUR NETWORK”
- “ap_pwd:PASSWORD” (must be at least 8 chars long, or else the device will not be able to create the access point in AP mode)
- “ap_port:PORT” (default is 4000 but if using several MUGIC™ devices, you may want to give each a different port number)

- “wifi_ssid:NAME OF YOUR WIFI CLIENT NETWORK”
- “wifi_pwd:WIFI NETWORK PASSWORD” (must be at least 8 chars long, or else the device will not be able to join an existing network in Client mode)
- “wifi_ip:IP.ADD.RE.SS” (default is 192.168.4.1, but if joining in client mode, you will need to configure to your computer’s IP address on the common network)

- “wifi_port:PORT” (default is 4000 but if using several MUGIC™ devices, you may want to give each a different port number)

Note: for a finer control of the device output, you can also use the commands to set WIFI mod and USB modes independently:

- “wifi:0” “wifi:client” or “wifi:server” to set the WIFI mode off, to client, or AP mode.
- “usb:0” or “usb:1” to disable or enable data via USB (independent of WIFI mode).

- “commit”, “reload” or “reset” to copy RAM to EEPROM, or EEPROM to RAM, or reset EEPROM to factory defaults.

- “loop:N” to set the loop delay to N milliseconds. This means data will be transmitted at the rate of one message every N milliseconds (if it can keep up, or as fast as it can transmit data if that turns out to be slower).

- “help” for this information.

C. MUGIC™ in AP (Access Point) mode

AP Mode

MUGIC™ is in **AP (Access Point) mode** as default, which means MUGIC™ creates its own wireless network. You are now receiving data via UDP (User Datagram Protocol) over the **default port, which is set to 4000.** You can always return to that state by pressing the **RESET button** and turning off/on your device.

Troubleshooting:
If you joined the MUGIC™ConnectXXXXXX network, but are not receiving any data:

Check your local IP (in your computer's settings or system preferences, network configuration). It should be 192.168.4.2 (the device should have the IP address 192.168.4.1). If this is not the case, you may not be the only computer or device to join the access point, try turning off the device and back on, then join again. Alternatively, in a browser, visit URL http://192.168.4.1/set?udp_ip=192.168.4.X where 192.168.4.X is your local IP address.

D. Using multiple MUGIC™

It is possible to connect multiple MUGIC™ to one computer. You need to put the MUGIC™(s) in "Client mode". We will upload more concise instructions shortly.

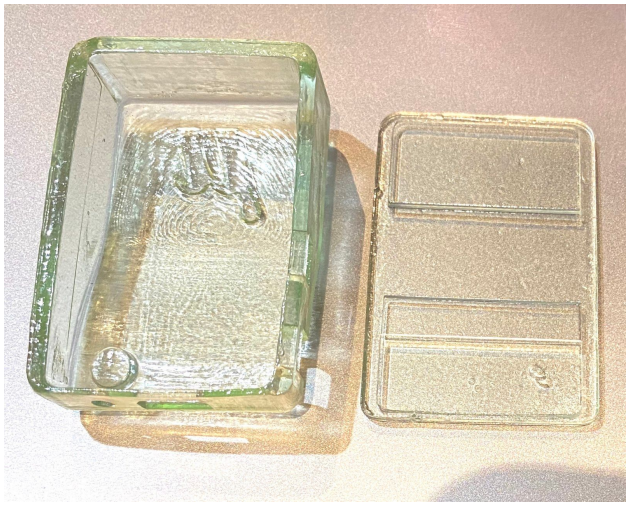
Appendix

MUGIC™ Care

The casing is made of resin, 3-D printed in two parts: the top cover and the bottom. If you drop MUGIC™ and the casing comes apart for some reason, you can glue it back carefully using a 'super glue', or any **cyanoacrylate adhesives**. Gorilla Glue, Loctite, Krazy Glue, others all make cyanoacrylate adhesives. For example:

Gorilla 7805601 Super Glue, 20 g, 1-Pack
https://www.amazon.com/dp/B00KPYB05A/ref=cm_sw_r_cp_api_i_hOS5EbYZRY2WC

Loctite Liquid Professional Super Glue 20-Gram Bottle (1365882)
https://www.amazon.com/dp/B004Y960MU/ref=cm_sw_r_cp_api_i_IOS5Eb39S9TDV



Data Specs

Q. How frequently is it sampled from the device / how much data does the device send?

A. The data is sampled by default every 25ms (40Hz) and sends a single UDP packet of less than 512 bytes, as a result the network traffic is minimal. The frequency can be adjusted through the loop_delay parameter, but the device maximum frequency is every 10ms (100Hz) and it is hard to configure the sensor to achieve this throughput.

Q. How physically accurate is MUGIC™?

A. The sensor integrated in MUGIC™ is a Bosch BNO055, one of the best fused IMU on the market. For technical documentation incl. range and accuracy, please see their documentation (https://cdn-shop.adafruit.com/datasheets/BST_BNO055_DS000_12.pdf)

Q. Can I track absolute position with MUGIC™?

A. This is a hard problem with any IMU sensor, since they only provide orientation and acceleration, not speed or position. For instance, it is physically impossible to distinguish

a device traveling at constant speed from an immobile device since in both cases acceleration is zero. Using additional constraints (such as when the device is mounted on a doorframe or other physically -constrained element, or if the device undergoes a cyclical motion such as a rotation about a fixed axis) it is possible to achieve excellent positioning. For a free-form sensor like MUGIC™, it remains an active research project to estimate accurate speed and position, although in theory using physical constraints from an instrument such as a violin (if mounted on the box hand) should help. https://cdn-shop.adafruit.com/datasheets/BST_BNO055_DS000_12.pdf?fbclid=IwAR39iBXEzhbg2LK9Cv4X-RsQeHW8es390-tidt0F-jdZSAhF7Ba_Mfz5J4g

Technical Specs

MUGIC™ is a prototype motion sensor. It contains:

- ESP8266 WIFI module (FCC ID 2AC7Z-ESPWROOM02, RoHS compliant)
- MUGIC™ circuit board containing BNO055 integrated sensor. Designed at Calit2/UCI, manufactured by Tailhoo Ltd., Shenzhen, China.
- 3.7V lithium polymer rechargeable battery
- Outer casing designed and made with Resin 3D-printer, assembled at Kimari, LLC (CA, NY licensed)

Dimensions: 1 x 1.8 x 1.4 inches (2.6 x 4.5 x 1.5 cm) and weighs approximately 0.6 ounces (18 grams.)