



**GENERAL DESCRIPTION**



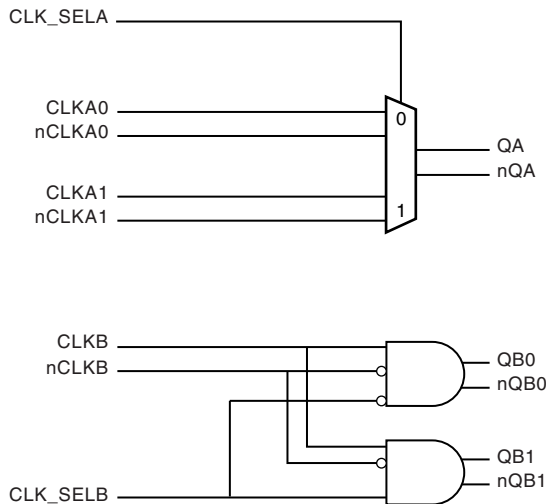
The ICS85354 is a 2:1/1:2 Multiplexer and a member of the HiPerClockS™ family of high performance clock solutions from ICS. The 2:1 Multiplexer allows one of 2 inputs to be selected onto one output pin and the 1:2 MUX switches one input to one of two outputs. This device may be useful for multiplexing multi-rate Ethernet Phys which have 100Mbit and 1000Mbit transmit/receive pairs onto an optical SFP module which has a single transmit/receive pair. Please refer to the Application Block diagram on page 2 of the data sheet.

The ICS85354 is optimized for applications requiring very high performance and has a maximum operating frequency in excess of 2GHz. The device is packaged in a small, 3mm x 3mm VFQFN package, making it ideal for use on space-constrained boards.

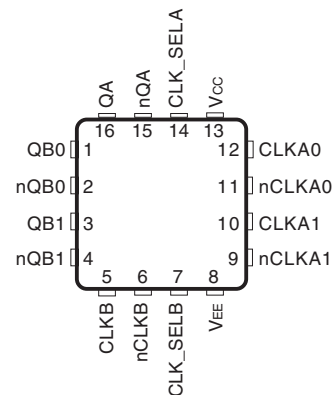
**FEATURES**

- Dual 2:1/1:2 MUX
- 3 LVPECL outputs
- 3 differential clock inputs
- CLKx pair can accept the following differential input levels: LVPECL, LVDS, CML
- Maximum output frequency: 3GHz
- Part-to-part skew: 85ps (typical)
- Additive jitter, RMS: 0.03ps (typical)
- Propagation delay: 330ps (typical)
- LVPECL mode operating voltage supply range:  $V_{CC} = 2.375V$  to  $3.465V$ ,  $V_{EE} = 0V$
- ECL mode operating voltage supply range:  $V_{CC} = 0V$ ,  $V_{EE} = -3.465V$  to  $-2.375V$
- $-40^{\circ}C$  to  $85^{\circ}C$  ambient operating temperature

**BLOCK DIAGRAM**



**PIN ASSIGNMENT**



**ICS85354**  
**16-Lead VFQFN**  
 3mm x 3mm x 0.95 package body  
**K Package**  
 Top View

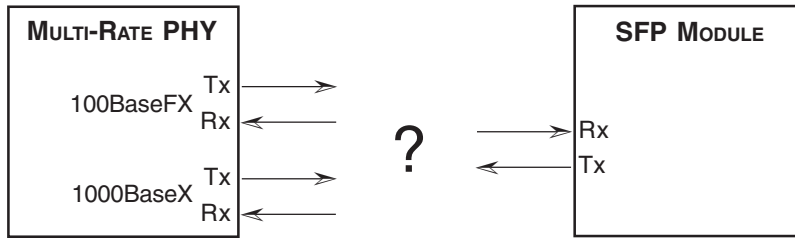
The Preliminary Information presented herein represents a product in prototyping or pre-production. The noted characteristics are based on initial product characterization. Integrated Circuit Systems, Incorporated (ICS) reserves the right to change any circuitry or specifications without notice.



**A TYPICAL APPLICATION FOR THE ICS85354**

Used to connect a multi-rate PHY with the Tx/Rx pins of an SFP Module.

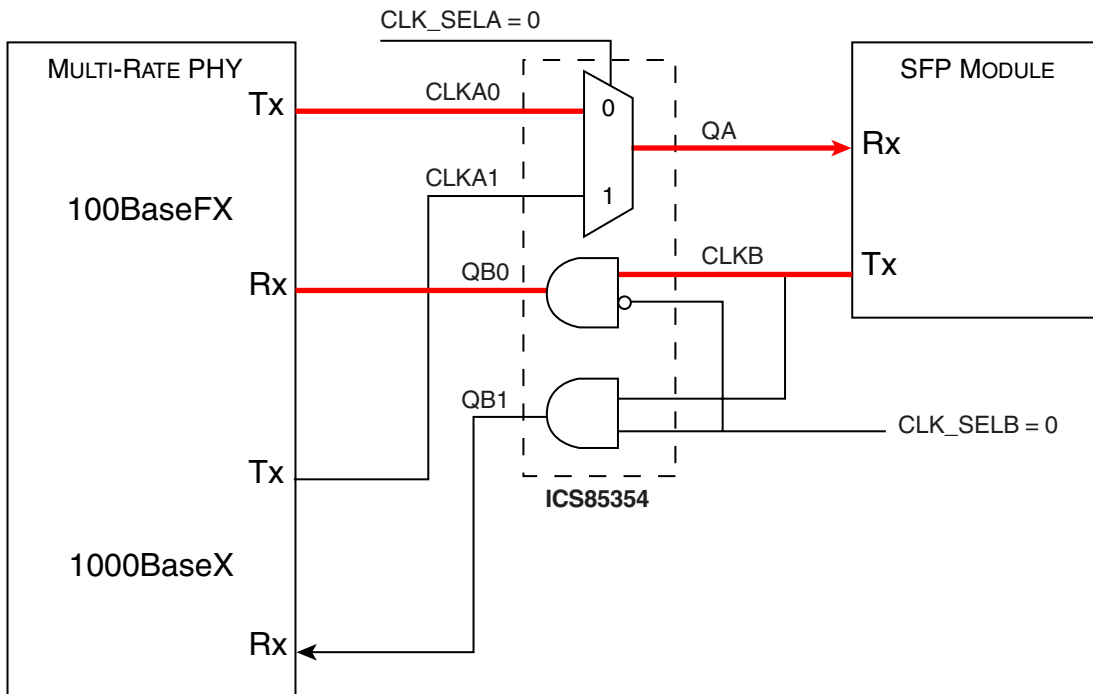
Problem Addressed: How to map the 2 Tx/Rx pairs of the multi-rate PHY to the single Tx/Rx pair on the SFP Module.



**MODE 1, 100BASEX CONNECTED TO SFP**

All lines are differential pairs, but drawn as single-ended to simplify the drawing.

Bold red lines are active connections highlighting the signal path.

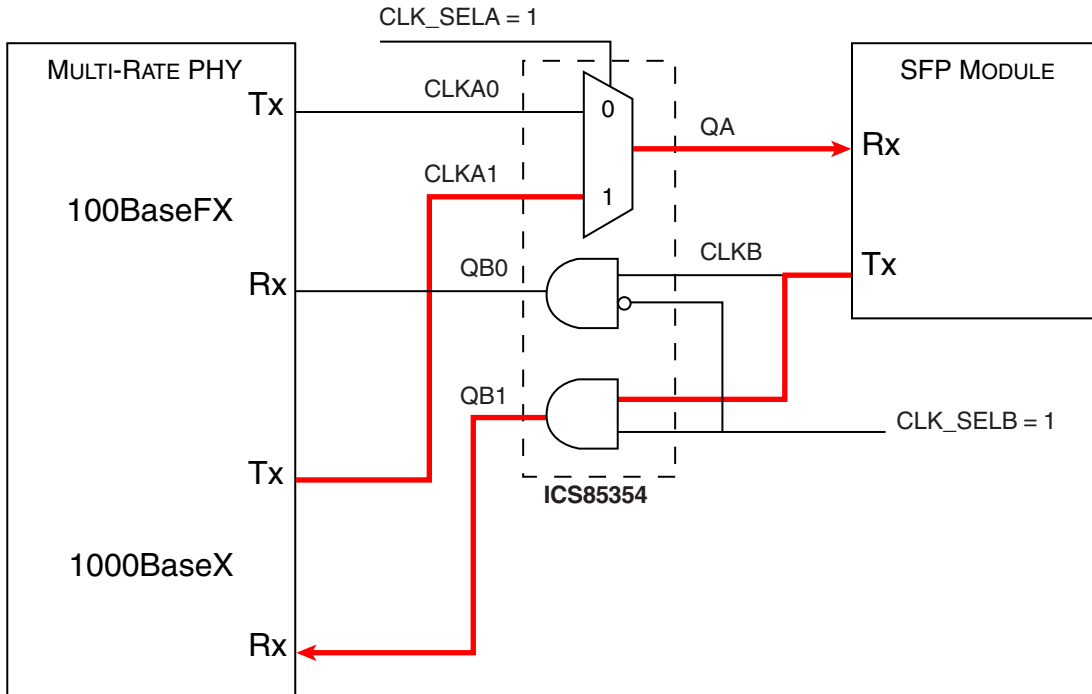




**MODE 2, 1000BASEX CONNECTED TO SFP**

All lines are differential pairs, but drawn as single-ended to simplify the drawing.

Bold red lines are active connections highlighting the signal path.





**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 2	QB0, nQB0	Output		Differential output pair. LVPECL/ECL interface levels.
3, 4	QB1, nQB1	Output		Differential output pair. LVPECL/ECL interface levels.
5	CLKB	Input	Pulldown	Non-inverting LVPECL/ECL differential clock input.
6	nCLKB	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input. $V_{CC}/2$ default when left floating.
7	CLK_SELB	Input	Pulldown	Clock select pin for QBx outputs. When HIGH, selects QB1, nQB1 outputs. When LOW, selects QB0, nQB0 outputs. LVCMOS/LVTTL interface levels.
8	$V_{EE}$	Power		Negative supply pin.
9	nCLKA1	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input. $V_{CC}/2$ default when left floating.
10	CLKA1	Input	Pulldown	Non-inverting LVPECL differential clock input.
11	nCLKA0	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input. $V_{CC}/2$ default when left floating.
12	CLKA0	Input	Pulldown	Non-inverting LVPECL differential clock input.
13	$V_{CC}$	Power		Positive supply pin.
14	CLK_SELA	Input	Pulldown	Clock select pin for QA outputs. When HIGH, selects QA output. When LOW, selects nQA output. LVCMOS/LVTTL interface levels.
15, 16	nQA, QA	Output		Differential output pair. LVPECL/ECL interface levels.

NOTE: *Pulldown* and *Pullup* 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
$R_{PULLDOWN}$	Input Pulldown Resistor			37.5		$K\Omega$
$R_{VCC/2}$	Pullup/Pulldown Resistors			37.5		$K\Omega$

**TABLE 3A. CONTROL INPUT FUNCTION TABLE, BANK A**

Bank A	
Control Inputs	Outputs
CLK_SELA	QA, nQA
0	Selects CLKA0, nCLKA0
1	Selects CLKA1, nCLKA1

**TABLE 3B. CONTROL INPUT FUNCTION TABLE, BANK B**

Bank B		
Control Inputs	Outputs	
CLK_SELB	QB0, nQB0	QB1, nQB1
0	Follows CLKB input	Low
1	Low	Follows CLKB input



**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{CC}$	4.6V (LVPECL mode, $V_{EE} = 0$ )
Negative Supply Voltage, $V_{EE}$	-4.6V (ECL mode, $V_{CC} = 0$ )
Inputs, $V_I$ (LVPECL mode)	-0.5V to $V_{CC} + 0.5V$
Inputs, $V_I$ (ECL mode)	0.5V to $V_{EE} - 0.5V$
Outputs, $I_O$	
Continuous Current	50mA
Surge Current	100mA
Operating Temperature Range, $T_A$	-40°C to +85°C
Storage Temperature, $T_{STG}$	-65°C to 150°C
Package Thermal Impedance, $\theta_{JA}$ (Junction-to-Ambient)	51.5°C/W (0 lfpm)

**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,  $V_{CC} = 2.375V$  TO  $3.465V$ ,  $V_{EE} = 0V$  OR  $V_{CC} = 0V$ ,  $V_{EE} = -3.465V$  TO  $-2.375V$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Positive Supply Voltage		3.135	3.3	3.465	V
			2.375	2.5	2.625	V
$I_{EE}$	Power Supply Current			38		mA

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{CC} = 2.375V$  TO  $3.465V$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	CLK_SELx $V_{CC} = 2.5V$ or $3.3V$	2		$V_{CC} + 0.3$	V
$V_{IL}$	Input Low Voltage	CLK_SELx $V_{CC} = 2.5V$ or $3.3V$	0		0.8	V
$I_{IH}$	Input High Current	CLK_SELA, CLK_SELB $V_{CC} = V_{IN} = 3.465V$ , $V_{CC} = V_{IN} = 2.625V$			150	$\mu A$
$I_{IL}$	Input Low Current	CLK_SELA, CLK_SELB $V_{CC} = 3.465$ $2.625V$ , $V_{IN} = 0V$	-150			$\mu A$



**TABLE 4C. LVPECL DC CHARACTERISTICS,  $V_{CC} = 3.3V$ ,  $V_{EE} = 0V$**

Symbol	Parameter	-40°C			25°C			85°C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OH}$	Output High Voltage; NOTE 1	$V_{CC}-1.125$	$V_{CC}-1.025$	$V_{CC}-0.92$	$V_{CC}-1.075$	$V_{CC}-1.005$	$V_{CC}-0.93$	$V_{CC}-1.005$	$V_{CC}-0.97$	$V_{CC}-0.935$	V
$V_{OL}$	Output Low Voltage; NOTE 1	$V_{CC}-1.895$	$V_{CC}-1.755$	$V_{CC}-1.62$	$V_{CC}-1.875$	$V_{CC}-1.78$	$V_{CC}-1.685$	$V_{CC}-1.86$	$V_{CC}-1.765$	$V_{CC}-1.67$	V
$V_{PP}$	Peak-to-Peak Input Voltage	150	800	1200	150	800	1200	150	800	1200	mV
$V_{CMR}$	Input High Voltage Common Mode Range; NOTE 2, 3	1.2		$V_{CC}$	1.2		$V_{CC}$	1.2		$V_{CC}$	V
$I_{IH}$	Input High Current			150			150			150	$\mu A$
$I_{IL}$	Input Low Current	CLKAx, CLKB	-10		-10			-10			$\mu A$
		nCLKAx, nCLKB	-150		-150			-150			$\mu A$

Input and output parameters vary 1:1 with  $V_{CC}$ .  $V_{CC}$  can vary +0.165V to -0.925V.

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

NOTE 2: Common mode voltage is defined as  $V_{IH}$ .

NOTE 3: For single-ended applications, the maximum input voltage for CLKAx, nCLKAx and CLKB, nCLKB is  $V_{CC} + 0.3V$ .

**TABLE 4D. ECL DC CHARACTERISTICS,  $V_{EE} = -3.465V$  TO  $-2.375V$ ,  $V_{CC} = 0V$**

Symbol	Parameter	-40°C			25°C			85°C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OH}$	Output High Voltage; NOTE 1	-1.125	-1.025	-0.92	-1.075	-1.005	-0.93	-1.005	-0.97	-0.935	V
$V_{OL}$	Output Low Voltage; NOTE 1	-1.895	-1.755	-1.62	-1.875	-1.78	-1.685	-1.86	-1.765	-1.67	V
$V_{PP}$	Peak-to-Peak Input Voltage	150	800	1200	150	800	1200	150	800	1200	mV
$V_{CMR}$	Input High Voltage Common Mode Range; NOTE 2, 3	$V_{EE}+1.2V$		$V_{CC}$	$V_{EE}+1.2V$		$V_{CC}$	$V_{EE}+1.2V$		$V_{CC}$	V
$I_{IH}$	Input High Current			150			150			150	$\mu A$
$I_{IL}$	Input Low Current	CLKAx, CLKB	-10		-10			-10			$\mu A$
		nCLKAx, nCLKB	-150		-150			-150			$\mu A$

Input and output parameters vary 1:1 with  $V_{CC}$ .

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

NOTE 2: Common mode voltage is defined as  $V_{IH}$ .

NOTE 3: For single-ended applications, the maximum input voltage for CLKAx, nCLKAx and CLKB, nCLKB is  $V_{CC} + 0.3V$ .



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**PRELIMINARY**

**ICS85354**

DUAL 2:1/1:2

DIFFERENTIAL -TO-LVPECL/ECL MULTIPLEXER

**TABLE 5. AC CHARACTERISTICS,  $V_{CC} = 2.375V$  TO  $3.465V$ ,  $V_{EE} = 0V$  OR  $V_{CC} = 0V$ ,  $V_{EE} = -3.465V$  TO  $-2.375V$**

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				3	GHz
$t_{PD}$	Propagation Delay; NOTE 1			330		ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4			85		ps
$\sigma_{jit}$	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter section			0.03		ps
	MUX Isolation			55		dB
$t_R/t_F$	Output Rise/Fall Time	20% to 80%		170		ps

All parameters are measured  $\leq 1GHz$  unless otherwise noted.

NOTE 1: Measured from the differential input crossing point to the differential output crossing point.

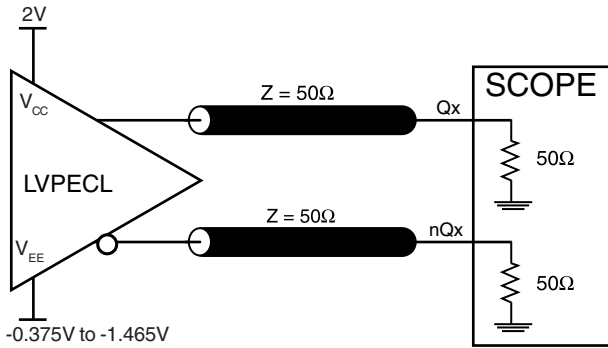
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.

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.

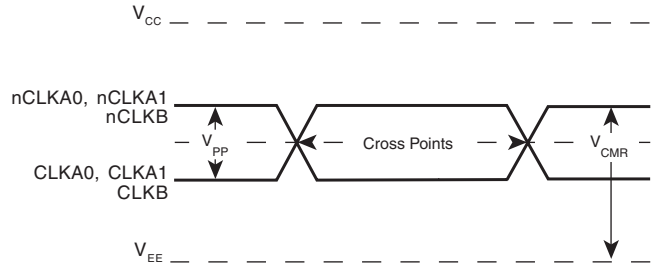
NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.



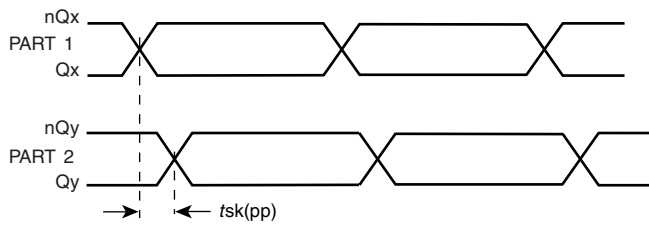
**PARAMETER MEASUREMENT INFORMATION**



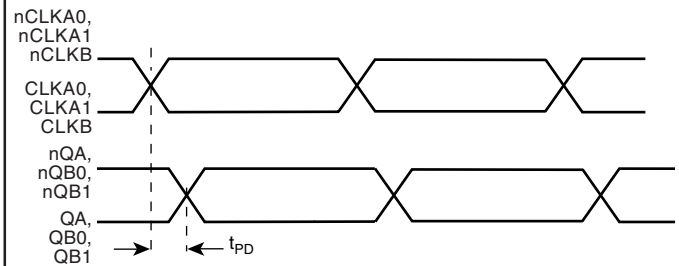
**OUTPUT LOAD AC TEST CIRCUIT**



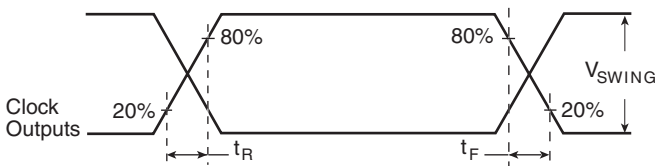
**DIFFERENTIAL INPUT LEVEL**



**PART-TO-PART SKEW**



**PROPAGATION DELAY**



**OUTPUT RISE/FALL TIME**



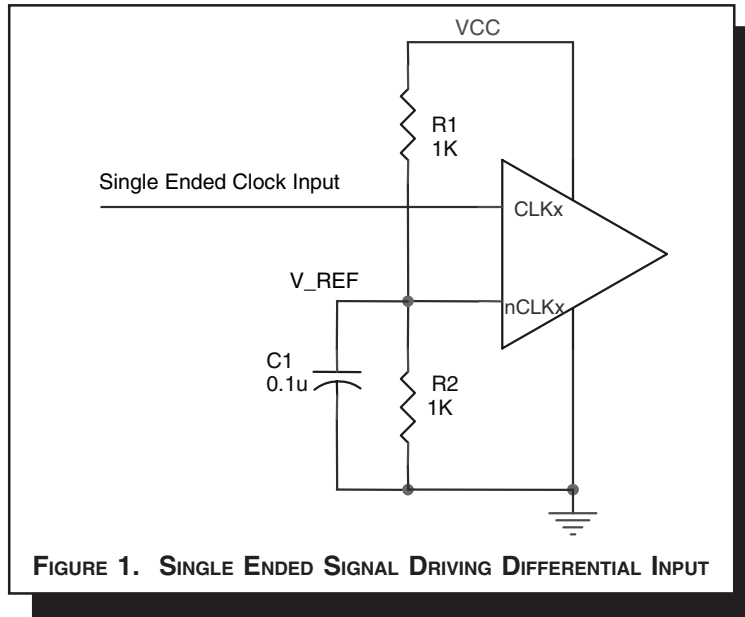


## APPLICATION INFORMATION

### 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  $V_{REF} = V_{CC}/2$  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  $R2/R1 = 0.609$ .

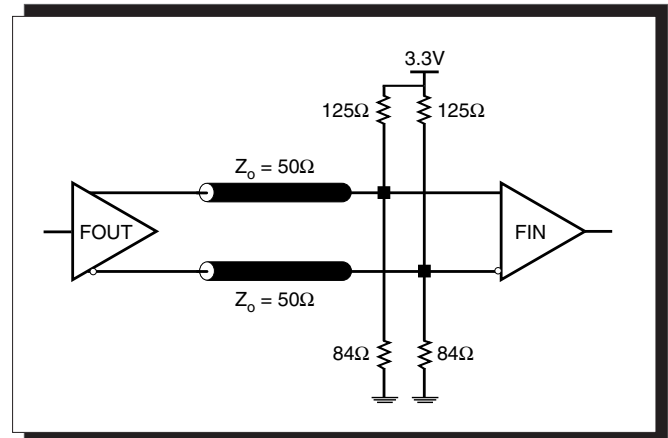
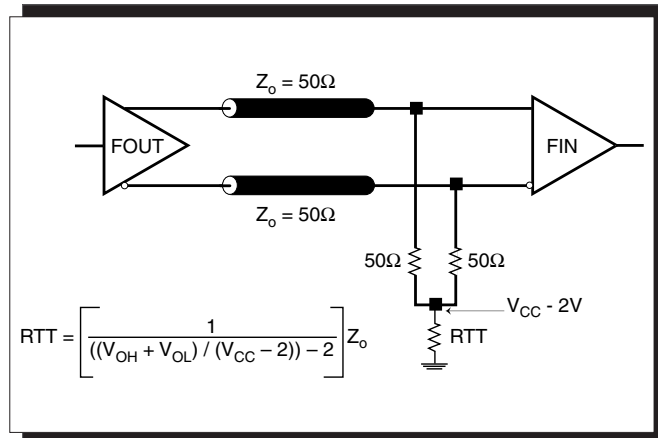


### TERMINATION FOR 3.3V LVPECL OUTPUTS

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 2A and 2B 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.

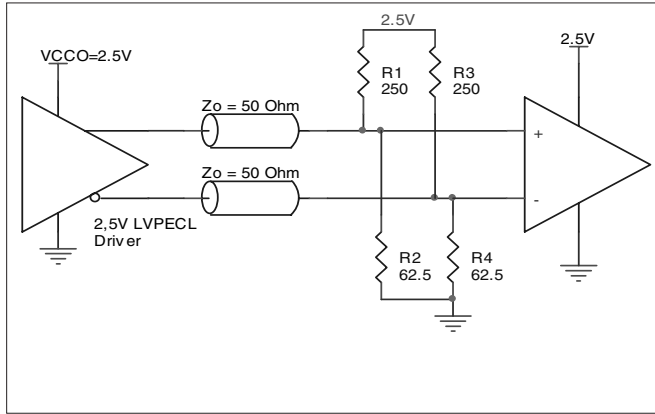




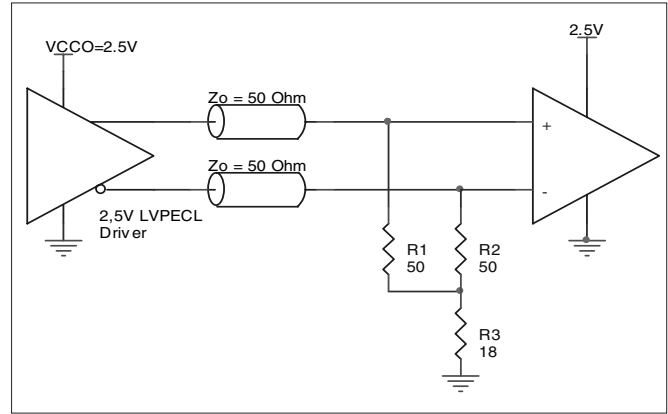
**TERMINATION FOR 2.5V LVPECL OUTPUT**

Figure 3A and Figure 3B 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

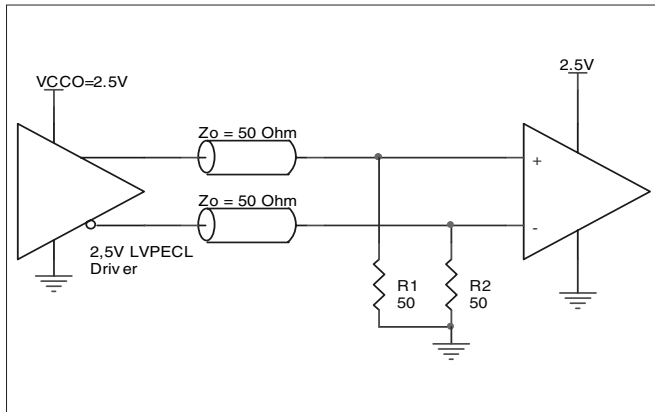
ground level. The R3 in Figure 3B can be eliminated and the termination is shown in Figure 3C.



**FIGURE 3A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE**



**FIGURE 3B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE**



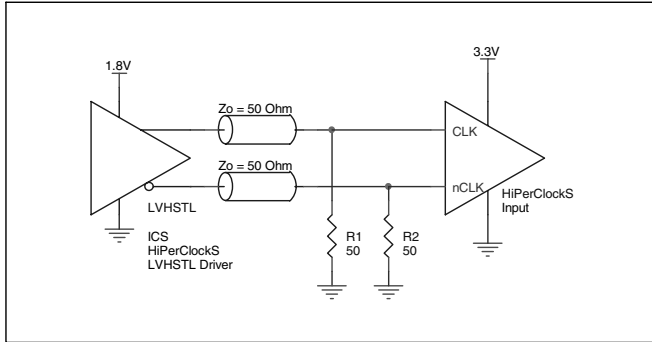
**FIGURE 3C. 2.5V LVPECL TERMINATION EXAMPLE**



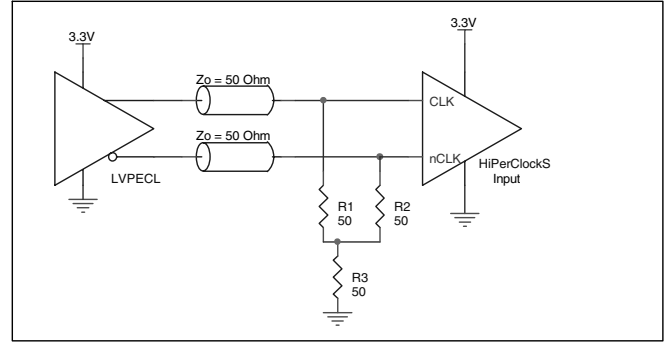
**DIFFERENTIAL CLOCK INPUT INTERFACE**

The CLK/nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSTL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. Figures 4A to 4E show interface examples for the HiPerClockS CLK/nCLK input driven by the most common driver types. The input interfaces suggested

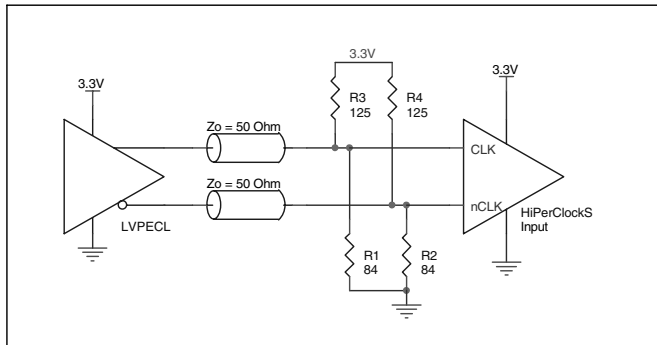
here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in Figure 4A, the input termination applies for ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



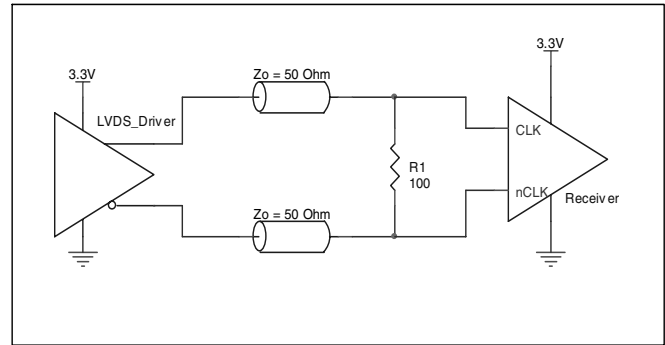
**FIGURE 4A. HiPerClockS CLK/nCLK INPUT DRIVEN BY ICS HiPerClockS LVHSTL DRIVER**



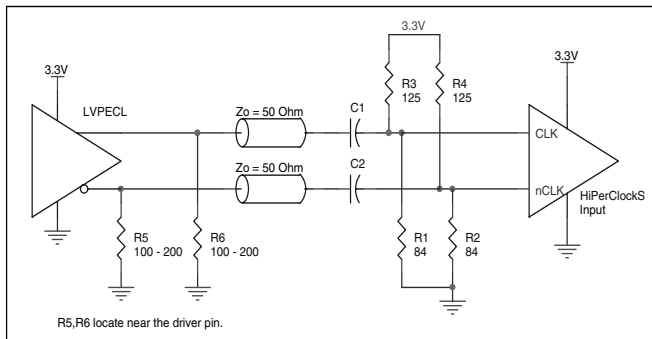
**FIGURE 4B. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER**



**FIGURE 4C. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER**



**FIGURE 4D. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER**



**FIGURE 4E. HiPerClockS 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 ICS85354. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS85354 is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.465V$ , which gives worst case results.

**NOTE:** Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 38mA = 131.7mW$
- Power (outputs)<sub>MAX</sub> = **27.83mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $4 * 27.83mW = 111.3mW$

$$\text{Total Power}_{MAX} (3.465, \text{ with all outputs switching}) = 131.7mW + 111.3mW = 243mW$$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , 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  $T_j$  is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = 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  $\theta_{JA}$  must be used. Assuming a moderate air flow of 0 linear feet per minute and a multi-layer board, the appropriate value is 51.5°C/W per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ C + 0.243W * 51.5^\circ C/W = 97.5^\circ C. \text{ This is well below the limit of } 125^\circ C.$$

This calculation is only an example.  $T_j$  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  $\theta_{JA}$  FOR 16-PIN VFQFN, FORCED CONVECTION**

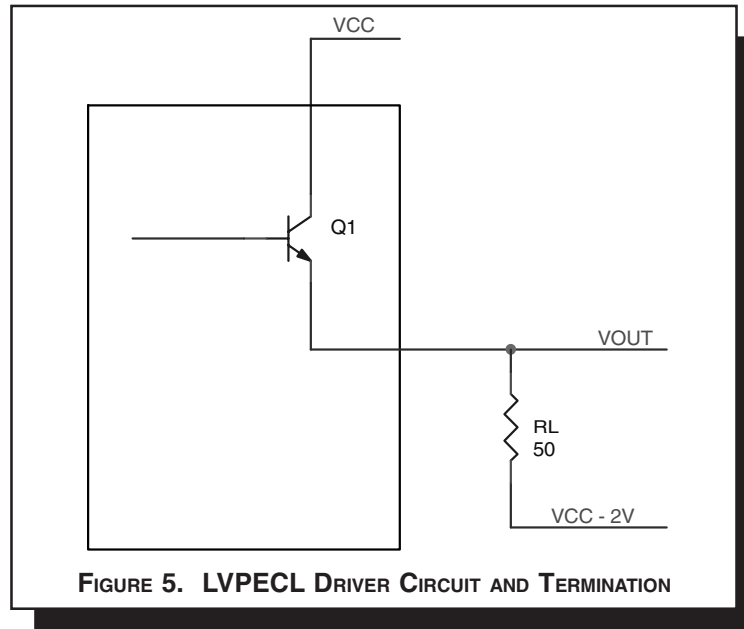
$\theta_{JA}$ by Velocity (Linear Feet per Minute)	
	0
Multi-Layer PCB, JEDEC Standard Test Boards	51.5°C/W



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 5.



**FIGURE 5. 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,  $V_{OUT} = V_{OH\_MAX} = V_{CC\_MAX} - 1.005V$

$$(V_{CC\_MAX} - V_{OH\_MAX}) = 1.005$$

- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CC\_MAX} - 1.78V$

$$(V_{CC\_MAX} - V_{OL\_MAX}) = 1.78V$$

$Pd\_H$  is power dissipation when the output drives high.

$Pd\_L$  is the power dissipation when the output drives low.

$$Pd\_H = [(V_{OH\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - 1.005V)/50\Omega] * 1.005V = 20mW$$

$$Pd\_L = [(V_{OL\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OL\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - 1.78V)/50\Omega] * 1.78V = 7.83mW$$

Total Power Dissipation per output pair =  $Pd\_H + Pd\_L = 27.83mW$



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**PRELIMINARY**

**ICS85354**

DUAL 2:1/1:2

DIFFERENTIAL -TO-LVPECL/ECL MULTIPLEXER

**RELIABILITY INFORMATION**

TABLE 7.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 16 LEAD VFQFN

$\theta_{JA}$ by Velocity (Linear Feet per Minute)	
	<b>0</b>
Multi-Layer PCB, JEDEC Standard Test Boards	51.5°C/W

**TRANSISTOR COUNT**

The transistor count for ICS85354 is: 210



PACKAGE OUTLINE - K SUFFIX FOR 16 LEAD VFQFN

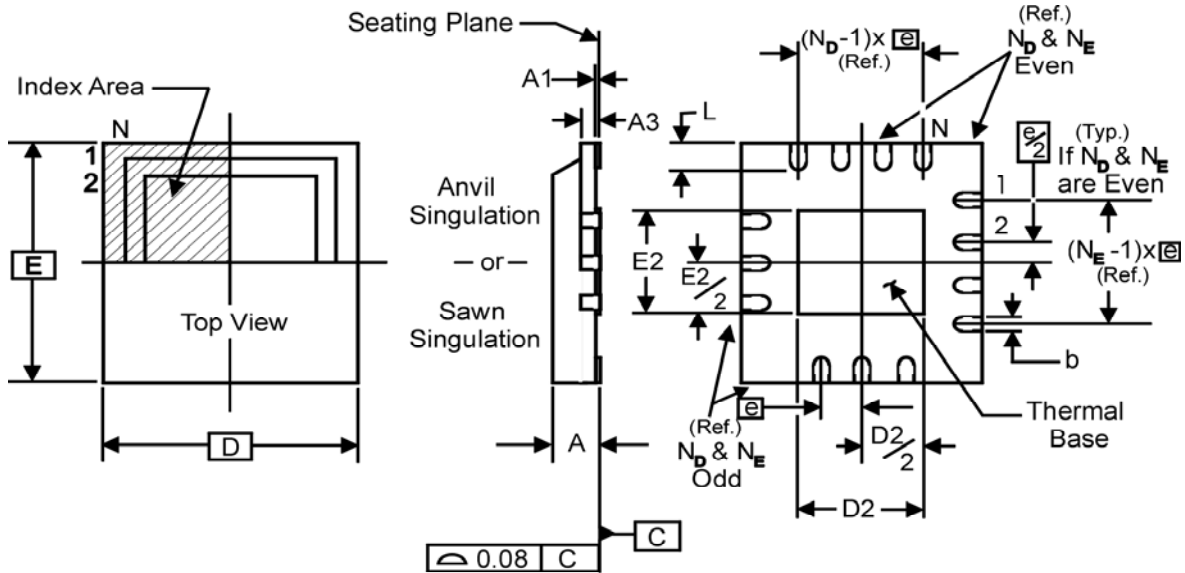


TABLE 8. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS		
SYMBOL	MINIMUM	MAXIMUM
N	16	
A	0.80	1.0
A1	0	0.05
A3	0.25 Reference	
b	0.18	0.30
e	0.50 BASIC	
$N_D$	4	
$N_E$	4	
D	3.0	
D2	0.25	1.25
E	3.0	
E2	0.25	1.25
L	0.30	0.50

Reference Document: JEDEC Publication 95, MO-220



Integrated  
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**PRELIMINARY**

**ICS85354**

DUAL 2:1/1:2

DIFFERENTIAL -TO-LVPECL/ECL MULTIPLEXER

**TABLE 9. ORDERING INFORMATION**

Part/Order Number	Marking	Package	Count	Temperature
ICS85354AK	354A	16 Lead VFQFN	120 per Tube	-40°C to 85°C
ICS85354AKT	354A	16 Lead VFQFN on Tape and Reel	3500	-40°C to 85°C

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