International IOR Rectifier

IR3230SPbF

April 2, 2012

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.

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:

Application:

- E-bike
- Fan and pump
- Actuators system
- Compressor

Package:





Qualification Information[†]

		Industrial'								
Qualifica	tion Level	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	MSL3260°C (per IPC/JEDEC J-STD-020)							
	Machina Madal	Class A								
	Machine Model	(per JEDEC standard JESD22-A115)								
FOD	Liveran Dark Madal	Cla	nss 1C							
ESD	Human Body Model	(per JEDEC standard JESD22-A114)								
	Charged Device Medal	Cla	ass IV							
	Charged Device Model	(per JEDEC stan	dard JESD22-C101)							
IC Latch-Un Tost		Class II, Level A								
le Laten-op lest		(per JEDEC standard JESD78)								
RoHS Co	ompliant	Yes								

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

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

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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	Symbol Parameter								
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	—	50	V						
V Dig in to Vcc	-0.3	75	V						
V Flt to Vcc	Flt to Vcc Maximum Flt to Vcc voltage								
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					
l 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	O°					

Thermal Characteristics

Symbol	Parameter	Тур.	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	μΑ
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		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.	Тур.	Max.	Units	Test Conditions
I Gnd Slp	Supply current in low consumption mode	0.3	1	2	mА	En = 0;
I Gnd On	Gnd current when the device is awake	1.2	2.5	4	mА	En = 1;
I Out_supply	Out _supply output current	1	1.7	3.1	mА	Vout_Vcc >6V
l Flt	Flt pin output current	3	6.6	10	mА	Flt = Gnd when fault
V Flt	Flt pin output voltage	4.5	5	5.8	V	$I Flt = 10 \mu A$
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
l 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	
l Hox Out_Gndpwr	High side gate output current Vsx < Vcc	38	50	85	mА	Hox = Vsx
I Hox Out_Vcc	High side gate output current Vsx > Vcc	7	15	19	mА	Hox = Vsx
l Hox In	High side gate input current	70	110	250	mА	(Hox - Vsx) = 6V, Vsx = Vcc
I Lox Out	Low side gate output current	250	350	700	mА	Lox = Gndpwr
I Lox In	Low side gate input current	250	350	700	mА	Lox = 6V

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

		Motor &	Regen r	node			
	Symbol	Parameter	Min.	Тур.	Max.	Units	Conditions
	Сритр	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
	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%
High side	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)
	Tr Lox	Low side rise time to turn on	0.04	0.1	0.3	μs	Lox load =2.2nF From 10% to 90%
de	Tf Lox	Low side fall time to turn off	0.04	0.1	0.3	μs	Lox load =2.2nF From 90% to 10%
-ow si	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

		Reg	jen mode	9			
	Symbol	Parameter	Min.	Тур.	Max.	Units	Conditions
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	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
		Mot	tor Mode)			
	Symbol	Parameter	Min.	Тур.	Max.	Units	Conditions
	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)
side	Td2 Sensx Hox onSensor to high side turn-on delay time Vsx = VccTd1 Sensx Hox offSensor to high side turn-off delay time Vsx = gndpwr		0.8	2.5	5	μs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 10% of (Hox – Vsx)
High			0.1	0.25	0.5	μs	(Hox-Vsx) load =2.2nF from 50% of Sensx to 90% of (Hox – Vsx)
	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)
	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
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	Td Sensx Lox on	Sensor to low side turn-off delay time		0.25	0.5	μs	Lox load =2.2nF from 50% of Sensx to 10% of Lox
	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.	Тур.	Max.	Units	Conditions
Vth Isd	Maximum over current shutdown threshold between Shtp and Shtm	65	80	97	mV	Rshunt =5 m $\Omega \rightarrow$ lmax =20A
Vth Tsd	External over temperature threshold	45	50	55	%	(Vtemp-VSht+)/(Vss- VSht+)
Tsd int	Internal over temperature threshold	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	

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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

			IR3230SPbF			
Lead	d assignments					
1	120/60	11	Shtm	21	Vs1	
2	Rev/Fwd	12	Тр	22	Ho2	
3	Mot/Regen	13	Vss	23	Vs2	
4	Pwm	14	Lo1	24	Ho3	the star
5	En	15	Lo2	25	Vs3	ALCON AP
6	Flt_rst	16	Lo3	26	Sens3	
7	Flt	17	Gndpwr	27	Sens2	2020
8	Out_supply	18	Vcc	28	Sens1	
9	Gnd	19	Pmp			
10	Shtp	20	Ho1			SOIC-28L Wide Body

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Typical Schematic:



High side source connection for high current application:





Functional Block Diagram

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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												
Se	ensor	elect	rical j	phasi	ng																		
12	20/60	=0	12	0/60	=1	Oper	ating mode selection	on	Diagnostic	Т	op driv	es	Bot	Bottom drives		Bottom drives		Bottom drives		Ph1	Ph2	Ph3	Direction
⇒∈	0° m	ode	⇒1:	20° n	iode																		
S1	S2	S3	S1	S2	S 3	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	-				
1	0	0	1	0	0	0	1	1	0	1	0	0	0	0	Pwm	1	Hz	0	tion				
1	1	0	1	1	0	0	1	1	0	0	1	0	0	0	Pwm	Hz	1	0	rec				
1	1	1	0	1	0	0	1	1	0	0	1	0	Pwm	0	0	0	1	Hz	1 di				
0	1	1	0	1	1	0	1	1	0	0	0	1	Pwm	0	0	0	Hz	1	ow5				
0	0	1	0	0	1	0	1	1	0	0	0	1	0	Pwm	0	Hz	0	1	Г				
0	0	0	1	0	1	1	1	1	0	0	1	0	Pwm	0	0	0	1	Hz					
1	0	0	1	0	0	1	1	1	0	0	0	1	Pwm	0	0	0	Hz	1	tior				
1	1	0	1	1	0	1	1	1	0	0	0	1	0	Pwm	0	Hz	0	1	rect				
1	1	1	0	1	0	1	1	1	0	1	0	0	0	Pwm	0	1	0	Hz	ib				
0	1	1	0	1	1	1	1	1	0	1	0	0	0	0	Pwm	1	Hz	0	Rev				
0	0	1	0	0	1	1	1	1	0	0	1	0	0	0	Pwm	Hz	1	0	-				
									Regen mod	le													
х	х	х	х	х	х	X	0	1	0	0	0	0	Pwm	Pwm	Pwm	Buc	k conve	erter	Generator				
									Disable mo	de													
х	х	х	х	х	х	х	х	0	0	0	0	0	0	0	0	Hz	Hz	Hz	Off				
									Fault mod	e													
1	0	1	1	1	1	х	x	1	1	0	0	0	0	0	0	Hz	Hz	Hz	Off				
0	1	0	0	0	0	х	x	1	1	0	0	0	0	0	0	Hz	Hz	Hz	UII				

	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	

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Logical equation:

1) 120° mode:

> Forward direction:

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

> Reverse direction:

$$\circ Ho1 = \overline{S1} \bullet S2 \qquad \circ Lo1 = S1 \bullet \overline{S2}$$

$$\circ Ho2 = \overline{S2} \bullet S3 \qquad \circ Lo2 = S2 \bullet \overline{S3}$$

$$\circ Ho3 = \overline{S3} \bullet S1 \qquad \circ Lo3 = S3 \bullet \overline{S1}$$

2) 60° mode:

> Forward direction:

$$\circ Ho1 = \overline{S2} \bullet \overline{S3} \qquad \circ Lo1 = S2 \bullet S3$$

$$\circ Ho2 = S1 \bullet S2 \qquad \circ Lo2 = \overline{S1} \bullet \overline{S2}$$

$$\circ Ho3 = \overline{S1} \bullet S3 \qquad \circ Lo3 = S1 \bullet \overline{S3}$$

> Reverse direction:

$$\begin{array}{cccc} \bullet & Ho1 = S2 \bullet S3 \\ \bullet & Ho2 = \overline{S1} \bullet \overline{S2} \\ \bullet & Ho3 = S1 \bullet \overline{S3} \end{array} \qquad \begin{array}{cccc} \bullet & Lo1 = \overline{S2} \bullet \overline{S3} \\ \bullet & Lo2 = S1 \bullet S2 \\ \bullet & Lo3 = \overline{S1} \bullet S3 \end{array}$$

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 μ P. 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 μ P. 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 μ P 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 the Tf 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 μ P 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 μ P 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, μ P...).

Rev/Fwd:

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

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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.

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Parameters curves:







Figure3: Output gate voltage vs. temperature



Figure 2: Low side gate current vs. temperature



Figure4: Vth Isd Vs Tj

Package outline:



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CARRIER TAPE DIMENSION FOR 28SOICW

	Metric		Imperial	
Code	Min	Max	Min	Max
A	11.90	12.10	0.468	0.476
В	3.90	4.10	0.153	0.161
С	23.70	24.30	0.933	0.956
D	11.40	11.60	0.448	0.456
Е	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
Н	1.50	1.60	0.059	0.062

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REEL DIMENSIONS FOR 28SOICW

	Metric		Imperial	
Code	Min	Max	Min	Max
Α	329.60	330.25	12.976	13.001
В	20.95	21.45	0.824	0.844
С	12.80	13.20	0.503	0.519
D	1.95	2.45	0.767	0.096
Е	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
Н	24.40	26.40	0.96	1.039

Part Marking Information



Ordering Information

Base Part Number	Package Type	Standard Pack		
		Form	Quantity	Complete Part Number
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
В	August 7, 2012	Typo correction front page

Mouser Electronics

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