

54622D

# Agilent I<sup>2</sup>C Debugging

Application Note1351

With embedded systems shrinking, I<sup>2</sup>C (Inter-integrated Circuit) protocol is being utilized as the communication channel of choice because it only needs two I/O lines for full implementation. However, with the benefit of using only two I/O lines comes the hassle of a complicated protocol. So, having a tool on the bench that eases I<sup>2</sup>C troubleshooting is sure to add days to embedded engineers' life spans everywhere. The new Agilent Technologies 54622D oscilloscope adds a few more arrows to the embedded engineer's quiver of debugging tools. The 54622D extends the MSO (Mixed Signal Oscilloscope) line of test instruments which was started with the 54645D. It includes two analog channels and 16 digital channels, all of which can capture data at 200 MSamples/second and 400 Msamples/second, respectively. This is all fairly routine for anyone familiar with the 54645D; however the 54622D exceeds the earlier scope with its powerful trigger capabilities that are reminiscent of a logic analyzer.



Specifically, the 54622D offers a full suite of I<sup>2</sup>C triggering capabilities. The I<sup>2</sup>C connections to the 54622D are fully configurable. The SCL line and the SDA line can be assigned to any of the scope's 16 digital channels or to the two analog channels. In addition, there are six I<sup>2</sup>C-specific triggers that are detailed below. Figure 1 shows the I<sup>2</sup>C trigger menu on the 54622D, Figure 1 also shows how the I<sup>2</sup>C lines can be configured to any channel – in this case the SCL line set on analog channel 1 and the SDA line set on analog channel 2.



Agilent Technologies

**Start Condition:** This triggers the scope anytime there is an I<sup>2</sup>C start condition.

**Stop Condition:** This triggers the scope anytime there is an I<sup>2</sup>C stop condition.

**Frame(Start: Addr: Read: Ack: Data):** The scope only triggers after the combination of start bit, control byte – configuring the slave to be read from, valid acknowledge, and then another byte. Both the control byte and the secondary byte can be set using the "Address" and the "Data" settings.

**Frame(Start: Addr: Write: Ack: Data):** This is the same as the previous trigger, except the slave must be configured to be written to.

**Frame(Start: -[Addr: Read: Ack: Data]):** This trigger fires if any bit in the control byte, or the read bits, ack bits, or data bits do not match what is entered. This allows for triggering deep into an I<sup>2</sup>C communication or to find spurious communication.

**Frame(Start: -[Addr: Write: Ack: Data]):** This is the same as the previous trigger, except it looks for the absence of a write bit. this with two separate instruments!).

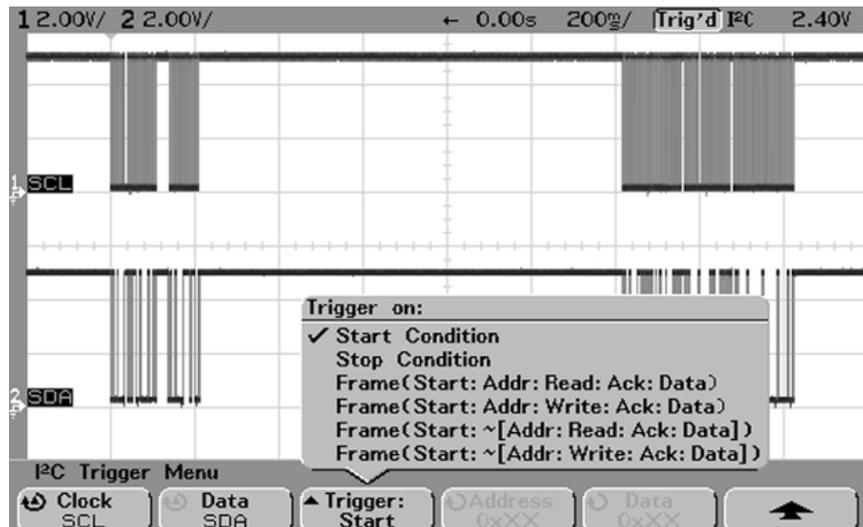


Figure 1. Shows the I<sup>2</sup>C trigger menu

Both the stop and start condition triggers could also be accomplished using a pattern trigger, edge trigger, or the like, which is common on most DSOs. It is the other four triggers that really ease an embedded designer's task of troubleshooting an I<sup>2</sup>C system.

For example, one common problem when using the I<sup>2</sup>C bus is a master not receiving any communication back from a slave device on the I<sup>2</sup>C bus. While this problem could be troubleshot with a standard DSO with a deep memory, the 54622D greatly speeds up the process. With a conventional DSO, the entire sequence must be captured and then zoomed-in and the individual transitions and data bytes must be analyzed one-by-one. This can become a tedious process in large systems with near-constant I<sup>2</sup>C communication where individual triggering is nigh on impossible. With the new MSO, likely trouble spots are easily triggered on and analyzed.

For example, Figures 2 and 3 show a bad and good communication sequence between a master device and an I<sup>2</sup>C temperature sensor. In this case, the temperature sensor was not sending information back to the master unit correctly. The 54622D was used to sift through a whole string of I<sup>2</sup>C data to analyze just the temperature sensor data. Eventually the problem was narrowed down to the "Read Temperature" command sent to the temperature sensor. This was easily triggered on by using the "write" trigger – after the scope sees a start bit, control byte 48 (hex) configured to write (this is the temperature sensor's address), then data AA (hex) (the read temperature command), the scope triggers. After the trigger, the master should put the temperature sensor into read mode by sending a start bit and then a 48 (hex) control byte configured to read.

As shown in Figure 2, after the trigger the master sends the 48 (hex), unfortunately a start bit does not preface the 48 (hex), thereby causing the temperature sensor to ignore the command.

Figure 3 shows the correct sequence. After the master was configured to send the start bit correctly, the temperature sensor started sending the correct temperature.

With I<sup>2</sup>C enjoying widespread industry support, debugging situations like the one described above are and will remain commonplace. The 54622D helps embedded engineers everywhere implement the bus with much less hassle.

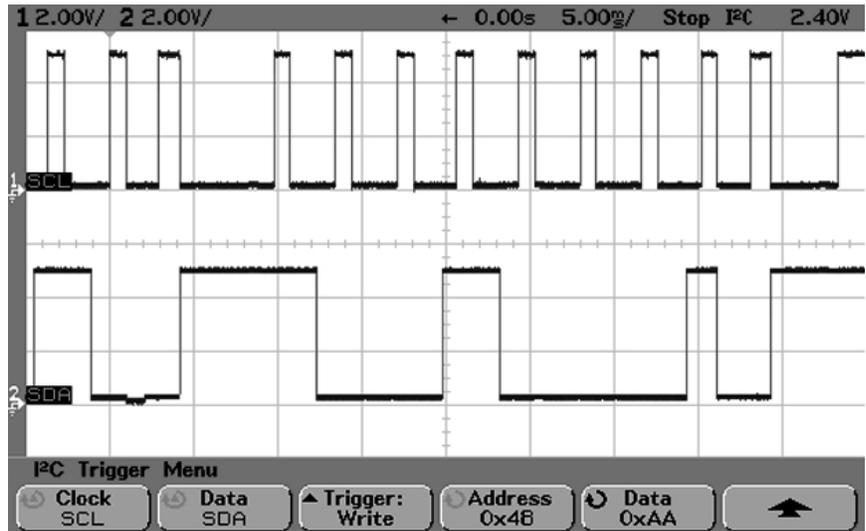


Figure 2. Shows a bad communication sequence

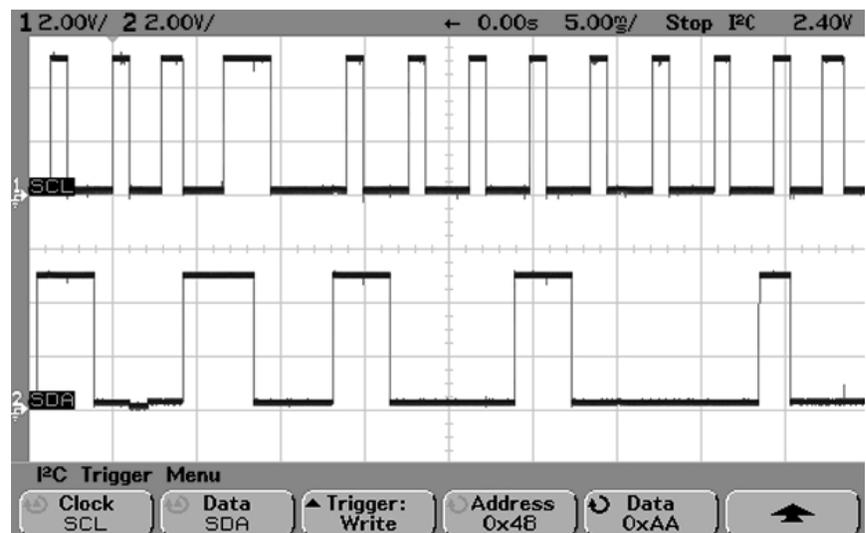
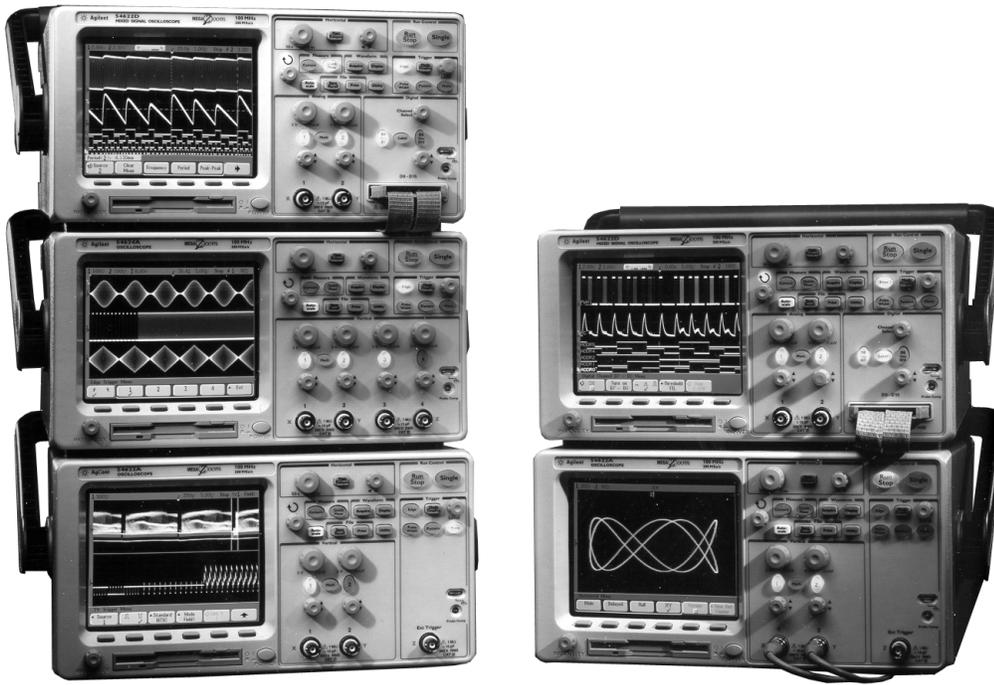


Figure 3. Shows the correct sequence



**Figure 4. Five models to satisfy your bandwidth, channel count and budget needs**

Unique 2+16 channel mixed signal oscilloscope and 2 or 4 channel models all optimized for mixed analog and digital debug:

- 2 MB of MegaZoom deep memory on all channels
- New high-definition analog-like display system with 32 levels of intensity
- Powerful triggering including edge, pulse width, pattern and new I<sup>2</sup>C
- Standard RS-232 and parallel ports for PC and printer connectivity
- Built-in floppy for data, image and setup storage
- Measurements and math functions including FFTs standard
- Quick Help in 11 languages
- Optional GPIB interface module
- Optional integrated thermal printer

Model Number	Bandwidth	Sample Rate	Channel Count	Memory Depth	Price
54621A	60 MHz	200 MSa/s	2	2 MB/ch	\$2,801
54621D	60 MHz	200 MSa/s	2 + 16	2 MB/ch	\$4,031
54622A	100 MHz	200 MSa/s	2	2 MB/ch	\$3,403
54622D	100 MHz	200 MSa/s	2 + 16	2 MB/ch	\$5,352
54624A	100 MHz	200 MSa/s	4	2 MB/ch	\$2,207

### Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

#### Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

#### Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.



### Agilent Email Updates

[www.agilent.com/find/emailupdates](http://www.agilent.com/find/emailupdates)

Get the latest information on the products and applications you select.



### Agilent Direct

[www.agilent.com/find/agilentdirect](http://www.agilent.com/find/agilentdirect)

Quickly choose and use your test equipment solutions with confidence.

### Agilent T&M Software and Connectivity

Agilent's Test and Measurement software and connectivity products, solutions and developer network allows you to take time out of connecting your instruments to your computer with tools based on PC standards, so you can focus on your tasks, not on your connections. Visit [www.agilent.com/find/connectivity](http://www.agilent.com/find/connectivity) for more information.

By internet, phone, or fax, get assistance with all your test & measurement needs

#### Online assistance:

[www.agilent.com/find/assist](http://www.agilent.com/find/assist)

#### Phone or Fax

##### United States:

(tel) 800 829 4444

##### Canada:

(tel) 877 894 4414

(fax) 800 282 6495

##### China:

(tel) 800 810 0189

(fax) 800 820 2816

##### Europe:

(tel) (31 20) 547 2323

(fax) (31 20) 547 2390

##### Japan:

(tel) (81) 426 56 7832

(fax) (81) 426 56 7840

##### Korea:

(tel) (82 2) 2004 5004

(fax) (82 2) 2004 5115

##### Latin America:

(tel) (305) 269 7500

(fax) (305) 269 7599

##### Taiwan:

(tel) 0800 047 866

(fax) 0800 286 331

##### Other Asia Pacific Countries:

(tel) (65) 6375 8100

(fax) (65) 6836 0252

Email: [tm\\_asia@agilent.com](mailto:tm_asia@agilent.com)

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2004

Printed in USA

November 15, 2004

**5980-0796EUS**

