2.5A USB/Adapter Switching Charger

General Description

The VAS5183 is a highly-integrated switch-mode battery charge management device for 1 cell Li-Ion and Li-polymer batteries in a wide range of tablet and other portable devices. Its low impedance power switch optimizes switch-mode operation efficiency, reduces battery charging time and heat. The VAS5183 supports a wide range of input sources, including standard USB host port, USB charging port, and high power DC adapter. It is compliant with USB 2.0 and USB 3.0 power spec with both input current limit and input voltage regulation to manage max input power without input source crash. The VAS5183 offers adjustable battery cell voltage that can fit various battery cells from different manufacturers, and the programmable safety timer can satisfy a wide range of battery capacity with different kinds of charging rate.
The VAS5183 features high integration with all power switches included inside. No external MOSFET, blocking diodes, or current sense resistor is required. The application circuit needs only few external resistors and MLCC capacitors for operation.

VAS5183 is available in QFN 4mmx4mm package.

Applications

- Power Bank
- Tablet PC
- Smart phone
- Portable Hand-held solutions

Features

- Integrated power MOSFETs
- 4.5~6.0V operating input voltage
- 20V input rating (surge protection)
- Programmable up to 2.5A charge current(set by ext. RISET resistor)
- Up to 92% efficiency
- Cover USB2.0 and USB3.0 input specification
- Programmable output voltage (4.20V to 4.4V) with ±1% accuracy
- Automatically reduce charge current when supplied by poor power source (VIN-DPM)
- Does not required reverse blocking diode or MOS
- No sense resistor required
- Fault indicator
- ±10% charge current accuracy
- 1.5MHz operating frequency to minimize external components size
- Protections:
  - VIN 6.6V OVP protection (stop switching)
  - Programmable safety timer(3~20 hours)
  - Thermal regulation / OTP shutdown
  - Cell temperature qualification

Typical Application Circuits

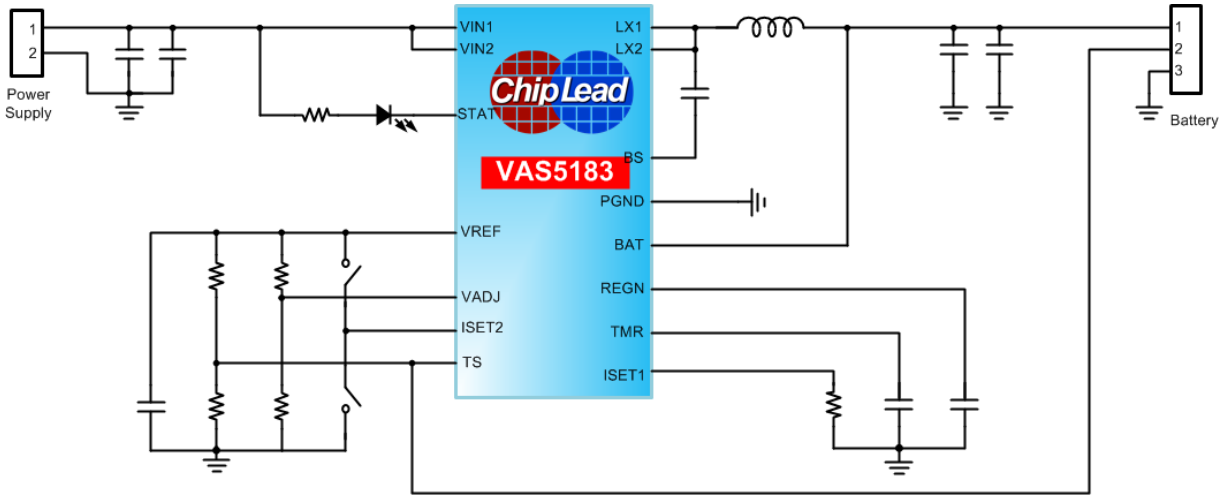
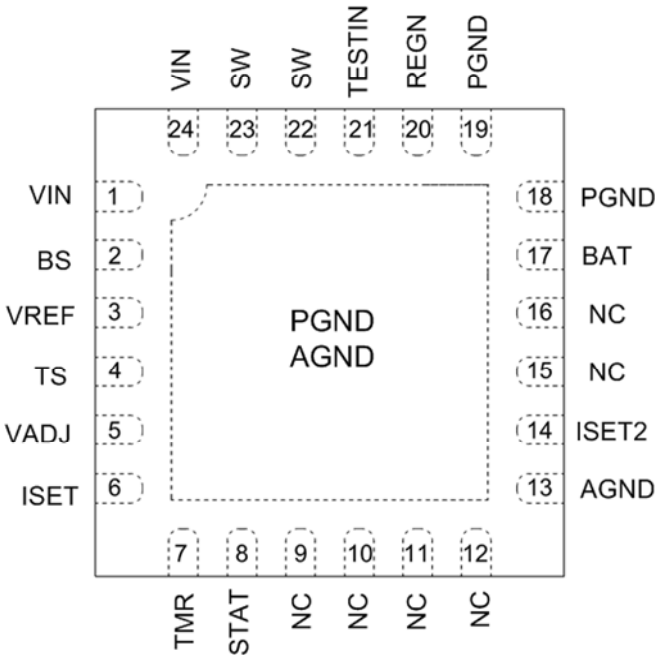


Figure1. Typical Application Schematic

PIN Configuration

Package	PIN-OUT
QFN-24	

PIN Description

PIN NO.	Name	Description		
1, 24	VIN	IC power supply of power device of Charger. Put 10uF MLCC from VIN to PGND.		
2	BS	Boostrap pin. Place a 47-nF MLCC from SW to BS		
3	VREF	3.3V reference output. A 1uF MLCC is placed from VREF to GND to make it stable.		
4	TS	NTC resistor connection. Cell temperature qualification input pin.		
5	VADJ	Set VADJ voltage between 0V~VREF to adjust charge regulation voltage (4.2~4.4V).		
6	ISET	Fast charge current set pin.		
7	TMR	Connect a capacitor from this node to AGND to set the fast charge safety timer. (5.6min/1nF)		
8	STAT	Open drain output		
		Hi-Z	Low	Blinking
		Charge complete or Sleep mode	Charging in progress	Fault
9,10, 11,12	NC	No connection.		
13	AGND	Analog Ground.		
14	ISET2	Programming the charge current limit for the USB or adapter source: High=1A(USB3.0), Low=0.5A(USB2.0), FLOAT=ISET(User define).		
15,16	NC	No connection.		
17	BAT	Charger voltage regulation sense input.		
18,19	PGND	Power ground.		
20	REGN	5V power supply output, Bypass 1u-F MLCC to AGND.		
22	TESTIN	Test input, keep no connection during normal operation.		
22, 23	LX	Switching node, charge current output inductor connection. Connect a 47-nF BS capacitor from LX to BS.		

Order Information

Order Number	Package Type	QTY/Reel	Green Status	Operation temp range
VAS5183IJ24E	QFN24	2500	RoHS	-40 °C to 85°C

VAS5183 □□ □□ □

Lead Free Code
E: Lead Free

Pin Code
24: 24pins

Package Type
J: QFN

Temperature Code
I: Industrial, -40°C to +85°C

Absolute Maximum Ratings

Parameters	Maximum Ratings
VIN, BS, STAT	-0.3V to 20V
LX	-2V to 7V
REGN, TMR, BAT, ISET, ISET2	-0.3V to 7V
VREF, VADJ, TS	-0.3V to 3.6V
PGND	-0.3V to +0.3V
Junction temperature range	-40°C to +150°C
Storage temperature range	-65°C to +150°C
Lead Temperature	260°C
Maximum Power Dissipation	2W
ESD (HBM)	2000V

Electrical Characteristics

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNITS
OPERATING CONDITIONS						
V_{VIN_OP}	VIN input voltage operating range during charging.		4.5		6	V
QUIESCENT CURRENT						
I_{IN}	Adapter supply current	VIN=5V		1.5	2	mA
I_{BAT}	Battery discharge current	VBAT=4.2V, standby mode		15	30	μA
CHARGE VOLTAGE REGULATION						
V_{BAT_REG}	BAT regulation voltage	Measured on BAT		4.2		V
	Charge voltage regulation accuracy	TJ = -20°C to 85°C	–1%		1%	
V_{VADJ}	VADJ voltage range		0		VREF	V
V_{BAT_ADJ}	Regulation voltage Adjustment	VADJ=0V,		4.2		V
		VADJ=1/2*VREF		4.3		V
		VADJ=VREF		4.41		V
CURRENT REGULATION						
I_{CHG}	Fast charge current	Programmable Mode(Max)		2.0	2.5	A
V_{ISET}	Fast charge current reference voltage			1.0		V
	Output “fast charge” formula	$V_{BAT\_REG} > V_{BAT} > V_{LOWV}$; ISET2=FLOAT RISET = 30kΩ to 200kΩ		KISET/ RISET		A
K_{ISET}	Fast charge current factor	RISET = K_{ISET} /IOUT ; 500<IOUT< 2500mA	75	80	85	AkΩ
CURRENT REGULATION –PRE- CHARGE						
$\%_{PRECHG}$	Pre-charge current, default setting	$V_{BAT} < V_{LOWV}$		10		$\%_{IOUT-CC}$
CHARGE TERMINATION						
$\%_{TERM}$	Termination threshold current, default setting	$V_{BAT} > V_{RECHG}$	5	10	15	$\%_{IOUT-CC}$
t_{TERM_DEG}	Deglitch time termination (both edges)	$V_{BAT} > V_{RECHG}$ and $I_{CHG} < I_{TERM}$		100		ms
BAT LOWV COMPARATOR						
V_{LOWV}	Precharge to fast charge transition threshold	Measured on BAT	2.85	2.9	2.95	V
RECHARGE COMPARATOR						
V_{RECHG}	Recharge threshold, below regulation voltage limit, V_{BAT_REG}-V_{BAT}	Measured on BAT	70	100	130	mV

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNITS
BAT OVER-VOLTAGE COMPARATOR						
V_{OV_RISE}	Battery over-voltage rising threshold	As percentage of V_{BAT_REG}		110		%
V_{OV_FALL}	Battery over-voltage falling threshold	As percentage of V_{BAT_REG}		105		%
INPUT OVER-VOLTAGE COMPARATOR (ACOV)						
V_{ACOV}	AC over-voltage rising threshold to disable charge	VIN rising	6.4	6.6	6.8	V
V_{ACOV_HYS}	AC over-voltage falling hysteresis	VIN falling		300		mV
Input Under-Voltage Lock-Out Comparator (UVLO)						
V_{UVLO}	AC under-voltage rising	Measure on VIN		3.3		V
$V_{UVLO-HSY}$	AC under-voltage hysteresis	Measure on VIN		300		mV
THERMAL REGULATION						
T_{J_REG}	Junction temperature regulation	Charging		125		°C
THERMAL SHUTDOWN COMPARATOR						
T_{SHUT}	Thermal shutdown temperature	Temperature rising		155		°C
THERMISTOR COMPARATOR						
V_{LTF}	Cold temperature threshold, TS pin voltage rising threshold	Charger suspends charge. As percentage to V_{VREF}	72.5	73.5	74.5	%
V_{LTF_HYS}	Cold temperature hysteresis, TS pin voltage falling threshold	As percentage to V_{VREF}	0.2	0.4	0.6	%
V_{HTF}	Hot temperature TS pin voltage falling threshold	As percentage to V_{VREF}	46.6	47.2	48.8	%
V_{TCO}	Cut-off temperature TS pin voltage falling threshold	As percentage to V_{VREF}	44.2	44.7	45.2	%
VREF REGULATOR						
V_{VREF}	REF regulator voltage	$V_{VIN} > V_{UVLO}$, No load	3.15	3.3	3.45	V
I_{VREF_LIM}	REF current limit	$V_{VREF} = 0$ V, $V_{VIN} > V_{UVLO}$		40		mA
REGN REGULATOR						
V_{REGN_REG}	REGN regulator voltage	$V_{VIN} > 10$ V	4.3	4.6	4.9	V
I_{REGN_LIM}	REGN current limit	$V_{REGN} = 0$ V, $V_{VIN} > 10$V		50		mA
INTERNAL PWM						
Fsw_{CHG}	PWM Switching Frequency	Measure at LX	1200	1400	1600	kHz

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNITS
R_{DS_HI}	High Side MOSFET On Resistance			80	120	mΩ
R_{DS_LO}	Low Side MOSFET On Resistance			40	60	mΩ
R_{DS_BD}	Block MOSFET On Resistance			50	70	mΩ
SAFETY TIMER						
$T_{PRE-CHARGE}$	Pre-charge timer		1848	2100	2352	Sec
$T_{FAST-CHARGE}$	Fast-charge timer	$T_{CHG}=C_{TMR}*K_{TMR}$	1		15	hr
K_{TMR}	Timer Multiplier			5.6		min/nF

Application Information

1. Typical Operation Theory

The charger of VAS5183 is optimized for charging 1-cell Li-ion or Li-polymer batteries. It charges a battery with constant current (CC) and constant voltage (CV) profile. In CV mode, if charge current reaches 1/10 constant current threshold, the STAT pin turn off and indicate end-of-charge. The typical charge profile is illustrated as below.

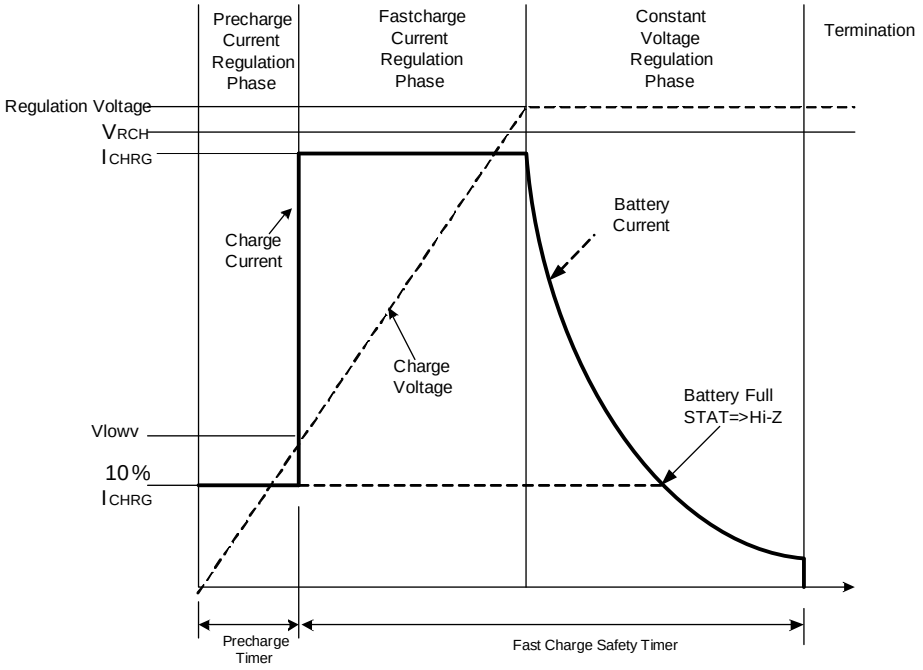


Figure2. Typical Charging Profile

2. Battery Voltage Regulation

The VAS5183 offers a high accuracy voltage regulator for the charging voltage. Battery regulation voltage could be adjusted by setting VADJ voltage and the equation for the adjustment is:

$$V_{BAT\_REG} = \left[\left(\frac{V_{ADJ}}{V_{REF} \cdot 20} + 1\right) \times 4.2\right]$$

3. Battery Current Regulation

The ISET input sets the maximum charging current. The equation for charge current is:

$$I_{CHG} = \frac{1}{R_{ISET}} \times 80K$$

Give a 40kΩ RISET to set 2A charge current, for instance. Under high ambient temperature, the charge current will fold back to keep IC temperature not exceeding 125°C.

4. USB2.0 and USB3.0 Charge

The charge current limit can be programmed to 500mA and 1A via the ISET2 logic pins to cover the USB2.0 and USB3.0, set ISET2 to high for 1A and low for 0.5A charging current.

5. Battery Pre-charge Current Regulation

If the battery voltage is below the VLOWV threshold, the VAS5183 applies the pre-charge current to the battery. This pre-charge feature is intended to revive deeply discharged cells. If the VLOWV threshold is not reached within 30 minutes of initiating pre-charge, the charger turns off and a FAULT is indicated on the status pins.

For VAS5183, the pre-charge current is set as 10% of the fast charge rate.

6. Input Over Voltage Protection

Input OVP provides protection to prevent device damage due to high input voltage. The threshold of input OVP is 6.6V typ., once input above threshold, the charger is disabled and STAT indicated FAULT.

7. Input Voltage Regulation

The input voltage can be limited in order to avoid overloading of DC adapter or USB power source, when the voltage on VIN pin drops and hits the threshold voltage of 4.7V, the charging current will be decreased and input voltage will be clamped to this value.

8. Charge Termination

The charger monitors the charging current during the voltage regulation phase. Termination is detected when the charge taper down to 1/10 of the fast charge rate.

9. Re-Charge

A new charge cycle is initiated when one of the following conditions occurs:

- The battery voltage falls below the recharge threshold
- A power-on-reset (POR) event occurs

10. Safety Timers

As a safety backup, the charger also provides an internal fixed 35 minutes pre-charge safety timer and programmable fast charge timer according to the capacitor value which connected to TMR pin.

11. Soft-Start Charger Current

The charger automatically soft-starts the charger regulation current every time the charger goes into fast-charge to ensure there is no overshoot or stress on the output capacitors or the power converter.

12. Temperature Qualification

The controller continuously monitors battery temperature by measuring the voltage between the TS pin and AGND. A negative temperature coefficient thermistor (NTC) and an external voltage divider typically develop this voltage. The controller compares this voltage against its internal thresholds to determine if charging is allowed. To initiate a charge cycle, the battery temperature must be within the VLTF to VHTF thresholds. If battery temperature is outside of this range, the controller suspends charge and waits until the battery temperature is within the VLTF to VHTF range. During the charge cycle the battery temperature must be within the VLTF to VTCO thresholds. If battery temperature is outside of this range, the controller suspends charge and waits until the battery temperature is within the VLTF to VHTF range. The controller suspends charge by turning off the PWM charge MOSFETs.

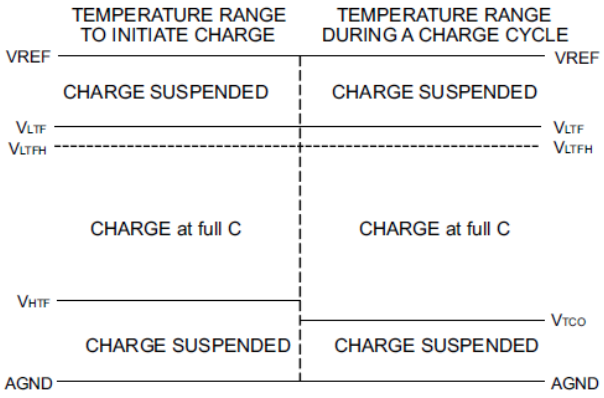


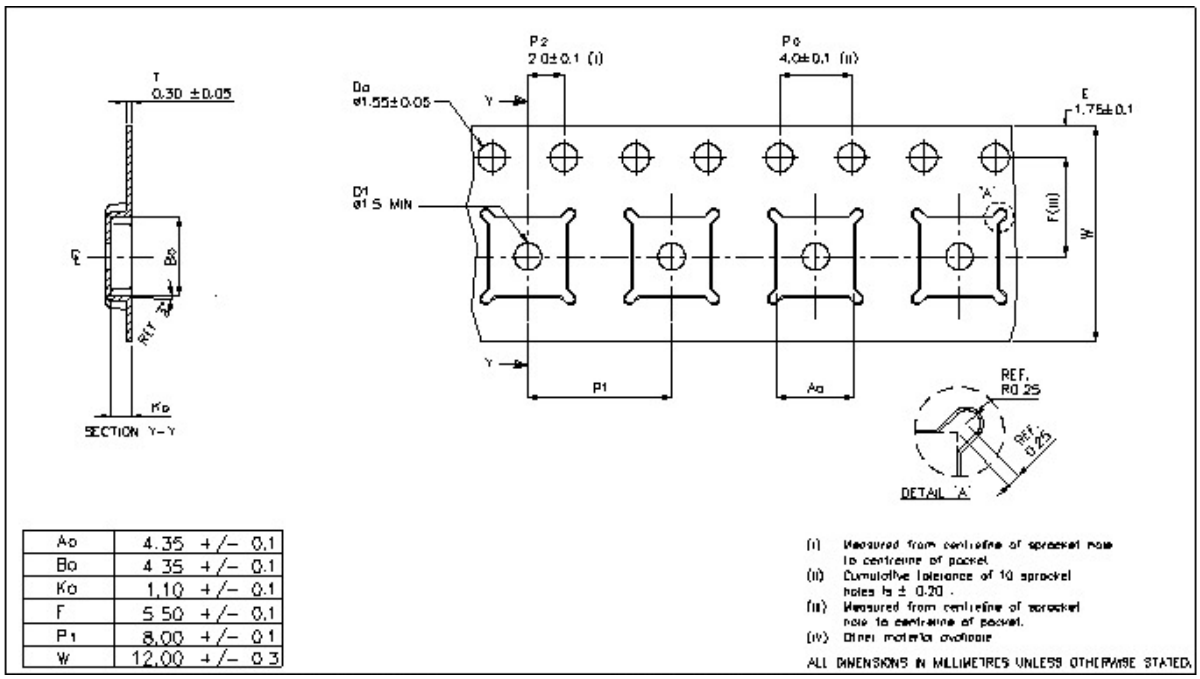
Figure3. TS Pin, Thermistor Sense Threshold

Assuming a NTC thermistor on the battery pack have resistance at 0°C and 45°C are RTH_{COLD} and RTH_{HOT}, the values of RT1 and RT2 can be determined by using below equations.

$$RT2 = \frac{V_{REF} \times RTH_{COLD} \times RTH_{HOT} \times (\frac{1}{V_{LTF}} - \frac{1}{V_{TCO}})}{RTH_{HOT} \times (\frac{V_{REF}}{V_{TCO}} - 1) - RTH_{COLD} \times (\frac{V_{REF}}{V_{LTF}} - 1)}$$

$$RT1 = \frac{\frac{V_{REF}}{V_{LTF}} - 1}{\frac{1}{RT2} + \frac{1}{RTH_{COLD}}}$$

Tape and Reel Information

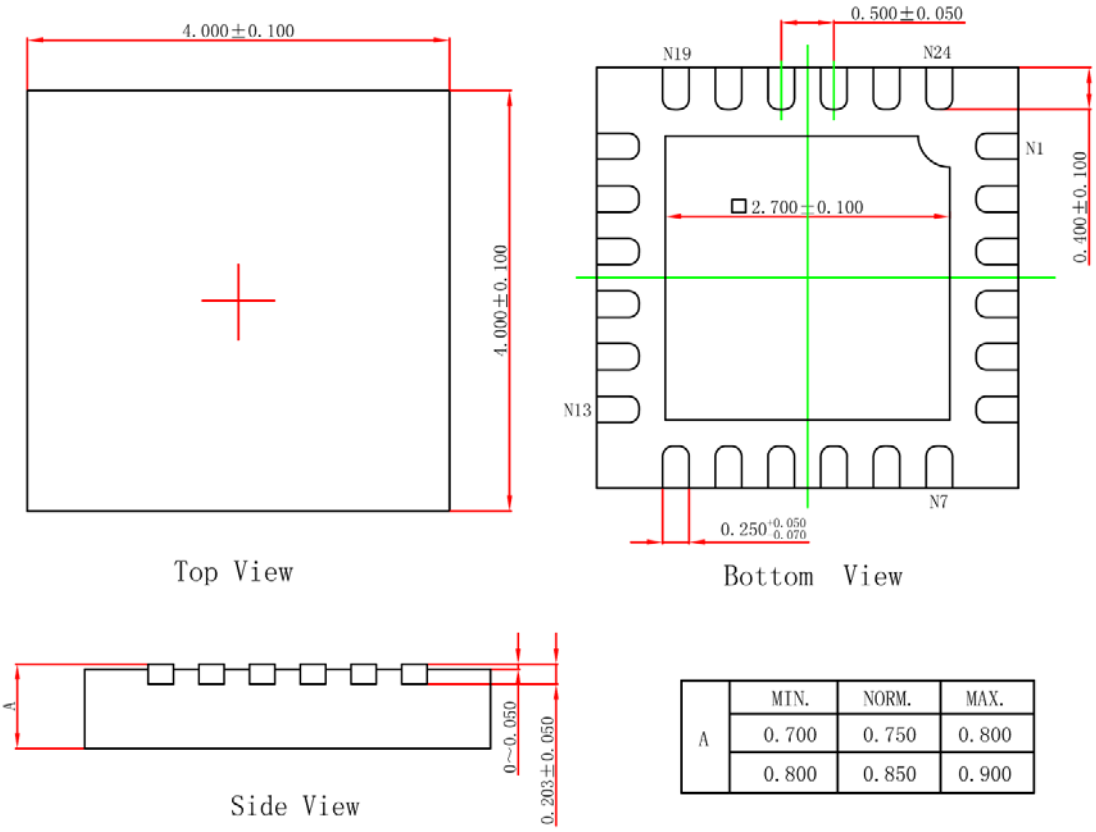


Ao	4.35 +/- 0.1
Bo	4.35 +/- 0.1
Ko	1.10 +/- 0.1
F	5.50 +/- 0.1
P1	8.00 +/- 0.1
W	12.00 +/- 0.3

(i) Measured from centreline of sprocket hole to centreline of pocket.
(ii) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(iii) Measured from centreline of sprocket hole to centreline of pocket.
(iv) Other material available

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

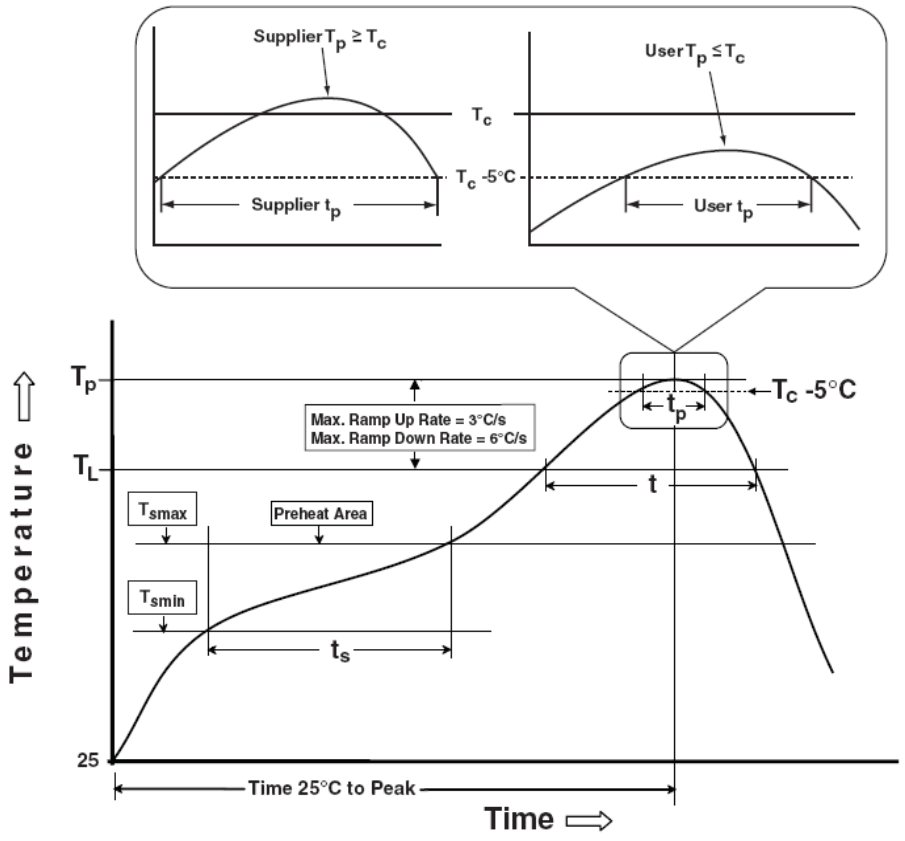
Package Information



	MIN.	NORM.	MAX.
A	0.700	0.750	0.800
	0.800	0.850	0.900

Classification Reflow Profiles

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature Max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.



Classification Profile

CAUTION

Storage Conditions

1) This product should be used within 12 months after delivered. Store in manufacturer's package keeping the seal of aluminum coated baggage or tightly re-closed box with the following conditions.
[Temperature:8℃...30℃,Humidity:30%...70% R.H.]

2) Keep the seal of aluminum coated baggage immediately before usage.

3) After breaking the seal of aluminum coated baggage, this product should be used within 1 week on the following conditions.
[Temperature:≤30℃, Humidity: ≤60% R.H.]