# Latch-Immune High-Speed, High-Current Single MOSFET/IGBT Driver IXLD4420/4429

## General Description

The IXLD4420/4429 MOSFET/IGBT Drivers are tough, efficient, and easy to use. This family of devices are 6A (peak) single output MOSFET or IGBT Drivers.

The IXLD4420/4429 will drive even the largest MOSFETs and IGBTs at high speed improving the safe operating area margins.

These devices are tough due to extra steps taken to protect them from failures. An epitaxial layer is used to prevent CMOS Latch-up. Proprietary circuits allow the input to swing negative as much as 5V without damaging the part. Special circuits have been added to protect against damage from Electro-static Discharge. A special molding compound is used for increased moisture resistance and increased ability to withstand high voltages.

Because these devices are fabricated in CMOS, they run cool, use less power and are easier to drive. The rail-to-rail swing capability of CMOS better insures adequate gate voltage to the MOSFET/IGBT during turn on and turn off.

The MOSFET/IGBT Drivers are flexible and easy to use. These devices replace three or more discrete components with a single device to save PCB area. Any logic input from 2.4V to $V_S$ can be used without the need for external speed-up capacitors or resistor networks.

This family of devices is available in inverting (IXLD4429) and non-inverting (IXLD4420) configurations. There is an IXYS MOSFET/IGBT Driver just right for any application.

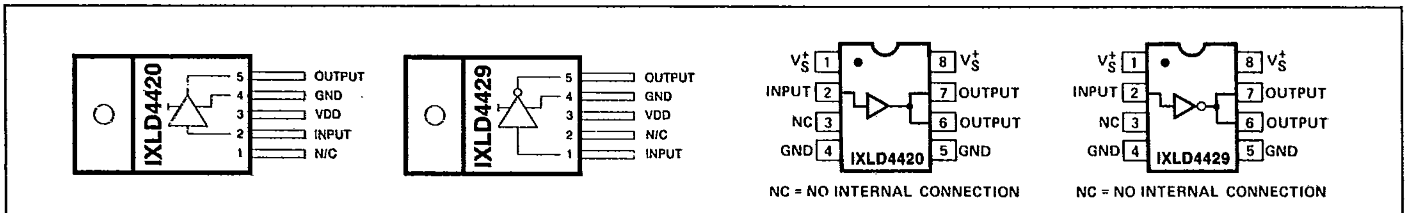
## Features

- Latch-Up Protected. Will Withstand 500mA Reverse Output Current
- Logic Input Will Withstand Negative Swing of Up to 5V
- Matched Rise and Fall Times . . . . . . . . . . . . . . . 25nS
- High Peak Output Current . . . . . . . . . . . 6.0 Amp Peak
- High Capacitive Load Drive Capability . . . . . . . . . . . . . . . . . . . 10,000pF in 60nS
- Wide Operating Range . . . . . . . . . . . . . . . 4.5V to 18V
- Low Delay Time . . . . . . . . . . . . . . . . . . . 55nS Max.
    - Rise Time, Typical . . . . . . . . . . . . . . . . 20nS
    - Fall Time, Typical . . . . . . . . . . . . . . . . 20nS
- Consistent Delay Times with Changes in Supply Voltage
- Logic High Input for any Voltage From 2.4V to $V_S$
- Logic Input Threshold Independent of Supply Voltage
- Low Supply Current
    - 450μA with Logic 1 Input
    - 55μA with Logic 0 Input
- Low Output Impedance . . . . . . . . . . . . . . . 2.5 Ohms
- Output Voltage Swing to Within 25mV of Ground or $V_S$+
- Available in Inverting (IXLD4429) and Non-Inverting (IXLD4420) Configurations

The IXLD4429 is pin-compatible with the popular IXLD429.

The TO-220 packaged version allows the user to utilize the driver at higher frequencies without the power dissipation limit of the DIP package.

## Pin Configuration




## Applications

- Switch Mode Power Supplies
- Motor Controls
- Pulse Transformer Drive
- Class D Switching Amplifiers

## Ordering Information

| Part No. | Package | Temperature Range |
|---|---|---|
| IXLD4420/29COA | 8-Pin SO | 0°C to 70°C |
| IXLD4420/29CPA | 8-Pin Plastic DIP | 0°C to 70°C |
| IXLD4420/29IJA* | 8-Pin CerDIP | −25°C to 85°C |
| IXLD4420/29MJA** | 8-Pin CerDIP | −55°C to 125°C |
| IXLD4420/29Y | CHIP | 25°C |
| IXLD4420/29CTA | TO-220 (5 lead) | 0°C to 70°C |

* For devices with 125°C, 160 Hour Burn In add /BI to part number suffix.

** 883 processing available.

# High-Speed, High-Current Single MOSFET/IGBT Driver

## IXLD4420/4429

### Absolute Maximum Ratings (Notes 1, 2, 3)

Power Dissipation
- Plastic ........ 500mW
- CerDIP ........ 800mW
- TO-220 ........ 16W

Derating Factors
- Plastic ........ 5.6mW/°C Above 36°C
- CerDIP ........ 6.0mW/°C
- TO-220 ........ 130mW/°C

Supply Voltage ........ 20V

Input Voltage Any Terminal ........ −5V to $V_S$ + 0.3V

Operating Temperature
- M Version ........ −55°C to +125°C
- I Version ........ −25°C to +85°C
- C Version ........ 0°C to +70°C

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

Storage Temperature ........ −55°C to +150°C

Lead Temperature (10 Sec) ........ 300°C

CerDIP $\theta_{JA}$ (Junction — Ambient) ........ 150°C/W

Plastic $\theta_{JA}$ (Junction — Ambient) ........ 170°C/W

TO-220 $\theta_{JA}$ (Junction — Ambient) ........ 80°C/W

TO-220 $\theta_{JC}$ (Junction — Case) ........ 7.5°C/W

## IXLD4420/4429
### Electrical Characteristics: $T_A$ = 25°C with 4.5V ≤ $V^+_S$ ≤ 18V unless otherwise specified.

| TYPE | SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| INPUT | $V_{IH}$ | Logic 1 Input Voltage | | 2.4 | 1.8 | — | V |
| INPUT | $V_{IL}$ | Logic 0 Input Voltage | | — | 1.3 | 0.8 | V |
| INPUT Note 2 | $V_{IN}$ (Max) | Input Voltage Range | | −5.0 | — | $V^+_S$+0.3 | V |
| INPUT Note 2 | $I_{IN}$ | Input Current | 0V≤$V_{IN}$≤$V_S$ | −10 | — | 10 | μA |
| OUTPUT | $V_{OH}$ | High Output Voltage | See Figure 1 | $V^+_S$−0.025 | — | — | V |
| OUTPUT | $V_{OL}$ | Low Output Voltage | See Figure 1 | — | — | 0.025 | V |
| OUTPUT | $R_O$ | Output Resistance | $V_{IN}$ = 0.8V for 4420; $V_{IN}$ = 2.4V for 4429 $I_{OUT}$ = 10mA, $V^+_S$ = 18V | — | 2.1 | 2.8 | Ω |
| OUTPUT | $R_O$ | Output Resistance | $V_{IN}$ = 2.4V for 4420; $V_{IN}$ = 0.8V for 4429 $I_{OUT}$ = 10mA, $V^+_S$ = 18V | — | 1.5 | 2.5 | Ω |
| OUTPUT | $I_{PK}$ | Peak Output Current | $V^+_S$ = 18V (See Figure 5) | — | 6.0 | — | A |
| OUTPUT | I | Latch-Up Protection | Withstand Reverse Current | >500 | — | — | mA |
| SWITCHING TIME | $T_R$ | Rise Time | Test Figure 1, $C_L$ = 2500pF | — | 25 | 35 | nS |
| SWITCHING TIME | $T_F$ | Fall Time | Test Figure 1, $C_L$ = 2500pF | — | 25 | 35 | nS |
| SWITCHING TIME | $T_{D1}$ | Delay Time | Test Figure 1 | — | 55 | 75 | nS |
| SWITCHING TIME Note 3 | $T_{D2}$ | Delay Time | Test Figure 1 | — | 55 | 75 | nS |
| POWER SUPPLY | $I_S$ | Power Supply Current | $V_{IN}$ = 3.0V | — | 0.45 | 1.5 | mA |
| POWER SUPPLY | $I_S$ | Power Supply Current | $V_{IN}$ = 0.0V | — | 55 | 150 | μA |
| POWER SUPPLY | $V^+_S$ | Operating Supply Voltage | | 4.5 | — | 18 | V |

**NOTES:**
1. Functional operation above maximum stress ratings is not implied.
2. Static Sensitive Device. Store only in conductive containers. Handling personnel and equipment should be grounded to prevent damage from static discharge.
3. Switching times guaranteed by design.

## IXLD4420/4429

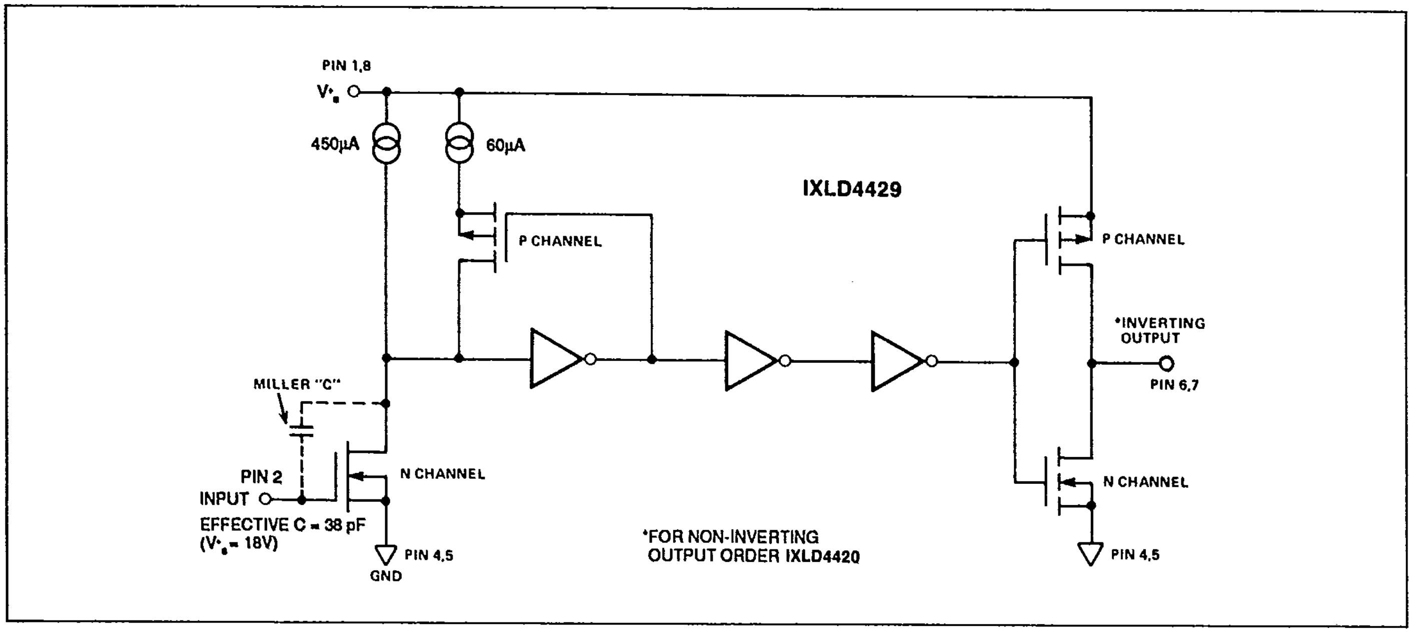
**Electrical Characteristics:** Over operating temperature range with $4.5V \leq V_S \leq 18V$ unless otherwise specified.

| TYPE | SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| INPUT | $V_{IH}$ | Logic 1 Input Voltage | | 2.4 | – | – | V |
| INPUT | $V_{IL}$ | Logic 0 Input Voltage | | – | – | 0.8 | V |
| Note 2 | $V_{IN}$ (Max) | Input Voltage Range | | −5.0 | – | $V^+_S+0.3$ | V |
| | $I_{IN}$ | Input Current | $0V \leq V_{IN} \leq V_S$ | −10 | – | 10 | μA |
| OUTPUT | $V_{OH}$ | High Output Voltage | See Figure 1 | $V^+_S-0.025$ | – | – | V |
| OUTPUT | $V_{OL}$ | Low Output Voltage | See Figure 1 | – | – | 0.025 | V |
| OUTPUT | $R_O$ | Output Resistance | $V_{IN}$ = 0.8V for 4420; $V_{IN}$ = 2.4V for 4429 $I_{OUT}$ = 10mA, $V_S$ = 18V | – | 3.0 | 5.0 | Ω |
| OUTPUT | $R_O$ | Output Resistance | $V_{IN}$ = 2.4V for 4420; $V_{IN}$ = 0.8V for 4429 $I_{OUT}$ = 10mA, $V_S$ = 18V | – | 2.3 | 5.0 | Ω |
| SWITCHING TIME | $T_R$ | Rise Time | Test Figure 1, $C_L$ = 2500pF | – | 32 | 60 | nS |
| SWITCHING TIME | $T_F$ | Fall Time | Test Figure 1, $C_L$ = 2500pF | – | 34 | 60 | nS |
| SWITCHING TIME | $T_{D1}$ | Delay Time | Test Figure 1 | – | 50 | 100 | nS |
| SWITCHING TIME | $T_{D2}$ | Delay Time | Test Figure 1 | – | 65 | 100 | nS |
| POWER SUPPLY | $I_S$ | Power Supply Current | $V_{IN}$ = 3.0V | – | .45 | 3.0 | mA |
| POWER SUPPLY | $I_S$ | Power Supply Current | $V_{IN}$ = 0.0V | – | .06 | 0.4 | mA |
| POWER SUPPLY | $V^+_S$ | Operating Supply Voltage | | 4.5 | – | 18 | V |

**NOTES:**
1. Functional operation above maximum stress ratings is not implied.
2. Static Sensitive Device. Store only in conductive containers. Handling personnel and equipment should be grounded to prevent damage from static discharge.
3. Switching times guaranteed by design.

## IXLD4420/4429

Figure 1. Functional Diagram



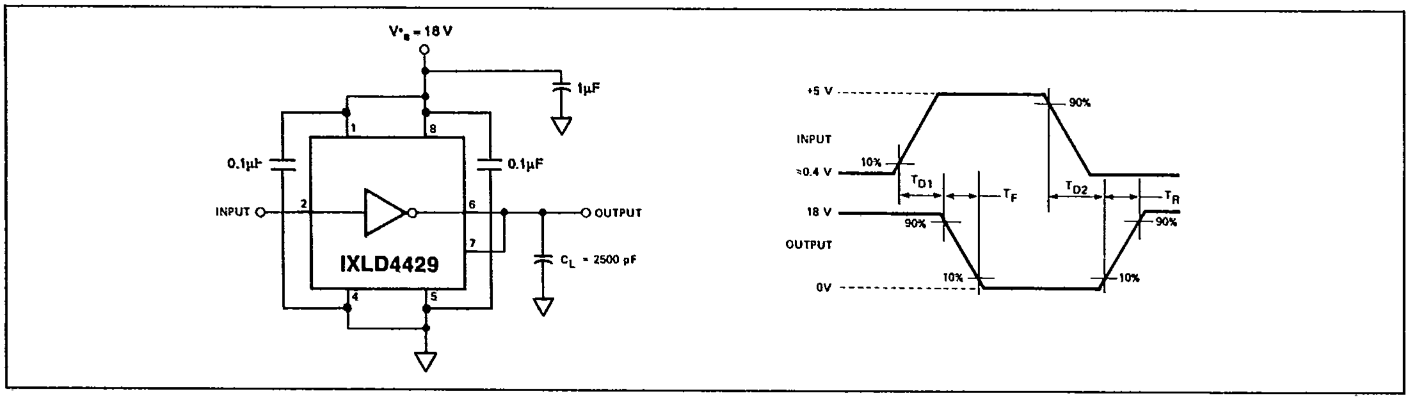




Figure 2. Switching Time Test Circuit

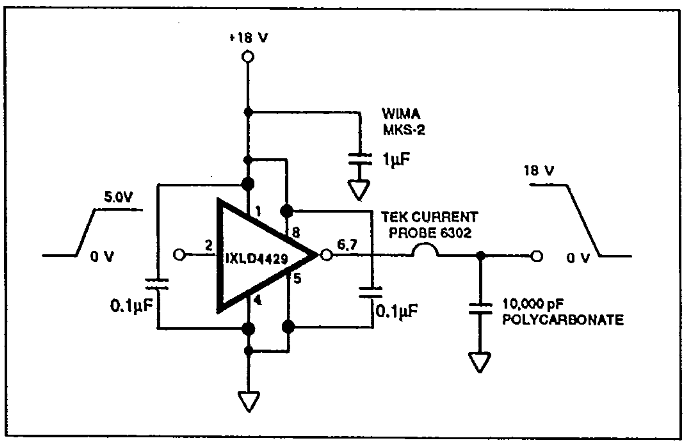


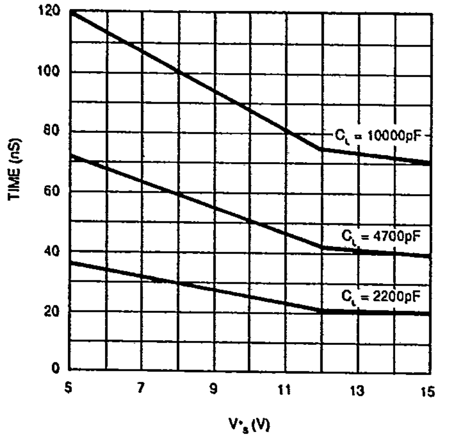

Figure 3. Peak Output Current Test Circuit

# High-Speed, High-Current Single MOSFET/IGBT Driver

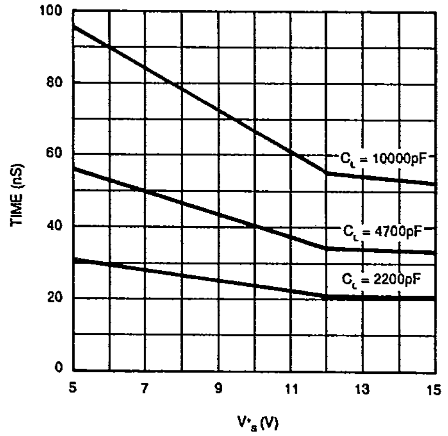


## Typical Characteristics Curves

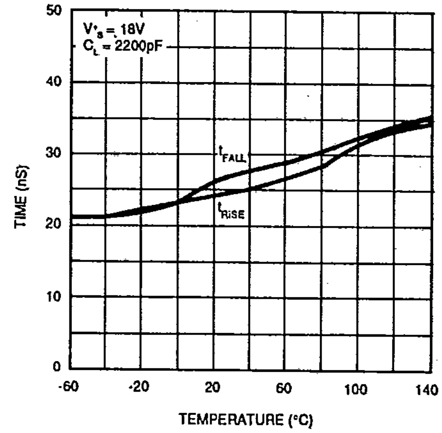
**Rise Time vs Supply Voltage**



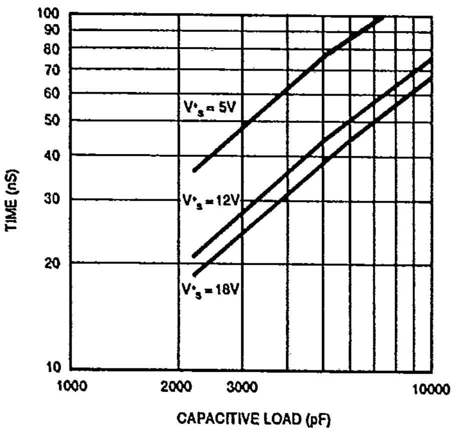

**Fall Time vs Supply Voltage**



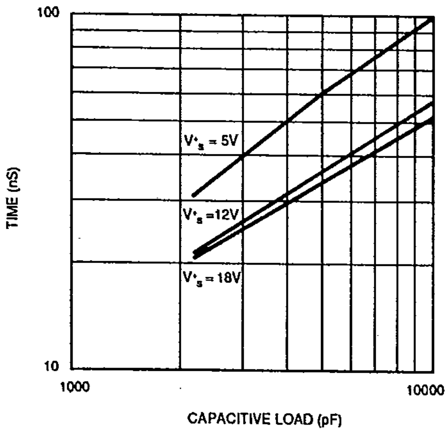

**Rise and Fall Time vs Temperature**



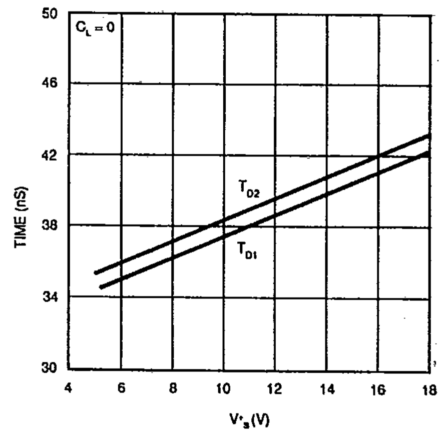

**Rise Time vs Capacitive Load**



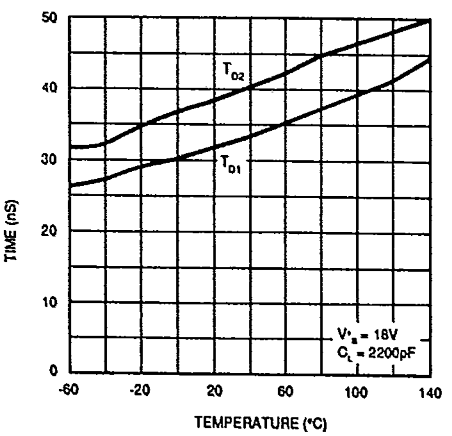

**Fall Time vs Capacitive Load**



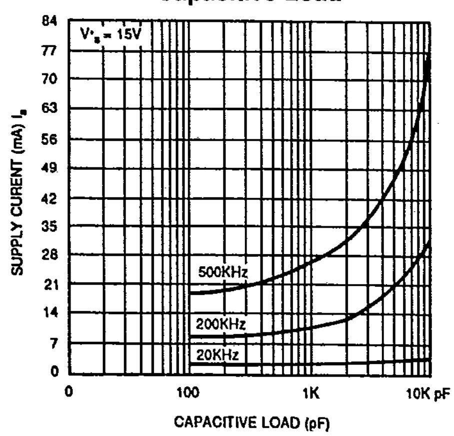

**Propagation Delay Time vs Supply Voltage**



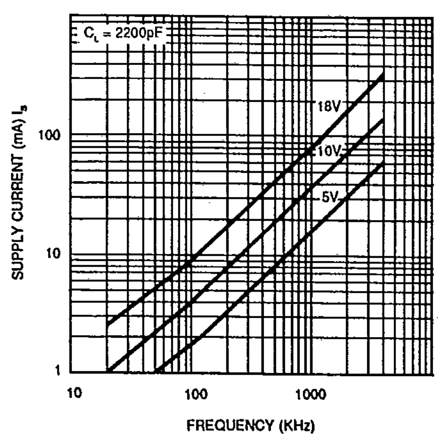

**Propagation Delay Time vs Temperature**




**Supply Current vs Capacitive Load**

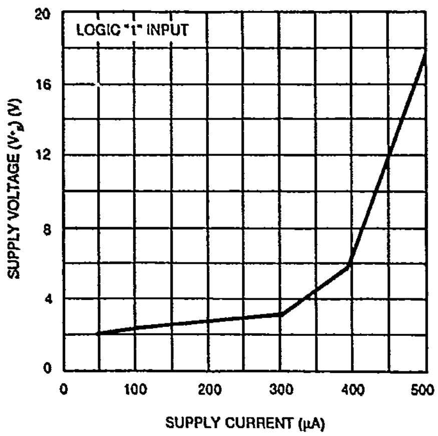



**Supply Current vs Frequency**

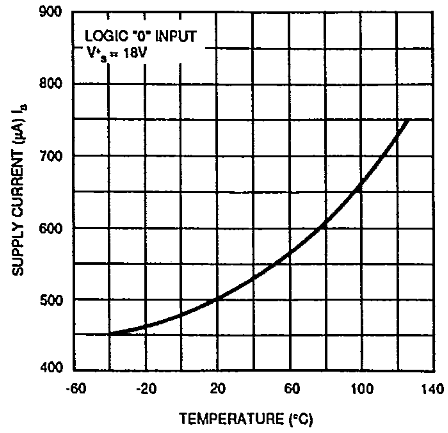


## Typical Characteristics Curves (Cont.)

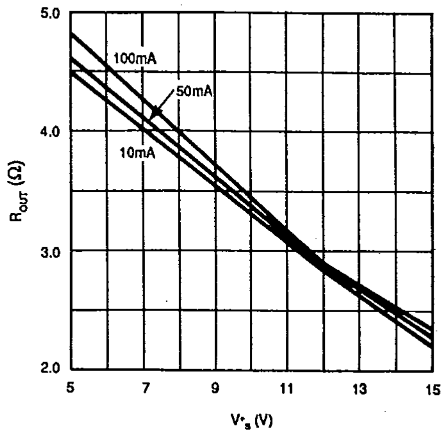
### Quiescent Power Supply Current vs Supply Voltage



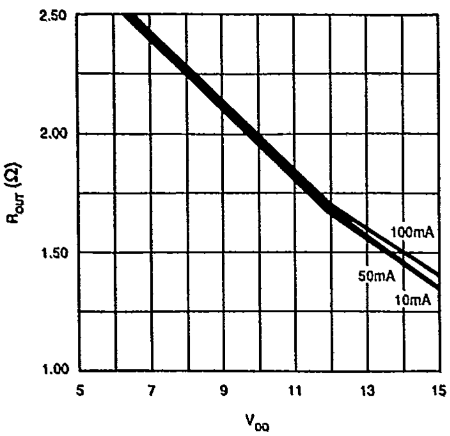

### Quiescent Power Supply Current vs Temperature



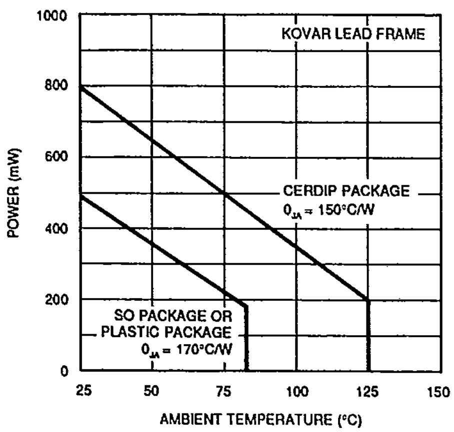

### High State Output Resistance




### Low State Output Resistance

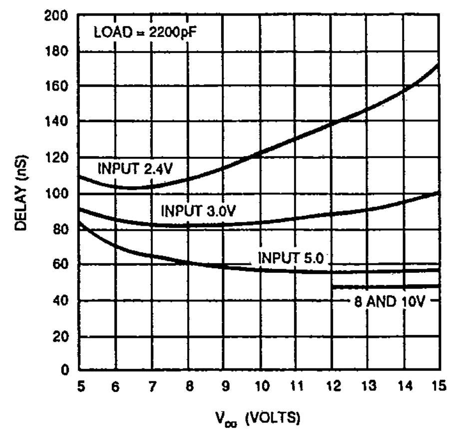



### Package Power Dissipation




**Notes:**
1. Derate Plastic 5.88mW/°C
2. Derate CerDIP 6.67mW/°C

### Effect of Input Amplitude on Propagation Delay



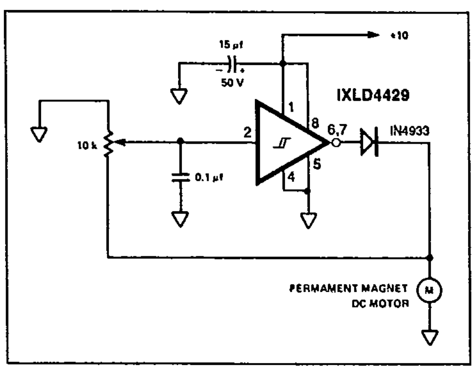




**Figure 4. Motor Speed Controller**

## Typical Applications

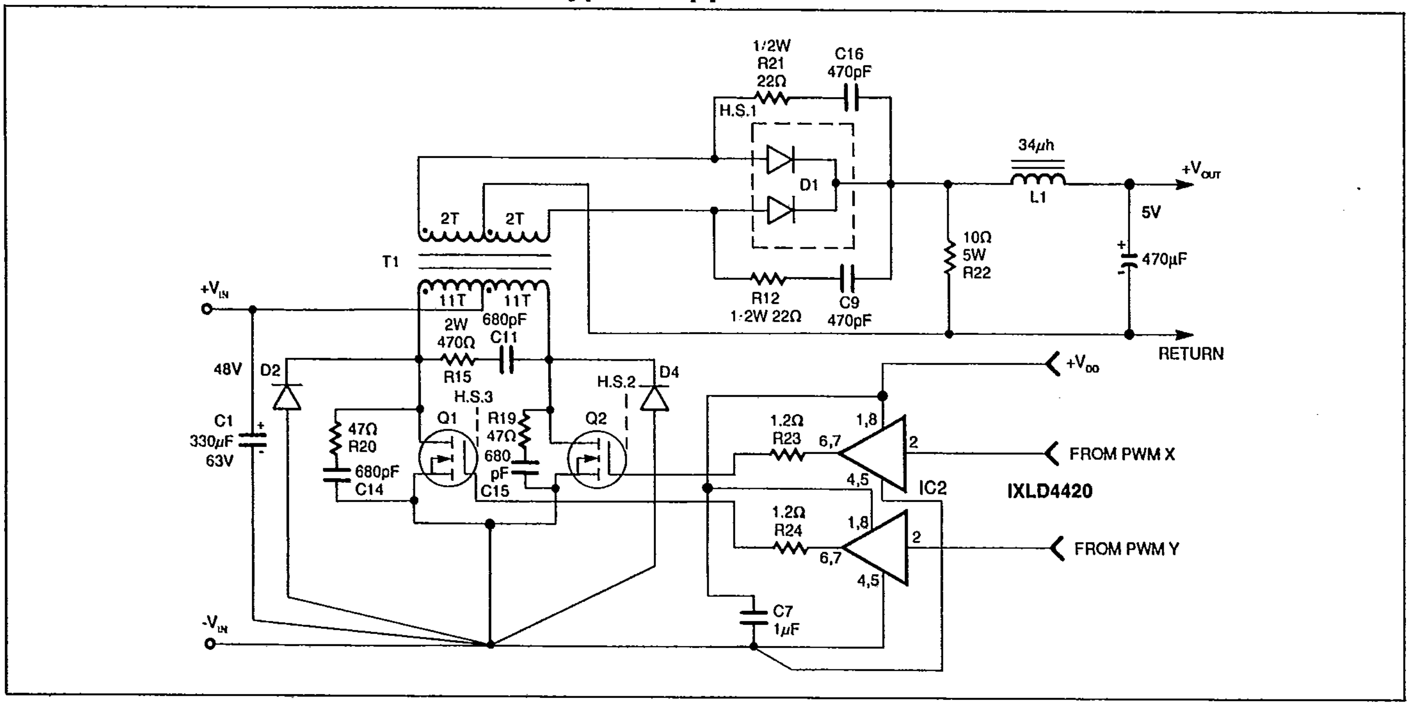



Figure 5. Push-Pull Power Stage

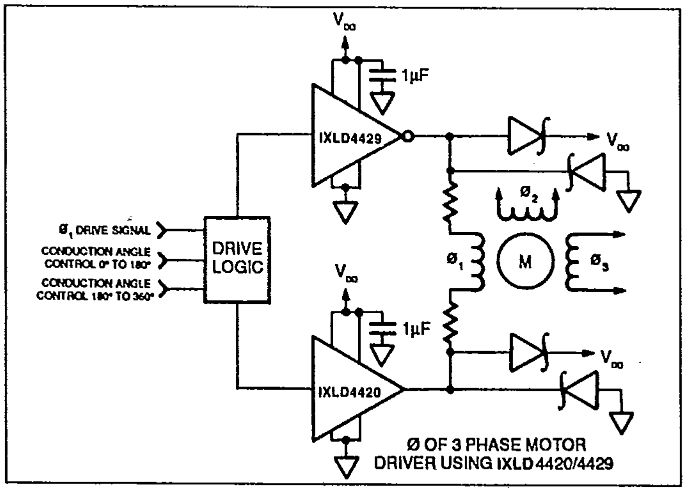



Figure 6. Direct Motor Drive

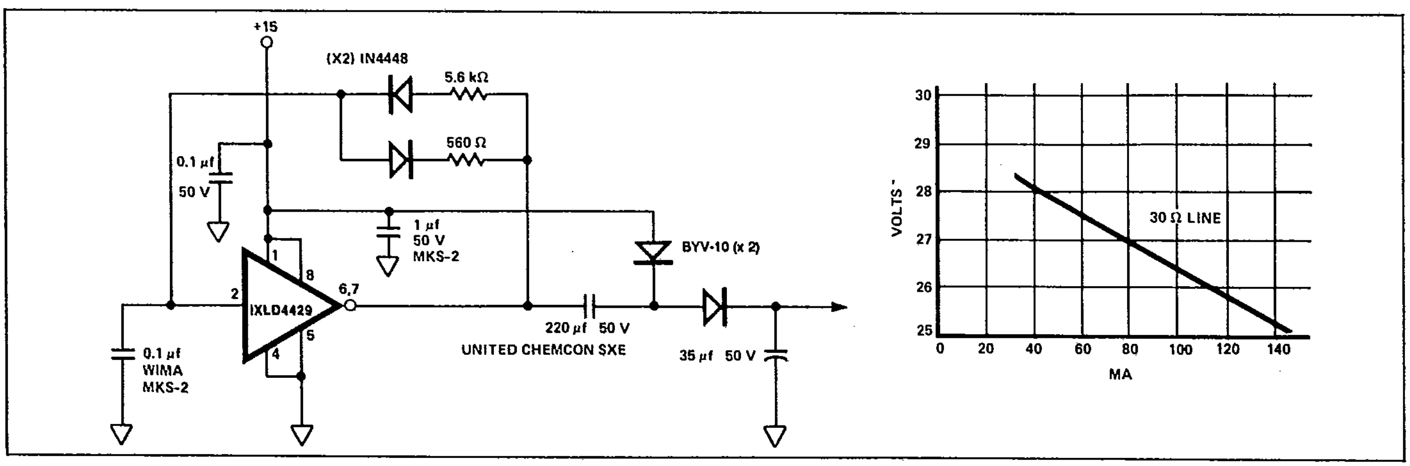



Figure 7. Self Contained Voltage Doubler

## Supply Bypassing

Charging and discharging large capacitive loads quickly requires large currents. For example, charging a 2500pF load 18 volts in 25nS requires a 1.8A current from the device power supply.

The IXLD4420/4429 has double bonding on the supply pins, the ground pins and output pins. This serves to reduce parasitic lead inductance. Low inductance enables large drive currents to be switched very fast. 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 .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 IXLD4420/4429 demands careful PC board layout for best performance. Since the IXLD4429 is an inverting driver, any ground lead impedance will appear as negative feedback which can degrade switching speed. The feedback is especially noticeable with slow-rise time inputs. The IXLD4429 input structure includes about 300mV of hysteresis to ensure clean transitions and freedom from oscillation, but attention to layout is still recommended.

Figure 8 shows the feedback effect in detail. As the IXLD4429 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 IXLD4429 ground pins. If the driving logic is referenced to power ground, the effective logic input level is reduced and oscillation may result.

To ensure optimum performance, separate ground traces should be provided for the logic and power connections. Connecting the logic ground directly to the IXLD4429 GND pins will ensure full logic drive to the input and ensure fast output switching. Both of the IXLD4429 GND pins should still be connected to power ground.

## Input Stage

The input voltage level of the IXLD4429 changes the quiescent supply current. The N-channel MOSFET input stage transistor drives a 450μA current source load. With a logic "1" input, the maximum quiescent supply current is 450μA. Logic "0" input level signals reduce quiescent current to 55μA maximum.

The IXLD4420/4429 input is designed to provide 300mV of hysteresis. This provides clean transitions, reduces noise sensitivity, and minimizes output stage current spiking when changing states. Input voltage threshold levels are approximately 1.5V, making the device TTL compatible over the 4.5V to 18V operating supply range. Input current is less than 10μA over this range.

The IXLD4429 can be directly driven by the TL494, SG1526/1527, SG1524, TSC170, TSC38C42 and similar switch mode power supply integrated circuits. By offloading the power-driving duties to the IXLD4420/4429, the power supply controller can operate at lower dissipation. This can improve performance and reliability.

The input can be greater than the $V^{+}_{S}$ supply, however, current will flow into the input lead. The propagation delay for $T_{D2}$ will increase to as much as 400nS at room temperature. The input currents can be as high as 30mA p-p (6.4 mA rms) with the input being 6V greater than the supply voltage. No damage will occur to the IXLD4420/4429 however, and it will not latch.

The input appears as a 38pF capacitance, and does not change even if the input is driven from an A.C. source. Care should be taken so that the input does not go more than 5 volts below the negative rail.

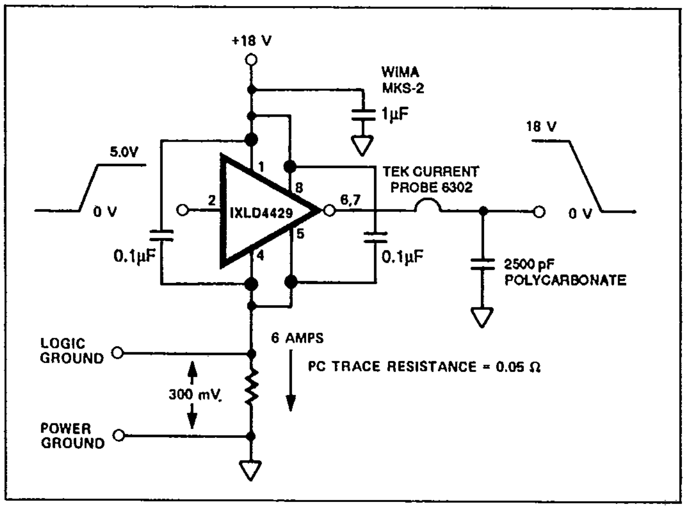



**Figure 8: Switching Time Degradation Due to Negative Feedback**

## Power Dissipation

CMOS circuits usually permit the user to ignore power dissipation. Logic families such as 4000 and 74C have outputs which can only supply a few milliamperes of current, and even shorting outputs to ground will not force enough current to destroy the device. The IXLD4420/4429 on the other hand, can source or sink several amperes and drive large capacitive loads at high frequency. The package power dissipation limit can easily be exceeded. Therefore, some attention should be given to power dissipation when driving low impedance loads and/or operating at high frequency. The TO-220 packaged device, with its higher power dissipation capability, permits driving low impedance loads at much higher frequency.

The supply current vs frequency and supply current vs capacitive load characteristics curves will aid in determining power dissipation calculations. Table 1 lists the maximum operating frequency for several power supply voltages when driving a 2500pF load. More accurate power dissipation figures can be obtained by adding the three dissipation sources.

Input signal duty cycle, power supply voltage, and capacitive load influence device power dissipation. Given power dissipation and package thermal resistance the maximum ambient operation temperature is easily calculated. The CerDIP 8-pin package junction to ambient thermal resistance is 150°C/W. At 25°C, the package is rated at 800mW maximum dissipation. Maximum allowable chip temperature is 150°C.

Three components make up total package power dissipation:

- Capacitive load dissipation ($P_C$)
- Quiescent power ($P_Q$)
- Transition power ($P_T$)

The capacitive load caused dissipation is a direct function of frequency, capacitive load, and supply voltage. The package power dissipation is:

EQ.1: $P_C = fCV_S^2$

where: f = switching frequency
C = capacitive load
$V_S$ = supply voltage

Quiescent power dissipation depends on input signal duty cycle. A logic low input results in a low power dissipation mode with only .40mA total current drain. Logic high signals raise the current to 1.5mA maximum at 25°C or 3mA at high ambient temperature.

EQ.2: $P_Q = V_S\,(D(I_H) + (1\text{-}D)\,I_L)$

where: $I_H$ = quiescent current with input high (3mA Max)
$I_L$ = quiescent current with input low (0.40mA Max)
D = duty cycle (% of time input is high)

Transition power dissipation arises because the output stage N- and P-channel MOS transistors are "on" simultaneously for a very short period when the output changes. The transition package power dissipation is approximately:

EQ.3: $P_T = fV_S^2$ (A•S rating from Figure 9)

An example shows the relative magnitude for each term.

Example 1:
C = 2500pF
$V_S$ = 15V
D = 50%
f = 200kHz
$P_D$ = package power dissipation = $P_C + P_T + P_Q$
= 112mW + 103mW + 26mW
= 241mW
$T_J = T_A + \theta_{JA} \times P_D$
25°C + 150 x .241 = 61.22°C

where: $T_J$ = Junction temperature (150°C Max)
$T_A$ = Ambient temperature
$\theta_{JA}$ = Junction to ambient thermal resistance (150°C/W, CerDIP)

**NOTE:** Ambient operating temperature should not exceed 85°C for "IJA" device or 125°C for "MJA" device.

**Table 1: IXLD4429 Maximum Operating Frequency**

| $V_S$ | Max Frequency |
|---|---|
| 18V | 500kHz |
| 15V | 700kHz |
| 10V | 1.6MHz |
| 5V | 6.5MHz |

Conditions: 1. CerDIP Package ($\theta_{JA}$ = 150°C/W)
2. $T_A$ = 25°C
3. $C_L$ = 2500pF

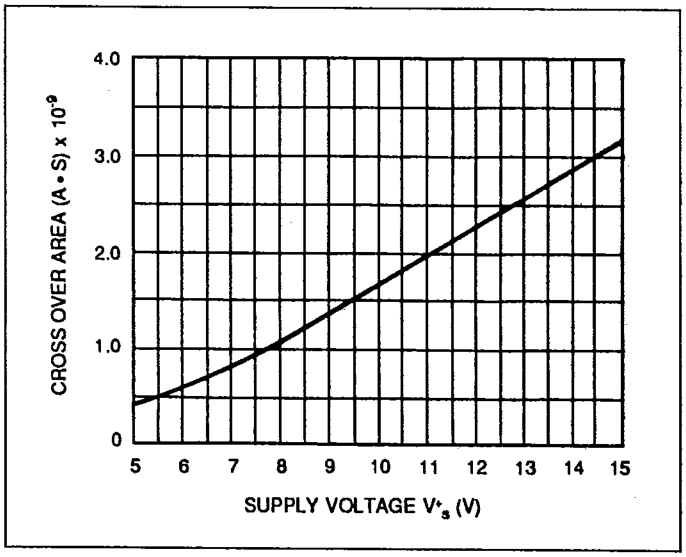
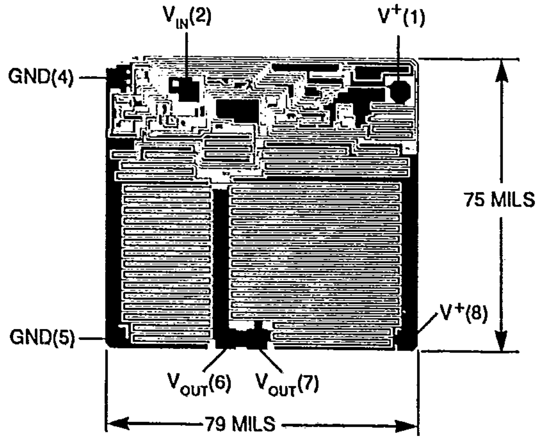



**Figure 9. Total nA•S Crossover**

# High-Speed, High-Current Single MOSFET/IGBT Driver

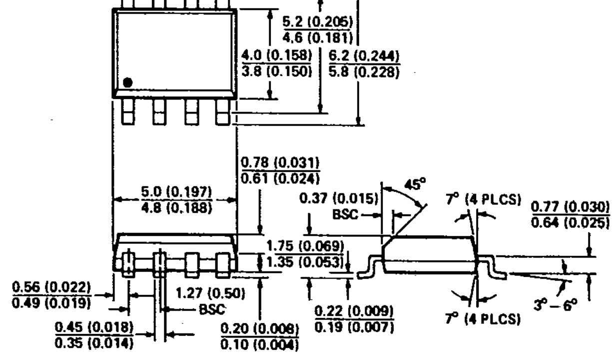
## IXLD4420/4429

### Bonding Diagram



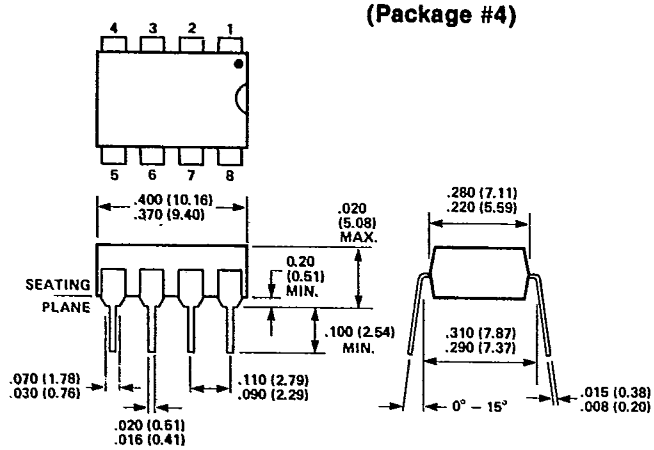

### Package Information

8-Pin Plastic "SO"

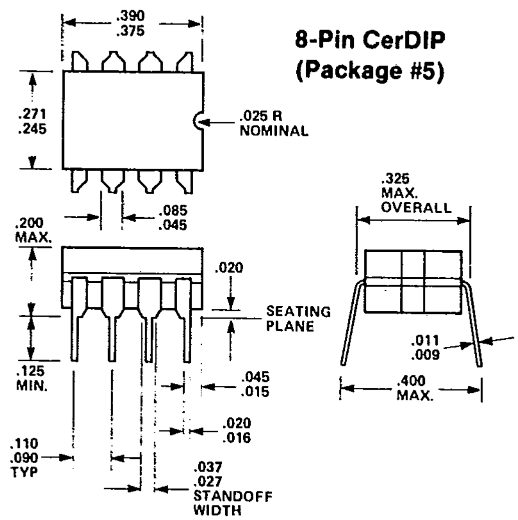



### Package Information

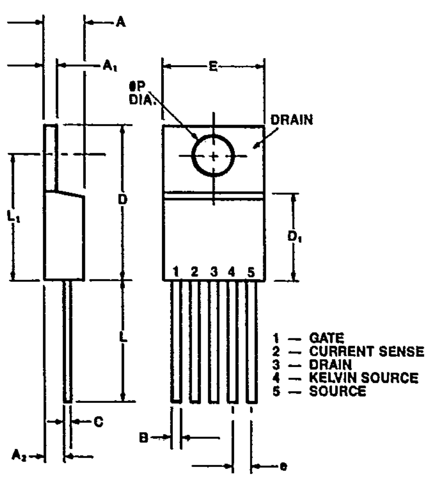
8-Pin Plastic DIP
(Package #4)




8-Pin CerDIP
(Package #5)




### TO-220 (5 Leaded)




| Dim. | Millimeter Min. | Millimeter Max. | Inches Min. | Inches Max. |
|---|---|---|---|---|
| A | 4.32 | 4.57 | .170 | .180 |
| $A_1$ | 1.14 | 1.40 | .045 | .055 |
| $A_2$ | 2.16 | 2.66 | .085 | .105 |
| B | 0.68 | 0.94 | .027 | .037 |
| C | 0.25 | 0.51 | .010 | .020 |
| D | 14.73 | 15.24 | .580 | .600 |
| $D_1$ | 8.89 | 9.14 | .350 | .360 |
| E | 10.00 | 10.54 | .395 | .415 |
| e | 1.45 | 1.95 | .057 | .077 |
| L | 13.21 | 14.48 | .520 | .570 |
| $L_1$ | 11.93 | 12.70 | .470 | .500 |
| ØP | 3.68 | 3.94 | .145 | .155 |

# High-Speed, High-Current Single MOSFET/IGBT Driver

## IXLD4420/4429

The following families of power drivers are made with a CMOS process to inferface between low-level control functions and high-power switching devices, particularly power MOSFETs. The devices are also an optimum choice for capacitive line drivers where 1.2 A-6 A may be switched. With both inverting and non-inverting inputs available, logic signals of either polarity may be accepted.

## Selecting MOSFET Drivers

| Device | Drive Current | Output No. & Type Invert. | | Non-Invert | Rated Load (pF) | Rise Time @ Rated Load (nS) | Fall Time @ Rated Load (nS) | Rising Edge Prop. Delay* (nS) | Falling Edge Prop. Delay (nS) | Latch | Input Protected to 5 V Below Gnd RAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IXLD1426 | 1.2 A Peak | dual | | | 1000 | 30 | 20 | 55 | 80 | Resistant | NO |
| IXLD1427 | 1.2 A Peak | | | dual | 1000 | 30 | 20 | 55 | 80 | Resistant | NO |
| IXLD1428 | 1.2 A Peak | single | & | single | 1000 | 30 | 20 | 55 | 80 | Resistant | NO |
| IXLD426 | 1.5 A Peak | dual | | | 1000 | 30 | 20 | 40 | 75 | Resistant | NO |
| IXLD427 | 1.5 A Peak | | | dual | 1000 | 30 | 20 | 40 | 75 | Resistant | NO |
| IXLD428 | 1.5 A Peak | single | & | single | 1000 | 30 | 20 | 40 | 75 | Resistant | NO |
| IXLD4426 | 1.5 A Peak | dual | | | 1000 | 30 | 30 | 40 | 55 | Immune | YES |
| IXLD4427 | 1.5 A Peak | | | dual | 1000 | 30 | 30 | 40 | 55 | Immune | YES |
| IXLD4428 | 1.5 A Peak | single | & | single | 1000 | 30 | 30 | 40 | 55 | Immune | YES |
| IXLD4423 | 3.0 A Peak | dual | | | 1800 | 20 | 20 | 40 | 40 | Immune | YES |
| IXLD4424 | 3.0 A Peak | | | dual | 1800 | 20 | 20 | 40 | 40 | Immune | YES |
| IXLD4425 | 3.0 A Peak | single | & | single | 1800 | 20 | 20 | 40 | 40 | Immune | YES |
| IXLD429 | 6.0 A Peak | single | | | 2500 | 23 | 25 | 53 | 60 | Resistant | NO |
| IXLD4420 | 6.0 A Peak | | | single | 2500 | 25 | 25 | 55 | 55 | Immune | YES |
| IXLD4429 | 6.0 A Peak | single | | | 2500 | 25 | 25 | 55 | 55 | Immune | YES |

## MOSFET Die Size vs. Suggested Driver Family

| MOSFET Size | Suggested Driver (@ 12 V) | Typical $t_r/t_f$ | Suggested Driver for faster speed (@ 12 V) | Typical $t_r/t_f$ |
|---|---|---|---|---|
| Size 3 | IXLD426/1426/4426 | 10/26 | IXLD4423 | 7/18 |
| Size 4 | IXLD426/1426/4426 | 26/31 | IXLD4420/4429 | 12/26 |
| Size 5 | IXLD426/1426/4426 | 40/40 | IXLD4420/4429 | 15/15 |
| Size 6 | IXLD4420/4429 | 25/20 | — | — |
| Size 7 | IXLD4420/4429 | 36/35 | — | — |
| Size 8 | IXLD4420/4429 | 50/50 | — | — |