SGS-THOMSON MICROELECTRONICS

L6230

BIDIRECTIONAL THREE-PHASE BRUSHLESS DC MOTOR DRIVER

PRELIMINARY DATA

- 3A OUTPUT CURRENT, CONTROLLED IN LINEAR MODE
- SUPPLY VOLTAGE UP TO 18 V
- 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 1/3 f CYCLE
- INTERNAL PROTECTION DIODES
- FEW EXTERNAL COMPONENTS

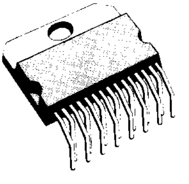
DESCRIPTION

The L6230 is a single-chip driver for three-phase brushless DC motors capable of delivering 3A output current with supply voltages to 18 V. 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 L6230 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 L6230 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.

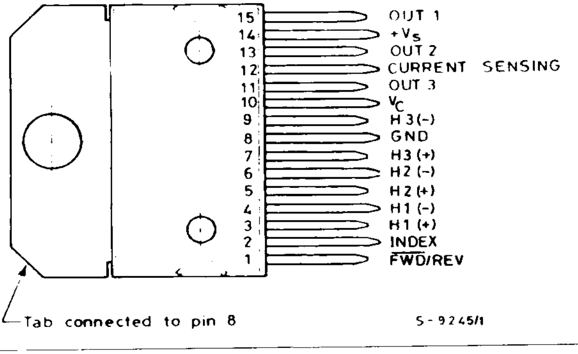
The power stage of the device is designed to eliminate the possibility of simultaneous conduction of the upper and lower power transistors of one output driver, when operating in the right loop.



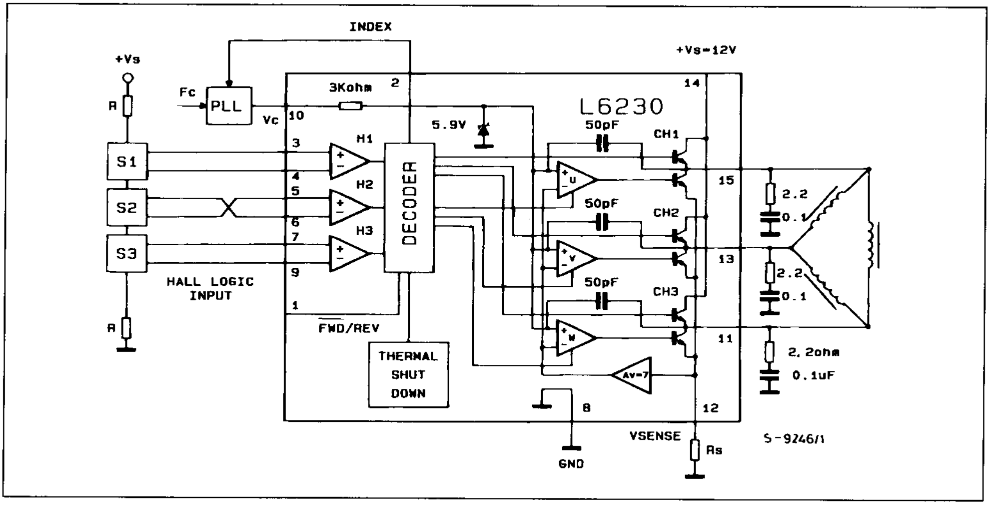
Multiwatt-15
(Horizontal)

ORDER CODE : L6230H

CONNECTION DIAGRAM (top view)



BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_s	Supply Voltage	20	V
I_o	Peak Output Current Each Channel – Non Repetitive (100 µs) – Repetitive (t = 10 ms) – DC Operation	 4 3.5 3	 A A A
V_i	Logic and Analogic Inputs	V_S	
P_{tot}	Total Power Dissipation T_{case} = 75 °C	25	W
T_{op}	Operating Temperature Range	0 to 70	°C
T_j, T_{stg}	Storage and Junction Temperature	– 40 to 150	°C

THERMAL DATA

$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max	3	°C/W

PIN FUNCTIONS

N°	Name	I/O	Function
1	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 position of the sensors in the motor.
2	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.
3	H1 (+)	I	Positive input of differential amplifier on channel 1. Interfaces with Hall Effect sensor, S1, from motor.
4	H1 (–)	I	Negative input of differential amplifier on channel 1. Interfaces with Hall Effect sensor, S1, from motor.
5	H2 (+)	I	Same as Pin 3 for Channel 2
6	H2 (–)	I	Same as Pin 4 for Channel 2
7	H3 (+)	I	Same as Pin 3 for Channel 3
8	GND		Ground Connection
9	H3 (–)	I	Same as Pin 4 for Channel 3
10	V_c	I	Speed control input. Connected to output of PLL in PLL speed control applications.
11	OUT3	O	Output motor drive for phase 3.
12	SENSE	I	Current Sensing. Input for load current sense voltage for output stage.
13	OUT2	O	Output motor drive for phase 2.
14	V_s		Motor Supply Voltage
15	OUT1	O	Output motor drive for phase 1.

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

Symbol	Parameter	Test Conditions	Min .	Typ .	Max .	Unit
V_s	Supply Voltage		10	12	18	V
I_s	Quiescent Supply Current			60	100	mA

HALL AMPLIFIERS

Symbol	Parameter	Test Conditions	Min .	Typ .	Max .	Unit
V_{CM}	Common Mode Voltage Range		0		10	V
V_{io}	Input Offset Voltage	V_i = 6 V		2	10	mV
I_{ib}	Input Bias Current	V_i = 6 V		2	10	µA
I_{io}	Input Offset Current	V_i = 6 V		0.1		µA

SPEED CONTROL INPUT (V_C)

Symbol	Parameter	Test Conditions	Min .	Typ .	Max .	Unit
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

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
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 = 5 mA			0.8	V
I_L	Leakage Current	V_{CE} = 12 V			10	µA
OUTPUT POWER STAGE						
V_{sat}	Total Saturation Voltage	I_o = 1 A I_o = 2 A I_o = 3 A		2.7 3.6 4.2	3.7 4.5	V
V_{OSR}	Ouput Voltage Slew-rate			100		V/ms
V_{sens}	Sens Voltage Range		0		0.7	V
THERMAL SHUTDOWN						
T_j	Junction Temperature		150			°C
T_H	Hysteresis				30	°C

DESCRIPTION

The L6230 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 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 1 V offset is added to the speed demand voltage to match the minimum output of the PLL.

An external resistor, R_s, senses the ouptut 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 (see fig.2).

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In this way the V_C / I_{out} characteristics can be modified as shown in Fig. 2. Note that V_X max is clamped at 5.9 V.

The most important feature of the L6230 is slew rate control. With this device a typical value of 0.1 V/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 in 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 L6230 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 in three terminals (of the same polarity) and a TTL level on the other three terminals.

Figure 1 : Truth Table for Forward Rotation.

Hall Effect Diff. Input 1 = Positive 2 = Negative			Upper Driver Status 1 = On 2 = Off			Lower Driver Status 1 = On 2 = 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

Figure 2 : Output Current vs. Control Voltage.

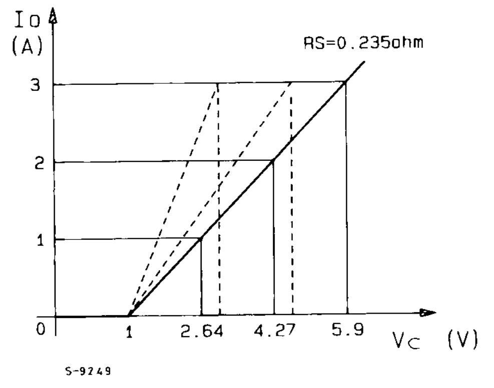
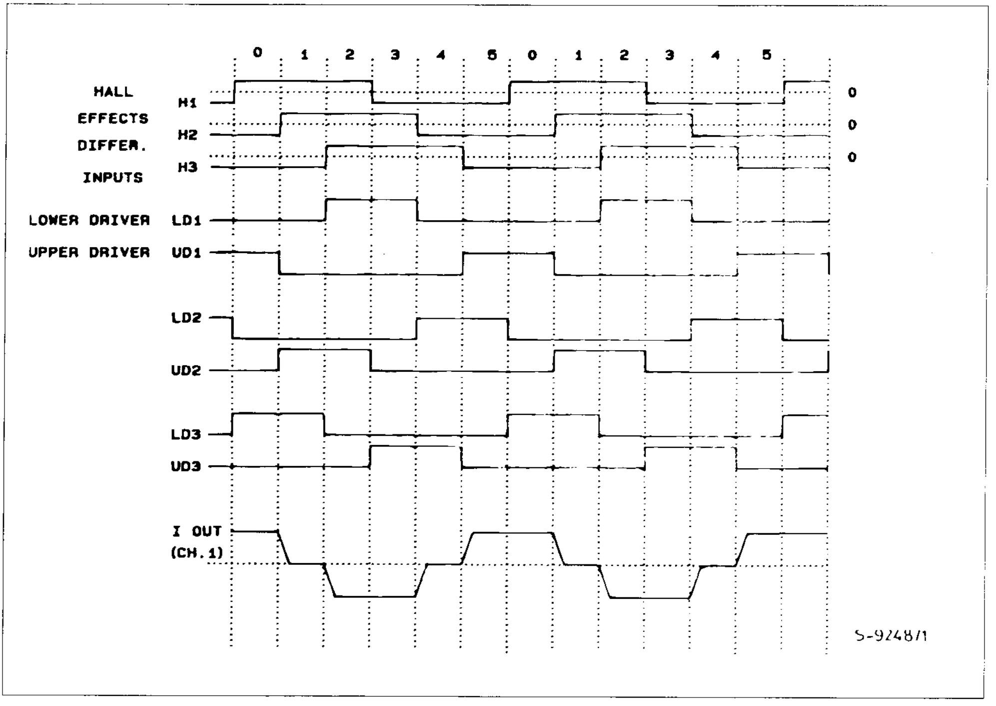


Figure 3 : Timing Diagram.



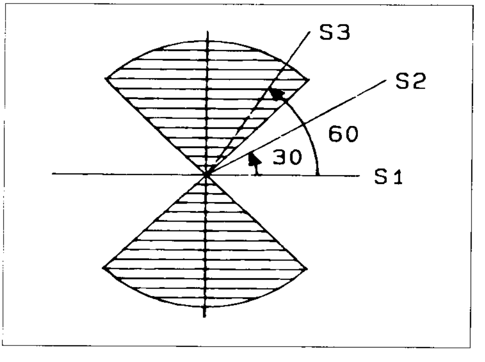
DETERMINING HALL EFFECT SENSOR CODING

The L6230 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.3, shows the waveforms produced. These waveforms must appear at the Hall Effect Inputs of the L6230. Note that the rotation in fig. 4 must be counter-clockwise for forward rotation of the motor in whatever manner that is defined for the motor.

Fig. 4 is a stylized concept for the 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 chosen whose sensor outputs do not match the L6230 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.

For example, let us ecamine the output pattern of a different type of motor (fig. 5). Assuming 90 windows at 180 intervals, then with respect to fig. 4, a similar diagram, fig. 6, results in sensors 60 apart with the windows rotating clockwise. This situation results in a "forward" rotation of the motor.

Figure 4.



Since S3 is the first sensor encountered by the window in fig. 6, this should be used for the L6230 Hall Effect Input, H1. After 30 of rotation CW, the H2 input of the L6230 must go high. The inverse of S1 from the motor would satisfy 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 continuing around the diagram, one can develop a pattern which matches that for the L6230.

Figure 5.

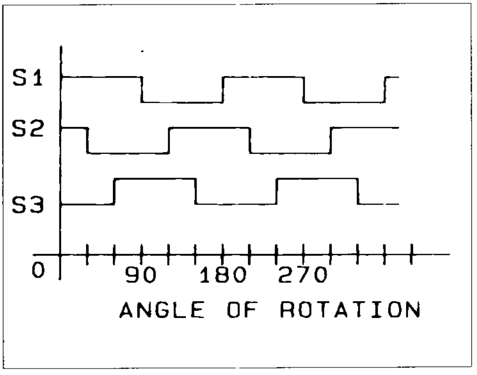
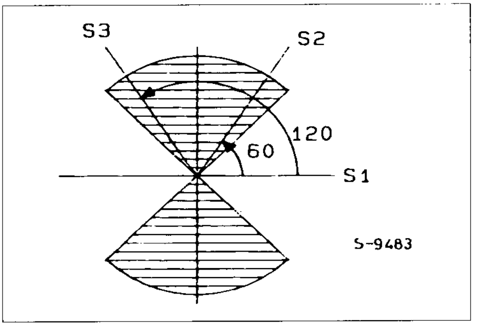


Figure 6.



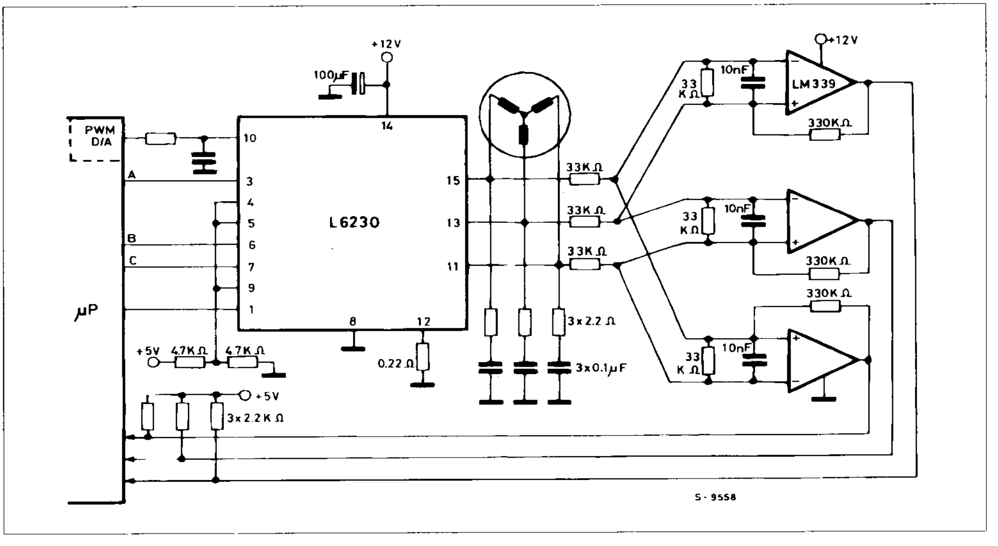
Thus, the conversion table for this particular motor is :

Motor Sensors	L6230 Inputs
S3	H1
S1	H2
S2	H3

Note, for the inverted signal from S1 an actual inverter gate is not necessary with the L6230. Since the L6230 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.

APPLICATION INFORMATION

Figure 7 : Brushless Motor Control without Hall Sensors.



L6230 can be adapted to a brushless motor without Hall sensors.

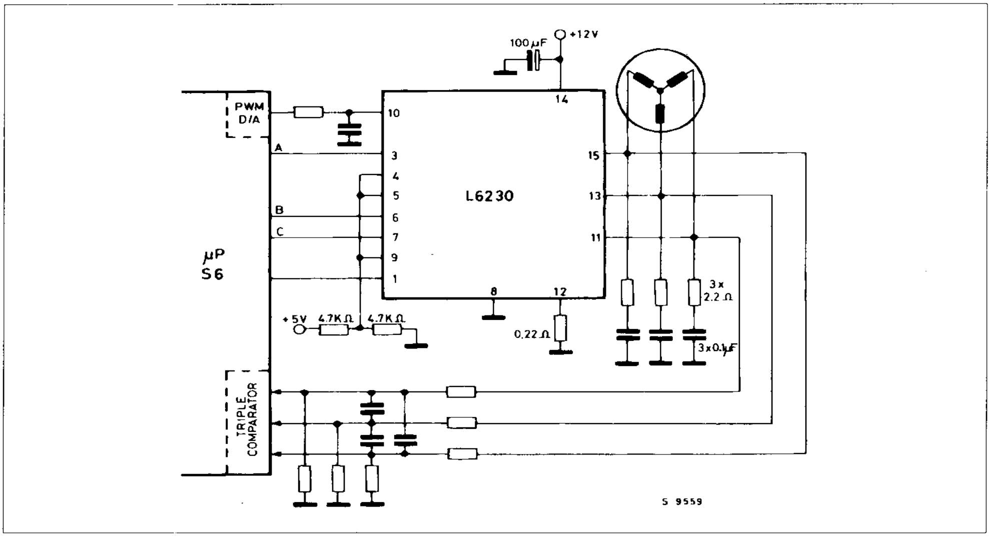
The circuit detects after filtering the back EMF of the motor and use this signal for commutation. This application needs a µP to start up the motor with a rotating clock pulse on the outputs until the back EMF is present.

The µP can also provide the speed regulation loop by software. For a quick performance test of application, it's possible to interconnect the comparator outputs directly to the L6230 inputs. In this case a manual start up is needed.

By using S6 µP with a dedicated ADC or comparator inputs, only passive external components are required.

A discussion with a motor producer give us the information, the cost of 3 phase hall sensors including assembly are in the range of 3 to 4 DM.

Figure 8 : Brushless Motor Control with Dedicated µP.



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