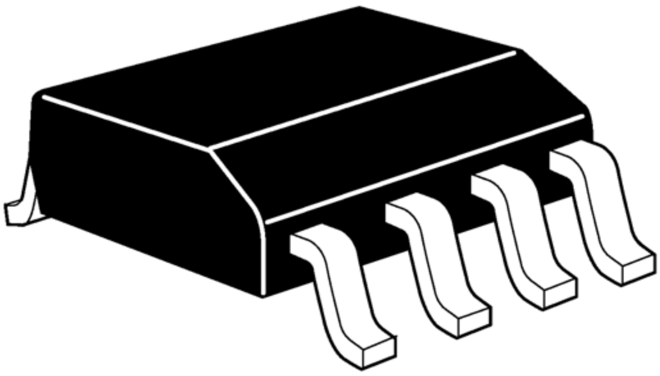
TMC32NP2-SM8

Manual

Complementary 30V Enhancement Mode MOSFET H-Bridge
For use with e.g. TMC239 or TMC249



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1 Features

This new generation of trench MOSFETs utilizes a unique structure that combines the benefits of low on-resistance with fast switching speed. Their unique high density four device package makes them ideal for high efficiency, low voltage, power management applications such as stepper motor drivers or DC motor drivers, using only a single package. Its low gate charge makes it an ideal power driver for the TMC239A and TMC249A family of stepper motor drivers. Using only two of these transistor packages, and the miniaturized TMC239A-LA or TMC249A-LA, a 1.5A (continuously) / 2.5A (current for 5 seconds) stepper driver can be build in the size of a stamp, using only three inexpensive devices.

SUMMARY

- N-Channel = $V_{(BR)DSS}$= 30V : $R_{DS(on)}$= 0.12 ; I_D= 3.1A
- P-Channel = $V_{(BR)DSS}$= -30V : $R_{DS(on)}$= 0.21 ; I_D= -2.3A

Applications

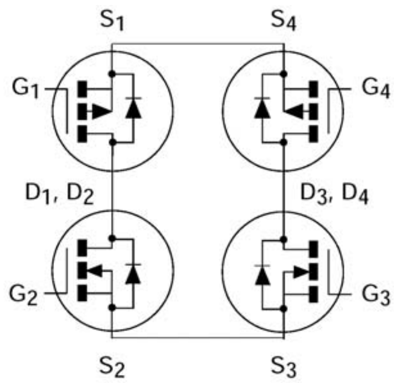
- Single phase stepper motor driver stage

Highlights

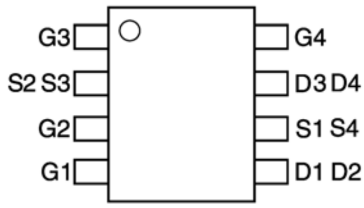
- Low on-resistance
- Fast switching speed
- Low threshold
- Low gate drive

Other

- Single SM-8 surface mount package
- RoHS compliant



Pinout



Top view

Order code	Description
TMC32NP2-SM8	Complementary 30V Enhancement Mode MOSFET H-Bridge

Table 1.1: Order codes

2 Life support policy

TRINAMIC Motion Control GmbH & Co. KG does not authorize or warrant any of its products for use in life support systems, without the specific written consent of TRINAMIC Motion Control GmbH & Co. KG.

Life support systems are equipment intended to support or sustain life, and whose failure to perform, when properly used in accordance with instructions provided, can be reasonably expected to result in personal injury or death.

3 Operational Ratings

3.1 Absolute Maximum Ratings

Symbol	Parameter	N-Channel	P-Channel	Unit
V_{DSS}	Drain-source voltage	30	-30	V
V_{GS}	Gate-source voltage	±20	±20	V
I_D	Continuos drain current (V_{GS}= 10V; T_A=25°C) (a) (d) (V_{GS}= 10V; T_A=25°C) (b) (d) (V_{GS}= 10V; T_A=70°C) (b) (d)	 2.7 3.1 2.5	 -2.0 -2.3 -1.8	A
I_{DM}	Pulsed drain current (c)	14.5	-10.8	A
I_S	Continuous source current (body diode) (b)	2.3	-2.2	A
I_{SM}	Pulsed source current (body diode) (c)	14.5	-10.8	A
P_D	Power dissipation at T_A =25°C (a) (d) Linear derating factor	1.3 10.4		W mW/°C
P_D	Power dissipation at T_A =25°C (b) (d) Linear derating factor	1.7 13.6		W mW/°C
T_j , T_{stg}	Operating and storage temperature range	-55 … +150		°C

Table 3.1: Absolute Maximum Ratings

3.2 Thermal Resistance

Symbol	Parameter	Value	Unit
$R_{θJA}$	Junction to ambient (a) (d)	96	°C/W
$R_{θJA}$	Junction to ambient (b) (d)	73	°C/W

Table 3.2: Thermal Resistance

(a) For a device surface mounted on 50mm x 50mm x 1.6mm FR4 PCB with high coverage of single sided 70µm copper, in still air conditions.
(b) For a device surface mounted on FR4 PCB measured at t ≤10 sec.
(c) Repetitive rating on 50mm x 50mm x 1.6mm FR4, D = 0.02, pulse width 300µS - pulse width limited by maximum junction temperature. Refer to transient thermal impedance graph.
(d) For device with one active die.

3.3 Characteristics

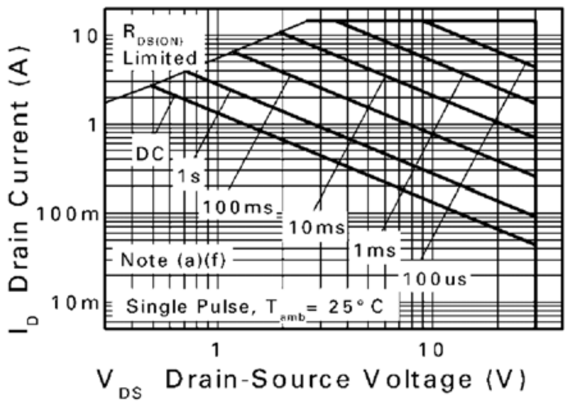


Figure 3.1: N-channel Safe Operating Area

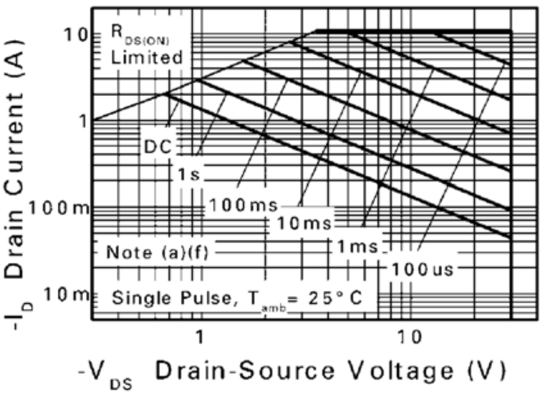


Figure 3.2: P-channel Safe Operating Area

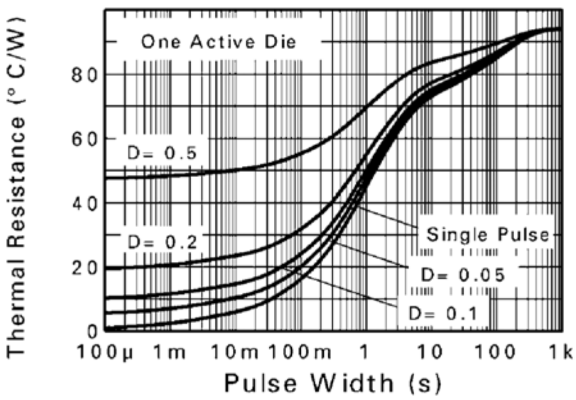


Figure 3.3: Transient Thermal Impedance

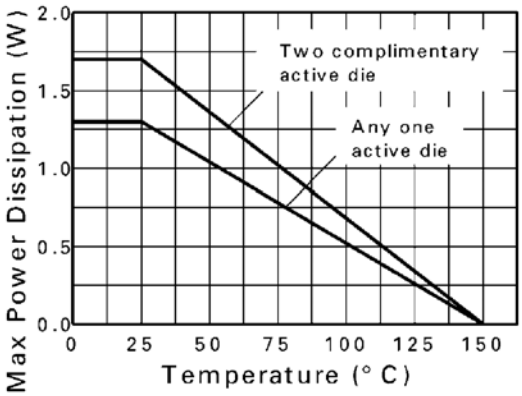


Figure 3.4: Derating Curve

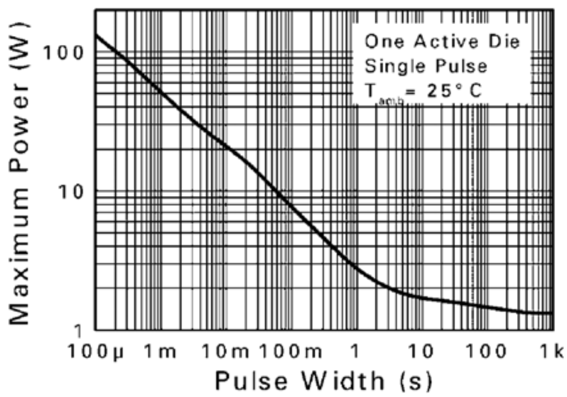


Figure 3.5: Pulse Power Dissipation

4 N-Channel

4.1 Electrical Characteristics

at T_{amb} = 25°C unless otherwise stated

Symbol	Parameter	Min	Typ	Max	Unit	Conditions
STATIC						
$V_{(BR)DSS}$	Drain-source breakdown voltage	30			V	I_D= 250µA, V_{GS}= 0V
I_{DSS}	Zero gate voltage drain current			1.0	µA	V_{DS}= 30V, V_{GS}= 0V
I_{GSS}	Gate-body leakage			100	nA	V_{GS}= ±20V, V_{DS}= 0V
$V_{GS(th)}$	Gate-source threshold voltage	1.0		3.0	V	I_D= 250µA, V_{DS}= V_{GS}
$R_{DS(on)}$	Static drain-source on-state resistance (1)			0.12 0.18	Ω Ω	V_{GS}= 10V, I_D= 2.5A V_{GS}= 4.5V, I_D= 2.0A
g_{fs}	Forward transconductance (1) (3)		3.5		S	V_{DS}= 4.5V, I_D= 2.5A
DYNAMIC (3)						
C_{iss}	Input capacitance		190		pF	V_{DS}= 25V, V_{GS}= 0V F = 1MHz
C_{oss}	Output capacitance		38		pF	
C_{rss}	Reverse transfer capacitance		20		pF	
SWITCHING (2) (3)						
$t_{d(on)}$	Turn-on-delay time		1.7		ns	V_{DD}= 15V, I_D= 2.5A R_G= 6.0Ω, V_{GS}= 10V
t_r	Rise time		2.3		ns	
$t_{d(off)}$	Turn-off delay time		6.6		ns	
t_f	Fall time		2.9		ns	
Q_g	Total gate charge		3.9		nC	V_{DS}= 15V, V_{GS}= 10V I_D= 2.5A
Q_{gs}	Gate-source charge		0.6		nC	
Q_{gd}	Gate drain charge		0.9		nC	
SOURCE-DRAIN-DIODE						
V_{SD}	Diode forward voltage (1)			0.95	V	T_j= 25°C, I_S= 1.7A, V_{GS}= 0V
t_{rr}	Reverse recovery time (3)		17.7		ns	T_j= 25°C, I_S= 2.5A, di/dt = 100A/µs
Q_{rr}	Reverse recovery charge (3)		13.0		nC	

Table 4.1: Electrical Characteristics, N-Channel

(1) Measured under pulsed conditions. Pulse width ≤ 300µs; duty cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.
(3) For design aid only, not subject to production testing.

4.2 Typical Characteristics

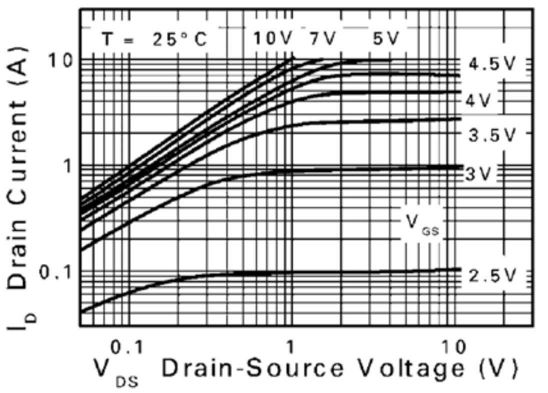


Figure 4.1: Output Characteristics (N)

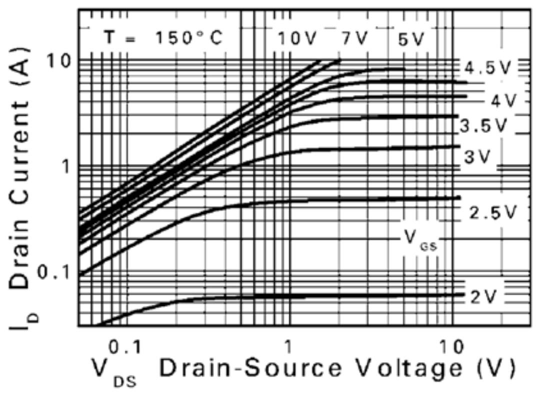


Figure 4.2: Output Characteristics (N)

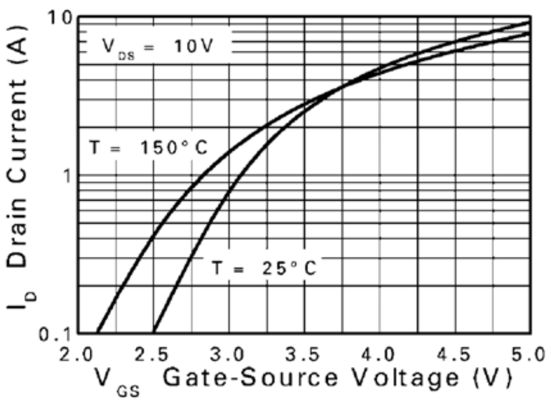


Figure 4.3: Typical Transfer Characteristics (N)

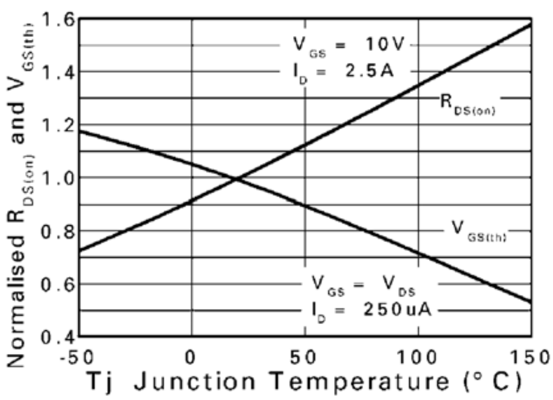


Figure 4.4: Normalized Curves v Temperature (N)

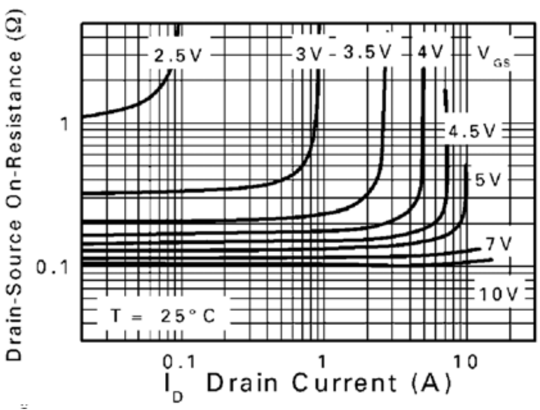


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Figure 4.5: On-Resistance v Drain Current (N)

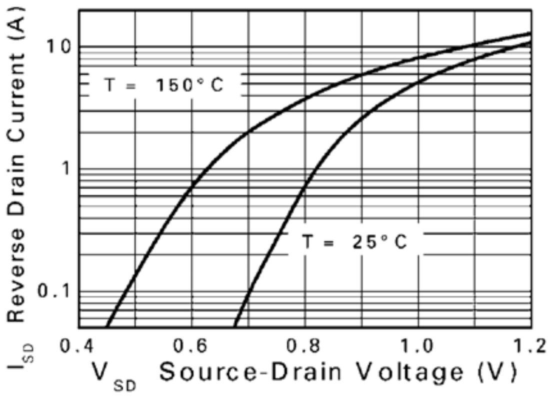


Figure 4.6: Source-Drain Diode Forward Voltage (N)

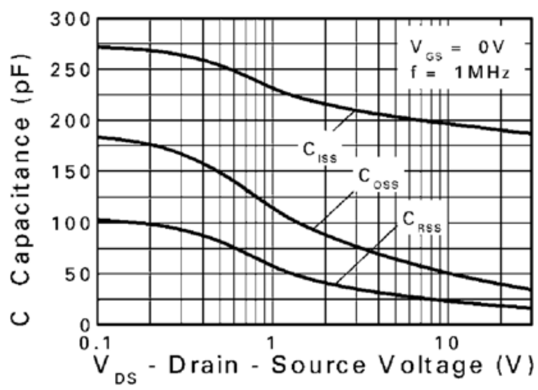


Figure 4.7: Capacity v Drain-Source Voltage (N)

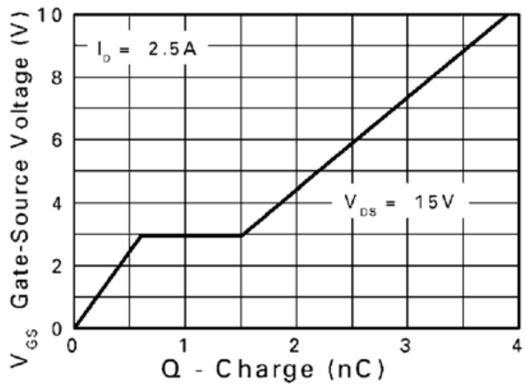


Figure 4.8: Gate-Source Voltage v Gate Charge (N)

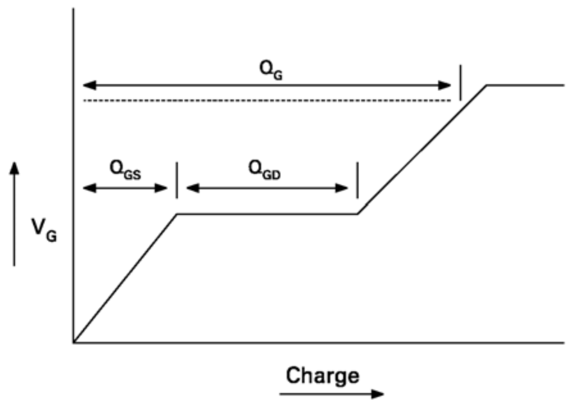


Figure 4.9: Basic Gate Charge Waveform (N)

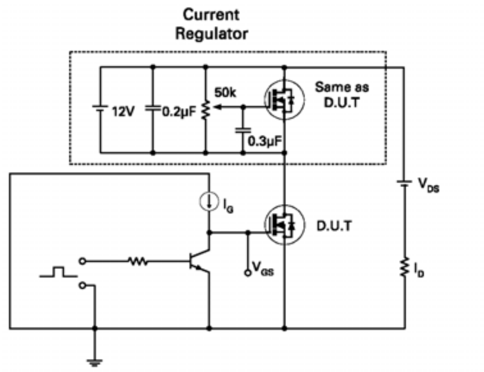


Figure 4.10: Gate Charge Test Circuit (N)

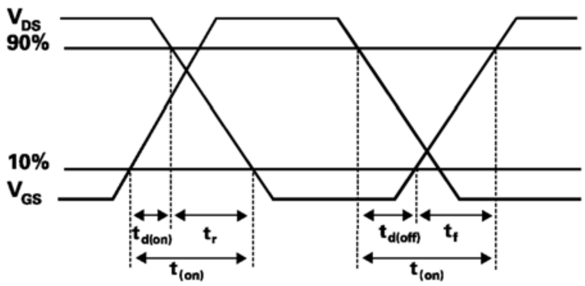


Figure 4.11: Switching Time Waveforms (N)

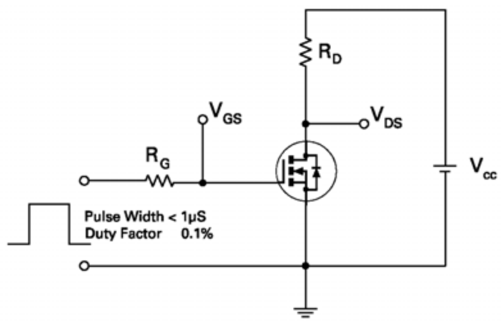


Figure 4.12: Switching Time Test Circuit (N)

5 P-Channel

5.1 Electrical Characteristics

at T_{amb} = 25°C unless otherwise stated

Symbol	Parameter	Min	Typ	Max	Unit	Conditions
STATIC						
$V_{(BR)DSS}$	Drain-source breakdown voltage	-30			V	I_D= -250µA, V_{GS}= 0V
I_{DSS}	Zero gate voltage drain current			-1.0	µA	V_{DS}= -30V, V_{GS}= 0V
I_{GSS}	Gate-body leakage			100	nA	V_{GS}= ±20V, V_{DS}= 0V
$V_{GS(th)}$	Gate-source threshold voltage	-1.0		-3.0	V	I_D= -250µA, V_{DS}= V_{GS}
$R_{DS(on)}$	Static drain-source on-state resistance [1]			0.21 0.33	Ω Ω	V_{GS}= -10V, I_D= -1.4A V_{GS}= -4.5V, I_D= -1.1A
g_{fs}	Forward transconductance [1] [3]		2.5		S	V_{DS}= -15V, I_D= 1.4A
DYNAMIC [3]						
C_{iss}	Input capacitance		204		pF	V_{DS}= -15V, V_{GS}= 0V F = 1MHz
C_{oss}	Output capacitance		39.8		pF	
C_{rss}	Reverse transfer capacitance		25.8		pF	
SWITCHING [2] [3]						
$t_{d(on)}$	Turn-on-delay time		1.2		ns	V_{DD}= 15V, I_D= 2.5A R_G= 6.0Ω, V_{GS}= 10V
t_r	Rise time		2.3		ns	
$t_{d(off)}$	Turn-off delay time		12.1		ns	
t_f	Fall time		7.5		ns	
	Total gate charge		2.6		nC	V_{DS}= -15V, V_{GS}= -5V I_D= -1.4A
Q_g	Total gate charge		5.2		nC	V_{DS}= -15V, V_{GS}= -10V I_D= -1.4A
Q_{gs}	Gate-source charge		0.7		nC	
Q_{gd}	Gate drain charge		0.9		nC	
SOURCE-DRAIN-DIODE						
V_{SD}	Diode forward voltage [1]		-0.85	-0.95	V	T_j= 25°C, I_S= -1.1A, V_{GS}= 0V
t_{rr}	Reverse recovery time [3]		19		ns	T_j= 25°C, I_S= -0.95A, di/dt = 100A/µs
Q_{rr}	Reverse recovery charge [3]		15		nC	

Table 5.1: Electrical Characteristics, P-Channel

[1] Measured under pulsed conditions. Pulse width ≤ 300_s; duty cycle ≤ 2%.
[2] Switching characteristics are independent of operating junction temperature.
[3] For design aid only, not subject to production testing.

5.2 Typical Characteristics

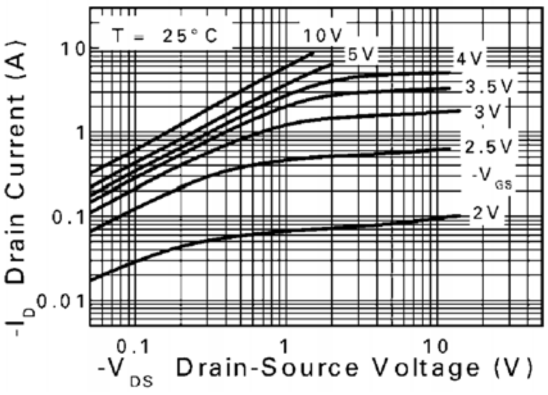


Figure 5.1: Output Characteristics (P)

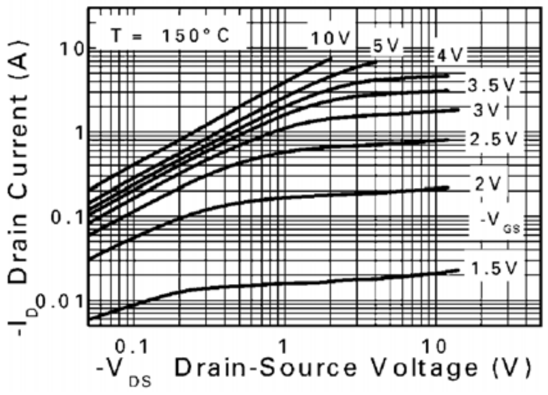


Figure 5.2: Output Characteristics (P)

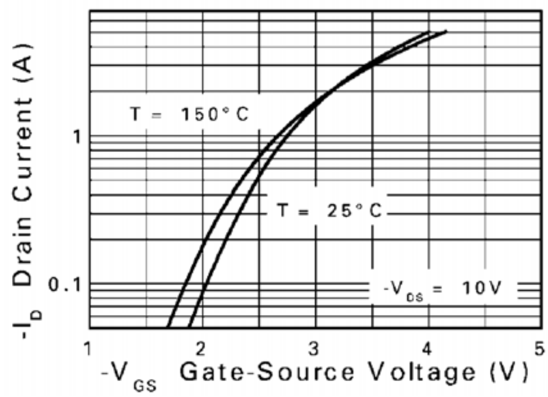


Figure 5.3: Typical Transfer Characteristics (P)

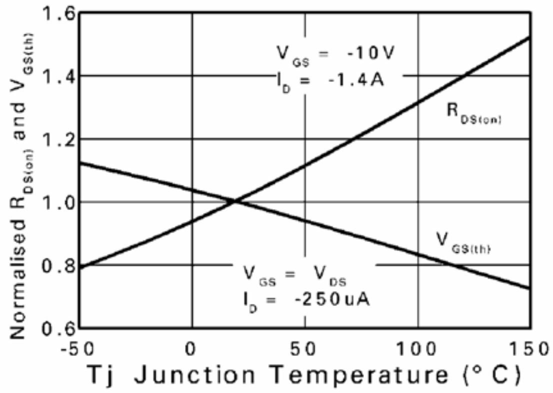


Figure 5.4: Normalized Curves v Temperature (P)

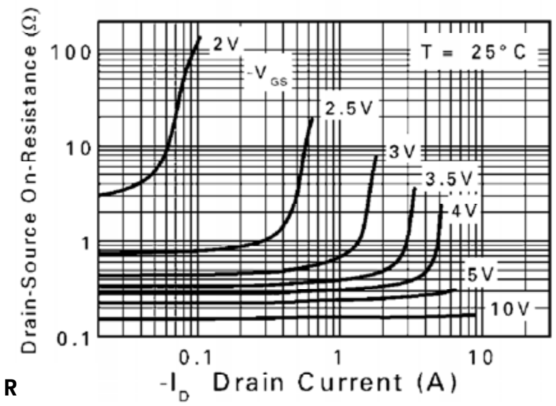


Figure 5.5: On-Resistance v Drain Current (P)

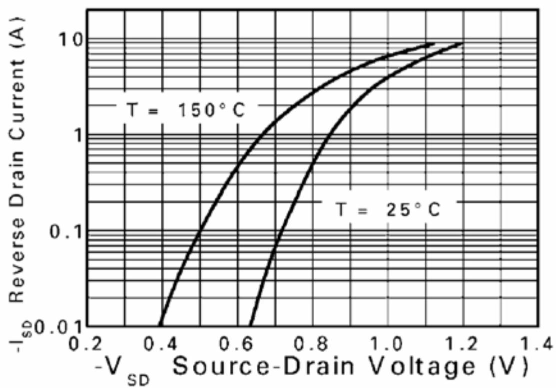


Figure 5.6: Source-Drain Diode Forward Voltage (P)

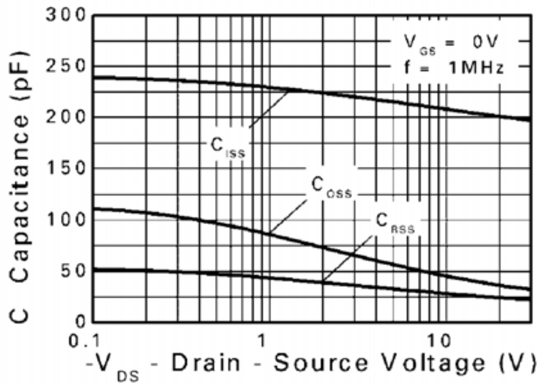


Figure 5.7: Capacity v Drain-Source Voltage (P)

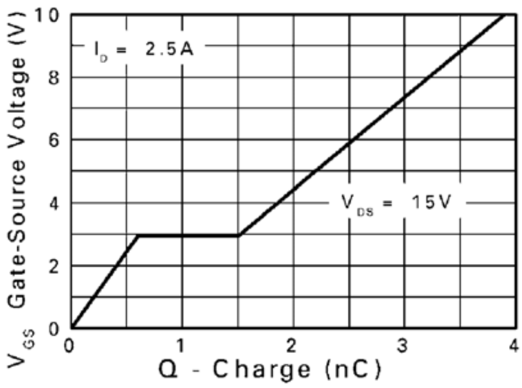


Figure 5.8: Gate-Source Voltage v Gate Charge (P)

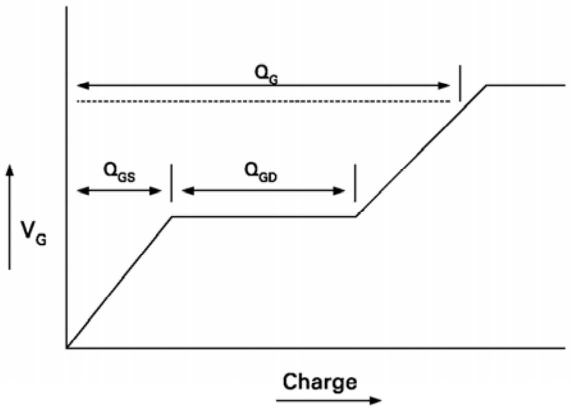


Figure 5.9: Basic Gate Charge Waveform (P)

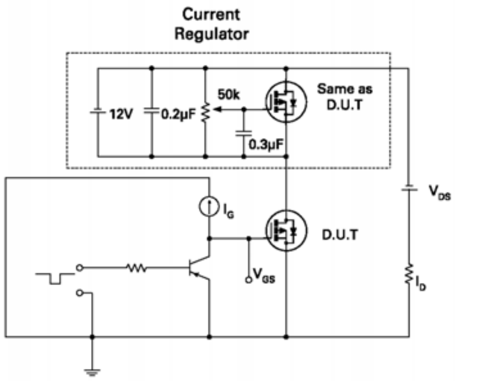


Figure 5.10: Gate Charge Test Circuit (P)

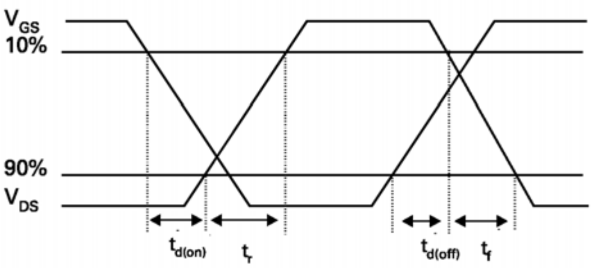


Figure 5.11: Switching Time Waveforms (P)

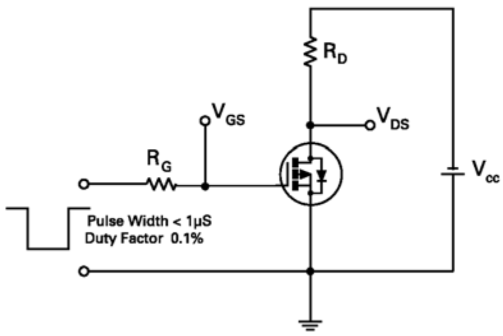


Figure 5.12: Switching Time Test Circuit (P)

6 Application with TMC239 / TMC249

6.1 Example Wiring

Example wiring with two TMC32NP2-SM8 and a TMC239. (Power supply capacitors not shown.)

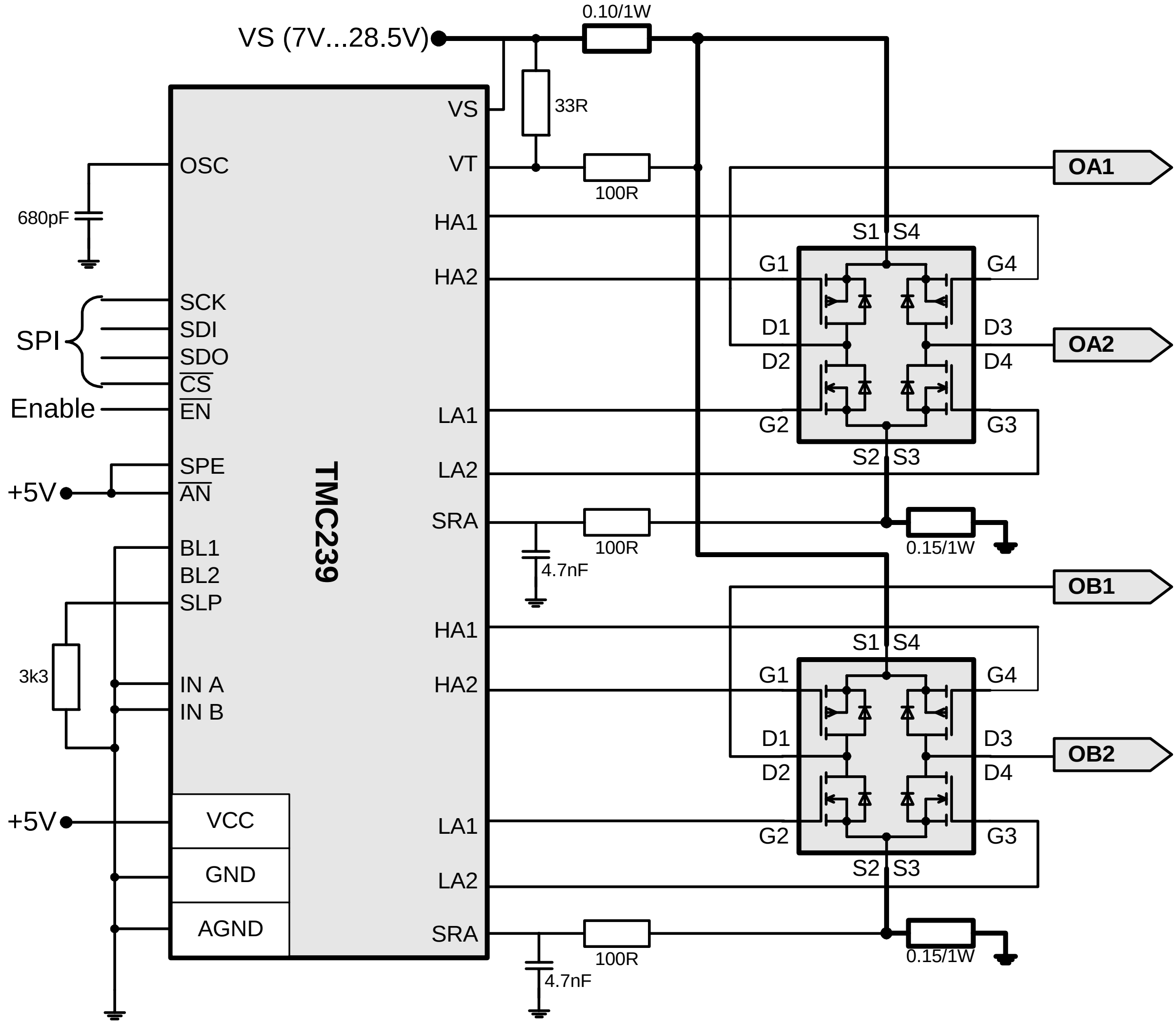


Figure 6.1: Example wiring with a TMC239

6.2 DC motor control with TMC239 and TMC32NP2-SM8

The TMC239 uses a constant current chopper principle, which is optimum for driving stepper motors. When operating DC motors with constant current, they provide a roughly constant torque. This in other words means, that velocity is very dependent upon mechanical load on the motor. Normally a velocity control is desired, with a torque limit as an add on. The TMC239 can do both! All of its advanced protection and diagnostic features can be used. One TMC239 can control two DC motors!

This solution uses the SPI interface of the TMC239 and allows full access to all of its features (Figure 6.2). The CPU provides three PWM signals to the TMC239: It directly controls the chopper clock (OSC) and uses INA / INB to provide a PWM signal for motor 1 and motor 2 (please keep in mind that the voltage for INA / INB should not be higher than 3V). The chopper clock can be in a range of a few kilo Hertz to a few ten kHz.

The PWM signal for motor 1 is related to the rising edge of the OSC pin (see Figure 6.3), while the PWM signal for motor 2 (if used) is related to the falling edge. The motor chopper is on, beginning from its related OSC edge until the processor switches the related INA / INB input to low. Required low time for INA / INB is 3µs or more. INA / INB shall return to high latest at the next related OSC edge. The resulting chopper on time controls the motor velocity. Please never let the OSC pin PWM output tri-stated. Provide a 10K pullup if this can not be guaranteed.

The motor torque is controlled by the current setting. The current calculation is identical as for a stepper motor: It is given via the digital current control bits in combination with the sense resistors and the INA / INB voltage divider control. You can try with slow or mixed decay setting for this mode. The motor direction is controlled by the SPI PHA / PHB bits. The motor can be stopped by programming the related DAC bits to zero. The three required PWM signals can be generated via a microcontroller with capture / compare unit, or using a single shot timer and interrupt operation.

This chopper scheme is the standard for DC motors. The TMC239 adds torque control and protection and diagnostic features.

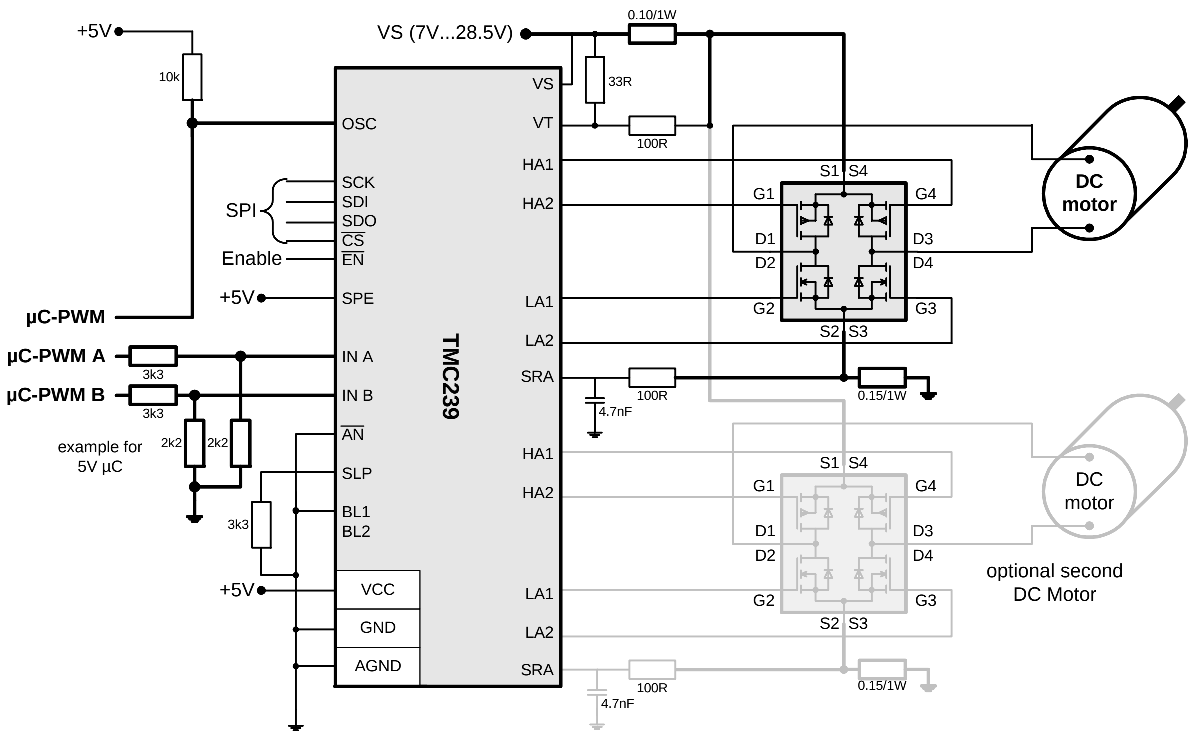


Figure 6.2: Example wiring for DC motor control with PWM using one TMC32NP2 per motor

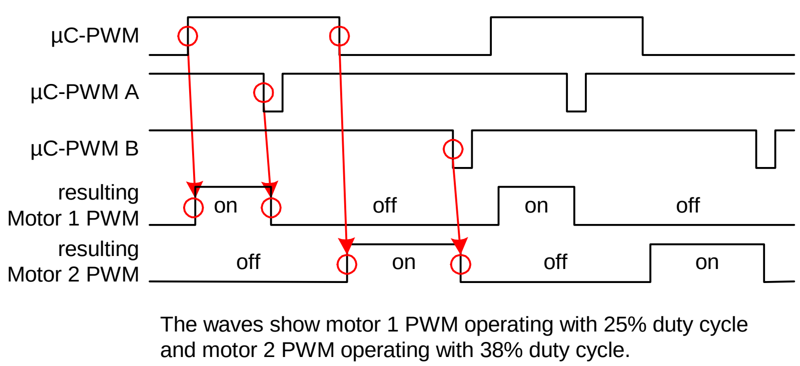


Figure 6.3: Microcontroller PWM and DC motor PWM

6.3 Example Layout

Table 6.1 shows an 2 layer example layout for two TMC32NP2-SM8 with a TMC249A-SA driver chip. Original size of this layout on a PCB is about 24x24mm, see Figure 6.4. Current capability is 1.5A peak (1.1A RMS) respectively 2.5A peak (1.8A RMS) with limited duty cycle.

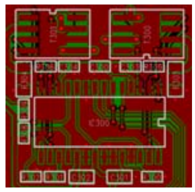
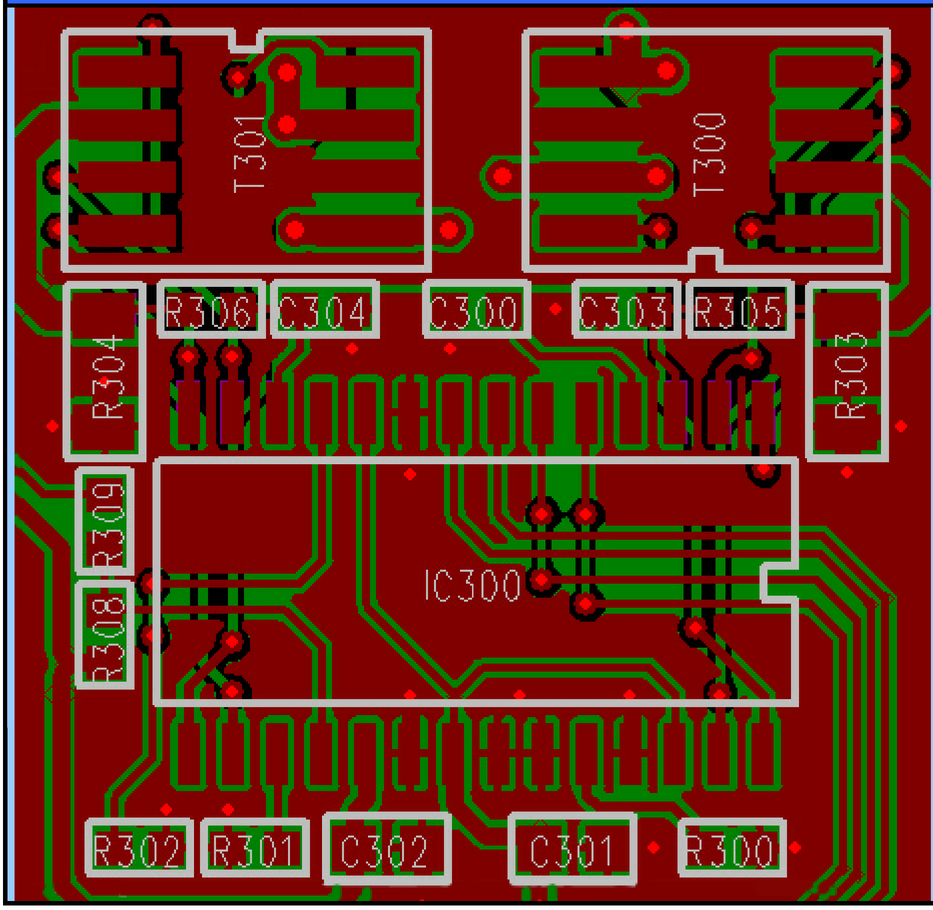


Figure 6.4: Example in original size on PCB



Layout	Name	Value/Description
	IC300	TMC249A-SA
	T300	TMC32NP2-SM8
	T301	
	R300	3k3 (RSLP) (0603)
	R301	0R (BL2 input)
	R302	Spare (BL1 input)
	R303	0R15/0.5W (0805)
	R304	
	R305	100R/1% (0603)
	R306	
	R308	33R/1% (optional short to GND protection)
	R309	100R/1% (optional short to GND protection)
	C300	680pF/50V (0603)
	C301	100nF/50V (0805)
	C302	
	C303	4.7nF/50V (0603)
	C304	

Table 6.1: Example Layout

Please refer to the evaluation board manual / website for more details.

7 Package Outline / Dimensions

Single SM-8 surface mount package

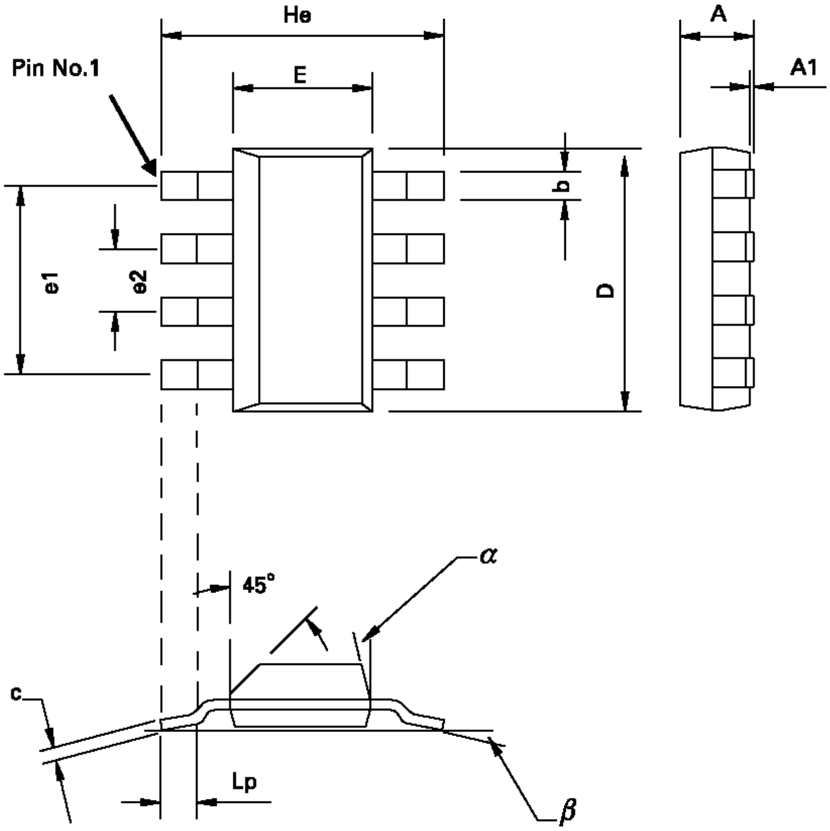


Figure 7.1: Package Outline

Controlling dimensions are in millimeters. Approximate conversions are given in inches.

DIM	Millimeters			Inches			DIM	Millimeters			Inches		
	Min	Max	Typ.	Min	Max	Typ.		Min	Max	Typ.	Min	Max	Typ.
A	-	1.7	-	-	0.067	-	e1	-	-	4.59	-	-	0.1807
A1	0.02	0.1	-	0.008	0.004	0.0275	e2	-	-	1.53	-	-	0.0602
b	-	-	0.7	-	-	-	He	6.7	7.3	-	0.264	0.287	-
c	0.24	0.32	-	0.009	0.013	-	Lp	0.9	-	-	0.035	-	-
D	6.3	6.7	-	0.248	0.264	-	□	-	15°	-	-	15°	-
E	3.3	3.7	-	0.130	0.145	-	□	-	-	10°	-	-	10°

Table 7.1: Package Dimensions

8 Revision History

8.1 Documentation Revision

Version	Comment	Author	Description
1.0	16-Mar-2007	HC	Initial Version
1.01	4-Apr-2007	HC	DC motor application added
1.02	11-Apr-2007	HC	Example Layout added
1.03	16-Aug-07	DW	Corrected DC motor schematic

Table 8.1: Documentation Revisions

9 References

[TMC239] Microstep driver manual (see http://www.trinamic.com)
[TMC249] Microstep driver manual, with StallGuard (see http://www.trinamic.com)