Operator’s Manual
Seizure Monitor

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Important Safety Instructions:

- This product is water resistant rather than water proof. This means the device can be worn while walking in light rain, but should not be used while swimming through a pool.
- This product should only be used within a temperature range of -35°C to 55°C.
- Do not use the device if the watch or alarm enclosures are open. This could result in electric shock or injury due to the bare circuitry.
- Ensure that the battery life is sufficient for the intended period of use. The watch’s battery life is 7 days and the alarm’s battery life is also 7 days.
- The seizure data should only be interpreted by a trained neurology or neurosurgery physician.
- This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
  - this device may not cause harmful interference, and
  - this device must accept any interference received, including interference that may cause undesired operation
- The watch should not exceed 800 meter distance from accompanying alarm device. The alarm device should not exceed 800 meter distance from computer. Failure to remain in range may result in undetected seizures.
- This device is designed only to monitor motor based seizures, and should not be worn by patients who suffer from non-motor based seizures such as atonic, psychic, or sensory seizures.
- The wrist watch portion of the device must be securely attached to the left or right arm of the patient to ensure proper positional readings acquired from the accelerometer. Failure to securely attach the watch may result in inaccurate detection.
- If the watch begins to heat up, the patient should immediately remove and turn off the watch. Have a professional check the internal circuitry before continued use.
- The alarm portion of the device must always be on when the patient is wearing the wrist watch.
- The caregiver must read and fully understand the operator’s manual before using the wrist watch on a patient.
Parts and Accessories:

Watch

Figure 1. Watch Subunit.
Alarm

Figure 2. Outside View of Alarm Subunit

Figure 3. Inner View of Alarm Subunit
Features:

- Adjustable Watch Strap
- Wireless Motor Seizure Detection and Transmission
- Alarm Signaling of Detection
  - Alert via LEDs
  - Alert via speakers
- Text Message Notification of Seizure
- Email Notification of Seizure
- Wireless Data Transmission to a LabVIEW Program
- Data Analysis in LabVIEW
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1. **Introduction**  
   
   1.1 **General Overview**

Seizures which go unnoticed while a patient’s asleep can be extremely detrimental to one’s health, resulting in loss of consciousness, exhaustion, nausea, vomiting, and inadvertent injury.

The seizure monitoring device consists of three units: a watch, an alarm, and a LabVIEW program. The watch is to be worn 24 hours a day to monitor seizures of patients suffering from epilepsy. In the event of a seizure, the alarm device signals to the caregiver that a seizure is in progress using LEDs and a speaker. The monitor will catalog the time, duration, and severity of the seizure for evaluation by one’s doctor. The monitor has Bluetooth communication for a close proximity auditory and visual warning system. This allows the caregiver to recognize an onset of a patient’s seizure. The size and wireless capability of the device is unusual and differs significantly from seizure monitors that lie under the patient’s mattress; this is what sets the device apart in the market.

1.2 **Operating the Seizure Monitor**

The following section describes step by step directions on how to properly use the seizure monitor.

1.2.1 **How to use the watch:**

1. Before securing the watch on the patient, the caregiver should check its battery life.
2. If the battery is charged, the caregiver should use the adjustable strap to secure the watch to the patient’s left or right wrist (For best results, the watch should be placed on the patient’s non-dominant hand).
3. The accelerometer will now automatically detect for patterns of seizure movement. In the event of a seizure, this data will be wirelessly transmitted via Bluetooth communication to the alarm component.

1.2.2 **How to use the alarm:**

1. Before use, the battery life of the alarm should be checked.
2. Turn toggle switch to “ON” position.
3. The alarm will automatically be receptive to the watch’s detection of movement via the Bluetooth communication.

4. Before use of watch and alarm, verify the system is operational by moving the watch in a seizure-like motion, which should set off the alarm accordingly.

5. Upon seizure detection, the alarm’s LEDs will instantly flash and its speaker will instantly sound.

6. Only turn alarm off when watch component is not in use.

1.2.3 **How to use the LabVIEW program:**

1. Prior to seizure detection, the caregiver should input his or her cell phone number and email address into the LabVIEW program. Figure 4 below shows where the email should be entered:

![LabVIEW Email Emergency User Interface](image)

Figure 4. LabVIEW Email Emergency User Interface

2. The seizure data will automatically transmit to the computer via Bluetooth communication.

3. Upon seizure detection, the caregiver’s cell phone will automatically receive a text, notifying the caregiver, “A seizure is occurring in Patient. Please
attend to the patient. After caring to the patient, save the data transmitted to the LabVIEW program.”

4. The user should then save the data from the LabVIEW program.
5. The data is now available for analysis by a qualified physician.

2. Maintenance

2.1 Electrical Maintenance

2.1.1. Batteries
It’s important that battery life is checked prior to use every few days. Battery death could result in seizures going undetected, which could have life threatening consequences. The recommended duration of use per battery in the watch and alarm is 7 days. Please use no longer than 7 days as this may result in a seizure going undetected.

2.1.2. Wires
It’s important that all wires remain within their casings to avoid injury. If there are any exposed wires, the power should immediately be shut off, and the watch should be removed. Only then may wires be touched by an experienced electrician, electrical engineer, or Seizure Monitor Senior Engineer Designer. Refer to the schematics to properly wire the device.

2.2 Computer Science Maintenance

2.1.1 Cutting Edge Research
A lot of research is currently underway regarding analysis of accelerometer readings for best detection and diagnosis of particular seizures. The detection and diagnosis is based on the various patterns retrieved from the data. As new research becomes publically available, the LabVIEW code must be revisited to yield the most up to date representation of seizure patterns. This re-coding must be done by a trained individual who is extremely knowledgeable in seizure detection, LabVIEW programming, and this particular seizure monitor device.
3. Technical Description

3.1 Watch

The circuit diagram in Figure 5 shows the watch’s internal wiring connections. As seen, the MMA7361L is the accelerometer, the ATtiny24A is the microcontroller, the WT41-A is the Bluetooth module, and the CR123Holder is the camera battery holder. Each ground connection is left open for simplicity in design, as the Bluetooth has numerous connections, and connecting these would clutter the image. Note that although the grounds aren’t connected, each GND in the diagram is a ground connection, and each of them should be grounded to a ground plane. The voltage coming out of port 1 of the battery holder should be the voltage of the camera battery input to the device, which is 3 volts. This voltage should enter VDD of the accelerometer, VCC of the microcontroller, and VDD_PA and VDD of the Bluetooth. Be sure that the remaining connections are in place, including the three axis outputs and the sleep port from the accelerometer going to the respective input ports of the microcontroller. Also
ensure that each of the UART ports of the Bluetooth are connected to the respective input ports of the microcontroller.

A picture of the watch’s printed circuit board with labeled parts is shown in figure 6.

Figure 6. Watch PCB with Components Attached.
3.2 Alarm

The circuit diagram in figure 7 shows the connections for the alarm component. The two HDR1X2 inputs are the 9 volt and 3 volt battery inputs. B1 is the 9 volt battery connector, and B2 is the 3 volt connector. J4 is the toggle switch, which allows the two battery voltages to supply the circuit with power. The voltage regulator is labeled U4 MCP1702, the ATmega644pa denotes the alarm’s microcontroller, and the WT41-A is the Bluetooth module. B3, B4, and B5 are the speaker and two LED inputs, respectively. Each of the ground pins are left unlabeled for simplicity in the image, and ease of selecting a ground plane using the netlist editor in Ultiboard. Although they aren’t connected, each of the battery connections, speaker, two LEDs, pin 2 of the voltage regulator, microcontroller, and Bluetooth
GND pins should be connected to a ground plane. AVCC, VCC1, VCC2, and VCC3 are the voltage inputs for the microcontroller and each should receive 3.3 volts, which is the voltage exiting the voltage regulator. The outputs to the LED lights and speaker should be driven high by the microcontroller code, and thus should receive 3 volts when activated. The Bluetooth input voltages, VDD and VDD_PA, should receive 3 volts from the 3-volt camera battery. Be sure that each of the Bluetooth UART pins are connected to the appropriate ports of the microcontroller. The RX of the Bluetooth should be connected to the TX of the microcontroller, and the TX of the Bluetooth should be connected to the RX of the microcontroller. RFGND of the Bluetooth is internally grounded.

Pictures of the alarm’s printed circuit board with labeled parts are shown in figures 8 and 9.

![Figure 8. Alarm PCB and Components](image-url)
Figure 10 represents the protoboard view of the watch set-up. Both the ATtiny24 and the ATmega644pa are set up for wiring ability because the ATmega644pa was first used to program the preliminary code, and then the ATtiny24 was programmed with the appropriate ports defined in the same manner as the ATmega644pa. The white wires represent inputs to the microcontrollers, the red wires represent input voltages, and the black wires represent ground.
4. Troubleshooting

Problem: Watch becomes loose.
Possible Cause:
1. Velcro is wet or worn
2. Watch improperly fastened to wrist
Possible Solution:
1. Re-fasten watch strap
2. Purchase new Velcro strap

Problem: Watch not making connection with alarm
Possible Cause:
1. Out of range
2. Insufficient power supply
Possible Solution:
1. Return to recommended 800 meter range
2. Replace batteries in watch and alarm components

Problem: Speaker not sounding
Possible Cause:
1. Insufficient power supply
2. Broken speaker
3. Internal short in circuit
Possible Solution:
1. Replace batteries in alarm
2. Contact qualified electronics specialist to replace speaker and/or troubleshoot wired connection

Problem: Alarm activating when seizure not occurring
Possible Cause:
1. Watch not secured properly to patient’s wrist
2. Circuit has become damaged
3. Microcontroller code inaccurate for selected patient
Possible Solution:
1. Refasten watch strap so the watch is secured to patient’s wrist
2. Consult qualified technician (senior design members) to review circuit and code to verify the system’s functionality

Problem: Alarm LED not illuminating
Possible Cause:
1. Insufficient power supply
2. Broken LED
3. Internal short in circuit
Possible Solution:
1. Replace batteries in alarm
2. Contact qualified electronics specialist to replace LED and/or troubleshoot wired connection

Problem: Toggle switch malfunction
Possible Cause:
1. Debris entered toggle cavity
2. Untightened nut
Possible Solution:
1. Clear toggle cavity of debris
2. Reposition nut to secure toggle
3. Contact qualified electronics specialist to replace toggle switch and/or troubleshoot wired connection

Problem: Text message not delivered
Possible Cause:
1. Incorrect phone number input
2. Faulty computer internet connection
3. Phone off
4. Phone text message limit exceeded
Possible Solution:
1. Verify correct phone number has been input
2. Verify substantial internet connection
3. Turn phone on
4. Contact service provider to expand text message service capabilities

To troubleshoot the circuitry, use the following devices, which will provide accurate readings:
The power supply in figure 11 will provide a DC voltage at whatever voltage specified by the user. A recommended 3 volts should power the watch and alarming devices.

Figure 12 represents an oscilloscope which can be used to view the 3-axis outputs of the accelerometer. There should be three probes, each properly grounded, to show the x, y, and z-axis changes in acceleration with respect to gravity. At rest, the oscilloscope should show a constant 1.5 volts, which corresponds to 1.5 g.

Figure 13 represents a digital multimeter, which can be used to measure voltages, resistances, or currents at any point on the circuit boards. Be sure to properly ground the ground lead, and place the input lead to a conductive portion where one takes a measurement.
If the code ever needs to be changed, or the microcontroller needs to be replaced, an AVRISP MKII programmer should be used with AVR Studio software to reprogram the code. The programmer can be seen in figure 14, and be sure to connect the appropriate wires to the respective ports of the microcontroller.

Figure 13. Digital Multimeter

Figure 14. AVRISP MKII Programmer
5. Appendix

BLUETOOTH:

Pinout and Terminal Description

![Pinout Diagram]

Figure 15. WT41-A Bluetooth Module Pinout
<table>
<thead>
<tr>
<th>PIN NUMBER</th>
<th>PAD TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>1, 52</td>
<td>Not connected. Pins 1 and 52 (GND) have been removed from the module.</td>
</tr>
<tr>
<td>RESET</td>
<td>33</td>
<td>Input, weak internal pull-up. Active low reset. Keep low for &gt;5 ms to cause a reset</td>
</tr>
<tr>
<td>GND</td>
<td>2-10, 16, 23,24,26-28, 30, 31,36,44-49, 53-59</td>
<td>GND</td>
</tr>
<tr>
<td>RF</td>
<td>51</td>
<td>RF output. RF output for WT41-N. For WT41-A and WT41-E this pin is not connected</td>
</tr>
<tr>
<td>RFGND</td>
<td>50</td>
<td>GND. RF ground. Connected to GND internally to the module.</td>
</tr>
<tr>
<td>VDD_PA</td>
<td>11</td>
<td>Supply voltage. Supply voltage for the RF power amplifier.</td>
</tr>
</tbody>
</table>

Table 1. Supply and RF Terminal Descriptions

<table>
<thead>
<tr>
<th>Rating</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Temperature</td>
<td>-40</td>
<td>85</td>
<td>°C</td>
</tr>
<tr>
<td>VDD_PA, VDD</td>
<td>-0.4</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Other Terminal Voltages</td>
<td>VSS-0.4</td>
<td>VDD+0.4</td>
<td>V</td>
</tr>
</tbody>
</table>

Table 2. Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature Range</td>
<td>-40</td>
<td>85</td>
<td>°C</td>
</tr>
<tr>
<td>VDD_PA, VDD</td>
<td>3.0</td>
<td>3.6</td>
<td>V</td>
</tr>
</tbody>
</table>

*) VDD_PA has an effect on the RF output power.

Table 3. Recommended Operating Conditions
ACCELEROMETER:

Specifications

- Dimensions: 0.4" x 0.5" x 0.09" (without header pins)
- Operating voltage (VDD): 2.2-3.6 V (pins are not 5V-tolerant)
- Supply current: 0.5 mA
- Sleep-mode current draw: < 3 μA
- Output format: 3 analog voltages (one signal for each axis) centered at VDD/2
- Sensitivity range (selectable using g-Select pin):
  - MMA7361L version: ±1.5g (default) or ±6g
  - MMA7341L version: ±3g (default) or ±11g
- Weight without header pins: 0.012 oz (0.35 g)

Using the sensor

The board is powered by supplying 2.2 to 3.6 V on the VDD pin. Note that this part does not have 5V-tolerant pins, so external components (such as voltage dividers) are required when interfacing the board’s g-Select, Self Test, and Sleep pins with 6V systems. Connections to these pins are optional; the board will work with these pins disconnected as long as the sleep pin is driven high with an on-board solder bridge as described below.

Pin Descriptions

Figure 16. Simplified Accelerometer Functional Block Diagram
Figure 17. Accelerometer Operating Conditions

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Range(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Voltage(3)</td>
<td>VDD</td>
<td>2.2</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current(4)</td>
<td>IDD</td>
<td>—</td>
<td>400</td>
<td>600</td>
<td>µA</td>
</tr>
<tr>
<td>Supply Current at Sleep Mode(4)</td>
<td>IDD</td>
<td>—</td>
<td>3</td>
<td>10</td>
<td>µA</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>TA</td>
<td>-40</td>
<td>—</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>Acceleration Range, X-Axis, Y-Axis, Z-Axis</td>
<td>g-Select: 0</td>
<td>—</td>
<td>±3</td>
<td>—</td>
<td>g</td>
</tr>
<tr>
<td>g-Select: 1</td>
<td>g-Select: 1</td>
<td>—</td>
<td>±11</td>
<td>—</td>
<td>g</td>
</tr>
<tr>
<td>Output Signal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero g (TA = 25°C, VDD = 3.3 V)(5)(6)</td>
<td>VOFF</td>
<td>1.551</td>
<td>1.86</td>
<td>1.740</td>
<td>V</td>
</tr>
<tr>
<td>Zero g(4)</td>
<td>VOFF, TA</td>
<td>-2.0</td>
<td>±0.5</td>
<td>+2.0</td>
<td>mg/°C</td>
</tr>
<tr>
<td>Sensitivity (TA = 25°C, VDD = 3.3 V)</td>
<td>S</td>
<td>413.6</td>
<td>440</td>
<td>468.4</td>
<td>mV/g</td>
</tr>
<tr>
<td>3g</td>
<td>S12</td>
<td>106</td>
<td>117</td>
<td>129</td>
<td>mV/g</td>
</tr>
<tr>
<td>11g</td>
<td>S13</td>
<td>0.0075</td>
<td>±0.002</td>
<td>+0.0075</td>
<td>%/°C</td>
</tr>
<tr>
<td>Sensitivity (4)</td>
<td>STA</td>
<td>0.0075</td>
<td>±0.002</td>
<td>+0.0075</td>
<td>%/°C</td>
</tr>
<tr>
<td>Bandwidth Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY</td>
<td>fSBXY</td>
<td>—</td>
<td>400</td>
<td>—</td>
<td>Hz</td>
</tr>
<tr>
<td>Z</td>
<td>fSBZ</td>
<td>—</td>
<td>300</td>
<td>—</td>
<td>Hz</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>Z0</td>
<td>—</td>
<td>32</td>
<td>—</td>
<td>kΩ</td>
</tr>
<tr>
<td>Self Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XOUT, YOUT</td>
<td>Δ8XY</td>
<td>0.05</td>
<td>-0.1</td>
<td>—</td>
<td>g</td>
</tr>
<tr>
<td>ZOUT</td>
<td>Δ8TZ</td>
<td>0.8</td>
<td>+1.0</td>
<td>+1.2</td>
<td>g</td>
</tr>
<tr>
<td>Input Low</td>
<td>VIL</td>
<td>—</td>
<td>VDD</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>Input High</td>
<td>VIH</td>
<td>0.7 VDD</td>
<td>—</td>
<td>VDD</td>
<td>V</td>
</tr>
<tr>
<td>Noise</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Power Spectral Density RMS (0.1 Hz – 1 kHz)(4)</td>
<td>nPSD</td>
<td>—</td>
<td>350</td>
<td>—</td>
<td>µg/Hz</td>
</tr>
<tr>
<td>Control Timing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power-Up Response Time(7)</td>
<td>tRESPONSE</td>
<td>—</td>
<td>1.0</td>
<td>2.0</td>
<td>ms</td>
</tr>
<tr>
<td>Enable Response Time(8)</td>
<td>tENABLE</td>
<td>—</td>
<td>0.5</td>
<td>2.0</td>
<td>ms</td>
</tr>
<tr>
<td>Self Test Response Time(9)</td>
<td>tST</td>
<td>—</td>
<td>2.0</td>
<td>5.0</td>
<td>ms</td>
</tr>
<tr>
<td>Sensing Element Resonant Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY</td>
<td>fSELXY</td>
<td>—</td>
<td>6.0</td>
<td>—</td>
<td>kHz</td>
</tr>
<tr>
<td>Z</td>
<td>fSELZ</td>
<td>—</td>
<td>3.4</td>
<td>—</td>
<td>kHz</td>
</tr>
<tr>
<td>Internal Sampling Frequency</td>
<td>tCLK</td>
<td>—</td>
<td>11</td>
<td>—</td>
<td>kHz</td>
</tr>
<tr>
<td>Output Stage Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-Scale Output Range (IOUT = 3 µA)</td>
<td>VFSO</td>
<td>—</td>
<td>VDD+0.1</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>Nonlinearity, XOUT, YOUT, ZOUT</td>
<td>NLOUT</td>
<td>-1.0</td>
<td>—</td>
<td>+1.0</td>
<td>%FSO</td>
</tr>
<tr>
<td>Cross-Axis Sensitivity(10)</td>
<td>VXY, XZ, YZ</td>
<td>—</td>
<td>-5.0</td>
<td>—</td>
<td>+5.0</td>
</tr>
</tbody>
</table>