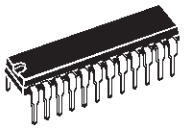
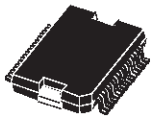
L6235

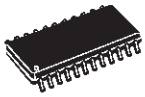
THREE PHASE BRUSHLESS DC MOTOR DRIVER

PRELIMINARY DATA

- OPERATING SUPPLY VOLTAGE FROM 8 TO 52V
- 5.6A PEAK CURRENT (2.8A DC)
- Rds(on)= 0.3Ω TYPICAL @ T_j = 25 °C
- HALL EFFECT SENSOR INPUT
- BUILT-IN DECODING LOGIC
- BUILT-IN CONSTANT OFF TIME PWM CURRENT CONTROL
- FREQUENCY-TO-VOLTAGE CONVERTER
- OPERATING FREQUENCY UP TO 100KHz
- HIGH SIDE OVER CURRENT PROTECTION
- CROSS CONDUCTION PROTECTION
- THERMAL SHUTDOWN
- CMOS/TTL INPUTS FOR FORWARD/ REVERSE
- ALL SWITCHES OFF ENABLE INPUT
- INTRINSIC FAST FREE WHEELING DIODES
- DIAG OPEN DRAIN
- UNDER VOLTAGE LOCKOUT







PowerDIP24 (20+2+2) | **PowerSO36** | **SO24 (20+2+2)**

ORDERING NUMBERS:

L6235N | **L6235PD** | **L6235D**

DESCRIPTION

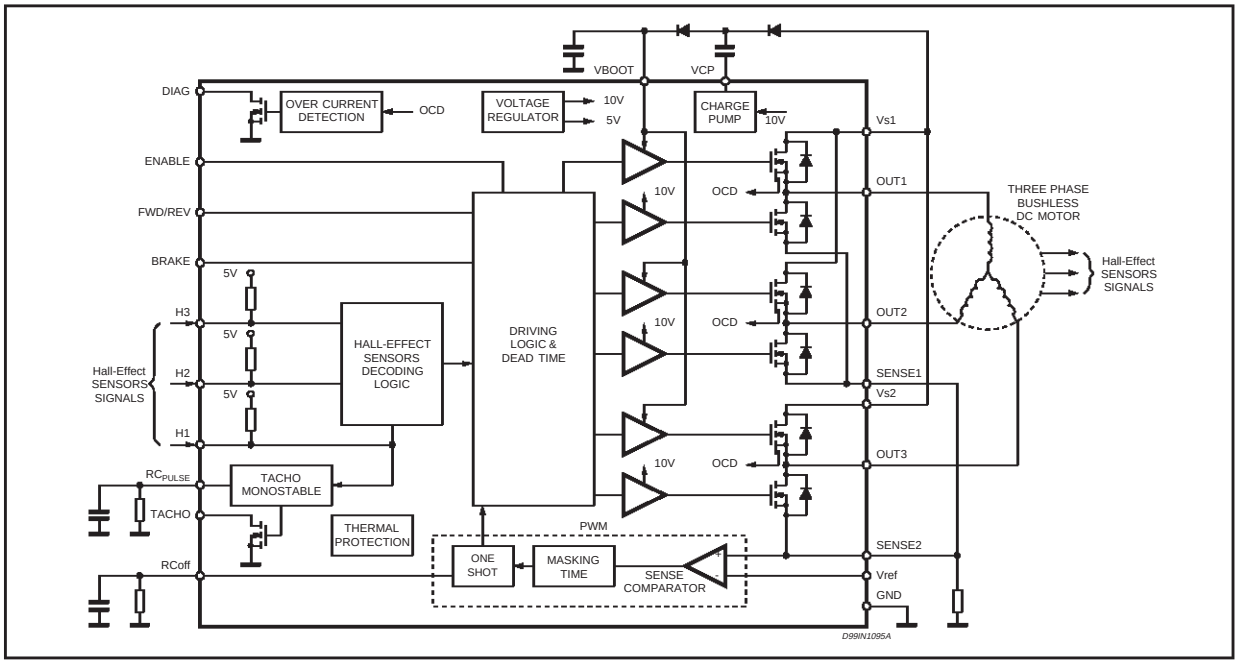
The L6235 is a Fully Integrated 3 Phase Motor Driver manufactured with Multipower BCD Technology which combines DMOS power transistors with CMOS and Bipolar circuits on the same chip.

The Logic Inputs are CMOS/TTL and µP compatible. All the required circuitry to built a constant off time PWM control has been implemented. Inputs for single ended hall sensor as well as the required decoding logic are provided.

Each high side power MOS is protected against over current conditions, with open drain diagnostic for fault. Other features are the thermal shutdown and the brake function.

The L6235 is assembled in PowerDIP24(20+2+2), PowerSO36 and SO24(20+2+2) packages.

BLOCK DIAGRAM



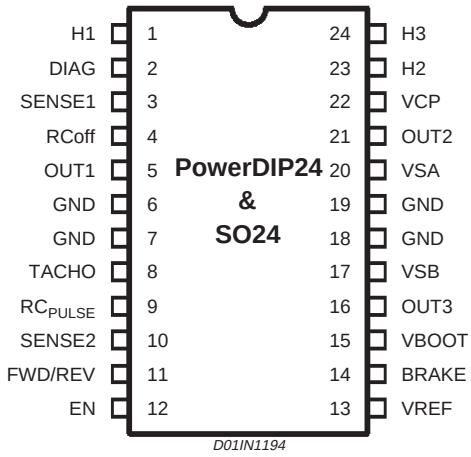
ABSOLUTE MAXIMUM RATINGS

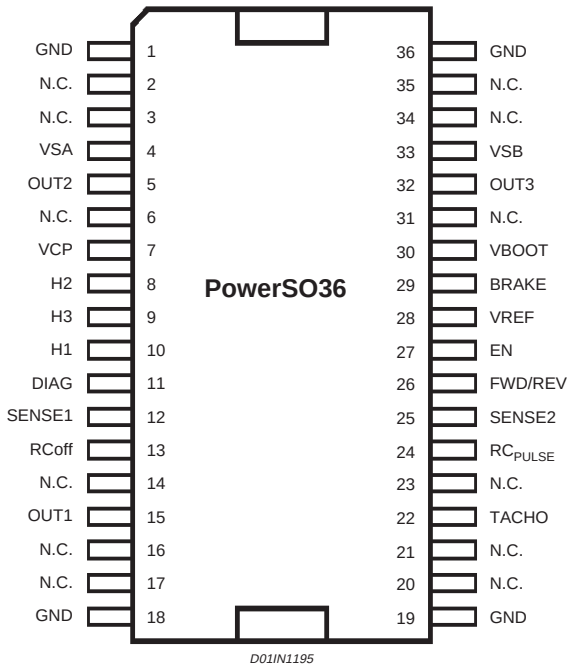
Symbol	Parameter	Test conditions	Value	Unit
V_S	Supply Voltage		60	V
V_{IN}, V_{EN}	Logic Inputs Voltage Range		-0.3 to +7	V
V_{ref}	Voltage Range at V_{ref} pin		-0.3 to +7	V
V_{RCoff}, $V_{RCpulse}$	Voltage Range at RC_{off} and RC_{pulse} pins		-0.3 to +7	V
V_{SENSE}	DC Sensing Voltage Range		-1 to +4	V
V_{BOOT}	Bootstrap Peak Voltage		V_S + 10	V
$I_{S(peak)}$	Pulsed Supply Current (for each V_S pin), internally limited by the overcurrent protection	t_{PULSE} < 1ms	7.1	A
I_S	DC Supply Current (for each V_S pin)		2.8	A
V_{OD}	Differential Voltage between V_{S1}, OUT_1, OUT_2, $SENSE_1$ and V_{S2}, OUT_3, $SENSE_2$		60	V
T_{stg}, T_{OP}	Storage and Operating Temperature Range		-40 to 150	°C

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	MIN	MAX	Unit
V_S	Supply Voltage	12	52	V
V_{OD}	Differential Voltage between V_{S1}, OUT_1, OUT_2, $SENSE_1$ and V_{S2}, OUT_3, $SENSE_2$		52	V
V_{SENSE}	Sensing voltage (pulsed tw<t_{rr}) (DC)	-6 -1	6 1	V V
V_{ref}	V_{ref} Operating Voltage	-0.1	5	V
I_{OUT}	DC Output Current		2.8	A
T_j	Operating Junction Temperature	-25	+125	°C
f_{sw}	Switching Frequency		100	kHz

PIN CONNECTIONS (Top view)





PIN DESCRIPTION

Name	PowerSO36	PowerDIP24/ SO24	Function
V_{S1}	4	20	Supply Voltage for Half Bridges 1 and 2.
V_{S2}	33	17	Supply Voltage for Half Bridge 3. This pin must be connected to V_{S1}.
OUT1 OUT2 OUT3	15 5 32	5 21 16	Half Bridges power output.
Sense1	12	3	Sense resistor for the Half Bridge 1 and 2.
Sense2	25	10	Sense resistor for the Half Bridge 3. Also Inverting Input of the Sense Comparator.
GND	1,18,19,36	6,7,18,19	Common ground terminals. In Powerdip and SO packages, these pins are also used for heat dissipation toward the PCB.
EN	27	12	PowerMOS Enable . A LOW logic level applied to this pin switches off all the power DMOS.
FWD/REV	26	11	TTL/CMOS compatible Input for Forward (HIGH) or Reverse (LOW) Operation.
H1,H2,H3	10, 8, 9	1, 23, 24	Single Ended Hall Effect Sensor TTL Threshold with hysteresys Input.
V_{cp}	7	22	Bootstrap Oscillator. Oscillator output for the external charge pump.

PIN DESCRIPTION (continued)

Name	PowerSO36	PowerDIP24/ SO24	Function
V_{boot}	30	15	Supply voltage for the upper DMOSs drive.
RC_{off}	13	4	A parallel RC network connected to this pin sets the OFF time of the lower power DMOS of the three Half Bridge. The pulse generator is a monostable triggered by the output of the Sense Comparator (t_{off} = 0.69RC).
RC_{pulse}	24	9	A parallel RC network connected to this pin sets the duration of the Monostable Pulse. Used to determin the F-to-V converter gain for Closed Loop Speed Control.
TACHO	22	8	Open Drain Output of the F-to-V Converter. Every pulse from H1 is shaped as a fixed (adjustable) lenght Pulse.
V_{ref}	28	13	Sense Comaprator Reference Voltage.
BRAKE	29	14	A Low logic Level applied to this pin switching on all the High Side Power DMOS, implementing the brake function.
DIAG	11	2	Open Drain Output. Diagnostic for Over Current Detection.

THERMAL DATA

Symbol	Description	PDIP24	SO24	PowerSO36	Unit
$R_{th\text{-}j\text{-}pins}$	MaximumThermal Resistance Junction-Pins	18	14	-	°C/W
$R_{th\text{-}j\text{-}case}$	Maximum Thermal Resistance Junction-Case	-	-	1	°C/W
$R_{th\text{-}j\text{-}amb1}$	MaximumThermal Resistance Junction-Ambient (1)	42	50	-	°C/W
$R_{th\text{-}j\text{-}amb1}$	Maximum Thermal Resistance Junction-Ambient (2)	-	-	35	°C/W
$R_{th\text{-}j\text{-}amb1}$	MaximumThermal Resistance Junction-Ambient (3)	-	-	15	°C/W
$R_{th\text{-}j\text{-}amb2}$	Maximum Thermal Resistance Junction-Ambient (4)	56	77	62	°C/W

(1) Mounted on a multilayer FR4 PCB with a dissipating copper surface on the bottom side of 6 cm^2 (with a thickness of 35 µm).
(2) Mounted on a multilayer FR4 PCB with a dissipating copper surface on the top side of 6 cm^2 (with a thickness of 35 µm).
(3) Mounted on a multilayer FR4 PCB with a dissipating copper surface on the top side of 6 cm^2 (with a thickness of 35 µm), 16 via holes and a ground layer.
(4) Mounted on a multiplayer PCB without any heatsinking surface on the board..

ELECTRICAL CHARACTERISTICS (V_S = 48 V , T_{amb} = 25 °C , unless otherwise specified).

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_S	Supply Voltage		8		52	V
I_S	Quiescent Supply Current	All Bridges OFF; -25°C<T_j <125°C		5.5	10	mA
T_j	Thermal Shutdown Temperature		150			°C
Output DMOS Transistors						
I_{DSS}	Leakage Current	V_S = 52V			1	mA
$R_{DS(ON)}$	High-side Switch ON Resistance	T_j = 25 °C		0.34	0.4	Ω
		T_j =125 °C		0.53	0.59	Ω
	Low-side Switch ON Resistance	T_j = 25 °C		0.28	0.34	Ω
		T_j =125 °C		0.47	0.53	Ω
Source Drain Diodes						
V_{SD}	Forward ON Voltage	I_{SD} = 2.8A, EN = LOW		1.2	1.4	V
t_{rr}	Reverse Recovery Time	I_f = 2.8A		300		ns
t_{fr}	Forward Recovery Time			200		ns
Switching Rates						
$t_{D(on)EN}$	Enable to out turn ON delay time (5)	I_{LOAD} = 2.8 A		250		ns
$t_{D(on)IN}$	Other Logic Inputs to out Turn ON delay Time (5)	I_{LOAD} = 2.8 A		600		ns
t_{ON}	Output Rise Time (5)	I_{LOAD} = 2.8 A		105		ns
$t_{D(off)EN}$	Enable to out turn OFF delay time (5)	I_{LOAD} = 2.8 A		450		ns
$t_{D(off)IN}$	Other Logic Inputs to out Turn OFF delay Time (5)	I_{LOAD} = 2.8 A		500		ns
t_{OFF}	Output Fall Time (5)	I_{LOAD} = 2.8 A		78		ns
t_{dt}	Dead Time Protection			1		µs
t_{blank}	Internal Blanking Time on V_{SENSE} pin			1		µs
f_{CP}	Charge Pump Frequency			0.75	1	MHz
UVLO comp						
$V_{th(ON)}$	Turn ON threshold		6.6	7	7.4	V
$V_{th(OFF)}$	Turn OFF threshold		5.6	6	6.4	V

Logic Input (H1, H2, H3, EN, FW/REV, BRAKE)

V_{INL}	Low level logic input voltage		-0.3		0.8	V
V_{INH}	High level logic input voltage		2		7	V
I_{INH}	High level logic input current	V_{pin} = 5 V			70	µA
I_{INL}	Low level logic input current	V_{pin} = GND			-10	µA

Over Current Protection

$I_{S\ OVER}$	Input supply over current protection threshold	-25°C<T_j <125°C	4	5.6	7.1	A
V_{DIAG}	Open drain low level output voltage	I = 4 mA			0.4	V

PWM Comparator and Monostable

I_{RCoff}	Source current at RC_{off} pin	V_{RCoff} =2.5 V	3	5		mA
V_{ref}	Input common mode comparator voltage range		-0.1		5	V
V_{th}	Comparator threshold voltage on SENSE pins	V_{ref} = 0.5 V	V_{ref} - 5mV		V_{ref} + 5mV	
t_{prop}	Turn OFF propagation delay (6)	V_{ref} = 0.5 V	0.1	0.2	0.3	µs
t_{OFF}	PWM Recirculation time	20 kΩ < R < 100 kΩ 0.1 nF < C < 100 nF	0.67RC	0.69RC	0.71RC	s
I_{bias}	Input bias current at V_{ref} pin			0.2		µA

RCpulse MONOSTABLE and TACHO OUTPUT

$I_{RCpulse}$	Source Current at RC_{pulse} pin	$V_{RCpulse}$ = 2.5 V		5		mA
t_{TACHO}	Tacho Output Pulse Time	20 kΩ < R < 100 kΩ 0.1 nF < C < 100nF	0.67 RC	0.69 RC	0.71 RC	s
$R_{DS(ON)}$: (TACHO)	Tacho Output Open Drain Source-Drain ON Resistance			100		Ω

(5) Resistive load used. See Fig. 1.
(6) Defined as the time between the voltage at the input of the current sense reaching the V_{ref} threshold and the lower DMOS switch beginning to turn off. The voltage at SENSE pin is increased instantaneously from V_{ref} -10 mV to V_{ref} +10 mV.

ELECTRICAL CHARACTERISTICS (continued)

Figure 1. Switching Rates Definition

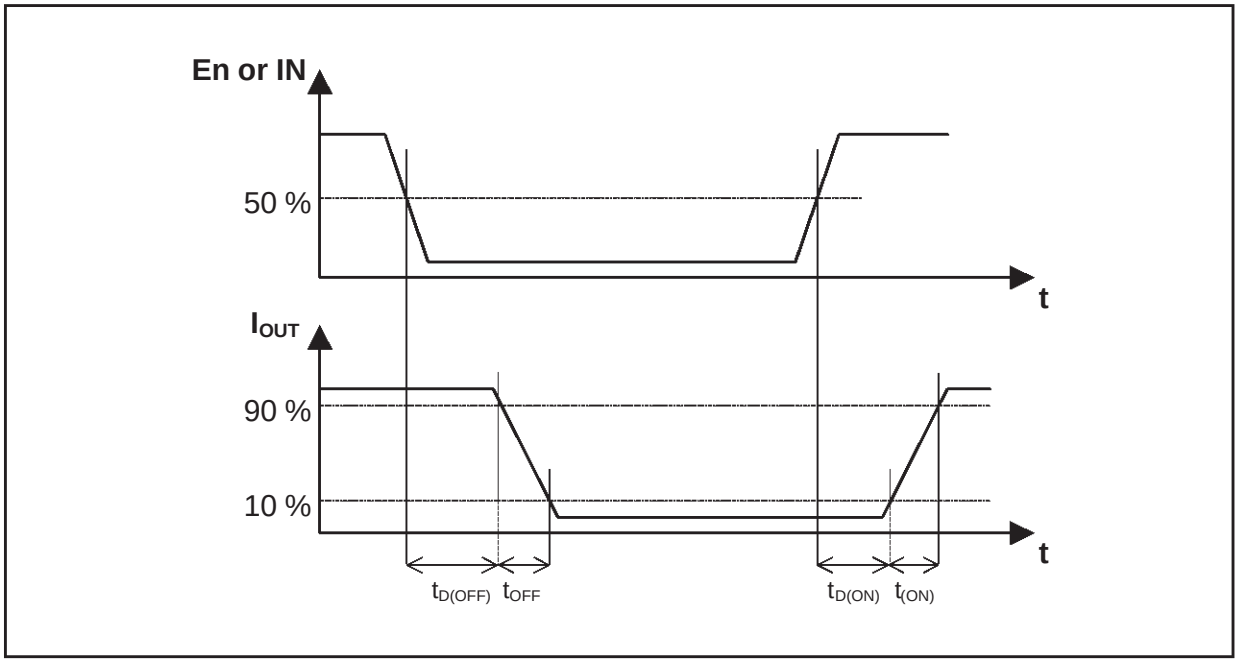


Figure 2. Typical Quiescent Current vs. Supply Voltage

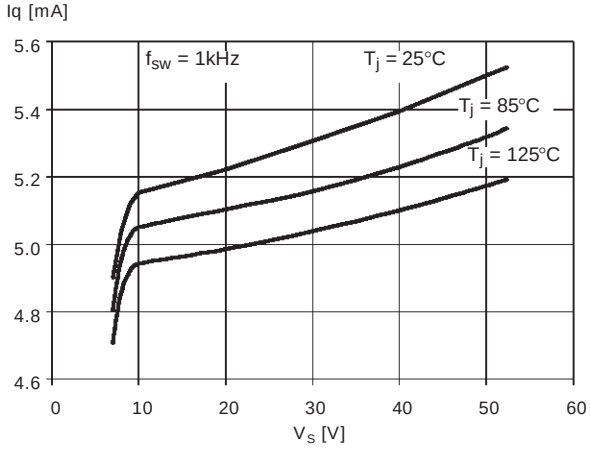


Figure 3. Normalized Typical Quiescent Current vs. Switching Frequency

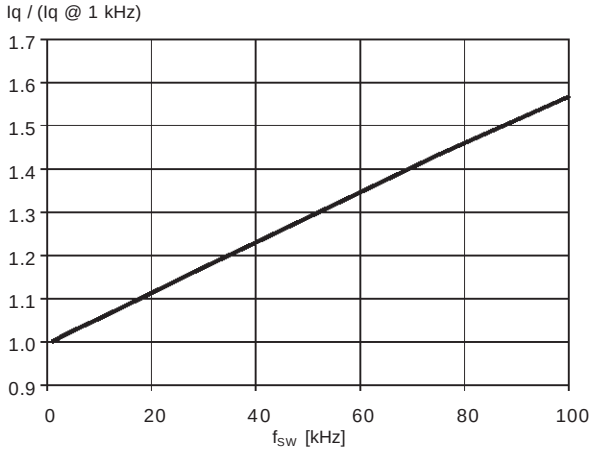


Figure 4. Typical Low-Side $R_{DS(ON)}$ vs. Supply Voltage

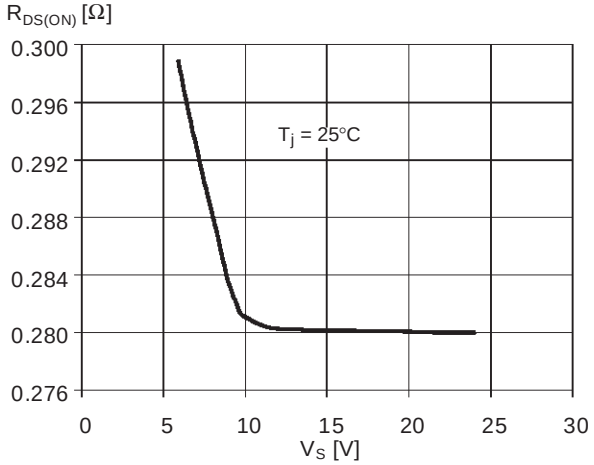


Figure 5. Typical High-Side RDS(ON) vs. Supply Voltage

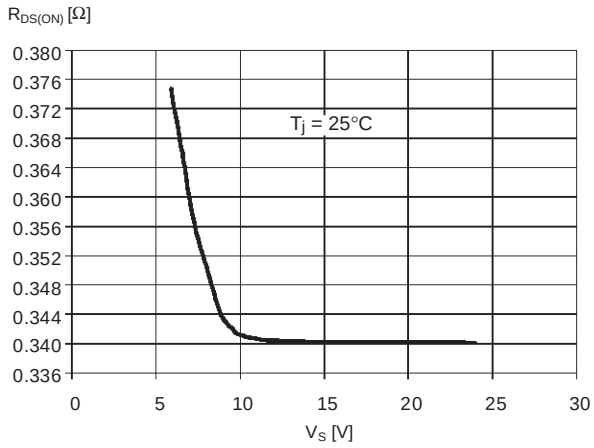


Figure 6. Normalized $R_{DS(ON)}$ vs.Junction Temperature (typical value)

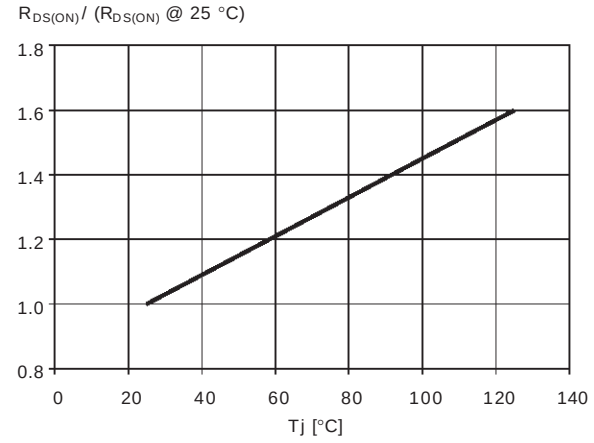
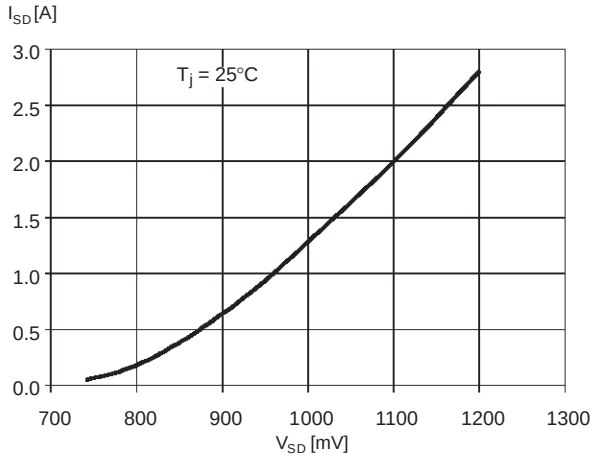


Figure 7. Typical Drain-Source Diode Forward ON Characteristic



CIRCUIT DESCRIPTION

Power Bridge

The Power Bridge is made with 6 Power MOSs rated 60V and 5A (peak), with an $R_{DS(ON)}$=0.3Ω (typical value). The intrinsic source drain diodes are fast and feature a low forward drop to ensure a low loss operation.
The PowerMOSs are internally arranged into two arrays: a full bridge and an half bridge. A 1µs (typ.) dead time between any of the High and Low side power MOSs in each of the bridge arm is provided for cross conduction protection. Note that the separate supply voltages pins (V_{S1} and V_{S2}) for the two arrays MUST be connected together. Access at the source terminal of the three powerMOS low side is provided to connect the current sense resistor. A non dissipative sensing of the drain current on each high side power DMOS is featured, with an internal reference and an open drain diagnostic (DIAG) Output, with a pull down capability of 4mA (typical value). Protection against short circuit to GND and between two phases can be implemanted.
Connecting the DIAG to the Enable input (EN) by means of an external R-C, the off time before recover normal operation conditions after a fault can be easily programmed, thanks to the accurate threshold of the Logic inputs. The trip point of this protection internally is set at 5.6A (typ value). Note that protection for short to the supply rail is typically provided by the external current control circuitry.
A thermal protection is also included with fault condition signalled on the DIAG pin.

Constant Toff Current Control

All the circuitry required to implement constant t_{off} current control scheme is internally provided: a low offset fast comparator, with the input internally connected to the sense pin, has an analog blanking time block with 1µs typical value. This will prevent false triggering of the sense comparator due to reverse recovery current from the freewheeling diodes. Sense comparator output will trigger a monostable Flip-Flop that will determine, via a proper selection of the R-C parallel network on the RCoff pin, the duration of the OFF time (t_{off}), implementing an ENABLE Chopping scheme (all of the PowerMOSs are OFF).

Decoding Logic

Inputs for single-ended (open collector) hall effect sensors is provided. The triggering levels are TTL. These signals, together with the output of the current control FF, are fed into a decoding logic that will generate the correct driving sequence for the 6 PowerMOSs. Decoding logic for either 60 and 120 degrees is supported. In addition the decoding logic will manage also the FWD/REV signal, to run the motor in Forward Or Reverse mode as well as the EN pin, that, when LOW, will turn OFF all of the PowerMOSs.

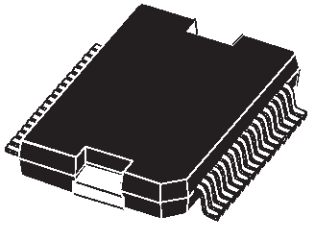
Tachometer

The L6235 includes a tachometer to realize a simple but yet effective speed control loop. The pulses from H1 pin, i.e. one of the hall effect, is squared generating a pulse whose width can be selected via the R-C parallel network to be placed on RCpulse pin. This pulse train, available on TACHO open drain output, can be low pass filtered obtaining a voltage proportional to the speed. This voltage can be comparated with a reference voltage in an error amplifier that drives the Vref pin of the device, realizing a closed loop speed regulation.

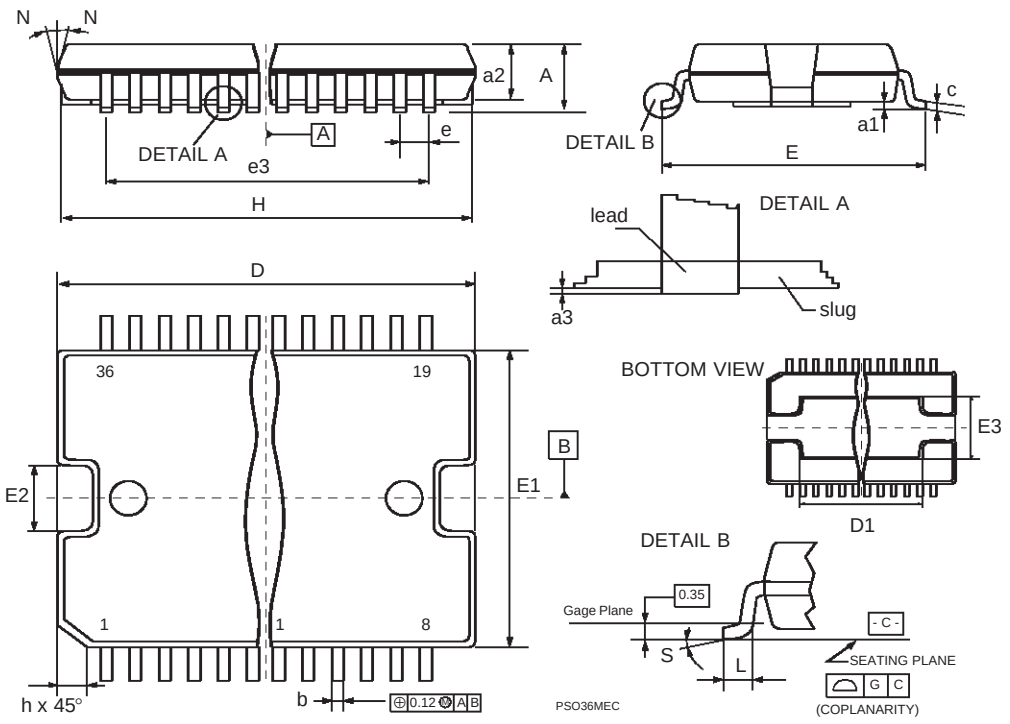
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.60			0.141
a1	0.10		0.30	0.004		0.012
a2			3.30			0.130
a3	0		0.10	0		0.004
b	0.22		0.38	0.008		0.015
c	0.23		0.32	0.009		0.012
D (1)	15.80		16.00	0.622		0.630
D1	9.40		9.80	0.370		0.385
E	13.90		14.50	0.547		0.570
e		0.65			0.0256	
e3		11.05			0.435	
E1 (1)	10.90		11.10	0.429		0.437
E2			2.90			0.114
E3	5.80		6.20	0.228		0.244
E4	2.90		3.20	0.114		0.126
G	0		0.10	0		0.004
H	15.50		15.90	0.610		0.626
h			1.10			0.043
L	0.80		1.10	0.031		0.043
N	10°(max.)					
S	8 °(max.)					

(1): "D" and "E1" do not include mold flash or protrusions
- Mold flash or protrusions shall not exceed 0.15mm (0.006 inch)
- Critical dimensions are "a3", "E" and "G".

OUTLINE AND MECHANICAL DATA

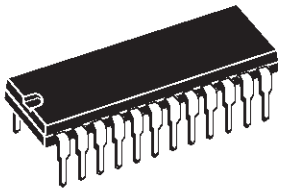


PowerSO36

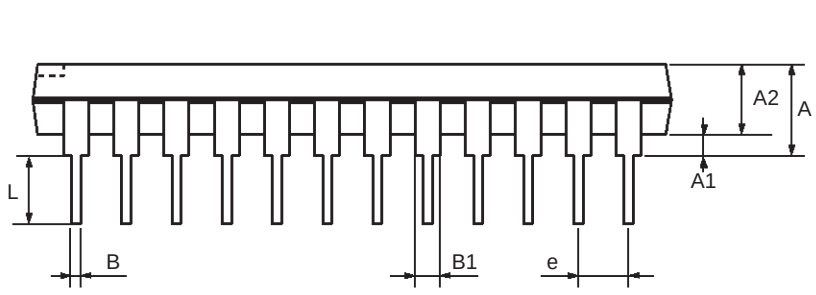


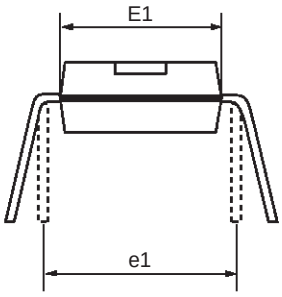
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			4.320			0.170
A1	0.380			0.015		
A2		3.300			0.130	
B	0.410	0.460	0.510	0.016	0.018	0.020
B1	1.400	1.520	1.650	0.055	0.060	0.065
c	0.200	0.250	0.300	0.008	0.010	0.012
D	31.62	31.75	31.88	1.245	1.250	1.255
E	7.620		8.260	0.300		0.325
e		2.54			0.100	
E1	6.350	6.600	6.860	0.250	0.260	0.270
e1		7.620			0.300	
L	3.180		3.430	0.125		0.135
M	0° min, 15° max.					

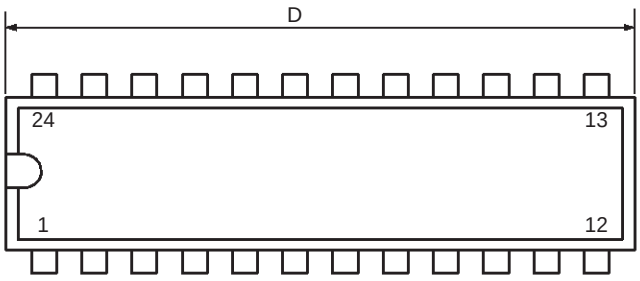
OUTLINE AND MECHANICAL DATA

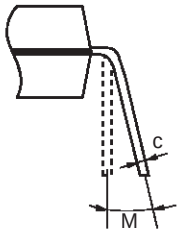


Powerdip 24





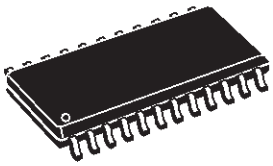




SDIP24L

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	2.35		2.65	0.093		0.104
A1	0.10		0.30	0.004		0.012
A2			2.55			0.100
B	0.33		0.51	0.013		0.0200
C	0.23		0.32	0.009		0.013
D	15.20		15.60	0.598		0.614
E	7.40		7.60	0.291		0.299
e		1.27			0,050	
H	10.0		10.65	0.394		0.419
h	0.25		0.75	0.010		0.030
k	0° (min.), 8° (max.)					
L	0.40		1.27	0.016		0.050

OUTLINE AND MECHANICAL DATA



SO24