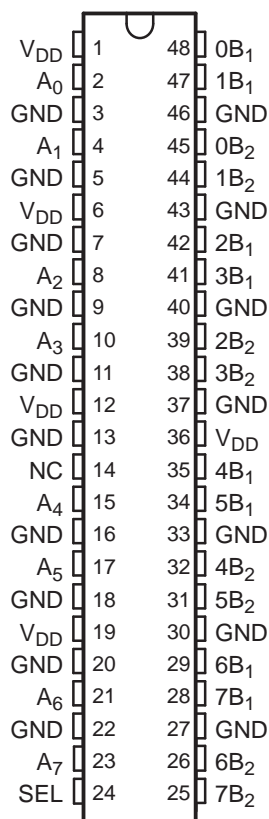


FEATURES

- **Compatible With HDMI v1.2a (Type A) DVI 1.0 High-Speed Digital Interface**
 - Wide Bandwidth of Over 1.65 Gbps (Bandwidth 1.8 Gbps Typ)
 - 165-MHz Speed Operation
 - Serial Data Stream at 10× 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 ($t_{sk(o)} = 0.2$ ns Max)**
- **Low and Flat ON-State Resistance ($r_{on} = 4 \Omega$ Typ, $r_{on(Flat)} = 0.7 \Omega$ Typ)**
- **Low Input/Output Capacitance ($C_{ON} = 10$ pF Typ)**
- **Rail-to-Rail Switching on Data I/O Ports (0 to 5 V)**
- **V_{DD} 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)

DGG OR DGV PACKAGE
(TOP VIEW)



NC – No internal connection

APPLICATIONS

- Digital Video Signal Switching
- Differential DVI, HDMI Signal Multiplexing for Audio/Video Receivers and High-Definition Television (HDTV)

DESCRIPTION/ORDERING INFORMATION

The TS3DV416 is a 16-bit to 8-bit multiplexer/demultiplexer digital video switch with a single select (SEL) input. SEL controls the data path of the multiplexer/demultiplexer.

The device provides a low and flat ON-state resistance (r_{on}) and an 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.



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.

TS3DV416 4-CHANNEL DIFFERENTIAL 8:16 MULTIPLEXER SWITCH FOR DVI/HDMI APPLICATIONS

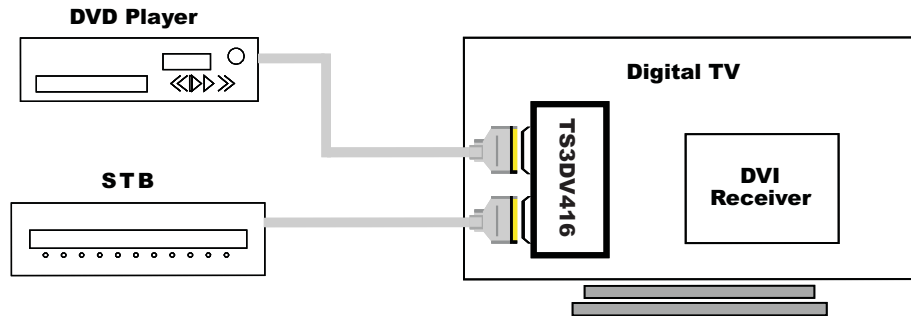
SCDS198C–OCTOBER 2005–REVISED MAY 2006

ORDERING INFORMATION

| T_A | PACKAGE ⁽¹⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|------------------------|---------------|-----------------------|------------------|
| –40°C to 85°C | TSSOP – DGG | Tape and reel | TS3DV416DGGR | TS3DV416 |
| | TVSOP – DGV | Tape and reel | TS3DV416DGVR | SD416 |

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

TYPICAL APPLICATION



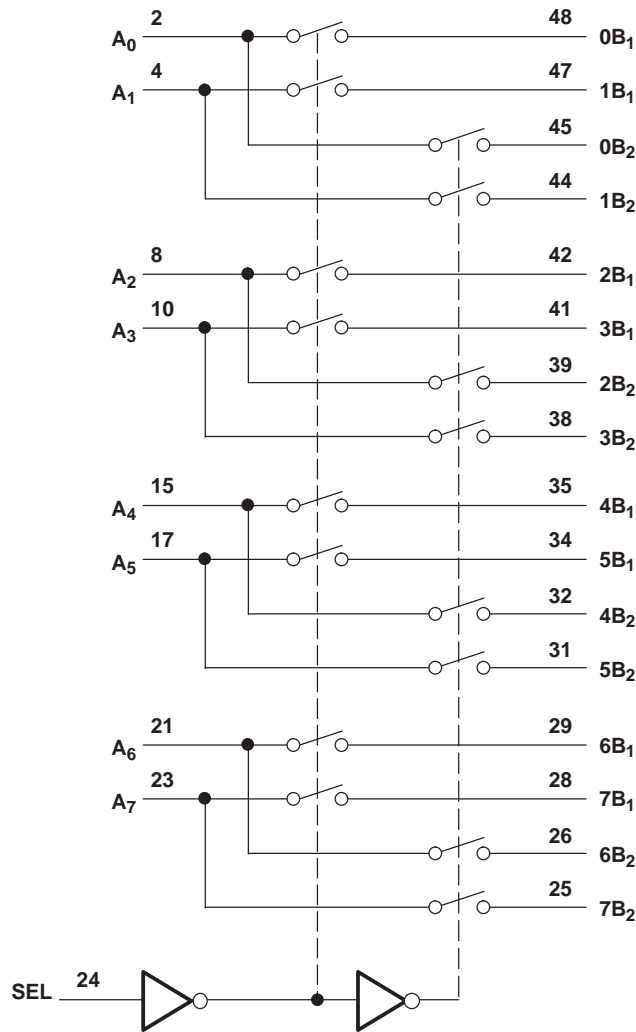
FUNCTION TABLE

| 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)



TS3DV416

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

SCDS198C–OCTOBER 2005–REVISED MAY 2006

Absolute Maximum Ratings⁽¹⁾

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

| | | MIN | MAX | UNIT |
|---------------|---|---------------|-----|---------|
| V_{DD} | Supply voltage range | -0.5 | 4.6 | V |
| V_{IN} | Control input voltage range ⁽²⁾⁽³⁾ | -0.5 | 7 | V |
| $V_{I/O}$ | Switch I/O voltage range ⁽²⁾⁽³⁾⁽⁴⁾ | -0.5 | 7 | V |
| I_{IK} | Control input clamp current | $V_{IN} < 0$ | | -50 mA |
| $I_{I/OK}$ | I/O port clamp current | $V_{I/O} < 0$ | | -50 mA |
| $I_{I/O}$ | ON-state switch current ⁽⁵⁾ | | | ±128 mA |
| | Continuous current through V_{DD} or GND | | | ±100 mA |
| θ_{JA} | Package thermal impedance ⁽⁶⁾ | DGG package | | 70 °C/W |
| | | DGV package | | 58 °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⁽¹⁾

| | | MIN | MAX | UNIT |
|-----------|--|-----|-----|------|
| V_{DD} | 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_{DD} 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⁽¹⁾

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

| PARAMETER | | TEST CONDITIONS | | MIN | TYP ⁽²⁾ | MAX | UNIT |
|--------------------------------------|--------|----------------------------|--|------------------------|--------------------|---------|---------------|
| V_{IK} | SEL | $V_{DD} = 3.6 \text{ V}$, | $I_{IN} = -18 \text{ mA}$ | | -0.7 | -1.2 | V |
| I_{IH} | SEL | $V_{DD} = 3.6 \text{ V}$, | $V_{IN} = V_{DD}$ | | | ± 1 | μA |
| I_{IL} | SEL | $V_{DD} = 3.6 \text{ V}$, | $V_{IN} = \text{GND}$ | | | ± 1 | μA |
| I_{off} | | $V_{DD} = 0$, | $V_O = 0 \text{ to } 3.6 \text{ V}$, | | | 1 | μA |
| I_{DD} | | $V_{DD} = 3.6 \text{ V}$, | $I_{IO} = 0$, | | 250 | 600 | μA |
| | | | Switch ON or OFF | | | | |
| C_{IN} | SEL | $f = 1 \text{ MHz}$, | $V_{IN} = 0$ | | 2.5 | 3 | pF |
| C_{OFF} | B port | $V_I = 0$, | $f = 1 \text{ MHz}$, | Outputs open, | 3.5 | 4 | pF |
| | | | | Switch OFF | | | |
| C_{ON} | | $V_I = 0$, | $f = 1 \text{ MHz}$, | Outputs open, | 10 | 10.9 | pF |
| | | | | Switch ON | | | |
| r_{on} | | $V_{DD} = 3 \text{ V}$, | $1.5 \text{ V} \leq V_I \leq V_{DD}$, | $I_O = -40 \text{ mA}$ | 4 | 8 | Ω |
| $r_{on(\text{flat})}$ ⁽³⁾ | | $V_{DD} = 3 \text{ V}$, | $V_I = 1.5 \text{ V}$ and V_{DD} , | $I_O = -40 \text{ mA}$ | 0.7 | | Ω |
| Δr_{on} ⁽⁴⁾ | | $V_{DD} = 3 \text{ V}$, | $1.5 \text{ V} \leq V_I \leq V_{DD}$, | $I_O = -40 \text{ mA}$ | 0.2 | 1.2 | Ω |

- (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 $V_{DD} = 3.3 \text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.
 (3) $r_{on(\text{flat})}$ is the difference of r_{on} in a given channel at specified voltages.
 (4) Δr_{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, $V_{DD} = 3.3 \text{ V} \pm 0.3 \text{ V}$, $R_L = 200 \Omega$, $C_L = 10 \text{ pF}$
(unless otherwise noted) (see [Figure 4](#) and [Figure 5](#))

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|----------------------------|--------------|-------------|-----|--------------------|------|------|
| t_{pd} ⁽²⁾ | A or B | B or A | | 0.04 | | ns |
| t_{PZH} , t_{PZL} | SEL | A or B | 1.5 | | 11.5 | ns |
| t_{PHZ} , t_{PLZ} | SEL | A or B | 1 | | 8.5 | ns |
| $t_{sk(o)}$ ⁽³⁾ | A or B | B or A | | 0.1 | 0.2 | ns |
| $t_{sk(p)}$ ⁽⁴⁾ | | | | 0.1 | 0.2 | ns |

- (1) All typical values are at $V_{DD} = 3.3 \text{ V}$ (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 $|t_{PHL} - t_{PLH}|$

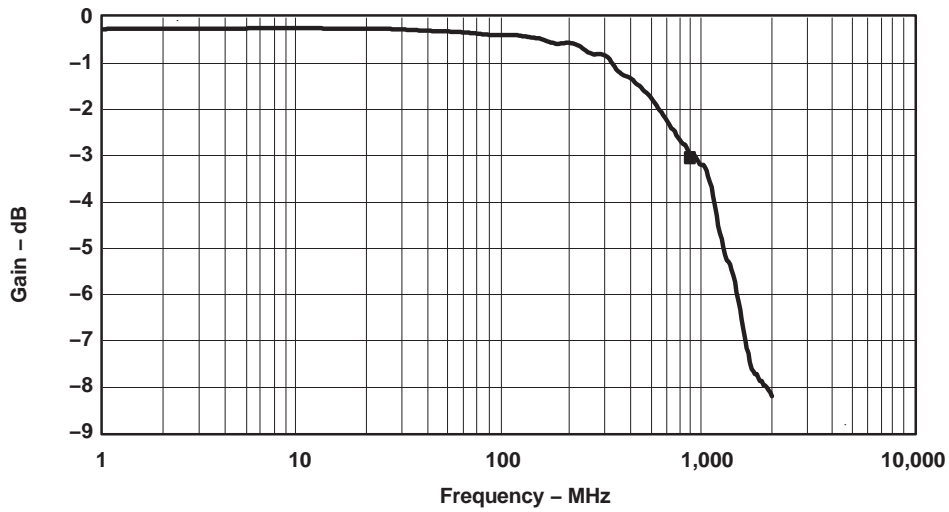
Dynamic Characteristics

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

| PARAMETER | TEST CONDITIONS | TYP ⁽¹⁾ | UNIT |
|------------|---|--------------------|------|
| X_{TALK} | $R_L = 100 \Omega$, $f = 250 \text{ MHz}$, See Figure 7 | -41 | dB |
| O_{IRR} | $R_L = 100 \Omega$, $f = 250 \text{ MHz}$, See Figure 8 | -39 | dB |
| BW | See Figure 6 | 900 | MHz |

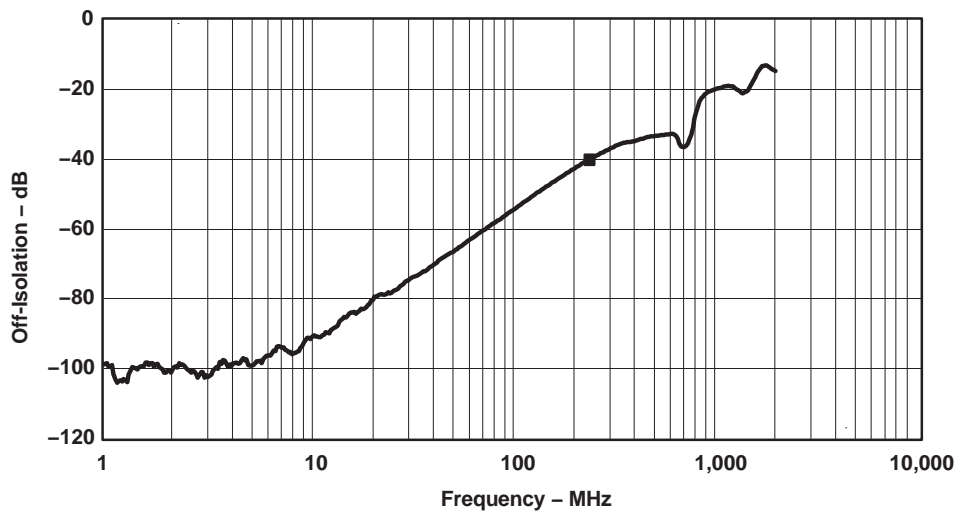
- (1) All typical values are at $V_{DD} = 3.3 \text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.

OPERATING CHARACTERISTICS



■ Gain at 900 MHz, -3 dB

Figure 1. Gain vs Frequency



■ OFF Isolation at 250 MHz, -39 dB

Figure 2. OFF Isolation vs Frequency

OPERATING CHARACTERISTICS (continued)

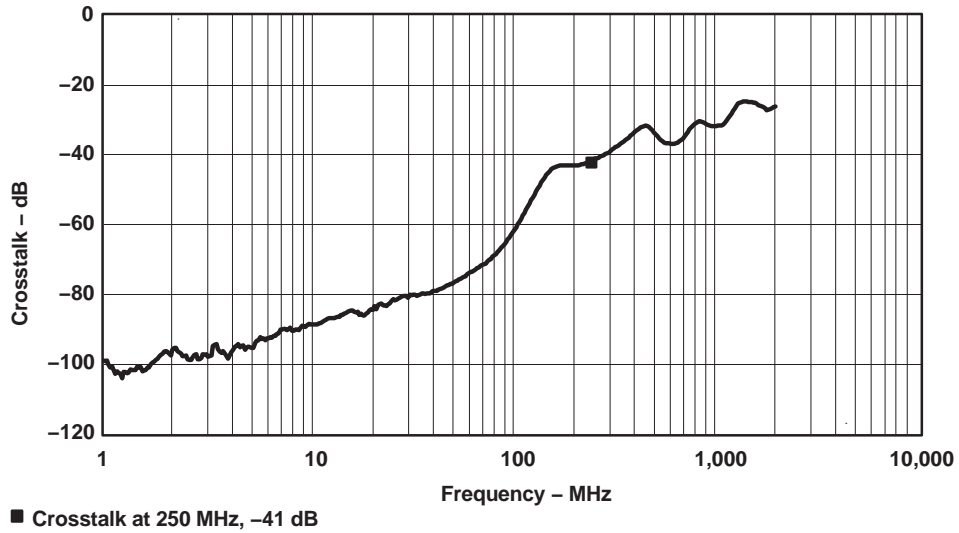
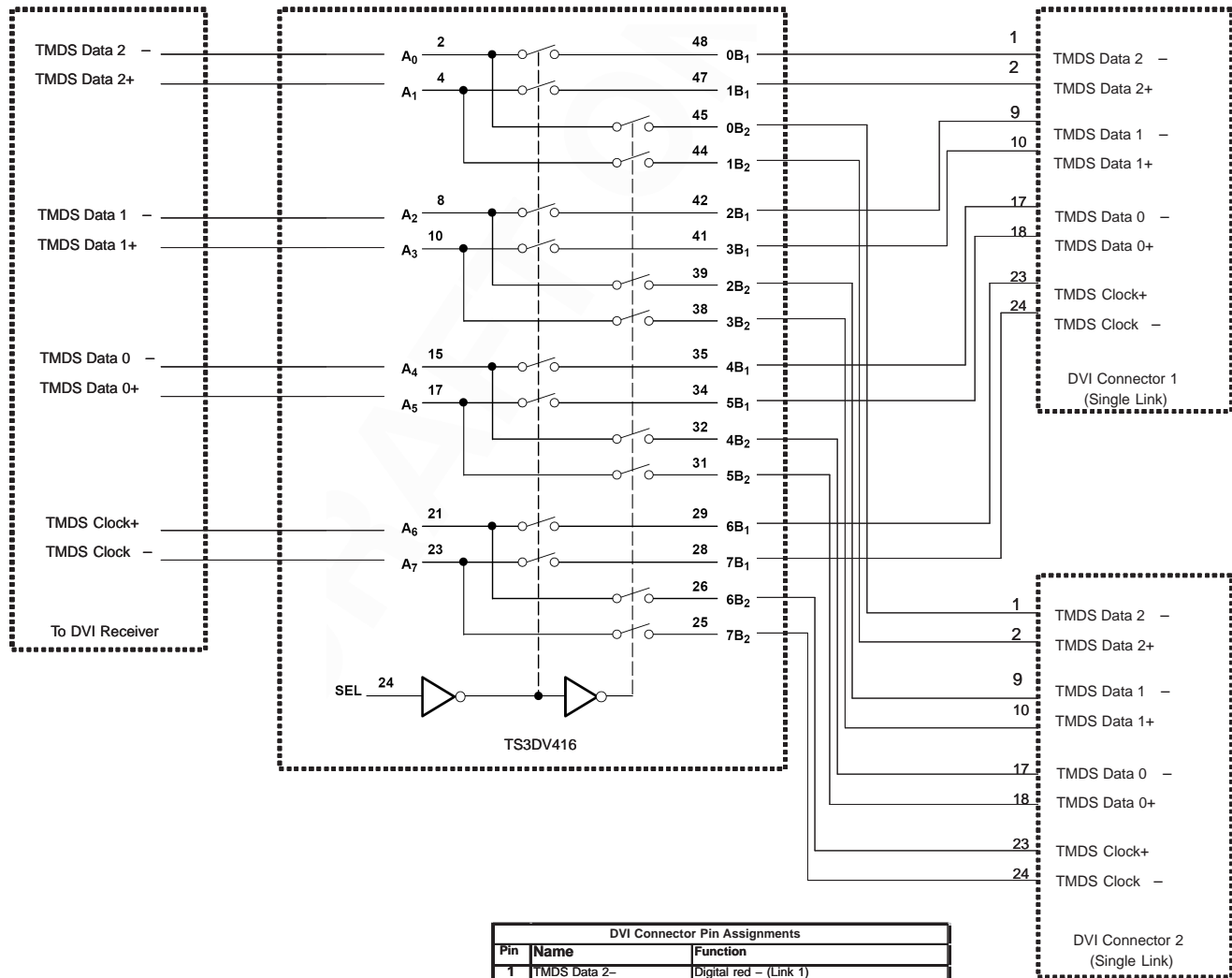


Figure 3. Crosstalk vs Frequency

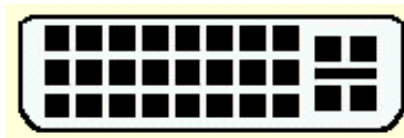
TS3DV416 4-CHANNEL DIFFERENTIAL 8:16 MULTIPLEXER SWITCH FOR DVI/HDMI APPLICATIONS

SCDS198C–OCTOBER 2005–REVISED MAY 2006

APPLICATION INFORMATION



Typical DVI Connector

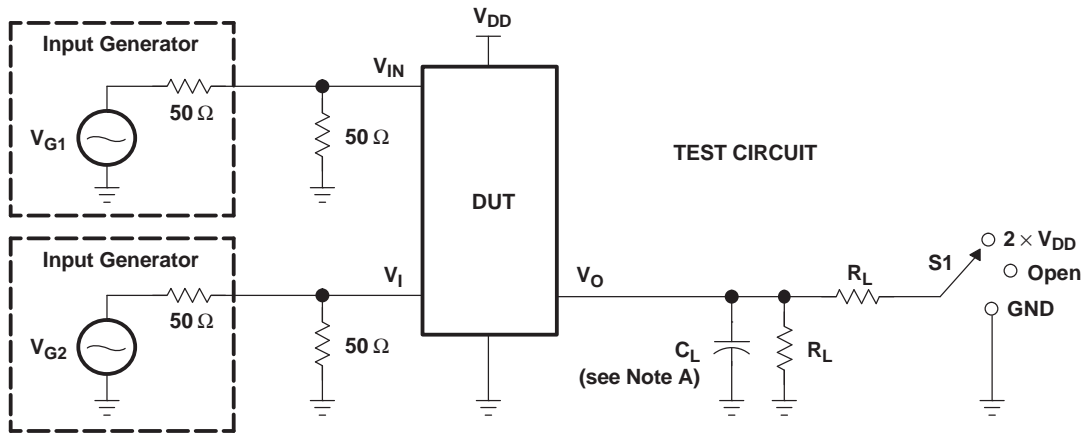


| | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | C1 | C2 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | C5 | |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | C3 | C4 |

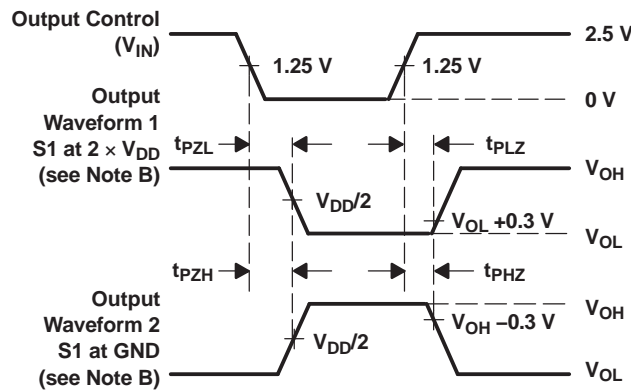
The TS3DV416 can be used to switch between two digital video ports.

| DVI Connector Pin Assignments | | |
|-------------------------------|------------------------|--|
| Pin | Name | Function |
| 1 | TMDS Data 2- | Digital red - (Link 1) |
| 2 | TMDS Data 2+ | Digital red + (Link 1) |
| 3 | TMDS Data 2/4 shield | |
| 4 | TMDS Data 4- | Digital green - (Link 2) |
| 5 | TMDS Data 4+ | Digital green + (Link 2) |
| 6 | DDC clock | |
| 7 | DDC data | |
| 8 | Analog Vertical Sync | |
| 9 | TMDS Data 1- | Digital green - (Link 1) |
| 10 | TMDS Data 1+ | Digital green + (Link 1) |
| 11 | TMDS Data 1/3 shield | |
| 12 | TMDS Data 3- | Digital blue - (Link 2) |
| 13 | TMDS Data 3+ | Digital blue + (Link 2) |
| 14 | +5V | Power for monitor when in standby |
| 15 | Ground | Return for pin 14 and analog sync |
| 16 | Hot Plug Detect | |
| 17 | TMDS data 0- | Digital blue - (Link 1) and digital sync |
| 18 | TMDS data 0+ | Digital blue + (Link 1) and digital sync |
| 19 | TMDS data 0/5 shield | |
| 20 | TMDS data 5- | Digital red - (Link 2) |
| 21 | TMDS data 5+ | Digital red + (Link 2) |
| 22 | TMDS clock shield | |
| 23 | TMDS clock+ | Digital clock + (Links 1 and 2) |
| 24 | TMDS clock- | Digital clock - (Links 1 and 2) |
| C1 | Analog Red | |
| C2 | Analog Green | |
| C3 | Analog Blue | |
| C4 | Analog Horizontal Sync | |
| C5 | Analog Ground | Return for R, G and B signals |

PARAMETER MEASUREMENT INFORMATION
(Enable and Disable Times)



| TEST | V _{DD} | S1 | R _L | V _I | C _L | V _Δ |
|------------------------------------|-----------------|---------------------|----------------|-----------------|----------------|----------------|
| t _{PLZ} /t _{PZL} | 3.3 V ± 0.3 V | 2 × V _{DD} | 200 Ω | GND | 10 pF | 0.3 V |
| t _{PHZ} /t _{PZH} | 3.3 V ± 0.3 V | GND | 200 Ω | V _{DD} | 10 pF | 0.3 V |

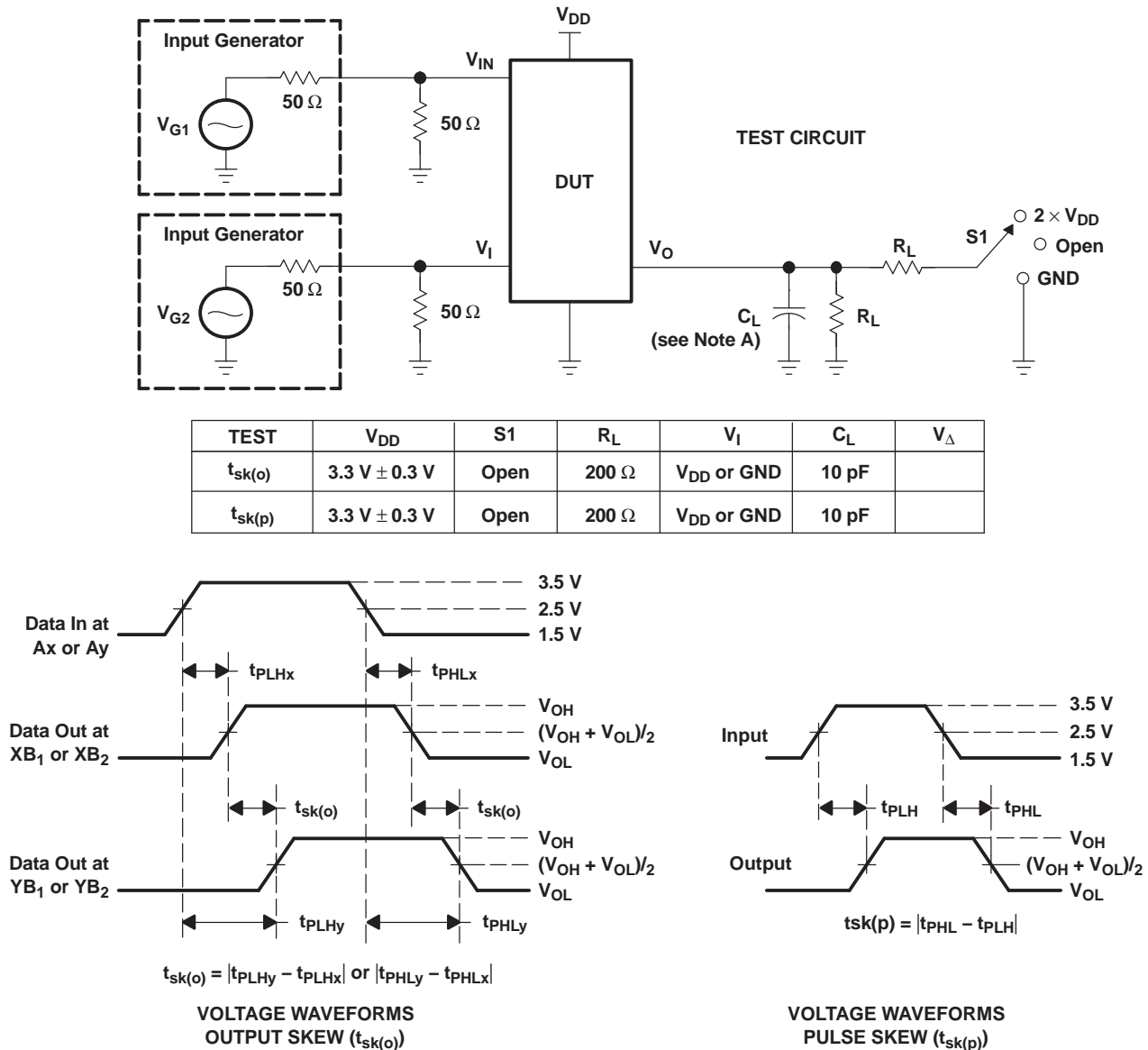


VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

- NOTES: A. C_L 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_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
 D. The outputs are measured one at a time, with one transition per measurement.
 E. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
 F. t_{PZL} and t_{PZH} are the same as t_{en}.

Figure 4. Test Circuit and Voltage Waveforms

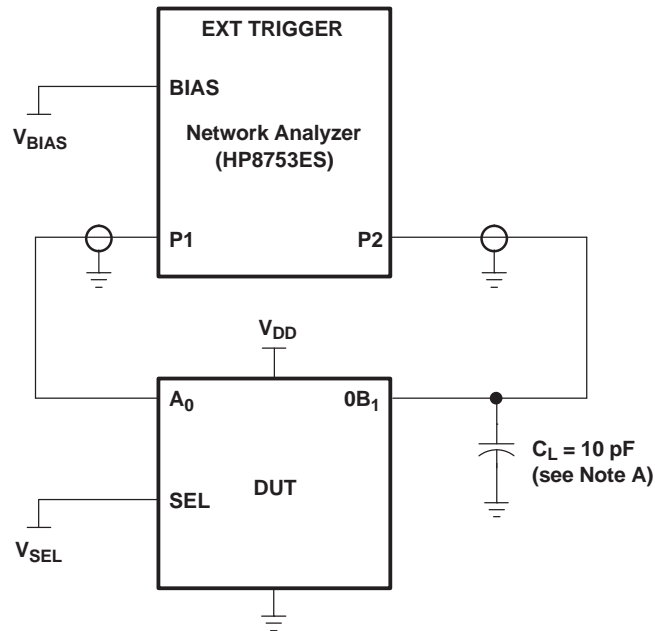
PARAMETER MEASUREMENT INFORMATION
(Skew)



- NOTES: A. C_L 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_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
 D. The outputs are measured one at a time, with one transition per measurement.

Figure 5. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes probe and jig capacitance.

Figure 6. 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

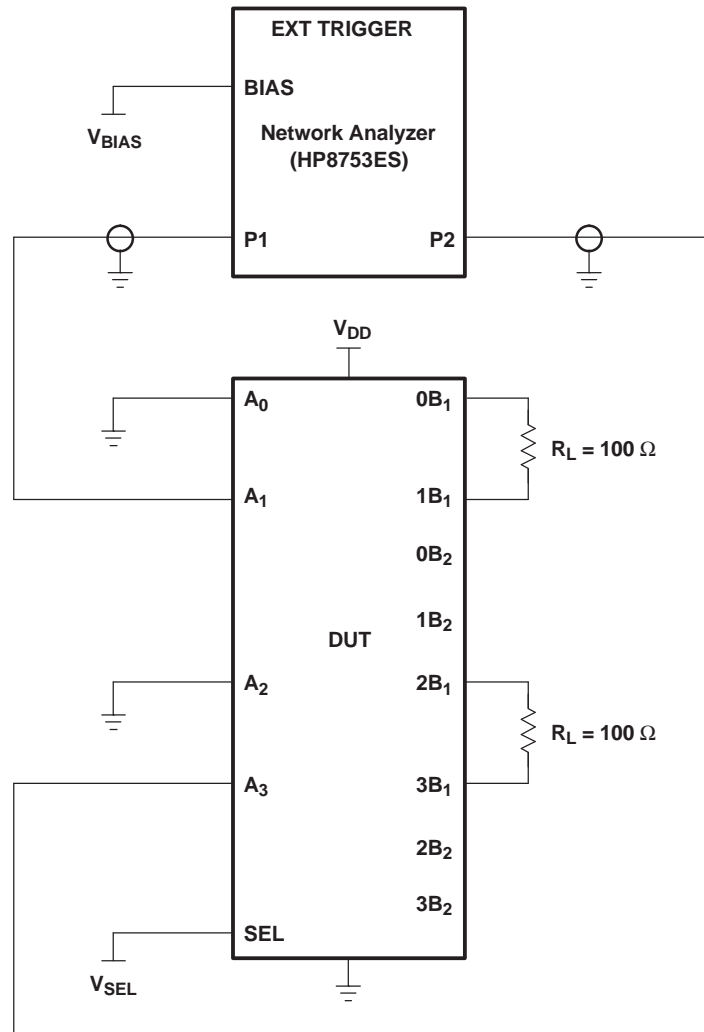
RBW = 3 kHz

$V_{BIAS} = 0.35$ V

ST = 2 s

P1 = 0 dBm

PARAMETER MEASUREMENT INFORMATION



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

Figure 7. 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_1 is the input, the output is measured at A_3 . All unused analog input (A) ports are connected to GND, and output (B) ports are left open.

HP8753ES Setup

Average = 4

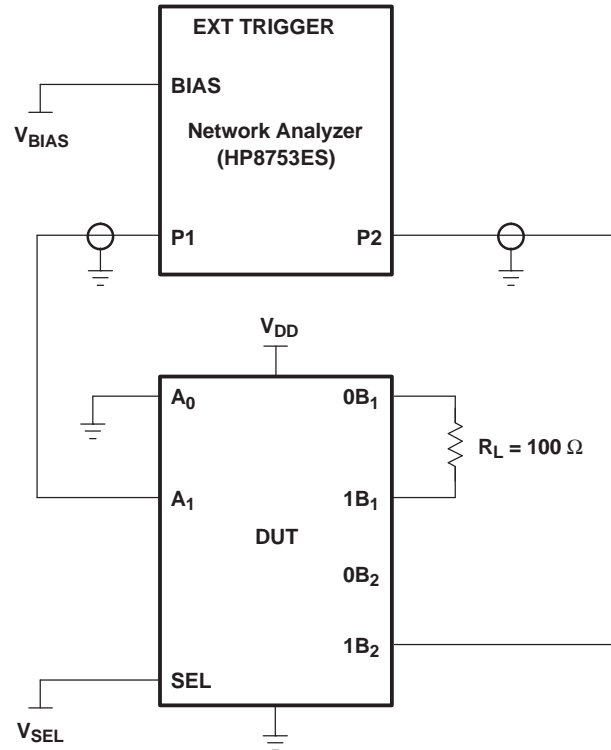
RBW = 3 kHz

$V_{BIAS} = 0.35$ V

ST = 2 s

P1 = 0 dBm

PARAMETER MEASUREMENT INFORMATION



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

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

OFF isolation is measured at the output of the OFF channel. For example, when $V_{SEL} = GND$ and A_1 is the input, the output is measured at $1B_2$. All unused analog input (A) ports are connected to ground, and output (B) ports are left open.

HP8753ES Setup

Average = 4

RBW = 3 kHz

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

ST = 2 s

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⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TS3DV416DGGR | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TS3DV416DGGRE4 | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TS3DV416DGGRG4 | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TS3DV416DGVR | ACTIVE | TVSOP | DGV | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TS3DV416DGVRG4 | ACTIVE | TVSOP | DGV | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽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.

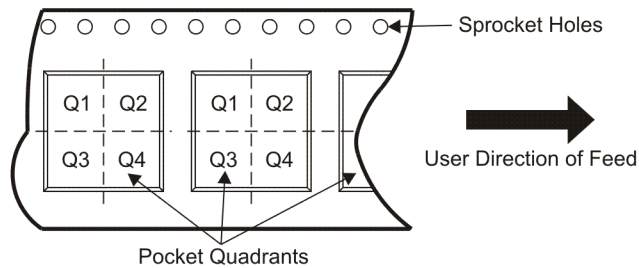
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TAPE AND REEL INFORMATION



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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TS3DV416DGGR | TSSOP | DGG | 48 | 2000 | 330.0 | 24.4 | 8.6 | 15.8 | 1.8 | 12.0 | 24.0 | Q1 |
| TS3DV416DGVR | TVSOP | DGV | 48 | 2000 | 330.0 | 16.4 | 7.1 | 10.2 | 1.6 | 12.0 | 16.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS

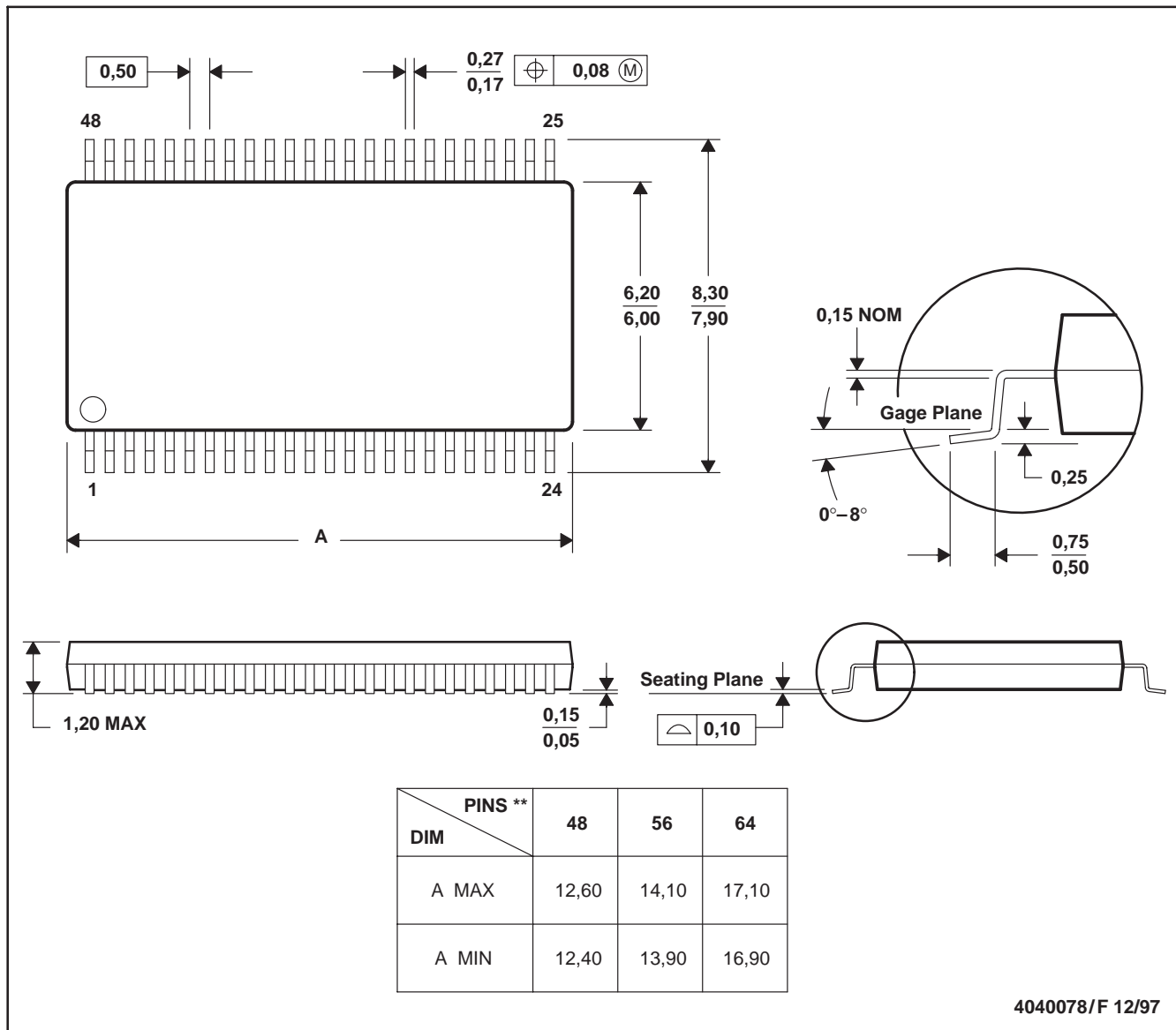

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TS3DV416DGGR | TSSOP | DGG | 48 | 2000 | 346.0 | 346.0 | 41.0 |
| TS3DV416DGVR | TVSOP | DGV | 48 | 2000 | 346.0 | 346.0 | 33.0 |

DGG (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

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