

Maxim > Design Support > Technical Documents > Application Notes > Automotive > APP 5053 Maxim > Design Support > Technical Documents > Application Notes > High-Speed Interconnect > APP 5053 Maxim > Design Support > Technical Documents > Application Notes > Video Circuits > APP 5053

Keywords: high speed interconnect, GMSL, BER, eye diagram, pre-emphasis, equalization, serializer, deserializer, serdes, PRBS

#### **APPLICATION NOTE 5053**

# Using 2.5Gbps SerDes with Built-In Bit-Error Rate Test Circuitry Makes Measuring Link Quality Easy

By: Craig Sakamoto Wai Phyo Jun 06, 2011

Abstract: Any application that involves sending information at high data rates over long distances requires tests to ensure good link quality. Thus, this applies to the MAX9259/MAX9260 gigabit multimedia serial link (GMSL) serializer/deserializer (SerDes), a chipset that sends audio/video data at payload rates of up to 2.5Gbps over a single twisted-pair cable up to 15m in length. This application note describes how to use the built-in bit-error rate (BER) tester and how to analyze eye diagrams to measure link quality with the MAX9259/MAX9260 evaluation (EV) kits. It also assists in proper jumper settings, measurement steps, and interpretation of results.

#### Introduction

Any application that involves sending information at high data rates over long distances requires tests to ensure good link quality, and the MAX9259/MAX9260 gigabit multimedia serial link (GMSL) serializer/deserializer (SerDes) are no exception. This chipset sends audio/video data at payload rates of up to 2.5Gbps over a single twisted-pair cable up to 15m in length. One of the most straightforward tests of link quality is the bit-error rate (BER) test. Here, the transmitter sends a known data pattern across the serial link and the receiver checks the incoming data for any bit errors. A second test, the eye diagram, gives a graphical presentation of the link quality.

Both of these tests require a suitable pattern to be generated and transmitted over the serial link. While various test patterns are available, one of the common choices is to use is a long pseudorandom bit sequence (PRBS).

The MAX9259/MAX9260 chipset features an internal PRBS generator and BER checker to simplify testing, requiring only a parallel clock and a UART port to program the devices. The MAX9259 sends a 2<sup>30</sup> - 1 (in 32-bit mode) or a 2<sup>22</sup> - 1 (in 24-bit mode) PRBS data pattern across the serial link. The MAX9260 checks the received data and records the number of bit errors. This application note describes how to set up the MAX9259/MAX9260 evaluation (EV) kits for the internal PRBS test with bit-error analysis. It also compares test results for the default and optimized preemphasis/equalizer settings using a 15m cable.

Note that data sheets for the chipset and the EV kits, as well as the latest software, can be obtained through Maxim's website.

### **Required Equipment**

- MAX9259 and MAX9260 EV kits
- Agilent® 33250A arbitrary waveform generator or similar device for clock generation
- USB cable
- · Shielded twisted-pair cable with Rosenberger connectors

(Optional to analyze the eye diagram)

Agilent DSO81004B or similar high-bandwidth digital oscilloscope

• Tektronix® P6248 differential probes or similar probes



Figure 1. MAX9259/MAX9260 EV kits with 15m STP cable bench setup.

## Built-In BER Test

Generally, getting a PRBS output from a serializer would require inputting data on all inputs to be serialized. For the MAX9259, this would require inputting data on the video, audio, and UART inputs. This can easily become very complicated due to the large differences in bit rates of the three interfaces. The MAX9259 includes an internal PRBS generator, which can be controlled through a single UART command. Set PRBSEN = 1 on the MAX9259 to turn on the PRBS generator. The serial data rate will be 30x PCLK (24-bit mode) or 40x PCLK (32-bit mode) based on the bus-width selection (BWS).

**Table 1** below shows the results of BER test performed with different PCLK frequencies, a 15m STP cable with Rosenberger connector, 1.1dB or 10.5dB preemphasis, and a 9.4dB equalization level.

Table 1. 15m, 32-Bit BER vs. PCLK Frequency for 1.1dB or 10.5dB Preemphasis and 9.4dB Equalization Settings			
Input PCLK Frequency (MHz)	Errors at 1.1dB Preemphasis	Errors at 10.5dB Preemphasis	
12.5	0	0	
15	0	0	
20	0	0	
25	0	0	
30	0	0	
35	0	0	

40	0	0
45	0	0
50	23	0
55	78	0
60	106	0
65	255	0

#### Activating the PRBS Mode

To begin the testing procedure, follow these guidelines to power up the EV kits and start the software.

- 1. Verify that the EV kit boards, software, and drivers are properly installed and operating by running through the *Quick Start* procedures as discussed in the MAX9259EVKIT/MAX9260EVKIT data sheets.
- 2. Verify that all the jumpers are set in the following positions, as shown in **Table 2**.

Table 2. MAX9259/MAX9260 EV Kits Jumper Settings for PRBS Test				
Jumper	Signal	Shunt Position	Description	
JU1	CDS	2-3	CDS = low; ECU attached to MAX9259; connect USB to MAX9259 EV kit	
SW1	MS	2-3 (toggle switch down)	MS = low; half-duplex base mode; required when writing to device registers or when using an external I <sup>2</sup> C peripheral	
JU2	BWS	1-2	BWS = high for 32-bit bus mode	
JU3	ES	2-3	ES = low	
JU4	DRS	2-3	DRS = low for parallel input data rates of 12.5MHz to 78MHz (32-bit bus mode)	
JU5	SSEN	2-3	SSEN = low	
JU6	PWDN	1-2	PWDN = high	
JU7	AUTOS	2-3	AUTOS = Iow	
JU8	H1 odd pins	2-3	2-3 H1 odd-numbered pins connect to GND	
JU9	BUS power	1-2	J1 pin 1, J4 pin 1, and J5 pin 1 connect to VIN	
JU10	BUS power	1-2	J1 pin 1, J4 pin 1, and J5 pin 1 connect to USB 5V	
JU21	AVDD	1-2	AVDD power from 1.8V LDO U2, powered by VIN	
JU22	DVDD	1-2	DVDD power from 1.8V LDO U2, powered by VIN	
JU23	IOVDD	1-2	1-2 IOVDD power from 1.8V LDO U2, powered by VIN	

3. Connect the STP cable from MAX9259 EV kit connector J1 to MAX9260 EV kit connector J1.

4. Connect the parallel data source or arbitrary waveform generator output to header H1-62, PCLK\_IN. Set the parallel data source frequency between 12.5MHz to 78MHz and enable the output.

5. Connect the USB cable from the PC to the MAX9259 EV kit.

- 6. Verify that MAX9259 EV kit LED120 lights up, indicating that the microcontroller is powered and enabled.
- 7. Verify that MAX9260 EV kit LED120 lights up, indicating that the microcontroller is powered and enabled.
- 8. Verify that MAX9260 EV kit LED2 lights up, indicating that the link has been successfully established. If LED2 is off or LED1 is on, double-check that the PCLK\_IN signal is clocking data.
- 9. Start the MAX9259/MAX9260 EV kit program by opening its icon in the **Start | Programs** menu. The EV kit software configuration window appears as shown in **Figure 2**.
- 10. Press the **Connect** button and the configuration window disappears.

MAX9259 and Controller Which side of the MAX9259 (s Device Address Connect USB of	MAX9260 EV kit Configuratio	<ul> <li>MAX9260 (dese Device Address of I</li> <li>KIT connector J10.</li> </ul>	rializer) Deserializer 0x90	
MAX9259EVKIT J	umpers and Switches	MAX9260EVKIT J	lumpers and Switches	
JU1 (CDS)	2-3 (low) ECU	JU1 (CDS)	2-3 (low) Peripheral	•
SW1 (MS)	DOWN (low) base mode	SW1 (MS)	DOWN (low) base mode	•
JU2 (BWS)	2-3 (low) 24 bit bus	JU2 (BWS)	2-3 (low) 24 bit bus	-
JU3 (ES)	2-3 (low) rising edge	JU3 (ES)	2-3 (low) rising edge	-
JU4 (DRS)	1-2 (high) slow	JU4 (DRS)	1-2 (high) slow	•
JU5 (SSEN)	2-3 (low) disable	JU5 (SSEN)	2-3 (low) disable	-
JU6 (PWRDN)	1-2 (high) operate	JU6 (PWRDN)	1-2 (high) operate	-
JU7 (AUTOS)	2-3 (low) auto link	JU7 (DCS)	2-3 (low) normal DOUT	-
		JU8 (ENABLE)	1-2 (high) enable DOUT	•
		JU9 (EQS)	2-3 (low) equalize long cable	•
		SW2 (INT)	DOWN (low)	-
MAX9259EVKIT A	Attached Peripherals	MAX9260EVKIT	Attached Peripherals	
I2S Audio Bus	12S Audio Input	12S Audio Bus	12S Audio Output	
External TX / RX	Control (EV kit USB)	External TX / RX	Optional I2C Peripheral	
Connect			Cancel - do not connec	x

Figure 2. MAX9259/60 EV kits software configuration window.

11. The **Read All** button reads the entire MAX9259 and MAX9260 device registers. The **Write All** button writes all MAX9259 and MAX9260 device registers with the values shown **Figure 3** and **Figure 4**.

IAX9259	Block Diagram MAX9259 MAX9260 MAX7324 PRBS Test Interface History and Low Level Access	MAX9260
PCLK source	Register 0x00 Read Device Address of Serializer Ox80 Write	PCLK sin
data source DINO	Register 0x01 Read Device Address of Deserializer 0x90 Write Register 0x02 CENC	data sink DINO
DIN20	Read 000: off T 11: auto detect T 11: auto detect T	DIN20
CLK.n.c. ⊮S.n.c.	Register 0x03 Read AUTOFM 00: one time V SDIV 0: auto calibrate Vite	SCLK gpio WS gpio
NT sink	Register 0x04	INT sourc
ECU	Register 0x05         I2CMETHOD         CMLLVL         PREEMP           Read         Image: Comparison of the second sec	periphera
of 10 read dress 0x80	Register 0x08           Read         LFPOS:         10: normal         Image: Comparison of the second	13 of 13 re address 0x5
	Register 0x0D Read SETINT Write	
	Register 0x1E Read Device ID: 0x01 Write	
	Register 0x1F Read Device Revision: 0x01	

Figure 3. MAX9259/MAX9260 EV kits software main window (MAX9259 tab).

	Block Diagram MAX9259 MAX9260 MAX7324 PRBS Test Interface History and Low Level Access	MAX92
CLK jurce	Register 0x00 Read P Device Address of Serializer 0x80 Write	PCLK s
lata	Register 0x01 Read Device Address of Deserializer 0x90 Write	data si
ino INO IN20	Register 0x02     SS     PRNG     SRNG       Read     00: off     Image: AUDIOEN     11: auto detect     Image: Million of the second seco	DIN DIN2
K.n.c. i.n.c.	Register 0x03       Read       AUTOFM       00: one time       SDIV       0: auto calibrate       Write	SCLK g WS gr
r sink	Register 0x04	INT sou
CU	Register 0x05 12CMETHOD HPFTUNE PDHF EQTUNE Write 1001: 10.7 dB	periphe
d All '59 10 read ess 0x80	Register 0x06 Read DISSTAG AUTORST DISINT INT Write GPI010UT GPI01 GPI000UT GPI00	Read Al 13 of 13 address (
	Register 0x0C Read P Error threshold ERRTHR: 0 Write	
	Register 0x0D Read Decoding error counter DECERR: 0	
	Register 0x0E Read PRBS error counter PRBSERR: 0	
	Register 0x12 Read MCLKSRC 0: BCLK Write	
	Register 0x1E Read Device ID: 0x02 Write	
	Register 0x1F Read Device Revision: 0x01 Write	

Figure 4. MAX9259/MAX9260 EV kits software main window (MAX9260 tab).

- 12. From the MAX9260 tab sheet (Figure 4), read the 8-bit error count register (0x0E) to clear the errors before the PRBS test.
- 13. Set PRBSEN = 1 (0x04 D5) first in the MAX9259 and then the MAX9260 to start the PRBS test.
- 14. Run the PRBS self test for the desired test time, and then set PRBSEN = 0 (0x04 D5), first in the MAX9260 tab and then the MAX9259 tab to exit the PRBS self test.
- 15. Read 8-bit error count register (0x0E) in the MAX9260 tab once. The total number of bit errors will report in the

window in "PRBS error counter PRBSERR." The error counter register is an 8-bit register, so the maximum number of errors that can be recorded is 255.

# Eye Diagram

The BER test is a straightforward method to measure the link quality. Another approach to evaluate the system performance is analyzing the eye diagram opening. This provides a graphical presentation of the link quality, as well as insight into the nature of channel imperfections. **Figure 5** and **Figure 6** are eye diagrams of a serial link captured with a high-bandwidth digital oscilloscope (in infinite persistence mode) at the deserializer side of a 15m STP cable. The preemphasis settings of 1.1dB (Figure 5) and 10.5dB (Figure 6) were selected to provide the visible differences in the eye diagrams. The user can determine impedance mismatches, reflections, timing variation, and even frequency attenuation issues from the analysis of eye diagrams.



Figure 5. PRBS mode—eye diagram (15m cable with 1.1dB preemphasis setting).



Figure 6. PRBS mode—eye diagram (15m cable with 10.5dB preemphasis setting).

Agilent is a registered trademark and registered service mark of Agilent Technologies, Inc. Tektronix is a registered trademark and registered service mark of Tektronix, Inc.

Related Parts		
MAX9259	Gigabit Multimedia Serial Link with Spread Spectrum and Full-Duplex Control Channel	Free Samples
MAX9259EVKIT	Evaluation Kit for the MAX9259	
MAX9260	Gigabit Multimedia Serial Link with Spread Spectrum and Full-Duplex Control Channel	Free Samples
MAX9260EVKIT	Evaluation Kit for the MAX9260	
MAX9263	HDCP Gigabit Multimedia Serial Link Serializer/Deserializer	Free Samples
MAX9264	HDCP Gigabit Multimedia Serial Link Serializer/Deserializer	Free Samples
MAX9265	HDCP Gigabit Multimedia Serial Link Serializer with LVDS System Interface	Free Samples
MAX9266	HDCP Gigabit Multimedia Serial Link Deserializer with LVDS System Interface	Free Samples
MAX9268	Gigabit Multimedia Serial Link Deserializer with LVDS System Interface	

More Information For Technical Support: http://www.maximintegrated.com/support For Samples: http://www.maximintegrated.com/samples Other Questions and Comments: http://www.maximintegrated.com/contact

Application Note 5053: http://www.maximintegrated.com/an5053 APPLICATION NOTE 5053, AN5053, AN 5053, APP5053, Appnote5053, Appnote 5053 Copyright © by Maxim Integrated Products Additional Legal Notices: http://www.maximintegrated.com/legal