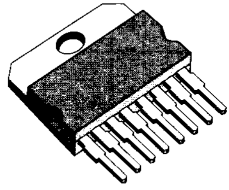
HALF BRIDGE MOTOR DRIVER

- 20A OUTPUT CURRENT / DC OPERATION
- LOW SATURATION VOLTAGE
- VERY LOW CONSUMPTION IN OFF STATE
- OVERLOAD DIAGNOSTIC OUTPUT
- INTERNAL TEMPERATURE SENSOR
- GROUNDED CASE
- MULTIWATT-8 PACKAGE WITH HIGH CURRENT LEADS



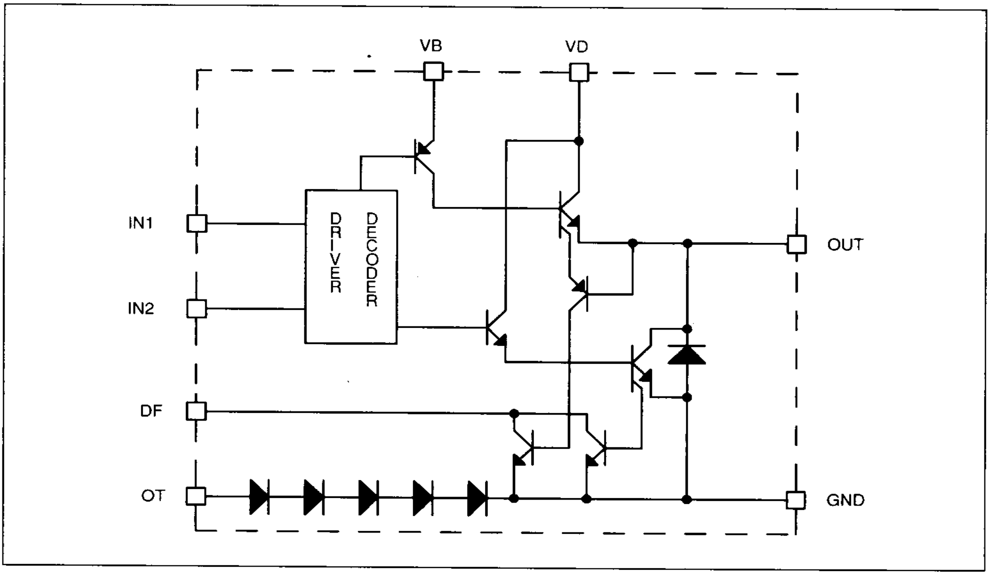
Multiwatt-8

ORDERING NUMBER: L9936

DESCRIPTION

The L9936 device is an half "H" bridge in bipolar technology particularly suited to drive up to 20A bidirectional DC motors.
The device also performs an overload diagnostic output and an internal temperature sensor.
The device is assembled in Multiwatt-8 package with the case connected to the ground terminal.

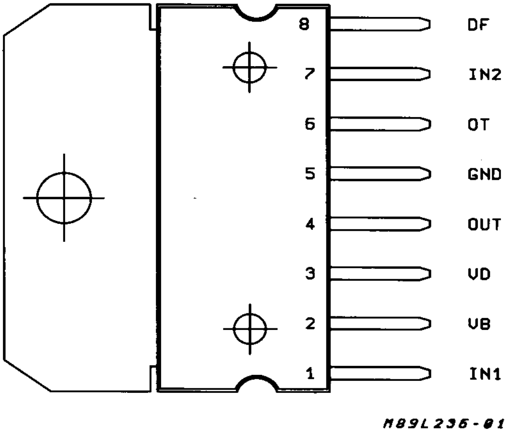
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_B	Maximum DC Voltage (non operating mode)	28	V
V_B	Maximum DC Operating Voltage	20	V
V_B	Maximum Transient Voltage tr = 5ms, td = 300ms (non operating mode)	50	V
V_i	Input Voltage	-0.3V to VB	V
V_{DF}	Diagnostic Feedback Voltage	-0.3 to 6	V
I_O	Output Current	30	A
T_j, T_{stg}	Junction and Storage Temperature Range	-40 to +150	°C

PIN CONNECTION (Top View)



PIN FUNCTIONS

N°	Name	Description
1	IN1	Command input to switch on the upper power transistor of the half bridge
2	VB	Positive supply voltage (to be connected before the reverse battery protection diode)
3	VD	Positive supply voltage (to be connected after the reverse battery protection diode)
4	OUT	Power Output
5	GND	Power ground (also connected to the case)
6	OT	Analog output to monitor the internal temperature of the device
7	IN2	Command input to switch on the lower power transistor of the half bridge
8	DF	Open collector output to monitor overload conditions

INPUT/OUTPUT TRUTH TABLE

IN1	IN2	OUT
L	L	Z
L	H	L
H	L	H

Note 1: Z means high impedance condition
Note 2: IN1 and IN2 must not be H at the same time

THERMAL RESISTANCE

Symbol	Parameter	Value	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	1.3	°C/W

ELECTRICAL CHARACTERISTICS (V_S = 14.4V; -40 < Tj < 125°C unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_B	Operating Voltage		8.5		19	V
V_D	Operating Voltage		7.5		18	V
V_{OL}	Output to GND Saturation Voltage	I_O = 20A		650	850	mV
V_{OHB}	V_B to Out Saturation Voltage	I_O = 20A		1.5	1.75	V
V_{OHD}	VD to Out Saturation Voltage	I_O = 20A		650	850	mV
I_{SD}	Supply ON Current (V_O = L)			1		A
I_{SU}	Supply ON Current (V_O = H)			300		mA
I_{off}	Supply Off State Current	Tj = 25°C			100	µA
I_{IN}	Input ON Current	V_{IN} = 6.5V		4	6	mA

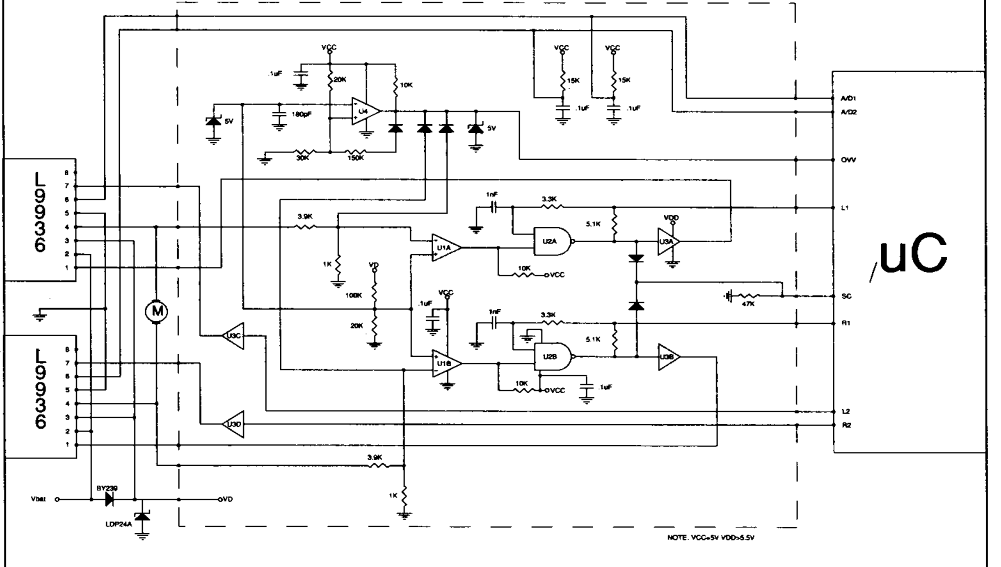
APPLICATION INFORMATIONS

L9936 is particularly suitable in full bridge configurations to drive high current bidirectional DC motors in µC based systems.
Fig. 1 shows a possible application circuit, with an analog interface between the power devices and the µC. In the following, the functions of each block of the analog interface are described.

1 - Overvoltage And Reverse Battery Protection

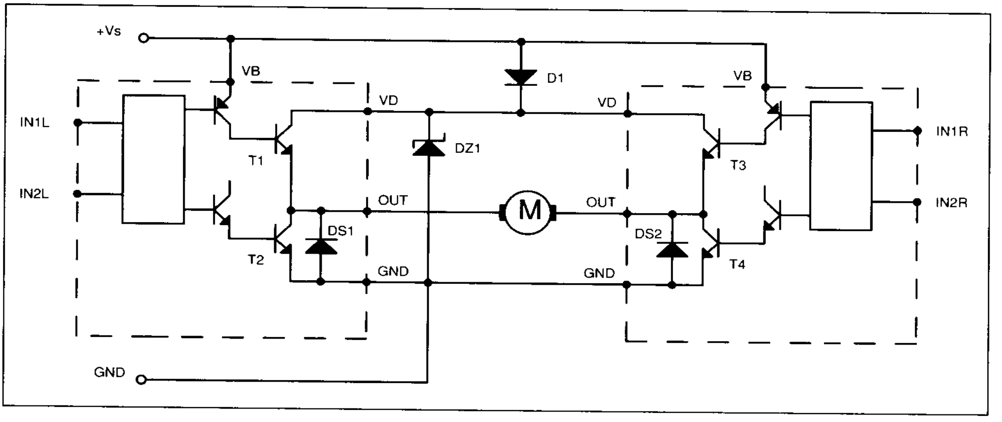
L9936 is particularly suitable as a full bridge to drive the window lift motors in automotive applications. Fig. 2 shows the circuit schematics; due to the hostile automotive environment, it is necessary a transil (suggested type LDP24A) between VD and GND, to protect the two L9936 against overvoltages higher than 50V. In addition, if the reverse battery protection is requested, the diode D1 between VB and VD can be used (suggested type BY239).

Figure 1



L9936
L9936
VCC
.1uF
20K
10K
180pF
U4
5V
30K
150K
15K
.1uF
A/D1
A/D2
O/V
1nF
3.3K
5.1K
VDD
L1
3.9K
U1A
U2A
U3A
1K
10K
VCC
SC
47K
100K
20K
R1
U2B
U3B
U1B
U3C
U3D
L2
R2
uC
M
BY239
Vbat
LDP24A
VD
NOTE: VCC=5V VDD>5.5V

Figure 2



2 - Switch-off Sequence

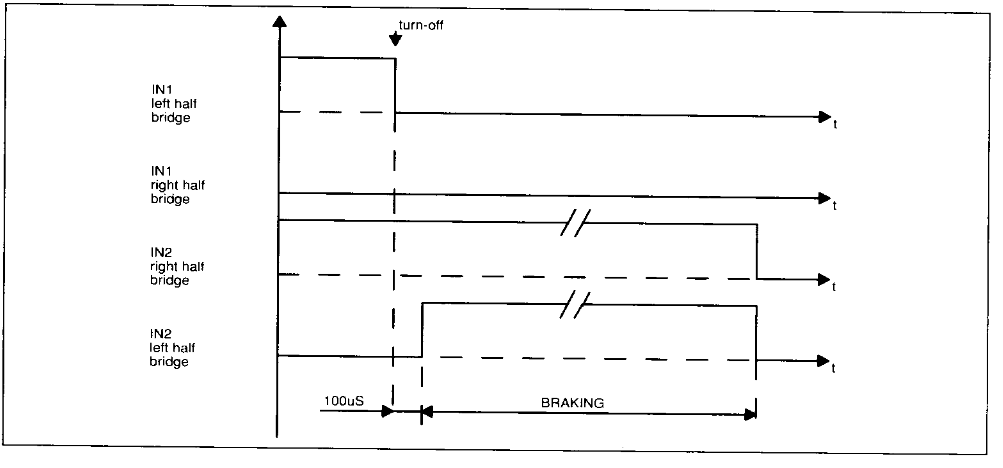
Referring to Fig. 2 and supposing i.e. T1 and T4 ON, T2 and T3 OFF (this means IN1L = IN2R = H, IN2L = IN1R = L), the following steps have to be observed to allow a correct recirculation of the current in the motor at the switch off (Ref. Fig. 3):

a)switch off T1 and wait for 100µsec about in this condition (IN1L = IN2L = IN1R = L, IN2R = H)
b)after the a.m. delay switch ON T2 (IN1L = IN1R = L, IN2L = IN2R = H)
c)switch off both T2 and T4 (IN1L = IN2L = IN1R = IN2R = L)

Step a) allows the recirculation of the motor current due to the inductive component of the motor itself between DS1 and T4; the 100µsec delay time is needed to avoid the cross-conduction in the left half bridge.

In step b) the motor is short circuited to GND (T2 and T4 ON) and this allows the dynamic braking.
In step c) T1, T2, T3 and T4 are OFF to allow a very low current consumption of the two half bridges.
If the dynamic braking is not requested, step b) can be omitted. In any case the lower power transistor of an half bridge must be kept ON, after the switch off of the upper transistor of the other half bridge, for a time longer than T = 5 • R_L / L_L, where R_L and L_L are the resistance and the inductance of the load.

Figure 3: Switch-off Sequence



3 - Input Driving Voltage

To allow a correct operation of L9936 over the full temperature range, the driving voltage at the input pins must be higher than 5.5V, with 5mA current capability.

4 - Short Circuit Protection

It is possible to protect L9936 against short circuit to ground and across the motor in the full bridge application.
The circuit schematics shown in Fig. 4 uses two voltage comparators (U1A, U1B) to detect the Vce of the upper power transistors.
U2A and U2B are open drain NAND gates (i.e. part no. HCC40107) and U3A/B/C/D are non inverting buffer to drive the two L9936 (i.e. part no. 74HC4050).
U1A and U1B sense the differential voltage VD-OUTL and VD-OUTR respectively.
Referring to Fig. 4, chosen R1=100K and R2 = 20K, the values of R3 and R4 may be calculated according to the following formula:

$$R3 = \frac{(V_D - V_{CETH}) - 0.166\ V_D}{0.166\ V_D} * R4$$

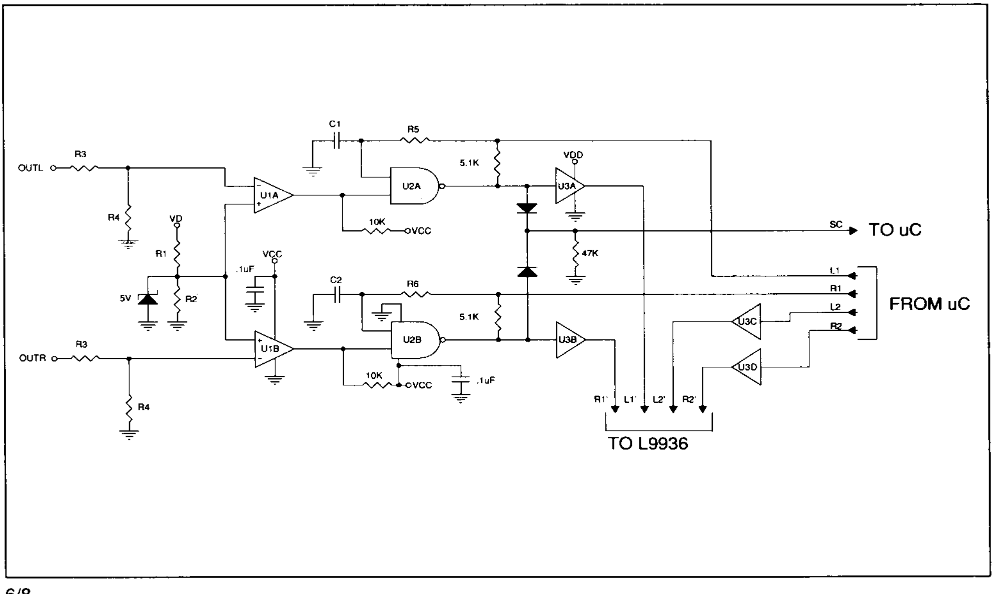
where :

V_D = bridge power supply
V_{CETH} = collector to emitter detection threshold.
Choosing V_{CETH} = 2V @ V_D = 12V and R4 = 1K, the above formula gives R3 = 4K.

When all signals from µC are at low level (motor off), the input to the two half bridges are low too; in these conditions the output voltage of the two comparators is high and therefore the outputs of U2A/U2B are free.
When the µC sends, for example, L1 and R2 high, the left half bridge output goes high and the right one goes low.
At this point the output of U1A pulls down the input of U2A before that the delay capacitor C1 is charged (through R5) up to the U2A threshold; in this way the U2A output remains free and the bridge drives the motor.
If a short circuit occurs, the Vce of the upper power transistor increases above the threshold and then the U2A output pulls down the L1 input to L9936.
Contemporary the SC signal to µC, high in normal conditions, goes low; at this point the µC executes the switch-off sequence.
We have just explained what happens when a short circuit occurs during the motor running phase.
Another faulting condition occurs switching on the bridge when a short circuit is present; in this case the bridge is driven for a time depending on the time constant R5 • C1 = R6 • C2. Choosing R5 = R6 = 3.3K and C1 = C2 = 1nF, then the time constant will be T = 3.3µsec, that is 5µsec about delay time. Longer delay time might allow the short circuit current to reach values beyond the absolute maximum ratings.

5 - Thermal Protection

Figure 4



The L9936 has 5 built-in diodes series-connected that can be used to implement a thermal protection for the device.
Fig. 5 shows the relationship between the voltage across the diodes and the temperature at 100μA diode current.

Fig. 6 shows the simplest solution to do a thermal protection; an A/D converter of the μC is used to detect the voltage drop across the 5 diodes. The 15K resistor sets the current in the diodes and the 100nF capacitor acts as a filter against the noise. When the μC detects a voltage lower than the low threshold chosen according to the diagram in Fig. 5, it executes the switch-off sequence and rejects any command to the bridge until the diodes voltage increases beyond the high threshold. The recommended hysteresis value is 30°C.

Figure 5

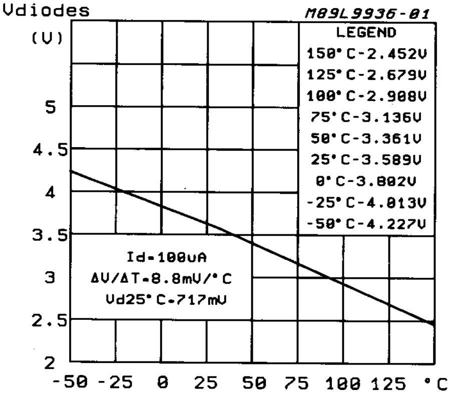
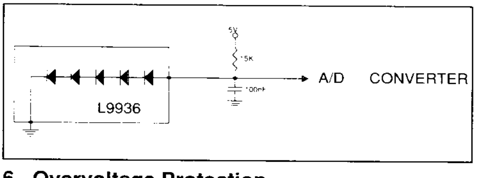


Figure 6

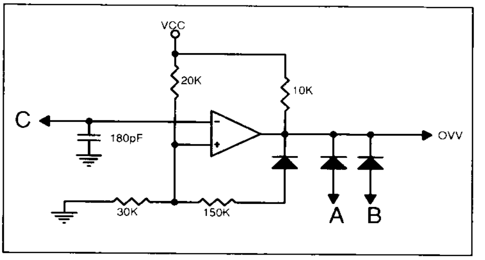


6 - Overvoltage Protection

At point 1 we suggest a way to protect the L9936 against the voltage transients. This protection allows the device to withstand overvoltages only if the bridge is not operating. To protect the device against the overvoltages in all the operating conditions it is possible to implement the circuit shown in Fig. 7.

(Note: A-B are connected to the nodes between R3 and R4 (left side and right side) in Fig. 4; C is connected to the node between R1 and R2 in Fig. 4).
When V_D reaches 18V the comparator output pulls down A and B, causing the intervention of the hardware protection shown in Fig. 4; at the same time the OVV signal is sent to μC, which executes the switch off sequence. The μC must reject any command to the bridge during the overvoltage conditions.

Figure 7



With the values showed in Fig. 7, a 1V hysteresis is provided.
It is possible to enhance the performances of the system just described avoiding the braking of the motor also for short duration voltage transients; to do this the μC, once received the overvoltage diagnostic signal (OVV), put at low level the commands to the upper transistors of the two half bridges (L1 and L2 in Fig. 4), allowing the free running of the motor.
The system holds this condition until OVV is active; when the OVV signal is released the μC restores the previous commands to the bridge.

7 - Diagnostic Feedback Output

DF pin is an open drain output to monitor overcurrent and overtemperature conditions.
The overcurrent detection threshold is inversely dependent from the temperature of the chip.
Typical application of this function is to send the DF signal, with an external pull-up to Vcc, to a digital input of the μC; when the DF signal goes at low level, the μC executes the switch-off sequence.

L9936 IN A BODY MULTIPLEX ENVIRONMENT

All the functions described above can be implemented in a custom integrated circuit together with a bus transceiver and a protocol handler. It is then possible to obtain a very small size module that can be integrated directly in the actuator. Fig. 8 shows a typical application of these modules as peripheral units in a "Class A" wired Multiplex System.

Figure 8: "Class A" Wired Peripheral Application