Integrated Circuit Systems, Inc.

ICS85211I-01

LOW SKEW, 1-TO-2 DIFFERENTIAL-TO-HSTL FANOUT BUFFER

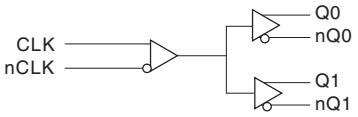
GENERAL DESCRIPTION

The ICS85211I-01 is a low skew, high performance 1-to-2 Differential-to-HSTL Fanout Buffer 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 ICS85211I-01 is characterized to operate from a 3.3V power supply. Guaranteed output and part-to-part skew characteristics make the ICS85211I-01 ideal for those clock distribution applications demanding well defined performance and repeatability. For optimal performance, terminate all outputs.

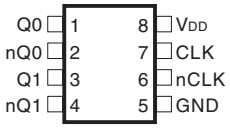
FEATURES

- Two differential HSTL compatible outputs
- One differential CLK, nCLK input pair
- CLK, nCLK pair can accept the following differential input levels: LVDS, LVPECL, HSTL, SSTL, HCSL
- Maximum output frequency: 700MHz
- Translates any single-ended input signal to HSTL levels with resistor bias on nCLK input
- Output skew: 30ps (maximum)
- Part-to-part skew: 250ps (maximum)
- Propagation delay: 1ns (maximum)
- Output crossover Voltage: 0.68V to 0.9V
- Output duty cycle: 49% - 51% up to 266.6MHz
- V_{OH} = 1.4V (maximum)
- 3.3V operating supply
- -40°C to 85°C ambient operating temperature
- Available in both standard and lead-free RoHS-compliant packages

BLOCK DIAGRAM



PIN ASSIGNMENT



ICS85211I-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, 2	Q0, nQ0	Output		Differential output pair. HSTL interface levels.
3, 4	Q1, nQ1	Output		Differential output pair. HSTL interface levels.
5	GND	Power		Power supply ground.
6	nCLK	Input	Pullup/ Pulldown	Inverting differential clock input. $V_{DD}/2$ default when left floating.
7	CLK	Input	Pulldown	Non-inverting differential clock input.
8	V_{DD}	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

TABLE 3. CLOCK INPUT FUNCTION TABLE

Inputs		Outputs		Input to Output Mode	Polarity
CLK	nCLK	Q0, Q1	nQ0, nQ1		
0	0	LOW	HIGH	Differential to Differential	Non Inverting
1	1	HIGH	LOW	Differential to Differential	Non Inverting
0	Biased; NOTE 1	LOW	HIGH	Single Ended to Differential	Non Inverting
1	Biased; NOTE 1	HIGH	LOW	Single Ended to Differential	Non Inverting
Biased; NOTE 1	0	HIGH	LOW	Single Ended to Differential	Inverting
Biased; NOTE 1	1	LOW	HIGH	Single Ended to Differential	Inverting

NOTE 1: Please refer to the Application Information section, "Wiring the Differential Input to Accept Single Ended Levels".

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD}	4.6V
Inputs, V_{DD}	-0.5V to V_{DD} + 0.5 V
Outputs, V_{DD}	-0.5V to V_{DD} + 0.5V
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 4A. POWER SUPPLY DC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Power Supply Voltage		3.135	3.3	3.465	V
I_{DD}	Power Supply Current				22	mA

TABLE 4B. DIFFERENTIAL DC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, TA = -40°C TO 85°C

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

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

TABLE 4C. HSTL DC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OH}	Output High Voltage; NOTE 1		1.0		1.4	V
V_{OL}	Output Low Voltage; NOTE 1		0		0.4	V
V_{OX}	Output Crossover Voltage		0.68		0.9	V
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.6	1.0	1.4	V

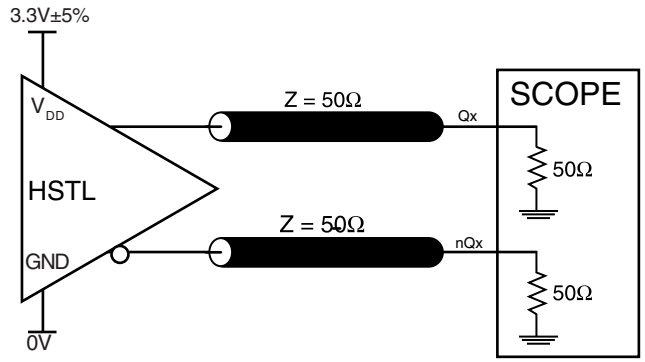
NOTE 1: All outputs must be terminated with 50Ω to ground.

TABLE 5. AC CHARACTERISTICS, V_{DD} = 3.3V ± 5%, T_A = -40°C TO 85°C

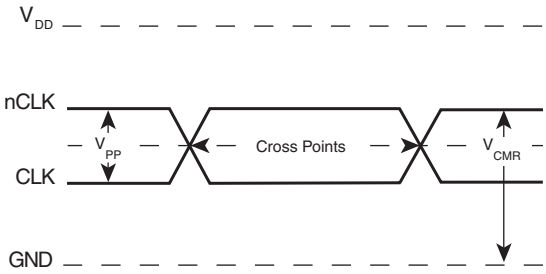
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency				700	MHz
t_{PD}	Propagation Delay; NOTE 1	$f \leq$ 600MHz	0.7		1.0	ns
*t*sk(o)	Output Skew; NOTE 2, 4				30	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 4				250	ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	200		500	ps
odc	Output Duty Cycle		48		52	%
		$f \leq$ 266.6MHz	49		51	%

All parameters measured at 600MHz unless noted otherwise.
The cycle-to-cycle jitter on the input will equal the jitter on the output. The part does not add jitter.
NOTE 1: Measured from the differential input crossing point to the differential output crossing point.
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions.
Measured at output differential cross points.
NOTE 3: 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 4: This parameter is defined in accordance with JEDEC Standard 65.

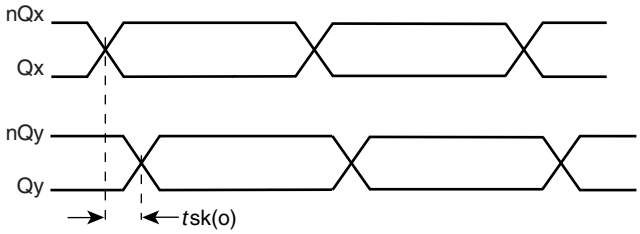
PARAMETER MEASUREMENT INFORMATION



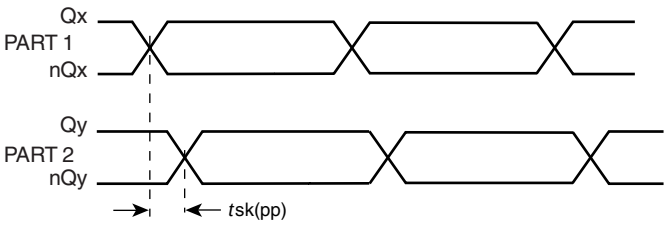
3.3V OUTPUT LOAD AC TEST CIRCUIT



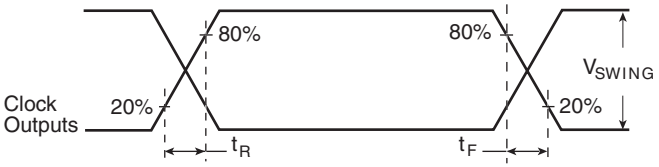
DIFFERENTIAL INPUT LEVEL



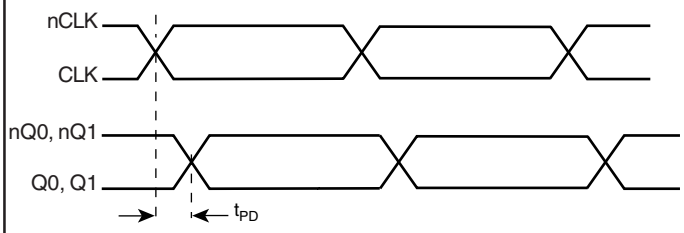
OUTPUT SKEW



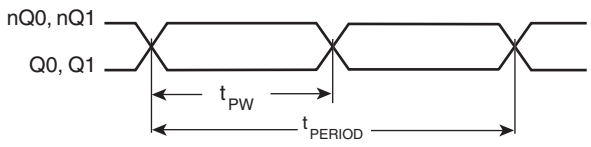
PART-TO-PART SKEW



OUTPUT RISE/FALL TIME



PROPAGATION DELAY



$$odc = \frac{t_{PW}}{t_{PERIOD}} \times 100\%$$

OUTPUT DUTY CYCLE/PULSE WIDTH/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 = 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.

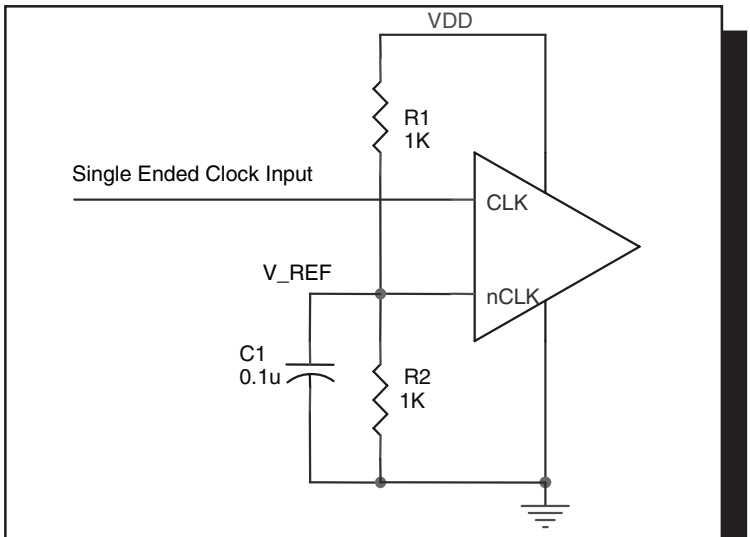


FIGURE 1. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT

SCHEMATIC EXAMPLE

Figure 2 shows a schematic example of ICS85211I-01. In this example, the input is driven by an ICS HiPerClockS HSTL driver. The decoupling capacitors should be physically located near the power pin. For ICS85211I-01, the unused outputs need to be terminated.

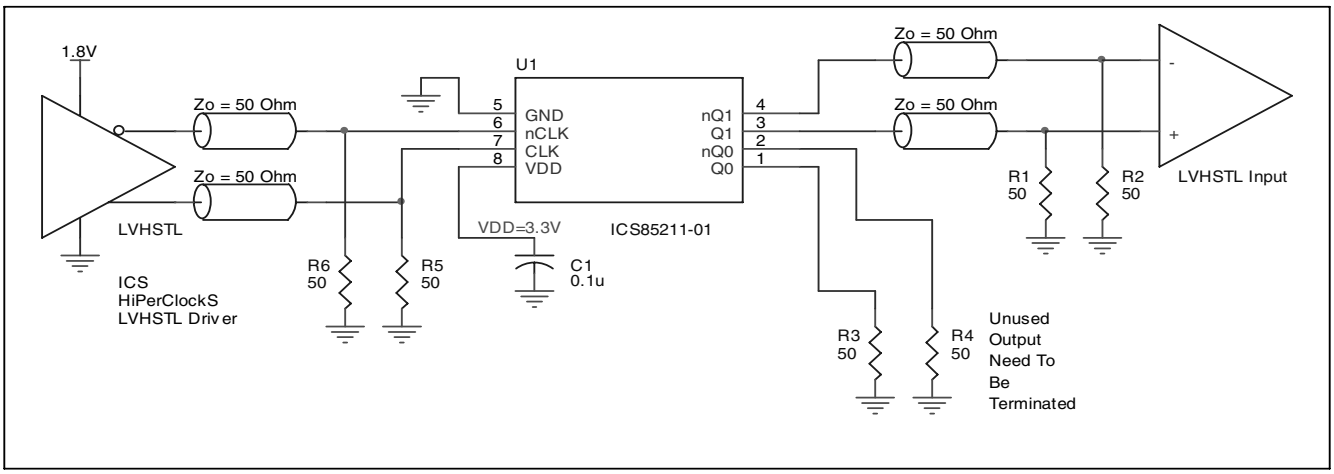


FIGURE 2. ICS85211I-01 HSTL BUFFER SCHEMATIC EXAMPLE

RECOMMENDATIONS FOR UNUSED OUTPUT PINS

OUTPUTS:

HSTL OUTPUT

All unused HSTL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.

CLOCK INPUT INTERFACE

The CLK /nCLK accepts differential input signals of both V_{SWING} and V_{OH} to meet the V_{PP} and V_{CMR} input requirements. *Figures 3A to 3D* show interface examples for the ICS85211I-01 clock input driven by most common driver types. The input interfaces suggested here are examples only. Please consult with the vendor of the driver components to confirm the driver termination requirement. For example in *Figure 3,* the input termination applies for ICS HiPerClockS HSTL drivers. If you are using an HSTL driver from another vendor, use their termination recommendation.

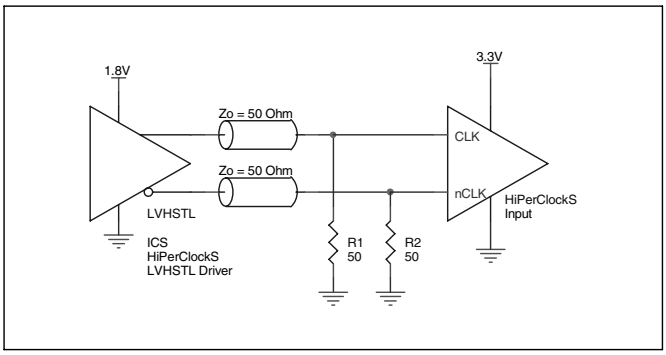


FIGURE 3A. ICS85211I-01 CLK/nCLK INPUT DRIVEN BY HIPERCLOCKS HSTL DRIVER

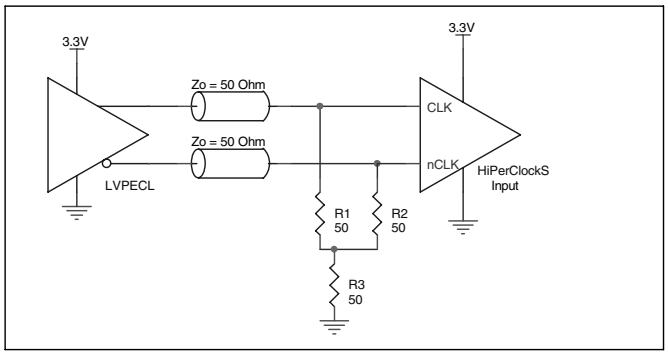


FIGURE 3B. ICS85211I-01 CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER (INTERFACE 1)

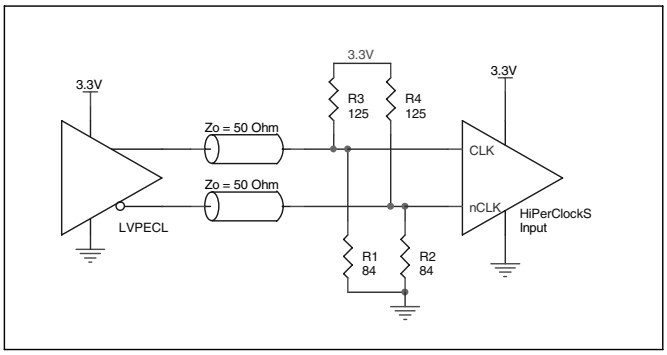


FIGURE 3C. ICS85211I-01 CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER (INTERFACE 2)

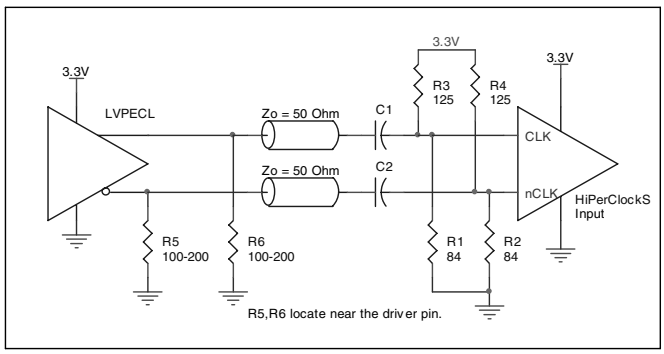


FIGURE 3D. ICS85211I-01 CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER WITH AC COUPLE

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS85211I-01. Equations and example calculations are also provided.

1. Power Dissipation.
The total power dissipation for the ICS85211I-01 is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for V_{DD} = 3.3V + 5% = 3.465V, which gives worst case results.
NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power $(core)_{MAX} = V_{DD\_MAX} * I_{DD\_MAX}$ = 3.465V * 22mA = **76.2mW**
- Power $(outputs)_{MAX}$ = **82.34mW/Loaded Output pair**
  If all outputs are loaded, the total power is 2 * 82.34mW = **164.7mW**

Total Power$_{_MAX}$ (3.465V, with all outputs switching) = 76.2mW + 164.7mW = **240.9mW**

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 6 below. Therefore, Tj for an ambient temperature of 85°C with all outputs switching is:

85°C + 0.241W * 103.3°C/W = 110°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 6. 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.

HSTL output driver circuit and termination are shown in *Figure 4.*

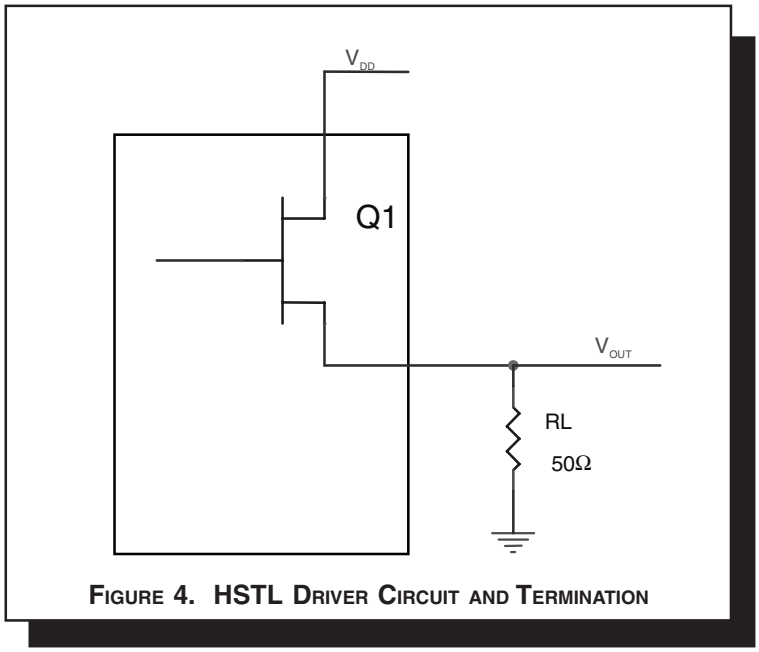


FIGURE 4. HSTL DRIVER CIRCUIT AND TERMINATION

To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load.

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

$Pd\_H = (V_{OH\_MAX}/R_L) * (V_{DD\_MAX} - V_{OH\_MAX})$

$Pd\_L = (V_{OL\_MAX}/R_L) * (V_{DD\_MAX} - V_{OL\_MAX})$

Pd_H = (1.4V/50Ω) * (3.465V - 1.4V) = 57.82mW
Pd_L = (0.4V/50Ω) * (3.465V - 0.4V) = 24.52mW

Total Power Dissipation per output pair = Pd_H + Pd_L = **82.34mW**

RELIABILITY INFORMATION

TABLE 7. θ_{JA} VS. AIR FLOW TABLE FOR 8 LEAD SOIC

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 ICS85211I-01 is: 411

PACKAGE OUTLINE - M SUFFIX FOR 8 LEAD SOIC

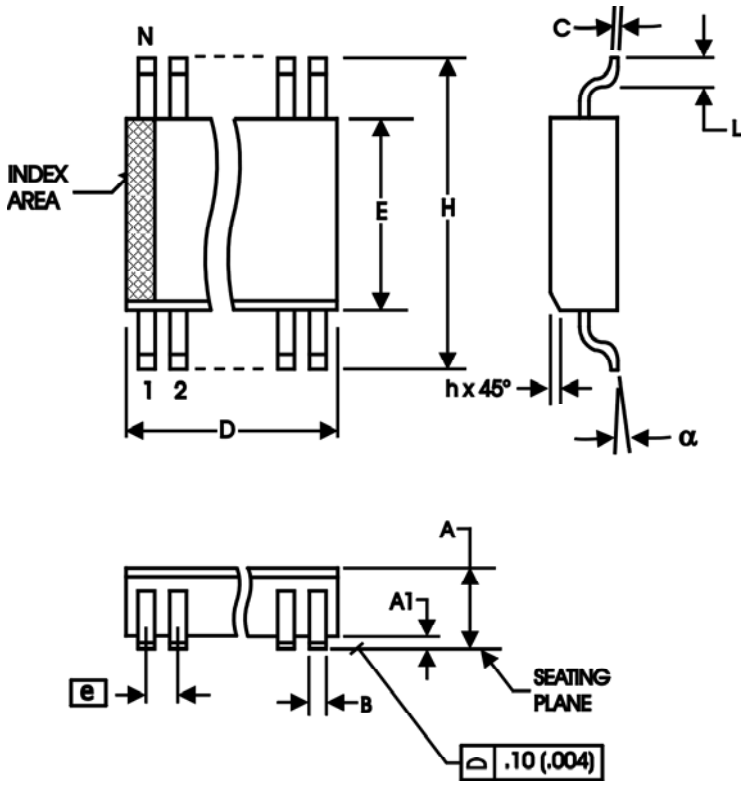


TABLE 8. PACKAGE DIMENSIONS

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

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS85211AMI-01	5211AI01	8 lead SOIC	tube	-40°C to 85°C
ICS85211AMI-01T	5211AI01	8 lead SOIC	2500 tape & reel	-40°C to 85°C
ICS85211AMI-01LF	211AI01L	8 lead "Lead-Free" SOIC	tube	-40°C to 85°C
ICS85211AMI-01LFT	211AI01L	8 lead "Lead-Free" SOIC	2500 tape & reel	-40°C to 85°C

NOTE: Parts thar 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	1 2	2 2	Throughout data sheet changed LVHSTL to HSTL. Changed nCLK Type from V_{DD}/2 to Pullup/Pulldown. Pin Characteristics Table - changed C_{IN} 4pF max. to 4pF typical. Changed R_{PULLUP} to R_{PULLUP}/$R_{PULLDOWN}$, Pullup/Pulldown Resistors.	7/16/03
A	 T9	1 7 12	Features section - added Lead Free/RoHS bullet. Added *Recommendations for Unused Output Pins.* Ordering Information Table - added Lead-Free part number and marking.	11/01/05