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STMicroelectronics
L9925

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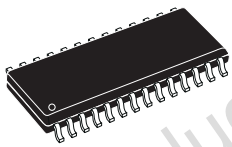
L9925

DMOS DUAL FULL BRIDGE DRIVER

- 2 INDEPENDENTLY CONTROLLED H-BRIDGES
- $R_{DS,ON}$ <0.9Ω @ T_{amb} = 25°C, V_S = 14V
- 0.8A DC CURRENT WITHOUT HEAT SINK
- LOW QUIESCENT MODE I_q <200µA
- THEMAL PROTECTION
- CROSS CONDUCTION PROTECTION
- SUPPLY VOLTAGE UP TO 40V
- CMOS COMPATIBLE INPUTS
- OUTPUT SHORT-CIRCUIT PROTECTION



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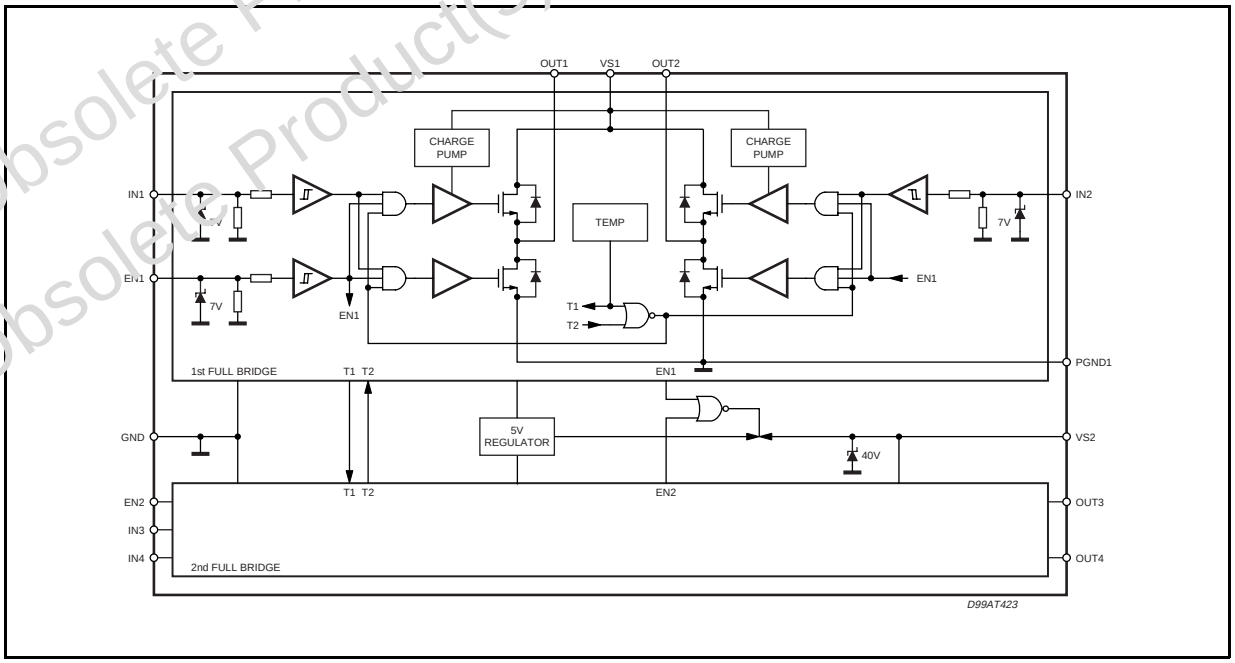
ORDERING NUMBER: L9925

DESCRIPTION

The L9925 is a dual full bridge driver for stepper motor applications. Realized in BCD (Bipolar, CMOS & DOS) techology, logic circuits, precise linear blocks and power transistors are combined to optimize circuit performance and minimize off chip components. Schmitt triggers are used for all input stages and are fully compatible with 5V CMOS logic levels. When both enable signals are low, the IC is commanded to a low quiescent current state and will draw less than 200µA from the battery.

The charge pump is integrated on chip; no external components are required. Full performance is maintained for 9V <Vs <16V. Extended ranges of 6V <Vs <9V and 16V <Vs <40V yields full functionality but with relaxed performance. Over temperature protection and ESD protection to all pins ensures relability and reduces system integration failures.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

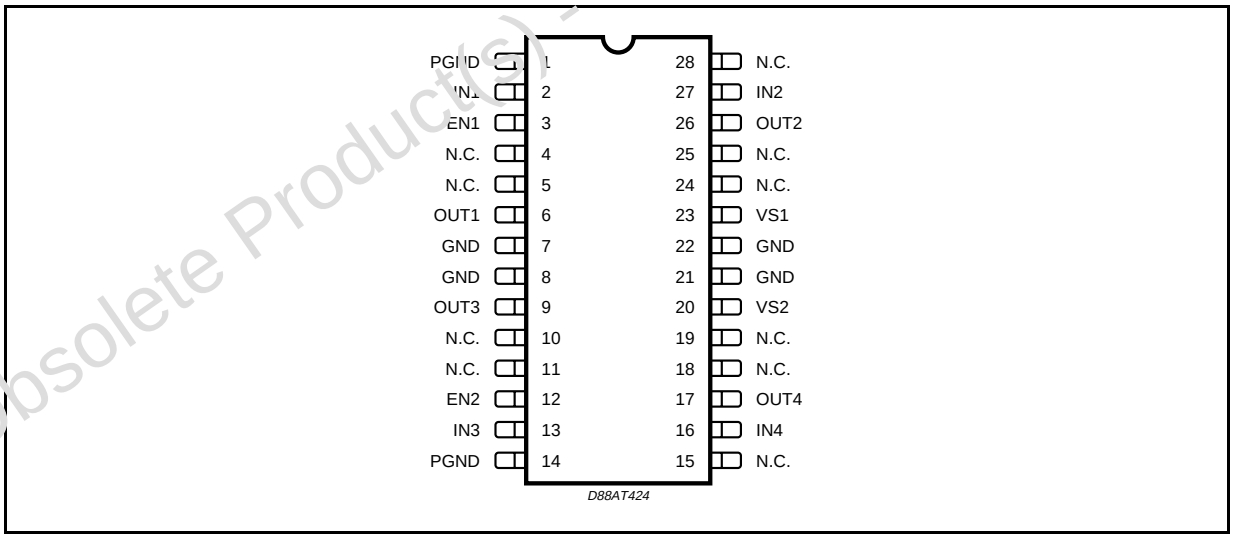
Absolute Maximum Ratings are those values beyond whih damage to the device may occur. Functional operation under these condition isn't implied.

For voltages and currents applied externally to the device:

Symbol	Parameter	Value	Unit
V_{VSDC}	Dc Supply Voltage	-0.3 to 26	V
V_{VSP}	Supply Voltage Pulse (T ≤400ms) (1)	40	V
I_{OUT}	DC Output Load Current	±1.2	A
$I_{OUT\ MAX}$	DC Output Current: for VOUT > VVS +0.3V or VOUT < -0.3V the internal DMOS reverse and/or substrate diode become conductive and the applied current should not exceed the specified limit.	±1.8	A
$V_{IN1,2}$	DC Input Voltage	-0.3 to 7	V
V_{EN}	Enable Input Voltage	-0.3 to 7	V
T_{stg}, T_j	Storage and Junction Temperature	-40 to 150	°C
P_{tot}	Total Power Dissipation (T_{pins} = 80°C) (T_{amb} = 70°C no copper area on PCB) (T_{amb} =70°C 8cm^2 copper area on PCB)	5 1.23 2	W W W

(1) Device may be overstressed if pulsed simultaneous with short circuit at one or more of the outputs will be present.

PIN CONNECTION



THERMAL DATA

Symbol	Parameter	Value	Unit
T_{jTS}	Thermal Shut-down junction temperature min.	150	°C
T_{jTSH}	Thermal Shut-down thereshold hysteresis typ.	25	°C
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient (2)	50	°C/W
$R_{th\ j\text{-}pins}$	Thermal Resistance Junction-pins	15	°C/W

(2) With 6cm^2 on board heat sink area

PIN FUNCTIONS

N.	Name	Function
1	PGND1	Ground for DMOS sources in bridge 1
2	IN1	Digital Input from motor controller for bridge 1
3	EN1	Logic enable/disable for bridge 1 (active high)
4, 5	NC	No connect
6	OUT1	Output of one half of bridge 1
7, 8	GND	Ground
9	OUT3	Output of one half of bridge 2
10, 11	NC	No connect
12	EN2	Logic enable/disable for bridge 2 (active high)
13	IN3	Digital Input from motor controller for bridge 2
14	PGND2	Ground for DMOS sources in bridge 2
15	NC	No connect
16	IN4	Digital Input from motor controller for bridge 2
17	OUT4	Output of one half of bridge 2
18, 19	NC	No connect
20	VS2	Supply Voltage for bridge 2
21, 22	GND	Ground
23	VS1	Supply Voltage for bridge 1
24, 25	NC	No connect
26	OUT2	Output of one half of bridge 1
27	IN2	Digital Input from motor controller for bridge 1
28	NC	No connect

ELECTRICAL CHARACTERISTICS (V_S = 9 to 16V; T_j = -40 to 150°C [3], unless otherwise specified.)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_S	Quiescent Current	EN1 = EN2 =0V; T_j = 85°C			200	µA
		EN1 = EN2 =5V; I_{load} = 0A		5	12	mA
R_{ds}	Switch on Resistance	T_j = 25°C; V_S = 14V; I_o =300mA		0.75	0.8	Ω
		T_j = 125°C; V_S = 6V; I_o =300mA		1.5	1.9	Ω
T_{d-on}	Turn-on delay	See Fig 1		10	50	µs
T_{d-SB}	Standby setting time	See Fig 1		50	200	µs
T_{d-off}	Turn-off delay	See Fig 1		10	50	µs
t_{rise}	Output rise time (10 to 90%)	See Fig 1	0.5	5	20	µs
t_{fall}	Output fall time (90 to 10%)	See Fig 1	0.5	5	20	µs
IL_o	Output leakage current	EN = 0V; V_o =V_S or GND	-10		10	mA
INx, ENx	Logic Input Low voltage		-0.3		1.5	V
	Logic Input High voltage		3.5		6	V
	Hysteresis		0.5	1.0	2.0	V
Ibias	Input bias current		-50		300	µA

The voltage refered to GND and currents are assumed positive, when the current flows into the pin.
(3) Tested up to 125°C, parameter guaranted by correlation up to 150°C

Logic Levels
All inputs are positive, non inverting logic

Logic State	Voltage Range
0	-0.3 to 1.5V
1	3.5 to 6.0V

Truth Table
Enable/ Disable

EN1	EN0	Bridge 1	Bridge 2	Iq
0	0	Disabled	Disabled	<200µA
0	1	Disabled	Enabled	<12mA
1	0	Enabled	Disabled	<12mA
1	1	Enabled	Enabled	<12mA

General Operation
With the bridge enabled, each input INx, maps directly to the corresponding output OUTx.

The output voltage will be equal to the difference between the supply rail and the product of the load current ad the on resistance of the output switch.$V_{out} = V_{supply} - (R_{DS,ON} \cdot I_{LOAD})$.

Sourced load currents are positive.

IN1	OUT1	IN2	OUT2	IN3	OUT3	IN4	OUT4
0	0	0	0	0	0	0	0
1	Vs	1	Vs	1	VS	1	VS

Figure 1. Timing Diagram

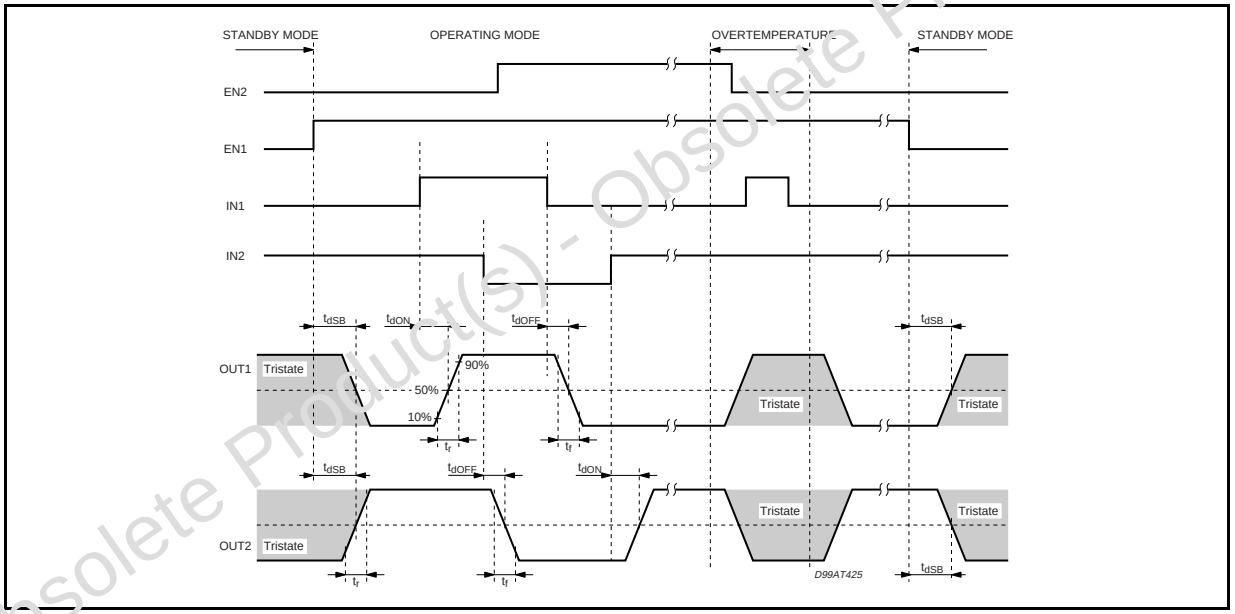


Figure 2. Typical RON - Characteristics of Source and Sink Stage

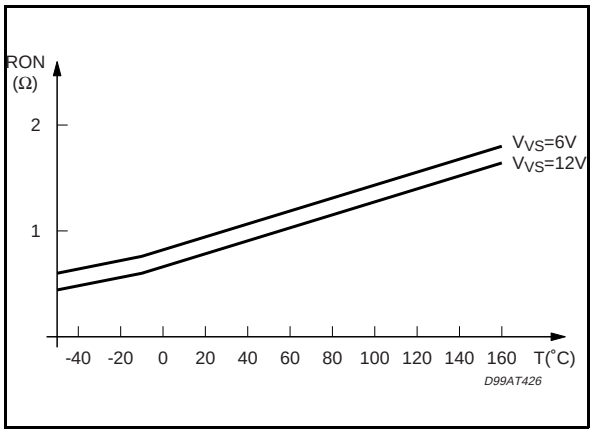


Figure 3. ON - Resistance vs Supply Voltage

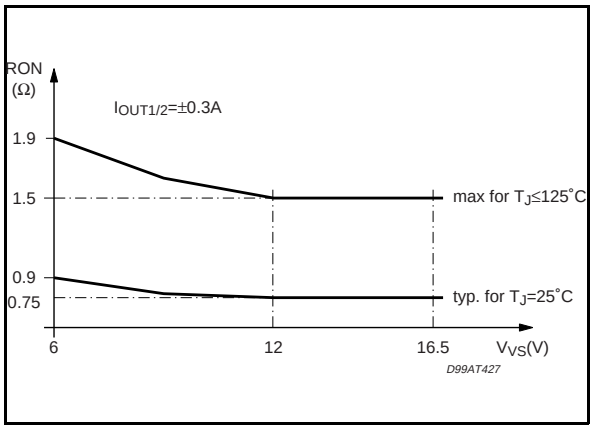


Figure 4. Application Diagram

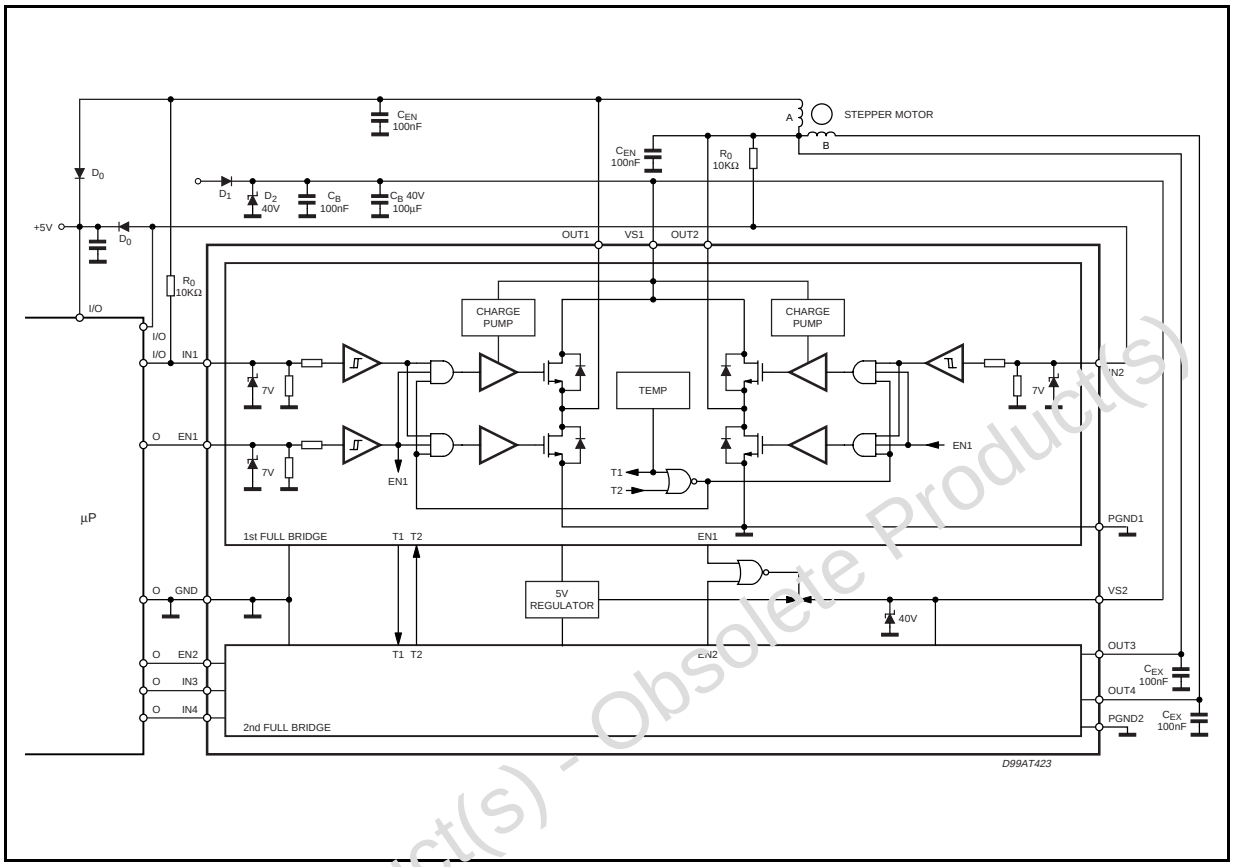


Figure 4 shows a typical application diagram for DC motor driving. To assure the safety of the circuit in the reverse battery condition a reverse protetion diode D_1 is necessary. The transient protection diode D_2 must assure that themaximum supply voltage V_S during the transients at the V_{BAT} line will be limited to a value lower than the absolute maximu ratings for V_{VSP}. The capacities C_B are used to lower Vs-EMR and its values depend on the driving load.

The resistance feedback loop realized by R_O limited to the µP power supply line by the diode D_O allows open load detection. To protect the device at the outputs against EMI or ESD > 2KV external capacitors C_{EX} may be used.

CIRCUIT DESCRIPTION

L9925 is a dual full bridge IC designed to drive DC motors, stepper motors and other inductive loads. Eah bridge has 4 power DMOS transistor with R_{DSon} = 0.75Ω and the relative protection and control circuitry (see fig. 5). Tthe 4 half bridges can be controlled independently by means of the 4 inputs IN1, IN3, IN4 and 2 enable inputs ENABLE1 and ENABLE2.

LOGIC DRIVE (true table for the two full bridges)

INPUTS			OUTPUT MOSFETS
	IN1 IN3	**IN2 IN4**	
EN1 = EN2 = H	L L H H	L H L H	Sink 1, Sink2 Sink1, Source2 Source1, Sink2 Source1, Source2
@Tj > 150°C	X	X	All transistors turned OFF
EN1 = EN2 = L	X	X	All transistors turned OFF

L = Low; H = High; X = Don't care

CROSS CONDUCTION

The device guarantees the absence of cross-conduction by watching internal gate-source voltage of the driving power DMOS.

TRANSISTOR OPERATION

ON STATE

When one of POWER DMOS transistors is ON it can be considered as a resistor $R_{DS(ON)}$ = 0.75Ω at a junction temperature of 25°C

In this condition the dissipated power is ginen by:

$$P_{ON} = R_{DS(ON)} \cdot I_{DS}^2$$

The low $R_{DS(ON)}$ of the Multipower BCD process can provide high currents with low power dissipation.

OFF STATE

When one of the POWER DMOS transistor is OFF the V_{DS} voltage is equal to the supply voltage and only the leakage current I_{DSS} flows.

The power dissipation during this period is given by:

$$P_{OFF} = V_S \cdot I_{DSS}$$

TRANSITIONS

Like all MOS power transistors the DMOS POWER transistors have an intrinsic diode between their source and drain that can operate as a fast freewheeling diode in switched mode applications. During recirculation with the ENABLE input is low, the POWER MOS is OFF and the diode voltage it is clamped to its characteristics. When the ENABLE input is low, the POWER MOS is OFF and the diode carries all of the recirculation current. The power dissipated in the transitional times in the cycle depends upon the voltage and current waveforms in the application.

$$P_{trans} = I_{DS}(t) \cdot V_{DS}(t)$$

Figure 5a. Two phase chopping

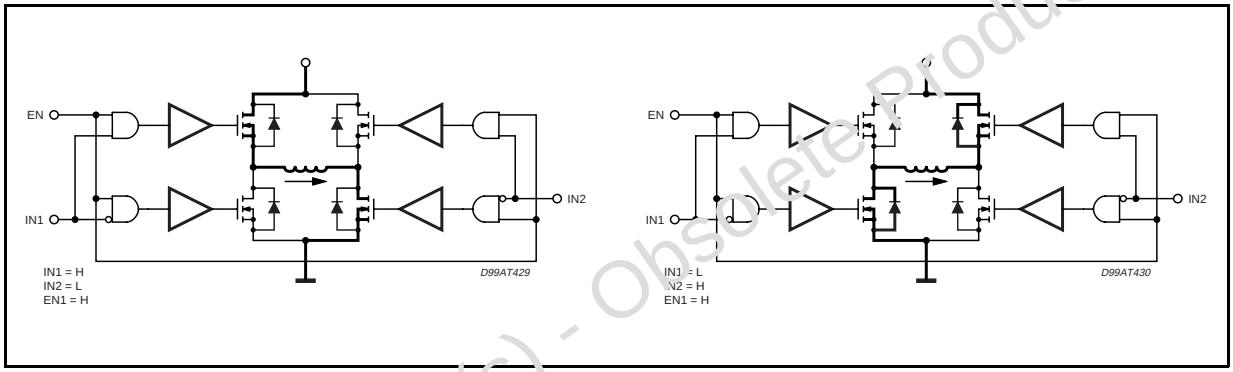


Figure 5b. One phase chopping

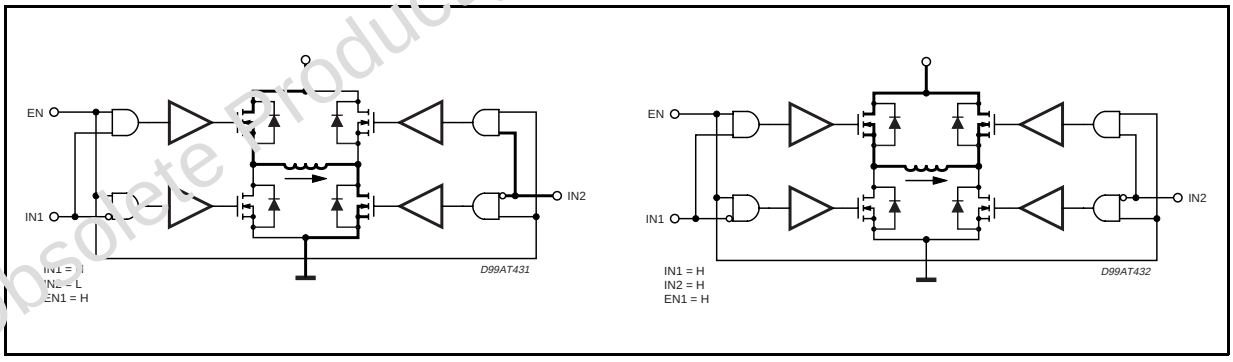
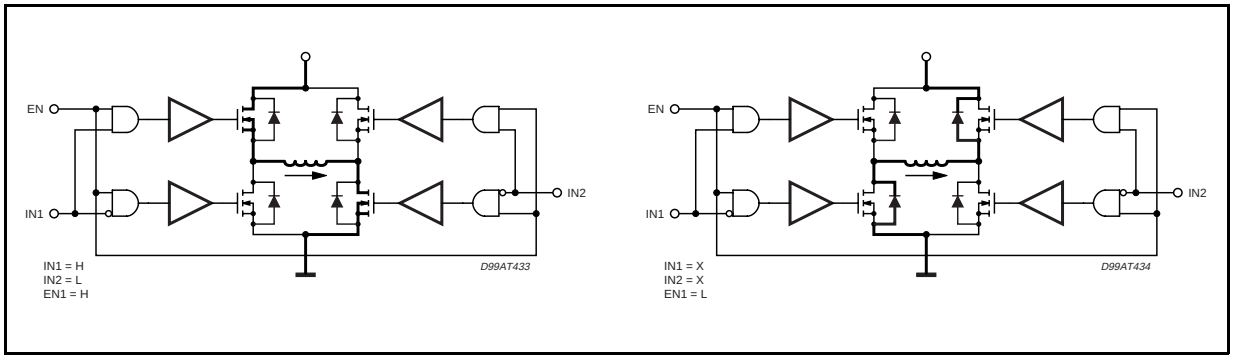


Figure 5c. Enable chopping



THERMAL PROTECTION

A thermalprotection circuit has been included that will disable the device if the junction temperature reaches 150°C. When the temperature has fallen to a safe level the device restarts under the control of the input and enable signals.

APPLICATION INFORMATION

RECIRCULATION

During recirculationwith the ENALBE input high, the voltage drop across the transistor is $R_{DS(ON)}$. for voltages less than 0.6V and is clamped at a voltages depending on the characteristics of the source-drain diode for greater voltages. Although the device is protected against cross conduction.

POWER DISSIPATION each bridge

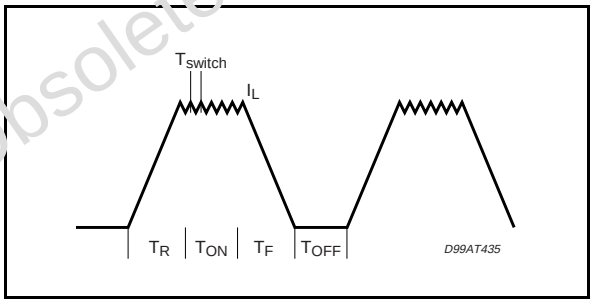
In order to achieve the high performance provided by the L9925 some attention must be paid t ensure that it has an adequate PCB area to dissipate the heat. The forst stage of any thermal design is to calculate the dissipated power in the application, for this example the half step operation shown in Fig. 6 is considered.

RISE TIME T_R

When an arm of the half bridge is turned on, current begins to flow in the inductive load until the maximum current I_L is reached after a time T_R, The dissipated energy $E_{OFF/ON}$.

$$E_{OFF/ON} = [R_{DS(ON)} \cdot I_L^2 \cdot T_R] \cdot \frac{2}{3}$$

Figure 6.



ON TIME T_{ON}

During this time the energy dissipated is due to the ON resistance of the transistors E_{ON} and the commutation E_{COM}. As two of the POWER DMOS transistors are ON E_{ON} is given by:

$$E_{ON} = I_L^2 \cdot R_{DS(ON)} \cdot 2 \cdot T_{ON}$$

In the commutation the energy dissipated is:

$$E_{CON} = V_S \cdot I_L \cdot T_{COM} \cdot f_{SWITCH} \cdot T_{ON}$$

Where:

T_{COM} = Communication Time and it is assumed that:;

$T_{COM} = t_{rise} = t_{fall} \leq 20\mu s$

T_{SWITCH} = Chopper frequency

FALL TIME T_F

For this example it is assumed that the energy dissipated in this part of the cycle takes the same form as that shown for the rise time:

$$E_{OFF/ON} = [R_{DS(ON)} \cdot I_L^2 \cdot T_F] \cdot \frac{2}{3}$$

QUIESCENT ENERGY

The last contribution of the energy dissipation is due to the quiescrent supply current and is given by:

$$E_{QUIESCENT} = I_{QUIESCENT} \cdot V_S \cdot T$$

TOTAL ENERGY PER CYCLE

$$E_{TOT} = (2 \cdot E_{OFF/ON} + E_{ON} + E_{COM})_{bridge1} + (2 \cdot E_{OFF/ON} + E_{ON} + E_{COM})_{bridg2} + E_{QUIESCENT}$$

The total power dissipation P_{DIS} is simply:

$$P_{DIS} = \frac{E_{tot}}{T}$$

T_R = Rise time

T_{ON} = ON time

T_F = Fall time

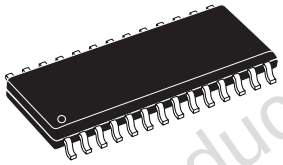
T_{OFF} = OFF time

T = Period

$$T = T_R + T_{ON} + T_F + T_{OFF}$$

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.3	0.004		0.012
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.013
C		0.5			0.020	
c1	45° (typ.)					
D	17.7		18.1	0.697		0.713
E	10		10.65	0.394		0.419
e		1.27			0.050	
e3		16.51			0.65	
F	7.4		7.6	0.291		0.299
L	0.4		1.27	0.016		0.050
S	8 ° (max.)					

OUTLINE AND MECHANICAL DATA



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