Model JI-210
I2C Bus Monitor

User's Manual

Version 2.0

Jupiter Instruments

1/29/2006 Edition

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1. INTRODUCTION

The JI-210 is a PC hosted I2C bus monitor used to non-invasively monitor and analyze a variety of I2C networks. The desktop unit captures and stores up to 32KBs of bus activity including data and address values, stop/start, read/write, ACK/NACK, and frame error events. Data is displayed as both I2C messages and Timing Waveforms. A Windows software application manages captured I2C messages, timing waveform display, trigger setup, and sampling rates. RS-232* provides the PC to desktop unit communications link.

A unique FPGA architecture allows the JI-210 to capture and display all I2C bus events (valid or invalid) between message Start and Stop conditions. For example, the action of a Master mistakenly ignoring the NACK response of a Slave by continuing to transmit data bytes will be captured, showing the invalid NACK response for each transfer. Bus anomalies such as a Start followed by a Stop without data, or multiple Stop/Starts conditions will be captured and displayed as they occurred. Additionally, the JI-210 can be configured to trigger and capture bus errors such as truncated address or data values or missing ACK/NACK responses.

Features

- Compatible with Standard (100kbit/s), Fast(400kbit/s), and bit rates up to 700kbit/s ***without clock stretching.***

- Timing Waveform sampling rates up to 50ns (20Mhz)

- Supports 7-bit and 10-bit addressing

- Compliant with 3.3V and 5.0V bus networks

- Combinational Event Triggering -- based on Address, Data, and R/W values, and Frame Error events.

- Selectable pre/post trigger position for both I2C Message capture and Timing Waveform data

- Message period timestamp with 1us resolution

- Trigger output signal available via BNC connector -- used to trigger a digital oscilloscope

- Easy to use Graphical User Interface (GUI) software included

Applications

- Firmware debugging and hardware troubleshooting

- Production line testing

- Equipment repair and diagnostics

*Note: If the host PC does not have an available COM port, but does have a free USB port, a USB to RS-232 converter can be used to communicate with the desktop unit. Successful operation has been achieved with the IOGear Model GUC232A USB to Serial/PDA converter cable.

1.1 Front Panel Description
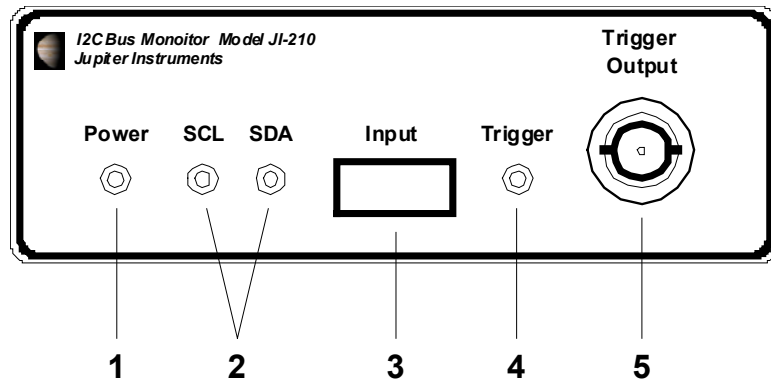
1. **Power** – Power on indicator.

2. **SCL, SDA** – I2C bus activity indicators.

3. **Input** – I2C probe cable jack input. 5-pin, polarized, latching header (Molex 70553-0004)

4. **Trigger** – Trigger event / Recording indicator. Blinking LED = Recording in progress, Solid LED = Trigger event has occurred.

5. **Output** – Trigger output signal. 3.3V, 10us pulse, BNC connector.

1.2 Rear Panel Description
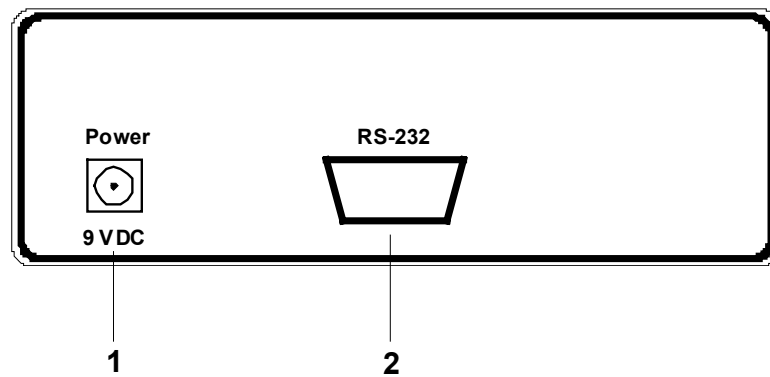
1. **Power** – Power input jack, 2.1mm x 5.5mm

2. **RS-232** – Serial Communications, RS-232, Sub-D, 9-pin, Female

2. GETTING STARTED

2.1 Software Installation

The I2C Bus Monitor software can be installed locally on the host PC's hard-drive or executed directly from the CD-ROM. To install on the **C:** drive:

1. Insert the JI-210 CD-ROM disk into the CD drive.

2. Using Windows Explorer, copy the **JI** folder containing the bus monitor executable (**I2C_Bus_Mon.exe**) from the CD-ROM to a convenient location on PC's **C:** drive.

2.2 Hardware Setup

1. Connect the I2C bus Monitor unit to the host PC using the 9-pin serial cable.

2. Connect the AC adapter to the power-jack on the rear panel of the I2C Bus Monitor unit. Then plug the adapter into the wall.

3. Ensure that the power-on LED on the I2C Bus Monitor unit is illuminated.

2.3 Communications Check

1. Go to the folder **C:\JI**

2. Launch the I2C Bus Monitor application by clicking **I2C_Bus_Mon.exe**.

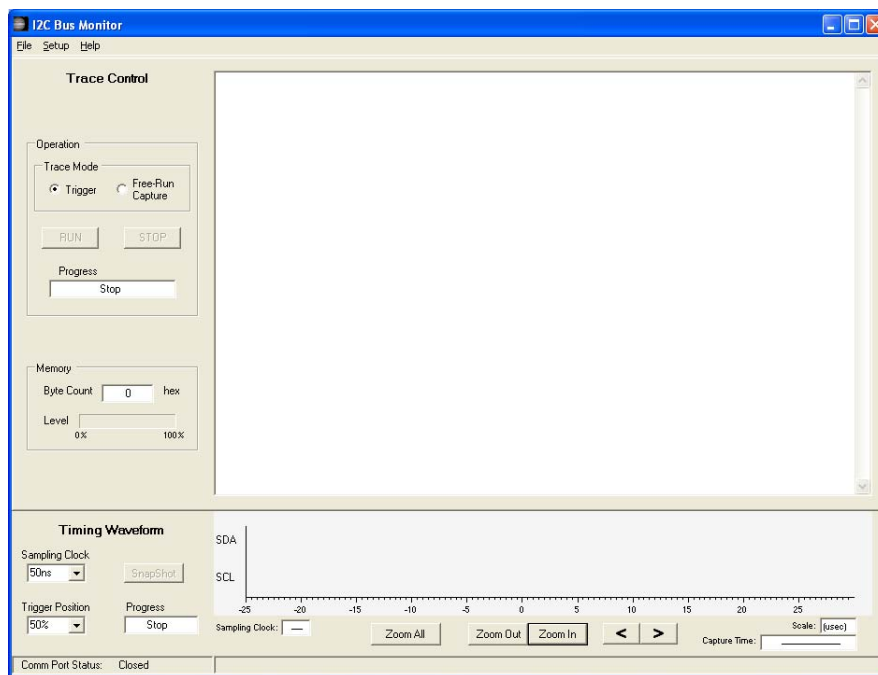3. Verify that the main I2C Bus Monitor window is displayed as shown in figure 1.

Figure 1. I2C Bus Monitor Window

If an error occurs and the window does not appear, begin by verifying that the .NET Framework 1.1 is installed. To do this, click **Start** on your windows desktop, select **Control Panel**, and then double-click the **Add or Remove Programs** icon. When the window appears, scroll through the list of applications. If you see the .NET Framework 1.1 listed, the latest version is installed. If not

listed, go to *msdn.microsoft.com/netframework/downloads/howtoget.aspx* for instructions on downloading and installing the latest .NET Framework version.

4. At the menu bar, configure the COM port by selecting **Setup** then **Comm Port**.

5. Verify that the *Comm Port* menu opens as shown in figure 2.
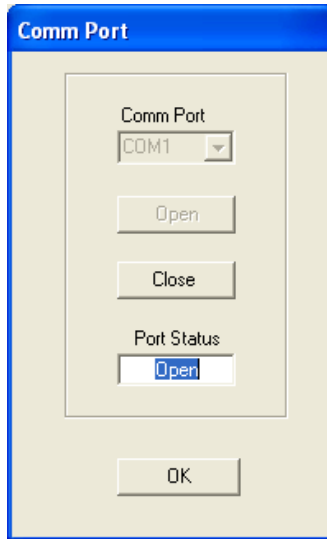
Figure 2. Comm Port Menu

6. Select the desired host COM port number (**COM 1 – COM4**), and then select **Open**.

7. Ensure that the selected port is available and open by verifying an open port status.

8. Click **OK** to save.

9. At the main window, click the **Run** button. Wait a few seconds, then click **Stop.**

10. Verify an output similar to that shown below is now displayed in the Trace Log pane.

I2C Bus Monitor Application Version 2.1 Date: 1/18/2006

Hardware Version 0d!

1/18/2006 8:48:34 AM

Memory count = 0000!

No Data!

2.4 I2C Message Capture w/o Trigger

1. Ensure the I2C bus Monitor unit is connected to the host PC.

2. Ensure that the Bus Monitor application is running and a host COM port has been selected.

3. Connect the I2C probe cable to the Input jack on the I2C bus Monitor front panel.

4. Connect the three I2C bus probes (SDA, SCL, and GND) to an active I2C bus.

5. Verify I2C bus activity by observing the SDA and SCL LEDs on the front panel of the I2C Bus Monitor unit.

6. At the main window, select **Free-Run Capture** in the Trace Mode group.

7. Click the **Run** button to begin capturing I2C data.

8. Verify I2C recording by observing an increasing byte count in the Record Memory text box and the message Recording in the Trace Control Progress text box.

9. Click the **Stop** recording button after filling memory with a few hundred bytes.

10. When the message Stopped is displayed in both the Trace Control and Timing Waveform Progress test boxes, click the **Zoom All** button in the Timing Waveform section.

11. Verify that I2C messages are now displayed in the Trace Log pane and that SDA and SCL waveforms have been captured (Note: If the density of I2C message traffic is low and/or the clock frequency is low, flat line waveforms may be displayed).

2.5 I2C Message Capture with Trigger

1. If you have not already done so, run the steps in section 2.4 *I2C Message Capture w/o Trigger.*

2. Scroll through the captured I2C messages in the Trace Log pane and locate a message with an infrequent occurrence suitable for use as a trigger. For this test, select a message with a 7-bit address that has at least one data argument. Note the address, R/W, and data values.

3. At the menu bar, open the trigger menu by selecting **Setup** then **Trigger**.

4. Using your selected I2C message, set the trigger menu as follows:

   - **Address Format:**   "7-bit"
   - **Trigger Configuration:**   "Address and Data"
   - **Address Value:**   *Your selected trigger Address value*
   - **Data Value:**   *Your selected trigger Data value*
   - **R/W Value:**   *Your selected trigger R/W value*
   - **Trigger Output:**   "Disabled"

5. Click **OK** to save the trigger setup.

6. Select a Timing Waveform sampling clock suitable for the I2C bus under test. To do this, click the **Sampling Clock** combo box at the lower left side of the window. Choose a sampling clock that is approximately 20x faster than the I2C clock rate.

7. At the main window, select a triggered trace by clicking the **Trigger** radio button.

8. Verify I2C bus activity by observing the SDA and SCL LEDs on the front panel of the I2C Bus Monitor unit.

9. At the main window, click the **Run** button to begin capturing I2C data.

10. Verify I2C message recording by observing an increasing byte count in the Record Memory text box.

11. Watch the Progress text box in the Trace Control section. When a *Triggered* message appears, wait a few seconds and then click the **Stop** button. If a *Triggered* message is never observed, click the **Stop** recording button and verify trigger menu settings, trace mode selection, and chosen trigger message.

12. At the Trace Log pane, scroll through the captured messages to locate the trigger message. This message is identified by an asterisk preceding the message number and horizontal bars above and below the message. As an example:

Msg 005   <Start>[Add:A1(R)]<ACK>[#12]<ACK>[#23]<ACK>[#56]<ACK>[#78]<ACK>[#9A]

           <ACK>[#BC]<ACK>[#DE]<ACK>[#F0]<ACK>[#11]<NACK><Stop>   t=109869us

Msg 006   <Start>[Add:A6(W)]<ACK>[#00]<ACK><Stop>   t=1202us

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* Msg 007   <Start>[Add:A7(R)]<ACK>[#22]<ACK>[#23]<ACK>[#24]<ACK>[#25]<ACK>[#26]

           <ACK>[#27]<ACK>[#FF]<ACK>[#FF]<ACK>[#FF]<NACK><Stop>   t=109361us

_____

Msg 008   <Start>[Add:A0(W)]<ACK>[#00]<ACK><Stop>   t=1202us

Msg 009   <Start>[Add:A1(R)]<ACK>[#12]<ACK>[#23]<ACK>[#56]<ACK>[#78]<NACK><Stop>   t=108373us

13. Examine the captured trigger message and verify a match with the trigger menu selections.

14. At the Timing Waveform display, use the zoom and scroll controls to locate the trigger message. This message's location is indicated by the blue vertical bar. This bar marks the point in time where the trigger condition was satisfied. Zoom-in to a point where SCL clock and SDA data signals are clearly visible and clocked data values can be determined.

15. Visually decode the timing signals and verify a match with the trigger menu trigger menu selections.

3. MAIN WINDOW AND MENU DESCRIPTIONS

3.1   Main Window

The I2C Bus Monitor main window is illustrated in Figure 3. The Trace Log pane and associated monitor and control options are located on the top 3/4s of the window, and the Timing Waveform display and associated monitor and control options are located towards the bottom.
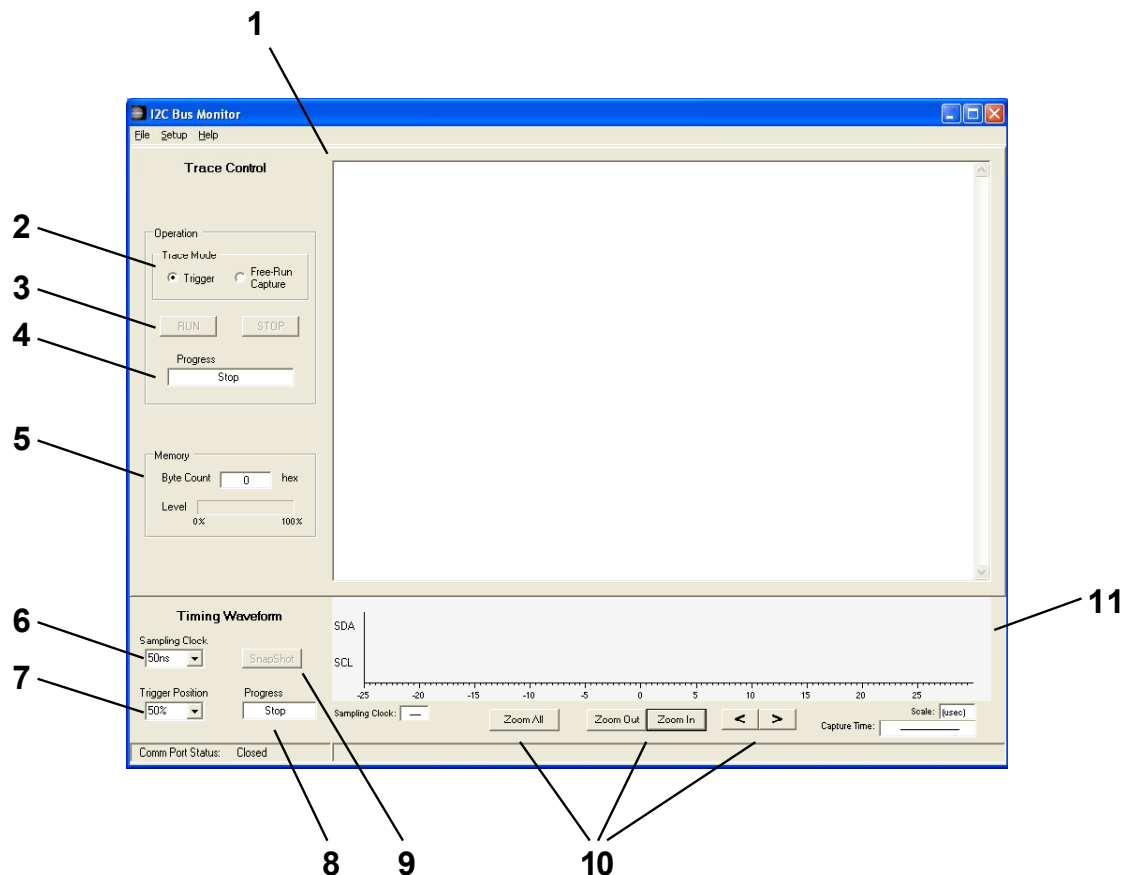

Figure 3. I2C Bus Monitor Main Window

1. **Trace Log** – Captured I2C messages are displayed in this pane.

2. **Trace Mode** – I2C data can be captured via two modes: **Trigger** and **Free-Run Capture**. In Trigger mode, captured data is written to memory using a circular buffer arrangement. When a trigger occurs, data is tagged and the remainder of memory is filled. The result is memory filled with pre and post trigger I2C data. In Free Run Capture mode, all triggering is ignored. I2C data is simply captured and written to memory, beginning at address 0 and ending at the selected memory depth.

3. **Run/Stop** – These buttons control the I2C capture session. The **Run** button initiates a session and the **Stop** button terminates it. A capture session will automatically stop when the both message and timing waveform memories are full.

4. **Progress (Trace)** – Messages reporting the status of the capture session are displayed here.

5. **Memory (Trace)** – The memory byte count is displayed both numerically and graphically.

6. **Sampling Clock** – The sampling rate for the Timing Waveform display is selected here.

7. **Trigger Position** – This control selects (in percentage) the amount of timing data recorded before and after the trigger event. This control is ignored when a non-triggered captured is initiated (i.e. Free-Run Capture mode or Snap-Shot)

8. **Progress (Timing Waveform)** – Messages reporting the status of the capture session (as related to the timing data) are displayed here.

9. **Snap-Shot** – This control initiates a non-triggered capture and display of timing data. It is used to take a quick look at the state of the SDA and SCL signals.

10. **Timing Waveform Control** – These controls are used to manipulate the timing signals displayed in the timing waveform display. Zoom in, zoom out, zoom all, scroll left (<), and scroll right (>) controls are available.

11. **Timing Waveform Display** – SDA and SCL signals are displayed here. When a *Trigger Trace Mode* is initiated and a trigger event has occurred, a blue vertical bar in the timing data is displayed. This bar marks the point in time where the trigger condition was satisfied and corresponds to the trigger message in the Trace Log. Note that only a single trigger event is generated during a session.

3.2 Trace Memory Setup Menu

This menu (Figure 4.) selects both the *Memory Depth* and the number of bytes recorded before and after a trigger event.
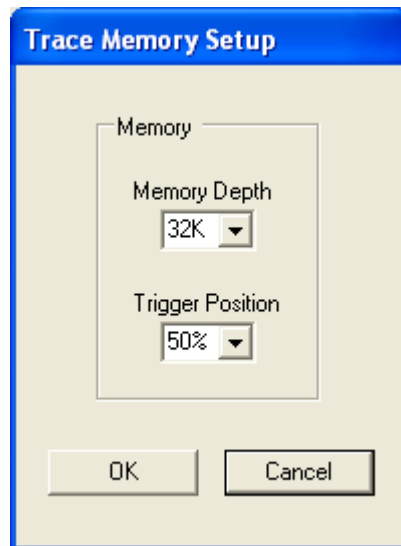
Figure 4. Trace Memory Setup Menu

When the *Trace Memory* is full, captured I2C messages will be automatically displayed in the *Trace Log*. To take advantage of this display feature, set the memory depth as small as possible for your testing. Otherwise, the memory should be set to the default value of 32K.

The *Trigger Position* is adjustable in three steps from 25% to 75% of the selected memory depth. By judicious selection of the *Trigger Position*, viewing a particular I2C message or bus event long before or after a trigger event is possible.

3.3 Comm Port Menu

The selection of a COM port (**COM1 – COM4**) and status (**Open/Closed**) is provided by the *Comm Port Menu* (Figure 5.)
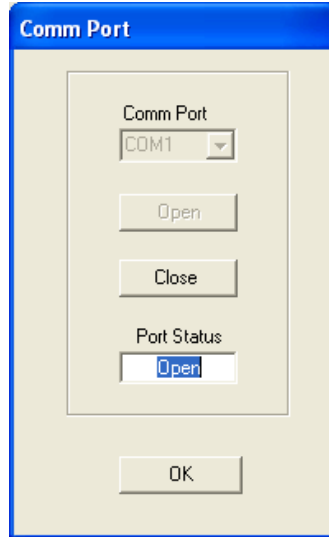
Figure 5. Comm Port Menu

Four COM port are available: COM1 (3F8h), COM2 (3F8h), COM3 (3F8h), or COM4 (3F8h). Click the **Open** or **Close** button to either open or close the selected port. Status of the selected port is indicated in the *Port Status* text box. A pop-up message warns against a nonexistent or unavailable COM port.

*Note: If the host PC does not have an available COM port, but does have a free USB port, a USB to RS-232 converter can be used to communicate with the desktop unit. Successful operation has been achieved with the IOGear Model GUC232A USB to Serial/PDA converter cable.

3.4 Trigger Menu

The *Trigger Menu* proves a simplified and convenient means of entering and maintaining a trigger setup. This menu is illustrated in Figure 6. A trigger event is generated if a match occurs between a captured I2C bus message and the trigger setup values. Only a single trigger event is generated during a recording session.
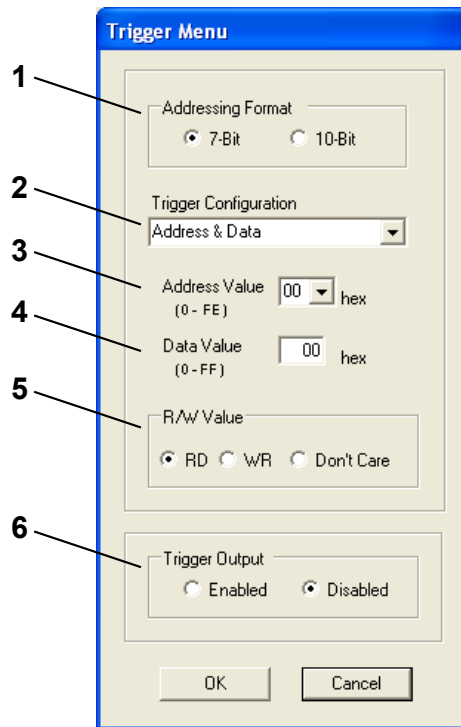
Figure 6. Trigger Menu

1. **Address Format** – Radio buttons select either a **7-Bit** or **10-Bi**t addressing. If the trigger type is not based on an address (such as *Frame Error Only*), the buttons are dimmed and not selectable.

2. **Trigger Configuration** – A list box selects 1 of 7 trigger configurations:

Configuration	Match Variables
• **Address and Data**	Address, Data, Address Format, and R/W
• **Address only**	Address, Address Format, and R/W
• **Data only**	Data and R/W
• **(Address & Data) or Frame Error**	(Address, Data, Address Format, and R/W) or Frame Error
• **Address or Frame Error**	(Address, Address Format, and R/W) or Frame Error
• **Data or Frame Error**	(Data and R/W) or Frame Error
• **Frame Error Only**	Frame Error Only

3. **Address Value** – Address trigger values for either 7-bit or 10-bit formats is entered here. When 7-bit addressing is selected, even address values from 0 to FEh are available. This follows the I2C convention using the upper 7-bit of a byte as the address and setting the LSB to 0. For 10-bit addressing, all values from 0 to 3FFh are available.

4. **Data Value** – Value range is from 0 to FFh.

5. **R/W Value** – Radio buttons select read (**RD**), write (**WR**), or a **Don't Care** value for the I2C message direction bit (R/W).

6. **Trigger Output** – The *Trigger Output* enables or disables the generation of 10us trigger event signal. This output signal is available at front panel BNC connector. Note that only a single trigger event is generated during a recording session.

4. TRACE LOG PANE

Captured I2C messages are assigned a message number and sequentially displayed in the trace log pane. Displayed message details include message data and address values, stop/start, read/write, ACK/NACK, and frame error events. Message execution time (Start to Stop or Start to repeated Start) is also displayed. An asterisk preceding the message number and horizontal bars above and below the message identifies a trigger message.

4.1 Message Syntax Definitions

Syntax	Description
<Start>	Start event
<Stop>	Stop event
<ACK>	Acknowledge event
<NACK>	not-Acknowledge event
[Add:*hh*(*d*)]	7-bit Message Address with direction. *hh* Address value displayed in conventional I2C hexadecimal format (i.e. upper 7-bits make up the slave address and the LSB determines message direction) *d* Message direction: R = Read, W = Write.
[Add10:*hh*(*d*)] followed by [Add10:*hh*]	10-bit Message Address with direction. Since a 10-bit address is formed from the first two bytes following a Start condition, the 10-bit address syntax is displayed as two bytes: the upper 2 bits of the 10-bit address make up the first byte value, and the remaining 8 bits of the 10-bit address make up the second byte value. Message direction is displayed in parentheses in the first byte. *hh* Address displayed as hexadecimal value *d* Message direction: R = Read, W = Write.
[#*hh*]	Data byte value *hh* Data displayed as hexadecimal value.

<Frame Error!>	An address or data value has been truncated by a Stop condition.
<ACK/NACK Error!>	A stop condition has terminated the message before an ACK/NACK is generated.
T=*ddddd*uS	Message execution time measured from Start to Stop or Start or repeated Start. *ddddd* Time displayed as a decimal value.
*Msg	An asterisk preceding the message number identifies a trigger message. Additionally, horizontal bars above and below the message body are added. A trace log example follows below:

Msg 005   <Start>[Add:A1(R)]<ACK>[#12]<ACK>[#23]<ACK>[#56]<ACK>[#78]<ACK>[#9A]

            <ACK>[#BC]<ACK>[#DE]<ACK>[#F0]<ACK>[#11]<NACK><Stop>   t=109869us

Msg 006   <Start>[Add:A6(W)]<ACK>[#00]<ACK><Stop>   t=1202us

_____

* Msg 007   <Start>[Add:A7(R)]<ACK>[#22]<ACK>[#23]<ACK>[#24]<ACK>[#25]<ACK>[#26]

            <ACK>[#27]<ACK>[#FF]<ACK>[#FF]<ACK>[#FF]<NACK><Stop>   t=109361us

_____

Msg 008   <Start>[Add:A0(W)]<ACK>[#00]<ACK><Stop>   t=1202us

Msg 009   <Start>[Add:A1(R)]<ACK>[#12]<ACK>[#23]<ACK>[#56]<ACK>[#78]<NACK><Stop>   t=108373us

APPENDIX A

1. <u>PC System Requirements</u>

    - Microsoft Windows 98*, 2000*, and XP

        *These OS require the .NET framework. If installation is required, go to *msdn.microsoft.com/net**framework**/ downloads/howtoget.aspx*

    - Serial port, 115.2K BAUD

    - CD ROM drive

    - 5 MB hard disk space

2. <u>Size and Weight</u>

    - 4.2x1.5x6.5 inches

    - 1.0 lbs.

APPENDIX B

1. **Specifications**

    Power

Input Power:	6VDC @100mA
Receptacle:	2.1mmx5.5mm coaxial DC jack

    PC Interface

Communications:	Serial RS-232C
BAUD rate:	115.2K
Connector:	9-pin, sub-D, female

    I2C Interface

Connector:	5-pin latching (0.100" spacing, 0.025" pins)
Pins:	Pin 1 = Gnd
	Pin 2 = SCL (Red)
	Pin 3 = Gnd (Black)
	Pin 4 = SDA (Green)
	Pin 5 = Gnd
Bus Speed:	0 to 1.0Mbit/s (w/o bus errors)
	0 to 700kbit/s (with bus errors)
Input Threshold:	V_{IL}: 1.0V (typ.)
	V_{IH}: 2.0V (typ.)
	V_H: 0.8V (typ.)
Input Range:	-0.3V to 5.5V (operational)
	-5.0 to +10V (max. rating)
Input Capacitance:	45pf – typical (including 34" probe cable)

    Trigger Output

Connector:	BNC
Output Signal:	10uS, 3.3V pulse

    LEDs

Power:	Power-On
SCL:	Bus clock activity
SDA:	Bus data activity
Trigger:	Message Recording / Trigger Event

    Message Recording

Capacity:	32Kb buffer
Triggering:	Address, Data, R/W, Frame Error combination
Pre-Trigger:	Selectable 25%, 50%, and 75% pre-trigger recording
Message Time Stamp:	1us to 1.0485s, 1us resolution. Period measured from Message Start to Stop, or Start to repeated Start.

Timing Waveform

Sampling Rates: Selectable – 50ns, 100ns, 200ns, 500ns, 1us, 2us, 5us, 10us, 20us, 50us, 100us, 200us, 500us, 1ms

Sampling Capacity: 8K/channel

Pre-Trigger Recording: Selectable – 0%, 25%, 50%, 75%, 100%

Capture Modes: Triggered and Free-run (SnapShot)

APPENDIX C

1. General Information

   1.1 Warranty

   The equipment is warranted for one year from data of purchase against defects in materials or workmanship. Jupiter Instruments reserves the right to repair or replace products at its own and complete discretion. Customer must obtain from Jupiter Instruments a Return Authorization Number (RMA) prior to returning any products to Jupiter Instruments. Products returned under this Warranty must be unmodified and in original packaging. Jupiter Instruments reserves the right to refuse warranty repairs or replacements for any products that are damaged or not in original form.

   The customer is responsible for the shipping and insurance cost arising from the return of products to Jupiter Instruments. Jupiter Instruments will return all in-warranty products with shipping cost prepaid.

   1.2 Thirty-Day Return Policy

   Customers may return Jupiter Instruments products for a full refund if Jupiter Instruments is contacted within thirty days of the customer's receipt of the product. Customer may return Jupiter Instruments products for credit, exchange, or a refund. Customer must obtain form Jupiter Instruments a Return Authorization Number (RMA) prior to returning any products to Jupiter Instruments. Products must be returned unmodified and in original packaging. Jupiter Instruments reserves the right to refuse return rights for any products that are damaged or not in original form. Volume orders may be subject to a significant restocking fee.

   1.3 Limitation of Liability

   Jupiter Instruments' liability shall be limited to the repair or replacement of defective products in accordance with the Jupiter Instruments limited warranty.

   Jupiter Instruments shall not be liable for any incidental, special or consequential damages for breach of any warranty, expressed or implied, directly or indirectly arising out of Jupiter Instruments' sale of merchandise, including any failure to deliver any merchandise, or arising out of customer's installation or use, whether proper or improper, of the product, separately or in combination with other equipment, or from any other cause. Use the JI-210 at your own risk.

   Products sold by Jupiter Instruments are not authorized for use as critical components in life support devices or systems.

   1.4 Contact Us

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