10-bit I^2C Triggering Using an Agilent 54620/54640 Series Oscilloscope

Application Note 1428

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Table of Contents

Introduction

The basic I^2C bus, an acronym for inter-IC bus, with a data transfer rate up to 100 kbits/s and 7-bit addressing, was originally introduced nearly 20 years ago. As data transfer rates and application functionality have rapidly increased, the I^2C-bus specification has been enhanced to include 10-bit addressing and Fast Mode, meeting the demand for higher speeds and more address spaces.

The Agilent 54620 Series oscilloscopes offer I^2C trigger mode to help designers verify the I^2C communication handshaking in their embedded designs. This paper explains how to trigger an Agilent 54620 Series oscilloscope on the addressing of a 10-bit I^2C device, as well as the first data byte read from a 10-bit I^2C device, in some common situations.

I^2C Basics

The I^2C bus is a simple bi-directional, 2-wire bus developed by Philips Semiconductor in the 1980's for efficient inter-IC control. A wide range of I^2C-bus chips are available now such as AD/DA converters, EEPROM, LCD drivers, digital controllable potentiometers, etc., that allow a micro-controller to connect easily to real-world components. Most of the frame grabber and TV tuner cards on the market use the I^2C bus, for example.

The bus physically consists of a ground connection and two active wires: a serial data line (SDA) and a serial clock line (SCL). Because of the efficient 2-wire configuration used by the I^2C interface compared to that of the MICROWIRE and SPI interface, reduced board space and pin count allow the designer to have more creative flexibility while reducing interconnecting costs.

10-bit I^{2}C Addressing

Ten-bit addressing allows the use of up to 1024 additional addresses to prevent problems with the allocation of slave addresses as the number of I^{2}C devices in a system rapidly expands. Ten-bit addressing does not affect the existing 7-bit addressing, allowing devices with 7-bit or 10-bit addresses to be connected to the same I^{2}C bus. Both 7-bit and 10-bit addressing devices can be used in Standard-, Fast- or High-speed mode systems. Memory devices such as EEPROMS are one of the more common 10-bit I^{2}C address usages.

Each device is recognized by a unique address. Before data can be transferred to or from a 10-bit device, the device must first be addressed. This involves telling the devices on the bus which one has to receive or transmit data. The format for addressing a 10-bit I^{2}C device is:

S 11110XX0 A XXXXXXXX A

Where

S = start condition,

A = acknowledge, and

“XX ... XXXXXXXX” = 10-bit address of the device.

The following steps explain how to set up the scope to trigger on the addressing of a 10-bit device with an address of 0x203 (1000000011_2). Figure 1 shows the correct setup after the following steps have been completed. (See table 1 for more examples of 10-bit addressing.)

1. Set up the “Clock” and “Data” source controls just as in 7-bit I^{2}C.

2. Set the “Trigger on:” control to “Frame(Start:Addr:Write: Ack:Data)”; this is the only selection that will work.

3. Set the “Address” control to the hexadecimal value of $11110XX_2$, where XX are the two most significant bits of the 10-bit address. In this example, the two most significant bits are 10_2, so the “Address” control would be set to 1111010_2 or “0x7A”. The “Address” control will always be between 0x78 and 0x7B, inclusive, when addressing 10-bit parts.

4. Set the “Data” control to the last 8 bits of the 10-bit address, for this example 00000011_2 or "0x03".

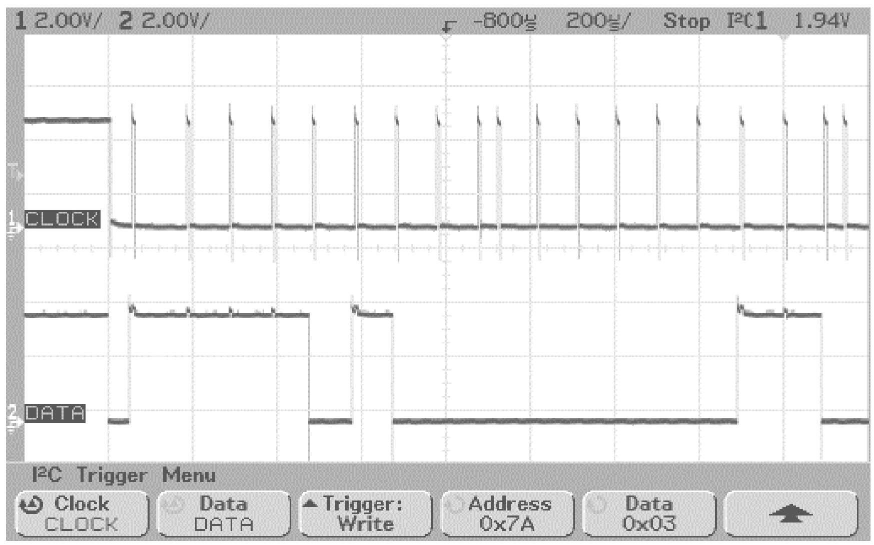

Figure 1. Setup for triggering an Agilent 54620 Series oscilloscope on the addressing of a 10-bit device with an address of 0x203 (1000000011_2)

10-Bit Address		Value of “Address” Control		Value of “Data” Control	
0x000	(0000000000_2)	“0x78”	(1111000_2)	0x00	(00000000_2)
0x001	(0000000001_2)	“0x78”	(1111000_2)	0x01	(00000001_2)
0x055	(0001010101_2)	“0x78”	(1111000_2)	0x55	(01010101_2)
0x1AA	(0110101010_2)	“0x79”	(1111001_2)	0xAA	(10101010_2)
0x1F5	(0111110101_2)	“0x79”	(1111001_2)	0xF5	(11110101_2)
0x255	(1001010101_2)	“0x7A”	(1111010_2)	0x55	(01010101_2)
0x2FA	(1011111010_2)	“0x7A”	(1111010_2)	0xFA	(11111010_2)
0x355	(1101010101_2)	“0x7B”	(1111011_2)	0x55	(01010101_2)
0x3AA	(1110101010_2)	“0x7B”	(1111011_2)	0xAA	(10101010_2)
0x3FE	(1111111110_2)	“0x7B”	(1111011_2)	0xFE	(11111110_2)
0x3FF	(1111111111_2)	“0x7B”	(1111011_2)	0xFF	(11111111_2)

Table 1. Examples of 10-bit addresses and corresponding “Address” and “Data” control values

10-bit I2C Reading

Let’s examine how to trigger an Agilent Technologies 54620 Series oscilloscope on a read from a 10-bit I2C device. The format for a read from a 10-bit I2C device is:

Sr 11110XX1 A YYYYYYYY A

Where

Sr = restart condition (sometime after the initial addressing of the 10-bit device),

A = acknowledge,

XX = two most significant bits of the 10-bit address, and

YYYYYYYY = first data byte read from the device.

Please note that this method cannot ensure that the analyzer will trigger on a specific 10-bit device, but rather it will trigger on a read from any 10-bit device that has the same two most significant bits in the address. This will not be a problem if only one 10-bit device is attached to the bus or if each of the 10-bit devices on the bus is from a different address range listed in table 2. However, if multiple 10-bit devices from the same address range are attached to the bus and can be read from, then any of those devices could generate the trigger.

The following steps explain how to set up the scope to trigger on a read from a 10-bit device with an address of 0x203 (1000000011_2)

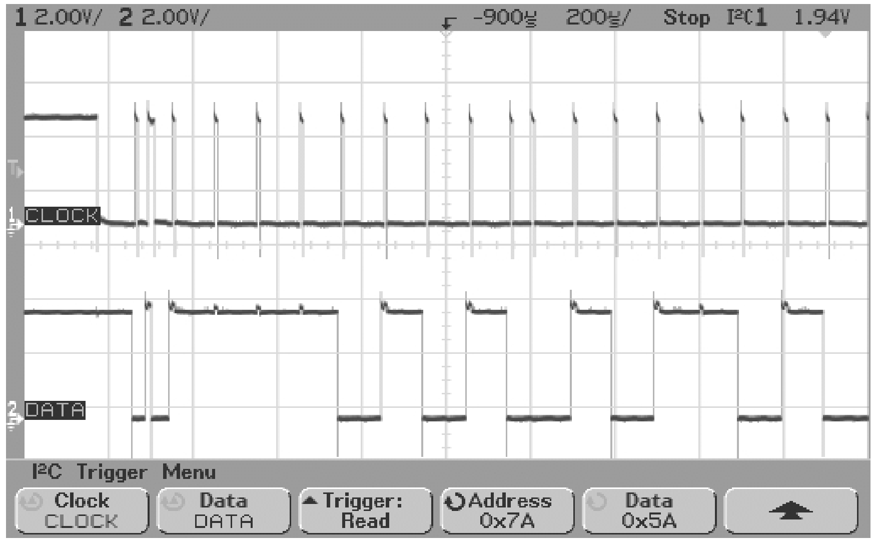

Figure 2. Setup for triggering an Agilent 54620 Series oscilloscope on the read from a 10-bit device with a 0x203 (1000000011_2) address and first data byte of 0x5A

and first data byte of 0x5A. Figure 2 shows the correct setup after the following steps have been completed.

1. Set up the “Clock” and “Data” source controls just as in 7-bit I2C.

2. Set the “Trigger on:” control to “Frame(Start:Addr:Read:Ack:Data)”; this is the only setting that will work.

3. Set the “Address” control to the hexadecimal value of 11110XX2, where XX are the two most significant bits of the 10-bit address. In this example, the two most significant bits are 10_2, so the “Address” control would be set to 11110102 or “0x7A”. The “Address” control will always be between 0x78 and 0x7B, inclusive, when addressing 10-bit parts. Refer to table 2 for the correct values of the “Address” control for a given 10-bit address.

10-bit Address Range	Value of “Address” Control
0x000 - 0x0ff	“0x78” (1111000_2)
0x100 - 0x1ff	“0x79” (1111001_2)
0x200 - 0x2ff	“0x7A’ (1111010_2)
0x300 - 0x3ff	“0x7B” (1111011_2)

Table 2. “Address” control values for 10-bit addresses

4. Set the “Data” control to either don’t care (“0xXX”) or the first byte of data expected from the 10-bit device. In this example, the first byte of data expected is 0x5A.

Conclusion

The I^2C bus is an easy and economic solution for adding peripherals to your micro-controller-based circuitry. Monitoring bus activities using a regular scope has been a very challenging job. However, with an Agilent 54620 Series oscilloscope offering I^2C trigger mode as standard, you can easily verify your I^2C communication handshaking and then use it to ensure that the correct data is being transmitted to and received from the I^2C devices.

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