

## High Voltage Synchronous Rectified Buck MOSFET Driver

The ISL6207 is a high frequency, dual MOSFET driver, optimized to drive two N-Channel power MOSFETs in a synchronous-rectified buck converter topology in mobile computing applications. This driver, combined with an Intersil Multi-Phase Buck PWM controller, such as ISL6223, ISL6215, and ISL6216, forms a complete single-stage core-voltage regulator solution for advanced mobile microprocessors.

The ISL6207 features 4A typical sink current for the lower gate driver. The 4A typical sink current is capable of holding the lower MOSFET gate during the Phase node rising edge to prevent the shoot-through power loss caused by the high  $dv/dt$  of the Phase node. The operation voltage matches the 30V breakdown voltage of the MOSFETs commonly used in mobile computer power supplies.

The ISL6207 also features a three-state PWM input that, working together with most of Intersil multiphase PWM controllers, will prevent a negative transient on the output voltage when the output is being shut down. This feature eliminates the Schottky diode, that is usually seen in a microprocessor power system for protecting the microprocessor, from reversed-output-voltage damage.

The ISL6207 has the capacity to efficiently switch power MOSFETs at frequencies up to 2MHz. Each driver is capable of driving a 3000pF load with a 8ns propagation delay and less than a 10ns transition time. This product implements bootstrapping on the upper gate with an internal bootstrap Schottky diode, reducing implementation cost, complexity, and allowing the use of higher performance, cost effective N-Channel MOSFETs. Adaptive shoot-through protection is integrated to prevent both MOSFETs from conducting simultaneously.

### Ordering Information

PART #	TEMP. RANGE (°C)	PACKAGE	PKG. DWG. #
ISL6207CB	-10 to 85	8 Lead SOIC	M8.15
ISL6207CB-T		8 Ld SOIC Tape & Reel	M8.15
ISL6207CR	-10 to 85	8 Lead 3x3 QFN	L8.3x3
ISL6207CR-T		8 Ld QFN Tape & Reel	L8.3x3
ISL6207CBZ	-10 to 85	8 Lead SOIC (Ld Free)	M8.15
ISL6207CBZ-T		8 Ld SOIC (Ld Free) Tape & Reel	M8.15
ISL6207HBZ	-10 to 100	8 Ld SOIC (Ld Free)	M8.15
ISL6207HBZ-T		8 Ld SOIC (Ld Free) Tape & Reel	M8.15
ISL6207CRZ	-10 to 85	8 Lead 3x3 QFN (Ld Free)	L8.3x3
ISL6207CRZ-T		8 Lead QFN (Ld Free) Tape & Reel	L8.3x3
ISL6207HRZ	-10 to 100	8 Ld 3x3 QFN (Ld Free)	L8.3x3
ISL6207HRZ-T		8 Lead QFN (Ld Free) Tape & Reel	L8.3x3

## Features

- Drives Two N-Channel MOSFETs
- Adaptive Shoot-Through Protection
- 30V Operation Voltage
- 0.4Ω On-Resistance and 4A Sink Current Capability
- Supports High Switching Frequency
  - Fast Output Rise Time
  - Propagation Delay 8ns
- Three-State PWM Input for Power Stage Shutdown
- Internal Bootstrap Schottky Diode
- QFN Package:
  - Compliant to JEDEC PUB95 MO-220 QFN - Quad Flat No Leads - Package Outline
  - Near Chip Scale Package footprint, which improves PCB efficiency and has a thinner profile

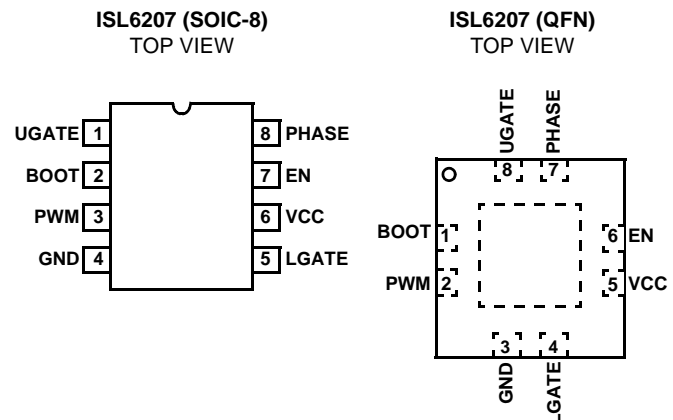
## Applications

- Core Voltage Supplies for Intel and AMD® Mobile Microprocessors
- High Frequency Low Profile DC-DC Converters
- High Current Low Output Voltage DC-DC Converters
- High Input Voltage DC-DC Converters

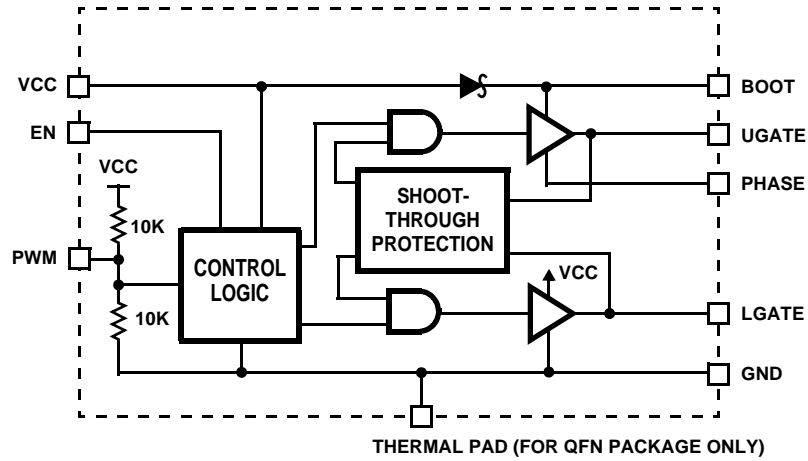
## Related Literature

- Technical Brief TB363 "Guidelines for Handling and Processing Moisture Sensitive Surface Mount Devices (SMDs)"
- Technical Brief TB389 "PCB Land Pattern Design and Surface Mount Guidelines for QFN Packages"

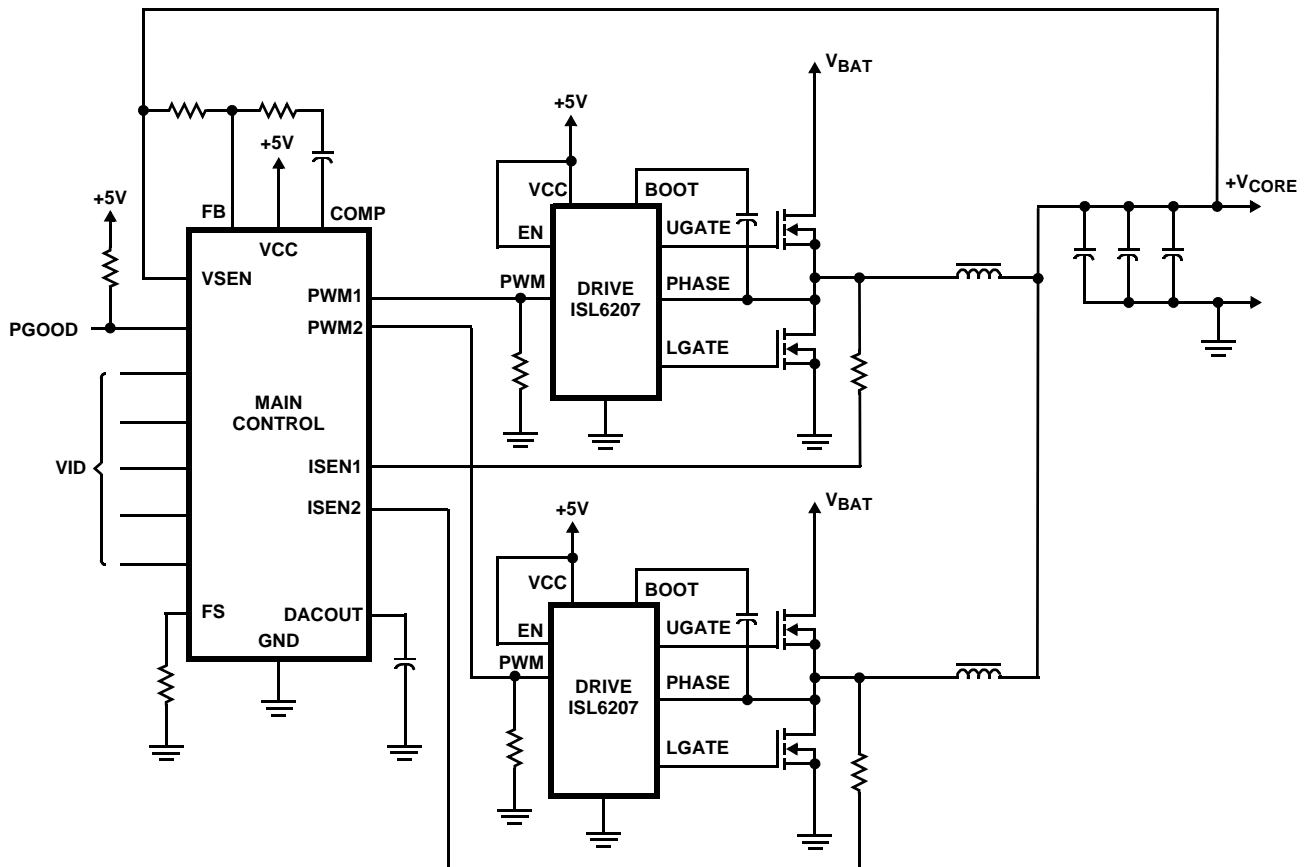
## Pinouts



**ISL6207 Block Diagram**



**Typical Application - Two Phase Converter Using ISL6207 Gate Drivers**



**Absolute Maximum Ratings**

Supply Voltage (V <sub>CC</sub> )	-0.3V to 7V
BOOT Voltage (V <sub>BOOT</sub> )	-0.3V to 36V
Phase Voltage (V <sub>PHASE</sub> ) (Note 1)	V <sub>BOOT</sub> - 7V to V <sub>BOOT</sub> + 0.3V
Input Voltage (V <sub>EN</sub> , V <sub>PWM</sub> )	-0.3V to V <sub>CC</sub> + 0.3V
UGATE	V <sub>PHASE</sub> - 0.3V to V <sub>BOOT</sub> + 0.3V
LGATE	-0.3V to V <sub>CC</sub> + 0.3V
Ambient Temperature Range	-40°C to 125°C

**Thermal Information**

Thermal Resistance (Typical Notes 3, 4, 5) θ <sub>JA</sub> (°C/W)	θ <sub>JC</sub> (°C/W)
SOIC Package (Note 2)	110 N/A
QFN Package (Notes 4, 5)	95 36
Maximum Junction Temperature (Plastic Package)	150°C
Maximum Storage Temperature Range	-65°C to 150°C
Maximum Lead Temperature (Soldering 10s)	300°C (SOIC - Lead Tips Only)

**Recommended Operating Conditions**

Ambient Temperature Range	-10°C to 100°C
Maximum Operating Junction Temperature	125°C
Supply Voltage, V <sub>CC</sub>	5V ±10%

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

1. The Phase Voltage is capable of withstanding -7V when the BOOT pin is at GND.
2. θ<sub>JA</sub> is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
3. θ<sub>JA</sub> is measured in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief TB379.
4. For θ<sub>JC</sub>, the "case temp" location is the center of the exposed metal pad on the package underside.

**Electrical Specifications** Recommended Operating Conditions, Unless Otherwise Noted.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>VCC SUPPLY CURRENT</b>						
Bias Supply Current	I <sub>VCC</sub>	EN = LOW	-	-	5.0	μA
Bias Supply Current	I <sub>VCC</sub>	PWM pin floating, V <sub>VCC</sub> = 5V	-	30	-	μA
<b>BOOTSTRAP DIODE</b>						
Forward Voltage	V <sub>F</sub>	V <sub>VCC</sub> = 5V, forward bias current = 2mA	0.45	0.60	0.65	V
<b>PWM INPUT</b>						
Input Current	I <sub>PWM</sub>	V <sub>PWM</sub> = 5V	-	250	-	μA
		V <sub>PWM</sub> = 0V	-	-250	-	μA
PWM Three-State Rising Threshold		V <sub>VCC</sub> = 5V	-	-	1.7	V
PWM Three-State Falling Threshold		V <sub>VCC</sub> = 5V	3.3	-	-	V
Three-State Shutdown Holdoff Time		V <sub>VCC</sub> = 5V, temperature = 25°C	-	300	-	ns
<b>EN INPUT</b>						
EN LOW Threshold			1.0	-	-	V
EN HIGH Threshold			-	-	2.0	V
<b>SWITCHING TIME</b>						
UGATE Rise Time	t <sub>RUGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	8	-	ns
LGATE Rise Time	t <sub>RLGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	8	-	ns
UGATE Fall Time	t <sub>FUGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	8	-	ns
LGATE Fall Time	t <sub>FLGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	4	-	ns
UGATE Turn-Off Propagation Delay	t <sub>PDLUGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	8	-	ns
LGATE Turn-Off Propagation Delay	t <sub>PDLLGATE</sub>	V <sub>VCC</sub> = 5V, 3nF Load	-	8	-	ns
UGATE Turn-On Propagation Delay	t <sub>PDHUGATE</sub>	V <sub>VCC</sub> = 5V, Outputs Unloaded	5	8	12	ns
LGATE Turn-On Propagation Delay	t <sub>PDHLGATE</sub>	V <sub>VCC</sub> = 5V, Outputs Unloaded	5	8	12	ns

**Electrical Specifications** Recommended Operating Conditions, Unless Otherwise Noted. (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>OUTPUT</b>						
Upper Drive Source Resistance	R <sub>UGATE</sub>	500mA Source Current	-	1.0	2.5	Ω
		-10°C to 85°C	-	1.0	2.2	Ω
Upper Driver Source Current (Note 5)	I <sub>UGATE</sub>	V <sub>UGATE-PHASE</sub> = 2.5V		2.0		A
Upper Drive Sink Resistance	R <sub>UGATE</sub>	500mA Sink Current	-	1.0	2.5	Ω
		-10°C to 85°C	-	1.0	2.2	Ω
Upper Driver Sink Current (Note 5)	I <sub>UGATE</sub>	V <sub>UGATE-PHASE</sub> = 2.5V		2.0		A
Lower Drive Source Resistance	R <sub>LGATE</sub>	500mA Source Current	-	1.0	2.5	Ω
		-10°C to 85°C		1.0	2.2	Ω
Lower Driver Source Current (Note 5)	I <sub>LGATE</sub>	V <sub>LGATE</sub> = 2.5V		2.0		A
Lower Drive Sink Resistance	R <sub>LGATE</sub>	500mA Sink Current	-	0.4	1.0	Ω
		-10°C to 85°C		0.4	0.8	Ω
Lower Driver Sink Current (Note 5)	I <sub>LGATE</sub>	V <sub>LGATE</sub> = 2.5V		4.0		A

NOTE:

5. Guaranteed by design, not tested.

**Functional Pin Description****UGATE (Pin 1 for SOIC-8, Pin 8 for QFN)**

The UGATE pin is the upper gate drive output. Connect to the gate of high-side power N-Channel MOSFET.

**BOOT (Pin 2 for SOIC-8, Pin 1 for QFN)**

BOOT is the floating bootstrap supply pin for the upper gate drive. Connect the bootstrap capacitor between this pin and the PHASE pin. The bootstrap capacitor provides the charge to turn on the upper MOSFET. See the Bootstrap Diode and Capacitor section under DESCRIPTION for guidance in choosing the appropriate capacitor value.

**PWM (Pin 3 for SOIC-8, Pin 2 for QFN)**

The PWM signal is the control input for the driver. The PWM signal can enter three distinct states during operation, see the three-state PWM Input section under DESCRIPTION for further details. Connect this pin to the PWM output of the controller. In addition, place a 500kΩ resistor to ground from this pin. This allows for proper three-state operation under all start-up conditions.

**GND (Pin 4 for SOIC-8, Pin 3 for QFN)**

GND is the ground pin. All signals are referenced to this node.

**LGATE (Pin 5 for SOIC-8, Pin 4 for QFN)**

LGATE is the lower gate drive output. Connect to gate of the low-side power N-Channel MOSFET.

**VCC (Pin 6 for SOIC-8, Pin 5 for QFN)**

Connect the VCC pin to a +5V bias supply. Place a high quality bypass capacitor from this pin to GND.

**EN (Pin 7 for SOIC-8, Pin 6 for QFN)**

EN is the enable input pin. Connect this pin to HIGH to enable, and LOW to disable, the IC. When disabled, the IC draws less than 1μA bias current.

**PHASE (Pin 8 for SOIC-8, Pin 7 for QFN)**

Connect the PHASE pin to the source of the upper MOSFET and the drain of the lower MOSFET. This pin provides a return path for the upper gate driver.

**Description****Operation**

Designed for speed, the ISL6207 dual MOSFET driver controls both high-side and low-side N-Channel FETs from one externally provided PWM signal.

A rising edge on PWM initiates the turn-off of the lower MOSFET (see Timing Diagram). After a short propagation delay [t<sub>PDLLGATE</sub>], the lower gate begins to fall. Typical fall times [t<sub>FLGATE</sub>] are provided in the Electrical Specifications section. Adaptive shoot-through circuitry monitors the LGATE voltage and determines the upper gate delay time [t<sub>PDHUGATE</sub>], based on how quickly the LGATE voltage drops below 1V. This prevents both the lower and upper MOSFETs from conducting simultaneously, or shoot-through. Once this delay period is completed, the upper gate drive begins to rise [t<sub>RUGATE</sub>], and the upper MOSFET turns on.

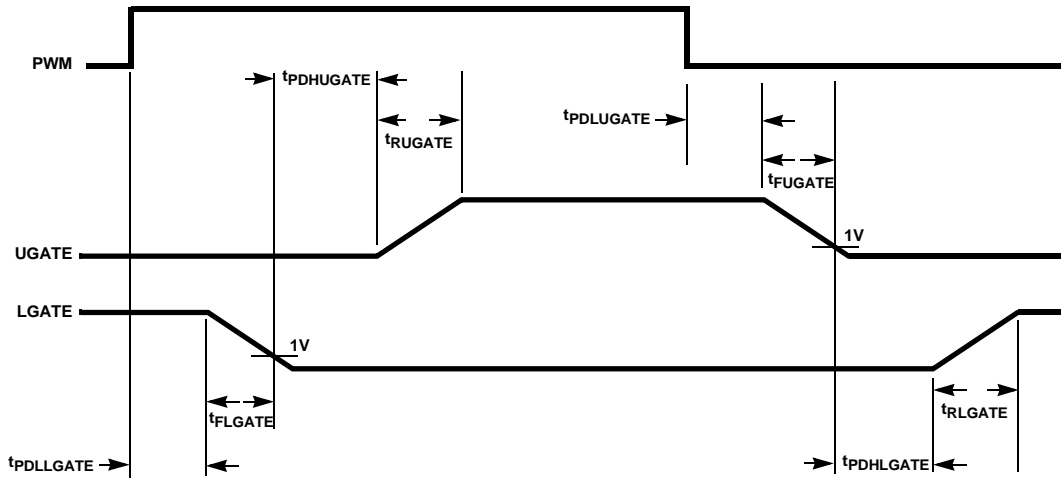


FIGURE 1. TIMING DIAGRAM

A falling transition on PWM indicates the turn-off of the upper MOSFET and the turn-on of the lower MOSFET. A short propagation delay [ $t_{PDLUGATE}$ ] is encountered before the upper gate begins to fall [ $t_{FUGATE}$ ]. Again, the adaptive shoot-through circuitry determines the lower gate delay time  $t_{PDHLGATE}$ . The upper MOSFET gate-to-source voltage is monitored, and the lower gate is allowed to rise, after the upper MOSFET gate-to-source voltage drops below 1V. The lower gate then rises [ $t_{RLGATE}$ ], turning on the lower MOSFET.

This driver is optimized for converters with large step down ratio, such as those used in a mobile-computer core voltage regulator. The lower MOSFET is usually sized much larger. Timing Diagram

This driver is optimized for converters with large step down compared to the upper MOSFET because the lower MOSFET conducts for a much longer time in a switching period. The lower gate driver is therefore sized much larger to meet this application requirement. The 0.4 $\Omega$  on-resistance and 4A sink current capability enable the lower gate driver to absorb the current injected to the lower gate through the drain-to-gate capacitor of the lower MOSFET and prevent a shoot through caused by the high dv/dt of the phase node.

### Three-State PWM Input

A unique feature of the ISL6207 and other Intersil drivers is the addition of a shutdown window to the PWM input. If the PWM signal enters and remains within the shutdown window for a set holdoff time, the output drivers are disabled and both MOSFET gates are pulled and held low. The shutdown state is removed when the PWM signal moves outside the shutdown window. Otherwise, the PWM rising and falling thresholds outlined in the ELECTRICAL SPECIFICATIONS determine when the lower and upper gates are enabled. During start-up, PWM should be in the three-state position ( $1/2 V_{CC}$ ). However, with rising  $V_{CC}$ , the active tracking elements for PWM are not active until  $V_{CC} > 1.2V$ , which

leaves PWM in a high impedance (undetermined) state; therefore, a 500K $\Omega$  resistor must be placed from the PWM pin to GND.

### Adaptive Shoot-Through Protection

Both drivers incorporate adaptive shoot-through protection to prevent upper and lower MOSFETs from conducting simultaneously and shorting the input supply. This is accomplished by ensuring the falling gate has turned off one MOSFET before the other is allowed to turn on.

During turn-off of the lower MOSFET, the LGATE voltage is monitored until it reaches a 1V threshold, at which time the UGATE is released to rise. Adaptive shoot-through circuitry monitors the upper MOSFET gate-to-source voltage during UGATE turn-off. Once the upper MOSFET gate-to-source voltage has dropped below a threshold of 1V, the LGATE is allowed to rise.

### Internal Bootstrap Diode

This driver features an internal bootstrap Schottky diode. Simply adding an external capacitor across the BOOT and PHASE pins completes the bootstrap circuit.

The bootstrap capacitor must have a maximum voltage rating above the maximum battery voltage plus 5V. The bootstrap capacitor can be chosen from the following equation:

$$C_{BOOT} \geq \frac{Q_{GATE}}{\Delta V_{BOOT}}$$

where  $Q_{GATE}$  is the amount of gate charge required to fully charge the gate of the upper MOSFET. The  $\Delta V_{BOOT}$  term is defined as the allowable droop in the rail of the upper drive.

As an example, suppose an upper MOSFET has a gate charge,  $Q_{GATE}$ , of 25nC at 5V and also assume the droop in the drive voltage over a PWM cycle is 200mV. One will find that a bootstrap capacitance of at least 0.125 $\mu$ F is required. The next larger standard value capacitance is 0.22 $\mu$ F. A good quality ceramic capacitor is recommended.

### **Power Dissipation**

Package power dissipation is mainly a function of the switching frequency and total gate charge of the selected MOSFETs. Calculating the power dissipation in the driver for a desired application is critical to ensuring safe operation. Exceeding the maximum allowable power dissipation level will push the IC beyond the maximum recommended operating junction temperature of 125°C. The maximum allowable IC power dissipation for the SO-8 package is approximately 800mW. When designing the driver into an application, it is recommended that the following calculation be performed to ensure safe operation at the desired frequency for the selected MOSFETs. The power dissipated by the driver is approximated as:

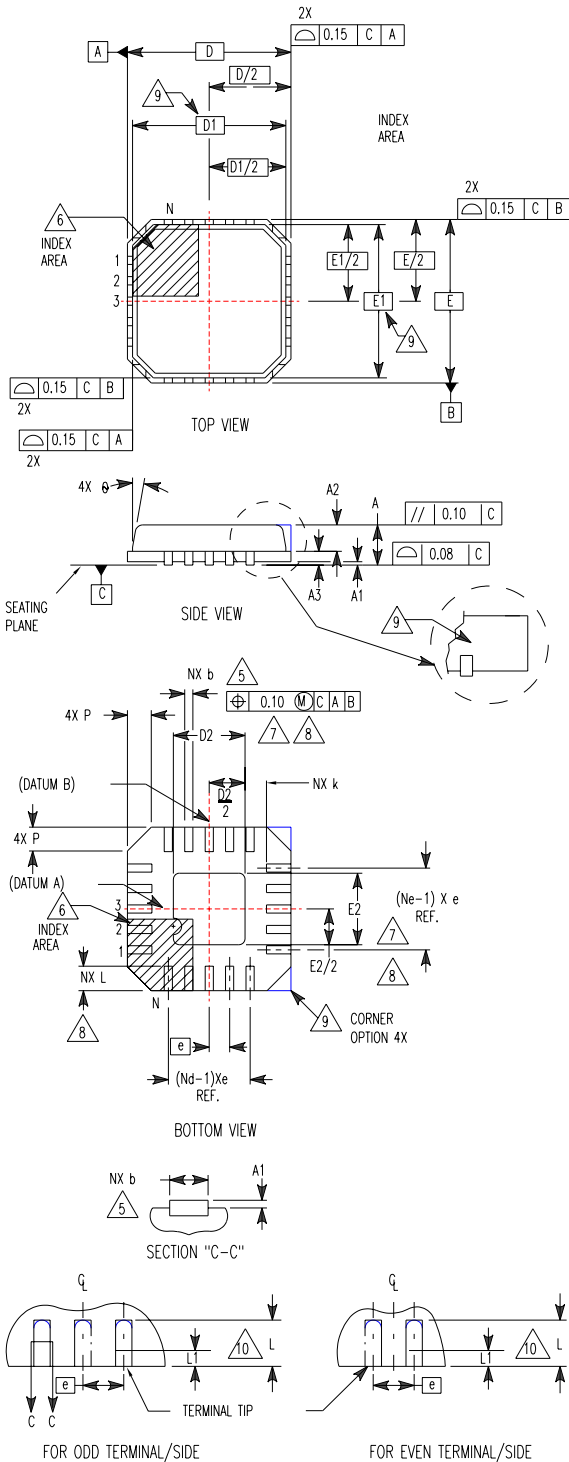
$$P = f_{sw}(1.5V_U Q_U + V_L Q_L) + I_{DDQ} V_{CC}$$

where  $f_{sw}$  is the switching frequency of the PWM signal.  $V_U$  and  $V_L$  represent the upper and lower gate rail voltage.  $Q_U$  and  $Q_L$  is the upper and lower gate charge determined by MOSFET selection and any external capacitance added to the gate pins. The  $I_{DDQ} V_{CC}$  product is the quiescent power of the driver and is typically negligible.

**Quad Flat No-Lead Plastic Package (QFN)  
Micro Lead Frame Plastic Package (MLFP)**

**L8.3x3**

**8 LEAD QUAD FLAT NO-LEAD PLASTIC PACKAGE  
(COMPLIANT TO JEDEC MO-220VEEC ISSUE C)**



SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.80	0.90	1.00	-
A1	-	-	0.05	-
A2	-	-	1.00	9
A3	0.20 REF			9
b	0.23	0.28	0.38	5, 8
D	3.00 BSC			-
D1	2.75 BSC			9
D2	0.25	1.10	1.25	7, 8
E	3.00 BSC			-
E1	2.75 BSC			9
E2	0.25	1.10	1.25	7, 8
e	0.65 BSC			-
k	0.25		-	-
L	0.35	0.60	0.75	8
L1	-	-	0.15	10
N	8			2
Nd	2			3
Ne	2			3
P	-	-	0.60	9
θ	-	-	12	9

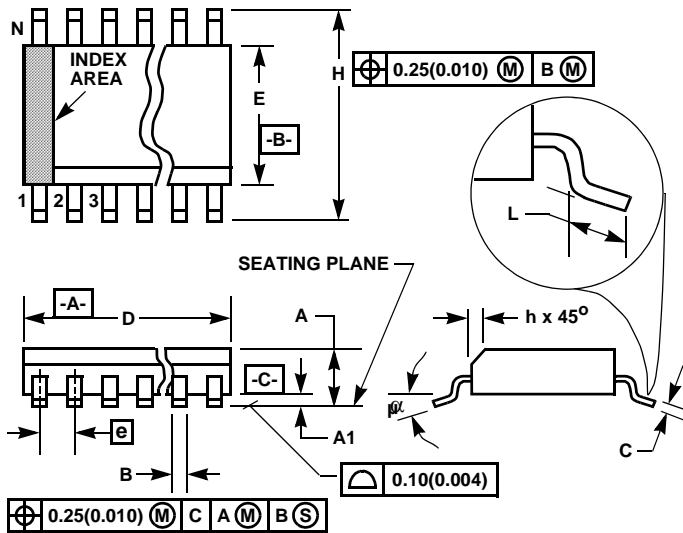
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**NOTES:**

Intersil Lead Free products employ special lead free material sets; molding compounds / die attach materials and 100% matte tin plate termination finish, which is compatible with both SnPb and lead free soldering operations. Intersil Lead Free products are MSL classified at lead free peak reflow temperatures that meet or exceed the lead free requirements of IPC/JEDEC J Std-020B.

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd and Ne refer to the number of terminals on each D and E.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
8. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.
9. Features and dimensions A2, A3, D1, E1, P & θ are present when Anvil singulation method is used and not present for saw singulation.
10. Depending on the method of lead termination at the edge of the package, a maximum 0.15mm pull back (L1) maybe present. L minus L1 to be equal to or greater than 0.3mm.

## Small Outline Plastic Packages (SOIC)



### NOTES:

- Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
- Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
- The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
- "L" is the length of terminal for soldering to a substrate.
- "N" is the number of terminal positions.
- Terminal numbers are shown for reference only.
- The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
- Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

### M8.15 (JEDEC MS-012-AA ISSUE C) 8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
$\alpha$	0°	8°	0°	8°	-

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