ICS8305

Low Skew, 1-to-4, Multiplexed Differential/ LVCMOS-to-LVCMOS/LVTTL Fanout Buffer

Integrated
Circuit
Systems, Inc.

General Description

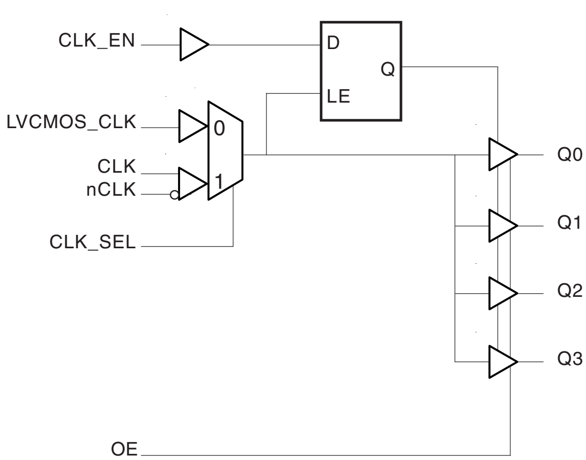
The ICS8305 is a low skew, 1-to-4, Differential/ LVCMOS-to-LVCMOS/LVTTL Fanout Buffer and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The ICS8305 has selectable clock inputs that accept either differential or single ended input levels. The clock enable is internally synchronized to eliminate runt pulses on the outputs during asynchronous assertion/ deassertion of the clock enable pin. Outputs are forced LOW when the clock is disabled. A separate output enable pin controls whether the outputs are in the active or high impedance state.

Guaranteed output and part-to-part skew characteristics make the ICS8305 ideal for those applications demanding well defined performance and repeatability.

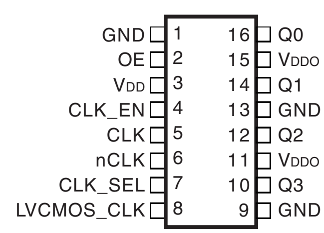
Features

- Four LVCMOS/LVTTL outputs
- Selectable differential or LVCMOS/LVTTL clock inputs
- CLK, nCLK pair can accept the following differential input levels: LVPECL, LVDS, LVHSTL, HCSL, SSTL
- LVCMOS_CLK supports the following input types: LVCMOS, LVTTL
- Maximum output frequency: 350MHz
- Output skew: 35ps (maximum)
- Part-to-part skew: 700ps (maximum)
- Additive phase jitter, RMS: 0.04ps (typical)
- Power supply modes:
  Core/Output
  3.3V/3.3V
  3.3V/2.5V
  3.3V/1.8V
  3.3V/1.5V
- 0°C to 70°C ambient operating temperature
- Available in both standard and lead-free RoHS complaint packages

Block Diagram



Pin Assignment



ICS8305
16-Lead TSSOP
4.4mm x 3.0mm x 0.92mm package body
G Package
Top View

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1, 9, 13	GND	Power		Power supply ground.
2	OE	Input	Pullup	Output enable. When LOW, outputs are in HIGH impedance state. When HIGH, outputs are active. LVCMOS / LVTTL interface levels.
3	V_{DD}	Power		Power supply pin.
4	CLK_EN	Input	Pullup	Synchronizing clock enable. When LOW, the output clocks are disabled. When HIGH, output clocks are enabled. LVCMOS / LVTTL interface levels.
5	CLK	Input	Pulldown	Non-inverting differential clock input.
6	nCLK	Input	Pullup/ Pulldown	Inverting differential clock input. $V_{DD}/2$ default when left floating.
7	CLK_SEL	Input	Pullup	Clock select input. When HIGH, selects CLK, nCLK inputs. When LOW, selects LVCMOS_CLK input. LVCMOS / LVTTL interface levels.
8	LVCMOS_CLK	Input	Pulldown	LVCMOS / LVTTL clock input.
10, 12, 14, 16	Q3, Q2, Q1, Q0	Output		Clock outputs. LVCMOS / LVTTL interface levels.
11, 15	V_{DDO}	Power		Output supply pins.

NOTE: *Pullup* and *Pulldown* refer to internal input resistors. See Table 2, Pin Characteristics, for typical values.

TABLE 2. PIN CHARACTERISTICS

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C_{IN}	Input Capacitance			4		pF
R_{PULLUP}	Input Pullup Resistor			51		kΩ
$R_{PULLDOWN}$	Input Pulldown Resistor			51		kΩ
C_{PD}	Power Dissipation Capacitance (per output)			11		pF
R_{OUT}	Output Impedance			7		Ω

TABLE 3A. CONTROL INPUT FUNCTION TABLE

Inputs				Outputs
OE	CLK_EN	CLK_SEL	Selected Source	Q0:Q3
1	0	0	LVCMOS_CLK	Disabled; LOW
1	0	1	CLK, nCLK	Disabled; LOW
1	1	0	LVCMOS_CLK	Enabled
1	1	1	CLK, nCLK	Enabled
0	X	X		HiZ

NOTE: After CLK_EN switches, the clock outputs are disabled or enabled following a rising and falling input clock edge as shown in Figure 1.

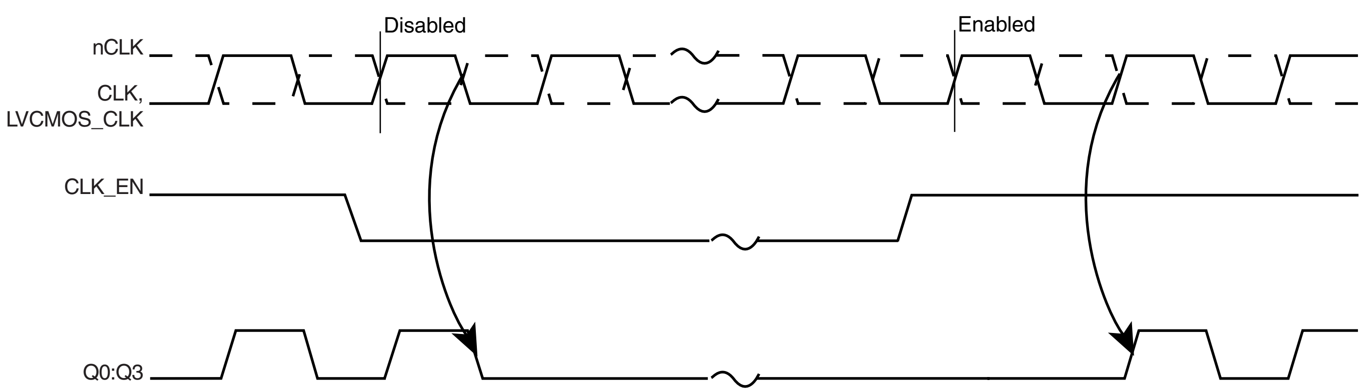


FIGURE 1. CLK_EN TIMING DIAGRAM

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to V_{DD} + 0.5 V
Outputs, V_O	-0.5V to V_{DD} + 0.5V
Package Thermal Impedance, θ_{JA}	89°C/W (0 lfpm)
Storage Temperature, T_{STG}	-65°C to 150°C

NOTE: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

TABLE 4A. POWER SUPPLY DC CHARACTERISTICS, $V_{DD} = V_{DDO}$ = 3.3V±5%, TA = 0°C TO 70°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Power Supply Voltage		3.135	3.3	3.465	V
V_{DDO}	Output Supply Voltage		3.135	3.3	3.465	V
			2.375	2.5	2.625	V
			1.65	1.8	1.95	V
			1.425	1.5	1.575	V
I_{DD}	Power Supply Current				21	mA
I_{DDO}	Output Supply Current				5	mA

TABLE 4B. LVCMOS/LVTTL DC CHARACTERISTICS, $V_{DD} = V_{DDO}$ = 3.3V±5%, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage	CLK_EN, CLK_SEL, OE		2		V_{DD} + 0.3	V
		LVCMOS_CLK		2		V_{DD} + 0.3	V
V_{IL}	Input Low Voltage	CLK_EN, CLK_SEL, OE		-0.3		0.8	V
		LVCMOS_CLK		-0.3		1.3	V
I_{IH}	Input High Current	CLK_EN, CLK_SEL, OE	$V_{DD} = V_{IN}$ = 3.465V			5	µA
		LVCMOS_CLK	$V_{DD} = V_{IN}$ = 3.465V			150	µA
I_{IL}	Input Low Current	CLK_EN, CLK_SEL, OE	V_{DD} = 3.465V, V_{IN} = 0V	-150			µA
		LVCMOS_CLK	V_{DD} = 3.465V, V_{IN} = 0V	-5			µA
V_{OH}	Output High Voltage; NOTE 1		V_{DDO} = 3.3V ± 5%	2.6			V
			V_{DDO} = 2.5V ± 5%	1.8			V
			V_{DDO} = 1.8V ± 0.15V	1.5			V
			V_{DDO} = 1.5V ± 5%	V_{DDO} - 0.3			V
V_{OL}	Output Low Voltage; NOTE 1		V_{DDO} = 3.3V ± 5%			0.5	V
			V_{DDO} = 2.5V ± 5%			0.5	V
			V_{DDO} = 1.8V ± 0.15V			0.4	V
			V_{DDO} = 1.5V ± 5%			0.35	V
I_{OZL}	Output Tristate Current Low			-5			µA
I_{OZH}	Output Tristate Current High					5	µA

NOTE 1: Outputs terminated with 50Ω to V_{DDO}/2. See Parameter Measurement Information, Output Load Test Circuit.

TABLE 4C. DIFFERENTIAL DC CHARACTERISTICS, $V_{DD} = V_{DDO} = 3.3V \pm 5\%$, $T_A = 0°C$ TO $70°C$

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input High Current	nCLK	$V_{IN} = V_{DD} = 3.465V$			150	µA
		CLK	$V_{IN} = V_{DD} = 3.465V$			150	µA
I_{IL}	Input Low Current	nCLK	$V_{IN} = 0V$, $V_{DD} = 3.465V$	-150			µA
		CLK	$V_{IN} = 0V$, $V_{DD} = 3.465V$	-5			µA
V_{PP}	Peak-to-Peak Input Voltage			0.15		1.3	V
V_{CMR}	Common Mode Input Voltage; NOTE 1, 2			GND + 0.5		V_{DD} - 0.85	V

NOTE 1: For single ended applications, the maximum input voltage for CLK, nCLK is V_{DD} + 0.3V.
NOTE 2: Common mode voltage is defined as V_{IH}.

TABLE 5A. AC CHARACTERISTICS, $V_{DD} = V_{DDO} = 3.3V \pm 5\%$, $T_A = 0°C$ TO $70°C$

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency					350	MHz
tp_{LH}	Propagation Delay, Low to High	LVCMOS_CLK; NOTE 1A CLK, nCLK; NOTE 1B		1.75		2.75	ns
*t*sk(o)	Output Skew; NOTE 2, 6		Measured on the Rising Edge			35	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 6					700	ps
*t*jit	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section, NOTE 5				0.04		ps
t_R / t_F	Output Rise/Fall Time; NOTE 4		20% to 80%	100		700	ps
odc	Output Duty Cycle		Ref = CLK/nCLK	45		55	%
			Ref = LVCMOS_CLK, $f \leq$ 300MHz	45		55	%
t_{EN}	Output Enable Time; NOTE 4					5	ns
t_{DIS}	Output Disable Time; NOTE 4					5	ns

All parameters measured at $f \leq$ 350MHz unless noted otherwise.
NOTE 1A: Measured from the $V_{DD}/2$ of the input to $V_{DDO}/2$ of the output.
NOTE 1B: Measured from the differential input crossing point to $V_{DDO}/2$ of the output.
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at $V_{DDO}/2$.
NOTE 3: Defined as skew between outputs on different devices operating a the same supply voltages and with equal load conditions. Using the same type of input on each device, the output is measured at $V_{DDO}/2$.
NOTE 4: These parameters are guaranteed by characterization. Not tested in production.
NOTE 5: Driving only one input clock.
NOTE 6: This parameter is defined in accordance with JEDEC Standard 65.

TABLE 5B. AC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, V_{DDO} = 2.5V ± 5%, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency					350	MHz
tp_{LH}	Propagation Delay, Low to High	LVCMOS_CLK; NOTE 1A CLK, nCLK; NOTE 1B		1.8		2.9	ns
*t*sk(o)	Output Skew; NOTE 2, 6		Measured on the Rising Edge			35	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 6					800	ps
tjit	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section, NOTE 5				0.04		ps
t_R / t_F	Output Rise/Fall Time; NOTE 4		20% to 80%	100		700	ps
odc	Output Duty Cycle		Ref = CLK/nCLK	44		56	%
			Ref = LVCMOS_CLK, $f \leq$ 300MHz	44		56	%
t_{EN}	Output Enable Time; NOTE 4					5	ns
t_{DIS}	Output Disable Time; NOTE 4					5	ns

All parameters measured at $f \leq$ 350MHz unless noted otherwise.
NOTE 1A: Measured from the $V_{DD}/2$ of the input to $V_{DDO}/2$ of the output.
NOTE 1B: Measured from the differential input crossing point to $V_{DDO}/2$ of the output.
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at $V_{DDO}/2$.
NOTE 3: Defined as skew between outputs on different devices operating a the same supply voltages and with equal load conditions. Using the same type of input on each device, the output is measured at $V_{DDO}/2$.
NOTE 4: These parameters are guaranteed by characterization. Not tested in production.
NOTE 5: Driving only one input clock.
NOTE 6: This parameter is defined in accordance with JEDEC Standard 65.

TABLE 5C. AC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, V_{DDO} = 1.8V ± -0.15V, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency					350	MHz
tp_{LH}	Propagation Delay, Low to High	LVCMOS_CLK; NOTE 1A CLK, nCLK; NOTE 1B		1.95		3.65	ns
*t*sk(o)	Output Skew; NOTE 2, 6		Measured on the Rising Edge			35	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 6					900	ps
tjit	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section, NOTE 5				0.04		ps
t_R / t_F	Output Rise/Fall Time; NOTE 4		20% to 80%	100		700	ps
odc	Output Duty Cycle		Ref = CLK/nCLK	44		56	%
			Ref = LVCMOS_CLK, $f \leq$ 300MHz	44		56	%
t_{EN}	Output Enable Time; NOTE 4					5	ns
t_{DIS}	Output Disable Time; NOTE 4					5	ns

See notes in Table 5B.

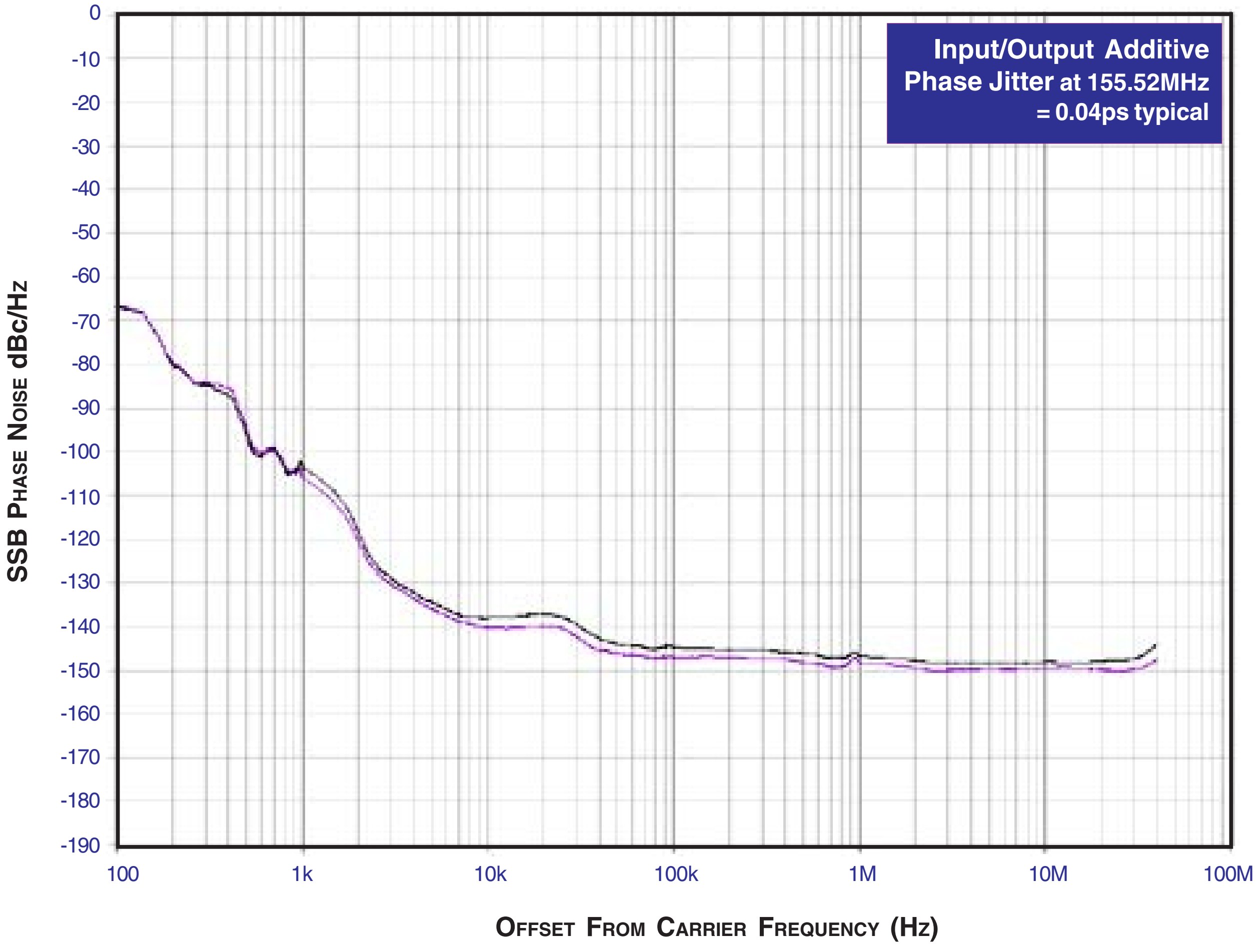
TABLE 5D. AC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, V_{DDO} = 1.5V ± 5%, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency					350	MHz
tp_{LH}	Propagation Delay, Low to High	LVCMOS_CLK; NOTE 1A CLK, nCLK; NOTE 1B		2		4	ns
*t*sk(o)	Output Skew; NOTE 2, 6		Measured on the Rising Edge			35	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 6					1	ns
tjit	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section, NOTE 5				0.04		ps
t_R / t_F	Output Rise/Fall Time; NOTE 4		20% to 80%	200		900	ps
odc	Output Duty Cycle		$f \leq$ 166MHz	45		55	%
			$f >$ 166MHz	42		58	%
t_{EN}	Output Enable Time; NOTE 4					5	ns
t_{DIS}	Output Disable Time; NOTE 4					5	ns

See notes in Table 5B.

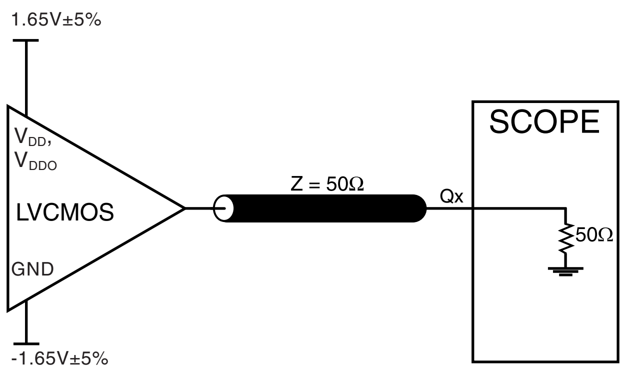
ADDITIVE PHASE JITTER

The spectral purity in a band at a specific offset from the fundamental compared to the power of the fundamental is called the ***dBc Phase Noise.*** This value is normally expressed using a Phase noise plot and is most often the specified plot in many applications. Phase noise is defined as the ratio of the noise power present in a 1Hz band at a specified offset from the fundamental frequency to the power value of the fundamental. This ratio is expressed in decibels (dBm) or a ratio of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a ***dBc*** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects on the desired application over the entire time record of the signal. It is mathematically possible to calculate an expected bit error rate given a phase noise plot.

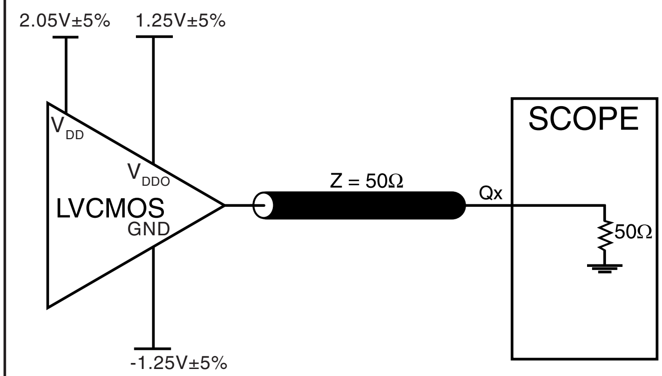


As with most timing specifications, phase noise measurements have issues. The primary issue relates to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor of the device. This is illustrated above. The device meets the noise floor of what is shown, but can actually be lower. The phase noise is dependant on the input source and measurement equipment.

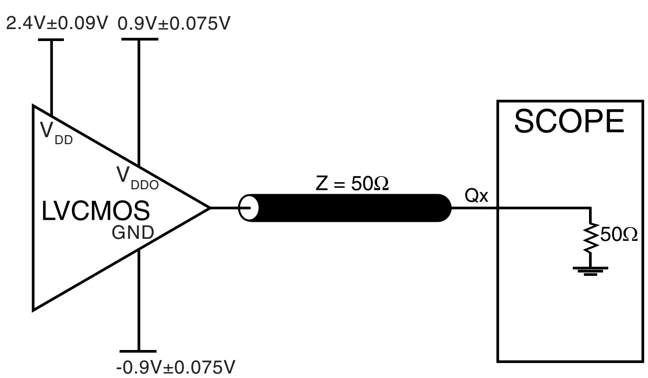
PARAMETER MEASUREMENT INFORMATION



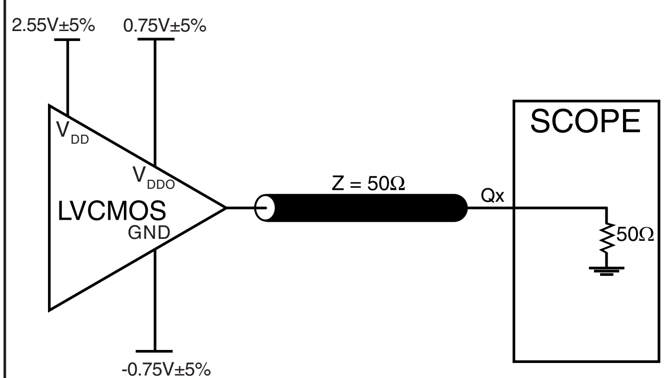
3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT



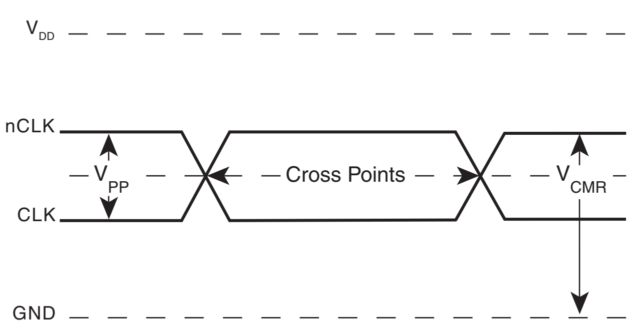
3.3V CORE/2.5V OUTPUT LOAD AC TEST CIRCUIT



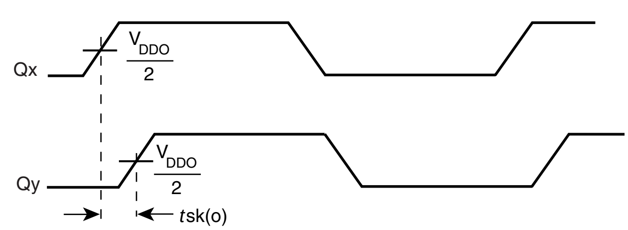
3.3V CORE/1.8V OUTPUT LOAD AC TEST CIRCUIT



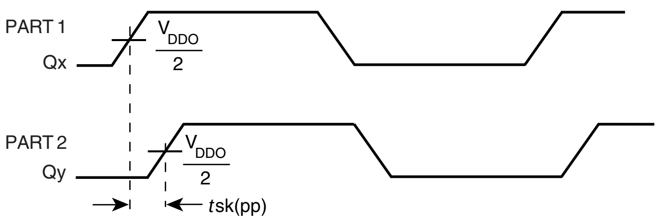
3.3V CORE/1.5V OUTPUT LOAD AC TEST CIRCUIT



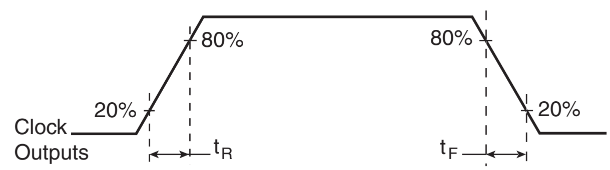
DIFFERENTIAL INPUT LEVEL



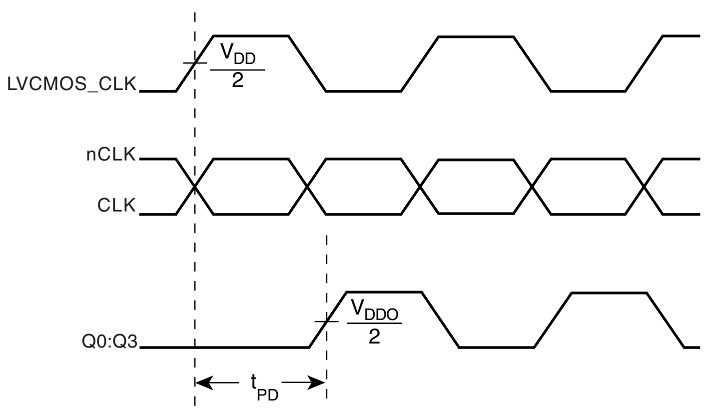
OUTPUT SKEW



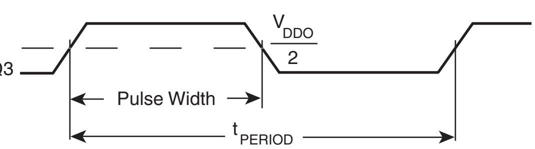
PART-TO-PART SKEW



OUTPUT RISE/FALL TIME



PROPAGATION DELAY



$$odc = \frac{t_{PW}}{t_{PERIOD}}$$

OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

APPLICATION INFORMATION

WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

Figure 2 shows how the differential input can be wired to accept single ended levels. The reference voltage $V\_REF = V_{DD}/2$ is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio of R1 and R2 might need to be adjusted to position the V_REF in the center of the input voltage swing. For example, if the input clock swing is only 2.5V and V_{DD} = 3.3V, V_REF should be 1.25V and R2/R1 = 0.609.

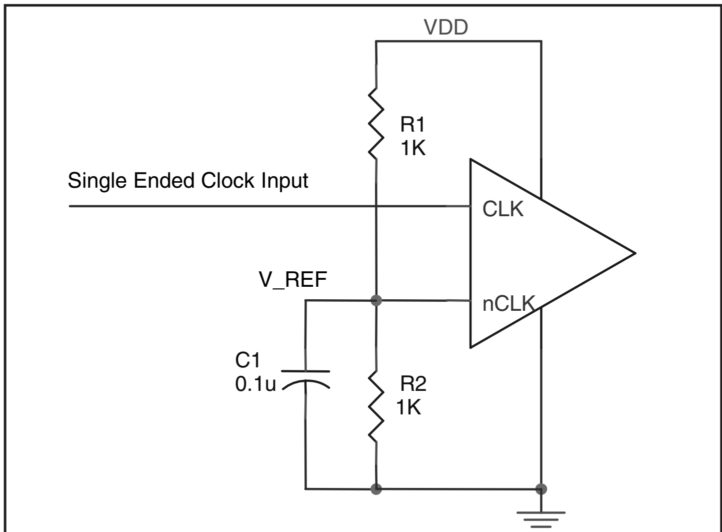


FIGURE 2. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT

RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS

INPUTS:

CLK INPUT:
For applications not requiring the use of a clock input, it can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from the CLK input to ground.

CLK/nCLK INPUT:
For applications not requiring the use of the differential input, both CLK and nCLK can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from CLK to ground.

LVCMOS CONTROL PINS:
All control pins have internal pull-ups or pull-downs; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

OUTPUTS:

LVCMOS OUTPUT:
All unused LVCMOS output can be left floating. We recommend that there is no trace attached.

DIFFERENTIAL CLOCK INPUT INTERFACE

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both V_{SWING} and V_{OH} must meet the V_{PP} and V_{CMR} input requirements. Figures 3A to 3E show interface examples for the HiPerClockS CLK/nCLK input driven by the most common driver types. The input interfaces suggested here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in *Figure 3A,* the input termination applies for ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.

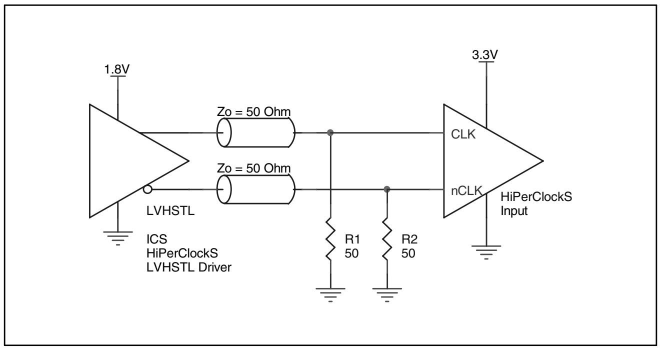


FIGURE 3A. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY ICS HIPERCLOCKS LVHSTL DRIVER

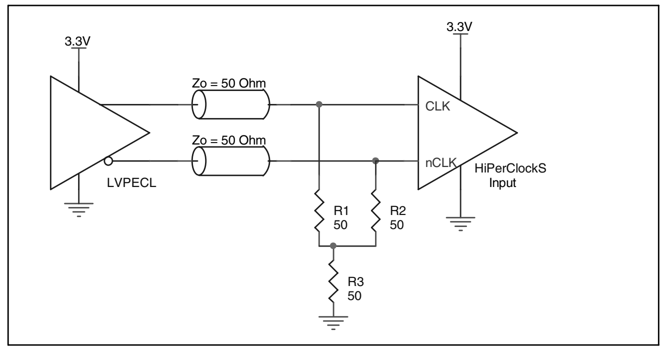


FIGURE 3B. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

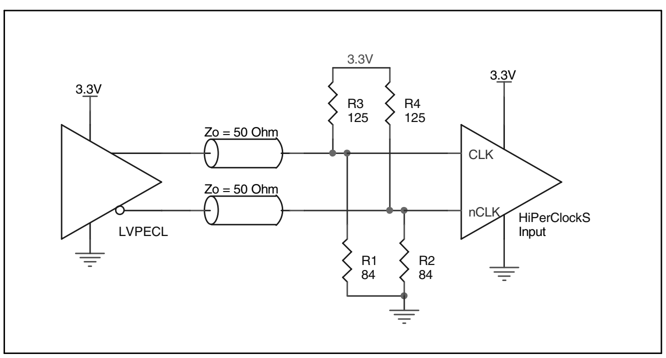


FIGURE 3C. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

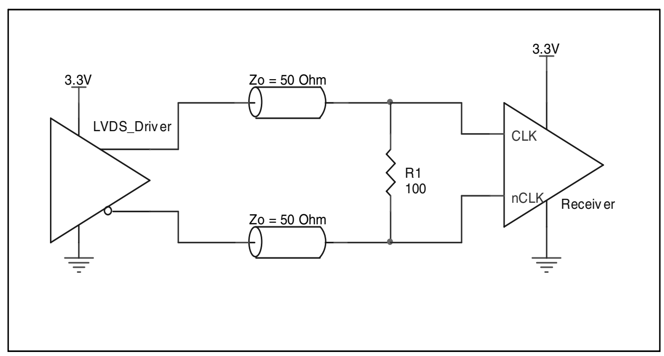


FIGURE 3D. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER

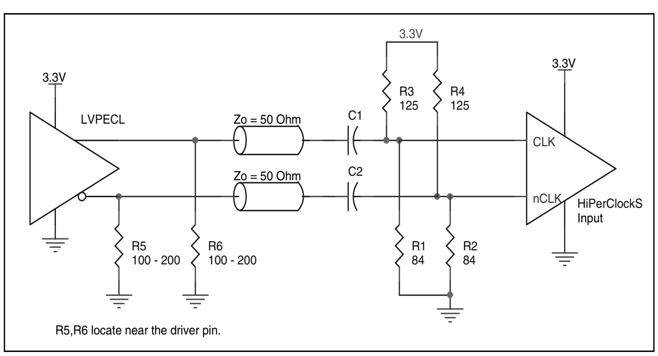


FIGURE 3E. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER WITH AC COUPLE

SCHEMATIC EXAMPLE

This application note provides general design guide using ICS8305 LVCMOS buffer. *Figure 3* shows a schematic example of the ICS8305 LVCMOS clock buffer. In this example, the input is driven by an LVCMOS driver. CLK_EN is set at logic low to select LVCMOS_CLK input.

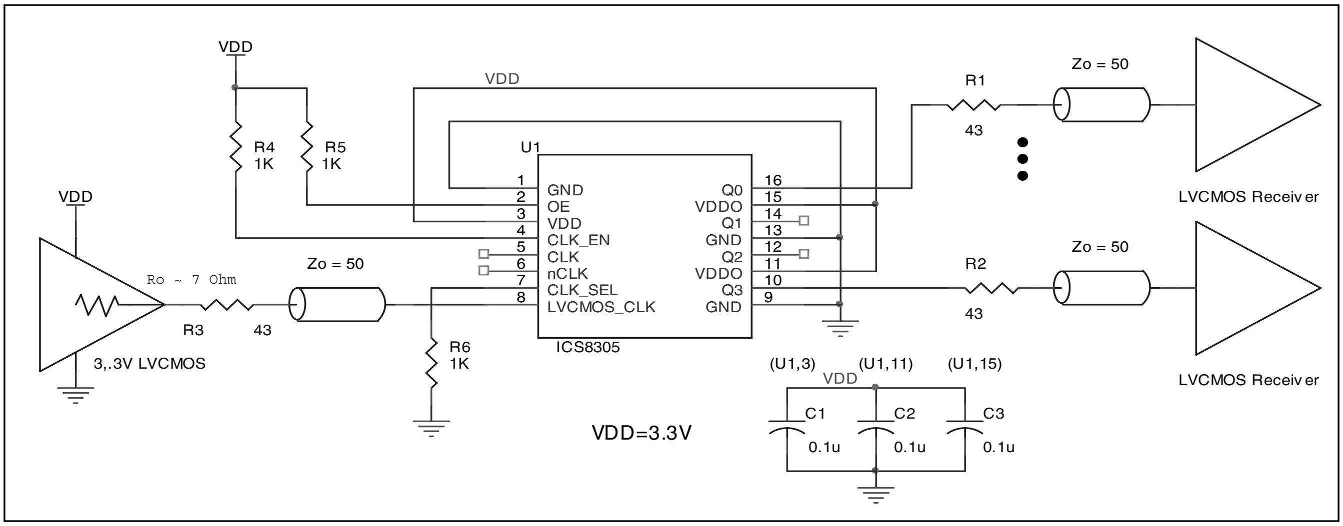


FIGURE 4. EXAMPLE ICS8305 LVCMOS CLOCK OUTPUT BUFFER SCHEMATIC

RELIABILITY INFORMATION

TABLE 6. θ_{JA} VS. AIR FLOW TABLE FOR 16 LEAD TSSOP

θ_{JA} by Velocity (Linear Feet per Minute)

	0	**200**	**500**
Single-Layer PCB, JEDEC Standard Test Boards	137.1°C/W	118.2°C/W	106.8°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	89.0°C/W	81.8°C/W	78.1°C/W

NOTE: Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

TRANSISTOR COUNT

The transistor count for ICS8305 is: 459

PACKAGE OUTLINE - G SUFFIX FOR 16 LEAD TSSOP

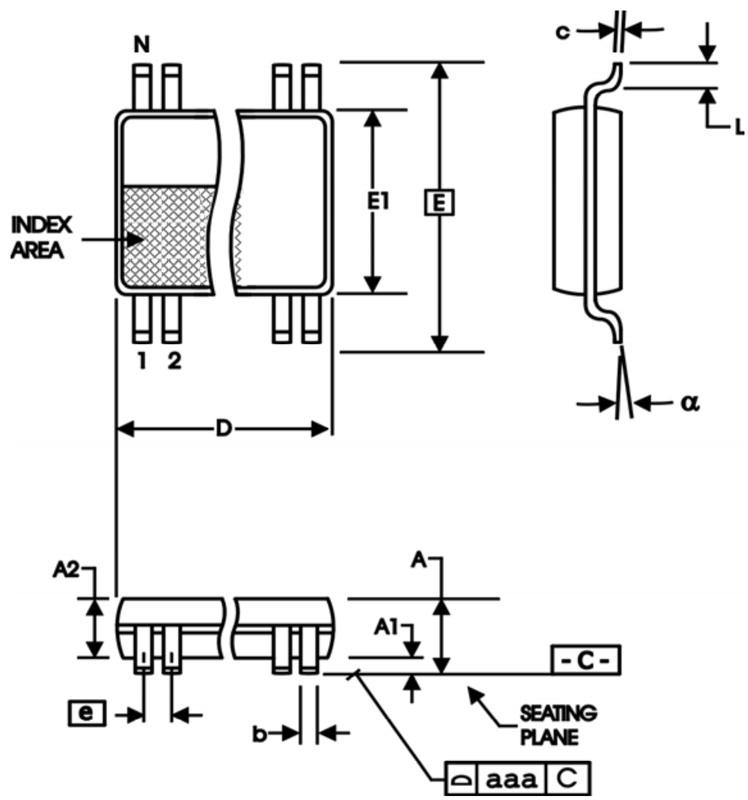


TABLE 7. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	Minimum	Maximum
N	16	
A	--	1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	4.90	5.10
E	6.40 BASIC	
E1	4.30	4.50
e	0.65 BASIC	
L	0.45	0.75
α	0°	8°
aaa	--	0.10

Reference Document: JEDEC Publication 95, MO-153

TABLE 8. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS8305AG	ICS8305AG	16 Lead TSSOP	tube	0°C to 70°C
ICS8305AGT	ICS8305AG	16 Lead TSSOP	2500 tape & reel	0°C to 70°C
ICS8305AGLF	TBD	16 Lead "Lead-Free" TSSOP	tube	0°C to 70°C
ICS8305AGLFT	TBD	16 Lead "Lead-Free" TSSOP	2500 tape & reel	0°C to 70°C

NOTE: Parts that are ordered with an "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

REVISION HISTORY SHEET

Rev	Table	Page	Description of Change	Date
A	T8	14	Ordering Information table - corrected Part/Order Number typo from ICS88305AGT to ICS8305AGT.	1/20/04
B	T5A - T5C	5 & 6 7	Added Additive Phase Jitter to AC Characteristics Tables. Added Additive Phase Jitter Section.	2/26/04
B	T1	2	Pin Description Table - corrected CLK_EN description.	12/6/04
C	 T4A T4B T5D T8	1 4 4 7 10 11 16	Features Section - added 1.5V output to Supply Mode bullet and added Lead-Free buttlet. Power Supply DC Characteristics Table - added V_{DDO} 1.5V. LVCMOS DC Characteristics Table - added V_{OH}/V_{OL} 1.5V. Added 3.3V/1.5V AC Characteristics Table. Added 3.3V/1.5V Output Load AC Test Circuit Drawing. Added *Recommendations for Unused Input and Output Pins.* Added Lead-Free part number.	11/17/05