



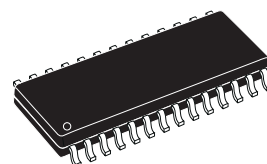
# VN770

## QUAD SMART POWER SOLID STATE RELAY FOR COMPLETE H-BRIDGE CONFIGURATIONS

TYPE	R <sub>DS(on)</sub> *	I <sub>OUT</sub>	V <sub>CC</sub>
VN770	0.240 Ω	9 A	26 V

\* Total resistance of one side in bridge configuration

- IDEAL AS A LOW VOLTAGE BRIDGE
- VERY LOW STAND-BY POWER DISSIPATION
- OVER-CURRENT PROTECTED
- STATUS FLAG DIAGNOSTICS ON UPPER SIDE
- OPEN DRAIN DIAGNOSTICS OUTPUT
- UNDER-VOLTAGE PROTECTION
- SUITABLE AS QUAD SWITCH



SO-28

### DESCRIPTION

The VN770 is a device formed by three monolithic chips housed in a standard SO-28 package: a double high side and two Power MOSFETs. The double high side are made using STMicroelectronics VIPower technology; Power MOSFETs are made by using the new advanced strip lay-out 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<sub>CC</sub>.

#### 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 load (tpol) 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 °C. When this temperature returns to 125 °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<sub>demag</sub>) of -18V. This function allows to greatly reduces the power dissipation according to the formula:

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

where f = switching frequency and  
V<sub>demag</sub> = demagnetization voltage.

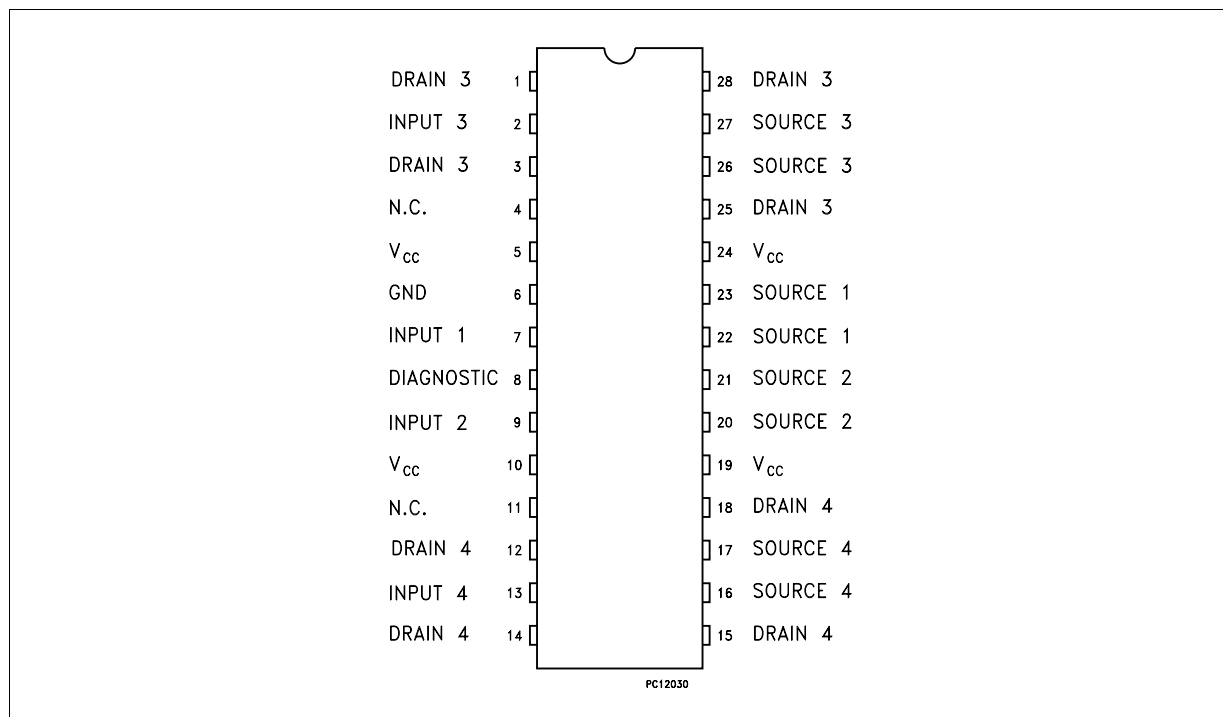
In this device if the GND pin is disconnected, with V<sub>CC</sub> not exceeding 16V, both channel will switch off.

#### Power MOSFETs

During normal operation, the Input pin is electrically connected to the gate of the internal power MOSFET. The devices can be used as a switch from DC to very high frequency.



## 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 <sub>CC</sub>	Drain of Switches 1 and 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 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  $V_{stat}$ .

### TRUTH TABLE (for Dual high-side switch only)

		INPUT 1	INPUT 2	SOURCE 1	SOURCE 2	DIAGNOSTIC
Normal Operation		L	L	L	L	H
		H	H	H	H	H
		L	H	L	H	H
		H	L	H	L	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	X	H	X	L
		L	L	L	L	L
	Channel 2	X	H	X	H	L
		L	L	L	L	L
Output Shorted to $V_{CC}$	Channel 1	H	X	H	X	L
		L	L	H	L	L
	Channel 2	X	H	X	H	L
		L	L	L	H	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 °C < $T_j$ < 150 °C)

#### HIGH SIDE SWITCH

Symbol	Parameter	Value	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	40	V
$I_{OUT}$	Output Current (continuous)	9	A
$I_R$	Reverse Output Current	-9	A
$I_{IN}$	Input Current	±10	mA
$-V_{CC}$	Reverse Supply Current	-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 @ $T_c = 25$ °C	Internally Limited	W
$T_j$	Junction Operating Temperature	-40 to 150	°C
$T_{stg}$	Storage Temperature	-55 to 150	°C

## LOW SIDE SWITCH

Symbol	Parameter	Value	Unit
$V_{DS}$	Drain-Source Voltage ( $V_{GS} = 0$ )	60	V
$V_{DGR}$	Drain-Gate Voltage ( $R_{GS} = 20\text{ K}\Omega$ )	60	V
$V_{GS}$	Gate-Source Voltage	$\pm 20$	V
$I_D$	Drain Current (continuous) @ $T_C = 25\text{ }^\circ\text{C}$	36	A
$I_D$	Drain Current (continuous) @ $T_C = 100\text{ }^\circ\text{C}$	24	A
$I_{DM(*)}$	Drain Current (pulsed)	144	A
$dv/dt\ (1)$	Peak Diode Recovery Voltage Slope	7	V/ns
$T_{stg}$	Storage Temperature	-55 to 150	$^\circ\text{C}$
$T_j$	Junction Operating Temperature	-40 to 150	$^\circ\text{C}$

## THERMAL DATA

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

## ELECTRICAL CHARACTERISTICS FOR DUAL HIGH SIDE SWITCH

( $8 < V_{CC} < 16\text{ V}$ ;  $-40 \leq T_j \leq 125\text{ }^\circ\text{C}$  unless otherwise specified)

## POWER

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{CC}$	Supply Voltage		6	13	26	V
$I_n(*)$	Nominal Current	$T_C = 85\text{ }^\circ\text{C}$ $V_{DS(on)} \leq 0.5\text{ V}$ $V_{CC} = 13\text{ V}$	1.6		2.6	A
$R_{on}$	On State Resistance	$I_{OUT} = I_n$ $V_{CC} = 13\text{ V}$ $T_j = 25\text{ }^\circ\text{C}$	0.13		0.2	$\Omega$
$I_s$	Supply Current	Off State $T_j = 25\text{ }^\circ\text{C}$ $V_{CC} = 13\text{ V}$		35	100	$\mu\text{A}$
$V_{DS(MAX)}$	Maximum Voltage Drop	$I_{OUT} = 7.5\text{ A}$ $T_j = 85\text{ }^\circ\text{C}$ $V_{CC} = 13\text{ V}$	1.44		2.3	V
$R_i$	Output to GND internal Impedance	$T_j = 25\text{ }^\circ\text{C}$	5	10	20	$\text{K}\Omega$

## SWITCHING

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

## ELECTRICAL CHARACTERISTICS FOR DUAL HIGH SIDE SWITCH (continued)

## 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	$V_{IN} = 5\text{ V}$ $T_j = 25\text{ }^{\circ}\text{C}$		30	100	$\mu\text{A}$
$V_{ICL}$	Input Clamp Voltage	$I_{IN} = 10\text{ mA}$ $I_{IN} = -10\text{ mA}$	5	6 -0.7	7	V V

## PROTECTION AND DIAGNOSTICS

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{STAT}$	Status Voltage Output Low	$I_{STAT} = 1.6\text{ mA}$			0.4	V
$V_{USD}$	Under Voltage Shut Down		3.5	4.5	6	V
$V_{SCL}$	Status Clamp Voltage	$I_{STAT} = 10\text{ mA}$ $I_{STAT} = -10\text{ mA}$	5	6 -0.7	7	V V
$T_{TSD}$	Thermal Shut-down Temperature		140	160	180	$^{\circ}\text{C}$
$T_{SD(hyst.)}$	Thermal Shut-down Hysteresis				50	$^{\circ}\text{C}$
$T_R$	Reset Temperature		125			$^{\circ}\text{C}$
$V_{OL}$	Open Voltage Level	Off-State (note 2)	2.5	4	5	V
$I_{OL}$	Open Load Current Level	On-State	5		180	mA
$t_{povl}$	Status Delay	(note 3)		5	10	$\mu\text{s}$
$t_{pol}$	Status Delay	(note 3)	50	500	2500	$\mu\text{s}$

(\*)  $I_N$  = 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  $T_c = 85\text{ }^{\circ}\text{C}$  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** ( $T_{\text{case}} = 25^{\circ}\text{C}$  unless otherwise specified)

**OFF**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(\text{BRDSS})}$	Drain-source Breakdown Voltage	$I_D = 250\ \mu\text{A}$ $V_{\text{GS}} = 0$	60			V
$I_{\text{DSS}}$	Zero Gate Voltage Drain Current ( $V_{\text{GS}} = 0$ )	$V_{\text{DS}} = \text{Max Rating}$ $V_{\text{DS}} = \text{Max Rating}$ , $T_C = 125^{\circ}\text{C}$			1 10	$\mu\text{A}$ $\mu\text{A}$
$I_{\text{GSS}}$	Gate-Body Leakage Current ( $V_{\text{DS}} = 0$ )	$V_{\text{GS}} = \pm 20\ \text{V}$			$\pm 100$	nA

**ON (\*)**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{\text{GS(th)}}$	Gate Threshold Voltage	$V_{\text{DS}} = V_{\text{GS}}$ $I_D = 250\ \mu\text{A}$	1.0		2.5	V
$R_{\text{DS(on)}}$	Static Drain-Source On Resistance	$V_{\text{GS}} = 10\ \text{V}$ $I_D = 18\ \text{A}$		0.032	0.04	$\Omega$
$I_{\text{D(on)}}$	On State Drain Current ( $V_{\text{DS}} = 0$ )	$V_{\text{DS}} > I_{\text{D(on)}} \times R_{\text{DS(on)max}}$ $V_{\text{GS}} = 10\ \text{V}$	36			A

**DYNAMIC**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$g_{\text{fs}} (*)$	Forward Transconductance	$V_{\text{DS}} > I_{\text{D(on)}} \times R_{\text{DS(on)max}}$ $I_D = 18\ \text{A}$	7			S
$C_{\text{iSS}}$ $C_{\text{oSS}}$ $C_{\text{rSS}}$	Input Capacitance Output Capacitance Reverse Transfer Capacitance	$V_{\text{DS}} = 25\ \text{V}$ $f = 1\ \text{MHz}$ $V_{\text{GS}} = 0$		2115 260 65	2800 350 90	pF pF pF

**SWITCHING-ON (\*\*)**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{\text{d(on)}}$ $t_r$	Turn-on Time Rise Time	$V_{\text{DD}} = 30\ \text{V}$ $I_D = 18\ \text{A}$ $R_G = 4.7\ \Omega$ $V_{\text{GS}} = 10\ \text{V}$		28 85	40 115	ns ns
$(di/dt)_{\text{on}}$	Turn-on Current Slope	$V_{\text{DD}} = 48\ \text{V}$ $I_D = 36\ \text{A}$ $R_G = 47\ \Omega$ $V_{\text{GS}} = 10\ \text{V}$		250		A/ $\mu\text{s}$
$Q_g$ $Q_{\text{gs}}$ $Q_{\text{gd}}$	Total Gate Charge Gate-Source Charge Gate-Drain Charge	$V_{\text{DD}} = 48\ \text{V}$ $I_D = 36\ \text{A}$ $V_{\text{GS}} = 10\ \text{V}$		50 13 18	70	nC nC nC

**SWITCHING-OFF**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{\text{r(Voff)}}$ $t_f$ $t_c$	Off-Voltage Rise Time Fall Time Cross-Over Time	$V_{\text{DD}} = 48\ \text{V}$ $I_D = 36\ \text{A}$ $R_G = 4.7\ \Omega$ $V_{\text{GS}} = 10\ \text{V}$		12 25 40	16 35 55	ns ns ns

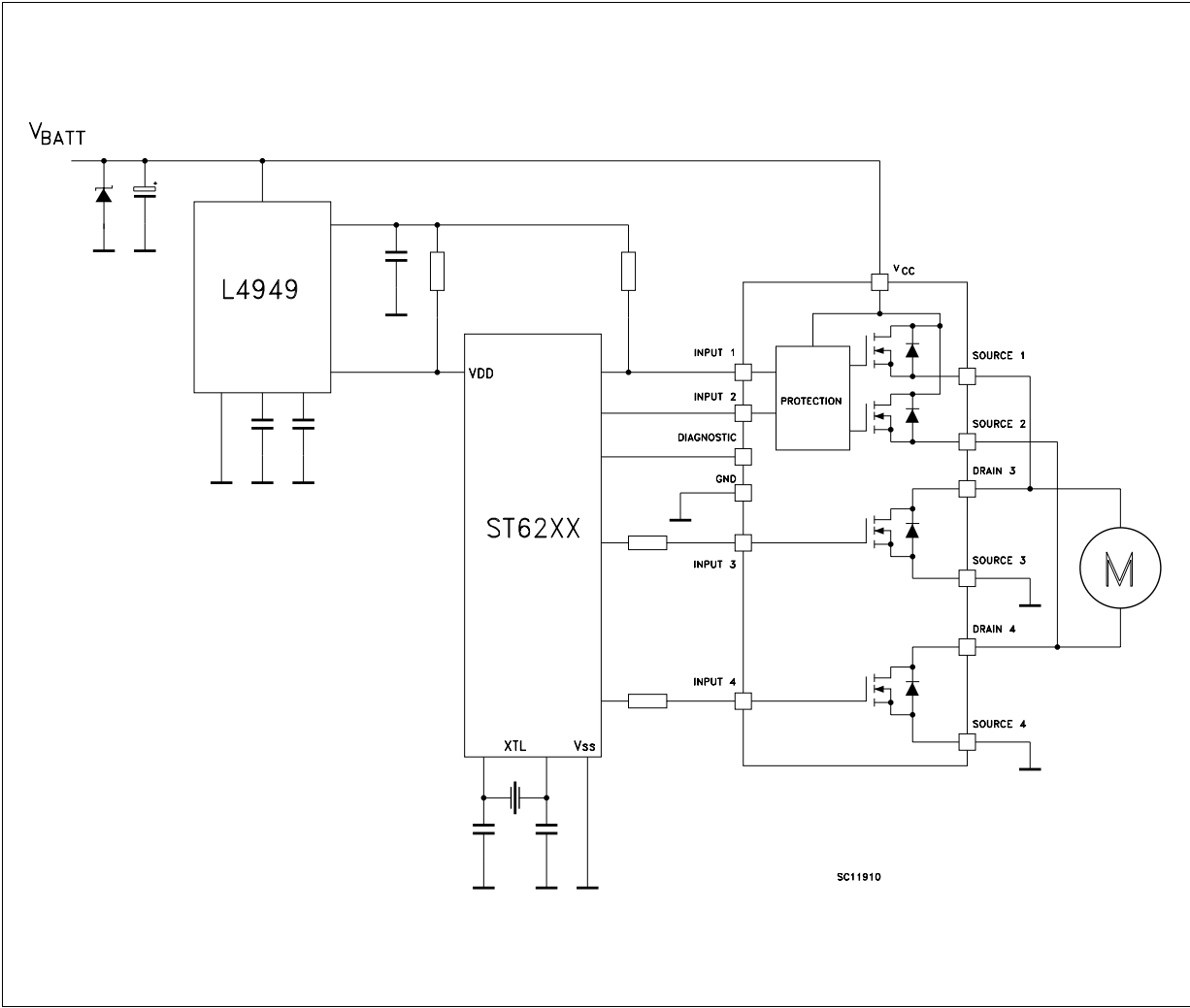
SOURCE-DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-Drain Current				36	A
$I_{SDM} (**)$	Source-Drain Current (pulsed)				144	A
$V_{SD} (*)$	Forward On Voltage	$I_{SD} = 36\text{ A}$ $V_{GS} = 0$			1.5	V
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 36\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_r = 30\text{ V}$ $T_j = 150\text{ }^{\circ}\text{C}$		75		ns
$Q_{rr}$	Reverse Recovery Charge			245		nC
$I_{RRM}$	Reverse Recovery Current			6.5		A

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %

(\*\*) Pulse width limited by Safe Operating Area.

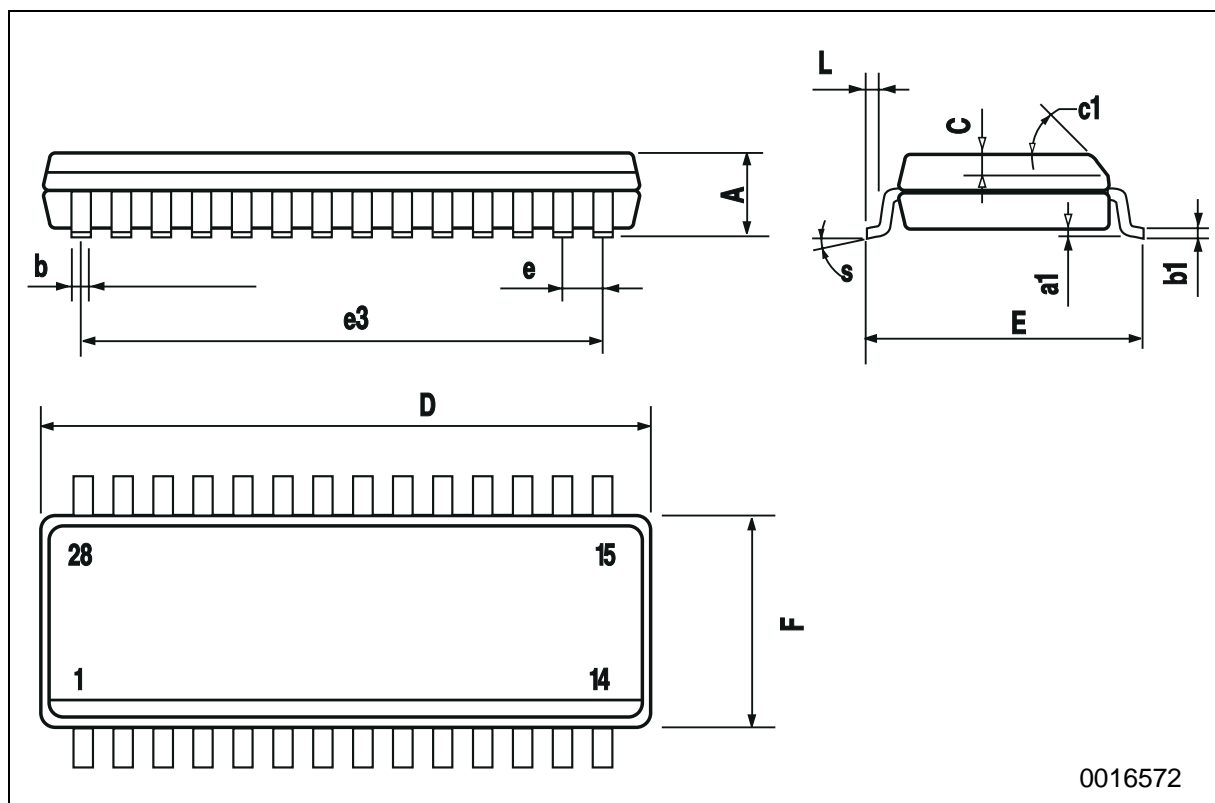
TYPICAL APPLICATION DIAGRAM





## 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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