

# 4-CHANNEL DIFFERENTIAL 8:16 MULTIPLEXER SWITCH FOR DVI/HDMI APPLICATIONS

Check for Samples: [TS3DV421](#)

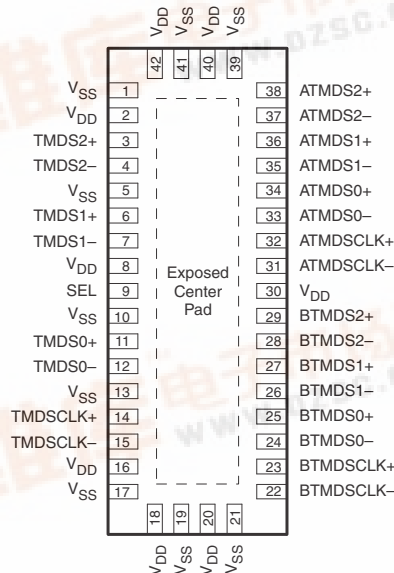
## FEATURES

- Compatible With HDMI v1.3 DVI 1.0 High-Speed Digital Interface
  - Wide Bandwidth of Over 3.8 Gbps
  - Serial Data Stream at 10x Pixel Clock Rate
  - Supports All Video Formats up to 1080p and SXGA (1280 × 1024 at 75 Hz)
  - High Bandwidth of 4.95 Gbps (Single Link)
  - HDCP Compatible
- Low Crosstalk ( $X_{TALK} = -50$  dB Typ at 1.65 Gbps)
- Off Isolation ( $O_{IRR} = -50$  dB Typ at 1.65 Gbps)
- Low Bit-to-Bit Skew ( $t_{sk(o)} = 0.1$  ns Max)
- Low and Flat ON-State Resistance ( $r_{ON} = 12.5 \Omega$  Max,  $r_{ON(flat)} = 0.5 \Omega$  Typ)
- Low Input/Output Capacitance ( $C_{ON} = 4.5$  pF Max)
- Enables Application-Specific Operating Voltage Selection
  - $V_{DD}$  Operating Range From 1.5 V to 2.1 V When  $V_{SS} = GND$
  - $V_{DD}$  Operating Range From 3.0 V to 3.6 V When  $V_{SS} = 1.5$  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)
- For DisplayPort Applications:  $V_{DD} = 1.8$  V,  $V_{SS} = GND$
- For HDMI /DVI Applications:  $V_{DD} = 3.3$  V,  $V_{SS} = 1.5$  V

## APPLICATIONS

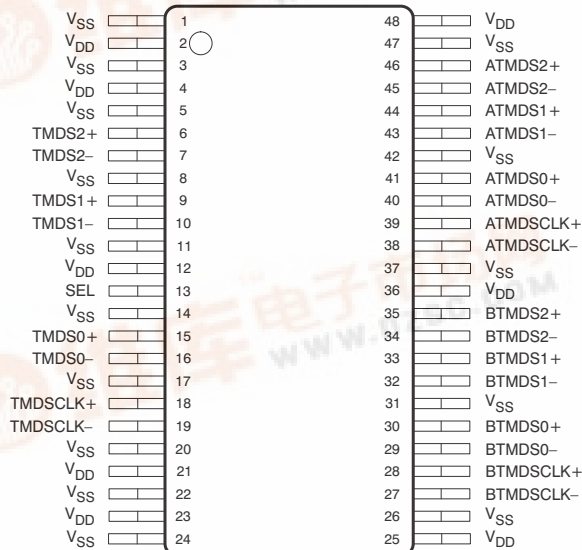
- DVI/HDMI Signal Switching
- Differential DVI, HDMI Signal Multiplexing for Audio/Video Receivers and High-Definition Televisions (HDTVs)

RUA PACKAGE  
(TOP VIEW)



For RUA, the exposed center pad must be connected to  $V_{SS}$  or electronically open. For this part to be used in HDMI/TMDS applications,  $V_{SS}$  can be elevated to 1.5 V. See Figure 1.

DGV PACKAGE  
(TOP VIEW)



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.

All trademarks are the property of their respective owners.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2008–2010, Texas Instruments Incorporated



[查询TS3DV421供应商](#)

**DESCRIPTION/ORDERING INFORMATION**

The TS3DV421 is a 4-channel differential 2:1 multiplexer/demultiplexer digital video switch controlled with one select input (SEL). SEL controls the data path of the multiplexer/demultiplexer and can be connected to any GPIO in the system, using an external voltage divider system. The device provides high bandwidth necessary for DVI and HDMI applications. This device expands the high-speed physical link interface from a single HDMI port to two HDMI ports (A or B port). The unselected channel is set to a high-impedance state.

The most common application for the TS3DV421 is in the sink application. In this case, there are two sources (i.e., DVD, set-top box, or game console) that must be routed to one HDMI receiver. The TS3DV421 can route the signals where one HDMI receiver (in a DLP, LCD TV, PDP, or other high-definition display) can be expanded to three ports.

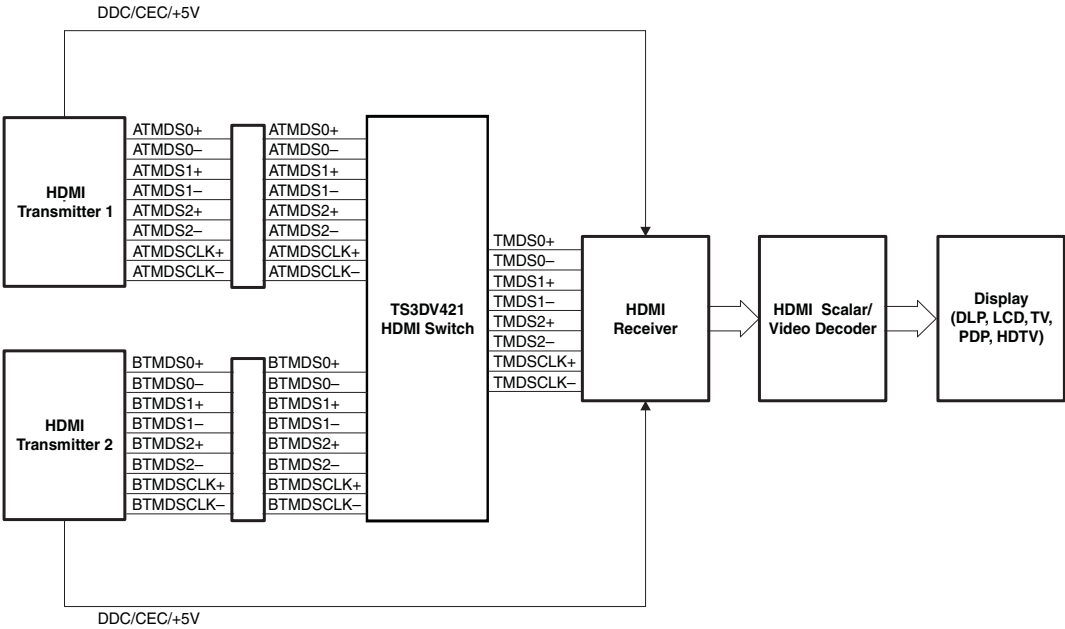
The HDMI application calls for a 100-Ω differential impedance between the differential lines (TMDSn+ and TMDSn-). Additionally, because the TS3DV421 is a high-bandwidth, low- $r_{ON}$  pass transistor-type switch, a properly designed board retains a 100-Ω differential impedance through the switch. The unselected port is in the high-impedance mode, such that the receiver receives information from only one source. HDCP encryption is passed through the switch for the HDMI receiver to decode.

**Table 1. ORDERING INFORMATION**

T <sub>A</sub>	PACKAGE <sup>(1)</sup> <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	QFN – RUA	Tape and reel	TS3DV421RUAR	SD421
	TVSOP – DGV	Tape and reel	TS3DV421DGVR	SD421

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

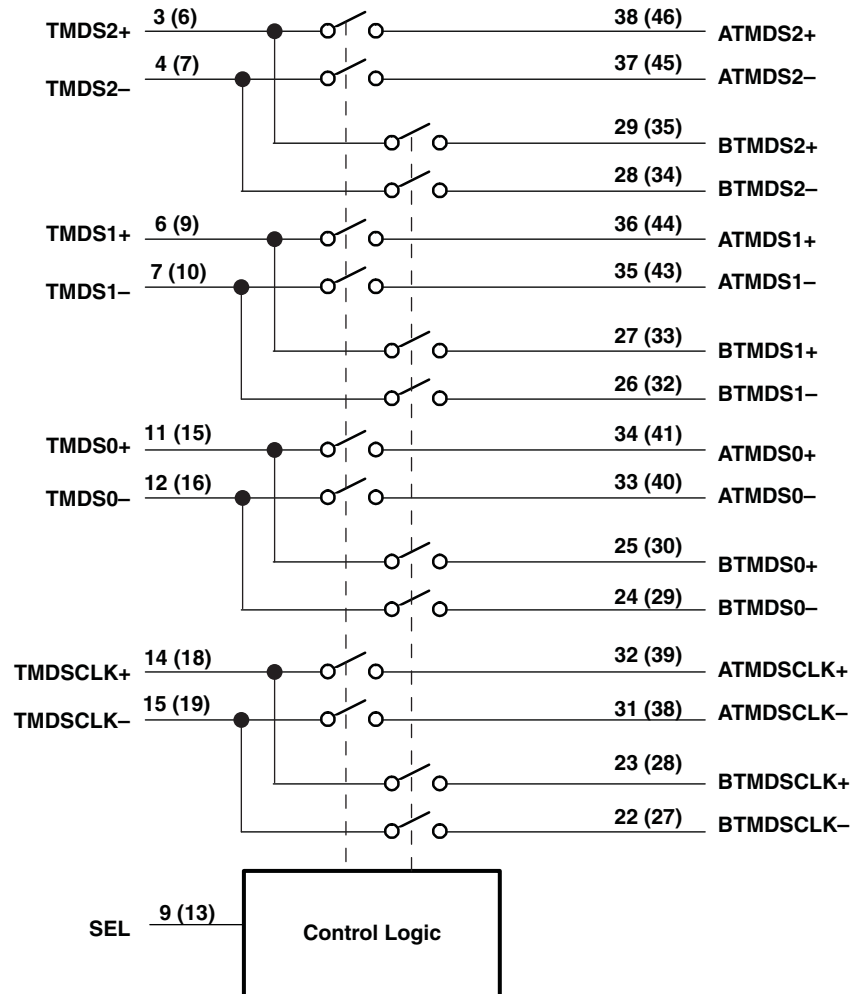
**TYPICAL APPLICATION**



**Table 2. FUNCTION TABLE**

SEL	FUNCTION	OUTPUT
L	$\text{TMDSn+} = \text{ATMDSn+}$ $\text{TMDSn-} = \text{ATMDSn-}$ $\text{TMDSCLK+} = \text{ATMDSCLK+}$ $\text{TMDSCLK-} = \text{ATMDSCLK-}$ $\text{BTMDSn+} = \text{High impedance}$ $\text{BTMDSn-} = \text{High impedance}$ $\text{BTMDSCLK+} = \text{High impedance}$ $\text{BTMDSCLK-} = \text{High impedance}$	$\text{TMDSn+}$ $\text{TMDSn-}$ $\text{TMDSCLK+}$ $\text{TMDSCLK-}$
H	$\text{TMDSn+} = \text{BTMDSn+}$ $\text{TMDSn-} = \text{BTMDSn-}$ $\text{TMDSCLK+} = \text{BTMDSCLK+}$ $\text{TMDSCLK-} = \text{BTMDSCLK-}$ $\text{ATMDSn+} = \text{High impedance}$ $\text{ATMDSn-} = \text{High impedance}$ $\text{ATMDSCLK+} = \text{High impedance}$ $\text{ATMDSCLK-} = \text{High impedance}$	$\text{TMDSn+}$ $\text{TMDSn-}$ $\text{TMDSCLK+}$ $\text{TMDSCLK-}$

**FUNCTIONAL DIAGRAM**



A. TVSOP package pin identification in parenthesis.

**TERMINAL FUNCTIONS**

TERMINAL			TYPE	DESCRIPTION
NAME	NO.			
	QFN (RUA)	TVSOP (DGV)		
ATMDS0–	33	40	I/O	Port A, channel 0, TMDS negative signal
ATMDS0+	34	41	I/O	Port A, channel 0, TMDS positive signal
ATMDS1–	35	43	I/O	Port A, channel 1, TMDS negative signal
ATMDS1+	36	44	I/O	Port A, channel 1, TMDS positive signal
ATMDS2–	37	45	I/O	Port A, channel 2, TMDS negative signal
ATMDS2+	38	46	I/O	Port A, channel 2, TMDS positive signal
ATMDSCLK–	31	38	I/O	Port A TMDS negative clock
ATMDSCLK+	32	39	I/O	Port A TMDS positive clock
BTMDS0–	24	29	I/O	Port B, channel 0, TMDS negative signal
BTMDS0+	25	30	I/O	Port B, channel 0, TMDS positive signal
BTMDS1–	26	32	I/O	Port B, channel 1, TMDS negative signal
BTMDS1+	27	33	I/O	Port B, channel 1, TMDS positive signal
BTMDS2–	28	34	I/O	Port B, channel 2, TMDS negative signal
BTMDS2+	29	35	I/O	Port B, channel 2, TMDS positive signal
BTMDSCLK–	22	27	I/O	Port B TMDS negative clock
BTMDSCLK+	23	28	I/O	Port B TMDS positive clock
SEL	9	13	I	Select pin to choose between port A or port B. Referenced to V <sub>SS</sub>
TMDS0–	12	16	I/O	TMDS channel 0 negative signal
TMDS0+	11	15	I/O	TMDS channel 0 positive signal
TMDS1–	7	10	I/O	TMDS channel 1 negative signal
TMDS1+	6	9	I/O	TMDS channel 1 positive signal
TMDS2–	4	7	I/O	TMDS channel 2 negative signal
TMDS2+	3	6	I/O	TMDS channel 2 positive signal
TMDSCLK–	15	19	I/O	TMDS negative clock
TMDSCLK+	14	18	I/O	TMDS positive clock
V <sub>DD</sub>	2, 8, 16, 18, 20, 30, 40, 42	2, 4, 12, 21, 23, 25, 36, 48	Power	Positive power supply voltage
V <sub>SS</sub>	1, 5, 10, 13, 17, 19, 21, 39, 41	1, 3, 5, 8, 14, 17, 20, 22, 24, 26, 31, 37, 42, 47	Power	Negative power supply voltage

## ABSOLUTE MINIMUM AND MAXIMUM RATINGS<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted), - All voltages are with respect to  $V_{SS}$

		MIN	MAX	UNIT
$V_{DD}$	Supply voltage range	-0.5	2.5	V
$V_{IN}$	Control input voltage range <sup>(2)</sup>	-0.5	2.5	V
$V_{I/O}$	Switch I/O voltage range <sup>(2) (3)</sup>	-0.5	2.5	V
$I_{IK}$	Control input clamp current	$V_{IN} < V_{SS}$		50 mA
$I_{I/OK}$	I/O port clamp current	$V_{I/O} < V_{SS}$		50 mA
$I_{I/O}$	ON-state switch current <sup>(4)</sup>			100 mA
$I_{DD}$	Continuous current through $V_{DD}$			100 mA
$I_{SS}$	Continuous current through $V_{SS}$			100 mA
$\theta_{JA}$	Package thermal impedance <sup>(5)</sup>	DGV package		58.0 °C/W
		RUA package		51.2 °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) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (3)  $V_I$  and  $V_O$  are used to denote specific conditions for  $V_{I/O}$ .
- (4)  $I_I$  and  $I_O$  are used to denote specific conditions for  $I_{I/O}$ .
- (5) The package thermal impedance is calculated in accordance with JESD 51-7.

## RECOMMENDED OPERATING CONDITIONS

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

		MIN	TYP	MAX	UNIT
$V_{DD}$	Supply voltage	$V_{SS} = \text{GND}$		1.5	V
		$V_{SS} = 1.5 \text{ V}$		3	
$V_{IH}$	High-level input voltage	$3 \text{ V} < V_{DD} < 3.6 \text{ V}, V_{SS} = 1.5 \text{ V}$		$0.65(V_{DD} - V_{SS}) + V_{SS}$	V
$V_{IL}$	Low-level input voltage	$1.5 \text{ V} < V_{DD} < 2.1 \text{ V}, V_{SS} = 0 \text{ V}$		$0.35(V_{DD} - V_{SS}) + V_{SS}$	V
$V_{IO}$	Switch input/output voltage	0		$V_{DD}$	V
$T_A$	Operating free-air temperature	0		85	°C

**ELECTRICAL CHARACTERISTICS FOR 1.8-V SUPPLY<sup>(1)</sup>**V<sub>DD</sub> = 1.5 V to 2.1 V, V<sub>SS</sub> = 0 V, T<sub>A</sub> = -40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(2)</sup>	MAX	UNIT
V <sub>IK</sub>	SEL	V <sub>DD</sub> = 2.1 V, I <sub>IN</sub> = -18 mA	-0.7	-1.2		V
I <sub>IH</sub>	SEL	V <sub>DD</sub> = 2.1 V, V <sub>IN</sub> = V <sub>DD</sub>			±1	μA
I <sub>IL</sub>	SEL	V <sub>DD</sub> = 2.1 V, V <sub>IN</sub> = V <sub>SS</sub>			±1	μA
I <sub>off</sub>		V <sub>DD</sub> = 0, V <sub>O</sub> = 0 to 2.1 V, V <sub>I</sub> = 0			1	μA
I <sub>CC</sub>		V <sub>DD</sub> = 2.1 V, I <sub>I/O</sub> = 0, Switch ON or OFF		230	450	μA
C <sub>IN</sub>	SEL	f = 1 MHz, V <sub>IN</sub> = 0		0.7	1	pF
C <sub>OFF</sub>	B port	V <sub>I</sub> = 0, f = 1 MHz, Outputs open, Switch OFF		1	1.5	pF
C <sub>ON</sub>		V <sub>I</sub> = 0, f = 1 MHz, Outputs open, Switch ON		4	4.5	pF
r <sub>on</sub>		V <sub>DD</sub> = 1.8 V, V <sub>SS</sub> ≤ V <sub>I</sub> ≤ V <sub>DD</sub> , I <sub>O</sub> = -40 mA		12.5	20	Ω
r <sub>on(flat)</sub> <sup>(3)</sup>		V <sub>DD</sub> = 1.8 V, V <sub>I</sub> = 1.65 V to 1.8 V, I <sub>O</sub> = -40 mA		0.5		Ω
Δr <sub>on</sub> <sup>(4)</sup>		V <sub>DD</sub> = 1.8 V, V <sub>SS</sub> ≤ V <sub>I</sub> ≤ V <sub>DD</sub> , I <sub>O</sub> = -40 mA		-0.1	0.2	Ω
<b>Dynamic</b>						
X <sub>TALK</sub>		R <sub>L</sub> = 50 Ω, f = 825 MHz, See Figure 7		-50		dB
O <sub>IRR</sub>		R <sub>L</sub> = 50 Ω, f = 825 MHz, See Figure 8		-50		dB
BW		See Figure 6		1.9		GHz
Max data rate		See Figure 6		3.8		Gbps

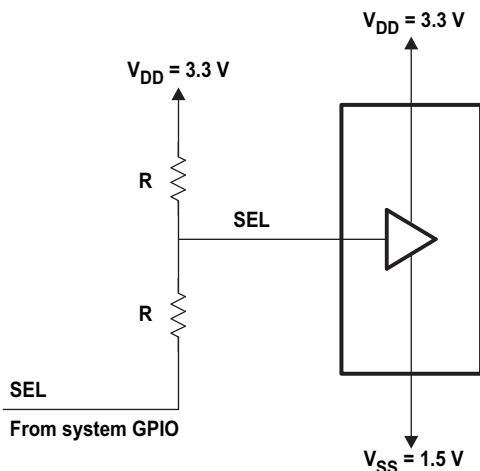
- (1) V<sub>I</sub>, V<sub>O</sub>, I<sub>I</sub>, and I<sub>O</sub> refer to I/O pins. V<sub>IN</sub> refers to the control inputs.  
 (2) All typical values are at V<sub>DD</sub> = 1.8 V (unless otherwise noted), T<sub>A</sub> = 25°C.  
 (3) r<sub>on(flat)</sub> is the difference of r<sub>on</sub> in a given channel at specified voltages.  
 (4) Δr<sub>on</sub> is the difference of r<sub>on</sub> from centerports to any other port.

**SWITCHING CHARACTERISTICS**

over recommended operating free-air temperature range, V<sub>DD</sub> = 1.5 V to 2.1 V, V<sub>SS</sub> = 0 V, R<sub>L</sub> = 200 Ω, C<sub>L</sub> = 10 pF  
 (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	TYP <sup>(1)</sup>	MAX	UNIT
t <sub>pd</sub> <sup>(2)</sup>	TMDSn or xTMDSn	xTMDSn or TMDSn		0.25		ns
t <sub>PZH</sub> , t <sub>PZL</sub>	SEL	TMDSn or xTMDSn	0.5		9	ns
t <sub>PHZ</sub> , t <sub>PLZ</sub>	SEL	TMDSn or xTMDSn	0.5		5	ns
t <sub>sk(o)</sub> <sup>(3)</sup>	TMDSn or xTMDSn	xTMDSn or TMDSn		0.06		ns
t <sub>sk(p)</sub> <sup>(4)</sup>				0.06	0.1	ns

- (1) All typical values are at V<sub>DD</sub> = 1.8 V (unless otherwise noted), T<sub>A</sub> = 25°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 to any other port  
 (4) Skew between opposite transitions of the same output in a given device |t<sub>PHL</sub> - t<sub>PLH</sub>|



This example circuit shows connecting control inputs to GPIOs of an application using  $V_{SS} = 1.5\text{ V}$ , which allows the device to pass TMDS signal levels

Figure 1. Example Voltage Divider Circuit

## TYPICAL CHARACTERISTICS

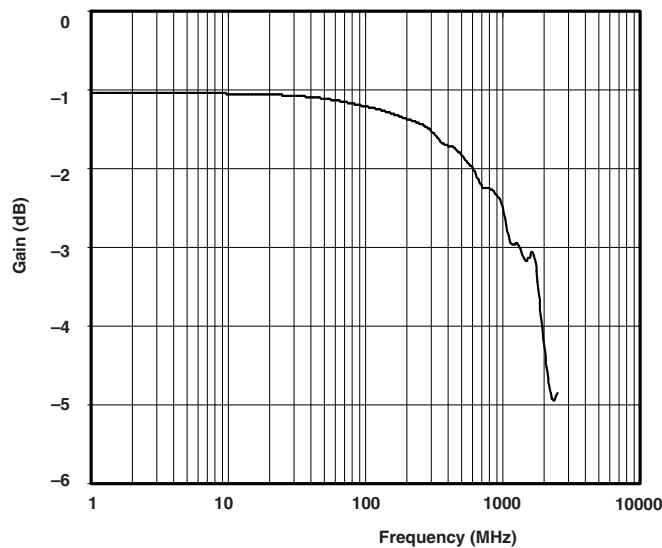


Figure 2. Insertion Loss

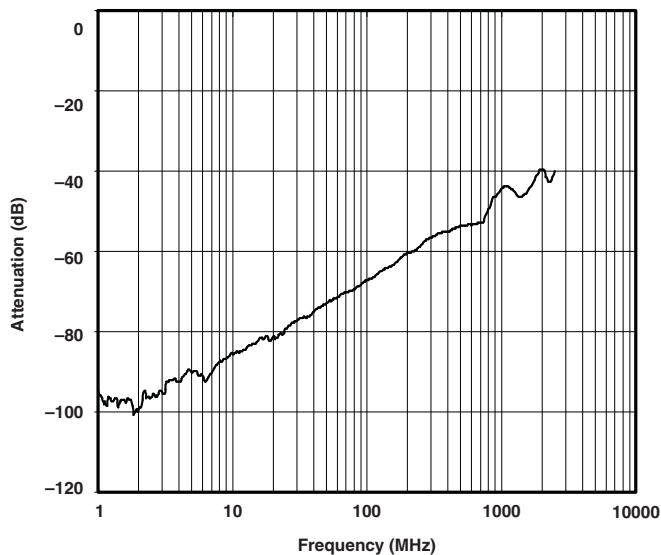


Figure 3. Crosstalk

## TYPICAL CHARACTERISTICS (continued)

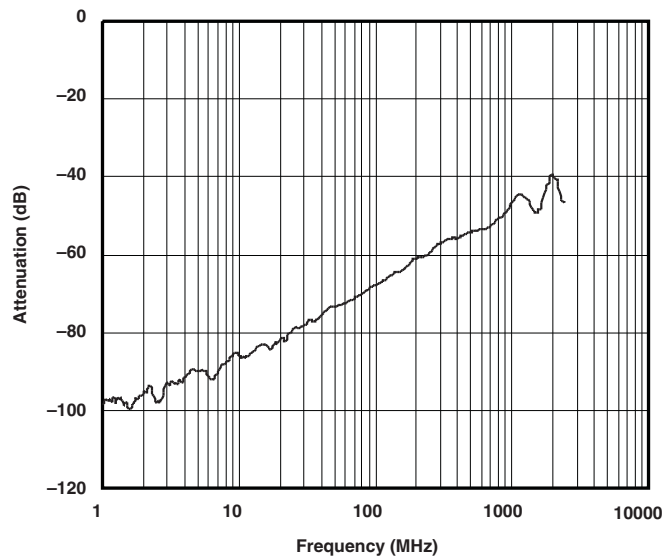
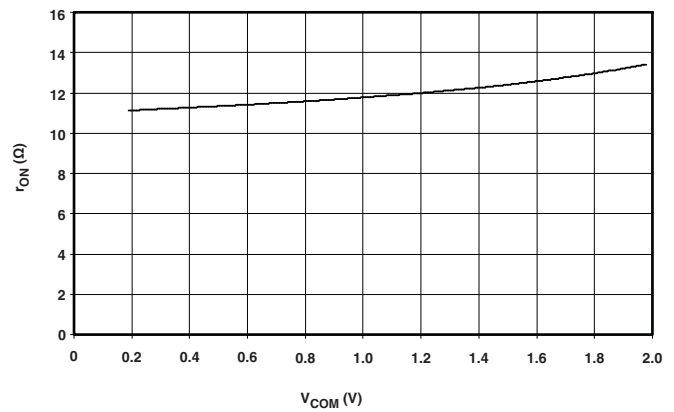
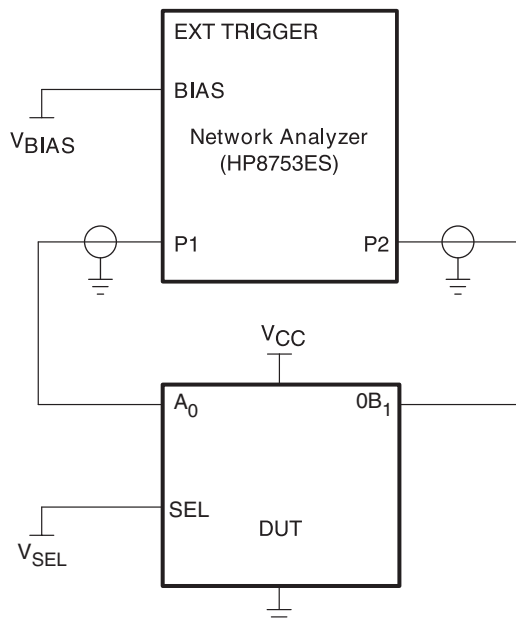


Figure 4. Off Isolation vs Frequency

Figure 5. r<sub>ON</sub> vs V<sub>COM</sub>



## PARAMETER MEASUREMENT INFORMATION



**Figure 6. Test Circuit for Frequency Response (BW)**

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

### HP8753ES setup

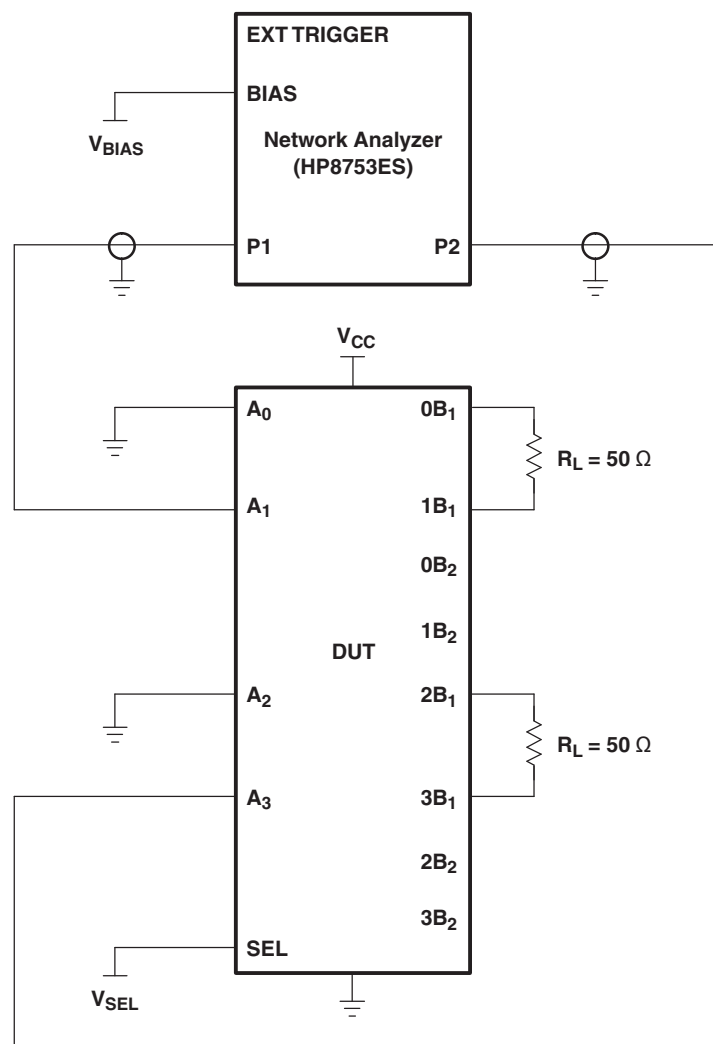
Average = 4

RBW = 3 kHz

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

ST = 2 s

P1 = 0 dBm

**PARAMETER MEASUREMENT INFORMATION (continued)****Figure 7. Test Circuit for Crosstalk ( $X_{TALK}$ )**

Crosstalk is measured at the output of the nonadjacent ON channel. For example, when  $V_{SEL}$  is low 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-Ω pull-down resistors.

**HP8753ES setup**

Average = 4

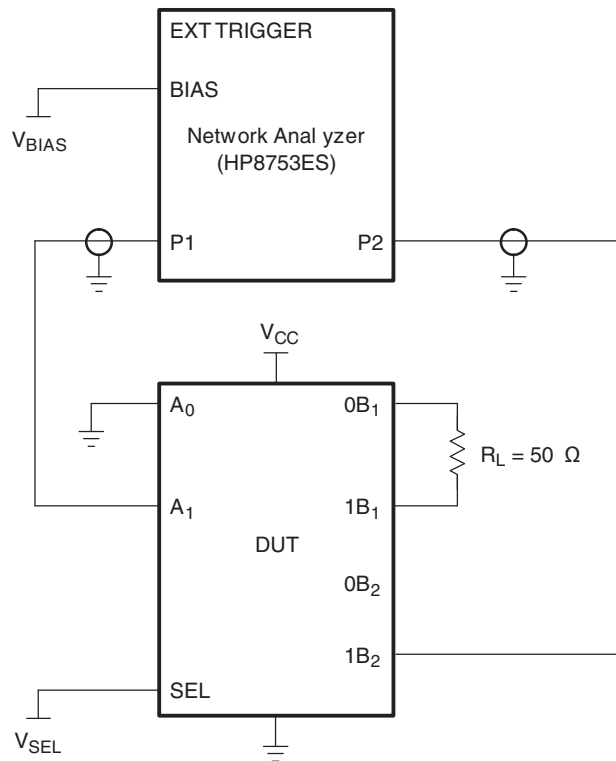
RBW = 3 kHz

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

ST = 2 s

P1 = 0 dBm

## PARAMETER MEASUREMENT INFORMATION (continued)



**Figure 8. Test Circuit for OFF Isolation ( $O_{IRR}$ )**

OFF isolation is measured at the output of the OFF channel. For example, when  $V_{SEL}$  is low 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

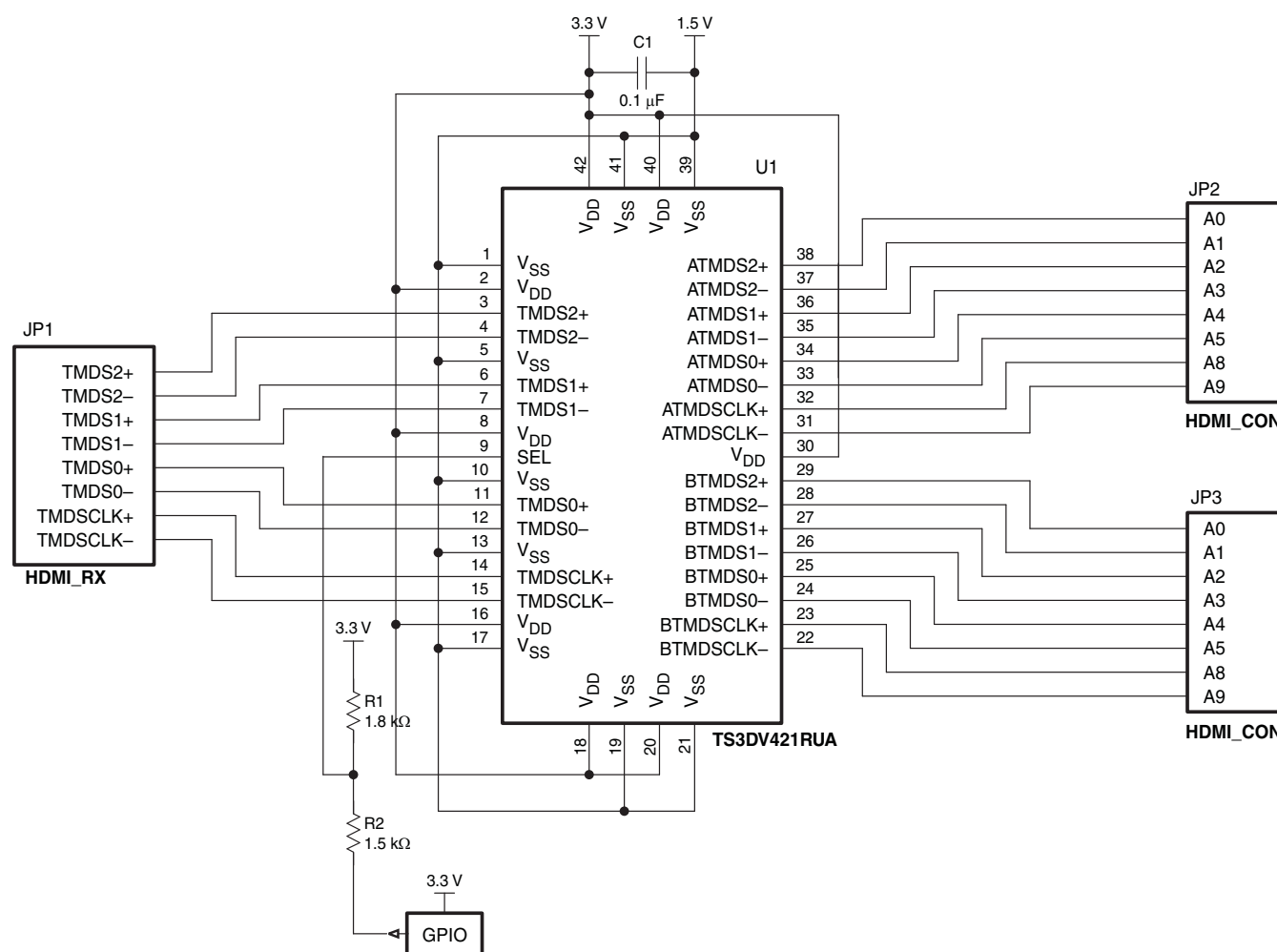
Average = 4

RBW = 3 kHz

$V_{BIAS} = 0.35$  V

ST = 2

P1 = 0 dBm

**APPLICATION INFORMATION****Figure 9. Reference Circuit for HDMI Application**



PACKAG

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak
TS3DV421DGVR	ACTIVE	TVSOP	DGV	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C
TS3DV421DGVRG4	ACTIVE	TVSOP	DGV	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C
TS3DV421RUAR	ACTIVE	WQFN	RUA	42	3000	TBD	Call TI	Call TI

<sup>(1)</sup> 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.

<sup>(2)</sup> 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> for more 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 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 high temperature applications.

**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 attach 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 (as applicable to the semiconductor material) and free of Beryllium (Be) and Hexavalent Chromium (Cr6) based flame retardants (as applicable to the semiconductor material) and all other RoHS prohibited substances.

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

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI does not warrant, represent, or make any representation as to the accuracy of such information. Efforts are underway to better integrate information from third parties and TI continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on all TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer.

**TAPE AND REEL INFORMATION**



\*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
TS3DV421DGVR	TVSOP	DGV	48	2000	330.0	16.4	7.1	10.2	1.6	12.0	16.0	Q1

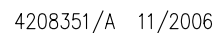
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS3DV421DGVR	TVSOP	DGV	48	2000	346.0	346.0	33.0

## PLASTIC QUAD FLATPACK



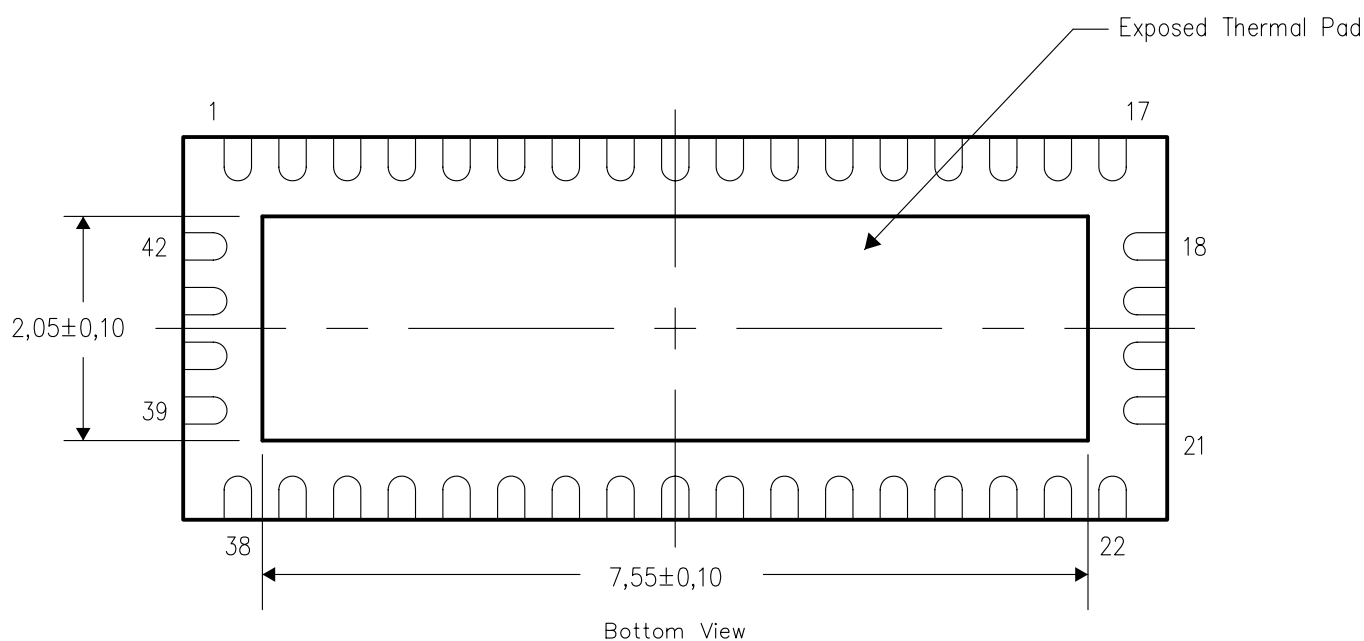


## THERMAL INFORMATION

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, Quad Flatpack No-Lead Logic Packages, Texas Instruments Literature No. SCBA017. This document is available at [www.ti.com](http://www.ti.com).

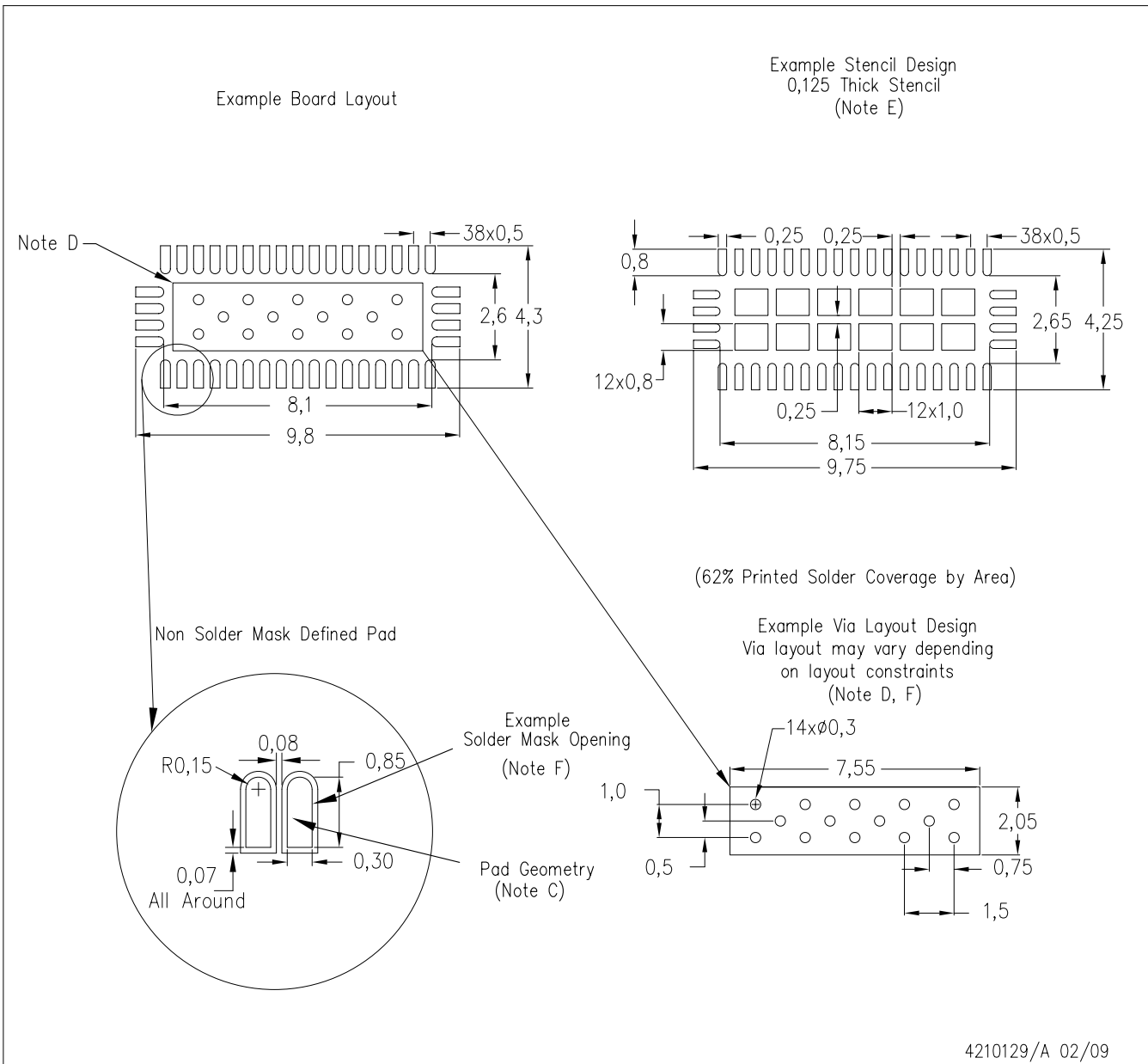
The exposed thermal pad dimensions for this package are shown in the following illustration.



NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

# RUA (R-PWQFN-N42)



- 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. SCBA017, 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 recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	Space, Avionics & Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless-apps">www.ti.com/wireless-apps</a>