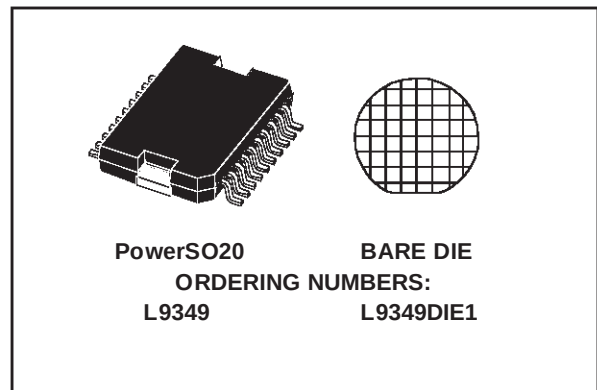


QUAD INTELLIGENT POWER LOW SIDE SWITCH

PRODUCT PREVIEW

- 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

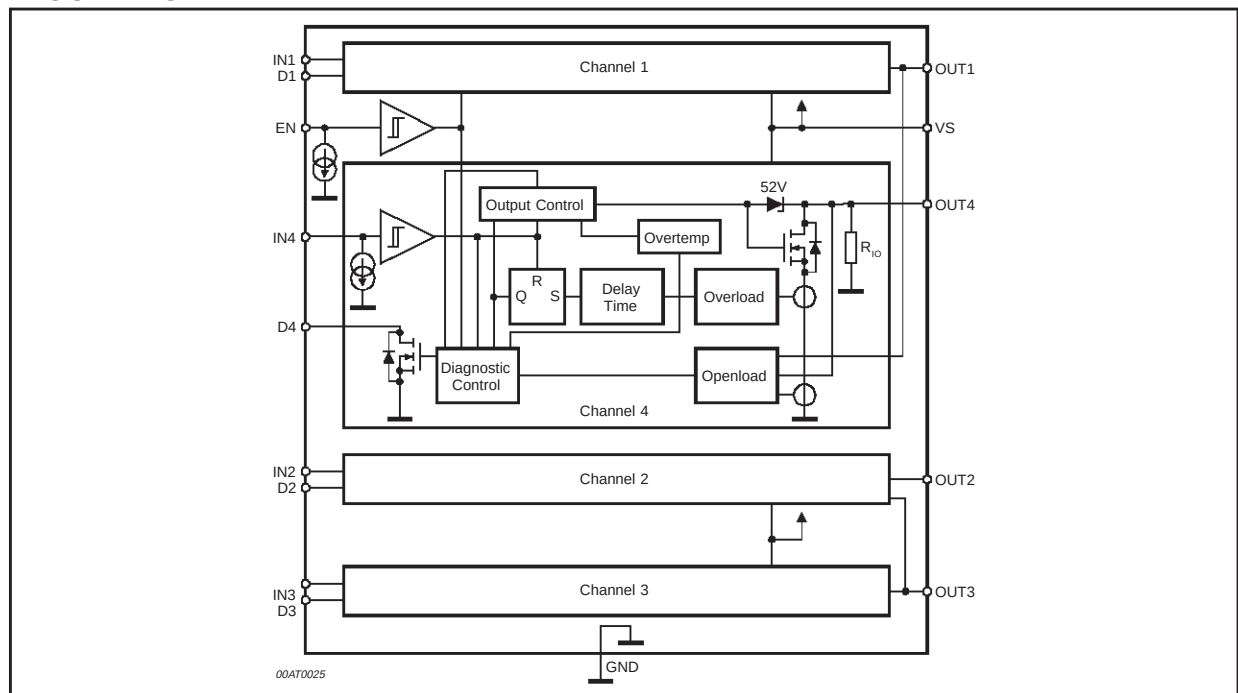


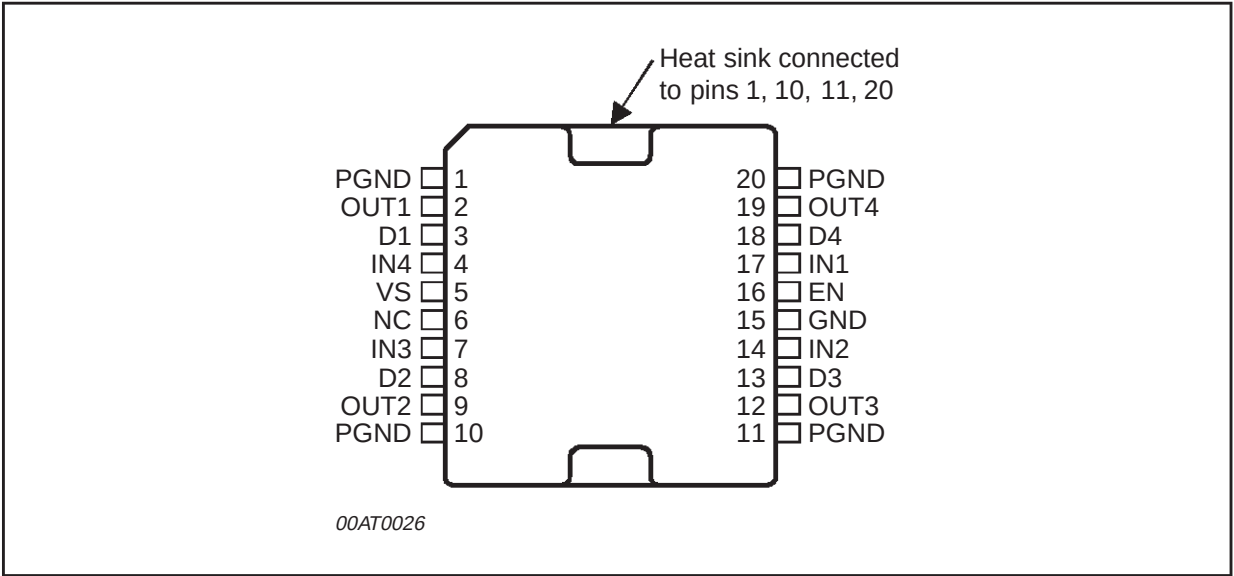
DESCRIPTION

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.

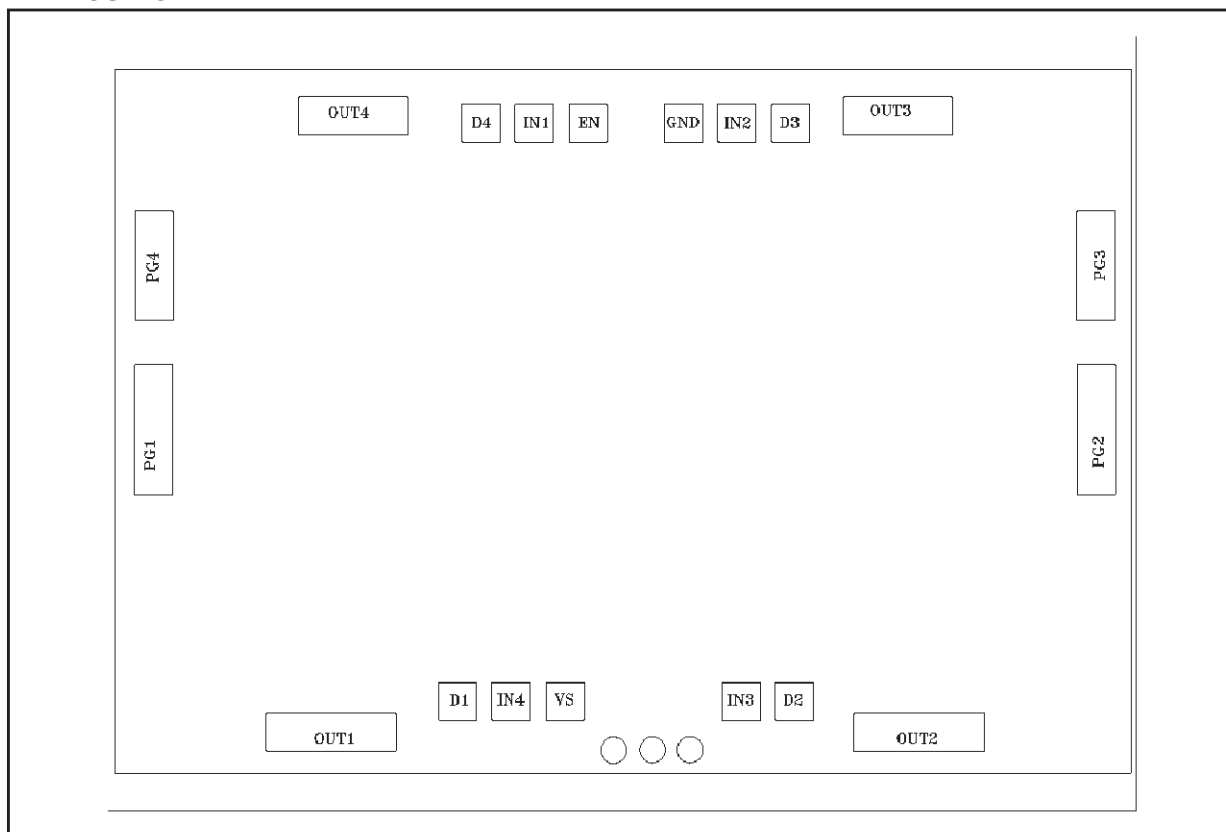
BLOCK DIAGRAM



PIN CONNECTION**PIN DESCRIPTION**

N°	Pin	Function
1	GND	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	GND	Power Ground
11	GND	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	GND	Power Ground

PAD POSITION



PAD COORDINATES

PIN Nr.	Pad name	Description	Size	X	Y
1	GND	Power Ground	510*150	-138.4	1846
2	Out1	Output 1 (5A)	510*150	-1219.2	1152.15
3	D1	Diagnostic 1	150 *150	-1092.95	662.05
4	IN4	Input 4	150 *150	-1092.95	452.05
5	VS	Supply Voltage	150 *150	-1092.95	242.05
7	IN3	Input 3	150 *150	-1092.95	-446.35
8	D2	Diagnostic 2	150 *150	-1092.95	-656.35
9	Out2	Output 2 (5A)	510 *150	-1219.2	-1147.9
10	GND	Power Ground	510 *150	-138.4	-1841.75
11	GND	Power Ground	430 *150	624.48	-1841.75
12	Out3	Output 3 (3A)	430 *150	1195	-1063.58
13	D3	Diagnostic 3	150 *150	1181.3	-556.75
14	IN2	Input 2	150 *150	1181.3	-346.75
15	GND	Signal Ground	150 *150	1181.3	-136.75
16	EN	Common Enable	150 *150	1181.3	155.7
17	IN1	Input 1	150 *150	1181.3	365.7
18	D4	Diagnostic 4	150 *150	1181.3	575.7
19	Out4	Output 4 (3A)	430 *150	1195	1067.83
20	GND	Power Ground	430*150	624.48	1846

THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{Th\ j-case}$	Thermal resistance junction to case	3	°C/W

ABSOLUTE MAXIMUM RATINGS

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/ μ s
$V_{IN, EN}$	Input Voltage	$ I \leq 10mA$	-1.5 to 6	V
V_D	Diagnostic DC Output Voltage	$ I \leq 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	$t_{EO} = 250\mu s, ^1)$	50	mJ
$E_{O3, 4}$		$T = 5ms$	30	mJ
ΔV_{GND}	GND Potential Difference	$T_j = -40$ to $150^\circ C$	± 0.3	V
T_{jEO}	Junction Temperature During Switch-off	$\Sigma t \leq 30$ min	175	°C
		$\Sigma t \leq 15$ 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 (PGND1-4 + SGND)	+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	$\Sigma t \leq 15min ^1)$ 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} 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} =32V T = 30 °C			1			μA
I _{OUT-LE}	OUT leakage current	V _{OUT} =32V T = 130 °C			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	V _{IN} > 2 ²⁾)	10	20	40			μA
I _{EN}	Enable Sink Current		10	20	40			μA
Timing								
t _{ON}	Output Delay ON Time	I _O = 1A V _S = 12V 3)) Fig. 2		4	25			μs
t _{f,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	

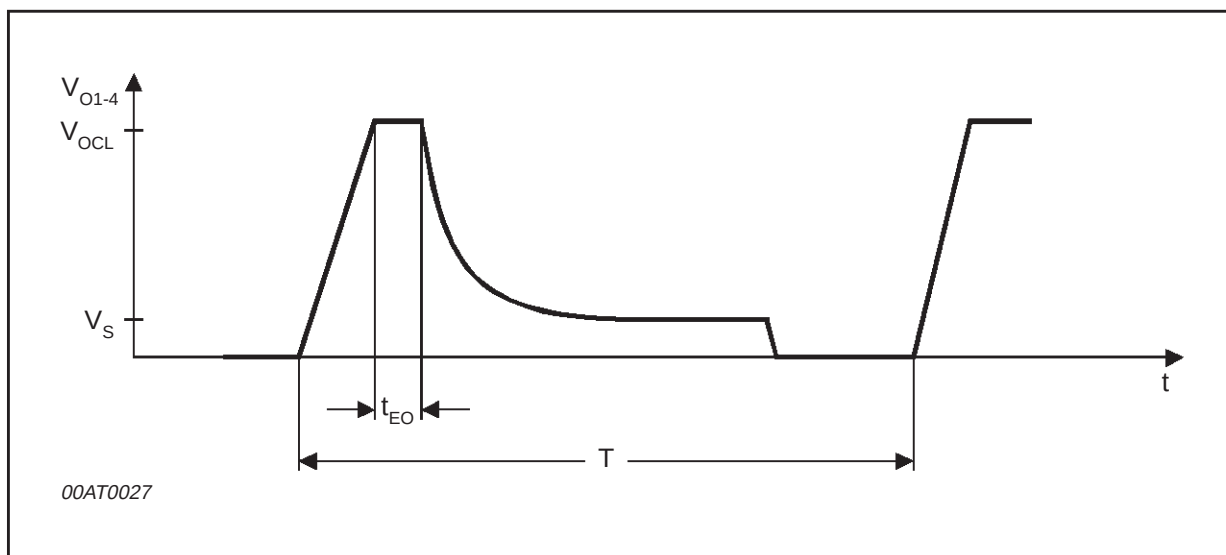
Figure 1. t_{EO} Clamping Time

Figure 2. Output Slope (resistive load for testing)

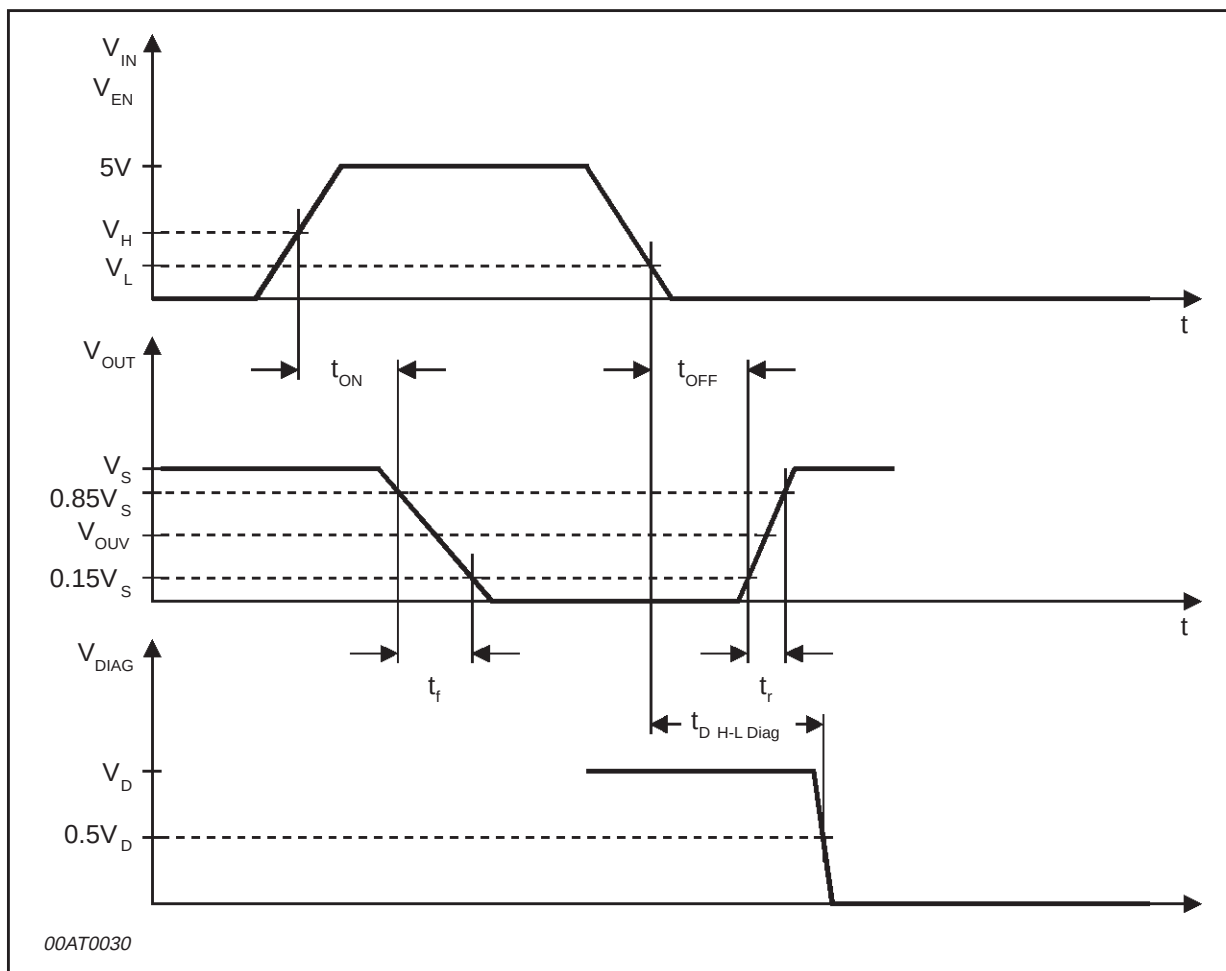
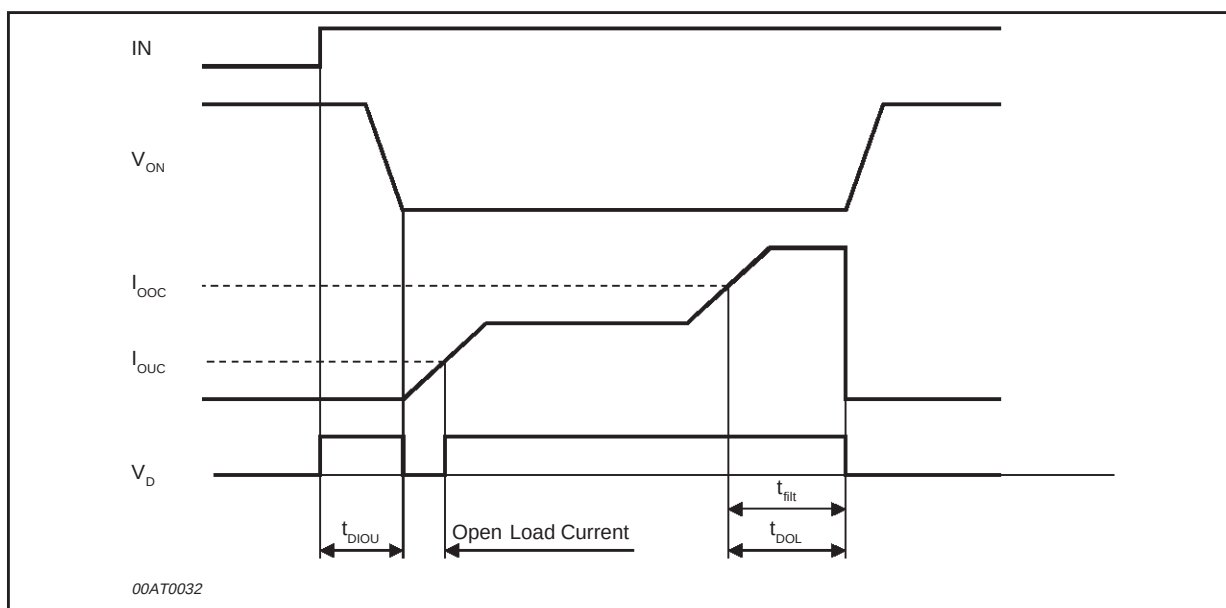
Figure 3. Timing (t_{DOL} , t_{DIOU})

Figure 4. Block Diagram - Open Load Voltage Detection

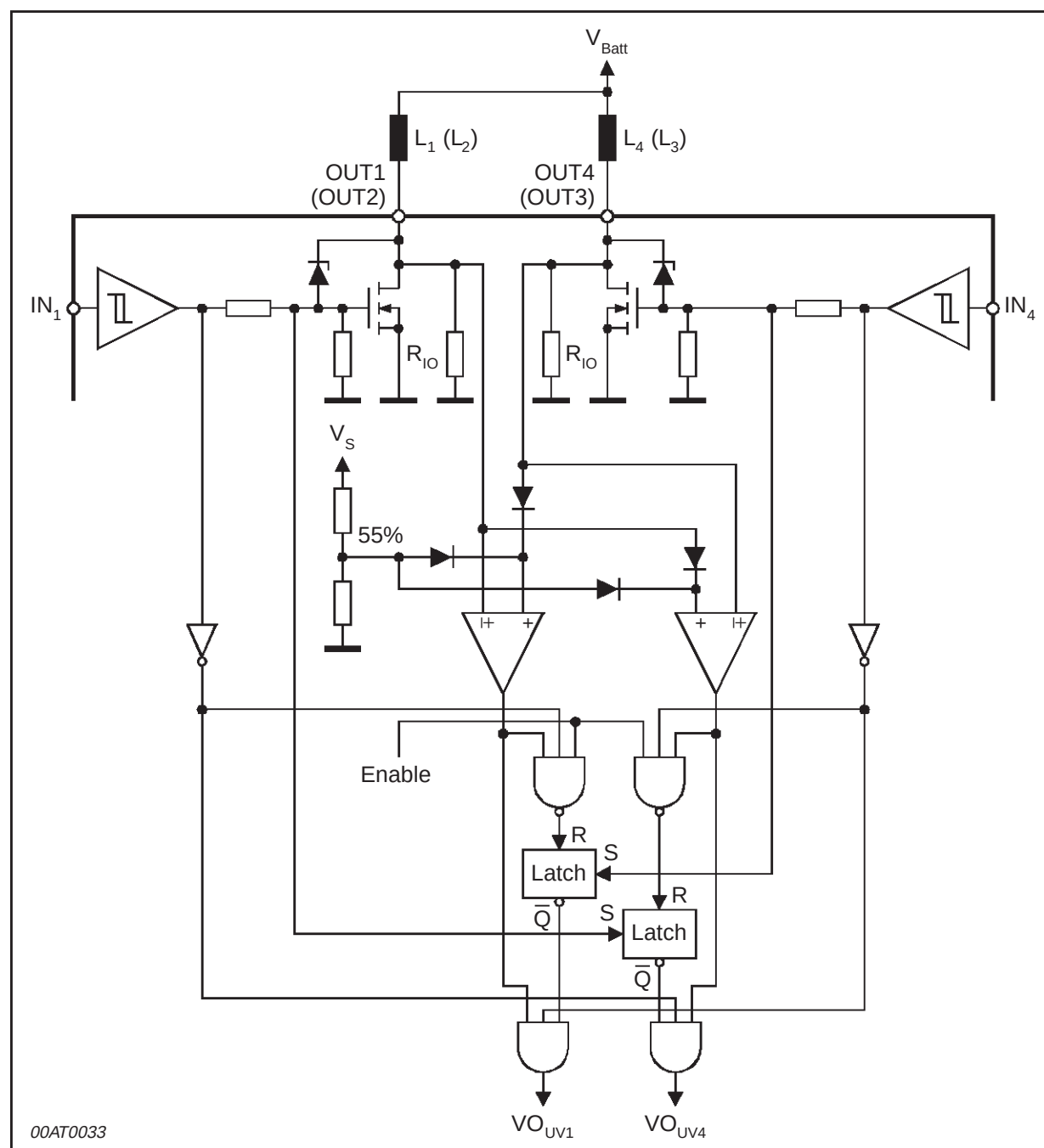


Figure 5. Logic Diagram

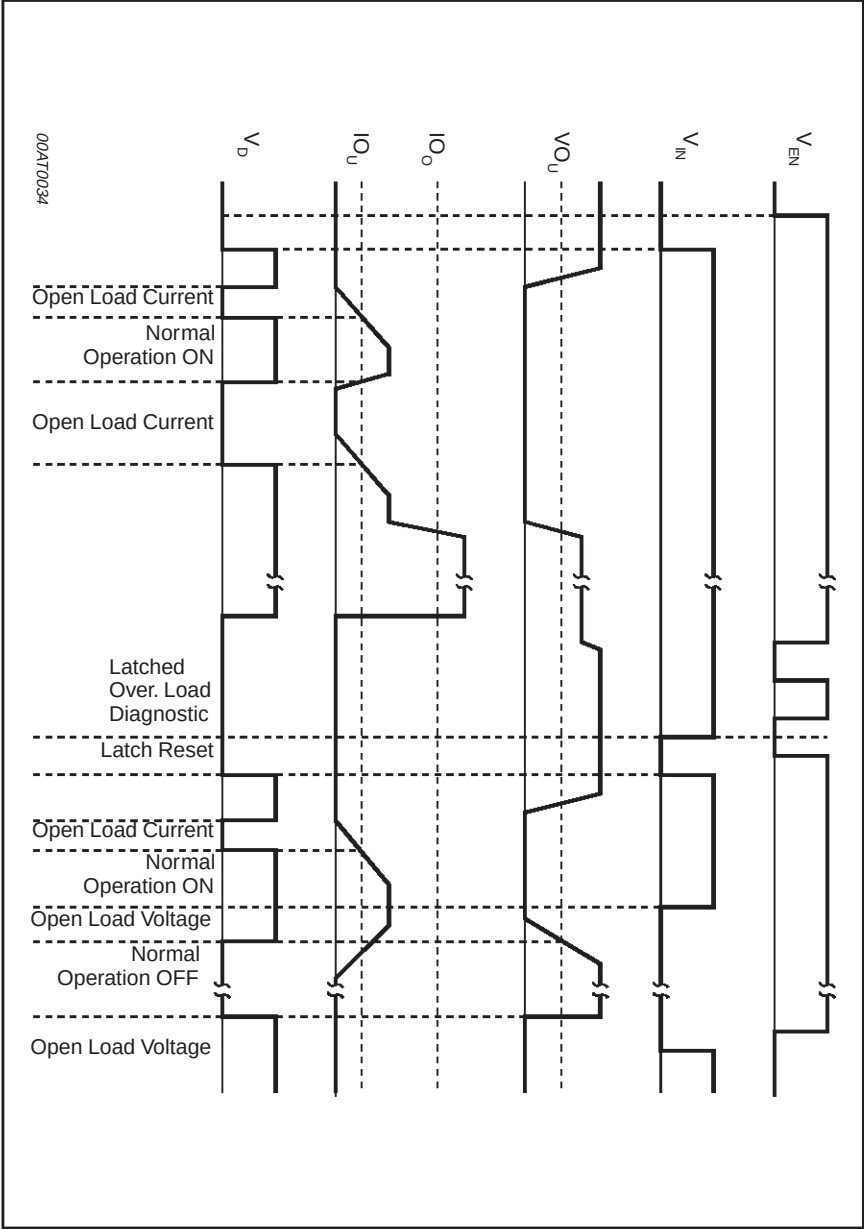
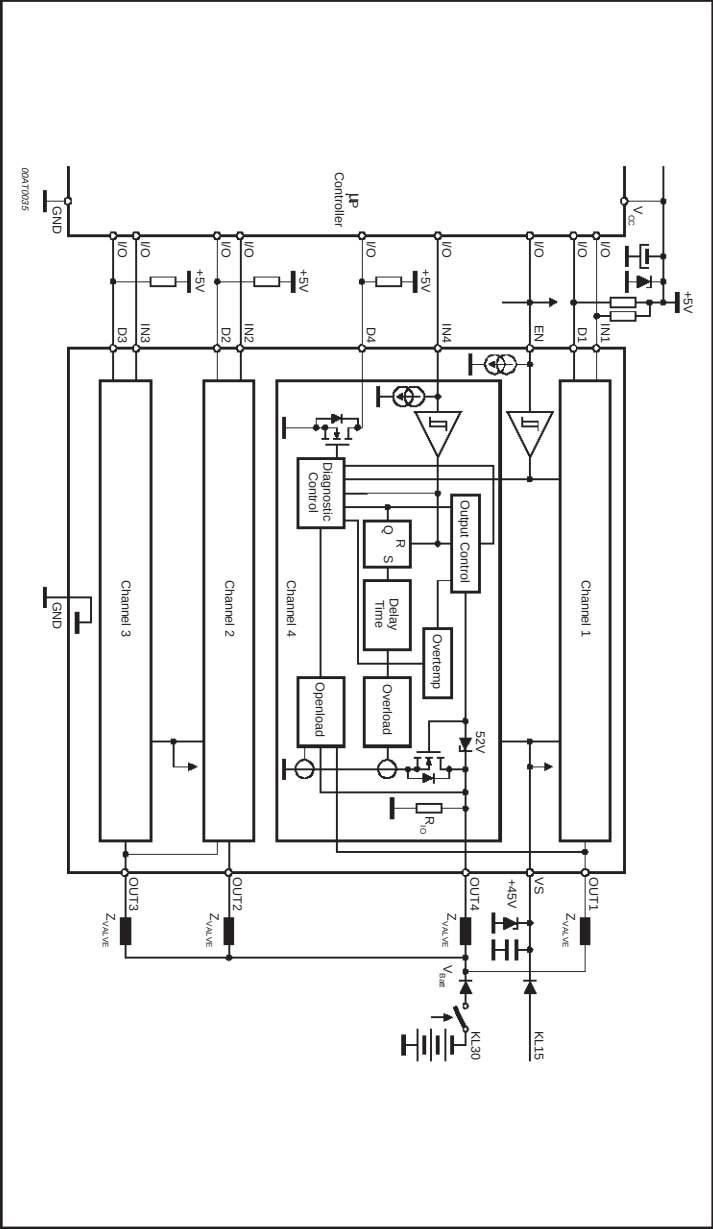


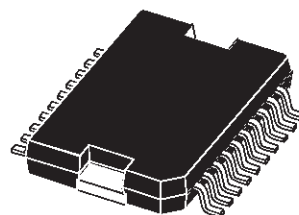
Figure 6. Application Circuit Diagram



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	10° (max.)					
S	8° (max.)					
T		10			0.394	

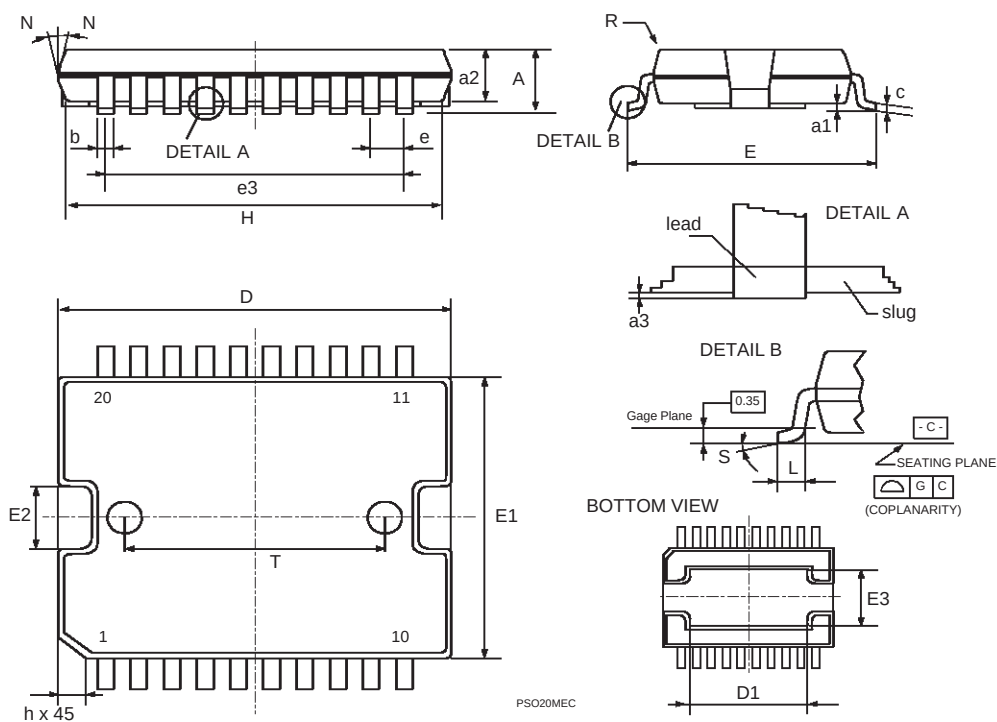
- (1) "D and F" do not include mold flash or protrusions.
 - Mold flash or protrusions shall not exceed 0.15 mm (0.006").
 - Critical dimensions "E", "G" and "a3"

OUTLINE AND MECHANICAL DATA



JEDEC MO-166

PowerSO20



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