SGS-THOMSON
MICROELECTRONICS

L9937

FULL BRIDGE MOTOR DRIVER

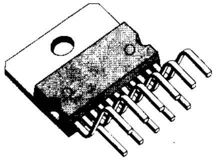
- 6A OUTPUT CURRENT
- LOW SATURATION VOLTAGE
- VERY LOW CONSUMPTION IN OFF STATE
- OVERLOAD DIAGNOSTIC OUTPUT
- INTERNAL TEMPERATURE SENSOR
- GROUNDED CASE

DESCRIPTION

The L9937 device is a full bridge for bidirectional motor driver applications realized in bipolar technology; it can deliver up to 6A output current with low saturation voltage.

Two diagnostic informations are provided to monitor overload conditions and the internal temperature.

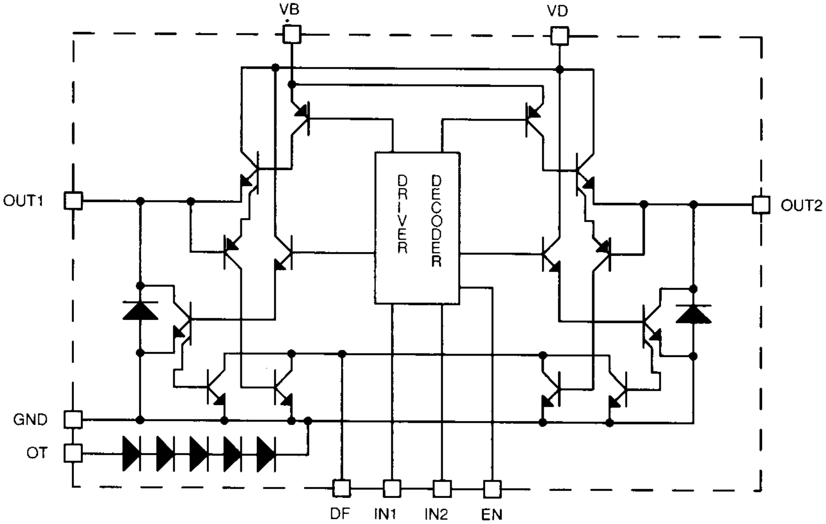
The device is assembled in the MULTIWATT-11 package with the case connected to the ground terminal.



Multiwatt 11

ORDERING NUMBER: L9937

BLOCK DIAGRAM



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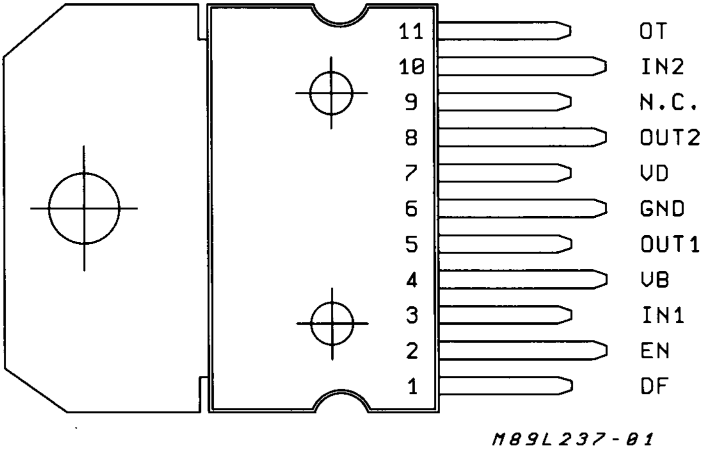
ABSOLUTE MAXIMUM RATINGS

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 Voltages	-0.3V to VB	V
V_{DF}	Diagnostic Feedback Voltage	-0.3 to 6	V
I_O	Output Current	10	A
T_j, T_{stg}	Junction and Storage Temperature Range	-40 to +150	°C

PIN CONNECTION (Top View)



PIN FUNCTIONS

N°	Name	Description
1	DF	Open collector output to monitor overload conditions
2	EN	Enable Input
3	IN1	Command input
4	VB	Positive supply voltage (to be connected before the reverse battery protection diode)
5	OUT1	Power output of the 1st half bridge
6	GND	Power ground (also connected to the case)
7	VD	Positive supply voltage (to be connected after the reverse battery protection diode)
8	OUT2	Power output of the 2nd half bridge
9	N.C.	Not connected
10	IN2	Command input
11	OT	Analog output to monitor the internal temperature of the device

INPUT/OUTPUT TRUTH TABLE

EN	IN1	IN2	OUT1	OUT2
L	L	L	Z	Z
L	H	L	Z	L
L	L	H	L	Z
L	H	H	L	L
H	L	L	Z	Z
H	H	L	H	L
H	L	H	L	H
H	H	H	L	L

Note 1: Z means high impedance condition
Note 2: All other conditions are not permitted

THERMAL RESISTANCE

Symbol	Parameter	Value	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	TBD	°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 1/2 to GND Saturation Voltage	$I_O = 6A$		650		mV
V_{OHB}	V_B to Out1/2 Saturation Voltage	$I_O = 6A$		1.5		V
V_{OHD}	VD to Out1/2 Saturation Voltage	$I_O = 6A$		650		mV
I_{SD}	Supply ON Current	OUT1 = H; OUT2 = L OUT1 = L; OUT2 = H		360		mA
I_{SH}	Supply ON Current	OUT1/2 = H		600		mA
I_{off}	Supply Off State Current	$Tj = 25°C$			100	µA
I_{IN}	Inputs ON Current	$V_{IN} = 6.5V$		3.5		mA

APPLICATION INFORMATIONS

L9937 is particularly suitable to drive up to 6A 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

L9937 is particularly suitable to drive the door lock motors in automotive applications. Fig. 2 shows the circuit schematics; due to the hostile automotive environment, it is necessary a transil (suggested type 1.5KE36) between V_D and GND, to protect the L9937 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 BYW29-200A).

Figure 1

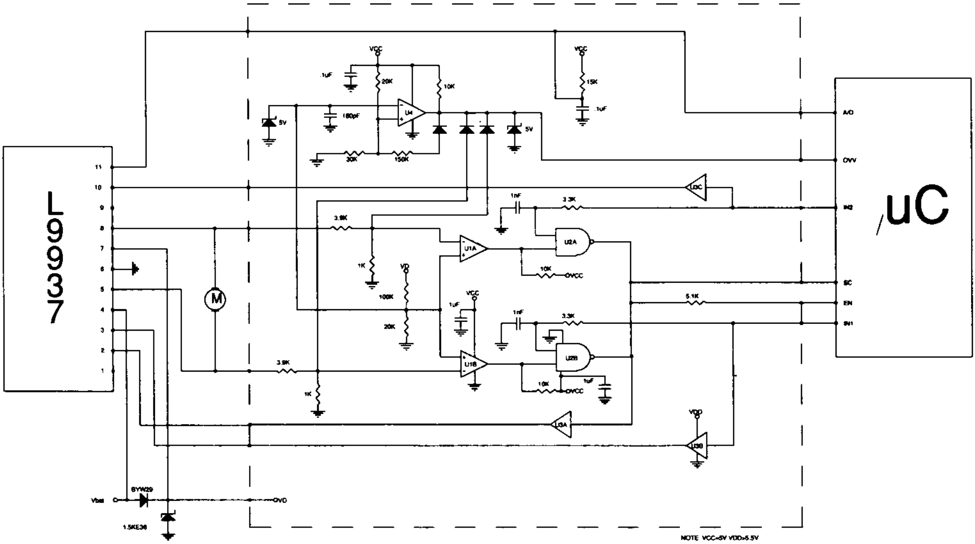


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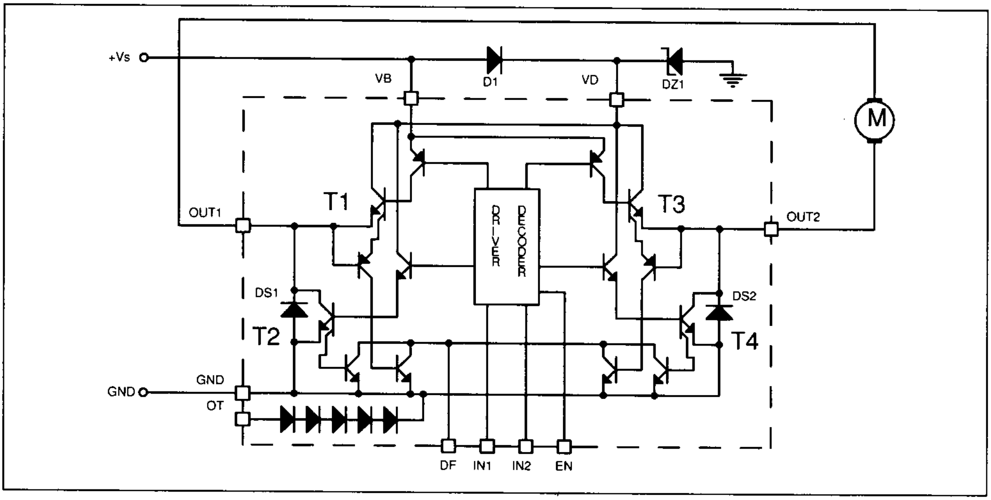
Figure 2



2 - Switch-off Sequence

Referring to Fig. 2 and supposing i.e. T1 and T4 ON, T2 and T3 OFF (this means EN=H IN1=H IN2=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 100sec about in this condition (EN = L IN1 = H IN2 = L)
b)after the a.m. delay switch ON T2 (EN = L IN1 = H IN2 = H)
c)switch off both T2 and T4 after the motor stop (EN = L IN1= L IN2 = L)

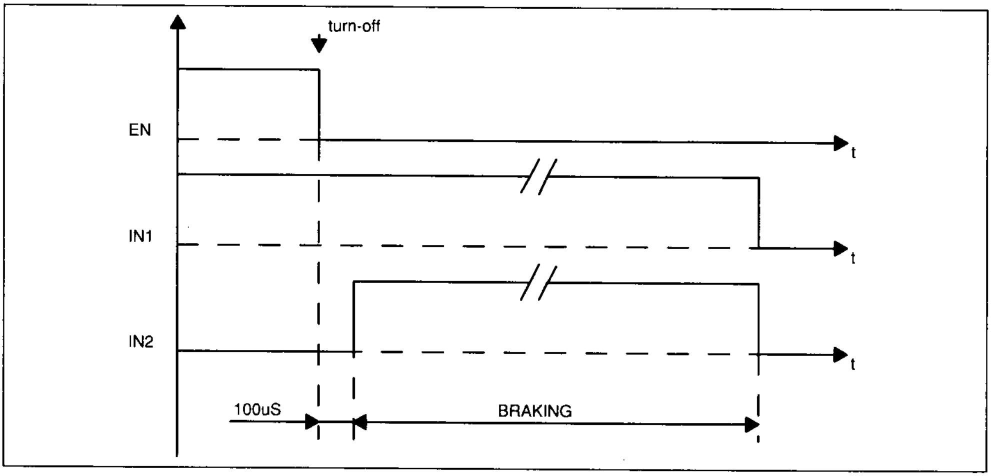
Step a) allows the recirculation of the motor current due to the inductive component of the motor itself between DS1 and T4; the 100µsec delay time is needed to avoid the cross-conduction in the left half bridge.

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 bridge.

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 Rl and Ll are the resistance and the inductance of the load.

Figure 3: Switch-off Sequence



3 - Input Driving Voltage

To allow a correct operation of L9937 over the full temperature range, the driving voltage at the input pins must be higher than 5.5V, with 4mA current capability.

4 - Short Circuit Protection

It is possible to protect L9937 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 L9937 (i.e. part no. 74HC4050).

U1A and U1B sense the differential voltage VD-OUT2 and VD-OUT1 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.

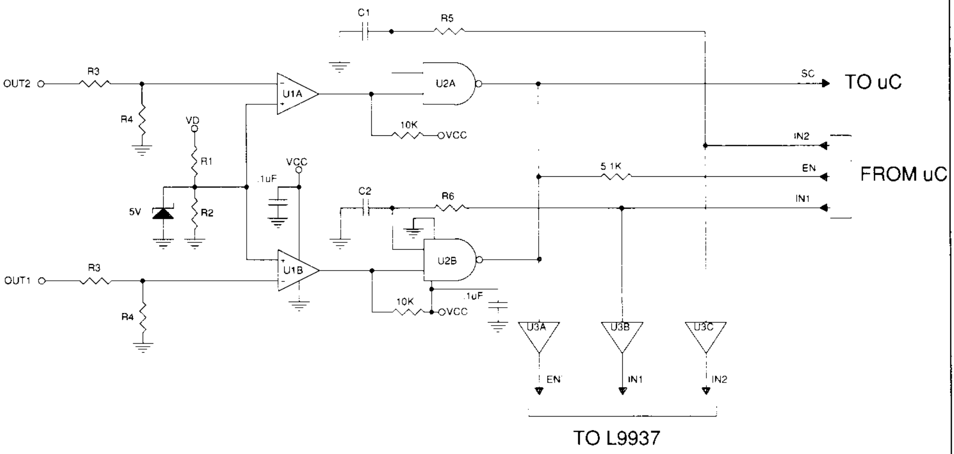
When all signals from µC are at low level (motor off), the inputs to the bridge are low too; in these conditions the output voltage of the two comparators is high and therefore the outputs of U2A/U2B are free. When the µC sends, for example, IN2 and EN high, OUT2 of the bridge goes high and OUT1 goes 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 enable input of L9937. 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.

Figure 4



5 - Thermal Protection

The L9937 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 100A diode current.

Figure 5

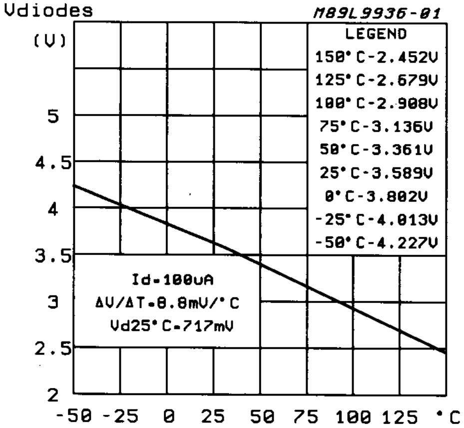
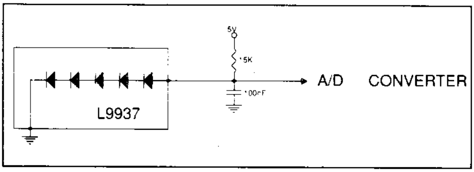


Fig. 6 shows the simplest solution to do a thermal protection; an A/D converter of the µC is used to detect the voltage drop across the 5 diodes. The 15K resistor sets the current in the diodes and the 100nF capacitor acts as a filter against the noise. When the µC detects a voltage lower than the low 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 6

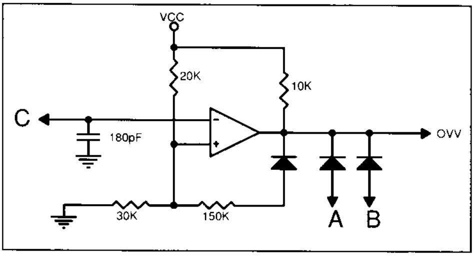


6 - Overvoltage Protection

At point 1 we suggest a way to protect the L9937 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).

Figure 7



When V_D reaches 18V the comparator output pulls down A and B, causing the intervention of the hardware protection showed 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.

With the values shown 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 enable of the L9937, confirming the hardware switch-off of the motor; in this condition an output of the half bridge is in high impedance state and the other one is low, allowing the recirculation of the current and the free running of the motor.

The system holds this condition until OVV is active; when the OVV signal is released the µC resets the hardware protection, sending EN = IN1 = IN2 = L and then restore the previous command to the bridge.

It is mandatory, however, to wait for the complete current recirculation of the motor before to reset the hardware protection; in facts, when EN = IN1 = IN2 = L both the L9937 outputs are in high impedance conditions.

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.

L9937 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