

## 3A High-Speed MOSFET Drivers

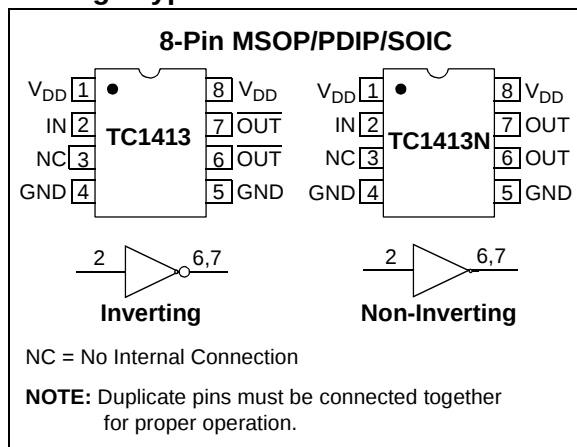
### Features

- Latch-Up Protected: Will Withstand 500 mA Reverse Current
- Input Will Withstand Negative Inputs Up to 5V
- ESD Protected: 4 kV
- High Peak Output Current: 3A
- Wide Input Supply Voltage Operating Range:
  - 4.5V to 16V
- High Capacitive Load Drive Capability:
  - 1800 pF in 20 nsec
- Short Delay Time: 35 nsec Typ
- Matched Delay Times
- Low Supply Current
  - With Logic '1' Input: 500  $\mu$ A
  - With Logic '0' Input: 100  $\mu$ A
- Low Output Impedance: 2.7 $\Omega$
- Available in Space-Saving 8-pin MSOP Package
- Pinout Same as TC1410/TC1411/TC1412

### Applications

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

### Package Type



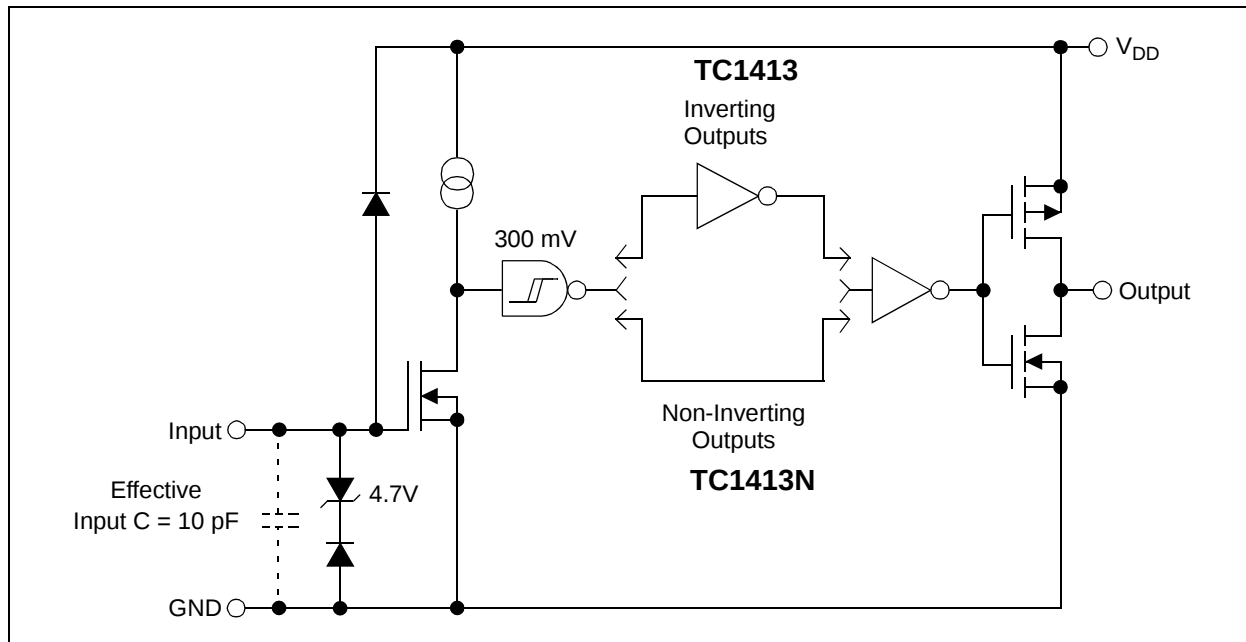
### General Description

The TC1413/TC1413N are 3A CMOS buffers/drivers. 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 the ground pin. They can accept, without damage or logic upset, up to 500 mA of current of either polarity being forced back into their output. All terminals are fully protected against up to 4 kV of electrostatic discharge.

As MOSFET drivers, the TC1413/TC1413N can easily charge an 1800 pF gate capacitance in 20 nsec with matched rise and fall times, and provide low enough impedance in both the ON and the OFF states to ensure the MOSFET's intended state will not be affected, even by large transients. The leading and trailing edge propagation delay times are also matched to allow driving short-duration inputs with greater accuracy.

# TC1413/TC1413N

## Functional Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

Supply Voltage ..... +20V  
 Input Voltage .....  $V_{DD} + 0.3V$  to GND – 5.0V  
 Power Dissipation ( $T_A \leq 70^\circ C$ )  
   MSOP ..... 340 mW  
   PDIP ..... 730 mW  
   SOIC ..... 470 mW  
 Storage Temperature Range .....  $-65^\circ C$  to  $+150^\circ C$   
 Maximum Junction Temperature .....  $+150^\circ C$

† 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

| Symbol   | Description                            |
|----------|----------------------------------------|
| $V_{DD}$ | Supply input, 4.5V to 16V              |
| INPUT    | Control input                          |
| NC       | No connection                          |
| GND      | Ground                                 |
| GND      | Ground                                 |
| OUTPUT   | CMOS push-pull output, common to pin 7 |
| OUTPUT   | CMOS push-pull output, common to pin 6 |
| $V_{DD}$ | Supply input, 4.5V to 16V              |

## DC ELECTRICAL CHARACTERISTICS

**Electrical Specifications:** Unless otherwise noted, over operating temperature range with  $4.5V \leq V_{DD} \leq 16V$ . Typical values are measured at  $T_A = +25^\circ C$ ,  $V_{DD} = 16V$ .

| Parameters                                    | Sym       | Min              | Typ               | Max               | Units    | Conditions                                                                                                                               |
|-----------------------------------------------|-----------|------------------|-------------------|-------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input</b>                                  |           |                  |                   |                   |          |                                                                                                                                          |
| Logic '1', High Input Voltage                 | $V_{IH}$  | 2.0              | —                 | —                 | V        |                                                                                                                                          |
| Logic '0', Low Input Voltage                  | $V_{IL}$  | —                | —                 | 0.8               | V        |                                                                                                                                          |
| Input Current                                 | $I_{IN}$  | -1.0<br>-10      | —<br>—            | 1.0<br>10         | $\mu A$  | $0V \leq V_{IN} \leq V_{DD}$ , $T_A = +25^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$                                            |
| <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                             | $R_O$     | —<br>—<br>—      | 2.7<br>3.3<br>3.3 | 4.0<br>5.0<br>5.0 | $\Omega$ | $V_{DD} = 16V$ , $I_O = 10 mA$ , $T_A = +25^\circ C$<br>$0^\circ C \leq T_A \leq +70^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$ |
| Peak Output Current                           | $I_{PK}$  | —                | 3.0               | —                 | A        | $V_{DD} = 16V$                                                                                                                           |
| Latch-Up Protection Withstand Reverse Current | $I_{REV}$ | —                | 0.5               | —                 | A        | Duty cycle $\leq 2\%$ , $t \leq 300 \mu sec$ , $V_{DD} = 16V$                                                                            |
| <b>Switching Time (Note 1)</b>                |           |                  |                   |                   |          |                                                                                                                                          |
| Rise Time                                     | $t_R$     | —<br>—<br>—      | 20<br>22<br>24    | 28<br>33<br>33    | nsec     | $T_A = +25^\circ C$<br>$0^\circ C \leq T_A \leq +70^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$ , <b>Figure 4-1</b>              |
| Fall Time                                     | $t_F$     | —<br>—<br>—      | 20<br>22<br>24    | 28<br>33<br>33    | nsec     | $T_A = +25^\circ C$<br>$0^\circ C \leq T_A \leq +70^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$ , <b>Figure 4-1</b>              |

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

# TC1413/TC1413N

## DC ELECTRICAL CHARACTERISTICS (CONTINUED)

| <b>Electrical Specifications:</b> Unless otherwise noted, over operating temperature range with $4.5V \leq V_{DD} \leq 16V$ . Typical values are measured at $T_A = +25^{\circ}C$ , $V_{DD} = 16V$ . |          |     |     |      |       |                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----|-----|------|-------|------------------------------------------------------------------------------------------------------------------------------------|
| Parameters                                                                                                                                                                                           | Sym      | Min | Typ | Max  | Units | Conditions                                                                                                                         |
| Delay Time                                                                                                                                                                                           | $t_{D1}$ | —   | 35  | 45   | nsec  | $T_A = +25^{\circ}C$ ,<br>$0^{\circ}C \leq T_A \leq +70^{\circ}C$<br>$-40^{\circ}C \leq T_A \leq +85^{\circ}C$ , <b>Figure 4-1</b> |
|                                                                                                                                                                                                      |          | —   | 40  | 50   |       |                                                                                                                                    |
|                                                                                                                                                                                                      |          | —   | 40  | 50   |       |                                                                                                                                    |
| Delay Time                                                                                                                                                                                           | $t_{D2}$ | —   | 35  | 45   | nsec  | $T_A = +25^{\circ}C$<br>$0^{\circ}C \leq T_A \leq +70^{\circ}C$<br>$-40^{\circ}C \leq T_A \leq +85^{\circ}C$ , <b>Figure 4-1</b>   |
|                                                                                                                                                                                                      |          | —   | 40  | 50   |       |                                                                                                                                    |
|                                                                                                                                                                                                      |          | —   | 40  | 50   |       |                                                                                                                                    |
| <b>Power Supply</b>                                                                                                                                                                                  |          |     |     |      |       |                                                                                                                                    |
| Power Supply Current                                                                                                                                                                                 | $I_S$    | —   | 0.5 | 1.0  | mA    | $V_{IN} = 3V$ , $V_{DD} = 16V$                                                                                                     |
|                                                                                                                                                                                                      |          | —   | 0.1 | 0.15 |       | $V_{IN} = 0V$                                                                                                                      |

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

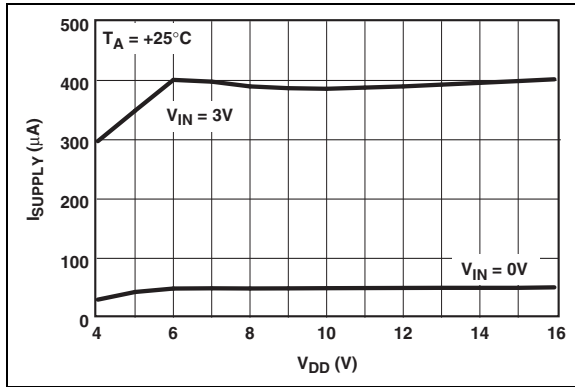
## TEMPERATURE CHARACTERISTICS

| <b>Electrical Specifications:</b> 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  | $^\circ C$   |            |
| 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-MSOP                                                                                       | $\theta_{JA}$ | —   | 206 | —    | $^\circ C/W$ |            |
| Thermal Resistance, 8L-PDIP                                                                                       | $\theta_{JA}$ | —   | 125 | —    | $^\circ C/W$ |            |
| Thermal Resistance, 8L-SOIC                                                                                       | $\theta_{JA}$ | —   | 155 | —    | $^\circ C/W$ |            |

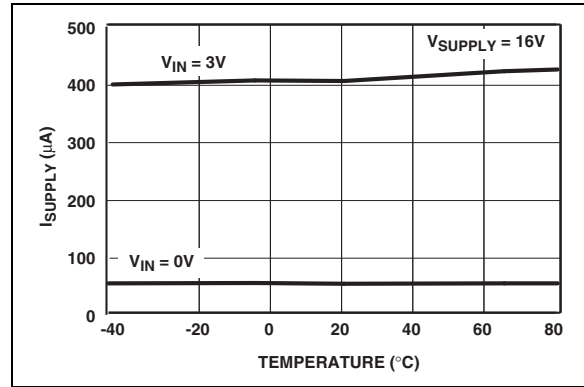
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

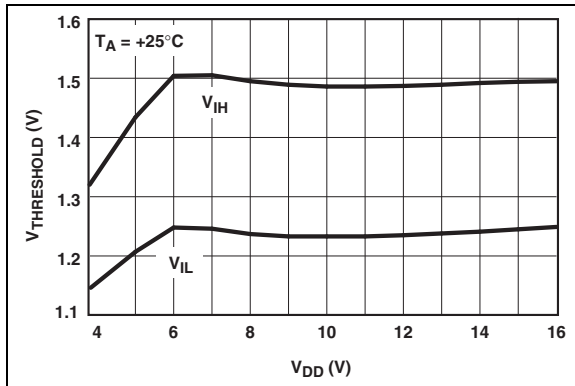
**Note:** Unless otherwise indicated, over operating temperature range with  $4.5V \leq V_{DD} \leq 16V$ .



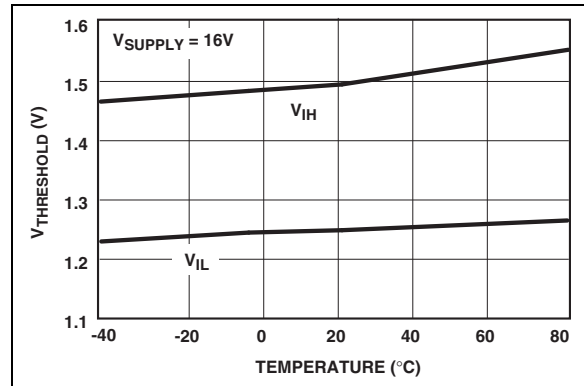
**FIGURE 2-1:** Quiescent Supply Current vs. Supply Voltage.



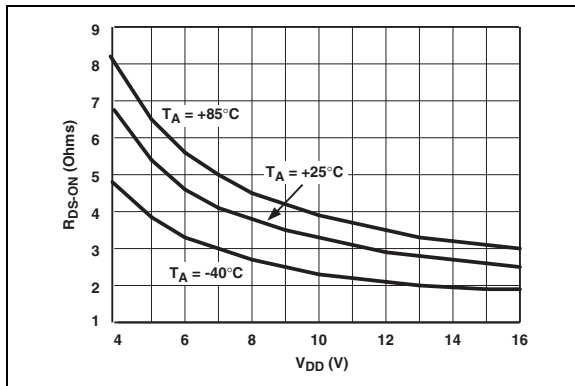
**FIGURE 2-4:** Quiescent Supply Current vs. Temperature.



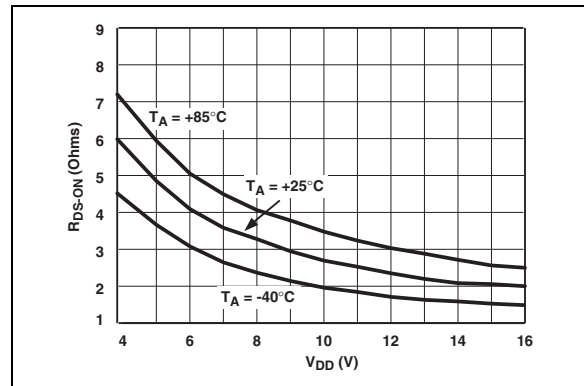
**FIGURE 2-2:** Input Threshold vs. Supply Voltage.



**FIGURE 2-5:** Input Threshold vs. Temperature.



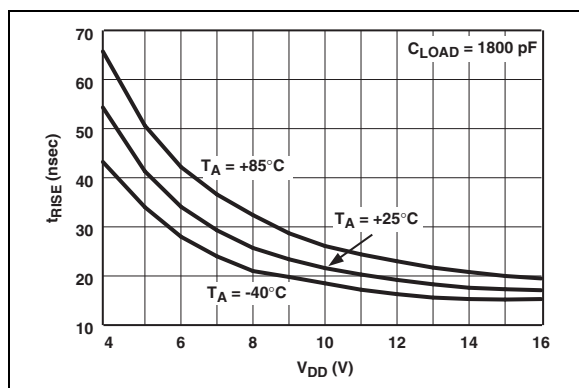
**FIGURE 2-3:** High-State Output Resistance vs. Supply Voltage



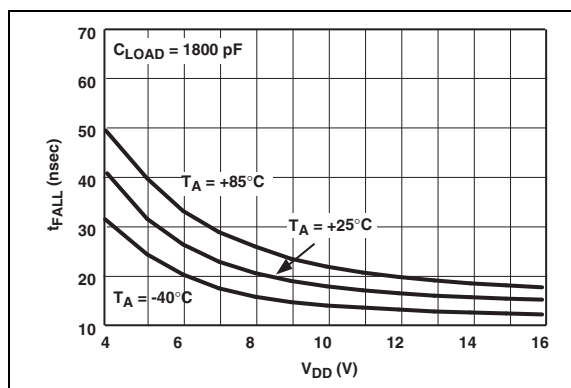
**FIGURE 2-6:** Low-State Output Resistance vs. Supply Voltage

# TC1413/TC1413N

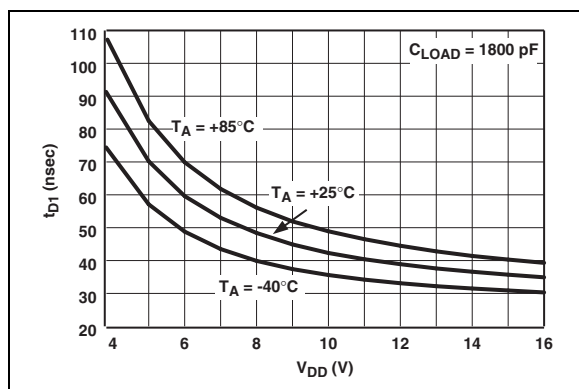
**Note:** Unless otherwise indicated, over operating temperature range with  $4.5V \leq V_{DD} \leq 16V$ .



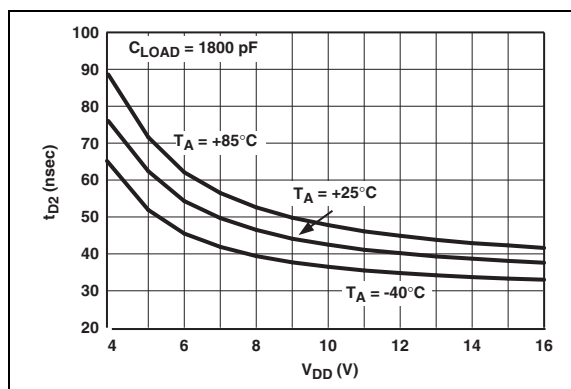
**FIGURE 2-7:** Rise Time vs. Supply Voltage.



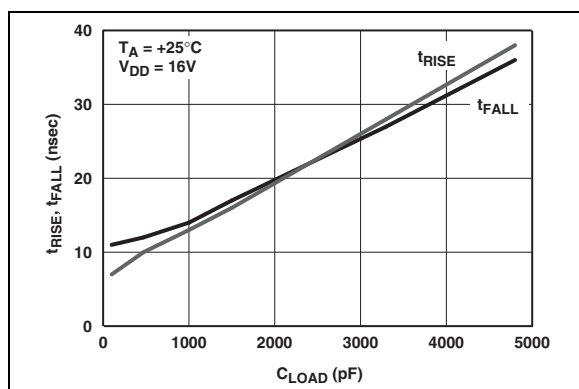
**FIGURE 2-10:** Fall Time vs. Supply Voltage.



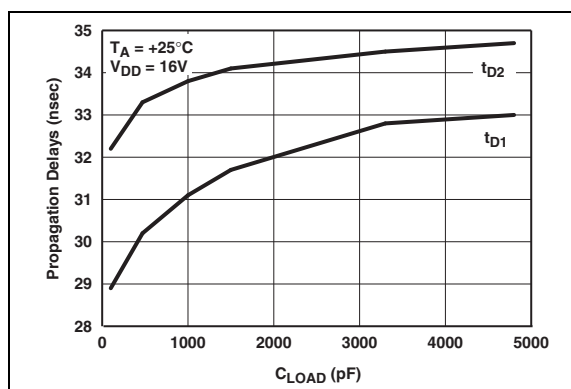
**FIGURE 2-8:** Propagation Delay vs. Supply Voltage.



**FIGURE 2-11:** Propagation Delay vs. Supply Voltage.



**FIGURE 2-9:** Rise and Fall Times vs. Capacitive Load.



**FIGURE 2-12:** Propagation Delays vs. Capacitive Load.

## 3.0 PIN DESCRIPTIONS

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

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

| Pin No. | Symbol          | Description                            |
|---------|-----------------|----------------------------------------|
| 1       | V <sub>DD</sub> | Supply input, 4.5V to 16V              |
| 2       | INPUT           | Control input                          |
| 3       | NC              | No connection                          |
| 4       | GND             | Ground                                 |
| 5       | GND             | Ground                                 |
| 6       | OUTPUT          | CMOS push-pull output, common to pin 7 |
| 7       | OUTPUT          | CMOS push-pull output, common to pin 6 |
| 8       | V <sub>DD</sub> | Supply input, 4.5V to 16V              |

### 3.1 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 16V with respect to the ground pin. The V<sub>DD</sub> 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 value of 1.0  $\mu$ F is suggested.

### 3.2 Control Input (INPUT)

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

### 3.3 CMOS Push-Pull Output (OUTPUT)

The MOSFET driver output is a low-impedance, CMOS push-pull style output, capable of driving a capacitive load with 3A peak currents.

### 3.4 Ground (GND)

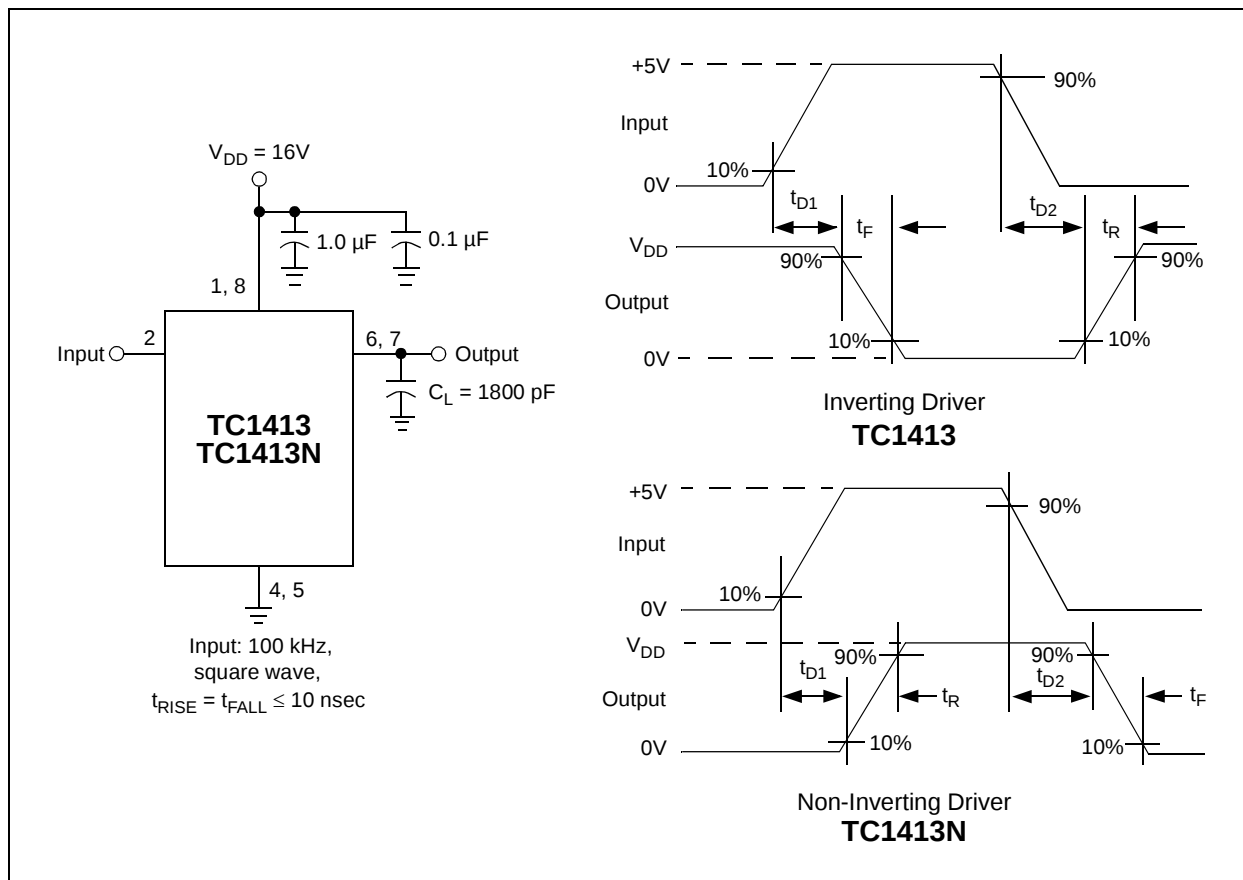
The ground pins are the return path for the bias current and for the high peak currents that discharge the load capacitor. The ground pins should be tied into a ground plane or have very short traces to the bias supply source return.

### 3.5 No Connect (NC)

No internal connection.

# TC1413/TC1413N

## 4.0 APPLICATION INFORMATION

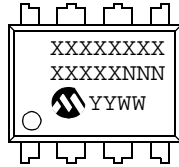


**FIGURE 4-1:** Switching Time Test Circuit.

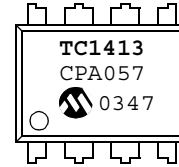
## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

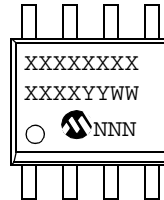
8-Lead PDIP (300 mil)



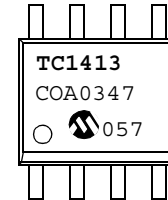
Example:



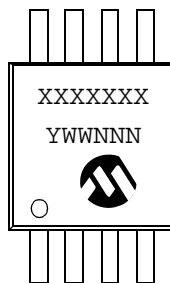
8-Lead SOIC (150 mil)



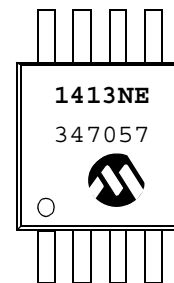
Example:



8-Lead MSOP



Example:



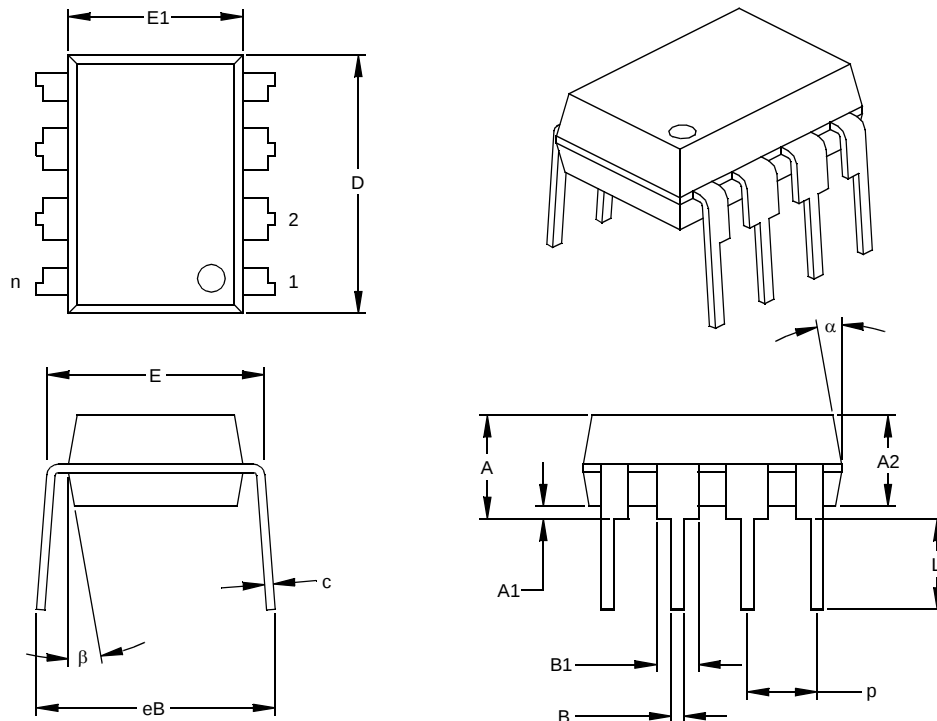
|                |        |                                                                                                                  |
|----------------|--------|------------------------------------------------------------------------------------------------------------------|
| <b>Legend:</b> | 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.

# TC1413/TC1413N

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

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



| Units                      |      | INCHES* |      |      | MILLIMETERS |      |       |
|----------------------------|------|---------|------|------|-------------|------|-------|
| Dimension Limits           |      | 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:

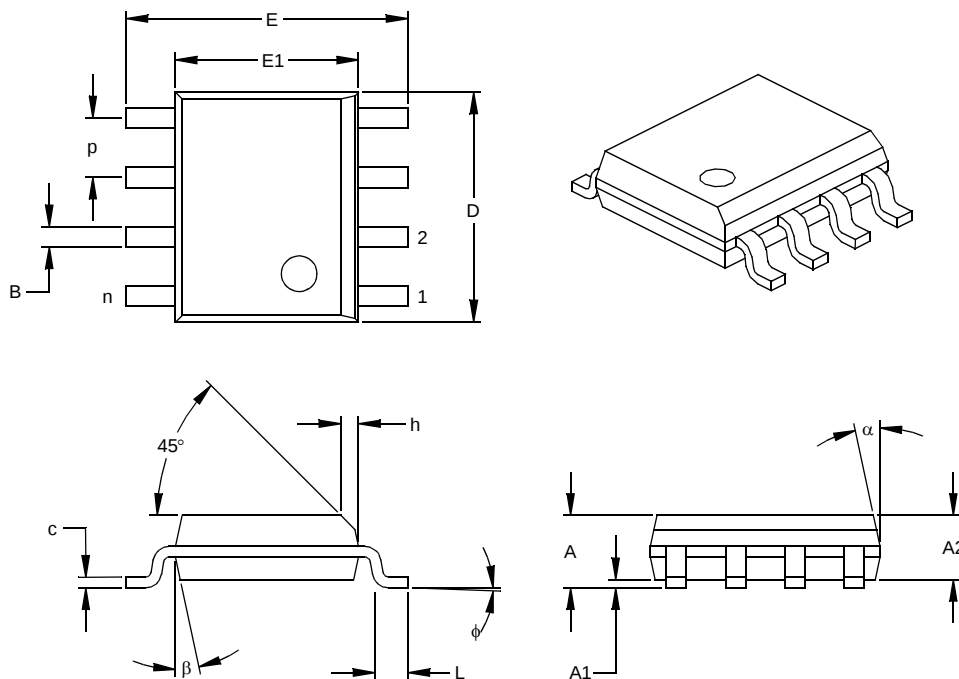
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: MS-001

Drawing No. C04-018

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

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



| 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      | .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.

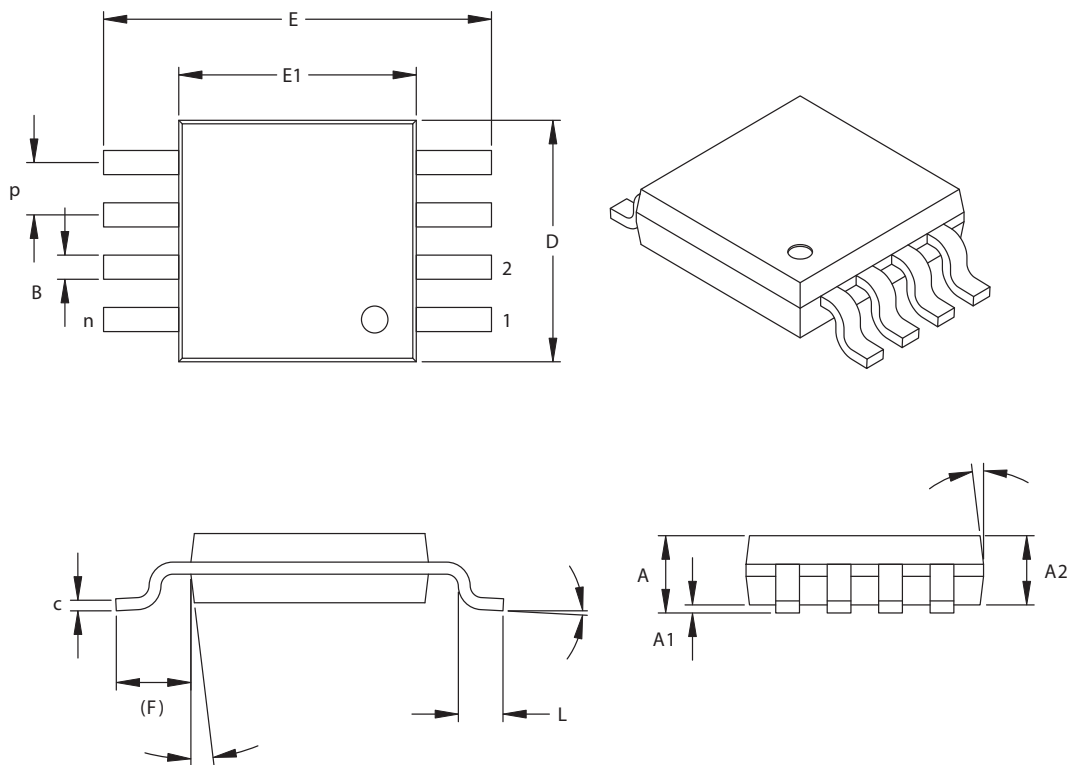
JEDEC Equivalent: MS-012

Drawing No. C04-057

# TC1413/TC1413N

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

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



| Units                    |    | INCHES   |      |      | MILLIMETERS* |      |      |
|--------------------------|----|----------|------|------|--------------|------|------|
| Dimension Limits         |    | 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               |    | 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     |    | 5°       | -    | 15°  | 5°           | -    | 15°  |
| Mold Draft Angle Bottom  |    | 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.

JEDEC Equivalent: MO-187

Drawing No. C04-111

## 6.0 REVISION HISTORY

### Revision D (December 2012)

Added a note to each package outline drawing.

# TC1413/TC1413N

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NOTES:

## 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> |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Device             | Temperature Range                                                                                                                                                                                                                                                                                                                | Package    |
| Device:            | TC1413: 3 A Single MOSFET Driver, Inverting<br>TC1413N: 3 A Single MOSFET Driver, Non-Inverting                                                                                                                                                                                                                                  |            |
| Temperature Range: | C = 0°C to +70°C<br>E = -40°C to +85°C                                                                                                                                                                                                                                                                                           |            |
| Package:           | OA = Plastic SOIC, (150 mil Body), 8-lead<br>OA713 = Plastic SOIC, (150 mil Body), 8-lead (Tape and Reel)<br>UA = Plastic Micro Small Outline (MSOP), 8-lead *<br>UA713 = Plastic Micro Small Outline (MSOP), 8-lead * (Tape and Reel)<br>PA = Plastic DIP (300 mil Body), 8-lead<br>* MSOP package is only available in E-Temp. |            |

**Examples:**

- a) TC1413COA: 3A Single MOSFET driver, SOIC package, 0°C to +70°C.
- b) TC1413CPA: 3A Single MOSFET driver, PDIP package, 0°C to +70°C.
- c) TC1413EUA713: Tape and Reel, 3A Single MOSFET driver, MSOP package, -40°C to +85°C.
- a) TC1413NCPA: 3A Single MOSFET driver, PDIP package, 0°C to +70°C.
- b) TC1413NEPA: 3A Single MOSFET driver, PDIP package, -40°C to +85°C.
- c) TC1413NEUA: 3A Single MOSFET driver, MSOP package, -40°C to +85°C.

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# TC1413/TC1413N

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NOTES:

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