

# SM72482

## SolarMagic Dual 5A Compound Gate Driver

### General Description

The SM72482 Dual Gate Driver replaces industry standard gate drivers with improved peak output current and efficiency. Each “compound” output driver stage includes MOS and bipolar transistors operating in parallel that together sink more than 5A peak from capacitive loads. Combining the unique characteristics of MOS and bipolar devices reduces drive current variation with voltage and temperature. Under-voltage lockout protection is also provided. The drivers can be operated in parallel with inputs and outputs connected to double the drive current capability. This device is available in the SOIC-8 package.

### Features

- Renewable Energy Grade
- Independently drives two N-Channel MOSFETs
- Compound CMOS and bipolar outputs reduce output current variation
- 5A sink/3A source current capability
- Two channels can be connected in parallel to double the drive current
- Independent inputs (TTL compatible)
- Fast propagation times (25 ns typical)

- Fast rise and fall times (14 ns/12 ns rise/fall with 2 nF load)
- Available in dual non-inverting, dual inverting and combination configurations
- Supply rail under-voltage lockout protection (UVLO)
- SM72482 UVLO configured to drive PFET through OUT\_A and NFET through OUT\_B
- Pin compatible with industry standard gate drivers

### Typical Applications

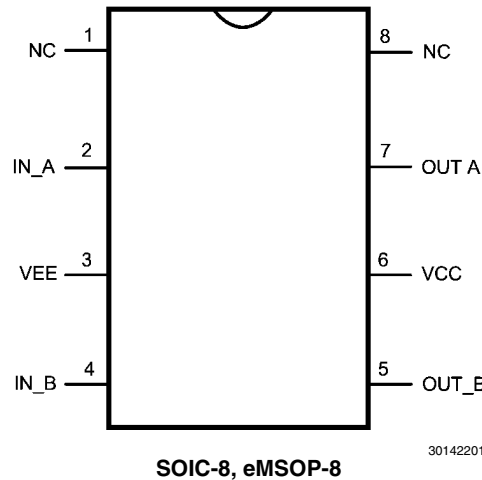
- Synchronous Rectifier Gate Drivers
- Switch-mode Power Supply Gate Driver
- Solenoid and Motor Drivers

### Packages

- SOIC-8
- Thermally Enhanced MSOP8–EP



### Connection Diagram



## Ordering Information

Order Number	Package Type	NSC Package Drawing	Package Marking	Supplied As
SM72482MY-1	MSOP-8-EP	MUY08A	SD8B	1000 Units in Tape and Reel
SM72482MYE-1	MSOP-8-EP	MUY08A	SD8B	250 Units in Tape and Reel
SM72482MYX-1	MSOP-8-EP	MUY08A	SD8B	3500 Units in Tape and Reel
SM72482MA-4	SOIC-8	M08A	S482	95 Units in Rail
SM72482MAE-4	SOIC-8	M08A	S482	250 Units in Tape and Reel
SM72482MAX-4	SOIC-8	M08A	S482	2500 Units in Tape and Reel

## Pin Descriptions

Pin	Name	Description	Application Information
1	NC	No Connect	
2	IN_A	'A' side control input	TTL compatible thresholds.
3	VEE	Ground reference for both inputs and outputs	Connect to power ground.
4	IN_B	'B' side control input	TTL compatible thresholds.
5	OUT_B	Output for the 'B' side driver.	Voltage swing of this output is from VCC to VEE. The output stage is capable of sourcing 3A and sinking 5A.
6	VCC	Positive output supply	Locally decouple to VEE.
7	OUT_A.	Output for the 'A' side driver.	Voltage swing of this output is from VCC to VEE. The output stage is capable of sourcing 3A and sinking 5A.
8	NC	No Connect	

## Configuration Table

Part Number	"A" Output Configuration	"B" Output Configuration	Package
SM72482MY-1	Non-Inverting (Low in UVLO)	Non-Inverting (Low in UVLO)	MSOP8-EP
SM72482MA-4	Inverting (High in UVLO)	Non-Inverting (Low in UVLO)	SOIC-8

## Absolute Maximum Ratings *(Note 1)*

If Military/Aerospace specified devices are required,  
please contact the National Semiconductor Sales Office/  
Distributors for availability and specifications.

$V_{CC}$ to $V_{EE}$	-0.3V to 15V
IN to $V_{EE}$	-0.3V to 15V
Storage Temperature Range, ( $T_{STG}$ )	-55°C to +150°C
Maximum Junction Temperature, ( $T_J(max)$ )	+150°C
Operating Junction Temperature	+125°C
ESD Rating	2kV

## Electrical Characteristics

$T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 12\text{V}$ ,  $V_{EE} = 0\text{V}$ , No Load on OUT\_A or OUT\_B, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	$V_{CC}$ Operating Range	$V_{CC}-V_{EE}$	3.5		14	V
$V_{CCR}$	$V_{CC}$ Under Voltage Lockout (rising)	$V_{CC}-V_{EE}$	2.3	2.9	3.5	V
$V_{CCH}$	$V_{CC}$ Under Voltage Lockout Hysteresis			230		mV
$I_{CC}$	$V_{CC}$ Supply Current ( $I_{CC}$ )	IN_A = IN_B = 0V (SM72482MY-1)		1	2	mA
		IN_A = $V_{CC}$ , IN_B = 0V (SM72482MA-4)		1	2	

### CONTROL INPUTS

$V_{IH}$	Logic High		2.2			V
$V_{IL}$	Logic Low				0.8	V
$V_{thH}$	High Threshold		1.3	1.75	2.2	V
$V_{thL}$	Low Threshold		0.8	1.35	2.0	V
HYS	Input Hysteresis			400		mV
$I_{IL}$	Input Current Low	IN_A=IN_B= $V_{CC}$	-1	0.1	1	$\mu\text{A}$
$I_{IH}$	Input Current High	IN_A=IN_B= $V_{CC}$ (SM72482MY-1)	10	18	25	
		IN_B= $V_{CC}$ (SM72482MA-4)	10	18	25	
		IN_A= $V_{CC}$ (SM72482MA-4)	-1	0.1	1	

### OUTPUT DRIVERS

$R_{OH}$	Output Resistance High	$I_{OUT} = -10\text{ mA}$ ( <i>Note 2</i> )		30	50	$\Omega$
$R_{OL}$	Output Resistance Low	$I_{OUT} = +10\text{ mA}$ ( <i>Note 2</i> )		1.4	2.5	$\Omega$
$I_{Source}$	Peak Source Current	OUTA/OUTB = $V_{CC}/2$ , 200 ns Pulsed Current		3		A
$I_{Sink}$	Peak Sink Current	OUTA/OUTB = $V_{CC}/2$ , 200 ns Pulsed Current		5		A

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>SWITCHING CHARACTERISTICS</b>						
td1	Propagation Delay Time Low to High, IN rising (IN to OUT)	$C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 1</a>		25	40	ns
td2	Propagation Delay Time High to Low, IN falling (IN to OUT)	$C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 1</a>		25	40	ns
$t_r$	Rise Time	$C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 1</a>		14	25	ns
$t_f$	Fall Time	$C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 1</a>		12	25	ns
<b>LATCHUP PROTECTION</b>						
	AEC - Q100, Method 004	$T_J = 150^\circ\text{C}$		500		mA
<b>THERMAL RESISTANCE</b>						
$\theta_{JA}$	Junction to Ambient, 0 LFPM Air Flow	SOIC-8 Package		170		$^\circ\text{C/W}$
		MSOP8-EP Package		60		
$\theta_{JC}$	Junction to Case	SOIC-8 Package		70		$^\circ\text{C/W}$
		MSOP8-EP Package		4.7		

**Note 1:** Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions under which operation of the device is intended to be functional. For guaranteed specifications and test conditions, see the Electrical Characteristics.

**Note 2:** The output resistance specification applies to the MOS device only. The total output current capability is the sum of the MOS and Bipolar devices.

## Timing Waveforms

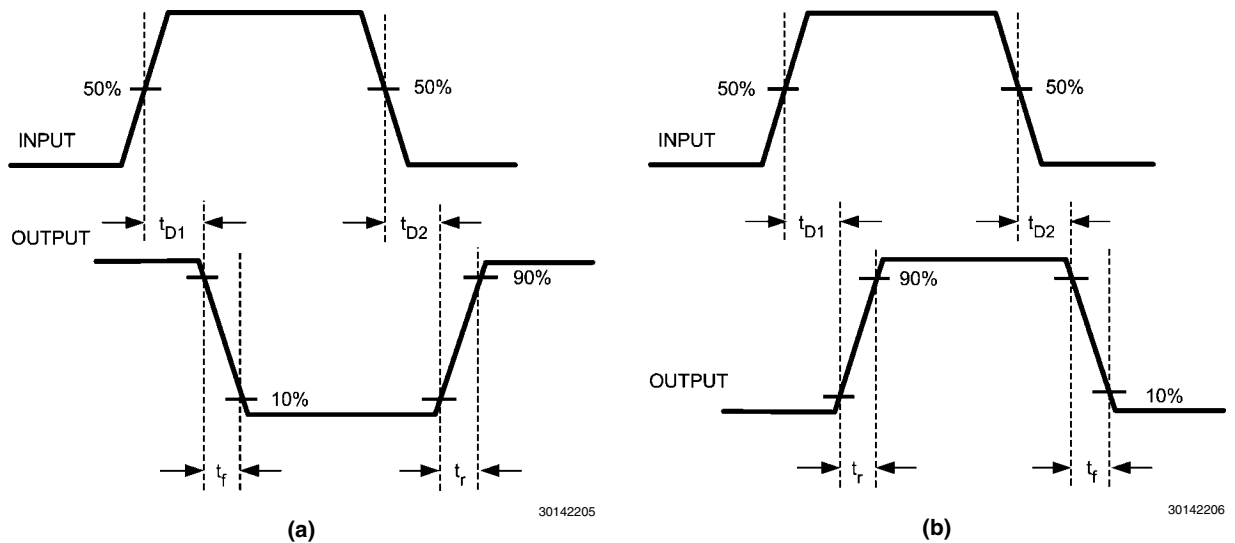
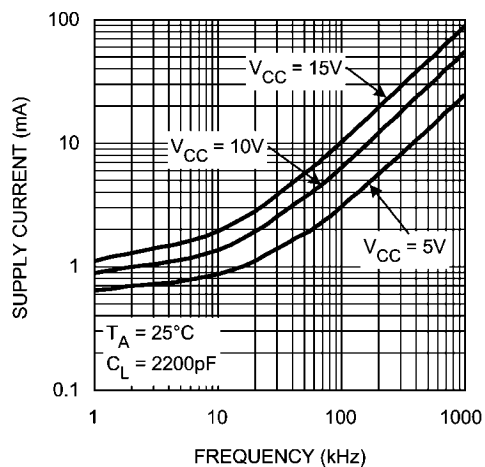


FIGURE 1. (a) Inverting, (b) Non-Inverting

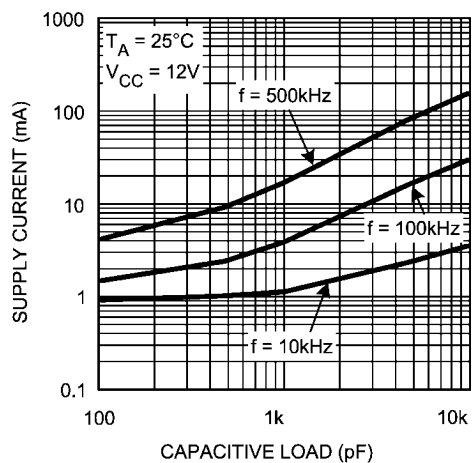
## Typical Performance Characteristics

### Supply Current vs Frequency



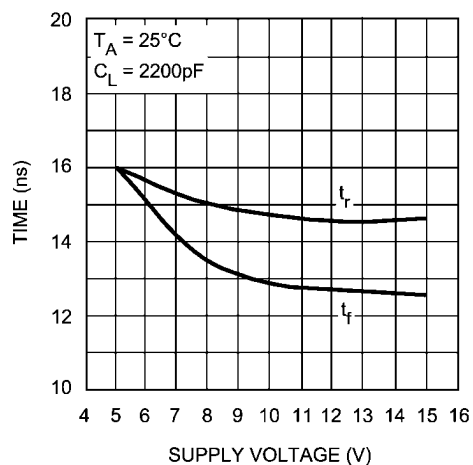
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### Supply Current vs Capacitive Load



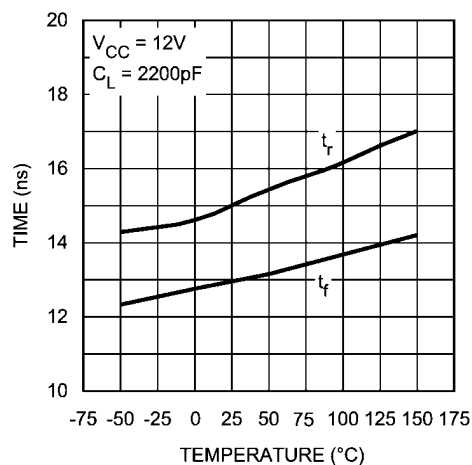
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### Rise and Fall Time vs Supply Voltage

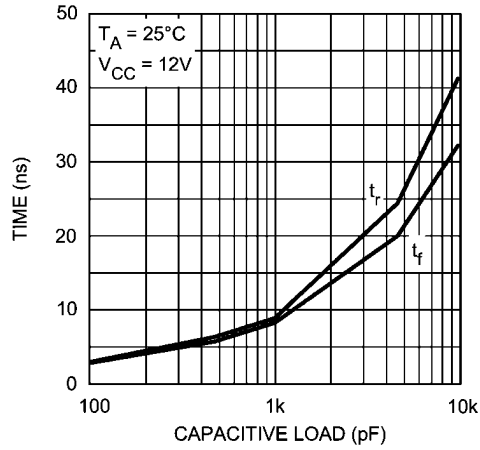


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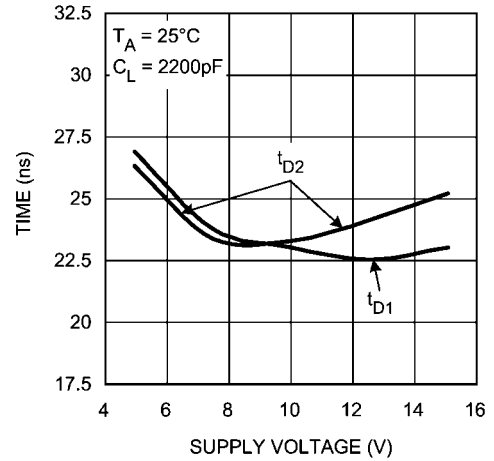
### Rise and Fall Time vs Temperature



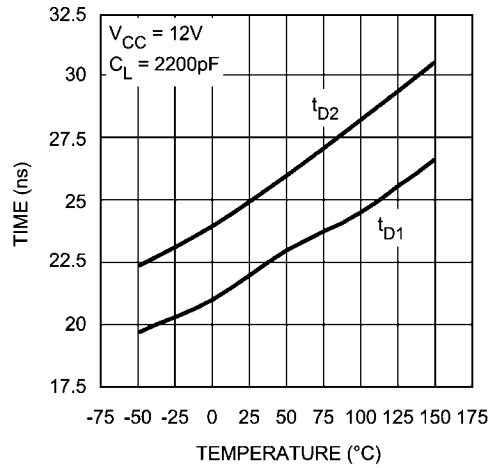
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**Rise and Fall Time vs Capacitive Load**

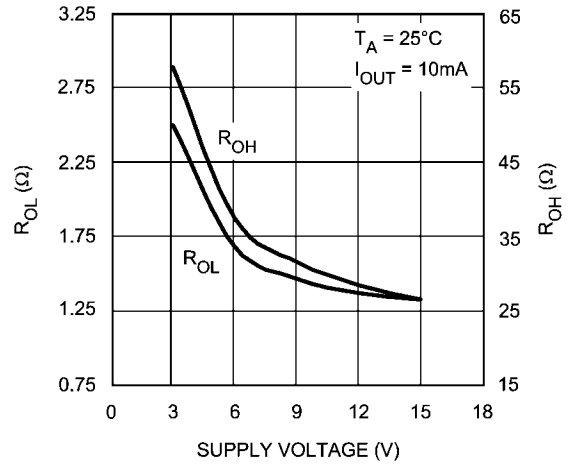
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**Delay Time vs Supply Voltage**

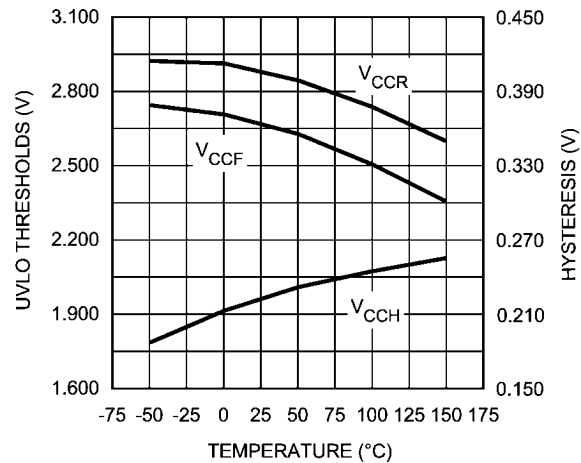
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**Delay Time vs Temperature**

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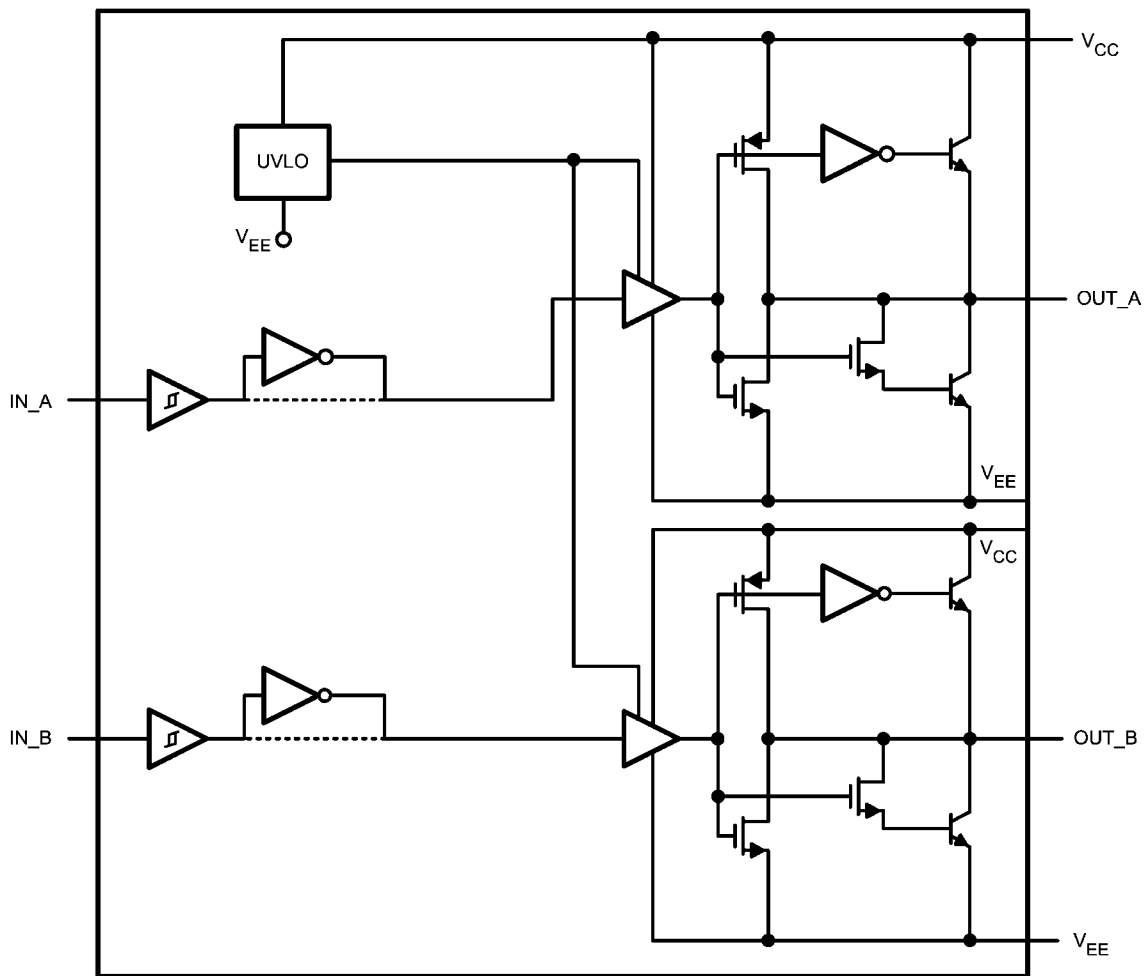
**RDSON vs Supply Voltage**

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**UVLO Thresholds and Hysteresis vs Temperature**

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## Block Diagram



Block Diagram of SM72482

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## Detailed Operating Description

The SM72482 dual gate driver consists of two independent and identical driver channels with TTL compatible logic inputs and high current totem-pole outputs that source or sink current to drive MOSFET gates. The driver output consists of a compound structure with MOS and bipolar transistor operating in parallel to optimize current capability over a wide output voltage and operating temperature range. The bipolar device provides high peak current at the critical threshold region of the MOSFET VGS while the MOS devices provide rail-to-rail output swing. The totem pole output drives the MOSFET gate between the gate drive supply voltage  $V_{CC}$  and the power ground potential at the  $V_{EE}$  pin.

The control inputs of the drivers are high impedance CMOS buffers with TTL compatible threshold voltages. The SM72482 pinout was designed for compatibility with industry standard gate drivers in single supply gate driver applications.

The input stage of each driver should be driven by a signal with a short rise and fall time. Slow rising and falling input signals, although not harmful to the driver, may result in the output switching repeatedly at a high frequency.

The two driver channels of the SM72482 are designed as identical cells. Transistor matching inherent to integrated circuit manufacturing ensures that the AC and DC performance of the channels are nearly identical. Closely matched propagation delays allow the dual driver to be operated as a single with inputs and output pins connected. The drive current capability in parallel operation is precisely 2X the drive of an individual channel. Small differences in switching speed between the driver channels will produce a transient current (shoot-through) in the output stage when two output pins are connected to drive a single load. Differences in input thresholds between the driver channels will also produce a transient current (shoot-through) in the output stage. Fast transition input signals are especially important while operating in a parallel configuration. The efficiency loss for parallel operation has been characterized at various loads, supply voltages and operating frequencies. The power dissipation in the SM72482 increases less than 1% relative to the dual driver configuration when operated as a single driver with inputs/ outputs connected.

An Under Voltage Lock Out (UVLO) circuit is included in the SM72482, which senses the voltage difference between  $V_{CC}$  and the chip ground pin,  $V_{EE}$ . When the  $V_{CC}$  to  $V_{EE}$  voltage difference falls below 2.8V both driver channels are disabled. The UVLO hysteresis prevents chattering during brown-out conditions and the driver will resume normal operation when the  $V_{CC}$  to  $V_{EE}$  differential voltage exceeds approximately 3.0V.

The SM72482MY -1 device holds both outputs in the low state in the under-voltage lockout (UVLO) condition. The SM72482MA-4 has an active high output state of OUT\_A during UVLO. When  $V_{CC}$  is less than the UVLO threshold voltage, OUT\_A will be locked in the high state while OUT\_B will be disabled in the low state. This configuration allows the SM72482MY -4 to drive a PFET through OUT\_A and an NFET through OUT\_B with both FETs safely turned off during UVLO.

## Layout Considerations

Attention must be given to board layout when using SM72482. Some important considerations include:

1. A Low ESR/ESL capacitor must be connected close to the IC and between the  $V_{CC}$  and  $V_{EE}$  pins to support high peak currents being drawn from  $V_{CC}$  during turn-on of the MOSFET.
2. Proper grounding is crucial. The drivers need a very low impedance path for current return to ground avoiding inductive loops. The two paths for returning current to ground are a) between SM72482  $V_{EE}$  pin and the ground of the circuit that controls the driver inputs, b) between SM72482  $V_{EE}$  pin and the source of the power MOSFET being driven. All these paths should be as short as possible to reduce inductance and be as wide as possible to reduce resistance. All these ground paths should be kept distinctly separate to avoid coupling between the high current output paths and the logic signals that drive the SM72482. A good method is to dedicate one copper plane in a multi-layered PCB to provide a common ground surface.
3. With the rise and fall times in the range of 10 ns to 30 ns, care is required to minimize the lengths of current carrying conductors to reduce their inductance and EMI from the high di/dt transients generated by the SM72482.
4. The SM72482 footprint is compatible with other industry standard drivers including the TC4426/27/28 and UCC27323/4/5.
5. If either channel is not being used, the respective input pin (IN\_A or IN\_B) should be connected to either  $V_{EE}$  or  $V_{CC}$  to avoid spurious output signals.

## Thermal Performance

### INTRODUCTION

The primary goal of thermal management is to maintain the integrated circuit (IC) junction temperature ( $T_J$ ) below a specified maximum operating temperature to ensure reliability. It is essential to estimate the maximum  $T_J$  of IC components in worst case operating conditions. The junction temperature is estimated based on the power dissipated in the IC and the junction to ambient thermal resistance  $\theta_{JA}$  for the IC package in the application board and environment. The  $\theta_{JA}$  is not a given constant for the package and depends on the printed circuit board design and the operating environment.

### DRIVE POWER REQUIREMENT CALCULATIONS IN SM72482

The SM72482 dual low side MOSFET driver is capable of sourcing/sinking 3A/5A peak currents for short intervals to drive a MOSFET without exceeding package power dissipation limits. High peak currents are required to switch the MOSFET gate very quickly for operation at high frequencies.



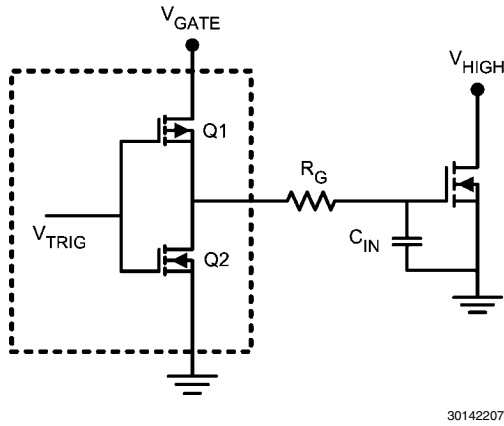


FIGURE 2.

The schematic above shows a conceptual diagram of the SM72482 output and MOSFET load. Q1 and Q2 are the switches within the gate driver.  $R_G$  is the gate resistance of the external MOSFET, and  $C_{IN}$  is the equivalent gate capacitance of the MOSFET. The gate resistance  $R_G$  is usually very small and losses in it can be neglected. The equivalent gate capacitance is a difficult parameter to measure since it is the combination of  $C_{GS}$  (gate to source capacitance) and  $C_{GD}$  (gate to drain capacitance). Both of these MOSFET capacitances are not constants and vary with the gate and drain voltage. The better way of quantifying gate capacitance is the total gate charge  $Q_G$  in coulombs.  $Q_G$  combines the charge required by  $C_{GS}$  and  $C_{GD}$  for a given gate drive voltage  $V_{GATE}$ .

Assuming negligible gate resistance, the total power dissipated in the MOSFET driver due to gate charge is approximated by

$$P_{DRIVER} = V_{GATE} \times Q_G \times F_{SW}$$

Where

$F_{SW}$  = switching frequency of the MOSFET.

For example, consider the MOSFET MTD6N15 whose gate charge specified as 30 nC for  $V_{GATE} = 12V$ .

The power dissipation in the driver due to charging and discharging of MOSFET gate capacitances at switching frequency of 300 kHz and  $V_{GATE}$  of 12V is equal to

$$P_{DRIVER} = 12V \times 30 \text{ nC} \times 300 \text{ kHz} = 0.108W.$$

If both channels of the SM72482 are operating at equal frequency with equivalent loads, the total losses will be twice as this value which is 0.216W.

In addition to the above gate charge power dissipation, - transient power is dissipated in the driver during output transitions. When either output of the SM72482 changes state, current will flow from  $V_{CC}$  to  $V_{EE}$  for a very brief interval of time through the output totem-pole N and P channel MOSFETs. The final component of power dissipation in the driver is the power associated with the quiescent bias current consumed by the driver input stage and Under-voltage lockout sections.

Characterization of the SM72482 provides accurate estimates of the transient and quiescent power dissipation components. At 300 kHz switching frequency and 30 nC load used in the example, the transient power will be 8 mW. The 1 mA nominal quiescent current and 12V  $V_{GATE}$  supply produce a 12 mW typical quiescent power.

Therefore the total power dissipation

$$P_D = 0.216 + 0.008 + 0.012 = 0.236W.$$

We know that the junction temperature is given by

$$T_J = P_D \times \theta_{JA} + T_A$$

Or the rise in temperature is given by

$$T_{RISE} = T_J - T_A = P_D \times \theta_{JA}$$

For SOIC-8 package  $\theta_{JA}$  is estimated as 170°C/W for the conditions of natural convection. For MSOP8-EP  $\theta_{JA}$  is typically 60°C/W.

Therefore for SOIC  $T_{RISE}$  is equal to

$$T_{RISE} = 0.236 \times 170 = 40.1^\circ C$$

### CONTINUOUS CURRENT RATING OF SM72482

The SM72482 can deliver pulsed source/sink currents of 3A and 5A to capacitive loads. In applications requiring continuous load current (resistive or inductive loads), package power dissipation, limits the SM72482 current capability far below the 5A sink/3A source capability. Rated continuous current can be estimated both when sourcing current to or sinking current from the load. For example when sinking, the maximum sink current can be calculated as:

$$I_{SINK} (MAX) := \sqrt{\frac{T_J(MAX) - T_A}{\theta_{JA} \cdot R_{DS} (ON)}}$$

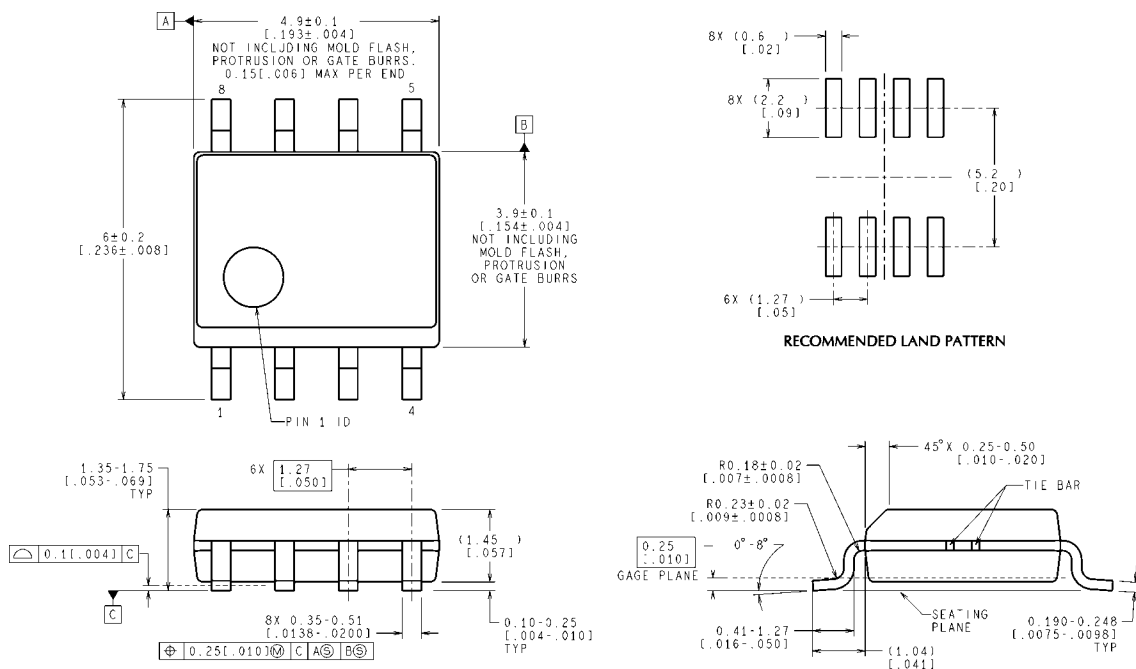
where  $R_{DS}(on)$  is the on resistance of lower MOSFET in the output stage of SM72482.

Consider  $T_J(max)$  of 125°C and  $\theta_{JA}$  of 170°C/W for an SO-8 package under the condition of natural convection and no air flow. If the ambient temperature ( $T_A$ ) is 60°C, and the  $R_{DS}(on)$  of the SM72482 output at  $T_J(max)$  is 2.5Ω, this equation yields  $I_{SINK}(max)$  of 391mA which is much smaller than 5A peak pulsed currents.

Similarly, the maximum continuous source current can be calculated as

$$I_{SOURCE} (MAX) := \frac{T_J(MAX) - T_A}{\theta_{JA} \cdot V_{DIODE}}$$

where  $V_{DIODE}$  is the voltage drop across hybrid output stage which varies over temperature and can be assumed to be about 1.1V at  $T_J(max)$  of 125°C. Assuming the same parameters as above, this equation yields  $I_{SOURCE}(max)$  of 347mA.

**Physical Dimensions** inches (millimeters) unless otherwise noted

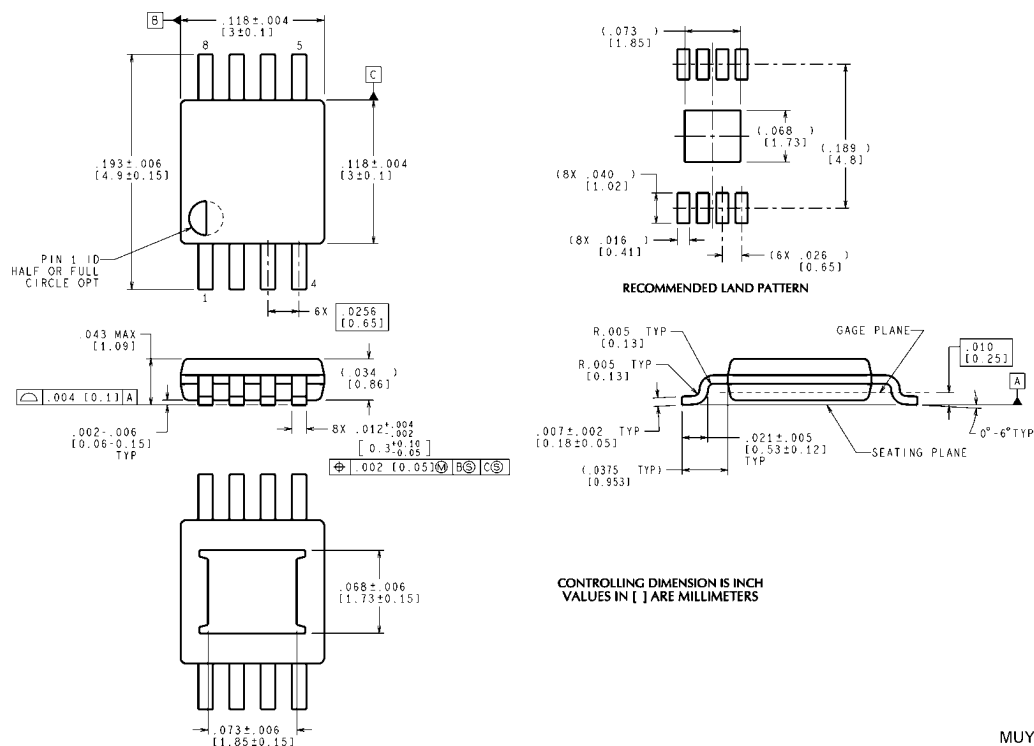
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VALUES IN [ ] ARE INCHES  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev M)

NOTES: UNLESS OTHERWISE SPECIFIED

1. STANDARD LEAD FINISH TO BE 200 MICRONS/5.08 MICROMETERS MINIMUM LEAD/TIN(SOLDER) ON COPPER.
2. DIMENSION DOES NOT INCLUDE MOLD FLASH.
3. REFERENCE JEDEC REGISTRATION MS-012, VARIATION AA, DATED MAY 1990.

**8-Lead SOIC Package**  
**NS Package Number M08A**



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MUY08A (Rev A)

**8-Lead Exposed Pad MSOP Package**  
**NS Package Number MUY08A**



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Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Samples	<a href="http://www.national.com/samples">www.national.com/samples</a>
Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Eval Boards	<a href="http://www.national.com/evalboards">www.national.com/evalboards</a>
LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
Power Management	<a href="http://www.national.com/power">www.national.com/power</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
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LDOs	<a href="http://www.national.com/ldo">www.national.com/ldo</a>	Quality and Reliability	<a href="http://www.national.com/quality">www.national.com/quality</a>
LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>	Feedback/Support	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Voltage References	<a href="http://www.national.com/vref">www.national.com/vref</a>	Design Made Easy	<a href="http://www.national.com/easy">www.national.com/easy</a>
PowerWise® Solutions	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>	Applications & Markets	<a href="http://www.national.com/solutions">www.national.com/solutions</a>
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>	Mil/Aero	<a href="http://www.national.com/milaero">www.national.com/milaero</a>
Temperature Sensors	<a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a>	SolarMagic™	<a href="http://www.national.com/solarmagic">www.national.com/solarmagic</a>
PLL/VCO	<a href="http://www.national.com/wireless">www.national.com/wireless</a>	PowerWise® Design University	<a href="http://www.national.com/training">www.national.com/training</a>

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