

### General Description

MIC4451 and MIC4452 CMOS MOSFET drivers are tough, efficient, and easy to use. The MIC4451 is an inverting driver, while the MIC4452 is a non-inverting driver.

Both versions are capable of 12A (peak) output and can drive the largest MOSFETs with an improved safe operating margin. The MIC4451/4452 accepts any logic input from 2.4V to  $V_S$  without external speed-up capacitors or resistor networks. Proprietary circuits allow the input to swing negative by as much as 5V without damaging the part. Additional circuits protect against damage from electrostatic discharge.

MIC4451/4452 drivers can replace three or more discrete components, reducing PCB area requirements, simplifying product design, and reducing assembly cost.

Modern Bipolar/CMOS/DMOS construction guarantees freedom from latch-up. The rail-to-rail swing capability of CMOS/DMOS insures adequate gate voltage to the MOSFET during power up/down sequencing. Since these devices are fabricated on a self-aligned process, they have very low crossover current, run cool, use little power, and are easy to drive.

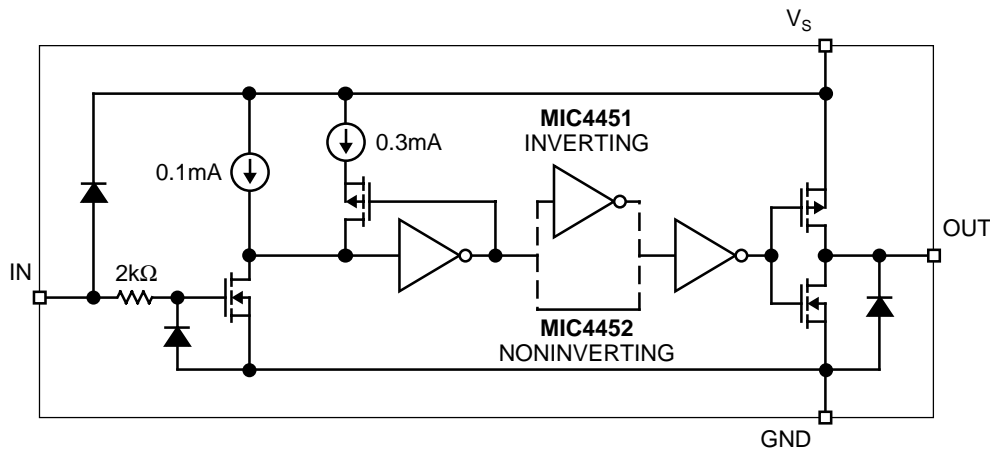
### Features

- BiCMOS/DMOS Construction
- Latch-Up Proof: Fully Isolated Process is Inherently Immune to Any Latch-up.
- Input Will Withstand Negative Swing of Up to 5V
- Matched Rise and Fall Times ..... 25ns
- High Peak Output Current ..... 12A Peak
- Wide Operating Range ..... 4.5V to 18V
- High Capacitive Load Drive ..... 62,000pF
- Low Delay Time ..... 30ns Typ.
- Logic High Input for Any Voltage from 2.4V to  $V_S$
- Low Supply Current ..... 450 $\mu$ A With Logic 1 Input
- Low Output Impedance ..... 1.0 $\Omega$
- Output Voltage Swing to Within 25mV of GND or  $V_S$
- Low Equivalent Input Capacitance (typ) ..... 7pF

### Applications

- Switch Mode Power Supplies
- Motor Controls
- Pulse Transformer Driver
- Class-D Switching Amplifiers
- Line Drivers
- Driving MOSFET or IGBT Parallel Chip Modules
- Local Power ON/OFF Switch
- Pulse Generators

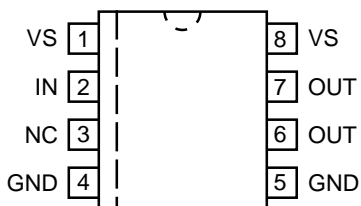
### Functional Diagram



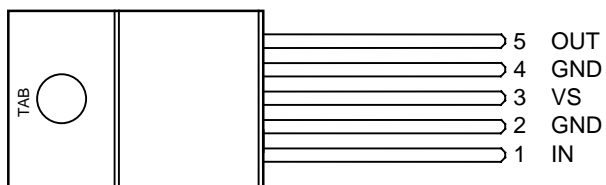
### Ordering Information

| Part No.  | Temperature Range | Package      | Configuration |
|-----------|-------------------|--------------|---------------|
| MIC4451BN | -40°C to +85°C    | 8-Pin PDIP   | Inverting     |
| MIC4451BM | -40°C to +85°C    | 8-Pin SOIC   | Inverting     |
| MIC4451CT | 0°C to +70°C      | 5-Pin TO-220 | Inverting     |
| MIC4452BN | -40°C to +85°C    | 8-Pin PDIP   | Non-Inverting |
| MIC4452BM | -40°C to +85°C    | 8-Pin SOIC   | Non-Inverting |
| MIC4452CT | 0°C to +70°C      | 5-Pin TO-220 | Non-Inverting |

### Pin Configurations



Plastic DIP (N)  
SOIC (M)



TO-220-5 (T)

### Pin Description

| Pin Number TO-220-5 | Pin Number DIP, SOIC | Pin Name       | Pin Function  |
|---------------------|----------------------|----------------|---|
| 1                   | 2                    | IN             | Control Input   |
| 2, 4                | 4, 5                 | GND            | Ground: Duplicate pins must be externally connected together.       |
| 3, TAB              | 1, 8                 | V <sub>S</sub> | Supply Input: Duplicate pins must be externally connected together. |
| 5                   | 6, 7                 | OUT            | Output: Duplicate pins must be externally connected together.       |
|                     | 3                    | NC             | Not connected.  |

**Absolute Maximum Ratings** (Notes 1, 2 and 3)

|  |                                 |
|--|---------------------------------|
| Supply Voltage .....                             | 20V                             |
| Input Voltage .....                              | $V_S + 0.3V$ to GND – 5V        |
| Input Current ( $V_{IN} > V_S$ ) .....           | 50 mA                           |
| Power Dissipation, $T_{AMBIENT} \leq 25^\circ C$ |                                 |
| PDIP .....                                       | 960mW                           |
| SOIC .....                                       | 1040mW                          |
| 5-Pin TO-220 .....                               | 2W                              |
| Power Dissipation, $T_{CASE} \leq 25^\circ C$    |                                 |
| 5-Pin TO-220 .....                               | 12.5W                           |
| Derating Factors (to Ambient)                    |                                 |
| PDIP .....                                       | 7.7mW/ $^\circ C$               |
| SOIC .....                                       | 8.3 mW/ $^\circ C$              |
| 5-Pin TO-220 .....                               | 17mW/ $^\circ C$                |
| Storage Temperature .....                        | $-65^\circ C$ to $+150^\circ C$ |
| Lead Temperature (10 sec) .....                  | $300^\circ C$                   |

**Operating Ratings**

|                                      |                                |
|--------------------------------------|--------------------------------|
| Operating Temperature (Chip) .....   | $150^\circ C$                  |
| Operating Temperature (Ambient)      |                                |
| C Version .....                      | $0^\circ C$ to $+70^\circ C$   |
| B Version .....                      | $-40^\circ C$ to $+85^\circ C$ |
| Thermal Impedances (To Case)         |                                |
| 5-Pin TO-220 ( $\theta_{JC}$ ) ..... | $10^\circ C/W$                 |

**Electrical Characteristics:**

( $T_A = 25^\circ C$  with  $4.5 V \leq V_S \leq 18 V$  unless otherwise specified.)

| Symbol                         | Parameter  | Conditions                                  | Min          | Typ       | Max        | Units         |
|--------------------------------|--|---|--------------|-----------|------------|---------------|
| <b>INPUT</b>                   |  |   |              |           |            |               |
| $V_{IH}$                       | Logic 1 Input Voltage                            |   | 2.4          | 1.3       |            | V             |
| $V_{IL}$                       | Logic 0 Input Voltage                            |   |              | 1.1       | 0.8        | V             |
| $V_{IN}$                       | Input Voltage Range                              |   | -5           |           | $V_S + 3$  | V             |
| $I_{IN}$                       | Input Current                                    | $0 V \leq V_{IN} \leq V_S$                  | -10          |           | 10         | $\mu A$       |
| <b>OUTPUT</b>                  |  |   |              |           |            |               |
| $V_{OH}$                       | High Output Voltage                              | See Figure 1                                | $V_S - .025$ |           |            | V             |
| $V_{OL}$                       | Low Output Voltage                               | See Figure 1                                |              |           | .025       | V             |
| $R_O$                          | Output Resistance,<br>Output High                | $I_{OUT} = 10 mA, V_S = 18V$                |              | 0.6       | 1.5        | $\Omega$      |
| $R_O$                          | Output Resistance,<br>Output Low                 | $I_{OUT} = 10 mA, V_S = 18V$                |              | 0.8       | 1.5        | $\Omega$      |
| $I_{PK}$                       | Peak Output Current                              | $V_S = 18 V$ (See Figure 6)                 |              | 12        |            | A             |
| $I_{DC}$                       | Continuous Output Current                        |   | 2            |           |            | A             |
| $I_R$                          | Latch-Up Protection<br>Withstand Reverse Current | Duty Cycle $\leq 2\%$<br>$t \leq 300 \mu s$ | >1500        |           |            | mA            |
| <b>SWITCHING TIME</b> (Note 3) |  |   |              |           |            |               |
| $t_R$                          | Rise Time  | Test Figure 1, $C_L = 15,000 pF$            |              | 20        | 40         | ns            |
| $t_F$                          | Fall Time  | Test Figure 1, $C_L = 15,000 pF$            |              | 24        | 50         | ns            |
| $t_{D1}$                       | Delay Time                                       | Test Figure 1                               |              | 15        | 30         | ns            |
| $t_{D2}$                       | Delay Time                                       | Test Figure 1                               |              | 35        | 60         | ns            |
| <b>Power Supply</b>            |  |   |              |           |            |               |
| $I_S$                          | Power Supply Current                             | $V_{IN} = 3 V$<br>$V_{IN} = 0 V$            |              | 0.4<br>80 | 1.5<br>150 | mA<br>$\mu A$ |
| $V_S$                          | Operating Input Voltage                          |   | 4.5          |           | 18         | V             |

### Electrical Characteristics:

(Over operating temperature range with  $4.5V < V_S < 18V$  unless otherwise specified.)

| Symbol                         | Parameter                      | Conditions                     | Min        | Typ        | Max      | Units    |
|--------------------------------|--------------------------------|--------------------------------|------------|------------|----------|----------|
| <b>INPUT</b>                   |                                |                                |            |            |          |          |
| $V_{IH}$                       | Logic 1 Input Voltage          |                                | 2.4        | 1.4        |          | V        |
| $V_{IL}$                       | Logic 0 Input Voltage          |                                |            | 1.0        | 0.8      | V        |
| $V_{IN}$                       | Input Voltage Range            |                                | -5         |            | $V_S+3$  | V        |
| $I_{IN}$                       | Input Current                  | $0V \leq V_{IN} \leq V_S$      | -10        |            | 10       | $\mu A$  |
| <b>OUTPUT</b>                  |                                |                                |            |            |          |          |
| $V_{OH}$                       | High Output Voltage            | Figure 1                       | $V_S-.025$ |            |          | V        |
| $V_{OL}$                       | Low Output Voltage             | Figure 1                       |            |            | 0.025    | V        |
| $R_O$                          | Output Resistance, Output High | $I_{OUT} = 10mA, V_S = 18V$    |            | 0.8        | 2.2      | $\Omega$ |
| $R_O$                          | Output Resistance, Output Low  | $I_{OUT} = 10mA, V_S = 18V$    |            | 1.3        | 2.2      | $\Omega$ |
| <b>SWITCHING TIME (Note 3)</b> |                                |                                |            |            |          |          |
| $t_R$                          | Rise Time                      | Figure 1, $C_L = 15,000pF$     |            | 23         | 50       | ns       |
| $t_F$                          | Fall Time                      | Figure 1, $C_L = 15,000pF$     |            | 30         | 60       | ns       |
| $t_{D1}$                       | Delay Time                     | Figure 1                       |            | 20         | 40       | ns       |
| $t_{D2}$                       | Delay Time                     | Figure 1                       |            | 40         | 80       | ns       |
| <b>POWER SUPPLY</b>            |                                |                                |            |            |          |          |
| $I_S$                          | Power Supply Current           | $V_{IN} = 3V$<br>$V_{IN} = 0V$ |            | 0.6<br>0.1 | 3<br>0.4 | mA       |
| $V_S$                          | Operating Input Voltage        |                                | 4.5        |            | 18       | V        |

**NOTE 1:** Functional operation above the absolute maximum stress ratings is not implied.

**NOTE 2:** Static-sensitive device. Store only in conductive containers. Handling personnel and equipment should be grounded to prevent damage from static discharge.

**NOTE 3:** Switching times guaranteed by design.

### Test Circuits

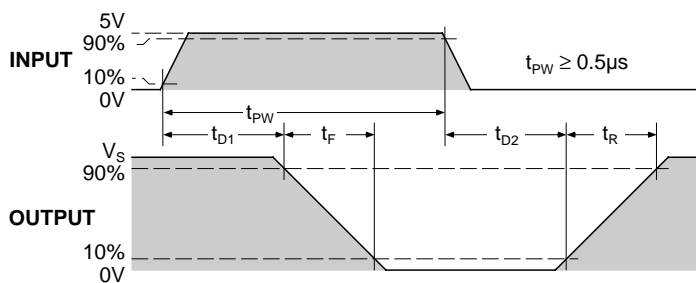
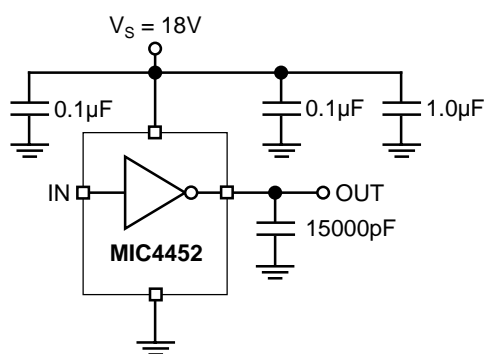
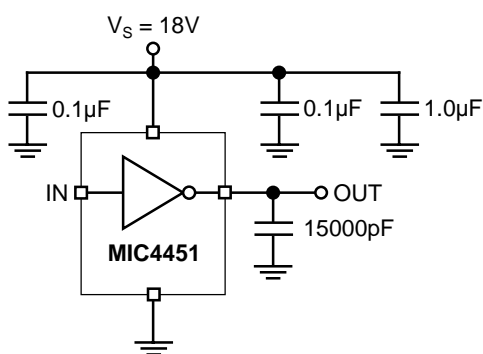


Figure 1. Inverting Driver Switching Time

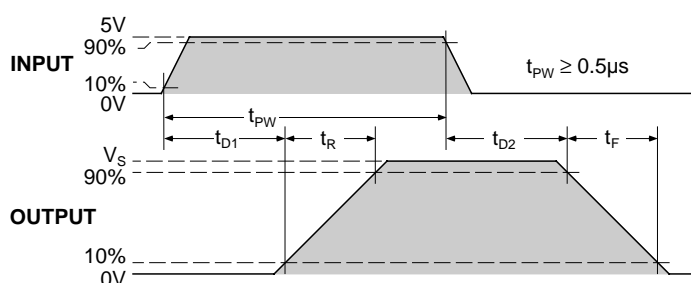
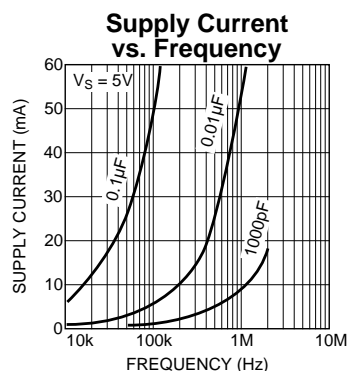
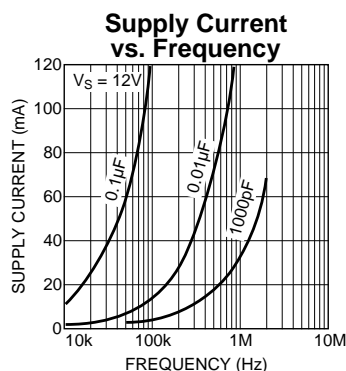
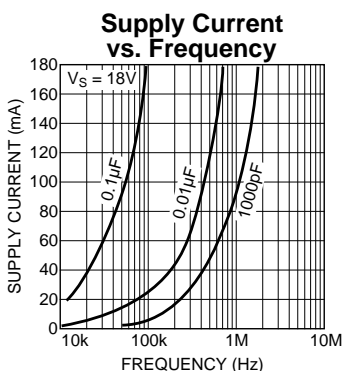
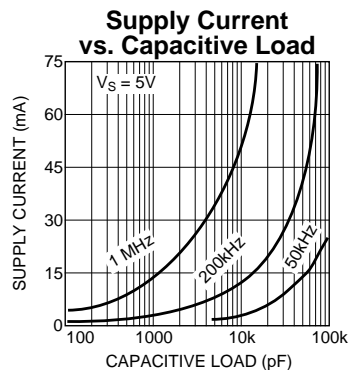
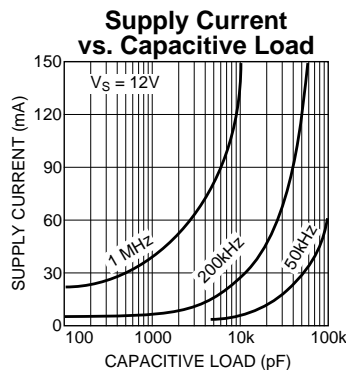
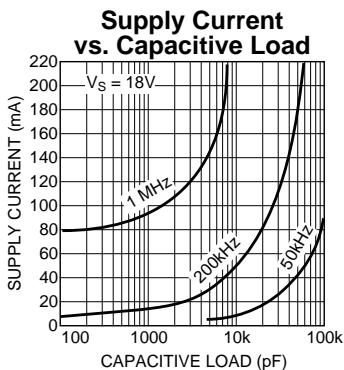
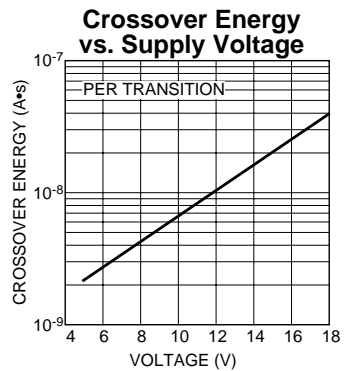
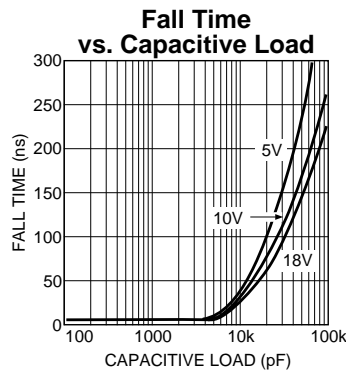
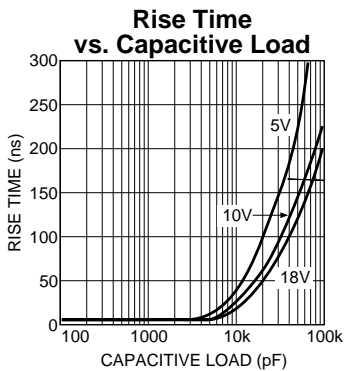
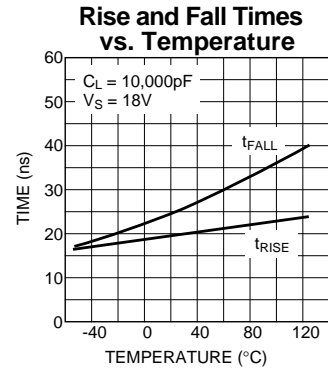
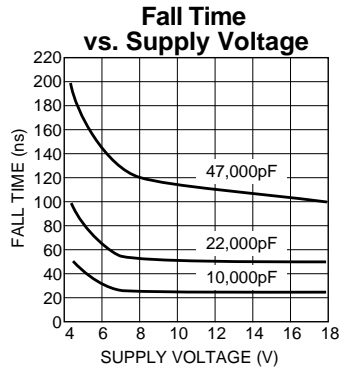
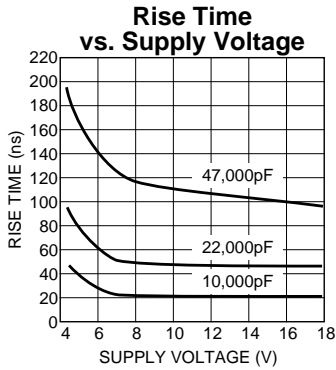
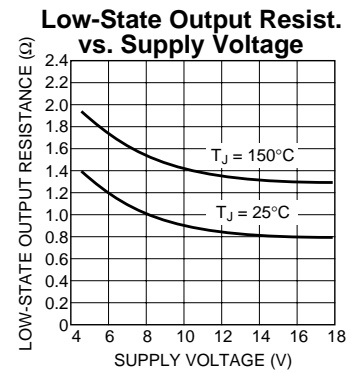
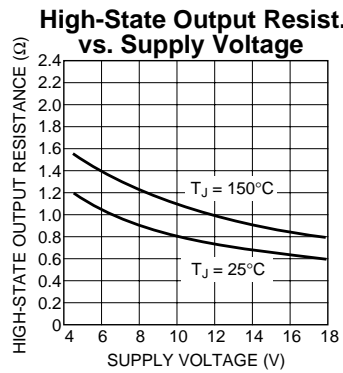
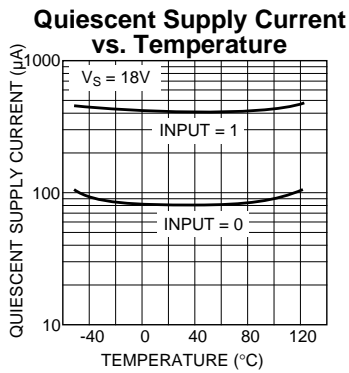
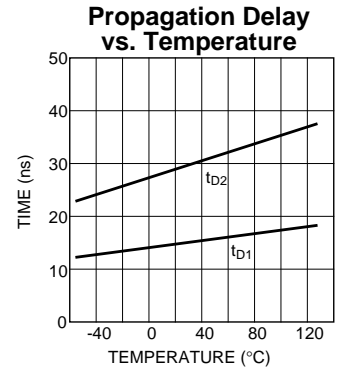
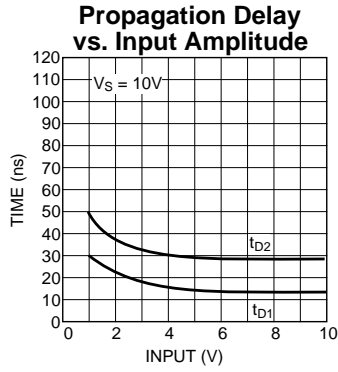
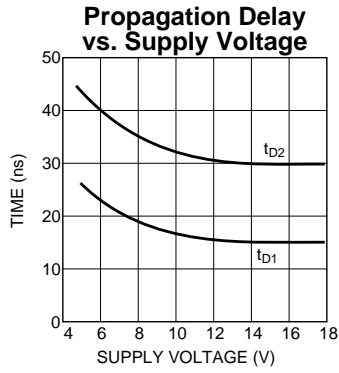


Figure 2. Noninverting Driver Switching Time

# Typical Characteristic Curves



### Typical Characteristic Curves (Cont.)



## Applications Information

### Supply Bypassing

Charging and discharging large capacitive loads quickly requires large currents. For example, changing a 10,000pF load to 18V in 50ns requires 3.6A.

The MIC4451/4452 has double bonding on the supply pins, the ground pins and output pins. This reduces parasitic lead inductance. Low inductance enables large currents to be switched rapidly. It also reduces internal ringing that can cause voltage breakdown when the driver is operated at or near the maximum rated voltage.

Internal ringing can also cause output oscillation due to feedback. This feedback is added to the input signal since it is referenced to the same ground.

To guarantee low supply impedance over a wide frequency range, a parallel capacitor combination is recommended for supply bypassing. Low inductance ceramic disk capacitors with short lead lengths (< 0.5 inch) should be used. A 1µF low ESR film capacitor in parallel with two 0.1µF low ESR ceramic capacitors, (such as AVX RAM GUARD®), provides adequate bypassing. Connect one ceramic capacitor directly between pins 1 and 4. Connect the second ceramic capacitor directly between pins 8 and 5.

### Grounding

The high current capability of the MIC4451/4452 demands careful PC board layout for best performance. Since the MIC4451 is an inverting driver, any ground lead impedance will appear as negative feedback which can degrade switching speed. Feedback is especially noticeable with slow-rise time inputs. The MIC4451 input structure includes 200mV of hysteresis to ensure clean transitions and freedom from oscillation, but attention to layout is still recommended.

Figure 5 shows the feedback effect in detail. As the MIC4451 input begins to go positive, the output goes negative and several amperes of current flow in the ground lead. As little as 0.05Ω of PC trace resistance can produce hundreds of millivolts at the MIC4451 ground pins. If the driving logic is referenced to power ground, the effective logic input level is reduced and oscillation may result.

To insure optimum performance, separate ground traces should be provided for the logic and power connections. Connecting the logic ground directly to the MIC4451 GND pins will ensure full logic drive to the input and ensure fast output switching. Both of the MIC4451 GND pins should, however, still be connected to power ground.

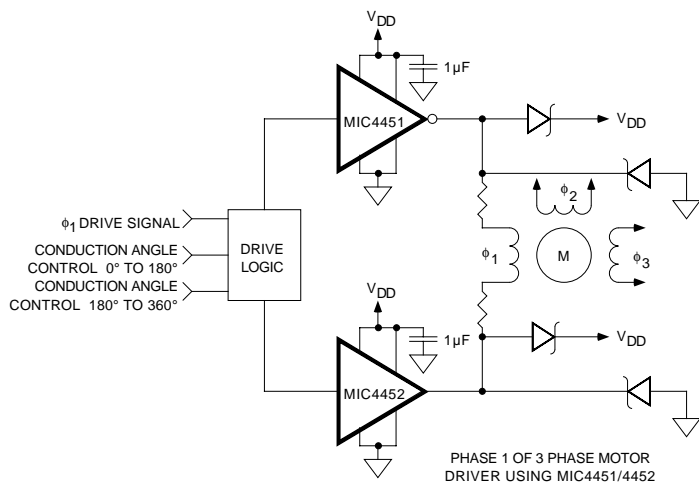


Figure 3. Direct Motor Drive

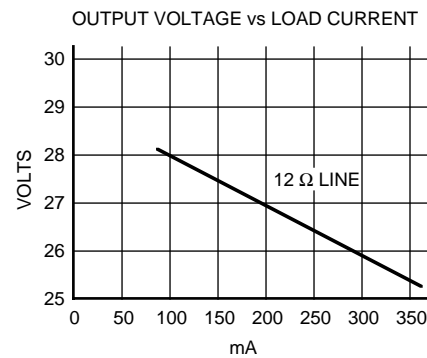
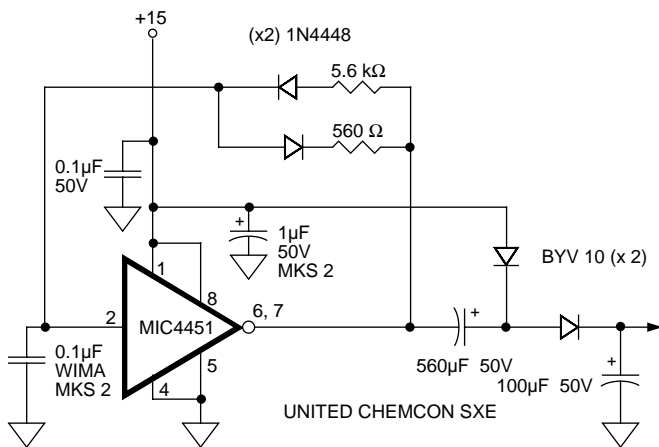


Figure 4. Self Contained Voltage Doubler





driver. The energy stored in a capacitor is described by the equation:

$$E = 1/2 C V^2$$

As this energy is lost in the driver each time the load is charged or discharged, for power dissipation calculations the 1/2 is removed. This equation also shows that it is good practice not to place more voltage on the capacitor than is necessary, as dissipation increases as the square of the voltage applied to the capacitor. For a driver with a capacitive load:

$$P_L = f C (V_S)^2$$

where:

- f = Operating Frequency
- C = Load Capacitance
- V<sub>S</sub> = Driver Supply Voltage

### Inductive Load Power Dissipation

For inductive loads the situation is more complicated. For the part of the cycle in which the driver is actively forcing current into the inductor, the situation is the same as it is in the resistive case:

$$P_{L1} = I^2 R_O D$$

However, in this instance the R<sub>O</sub> required may be either the on resistance of the driver when its output is in the high state, or its on resistance when the driver is in the low state, depending on how the inductor is connected, and this is still only half the story. For the part of the cycle when the inductor is forcing current through the driver, dissipation is best described as

$$P_{L2} = I V_D (1 - D)$$

where V<sub>D</sub> is the forward drop of the clamp diode in the driver (generally around 0.7V). The two parts of the load dissipation must be summed in to produce P<sub>L</sub>

$$P_L = P_{L1} + P_{L2}$$

### Quiescent Power Dissipation

Quiescent power dissipation (P<sub>Q</sub>, as described in the input section) depends on whether the input is high or low. A low input will result in a maximum current drain (per driver) of ≤ 0.2mA; a logic high will result in a current drain of ≤ 3.0mA. Quiescent power can therefore be found from:

$$P_Q = V_S [D I_H + (1 - D) I_L]$$

where:

- I<sub>H</sub> = quiescent current with input high
- I<sub>L</sub> = quiescent current with input low
- D = fraction of time input is high (duty cycle)

V<sub>S</sub> = power supply voltage

### Transition Power Dissipation

Transition power is dissipated in the driver each time its output changes state, because during the transition, for a very brief interval, both the N- and P-channel MOSFETs in the output totem-pole are ON simultaneously, and a current is conducted through them from V<sub>S</sub> to ground. The transition power dissipation is approximately:

$$P_T = 2 f V_S (A \bullet s)$$

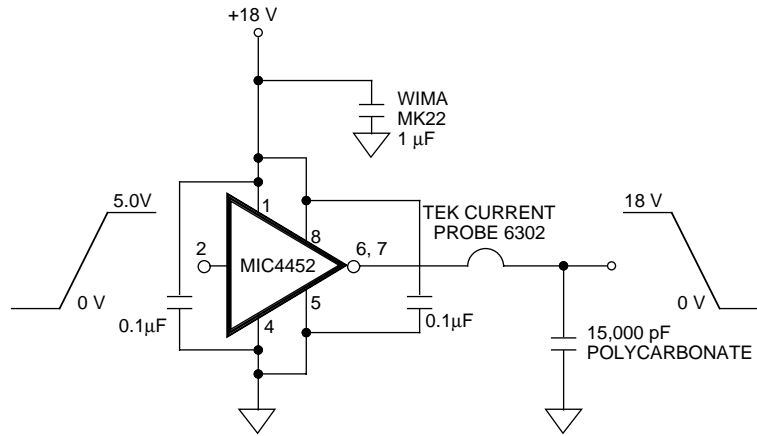
where (A•s) is a time-current factor derived from the typical characteristic curve "Crossover Energy vs. Supply Voltage."

Total power (P<sub>D</sub>) then, as previously described is:

$$P_D = P_L + P_Q + P_T$$

### Definitions

- C<sub>L</sub> = Load Capacitance in Farads.
- D = Duty Cycle expressed as the fraction of time the input to the driver is high.
- f = Operating Frequency of the driver in Hertz
- I<sub>H</sub> = Power supply current drawn by a driver when both inputs are high and neither output is loaded.
- I<sub>L</sub> = Power supply current drawn by a driver when both inputs are low and neither output is loaded.
- I<sub>D</sub> = Output current from a driver in Amps.
- P<sub>D</sub> = Total power dissipated in a driver in Watts.
- P<sub>L</sub> = Power dissipated in the driver due to the driver's load in Watts.
- P<sub>Q</sub> = Power dissipated in a quiescent driver in Watts.
- P<sub>T</sub> = Power dissipated in a driver when the output changes states ("shoot-through current") in Watts. NOTE: The "shoot-through" current from a dual transition (once up, once down) for both drivers is stated in Figure 7 in ampere-nanoseconds. This figure must be multiplied by the number of repetitions per second (frequency) to find Watts.
- R<sub>O</sub> = Output resistance of a driver in Ohms.
- V<sub>S</sub> = Power supply voltage to the IC in Volts.



**Figure 6. Peak Output Current Test Circuit**