

- **Controlled Baseline**
  - One Assembly/Test Site, One Fabrication Site
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **21:3 Data Channel Compression at up to 1.36 Gigabits per Second Throughput**
- **Suited for Point-to-Point Subsystem Communication With Very Low EMI**
- **21 Data Channels Plus Clock in Low-Voltage TTL and 3 Data Channels Plus Clock Out Low-Voltage Differential**
- **Operates From a Single 3.3-V Supply and 250 mW (Typ)**
- **5-V Tolerant Data Inputs**
- **'LVDS95 Has Rising Clock Edge Triggered Inputs**
- **Bus Pins Tolerate 6-kV HBM ESD**
- **Packaged in Thin Shrink Small-Outline Package With 20 Mil Terminal Pitch**
- **Consumes <1 mW When Disabled**
- **Wide Phase-Lock Input Frequency Range 20 MHz to 68 MHz**
- **No External Components Required for PLL**
- **Inputs Meet or Exceed the Requirements of ANSI EIA/TIA-644 Standard**
- **Industrial Temperature Qualified**  
 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$
- **Replacement for the National DS90CR215**

DGG PACKAGE  
(TOP VIEW)

D4	1	48	D3
V <sub>CC</sub>	2	47	D2
D5	3	46	GND
D6	4	45	D1
GND	5	44	D0
D7	6	43	NC
D8	7	42	LVDSGND
V <sub>CC</sub>	8	41	Y0M
D9	9	40	Y0P
D10	10	39	Y1M
GND	11	38	Y1P
D11	12	37	LVDSV <sub>CC</sub>
D12	13	36	LVDSGND
NC	14	35	Y2M
D13	15	34	Y2P
D14	16	33	CLKOUTM
GND	17	32	CLKOUTP
D15	18	31	LVDSGND
D16	19	30	PLL <sub>GND</sub>
D17	20	29	PLL <sub>V<sub>CC</sub></sub>
V <sub>CC</sub>	21	28	PLL <sub>GND</sub>
D18	22	27	SHTDN
D19	23	26	CLKIN
GND	24	25	D20

† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

## description/ordering information

The SN65LVDS95 LVDS serdes (serializer/deserializer) transmitter contains three 7-bit parallel-load serial-out shift registers, a 7× clock synthesizer, and four low-voltage differential signaling (LVDS) line drivers in a single integrated circuit. These functions allow 21 bits of single-ended LVTTTL data to be synchronously transmitted over 4 balanced-pair conductors for receipt by a compatible receiver, such as the SN65LVDS96.

When transmitting, data bits D0 through D20 are each loaded into registers of the SN65LVDS95 on the rising edge of the input clock signal (CLKIN). The frequency of CLKIN is multiplied seven times and then used to serially unload the data registers in 7-bit slices. The three serial streams and a phase-locked clock (CLKOUT) are then output to LVDS output drivers. The frequency of CLKOUT is the same as the input clock, CLKIN.



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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# SN65LVDS95-EP

## LVDS SERDES TRANSMITTER

SGLS296A "SN65LVDS95-EP" REVISION NUMBER 2009

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### description/ordering information (continued)

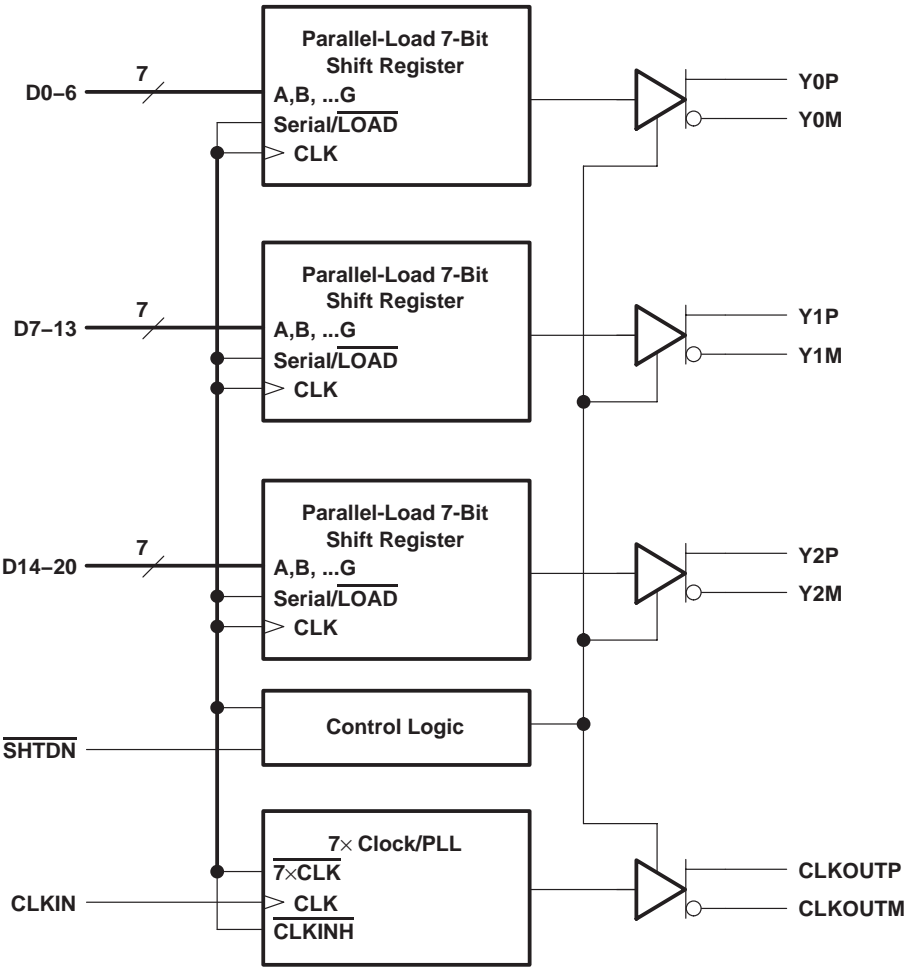
The SN65LVDS95 requires no external components and little or no control. The data bus appears the same at the input to the transmitter and output of the receiver with data transmission transparent to the user(s). The only user intervention is the possible use of the shutdown/clear ( $\overline{\text{SHTDN}}$ ) active-low input to inhibit the clock and shut off the LVDS output drivers for lower power consumption. A low level on this signal clears all internal registers to a low level.

### ORDERING INFORMATION

T <sub>A</sub>	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	TSSOP – DGG	Tape and reel	SN65LVDS95DGGREP	65LVDS95EP

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

### functional block diagram



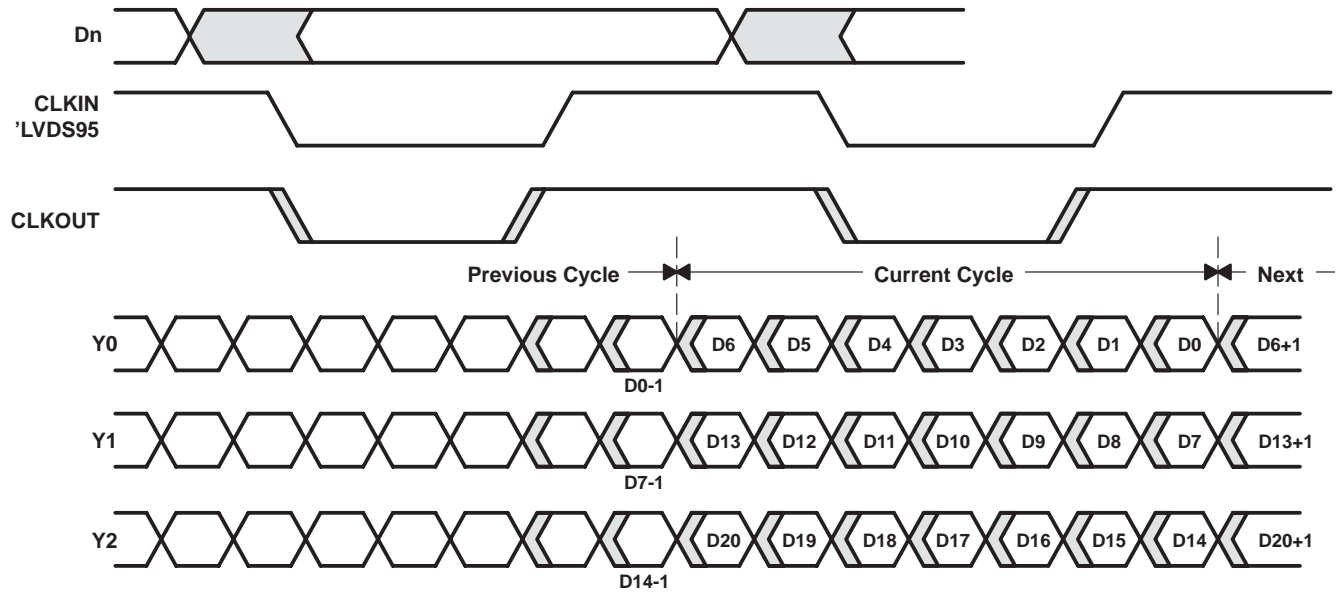
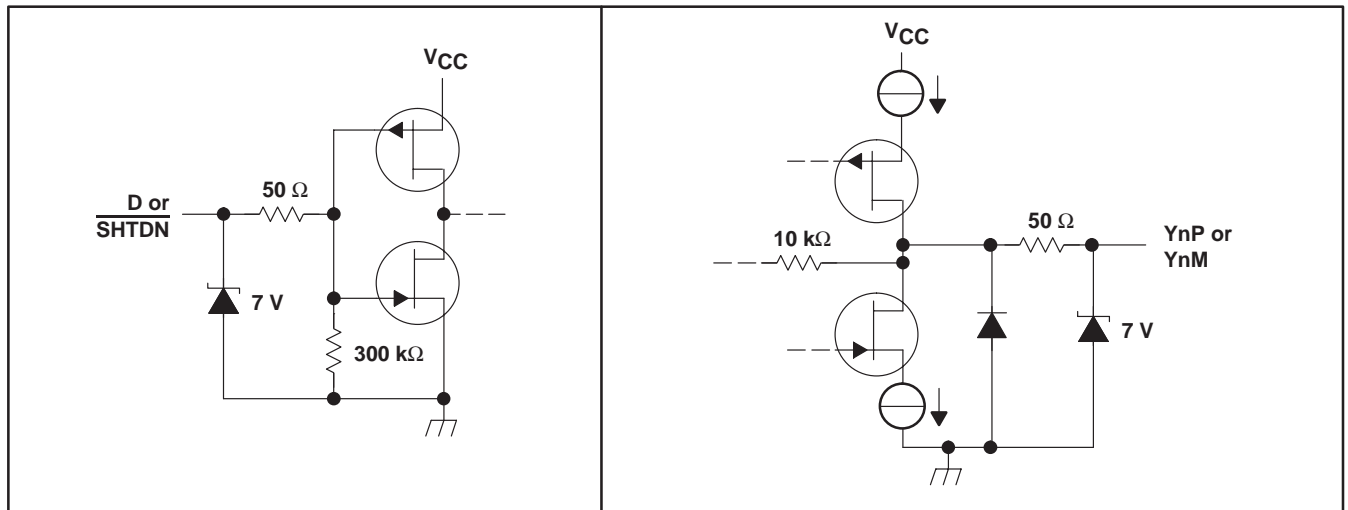


Figure 1. 'LVDS95 Load and Shift Sequences

equivalent input and output schematic diagrams



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Supply voltage range, $V_{CC}$ (see Note 1)	.....	-0.5 V to 4 V
Voltage range at any output terminal, $V_O$	.....	-0.5 V to $V_{CC} + 0.5$ V
Voltage range at any input terminal, $V_I$	.....	-0.5 V to 5.5 V
Electrostatic discharge (see Note 2):		
Bus pins (Class 3A)	.....	6 kV
Bus pins (Class 2B)	.....	400 V
All pins (Class 3A)	.....	6 kV
All pins (Class 2B)	.....	200 V
Continuous total power dissipation	.....	(see Dissipation Rating Table)
Operating free-air temperature range, $T_A$	.....	-40°C to 85°C
Storage temperature range, $T_{stg}$	.....	-65°C to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	.....	260°C

NOTES: 1. All voltage values are with respect to the GND terminals.  
2. This rating is measured using MIL-STD-883C Method, 3015.7.

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR‡ ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
DGG	1316 mW	13.1 mW/°C	724 mW	526 mW

	MIN	NOM	MAX	UNIT
Supply voltage, $V_{CC}$	3	3.3	3.6	V
High-level input voltage, $V_{IH}$	2			V
Low-level input voltage, $V_{IL}$			0.8	V
Differential load impedance, $Z_L$	90		132	$\Omega$
Operating free-air temperature, $T_A$	-40		85	$^{\circ}\text{C}$

**electrical characteristics over recommended operating conditions (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
$V_{IT}$ Input voltage threshold			1.4		V
$ V_{OD} $ Differential steady-state output voltage magnitude	$R_L = 100\ \Omega$ , See Figure 3	247		454	mV
$\Delta V_{OD} $ Change in the steady-state differential output voltage magnitude between opposite binary states				50	
$V_{OC(SS)}$ Steady-state common-mode output voltage	See Figure 3	1.125		1.375	V
$V_{OC(PP)}$ Peak-to-peak common-mode output voltage			80	150	mV
$I_{IH}$ High-level input current	$V_{IH} = V_{CC}$			20	$\mu A$
$I_{IL}$ Low-level input current	$V_{IL} = 0\ V$			$\pm 10$	$\mu A$
$I_{OS}$ Short-circuit output current	$V_{OY} = 0\ V$			$\pm 24$	mA
	$V_{OD} = 0\ V$			$\pm 12$	mA
$I_{OZ}$ High-impedance state output current	$V_O = 0\ V$ to $V_{CC}$			$\pm 10$	$\mu A$
$I_{CC(AVG)}$ Quiescent current (average)	Disabled, all inputs at GND			280	$\mu A$
	Enabled, $R_L = 100\ \Omega$ (4 places), Worst-case pattern (see Figure 4), $t_C = 15.38\ ns$		85	110	mA
$C_i$ Input capacitance			3		pF

† All typical values are  $V_{CC} = 3.3\ V$ ,  $T_A = 25^\circ C$ .

**timing requirements**

	MIN	NOM	MAX	UNIT
$t_C$ Input clock period	14.7	$t_C$	50	ns
$t_W$ High-level input clock pulse width duration	$0.4t_C$		$0.6t_C$	ns
$t_t$ Input signal transition time			5	ns
$t_{su}$ Data setup time, D0 through D27 before $CLKIN\uparrow$ ('95) (see Figure 2)	3			ns
$t_h$ Data hold time, D0 through D27 after $CLKIN\uparrow$ ('95) (see Figure 2)	1.5			ns

# SN65LVDS95-EP

## LVDS SERDES TRANSMITTER

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### switching characteristics over recommended operating conditions (unless otherwise noted)

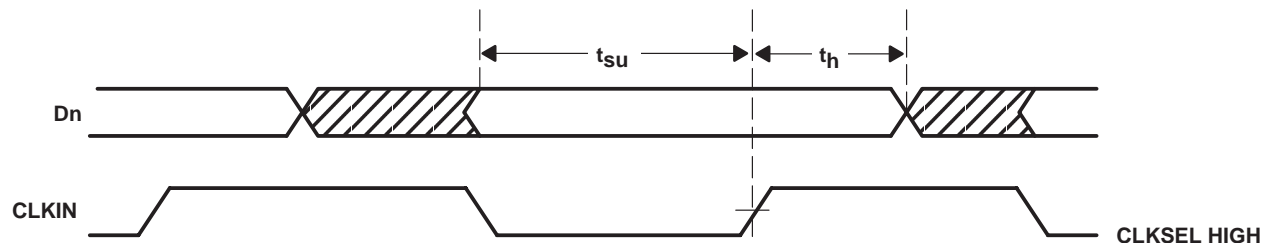
PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
$t_0$ Delay time, CLKOUT serial bit position 0	$t_C = 15.38 \text{ ns } (\pm 0.2\%),$ $ \text{Input clock jitter}  < 50 \text{ ps}^\ddagger,$ See Figure 5	-0.20	0	0.20	ns
$t_1$ Delay time, CLKOUT serial bit position 1		$1/7 t_C - 0.20$	$1/7 t_C + 0.20$		ns
$t_2$ Delay time, CLKOUT serial bit position 2		$2/7 t_C - 0.20$	$2/7 t_C + 0.20$		ns
$t_3$ Delay time, CLKOUT serial bit position 3		$3/7 t_C - 0.20$	$3/7 t_C + 0.20$		ns
$t_4$ Delay time, CLKOUT serial bit position 4		$4/7 t_C - 0.20$	$4/7 t_C + 0.20$		ns
$t_5$ Delay time, CLKOUT serial bit position 5		$5/7 t_C - 0.20$	$5/7 t_C + 0.20$		ns
$t_6$ Delay time, CLKOUT serial bit position 6		$6/7 t_C - 0.20$	$6/7 t_C + 0.20$		ns
$t_{sk(o)}$ Output skew, $t_n - n/7 t_C$		-0.20		0.20	ns
$t_7$ Delay time, CLKIN to CLKOUT	$t_C = 15.38 \text{ ns } (\pm 0.2\%),$ $ \text{Input clock jitter}  < 50 \text{ ps}^\ddagger,$ See Figure 5		4.2		ns
$\Delta t_{C(O)}$ Output clock cycle-to-cycle jitter§	$t_C = 15.38 \text{ ns } + 0.75 \sin(2\pi 500 E3 t)$ $\pm 0.05 \text{ ns},$ See Figure 6		$\pm 80$		ps
	$t_C = 15.38 \text{ ns } + 0.75 \sin(2\pi 2 E6 t)$ $\pm 0.05 \text{ ns},$ See Figure 6		$\pm 300$		ps
$t_W$ High-level output clock pulse duration			$4/7 t_C$		ns
$t_t$ Differential output voltage transition time ( $t_r$ or $t_f$ )	See Figure 3	260	700	1500	ps
$t_{en}$ Enable time, $\overline{\text{SHTDN}}$ to phase lock (Yn valid)	See Figure 7		1		ms
$t_{dis}$ Disable time, $\overline{\text{SHTDN}}$ to off-state (CLKOUT low)	See Figure 8		250		ns

† All typical values are  $V_{CC} = 3.3 \text{ V}, T_A = 25^\circ\text{C}.$

‡  $|\text{Input clock jitter}|$  is the magnitude of the change in the input clock period.

§ The output clock jitter is the change in the output clock period from one cycle to the next cycle observed over 15,000 cycles.

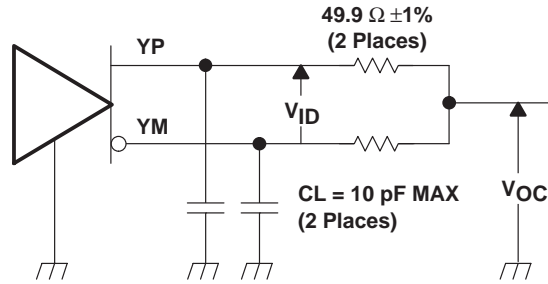
### PARAMETER MEASUREMENT INFORMATION



NOTE: All input timing is defined at 1.4 V on an input signal with a 10% to 90% rise or fall time of less than 5 ns.

Figure 2. Setup and Hold Time Definition

## PARAMETER MEASUREMENT INFORMATION



NOTE: The lumped instrumentation capacitance for any single ended voltage measurement is less than or equal to 10 pF. When making measurements at YP or YM, the complementary output shall be similarly loaded.

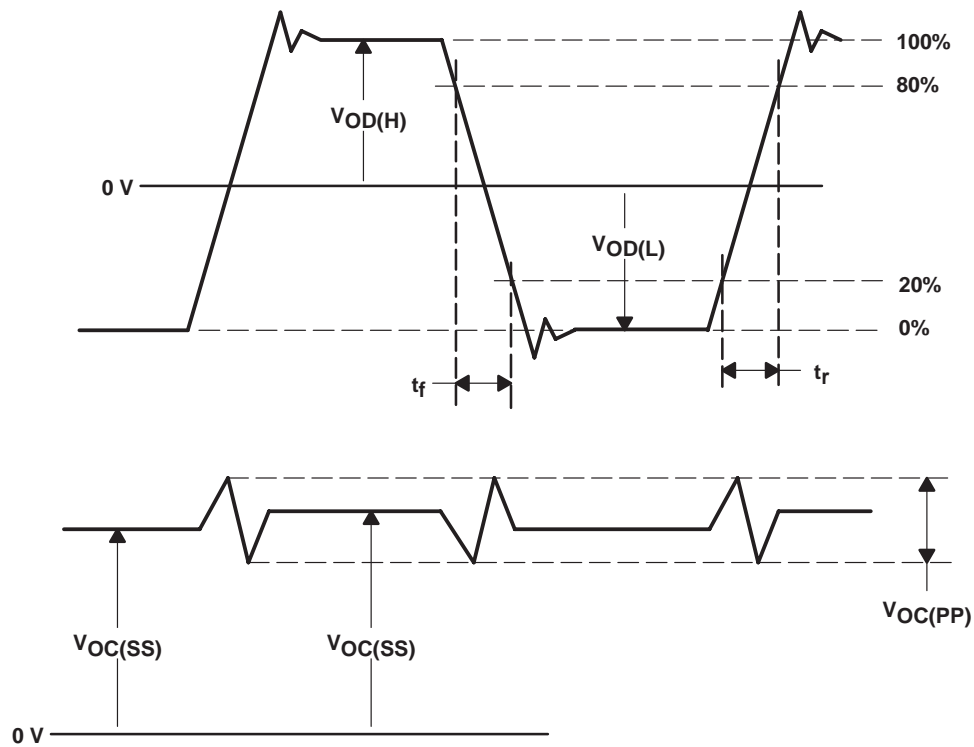


Figure 3. Test Load and Voltage Definitions for LVDS Outputs

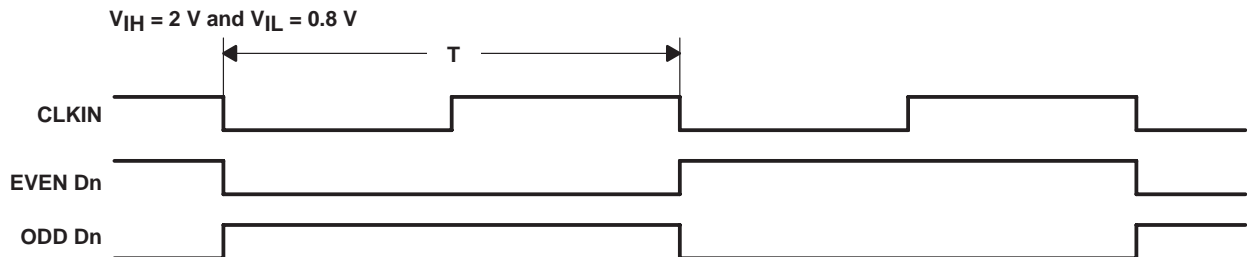


Figure 4. Worst-Case<sup>‡</sup> Power Test Pattern

<sup>‡</sup> The worst-case test pattern produces nearly the maximum switching frequency for all of the LV-TTL outputs.

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LVDS SERDES TRANSMITTER

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PARAMETER MEASUREMENT INFORMATION

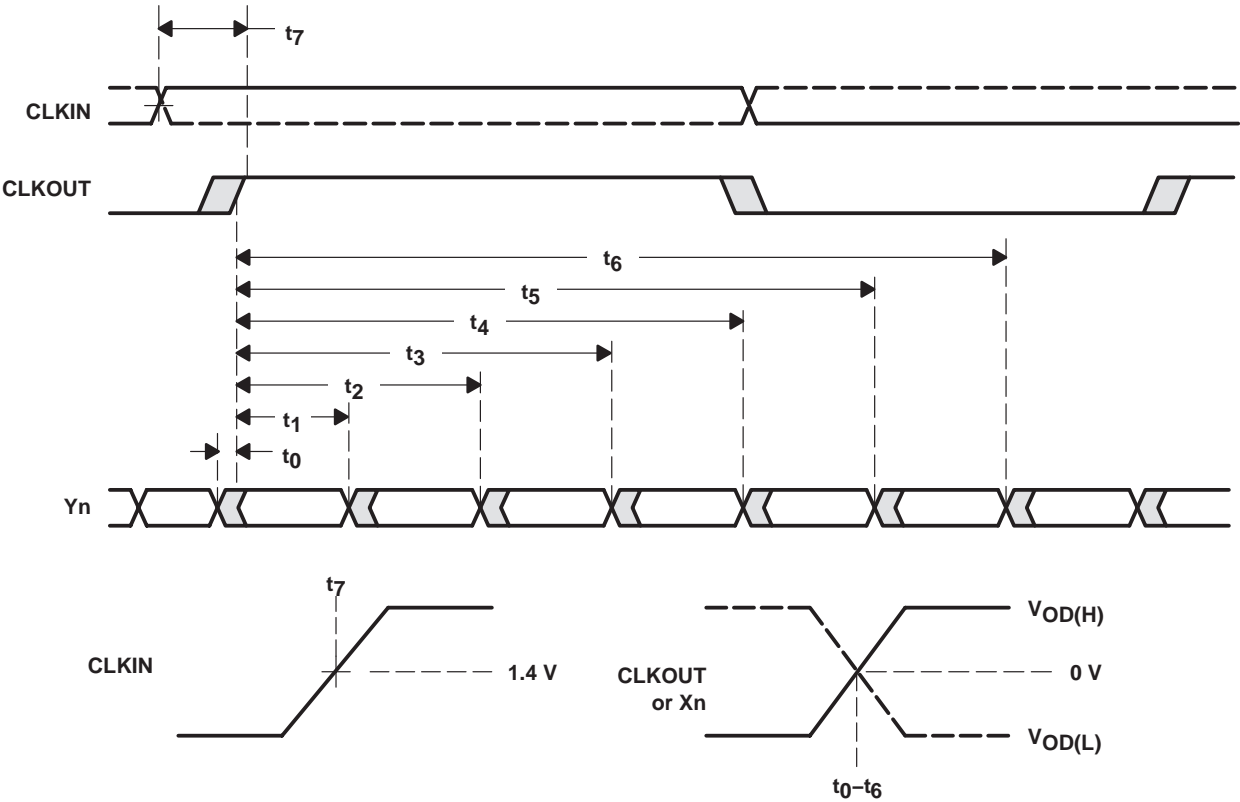


Figure 5. Timing Definitions

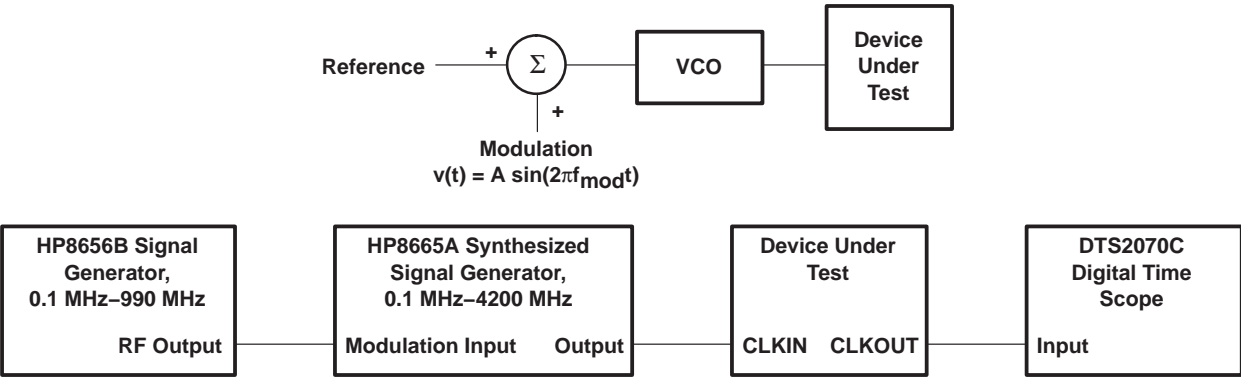


Figure 6. Clock Jitter Test Setup



## PARAMETER MEASUREMENT INFORMATION

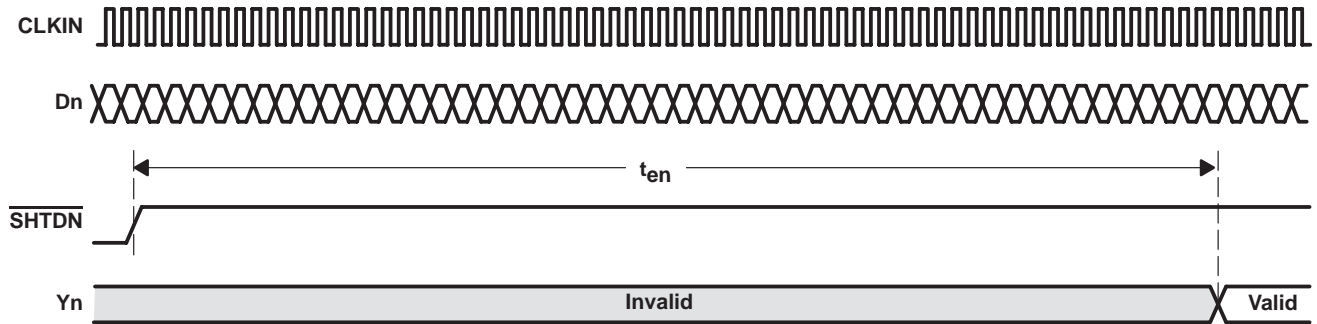


Figure 7. Enable Time Measurement Definition

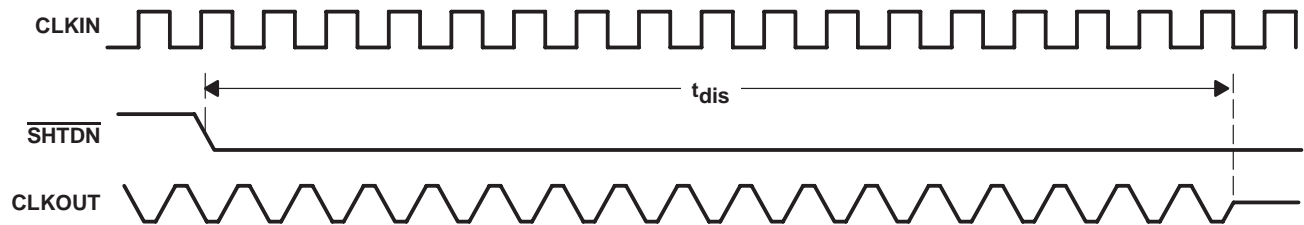


Figure 8. Disable Time Measurement Definition

## TYPICAL CHARACTERISTICS

### WORST-CASE SUPPLY CURRENT VS FREQUENCY

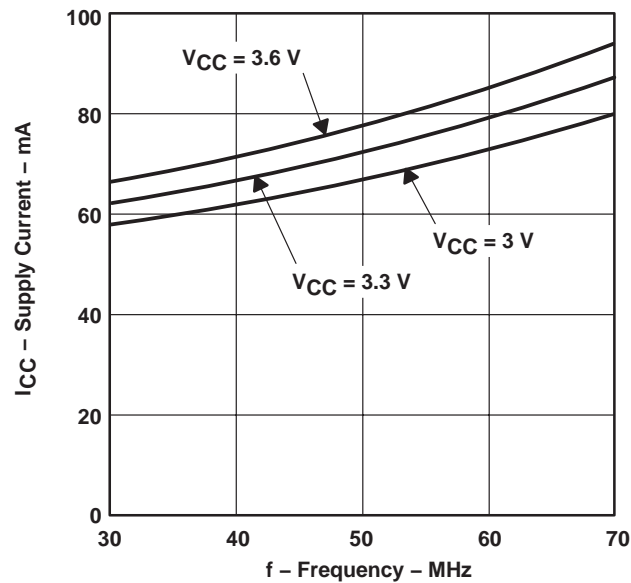


Figure 9

# SN65LVDS95-EP LVDS SERDES TRANSMITTER

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## APPLICATION INFORMATION

### 16-bit bus extension

In a 16-bit bus application (Figure 10), TTL data and clock coming from bus transceivers that interface the backplane bus arrive at the Tx parallel inputs of the LVDS serdes transmitter. The clock associated with the bus is also connected to the device. The on-chip PLL synchronizes this clock with the parallel data at the input. The data is then multiplexed into three different line drivers which perform the TTL to LVDS conversion. The clock is also converted to LVDS and presented to a separate driver. This synchronized LVDS data and clock at the receiver, which recovers the LVDS data and clock, performs a conversion back to TTL. Data is then demultiplexed into a parallel format. An on-chip PLL synchronizes the received clock with the parallel data, and then all are presented to the parallel output port of the receiver.

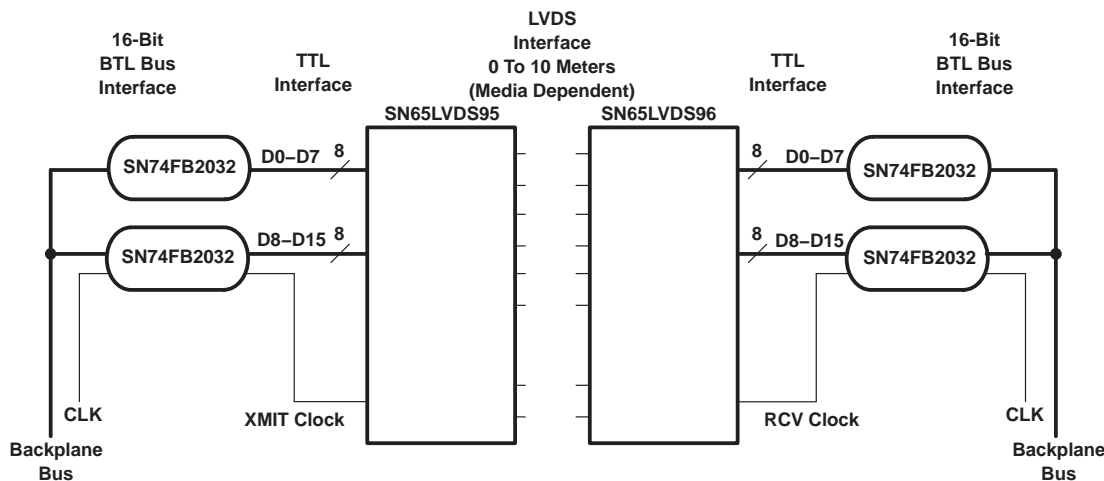


Figure 10. 16-Bit Bus Extension

### 16-bit bus extension with parity

In the previous application we did not have a checking bit that would provide assurance that the data crosses the link. If we add a parity bit to the previous example, we would have a diagram similar to the one in Figure 11. The device following the SN74FB2032 is a low cost parity generator. Each transmit-side transceiver/parity generator takes the LVTTTL data from the corresponding transceiver, performs a parity calculation over the byte, and then passes the bits with its calculated parity value on the parallel input of the LVDS serdes transmitter. Again, the on-chip PLL synchronizes this transmit clock with the eighteen parallel bits (16 data + 2 parity) at the input. The synchronized LVDS data/parity and clock arrive at the receiver.

The receiver performs the conversion from LVDS to LVTTTL and the transceiver/parity generator performs the parity calculations. These devices compare their corresponding input bytes with the value received on the parity bit. The transceiver/parity generator will assert its parity error output if a mismatch is detected.

## APPLICATION INFORMATION

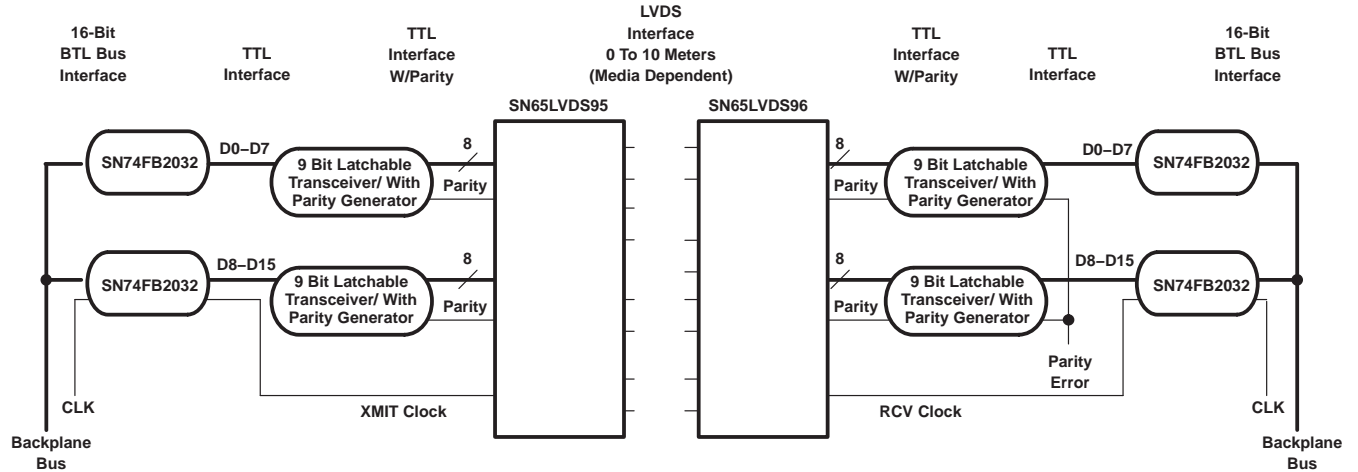


Figure 11. 16-Bit Bus Extension With Parity

### low cost virtual backplane transceiver

Figure 12 represents LVDS serdes in an application as a virtual backplane transceiver (VBT). The concept of a VBT can be achieved by implementing individual LVDS serdes chipsets in both directions of subsystem serialized links.

Depending on the application, the designer will face varying choices when implementing a VBT. In addition to the devices shown in Figure 12, functions such as parity and delay lines for control signals could be included. Using additional circuitry, half-duplex or full-duplex operation can be achieved by configuring the clock and control lines properly.

The designer may choose to implement an independent clock oscillator at each end of the link and then use a PLL to synchronize LVDS serdes's parallel I/O to the backplane bus. Resynchronizing FIFOs may also be required.

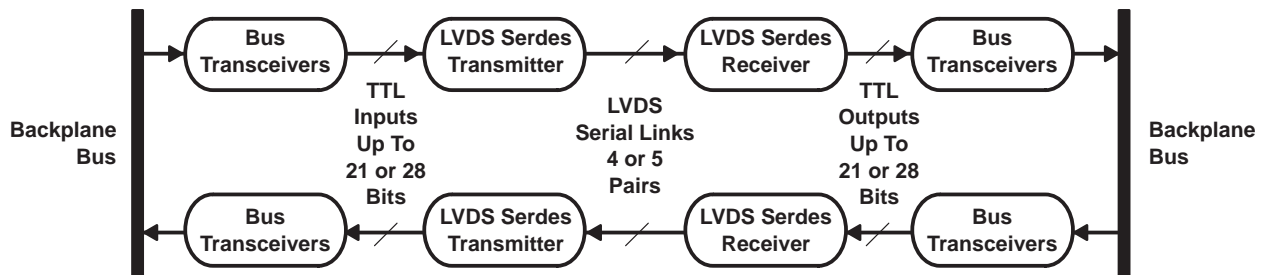


Figure 12. Virtual Backplane Transceiver

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
SN65LVDS95DGGREP	ACTIVE	TSSOP	DGG	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
V62/04643-01XE	ACTIVE	TSSOP	DGG	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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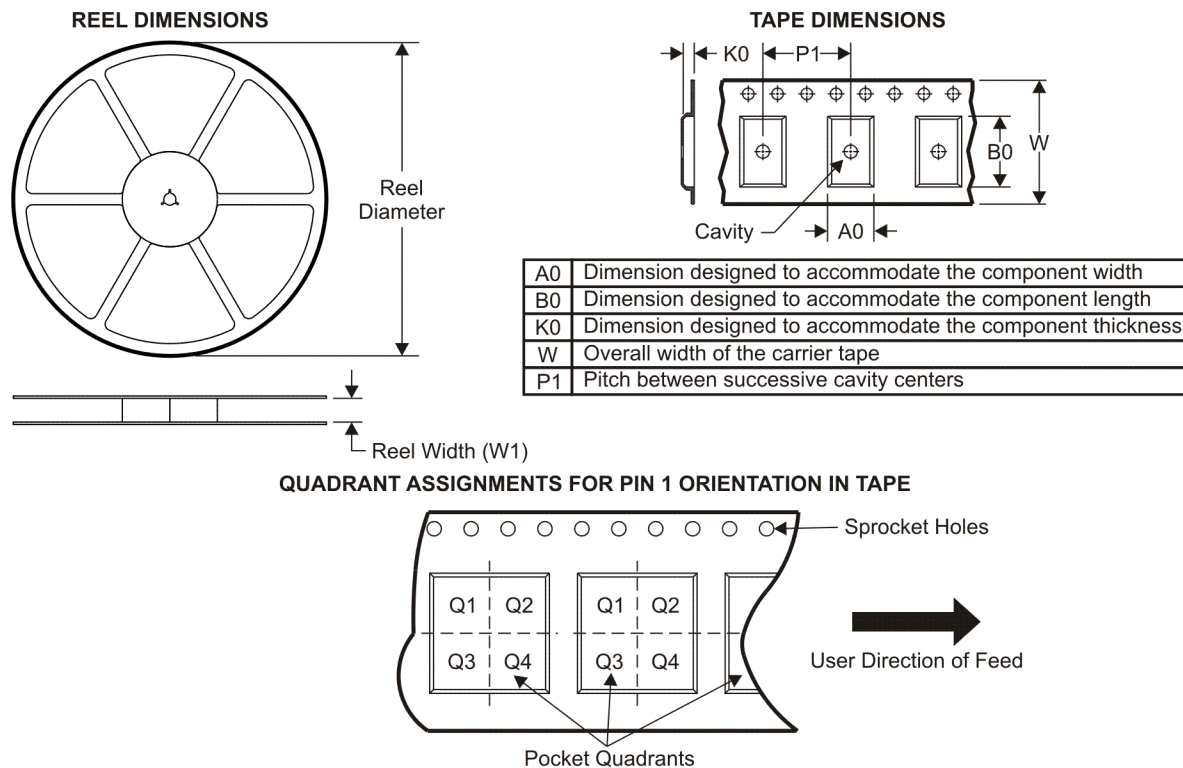
### OTHER QUALIFIED VERSIONS OF SN65LVDS95-EP :

- Catalog: [SN65LVDS95](#)
- Automotive: [SN65LVDS95-Q1](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN65LVDS95DGGREP	TSSOP	DGG	48	2000	330.0	24.4	8.6	15.8	1.8	12.0	24.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVDS95DGGREP	TSSOP	DGG	48	2000	346.0	346.0	41.0

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DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
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Logic	<a href="http://logic.ti.com">logic.ti.com</a>
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