

High Voltage 4-Ω Quad SPST CMOS Analog Switch

DESCRIPTION

The DG451 series has four independently selectable high voltage (44 V) SPST switches, each with a typical on resistance of 4 Ω and a typical flatness of 0.2 Ω, ideal parameters for low distortion audio signal switching.

The DG451 (NC) and DG452 (NO) are identical except for the digital logic control input, which is inverted as shown in the Truth Table. The DG453 has two normally closed and two normally open switches.

These are high voltage switches that are fully specified with dual supplies at ± 5 V and ± 15 V and a single supply of 12 V and operating with ultra low power dissipation (18 μW).

Fast switching speeds coupled with high signal bandwidth makes these parts suitable for video switching applications.

All digital inputs have 0.8 V and 2.4 V logic thresholds ensuring low voltage TTL/CMOS compatibility. Each switch conducts equally well in both directions when on and can handle an input signal range that extends to the supply voltage rails.

The DG451, DG452, and DG453 are pin compatible with the DG411, DG412, and DG413.

FEATURES

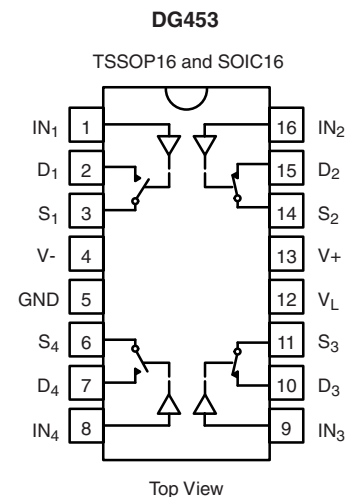
- Low on-resistance (4 Ω typical)
- On-resistance flatness (0.2 Ω typical)
- 100 mA continuous current
- 44 V supply maximum rating
- ± 15 V analog signal range
- Fully specified at supply voltages of ± 5 V, 12 V and ± 15 V
- Ultra low power dissipation of (18 μW)
- Fast switching speed:
 - t_{on} 80 ns
 - t_{off} 60 ns
- TTL/CMOS compatible
- ESD protection 2 kV
- Pin compatible with DG411, DG412, and DG413
- **Compliant to RoHS directive 2002/95/EC**


RoHS
COMPLIANT

APPLICATIONS

- Audio and video signal switching
- Precision automatic test equipment
- Precision data acquisition
- Relay replacement
- Communications systems
- Automotive and avionics applications
- Sample and hold systems

FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



| TRUTH TABLE | | |
|-------------|-------|-------|
| Logic | DG451 | DG452 |
| 0 | On | Off |
| 1 | Off | On |

| TRUTH TABLE | | |
|-------------|-----------------------------------|-----------------------------------|
| Logic | SW ₁ , SW ₄ | SW ₂ , SW ₃ |
| 0 | Off | On |
| 1 | On | Off |



| ORDERING INFORMATION | | |
|--------------------------------|--------------------|-------------------------------------------------|
| Temp. Range | Package | Part Number |
| DG451, DG452, DG453 | | |
| - 40 °C to 125 °C ^a | 16 Pin TSSOP | DG451EQ-T1-E3 DG452EQ-T1-E3 DG453EQ-T1-E3 |
| | 16 Pin Narrow SOIC | DG451EY-T1-E3 DG452EY-T1-E3 DG453EY-T1-E3 |

Notes:

a. - 40 °C to 85 °C datasheet limits apply.

| ABSOLUTE MAXIMUM RATINGS $T_A = 25\text{ °C}$, unless otherwise noted | | | |
|------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------|------|
| Parameter | | Limit | Unit |
| V+ to V- | | 44 | V |
| GND to V- | | 25 | |
| V_L | | (GND - 0.3) to (V+) + 0.3 | |
| Digital Inputs ^a , V_S , V_D | | (V-) - 2 to (V+) + 2 or 30 mA, whichever occurs first | |
| Continuous Current (D, S only) | | 100 | mA |
| Peak Current, S or D (Pulsed 1 ms, 10 % Duty Cycle) | | 300 | |
| Storage Temperature | | - 65 to 150 | °C |
| Power Dissipation (Package) ^b | 16 Pin TSSOP ^c | 450 | mW |
| | 16 Pin Narrow SOIC ^d | 600 | |
| Thermal Resistance (Package) ^b | 16 Pin TSSOP | 178 | C/W |
| | 16 Pin Narrow SOIC | 125 | |
| ESD (HBM) | | 2 | kV |

Notes:

a. Signals on S_X , D_X , or IN_X exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current ratings.

b. All leads welded or soldered to PC board.

c. Derate 5.6 mW/°C above 70 °C.

d. Derate 8.0 mW/°C above 75 °C.

| SPECIFICATIONS FOR DUAL SUPPLIES | | | | | | | | | |
|----------------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|----------|
| Parameter | Symbol | Test Conditions Unless Specified $V_+ = 15\text{ V}$, $V_- = -15\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 2.4\text{ V}$, 0.8 V^a | Temp. ^b | Typ. ^c | - 40 °C to 125 °C | | - 40 °C to 85 °C | | Unit |
| | | | | | Min. ^d | Max. ^d | Min. ^d | Max. ^d | |
| Analog Switch | | | | | | | | | |
| Analog Signal Range ^e | V_{ANALOG} | | Full | | - 15 | 15 | - 15 | 15 | V |
| On-Resistance | R_{ON} | $I_S = -10\text{ mA}$, $V_D = -10\text{ V to } +10\text{ V}$ | Room Full | 3.8 | | 5.3 8.3 | | 5.3 7.3 | Ω |
| On-Resistance Match | ΔR_{ON} | $I_S = -10\text{ mA}$, $V_D = \pm 10\text{ V}$ | Room Full | 0.12 | | 0.5 1 | | 0.5 0.5 | |
| On-Resistance Flatness | $R_{FLATNESS}$ | $I_S = -10\text{ mA}$, $V_D = -5\text{ V}, 0\text{ V}, +5\text{ V}$ | Room Full | 0.25 | | 0.5 0.5 | | 0.5 0.5 | |
| Switch Off Leakage Current | $I_{S(off)}$ | $V_D = \pm 10\text{ V}$, $V_S = \mp 10\text{ V}$ | Room Full | ± 0.1 | - 0.5 - 20 | 0.5 20 | - 0.5 - 2.5 | 0.5 2.5 | nA |
| | $I_{D(off)}$ | | Room Full | ± 0.1 | - 0.5 - 20 | 0.5 20 | - 0.5 - 2.5 | 0.5 2.5 | |
| Channel On Leakage Current | $I_{D(on)}$ | $V_S = V_D = \pm 10\text{ V}$ | Room Full | ± 0.1 | - 0.4 - 40 | 0.4 40 | - 1 - 5 | 1 5 | |

| SPECIFICATIONS FOR DUAL SUPPLIES | | | | | | | | | |
|-------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------|
| Parameter | Symbol | Test Conditions Unless Specified $V_+ = 15\text{ V}$, $V_- = -15\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 2.4\text{ V}$, 0.8 V^a | Temp. ^b | Typ. ^c | - 40 °C to 125 °C | | - 40 °C to 85 °C | | Unit |
| | | | | | Min. ^d | Max. ^d | Min. ^d | Max. ^d | |
| Digital Control | | | | | | | | | |
| Input Current, V_{IN} Low | I_{IL} | V_{IN} Under Test = 0.8 V | Full | 0.005 | - 0.5 | 0.5 | - 0.5 | 0.5 | μA |
| Input Current, V_{IN} High | I_{IH} | V_{IN} Under Test = 2.4 V | Full | 0.005 | - 0.5 | 0.5 | - 0.5 | 0.5 | |
| Input Capacitance ^e | C_{IN} | $f = 1\text{ MHz}$ | Room | 7 | | | | | pF |
| Dynamic Characteristics | | | | | | | | | |
| Turn-On Time | t_{ON} | $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ $V_S = \pm 10\text{ V}$, See Figure 2 | Room | 88 | | 118 | | 118 | ns |
| Turn-Off Time | t_{OFF} | | Room | 69 | | 97 | | 97 | |
| Break-Before-Make Time Delay | t_D | DG453 only, $V_S = 10\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ | Room | 18 | | | | | |
| Charge Injection ^e | Q | $V_g = 0\text{ V}$, $R_g = 0\ \Omega$, $C_L = 1\text{ nF}$ | Room | 22 | | | | | pC |
| Off Isolation ^e | OIRR | $R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $f = 1\text{ MHz}$ | Room | - 60 | | | | | dB |
| Channel-to-Channel Crosstalk ^e | X_{TALK} | | Room | - 85 | | | | | |
| Source Off Capacitance ^e | $C_{S(off)}$ | $f = 1\text{ MHz}$ | Room | 31 | | | | | pF |
| Drain Off Capacitance ^e | $C_{D(off)}$ | | Room | 34 | | | | | |
| Channel On Capacitance ^e | $C_{D(on)}$ | | Room | 103 | | | | | |
| Total Harmonic Distortion ^e | THD | Signal = 5 V_{RMS} , 20 Hz to 20 kHz, $R_L = 600\ \Omega$ | Room | 0.04 | | | | | % |
| Power Supplies | | | | | | | | | |
| Power Supply Current | I_+ | $V_+ = 16.5\text{ V}$, $V_- = -16.5\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 0$ or 5 V | Room | 0.001 | | 0.5 | | 0.5 | μA |
| Negative Supply Current | I_- | | Full | - 0.001 | - 0.5 | - 5 | - 0.5 | - 5 | |
| Logic Supply Current | I_L | | Room | 0.001 | | 0.5 | | 0.5 | |
| Ground Current | I_{GND} | | Full | - 0.001 | - 0.5 | - 5 | - 0.5 | - 5 | |

| SPECIFICATIONS FOR DUAL SUPPLIES | | | | | | | | | |
|-------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------|
| Parameter | Symbol | Test Conditions Unless Specified $V_+ = 5\text{ V}$, $V_- = -5\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 2.4\text{ V}$, 0.8 V^a | Temp. ^b | Typ. ^c | - 40 °C to 125 °C | | - 40 °C to 85 °C | | Unit |
| | | | | | Min. ^d | Max. ^d | Min. ^d | Max. ^d | |
| Analog Switch | | | | | | | | | |
| Analog Signal Range ^e | V_{ANALOG} | | Full | | - 5 | 5 | - 5 | 5 | V |
| On-Resistance | R_{ON} | $V_+ = +5\text{ V}$, $V_- = -5\text{ V}$ $I_S = -10\text{ mA}$, $V_D = -3.5\text{ V}$ to $+3.5\text{ V}$ | Room | 3.8 | | 11 | | 11 | Ω |
| On-Resistance Match | ΔR_{ON} | $V_+ = +5\text{ V}$, $V_- = -5\text{ V}$, $I_S = -10\text{ mA}$, $V_D = \pm 3.5\text{ V}$ | Room | 0.13 | | 0.5 | | 0.5 | |
| Dynamic Characteristics | | | | | | | | | |
| Turn-On Time ^e | t_{ON} | $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ $V_S = 3\text{ V}$, See Figure 2 | Room | 170 | | 200 | | 200 | ns |
| Turn-Off Time ^e | t_{OFF} | | Full | 66 | | 96 | | 96 | |
| Break-Before-Make ^e Time Delay | t_D | DG451 only, $V_S = 3\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ | Room | 98 | | | | | |
| Charge Injection ^e | Q | $V_g = 0\text{ V}$, $R_g = 0\ \Omega$, $C_L = 1\text{ nF}$ | Full | 8 | | | | | pC |

| SPECIFICATIONS FOR DUAL SUPPLIES | | | | | | | | | |
|----------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------|
| Parameter | Symbol | Test Conditions Unless Specified $V_+ = 5\text{ V}$, $V_- = -5\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 2.4\text{ V}$, 0.8 V^a | Temp. ^b | Typ. ^c | - 40 °C to 125 °C | | - 40 °C to 85 °C | | Unit |
| | | | | | Min. ^d | Max. ^d | Min. ^d | Max. ^d | |
| Power Supplies | | | | | | | | | |
| Power Supply Current | I+ | $V_L = 5\text{ V}$, $V_{IN} = 0$ or 5 V | Room Full | 0.001 | | - 0.5 - 5 | | - 0.5 - 5 | μA |
| Negative Supply Current | I- | | Room Full | - 0.001 | - 0.5 - 5 | | - 0.5 - 5 | | |
| Logic Supply Current | I _L | | Room Full | 0.001 | | - 0.5 - 5 | | - 0.5 - 5 | |
| Ground Current | I _{GND} | | Room Full | - 0.001 | - 0.5 - 5 | | - 0.5 - 5 | | |

| SPECIFICATIONS FOR UNIPOLAR SUPPLIES | | | | | | | | | |
|--------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------|
| Parameter | Symbol | Test Conditions Unless Specified $V_+ = 12\text{ V}$, $V_- = 0\text{ V}$ $V_L = 5\text{ V}$, $V_{IN} = 2.4\text{ V}$, 0.8 V^a | Temp. ^b | Typ. ^c | - 40 °C to 125 °C | | - 40 °C to 85 °C | | Unit |
| | | | | | Min. ^d | Max. ^d | Min. ^d | Max. ^d | |
| Analog Switch | | | | | | | | | |
| Analog Signal Range ^e | V _{ANALOG} | | Full | | | 12 | | 12 | V |
| On-Resistance | R _{ON} | I _S = - 10 mA, V _D = 0 V to + 10 V | Room Full | 5.5 | | 8.1 12.4 | | 8.1 10.4 | Ω |
| On-Resistance Match | ΔR_{ON} | I _S = - 10 mA, V _D = + 10 V | Room Full | 0.14 | | 0.5 1 | | 0.5 0.5 | |
| On-Resistance Flatness | R _{FLATNESS} | I _S = - 10 mA, V _D = 0 V, + 5 V, + 10 V | Room Full | 0.94 | | 1.5 1.7 | | 1.5 1.5 | |
| Dynamic Characteristics | | | | | | | | | |
| Turn-On Time | t _{ON} | R _L = 300 Ω , C _L = 35 pF V _S = 8 V, See Figure 2 | Room Full | 132 | | 162 238 | | 162 210 | ns |
| Turn-Off Time | t _{OFF} | | Room Full | 61 | | 91 117 | | 91 105 | |
| Break-Before-Make Time Delay | t _D | DG453 only, V _S = 8 V R _L = 300 Ω , C _L = 35 pF | Room | 70 | | | | | |
| Charge Injection ^e | Q | V _g = 0 V, R _g = 0 Ω , C _L = 1 nF | Room | 1 | | | | | pC |
| Power Supplies | | | | | | | | | |
| Power Supply Current | I+ | $V_L = 5\text{ V}$, $V_{IN} = 0$ or 5 V | Room Full | 0.001 | | 0.5 5 | | 0.5 5 | μA |
| Negative Supply Current | I- | | Room Full | - 0.001 | - 0.5 - 5 | | - 0.5 - 5 | | |
| Logic Supply Current | I _L | | Room Full | 0.001 | | 0.5 5 | | 0.5 5 | |
| Ground Current | I _{GND} | | Room Full | - 0.001 | - 0.5 - 5 | | - 0.5 - 5 | | |

Notes:

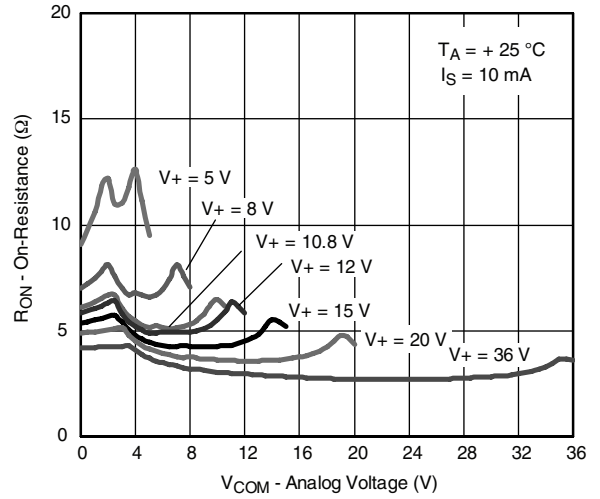
- V_{IN} = input voltage to perform proper function.
- Room = 25 °C, Full = as determined by the operating temperature suffix.
- Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- Guaranteed by design, not subject to production test.

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

TYPICAL CHARACTERISTICS 25°C , $V_L = 5\text{ V}$, unless otherwise noted



On-Resistance vs. V_D and Dual Supply Voltage



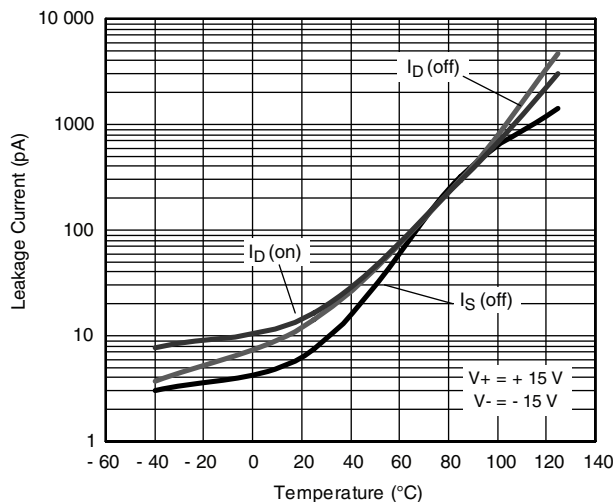
On-Resistance vs. V_D and Single Supply Voltage



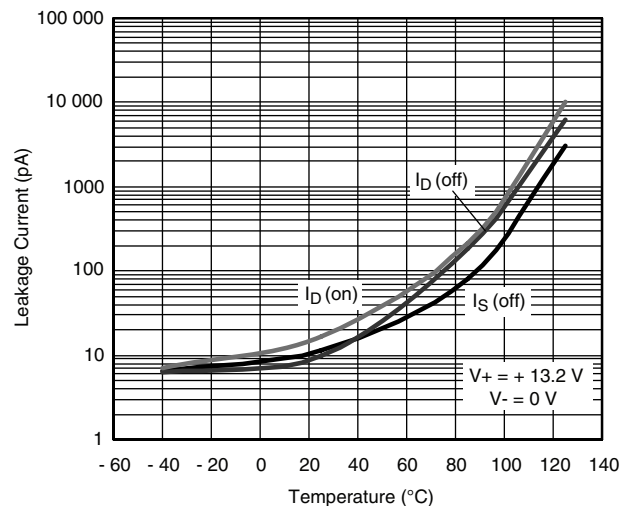
On-Resistance vs. V_D and Temperature



On-Resistance vs. V_D and Temperature



Leakage Current vs. Temperature



Leakage Current vs. Temperature

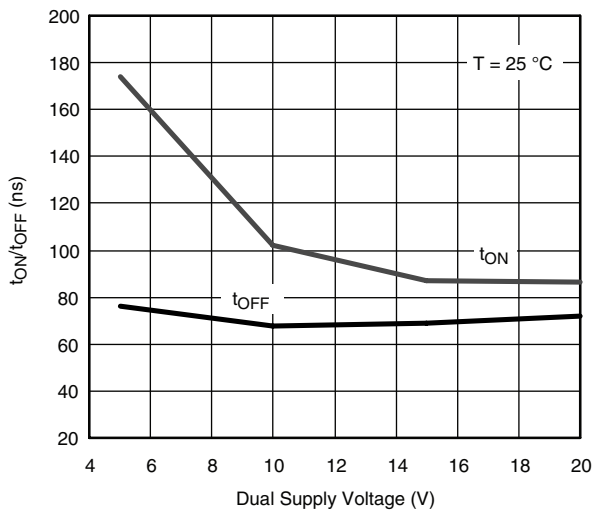
TYPICAL CHARACTERISTICS 25 °C, $V_L = 5$ V, unless otherwise noted



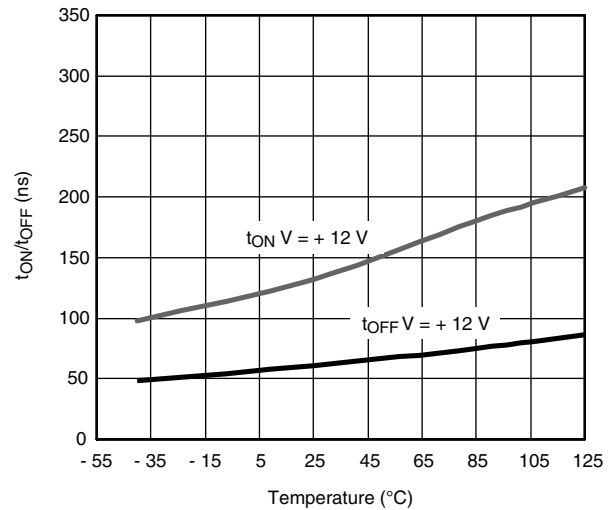
Charge Injection vs. Analog Voltage



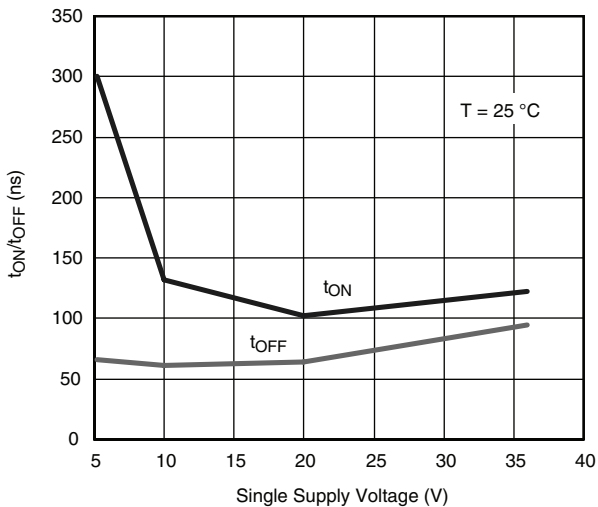
Switching Time vs. Temperature and Dual Supply Voltage



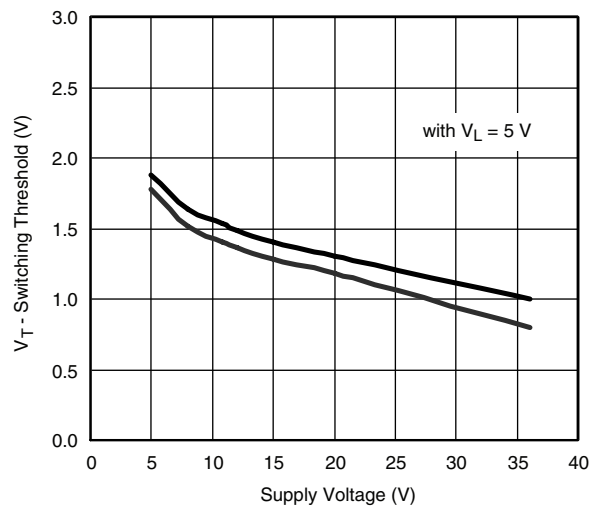
Switching Time vs. Dual Supply Voltage



Switching Time vs. Temperature and Single Supply Voltage



Switching Time vs. Single Supply Voltage



Switching Threshold vs. Supply Voltage

TYPICAL CHARACTERISTICS 25 °C, $V_L = 5\text{ V}$, unless otherwise noted

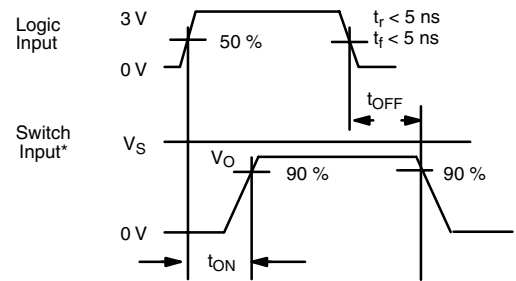


TEST CIRCUITS



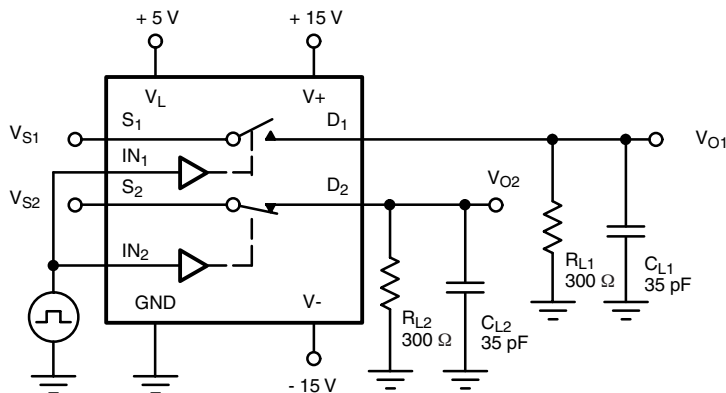
C_L (includes fixture and stray capacitance)

$$V_O = V_S \frac{R_L}{R_L + R_{DS(on)}}$$



Note: Logic input waveform is inverted for switches that have the opposite logic sense control

Figure 1. Switching Time



C_L (includes fixture and stray capacitance)

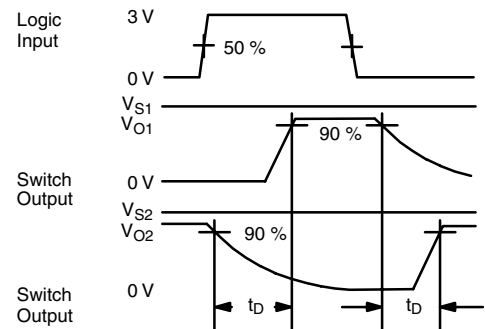


Figure 2. Break-Before-Make (DG453)

TEST CIRCUITS



Figure 3. Charge Injection

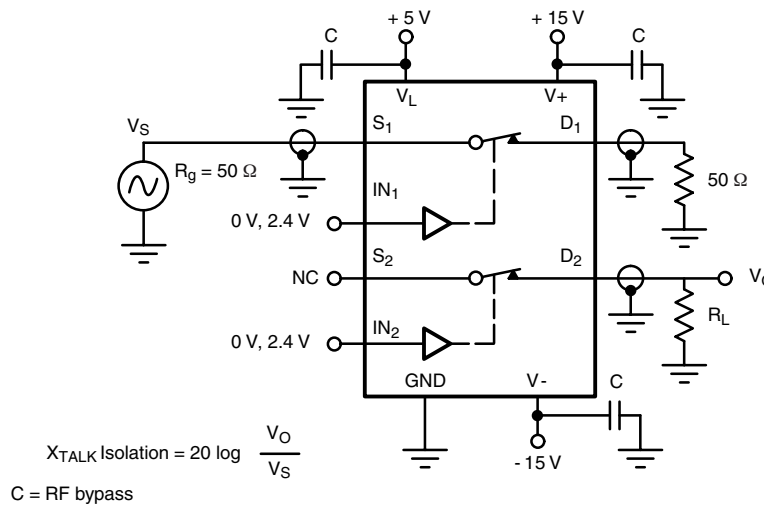


Figure 4. Crosstalk

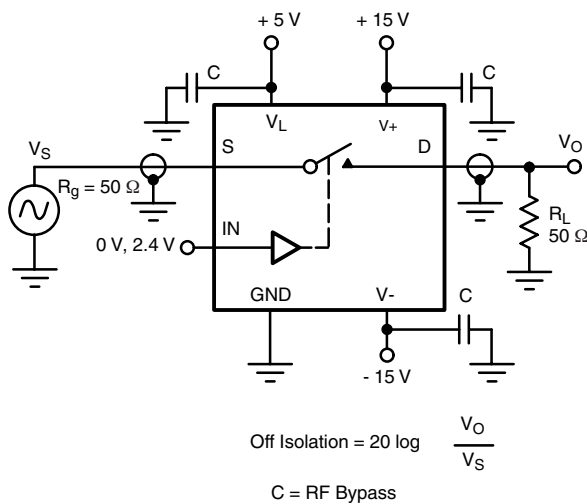


Figure 5. Off-Isolation

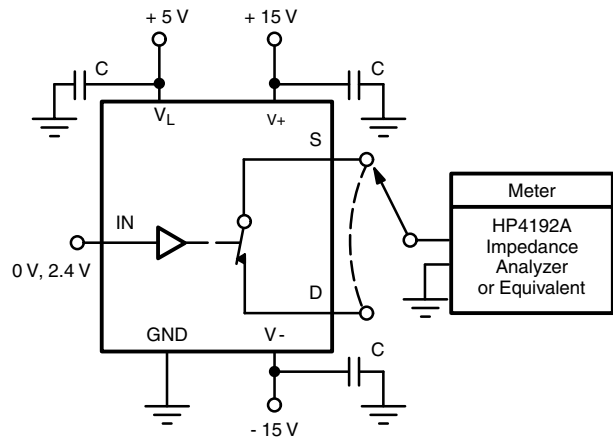


Figure 6. Source/Drain Capacitances

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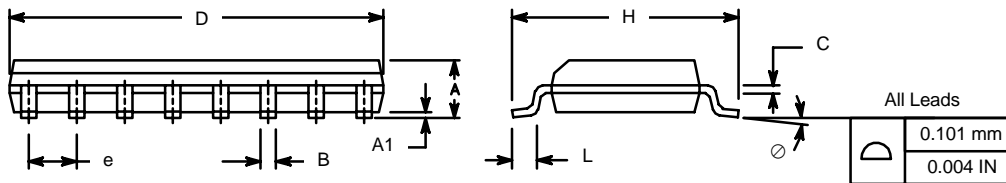


SOIC (NARROW): 16-LEAD
JEDEC Part Number: MS-012

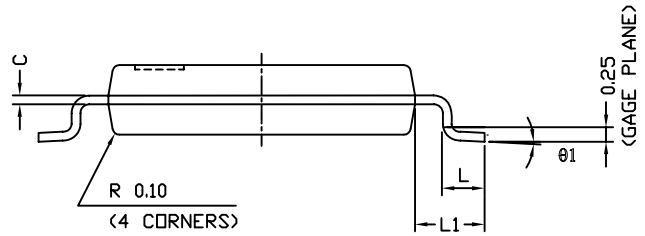
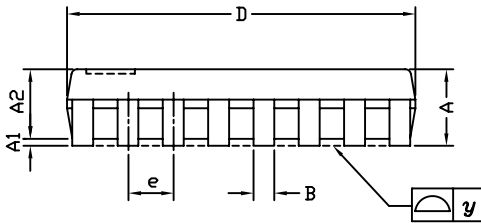


| Dim | MILLIMETERS | | INCHES | |
|----------------|-------------|-------|-----------|-------|
| | Min | Max | Min | Max |
| A | 1.35 | 1.75 | 0.053 | 0.069 |
| A ₁ | 0.10 | 0.20 | 0.004 | 0.008 |
| B | 0.38 | 0.51 | 0.015 | 0.020 |
| C | 0.18 | 0.23 | 0.007 | 0.009 |
| D | 9.80 | 10.00 | 0.385 | 0.393 |
| E | 3.80 | 4.00 | 0.149 | 0.157 |
| e | 1.27 BSC | | 0.050 BSC | |
| H | 5.80 | 6.20 | 0.228 | 0.244 |
| L | 0.50 | 0.93 | 0.020 | 0.037 |
| ∅ | 0° | 8° | 0° | 8° |

ECN: S-03946—Rev. F, 09-Jul-01
DWG: 5300



TSSOP: 16-LEAD



| Symbols | DIMENSIONS IN MILLIMETERS | | |
|---------|---------------------------|-------|------|
| | Min | Nom | Max |
| A | - | 1.10 | 1.20 |
| A1 | 0.05 | 0.10 | 0.15 |
| A2 | - | 1.00 | 1.05 |
| B | 0.22 | 0.28 | 0.38 |
| C | - | 0.127 | - |
| D | 4.90 | 5.00 | 5.10 |
| E | 6.10 | 6.40 | 6.70 |
| E1 | 4.30 | 4.40 | 4.50 |
| e | - | 0.65 | - |
| L | 0.50 | 0.60 | 0.70 |
| L1 | 0.90 | 1.00 | 1.10 |
| y | - | - | 0.10 |
| theta1 | 0° | 3° | 6° |

ECN: S-61920-Rev. D, 23-Oct-06
DWG: 5624



RECOMMENDED MINIMUM PAD FOR TSSOP-16



Recommended Minimum Pads
Dimensions in inches (mm)

RECOMMENDED MINIMUM PADS FOR SO-16



Recommended Minimum Pads
Dimensions in Inches/(mm)

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