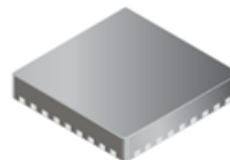
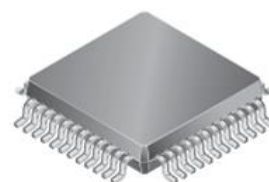


## Quad DMOS Full Bridge Driver

### PRODUCT DESCRIPTION

The MS35612N/MS35612 is a quad DMOS full bridge driver, which can drive two stepper motors or four DC motors. The driving current of each full bridge can be 1.2A in 24V power supply. The MS35612N/MS35612 integrates a fixed off-time PWM current regulator. It uses mixed decay mode and can reduce audio motor noise and power dissipation and improve step accuracy. The MS35612N/MS35612 also integrates internal synchronous rectification control circuit to reduce PWM operating power dissipation.

The MS35612N/MS35612 integrates protection circuits, such as undervoltage protection (UVLO), overcurrent protection, overturning current protection and thermal shutdown,, thus don't require specified power start sequence.

**QFN36****TQFP48**

### FEATURES

- Quad Full Bridge
- When EN,PH,ENx=1, Enable Corresponding Dual Low-side FETs
- Dual Stepper Motor Driving
- Large Current Output
- 3.3V and 5V Logic
- Synchronous Rectification
- Built-in UVLO
- Overcurrent Protection
- Overturn Protection
- Thermal Shutdown

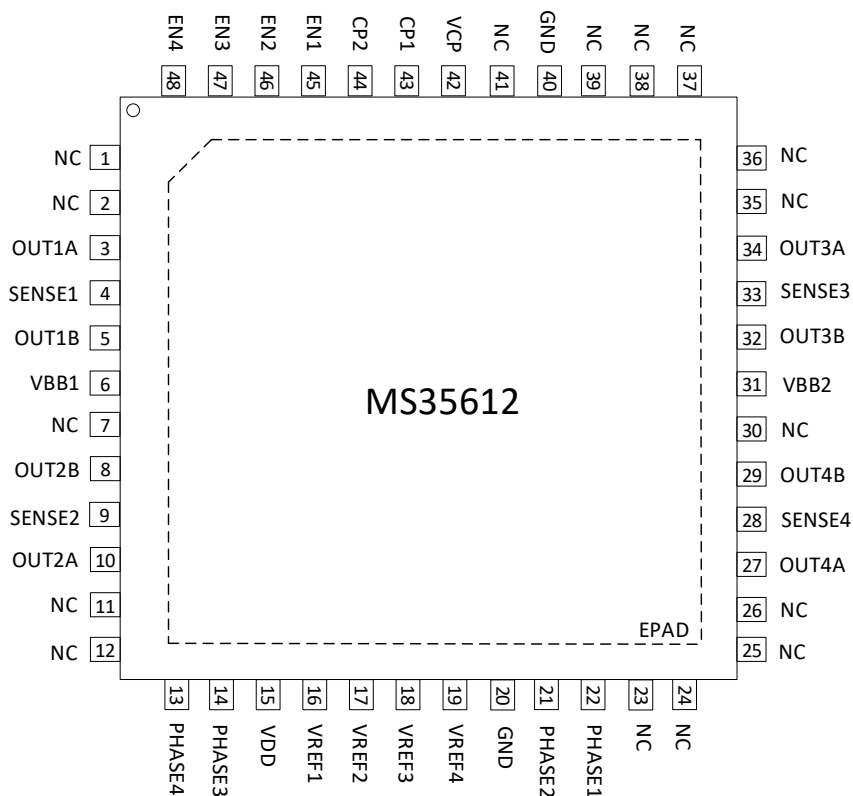
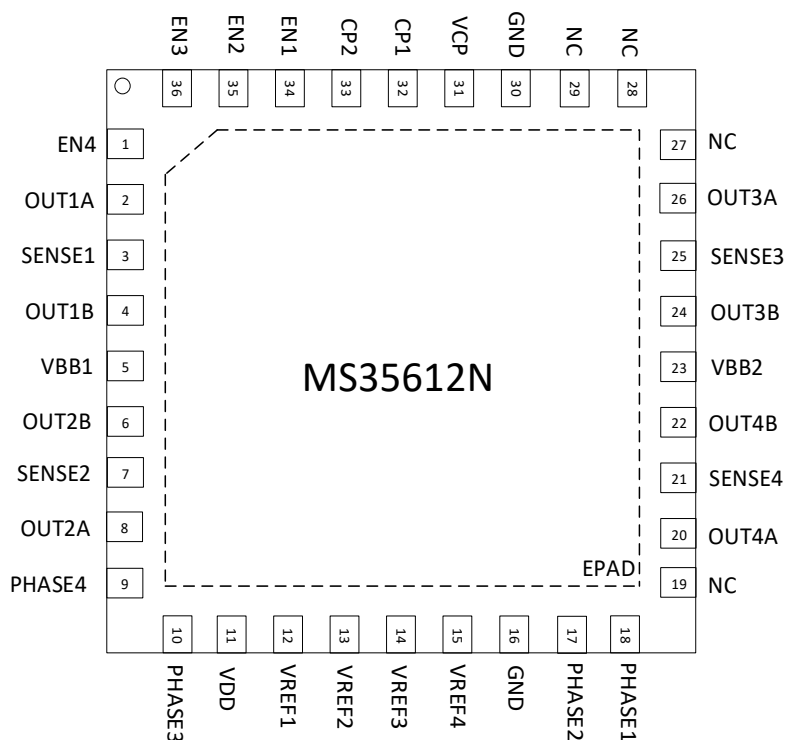
### APPLICATIONS

- Security Monitoring
- Stage Lights
- Toys
- Robotic Technology
- Medical Equipment

### PRODUCT SPECIFICATION

Part Number	Package	Marking
MS35612N	QFN36	MS35612N
MS35612	TQFP48	MS35612

## PIN CONFIGURATION

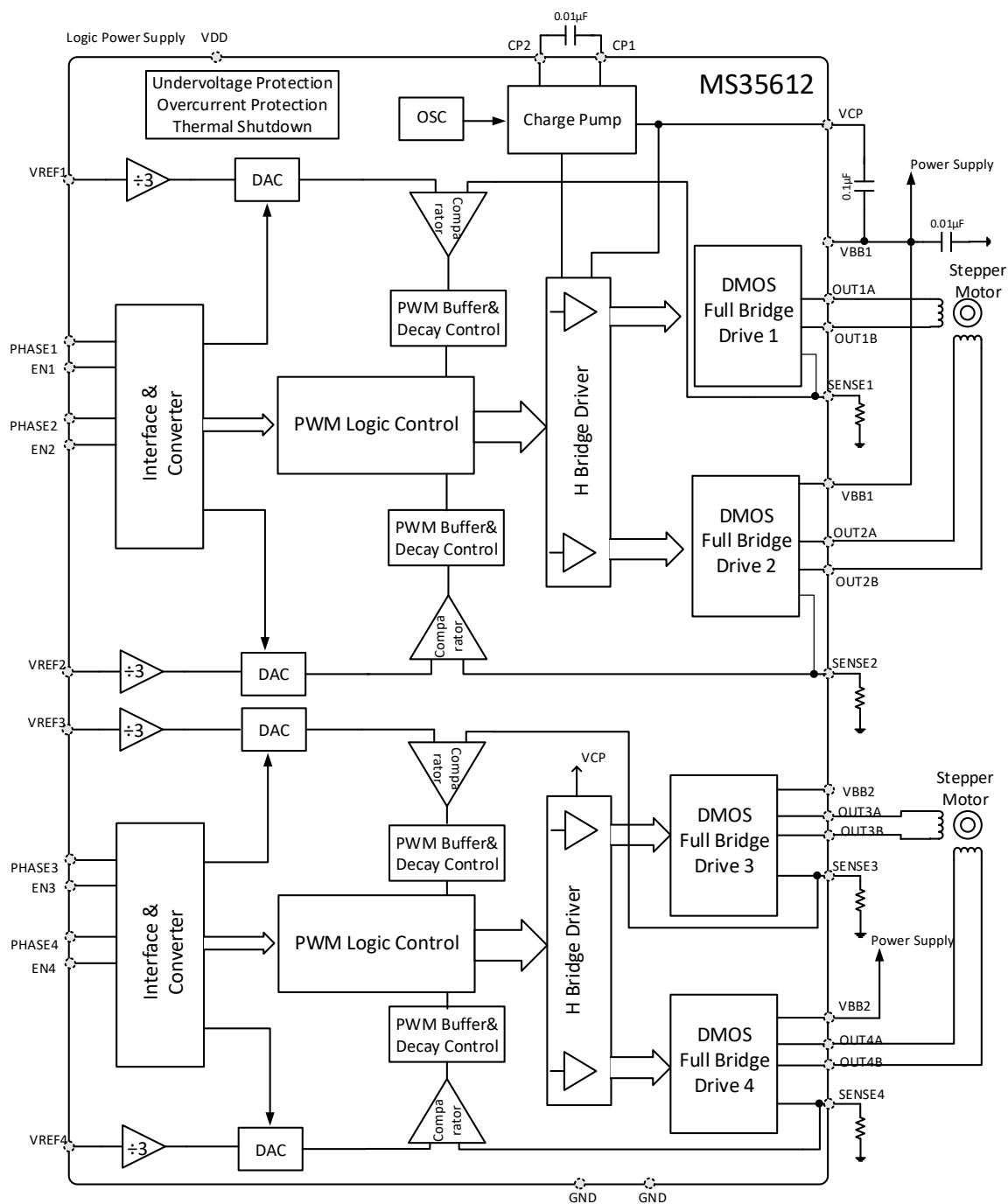


## PIN DESCRIPTION

Pin		Name	Description
MS35612N	MS35612		
1	48	EN4	Channel 4, Control Input Pin
2	3	OUT1A	DMOS H-Bridge Channel 1 Output A
3	4	SENSE1	Channel 1, Sense Resistor Pin
4	5	OUT1B	DMOS H-Bridge Channel 1 Output B
5	6	VBB1	Power Supply
6	8	OUT2B	DMOS H-Bridge Channel 2 Output B
7	9	SENSE2	Channel 2, Sense Resistor Pin
8	10	OUT2A	DMOS H-Bridge Channel 2 Output A
9	13	PHASE4	Channel 4, Control Input Pin
10	14	PHASE3	Channel 3, Control Input Pin
11	15	VDD	Logic Power Supply
12	16	VREF1	Channel 1, Analog Input Pin
13	17	VREF2	Channel 2, Analog Input Pin
14	18	VREF3	Channel 3, Analog Input Pin
15	19	VREF4	Channel 4, Analog Input Pin
16	20	GND	Ground
17	21	PHASE2	Channel 2, Control Input Pin
18	22	PHASE1	Channel 1, Control Input Pin
20	27	OUT4A	DMOS H-Bridge Channel 4 Output A
21	28	SENSE4	Channel 4, Sense Resistor Pin
22	29	OUT4B	DMOS H-Bridge Channel 4 Output B
23	31	VBB2	Power Supply
24	32	OUT3B	DMOS H-Bridge Channel 3 Output B
25	33	SENSE3	Channel 3, Sense Resistor Pin
26	34	OUT3A	DMOS H-Bridge Channel 3 Output A
30	40	GND	Ground
31	42	VCP	Reservoir Charge Capacitor Pin
32	43	CP1	Charge-pump Capacitor Pin
33	44	CP2	Charge-pump Capacitor Pin
34	45	EN1	Channel 1, Control Input Pin

Pin		Name	Description
MS35612N	MS35612		
35	46	EN2	Channel 2,Control Input Pin
36	47	EN3	Channel 3,Control Input Pin
19,27,28,29	1,2,7,11,12,23, 24,25,26,30,35, 36,37,38,39,41	NC	Not Connection
-	-	EPAD	Exposed Thermal Pad, soldered to PCB directly and connected to 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	Range	Unit
Power Supply	$V_{BB}$	-0.5 ~ 38	V
Logic Supply	$V_{DD}$	-0.4 ~ 6	V
Output Current	$I_{OUT}$	1.2	A
Logic Input Voltage	$V_{IN}$	-0.3 ~ 6	V
SENSEx Pin Voltage	$V_{SENSEX}$	0.5	V
VREFx Pin Voltage	$V_{REFX}$	2.5	V
Operating Temperature	$T_A$	-40 ~ 105	°C
Junction Temperature	$T_{JMAX}$	150	°C
Storage Temperature	$T_{STG}$	-65 ~ 150	°C
ESD(HBM)	$V_{ESD}$	>±3k	V

## Thermal Resistance

Parameter	Symbol	MS35612N	MS35612	Unit
		QFN36	TQFP48	
Junction to Ambient	$R_{\theta JA}$	19.02	17.50	°C/W

## ELECTRICAL CHARACTERISTICS

Unless otherwise noted,  $T_A = 25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ,  $V_{BB}=24\text{V}$ ,  $V_{DD}=3.3\text{V}$ .

### Power

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power Supply	$V_{BB}$		8		36	V
Logic Supply	$V_{DD}$		3		5.5	V
Power Supply Current	$I_{BB}$			2.4	10	mA
Logic Supply Current	$I_{VDD}$			1.84		mA

### Output Power FET

Parameter	Symbol	Condition	Min	Typ	Max	Unit
High-side FET Output On- Resistance	$R_{DS\text{ONH}}$	$I_{\text{OUT}}=500\text{mA}$ , $T_J=25^{\circ}\text{C}$		0.5	0.7	$\Omega$
Low-side FET Output On- Resistance	$R_{DS\text{ONL}}$	$I_{\text{OUT}}=500\text{mA}$ , $T_J=25^{\circ}\text{C}$		0.5	0.8	$\Omega$

### Logic and Low Voltage Input

Parameter	Symbol	Condition	Min	Typ	Max	Unit
High-level Input Voltage	$V_{\text{IN(H)}}$		$0.7 \times V_{DD}$		$V_{DD}+0.3$	V
Low-level Input Voltage	$V_{\text{IN(L)}}$		-0.3		$0.3 \times V_{DD}$	V
VREFx Input Voltage	$V_{\text{REFX}}$		0		2.5	V
VREFx Input Current	$I_{\text{REF}}$	$V_{\text{REF}}=1.5\text{V}$			$\pm 1$	$\mu\text{A}$

### Timing

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Propagation Delay	$t_{d1}$	PWM Conversion, HS FET Open	350	550	1000	ns
	$t_{d2}$	PWM Conversion, HS FET Closed	35		300	ns
	$t_{d3}$	PWM Conversion, LS FET Open	350	550	1000	ns
	$t_{d4}$	PWM Conversion, LS FET Closed	35		250	ns
Overturn Delay	$t_{\text{COD}}$		300	425	1000	ns
Blank Time	$t_{\text{BLANK}}$		0.7	1	1.3	$\mu\text{s}$

**Output Current Accuracy**

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Current Error <sup>1</sup>	V <sub>ERR</sub>	V <sub>REF</sub> =1.5V, Phase Current 100%	-5		5	%

Note 1:  $V_{ERR} = (V_{REF}/3 - V_{SENSE})/(V_{REF}/3)$ .

**Protection Circuit**

Parameter	Symbol	Condition	Min	Typ	Max	Unit
VBB Undervoltage Protection	V <sub>UV(VBB)</sub>	VBB Rise	6.5	6.8	7.1	V
VBB Undervoltage Hysteresis	V <sub>UV(VBB)HYS</sub>		0.3	0.4	0.5	V
VDD Undervoltage Protection	V <sub>UV(VDD)</sub>	VDD Rise	2.6	2.7	2.8	V
VDD Undervoltage Hysteresis	V <sub>UV(VDD)HYS</sub>		75	105	125	mV
Thermal Shutdown	T <sub>JS</sub>	Temperature Rise	155	165	175	°C
Thermal Shutdown Hysteresis	T <sub>JS_HYS</sub>			15		°C
Overcurrent Protection Trip Point	I <sub>OC</sub>			3		A
Overcurrent Protection Detection Time	t <sub>OC</sub>			1		μs
Overcurrent Protection Self-start Output Close Time	t <sub>PRO</sub>	Trigger Overcurrent Protection		10		ms



## FUNCTION DESCRIPTION

### Device Characteristics

The MS35612N/MS35612 could drive two stepper motors or four DC motors, and also one stepper motor plus two DC motors. The output H full bridges are four N-channel DMOS FETs, controlled by PWM. The output peak current of each full bridge is decided by  $R_{SENSE}$  and  $V_{REFx}$  together. Logic input pins include PHASEx and ENx.

### Full Bridge Control Logic

PHASEx input pin controls current direction of H bridge. When ENx pin is low-level, corresponding full-bridge output is turned on. The following table is logic of full bridge control.

ENx	PHASEx	OUTxA	OUTxB
1	X	L	L
0	1	H	L
0	0	L	H

### Internal PWM Current Control Principle

Each full bridge has PWM current control circuit with fixed decay time, which makes load current not more than setting value,  $I_{TRIP}$ . One H-bridge diagonal pair of source and drain DMOS FETs are enabled, and current flows into motor and  $R_{SENSE}$  resistor. When the voltage on  $R_{SENSE}$  is equal to one third of  $V_{REF}$  voltage, current detection comparator would reset PWM controller and disable corresponding source DMOS FET. The current limit is determined by the resistance of  $R_{SENSE}$  and the voltage on  $V_{REF}$  terminal. The current is calculated:

$$I_{TRIP} = V_{REF} / (3 \times R_{SENSE})$$

Note that the maximum voltage on  $R_{SENSE}$  doesn't exceed  $\pm 500\text{mV}$  in application.

### Fixed Off-time

Internal PWM control circuit integrates one fixed-time pulse to disable FETs. The off-time,  $t_{OFF}$ , is set as  $10\mu\text{s}$ .

### Blank Time

When output is changed caused by internal circuit, the output of current detection comparator would be ignored within blank time to avoid output false detection, such as reverse recovery current of clamp diode or the overcurrent due to on/off for load capacitor. The blank time is set as  $1\mu\text{s}$ .

### Charge-pump (CP1, CP2)

The charge-pump circuit generates a higher power supply than VBB to drive the source FET of the H-bridge. In application, due to the need for charge and discharge, a 0.01 $\mu$ F ceramic capacitor is needed to be connected between CP1 and CP2. A 0.1 $\mu$ F ceramic capacitor is also required between VCP and VBBx to store charge.

### Protection Function

The MS35612N/MS35612 integrates perfect protection functions, including undervoltage protection, overcurrent protection and thermal shutdown.

The overcurrent protection function could detect many shorted conditions, such as output to power, ground and output-to-output. When short-circuit time is detected over 1 $\mu$ s, the output is disabled. After 10ms, the MS35612N/MS35612 would attempt to restart automatically.

### Synchronous Rectification

When the internal fixed decay time circuit is triggered and the PWM-off works, the load current will return. During current decay, the synchronous rectification function will turn on the corresponding DMOS FET and short out the parasitic diode with Rdson resistance, which can effectively reduce power dissipation. When zero current is detected, synchronous rectification is turned off to prevent the load current from reversing.

### Mixed Decay Mode

H bridge operates in mixed decay mode as shown in following figures. When current reaches current limit, fast decay mode is entered and the duration time ( $t_{FD}$ ) occupies 33% of total decay period. Then system enters into slow decay mode. During the conversion from fast to slow decay modes, driver would be disabled for 300ns (dead time). The setting could avoid bridge throughout.

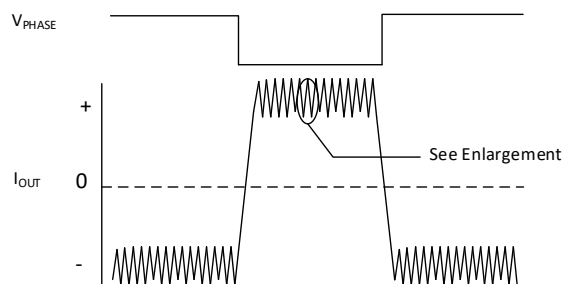


Figure 1. Mixed Decay Mode

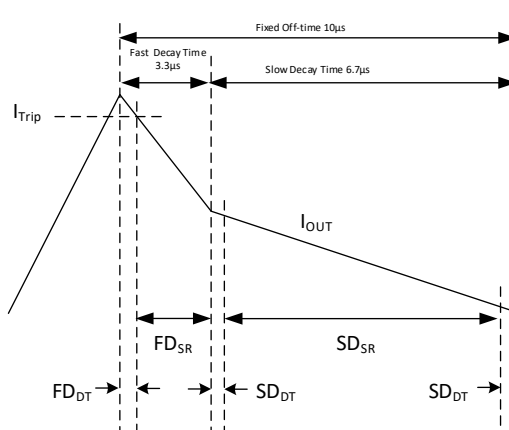
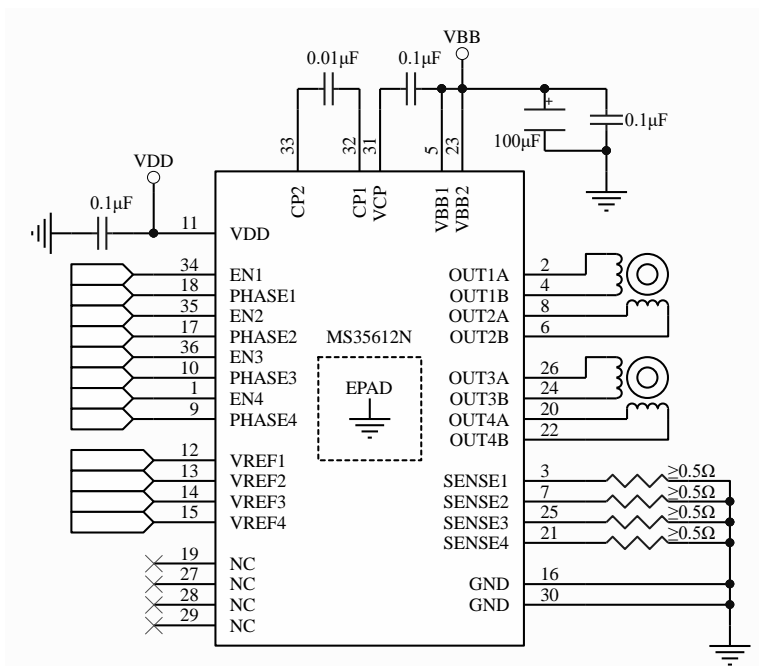


Figure 2. Enlarged View of Mixed Decay Mode

## TYPICAL APPLICATION



### DC Motor Control

The MS35612N/MS35612 integrates four H-bridge drives, each of which is equipped with an independent PWM current control circuit, so it can drive four DC motors. In application, the maximum current can be set by the VREF pin, and ENx and PHASEx pins are used to control motor current.

### Layout Making

Heavy ground plane is required for printed circuit board. In order to achieve better performance and heat dissipation, the MS35612N/MS35612 should be directly soldered to the board. On the back of the MS35612N/MS35612 is a metal thermal pad, which is directly soldered on the exposed PCB board to radiate heat to other layers.

### Layout Ground Trace

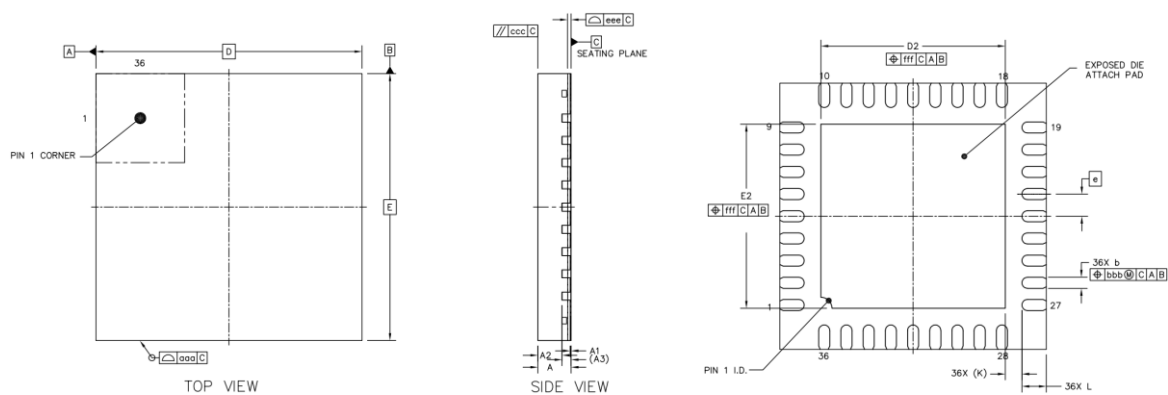
In order to solve ground drift problem, it is necessary to set one special ground trace with single point and low impedance near the chip in PCB. Generally, the position, where the grounding plane is just below the the thermal pad, is the ideal special ground trace. Special low-impedance ground trace could effectively avoid ground level drift and ensure the stability of power supply.

### SENSE Pin Setting

$R_{SENSE}$  resistor on SENSE pin must be connected with one low-impedance path to ground. Because  $R_{SENSE}$  would flow through large current and generate accurate feedback voltage to SENSE comparator. Long ground trace would generate extra resistance, thus causing uncertain voltage drop and reducing the accuracy of SENSE comparator. When select SENSE resistor, note that the voltage on SENSE pin should not exceed  $\pm 500\text{mV}$  in operation.

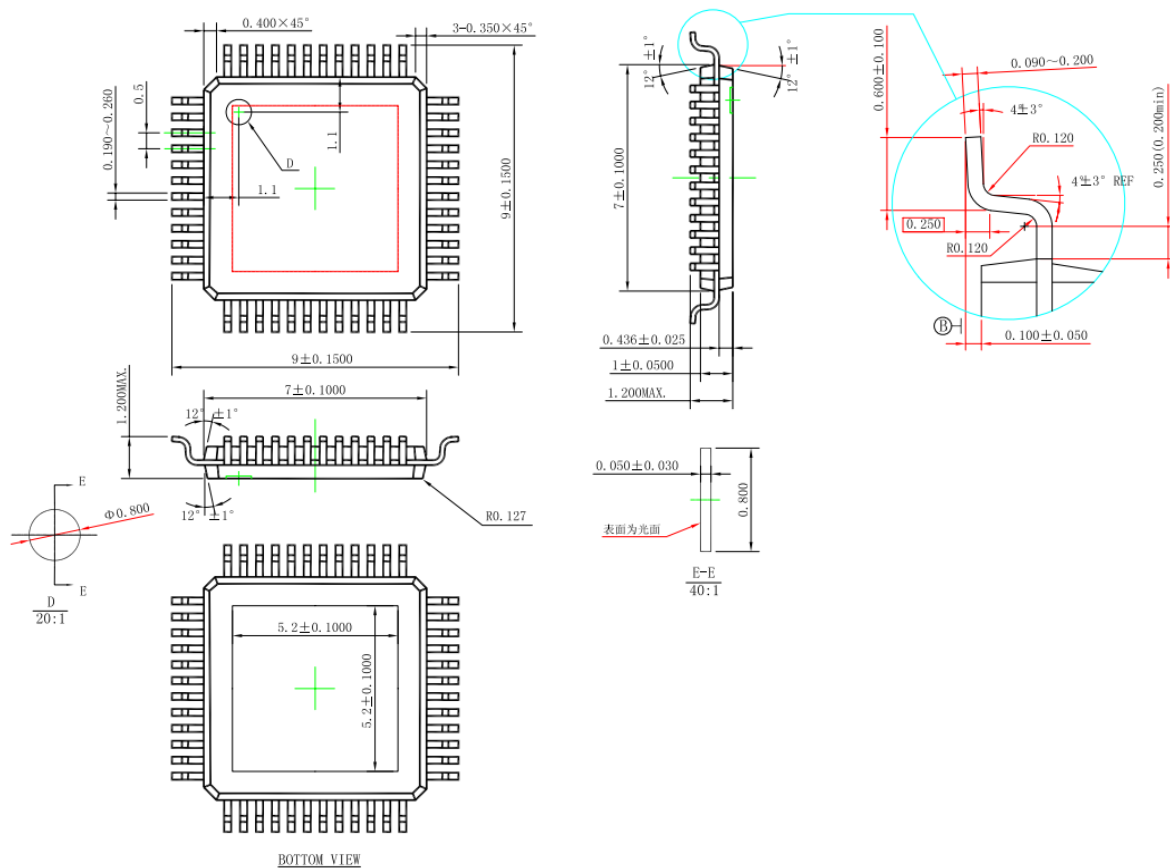
# PACKAGE OUTLINE DIMENSIONS

## QFN36(06X06) (Back Thermal Pad)



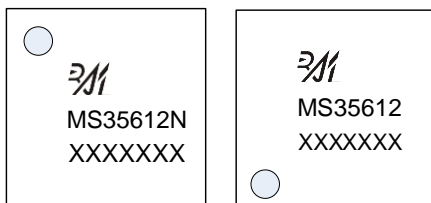
Symbol	Dimensions in Millimeters		
	Min	Typ	Max
A	0.7	0.75	0.8
A1	0	0.02	0.05
A2	-	0.55	-
A3	0.203REF		
b	0.2	0.25	0.3
D	6BSC		
E	6BSC		
e	0.5BSC		
D2	4.05	4.15	4.25
E2	4.05	4.15	4.25
L	0.45	0.55	0.65
K	0.375REF		
aaa	0.1		
ccc	0.1		
eee	0.08		
bbb	0.1		
fff	0.1		

**TQFP48(07X07) (Back Thermal Pad)**



## MARKING and PACKAGING SPECIFICATION

### 1. Marking Drawing Description



Product Name : MS35612N、MS35612

Product Code : XXXXXXXX

### 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
MS35612N	QFN36	2000	1	2000	8	16000

Device	Package	Piece/Tray	Tray/Box	Piece/Box	Box/Carton	Piece/Carton
MS35612	TQFP48	250	10	2500	4	10000

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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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