



## 2.5V SINGLE DATA RATE 1:5 CLOCK BUFFER

**IDT5T905**  
**ADVANCED**  
**INFORMATION**

### FEATURES:

- Guaranteed Low Skew < 25ps (typ)
- Very low duty cycle distortion < 300ps (max)
- High speed propagation delay < 2.5ns. (max)
- Up to 250MHz operation
- Very low CMOS power levels
- 1.5V V<sub>DDQ</sub> for HSTL interface
- Hot insertable and over-voltage tolerant inputs
- 3-level inputs for selectable interface
- Selectable HSTL, eHSTL, 1.8V / 2.5V LVTTTL, or LVEPECL input interface
- Selectable differential or single-ended inputs and five single-ended outputs
- 2.5V V<sub>DD</sub>
- Available in TSSOP package

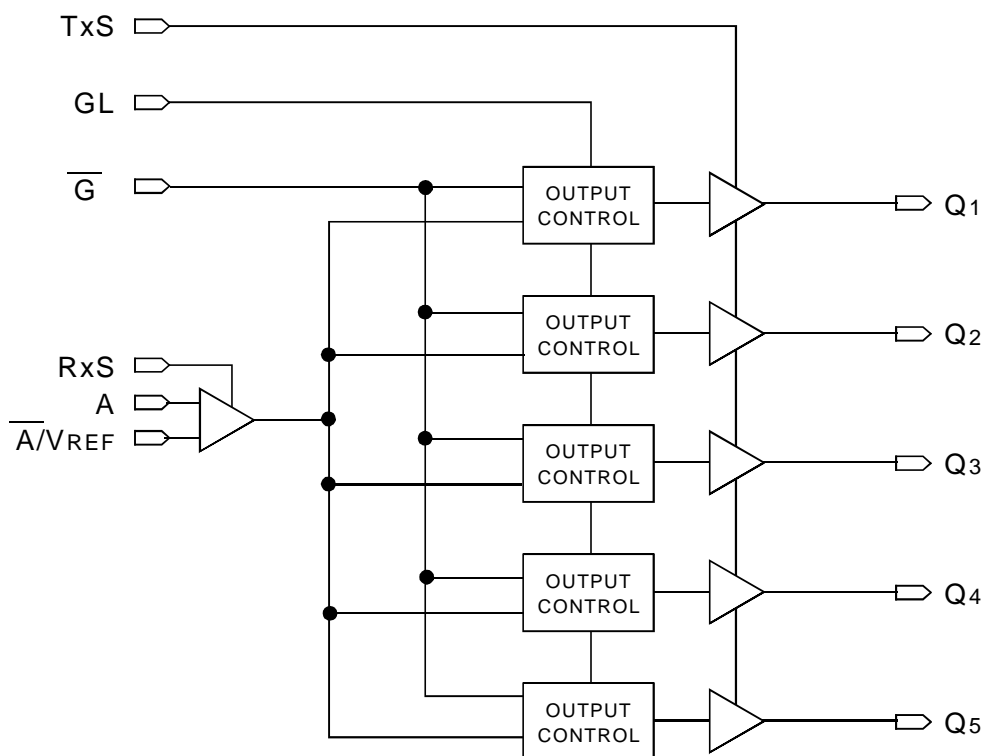
### APPLICATIONS:

- Clock and signal distribution

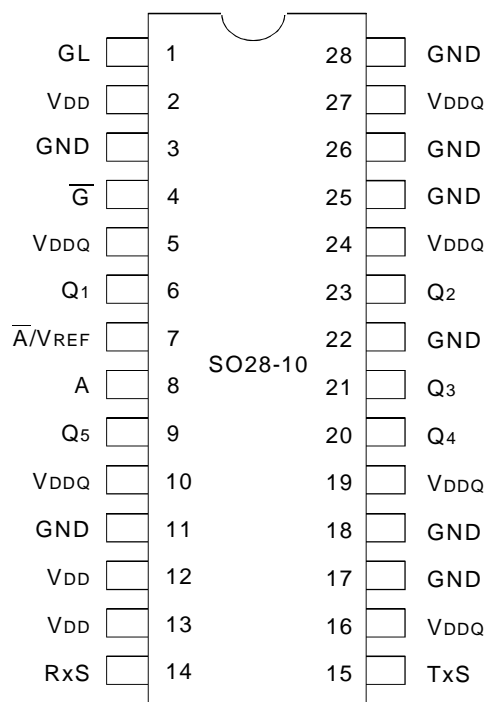
### DESCRIPTION:

The IDT5T905 2.5V single data rate (SDR) clock buffer is a user-selectable single-ended or differential input to five single-ended outputs buffer built on advanced metal CMOS technology. The SDR clock buffer fanout from a single or differential input to five single-ended outputs reduces the loading on the preceding driver and provides an efficient clock distribution network. The IDT5T905 can act as a translator from a differential HSTL, eHSTL, 1.8V/2.5V LVTTTL, LVEPECL, or single-ended 1.8V/2.5V LVTTTL input to HSTL, eHSTL, 1.8V/2.5V LVTTTL outputs. Selectable interface is controlled by 3-level input signals that may be hard-wired to appropriate high-mid-low levels. Multiple power and grounds reduce noise.

### FUNCTIONAL BLOCK DIAGRAM



## PIN CONFIGURATION



TSSOP  
TOP VIEW

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Symbol	Description	Max	Unit
V <sub>DD</sub>	Power Supply Voltage	-0.5 to +3.6	V
V <sub>DDQ</sub>	Output Power Supply <sup>(2)</sup>	-0.5 to +3.6	V
V <sub>I</sub>	Input Voltage	-0.5 to +3.6	V
V <sub>O</sub>	Output Voltage <sup>(3)</sup>	-0.5 to V <sub>DDQ</sub> + 0.5	V
V <sub>REF</sub>	Reference Voltage <sup>(3)</sup>	-0.5 to +3.6	V
T <sub>STG</sub>	Storage Temperature	-65 to +165	°C
T <sub>J</sub>	Junction Temperature	150	°C

### NOTES:

- Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
- V<sub>DDQ</sub> and V<sub>DD</sub> operate independently. No power sequencing requirements need to be met.
- Not to exceed 3.6V.

## CAPACITANCE<sup>(1)</sup> (T<sub>A</sub> = +25°C, F = 1.0MHz)

Symbol	Parameter	Min	Typ.	Max.	Unit
C <sub>IN</sub>	Input Capacitance	—	6	—	pF

### NOTE:

- This parameter is measured at characterization but not tested.

## RECOMMENDED OPERATING RANGE

Symbol	Description	Min.	Typ.	Max.	Unit
T <sub>A</sub>	Ambient Operating Temperature	-40	+25	+85	°C
V <sub>DD</sub>	Internal Power Supply Voltage	2.3	2.5	2.7	V
V <sub>DDQ</sub>	HSTL Output Power Supply Voltage	1.4	1.5	1.6	V
	Extended HSTL and 1.8V LVTTTL Output Power Supply Voltage	1.65	1.8	1.95	V
	2.5V LVTTTL Output Power Supply Voltage		V <sub>DD</sub>		V
V <sub>T</sub>	Termination Voltage		V <sub>DDQ</sub> / 2		V

## PIN DESCRIPTION

Symbol	I/O	Type	Description
A	I	Adjustable <sup>(1)</sup>	Clock input. A is the "true" side of the differential clock input. If operating in single-ended mode, A is the clock input.
$\bar{A}/V_{REF}$	I	Adjustable <sup>(1)</sup>	Complementary clock input. $\bar{A}/V_{REF}$ is the "complementary" side of A if the input is in differential mode. If operating in single-ended mode, $\bar{A}/V_{REF}$ is connected to GND. For single-ended operation in differential mode, $\bar{A}/V_{REF}$ should be set to the desired toggle voltage for A: <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div>2.5V LVTTTL</div> <div><math>V_{REF} = 1250mV</math></div> </div> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div>1.8V LVTTTL, eHSTL</div> <div><math>V_{REF} = 900mV</math></div> </div> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div>HSTL</div> <div><math>V_{REF} = 750mV</math></div> </div> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div>LVEPECL</div> <div><math>V_{REF} = 1082mV</math></div> </div>
$\bar{G}$	I	LVTTTL	Gate control for Qn outputs. When $\bar{G}$ is LOW, these outputs are enabled. When $\bar{G}$ is HIGH, these outputs are asynchronously disabled to the level designated by GL <sup>(4)</sup> .
GL	I	LVTTTL	Specifies output disable level. If HIGH, the outputs disable HIGH. If LOW, the outputs disable LOW.
Qn	O	Adjustable <sup>(2)</sup>	Clock outputs
RxS	I	3 Level <sup>(3)</sup>	Selects single-ended 2.5V LVTTTL (HIGH), 1.8V LVTTTL (MID) clock input or differential (LOW) clock input
TxS	I	3 Level <sup>(3)</sup>	Sets the drive strength of the output drivers to be 2.5V LVTTTL (HIGH), 1.8V LVTTTL (MID) or HSTL (LOW) compatible. Used in conjunction with VDDQ to set the interface levels.
VDD		PWR	Power supply for the device core and inputs
VDDQ		PWR	Power supply for the device outputs. When utilizing 2.5V LVTTTL outputs, VDDQ should be connected to VDD.
GND		PWR	Power supply return for all power

### NOTES:

- Inputs are capable of translating the following interface standards. User can select between:  
 Single-ended 2.5V LVTTTL levels  
 Single-ended 1.8V LVTTTL levels  
 or  
 Differential 2.5V/1.8V LVTTTL levels  
 Differential HSTL and eHSTL levels  
 Differential LVEPECL levels
- Outputs are user selectable to drive 2.5V, 1.8V LVTTTL, eHSTL, or HSTL interface levels when used with the appropriate VDDQ voltage.
- 3 level inputs are static inputs and must be tied to VDD or GND or left floating. These inputs are not hot-insertable or over-voltage tolerant.
- Because the gate controls are asynchronous, runt pulses are possible. It is the user's responsibility to either time the gate control signals to minimize the possibility of runt pulses or be able to tolerate them in down stream circuitry.

## INPUT/OUTPUT SELECTION<sup>(1)</sup>

Input	Output	Input	Output
2.5V LVTTTL SE	2.5V LVTTTL	2.5V LVTTTL SE	eHSTL
1.8V LVTTTL SE		1.8V LVTTTL SE	
2.5V LVTTTL DSE		2.5V LVTTTL DSE	
1.8V LVTTTL DSE		1.8V LVTTTL DSE	
LVEPECL DSE		LVEPECL DSE	
eHSTL DSE		eHSTL DSE	
HSTL DSE		HSTL DSE	
2.5V LVTTTL DIF		2.5V LVTTTL DIF	
1.8V LVTTTL DIF		1.8V LVTTTL DIF	
LVEPECL DIF		LVEPECL DIF	
eHSTL DIF		eHSTL DIF	
HSTL DIF		HSTL DIF	
2.5V LVTTTL SE	1.8V LVTTTL	2.5V LVTTTL SE	HSTL
1.8V LVTTTL SE		1.8V LVTTTL SE	
2.5V LVTTTL DSE		2.5V LVTTTL DSE	
1.8V LVTTTL DSE		1.8V LVTTTL DSE	
LVEPECL DSE		LVEPECL DSE	
eHSTL DSE		eHSTL DSE	
HSTL DSE		HSTL DSE	
2.5V LVTTTL DIF		2.5V LVTTTL DIF	
1.8V LVTTTL DIF		1.8V LVTTTL DIF	
LVEPECL DIF		LVEPECL DIF	
eHSTL DIF		eHSTL DIF	
HSTL DIF		HSTL DIF	

### NOTE:

- The INPUT/OUTPUT SELECTION Table describes the total possible combinations of input and output interfaces. Single-Ended (SE) inputs in a single-ended mode require the  $\bar{A}/V_{REF}$  pin to be connected to GND. Differential Single-Ended (DSE) is for single-ended operation in differential mode, requiring a  $V_{REF}$ . Differential (DIF) inputs are used only in differential mode.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE

Symbol	Parameter	Test Conditions		Min.	Max	Unit
$V_{IHH}$	Input HIGH Voltage Level <sup>(1)</sup>	3-Level Inputs Only		$V_{DD} - 0.6$	—	V
$V_{IMM}$	Input MID Voltage Level <sup>(1)</sup>	3-Level Inputs Only		$V_{DD}/2 - 0.3$	$V_{DD}/2 + 0.3$	V
$V_{ILL}$	Input LOW Voltage Level <sup>(1)</sup>	3-Level Inputs Only		—	0.6	V
$I_3$	3-Level Input DC Current (RxS, TxS)	$V_{IN} = V_{DD}$	HIGH Level	—	200	$\mu A$
		$V_{IN} = V_{DD}/2$	MID Level	-50	+50	
		$V_{IN} = GND$	LOW Level	-200	—	

### NOTE:

- These inputs are normally wired to  $V_{DD}$ , GND, or left floating.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE FOR HSTL<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Min.	Typ. <sup>(7)</sup>	Max	Unit
<b>Input Characteristics</b>						
I <sub>IH</sub>	Input HIGH Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = V <sub>DDQ</sub> /GND	—	—	±5	μA
I <sub>IL</sub>	Input LOW Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = GND/V <sub>DDQ</sub>	—	—	±5	μA
V <sub>IK</sub>	Clamp Diode Voltage	V <sub>DD</sub> = 2.3V, I <sub>IN</sub> = -18mA	—	-0.7	-1.2	V
V <sub>IN</sub>	DC Input Voltage		-0.3		+3.6	V
V <sub>DIF</sub>	DC Differential Voltage <sup>(2,8)</sup>		0.2		—	V
V <sub>CM</sub>	DC Common Mode Input Voltage <sup>(3,8)</sup>		680	750	900	mV
V <sub>IH</sub>	DC Input HIGH <sup>(4,5,8)</sup>		V <sub>REF</sub> + 100		—	mV
V <sub>IL</sub>	DC Input LOW <sup>(4,6,8)</sup>		—		V <sub>REF</sub> - 100	mV
V <sub>REF</sub>	Single-Ended Reference Voltage <sup>(4,8)</sup>		—	750	—	mV
<b>Output Characteristics</b>						
V <sub>OH</sub>	Output HIGH Voltage	I <sub>OH</sub> = -8mA	V <sub>DDQ</sub> - 0.4		—	V
		I <sub>OH</sub> = -100μA	V <sub>DDQ</sub> - 0.1		—	V
V <sub>OL</sub>	Output LOW Voltage	I <sub>OL</sub> = 8mA	—		0.4	V
		I <sub>OL</sub> = 100μA	—		0.1	V

### NOTES:

- See RECOMMENDED OPERATING RANGE table.
- V<sub>DIF</sub> specifies the minimum input differential voltage (V<sub>TR</sub> - V<sub>CP</sub>) required for switching where V<sub>TR</sub> is the "true" input level and V<sub>CP</sub> is the "complement" input level. Differential mode only. The DC differential voltage must be maintained to guarantee retaining the existing HIGH or LOW input. The AC differential voltage must be achieved to guarantee switching to a new state.
- V<sub>CM</sub> specifies the maximum allowable range of (V<sub>TR</sub> + V<sub>CP</sub>) / 2. Differential mode only.
- For single-ended operation, in differential mode,  $\bar{A}/V_{REF}$  is tied to the DC voltage V<sub>REF</sub>.
- Voltage required to maintain a logic HIGH, single-ended operation in differential mode.
- Voltage required to maintain a logic LOW, single-ended operation in differential mode.
- Typical values are at V<sub>DD</sub> = 2.5V, V<sub>DDQ</sub> = 1.5V, +25°C ambient.
- The reference clock input is capable of HSTL, eHSTL, LVEPECL, 1.8V or 2.5V LVTTTL operation independent of the device output. The correct input interface table should be referenced.

## POWER SUPPLY CHARACTERISTICS FOR HSTL OUTPUTS<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Typ.	Max	Unit
I <sub>DDQ</sub>	Quiescent V <sub>DD</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDQQ</sub>	Quiescent V <sub>DDQ</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDD</sub>	Dynamic V <sub>DD</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>DDQD</sub>	Dynamic V <sub>DDQ</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>TOT</sub>	Total Power V <sub>DD</sub> Supply Current	V <sub>DDQ</sub> = 1.5V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.5V, F <sub>REFERENCE CLOCK</sub> = 250MHz, C <sub>L</sub> = 15pF	—	—	
I <sub>TOTQ</sub>	Total Power V <sub>DDQ</sub> Supply Current	V <sub>DDQ</sub> = 1.5V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.5V, F <sub>REFERENCE CLOCK</sub> = 250MHz, C <sub>L</sub> = 15pF	—	—	

### NOTES:

- These power consumption characteristics are for all the valid input interfaces and cover the worst case input and output interface combinations.
- If the differential input interface is used, the true input is held LOW and the complementary input is held HIGH.

## DIFFERENTIAL INPUT AC TEST CONDITIONS FOR HSTL

Symbol	Parameter	Value	Units
V <sub>DIF</sub>	Input Signal Swing <sup>(1)</sup>	1	V
V <sub>X</sub>	Differential Input Signal Crossing Point <sup>(2)</sup>	750	mV
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
t <sub>r</sub> , t <sub>f</sub>	Input Signal Edge Rate <sup>(4)</sup>	1	V/ns

### NOTES:

1. The 1V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>DIF</sub> (AC) specification under actual use conditions.
2. A 750mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>X</sub> specification under actual use conditions.
3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.
4. The input signal edge rate of 1V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE FOR eHSTL<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Min.	Typ. <sup>(7)</sup>	Max	Unit
<b>Input Characteristics</b>						
I <sub>IH</sub>	Input HIGH Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = V <sub>DDQ</sub> /GND	—	—	±5	μA
I <sub>IL</sub>	Input LOW Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = GND/V <sub>DDQ</sub>	—	—	±5	
V <sub>IK</sub>	Clamp Diode Voltage	V <sub>DD</sub> = 2.3V, I <sub>IN</sub> = -18mA	—	-0.7	-1.2	V
V <sub>IN</sub>	DC Input Voltage		-0.3		+3.6	V
V <sub>DIF</sub>	DC Differential Voltage <sup>(2,8)</sup>		0.2		—	V
V <sub>CM</sub>	DC Common Mode Input Voltage <sup>(3,8)</sup>		800	900	1000	mV
V <sub>IH</sub>	DC Input HIGH <sup>(4,5,8)</sup>		V <sub>REF</sub> + 100		—	mV
V <sub>IL</sub>	DC Input LOW <sup>(4,6,8)</sup>		—		V <sub>REF</sub> - 100	mV
V <sub>REF</sub>	Single-Ended Reference Voltage <sup>(4,8)</sup>		—	900	—	mV
<b>Output Characteristics</b>						
V <sub>OH</sub>	Output HIGH Voltage	I <sub>OH</sub> = -8mA	V <sub>DDQ</sub> - 0.4		—	V
		I <sub>OH</sub> = -100μA	V <sub>DDQ</sub> - 0.1		—	V
V <sub>OL</sub>	Output LOW Voltage	I <sub>OL</sub> = 8mA	—		0.4	V
		I <sub>OL</sub> = 100μA	—		0.1	V

### NOTES:

1. See RECOMMENDED OPERATING RANGE table.
2. V<sub>DIF</sub> specifies the minimum input differential voltage (V<sub>TR</sub> - V<sub>CP</sub>) required for switching where V<sub>TR</sub> is the "true" input level and V<sub>CP</sub> is the "complement" input level. Differential mode only. The DC differential voltage must be maintained to guarantee retaining the existing HIGH or LOW input. The AC differential voltage must be achieved to guarantee switching to a new state.
3. V<sub>CM</sub> specifies the maximum allowable range of (V<sub>TR</sub> + V<sub>CP</sub>) / 2. Differential mode only.
4. For single-ended operation, in a differential mode,  $\bar{A}/V_{REF}$  is tied to the DC voltage V<sub>REF</sub>.
5. Voltage required to maintain a logic HIGH, single-ended operation in differential mode.
6. Voltage required to maintain a logic LOW, single-ended operation in differential mode.
7. Typical values are at V<sub>DD</sub> = 2.5V, V<sub>DDQ</sub> = 1.8V, +25°C ambient.
8. The reference clock input is capable of HSTL, eHSTL, LVEPECL, 1.8V or 2.5V LVTTTL operation independent of the device output. The correct input interface table should be referenced.

## POWER SUPPLY CHARACTERISTICS FOR eHSTL OUTPUTS<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Typ.	Max	Unit
I <sub>DDQ</sub>	Quiescent V <sub>DD</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDOQ</sub>	Quiescent V <sub>DDO</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDD</sub>	Dynamic V <sub>DD</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>DDOQ</sub>	Dynamic V <sub>DDO</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>TOT</sub>	Total Power V <sub>DD</sub> Supply Current	V <sub>DDQ</sub> = 1.8V, REFERENCE CLOCK = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.8V, REFERENCE CLOCK = 250MHz, C <sub>L</sub> = 15pF	—	—	
I <sub>TOQ</sub>	Total Power V <sub>DDO</sub> Supply Current	V <sub>DDQ</sub> = 1.8V, REFERENCE CLOCK = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.8V, REFERENCE CLOCK = 250MHz, C <sub>L</sub> = 15pF	—	—	

### NOTES:

- These power consumption characteristics are for all the valid input interfaces and cover the worst case input and output interface combinations.
- If the differential input interface is used, the true input is held LOW and the complementary input is held HIGH.

## DIFFERENTIAL INPUT AC TEST CONDITIONS FOR eHSTL

Symbol	Parameter	Value	Units
V <sub>DIF</sub>	Input Signal Swing <sup>(1)</sup>	1	V
V <sub>X</sub>	Differential Input Signal Crossing Point <sup>(2)</sup>	900	mV
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
t <sub>R</sub> , t <sub>F</sub>	Input Signal Edge Rate <sup>(4)</sup>	1	V/ns

### NOTES:

- The 1V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>DIF</sub> (AC) specification under actual use conditions.
- A 900mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>X</sub> specification under actual use conditions.
- In all cases, input waveform timing is marked at the differential cross-point of the input signals.
- The input signal edge rate of 1V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE FOR LVEPECL<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Min.	Typ. <sup>(2)</sup>	Max	Unit
<b>Input Characteristics</b>						
I <sub>IH</sub>	Input HIGH Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = V <sub>DDQ</sub> /GND	—	—	±5	μA
I <sub>IL</sub>	Input LOW Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = GND/V <sub>DDQ</sub>	—	—	±5	
V <sub>IK</sub>	Clamp Diode Voltage	V <sub>DD</sub> = 2.3V, I <sub>IN</sub> = -18mA	—	-0.7	-1.2	V
V <sub>IN</sub>	DC Input Voltage		-0.3	—	3.6	V
V <sub>CM</sub>	DC Common Mode Input Voltage <sup>(3,5)</sup>		915	1082	1248	mV
V <sub>REF</sub>	Single-Ended Reference Voltage <sup>(4,5)</sup>		—	1082	—	mV
V <sub>IH</sub>	DC Input HIGH		1275	—	1620	mV
V <sub>IL</sub>	DC Input LOW		555	—	875	mV

### NOTES:

- See RECOMMENDED OPERATING RANGE table.
- Typical values are at V<sub>DD</sub> = 2.5V, +25°C ambient.
- V<sub>CM</sub> specifies the maximum allowable range of (V<sub>TR</sub> + V<sub>CP</sub>) / 2. Differential mode only.
- For single-ended operation while in differential mode,  $\bar{A}/V_{REF}$  is tied to the DC voltage V<sub>REF</sub>.
- The reference clock input is capable of HSTL, eHSTL, LVEPECL, 1.8V or 2.5V LVTTTL operation independent of the device output. The correct input interface table should be referenced.

## DIFFERENTIAL INPUT AC TEST CONDITIONS FOR LVEPECL

Symbol	Parameter	Value	Units
$V_{DIF}$	Input Signal Swing <sup>(1)</sup>	732	mV
$V_X$	Differential Input Signal Crossing Point <sup>(2)</sup>	1082	mV
$V_{THI}$	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
$t_R, t_F$	Input Signal Edge Rate <sup>(4)</sup>	1	V/ns

### NOTES:

1. The 732mV peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the  $V_{DIF}$  (AC) specification under actual use conditions.
2. A 1082mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the  $V_X$  specification under actual use conditions.
3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.
4. The input signal edge rate of 1V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE FOR 2.5V LVTTTL<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Min.	Typ. <sup>(8)</sup>	Max	Unit
<b>Input Characteristics</b>						
$I_{IH}$	Input HIGH Current	$V_{DD} = 2.7V$ $V_I = V_{DDQ}/GND$	—	—	$\pm 5$	$\mu A$
$I_{IL}$	Input LOW Current	$V_{DD} = 2.7V$ $V_I = GND/V_{DDQ}$	—	—	$\pm 5$	
$V_{IK}$	Clamp Diode Voltage	$V_{DD} = 2.3V$ , $I_{IN} = -18mA$	—	-0.7	-1.2	V
$V_{IN}$	DC Input Voltage		-0.3		+3.6	V
<b>Single-Ended Inputs<sup>(2)</sup></b>						
$V_{IH}$	DC Input HIGH		1.7		—	V
$V_{IL}$	DC Input LOW		—		0.7	V
<b>Differential Inputs</b>						
$V_{DIF}$	DC Differential Voltage <sup>(3,9)</sup>		0.2		—	V
$V_{CM}$	DC Common Mode Input Voltage <sup>(4,9)</sup>		1150	1250	1350	mV
$V_{IH}$	DC Input HIGH <sup>(5,6,9)</sup>		$V_{REF} + 100$		—	mV
$V_{IL}$	DC Input LOW <sup>(5,7,9)</sup>		—		$V_{REF} - 100$	mV
$V_{REF}$	Single-Ended Reference Voltage <sup>(5,9)</sup>		—	1250	—	mV
<b>Output Characteristics</b>						
$V_{OH}$	Output HIGH Voltage	$I_{OH} = -12mA$	$V_{DDQ} - 0.4$		—	V
		$I_{OH} = -100\mu A$	$V_{DDQ} - 0.1$		—	V
$V_{OL}$	Output LOW Voltage	$I_{OL} = 12mA$	—		0.4	V
		$I_{OL} = 100\mu A$	—		0.1	V

### NOTES:

1. See RECOMMENDED OPERATING RANGE table.
2. For 2.5V LVTTTL single-ended operation, the  $RxS$  pin is tied HIGH and  $\bar{A}/V_{REF}$  is tied to GND.
3.  $V_{DIF}$  specifies the minimum input differential voltage ( $V_{TR} - V_{CP}$ ) required for switching where  $V_{TR}$  is the "true" input level and  $V_{CP}$  is the "complement" input level. Differential mode only. The DC differential voltage must be maintained to guarantee retaining the existing HIGH or LOW input. The AC differential voltage must be achieved to guarantee switching to a new state.
4.  $V_{CM}$  specifies the maximum allowable range of  $(V_{TR} + V_{CP}) / 2$ . Differential mode only.
5. For single-ended operation, in differential mode,  $\bar{A}/V_{REF}$  is tied to the DC voltage  $V_{REF}$ .
6. Voltage required to maintain a logic HIGH, single-ended operation in differential mode.
7. Voltage required to maintain a logic LOW, single-ended operation in differential mode.
8. Typical values are at  $V_{DD} = 2.5V$ ,  $V_{DDQ} = V_{DD}$ , +25°C ambient.
9. The reference clock input is capable of HSTL, eHSTL, LVEPECL, 1.8V or 2.5V LVTTTL operation independent of the device output. The correct input interface table should be referenced.



## POWER SUPPLY CHARACTERISTICS FOR 2.5V LVTTTL OUTPUTS<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Typ.	Max	Unit
I <sub>DDQ</sub>	Quiescent V <sub>DD</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDQQ</sub>	Quiescent V <sub>DDQ</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDD</sub>	Dynamic V <sub>DD</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>DDQD</sub>	Dynamic V <sub>DDQ</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>TOT</sub>	Total Power V <sub>DD</sub> Supply Current	V <sub>DDQ</sub> = 2.5V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 2.5V, F <sub>REFERENCE CLOCK</sub> = 200MHz, C <sub>L</sub> = 15pF	—	—	
I <sub>TOTQ</sub>	Total Power V <sub>DDQ</sub> Supply Current	V <sub>DDQ</sub> = 2.5V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 2.5V, F <sub>REFERENCE CLOCK</sub> = 200MHz, C <sub>L</sub> = 15pF	—	—	

### NOTES:

- These power consumption characteristics are for all the valid input interfaces and cover the worst case input and output interface combinations.
- If the differential input interface is used, the true input is held LOW and the complementary input is held HIGH.

## DIFFERENTIAL INPUT AC TEST CONDITIONS FOR 2.5V LVTTTL

Symbol	Parameter	Value	Units
V <sub>DIF</sub>	Input Signal Swing <sup>(1)</sup>	V <sub>DD</sub>	V
V <sub>X</sub>	Differential Input Signal Crossing Point <sup>(2)</sup>	V <sub>DD</sub> /2	V
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
t <sub>R</sub> , t <sub>F</sub>	Input Signal Edge Rate <sup>(4)</sup>	2.5	V/ns

### NOTES:

- A nominal 2.5V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>DIF</sub> (AC) specification under actual use conditions.
- A nominal 1.25V crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>X</sub> specification under actual use conditions.
- In all cases, input waveform timing is marked at the differential cross-point of the input signals.
- The input signal edge rate of 2.5V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

## SINGLE-ENDED INPUT AC TEST CONDITIONS FOR 2.5V LVTTTL

Symbol	Parameter	Value	Units
V <sub>IH</sub>	Input HIGH Voltage	V <sub>DD</sub>	V
V <sub>IL</sub>	Input LOW Voltage	0	V
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(1)</sup>	V <sub>DD</sub> /2	V
t <sub>R</sub> , t <sub>F</sub>	Input Signal Edge Rate <sup>(2)</sup>	2	V/ns

### NOTES:

- A nominal 1.25V timing measurement reference level is specified to allow constant, repeatable results in an automatic test equipment (ATE) environment.
- The input signal edge rate of 2V/ns or greater is to be maintained in the 10% to 90% range of the input waveform.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE FOR 1.8V LVTTTL<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Min.	Typ. <sup>(8)</sup>	Max	Unit
<b>Input Characteristics</b>						
I <sub>IH</sub>	Input HIGH Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = V <sub>DDQ</sub> /GND	—	—	±5	μA
I <sub>IL</sub>	Input LOW Current	V <sub>DD</sub> = 2.7V V <sub>I</sub> = GND/V <sub>DDQ</sub>	—	—	±5	μA
V <sub>IK</sub>	Clamp Diode Voltage	V <sub>DD</sub> = 2.3V, I <sub>IN</sub> = -18mA	—	-0.7	-1.2	V
V <sub>IN</sub>	DC Input Voltage		-0.3		V <sub>DDQ</sub> + 0.3	V
<b>Single-Ended Inputs<sup>(2)</sup></b>						
V <sub>IH</sub>	DC Input HIGH		1.073 <sup>(10)</sup>		—	V
V <sub>IL</sub>	DC Input LOW		—		0.683 <sup>(11)</sup>	V
<b>Differential Inputs</b>						
V <sub>DIF</sub>	DC Differential Voltage <sup>(3,9)</sup>		0.2		—	V
V <sub>CM</sub>	DC Common Mode Input Voltage <sup>(4,9)</sup>		825	900	975	mV
V <sub>IH</sub>	DC Input HIGH <sup>(5,6,9)</sup>		V <sub>REF</sub> + 100		—	mV
V <sub>IL</sub>	DC Input LOW <sup>(5,7,9)</sup>		—		V <sub>REF</sub> - 100	mV
V <sub>REF</sub>	Single-Ended Reference Voltage <sup>(5,9)</sup>		—	900	—	mV
<b>Output Characteristics</b>						
V <sub>OH</sub>	Output HIGH Voltage	I <sub>OH</sub> = -6mA	V <sub>DDQ</sub> - 0.4		—	V
		I <sub>OH</sub> = -100μA	V <sub>DDQ</sub> - 0.1		—	V
V <sub>OL</sub>	Output LOW Voltage	I <sub>OL</sub> = 6mA	—		0.4	V
		I <sub>OL</sub> = 100μA	—		0.1	V

### NOTES:

- See RECOMMENDED OPERATING RANGE table.
- For 1.8V LVTTTL single-ended operation, the RxS pin is allowed to float or tied to V<sub>DD</sub>/2 and  $\bar{A}/V_{REF}$  is tied to GND.
- V<sub>DIF</sub> specifies the minimum input differential voltage (V<sub>TR</sub> - V<sub>CP</sub>) required for switching where V<sub>TR</sub> is the "true" input level and V<sub>CP</sub> is the "complement" input level. Differential mode only. The DC differential voltage must be maintained to guarantee retaining the existing HIGH or LOW input. The AC differential voltage must be achieved to guarantee switching to a new state.
- V<sub>CM</sub> specifies the maximum allowable range of (V<sub>TR</sub> + V<sub>CP</sub>) /2. Differential mode only.
- For single-ended operation in differential mode,  $\bar{A}/V_{REF}$  is tied to the DC voltage V<sub>REF</sub>. The input is guaranteed to toggle within ±200mV of V<sub>REF</sub> when V<sub>REF</sub> is constrained within +600mV and V<sub>DDI</sub>-600mV, where V<sub>DDI</sub> is the nominal 1.8V power supply of the device driving the A input. To guarantee switching in voltage range specified in the JEDEC 1.8V LVTTTL interface specification, V<sub>REF</sub> must be maintained at 900mV with appropriate tolerances.
- Voltage required to maintain a logic HIGH, single-ended operation in differential mode.
- Voltage required to maintain a logic LOW, single-ended operation in differential mode.
- Typical values are at V<sub>DD</sub> = 2.5V, V<sub>DDQ</sub> = 1.8V, +25°C ambient.
- The reference clock input is capable of HSTL, eHSTL, LVEPECL, 1.8V or 2.5V LVTTTL operation independent of the device output. The correct input interface table should be referenced.
- This value is the worst case minimum V<sub>IH</sub> over the specification range of the 1.8V power supply. The 1.8V LVTTTL specification is V<sub>IH</sub> = 0.65 • V<sub>DD</sub> where V<sub>DD</sub> is 1.8V ± 0.15V. However, the LVTTTL translator is supplied by a 2.5V nominal supply on this part. To ensure compliance with the specification, the translator was designed to accept the calculated worst case value (V<sub>IH</sub> = 0.65 • [1.8 - 0.15V]) rather than reference against a nominal 1.8V supply.
- This value is the worst case maximum V<sub>IL</sub> over the specification range of the 1.8V power supply. The 1.8V LVTTTL specification is V<sub>IL</sub> = 0.35 • V<sub>DD</sub> where V<sub>DD</sub> is 1.8V ± 0.15V. However, the LVTTTL translator is supplied by a 2.5V nominal supply on this part. To ensure compliance with the specification, the translator was designed to accept the calculated worst case value (V<sub>IL</sub> = 0.35 • [1.8 + 0.15V]) rather than reference against a nominal 1.8V supply.

## POWER SUPPLY CHARACTERISTICS FOR 1.8V LVTTTL OUTPUTS<sup>(1)</sup>

Symbol	Parameter	Test Conditions	Typ.	Max	Unit
I <sub>DDQ</sub>	Quiescent V <sub>DD</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDOQ</sub>	Quiescent V <sub>DDQ</sub> Power Supply Current	V <sub>DDQ</sub> = Max., Reference Clock = LOW <sup>(2)</sup> Outputs enabled, All outputs unloaded	—	—	mA
I <sub>DDD</sub>	Dynamic V <sub>DD</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>DDOQ</sub>	Dynamic V <sub>DDQ</sub> Power Supply Current per Output	V <sub>DD</sub> = Max., V <sub>DDQ</sub> = Max., C <sub>L</sub> = 0pF	—	—	μA/MHz
I <sub>TOT</sub>	Total Power V <sub>DD</sub> Supply Current	V <sub>DDQ</sub> = 1.8V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.8V, F <sub>REFERENCE CLOCK</sub> = 200MHz, C <sub>L</sub> = 15pF	—	—	
I <sub>TOTQ</sub>	Total Power V <sub>DDQ</sub> Supply Current	V <sub>DDQ</sub> = 1.8V, F <sub>REFERENCE CLOCK</sub> = 100MHz, C <sub>L</sub> = 15pF	—	—	mA
		V <sub>DDQ</sub> = 1.8V, F <sub>REFERENCE CLOCK</sub> = 200MHz, C <sub>L</sub> = 15pF	—	—	

### NOTES:

- These power consumption characteristics are for all the valid input interfaces and cover the worst case input and output interface combinations.
- If the differential input interface is used, the true input is held LOW and the complementary input is held HIGH.

## DIFFERENTIAL INPUT AC TEST CONDITIONS FOR 1.8V LVTTTL

Symbol	Parameter	Value	Units
V <sub>DIF</sub>	Input Signal Swing <sup>(1)</sup>	V <sub>DDI</sub>	V
V <sub>X</sub>	Differential Input Signal Crossing Point <sup>(2)</sup>	V <sub>DDI</sub> /2	mV
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
t <sub>R</sub> , t <sub>F</sub>	Input Signal Edge Rate <sup>(4)</sup>	1.8	V/ns

### NOTES:

- V<sub>DDI</sub> is the nominal 1.8V supply (1.8V ± 0.15V) of the part or source driving the input. A nominal 1.8V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>DIF</sub> (AC) specification under actual use conditions.
- A nominal 900mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. Compliant devices must meet the V<sub>X</sub> specification under actual use conditions.
- In all cases, input waveform timing is marked at the differential cross-point of the input signals.
- The input signal edge rate of 1.8V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

## SINGLE-ENDED INPUT AC TEST CONDITIONS FOR 1.8V LVTTTL

Symbol	Parameter	Value	Units
V <sub>IH</sub>	Input HIGH Voltage <sup>(1)</sup>	V <sub>DDI</sub>	V
V <sub>IL</sub>	Input LOW Voltage	0	V
V <sub>THI</sub>	Input Timing Measurement Reference Level <sup>(2)</sup>	V <sub>DDI</sub> /2	mV
t <sub>R</sub> , t <sub>F</sub>	Input Signal Edge Rate <sup>(3)</sup>	2	V/ns

### NOTES:

- V<sub>DDI</sub> is the nominal 1.8V supply (1.8V ± 0.15V) of the part or source driving the input.
- A nominal 900mV timing measurement reference level is specified to allow constant, repeatable results in an automatic test equipment (ATE) environment.
- The input signal edge rate of 2V/ns or greater is to be maintained in the 10% to 90% range of the input waveform.

## AC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE

Symbol	Parameter	Min.	Typ.	Max	Unit
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### Skew Parameters

$t_{sk(o)}$	Same Device Output Pin-to-Pin Skew <sup>(1)</sup>	Single-Ended and Differential Modes	—	25	—	ps
		Single-Ended in Differential Mode (DSE)	—	25	—	
$t_{sk(p)}$	Pulse Skew <sup>(2)</sup>	Single-Ended and Differential Modes	—	—	300	ps
		Single-Ended in Differential Mode (DSE)	—	300	—	
$t_{sk(pp)}$	Part-to-Part Skew <sup>(3)</sup>	Single-Ended and Differential Modes	—	—	300	ps
		Single-Ended in Differential Mode (DSE)	—	300	—	

### Propagation Delay

$t_{PLH}$ $t_{PHL}$	Propagation Delay A to Qn	—	—	2.5	ns
fo	Frequency Range (HSTL/eHSTL outputs)	—	—	250	MHz
	Frequency Range (2.5V/1.8V LVTTTL outputs)	—	—	200	

### Output Gate Enable/Disable Delay

$t_{PGE}$	Output Gate Enable to Qn	—	—	3.5	ns
$t_{PGD}$	Output Gate Enable to Qn Driven to GL Designated Level	—	—	3	ns

#### NOTES:

1. Skew measured between all outputs under identical input and output interfaces, transitions, and load conditions on any one device.
2. Skew measured is difference between propagation times  $t_{PLH}$  and  $t_{PHL}$  of any output under identical input and output interfaces, transitions, and load conditions on any one device.
3. Skew measured is the magnitude of the difference in propagation times between any outputs of two devices, given identical transitions and load conditions at identical  $V_{DD}/V_{DDO}$  levels and temperature.

## AC DIFFERENTIAL INPUT SPECIFICATIONS<sup>(1)</sup>

Symbol	Parameter	Min.	Typ.	Max	Unit
tw	Reference Clock Pulse Width HIGH or LOW (HSTL/eHSTL outputs) <sup>(2)</sup>	1.73	—	—	ns
	Reference Clock Pulse Width HIGH or LOW (2.5V / 1.8V LVTTTL outputs) <sup>(2)</sup>	2.17	—	—	

### HSTL/eHSTL/1.8V LVTTTL/2.5V LVTTTL

$V_{DIF}$	AC Differential Voltage <sup>(3)</sup>	400	—	—	mV
$V_{IH}$	AC Input HIGH <sup>(4,5)</sup>	$V_x + 200$	—	—	mV
$V_{IL}$	AC Input LOW <sup>(4,6)</sup>	—	—	$V_x - 200$	mV

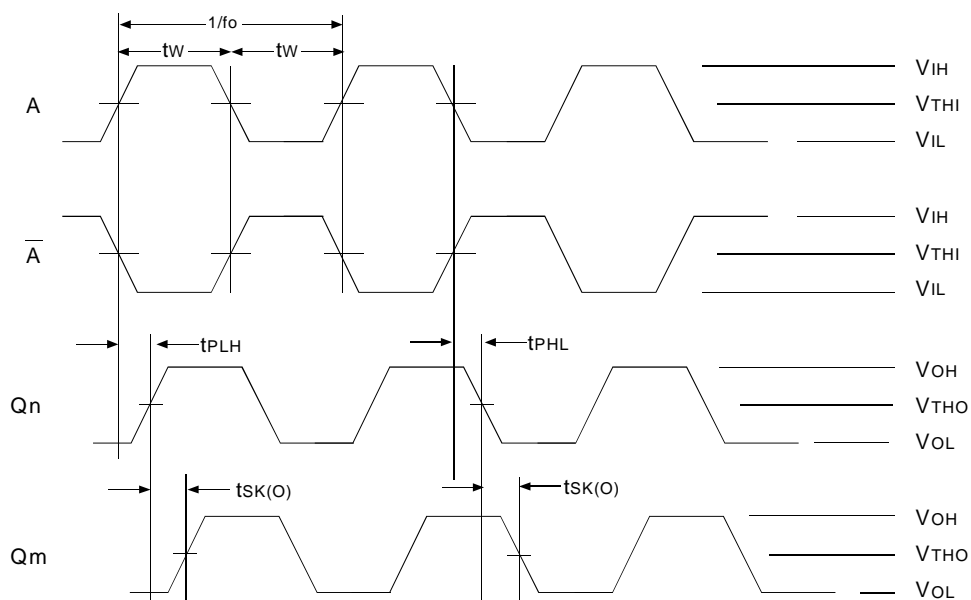
### LVEPECL

$V_{DIF}$	AC Differential Voltage <sup>(3)</sup>	400	—	—	mV
$V_{IH}$	AC Input HIGH <sup>(4)</sup>	1275	—	—	mV
$V_{IL}$	AC Input LOW <sup>(4)</sup>	—	—	875	mV

#### NOTES:

1. For differential input mode, RxS is tied to GND.
2. Both differential input signals should not be driven to the same level simultaneously. The input will not change state until the inputs have crossed and the voltage range defined by  $V_{DIF}$  has been met or exceeded.
3. Differential mode only.  $V_{DIF}$  specifies the minimum input voltage ( $V_{TR} - V_{CP}$ ) required for switching where  $V_{TR}$  is the "true" input level and  $V_{CP}$  is the "complement" input level. The AC differential voltage must be achieved to guarantee switching to a new state.
4. For single-ended operation,  $\bar{A}/V_{REF}$  is tied to DC voltage ( $V_{REF}$ ). Refer to each input interface's DC specification for the correct  $V_{REF}$  range.
5. Voltage required to switch to a logic HIGH, single-ended operation only.
6. Voltage required to switch to a logic LOW, single-ended operation only.

## AC TIMING WAVEFORMS



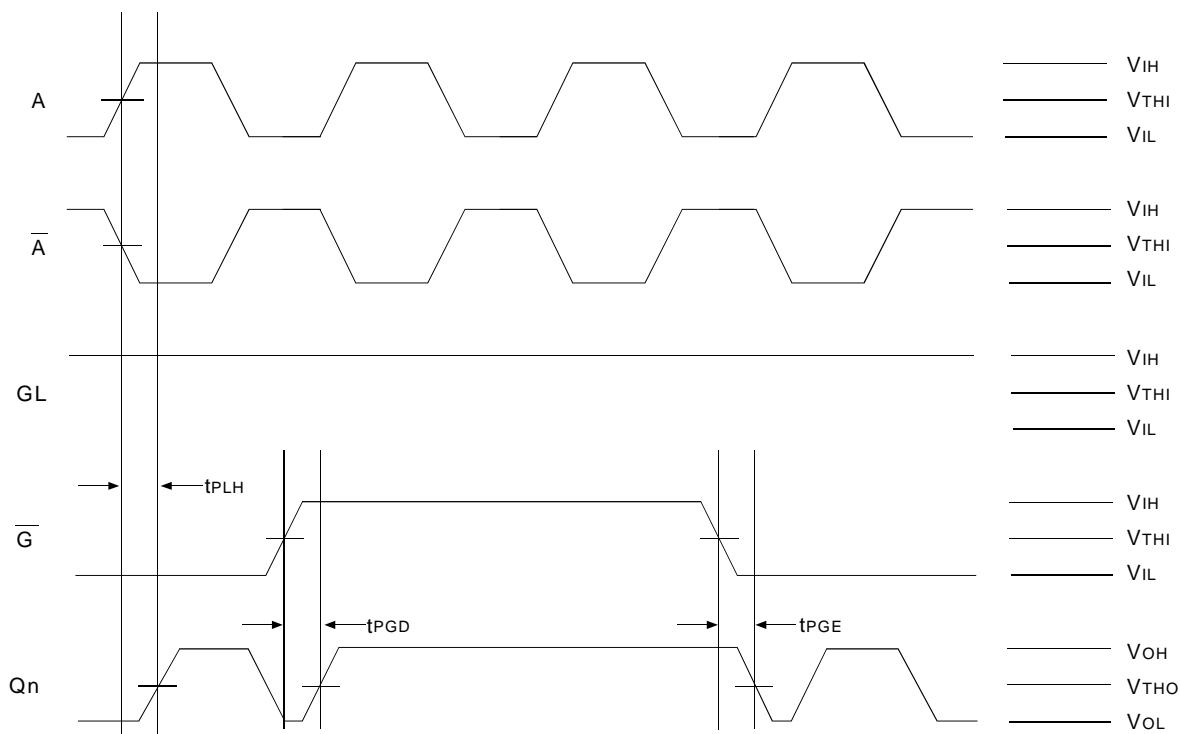
*Propagation and Skew Waveforms*

### NOTES:

1.  $t_{PHL}$  and  $t_{PLH}$  signals are measured from the input passing through  $V_{THI}$  or input pair crossing to Qn passing through  $V_{THO}$ .
2. Pulse Skew is calculated using the following expression:

$$t_{SK(P)} = |t_{PHL} - t_{PLH}|$$

where  $t_{PHL}$  and  $t_{PLH}$  are measured on the controlled edges of any one output from rising and falling edges of a single pulse. Please note that the  $t_{PHL}$  and  $t_{PLH}$  shown are not valid measurements for this calculation because they are not taken from the same pulse.

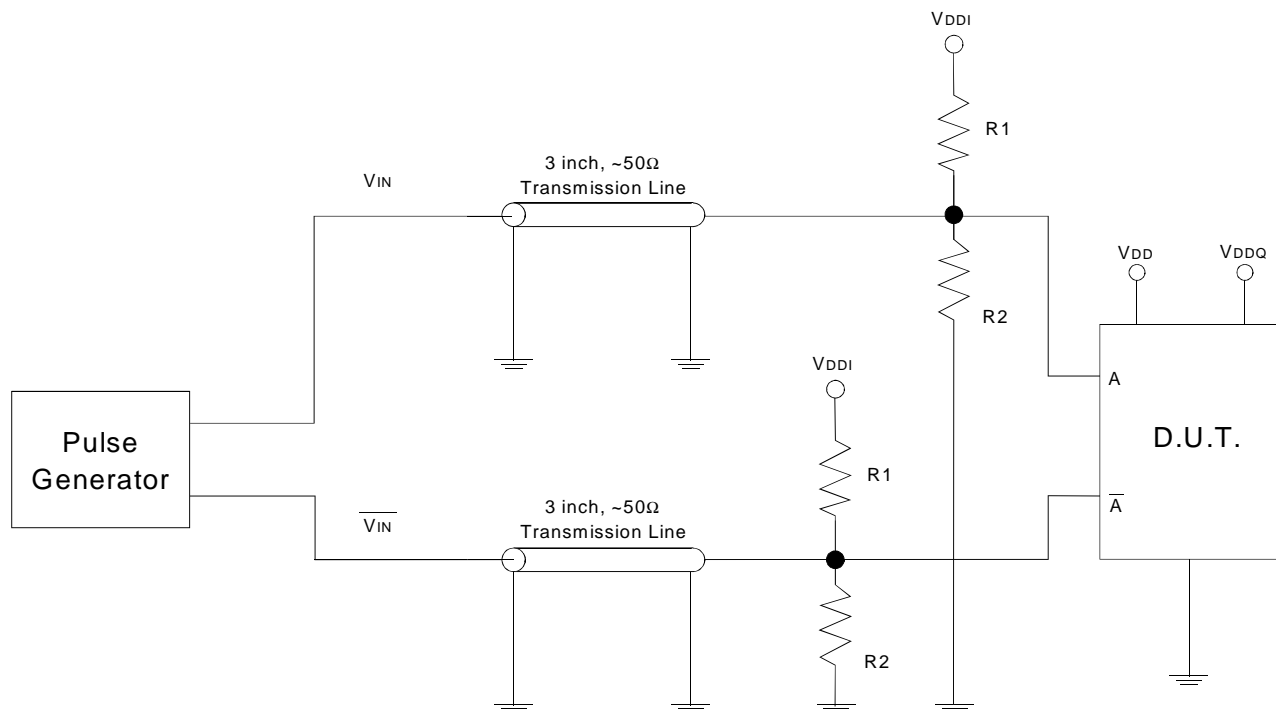


*Gate Disable/Enable Showing Runt Pulse Generation*

### NOTE:

As shown, it is possible to generate runt pulses on gate disable and enable of the outputs. It is the user's responsibility to time their  $\overline{G}_x$  signals to avoid this problem.

## TEST CIRCUITS AND CONDITIONS



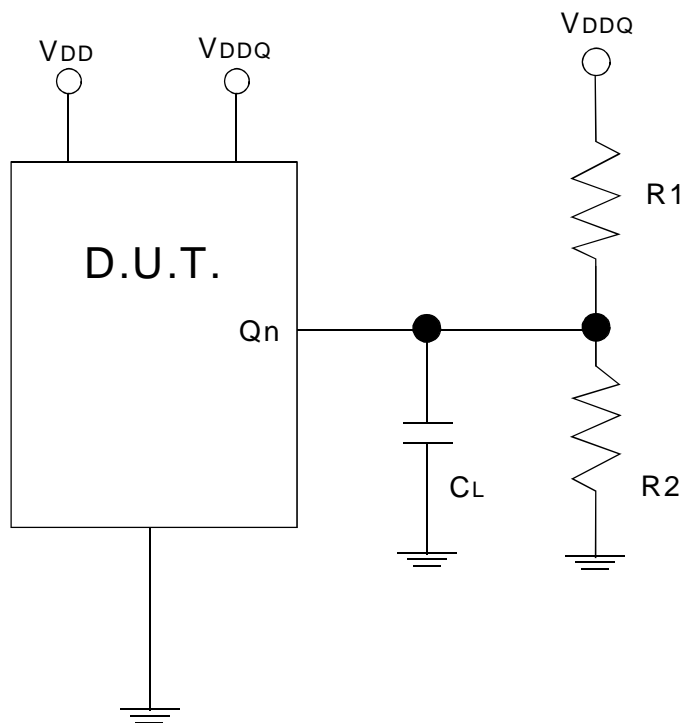
Test Circuit for Differential Input<sup>(1)</sup>

## DIFFERENTIAL INPUT TEST CONDITIONS

Symbol	$V_{DD} = 2.5V \pm 0.2V$	Unit
R1	100	$\Omega$
R2	100	$\Omega$
$V_{DDI}$	$V_{CM} \times 2$	V
$V_{THI}$	HSTL: Crossing of A and $\bar{A}$ eHSTL: Crossing of A and $\bar{A}$ LVEPECL: Crossing of A and $\bar{A}$ 1.8V LVTTTL: $V_{DDI}/2$ 2.5V LVTTTL: $V_{DD}/2$	V

**NOTE:**

1. This input configuration is used for all input interfaces. For single-ended testing, the  $\bar{V}_{IN}$  input is tied to GND. For testing single-ended in differential input mode, the  $\bar{V}_{IN}$  is left floating.



*Test Circuit for SDR Outputs*

### SDR OUTPUT TEST CONDITIONS

Symbol	$V_{DD} = 2.5V \pm 0.2V$ $V_{DDQ} = \text{Interface Specified}$	Unit
$C_L$	15	pF
$R_1$	100	$\Omega$
$R_2$	100	$\Omega$
$V_{THO}$	$V_{DDQ} / 2$	V

## ORDERING INFORMATION

IDT	XXXXX	XX	X		
Device Type	Package	Package			
			I	-40°C to +85°C (Industrial)	
			PG	Thin Shrink Small Outline Package (SO28-10)	
			5T905	2.5V Single Data Rate 1:5 Clock Buffer	



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