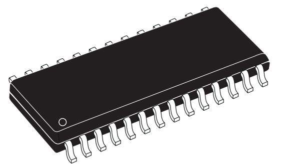
VN770P

QUAD SMART POWER SOLID STATE RELAY FOR COMPLETE H BRIDGE CONFIGURATIONS

TYPE	$R_{DS(on)}$ *	I_{OUT}	V_{CC}
VN770P	0.270 Ω	9 A	26 V

* Total resistance of one side in bridge configuration



SO-28

- IDEAL AS A LOW VOLTAGE BRIDGE
- LINEAR CURRENT LIMITATION
- VERY LOW STAND-BY POWER DISSIPATION
- SHORT CIRCUIT PROTECTED
- STATUS FLAG DIAGNOSTICS
- OPEN DRAIN DIAGNOSTICS OUTPUT
- INTEGRATED CLAMPING CIRCUITS
- UNDER-VOLTAGE PROTECTION
- ESD PROTECTION

DESCRIPTION

The VN770P is a device formed by three monolithic chips housed in a standard SO28 package: a double high side and two low side switches. Both the double high side and low side switches are made using STMicroelectronics VIPower technology. This device is suitable to drive a DC motor in a bridge configuration as well as to be used as a quad switch for any low voltage application. The dual high side switches have built-in thermal shut-down to protect the chip from over temperature and short circuit, status output to provide indication for open load in off and on state, overtemperature conditions and stuck-on to V_{CC}. The low side switches are two OMNIFET types (fully autoprotected Power MOSFET in VIPower™ technology). They have built-in thermal shut-down, linear current limitation and overvoltage clamping. Fault feedback for thermal intervention can be detected by monitoring the voltage at the input pin.

DUAL HIGH-SIDE SWITCH

From the falling edge of the input signal, the status output, initially low to signal a fault condition (overtemperature or open load on-state), will go back to a high state with a different delay in case of overtemperature (tpovl) and in case of open open load (t_{pol}) respectively. This feature allows to discriminate the nature of the detected fault. To protect the device against short circuit and over current condition, the thermal protection turns the integrated Power MOS off at a minimum junction temperature of 140 ^{o}C. When this temperature returns to 125 ^{o}C the switch is automatically turned on again. In short circuit the protection reacts with virtually no delay, the sensor (one for each channel) being located inside each of the two Power MOS areas. This positioning allows the device to operate with one channel in automatic thermal cycling and the other one on a normal load. An internal function of the devices ensures the fast demagnetization of inductive loads with a typical voltage (V_{demag}) of -18V. This function allows to greatly reduces the power dissipation according to the formula:

$$P_{dem} = 0.5 \bullet L_{load} \bullet (I_{load})^2 \bullet [(V_{CC}+V_{demag})/V_{demag}] \bullet f$$

where f = switching frequency and

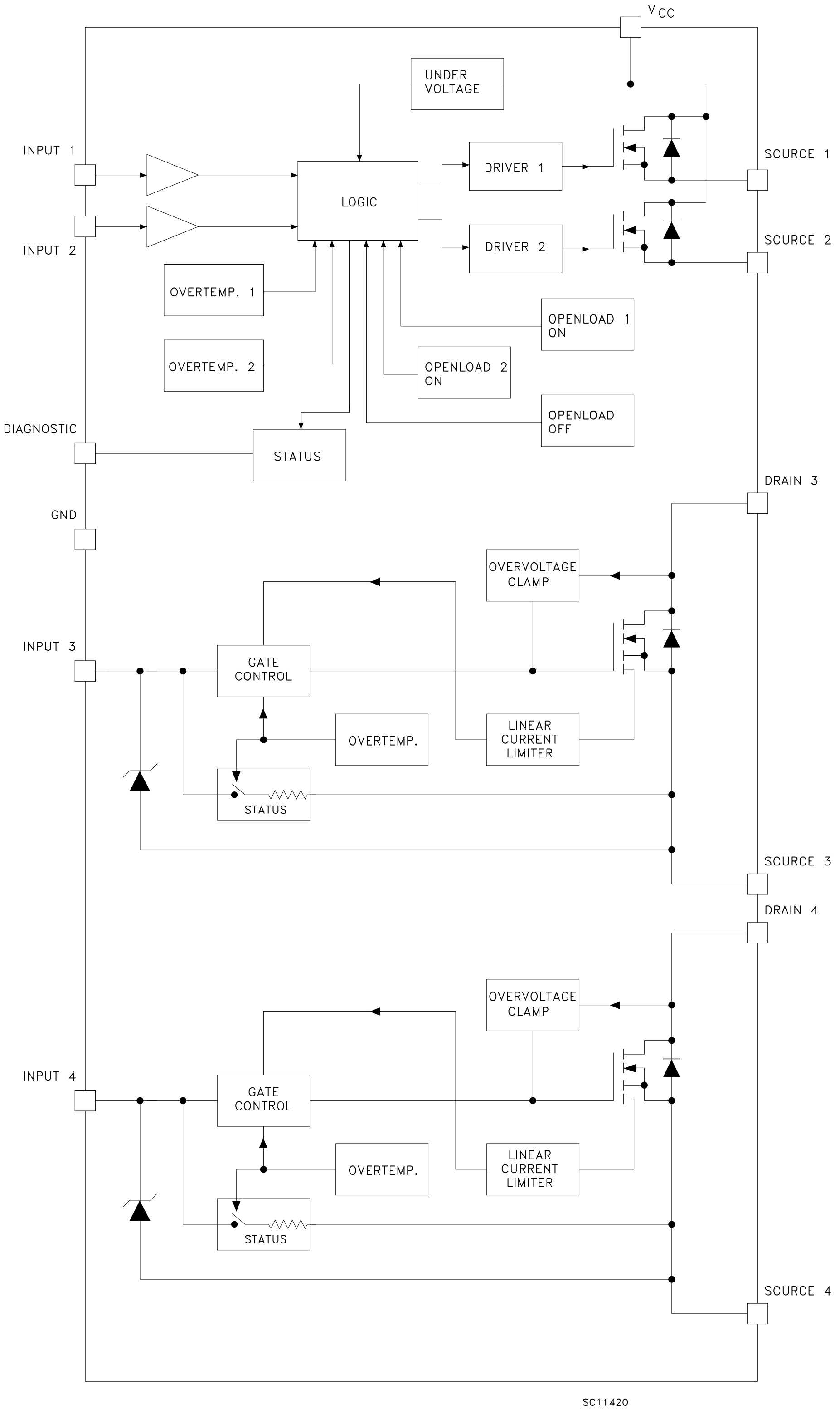
V_{demag} = demagnetization voltage.

In this device if the GND pin is disconnected, with V_{CC} not exceeding 16V, both channel will switch off.

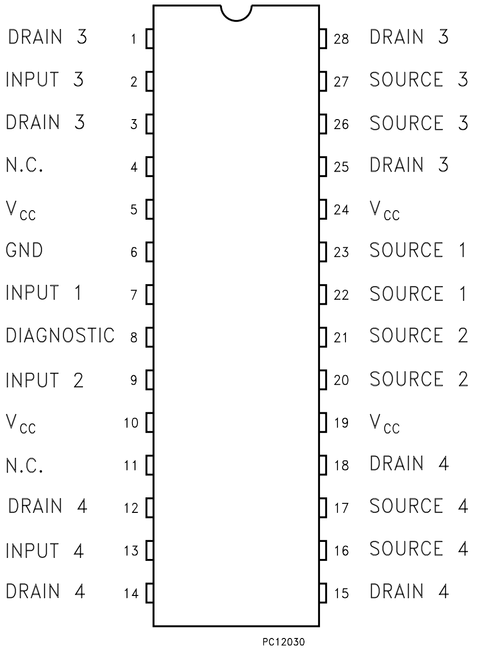
LOW-SIDE SWITCHES

During normal operation, the Input pin is electrically connected to the gate of the internal power MOSFET. The device then behaves like a standard power MOSFET and can be used as a switch from DC to 50 KHz. The only difference from the user's standpoint is that a small DC current (I_{iss}) flows into the Input pin in order to supply the internal circuitry.

BLOCK DIAGRAM



CONNECTION DIAGRAM



PIN FUNCTION

No	NAME	FUNCTION
1, 3, 25, 28	DRAIN 3	Drain of Switch 3 (low-side switch)
2	INPUT 3	Input of Switch 3 (low-side switch)
4, 11	N.C.	Not Connected
5, 10, 19, 24	V_{CC}	Drain of Switches 1and 2 (high-side switches) and Power Supply Voltage
6	GND	Ground of Switches 1 and 2 (high-side switches)
7	INPUT 1	Input of Switch 1 (high-side switch)
8	DIAGNOSTIC	Diagnostic of Switches 1 and 2 (high-side switches)
9	INPUT 2	Input of Switch 2 (high-side switch)
12, 14, 15, 18	DRAIN 4	Drain of Switch 4 (low-side switch)
13	INPUT 4	Input of Switch 4 (low-side switch)
16, 17	SOURCE 4	Source of Switch 4 (low-side switch)
20, 21	SOURCE 2	Source of Switch 2 (high-side switch)
22, 23	SOURCE 1	Source of Switch 1 (high-side switch)
26, 27	SOURCE 3	Source of Switch 3 (low-side switch)

PROTECTION CIRCUITS

DUAL HIGH SIDE SWITCH

The simplest way to protect the device against a continuous reverse battery voltage (-26V) is to insert a a small resistor between pin 2 (GND) and ground. The suggested resistance value is about 150Ω. In any case the maximum voltage drop on this resistor should not overcome 0.5V.

If there is no need for the control unit to handle external analog signals referred to the power GND, the best approach is to connect the reference potential of the control unit to the device ground (see application circuit in fig. 3), which becomes the common signal GND for the whole control board avoiding shift of V_{ih}, V_{il} and V_{stat}.

LOW SIDE SWITCHES

The devices integrate:

- OVERVOLTAGE CLAMP PROTECTION: internally set at 42V, along with the rugged avalanche characteristics of the Power MOSFET stage give this device unrivalled ruggedness and energy handling capability. This feature is mainly important when driving inductive loads.
- OVERTEMPERATURE AND SHORT CIRCUIT PROTECTION: these are based on sensing the chip temperature and are not dependent on the input voltage. The location of the sensing element on the chip in the power stage area ensures fast, accurate detection of the junction temperature. Overtemperature cutout occurs at minimum 150^{o}C. The device is automatically restarted when the chip temperature falls below 135^{o}C.
- STATUS FEEDBACK: In the case of an overtemperature fault condition, a Status Feedback is provided through the Input pin. The internal protection circuit disconnects the input from the gate and connects it instead to ground via an equivalent resistance of 100 Ω. The failure can be detected by monitoring the voltage at the Input pin, which will be close to ground potential.

Additional features of these devices are ESD protection according to the Human Body model and the ability to be driven from a TTL Logic circuit (with a small increase in $R_{DS(on)}$).

TRUTH TABLE (for Dual high-side switch only)

		INPUT 1	INPUT 2	SOURCE 1	SOURCE 2	DIAGNOSTIC
Normal Operation		L H L H	L H H L	L H L H	L H H L	H H H H
Under-voltage		X	X	L	L	H
Thermal Shutdown	Channel 1	H	X	L	X	L
	Channel 2	X	H	X	L	L
Open Load	Channel 1	H L	X L	H L	X L	L L
	Channel 2	X L	H L	X L	H L	L L
Output Shorted to V_{CC}	Channel 1	H L	X L	H H	X L	L L
	Channel 2	X L	H L	X L	H H	L L

NOTE: The low-side switches have the fault feedback which can be detected by monitoring the voltage at the input pins.
L = Logic LOW, H = Logic HIGH, X = Don't care

ABSOLUTE MAXIMUM RATING (-40 $^oC < T_j < 150$ ^oC)

HIGH SIDE SWITCH

Symbol	Parameter	Value	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	40	V
I_{OUT}	Output Current (cont.)	9	A
I_R	Reverse Output Current	-9	A
I_{IN}	Input Current	±10	mA
$-V_{CC}$	Reverse Supply Voltage	-4	V
I_{STAT}	Status Current	±10	mA
V_{ESD}	Electrostatic Discharge (C = 100 pF, R =1.5 KΩ)	2000	V
P_{tot}	Power Dissipation at T_c = 25 ^oC	Internally Limited	W
T_j	Junction Operating Temperature	-40 to 150	^oC
T_{stg}	Storage Temperature	-55 to 150	^oC

LOW SIDE SWITCH

Symbol	Parameter	Value	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	Internally Clamped	V
V_{IN}	Input Voltage	18	V
I_D	Drain Current	Internally Limited	A
I_R	Reverse DC Output Current	-14	A
V_{ESD}	Electrostatic Discharge (C = 100 pF, R =1.5 KΩ)	2000	V
P_{tot}	Total Dissipation at T_c = 25 ^oC	Internally Limited	W
T_j	Operating Junction Temperature	Internally Limited	^oC
T_{stg}	Storage Temperature	-55 to 150	^oC

THERMAL DATA

$R_{thj-case}$	Thermal Resistance Junction-case (High-side switch) Max	20	$^oC/W$
$R_{thj-case}$	Thermal Resistance Junction-case (Low-side switch) Max	20	$^oC/W$
$R_{thj-amb}$	Thermal Resistance Junction-ambient Max	60	$^oC/W$

ELECTRICAL CHARACTERISTICS FOR DUAL HIGH SIDE SWITCH

(8 < V_{CC} < 16 V; -40 ≤ T_j ≤ 125 ^oC unless otherwise specified)

POWER

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply Voltage		6	13	26	V
In(*)	Nominal Current	T_c = 85 ^oC $V_{DS(on)}$ ≤ 0.5 V_{CC} = 13 V	1.6		2.6	A
R_{on}	On State Resistance	I_{OUT} = I_n V_{CC} = 13 V T_j = 25 ^oC	0.13		0.2	Ω
I_S	Supply Current	Off State T_j = 25 ^oC V_{CC} = 13 V		35	100	μA
$V_{DS(MAX)}$	Maximum Voltage Drop	I_{OUT} = 7.5 A T_j = 85 ^oC V_{CC} = 13 V	1.44		2.3	V

ELECTRICAL CHARACTERISTICS FOR DUAL HIGH SIDE SWITCH (continued)

R_i	Output to GND internal Impedance	T_j = 25 °C	5	10	20	KΩ

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$(^)	Turn-on Delay Time Of Output Current	R_{out} = 5.4 Ω	5	25	200	µs
t_r(^)	Rise Time Of Output Current	R_{out} = 5.4 Ω	10	50	180	µs
$t_{d(off)}$(^)	Turn-off Delay Time Of Output Current	R_{out} = 5.4 Ω	10	75	250	µs
t_f(^)	Fall Time Of Output Current	R_{out} = 5.4 Ω	10	35	180	µs
$(di/dt)_{on}$	Turn-on Current Slope	R_{out} = 5.4 Ω	0.003		0.1	A/µs
$(di/dt)_{off}$	Turn-off Current Slope	R_{out} = 5.4 Ω	0.005		0.1	A/µs

LOGIC INPUT

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input Low Level Voltage				1.5	V
V_{IH}	Input High Level Voltage		3.5		(•)	V
$V_{I(hyst.)}$	Input Hysteresis Voltage		0.2	0.9	1.5	V
I_{IN}	Input Current	V_{IN} = 5 V T_j = 25 °C		30	100	µA
V_{ICL}	Input Clamp Voltage	I_{IN} = 10 mA I_{IN} = -10 mA	5	6 -0.7	7	V V

PROTECTION AND DIAGNOSTICS

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status Voltage Output Low	I_{STAT} = 1.6 mA			0.4	V
V_{USD}	Under Voltage Shut Down		3.5	4.5	6	V
V_{SCL}	Status Clamp Voltage	I_{STAT} = 10 mA I_{STAT} = -10 mA	5	6 -0.7	7	V V
T_{TSD}	Thermal Shut-down Temperature		140	160	180	°C
$T_{SD(hyst.)}$	Thermal Shut-down Hysteresis				50	°C
T_R	Reset Temperature		125			°C
V_{OL}	Open Voltage Level	Off-State (note 2)	2.5	4	5	V

ELECTRICAL CHARACTERISTICS FOR DUAL HIGH SIDE SWITCH (continued)

PROTECTION AND DIAGNOSTICS

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{OL}	Open Load Current Level	On-State	5		180	mA
t_{povl}	Status Delay	(note 3)		5	10	µs
t_{pol}	Status Delay	(note 3)	50	500	2500	µs

(*) In= Nominal current according to ISO definition for high side automotive switch (see note 1)
(^) See switching time waveform
() The V_{IH} is internally clamped at 6V about. It is possible to connect this pin to an higher voltage via an external resistor calculated to not exceed 10 mA at the input pin.
note 1: The Nominal Current is the current at T_c = 85 °C for battery voltage of 13V which produces a voltage drop of 0.5 V
note 2: $I_{OL(off)} = (V_{CC} - V_{OL})/R_{OL}$
note 3: t_{povl} t_{pol}: ISO definition

ELECTRICAL CHARACTERISTICS FOR LOW SIDE SWITCHES

(T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{CLAMP}	Drain-source Clamp Voltage	I_D = 7 A V_{in} = 0	36	42	48	V
V_{CLTH}	Drain-source Clamp Threshold Voltage	I_D = 2 mA V_{in} = 0	35			V
V_{INCL}	Input-Source Reverse Clamp Voltage	I_{in} = -1 mA	-1		-0.3	V
I_{DSS}	Zero Input Voltage Drain Current (V_{in} = 0)	V_{DS} = 13 V V_{in} = 0 V_{DS} = 25 V V_{in} = 0			50 200	µA µA
I_{ISS}	Supply Current from Input Pin	V_{DS} = 0 V V_{in} = 10 V		250	500	µA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{IN(th)}$	Input Threshold Voltage	$V_{DS} = V_{in}$ $I_D + I_{in}$ = 1 mA	0.8		3	V
$R_{DS(on)}$	Static Drain-source On Resistance	V_{in} = 10 V I_D = 7 A V_{in} = 5 V I_D = 7 A			0.07 0.1	Ω Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit

ELECTRICAL CHARACTERISTICS FOR LOW SIDE SWITCHES (continued)

g_{fs} (*)	Forward Transconductance	V_{DS} = 13 V I_D = 7 A	8	10		S
C_{oss}	Output Capacitance	V_{DS} = 13 V f = 1 MHz V_{in} = 0		400	500	pF

SWITCHING (**)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Delay Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 15 V I_d = 7A V_{gen} = 10 V R_{gen} = 10 Ω (see figure 3)		60 160 250 100	120 300 400 200	ns ns ns ns
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Delay Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 15 V I_d = 7 A V_{gen} = 10 V R_{gen} = 1000 Ω (see figure 3)		300 1.5 5.5 1.8	500 2.2 7.5 2.5	ns µs µs µs
$(di/dt)_{on}$	Turn-on Current Slope	V_{DD} = 15 V I_D = 7A V_{in} = 10 V R_{gen} = 10 Ω		120		A/µs
Q_i	Total Input Charge	V_{DD} = 12 V I_D = 7 A V_{in} = 10 V		30		nC

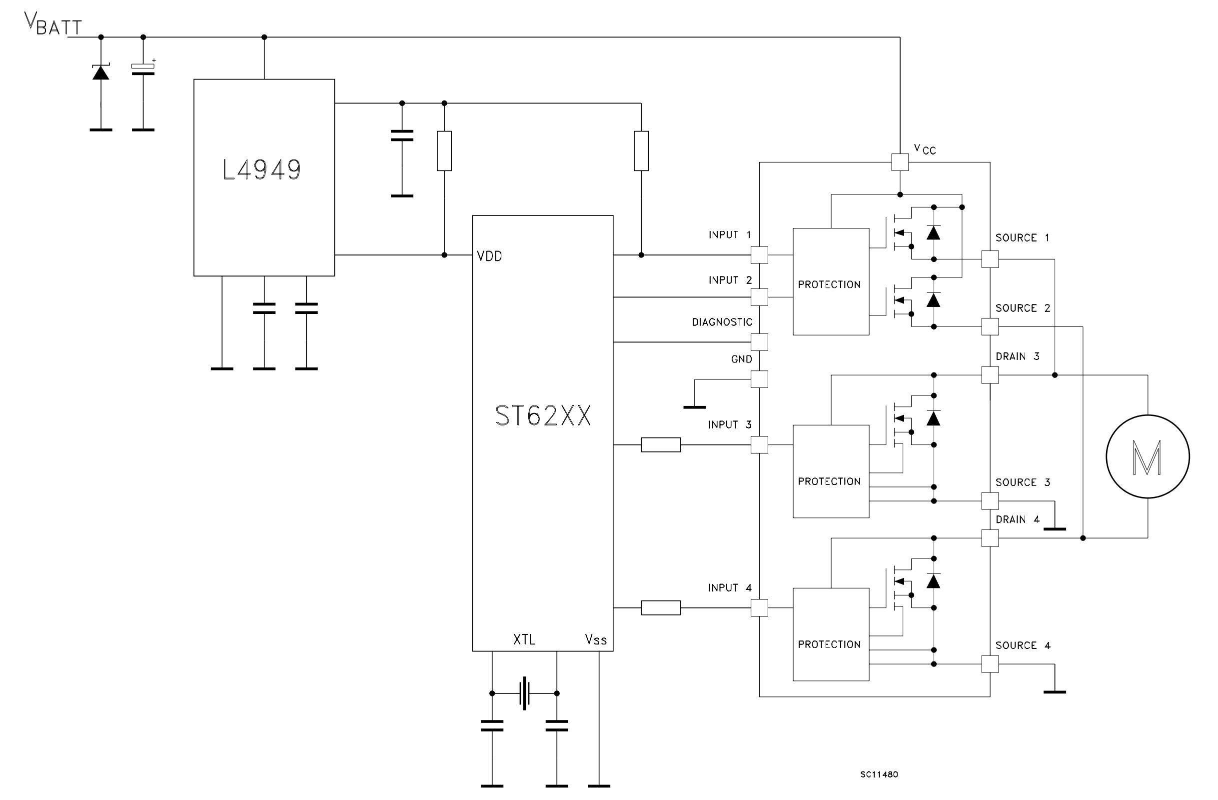
SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{SD} (*)	Forward On Voltage	I_{SD} = 10 A V_{in} = 0			1.6	V
t_{rr} (**) Q_{rr} (**) I_{RRM} (**)	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	I_{SD} = 7 A di/dt = 100 A/µs V_{DD} = 30 V T_j = 25 °C (see test circuit, figure 5)		110 0.34 6.1		ns µC A

PROTECTION

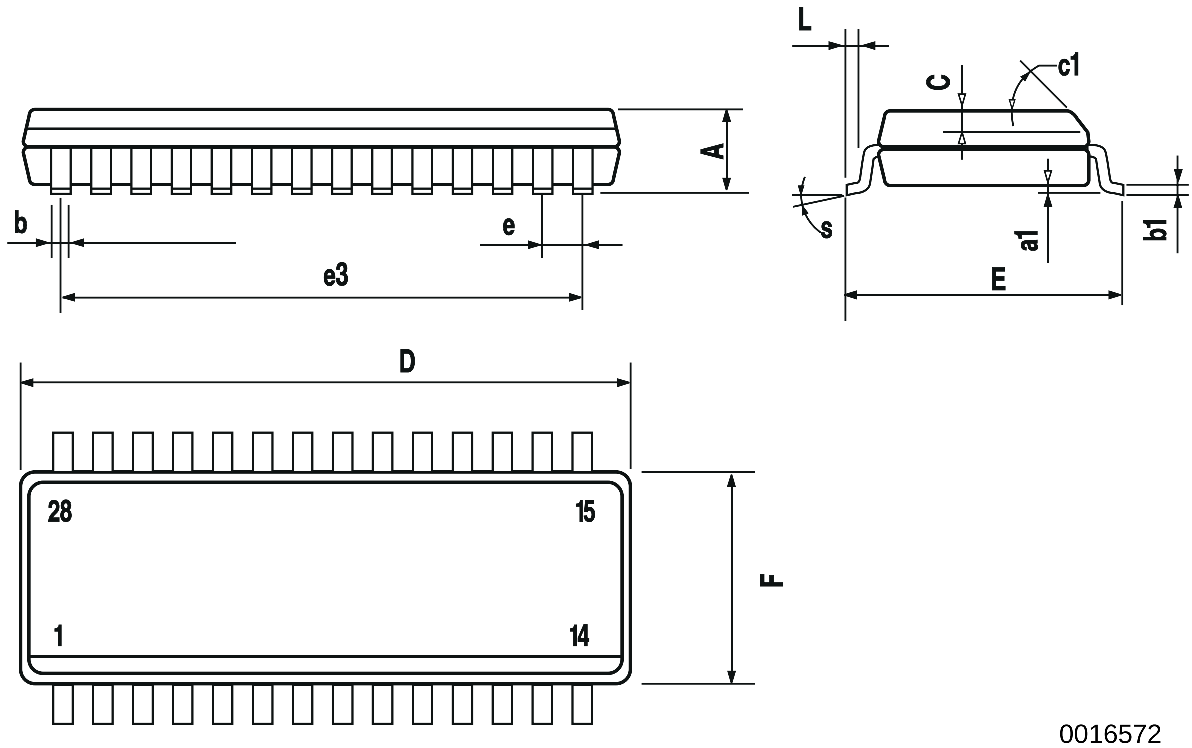
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_{jsh} (**)	Overtemperature Shutdown		150			°C
T_{jrs} (**)	Overtemperature Reset		135			°C
I_{gf} (**)	Fault Sink Current	V_{in} = 10 V V_{DS} = 13 V V_{in} = 5 V V_{DS} = 13 V		50 20		mA mA
I_{lim}	Drain Current Limit	V_{in} = 10 V V_{DS} = 13 V V_{in} = 5 V V_{DS} = 13 V	10 10	14 14	20 20	A A
t_{dlim} (**)	Step Response Current Limit	V_{in} = 10 V V_{in} = 5 V		30 80	60 150	µs µs

TYPICAL APPLICATION DIAGRAM



SO-28 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.10		0.30	0.004		0.012
b	0.35		0.49	0.013		0.019
b1	0.23		0.32	0.009		0.012
C		0.50			0.020	
c1	45 (typ.)					
D	17.7		18.1	0.697		0.713
E	10.00		10.65	0.393		0.419
e		1.27			0.050	
e3		16.51			0.650	
F	7.40		7.60	0.291		0.299
L	0.40		1.27	0.016		0.050
S	8 (max.)					



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