

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

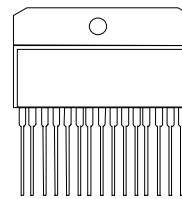
Product Summary

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

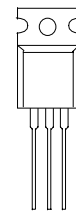
Description

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

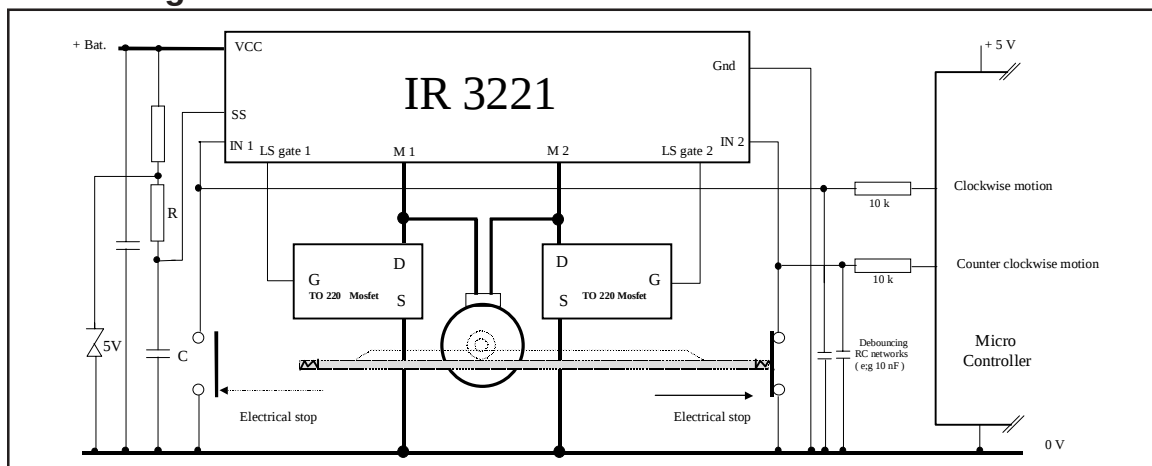


SIP 15



TO220 - IRL1404

Block Diagram



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
V _{m1(2)}	Maximum M1 (M2) voltage (active clamp)	V _{CC} -37	V _{CC} +0.3	V
V _{in1 (2)}	Maximum IN 1 (IN 2) voltage	-0.3	5.5	V
I _{in1 (2)}	Maximum IN1 (IN 2) current	-1	10	mA
V _{g1 (2)}	Maximum Gate 1 (Gate 2) voltage	-0.3	7.5	V
V _{ss}	Maximum SS voltage	-0.3	5.5	V
I _{sd cont.}	Diode max. permanent current (R _{th} =50°C/W)	○ 1	4	A
I _{sd pulsed}	Diode max. pulsed current	○ 1	45	A
E _{sd 1}	Electrostatic Disch. (human body model)C=100 pF R= 1500 Ω	-	4	kV
E _{sd 2}	Electrostatic Disch. (Machine model) C=200 pF R= 0 Ω	-	0.5	kV
P _d	Maximum power dissipation (R _{th} =50°C/W)	-	2.5	W
T _{j 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

Static Electrical Characteristics

$T_j = 25^{\circ}\text{C}$, $V_{CC} = 14\text{V}$ unless otherwise specified.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
$R_{ds\ on\ @\ T_j = 25^{\circ}\text{C}}$	ON state resistance $T_j = 25^{\circ}\text{C}$	-	12	16	$\text{m}\Omega$	$V_{in1,2} = 5\text{V}$; $I_{m1,2} = 5\text{A}$
$R_{ds\ on\ @\ T_j = 150^{\circ}\text{C}}$	ON state resistance $T_j = 150^{\circ}\text{C}$	-	20	-	$\text{m}\Omega$	$V_{in1,2} = 5\text{V}$; $I_{m1,2} = 5\text{A}$
$V_{cc\ oper.}$	Operating voltage range	5.5	-	35	V	
$V_{clamp1\ (2)}$	V_{CC} to M1 (M2) clamp voltage	37	40	48	V	$I_d = 10\text{mA}$ see Fig. 1 & 2
$V_{f1(2)}$	Body diode 1(2) forward voltage	-	0.9	-	V	$I_d = 5\text{A}$; $V_{in1,2} = 0\text{V}$
$I_{M1(2)\ leakage}$	M1 (M2) output leakage current	-	10	50	μA	$V_{m1,2} = 0\text{V}$; $T_j = 25^{\circ}\text{C}$
$I_{cc\ off}$	Supply current when off (sleep mode)	-	10	50	μA	$V_{in1,2} = 0\text{V}$, $T_j = 25^{\circ}\text{C}$
$I_{cc\ on}$	Supply current when on	-	8	-	mA	$V_{in1} = 5\text{V}$
$V_{ih1(2)\ threshold}$	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	$V_{in1,2} = 5\text{V}$
V_{ccuv+}	V_{CC} UVLO positive going threshold	-	4.5	-	V	
V_{ccuv-}	V_{CC} UVLO negative going threshold	-	4.2	-	V	
$V_{ss\ +}$	SS high level threshold	-	4.2	-	V	
$V_{ss\ -}$	SS low level threshold	-	1.2	-	V	
$I_{ss\ leakage}$	SS pin leakage current	-	-	10	μA	

Switching Electrical Characteristics

$V_{CC} = 14\text{V}$, Resistive Load $= 2.8\Omega$, R input $= 10\text{k}\Omega$, and $T_j = 25^{\circ}\text{C}$ for each high side switch (unless otherwise specified).

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
t_{d-on}	Turn-on delay time	-	5	-	μS	see fig. 3
$T_r\ 1$	Rise time to $V_{out} = V_{CC} - 5\text{V}$	-	4	-	μS	see fig. 3
$T_r\ 2$	Rise time to $V_{out} = 90\%$ of V_{CC}	-	65	-	μS	see fig. 3
$dV/dt\ (on)$	Turn-ON dV/dt	-	3	-	$\text{V}/\mu\text{S}$	see fig. 3
E_{on}	Turn-ON energy	-	3	-	mJ	
t_{d-off}	Turn-off delay time	-	65	-	μS	see fig. 4
T_f	Fall time to $V_{out} = 10\%$ of V_{CC}	-	8	-	μS	see fig. 4
$dV/dt\ (off)$	Turn-OFF dV/dt	-	5	-	$\text{V}/\mu\text{S}$	see fig. 4
E_{off}	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
T_{rd}	Min. IN1(2) OFF time to reset SS	2.0	-	-	mS	$C = 3.0\ \mu\text{F}$, $I_{N1} = I_{N2}$

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.

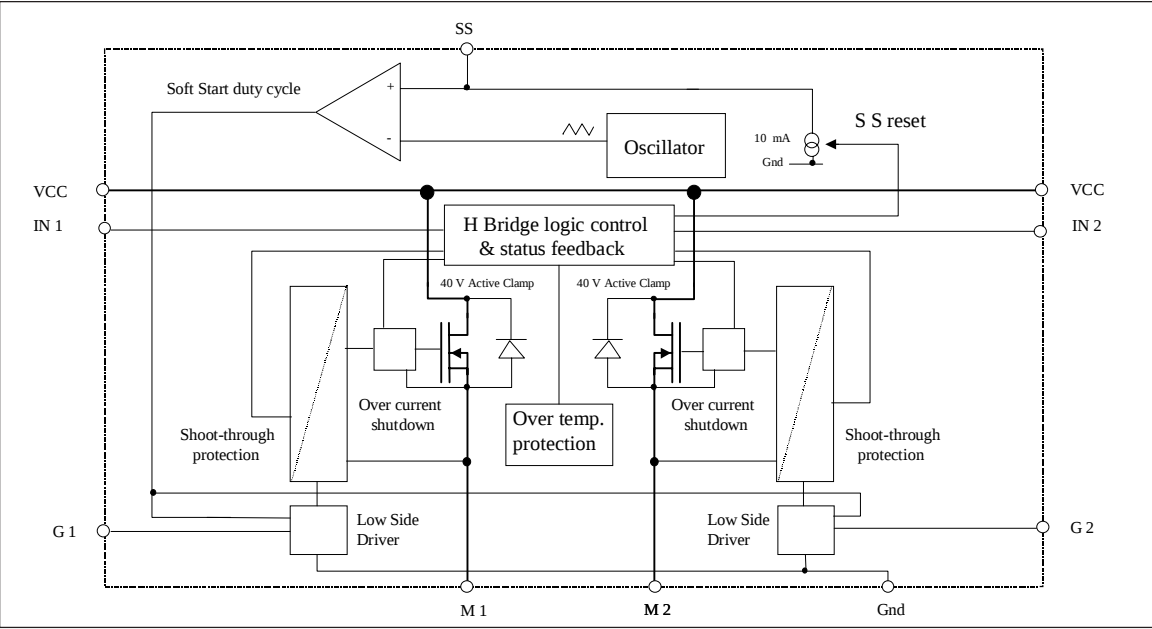
Truth Table

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



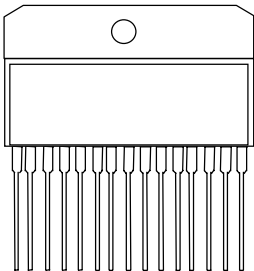
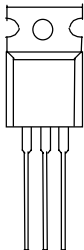
Lead Definitions

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 drives the switching duty cycle)
G1	Gate 1 drive output (low side gate - leg 1)		
G2	Gate 2 drive output (low side gate - leg 2)		
Gnd	Power supply return		

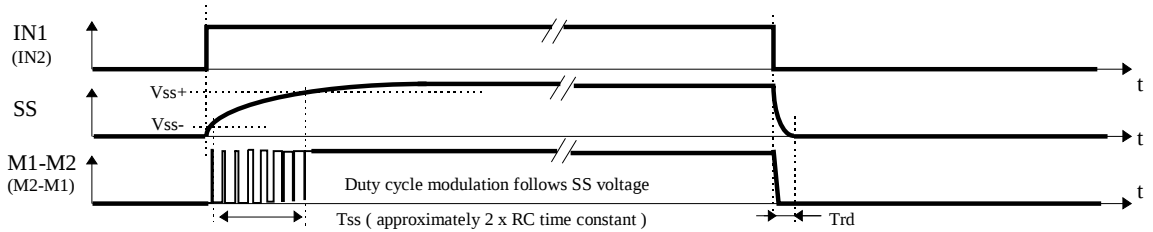
Recommended Low Side Mosfet

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

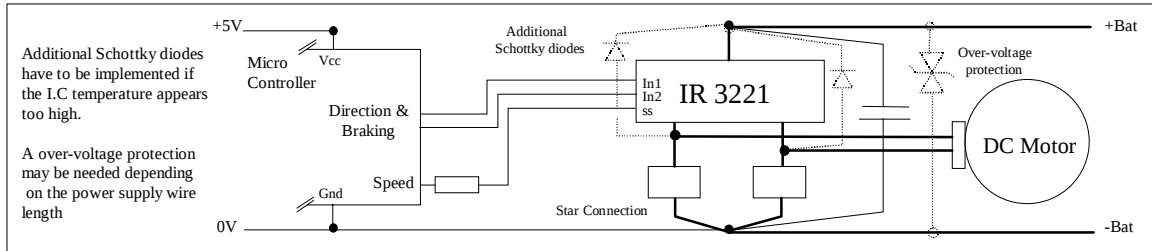
 m1 m1 m1 nc g1 gnd ss Vcc in2 in1 g2 nc m2 m2 m2 SIP 15 IR 3221	 G D S TO 220 IRL1404
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Soft-Start Sequence



Permanent Switching Operation

(Without external RC time constant)



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).

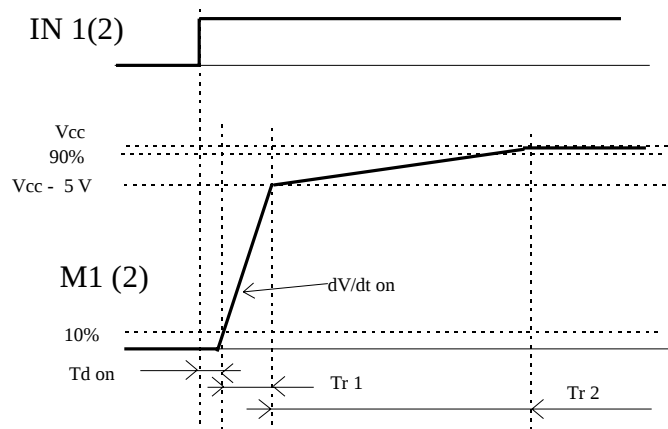


Figure 3 - Switching times definition (turn-on)

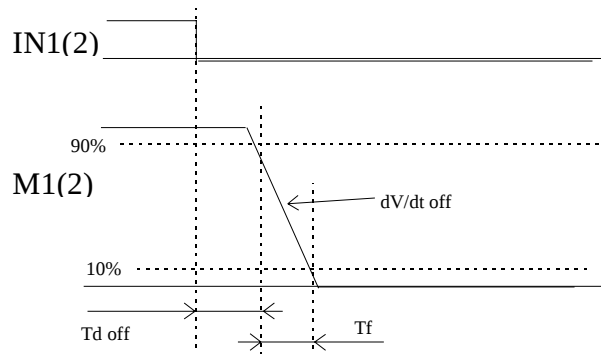


Figure 4 - Switching times definition (turn-off)

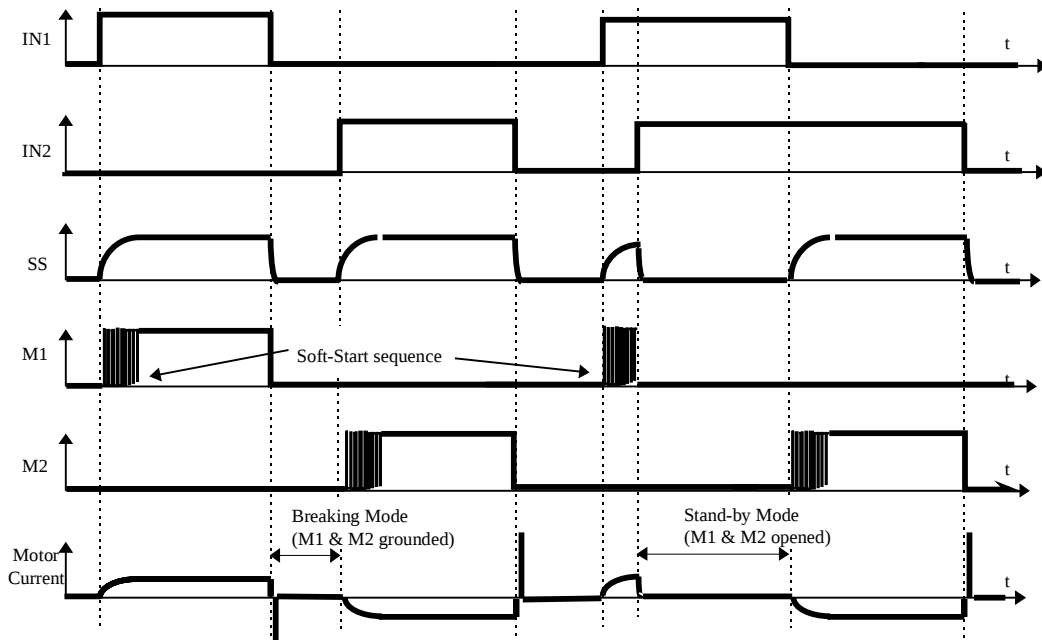


Figure 5 - IN1 (2) & M1 (2) Timing Diagrams

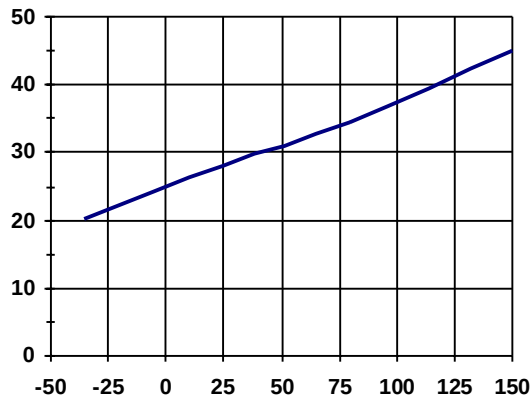


Figure 6 - IN1 (2) current (μA) Vs T_j ($^{\circ}\text{C}$)

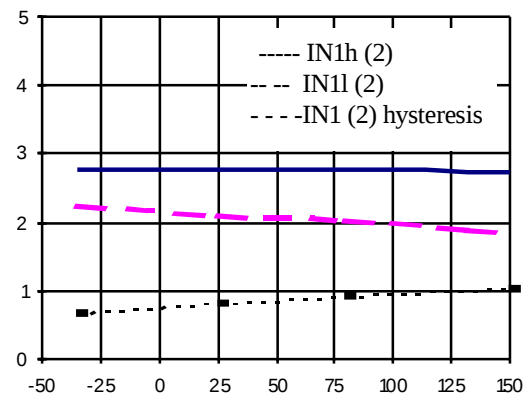


Figure 7 - IN1 & IN1h (2) thresholds (V) Vs T_j ($^{\circ}\text{C}$)

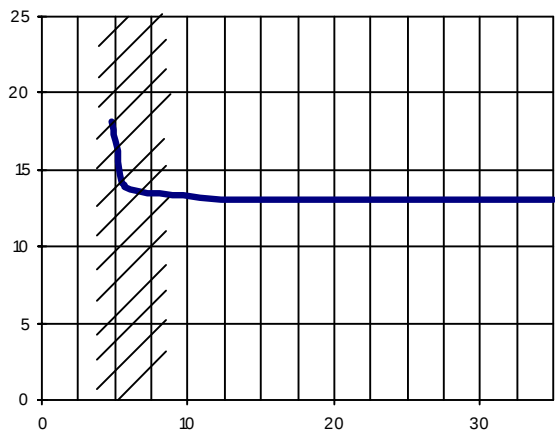


Figure 8 - Rdson (mΩ) (V) Vs Vcc (V)

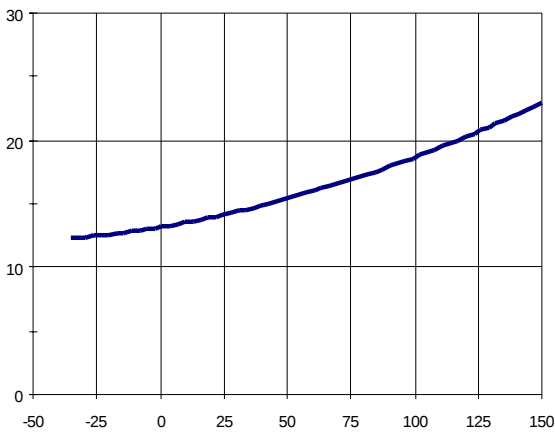


Figure 9 - Rdson (mΩ) (V) Vs Tj (°C)

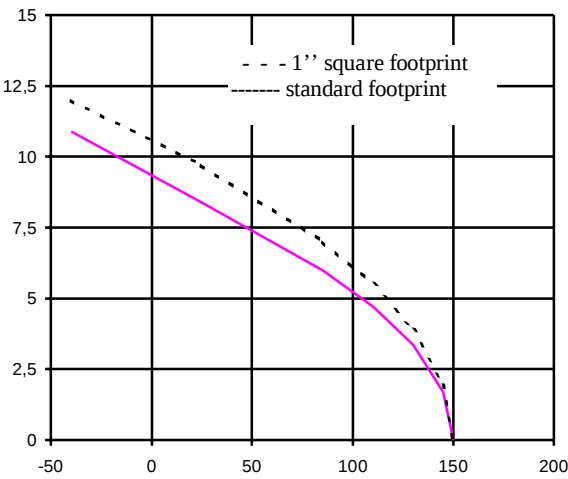


Figure 10 - Max. Cont. current (A) Vs Amb. Temp. (°C)

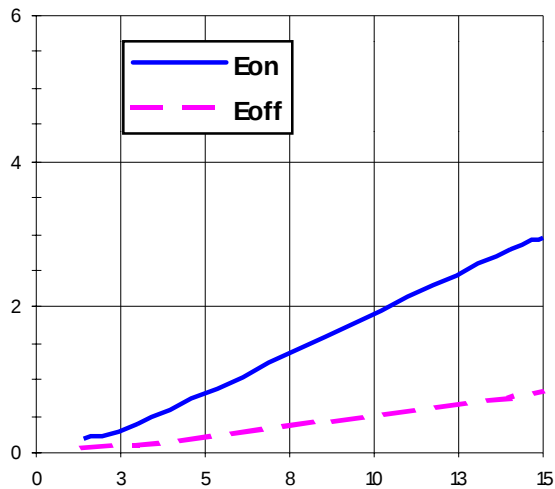


Figure 11 - Eon, Eoff (mJ) Vs |M1(2)| (A)

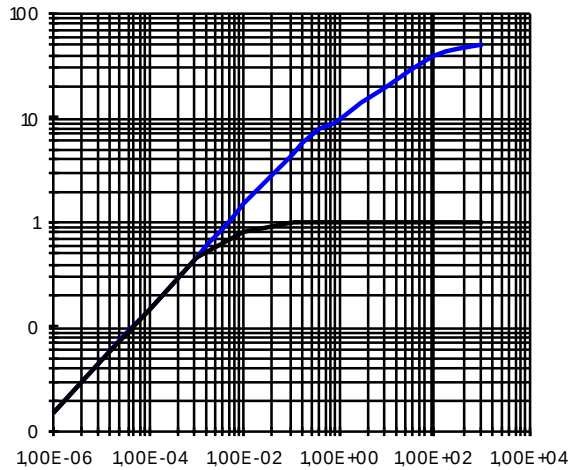


Figure 12 - Transient Thermal Imped. ($^{\circ}\text{C}/\text{W}$) Vs Time (S)

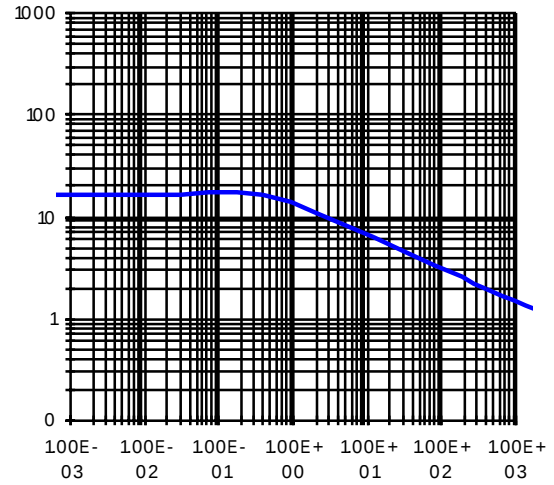
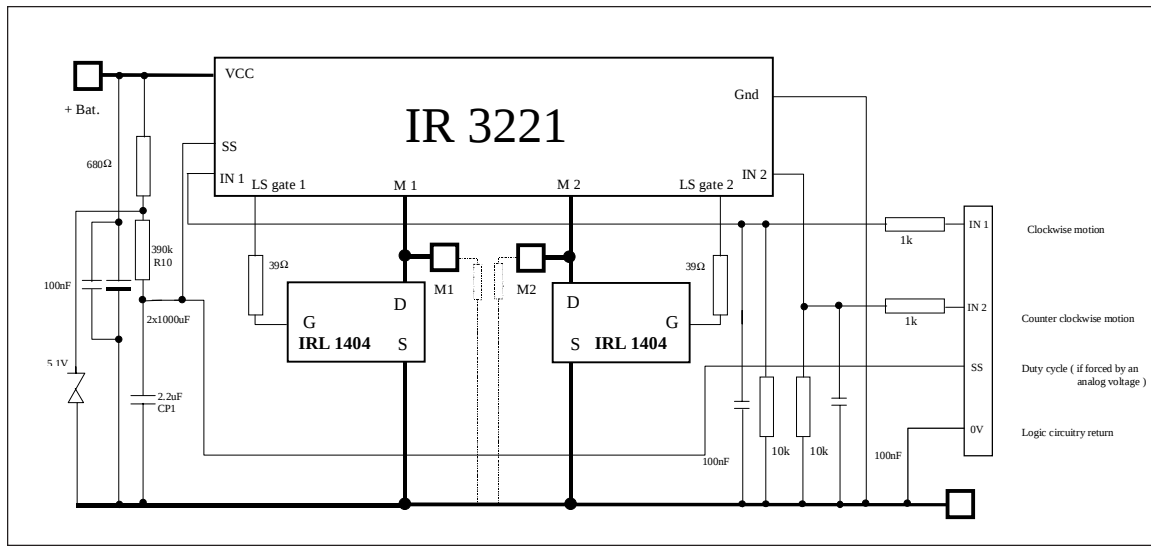


Figure 13 - I_{clamp} (A) Vs Power Supply Wire Inductance (mH - single pulse)

20 A H-Bridge Demoboard



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

