Integrated
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Systems, Inc.

ICS87332I-01
÷2 Differential-to-2.5V/3.3V ECL/LVPECL Clock Generator

General Description

The ICS87332I-01 is a high performance ÷2 Differential-to-2.5V/3.3V ECL/LVPECL Clock Generator and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The CLK, nCLK pair can accept most standard differential input levels The ICS87332I-01 is characterized to operate from either a 2.5V or a 3.3V power supply. Guaranteed output and part-to-part skew characteristics make the ICS87332I-01 ideal for those clock distribution applications demanding well defined performance and repeatability.

Features

- One ÷2 differential 2.5V/3.3V LVPECL / ECL output

- One CLK, nCLK input pair

- CLK, nCLK pair can accept the following differential input levels: LVDS, LVPECL, LVHSTL, SSTL, HCSL

- Maximum output frequency: 500MHz

- Maximum input frequency: 1GHz

- Translates any single ended input signal to 3.3V LVPECL levels with resistor bias on nCLK input

- Part-to-part skew: 400ps (maximum)

- Propagation delay: 1.6ns (maximum)

- LVPECL mode operating voltage supply range: V_{CC} = 2.375V to 3.8V, V_{EE} = 0V

- ECL mode operating voltage supply range: V_{CC} = 0V, V_{EE} = -2.375V to -3.8V

- -40°C to 85°C ambient operating temperature

- Lead-Free package fully RoHS compliant

Block Diagram

Pin Assignment

MR	1	8	Vcc
CLK	2	7	Q
nCLK	3	6	nQ
nc	4	5	V_{EE}
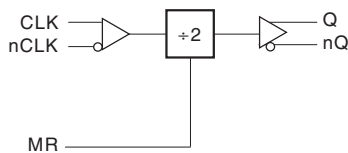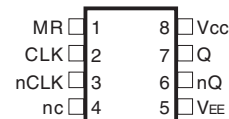
ICS87332I-01
8-Lead SOIC
3.90mm x 4.90mm x 1.37mm package body
M Package
Top View

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1	MR	Input	Pulldown	Master reset. When LOW, outputs are enabled. When HIGH, divider is reset forcing Q output LOW and nQ output HIGH. LVCMOS / LVTTL interface level.
2	CLK	Input	Pulldown	Non-inverting differential clock input.
3	nCLK	Input	Pullup	Inverting differential clock input.
4	nc	Unused		No connect.
5	V_{EE}	Power		Negative supply pin.
6, 7	Q, nQ	Output		Differential output pair. LVPECL interface levels.
8	V_{CC}	Power		Positive supply pin.

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

TABLE 2. PIN CHARACTERISTICS

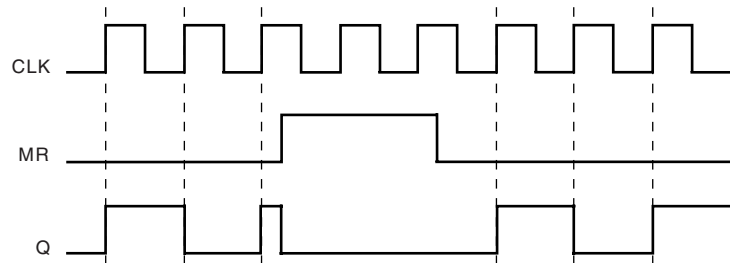| Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C_{IN}	Input Capacitance			4		pF
R_{PULLUP}	Input Pullup Resistor			51		kΩ
$R_{PULLDOWN}$	Input Pulldown Resistor			51		kΩ

FIGURE 1. TIMING DIAGRAM

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} 4.6V

Inputs, V_I -0.5V to V_{CC} + 0.5 V

Outputs, I_O
  Continuous Current   50mA
  Surge Current   100mA

Package Thermal Impedance, θ_{JA} 112.7°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 3A. POWER SUPPLY DC CHARACTERISTICS, V_{CC} = 2.375V TO 3.8V, V_{EE} = 0, T_A = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Positive Supply Voltage		2.375	3.3	3.8	V
I_{EE}	Power Supply Current				30	mA

TABLE 3B. LVCMOS DC CHARACTERISTICS, V_{CC} = 2.375V TO 3.8V, V_{EE} = 0, T_A = -40°C TO 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage	MR		2		V_{CC} + 0.3	V
V_{IL}	Input Low Voltage	MR		-0.3		0.8	V
I_{IH}	Input High Current	MR	V_{CC} = V_{IN} = 3.8V			150	µA
I_{IL}	Input Low Current	MR	V_{CC} = 3.8V, V_{IN} = 0V	-5			µA

TABLE 3C. DIFFERENTIAL DC CHARACTERISTICS, V_{CC} = 2.375V TO 3.8V, V_{EE} = 0, T_A = -40°C TO 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input High Current	CLK	V_{CC} = V_{IN} = 3.8V			150	µA
		nCLK	V_{CC} = V_{IN} = 3.8V			5	µA
I_{IL}	Input Low Current	CLK	V_{CC} = 3.8V, V_{IN} = 0V	-5			µA
		nCLK	V_{CC} = 3.8V, V_{IN} = 0V	-150			µA
V_{PP}	Peak-to-Peak Input Voltage			0.15		1.3	V
V_{CMR}	Common Mode Input Voltage; NOTE 1, 2			V_{EE} + 0.5		V_{CC} - 0.85	V

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

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TABLE 3D. LVPECL DC CHARACTERISTICS, V_{CC} = 2.375V TO 3.8V, V_{EE} = 0, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OH}	Output High Voltage; NOTE 1		V_{CC} - 1.4		V_{CC} - 0.9	V
V_{OL}	Output Low Voltage; NOTE 1		V_{CC} - 2.0		V_{CC} - 1.7	V
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.65		1.0	V

NOTE 1: Outputs terminated with 50Ω to V_{CC} - 2V.

TABLE 4. AC CHARACTERISTICS, V_{CC} = 2.375V TO 3.8V, V_{EE} = 0, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Input Frequency				1	GHz
t_{PD}	Propagation Delay; NOTE 1	$f \leq$ 1GHz	1.1	1.4	1.6	ns
$t$sk(pp)	Part-to-Part Skew; NOTE 2, 3				400	ps
t_R	Output Rise Time	20% to 80%	200		700	ps
t_F	Output Fall Time	20% to 80%	200		700	ps
odc	Output Duty Cycle		49		51	%

All parameters measured at 500MHz unless noted otherwise.
NOTE 1: Measured from the differential input crossing point to the differential output crossing point.
NOTE 2: Defined as skew between outputs on different devices operating at the same supply voltages
and with equal load conditions. Using the same type of inputs on each device, the outputs are measured
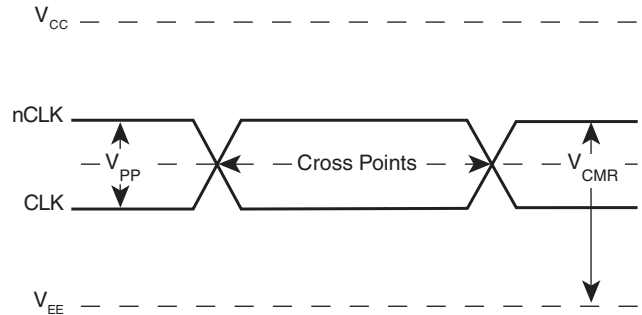at the differential cross points.
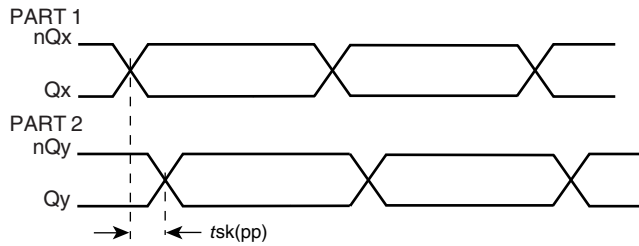NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.
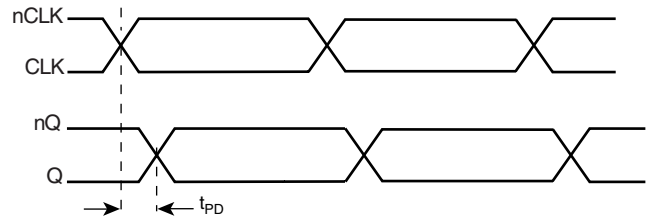
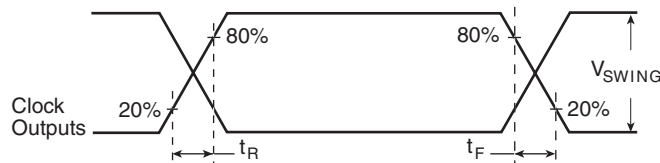# PARAMETER MEASUREMENT INFORMATION
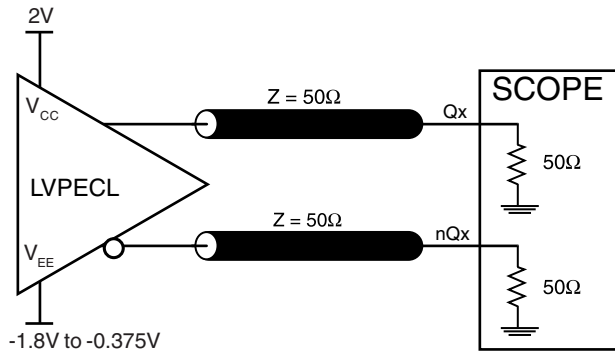
3.3V OUTPUT LOAD AC TEST CIRCUIT

DIFFERENTIAL INPUT LEVEL

PART-TO-PART SKEW

PROPAGATION DELAY

OUTPUT RISE/FALL TIME

$$odc = \frac{t_{PW}}{t_{PERIOD}} \times 100\%$$
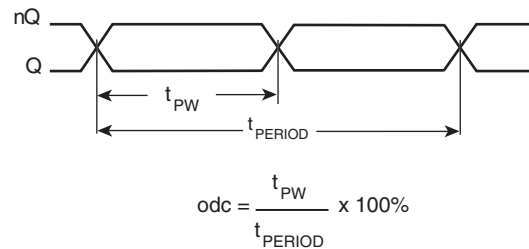
**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**

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_{CC}/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_{CC} = 3.3V, V_REF should be 1.25V and R2/R1 = 0.609.

FIGURE 2. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT
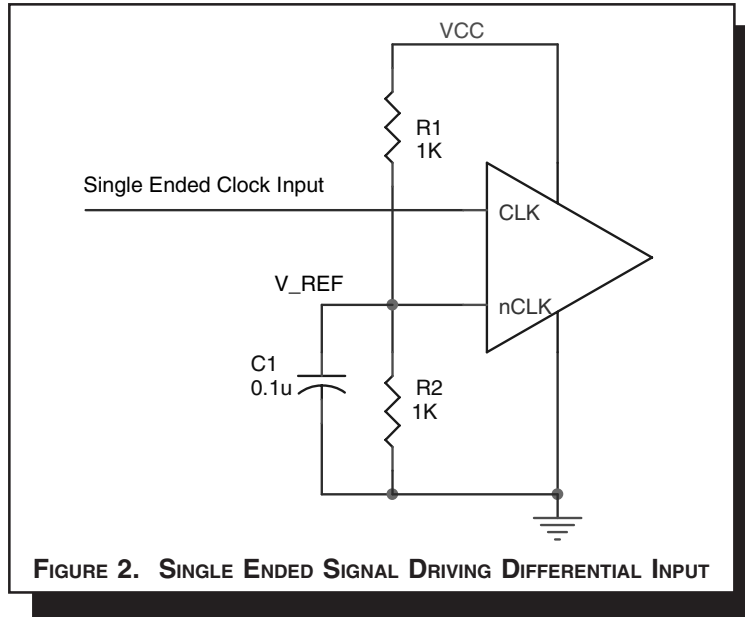
TERMINATION FOR 3.3V LVPECL OUTPUT

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

FOUT and nFOUT are low impedance follower outputs that generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to drive 50Ω transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 3A and 3B* show two different layouts which are recommended only as guidelines. Other suitable clock layouts may exist and it would be recommended that the board designers simulate to guarantee compatibility across all printed circuit and clock component process variations.
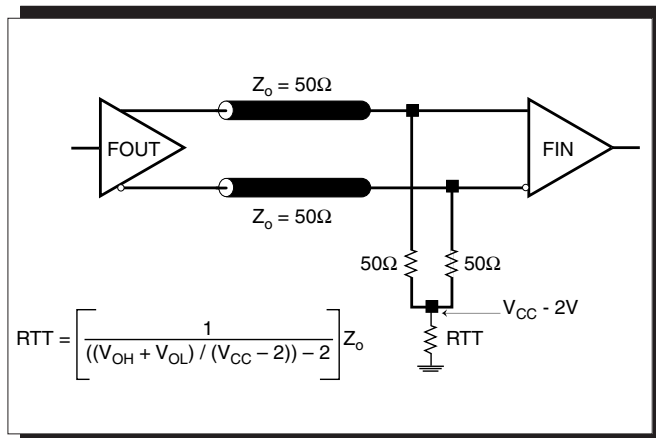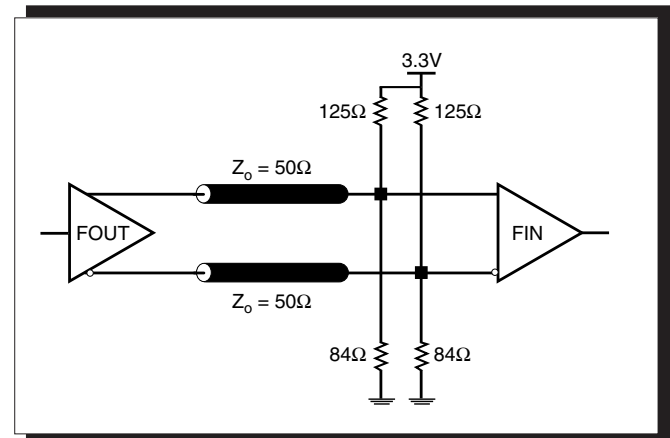

$$RTT = \left[\frac{1}{((V_{OH} + V_{OL}) / (V_{CC} - 2)) - 2} \right] Z_o$$

FIGURE 3A. LVPECL OUTPUT TERMINATION

FIGURE 3B. LVPECL OUTPUT TERMINATION

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TERMINATION FOR 2.5V LVPECL OUTPUT

Figure 4A and *Figure 4B* show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating 50Ω to V_{CC} - 2V. For V_{CC} = 2.5V, the V_{CC} - 2V is very close to

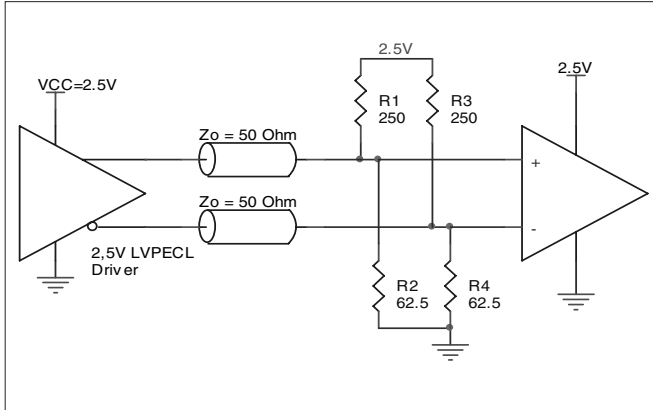ground level. The R3 in Figure 4B can be eliminated and the termination is shown in *Figure 4C.*

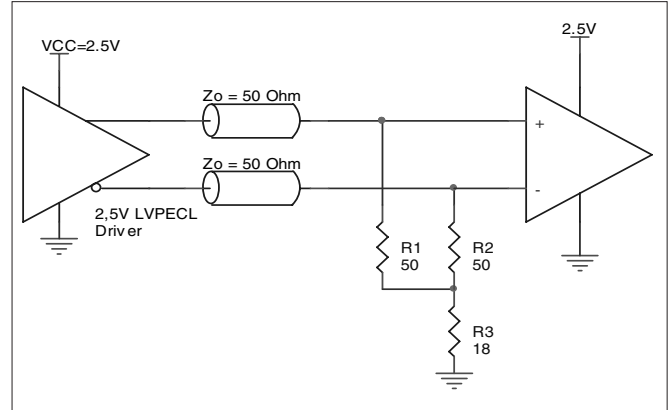
FIGURE 4A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

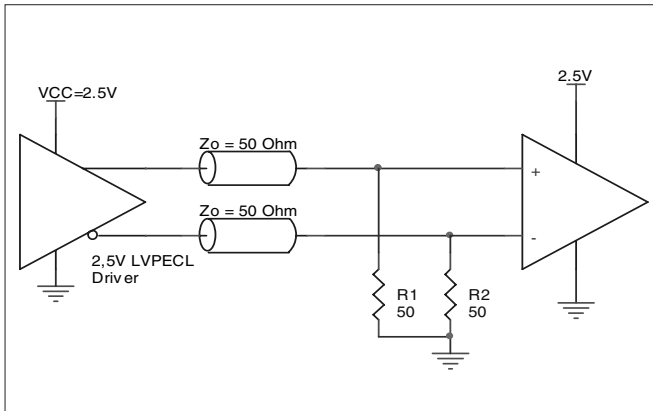**FIGURE 4B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE**

FIGURE 4C. 2.5V LVPECL TERMINATION EXAMPLE

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 5A to 5E 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 5A,* the input termination applies for ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.
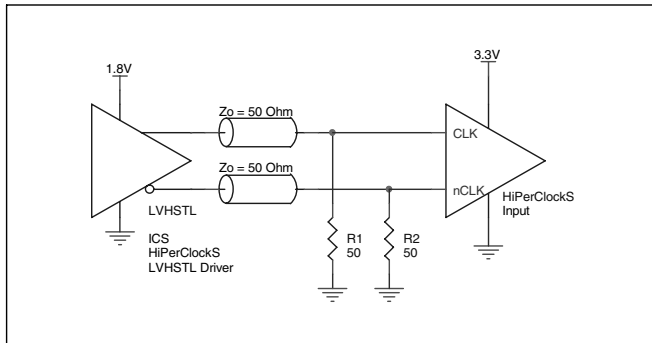

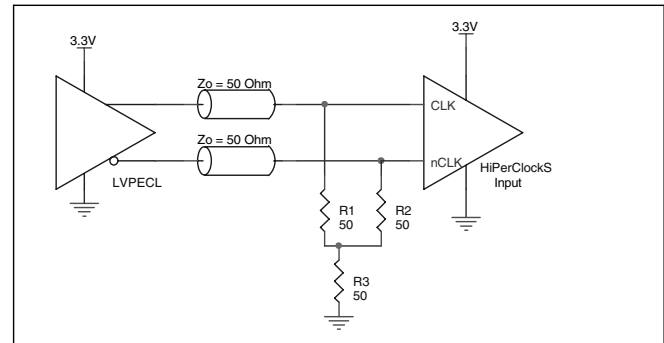**FIGURE 5A. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY ICS HIPERCLOCKS LVHSTL DRIVER**

FIGURE 5B. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER
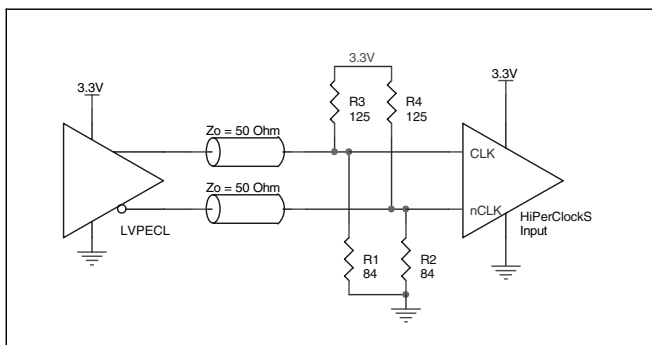

FIGURE 5C. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER
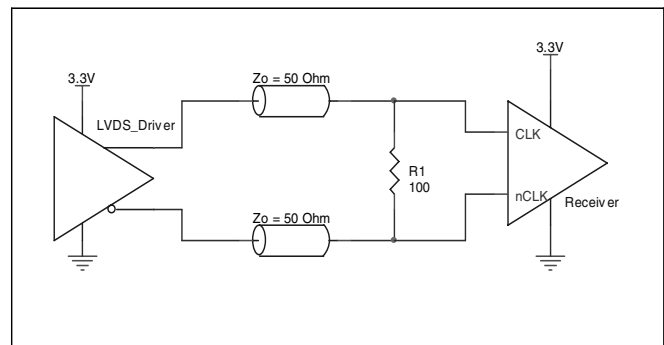

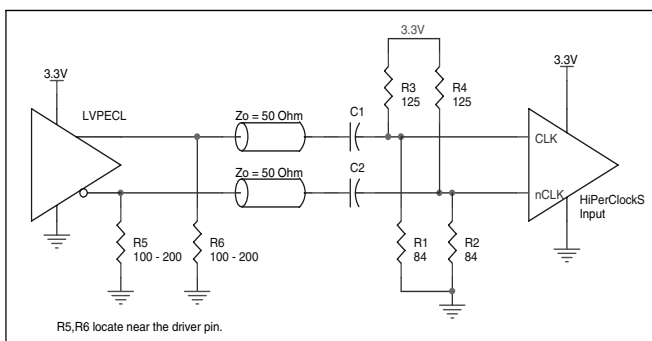**FIGURE 5D. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER**

FIGURE 5E. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER WITH AC COUPLE

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POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS87332I-01.
Equations and example calculations are also provided.

1. Power Dissipation.
The total power dissipation for the ICS87332I-01 is the sum of the core power plus the power dissipated in the load(s).
The following is the power dissipation for V_{CC} = 3.8V, which gives worst case results.
NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)$_{MAX}$ = V_{CC_MAX} * I_{EE_MAX} = 3.8V * 30mA = **114mW**

- Power (outputs)$_{MAX}$ = **30mW/Loaded Output pair**

    Total Power $_{MAX}$ (3.8V, with all outputs switching) = 114mW + 30mW = **144mW**

2. Junction Temperature.
Junction temperature, Tj, is the temperature at the junction of the bond wire and bond pad and directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS™ devices is 125°C.

   The equation for Tj is as follows: $Tj = \theta_{JA} * Pd\_total + T_A$

   Tj = Junction Temperature

   θ_{JA} = Junction-to-Ambient Thermal Resistance

   Pd_total = Total Device Power Dissipation (example calculation is in section 1 above)
   T_A = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance θ_{JA} must be used. Assuming a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 103.3°C/W per Table 5 below.

Therefore, Tj for an ambient temperature of 85°C with all outputs switching is:
   85°C + 0.144W * 103.3°C/W = 99.9°C. This is well below the limit of 125°C

This calculation is only an example. Tj will obviously vary depending on the number of loaded outputs, supply voltage, air flow, and the type of board (single layer or multi-layer).

TABLE 5. THERMAL RESISTANCE θ_{JA} FOR 8-PIN SOIC, FORCED CONVECTION

| θ_{JA} by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	153.3°C/W	128.5°C/W	115.5°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	112.7°C/W	103.3°C/W	97.1°C/W

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

3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

LVPECL output driver circuit and termination are shown in *Figure 6.*

FIGURE 6. LVPECL DRIVER CIRCUIT AND TERMINATION
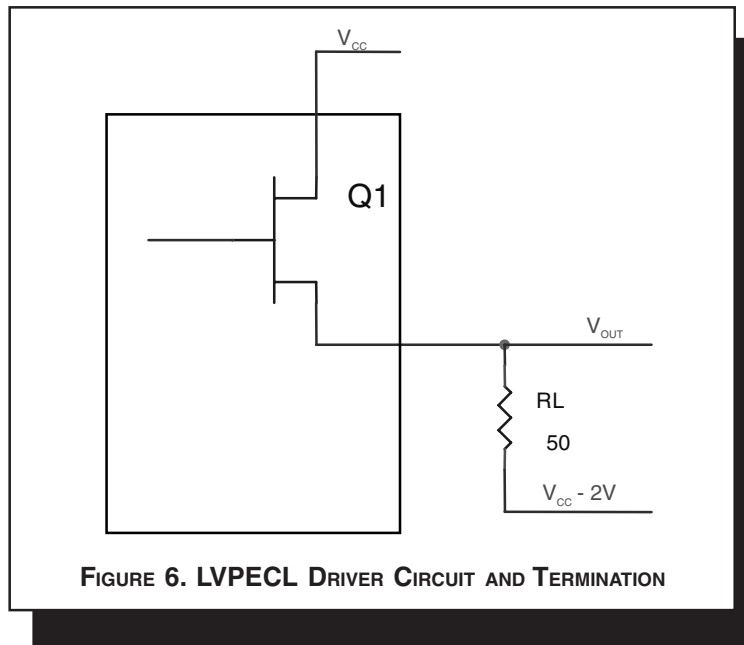
To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load, and a termination voltage of V_{CC} - 2V.

- For logic high, $V_{OUT} = V_{OH\_MAX} = \mathbf{V_{CC\_MAX} - 0.9V}$

  $(V_{CC\_MAX} - V_{OH\_MAX}) = \mathbf{0.9V}$

- For logic low, $V_{OUT} = V_{OL\_MAX} = \mathbf{V_{CC\_MAX} - 1.7V}$

  $(V_{CC\_MAX} - V_{OL\_MAX}) = \mathbf{1.7V}$

Pd_H is power dissipation when the output drives high.
Pd_L is the power dissipation when the output drives low.

$Pd\_H = [(V_{OH\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) =$
$[(2V - 0.9V)/50Ω] * 0.9V = \mathbf{19.8mW}$

$Pd\_L = [(V_{OL\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OL\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) =$
$[(2V - 1.7V)/50Ω] * 1.7V = \mathbf{10.2mW}$

Total Power Dissipation per output pair = Pd_H + Pd_L = **30mW**

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RELIABILITY INFORMATION

TABLE 6. θ_{JA} VS. AIR FLOW TABLE

θ_{JA} by Velocity (Linear Feet per Minute)			
	0	**200**	**500**
Single-Layer PCB, JEDEC Standard Test Boards	153.3°C/W	128.5°C/W	115.5°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	112.7°C/W	103.3°C/W	97.1°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 ICS87332I-01 is: 383
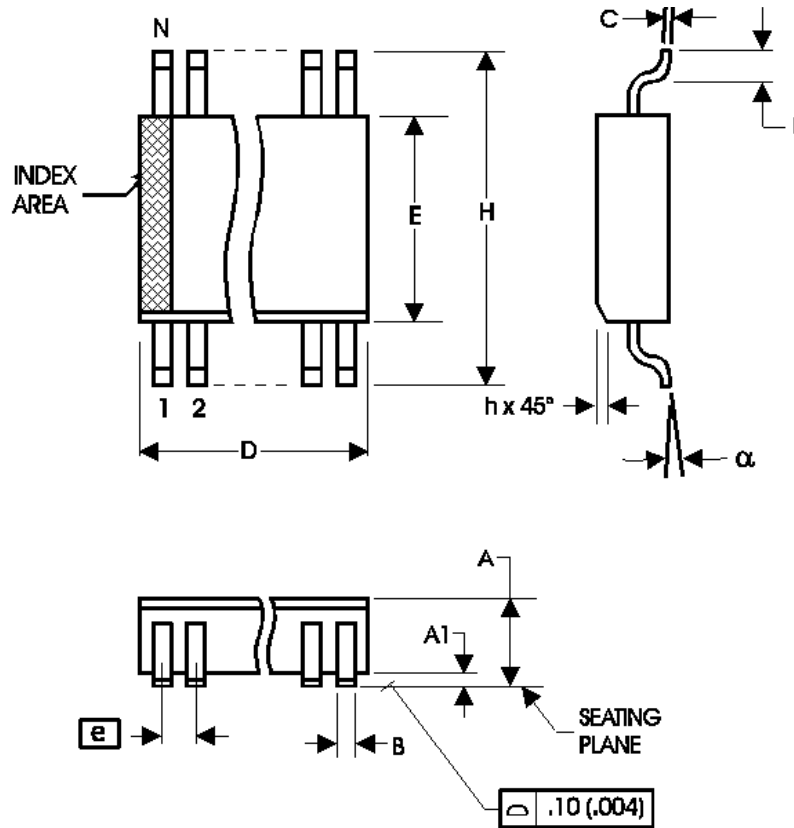
Compatible to part number MC100EP32

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PACKAGE OUTLINE - M SUFFIX

TABLE 7. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	MINIMUN	**MAXIMUM**
N	8	
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.51
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BASIC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.27
α	0°	8°

Reference Document: JEDEC Publication 95, MS-012

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TABLE 8. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Package	Temperature
87332AMI-01	7332AI01	8 lead SOIC	tube	-40°C to 85°C
87332AMI-01T	7332AI01	8 lead SOIC	2500 tape & reel	-40°C to 85°C
87332AMI-01LF	TBD	8 lead "Lead-Free" SOIC	tube	-40°C to 85°C
87332AMI-01LFT	TBD	8 lead "Lead-Free" SOIC	2500 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	T2 T8	1 2 6 6 7 8 13	Features Section - added Lead-Free bullet. Pin Characteristics Table - changed CIN from 4pF max. to 4pF typical. Added "Wiring the Differential Input to Accept Single Ended Levels. Added Termination for 3.3V LVPECL Output. Added Termination for 2.5V LVPECL Output. Added Differential Clock Input Interface. Ordering Information Table - corrected marking. Added Lead-Free part number and note. Updated format of datasheet.	7/5/05
C	T3D	4 9 - 10	LVPECL DC Characteristics Table -corrected V_{OH} max. from V_{CC} - 1.0V to V_{CC} - 0.9V; and V_{SWING} max. from 0.9V to 1.0V. Power Considerations - corrected power dissipation to reflect V_{OH} max in Table 3D.	4/13/07