Stepper Motor Controller

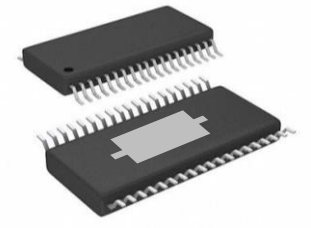
PRODUCT DESCRIPTION

The MS35711T/MS35711TE is a stepper motor controller, using external N-channel MOSFET to drive one bipolar stepper motor or two brushed DC motors.

The MS35711T/MS35711TE supports full step to 1/256 step drive modes. Smooth motion process can be achieved by self-adaption blank time and different current decay modes, including automatic mixed decay.

The motor motion is controlled by SPI serial interface, adopting standard DIR/STEP control method. Output current (torque), step mode, decay mode and lock detection all can be programmed through SPI serial interface.

TSSOP38



TSSOP38/PP

FEATURES

- PWM Microstepping Motor Controller
- Built-in 256 Microstep
- Optional STEP/DIR Interface Control or Direct PWM Control Interface
- Direct PWM Control Logic,including IN1,IN2 control and EN,PH control
- Flexible Decay Mode
- SPI Serial Interface Control
- Lock Detection with Optional BEMF Output
- 8V-55V Power Supply
- Drive Dual-N MOSFETs, Adjustable Pre-drive Capacity
- Complete Protection Function: Overcurrent Protection, Overtemperature Protection, Undervoltage Lockout
- Fault Indication Pin

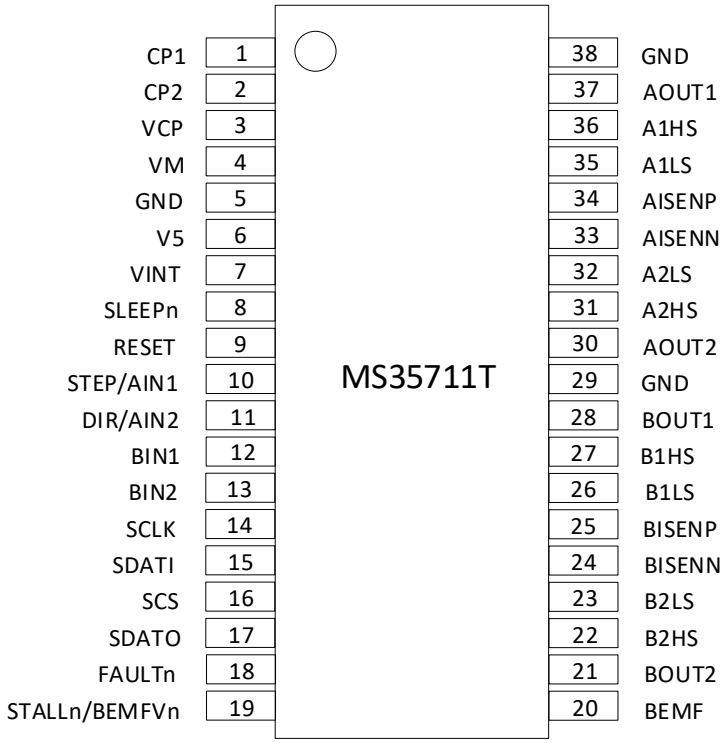
APPLICATIONS

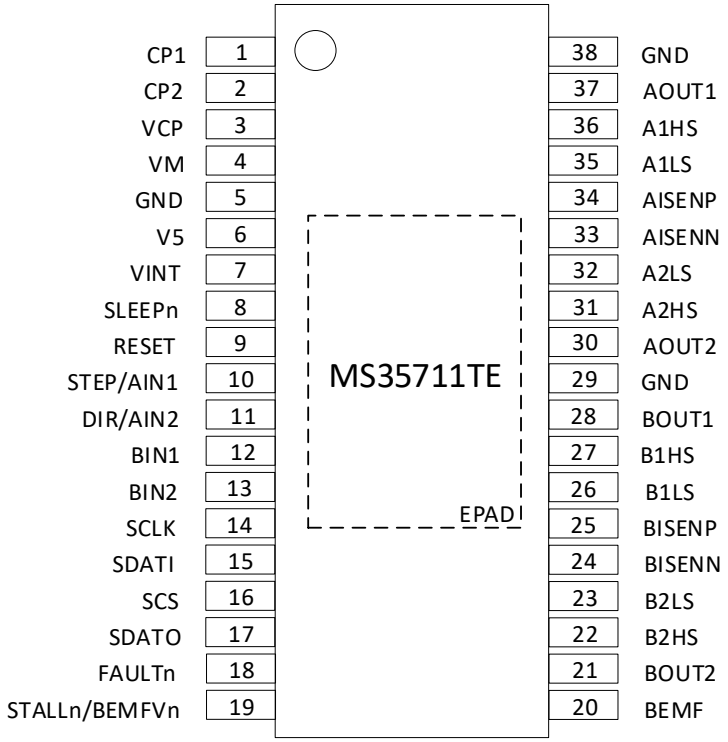
- Office and Industry Automation
- Robots

PRODUCT SPECIFICATION

Part Number	Package	Marking
MS35711T	TSSOP38	MS35711T
MS35711TE	TSSOP38/PP	MS35711TE

PIN CONFIGURATION



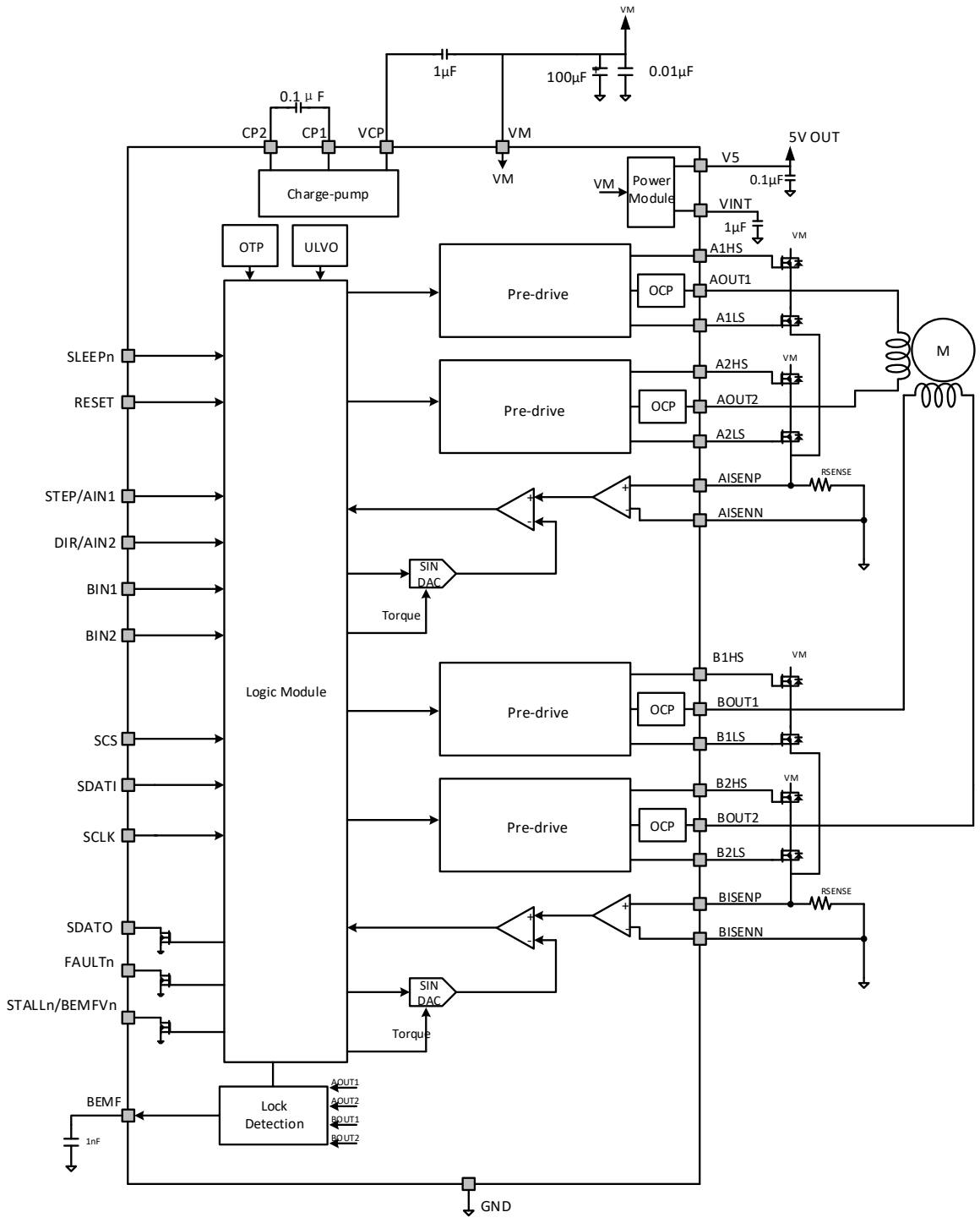


PIN DESCRIPTION

Pin	Name	Type	Description
1	CP1	IO	Charge-pump External Capacitance
2	CP2	IO	Charge-pump External Capacitance
3	VCP	IO	Charge-pump Voltage, 10V Higher than VM
4	VM	P	Power Supply
5	GND	-	Ground
6	V5	O	5V LDO Output, Connected with 0.1μF capacitance to ground
7	VINT	O	1.8V LDO Capacitance, Connected with 1μF capacitance to ground
8	SLEEPn	I	Sleep Mode Input
9	RESET	I	Reset Input
10	STEP/AIN1	I	Stepping Input/Bridge A IN1
11	DIR/AIN2	I	Direction Input/Bridge A IN2
12	BIN1	I	Bridge B IN1
13	BIN2	I	Bridge B IN2
14	SCLK	I	Serial Clock Input
15	SDATI	I	Serial Data Input
16	SCS	I	Serial Chip Select Input
17	SDATO	OD	Serial Data Output
18	FAULTn	OD	Fault Signal
19	STALLn/BEMFVn	OD	Lock/BEMF Flag Signal
20	BEMF	O	Back Electromotive Force
21	BOUT2	I	Bridge B2 Output
22	B2HS	O	Bridge B2 HS Gate
23	B2LS	O	Bridge B2 LS Gate
24	BISENN	I	Bridge B Current Sense Resistor, Negative Input
25	BISENP	I	Bridge B Current Sense Resistor, Positive Input
26	B1LS	O	Bridge B1 LS Gate
27	B1HS	O	Bridge B1 HS Gate
28	BOUT1	I	Bridge B1 Output

Pin	Name	Type	Description
29	GND	-	Ground
30	AOUT2	I	Bridge A2 Output
31	A2HS	O	Bridge A2 HS Gate
32	A2LS	O	Bridge A2 LS Gate
33	AISENN	I	Bridge A Current Sense Resistor, Negative Input
34	AISENP	I	Bridge A Current Sense Resistor, Positive Input
35	A1LS	O	Bridge A1 LS Gate
36	A1HS	O	Bridge A1 HS Gate
37	AOUT1	I	Bridge A1 Output
38	GND	-	Ground
-	EPAD	-	Thermal Pad, Recommend to Connect with Ground

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Any exceeding absolute maximum rating application causes permanent damage to device. Because long-time absolute operation state affects device reliability. Absolute ratings just conclude from a series of extreme tests. It doesn't represent chip can operate normally in these extreme conditions.

Parameter	Symbol	Ratings	Unit
Power Supply	V_{VM}	-0.6 ~ 60	V
Charge-pump Voltage (VCP)	V_{VCP}	-0.6 ~ V_{VM}+12	V
Charge-pump Voltage (CP2)	V_{CP1}	-0.6 ~ V_{VM}+12	V
Charge-pump Voltage (CP1)	V_{CP1}	-0.6 ~ V_{VM}+0.6	V
5V Output	V_{V5}	-0.6 ~ 5.5	V
Internal 1.8V Output	V_{VINT}	-0.6 ~ 2	V
Digital IO (SLEEPn,RESET,STEP/AIN1,DIR/AIN2,BIN1,BIN2,SCS,SCLK ,SDATI,SDATO,FAULTn,STALLn / BEMFVn)	V_{DIG_IO}	-0.6 ~ 5.5	V
ISENSEx Voltage (AISENP,AISENN,BISENP,BISENN)	V_{SENSE}	<0.6	V
HS Gate Drive Pin Voltage (A1HS,A2HS,B1HS,B2HS)	V_{HS}	-0.6 ~ V_{VM}+12	V
LS Gate Drive Pin Voltage (A1LS,A2LS,B1LS,B2LS)	V_{LS}	-0.6 ~ 12	V
Phase Node Pin Voltage (AOUT1,AOUT2,BOUT1,BOUT2)	V_{OUT}	0.6 ~ V_{VM}+0.6	
BEMF Pin Voltage (BEMF)	V_{IN}	5.5	V
ESD (HBM)	V_{ESD}	±3k	V
Operating Junction Temperature	T_J	-40 ~ 150	°C
Storage Temperature	T_{STG}	-40 ~ 150	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Range			Unit
		Min	Typ	Max	
Power Supply	V_{VM}	8		55	V
Operating Temperature	T_A	-40		85	°C

ELECTRICAL CHARACTERISTICS

V_{VM}=24V. Note: unless otherwise specified, T_A = 25°C ±2°C.

Current Consumption

Parameter	Symbol	Condition	Min	Typ	Max	Unit
VM Power Supply Current	I_{VM}			23		mA
Sleep Mode, Power Supply Current	I_{VMQ}	SLEEPn=0		60		μA

Internal LDO

Parameter	Symbol	Condition	Min	Typ	Max	Unit
V5 Output Voltage	V_{V5}	Output current 1mA to 10mA	4.8	5	5.2	V
VINT Output Voltage	V_{VINT}	No load, only as reference voltage	1.7	1.8	1.9	V

Digital Input and Output

Parameter	Symbol	Condition	Min	Typ	Max	Unit
High-level Input	$V_{in(H)}$		1.5			V
Low-level Input	$V_{in(L)}$				0.8	V
Input Hysteresis	$V_{in(hys)}$			0.3		V
Port Pull-low Current	I_{IL}	V_{IN}=0V		0		μA
Port Pull-up Current	I_{IH}	V_{IN}=5V		50		μA

SDATAO,STALLn,FAULTn Output (Open-drain)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Output Saturation Voltage Drop	V_{ODSAT}	Iout=5mA		160	500	mV
Output Leak Current	I_{ODLK}	VO=3.3V		1		μA

Gate Drive

Parameter	Symbol	Condition	Min	Typ	Max	Unit
HS Gate Drive Voltage	V_{OUTH}	Io=100μA		V_{VM}+10		V
LS Gate Drive Voltage	V_{OUTL}	Io=100μA		10		V
Dead Time	t_{DEAD}	DTIME=00		400		ns
		DTIME=01		450		
		DTIME=10		650		
		DTIME=11		850		
Pull-up Peak Current	I_{OUTPU}	IDRIVEP=00		50		mA
		IDRIVEP=01		100		
		IDRIVEP=10		150		
		IDRIVEP=11		200		

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Pull-down Peak Current	I_{OUTPD}	IDRIVEN=00		100		mA
		IDRIVEN=01		200		
		IDRIVEN=10		300		
		IDRIVEN=11		400		
Duration Time, Pull-up Strong Peak Current	t_{DRIVEP}	TDRIVEP=00		250		ns
		TDRIVEP=01		500		
		TDRIVEP=10		1000		
		TDRIVEP=11		2000		
Duration Time, Pull-down Strong Peak Current	t_{DRIVEN}	TDRIVEN=00		250		ns
		TDRIVEN=01		500		
		TDRIVEN=10		1000		
		TDRIVEN=11		2000		

Current Chopper

Parameter	Symbol	Condition	Min	Typ	Max	Unit
PWM Off Time		Setting Register TOFF	0.5		128	μs
Blank Time	$V_{in(L)}$	Setting Register TBLANK	0.5		5.12	μs

Protection Circuit

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Overcurrent Protection Threshold	V_{OCP}	OCPTH=00		250		mV
		OCPTH=01		500		
		OCPTH=10		750		
		OCPTH=11		1000		
Overtemperature Protection	T_{OTP}	Temperature rising	150	160	180	°C
Overtemperature Protection Hysteresis	T_{OTPHYS}			20		°C

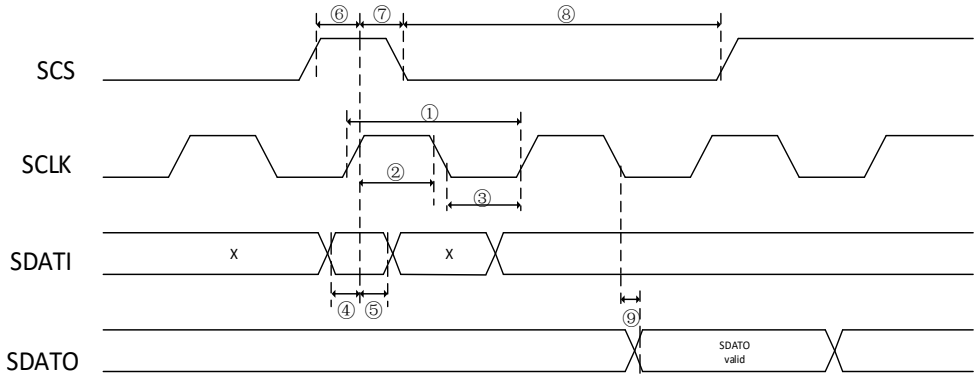
Current Sense Amplifier

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Gain	A_V	ISGAIN=00		5		V/V
		ISGAIN=01		10		
		ISGAIN=10		20		
		ISGAIN=11		40		

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Setup Time	t_{SET}	ISGAIN=00,ΔVIN=400mV		150		ns
		ISGAIN=01,ΔVIN=200mV		300		
		ISGAIN=10,ΔVIN=100mV		600		
		ISGAIN=11,ΔVIN=50mV		1200		
Offset Voltage	V_{OFS}	ISGAIN=00,Input Shorted			4	mV
Input Range	V_{INAMP}		-600		600	mV

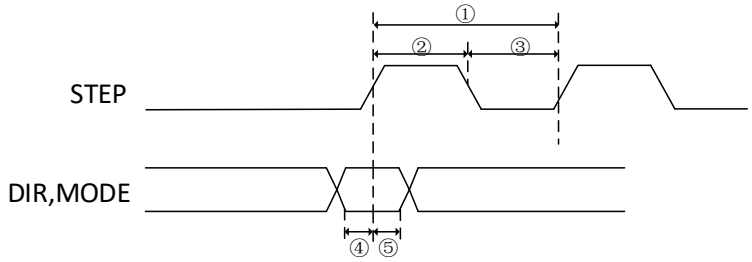
Timing

SPI Communication Timing



Number	Parameter	Symbol	Min	Typ	Max	Unit
1	Clock Period	t_{CYC}	250			ns
2	Clock High-level Time	t_{CLKH}	25			ns
3	Clock Low-level Time	t_{CLKL}	25			ns
4	Setup Time, SDATI to SCLK	$t_{SU(SDATI)}$	5			ns
5	Hold Time, SDATI to SCLK	$t_{H(SDATI)}$	1			ns
6	Setup Time, SCS to SCLK	$t_{SU(SCS)}$	5			ns
7	Setup Time, SCS to SCLK	$t_{H(SCS)}$	1			ns
8	Inactive Time, SCS (Between Writing and Reading)	$t_{L(SCS)}$	100			ns
9	Delay Time, SCLK to SDATO (Reading Period)	$t_{D(SDATO)}$			10	ns
	Wake Time (SLEEPn Off to HS Gate Enabled)	t_{SLEEP}			1	ms
	Delay Time, From Reset or RESETn High to Serial Interface Operating	t_{RESET}			10	µs

Stepping Control Timing



Number	Parameter	Symbol	Min	Typ	Max	Unit
1	Step Frequency	f_{STEP}			250	kHz
2	STEP High-level Duration	t_{WH}	1.9			μs
3	STEP Low-level Duration	t_{WL}	1.9			μs
4	STEP Setup Time	t_{SU}	200			ns
5	STEP Hold Time	t_H	200			ns

FUNCTION DESCRIPTION

Overview

The MS35711T/MS35711TE is a stepper motor controller, using external N-channel MOSFET to drive one bipolar stepper motor or two brushed DC motors.

The MS35711T/MS35711TE supports full to 1/256 step drive modes. Smooth motion system configuration can be achieved by self-adaption blank time, adjustable decay time and different current decay modes.

The motor motion is controlled by SPI serial interface, adopting standard DIR/STEP control method. Output current (torque), step mode, decay mode and lock detection all can be programmed through SPI serial interface.

The MS35711T/MS35711TE provides complete protection function, including overcurrent protection, overtemperature protection, undervoltage lockout and so on. The fault state is indicated by FAULTn pin and each fault state is achieved by a SPI dedicated bit.

Reset

The MS35711T/MS35711TE has internal power-up-reset circuit to monitor VM pin voltage. If VM voltage is less than UVLO voltage, the MS35711T/MS35711TE is reset. If RESET pin is set as high level, all internal logic are reset and power part will be disabled. And all inputs of the step and serial interface will be ignored.

When RESET state (set as low level) exits, after about 1 ms, the MS35711T/MS35711TE recovers normal operation.

Low Power Dissipation Mode

When SLEEPn pin is set to low level, the device enter into low power dissipation mode. In sleep mode, the motor drive circuit, gate drive regulator and charge-pump are disabled. All analog circuits are set in low power state, while digital circuits still operate. Therefore, device registers still can be accessed through serial interface.

When SLEEPn pin is activated, RESET pin can not work. Before RESET is activated, the MS35711T/MS35711TE must exit from low power dissipation mode.

When exiting from low power dissipation mode, it needs about 1ms before STEP input is applied.

Direct PWM Input Mode

Direct PWM mode is enabled by setting PWMMODE bit of 0x2 register, and PWM_MODESEL to choose input mode logic. In direct PWM input mode, AIN1, AIN2, BIN1 and BIN2 control output driver state, thus driving two brushed DC motors at most.

When PWM_MODESEL = 2’b00, xIN1 and xIN2 are common IN1,IN2 control logic as follows:

xIN1	xIN2	xOUT1	xOUT2
0	0	Z	Z
0	1	L	H
1	0	H	L
1	1	L	L

When PWM_MODESEL = 2’b01, xIN1 is enable control xEN, and xIN2 is direction control xPH. When xIN1=0, output is high-impedance state. The logic table is as follows:

xIN1	xIN2	xOUT1	xOUT2
0	0	Z	Z
0	1	Z	Z
1	0	L	H
1	1	H	L

When PWM_MODESEL = 2’b10, xIN1 is enable control xEN, and xIN2 is direction control xPH. When xIN1=0, output is brake state. The logic table is as follows:

xIN1	xIN2	xOUT1	xOUT2
0	0	L	L
0	1	L	L
1	0	L	H
1	1	H	L

When PWM_MODESEL = 2’b11, xIN1 is enable control xEN, and xIN2 is direction control xPH. The logic table is as follows:

xIN1	xIN2	xOUT1	xOUT2
0	0	Z	Z
0	1	L	L
1	0	L	H
1	1	H	L

If mixed or automatic mixed decay mode are used in direct PMW mode, they will be applied to each period. Because current change information can not used.

In direct PWM mode, current control circuit (Torque) is at open state, and TORGUE register is used to scale current. Setting ISEN sense amplifier gain by ISGAIN bit of 0x1 register.

The current of motor winding can be adjusted through PWM current regulator circuit of programmable fixed off-time. When H bridge is enabled, current rises at a rate. And the rate depends on DC voltage, inductance and BEMF. Once the current reaches current chopping threshold, the bridge will disable the current in fixed time period, which can be programmed between 500ns and 128μs by writing to TOFF bit of off register. After the off time, the bridge would be enabled again and start another PWM period.

Chopping current is set by comparator, which compares the reference voltage with the voltage of current sense resistor. The resistor is connected to xISENx pin. The voltage across the resistor is magnified by current sense amplifier, which is programmed in control register. When driving in PWM mode, the chopping current is calculated as follows :

$$I_{CHOP} = \frac{2.75V \times TORQUE}{256 \times ISGAIN \times R_{ISENSE}}$$

Full-scale VREF is set to 2.75V. TORQUE is the setting of TORQUE bit, and ISGAIN is programmable gain of ISENSE amplifier (5x, 10x, 20x or 40x).

Microstep Control STEP/DIR Input Control Mode

The built-in indexer logic allows different step configurations.

MODE bit of 0x0 register is applied to configure microstep as follows:

MODE[3]	MODE[2]	MODE[1]	MODE[0]	Step Mode
0	0	0	0	Full step(two-phase excitation), 71% Current
0	0	0	1	1/2 Step
0	0	1	0	1/4 Step
0	0	1	1	1/8 Step
0	1	0	0	1/16 Step
0	1	0	1	1/32 Step
0	1	1	0	1/64 Step
0	1	1	1	1/128 Step
1	0	0	0	1/256 Step

The following table shows the relative current and step direction for full step to 1/8 step modes. Higher microstep resolution follows the same mode. AOUT current is sine value of electrical angle; BOUT current is cosine value of electrical angle. The reset state is 45° position and the state is entered when power up or using RESETn.

Full Step	1/2 Step	1/4 Step	1/8 Step	AOUT Current (% Full-scale)	BOUT Current (% Full-scale)	Electrical Angel (Degree)
	1	1	1	0	100	0
			2	20	98	11.325
		2	3	38	92	22.5
			4	56	83	33.75
1	2	3	5	71	71	45 (Inital State)
			6	83	56	56.25
		4	7	92	38	67.5
			8	98	20	78.75
	3	5	9	100	0	90
			10	98	-20	101.25
		6	11	92	-38	112.5
			12	83	-56	123.75
2	4	7	13	71	-71	135
			14	56	-83	146.25
		8	15	38	-92	157.5
			16	20	-98	168.75
	5	9	17	0	-100	180
			18	-20	-98	191.25
		10	19	-38	-92	202.5
			20	-56	-83	213.75
3	6	11	21	-71	-71	225
			22	-83	-56	236.25
		12	23	-92	-38	247.5
			24	-98	-20	258.75
	7	13	25	-100	0	270
			26	-98	20	281.25
		14	27	-92	38	292.5
			28	-83	56	303.75
4	8	15	29	-71	71	315
			30	-56	83	326.25
		16	31	-38	92	337.5
			32	-20	98	348.75

At each rising edge of STEP input, or every time writing 1 to RSTEP bit of 0x0 register, the indexer would enter into next state.

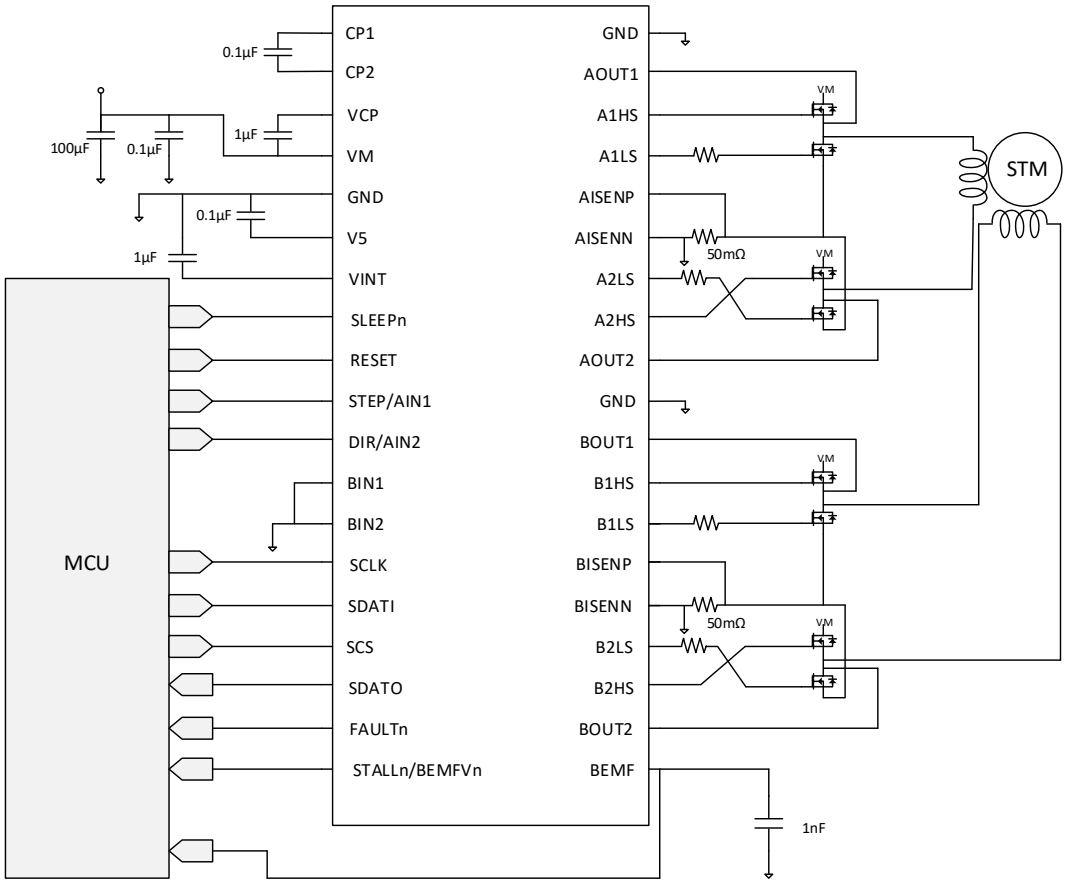
If DIR pin is high and RDIR (0x0address) is set to 0, or DIR pin is low and RDIR is set to 1, the direction is forward.

If DIR pin is low and RDIR is set to 0, or DIR pin is high and RDIR is set to 1, the direction is reverse.

Positive current is defined as xOUT1 positive and xOUT2 negative relatively.

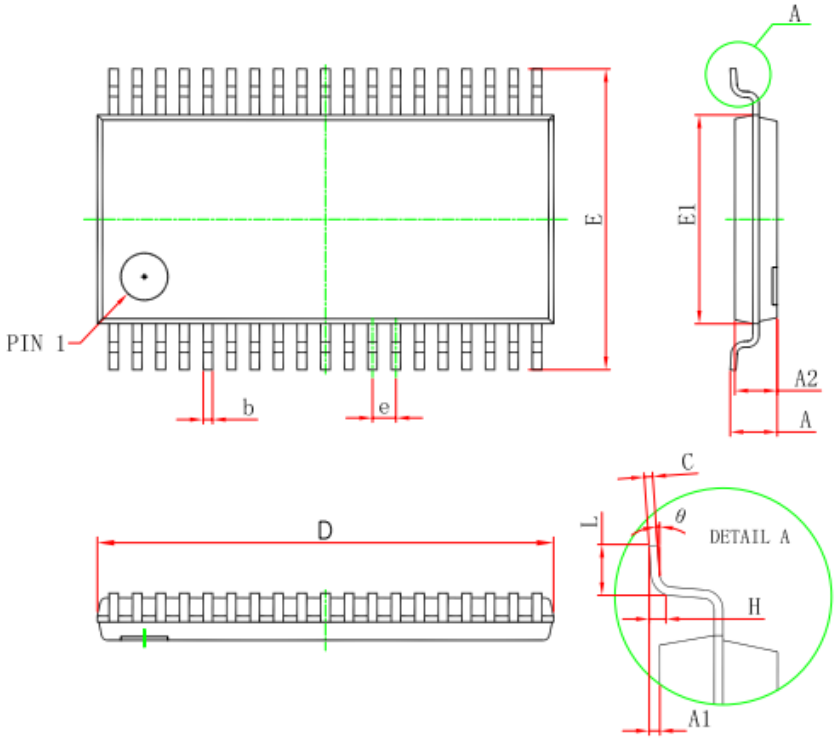
If microstep is changed in stepping process, the indexer will become the next valid state of new microstep at the rising edge of next STEP.

TYPICAL APPLICATION DIAGRAM



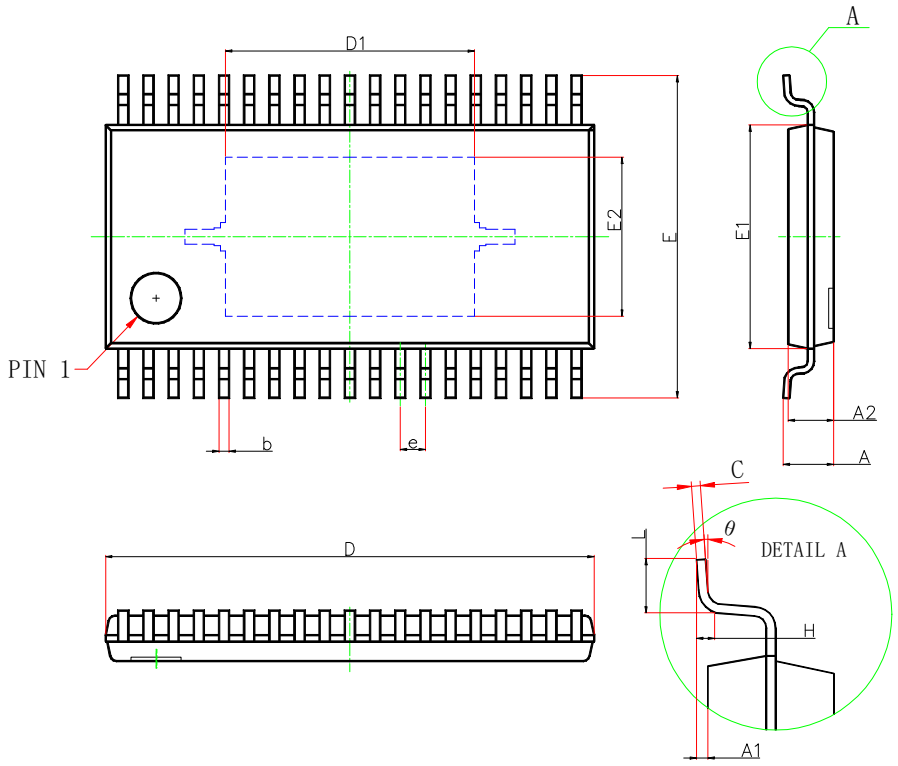
PACKAGE OUTLINE DIMENSIONS

TSSOP38



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	-	1.200	-	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.170	0.270	0.007	0.011
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
e	0.50 (BSC)		0.020 (BSC)	
H	0.25 (TYP)		0.01 (TYP)	
L	0.500	0.700	0.020	0.028
θ	1°	7°	1°	7°

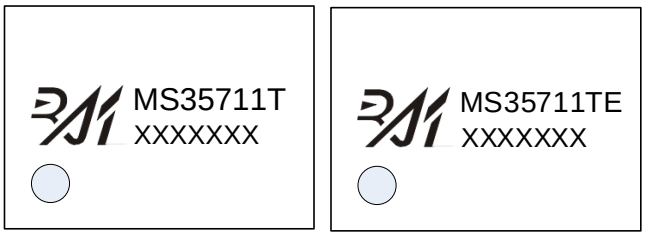
TSSOP38/PP



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	-	1.200	-	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.170	0.270	0.007	0.011
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
D1	4.840	5.040	0.191	0.198
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
E2	3.060	3.260	0.120	0.128
e	0.50 (BSC)		0.020 (BSC)	
H	0.25 (TYP)		0.01 (TYP)	
L	0.500	0.700	0.020	0.028
θ	1°	7°	1°	7°

MARKING and PACKAGING SPECIFICATION

1. Marking Drawing Description



Product Name : MS35711T, MS35711TE

Product Code : XXXXXXX

2. Marking Drawing Demand

Laser printing, contents in the middle, font type Arial.

3. Packaging Specification

Device	Package	Piece/Reel	Reel/Box	Piece/Box	Box/Carton	Piece/Carton
MS35711T	TSSOP38	3000	1	3000	8	24000
MS35711TE	TSSOP38/PP	3000	1	3000	8	24000

STATEMENT

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- The process of improving product is endless. And our company would sincerely provide more excellent product for customer.

MOS CIRCUIT OPERATION PRECAUTIONS

Static electricity can be generated in many places. The following precautions can be taken to effectively prevent the damage of MOS circuit caused by electrostatic discharge:

1. The operator shall ground through the anti-static wristband.
2. The equipment shell must be grounded.
3. The tools used in the assembly process must be grounded.
4. Must use conductor packaging or anti-static materials packaging or transportation.

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