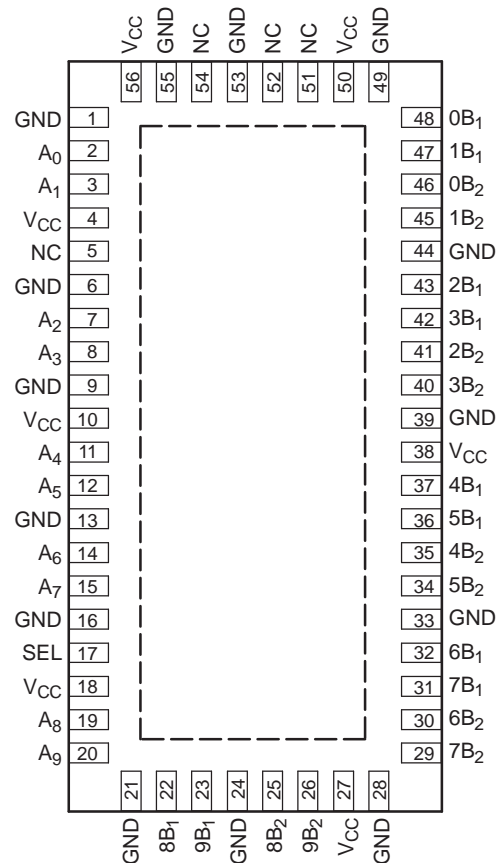


# 5-CHANNEL DIFFERENTIAL 10:20 MULTIPLEXER SWITCH FOR DVI/HDMI APPLICATIONS

Check for Samples: [TS3DV520](#)

## FEATURES

- **Compatible With HDMI v1.2a (Type A) DVI 1.0 High-Speed Digital Interface**
  - Wide Bandwidth of Over 1.65 Gbps (Bandwidth 2.4 Gbps Typ)
  - 165-MHz Speed Operation
  - Serial Data Stream at 10x Pixel Clock Rate
  - Supports All Video Formats up to 1080p and SXGA (1280 × 1024 at 75 Hz)
  - Total Raw Capacity 4.95 Gbps (Single Link)
  - HDCP Compatible
- **Low Crosstalk ( $X_{TALK} = -41$  dB Typ)**
- **Low Bit-to-Bit Skew ( $t_{sk(o)} = 0.1$  ns Max)**
- **Low and Flat ON-State Resistance ( $r_{on} = 6 \Omega$  Max,  $r_{on(flat)} = 0.5 \Omega$  Typ)**
- **Low Input/Output Capacitance ( $C_{ON} = 7.8$  pF Typ)**
- **Rail-to-Rail Switching on Data I/O Ports (0 to 5 V)**
- **$V_{CC}$  Operating Range From 3 V to 3.6 V**
- **$I_{off}$  Supports Partial-Power-Down Mode Operation**
- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**
- **ESD Performance Tested Per JESD 22**
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)

**TQFN PACKAGE  
(TOP VIEW)**


NC – No internal connection

## APPLICATIONS

- **DVI/HDMI Signal Switching**
- **Differential DVI, HDMI Signal Multiplexing for Audio/Video Receivers and High-Definition Televisions (HDTVs)**
- **10/100/1000 Base-T Signal Switching**
- **Hub and Router Signal Switching**

## DESCRIPTION/ORDERING INFORMATION

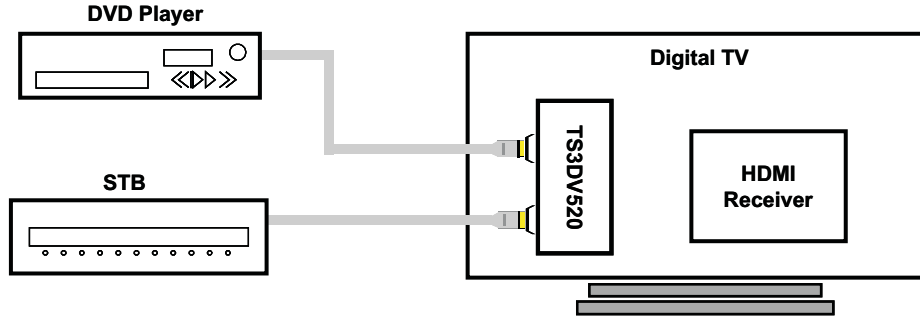
The TS3DV520 is a 20-bit to 10-bit multiplexer/demultiplexer digital video switch with a single select (SEL) input. SEL controls the data path of the multiplexer/demultiplexer. The device provides five differential channels for digital video signal switching. This device can also be used to replace mechanical relays in LAN applications and allows for signals to be routed from a 10/100/1000 Base-T transceiver to the RJ-45 connectors in laptops or docking stations.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

This device provides low and flat ON-state resistance ( $r_{on}$ ) and excellent ON-state resistance match. Low input/output capacitance, high bandwidth, low skew, and low crosstalk among channels make this device suitable for various digital video applications, such as DVI and HDMI.

This device is fully specified for partial-power-down applications using  $I_{off}$ . The  $I_{off}$  feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.



**Table 1. ORDERING INFORMATION<sup>(1)</sup>**

$T_A$	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	TQFN	Tape and reel	TS3DV520RHUR	SD520

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

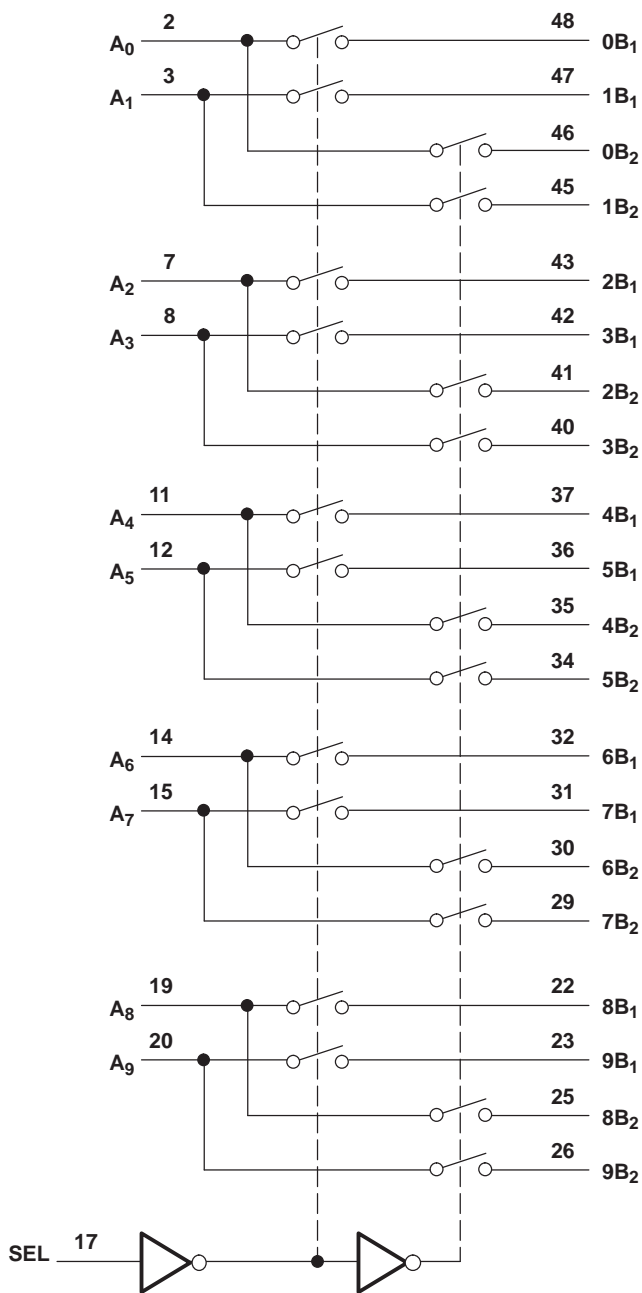
**FUNCTION TABLE**

INPUT SEL	INPUT/OUTPUT $A_n$	FUNCTION	
L	$nB_1$	$A_n = nB_1$	$nB_2$ high-impedance mode
H	$nB_2$	$A_n = nB_2$	$nB_1$ high-impedance mode

**PIN DESCRIPTION**

NAME	DESCRIPTION
$A_n$	Data I/O
$nB_m$	Data I/O
SEL	Select input

**LOGIC DIAGRAM (POSITIVE LOGIC)**



## Absolute Maximum Ratings<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
$V_{CC}$	Supply voltage range	-0.5	4.6	V
$V_{IN}$	Control input voltage range <sup>(2)</sup> <sup>(3)</sup>	-0.5	7	V
$V_{I/O}$	Switch I/O voltage range <sup>(2)</sup> <sup>(3)</sup> <sup>(4)</sup>	-0.5	7	V
$I_{IK}$	Control input clamp current		-50	mA
			$V_{IN} < 0$	
$I_{I/OK}$	I/O port clamp current		-50	mA
			$V_{I/O} < 0$	
$I_{I/O}$	ON-state switch current <sup>(5)</sup>		±128	mA
	Continuous current through $V_{CC}$ or GND		±100	mA
$\theta_{JA}$	Package thermal impedance <sup>(6)</sup>		31.8	°C/W
$T_{stg}$	Storage temperature range	-65	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltages are with respect to ground, unless otherwise specified.

(3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

(4)  $V_I$  and  $V_O$  are used to denote specific conditions for  $V_{I/O}$ .

(5)  $I_I$  and  $I_O$  are used to denote specific conditions for  $I_{I/O}$ .

(6) The package thermal impedance is calculated in accordance with JESD 51-7.

## Recommended Operating Conditions<sup>(1)</sup>

		MIN	MAX	UNIT
$V_{CC}$	Supply voltage	3	3.6	V
$V_{IH}$	High-level control input voltage (SEL)	2	5.5	V
$V_{IL}$	Low-level control input voltage (SEL)	0	0.8	V
$V_{I/O}$	Input/output voltage	0	5.5	V
$T_A$	Operating free-air temperature	-40	85	°C

(1) All unused inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

## Electrical Characteristics<sup>(1)</sup>

for high-frequency switching over recommended operating free-air temperature range,  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$   
(unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(2)</sup>	MAX	UNIT	
$V_{IK}$	SEL	$V_{CC} = 3.6 \text{ V}$ ,	$I_{IN} = -18 \text{ mA}$		-0.7	-1.2	V	
$I_{IH}$	SEL	$V_{CC} = 3.6 \text{ V}$ ,	$V_{IN} = V_{CC}$			$\pm 1$	$\mu\text{A}$	
$I_{IL}$	SEL	$V_{CC} = 3.6 \text{ V}$ ,	$V_{IN} = \text{GND}$			$\pm 1$	$\mu\text{A}$	
$I_{off}$		$V_{CC} = 0$ ,	$V_O = 0 \text{ to } 3.6 \text{ V}$ ,			1	$\mu\text{A}$	
$I_{CC}$		$V_{CC} = 3.6 \text{ V}$ ,	$I_{I/O} = 0$ ,		250	500	$\mu\text{A}$	
$C_{IN}$	SEL	$f = 1 \text{ MHz}$ ,	$V_{IN} = 0$		2	2.5	pF	
$C_{OFF}$	B port	$V_I = 0$ ,	$f = 1 \text{ MHz}$ ,	Outputs open,		2.5	3	pF
$C_{ON}$		$V_I = 0$ ,	$f = 1 \text{ MHz}$ ,	Outputs open,		7.8	8.5	pF
$r_{on}$		$V_{CC} = 3 \text{ V}$ ,	$1.5 \text{ V} \leq V_I \leq V_{CC}$ ,	$I_O = -40 \text{ mA}$		3.5	6	$\Omega$
$r_{on(Flat)}$ <sup>(3)</sup>		$V_{CC} = 3 \text{ V}$ ,	$V_I = 1.5 \text{ V}$ and $V_{CC}$ ,	$I_O = -40 \text{ mA}$		0.5		$\Omega$
$\Delta r_{on}$ <sup>(4)</sup>		$V_{CC} = 3 \text{ V}$ ,	$1.5 \text{ V} \leq V_I \leq V_{CC}$ ,	$I_O = -40 \text{ mA}$		0.4	1	$\Omega$

- (1)  $V_I$ ,  $V_O$ ,  $I_I$ , and  $I_O$  refer to I/O pins.  $V_{IN}$  refers to the control inputs.  
 (2) All typical values are at  $V_{CC} = 3.3 \text{ V}$  (unless otherwise noted),  $T_A = 25^\circ\text{C}$ .  
 (3)  $r_{on(Flat)}$  is the difference of  $r_{on}$  in a given channel at specified voltages.  
 (4)  $\Delta r_{on}$  is the difference of  $r_{on}$  from center ( $A_4$ ,  $A_5$ ) ports to any other port.

## Switching Characteristics

over recommended operating free-air temperature range,  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ ,  $R_L = 200 \Omega$ ,  $C_L = 10 \text{ pF}$   
(unless otherwise noted) (see [Figure 4](#) and [Figure 5](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$t_{pd}$ <sup>(2)</sup>	A or B	B or A		0.25		ns
$t_{PZH}$ , $t_{PZL}$	SEL	A or B	0.5		15	ns
$t_{PHZ}$ , $t_{PLZ}$	SEL	A or B	0.5		9	ns
$t_{sk(o)}$ <sup>(3)</sup>	A or B	B or A		0.05	0.1	ns
$t_{sk(p)}$ <sup>(4)</sup>				0.05	0.1	ns

- (1) All typical values are at  $V_{CC} = 3.3 \text{ V}$  (unless otherwise noted),  $T_A = 25^\circ\text{C}$ .  
 (2) The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance when driven by an ideal voltage source (zero output impedance).  
 (3) Output skew between center port ( $A_4$  to  $A_5$ ) to any other port  
 (4) Skew between opposite transitions of the same output in a given device  $|t_{PHL} - t_{PLH}|$

## Dynamic Characteristics

over recommended operating free-air temperature range,  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TYP <sup>(1)</sup>	UNIT	
$X_{TALK}$	$R_L = 100 \Omega$ ,	$f = 250 \text{ MHz}$ ,		-41	dB
$O_{IRR}$	$R_L = 100 \Omega$ ,	$f = 250 \text{ MHz}$ ,		-39	dB
BW	$R_L = 100 \Omega$ ,	See <a href="#">Figure 6</a>		1.2	GHz

- (1) All typical values are at  $V_{CC} = 3.3 \text{ V}$  (unless otherwise noted),  $T_A = 25^\circ\text{C}$ .

**OPERATING CHARACTERISTICS**

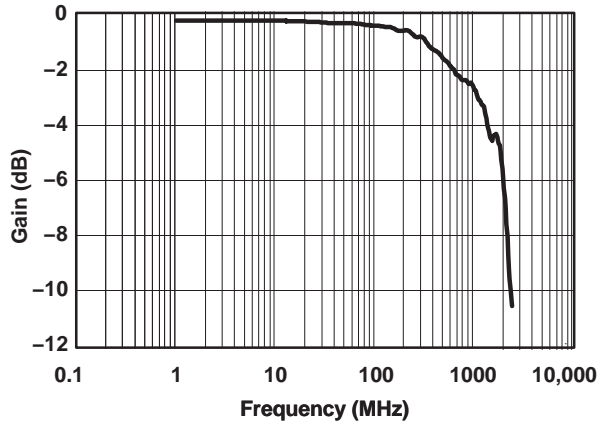


Figure 1. Gain/Phase vs Frequency

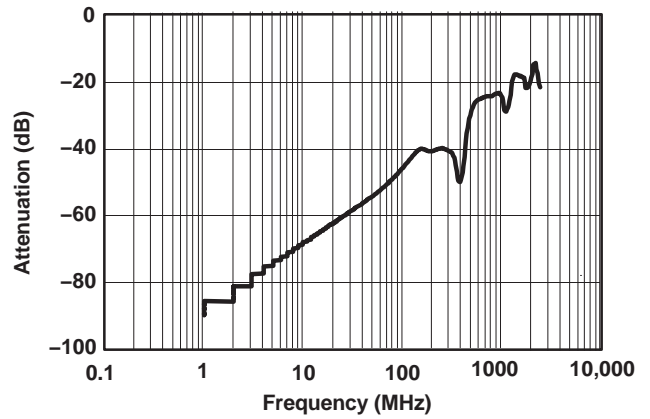


Figure 2. OFF Isolation vs Frequency

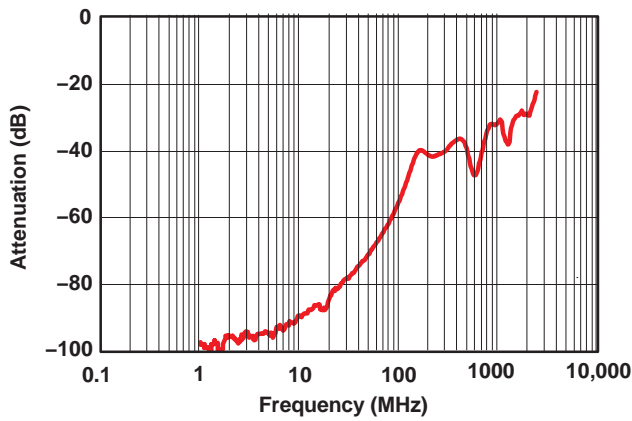


Figure 3. Crosstalk vs Frequency

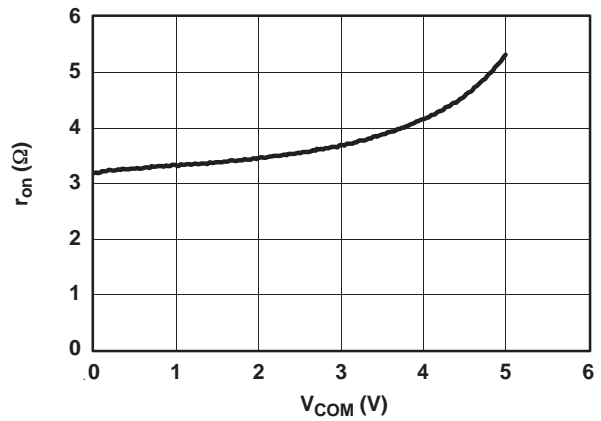
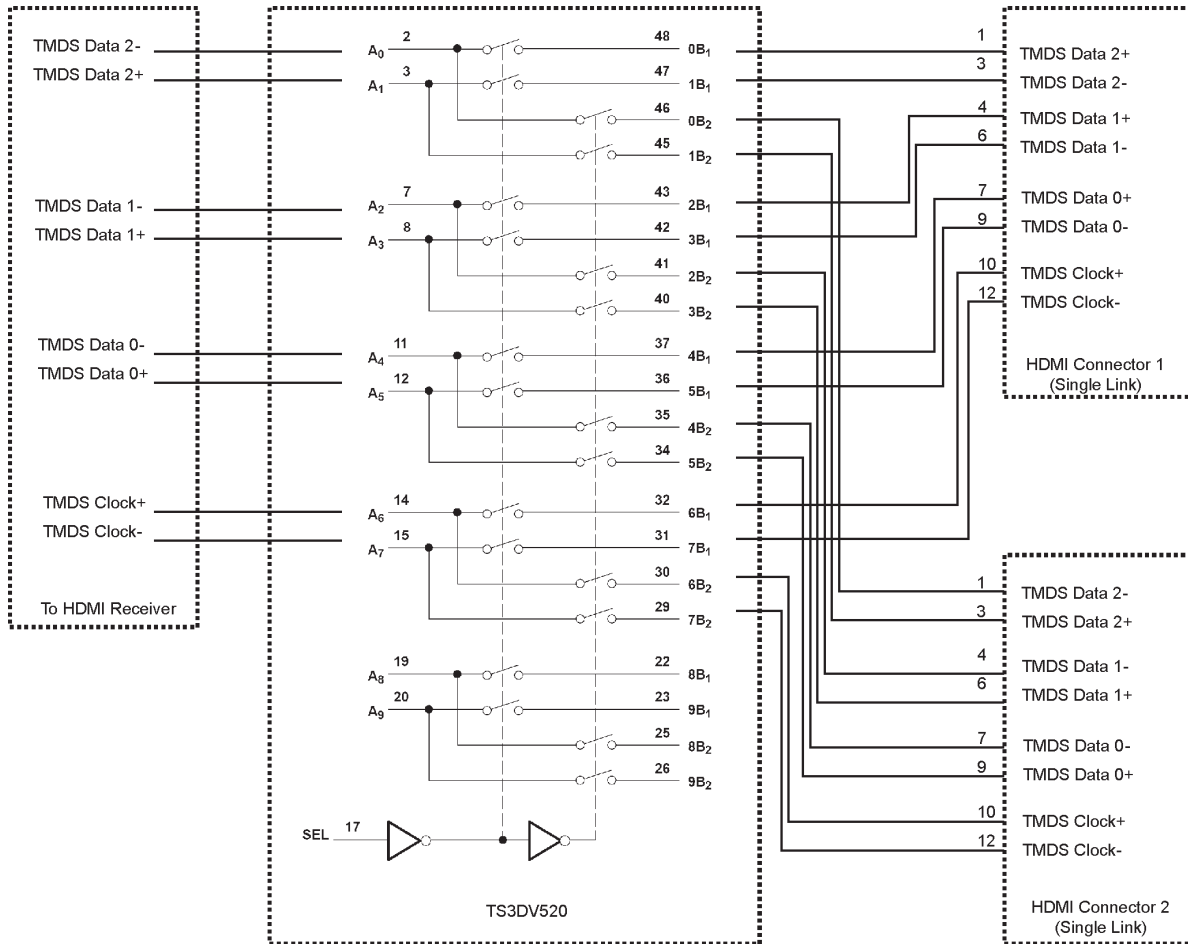
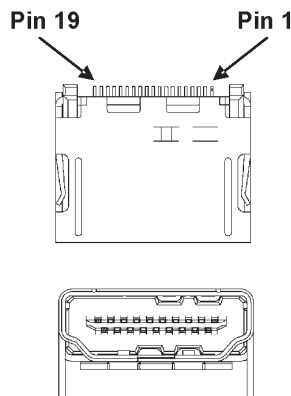


Figure 4.  $r_{on}$  and  $V_0$  vs  $V_1$

APPLICATION INFORMATION



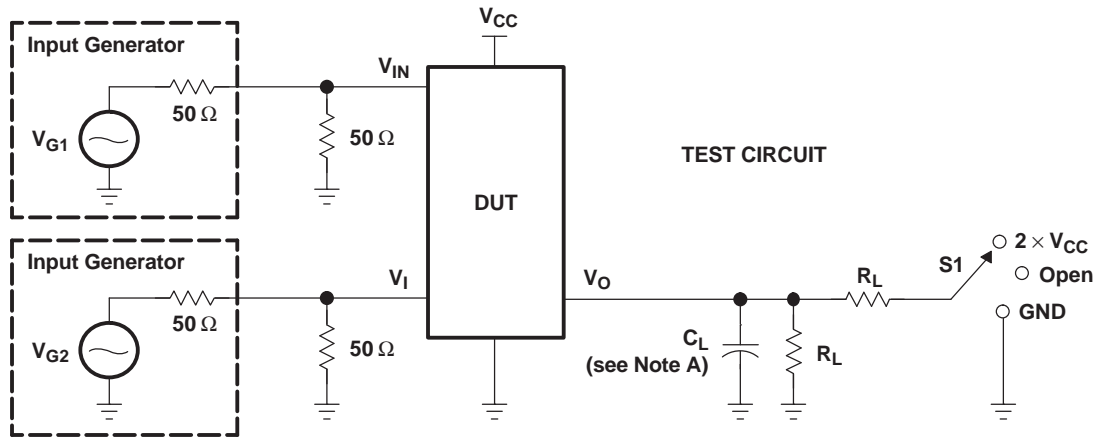
Typical HDMI Connector



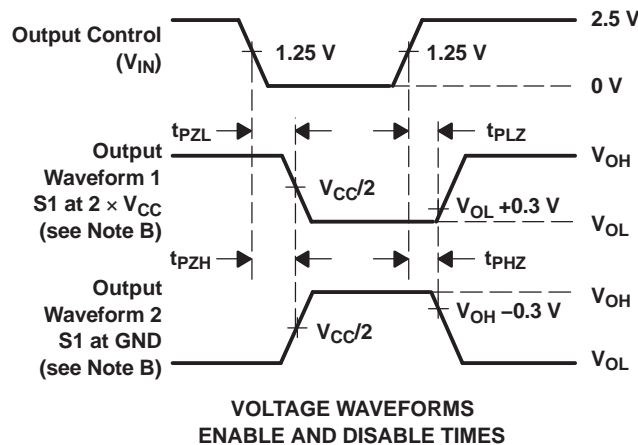
The TS3DV520 can be used to switch between two digital video ports.

Pin	Signal Assignment
1	TMDS Data2+
2	TMDS Data2 Shield
3	TMDS Data 2-
4	TMDS Data 1+
5	TMDS Data1 Shield
6	TMDS Data 1-
7	TMDS Data0+
8	TMDS Data0 Shield
9	TMDS Data 0-
10	TMDS Clock+
11	TMDS Clock Shield
12	TMDS Clock-
13	CEC
14	Reserved (N.C. on device)
15	SCL
16	SDA
17	DDC/CEC Ground
18	+5V Power
19	Hot Plug Detect

### PARAMETER MEASUREMENT INFORMATION (Enable and Disable Times)



TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	V <sub>I</sub>	C <sub>L</sub>	V <sub>Δ</sub>
t <sub>PLZ</sub> /t <sub>PZL</sub>	3.3 V ± 0.3 V	2 × V <sub>CC</sub>	200 Ω	GND	10 pF	0.3 V
t <sub>PHZ</sub> /t <sub>PZH</sub>	3.3 V ± 0.3 V	GND	200 Ω	V <sub>CC</sub>	10 pF	0.3 V

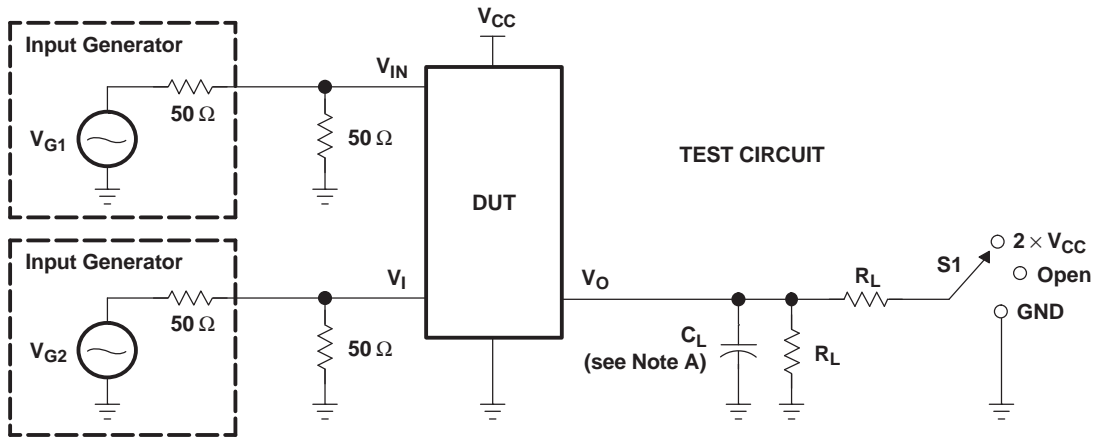


- NOTES: A. C<sub>L</sub> includes probe and jig capacitance.  
 B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.  
 C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub> ≤ 2.5 ns, t<sub>f</sub> ≤ 2.5 ns.  
 D. The outputs are measured one at a time, with one transition per measurement.  
 E. t<sub>PLZ</sub> and t<sub>PHZ</sub> are the same as t<sub>dis</sub>.  
 F. t<sub>PZL</sub> and t<sub>PZH</sub> are the same as t<sub>en</sub>.

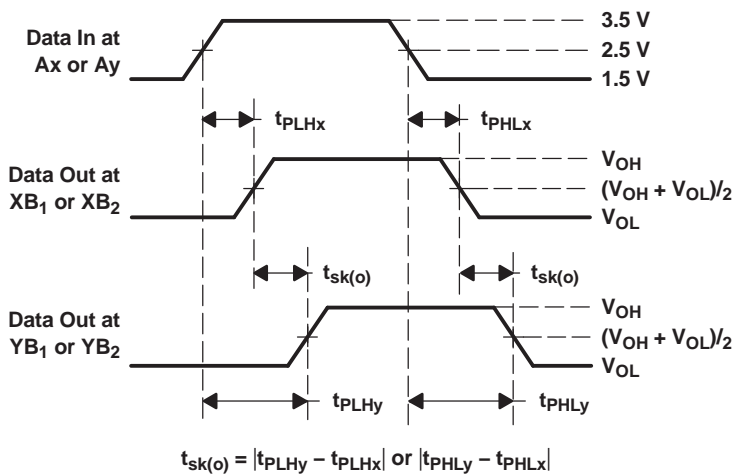
Figure 5. Test Circuit and Voltage Waveforms



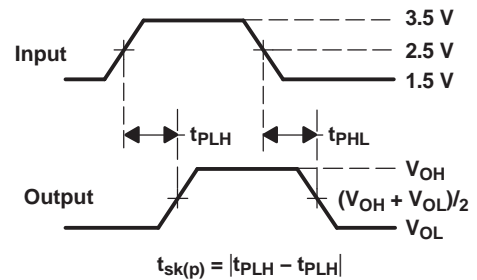
PARAMETER MEASUREMENT INFORMATION  
(Skew)



TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	V <sub>I</sub>	C <sub>L</sub>	V <sub>Δ</sub>
t <sub>sk(o)</sub>	3.3 V ± 0.3 V	Open	200 Ω	V <sub>CC</sub> or GND	10 pF	
t <sub>sk(p)</sub>	3.3 V ± 0.3 V	Open	200 Ω	V <sub>CC</sub> or GND	10 pF	



VOLTAGE WAVEFORMS  
OUTPUT SKEW (t<sub>sk(o)</sub>)

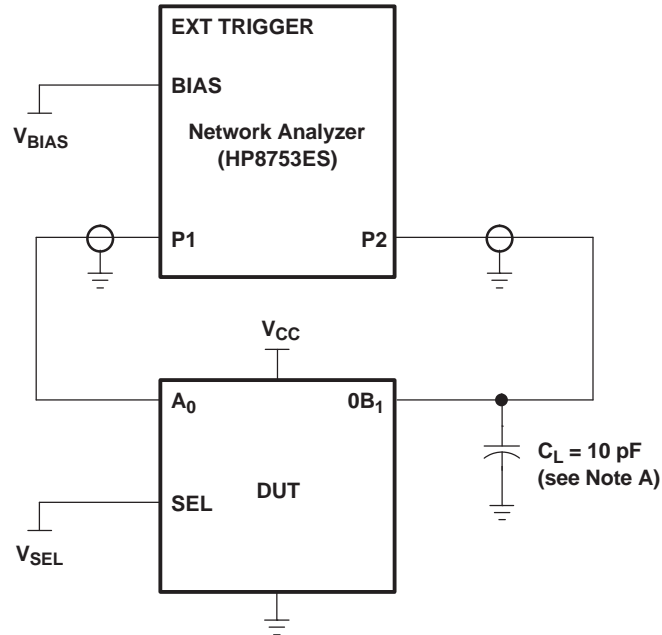


VOLTAGE WAVEFORMS  
PULSE SKEW (t<sub>sk(p)</sub>)

- NOTES: A. C<sub>L</sub> includes probe and jig capacitance.  
 B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.  
 C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub> ≤ 2.5 ns, t<sub>f</sub> ≤ 2.5 ns.  
 D. The outputs are measured one at a time, with one transition per measurement.

Figure 6. Test Circuit and Voltage Waveforms

## PARAMETER MEASUREMENT INFORMATION



NOTE A:  $C_L$  includes probe and jig capacitance.

**Figure 7. Test Circuit for Frequency Response (BW)**

Frequency response is measured at the output of the ON channel. For example, when  $V_{SEL} = 0$  and  $A_0$  is the input, the output is measured at  $0B_1$ . All unused analog I/O ports are left open.

### HP8753ES setup

Average = 4

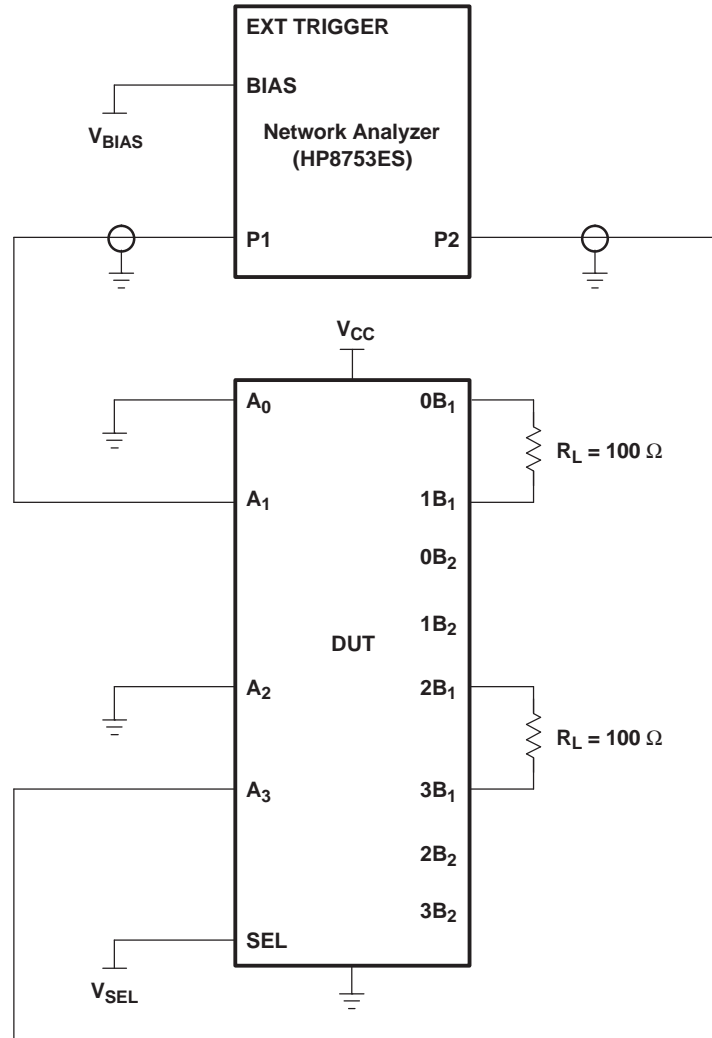
RBW = 3 kHz

$V_{BIAS} = 0.35$  V

ST = 2 s

P1 = 0 dBm

PARAMETER MEASUREMENT INFORMATION



- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. A 50- $\Omega$  termination resistor is needed to match the loading of the network analyzer.

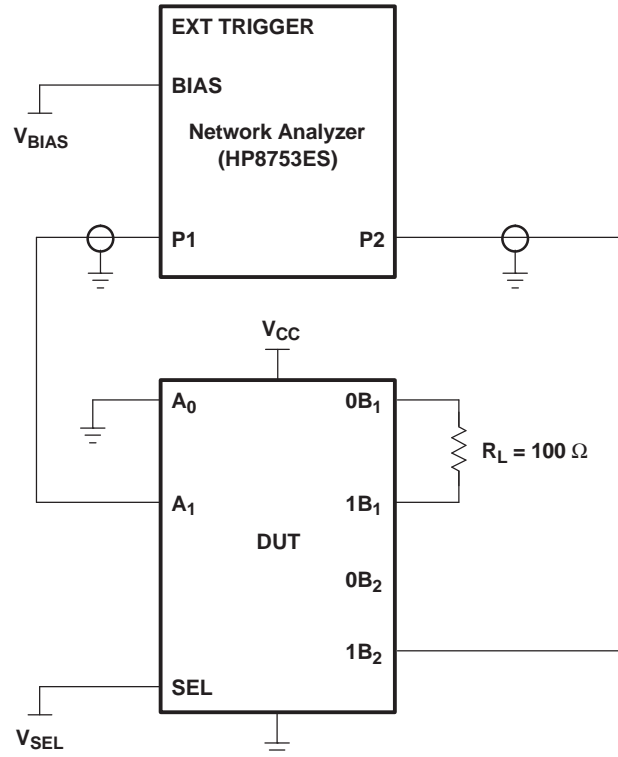
Figure 8. Test Circuit for Crosstalk ( $X_{TALK}$ )

Crosstalk is measured at the output of the nonadjacent ON channel. For example, when  $V_{SEL} = 0$  and  $A_0$  is the input, the output is measured at  $1B_1$ . All unused analog input (A) ports are connected to GND, and output (B) ports are connected to GND through 50- $\Omega$  pulldown resistors.

HP8753ES setup

- Average = 4
- RBW = 3 kHz
- $V_{BIAS} = 0.35$  V
- ST = 2 s
- P1 = 0 dBm

## PARAMETER MEASUREMENT INFORMATION



- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. A 50- $\Omega$  termination resistor is needed to match the loading of the network analyzer.

**Figure 9. Test Circuit for OFF Isolation ( $O_{IRR}$ )**

OFF isolation is measured at the output of the OFF channel. For example, when  $V_{SEL} = V_{CC}$  and  $A_0$  is the input, the output is measured at  $0B_2$ . All unused analog input (A) ports are left open, and output (B) ports are connected to GND through 50- $\Omega$  pulldown resistors.

### HP8753ES setup

Average = 4

RBW = 3 kHz

$V_{BIAS} = 0.35 \text{ V}$

ST = 2

P1 = 0 dBm

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TS3DV520ERHUR	ACTIVE	WQFN	RHU	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	SD520E	<a href="#">Samples</a>
TS3DV520RHUR	ACTIVE	WQFN	RHU	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	SD520	<a href="#">Samples</a>
TS3DV520RHURG4	ACTIVE	WQFN	RHU	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	SD520	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS3DV520ERHUR	WQFN	RHU	56	2000	330.0	24.4	5.3	11.3	1.0	12.0	24.0	Q1
TS3DV520RHUR	WQFN	RHU	56	2000	330.0	24.4	5.3	11.3	1.0	12.0	24.0	Q1

TAPE AND REEL BOX DIMENSIONS



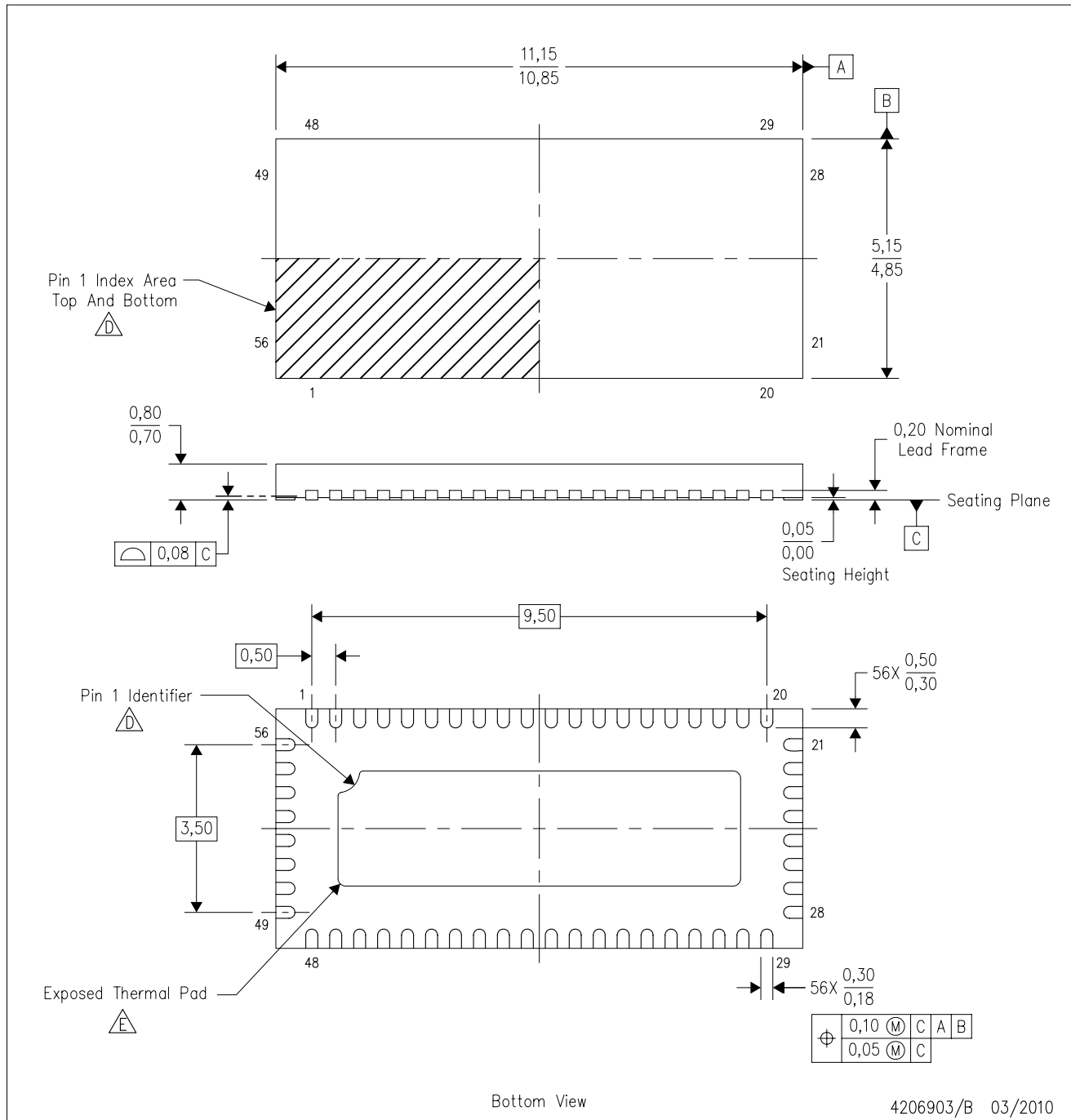
\*All dimensions are nominal



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS3DV520ERHUR	WQFN	RHU	56	2000	346.0	346.0	35.0
TS3DV520RHUR	WQFN	RHU	56	2000	346.0	346.0	35.0



RHU (R-PWQFN-N56)

PLASTIC QUAD FLATPACK NO-LEAD



- Notes:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. QFN (Quad Flatpack No-Lead) package configuration.
  -  Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.
  -  The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - F. JEDEC MO-220 package registration is pending.

# THERMAL PAD MECHANICAL DATA

RHU (R-PWQFN-N56)

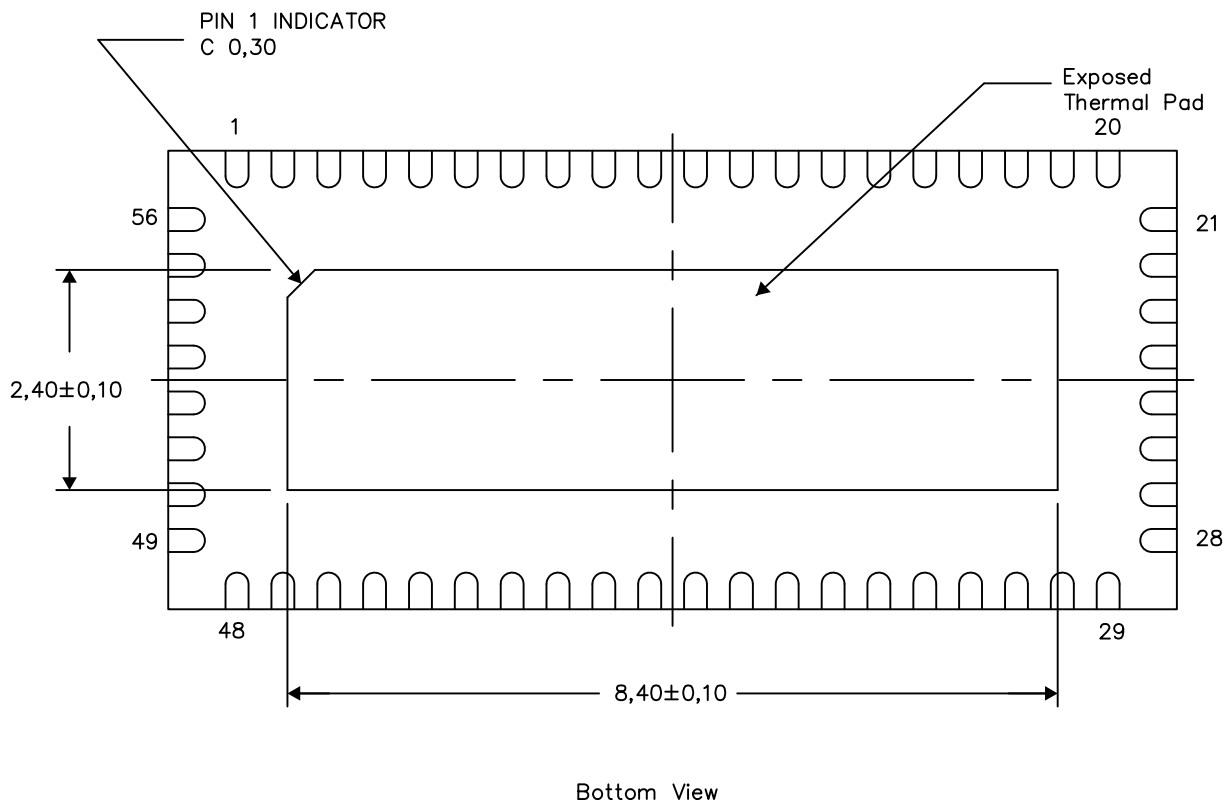
PLASTIC QUAD FLATPACK NO-LEAD

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



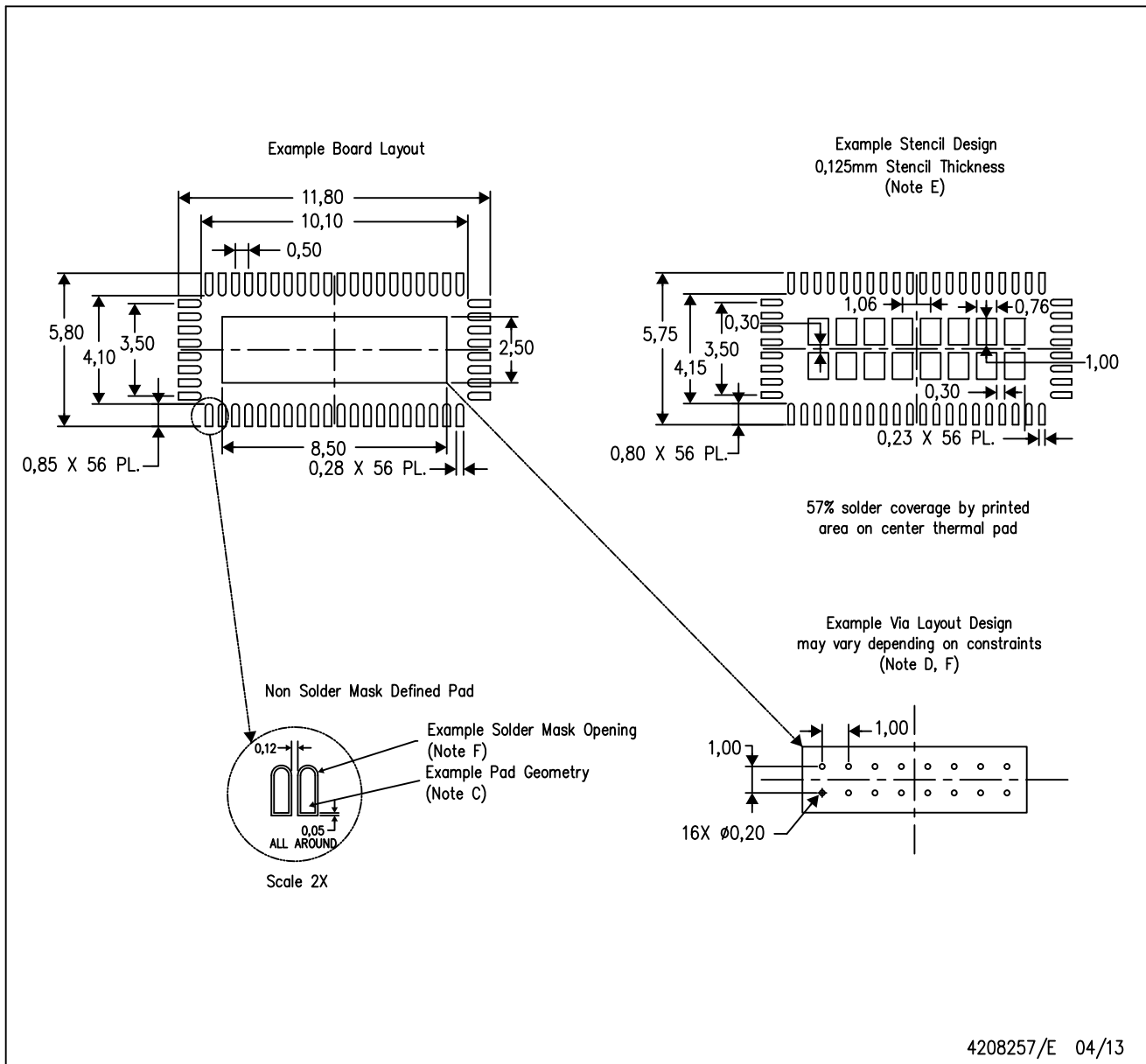
Exposed Thermal Pad Dimensions

4206904/F 04/13

NOTE: All linear dimensions are in millimeters

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- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

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