

K7308BM

Synchronous Rectifier

1. Features

- Built-in 9.2mΩ on-resistance and 40V breakdown voltage MOSFET
- Programmable resistor to filter resonant ringing signals
- Fewest components counts

- Excellent system ESD and EFT performance

2. Applications

- Smart phone chargers
- Power strip with USB ports
- 5V adapters

3. Typical applications (5V/3.4A charger)

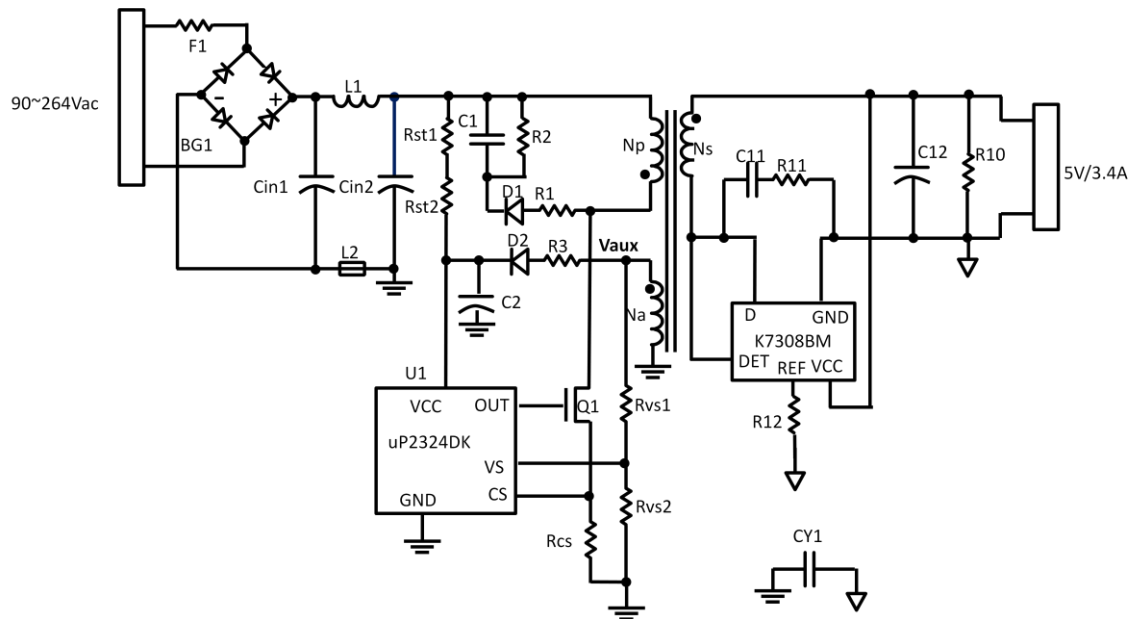
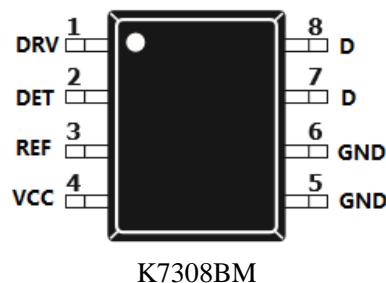


Fig.1 Typical applications

4. Pin definitions



Pin Name	Pin Type	Pinout	Pin Functions
DRV	Output	1	Gate drive of SR MOSFET
DET	Input	2	Drain voltage detection of SR MOSFET
REF	Output	3	Volt-second setting for SR MOSFET turn on

VCC	Power supply	4	Power supply of the rectifier
GND	Ground	5, 6	Source of the SR MOSFET and the power ground.
D	Drain	7, 8	Drain of the SR MOSFET

5. Absolute maximum ratings (Note 1)

Parameter	Name	Range	Unit
Voltage at VCC to Ground	VCC	-0.3 to 7	V
Voltage at DRV to Ground	DRV	-0.3 to 6	V
Voltage at DET to Ground	DET	-2 to 50	V
Voltage at REF to Ground	REF	-0.3 to 6	V
Voltage at D to Ground	D	-2 to 40	V
Power dissipation @ T _A =25 °C	P _D	0.7	W
Maximum junction temperature	T _{JMAX}	150	°C
Lead temperature	T _{LEAD}	300	°C
Storage temperature	T _{STG}	-55 to 150	°C
ESD rating per ANSI/STM5.1-2001	HBM	2000	V
ESD rating per JEDEC JESD22-C101F	CDM	1000	V
Latchup test per JEDEC 78D		+/-200	mA

Note1: Stresses over those listed under “Absolute maximum ratings” may cause permanent damages to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods of time may affect device reliability.

6. Thermal parameter

Junction to ambient thermal resistance	$\theta_{JA}(\text{SOP-8})$	90	°C/W
Junction to case thermal resistance	$\theta_{JC}(\text{SOP-8})$	45	°C/W

7. Recommended operating conditions

Parameter	Symbol	Min	Max	Unit
Supply voltage	VCC	3.3	6	V
Ambient Temperature	T _A	-40	85	°C

8. Electrical parameters

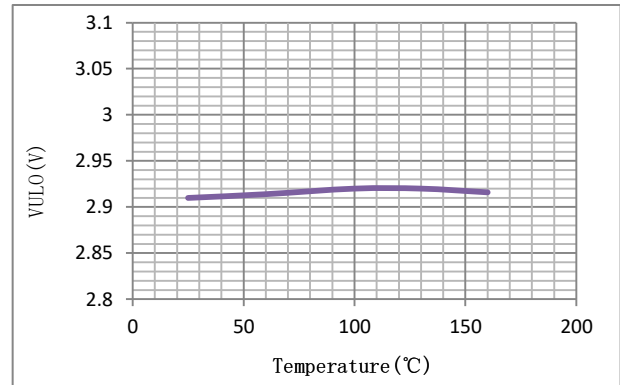
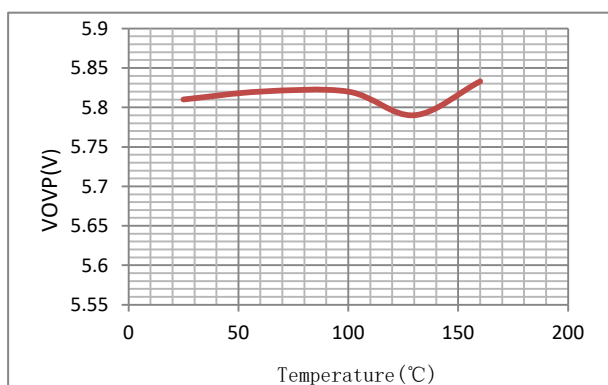
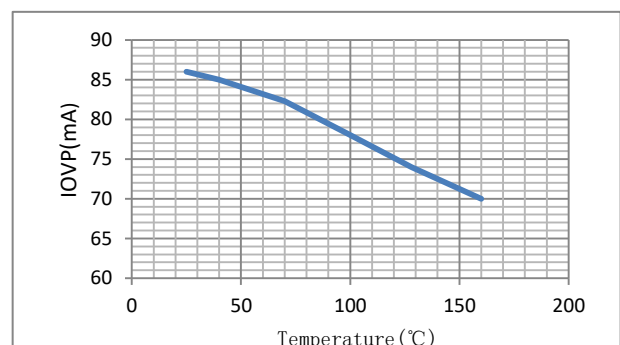
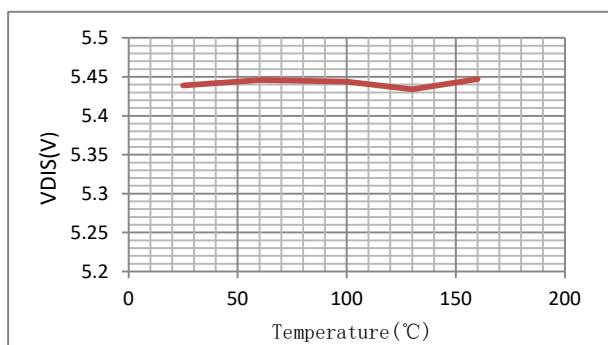
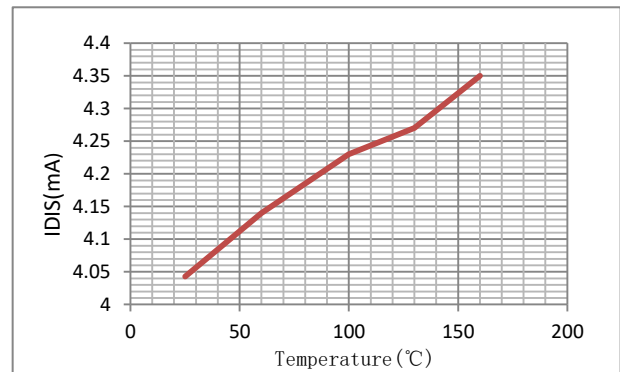
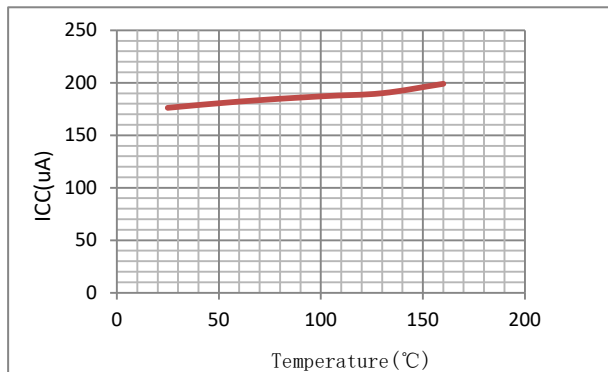
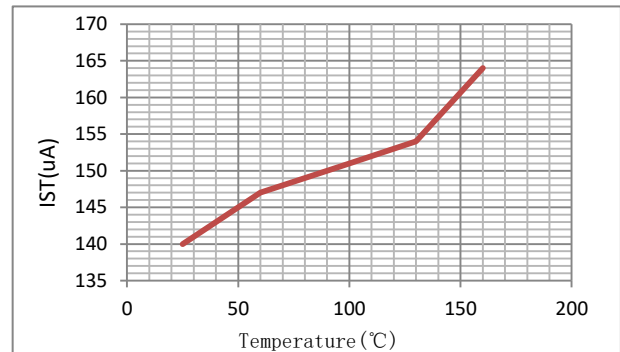
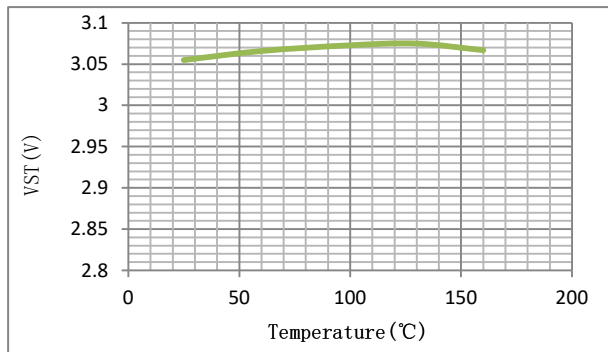
$T_A = 25^\circ\text{C}$, unless otherwise specified

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power supply(VCC pin)						
Operating current	I_{CC}		180	200	220	μA
Startup voltage	V_{ST}		2.68	2.98	3.28	V
Minimum operating voltage	V_{UVLO}		2.5	2.8	3.1	V
Startup current	I_{ST}	$V_{CC} = V_{ST} - 0.1\text{V}$	110	140	170	μA
Output voltage monitor						
VCC discharge voltage	V_{DIS}		5.39	5.47	5.55	V
VCC discharge current	I_{DIS}	$V_{CC} = V_{DIS} + 0.1\text{V}$	1.5	3	4.5	mA
VCC protection voltage	V_{OVP}		5.75	5.85	5.95	V
VCC over voltage discharge current	I_{OVP}	$V_{CC} = V_{OVP} + 0.1\text{V}$	40	97	130	mA
VCC OVP discharge time	T_{OVPDIS}		672	800	928	μS
Internal oscillator period	T_{OSC}		21	25	29	μS
Synchronous rectification control						
SR turn on voltage	V_{THON}			75		mV
SR turn off voltage	V_{THOFF}		-6	-2	2	mV
SR turn on delay time	T_{DON}		10	70	130	nS
SR turn off delay time	T_{DOFF}		10	100	150	nS
SR turn on rising time	T_R	$C_L = 4.7\text{nF}$	10		100	nS
SR turn off falling time	T_F	$C_L = 4.7\text{nF}$	10		100	nS
SR minimum on time	T_{LEB_S}	$(V_{DET} - V_{CC}) * T_{ONP} = 30\text{V} * \mu\text{S}$		2.2		μS
SR minimum operating voltage($V_{DET} - V_{CC}$)	V_{S_MIN}	Minimum DET pin voltage@ $V_{CC} = 5\text{V}$		3.0		V
Ampere Second Product	ASP	$(V_{DET} - V_{CC}) * T_{ONP} = 25\text{V} * \mu\text{S}$	0.5	0.7	0.9	mA * μS
SR MOSFET characteristics						
Drain to source breakdown	BV_{DSS}	$V_{GS} = 0\text{V}, I_D = 0.25\text{mA}$	40			V
Gate threshold voltage	$V_{GS(TH)}$	$V_{DS} = V_{GS}, I_D = 0.25\text{mA}$	1.0	1.5	2.0	V
Static Drain-to-Source On Resistance	$R_{DS(on)}$	$V_{GS} = 5.5\text{V}, I_D = 8\text{A}$		6.8	9.2	$\text{m}\Omega$
Drain-to-Source leakage	I_{DSS}	$V_{GS} = 0\text{V}, V_{DS} = 40\text{V}$ $T_J = 25^\circ\text{C}$			1	μA
Gate to source leakage	I_{GSS}	$V_{GS} = \pm 20\text{V}$	-100		100	nA

9. Typical Characteristics

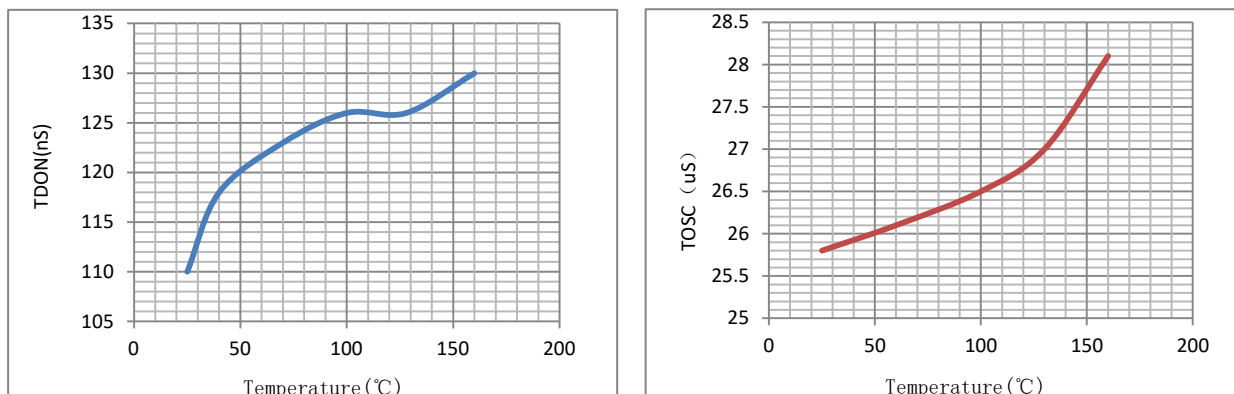
K7308BM

Synchronous Rectifier



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10. Functional block diagram

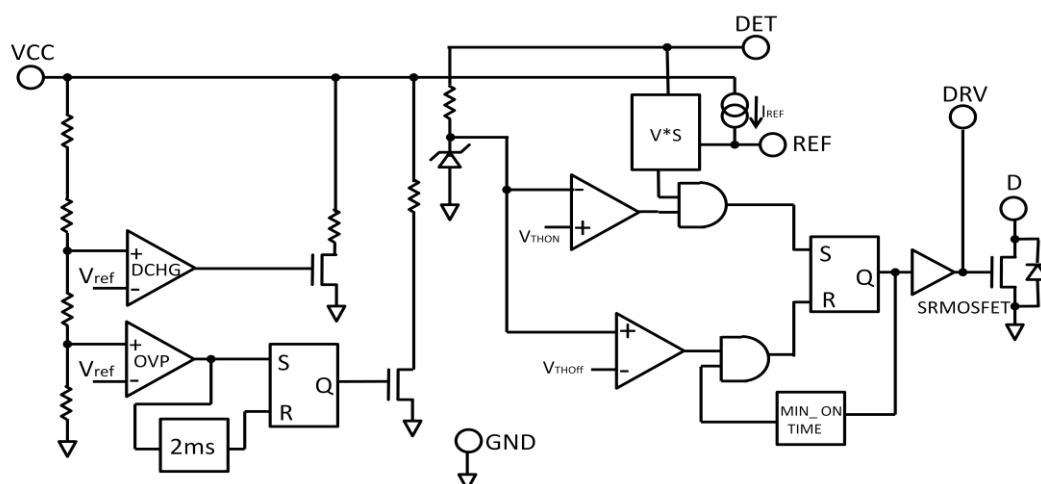


Fig.2, K7308BM block diagram

11. Principle of operation

The K7308BM has two major functions: output voltage monitor to discharge output capacitor at certain conditions and synchronous rectification. The device must work in Discontinuous Conduction Mode (DCM) or Quasi-Resonant Mode (QRM).

11.1 Power up and power down sequences

Refer to Fig.1 and Fig.2, after AC power supply is applied to the converter, the primary controller uP2324D (U1) starts to deliver energy to the output capacitor C11, the output voltage begins rising from 0V. When the VCC voltage of K7308BM (U2) is lower than the startup voltage V_{ST} , the synchronous rectifier does not work, the body diode of the SR MOSFET acts as the rectification diode, with around -1.5V forward conduction voltage since the body diode of the SR MOSFET is just an ordinary PN junction. When the VCC voltage of K7308BM (U2) is larger than the startup voltage V_{ST} , the synchronous rectifier starts to work, as described in 10.3. When the AC power

supply is removed from the converter, the VCC voltage of K7308BM (U2) falls below V_{UVLO} , the synchronous rectifier stops working, the body diode of the SRMOSFET acts again as the rectification diode.

11.2 Discharge of output capacitor

When the VCC voltage of K7308BM (U2) is higher than a specified voltage V_{DIS} , K7308BM will turn on a discharge path from VCC to GND with typical 3mA current capacity to make the system output voltage stay around V_{DIS} . When the VCC voltage of K7308BM (U2) is further higher than a specified voltage V_{OVP} , such as in case of load transient from full load to no load, K7308BM will turn on another discharge path from VCC to GND with typical 70mA current capacity to limit the system output over shoot voltage.

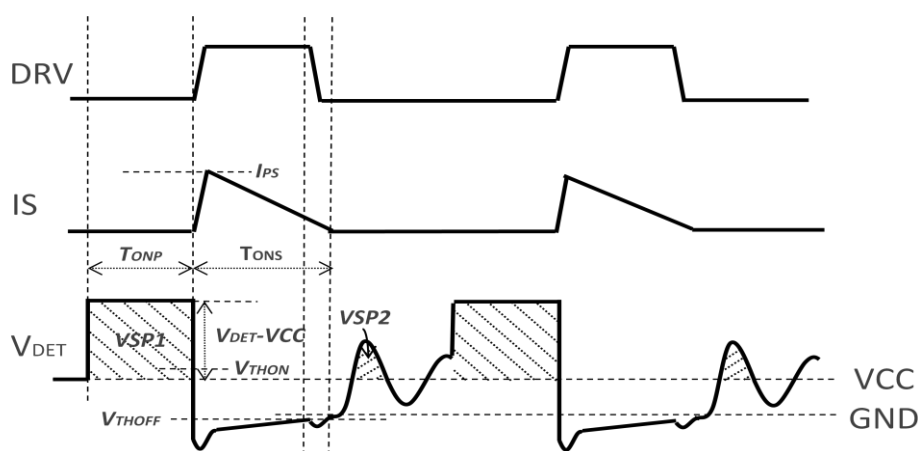


Fig.3, K7308BM SR operation

11.3 Synchronous rectification

Refer to Fig3, K7308BM monitors the SR MOSFET drain to source voltage at DET pin. When the V_{DET} is lower than the turn-on threshold voltage V_{THON} , K7308BM DRV pin generates a positive drive voltage after a turn-on delay time (T_{DON}). The SR MOSFET will turn on and the current will transfer from the body diode to the channel of the SR MOSFET.

After the conduction of the SR MOSFET, the V_{DET} rises linearly. When it rises over the turn off threshold voltage V_{THOFF} , K7308BM DRV pin generates a pull down signal after a turn-off delay (T_{DOFF}).

During the SRMOSFET turn on process, some ringing noise may be generated. The minimum on-time block blanks the output of V_{THOFF} comparator, keeping the SR MOSFET on for at least the minimum on time. The minimum on time is proportional to the volt second product (VSP) of the primary side power switch on state, which is equal to $(V_{DET}-V_{CC}) \cdot T_{ONP}$. If $(V_{DET}-V_{CC}) \cdot T_{ONP} = 30V \cdot \mu s$, the minimum on time is about 2.2 μs .

As the convertor operates in DCM or QRM, after synchronous rectifier stops conduction, resonant ringing is resulted due to the primary inductance and power switch parasitic capacitance. This

ringing waveform may leads to the error conduction of the synchronous rectifier. To avoid this fault, K7308BM judges the primary power switch turn on by the Volt-Second Product (VSP) of the system. The volt-second product (VSP1) of a primary switch turn on is much higher than the volt-second product (VSP2) of the resonant ringing waveform, as illustrated in Fig.3. Thus, before to turn on the synchronous rectifier, K7308BM judges if the detected volt-second product of V_{DET} voltage above VCC is higher than a threshold (VSP_{REF}) and then turn on synchronous rectifier if the detected VSP is larger than VSP_{REF} . The purpose of REF resistor is to set the volt-second product threshold (VSP_{REF}). The detected volt-second product

$$VSP = \int (V_{DET} - V_{CC}) * dt = R_{VSP} * C_{VSP} * V_{VSP}$$

Where R_{VSP} is an internal resistor to convert the ($V_{DET} - V_{CC}$) voltage to charge an internal capacitor C_{VSP} , and V_{VSP} is the voltage rise on C_{VSP} when the charging phase is completed. In K7308BM, the V_{VSP} to judge whether the VSP is generated by primary side power switch or not is set by an internal current source I_{REF} and outside resistor R_{REF} (R12 in Fig.1). So, the judging volt-second product

$$VSP_{REF} = (R_{VSP} * C_{VSP} * I_{REF}) * R_{REF} = ASP * R_{REF}$$

Where $ASP = (R_{VSP} * C_{VSP} * I_{REF})$ is a K7308BM determined “Ampere Second Product” to set system VSP_{REF} with R_{REF} . VSP_{REF} depends on system design and are always fixed after system design is frozen. R_{REF} resistor should be considered for the worst case, that is, the minimum primary peak current condition. VSP_{REF} should be designed in the middle of VSP1 and VSP2. K7308BM also sets a minimum line voltage to operate the SR MOSFET. The value of $V_{DET} - V_{CC}$ during primary side power switch turn on time (T_{ONP}) must be higher than V_{S_MIN} to enable the synchronous rectifier. That is, the minimum rectified input line voltage (V_{IN_MIN}) to enable the SR is

$$V_{IN_MIN} = V_{S_MIN} * (N_P / N_S)$$

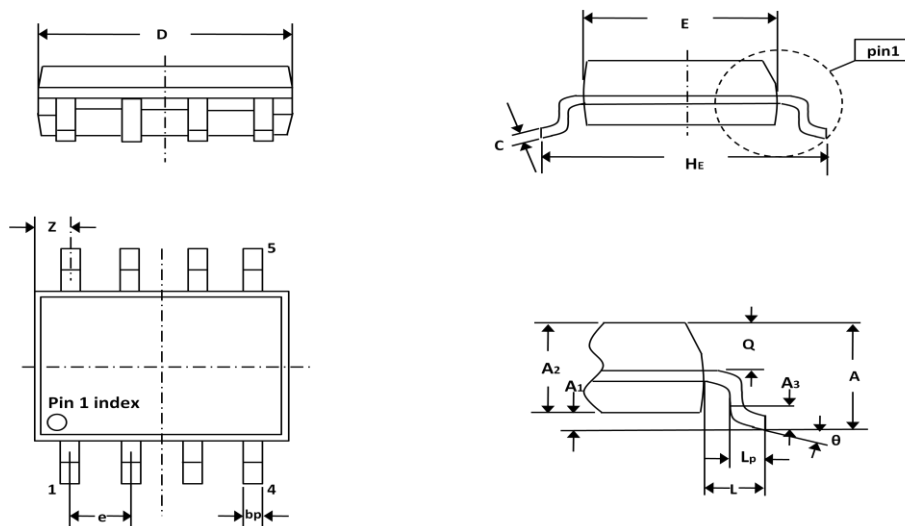
12. Ordering information

Part number	Mark ID	Package	Packing	Output power
K7308BM	7308BM	SOP-8	3,000 / Reel	15~17W

13. Mechanical dimensions

K7308BM

Synchronous Rectifier



UNIT	A	A1	A2	A3	bp	c	D	E	e	HE	L	Lp	Q	θ
mm	1.75	0.1/ 0.25	1.25/ 1.5	0.25	0.33/ 0.51	0.19/ 0.25	4.7/ 5.1	3.8/ 4.0	1.27	5.8/ 6.2	1.05	0.4/ 1.0	0.6/ 0.7	8°