

# 1.6 $\Omega$ On Resistance, $\pm 5$ V, +12 V, and +3 V Quad SPST Switches

## DESCRIPTION

The DG9424E, DG9425E, DG9426E are monolithic quad single-pole-single-throw analog switches. The G9424E and DG9425E differ only in that they respond to opposite logic levels. The DG9426E has two normally open and two normally closed switches. It can be given various configurations, including four SPST, two SPDT, and one DPDT.

Using BiCMOS wafer fabrication technology allows the DG9424E, DG9425E, and DG9426E to operate on single and dual supplies. Single supply voltage ranges from 3 V to 16 V while dual supply operation is recommended with  $\pm 3$  V to  $\pm 8$  V. Each switch conducts equally well in both direction when on, and blocks input voltages up to the supply levels when off.

The low and flat on resistance over the full input signal voltage rang bring excellent linearity, reduce insertion loss and signal distortion, make them ideal for data acquisition and programmable gain control applications. These switch characters also make them ideal fit for audio signal switch and reed relay replacement.

The DG9424E, DG9425E, DG9426E feature low power dissipation, fast switching speed, and low voltage logic control threshold. Proprietary design enables the low charge injection that minimize the switching transient.

Operation temperature is specified from  $-40$   $^{\circ}\text{C}$  to  $+85$   $^{\circ}\text{C}$ . The DG9424E, DG9425E, DG9426E are available in 16 lead TSSOP packages.

## FEATURES

- 3 V to 16 V single supply or  $\pm 3$  V thru  $\pm 8$  V dual supply operation
- 1.6  $\Omega$  typical on resistance
- 3 V logic compatible for control
- Bi-directional rail to rail signal switching
- Fast switching speed
- $< 0.2$  nA switch on leakage
- Break-before-make switching - DG9426

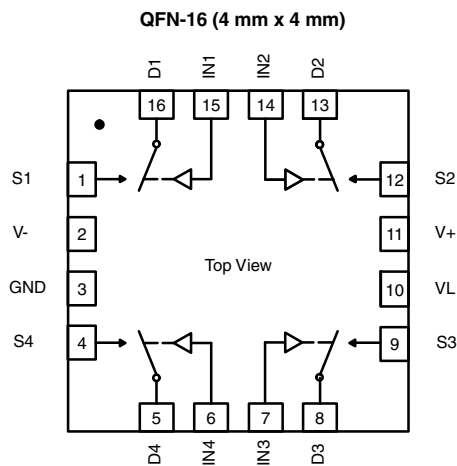
## BENEFITS

- Wide operation voltage range
- Low signal errors and distortion
- Fast switching time
- Simple interfacing

## APPLICATIONS

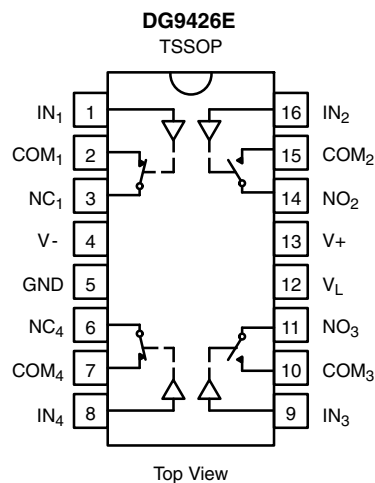
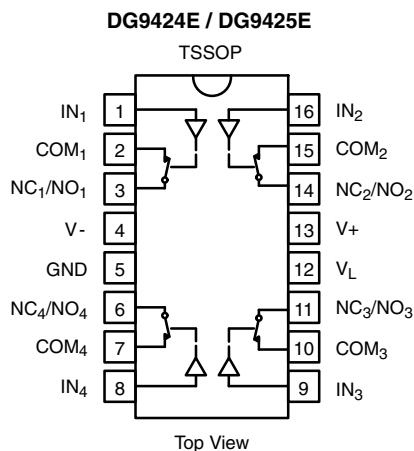
- Automatic test equipment
- Data acquisition systems
- Meters and instruments
- Medical and healthcare systems
- Communication systems
- Audio and video signal routing
- Relay replacement
- Battery powered systems
- Computer peripherals
- Audio and video signal routing

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION





## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



TRUTH TABLE		
LOGIC	DG9424E	DG9425E
0	OFF	ON
1	ON	OFF

TRUTH TABLE		
LOGIC	SW <sub>1</sub> , SW <sub>4</sub>	SW <sub>2</sub> , SW <sub>3</sub>
0	ON	OFF
1	OFF	ON

ORDERING INFORMATION				
TEMP. RANGE	PACKAGE	PART NUMBER	PART MARKING	STD PACK QUANTITY
-40 °C to +85 °C	16-pin TSSOP	DG9424EDQ-T1-GE3	9424E	Tape and reel 3000 units
		DG9425EDQ-T1-GE3	9425E	Tape and reel 3000 units
		DG9426EDQ-T1-GE3	9426E	Tape and reel 3000 units
	16-pin QFN (4 mm x 4 mm)	DG9424EDN-T1-GE4	9424E	Tape and reel 2500 units

ABSOLUTE MAXIMUM RATINGS			
PARAMETER		LIMIT	UNIT
V+ to V-		-0.3 to +18	V
GND to V-		18	
V <sub>L</sub>		(GND - 0.3) to (V+) + 0.3	
IN, COM, NC, NO <sup>a</sup>		(V-) - 0.3 to (V+) + 0.3	
Continuous current (NO, NC, COM pins)		100	mA
Peak current, S or D (pulsed 1 ms, 10 % duty cycle)		200	
Storage temperature		-65 to +150	°C
Power dissipation (package) <sup>b</sup>	16-pin TSSOP <sup>c</sup>	450	mW
Thermal resistance <sup>b</sup>		178	°C/W
ESD human body model (HBM); per ANSI / ESDA / JEDEC® JS-001		>1500	V
Latch up current, per JESD78D		400	mA

## Notes

- a. Signals on NC, NO, COM or IN exceeding V<sub>+</sub> or V<sub>-</sub> 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 7 mW/°C above 25 °C

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.



SPECIFICATIONS <sup>a</sup> Single Supply 12 V								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V <sub>+</sub> = 12 V, V <sub>-</sub> = 0 V V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT	
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>		
Analog Switch								
Analog signal range <sup>e</sup>	V <sub>ANALOG</sub>		Full	0	-	12	V	
On-resistance	R <sub>ON</sub>	V <sub>+</sub> = 10.8 V, V <sub>-</sub> = 0 V I <sub>NO</sub> , I <sub>NC</sub> = 50 mA, V <sub>COM</sub> = 2/9 V	Room	-	1.6	3	Ω	
			Full	-	-	4		
Digital Control								
Input current	I <sub>INL</sub> or I <sub>INH</sub>		Full	-1	0.01	1	μA	
Dynamic Characteristics								
Turn-on time <sup>e</sup>	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>NO</sub> , V <sub>NC</sub> = 5 V, see fig. 2	Room	-	36	51	ns	
			Full	-	-	65		
Turn-off time <sup>e</sup>	t <sub>OFF</sub>		Room	-	20	35		
			Full	-	-	44		
Break-before-make time delay <sup>e</sup>	t <sub>D</sub>	DG9426E only, V <sub>NO</sub> , V <sub>NC</sub> = 5 V R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	2	-	-		
Charge injection <sup>e</sup>	Q <sub>INJ</sub>	V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 1 nF	Room	-	38	-	pC	
Off-isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF f = 1 MHz	Room	-	-56	-	dB	
Channel-to-channel crosstalk <sup>e</sup>	X <sub>TALK</sub>		Room	-	-77	-		
NO, NC off capacitance <sup>e</sup>	C <sub>NO(off)</sub>	f = 1 MHz	Room	-	49	-	pF	
	C <sub>NC(off)</sub>							
COM off capacitance <sup>e</sup>	C <sub>COM(off)</sub>		Room	-	37	-		
Channel on capacitance <sup>e</sup>	C <sub>COM(on)</sub>		Room	-	89	-		
Power Supplies								
Positive supply current	I <sub>+</sub>	V <sub>IN</sub> = 0 or V <sub>L</sub>	Room	-	0.02	1	μA	
			Full	-	-	5		
Negative supply current	I <sub>-</sub>		Room	-1	-0.002	-		
			Full	-5	-	-		
Logic supply current	I <sub>L</sub>		Room	-	0.002	1		
			Full	-	-	5		
Ground current	I <sub>GND</sub>		Room	-1	-0.002	-		
			Full	-5	-	-		



SPECIFICATIONS <sup>a</sup> Dual Supply $\pm 5$ V								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED $V_+ = 5$ V, $V_- = -5$ V $V_L = 5$ V, $V_{IN} = 2.4$ V, $0.8$ V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT	
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>		
Analog Switch								
Analog signal range <sup>e</sup>	$V_{ANALOG}$		Full	-5		5	V	
On-resistance	$R_{ON}$	$V_+ = 4.5$ V, $V_- = -4.5$ V $I_{NO}, I_{NC} = 50$ mA	Room	-	1.9	3.3	$\Omega$	
			Full	-	-	4.3		
Switch off leakage current	$I_{NO(off)}$	$V_+ = 5.5$ V, $V_- = -5.5$ V $V_{COM} = \pm 4.5$ V, $V_{NO}, V_{NC} = \pm 4.5$ V	Room	-1	-	1	nA	
	$I_{NC(off)}$		Full	-10	-	10		
	$I_{COM(off)}$		Room	-1	-	1		
			Full	-10	-	10		
Channel on leakage current	$I_{COM(on)}$	$V_+ = 5.5$ V, $V_- = -5.5$ V, $V_{NO}, V_{NC} = V_{COM} = \pm 4.5$ V	Room	-1	-	1		
			Full	-10	-	10		
Digital Control								
Input current <sup>a</sup>	$I_{INL}$ or $I_{INH}$		Full	-1	0.05	1	$\mu$ A	
Dynamic Characteristics								
Turn-on time <sup>e</sup>	$t_{ON}$	$R_L = 300 \Omega$ , $C_L = 35$ pF $V_{NO}, V_{NC} = \pm 3.5$ V, see fig. 2	Room	-	48	67	ns	
			Full	-	-	81		
Turn-off time <sup>e</sup>	$t_{OFF}$		Room	-	34	57		
			Full	-	-	67		
Break-before-make time delay <sup>e</sup>	$t_D$	DG9426E only, $V_{NO}, V_{NC} = 3.5$ V $R_L = 300 \Omega$ , $C_L = 35$ pF	Room	2	-	-		
Charge injection <sup>e</sup>	$Q_{INJ}$	$V_g = 0$ V, $R_g = 0 \Omega$ , $C_L = 1$ nF	Room	-	112	-	pC	
Off isolation <sup>e</sup>	OIRR	$R_L = 50 \Omega$ , $C_L = 5$ pF, $f = 1$ MHz	Room	-	-56	-	dB	
Channel-to-channel crosstalk <sup>e</sup>	$X_{TALK}$		Room	-	-82	-		
Source off capacitance <sup>e</sup>	$C_{NO(off)}$ $C_{NC(off)}$	$f = 1$ MHz	Room	-	38	-	pF	
Drain off capacitance <sup>e</sup>	$C_{COM(off)}$		Room	-	38	-		
Channel on capacitance <sup>e</sup>	$C_{COM(on)}$		Room	-	89	-		
Power Supplies								
Positive supply current <sup>e</sup>	$I_+$	$V_{IN} = 0$ or $V_L$	Room	-	0.03	1	$\mu$ A	
			Full	-	-	5		
Negative supply current <sup>e</sup>	$I_-$		Room	-1	-0.002	-		
			Full	-5	-	-		
Logic supply current <sup>e</sup>	$I_L$		Room	-	0.002	1		
			Full	-	-	5		
Ground current <sup>e</sup>	$I_{GND}$		Room	-1	-0.002	-		
			Full	-5	-	-		



SPECIFICATIONS <sup>a</sup> Single Supply 5 V							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V <sub>+</sub> = 5 V, V <sub>-</sub> = 0 V V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
Analog Switch							
Analog signal range <sup>e</sup>	V <sub>ANALOG</sub>		Full	-	-	5	V
On-resistance <sup>e</sup>	R <sub>ON</sub>	V <sub>+</sub> = 4.5 V, I <sub>NO</sub> , I <sub>NC</sub> = 50 mA	Room	-	3.1	4.8	Ω
			Full	-	-	5.8	
Dynamic Characteristics							
Turn-on time <sup>e</sup>	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>NO</sub> , V <sub>NC</sub> = 3.5 V, see fig. 2	Room	-	62	78	ns
			Hot	-	-	106	
Turn-off time <sup>e</sup>	t <sub>OFF</sub>		Room	-	29	44	
			Hot	-	-	56	
Break-before-make time delay <sup>e</sup>	t <sub>D</sub>	DG9426E only, V <sub>NO</sub> , V <sub>NC</sub> = 3.5 V R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	5	-	-	
Charge injection <sup>e</sup>	Q <sub>INJ</sub>	V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 1 nF	Room	-	10	-	pC
Power Supplies							
Positive supply current <sup>e</sup>	I <sub>+</sub>	V <sub>IN</sub> = 0 or V <sub>L</sub>	Room	-	0.02	1	μA
			Hot	-	-	5	
Negative supply current <sup>e</sup>	I <sub>-</sub>		Room	-1	-0.002	-	
			Hot	-5	-	-	
Logic supply current <sup>e</sup>	I <sub>L</sub>		Room	-	0.002	1	
			Hot	-	-	5	
Ground current <sup>e</sup>	I <sub>GND</sub>		Room	-1	-0.002	-	
			Hot	-5	-	-	



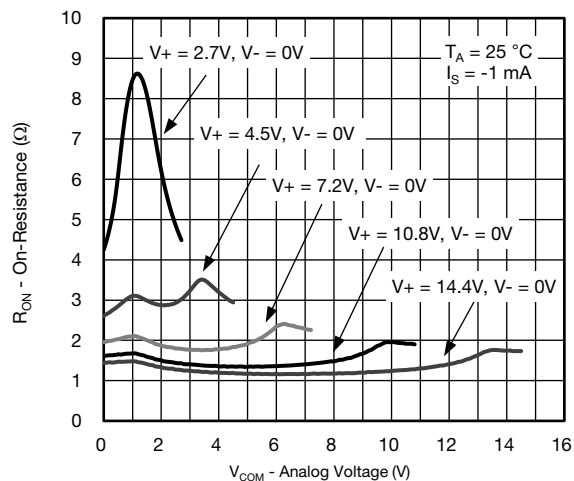
SPECIFICATIONS <sup>a</sup> Single Supply 3 V							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V <sub>+</sub> = 3 V, V <sub>-</sub> = 0 V V <sub>L</sub> = 3 V, V <sub>IN</sub> = 2.4 V, 0.4 V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
Analog Switch							
Analog signal range <sup>e</sup>	V <sub>ANALOG</sub>		Full	0	-	3	V
On-resistance	R <sub>ON</sub>	V <sub>+</sub> = 2.7 V, V <sub>-</sub> = 0 V I <sub>NO</sub> , I <sub>NC</sub> = 5 mA, V <sub>COM</sub> = 0.5, 2.2 V	Room	-	6	-	Ω
			Full	-	-	-	
Switch off leakage current <sup>a</sup>	I <sub>NO(off)</sub>	V <sub>+</sub> = 3.3 V, V <sub>-</sub> = 0 V V <sub>COM</sub> = 0.3, 3 V, V <sub>NO</sub> , V <sub>NC</sub> = 3, 0.3 V	Room	-1	-	1	nA
	I <sub>NC(off)</sub>		Full	-10	-	10	
	I <sub>COM(off)</sub>		Room	-1	-	1	
			Full	-10	-	10	
Channel on leakage current <sup>a</sup>	I <sub>COM(on)</sub>	V <sub>+</sub> = 3.3 V, V <sub>-</sub> = 0 V, V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 0.3, 3 V	Room	-1	-	1	
			Full	-10	-	10	
Digital Control <sup>e</sup>							
Input current	I <sub>INL</sub> or I <sub>INH</sub>		Full	-1	0.005	1	μA
Dynamic Characteristics							
Turn-on time	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>NO</sub> , V <sub>NC</sub> = 1.5 V, see fig. 2	Room	-	140	-	ns
			Full	-	-	193	
Turn-off time	t <sub>OFF</sub>		Room	-	65	-	
			Full	-	-	89	
Break-before-make time delay	t <sub>D</sub>	DG9426E only, V <sub>NO</sub> , V <sub>NC</sub> = 1.5 V R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	5			
Charge injection <sup>e</sup>	Q <sub>INJ</sub>	V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 1 nF	Room	-	15	-	pC
Off isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF f = 1 MHz	Room	-	-56	-	dB
Channel-to-channel crosstalk <sup>e</sup>	X <sub>TALK</sub>		Room	-	-80	-	
Source off capacitance <sup>e</sup>	C <sub>NO(off)</sub>	f = 1 MHz	Room	-	53	-	pF
	C <sub>NC(off)</sub>						
Drain off capacitance <sup>e</sup>	C <sub>COM(off)</sub>		Room	-	42	-	
Channel on capacitance <sup>e</sup>	C <sub>COM(on)</sub>		Room	-	92	-	

**Notes**

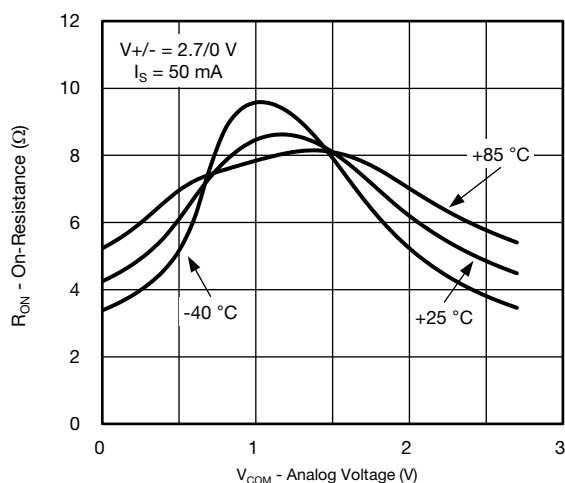
- a. Leakage parameters are guaranteed by worst case test conditions and not subject to production test
- b. Room = 25 °C, Full = As determined by the operating temperature suffix
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing
- d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet
- e. Guaranteed by design, not subject to production test
- f.  $V_{IN}$  = Input voltage to perform proper function



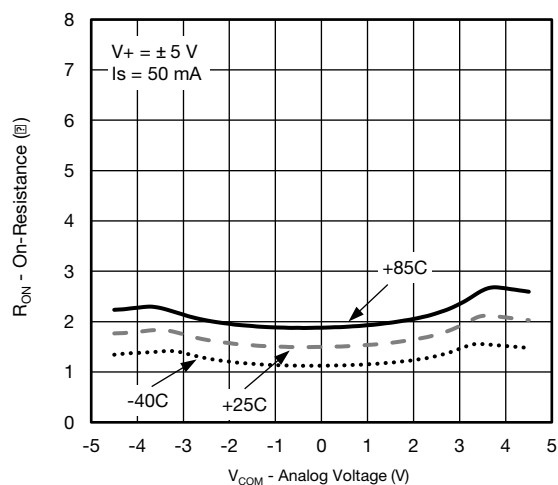
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



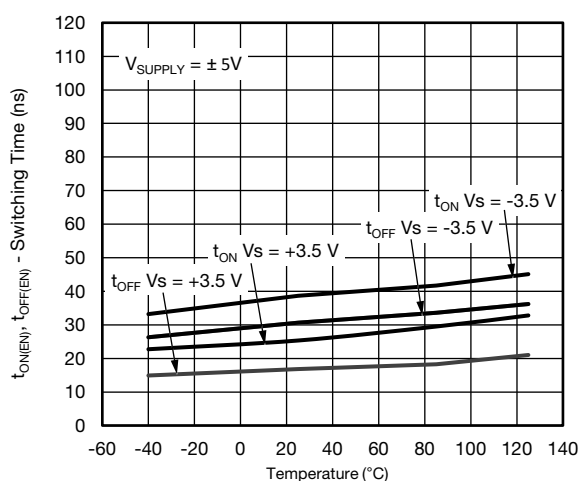
**RON vs. VCOM and Supply Voltage**



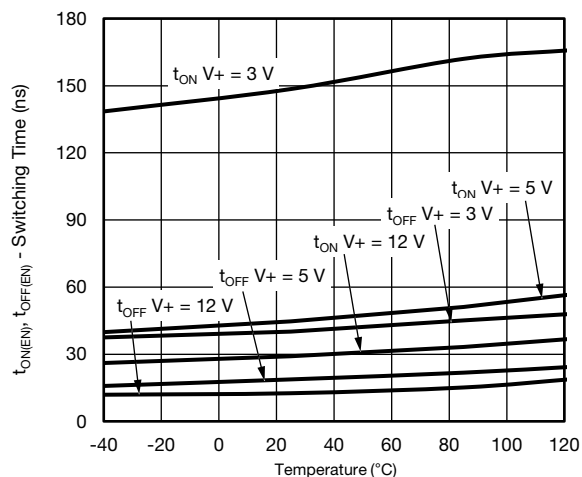
**RON vs. Analog Voltage and Temperature**



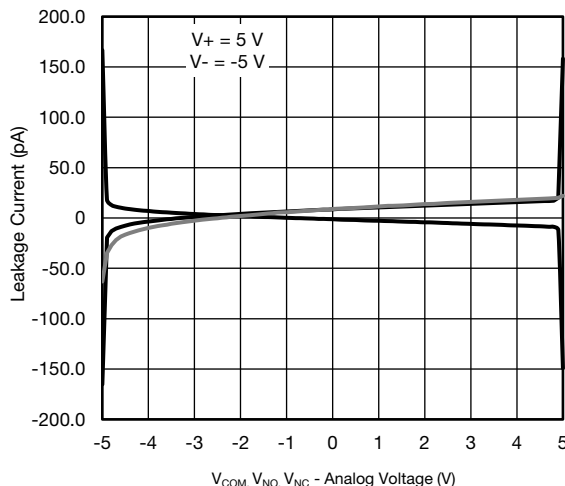
**RON vs. Analog Voltage and Temperature**



**Switching Time vs. Temperature and Dual Supply Voltage**



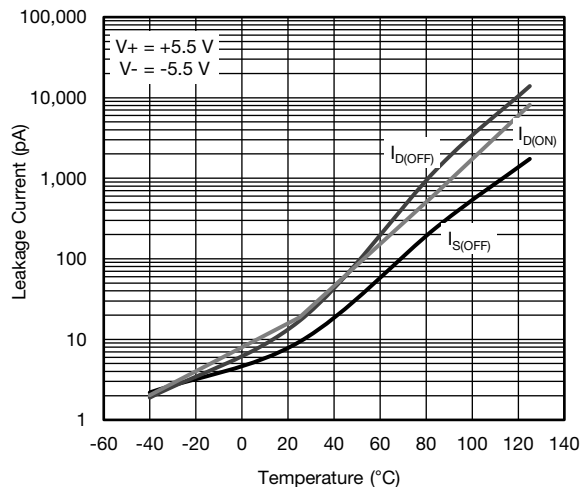
**Switching Time vs. Temperature and Single Supply Voltage**



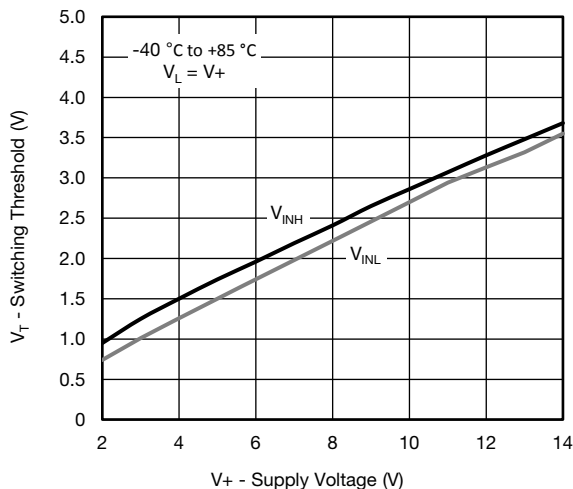
**Leakage Current vs. Analog Voltage**



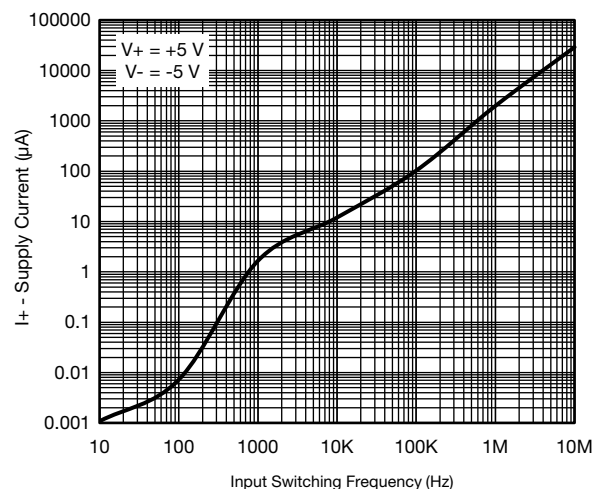
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



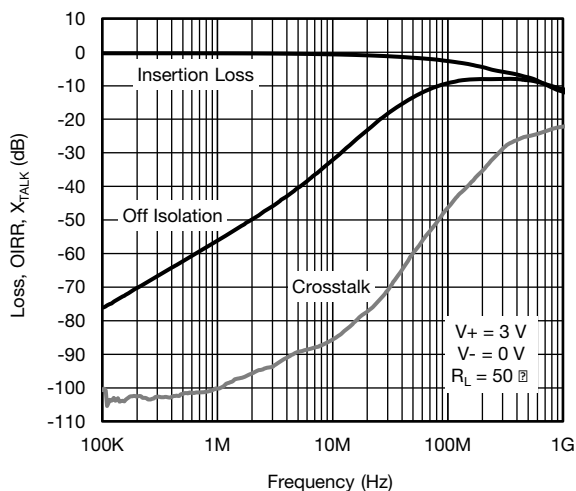
**Leakage Current vs. Temperature**



**Switching Threshold vs. Supply Voltage**

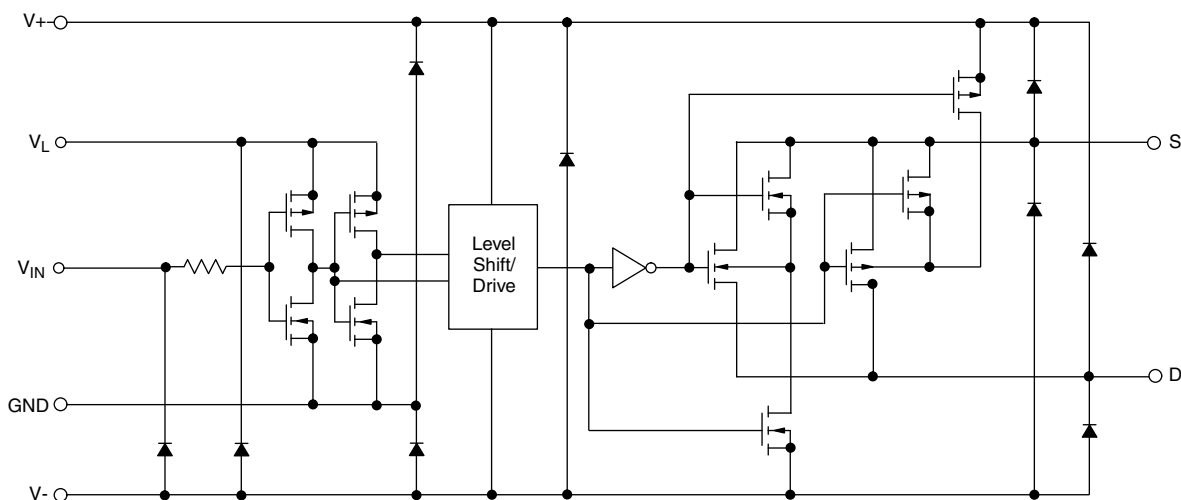
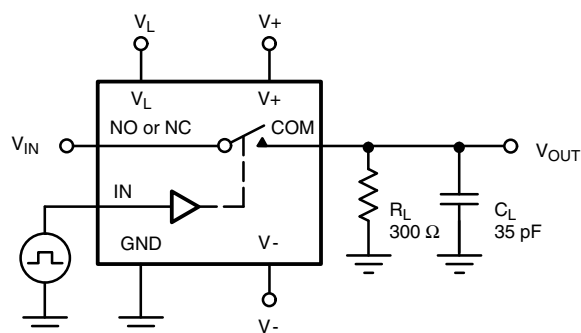


**Switching Current vs. Input Switching Frequency**

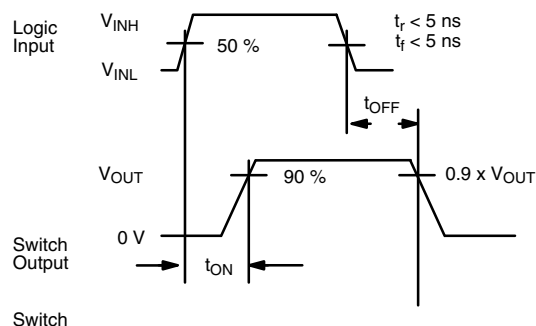


**Insertion Loss, Off Isolation and Crosstalk vs. Frequency**

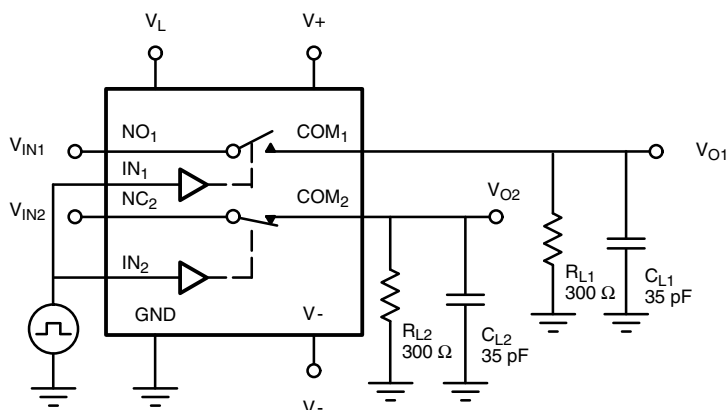
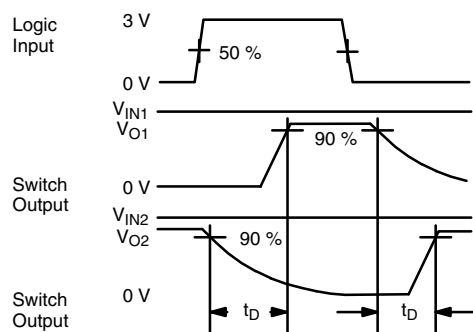


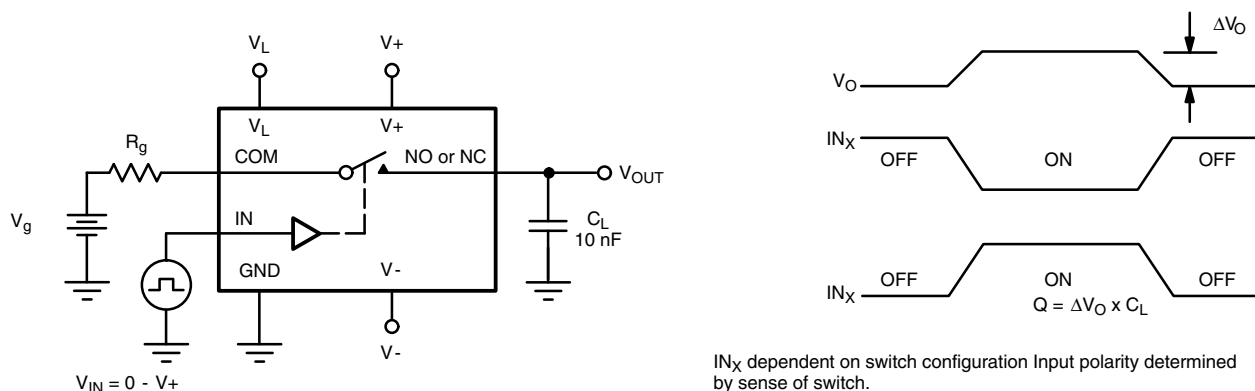
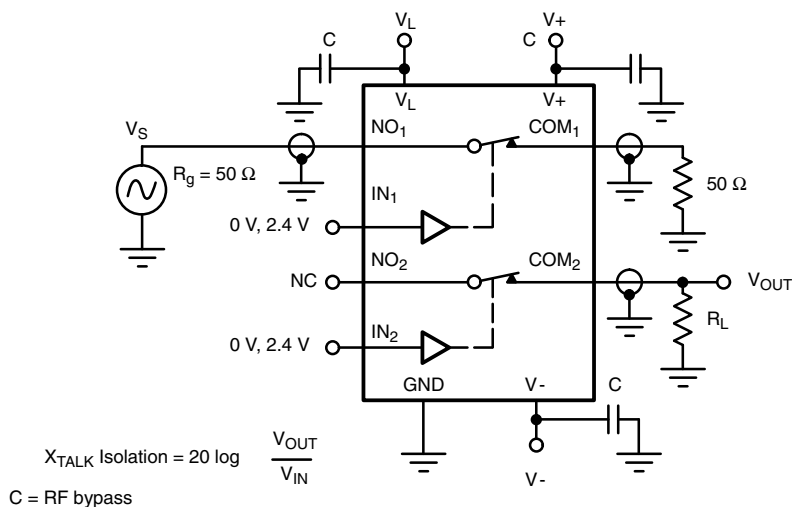
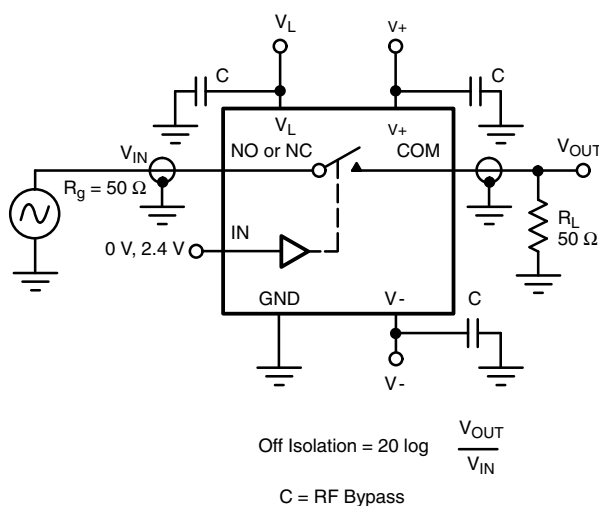
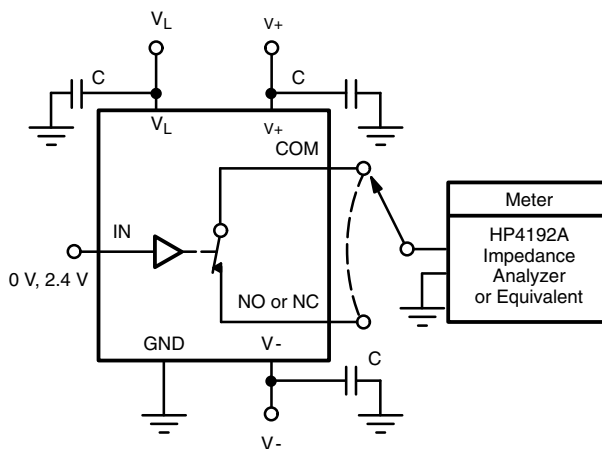
**SCHEMATIC DIAGRAM** (typical channel)

**Fig. 1**
**TEST CIRCUITS**

 $C_L$  (includes fixture and stray capacitance)

$$V_{OUT} = V_{IN} \frac{R_L}{R_L + r_{ON}}$$



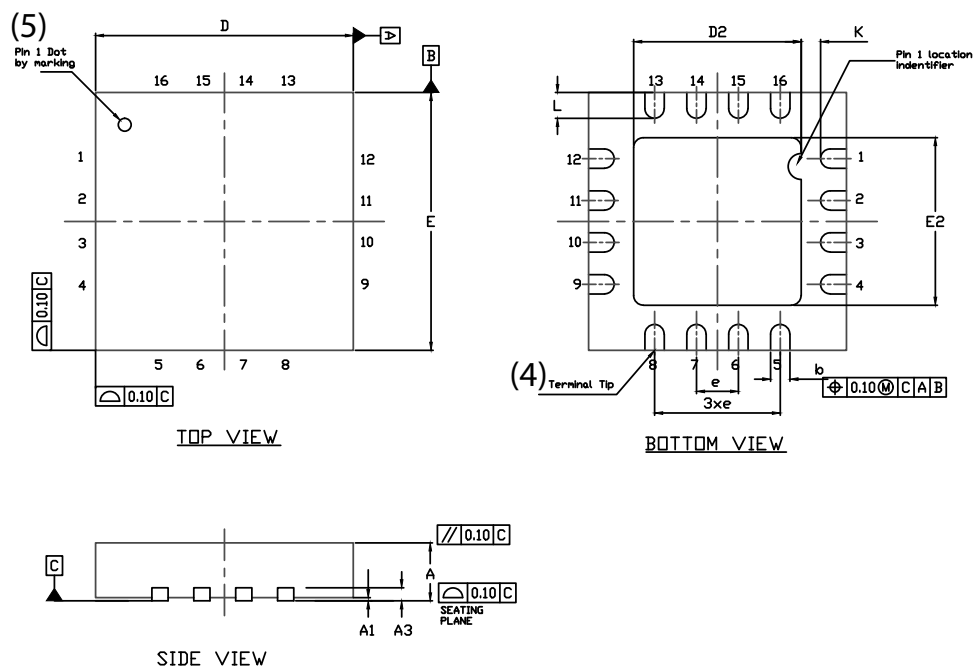
Note: Logic input waveform is inverted for switches that have the opposite logic sense control

**Fig. 2 - Switching Time**

 $C_L$  (includes fixture and stray capacitance)

**Fig. 3 - Break-Before-Make (DG9426E)**

**TEST CIRCUITS**

**Fig. 4 - Charge Injection**

**Fig. 5 - Crosstalk**

**Fig. 6 - Off-Isolation**

**Fig. 7 - Source/Drain Capacitances**

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## QFN 4x4-16L Case Outline



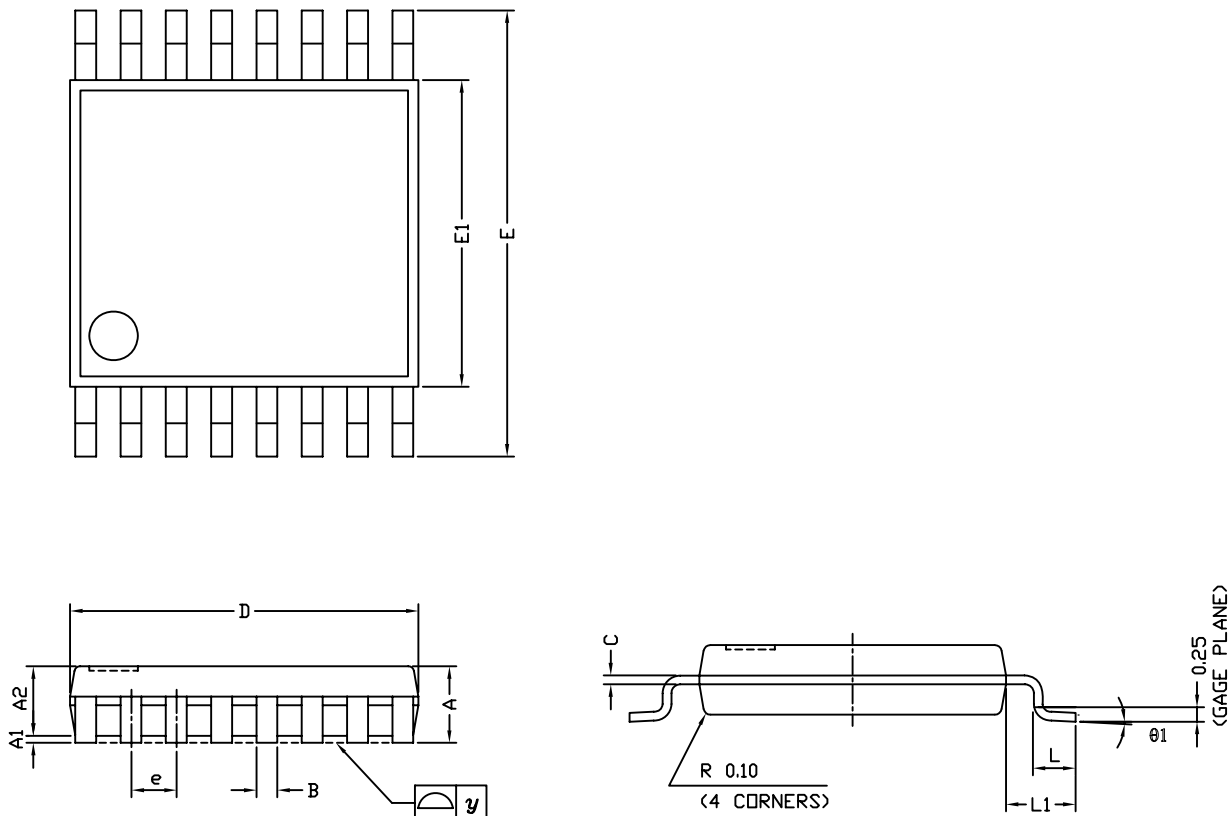
DIM	VARIATION 1						VARIATION 2					
	MILLIMETERS <sup>(1)</sup>			INCHES			MILLIMETERS <sup>(1)</sup>			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.75	0.85	0.95	0.029	0.033	0.037	0.75	0.85	0.95	0.029	0.033	0.037
A1	0	-	0.05	0	-	0.002	0	-	0.05	0	-	0.002
A3	0.20 ref.			0.008 ref.			0.20 ref.			0.008 ref.		
b	0.25	0.30	0.35	0.010	0.012	0.014	0.25	0.30	0.35	0.010	0.012	0.014
D	4.00 BSC			0.157 BSC			4.00 BSC			0.157 BSC		
D2	2.0	2.1	2.2	0.079	0.083	0.087	2.5	2.6	2.7	0.098	0.102	0.106
e	0.65 BSC			0.026 BSC			0.65 BSC			0.026 BSC		
E	4.00 BSC			0.157 BSC			4.00 BSC			0.157 BSC		
E2	2.0	2.1	2.2	0.079	0.083	0.087	2.5	2.6	2.7	0.098	0.102	0.106
K	0.20 min.			0.008 min.			0.20 min.			0.008 min.		
L	0.5	0.6	0.7	0.020	0.024	0.028	0.3	0.4	0.5	0.012	0.016	0.020
N <sup>(3)</sup>	16			16			16			16		
Nd <sup>(3)</sup>	4			4			4			4		
Ne <sup>(3)</sup>	4			4			4			4		

### Notes

- Use millimeters as the primary measurement.
- Dimensioning and tolerances conform to ASME Y14.5M. - 1994.
- N is the number of terminals. Nd and Ne is the number of terminals in each D and E site respectively.
- Dimensions b applies to plated terminal and is measured between 0.15 mm and 0.30 mm from terminal tip.
- The pin 1 identifier must be existed on the top surface of the package by using identification mark or other feature of package body.
- Package warpage max. 0.05 mm.

ECN: S13-0893-Rev. B, 22-Apr-13  
DWG: 5890

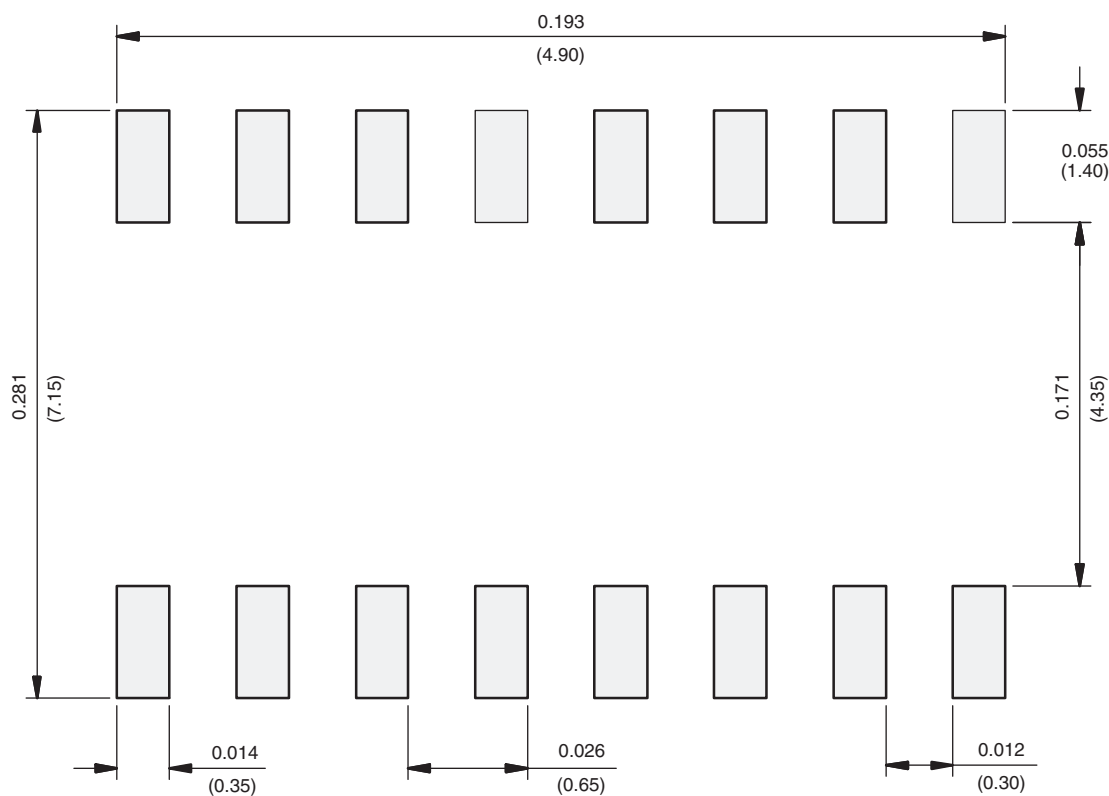
## TSSOP: 16-LEAD



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
θ1	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)



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