International **I⊘R** Rectifier

IR3221

FULLY PROTECTED H-BRIDGE for DC MOTOR

Features

- Over temperature shutdown
- Over current shutdown
- Inrush current limited by Soft-Start sequence
- E.S.D protection
- Sleep mode for direct battery connection
- Braking / non-braking operation
- Internal switching oscillator
- Direct interface for End switches

Product Summary

|	
Rdson	15 mΩ max.
Vcc.op.	5.5 to 35 V
I cont. (heat sink)	20.0 A
I shutdown	50 A
Oper. Freq.	20 kHz

Description

The IR3221 is a Fully Protected Dual High Side Switch I.C. With two additional Low Side switches (IRL1404), the IR3221 drives and controls the whole H bridge topology. It provides shoot-through protection for each leg, H bridge logic control, soft-start sequence and over-current /over-temp. protections. The signals IN1 and IN2 select the operation modes and the PWM Soft-Start sequence cycles the corresponding active low side switch in order to limit the motor inrush current. By using the recommended part number and the proper cooling, the inner High Side IPS protects the whole H-bridge function. The Soft-Start sequence is programmed by an RC time constant and reset itself automatically.

Packages

SIP 15   TO220 - IRL1404

Block Diagram

IR3221

International
IOR Rectifier
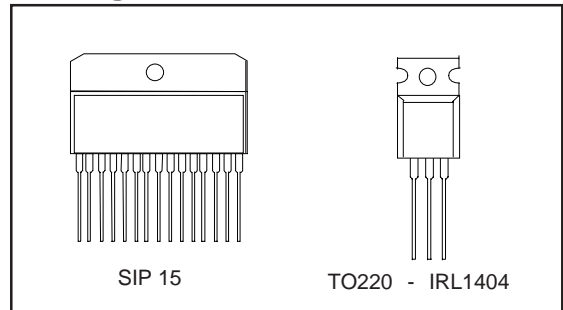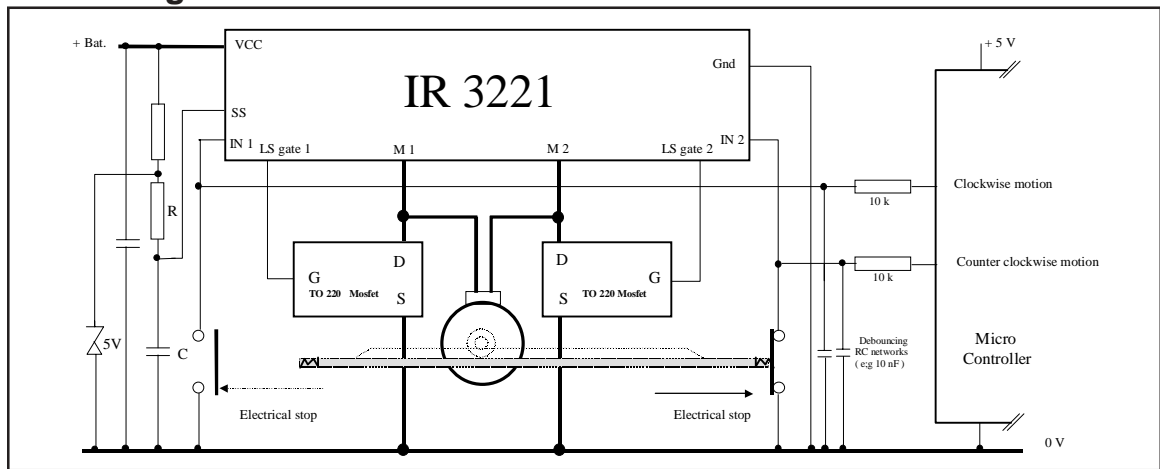
Absolute Maximum Ratings

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to GROUND pin . T Ambient = 25 °c unless otherwise specified.

Symbol	Parameter	Min.	Max.	Unit
Vm1(2)	Maximum M1 (M2) voltage (active clamp)	Vcc-37	Vcc+0.3	V
Vin1 (2)	Maximum IN 1 (IN 2) voltage	-0.3	5.5	V
I in1 (2)	Maximum IN1 (IN 2) current	-1	10	mA
Vg1 (2)	Maximum Gate 1 (Gate 2) voltage	-0.3	7.5	V
Vss	Maximum SS voltage	-0.3	5.5	V
Isd cont.	Diode max. permanent current (Rth=50°C/W) ◯ 1	-	4	A
Isd pulsed	Diode max. pulsed current ◯ 1	-	45	A
Esd 1	Electrostatic Disch. (human body model)C=100 pF R= 1500 Ω	-	4	kV
Esd 2	Electrostatic Disch. (Machine model) C=200 pF R= 0 Ω	-	0.5	kV
Pd	Maximum power dissipation (Rth=50°C/W)	-	2.5	W
Tj max.	Maximum storage & operating junction temperature	-40	+150	°C
T lead	Lead temperature (soldering 10 s)	-	300	°C

① Limited by junction temperature (pulsed current limited also by internal wiring

Thermal Characteristics

Symbol	Parameter	typ	max	Unit
R th 1	Junction to amb. Thermal resistance	50	-	°C/W
R th 2	Junction to tab Thermal resistance	1.0	-	°C/W

Recommended Operating Conditions

Those values are given for a quick design. For operation outside those conditions, please consult the application note AN 1032

Symbol	Parameter	Min.	Max.	Unit
Vcc	Continuous Vcc voltage ②	8	28	V
Vin1(2)	High level IN1 (IN 2) input voltage	4	5.5	V
Vin1(2)	Low level IN1 (IN2) input voltage	-0.3	0.9	V
Iout max. 1	Output cont. current (Rthja=50°C/w, tamb=85°C, Tj=150°C)	-	7.7	A
Iout max 2	Output cont. current (Rthja=5°C/w, tamb=105°C, Tj=150°C)	-	24	A
R in	Recommended resistor in series with IN pin	10	20	kΩ
R	Soft-Start resistor	5.0	390	kΩ
C	Soft-Start capacitor	0.1	3.3	µF
R gates	Recommended gate resistors for Low Side Switches	0	50	Ω

② Protections are operating down to 5.5 V

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Static Electrical Characteristics

$T_j = 25^oC$, $V_{CC} = 14V$ unless otherwise specified.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
Rds on @ Tj = 25°C	ON state resistance Tj = 25 °C	-	12	16	mΩ	Vin1,2 = 5 V ; Im1,2 = 5 A
Rds on @ Tj = 150°C	ON state resistance Tj = 150 °C	-	20	-	mΩ	Vin1,2 = 5 V ; Im1,2 = 5 A
Vcc oper.	Operating voltage range	5.5	-	35	V	
V clamp1 (2)	Vcc to M1 (M2) clamp voltage	37	40	48	V	Id = 10 mA see Fig. 1 & 2
Vf1(2)	Body diode 1(2)forward voltage	-	0.9	-	V	Id = 5 A ; Vin1,2 = 0 V
I M1(2) leakage	M1 (M2) output leakage current	-	10	50	μA	Vm1,2 = 0 V ; Tj = 25 °c
Icc off	Supply current when off (sleep mode)	-	10	50	μA	Vin1,2 = 0 V, Tj = 25 °c
Icc on	Supply current when on	-	8	-	mA	Vin1 = 5 V
V ih1(2) threshold	IN1 (IN2) high threshold voltage	-	2.6	-	V	
V il1 (2) threshold	IN1 (IN2) low threshold voltage	-	2.0	-	V	
I in1(2)	ON state IN1 (IN2) positive current	-	35	-	μA	Vin1,2 = 5 V
Vccuv+	Vcc UVLO positive going threshold	-	4.5	-	V	
Vccuv-	Vcc UVLO negative going threshold	-	4.2	-	V	
Vss +	SS high level threshold	-	4.2	-	V	
Vss -	SS low level threshold	-	1.2	-	V	
I ss leakage	SS pin leakage current	-	-	10	uA	

Switching Electrical Characteristics

$V_{CC} = 14V$, Resistive Load =2.8Ω, R input = 10kΩ, and $T_j = 25^oC$ for each high side switch (unless otherwise specified).

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
td-on	Turn-on delay time	-	5	-	μS	see fig. 3
Tr 1	Rise time to Vout = Vcc - 5 V	-	4	-	μS	see fig. 3
Tr 2	Rise time to Vout = 90% of Vcc	-	65	-	μS	see fig. 3
dV/dt (on)	Turn-ON dV/dt	-	3	-	V/μs	see fig. 3
Eon	Turn-ON energy	-	3	-	mJ	
td-off	Turn-off delay time	-	65	-	μS	see fig. 4
Tf	Fall time to Vout = 10% of Vcc	-	8	-	μS	see fig. 4
dV/dt (off)	Turn-OFF dV/dt	-	5	-	V/μs	see fig. 4
Eoff	Turn-OFF energy	-	0.75	-	mJ	
IN1(2) Max. Freq.	Max. Frequency on IN1 (IN2)	-	500	-	Hz	
Soft-Start freq.	Soft-Start oscillator frequency	15	20	30	kHz	
I g1 (2) Max.	Max. Gate 1 (Gate 2) current	50	-	-	mA	low side driver
Trd	Min. IN1(2) OFF time to reset SS	2.0	-	-	mS	C=3.0 uF,IN1=IN2

Protection Characteristics

(High side switch protection)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
Tsd	Over-temperature threshold	-	165	-	°C	see fig. 2
Isd	Over-current threshold	42	50	60	A	see fig. 2
T reset	Minimum time to reset protections		300	-	µS	IN1=IN2 = 0 V

Note : The low side switches present sufficient cooling capability in order to have the whole H-bridge function
protected by the IR 3221 inner temperature sensor.

Truth Table

IN1	IN2	MODES	HS1	LSS1	HS2	LSS2	SS reset
L	L	Stand-by with braking - sleep mode **	OFF	ON	OFF	ON	ON
L	H	forward rotation (normal operation)	OFF	ON*	ON	OFF	OFF
L	H	forward rotation (protection triggered)	OFF	ON*	OFF	OFF	OFF
H	L	reverse rotation (normal operation)	ON	OFF	OFF	ON*	OFF
H	L	reverse rotation (protection triggered)	OFF	OFF	OFF	ON*	OFF
H	H	Stand-by without braking	OFF	OFF	OFF	OFF	ON

* During Soft-Start sequence, the low side part is switching.   ** Protections are reset in this mode

Block Diagram
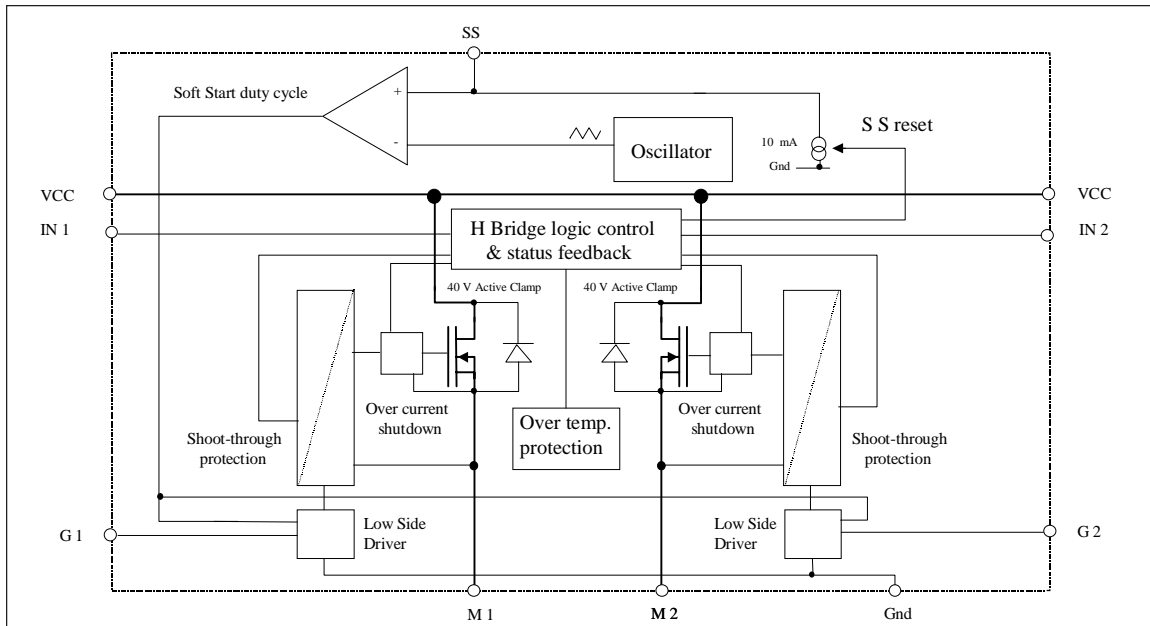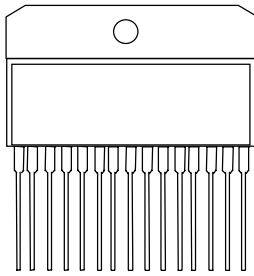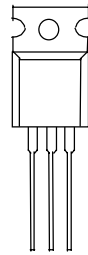
Lead Definitions

Vcc	Positive power supply	IN1	Logic input 1 (Leg 1 Cdt. / mode)
M1	Motor 1 output (high side source - leg 1)	IN2	Logic input 2 (Leg 2 Cdt. / mode)
M2	Motor 2 output (high side source - leg 2)	SS	RC soft-start input (the voltage on this input
G1	Gate 1 drive output (low side gate - leg 1)		drives the switching duty cycle)
G2	Gate 2 drive output (low side gate - leg 2)		
Gnd	Power supply return		

Recommended Low Side Mosfet

IRL1404	4.5 m Ω / 40 V – TO 220 packaged Power Mosfet

Lead Assignments

m1 m1 m1 nc g1 gnd ss Vcc in2 in1 g2 nc m2 m2 m2

SIP 15

G D S

TO 220

IR 3221

IRL1404

Soft-Start Sequence

IN1
(IN2)

SS

Vss+
Vss-

M1-M2
(M2-M1)

Duty cycle modulation follows SS voltage

Tss (approximately 2 x RC time constant)

Trd

t
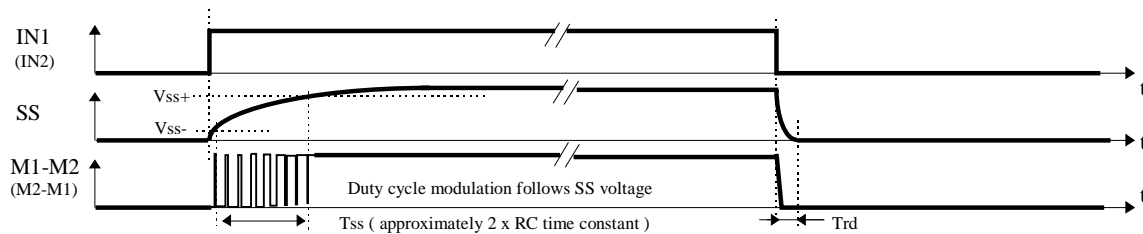
Permanent Switching Operation

(Without external RC time constant)

Additional Schottky diodes have to be implemented if the I.C temperature appears too high.

A over-voltage protection may be needed depending on the power supply wire length
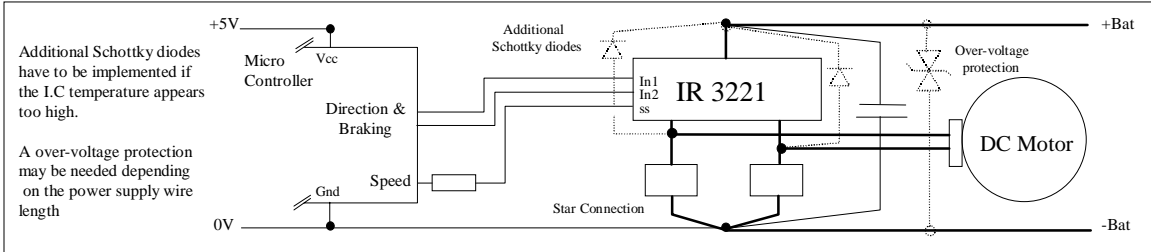
Note: SS pin (through a resistor) can either drive the PWM duty cycle of the inner 20 kHz oscillator or force the switching frequency (5V external clock signal).
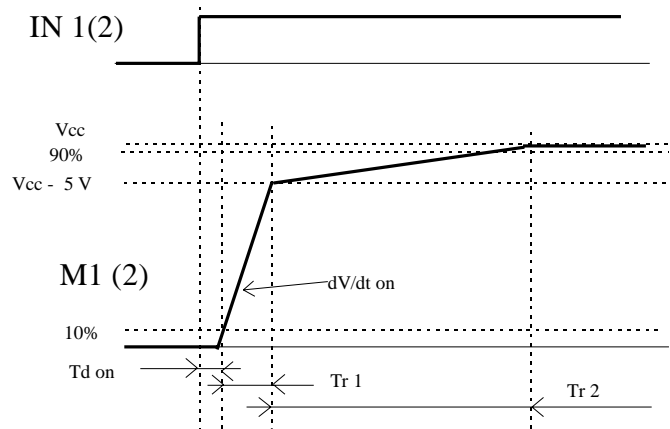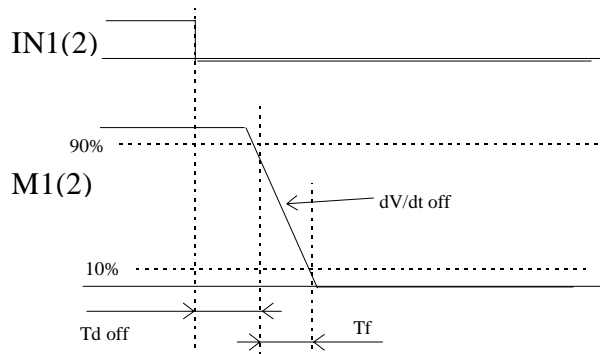

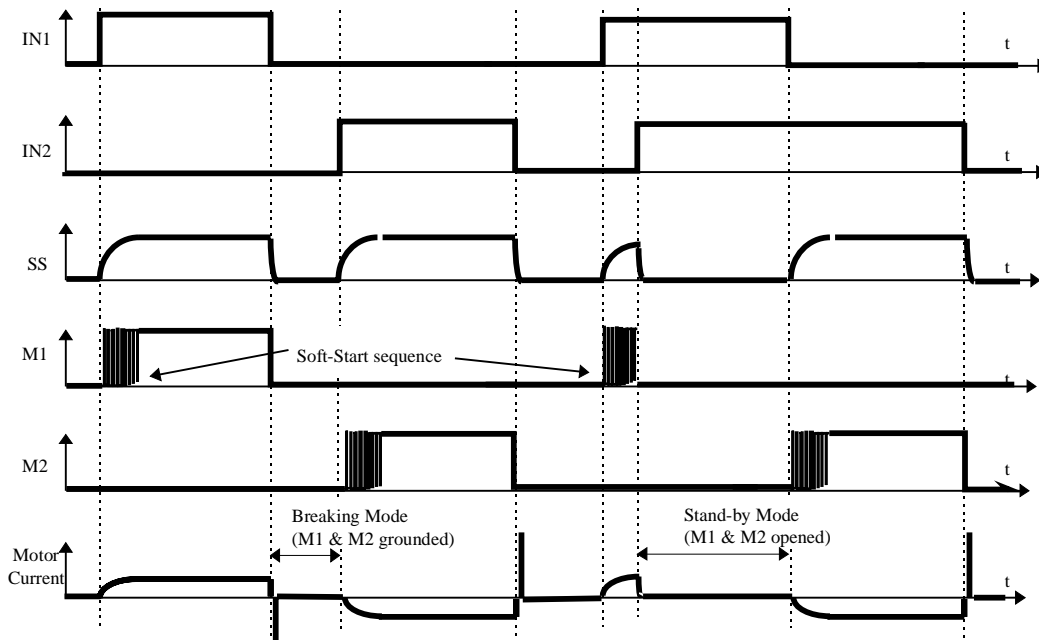Figure 3 - Switching times definition (turn-on)

Figure 4 - Switching times definition (turn-off)

Figure 5 - IN1 (2) & M1 (2) Timing Diagrams
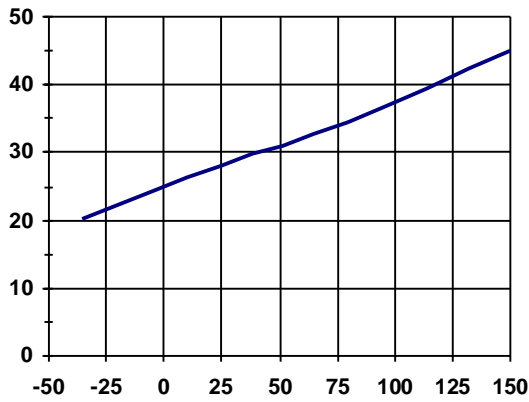
Figure 6 - IN1 (2) current (µA) Vs Tj (ºC)
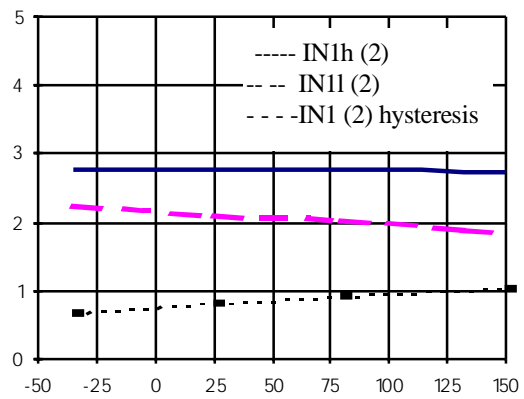
Figure 7 - IN1 & IN1h (2) thresholds (V) Vs Tj (ºC)
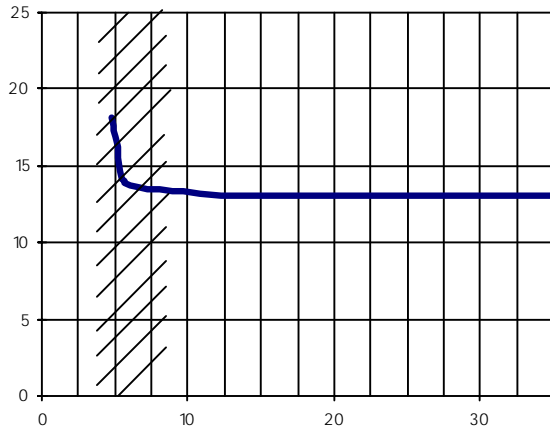
Figure 8 - Rdson (mΩ) (V) Vs Vcc (V)

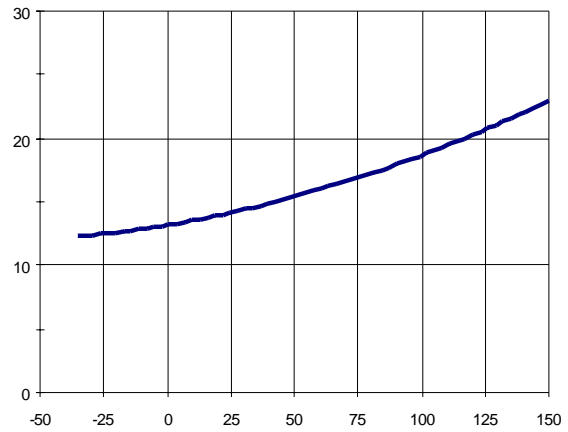Figure 9 - Rdson (mΩ) (V) Vs Tj (ºC)

- - - 1'' square footprint
------- standard footprint

Eon
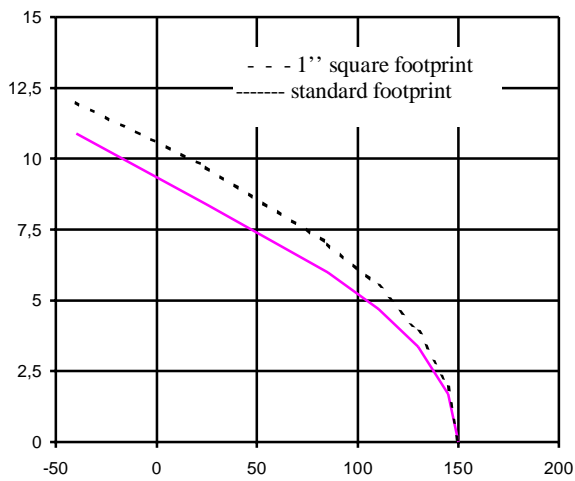
Eoff

Figure 10 - Max. Cont. current (A) Vs Amb. Temp. (ºC)
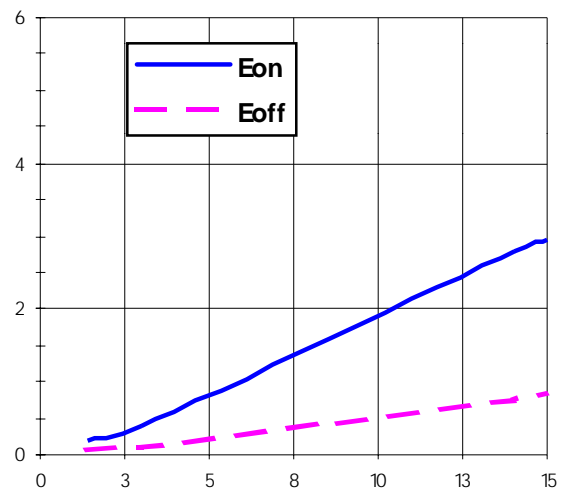
Figure 11 - Eon, Eoff (mJ) Vs | M1(2) (A)
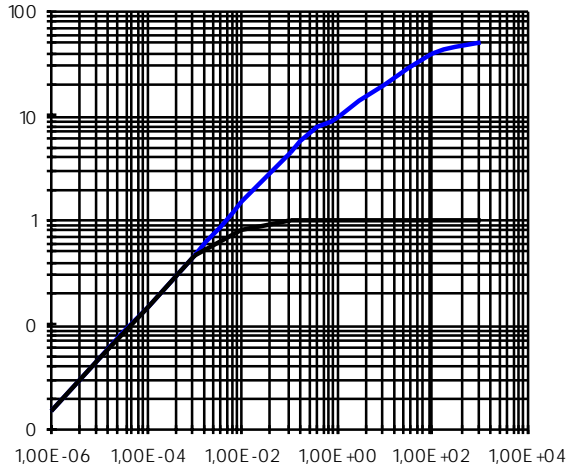
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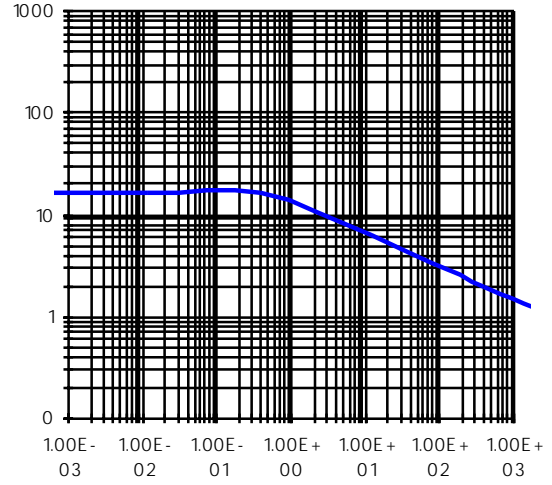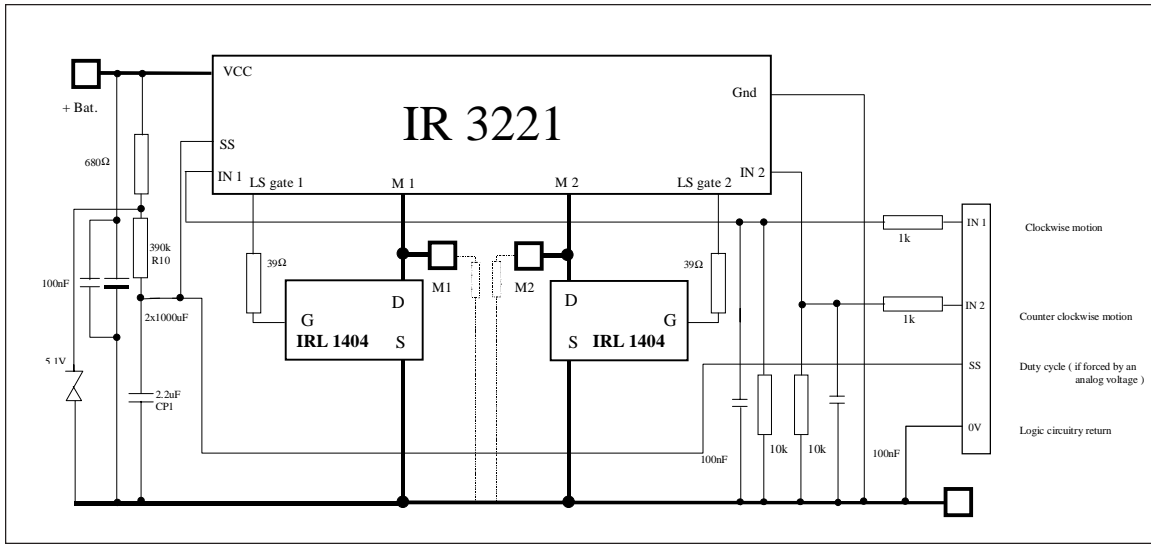Figure 12 - Transient Thermal Imped. (ºC/W) Vs Time (S)

Figure 13 - Iclamp (A) Vs Power Supply Wire
Inductance (mH - single pulse)

20 A H-Bridge Demoboard

Note: Refer to AN 1032 application note for a detailed description of the functionality.

DC Power Suplly

20 A Continuous operation DC Motor

5V Logic command signals
(forward, reverse, braking, variable duty cycle … etc)

Soft Start Programmable time constant R10 / CP1