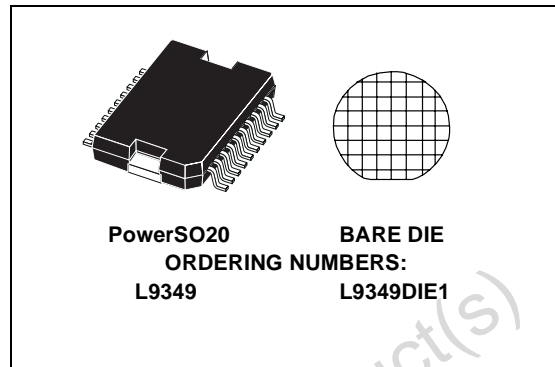


QUAD INTELLIGENT POWER LOW SIDE SWITCH

- Quad power low side driver with 2 x 5A and 2 x 3A output current capability
- Low $R_{DS(on)}$ typically 200m Ω and 300m Ω @ $T_j = 25^\circ\text{C}$
- Internal output clamping structures with $V_{FB} = 50\text{V}$ for fast inductive load current recirculation
- Limited output voltage slew rate for low EMI
- Protected μP compatible enable and input
- Wide operating supply voltage range 4.5V to 32V
- Real time diagnostic functions:
 - Output shorted to GND
 - Output shorted to V_{SS}
 - Open load detection in ON and OFF condition
 - Load bypass detection
 - Overtemperature detection
- Device protection functions:
 - Overload disable
 - Selective thermal shutdown
- Signal- and Power-Ground-loss shutdown

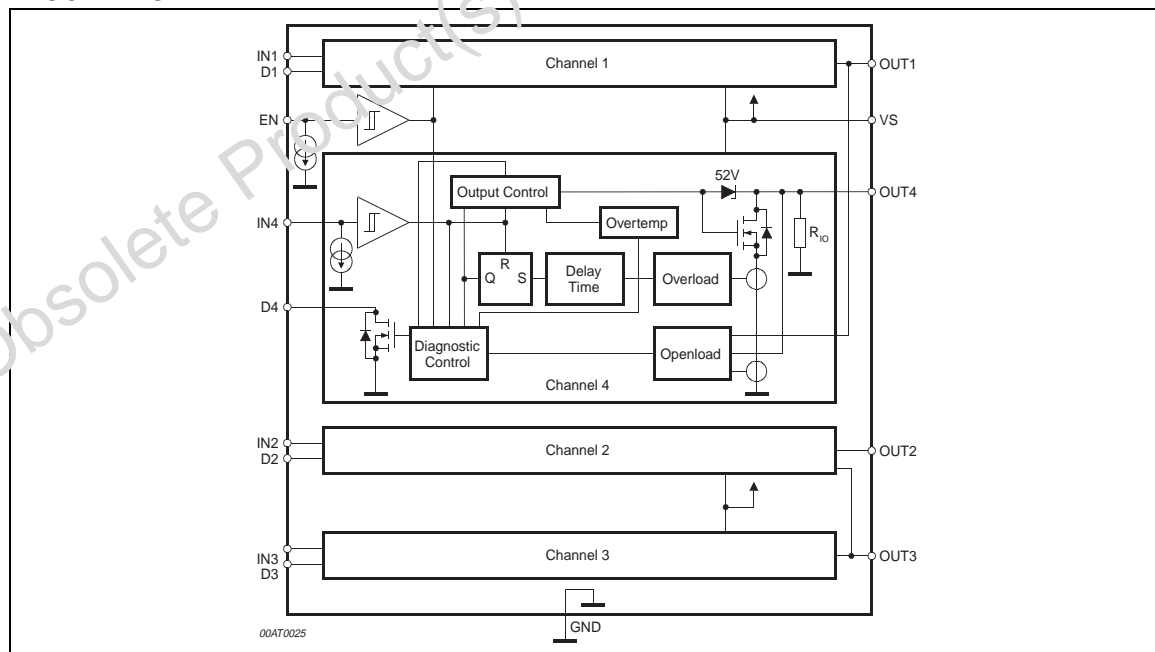


DESCRIPTION

The L9349 is a monolithic integrated quad low side driver realized in an advanced MultipowerBCD mixed technology. The device is intended to drive valves in automotive environment.

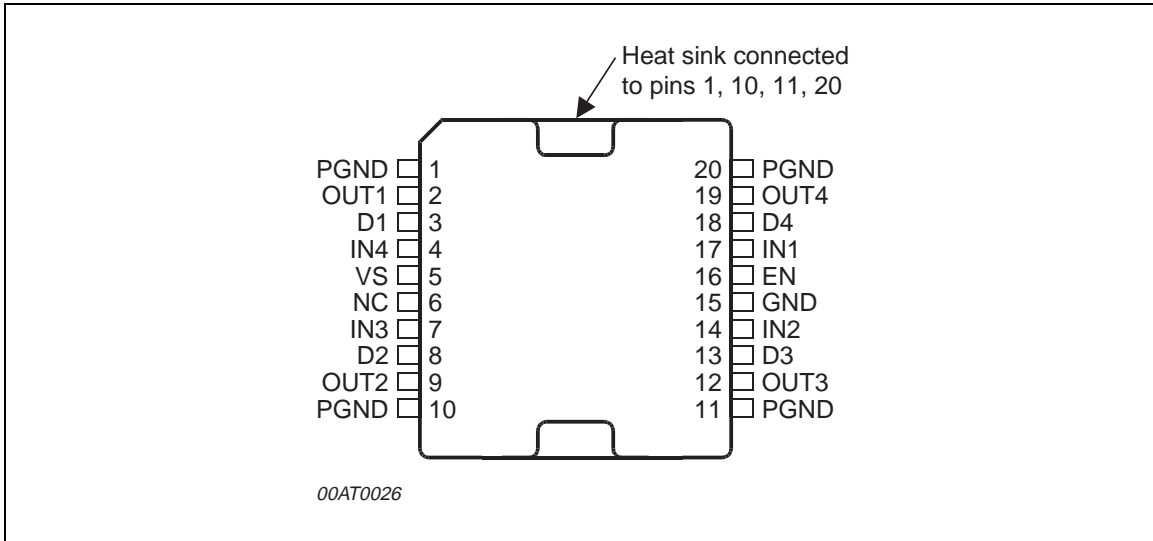
The inputs are μP compatible. Particular care has been taken to protect the device against failures, to avoid electromagnetic interferences and to offer extensive real time diagnostic.

BLOCK DIAGRAM



L9349

PIN CONNECTION



PIN DESCRIPTION

| N° | Pin | Function |
|----|------|----------------|
| 1 | PGND | Power Ground |
| 2 | Out1 | Output 1 (5A) |
| 3 | D1 | Diagnostic 1 |
| 4 | IN4 | Input 4 |
| 5 | VS | Supply Voltage |
| 6 | NC | Not Connected |
| 7 | IN3 | Input 3 |
| 8 | D2 | Diagnostic 2 |
| 9 | Out2 | Output 2 (5A) |
| 10 | PGND | Power Ground |
| 11 | PGND | Power Ground |
| 12 | Out3 | Output 3 (3A) |
| 13 | D3 | Diagnostic 3 |
| 14 | IN2 | Input 2 |
| 15 | GND | Signal Ground |
| 16 | EN | Common Enable |
| 17 | IN1 | Input 1 |
| 18 | D4 | Diagnostic 4 |
| 19 | Out4 | Output 4 (3A) |
| 20 | PGND | Power Ground |

THERMAL DATA

| Symbol | Parameter | Value | Unit |
|------------------------|-------------------------------------|-------|------|
| R _{Th j-case} | Thermal resistance junction to case | 3 | °C/W |

ABSOLUTE MAXIMUM RATINGSI

| Symbol | Parameter | Conditions | Value | Unit |
|---------------------|--|--|--------------------------|------|
| V _S | DC Supply Voltage | | -0.3 to 32 | V |
| V _{SP} | Supply Voltage Pulse (duration <200ms) | | -0.3 to 45 | V |
| dV _S /dt | Supply Voltage Slope | | 10 | V/μs |
| V _{IN, EN} | Input Voltage | I 10mA | -1.5 to 6 | V |
| V _D | Diagnostic DC Output Voltage | I 50mA | -0.3 to 16 | V |
| V _{ODC} | DC Output Voltage | | -0.3 to 45 | V |
| I _{O1, 2} | DC Output Current Out 1, 2 | | 5 | A |
| I _{O3, 4} | DC Output Current Out 3, 4 | | 3 | A |
| I _{OR1, 2} | Reverse Output Current | | -5 | A |
| I _{OR3, 4} | Reverse Output Current | | -3 | A |
| E _{O1, 2} | Switch-off Energy for Inductive Loads | t _{EO} = 250μs, ¹⁾ | 50 | mJ |
| E _{O3, 4} | | T = 5ms | 30 | mJ |
| ΔV _{GND} | GND Potential Difference | T _j = -40 to 150°C | ±0.3 | V |
| T _{jEO} | Junction Temperature During Switch-off | Σt ≤ 30 min | 175 | °C |
| | | Σt ≤ 15 min | 190 | °C |
| T _j | Junction Temperature | | -40 to T _{jDIS} | °C |
| T _{stg} | Storage Temperature | | -55 to 150 | °C |
| T _{jDIS} | Thermal Disable Junction Temp. Threshold | | 180 to 210 | °C |
| ESD | Electrostatical Discharging | MIL883C | +2 | kV |
| ESD | OUT1 - 4 | vs. Common-GND (PGNDs + GND) | +4 | kV |

1) t_{EO} is the clamping time (see Figure 1)

Electrical Characteristics (Operating Range)

The electrical characteristics are valid within the below defined operating range, unless otherwise specified.

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|-----------------|----------------------|---|------|------|-------------------|------|
| V _S | Board Supply Voltage | | 4.5 | 12 | 32 | V |
| T _{j1} | Junction Temperature | | -40 | | 150 | °C |
| T _{j2} | Junction Temperature | Σt ≤ 15min ¹⁾ over life time | 150 | | T _{jDIS} | °C |

1) Parameters guaranteed by correlation

ELECTRICAL CHARACTERISTICS(V_S = 4.5 to 32V; -40°C ≤ T_{j1} ≤ 150°C < T_{j2} ≤ T_{jDIS}, unless other-wise specified.)

| Symbol | Parameter | Test Conditions | Values T _{j1} | | | Values T _{j2} | | Unit |
|--|--|---|------------------------|-------------------------|------------------------|------------------------|------|------|
| | | | Min. | Typ. | Max. | Min. | Max. | |
| Supply | | | | | | | | |
| I _{VS OFF} | DC Supply Current Off | EN = 1.0V | | 5 | 10 | | | mA |
| I _{VS ON} | DC Supply Current On | V _S ≤ 14V; V _{IN} , V _{EN} = 2V | | 8 | | | | mA |
| Diagnostic Outputs D1 - D4 | | | | | | | | |
| V _{DL} | Diagnostic Output Low Voltage | I _D ≤ 3mA | | 0.65 | 1.0 | | 1.5 | V |
| I _{DLE} | Diagnostic Output Leakage Current | V _D = 14V ¹⁾ | | 0.1 | 2 | | 20 | μA |
| Outputs Out 1 - Out 4 | | | | | | | | |
| R _{DS ON 1, 2} | Output On Resistance | T _j = 25°C T _j = 150°C V _S > 9.5V I _{O1,2} = 2A | | 200 | 300 500 | | | mΩ |
| R _{DS ON 3, 4} | | T _j = 25°C T _j = 150°C V _S > 9.5V I _{O3,4} = 1.3A | | 300 | 450 750 | | | mΩ |
| V _Z | Z-diode clamping voltage | I _{oCL} ≥ 200mA | 45 | | 60 | | | V |
| R _O | Output pull down resistor | V _S > 9.5V EN = 0V | 10 | | 40 | | 50 | kΩ |
| V _{OUV 1-4} | Open Load Voltage Threshold | V _{IN} = 1V | 0.525 x V _S | 0.55 x V _S | 0.575 x V _S | | | V |
| V _{OUV hys 1-4} | Hysteresis | | | 0.003 x V _S | | | | V |
| ΔV _{OUV 1-4, 2-3, 4-1, 3-2} | Open Load Difference Voltage Threshold | V _{IN1,4/2,3} = 1V V _S ≤ 16V V _{OC} Š 4.5V V _{OC} = output voltage of other channel | V _{OC} - 1.0V | V _{OC} - 1.25V | V _{OC} - 1.5V | | | V |
| ΔV _{OUV hys 1-4, 2-3, 4-1, 3-2} | Open Load Hysteresis | | | 40 | | | | mV |
| I _{OUC 1, 2, 3, 4} | Open Load Current Threshold | V _{EN} =V _{IN} =2V; V _S =6.5 - 16V | 160 | 320 | 480 | | | mA |
| I _{OOC 1, 2} | Over Load Current Threshold | V _S > 6.5V; V _{OUT} = 32V | 5 | 10 | | | | A |
| I _{OOC 3, 4} | | | 3 | 6 | | | | A |
| T _{SD} | Thermal Shut Down | | 180 | 195 | 210 | | | °C |
| T _{SD-hys} | Thermal Shut Down hysteresis | | | 20 | | | | °C |

ELECTRICAL CHARACTERISTICS (continued)(V_S = 4.5 to 32V; -40°C ≤ T_{J1} ≤ 150°C < T_{J2} ≤ T_{JDIS}, unless other-wise specified.)

| Symbol | Parameter | Test Conditions | Values T _{J1} | | | Values T _{J2} | | Unit |
|-------------------------|---|---|------------------------|------|------|------------------------|------|------|
| | | | Min. | Typ. | Max. | Min. | Max. | |
| I _{OUT-LE} | OUT leakage current | V _{OUT} = 20V V _S = 0V | | | 5 | | | μA |
| Inputs IN1-4, EN | | | | | | | | |
| V _{IN,EN L} | Logic Input/Enable Low Voltage | | -0.3 | | 1 | | | V |
| V _{IN,EN H} | Logic Input/Enable High Voltage | IN, EN | 2.0 | | 6 | | | V |
| V _{EN,IN hys} | Logic Input Hysteresis | | 50 | 100 | | | | mV |
| I _{IN} | Input Sink Current | 2V < V _{IN} , V _{EN} < 6V ²⁾ | 10 | 20 | 40 | | | μA |
| I _{EN} | Enable Sink Current | V _{IN} , V _{EN} < V _S | 10 | 20 | 40 | | | μA |
| Timing | | | | | | | | |
| t _{ON} | Output Delay ON Time | I _O = 1A V _S = 12V 3) Fig. 2 | | 4 | 25 | | | μs |
| t _{r,r} | Output fall and rise time | I _O = 1A V _S = 12V Fig. 2 | 3 | 10 | 30 | | | μs |
| t _{OFF} | Output Delay OFF Time | I _O = 1A V _S = 12V 3) Fig. 2 | 5 | 15 | 30 | | | μs |
| t _{DH-L, Diag} | Diag. Delay Output OFF Time | 3) Fig. 2 | 8 | | 65 | | 90 | μs |
| t _{D IOU} | Diagnostic Open Load Delay Time | 9V < V _S < 16V, Fig 3 | | 8 | 50 | | | μs |
| t _{DOL} | Diagnostic Overload Delay Switch-OFF Time | 9V < V _S < 16V, Fig 3 | 6 | | 65 | | | μs |
| t _{filt} | Filter time | | 4 | | 24 | | | μs |
| PGND | | | | | | | | |
| PGND _{loss,h} | Power GND loss threshold high | | | 3 | | | | V |
| PGND _{loss,l} | Power GND loss threshold low | | | 2 | | | | V |

1) The diagnostic output is short circuit protected up to V_D = 16V

2) Open pins (EN, IN) are detected as low

3) V_S = 9 to 16V ∧ I_{oUC} ≤ I_O ≤ I_{oOC}

DIAGNOSTIC TABLE

| Conditions | | EN | IN | OUT | DIAG. |
|---|--|----|----|-----|-------|
| Normal Function | | L | X | off | L |
| | | H | L | off | L |
| | | H | H | on | H |
| GND short | $V_{Otyp} < 0.55V_S$ | L | X | off | H |
| Load bypass | $\Delta V_{O1-4/2-3} \geq 1.25V$ | H | L | off | H |
| Open Load | $I_{O1,2,3,4typ} < 320mA$ | H | H | on | L |
| $T_{jtyp} \geq 190^\circ C$ Overtemperature | | X | X | off | L |
| Over Load | $I_{Omin 1,2} > 5A$ $I_{Omin 3,4} > 3A$ | H | H | off | L |
| SGND or PGND loss | channel off | X | L | off | H |
| SGND or PGND loss | channel on | H | H | off | L |

CIRCUIT DESCRIPTION

The L9349 is a quad low side driver for inductive loads like valves in automotive environment. The internal pull down current sources at the ENable and INput pins assure in case of open input conditions that the device is switched off. An output voltage slope limitation for du/dt is implemented to reduce the EMI. An integrated active flyback voltage limitation clamps the output voltage during the flyback phase to 50 V.

Each driver is protected against short circuit at $V_{OUT} < 32V$ and thermal overload. In short circuit condition the output will be disabled after a short delay time t_{DOL} . The thermal disable for $T_J > 180^\circ C$ of the output will be reset if the junction temperature decreases about $20^\circ C$ below the disable threshold temperature.

The overtemperature, overload and groundloss information is stored until IN is low.

For the real time error diagnosis the voltage and the current of the outputs are compared with internal fixed values V_{OUV} for OFF and I_{OUC} for ON conditions to recognize open load ($R_L \geq 20K\Omega$, $R_L > 38\Omega$) in OFF and ON conditions.

Also the output voltages V_{O1-4} are compared to each other output in OFF condition with a fixed offset of ΔV_{OUV} to recognize load bypasses. The ΔV_{OUV} diagnoses is suppressed during the flyback phases of the compared output. The outputs 1 and 4 are compared for ΔV_{OUV} and also outputs 2 and 3 are compared.

The diagnostic output level in connection with different ENable and INput conditions allows to recognize different fail states, like overtemp, short to V_S , short to GND, bypass to GND and disconnected load (see diagnostic table).

The diagnostic output is protected against short circuit. Exceeding the over load current threshold I_{OOC} , the output current will be limited internally during the diagnostic overload delay switch-off time t_{DOL} .

The device complies the I_{SO} pulses imposed to the supply voltage of the valves without any failures of the functionality. Therefore some diagnostic functions are internal filtered. The following table shows the corresponding filter time for each detected signal.

| | ON State EN and IN = HIGH | OFF State EN or IN, = LOW | min. Filter time | Reset done by |
|--|---------------------------------|---------------------------------|---------------------|---------------|
| Overloading of output (also shorted load to supply) | X | | 4 μ s | INx = "LOW" |
| Open load (under voltage detection) | | X | - | |
| Open load (under current detection) | X | | - | |
| Overtemperature | X | | 4 μ s | INx = "LOW" |
| Power-Signal GND-loss | X | | 4 μ s | INx = "LOW" |
| Power- Signal-GND-loss | | X | 4 μ s | |
| Openload difference | | X | 4 μ s | |

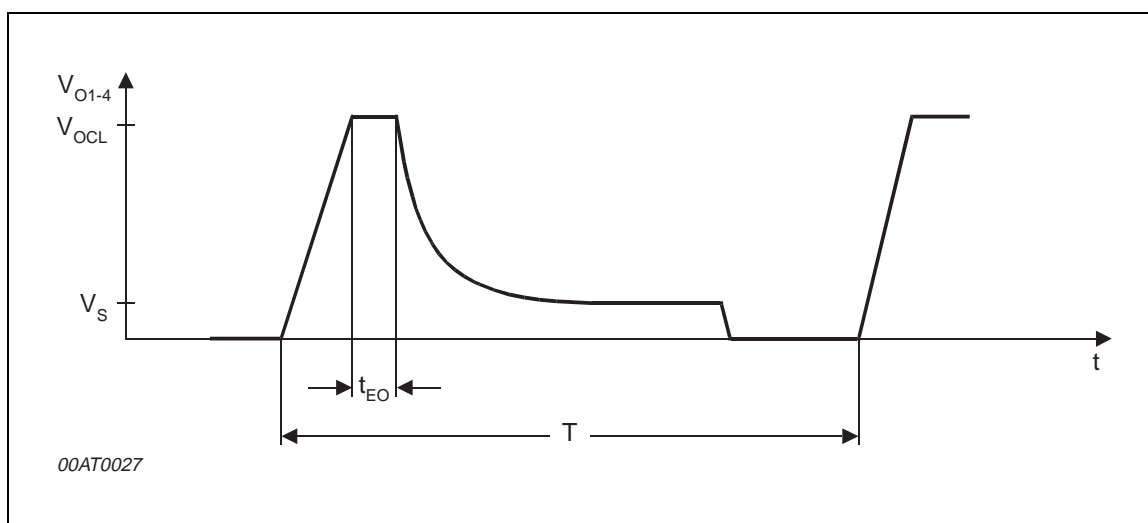
Figure 1. t_{EO} Clamping Time

Figure 2. Output Slope (resistive load for testing)

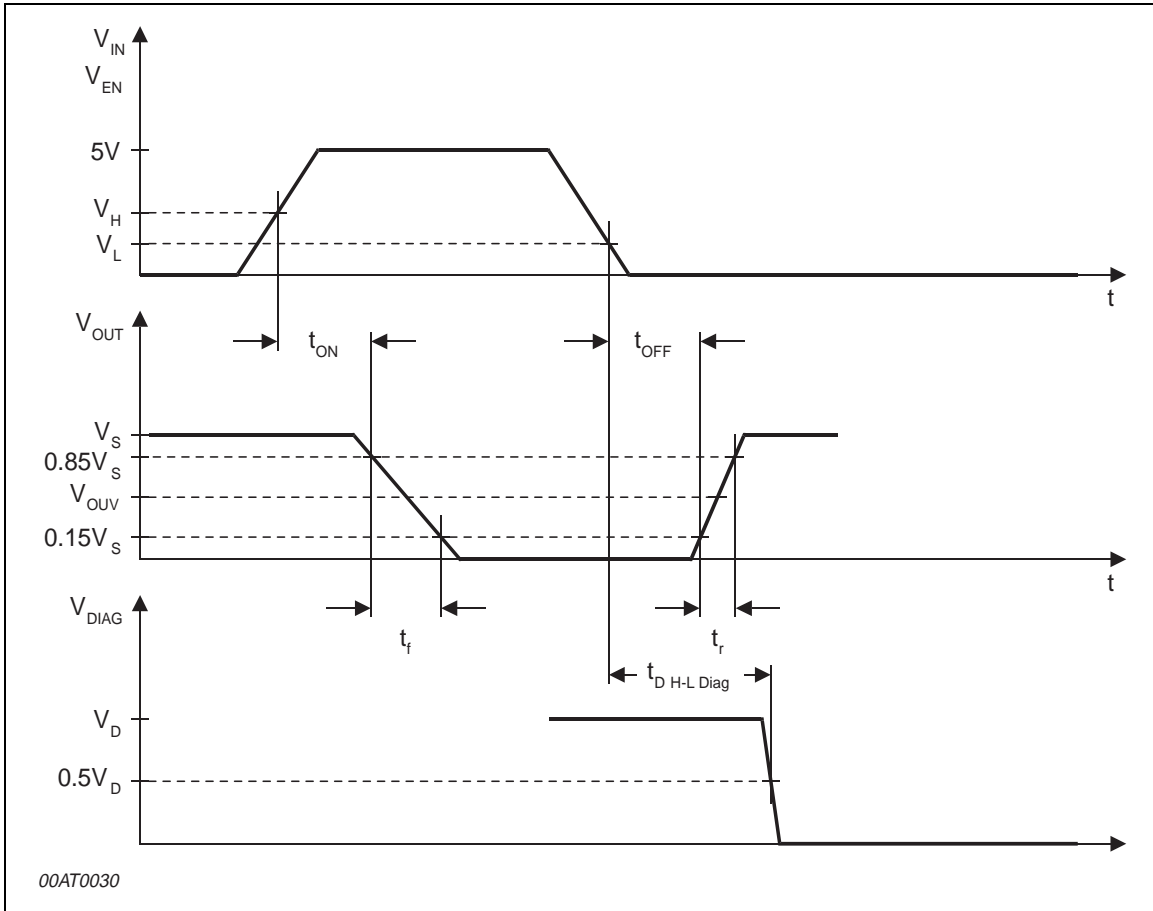


Figure 3. Timing (t_{DOL} , t_{DIOU})

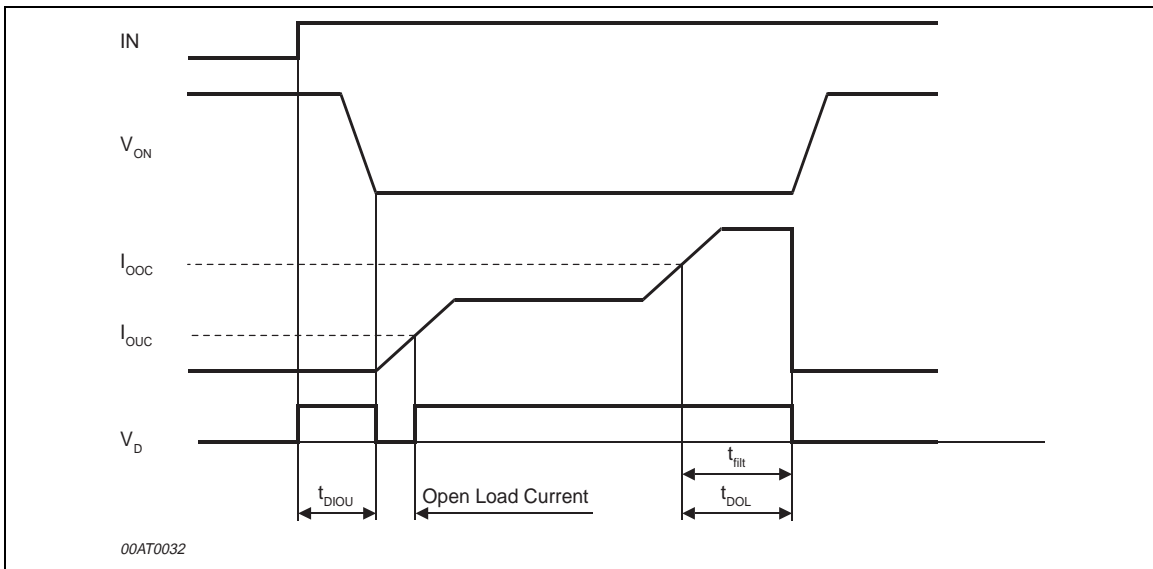


Figure 4. Block Diagram - Open Load Voltage Detection

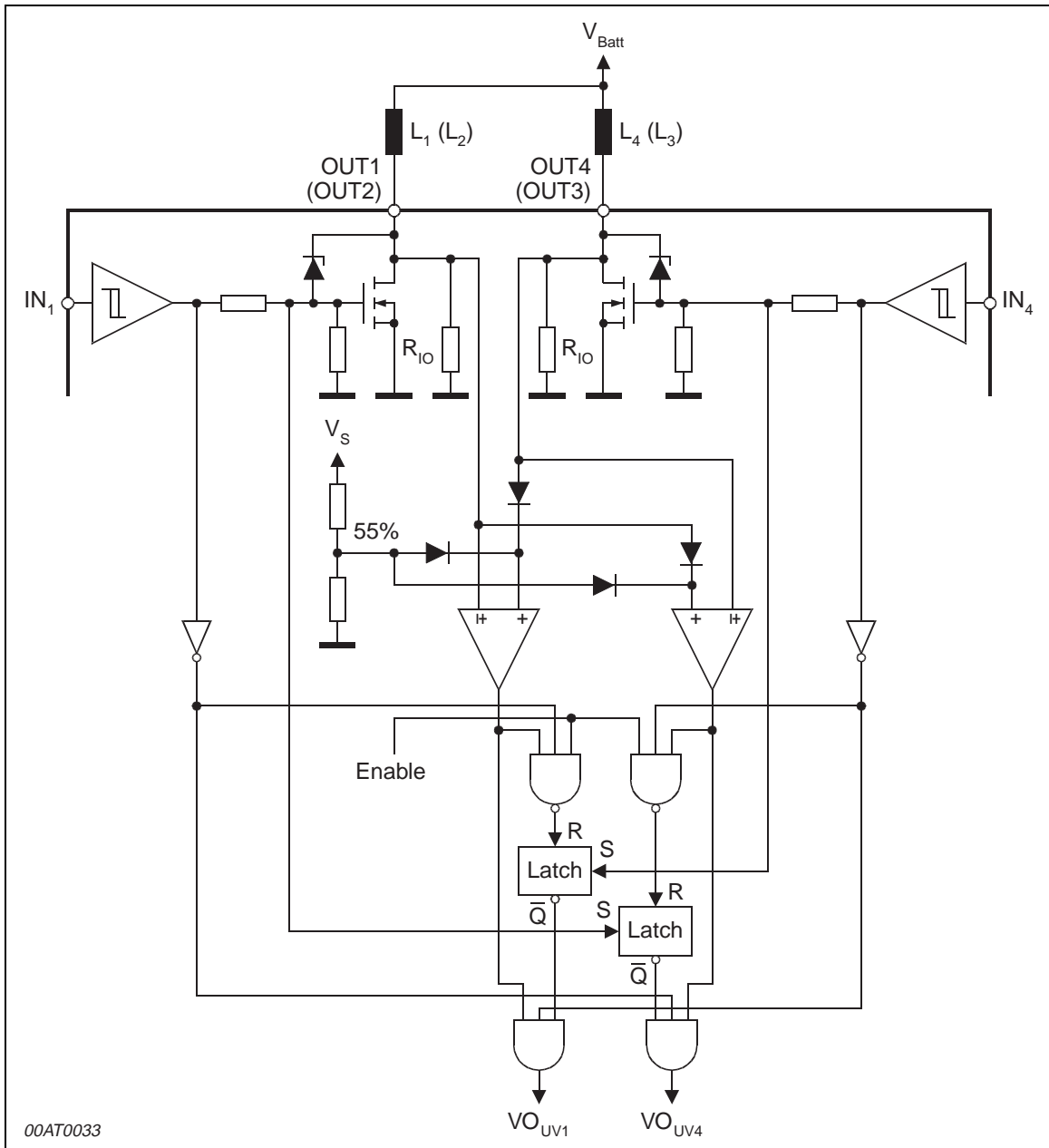


Figure 5. Logic Diagram

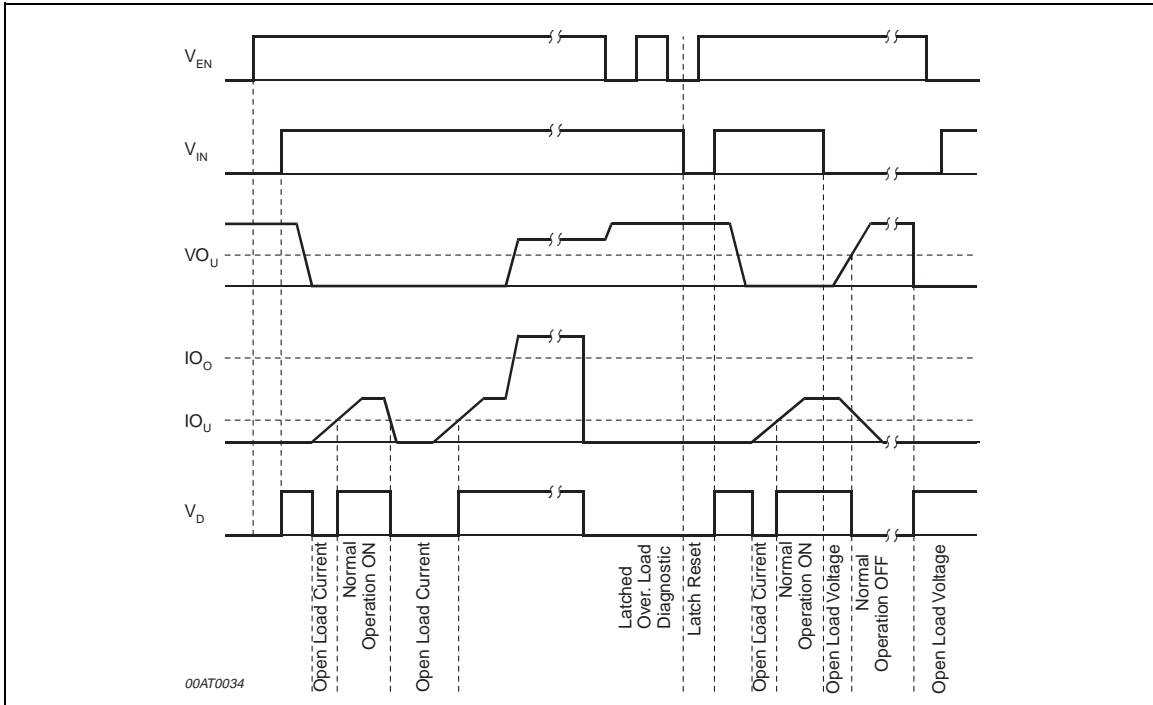
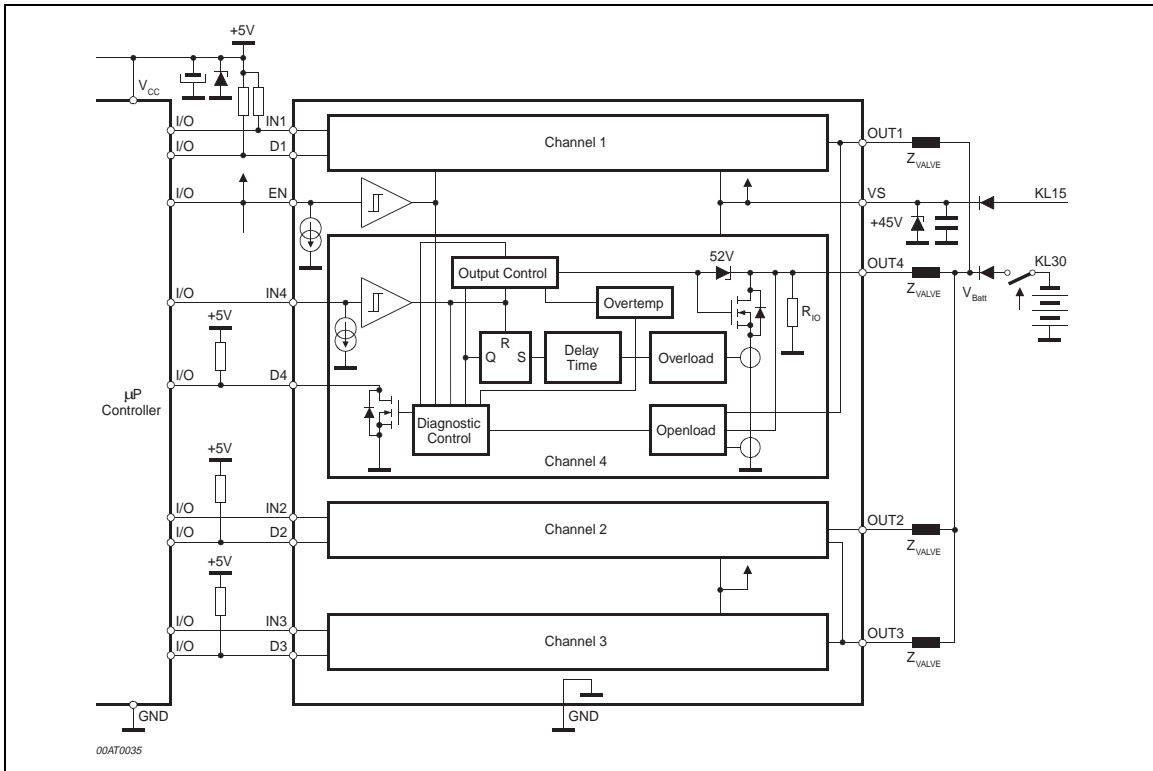


Figure 6. Application Circuit Diagram

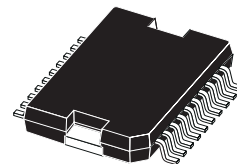


| DIM. | mm | | | inch | | |
|--------|-----------|-------|------|-------|-------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 3.6 | | | 0.142 |
| a1 | 0.1 | | 0.3 | 0.004 | | 0.012 |
| a2 | | | 3.3 | | | 0.130 |
| a3 | 0 | | 0.1 | 0.000 | | 0.004 |
| b | 0.4 | | 0.53 | 0.016 | | 0.021 |
| c | 0.23 | | 0.32 | 0.009 | | 0.013 |
| D (1) | 15.8 | | 16 | 0.622 | | 0.630 |
| D1 | 9.4 | | 9.8 | 0.370 | | 0.386 |
| E | 13.9 | | 14.5 | 0.547 | | 0.570 |
| e | | 1.27 | | | 0.050 | |
| e3 | | 11.43 | | | 0.450 | |
| E1 (1) | 10.9 | | 11.1 | 0.429 | | 0.437 |
| E2 | | | 2.9 | | | 0.114 |
| E3 | 5.8 | | 6.2 | 0.228 | | 0.244 |
| G | 0 | | 0.1 | 0.000 | | 0.004 |
| H | 15.5 | | 15.9 | 0.610 | | 0.626 |
| h | | | 1.1 | | | 0.043 |
| L | 0.8 | | 1.1 | 0.031 | | 0.043 |
| N | 8° (typ.) | | | | | |
| S | 8° (max.) | | | | | |
| T | | 10 | | | 0.394 | |

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

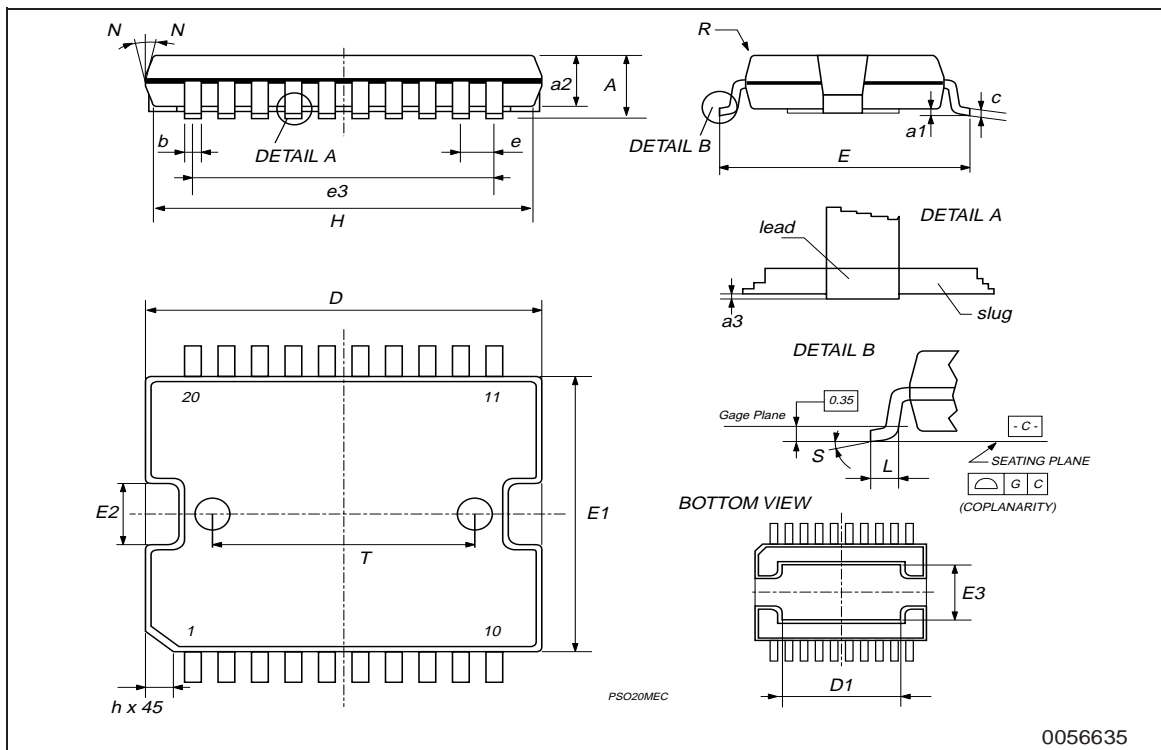
OUTLINE AND MECHANICAL DATA

Weight: 1.9gr



JEDEC MO-166

PowerSO20



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