

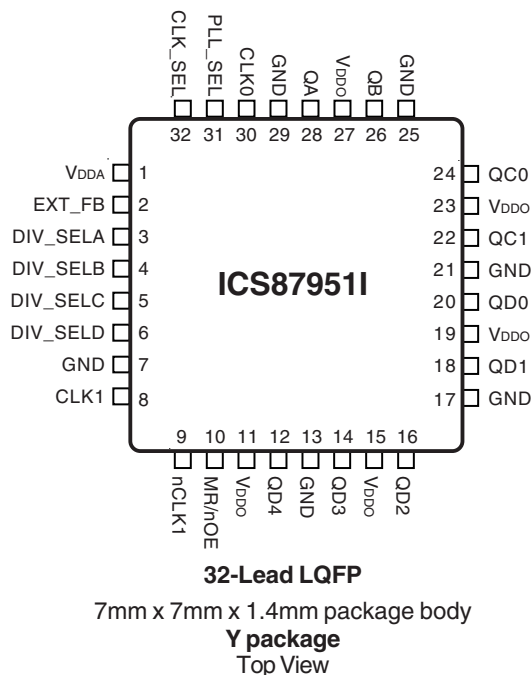
### GENERAL DESCRIPTION

The ICS87951I is a low voltage, low skew 1-to-9 Differential-to-LVCMOS/LVTTL Clock Generator. The ICS87951I has two selectable clock inputs. The single ended clock input accepts LVCMOS or LVTTL input levels. The CLK1, nCLK1 pair can accept most standard differential input levels. With output frequencies up to 180MHz, the ICS87951I is targeted for high performance clock applications. Along with a fully integrated PLL, the ICS87951I contains frequency configurable outputs and an external feedback input for regenerating clocks with “zero delay”.

### FEATURES

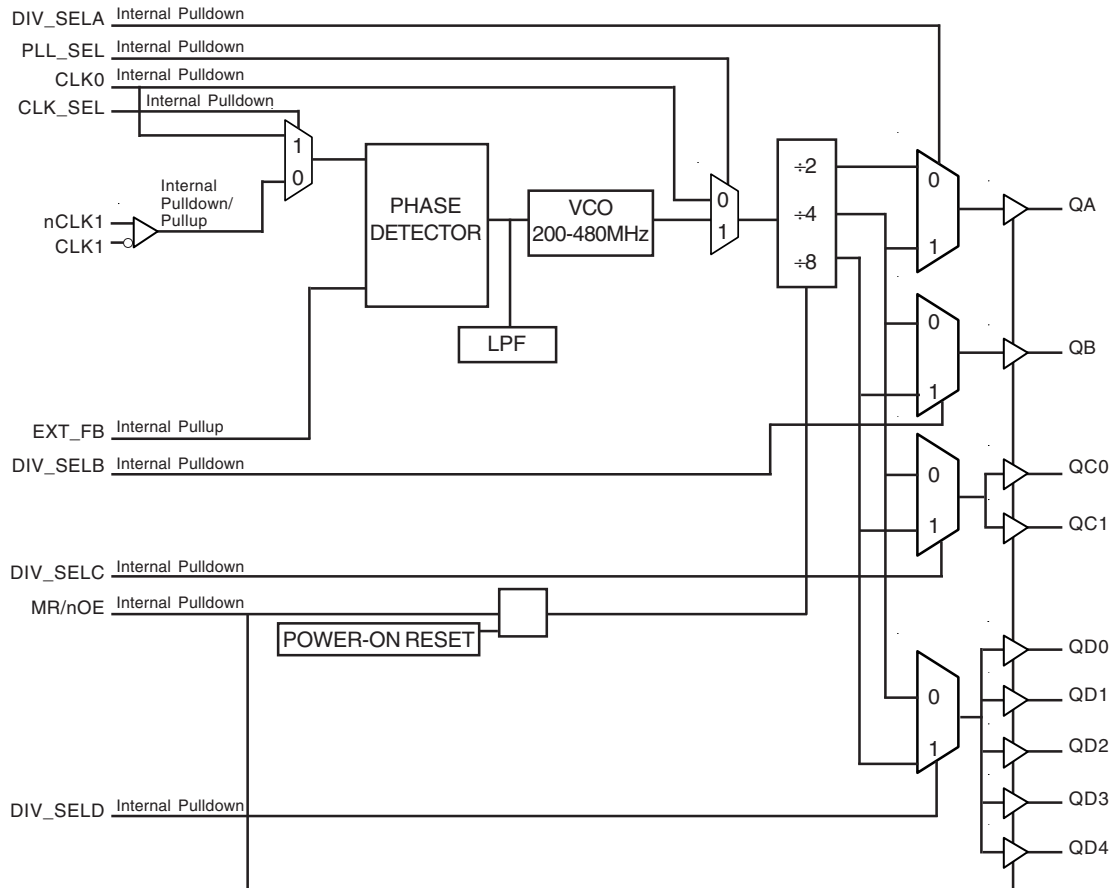
- Fully integrated PLL
- Nine single ended 3.3V LVCMOS/LVTTL outputs
- Selectable single ended CLK0 or differential CLK1, nCLK1 inputs
- The single ended CLK0 input can accept the following input levels: LVCMOS or LVTTL input levels
- CLK1, nCLK1 supports the following input types: LVDS, LVPECL, LVHSTL, SSTL, HCSL
- Output frequency range: 25MHz to 180MHz
- VCO range: 200MHz to 480MHz
- External feedback for “zero delay” clock regeneration
- Cycle-to-cycle jitter:  $\pm 100\text{ps}$  (typical)
- Output skew: 375ps (maximum)
- PLL reference zero delay: 350ps window (maximum)
- 3.3V operating supply
- $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  ambient operating temperature
- Available in both standard and lead-free RoHS-compliant packages

### PIN ASSIGNMENT





## BLOCK DIAGRAM





# ICS879511

## LOW SKEW, 1-TO-9 DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1	V <sub>DDA</sub>	Power		Analog supply pin.
2	EXT_FB	Input	Pullup	Feedback input to phase detector for regenerating clocks with "zero delay". LVCMOS / LVTTL interface levels.
3	DIV_SELA	Input	Pulldown	Selects divide value for Bank A output as described in Table 3D. LVCMOS / LVTTL interface levels.
4	DIV_SELB	Input	Pulldown	Selects divide value for Bank B output as described in Table 3D. LVCMOS / LVTTL interface levels.
5	DIV_SELC	Input	Pulldown	Selects divide value for Bank C outputs as described in Table 3D. LVCMOS / LVTTL interface levels.
6	DIV_SELD	Input	Pulldown	Selects divide value for Bank D outputs as described in Table 3D. LVCMOS / LVTTL interface levels.
7, 13, 17, 21, 25, 29	GND	Power		Power supply ground.
8	CLK1	Input	Pullup	Non-inverting differential clock input.
9	nCLK1	Input	Pulldown	Inverting differential clock input.
10	MR/nOE	Input	Pulldown	Active HIGH Master Reset. Active LOW output enable. When logic HIGH, the internal dividers are reset and the outputs are tri-stated (HiZ). When logic LOW, the internal dividers and the outputs are enabled. LVCMOS / LVTTL interface levels.
11, 15, 19, 23, 27	V <sub>DDO</sub>	Power		Output supply pins.
12, 14, 16, 18, 20	QD4, QD3, QD2, QD1, QD0	Output		Bank D clock outputs. 7Ω typical output impedance. LVCMOS / LVTTL interface levels.
22, 24	QC1, QC0	Output		Bank C clock outputs. 7Ω typical output impedance. LVCMOS / LVTTL interface levels.
26	QB	Output		Bank B clock output. 7Ω typical output impedance. LVCMOS / LVTTL interface levels.
28	QA	Output		Bank A clock output. 7Ω typical output impedance. LVCMOS / LVTTL interface levels.
30	CLK0	Input	Pulldown	LVCMOS / LVTTL phase detector reference clock input.
31	PLL_SEL	Input	Pulldown	Selects between the PLL and the reference clock as the input to the dividers. When HIGH, selects PLL. When LOW, selects the reference clock. LVCMOS / LVTTL interface levels.
32	CLK_SEL	Input	Pulldown	Clock select input. When HIGH, selects CLK0. When LOW, selects CLK1, nCLK1. LVCMOS / LVTTL interface levels.

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 <sub>IN</sub>	Input Capacitance			4		pF
C <sub>PD</sub>	Power Dissipation Capacitance (per output)	V <sub>DDA</sub> , V <sub>DDO</sub> = 3.47V		25		pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		KΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		KΩ
R <sub>OUT</sub>	Output Impedance		5	7	12	Ω



**TABLE 3A. OUTPUT CONTROL PIN FUNCTION TABLE**

Inputs	Outputs				
	MR/nOE	QA	QB	QC0, QC1	QD0:QD4
1	HiZ	HiZ	HiZ	HiZ	HiZ
0	Enabled	Enabled	Enabled	Enabled	Enabled

**TABLE 3B. OPERATING MODE FUNCTION TABLE**

Inputs	Operating Mode
PLL_SEL	
0	Bypass
1	PLL

**TABLE 3C. PLL INPUT FUNCTION TABLE**

Inputs	
CLK_SEL	PLL Input
0	CLK1, nCLK1
1	CLK0

**TABLE 3D. PROGRAMMABLE OUTPUT FREQUENCY FUNCTION TABLE**

Inputs				Outputs			
DIV_SELA	DIV_SELB	DIV_SELC	DIV_SELD	QA	QB	QCx	QDx
0	0	0	0	VCO/2	VCO/4	VCO/4	VCO/4
0	0	0	1	VCO/2	VCO/4	VCO/4	VCO/8
0	0	1	0	VCO/2	VCO/4	VCO/8	VCO/4
0	0	1	1	VCO/2	VCO/4	VCO/8	VCO/8
0	1	0	0	VCO/2	VCO/8	VCO/4	VCO/4
0	1	0	1	VCO/2	VCO/8	VCO/4	VCO/8
0	1	1	0	VCO/2	VCO/8	VCO/8	VCO/4
0	1	1	1	VCO/2	VCO/8	VCO/8	VCO/8
1	0	0	0	VCO/4	VCO/4	VCO/4	VCO/4
1	0	0	1	VCO/4	VCO/4	VCO/4	VCO/8
1	0	1	0	VCO/4	VCO/4	VCO/8	VCO/4
1	0	1	1	VCO/4	VCO/4	VCO/8	VCO/8
1	1	0	0	VCO/4	VCO/8	VCO/4	VCO/4
1	1	0	1	VCO/4	VCO/8	VCO/4	VCO/8
1	1	1	0	VCO/4	VCO/8	VCO/8	VCO/4
1	1	1	1	VCO/4	VCO/8	VCO/8	VCO/8



# ICS879511

## LOW SKEW, 1-TO-9 DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DDA} + 0.5V$
Outputs, $V_O$	-0.5V to $V_{DDO} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	42.1°C/W (0 lfp/m)
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,  $V_{DDA} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DDA}$	Analog Supply Voltage		3.135	3.3	3.465	V
$V_{DDO}$	Output Supply Voltage		3.135	3.3	3.465	V
$I_{DDO}$	Power Supply Current	All $V_{DD}$ pins			115	mA
$I_{DDA}$	Analog Supply Current				20	mA

**TABLE 4B. DC CHARACTERISTICS,  $V_{DDA} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	CLK0	2		$V_{DD} + 0.3$	V
		DIV_SELA:DIV_SELD, PLL_SEL, CLK_SEL, EXT_FB, MR/nOE	2		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage	CLK0	-0.3		1.3	V
		DIV_SELA:DIV_SELD, PLL_SEL, CLK_SEL, EXT_FB, MR/nOE	-0.3		0.8	V
$V_{PP}$	Peak-to-Peak Input Voltage	CLK1, nCLK1	300		1000	mV
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		GND + 0.5		$V_{DD} - 0.85$	V
$V_{OH}$	Output High Voltage	$I_{OH} = -40mA$	2.4			V
$V_{OL}$	Output Low Voltage	$I_{OL} = 40mA$			0.5	V
$I_{IN}$	Input Current				$\pm 120$	$\mu A$

NOTE 1: Common mode voltage is defined as  $V_{IH}$ .

NOTE 2: For single ended applications, the maximum input voltage for CLK1 and nCLK1 is  $V_{DDA} + 0.3V$ .



# ICS87951I

## LOW SKEW, 1-TO-9 DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

**TABLE 5. PLL INPUT REFERENCE CHARACTERISTICS,  $V_{DDA} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{REF}$	Input Reference Frequency				100	MHz

**TABLE 6. AC CHARACTERISTICS,  $V_{DDA} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency	QA $\div$ 2			180	MHz
		QA/QB $\div$ 4			120	MHz
		QB $\div$ 8			60	MHz
$f_{VCO}$	PLL VCO Lock Range		200		480	MHz
$t(\emptyset)$	Static Phase Offset; NOTE 1,3	CLK0	fREF = 50MHz Feedback = VCO/8	15	165	ps
		CLK1, nCLK1			-445	-95
$t_{sk(o)}$	Output Skew; NOTE 2, 3	Same Frequencies			375	ps
		Different Frequencies QAf <sub>MAX</sub> < 150MHz QAf <sub>MAX</sub> > 150MHz			500	ps
					750	ps
$f_{jit(cc)}$	Cycle-to-Cycle Jitter; NOTE 3			$\pm 100$		ps
$t_{LOCK}$	PLL Lock Time; NOTE 3				10	mS
$t_R$	Output Rise Time	0.8 to 2V	0.1		1.0	ns
$t_F$	Output Fall Time	0.8 to 2V	0.1		1.0	ns
$t_{PW}$	Output Pulse Width		tcycle/2 - 1000		tcycle/2 + 1000	ps
$t_{PZL}$	Output Enable Time				6	ns
$t_{PLZ}, t_{PHZ}$	Output Disable Time				7	ns

All parameters measured at  $f_{MAX}$  unless noted otherwise.

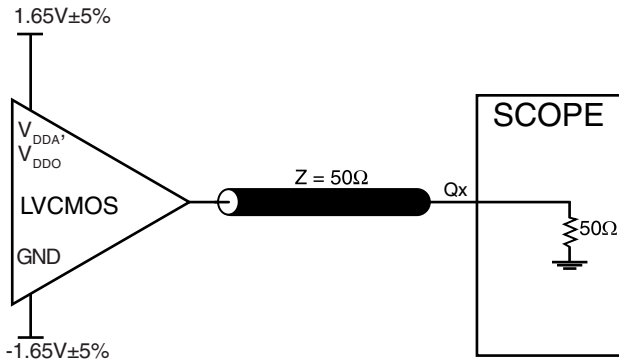
NOTE 1: Defined as the time difference between the input reference clock and the averaged feedback input signal, when the PLL is locked and the input reference frequency is stable.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions.

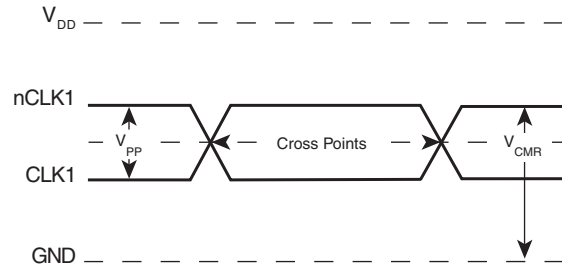
Measured at  $V_{DDO}/2$ .

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

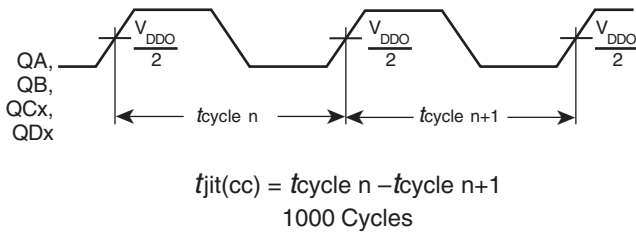
## PARAMETER MEASUREMENT INFORMATION



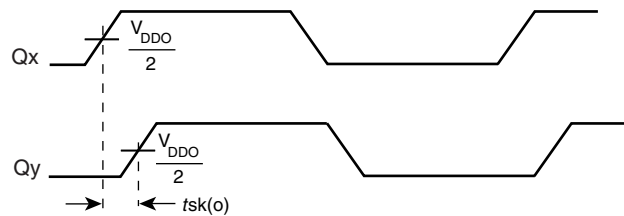
**3.3V OUTPUT LOAD AC TEST CIRCUIT**



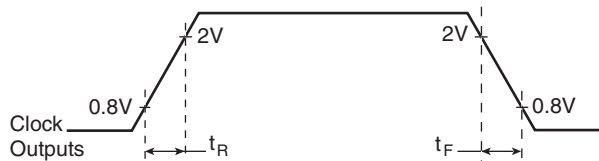
**DIFFERENTIAL INPUT LEVEL**



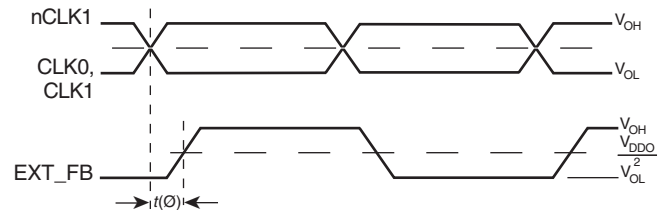
**CYCLE-TO-CYCLE JITTER**



**OUTPUT SKEW**



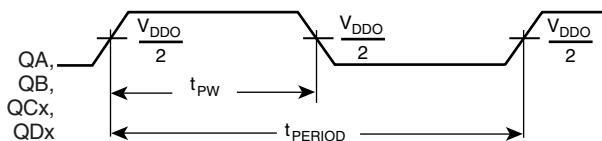
**OUTPUT RISE/FALL TIME**



$$t_{jit}(\emptyset) = |t(\emptyset) - t(\emptyset)_{mean}| = \text{Phase Jitter}$$

$$t(\emptyset)_{mean} = \text{Static Phase Offset}$$

(where t(∅) is any random sample, and t(∅) mean is the average of the sampled cycles measured on controlled edges)



**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**

**PHASE JITTER AND STATIC PHASE OFFSET**

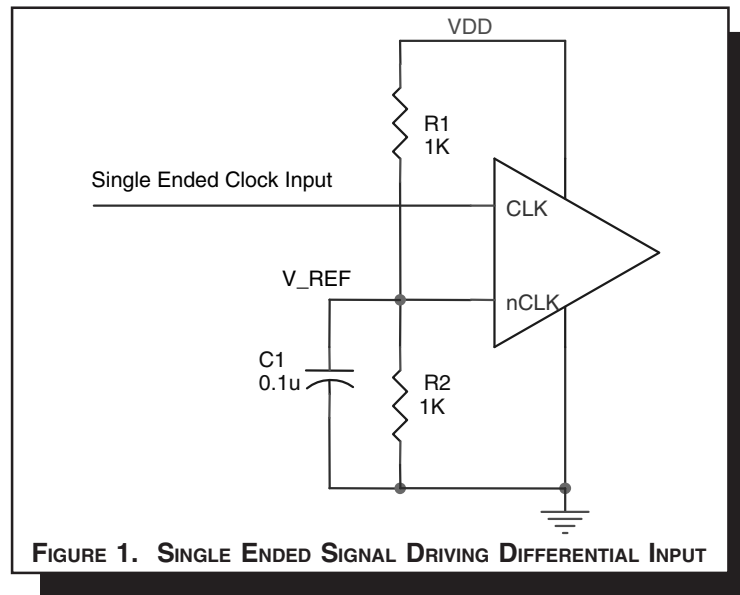
$$odc = \frac{t_{PW}}{t_{PERIOD}}$$

## APPLICATION INFORMATION

### WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

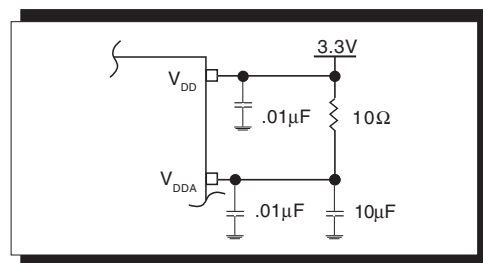
Figure 1 shows how the differential input can be wired to accept single ended levels. The reference voltage  $V_{REF} \approx V_{DD}/2$  is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio

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  $R2/R1 = 0.609$ .



### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS87951I provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DDA}$  and  $V_{DDO}$  should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. Figure 2 illustrates how a  $10\Omega$  resistor along with a  $10\mu F$  and a  $.01\mu F$  bypass capacitor should be connected to each  $V_{DDA}$  pin.



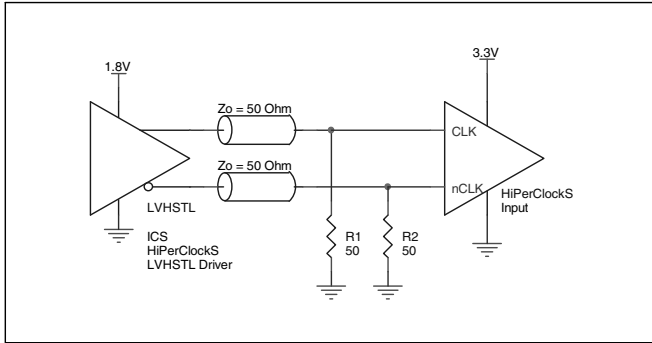
**FIGURE 2. POWER SUPPLY FILTERING**



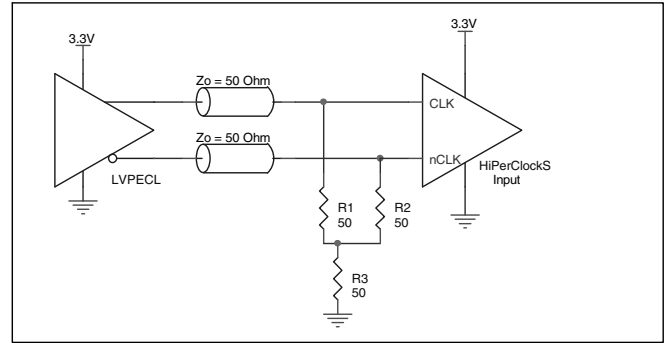
### DIFFERENTIAL CLOCK INPUT INTERFACE

The CLK1 /nCLK1 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 4A to 4D show interface examples for the CLK1/nCLK1 input driven by the most common driver types. The input interfaces suggested

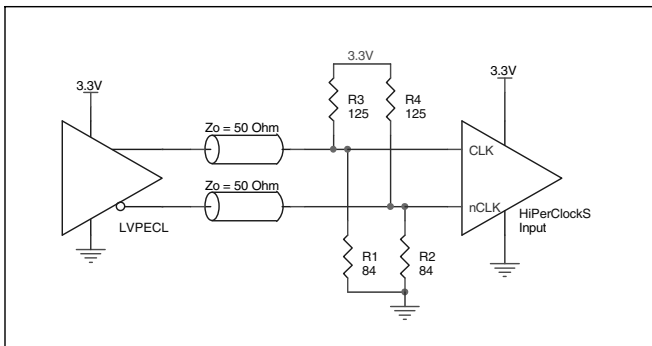
here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in *Figure 3A*, the input termination applies for LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



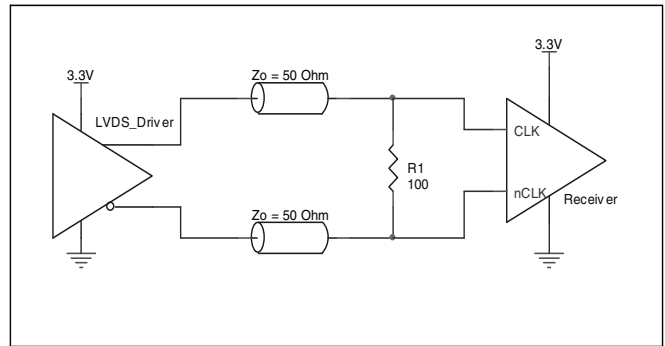
**FIGURE 3A. CLK/nCLK INPUT DRIVEN BY LVHSTL DRIVER**



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



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



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

### 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 1k $\Omega$  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 1k $\Omega$  resistor can be tied from CLK to ground.

##### LVC MOS 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 1k $\Omega$  resistor can be used.

#### OUTPUTS:

##### LVC MOS OUTPUT:

All unused LVC MOS output can be left floating. We recommend that there is no trace attached.



## RELIABILITY INFORMATION

TABLE 7.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 32 LEAD LQFP

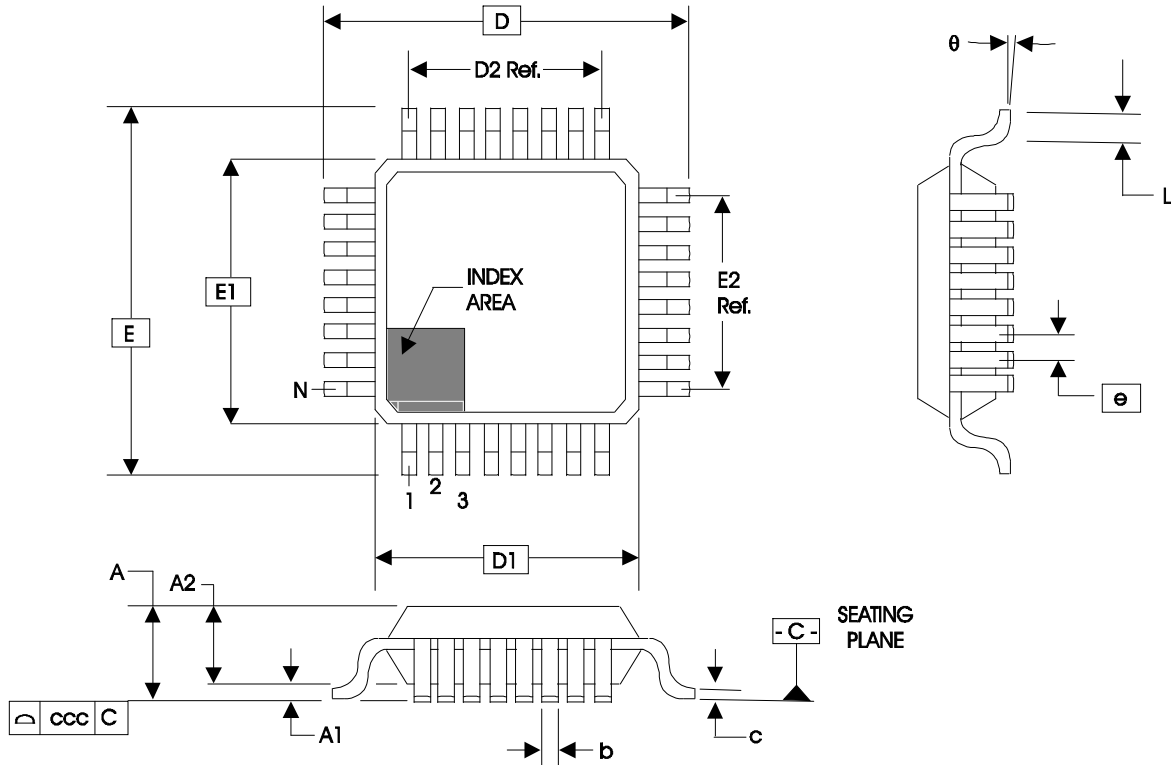
$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°C/W

**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 ICS879511 is: 2674

**PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP**



**TABLE 8. PACKAGE DIMENSIONS**

SYMBOL	JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS		
	BBA		
	MINIMUM	NOMINAL	MAXIMUM
N	32		
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
c	0.09	--	0.20
D	9.00 BASIC		
D1	7.00 BASIC		
D2	5.60 Ref.		
E	9.00 BASIC		
E1	7.00 BASIC		
E2	5.60 Ref.		
e	0.80 BASIC		
L	0.45	0.60	0.75
$\theta$	0°	--	7°
ccc	--	--	0.10

Reference Document: JEDEC Publication 95, MS-026



# ICS87951I

LOW SKEW, 1-TO-9  
DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
87951AYI	ICS87951AYI	32 Lead LQFP	tube	-40°C to 85°C
87951AYIT	ICS87951AYI	32 Lead LQFP	1000 tape & reel	-40°C to 85°C
87951AYILF	ICS87951AYIL	32 Lead "Lead-Free" LQFP	tube	-40°C to 85°C
87951AYILFT	ICS87951AYIL	32 Lead "Lead-Free" LQFP	1000 tape & reel	-40°C to 85°C

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

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**ICS879511**  
LOW SKEW, 1-TO-9  
DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

REVISION HISTORY SHEET				
Rev	Table	Page	Description of Change	Date
B	T1	3	Pin Description Table - revised MR/nOE description.	7/10/03
	T2	3	Pin Characteristics Table - changed $C_{IN}$ 4pf max. to 4pf typical. Added $R_{OUT}$ row.	
		5	DC Characteristics - changed $V_{IH}$ CLK0 from 3.6V max to $V_{DD} + 0.3V$ and added $V_{IL}$ CLK0 row.	
		8	Updated Single Ended Signal Driving Differential Input diagram.	
		9	Added CLK/nCLK Input Interface section.	
	T9	1	Features Section - added lead-free bullet.	11/23/05
		9	Added <i>Recommendations for Unused Input and Output Pins</i> .	
		12	Ordering Information Table - added lead-free part number, marking, and note.	
C	T9	12	Updated datasheet's header/footer with IDT from ICS.	7/17/10
		14	Removed ICS prefix from Part/Order Number column. Added Contact Page.	



**ICS87951I**  
LOW SKEW, 1-TO-9  
DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

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