

General Description

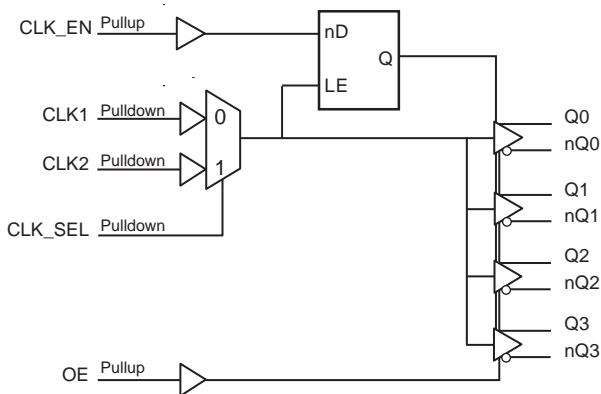
The 8545I-02 is a low skew, high performance 1-to-4 LVCMOS/LVTTL-to-LVDS Clock Fanout Buffer. Utilizing Low Voltage Differential Signaling (LVDS) the 8545I-02 provides a low power, low noise, solution for distributing clock signals over controlled impedances of 100Ω. The 8545I-02 accepts an LVCMOS/LVTTL input level and translates it to 3.3V LVDS output levels.

Guaranteed output and part-to-part skew characteristics make the 8545I-02 ideal for those applications demanding well defined performance and repeatability.

Features

- Four differential LVDS output pairs
- Two LVCMOS/LVTTL clock inputs to support redundant or selectable frequency fanout applications
- Maximum output frequency: 350MHz
- Translates LVCMOS/LVTTL input signals to LVDS levels
- Output skew: 60ps (maximum)
- Part-to-part skew: 450ps (maximum)
- Propagation delay: 1.45ns (maximum)
- Additive phase jitter, RMS: 0.14ps (typical)
- Full 3.3V supply mode
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

Block Diagram



Pin Assignment

GND	1	20	Q0
CLK_EN	2	19	nQ0
CLK_SEL	3	18	V _{DD}
CLK1	4	17	Q1
nc	5	16	nQ1
CLK2	6	15	Q2
nc	7	14	nQ2
OE	8	13	GND
GND	9	12	Q3
V _{DD}	10	11	nQ3

8545I-02

20-Lead TSSOP

6.5mm x 4.4mm x 0.925mm

package body

G Package

Top View

Table 1. Pin Descriptions

Number	Name	Type		Description
1, 9, 13	GND	Power		Power supply ground.
2	CLK_EN	Input	Pullup	Synchronizing clock enable. When HIGH, clock outputs follows clock input. When LOW, Qx outputs are forced low, nQx outputs are forced high. LVCMOS / LVTTTL interface levels.
3	CLK_SEL	Input	Pulldown	Clock select input. When HIGH, selects CLK2 input. When LOW, selects CLK1 input. LVCMOS / LVTTTL interface levels.
4	CLK1	Input	Pulldown	Single-ended clock input. LVCMOS/LVTTTL interface levels.
5, 7	nc	Unused		No connect.
6	CLK2	Input	Pulldown	Single-ended clock input. LVCMOS/LVTTTL interface levels.
8	OE	Input	Pullup	Output enable. Controls enabling and disabling of outputs Q0/nQ0 through Q3/nQ3. LVCMOS/LVTTTL interface levels.
10, 18	V _{DD}	Power		Positive supply pins.
11, 12	nQ3, Q3	Output		Differential output pair. LVDS interface levels.
14, 15	nQ2, Q2	Output		Differential output pair. LVDS interface levels.
16, 17	nQ1, Q1	Output		Differential output pair. LVDS interface levels.
19, 20	nQ0, Q0	Output		Differential output pair. LVDS 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
R _{PULLUP}	Input Pullup Resistor			51		kΩ
R _{PULLDOWN}	Input Pulldown Resistor			51		kΩ

Function Tables

Table 3A. Control Input Function Table

Inputs				Outputs	
OE	CLK_EN	CLK_SEL	Selected Source	Q0:Q3	nQ0:nQ3
0	X	X		High-Impedance	High-Impedance
1	0	0	CLK1	Low	High
1	0	1	CLK2	Low	High
1	1	0	CLK1	Active	Active
1	1	1	CLK2	Active	Active

After CLK_EN switches, the clock outputs are disabled or enabled following a rising and falling input clock edge as shown in Figure 1. In the active mode, the state of the outputs are a function of the CLK1 and CLK2 inputs as described in Table 3B.

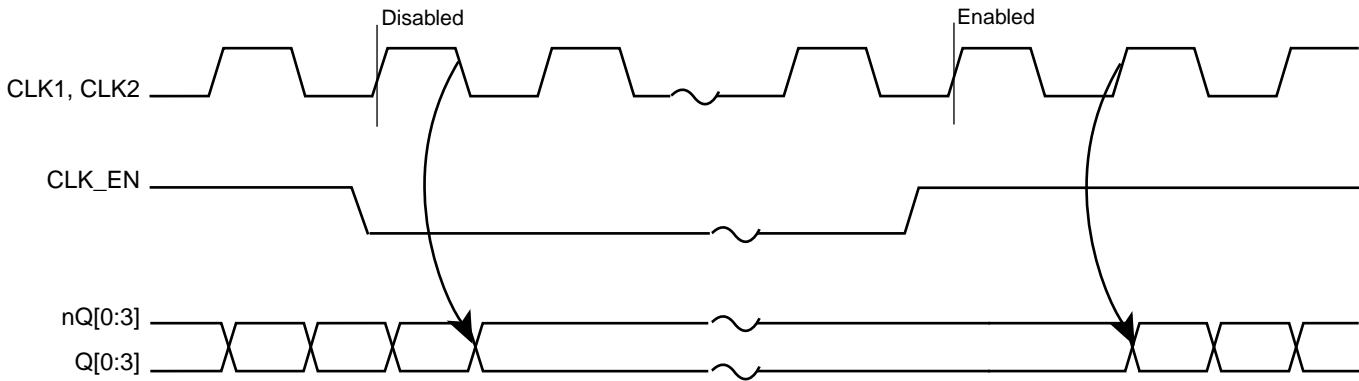


Figure 1. CLK_EN Timing Diagram

Table 3B. Clock Input Function Table

Inputs	Outputs	
	Q0:Q3	nQ0:nQ3
CLK1 or CLK2	LOW	HIGH
	HIGH	LOW

Absolute Maximum Ratings

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.

Item	Rating
Supply Voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to $V_{DD} + 0.5V$
Outputs, I_O Continuous Current Surge Current	10mA 15mA
Package Thermal Impedance, θ_{JA}	91.1°C/W (0 mps)
Storage Temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 4A. Power Supply DC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ to $85^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Positive Supply Voltage		3.135	3.3	3.465	V
I_{DD}	Power Supply Current				90	mA

Table 4B. LVCMOS/LVTTL DC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ to $85^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage		2		$V_{DD} + 0.3$	V
V_{IL}	Input Low Voltage		-0.3		0.8	V
I_{IH}	Input High Current	CLK1, CLK2, CLK_SEL	$V_{DD} = V_{IN} = 3.465V$		150	μA
		OE, CLK_EN	$V_{DD} = V_{IN} = 3.465V$		5	μA
I_{IL}	Input Low Current	CLK1, CLK2, CLK_SEL	$V_{DD} = 3.465V, V_{IN} = 0V$	-5		μA
		OE, CLK_EN	$V_{DD} = 3.465V, V_{IN} = 0V$	-150		μA

Table 4C. LVDS DC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ to $85^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OD}	Differential Output Voltage		275		525	mV
ΔV_{OD}	V_{OD} Magnitude Change				50	mV
V_{OS}	Offset Voltage		1.1	1.25	1.4	V
ΔV_{OS}	V_{OS} Magnitude Change			5	50	mV

AC Electrical Characteristics

Table 5. AC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = -40^{\circ}C$ to $85^{\circ}C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency				350	MHz
t_{PD}	Propagation Delay; NOTE 1		1.0		1.45	ns
f_{jit}	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section	155.52MHz, Integration Range: 12kHz – 20MHz		0.14		ps
$t_{sk(o)}$	Output Skew; NOTE 2, 4				60	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				450	ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	150		700	ps
odc	Output Duty Cycle; NOTE 5	$f \leq 166MHz$	45		55	%
		$f > 166MHz$	40		60	%

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

All parameters measured at f_{MAX} unless noted otherwise.

NOTE 1: Measured from $V_{DD}/2$ of the input to the differential output crossing point.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions.

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.

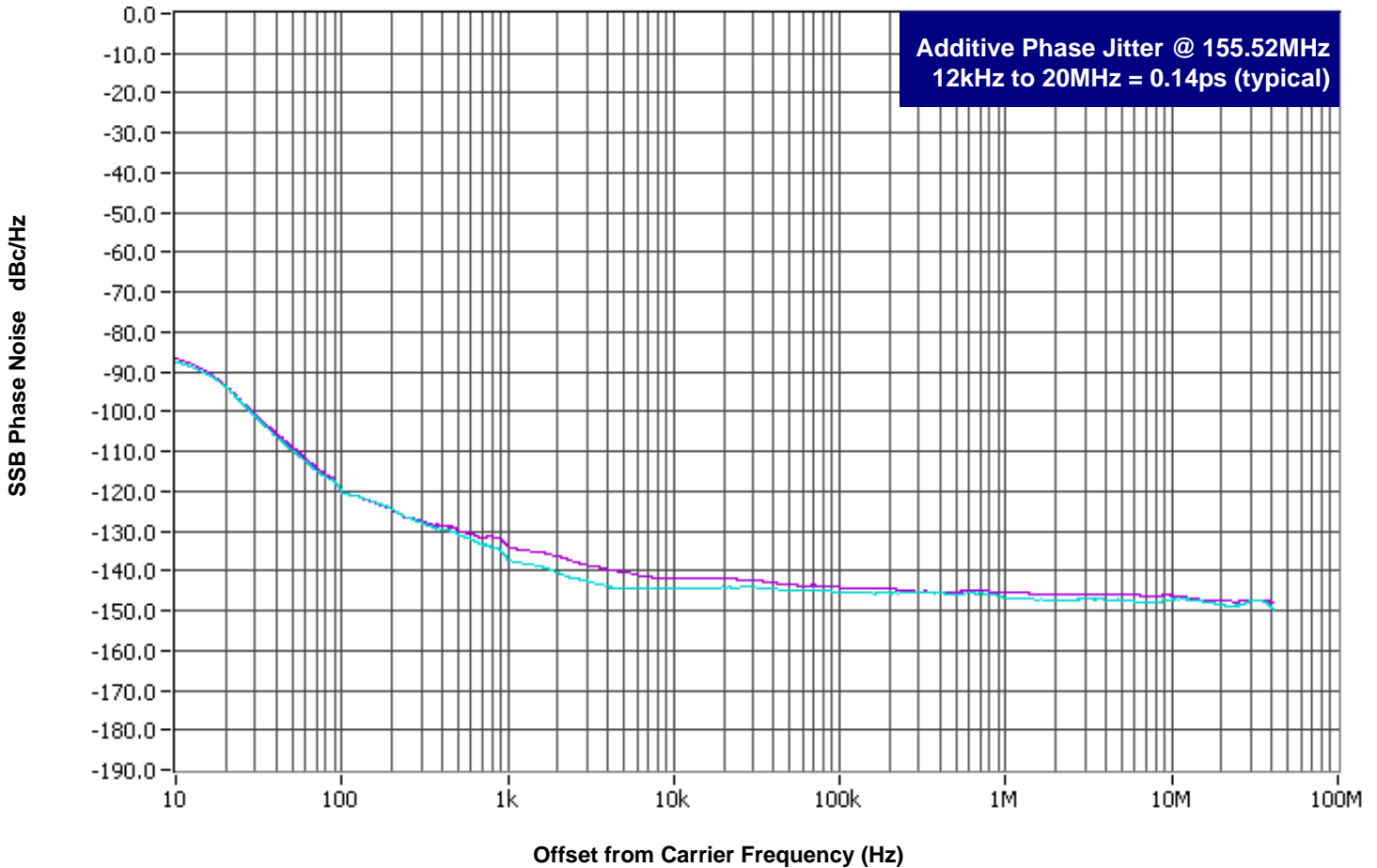
NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 5: Measured using 50% duty cycle.

Additive Phase Jitter

The spectral purity in a band at a specific offset from the fundamental compared to the power of the fundamental is called the **dBc Phase Noise**. This value is normally expressed using a Phase noise plot and is most often the specified plot in many applications. Phase noise is defined as the ratio of the noise power present in a 1Hz band at a specified offset from the fundamental frequency to the power value of the fundamental. This ratio is expressed in decibels (dBm) or a ratio

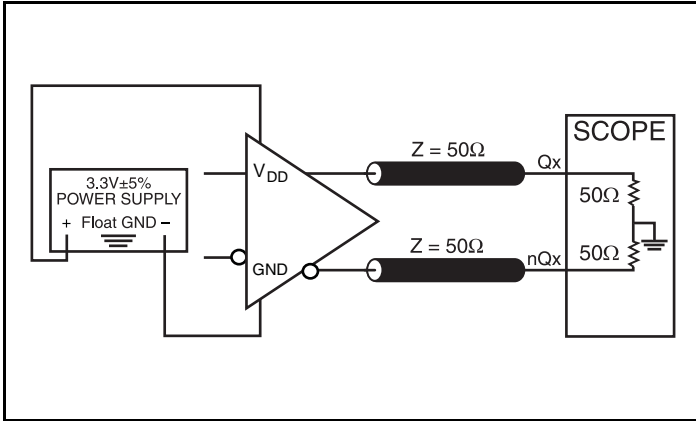
of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a **dBc** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects on the desired application over the entire time record of the signal. It is mathematically possible to calculate an expected bit error rate given a phase noise plot.



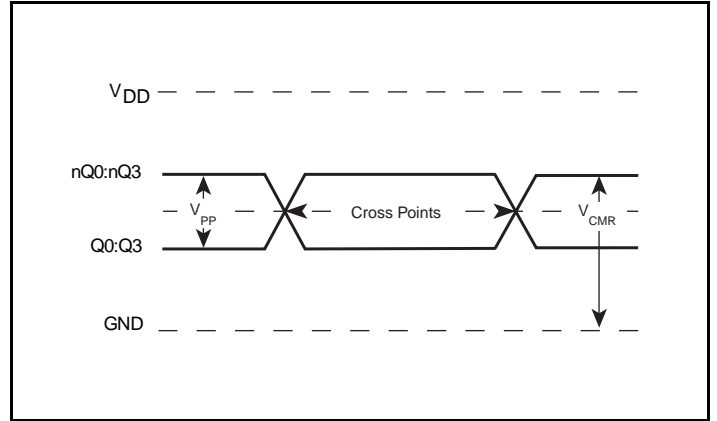
As with most timing specifications, phase noise measurements has issues relating to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor of the device. This

is illustrated above. The device meets the noise floor of what is shown, but can actually be lower. The phase noise is dependent on the input source and measurement equipment.

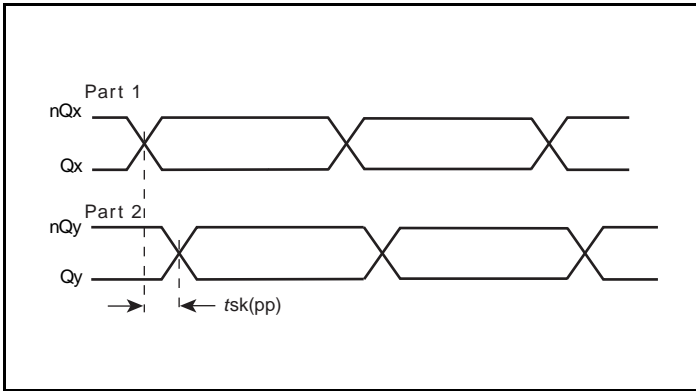
Parameter Measurement Information



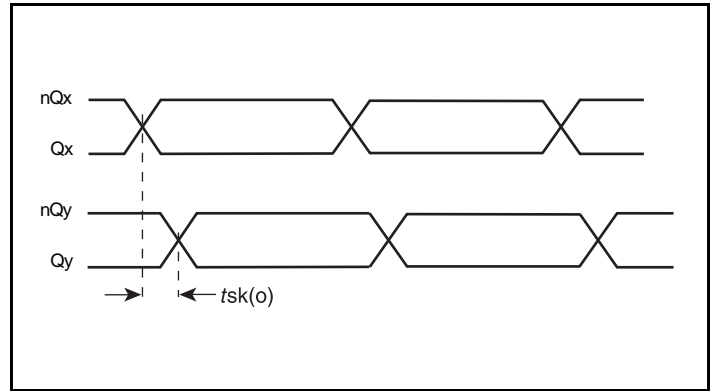
3.3V LVDS Output Load AC Test Circuit



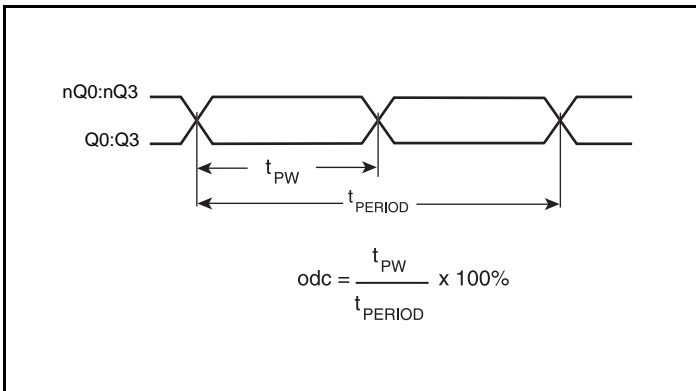
Differential Output Level



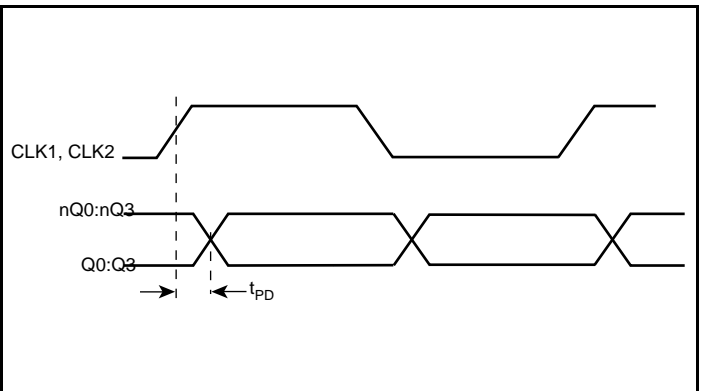
Part-to-Part Skew



Output Skew

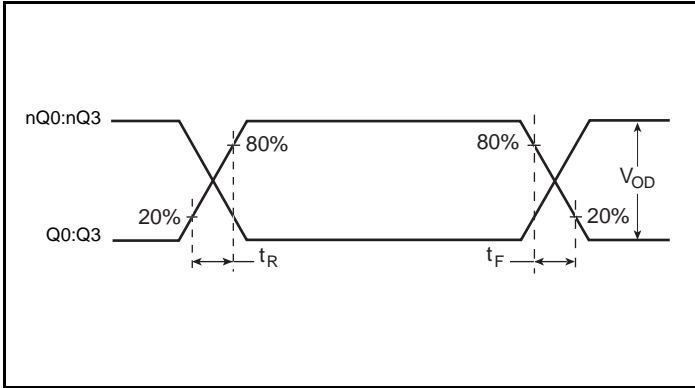


Output Duty Cycle/Pulse Width/Period

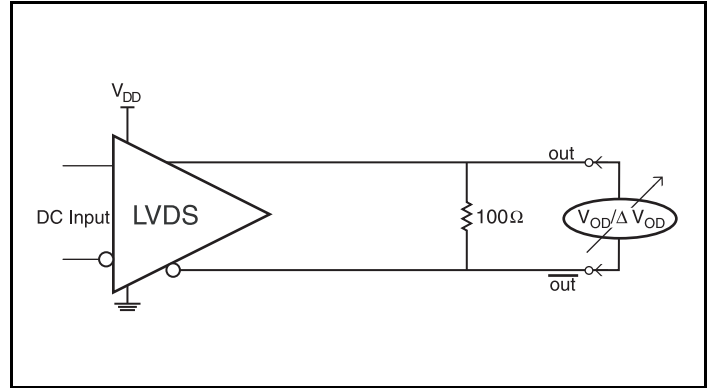


Propagation Delay

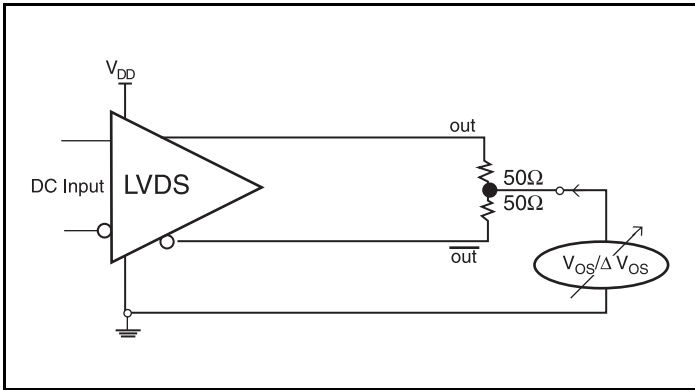
Parameter Measurement Information, continued



Output Rise/Fall Time



Differential Output Voltage Setup



Offset Voltage Setup

Application Information

Recommendations for Unused Input and Output Pins

Inputs:

CLK Inputs

For applications not requiring the use of a clock input, it can be left floating. Though not required, but for additional protection, a $1\text{k}\Omega$ resistor can be tied from the CLK input to ground.

LVC MOS 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 $1\text{k}\Omega$ resistor can be used.

Outputs:

LVDS Outputs

All unused LVDS output pairs can be either left floating or terminated with 100Ω across. If they are left floating, there should be no trace attached.

3.3V LVDS Driver Termination

A general LVDS interface is shown in Figure 2. In a 100Ω differential transmission line environment, LVDS drivers require a matched load termination of 100Ω across near the receiver input. For a multiple

LVDS outputs buffer, if only partial outputs are used, it is recommended to terminate the unused outputs.

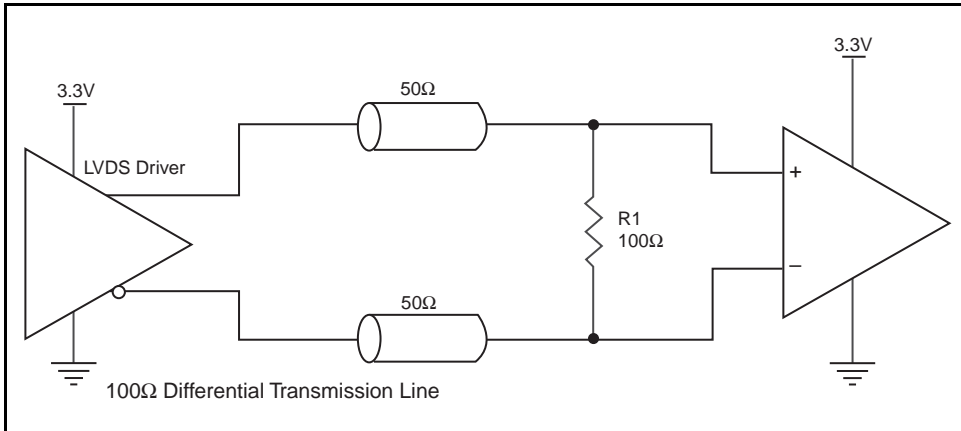


Figure 2. Typical LVDS Driver Termination

Power Considerations

This section provides information on power dissipation and junction temperature for the 8545I-02. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the 8545I-02 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} = $V_{DD_MAX} * I_{DD_MAX} = 3.465V * 90mA = 311.85mW$

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

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 no air flow and a multi-layer board, the appropriate value is 91.1°C/W per Table 6 below.

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

$$85^\circ\text{C} + 0.312\text{W} * 91.1^\circ\text{C/W} = 113.4^\circ\text{C}. \text{ This is well below the limit of } 125^\circ\text{C}.$$

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 (multi-layer).

Table 6. Thermal Resistance θ_{JA} for 20 Lead TSSOP, Forced Convection

θ_{JA} by Velocity			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	91.1°C/W	86.7°C/W	84.6°C/W

Reliability Information

Table 7. θ_{JA} vs. Air Flow Table for a 20 Lead TSSOP

θ_{JA} by Velocity			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	91.1°C/W	86.7°C/W	84.6°C/W

Transistor Count

The transistor count for 8545I-02 is: 360

Package Outline and Package Dimensions

Package Outline - G Suffix for 20 Lead TSSOP

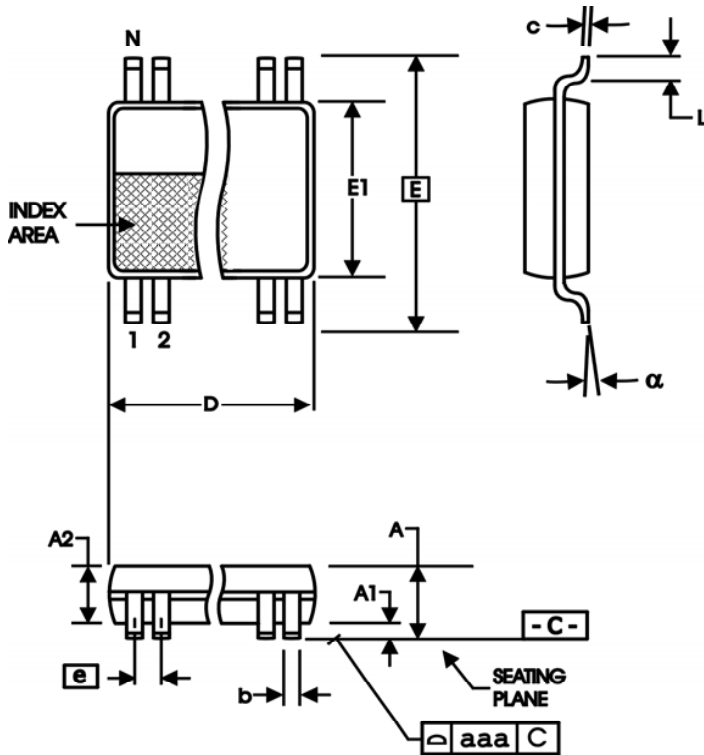


Table 8. Package Dimensions

All Dimensions in Millimeters		
Symbol	Minimum	Maximum
N	20	
A		1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	6.40	6.60
E	6.40 Basic	
E1	4.30	4.50
e	0.65 Basic	
L	0.45	0.75
α	0°	8°
aaa		0.10

Reference Document: JEDEC Publication 95, MO-153

Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
8545AGI-02LF	ICS8545AI02L	"Lead-Free" 20 Lead TSSOP	Tube	-40°C to 85°C
8545AGI-02LFT	ICS8545AI02L	"Lead-Free" 20 Lead TSSOP	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.

Revision History

5/7/15 Product Discontinuation Notice - PDN CQ-15-03.

IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD-PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers who are designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only to develop an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third-party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising from your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Disclaimer Rev.1.01 Jan 2024)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.