

DG406, DG407

Single 16-Channel/Differential 8-Channel, CMOS Analog Multiplexers

FN3116  
Rev 11.00  
October 1, 2013

The DG406 and DG407 monolithic CMOS analog multiplexers are drop-in replacements for the popular DG506A and DG507A series devices. They each include an array of sixteen analog switches, a TTL and CMOS compatible digital decode circuit for channel selection, a voltage reference for logic thresholds, and an ENABLE input for device selection when several multiplexers are present.

These multiplexers feature lower signal ON-resistance (<100Ω) and faster transition time ( $t_{TRANS} < 300ns$ ) compared to the DG506A and DG507A. Charge injection has been reduced, simplifying sample and hold applications.

The improvements in the DG406 series are made possible by using a high voltage silicon-gate process. An epitaxial layer prevents the latch-up associated with older CMOS technologies. The 44V maximum voltage range permits controlling 30V<sub>P-P</sub> signals when operating with ±15V power supplies.

The sixteen switches are bilateral, equally matched for AC or bidirectional signals. The ON-resistance variation with analog signals is quite low over a ±5V analog input range.

Features

- ON-Resistance (Max) .....100Ω
- Low Power Consumption (P<sub>D</sub>) ..... <1.2mW
- Fast Transition Time (Max) ..... 300ns
- Low Charge Injection
- TTL, CMOS Compatible
- Single or Split Supply Operation
- Pb-Free (RoHS Compliant)

Applications

- Battery Operated Systems
- Data Acquisition
- Medical Instrumentation
- Hi-Rel Systems
- Communication Systems
- Automatic Test Equipment

Related Literature

- Technical Brief [TB363](#) "Guidelines for Handling and Processing Moisture Sensitive Surface Mount Devices (SMDs)"

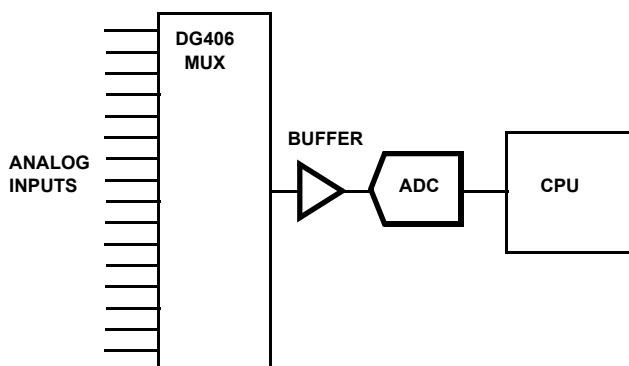


FIGURE 1. TYPICAL APPLICATION

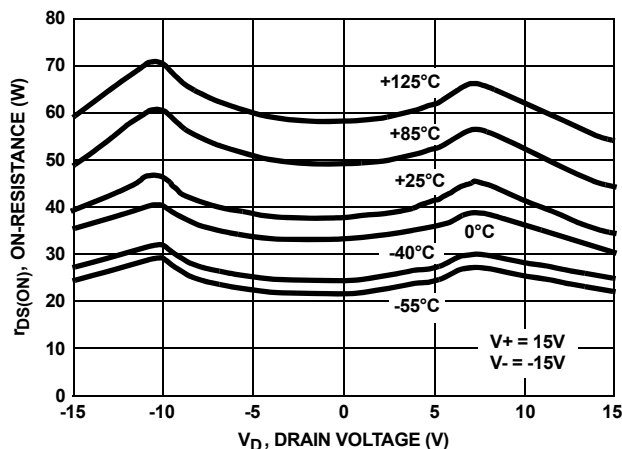
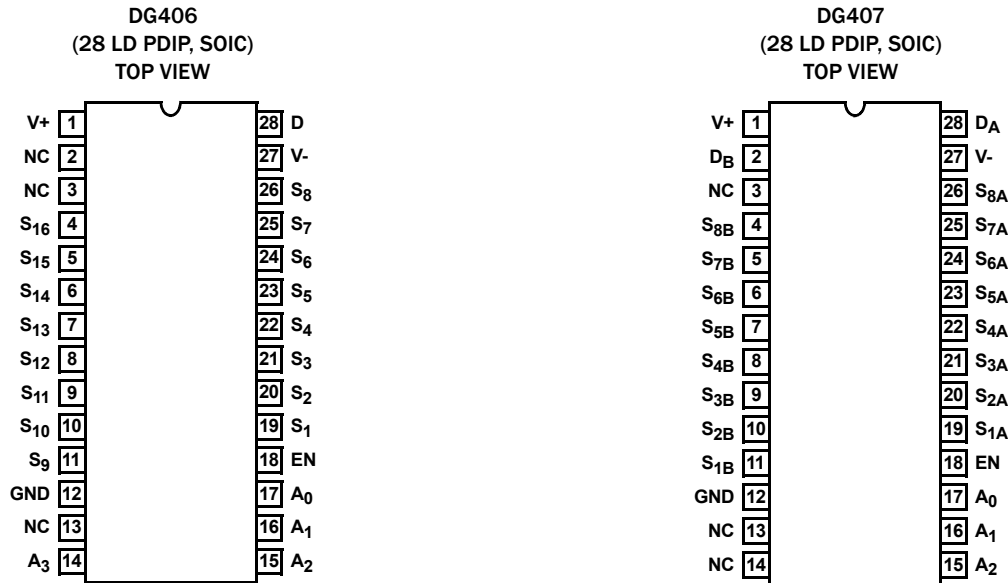


FIGURE 2. ±15V DUAL SUPPLY  $r_{ON}$  CURVES AT VARIOUS TEMPERATURES

## Pin Configurations

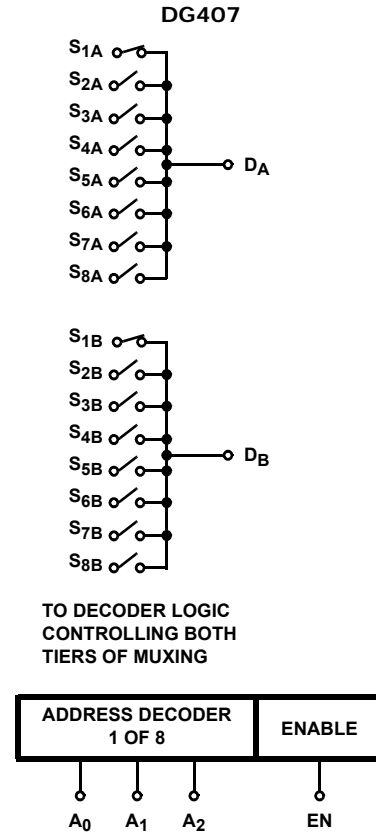
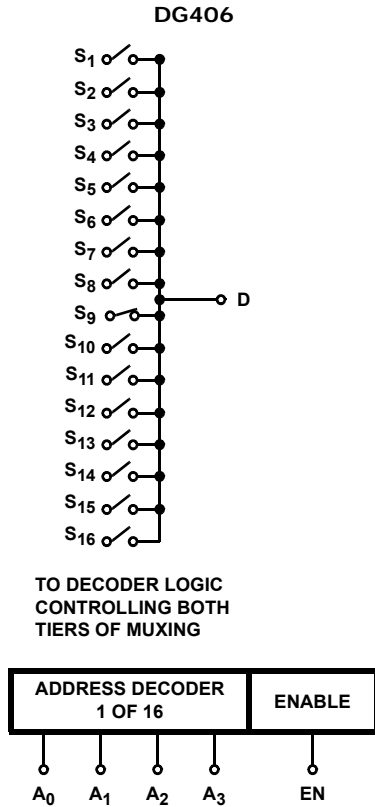


## Pin Description

DG406 (PDIP, SOIC)	DG407 (PDIP, SOIC)	SYMBOL	DESCRIPTION
1	1	V+	Positive Power Supply
2, 3, 13	3, 13, 14,	NC	No Connect- No Internal Connection
4, 5, 6, 7, 8, 9, 10, 11	-	S <sub>16</sub> thru S <sub>9</sub>	Source Switch Terminals (These pins can be an input or output)
12	12	GND	Ground (0V) Reference
14, 15, 16, 17	-	A <sub>3</sub> thru A <sub>0</sub>	Logic Control Inputs
-	15, 16, 17	A <sub>2</sub> thru A <sub>0</sub>	Logic Control Inputs
18	18	EN	Active High Digital Input (When low device is disabled and all switches are turned off. When high the A <sub>x</sub> logic inputs determine which switch is turned on.
19, 20, 21, 22, 23, 24, 25, 26	-	S <sub>1</sub> thru S <sub>8</sub>	Source Switch Terminals (These pins can be an input or output)
27	27	V-	Negative Power Supply (Single supply application this pin will be connected to ground.)
28	-	D	Drain Switch Terminal (This pin can be an input or output)
-	2, 28	D <sub>B</sub> , D <sub>A</sub>	Drain Switch Terminal (This pin can be an input or output)
-	4, 5, 6, 7, 8, 9, 10, 11	S <sub>1B</sub> thru S <sub>8B</sub>	Source Switch Terminals B (These pins can be an input or output)
-	19, 20, 21, 22, 23, 24, 25, 26	S <sub>1A</sub> thru S <sub>8A</sub>	Source Switch Terminals A (These pins can be an input or output)



## Functional Diagrams



## Truth Tables

**TABLE 1. DG406 TRUTH TABLE**

A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>	EN	ON SWITCH
X	X	X	X	0	None
0	0	0	0	1	1
0	0	0	1	1	2
0	0	1	0	1	3
0	0	1	1	1	4
0	1	0	0	1	5
0	1	0	1	1	6
0	1	1	0	1	7
0	1	1	1	1	8
1	0	0	0	1	9
1	0	0	1	1	10
1	0	1	0	1	11
1	0	1	1	1	12
1	1	0	0	1	13
1	1	0	1	1	14
1	1	1	0	1	15
1	1	1	1	1	16

**TABLE 2. DG407 TRUTH TABLE**

A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>	EN	ON SWITCH PAIR
X	X	X	0	None
0	0	0	1	1A, 1B
0	0	1	1	2A, 2B
0	1	0	1	3A, 3B
0	1	1	1	4A, 4B
1	0	0	1	5A, 5B
1	0	1	1	6A, 6B
1	1	0	1	7A, 7B
1	1	1	1	8A, 8B

Logic "0" = V<sub>AL</sub> < 0.8V.  
 Logic "1" = V<sub>AH</sub> > 2.4V.  
 X = Don't Care.

## Absolute Maximum Ratings

V+ to V- .....	44.0V
GND to V- .....	25V
Digital Inputs, V <sub>S</sub> , V <sub>D</sub> (Note 6)	
.....(V-) -2V to (V+) +2V or 20mA,	
Whichever Occurs First	
Continuous Current (Any Terminal) .....	30mA
Peak Current, S or D	
(Pulsed 1ms, 10% Duty Cycle Max) .....	100mA

## Operating Conditions

Temperature Range .....	-40 °C to +85 °C
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CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

### NOTES:

5.  $\theta_{JA}$  is measured with the component mounted on a low effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
6. Signals on S<sub>X</sub>, D<sub>X</sub>, EN or A<sub>X</sub> exceeding V+ or V- are clamped by internal diodes. Limit diode current to maximum current ratings.

## Thermal Information

Thermal Resistance (Typical, Note 5)	$\theta_{JA}$ (°C/W)
PDIP Package* .....	60
SOIC Package .....	75
Maximum Junction Temperature .....	+150 °C
Maximum Storage Temperature Range .....	-65 °C to +150 °C
Pb-Free Reflow Profile .....	see link below
<a href="http://www.intersil.com/pbfree/Pb-FreeReflow.asp">http://www.intersil.com/pbfree/Pb-FreeReflow.asp</a>	
*Pb-free PDIPs can be used for through-hole wave solder processing only.	
They are not intended for use in Reflow solder processing applications.	

**Electrical Specifications** Test Conditions: V+ = +15V, V- = -15V, V<sub>AL</sub> = 0.8V, V<sub>AH</sub> = 2.4V Unless Otherwise Specified. **Bold-face limits apply over the operating temperature range, -40 °C to +85 °C.**

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN (Notes 7, 12)	TYP (Note 8)	MAX (Notes 7, 12)	UNITS	
<b>DYNAMIC CHARACTERISTICS</b>							
Transition Time, t <sub>TRANS</sub>	(See Figure 3)	25	-	200	300	ns	
		Full	-	-	<b>400</b>	ns	
Break-Before-Make Interval, t <sub>OPEN</sub>	(See Figure 5)	25	25	50	-	ns	
		Full	<b>10</b>	-	-	ns	
Enable Turn-ON Time, t <sub>ON(EN)</sub>	(See Figure 4)	25	-	150	200	ns	
		Full	-	-	<b>400</b>	ns	
Enable Turn-OFF Time, t <sub>OFF(EN)</sub>		25	-	70	150	ns	
		Full	-	-	<b>300</b>	ns	
Charge Injection, Q	C <sub>L</sub> = 1nF, V <sub>S</sub> = 0V, R <sub>S</sub> = 0Ω	25	-	40	-	pC	
OFF-Isolation, OIRR	V <sub>EN</sub> = 0V, R <sub>L</sub> = 1kΩ, f = 100kHz (Note 11)	25	-	-69	-	dB	
Logic Input Capacitance, C <sub>IN</sub>	f = 1MHz	25	-	7	-	pF	
Source OFF Capacitance, C <sub>S(OFF)</sub>	V <sub>EN</sub> = 0V, V <sub>S</sub> = 0V, f = 1MHz	25	-	8	-	pF	
Drain OFF Capacitance, C <sub>D(OFF)</sub>	V <sub>EN</sub> = 0V, V <sub>D</sub> = 0V, f = 1MHz	DG406	25	-	160	-	pF
		DG407	25	-	80	-	pF
Drain ON Capacitance, C <sub>D(ON)</sub>	V <sub>EN</sub> = 5V, V <sub>D</sub> = 0V, f = 1MHz	DG406	25	-	180	-	pF
		DG407	25	-	90	-	pF
<b>DIGITAL INPUT CHARACTERISTICS</b>							
Logic High Input Voltage, V <sub>INH</sub>		Full	<b>2.4</b>	-	-	V	
Logic Low Input Voltage, V <sub>INL</sub>		Full	-	-	<b>0.8</b>	V	
Logic High Input Current, I <sub>AH</sub>	V <sub>A</sub> = 2.4V, 15V	Full	<b>-1</b>	-	<b>1</b>	μA	
Logic Low Input Current, I <sub>AL</sub>	V <sub>EN</sub> = 0V, 2.4V, V <sub>A</sub> = 0V	Full	<b>-1</b>	-	<b>1</b>	μA	
<b>ANALOG SWITCH CHARACTERISTICS</b>							
Drain-Source ON-Resistance, r <sub>DS(ON)</sub>	V <sub>D</sub> = ±10V, I <sub>S</sub> = +10mA (Note 9)	25	-	50	100	Ω	
		Full	-	-	<b>125</b>	Ω	
r <sub>DS(ON)</sub> Matching Between Channels, Δr <sub>DS(ON)</sub>	V <sub>D</sub> = 10V, -10V (Note 10)	25	-	5	-	%	

**Electrical Specifications** Test Conditions:  $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_{AL} = 0.8V$ ,  $V_{AH} = 2.4V$  Unless Otherwise Specified. **Bold-face limits apply over the operating temperature range, -40 °C to +85 °C. (Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN (Notes 7, 12)	TYP (Note 8)	MAX (Notes 7, 12)	UNITS
Source OFF Leakage Current, $I_{S(OFF)}$	$V_{EN} = 0V$ , $V_S = \pm 10V$ , $V_D = \mp 10V$	25	-0.5	0.01	0.5	nA
		Full	<b>-5</b>	-	<b>5</b>	nA
Drain OFF Leakage Current, $I_{D(OFF)}$ DG406		25	-1	0.04	1	nA
		Full	<b>-40</b>	-	<b>40</b>	nA
		25	-1	0.04	1	nA
		Full	<b>-20</b>	-	<b>20</b>	nA
Drain ON Leakage Current, $I_{D(ON)}$ DG406	$V_S = V_D = \pm 10V$ (Note 9)	25	-1	0.04	1	nA
		Full	<b>-40</b>	-	<b>40</b>	nA
		25	-1	0.04	1	nA
		Full	<b>-20</b>	-	<b>20</b>	nA
<b>POWER SUPPLY CHARACTERISTICS</b>						
Positive Supply Current, I+	$V_{EN} = V_A = 0V$ or 5V (Standby)	25	-	13	30	$\mu A$
		Full	-	-	<b>75</b>	$\mu A$
Negative Supply Current, I-		25	-1	-0.01	-	$\mu A$
		Full	<b>-10</b>	-	-	$\mu A$
Positive Supply Current, I+	$V_{EN} = 2.4V$ , $V_A = 0V$ (Enabled)	25	-	80	100	$\mu A$
		Full	-	-	<b>200</b>	$\mu A$
Negative Supply Current, I-		25	-1	-0.01	-	$\mu A$
		Full	<b>-10</b>	-	-	$\mu A$

**Electrical Specifications** MSingle Supply Test Conditions:  $V_+ = 12V$ ,  $V_- = 0V$ ,  $V_{AL} = 0.8V$ ,  $V_{AH} = 2.4V$ , Unless Otherwise Specified.

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN (Notes 7, 12)	TYP (Note 8)	MAX (Notes 7, 12)	UNITS
<b>DYNAMIC CHARACTERISTICS</b>						
Switching Time of Multiplexer, $t_{TRANS}$	$V_{S1} = 8V$ , $V_{S8} = 0V$ , $V_{IN} = 2.4V$	25	-	300	450	ns
Enable Turn-ON Time, $t_{ON(EN)}$	$V_{INH} = 2.4V$ , $V_{INL} = 0V$ , $V_{S1} = 5V$	25	-	250	600	ns
Enable Turn-OFF Time, $t_{OFF(EN)}$		25	-	150	300	ns
Charge Injection, Q	$C_L = 1nF$ , $V_S = 6V$ , $R_S = 0\Omega$	25	-	20	-	pC
<b>ANALOG SWITCH CHARACTERISTICS</b>						
Analog Signal Range, $V_{ANALOG}$		Full	<b>0</b>	-	<b>12</b>	V
Drain-Source ON-Resistance, $r_{DS(ON)}$	$V_D = 3V$ , 10V, $I_S = -1mA$ (Note 9)	25	-	90	120	$\Omega$
$r_{DS(ON)}$ Matching Between Channels (Note 6), $\Delta r_{DS(ON)}$		25	-	5	-	%
Source Off Leakage Current, $I_{S(OFF)}$	$V_{EN} = 0V$ , $V_D = 10V$ or 0.5V, $V_S = 0.5V$ or 10V	25	-	0.01	-	nA
Drain Off Leakage Current, $I_{D(OFF)}$ DG406		25	-	0.04	-	nA
DG407		25	-	0.04	-	nA

**Electrical Specifications** Single Supply Test Conditions:  $V_+ = 12V$ ,  $V_- = 0V$ ,  $V_{AL} = 0.8V$ ,  $V_{AH} = 2.4V$ , Unless Otherwise Specified. (Continued)

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN (Notes 7, 12)	TYP (Note 8)	MAX (Notes 7, 12)	UNITS
Drain On Leakage Current, $I_{D(ON)}$	$V_S = V_D = \pm 10V$ (Note 9)	25	-	0.04	-	nA
		25	-	0.04	-	nA
<b>POWER SUPPLY CHARACTERISTICS</b>						
Positive Supply Current ( $I_+$ ) (Standby)	$V_{EN} = 0V$ or $5V$ , $V_A = 0V$ or $5V$	25	-	13	30	$\mu A$
		Full	-	13	75	$\mu A$
Negative Supply Current ( $I_-$ ) (Enabled)		25	-1	-0.01	-	$\mu A$
		Full	-5	-0.01	-	$\mu A$

NOTES:

- The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- Typical values are for design only and are not production tested.
- Sequence each switch ON.
- $\Delta r_{DS(ON)} = (r_{DS(ON)}(Max) - r_{DS(ON)}(Min)) \div r_{DS(ON)} \text{ average}$ .
- Worst case isolation occurs on channel 8B due to proximity to the drain pin.
- Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

**Test Circuits and Waveforms**

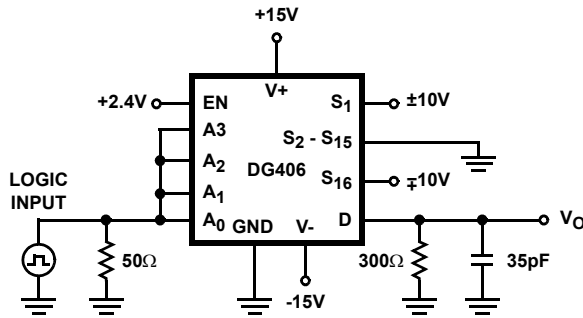


FIGURE 3A. DG406 TEST CIRCUIT

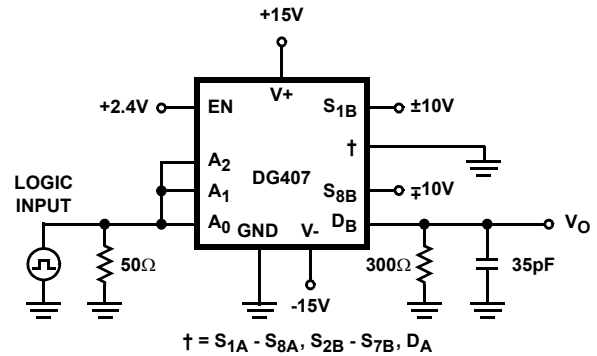


FIGURE 3B. DG407 TEST CIRCUIT

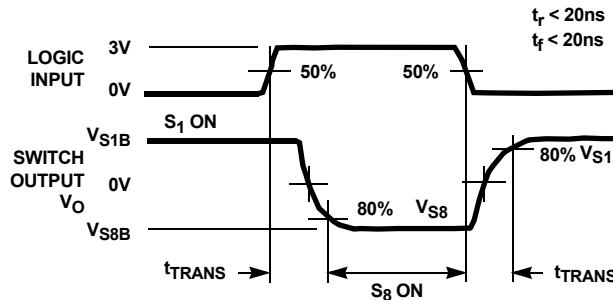


FIGURE 3C. MEASUREMENT POINTS  
FIGURE 3. TRANSITION TIME

## Test Circuits and Waveforms (Continued)

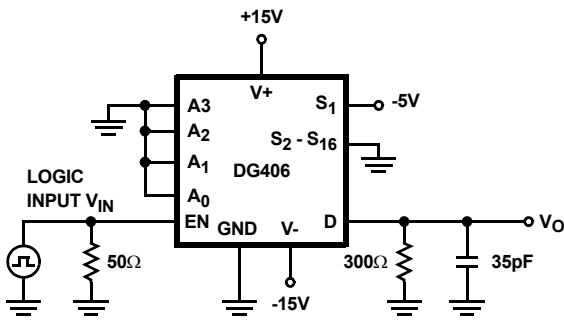


FIGURE 4A. DG406 TEST CIRCUIT

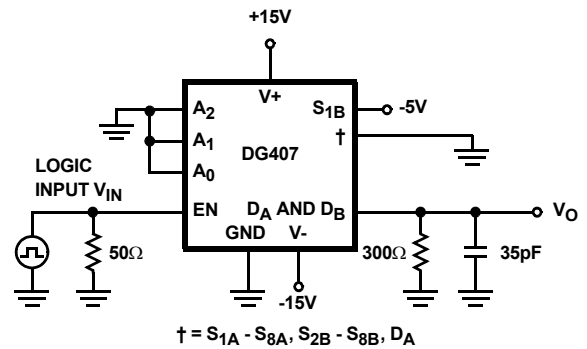


FIGURE 4B. DG407 TEST CIRCUIT

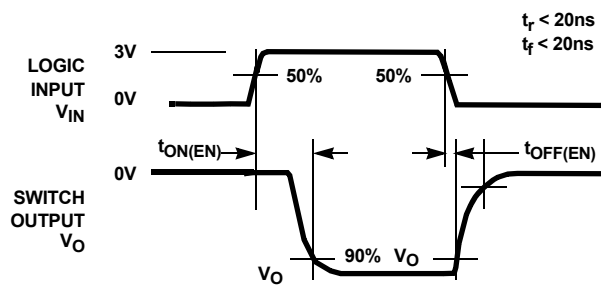


FIGURE 4C. MEASUREMENT POINTS  
FIGURE 4. ENABLE SWITCHING TIMES

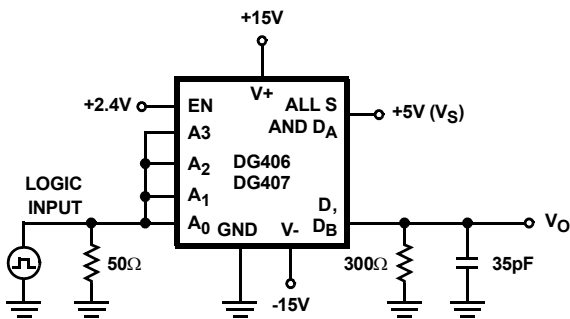


FIGURE 5A. TEST CIRCUIT

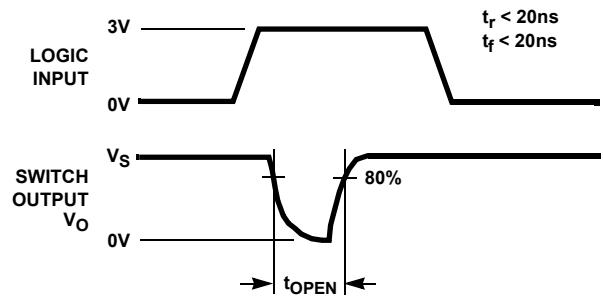


FIGURE 5B. MEASUREMENT POINTS

FIGURE 5. BREAK-BEFORE-MAKE INTERVAL



# Typical Performance Curves

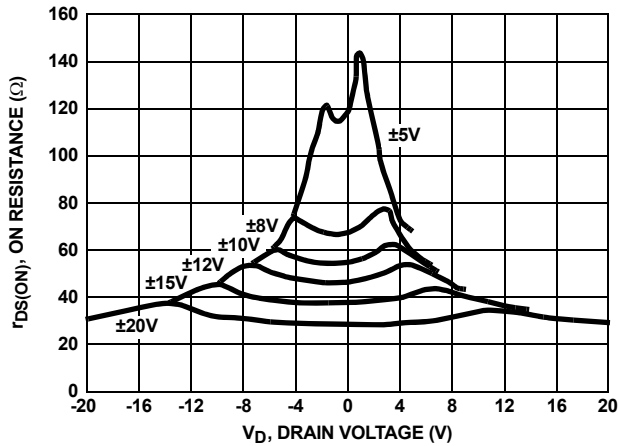


FIGURE 6.  $r_{DS(ON)}$  vs  $V_D$  AND SUPPLY

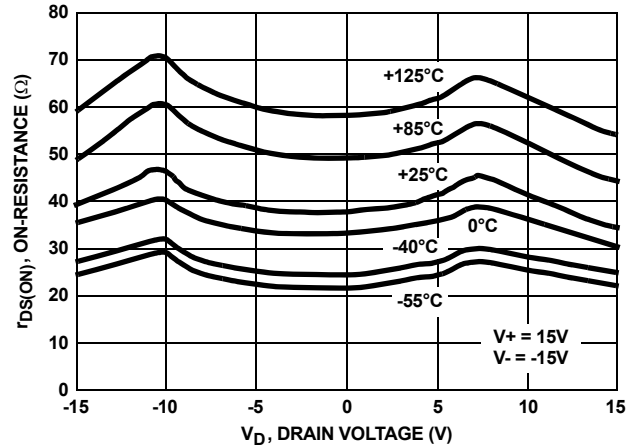


FIGURE 7.  $r_{DS(ON)}$  vs  $V_D$  AND TEMPERATURE

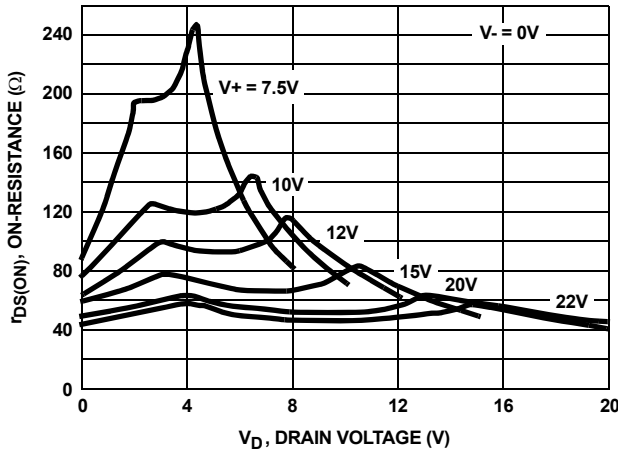


FIGURE 8.  $r_{DS(ON)}$  vs  $V_D$  AND SUPPLY

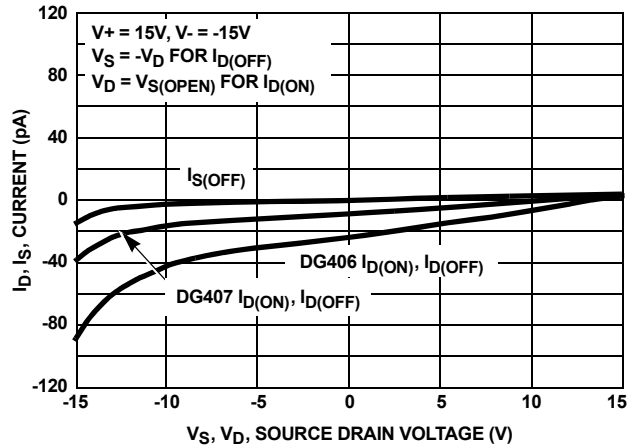


FIGURE 9.  $I_D$ ,  $I_S$  LEAKAGE CURRENTS vs ANALOG VOLTAGE

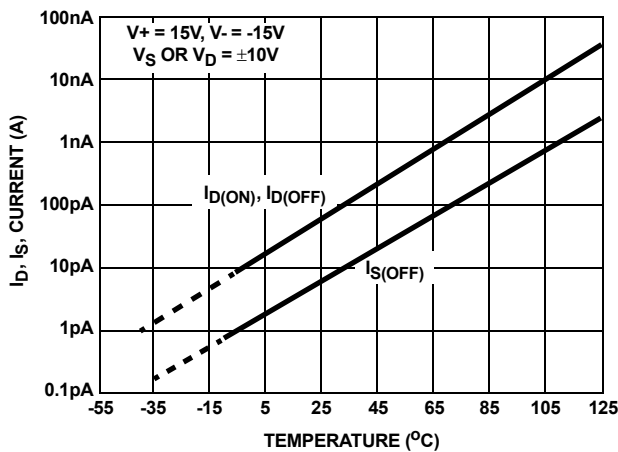


FIGURE 10.  $I_D$ ,  $I_S$  LEAKAGE vs TEMPERATURE

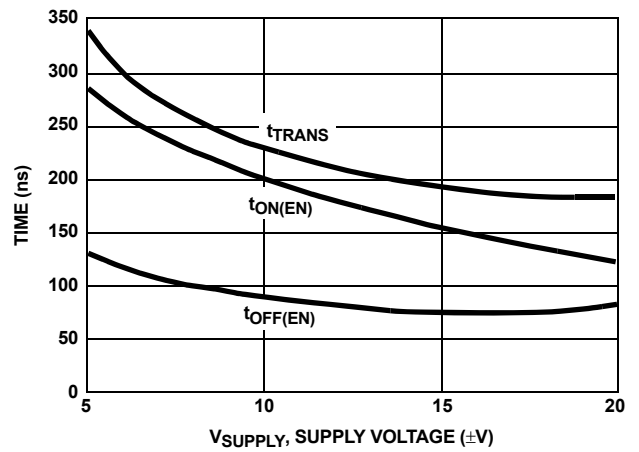


FIGURE 11. SWITCHING TIMES vs BIPOLAR SUPPLIES

## Typical Performance Curves (Continued)

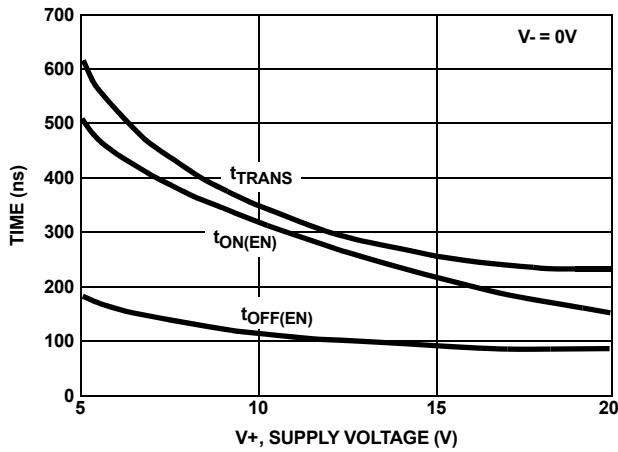


FIGURE 12. SWITCHING TIMES vs SINGLE SUPPLY

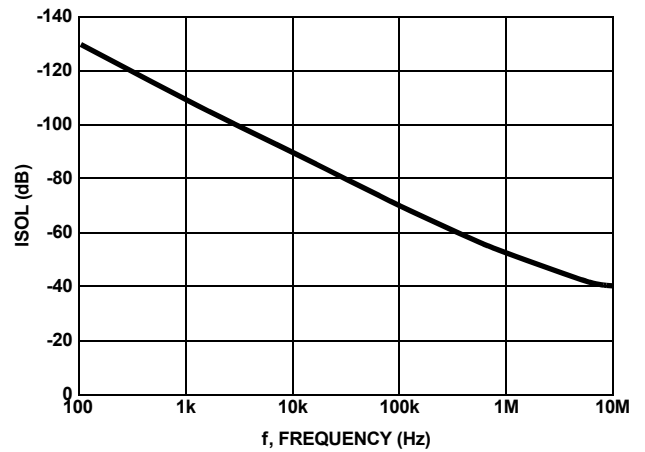


FIGURE 13. OFF-ISOLATION vs FREQUENCY

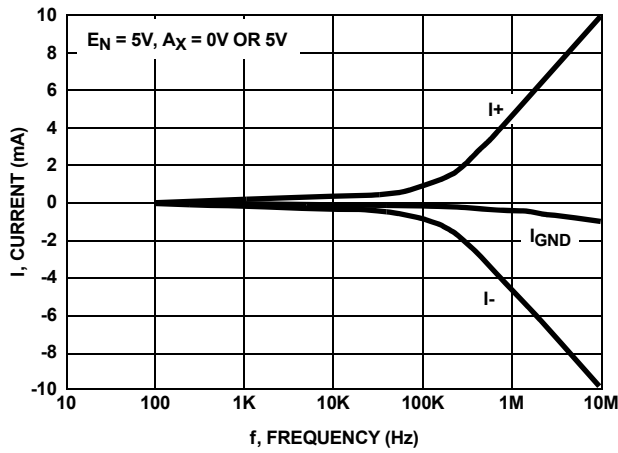


FIGURE 14. SUPPLY CURRENTS vs SWITCHING FREQUENCY

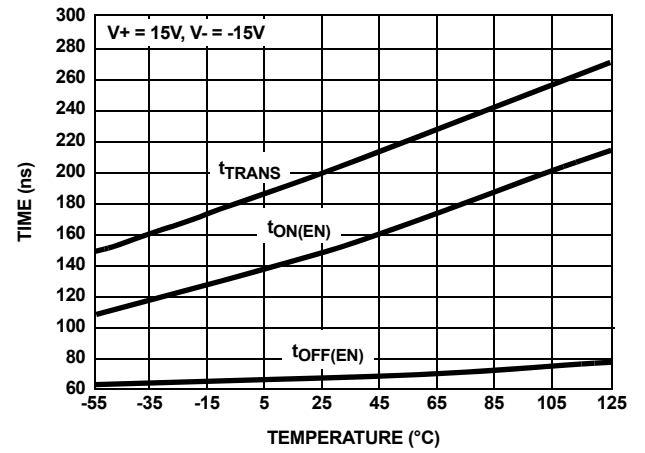


FIGURE 15.  $t_{ON}/t_{OFF}$  vs TEMPERATURE

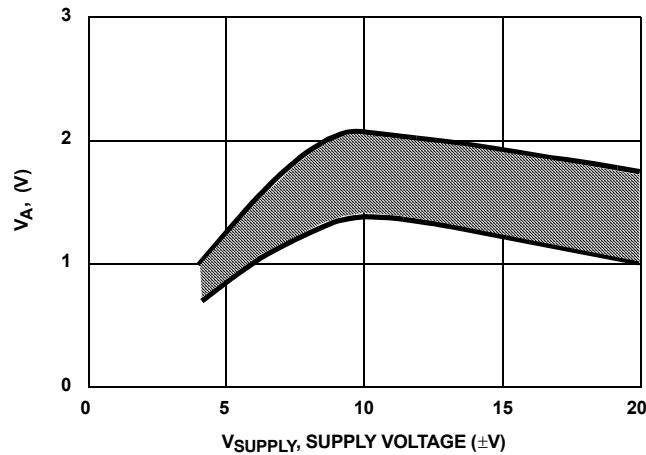


FIGURE 16. SWITCHING THRESHOLD vs SUPPLY VOLTAGE

## Die Characteristics

### DIE DIMENSIONS:

2490µm x 4560µm x 485µm

### METALLIZATION:

Type: SiAl

Thickness: 12kÅ ±1kÅ

### PASSIVATION:

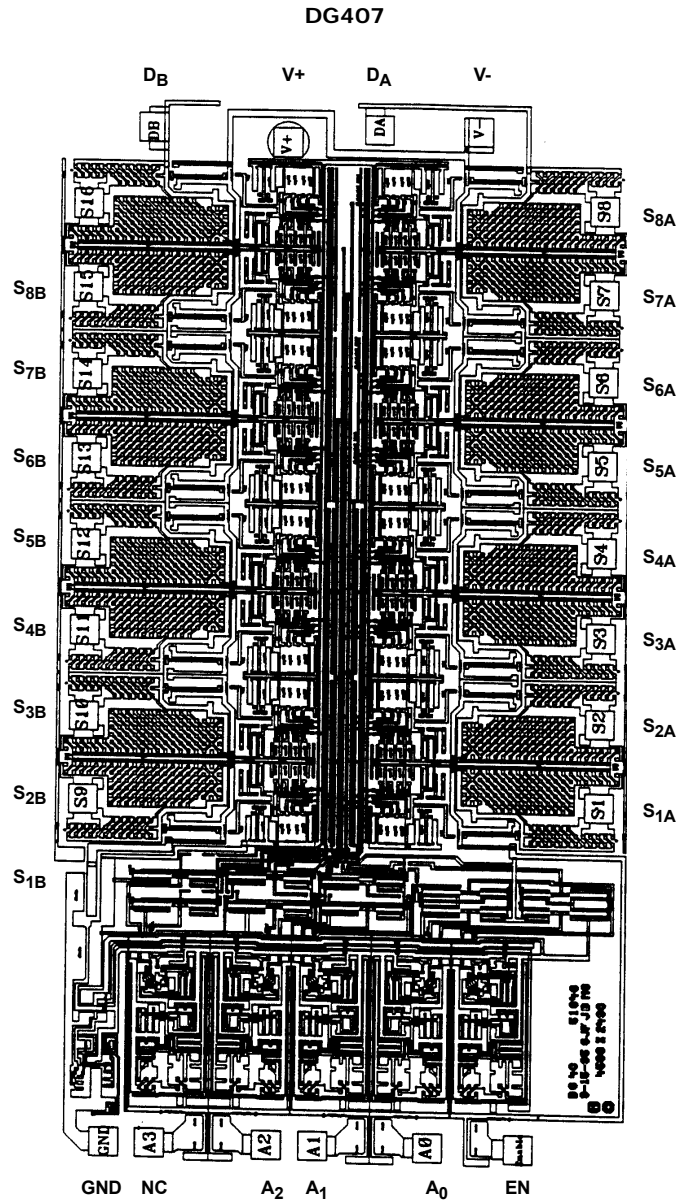
Type: Nitride

Thickness: 8kÅ ±1kÅ

### WORST CASE CURRENT DENSITY:

$9.1 \times 10^4 \text{ A/cm}^2$

## Metallization Mask Layout



## Die Characteristics

### DIE DIMENSIONS:

2490μm x 4560μm x 485μm

### METALLIZATION:

Type: SiAl

Thickness: 12kÅ ±1kÅ

### PASSIVATION:

Type: Nitride

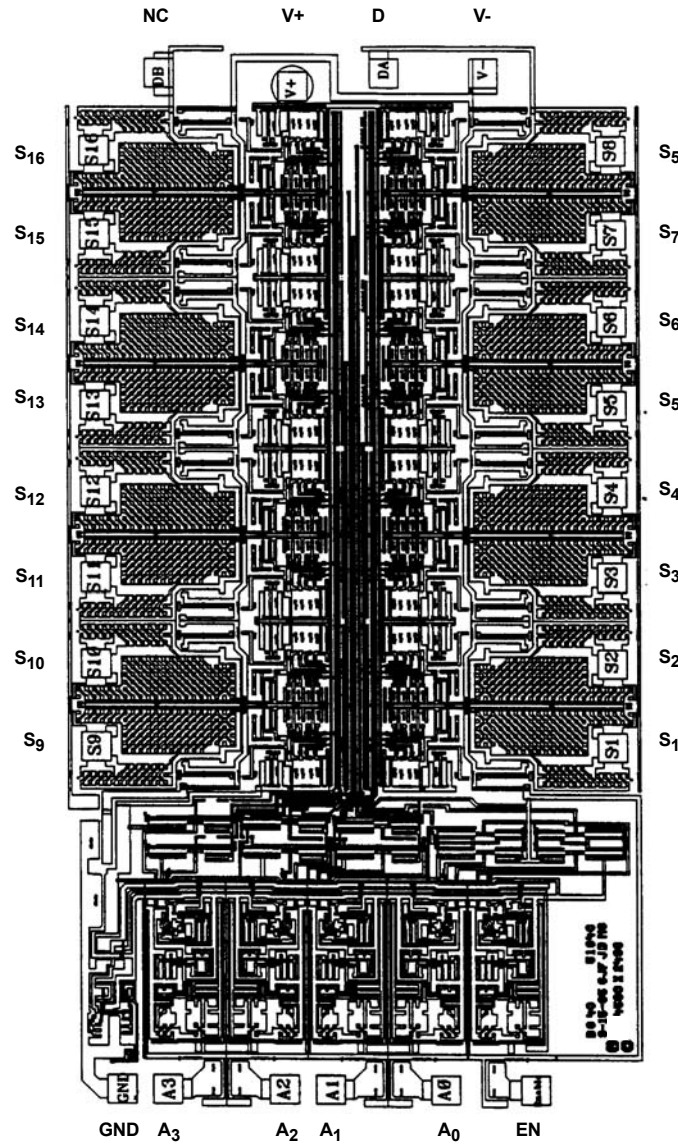
Thickness: 8kÅ ±1kÅ

### WORST CASE CURRENT DENSITY:

$9.1 \times 10^4 \text{ A/cm}^2$

## Metallization Mask Layout

DG406



## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest Rev.

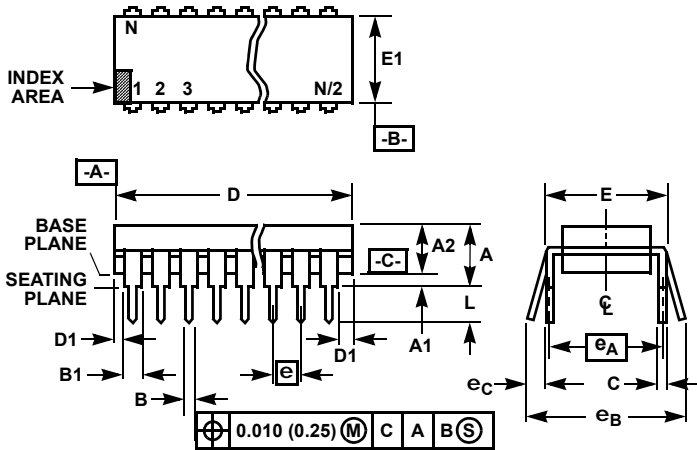
DATE	REVISION	CHANGE
October 1, 2013	FN3116.11	Converted to new Intersil template. Removed obsolete parts from ordering information as follows: DG406DJ DG406DY DG406DY-T DG407DY DG407DJ Added P/N DG407DYZ-T to Ordering Information table.
March 13, 2006	FN3116.9	Redline Release parts added to ordering information.
September 17, 2004	FN3116.8	Pb-free parts added.
August 1, 2000	FN3116.6	Initial Release to web.

## About Intersil

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**Dual-In-Line Plastic Packages (PDIP)**



**NOTES:**

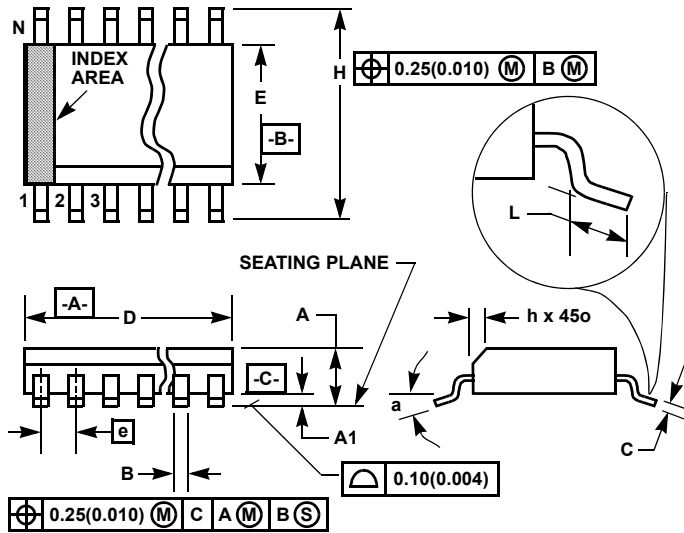
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and  $e_A$  are measured with the leads constrained to be perpendicular to datum  $-C-$ .
7.  $e_B$  and  $e_C$  are measured at the lead tips with the leads unconstrained.  $e_C$  must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

**E28.6 (JEDEC MS-011-AB ISSUE B)  
28 LEAD DUAL-IN-LINE PLASTIC PACKAGE**

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.250	-	6.35	4
A1	0.015	-	0.39	-	4
A2	0.125	0.195	3.18	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.030	0.070	0.77	1.77	8
C	0.008	0.015	0.204	0.381	-
D	1.380	1.565	35.1	39.7	5
D1	0.005	-	0.13	-	5
E	0.600	0.625	15.24	15.87	6
E1	0.485	0.580	12.32	14.73	5
e	0.100 BSC		2.54 BSC		-
$e_A$	0.600 BSC		15.24 BSC		6
$e_B$	-	0.700	-	17.78	7
L	0.115	0.200	2.93	5.08	4
N	28		28		9

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### Small Outline Plastic Packages (SOIC)



**M28.3 (JEDEC MS-013-AE ISSUE C)**  
**28 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE**

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.0200	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.6969	0.7125	17.70	18.10	3
E	0.2914	0.2992	7.40	7.60	4
e	0.05 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.01	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	28		28		7
$\alpha$	0°	8°	0°	8°	-

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NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch)
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

TYPICAL RECOMMENDED LAND PATTERN



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