



## VNH2SP30-E

# AUTOMOTIVE FULLY INTEGRATED H-BRIDGE MOTOR DRIVER

**Table 1. General Features**

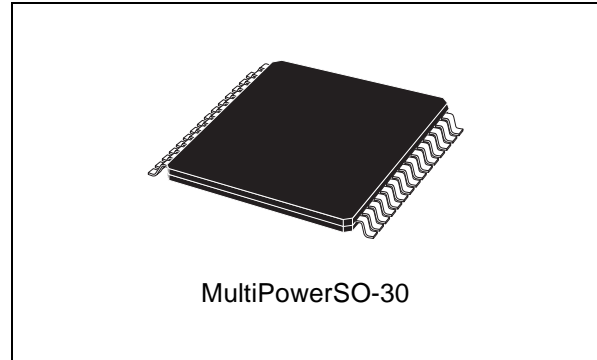
Type	R <sub>DS(on)</sub>	I <sub>out</sub>	V <sub>CCmax</sub>
VNH2SP30-E	19 mΩ max (per leg)	30 A	41 V

- OUTPUT CURRENT: 30A
- 5V LOGIC LEVEL COMPATIBLE INPUTS
- UNDERVOLTAGE AND OVERVOLTAGE SHUT-DOWN
- OVERVOLTAGE CLAMP
- THERMAL SHUT DOWN
- CROSS-CONDUCTION PROTECTION
- LINEAR CURRENT LIMITER
- VERY LOW STAND-BY POWER CONSUMPTION
- PWM OPERATION UP TO 20 KHz
- PROTECTION AGAINST:  
LOSS OF GROUND AND LOSS OF V<sub>CC</sub>
- CURRENT SENSE OUTPUT PROPORTIONAL TO MOTOR CURRENT
- IN COMPLIANCE WITH THE 2002/95/EC EUROPEAN DIRECTIVE

### DESCRIPTION

The VNH2SP30-E is a full bridge motor driver intended for a wide range of automotive applications. The device incorporates a dual monolithic High-Side drivers and two Low-Side switches. The High-Side driver switch is designed using STMicroelectronics' well known and proven proprietary VIPower™ M0 technology that allows to efficiently integrate on the same die a true Power MOSFET with an intelligent signal/protection circuitry.

**Figure 1. Package**



The Low-Side switches are vertical MOSFETs manufactured using STMicroelectronics' proprietary EHD ('STripFET™') process. The three dice are assembled in MultiPowerSO-30 package on electrically isolated leadframes. This package, specifically designed for the harsh automotive environment offers improved thermal performance thanks to exposed die pads. Moreover, its fully symmetrical mechanical design allows superior manufacturability at board level. The input signals IN<sub>A</sub> and IN<sub>B</sub> can directly interface to the microcontroller to select the motor direction and the brake condition. The DIAG<sub>A</sub>/EN<sub>A</sub> or DIAG<sub>B</sub>/EN<sub>B</sub>, when connected to an external pull-up resistor, enable one leg of the bridge. They also provide a feedback digital diagnostic signal. The normal condition operation is explained in the truth table on page 14. The CS pin allows to monitor the motor current by delivering a current proportional to its value. The PWM, up to 20KHz, lets us to control the speed of the motor in all possible conditions. In all cases, a low level state on the PWM pin will turn off both the LS<sub>A</sub> and LS<sub>B</sub> switches. When PWM rises to a high level, LS<sub>A</sub> or LS<sub>B</sub> turn on again depending on the input pin state.

**Table 2. Order Codes**

Package	Tube	Tape and Reel
MultiPowerSO-30	VNH2SP30-E	VNH2SP30TR-E

Figure 2. Block Diagram

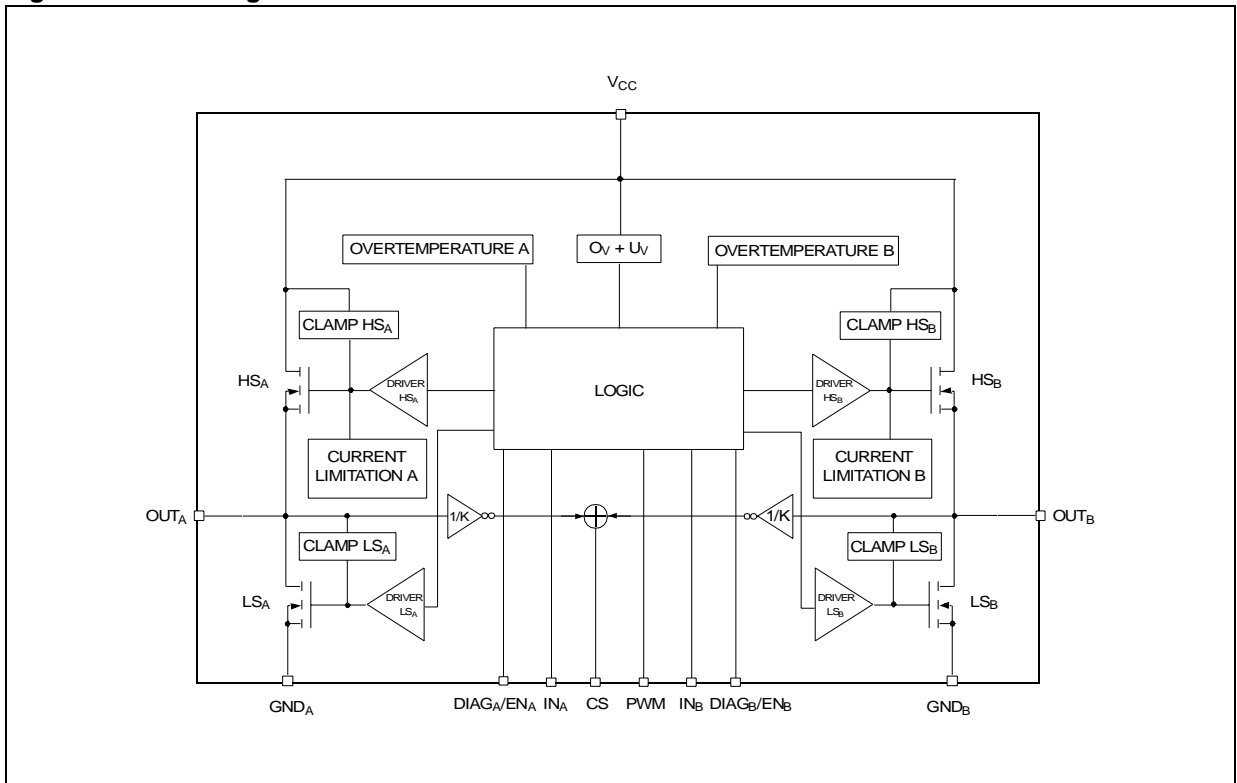
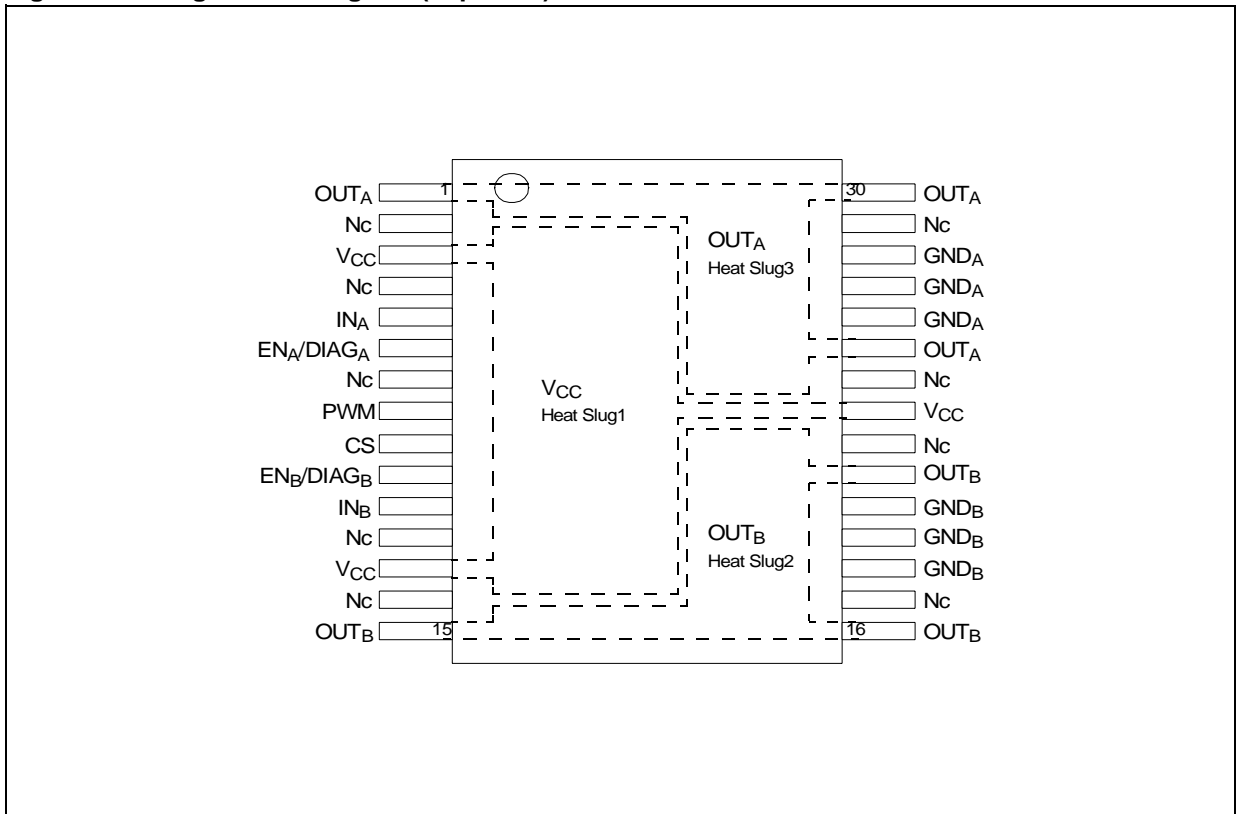


Figure 3. Configuration Diagram (Top View)



**Table 3. Pin Definitions And Functions**

Pin No	Symbol	Function
1, 25, 30	OUT <sub>A</sub> , Heat Slug2	Source of High-Side Switch A / Drain of Low-Side Switch A
2,4,7,12,14,17, 22, 24,29	NC	Not connected
3, 13, 23	VCC, Heat Slug1	Drain of High-Side Switches and Power Supply Voltage
6	EN <sub>A</sub> /DIAG <sub>A</sub>	Status of High-Side and Low-Side Switches A; Open Drain Output
5	IN <sub>A</sub>	Clockwise Input
8	PWM	PWM Input
9	CS	Output of Current sense
11	IN <sub>B</sub>	Counter Clockwise Input
10	EN <sub>B</sub> /DIAG <sub>B</sub>	Status of High-Side and Low-Side Switches B; Open Drain Output
15, 16, 21	OUT <sub>B</sub> , Heat Slug3	Source of High-Side Switch B / Drain of Low-Side Switch B
26, 27, 28	GND <sub>A</sub>	Source of Low-Side Switch A (*)
18, 19, 20	GND <sub>B</sub>	Source of Low-Side Switch B (*)

Note: (\*) GND<sub>A</sub> and GND<sub>B</sub> must be externally connected together

**Table 4. Pin Functions Description**

Name	Description
VCC	Battery connection.
GND <sub>A</sub> GND <sub>B</sub>	Power grounds, must always be externally connected together.
OUT <sub>A</sub> OUT <sub>B</sub>	Power connections to the motor.
IN <sub>A</sub> IN <sub>B</sub>	Voltage controlled input pins with hysteresis, CMOS compatible. These two pins control the state of the bridge in normal operation according to the truth table (brake to VCC, Brake to GND, clockwise and counterclockwise).
PWM	Voltage controlled input pin with hysteresis, CMOS compatible. Gates of Low-Side FETS get modulated by the PWM signal during their ON phase allowing speed control of the motor
EN <sub>A</sub> /DIAG <sub>A</sub> EN <sub>B</sub> /DIAG <sub>B</sub>	Open drain bidirectional logic pins. These pins must be connected to an external pull up resistor. When externally pulled low, they disable half-bridge A or B. In case of fault detection (thermal shutdown of a High-Side FET or excessive ON state voltage drop across a Low-Side FET), these pins are pulled low by the device (see truth table in fault condition).
CS	Analog current sense output. This output sources a current proportional to the motor current. The information can be read back as an analog voltage across an external resistor.

# VNH2SP30-E

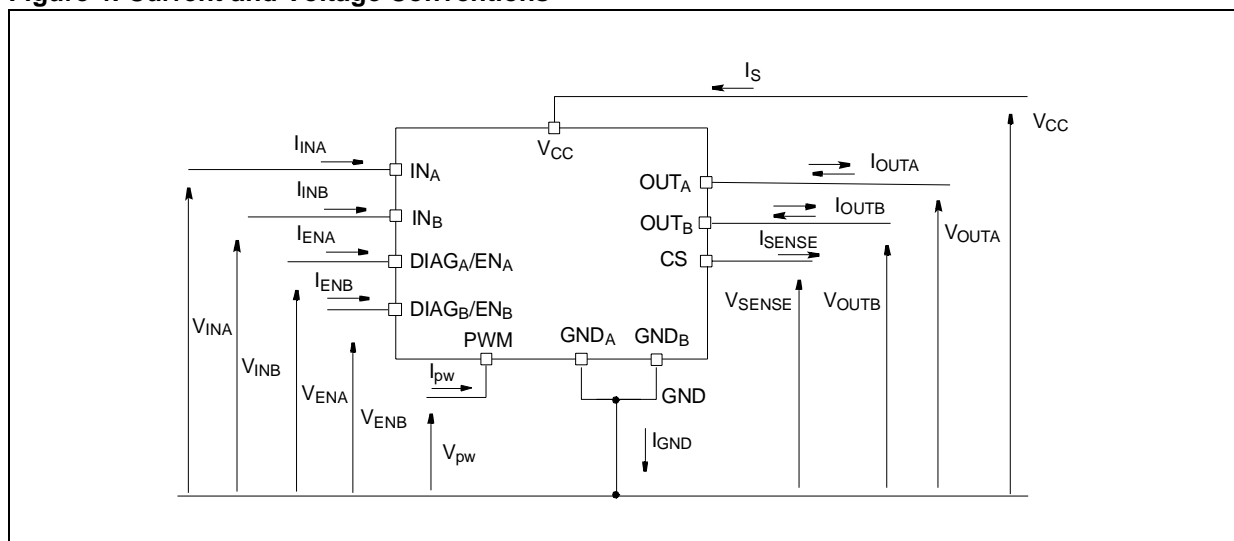
**Table 5. Block Descriptions** (see Block Diagram)

Name	Description
LOGIC CONTROL	Allows the turn-on and the turn-off of the High Side and the Low Side switches according to the truth table.
OVERVOLTAGE + UNDERVOLTAGE	Shut-down the device outside the range [5.5V..16V] for the battery voltage.
HIGH SIDE AND LOW SIDE CLAMP VOLTAGE	Protect the High Side and the Low Side switches from the high voltage on the battery line in all configuration for the motor.
HIGH SIDE AND LOW SIDE DRIVER	Drive the gate of the concerned switch to allow a proper $R_{DS(on)}$ for the leg of the bridge.
LINEAR CURRENT LIMITER	Limits the motor current, by reducing the High Side Switch gate-source voltage when short-circuit to ground occurs.
OVERTEMPERATURE PROTECTION	In case of short-circuit with the increase of the junction's temperature, shuts-down the concerned High Side to prevent its degradation and to protect the die.
FAULT DETECTION	Signalize an abnormal behavior of the switches in the half-bridge A or B by pulling low the concerned ENx/DIAGx pin.

**Table 6. Absolute Maximum Rating**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply Voltage	+ 41	V
$I_{max}$	Maximum Output Current (continuous)	30	A
$I_R$	Reverse Output Current (continuous)	-30	A
$I_{IN}$	Input Current ( $IN_A$ and $IN_B$ pins)	+/- 10	mA
$I_{EN}$	Enable Input Current ( $DIAG_A/EN_A$ and $DIAG_B/EN_B$ pins)	+/- 10	mA
$I_{pw}$	PWM Input Current	+/- 10	mA
$V_{CS}$	Current Sense Maximum Voltage	-3/+15	V
$V_{ESD}$	Electrostatic Discharge (R=1.5kΩ, C=100pF)		
	- CS pin	2	kV
	- logic pins	4	kV
	- output pins: $OUT_A$ , $OUT_B$ , $V_{CC}$	5	kV
$T_j$	Junction Operating Temperature	Internally Limited	°C
$T_C$	Case Operating Temperature	-40 to 150	°C
$T_{STG}$	Storage Temperature	-55 to 150	°C

**Figure 4. Current and Voltage Conventions**



**Table 7. Thermal Data**

See MultiPowerSO-30 Thermal Data section (page )

**ELECTRICAL CHARACTERISTICS**

 ( $V_{CC}=9V$  up to  $16V$ ;  $-40^{\circ}C < T_j < 150^{\circ}C$ ; unless otherwise specified)

**Table 8. Power**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{CC}$	Operating supply voltage		5.5		16	V
$I_S$	Supply Current	Off state: $I_{NA}=I_{NB}=PWM=0$ ; $T_j=25^{\circ}C$ ; $V_{CC}=13V$ $I_{NA}=I_{NB}=PWM=0$		12	30 60	$\mu A$ $\mu A$
		On state: $I_{NA}$ or $I_{NB}=5V$ , no PWM			10	mA
$R_{ONHS}$	Static High-Side resistance	$I_{OUT}=15A$ ; $T_j=25^{\circ}C$			14	$m\Omega$
		$I_{OUT}=15A$ ; $T_j= -40$ to $150^{\circ}C$			28	$m\Omega$
$R_{ONLS}$	Static Low-Side resistance	$I_{OUT}=15A$ ; $T_j=25^{\circ}C$			5	$m\Omega$
		$I_{OUT}=15A$ ; $T_j= -40$ to $150^{\circ}C$			10	$m\Omega$
$V_f$	High Side Free-wheeling Diode Forward Voltage	$I_f=15A$		0.8	1.1	V
$I_{L(off)}$	High Side Off State Output Current (per channel)	$T_j=25^{\circ}C$ ; $V_{OUTX}=ENX=0V$ ; $V_{CC}=13V$			3	$\mu A$
		$T_j=125^{\circ}C$ ; $V_{OUTX}=ENX=0V$ ; $V_{CC}=13V$			5	$\mu A$
$I_{RM}$	Dynamic Cross-conduction Current	$I_{OUT}=15A$ (see fig. 8)		0.7		A

**Table 9. Logic Inputs ( $I_{NA}$ ,  $I_{NB}$ ,  $EN_A$ ,  $EN_B$ )**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{IL}$	Input Low Level Voltage	Normal operation ( $DIAG_X/EN_X$ pin acts as an input pin)			1.25	V
$V_{IH}$	Input High Level Voltage	Normal operation ( $DIAG_X/EN_X$ pin acts as an input pin)	3.25			V
$V_{IHYST}$	Input Hysteresis Voltage	Normal operation ( $DIAG_X/EN_X$ pin acts as an input pin)	0.5			V
$V_{ICL}$	Input Clamp Voltage	$I_{IN}=1mA$	5.5	6.3	7.5	V
		$I_{IN}=-1mA$	-1.0	-0.7	-0.3	V
$I_{INL}$	Input Current	$V_{IN}=1.25V$	1			$\mu A$
$I_{INH}$	Input Current	$V_{IN}=3.25V$			10	$\mu A$
$V_{DIAG}$	Enable Output Low Level Voltage	Fault operation ( $DIAG_X/EN_X$ pin acts as an output pin); $I_{EN}=1mA$			0.4	V

**ELECTRICAL CHARACTERISTICS** (continued)

**Table 10. PWM**

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V <sub>pwl</sub>	PWM Low Level Voltage				1.25	V
I <sub>pwl</sub>	PWM Pin Current	V <sub>pw</sub> =1.25V	1			μA
V <sub>pwh</sub>	PWM High Level Voltage		3.25			V
I <sub>pwh</sub>	PWM Pin Current	V <sub>pw</sub> =3.25V			10	μA
V <sub>pwhhyst</sub>	PWM Hysteresis Voltage		0.5			V
V <sub>pwcl</sub>	PWM Clamp Voltage	I <sub>pw</sub> = 1 mA I <sub>pw</sub> = -1 mA	V <sub>CC</sub> +0.3 -6.0	V <sub>CC</sub> +0.7 -4.5	V <sub>CC</sub> +1.0 -3.0	V V
C <sub>INPWM</sub>	PWM Pin Input Capacitance	V <sub>IN</sub> =2.5V			25	pF

**Table 11. Switching** (V<sub>CC</sub>=13V, R<sub>LOAD</sub>=0.87Ω)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
f	PWM Frequency		0		20	kHz
t <sub>d(on)</sub>	Turn-on Delay Time	Input rise time < 1μs (see fig. 8)			250	μs
t <sub>d(off)</sub>	Turn-off Delay Time	Input rise time < 1μs (see fig. 8)			250	μs
t <sub>r</sub>	Rise Time	(see fig. 7)		1	1.6	μs
t <sub>f</sub>	Fall Time	(see fig. 7)		1.2	2.4	μs
t <sub>DEL</sub>	Delay Time During Change of Operating Mode	(see fig. 6)	300	600	1800	μs
t <sub>rr</sub>	High Side Free Wheeling Diode Reverse Recovery Time	(see fig. 9)		110		ns
t <sub>off(min)</sub>	PWM Minimum off time	9V<V <sub>CC</sub> <16V; -40°C<T <sub>j</sub> <150°C; I <sub>OUT</sub> =15A			6	μs

**Table 12. Protection And Diagnostic**

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V <sub>USD</sub>	Undervoltage Shut-down Undervoltage Reset			4.7	5.5	V V
V <sub>OV</sub>	Overvoltage Shut-down		16	19	22	V
I <sub>LIM</sub>	High-Side Current Limitation		30	50	70	A
V <sub>CLP</sub>	Total Clamp Voltage (V <sub>CC</sub> to GND)	I <sub>OUT</sub> =15A	43	48	54	V
T <sub>TSD</sub>	Thermal Shut-down Temperature	V <sub>IN</sub> = 3.25 V	150	175	200	°C
T <sub>TR</sub>	Thermal Reset Temperature		135			°C
T <sub>HYST</sub>	Thermal Hysteresis		7	15		°C

**ELECTRICAL CHARACTERISTICS** (continued)

**Table 13. Current Sense** ( $9V < V_{CC} < 16V$ )

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$K_1$	$I_{OUT}/I_{SENSE}$	$I_{OUT}=30A$ ; $R_{SENSE}=1.5k\Omega$ $T_j = -40$ to $150^\circ C$	9665	11370	13075	
$K_2$	$I_{OUT}/I_{SENSE}$	$I_{OUT}=8A$ ; $R_{SENSE}=1.5k\Omega$ $T_j = -40$ to $150^\circ C$	9096	11370	13644	
$dK_1 / K_1$ (*)	Analog sense current drift	$I_{OUT}=30A$ ; $R_{SENSE}=1.5k\Omega$ $T_j = -40$ to $150^\circ C$	-8		+8	%
$dK_2 / K_2$ (*)	Analog sense current drift	$I_{OUT} > 8A$ ; $R_{SENSE}=1.5k\Omega$ $T_j = -40$ to $150^\circ C$	-10		+10	%
$I_{SENSE0}$	Analog Sense Leakage Current	$I_{OUT}=0A$ ; $V_{SENSE}=0V$ ; $T_j = -40$ to $150^\circ C$	0		65	$\mu A$

Note:(\*) Analog sense current drift is deviation of factor K for a given device over (-40°C to 150°C and  $9V < V_{CC} < 16V$ ) with respect to it's value measured at  $T_j=25^\circ C$ ,  $V_{CC}=13V$ .

**WAVEFORMS AND TRUTH TABLE**

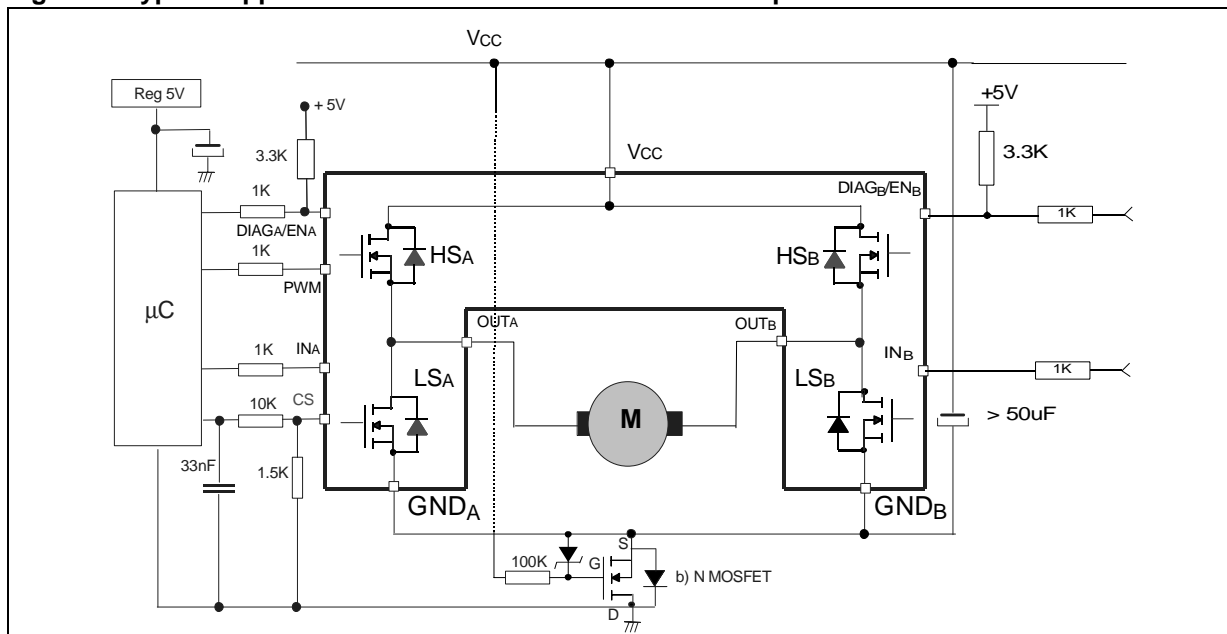
**Table 14. Truth Table In Normal Operating Conditions**

In normal operating conditions the  $DIAG_x/EN_x$  pin is considered as an input pin by the device. This pin must be externally pulled high.

PWM pin usage: in all cases, a "0" on the PWM pin will turn-off both  $LS_A$  and  $LS_B$  switches. When PWM rises back to "1",  $LS_A$  or  $LS_B$  turn on again depending on the input pin state.

$IN_A$	$IN_B$	$DIAG_A/EN_A$	$DIAG_B/EN_B$	$OUT_A$	$OUT_B$	CS	Operating mode
1	1	1	1	H	H	High Imp.	Brake to $V_{CC}$
1	0	1	1	H	L	$I_{SENSE}=I_{OUT}/K$	Clockwise (CW)
0	1	1	1	L	H	$I_{SENSE}=I_{OUT}/K$	Counterclockwise (CCW)
0	0	1	1	L	L	High Imp.	Brake to GND

Figure 5. Typical Application Circuit For Dc To 20kHz PWM Operation Short Circuit Protection



In case of a fault condition the DIAG<sub>X</sub>/EN<sub>X</sub> pin is considered as an output pin by the device.

The fault conditions are:

- overtemperature on one or both high sides (for example if a short to ground occurs as it could be the case described in line 1 and 2 in the table below);
- short to battery condition on the output (saturation detection on the Low-Side Power MOSFET).

Possible origins of fault conditions may be:

OUT<sub>A</sub> is shorted to ground ----> overtemperature detection on high side A.

OUT<sub>A</sub> is shorted to V<sub>CC</sub> ----> Low-Side Power MOSFET saturation detection.

When a fault condition is detected, the user can know

which power element is in fault by monitoring the IN<sub>A</sub>, IN<sub>B</sub>, DIAG<sub>A</sub>/EN<sub>A</sub> and DIAG<sub>B</sub>/EN<sub>B</sub> pins.

In any case, when a fault is detected, the faulty leg of the bridge is latched off. To turn-on the respective output (OUT<sub>X</sub>) again, the input signal must rise from low to high level.

Table 15. Truth Table In Fault Conditions (Detected On OUT<sub>A</sub>)

IN <sub>A</sub>	IN <sub>B</sub>	DIAG <sub>A</sub> /EN <sub>A</sub>	DIAG <sub>B</sub> /EN <sub>B</sub>	OUT <sub>A</sub>	OUT <sub>B</sub>	CS
1	1	0	1	OPEN	H	High Imp.
1	0	0	1	OPEN	L	High Imp.
0	1	0	1	OPEN	H	I <sub>OUTB</sub> /K
0	0	0	1	OPEN	L	High Imp.
X	X	0	0	OPEN	OPEN	High Imp.
X	1	0	1	OPEN	H	I <sub>OUTB</sub> /K
X	0	0	1	OPEN	L	High Imp.

Fault Information

Protection Action



**Table 16. Electrical Transient Requirements**

ISO T/R 7637/1 Test Pulse	Test Level I	Test Level II	Test Level III	Test Level IV	Test Levels Delays and Impedance
1	-25V	-50V	-75V	-100V	2ms, 10Ω
2	+25V	+50V	+75V	+100V	0.2ms, 10Ω
3a	-25V	-50V	-100V	-150V	0.1μs, 50Ω
3b	+25V	+50V	+75V	+100V	0.1μs, 50Ω
4	-4V	-5V	-6V	-7V	100ms, 0.01Ω
5	+26.5V	+46.5V	+66.5V	+86.5V	400ms, 2Ω

ISO T/R 7637/1 Test Pulse	Test Levels Result I	Test Levels Result II	Test Levels Result III	Test Levels Result IV
1	C	C	C	C
2	C	C	C	C
3a	C	C	C	C
3b	C	C	C	C
4	C	C	C	C
5	C	E	E	E

Class	Contents
C	All functions of the device are performed as designed after exposure to disturbance.
E	One or more functions of the device are not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device.

**Reverse Battery Protection**

Three possible solutions can be thought of:

- a) a Schottky diode D connected to V<sub>CC</sub> pin
- b) a N-channel MOSFET connected to the GND pin (see Typical Application Circuit on page 8)
- c) a P-channel MOSFET connected to the V<sub>CC</sub> pin

The device sustains no more than -30A in reverse battery conditions because of the two Body diodes of the Power MOSFETs. Additionally, in reverse battery condition the I/Os of VNH2SP30-E will be pulled down to the V<sub>CC</sub> line (approximately -1.5V). Series resistor must be inserted to limit the current sunk from the microcontroller I/Os. If I<sub>Rmax</sub> is the maximum target reverse current through μC I/Os, series resistor is:

$$R = \frac{V_{IOs} - V_{CC}}{I_{Rmax}}$$

Figure 6. Definition Of The Delay Times Measurement

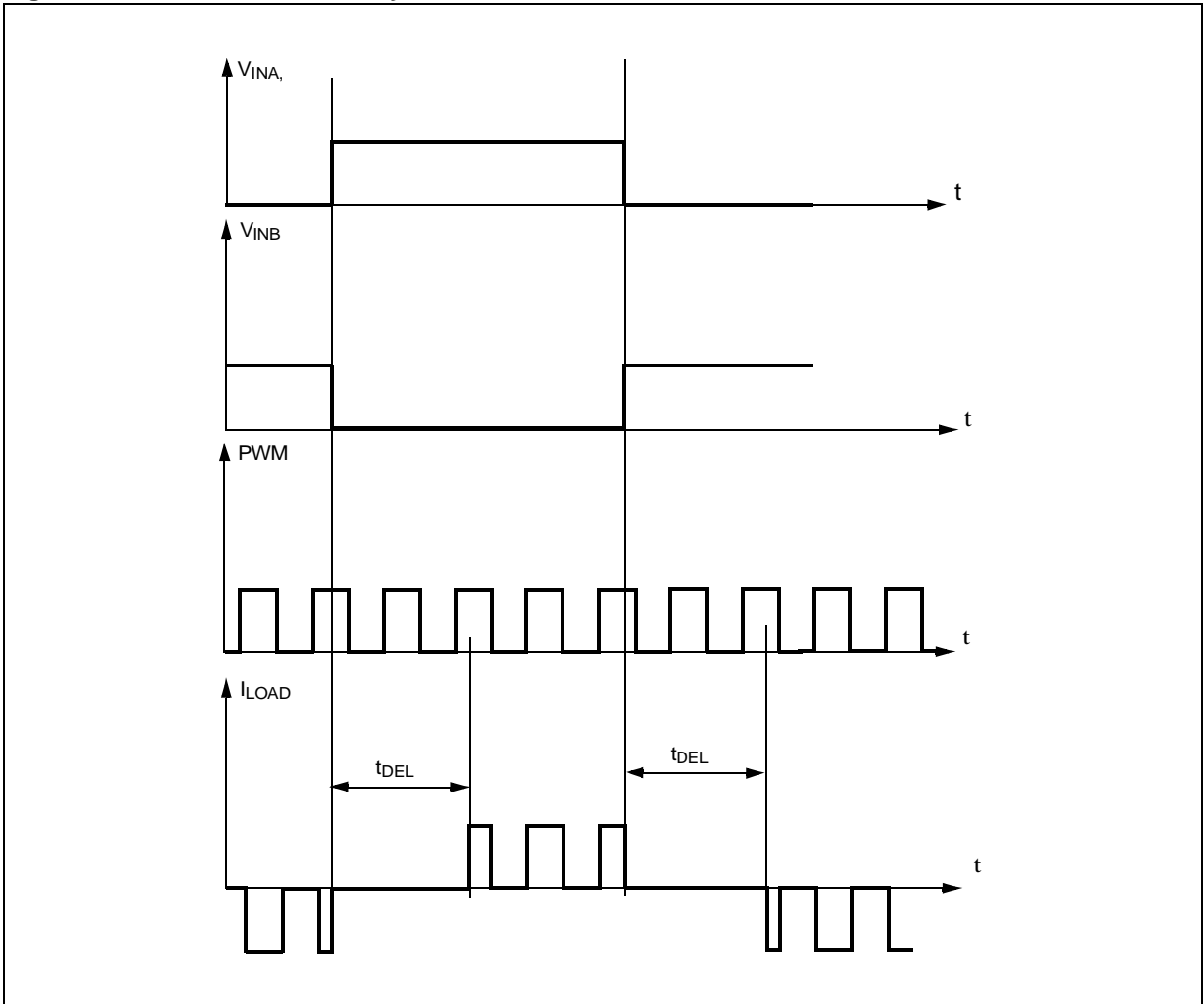


Figure 7. Definition Of The Low Side Switching Times

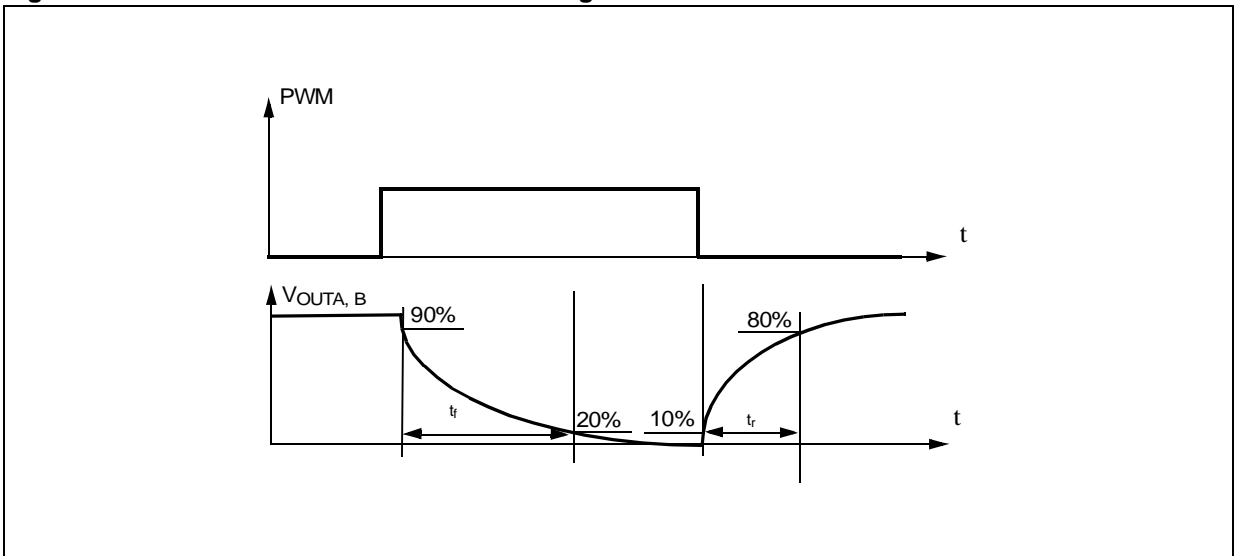


Figure 8. Definition Of The High Side Switching Times

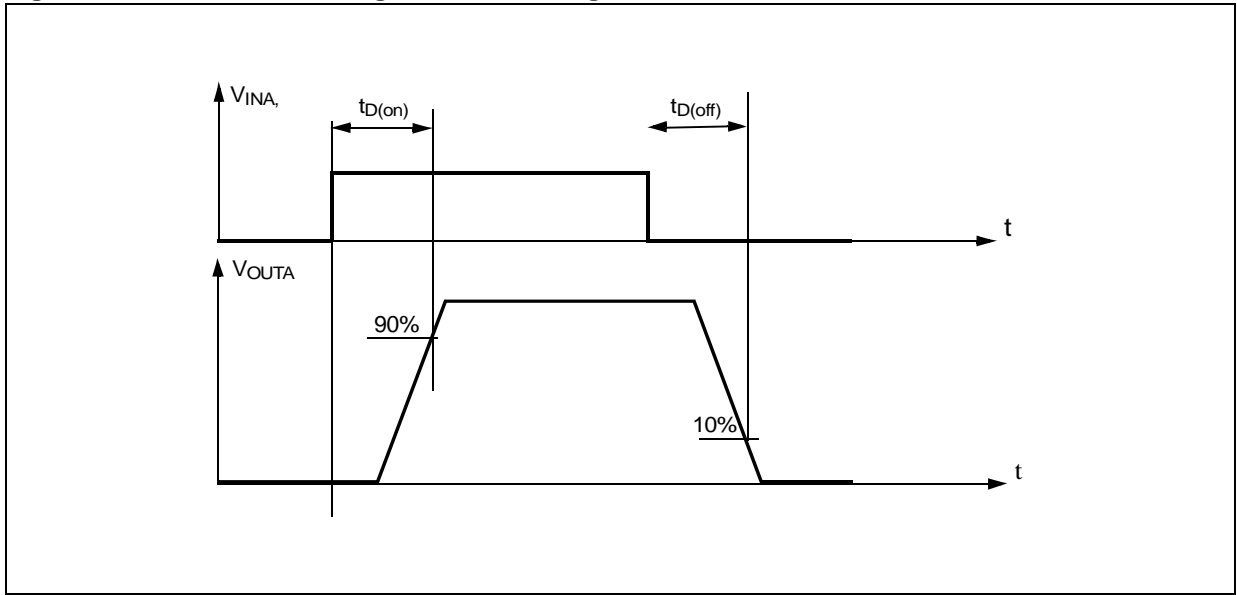


Figure 9. Definition Of Dynamic Cross Conduction Current During A Pwm Operation

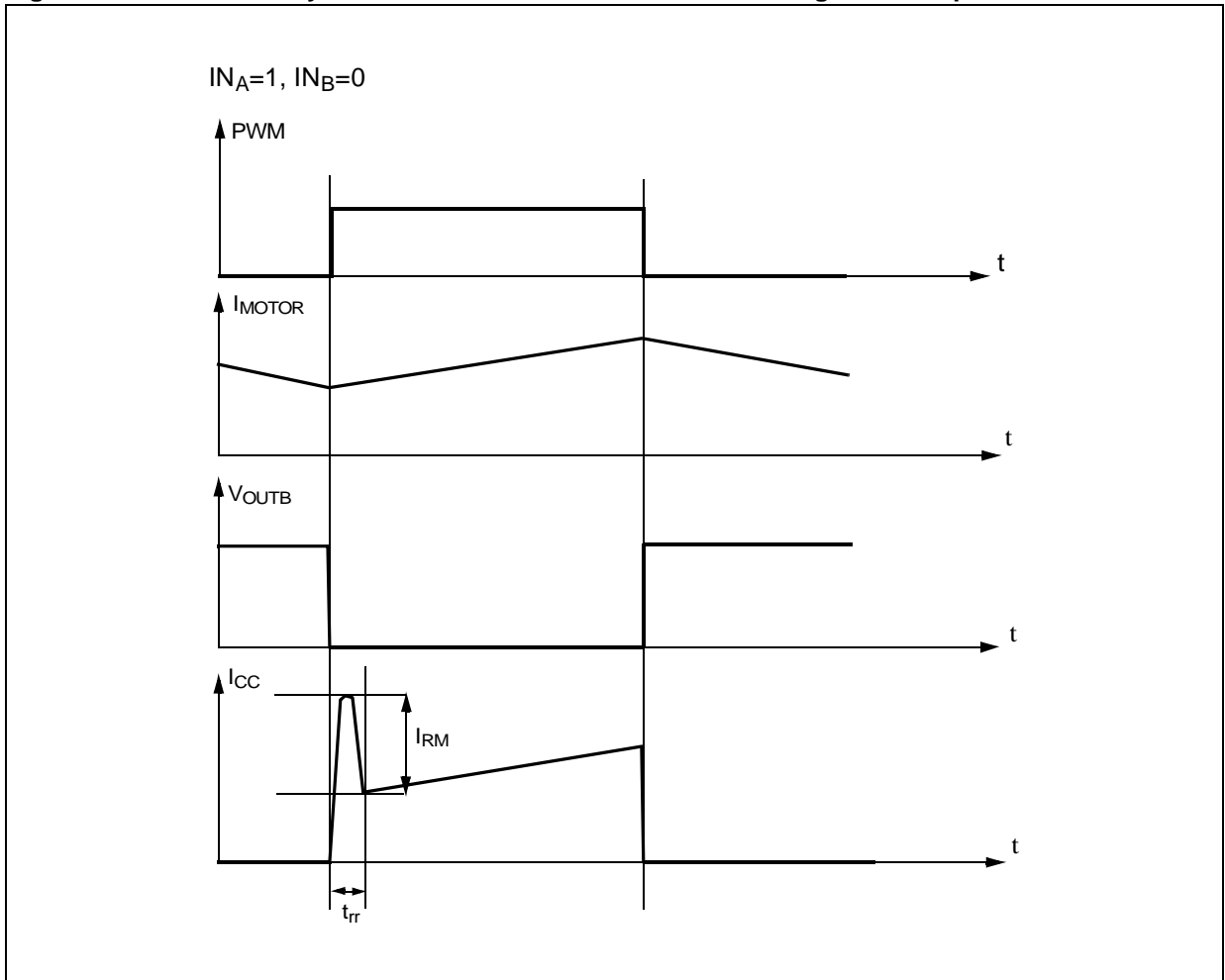


Figure 10. Waveforms in full bridge operation

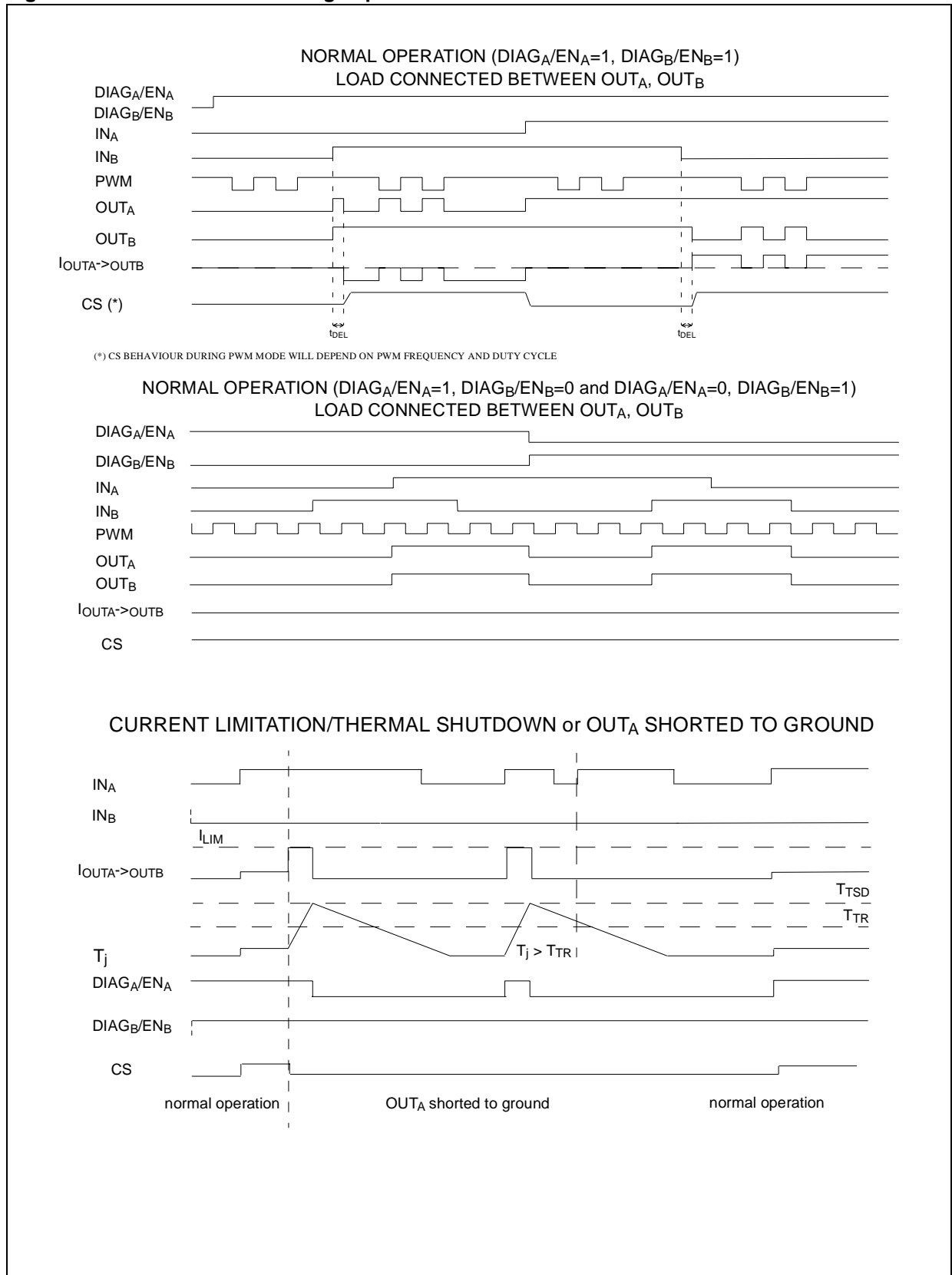
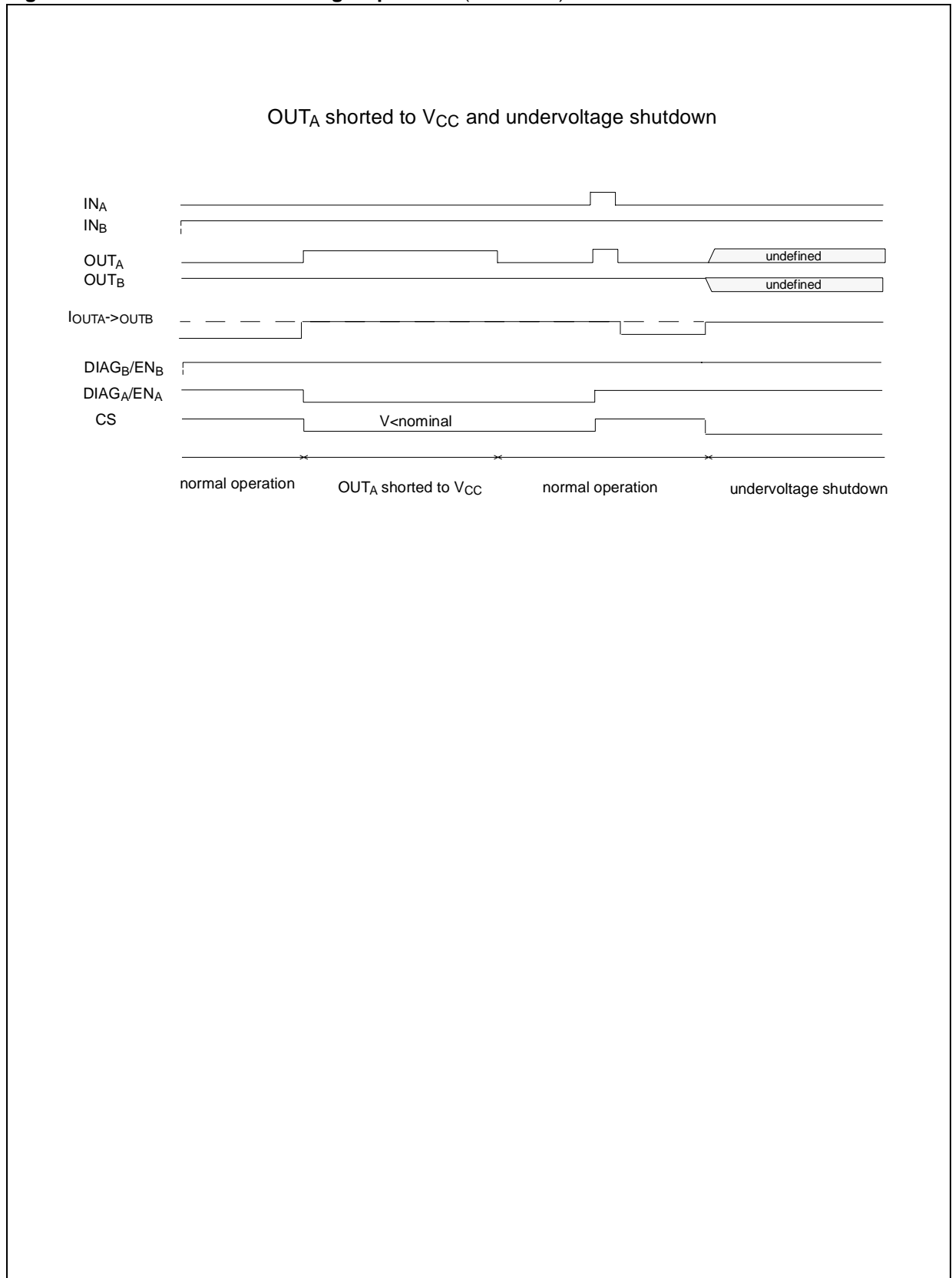
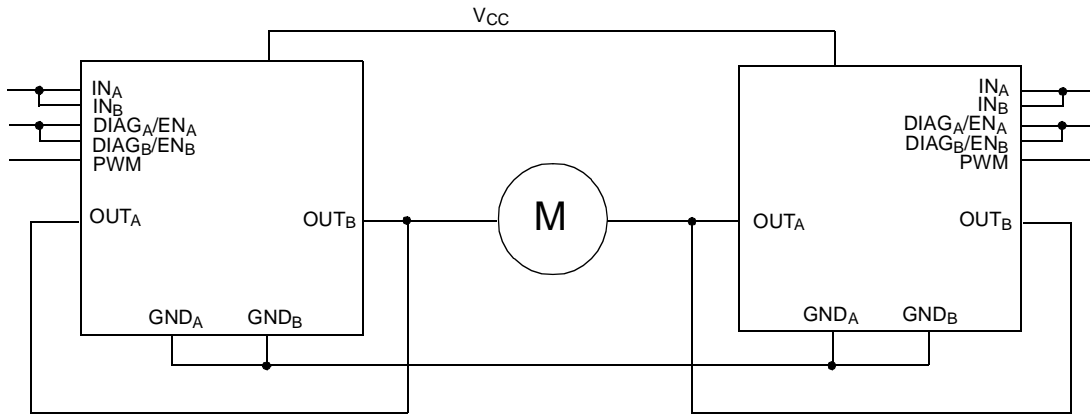


Figure 11. Waveforms In Full Bridge Operation (continued)



**Figure 12. Half-bridge Configuration**

The VNH2SP30-E can be used as a high power half-bridge driver achieving an On resistance per leg of 9.5mΩ. Suggested configuration is the following:



**Figure 13. Multi-motors Configuration**

The VNH2SP30-E can easily be designed in multi-motors driving applications such as seat positioning systems where only one motor must be driven at a time. DIAG<sub>x</sub>/EN<sub>x</sub> pins allow to put unused half-bridges in high impedance. Suggested configuration is the following:

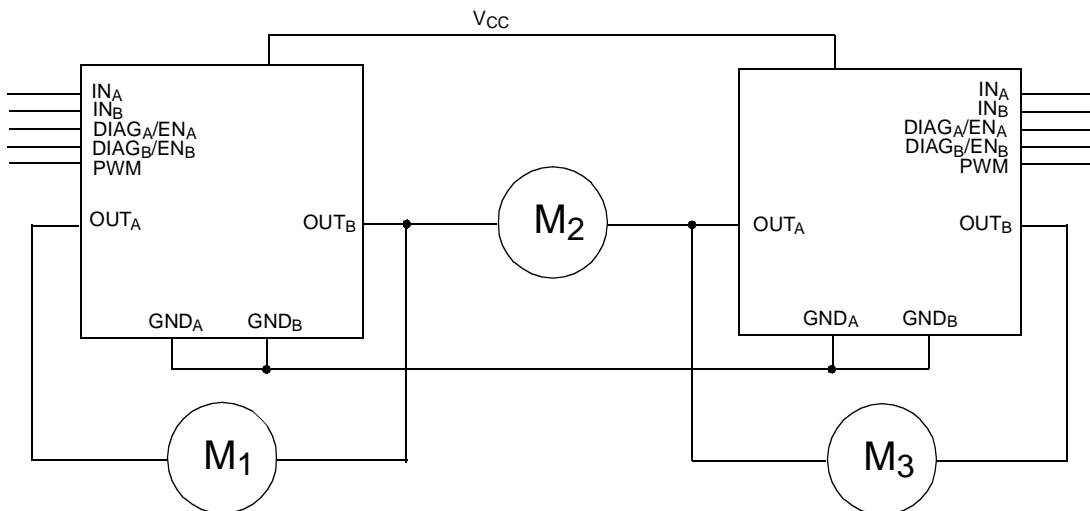


Figure 14. On State Supply Current

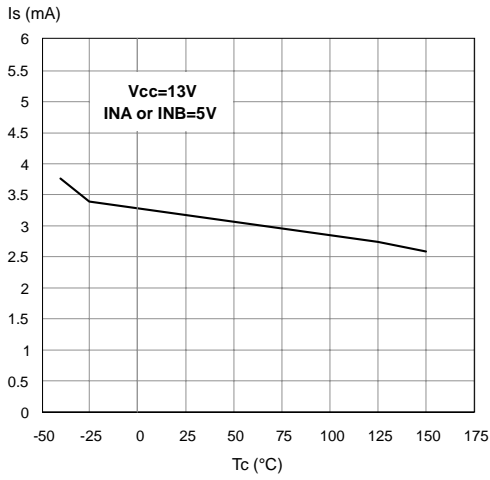


Figure 17. Off State Supply Current

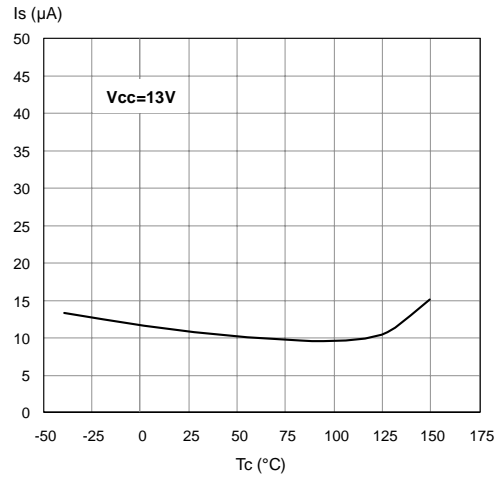


Figure 15. High Level Input Current

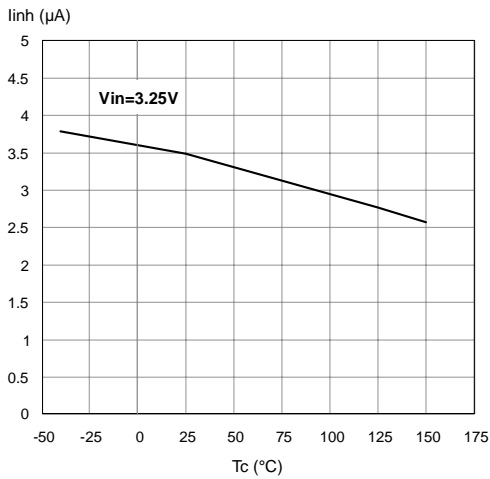


Figure 18. Input Clamp Voltage

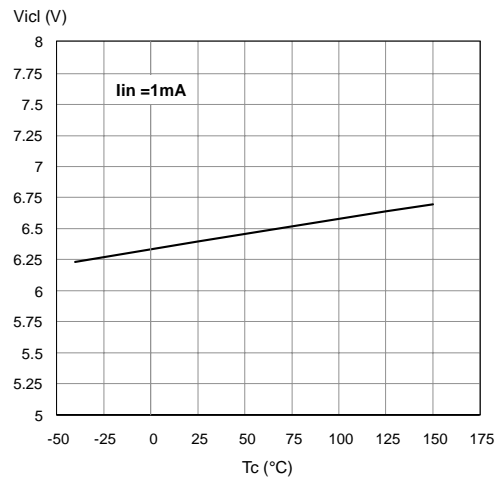


Figure 16. Input High Level Voltage

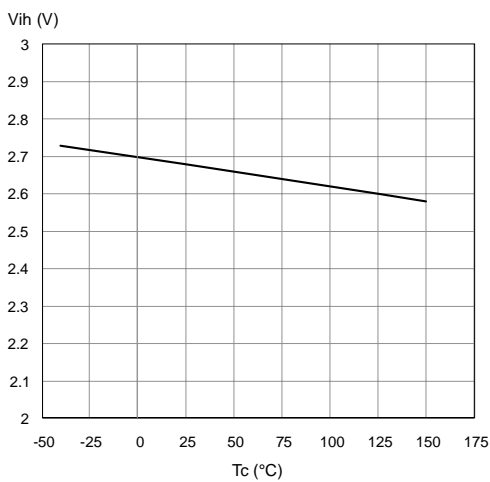


Figure 19. Input Low Level Voltage

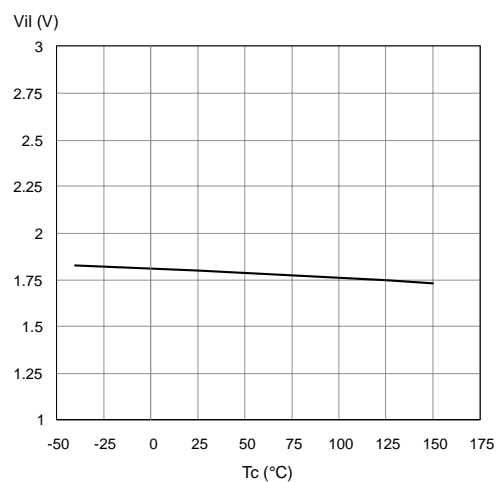


Figure 20. Input Hysteresis Voltage

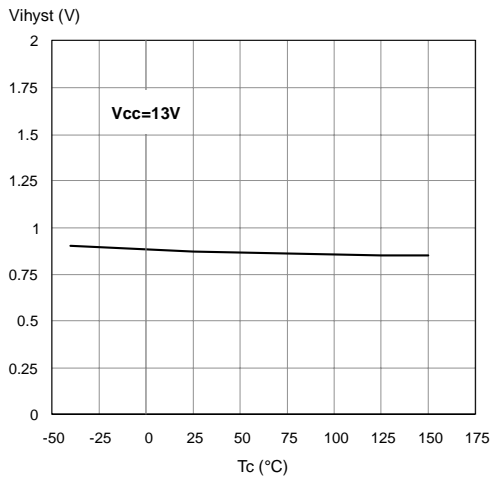


Figure 23. High Level Enable Pin Current

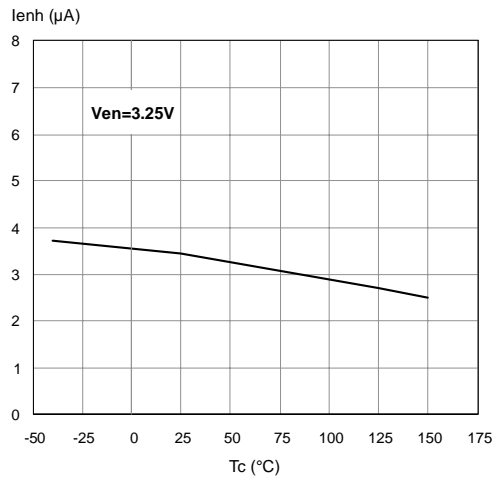


Figure 21. Delay Time during change of operation mode

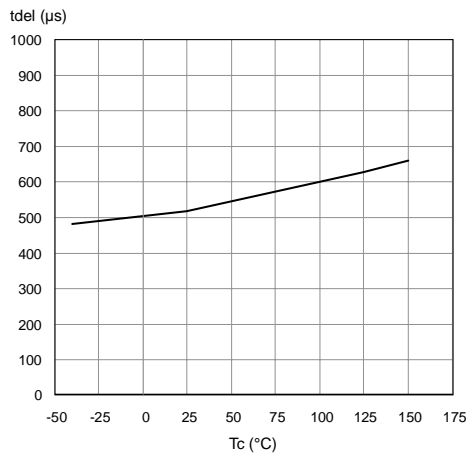


Figure 24. Enable Clamp Voltage

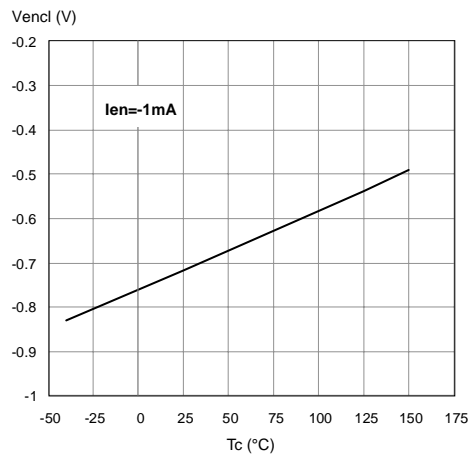


Figure 22. High Level Enable Voltage

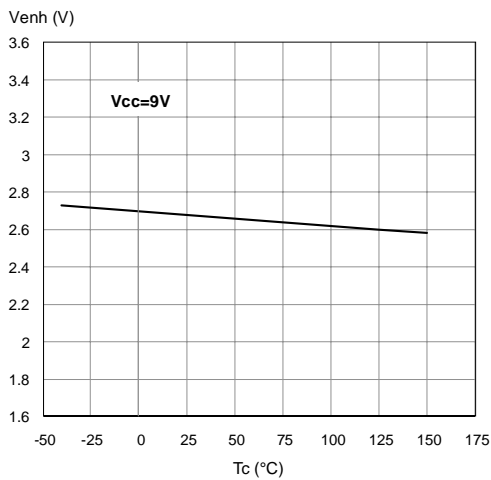


Figure 25. Low Level Enable Voltage

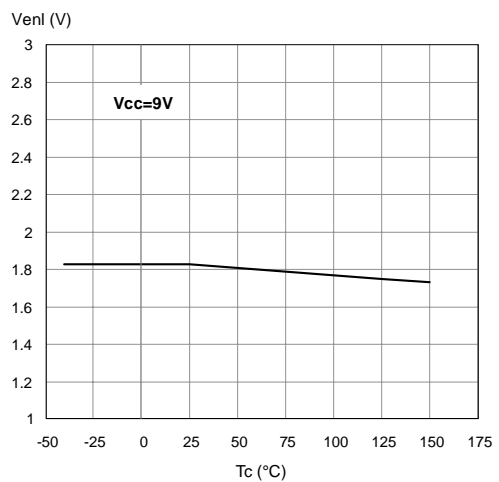




Figure 26. PWM High Level Voltage

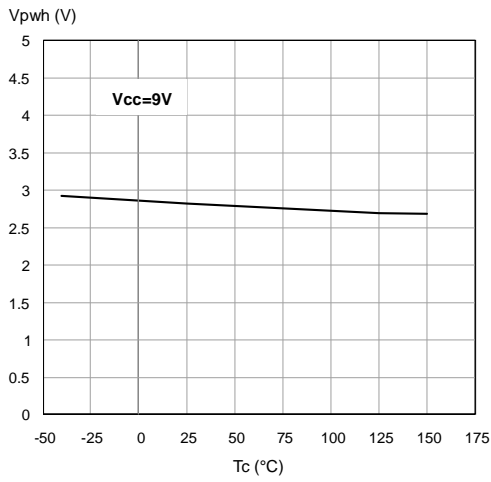


Figure 29. PWM Low Level Voltage

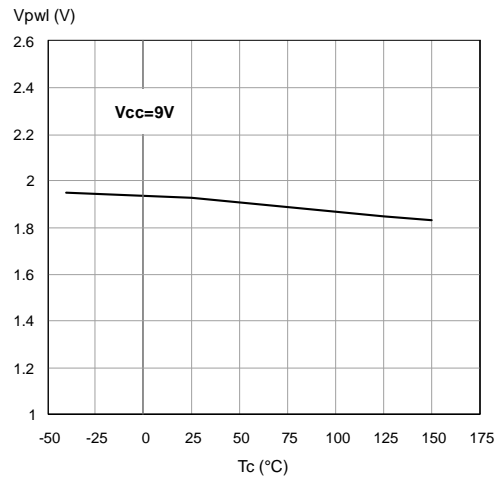


Figure 27. PWM High Level Current

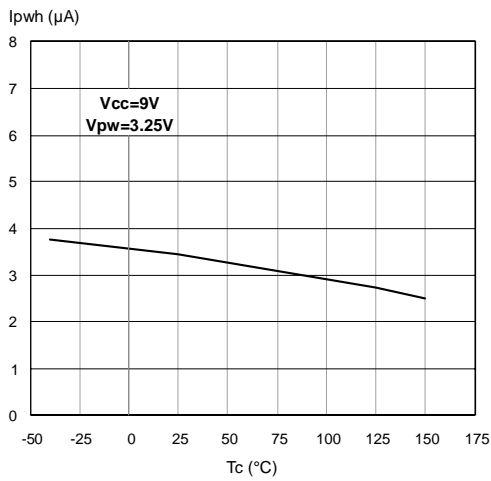


Figure 30. Overvoltage Shutdown

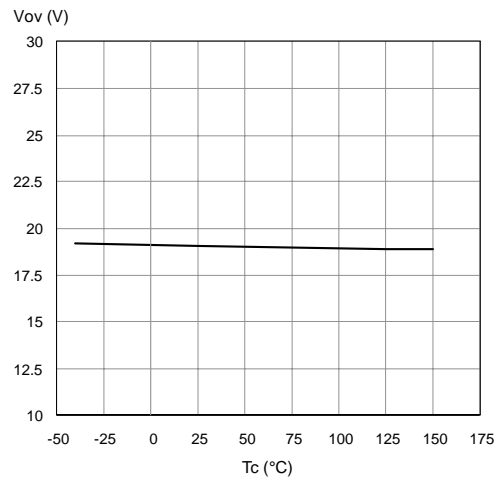


Figure 28. Undervoltage Shutdown

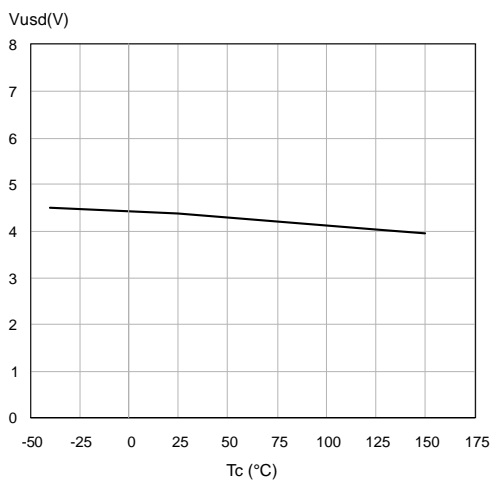
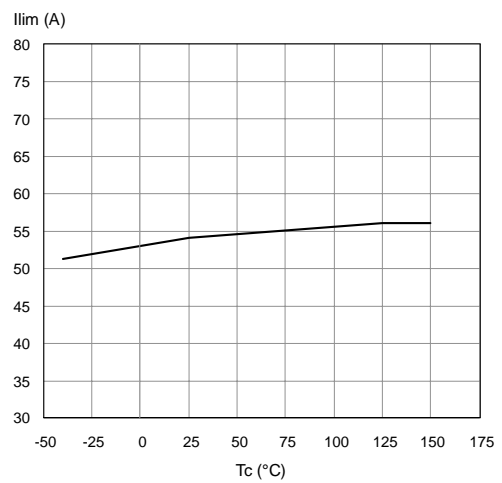
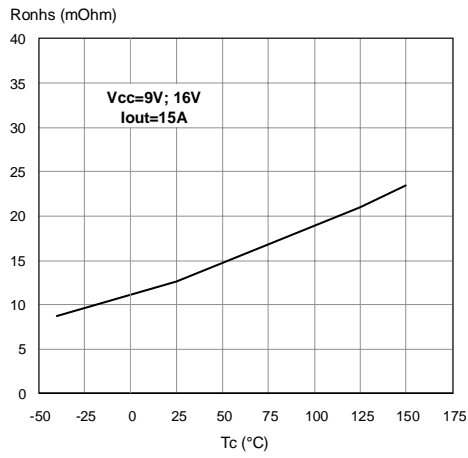


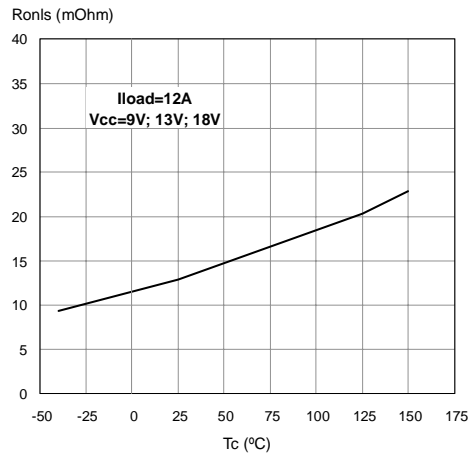
Figure 31. Current Limitation



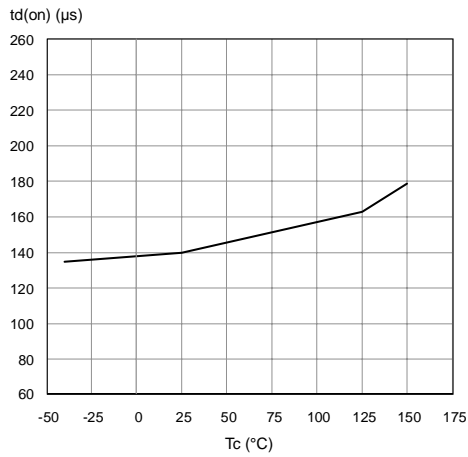
**Figure 32. On State High Side Resistance Vs.  $T_{case}$**



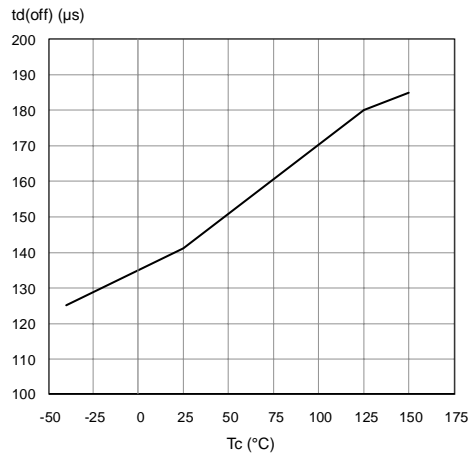
**Figure 35. On State Low Side Resistance Vs.  $T_{case}$**



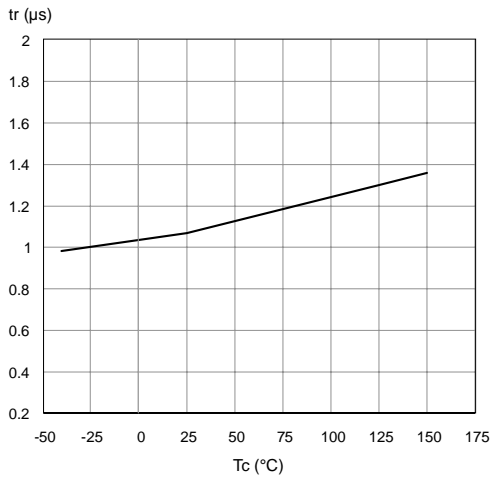
**Figure 33. Turn-on Delay Time**



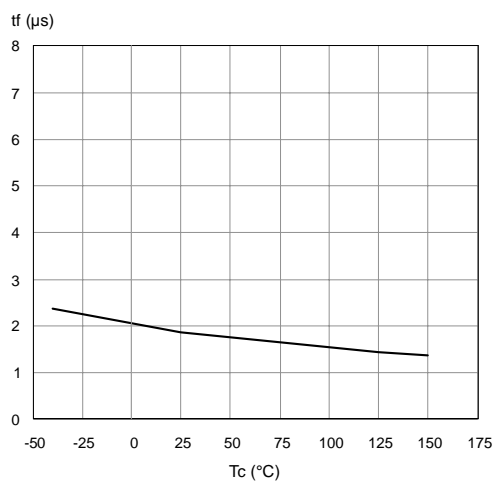
**Figure 36. Turn-off Delay Time**



**Figure 34. Output Voltage Rise Time**



**Figure 37. Output Voltage Fall Time**



MultiPowerSO-30™ Thermal Data

Figure 38. MultiPowerSO-30™ PC Board

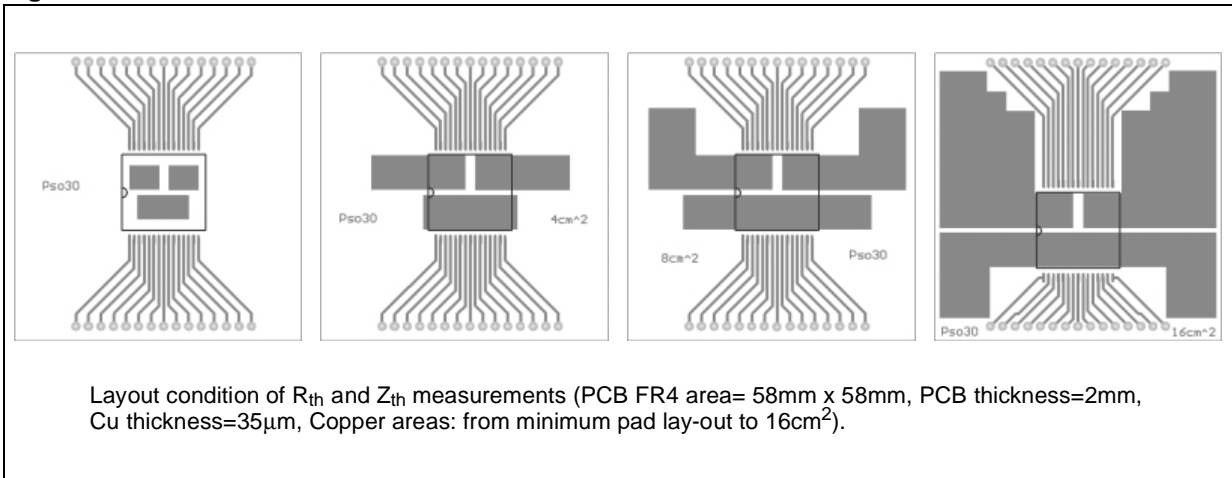


Figure 39. Chipset Configuration

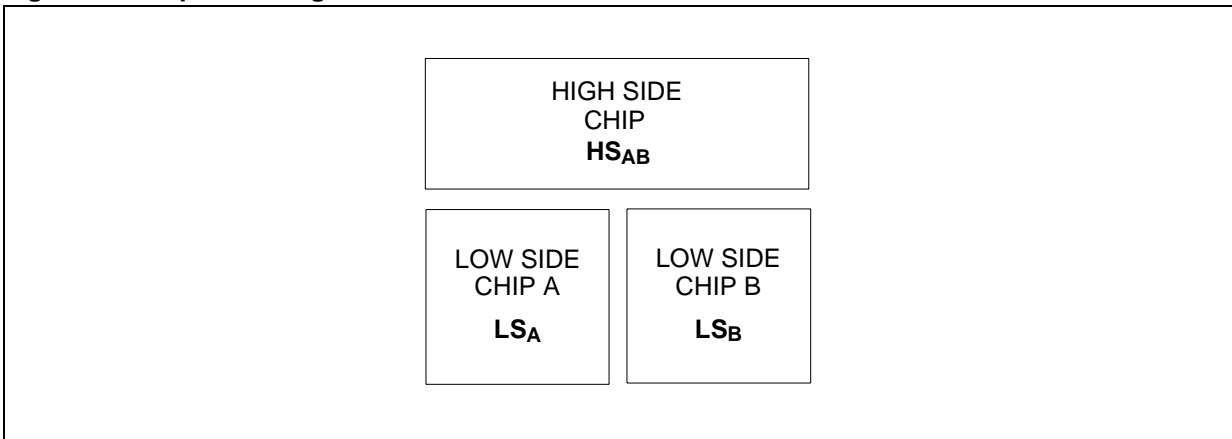
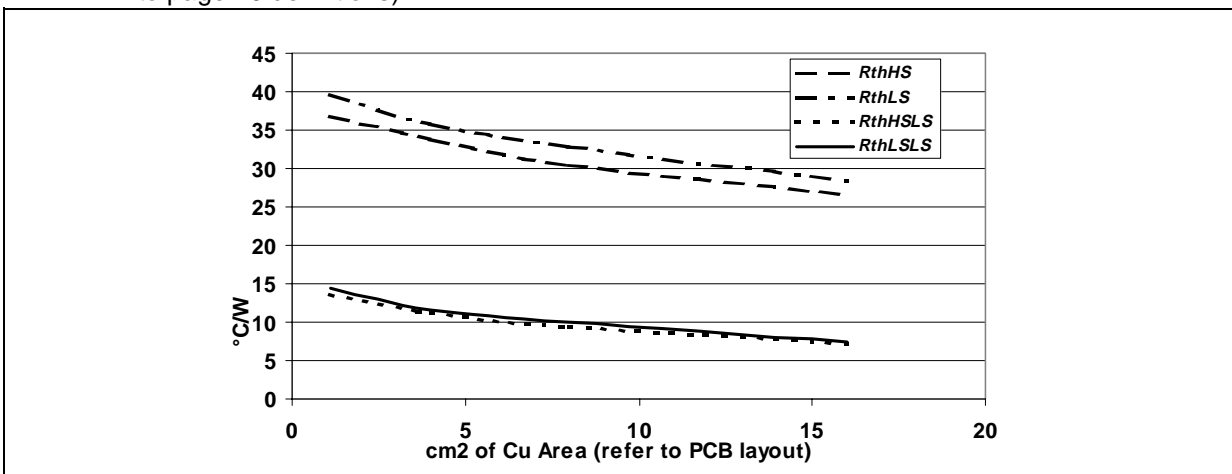


Figure 40. Auto and mutual  $R_{thj-amb}$  Vs PCB copper area in open box free air condition (according to page 20 definitions)



**Table 17. Thermal Calculation In Clockwise And Anti-clockwise Operation In Steady-state Mode**

HS <sub>A</sub>	HS <sub>B</sub>	LS <sub>A</sub>	LS <sub>B</sub>	T <sub>jHSAB</sub>	T <sub>jLSA</sub>	T <sub>jLSB</sub>
ON	OFF	OFF	ON	$P_{dHSA} \times R_{thHS} + P_{dLSB} \times R_{thHSL} + T_{amb}$	$P_{dHSA} \times R_{thHSL} + P_{dLSB} \times R_{thLS} + T_{amb}$	$P_{dHSA} \times R_{thHSL} + P_{dLSB} \times R_{thLS} + T_{amb}$
OFF	ON	ON	OFF	$P_{dHSB} \times R_{thHS} + P_{dLSA} \times R_{thHSL} + T_{amb}$	$P_{dHSB} \times R_{thHSL} + P_{dLSA} \times R_{thLS} + T_{amb}$	$P_{dHSB} \times R_{thHSL} + P_{dLSA} \times R_{thLS} + T_{amb}$

**Thermal Resistances Definition** (values according to the PCB heatsink area)

**R<sub>thHS</sub>** = R<sub>thHSA</sub> = R<sub>thHSB</sub> = High Side Chip Thermal Resistance Junction to Ambient (HS<sub>A</sub> or HS<sub>B</sub> in ON state)

**R<sub>thLS</sub>** = R<sub>thLSA</sub> = R<sub>thLSB</sub> = Low Side Chip Thermal Resistance Junction to Ambient

**R<sub>thHSLs</sub>** = R<sub>thHSA<sub>LSB</sub></sub> = R<sub>thHSB<sub>LSA</sub></sub> = Mutual Thermal Resistance Junction to Ambient between High Side and Low Side Chips

**R<sub>thLSLs</sub>** = R<sub>thLSA<sub>LSB</sub></sub> = Mutual Thermal Resistance Junction to Ambient between Low Side Chips

**Thermal Calculation In Transient Mode (\*)**

$$T_{jHSAB} = Z_{thHS} \times P_{dHSAB} + Z_{thHSLs} \times (P_{dLSA} + P_{dLSB}) + T_{amb}$$

$$T_{jLSA} = Z_{thHSLs} \times P_{dHSAB} + Z_{thLS} \times P_{dLSA} + Z_{thLSLs} \times P_{dLSB} + T_{amb}$$

$$T_{jLSB} = Z_{thHSLs} \times P_{dHSAB} + Z_{thLSLs} \times P_{dLSA} + Z_{thLS} \times P_{dLSB} + T_{amb}$$

**Single Pulse Thermal Impedance Definition** (values according to the PCB heatsink area)

**Z<sub>thHS</sub>** = High Side Chip Thermal Impedance Junction to Ambient

**Z<sub>thLS</sub>** = Z<sub>thLSA</sub> = Z<sub>thLSB</sub> = Low Side Chip Thermal Impedance Junction to Ambient

**Z<sub>thHSLs</sub>** = Z<sub>thHSA<sub>LSA</sub></sub> = Z<sub>thHSA<sub>LSB</sub></sub> = Mutual Thermal Impedance Junction to Ambient between High Side and Low Side Chips

**Z<sub>thLSLs</sub>** = Z<sub>thLSA<sub>LSB</sub></sub> = Mutual Thermal Impedance Junction to Ambient between Low Side Chips

**Pulse Calculation Formula**

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp} (1 - \delta)$$

where  $\delta = t_p / T$

(\*) Calculation is valid in any dynamic operating condition. P<sub>d</sub> values set by user.

Figure 41. MultiPowerSO-30 HSD Thermal Impedance Junction Ambient Single Pulse

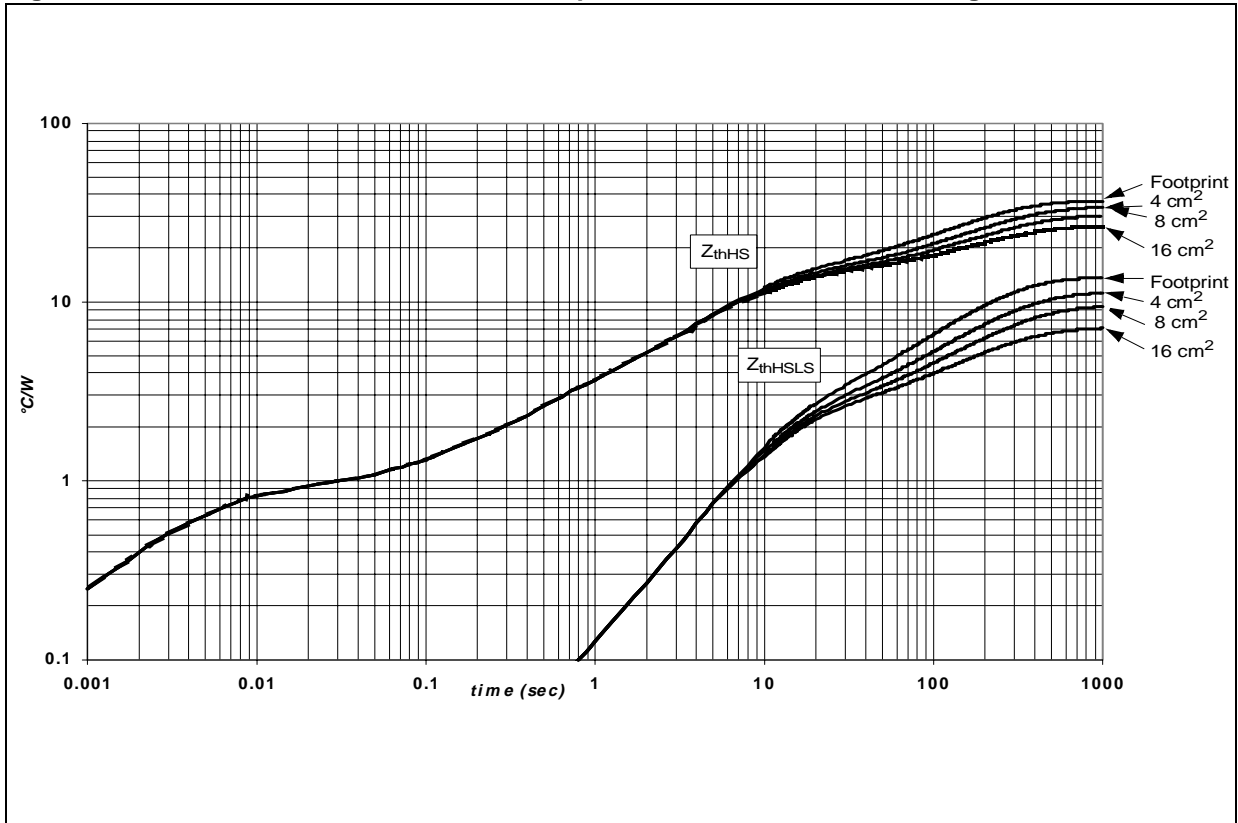


Figure 42. MultiPowerSo-30 LSD Thermal Impedance Junction Ambient Single Pulse

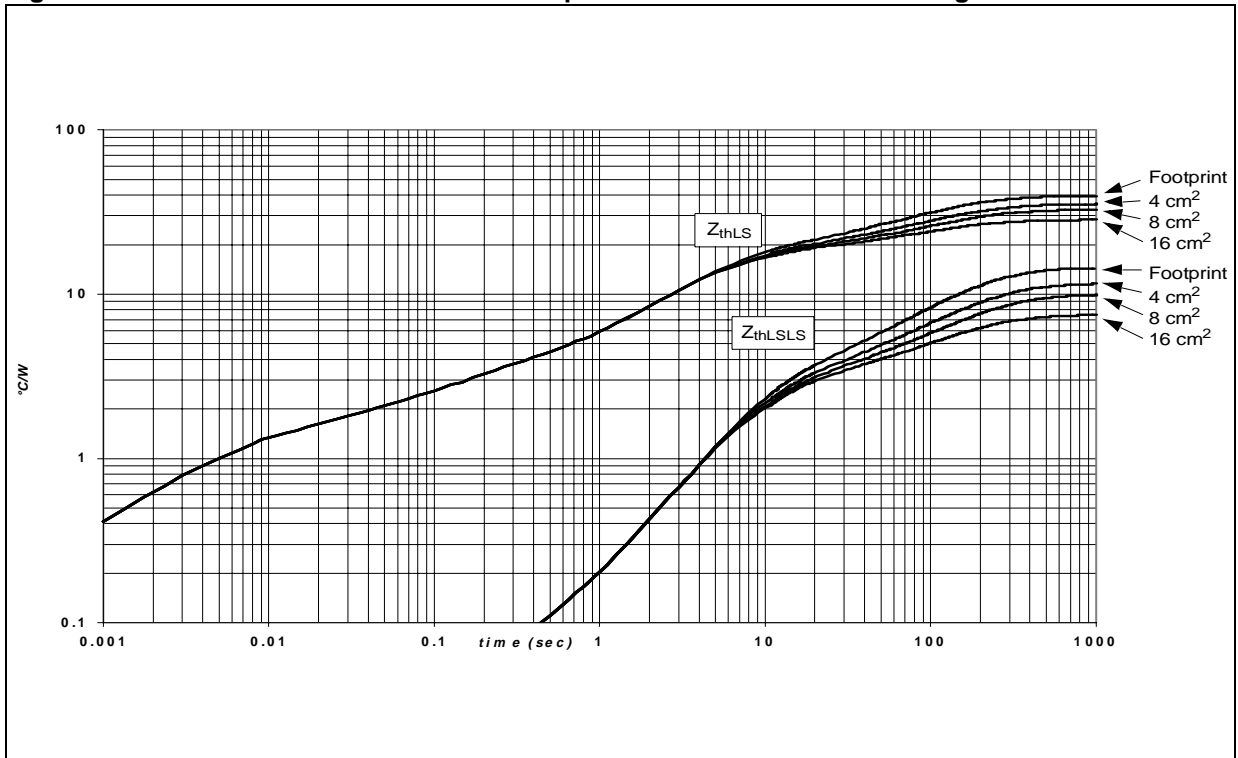


Figure 43. Thermal fitting model of an H-Bridge in MultiPowerSO-30

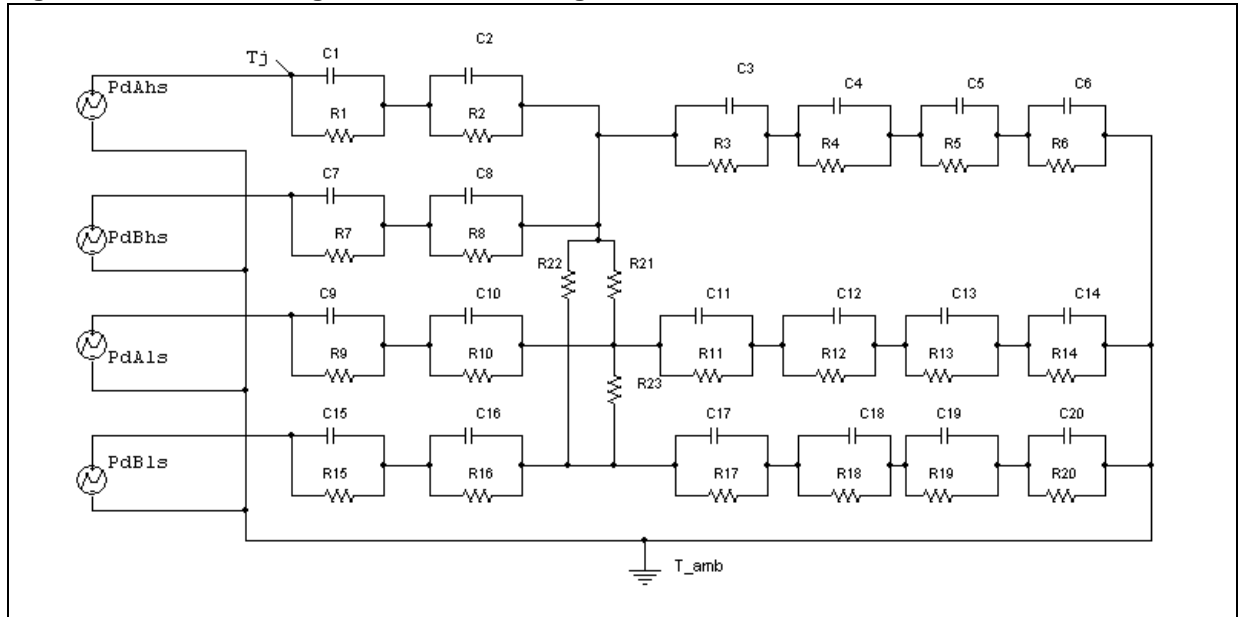


Table 18. Thermal Parameter (\*)

Area/island (cm <sup>2</sup> )	Footprint	4	8	16
R1=R7 (°C/W)	0.05			
R2=R8 (°C/W)	0.3			
R3 (°C/W)	0.5			
R4 (°C/W)	1.3			
R5 (°C/W)	1.4			
R6 (°C/W)	44.7	39.1	31.6	23.7
R9=R15 (°C/W)	0.2			
R10=R16 (°C/W)	0.4			
R11=R17 (°C/W)	0.8			
R12=R18 (°C/W)	1.5			
R13=R19 (°C/W)	20			
R14=R20 (°C/W)	46.9	36.1	30.4	20.8
R21=R22=R23 (°C/W)	115			
C1=C7 (W.s/°C)	0.005			
C2=C8 (W.s/°C)	0.008			
C3=C11=C17 (W.s/°C)	0.01			
C4=C13=C19 (W.s/°C)	0.3			
C5 (W.s/°C)	0.6			
C6 (W.s/°C)	5	7	9	11
C9=C15 (W.s/°C)	0.003			
C10=C16 (W.s/°C)	0.006			
C12=C18 (W.s/°C)	0.075			
C14=C20 (W.s/°C)	2.5	3.5	4.5	5.5

Note: (\*) The blank space means that the value is the same as the previous one.

PACKAGE MECHANICAL

Table 19. MultiPowerSO-30 Mechanical Data

Symbol	millimeters		
	Min.	Typ	Max.
A			2.35
A2	1.85		2.25
A3	0		0.1
B	0.42		0.58
C	0.23		0.32
D	17.1	17.2	17.3
E	18.85		19.15
E1	15.9	16	16.1
e		1	
F1	5.55		6.05
F2	4.6		5.1
F3	9.6		10.1
L	0.8		1.15
N			10deg
S	0deg		7deg

Figure 44. MultiPowerSO-30 Package Dimensions

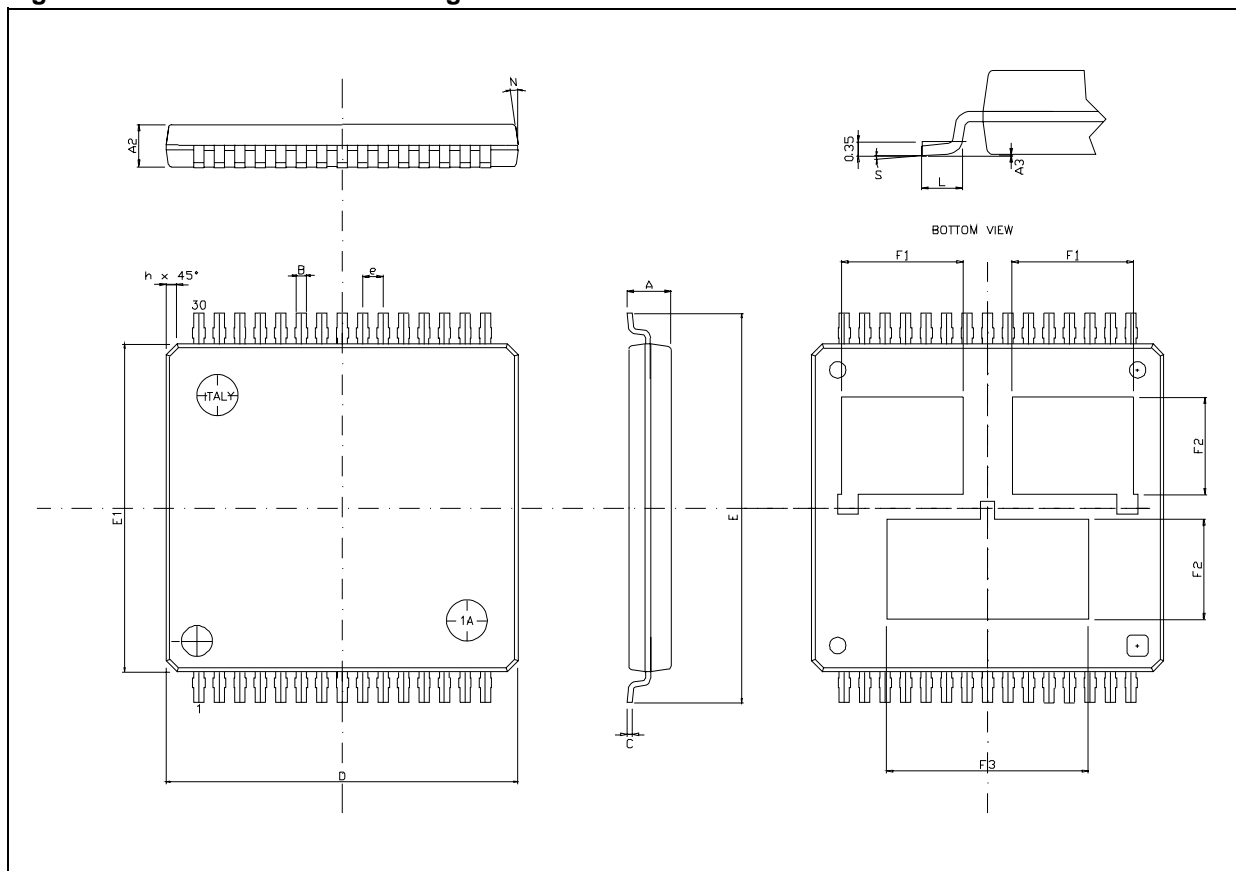
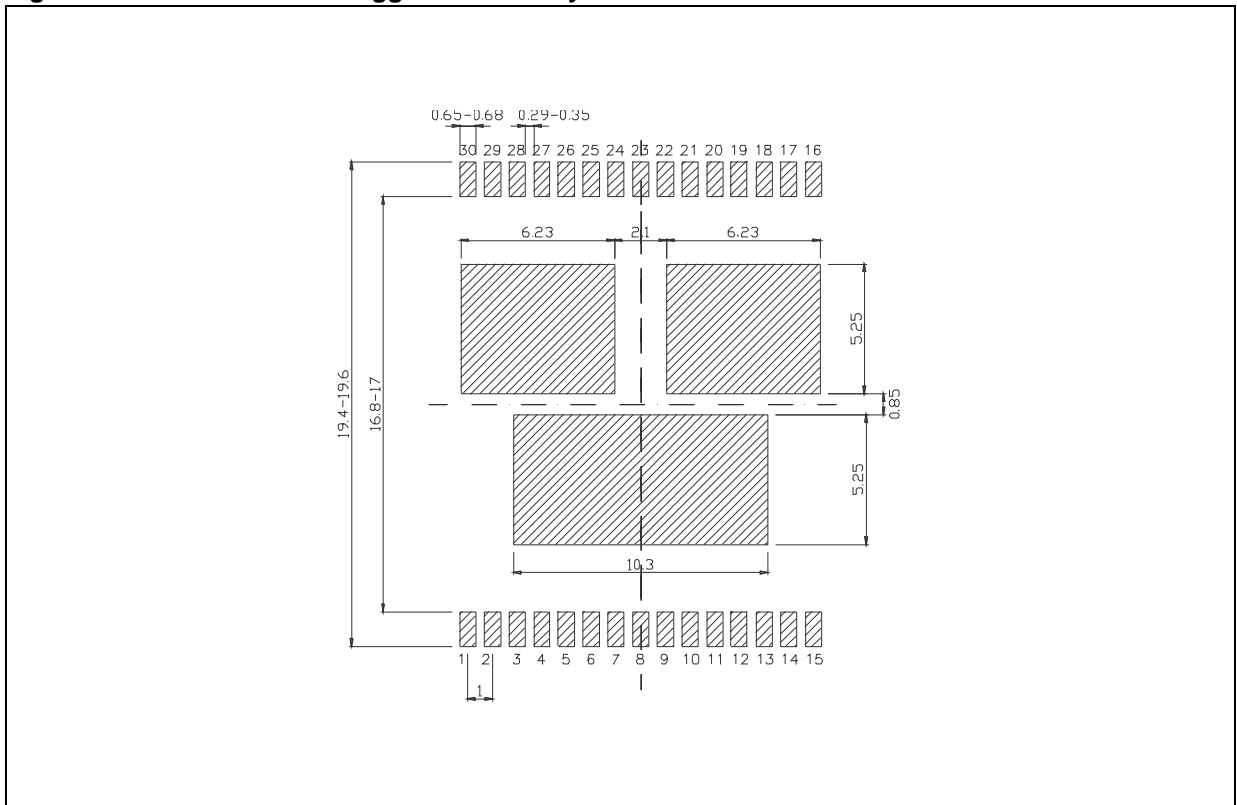


Figure 45. MultiPowerSO-30 Suggested Pad Layout





**REVISION HISTORY**

<b>Date</b>	<b>Revision</b>	<b>Description of Changes</b>
Sep. 2004	1	- First issue.

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