Voltage Regulator Controller for Motorbike

Features

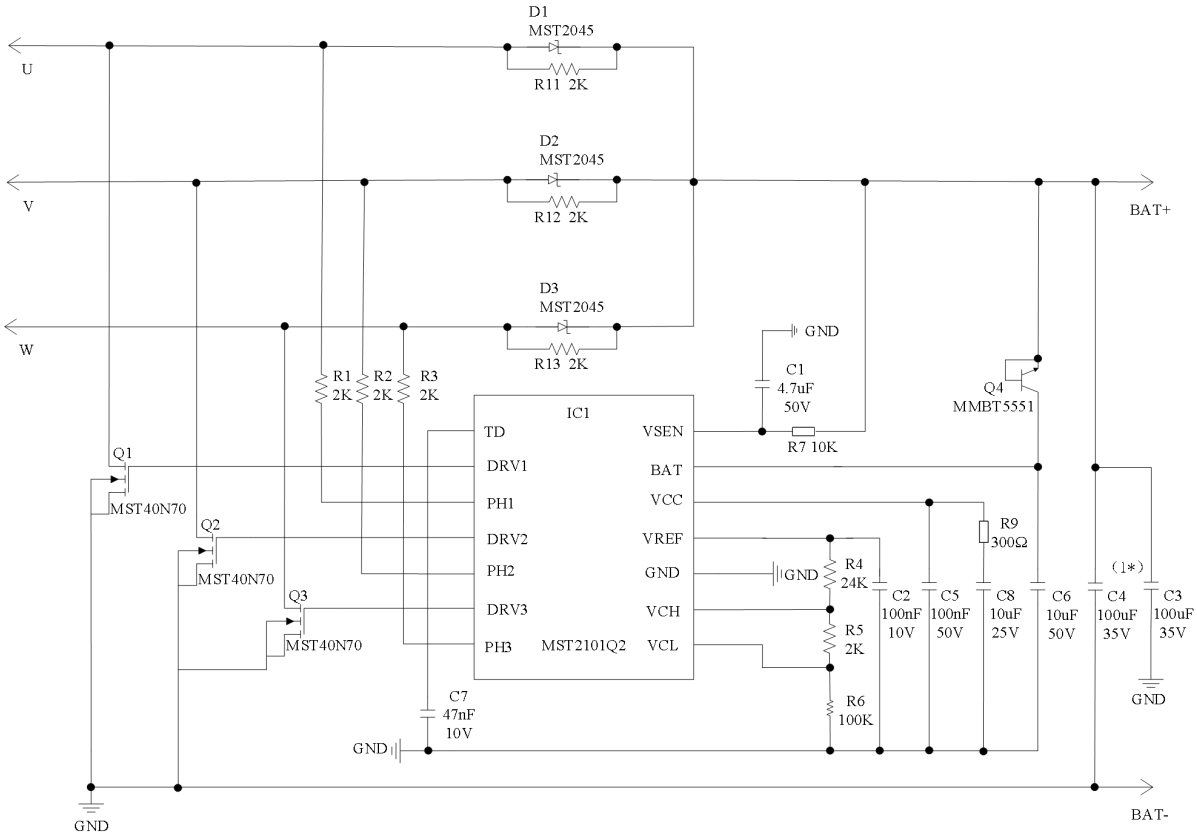
- Adaptive to magneto
- Zero crossing regulation
- Over voltage protection with fast response
- Group wave modulation to keep each phase in balance
- Integrated internal regulator LDO
- Hot-plug protection for MOSFETs
- The voltage of the battery is adjustable
- Easy to use:only fewexternal components
- Available packages：SOP14

Description

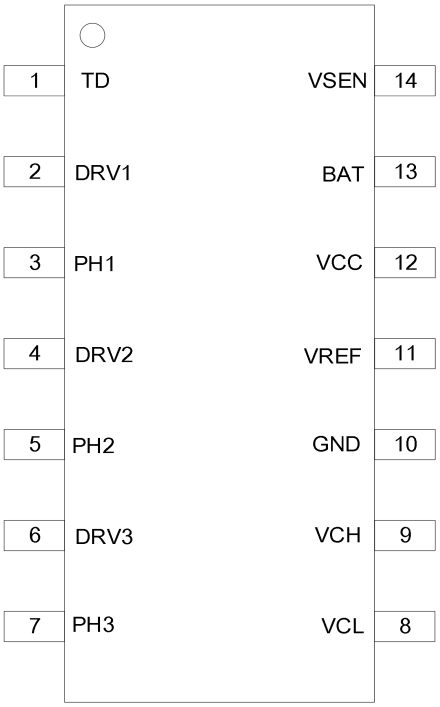
MST2101Q2KD is a voltage regulator controller adaptive for high speed magneto applications. It receives power from magneto and regulates battery voltage through low Rdson MOSFETs, the MST2101Q2KD can keep energy conversion most efficient, and reduce regulator power loss and self heat.

Multiple built-in protection mechanisms in MST2101Q2KD can prevent regulator and motorcycle load from damage. OVP circuit (Over Voltage Protection) can disconnect power from the load when voltage stress occurs on the load, especially on the battery absent condition. Hot Plug function integrated with MST2101Q2KD will prevent regulator from voltage spike damage due to loosing wires caused by driving vibration.

Typical Application



Pin Configuration and Functions



Pin Functions

Pin	Name	Description
1	TD	Detect whether the magnetic motor is working, connect a 47nF capacitor to the ground
2	DRV1	The switch driver of the first phase, connect to the NMOS's gate
3	PH1	The sense of the first phase, connect to the magneto first phase output through a 2 KΩ resistance
4	DRV2	The switch driver of the second phase, connect to the NMOS's gate
5	PH2	The sense of the third phase, connect to the magneto second phase output through a 2 KΩ resistance
6	DRV3	The switch driver of the third phase, connect to the NMOS's gate
7	PH3	The sense of the second phase, connect to the magneto second phase output through a 2 KΩ resistance
8	VCL	Voltage setting for output voltage lower limit
9	VCH	Voltage setting for output voltage upper limit
10	GND	GND of the chip and system
11	VREF	2.5V reference voltage, connect an external 100nFcapacitor
12	VCC	The internal power output of the chip, connect to a 10uF capacitor with voltage rating more than 25V
13	BAT	Battery terminal
14	VSEN	Battery voltage detection terminal

Absolute Maximum Ratings

Characteristics	Symbol	Rating	Unit
PH1 to GND		-0.3 to 40	V
PH2 to GND		-0.3 to 40	V
PH3 to GND		-0.3 to 40	V
DRV1 to GND		-0.3 to 20	V
DRV2 to GND		-0.3 to 20	V
DRV3to GND		-0.3 to 20	V
BAT to GND		-0.3 to 40	V
VCC to GND		-0.3 to 20	V
TD to GND		-0.3 to 5.5	V
VCH to GND		-0.3 to 5.5	V
VCL to GND		-0.3 to 5.5	V
Operating Junction Temperature		-40 to 125	°C
Storage Junction Temperature		-40 to 150	°C
Thermal Resistance from Junction to ambient(θ_{JA})	SOP14	125	°C/W

Note:

exceeding the range specified by the rated parameters will cause damage to the chip, and the working state of the chip beyond the range of rated parameters cannot be guaranteed. Exposure outside the rated parameter range will affect the reliability of the chip.

ESD Ratings

Parameter	Description	Range	Unit
V_{ESD}	Human Body Model(HBM)	2	KV

Note:

JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

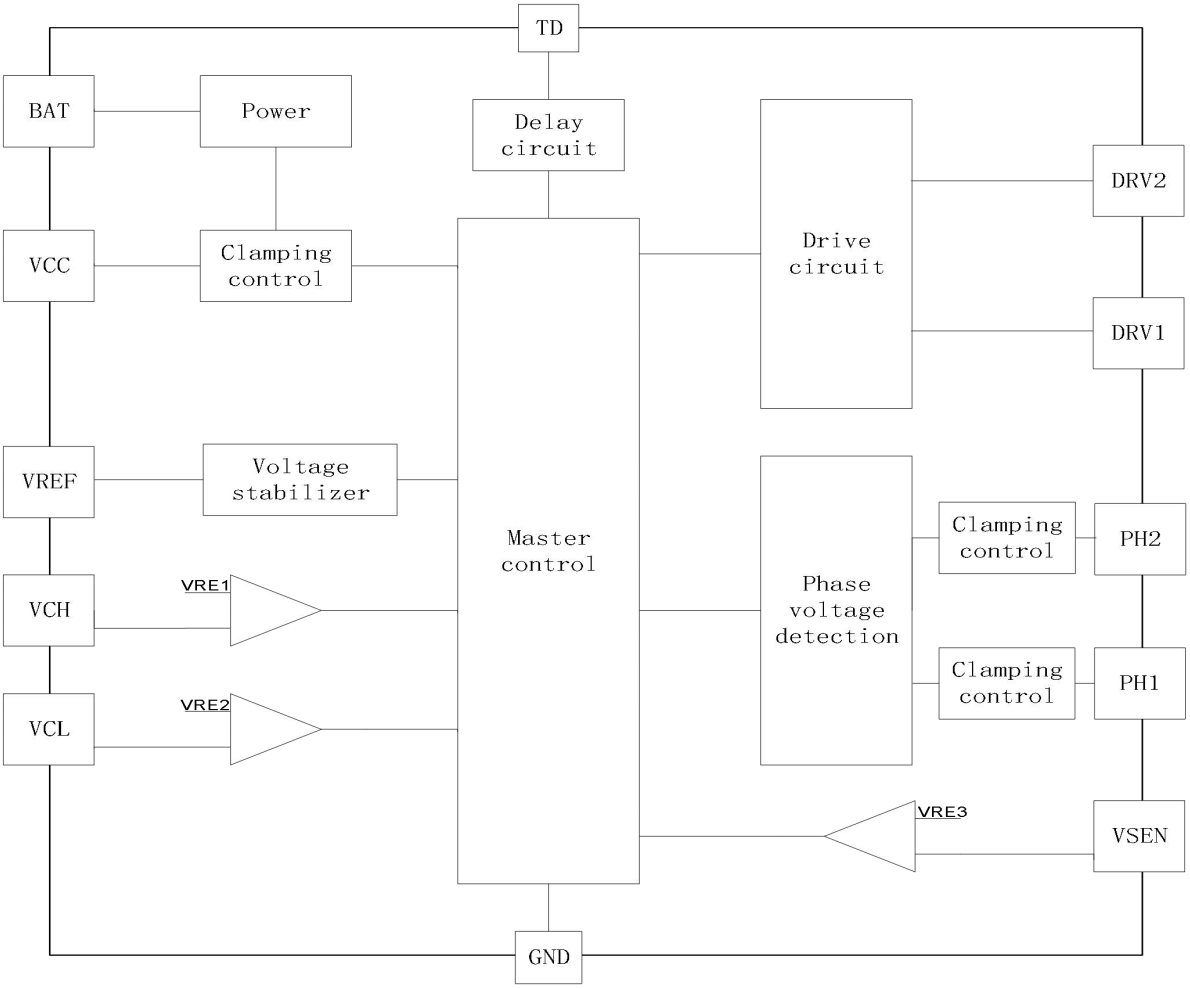
JEDEC document JEP157 states that 200-V CDM allows safe manufacturing with a standard ESD control process.

Electrical Characteristics

(At T_A=25°C, V_{BAT}=12V,unless otherwise noted)

Characteristics	Symbol	Conditions	Min	Typ	Max	Unit
Regulator output	V_{BAT}	Connect to battery or load	14	14.5	15	V
Sleep current	I_{SLEEP}	The magneto stops working	-	50	-	uA
Static working current	I_Q	PH1=PH2=PH3=0	-	750	1000	uA
VCC operating voltage	V_{CC_MAX}	PH1=PH2=PH3=0 V_{BAT}=7V ~ 15V	4	-	15	V
VREF voltage(A)	V_{REF}	PH1=PH2=PH3=0 V_{BAT}=7V to 15V	2.475	2.5	2.525	V
VREF voltage(B)			2.425	2.45	2.475	V
VREF voltage(C)			2.525	2.55	2.575	V
Phase voltage cross zero from negative to positive	V_{ZERO_P}	——	3	5	7	mV
Phase voltage cross zero From positive to negative	V_{ZERO_N}		-7	-5	-3	mV
Over voltage protection	V_{OVP}	——	20	21	22	V
Drive current	I	——	-	30	-	mA

Functional Block Diagram



Detailed Description

Overview

MST2101Q2KD is a voltage regulator controller adaptive for high speed magneto applications. It receives power from magneto and regulates battery voltage through low Rdson MOSFETs, the MST2101Q2KD can keep energy conversion most efficient, and reduce regulator power loss and self heat.

Multiple built-in protection mechanisms in MST2101Q2KD can prevent regulator and motorcycle load from damage. OVP circuit (Over Voltage Protection) can disconnect power from the load when voltage stress occurs on the load, especially on the battery absent condition. Hot Plug function integrated with MST2101Q2KD will prevent regulator from voltage spike damage due to loosing wires caused by driving vibration.

MST2101Q2KD controller starts to regulate battery voltage when each phase current goes to zero crossing. With zero crossing regulation approach, the controller can greatly reducing switching loss avoiding regulator from heating, the most important, it greatly suppress electromagnetic interference in the system,

Through internal ON/OFF time sequence management, the power of each phase will be distributed to the battery and load evenly (Group Wave Modulation), avoiding the phenomenon of only one phase working while other phases idle. With the smooth and orderly control of each phase,the regulator ensures the reliability of the whole magnetic motor system.

When the magneto motor stops working, the controller will disconnect the whole circuit from battery guarantees low static current consumption of the battery and extend the life of the battery.

Zero-Crossing Detection

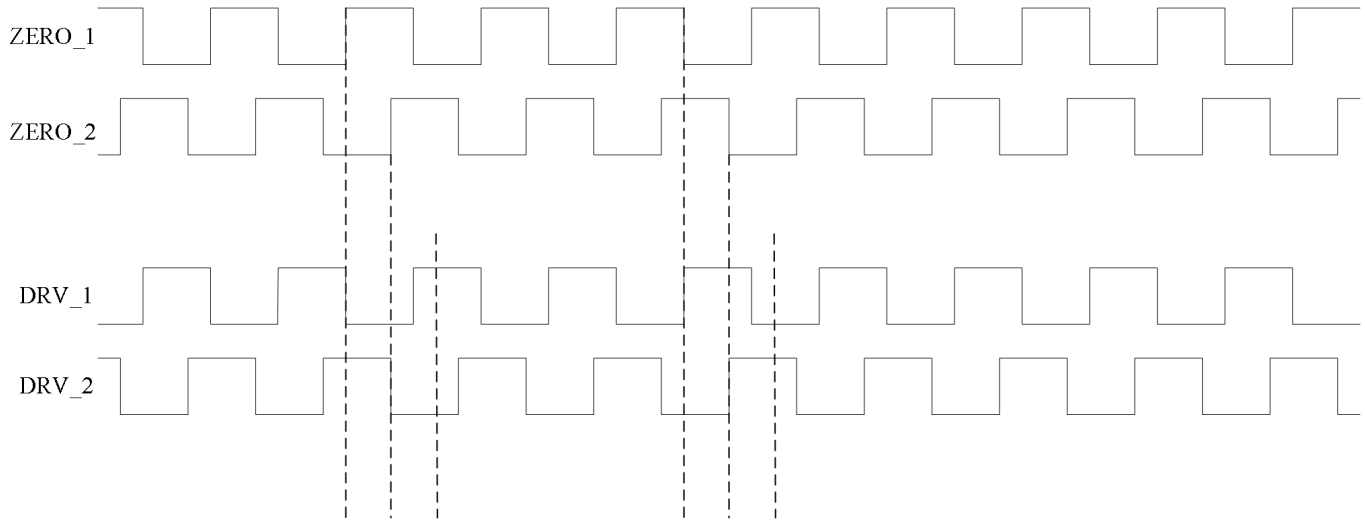


Figure1 Zero-Crossing Detection

NOTE：

1. ZERO_1 and ZERO_2 are each phase voltage zero-crossing detection signal
2. DRV_1 and DRV_2 are each phase driver output signal

The zero-crossing detection function is shown in figure 1. When the phase voltage signal is increased from negative voltage to 5mV, the output current of the corresponding phase of the magneto is judged as zero cross from negative to positive. The phase control circuit outputs low level, MOSFET is off and the voltage regulator starts to charge the battery. In the same way, when the input phase voltage is dropped from the positive voltage to -5mv, the output current of the

corresponding phase of the magneto is judged as zero cross from positive to negative. The phase control circuit outputs high level, MOSFET turns on, and the voltage regulator stops to charge the battery.

Suppose that N-MOSFET Rdson is about 10mΩ, then when the magneto output current rises up to 0.5A from negative, this phase is judged to zero cross from negative to positive; when the magneto output current drops to -0.5A from positive, this phase is judged as zero cross from positive to negative.

Voltage modulation mode

MST2101Q2KD can regulate battery voltage by setting upper threshold voltage, medium threshold voltage, and lower threshold voltage. The setting formula for adjusting the upper and lower limits of the battery voltage is as following:

$$V_{ADJ\_L} = \frac{R_6}{R_5 + R_6 + R_4} \times 2.5V \times 7.25\,V$$

$$V_{ADJ\_H} = \frac{R_6 + R_5}{R_5 + R_6 + R_4} \times 2.5 \times 7.25\,V$$

The setting formula for adjusting the medium value of the battery voltage is

$$V_{ADJ} = \frac{R_5 + 2R_6}{2\,（R_5 + R_6 + R_4）} \times 2.5 \times 7.25\,V$$

The battery voltage ripple is calculated as following:

$$V_{ADJ} = \frac{R_5}{R_5 + R_6 + R_4} \times 2.5 \times 7.25\,V$$

The working principle of voltage regulator control method is shown in the figure 2. When the battery sense voltage is lower than the preset threshold voltage, the voltage regulator system will shut off the MOSFET of corresponding phase in the positive half cycle, and charge the battery or load.

In the same way, when the battery sense voltage is higher than the preset threshold voltage, the voltage regulator system will turn on the MOSFET of corresponding phase in the positive half cycle, and stop charging the battery or load.

Meanwhile, MST2101Q2KD has a built-in automatic equalization logic circuit, which guarantees each phase charging battery every cycle during the battery charging process, and avoids some phases working while other phases always idle.

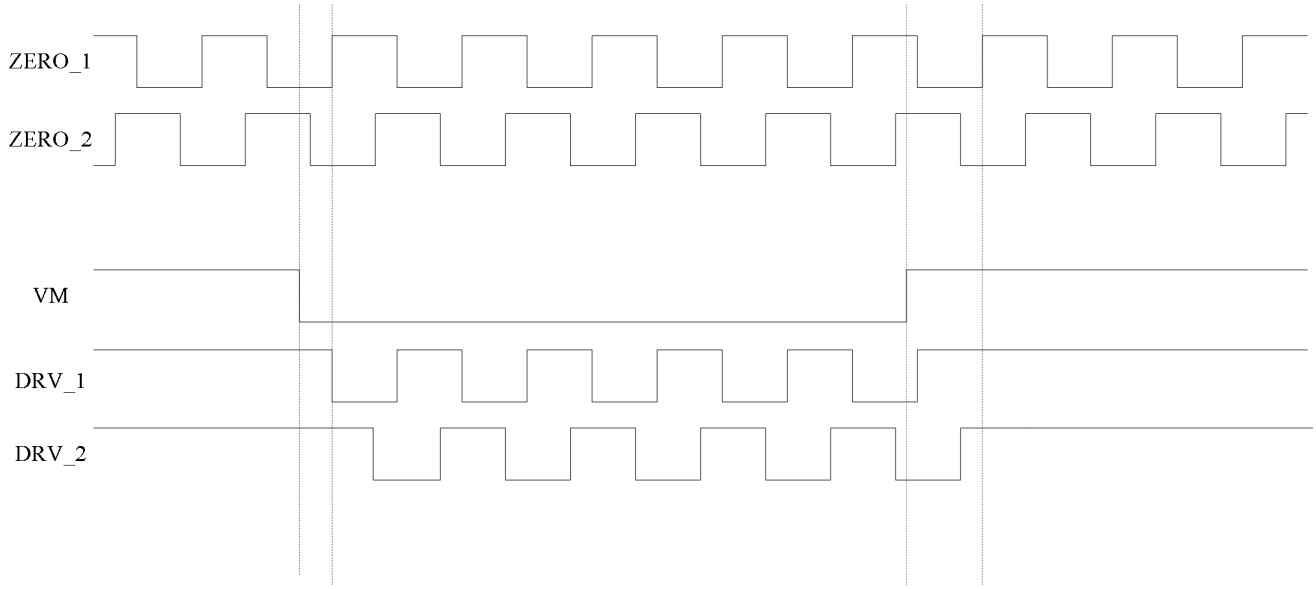


Figure2 Voltage modulation mode

NOTE：

1.ZERO_1 and ZERO_2 are each phase voltage zero-crossing detection signal

2.VM is the adjusting voltage detection signal

3.DRV_1 and DRV_2 are each phase driver output signal

Over voltage mode

The operating principle of over voltage mode is shown in Figure 3. When the phase voltage is higher than the over voltage protection voltage 21V, the MOSFET of the corresponding phase is immediately turned on, and the phase voltage is pulled down until the next cycle crosses zero, and then it returns to normal output.

Hot-plug Protection

The magneto can cause sudden access or disconnection from the voltage regulator due to various reasons. If the power supply system of the whole chip has not been established yet, the output voltage spike of the magneto may damage the voltage regulator. For this abnormal usage, MST2101Q2KD has the hot-plug protection function that can prevent damage happening.At the moment that the voltage regulator is connected with the magneto motor, if the phase voltage is higher than 30V,the MOSFET of the corresponding phase is turned on immediately to avoid the voltage regulator damage. The hot-plug protection system is safe and reliable.

Shutdown state

When the magneto stops working, MST2101Q2KD goes into the sleep mode and does not consume current from the battery.

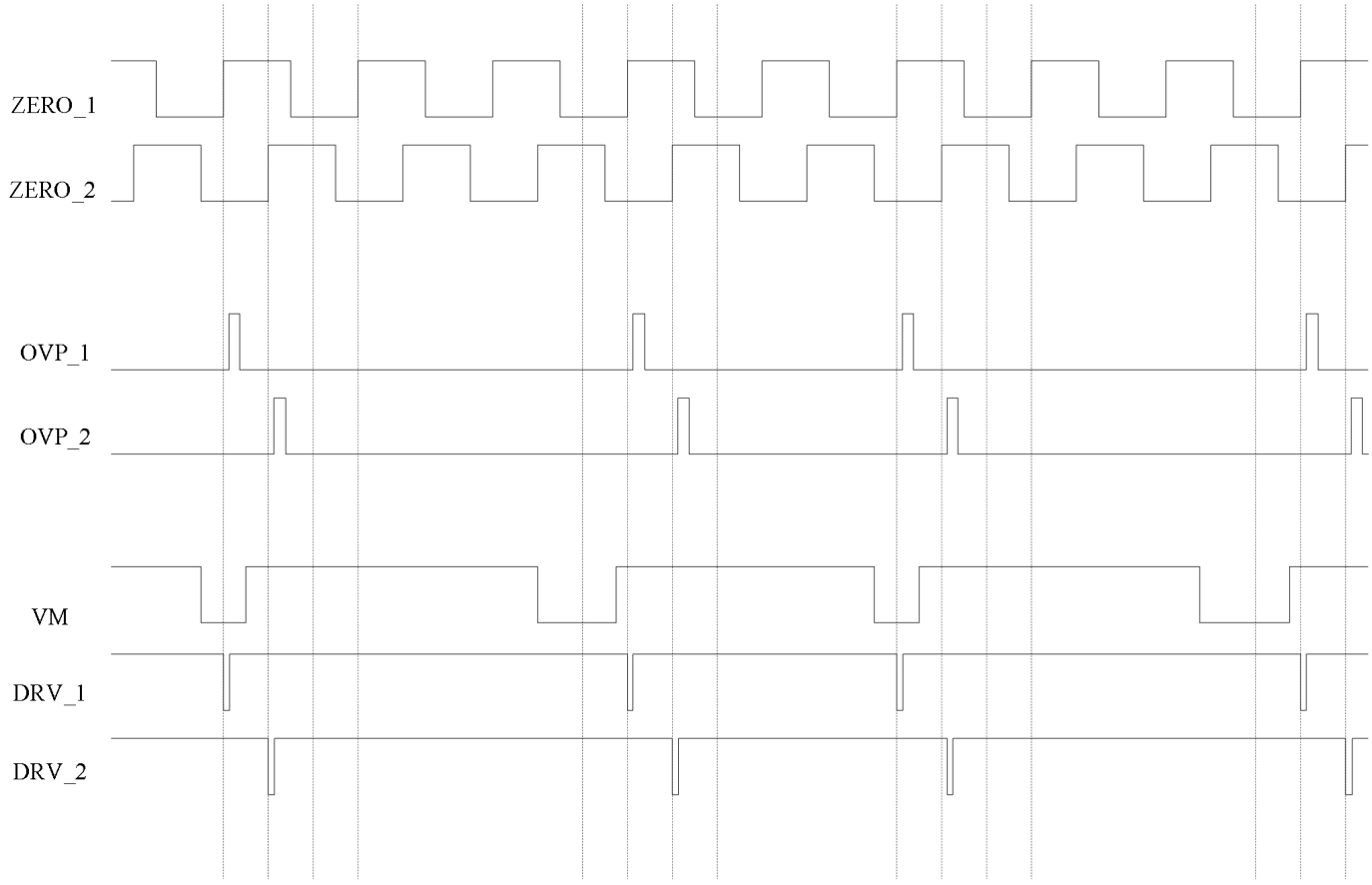


Figure3　Over voltage mode

NOTE：

1.ZERO_1 and ZERO_2 are each phase voltage zero-crossing detection signal

2.OVP_1 and OVP_2 are each phase overvoltage detection signal

3.VM is the adjusting voltage detection signal, VM_3 is a logically processed signal for VM

4.DRV_1 and DRV_2 are each phase driver output signal

Ordering And Marking Information

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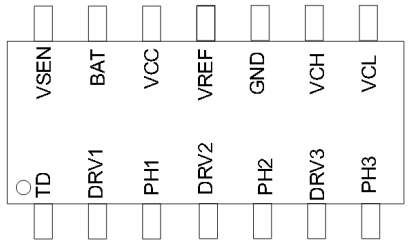
MST2101Q2KD
Package Definition
Product Name
Company Name</td><td>Package Outline</td><td> 
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<tr><td rowspan="2"></td><td>Minimum Package</td><td>SOP14
2500pcs/Reel</td></tr>
<tr><td>Marking</td><td>MST2101Q2
314 T
Version
2101：Product Name
T:Packaging Factory
314-2023;14-the 14th week of this year
MST: Company Name</td></tr>
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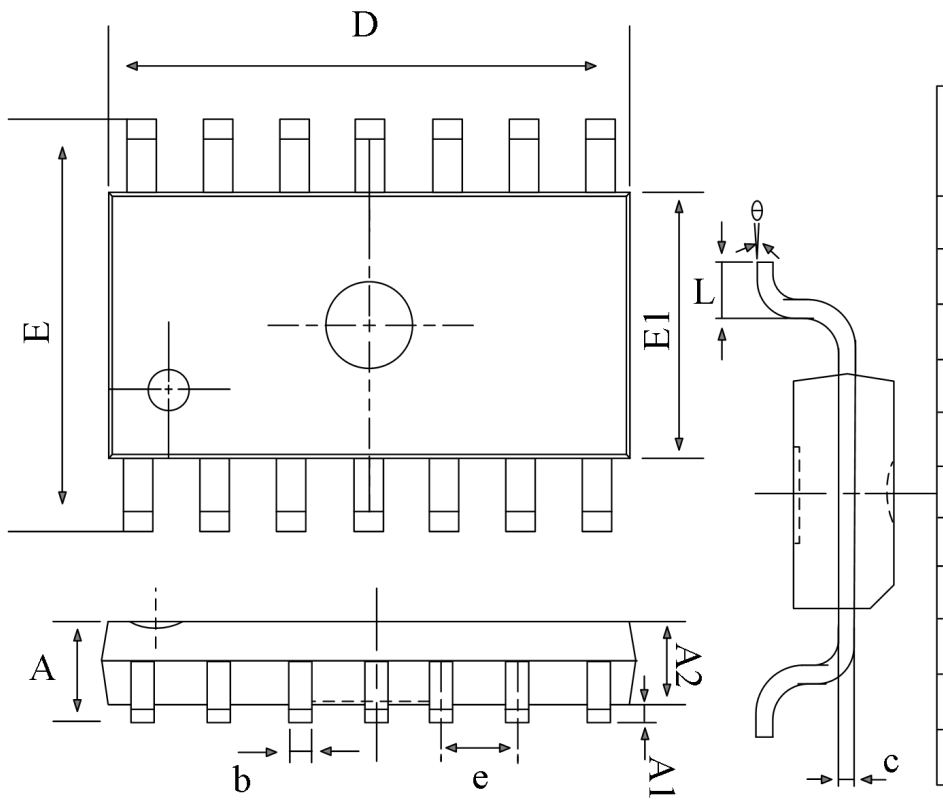
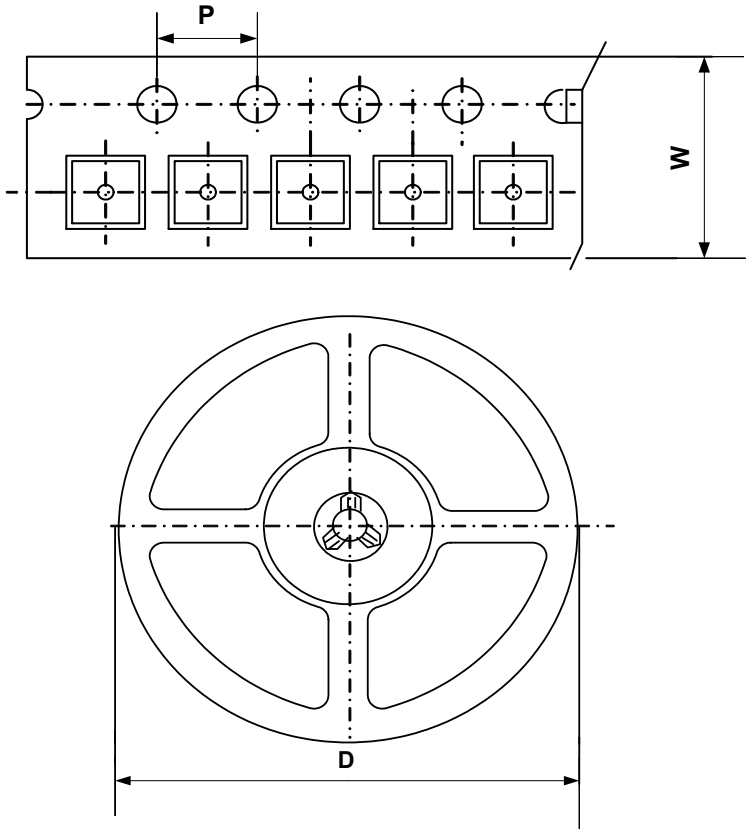
Package Outline

SOP14



REF.	Millimeter	
	Min.	Max.
A	--	1.750
A1	0.100	0.250
A2	1.250	1.550
c	0.100	0.250
D	8.450	8.850
E	5.800	6.200
E1	3.800	4.000
L	0.400	1.270
b	0.310	0.510
e	1.270(TYP)	
θ	0°	8°

Packing Information



Type	W(mm)	P(mm)	D(mm)	Qty (pcs)
SOP14	16.0mm	4.0mm	330.0mm	2500pcs

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