



ICS87951I

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

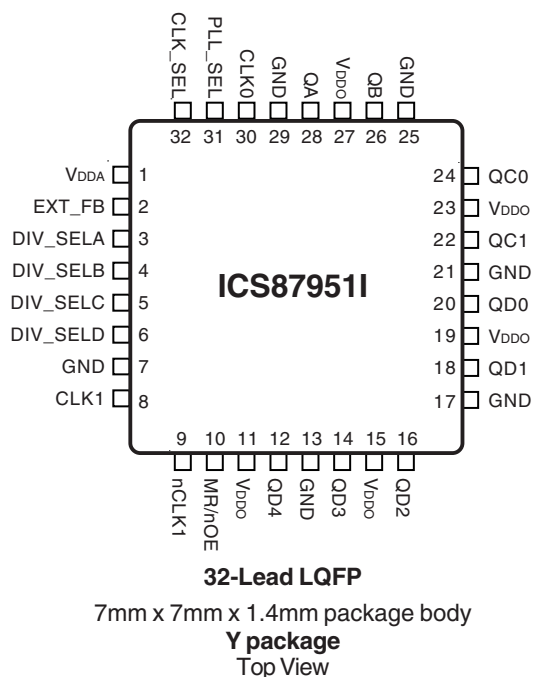
GENERAL DESCRIPTION

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°C to 85°C ambient operating temperature
- Available in both standard and lead-free RoHS-compliant packages

PIN ASSIGNMENT





The diagram illustrates the PLL and Frequency Divider circuit. It includes the following components and connections:

- Inputs:**
 - DIV_SELA:** Internal Pulldown. Connected to the $\div 2$ divider.
 - PLL_SEL:** Internal Pulldown. Connected to the $\div 4$ divider.
 - CLK0:** Internal Pulldown. Connected to the $\div 8$ divider.
 - CLK_SEL:** Internal Pulldown. Connected to the $\div 2$ divider.
 - nCLK1:** Inverted input to the Phase Detector.
 - CLK1:** Input to the Phase Detector.
 - EXT_FB:** Internal Pullup. Connected to the feedback path.
 - DIV_SELB:** Internal Pulldown. Connected to the $\div 2$ divider.
 - DIV_SELC:** Internal Pulldown. Connected to the $\div 4$ divider.
 - MR/nOE:** Internal Pulldown. Connected to the $\div 8$ divider.
 - DIV_SELD:** Internal Pulldown. Connected to the $\div 2$ divider.
- Core Components:**
 - PHASE DETECTOR:** Receives nCLK1 and CLK1. Its output goes to the VCO.
 - VCO (200-480MHz):** Receives the Phase Detector output and provides a feedback signal to the Phase Detector.
 - LPF (Low Pass Filter):** Receives the VCO output and provides a feedback signal to the Phase Detector.
- Dividers and Multiplexers:**
 - A $\div 2$ divider receives the VCO output and the output of the $\div 4$ divider.
 - A $\div 4$ divider receives the VCO output and the output of the $\div 8$ divider.
 - A $\div 8$ divider receives the VCO output and the output of the $\div 2$ divider.
 - Three 2-to-1 multiplexers select between the outputs of the $\div 2$, $\div 4$, and $\div 8$ dividers based on the DIV_SELA, PLL_SEL, and CLK_SEL inputs.
- Outputs:**
 - QA, QB, QC0, QC1, QD0, QD1, QD2, QD3, QD4:** The outputs of the multiplexers, each followed by an inverter.
- Power-On Reset:** A block that receives the MR/nOE input and provides a reset signal to the Phase Detector.



ICS879511

LOW SKEW, 1-TO-9

DIFFERENTIAL-TO-LVCMOS/LVTTL ZERO DELAY BUFFER

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1	V _{DDA}	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 _{DDO}	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 _{IN}	Input Capacitance			4		pF
C _{PD}	Power Dissipation Capacitance (per output)	V _{DDA} , V _{DDO} = 3.47V		25		pF
R _{PULLUP}	Input Pullup Resistor			51		KΩ
R _{PULLDOWN}	Input Pulldown Resistor			51		KΩ
R _{OUT}	Output Impedance		5	7	12	Ω



ICS87951I

Low SKEW, 1-TO-9
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TABLE 3A. OUTPUT CONTROL PIN FUNCTION TABLE

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



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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, θ_{JA}	42.1°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, $V_{DDA} = V_{DDO} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ 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				± 120	μA

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
$t(\phi)$	Static Phase Offset; NOTE 1,3	CLK0	$f_{REF} = 50MHz$ Feedback = VCO/8	15	165	ps
		CLK1, nCLK1		-265	-95	ps
$t_{sk(o)}$	Output Skew; NOTE 2, 3	Same Frequencies			375	ps
		Different Frequencies			500	ps
		QA $f_{MAX} < 150MHz$ QA $f_{MAX} > 150MHz$			750	ps
$f_{jit(cc)}$	Cycle-to-Cycle Jitter; NOTE 3			± 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.

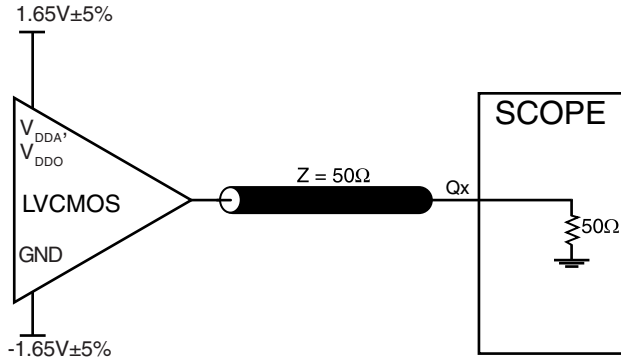


ICS879511

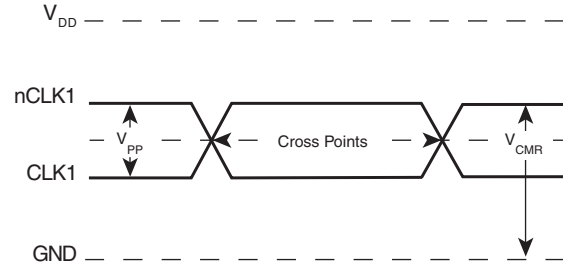
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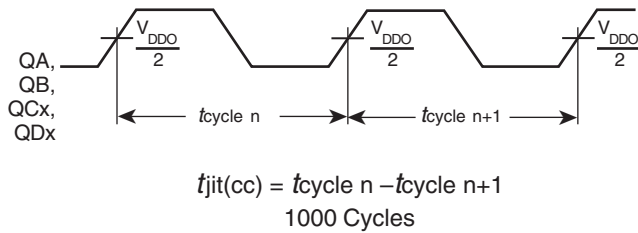
PARAMETER MEASUREMENT INFORMATION



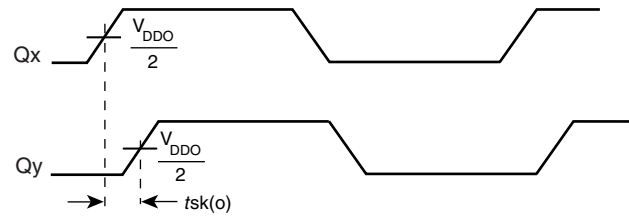
3.3V OUTPUT LOAD AC TEST CIRCUIT



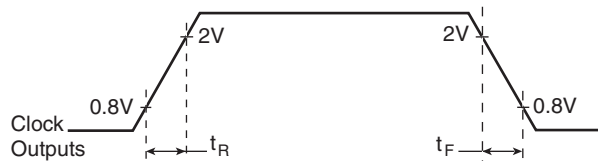
DIFFERENTIAL INPUT LEVEL



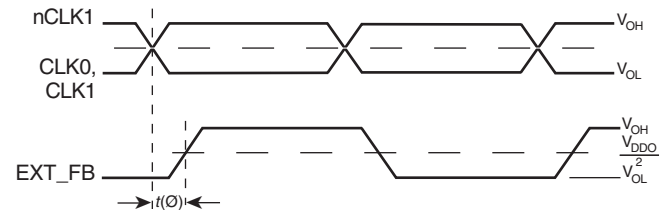
CYCLE-TO-CYCLE JITTER



OUTPUT SKEW



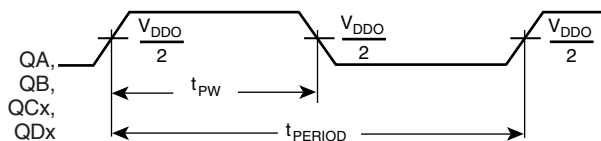
OUTPUT RISE/FALL TIME



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

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

(where $t(\phi)$ is any random sample, and $t(\phi)_{mean}$ is the average of the sampled cycles measured on controlled edges)



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

OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

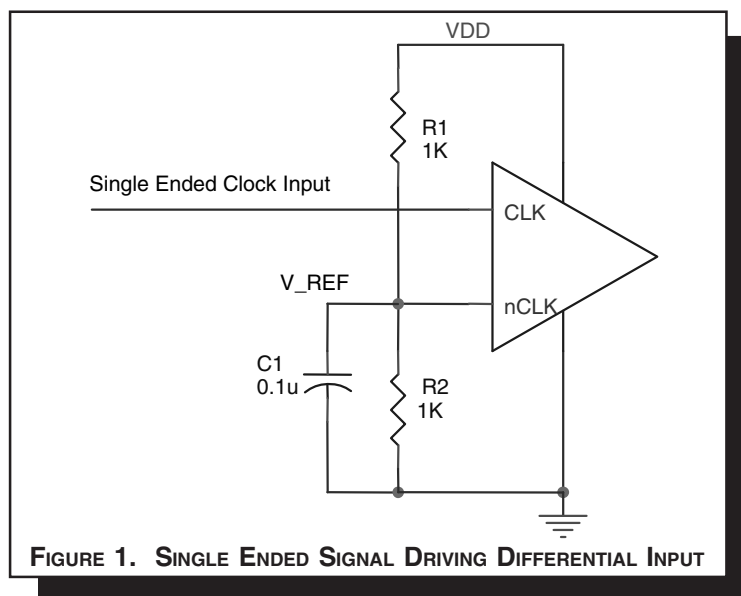
PHASE JITTER AND STATIC PHASE OFFSET

APPLICATION INFORMATION

WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

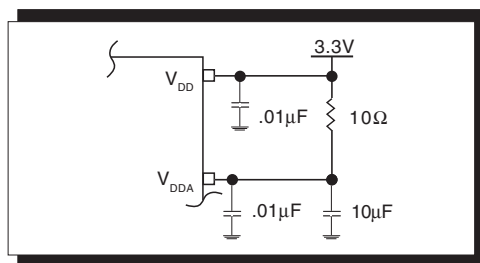
Figure 1 shows how the differential input can be wired to accept single ended levels. The reference voltage $V_{REF} \approx V_{DD}/2$ is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio

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 10Ω resistor along with a $10\mu F$ and a $.01\mu F$ bypass capacitor should be connected to each V_{DDA} pin.



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.

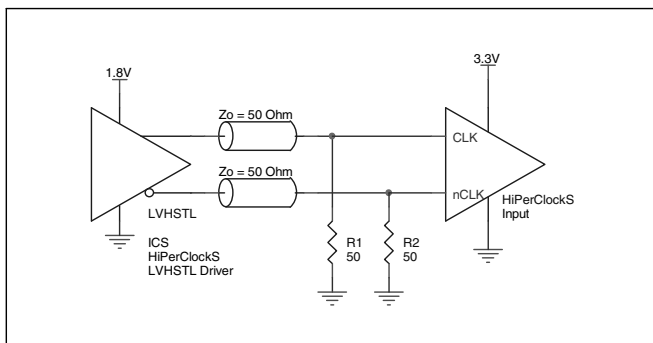


FIGURE 3A. CLK/nCLK INPUT DRIVEN BY LVHSTL DRIVER

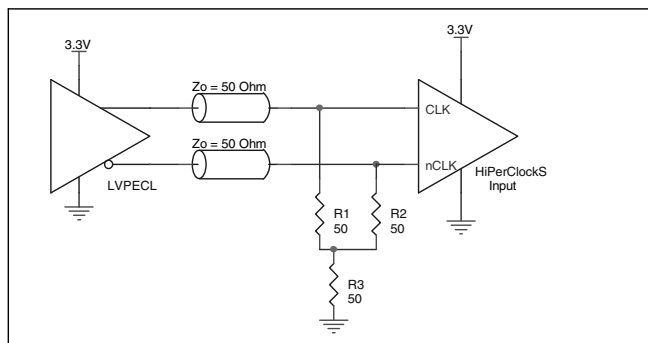


FIGURE 3B. CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

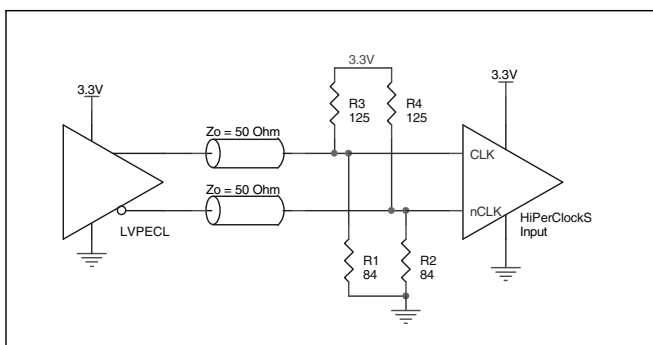


FIGURE 3C. CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

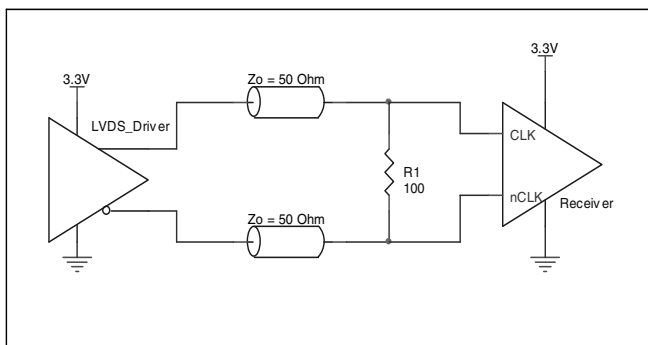


FIGURE 3D. CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER

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 Ω 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 Ω 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 1k Ω resistor can be used.

OUTPUTS:

LVCMOS OUTPUT:

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



RELIABILITY INFORMATION

TABLE 7. θ_{JA} VS. AIR FLOW TABLE FOR 32 LEAD LQFP

θ_{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 ICS87951I is: 2674



ICS879511

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PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

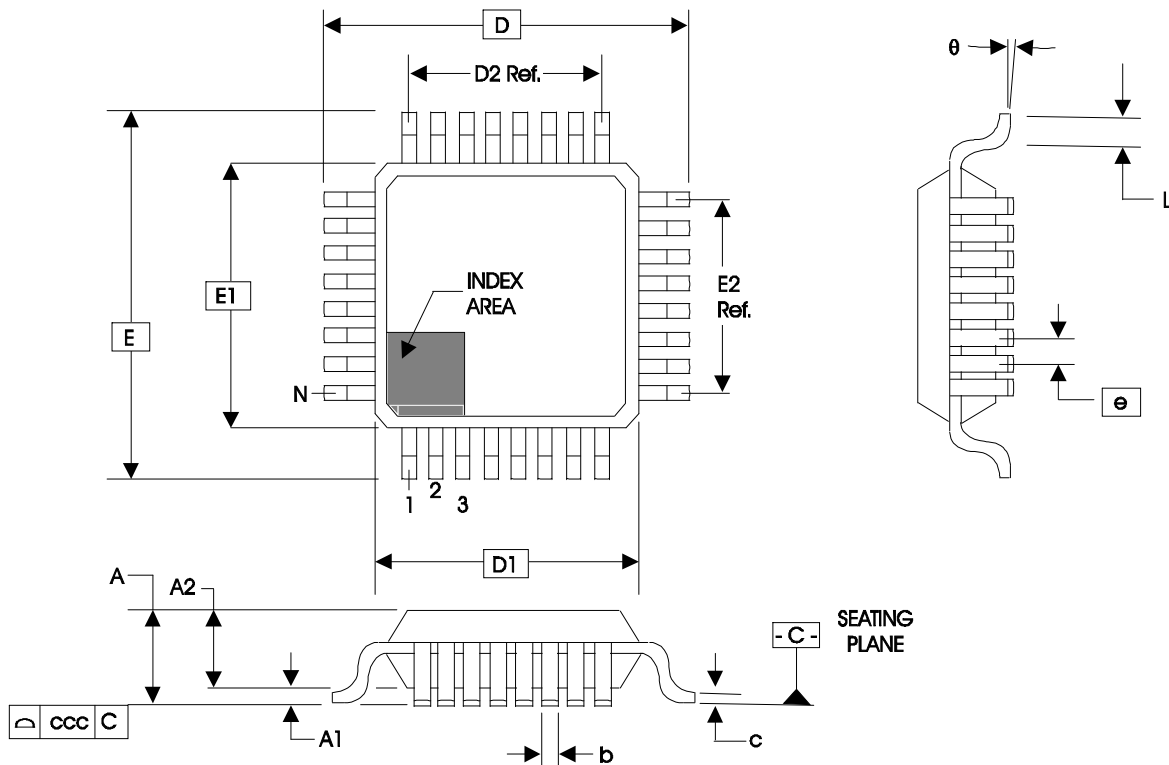


TABLE 8. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	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
θ	0°	--	7°
ccc	--	--	0.10

Reference Document: JEDEC Publication 95, MS-026



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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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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.	



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We've Got Your Timing Solution.



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