

## 9A High-Speed MOSFET Drivers

### Features

- High Peak Output Current: 9A
- Wide Input Supply Voltage Operating Range:
  - 4.5V to 18V
- High Continuous Output Current: 2A Max
- Fast Rise and Fall Times:
  - 30 ns with 4,700 pF Load
  - 180 ns with 47,000 pF Load
- Short Propagation Delays: 30 ns (typ)
- Low Supply Current:
  - With Logic '1' Input – 200  $\mu$ A (typ)
  - With Logic '0' Input – 55  $\mu$ A (typ)
- Low Output Impedance: 1.4 $\Omega$  (typ)
- Latch-Up Protected: Will Withstand 1.5A Output Reverse Current
- Input Will Withstand Negative Inputs Up To 5V
- Pin-Compatible with the TC4420/TC4429 6A MOSFET Driver
- Space-saving 8-Pin 6x5 DFN Package

### Applications

- Line Drivers for Extra Heavily-Loaded Lines
- Pulse Generators
- Driving the Largest MOSFETs and IGBTs
- Local Power ON/OFF Switch
- Motor and Solenoid Driver

### General Description

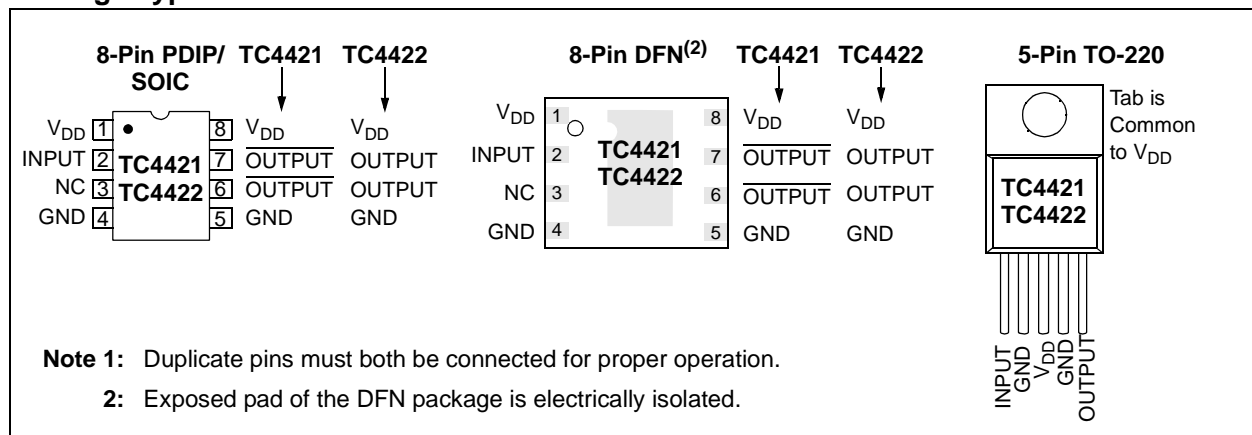
The TC4421/TC4422 are high-current buffer/drivers capable of driving large MOSFETs and IGBTs.

These devices are essentially immune to any form of upset, except direct overvoltage or over-dissipation. They cannot be latched under any conditions within their power and voltage ratings. These parts are not subject to damage or improper operation when up to 5V of ground bounce is present on their ground terminals. They can accept, without damage or logic upset, more than 1A inductive current of either polarity being forced back into their outputs. In addition, all terminals are fully protected against up to 4 kV of electrostatic discharge.

The TC4421/TC4422 inputs may be driven directly from either TTL or CMOS (3V to 18V). In addition, 300 mV of hysteresis is built into the input, providing noise immunity and allowing the device to be driven from slowly rising or falling waveforms.

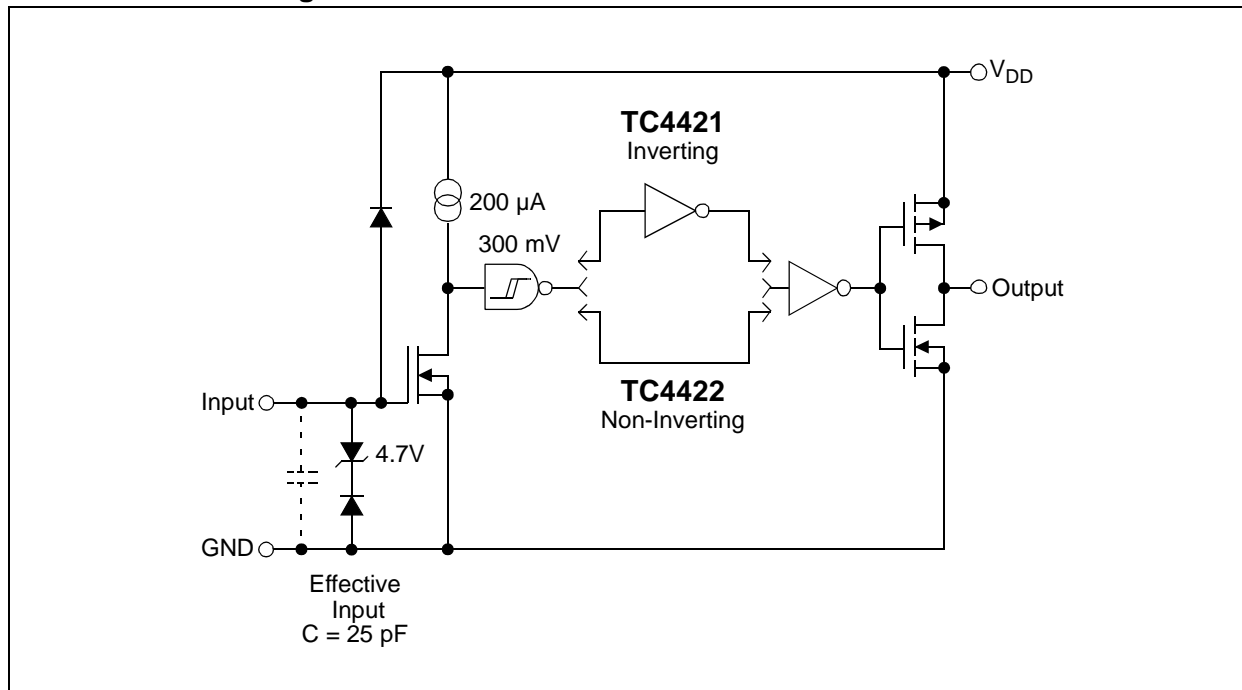
With both surface-mount and pin-through-hole packages and four operating temperature range offerings, the TC4421/22 family of 9A MOSFET drivers fit into most any application where high gate/line capacitance drive is required.

### Package Types<sup>(1)</sup>



# TC4421/TC4422

## Functional Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

Supply Voltage .....	+20V
Input Voltage .....	( $V_{DD} + 0.3V$ ) to (GND – 5V)
Input Current ( $V_{IN} > V_{DD}$ ).....	50 mA
Package Power Dissipation ( $T_A \leq 70^\circ C$ )	
5-Pin TO-220 .....	1.6W
DFN .....	<b>Note 2</b>
PDIP .....	730 mW
SOIC.....	750 mW
Package Power Dissipation ( $T_A \leq 25^\circ C$ )	
5-Pin TO-220 (With Heatsink) .....	12.5W
Thermal Impedances (To Case)	
5-Pin TO-220 $R_{\theta J-C}$ .....	10°C/W

† Stresses above 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 above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

## DC CHARACTERISTICS

Electrical Specifications: Unless otherwise noted, $T_A = +25^\circ C$ with $4.5V \leq V_{DD} \leq 18V$ .						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Input</b>						
Logic '1', High Input Voltage	$V_{IH}$	2.4	1.8	—	V	
Logic '0', Low Input Voltage	$V_{IL}$	—	1.3	0.8	V	
Input Current	$I_{IN}$	-10	—	+10	$\mu A$	$0V \leq V_{IN} \leq V_{DD}$
<b>Output</b>						
High Output Voltage	$V_{OH}$	$V_{DD} - 0.025$	—	—	V	DC TEST
Low Output Voltage	$V_{OL}$	—	—	0.025	V	DC TEST
Output Resistance, High	$R_{OH}$	—	1.4	—	$\Omega$	$I_{OUT} = 10\text{ mA}$ , $V_{DD} = 18V$
Output Resistance, Low	$R_{OL}$	—	0.9	1.7	$\Omega$	$I_{OUT} = 10\text{ mA}$ , $V_{DD} = 18V$
Peak Output Current	$I_{PK}$	—	9.0	—	A	$V_{DD} = 18V$
Continuous Output Current	$I_{DC}$	2	—	—	A	$10V \leq V_{DD} \leq 18V$ , $T_A = +25^\circ C$ (TC4421/TC4422 CAT only) ( <b>Note 3</b> )
Latch-Up Protection Withstand Reverse Current	$I_{REV}$	—	>1.5	—	A	Duty cycle $\leq 2\%$ , $t \leq 300\ \mu\text{sec}$
<b>Switching Time (Note 1)</b>						
Rise Time	$t_R$	—	60	75	ns	Figure 4-1, $C_L = 10,000\text{ pF}$
Fall Time	$t_F$	—	60	75	ns	Figure 4-1, $C_L = 10,000\text{ pF}$
Delay Time	$t_{D1}$	—	30	60	ns	Figure 4-1
Delay Time	$t_{D2}$	—	33	60	ns	Figure 4-1
<b>Power Supply</b>						
Power Supply Current	$I_S$	—	0.2	1.5	mA	$V_{IN} = 3V$
		—	55	150	$\mu A$	$V_{IN} = 0V$
Operating Input Voltage	$V_{DD}$	4.5	—	18	V	

**Note 1:** Switching times ensured by design.

**2:** Package power dissipation is dependent on the copper pad area on the PCB.

**3:** Tested during characterization, not production tested.

# TC4421/TC4422

## DC CHARACTERISTICS (OVER OPERATING TEMPERATURE RANGE)

Electrical Specifications: Unless otherwise noted, over operating temperature range with $4.5V \leq V_{DD} \leq 18V$ .						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Input</b>						
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	$\mu A$	$0V \leq V_{IN} \leq V_{DD}$
<b>Output</b>						
High Output Voltage	$V_{OH}$	$V_{DD} - 0.025$	—	—	V	DC TEST
Low Output Voltage	$V_{OL}$	—	—	0.025	V	DC TEST
Output Resistance, High	$R_{OH}$	—	2.4	3.6	$\Omega$	$I_{OUT} = 10 \text{ mA}, V_{DD} = 18V$
Output Resistance, Low	$R_{OL}$	—	1.8	2.7	$\Omega$	$I_{OUT} = 10 \text{ mA}, V_{DD} = 18V$
<b>Switching Time (Note 1)</b>						
Rise Time	$t_R$	—	60	120	ns	Figure 4-1, $C_L = 10,000 \text{ pF}$
Fall Time	$t_F$	—	60	120	ns	Figure 4-1, $C_L = 10,000 \text{ pF}$
Delay Time	$t_{D1}$	—	50	80	ns	Figure 4-1
Delay Time	$t_{D2}$	—	65	80	ns	Figure 4-1
<b>Power Supply</b>						
Power Supply Current	$I_S$	—	—	3 0.2	mA	$V_{IN} = 3V$ $V_{IN} = 0V$
Operating Input Voltage	$V_{DD}$	4.5	—	18	V	

**Note 1:** Switching times ensured by design.

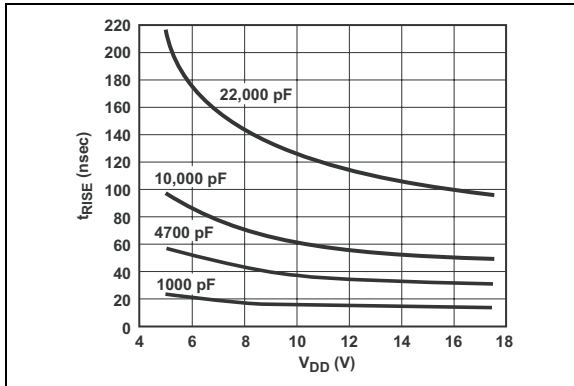
## TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise noted, all parameters apply with $4.5V \leq V_{DD} \leq 18V$ .						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range (C)	$T_A$	0	—	+70	$^{\circ}C$	
Specified Temperature Range (E)	$T_A$	-40	—	+85	$^{\circ}C$	
Specified Temperature Range (V)	$T_A$	-40	—	+125	$^{\circ}C$	
Maximum Junction Temperature	$T_J$	—	—	+150	$^{\circ}C$	
Storage Temperature Range	$T_A$	-65	—	+150	$^{\circ}C$	
<b>Package Thermal Resistances</b>						
Thermal Resistance, 5L-TO-220	$\theta_{JA}$	—	71	—	$^{\circ}C/W$	
Thermal Resistance, 8L-6x5 DFN	$\theta_{JA}$	—	33.2	—	$^{\circ}C/W$	Typical 4-layer board with vias to ground plane
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	125	—	$^{\circ}C/W$	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	120	—	$^{\circ}C/W$	

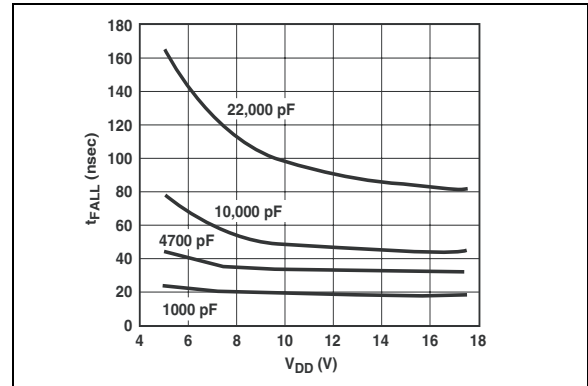
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

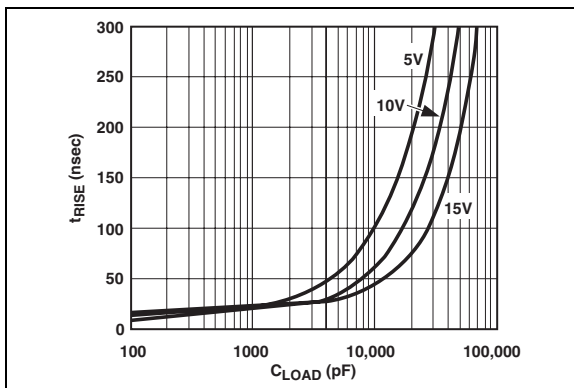
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$  with  $4.5\text{V} \leq V_{DD} \leq 18\text{V}$ .



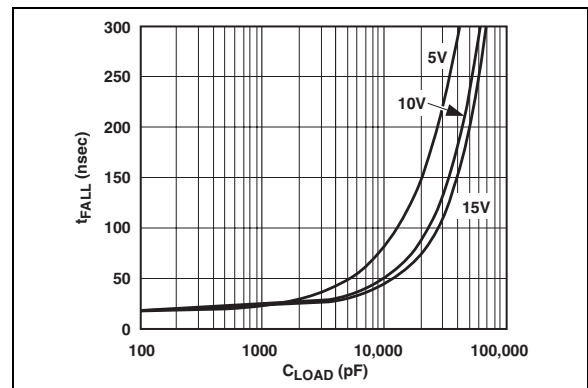
**FIGURE 2-1:** Rise Time vs. Supply Voltage.



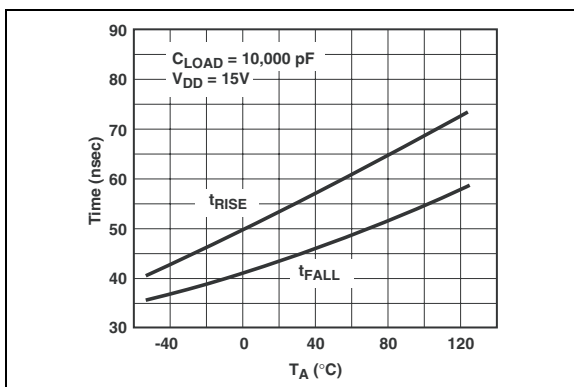
**FIGURE 2-4:** Fall Time vs. Supply Voltage.



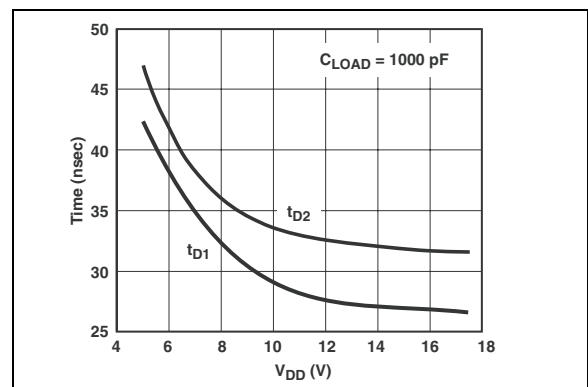
**FIGURE 2-2:** Rise Time vs. Capacitive Load.



**FIGURE 2-5:** Fall Time vs. Capacitive Load.



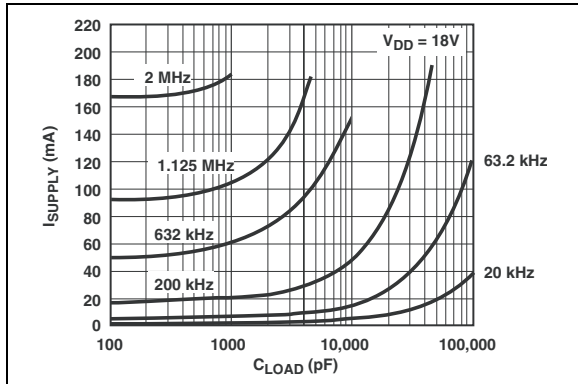
**FIGURE 2-3:** Rise and Fall Times vs. Temperature.



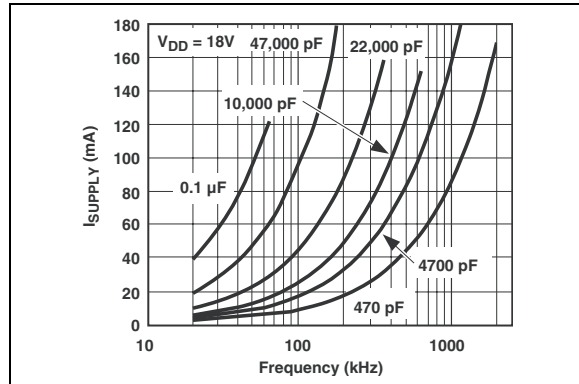
**FIGURE 2-6:** Propagation Delay vs. Supply Voltage.

# TC4421/TC4422

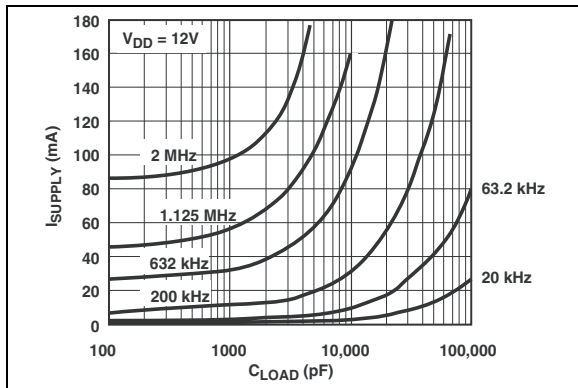
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$  with  $4.5\text{V} \leq V_{DD} \leq 18\text{V}$ .



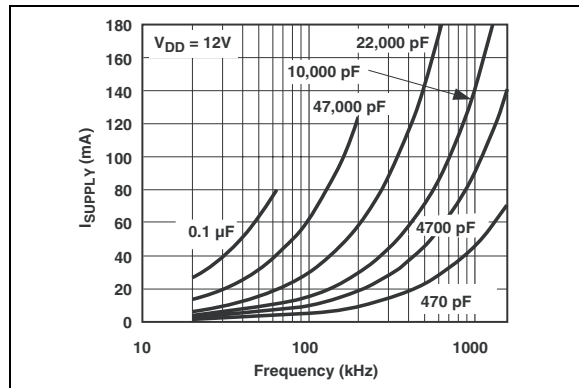
**FIGURE 2-7:** Supply Current vs. Capacitive Load ( $V_{DD} = 18\text{V}$ ).



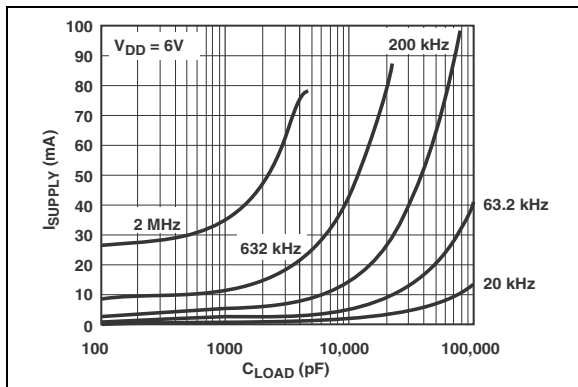
**FIGURE 2-10:** Supply Current vs. Frequency ( $V_{DD} = 18\text{V}$ ).



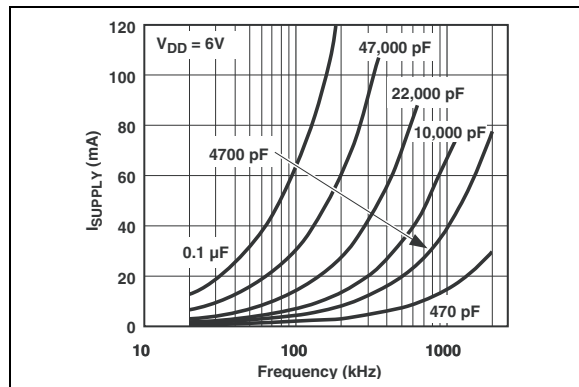
**FIGURE 2-8:** Supply Current vs. Capacitive Load ( $V_{DD} = 12\text{V}$ ).



**FIGURE 2-11:** Supply Current vs. Frequency ( $V_{DD} = 12\text{V}$ ).

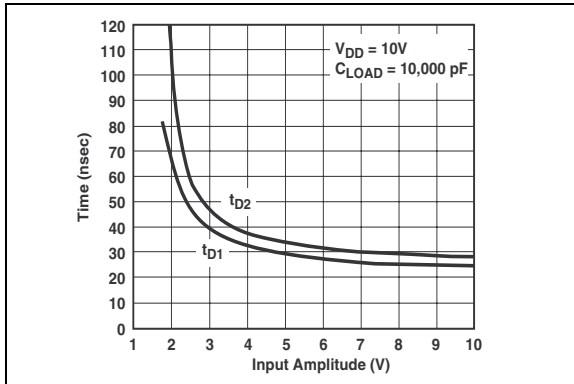


**FIGURE 2-9:** Supply Current vs. Capacitive Load ( $V_{DD} = 6\text{V}$ ).

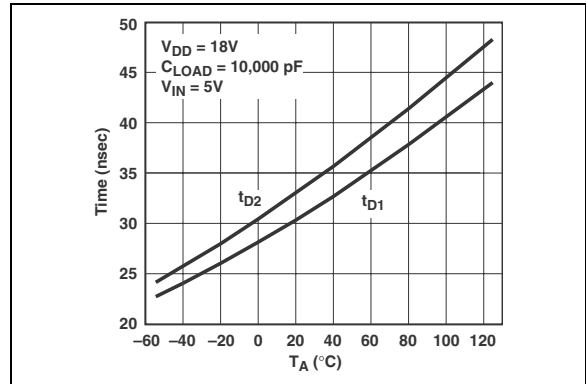


**FIGURE 2-12:** Supply Current vs. Frequency ( $V_{DD} = 6\text{V}$ ).

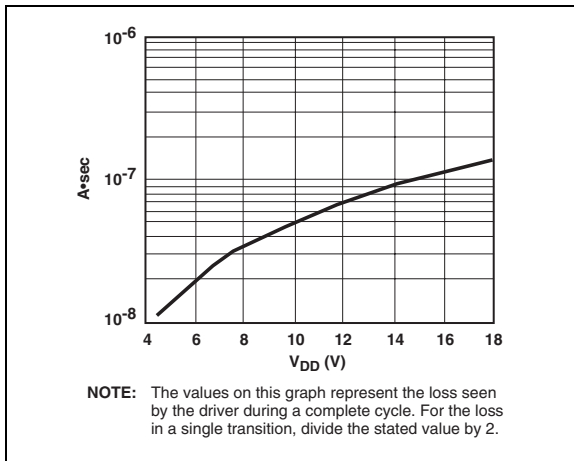
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$  with  $4.5\text{V} \leq V_{DD} \leq 18\text{V}$ .



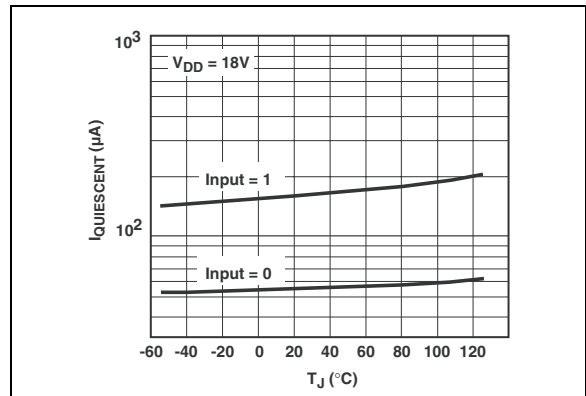
**FIGURE 2-13:** Propagation Delay vs. Input Amplitude.



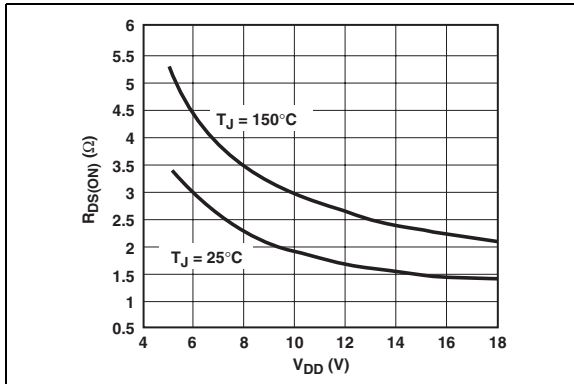
**FIGURE 2-16:** Propagation Delay vs. Temperature.



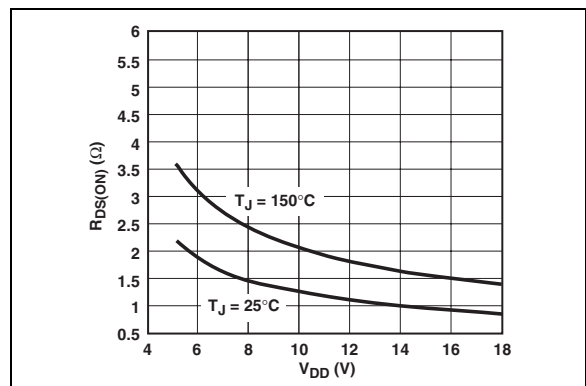
**FIGURE 2-14:** Crossover Energy vs. Supply Voltage.



**FIGURE 2-17:** Quiescent Supply Current vs. Temperature.



**FIGURE 2-15:** High-State Output Resistance vs. Supply Voltage.



**FIGURE 2-18:** Low-State Output Resistance vs. Supply Voltage.

# TC4421/TC4422

## 3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

Pin No. 8-Pin PDIP, SOIC	Pin No. 8-Pin DFN	Pin No. 5-Pin TO-220	Symbol	Description
1	1	—	$V_{DD}$	Supply input, 4.5V to 18V
2	2	1	INPUT	Control input, TTL/CMOS compatible input
3	3	—	NC	No connection
4	4	2	GND	Ground
5	5	4	GND	Ground
6	6	5	OUTPUT	CMOS push-pull output
7	7	—	OUTPUT	CMOS push-pull output
8	8	3	$V_{DD}$	Supply input, 4.5V to 18V
—	PAD	—	NC	Exposed metal pad
—	—	TAB	$V_{DD}$	Metal tab is at the $V_{DD}$ potential

### 3.1 Supply Input ( $V_{DD}$ )

The  $V_{DD}$  input is the bias supply for the MOSFET driver and is rated for 4.5V to 18V with respect to the ground pin. The  $V_{DD}$  input should be bypassed to ground with a local ceramic capacitor. The value of the capacitor should be chosen based on the capacitive load that is being driven. A minimum value of 1.0  $\mu$ F is suggested.

### 3.2 Control Input

The MOSFET driver input is a high-impedance, TTL/CMOS compatible input. The input also has 300 mV of hysteresis between the high and low thresholds that prevents output glitching even when the rise and fall time of the input signal is very slow.

### 3.3 CMOS Push-Pull Output

The MOSFET driver output is a low-impedance, CMOS, push-pull style output capable of driving a capacitive load with 9.0A peak currents. The MOSFET driver output is capable of withstanding 1.5A peak reverse currents of either polarity.

### 3.4 Ground

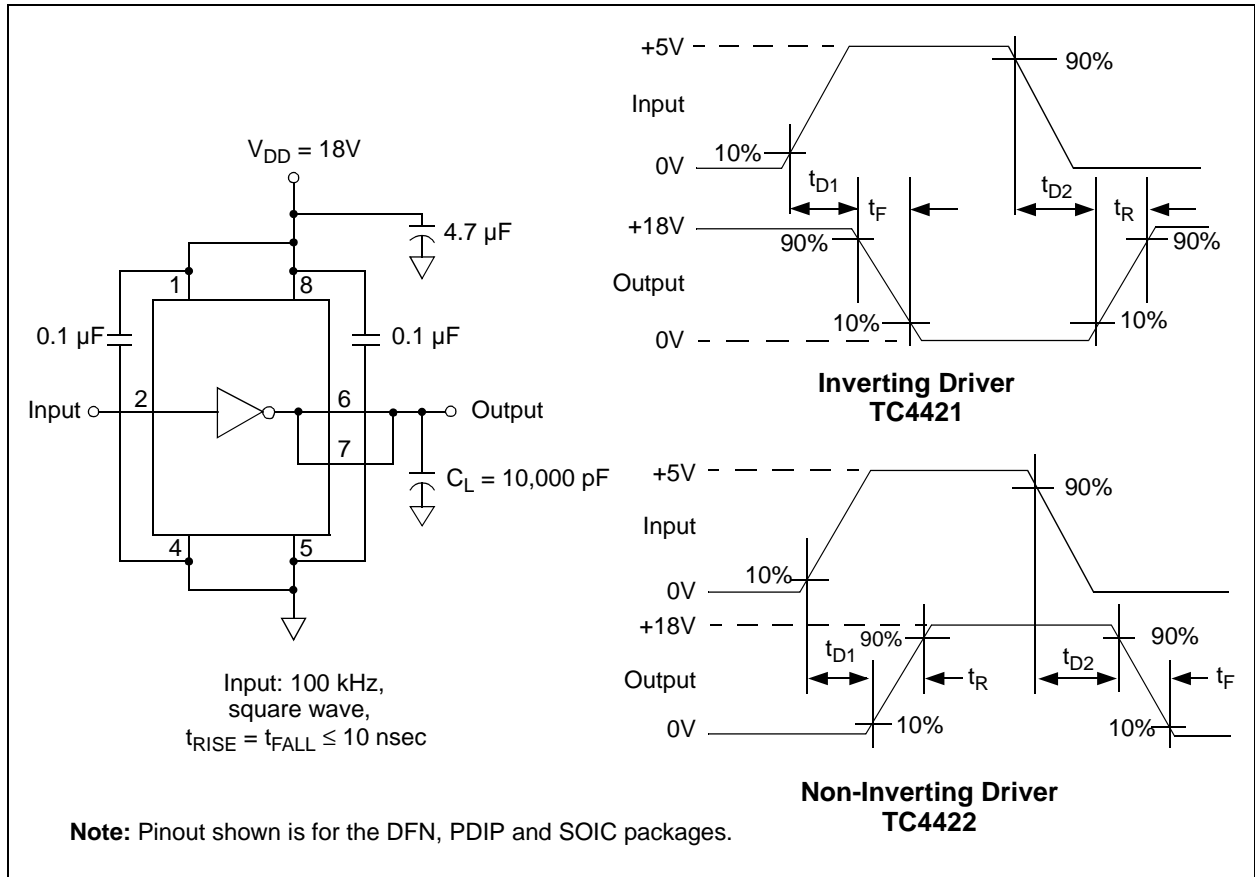
The ground pins are the return path for the bias current and for the high peak currents that discharge the load capacitor. The ground pins should be tied into a ground plane or have very short traces to the bias supply source return.

### 3.5 Exposed Metal Pad

The exposed metal pad of the 6x5 DFN package is not internally connected to any potential. Therefore, this pad can be connected to a ground plane or other copper plane on a printed circuit board to aid in heat removal from the package.



## 4.0 APPLICATIONS INFORMATION



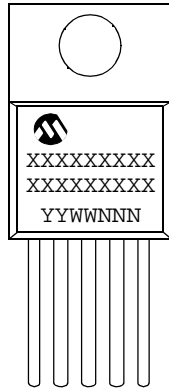
**FIGURE 4-1:** Switching Time Test Circuits.

# TC4421/TC4422

## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

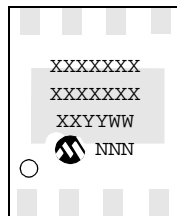
5-Lead TO-220



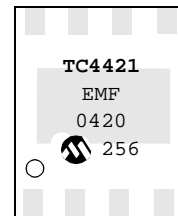
Example:



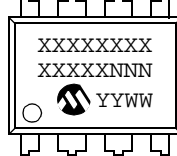
8-Lead DFN



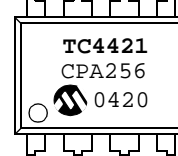
Example:



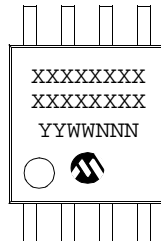
8-Lead PDIP (300 mil)



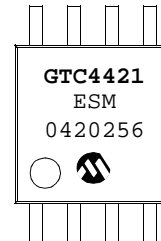
Example:



8-Lead SOIC (208 mil)



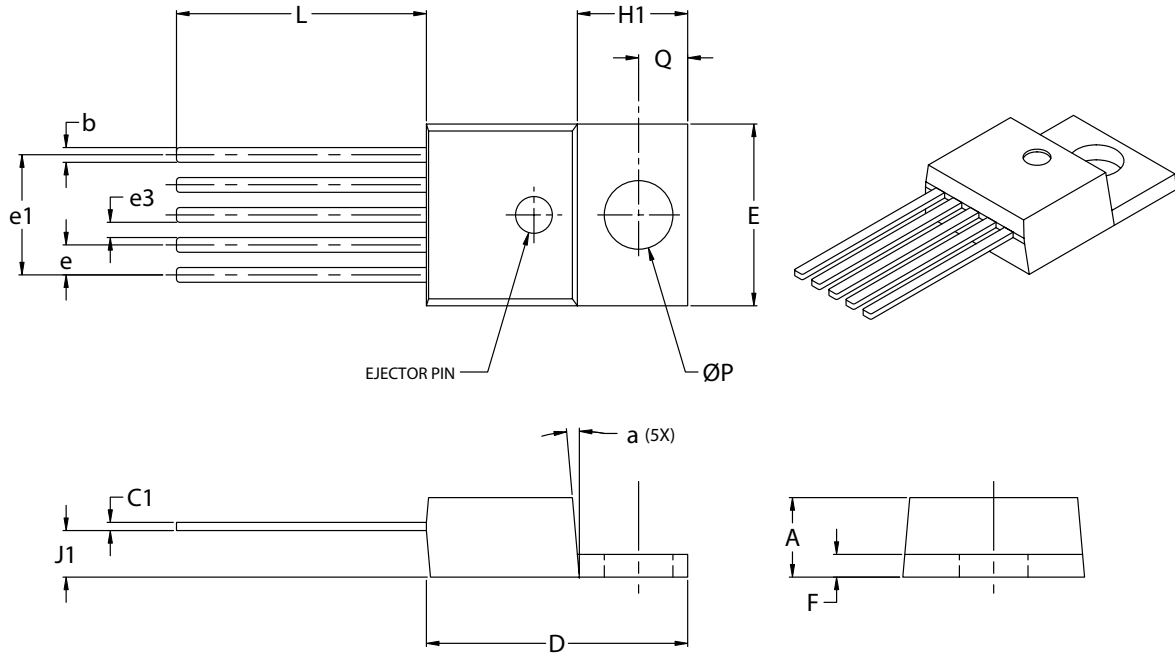
Example:



<b>Legend:</b>	XX...X	Customer specific information*
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
<b>Note:</b>	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.	

\* Standard OTP marking consists of Microchip part number, year code, week code, and traceability code.

## 5-Lead Plastic Transistor Outline (AT) (TO-220)



Dimension Limits	Units	INCHES*		MILLIMETERS	
		MIN	MAX	MIN	MAX
Lead Pitch	e	.060	.072	1.52	1.83
Overall Lead Centers	e1	.263	.273	6.68	6.93
Space Between Leads	e3	.030	.040	0.76	1.02
Overall Height	A	.160	.190	4.06	4.83
Overall Width	E	.385	.415	9.78	10.54
Overall Length	D	.560	.590	14.22	14.99
Flag Length	H1	.234	.258	5.94	6.55
Flag Thickness	F	.045	.055	1.14	1.40
Through Hole Center	Q	.103	.113	2.62	2.87
Through Hole Diameter	P	.146	.156	3.71	3.96
Lead Length	L	.540	.560	13.72	14.22
Base to Bottom of Lead	J1	.090	.115	2.29	2.92
Lead Thickness	C1	.014	.022	0.36	0.56
Lead Width	b	.025	.040	0.64	1.02
Mold Draft Angle	a	3°	7°	3°	7°

\*Controlling Parameter

Notes:

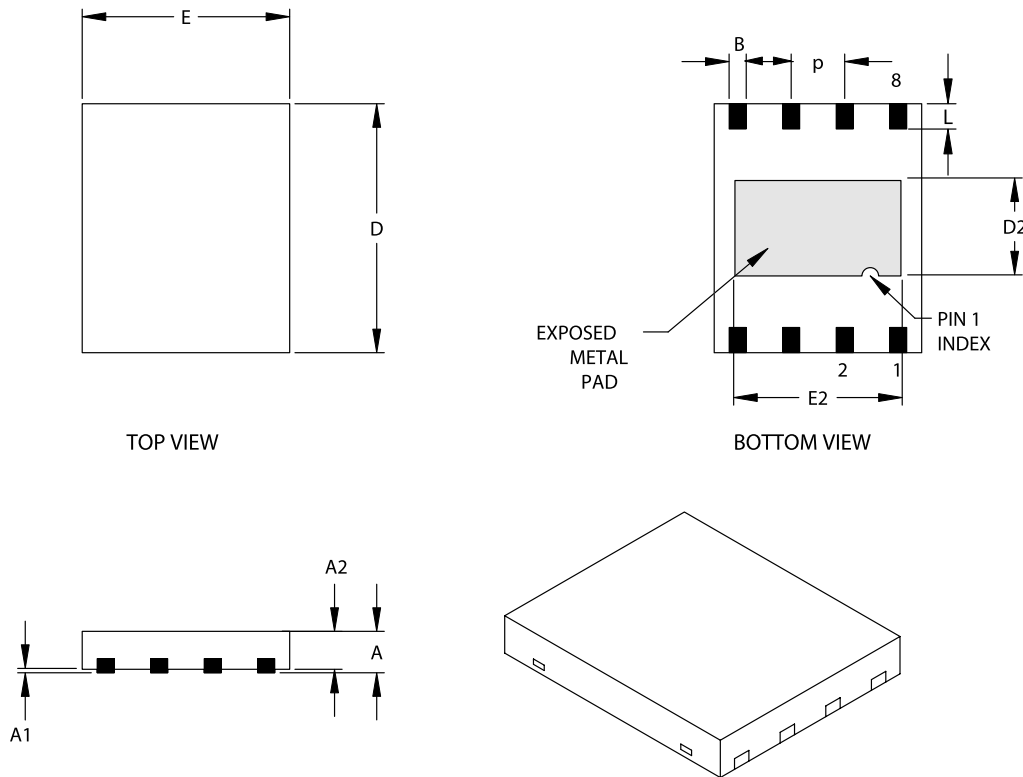
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC equivalent: TO-220

Drawing No. C04-036

# TC4421/TC4422

## 8-Lead Plastic Dual Flat No Lead Package (MF) 6x5 mm Body (DFN-S) – Saw Singulated



Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n	8			8		
Pitch	P	.050 BSC			1.27 BSC		
Overall Height	A	.033	.035	.037	0.85	0.90	0.95
Package Thickness	A2	.031	.035	.037	0.80	0.89	0.95
Standoff	A1	.000	.0004	.002	0.00	0.01	0.05
Base Thickness	A3	.007	.008	.009	0.17	0.20	0.23
Overall Length	E	.195	.197	.199	4.95	5.00	5.05
Exposed Pad Length	E2	.152	.157	.163	3.85	4.00	4.15
Overall Width	D	.234	.236	.238	5.95	6.00	6.05
Exposed Pad Width	D2	.089	.091	.093	2.25	2.30	2.35
Lead Width	B	.014	.016	.019	0.35	0.40	0.47
Lead Length	L	.024		.026	0.60		0.65

Notes:

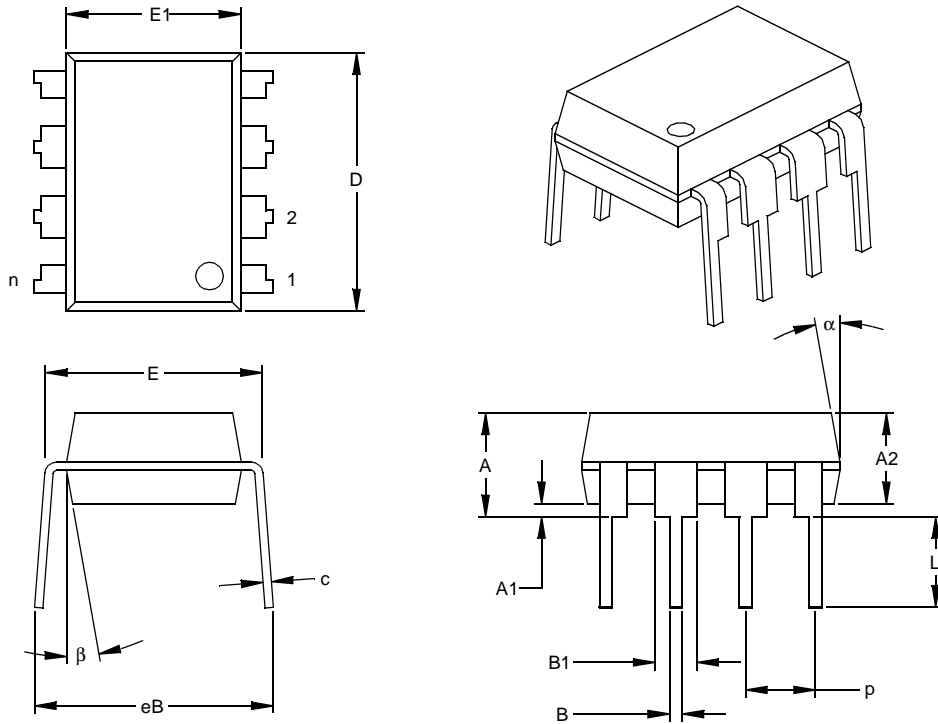
JEDEC equivalent: MO-220

Drawing No. C04-122

Revised 11/3/03

# TC4421/TC4422

## 8-Lead Plastic Dual In-line (P) – 300 mil (PDIP)



Dimension Limits	Units	INCHES*			MILLIMETERS		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.140	.155	.170	3.56	3.94	4.32
Molded Package Thickness	A2	.115	.130	.145	2.92	3.30	3.68
Base to Seating Plane	A1	.015			0.38		
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Molded Package Width	E1	.240	.250	.260	6.10	6.35	6.60
Overall Length	D	.360	.373	.385	9.14	9.46	9.78
Tip to Seating Plane	L	.125	.130	.135	3.18	3.30	3.43
Lead Thickness	c	.008	.012	.015	0.20	0.29	0.38
Upper Lead Width	B1	.045	.058	.070	1.14	1.46	1.78
Lower Lead Width	B	.014	.018	.022	0.36	0.46	0.56
Overall Row Spacing	§ eB	.310	.370	.430	7.87	9.40	10.92
Mold Draft Angle Top	α	5	10	15	5	10	15
Mold Draft Angle Bottom	β	5	10	15	5	10	15

\* Controlling Parameter  
 § Significant Characteristic

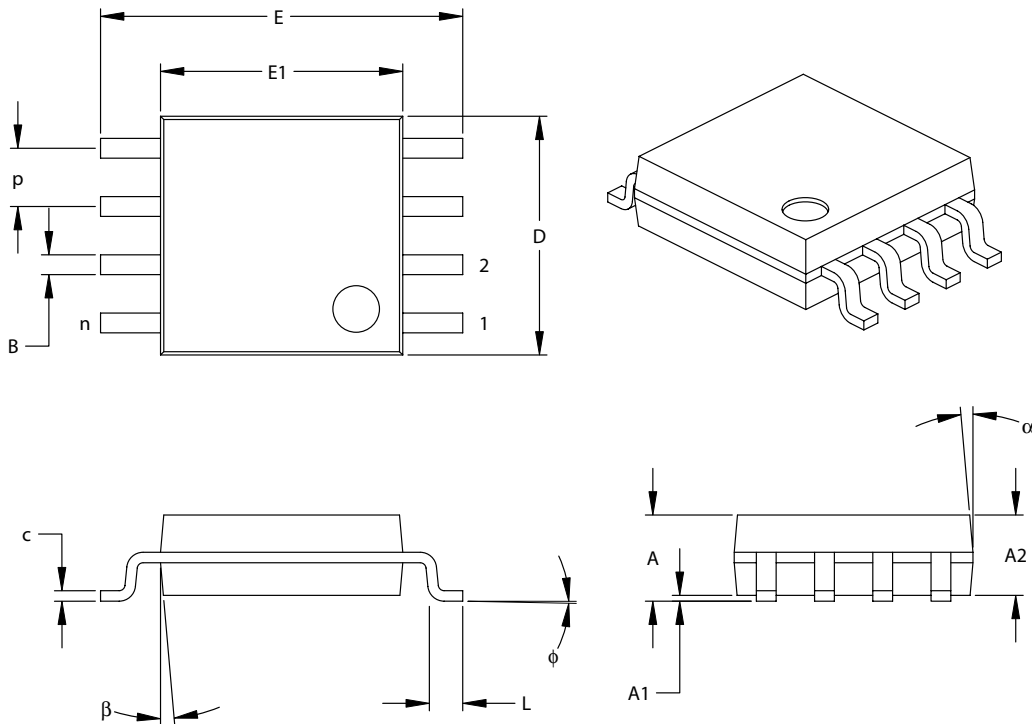
### Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.  
 JEDEC Equivalent: MS-001  
 Drawing No. C04-018

# TC4421/TC4422

## 8-Lead Plastic Small Outline (SM) – Medium, 208 mil Body (SOIJ)

(JEITA/EIAJ Standard, Formerly called SOIC)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n	8			8		
Pitch	P		.050			1.27	
Overall Height	A	.070	.075	.080	1.78	1.97	2.03
Molded Package Thickness	A2	.069	.074	.078	1.75	1.88	1.98
Standoff	A1	.002	.005	.010	0.05	0.13	0.25
Overall Width	E	.300	.313	.325	7.62	7.95	8.26
Molded Package Width	E1	.201	.208	.212	5.11	5.28	5.38
Overall Length	D	.202	.205	.210	5.13	5.21	5.33
Foot Length	L	.020	.025	.030	0.51	0.64	0.76
Foot Angle	φ	0	4	8	0	4	8
Lead Thickness	c	.008	.009	.010	0.20	0.23	0.25
Lead Width	B	.014	.017	.020	0.36	0.43	0.51
Mold Draft Angle Top	α	0	12	15	0	12	15
Mold Draft Angle Bottom	β	0	12	15	0	12	15

\*Controlling Parameter

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

Drawing No. C04-056

## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>X</u>	<u>XX</u>	<u>XXX</u>	<u>X</u>	<b>Examples:</b>	
<b>Device</b>	<b>Temperature Range</b>	<b>Package</b>	<b>Tape &amp; Reel</b>	<b>PB Free</b>		
Device:	TC4421:	9A High-Speed MOSFET Driver, Inverting			a) TC4421CAT:	9A High-Speed Inverting MOSFET Driver, TO-220 package, 0°C to +70°C.
	TC4422:	9A High-Speed MOSFET Driver, Non-Inverting			b) TC4421ESMG:	9A High-Speed Inverting MOSFET Driver, PB Free SOIC package, -40°C to +85°C.
Temperature Range:	C	= 0°C to +70°C (PDIP and TO-220 Only)			c) TC4421VMF:	9A High-Speed Inverting MOSFET Driver, DFN package, -40°C to +125°C.
	E	= -40°C to +85°C			a) TC4422VPA:	9A High-Speed Non-Inverting MOSFET Driver, PDIP package, -40°C to +125°C.
	V	= -40°C to +125°C			b) TC4422EPA:	9A High-Speed Non-Inverting MOSFET Driver, PDIP package, -40°C to +85°C.
Package:	AT	= TO-220, 5-lead (C-Temp Only)			c) TC4422EMF:	9A High-Speed Inverting MOSFET Driver, DFN package, -40°C to +85°C.
	MF	= Dual, Flat, No-Lead (6x5 mm Body), 8-lead				
	MF713	= Dual, Flat, No-Lead (6x5 mm Body), 8-lead (Tape and Reel)				
	PA	= Plastic DIP (300 mil Body), 8-lead				
	SM	= Plastic SOIC (208 mil Body), 8-lead				
	SM713	= Plastic SOIC (208 mil Body), 8-lead (Tape and Reel)				
PB Free	G	= Lead-Free device				
		= Blank				
		* Available on selected packages. Contact your local sales representative for availability				

## Sales and Support

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1. Your local Microchip sales office
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3. The Microchip Worldwide Site ([www.microchip.com](http://www.microchip.com))

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

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# TC4421/TC4422

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NOTES:



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- Microchip products meet the specification contained in their particular Microchip Data Sheet.
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