

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

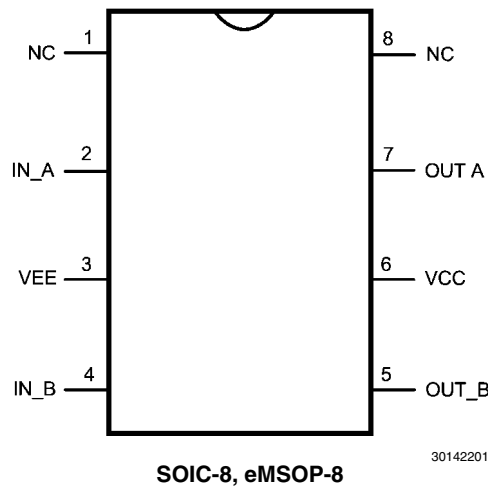
- Synchronous Rectifier Gate Drivers
- Switch-mode Power Supply Gate Driver
- Solenoid and Motor Drivers

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 | μA |
| 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 | $I_{OUT} = -10\text{ mA}$ (Note 2) | | 30 | 50 | Ω |
| R_{OL} | Output Resistance Low | $I_{OUT} = +10\text{ mA}$ (Note 2) | | 1.4 | 2.5 | Ω |
| 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 |
|----------------------------------|--|---|-----|-----|-----|--------------------|
| SWITCHING CHARACTERISTICS | | | | | | |
| td1 | Propagation Delay Time Low to High, IN rising (IN to OUT) | $C_{LOAD} = 2 \text{ nF}$, see <i>Figure 1</i> | | 25 | 40 | ns |
| td2 | Propagation Delay Time High to Low, IN falling (IN to OUT) | $C_{LOAD} = 2 \text{ nF}$, see <i>Figure 1</i> | | 25 | 40 | ns |
| t_r | Rise Time | $C_{LOAD} = 2 \text{ nF}$, see <i>Figure 1</i> | | 14 | 25 | ns |
| t_f | Fall Time | $C_{LOAD} = 2 \text{ nF}$, see <i>Figure 1</i> | | 12 | 25 | ns |
| LATCHUP PROTECTION | | | | | | |
| | AEC - Q100, Method 004 | $T_J = 150^\circ\text{C}$ | | 500 | | mA |
| THERMAL RESISTANCE | | | | | | |
| θ_{JA} | Junction to Ambient, 0 LFPM Air Flow | SOIC-8 Package | | 170 | | $^\circ\text{C/W}$ |
| | | MSOP8-EP Package | | 60 | | |
| θ_{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

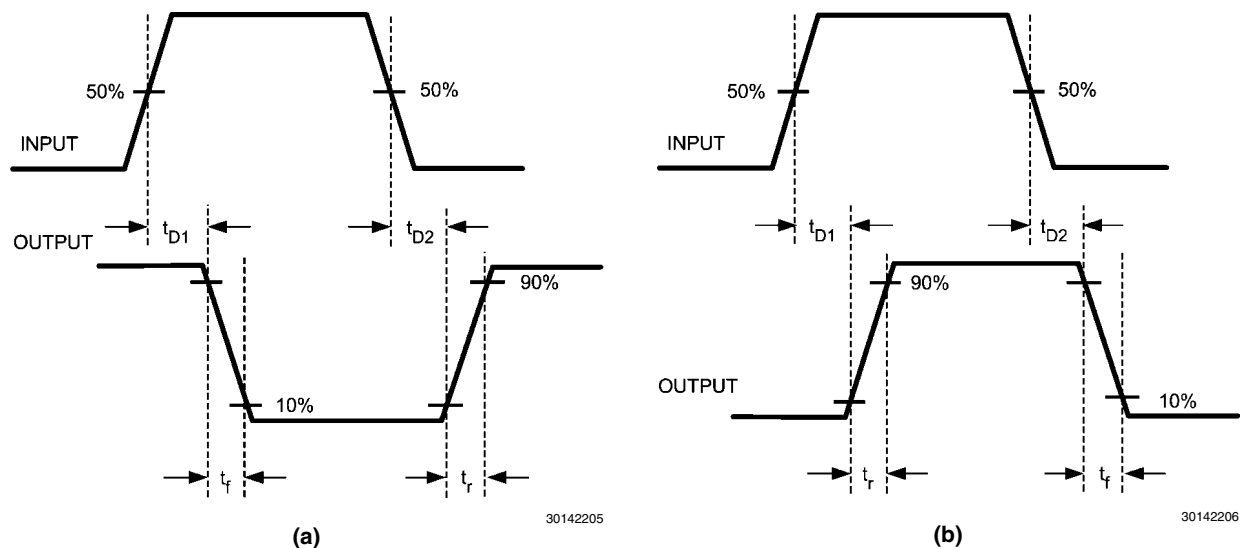
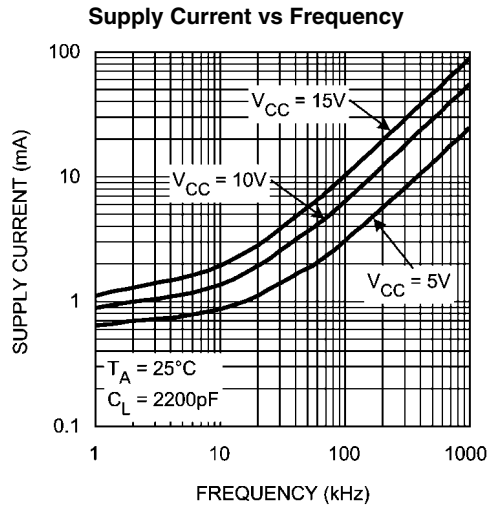
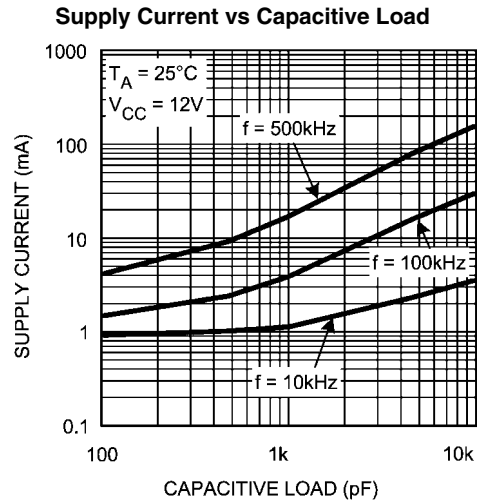


FIGURE 1. (a) Inverting, (b) Non-Inverting

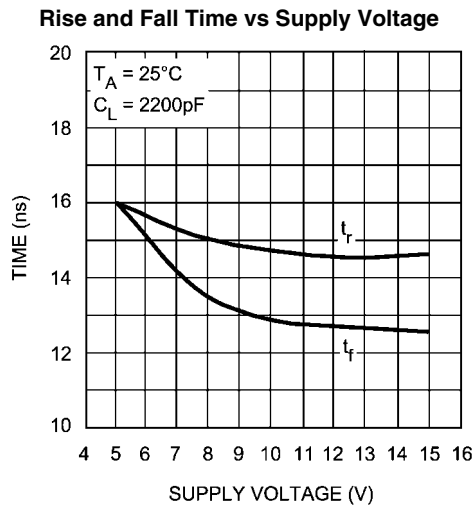
Typical Performance Characteristics



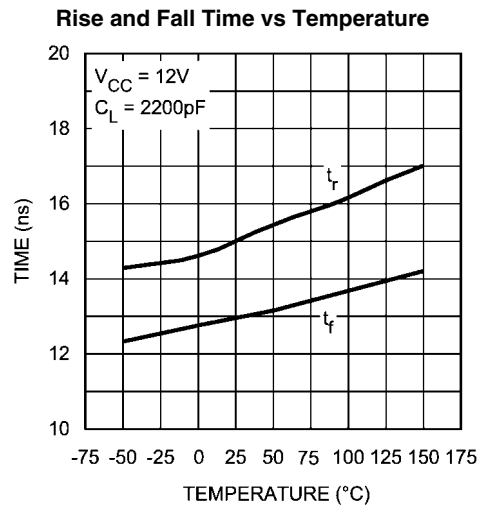
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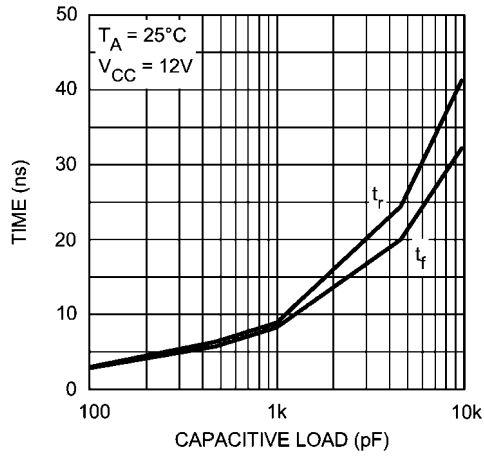


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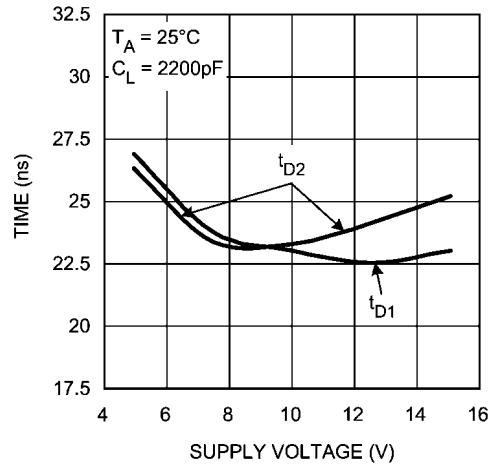
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Rise and Fall Time vs Capacitive Load



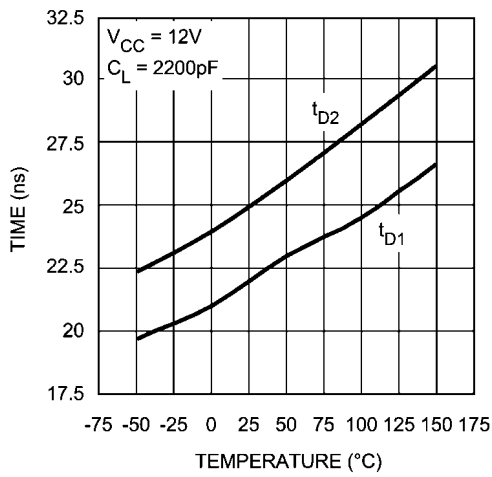
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Delay Time vs Supply Voltage



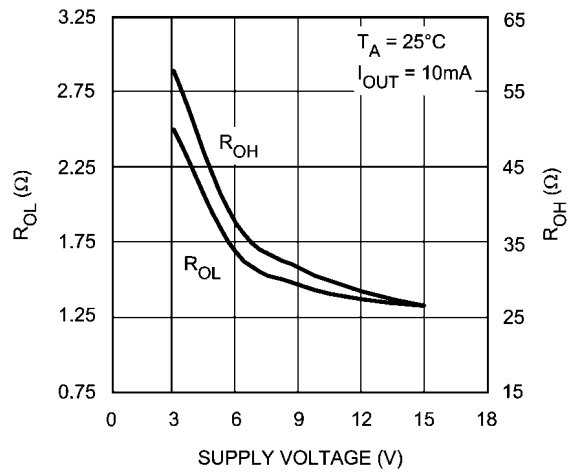
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Delay Time vs Temperature



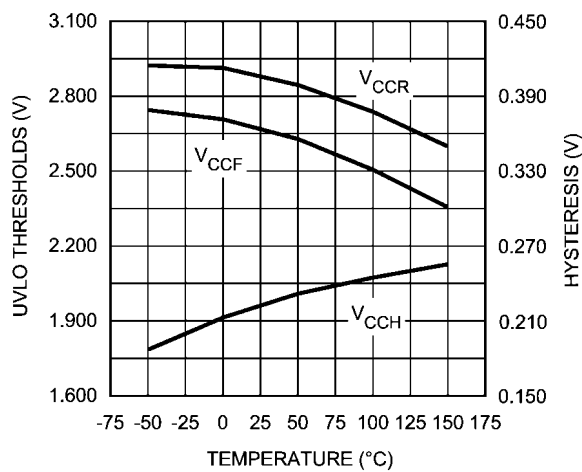
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RDSON vs Supply Voltage



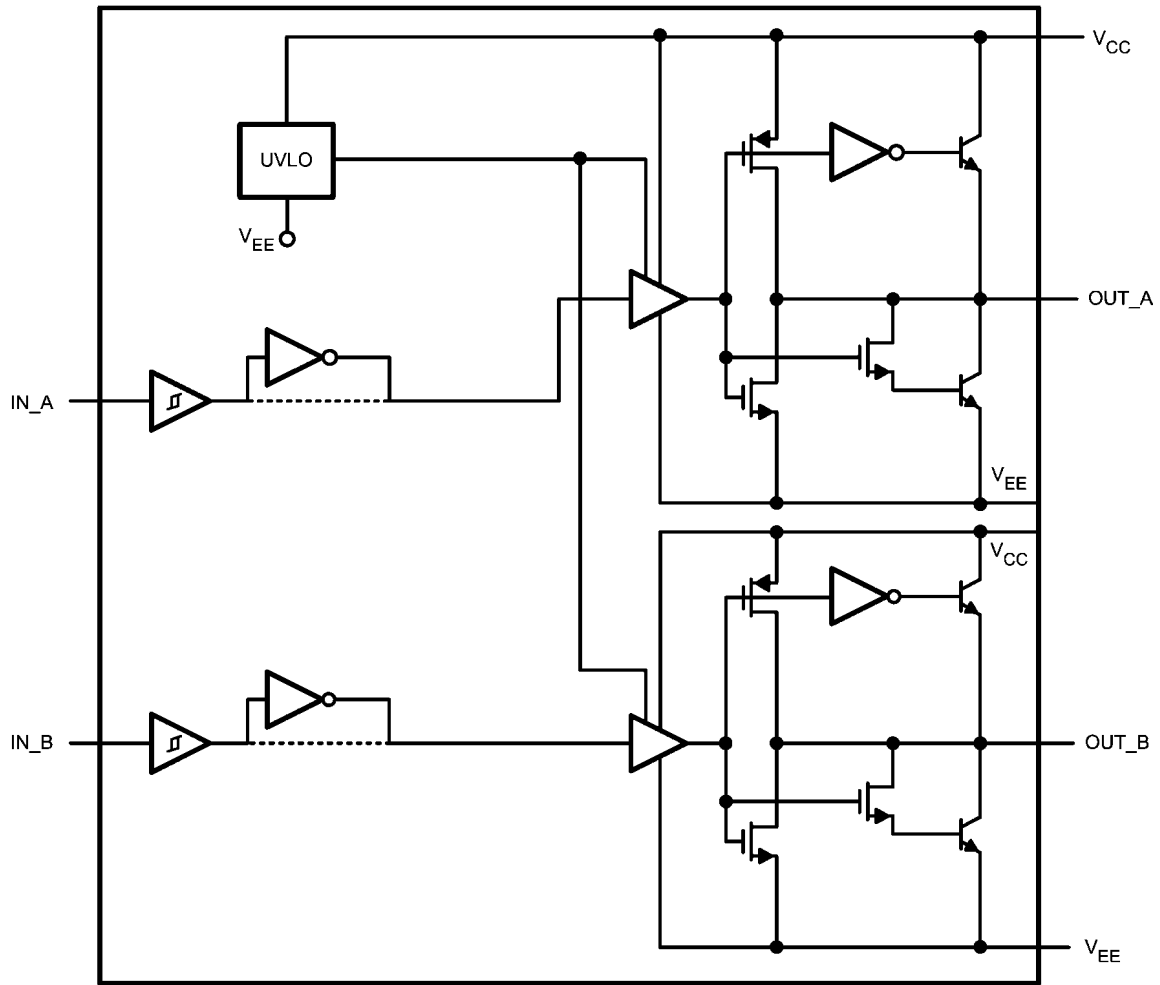
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UVLO Thresholds and Hysteresis vs Temperature



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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 consist 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 hold 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 VCC 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 θ_{JA} for the IC package in the application board and environment. The θ_{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.

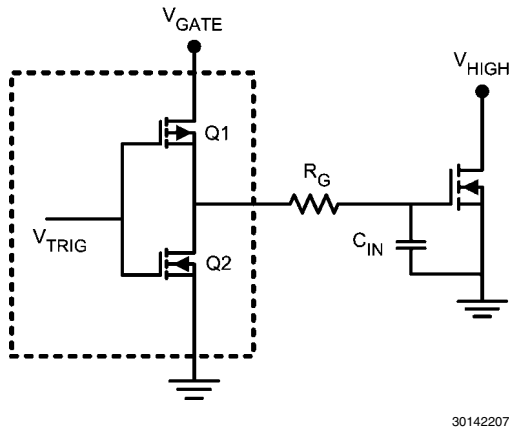


FIGURE 2.

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 θ_{JA} is estimated as 170°C/W for the conditions of natural convection. For MSOP8-EP θ_{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.

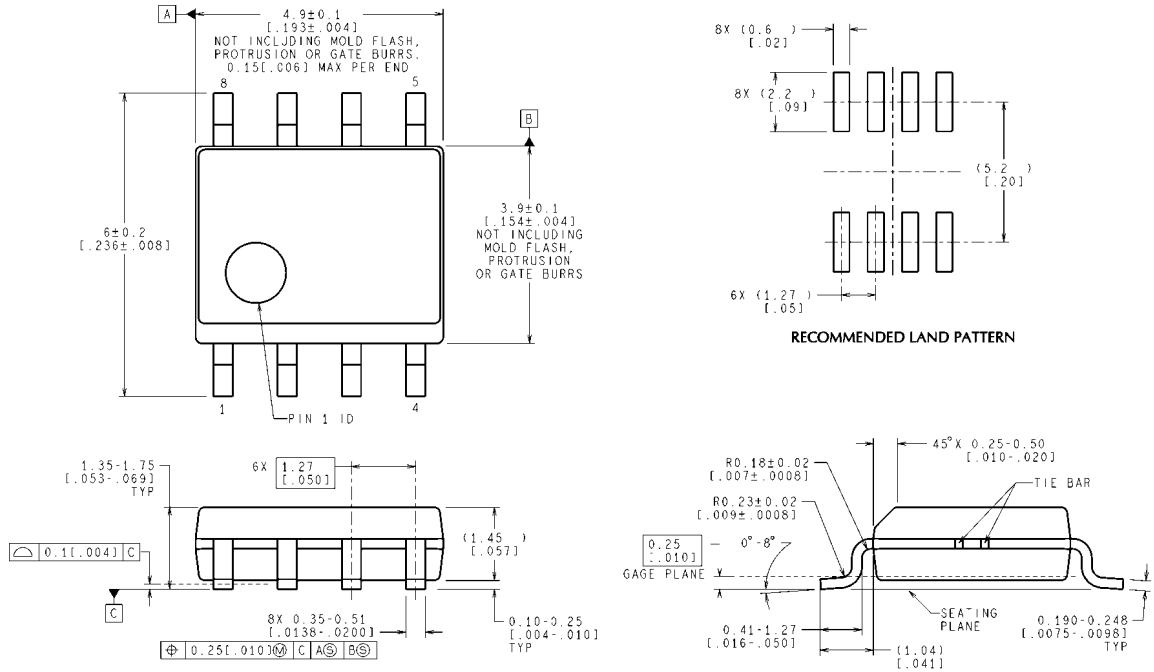
Consider $T_J(max)$ of 125°C and θ_{JA} of 170°C/W for an SO-8 package under the condition of natural convection and no air flow. If the ambient temperature (T_A) is 60°C, and the $R_{DS}(on)$ of the SM72482 output at $T_J(max)$ is 2.5Ω, this equation yields $I_{SINK}(max)$ of 391mA which is much smaller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



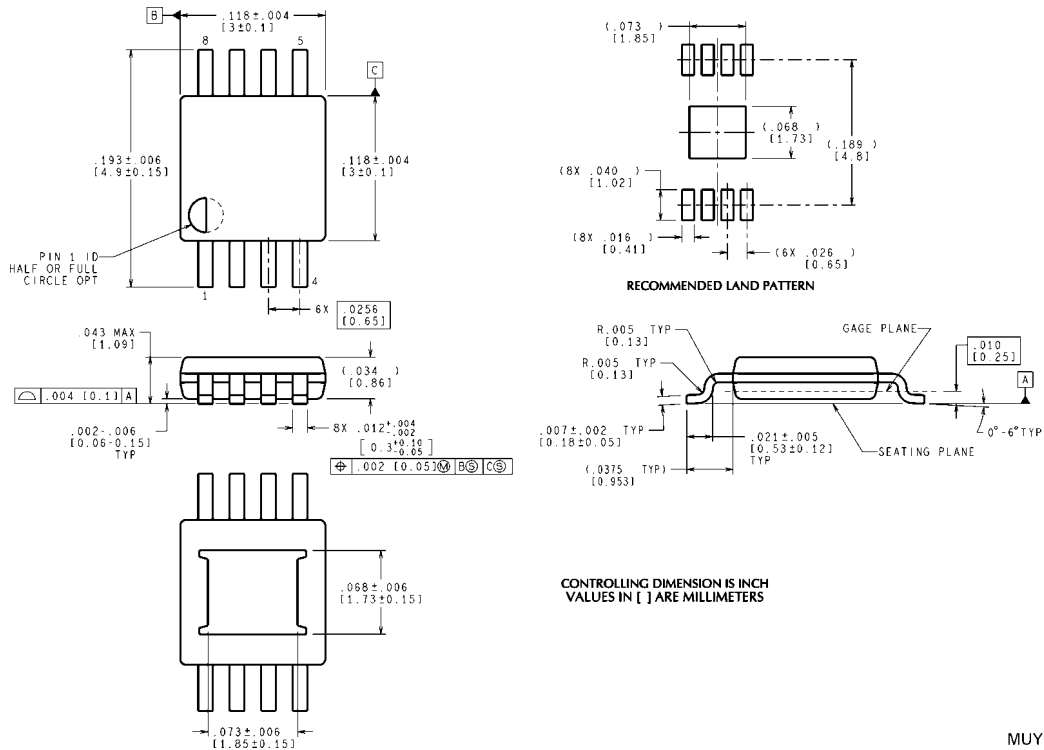
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M08A (Rev M)

NOTES: UNLESS OTHERWISE SPECIFIED

1. STANDARD LEAD FINISH TO BE 200 MICRINCHES/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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