



JW4054/JW4054A

500mA/18V Linear Charger for

Single Cell Li-Ion Battery with Thermal Regulation

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW[®]4054/JW4054A is a complete constant-current and constant-voltage linear charger for single cell lithium-ion batteries. Its compact package and low external component count make the JW4054/JW4054A ideally suited for portable applications. Furthermore, the JW4054/JW4054A is specifically designed to work within USB power specifications.

No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V (JW4054) or 4.35V (JW4054A), and the charge current can be programmable externally. The JW4054/JW4054A terminates the charge cycle when the charge current drops to 1/10 of the presetting value after the final float voltage is reached.

When the input supply is removed, the JW4054/JW4054A enters a low current state, dropping the battery drain current to less than 1 μ A. The JW4054/JW4054A can be put into shutdown mode, reducing the supply current to 75 μ A during adaptor is present.

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The JW4054/JW4054A guarantees robustness with input and battery reverse connection protection, input under voltage lockout, input over voltage protection and thermal shutdown.

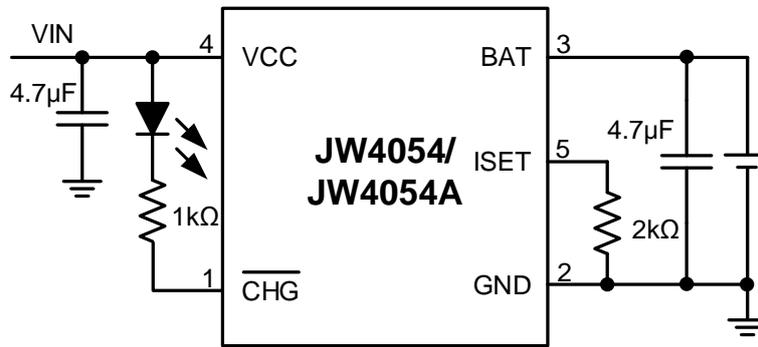
FEATURES

- 18V Input Rating, 7.5V Input Over Voltage Protection
- Programmable Charge Current Up to 500mA
- Input Reverse Polarity Protection
- Battery Reverse Polarity Protection
- Charging Management (Trickle Charge, Constant Current Charge, Constant Voltage Charge, Charge Termination, Auto Recharge)
- 4.2V/4.35V Charge Voltage with 1% Accuracy
- 2.9V Trickle Charge Threshold
- 1/10 I_{CHG} Charge Termination
- Soft-Start Limits Inrush Current
- Input Under Voltage Lockout, Thermal Shutdown
- Charge Status Indicator
- Available in SOT23-5 Package

APPLICATIONS

- Portable Media Players, Digital Cameras
- Bluetooth Applications
- Toys
- Li-Ion Battery Powered Devices

TYPICAL APPLICATION

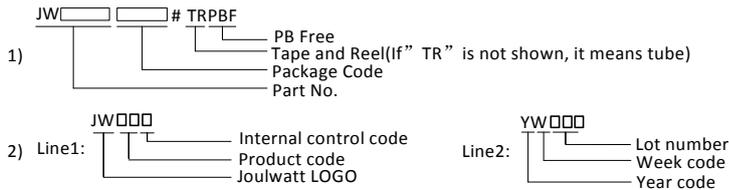


Typical Application Circuit

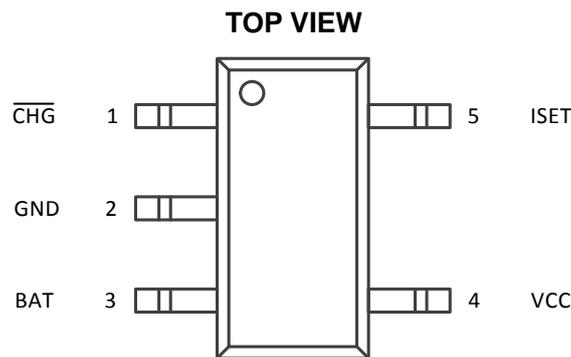
ORDER INFORMATION

DEVICE ¹⁾	PACKAGE	TOP MARKING ²⁾
JW4054SOTA#TRPBF	SOT23-5	JWHF□ YW□□□
JW4054ASOTA#TRPBF	SOT23-5	JWHG□ YW□□□

Notes:



PIN CONFIGURATION



ABSOLUTE MAXIMUM RATING¹⁾

VCC.....	-5.5V to 18V
VCC-BAT.....	-8.5V to 18V
BAT.....	-5.5V to 5.5V
CHG.....	-0.3V to 18V
ISET.....	-0.3V to 6.5V
Junction Temperature ²⁾	150°C
Lead Temperature	260°C
Storage Temperature	-65°C to +150°C
ESD Rating (Human-Body Model, HBM).....	±2kV
ESD Rating (Charged-Device Model, CDM).....	±1kV

RECOMMENDED OPERATING CONDITIONS³⁾

VCC.....	4.3V to 7.5V
Operation Junction Temperature (T _J)	-40°C to 125°C
Continuous Power Dissipation (T _A =25°C) ⁴⁾ SOT23-5.....	0.5W

THERMAL PERFORMANCE⁵⁾

θ_{JA} θ_{JC}

SOT23-5.....	200...130°C/W
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Note:

- 1) Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under RECOMMEND OPERATION CONDITIONS.
- 2) The JW4054/JW4054A includes thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
- 3) The device is not guaranteed to function outside of its operating conditions.
- 4) The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$.
- 5) Measured on JESD51-7, 4-layer PCB

ELECTRICAL CHARACTERISTICS

<i>T_A=T_J=25°C and the recommended supply voltage range, unless otherwise stated</i>						
Item	Symbol	Condition	Min.	Typ.	Max.	Units
INPUT						
Input operation voltage range	V _{CC}			5		V
Input under-voltage lock-out threshold	V _{UV}	V _{CC} rising, V _{CC} >V _{BAT} + V _{ASD}		4.0		V
Input under-voltage lock-out hysteresis	V _{UV_HYS}	V _{CC} falling, V _{CC} >V _{BAT} + V _{ASD}		150		mV
V _{CC} -V _{BAT} lock-out threshold	V _{ASD}	V _{CC} rising		100		mV
		V _{CC} falling		30		mV
Input over-voltage protection threshold	V _{OVP}	V _{CC} rising		7.5		V
Hysteresis on input OVP	V _{OVP_HYS}	V _{CC} falling		150		mV
Input OVP deglitch time ⁶⁾	t _{OVP_DEG}			50		µs
Input OVP recovery time ⁶⁾	t _{OVP_REC}			400		µs
Input pull-down resistance ⁶⁾	R _{PD}			100		kΩ
QUIESCENT CURRENT						
Quiescent V _{CC} supply current	I _{Q_VCC}	I _{VCC} -I _{BAT} , charge mode		1.12		mA
		Charge terminated		120		µA
		R _{ISSET} disconnected; Or V _{CC} <V _{BAT} +V _{ASD} ; Or V _{CC} <V _{UV}		75		µA
Quiescent BAT supply current	I _{Q_BAT}	Charge terminated		2.5		µA
		R _{ISSET} disconnected; Or V _{CC} <V _{BAT} +V _{ASD} ; Or V _{CC} <V _{UV}		±1		µA
BATTERY CHARGER						
Battery regulation voltage	V _{FLOAT}	JW4054, 0°C≤T _A ≤85°C		4.2		V
		JW4054A, 0°C≤T _A ≤85°C		4.35		V
Soft-start time ⁶⁾	t _{SS}	I _{BAT} =0 to I _{CHG}		25		ms
Power FET “ON” resistance (between V _{CC} and BAT) ⁶⁾	R _{ON}			700		mΩ
I _{SET} pin voltage on CC charge phase	V _{ISSET_CC}	R _{ISSET} =2kΩ~10kΩ		1.0		V
I _{SET} pin voltage on trickle charge phase	V _{ISSET_TRIK}	R _{ISSET} =2kΩ~10kΩ, trickle charge		0.1		V
Constant current factor	K _{CC}			1000		AΩ

Trickle current factor	K_{TRIK}			100		$A\Omega$
Charge current in CC charge phase	I_{CHG}	$V_{CC} > V_{UV}, V_{CC} > V_{BAT} + V_{ASD}, V_{BAT} > V_{TRIK}$, not DPM	K_{CC} / R_{ISET}			A
Charge current in trickle charge phase	I_{TRIK}		K_{TRIK} / R_{ISET}			A
Trickle charge threshold voltage	V_{TRIK}	V_{BAT} rising		2.9		V
Trickle charge hysteresis voltage	V_{TRIK_HYS}			150		mV
Deglitch time on charge phase switch between trickle mode and CC mode ⁶⁾	t_{TC_DEG}	Trickle to CC charge		25		ms
		CC to trickle charge		25		ms
Termination comparator detection threshold	I_{TERM}			0.1		$\times I_{CHG}$
Termination detected deglitch time ⁶⁾	t_{TERM}			50		ms
Recharge detection threshold	ΔV_{RCHG}	V_{BAT} falling, $V_{FLOAT} - V_{RCHG}$		150		mV
Recharge detected deglitch time ⁶⁾	t_{RCHG}			50		ms
VINDPM AND THERMAL REGULATION						
Input voltage threshold when charge current is reduced	V_{IN_DPM}			4.3		V
Junction temperature threshold when charge current is reduced ⁶⁾	T_{J_DPM}			125		°C
Thermal shut down threshold ⁶⁾	T_{J_SD}	T_J rising		155		°C
Thermal shut down hysteresis ⁶⁾	T_{J_SDHYS}			20		°C
ISET						
ISET pin pull-up current ⁶⁾	I_{ISET}			2		μA
Manual shutdown threshold voltage	V_{MSD}	ISET pin rising		1.5		V
		ISET pin falling		1.2		V
Maximum charge current	I_{CHG_MAX}	ISET connected to GND		1.3		A
INDICATOR						
Output LOW voltage on \overline{CHG} pin ⁶⁾	$V_{\overline{CHG}}$	$I_{\overline{CHG}} = 5mA$, sink current			0.6	V
\overline{CHG} pin weak pull-down current ⁶⁾				20		μA
VCC, BAT REVERSE LEAKAGE						
VCC reverse leakage	I_{VCC_R}	$V_{CC} = -5V, V_{BAT} = V_{FLOAT}$			10	mA
BAT reverse leakage	I_{BAT_R}	$V_{CC} = 5V, V_{BAT} = -V_{FLOAT}$			5	mA

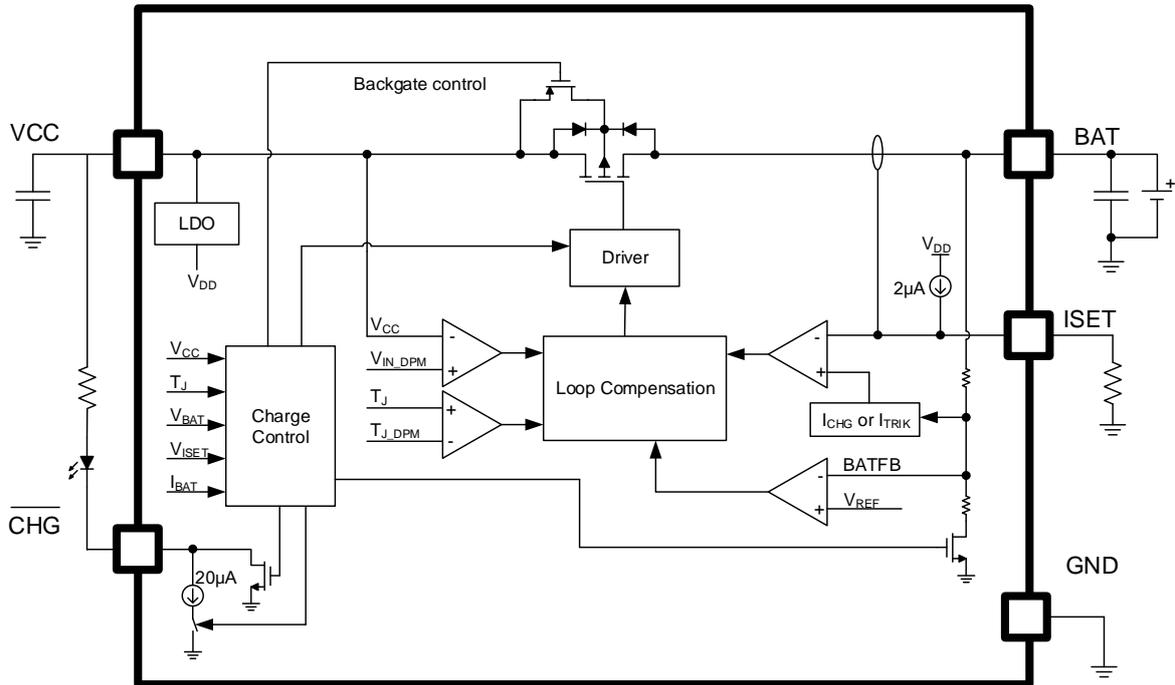
Notes:

6) Guaranteed by design.

PIN DESCRIPTION

Pin No.	Name	Description
1	$\overline{\text{CHG}}$	Open-drain charges status indication output. When the battery is charging, the $\overline{\text{CHG}}$ pulled low by an internal N-channel MOSFET. When the charge cycle is completed, a weak pull-down of approximately 20 μA is connected to the $\overline{\text{CHG}}$ pin, indicating an “AC present” condition. When the JW4054/JW4054A detects an under-voltage lockout condition, $\overline{\text{CHG}}$ is forced high impedance.
2	GND	Ground. Connect to the thermal pad and to the ground rail of the circuit.
3	BAT	Charge current output. Provides charge current to the battery and regulates the final float voltage to 4.2V or 4.35V. Bypass BAT to GND with a 4.7 μF to 47 μF ceramic capacitor.
4	VCC	Input power connection. This pin provides power to the charger. Connect bypass ceramic capacitor 1 μF to 10 μF to ground.
5	ISET	ISET pin sets the charge current of constant-current phase by regulating the ISET voltage at 1V. A resistor is connected from ISET pin to ground to set the constant-current as $I_{\text{CHG}}=1000\text{A}\Omega/R_{\text{ISET}}$. In trickle charge phase, the ISET voltage is regulating at 0.1V and set the trickle-current as $I_{\text{TRIK}}=100\text{A}\Omega/R_{\text{ISET}}$.

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The JW4054/JW4054A is a complete constant-current and constant-voltage linear charger for single cell lithium-ion batteries. It can deliver up to 500mA charge current (using a good thermal PCB layout) with a final voltage accuracy of $\pm 1\%$. No blocking diode or external current sense resistor is required. The input power source for charging the battery can be an AC adapter or a USB port. When charging from a USB port, the input dynamic power management (V_{IN-DPM}) circuit reduced the input current if the input voltage falls below a threshold, thus preventing the USB port from crashing. An internal thermal limit reduces the charge current if the die temperature attempts to rise above a preset value of approximately $125\text{ }^{\circ}\text{C}$. This feature protects the JW4054/JW4054A from excessive temperature, and allows the user to take full advantage of the power handling capability at a given circuit board without risk of damaging the JW4054/JW4054A or external components.

Normal Charge Cycle

The JW4054/JW4054A powers internal bias circuits from VCC. When VCC rises above UVLO threshold, the device wakes up from sleep mode, the VCC comparator, ISET comparator and junction temperature comparator are active.

JW4054/JW4054A enables the power MOSFET and starts a charge cycle when all the below conditions are valid:

- V_{CC} above V_{UV}
- V_{CC} above $V_{BAT}+V_{ASD}$
- V_{CC} below V_{OVP}
- T_J below T_{J_SD}
- $V_{ISET}<V_{MSD}$

If any one of the above conditions is not valid, the device keeps the power MOSFET off, and draws less than typical $75\mu\text{A}$ from VCC, draws less than typical $1\mu\text{A}$ from battery.

The device charges the battery in three phases: trickle charging, constant current charging and constant voltage charging. At the beginning of a charging cycle, the device checks the battery voltage and regulates current and voltage accordingly. If the voltage at the BAT pin is less than V_{TRIK} , the charger enters trickle charging phase, the charge current is reduced to nearly 1/10 of the presetting values (I_{CHG}). The charger switches to constant current charging phase as the BAT pin voltages rise above V_{TRIK} , the charge current is thus resumed to full presetting value. When the final float voltage is reached, the device enters constant voltage charging phase and charge current begins to decrease until it drops to 1/10 of the presetting value and end the charge cycle.

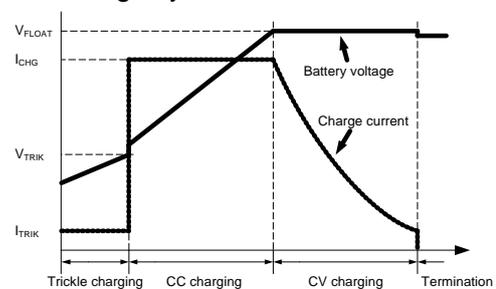


Figure 1. Battery Charging Profile

Programming Charge Current

The charge current is programmable using a single resistor from the ISET pin to ground. The battery charge current is 1000 times the current out of the ISET pin. The program resistor and the charge current are calculated using the following equations:

$$R_{ISET} = 1000V / I_{CHG}, I_{CHG} = 1000V / R_{ISET}$$

The ISET pin voltage is regulated at 1V in constant current charging and 0.1V in trickle charging. The charge current can be determined at any time by monitoring the ISET pin voltage using the following equation:

$$I_{BAT} = 1000 \times V_{ISET} / R_{ISET}$$

Charge Termination and Recharge

JW4054/JW4054A terminates a charge cycle when the battery voltage is above the recharge threshold V_{RCHG} , and the current is below termination current I_{TERM} for longer than t_{TERM} .

After charge termination, JW4054/JW4054A constantly monitors the BAT pin voltage. If the voltage drops below the recharge threshold V_{RCHG} longer than t_{RCHG} , another charge cycle automatic begins and current is once again supplied to the battery. To manually restart a charge cycle after charge termination, the input voltage must be removed and reapplied, or the charge current program resistor R_{ISET} must be disconnected and reconnected.

Input Dynamic Power Management

To meet maximum current in USB spec and avoid over loading the adapter, JW4054/JW4054A features input dynamic power management which continuously monitors the input voltage when charging. When input source is over-loaded, the input voltage falls below the input voltage limit (V_{IN_DPM}). The device then reduces the charge current until the input voltage rises above the input voltage limit.

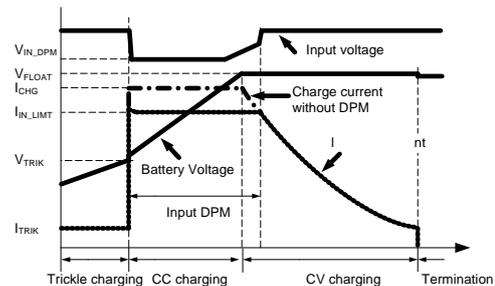


Figure 2. Battery Charging Profile with Input DPM

Thermal Limiting

An internal thermal feedback loop reduces the charge current if the die temperature attempts to rise above a preset value of approximately $125^{\circ}C$, hence prevents the temperature from further increase and ensure device safe operation.

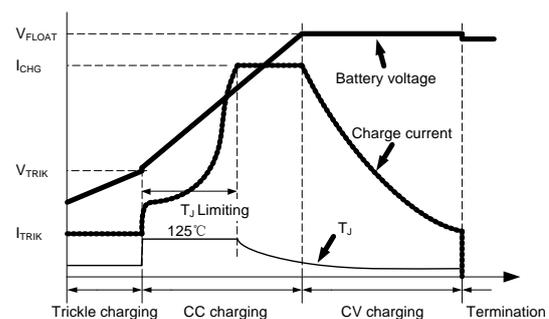


Figure 3. Battery Charging Profile with T_j Limiting

Under-Voltage Lockout

Build-in under-voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the under-voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 150mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if VCC falls below the $V_{BAT} + 30mV$. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 100mV above the battery voltage.

Input Over-voltage

If VCC voltage exceeds V_{OVP} longer than t_{OVP_DEG} , the power MOSFET turns off. During input over-voltage event, \overline{CHG} is forced high impedance. The device will automatically resume normal operation when VCC falls 150mV below over-voltage threshold longer than 400 μ s.

Manual Shutdown

At any point in the charge cycle, the JW4054/JW4054A can enter shutdown mode by removing R_{ISET} and floating the ISET pin. In shutdown mode, the battery current is less than 1 μ A and the VCC current is less than 75 μ A. A new charge cycle can be initiated by reconnecting the R_{ISET} resistor.

Charge Current Soft-Start

The JW4054/JW4054A includes a soft-start circuit to minimize the inrush current. When a charge cycle is initiated or charge phase transfers from trickle charging to constant current charging, the charge current ramps from zero to the full-scale current over a period of approximately 25ms.

Charge Status Indicators

The charge status output has three different states: strong pull-down, weak pull-down and high impedance. \overline{CHG} is pulled LOW when battery in charging. A weak pull-down indicates that the V_{CC} meets the operation voltage range ($V_{UV} < V_{CC} < V_{OVP}$ & $V_{BAT}+V_{ASD} < V_{CC} < V_{OVP}$)

and battery is no in charging (charge finished, OTP or Manual shutdown). High impedance indicates that the JW4054/JW4054A is in under-voltage lockout mode or reverse polarity protection mode.

Charge Status	\overline{CHG}
<ul style="list-style-type: none"> In charging 	Low
<ul style="list-style-type: none"> Power good and no in charging.(Charge finished, OTP, $V_{ISET}>V_{MSD}$) 	Weak pull-down
<ul style="list-style-type: none"> $V_{CC}<V_{UV}$ $V_{CC}<V_{BAT}+V_{ASD}$ VCC OVP VCC reverse connection Battery reverse connection 	High Z

VCC Reverse Polarity Protection

JW4054/JW4054A provides reverse polarity input voltage protection. The device keeps in shutdown mode when input voltage polarity is reversed, and \overline{CHG} pin is high impedance. The reverse leakage current is below 10mA. When battery is connected, the reverse input voltage should not exceed 5.5V. Exceeding this rating may damage the device.

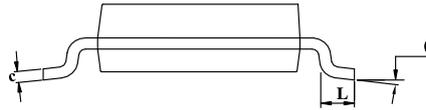
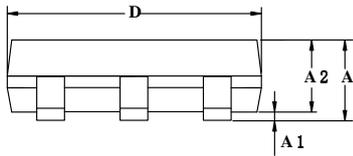
Battery Reverse Polarity Protection

JW4054/JW4054A provides reverse polarity battery voltage protection. The device keeps in shutdown mode when battery voltage polarity is reversed, and \overline{CHG} pin is high impedance. The reverse leakage current is below 5mA. The device will automatically resume normal operation when battery is connected correctly.

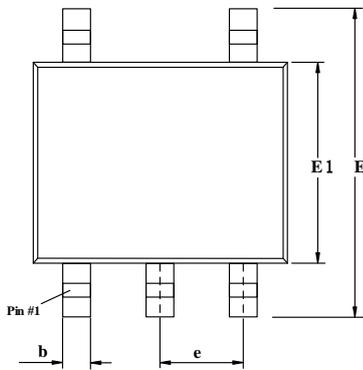
PACKAGE OUTLINE

SOT23-5

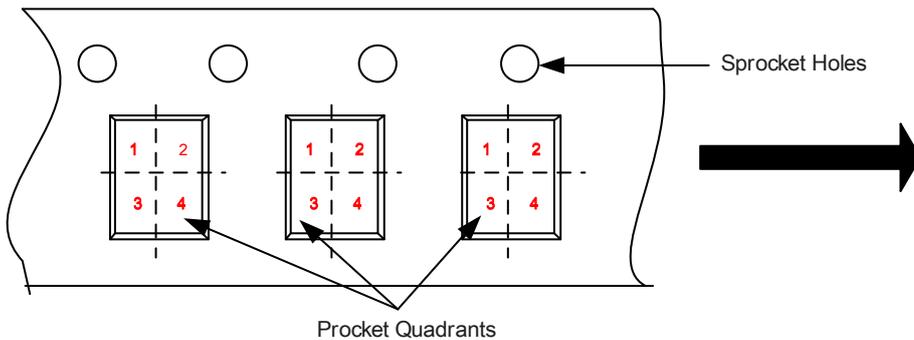
UNIT: mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.05	1.15	1.25
A1	0	0.05	0.15
A2	0.95	1.10	1.20
b	0.20	0.40	0.60
c	0.05	—	0.21
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95 (BSC)		
L	0.30	0.45	0.60
θ	0°	—	8°



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Package Type	Pin1 Quadrant
SOT23-5	3

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