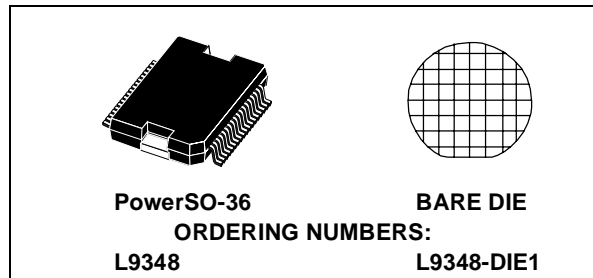


QUAD LOW SIDE DRIVER

- SUPPLY VOLTAGE RANGE: 4.8 TO 18V
- OUTPUT VOLTAGE UP TO 40V
- OUTPUT VOLTAGE CLAMP DURING RECIRCULATION OF INDUCTIVE LOADS
- OUTPUT CURRENT CAPABILITY 2 X 5A AND 2 X 3A
- LOW POWER DISSIPATION DURING RECIRCULATION OF INDUCTIVE LOADS BY INTEGRATED FREE WHEELING DIODES (3A-DRIVERS ONLY)
- LOW ON-RESISTANCE 2 X 0.2Ω , 2 X 0.35Ω (TYP.)
- OUTPUT SHORT CIRCUIT CURRENT PROTECTION
- REAL TIME DIAGNOSTIC FUNCTIONS
- OVERTEMPERATURE SHUTDOWN
- SIGNAL- AND POWER-GROUND-LOSS SHUTDOWN



- 3.3V CMOS COMPATIBLE INPUTS AND STATUS

DESCRIPTION

The L9348 is a monolithic integrated quad low side driver realized in advanced Multipower-BCD technology. It is intended to drive inductive loads (relays, electromagnetic valves) in automotive and industrial applications.

Figure 1. Block Diagram

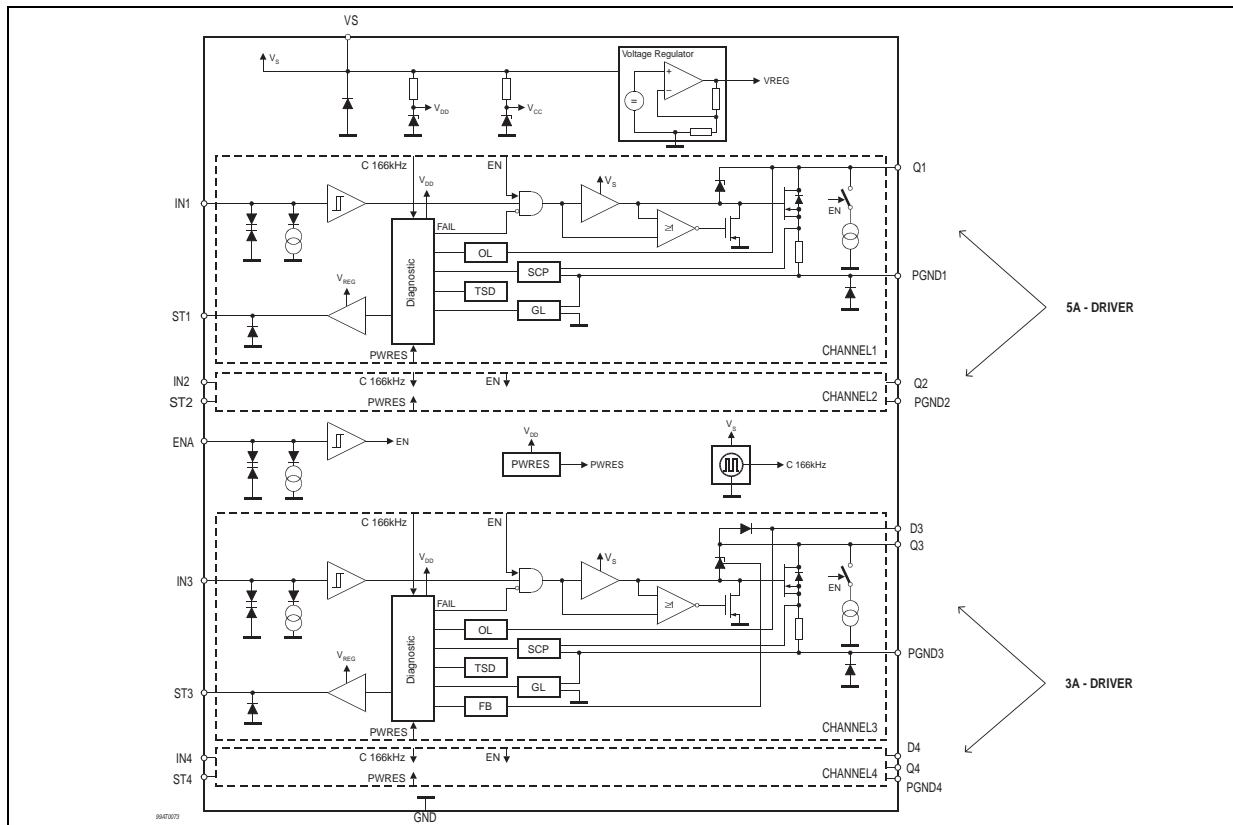


Figure 2. Pin Connection

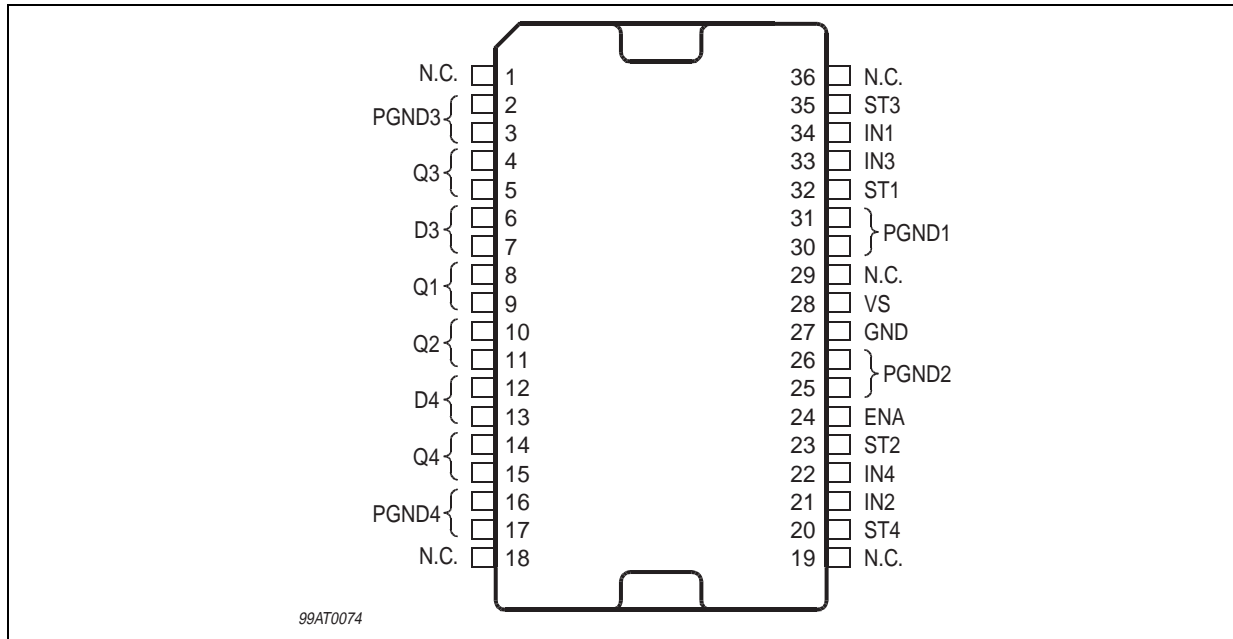


Table 1. Pin Description

| N° | Pin | Function |
|---------------|-------|------------------------------------|
| 1, 18, 19, 36 | N.C. | (GND) |
| 2, 3 | PGND3 | Power Ground Channel 3 |
| 4, 5 | Q3 | Power Output Channel 3 (3A switch) |
| 6, 7 | D3 | Recirculation Diode Channel 3 |
| 8, 9 | Q1 | Power Output Channel 1 (5A switch) |
| 10, 11 | Q2 | Power Output Channel 2 (5A switch) |
| 12, 13 | D4 | Recirculation Diode Channel 4 |
| 14, 15 | Q4 | Power Output Channel 4 (3A switch) |
| 16, 17 | PGND4 | Power Ground Channel 4 |
| 20 | ST4 | Status Output Channel 4 |
| 21 | IN2 | Control Input Channel 2 |
| 22 | IN4 | Control Input Channel 4 |
| 23 | ST2 | Status Output Channel 2 |
| 24 | ENA | Enable |
| 25, 26 | PGND2 | Power Ground Channel 2 |
| 27 | GND | Signal Ground |
| 28 | VS | Supply Voltage |
| 29 | N.C. | Not Connected |
| 30, 31 | PGND1 | Power Output Channel 3 |
| 32 | ST1 | Status Output Channel 1 |
| 33 | IN3 | Control Input Channel 3 |
| 34 | IN1 | Control Input Channel 1 |

Table 2. Thermal Data

| Symbol | Parameter | Test Conditions | Values | | | Unit |
|------------------------|--|--------------------------|--------|------|------------|----------|
| | | | Min. | Typ. | Max. | |
| T _j | Junction temperature | | -40 | | 150 | °C |
| T _{jc} | Junction temperature during clamping (life time) | Σt = 30min Σt = 15min | | | 175 190 | °C °C |
| T _{stg} | Storage temperature | | -55 | | 150 | °C |
| R _{th j-case} | Thermal resistance junction to case | | | | 2 | °C/W |

Table 3. Absolute Maximum Ratings

The absolute maximum ratings are the limiting values for this device. Damage may occur if this device is subjected to conditions which are beyond these values.

| Symbol | Parameter | Test Conditions | Value | Unit |
|--|--|---|------------|------|
| Voltages | | | | |
| V _S | Supply voltage range | | -0.3 to 40 | V |
| V _Q , V _D | max. static Output voltage | | 40 | V |
| V _{IN} , V _{EN} | Input voltage range (IN1 to IN4, EN) | I _I < 10mA | -1.5 to 6 | V |
| V _{ST} | Status output voltage range | I _I < 1mA | -0.3 to 6 | V |
| V _{DRmax} | max. Reverse breakdown voltage free wheeling diodes D3, D4 | I _R = 100 μA | 55 | V |
| Currents | | | | |
| I _{Q 1/2} | Output current at reversal supply for Q1, Q2 | | -4 | A |
| I _{Q 3/4} | Output current at reversal supply for Q3, Q4 | | -2 | A |
| I _{ST} | Status output current range | | -1 to 1 | mA |
| E _{Q1/2} | max. Discharging energy for inductive loads per channel Q1, Q2 | T _j = 25°C | 50 | mJ |
| | | T _j = 150°C | 30 | mJ |
| I _{FDmax} | max. load current free wheeling diodes | t < 5ms | 3 | A |
| ESD Protection | | | | |
| Supply and Signal pins | | versus GND | ±2 | kV |
| Output pins (Q _X , D _X) | | versus common ground (=short of SGND with all PGND) | ±4 | kV |

Note: Human Body Model according to MIL883C. The device withstands ST1 class level.

Table 4. Operating Range.

| Symbol | Parameter | Test Conditions | Values | | | Unit |
|----------------|----------------------|-----------------|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| V _S | Supply voltage | | 4.8 | | 18 | V |
| T _j | Junction temperature | | -40 | | 150 | °C |

Table 5. Electrical Characteristics

The electrical characteristics are valid within the operating range (Table 4), unless otherwise specified

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---------------------------------|--|--|------|------|------|-------------|
| Power Supply | | | | | | |
| I_S | Supply current | $V_{IN1...IN4}, ENA = H$ | | | 8 | mA |
| I_Q | Quiescent current (outputs OFF) | $V_{ENA} = L$ | | | 6 | mA |
| $I_{D3/4}$ | Quiescent current at pins D3/4 | $V_{D3/4} \leq 18V;$ $V_{IN3/4} = L$ | 10 | | 400 | μA |
| Diagnostic Functions | | | | | | |
| $V_{QU1\ to\ 4}$ | Output open load voltage threshold | $V_S \geq 6.5V$ $V_{EN} = X; V_{IN} = L$ | 0.3 | 0.33 | 0.36 | $x V_S$ |
| $I_{QU1\ to\ 4}$ | Output open load current threshold | $V_S \geq 6.5V$ $V_{EN} = H; V_{IN} = H$ | 50 | | 140 | mA |
| $I_{QO1/2}$ | Overload current threshold Q 1, 2 | $V_S \geq 6.5V$ | 5 | 7.5 | 9 | A |
| $I_{QO3/4}$ | Overload current threshold Q 3, 4 | $V_S \geq 6.5V$ | 3 | 5 | 8 | A |
| T_{th} | Overtemperature shutdown threshold | 2) | 175 | | 210 | $^{\circ}C$ |
| T_{hy} | Overtemperature hysteresis | | | 10 | | $^{\circ}C$ |
| V_{thPGL} | Power-GND-loss threshold | | 1.5 | 2.5 | 3.5 | V |
| V_{thSGL} | Signal-GND-loss threshold | | 150 | 330 | 510 | mV |
| Power Outputs (Q1 to Q4) | | | | | | |
| $R_{DS(ON)1/2}$ | Static drain-source ON-resistance Q1, Q2 | $I_Q = 1A; V_S \geq 9.5V$ $T_j = 25^{\circ}C$ | | 0.2 | | Ω |
| | | $T_j = 125^{\circ}C$ ³⁾ | | | 0.5 | Ω |
| | | $T_j = 150^{\circ}C$ ⁴⁾ | | | 0.5 | Ω |
| $R_{DS(ON)3,4}$ | Static drain-source ON-resistance Q3, Q4 | $I_Q = 1A; V_S \geq 9.5V$ $T_j = 25^{\circ}C$ | | 0.35 | | Ω |
| | | $T_j = 125^{\circ}C$ ³⁾ | | | 0.75 | Ω |
| | | $T_j = 150^{\circ}C$ ⁴⁾ | | | 0.75 | Ω |
| V_Z | Z-diode clamping voltage = threshold of flyback detection Q3/4 | $I_Q \geq 100mA,$ pos. supply $V_{D3/4}$ | 45 | | 60 | V |
| V_C | Clamping voltage | $I_Q \geq 100mA,$ neg. supply $V_{D3/4}$ | 4 | | 10 | V |
| I_{PD} | Output pull down current | $V_{ENA} = H, V_{IN} = L$ | 10 | 20 | 50 | μA |

Table 5. Electrical Characteristics

The electrical characteristics are valid within the operating range (Table 4), unless otherwise specified

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---|--|--|------|------|------|------|
| I _{Qlk} | Output leakage current | V _{ENA} = L, T _j = 25°C | | | 1 | μA |
| | | T _j = 125°C | | | 5 | μA |
| V _{FD3/4} | Forward voltage of free wheeling diodes D3, D4 | I _{D3/4} = -1.5A | 0.5 | | 1.75 | V |
| R _{PD0} | Gate pull down resistor for nonsupplied V _S | V _S = 0V, V _{D3/4} ≥ 6.5V | 0.3 | | 3 | kΩ |
| Timings | | | | | | |
| t _{ON} | Output ON delay time | I _Q = 1A ¹⁾ | 0 | 5 | 20 | μs |
| t _f | Output ON fall time | I _Q = 1A ¹⁾ | 0.5 | 1.5 | 8 | μs |
| t _{OFF} | Output OFF delay time | I _Q = 1A ¹⁾ | 0 | 10 | 30 | μs |
| t _r | Output OFF rise time | I _Q = 1A ¹⁾ | 0.5 | 1.5 | 5 | μs |
| t _{DSO} | Overload switch-OFF delay time | | 6 | 30 | 65 | μs |
| t _D | Output OFF status delay time | | 0.75 | 1.5 | 2.25 | ms |
| t _{filter} | error detection filter time | 2) | 5.8 | | 35 | μs |
| t _{OLOFF} | OLOFF error detection filter time | | 20 | | 70 | μs |
| Digital Inputs (IN1 to IN4, ENA) | | | | | | |
| V _{IL} | Input low voltage | | -1.5 | | 1 | V |
| V _{IH} | Input high voltage | | 2 | | 6 | V |
| V _{IHy} | Input voltage hysteresis | 2) | 50 | 100 | | mV |
| I _{IN} | Input pull down current | V _{IN} = 5V, V _S ≥ 6.5V | 8 | 20 | 40 | μA |
| Digital Outputs (ST1 to ST4) | | | | | | |
| V _{STL} | Status output voltage in low state ⁵⁾ | I _{ST} ≤ 40μA | 0 | | 0.4 | V |
| V _{STH} | Status output voltage in high state ⁵⁾ | I _{ST} ≥ -40μA | 2.5 | | 3.45 | V |
| | | I _{ST} ≥ -120μA | 2 | | 3.45 | V |
| R _{DIAGL} | R _{OUT} + R _{DSON} in low state | | 0.3 | 0.64 | 1.5 | kΩ |
| R _{DIAGH} | R _{OUT} + R _{DSON} in high state | | 1.5 | 3.2 | 7 | kΩ |

(1). See chapter 2.0 Timing Diagrams; resistive load condition; V_S ≥ 9V

(2). This parameter will not be tested but assured by design

(3). Wafer-measurement

(4). Measured on P-SO36 devices

(5). Short circuit between two digital outputs (one in high the other in low state) will lead to the defined result "LOW"

1.0 FUNCTIONAL DESCRIPTION

1.1 Overview

The four low-side switches are designed to drive inductive loads (relays, electromagnetic valves). For the 3A switches (Q3/4) integrated free-wheeling diodes (D3/4) are available and can be used as recirculation path for inductive loads. If either integrated nor external free-wheeling diodes are used the output voltage is clamped internally during discharge of inductive loads. The switches are controlled by CMOS compatible inputs (IN1-4) if the enable input is set to "high". The status of each switch is monitored by the related status output (ST1-4).

1.2 Input Circuits

The control and enable inputs are active high, featuring switching thresholds with hysteresis and pull-down current sources. Not connected inputs are interpreted as "LOW". If the enable input is set to "LOW" the outputs are switched off independent of the control input state (IN1-4).

1.3 Switching Stages

The four power outputs consist of DMOS-power transistors. The output stages are protected against short circuit to supply. Integrated output voltage clamp limits the output voltage in case of inductive load current flyback. Internal pull down current sources are provided at the outputs to assure a defined condition in OFF mode. They will be disconnected in the disable mode (ENA=L). If the supply of the device gets lost but the loads and D3/4 are still supplied, an internal pull down resistor discharges the gate of the DMOS-power transistor to avoid switch on due to capacitive coupling.

1.4 Status Outputs

The CMOS compatible status outputs indicate the state of the drivers (LOW-level indicates driver in OFF state, HIGH-level indicates driver in ON state). If an error occurs the status output voltage changes like described in **chapter 1.6 Error Detection**.

1.5 Protective Circuits

The outputs are protected against current overload, overtemperature, and Power-GND-loss.

1.6 Error Detection

Two main error types are distinguished in the diagnostic logic. If current overload, overtemperature, signal-GND-loss or a power-GND-loss occurs, the status output signal is inverted, an internal register is set and the driver is shutdown. The reset is done by switching off the corresponding control input or the enable input for at least the time t_D (defined to 1.5ms typ.). See also **Figure 6** in **chapter 2.0 Timing Diagrams**.

All other errors (openload, active output voltage clamp) only cause an inverted status output signal but no shutdown of the driver. An internal register is set too, but the reset is triggered automatically after the time t_D , if the error condition is no longer valid (see **Figure 7** and **Figure 8**).

Excepting the detection of the active output voltage clamp all errors are digitally filtered before they are interpreted by the diagnostic logic.

The table 6 below shows the different failure conditions monitored in ON and OFF state:

Table 6.

| | ON State ENA = HIGH, IN = HIGH | OFF State ENA = HIGH, IN = LOW | typ. Filter time | Reset done by |
|--|--------------------------------------|--------------------------------------|---------------------|--|
| Overloading of output (also shorted load to supply) | X | | 18 μ s | ENA or INx = "LOW" for $t \geq 1.5$ ms (typ.) |
| Open load (under voltage detection) | | X | 44 μ s | internal timer (1.5ms typ.) |

Table 6.

| | ON State ENA = HIGH, IN = HIGH | OFF State ENA = HIGH, IN = LOW | typ. Filter time | Reset done by |
|--|--------------------------------------|--------------------------------------|---------------------|--|
| Open load (under current detection) | X | | 18µs | internal timer (1.5ms typ.) |
| Overtemperature | X | | 18µs | ENA or INx = "LOW" for t ≥ 1.5ms (typ.) |
| Power-GND-loss | X | X | 18µs | ENA or INx = "LOW" for t ≥ 1.5ms (typ.) |
| Signal-GND-loss | X | X | 18µs | ENA or INx = "LOW" for t ≥ 1.5ms (typ.) |
| Output voltage clamp active (Q3/4 only) | | X | - | internal timer (1.5ms typ.) |

1.7 Diagnostic Output at Pulse Width Operation (PWM)

If an input is operated with a pulsed signal ($f \geq 1/t_D = 667$ Hz typ.), the status does not follow each single pulse. An internal delay t_D of typ. 1.5ms leads to a continuous status output signal (see **Figure 4** in **chapter 2.0 Timing Diagrams**).

1.8 Diagnostic Table

In general the diagnostic follows the input signal in normal operating conditions. If any error is detected the diagnostic is inverted.

Table 7.

| Operating Condition | Enable Input ENA | Control Input IN | Power Output Q | Status Output ST |
|---|------------------------|------------------------|----------------------|------------------------|
| Normal function | L | L | OFF | L |
| | L | H/PWM | OFF | L |
| | H | L | OFF | L |
| | H | H/PWM | ON | H |
| Open load or short to ground | L | L | OFF | X |
| | L | H/PWM | OFF | X |
| | H | L | OFF | H |
| | H | H/PWM | ON | L |
| Overload or short to supply Latched overload | H | H/PWM | OFF | L |
| | H | H/PWM | OFF | L |
| | H → L | X | OFF | L |
| | Reset latch | H | H/PWM → L | OFF |
| Overtemperature Latched overtemperature | H | H/PWM | OFF | L |
| | H | H/PWM | OFF | L |
| | H → L | X | OFF | L |
| | Reset latch | H | H/PWM → L | OFF |

2.0 TIMING DIAGRAMS

Figure 3. Output slope with Resistive Load

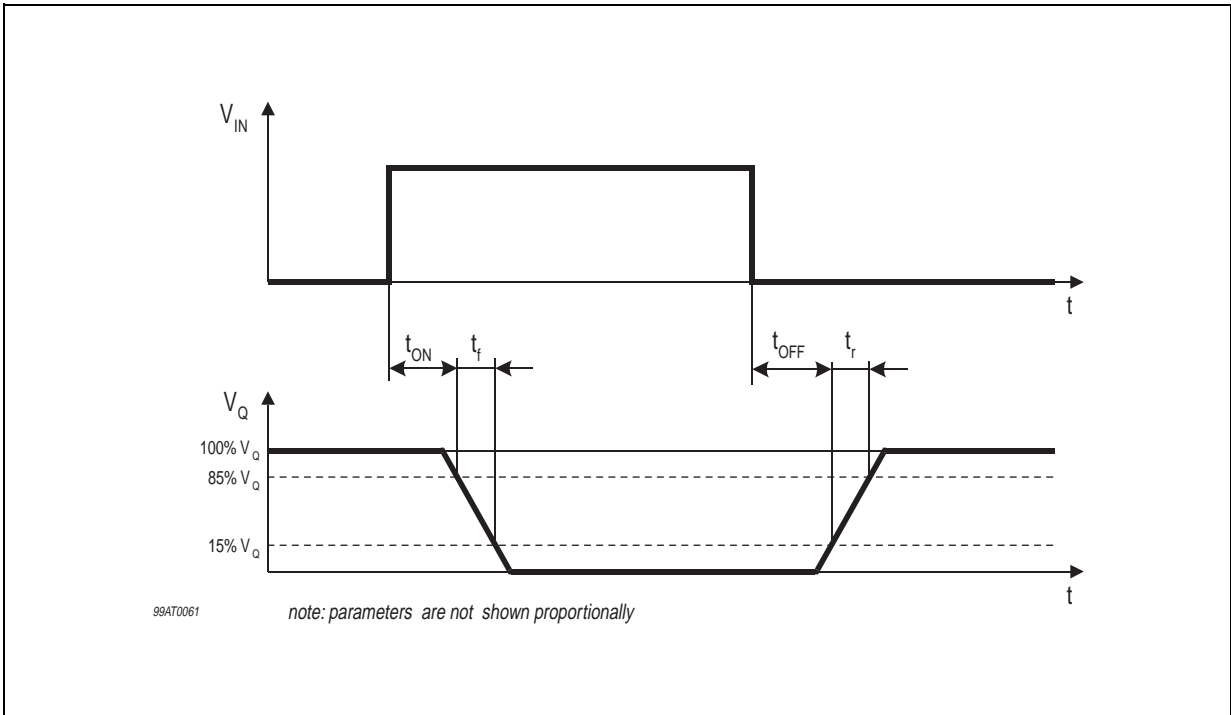


Figure 4. Diagnostic Output at PWM operation

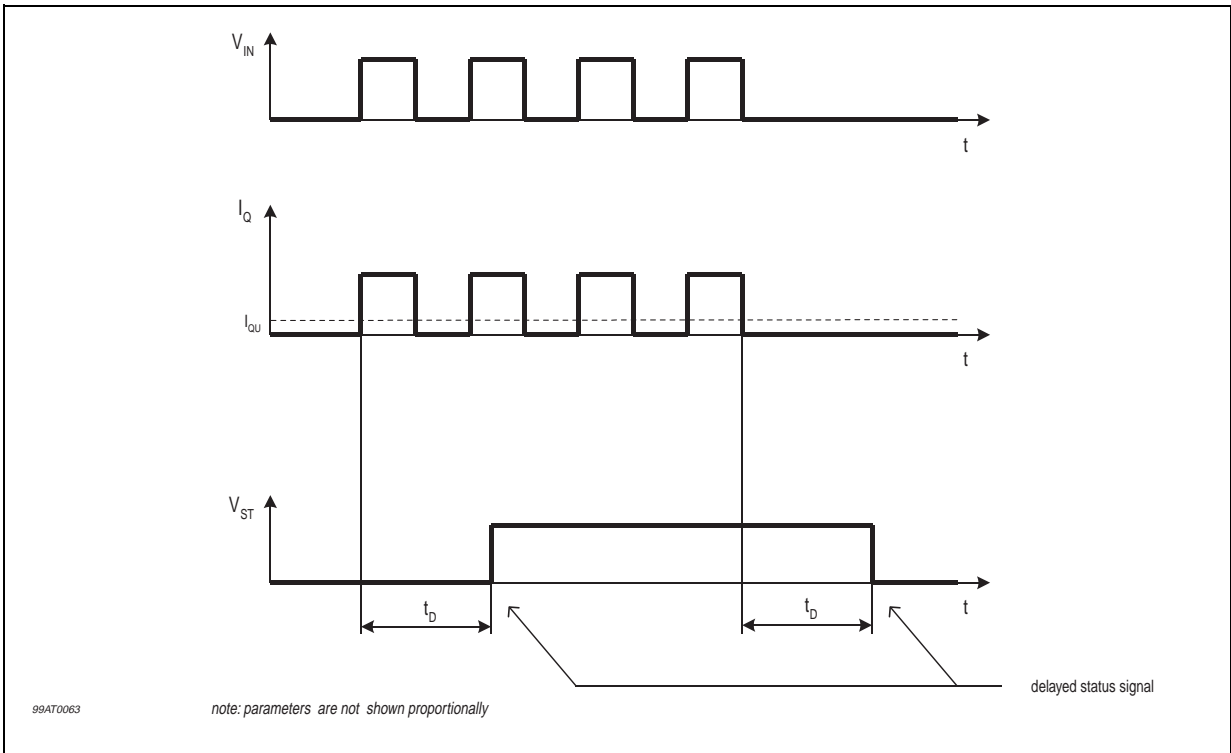


Figure 5. Overload Detection

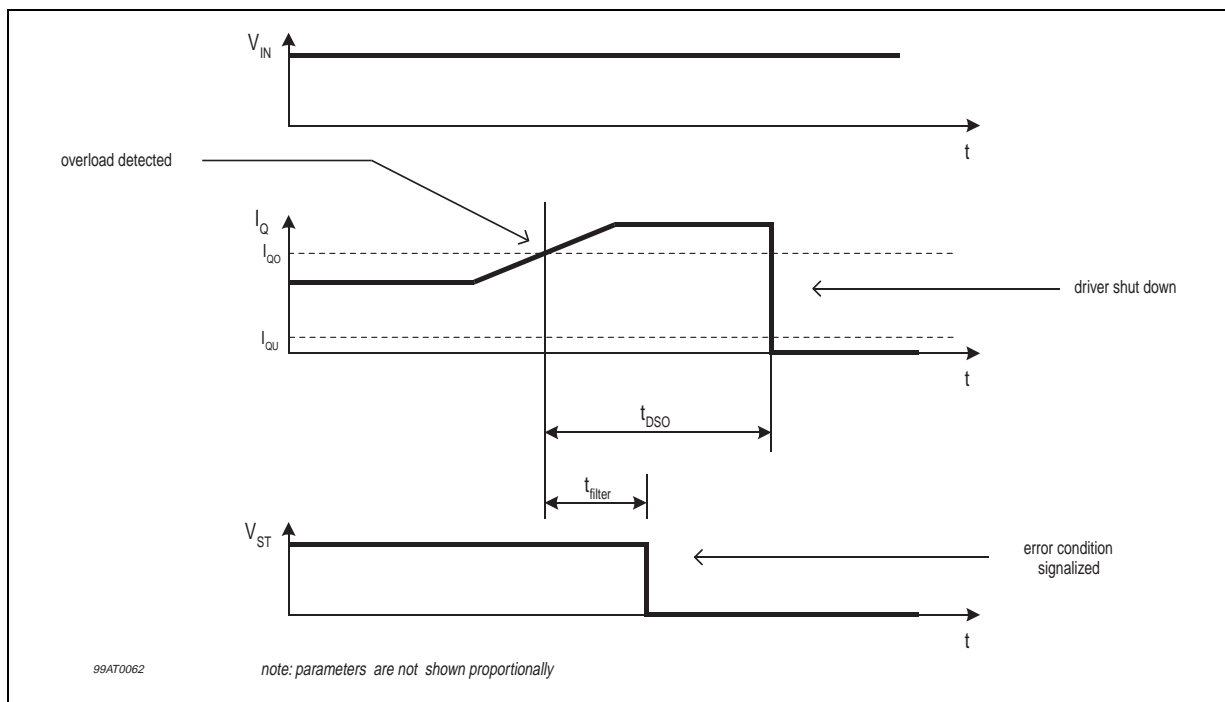


Figure 6. Driver Shut Down in Case of Overload

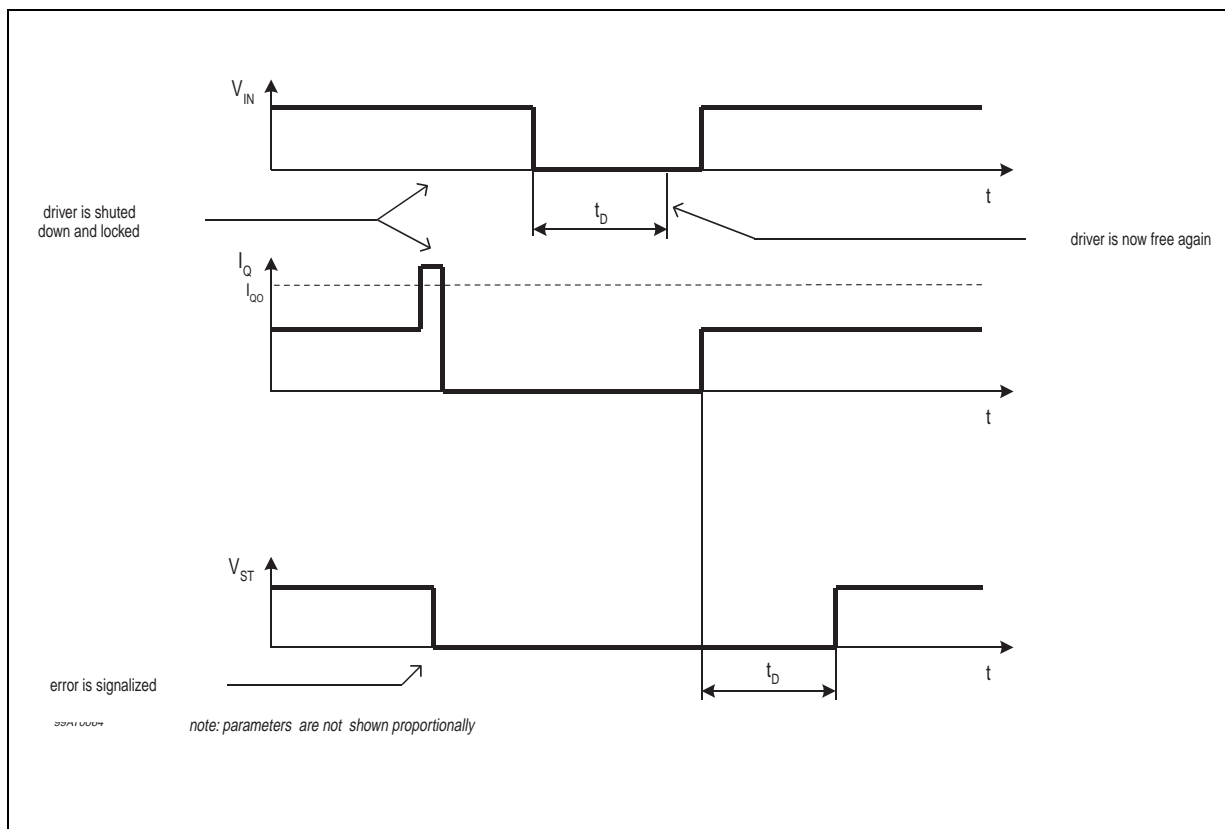


Figure 7. Under Current Condition

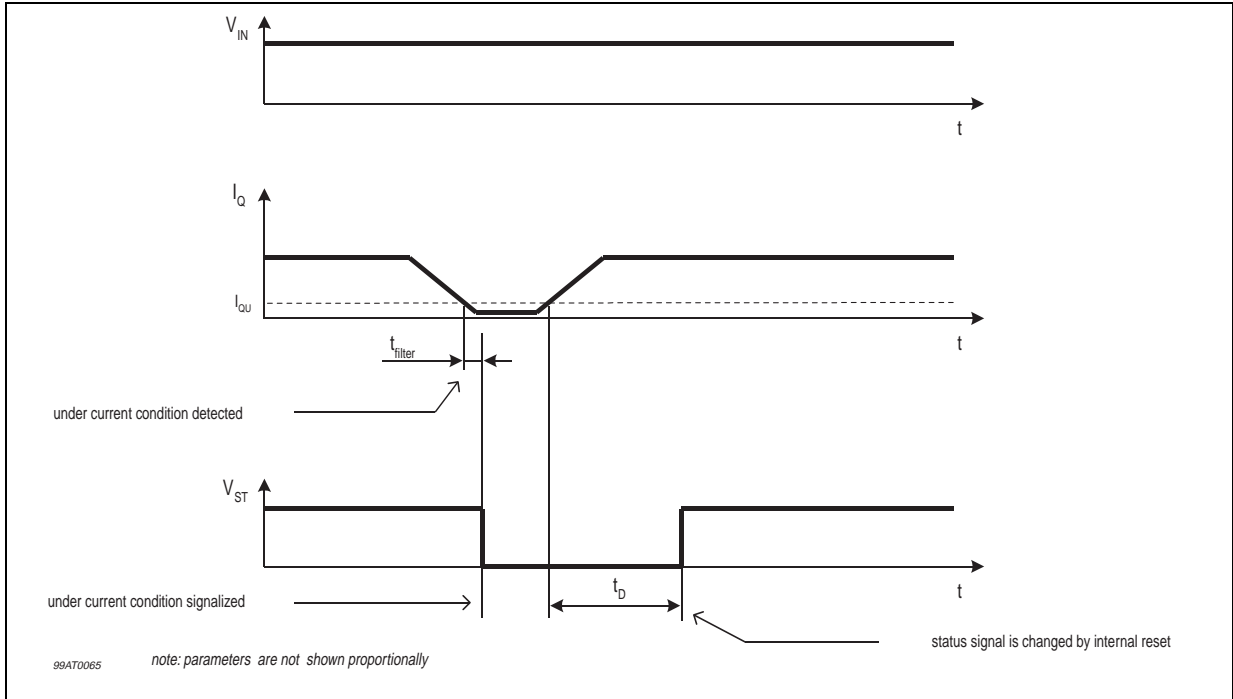


Figure 8. Open Load Condition in Off State

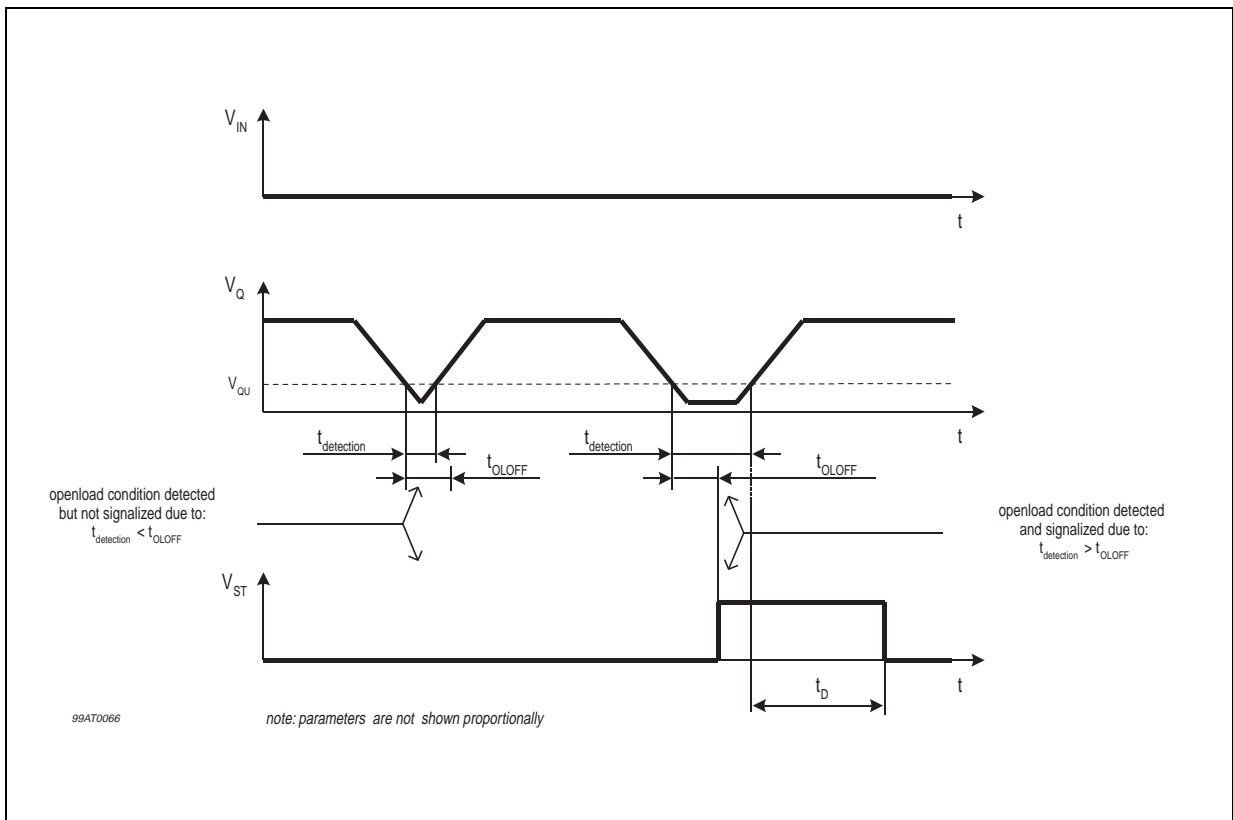
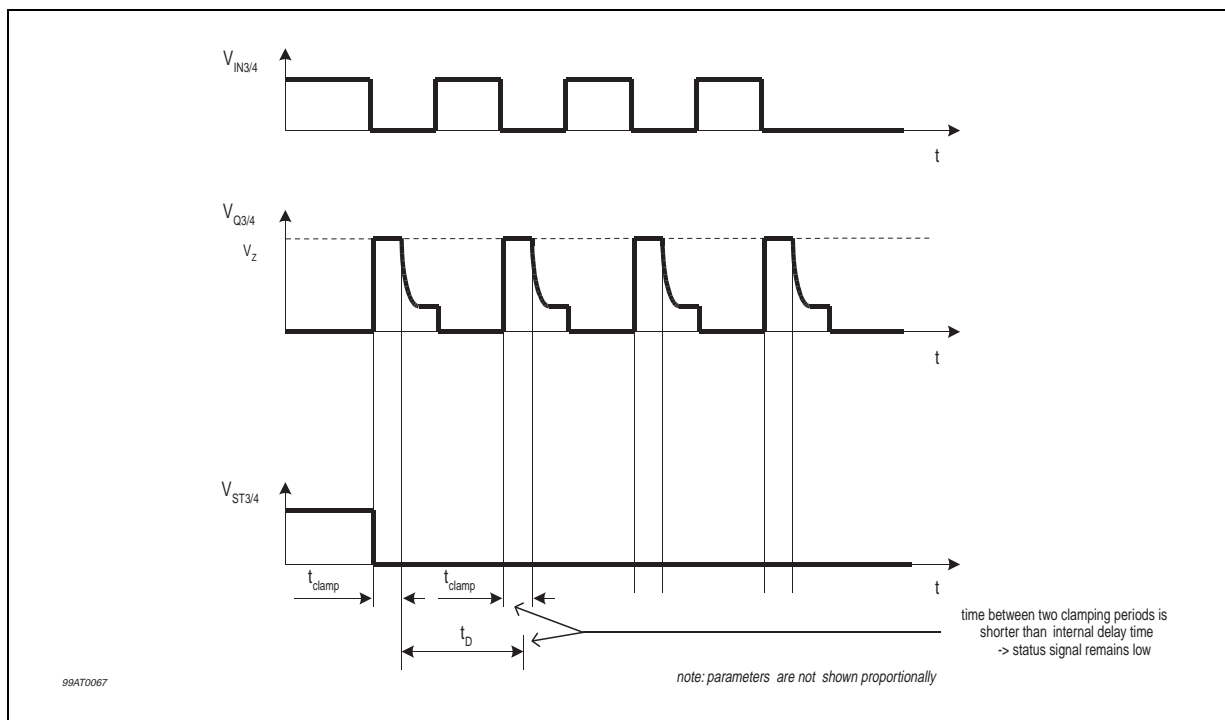


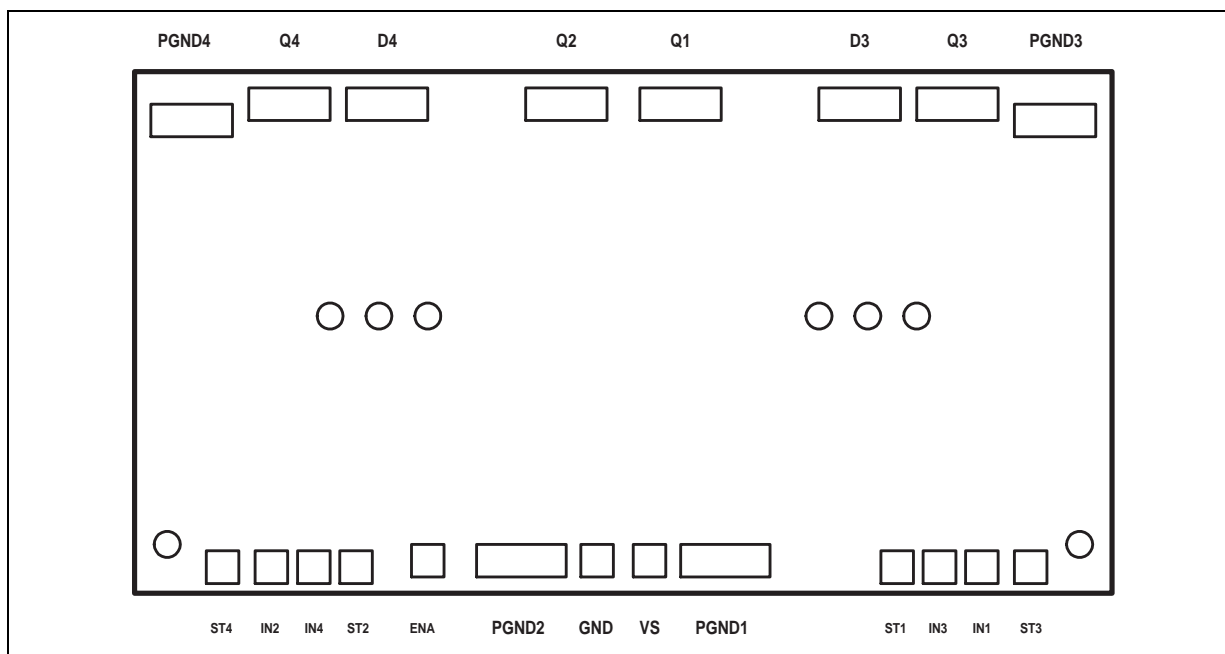
Figure 9. Output Voltage Clamp Detection



3.0 PAD POSITIONS

Chip Size: 5.17 x 2.76 mm²

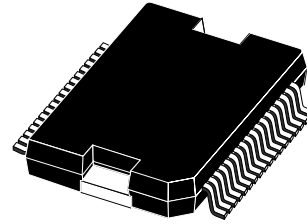
Figure 10.



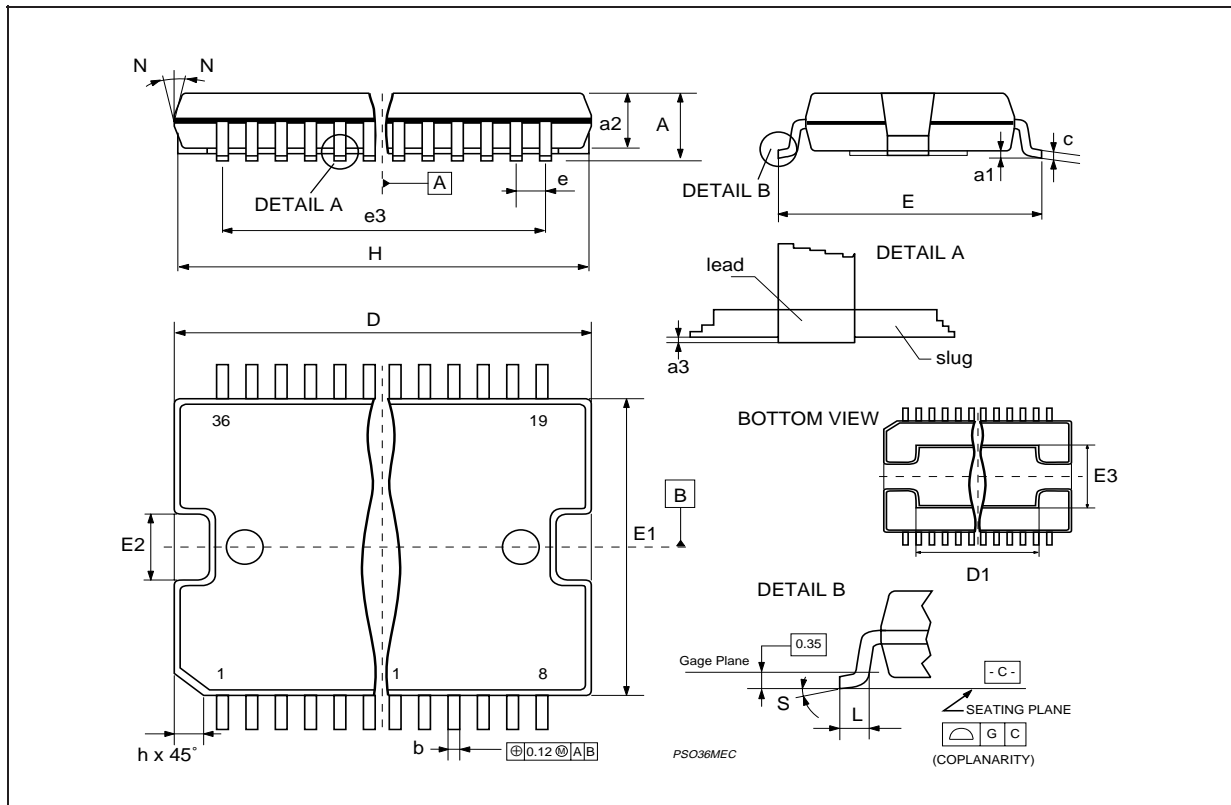
| DIM. | mm | | | inch | | |
|--------|-----------|-------|-------|-------|--------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 3.60 | | | 0.141 |
| a1 | 0.10 | | 0.30 | 0.004 | | 0.012 |
| a2 | | | 3.30 | | | 0.130 |
| a3 | 0 | | 0.10 | 0 | | 0.004 |
| b | 0.22 | | 0.38 | 0.008 | | 0.015 |
| c | 0.23 | | 0.32 | 0.009 | | 0.012 |
| D (1) | 15.80 | | 16.00 | 0.622 | | 0.630 |
| D1 | 9.40 | | 9.80 | 0.370 | | 0.385 |
| E | 13.90 | | 14.50 | 0.547 | | 0.570 |
| e | | 0.65 | | | 0.0256 | |
| e3 | | 11.05 | | | 0.435 | |
| E1 (1) | 10.90 | | 11.10 | 0.429 | | 0.437 |
| E2 | | | 2.90 | | | 0.114 |
| E3 | 5.80 | | 6.20 | 0.228 | | 0.244 |
| E4 | 2.90 | | 3.20 | 0.114 | | 0.126 |
| G | 0 | | 0.10 | 0 | | 0.004 |
| H | 15.50 | | 15.90 | 0.610 | | 0.626 |
| h | | | 1.10 | | | 0.043 |
| L | 0.80 | | 1.10 | 0.031 | | 0.043 |
| N | 10°(max.) | | | | | |
| S | 8°(max.) | | | | | |

(1): "D" and "E1" do not include mold flash or protrusions
 - Mold flash or protrusions shall not exceed 0.15mm (0.006 inch)
 - Critical dimensions are "a3", "E" and "G".

OUTLINE AND MECHANICAL DATA



PowerSO36



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