

# CFMRI Physiological Monitoring System

## Operator's Manual

*This manual provides a quick guidance to using the physiological monitoring system during an MRI session. It is not intended as a substitute for training. All users are required to attend a training session in order to use the physiological monitoring system.*

### Safety Precautions

**The Invivo Magnitude™ 3150M MRI patient monitor unit should be placed at least 2 feet away from the bore.**

**Always secure the 3150M MRI monitor wheel locks when placed within the MRI magnet room**

**Cables and lead wires (MRI compatible) can cause patient heating or burn if not used properly. To minimize the risk of RF current burn:**

- **Place cables and lead wires neatly in straight alignment with no looping.**
- **Keep the length of lead wires and patient cable within the bore to a minimum.**

**Never use custom wire or leads that are not inspected for MRI safety. Contact Larry May (lmay@ucsd.edu) for an MRI safety check of equipment.**

## 1. Introduction

At 3.0 Tesla, physiological noise exceeds other sources of noise such as thermal noise. In addition, it has been shown that physiological noise is significantly greater in cortical gray matter than white matter<sup>1</sup>. Therefore, physiological noise estimation and correction are often desired for functional MRI (fMRI) data analysis. At the Center for fMRI (CFMRI), we provide a physiological monitoring system that can accurately monitor a

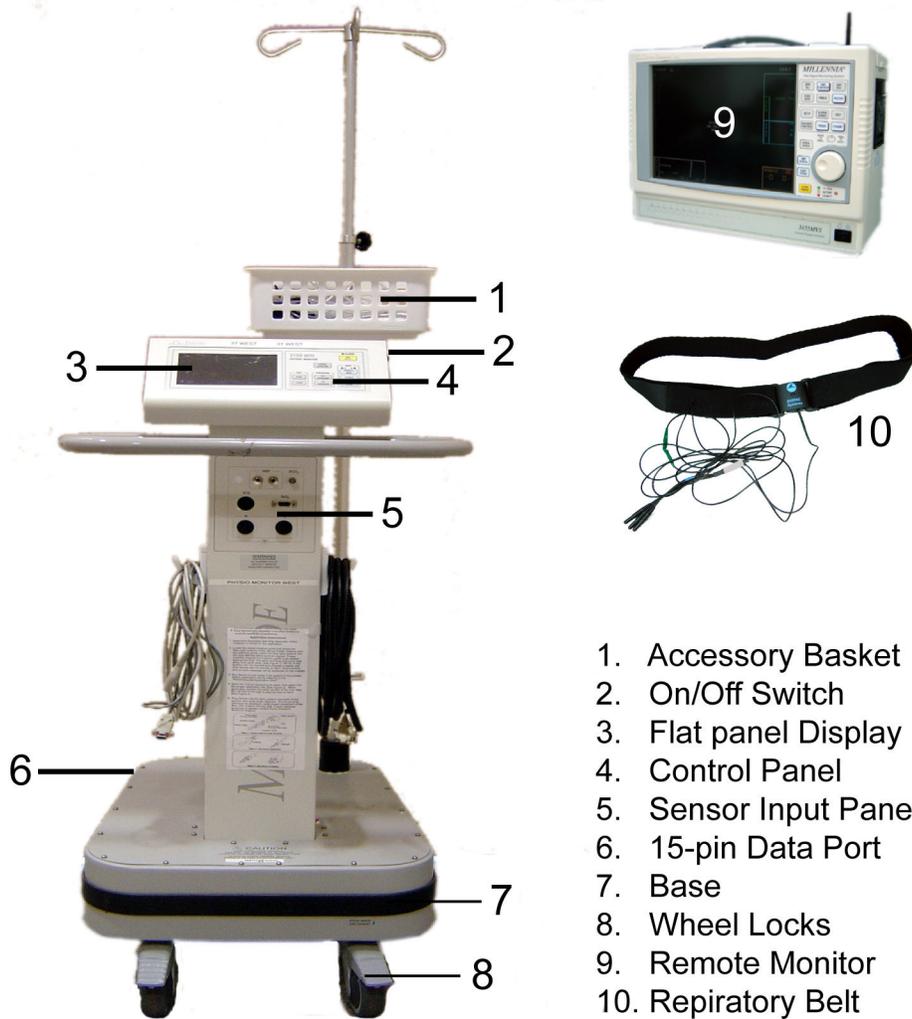
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<sup>1</sup> Kruger et al MRM 46:631-637 (2001)

subject's physiological parameters. Currently, we support Pulse Oximetry (SpO<sub>2</sub>), End-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) and respiratory effort (by respiratory belt).

The following is a list of available instrumentation for physiological monitoring at CFMRI:

- **Invivo Magnitude<sup>â</sup> TM 3150M MRI patient monitor (#1 - 8 in Figure 1)**
- **Invivo millennia<sup>â</sup> 3155MVS remote monitor (#9 in Figure 1)**
- **BioPac System - Respiratory Belt (#10 in Figure 1)**



*Figure 1. Physiological monitoring Instrumentation at the Center for functional MRI, UCSD.*

## 2. Preparing for Physiological Monitoring

Follow the steps listed below to prepare for physiological monitoring:

1. Turn on the TTL pulse expander located at the bottom of the projector cabinet. Adjust the **yellow** TTL pulse duration knob (TTL/SLICE) on the TTL pulse expander to 5 msec.
2. (OPTIONAL) Turn on the Invivo 3155MVS remote monitor located in the control room.
  - *Invivo 3155MVS should be on prior to turning on the Invivo 3150M MRI patient monitor (located inside the scanner room). Failing to do so will cause false readings of end tidal CO<sub>2</sub> (EtCO<sub>2</sub>).*
  - *The build-in alarm may go off occasionally depending on certain preset conditions. After you make sure that there is no real alarming condition exists, press the ALARM SILENCE (yellow button) located on the remote monitor to silence the alarm.*
3. Log into the physiological monitoring computer and start the **Physio** application located on the desktop (a Labview program).
4. Slowly pull the Invivo 3150M MRI patient monitor (located inside the scanner room) towards the patient bed and STOP at least 2 feet from the bore. Lock the wheel locks.
  - *The monitor unit will shut off automatically if put too close to the bore.*
5. Locate the **Physio** data cable (labeled “**Physio**” in red). Connect the 15-pin male connector to the data port (#6 in Figure 1) on the base of the Invivo 3150M. Then connect the 9-pin male connector to the penetration panel (labeled “**Physio**” in red).
6. Turn on the Invivo 3150M Patient Monitor by pushing the On/Off switch (#2 in Figure 1).
  - *The alarm usually goes off due to not being able to detect any sensor connections. Press the ALARM button located on the control panel of the unit to silence the alarm.*

7. AS NEEDED: set up Pulse Oximeter (SpO<sub>2</sub>).

7.1 Connect the fiber optic pulse oximeter sensor to the SpO<sub>2</sub> connector located on the sensor input panel.

7.2 Determine the proper size Grip (Neonatal, Infant, Pediatric or Adult). Follow the insertion guide (Figure 2A) to insert the fiber optic buttons into the Grip with the white symbols aligned. The white and blue dots must face away from each other. Improper insertion will cause failure in measuring SpO<sub>2</sub>.

7.3 Open the Grip by squeezing its sides and apply it to a desired finger. The white symbol of the Grip should be positioned atop the nail bed (Figure 2B).

7.4 Ensure that the surface of the finger top covers the detector window indicated by a red light inside the Grip (Figure 2C ). DO NOT place the probe on the same limb with an inflated blood pressure cuff.

7.5 Check the SpO<sub>2</sub> reading and waveform on the flat panel display.

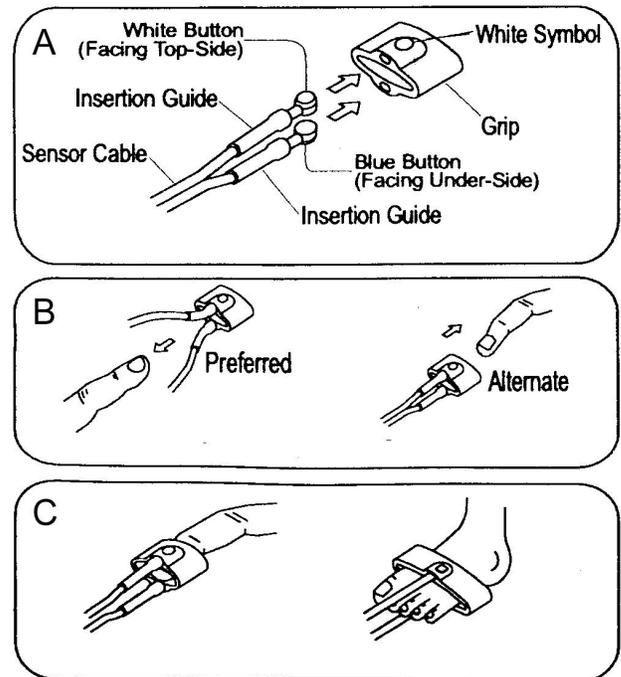


Figure 2. SpO<sub>2</sub> sensor assembly

8. AS NEEDED: set up End-tidal CO<sub>2</sub> (EtCO<sub>2</sub>).

8.1 Press the EtCO<sub>2</sub> ZERO/ON button to turn on the EtCO<sub>2</sub> pump. The flat panel monitor will display "EtCO<sub>2</sub> bench warm up" and "now zeroing". Warm up takes about 3-5 minutes and zeroing takes about 2 seconds. Wait till the warm-up finishes before starting EtCO<sub>2</sub> measurement.

8.2 Insert a moisture filter (Figure 3) to the EtCO<sub>2</sub> port located on the sensor input panel.



Figure 3. Moisture filter

8.3 Connect the provided nasal cannula tube to the moisture filter.

8.4 Place the nasal pieces gently inside the patient's nose, loop the excess tubing over the patient's ear and then down under the chin.

8.5 Check the EtCO<sub>2</sub> readings on the flat panel display.

9. AS NEEDED: set up the respiratory belt.

9.1 Locate the respiratory belt cable (labeled “Resp Signal”). Connect the 9-pin female connector to the penetration panel (labeled 'Resp Signal'). Tie the other end of the cable (lead sockets) loosely on the end of the scanner bed. (leave plenty of length so that the advancement of the bed will not pull on the cable.)

9.2 Insert the color-coded leads of the respiratory belt into the lead sockets on the respiratory belt cable (Figure 4).



*Figure 4. Respiratory belt lead connection*

9.3 While the patient is in sitting up position, place the belt around the patient’s lower rib cage (approximately the 10th rib). Make sure the sensor buckle is in front of the patient (Figure 5). Adjust the belt so that it feels snug with enough room to fit a finger under the belt.



*Figure 5. Respiratory belt placement*

9.4 Lay down the patient in supine position.

9.5 Start an acquisition (see page 6) and check the dynamic range of the respiratory effort signal. Tighten or loosen the respiratory belt as needed. STOP acquisition after done.

10. Visually inspect the positioning of all the cables and adjust to avoid risks of any cable being caught during bed movement. Then advance scanner bed to scan position.

- Place the cables in between patient's legs if possible to make sure all cables are in straight alignment with the scanner bore with no kinks or loops.

### 3. Collect Physiological Data

You should have logged into the physiological monitoring computer and started the **physio** application as shown in Figure 6. Follow the steps below to start acquiring physiological data.

**Notes: For users who are interested in physiological noise correction**

You are recommended to acquire a new data file for each scan (remember to specify a new Subject ID for every scan). The actions in sequential order are: prescan ->start an acquisition ->wait for about 5 seconds ->start the scan -> the scan finishes ->wait for about 5 seconds -> stop the acquisition.

If you choose to acquire a single large file containing multiple scans, this file will then need to be parsed into individual scans. We provide MATLAB programs for parsing such large files. Please leave at least 5 seconds time gap between two successive scans (including prescans).

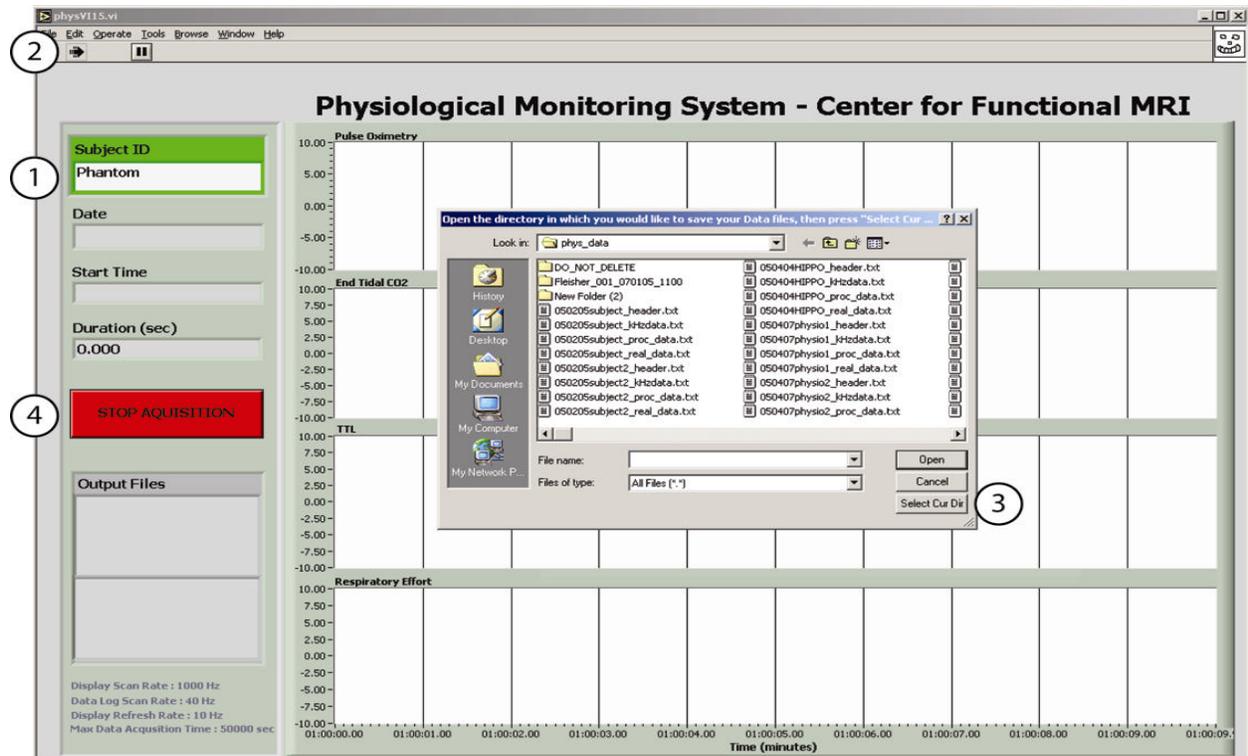


Figure 6. Physio.vi screen shot

1. Type in a Subject ID (the default subject ID is “phantom”).
2. Click  to start data acquisition.
3. In the pop-up window, select a desired folder where you want to save the data files and click “**Select Cur Dir**” button (The default folder is “phys\_data” located on the desktop of the computer). Data acquisition should start now.
4. To stop data acquisition, press **STOP ACQUISITION** button

## 4. Transfer Data and Clean Up

Congratulations. You have now successfully collected physiological data during an MRI scan. However before you leave, please make sure to:

### 1. Transfer data

- The name and location of the data files are displayed on the screen. File “*prefix\_real\_data.txt*” contains physiological data sampled at 40Hz; File “*prefix\_kHzdata.txt*” contains TTL signal sampled at 1KHz.
- The physiological monitoring computer is equipped with Secure SSH and a CD-R/W drive for data transferring purpose. No retrieval of data is guaranteed after the user has left the scanner.

### 2. Clean up

- The physiological monitoring system consists of many cables and sensor wires and requires extra responsibility to keep it neat and clean. Please wind up all the cables and hang them on the cable hangers mounted on the monitor unit. Collect all the accessories, including wires, leads, belts, gel and pads and place them neatly in the accessory basket located on top of the monitor unit. Failure to do so will result in suspension of the privilege to use the physiological monitoring system.
- Gently push the unit back against the sidewall and lock the wheel lock. Inspect one last time that there is nothing left behind.
- Use the problem report button on the web scheduling page to report any problems or suggestions you may have using the system. THANK YOU!

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Graphical Assistance: Cameron Perry

For questions about this manual, please contact Kun Lu ([kunlu@ucsd.edu](mailto:kunlu@ucsd.edu)). 03/30/2005