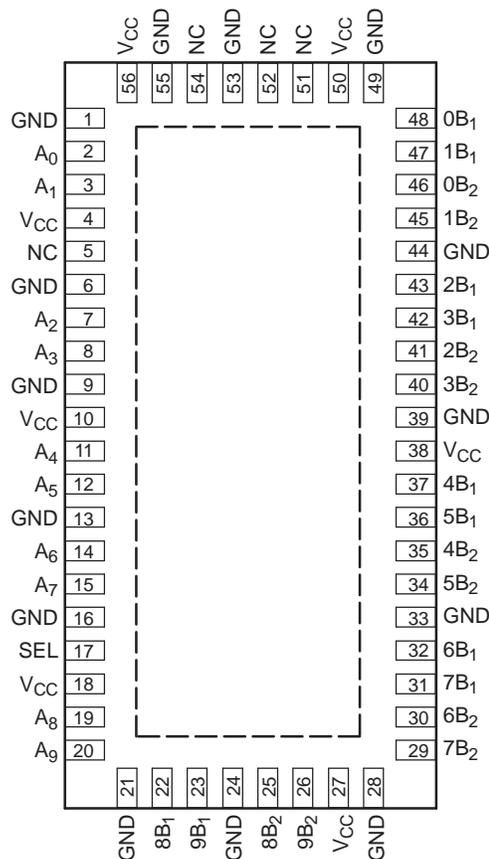


# 5-CHANNEL DIFFERENTIAL 10:20 MULTIPLEXER SWITCH FOR DVI/HDMI APPLICATIONS

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

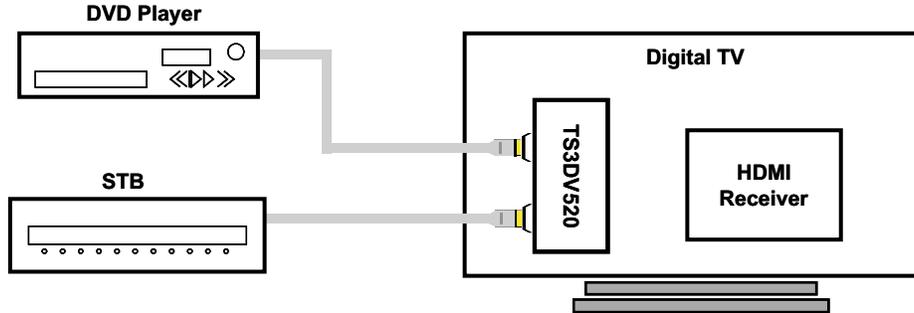
The TS3DV520 is a 20-bit to 10-bit multiplexer/demultiplexer digital video switch with a single select (SEL) input. SEL controls the data path of the multiplexer/demultiplexer. The device provides five differential channels for digital video signal switching. This device can also be used to replace mechanical 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).

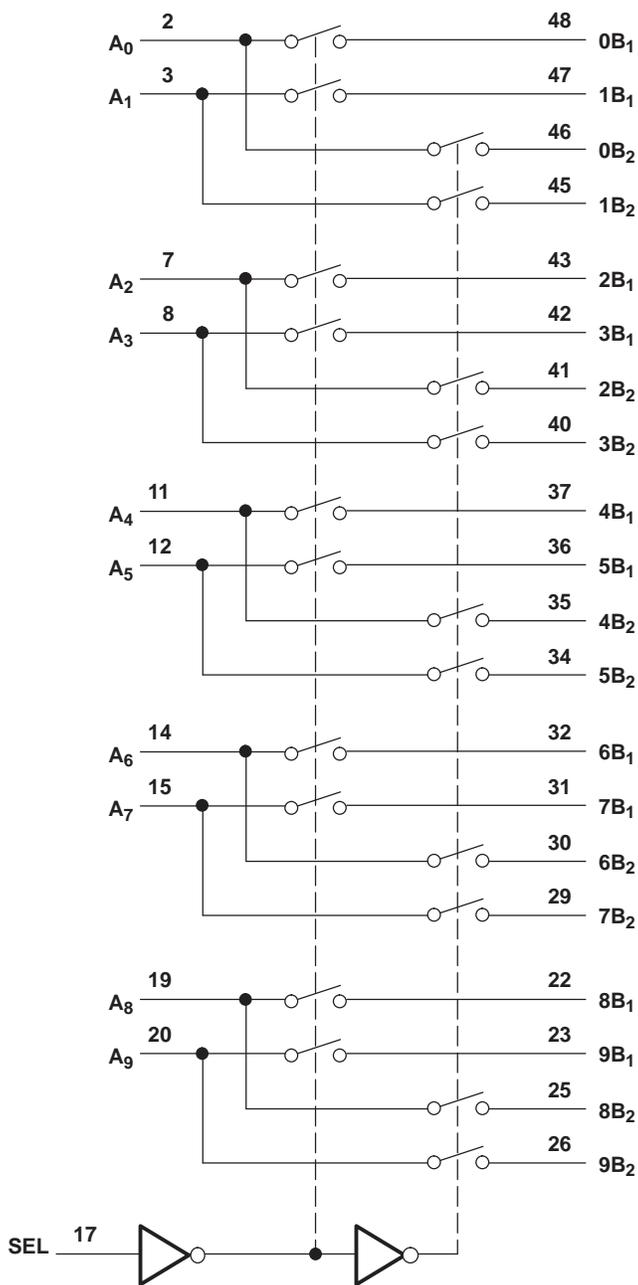
**FUNCTION TABLE**

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	$V_{CC} = 3.6 \text{ V}$ ,	$V_{IN} = \text{GND}$				$\pm 1$	$\mu\text{A}$
$I_{off}$		$V_{CC} = 0$ ,	$V_O = 0 \text{ to } 3.6 \text{ V}$ ,	$V_I = 0$			1	$\mu\text{A}$
$I_{CC}$		$V_{CC} = 3.6 \text{ V}$ ,	$I_{I/O} = 0$ ,	Switch ON or OFF		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, Switch OFF		2.5	3	pF
$C_{ON}$		$V_I = 0$ ,	$f = 1 \text{ MHz}$ ,	Outputs open, Switch ON		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
$X_{TALK}$	$R_L = 100 \Omega$ ,	$f = 250 \text{ MHz}$ ,	See <a href="#">Figure 7</a>	-41	dB
$O_{IRR}$	$R_L = 100 \Omega$ ,	$f = 250 \text{ MHz}$ ,	See <a href="#">Figure 8</a>	-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**

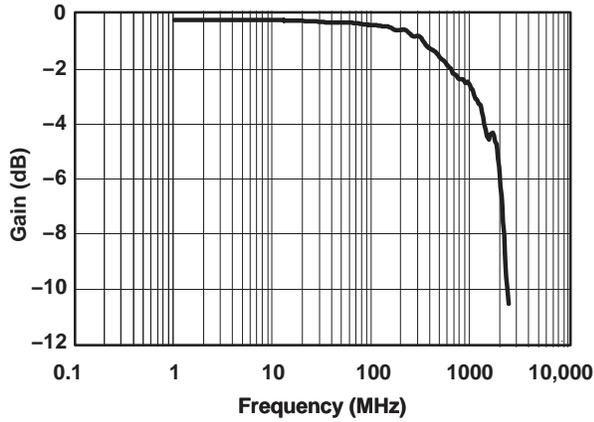


Figure 1. Gain/Phase vs Frequency

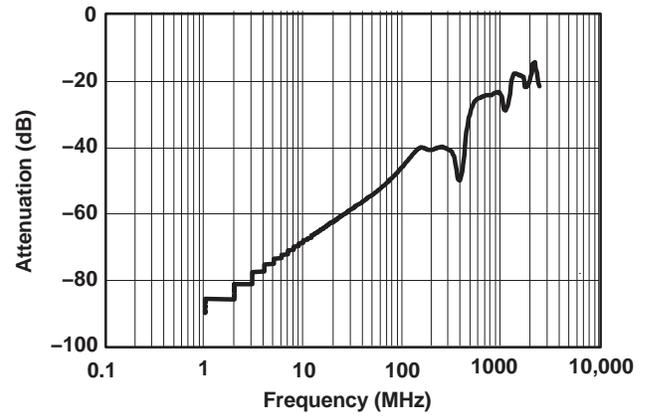


Figure 2. OFF Isolation vs Frequency

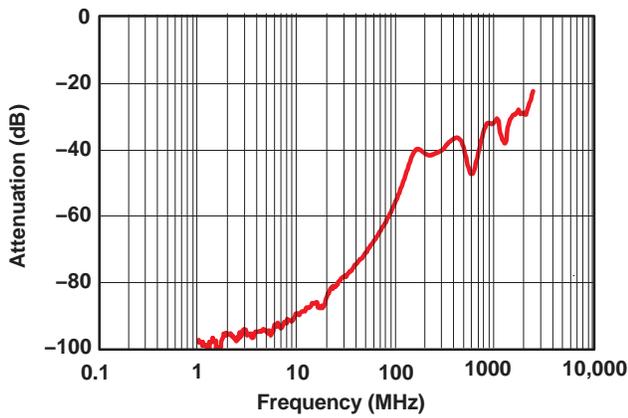


Figure 3. Crosstalk vs Frequency

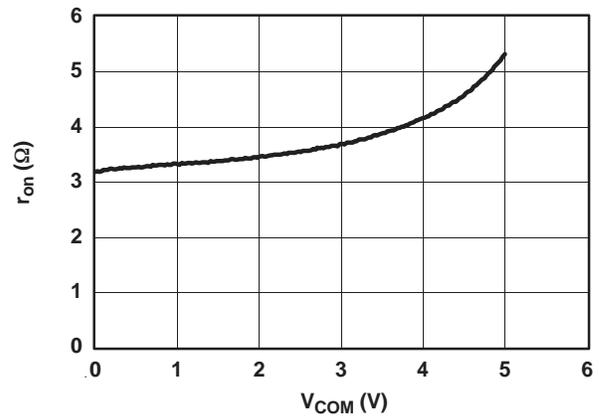
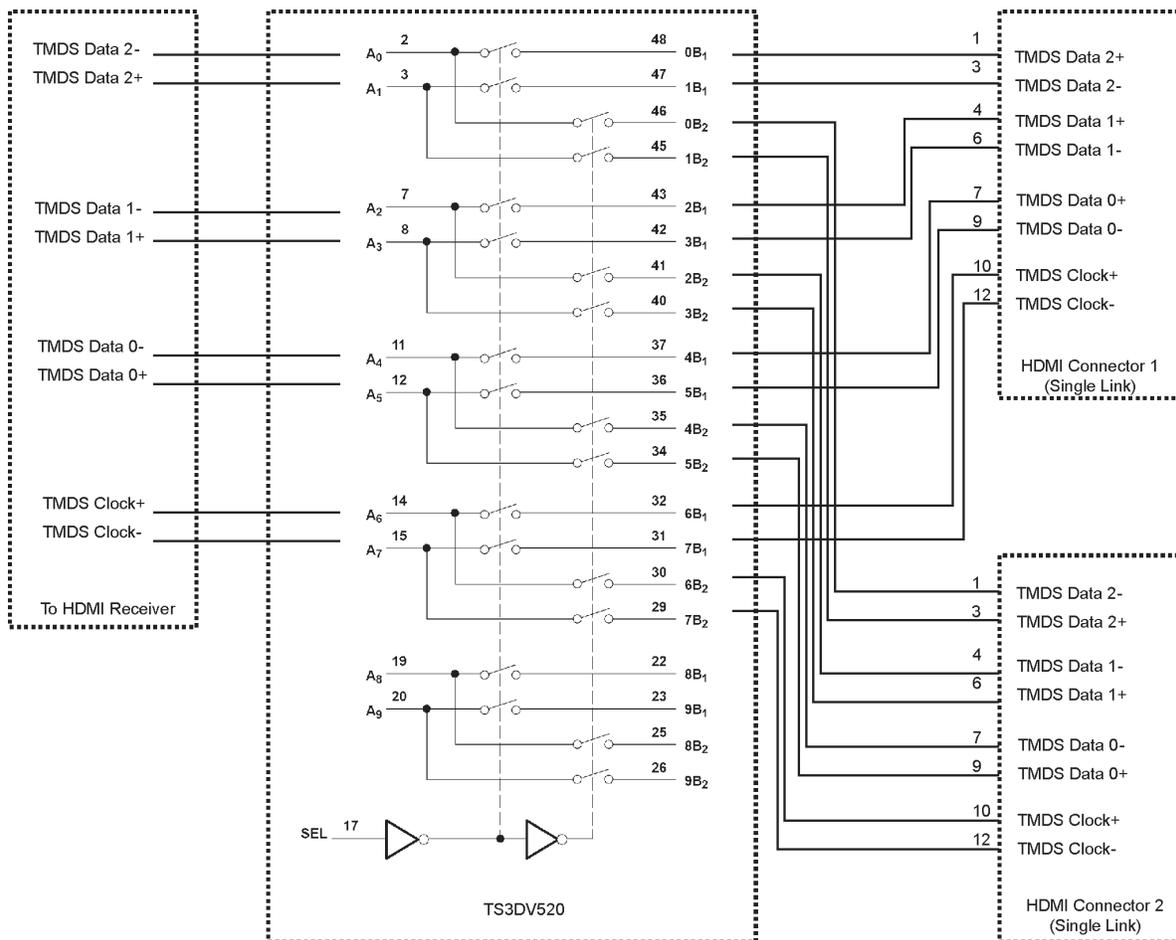
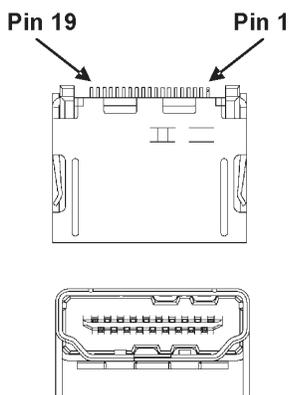


Figure 4.  $r_{on}$  and  $V_0$  vs  $V_1$

APPLICATION INFORMATION



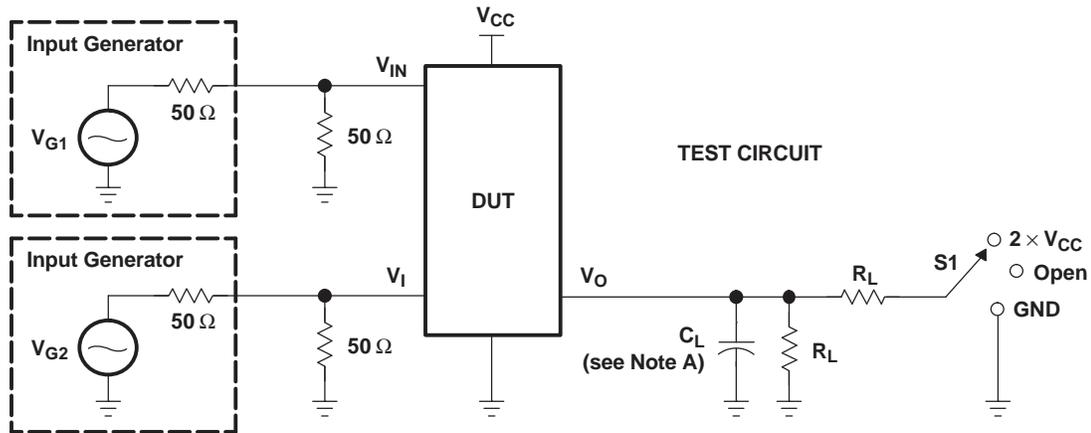
Typical HDMI Connector



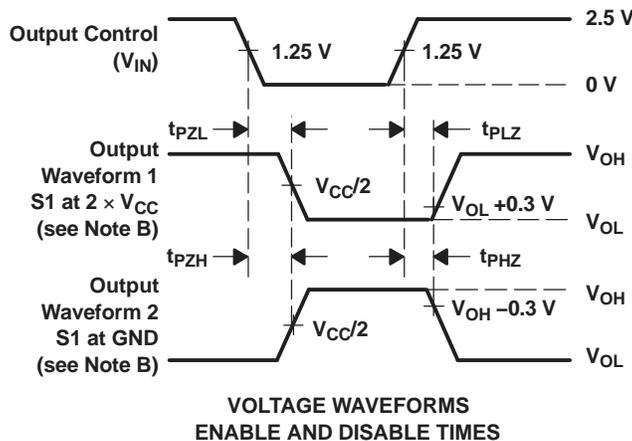
The TS3DV520 can be used to switch between two digital video ports.

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)



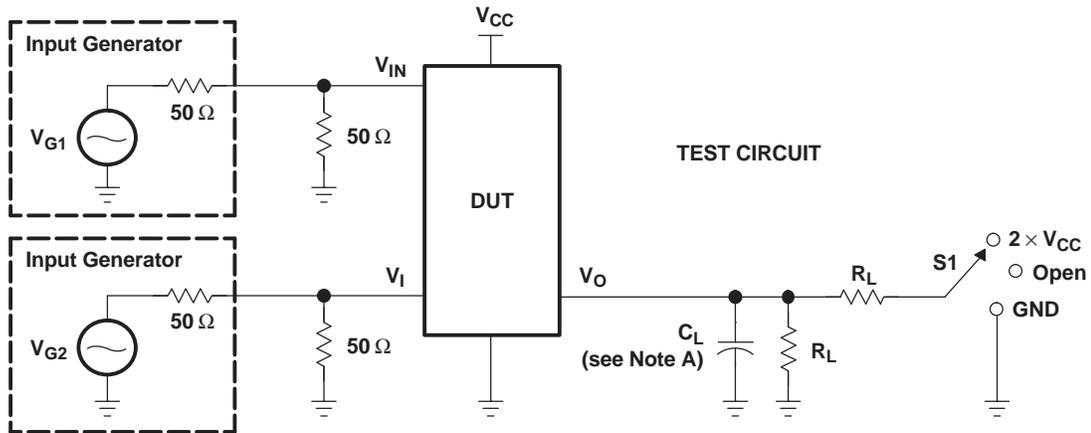
TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	V <sub>I</sub>	C <sub>L</sub>	V <sub>Δ</sub>
t <sub>PLZ</sub> /t <sub>PZL</sub>	3.3 V ± 0.3 V	2 × V <sub>CC</sub>	200 Ω	GND	10 pF	0.3 V
t <sub>PHZ</sub> /t <sub>PZH</sub>	3.3 V ± 0.3 V	GND	200 Ω	V <sub>CC</sub>	10 pF	0.3 V



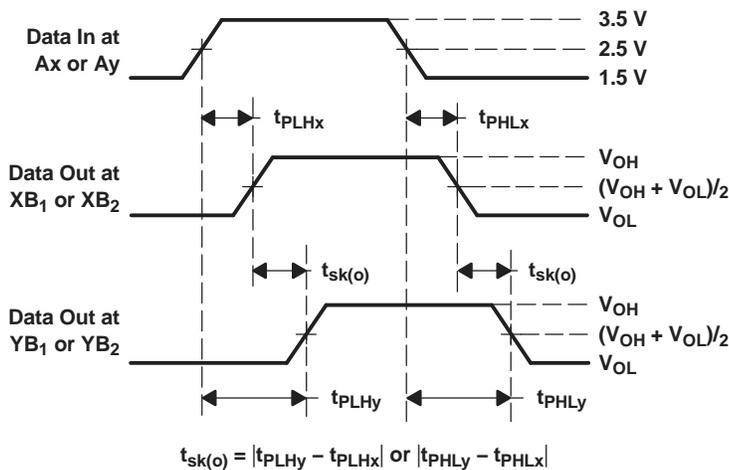
- NOTES:
- A. C<sub>L</sub> includes probe and jig capacitance.
  - B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled 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

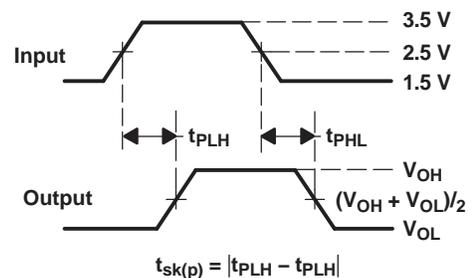
PARAMETER MEASUREMENT INFORMATION  
(Skew)



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>)

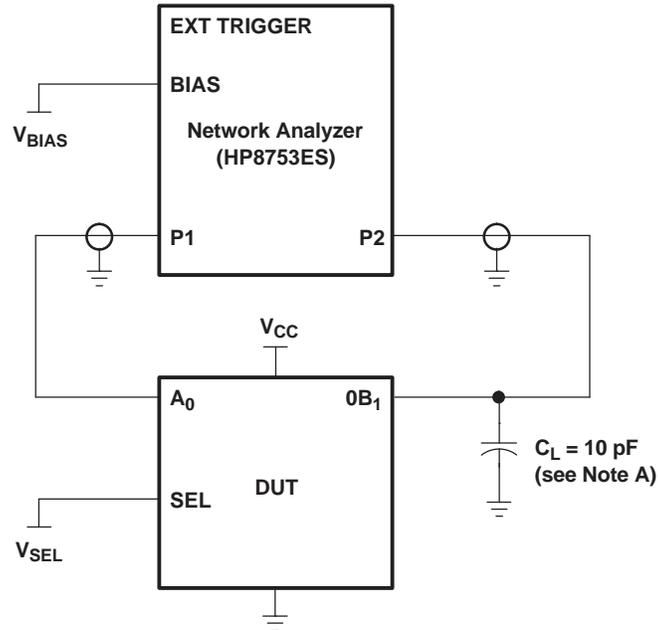


VOLTAGE WAVEFORMS  
PULSE SKEW (t<sub>sk(p)</sub>)

- 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

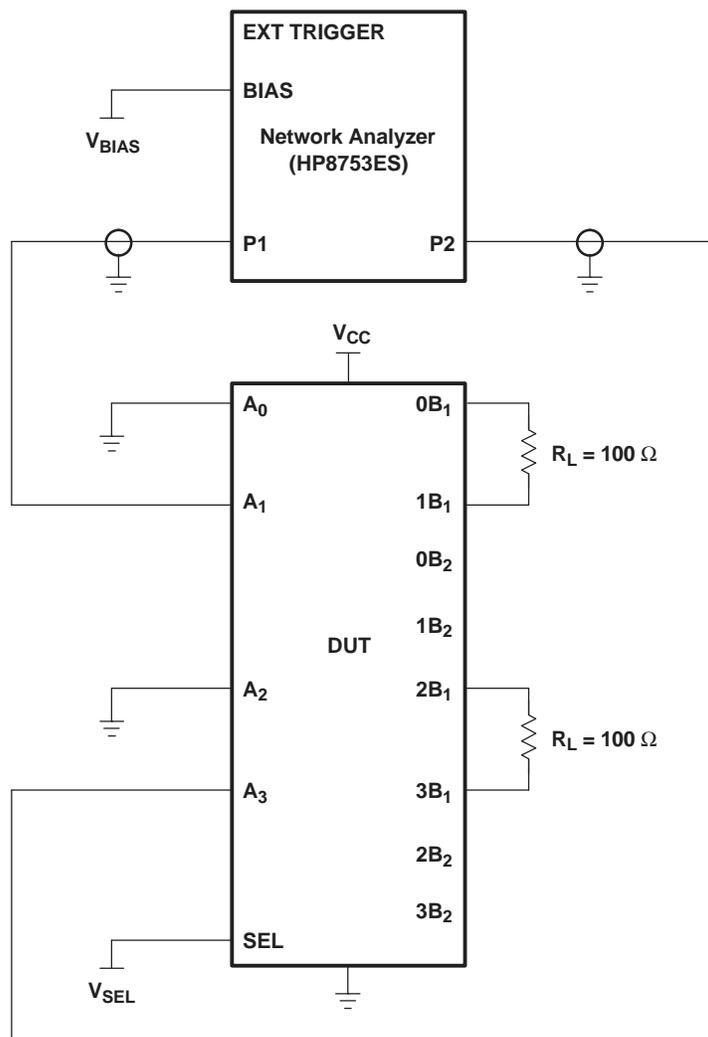
RBW = 3 kHz

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

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.

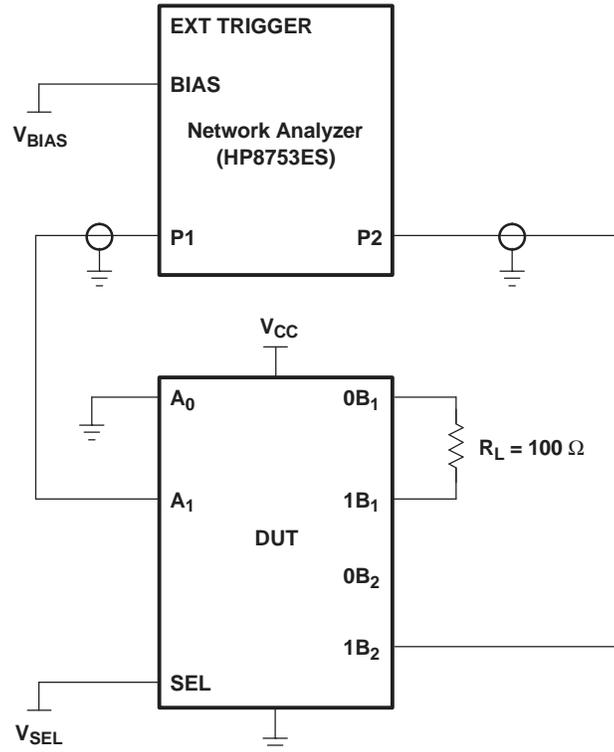
Figure 8. Test Circuit for Crosstalk ( $X_{TALK}$ )

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- $\Omega$  pull-down resistors.

### HP8753ES setup

Average = 4

RBW = 3 kHz

$V_{BIAS} = 0.35$  V

ST = 2

P1 = 0 dBm

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TS3DV520ERHUR	ACTIVE	WQFN	RHU	56	2000	RoHS & Green	NIPDAU   NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	SD520E	<a href="#">Samples</a>
TS3DV520ERHURG4	ACTIVE	WQFN	RHU	56	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	SD520E	<a href="#">Samples</a>
TS3DV520RHUR	ACTIVE	WQFN	RHU	56	2000	RoHS & Green	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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

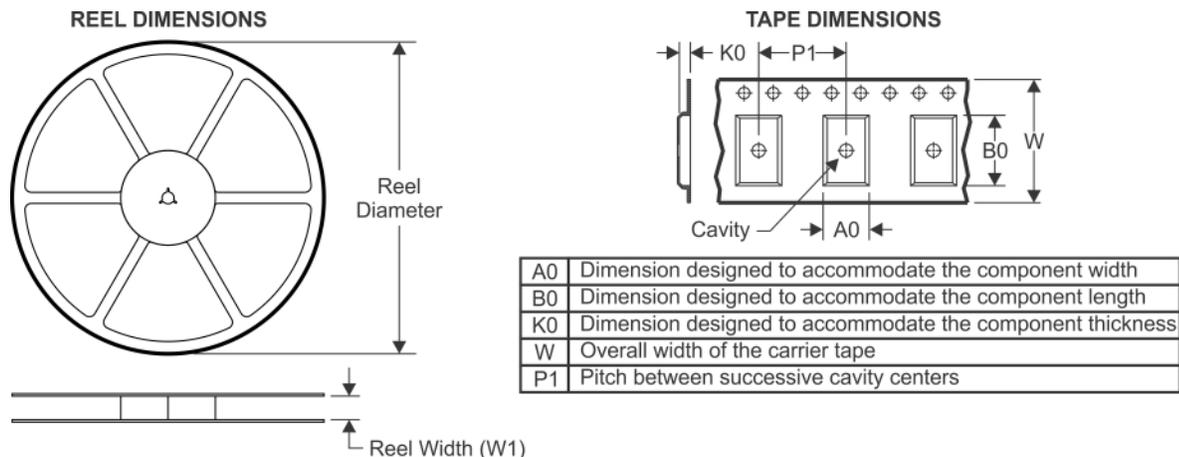
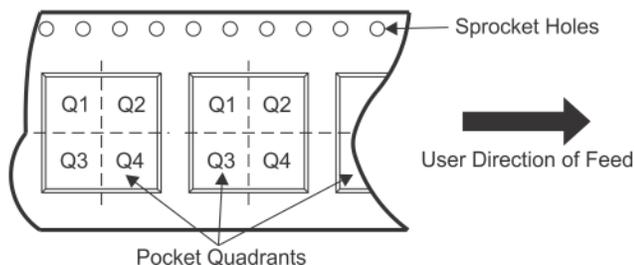
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

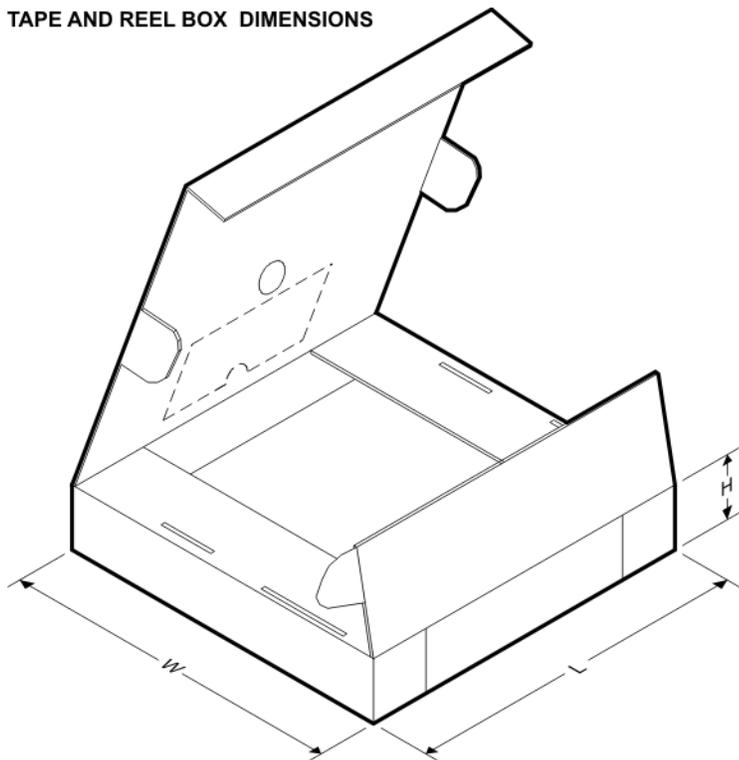
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**TAPE AND REEL INFORMATION**

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


\*All dimensions are nominal

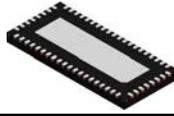
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS3DV520ERHUR	WQFN	RHU	56	2000	330.0	24.4	5.3	11.3	1.0	12.0	24.0	Q1
TS3DV520ERHUR	WQFN	RHU	56	2000	330.0	24.4	5.3	11.3	1.0	8.0	24.0	Q1
TS3DV520RHUR	WQFN	RHU	56	2000	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
TS3DV520ERHUR	WQFN	RHU	56	2000	367.0	367.0	45.0
TS3DV520RHUR	WQFN	RHU	56	2000	346.0	346.0	35.0

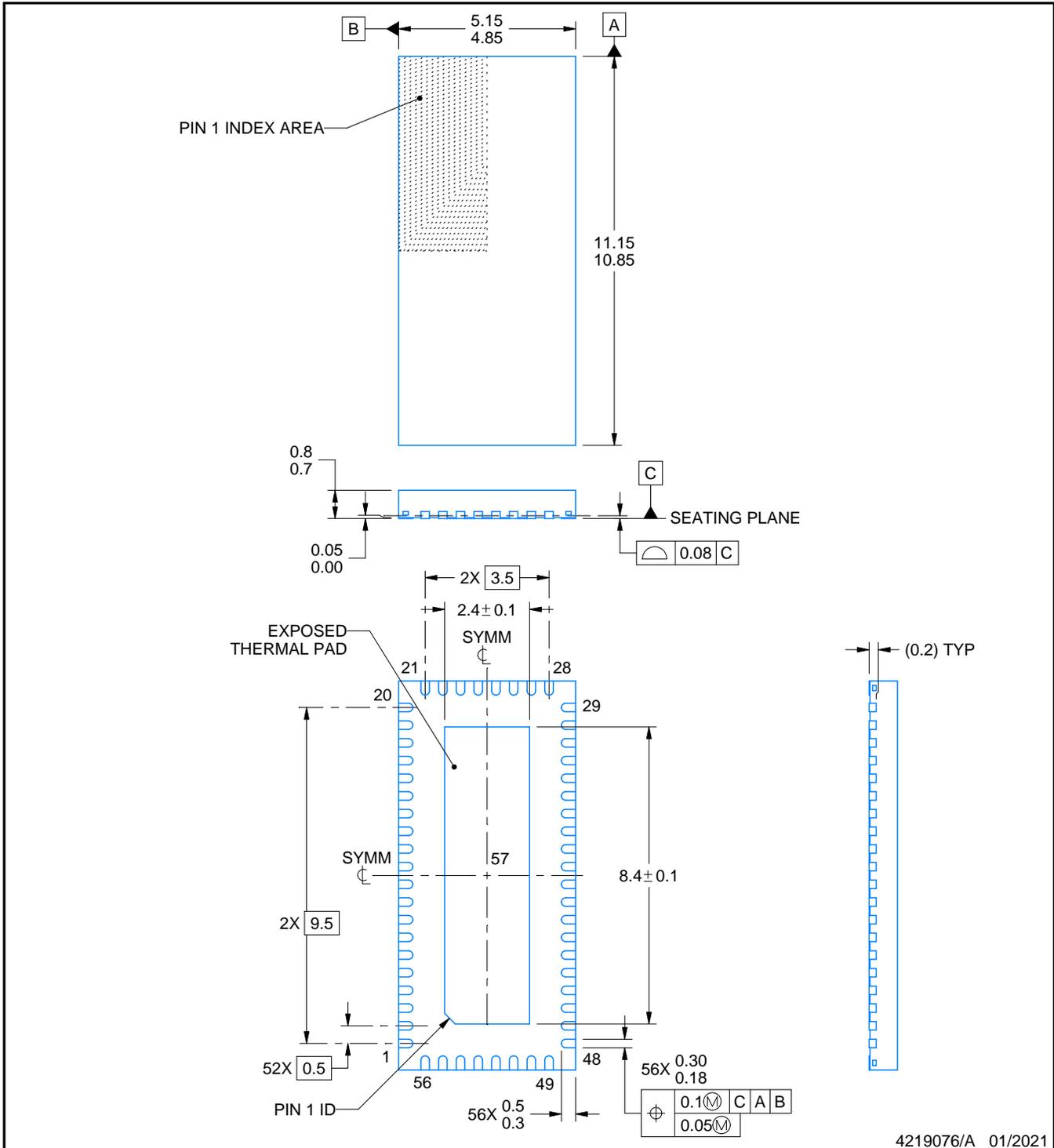
RHU0056A



PACKAGE OUTLINE

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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NOTES:

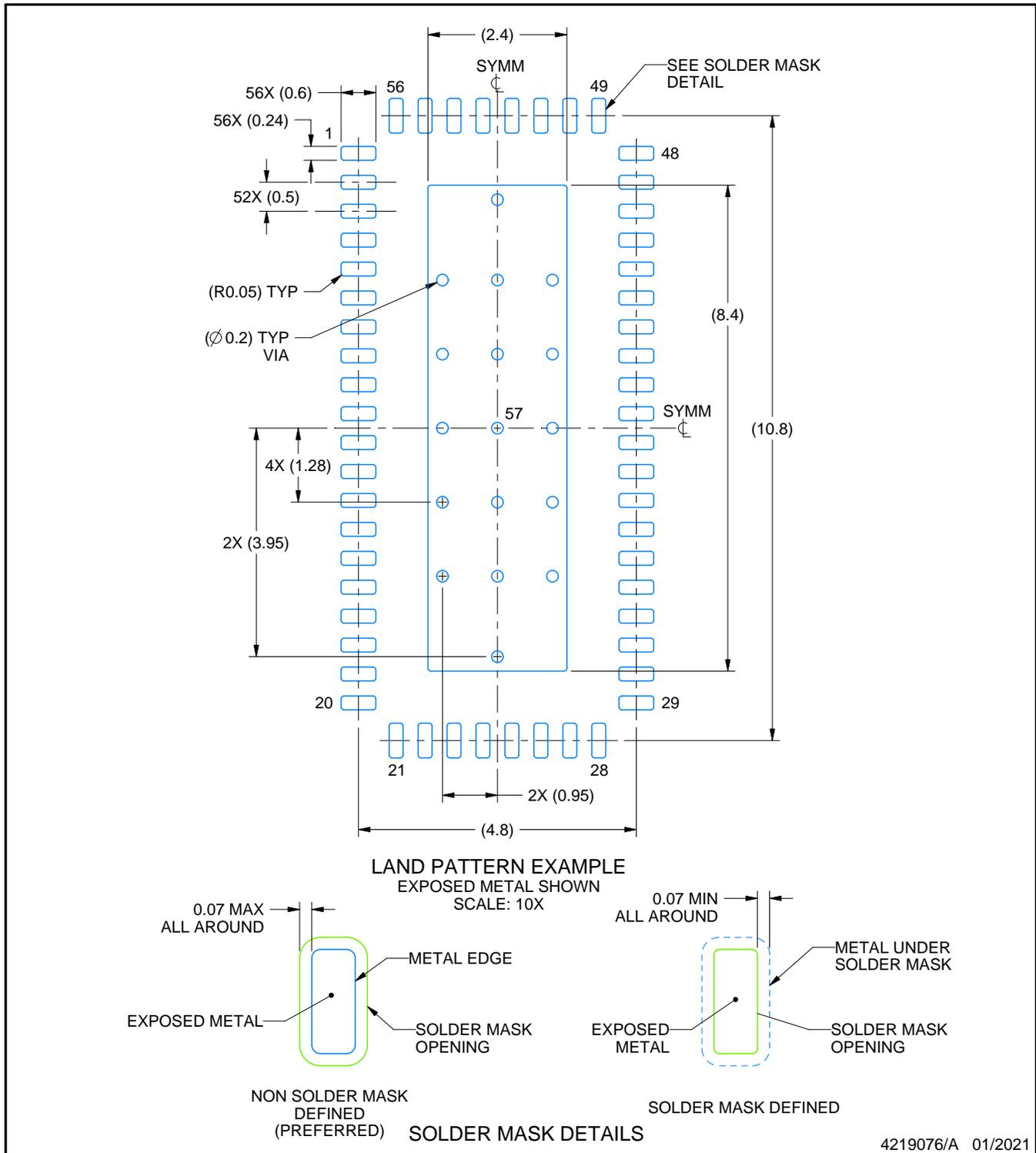
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

RHU0056A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

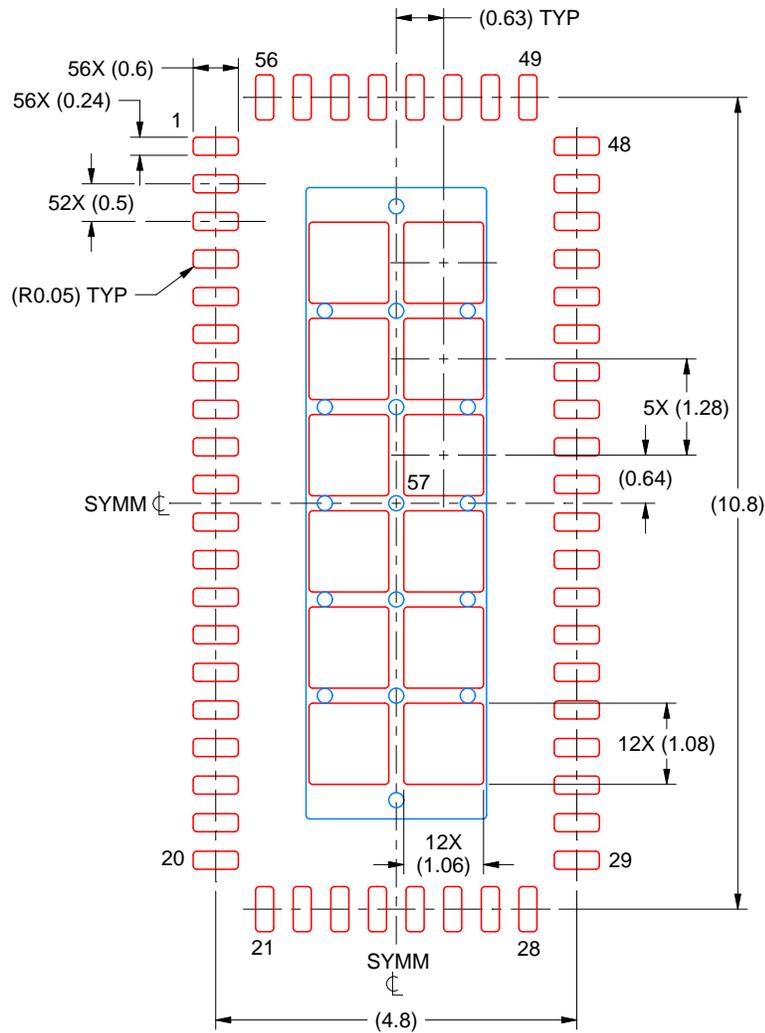
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RHU0056A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 MM THICK STENCIL  
SCALE: 10X

EXPOSED PAD 57  
68% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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