MindBand Research Instruction Manual

November 29, 2011

NeuroSky
Brain-Computer Interface Technologies

The NeuroSky® product families consist of hardware and software components for simple integration of this biosensor technology into consumer and industrial end-applications. All products are designed and manufactured to meet consumer thresholds for quality, pricing, and feature sets. NeuroSky sets itself apart by providing building block component solutions that offer friendly synergies with related and complementary technological solutions.

Contents

Introduction to the MindBand

Thank you for purchasing NeuroSky's MindBand. The band was designed to be used for research. This Brain-Computer Interface (BCI) device turns your brainwaves into actions, unlocking new worlds of interactivity. The MindBand reports the wearer's mental state in the form of NeuroSky's proprietary Attention and Meditation eSense™ algorithms, along with raw wave and information about the brainwave frequency bands. The NeuroSky MindBand can be used with supported video games, research software, or a number of other applications for an enhanced user experience.

For any technical information updates and additional support questions not answered by this document, please register at the NeuroSky support website at http://support.neurosky.com. We also recommend you join our email list by filling out the form on http://www.neurosky.com to receive general information about NeuroSky, new products announcements, and any technical information updates.

MindBand Package Contents

- MindBand headband
- MindBand BCI Demonstration Software, containing:
  - **PDF documents**:
    - MindBand Instruction Manual
    - Brainwave Visualizer Manual
  - **Applications** for PC and Mac:
    - Brainwave Visualizer
- USB charging cable
- USB Bluetooth adapter

Setting Up Your MindBand

System Requirements

	PC	Mac
OS	Windows XP/Vista/7	OS X 10.5.8 or later
Processor	Core 2 Duo	
Memory	1GB	
Hard disk	500MB free space	
Bluetooth	Bundled USB dongle	Bundled USB dongle or built-in

Power

To turn on the MindBand, hold down the power button until you see the blue light turn on. Turn off the MindBand by holding down the same power button until the blue light goes from flashing to solid.

Charging

To charge the MindBand's lithium-ion battery, plug the supplied USB cable into the MindBand, and connect the other end to a powered USB port. An blue light will indicate that the MindBand is charging. The MindBand may take up to four hours to charge.

Important: Do not wear the MindBand while charging.

Figure 2.1: Charging

Software Installation

Windows

1. Download and run `MindBand-Setup.exe` and follow the on-screen instructions.
2. If prompted, reboot your computer.

Mac OS X

Important: If your Mac already has Bluetooth, please use your Mac's built-in Bluetooth. Otherwise, simply plug the included Bluetooth dongle into an open USB slot. Mac OS X will automatically utilize the appropriate device drivers.

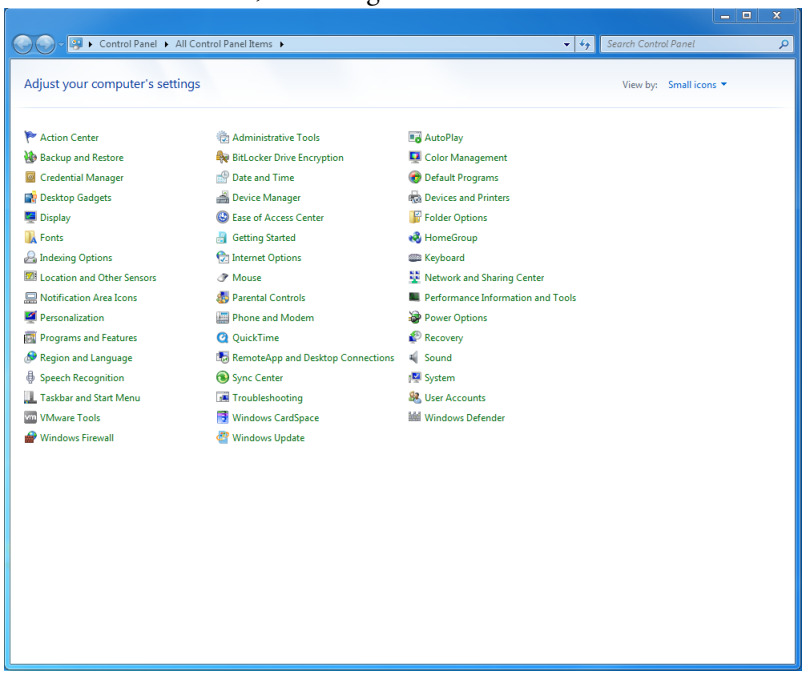
1. Insert the MindBand Disc into your computer's DVD drive.

2. Navigate to the MindBand Disc in Finder.
3. Copy the NeuroSkyLab folder to your MATLAB workspace.
4. Documentation is available in the Docs folder.

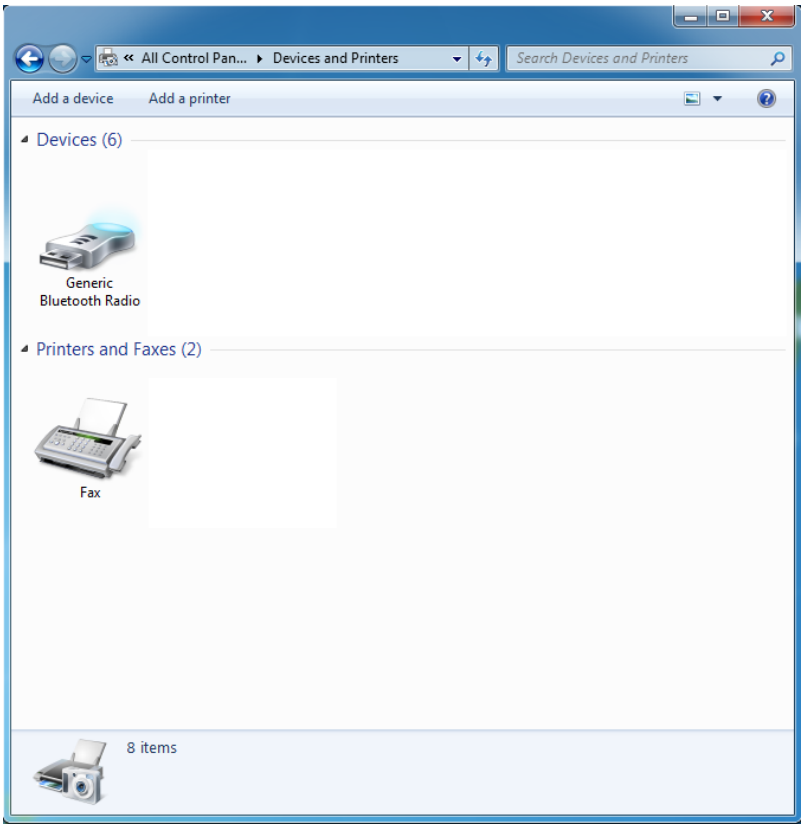
Bluetooth Pairing

Windows 7

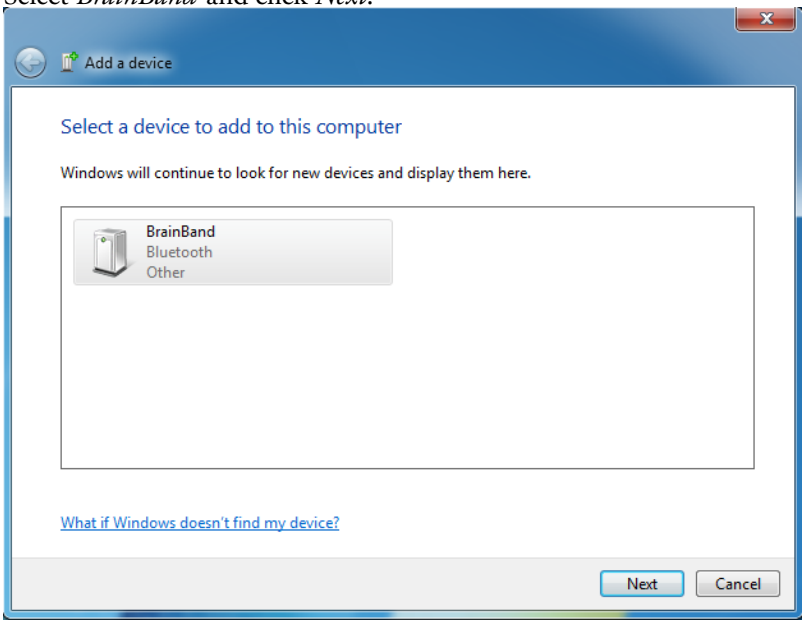
1. Turn on the MindBand and plug in the provided USB Bluetooth adaptor.
2. Click the *Start* button, and navigate to *Devices and Printers*.



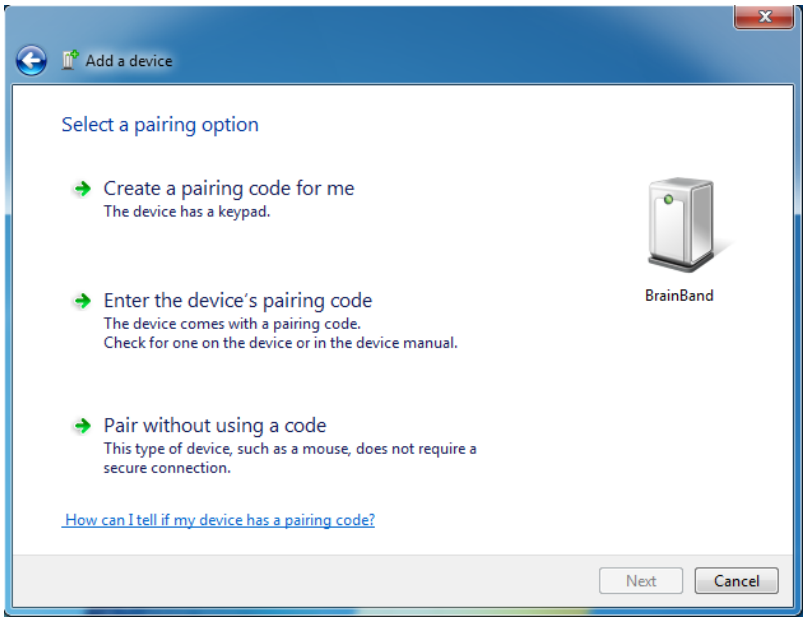
3. Click on *Add a Device*.



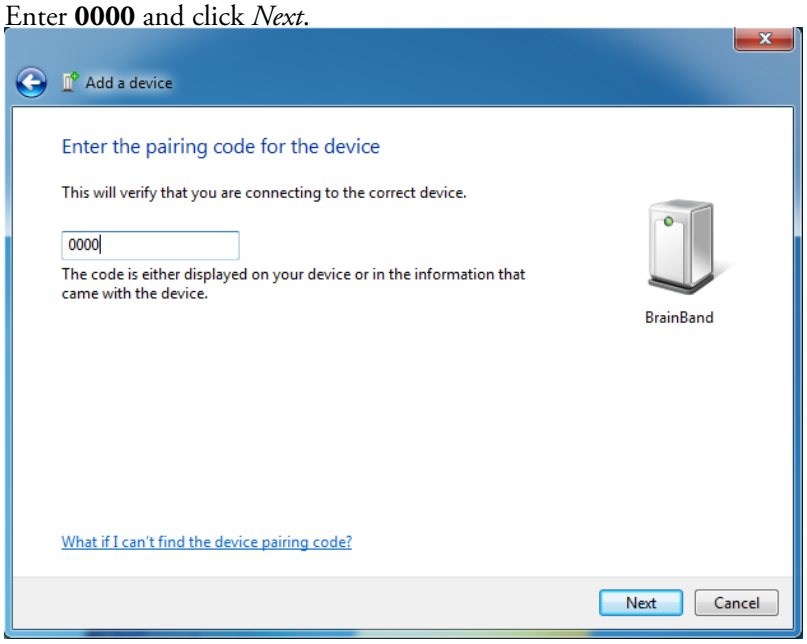
4. Select *BrainBand* and click *Next*.



5. Select *Enter the device's pairing code*.



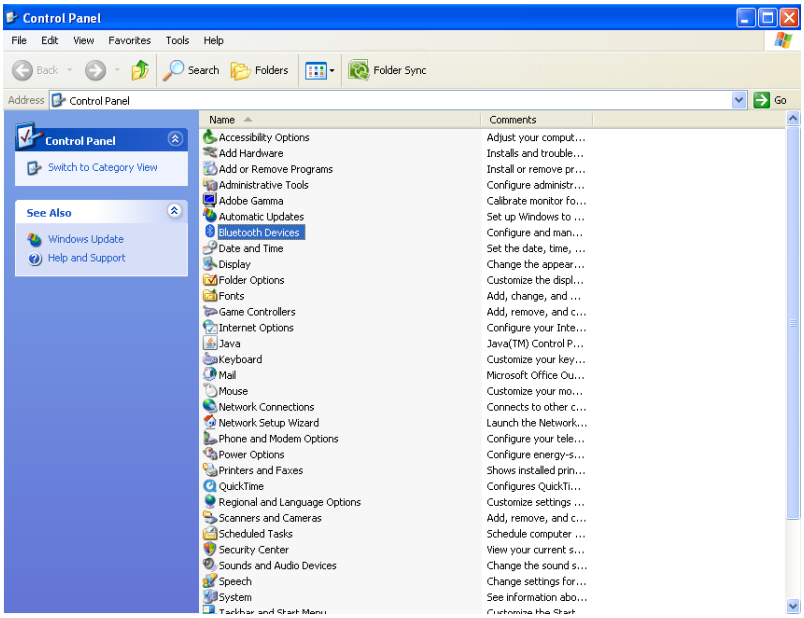
6. Enter **0000** and click *Next*.



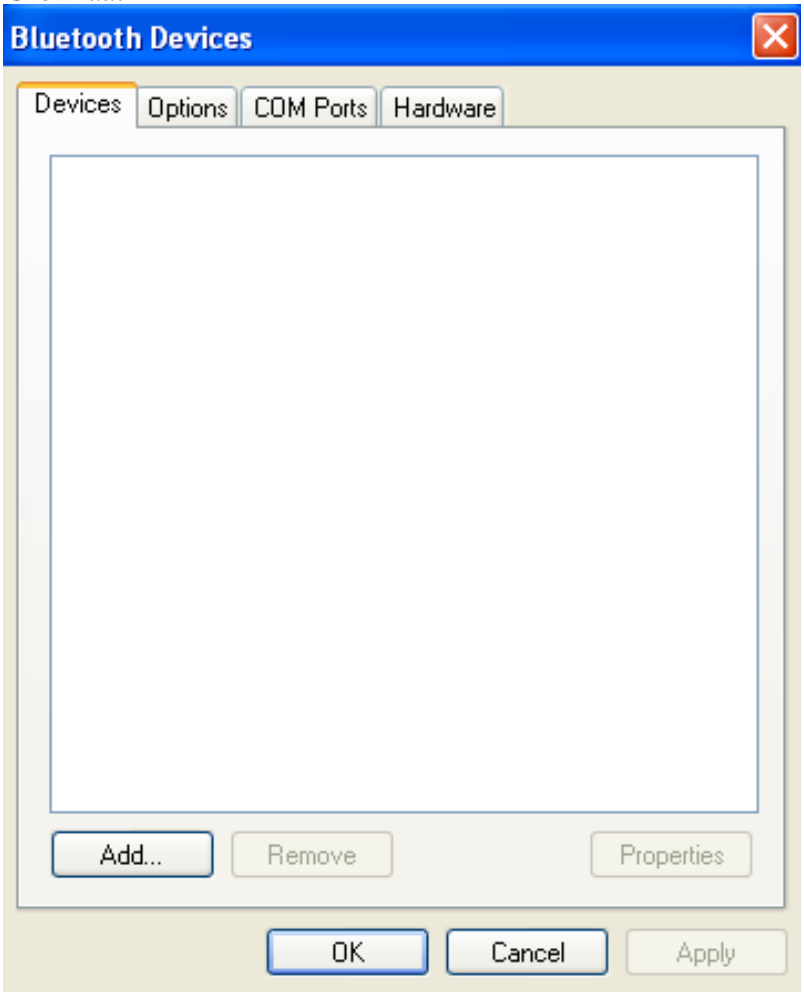
7. Click *Close*. Pairing is now complete.

Windows XP/Vista

1. Turn on the MindBand and plug in the provided USB Bluetooth adaptor.
2. Click the *Start* button, and navigate to the *Control Panel*. Double click on *Bluetooth Devices*.

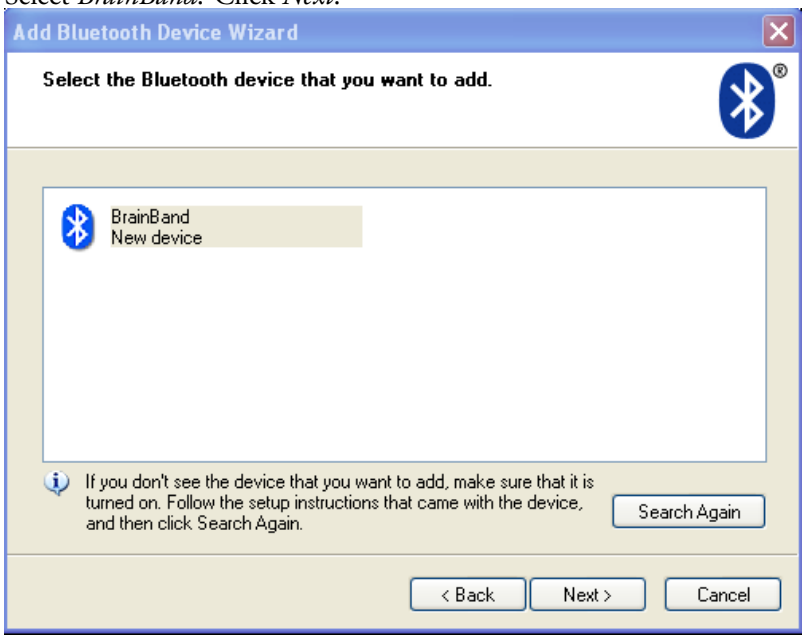


3. Click *Add*.

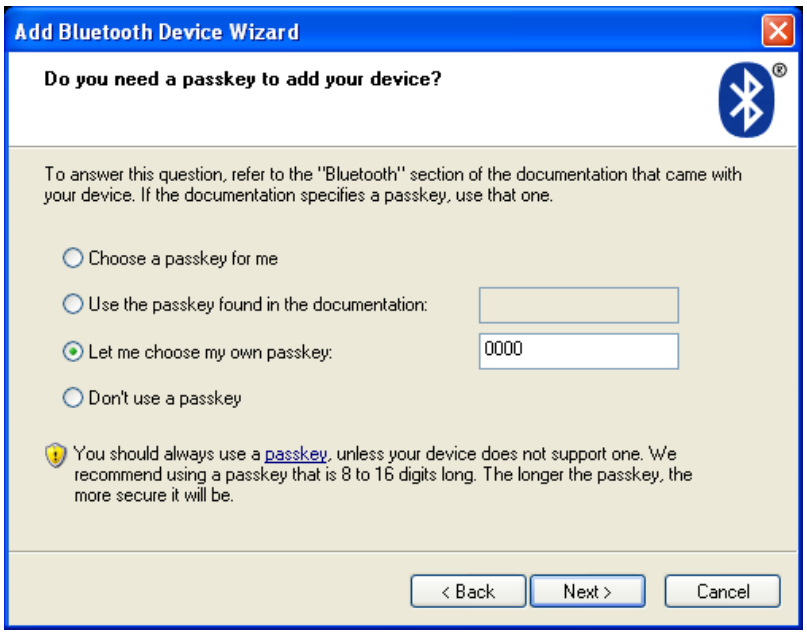


4. Check the *My device is set up and ready to be found* box and then click *Next*.

5. Select *BrainBand*. Click *Next*.



6. Select *Let me choose my own passkey*. Enter **0000** and click *Next*.



7. Click “Finish”. Pairing is now complete.

Mac OS X 10.6

1. Turn on the MindBand.
2. Open *System Preferences*, and click on the *Bluetooth* icon to configure Bluetooth devices.
3. Click on the " + " icon in the lower-left to add a new device.
4. The *Bluetooth Setup Assistant* will appear and will start searching for devices. Select "BrainBand" and click *Continue*.

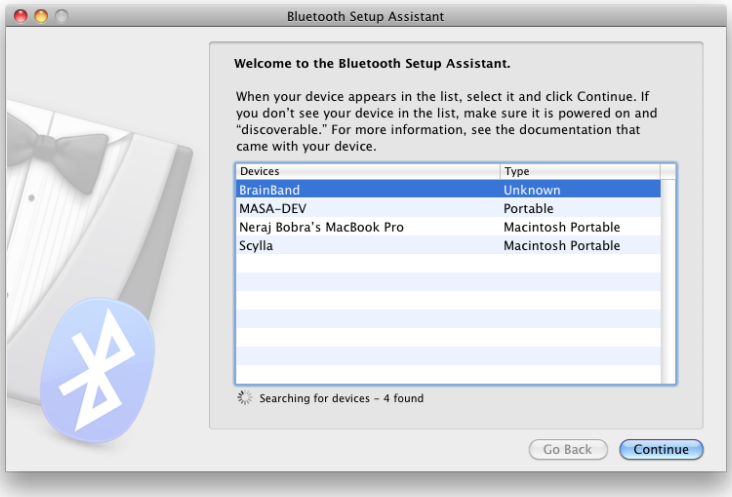


Figure 2.2: Device Selection

1. The *Bluetooth Setup Assistant* will start pairing with the MindBand.

Figure 2.3: Pairing

2. Pairing is now complete.

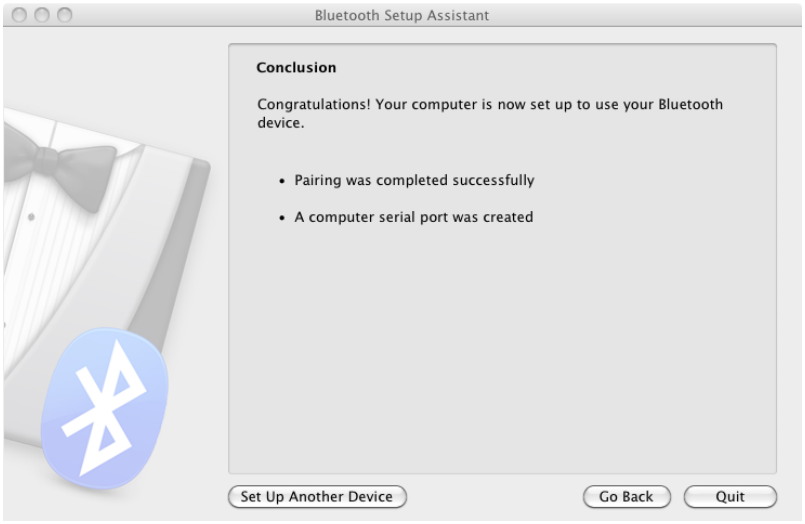


Figure 2.4: Pairing Complete

Mac OS X 10.5

1. Turn on the MindBand.
2. Open *System Preferences*, and click on the *Bluetooth* icon to configure *Bluetooth* devices.
3. Click on the " **+** " icon in the lower-left to add a new *Bluetooth* device.

4. When asked to *Select Device Type*, choose "Any Device", then click "Continue".
5. Click the "Passkey Options…" button at the bottom, and make sure the option is set to "Use a specific passkey". Click "OK".
6. In the same window, "BrainBand" should appear in the list of *Bluetooth* devices in range. Select it, then click "Continue".
7. Once the wizard is done gathering information about the MindBand, click "Continue".
8. When prompted for a passkey, fill in the passkey **0000**, then click "Continue".
9. When asked about services, just use the default setting, then click "Continue".
10. Pairing is now complete.

Serial Port Name

Windows

To find your MindBand's serial port, right-click on the BrainBand icon in the Bluetooth Settings manager and select *Detail.…* The serial port name will be shown as **COM_**.

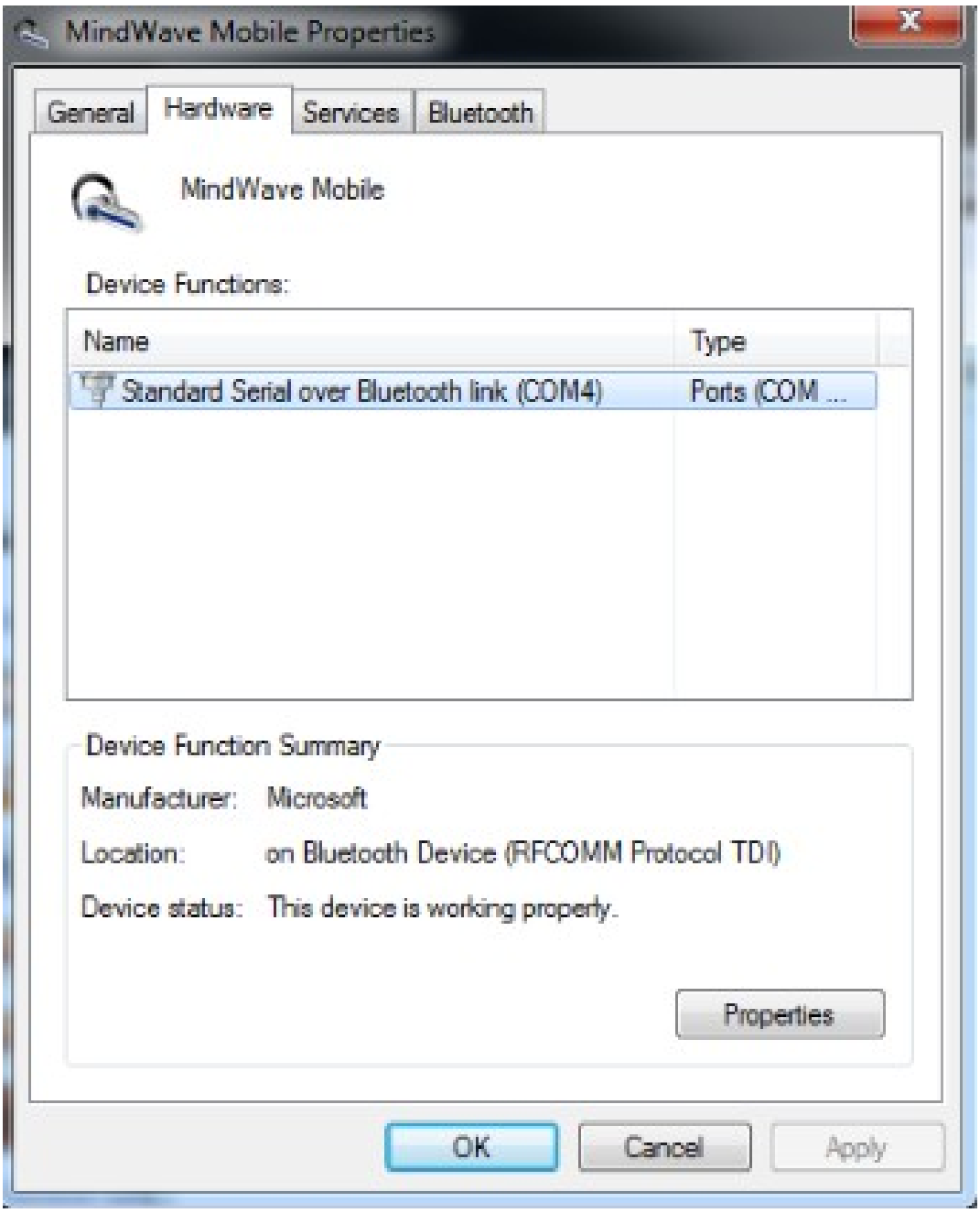


Figure 2.5: Serial Port

Mac OS X

Since the Mac does not use numbered serial ports, users must manually determine the MindBand's serial port. Once you've completed the pairing procedure, load up the *System Preferences*, and click on the *Bluetooth* icon. Select the "BrainBand" in the list of devices, then click on the gear icon underneath. Then, click on the `Edit Serial Ports…` menu option.

Simply copy the text listed next to the *Path* label. For example, `/dev/tty.BrainBand-DevB`. This is

the MindBand's serial port. Paste this text back into the *Port* field of your application.

Wearing the MindBand

Figure 3.1: Side View

Important: In order to take full advantage of these functions and features of the MindBand, the MindBand must be properly worn.

1. Open the MindBand band by pulling apart the velcro fastener
2. Orient the headband so that the forehead sensors are facing you and the ear-loop is on the left
3. Place the MindBand towards your head and wrap the band around your head with a secure fit
4. Guide the ear-loop behind your ear lobe
5. Use Velcro extension strip to extend the MindBand if needed.

Note: Remove the ear-loop before removing the MindBand to avoid discomfort

NeuroSky Technology Overview

Brainwaves

The last century of neuroscience research has greatly increased our knowledge about the brain and particularly, the electrical signals emitted by neurons firing in the brain. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The MindBand contains NeuroSky ThinkGear™ technology, which measures the analog electrical signals, commonly referred to as brainwaves, and processes them into digital signals to make the measurements available to games and applications. The table below gives a general synopsis of some of the commonly-recognized frequencies that tend to be generated by different types of activity in the brain:

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

ThinkGear

ThinkGear is the technology inside every NeuroSky product or partner product that enables a device to interface with the wearers' brainwaves. It includes the sensor that touches the forehead, the contact and reference points located on the ear pad, and the on-board chip that processes all of the data. Both the raw brainwaves and the eSense Meters (Attention and Meditation) are calculated on the ThinkGear chip.

eSense

eSense™ is a NeuroSky's proprietary algorithm for characterizing mental states. To calculate eSense, the NeuroSky ThinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values. Please note that eSense meter values do not describe an exact number, but instead describe ranges of activity.

eSense Meter - General Information

The eSense meters are a way to show how effectively the user is engaging Attention (similar to concentration) or Meditation (similar to relaxation).

Like exercising an unfamiliar muscle, it may take some time to gain full proficiency with each of the eSense™ meters. In many cases, people tend to be better at one eSense than the other when they first begin. We recommend trying different tactics until you are successful with one. Once you see a reaction on the screen from your efforts, you will be able to duplicate the action more easily with additional practice.

Generally, Attention can be controlled through a visual focus. Focus on a singular idea. Try to "funnel" your concentration and focus your train of thought towards pushing up the meter. Other suggestions include picking a point on the screen to stare at or imagining the action you are trying to accomplish happening. For example, look at the Attention eSense meter and imagine the dial moving towards higher numbers.

For Meditation, it typically helps to try to relax yourself. Connect to a sense of peace and calm by clearing your mind of thoughts and distractions. If you are having difficulty engaging Meditation, close your eyes, wait a number of seconds, and then open your eyes to see how the meter has responded.

If you have trouble at first in controlling your eSense meter levels, be patient. Try different techniques and practice. Also be sure to read and try to understand the Technical Description in order to get a better idea about how eSense actually works under the hood.

eSense Meter - Technical Description

For each different type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 to 60 at any given moment in time is considered "neutral" and is similar in notion to "baselines" that are established in conventional brainwave measurement techniques (though the method for determining a ThinkGear baseline is proprietary and may differ from conventional brainwaves).

A value from 60 to 80 is considered "slightly elevated", and may be interpreted as levels tending to be higher than normal (levels of Attention or Meditation that may be higher than normal for a given person). Values from 80 to 100 are considered "elevated", meaning they are strongly indicative of heightened levels of that eSense.

Similarly, on the other end of the scale, a value between 20 to 40 indicates "reduced" levels of the eSense, while a value between 1 to 20 indicates "strongly lowered" levels of the eSense. These levels may indicate states of distraction, agitation, or abnormality, according to the opposite of each eSense.

The reason for the somewhat wide ranges for each interpretation is that some parts of the eSense algorithm are dynamically learning and at times employ some "slow-adaptive" algorithms to adjust to natural fluctuations and trends of each user, accounting for and compensating for the fact that brainwaves in the human brain are subject to normal ranges of variance and fluctuation. This is part of the reason why ThinkGear sensors are able to operate on a wide range of individuals under an extremely wide range of personal and environmental conditions, while still giving good accuracy and reliability.

ATTENTION eSense

The eSense Attention meter indicates the intensity of a user's level of mental “focus” or “attention”, such as that which occurs during intense concentration and directed (but stable) mental activity. Its value ranges from 0 to 100. Distractions, wandering thoughts, lack of focus, or anxiety may lower the Attention meter level. See eSense Meter - General Information for details about interpreting eSense levels in general.

MEDITATION eSense

The eSense Meditation meter indicates the level of a user's mental “calmness” or “relaxation”. Its value ranges from 0 to 100. Note that Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the muscles of the body may not immediately result in a heightened Meditation level. However, for most people in most normal circumstances, relaxing the body often helps the mind to relax as well. Meditation is related to reduced activity by the active mental processes in the brain. It has long been an observed effect that closing one's eyes turns off the mental activities which process images from the eyes. So closing the eyes is often an effective method for increasing the Meditation meter level. Distractions, wandering thoughts, anxiety, agitation, and sensory stimuli may lower the Meditation meter levels. See eSense Meter - General Information for details about interpreting eSense levels in general.

Brainwave Visualizer

The Brainwave Visualizer is a colorful, interactive application controlled by your brain that shows you a graphical representation of your brain’s activity. The Brainwave Visualizer includes the Brainwave Visualization, Brainwave Power Spectrum Graph, and the eSense Attention and Meditation meters.

The on-screen shapes morph and change color depending on your state of mind. Please refer to the included Brainwave Visualizer Manual for more details.

Additional Products

To find new and exciting ways to unlock the full potential of you MindBand, visit the NeuroSky Store for additional software and applications: http://store.neurosky.com

MindSet Development Tools (MDT)

The NeuroSky MindSet Development Tools (MDT) is available for free from the NeuroSky Store, and provides all the tools and resources necessary to create and publish games and applications capable of taking advantage of the exciting new Brain-Computer Interface (BCI) technology of NeuroSky's MindSet headset. The MDT includes drivers, sample code, and documentation describing how to develop applications for several software platforms, including PC, Symbian, and even lower level platforms such as microcontrollers like the Arduino™.

Languages directly supported include C/C++, C#, Java (through JNI), and J2ME. In addition, the MDT provides the ThinkGear Connector (TGC), a daemon-like software that runs on Windows or Mac OS X, and opens a TCP port on the user's local computer so that applications can connect to it and retrieve MindSet data. As long as the TGC is running on one of the supported platforms and connected to a MindSet, then any application written in any language that can communicate through TCP sockets (such as Flash's ActionScript3 and scripting languages in general) can connect to the TGC to read data from the MindSet.

Create exciting new games that challenge people to use the power of their mind or retrofit your existing games with a new dimension of brainwave control.

The MindSet Development Tools (MDT) are available for *free* and can be downloaded from the NeuroSky Store at http://store.neurosky.com.

MindSet Research Tools (MRT)

The NeuroSky MindSet Research Tools (MRT) enable researchers to use the MindSet as a data collection device. Using the cost effective and user-friendly features of MindSet in conjunction with the MRT allows researchers to broaden the scope of their research and to make efficient use of resources.

The MRT includes the NeuroView software, which make it easy to connect, graph, view, and record MindSet data in real time. The MRT also includes the more advanced NeuroSkyLab MATLAB module, which adds the ability to define custom MATLAB scripts and functions for customized processing and analysis of MindSet data.

For more information on the uses and capabilities of the MindSet Research Tools, please visit: http://store.neurosky.com/products/mindset-research-tools.

Care and Maintenance

- Clean the MindBands's sensors and ear loop contacts with alcohol-wipes periodically to ensure the best signal quality. Use a soft cloth to clean the MindBands's electronics casing.
- Occasionally you may want to wash the headband fabric. You must first remove all the electronics from the headband.

  1. Touch a grounded metal surface to avoid any static discharge.
  2. Gently disconnect all the sensors from the electrical housing and clip it off from the headband.
  3. Slide the end of the cables out of the band.
  4. Remove the electronics case from its hole.
  5. Set aside all the electronics and cables.
  6. The headband may be washed in cold water on the gentle cycle.

Troubleshooting

Problem	Cause	Solution
MindBand does not turn on	MindBands's battery may be low	Charge the MindBand
Pairing failed	Incorrect passkey	Use **0000** as the passkey while pairing.
Pairing failed	Low battery	Charge the MindBand completely before use.
Cannot see the MindBand while searching for Bluetooth devices	MindBand is not turned on.	Turn on the MindBand
Cannot add the SPP service during pairing	The MindBand's SPP service is not available.	Power cycle the MindBand and pair again.

The signal quality status is consistently poor (fewer than three bars).
The ear contacts should be resting directly on your ear and the forehead sensor should be on your forehead. Also, check that the sensors and contacts are making good contact with the skin. Make sure to remove all obstructions including hair and jewelry.

It usually takes three or four seconds for the headset to validate the signal after holding still. Also make certain to keep the sensor and contacts clean.

The eSense meters do not move.
Verify that the *Bluetooth* is paired correctly. You can use the Brainwave Visualizer to verify if the headset is transmitting. Select "Show data output" from the menu. If the numbers are changing, that means the headset is transmitting data to the PC.

Allow the eSense meters to go through a few moments to go through initialization before troubleshooting. If the meters do not move after 10 seconds, make sure the sensor rests on the forehead and the contacts are on the left ear. The sensor and contacts should make firm and consistent contact with your skin.

I don't seem to be able to control the eSense™ meters.
Like exercising an unfamiliar muscle, it may take some time to gain full proficiency with the eSense™ meters. First, be sure you understand how the eSense meters work and what they are measuring. Generally, we recommend engaging Attention by concentrating and Meditation by relaxing. Most importantly, be sure you have read the detailed explanation of eSense previously described in the *eSense™* sections.

For further technical support, please register on the NeuroSky Support Forums at http://support.neurosky.com.

Warnings

- Batteries shall not be exposed to excessive heat such as sunshine, fire, or the like.
- Do not drop or throw the MindBand. Doing so may cause damage to the MindBand.

Environmental requirements

- Operating temperature: 0-35˚C
  - Do not expose the MindBand to temperatures above 140°F (60°C).
- Operating Voltage:
  - 5V (when recharging through the USB Port.
  - 4.3V (normal operation with battery)
- Current Rating: During battery recharging: 250 mA maximum
- Normal use under battery power: 60 mA maximum.