

12 mΩ Power Switch with Current Limit and Charging Port Controller

1 DESCRIPTION

The SC7005 is a power switch that integrates an ultra-low Rdson (12mΩ) N-channel MOSFET. It is designed for USB port applications or other applications which require a high current switch. It provides a current limit function, and the current limit can be programmable through an external resistor. The SC7005 also integrates the USB Type-C Downstream Facing Port (DFP) controller function. It can support the type-C USB port with Channel Configuration (CC) signals. It can detect the attachment/detachment of the sink device, and control the on/off of the switch automatically.

The SC7005 also supports various protections, including over-voltage protection, under-voltage protection, short circuit protection, and thermal shutdown protection.

The SC7005 requires a minimum number of external components to complete the USB switch and charging port solution. It is available in the TSOT23-8 package.

3 APPLICATIONS

- USB chargers
- Type-C charger
- USB HUB
- USB power supplies
- USB peripherals

2 FEATURES

- 12mΩ Ultra-low Rdson NMOS Switch
- Programmable Current Limit
- ± 5% Current Limit Accuracy at typical application
- Built-in Soft-Start
- Ultra-low Operation Current
- Status Indication
 - ✓ Device Removal Indication
 - ✓ Short Circuit Fault Indication
- USB Type-C Downstream Facing Port (DFP/Source) Controller Function
- Input Under Voltage Protection
- Input Over Voltage Protection
- Over Current Protection
- Short Circuit Protection
- Thermal Shutdown Protection
- ±8kV HBM ESD Rating for USB IO pins
- TSOT23-8 package

4 ORDERING INFORMATION

Part Number	Package	Dimension
SC7005SAER	TSOT23-8	2.92*2.8*0.95 mm

5 Typical Application Circuit

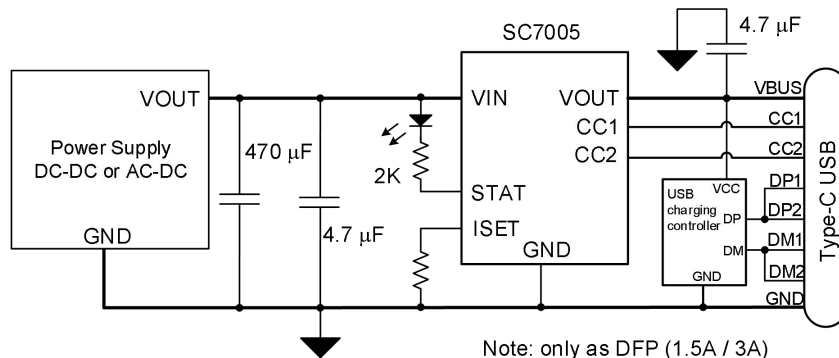


Figure 1 SC7005 typical application circuit for generic charging port.

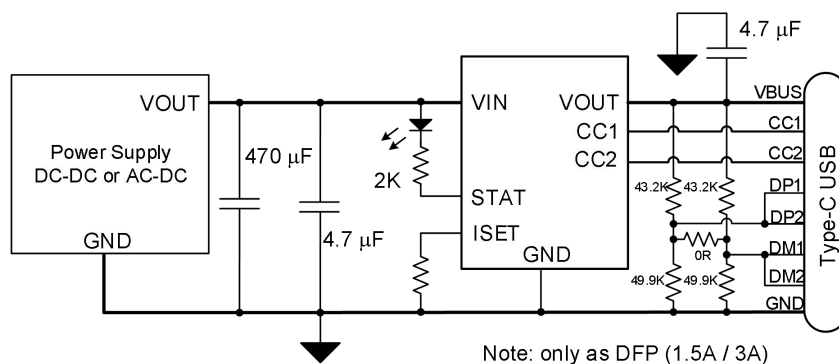


Figure 2 SC7005 typical application circuit for the dedicated charging port

Note:

For some devices which use DP/DM as charging control interface, an additional USB charging controller IC is recommended for a general-purpose charging port. As shown in figure 1, this application has the best compatibility.

For dedicated adapter or charger, we recommend using a resistors divider or just short DP/DM to configure the type-c USB port as shown in figure 2. For example, shorting DP/DM for android devices and using 47K and 56K resistors for Apple devices. Keeping DP/DM floating is also allowed to most devices that support USB Type-C Downstream Facing Port (DFP).

6 Pin Configurations and Functions

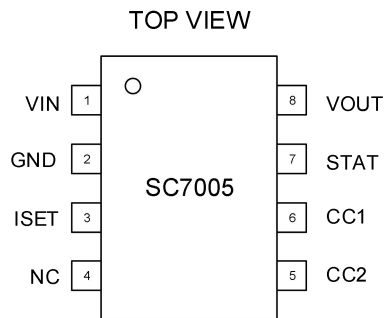


Table 1 Pin description

Terminals	NAME	I/O	Description
1	VIN	I	Input to the switch
2	GND	IO	Ground
3	ISET	I	Set the current limit value
4	NC	-	Not connected
5	CC2	IO	Channel Configuration 2 line for Type C USB port interface
6	CC1	IO	Channel Configuration 1 line for Type C USB port interface
7	STAT	O	Open-drain output. Connect an LED from the VIN pin to the STAT pin for status indication. It is internally pulled low to indicate the port is active.
8	VOUT	O	The output of the switch

7 Electrical Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		Min.	Max.	Unit
Voltage ⁽²⁾	VIN, VOUT, STAT	-0.3	7	V
	CC1, CC2	-0.3	VIN+0.3V or 5.7V	V
	ISET	-0.3	5.5	V
T _J	Operating junction temperature	-40	150	°C
T _{stg}	Storage temperature	-65	150	°C
T _L	Lead Temperature		260	°C
T _D	Continuous power dissipation (TA=25°C)		1.25	W
T _{ΘJA} ⁽³⁾	Junction to ambient thermal resistance	100		°C/W
T _{ΘJC} ⁽³⁾	Junction to case thermal resistance	12		°C/W

- (1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device.
- (2) All voltages are concerning the network ground terminal.
- (3) Measured on JESD51-7, 4-layer PCB.

7.2 ESD Ratings

			Min.	Max.	Unit
$V_{ESD}^{(1)}$	Human-body Model (HBM) ⁽²⁾	All pins except CC1 / CC2	-4	4	kV
		CC1 / CC2	-8	8	kV
	Charged-device Model (CDM) ⁽³⁾		-1000	1000	V

- (1) Electrostatic discharge (ESD) to measure device sensitivity and immunity to damage caused by assembly line electrostatic discharges into the device.
- (2) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (3) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operation Conditions

		Min.	Typ.	Max.	Unit
V_{IN}	VIN votlage range	4	5	5.6	V
C_{IN}	VIN capacitor	4.7			μF
C_{OUT}	VOU Tcapacitor	3.3		22	μF
T_A	Operating ambient temperature	-40		85	$^{\circ}C$
T_J	Operating junction temperature	-40		125	$^{\circ}C$

7.4 Electrical Characteristics

$T_J = 25^{\circ}\text{C}$ and $V_{IN} = 5\text{V}$ and $V_{OUT} = 5\text{V}$ unless otherwise noted.

PARAMETER				TEST CONDITIONS		MIN	TYP	MAX	UNIT
SUPPLY VOLTAGE									
V _{IN}	Operating voltage					4		5.6	V
V _{IN_UVLO}	Under-voltage lockout threshold			Rising		3.7	3.8	3.9	V
				Hysteresis		0.5	0.6	0.7	V
I _Q	Quiescent current			VIN=5V, No-load		80	145	180	μA
POWER FET									
R _{DS_ON}	Rdson of switch			VIN=5V		12			mΩ
T _{SS}	Soft start time			VIN = 5V, turning on, no load		1			ms
				VIN = 5V, turning on, IO _{UT} = 3A		1.5			ms
CURRENT LIMIT									
V _{REF}	Reference voltage					1.176	1.2	1.224	V
I _{LIM}	Current limit accuracy			R _{ISET} = 120 KΩ		3.42	3.5	3.69	A
I _{LIM_CC}	1.5A/3A level detection threshold			Rising		2.2	2.5	2.8	A
				Hysteresis		0.16	0.22	0.28	A
STATUS INDICATION									
I _{STAT}	STAT pin sink current			VSTAT = 0.4 V		3	4	5	mA
PROTECTION									
V _{IN_OVP}	VIN OVP protection			Rising edge, over V _{OUT} , V _{OUT} = 5V		5.6	5.8	6	V
				Falling edge		5.5	5.7	5.9	V
I _{ML}	Maximum current limit			R _{ISET} =0		5.5			A
V _{SC-th}	VOUT short circuit protection threshold					3.4	3.6	3.8	V
T _{HIC_ON}	OCP on time of hiccup			VOUT<1.1V		3			ms
T _{HIC_OFF}	OCP off time of hiccup					0.5			s
TSD	Thermal shutdown temperature threshold			Not in the current limit		150			°C
				In current limit		140			°C
	Thermal shutdown hysteresis			Thermal shutdown hysteresis		25			°C
CC LOGIC									
V _{CCTH=0.4}	CC1/2	0.4V	comparison			0.35	0.4	0.45	V
V _{CCTH=0.8}	CC1/2	0.4V	comparison			0.75	0.8	0.85	V
V _{CCTH=1.6}	CC1/2	1.6V	comparison			1.5	1.6	1.65	V
V _{CCTH=2.6}	CC1/2	2.6V	comparison			2.45	2.6	2.75	V

Electrical Characteristics (Continued)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{CC1/2_180\mu A}$	CC1/2 pull up current	$I_{LIM_SET} < I_{LIM_CC}$ $V_{CC_{TH}=0.4} < V_{CC1/2} < V_{CC_{TH}=1.6}$	165.6	180	194.4	μA
$I_{CC1/2_330\mu A}$	CC1/2 pull up current	$I_{LIM_SET} > I_{LIM_CC}$ $V_{CC_{TH}=0.8} < V_{CC1/2} < V_{CC_{TH}=2.6}$	303.6	330	356.4	μA
T_{CC_DEB}	CC debounce time		100	150	200	ms
T_{PD_DEB}	PD debounce time		10	15	20	ms

7.5 Typical Characteristics

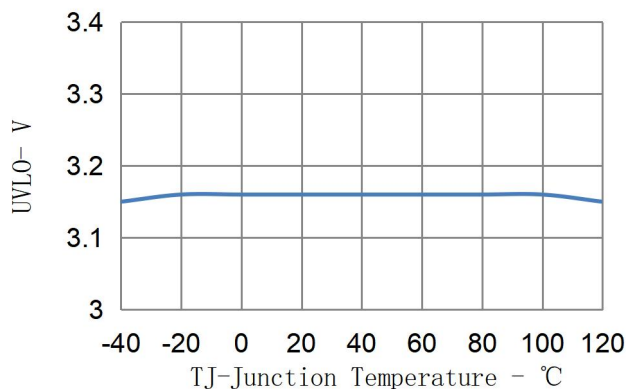


Figure 2 Under Voltage Lock Output VS. Temperature

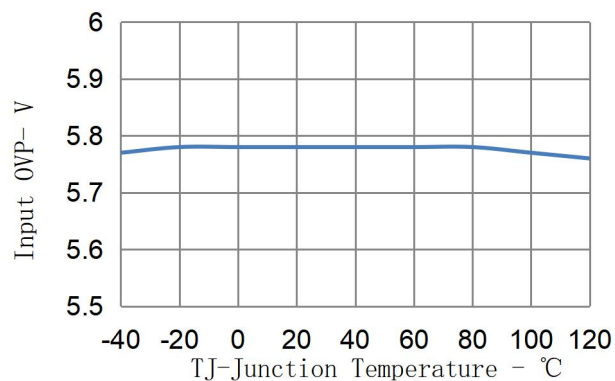


Figure 3 Input Over Voltage Protection VS. Temperature

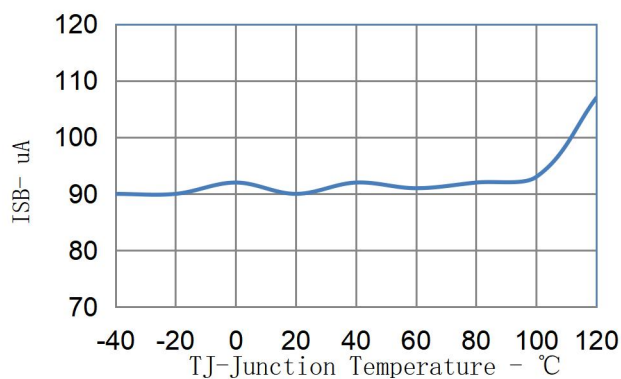


Figure 4 Standby Current (VIN=5V) VS. Temperature

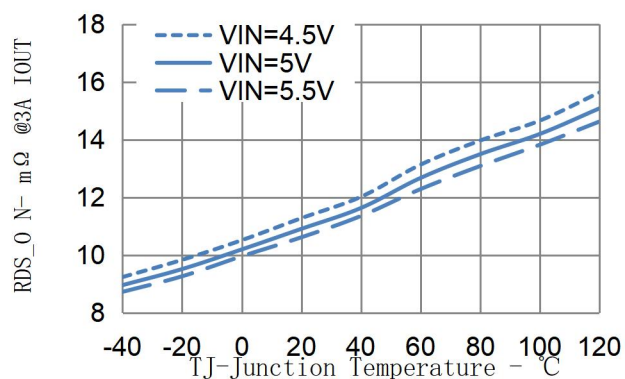


Figure 5 ON-Resistance VS. Temperature

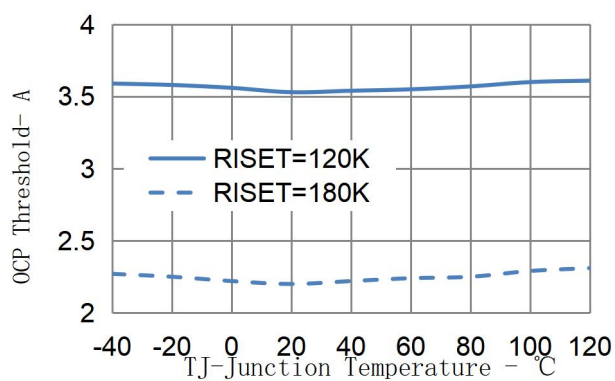
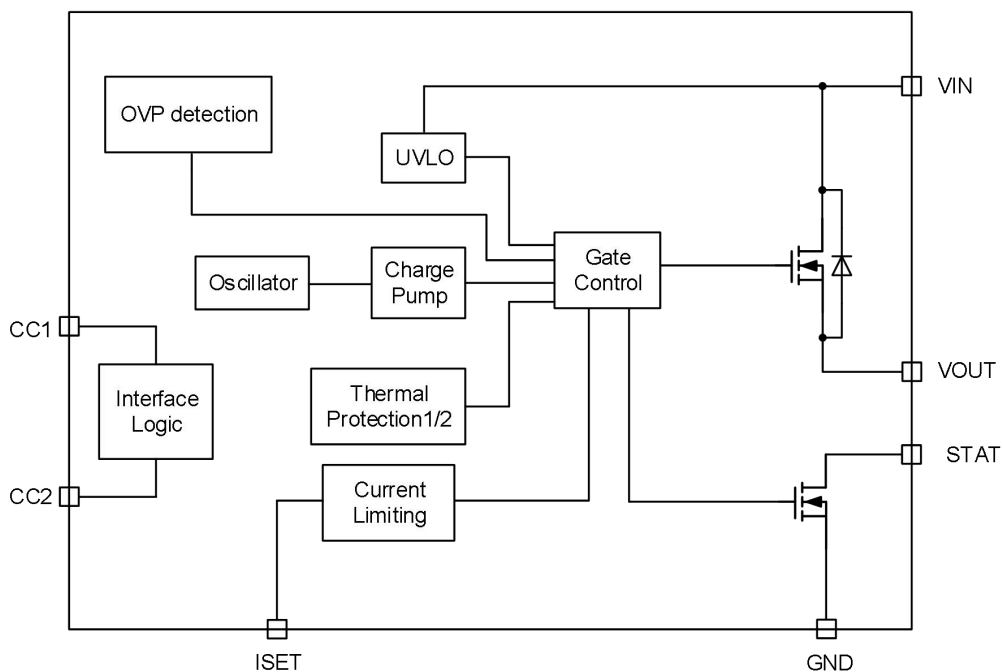


Figure 6 Over Current Protection (OCP) Threshold VS. Temperature

8 Functional Block Diagram



9 Function Description

9.1 Under Voltage Lock-Out Protection

The SC7005 provides Under Voltage Lock Out (UVLO) protection. The switch is turned off when the input voltage is below the UVLO threshold. Once VIN is above the UVLO threshold, the IC is enabled and it turns on the power switch after a 6ms delay time. Built-in hysteresis for UVLO threshold is implemented to prevent unwanted shutdown due to the input voltage variation caused by load transient.

9.2 Enable and Disable

The SC7005 is enabled automatically once the input voltage is above the UVLO threshold. With VIN power on, these parts can't be disabled.

9.3 Internal soft-start

The SC7005 provides a built-in soft-start function. After enabled, it turns on the switch slowly (in 1 ~ 2ms) to limit the inrush current and voltage surges.

9.4 Constant Current Mode

The SC7005 provides a constant current function that can be programmable through an external resistor at the ISET pin. Once the device detects the current reaches the current limit value, it works in constant current mode: it controls the gate driver voltage of the power switch so to regulate the current of the switch at the set value. The current limit value can be calculated by the below equation:

$$ICC_LIM = \frac{VREF}{RISET} \times k$$

where ICC_LIM is the target current limit

VREF = internal reference voltage, 1.2V typically

RISET = ISET resistor value

k = 350,000 typically

For example, if a 120k resistor is connected to the ISET pin, the ICC_LIM is 3.5A.

When the IC works in constant current mode, the output voltage will be pulled down by the load current. If the output voltage still keeps higher than 3.8V at this mode, the SC7005 keeps limiting the current at the set value until the overload condition is removed or the IC begins thermal shutdown cycling. If the IC detects the output voltage drops below 3.8V, it starts short circuit protection (SCP).

9.5 Short Circuit Protection

When the IC detects the output voltage drops below 3.8V, the SC7005 enters into short circuit hiccup mode. The SC7005 stays in hiccup mode until the overload or short circuit fault is removed.

Through the power cycling in hiccup mode, the average output current under short circuit conditions can be significantly reduced to relieve the thermal stress on the chip.

The parasitic inductance at power leads and PCB traces may cause high voltage spikes between VIN and VOUT pin when the Power FET turn-off rapidly. This may happen during VOUT short to ground, over current, and fast load release from a heavy load. These voltage spikes with current may exceed the SOA area and damage the device. To decrease the parasitic inductance and improve the robustness, multi-layer ceramic capacitors (MLCC) are highly recommended and applied to the VIN and VOUT pin. Place at least a 4.7μF 0805 size MLCC close to the VIN and GND pin and a 10μF 0805 size MLCC close to the VOUT and GND pin. If a 0603 size MLCC is applied, a higher capacitance with enough effective value is recommended due to the derating effect of MLCC.

9.6 Thermal Shutdown Cycling

The SC7005 provides two independent thermal sensing blocks that monitor the junction temperature in constant current mode and load switch mode.

When the SC7005 works in constant current mode, the IC keeps the switch on if the output voltage stays above 3.8V. In this case, there is a large voltage drop across the power switch, leading to high thermal dissipation. Once the SC7005 detects the junction temperature rises above 140°C, it turns off the switch; after it detects the temperature falls below 115°C, it turns on the switch again with the soft-start process.

When the SC7005 works in load switch mode, the IC turn on the switch fully, and the output voltage is almost equal to the input put voltage with dozens of millivolts drop caused by the R_{DS(on)}. Once the SC7005 detects the junction temperature rises above 150°C, it turns off the switch; after it detects the temperature falls below 125°C, it turns on the switch again with the soft-start process.

9.7 Status Indicator

The SC7005 features a status indication at the STAT pin. STAT pin is an open-drain output, so can be connected

with a pull-up resistor and LED to VIN. The STAT pin is pulled low by the IC when the output is active.

9.8 Type C Controller

The SC7005 integrates a USB Type-C Downstream Facing Port (DFP) controller. It acts as a DFP/Source device and monitors the Type-C Configuration Channel (CC) lines to determine when a USB device is attached. If an Upstream Facing Port (UFP) or Sink device is attached, the SC7005 turns on the power switch automatically with soft-start to apply power to VOUT. Then it advertises its current source capability through the CC line.

The SC7005 can support 1.5A and 3A Type-C current advertisements. The current capability is determined by the ISET pin. If the IC detects the ISET current is set $\geq 3A$, it advertises the 3A level to UFP; if it detects the ISET current is lower than 2.2A, it advertises 1.5A. The real current limit value is still set by the ISET resistor.

For example, if a 120k Ω resistor is connected to an ISET pin, the SC7005 detects the ISET current is 3.5A, so it will advertise the 3A level to UFP, and it limits the current to 3.5A; if a 220k Ω resistor is applied, the SC7005 detects the ISET current is 1.8A, so it advertises 1.5A level and limits the current at 1.8A.

To avoid that the output current can't satisfy the UFP device, it is required to set the current limit value higher

than the advertisement value. The below setting is highly recommended.

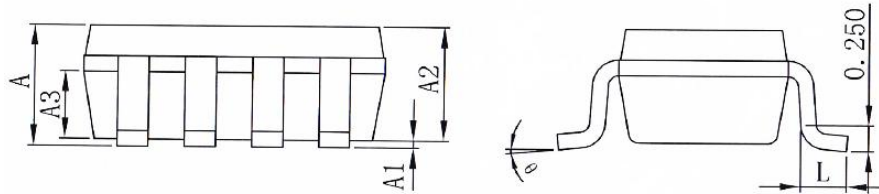
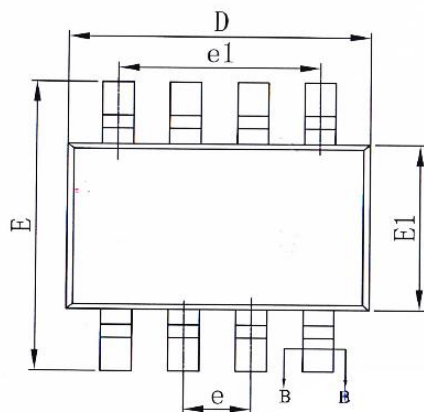
Table 2 ISET Setting for Type-C Advertisement

Advertisement	ISET Current	RISSET Value
1.5A level	1.8A	220k Ω
3A level	3.5A	120k Ω

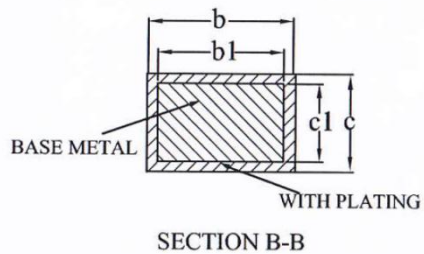
If the ISET is set within 2.2A ~ 3A, it may cause the wrong advertisement, so the user should avoid the 2.2A~3A setting.

PACKAGE

TSOT23-8



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	0.95
A1	0.00	—	0.10
A2	0.75	0.80	0.85
A3	0.35	0.40	0.45
b	0.28	—	0.38
b1	0.27	0.30	0.33
c	0.11	—	0.21
c1	0.11	0.13	0.15
D	2.82	2.92	3.02
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.65BSC		
e1	1.95BSC		
L	0.30	—	0.60
θ	0	—	8°



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