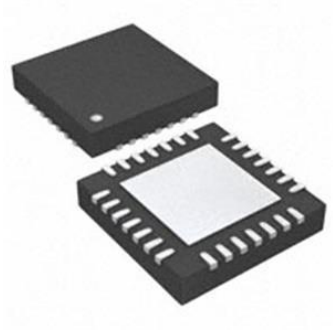
Low Noise, 256 Microstepping Motor Driver

PRODUCT DESCRIPTION

The MS35776/MS35776A is a two-phase stepping driver featured by high-precision and low noise. The chip is integrated with fast mode and silent mode to satisfy different applications in high speed and low speed. The chip is built in power MOSFET. The averaged operating current for long time can reach 1.4A and the peak current is 2A. The chip integrates undervoltage protection, overcurrent protection, short-ground protection, short-power protection and thermal shutdown。



QFN28

FEATURES

- Two-phase Stepping Motor, Reach 2A Peak Current
- Low On-resistance
- Voltage Range 4.7 ~ 36V
- STEP/DIR Interface, Select 2,4,8 or 16 Microstepping
- Internal 256 Microstepping
- Automatically Enter Power Saving Mode at Motor Stopping
- Built-in Optional Sense Resistance Mode
  (No Need for External Sense Resistor)
- QFN28 Package with Back Thermal PAD
- MS35776A, AEC-Q100

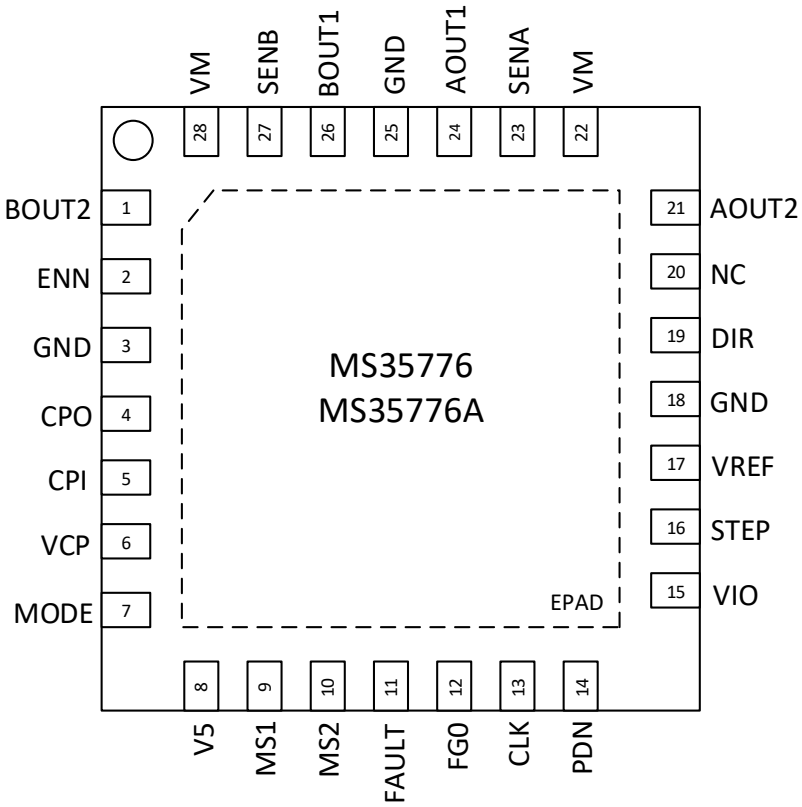
APPLICATIONS

- Precise Industrial Device
- Medical Device
- 3D Print
- Motoring

PRODUCT SPECIFICATION

Part Number	Package	Marking
MS35776	QFN28	MS35776
MS35776A	QFN28	MS35776A

PIN CONFIGURATION

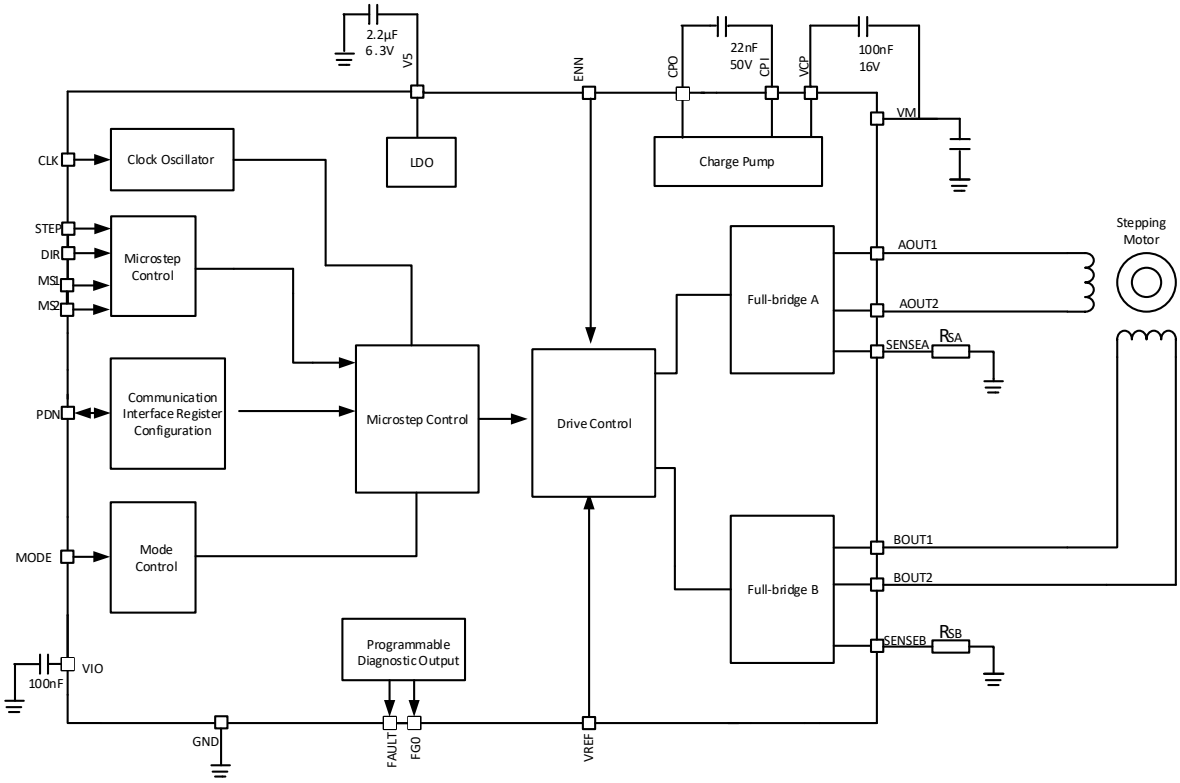


PIN DESCRIPTION

Pin	Name	Type	Description
1	BOUT2	IO	Motor Coil B Output 2
2	ENN	DI	Enable Input. Output is turned off when in high level.
3	GND	-	Ground
4	CPO	IO	Charge-pump Capacitance Output
5	CPI	IO	Charge-pump Capacitance Input, Connected to CPO with 22nF(50V) Capacitance
6	VCP	IO	Charge-pump Voltage, Connected to VM with 100nF Capacitance
7	MODE	DI	Operating Mode Selection, with pull-up Resistor: 1: Silent Mode, 0: Fast Mode
8	V5	IO	Internal 5V LDO, Connected to Ground with 2.2μF~4.7μF Capacitance
9	MS1	DI	Microstepping Configuration Port (Built in Pull-down Resistor)
10	MS2	DI	Microstepping Configuration Port (Built in Pull-down Resistor)
11	FAULT	DO	Internal Fault Signal Output, Driver is Off When in High-level. Reset by ENN to High Level
12	FG0	DO	Provide Coil A Forward Zero-crossing Pulse
13	CLK	DI	Clock Input, Can Be Grounded When Using Internal Clock
14	PDN	DIO	Automatic Current Decay Mode Input Control. (When in low level, enable the automatic current attenuation function at a standstill).
15	VIO	-	3.3V to 5V Power Supply for Each Digital Input and Output Pins
16	STEP	DI	Microstepping Input Pin
17	VREF	AI	Analog Reference Voltage Controlling Current Input Pin, or Analog Reference Current Input in Internal Sense Resistor Mode
18	GND	-	Ground
19	DIR	DI	DIR Input Pin (Built in Pull-down Resistor)
20	NC	-	Unused Pin, Recommended Grounding
21	AOUT2	IO	Motor Coil A Output 2

Pin	Name	Type	Description
22	VM	-	Motor Power Supply
23	SENA	IO	Coil A Low-side MOS Source Terminal, Connected to Ground with sense Resistor. Can Be Grounded Directly in Internal sense Resistor Mode
24	AOUT1	IO	Motor Coil A Output 1
25	GND	-	Ground
26	BOUT1	IO	Motor Coil B Output 1
27	SENB	IO	Coil B Low-side MOS Source Terminal, Connected to Ground with sense Resistor. Can Be Grounded Directly in Internal sense Resistor Mode
28	VM	-	Motor Power Supply
-	EPAD	-	Thermal Pad, Must Be 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_M	-0.5 ~ 39	V
IO Supply Voltage	V_{VIO}	-0.5 ~ 5.5	V
Digital Power Supply with External Power	V_{5VOUT}	-0.5 ~ 5.5	V
Logic Input Voltage	V_I	-0.5 ~ V_{IO}+0.5	V
VREF Input Voltage [1]	V_{VREF}	-0.5 ~ 6	V
Maximum Current of Analog Digital Port	I_{IO}	±10	mA
Output Current Capacity for 5V Internal Power	I_{5VOUT}	25	mA
Power Drive, Output Current	I_{Ox}	2.5	A
Operating Temperature	T_A	-40 ~ 125	°C
Junction Temperature	T_J	-50 ~ 150	°C
Storage Temperature	T_{STG}	-65 ~ 150	°C
ESD (HBM)	V_{ESD}	4k	V

Note 1: The VREF voltage cannot exceed 10% of VIO and V5 voltage simultaneously, as this will enter the testing mode.

Thermal Resistance

Parameter	Symbol	Value	Unit
Junction-to-ambient Thermal Resistance	$R_{\theta JA}$	25	°C/W
Junction-to-case Thermal Resistance	$R_{\theta JC}$	13	°C/W

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Range			Unit
		Min	Typ	Max	
Power Supply (Using Internal V5)	V_M	5.5		36	V
Power Supply (VM and V5 Connected Together)	V_M	4.7		5.4	V
I/O Supply Voltage	V_{VIO}	3.3		5.25	V
RMS Current, Each Motor Coil	I_{RMS}			1.2	A
RMS Current, One Second On, One Second Off	I_{RMS}			1.4	A
Peak Current, Each Motor Coil	I_{Ox}			2	A

ELECTRICAL CHARACTERISTICS

VM=24V. Note: Unless otherwise noted, T_A = 25°C ±2°C

Current Consumption

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Current Consumption, without Load	I_S	Fclk=12MHz, without Chopping		10	14	mA
Current Consumption, without Load	I_S	Fclk=12MHz, 35kHz Chopping		11		mA
V5 Supply Current	I_{VCC}	Fclk=12MHz, 35kHz Chopping		10		mA
IO Supply Current	I_{VIO}	IO without any Load		30		μA

Digital Input and Output

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Low Voltage	V_{INLO}		-0.3		0.3Vio	V
Input High Voltage	V_{INHI}		0.7Vio		Vio+0.3	V
Input SMIT Hysteresis	V_{INHYST}			0.12Vio		V
Output High Voltage	V_{OUTLO}	I=2mA	Vio-0.2			V
Output Low Voltage	V_{OUTHI}	I=2mA			0.2	V
Input Leakage Current	I_{ILEAK}		-10		10	μA
Pull-up, Pull-down Resistance	R_{PU}/R_{PD}			150		kΩ
Digital Port Capacitance	C			8		pF

Motor Drive

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Low-side rdson	R_{ONL}	I=100mA		0.28	0.38	Ω
High-side rdson	R_{ONH}	I=100mA		0.29	0.39	Ω
Rising Time	t_{SLPON}	I=700mA	40	80	160	ns
Falling Time	t_{SLPOFF}	I=700mA	40	80	160	ns
Source Current at Drive Off	I_{OIDLE}	OUTX Connected to GND	120	330	400	μA

Charge-pump

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Charge-pump Output Voltage	V_{VCP}-V_M	Operating at fchop<40kHz	4	Vcc-0.3	VCC	V
Charge-pump Output Undervoltage Threshold	V_{VCP}-V_M	Using Internal 5V LDO	3.7	4	4.3	V
Charge-pump Frequency	f_{CP}			1/16CLK		

5V LDO

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Output Voltage	V_5	I5v=0mA	4.8	5	5.2	V
Output Resistance	R_{V5}	Static Load		1		Ω
Deviation within Whole Temperature Range	$V5_{T(DEV)}$	I=5mA, Whole Operating Temperature Range		±90	±200	mV
Deviation within Whole Voltage Range	$V5_{V(DEV)}$	I=5mA, Whole Operating Voltage Range		±50	±150	mV/10V

Clock Oscillator

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Clock Frequency (Default Setting)	f_{CLKOSC}	T=-50°C		12.1		MHz
	f_{CLKOSC}	T=25°C	11.5	12.0	12.5	MHz
	f_{CLKOSC}	T=150°C		11.6		MHz
Additional Clock Frequency	f_{CLK}		4	10-16	18	MHz
Rising and Falling Time for Additional Clock Frequency	t_{CLK}	CLK from 0.1Vio to 0.9Vio	10			ns
Overtime Detection for Additional Clock	$X_{timeout}$		32		48	Fclk Period

Detection Signal

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Undervoltage Protection	V_{UV_VM}	Power Supply Rising	3.5	4.3	4.6	V
V5 Undervoltage Protection	V_{UV_V5}	5V LDO Rising		4.2		V
Undervoltage Protection VIO	V_{UV_VIO}	Voltage on VIO Pin Rises		2		V
Overcurrent Protection Voltage(HS)	V_{OS2G}		2	2.5	3	V
Overcurrent Protection Voltage(LS)	V_{OS2VM}		1.6	2	2.3	V
Short-circuit Protection Detection Time(HS+LS)	t_{S2G}	High-side Output Level to VM-3V	0.8	1	2	μs
Overtemperature Pre-warning	t_{OTPW}	Temperature Rises	100	120	140	°C
Overtemperature Shutdown or Overtemperature Pre-warning	t_{OT143}	Temperature Rises	128	143	163	°C
Overtemperature Shutdown	t_{OT150}	Temperature Rises	135	150	170	°C
Overtemperature Shutdown	t_{OT157}	Temperature Rises	142	157	177	°C
Temperature Difference between Power FET and Temperature Detection Module	t_{OTDIFF}			10		°C

Sense

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Sense Peak Voltage (Low Sensitivity)	V_{SRTL}			325		mV
Sense Peak Voltage (High Sensitivity)	V_{SRTH}			180		mV
Internal Resistance between Internal Brx to External Sense Resistance	R_{xy}			15		mΩ

FUNCTION DESCRIPTION

The MS35776/MS35776A is a two-phase stepping motor driver, with full-bridge output structure consisting of dual NDMOS, which can provide larger current driving capacity. ENN controls output drive and when it is in low level, output drive is ON.

The MS35776/MS35776A has easy peripheral control and it is especially appropriate to domestic or office application because of its silence performance.

Operating Mode

The MS35776/MS35776A is configured with two modes: silent mode and fast mode, which can be configured with the MODE pin.

MODE Pin	Mode	Characteristics
Float	Silent Mode	Low Vibration, Suitable for Medium to Low Speed Operation.
High-level		
Low-level	Fast Mode	Fast Dynamic Response, Ultra Silent in Faster Speed.

Microstepping Control

Microstepping orders are controlled by MS1 and MS2, as shown in following table. MSx is built in a 160kΩ pull-down resistor.

MS2	MS1	Step Mode
0	0	1/8
0	1	1/2
1	0	1/4
1	1	1/16

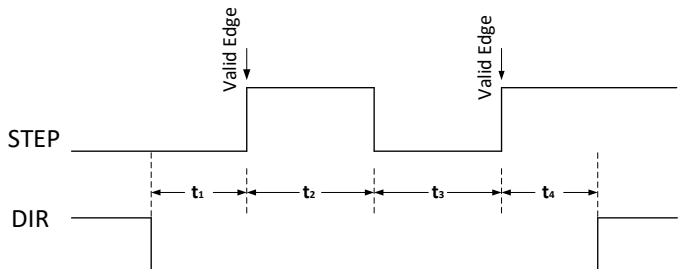
STEP Input

Each STEP can be full-step or microstepping. One full-step could be equal to 2,4,8,16,32,64,128,256 microstepping. The internal table is translated to sine and cosine values, controlling motor current.

The MS35776/MS35776A also integrates internal STEP pulse generator, meeting some applications, which require precise time and speed rather than position.

Direction Control DIR

The motor direction is controlled by the DIR pin. The timing diagram is for STEP, DIR control as follows.



Parameter	Symbol	Condition	Min	Typ	Max	Unit
STEP Frequency	f_{STEP}				1/2 f_{CLK}	
Full-step Frequency	f_{FS}				f_{CLK}/512	
Setup Time, DIR to STEP	t_1		20			ns
STEP Minimum High-level Time	t_2			100		ns
STEP Minimum Low-level Time	t_3			100		ns
Hold Time, DIR to STEP	t_4		20			ns
Filtering Time for STEP and DIR Glitches	t_5	Rising or Falling Edge	13	20	30	ns

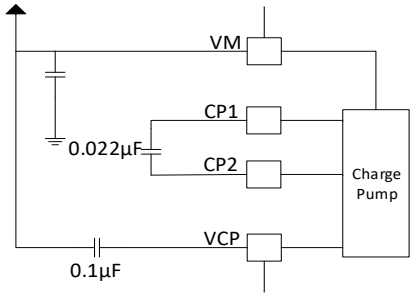
5V Regulated Power

The MS35776/MS35776A also provides 5V regulated power output, which is required to connect with a capacitor from 2.2μF to 4.7μF in applications. It has internal V5 voltage detection structure. If fault occurs (low-voltage), all outputs are turned off.

Charge-pump

Because output stage adopts N-channel FETs, which are fully enabled only when the required gate drive voltage is higher than the power supply. And the MS35776/MS35776A integrates charge-pump circuit to generate this high voltage.

When normally operating, charge-pump circuit needs to connect with two external capacitors as shown below.



Current Control

The motor peak current is determined by R_{SENSE} and input voltage on the VREF pin.

The peak current calculation formula is as shown as follows:

$$I_{RMS}=\frac{325mV}{R_{SENSE}+15m\Omega}\times\frac{V_{VREF}}{2.5V}$$

The corresponding RMS current formula is as shown as follows:

$$I_{RMS}=\frac{325mV}{R_{SENSE}+15m\Omega}\times\frac{1}{\sqrt{2}}\times\frac{V_{VREF}}{2.5V}$$

Automatic Current Decay

The automatic current decay function is enabled by pulling the PDN pin down. When the operating current is about 50%, the power dissipation can be reduced to 33%.

Zero-crossing Output Flag

The MS35776/MS35776Aprovides zero-crossing output flag, FG0. When motor coil current is forward zero-crossing, a pulse signal will be output.

Fault Output Flag

When fault signal occurs, the diagnostic signal is output through fault indication pin, FAULT. The fault signal can be reset via ENN pin, and FAULT is in low level at normal operation.

Protection Circuit

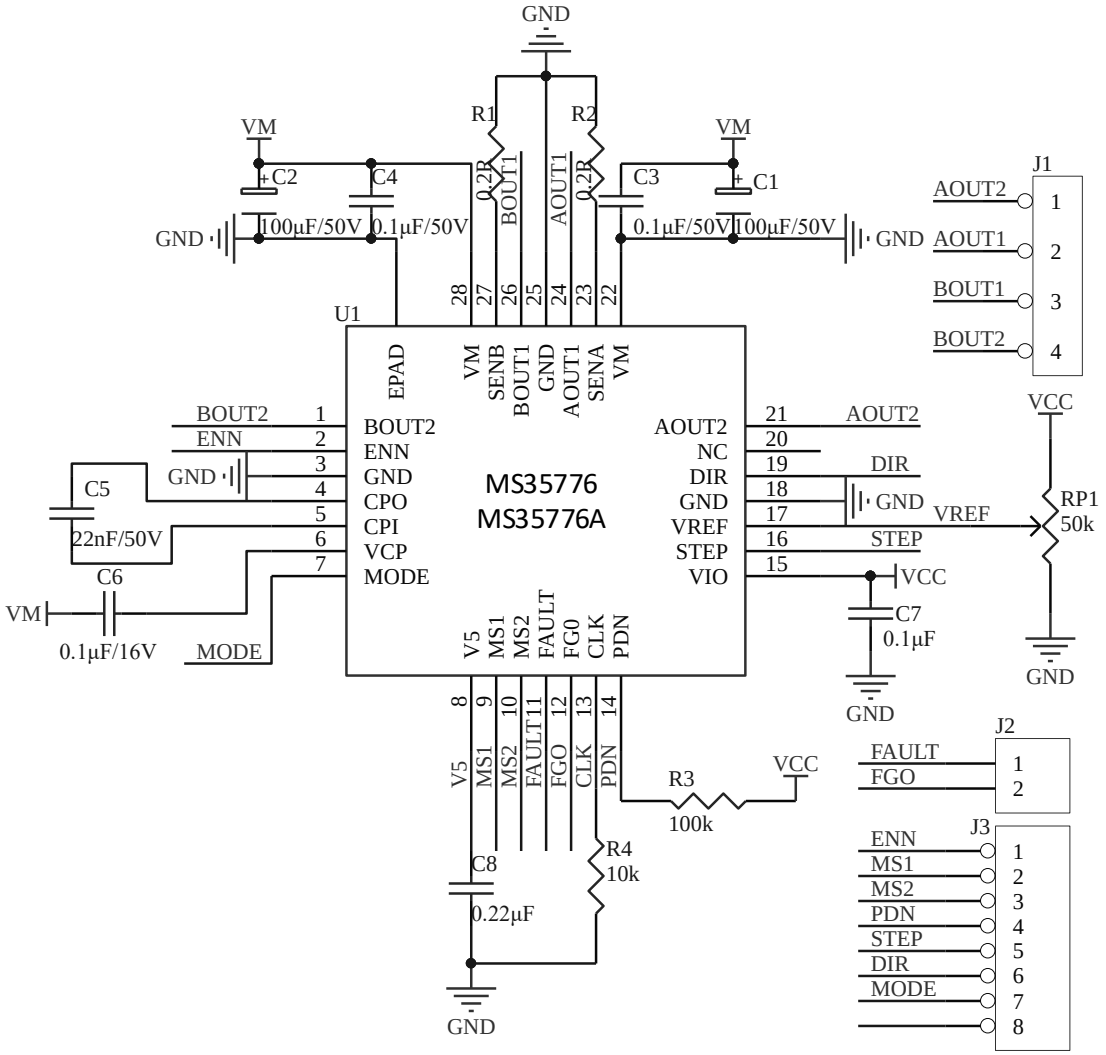
The MS35776/MS35776A has protection function, including overcurrent protection, undervoltage protection and thermal shutdown.

When the power supply falls below undervoltage protection threshold, all the channels are OFF, and internal logic circuit is reset. When the voltage rises above the threshold, the chip is in normal operating state.

When motor loads are shorted together or grounded directly, the MS35776/MS35776A will protect itself by detecting overcurrent and turn off shorted FETs, preventing internal devices from damage. And a high-level signal output on the FAULT pin, the ENN pin is needed to reset.

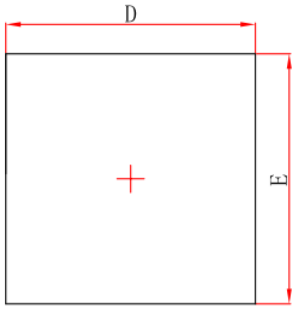
When the temperature exceeds setting threshold, the thermal shutdown will work. At this time, all channels would be off and a high-level signal outputs on the FAULT pin. When the temperature drops to safety temperature, the MS35776/MS35776A will return to normal operation state.

TYPICAL APPLICATION DIAGRAM

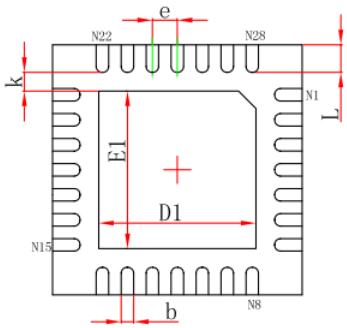


PACKAGE OUTLINE DIMENSIONS

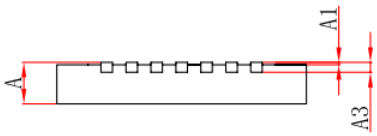
MS35776 QFN28



Top View



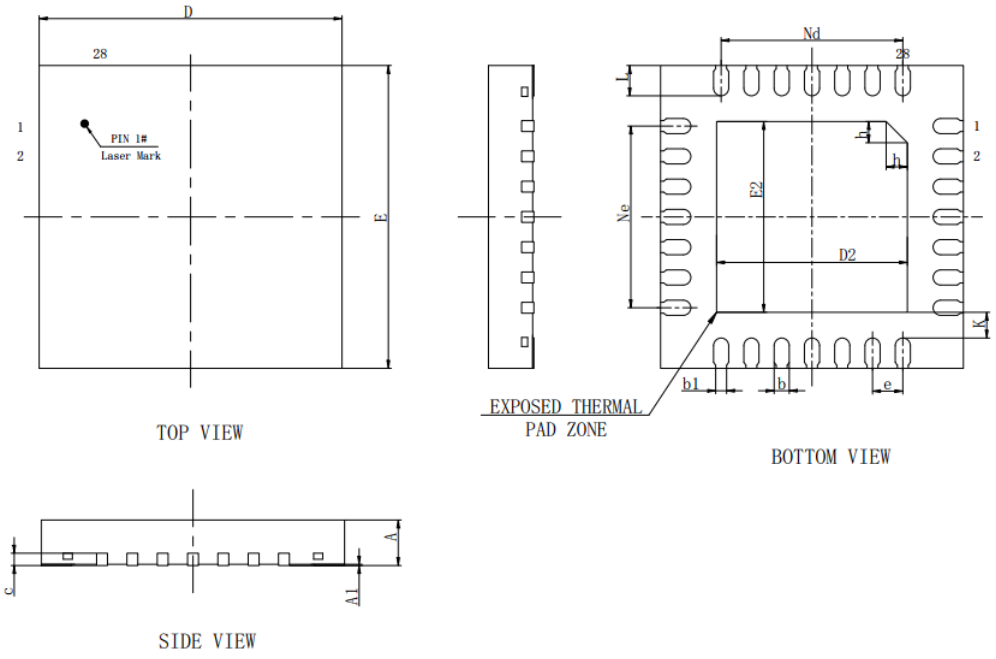
Bottom View



Side View

Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF		0.008REF	
D	4.900	5.100	0.193	0.201
E	4.900	5.100	0.193	0.201
D1	3.050	3.250	0.120	0.128
E1	3.050	3.250	0.120	0.128
k	0.200MIN		0.008MIN	
b	0.180	0.300	0.007	0.012
e	0.500TYP		0.020TYP	
L	0.450	0.650	0.018	0.026

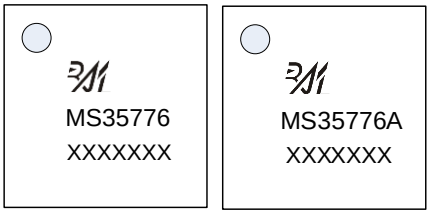
MS35776A QFN28



Symbol	Dimensions in Millimeters		
	Min	Typ	Max
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.20	0.25	0.30
b1	0.18REF		
c	0.203REF		
D	4.90	5.00	5.10
D2	3.05	3.15	3.25
e	0.50BSC		
Nd	3.00BSC		
Ne	3.00BSC		
E	4.90	5.00	5.10
E2	3.05	3.15	3.25
L	0.45	0.50	0.55
h	0.30	0.35	0.40
K	0.425REF		

MARKING and PACKAGING SPECIFICATION

1. Marking Drawing Description



Product Name: MS35776, MS35776A

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
MS35776	QFN28	4000	1	4000	8	32000
MS35776A	QFN28	1000	8	8000	4	32000

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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