OptoACTIVE™

Active Noise Control

Optical MRI Communication System

User Guide

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Optoacoustics Ltd.
SOUND SOLUTIONS FROM LIGHT TECHNOLOGY
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About This Manual

This manual provides guidance for routine use of the OptoACTIVE™ Active Noise Control Optical MRI Communication System after it has been formally installed by Optoacoustics' field service engineers.

General Notices

This manual is made available subject to the following terms and conditions:

- Proprietary information supplied within this manual remains the sole property of Optoacoustics.
- This manual is intended solely and exclusively for the use of authorized operators of the OptoACTIVE Active Noise Control Optical MRI Communication System. No part of this manual shall be disclosed to any third party, electronically, mechanically or by any other means, without the express prior permission of Optoacoustics.
- All statements, technical information and recommendations related to the products herein are based upon information believed to be reliable and accurate. However, the accuracy or completeness thereof is not guaranteed, and no responsibility is assumed for any inaccuracies. Optoacoustics Ltd. reserves the right to change at any time and without notice the design, specification, function, fit or form of its products described herein, including withdrawal at any time of a product offered for sale herein.
- All text and images within this manual are for illustration and reference purposes only, and should not be construed to constitute any form of product specification. Both text and images are subject to change without notice at any time.
- The OptiMRI software is provided under license from Optoacoustics. The software may only be used in accordance with the terms of that agreement.

Table of Contents

Notices

The following are important notices regarding use of this equipment:

Intended Use

The OptoACTIVE System is intended for use by trained personnel in functional, interventional and clinical MRI environments to facilitate audio communications during a scanning session. System devices provide real-time Scanner noise reduction and/or noise cancellation.

Personal Safety Precautions

The OptoACTIVE System is certified completely safe for use in advanced as well as standard MRI environments, when it has been installed and configured by field service engineers who are authorized by Optoacoustics.

No special precautions for operation of this system by end users are required.

Equipment Safety Precautions

WARNING: To avoid the risk of electric shock, this equipment must only be connected to a supply mains with protective earth.

Do not open any module or device of the OptoACTIVE System. Only authorized Optoacoustics field service engineers are authorized to open the System.

Do not twist or bend the optical cables to within a radius of less than 1 inch (2.5 cm). Excessive twisting or bending of the optical cables can cause optical signal loss and/or fiber breakage.

Electromagnetic Compatibility (EMC) Compliance

The OptoACTIVE System is certified as compliant with IEC 60601-1-2, Medical Electrical Equipment - Part 1-2. (General requirements for basic safety and essential performance - Collateral Standard: Electromagnetic disturbances - Requirements and tests). Refer to document: OPTO-IEC60601-1-2 2021.

Sanitary Precautions

- Headphones: Left and right hygienic earphone covers should be replaced before each use.
- Microphones: The hygienic pop screen should be replaced before each use.

Headset Handling and Care

- Always return the OptoACTIVE headset to their velcro hooks at the end of each session.
- Always handle and carry the OptoACTIVE headset by the earphone cups or head band – do not carry it using the fiber optic cable.

Identification and Regulatory Labels

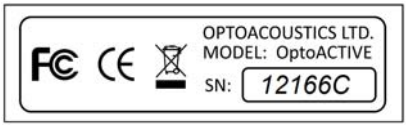
The following identification and regulatory labels are used with the OptoACTIVE System:

Manufacturer's Identification Label:

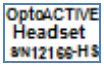
Following shows the label placed on each System component:

Label on the EOU (includes Model Identification):

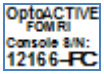
Labels on the Control Console:



Labels on the Headset:



Labels on the Microphone:



Regulatory Label Symbol Explanations:

Consult instructions for use or consult electronic instructions for use.

This item is designated as Body Floating (BF) Applied Part. (IEC 60601-1).

Do not discard this item as unsorted waste. Send to separate collection facilities for recovery and recycling. (EU WEEE Directive)

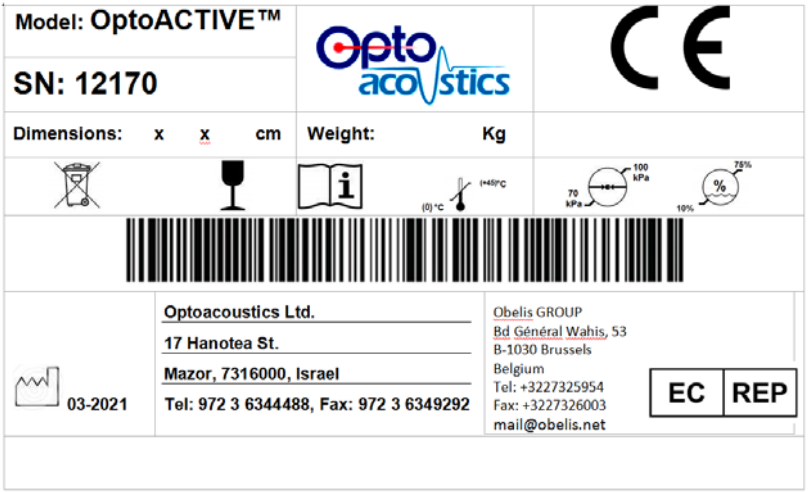
This electrical item is MR safe. It can be placed and used in the MRI scan room.

This electrical item is MR conditional. It can be used in the MRI scan room when it has been installed at the required distance from the scanner bore by an Optoacoustics engineer.

This electrical item is MR unsafe. Do not use or place this item in the MRI scan room.

Conformitè Europëenne (CE) certification.

Example Packaging Label



CHAPTER

1

Introduction

The Optoacoustics **OptoACTIVE™ Active Noise Control Optical MRI Communication System** is an optical fiber-based product with advanced noise-cancelling features that enables real time high-fidelity communications between doctors, staff and patients in magnetic resonance imaging (MRI) environments.

About the System

Magnetic resonance imaging is a safe and non-invasive method of obtaining valuable medical data. However, normal communications among staff and patients during an MRI scan is problematic, because the MRI process produces high levels of electromagnetic, RF and acoustic noise. Conventional microphones, headphones and intercom systems are not appropriate for use in MRI environments, since they generally contain electronics and metal components that are not safe to use in the MRI room, they can distort MRI imaging, and they are unable to successfully handle the extreme MRI signals and noise.

The OptoACTIVE System provides an unparalleled solution for clear, real-time communications during an MRI scan. Using a proprietary combination of passive noise reduction, real-time active noise cancelling and adaptive algorithms, the System attains the highest available levels of noise reduction in MRI while maintaining audio quality for speech and music. OptoACTIVE is ideally suited for use during high resolution EPI scans with 1.5T, 3T, 4T and 7T scanners.

System Features

OptoACTIVE™ is the only MRI communications system to use real-time algorithmic, active harmonic noise cancelling, as well as Optoacoustics' proprietary passive noise reduction techniques, to reduce 95 percent of MR EPI main gradient noise for the wearer.

About the OptoACTIVE Headset

- Safely cancels most MR EPI noise for the patient
- Provides unsurpassed sound clarity and fidelity
- Enables use of high fidelity audio stimuli during a scan
- Enables audio sound monitoring and recording exactly as a patient hears it during a scan
- Automatically performs self-calibration with SPL monitoring in real time
- Enables instant control over performance using a digital touch console and display
- Supports concurrent multiple audio inputs, including up to three TTL synchronization signals
- Provides PTT two-way communications in simplex or full duplex modes
- Is vendor certified and field proven as EMI/RFI immune

theMicrophoneSystem Handling and Care

- Always and carry the headphone by the ear cups or headband. Do not suspend or carry it by its cable.
- hang the components back on their Velcro storage hooks at the end of a session.
- Keep the headset clean. Refer to the cleaning instructions in this Guide.

Usage Best Practices

For highest performance when using the OptoACTIVE headphones:

a. Ensure a snug fit. The headphones should entirely cover the ears and some pressure should be felt by the user. Move excess hair to improve the fit.

b. When used inside a head coil, place some foam padding between the outside of each earpiece and the coil interior to reduce head movements and enhance passive noise reduction.

Prescription Device Statement

In accordance with 21 CFR §801.109, United States Federal Law restricts this device to sale by or on order of a physician.

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CHAPTER

2

Getting Started

System Components

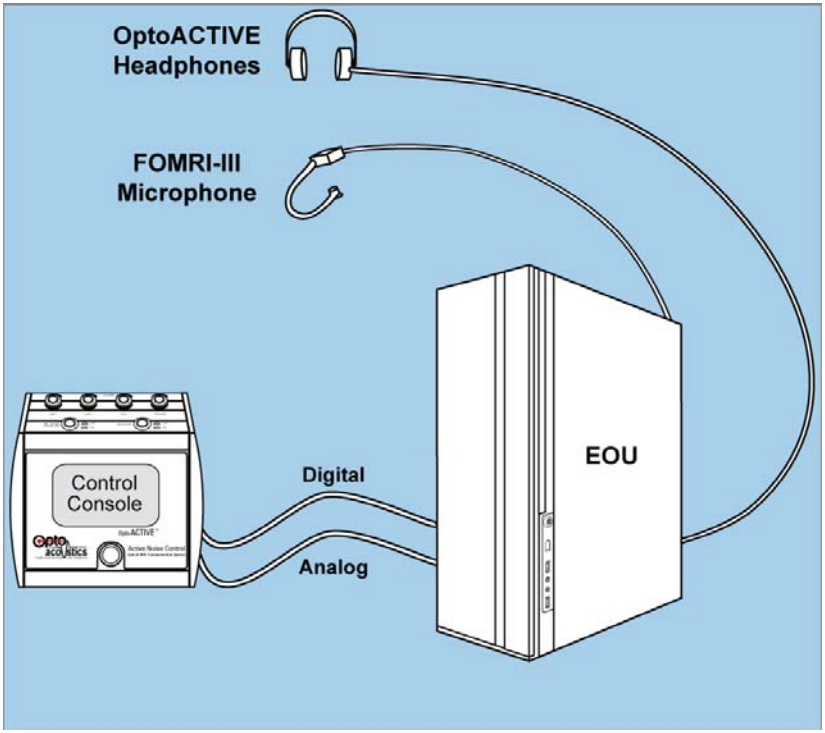

Figure 2-1. *OptoACTIVE Optical MRI Communication System*

As shown in *OptoACTIVE*, the OptoACTIVE™ Active Noise Control Optical MRI Communication System consists of the following components:

1. OptoACTIVE Ultra Slim Optical Headphones
2. Electro-Optical Unit (EOU)
    - Electro-optical TTL input signal interface cable
3. OptoACTIVE Mix and Control Console
    - Power cable
    - Digital cable
    - Analog cable
    - Standalone microphone with talk button
4. FOMRI-III™ Dual Channel Microphone
    - Power adapter (110V or 240V)
    - Starter set of microphone hygienic pop screens
    - MRI head coil mounting kit
    - Audio cables (RCA and 3.5 mm for IP network)
    - 2 USB cables (one cable is provided with the System)
    - OptiMRI 3.1 audio post-processing software CD
    - Fiber optic extension cable (optional)

System Requirements

Note: Exercise extreme care whenever handling System components and connection cables.

Do not bend or twist optical cables to within a radius of less than 1 inch (2.5 cm). Bending or twisting of an optical cable can cause excessive optical signal loss and/or fiber breakage.

Do not carry or drag a component by its optical cable. Doing so can damage internal optical connections. Always grasp the component unit directly when moving it.

Optoacoustics recommends the following operating conditions for best System performance.

OptoACTIVE Active Noise Control Headphones

- Standard room temperature range for operation and storage

FOMRI-III Dual Channel Microphone

- Standard room temperature range for operation and storage

OptiMRI Audio Post-Processing Software

- Dedicated PC with minimum Intel Pentium 4, 800 MHz processor; 1 Gb of RAM; Microsoft Windows XP; 5 Gb of unfragmented hard drive space.

Installing the OptoACTIVE System

The OptoACTIVE system is installed and configured only by field service engineers who are authorized and certified by Optoacoustics.

Following System installation:

- OptoACTIVE EOU resides in the control room
- OptoACTIVE Mix and Control Console resides in the control room
- OptoACTIVE Active Noise Control headphones and FOMRI-III Dual Channel Microphone reside in the scanner room

Note: The headphones and microphone are connected permanently to the OptoACTIVE EOU via optical cables which are passed from the scanner room to the control room via the wave guide.

For information on basic operation of the OptoACTIVE system, see "Using the OptoACTIVE System".

Fitting the Headphones

OptoACTIVE Active Noise Control headphones are among the most advanced audio instruments available today. For the headphones to operate most effectively, please use the following guidelines when fitting them to each patient:

1. Replace the left and right hygienic earphone covers before the scanning session.
1. Ensure a snug fit. The headphones should entirely cover the ears and some pressure should be felt by the patient. Move excess hair to improve the fit.

2. When used inside a head coil, place some foam padding between the outside of each earpiece and the coil interior to reduce head movements and enhance passive noise reduction.

Note: The OptoACTIVE headphones are attached to a optical fiber cable. When handling them, please observe the following precautions:

1. Do not twist the optical cable or bend it to a radius smaller than 3 inches, as this may cause excessive optical loss and/or fiber breakage.

2. Do not suspend or carry the headphones by the cable.

3. Always return the headphones to their Velcro storage hooks at the end of a session.

Fitting the FOMRI-III Microphone

In order to get optimal results from the FOMRI-III microphone, it must be installed and fitted correctly.

The FOMRI microphone can be attached to any scanner head coil using a specially-designed plexiglass mount and adhesive velcro strips, all supplied. This design enables you to move the FOMRI microphone between head coils whenever needed.

To attach the microphone to the head coil:

On the head coil that will be used, locate a small rectangular area close to an opening that exposes the patient's mouth during the scan. The area must be wide enough to securely hold the plexiglass mount. The area must be wide enough to securely hold the plexiglass mount.

If needed, trim the velcro strip to fit the mounting area before attaching it to the head coil. Do not trim the velcro strip smaller than 6 x 3 cm in size.

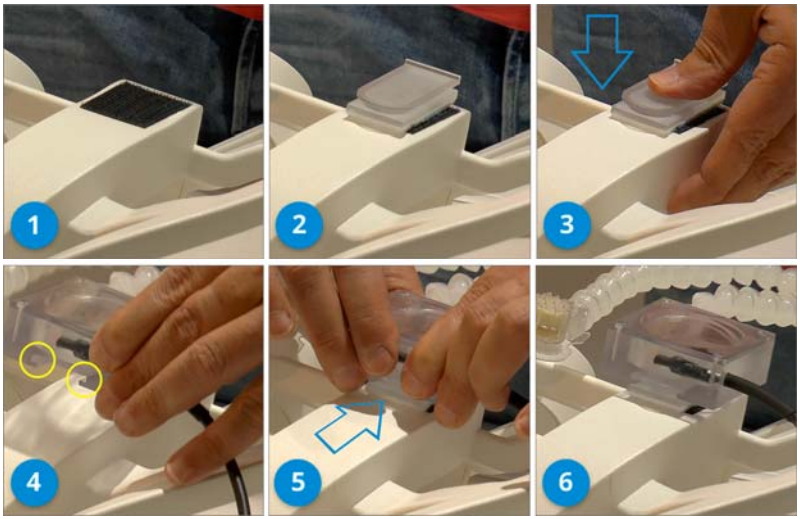

Figure 2-2. *Attaching the FOMRI-III microphone to the coil*

1. Remove the paper backings from the adhesive velcro strip and press the strip into the chosen location on the head coil.
2. Remove the paper backing from the velcro strip on the plexiglass mount and press the mount onto the velcro strip. Ensure that the mount is positioned and aligned properly -- note particularly the orientation of the mount.
3. Using your thumb, press down on the plexiglass mount. Apply enough pressure to the mount so that the adhesive strip underneath will fasten securely onto the head coil.
4. Bring the FOMRI microphone base close to the plexiglass mount and align the two fastening slots (marked by the yellow circles) with their fastening tracks on the mount.

5. Gently slide the FOMRI microphone base onto the mount. The microphone base will stop when it reaches the end of the fastening tracks.
6. Once mounted, adjust the FOMRI microphone gooseneck as needed for each patient. There is no need to remove the microphone base from the mount, unless you are moving the entire FOMRI assembly to another head coil.

NOTE: One FOMRI mount is supplied with each OptoACTIVE System. You can order additional mounts for use on additional head coils, when required.

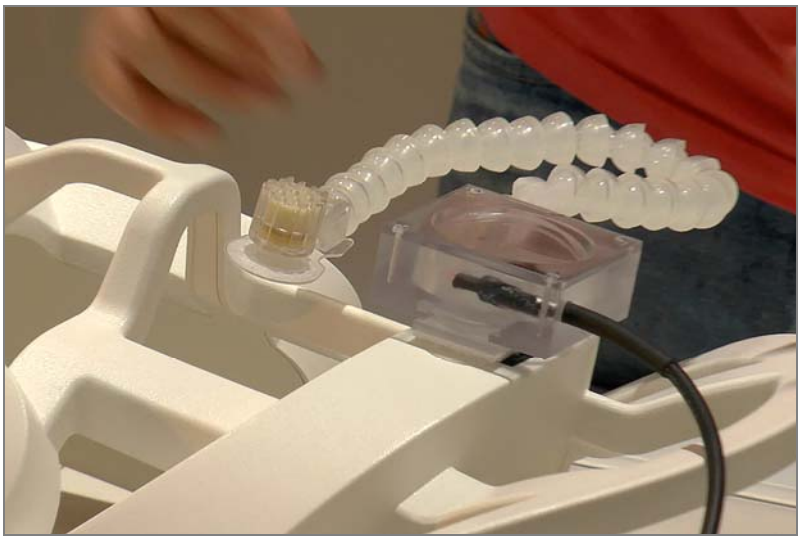

Figure 2-3. FOMRI-III after attachment

To adjust the microphone position for a patient:

Note: For hygienic purposes, always replace the disposable pop screen for each new patient.

1. When the patient is positioned on the bed in the MRI scanner room, attach a new hygienic pop-screen to the microphone.

   After the patient's head is positioned in the head coil, bend the flexible gooseneck to bring the FOMRI-III directly over the patient's mouth, as shown below. When speaking, the pop screen should be directly against the patient's lips.

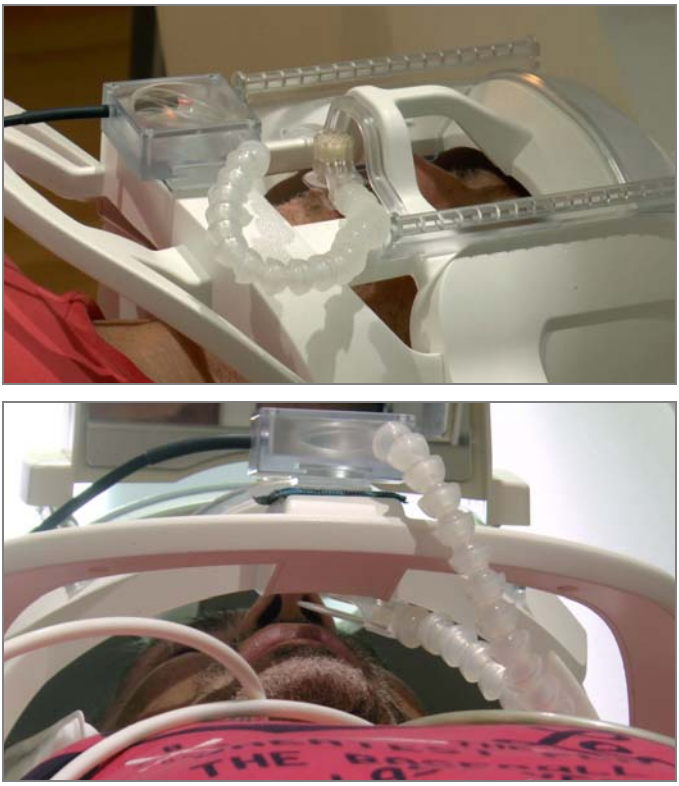

Figure 2-6. *Position the pop screen over the patient's mouth*

Testing the FOMRI-III Microphone

When it is part of the System, Optoacoustics recommends testing the FOMRI-III microphone before attempting to use it on a patient in the MRI scanner room.

To test basic microphone operations:

1. The microphone is ready to be tested once the following have taken place:
    - The EOU has been plugged into the power supply.
    - The microphone's fiber optic connectors have been attached to the back of the EOU (after being passed through the wave guide).
    - The system has been turned on.
2. Install a hygienic pop screen. The patient should be close to the pop screen (lips nearly touching the membrane) when speaking into the microphone. Close proximity improves noise reduction.
3. On the OptoACTIVE Control Console, ensure that the MIC NOISE CANCELLER button is toggled ON.
4. Use the Speaker knob on the OptoACTIVE Control Console to set to a comfortable listening volume.

Cleaning the System

COVID-19 NOTICE: Find specific cleaning instructions in the *COVID-19 Cleaning Notice* (Optoacoustics Document NOTICE-COVID19-01 2020).

With the exception of the EOU, all components of the OptoACTIVE System should be cleaned after each use with standard sanititizing solutions that are approved for use in medical environments. Use a soft tissue or cloth on all surfaces. Wiping should be performed only – do not scrub or apply pressure to any OptoACTIVE component surfaces, or submerge any component in liquid. Following cleaning, all components should be completely dry before using the System.

Note: Clean the headset and fiber optic connecting cables with great caution, so as not to cause stress to any fiber optic cable connections.

Service and Maintenance

The OptoACTIVE System should be serviced at least once every 24 months by Optoacoustics' Technical Support personnel.

CHAPTER

3

OptoACTIVE Hardware Reference

OptoACTIVE Control Console

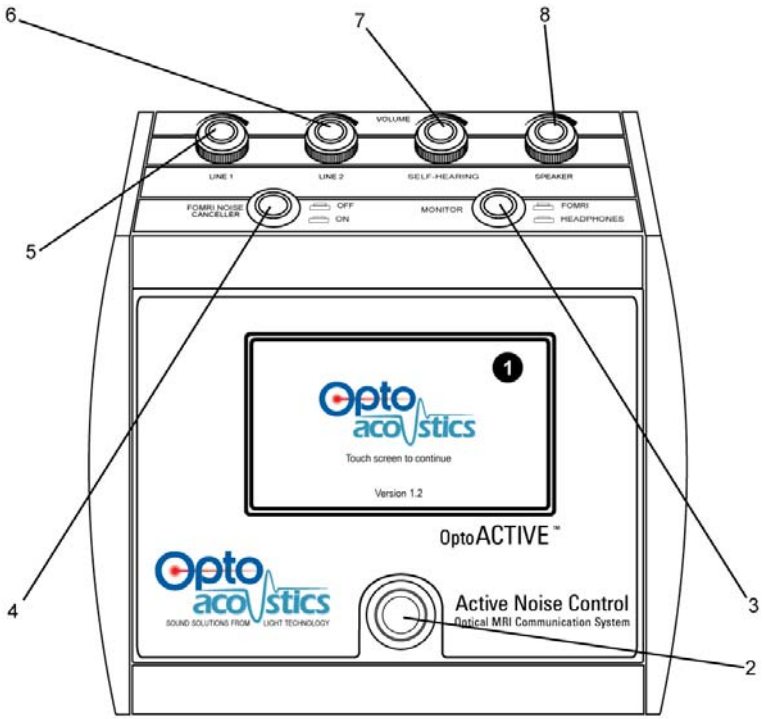

Figure 3-1. *Front Panel OptoACTIVE Control Console*

Front Panel Controls

1

System Control Touch Screen

Enables operator to view real-time signal wave forms as well as select calibration and operating parameters for active noise cancelling.

2.

Push to Talk (PTT) Toggle Button

Enables operator to talk to the patient using the built-in mic on the console panel. When the PTT button is pressed and held down, the speakers on the console are deactivated (temporarily turned off), and remain off until the PTT button is released.

While the PPT button is pressed, an audio channel from the operator to the patient is opened and the audio signal from MP3 (music) that is fed into the headphones is switched off. When the PPT button is released, the audio signal from the MP3 is resumed and the communication channel with the operator is closed.

Note: Use the PPT Button only when the Monitor Toggle Button is in the 'FOMRI' position.

3

Monitor On/Off Toggle Button

FOMRI (Off): the signal from the FOMRI-III microphone is output to the console speaker. This is the normal operating position for the button.

Headphones (On): the signal from the OptoActive is output to the console speaker.

4

FOMRI Noise Canceller On/Off Toggle Button

Activates noise cancelling for the FOMRI-III microphone used by the patient to talk to the operator. This button has no effect on the reference microphone residing inside the headphones. By default, this button should be in the 'On' position.

5

Volume Knob Line 1

Potentiometer for Line 1 input.

6

Volume Knob Line 2

Potentiometer for Line 2 input.

7

Volume Knob Self-Hearing

Potentiometer for patient self-hearing microphone.

8

Volume Speaker

Potentiometer for built-in console speaker.

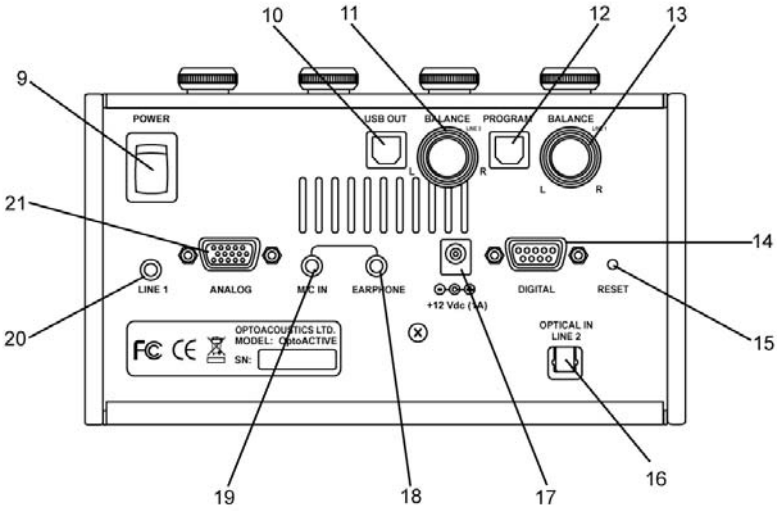

Figure 3-2. *Back Panel OptoACTIVE Control Console*

Back Panel Controls and I/O

9

On/Off Power Switch

Turns the System (Console and EOU) On and Off.

10

USB Output Port

Outputs microphone and TTL signals produced from the FOMRI-III device, when applicable.

11

Balance Knob Line 1

Potentiometer for balancing Line 1 left and right channels.

12

Program Input Port

Reserved for future use. Port for uploading external program code, such as new algorithms or software to the OptoACTIVE System.

13

Balance Knob Line 2

Potentiometer for balancing Line 2 left and right channels.

14

Digital EOU Port

Digital connection to the EOU.

15

Reset Button

For use by authorized technicians only.

16

Optical Input Port - Line 2

Port for receiving external data from a connected optical device. Available for Line 2 only.

17

Power Supply Connector

Connection to 12V dc power supply.

18

Earphone

Standard output jack for transferring all console audio to connected earphone.

19

MIC IN

Input jack for standard audio microphone.

20

Standard Input Port - Line 1

Port for receiving external data from a connected standard audio device. Available for Line 1 only.

21

Analog EOU Port

Analog connection to the EOU.

OptoACTIVE Electro-Optical Unit (EOU)

Rear Panel

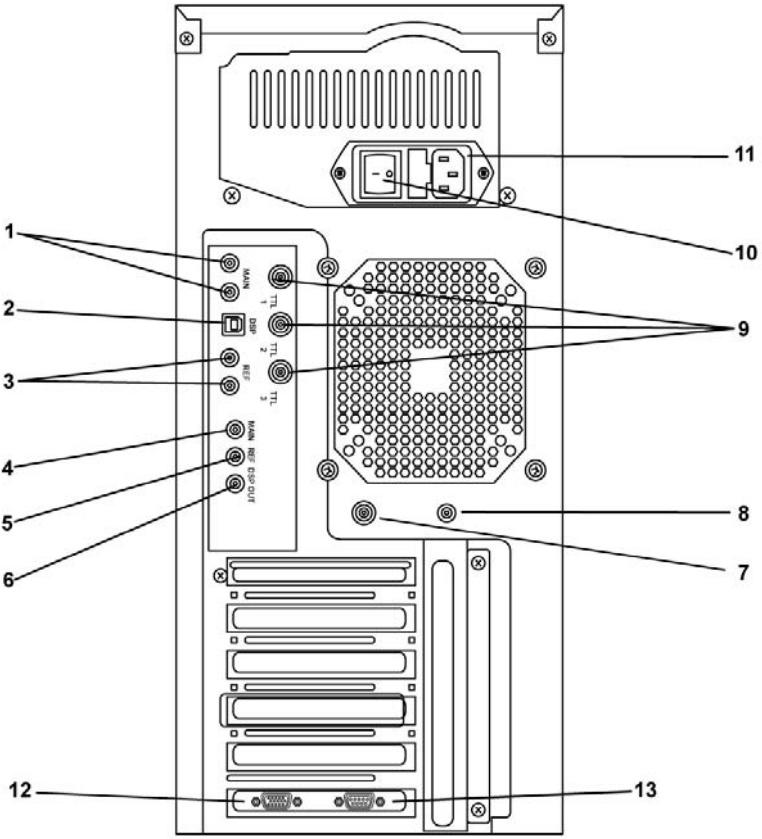

Figure 3-3. *Rear Panel EOU*

1

FOMRI-III Microphone Optical Connectors

Two audio inputs (both are required) from the FOMRI-III optical microphone.

These connections, together with the reference mic connections, enable communication between the patient and operator.

2

FOMRI-III DSP Connector

DSP update of FOMRI algorithm, there are various HEX patches in the CD with different sampling frequencies, different latencies, etc.

3

OptoACTIVE Reference Microphone Optical Connectors

Two audio inputs (both are required) from reference mics inside the OptoACTIVE Ultra Slim Optical Headphones.

These connections, together with the main microphone connections, enable communication between the patient and operator.

4

Main

Red RCA connector. Main microphone analog output.

5

Ref

Blue RCA connector. Reference microphone analog output.

6

DSP

White RCA connector. Analog output of the DSP processed speech.

7

Input TTL Source Port

BNC connector receives TTL signals from MRI source. (Use the electro-optical converter cable that is supplied with the System.)

8

Output TTL Monitoring Port

RCA connector outputs TTL for synchronization. (A combined TTL and audio monitoring cable is provided.)

9

TTL 1, TTL 2, and TTL 3 for FOMRI-III

BNC ports. Three TTL inputs for FOMRI. Signals are converted into oscillated tones and recorded by OptiMRI software.

10

On/Off Switch

On/Off power switch and safety fuse.

11

Power Supply Connector

Standard connection to electrical power mains with built-in protection fuse.

12

Analog EOU Port

Analog connection to the EOU.

13

Digital EOU Port

Digital connection to the EOU.

Side Panel

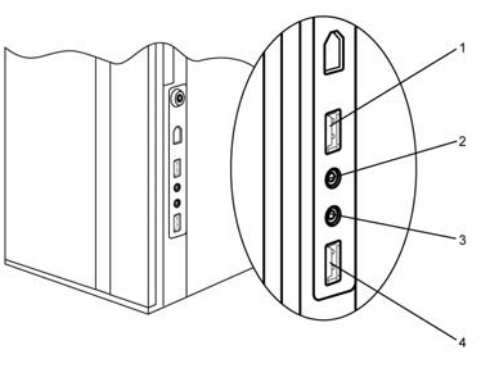

Figure 3-4. *Side Panel EOU*

1

USB Port

Reserved for future use.

2

Stereo Audio Out 1

Standard 3.5 mm stereo line output for monitoring purposes.

3

Stereo Audio Out 2

Standard 3.5 mm stereo line output for monitoring purposes.

4

USB Port

Reserved for future use.

CHAPTER

4

Using the OptoACTIVE System

The OptoACTIVE Active Noise Control (ANC) System enables clear, real-time communications among doctors, staff and patient during an MRI scan. OptoACTIVE uses a proprietary combination of active noise cancelling and sound enhancement hardware and adaptive acoustic algorithms to dynamically achieve the highest possible levels of noise reduction in MRI without loss of speech quality.

The current version of OptoACTIVE is able to dramatically reduce noise and enhance communications on most available MRI scanning equipment, regardless of manufacturer, using both active and passive elements. The OptoACTIVE System automatically adjusts to different scan types and to different users.

Operating OptoACTIVE requires the following basic steps:

1. Adjust the OptoACTIVE System headphones and microphone to the current patient.
2. Initialize the ANC function.
3. Learn and 'plant' the current MRI noise signal model.
4. Activate the ANC function for the current scan.

The above steps are repeated each time the headphones or patient are moved, or scan type is changed.

The System is operated entirely from the Control Console located in the control room.

Ready the Patient

- Determine which OptoACTIVE headphone model (for example, Slim or Ultra-Slim) will perform best for the current scan.
- Position the patient exactly where required to achieve the best scan results.
- Adjust the OptoACTIVE headphones position for the patient. (See “Fitting the Headphones”.)
- Adjust the FOMRI-III microphone position for the patient. (See “Fitting the FOMRI-III Microphone”.)

Note: The patient should not move after the headphones and microphone position have been adjusted.

Run the ANC Console Wizard

The Control Console’s touch screen Wizard is used to train the OptoACTIVE system before each session and each use.

The ANC Wizard:

1. Initializes the System hardware and DSP
2. Checks the System and models the current EPI noise signals
3. Learns and synchronizes noise reduction as required

A description of each of the Console Touch Screen icons is found in the following Table.

Console Touch Screen Icons

	Laser Fault Laser is not connected or otherwise not functional
	Checking headphone channel prior to calibration
	Calibration has succeeded for this headphone channel
	Calibration has failed for this headphone channel
	TTL Synchronizing (when the icon is moving)
	Connection is good Communication with System DSP has been established
	Connection is bad Communication with System DSP has not been established
	VU Meter Panels (Left and Right) Measures signal from reference SPL microphone located inside the optical headphones
	Monitored Signal (Left and Right) Shows source and treated audio signals during the scan, after ANC function has been started

Table 1: *OptoACTIVE Control Console Touch Screen Icons*

Initializing the Active Noise Control System

1. If not already on, turn on the OptoACTIVE Control Console using the Power Switch on the back . The Touch Screen display becomes active.
2. **Touch the screen** anywhere to start the ANC Wizard.

   The Start DSP Mode screen appears (*Start DSP Mode Window*). The message in the Status area will read **DSP Connected**.

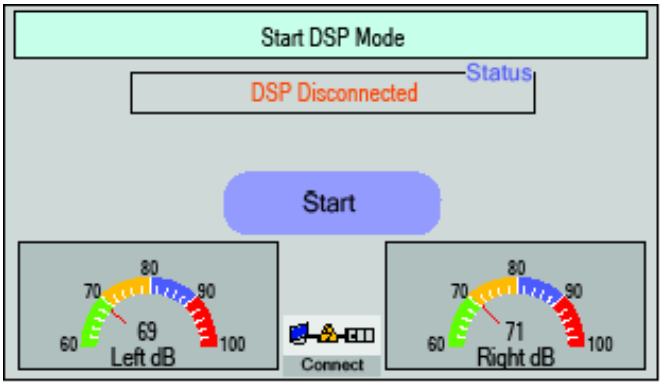

Figure 4-1. *Start DSP Mode Window*

3. Touch the **Start** button to initialize the ANC System. Upon successful completion, the System is ready for Headphone Calibration.

Note: After touching Start, should the Status area message continue to read **DSP Disconnected**, then press the Hardware Reset button that is located on the back of the Console. The System DSP will reset and connect.

If the Connection is Bad icon appears, ensure that both the communication and power cables are functional, then reset the DSP connection as described in the paragraph above.

Calibrating the Headphones

The Headphone Calibration screen appears (*Headphone Calibration Screen - Start*):

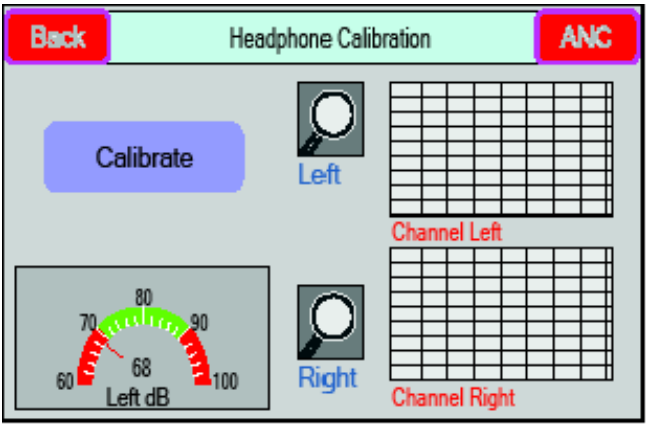

Figure 4-2. *Headphone Calibration Screen - Start*

This stage models the headphones as they are worn by each patient and builds a noise response model. Left and right channel display graphs appear on the right side of the screen.

Note: At this time, the headphones should be worn by the patient, who is in the ready-to-scan position. The patient should not talk during calibration. No stimuli signals should be injected during calibration. The headphones need to be re-calibrated whenever that patient has moved or has changed position.

4. With the patient and headphones in place, touch **Calibrate** on the Headphone Calibration screen. The Wizard will now calibrate the headphones. Left and right channel dB meters will show the progress.

Note: Use the Volume and Balance knobs on the Control Console to adjust sound levels. The recommended level is 84 dB SPL.

Upon completion, the left and right channel graphs will display the calibrated shape of the left and right channel impulse responses and a success checkmark appears next to each channel graph. *Headphone Calibration Screen - Finish* shows an example of a successful calibration.

The System is ready to model noise cancelling for the specific scan.

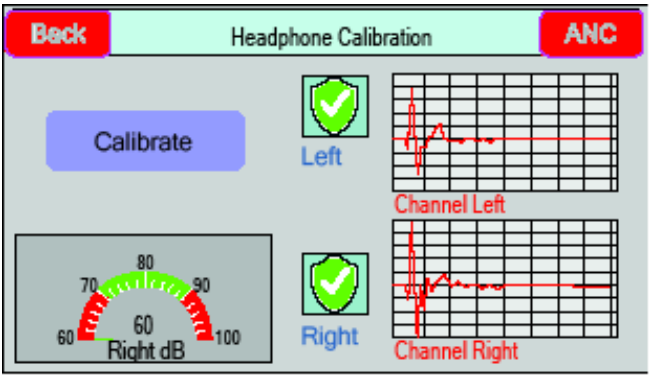

Figure 4-3. *Headphone Calibration Screen - Finish*

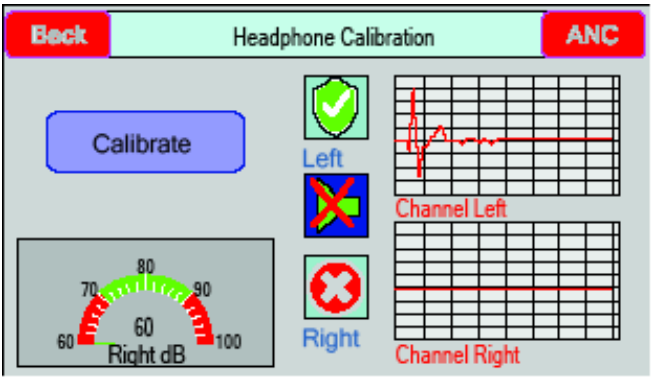

Figure 4-4. *Bad Calibration Event*

Figure 4-4. If the calibration did not succeed, the impulse response will display as a flat line in the non-modeled channel, similar to that shown in

.

Should calibration fail for one or more channels, ensure that the headphones are connected and positioned properly, then touch Calibrate to retry.

Learning the Active Noise Cancellation Model

After successful headphone calibration, the Active Noise Control screen appears (*Active Noise Control - Learning Mode*):

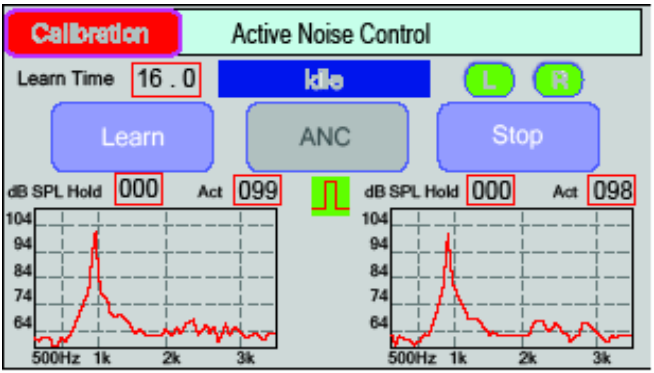

Figure 4-5. *Active Noise Control - Learning Mode*

This stage learns the actual EPI sequence noise that is created during the specific MRI scan, and builds a noise cancellation and control model that will eliminate most of the noise. Before learning starts, the left and right channel graphs do not display any data.

Note: The patient should still be in the ready-to-scan position and should not talk during the Learning stage. No stimuli signals

should be injected. If the patient and the headphones have moved between Calibration and Learning stages, then a headphone re-calibration (see "Calibrating the Headphones") should be performed.

5. Start the scanner.
6. Touch **Learn** to initiate learning for the active noise cancellation and control algorithms.

   With the MRI scanner turned on and the EPI sequence running, the System synchronizes the TTL signal from the scanner and dynamically learns the noise cancelling required.

   Note: If the TTL signal isn't received, check the TTL cable connection between the scanner and the EOU.

   The algorithm learning process takes 16 seconds. The **Learn Time** field counts down the time remaining in this process.

Active Noise Cancellation Mode

Upon completion of the EPI sequence learning process, the System creates a dynamic noise cancellation algorithm and automatically enters active noise control mode (*Active Noise Control Mode*):

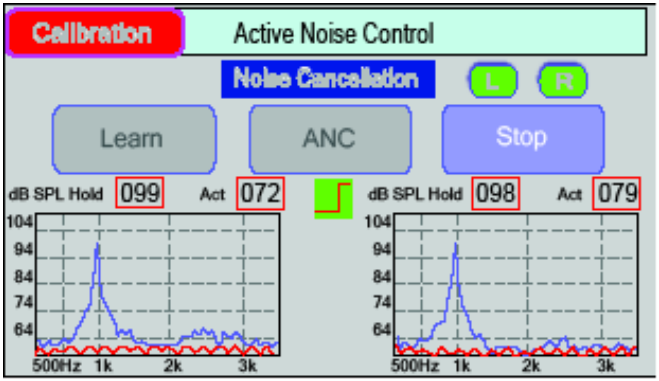

Figure 4-6. *Active Noise Control Mode*

In this mode, the system actively cancels the EPI sequence noise arriving to the patient headphones.

During cancellation, the left and right channel graphs will display:

- raw noise level in the scanner bore (shown in blue)
- treated noise level inside the patient headphones (shown in red).

In addition, combined raw noise levels from the MRI scanner, operator-patient voice communications (via the PTT channel), and any music being fed into the headphones is also displayed numerically in the **dB SPL Act** field boxes, just above each channel graph.

Active noise cancellation mode continues until the current scan ends or one of the activities in the following section is performed.

Activities Available in Active Noise Canceller Mode

Stop

Touch Stop to pause active noise cancelling. To return the system to active noise control mode, touching **ANC**.

Idle Mode

During the routine scan process, you can move from ANC Mode to Idle Mode and back again by touching the **Stop** and **ANC** buttons.

Note: If the scanner stops for longer than 10 seconds (and Stop has not been selected manually), noise control will resume automatically as soon as the scanner starts again with the same MRI sequence.

Recalibration after Patient Movement

When either the patient or the headphones change position, the System needs to be recalibrated (see "Calibrating the Headphones") and learning needs to be re-performed (see "Learning the Active Noise Cancellation Model").

Create a New Calibration for a Patient

A new headphone calibration can be performed at any time. From the Active Noise Control screen, touch **Calibration** to return to the Headphone Calibration Screen.

Optional ANC Performance Parameters

Left/Right Channel Noise Cancellation Control

You can turn off active noise cancellation for a selected channel for a specific scan. Before touching **Learn**, simply toggle either the **L** or **R** button located in the upper right of the Active Noise Control screen.

By default, noise cancellation for all new scans will revert to both channels.

Stimuli Injection

When noise cancellation is active, stimuli can be sent to the patient from an audio source using the Line 1 or Line 2 input connectors located on the back of the Control Console. Stimuli volume and balance may be changed using controls provided on the Console.

Monitoring the Patient Headphones

The OptoACTIVE System enables real-time stereo monitoring and recording of the actual sound that is being heard by the patient.

- To monitor the patient headphones, connect your monitoring or recording device to one of the standard 3.5 mm stereo line output jacks located on the right side panel of the EOU (see Figure 3-4). Two separate stereo output jacks are provided.
- To monitor both System audio and TTL signal output, use the special cable supplied with the OptoACTIVE.

Operating the FOMRI-III Microphone

Confirm that the microphone is correctly positioned, with the pop-screen is directly against the patient's mouth.

Before beginning the MRI scan, always confirm that the microphone can record a loud, clear sound signal in a noise-free environment.

To record a patient's speech:

1. Start the MRI scan and wait until it has reached its normal operation.
2. In the OptiMRI software, select the top three channels for speech recordings and all four channels if also connected to the TTL cables.

Analyzing the Recordings

The OptiMRI software can record sound from the microphone input without noise reduction, or with active noise reduction using the OptoACTIVE Control Console. It can also record additional tracks from the main microphone channel or from the reference microphone channel. You can use an audio editor, such as Adobe Audition™ or the freeware utility Audacity™, to view and analyze the files.

Optional Audio Outputs

The three RCA connectors marked MAIN, REF and DSP at the rear panel of the EOU produce an analog sound signal that can be connected to any conventional sound system, such as a DAT or as an input to Voice Over IP (VoIP) applications such as Skype

Note: A custom cable is provided in order to attenuate the System output to match the sensitivity expected by Skype.

Use the MAIN connector to record input from the FOMRI-III microphone's main channel and the REF connector to record input from the FOMRI-III microphone's reference channel.

Handling System Faults

Laser Faults

If during the connection a laser problem arises, the Laser Fault icon will appear on the touch screen.

1. Check the headphone optical cables to ensure they are free of defect.
2. Verify the optical cable connections are seated properly, and power off the System for two minutes.
3. Power on the System, and reset the DSP connection.
4. If the laser Fault icon persists, one of the optical cables may be broken, and the headphone must not be used.

Other Faults

If the System experiences an unknown failure during operation, recycle Control Console power using the On/Off switch. After powering on, there is generally no need to reset the DSP.

CHAPTER

5

Using OptiMRI 3.1 Software

Overview

The OptiMRI 3.1 is a multichannel digital recording Win32 application for FOMRI™ microphones. The application supports audio signal data acquisition from up to 4 mono channels with a 16 bit per sample resolution and an 8 or 16 KHz sampling rate. All channels are synced with a time error of less than 1 msec.

Note: OptiMRI is post-processing audio software and is not used in real-time during a MRI scanning session.

Interface

The GUI application comprises a collection of interactive tools for the manipulation and configuration of digital recordings including audio card mapping, record channel selection and wave monitoring display preferences. It also includes target file location, name-related options, sampling rate choice and firmware update options.

Selecting a Device

To select one of two USB sound cards:

1. Connect the PC to the EOU before running OptiMRI so it recognizes both USB drivers.

2. Choose one of the microphone devices from the popup list (see *Choose a Sound Card for the Microphones*).

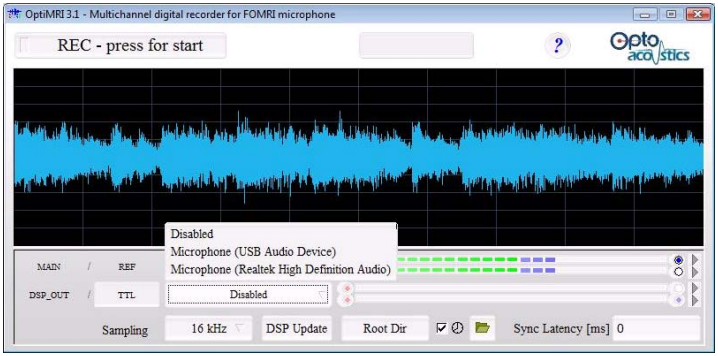

Figure 5-1. *Choose a Sound Card for the Microphones*

Both device choice combo boxes enable the unique mapping of USB sound cards to the FOMRI™ microphone output channels. T The upper combo box specifies the choice of device serving MAIN and REF channels while the bottom one defines DSP OUT and the TTL handling card. Either of the device choice combo boxes can be disabled if the correspondent channels are not used for recording or monitoring.

The TTL device name can be changed by means of the text input box.

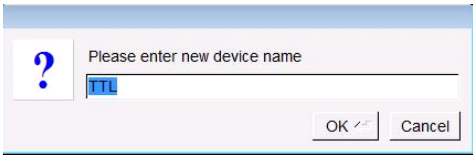

Figure 5-2. *Renaming the TTL Device*

TTL can be changed to any name which reflects the input requiring synchronization(e.g. ECG, gating, PC software generated, etc.)

Channel Visualization and Record Options

Each device choice combo box specifies a sound card which is capable of recording/monitoring two mono channels. The red radio buttons located on the left of the signal strength light-bar specify which channels have been chosen for recording during the subsequent session. The blue radio buttons located on the right of the signal strength light-bar specify which channels are to be visualized.

Selecting the four blue radio buttons enables visualization of four wave patterns. By selecting the four red radio buttons, and pressing REC, all four wave patterns will be recorded (*Wave Pattern Visualization*).

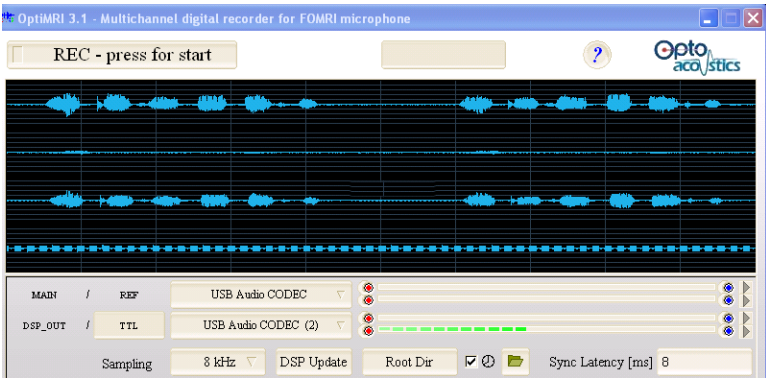

Figure 5-3. *Wave Pattern Visualization*

Concurrent Wave File Visualization shows the four concurrent wave files in visualization mode (blue wave form) as a result of the four blue radio buttons having been turned on. If the REC button is pressed, all 4 mono wave files will be recorded.

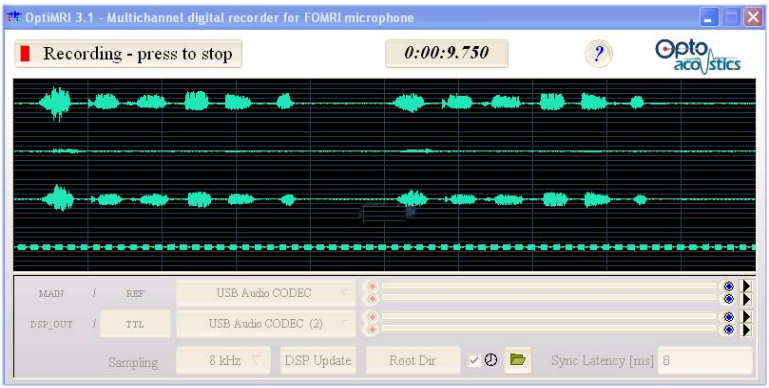

Figure 5-4. *Concurrent Wave File Visualization*

You can record both main and reference wave forms but only the main wave form can be visualized (two red buttons, one blue). In *Recording Channels to Disk* the four channels are being recorded to the disk (process appears in green).

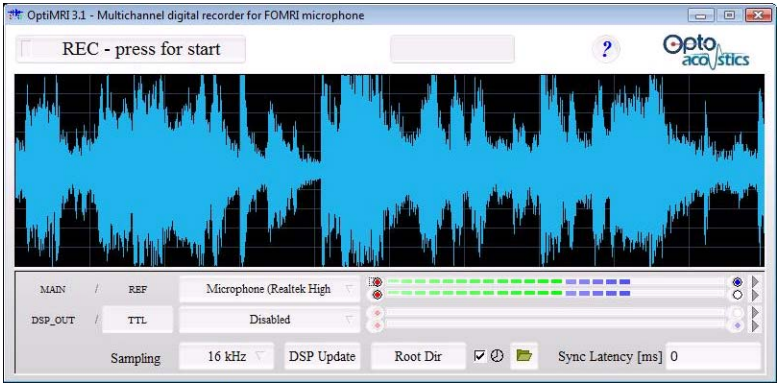

Figure 5-5. *Recording Channels to Disk*

Sampling Rate

The “sampling rate choice” combo box defines the sampling frequency for all relevant channels monitoring and recording. Supported options are 8 and 16 kHz with a 16 bit per sample resolution. Note: analog outputs of the microphones are open between 50 Hz and 20,000 Hz.

Sync Latency

Synchronization latency is defined in ms units and specifies time period filled with zero level signals in MAIN, REF and DSP OUT channels corresponding audio files during the consequent recording session. The parameter does not affect the TTL channel. The default latency is 0 msec, as the default latency of the algorithm is 16 msec and the TTL is delayed by analog hardware by 16 msec.

Root Directory

The root directory can be adapted from the default to separate/organize accumulated data. The adjacent check box widget enables the option of adding a record start time to the resulting audio file names. This tool supports the generation of unique filenames, thereby preventing the overwriting of data. The “recently recorded files” location folder can be opened by means of the button.

Playback of Recently Recorded Audio Files

Recorded audio files can be played back by means of a default OS audio player application. This is launched by pressing the corresponding channel button while the widget tooltip specifies the file location.

Updating the DSP Firmware

To update the DSP firmware:

1. Click the DSP Update button.

   The software connects to Optoacoustics (*DSP Update Connection*).

Figure 5-6. *DSP Update Connection*

2. It is possible to download an algorithm to the DSP which is tailor-made to a specific MRI scan pattern.

   Select a DSP algorithm from the library and click Open (*DSP Algorithm Open Dialog Box*).

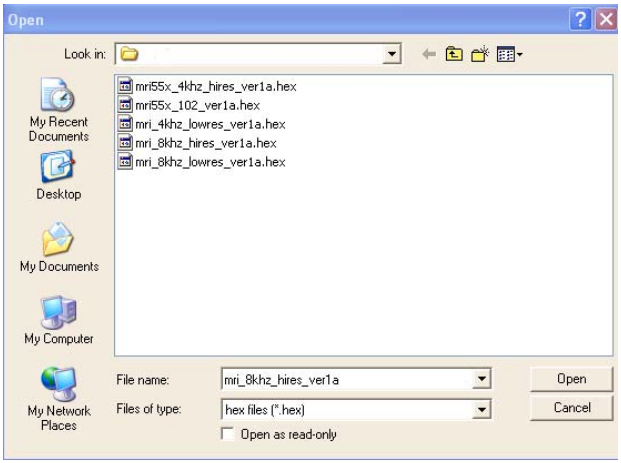

Figure 5-7. *DSP Algorithm Open Dialog Box*

The selected firmware downloads to the PC. When the download is complete, the focus returns to the DSP Update Connection dialog box. (*DSP Update Connection*).

3. Click Burn.

   During the Burn process, sounds of the DSP link emanate from the loudspeaker.

Synchronizing TTL Signals

The following series of screens show amplitude gains for a combination of three TTL signals.

In wave file shown in *Amplitude Gains for Three TTL Signals*, seven amplitude gains are shown for a combination of 3 TTL signals (1,2,3, 1+2, 2+3, 1+3, 1+2+3)

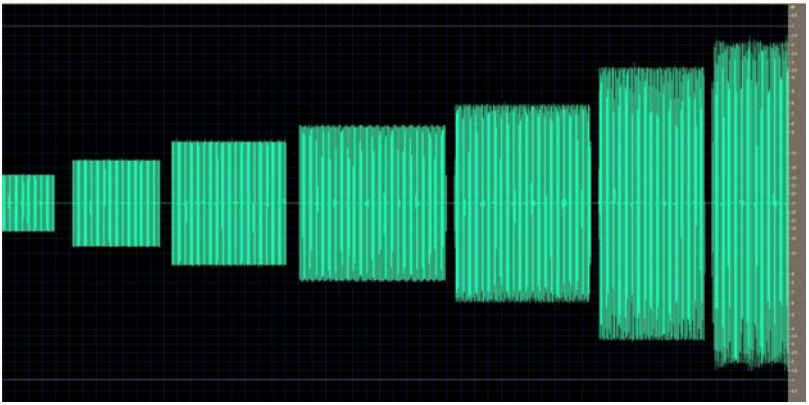

Figure 5-8. *Amplitude Gains for Three TTL Signals*

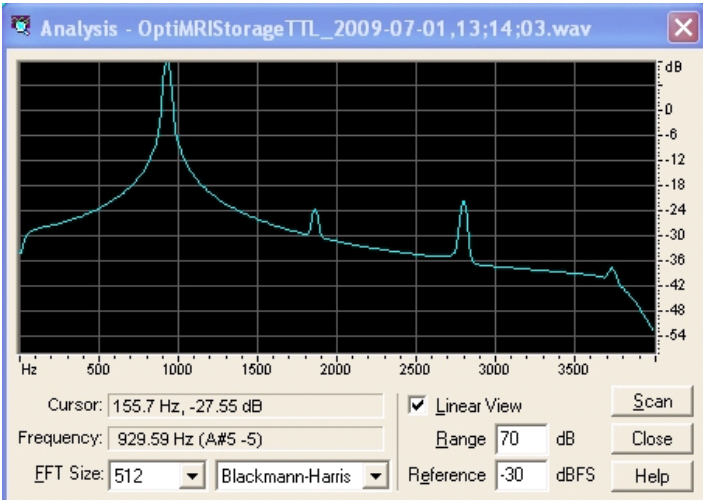

Figure 5-9. *2nd TTL Signal*

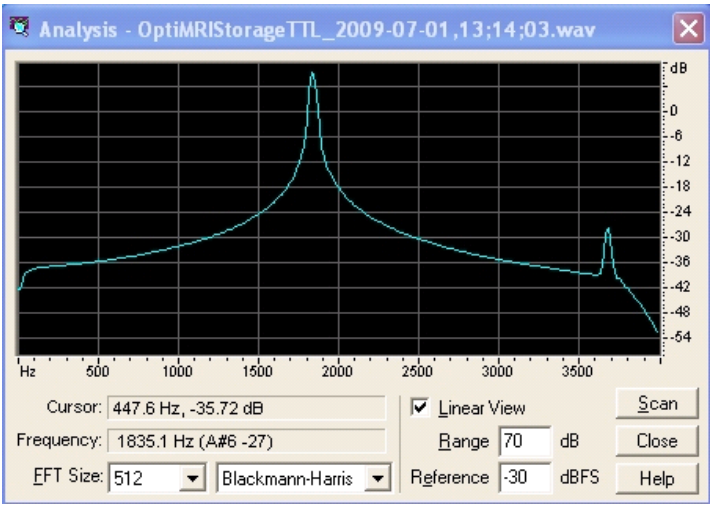

Figure 5-10. *1st TTL Signal*

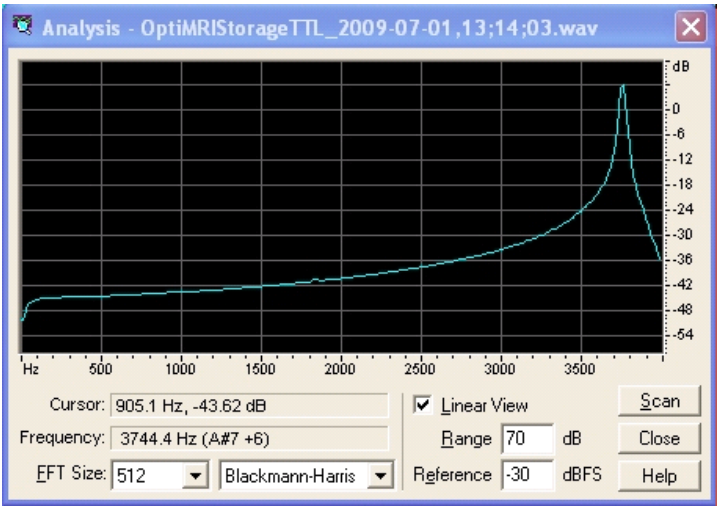

Figure 5-11. *3rd TTL Signal*

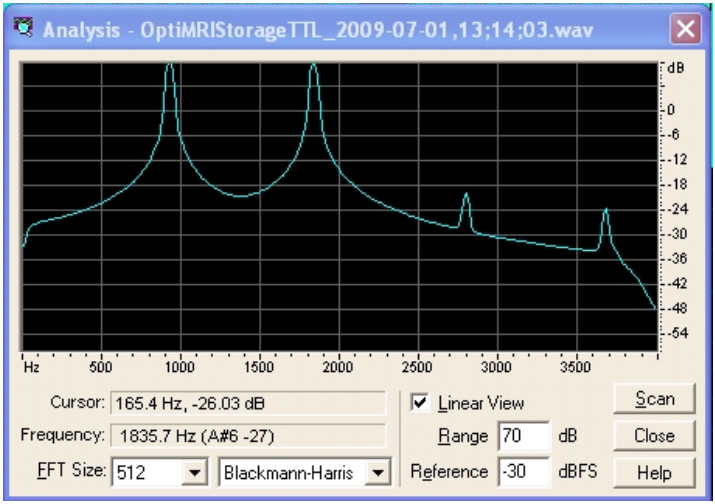

Figure 5-12. *1st + 2nd TTL Signals*

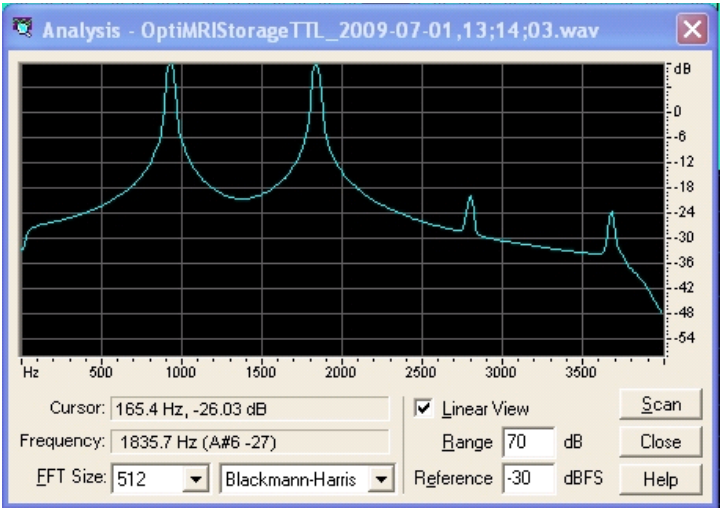

Figure 5-13. *2nd + 3rd TTL Signals*

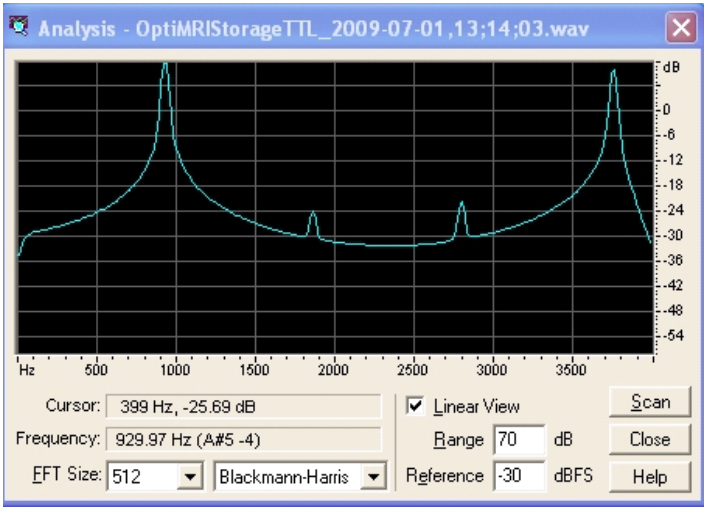

Figure 5-14. *1st + 3rd TTL Signals*

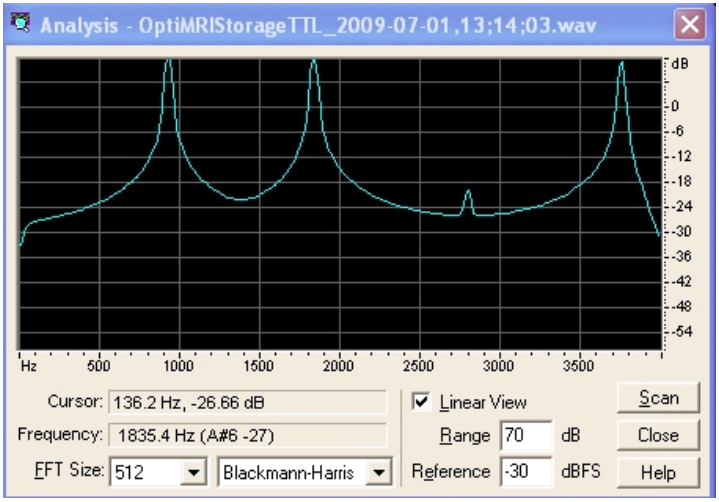

Figure 5-15. *1st + 2nd + 3rd TTL Signals*

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APPENDIX

A

Installing the OptiMRI 3.1 Software

The OptiMRI 3.1 software provides the ability to synchronize speech audio channel with TTL sequences. The delay is exceedingly small, fixed, and independent of the operating system.

The software is installed on your PC that is connected to the Optical MRI Communication System. Do not install the software until all system components are setup and connected.

Before installing the software, ensure that the FOMRI™ III microphone cables are attached to the Electro-Optic Unit, and that the unit is powered on. (Illuminated blue lights indicate this condition is met).

1. Connect the Electro-Optic Unit DIGITAL OUT cables to the computer's USB ports.
2. Insert the CD into your computer's CD drive.
3. Open 'My Computer' and double-click the CD drive icon.
4. Double click the *.msi. Ignore the security warning and click Run to execute the setup file (**.MSI Open File Security Warning Dialog*).

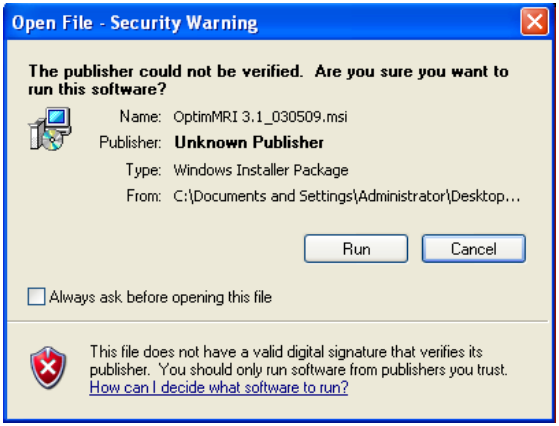

Figure A-1. **.MSI Open File Security Warning Dialog*

5. Accept the defaults and click Next at wizard screen until you are asked to chose Free Wave editors and Windows audio drivers.

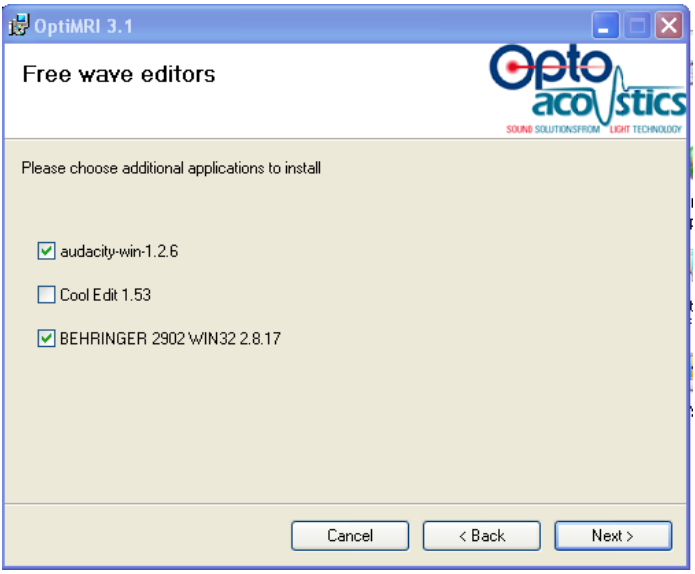

Figure A-2. *Install Wave Editors Screen*

6. Select Behringer 2902 WIN32 2.8.17 and any other the editor listed you want to install, and click Next (*Install Wave Editors Screen*).

   The Behringer USB Audio Driver 2.8.17 dialog appears (*Install the Driver*).

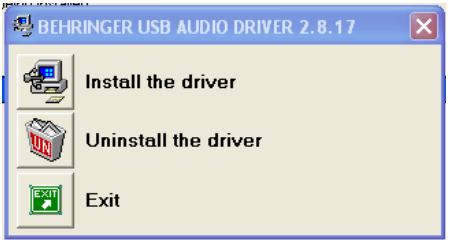

Figure A-3. *Install the Driver*

7. Click Install the Driver.

   The Behringer USB audio driver installs on your system.

8. After the driver is installed, click Reboot Now to reboot the PC and complete the installation (*Reboot Screen*).

Figure A-4. *Reboot Screen*

Associating .WAV Files to the Audio Editor

It is important that a wave editor is available for your use. If you didn't install one during the OptiMRI 3.1 installation process, install one from the CD now.

After the FOMRI™ III microphone has been properly set up and the software installed, you need to test the software and the microphone together. Before doing so, audio wave files should be associated with one of the audio editors you installed with the OptiMRI 3.1 software. Windows associates .WAV files with the Windows Media Player application by default. Windows Media Player is not recommended for use with the FOMRI™ III optical microphone.

In addition to the free audio editors included in the CD, we also recommend the use of Adobe Audition™ for comprehensive wave file editing.

To associate .wav files with your audio editor:

1. Click Start > Run.

   The Run dialog box opens.

2. In Open, type Explorer, and click OK.

   Windows Explorer opens.

3. In Windows Explorer, click Tools > Folder Options > File types tab (*File Types Tab in Folder Options*).

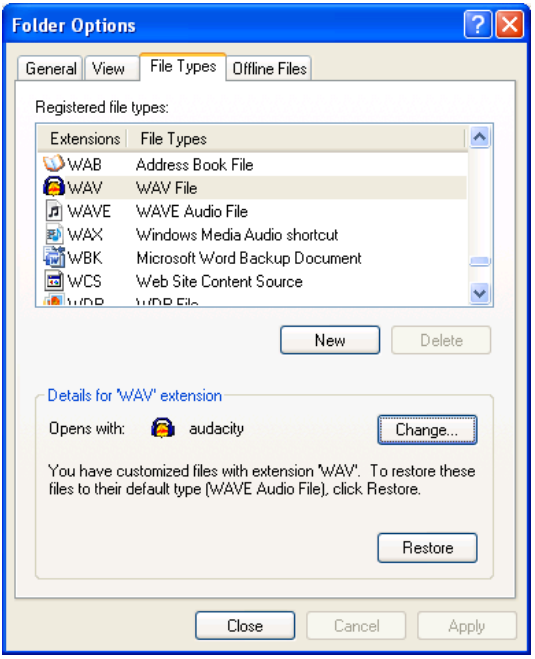

Figure A-5. *File Types Tab in Folder Options*

4. Press w, and scroll to WAV File in File Types.
5. In the Details for "WAV extension, verify that .wav files open with one of the recommended audio editors. If not:
   a. Click Change.

      The Open With dialog appears (*Open With Dialog*).

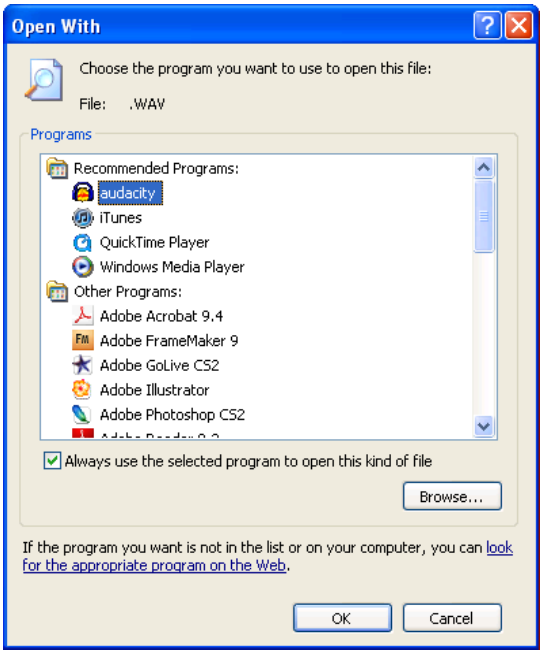

Figure A-6. *Open With Dialog*

b. If audio editor you want to use is listed in the Programs list box, select it and choose OK. Otherwise, click Browse and locate the audio editor .exe file in the Program Files directory. Select it, and the click OK to associate the file type and close the open dialog boxes.

The OptiMRI system is now installed and ready for use.

Uninstalling the Software

To uninstall the software:

1. Click Start > All Programs > Optoacoustics > Uninstall.

   The Uninstall wizard starts.

   Note: If the uninstall wizard is not available for the Optoacoustics All Programs menu item, you can launch it from Start > Control Panel > Add or Remove Programs.

2. Follow the prompts of wizard to uninstall the software from your system.

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APPENDIX

B

Consumables and Accessories

The following are available from Optoacoustics:

Hygienic Pop Screens

Microphone pop screens ensure that the FOMRI-III System microphone is used in compliance with sanitary requirements. They also ensure that the microphone is positioned on a patient to optimize noise cancelling and sound reproduction. They can be purchased in packs of 100 units.

OptoVAC Vacuum Enhancer

This specially designed air evacuator instantly attaches to the OptoACTIVE to improve the effective vacuum inside the headphones and increase active noise cancelling performance by as much as 10 dB. (Note that the OptoVAC device is not intended for use in slim head coils.)

Passive Noise Earpad Cushions

Periodic replacement of earpad cushions helps maintain optimum headphone airseal and ensure maximum passive noise reduction. They can be purchased in packs of 10 units.

Hygienic Earpad Covers

In standard research and clinical facilities, these hygienic earpad covers ensure that the OptoACTIVE System microphone is used in

compliance with sanitary requirements. They can be purchased in packs of 100 units.

Extension Cables

Indoor zip cord extension cables are available for use with System, in any length between 10 and 50 meters. All extension cables need to be custom calibrated to your System. They are ruggedized against damage and especially suited for use in medical environments.

APPENDIX

C

Troubleshooting and Tips

Table 2: Troubleshooting and Tips

Problem	**'Out of Range' Message Appears on Screen**
Description	The acceptable range of operation is 70-103dB or 85-111dB (specified on the Screen). If the noise level during the Learn stage is lower than the minimum, or the noise during the ANC stage is higher than the maximum, then noise cancellation stops, and this message appears. Generally, once the cause is identified, press STOP followed by ANC to recover and resume.
Possible Solutions	• During very short TTL sequences, this message may often always at the beginning of a test. Press STOP followed by ANC to bypass the message. • If one or both sides of the headphones are not sealed properly, this message may appear at the start of ANC. Check the spectrum graphs and the decibel range appearing on the Screen. If the range in one or both ears is higher than the maximum, than you need to realign the headphone on the patient's head. • During a scan, if the operator speaks very loudly into the the Console microphone, or a stimulus is too loud, this message may appear. Press STOP followed by ANC to recover.

Problem	**Sharp Noise When Talking to Patient**
Description	A loud or sharp noise is heard while talking to patient via the Control Console microphone.
Solution	Set the Monitor toggle button at the top right side of the Console to 'FOMRI'.

Problem	**Stimuli Not Working**
Description	Stimuli injections are not being heard by the patient during the scan.
Possible Solutions	• Verify that the stimulus source cable is connected to Line 1/2 on the back of the Control Console. • Ensure that the line's volume control is not at the minimum setting. • Ensure that the line's balance control is set in the middle. • Verify that the stimuli audio source is connection and working.

Problem	**FOMRI-III Not Heard Clearly by Operator**
Description	The FOMRI-III microphone on the patient is not being heard clearly in the Operator's room.

Possible Solutions	• Verify that the Monitor toggle button at the top right side of the Console to 'FOMRI'. • Ensure that the Speaker volume knob at the top right side of the Console is not at its minimu setting. • Verify that the FOMRI Noise Canceller toggle button at the top left side of the Console is in the On position. • Ensure that the FOMRI-III on the patient side is correctly positioned, about 2 cm away from the patient's mouth. It should be close enough so that the patient exhales onto the microphone, and not too far away, so that the FOMRI-III will be able to separate the patient's voice from the scanner noise.

Problem	**ANC Noise Reduction Performance is Poor**
Description	Actual noise reduction performance can change between different sequences. Generally, the ANC algorithm performance depends critically on the noise characteristics of a sequence, as well on correct positioning of the headphones on the patient's head.

Possible Solutions	• Ensure that there is no air gap between the patient's ears and the headphones. • Verify that the MRI sequence is within System TTL requirements: Minimum TTL time 30 microseconds, Maximum TTL time 3.45 seconds. • For sequences which use a very small amount of the TTL time, the ANC performance will be less than optimum. (Because noise cancellation uses the energy of the signal itself to adapt, the minimum length of time is essential.) • The sequence must be repetitive with regard to the TTL. • If the scanner noise level is lower than the minimum operating range, the System will not actively reduce the noise. • Verify that no stimuli signals are being sent during System Calibration and Learning stages.

APPENDIX

D

System Specifications

The following environmental and equipment specifications are required for safe and effective operation of the OptoACTIVE System:

SPECIFICATION	DETAIL
Operating Temperature	15-25°C (59-77°F)
Relative Humidity	Up to 75%
Atmospheric Pressure	100 kPa
Electrical (EOU): Rated Input: Classification: Fuse Type, Rating:	 100-240 Vac, 50–60 Hz, Max. 1.6A Class I Equipment (Type BF) One (1) Glass Type, 10A 250A VC

The following environmental and equipment specifications are required for shipping and storage of the OptoACTIVE System:

SPECIFICATION	DETAIL
Temperature	0-45°C (59-77°F)
Relative Humidity	Up to 75%
Atmospheric Pressure	70-100 kPa

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APPENDIX

E

EMC Declarations and Recommendations

This section provides electromagnetic compatibility declarations and recommendations for safe and effective operation of the OptoACTIVE System, in accordance with regulatory requirements.

Declaration – Electromagnetic Emissions		
Emissions test	**Compliance**	**Electromagnetic environment – guidance**
RF emissions CISPR 11	Group1 Class A	The OPTOACTIVE uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
Harmonic emissions IEC61000-3-2	Class A	The OPTOACTIVE is suitable for use in all establishments other than domestic, and may be used in domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes, provided the following warning is heeded: Warning: This equipment/system is intended for use by healthcare professionals only. This equipment/system may cause radio interference or may disrupt the operation of nearby equipment. It may be necessary to take mitigation measures, such as re-orienting or relocating the OPTOACTIVE or shielding the location.
Voltage Fluctuations And Flicker IEC 61000-3-3:2013	Complies	

Declaration – Electromagnetic Immunity			
IMMUNITY test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment – guidance**
Electrostatic discharge (ESD) IEC 61000-4-2	8 kV contact 2, 4, 8, 15kV air	8 kV contact 2, 4, 8, 15kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %.
Electrical fast transient/burst IEC 61000-4-4	2 kV for power supply lines 1 kV for input/output lines	2 kV for power supply lines N/A	Mains power quality should be that of atypical commercial or hospital environment.
Surge IEC 61000-4-5	1 kV line(s) to line(s) 2 kV line(s) to earth 2 kV Signal input/output) to earth	1 kV line(s) to line(s) 2 kV line(s) to earth N/A	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	0% UT; 0.5cycle at 0°, 45°, 90°, 135°,180°, 225°, 270° and 315° 0% UT; 1cycle and 70% UT; 25/30 cycles Single phase at 0° 0% UT; 250/300 cycle	0% UT; 0.5cycle at 0°, 45°, 90°, 135°,180°, 225°, 270° and 315° 0% UT; 1cycle and 70% UT; 25/30 cycles Single phase at 0° 0% UT; 250/300 cycle	Mains power quality should be that of atypical commercial or hospital environment. If the user of the OPTOACTIVE requires continued operation during power mains interruptions, it is recommended that the OPTOACTIVE be powered from an uninterruptible power supply or a battery.
Power frequency(50/60 Hz)magnetic field IEC 61000-4-8	30 (A/m)	30 (A/m)	Power frequency magnetic fields should be at levels characteristic of atypical location in a typical commercial or hospital environment.
NOTE: UT is the a.c. mains voltage prior to application of the test level.			

Declaration – Electromagnetic Immunity			
IMMUNITY test	**IEC 60601 TEST LEVEL**	**Compliance level**	**Electromagnetic environment – guidance**
			Portable and mobile RF communications equipment should be used no closer to any part of the OPTOACTIVE, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.
Conducted RF IEC 61000-4-6	3V, 6V	3Vrms, 6V	**Recommended separation distance** $d = [\frac{3,5}{V_1}]\sqrt{P}$ $d = [\frac{12}{V_2}]\sqrt{P}$
Radiated RF IEC 61000-4-3	3V/m	3V/m	$d = [\frac{12}{E_1}]\sqrt{P}$ 80 MHz to 800 MHz $d = [\frac{23}{E_1}]\sqrt{P}$ 800 MHz to 2,5 GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation
	3V from 0.15 to 80MHz; 6V from 0.15 to 80MHz and 80% AM at 1kHz	3V from 0.15 to 80MHz; 6V from 0.15 to 80MHz and 80% AM at 1kHz	distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, should be less than the compliance level in each frequency range. D Interference may occur in the vicinity of equipment marked with the following symbol:
	3V/m from 80MHz to 2.7GHz	3V/m from 80MHz to 2.7GHz	

Recommended separation distances between portable and mobile RF communications equipment and the OPTOACTIVE				
Rated maximum output power of transmitter W	Separation distance according to frequency of transmitter m			
	150 kHz to 80 MHz outside ISM bands $d = [\frac{3,5}{V_1}]\sqrt{P}$	150 kHz to 80 MHz in ISM bands $d = [\frac{12}{V_2}]\sqrt{P}$	80 MHz to 800 MHz $d = [\frac{12}{E_1}]\sqrt{P}$	800 MHz to 2,5 GHz $d = [\frac{23}{E_1}]\sqrt{P}$
0.01	0.12	0.2	0.4	1
0.1	0.37	0.64	1.3	2.6
1	1.17	2	4	8
10	3.7	6.4	13	26
100	11.7	20	40	80

Test specifications for ENCLOSURE PORT IMMUNITY to RF wireless communications equipment							
Test frequency (MHz)	**Band [a] (MHz)**	**Service [a]**	**Modulation [b]**	**Maximum power (W)**	**Distance (m)**	**Immunity Test level (V/m)**	**Compliance level (V/m)**
385	380 – 390	TETRA 400	Pulse modulation [b] 18 Hz	1.8	0.3	27	27
450	430 – 470	GMRS 460, FRS 460	FM [c] ± 5 kHz deviation 1 kHz sine	2	0.3	28	28
710	704 – 787	LTE Band 13, 17	Pulse modulation [b] 217 Hz	0.2	0.3	9	9
745							
780							
810	800 – 960	GSM 800/900, TETRA 800, iDEN 820, CDMA 850, LTE Band 5	Pulse modulation [b] 18 Hz	2	0.3	28	28
870							
930							
1720	1 700 – 1 990	GSM 1800; CDMA 1900; GSM 1900; DECT; LTE Band 1, 3, 4, 25; UMTS	Pulse modulation [b] 217 Hz	2	0.3	28	28
1845							
1970							
2450	2 400 – 2 570	Bluetooth, WLAN, 802.11 b/g/n, RFID 2450, LTE Band 7	Pulse modulation [b] 217 Hz	2	0.3	28	28
5240	5 100 – 5 800	WLAN 802.11 a/n	Pulse modulation [b] 217 Hz	0.2	0.3	9	9
5500							
5785							

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APPENDIX

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Acronyms

Table 3: *Acronyms*

Term	Definition
ADSP	Advanced Digital Signal Processor
ANC	Active Noise Control
BNC	Bayonet Nut Coupling
dB	decibel
dc	Direct Current
DSP	Digital Signal Processor
EOU	Electro-Optical Unit
EPI	Echo Planar Imaging
fMRI	functional Magnetic Resonance Imaging
g	grams
GUI	Graphical user Interface
H/D/W	Height/Depth/Width
Hz	Hertz
kg	kilogram

L/D	Length/Depth
L/W/H	Length/Width/Height
m	meter(s)
mA	milliAmphere
max	maximum
MIL STD	Military Standard
mm	millimeters
MRI	Magnetic Resonance Imaging
msec	millisecond
mV/Pa	millivolts per Pascal
nom	nominal
NRR	Noise Reduction Rating
Pa	Pascal
PTT	Push to Talk
RCA	Radio Corporation of America
REF	Reference (microphone)
SPDIF	Sony-Philips Digital interface Format
SPL	Sound Pressure Level
ST	Straight Tip (fiber optic connector)
TTL	Transistor-Transistor Logic

V	volts
Vac	volts alternating current
Vdc	volts direct current

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