ICS87951I

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

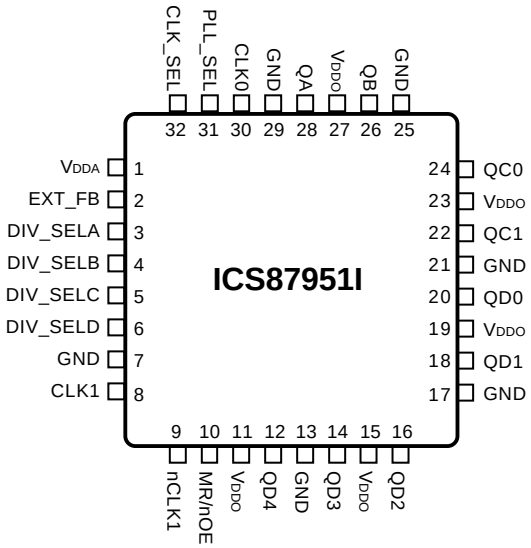
GENERAL DESCRIPTION

The ICS87951I is a low voltage, low skew 1-to-9 Differential-to-LVCMOS/LVTTL Cock Generator and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. 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
- 9 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: ±100ps (typical)
- Output skew: 375ps (maximum)
- PLL reference zero delay: 350ps window (maximum)
- 3.3V operating supply
- -40°C to 85°C ambient operating temperature
- Pin compatible with the MPC951

PIN ASSIGNMENT



32-Lead LQFP

7mm x 7mm x 1.4mm package body

Y package

Top View

BLOCK DIAGRAM

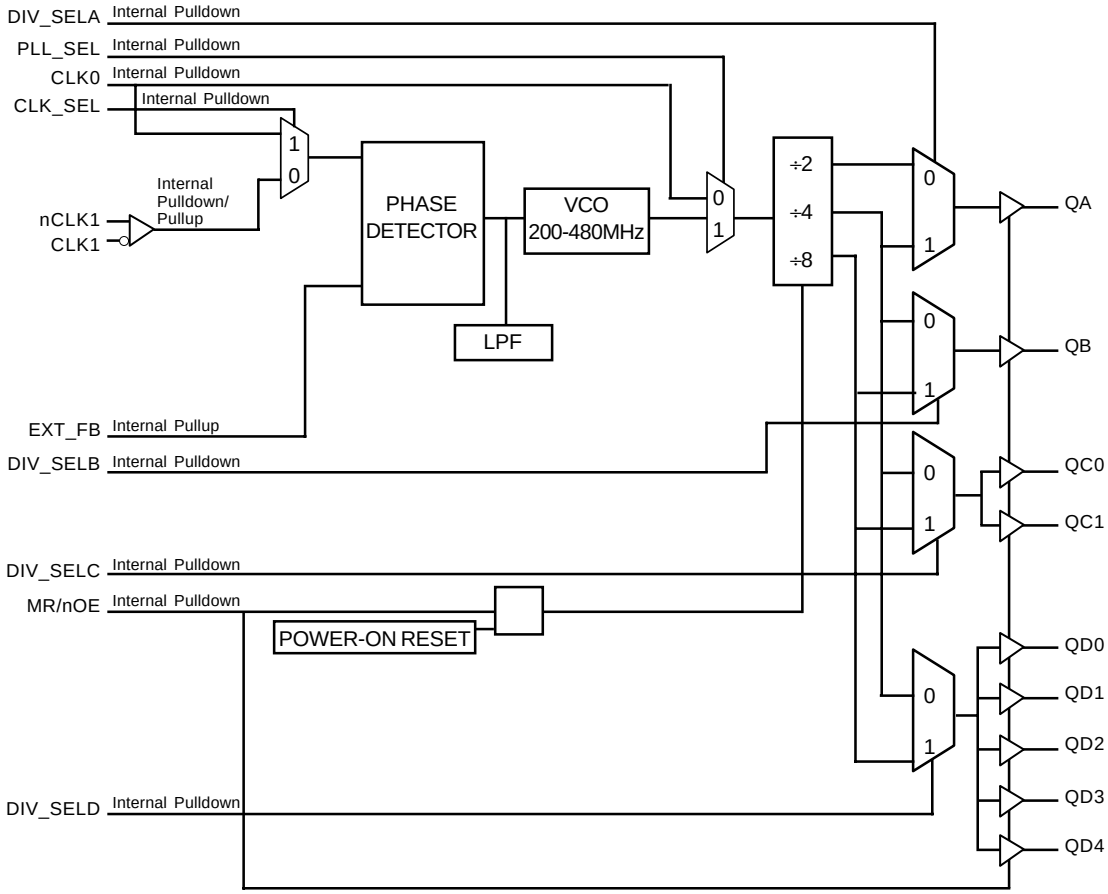


TABLE 1. PIN DESCRIPTIONS

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

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

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to V_{DDA} + 0.5 V
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°C TO 85°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°C TO 85°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.

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

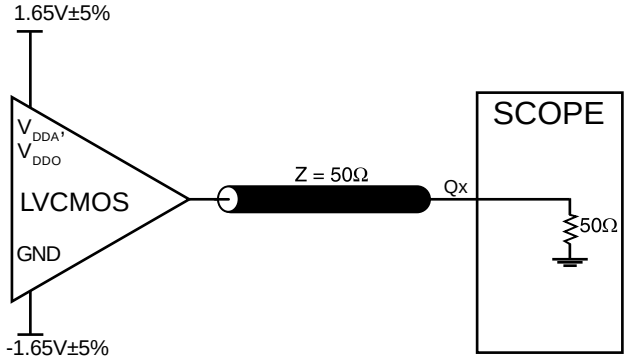
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{REF}	Input Reference Frequency				100	MHz

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

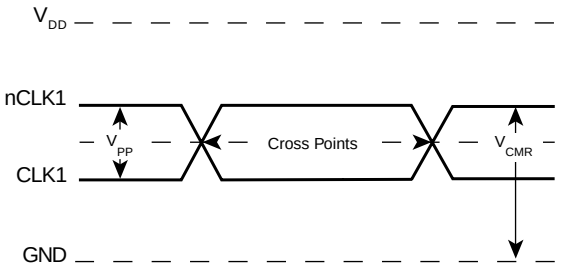
Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency		QA ÷2			180	MHz
			QA/QB ÷4			120	MHz
			QB ÷8			60	MHz
f_{VCO}	PLL VCO Lock Range			200		480	MHz
t(Ø)	Static Phase Offset; NOTE 1,3	CLK0	fREF = 50MHz Feedback = VCO/8	-185	15	165	ps
		CLK1, nCLK1		-445	-265	-95	ps
*t*sk(o)	Output Skew; NOTE 2, 3		Same Frequencies			375	ps
			Different Frequencies QAf_{MAX} < 150MHz QAf_{MAX} > 150MHz			 500 750	 ps ps
*t*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.

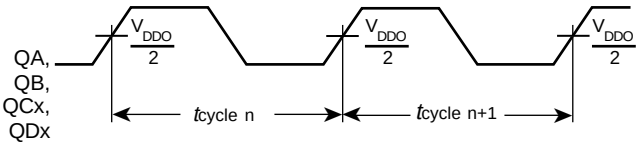
PARAMETER MEASUREMENT INFORMATION



3.3V OUTPUT LOAD AC TEST CIRCUIT



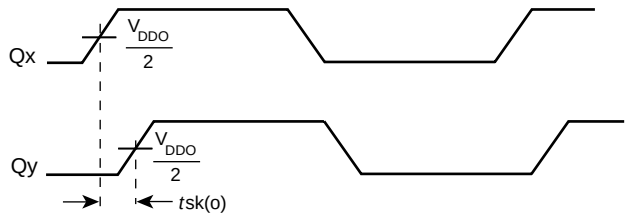
DIFFERENTIAL INPUT LEVEL



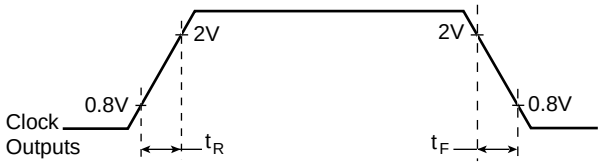
$t_{jit(cc)} = t_{cycle\ n} - t_{cycle\ n+1}$

1000 Cycles

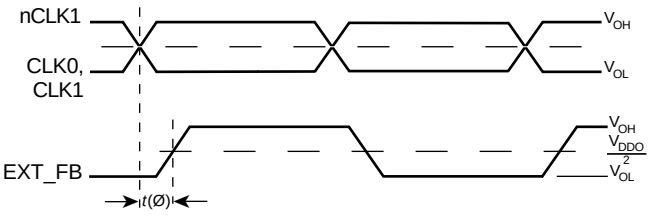
CYCLE-TO-CYCLE JITTER



OUTPUT SKEW



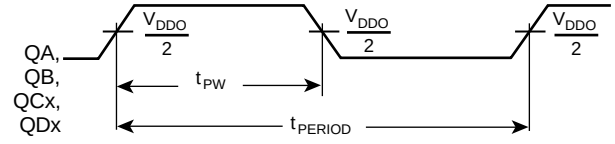
OUTPUT RISE/FALL TIME



$t_{jit(Ø)} = \left| t(Ø) - t(Ø)_{mean} \right|$ = Phase Jitter

$t(Ø)_{mean}$ = Static Phase Offset

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



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

t_{PW} & t_{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 ~ 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.

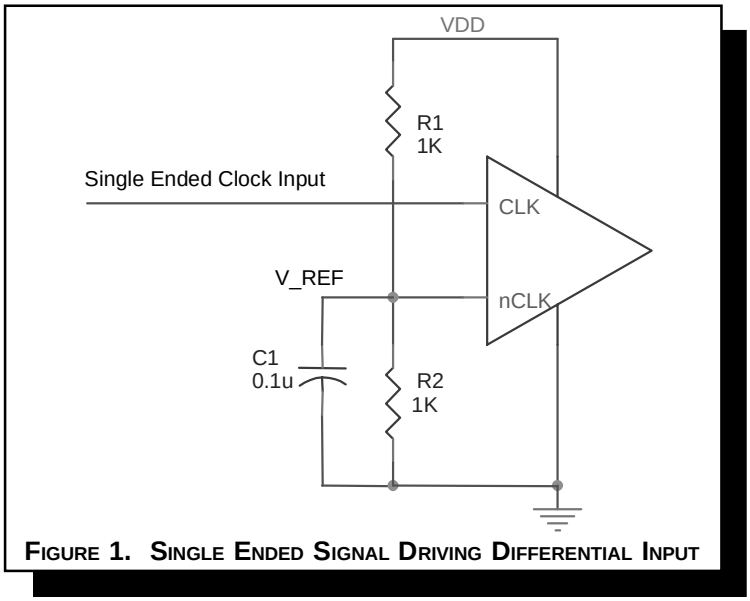


FIGURE 1. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT

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 10µF and a .01µF bypass capacitor should be connected to each V_{DDA} pin.

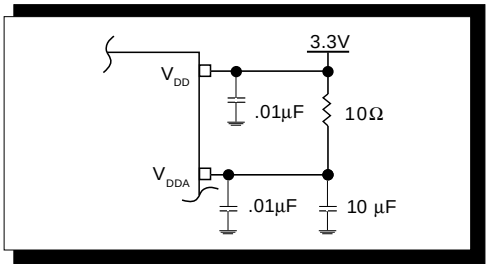


FIGURE 2. POWER SUPPLY FILTERING

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 HiPerClockS 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 ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.

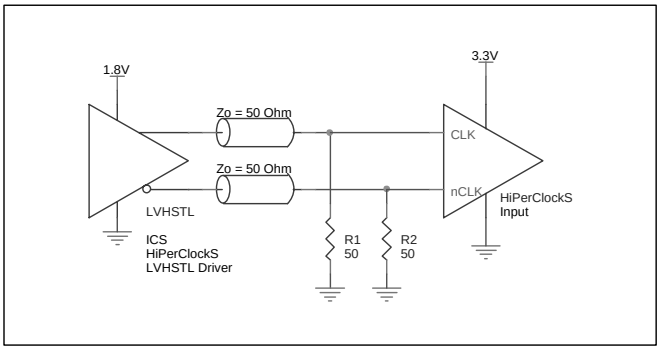


FIGURE 3A. HIPERCLOCKS CLK/NCLK INPUT DRIVEN BY ICS HIPERCLOCKS LVHSTL DRIVER

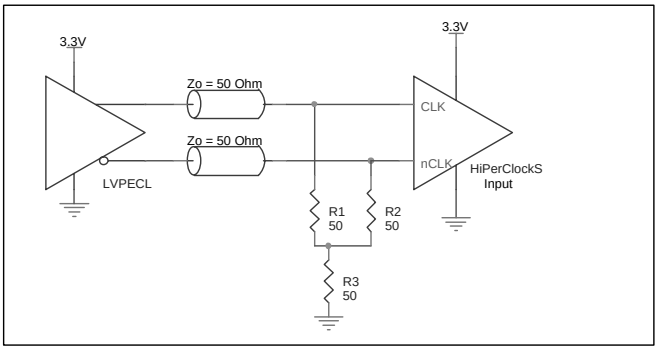


FIGURE 3B. HIPERCLOCKS CLK/NCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

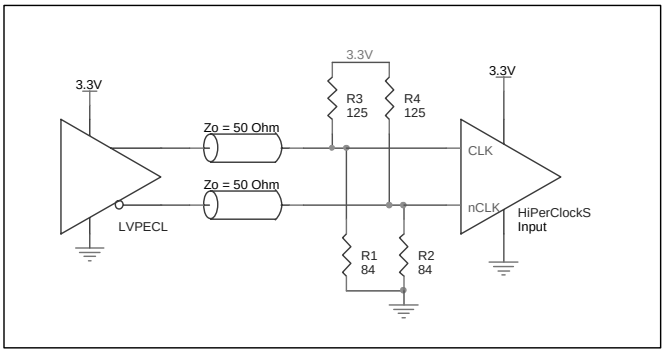


FIGURE 3C. HIPERCLOCKS CLK/NCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

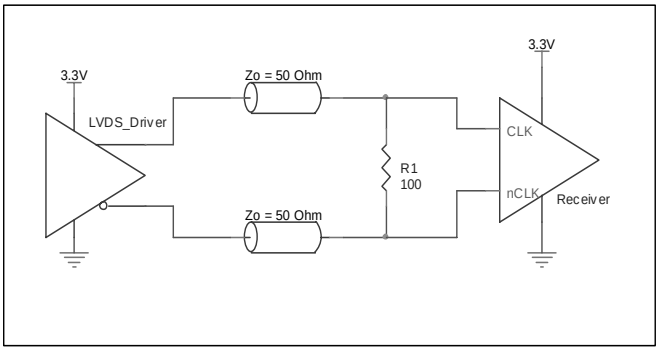


FIGURE 3D. HIPERCLOCKS CLK/NCLK INPUT DRIVEN BY 3.3V LVDS DRIVER

RELIABILITY INFORMATION

TABLE 7. θ_{JA} VS. AIR FLOW TABLE

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

PACKAGE OUTLINE - Y SUFFIX

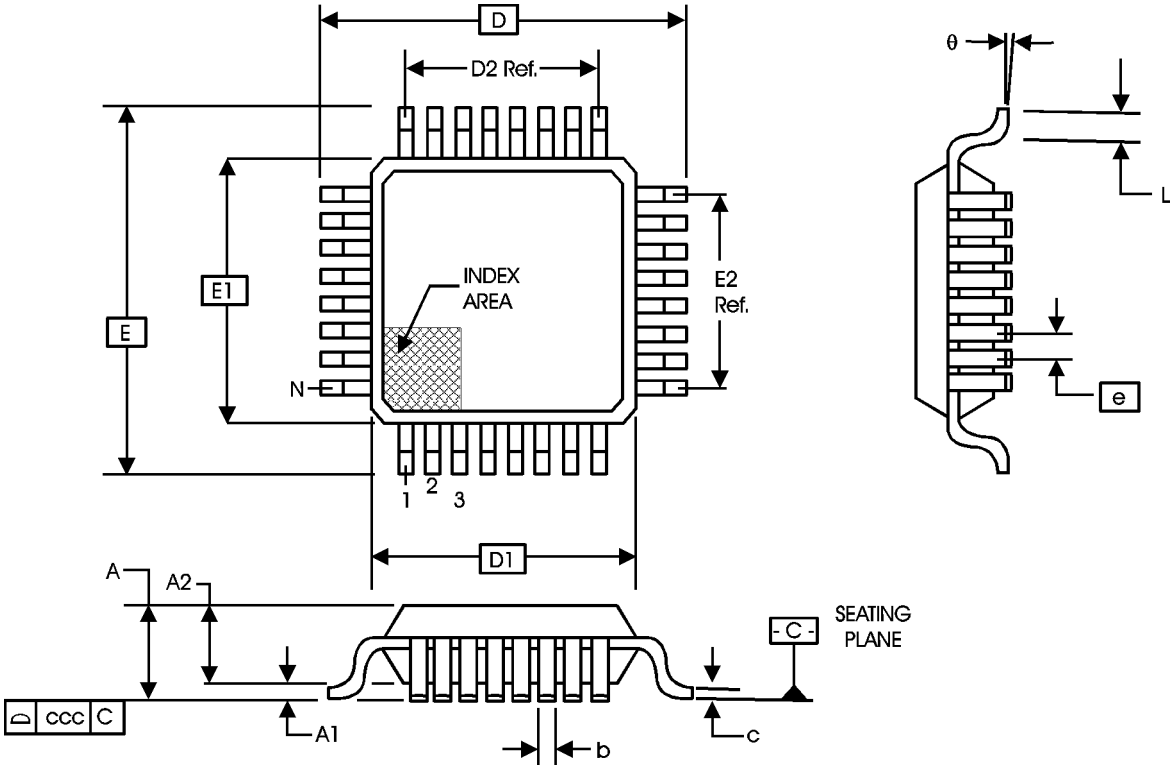


TABLE 8. PACKAGE DIMENSIONS

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

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Count	Temperature
ICS87951AYI	ICS87951AYI	32 Lead LQFP	250 per tray	-40°C to 85°C
ICS87951AYIT	ICS87951AYI	32 Lead LQFP on Tape and Reel	1000	-40°C to85°C

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.	