



# MICROCHIP TC4426/TC4427/TC4428

## 1.5A Dual High-Speed Power MOSFET Drivers

### Features:

- High Peak Output Current – 1.5A
- Wide Input Supply Voltage Operating Range:
  - 4.5V to 18V
- High Capacitive Load Drive Capability – 1000 pF in 25 ns (typ.)
- Short Delay Times – 40 ns (typ.)
- Matched Rise and Fall Times
- Low Supply Current:
  - With Logic '1' Input – 4 mA
  - With Logic '0' Input – 400  $\mu$ A
- Low Output Impedance – 7 $\Omega$
- Latch-Up Protected: Will Withstand 0.5A Reverse Current
- Input Will Withstand Negative Inputs Up to 5V
- ESD Protected – 4 kV
- Pin-compatible with the TC426/TC427/TC428
- Space-saving 8-Pin MSOP and 8-Pin 6x5 DFN Packages

### Applications:

- Switch Mode Power Supplies
- Line Drivers
- Pulse Transformer Drive

### General Description:

The TC4426/TC4427/TC4428 are improved versions of the earlier TC426/TC427/TC428 family of MOSFET drivers. The TC4426/TC4427/TC4428 devices have matched rise and fall times when charging and discharging the gate of a MOSFET.

These devices are highly latch-up resistant 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 the ground pin. They can accept, without damage or logic upset, up to 500 mA of reverse current (of either polarity) being forced back into their outputs. All terminals are fully protected against Electrostatic Discharge (ESD) up to 4 kV.

The TC4426/TC4427/TC4428 MOSFET drivers can easily charge/discharge 1000 pF gate capacitances in under 30 ns. These devices provide low enough impedances in both the on and off states to ensure the MOSFET's intended state will not be affected, even by large transients.

Other compatible drivers are the TC4426A/TC4427A/TC4428A family of devices. The TC4426A/TC4427A/TC4428A devices have matched leading and falling edge input-to-output delay times, in addition to the matched rise and fall times of the TC4426/TC4427/TC4428 devices.

### Package Types



# TC4426/TC4427/TC4428

## Functional Block Diagram



# TC4426/TC4427/TC4428

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage ..... +22V

Input Voltage, IN A or IN B  
..... ( $V_{DD} + 0.3V$ ) to (GND – 5V)

Package Power Dissipation ( $T_A \leq 70^\circ C$ )  
DFN ..... **Note 3**  
MSOP ..... 340 mW  
PDIP ..... 730 mW  
SOIC ..... 470 mW

Storage Temperature Range ..... -65°C to +150°C

Maximum Junction Temperature ..... +150°C

† 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.

## PIN FUNCTION TABLE

Name	Function
NC	No Connection
IN A	Input A
GND	Ground
IN B	Input B
OUT B	Output B
$V_{DD}$	Supply Input
OUT A	Output A
NC	No Connection

## 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	—	—	V	<b>Note 2</b>
Logic '0', Low Input Voltage	$V_{IL}$	—	—	0.8	V	
Input Current	$I_{IN}$	-1.0	—	+1.0	$\mu A$	$0V \leq V_{IN} \leq V_{DD}$
<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	$R_O$	—	7	10	$\Omega$	$I_{OUT} = 10\text{ mA}$ , $V_{DD} = 18V$
Peak Output Current	$I_{PK}$	—	1.5	—	A	$V_{DD} = 18V$
Latch-Up Protection Withstand Reverse Current	$I_{REV}$	—	> 0.5	—	A	Duty cycle $\leq 2\%$ , $t \leq 300\ \mu s$ $V_{DD} = 18V$
<b>Switching Time (Note 1)</b>						
Rise Time	$t_R$	—	19	30	ns	<b>Figure 4-1</b>
Fall Time	$t_F$	—	19	30	ns	<b>Figure 4-1</b>
Delay Time	$t_{D1}$	—	20	30	ns	<b>Figure 4-1</b>
Delay Time	$t_{D2}$	—	40	50	ns	<b>Figure 4-1</b>
<b>Power Supply</b>						
Power Supply Current	$I_S$	—	—	4.5	mA	$V_{IN} = 3V$ (Both inputs)
		—	—	0.4		$V_{IN} = 0V$ (Both inputs)

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

**2:** For V temperature range devices, the  $V_{IH}$  (Min) limit is 2.0V.

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

# TC4426/TC4427/TC4428

## 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	Note 2
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	$R_O$	—	9	12	$\Omega$	$I_{OUT} = 10 \text{ mA}$ , $V_{DD} = 18V$
Peak Output Current	$I_{PK}$	—	1.5	—	A	$V_{DD} = 18V$
Latch-Up Protection Withstand Reverse Current	$I_{REV}$	—	>0.5	—	A	Duty cycle $\leq 2\%$ , $t \leq 300 \mu s$ $V_{DD} = 18V$
<b>Switching Time (Note 1)</b>						
Rise Time	$t_R$	—	—	40	ns	Figure 4-1
Fall Time	$t_F$	—	—	40	ns	Figure 4-1
Delay Time	$t_{D1}$	—	—	40	ns	Figure 4-1
Delay Time	$t_{D2}$	—	—	60	ns	Figure 4-1
<b>Power Supply</b>						
Power Supply Current	$I_S$	—	—	8.0	mA	$V_{IN} = 3V$ (Both inputs)
		—	—	0.6		$V_{IN} = 0V$ (Both inputs)

Note 1: Switching times ensured by design.

2: For V temperature range devices, the  $V_{IH}$  (Min) limit is 2.0V.

## 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, 8L-6x5 DFN	$\theta_{JA}$	—	33.2	—	$^{\circ}C/W$	
Thermal Resistance, 8L-MSOP	$\theta_{JA}$	—	206	—	$^{\circ}C/W$	
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	125	—	$^{\circ}C/W$	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	155	—	$^{\circ}C/W$	

## 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 Time vs. Supply Voltage.

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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:** Propagation Delay Time vs. Input Amplitude.



**FIGURE 2-10:** Propagation Delay Time vs. Temperature.



**FIGURE 2-8:** Supply Current vs. Supply Voltage.



**FIGURE 2-11:** Supply Current vs. Temperature.



**FIGURE 2-9:** Output Resistance ( $R_{OH}$ ) vs. Supply Voltage.



**FIGURE 2-12:** Output Resistance ( $R_{OL}$ ) vs. Supply Voltage.

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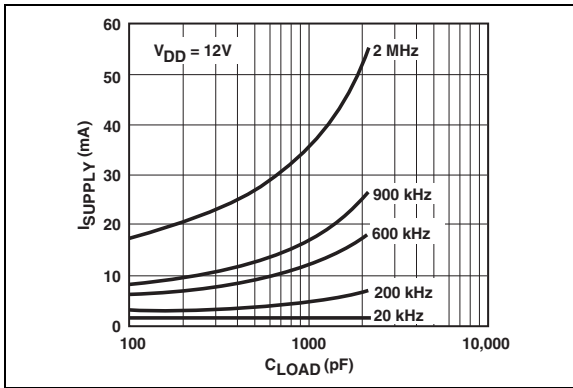
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$  with  $4.5\text{V} \leq V_{DD} \leq 18\text{V}$ .



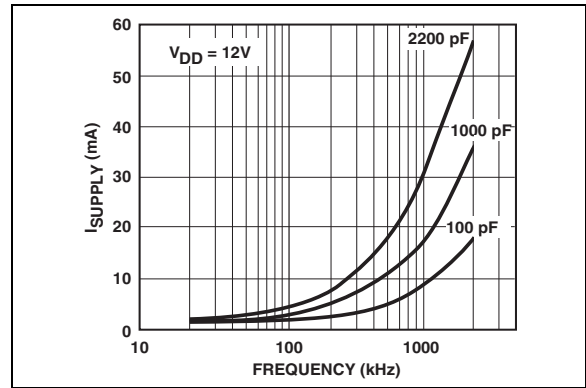
**FIGURE 2-13:** Supply Current vs. Capacitive Load.



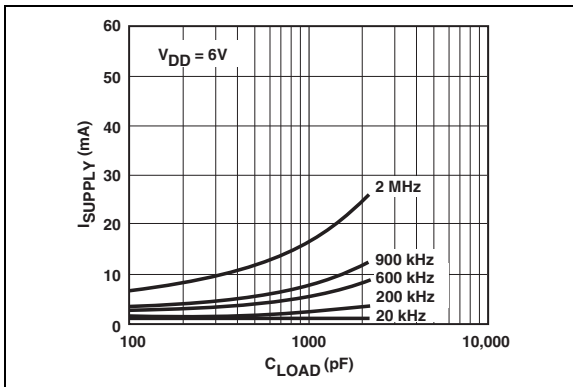
**FIGURE 2-16:** Supply Current vs. Frequency.



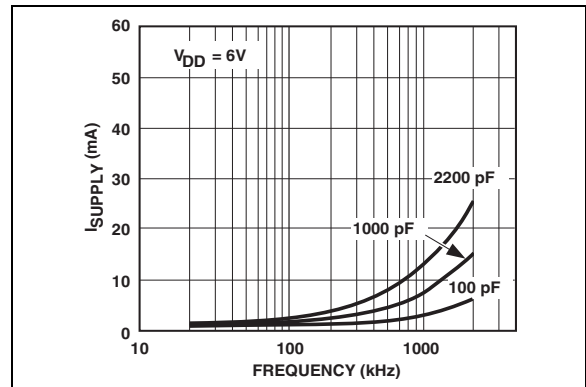
**FIGURE 2-14:** Supply Current vs. Capacitive Load.



**FIGURE 2-17:** Supply Current vs. Frequency.



**FIGURE 2-15:** Supply Current vs. Capacitive Load.



**FIGURE 2-18:** Supply Current vs. Frequency.

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



**FIGURE 2-19:** Crossover Energy vs. Supply Voltage.



## 3.0 PIN DESCRIPTIONS

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

**TABLE 3-1: PIN FUNCTION TABLE (1)**

8-Pin PDIP/ MSOP/SOIC	8-Pin DFN	Symbol	Description
1	1	NC	No connection
2	2	IN A	Input A
3	3	GND	Ground
4	4	IN B	Input B
5	5	OUT B	Output B
6	6	V <sub>DD</sub>	Supply input
7	7	OUT A	Output A
8	8	NC	No connection
—	PAD	NC	Exposed Metal Pad

**Note 1:** Duplicate pins must be connected for proper operation.

### 3.1 Inputs A and B

MOSFET driver inputs A and B are high-impedance, TTL/CMOS compatible inputs. These inputs also have 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.

### 3.2 Ground (GND)

Ground is the device return pin. The ground pin(s) should have a low-impedance connection to the bias supply source return. High peak currents will flow out the ground pin(s) when the capacitive load is being discharged.

### 3.3 Output A and B

MOSFET driver outputs A and B are low-impedance, CMOS push-pull style outputs. The pull-down and pull-up devices are of equal strength, making the rise and fall times equivalent.

### 3.4 Supply Input (V<sub>DD</sub>)

The V<sub>DD</sub> 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<sub>DD</sub> input should be bypassed with local ceramic capacitors. The value of these capacitors should be chosen based on the capacitive load that is being driven. A value of 1.0 μF is suggested.

### 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.

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## 4.0 APPLICATIONS INFORMATION



FIGURE 4-1: Switching Time Test Circuit.

## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

8-Lead DFN



Example:



8-Lead MSOP



Example:



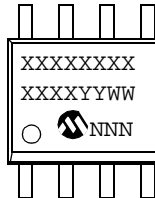
8-Lead PDIP (300 mil)



Example:



8-Lead SOIC (150 mil)



Example:



<b>Legend:</b>	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.

# TC4426/TC4427/TC4428

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

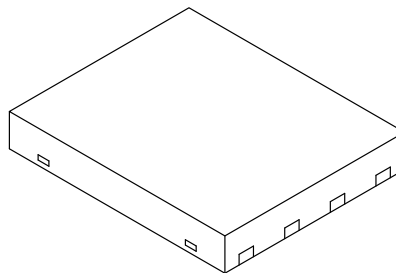
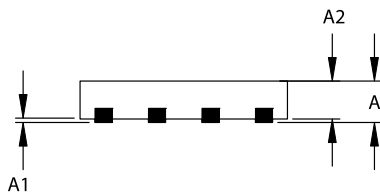
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



TOP VIEW



BOTTOM VIEW



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

# TC4426/TC4427/TC4428

## 8-Lead Plastic Micro Small Outline Package (MS) (MSOP)

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



Dimension Limits	Units	INCHES			MILLIMETERS*		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p	.026 BSC			0.65 BSC		
Overall Height	A	-	-	.043	-	-	1.10
Molded Package Thickness	A2	.030	.033	.037	0.75	0.85	0.95
Standoff	A1	.000	-	.006	0.00	-	0.15
Overall Width	E	.193 BSC			4.90 BSC		
Molded Package Width	E1	.118 BSC			3.00 BSC		
Overall Length	D	.118 BSC			3.00 BSC		
Foot Length	L	.016	.024	.031	0.40	0.60	0.80
Footprint (Reference)	F	.037 REF			0.95 REF		
Foot Angle	φ	0°	-	8°	0°	-	8°
Lead Thickness	c	.003	.006	.009	0.08	-	0.23
Lead Width	B	.009	.012	.016	0.22	-	0.40
Mold Draft Angle Top	α	5°	-	15°	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°	5°	-	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.

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

See ASME Y14.5M

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

See ASME Y14.5M

JEDEC Equivalent: MO-187

Drawing No. C04-111

Revised 07-21-05

# TC4426/TC4427/TC4428

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

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



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

# TC4426/TC4427/TC4428

## 8-Lead Plastic Small Outline (SN) – Narrow, 150 mil (SOIC)

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



Dimension Limits	Units	INCHES*			MILLIMETERS		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n	8			8		
Pitch	P		.050			1.27	
Overall Height	A	.053	.061	.069	1.35	1.55	1.75
Molded Package Thickness	A2	.052	.056	.061	1.32	1.42	1.55
Standoff §	A1	.004	.007	.010	0.10	0.18	0.25
Overall Width	E	.228	.237	.244	5.79	6.02	6.20
Molded Package Width	E1	.146	.154	.157	3.71	3.91	3.99
Overall Length	D	.189	.193	.197	4.80	4.90	5.00
Chamfer Distance	h	.010	.015	.020	0.25	0.38	0.51
Foot Length	L	.019	.025	.030	0.48	0.62	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	.013	.017	.020	0.33	0.42	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

§ 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-012

Drawing No. C04-057

# TC4426/TC4427/TC4428

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## 6.0 REVISION HISTORY

### Revision E (December 2012)

Added a note to each package outline drawing.



# TC4426/TC4427/TC4428

## 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>	X	XX	XXX	X	<b>Examples:</b>
Device	Temperature Range	Package	Tape & Reel	PB Free	
Device:	TC4426:	1.5A Dual MOSFET Driver, Inverting			a) TC4426COA: 1.5A Dual Inverting MOSFET driver, 0°C to +70°C SOIC package.
	TC4427:	1.5A Dual MOSFET Driver, Non-Inverting			b) TC4426EUA: 1.5A Dual Inverting MOSFET driver, -40°C to +85°C. MSOP package.
	TC4428:	1.5A Dual MOSFET Driver, Complementary			c) TC4426EMF: 1.5A Dual Inverting MOSFET driver, -40°C to +85°C, DFN package.
Temperature Range:	C =	0°C to +70°C (PDIP and SOIC only)			a) TC4427CPA: 1.5A Dual Non-Inverting MOSFET driver, 0°C to +70°C PDIP package.
	E =	-40°C to +85°C			b) TC4427EPA: 1.5A Dual Non-Inverting MOSFET driver, -40°C to +85°C PDIP package.
	V =	-40°C to +125°C			a) TC4428COA713: 1.5A Dual Complementary MOSFET driver, 0°C to +70°C, SOIC package, Tape and Reel.
Package:	MF =	Dual, Flat, No-Lead (6X5 mm Body), 8-lead			b) TC4428EMF: 1.5A Dual Complementary, MOSFET driver, -40°C to +85°C DFN package.
	MF713 =	Dual, Flat, No-Lead (6X5 mm Body), 8-lead (Tape and Reel)			
	OA =	Plastic SOIC, (150 mil Body), 8-lead			
	OA713 =	Plastic SOIC, (150 mil Body), 8-lead (Tape and Reel)			
	PA =	Plastic DIP (300 mil Body), 8-lead			
	UA =	Plastic Micro Small Outline (MSOP), 8-lead			
	UA713 =	Plastic Micro Small Outline (MSOP), 8-lead (Tape and Reel)			

## Sales and Support

### Data Sheets

Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. 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.

### Customer Notification System

Register on our web site ([www.microchip.com/cn](http://www.microchip.com/cn)) to receive the most current information on our products.

# TC4426/TC4427/TC4428

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NOTES:

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**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.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

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Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

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#### Как с нами связаться

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