

## 24-bit Color FPD-Link III Deserializer

### General Description

The DS90UB302Q deserializer, in conjunction with the DS90UB301Q serializer, provides a complete solution for distribution of digital video and audio within automotive entertainment systems. This chipset translates FPD-Link III, a single pair high-speed serialized interface, back to a parallel RGB Video Interface. The serial bus scheme, FPD-Link III, supports full duplex of high speed forward data transmission and low speed backchannel communication over a single differential link. Consolidation of video data and control over a single differential pair reduces the interconnect size and weight, while also eliminating skew issues and simplifying system design.

The DS90UB302Q deserializer recovers the RGB data, three video control signals and three synchronized I2S audio signals. It extracts the clock from a high speed serial stream. An output LOCK pin provides the link status if the incoming data stream is locked, without the use of a training sequence or special SYNC patterns, as well as a reference clock.

The DS90UB302Q deserializer has a 31-bit parallel LVCMOS output interface to accommodate the RGB, video control, and audio data.

An adaptive equalizer optimizes the maximum cable reach. EMI is minimized by output SSC generation (SSCG) and enhanced progressive turn-on (EPTO) features.

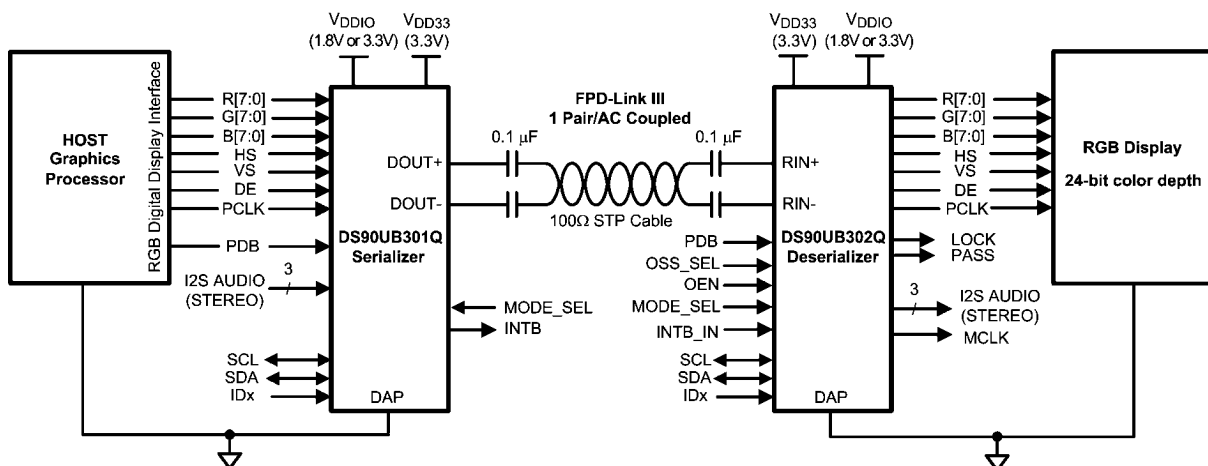
### Features

- Bidirectional control interface channel interface with I2C compatible serial control bus
- RGB888 + VS, HS, DE and synchronized I2S audio supported
- 15 to 45MHz PCLK supported
- Single 3.3V Operation with 1.8V or 3.3V compatible LVCMOS I/O interface
- AC-coupled STP Interconnect up to 10 meters
- Parallel LVCMOS video outputs
- I2C compatible serial control bus for configuration
- DC-balanced & scrambled Data w/ Embedded Clock
- Adaptive cable equalization
- Supports repeater application
- @SPEED Link BIST Mode and LOCK status pin
- Image Enhancement (White Balance) and Internal pattern generation
- EMI Minimization (SSCG and EPTO)
- Low power modes minimize power dissipation
- Automotive grade product: AEC-Q100 Grade 2 qualified
- >8kV HBM and ISO 10605 ESD rating

### Applications

- Automotive Display for Navigation
- Rear Seat Entertainment Systems
- Automotive Drive Assistance
- Automotive Megapixel Camera Systems

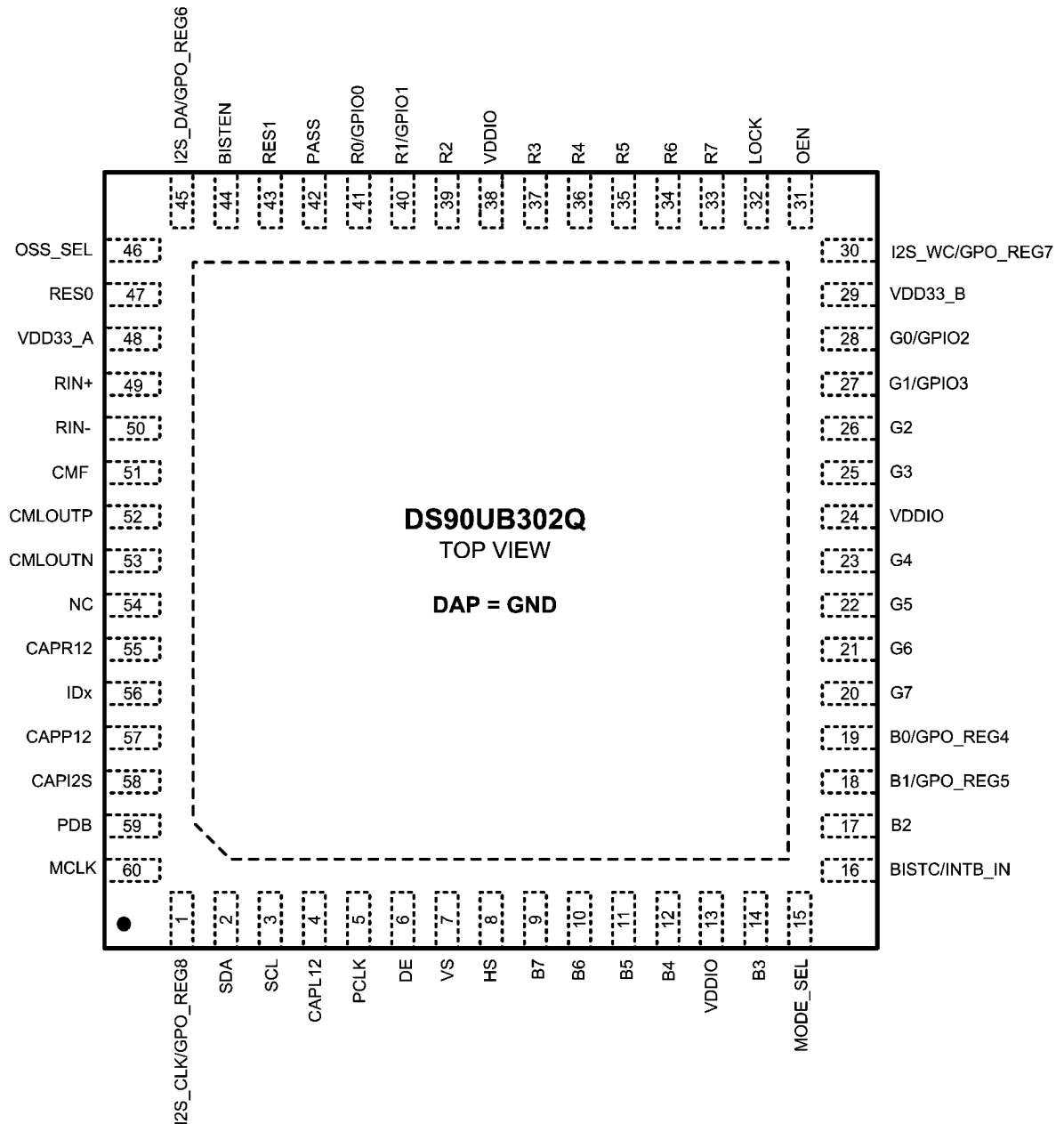
### Applications Diagram



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## DS90UB302Q Pin Diagram



DS90UB302Q — Top View

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## Pin Descriptions

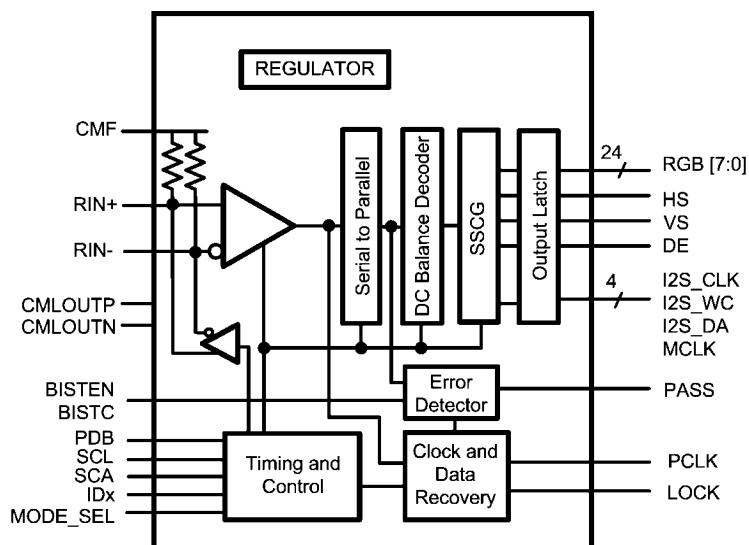
Pin Name	Pin #	I/O, Type	Description
<b>LVCMOS Parallel Interface</b>			
R[7:0]	33, 34, 35, 36, 37, 39, 40, 41	O, LVCMOS w/ pull down	RED Parallel Interface Data Output Pins Leave open if unused R0 can optionally be used as GPIO0 and R1 can optionally be used as GPIO1.
G[7:0]	20, 21, 22, 23, 25, 26, 27, 28	O, LVCMOS w/ pull down	GREEN Parallel Interface Data Output Pins Leave open if unused G0 can optionally be used as GPIO2 and G1 can optionally be used as GPIO3.
B[7:0]	9, 10, 11, 12, 14, 17, 18, 19	O, LVCMOS w/ pull down	BLUE Parallel Interface Data Output Pins Leave open if unused B0 can optionally be used as GPO_REG4 and B1 can optionally be used as GPO_REG5.
HS	8	O, LVCMOS w/ pull down	Horizontal Sync Output Pin Video control signal pulse width must be 3 PCLKs or longer to be transmitted when the Control Signal Filter is enabled. There is no restriction on the minimum transition pulse when the Control Signal Filter is disabled. The signal is limited to 2 transitions per 130 PCLKs. See <a href="#">Table 8</a>
VS	7	O, LVCMOS w/ pull down	Vertical Sync Output Pin Video control signal is limited to 1 transition per 130 PCLKs. Thus, the minimum pulse width is 130 PCLKs.
DE	6	O, LVCMOS w/ pull down	Data Enable Output Pin Video control signal pulse width must be 3 PCLKs or longer to be transmitted when the Control Signal Filter is enabled. There is no restriction on the minimum transition pulse when the Control Signal Filter is disabled. The signal is limited to 2 transitions per 130 PCLKs. See <a href="#">Table 8</a>
PCLK	5	O, LVCMOS w/ pull down	Pixel Clock Output Pin Strobe edge set by RFB configuration register. See <a href="#">Table 8</a>
I2S_CLK, I2S_WC, I2S_DA	1, 30, 45	O, LVCMOS w/ pull down	Digital Audio Interface Data Output Pins Leave open if unused I2S_CLK can optionally be used as GPO_REG8, I2S_WC can optionally be used as GPO_REG7, and I2S_DA can optionally be used as GPO_REG6.
MCLK	60	O, LVCMOS w/ pull down	I2S Master Clock Output x1, x2, or x4 of I2S_CLK Frequency.
<b>Optional Parallel Interface</b>			
GPIO[3:0]	27, 28, 40, 41	I/O, LVCMOS w/ pull down	Standard General Purpose IOs Available only in 18-bit color mode, and set by MODE_SEL or configuration register. See <a href="#">Table 8</a> Leave open if unused Shared with G1, G0, R1 and R0.
GPO_REG [8:4]	1, 30, 45, 18, 19	O, LVCMOS w/ pull down	General Purpose Outputs The GPOs must be set by configuration register. See <a href="#">Table 8</a> Shared with I2S_CLK, I2S_WC, I2S_DA or B1, B0.
INTB_IN	16	Input, LVCMOS w/ pull-down	Interrupt Input Shared with BISTC
<b>Optional Parallel Interface</b>			
PDB	59	I, LVCMOS w/ pull-down	Power-down Mode Input Pin PDB = H, device is enabled (normal operation) Refer to "Power Up Requirements and PDB Pin" in the Applications Information Section. PDB = L, device is powered down. When the device is in the POWER DOWN state, the LVCMOS Outputs are in TRI-STATE, the PLL is shutdown and IDD is minimized.

Pin Name	Pin #	I/O, Type	Description
OEN	31	Input, LVCMOS w/ pull-down	Output Enable Pin. See <a href="#">Table 2</a>
OSS_SEL	46	Input, LVCMOS w/ pull-down	Output Sleep State Select Pin See <a href="#">Table 2</a>
MODE_SEL	15	I, Analog	Device Configuration Select See <a href="#">Table 3</a>
IDx	56	I, Analog	I2C Serial Control Bus Device ID Address Select External pull-up to $V_{DD33}$ is required under all conditions, DO NOT FLOAT. Connect to external pull-up and pull-down resistor to create a voltage divider. See <a href="#">Figure 19</a>
SCL	3	I/O, LVCMOS Open Drain	I2C Clock Input / Output Interface Must have an external pull-up to $V_{DD33}$ , DO NOT FLOAT. Recommended pull-up: 4.7k $\Omega$ .
SDA	2	I/O, LVCMOS Open Drain	I2C Data Input / Output Interface Must have an external pull-up to $V_{DD33}$ , DO NOT FLOAT. Recommended pull-up: 4.7k $\Omega$ .
BISTEN	44	I, LVCMOS w/ pull-down	BIST Enable Pin 0: BIST Mode is disabled. 1: BIST Mode is enabled.
BISTC	16	I, LVCMOS w/ pull-down	BIST Clock Select Shared with INTB_IN 0: PCLK 1: 33MHz
<b>Status</b>			
LOCK	32	O, LVCMOS w/ pull down	LOCK Status Output Pin 0: PLL is unlocked, RGB[7:0], I2S, HS, VS, DE and PCLK output states are controlled by OEN. May be used as Link Status or Display Enable 1: PLL is Locked, outputs are active
PASS	42	O, LVCMOS w/ pull down	PASS Output Pin 0: One or more errors were detected in the received payload 1: ERROR FREE Transmission Leave Open if unused. Route to test point (pad) recommended
<b>FPD-Link III Serial Interface</b>			
RIN+	49	I, LVDS	True Input The interconnection should be AC Coupled to this pin with a 0.1 $\mu$ F capacitor.
RIN-	50	I, LVDS	Inverting Input The interconnection should be AC Coupled to this pin with a 0.1 $\mu$ F capacitor.
CMLOUTP	52	O, LVDS	True CML Output Monitor point for equalized differential signal
CMLOUTN	53	O, LVDS	Inverting CML Output Monitor point for equalized differential signal
CMF	51	Analog	Common Mode Filter Connect 0.1 $\mu$ F capacitor to GND
<b>Power and Ground</b>			
$V_{DD33\_A}$ , $V_{DD33\_B}$	48, 29	Power	Power to on-chip regulator <b>3.0 V - 3.6 V</b> . Requires 4.7 $\mu$ F to GND at each VDD pin.
$V_{DDIO}$	13, 24, 38	Power	LVCMOS I/O Power <b>1.71V - 1.89V OR 3.0 V - 3.6 V</b> . Requires 4.7 $\mu$ F to GND at each VDDIO pin.
GND	DAP	Ground	DAP is the large metal contact at the bottom side, located at the center of the LLP package. <b>Connect to the ground plane (GND)</b> with at least 9 vias.

Pin Name	Pin #	I/O, Type	Description
<b>Regulator Capacitor</b>			
CAPR12, CAPP12, CAPI2S	55, 57, 58	CAP	Decoupling capacitor connection for on-chip regulator Requires a 4.7μF to GND at each CAP pin.
CAPL12	4	CAP	Decoupling capacitor connection for on-chip regulator Requires two 4.7μF to GND at this CAP pin.
<b>Others</b>			
NC	54	NC	No connect This pin may be left open or tied to any level.
RES[1:0]	43, 47	GND	Reserved. Tie to Ground.

The VDD ( $V_{DD33}$  and  $V_{DDIO}$ ) supply ramp should be faster than 1.5ms with a monotonic rise.

## Block Diagram



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## Ordering Information

NSID	Package Description	Quantity	SPEC	Package ID
DS90UB302QSQE	60-pin LLP, 9.0 X 9.0 X 0.8 mm, 0.5 mm pitch	250	NOPB	SQA60B
DS90UB302QSQ	60-pin LLP, 9.0 X 9.0 X 0.8 mm, 0.5 mm pitch	1000	NOPB	SQA60B
DS90UB302QSQX	60-pin LLP, 9.0 X 9.0 X 0.8 mm, 0.5 mm pitch	2500	NOPB	SQA60B

Note: Automotive Grade (Q) product incorporates enhanced manufacturing and support processes for the automotive market, including defect detection methodologies. Reliability qualification is compliant with the requirements and temperature grades defined in the AEC Q100 standard. Automotive Grade products are identified with the letter Q. For more information go to <http://www.ti.com/automotive>.

## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.

Supply Voltage – $V_{DD33}$	–0.3V to +4.0V
Supply Voltage – $V_{DDIO}$	–0.3V to +4.0V
LVC MOS I/O Voltage	–0.3V to ( $V_{DDIO} + 0.3V$ )
Deserializer Input Voltage	–0.3V to +2.75V
Junction Temperature	+150°C
Storage Temperature	–65°C to +150°C
60 LLP Package	
Maximum Power Dissipation Capacity at 25°C	
Derate above 25°C	1/ $\theta_{JA}$ °C/W
$\theta_{JA}$	31 °C/W
$\theta_{JC}$	2.4 °C/W
ESD Rating (IEC, powered-up only), $R_D = 330\Omega$ , $C_S = 150pF$	
Air Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 15$ kV
Contact Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 8$ kV
ESD Rating (ISO10605), $R_D = 330\Omega$ , $C_S = 150pF$	
Air Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 15$ kV
Contact Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 8$ kV
ESD Rating (ISO10605), $R_D = 2k\Omega$ , $C_S = 150$ & $330pF$	
Air Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 15$ kV
Contact Discharge ( $R_{IN+}$ , $R_{IN-}$ )	$\geq \pm 8$ kV
ESD Rating (HBM)	$\geq \pm 8$ kV
ESD Rating (CDM)	$\geq \pm 1.25$ kV
ESD Rating (MM)	$\geq \pm 250$ V
For soldering specifications: see products folder at <a href="http://www.ti.com">www.ti.com</a> and <a href="http://www.ti.com/lit/an/snoa549c/snoa549c.pdf">www.ti.com/lit/an/snoa549c/snoa549c.pdf</a>	

## Recommended Operating Conditions

	Min	Nom	Max	Units
Supply Voltage ( $V_{DD33}$ )	3.0	3.3	3.6	V
LVC MOS Supply Voltage ( $V_{DDIO}$ )	3.0	3.3	3.6	V
<b>OR</b>				
LVC MOS Supply Voltage ( $V_{DDIO}$ )	1.71	1.8	1.89	V
Operating Free Air Temperature ( $T_A$ )	–40	+25	+105	°C
PCLK Frequency	15		45	MHz
Supply Noise <small>(Note 7)</small>			100	mV <sub>P-P</sub>

## DC Electrical Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified. ([Note 2](#), [Note 3](#), [Note 4](#))

Symbol	Parameter	Conditions		Pin/Freq.	Min	Typ	Max	Units
LVCMOS I/O DC SPECIFICATIONS								
V <sub>IH</sub>	High Level Input Voltage	V <sub>DDIO</sub> = 3.0 to 3.6V		PDB	2.0		V <sub>DDIO</sub>	V
V <sub>IL</sub>	Low Level Input Voltage	V <sub>DDIO</sub> = 3.0 to 3.6V			GND		0.8	V
I <sub>IN</sub>	Input Current	V <sub>IN</sub> = 0V or V <sub>DDIO</sub> = 3.0 to 3.6V			-10	±1	+10	µA
V <sub>IH</sub>	High Level Input Voltage	V <sub>DDIO</sub> = 3.0 to 3.6V		OEN, OSS_SEL, BISTEN, BISTC / INTB_IN, GPIO[3:0]	2.0		V <sub>DDIO</sub>	V
		V <sub>DDIO</sub> = 1.71 to 1.89V			0.65* V <sub>DDIO</sub>		V <sub>DDIO</sub>	V
V <sub>IL</sub>	Low Level Input Voltage	V <sub>DDIO</sub> = 3.0 to 3.6V			GND		0.8	V
		V <sub>DDIO</sub> = 1.71 to 1.89V			GND		0.35* V <sub>DDIO</sub>	V
I <sub>IN</sub>	Input Current	V <sub>IN</sub> = 0V or V <sub>DDIO</sub>	V <sub>DDIO</sub> = 3.0 to 3.6V		-10	±1	+10	µA
			V <sub>DDIO</sub> = 1.7 to 1.89V		-10	±1	+10	µA
V <sub>OH</sub>	High Level Output Voltage	I <sub>OH</sub> = -4mA	V <sub>DDIO</sub> = 3.0 to 3.6V	R[7:0], G [7:0], B[7:0], HS, VS, DE, PCLK, LOCK, PASS, MCLK, I2S_CLK, I2S_WC, I2S_DA, GPO_REG [8:4]	2.4		V <sub>DDIO</sub>	V
			V <sub>DDIO</sub> = 1.7 to 1.89V		V <sub>DDIO</sub> - 0.45		V <sub>DDIO</sub>	V
V <sub>OL</sub>	Low Level Output Voltage	I <sub>OL</sub> = +4mA	V <sub>DDIO</sub> = 3.0 to 3.6V		GND		0.4	V
			V <sub>DDIO</sub> = 1.7 to 1.89V		GND		0.35	V
I <sub>OS</sub>	Output Short Circuit Current	V <sub>OUT</sub> = 0V				-60		mA
I <sub>OZ</sub>	TRI-STATE® Output Current	V <sub>OUT</sub> = 0V or V <sub>DDIO</sub> , PDB = L			-10		+10	µA
FPD-LINK III CML RECEIVER INPUT DC SPECIFICATIONS								
V <sub>TH</sub>	Differential Threshold High Voltage			RIN+, RIN-			+50	mV
V <sub>TL</sub>	Differential Threshold Low Voltage				-50			mV
R <sub>T</sub>	Internal Termination Resistor - Differential				80	100	120	Ω
CML MONITOR DRIVER OUTPUT DC SPECIFICATIONS								
V <sub>ODp-p</sub>	Differential Output Voltage	R <sub>L</sub> = 100Ω		CMLOUTP, CMLOUTN	360			mVp-p
SUPPLY CURRENT								
I <sub>DD1</sub>	Supply Current (includes load current) f = 45MHz	C <sub>L</sub> = 12pF, Checker Board Pattern <i>Figure 1</i>	V <sub>DD33</sub> = 3.6V	V <sub>DD33</sub>		105	125	mA
I <sub>DDIO1</sub>			V <sub>DDIO</sub> = 3.6V	V <sub>DDIO</sub>		70	75	mA
			V <sub>DDIO</sub> = 1.89V			40	50	mA
I <sub>DD2</sub>	Supply Current (includes load current) f = 45MHz	C <sub>L</sub> = 4pF, Checker Board Pattern, <i>Figure 1</i>	V <sub>DD33</sub> = 3.6V	V <sub>DD33</sub>		105	125	mA
I <sub>DDIO2</sub>			V <sub>DDIO</sub> = 3.6V	V <sub>DDIO</sub>		50	55	mA
			V <sub>DDIO</sub> = 1.89V			35	45	mA
I <sub>DDZ</sub>	Supply Current Power Down	PDB = L, All LVCMOS inputs are floating or tied to GND	V <sub>DD33</sub> = 3.6V	V <sub>DD33</sub>		2	10	mA
I <sub>DDIOZ</sub>			V <sub>DDIO</sub> = 3.6V	V <sub>DDIO</sub>		0.05	10	mA
			V <sub>DDIO</sub> = 1.89V			0.05	10	mA



## AC Electrical Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified. (Note 2, Note 3, Note 4)

Symbol	Parameter	Conditions	Pin/Freq.	Min	Typ	Max	Units
GPIO BIT RATE							
B <sub>R</sub>	Forward Channel Bit Rate	(Note 8, Note 9)	f = 15 - 45MHz, GPIO[3:0]		0.25*f		Mbps
	Back Channel Bit Rate			>50	>75		kbps
CML MONITOR DRIVER OUTPUT AC SPECIFICATIONS							
E <sub>W</sub>	Differential Output Eye Opening Width (Note 6)	R <sub>L</sub> = 100Ω, Jitter Freq >f / 40 Figure 2 (Note 8, Note 9)	CMLOUTP, CMLOUTN, f = 45MHz	0.3	0.4		UI
E <sub>H</sub>	Differential Output Eye Height			200	300		mV
SWITCHING CHARACTERISTICS							
t <sub>RCP</sub>	PCLK Output Period	t <sub>RCP</sub> = t <sub>TCP</sub>	PCLK	22.222	T	66.666	ns
t <sub>RDC</sub>	PCLK Output Duty Cycle			45	50	55	%
t <sub>CLH</sub>	LVCMOS Low-to-High Transition Time Figure 3	V <sub>DDIO</sub> = 1.71 - 1.89V, C <sub>L</sub> = 12pF	R[7:0], G[7:0], B[7:0], HS, VS, DE, PCLK, LOCK, PASS, MCLK, I2S_CLK, I2S_WC, I2S_DA		2	3	ns
		V <sub>DDIO</sub> = 3.0 - 3.6V, C <sub>L</sub> = 12pF			2	3	ns
t <sub>CHL</sub>	LVCMOS High-to-Low Transition Time Figure 3	V <sub>DDIO</sub> = 1.71 - 1.89V, C <sub>L</sub> = 12pF			2	3	ns
		V <sub>DDIO</sub> = 3.0 - 3.6V, C <sub>L</sub> = 12pF			2	3	ns
t <sub>ROS</sub>	Data Valid before PCLK – Setup Time SSCG = OFF Figure 6	V <sub>DDIO</sub> = 1.71 - 1.89V, C <sub>L</sub> = 12pF		2.2			ns
		V <sub>DDIO</sub> = 3.0 - 3.6V, C <sub>L</sub> = 12pF		2.2			ns
t <sub>ROH</sub>	Data Valid after PCLK – Hold Time SSCG = OFF Figure 6	V <sub>DDIO</sub> = 1.71 - 1.89V, C <sub>L</sub> = 12pF		3.0			ns
		V <sub>DDIO</sub> = 3.0 - 3.6V, C <sub>L</sub> = 12pF		3.0			ns
t <sub>XZR</sub>	Active to OFF Delay Figure 5 (Note 8, Note 9)	OEN = L, OSS_SEL = H	R[7:0], G[7:0], B[7:0]		10		ns
			HS, VS, DE, PCLK, LOCK, PASS		15		ns
			MCLK, I2S_CLK, I2S_WC, I2S_DA		60		ns
t <sub>DDL</sub> T	Lock Time Figure 5 (Note 8, Note 9)	SSCG = OFF	f = 15 - 45MHz		5	40	ms
t <sub>DD</sub>	Delay – Latency (Note 8, Note 9)		f = 15 - 45MHz		147*T		ns
t <sub>DCCJ</sub>	Cycle-to-Cycle Jitter (Note 8, Note 9)	SSCG = OFF	f = 15 - 45MHz		0.2		ns
			I2S_CLK = 1 - 12.28MHz		±2		ns

Symbol	Parameter	Conditions	Pin/Freq.	Min	Typ	Max	Units
$t_{\text{ONS}}$	Data Valid After OEN = H SetupTime <i>Figure 7 (Note 8, Note 9)</i>	VDDIO = 1.71 - 1.89V, CL = 12pF	R[7:0], G [7:0], B[7:0], HS, VS, DE, PCLK, MCLK, I2S_CLK, I2S_WC, I2S_DA		50		ns
		VDDIO = 3.0 - 3.6V, CL = 12pF			50		ns
$t_{\text{ONH}}$	Data Tri-State After OEN = L SetupTime <i>Figure 7 (Note 8, Note 9)</i>	VDDIO = 1.71 - 1.89V, CL = 12pF			50		ns
		VDDIO = 3.0 - 3.6V, CL = 12pF			50		ns
$t_{\text{SES}}$	Data Tri-State after OSS_SEL = H, Setup Time <i>Figure 7 (Note 8, Note 9)</i>	VDDIO = 1.71 - 1.89V, CL = 12pF			5		ns
		VDDIO = 3.0 - 3.6V, CL = 12pF			5		ns
$t_{\text{SEH}}$	Data to Low after OSS_SEL = L Setup Time <i>Figure 7 (Note 8, Note 9)</i>	VDDIO = 1.71 - 1.89V, CL = 12pF			5		ns
		VDDIO = 3.0 - 3.6V, CL = 12pF			5		ns
BIST Mode							
$t_{\text{PASS}}$	BIST PASS Valid Time BISTEN = H <i>Figure 8 (Note 8, Note 9)</i>		PASS		800		ns
SSCG Mode							
$f_{\text{DEV}}$	Spread Spectrum Clocking Deviation Frequency	<i>Figure 12</i> <i>Table 1 (Note 8, Note 9)</i>	$f = 45\text{MHz}$ , SSCG = ON	$\pm 0.5$		$\pm 2.5$	%
$f_{\text{MOD}}$	Spread Spectrum Clocking Modulation Frequency			8		100	kHz

## Recommended Timing for the Serial Control Bus

Over 3.3V supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$f_{SCL}$	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 <a href="#">Figure 9</a>	Standard Mode	4.0			µs
		Fast Mode	0.6			µs
$t_{SU;STA}$	Set Up time for a start or a repeated start condition <a href="#">Figure 9</a>	Standard Mode	4.7			µs
		Fast Mode	0.6			µs
$t_{HD;DAT}$	Data Hold Time <a href="#">Figure 9</a>	Standard Mode	0		3.45	µs
		Fast Mode	0		0.9	µs
$t_{SU;DAT}$	Data Set Up Time <a href="#">Figure 9</a>	Standard Mode	250			ns
		Fast Mode	100			ns
$t_{SU;STO}$	Set Up Time for STOP Condition, <a href="#">Figure 9</a>	Standard Mode	4.0			µs
		Fast Mode	0.6			µs
$t_{BUF}$	Bus Free Time Between STOP and START, <a href="#">Figure 9</a>	Standard Mode	4.7			µs
		Fast Mode	1.3			µs
$t_r$	SCL & SDA Rise Time, <a href="#">Figure 9</a>	Standard Mode			1000	ns
		Fast Mode			300	ns

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_f$	SCL & SDA Fall Time, <a href="#">Figure 9</a>	Standard Mode			300	ns
		Fast mode			300	ns

## DC and AC Serial Control Bus Characteristics

Over 3.3V supply and temperature ranges unless otherwise specified. ([Note 2](#), [Note 3](#), [Note 4](#))

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{IH}$	Input High Level	SDA and SCL	0.7* $V_{DDIO}$		$V_{DDIO}$	V
$V_{IL}$	Input Low Level Voltage	SDA and SCL	GND		0.3* $V_{DDIO}$	V
$V_{HY}$	Input Hysteresis			>50		mV
$V_{OL}$		SDA, IOL = 1.25mA	0		0.36	V
$I_{in}$		SDA or SCL, $V_{in} = V_{DDIO}$ or GND	-10		+10	$\mu$ A
$t_R$	SDA RiseTime – READ	SDA, RPU = 10k $\Omega$ , $C_b \leq 400$ pF, <a href="#">Figure 9</a>		430		ns
$t_F$	SDA Fall Time – READ			20		ns
$t_{SU;DAT}$	Set Up Time – READ	<a href="#">Figure 9</a>		560		ns
$t_{HD;DAT}$	Hold Up Time – READ	<a href="#">Figure 9</a>		615		ns
$t_{SP}$	Input Filter			50		ns
$C_{in}$	Input Capacitance	SDA or SCL		<5		pF

**Note 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 and the device should not be operated beyond such conditions.

**Note 2:** The Electrical Characteristics tables list guaranteed 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 guaranteed.

**Note 3:** Typical values represent most likely parametric norms at  $V_{DD33} = 3.3$ V,  $T_a = +25^\circ$ C, and at the Recommended Operation Conditions at the time of product characterization and are not guaranteed.

**Note 4:** 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 and  $\Delta$ VOD, which are differential voltages.

**Note 5:**  $t_{DDL_T}$  is the time required by the device to obtain lock when exiting power-down state with an active serial stream.

**Note 6:** UI – Unit Interval is equivalent to one serialized data bit width  $1UI = 1 / (35 \times PCLK)$ . The UI scales with PCLK frequency.

**Note 7:** Supply noise testing was done with minimum capacitors on the PCB. A sinusoidal signal is AC coupled to the  $V_{DD33}$  and  $V_{DDIO}$  supplies with amplitude = 100 mV<sub>P-P</sub> measured at the device  $V_{DD33}$  and  $V_{DDIO}$  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 Des is less than 50MHz.

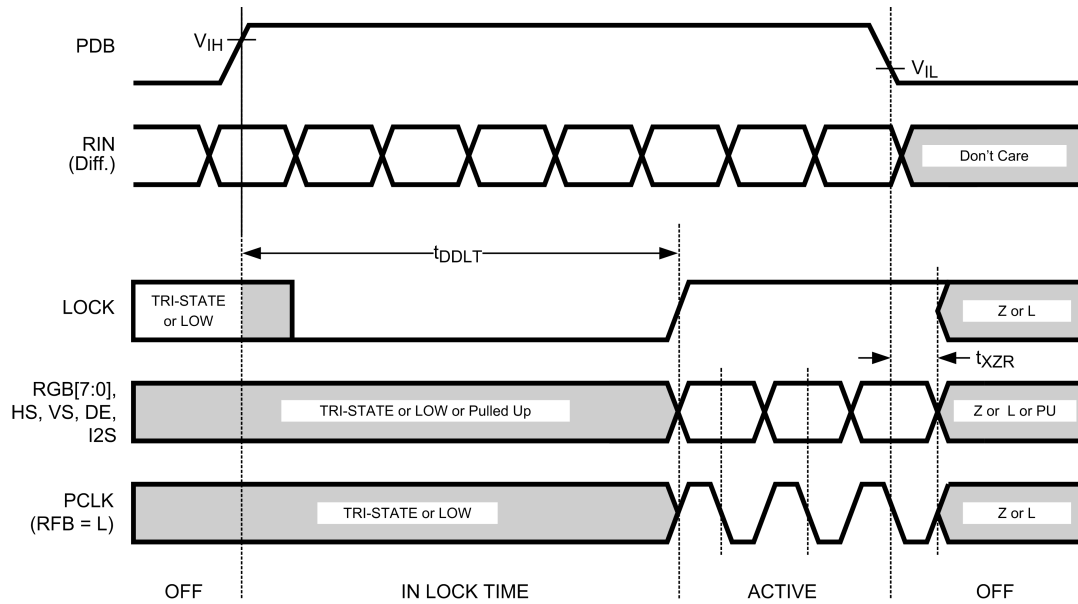
**Note 8:** Specification is guaranteed by characterization and is not tested in production.

**Note 9:** Specification is guaranteed by design and is not tested in production.

The diagram shows three digital signals over time. The top signal, PCLK, is a periodic square wave. The middle signal, RGB[n] (odd), VS, HS, is high during the first half of each PCLK period and low during the second half. The bottom signal, RGB[n] (even), DE, is low during the first half of each PCLK period and high during the second half. Vertical dashed lines mark the midpoints of the PCLK periods. The signal levels are labeled as V<sub>DDIO</sub> for high and GND for low.

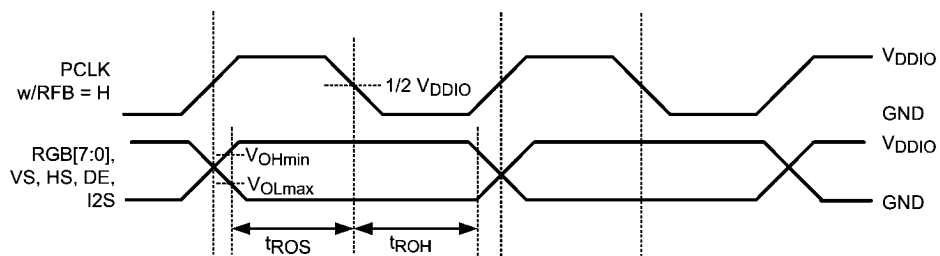
The diagram illustrates the timing relationship between the RIN input signal and the PCLK and video data signals. The RIN signal is a differential signal with a period  $t_{DD}$ . It shows two full symbols, SYMBOL N and SYMBOL N+1, each consisting of a START BIT and a STOP BIT. The PCLK signal is a clock signal. The RGB, I2S, HS, VS, and DE signals are shown as a single trace with data for SYMBOL N-2, SYMBOL N-1, and SYMBOL N.

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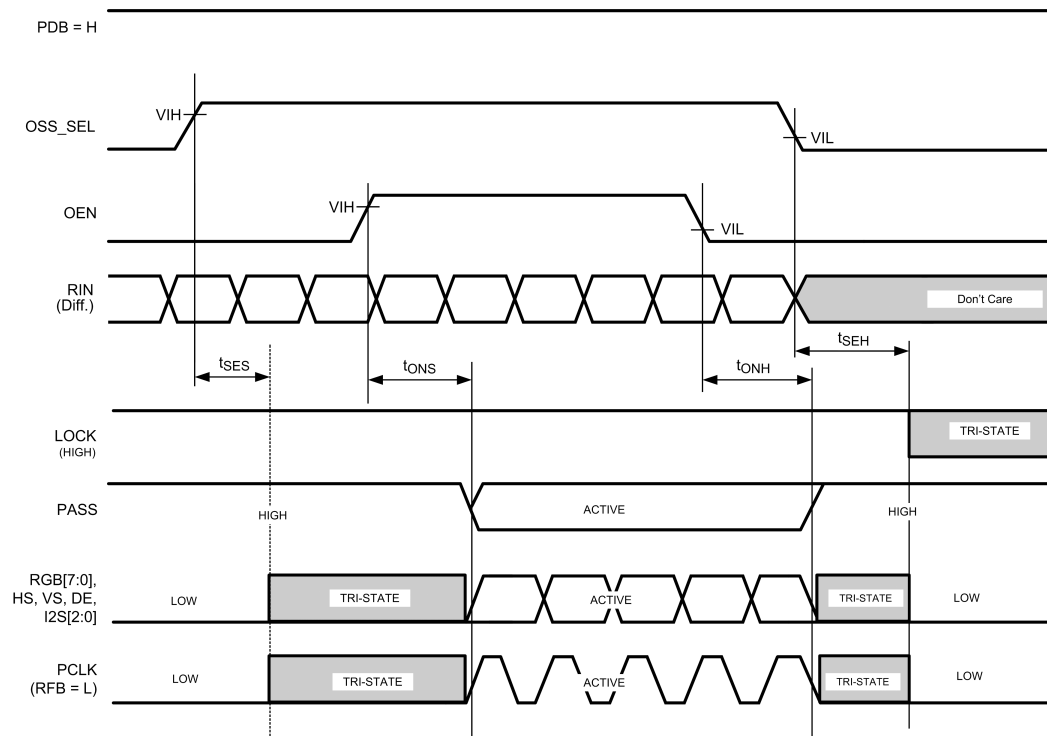
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FIGURE 5. PLL Lock Times and PDB TRI-STATE Delay

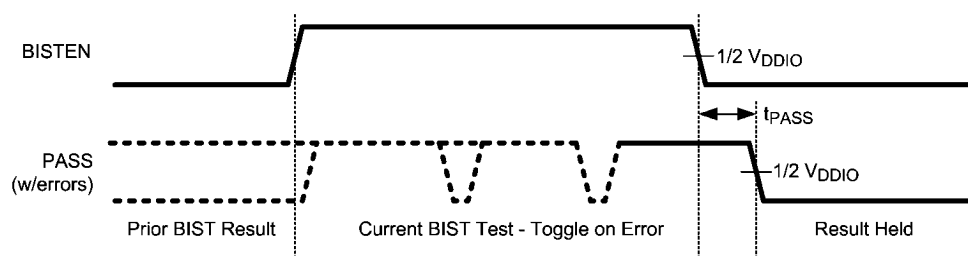


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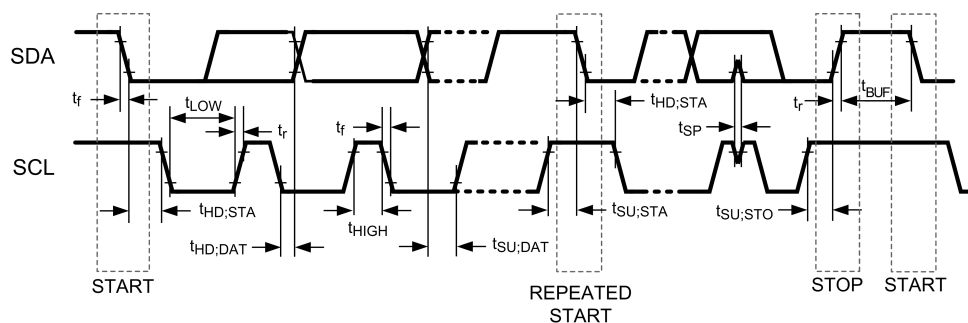
FIGURE 6. Output Data Valid (Setup and Hold) Times with SSCG = Off



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**FIGURE 7. Output State (Setup and Hold) Times**

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**FIGURE 8. BIST PASS Waveform**

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**FIGURE 9. Serial Control Bus Timing Diagram**

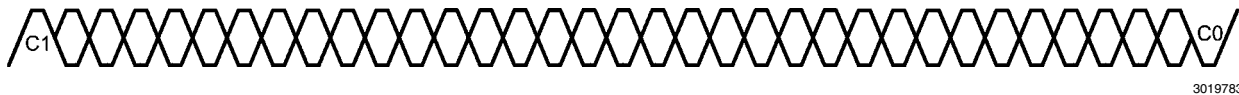
## Functional Description

The DS90UB302Q deserializer receives a 35-bit symbol over a single serial FPD-Link III pair operating up to 1.575Gbps application payload. The serial stream contains an embedded clock, video control signals and the DC-balanced video data and audio data which enhance signal quality to support AC coupling.

The DS90UB302Q deserializer attains lock to a data stream without the use of a separate reference clock source, which greatly simplifies system complexity and overall cost. The deserializer also synchronizes to the serializer regardless of the data pattern, delivering true automatic “plug and lock” performance. It can lock to the incoming serial stream without the need of special training patterns or sync characters. The deserializer recovers the clock and data by extracting the embedded clock information, validating then deserializing the incoming data stream. The deserialized parallel LVCMOS video bus is provided to the display. The deserializer is intended for use with the DS90UB301Q serializer.

### HIGH SPEED FORWARD CHANNEL DATA TRANSFER

The High Speed Forward Channel is composed of 35 bits of data containing RGB data, sync signals, I2C, and I2S audio transmitted from Serializer to Deserializer. [Figure 10](#) illustrates the serial stream per PCLK cycle. This data payload is optimized for signal transmission over an AC coupled link. Data is randomized, balanced and scrambled.



**FIGURE 10. FPD-Link III Serial Stream**

The device supports clocks in the range of 15MHz to 45MHz. The application payload rate is 1.575Gbps maximum (525Mbps minimum).

### LOW SPEED BACK CHANNEL DATA TRANSFER

The Low-Speed Backward Channel of the DS90UB302Q provides bidirectional communication between the display and host processor. The information is carried back from the Deserializer to the Serializer per serial symbol. The back channel control data is transferred over the single serial link along with the high-speed forward data, DC balance coding and embedded clock information. This architecture provides a backward path across the serial link together with a high speed forward channel. The back channel contains the I2C, CRC and 4 bits of standard GPIO information with 10Mbps line rate.

### INPUT EQUALIZATION GAIN

FPD-Link III input adaptive equalizer provides compensation for transmission medium losses and reduces the medium-induced deterministic jitter. It equalizes up to 10m STP cables with 3 connection breaks at maximum serialized stream payload rate of 1.575Gbps.

### COMMON MODE FILTER PIN (CMF)

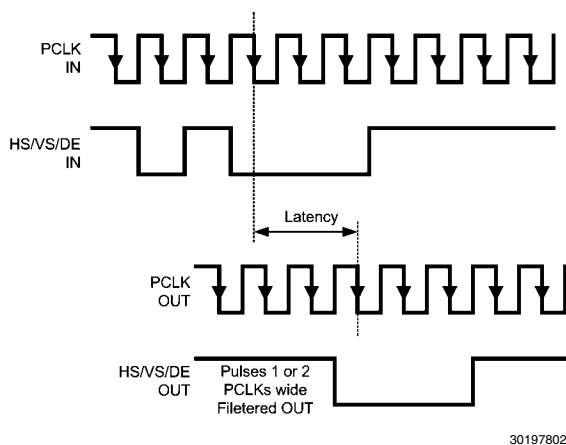
The deserializer provides access to the center tap of the internal termination. A capacitor must be placed on this pin for additional common-mode filtering of the differential pair. This can be useful in high noise environments for additional noise rejection capability. A 0.1μF capacitor has to be connected to this pin to Ground.

### VIDEO CONTROL SIGNAL FILTER

When operating the devices in Normal Mode, the Video Control Signals (DE, HS, VS) have the following restrictions:

- Normal Mode with Control Signal Filter Enabled: DE and HS — Only 2 transitions per 130 clock cycles are transmitted, the transition pulse must be 3 PCLK or longer.
- Normal Mode with Control Signal Filter Disabled: DE and HS — Only 2 transitions per 130 clock cycles are transmitted, no restriction on minimum transition pulse.
- VS — Only 1 transition per 130 clock cycles are transmitted, minimum pulse width is 130 clock cycles.

Video Control Signals are defined as low frequency signals with limited transitions. Glitches of a control signal can cause a visual display error. This feature allows for the chipset to validate and filter out any high frequency noise on the control signals. See [Figure 11](#).



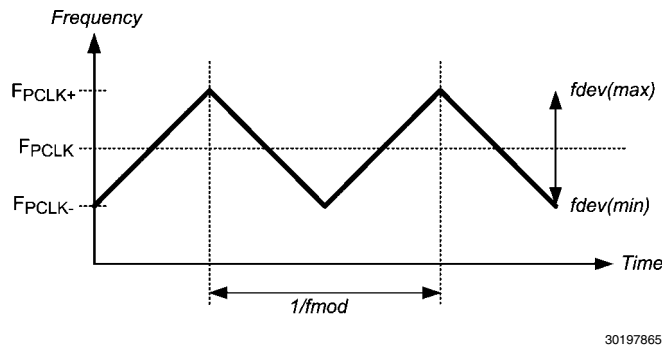
**FIGURE 11. Video Control Signal Filter Waveform**



## EMI REDUCTION FEATURES

### Spread Spectrum Clock Generation (SSCG)

The DS90UB302Q provides an internally generated spread spectrum clock (SSCG) to modulate its outputs. Both clock and data outputs are modulated. This will aid to lower system EMI. Output SSCG deviations to  $\pm 2.5\%$  (5% total) at up to 100kHz modulations are available. This feature may be controlled by register. See [Table 1](#) and [Table 8](#).



**FIGURE 12. SSCG Waveform**

**TABLE 1. SSCG Configuration**

SSCG Configuration (0x2C) (15 - 45MHz)			Spread Spectrum Output	
SSC[2]	SSC[1]	SSC[0]	Fdev (%)	Fmod (kHz)
L	L	L	$\pm 0.9$	PCLK / 2168
L	L	H	$\pm 1.2$	
L	H	L	$\pm 1.9$	
L	H	H	$\pm 2.5$	
H	L	L	$\pm 0.7$	PCLK / 1300
H	L	H	$\pm 1.3$	
H	H	L	$\pm 2.0$	
H	H	H	$\pm 2.5$	

### Enhanced Progressive Turn-On (EPTO)

The deserializer LVCMOS parallel outputs timing are delayed. Groups of 8-bit R, G, and B outputs switch in a different time. 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.

### LVCMOS VDDIO Option

The deserializer parallel bus can operate with 1.8 V or 3.3 V levels (VDDIO) for target (Display) compatibility. The 1.8 V levels will offer a lower noise (EMI) and also a system power savings.

### POWER DOWN (PDB)

The Serializer has a PDB input pin to ENABLE or POWER DOWN the device. This pin can be controlled by the host or through the VDDIO, where VDDIO = 3.0V to 3.6V or VDD33. To save power disable the link when the display is not needed (PDB = LOW). When the pin is driven by the host, make sure to release it after VDD33 and VDDIO have reached final levels; no external components are required. In the case of driven by the VDDIO = 3.0V to 3.6V or VDD33 directly, a 10k $\Omega$  resistor to the VDDIO = 3.0V to 3.6V or VDD33, and a >10 $\mu$ F capacitor to the GND are required (See [Figure 21](#) Typical Connection Diagram).

### STOP STREAM SLEEP

The deserializer enters a low power SLEEP state when the input serial stream is stopped. A STOP condition is detected when the embedded clock bits are not present. When the serial stream starts again, the deserializer will then lock to the incoming signal and recover the data. Note: in STOP STREAM SLEEP, the Serial Control Bus Registers values are retained.

### SERIAL LINK FAULT DETECT

The serial link fault detection is able to detect any of following seven (7) conditions

- 1) Cable open
- 2) "+" to "-" short
- 3) "+" short to GND
- 4) "-" short to GND
- 5) "+" short to battery
- 6) "-" short to battery
- 7) Cable is linked incorrectly

If any one of the fault conditions occurs, The Link Detect Status is 0 (cable is not detected) on the Serial Control Bus Register bit 0 of address 0x1C [Table 8](#). The link errors can be monitored through Link Error Count of the Serial Control Bus Register bit [4:0] of address 0x41 [Table 8](#).

### OSCILLATOR OUTPUT

The deserializer provides an optional PCLK output when the input clock (serial stream) has been lost. This is based on an internal oscillator. The frequency of the oscillator may be selected. This feature is controlled by register Address 0x02, bit 5 (OSC Clock Enable). See [Table 8](#).

### PIXEL CLOCK EDGE SELECT (RFB)

The RFB determines the edge that the data is strobed on. If RFB is *HIGH*, output data is strobed on the Rising edge of the PCLK. If RFB is *LOW*, data is strobed on the Falling edge of the PCLK. This allows for inter-operability with downstream devices. The deserializer output does not need to use the same edge as the serializer input. This feature may be controlled by register. See [Table 8](#).

### CLOCK-DATA RECOVERY STATUS FLAG (LOCK), OUTPUT ENABLE (OEN) AND OUTPUT STATE SELECT (OSS\_SEL)

When PDB is driven *HIGH*, the 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 DS90UB302Q 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 State of the outputs are based on the OEN and OSS\_SEL setting ([Table 2](#)) or register bit ([Table 8](#)). See [Figure 7](#).

**TABLE 2. Output States**

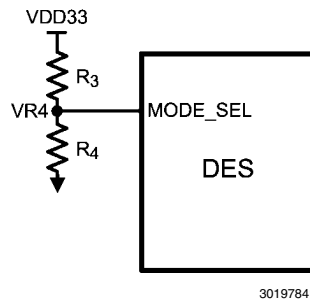
Inputs				Outputs			
Serial input	PDB	OEN	OSS_SEL	Lock	Pass	Data, GPIO, I2S	CLK
X	0	X	X	Z	Z	Z	Z
X	1	0	0	L or H	L	L	L
X	1	0	1	L or H	Z	Z	Z
Static	1	1	0	L	L	L	L/OSC (Register bit enable)
Static	1	1	1	L	Previous Status	L	L
Active	1	1	0	H	L	L	L
Active	1	1	1	H	Valid	Valid	Valid

### INTERRUPT PIN — FUNCTIONAL DESCRIPTION AND USAGE (INTB\_IN)

- On DS90UB301Q, set register 0xC6[5] = 1 and 0xC6[0] = 1
  - DS90UB302Q deserializer INTB\_IN (pin 16) is set *LOW* by some downstream device.
  - DS90UB301Q serializer pulls INTB (pin 31) *LOW*. The signal is active low, so a *LOW* indicates an interrupt condition.
  - External controller detects INTB = *LOW*; to determine interrupt source, read ISR register .
  - A read to ISR will clear the interrupt at the DS90UB301Q, releasing INTB.
  - The external controller typically must then access the remote device to determine downstream interrupt source and clear the interrupt driving INTB\_IN. This would be when the downstream device releases the INTB\_IN (pin 16) on the DS90UB302Q.
- The system is now ready to return to step (1) at next falling edge of INTB\_IN.

### CONFIGURATION SELECT (MODE\_SEL)

Configuration of the device may be done via the MODE\_SEL input pin, or via the configuration register bit. A pull-up resistor and a pull-down resistor of suggested values may be used to set the voltage ratio of the MODE\_SEL input ( $V_{R4}$ ) and  $V_{DD33}$  to select one of the other 4 possible selected modes. See [Figure 13](#) and [Table 3](#).



**FIGURE 13. MODE\_SEL Connection Diagram**

**TABLE 3. Configuration Select (MODE\_SEL)**

#	Ideal Ratio $V_{R4}/V_{DD33}$	Ideal $V_{R4}$ (V)	Suggested Resistor R3 k $\Omega$ (1% tol)	Suggested Resistor R4 k $\Omega$ (1% tol)	Repeater	24/18-bit Mode
1	0	0	Open	40.2 or Any	L	L
2	0.121	0.399	294	40.2	L	H
3	0.152	0.502	280	49.9	H	L
4	0.242	0.799	240	76.8	H	H
Repeater: L = Repeater Off (Default) H = Repeater On 24/18-bit Mode L = Normal 24-bit RGB Mode (Default) H = 18-bit RGB Mode Enabled. Note: use of GPIO(s) on unused inputs must be enabled by register.						

**I2S RECEIVING**

In normal 24-bit RGB operation mode, the DS90UB302Q provides up to 3-bit of I2S. They are I2S\_CLK, I2S\_WC and I2S\_DA, as well as the Master I2S Clock (MCLK). The encrypted and packetized audio information is received during the video blanking periods along with specific information about the clock frequency. A jitter cleaning feature reduces I2S\_CLK output jitter to  $\pm 2$ ns.

**I2S Jitter Cleaning**

The DS90UB302Q features a standalone PLL to clean the I2S data jitter supporting high end car audio systems. If I2S CLK frequency is less than 1MHz, this feature must be disabled through the register bit I2S Control (0x2B) in [Table 8](#).

**MCLK**

The deserializer has an I2S Master Clock Output. It supports x1, x2, or x4 of I2S CLK Frequency. When the I2S PLL is disabled, the MCLK output is off. below covers the range of I2S sample rates and MCLK frequencies.

By default, all the MCLK output frequencies are x2 of the I2S CLK frequencies. The MCLK frequencies can also be enabled through the register bit [7:4] (I2S MCLK Output) of 0x3A shown in [Table 8](#). To select desired MCLK frequency, write bit 7 (0x3A) = 1, then write to bit [6:4] accordingly.

**TABLE 4. Audio Interface Frequencies**

Sample Rate (kHz)	I2S Data Word Size (bits)	I2S CLK (MHz)	MCLK Output (MHz)	Bit [6:4] (Address 0x3A)
32	16	1.024	x1 of I2S CLK	000
			x2 of I2S CLK	001
			x4 of I2S CLK	010
44.1	16	1.411	x1 of I2S CLK	000
			x2 of I2S CLK	001
			x4 of I2S CLK	010
48	16	1.536	x1 of I2S CLK	000
			x2 of I2S CLK	001
			x4 of I2S CLK	010
96	16	3.072	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
192	16	6.144	x1 of I2S CLK	010
			x2 of I2S CLK	011
			x4 of I2S CLK	100
32	24	1.536	x1 of I2S CLK	000
			x2 of I2S CLK	001
			x4 of I2S CLK	010
44.1	24	2.117	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
48	24	2.304	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
96	24	4.608	x1 of I2S CLK	010
			x2 of I2S CLK	011
			x4 of I2S CLK	100
192	24	9.216	x1 of I2S CLK	011
			x2 of I2S CLK	100
			x4 of I2S CLK	101
32	32	2.048	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
44.1	32	2.822	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
48	32	3.072	x1 of I2S CLK	001
			x2 of I2S CLK	010
			x4 of I2S CLK	011
96	32	6.144	x1 of I2S CLK	010
			x2 of I2S CLK	011
			x4 of I2S CLK	100
192	32	12.288	x1 of I2S CLK	011
			x2 of I2S CLK	100
			x4 of I2S CLK	110

### GPIO[3:0] and GPO\_REG[8:4]

In 18-bit RGB operation mode, the optional R[1:0] and G[1:0] of the DS90UB302Q can be used as the general purpose IOs GPIO [3:0] in either forward channel (Outputs) or back channel (Inputs) application.

#### GPIO[3:0] Enable Sequence

See [Table 5](#) for the GPIO enable sequencing.

**Step 1:** Enable the 18-bit mode either through the configuration register bit [Table 8](#) on DS90UB301Q only. DS90UB302Q is automatically configured as in the 18-bit mode.

**Step 2:** To enable GPIO3 forward channel, write 0x03 to address 0x0F on DS90UB301Q, then write 0x05 to address 0x1F on DS90UB302Q.

**TABLE 5. GPIO Enable Sequencing Table**

#	Description	Device	Forward Channel	Back Channel
1	Enable 18-bit mode	DS90UB301Q	0x12 = 0x04	0x12 = 0x04
		DS90UB302Q	Auto Load from DS90UB301Q	Auto Load from DS90UB301Q
2	GPIO3	DS90UB301Q	0x0F = 0x03	0x0F = 0x05
		DS90UB302Q	0x1F = 0x05	0x1F = 0x03
3	GPIO2	DS90UB301Q	0x0E = 0x30	0x0E = 0x50
		DS90UB302Q	0x1E = 0x50	0x1E = 0x30
4	GPIO1	DS90UB301Q	0x0E = 0x03	0x0E = 0x05
		DS90UB302Q	0x1E = 0x05	0x0E = 0x05
5	GPIO0	DS90UB301Q	0x0D = 0x93	0x0D = 0x95
		DS90UB302Q	0x1D = 0x95	0x1D = 0x93

#### GPO\_REG[8:4] Enable Sequence

GPO\_REG[8:4] are output-only pins. They must be programmed through the local register bits. See [Table 6](#) for the GPO\_REG enable sequencing.

**Step 1:** Enable the 18-bit mode either through the configuration register bit on DS90UB301Q only. DS90UB302Q is automatically configured as in the 18-bit mode.

**Step 2:** To enable GPO\_REG8 outputs an “1”, write 0x90 to address 0x21 on DS90UB302Q..

**TABLE 6. GPO\_REG Enable Sequencing Table**

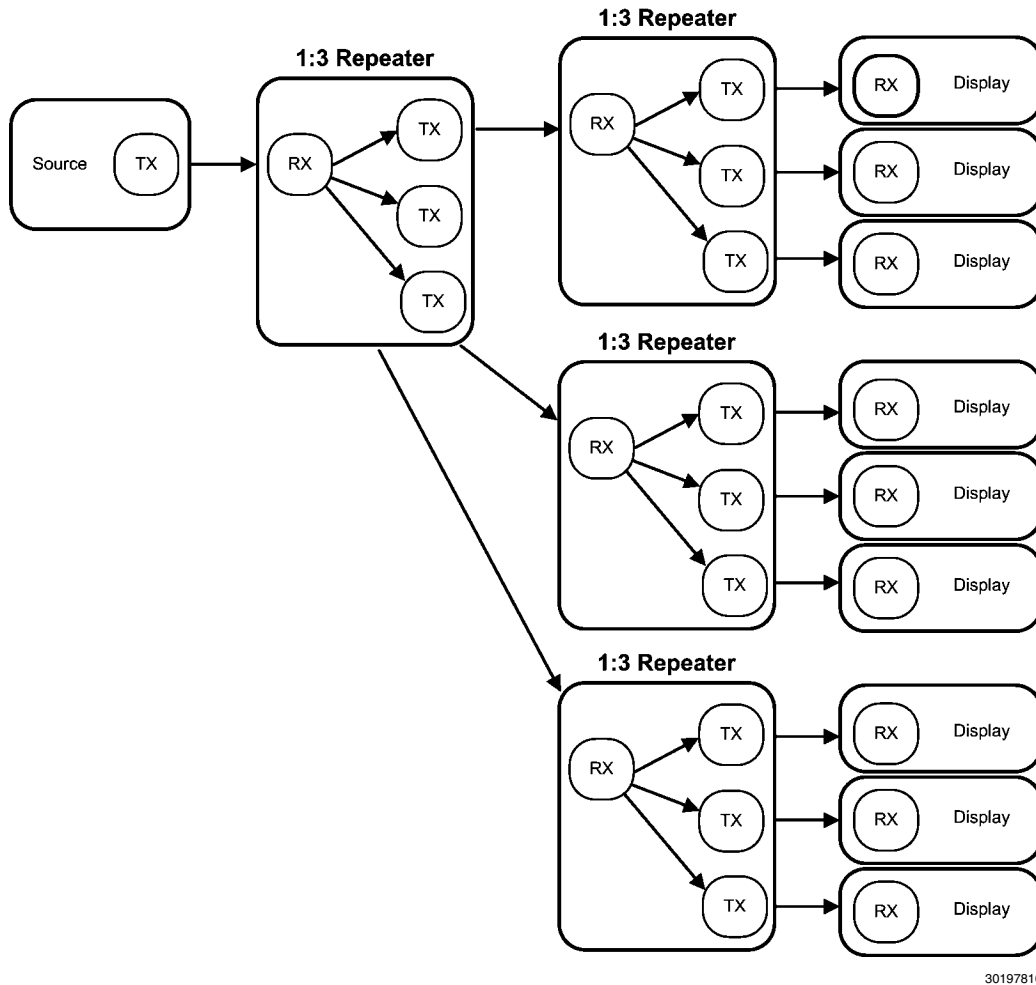
#	Description	Device	Local Access	Local Output Value
1	Enable 18-bit mode	DS90UB302Q	0x12 = 0x04 (on DS90UB301Q)	n/a
2	GPO_REG8	DS90UB302Q	0x21 = 0x90	HIGH
			0x21 = 0x10	LOW
3	GPO_REG7	DS90UB302Q	0x21 = 0x09	HIGH
			0x21 = 0x01	LOW
4	GPO_REG6	DS90UB302Q	0x20 = 0x90	HIGH
			0x20 = 0x10	LOW
5	GPO_REG5	DS90UB302Q	0x20 = 0x09	HIGH
			0x20 = 0x01	LOW
6	GPO_REG4	DS90UB302Q	0x1F = 0x90	HIGH
			0x1F = 0x10	LOW

## REPEATER

When DS90UB301Q and DS90UB302Q are configured in the repeater application, it provides a mechanism to extend transmission over multiple links to multiple display devices.

### Repeater Configuration

In repeater application, in this document, the DS90UB301Q is referred to as the Transmitter or transmit port (TX), and the DS90UB302Q is referred to as the Receiver (RX). [Figure 14](#) shows the maximum configuration supported for repeater implementations using the DS90UB301Q (TX) and DS90UB302Q (RX). Two levels of repeaters are supported with a maximum of three Transmitters per Receiver.

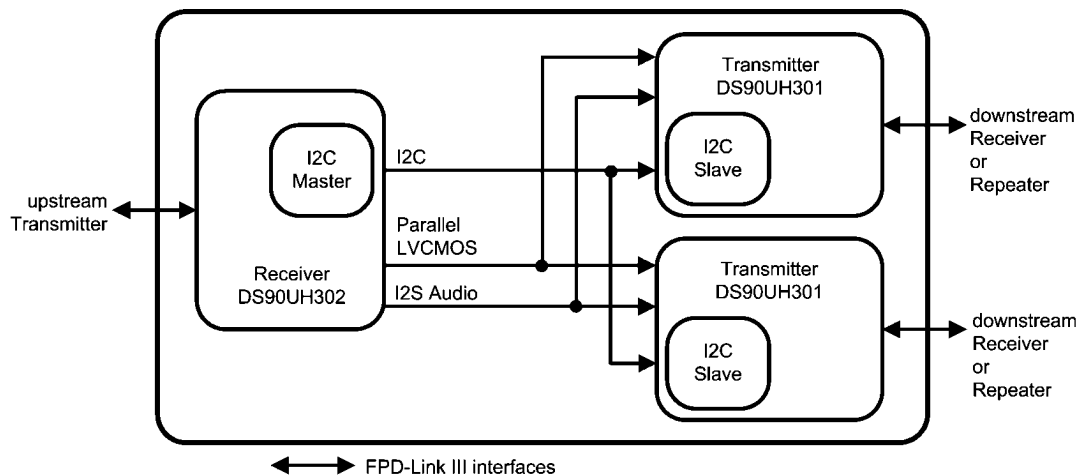


**FIGURE 14. Maximum Repeater Application**

In a repeater application, the I2C interface at each TX and RX may be configured to transparently pass I2C communications upstream or downstream to any I2C device within the system. This includes a mechanism for assigning alternate IDs (Slave Aliases) to downstream devices in the case of duplicate addresses.

At each repeater node, the parallel LVCMOS interface fans out to up to three serializer devices, providing parallel RGB video data, HS/VS/DE control signals and, optionally, packetized audio data (transported during video blanking intervals). Alternatively, the I2S audio interface may be used to transport digital audio data between receiver and transmitters in place of packetized audio. All audio and video data is transmitted at the output of the Receiver and is received by the Transmitter.

[Figure 15](#) provides more detailed block diagram of a 1:2 repeater configuration.

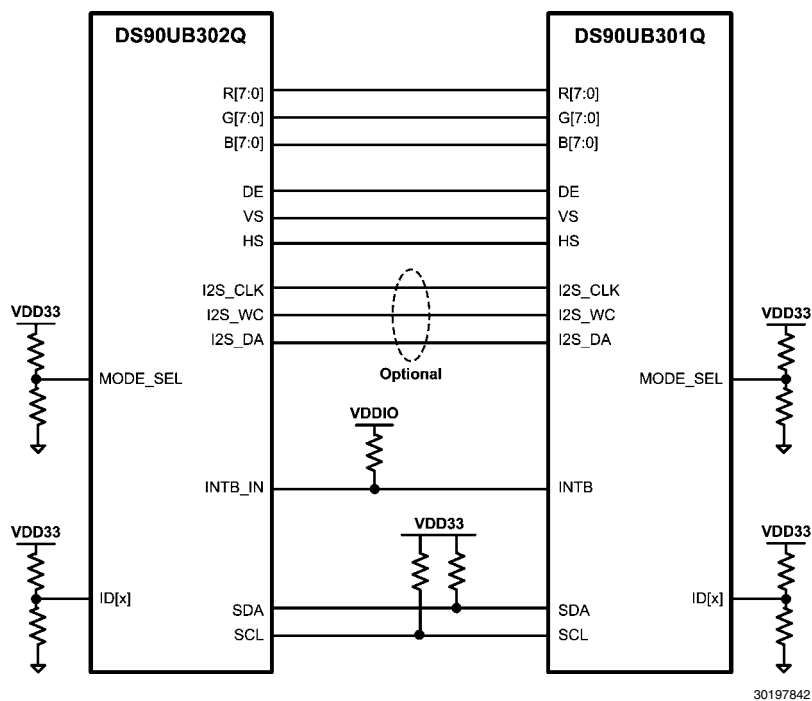


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**FIGURE 15. 1:2 Repeater Configuration****Repeater Connections**

The repeater requires the following connections between the Receiver and each Transmitter [Figure 16](#).

- 1) Video Data – Connect PCLK, RGB and control signals (DE, VS, HS).
- 2) I2C – Connect SCL and SDA signals. Both signals should be pulled up to  $V_{DD33}$  with 4.7k $\Omega$  resistors.
- 3) Audio (optional) – Connect I2S\_CLK, I2S\_WC, and I2S\_DA signals.
- 4) IDx pin – Each Transmitter and Receiver must have a unique I2C address.
- 5) MODE\_SEL pin – All Transmitter and Receiver must be set into the Repeater Mode.
- 6) Interrupt pin– Connect DS90UB302Q INTB\_IN pin to DS90UB301Q INTB pin. The signal must be pulled up to  $V_{DDIO}$ .



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**FIGURE 16. Repeater Connection Diagram**



## BUILT IN SELF TEST (BIST)

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

### BIST Configuration and Status

The BIST mode is enabled at the deserializer by the pin select (Pin 44 BISTEN and Pin 16 BISTC) or configuration register ([Table 8](#)) through the deserializer. The pin based configuration defaults to external PCLK or 33MHz internal Oscillator clock (OSC) frequency. In the absence of PCLK, the user can select the desired OSC frequency (default 33MHz ) through the register bit.

When BISTEN of the deserializer is high, the BIST mode enable information is sent to the serializer through the Back Channel. The serializer outputs a test pattern and drives the link at speed. The deserializer detects the test pattern and monitors it for errors. The PASS output pin toggles to flag any payloads that are received with 1 to 35 bit errors.

The BIST status is monitored real time on PASS pin. The result of the test is held on the PASS output until reset (new BIST test or Power Down). A *HIGH* on PASS indicates NO ERRORS were detected. A *LOW* on PASS indicates one or more errors were detected. The duration of the test is controlled by the pulse width applied to the deserializer BISTEN pin. This BIST feature also contains a Link Error Count and a Lock Status. If the connection of the serial link is broken, then the link error count is shown in the register. When the PLL of the deserializer is locked or unlocked, the lock status can be read in the register. See [Table 8](#).

### Sample BIST Sequence

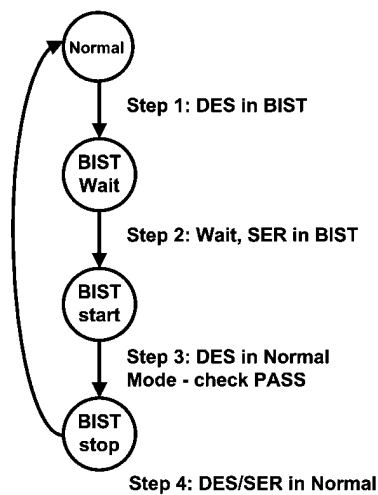
See [Figure 17](#) for the BIST mode flow diagram.

**Step 1:** For the DS90UB301Q and DS90UB302Q FPD-Link III chipset, BIST Mode is enabled via the BISTEN pin of DS90UB302Q FPD-Link III deserializer. The desired clock source is selected through BISTC pin.

**Step 2:** The DS90UB301Q serializer is woken up through the back channel if it is not already on. The all zero pattern on the data pins is sent through the FPD-Link III to the deserializer. Once the serializer and the deserializer are in BIST mode and the deserializer acquires Lock, the PASS pin of the deserializer goes *HIGH* and BIST starts checking the data stream. If an error in the payload (1 to 35) 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.

**Step 3:** To Stop the BIST mode, the deserializer BISTEN pin is set *LOW*. The deserializer stops checking the data. The final test result is held on the PASS pin. If the test ran error free, the PASS output will be *HIGH*. If there was one or more errors detected, the PASS output will be *LOW*. The PASS output state is held until a new BIST is run, the device is RESET, or Powered Down. The BIST duration is user controlled by the duration of the BISTEN signal.

**Step 4:** The Link returns to normal operation after the deserializer BISTEN pin is *LOW*. [Figure 18](#) 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, reducing signal condition enhancements (Rx Equalization).



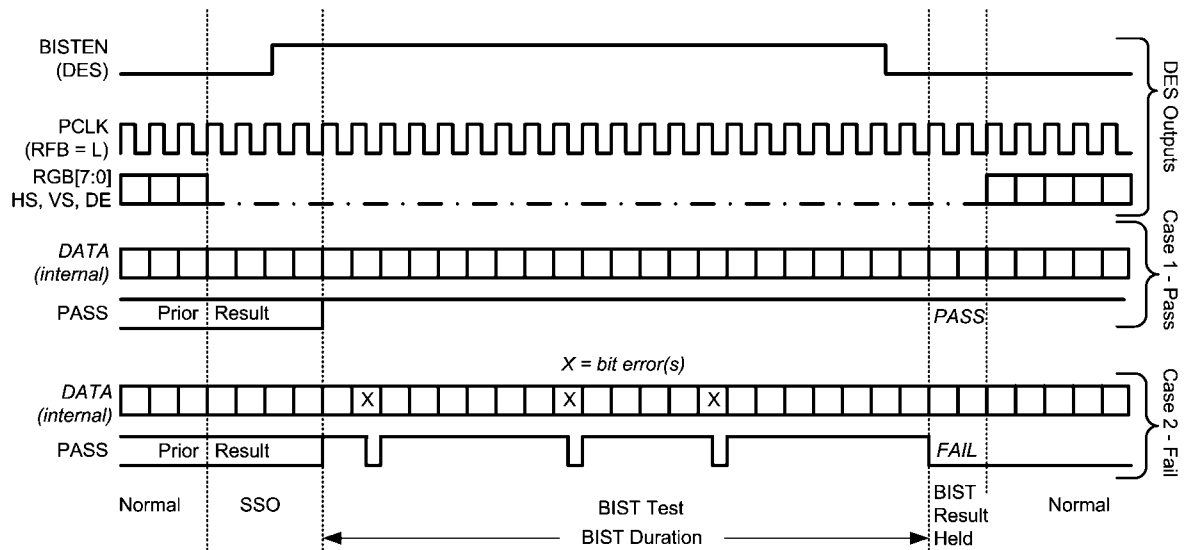
**FIGURE 17. BIST Mode Flow Diagram**

### Forward Channel and Back Channel Error Checking

While in BIST mode, the serializer stops sampling RGB input pins and switches over to an internal test pattern. The internal all-zeroes pattern goes through scrambler, dc-balancing etc. and over the serial link to the deserializer. The deserializer on locking to the serial stream compares the recovered serial stream with all-zeroes and records any errors in status registers and dynamically indicates the status on PASS pin.

The back-channel data is checked for CRC errors once the serializer locks onto back-channel serial stream as indicated by link detect status (register bit 0x0C[0]). The CRC errors are recorded in an 8-bit register. The register is cleared when the serializer enters the BIST mode. As soon as the serializer exits BIST mode, the functional mode CRC register starts recording the CRC

errors. The BIST mode CRC error register is active in BIST mode only and keeps the record of last BIST run until cleared or enters BIST mode again.



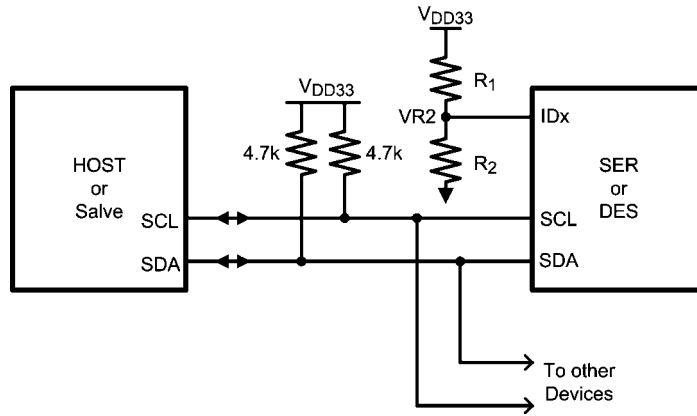
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**FIGURE 18. BIST Waveforms**

## Serial Control Bus

The DS90UB302Q is configured by the use of a serial control bus that is I2C protocol compatible. Multiple deserializer devices may share the serial control bus since 16 device addresses are supported. Device address is set via  $R_1$  and  $R_2$  values on IDx pin. See [Figure 19](#) below.

The serial control bus consists of two signals and a configuration pin. The SCL is a Serial Bus Clock Input / Output. The SDA is the Serial Bus Data Input / Output signal. Both SCL and SDA signals require an external pull-up resistor to  $V_{DD33}$ . For most applications a 4.7k $\Omega$  pull-up resistor to  $V_{DD33}$  may be used. The resistor value may be adjusted for capacitive loading and data rate requirements. The signals are either pulled *HIGH*, or driven *LOW*.



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**FIGURE 19. Serial Control Bus Connection**

The configuration pin is the IDx pin. This pin sets one of 16 possible device addresses. A pull-up resistor and a pull-down resistor of suggested values may be used to set the voltage ratio of the IDx input ( $V_{R2}$ ) and  $V_{DD33}$  to select one of the other 16 possible addresses. See [Table 7](#).

**TABLE 7. Serial Control Bus Addresses for IDx**

#	Ideal Ratio $V_{R2} / V_{DD33}$	Ideal $V_{R2}$ (V)	Suggested Resistor R1 k $\Omega$ (1% tol)	Suggested Resistor R2 k $\Omega$ (1% tol)	Address 7'b	Address 8'b Appended
1	0	0	Open	40.2 or Any	0x2C	0x58
2	0.121	0.399	294	40.2	0x2D	0x5A
3	0.152	0.502	280	49.9	0x2E	0x5C
4	0.182	0.601	270	60.4	0x2F	0x5E
5	0.212	0.700	267	71.5	0x30	0x60
6	0.242	0.799	240	76.8	0x31	0x62
7	0.273	0.901	243	90.9	0x32	0x64
8	0.310	1.023	226	102	0x33	0x66
9	0.356	1.175	210	115	0x34	0x68
10	0.402	1.327	196	130	0x35	0x6A
11	0.447	1.475	182	147	0x36	0x6C
12	0.492	1.624	169	165	0x37	0x6E
13	0.538	1.775	154	180	0x38	0x70
14	0.583	1.924	137	191	0x39	0x72
15	0.629	2.076	124	210	0x3A	0x74
16	0.727	2.399	90.9	243	0x3B	0x76

TABLE 8. Serial Control Bus Registers

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
0	0x00	I2C Device ID	7:1	RW		Device ID	7-bit address of Deserializer See <a href="#">Table 3</a>
			0	RW		ID Setting	I2C ID Setting 1: Register I2C Device ID (Overrides IDx pin) 0: Device ID is from IDx pin
1	0x01	Reset	7:3	RW	0x04		<b>Reserved</b>
			2	RW		BC Enable	Back channel enable 1: Enable 0: Disable
			1	RW		Digital RESET1	Reset the entire digital block including registers This bit is self-clearing 1: Reset 0: Normal operation
			0	RW		Digital RESET0	Reset the entire digital block except registers This bit is self-clearing 1: Reset 0: Normal operation
2	0x02	Configuration [0]	7	RW	0x00	Output Enable	LVC MOS Output Enable 1: Enable 0: Disable. Tri-state Outputs
			6	RW		OEN and OSS_SEL Override	Overrides Output Enable Pin and Output State pin 1: Enable override 0: Disable - no override
			5	RW		OSC Clock Enable	OSC Clock Output Enable If loss of lock OSC clock is output onto PCLK 1: Enable 0: Disable
			4	RW		Output Sleep State Select (OSS_SEL)	OSS Select to Control Output State during Lock Low Period 1: Enable 0: Disable
			3:0	RW			<b>Reserved</b>

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
3	0x03	Configuration [1]	7		0xF0		<b>Reserved.</b>
			6	RW		CRC Generator Enable	CRC Generator Enable (Back Channel) 1: Enable 0: Disable
			5				<b>Reserved</b>
			4	RW		Filter Enable	HS, VS, DE two clock filter When enabled, pulses less than two full PCLK cycles on the DE, HS, and VS inputs will be rejected 1: Filtering enable 0: Filtering disable
			3	RW		I2C Pass-through	I2C Pass-Through Mode 1: Pass-Through Enabled 0: Pass-Through Disabled
			2	RW		Auto ACK	ACK Select 1: Auto ACK enable 0: Self ACK
			1				<b>Reserved</b>
			0	RW		RRFB	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.
4	0x04	BCC Watchdog Control	7:1	RW	0xFE	BCC Watchdog Timer	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 2 milliseconds. This field should not be set to 0
			0	RW		BCC Watchdog Timer Disable	Disable Bidirectional Control Channel Watchdog Timer 1: Disables BCC Watchdog Timer operation 0: Enables BCC Watchdog Timer operation
5	0x05	I2C Control 1	7	RW	0x2E	I2C Pass Through All	I2C Pass-Through All Transactions 1: Enabled 0: Disabled
			6:4	RW		I2C SDA Hold Time	Internal I2C SDA Hold Time It configures the amount of internal hold time provided for the SDA input relative to the SCL input. Units are 50ns.
			3:0	RW		I2C Filter Depth	I2C Glitch Filter Depth It configures the maximum width of glitch pulses on the SCL and SDA inputs that will be rejected. Units are 5ns.

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
6	0x06	I2C Control 2	7	R	0x00	Forward Channel Sequence Error	Control Channel Sequence Error Detected It indicates a sequence error has been detected in forward control channel. If this bit is set, an error may have occurred in the control channel operation.
			6	RW		Clear Sequence Error	It clears the Sequence Error Detect bit This bit is not self-clearing
			5				<b>Reserved</b>
			4:3	RW		SDA Output Delay	SDA Output Delay This field configures output delay on the SDA output. Setting this value will increase output delay in units of 50 ns. Nominal output delay values for SCL to SDA are: 00 : 250ns 01: 300ns 10: 350ns 11: 400ns
			2	RW		Local Write	Disable Remote Writes to Local Registers through Serializer (Does not affect remote access to I2C slaves at Deserializer) 1: Stop remote write to local device registers 0: remote write to local device registers
			1	RW		I2C Bus Timer Speed	Speed up I2C Bus Watchdog Timer 1: Timer expires after approximately 50ms 0: Timer expires after approximately 1s
7	0x07	Remote Device ID	7:1	RW	0x18	Remote ID	Remote ID Configures the I2C Slave ID of the remote Serializer. A value of 0 in this field disables I2C access to remote Serializer. This field is automatically configured via the Serializer Forward Channel. Software may overwrite this value, but should also set the FREEZE DEVICE ID bit to prevent overwriting by the Forward Channel.
			0	RW		Freeze Device ID	Freeze Serializer Device ID 1: Prevent auto-loading of the Serializer Device ID from the Forward Channel. The ID will be frozen at the value written. 0: Update
8	0x08	SlaveID[0]	7:1	RW	0x00	Target Slave Device ID0	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				<b>Reserved</b>

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
9	0x09	SlaveID[1]	7:1	RW	0x00	Target Slave Device ID1	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				<b>Reserved</b>
10	0x0A	SlaveID[2]	7:1	RW	0x00	Target Slave Device ID2	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				<b>Reserved</b>
11	0x0B	SlaveID[3]	7:1	RW	0x00	Target Slave Device ID3	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				<b>Reserved</b>
12	0x0C	SlaveID[4]	7:1	RW	0x00	Target Slave Device ID4	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				<b>Reserved</b>
13	0x0D	SlaveID[5]	7:1	RW	0x00	Target Slave Device ID5	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				<b>Reserved</b>
14	0x0E	SlaveID[6]	7:1	RW	0x00	Target Slave Device ID6	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				<b>Reserved</b>

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
15	0x0F	SlaveID[7]	7:1	RW	0x00	Target Slave Device ID7	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				<b>Reserved</b>
16	0x10	SlaveAlias [0]	7:1	RW	0x00	ID[0] Match	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				<b>Reserved</b>



ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
17	0x11	SlaveAlias [1]	7:1	RW	0x00	ID[1] Match	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				<b>Reserved</b>
18	0x12	SlaveAlias [2]	7:1	RW	0x00	ID[2] Match	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				<b>Reserved</b>
19	0x13	SlaveAlias [3]	7:1	RW	0x10	ID[3] Match	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				<b>Reserved</b>
20	0x14	SlaveAlias [4]	7:1	RW	0x00	ID[4] Match	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				<b>Reserved</b>
21	0x15	SlaveAlias [5]	7:1	RW	0x00	ID[5] Match	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				<b>Reserved</b>
22	0x16	SlaveAlias [6]	7:1	RW	0x00	ID[6] Match	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	RW			<b>Reserved</b>

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
23	0x17	SlaveAlias [7]	7:1	RW	0x00	ID[7] Match	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				<b>Reserved</b>
28	0x1C	General Status	7:4	RW	0x00		<b>Reserved</b>
			3	R		I2S Locked	I2S Lock Status 1: I2S PLL controller locked to input I2S clock 0: I2S PLL controller not locked
			2				<b>Reserved</b>
			1	R		Signal Detect	Signal Detect 1: Serial input detected 0: Serial input not detected
			0	R		Lock	Deserializer CDR, PLL's clock to recovered clock frequency 1: Deserializer locked to recovered clock 0: Deserializer not locked
29	0x1D	GPIO0 Config	7:4	R	0xA0	Rev-ID	Revision ID: 1010: Production Device
			3	RW		GPIO0 Output Value	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	RW		GPIO0 Remote Enable	Remote GPIO0 Control 1: Enable GPIO control from remote Serializer. The GPIO pin will be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Serializer
			1	RW		GPIO0 Direction	Local GPIO Direction 1: Input 0: Output
			0	RW		GPIO0 Enable	GPIO Function Enable 1: Enable GPIO operation 0: Enable normal operation

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
30	0x1E	GPIO2 and GPIO1 Config	7	RW	0x00	GPIO2 Output Value	Local GPIO Output Value This value is output on the GPIO when the GPIO function is enabled, the local GPIO direction is Output, and remote GPIO control is disabled.
			6	RW		GPIO2 Remote Enable	Remote GPIO2 Control 1: Enable GPIO control from remote Serializer. The GPIO pin will be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Serializer.
			5	RW		GPIO2 Direction	Local GPIO Direction 1: Input 0: Output
			4	RW		GPIO2 Enable	GPIO Function Enable 1: Enable GPIO operation 0: Enable normal operation
			3	RW		GPIO1 Output Value	Local GPIO Output Value This value is output on the GPIO when the GPIO function is enabled, the local GPIO direction is Output, and remote GPIO control is disabled.
			2	RW		GPIO1 Remote Enable	Remote GPIO1 Control 1: Enable GPIO control from remote Serializer. The GPIO pin will be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Serializer.
			1	RW		GPIO1 Direction	Local GPIO Direction 1: Input 0: Output
			0	RW		GPIO1 Enable	GPIO Function Enable 1: Enable GPIO operation 0: Enable normal operation
31	0x1F	GPO_REG4 and GPO3 Config	7	RW	0x00	GPO_REG 4 Output Value	Local GPO_REG4 Output Value This value is output on the GPO when the GPO function is enabled, the local GPO direction is Output, and remote GPO control is disabled.
			6:5				<b>Reserved</b>
			4	RW		GPO_REG 4 Enable	GPO_REG4 Function Enable 1: Enable GPO operation 0: Enable normal operation
			3	RW		GPIO3 Output Value	Local GPIO Output Value This value is output on the GPIO when the GPIO function is enabled, the local GPIO direction is Output, and remote GPIO control is disabled.
			2	RW		GPIO3 Remote Enable	Remote GPIO3 Control 1: Enable GPIO control from remote Serializer. The GPIO pin will be an output, and the value is received from the remote Deserializer. 0: Disable GPIO control from remote Serializer.
			1	RW		GPIO3 Direction	Local GPIO Direction 1: Input 0: Output
			0	RW		GPIO3 Enable	GPIO Function Enable 1: Enable GPIO operation 0: Enable normal operation

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
32	0x20	GPO_REG6 and GPO_REG5 Config	7	RW	0x00	GPO_REG 6 Output Value	Local GPO_REG6 Output Value This value is output on the GPO when the GPO function is enabled, the local GPO direction is Output, and remote GPO control is disabled.
			6:5				<b>Reserved</b>
			4	RW		GPO_REG 6 Enable	GPO_REG6 Function Enable 1: Enable GPO operation 0: Enable normal operation
			3	RW		GPO_REG 5 Output Value	Local GPO_REG5 Output Value This value is output on the GPO when the GPO function is enabled, the local GPO direction is Output, and remote GPO control is disabled.
			2:1				<b>Reserved</b>
			0	RW		GPO_REG 5 Enable	GPO_REG5 Function Enable 1: Enable GPO operation 0: Enable normal operation
33	0x21	GPO8 and GPO7 Config	7	RW	0x00	GPO_REG 8 Output Value	Local GPO_REG8 Output Value This value is output on the GPO when the GPO function is enabled, the local GPO direction is Output, and remote GPO control is disabled.
			6:5				<b>Reserved</b>
			4	RW		GPO_REG 8 Enable	GPO_REG8 Function Enable 1: Enable GPO operation 0: Enable normal operation
			3	RW		GPO_REG 7 Output Value	Local GPO_REG7 Output Value This value is output on the GPO when the GPO function is enabled, the local GPO direction is Output, and remote GPO control is disabled.
			2:1				<b>Reserved</b>
			0	RW		GPO_REG 7 Enable	GPO_REG7 Function Enable 1: Enable GPO operation 0: Enable normal operation

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
34	0x22	Data Path Control	7	RW	0x0	Override FC Config	1: Disable loading of this register from the forward channel, keeping locally written values intact 0: Allow forward channel loading of this register
			6	RW		Pass RGB	Setting this bit causes RGB data to be sent independent of DE. This allows operation in systems which may not use DE to frame video data or send other data when DE is de-asserted. Note that setting this bit blocks packetized audio. 1: Pass RGB independent of DE 0: Normal operation Note: this bit is automatically loaded from the remote serializer unless bit 7 of this register is set.
			5	RW		DE Polarity	This bit indicates the polarity of the DE (Data Enable) signal. 1: DE is inverted (active low, idle high) 0: DE is positive (active high, idle low) Note: this bit is automatically loaded from the remote serializer unless bit 7 of this register is set.
			4	RW		I2S_Gen	This bit controls whether the Receiver outputs packetized Auxiliary/Audio data on the RGB video output pins. 1: Don't output packetized audio data on RGB video output pins 0: Output packetized audio on RGB video output pins. Note: this bit is automatically loaded from the remote serializer unless bit 7 of this register is set.
			3	RW			<b>Reserved</b>
			2	RW		18-bit Video Select	1: Select 18-bit video mode 0: Select 24-bit video mode Note: this bit is automatically loaded from the remote serializer unless bit 7 of this register is set.
			1	RW		I2S Transport Select	1: Enable I2S Data Forward Channel Frame Transport 0: Enable I2S Data Island Transport Note: this bit is automatically loaded from the remote serializer unless bit 7 of this register is set.
			0	RW			<b>Reserved</b>
35	0x23	General Purpose Control	7	RW	0x10	Rx RGB Checksum	RX RGB Checksum Enable Setting this bit enables the Receiver to validate a one-byte checksum following each video line. Checksum failures are reported in the STS register
			6:5				<b>Reserved</b>
			4	R		MODE_SEL	Mode Select is Done
			3	R			<b>Reserved</b>
			2	R		Repeater	Repeater Mode Status
			1:0	R			<b>Reserved</b>

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
36	0x24	BIST Control	7:4		0x08		<b>Reserved</b>
			3	RW		BIST Pin Config	BIST Configured through Pin 1: BIST configured through pin 0: BIST configured through register bit
			2:1	RW		BIST Clock Source	BIST Clock Source 00: External Pixel Clock 01: 33MHz Oscillator 10: Reserved 11: Reserved
			0	RW		BIST Enable	BIST Control 1: Enabled 0: Disabled
37	0x25	BIST Error	7:0	R	0x00	BIST Error Count	BIST Error Count
38	0x26	SCL High Time	7:0	RW	0x83	SCL High Time	I2C Master SCL High Time This field configures the <i>HIGH</i> pulse width of the SCL output when the Deserializer is the Master on the local I2C bus. Units are 50ns for the nominal oscillator clock frequency. The default value is set to provide a minimum 5us SCL <i>HIGH</i> time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
39	0x27	SCL Low Time	7:0	RW	0x84	SCL Low Time	I2C SCL Low Time This field configures the <i>LOW</i> 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 50ns for the nominal oscillator clock frequency. The default value is set to provide a minimum 5us SCL Low time with the internal oscillator clock running at 26MHz rather than the nominal 20MHz.
42	0x2A	White Balance Control	7:6	RW	0x00	Page Setting	00: Configuration Registers 01: Red LUT 10: Green LUT 11: Blue LUT
			5	RW		White Balance Enable	1: White Balance Enable 0: White Balance Disable
			4	RW		LUT Reload Enable	1: Reload Enable 0: Reload Disable
			3:0				<b>Reserved</b>
43	0x2B	I2S Control	7	RW	0x00	I2S PLL	I2S PLL Control 1: I2S PLL is off. No jitter cleaning 0: I2S PLL is on for I2S data jitter cleaning
			6:1				<b>Reserved</b>
			0	RW		I2S Clock Edge	I2S Clock Edge Select 1: I2S Data is strobed on the Falling Clock Edge 0: I2S Data is strobed on the Rising Clock Edge

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
44	0x2C	SSCG Control	7:4		0x00		<b>Reserved</b>
			3	RW		SSCG Enable	Enable Spread Spectrum Clock Generator 1: Enable 0: Disable
			2:0	RW		SSCG Selection	SSCG Frequency Deviation: fdev fmod 000: +/- 0.9 CLK/2168 001: +/- 1.2 010: +/- 1.9 011: +/- 2.5 100: +/- 0.7 CLK/1300 101: +/- 1.3 110: +/- 2.0 111: +/- 2.5
58	0x3A	I2S MCLK Output	7	RW	0x00	MCLK Override	1: Override divider select for MCLK 0: No override for MCLK divider
			6:4	RW		MCLK Frequency Slect	See <a href="#">Table 4</a>
			3:0				<b>Reserved</b>
65	0x41	Link Error Count	7:5		0x03		<b>Reserved</b>
			4	RW		Link Error Count Enable	Enable serial link data integrity error count 1: Enable error count 0: Disable
			3:0	RW		Link Error Count	Link error count threshold. Counter is pixel clock based. clk0, clk1 and DCA are monitored for link errors, if error count is enabled, deserializer loose lock once error count reaches threshold. If disabled deserializer loose lock with one error.
68	0x44	Equalization	7:5	RW	0x60	EQ Stage 1 Select	EQ select value. Used if adaptive EQ is bypassed. 000 Min EQ 1st Stage 001 010 011 100 101 110 111 Max EQ 1st Stage
			4				<b>Reserved</b>
			3:1	RW		EQ Stage 2 Select	EQ select value. Used if adaptive EQ is bypassed. 000 Min EQ 2nd Stage 001 010 011 100 101 110 111 Max EQ 2nd Stage
			0	RW		Adaptive EQ	1: Disable adaptive EQ (to write EQ select values) 0: Enable adaptive EQ

ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
86	0x56	CML Output	7:4		0x08		<b>Reserved</b>
			3	RW		CMLOUTP/ N Enable	1: Disabled (Default) 0: Enabled
			2:0				<b>Reserved</b>
100	0x64	Pattern Generator Control	7:4	RW	0x10	Pattern Generator Select	Fixed Pattern Select This field selects the pattern to output when in Fixed Pattern Mode. Scaled patterns are evenly distributed across the horizontal or vertical active regions. This field is ignored when Auto-Scrolling Mode is enabled. The following table shows the color selections in non-inverted followed by inverted color mode 0000: Reserved 0001: White/Black 0010: Black/White 0011: Red/Cyan 0100: Green/Magenta 0101: Blue/Yellow 0110: Horizontally Scaled Black to White/White to Black 0111: Horizontally Scaled Black to Red/Cyan to White 1000: Horizontally Scaled Black to Green/Magenta to White 1001: Horizontally Scaled Black to Blue/Yellow to White 1010: Vertically Scaled Black to White/White to Black 1011: Vertically Scaled Black to Red/Cyan to White 1100: Vertically Scaled Black to Green/Magenta to White 1101: Vertically Scaled Black to Blue/Yellow to White 1110: Custom color (or its inversion) configured in PGRS, PGGS, PGBS registers 1111: Reserved
			3:1				<b>Reserved</b>
			0	RW		Pattern Generator Enable	Pattern Generator Enable 1: Enable Pattern Generator 0: Disable Pattern Generator



ADD (dec)	ADD (hex)	Register Name	Bit(s)	Register Type	Default (hex)	Function	Descriptions
101	0x65	Pattern Generator Configuration	7:5		0x00		<b>Reserved</b>
			4	RW		Pattern Generator 18/24-bit	18/24-bit Mode Select 1: Enable 18-bit color pattern generation. Scaled patterns will have 64 levels of brightness and the R, G, and B outputs use the six most significant color bits. 0: Enable 24-bit pattern generation. Scaled patterns use 256 levels of brightness.
			3	RW		Pattern Generator External Clock	Select External Clock Source 1: Selects the external pixel clock when using internal timing 0: Selects the internal divided clock when using internal timing This bit has no effect in external timing mode (PATGEN_TSEL = 0).
			2	RW		Pattern Generator Timing Select	Timing Select Control 1: The Pattern Generator creates its own video timing as configured in the Pattern Generator Total Frame Size, Active Frame Size, Horizontal Sync Width, Vertical Sync Width, Horizontal Back Porch, Vertical Back Porch, and Sync Configuration registers. 0: the Pattern Generator uses external video timing from the pixel clock, Data Enable, Horizontal Sync, and Vertical Sync signals.
			1	RW		Pattern Generator Color Invert	Enable Inverted Color Patterns 1: Invert the color output. 0: Do not invert the color output.
			0	RW		Pattern Generator Auto-Scroll Enable	Auto-Scroll Enable: 1: The Pattern Generator will automatically move to the next enabled pattern after the number of frames specified in the Pattern Generator Frame Time (PGFT) register. 0: The Pattern Generator retains the current pattern.
102	0x66	Pattern Generator Indirect Address	7:0	RW	0x00	Indirect Address	This 8-bit field sets the indirect address for accesses to indirectly-mapped registers. It should be written prior to reading or writing the Pattern Generator Indirect Data register. See AN-2198
103	0x67	Pattern Generator Indirect Data	7:0	RW	0x00	Indirect Data	When writing to indirect registers, this register contains the data to be written. When reading from indirect registers, this register contains the read back value. See AN-2198

## Image Enhancement Features

Several image enhancement features are provided. White balance LUTs allow the user to define and target the color temperature of the display.

### WHITE BALANCE

The White Balance feature enables similar display appearance when using LCD's from different vendors. It compensates for native color temperature of the display, and adjusts relative intensities of R, G, B to maintain specified color temperature. Programmable control registers are used to define the contents of three LUTs (8-bit color value for Red, Green and Blue) for the White Balance Feature. The LUTs map input RGB values to new output RGB values. There are three LUTs, one LUT for each color. Each LUT contains 256 entries, 8-bits per entry with a total size of 6144 bits (3 x 256 x 8). All entries are readable and writable. Calibrated values are loaded into registers through the I2C interface (deserializer is a slave device). This feature may also be applied to lower color depth applications such as 18-bit (666) and 16-bit (565). White Balance is enabled and configured via serial control bus register.

### LUT contents

The user must define and load the contents of the LUT for each color (R,G,B). Regardless of the color depth being driven (888, 666, 656), the user must always provide contents for 3 complete LUTs - 256 colors x 8 bits x 3 tables. Unused bits - LSBs shall be set to "0" by the user.

When 24-bit (888) input data is being driven to a 24-bit display, each LUT (R, G and B) must contain 256 unique 8-bit entries. The 8-bit white balanced data is then available at the output of the DS90UB302Q deserializer, and driven to the display.

When 18-bit (666) input data is being driven to an 18-bit display, the white balance feature can still be used. Simply load each LUT with 256, 8-bit entries. Each 8-bit entry is a 6-bit value (6 MSBs) with the 2 LSBs set to "00". Thus as total of 64 unique 6-bit white balance output values are available for each color (R, G and B). The 6-bit white balanced data is available at the output of the DS90UB302Q deserializer, and driven directly to the display.

Examples of the three types of LUT configurations described are shown in [Figure 20](#).

### Enabling white balance

The user must load all 3 LUTs prior to enabling the white balance feature. The following sequence must be followed by the user.

To initialize white balance after power-on ([Table 9](#)):

- 1) Load contents of all 3 LUTs . This requires a sequential loading of LUTs - first RED, second GREEN, third BLUE. 256, 8-bit entries must be loaded to each LUT. Page registers must be set to select each LUT.

- 2) Enable white balance

By default, the LUT data may not be reloaded after initialization at power-on.

An option does exist to allow LUT reloading after power-on and initial LUT loading (as described above). This option may only be used after enabling the white balance reload feature via the associated serial control bus register. In this mode the LUTs may be reloaded by the master controller via I2C. This provides the user with the flexibility to refresh LUTs periodically , or upon system requirements to change to a new set of LUT values. The host controller loads the updated LUT values via the serial bus interface. There is no need to disable the white balance feature while reloading the LUT data. Refreshing the white balance to the new set of LUT data will be seamless - no interruption of displayed data.

It is important to note that initial loading of LUT values requires that all 3 LUTs be loaded sequentially. When reloading, partial LUT updates may be made.

8-bit in / 8 bit out		6-bit in / 6 bit out		6-bit in / 8 bit out	
Gray level Entry	Data Out (8-bits)	Gray level Entry	Data Out (8-bits)	Gray level Entry	Data Out (8-bits)
0	00000000b	0	00000000b	0	00000001b
1	00000001b	1	N/A	1	N/A
2	00000011b	2	N/A	2	N/A
3	00000011b	3	N/A	3	N/A
4	00000110b	4	00000100b	4	00000110b
5	00000110b	5	N/A	5	N/A
6	00000111b	6	N/A	6	N/A
7	00000111b	7	N/A	7	N/A
8	00001000b	8	00001000b	8	00001011b
9	00001010b	9	N/A	9	N/A
10	00001001b	10	N/A	10	N/A
11	00001011b	11	N/A	11	N/A
...	...	...	...	...	...
248	11111010b	248	11111000b	248	11111010b
249	11111010b	249	N/A	249	N/A
250	11111011b	250	N/A	250	N/A
251	11111011b	251	N/A	251	N/A
252	11111110b	252	11111100b	252	11111111b
253	11111101b	253	N/A	253	N/A
254	11111101b	254	N/A	254	N/A
255	11111111b	255	N/A	255	N/A

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**FIGURE 20. White Balance LUT Configurations**
**TABLE 9. White Balance Register Table**

PAGE	ADD (dec)	ADD (hex)	Register Name	Bit(s)	Access	Default (hex)	Function	Description
0	42	0x2A	White Balance Control	7:6	RW	0x00	Page Setting	00: Configuration Registers 01: Red LUT 10: Green LUT 11: Blue LUT
				5	RW		White Balance Enable	0: White Balance Disable 1: White Balance Enable
				4	RW			0: Reload Disable 1: Reload Enable
				3:0				<b>Reserved</b>
1	0 – 255	00 – FF	White Balance Red LUT	FF:0	RW	N/A	Red LUT	256 8-bit entries to be applied to the Red subpixel data
2	0 – 255	00 – FF	White Balance Green LUT	FF:0	RW	N/A	Green LUT	256 8-bit entries to be applied to the Green subpixel data
3	0 – 255	00 – FF	White Balance Blue LUT	FF:0	RW	N/A	Blue LUT	256 8-bit entries to be applied to the Blue subpixel data

## Internal Pattern Generation

The DS90UB302Q serializer supports the internal pattern generation feature. It allows basic testing and debugging of an integrated panel. The test patterns are simple and repetitive and allow for a quick visual verification of panel operation. As long as the device is not in power down mode, the test pattern will be displayed even if no parallel input is applied. If no PCLK is received, the test pattern can be configured to use a programmed oscillator frequency. For detailed information, refer to Application Note AN-2198.

## Applications Information

### DISPLAY APPLICATION

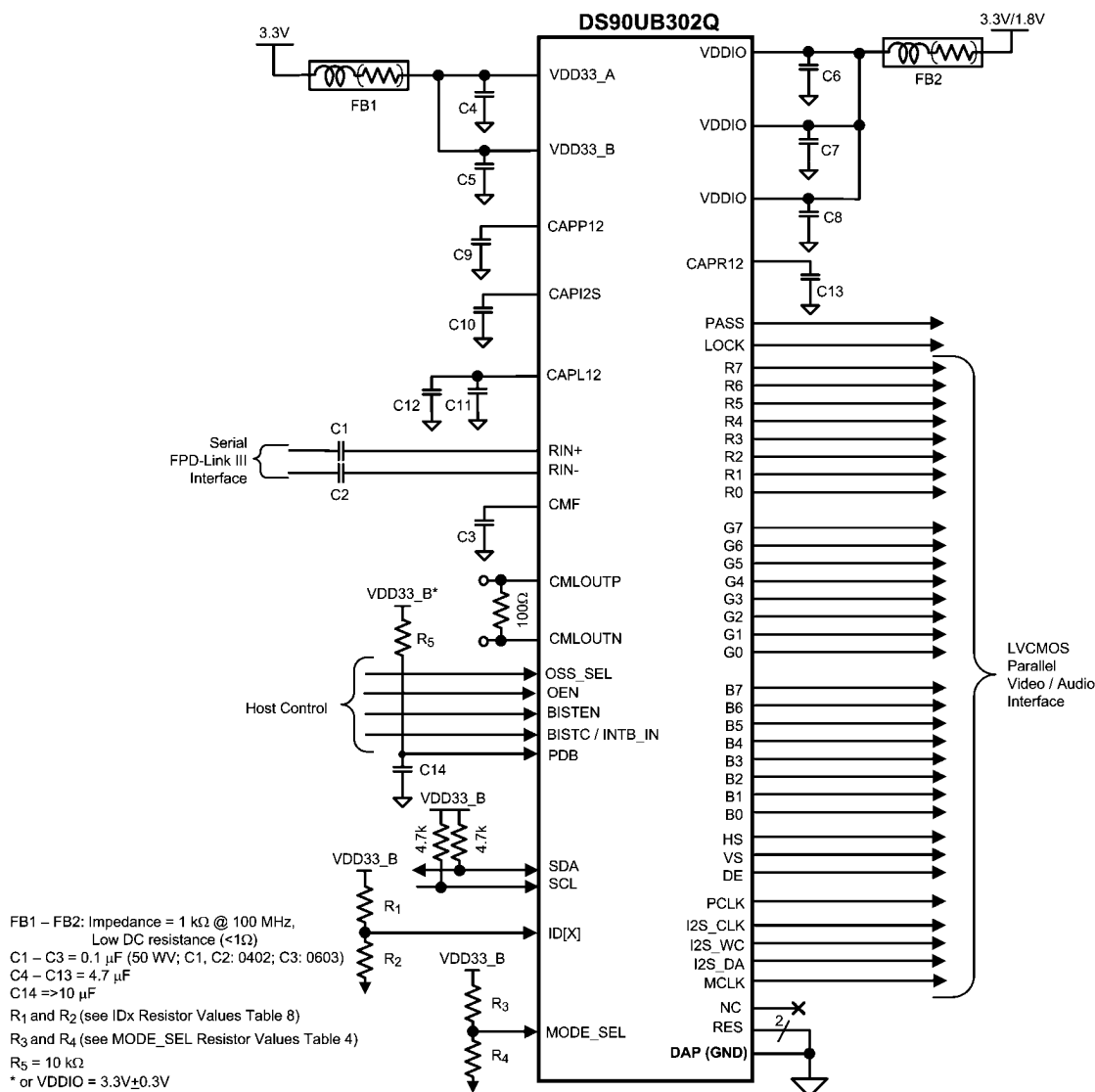
The DS90UB302Q, in conjunction with the DS90UB301Q, is intended for interface between a host (graphics processor) and a Display. It supports an 24-bit color depth (RGB888). It allows to receive a three 8-bit RGB stream with a pixel rate up to 45MHz together with three control bits (VS, HS and DE) and three I2S-bus audio stream with an audio sampling rate up to 192kHz.

The deserializer is expected to be located close to its target device. The interconnect between the deserializer and the target device is typically in the 1 to 3 inch separation range. The input capacitance of the target device is expected to be in the 5 to 10 pF range. Care should be taken on the PCLK output trace as this signal is edge sensitive and strobes the data. It is also assumed that the fanout of the deserializer is up to three in the repeater mode. If additional loads need to be driven, a logic buffer or mux device is recommended.

### TYPICAL APPLICATION CONNECTION

Figure 21 shows a typical application of the DS90UB302Q deserializer for an 45MHz 24-bit Color Display Application. inputs utilize 0.1μF coupling capacitors to the line and the deserializer provides internal termination. Bypass capacitors are placed near the power supply pins. At a minimum, seven 0.1μF capacitors and two 4.7μF capacitors should be used for local device bypassing. Ferrite beads are placed on the power lines for effective noise suppression. Since the device in the Pin/STRAP mode, two 10kΩ pull-up resistors are used on the parallel output bus to select the desired device features.

The interface to the target display is with 3.3V LVCMOS levels, thus the V<sub>DDIO</sub> pins are connected to the 3.3V rail. A delay cap is placed on the PDB signal to delay the enabling of the device until power is stable.



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FIGURE 21. Typical Connection Diagram

## POWER UP REQUIREMENTS AND PDB PIN

The VDDs ( $V_{DD33}$  and  $V_{DDIO}$ ) supply ramp should be faster than 1.5ms with a monotonic rise. A large capacitor on the PDB pin is needed to ensure PDB arrives after all the VDDs have settled to the recommended operating voltage. When PDB pin is pulled to  $V_{DDIO} = 3.0V$  to  $3.6V$  or  $V_{DD33}$ , it is recommended to use a  $10k\Omega$  pull-up and a  $>10\mu F$  cap to GND to delay the PDB input signal. All inputs must not be driven until  $V_{DD33}$  and  $V_{DDIO}$  has reached its steady state value.

## TRANSMISSION MEDIA

The DS90UB301Q and DS90UB302Q 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 connector) between the serializer and deserializer should have a differential impedance of  $100\Omega$ . The maximum length of cable that can be used is dependant 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.) and the application environment.

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. The Receiver CML Monitor Driver Output Specifications define the acceptable data eye opening width and eye opening height. A differential probe should be used to measure across the termination resistor at the CMLOUTP/N pin [Figure 2](#).

## PCB LAYOUT AND POWER SYSTEM CONSIDERATIONS

Circuit board layout and stack-up for the FPD-Link III 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  $0.01\mu F$  to  $0.1\mu F$ . Tantalum capacitors may be in the  $2.2\mu F$  to  $10\mu F$  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  $50\mu F$  to  $100\mu F$  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 or 0402, 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 20-30MHz. 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 and ground pins 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 may 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 CML lines to prevent coupling from the LVCMOS lines to the CML lines. Closely-coupled differential lines of  $100\Omega$  are typically recommended for CML 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.

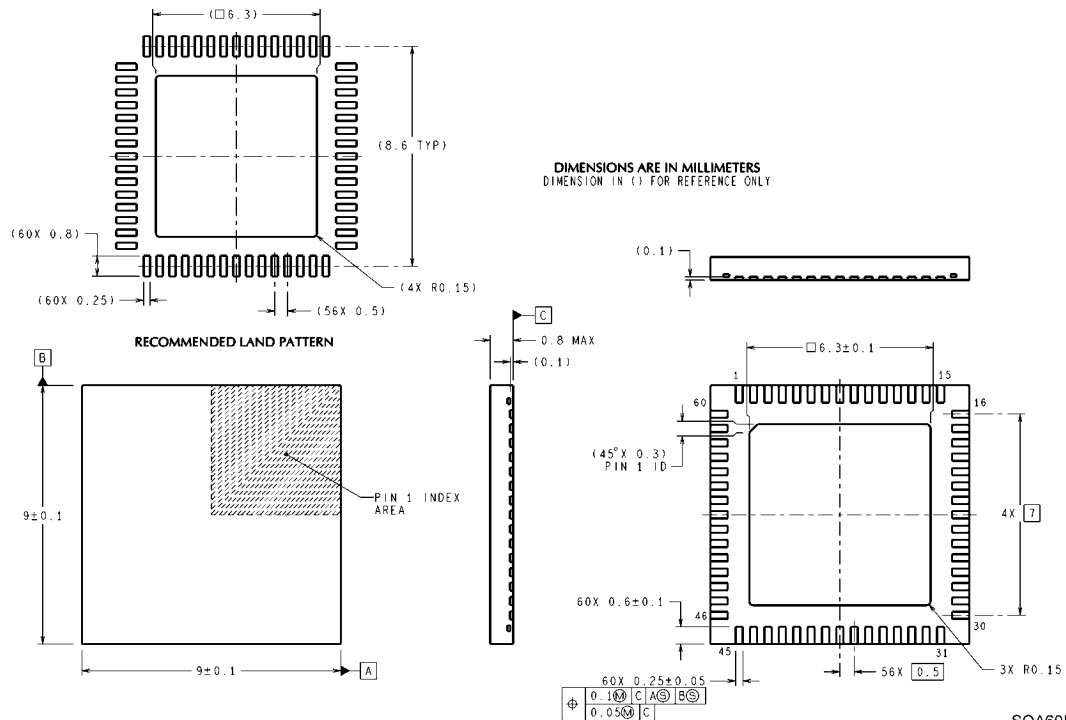
Information on the LLP style package is provided in TI Application Note: AN-1187.

## CML INTERCONNECT GUIDELINES

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

- Use  $100\Omega$  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 TI web site at: [www.ti.com/lvds](http://www.ti.com/lvds)

**Physical Dimensions** inches (millimeters) unless otherwise noted

**60-pin LLP Package (9.0 mm X 9.0 mm X 0.8 mm, 0.5 mm pitch)**  
**NS Package Number SQA60B**

SQA60B (Rev B)

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## Notes

## Notes