DS90UB913A-Q1/DS90UB914A-Q1 25 to100 MHz 10/12-Bit FPD-Link III Serializer and Deserializer

Check for Samples: DS90UB913A-Q1, DS90UB914A-Q1

FEATURES

- **25 MHz to 100 MHz Input Pixel Clock Support**
- **Coaxial or Single Differential Pair Interconnect**
- **Programmable Data Payload:**
  - **10-bit Payload up to 100 Mhz**
  - **12-bit Payload up to 75 MHz**
- **Continuous Low Latency Bidirectional Control Interface Channel with I2C™ Support @400 kHz**
- **2:1 Multiplexer to choose between two input images**
- **Embedded Clock with DC-balanced Coding to Support AC-coupled Interconnects**
- **Capable of Driving up to 15m Coaxial or 20m Shielded Twisted-pair Cables**
- **Receive Equalizer Automatically Adapts for Changes in Cable Loss**
- **4 Dedicated General Purpose Input (GPI)/ Output (GPO)**
- **LOCK Output Reporting Pin and @SPEED BIST Diagnosis Feature to Validate Link Integrity**
- **1.8V, 2.8V or 3.3V-Compatible Parallel Inputs on Serializer**
- **Single Power Supply at 1.8V**
- **ISO 10605 and IEC 61000-4-2 ESD Compliant**
- **Automotive Grade Product: AEC-Q100 Grade 2 qualified**
- **Temperature Range −40°C to +105°C**
- **Small Serializer Rootprint (5mm x 5mm)**
- **EMI/EMC Mitigation - Deserializer**
  - **Programmable Spread Spectrum (SSCG) Outputs**
  - **Receiver Staggered Outputs**

APPLICATIONS

- **Front or Rear-View Camera for Collision Mitigation**
- **Surround View for Parking Assistance**

DESCRIPTION

The DS90UB913A-Q1/DS90UB914A-Q1 chipset offers a FPD-Link III interface with a high-speed forward channel and a bidirectional control channel for data transmission over a single coaxial cable or differential pair. The DS90UB913A-Q1/914A-Q1 chipset incorporates differential signaling on both the high-speed forward channel and bidirectional control channel data paths. The serializer/deserializer pair is targeted for connections between imagers and video processors in an ECU (Electronic Control Unit). This chipset is ideally suited for driving video data requiring up to 12-bit pixel depth plus two synchronization signals along with bidirectional control channel bus.

The deserializer features a multiplexer to allow selection between two input imagers, one active at a time. The primary video transport converts 10-bit or 12-bit data to a single high-speed serial stream, along with a separate low latency bidirectional control channel transport that accepts control information from an I2C port and is independent of video blanking period.

Using TI's embedded clock technology allows transparent full-duplex communication over a single differential pair, carrying asymmetrical bidirectional control channel information in both directions. This single serial stream simplifies transferring a wide data bus over PCB traces and cable by eliminating the skew problems between parallel data and clock paths. This significantly saves system cost by narrowing data paths that in turn reduce PCB layers, cable width, and connector size and pins. In addition, the Deserializer inputs provide adaptive equalization to compensate for loss from the media over longer distances. Internal DC-balanced encoding/decoding is used to support AC-coupled interconnects. The DS90UB913A-Q1 serializer is offered in a 32-pin WQFN package and the DS90UB914A-Q1 deserializer is offered in a 48-pin WQFN package.

Typical Application Diagram

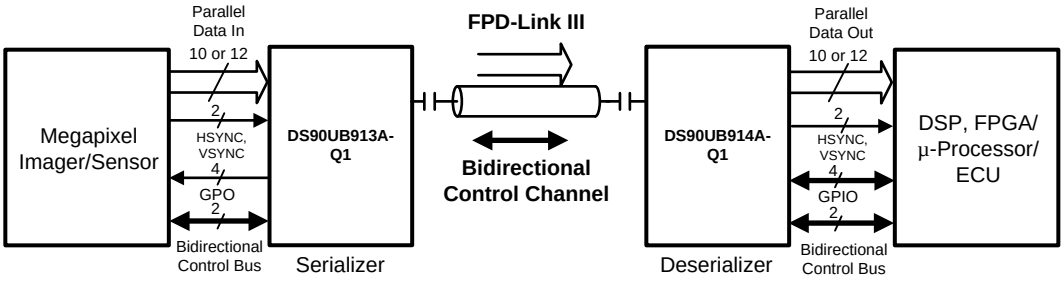

Figure 1. Typical Application Circuit

Block Diagrams

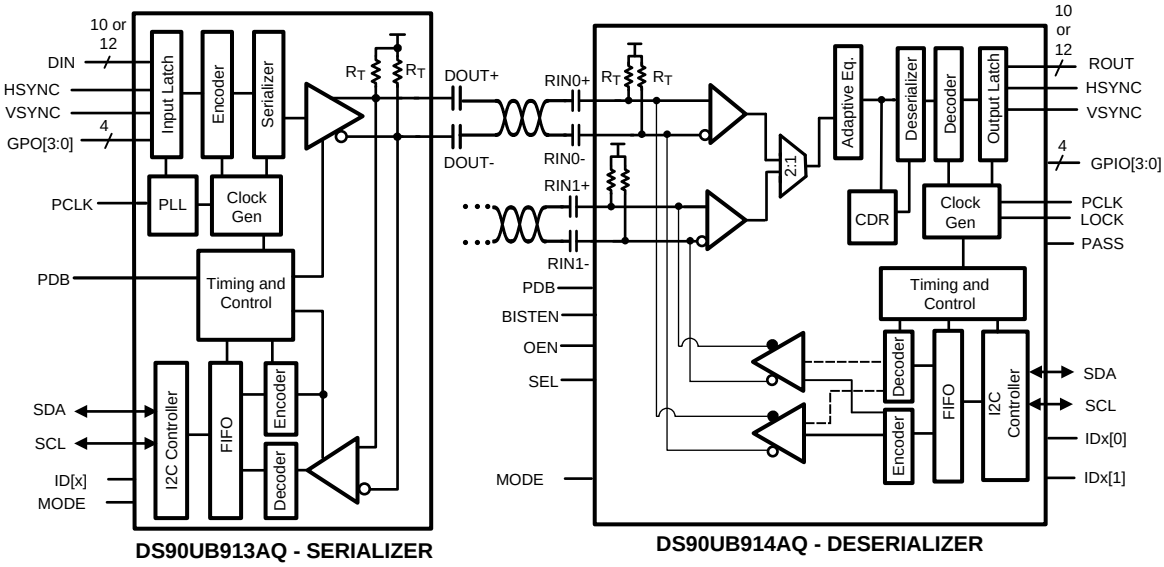

Figure 2. Block Diagram

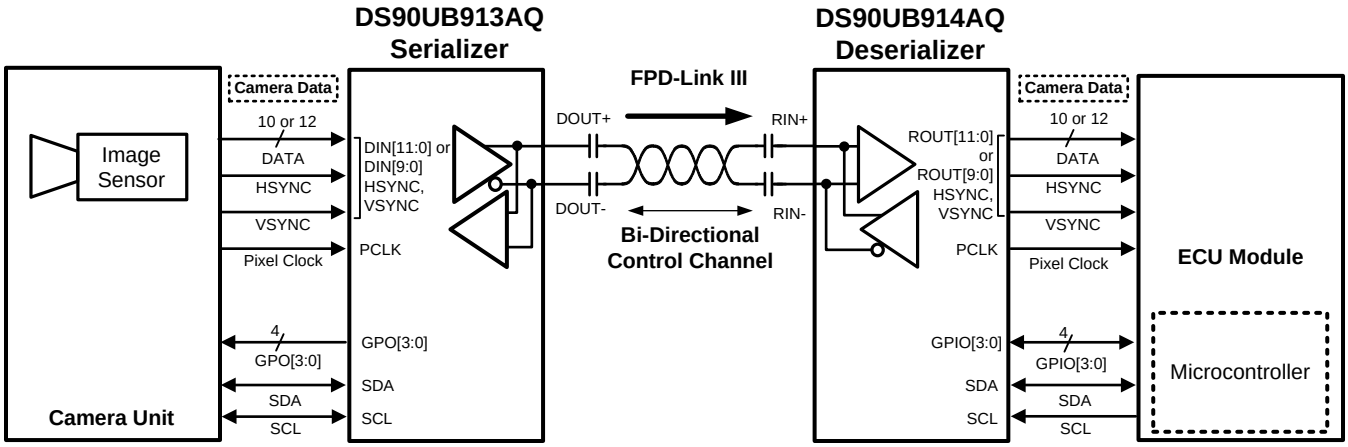

Figure 3. Application Block Diagram

DS90UB913A-Q1 Pin Diagram

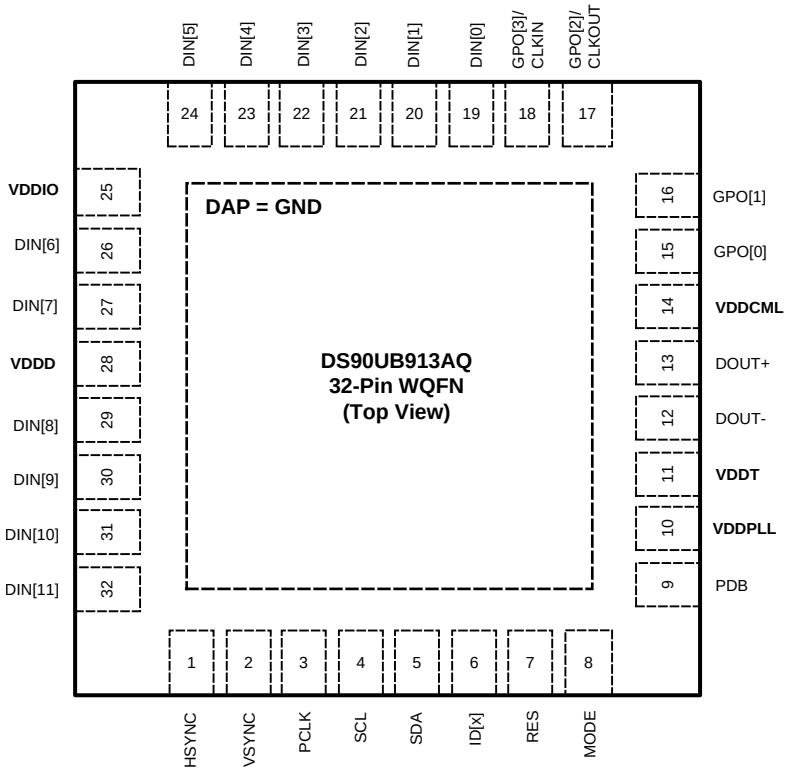

Figure 4. Serializer - DS90UB913A-Q1 — Top View

DS90UB913A-Q1 Serializer Pin Descriptions

Table 1. Pin Descriptions

Pin Name	Pin No.	I/O, Type	Description
LVCMOS PARALLEL INTERFACE			
DIN[0:11]	19,20,21,22, 23,24,26,27, 29,30,31,32	Inputs, LVCMOS w/ pull down	Parallel Data Inputs.
HSYNC	1	Inputs, LVCMOS w/ pull down	Horizontal SYNC Input.
VSYNC	2	Inputs, LVCMOS w/ pull down	Vertical SYNC Input.
PCLK	3	Input, LVCMOS w/ pull down	Pixel Clock Input Pin. Strobe edge set by TRFB control register.
GENERAL PURPOSE OUTPUT (GPO)			
GPO[1:0]	16,15	Output, LVCMOS	General-purpose output pins can be configured as outputs; used to control and respond to various commands. GPO[1:0] can be configured to be the outputs for input signals coming from GPIO[1:0] pins on the Deserializer or can be configured to be outputs of the local register on the Serializer.
GPO[2]/CLKOUT	17	Output, LVCMOS	GPO2 pin can be configured to be the output for input signal coming from the GPIO2 pin on the Deserializer or can be configured to be the output of the local register on the Serializer. It can also be configured to be the output clock pin when the DS90UB913A-Q1 device is used in the External Oscillator mode. See Applications Information for a detailed description of the DS90UB913A/914A chipsets working with the external oscillator.

Table 1. Pin Descriptions (continued)

Pin Name	Pin No.	I/O, Type	Description
GPO[3]/CLKIN	18	Input/Output, LVCMOS	GPO3 can be configured to be the output for input signals coming from the GPIO3 pin on the Deserializer or can be configured to be the output of the local register setting on the Serializer. It can also be configured to be the input clock pin when the DS90UB913A-Q1 Serializer is working with an external oscillator. See Applications Information section for a detailed description of the DS90UB913A/914A chipsets working with an external oscillator.
BIDIRECTIONAL CONTROL BUS - I2C-COMPATIBLE			
SCL	4	Input/Output, Open Drain	Clock line for the bidirectional control bus communication. SCL requires an external pull-up resistor to V_{DDIO}.
SDA	5	Input/Output, Open Drain	Data line for the bidirectional control bus communication. SDA requires an external pull-up resistor to V_{DDIO}.
MODE	8	Input, LVCMOS w/ pull down	**Device mode select**. Resistor to Ground and 10 kΩ pull-up to 1.8V rail. MODE pin on the Serializer can be used to select whether the system is running off the PCLK from the imager or an external oscillator. See details in Table 7.
ID[x]	6	Input, analog	**Device ID Address Select**. The ID[x] pin on the Serializer is used to assign the I2C device address. Resistor to Ground and 10 kΩ pull-up to 1.8V rail. See Table 9.
CONTROL AND CONFIGURATION			
PDB	9	Input, LVCMOS w/ pull down	**Power down Mode Input Pin.** PDB = H, Serializer is enabled and is ON. PDB = L, Serializer is in Power Down mode. When the Serializer is in Power Down, the PLL is shutdown, and IDD is minimized. Programmed control register data are NOT retained and reset to default values.
RES	7	Input, LVCMOS w/ pull down	Reserved. **This pin MUST be tied LOW.**
FPD–Link III INTERFACE			
DOUT+	13	Input/Output, CML	Non-inverting differential output, bidirectional control channel input. The interconnect must be AC Coupled with a 0.1µF capacitor.
DOUT-	12	Input/Output, CML	Inverting differential output, bidirectional control channel input. The interconnect must be AC Coupled with a 0.1µF capacitor. For applications using single-ended coaxial interconnect, terminate to Ground with a 0.047µF capacitor.
POWER AND GROUND			
VDDPLL	10	Power, Analog	PLL Power, 1.8V ±5%.
VDDT	11	Power, Analog	Tx Analog Power, 1.8V ±5%.
VDDCML	14	Power, Analog	CML & Bidirectional Channel Driver Power, 1.8V ±5%.
VDDD	28	Power, Digital	Digital Power, 1.8V ±5%.
VDDIO	25	Power, Digital	Power for I/O stage. The single-ended inputs and SDA, SCL are powered from V_{DDIO}. V_{DDIO} can be connected to a 1.8V ±5% or 2.8±10% or 3.3V ±10%.
VSS	DAP	Ground, DAP	DAP must be grounded. DAP is the large metal contact at the bottom side, located at the center of the WQFN package. Connected to the ground plane (GND) with at least 9 vias.

DS90UB914A-Q1 Pin Diagram

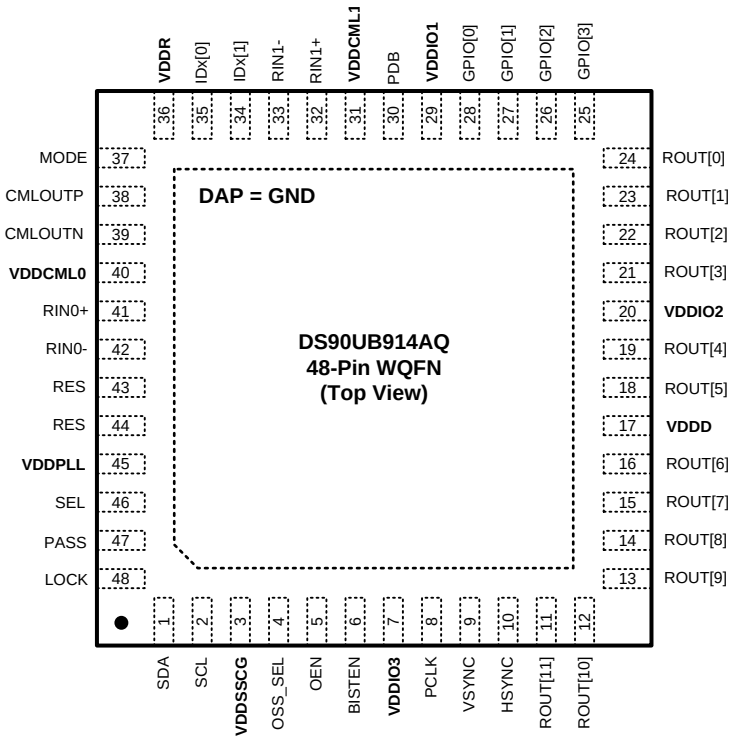

Figure 5. Deserializer - DS90UB914A-Q1 — Top View

DS90UB914A-Q1 Deserializer Pin Descriptions

Table 2. Pin Descriptions

Pin Name	Pin No.	I/O, Type	Description
LVCMOS PARALLEL INTERFACE			
ROUT[11:0]	11,12,13,14, 15,16,18,19, 21,22,23,24	Outputs, LVCMOS	Parallel Data Outputs.
HSYNC	10	Output, LVCMOS	Horizontal SYNC Output. Note: HS transition restrictions: 1. 12-bit Low-Frequency mode: No HS restrictions (raw) 2. 12-bit High-Frequency mode: No HS restrictions (raw) 3. 10-bit High-Frequency mode: HS restricted to no more than one transition per 10 PCLK cycles.
VSYNC	9	Output, LVCMOS	Vertical SYNC Output. Note: VS transition restrictions: 1. 12-bit Low-Frequency mode: No VS restrictions (raw) 2. 12-bit High-Frequency mode: No VS restrictions (raw) 3. 10-bit High-Frequency mode: VS restricted to no more than one transition per 10 PCLK cycles.
PCLK	8	Output, LVCMOS	Pixel Clock Output Pin. Strobe edge set by RRFB control register.
GENERAL PURPOSE INPUT/OUTPUT (GPIO)			
GPI0[1:0]	27,28	Digital Input/Output, LVCMOS	General-purpose input/output pins can be used to control and respond to various commands. They may be configured to be the input signals for the corresponding GPOs on the serializer or they may be configured to be outputs to follow local register settings.
GPIO[3:2]	25,26	Digital Input/Output LVCMOS	General purpose input/output pins GPO[3:2] can be configured to be input signals for GPOs on the Serializer. In addition they can also be configured to be outputs to follow the local register settings. When the SerDes chipsets are working with an external oscillator, these pins can be configured only to be outputs to follow the local register settings.

Table 2. Pin Descriptions (continued)

Pin Name	Pin No.	I/O, Type	Description
BIDIRECTIONAL CONTROL BUS - I2C COMPATIBLE			
SCL	2	Input/Output, Open Drain	Clock line for the bidirectional control bus communication. SCL requires an external pull-up resistor to V_{DDIO}.
SDA	1	Input/Output, Open Drain	Data line for bidirectional control bus communication SDA requires an external pull-up resistor to V_{DDIO}.
MODE	37	Input, LVCMOS w/ pull up	**Device mode select pin** Resistor to Ground and 10 kΩ pull-up to 1.8V rail. The MODE pin on the Deserializer can be used to configure the Serializer and Deserializer to work in different input PCLK range. See details in Table 8. **12– bit low frequency mode – (25- 50 MHz operation):** In this mode, the Serializer and Deserializer can accept up to 12-bits DATA+2 SYNC. Input PCLK range is from 25MHz to 50MHz. Note: No HS/VS restrictions. **12– bit high frequency mode – (25-75 MHz operation):** In this mode, the Serializer and Deserializer can accept up to 12-bits DATA + 2 SYNC. Input PCLK range is from 25MHz to 75MHz. Note: No HS/VS restrictions. **10–bit mode– (25–100 MHz operation):** In this mode, the Serializer and Deserializer can accept up to 10-bits DATA + 2 SYNC. Input PCLK frequency can range from 25 MHz to 100MHz. Note: HS/VS restricted to no more than one transition per 10 PCLK cycles. Please refer to Table 8 on how to configure the MODE pin on the Deserializer.
IDx[0:1]	35,34	Input, analog	The IDx[0] and IDx[1] pins on the Deserializer are used to assign the I2C device address. Resistor to Ground and 10 kΩ pull-up to 1.8V rail. See Table 10 Input pin to select the Slave Device Address. Input is connected to external resistor divider to set programmable Device ID address.
CONTROL AND CONFIGURATION			
PDB	30	Input, LVCMOS w/ pull down	**Power down Mode Input Pin.** PDB = H, Deserializer is enabled and is ON. PDB = L, Deserializer is in power down mode. When the Deserializer is in power down mode, programmed control register data are NOT retained and reset to default values.
LOCK	48	Output, LVCMOS	**LOCK Status Output Pin.** LOCK = H, PLL is Locked, outputs are active. LOCK = L, PLL is unlocked, ROUT and PCLK output states are controlled by OSS_SEL control register. May be used as Link Status.
BISTEN	6	Input LVCMOS w/ pulldown	**BIST Enable pin** **BISTEN=H**, BIST Mode is enabled. **BISTEN=L**, BIST Mode is disabled.
PASS	47	Output, LVCMOS	**PASS Output Pin for BIST mode.** **PASS = H**, ERROR FREE Transmission. **PASS = L**, one or more errors were detected in the received payload. See BIST section for more information. Leave Open if unused. Route to test point (pad) recommended.
OEN	5	Input LVCMOS w/ pulldown	Output Enable Input. Refer to Table 11.
OSS_SEL	4	Input LVCMOS w/ pulldown	Output Sleep State Select Pin Refer to Table 11.
SEL	46	Input LVCMOS w/ pulldown	MUX Select line. **SEL = L**, RIN0+/- input. This selects input A as the active channel on the Deserializer. **SEL = H**, RIN1+/- input. This selects input B as the active channel on the Deserializer.
FPD–Link III INTERFACE			
RIN0+	41	Input/Output, CML	Non-Inverting Differential input, bidirectional control channel. The IO must be AC coupled with a 0.1µF capacitor.
RIN0-	42	Input/Output, CML	Inverting Differential input, bidirectional control channel. The IO must be AC coupled with a 0.1µF capacitor. For applications using single-ended coaxial interconnect, terminate to Ground with a 0.047µF capacitor.
RIN1+	32	Input/Output, CML	Non-Inverting Differential input, bidirectional control channel. The IO must be AC coupled with a 0.1µF capacitor.

Table 2. Pin Descriptions (continued)

Pin Name	Pin No.	I/O, Type	Description
RIN1-	33	Input/Output, CML	Inverting Differential input, bidirectional control channel. The IO must be AC coupled with a 0.1µF capacitor. For applications using single-ended coaxial interconnect, terminate to Ground with a 0.047µF capacitor.
RES	43,44	—	Reserved. **This pin must always be tied low**.
CMLOUTP/N	38,39		Route to test point or leave open if unused.
POWER AND GROUND			
VDDIO1/2/3	29, 20, 7	Power, Digital	LVCMOS I/O Buffer Power, The single-ended outputs and control input are powered from V_{DDIO}. V_{DDIO} can be connected to a 1.8V ±5% or 3.3V ±10%.
VDDD	17	Power, Digital	Digital Core Power, 1.8V ±5%.
VDDSSCG	3	Power, Analog	SSCG PLL Power, 1.8V ±5%.
VDDR	36	Power, Analog	Rx Analog Power, 1.8V ±5%.
VDDCML0/1	40,31	Power, Analog	CML and Bidirectional control channel Drive Power, 1.8V±5%.
VDDPLL	45	Power, Analog	PLL Power, 1.8V ±5%.
VSS	DAP	Ground, DAP	DAP must be grounded. DAP is the large metal contact at the bottom side, located at the center of the WQFN package. Connected to the ground plane (GND) with at least 16 vias.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage – V_{DDn} (1.8V)	−0.3V to +2.5V
Supply Voltage – V_{DDIO}	−0.3V to +4.0V
LVCMOS Input Voltage I/O Voltage	−0.3V to + (VDDIO + 0.3V)
CML Driver I/O Voltage (V_{DD})	−0.3V to +(V_{DD} + 0.3V)
CML Receiver I/O Voltage (V_{DD})	−0.3V to (V_{DD} + 0.3V)
Junction Temperature	+150°C
Storage Temperature	−65°C to +150°C
Package Derating: DS90UB913A-Q1 32L WQFN	
θ_{JA} *(based on 16 thermal vias)*	38.4 °C/W
θ_{JC} *(based on 16 thermal vias)*	6.9 °C/W
Package Derating: DS90UB914A-Q1 48L WQFN	
θ_{JA} *(based on 16 thermal vias)*	26.9 °C/W
θ_{JC} *(based on 16 thermal vias)*	4.4 °C/W
ESD Rating (IEC 61000-4-2)	R_D = 330Ω, C_S = 150pF
Air Discharge (DOUT+, DOUT-, RIN+, RIN-)	≥±25 kV
Contact Discharge (DOUT+, DOUT-, RIN+, RIN-)	≥±7 kV
ESD Rating (ISO10605)	R_D = 330Ω, C_S = 150/330pF
ESD Rating (ISO10605)	R_D = 2KΩ, C_S = 150/330pF
Air Discharge (DOUT+, DOUT-, RIN+, RIN-)	≥±15 kV
Contact Discharge (DOUT+, DOUT-, RIN+, RIN-)	≥±8 kV
ESD Rating (HBM)	≥±8 kV
ESD Rating (CDM)	≥±1 kV
ESD Rating (MM)	≥±250 V

For soldering specifications: see product folder at www.ti.com and www.ti.com/lit/an/snoa549c/snoa549c.pdf

(1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional; the device should not be operated beyond such conditions.

RECOMMENDED OPERATING CONDITIONS

	Min	Nom	Max	Units
Supply Voltage (V_{DDn})	1.71	1.8	1.89	V
LVCMOS Supply Voltage (V_{DDIO}) OR	1.71	1.8	1.89	V
LVCMOS Supply Voltage (V_{DDIO}) OR	3.0	3.3	3.6	V
LVCMOS Supply Voltage (V_{DDIO}) Only Serializer	2.52	2.8	3.08	V
Supply Noise (1)				
V_{DDn} (1.8V)			25	mVp-p
V_{DDIO} (1.8V)			25	mVp-p
V_{DDIO} (3.3V)			50	mVp-p
Operating Free Air Temperature (T_A)	-40	+25	+105	°C
PCLK Clock Frequency	25		100	MHz

(1) Supply noise testing was done with minimum capacitors (as shown on Figure 49, Figure 47, Figure 50, and Figure 48 on the PCB. A sinusoidal signal is AC coupled to the VDDn (1.8V) supply with amplitude = 25 mVp-p measured at the device VDDn pins. Bit error rate testing of input to the Ser and output of the Des with 10 meter cable shows no error when the noise frequency on the Ser is less than 1 MHz. The Des on the other hand shows no error when the noise frequency is less than 750 kHz.

ELECTRICAL CHARACTERISTICS (1) (2) (3)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
LVCMOS DC SPECIFICATIONS 3.3V I/O (SER INPUTS, DES OUTPUTS, GPI, GPO, CONTROL INPUTS AND OUTPUTS)							
V_{IH}	High Level Input Voltage	V_{IN} = 3.0V to 3.6V		2.0		V_{IN}	V
V_{IL}	Low Level Input Voltage	V_{IN} = 3.0V to 3.6V		GND		0.8	V
I_{IN}	Input Current	V_{IN} = 0V or 3.6V V_{IN} = 3.0V to 3.6V		-20	±1	+20	µA
V_{OH}	High Level Output Voltage	V_{DDIO} = 3.0V to 3.6V I_{OH} = −4 mA		2.4		V_{DDIO}	V
V_{OL}	Low Level Output Voltage	V_{DDIO} = 3.0V to 3.6V I_{OL} = +4 mA		GND		0.4	V
I_{OS}	Output Short Circuit Current	V_{OUT} = 0V	Serializer GPO Outputs		-15		mA
			Deserializer LVCMOS Outputs		-35		
I_{OZ}	TRI-STATE® Output Current	PDB = 0V, V_{OUT} = 0V or V_{DD}	LVCMOS Outputs	-20		+20	µA
LVCMOS DC SPECIFICATIONS 1.8V I/O (SER INPUTS, DES OUTPUTS, GPI, GPO, CONTROL INPUTS AND OUTPUTS)							
V_{IH}	High Level Input Voltage	V_{IN} = 1.71V to 1.89V		0.65 V_{IN}		V_{IN}	V
V_{IL}	Low Level Input Voltage	V_{IN} = 1.71V to 1.89V		GND		0.35 V_{IN}	
I_{IN}	Input Current	V_{IN} = 0V or 1.89V V_{IN} = 1.71V to 1.89V		-20	±1	+20	µA
V_{OH}	High Level Output Voltage	V_{DDIO} = 1.71V to 1.89V I_{OH} = −4 mA		V_{DDIO} - 0.45		V_{DDIO}	V
V_{OL}	Low Level Output Voltage	V_{DDIO} = 1.71V to 1.89V I_{OL} = +4 mA	Deserializer LVCMOS Outputs	GND		0.45	V
I_{OS}	Output Short Circuit Current	V_{OUT} = 0V	Serializer GPO Outputs		-11		mA
			Deserializer LVCMOS Outputs		-17		
I_{OZ}	TRI-STATE® Output Current	PDB = 0V, V_{OUT} = 0V or V_{DD}	LVCMOS Outputs	-20		+20	µA
LVCMOS DC SPECIFICATIONS 2.8V I/O (SER INPUTS, GPI, GPO, CONTROL INPUTS AND OUTPUTS)							
V_{IH}	High Level Input Voltage	V_{IN} = 2.52V to 3.08V		0.7 V_{IN}		V_{IN}	V
V_{IL}	Low Level Input Voltage	V_{IN} = 2.52V to 3.08V		GND		0.3 V_{IN}	
I_{IN}	Input Current	V_{IN} = 0V or 3.08V V_{IN} = 2.52V to 3.08V		-20	±1	+20	µA
V_{OH}	High Level Output Voltage	V_{DDIO} = 2.52V to 3.08V I_{OH} = −4 mA		V_{DDIO} - 0.4		V_{DDIO}	V
V_{OL}	Low Level Output Voltage	V_{DDIO} =2.52V to 3.08V I_{OL} = +4 mA	Deserializer LVCMOS Outputs	GND		0.4	V
I_{OS}	Output Short Circuit Current	V_{OUT} = 0V	Serializer GPO Outputs		-11		mA
			Deserializer LVCMOS Outputs		-20		

(1) The Electrical Characteristics tables list verified specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not verified.

(2) Current into device pins is defined as positive. Current out of a device pin is defined as negative. Voltages are referenced to ground except VOD, ΔVOD, VTH and VTL which are differential voltages.

(3) Typical values represent most likely parametric norms at 1.8V or 3.3V, T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not verified.

ELECTRICAL CHARACTERISTICS (1) (2) (3) (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{OZ}	TRI-STATE® Output Current	PDB = 0V, V_{OUT} = 0V or V_{DD}	LVCMOS Outputs	-20		+20	µA
CML DRIVER DC SPECIFICATIONS (DOUT+, DOUT-)							
$\|V_{OD}\|$	Output Differential Voltage	R_L = 100Ω (Figure 11)		268	340	412	mV
	Output Single-ended Voltage	R_L = 500Ω		134	170	206	
ΔV_{OD}	Output Differential Voltage Unbalance	R_L = 100Ω			1	50	mV
V_{OS}	Output Offset Voltage	R_L = 100Ω (Figure 11)			V_{DD} - $V_{OD/2}$		V
ΔV_{OS}	Offset Voltage Unbalance	R_L = 100Ω			1	50	mV
I_{OS}	Output Short Circuit Current	DOUT+ = 0V or DOUT- = 0V			-26		mA
R_T	Differential Internal Termination Resistance	Differential across DOUT+ and DOUT-		80	100	120	Ω
	Single-ended Termination Resistance	DOUT+ or DOUT-		40	50	60	
CML RECEIVER DC SPECIFICATIONS (RIN0+,RIN0–,RIN1+,RIN1–)							
I_{IN}	Input Current	V_{IN} = V_{DD} or 0V, V_{DD} = 1.89V		-20	1	+20	µA
R_T	Differential Internal Termination Resistance	Differential across RIN+ and RIN-		80	100	120	Ω
CML RECEIVER AC SPECIFICATIONS (RIN0+,RIN0–,RIN1+,RIN1–)							
$\|V_{swing}\|$	Minimum allowable swing for 1010 pattern (4)	Line Rate = 1.4Gbps (Figure 12)		135			mV
CML MONITOR OUTPUT DRIVER SPECIFICATIONS(CMLOUTP, CMLOUTN)							
E_w	Differential Output Eye Opening	R_L = 100Ω Jitter Frequency > f/40 (Figure 21)			0.45		UI
E_H	Differential Output Eye Height				200		mV

(4) Specification is verified by characterization and is not tested in production.

ELECTRICAL CHARACTERISTICS (1) (2) (3) (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
SER/DES SUPPLY CURRENT DIGITAL, PLL, AND ANALOG VDD							
I_{DDT}	Serializer (Tx) V_{DDn} Supply Current (includes load current)	R_L = 100Ω WORST CASE pattern (Figure 7)	VDDn=1.89V VDDIO=3.6V f = 100 MHz, 10-bit mode Default Registers		61	80	mA
			VDDn=1.89V VDDIO=3.6V f = 75 MHz, 12-bit high frequency mode Default Registers		61	80	mA
			VDDn=1.89V VDDIO=3.6V f = 50 MHz, 12-bit low frequency mode Default Registers		61	80	
		R_L = 100Ω RANDOM PRBS-7 pattern	VDDn=1.89V VDDIO=3.6V f = 100 MHz, 10-bit mode Default Registers		54		mA
			VDDn=1.89V VDDIO=3.6V f = 75 MHz, 12-bit high frequency mode Default Registers		54		
			VDD=1.89V VDDIO=3.6V f = 50 MHz, 12-bit low frequency mode Default Registers		54		
I_{DDIOT}	Serializer (Tx) VDDIO Supply Current (includes load current)	R_L = 100Ω WORST CASE pattern (Figure 7)	VDDIO=1.89V f = 75 MHz, 12-bit high frequency mode Default Registers		1.5	3	mA
			VDDIO=3.6V f = 75 MHz, 12-bit high frequency mode Default Registers		5	8	
I_{DDTZ}	Serializer (Tx) Supply Current Power-down	PDB = 0V; All other LVCMOS Inputs = 0V	VDDIO=1.89V Default Registers		300	1000	µA
			VDDIO=3.6V Default Registers		300	1000	µA
I_{DDIOTZ}	Serializer (Tx) VDDIO Supply Current Power-down	PDB = 0V; All other LVCMOS Inputs = 0V	VDDIO=1.89V Default Registers		15	100	µA
			VDDIO=3.6V Default Registers		15	100	µA

ELECTRICAL CHARACTERISTICS (1) (2) (3) (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{DDIOR}	Deserializer (Rx) Total Supply Current (includes load current)	V_{DDIO}=1.89V C_L=8pF Worst Case Pattern	f = 100 MHz, 10–bit mode		22	42	mA
			f = 75 MHz, 12–bit high freq mode		19	39	
			f = 50 MHz, 12–bit low freq mode		21	32	
		V_{DDIO}=1.89V C_L=8pF Random Pattern	f = 100 MHz, 10–bit mode		15		mA
			f = 75 MHz, 12–bit high freq mode		12		
			f = 50 MHz, 12–bit low freq mode		14		
		V_{DDIO}=3.6V C_L=8pF Worst Case Pattern	f = 100 MHz, 10–bit mode		42	55	mA
			f = 75 MHz, 12–bit high freq mode		37	50	
			f = 50 MHz, 12–bit low freq mode		25	38	
		V_{DDIO}=3.6V C_L=8pF Random Pattern	f = 100 MHz, 10–bit mode		35		mA
			f = 75 MHz, 12–bit high freq mode		30		
			f = 50 MHz, 12–bit low freq mode		18		
		V_{DDIO}=1.89V C_L=4pF Worst Case Pattern	f = 100 MHz, 10–bit mode		15		mA
			f = 75 MHz, 12–bit high freq mode		11		
			f = 50 MHz, 12–bit low freq mode		16		
		V_{DDIO}=1.89V C_L=4pF Random Pattern	f = 100 MHz, 10–bit mode		8		mA
			f = 75 MHz, 12–bit high freq mode		4		
			f = 50 MHz, 12–bit low freq mode		9		

ELECTRICAL CHARACTERISTICS (1) (2) (3) (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{DDIOR} (cont)	Deserializer (Rx) Total Supply Current (includes load current) (cont)	V_{DDIO}=3.6V C_L=4pF Worst Case Pattern	f = 100 MHz, 10–bit mode		36		mA
			f = 75 MHz, 12–bit high freq mode		29		
			f = 50 MHz, 12–bit low freq mode		20		
		V_{DDIO}=3.6V C_L=4pF Random Pattern	f = 100 MHz, 10–bit mode		29		mA
			f = 75 MHz, 12–bit high freq mode		22		
			f = 50 MHz, 12–bit low freq mode		13		
I_{DDR}	Deserializer (Rx) VDDn Supply Current (includes load current)	V_{DDn}=1.89V C_L=4pF Worst Case Pattern	f = 100 MHz, 10–bit mode		64	110	mA
			f = 75 MHz, 12–bit high freq mode		67	114	
			f = 50 MHz, 12–bit low freq mode		63	96	
		V_{DDn}=1.89V C_L=4pF Random Pattern	f = 100 MHz, 10–bit mode		57		
			f = 75 MHz, 12–bit high freq mode		60		
			f = 50 MHz, 12–bit low freq mode		56		
I_{DDRZ}	Deserializer (Rx) Supply Current Power-down	PDB=0V All other LVCMOS Inputs=0V	VDDIO = 1.89V Default Registers		42	900	µA
		PDB=0V All other LVCMOS Inputs=0V	VDDIO=3.6V Default Registers		42	900	
I_{DDIORZ}	Deserializer (Rx) VDDIO Supply Current Power-down	PDB = 0V All other LVCMOS Inputs = 0V	V_{DDIO} = 1.89V		8	40	µA
			V_{DDIO} = 3.6V		360	800	

ELECTRICAL CHARACTERISTICS (1) (2) (3)
RECOMMENDED SERIALIZER TIMING FOR PCLK (4)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Pin/Freq	Min	Typ	Max	Units
t_{TCP}	Transmit Clock Period	10–bit Mode		10	T	40	ns
		12–bit high frequency mode		13.33	T	40	ns
		12–bit low frequency mode		20	T	40	ns
t_{TCIH}	Transmit Clock Input High Time			0.4T	0.5T	0.6T	ns
t_{TCIL}	Transmit Clock Input Low Time			0.4T	0.5T	0.6T	ns
t_{CLKT}	PCLK Input Transition Time (Figure 13)	25 MHz – 100 MHz, 10-bit mode		0.05T	0.25T	0.3T	ns
		25 MHz - 75MHz, 12-bit high frequency mode		0.05T	0.25T	0.3T	ns
		25 MHz - 50MHz, 12-bit low frequency mode		0.05T	0.25T	0.3T	ns
t_{JIT0}	PCLK Input Jitter (PCLK from imager mode)	Refer to Jitter freq > f/40	f = 25 – 100 MHz		0.1T		ns
t_{JIT1}	PCLK Input Jitter (External Oscillator mode)	Refer to Jitter freq > f/40	f = 25 – 100 MHz		1T		ns
t_{JIT2}	External Oscillator Jitter				0.1		UI

(1) The Electrical Characteristics tables list verified specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not verified.
(2) Current into device pins is defined as positive. Current out of a device pin is defined as negative. Voltages are referenced to ground except VOD, ΔVOD, VTH and VTL which are differential voltages.
(3) Typical values represent most likely parametric norms at 1.8V or 3.3V, T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not verified.
(4) Recommended Input Timing Requirements are input specifications and not tested in production.

ELECTRICAL CHARACTERISTICS (1) (2) (3)
SERIALIZER SWITCHING CHARACTERISTICS

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{LHT}	CML Low-to-High Transition Time	R_L = 100Ω (Figure 8)		150	330	ps
t_{HLT}	CML High-to-Low Transition Time	R_L = 100Ω (Figure 8)		150	330	ps
t_{DIS}	Data Input Setup to PCLK	Serializer Data Inputs (Figure 14)	2			ns
t_{DIH}	Data Input Hold from PCLK		2			ns
t_{PLD}	Serializer PLL Lock Time	R_L = 100Ω (4) (5), (Figure 15)		1	2	ms
t_{SD}	Serializer Delay (5)	R_T = 100Ω 10–bit mode Register 0x03h b[0] (TRFB = 1) (Figure 16)	32.5T	38T	44T	ns
		R_T = 100Ω 12–bit mode Register 0x03h b[0] (TRFB = 1) (Figure 16)	11.75T	13T	15T	ns
t_{JIND}	Serializer Output Deterministic Jitter	Serializer output intrinsic deterministic jitter . Measured (cycle-cycle) with PRBS-7 test pattern (3) (6)		0.13		UI
t_{JINR}	Serializer Output Random Jitter	Serializer output intrinsic random jitter (cycle-cycle). Alternating-1,0 pattern. (3) (6)		0.04		UI
t_{JINT}	Peak-to-peak Serializer Output Jitter	Serializer output peak-to-peak jitter includes deterministic jitter, random jitter, and jitter transfer from serializer input. Measured (cycle-cycle) with PRBS-7 test pattern. (3) (6)		0.396		UI
λ_{STXBW}	Serializer Jitter Transfer Function -3 dB Bandwidth (7)	PCLK = 100 MHz 10–bit mode. Default Registers		2.2		MHz
		PCLK = 75 MHz 12–bit high frequency mode. Default Registers		2.2		
		PCLK = 50 MHz 12–bit low frequency mode. Default Registers		2.2		
δ_{STX}	Serializer Jitter Transfer Function (Peaking) (7)	PCLK = 100 MHz 10–bit mode. Default Registers		1.06		dB
		PCLK = 75 MHz 12–bit high frequency mode. Default Registers		1.09		
		PCLK = 50 MHz 12–bit low frequency mode. Default Registers		1.16		

(1) The Electrical Characteristics tables list verified specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not verified.
(2) Current into device pins is defined as positive. Current out of a device pin is defined as negative. Voltages are referenced to ground except VOD, ΔVOD, VTH and VTL which are differential voltages.
(3) Typical values represent most likely parametric norms at 1.8V or 3.3V, T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not verified.
(4) t_{PLD} and t_{DDLT} is the time required by the serializer and deserializer to obtain lock when exiting power-down state with an active PCLK
(5) Specification is verified by design.
(6) UI – Unit Interval is equivalent to one ideal serialized data bit width. The UI scales with PCLK frequency.
(7) Specification is verified by characterization and is not tested in production.

ELECTRICAL CHARACTERISTICS (1) (2) (3)
SERIALIZER SWITCHING CHARACTERISTICS (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
δ_{STXf}	Serializer Jitter Transfer Function (Peaking Frequency) (7)	PCLK = 100 MHz 10–bit mode. Default Registers		400		kHz
		PCLK = 75 MHz 12–bit high frequency mode. Default Registers		500		
		PCLK = 50 MHz 12–bit low frequency mode. Default Registers		600		

ELECTRICAL CHARACTERISTICS (1) (2) (3)
DESERIALIZER SWITCHING CHARACTERISTICS

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Pin/Freq.	Min	Typ	Max	Units
t_{RCP}	Receiver Output Clock Period	10–bit mode	PCLK (Figure 20)	10		40	ns
		12–bit high frequency mode		13.33		40	
		12–bit low frequency mode		10		40	
t_{PDC}	PCLK Duty Cycle	10–bit mode	PCLK	45	50	55	%
		12–bit high frequency mode		40	50	60	
		12–bit low frequency mode		40	50	60	
t_{CLH}	LVCMOS Low-to-High Transition Time	V_{DDIO}: 1.71V to 1.89V or 3.0V to 3.6V, C_L = 8 pF (lumped load) Default Registers (*Figure 18*), (4)	PCLK	1.3	2	2.8	ns
t_{CHL}	LVCMOS High-to-Low Transition Time			1.3	2	2.8	
t_{CLH}	LVCMOS Low-to-High Transition Time	V_{DDIO}: 1.71V to 1.89V or 3.0V to 3.6V, C_L = 8 pF (lumped load) Default Registers (*Figure 18*) ,(4)	ROUT[11:0], HS, VS	1	2.5	4	ns
t_{CHL}	LVCMOS High-to-Low Transition Time			1	2.5	4	
t_{ROS}	ROUT Setup Data to PCLK	V_{DDIO}: 1.71V to 1.89V or 3.0V to 3.6V, C_L = 8 pF (lumped load) Default Registers (Figure 20)	ROUT[11:0], HS, VS	0.38T	0.5T		ns
t_{ROH}	ROUT Hold Data to PCLK			0.38T	0.5T		
t_{DD}	Deserializer Delay	Default Registers Register 0x03h b[0] (RRFB = 1) (Figure 19),(4)	10–bit mode	154T		158T	ns
			12–bit low frequency mode	109T		112T	
			12–bit high frequency mode	73T		75T	
t_{DDLT}	Deserializer Data Lock Time	With Adaptive Equalization (Figure 17)	10–bit mode		15	22	ms
			12–bit low frequency mode		15	22	
			12–bit high frequency mode		15	22	
t_{RCJ}	Receiver Clock Jitter	PCLK SSCG[3:0] = OFF (4)	10–bit mode PCLK = 100 MHz		20	30	ps
			12–bit low frequency mode PCLK = 50 MHz		22	35	
			12–bit high frequency mode PCLK = 75 MHz		45	90	
t_{DPJ}	Deserializer Period Jitter	PCLK SSCG[3:0] = OFF (5) (4)	10–bit mode PCLK = 100 MHz		170	815	ps
			12–bit low frequency mode PCLK = 50 MHz		180	330	
			12–bit high frequency mode PCLK = 75 MHz		300	515	

(1) The Electrical Characteristics tables list verified specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not verified.
(2) Current into device pins is defined as positive. Current out of a device pin is defined as negative. Voltages are referenced to ground except VOD, ΔVOD, VTH and VTL which are differential voltages.
(3) Typical values represent most likely parametric norms at 1.8V or 3.3V, T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not verified.
(4) Specification is verified by characterization and is not tested in production.
(5) t_{DPJ} is the maximum amount the period is allowed to deviate measured over 30,000 samples.

ELECTRICAL CHARACTERISTICS (1) (2) (3)
DESERIALIZER SWITCHING CHARACTERISTICS (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Pin/Freq.	Min	Typ	Max	Units
t_{DCCJ}	Deserializer Cycle-to-Cycle Clock Jitter	PCLK SSCG[3:0] = OFF (6) (4)	10–bit mode PCLK = 100 MHz		440	1760	ps
			12–bit low frequency mode PCLK = 50 MHz		460	730	
			12–bit high frequency mode PCLK = 75 MHz		565	985	
fdev	Spread Spectrum Clocking Deviation Frequency	LVCMOS Output Bus SSC[3:0] = ON (Figure 25), (4)	25 MHz – 100 MHz		±0.5 to ±1.5		%
fmod	Spread Spectrum Clocking Modulation Frequency		25 MHz – 100 MHz		5 to 50		kHz

(6) t_{DCCJ} is the maximum amount of jitter between adjacent clock cycles measured over 30,000 samples.

AC TIMING SPECIFICATIONS (SCL, SDA) - I2C COMPLIANT

Over recommended supply and temperature ranges unless otherwise specified.(Figure 6)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Recommended Input Timing Requirements						
f_{SCL}	SCL Clock Frequency	Standard Mode	>0		100	kHz
		Fast Mode	>0		400	kHz
t_{LOW}	SCL Low Period	Standard Mode	4.7			µs
		Fast Mode	1.3			µs
t_{HIGH}	SCL High Period	Standard Mode	4.0			µs
		Fast Mode	0.6			µs
$t_{HD:STA}$	Hold time for a start or a repeated start condition	Standard Mode	4.0			µs
		Fast Mode	0.6			µs
$t_{SU:STA}$	Set Up time for a start or a repeated start condition	Standard Mode	4.7			µs
		Fast Mode	0.6			µs
$t_{HD:DAT}$	Data Hold Time	Standard Mode	0		3.45	µs
		Fast Mode	0		900	ns
$t_{SU:DAT}$	Data Set Up Time	Standard Mode	250			ns
		Fast Mode	100			ns
$t_{SU:STO}$	Set Up Time for STOP Condition	Standard Mode	4.0			µs
		Fast Mode	0.6			µs
t_{BUF}	Bus Free time between Stop and Start	Standard Mode	4.7			µs
		Fast Mode	1.3			µs
t_r	SCL & SDA Rise Time	Standard Mode			1000	ns
		Fast Mode			300	ns
t_f	SCL & SDA Fall Time	Standard Mode			300	ns
		Fast Mode			300	ns

BIDIRECTIONAL CONTROL BUS DC TIMING SPECIFICATIONS (SCL, SDA) - I2C COMPLIANT(1)

Over recommended supply and temperature ranges unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Recommended Input Timing Requirements						
V_{IH}	Input High Level	SDA and SCL	0.7*V_{DDIO}		V_{DDIO}	V
V_{IL}	Input Low Level	SDA and SCL	GND		0.3*V_{DDIO}	V
V_{HY}	Input Hysteresis			>50		mV
V_{OL}	Output Low Level	SDA, I_{OL}=0.5mA	0		0.4	V
I_{IN}	Input Current	SDA or SCL, V_{IN}=V_{DDIO} OR GND	—10		10	µA
t_R	SDA Rise Time-READ	SDA, RPU = 10kΩ, Cb ≤ 400pF (Figure 6)		430		ns
t_F	SDA Fall Time-READ			20		ns
$t_{SU;DAT}$		(See Figure 6)		560		ns
$t_{HD;DAT}$		(See Figure 6)		615		ns
t_{SP}				50		ns
C_{IN}		SDA or SCL		<5		pF

(1) Specification is verified by design.

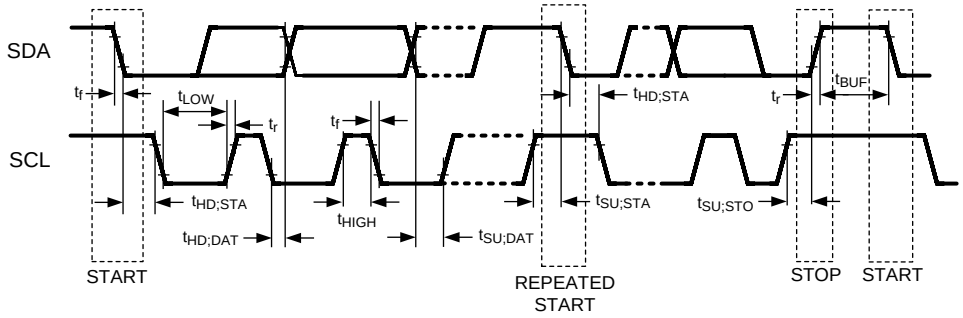

Figure 6. Bi-directional Control Bus Timing

AC Timing Diagrams and Test Circuits

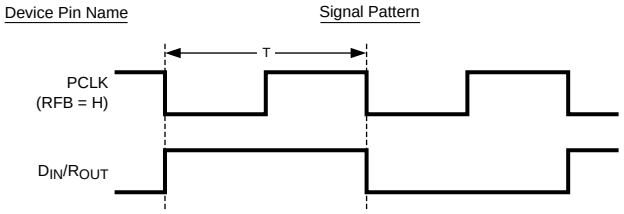

Figure 7. "Worst Case" Test Pattern

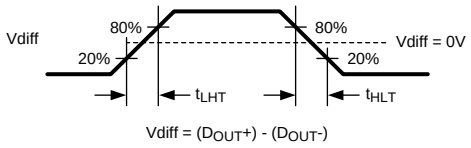

Figure 8. Serializer CML Output Load and Transition Times

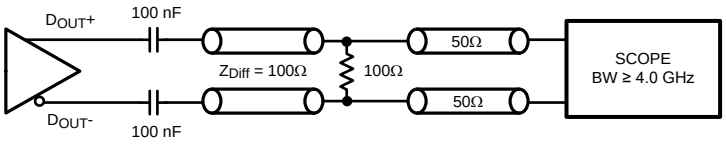

Figure 9. Serializer CML Output Load and Transition Times

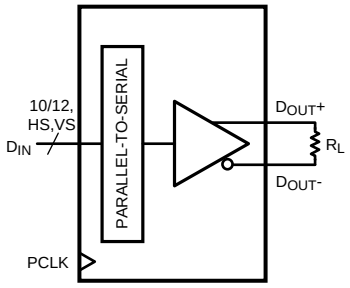

Figure 10. Serializer VOD Setup

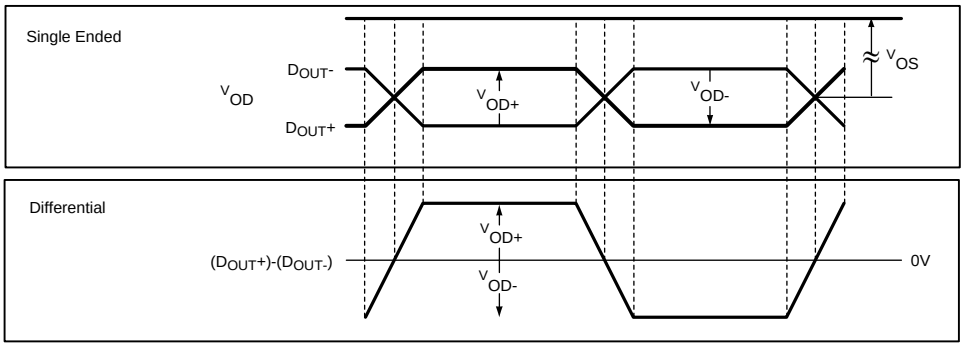

Figure 11. Serializer VOD Diagram

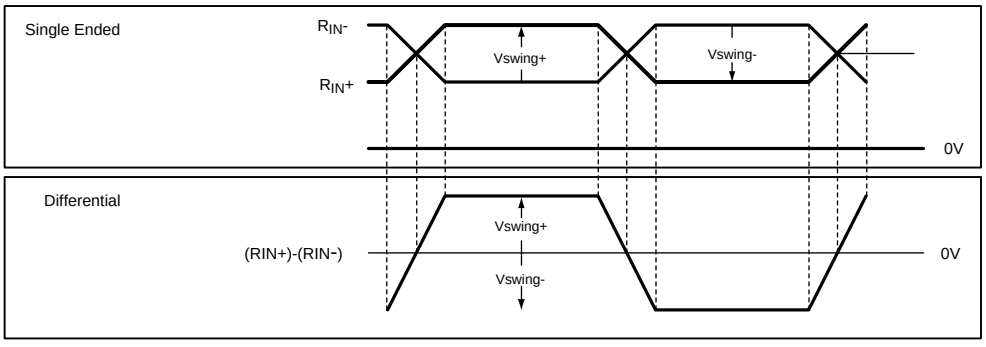

Figure 12. Deserializer Vswing Diagram

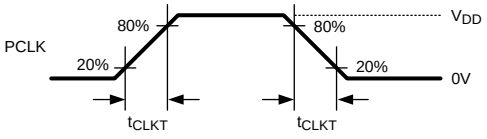

Figure 13. Serializer Input Clock Transition Times

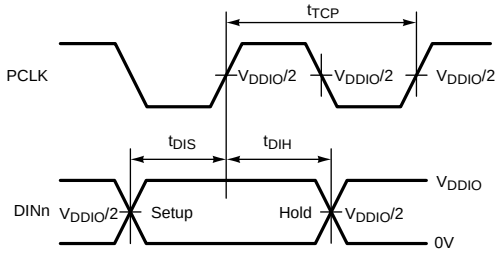

Figure 14. Serializer Setup/Hold Times

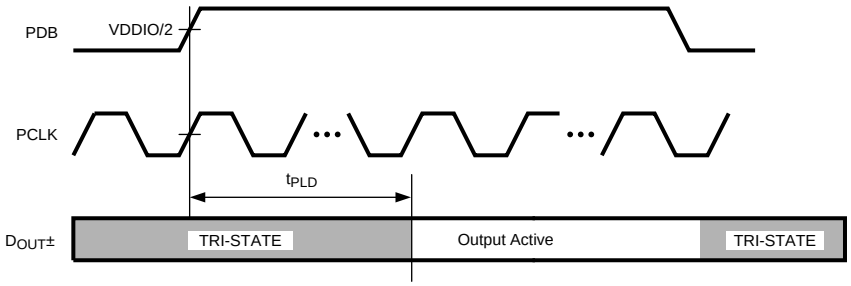

Figure 15. Serializer PLL Lock Time

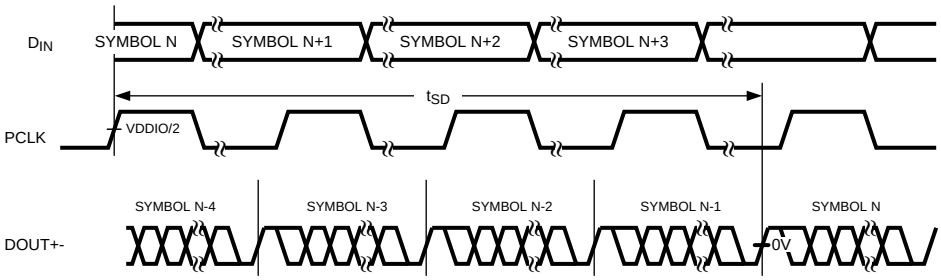

Figure 16. Serializer Delay

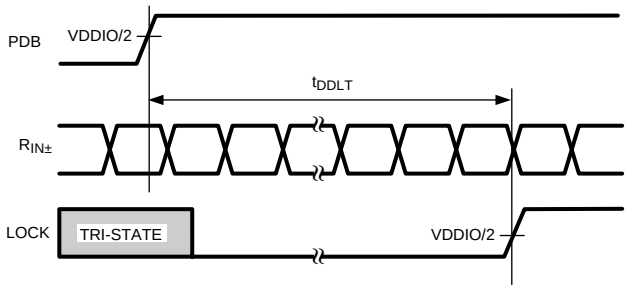

Figure 17. Deserializer Data Lock Time

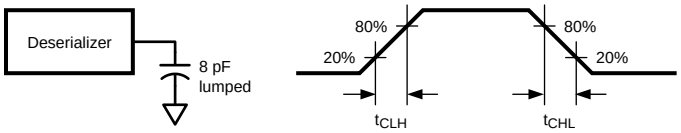

Figure 18. Deserializer LVCMOS Output Load and Transition Times

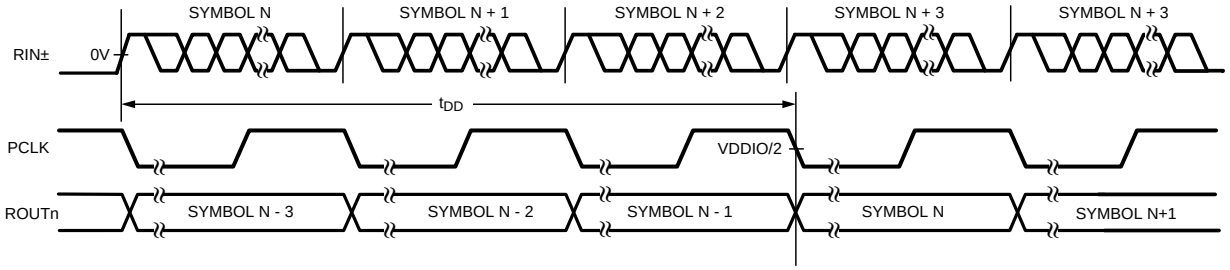

Figure 19. Deserializer Delay

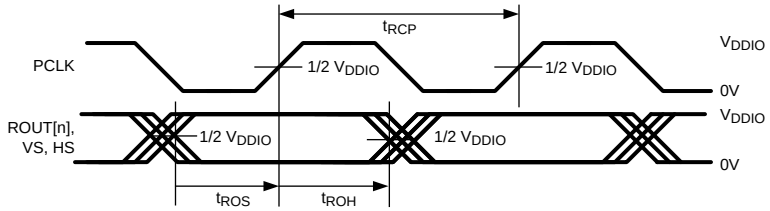

Figure 20. Deserializer Output Setup/Hold Times

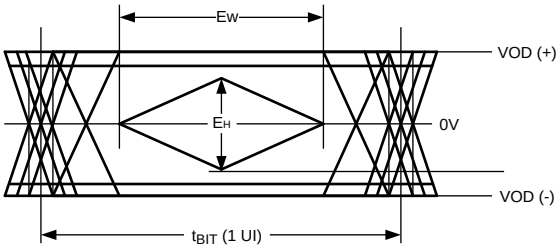

Figure 21. CML Output Driver

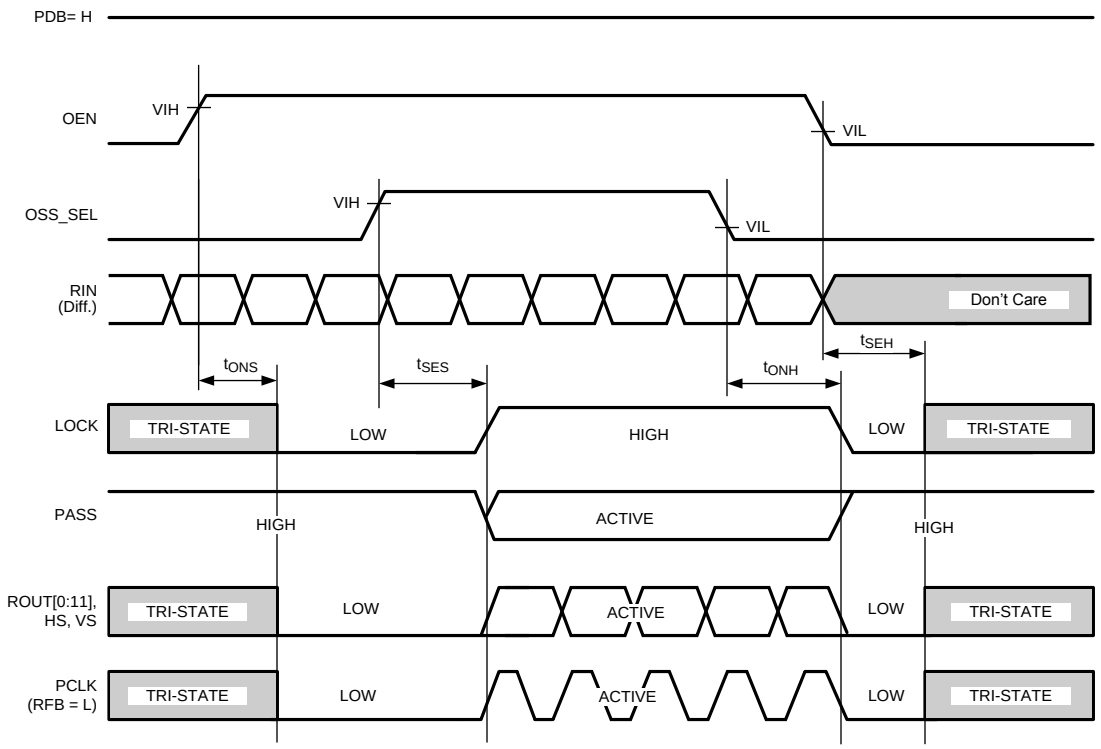

Figure 22. Output State (Setup and Hold) Times

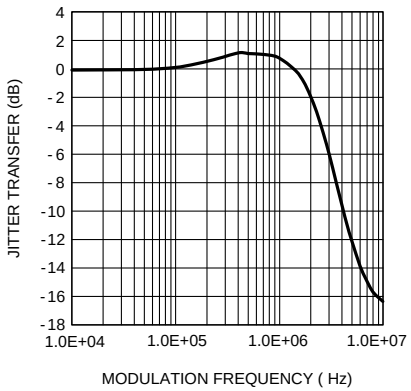

Figure 23. Typical Serializer Jitter Transfer Function at 100MHz

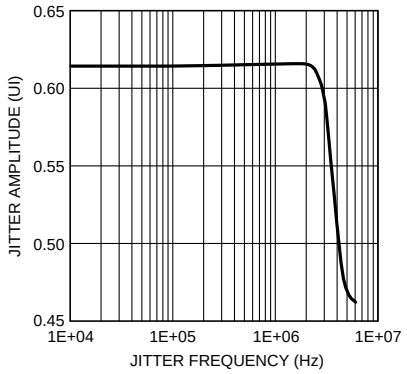

Figure 24. Typical Deserializer Input Jitter Tolerance Curve at 1.4Gbps Line Rate

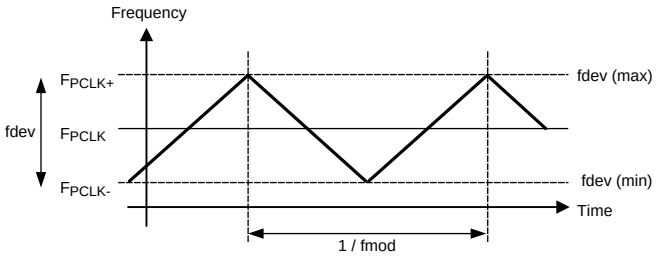

Figure 25. Spread Spectrum Clock Output Profile

Table 3. DS90UB913A-Q1 Control Registers

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x00	I2C Device ID	7:1	DEVICE ID	RW	0xB0'h (1011_000)	7-bit address of Serializer; 0x58'h. (0101_100x'b) default.
		0	SER ID SEL			0: Device ID is from ID[x]. 1: Register I2C Device ID overrides ID[x].
0x01	Power and Reset	7	RSVD			Reserved.
		6	RDS	RW	0	Digital Output Drive Strength. 1: High Drive Strength. 0: Low Drive Strength.
		5	VDDIO Control	RW	1	Auto Voltage Control. 1: Enable. 0: Disable.
		4	VDDIO MODE	RW	1	V_{DDIO} Voltage set. 1: V_{DDIO} = 3.3V. 0: V_{DDIO} = 1.8V.
		3	ANAPWDN	RW	0	This register can be set only through local I2C access. 1: Analog power-down. Powers Down the analog block in the Serializer. 0: No effect.
		2	RSVD	RW	0	Reserved.
		1	DIGITAL RESET1	RW	0	1: Resets the digital block except for register values. Does not affect device I2C Bus or Device ID. This bit is self-clearing. 0: Normal Operation.
		0	DIGITAL RESET0	RW	1	1: Digital Reset, resets the entire digital block including all register values. This bit is self-clearing. 0: Normal Operation.
0x02	**Reserved.**					

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x03	General Configuration	7	RX CRC Checker Enable	RW	1	Back-channel CRC Checker Enable. 1:Enable. 0: Disable.
		6	TX Parity Generator Enable	RW	1	Forward channel Parity Generator Enable. 1: Enable. 0: Disable.
		5	CRC Error Reset	RW	0	Clear CRC Error Counters. This bit is NOT self-clearing. 1: Clear Counters. 0: Normal Operation.
		4	I2C Remote Write Auto Acknowledge	RW	0	Automatically Acknowledge I2C Remote Write. The mode works when the system is LOCKed. 1: Enable: When enabled, I2C writes to the Deserializer (or any remote I2C Slave, if I2C PASS ALL is enabled) are immediately acknowledged without waiting for the Deserializer to acknowledge the write. The accesses are then remapped to address specified in 0x06. 0: Disable.
		3	I2C Pass-Through All	RW	0	1: Enable Forward Control Channel pass-through of all I2C accesses to I2C IDs that **do not match** the Serializer I2C ID. **The I2C accesses are then remapped to address specified in register 0x06.** 0: Enable Forward Control Channel pass-through only of I2C accesses to I2C IDs **matching** either the remote Deserializer ID or the remote I2C IDs.
		2	I2C Pass-Through	RW	1	I2C Pass-Through Mode. 1: Pass-Through Enabled. DES Alias 0x07 and Slave Alias 0x09. 0: Pass-Through Disabled.
		1	OV_CLK2PLL	RW	0	1:Enabled : When enabled this register overrides the clock to PLL mode (External Oscillator mode or Direct PCLK mode) defined through MODE pin and allows selection through register 0x35 in the Serializer. 0: Disabled : When disabled, Clock to PLL mode (External Oscillator mode or Direct PCLK mode) is defined through MODE pin on the Serializer.
		0	TRFB	RW	1	Pixel Clock Edge Select. 1: Parallel Interface Data is strobed on the Rising Clock Edge. 0: Parallel Interface Data is strobed on the Falling Clock Edge.
0x04	**Reserved.**					
0x05	Mode Select	7	RSVD	RW	0	Reserved.
		6	RSVD	RW	0	Reserved.
		5	MODE_OVERRIDE	RW	0	Allows overriding mode select bits coming from back-channel. 1: Overrides MODE select bits. 0: Does not override MODE select bits.
		4	MODE_UP_TO_DATE	R	0	Indicates that the status of mode select from Deserializer is up to date.
		3	Pin_MODE_12–bit High Frequency	R	0	1: 12-bit high frequency mode is selected. 0: 12-bit high frequency mode is not selected.
		2	Pin_MODE_10–bit mode	R	0	1: 10-bit mode is selected. 0: 10-bit mode is not selected.
		1:0	RSVD			Reserved.

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x06	DES ID	7:1	Deserializer Device ID	RW	0x00	7-bit **Deserializer** Device ID Configures the I2C Slave ID of the remote **Deserializer**. A value of 0 in this field disables I2C access to the remote **Deserializer**. This field is automatically configured by the Bidirectional Control Channel once RX Lock has been detected. Software may overwrite this value, but should also assert the FREEZE DEVICE ID bit to prevent overwriting by the Bidirectional Control Channel.
		0	Freeze Device ID	RW	0	1: Prevents auto-loading of the **Deserializer** Device ID by the bidirectional control channel. The ID will be frozen at the value written. 0: Update.
0x07	DES Alias	7:1	Deserializer ALIAS ID	RW	0	7-bit Remote **Deserializer** Device Alias ID Configures the decoder for detecting transactions designated for an I2C **Deserializer** device. The transaction will be remapped to the address specified in the DES ID register. A value of 0 in this field disables access to the remote **Deserializer.**
		0	RSVD			Reserved.
0x08	SlaveID	7:1	SLAVE ID	RW	0x00	7-bit Remote Slave Device ID Configures the physical I2C address of the remote I2C Slave device attached to the remote **Deserializer**. If an I2C transaction is addressed to the Slave Alias ID, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the **Deserializer** and then to remote slave. A value of 0 in this field disables access to the remote I2C slave.
		0	RSVD			Reserved.
0x09	Slave Alias	7:1	SLAVE ALIAS ID	RW	0x00	7-bit Remote Slave Device Alias ID Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote **Deserializer**. The transaction will be remapped to the address specified in the Slave ID register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x0A	CRC Errors	7:0	CRC Error Byte 0	R	0	Number of back-channel CRC errors during normal operation. Least Significant byte.
0x0B	CRC Errors	7:0	CRC Error Byte 1	R	0	Number of back-channel CRC errors during normal operation. Most Significant byte.

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x0C	General Status	7:5	Rev-ID	R	0	Revision ID. 0x00: Production Revision ID.
		4	RX Lock Detect	R	0	1: RX LOCKED. 0: RX not LOCKED.
		3	BIST CRC Error Status	R	0	1: CRC errors in BIST mode. 0: No CRC errors in BIST mode.
		2	PCLK Detect	R	0	1: Valid PCLK detected. 0: Valid PCLK not detected.
		1	DES Error	R	0	1: CRC error is detected during communication with Deserializer. This bit is cleared upon loss of link or assertion of CRC ERROR RESET in register 0x04. 0: No effect.
		0	LINK Detect	R	0	1: Cable link detected. 0: Cable link not detected. This includes any of the following faults: — Cable Open. — '+' and '-' shorted. — Short to GND. — Short to battery.
0x0D	GPO[0] and GPO[1] Configuration	7	GPO1 Output Value	RW	0	Local GPIO Output Value. This value is output on the GPIO pin when the GPIO function is enabled. The local GPIO direction is Output, and remote GPIO control is disabled.
		6	GPO1 Remote Enable	RW	1	Remote GPIO Control. 1: Enable GPIO control from remote Deserializer. The GPIO pin needs to be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Deserializer.
		5	GPO1 Direction	RW	0	1: Input. 0: Output.
		4	GPO0 Enable	RW	1	1: GPIO enable. 0: Tri-state.
		3	GPO0 Output Value	RW	0	Local GPIO Output Value. This value is output on the GPIO pin when the GPIO function is enabled. The local GPIO direction is Output, and remote GPIO control is disabled.
		2	GPO0 Remote Enable	RW	1	Remote GPIO Control. 1: Enable GPIO control from remote Deserializer. The GPIO pin needs to be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Deserializer.
		1	GPO0 Direction	RW	0	1: Input. 0: Output.
		0	GPO0 Enable	RW	1	1: GPIO enable. 0: Tri-state.

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x0E	GPO[2] and GPO[3] Configuration	7	GPO3 Output Value	RW	0	Local GPIO Output Value. This value is output on the GPIO pin when the GPIO function is enabled. The local GPIO direction is Output, and remote GPIO control is disabled.
		6	GPO3 Remote Enable	RW	0	Remote GPIO Control. 1: Enable GPIO control from remote Deserializer. The GPIO pin needs to be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Deserializer.
		5	GPO3 Direction	RW	1	1: Input. 0: Output.
		4	GPO3 Enable	RW	1	1: GPIO enable. 0: Tri-state.
		3	GPO2 Output Value	RW	0	Local GPIO Output Value. This value is output on the GPIO pin when the GPIO function is enabled. The local GPIO direction is Output, and remote GPIO control is disabled.
		2	GPO2 Remote Enable	RW	1	Remote GPIO Control. 1: Enable GPIO control from remote Deserializer. The GPIO pin needs to be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Deserializer.
		1	GPO2 Direction	RW	0	1: Input. 0: Output.
		0	GPO2 Enable	RW	1	1: GPIO enable. 0: Tri-state.
0x0F	I2C Master Config	7:5	RSVD			Reserved.
		4:3	SDA Output Delay	RW	00	SDA Output Delay This field configures output delay on the SDA output. Setting this value will increase output delay in units of 50ns. Nominal output delay values for SCL to SDA are: 00: ~350ns 01: ~400ns 10: ~450ns 11: ~500ns
		2	Local Write Disable	RW	0	Disable Remote Writes to Local Registers Setting this bit to a 1 will prevent remote writes to local device registers from across the control channel. This prevents writes to the Serializer registers from an I2C master attached to the Deserializer. Setting this bit does not affect remote access to I2C slaves at the Serializer.
		1	I2C Bus Timer Speed up	RW	0	Speed up I2C Bus Watchdog Timer. 1: Watchdog Timer expires after approximately 50 microseconds. 0: Watchdog Timer expires after approximately 1 second.
		0	I2C Bus Timer Disable	RW	0	1. Disable I2C Bus Watchdog Timer When the I2C Watchdog Timer may be used to detect when the I2C bus is free or hung up following an invalid termination of a transaction. If SDA is high and no signaling occurs for approximately 1 second, the I2C bus will assumed to be free. If SDA is low and no signaling occurs, the device will attempt to clear the bus by driving 9 clocks on SCL. 0: No effect.

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x10	I2C Control	7	RSVD			Reserved.
		6:4	SDA Hold Time	RW	0x1	Internal SDA Hold Time. This field configures the amount of internal hold time provided for the SDA input relative to the SCL input. Units are 50ns.
		3:0	I2C Filter Depth	RW	0x7	I2C Glitch Filter Depth This field configures the maximum width of glitch pulses on the SCL and SDA inputs that will be rejected. Units are 10ns.
0x11	SCL High Time	7:0	SCL High Time	RW	0x82	I2C Master SCL High Time This field configures the high pulse width of the SCL output when the Serializer is the Master on the local I2C bus. Units are 50 ns for the nominal oscillator clock frequency. The default value is set to provide a minimum (4µs + 1µs of rise time for cases where rise time is very fast) SCL high time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
0x12	SCL LOW Time	7:0	SCL Low Time	RW	0x82	I2C SCL Low Time This field configures the low pulse width of the SCL output when the Serializer is the Master on the local I2C bus. This value is also used as the SDA setup time by the I2C Slave for providing data prior to releasing SCL during accesses over the Bidirectional Control Channel. Units are 50 ns for the nominal oscillator clock frequency. The default value is set to provide a minimum (4.7µs + 0.3µs of fall time for cases where fall time is very fast) SCL low time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
0x13	General Purpose Control	7:0	GPCR[7:0]	RW	0	1: High. 0: Low.
0x14	BIST Control	7:3	RSVD			Reserved.
		2:1	Clock Source	RW	0x0	Allows choosing different OSC clock frequencies for forward channel frame. OSC Clock Frequency in Functional Mode when OSC mode is selected or when the selected clock source is not present e.g. missing PCLK/ External Oscillator. See Table 5 for oscillator clock frequencies when PCLK/ External Clock is missing.
		0	RSVD			Reserved.
0x15–0x1D	**Reserved.**					
0x1E	BCC Watchdog Control	7:1	BCC Watchdog Timer	RW	0x7F	The watchdog timer allows termination of a control channel transaction if it fails to complete within a programmed amount of time. This field sets the Bidirectional Control Channel Watchdog Timeout value in units of 2ms. This field should not be set to 0.
		0	BCC Watchdog Timer Disable	RW	0	Disable Bidirectional Control Channel Watchdog Timer. 1: Disables BCC Watchdog Timer operation. 0: Enables BCC Watchdog Timer operation.
0x1F-0x29	**Reserved.**					
0x2A	CRC Errors	7:0	BIST Mode CRC Errors Count	R	0	Number of CRC Errors in the back channel when in BIST mode.
0x2B-0x34	**Reserved.**					

Table 3. DS90UB913A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x35	PLL Clock Overwrite	7:4	RSVD			Reserved.
		3	PIN_LOCK to External Oscillator	RW	0	Status of mode select pin. 1: Indicates External Oscillator mode is selected by mode-resistor. 0: External Oscillator mode is not selected by mode-resistor.
		2	RSVD		0	Reserved.
		1	LOCK to External Oscillator	RW	0	Affects only when 0x03[1]=1 (OV_CLK2PLL) and 0x35[0]=0. 1: Routes GPO3 directly to PLL. 0: Allows PLL to lock to PCLK.
		0	LOCK2OSC	RW	1	Affects only when 0x03[1]=1 (OV_CLK2PLL). 1: Allows internal OSC clock to feed into PLL. 0: Allows PLL to lock to either PCLK or external clock from GPO3.

Table 4. DS90UB914A-Q1 Control Registers

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x00	I2C Device ID	7:1	DEVICE ID	RW	0xC0'h (1100_000)	7-bit address of Deserializer; 0x60'h. (0110_000x'b) default
		0	Deserializer ID Select	RW		0: De-Serializer Device ID is set using address coming from CAD. 1: Register I2C Device ID overrides ID[x].
0x01	Reset	7:6	RSVD			Reserved.
		5	ANAPWDN	RW	0	This register can be set only through local I2C access. 1: Analog power-down : Powers Down the analog block in the Serializer. 0: No effect.
		4:2	RSVD			Reserved.
		1	Digital Reset 1	RW	0	Digital Reset Resets the entire digital block except registers. This bit is self-clearing. 1: Reset. 0: No effect.
		0	Digital Reset 0	RW	0	Digital Reset Resets the entire digital block including registers. This bit is self-clearing. 1: Reset. 0: No effect.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x02	General Configuration 0	7	RSVD			Reserved.
		6	RSVD			Reserved.
		5	Auto-Clock	RW	0	1: Output PCLK or OSC clock when not LOCKED. 0: Only PCLK.
		4	SSCG LFMODE	RW	0	1: Selects 8x mode for 10-18 MHz frequency range in SSCG. 0: SSCG running at 4X mode.
		3:0	SSCG	RW	0	SSCG Select. 0000: Normal Operation, SSCG OFF. 0001: fmod (kHz) PCLK/2168, fdev +/-0.50%. 0010: fmod (kHz) PCLK/2168, fdev +/-1.00%. 0011: fmod (kHz) PCLK/2168, fdev +/-1.50%. 0100: fmod (kHz) PCLK/2168, fdev +/-2.00%. 0101: fmod (kHz) PCLK/1300, fdev +/-0.50%. 0110: fmod (kHz) PCLK/1300, fdev +/-1.00%. 0111: fmod (kHz) PCLK/1300, fdev +/-1.50%. 1000: fmod (kHz) PCLK/1300, fdev +/-2.00%. 1001: fmod (kHz) PCLK/868, fdev +/-0.50%. 1010: fmod (kHz) PCLK/868, fdev +/-1.00%. 1011: fmod (kHz) PCLK/868, fdev +/-1.50%. 1100: fmod (kHz) PCLK/868, fdev +/-2.00%. 1101: fmod (kHz) PCLK/650, fdev +/-0.50%. 1110: fmod (kHz) PCLK/650, fdev +/-1.00%. 1111: fmod (kHz) PCLK/650, fdev +/-1.50%. Note: **This register should be changed only after disabling SSCG.**
0x03	General Configuration 1	7	RX Parity Checker Enable	RW	1	Forward Channel Parity Checker Enable. 1: Enable. 0: Disable.
		6	TX CRC Checker Enable	RW	1	Back Channel CRC Generator Enable. 1: Enable. 0: Disable.
		5	V_{DDIO} Control	RW	1	Auto voltage control. 1: Enable (auto detect mode). 0: Disable.
		4	V_{DDIO} Mode	RW	0	VDDIO voltage set. 1: 3.3V 0: 1.8V
		3	I2C Pass-Through	RW	1	II2C Pass-Through Mode. 1: Pass-Through Enabled. SER Alias 0x07 and Slave Alias 0x09- 0x17. 0: Pass-Through Disabled.
		2	AUTO ACK	RW	0	Automatically Acknowledge I2C Remote Write When enabled, I2C writes to the Deserializer (or any remote I2C Slave, if I2C PASS ALL is enabled) are immediately acknowledged without waiting for the Deserializer to acknowledge the write. The accesses are then remapped to address specified in 0x06. This allows I2C bus without LOCK. 1: Enable. 0: Disable.
		1	Parity Error Reset	RW	0	Parity Error Reset, This bit is self-clearing. 1: Parity Error Reset. 0: No effect.
		0	RRFB	RW	1	Pixel Clock Edge Select. 1: Parallel Interface Data is strobed on the Rising Clock Edge. 0: Parallel Interface Data is strobed on the Falling Clock Edge.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x04	EQ Feature Control	7:0	EQ level - when AEQ bypass is enabled EQ setting is provided by this register	RW	0x0F	Equalization gain. 0x0F = ~8.0 dB (minimum) 0x0F = ~11.0 dB 0x0F = ~12.5 dB 0x0F = ~14.0 dB 0x0F = ~16.0 dB (maximum)
0x05	**Reserved.**					
0x06	SER ID	7:1	Remote ID	RW	0x0C	Remote Serializer ID.
		0	Freeze Device ID	RW	0	Freeze Serializer Device ID Prevent auto-loading of the Serializer Device ID from the Forward Channel. The ID will be frozen at the value written.
0x07	SER Alias	7:1	Serializer Alias ID	RW	0x00	7-bit Remote Serializer Device Alias ID Configures the decoder for detecting transactions designated for an I2C Serializer device. The transaction will be remapped to the address specified in the SER ID register. A value of 0 in this field disables access to the remote I2C Serializer.
		0	RSVD			Reserved.
0x08	Slave ID[0]	7:1	Slave ID0	RW	0	7-bit Remote Slave Device ID 0 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID0, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x09	Slave ID[1]	7:1	Slave ID1	RW	0	7-bit Remote Slave Device ID 1 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID1, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x0A	Slave ID[2]	7:1	Slave ID2	RW	0x00	7-bit Remote Slave Device ID 2 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID2, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x0B	Slave ID[3]	7:1	Slave ID3	RW	0	7-bit Remote Slave Device ID 3 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID3, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x0C	Slave ID[4]	7:1	Slave ID4	RW	0	7-bit Remote Slave Device ID 4 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID4, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x0D	Slave ID[5]	7:1	Slave ID5	RW	0x00	7-bit Remote Slave Device ID 5 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID5 , the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x0E	Slave ID[6]	7:1	Slave ID6	RW	0	7-bit Remote Slave Device ID 6 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID6, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x0F	Slave ID[7]	7:1	Slave ID7	RW	0x00	7-bit Remote Slave Device ID 7 Configures the physical I2C address of the remote I2C Slave device attached to the remote Serializer. If an I2C transaction is addressed to the Slave Alias ID7, the transaction will be remapped to this address before passing the transaction across the Bidirectional Control Channel to the Serializer.
		0	RSVD			Reserved.
0x10	Slave Alias[0]	7:1	Slave Alias ID0	RW	0x00	7-bit Remote Slave Device Alias ID 0 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID0 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x11	Slave Alias[1]	7:1	Slave Alias ID1	RW	0x00	7-bit Remote Slave Device Alias ID 1 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID1 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x12	Slave Alias[2]	7:1	Slave Alias ID2	RW	0x00	7-bit Remote Slave Device Alias ID 2 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID2 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x13	Slave Alias[3]	7:1	Slave Alias ID3	RW	0x00	7-bit Remote Slave Device Alias ID 3 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID3 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x14	Slave Alias[4]	7:1	Slave Alias ID4	RW	0x00	7-bit Remote Slave Device Alias ID 4 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID4 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x15	Slave Alias[5]	7:1	Slave Alias ID5	RW	0x00	7-bit Remote Slave Device Alias ID 5 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID5 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x16	Slave Alias[6]	7:1	Slave Alias ID6	RW	0x00	7-bit Remote Slave Device Alias ID 6 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID6 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x17	Slave Alias[7]	7:1	Slave Alias ID7	RW	0x00	7-bit Remote Slave Device Alias ID 7 Configures the decoder for detecting transactions designated for an I2C Slave device attached to the remote Serializer. The transaction will be remapped to the address specified in the Slave ID7 register. A value of 0 in this field disables access to the remote I2C Slave.
		0	RSVD			Reserved.
0x18	Parity Errors Threshold	7:0	Parity Error Threshold Byte 0	RW	0	Parity errors threshold on the Forward channel during normal information. This sets the maximum number of parity errors that can be counted using register 0x1A. Least significant Byte.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x19	Parity Errors Threshold	7:0	Parity Error Threshold Byte 1	RW	0	Parity errors threshold on the Forward channel during normal operation. This sets the maximum number of parity errors that can be counted using register 0x1B. Most significant Byte.
0x1A	Parity Errors	7:0	Parity Error Byte 0	RW	0	Number of parity errors in the Forward channel during normal operation. Least significant Byte.
0x1B	Parity Errors	7:0	Parity Error Byte 1	RW	0	Number of parity errors in the Forward channel during normal operation. Most significant Byte.
0x1C	General Status	7:4	Rev-ID	R	0	Revision ID. 0x0000: Production
		3	RSVD			Reserved.
		2	Parity Error	R	0	Parity Error detected. 1: Parity Errors detected. 0: No Parity Errors.
		1	Signal Detect	R	0	1: Serial input detected. 0: Serial input not detected.
		0	Lock	R	0	De-Serializer CDR, PLL's clock to recovered clock frequency. 1: De-Serializer locked to recovered clock. 0: De-Serializer not locked.
0x1D	GPIO[1] and GPIO[0] Config	7	GPIO1 Output Value	RW	0	Local GPIO Output Value This value is the output on the GPIO pin when the GPIO function is enabled, the local GPIO direction is Output.
		6	RSVD			Reserved.
		5	GPIO1 Direction	RW	1	Local GPIO Direction. 1: Input. 0: Output.
		4	GPIO1 Enable	RW	1	GPIO Function Enable. 1: Enable GPIO operation. 0: Enable normal operation.
		3	GPIO0 Output Value	RW	0	Local GPIO Output Value This value is output on the GPIO pin when the GPIO function is enabled, the local GPIO direction is Output.
		2	RSVD			Reserved.
		1	GPIO0 Direction	RW	1	Local GPIO Direction. 1: Input. 0: Output.
		0	GPIO0 Enable	RW	1	GPIO Function Enable. 1: Enable GPIO operation. 0: Enable normal operation.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x1E	GPIO[3] and GPIO[2] Config	7	GPIO3 Output Value	RW	0	Local GPIO Output Value This value is the output on the GPIO pin when the GPIO function is enabled, the local GPIO direction is Output.
		6	RSVD			Reserved.
		5	GPIO3 Direction	RW	1	Local GPIO Direction. 1: Input. 0: Output.
		4	GPIO3 Enable	RW	1	GPIO Function Enable. 1: Enable GPIO operation. 0: Enable normal operation.
		3	GPIO2 Output Value	RW	0	Local GPIO Output Value This value is output on the GPIO pin when the GPIO function is enabled, the local GPIO direction is Output.
		2	RSVD			Reserved.
		1	GPIO2 Direction	RW	1	Local GPIO Direction. 1: Input. 0: Output.
		0	GPIO2 Enable	RW	1	GPIO Function Enable. 1: Enable GPIO operation. 0: Enable normal operation.
0x1F	Mode and OSS Select	7	OEN_OSS Override	RW	0	Allows overriding OEN and OSS select coming from Pins. 1: Overrides OEN/OSS_SEL selected by pins. 0: Does NOT override OEN/OSS_SEL select by pins.
		6	OEN Select	RW	0	OEN configuration from register.
		5	OSS Select	RW	0	OSS_SEL configuration from register.
		4	MODE_OVERRIDE	RW	0	Allows overriding mode select bits coming from forward-channel. 1: Overrides MODE select bits. 0: Does not override MODE select bits.
		3	PIN_MODE_12–bit HF mode	R	0	Status of mode select pin.
		2	PIN_MODE_10-bit mode	R	0	Status of mode select pin.
		1	MODE_12–bit High Frequency	RW	0	Selects 12-bit high frequency mode. This bit is automatically updated by the mode settings from MODE pin unless MODE_OVERRIDE is SET. 1: 12-bit high frequency mode is selected. 0: 12-bit high frequency mode is not selected.
		0	MODE_10–bit mode	RW	0	Selects 10-bit mode. This bit is automatically updated by the mode settings from MODE pin unless MODE_OVERRIDE is SET. 1: Enables 10-bit mode. 0: Disables 10-bit mode.
0x20	BCC Watchdog Control	7:1	BCC Watchdog timer	RW	0	The watchdog timer allows termination of a control channel transaction if it fails to complete within a programmed amount of time. This field sets the Bidirectional Control Channel Watchdog Timeout value in units of 2ms. This field should not be set to 0.
		0	BCC Watchdog Timer Disable	RW	0	Disable Bidirectional Control Channel Watchdog Timer. 1: Disables BCC Watchdog Timer operation. 0: Enables BCC Watchdog Timer operation.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x21	I2C Control 1	7	I2C Pass-Through All	RW	0	1: Enable Forward Control Channel pass-through of all I2C accesses to I2C IDs that **do not match** the Deserializer I2C ID. **The I2C accesses are then remapped to address specified in register 0x06 (SER ID).** 0: Enable Forward Control Channel pass-through only of I2C accesses to I2C IDs **matching** either the remote Serializer ID or the remote I2C IDs.
		6:4	I2C SDA Hold	RW	0	Internal SDA Hold Time This field configures the amount of internal hold time provided for the SDA input relative to the SCL input. Units are 50ns.
		3:0	I2C Filter Depth	RW	0	I2C Glitch Filter Depth This field configures the maximum width of glitch pulses on the SCL and SDA inputs that will be rejected. Units are 10ns.
0x22	I2C Control 2	7	Forward Channel Sequence Error	R	0	Control Channel Sequence Error Detected This bit indicates a sequence error has been detected in forward control channel. 1: If this bit is set, an error may have occurred in the control channel operation. 0: No forward channel errors have been detected on the control channel.
		6	Clear Sequence Error	RW	0	Clears the Sequence Error Detect bit.
		5	RSVD			Reserved.
		4:3	SDA Output Delay	RW	0	SDA Output Delay This field configures output delay on the SDA output. Setting this value will increase output delay in units of 50ns. Nominal output delay values for SCL to SDA are: 00 : ~350ns 01: ~400ns 10: ~450ns 11: ~500ns
		2	Local Write Disable	RW	0	Disable Remote Writes to local registers Setting this bit to a 1 will prevent remote writes to local device registers from across the control channel. This prevents writes to the Deserializer registers from an I2C master attached to the Serializer. Setting this bit does not affect remote access to I2C slaves at the Deserializer.
		1	I2C Bus Timer Speedup	RW	0	Speed up I2C Bus Watchdog Timer. 1: Watchdog Timer expires after approximately 50µs. 0: Watchdog Timer expires after approximately 1s.
		0	I2C Bus Timer Disable	RW	0	Disable I2C Bus Watchdog Timer When the I2C Watchdog Timer may be used to detect when the I2C bus is free or hung up following an invalid termination of a transaction. If SDA is high and no signaling occurs for approximately 1 second, the I2C bus will assumed to be free. If SDA is low and no signaling occurs, the device will attempt to clear the bus by driving 9 clocks on SCL.
0x23	General Purpose Control	7:0	GPCR	RW	0	Scratch Register.

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x24	BIST Control	7:4	RSVD			Reserved.
		3	BIST Pin Configuration	RW	1	Bist Configured through Pin. 1: Bist configured through pin. 0: Bist configured through register bit "reg_24[0]".
		2:1	BIST Clock Source	RW	00	BIST Clock Source. See Table 6
		0	BIST Enable	RW	0	BIST Control. 1: Enabled. 0: Disabled.
0x25	Parity Error Count	7:0	BIST Error Count	R	0	Number of Forward channel Parity errors in the BIST mode.
0x26–0x3B	**Reserved.**					
0x3C	Oscillator output divider select	7:2	RSVD			Reserved.
		1:0	OSC OUT DIVIDER SEL	RW	0	Selects the divider for the OSC clock out on PCLK when system is not locked and selected by OEN/OSS_SEL 0x02[5]: 00: 50M (+/- 30%) 01: 25M (+/- 30%) 1X: 12.5M (+/- 30%)
0x3D-0x3E	**Reserved.**					
0x3F	CML Output Enable	7:5	RSVD			Reserved.
		4	CML OUT Enable	RW	1	0: CML Loop-through Driver is powered up. 1: CML Loop-through Driver is powered down.
		3:0	RSVD			Reserved.
0x40	SCL High Time	7:0	SCL High Time	RW	0x82	I2C Master SCL High Time This field configures the high pulse width of the SCL output when the De-Serializer is the Master on the local I2C bus. Units are 50 ns for the nominal oscillator clock frequency. The default value is set to provide a minimum (4µs + 0.3µs of rise time for cases where rise time is very fast) SCL high time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
0x41	SCL Low Time	7:0	SCL Low Time	RW	0x82	I2C SCL Low Time This field configures the low pulse width of the SCL output when the De-Serializer is the Master on the local I2C bus. This value is also used as the SDA setup time by the I2C Slave for providing data prior to releasing SCL during accesses over the Bidirectional Control Channel. Units are 50 ns for the nominal oscillator clock frequency. The default value is set to provide a minimum (4.7µs + 0.3µs of fall time for cases where fall time is very fast) SCL low time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
0x42	CRC Force Error	7:2	RSVD			Reserved.
		1	Force Back Channel Error	RW	0	1: This bit introduces multiple errors into Back channel frame. 0: No effect.
		0	Force One Back Channel Error	RW	0	1: This bit introduces ONLY one error into Back channel frame. Self clearing bit. 0: No effect.
0x43-0x4C	**Reserved.**					

Table 4. DS90UB914A-Q1 Control Registers (continued)

Addr (Hex)	Name	Bits	Field	R/W	Default	Description
0x4D	AEQ Test Mode Select	7	RSVD			Reserved.
		6	AEQ Bypass	RW	0	Bypass AEQ and use set manual EQ value using register 0x04.
		5:0	RSVD			Reserved.
0x4E	EQ Value	7:0	AEQ / Manual Eq Readback	R	0x_F	Read back the adaptive and manual Equalization value EQ level: 0000 = ~8.0dB (minimum) 0001 = ~11.0dB 0011 = ~12.5dB 0111 = ~14.0dB 1111 = ~16.0dB (maximum)

Table 5. Clock Sources for Forward Channel Frame on the Serializer During Normal Operation

DS90UB913A-Q1 Reg 0x14 [2:1]	10–bit Mode	12–bit High Frequency Mode	12–bit Low Frequency Mode
00	50 MHz	37.5 MHz	25 MHz
01	100 MHz	75 MHz	50 MHz
10	50 MHz	37.5 MHz	25 MHz
11	25MHz	-	-

Table 6. BIST Clock Sources

DS90UB914A-Q1 Reg 0x24 [2:1]	10–bit Mode	12–bit High Frequency Mode	12–bit Low Frequency Mode
00	PCLK	PCLK	PCLK
01	100 MHz	75 MHz	50 MHz
10	50 MHz	37.5 MHz	25 MHz
11	25MHz	-	-

FUNCTIONAL DESCRIPTION

The DS90UB913A-Q1 is optimized to interface with the DS90UB914A-Q1 using a 50Ω coax interface. The DS90UB913A-Q1 will also work with the DS90UB914A-Q1 using an STP interface.

The DS90UB913A/914A FPD- Link III chipsets are intended to link mega-pixel camera imagers and video processors in ECUs. The Serializer/Deserializer chipset can operate from 25 MHz to 100 MHz pixel clock frequency. The DS90UB913A-Q1 device transforms a 10/12-bit wide parallel LVCMOS data bus along with a bidirectional control channel control bus into a single high-speed differential pair. The high speed serial bit stream contains an embedded clock and DC-balanced information which enhances signal quality to support AC coupling. The DS90UB914A-Q1 device receives the single serial data stream and converts it back into a 10/12-bit wide parallel data bus together with the control channel data bus. The DS90UB913A/914A chipsets can accept up to:

- 12-bits of DATA + 2 bits SYNC for an input PCLK range of 25 MHz to 50 MHz in the 12-bit low frequency mode. Note: No HS/VS restrictions (raw).
- 12-bits of DATA + 2 SYNC bits for an input PCLK range of 25 MHz to 75 MHz in the 12-bit high frequency mode. Note: No HS/VS restrictions (raw).
- 10-bits of DATA + 2 SYNC bits for an input PCLK range of 25 MHz to 100 MHz in the 10-bit mode. Note: HS/VS restricted to no more than one transition per 10 PCLK cycles.

The DS90UB914A-Q1 chipset has a 2:1 multiplexer which allows customers to select between two Serializer inputs. The control channel function of the DS90UB913A/DS90UB914A-Q1 chipset provides bidirectional communication between the image sensor and ECUs. The integrated bidirectional control channel transfers data bidirectionally over the same differential pair used for video data interface. This interface offers advantages over other chipsets by eliminating the need for additional wires for programming and control. The bidirectional control channel bus is controlled via an I2C port. The bidirectional control channel offers asymmetrical communication and is not dependent on video blanking intervals.

The DS90UB913A/914A chipset offer customers the choice to work with different clocking schemes. The DS90UB913A/914A chipsets can use an external oscillator as the reference clock source for the PLL (see section DS90UB913A/914A Operation with External Oscillator as Reference Clock) or PCLK from the imager as primary reference clock to the PLL (see section DS90UB913A/914A Operation with Pixel Clock from Imager as Reference Clock.

Transmission Media

The DS90UB913A/914A chipset is intended to be used in a point-to-point configuration through a shielded twisted pair cable. The Serializer and Deserializer provide internal termination to minimize impedance discontinuities. The interconnect (cable and connectors) should have a differential impedance of 100Ω, or a single-ended impedance of 50Ω. The maximum length of cable that can be used is dependent on the quality of the cable (gauge, impedance), connector, board(discontinuities, power plane), the electrical environment (e.g power stability, ground noise, input clock jitter, PCLK frequency, etc). The resulting signal quality at the receiving end of the transmission media may be assessed by monitoring the differential eye opening of the serial data stream. A differential probe should be used to measure across the termination resistor at the CMLOUTP/N pins. Figure 21 illustrates the minimum eye width and eye height that is necessary for bit error free operation.

DS90UB913A/914A Operation with External Oscillator as Reference Clock

In some applications, the pixel clock that comes from the imager can have jitter which exceeds the tolerance of the DS90UB913A/914A chipsets. In this case, the DS90UB913A-Q1 device should be operated by using an external clock source as the reference clock for the DS90UB913A/914A chipsets. **This is the recommended operating mode.** The external oscillator clock output goes through a divide-by-2 circuit in the DS90UB913A-Q1 Serializer and this divided clock output is used as the reference clock for the imager. The output data and pixel clock from the imager are then fed into the DS90UB913A-Q1 device. Figure 26 shows the operation of the DS90UB13A/914A chipsets while using an external automotive grade oscillator.

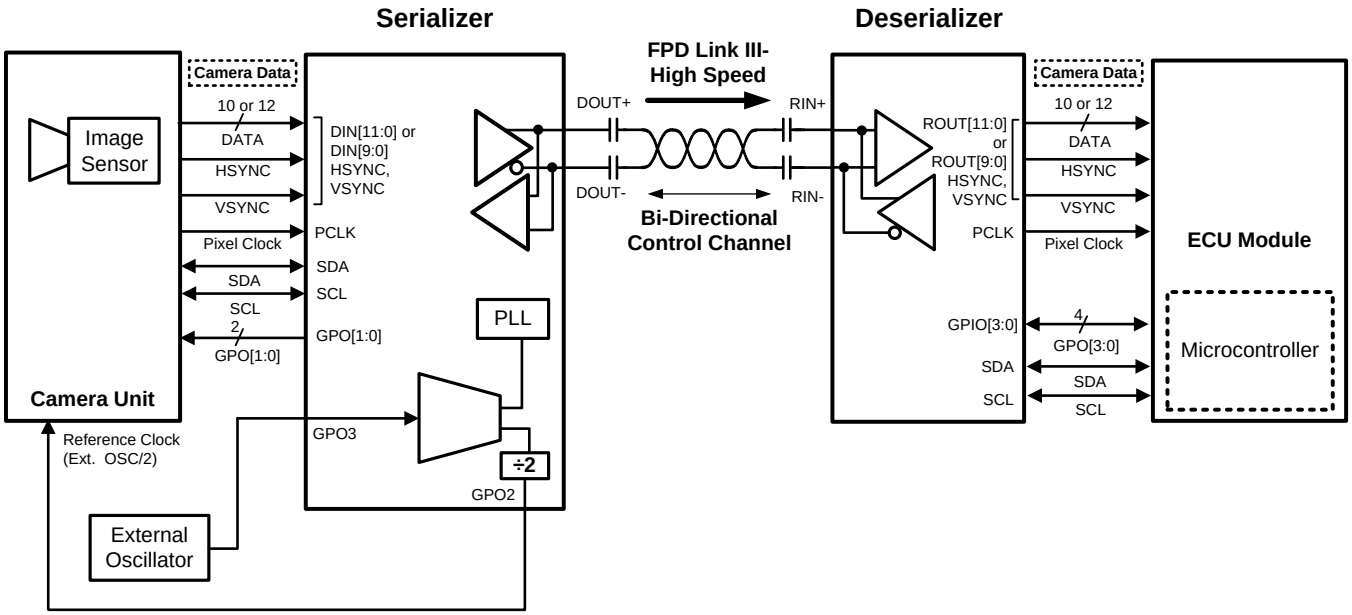

Figure 26. DS90UB913A-Q1/914A-Q1 Operation in the External Oscillator Mode

When the DS90UB913A-Q1 device is operated using an external oscillator, the GPO3 pin on the DS90UB913A-Q1 is the input pin for the external oscillator. In applications where the DS90UB913A-Q1 device is operated from an external oscillator, the divide-by-2 circuit in the DS90UB913A-Q1 device feeds back the divided clock output to the imager device through GPO2 pin. The pixel clock to external oscillator ratios needs to be fixed for the 12–bit high frequency mode and the 10–bit mode. **In the 10-bit mode, the pixel clock frequency divided by the external oscillator frequency must be 2. In the 12-bit high frequency mode, the pixel clock frequency divided by the external oscillator frequency must be 1.5.** For example, if the external oscillator frequency is 48MHz in the 10–bit mode, the pixel clock frequency of the imager needs to be twice of the external oscillator frequency, i.e. 96MHz. If the external oscillator frequency is 48MHz in the 12-bit high frequency mode, the pixel clock frequency of the imager needs to be 1.5 times of the external oscillator frequency, i.e. 72MHz. In this mode, GPO2 and GPO3 on the Serializer cannot act as the output of the input signal coming from GPIO2 or GPIO3 on the Deserializer.

DS90UB913A/914A Operation with Pixel Clock from Imager as Reference Clock

The DS90UB913A/914A chipsets can be operated by using the pixel clock from the imager as the reference clock. Figure 27 shows the operation of the DS90UB913A/914A chipsets using the pixel clock from the imager. If the DS90UB913A-Q1 device is operated using the pixel clock from the imager as the reference clock, then the imager uses an external oscillator as its reference clock. There are 4 GPIOs available in this mode (PCLK from imager mode).

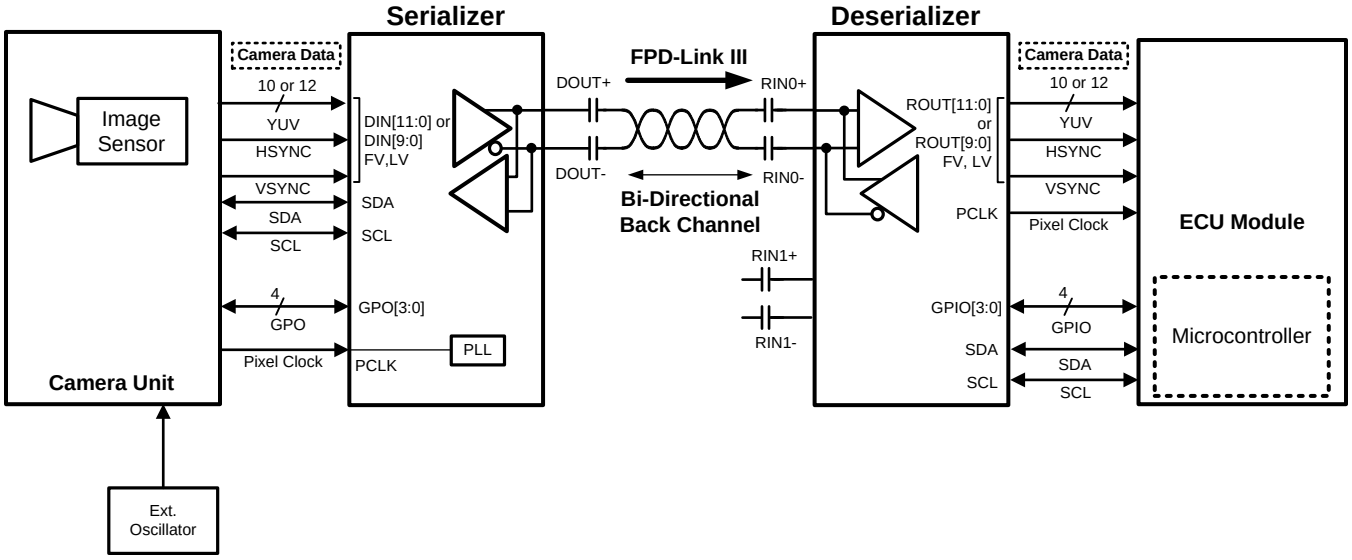

Figure 27. DS90UB913A-Q1/914A-Q1 Operation in PCLK mode

MODE Pin on Serializer

The mode pin on the Serializer can be configured to select if the DS90UB913A-Q1 device is to be operated from the external oscillator or the PCLK from the imager. The pin must be pulled to V_{DD}(1.8V, not V_{DDIO}) with a 10 kΩ resistor and a pull down resistor R_{MODE}) of the recommended value to set the modes shown in Figure 28. The recommended maximum resistor tolerance is 1%.

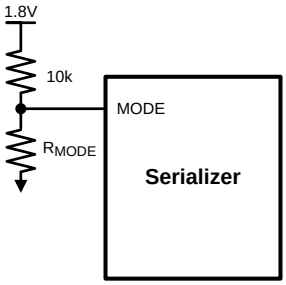

Figure 28. MODE Pin configuration on DS90UB913A-Q1

Table 7. DS90UB913A-Q1 Serializer MODE Resistor Value

DS90UB913A-Q1 Serializer MODE Resistor Value	
Mode Select	**R_{MODE} Resistor Value**
PCLK from imager mode	100kΩ
External Oscillator mode	4.7kΩ

MODE Pin on Deserializer

The mode pin on the Deserializer can be used to configure the device to work in the 12-bit low frequency mode, 12-bit high frequency mode or the 10-bit mode of operation. Internally, the DS90UB913A/914A chipset operates in a divide-by-1 mode in the 12-bit low frequency mode, divide-by-2 mode in the 10-bit mode and a divide-by-1.5 mode in the 12-bit high frequency mode. The pin must be pulled to V_{DD} (1.8V, not V_{DDIO}) with a 10 kΩ resistor and a pull down resistor ®$_{MODE}$) of the recommended value to set the different modes in the Deserializer as mentioned in Table 8. The Deserializer automatically configures the Serializer to correct mode via the back-channel. The recommended maximum resistor tolerance is 1%.

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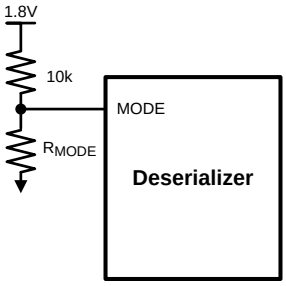

Figure 29. Mode Pin Configuration on DS90UB914A-Q1 Deserializer

Table 8. DS90UB914A-Q1 Deserializer MODE Resistor Value

DS90UB914A-Q1 Deserializer MODE resistor Value	
MODE Select	**R_{MODE} Resistor Value**
12-bit low frequency mode 25-50 MHz PCLK, 10/12-bits DATA+ 2 SYNC. Note: No HS/VS restrictions (raw).	0kΩ
12-bit high frequency mode 25-75 MHz PCLK, 10/12-bits DATA+ 2 SYNC. Note: No HS/VS restrictions (raw).	3kΩ
10-bit mode 25–100 MHz PCLK, 10-bits DATA+ 2 SYNC. Note: HS/VS restricted to no more than one transition per 10 PCLK cycles.	11kΩ

Line Rate Calculations for the DS90UB913A/914A

The DS90UB913A-Q1 device divides the clock internally by divide-by-1 in the 12-bit low frequency mode, by divide-by-2 in the 10-bit mode and by divide-by-1.5 in the 12-bit high frequency mode. Conversely, the DS90UB914A-Q1 multiplies the recovered serial clock to generate the proper pixel clock output frequency. Thus the maximum line rate in the three different modes remains 1.4Gbps. The following are the formulae used to calculate the maximum line rate in the different modes:

- For the 12-bit low frequency mode, Line rate = f_{PCLK}*28; e.g. f_{PCLK} = 50MHz, line rate = 50*28 = 1.4Gbps
- For the 12-bit high frequency mode, Line rate = f_{PCLK}*(2/3)*28; e.g. f_{PCLK} = 75MHz, line rate = (75)*(2/3)*28 = 1.4Gbps
- For the 10-bit mode, Line rate = f_{PCLK}/2*28; e.g. f_{PCLK} = 100MHz, line rate = (100/2)*28 = 1.4Gbps

Deserializer Multiplexer Input

The DS90UB914A-Q1 offers a 2:1 multiplexer that can be used to select which camera is used as the input. Figure 30 shows the operation of the 2:1 multiplexer in the Deserializer. The selection of the camera can be pin controlled as well as register controlled. Both the Deserializer inputs cannot be enabled at the same time. If the Serializer A is selected as the active Serializer, the back-channel for Deserializer A turns ON and vice versa. To switch between the two cameras, first the Serializer B has to be selected using the SEL pin/register on the Deserializer. After that the back channel driver for Deserializer B has to be enabled using the register in the Deserializer.

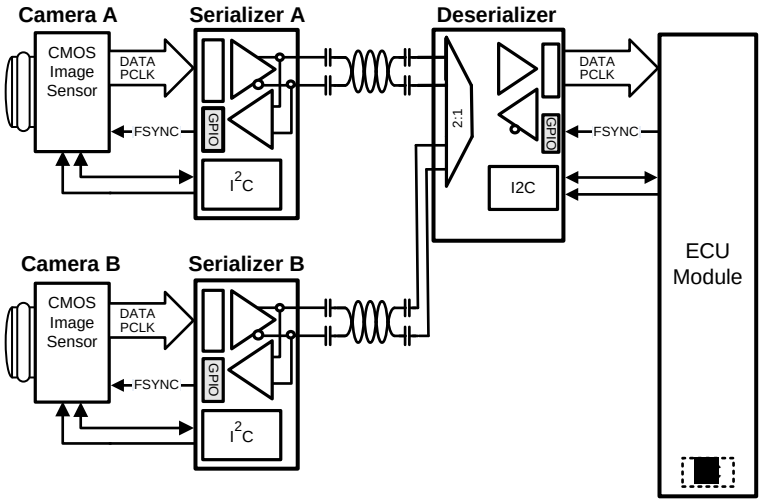

Figure 30. Using the multiplexer on the Deserializer to enable a two camera system

Serial Frame Format

The High Speed Forward Channel is composed of 28 bits of data containing video data, sync signals, I2C and parity bits. This data payload is optimized for signal transmission over an AC-coupled link. Data is randomized, balanced and scrambled. The 28-bit frame structure changes in the 12-bit low frequency mode, 12-bit high frequency mode and the 10-bit mode internally and is seamless to the customer. The bidirectional control channel data is transferred over the single serial link along with the high-speed forward data. This architecture provides a full duplex low speed forward and backward path across the serial link together with a high speed forward channel without the dependence on the video blanking phase.

Error Detection

The chipset provides error detection operations for validating data integrity in long distance transmission and reception. The data error detection function offers users flexibility and usability of performing bit-by-bit data transmission error checking. The error detection operating modes support data validation of the following signals:

- Bidirectional control channel data across the serial link
- Parallel video/sync data across the serial link

The chipset provides 1 parity bit on the forward channel and 4 CRC bits on the back channel for error detection purposes. The DS90UB913A/914A chipset checks the forward and back channel serial links for errors and stores the number of detected errors in two 8-bit registers in the Serializer and the Deserializer respectively.

To check parity errors on the forward channel, monitor registers 0x1A and 0x1B on the Deserializer. If there is a loss of LOCK, then the counters on registers 0x1A and 0x1B are reset.**Whenever there is a parity error on the forward channel, the PASS pin will go low.**

To check CRC errors on the back-channel, monitor registers 0x0A and 0x0B on the Serializer.

Description of Bidirectional Control Bus and I2C Modes

The I2C compatible interface allows programming of the DS90UB913A-Q1, DS90UB914A-Q1, or an external remote device (such as image sensor) through the bidirectional control channel. Register programming transactions to/from the DS90UB913A-Q1/914A-Q1 chipset are employed through the clock (SCL) and data (SDA) lines. These two signals have open drain I/Os and both lines must be pulled-up to VDDIO by an external resistor. Pull-up resistors or current sources are required on the SCL and SDA busses to pull them high when they are not being driven low. A logic LOW is transmitted by driving the output low. Logic HIGH is transmitted by releasing the output and allowing it to be pulled-up externally. The appropriate pull-up resistor values will depend upon the total bus capacitance and operating speed. The DS90UB913A/914A I2C bus data rate supports up to 400 kbps according to I2C fast mode specifications.

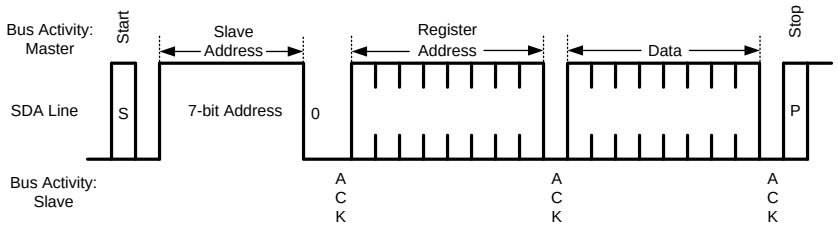

Figure 31. Write Byte

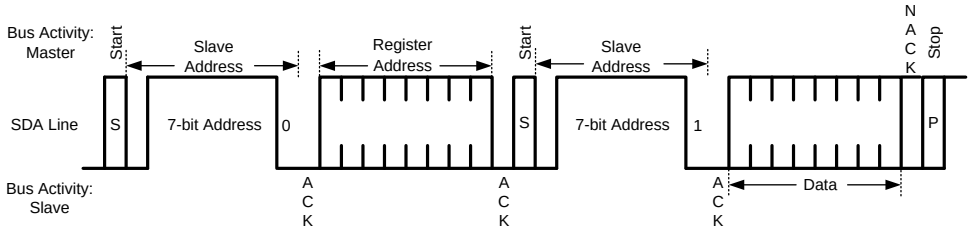

Figure 32. Read Byte

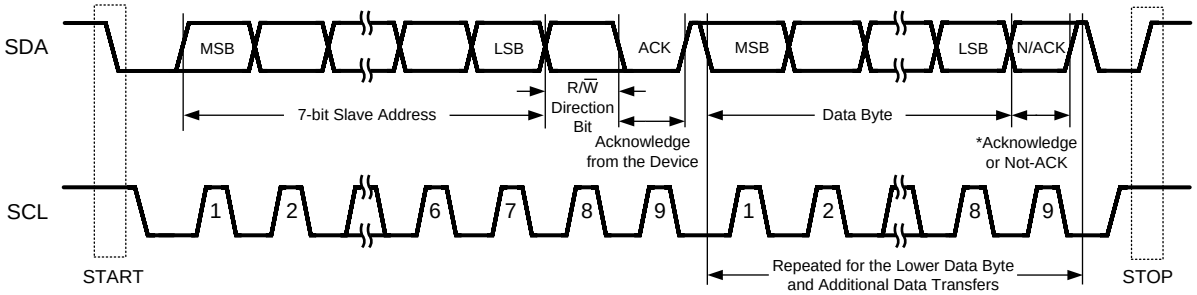

Figure 33. Basic Operation

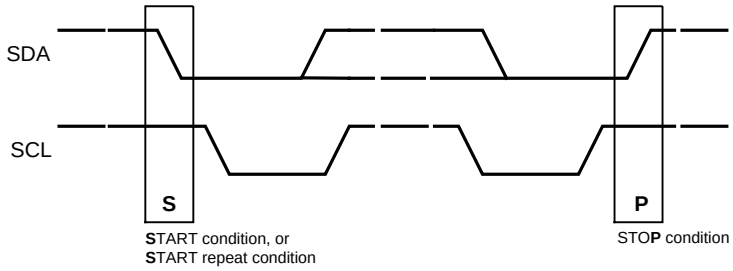

Figure 34. Start and Stop Conditions

Slave Clock Stretching

The I2C compatible interface allows programming of the DS90UB913A-Q1, DS90UB914A-Q1, or an external remote device (such as image sensor) through the bidirectional control. To communicate and synchronize with remote devices on the I2C bus through the bidirectional control channel/MCU, **the chipset utilizes bus clock stretching (holding the SCL line low) during data transmission**; where the I2C slave pulls the SCL line low on the 9th clock of every I2C transfer (before the ACK signal). The slave device will not control the clock and only stretches it until the remote peripheral has responded. The I2C master must support clock stretching to operate with the DS90UB913A/914A chipset.

I2C Pass-Through

I2C pass-through provides a way to access remote devices at the other end of the FPD-Link III interface. This option is used to determine if an I2C instruction is transferred over to the remote I2C bus. For example, when the I2C master is connected to the deserializer and I2C pass-through is enabled on the deserializer, any I2C traffic targeted for the remote serializer or remote slave will be allowed to pass through the deserializer to reach those respective devices.

See Figure 35 for an example of this function and refer to application note: I2C over DS90UB913/4 FPD-Link III with Bidirectional Control Channel ().

If master controller transmits I2C transaction for address 0xA0, the DES A with I2C pass-through enabled will transfer I2C commands to remote Camera A. The DES B with I2C pass-through disabled, any I2C commands will NOT be passed on the I2C bus to Camera B.

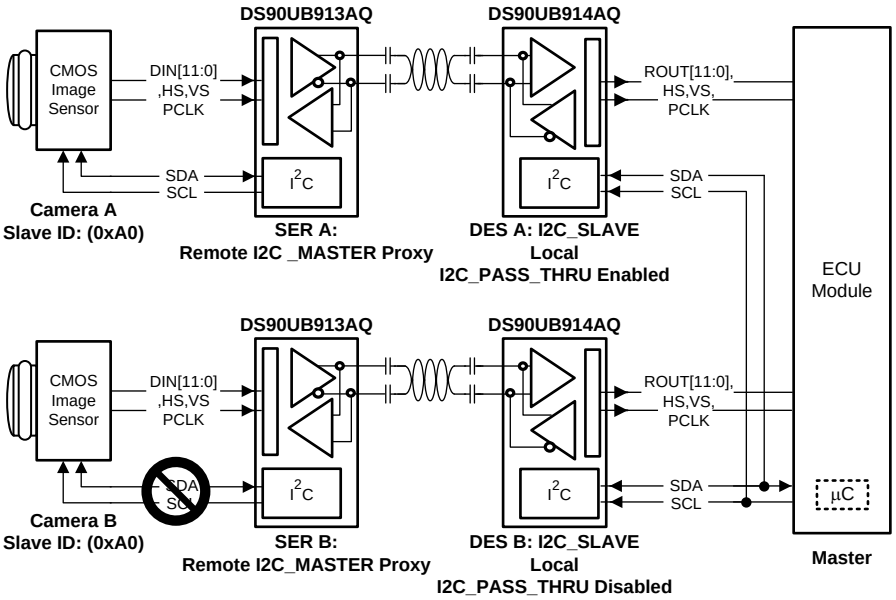

Figure 35. I2C Pass-Through

ID[x] Address Decoder on the Serializer

The ID[x] pin on the Serializer is used to decode and set the physical slave address of the Serializer (I2C only) to allow up to five devices on the bus connected to the Serializer using only a single pin. The pin sets one of the 6 possible addresses for each Serializer device. The pin must be pulled to VDD (1.8V, not VDDIO) with a 10 kΩ resistor and a pull down resistor (R_{ID}) of the recommended value to set the physical device address. The recommended maximum resistor tolerance is 1%.

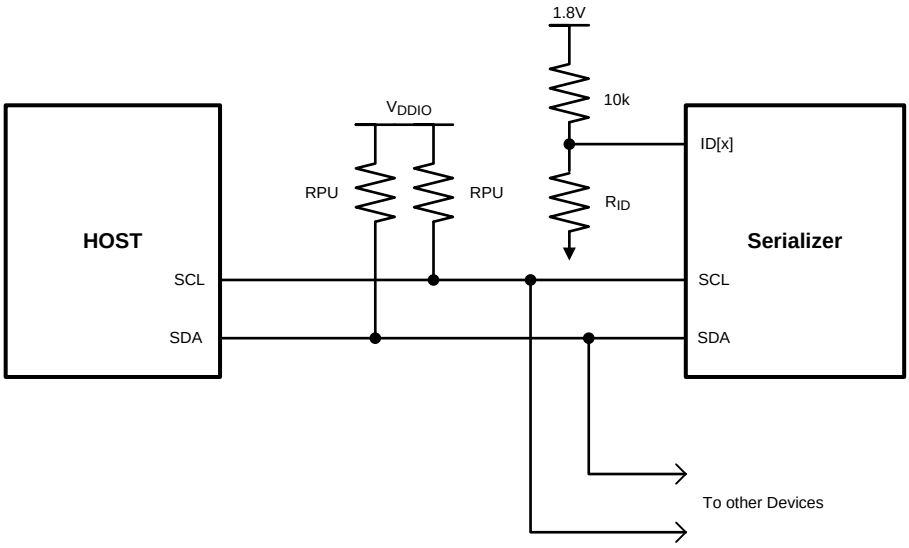

Figure 36. ID[x] Address Decoder on the Serializer

Table 9. ID[x] Resistor Value for DS90UB913A-Q1 Serializer

ID[x] Resistor Value — DS90UB913A-Q1 Serializer		
Resistor RID0 Ω (1% Tolerance)	**Address 7'b**	**Address 8'b 0 appended (WRITE)**
0k	0x58	0xB0
2k	0x59	0xB2
4.7k	0x5A	0xB4
8.2k	0x5B	0xB6
14k	0x5C	0xB8
100k	0x5D	0xBA

ID[x] Address Decoder on the Deserializer

The IDx[0] and IDx[1] pins on the Deserializer are used to decode and set the physical slave address of the Deserializer (I2C only) to allow up to 16 devices on the bus using only two pins. The pins set one of 16 possible addresses for each Deserializer device. As there will be more Deserializer devices connected on the same board than Serializers, more I2C device addresses have been defined for the DS90UB914A-Q1 Deserializer than the DSDS90UB913A-Q1 Serializer. The pins must be pulled to VDD (1.8V, not VDDIO) with a 10 kΩ resistor and two pull down resistors (R_{ID0} and R_{ID1}) of the recommended value to set the physical device address. The recommended maximum resistor tolerance is 1%.

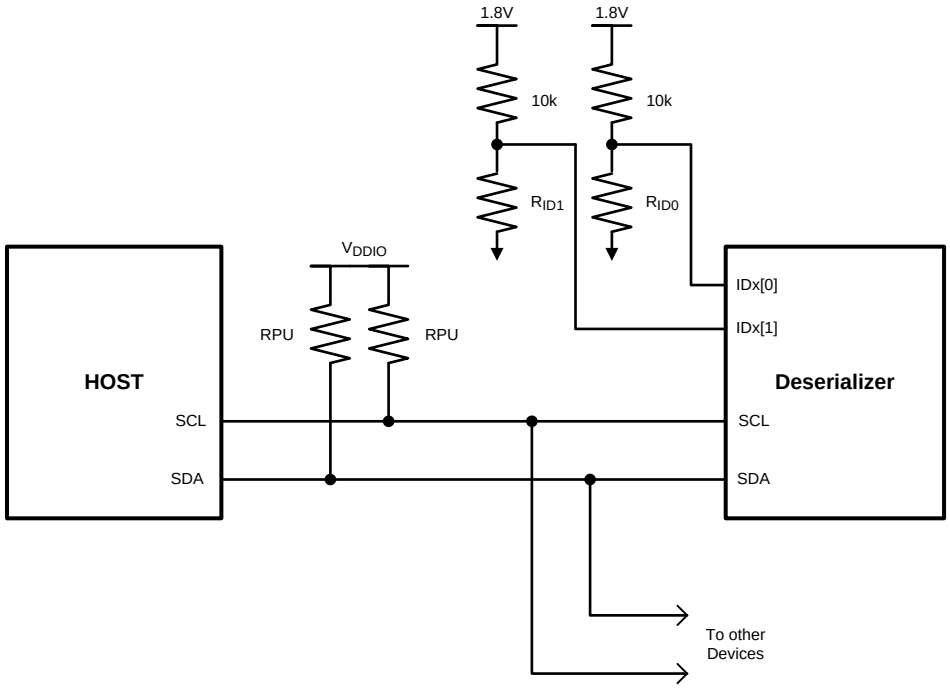

Figure 37. ID[x[Address Decoder on the Deserializer

Table 10. Resistor Values for IDx[0] and IDx[1] on DS90UB914A-Q1 Deserializer

ID[x] Resistor Value — DS90UB913A-Q1 Serializer			
Resistor RID1 Ω (1%Tolerance)	**Resistor R_{ID0} Ω** (1%Tolerance)	**Address 7'b**	**Address 8'b 0 appended (WRITE)**
0k	0k	0x60	0xC0
0k	3k	0x61	0xC2
0k	11k	0x62	0xC4
0k	100k	0x63	0xC6
3k	0k	0x64	0xC8
3k	3k	0x65	0xCA
3k	11k	0x66	0XCC
3k	100k	0x67	0XCE
11k	0k	0x68	0XD0
11k	3k	0x69	0XD2
11k	11k	0x6A	0XD4
11k	100k	0x6B	0XD6
100k	0k	0x6C	0XD8
100k	3k	0x6D	0XDA
100k	11k	0x6E	0XDC
100k	100k	0x6F	0XDE

Clock-Data Recovery Status Flag (LOCK), Output Enable (OEN) and Output State Select (OSS_SEL)

When PDB is driven HIGH, the Deserializer's CDR PLL begins locking to the serial input and LOCK is TRI-STATE or LOW (depending on the value of the OEN setting). After the DS90UB914A-Q1 completes its lock sequence to the input serial data, the LOCK output is driven HIGH, indicating valid data and clock recovered from the serial input is available on the parallel bus and PCLK outputs. The states of the outputs are based on the OEN and OSS_SEL setting (Table 11). See Figure Figure 22.

Table 11. Output States

Inputs				Outputs			
Serial Inputs	**PDB**	**OEN**	**OSS_SEL**	**LOCK**	**Pass**	**DATA, GPIO**	**CLK**
X	0	X	X	Z	Z	Z	Z
X	1	0	0	L or H	L	L	L
X	1	0	1	L or H	Z	Z	Z
Static	1	1	0	L	L	L	L/Osc(Register Bit Enable)
Static	1	1	1	H	Previous State	L	L
Active	1	1	0	H	L	L	L
Active	1	1	1	H	Valid	Valid	Valid

Programmable Controller

An integrated I2C slave controller is embedded in the DS90UB913A-Q1 Serializer as well as the DS90UB914A-Q1 Deserializer. It must be used to configure the extra features embedded within the programmable registers or it can be used to control the set of programmable GPIOs.

Multiple Device Addressing

Some applications require multiple camera devices with the same fixed address to be accessed on the same I2C bus. The DS90UB913A/914 provides slave ID matching/aliasing to generate different target slave addresses when connecting more than two identical devices together on the same bus. This allows the slave devices to be independently addressed. Each device connected to the bus is addressable through a unique ID by programming of the Slave alias register on Deserializer. This will remap the Slave alias address to the target SLAVE_ID address; up to 8 ID Alias's are supported when slaves are attached to the SER and up to slave on the DES. The ECU Controller must keep track of the list of I2C peripherals in order to properly address the target device.

See Figure 38 for an example of this function.

- ECU is the I2C master and has an I2C master interface
- The I2C interfaces in DES A and DES B are both slave interfaces
- The I2C protocol is bridged from DES A to SER A and from DES B to SER B
- The I2C interfaces in SER A and SER B are both master interfaces

If master controller transmits I2C slave 0xA0, DES A (address 0xC0), with pass through enabled, will forward the transaction to remote Camera A. If the controller transmits slave address 0xA4, the DES B 0xC2 will recognize that 0xA4 is mapped to 0xA0 and will be transmitted to the remote Camera B. If controller sends command to address 0xA6, the DES B (address 0xC2), with pass through enabled, will forward the transaction to slave device 0xA2.

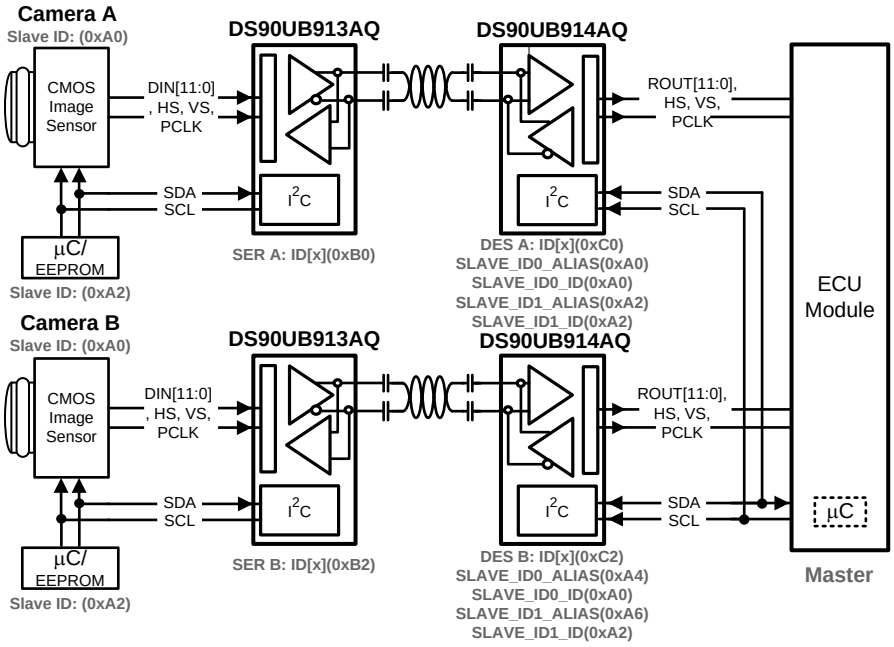

Figure 38. Multiple Device Addressing

Synchronizing Multiple Cameras

For applications requiring multiple cameras for frame-synchronization, it is recommended to utilize the General Purpose Input/Output (GPIO) pins to transmit control signals to synchronize multiple cameras together. To synchronize the cameras properly, the system controller needs to provide a field sync output (such as a vertical or frame sync signal) and the cameras must be set to accept an auxiliary sync input. The vertical synchronize signal corresponds to the start and end of a frame and the start and end of a field. Note this form of synchronization timing relationship has a non-deterministic latency. After the control data is reconstructed from the bidirectional control channel, there will be a time variation of the GPIO signals arriving at the different target devices (between the parallel links). The maximum latency delta (t1) of the GPIO data transmitted across multiple links is 25 µs.

Note: The user must verify that the timing variations between the different links are within their system and timing specifications.

See Figure 39 for an example of this function.

The maximum time (t1) between the rising edge of GPIO (i.e. sync signal) arriving at Camera A and Camera B is 25 µs.

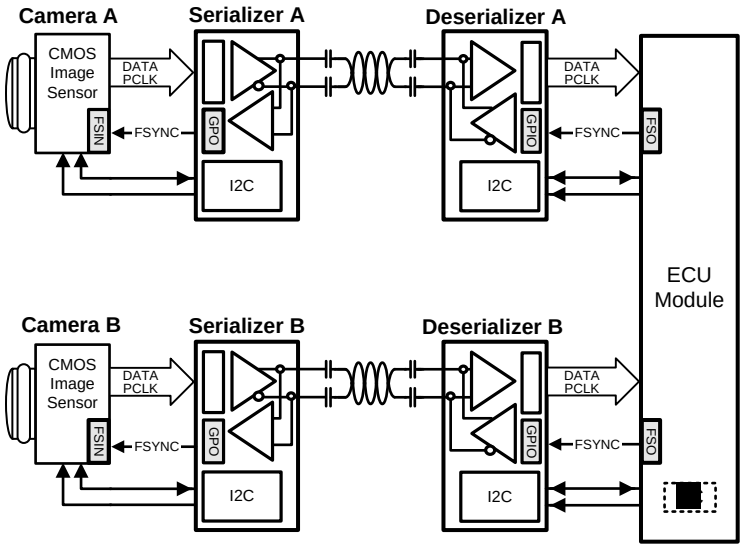

Figure 39. Synchronizing Multiple Cameras

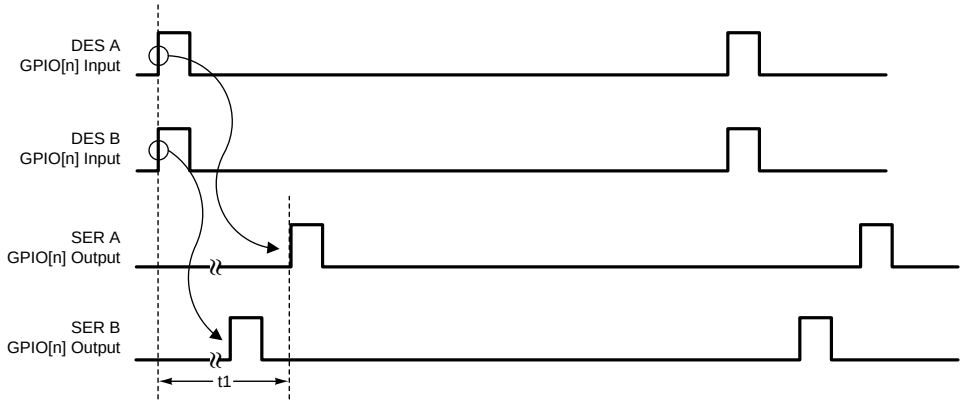

Figure 40. GPIO Delta Latency

General Purpose I/O (GPIO) Descriptions

There are 4 GPOs on the Serializer and 4 GPIOs on the Deserializer when the DS90UB913A/914A chipsets are run off the pixel clock from the imager as the reference clock source. The GPOs on the Serializer can be configured as outputs for the input signals that are fed into the Deserializer GPIOs. In addition, the GPOs on the Serializer can behave as outputs of the local register on the Serializer. The GPIOs on the Deserializer can be configured to be the input signals feeding the output of the GPOs on the Serializer. In addition the GPIOs on the Deserializer can be configured to behave as outputs of the local register on the Deserializer. If the DS90UB913A/914A chipsets are run off the external oscillator source as the reference clock, then GPO3 on the Serializer is automatically configured to be the input for the external clock and GPIO2 on the Deserializer is configured to be the output of the divide-by-2 clock which is fed into the imager as its reference clock. In this case, the GPIO2 and GPIO3 on the Deserializer can only behave as outputs of the local register on the Deserializer. The GPIO maximum switching rate is up to 66 kHz when configured for communication between Deserializer GPIO to Serializer GPO.

LVCMOS VDDIO Option

1.8V/2.8V/3.3V Serializer inputs and 1.8V/3.3V Deserializer outputs are user configurable to provide compatibility with 1.8V, 2.8V and 3.3V system interfaces.

EMI Reduction

Deserializer Staggered Output

The receiver staggers output switching to provide a random distribution of transitions within a defined window. Outputs transitions are distributed randomly. This minimizes the number of outputs switching simultaneously and helps to reduce supply noise. In addition it spreads the noise spectrum out reducing overall EMI.

Spread Spectrum Clock Generation(SSCG) on the Deserializer

The DS90UB914A-Q1 parallel data and clock outputs have programmable SSCG ranges from 25 MHz to 100 MHz. The modulation rate and modulation frequency variation of output spread is controlled through the SSCG control registers on the DS90UB914A-Q1 device. SSCG profiles can be generated using bits [3:0] in register 0x02 in the Deserializer.

Powerdown

The SER has a PDB input pin to ENABLE or powerdown the device. Enabling PDB on the SER will disable the link to save power. If PDB=HIGH, the SER will operate at its internal default oscillator frequency when the input PCLK stops. When the PCLK starts again, the SER will then lock to the valid input PCLK and transmit the data to the DES. When PDB=LOW, the high-speed driver outputs are static HIGH. The DES has a PDB input pin to ENABLE or Powerdown the device. Enabling PDB on the DES will disable the link to save power. If PDB=HIGH, the DES will lock to the input stream and assert the LOCK pin (HIGH) and output valid data. When PDB=LOW, all outputs are in TRI-STATE.

Pixel Clock Edge Select (TRFB / RRFB)

The TRFB/RRFB selects which edge of the Pixel Clock is used. For the SER, this register determines the edge that the data is latched on. If TRFB register is 1, data is latched on the Rising edge of the PCLK. If TRFB register is 0, data is latched on the Falling edge of the PCLK. For the DES, this register determines the edge that the data is strobed on. If RRFB register is 1, data is strobed on the Rising edge of the PCLK. If RRFB register is 0, data is strobed on the falling edge of the PCLK.

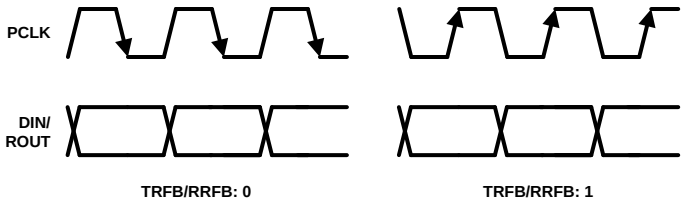

Figure 41. Programmable PCLK Strobe Select

Power Up Requirements and PDB Pin

It is required to delay and release the PDB Signal after VDD (VDDn and VDDIO) power supplies have settled to the recommended operating voltage. An external RC network can be connected to the PDB pin to ensure PDB arrives after all the VDD has stabilized.

Built In Self Test

An optional At-Speed Built In Self Test (BIST) feature supports the testing of the high speed serial link and low-speed back channel. This is useful in the prototype stage, equipment production, and in-system test and also for system diagnostics.

BIST Configuration and Status

The chipset can be programmed into BIST mode using either pins or registers on the DES only. By default BIST configuration is controlled through pins. BIST can be configured via registers using BIST Control register (0x24). Pin-based configuration is defined as follows:

- BISTEN = HIGH: Enable the BIST mode, BISTEN = LOW: Disable the BIST mode.
- Deserializer GPIO0 and GPIO1: Defines the BIST clock source (PCLK vs. various frequencies of internal

OSC)

Table 12. BIST Configuration

Deserializer GPIO[0:1]	Oscillator Source	BIST Frequency (MHz)
00	External PCLK	PCLK or External Oscillator
01	Internal	~50
10	Internal	~25

BIST mode provides various options for the PCLK source. Either external pins (GPIO0 and GPIO1) or registers can be used to program the BIST to use external PCLK or various OSC frequencies. Refer to Table 12 for pin settings and refer to Table 4 for register settings.
The BIST status can be monitored real-time on the PASS pin. For every frame with error(s), the PASS pin toggles low for one-half PCLK period. If two consecutive frames have errors, PASS will toggle twice to allow counting of frames with errors. Once the BIST is done, the PASS pin reflects the pass/fail status of the last BIST run only for one PCLK cycle. The status can also be read through I2C for the number of frames in errors. BIST status register retains results until it is reset by a new BIST session or a device reset. To evaluate BIST in external oscillator mode, both the external oscillator and PCLK need to be present. For all practical purposes, the BIST status can be monitored from the BIST Error Count register 0x25 on the DS90UB914A Deserializer.

Sample BIST Sequence

Step1. For the DS90UB913A/914A FPD-Link III chipset, BIST Mode is enabled via the BISTEN pin of DS90UB914A-Q1 FPD-Link III deserializer. The desired clock source is selected through the deserializer GPIO0 and GPIO1 pins as shown in Table 12.

Step2. The DS90UB913A-Q1 Serializer BIST pattern is enabled through the back channel. The BIST pattern is sent through the FPD-Link III to the deserializer. Once the serializer and deserializer are in the BIST mode and the deserializer acquires Lock, the PASS pin of the deserializer goes high and BIST starts checking FPD-Link III serial stream. If an error in the payload is detected, the PASS pin will switch low for one half of the clock period. During the BIST test, the PASS output can be monitored and counted to determine the payload error rate.

Step3. To stop the BIST mode, the deserializer BISTEN pin is set LOW. The deserializer stops checking the data. The final test result is not maintained on the PASS pin. To monitor the BIST status, check the BIST Error Count register, 0x25 on the Deserializer.

Step4. The link returns to normal operation after the deserializer BISTEN pin is low. Figure 43 shows the waveform diagram of a typical BIST test for two cases. Case 1 is error free, and Case 2 shows one with multiple errors. In most cases, it is difficult to generate errors due to the robustness of the link (differential data transmission etc.), thus they may be introduced by greatly extending the cable length, faulting the interconnect, or by reducing signal condition enhancements (Rx equalization).

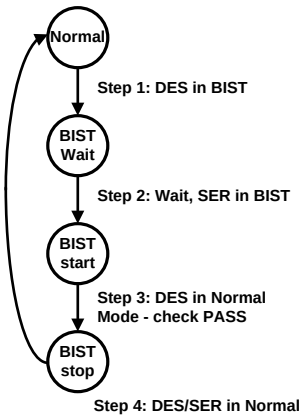

Figure 42. AT-Speed BIST System Flow Diagram

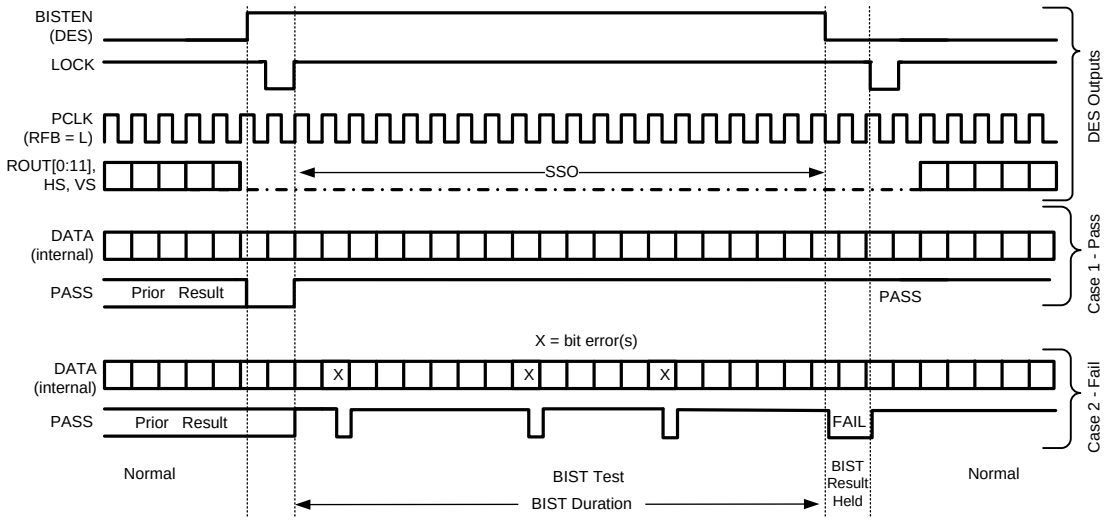

Figure 43. BIST Timing Diagram

APPLICATION INFORMATION

AC Coupling

The SER/DES supports only AC-coupled interconnects through an integrated DC-balanced decoding scheme. External AC coupling capacitors must be placed in series in the FPD-Link III signal path as illustrated in Figure 44. For applications utilizing single-ended 50Ω coaxial cable, the unused data pin (DOUT-, RIN-) should utilize a 0.047µF capacitor and should be terminated with a 50Ω resistor.

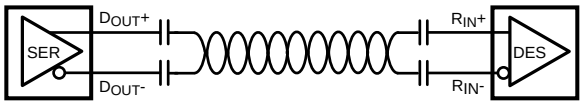

Figure 44. AC-Coupled Connection (STP)

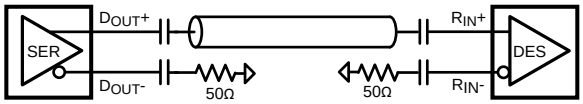

Figure 45. AC-Coupled Connection (Coaxial)

For high-speed FPD–Link III transmissions, the smallest available package should be used for the AC coupling capacitor. This will help minimize degradation of signal quality due to package parasitics. The I/O's require a 0.1µF AC coupling capacitors to the line.

Adaptive Equalizer – Loss Compensation

The receiver inputs provide an adaptive equalization filter in order to compensate for signal degradation from the interconnect components. There are limits to the amount of loss that can be compensated – these limits are defined by the gain curve of the equalizer. In addition, there is a minimum tolerance for loss defined by the delta between the serializer's minimum VOD and the input threshold of the deserializer (Vswing). In order to determine the maximum cable reach, factors that affect signal integrity such as jitter, skew, ISI, crosstalk, etc. need to be taken into consideration. Figure 46 illustrates the maximum allowable interconnect loss for coax/STP cable with the adaptive equalizer at various gain settings.
The level of equalization can also be manually selected via register controls. The adaptive equalized output can be seen using the CMLOUTP/CMLOUTN pins in the Deserializer.

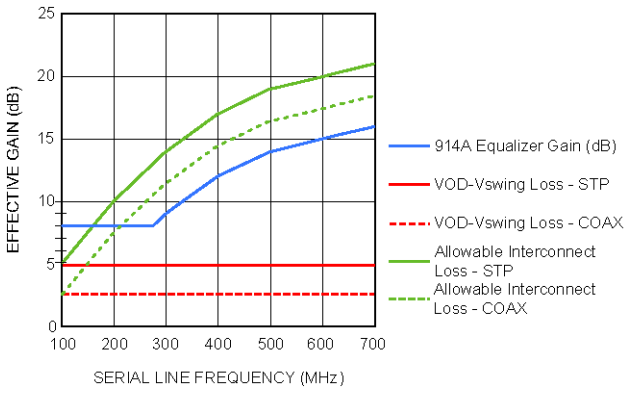

Figure 46. Adaptive Equalizer – Interconnect Loss Compensation (Coax/STP)

Figure 47 shows the typical connection of a DS90UB913A-Q1 Serializer using a **coax** interface.

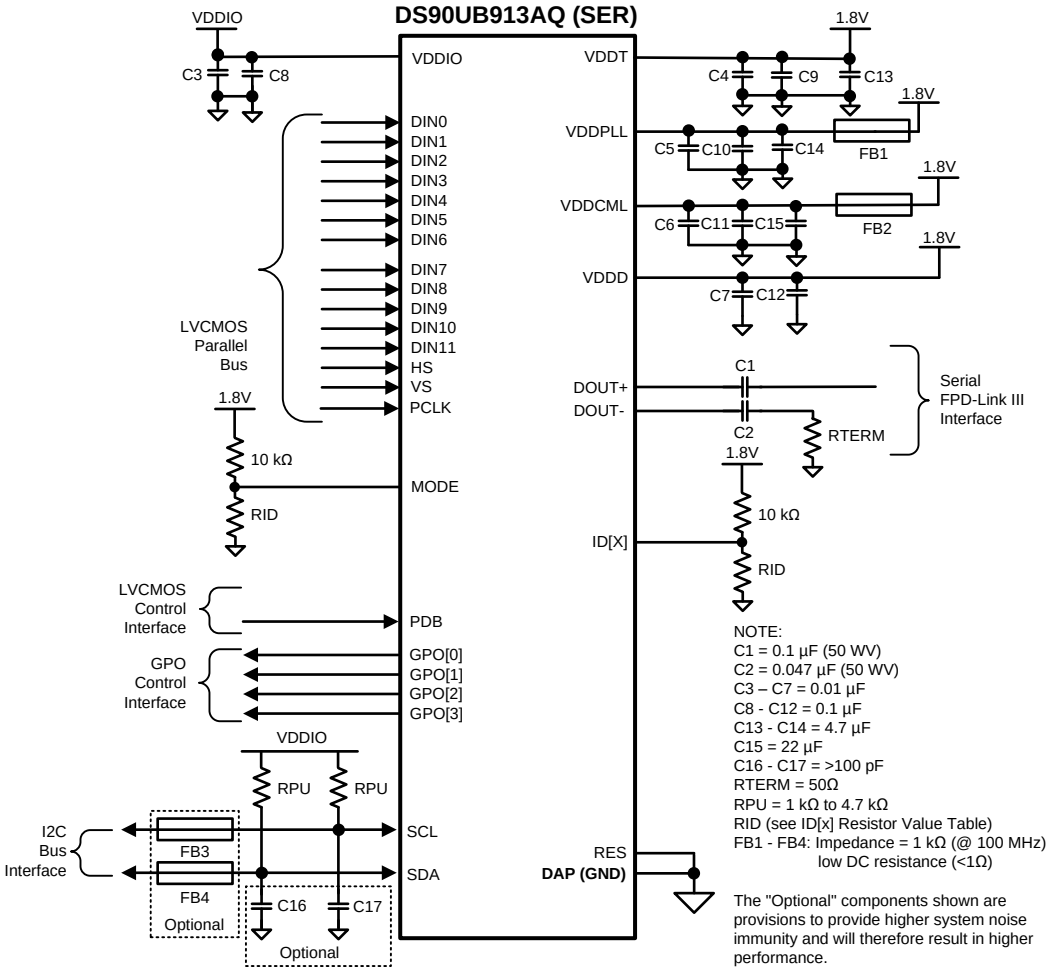

Figure 47. DS90UB913A-Q1 Typical Connection Diagram — Pin Control (Coax)

Figure 48 shows a typical connection using a **Coax** interface to the DS90UB914A-Q1 Deserializer.

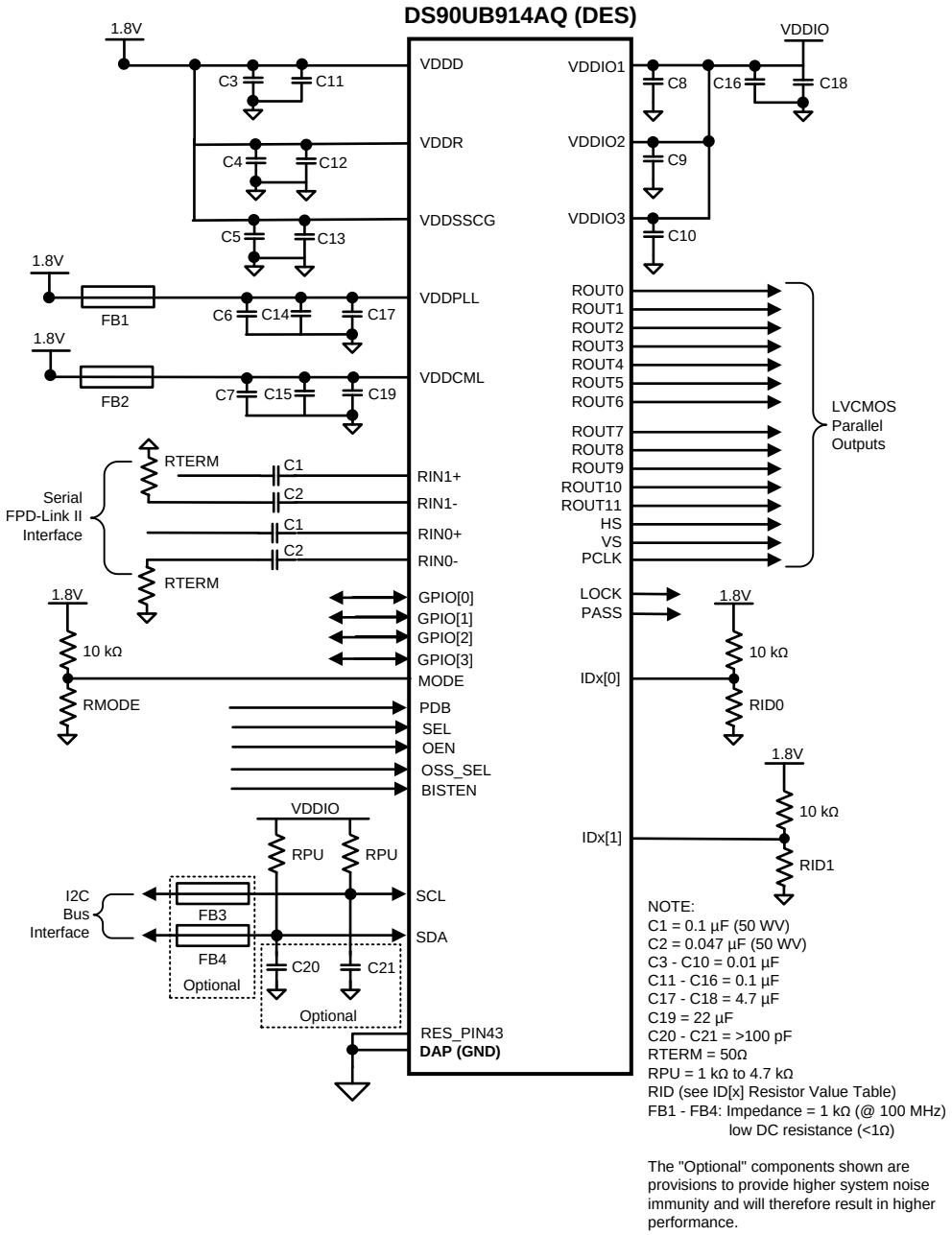

Figure 48. DS90UB914A-Q1 Typical Connection Diagram — Pin Control (Coax)

Figure 49 shows a typical connection of a DS90UB913A-Q1 Serializer using an **STP** interface.

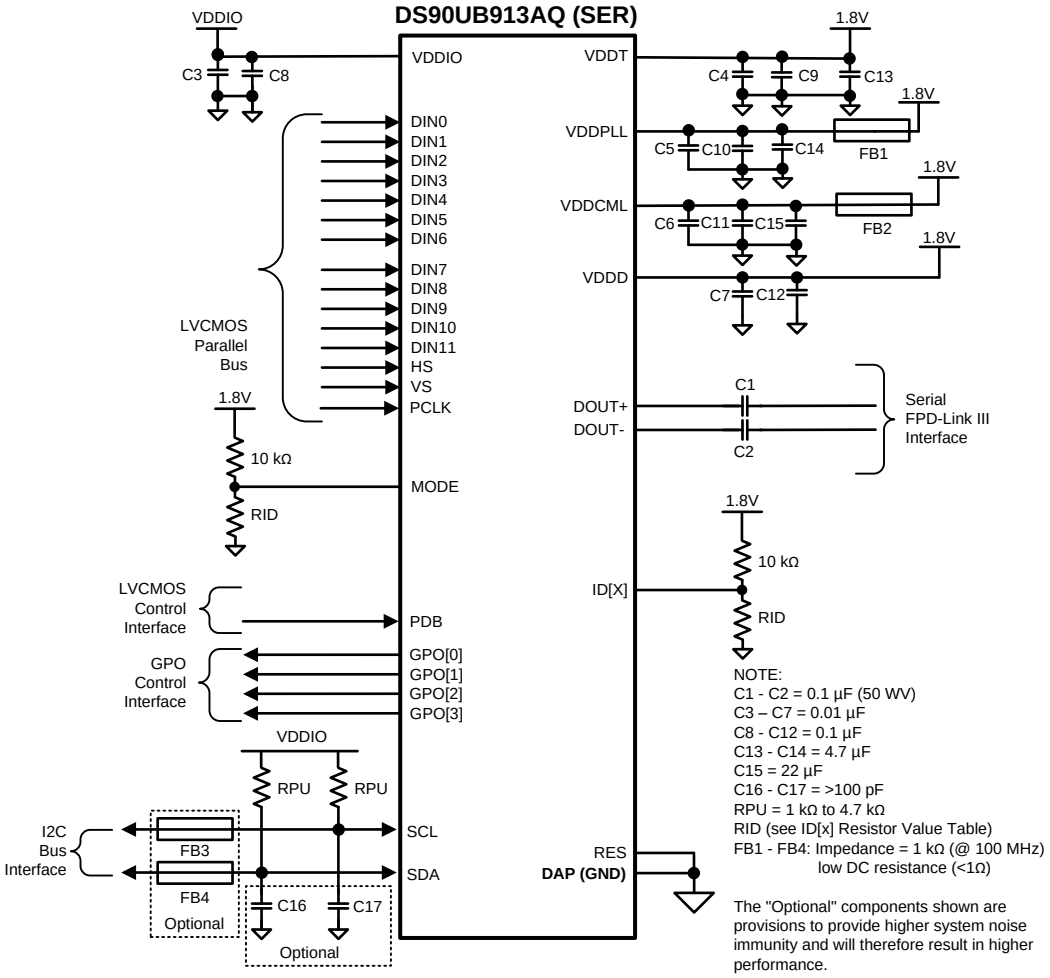

Figure 49. DS90UB913A-Q1 Typical Connection Diagram — Pin Control (STP)

Figure 50 shows a typical connection using an **STP** interface to the DS90UB914A-Q1 Deserializer.

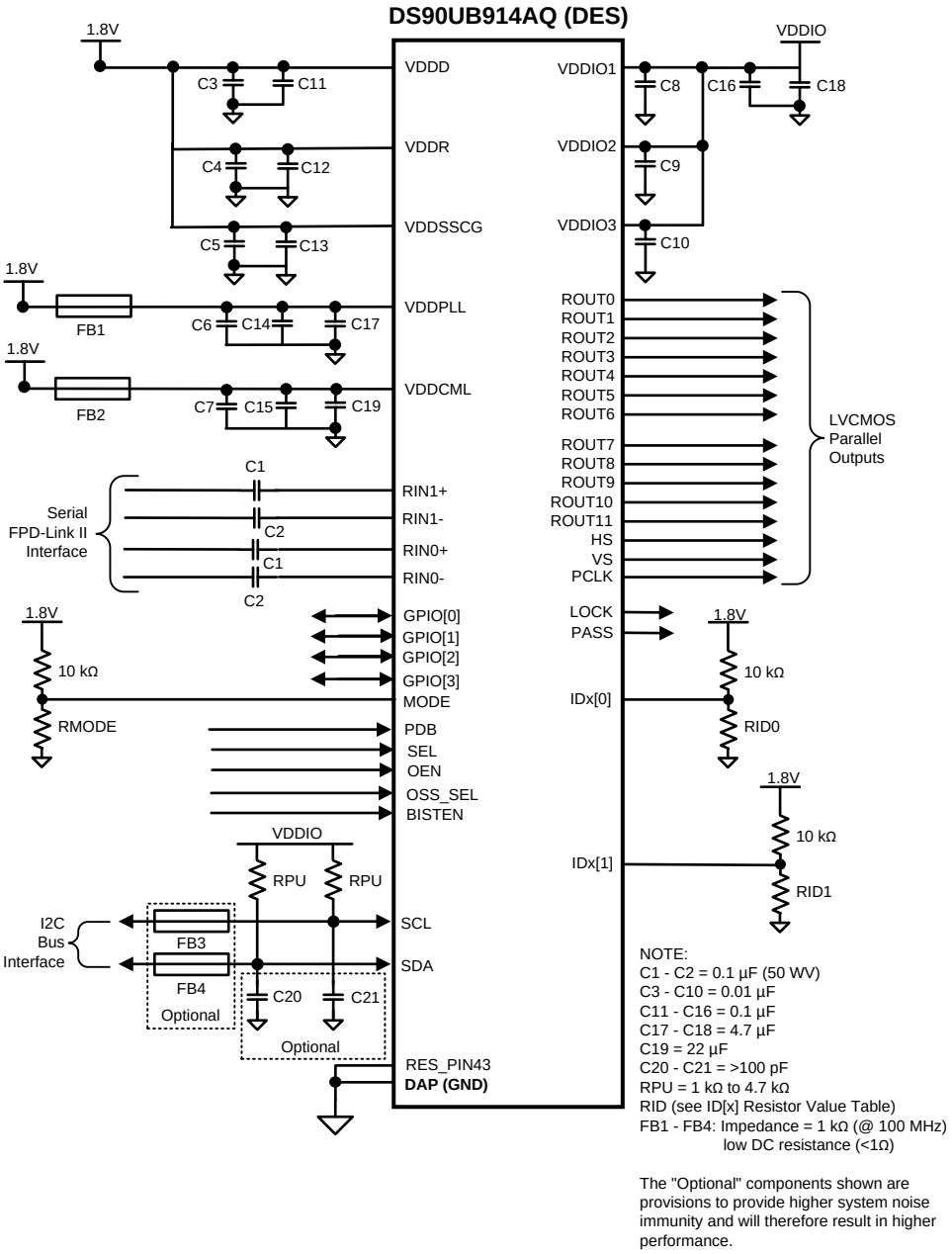

Figure 50. DS90UB914A-Q1 Typical Connection Diagram — Pin Control (STP)

PCB Layout and Power System Considerations

Circuit board layout and stack-up for the Ser/Des devices should be designed to provide low-noise power feed to the device. Good layout practice will also separate high frequency or high-level inputs and outputs to minimize unwanted stray noise pickup, feedback and interference. Power system performance may be greatly improved by using thin dielectrics (2 to 4 mils) for power / ground sandwiches. This arrangement provides plane capacitance for the PCB power system with low-inductance parasitics, which has proven especially effective at high frequencies, and makes the value and placement of external bypass capacitors less critical. External bypass capacitors should include both RF ceramic and tantalum electrolytic types. RF capacitors may use values in the range of 0.01 µF to 0.1 µF. Tantalum capacitors may be in the 2.2 µF to 10 µF range. Voltage rating of the tantalum capacitors should be at least 5X the power supply voltage being used.

Surface mount capacitors are recommended due to their smaller parasitics. When using multiple capacitors per supply pin, locate the smaller value closer to the pin. A large bulk capacitor is recommend at the point of power entry. This is typically in the 50µF to 100 µF range and will smooth low frequency switching noise. It is recommended to connect power and ground pins directly to the power and ground planes with bypass capacitors connected to the plane with via on both ends of the capacitor. Connecting power or ground pins to an external bypass capacitor will increase the inductance of the path.

A small body size X7R chip capacitor, such as 0603, is recommended for external bypass. Its small body size reduces the parasitic inductance of the capacitor. The user must pay attention to the resonance frequency of these external bypass capacitors, usually in the range of 20-30 MHz. To provide effective bypassing, multiple capacitors are often used to achieve low impedance between the supply rails over the frequency of interest. At high frequency, it is also a common practice to use two vias from power and ground pins to the planes, reducing the impedance at high frequency.

Some devices provide separate power for different portions of the circuit. This is done to isolate switching noise effects between different sections of the circuit. Separate planes on the PCB are typically not required. Pin Description tables typically provide guidance on which circuit blocks are connected to which power pin pairs. In some cases, an external filter many be used to provide clean power to sensitive circuits such as PLLs.

Use at least a four layer board with a power and ground plane. Locate LVCMOS signals away from the differential lines to prevent coupling from the LVCMOS lines to the differential lines. Closely-coupled differential lines of 100Ω are typically recommended for differential interconnect. The closely coupled lines help to ensure that coupled noise will appear as common-mode and thus is rejected by the receivers. The tightly coupled lines will also radiate less.

Information on the WQFN style package is provided in TI Application Note: AN-1187/SNOA401Q.

Interconnect Guidelines

See AN-1108 and AN-905 for full details.

- Use 100Ω coupled differential pairs
- Use the S/2S/3S rule in spacings
  - – S = space between the pair
  - – 2S = space between pairs
  - – 3S = space to LVCMOS signal
- Minimize the number of Vias
- Use differential connectors when operating above 500Mbps line speed
- Maintain balance of the traces
- Minimize skew within the pair

Additional general guidance can be found in the LVDS Owner's Manual - available in PDF format from the Texas Instrument web site at: www.ti.com/lvds.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DS90UB913ATRTVJQ1	PREVIEW	WQFN	RTV	32	2500	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 105	UB913AQ	
DS90UB913ATRTVRQ1	PREVIEW	WQFN	RTV	32	1000	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 105	UB913AQ	
DS90UB913ATRTVTQ1	PREVIEW	WQFN	RTV	32	250	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 105	UB913AQ	
DS90UB914ATRHSJQ1	PREVIEW	WQFN	RHS	48	2500	TBD	Call TI	Call TI	-40 to 105		
DS90UB914ATRHSRQ1	PREVIEW	WQFN	RHS	48	1000	TBD	Call TI	Call TI	-40 to 105		
DS90UB914ATRHSTQ1	PREVIEW	WQFN	RHS	48	250	TBD	Call TI	Call TI	-40 to 105		

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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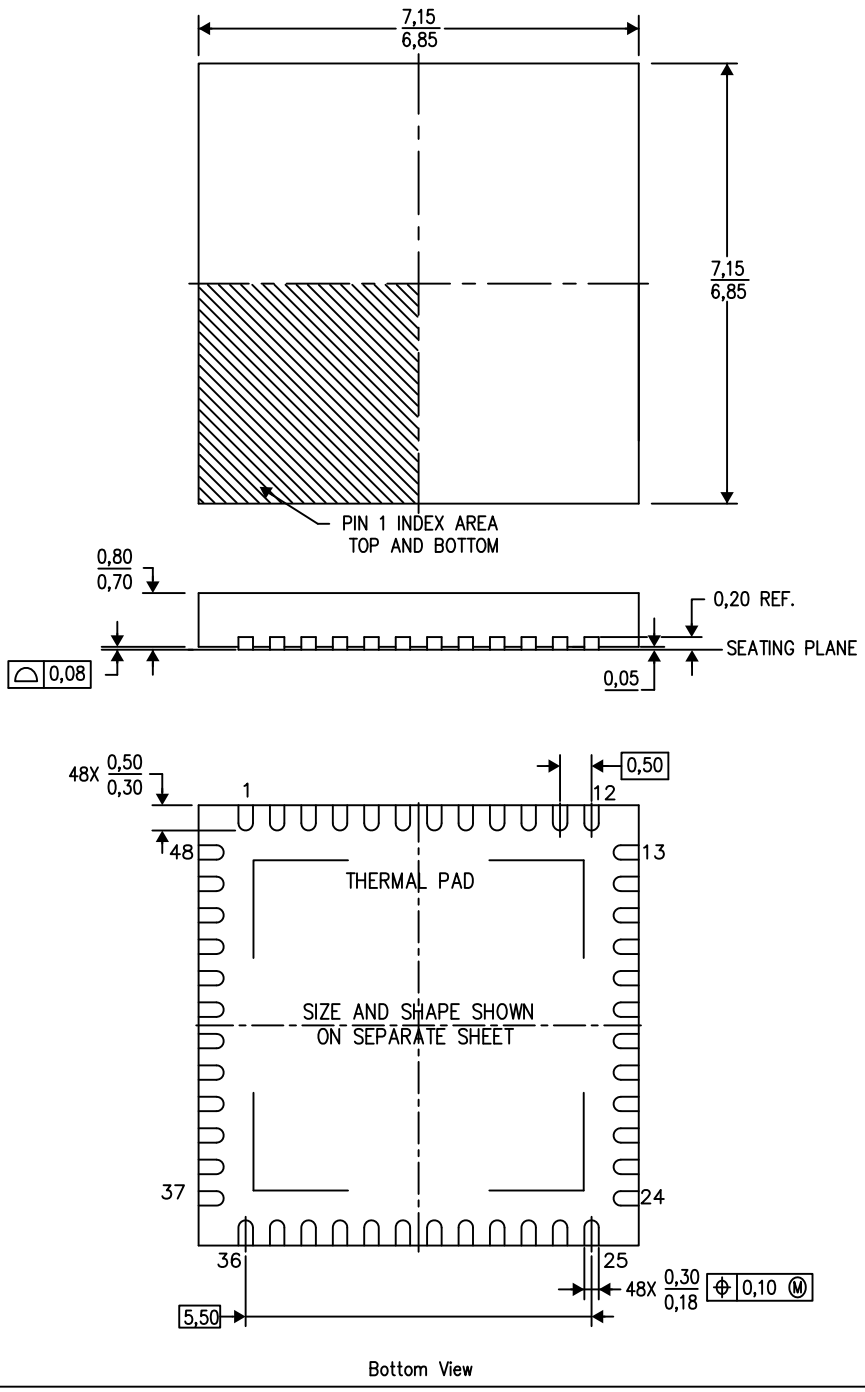
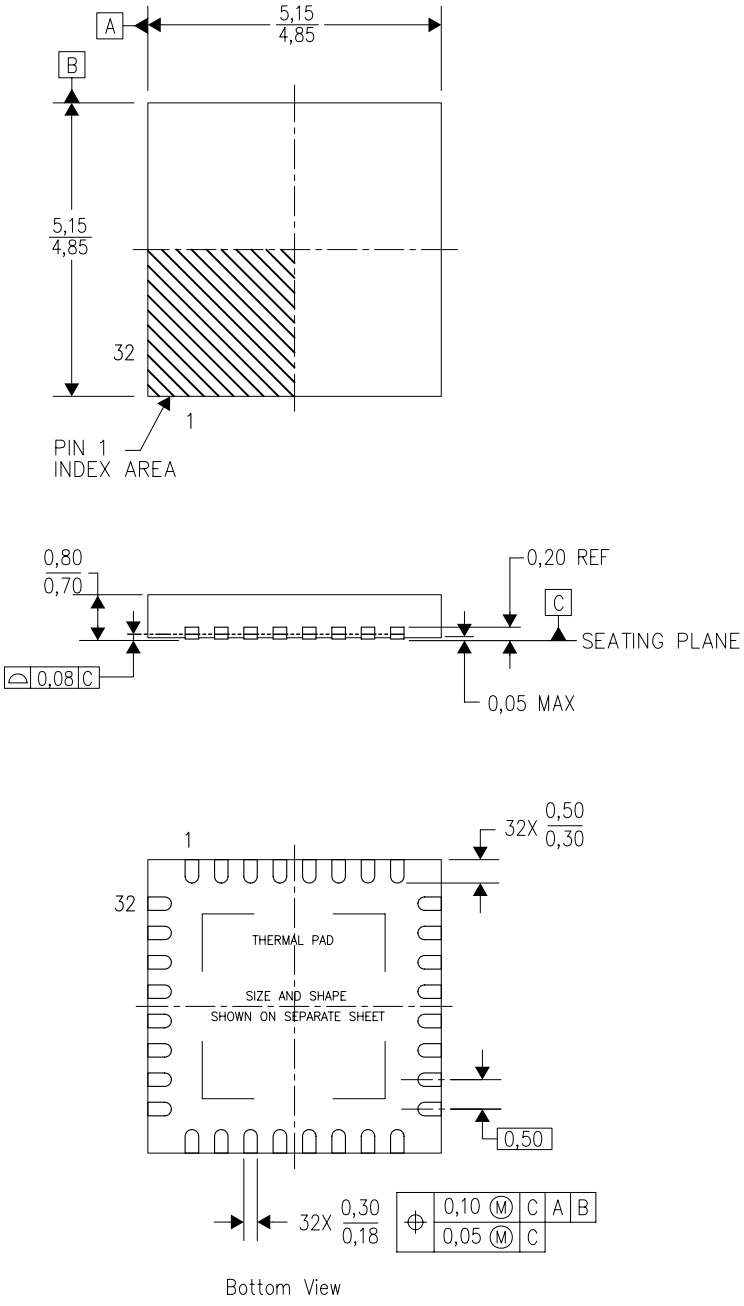
RHS (S–PWQFN–N48) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Quad Flatpack, No–leads (QFN) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Falls within JEDEC MO–220.

RTV (S–PWQFN–N32) PLASTIC QUAD FLATPACK NO–LEAD



4206245/C 10/11

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5–1994.
B. This drawing is subject to change without notice.
C. Quad Flatpack, No–Leads (QFN) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Falls within JEDEC MO–220.

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