SGS-THOMSON MICROELECTRONICS

L6236

BIDIRECTIONAL R-DAT BRUSHLESS DC MOTOR DRIVER

ADVANCE DATA

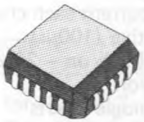
- 400mA OUTPUT CURRENT, CONTROLLED IN LINEAR MODE
- COMPATIBLE WITH ANI F-TO-V CONVERTER AND PLL SPEED CONTROL SYSTEM
- SLEW RATE LIMITING FOR EMI REDUCTION
- CONNECTS DIRECTLY TO HALL EFFECT CELLS
- THERMAL SHUTDOWN WITH HYSTERESIS
- THREE-STATE OPERATION ALLOWS NEGLIGIBLE POWER DISSIPATION DURING 1/3f CYCLE
- INTERNAL PROTECTION DIODES
- FEW EXTERNAL COMPONENTS

The L6236 is a single-chip driver for three-phase brushless DC motors capable of delivering 400mA output current with supply voltages to 18V. Designed to accept differential input from the Hall effect sensors, the device drives the three phases of a brushless DC motor and includes all the commutation logic required for a three phase bidirectional drive. Both delta and wye configurations may be used.

To limit EMI esmission the L6236 operates in a linear mode and controls the rise and fall times of the output stage. In addition the device is designed to limit power dissipation: during recirculation the output stage is switched to an off state reducing dissipation to a very low value and minimizing torque ripple.

A speed control input controls the base current to the lower transistors to limit the motor current and hence control the speed. Any type of speed control system, including F to V and PLL systems, may be used with the L6236 by providing an analog signal at this input. The motor current may be sensed by an external resistor connected to a sensing pin on the device.

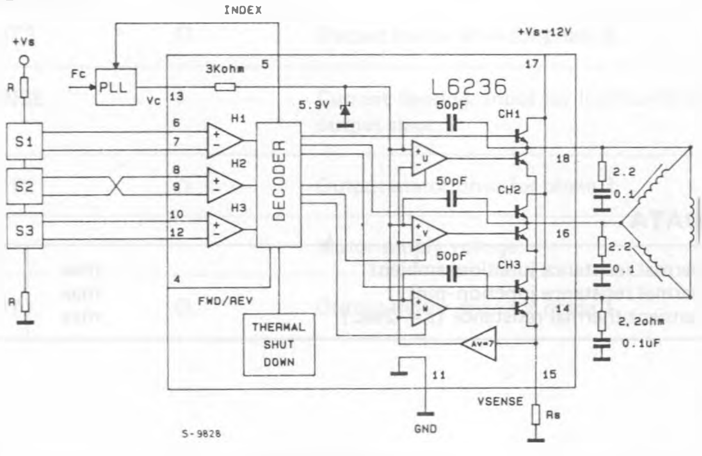
The power stage of the device is designed to eliminate the possibility of simultaneous conduction of the upper and lower power transistors of one output driver, when operating in the right loop.



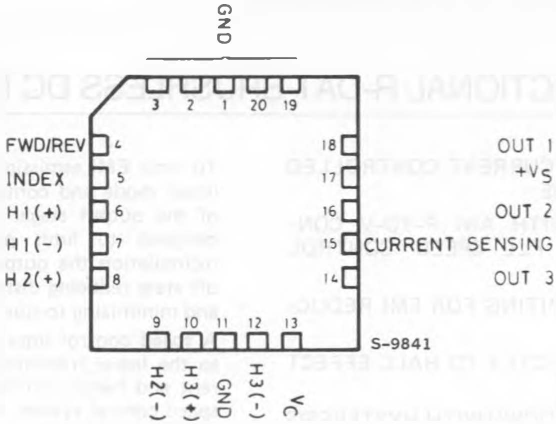
PLCC (15 + 5)

ORDERING NUMBER: L6236

BLOCK DIAGRAM



CONNECTION DIAGRAM
(Top view)



ABSOLUTE MAXIMUM RATINGS

V_s	Supply voltage	18	V
I_o	Peak output current each channel		
	– non repetitive (100μs)	1.5	A
	– repetitive (80% on - 20% off; t_{on} = 10ms)	500	mA
	– DC operation	400	mA
V_I	Logic and analogic inputs	$+V_s$	
P_{tot}	Total power dissipation at T_{pins} = 50°C	5	W
T_{op}	Operating temperature range	0 to 70	°C
T_j, T_{stg}	Storage and junction temperature	-40 to 150	°C

THERMAL DATA

$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	100	°C/W
$R_{th\ j\text{-}pins}$	Thermal resistance junction-pins	max	20	°C/W
R_{tt}	Transient thermal resistance (t = 2sec.)	max	30	°C/W

PIN FUNCTIONS

N°	NAME	I/O	FUNCTION
4	FWD/REV	I	Direction Control. When this pin is low, the motor will run in the forward direction. A high will drive the motor in the reverse direction. Direction is defined by the positive of the sensors in the motor.
5	INDEX	O	Signal pulse proportional to the motor speed. In PLL speed control applications, this is the feedback to the PLL. One pulse per electrical rotation. This is an open collector output.
6	H1 (+)	I	Positive input of differential amplifier on channel 1. Interfaces with Hall Effect sensor, S1, from motor.
7	H1 (-)	I	Negative input of differential amplifier on channel 1. Interfaces with Hall Effect sensor, S1, from motor.
8	H2 (+)	I	Same as pin 3 for channel 2.
9	H2 (-)	I	Same as pin 4 for channel 2.
10	H3 (+)	I	Same as pin 3 for channel 3.
11	GND		Ground connection.
12	H3 (-)	I	Same as pin 4 for channel 3.
13	V_C	I	Speed control input. Connected to output of PLL in PLL speed control applications.
14	OUT3	O	Output motor drive for phase 3.
15	SENSE	I	Current Sensing. Input for load current sense voltage for output stage.
16	OUT2	O	Output motor drive for phase 2.
17	V_S		Motor supply voltage.
18	OUT1	O	Output motor drive for phase 1.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C; V_s = 12V unless otherwise specified)

Parameter		Test Conditions	Min.	Typ.	Max.	Unit
V_s	Supply voltage		10	12		V
I_s	Quiescent supply current			30	60	mA
HALL AMPLIFIERS						
V_{CM}	Common mode voltage range		0		10	V
V_{io}	Input offset voltage	V_i = 6V		2	10	mV
I_{Ib}	Input bias current	V_i = 6V		2	10	μA
I_{Io}	Input offset current	V_i = 6V		0.1		μA
SPEED CONTROL INPUT (V_C)						
V_I	Input voltage range		0		5	V
I_{Ib}	Input bias current	$V_C < V_{sens}$		1	5	μA
V_{ic}	Input clamping voltage			5.9		V
FWD/REVERSE INPUT						
V_{IH}	Input high voltage		2		V_s	V
V_{IL}	Input low voltage		0		0.8	V
I_{IH}	Input high current				10	μA
I_{IL}	Input low current			-5	-50	μA
HALL LOGIC OUTPUT						
V_{LO}	Low output voltage	I = 5mA			0.8	V
I_L	Leakage current	V_{CE} = 12V			10	μA
OUTPUT POWER STAGE						
V_{sat}	Total saturation voltage	I_o = 0.15A I_o = 0.4A I_o = 1.0A		2.2 2.5 2.7		V
V_{OSR}	Output voltage slew-rate			100		V/ms
V_{sens}	Sense voltage range		0		0.7	V
THERMAL SHUTDOWN						
T_j	Junction temperature		150			°C
T_H	Hysteresis				30	°C

DESCRIPTION

The L6236 is a three-phase brushless motor driver IC containing all the power stages and commutation logic required for a three-phase bidirectional drive.

Logic signals from the motor's Hall effect sensors are decoded to generate the correct driving sequence according to the truth-table of Fig. 1.

The direction of rotation is controlled by the forward/reverse input (pin 1). When this pin is at a low level the motor rotates in the forward direction.

When one of the push-pull output drivers is activated the upper transistor is always in saturation while the lower transistor is controlled in linear mode to set the desired speed in steady state conditions.

In PLL speed control applications the device provides a signal proportional to the motor speed at pin 2 (it is the buffered H1 input). The output of the PLL is connected to the speed control input on the device at pin 10, V_C.

In addition, a 1V offset is added to the speed demand voltage to match the minimum output on the PLL.

An external resistor, R_s, sense the output stage current. The sensing voltage across this resistor is amplified in the device by a factor of 7 to allow a reduction in the voltage drop in the resistor.

The amplified sensing voltage is then compared with the speed demand signal from the PLL and the resulting error signal sets the amplifier output accordingly.

The output current is related to the speed control voltage by:

$$I_o = (V_C - 1)/7\,R_s$$

The value of the sensing resistor is given by:

$$R_s = (V_X - 1)/(7\,I_{max})$$

where V_X is the full scale voltage of V_C.

In this way the V_C/I_{out} characteristics can be modified. Note that V_X max is clamped at 5.9V.

The most important feature of the L6236 is slew rate control. With this device a typical value of 0.1V/μs is achieved, reducing EMI to a very low value.

In a delta configuration a key feature is three-state operation; when the current is recirculating the corresponding phase driver is switched off and power dissipation is negligible. Current recirculates through the integrated free-wheeling diodes in the acceleration phase and through the motor in steady-state conditions. Torque ripple is also minimized.

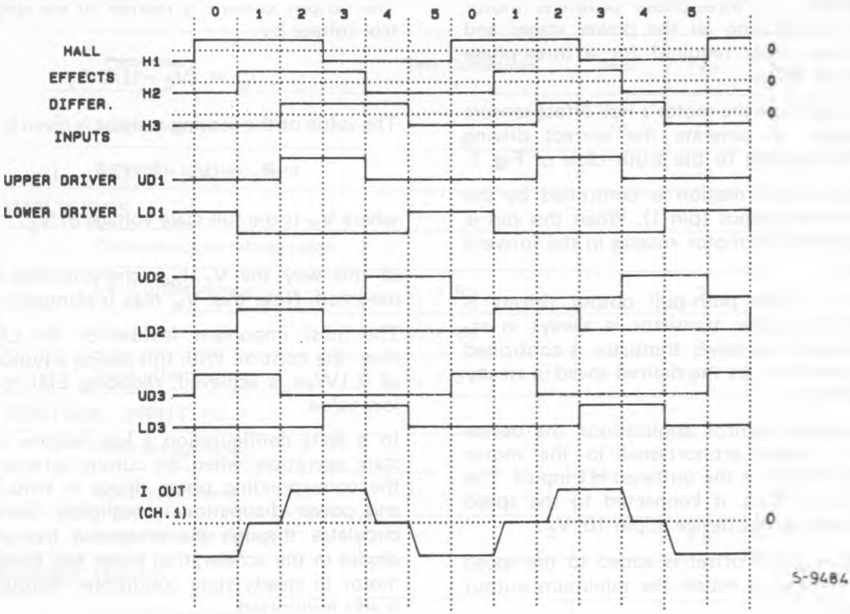
The L6236 can also operate with a brushless motor connected in a star configuration, leaving the center floating.

The Hall inputs are ground compatible comparators and can work with direct active digital Hall signals on three terminals (of the same polarity) and a TTL level on the other three terminals.

Fig. 1 - **TRUTH TABLE FOR FORWARD ROTATION**

HALL EFFECT DIFF. INPUT			UPPER DRIVER STATUS			LOWER DRIVER STATUS		
1 = POSITIVE 0 = NEGATIVE			1 = ON 0 = OFF			1 = ON 0 = OFF		
H1	H2	H3	UD1	UD2	UD3	LD1	LD2	LD3
1	0	0	1	0	0	0	0	1
1	1	0	0	1	0	0	0	1
1	1	1	0	1	0	1	0	0
0	1	1	0	0	1	1	0	0
0	0	1	0	0	1	0	1	0
0	0	0	1	0	0	0	1	0

Fig. 2 - Timing diagram

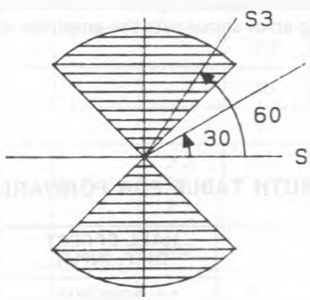


DETERMINING HALL EFFECT SENSOR CODING

The L6236 assumes that the positioning of the Hall Effect sensors in a three-phase brushless DC bipolar motor are at 30 intervals. One can imagine two "windows" on the rotor each of which is 90 wide and 180 apart, see fig. 4. As a window passes over a sensor, the sensor output goes high. The timing diagram, fig. 2, shows the waveforms produced. These waveforms must appear at the Hall Effect Inputs of the L6236. Note that the rotation in fig. 3 must be counterclockwise for forward rotation of the motor in whatever manner that is defined for the motor.

Fig. 3 is a stylized concept for determining the Hall Effect code pattern and does not reflect the actual direction of rotation of the motor in a physical sense. If a motor is chose whose sensor outputs do not match the L6236 desired input pattern, a signal set conversion must be determined. It is helpful to visualize this by developing a diagram similar to that of fig. 4.

Fig. 3



For example, let us examine the output pattern of a different type of motor (fig. 4). Assuming 90 windows at 180 intervals, then with respect to fig. 3, a similar diagram, fig. 5, results in sensors 60 apart with the windows rotating clockwise. The situation results in a "forward" rotation of the motor.

Since S3 is the first sensor encountered by the window in fig. 5, this should be used for the L6236 Hall Effect Input H1. After 30 of rotation CW, the H2 input of the L6236 must go high. The inverse of S1 from the motor would satisfly this. After an additional 30 of rotation, the H3 input must go high. The S2 sensor is encountered by the window. Thus, S2 is applied to this input, H3. By countinuing around the diagram, one can develop a pattern which matches that for the L6236.

Fig. 4

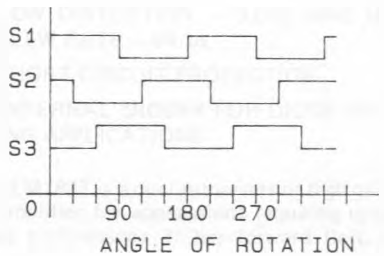
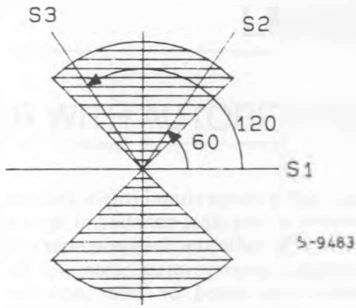


Fig. 5



Thus the conversione table for this particular motor is:

Motor Sensors	L6236 inputs
S3	H1
S1	H2
S2	H3

Note, for the inverted signal from S1 actual inverter gate is not necessary with the L6236. Since the L6236 has differential inputs, the negative input pin may be used. Therefore, with TTL compatible Hall Effect sensors, the positive input is connected to a reference point along with the other negative inputs.

Fig. 6 - Application circuit using the L6233 PLL-Controller