CSM4057H High Voltage Linear Li-Ion Battery Charger with OVP

CSM4057H GENERAL DESCRIPTION

The CSM4057H is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. Its compact size and low external component count make the CSM4057H ideally suited for portable applications. Furthermore, the CSM4057H is specifically designed to work charging the battery from the power supplies of the 5V adapter and the USB port.

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, and the charge current can be programmed externally with a single resistor. The CSM4057H automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

Other features include charge current monitor, under voltage lockout, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

The CSM4057H is available in SOT23-6 package requiring minimum board space and smallest components. It is rated over the -40°C to +85°C temperature range.

CSM4057H FEATURES

- **Maximum 40V Input Voltage and 6.0V OVP**
- **Programmable Charge Current up to 600mA**
- **No MOSFET, Sense Resistor or Blocking Diode Required**
- **Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate without Risk of Overheating**
- **Charge Single Cell Li-Ion Batteries Directly from USB Port**
- **Charge Current Monitor Output for Gas Gauging**
- **Preset 4.2V Charge Voltage with 1% Accuracy**
- **2.9V Trickle Charge Threshold**
- **C/10 Charge Termination**
- **55µA Supply Current in Shutdown Mode**
- **Automatic Recharge**
- **Soft-Start Limits Inrush Current**
- **Available in the Green SOT23-6 Package**

CSM4057H APPLICATIONS

- **Mobile Phones, PDAs, MP3 Players**
- **Charging Docks and Cradles**
- **Bluetooth Applications**
- **Other Handheld Devices**

CSM4057H TYPICAL APPLICATION

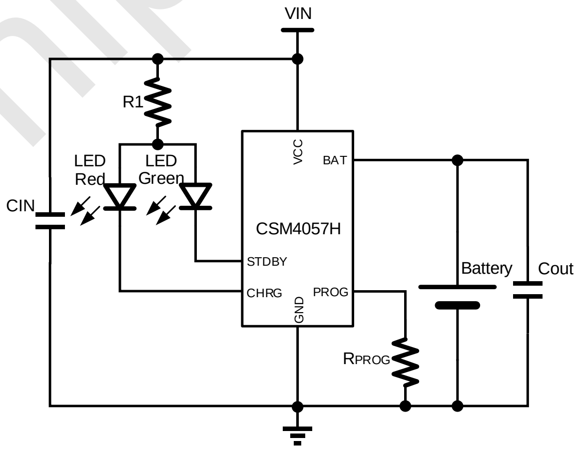


Figure 1. Typical Application Circuit

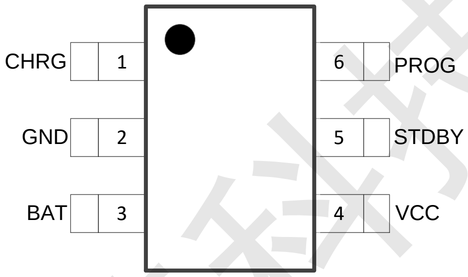
TEL: +86-0755-27595155 27595165
FAX: +86-0755-27594792
WEB:Http://www.ChipSourceTek.com
E-mail: Sales@ChipSourceTek.com Tony.Wang@ChipSourceTek.com

CSM4057H PACKAGING/ORDERING INFORMATION

Device	Package Type	Op Temperature	Ordering Number	Package Marking	Package Option
CSM4057H	SOT-23-6	-40°C to +85°C	CSM4057HST26RY	--	Tape and Reel 3000

CSM4057H PIN CONFIGURATIONS (TOP VIEW)

SOT23-6



CSM4057H PIN INFORMATION

Table 1. PIN Descriptions

PIN	NAME	PIN FUNCTION
1	CHRG	Open-drain charge status output.
2	GND	Ground voltage.
3	BAT	Charge current output.
4	VCC	Power input supply voltage.
5	STDBY	Charge terminated status output.
6	PROG	Constant Charge Current Setting and Charge Current Monitor Pin.

ABSOLUTE MAXIMUM RATINGS

Description		Range	Units
Input Voltage PIN		-0.3 ~+40.0	V
BAT Voltage PIN		-4.2 ~ 12.0	V
Other PINS		-0.3~13.0	V
Storage Temperature		-65 ~ +150	°C
Junction Temperature		150	°C
Lead Temperature(10s)		260	°C
ESD	HBM	2000	V
	CDM	1000	V
Junction to Ambient Thermal Resistance (θ_{JA})	SOT23-6	250	°C/W
P_D@T_A=25°C	SOT23-6	0.3	W

Overstress Caution

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

RECOMMENDED CONDITIONS

Description	Range	Units
Operating Junction Temperature (T_J)	-40 ~ 125	°C
Operating free air Temperature (T_A)	-40 ~ 85	°C
Supply Voltage (VCC)	+4.0~+36	V
Continuous Output Current （SOT23-6）	0.5	A

ESD Sensitivity Caution

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. CSM Corp recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Disclaimer

CSM Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

CSM4057H APPLICATION NOTES

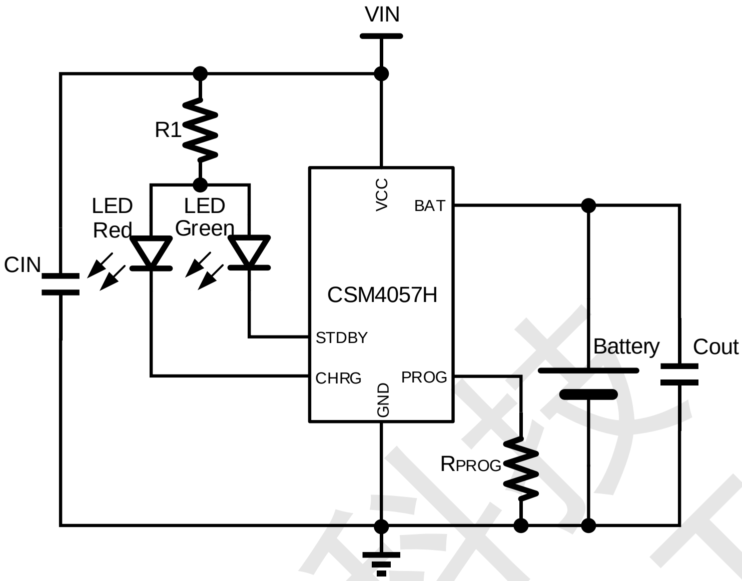


Figure 2. Typical Application Circuit

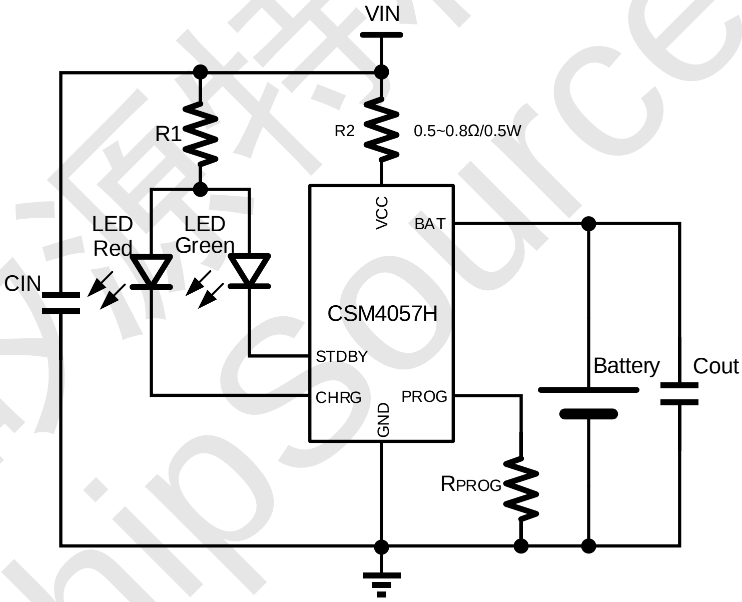


Figure 3. Typical Application Circuit

TEL: +86-0755-27595155 27595165
FAX: +86-0755-27594792
WEB:Http://www.ChipSourceTek.com
E-mail: Sales@ChipSourceTek.com Tony.Wang@ChipSourceTek.com

CSM4057H ELECTRICAL CHARACTERISTICS

(V_{IN} = 5V, V_{BAT}=3.6V, T_J = 25°C, unless otherwise specified.)

Parameter	Symbol	Conditions	MIN	TYP	MAX	Units
Input Voltage Range	V_{CC}		4.5	5	36	V
Quiescent Supply Current	I_Q	Charge Mode，R_{PROG}=2k		240	360	µA
		Standby Mode (Charge Terminated)		220	300	µA
		Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < V_{UV})		220	300	µA
		OVP state		120	250	µA
Regulated Output (Float)Voltage	V_{FLOAT}	0°C≤T_A≤85°C, R_{PROG} = 2k	4.158	4.200	4.242	V
BAT Pin Current	I_{BAT}	R_{PROG} =2k, Current Mode	540	600	660	mA
		Standby Mode, V_{BAT} = 4.2V	0	-2.5	-6	µA
		Shutdown Mode (R_{PROG} Not Connected)		±1	±2	µA
		Sleep Mode, V_{CC} = 0V		-1	-2	µA
Trickle Charge Current	I_{TRIKL}	V_{BAT} < V_{TRIKL}, R_{PROG} = 2K	10	15	20	mA
Trickle Charge Threshold Voltage	V_{TRIKL}	R_{PROG} = 2k, VBAT Rising	2.6	2.8	3.0	V
Trickle Charge Hysteresis Voltage	V_{TRHYS}	R_{PROG} =2k	60	80	100	mV
VCC Undervoltage Lockout Threshold	V_{UV}	From V_{CC} Low to High	3.3	3.5	3.7	V
VCC Undervoltage Lockout Hysteresis	V_{UVHYS}		100	200	300	mV
VCC-VBAT Lockout Threshold Voltage	V_{ASD}	V_{CC} from Low to High		200		mV
		V_{CC} from High to Low		50		mV
C/10 Termination Current Threshold	I_{TERM}	R_{PROG} = 2k	50	60	70	mA
PROG Pin Voltage	V_{PROG}	R_{PROG} = 2k, Current Mode	0.9	1.0	1.1	V
CHRG Pin Output Low Voltage	V_{CHRG}	I_{CHRG} = 5mA		0.3	0.6	V
STDBY Pin Output Low Voltage	V_{STDBY}	I_{STDBY} = 5mA		0.3	0.6	V
Recharge Battery Threshold Voltage	ΔV_{RECHRG}	V_{FLOAT} - V_{RECHRG}	100	150	200	mV
Junction Temperature in Constant Temperature Mode	T_{LIM}			145		℃
Power FET “ON” Resistance (Between VCC and BAT)	R_{ON}			600		mΩ
Soft-Start Time	t_{SS}	I_{BAT} = 0 to I_{BAT} =1000V/R_{PROG}		20		µs
Recharge Comparator Filter Time	$t_{RECHARGE}$	V_{BAT} High to Low	0.8	1.8	4.0	ms
Termination Comparator Filter Time	t_{TERM}	I_{BAT} Falling Below I_{CHG}/10	0.8	1.8	4.0	ms
PROG Pin Pull-Up Current	I_{PROG}			1.0		µA
Manual shutdown threshold voltage	V_{MSD}	PROG rise	3.40	3.50	3.60	V
		PROG drop	1.90	2.00	2.10	V

TEL: +86-0755-27595155 27595165
FAX: +86-0755-27594792
WEB:Http://www.ChipSourceTek.com
E-mail: Sales@ChipSourceTek.com Tony.Wang@ChipSourceTek.com

CSM4057H BLOCK DIAGRAM

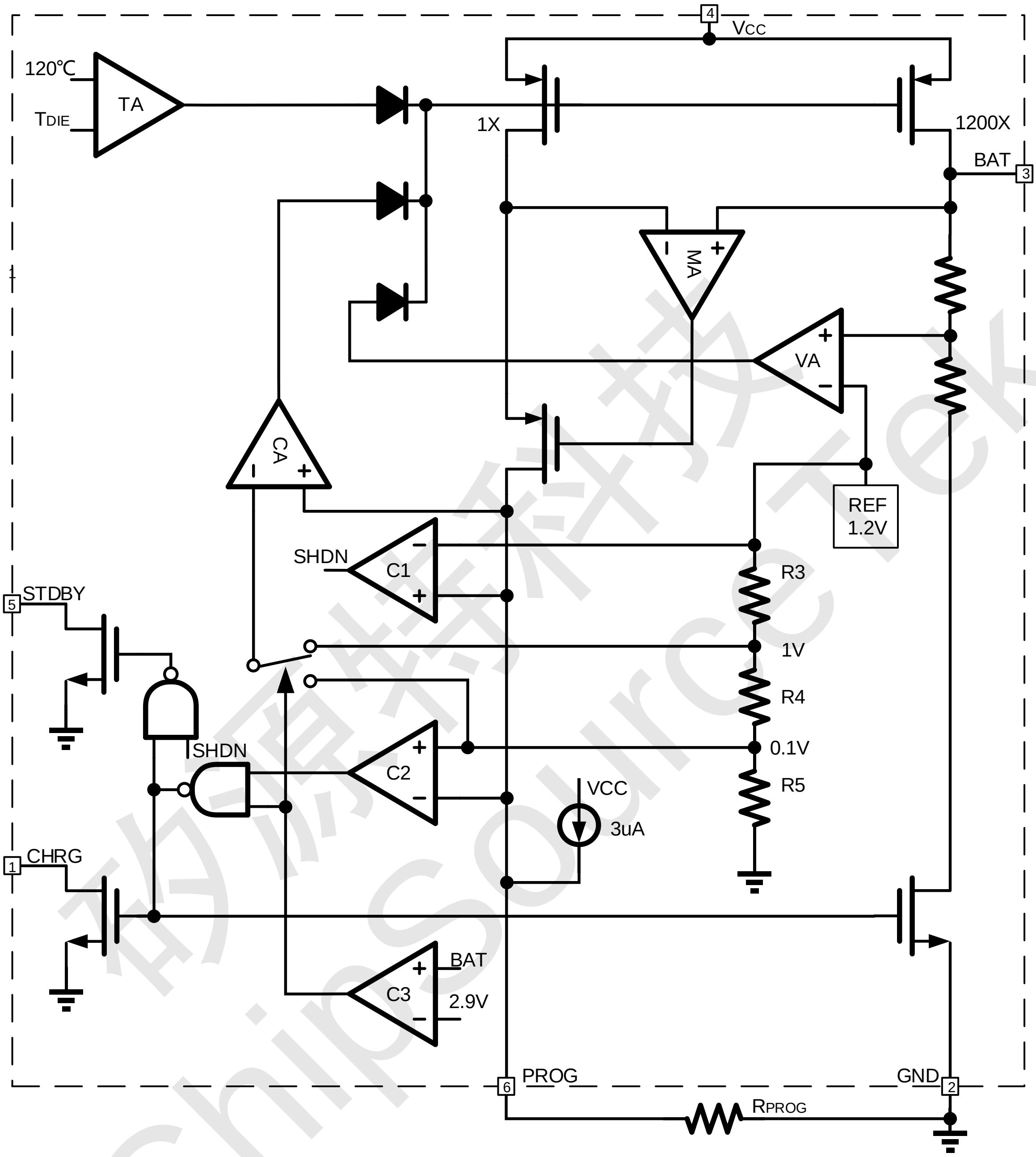


Figure 4. Block Diagram

CSM4057H FUNCTION DESCRIPTION

The CSM4057H is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 600mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The CSM4057H includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only two external components. Furthermore, the CSM4057H is capable of operating from a USB power source.

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 CSM4057H 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 CSM4057H 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.

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:

$$R_{PROG} = \frac{1200}{I_{CHG}}, \text{ or } I_{CHG} = \frac{1200}{R_{PROG}}$$

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

$$I_{BAT} = \frac{V_{PROG} \bullet 1200}{R_{PROG}}$$

R_{PROG} Selected table

R_{PROG}（KΩ）	I_{CHG}（mA）
2.0	600
2.4	500
5.0	240
10	120

Charge Termination

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 100mV for longer than t_{TERM}, charging is terminated. The charge current is latched off and the CSM4057H enters standby mode, where the input supply current drops to 55μA. (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 (t_{TERM}) 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 CSM4057H 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 CSM4057H constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold (V_{RECHRG}), 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 5 shows the state diagram of a typical charge cycle.

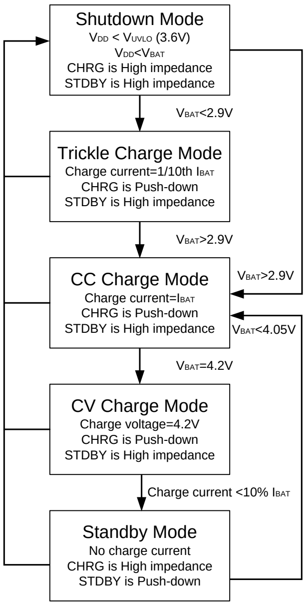


Figure 5. State Diagram of a Typical Charge Cycle

Charge Status Indicator

CSM4057H has two open-drain status indicator output CHRG and STDBY. CHRG is pull-down when the CSM4057H in a charge cycle. In other status CHRG is in high impedance. CHRG and STDBY are all in high impedance when the battery out of the normal temperature.

if BAT pin connects a 10µF capacitor and the battery is not connected, the green LED is light and the red LED is blinked with 1-4s cycle time.

Charger's status	Red LED CHRG	Green LED STDBY
Charging	Light	Dark
Charge termination	Dark	Light
UVLO, or battery is not connected	Dark	Dark
10uF capacitor is connected to BAT pin, and battery is not connected	Green LED is light, red LED is blinked with T=1-4s	

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 145°C. This feature protects the CSM4057H 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 CSM4057H. 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.

Undervoltage 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.

Automatic Recharge

Once the charge cycle is terminated, the CSM4057H continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time ($t_{RECHARGE}$). 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 is push-down and the STDBY is in high impedance during recharge cycles.

Stability Considerations

The constant-voltage mode feedback loop is stable without an output capacitor provided and a battery is connected to the charger output.

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz. Therefore, if the PROG pin is loaded with a capacitance, C_{PROG}, the following equation can be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \leq \frac{1}{2\pi \cdot 10^5 \cdot C_{PROG}}$$

Average, rather than instantaneous, charge current may be of interest to the user. For example, if a switching power supply operating in low current mode is connected in parallel with the battery, the average current being pulled out of the BAT pin is typically of more interest than the instantaneous current pulses. In such a case, a simple RC filter can be used on the PROG pin to measure the average battery current as shown in Figure 6. A 10k resistor has been added between the PROG pin and the filter capacitor to ensure stability.

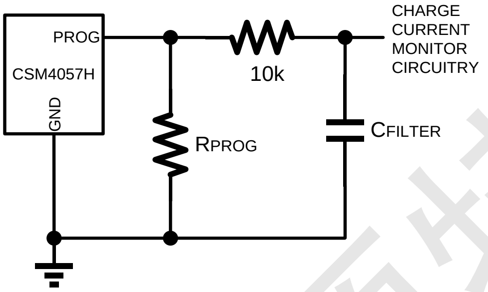


Figure 6. Isolating Capacitive Load on PROG Pin and Filtering

Power Dissipation

The device's junction temperature depends on several factors such as ambient temperature, PCB layout, the load and package type. Equations that can be used to calculate power dissipation and junction temperature are found below:

$P_D=R_{DS(ON)}\times I_{OUT}^2$

To relate this P_D to junction temperature, the following equation can be used:

$T_J=P_D\times\theta_{JA} + T_A$

Where:

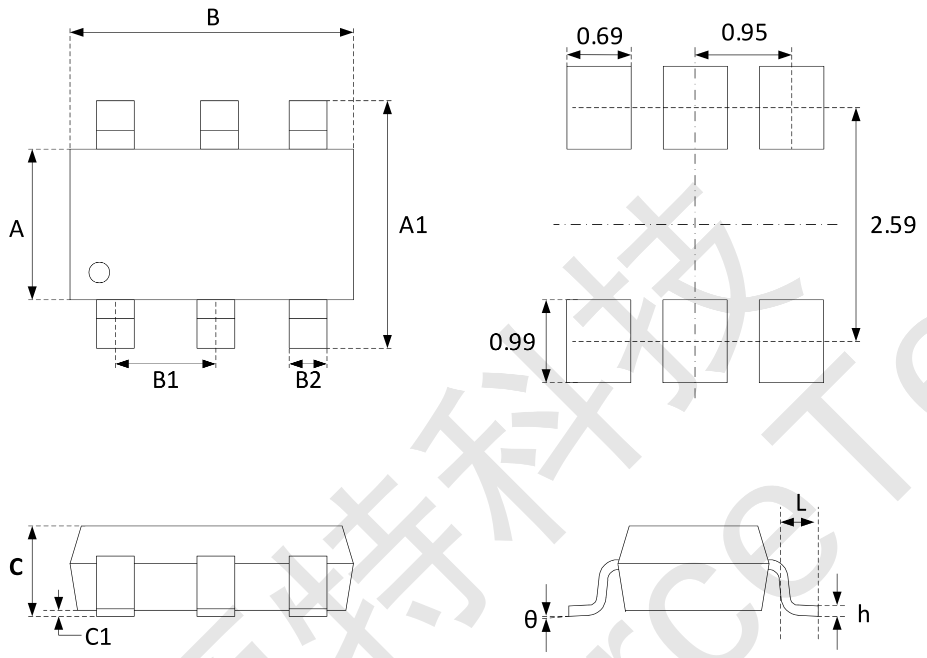
T_J is junction temperature,

T_A is ambient temperature,

θ_{JA} is the thermal resistance of the package type.

CSM4057H PACKAGE DESCRIPTION

SOT23-6 package mechanical drawing



package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	1.500	1.700	0.059	0.067
A1	2.650	2.950	0.104	0.116
B	2.820	3.020	0.111	0.119
B1	0.950		0.037	
B2	0.300	0.500	0.012	0.020
C	1.050	1.250	0.041	0.049
C1	0.000	0.100	0.000	0.004
L	0.300	0.600	0.012	0.024
h	0.100	0.200	0.004	0.008
θ	0º	8º	0º	8º