TC4404/TC4405

1.5A Dual Open-Drain MOSFET Drivers

Features

- Independently Programmable Rise and Fall Times
- Low Output Impedance: 7Ω Typical
- High Speed t_R, t_F: <30 ns with 1000 pF Load
- Short Delay Times: <30 ns
- Wide Operating Range: 4.5V to 18V
- Latch-Up Protected: withstands > 500 mA Reverse Current (Either Polarity)
- Input Withstands Negative Swings up to -5V

Applications

- Motor Controls
- Driving Bipolar Transistors
- Driver for Non-Overlapping Totem Poles
- Reach-Up/Reach-Down Driver

TABLE 1: DEVICE SELECTION TABLE

Part Number	Package	Temp. Range
TC4404COA	8-Lead SOIC	0°C to +70°C
TC4404CPA	8-Lead PDIP	0°C to +70°C
TC4404EOA	8-Lead SOIC	-40°C to +85°C
TC4404EPA	8-Lead PDIP	-40°C to +85°C
TC4405COA	8-Lead SOIC	0°C to +70°C
TC4405CPA	8-Lead PDIP	0°C to +70°C
TC4405EOA	8-Lead SOIC	-40°C to +85°C
TC4405EPA	8-Lead PDIP	-40°C to +85°C

General Description

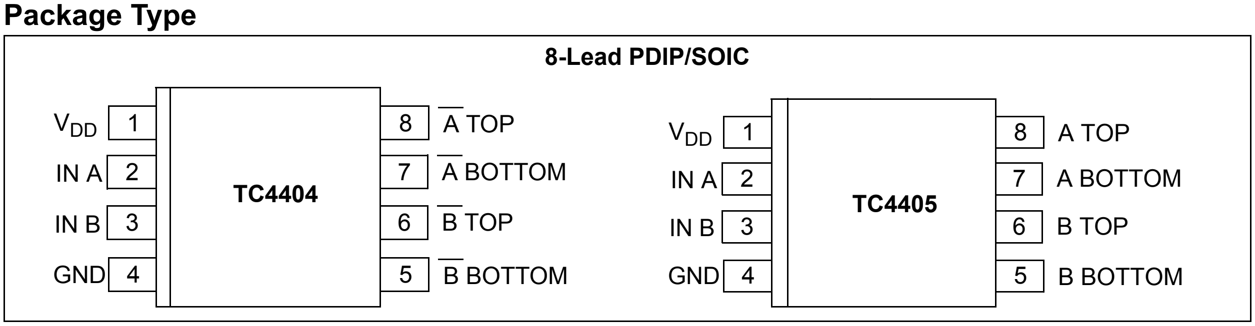
The TC4404/TC4405 are CMOS buffer-drivers constructed with complementary MOS outputs, where the drains of the totem-pole output have been left separated so that individual connections can be made to the pull-up and pull-down sections of the output. This allows the insertion of drain-current-limiting resistors in the pull-up and/or pull-down sections, allowing the user to define the rates of rise and fall for a capacitive load. It also enables a reduced output swing, if driving a resistive load, or limiting base current when driving a bipolar transistor. Minimum rise and fall times, with no resistors, will be less than 30 ns for a 1000 pF load.

For driving MOSFETs in motor-control applications, where slow-ON/fast-OFF operation is desired, these devices are superior to the previously used technique of adding a diode-resistor combination between the driver output and the MOSFET, because they allow accurate control of turn-on, while maintaining fast turn-off and maximum noise immunity for an OFF device.

When used to drive bipolar transistors, these drivers maintain the high speeds common to other Microchip drivers. They allow insertion of a base current-limiting resistor, while providing a separate half-output for fast turn-off. By proper positioning of the resistor, either NPN or PNP transistors can be driven.

For driving many loads in low-power regimes, these drivers require significantly less power at higher frequencies and can be helpful in meeting low-power budgets as they eliminate shoot-through currents in the output stage.

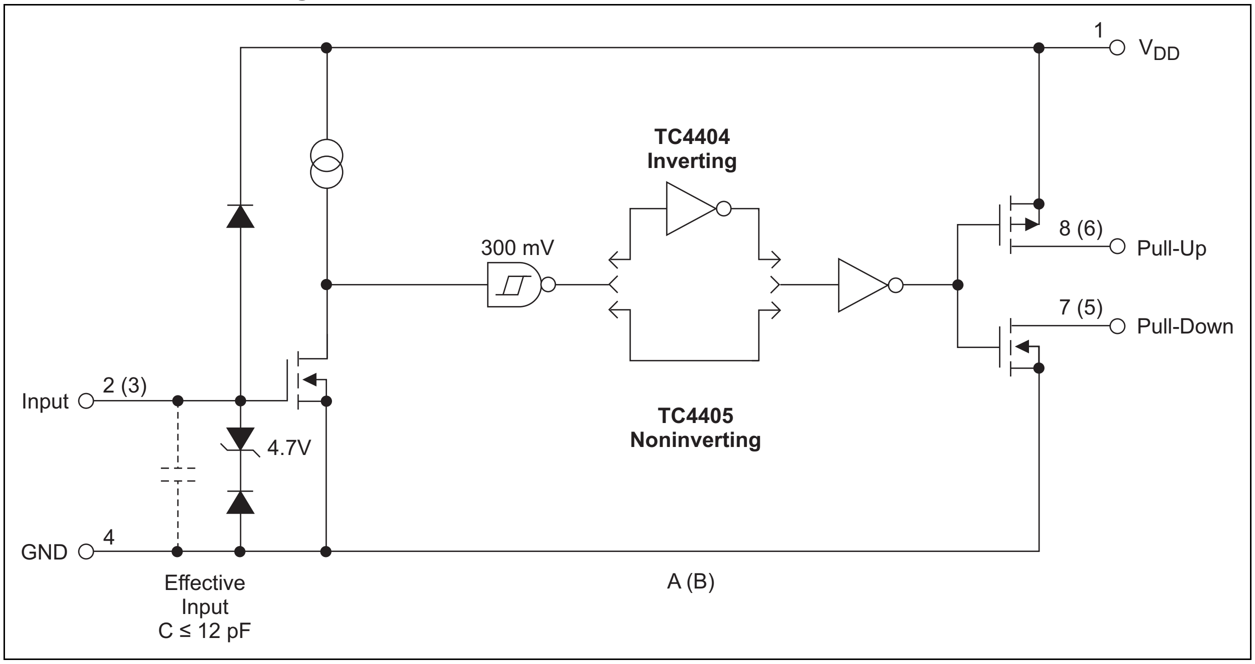
Package Type



Because neither drain in an output is dependent on the other, these devices can also be used as open-drain buffer/drivers where both drains are available in one device, thus minimizing chip count. Unused open drains should be returned to the supply rail so that their device sources are connected (pull-downs to ground, pull-ups to V_{DD}), to prevent static damage. In addition, in situations where timing resistors or other means of limiting crossover currents are used, like drains from drivers A and B, they may be paralleled for greater current carrying capacity.

These devices are built to operate in the most demanding electrical environments. They will not latch-up under any conditions within their power and voltage ratings; they are not subject to damage when up to 5V of noise spiking of either polarity occurs on their ground pin; and they can accept, without damage or logic upset, up to 0.5A of reverse current (of either polarity) being forced back into their outputs. All terminals are fully protected against up to 2 kV (HBM) of electrostatic discharge.

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage ....+22V
Power Dissipation ($T_A \leq +70°C$)
PDIP ....730 mW
SOIC ....470 mW
Operating Temperature Range
C Version .... 0°C to +70°C
E Version.....................................-40°C to +85°C
Storage Temperature Range..............-65°C to +150°C

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Characteristics: Unless otherwise specified, all limits apply for typical values at ambient temperature T_A = +25°C, with 4.5V ≤ VDD ≤ 18V.

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Input						
Logic 1, High Input Voltage	V_{IH}	2.4	—	—	V	
Logic 0, Low Input Voltage	V_{IL}	—	—	0.8	V	
Input Current	I_{IN}	–1	—	1	µA	$0V \leq V_{IN} \leq V_{DD}$
Output						
High Output Voltage	V_{OH}	V_{DD} – 0.025	—	—	V	
Low Output Voltage	V_{OL}	—	—	0.025	V	
Output Resistance	R_O	—	7	10	Ω	I_{OUT} = 10 mA, V_{DD} = 18V; any drain
Peak Output Current (Any Drain)	I_{PK}	—	1.5	—	A	Duty cycle ≤ 2%, t ≤ 300 µsec
Continuous Output Current (Any Drain)	I_{DC}	—	—	100	mA	
Latch-Up Protection (Any Drain) Withstand Reverse Current	I_R	—	> 500	—	mA	Duty cycle ≤ 2%, t ≤ 300 µsec
Switching Time (Note 1)						
Rise Time	t_R	—	25	30	ns	Figure 4-1, C_L = 1000 pF
Fall Time	t_F	—	25	30	ns	Figure 4-1, C_L = 1000 pF
Delay Time	t_{D1}	—	15	30	ns	Figure 4-1, C_L = 1000 pF
Delay Time	t_{D2}	—	32	50	ns	Figure 4-1, C_L = 1000 pF
Power Supply						
Power Supply Current	I_S	— —	— —	4.5 0.4	mA	V_{IN} = 3V (both inputs) V_{IN} = 0V (both inputs)

Note 1: Switching times ensured by design.

DC CHARACTERISTICS (OVER OPERATING TEMPERATURE RANGE)

Electrical Characteristics: Unless otherwise indicated, operating temperature range with $4.5V \le V_{DD} \le 18V$.

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Logic 1, High Input Voltage	V_{IH}	2.4	—	—	V	
Logic 0, Low Input Voltage	V_{IL}	—	—	0.8	V	
Input Current	I_{IN}	–10	—	10	µA	$0V \le V_{IN} \le V_{DD}$
Output						
High Output Voltage	V_{OH}	V_{DD} – 0.025	—	—	V	
Low Output Voltage	V_{OL}	—	—	0.025	V	
Output Resistance	R_O	—	9	12	Ω	I_{OUT} = 10 mA, V_{DD} = 18V; any drain
Peak Output Current (Any Drain)	I_{PK}	—	1.5	—	A	Duty cycle ≤ 2%, t ≤ 300 µsec
Continuous Output Current (Any Drain)	I_{DC}	—	—	100	mA	
Latch-Up Protection (Any Drain) Withstand Reverse Current	I_R	—	> 500	—	mA	Duty cycle ≤ 2%, t ≤ 300 µsec
Switching Time (Note 1)						
Rise Time	t_R	—	—	40	ns	Figure 4-1, C_L = 1000 pF
Fall Time	t_F	—	—	40	ns	Figure 4-1, C_L = 1000 pF
Delay Time	t_{D1}	—	—	40	ns	Figure 4-1, C_L = 1000 pF
Delay Time	t_{D2}	—	—	60	ns	Figure 4-1, C_L = 1000 pF
Power Supply						
Power Supply Current	I_S	— —	— —	8 0.6	mA	V_{IN} = 3V (both inputs) V_{IN} = 0V (both inputs)

Note 1: Switching times ensured by design.

TEMPERATURE SPECIFICATIONS

Electrical Specifications: Unless otherwise noted, all parameters apply with $4.5V \le V_{DD} \le 18V$.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Temperature Range, C Version	T_A	0	—	+70	°C	
Operating Temperature Range, E Version	T_A	-40	—	+85	°C	
Storage Temperature Range	T_A	-65	—	+150	°C	
Package Thermal Resistances						
Thermal Resistance, 8-Lead PDIP	θ_{JA}	—	+94	—	°C/W	
Thermal Resistance, 8-Lead PDIP	θ_{JC}	—	+45	—	°C/W	
Thermal Resistance, 8-Lead SOIC	θ_{JA}	—	+163	—	°C/W	
Thermal Resistance, 8-Lead SOIC	θ_{JC}	—	+42	—	°C/W	

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

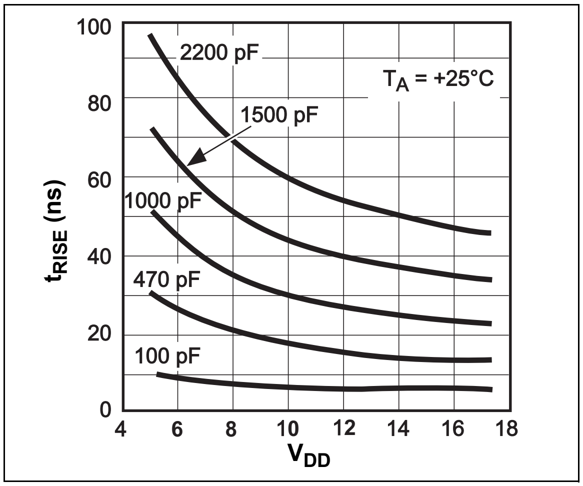


FIGURE 2-1: *Rise Time vs. Supply Voltage.*

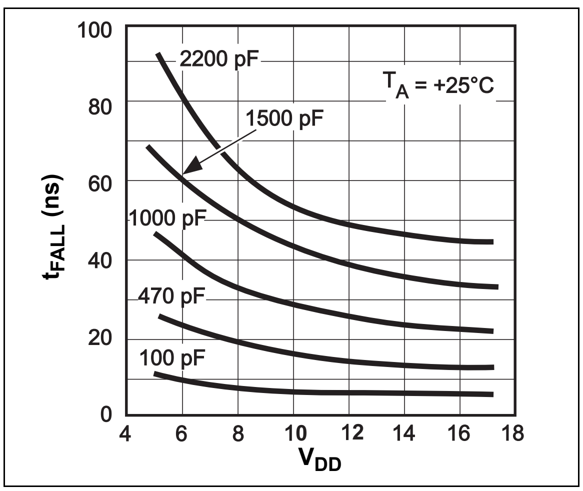


FIGURE 2-2: *Fall Time vs. Supply Voltage.*

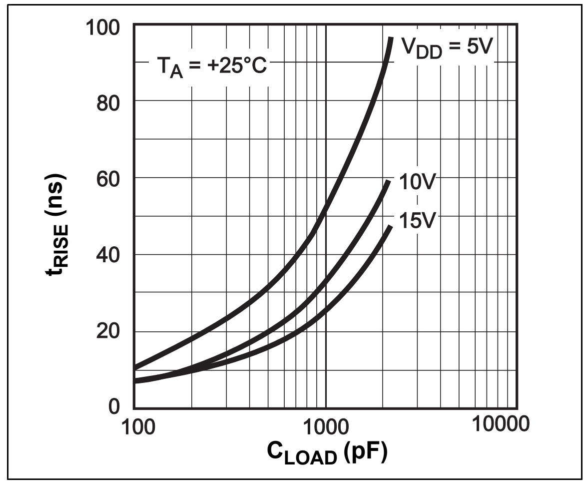


FIGURE 2-3: *Rise Time vs. Capacitive Load.*

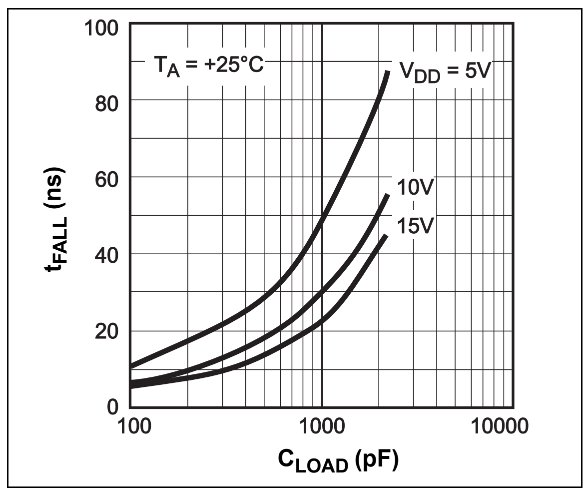


FIGURE 2-4: *Fall Time vs. Capacitive Load.*

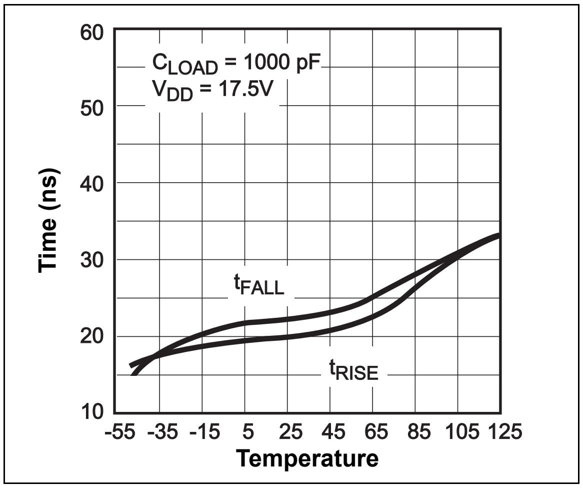


FIGURE 2-5: *Rise and Fall Times vs. Temperature.*

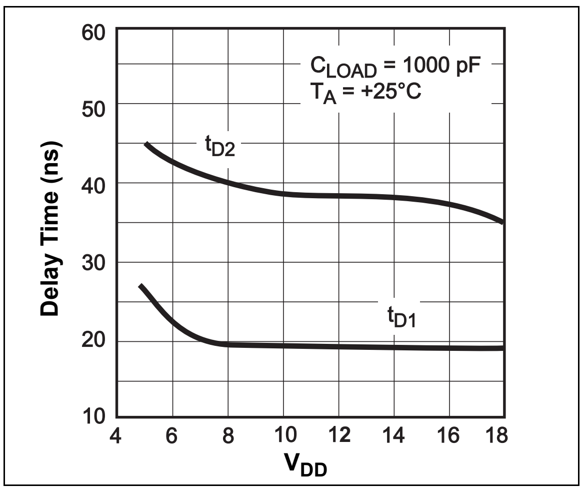


FIGURE 2-6: *Propagation Delay vs. Supply Voltage.*

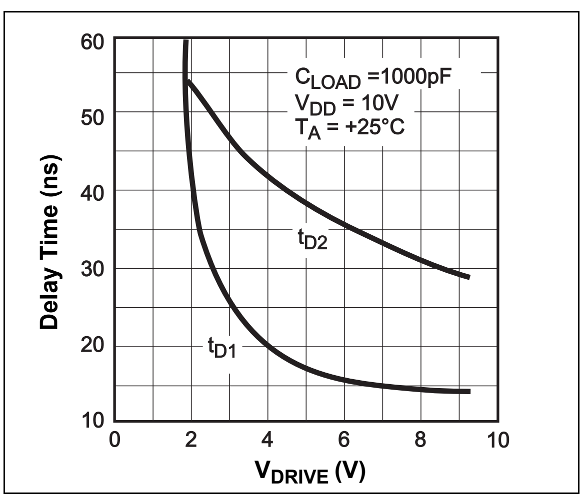


FIGURE 2-7: *Effect of Input Amplitude on Delay Time.*

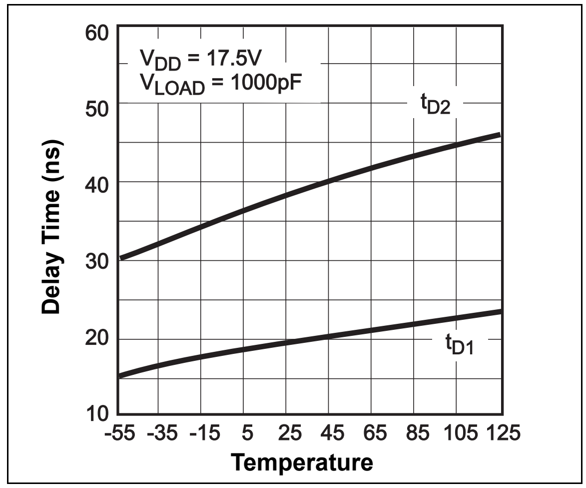


FIGURE 2-8: *Propagation Delay Time vs. Temperature.*

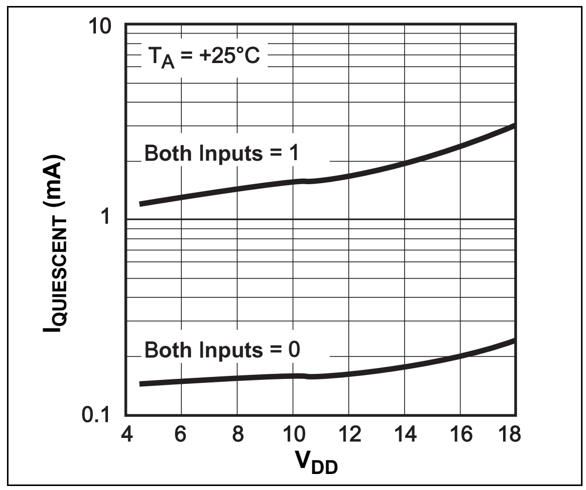


FIGURE 2-9: *Quiescent Supply Current vs. Voltage.*

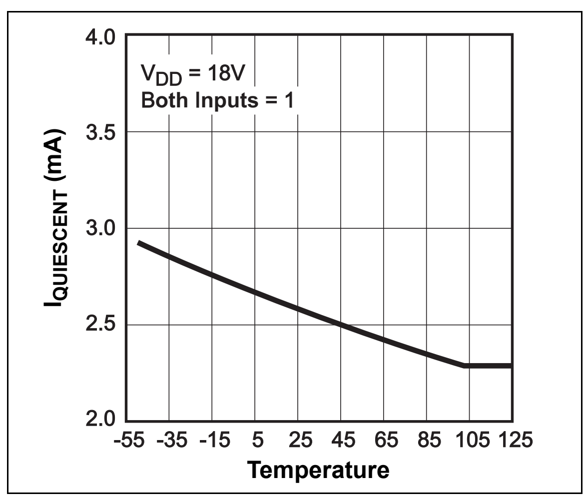


FIGURE 2-10: *Quiescent Supply Current vs. Temperature.*

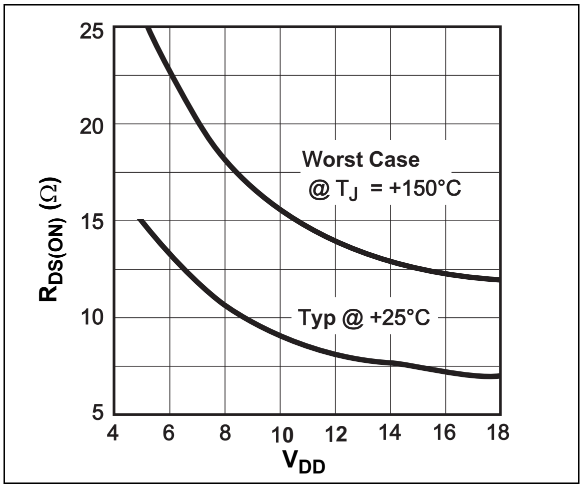


FIGURE 2-11: *Pull-Up Output Resistance.*

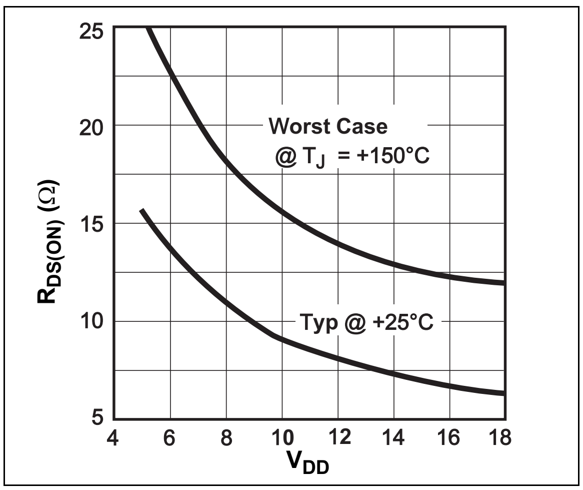


FIGURE 2-12: *Pull-Down Output Resistance.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

8-Lead PDIP/SOIC	Symbol	Description
1	V_{DD}	Supply Input, 4.5V to 18V
2	IN A	Control Input A, TTL/CMOS compatible input
3	IN B	Control Input B, TTL/CMOS compatible input
4	GND	Ground
5	B BOTTOM	Output B, pull-down
6	B TOP	Output B, pull-up
7	A BOTTOM	Output A, pull-down
8	A TOP	Output A, pull-up

4.0 APPLICATIONS INFORMATION

4.1 Circuit Layout Guidelines

Long power supply and ground traces should be avoided as the added inductance causes unwanted voltage transients. Power and ground planes should be used wherever possible.

In addition, it is advisable that low ESR (Equivalent Series Resistance) bypass capacitors (4.7 µF or 10 µF tantalum) be placed as close to the driver as possible. In order to minimize the length of the output trace, the driver should be physically located as close as possible to the device it is driving.

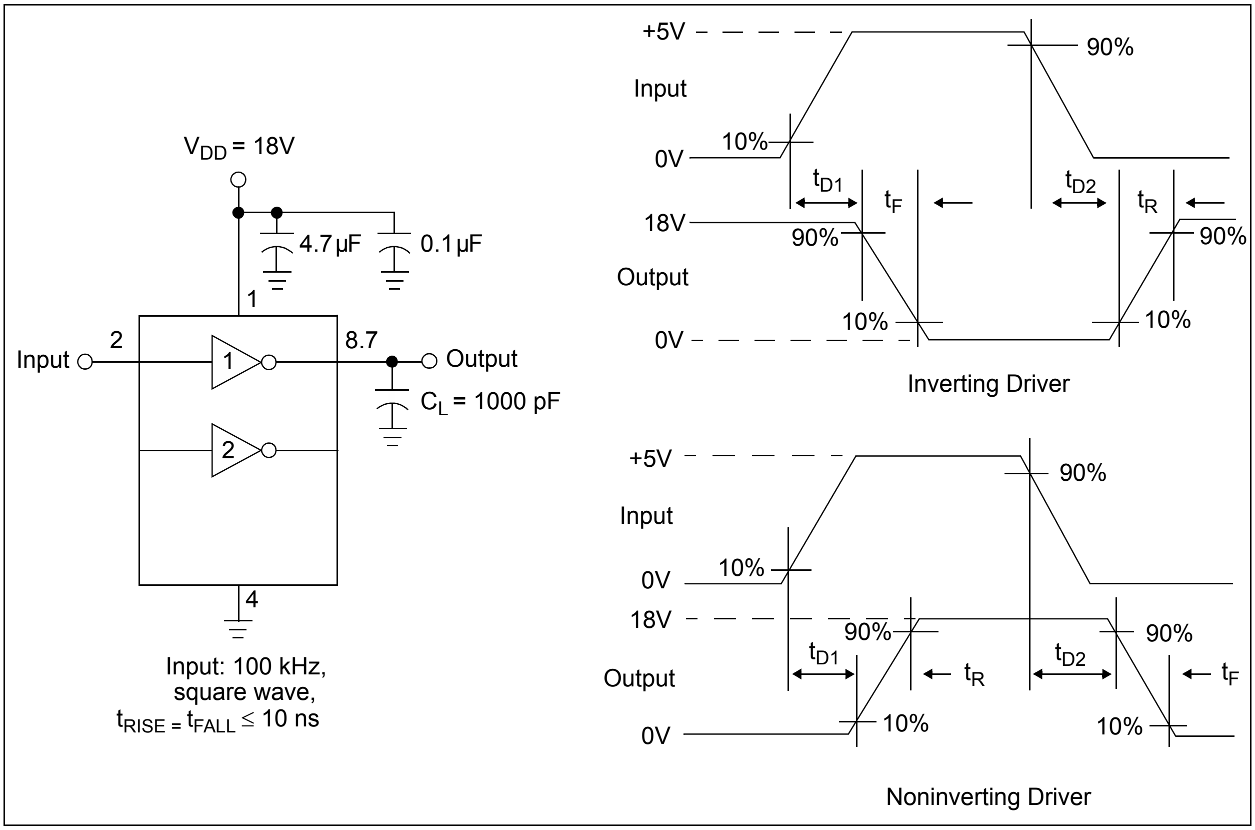


FIGURE 4-1: Switching Time Test Circuit.

4.2 Typical Applications

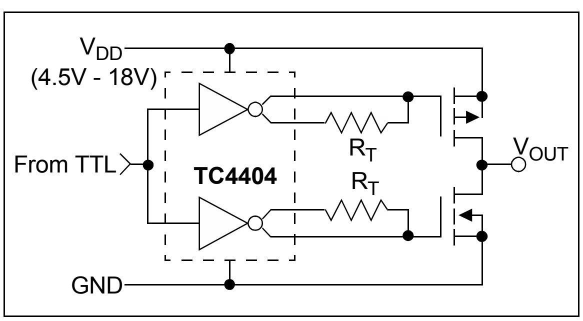


FIGURE 4-2: Zero Crossover Current Totem-Pole Switch.

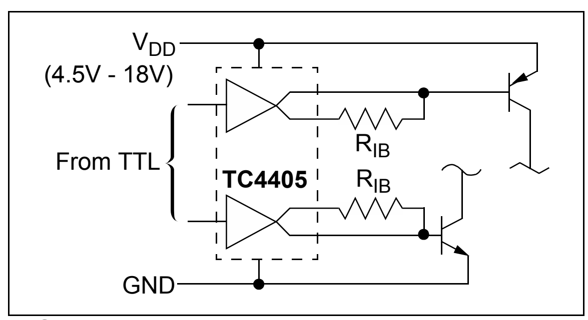


FIGURE 4-3: Driving Bipolar Transistors.

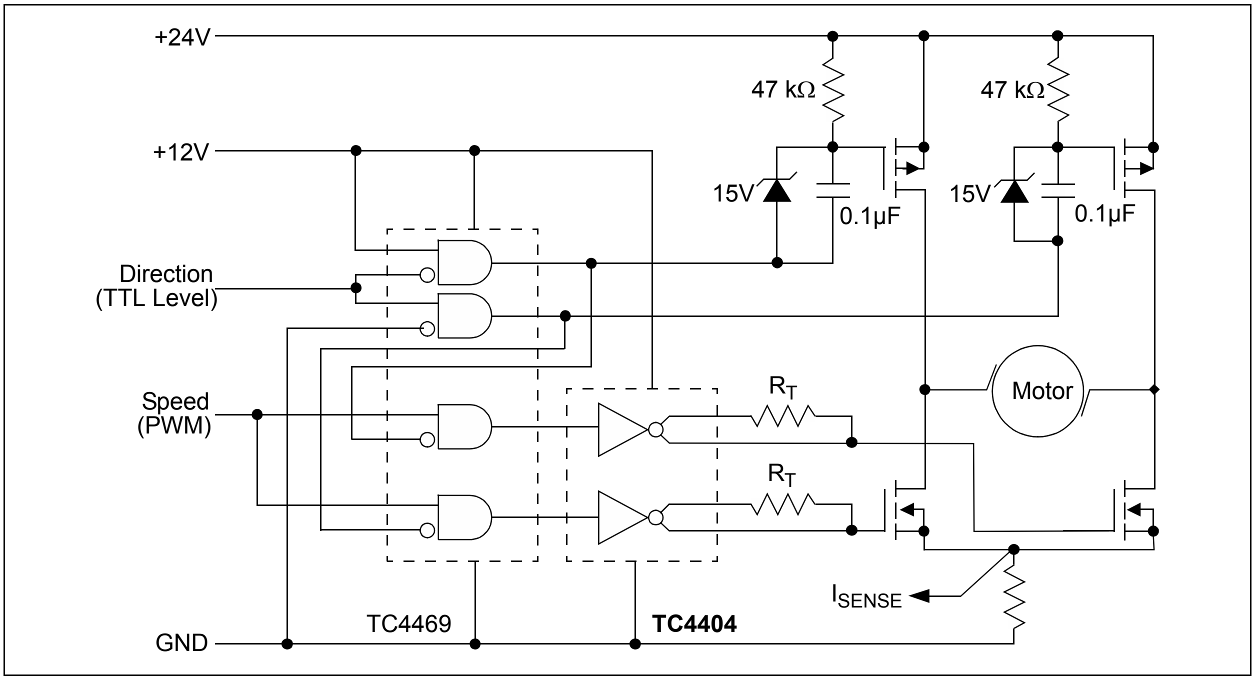


FIGURE 4-4: *Servo Motor Control.*

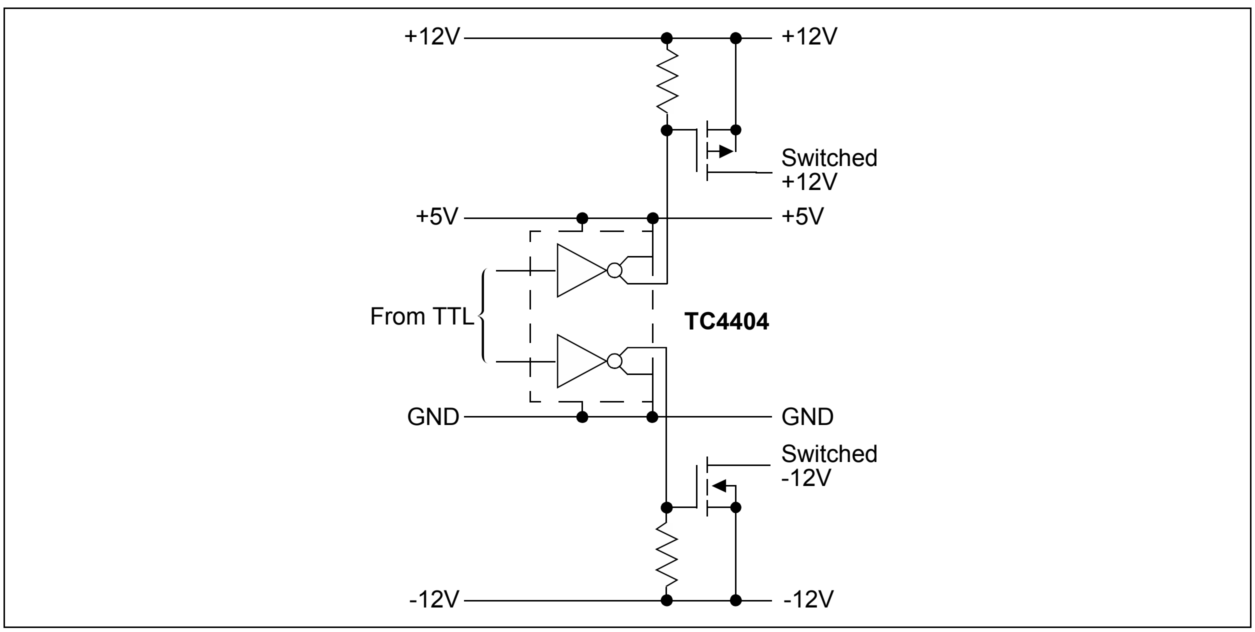
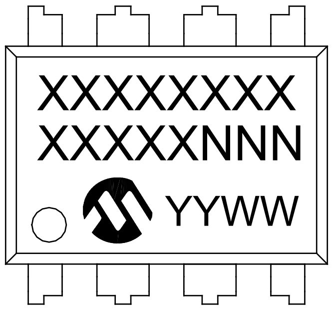


FIGURE 4-5: *Reach-Up and Reach-Down Driving.*

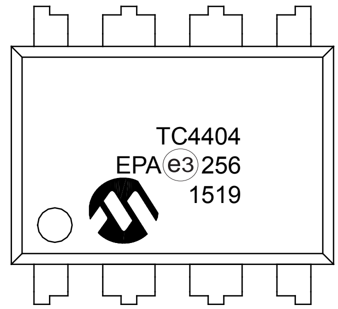
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

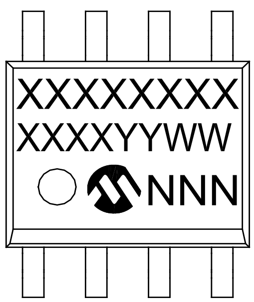
8-Lead PDIP (300 mil)



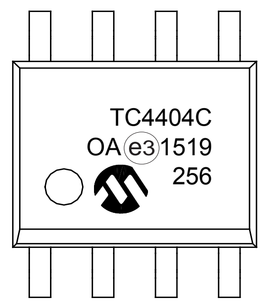
Example



8-Lead SOIC (3.90 mm)



Example

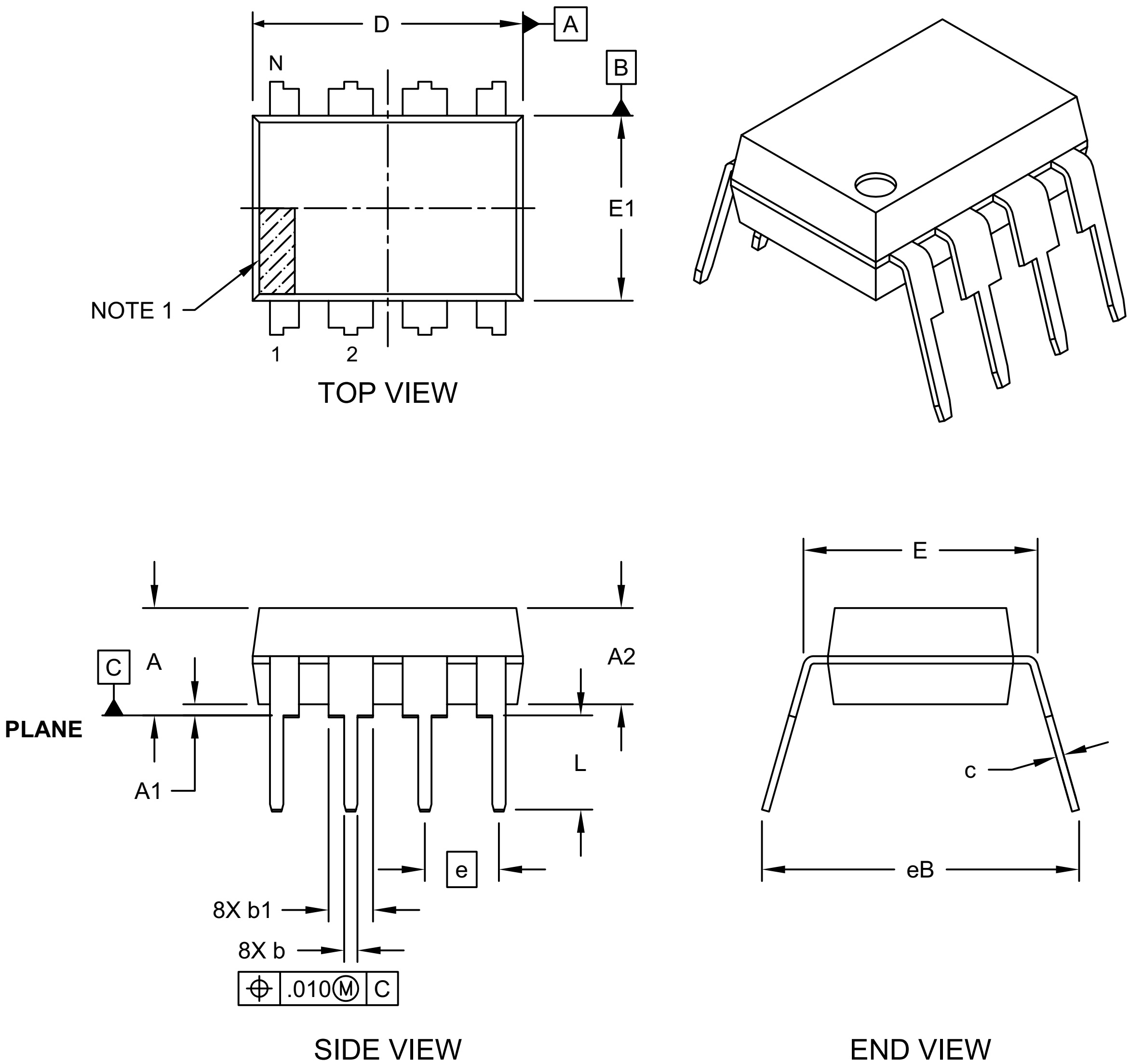


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

8-Lead Plastic Dual In-Line (PA) - 300 mil Body [PDIP]

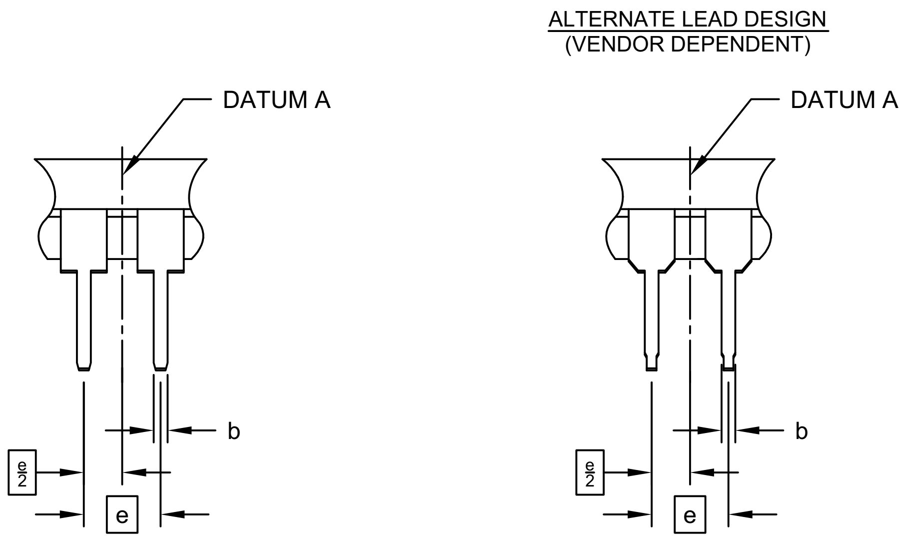
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-018D Sheet 1 of 2

8-Lead Plastic Dual In-Line (PA) - 300 mil Body [PDIP]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



		Units	INCHES		
		Dimension Limits	MIN	NOM	MAX
Number of Pins		N		8	
Pitch		e		.100 BSC	
Top to Seating Plane		A	-	-	.210
Molded Package Thickness		A2	.115	.130	.195
Base to Seating Plane		A1	.015	-	-
Shoulder to Shoulder Width		E	.290	.310	.325
Molded Package Width		E1	.240	.250	.280
Overall Length		D	.348	.365	.400
Tip to Seating Plane		L	.115	.130	.150
Lead Thickness		c	.008	.010	.015
Upper Lead Width		b1	.040	.060	.070
Lower Lead Width		b	.014	.018	.022
Overall Row Spacing	§	eB	-	-	.430

Notes:

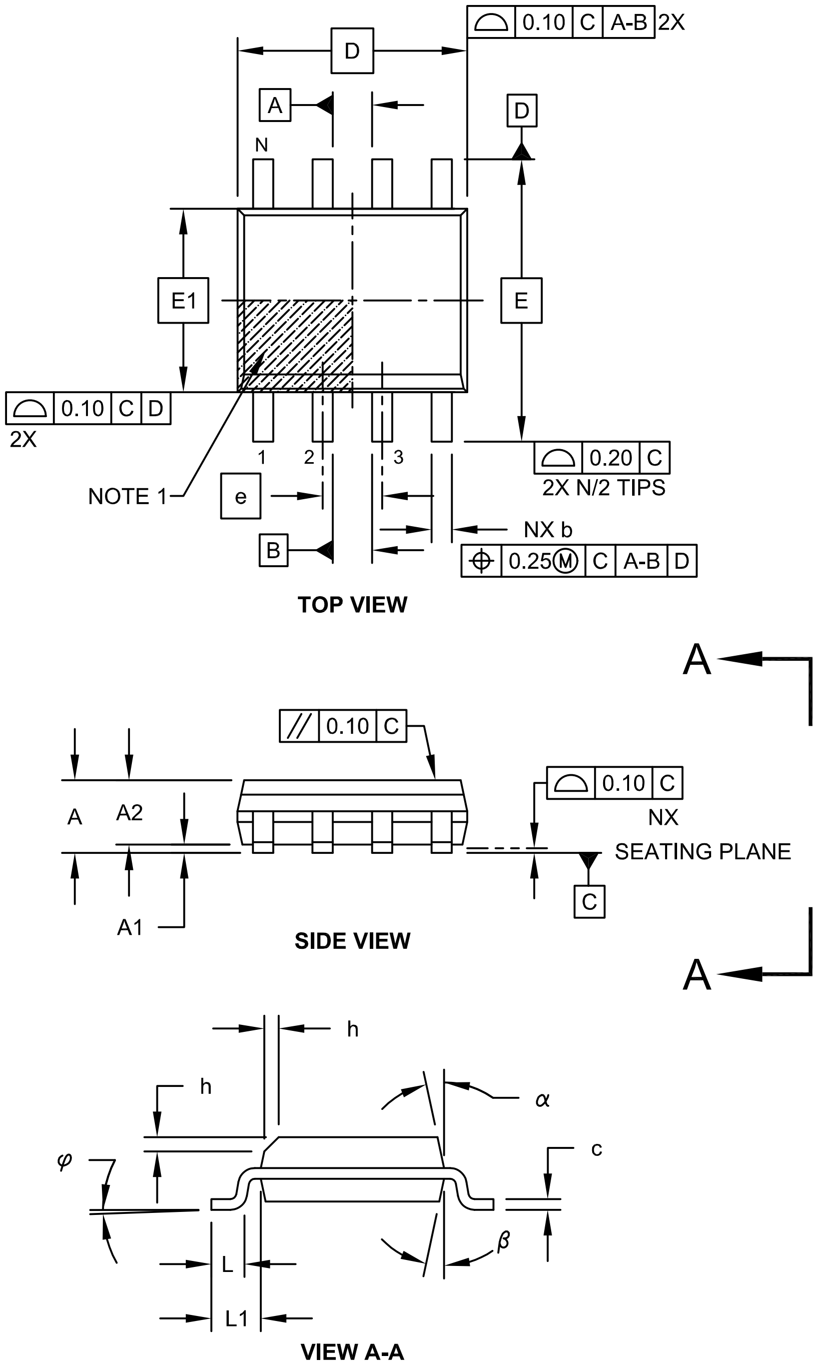
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-018D Sheet 2 of 2

8-Lead Plastic Small Outline (OA) - Narrow, 3.90 mm Body [SOIC]

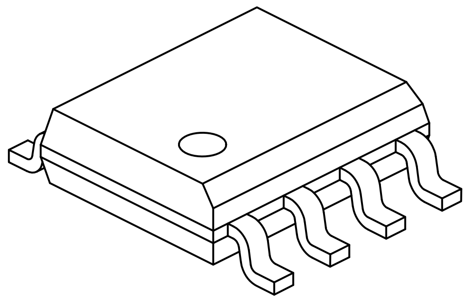
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-057C Sheet 1 of 2

8-Lead Plastic Small Outline (OA) - Narrow, 3.90 mm Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.10	-	0.25
Overall Width	E	6.00 BSC		
Molded Package Width	E1	3.90 BSC		
Overall Length	D	4.90 BSC		
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1	1.04 REF		
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

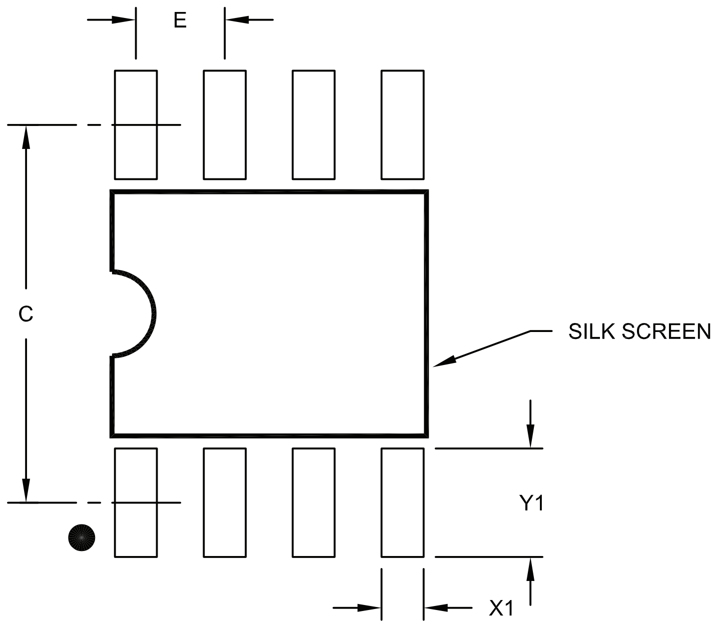
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-057C Sheet 2 of 2

8-Lead Plastic Small Outline (OA) – Narrow, 3.90 mm Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	1.27 BSC		
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2057A

APPENDIX A: REVISION HISTORY

Revision E (April 2016)

The following is the list of modifications:

1. Removed all information regarding the discontinued CERDIP package.
2. Added Temperature Specifications Table.
3. Added **Section 5.0, Packaging Information**.
4. Added Product Identification System page.

Revision D (December 2012)

Added a note to each package outline drawing.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	X	XX
Device	Temperature Range	Package

Device:	TC4404:	Dual Open-Drain MOSFET Driver
	TC4405:	Dual Open-Drain MOSFET Driver
Temperature Range:	C	= 0°C to +70°C
	E	= -40°C to +85°C
Package:	OA	= Plastic Small Outline (3.90 mm Body),8-Lead, SOIC
	PA	= Plastic Dual In-Line (300 mil Body), 8-Lead, PDIP
	OA713	= Plastic Small Outline (3.90 mm Body),8-Lead, SOIC (Tape and Reel)

Examples:

a) TC4404COA: 1.5A Dual Open-Drain MOSFET Driver, 0°C to +70°C, 8LD SOIC Package

b) TC4404EOA: 1.5A Dual Open-Drain MOSFET Driver, -40°C to +85°C, 8LD SOIC Package

c) TC4404CPA: 1.5A Dual Open-Drain MOSFET Driver, 0°C to +70°C, 8LD PDIP Package

d) TC4405EPA: 1.5A Dual Open-Drain MOSFET Driver, -40°C to +85°C, 8LD PDIP Package

e) TC4404EOA713: 1.5A Dual Open-Drain MOSFET Driver, -40°C to +85°C, 8LD SOIC Package, Tape and Reel

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
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ISBN: 978-1-5224-0445-3

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