Description

The PJ4054C is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its SOT package and low external component count make the PJ4054C ideally suited for portable applications. Furthermore, the PJ4054C 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 4.25V, and the charge current can be programmed externally with a single resistor. The PJ4054C automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.When the input supply (wall adapter or USB supply) is removed, the PJ4054C automatically enters a low current state, dropping the battery drain current to less than 1μA. The PJ4054C can be put into shutdown mode, reducing the supply current to 25μA. Other features include charge current monitor, undervoltage lockout, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

Features

- Programmable Charge Current Up to 500mA
- No External MOSFET, Sense Resistor or Blocking Diode Required
- Charges Single Cell Li- Ion Batteries Directly from USB Port
- Preset 4.25V Charge Voltage with ±1% Accuracy
- Constant-Current/Constant-Voltage

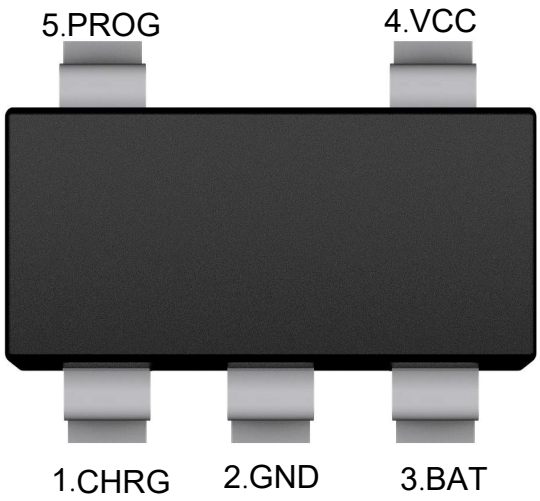
  Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Charge Status Output Pin
- 25μA Shutdown Current
- 2.9V Trickle Charge Threshold
- C/10 ChargeTermination
- Soft-Start Limits Inrush Current
- Automatic Recharge
- Battery Reverse Polarity Voltage Protection
- Charge Current Monitor Output for Gas Gauging
- Small Package SOT-23-5 Package for Single Cell Lithium- Ion Batteries

Application

- Cellular Telephones
- Charging Docks and Cradles
- Bluetooth Application
- Wearable Application

Pin Distribution

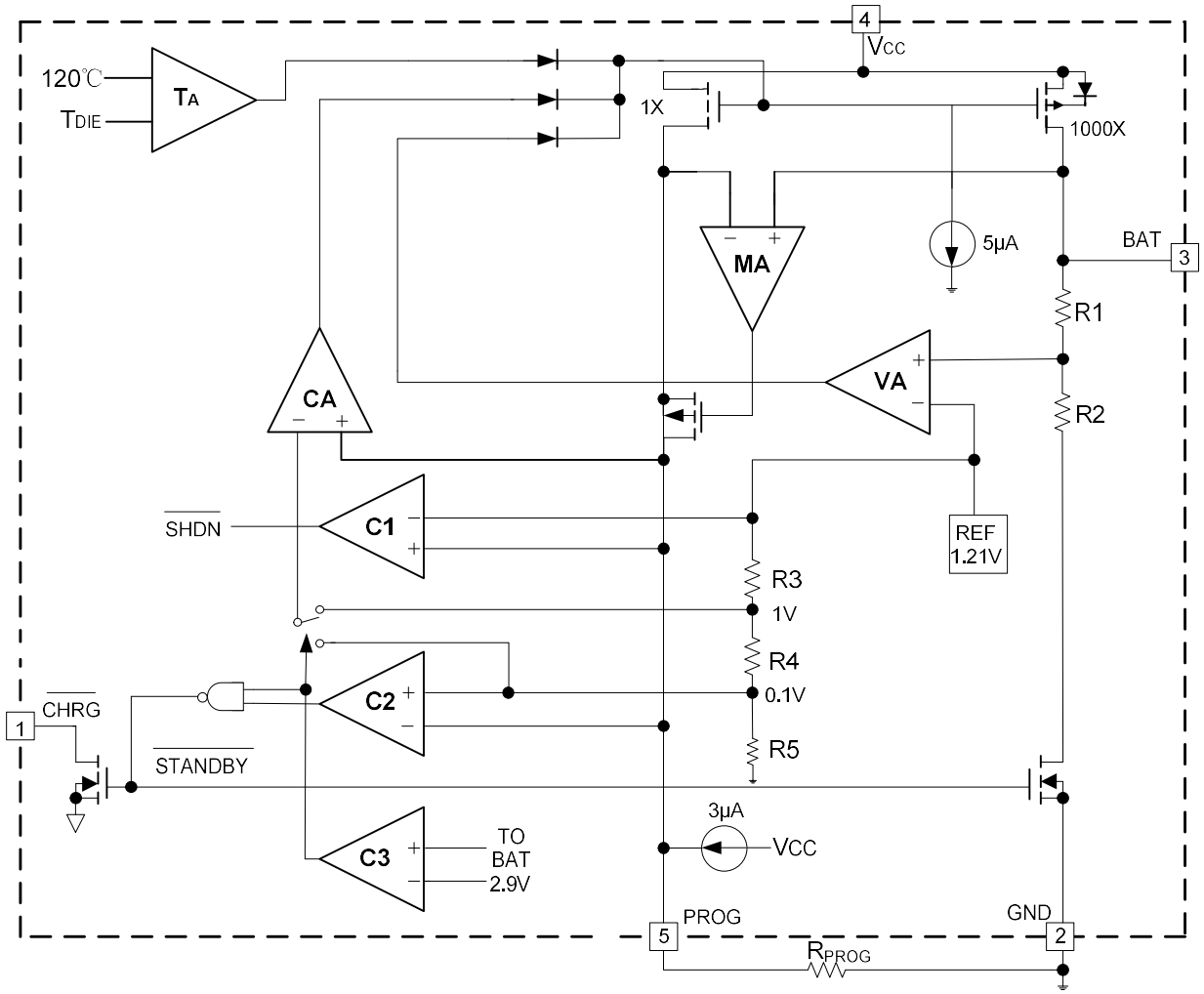
SOT-23-5



Pin Function

Pin No.	Symbol	Pin Function
1	CHRG	Open-Drain Charge Status Output.
2	GND	Ground Pin.
3	BAT	Charging Current Output.
4	VCC	Positive Input Vower Voltage.
5	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.

Block Diagram



Absolute Maximum Ratings Note1,2

Ratings at 25℃ ambient temperature unless otherwise specified.

Parameter	Symbol	Ratings	Unit
VCC Input Voltage	V_{CC}	-0.3~9	V
Prog Pin Voltage	V_{PROG}	-0.3~V_{CC}+0.3	V
CHG,BAT Pin Voltage	V_{BAT}	-0.3~7	V
BAT Pin Current	I_{BAT}	500	mA
Power Dissipation	P_D	Internally Limited	
Operating Junction Temperature Range	T_j	-40~+150	°C
Storage Temperature	T_{stg}	-65~+125	°C
Lead Temperature (Soldering, 10sec.)	T_L	260	°C

Note: 1. Exceeding these ratings may damage the device.
2. The device is not guaranteed to function outside of its operating conditions.

ESD Ratings

Parameter	Symbol	Ratings	Unit
Human Body Model (HBM) ANSI/ESDA/JEDEC JS-001-2014 Classification, Class: 2	$V_{ESD(HBM)}$	±2000	V
Charged Device Model (CDM) ANSI/ESDA/JEDEC JS-002-2014 Classification, Class: C0b	$V_{ESD(CDM)}$	±200	V
JEDEC STANDARD NO.78E APRIL 2016 Temperature Classification, Class: I	$I_{LATCH(UP)}$	±400	mA

Recommended Operating Conditions

Parameter	Symbol	Ratings	Unit
Operating Temperature Range Note1	T_{opr}	-40~+85	°C
Operating Junction Temperature Range	T_j	-40~+125	°C

Note: 1. All limits specified at room temperature (TA = 25°C) unless otherwise specified. All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Thermal Information

Parameter	Symbol	Ratings	Unit
Junction-to-Ambient Thermal Resistance Note1,2	$R_{\theta JA}$	180	°C/W
Junction-to-Case (top) Thermal Resistance	$R_{\theta JC}$	130	°C/W

Note: 1. The package thermal impedance is calculated in accordance to JESD 51-7.
2. Thermal Resistances were simulated on a 4-layer, JEDEC board.

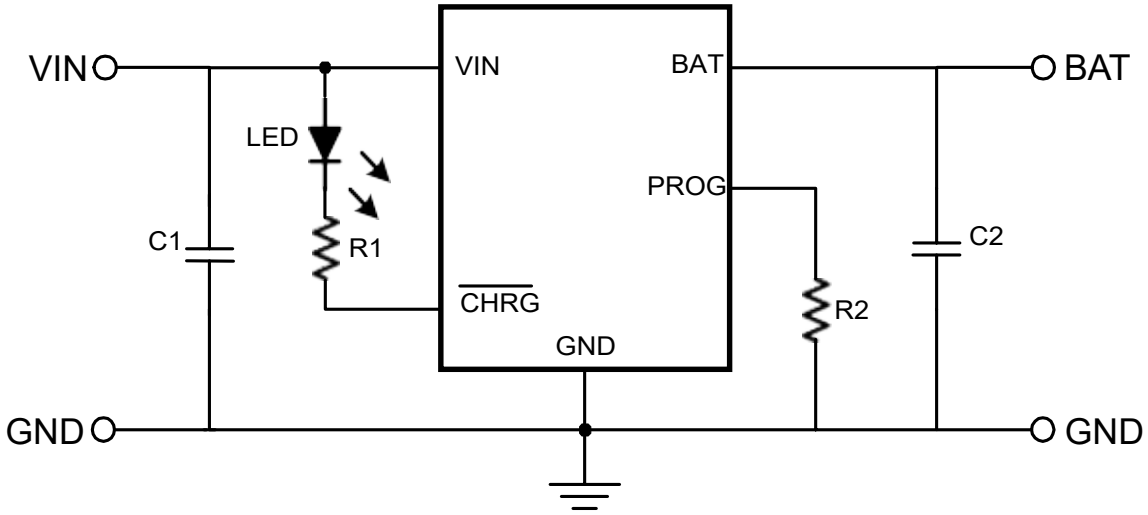
Electrical Characteristics Note1,2,3

(V_{CC}=5V, T_A=25℃ , unless otherwise noted.)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input Supply Voltage	V_{CC}		4.0	5.00	6.50	V
Input Supply Current	I_{CC}	Charge Mode Note4,R_{PROG}=12k	--	240	500	μA
		Standby Mode(Charge Terminated)	--	50	100	
		Shutdown Mode: R_{PROG} Not Connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UVLO}	--	25	50	
Regulated Output (Float) Voltage	V_{FLOAT}	0°C ≤ T_A ≤ 85°C, I_{BAT} =40mA	4.186	4.250	4.313	V
BAT Pin Current	I_{BAT}	R_{PROG} = 2k, Current Mode	450	500	550	mA
		Standby Mode, V_{BAT} = 4.2V	0	-2.5	-6.0	μA
		Shutdown Mode (R_{PROG} Not Connected)	--	0	1	
		Sleep Mode, V_{CC} = 0V	--	1	2	
Trickle Charge Current	I_{TRIKL}	V_{BAT} < V_{TRIKL}, R_{PROG} = 2k	40	50	60	mA
		V_{BAT} < V_{TRIKL}, R_{PROG} = 1.2k	75	80	85	
Trickle Charge Threshold	V_{TRIKL}	R_{PROG} =10k, V_{BAT} Rising	2.8	2.9	3.0	V
Trickle Charge Hysteresis	V_{TRHYS}	R_{PROG} = 10k	60	80	110	mV
VCC Under voltage Lockout Threshold	V_{UV}	V_{CC} from Low to High	3.7	3.8	3.92	V
VCC Under voltage Lockout Hysteresis	V_{UVHYS}	V_{CC} from High to Low	150	200	300	mV
Manual Shutdown Threshold	V_{MSD}	P_{ROG} Pin Rising	1.10	1.20	1.30	V
		P_{ROG} Pin Falling	0.90	1.00	1.10	
VCC – VBAT Lockout Threshold	A_{MSD}	V_{CC} from Low to High	70	100	140	mV
		V_{CC} from High to Low	5	30	50	
C/10 Termination Current Threshold	I_{TERM}	R_{PROG} = 2k Note5	0.085	0.1	0.115	mA/mA
		R_{PROG} = 1.2k				
PROG Pin Voltage	V_{PROG}	R_{PROG} = 10k, Current Mode	0.93	1.0	1.07	V
CHG Pin Weak Pull Down Current	I_{CHG}	V_{CHG}=5.0V	25	30	35	μA
CHG Pin Output Low Voltage	V_{CHG}	I_{CHG}=5.0mA	--	0.35	0.60	V
Recharge Battery Threshold	$\triangle V_{RECHG}$	V_{FLOAT}—V_{RECHRG}	--	--	200	mV
RechargeComparat or Filter time	$t_{RECHARGE}$	V_{BAT} High to Low	0.8	1.8	4	mS
Termination comparator Filter time	t_{TERM}	I_{BAT} Falling Below ICHG/10	0.63	1.4	3	mS
Soft-Start time	t_{SS}	I_{BAT}= 0 to I_{BAT}=1000V/R_{PROG}	--	100	--	μS
PROG Pin Pull-Up Current	I_{PROG}		--	3	--	μA

Note: 1. Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.
2. The PJ4054C is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the –40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.
3. See Thermal Considerations.
4. (Charge Mode :ICC=IVCC-IBAT)Supply current includes PROG pin current (approximately 100μA) but does not include any current delivered to the battery through the BAT pin (approximately 100mA).
5. ITERM is expressed as a fraction of measured full charge current with indicated PROG resistor

Typical Applications



Functions Description

Normal Charge Cycle

A charge cycle begins when the voltage at the VCC pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode. In this mode, the PJ4054C supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging.When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the PJ4054C enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Application Information

Programming Charge Current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1200 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG}=\frac{1000V}{I_{CHG}} \qquad I_{PROG}=\frac{1000V}{R_{PROG}}$$

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:

$$I_{BAT}=\frac{V_{PROG}}{R_{PROG}}\times 1000$$

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV1 for longer than tTERM (typically 1ms), charging is terminated. The charge current is latched off and the PJ4054C enters standby mode, where the input supply current drops to 200μA. (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. The 1ms filter time (tTERM) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10th the programmed value, the PJ4054C terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.The PJ4054C constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold (VRECHRG), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin. Figure 4 shows the state diagram of a typical charge cycle.

Charge Status Indicator

The charge status output has three different states: strong pull-down (~10mA), weak pull-down (~20μA) and high impedance. The strong pull-down state indicates that the PJ4054C is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by undervoltage lockout conditions. A weak pull-down indicates that VCC meets the UVLO conditions and the PJ4054C is ready to charge. High impedance indicates that the PJ4054C is in undervoltage lockout mode: either VCC is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the VCC pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

Condition	LED
Battery Charging	ON
Charge Complete (done)	OFF
VCC Undervoltage	OFF
NO Battery	Scintillation(20HZ)

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120°C. This feature protects the PJ4054C from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the PJ4054C. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions. ThinSOT power considerations are discussed further in the Applications Information section.

Under voltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if VCC falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 100mV above the battery voltage.

Manual Shutdown

At any point in the charge cycle, the PJ4054C can be put into shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 2μA and the supply current to less than 50μA. A new charge cycle can be initiated by reconnecting the program resistor. In manual shutdown, the CHRG pin is in a weakpull-down state as long as VCC is high enough to exceed the UVLO conditions. The CHRG pin is in a high impedance state if the PJ4054C is in undervoltage lockout mode: either VCC is within 100Mv of the BAT pin voltage or insufficient voltage is applied to the VCC pin.

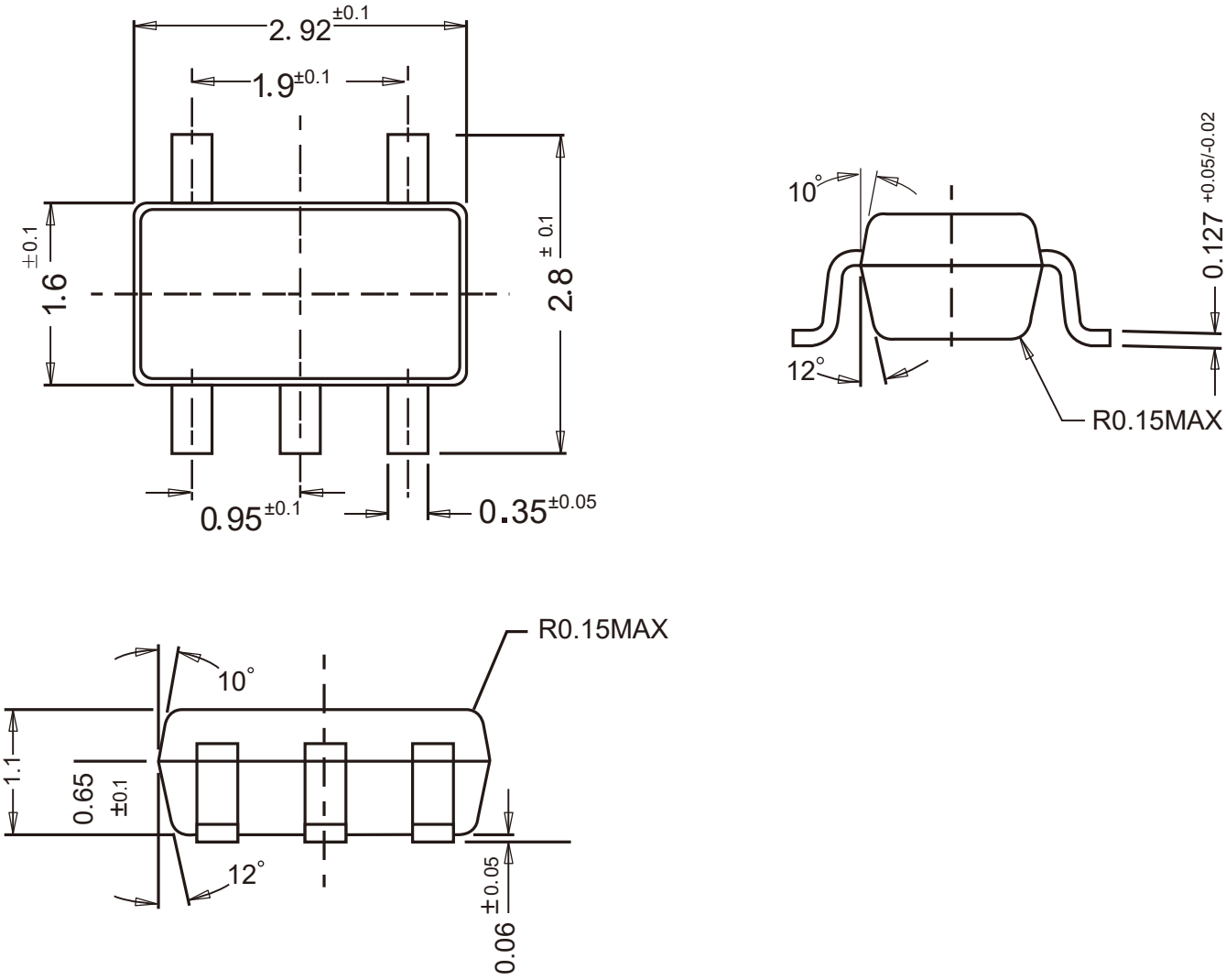
Automatic Recharge

Once the charge cycle is terminated, the PJ4054C continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (tRECHARGE). A charge cycle restarts when the battery voltage falls below 4.05V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. CHRG output enters a strong pulldown state during recharge cycles.

Package Outline

SOT-23-5

Dimensions in mm



Ordering Information

Device	Package	Shipping
PJ4054C	SOT-23-5	3,000PCS/Reel&7inches