International
IOR Rectifier

IR3230SPbF

3 PHASE CONTROLLER
FOR DC BRUSHLESS MOTOR

Features:
- *Up to 50 KHz PWM switching capability.*
- *No bootstrap capacitor.*
- *Trapezoidal 120° or 60° compatibility.*
- *Forward and reverse direction.*
- *Regeneration mode.*
- *Programmable over current shutdown.*
- *Programmable over temperature shutdown.*
- *E.S.D protection.*
- *Lead-free, RoHS compliant.*

Application:
- *E-bike*
- *Fan and pump*
- *Actuators system*
- *Compressor*

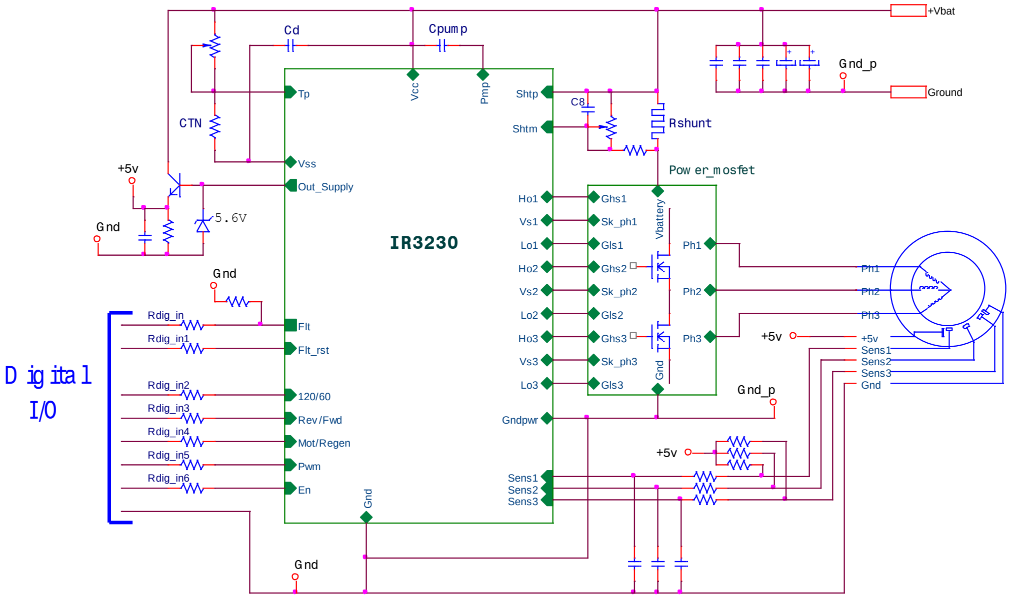
Package:

SOIC-28L Wide Body

Description:

The IR3230 is a three-phase brushless DC motor controller/driver with many integrated features.
They provide large flexibility in adapting the IR3230 to a specific system requirement and simplify the system design.

Typical connection:



Qualification Information†

Qualification Level		*Industrial*††	
		Comments: This family of ICs has passed JEDEC industrial qualification. IR's Consumer qualification level is granted by extension of the higher Industrial level.	
Moisture Sensitivity Level		*SOIC28W*	*MSL3 260°C (per IPC/JEDEC J-STD-020)*
ESD	*Machine Model*	*Class A (per JEDEC standard JESD22-A115)*	
	Human Body Model	*Class 1C (per JEDEC standard JESD22-A114)*	
	Charged Device Model	*Class IV (per JEDEC standard JESD22-C101)*	
IC Latch-Up Test		*Class II, Level A (per JEDEC standard JESD78)*	
RoHS Compliant		*Yes*	

† *Qualification standards can be found at International Rectifier's web site http://www.irf.com/*

†† *Higher qualification ratings may be available should the user have such requirement. Please contact your International Rectifier sales representative for further information.*

Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. (Tj= -40°C..150°C, Vcc=6..65V unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
V Gnd to Vcc	Maximum Gnd to Vcc voltage	-0.3	75	V
V Gndpwr to Vcc	Maximum Gndpwr to Vcc voltage	-0.3	65	V
V Gnd to Gndpwr	Maximum Gnd to Gndpwr voltage	-40	40	V
V Latch test	Maximum power supply voltage to perform the latch test	—	50	V
V Dig in to Vcc	Maximum all digital input to Vcc voltage	-0.3	75	V
V Flt to Vcc	Maximum Flt to Vcc voltage	-0.3	75	V
V Vsx to Vcc	Maximum Vsx to Vcc voltage	-1.5	75	V
V Shtp to Vcc	Maximum Shtp to Vcc voltage	-0.3	0.3	V
V Shtm to Vcc	Maximum Shtm to Vcc voltage	-0.3	75	V
V Out_supply to Vcc	Maximum Out_supply to Vcc voltage	-0.3	75	V
V Tp to Vcc	Maximum Tp to Vcc voltage	-0.3	75	V
I flt	Maximum continous output current on the Flt pin	—	4	mA
Pd 3230s	Maximum power dissipation (1) Rth=80°C/W	—	1.5	W
Tj max.	Max. storage & operating temperature junction temperature	-40	150	°C

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
Rth 3230s	Thermal resistance junction to ambient	80	—	°C/W

Recommended Operating Conditions

These values are given for a quick design. For operation outside these conditions, please consult the application notes.

Symbol	Parameter	Min.	Max.	Units
Vcc opp	Power supply voltage	6	60	V
Cpump	Charge pump capacitor	0.22	4.7	µF
Max consumption Vss	Maximum consumption on the Vss		100	µA
Cd	Recommended capacitor between Vcc and Vss	10	100	nF
R Dig in	Recommended resistor in series with digital input pin	0	10	kΩ
R pld Flt	Recommended pull down resistor on the Flt pin (no internal pull down)	1.5	-	kΩ
RVsx	Recommended resistor in series with high side source (recommended RVsx = RLox)	5	100	Ω
RLox	Recommended resistor in series with low side gate	5	100	Ω
F_Hox max	Maximum recommended high side MOSFET frequency (Hox-Vsx) load =2.2nF, Cpump = 220nF		2	kHz
F_Lox max	Maximum recommended low side MOSFET frequency Lox load =2.2nF, Cpump = 220nF		50	kHz

Static Electrical Characteristics

Tj=25°C, Vcc=48V (unless otherwise specified), Dig in = All except Hox, Lox, Vsx, Flt, Pmp, Tp, Shtp, Shtm, Vcc, Gnd, Gndpwr, Out_supply.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I Gnd Slp	Supply current in low consumption mode	0.3	1	2	mA	En = 0;
I Gnd On	Gnd current when the device is awake	1.2	2.5	4	mA	En = 1;
I Out_supply	Out _supply output current	1	1.7	3.1	mA	Vout_Vcc >6V
I Flt	Flt pin output current	3	6.6	10	mA	Flt = Gnd when fault
V Flt	Flt pin output voltage	4.5	5	5.8	V	I Flt = 10µA
V dig_in Off	All digital input Low threshold voltage	0.6	1	1.6	V	
V dig_in On	All digital input High threshold voltage	1.9	2.8	3.8	V	
V dig_in Hyst	All digital input hysteresis	1.3	1.8	2.5	V	
I dig_in On	All digital input On state current	3.8	8	16	µA	Vdig in= 5v
I sensor	All digital input On state current	8.8	18	36	µA	Vsensx = ov
V Hox-Vsx	High side gate voltage	5.8	6.1	7	V	
V Lox	Low side gate voltage	5.8	6.5	11	V	
I Hox Out_Gndpwr	High side gate output current Vsx < Vcc	38	50	85	mA	Hox = Vsx
I Hox Out_Vcc	High side gate output current Vsx > Vcc	7	15	19	mA	Hox = Vsx
I Hox In	High side gate input current	70	110	250	mA	(Hox –Vsx)=6V, Vsx = Vcc
I Lox Out	Low side gate output current	250	350	700	mA	Lox = Gndpwr
I Lox In	Low side gate input current	250	350	700	mA	Lox = 6V

Switching Electrical Characteristics

Vcc=48V, Tj=25°C (unless otherwise specified)

	Motor & Regen mode						
	Symbol	**Parameter**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
	Cpump	*Time to charge the pump capacitor*	*1.5*	*5*	*8*	*ms*	*Cpump = 220nF from EN = hi to (Vcpump-Vcc) = 5.3v*
	Tpwr_on_rst	*Power on reset time*	*180*	*600*	*1200*	*µs*	*Cpump = 6V*
High side	*Tr1 Hox-Vsx*	*Rise time high side gate with Vsx = gndpwr*	*0.1*	*0.3*	*0.5*	*µs*	*(Hox-Vsx) load =2.2nF From 10% to 90%*
	Tr2 Hox-Vsx	*Rise time high side gate with Vsx = Vcc*	*0.8*	*2.5*	*5*	*µs*	*(Hox-Vsx) load =2.2nF From 10% to 90%*
	Tf1 Hox-Vsx	*Fall time high side gate with Vsx = Gndpwr*	*0.05*	*0.15*	*0.25*	*µs*	*(Hox-Vsx) load =2.2nF From 90% to 10%*
	Tf2 Hox-Vsx	*Fall time high side gate with Vsx = Vcc*	*0.15*	*0.7*	*1.4*	*µs*	*(Hox-Vsx) load =2.2nF From 90% to 10%*
	Td1 MtoR Hox off	*Motor to Regen mode High side turn-off delay time Vsx = gndpwr*	*0.1*	*0.3*	*0.5*	*µs*	*(Hox-Vsx) load =2.2nF from 50% of Reg/mot to 90% of (Hox – Vsx)*
	Td2 MtoR Hox off	*Motor to Regen mode High side turn-off delay time Vsx = Vcc*	*0.8*	*2.5*	*5*	*µs*	*(Hox-Vsx) load =2.2nF from 50% of Reg/mot to 90% of (Hox – Vsx)*
	Td1 RtoM Hox on	*Regen to Motor mode High side turn-on delay time Vsx = gndpwr*	*0.1*	*0.3*	*0.5*	*µs*	*(Hox-Vsx) load =2.2nF from 50% of Reg/mot to 10% of (Hox – Vsx)*
	Td2 RtoM Hox on	*Regen to Motor mode High side turn-on delay time Vsx = Vcc*	*0.8*	*2.5*	*5*	*µs*	*(Hox-Vsx) load =2.2nF from 50% of Reg/mot to 10% of (Hox – Vsx)*
Low side	*Tr Lox*	*Low side rise time to turn on*	*0.04*	*0.1*	*0.3*	*µs*	*Lox load =2.2nF From 10% to 90%*
	Tf Lox	*Low side fall time to turn off*	*0.04*	*0.1*	*0.3*	*µs*	*Lox load =2.2nF From 90% to 10%*
	Td MtoR Lox on	*Motor to Regen mode low side turn-on delay time*	*0.1*	*0.25*	*0.5*	*µs*	*Lox load =2.2nF from 50% of Reg/mot to 10% of Lox*
	Td RtoM Lox off	*Regen to Motor mode low side turn-off delay time*	*0.1*	*0.25*	*0.5*	*µs*	*Lox load =2.2nF from 50% of Reg/mot to 10% of Lox*

	Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
Regen mode							
Low side	Td Pwm Lox on	Pwm to low side turn-on delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of Pwm to 10% of Lox
Low side	Td Pwm Lox off	Pwm to low side turn-off delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of Pwm to 90% of Lox
Motor Mode							
	Symbol	**Parameter**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
High side	Td1 Sensx Hox on	Sensor to high side turn-on delay time Vsx = gndpwr	0.1	0.25	0.5	µs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 10% of (Hox - Vsx)
High side	Td2 Sensx Hox on	Sensor to high side turn-on delay time Vsx = Vcc	0.8	2.5	5	µs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 10% of (Hox – Vsx)
High side	Td1 Sensx Hox off	Sensor to high side turn-off delay time Vsx = gndpwr	0.1	0.25	0.5	µs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 90% of (Hox – Vsx)
High side	Td2 Sensx Hox off	Sensor to high side turn-off delay time Vsx = Vcc	0.8	2	5	µs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 90% of (Hox – Vsx)
Low side	Td Pwm Lox on	Pwm to low side turn-on delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of Pwm to 10% of Lox
Low side	Td Pwm Lox off	Pwm to low side turn-off delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of Pwm to 90% of Lox
Low side	Td Sensx Lox on	Sensor to low side turn-off delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of Sensx to 10% of Lox
Low side	Td Sensx Lox off	Sensor to low side turn-off delay time	0.1	0.25	0.5	µs	Lox load =2.2nF from 50% of sensx to 90% of Lox

Protection Characteristics

Vcc=48V, Tj=25°C (unless otherwise specified).

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
Vth Isd	Maximum over current shutdown threshold between Shtp and Shtm	65	80	97	mV	Rshunt =5 mΩ → Imax =20A
Vth Tsd	External over temperature threshold	45	50	55	%	(Vtemp-VSht+)/(Vss-VSht+)
Tsd int	Internal over temperature threshold Guaranteed by design	150	165		°C	
Dly Latch set	Delay to set the latch	0.3	1	3	µs	Delay fault from Vth(Isd) = 200mV
Dly Latch reset	Delay to reset the latch by Flt_rst pin	5	25	60	µs	

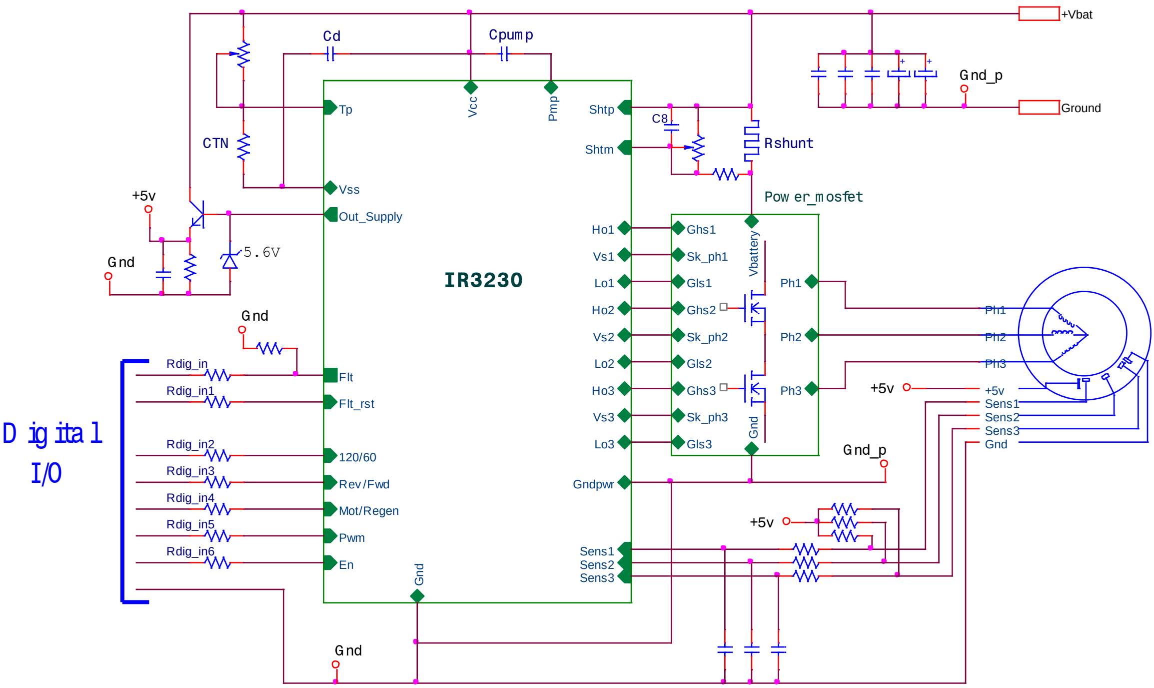
UV Pump on	*Shtp – Pmp charge pump under voltage on*	*4.9*	*5.3*	*5.75*	*V*	
UV Pump off	*Shtp – Pmp charge pump under voltage off*	*4.5*	*4.9*	*5.4*	*V*	
UV Pump hyst	*Shtp – Pmp charge pump under voltage hysteresis*	*0.2*	*0.37*	*0.6*	*V*	
UV Vss	*Vcc (Shtp)- Vss under voltage*	*3.9*	*4.8*	*5.7*	*V*	
UV Vcc gnd	*Vcc (Shtp)-Gnd under voltage*	*4.6*	*5.4*	*6*	*V*	
UV Vcc gndpwr	*Vcc-Gndpwp under voltage*	*4.6*	*5.4*	*6*	*V*	

Lead Assignments 4.6

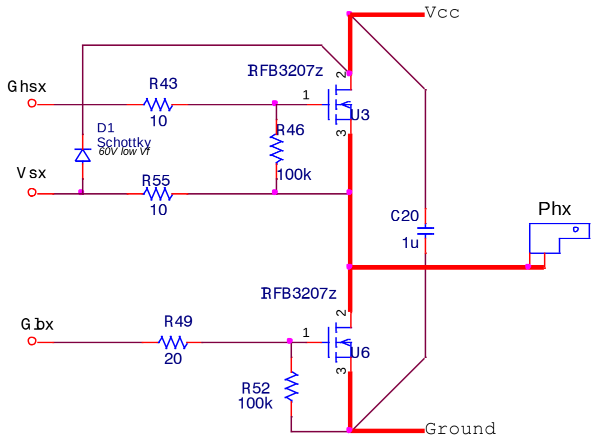
Part number / Lead assignments						IR3230SPbF
1	**120/60**	**11**	**Shtm**	**21**	**Vs1**	
2	**Rev/Fwd**	**12**	**Tp**	**22**	**Ho2**	
3	**Mot/Regen**	**13**	**Vss**	**23**	**Vs2**	
4	**Pwm**	**14**	**Lo1**	**24**	**Ho3**	
5	**En**	**15**	**Lo2**	**25**	**Vs3**	
6	**Flt_rst**	**16**	**Lo3**	**26**	**Sens3**	
7	**Flt**	**17**	**Gndpwr**	**27**	**Sens2**	
8	**Out_supply**	**18**	**Vcc**	**28**	**Sens1**	
9	**Gnd**	**19**	**Pmp**			
10	**Shtp**	**20**	**Ho1**			

SOIC-28L Wide Body

Typical Schematic:

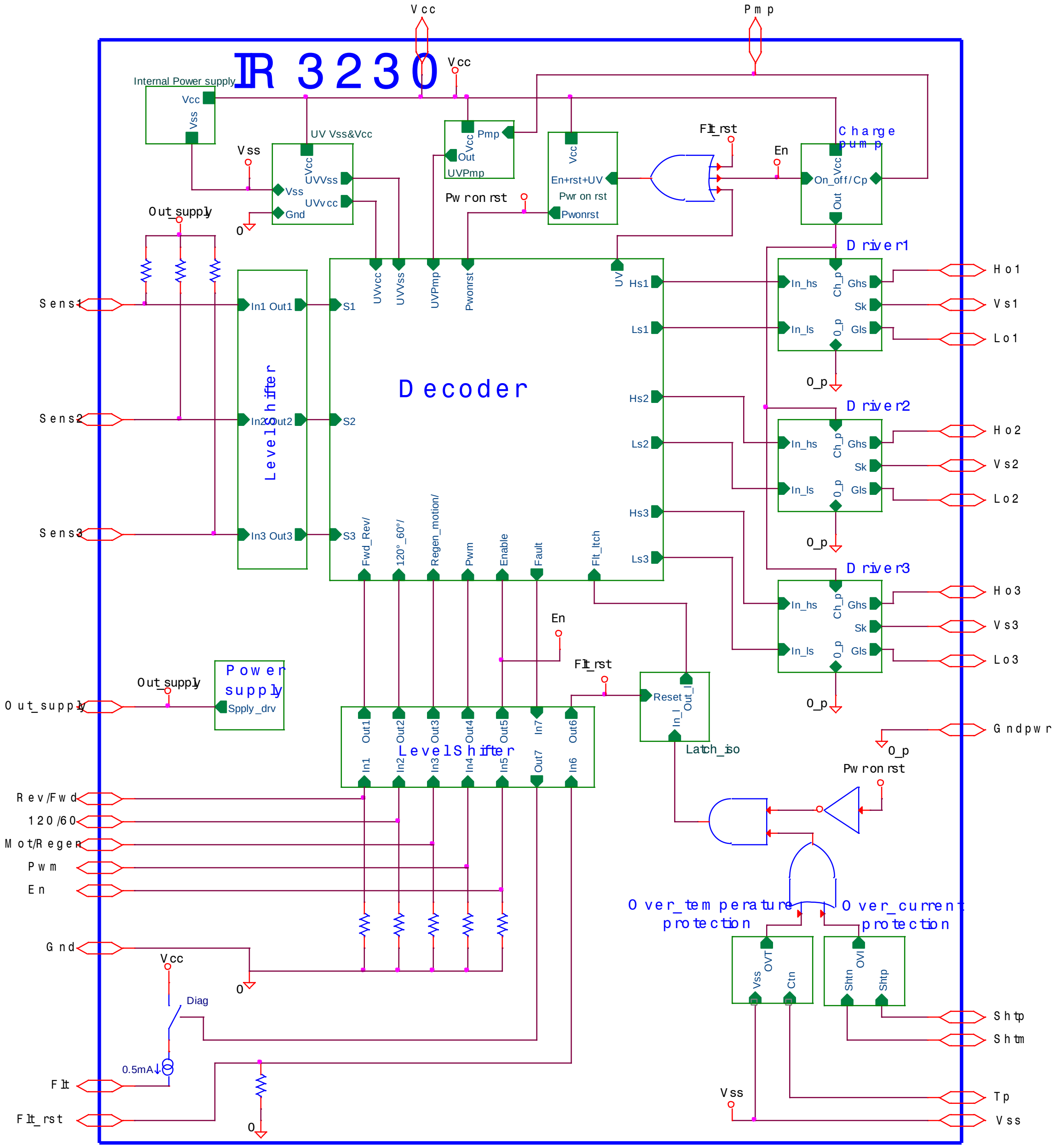


High side source connection for high current application:



Functional Block Diagram

All values are typical


IR3230
Vcc
Pmp
Internal Power supply
UV Vss&Vcc
Charge pump
Decoder
Level Shifter
Driver1
Driver2
Driver3
Power supply
Spply_drv
Out_supply
Pwron rst
Flt_rst
En
Latch_iso
Reset
Over_temperature protection
Over_current protection
Sens1
Sens2
Sens3
Rev/Fwd
120/60
Mot/Regen
Pwm
En
Gnd
Flt
Flt_rst
Ho1
Vs1
Lo1
Ho2
Vs2
Lo2
Ho3
Vs3
Lo3
Gndpwr
Shtp
Shtm
Tp
Vss
Diag
0.5mA

Simplified schematic:

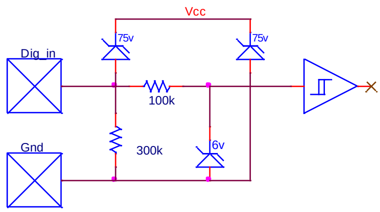


Figure 1: Digital input

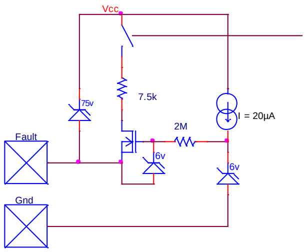


Figure 2: Fault output

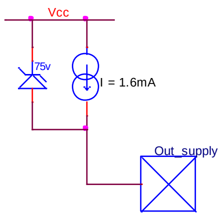


Figure 3: Out_supply

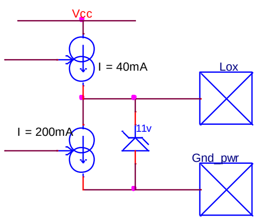


Figure 4: Lo output

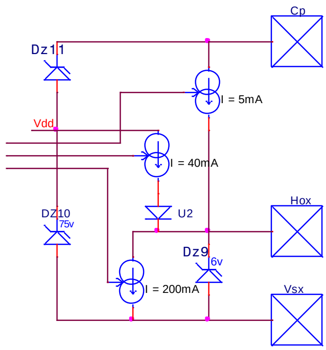


Figure 5: Hox output

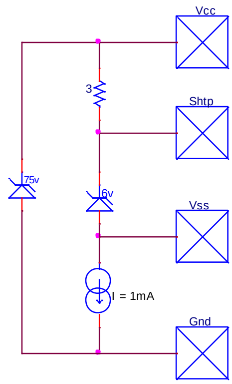


Figure 6: Vss pin

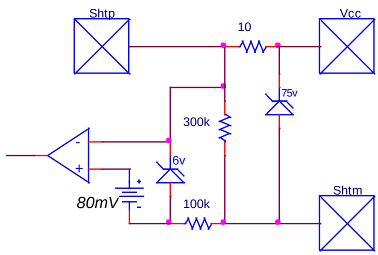


Figure 7: Sht_in

Decoder Table:

Inputs									Outputs							Motor			
Sensor electrical phasing						Operating mode selection			Diagnostic	Top drives			Bottom drives			Ph1	Ph2	Ph3	Direction
120/60 =0 ⇨60° mode			120/60 =1 ⇨120° mode																
S1	S2	S3	S1	S2	S3	Rev/Fwd	Mot/Regen	En	Flt	Ho1	Ho2	Ho3	Lo1	Lo2	Lo3				
Motor mode																			
0	0	0	1	0	1	0	1	1	0	1	0	0	0	Pwm	0	1	0	Hz	Fwd direction
1	0	0	1	0	0	0	1	1	0	1	0	0	0	0	Pwm	1	Hz	0	
1	1	0	1	1	0	0	1	1	0	0	1	0	0	0	Pwm	Hz	1	0	
1	1	1	0	1	0	0	1	1	0	0	1	0	Pwm	0	0	0	1	Hz	
0	1	1	0	1	1	0	1	1	0	0	0	1	Pwm	0	0	0	Hz	1	
0	0	1	0	0	1	0	1	1	0	0	0	1	0	Pwm	0	Hz	0	1	
0	0	0	1	0	1	1	1	1	0	0	1	0	Pwm	0	0	0	1	Hz	Rev direction
1	0	0	1	0	0	1	1	1	0	0	0	1	Pwm	0	0	0	Hz	1	
1	1	0	1	1	0	1	1	1	0	0	0	1	0	Pwm	0	Hz	0	1	
1	1	1	0	1	0	1	1	1	0	1	0	0	0	Pwm	0	1	0	Hz	
0	1	1	0	1	1	1	1	1	0	1	0	0	0	0	Pwm	1	Hz	0	
0	0	1	0	0	1	1	1	1	0	0	1	0	0	0	Pwm	Hz	1	0	
Regen mode																			
x	x	x	x	x	x	x	0	1	0	0	0	0	Pwm	Pwm	Pwm	Buck converter			Generator
Disable mode																			
x	x	x	x	x	x	x	x	0	0	0	0	0	0	0	0	Hz	Hz	Hz	Off
Fault mode																			
1	0	1	1	1	1	x	x	1	1	0	0	0	0	0	0	Hz	Hz	Hz	Off
0	1	0	0	0	0	x	x	1	1	0	0	0	0	0	0	Hz	Hz	Hz	

Keys	
x	Don't care
1	Active
0	not active
Hz	High impedance
Pwm	Signal on the pwm input

Fault Table:

latched fault	
Flt = 1	If [V(Sht+) - V(Sht-)] > 80mv
	or
	If [V(Vcc) - V(Tp)] > 50% of [V(Vcc) -V(Vss)]
	or
	If the sensor code is wrong

Not latched fault	
Flt = 1	If Flt_rst = 5v
	or
	If one of all UV is activated
	or
	If En is not activated
	or
	If the Tpwr_on_rst is activated

Logical equation:

1) 120° mode:

- *Forward direction:*

  - $Ho1 = S1 \bullet \overline{S2}$
  - $Ho2 = S2 \bullet \overline{S3}$
  - $Ho3 = S3 \bullet \overline{S1}$
  - $Lo1 = \overline{S1} \bullet S2$
  - $Lo2 = \overline{S2} \bullet S3$
  - $Lo3 = \overline{S3} \bullet S1$

- *Reverse direction:*

  - $Ho1 = \overline{S1} \bullet S2$
  - $Ho2 = \overline{S2} \bullet S3$
  - $Ho3 = \overline{S3} \bullet S1$
  - $Lo1 = S1 \bullet \overline{S2}$
  - $Lo2 = S2 \bullet \overline{S3}$
  - $Lo3 = S3 \bullet \overline{S1}$

2) 60° mode:

- *Forward direction:*

  - $Ho1 = \overline{S2} \bullet \overline{S3}$
  - $Ho2 = S1 \bullet S2$
  - $Ho3 = \overline{S1} \bullet S3$
  - $Lo1 = S2 \bullet S3$
  - $Lo2 = \overline{S1} \bullet \overline{S2}$
  - $Lo3 = S1 \bullet \overline{S3}$

- *Reverse direction:*

  - $Ho1 = S2 \bullet S3$
  - $Ho2 = \overline{S1} \bullet \overline{S2}$
  - $Ho3 = S1 \bullet \overline{S3}$
  - $Lo1 = \overline{S2} \bullet \overline{S3}$
  - $Lo2 = S1 \bullet S2$
  - $Lo3 = \overline{S1} \bullet S3$

Shtp & Shtm, over Current protection:

The IR3230 has shunt interface input: Shtp & Shtm. This shunt measurement is referenced to the Vcc (measurement on the battery line). Thanks to the shunt value and an external divider resistor, the user can adjust the maximum current in the motor. The internal threshold is Vth Isd. This protection is latched so the Flt output is activated (High state) to provide a diagnostic to the µP. This protection can be reset by activating Flt_rst high for more than Trst time. This protection works only in the motor mode.

Tp & Vss, over temperature protection:

The IR3230 has CTN interface input: Tp, Vss. This CTN is referenced to the Vss. Thanks to an external resistor in series with the CTN resistor; the user can adjust the maximum temperature threshold. The internal threshold is Vth Tsd. This protection is latched so the Flt output is activated (high state) to provide a diagnostic to the µP. This protection can be reset by activating Flt_rst high for more than Trst time.

Mot/Regen:

This digital input allows selecting the motor mode or the regeneration mode (braking mode). The µP needs to implement a delay to switch from one to the other to avoid shoot through short circuit and activate the over current fault. This can be calculating by using the "Td xxx xx" parameters in the Switching electrical characteristics. Use the following parameters as a simple rule:

- *Delay to go from the motor mode to the regen mode: use the maximum of the Td2 MtoR Hox off + the maximum of the Tf2_Hox-Vsx parameter.*
- *Delay to go from the regen mode to the motor mode: use the maximum of the Td1 RtoM Lox off + the maximum of theTf Lox parameter.*

Pwm:

In motion mode, through the pwm input, the µp controls the speed of the motor. This input provides duty cycle and the frequency to the low side switches in order of the sensor table selected by logical sensor input.
In regen mode (buck converter operation), It provides the duty cycle and the frequency to the 3 low side switches in same time independently of the sensor input sequence. So the µP can controls the regeneration current level in the battery and breaking the motor.

En:

The input Pin enable allows switching off all output power Mosfets and the Charge pump. This reduces the consumption of the device. The Out_supply output stays active to power supply the µP even if the Enable is set at 0V. En pin high wake up the device. When the voltage of charge pump capacitor reaches the UV pump threshold, the device wait for the power reset (Pwr on rst) and then it is ready to operate.

120/60°:

This digital input selects the right sensor table in order to the sensor electrical position 120° or 60°.

Out_supply:

This output provides a 1.6mA regulated current. This output can be used as a biasing to create a power supply thanks to an external zener diode and a bipolar ballast transistor. The created voltage of this power supply is defined by the value of the zener diode implemented. This power supply could be used to supply all external circuitries (Sensor, µP…).

Rev/Fwd:

This digital input selects the right sensor table in order to choose the motor direction forward and reverse.

Fault:

A minimum pull down resistor to gnd must be used to limit the current on this output. Please refer to the Absolute maximum ratings table. There is no internal pull down: value is undefined when not in fault if no external pull down resistor is used.
Refer to Fault table to check witch event will be latched or not.

Parameters curves:

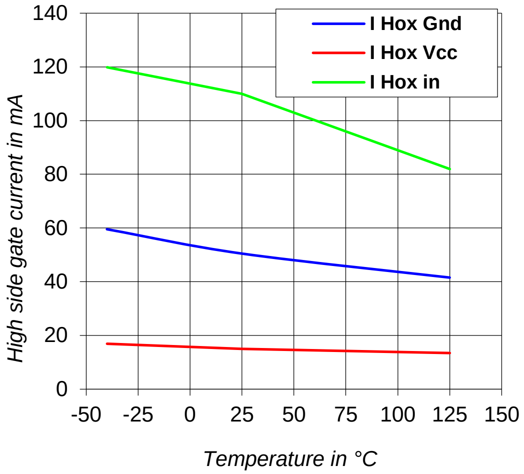


Figure 1: High side gate current vs. temperature

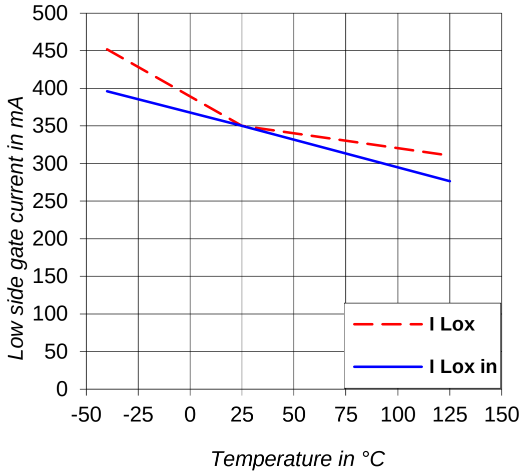


Figure 2: Low side gate current vs. temperature

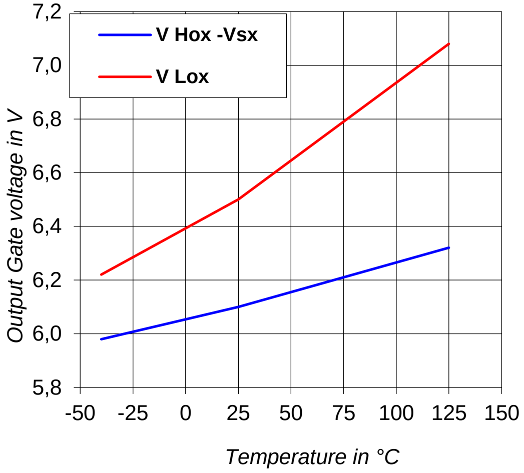


Figure3: Output gate voltage vs. temperature

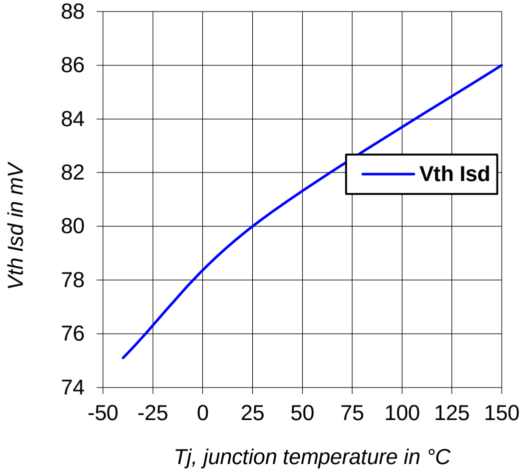
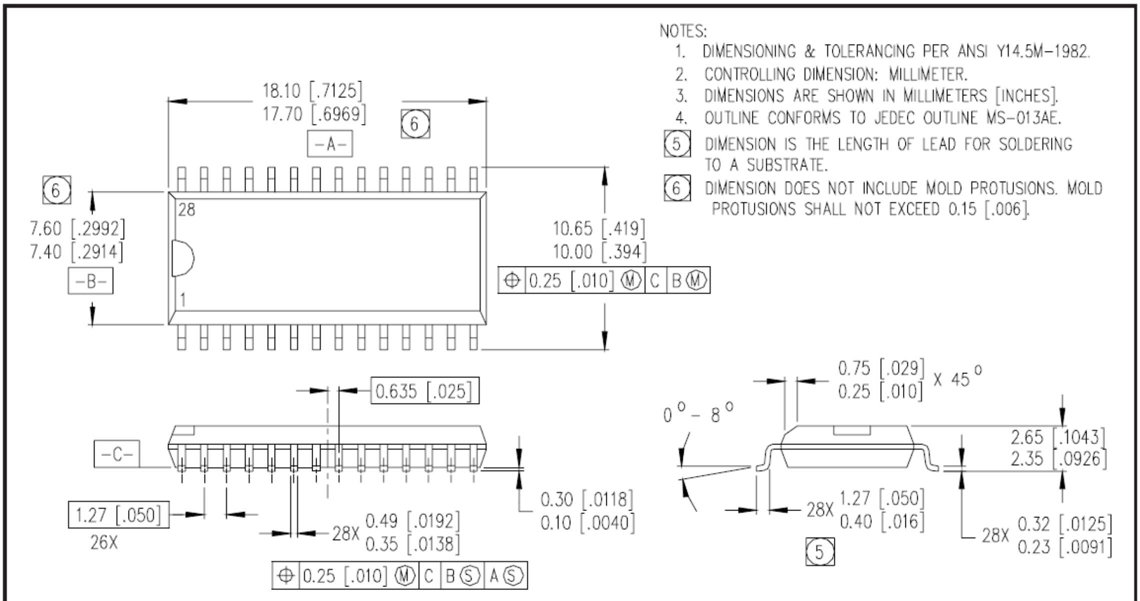
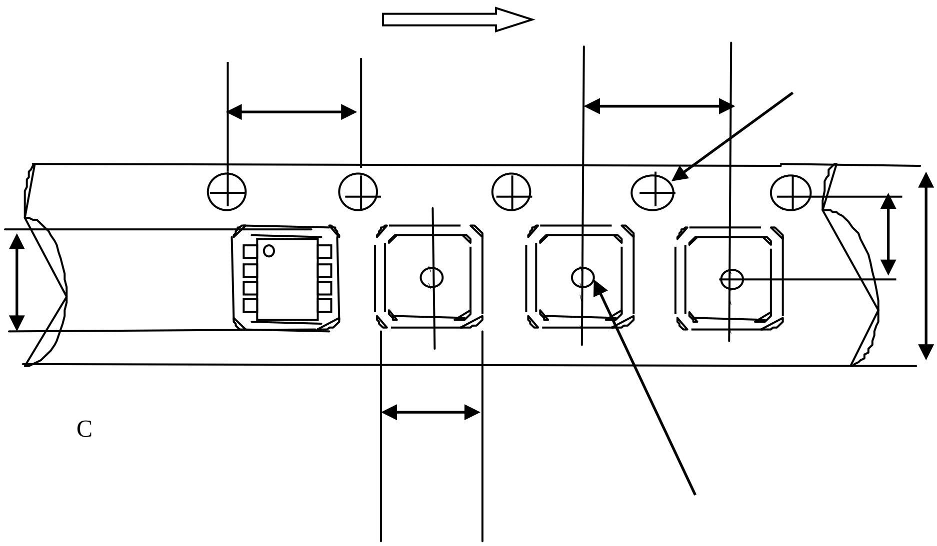


Figure4: Vth Isd Vs Tj

Package outline:

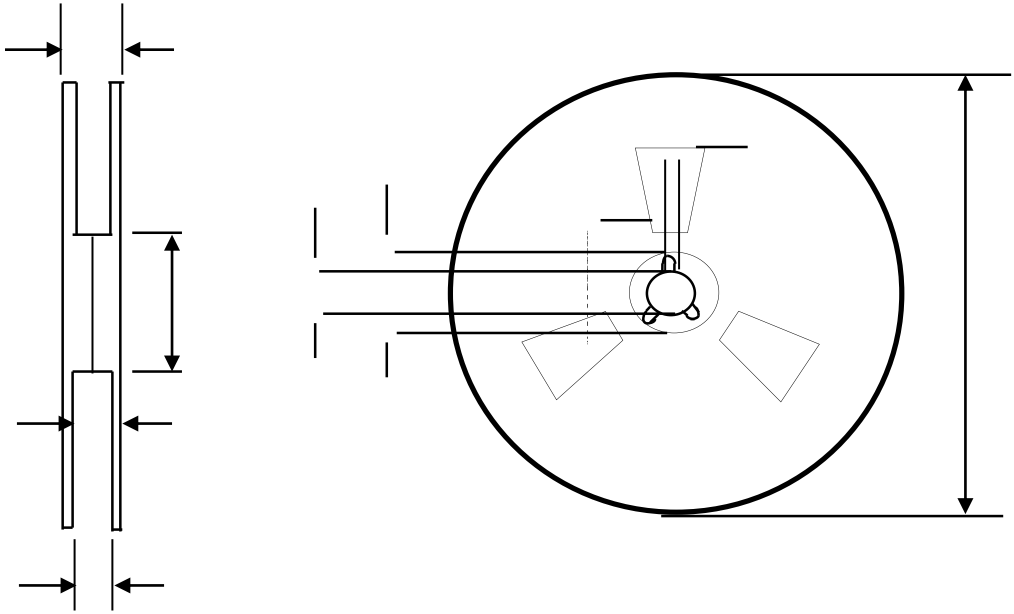


28 Lead SOIC (wide body)



CARRIER TAPE DIMENSION FOR 28SOICW

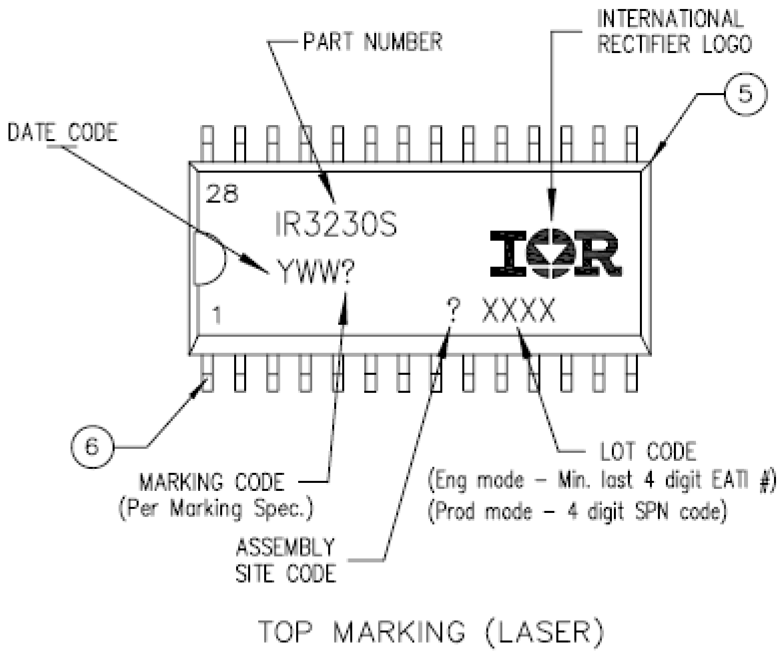
Code	Metric		Imperial	
	Min	*Max*	*Min*	*Max*
A	*11.90*	*12.10*	*0.468*	*0.476*
B	*3.90*	*4.10*	*0.153*	*0.161*
C	*23.70*	*24.30*	*0.933*	*0.956*
D	*11.40*	*11.60*	*0.448*	*0.456*
E	*10.80*	*11.00*	*0.425*	*0.433*
F	*18.20*	*18.40*	*0.716*	*0.724*
G	*1.50*	*n/a*	*0.059*	*n/a*
H	*1.50*	*1.60*	*0.059*	*0.062*



REEL DIMENSIONS FOR 28SOICW

Code	Metric		Imperial	
	Min	Max	Min	Max
A	329.60	330.25	12.976	13.001
B	20.95	21.45	0.824	0.844
C	12.80	13.20	0.503	0.519
D	1.95	2.45	0.767	0.096
E	98.00	102.00	3.858	4.015
F	n/a	30.40	n/a	1.196
G	26.50	29.10	1.04	1.145
H	24.40	26.40	0.96	1.039

Part Marking Information



Ordering Information

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
IR3230SPBF	*SOIC28W*	*Tube/Bulk*	*25*	*IR3230SPBF*
		Tape and Reel	*1000*	*IR3230STRPBF*

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Revision History

Revision	Date	Notes/Changes
A	*26/03/12*	*First release*
B	*August 7, 2012*	*Typo correction front page*