TCS2001

Ultra-low-Rdson load switch with smart detection

1. Features

- Ultra low R_{ON} High Side MOSFET
  - 16 mΩ @ 3.6A, 25℃
- Programmable current limit
- ±7% current limitation at 3A load current
- Operating voltage range: 4.5V to 6.0V
- Build-in soft-start
- Supports smart detection on D+ and D- lines
  - Battery Charging specification BC1.2 for DCP
  - Chinese Telecommunication industrial standard YD/T 1591-2009
  - D+/D- option for Apple device with 2.4A
  - D+/D- option for Samsung device
- ESD protection on USB ports (VOUT, DP, DM)
  - Human Body Model (HBM): >8 kV
- SOT23-6 package

2. Applications

- USB wall Adapters
- USB car chargers
- Power Banks
- USB Peripherals

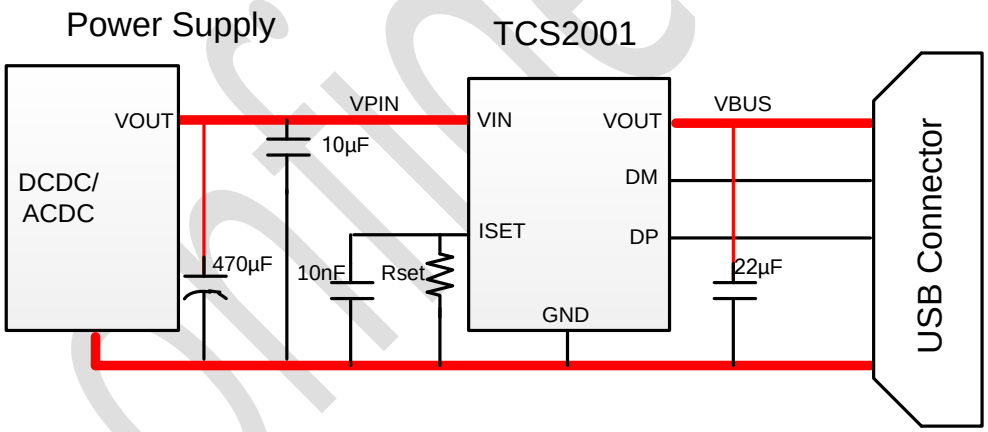
3. Description

The TCS2001 is a 16-mΩ current limiting power switch, integrated with the USB proprietary charging methods smart detection.

Due to integrated auto-detect and auto-switch circuitry, the TCS2001 can apply correct electrical signatures automatically on the USB data lines to charge compliant devices among Apple, Samsung and BC1.2 DCP modes.

The TCS2001 provides accurate and programmable current limitation. When the output voltage is less than 4.0V or when an over temperature protection occurs during an overload condition, the TCS2001 enters hiccup modes.

4. Typical Application Circuit



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5. Pinning information

5.1 Pinning

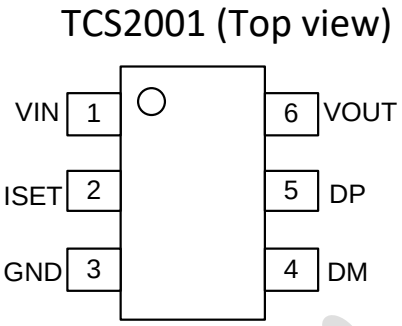

Figure 1 TCS2001 Package

5.2 Pin Description

Symbol	Pin	IP Type	Description
VIN	1	Power	Input of the load switch, decoupling a 10μF low ESR capacitor to ground
ISET	2	Output	Connect to current limitation configuration resistor, relation between limited current and R_{SET}: ILIM=1905/R_{SET}
GND	3	Ground	Ground of chip
DM	4	I/O	D- terminal of USB connector, typical 2.7V
DP	5	I/O	D+ terminal of USB connector, typical 2.7V
VOUT	6	Output	Output connecting to VBUS of USB, decoupling a 22μF low ESR capacitor to ground

6. Absolute DC Maximum Ratings

Items	Descriptions		Min.	Max.	Unit
VIN	Supply voltage range	VIN,VOUT	-0.3	6.5	V
V_IO	IO voltage range	DP, DM, ISET	-0.3	5.5	V
IDPDM	While DPDM shorted, source current from DP to DM			10	mA
V(ESD)	Human Body Model for chip	DP, DM, VOUT		8	KV
		Others		4	KV
T_{stg}	Storage temperature		-65	150	°C
T_{JMAX}	Maximum junction temperature			150	°C

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7. Recommended Operation Conditions

Parameters	Descriptions	Min.	Max.	Unit
VIN	Supply voltage range	4.5	6.0	V
T_A	Free air temperature	-40	105	°C

8. Characteristics

Parameters	Descriptions	Test conditions	Min.	Typ.	Max.	Unit
POWER SWITCH						
$R_{DS(on)}$	Static on-state resistance	I_{OUT}=3A，V_{IN}=5V		16		mΩ
t_R	Output voltage rising time	V_{IN}=5V, C_L=10μF, R_L=100Ω	0.1	0.15	0.2	ms
I_{OC}	Current limitation	R_{SET}=0.68K	2.6	2.8	3	A
R_{BLD_DSCH}	Bleeding discharge resistance	V_{IN}=5V		150		kΩ
PROTECTIONS						
V_{UVLO}	VIN UVLO threshold voltage	V_{IN} rising	3.9	4.1	4.3	V
V_{UVLO_HYS}	VIN UVLO hysteresis	V_{IN} falling hysteresis		0.2		V
T_{Rising}	Temperature rising threshold for over temperature protection	Not in current limit		150		℃
		In current limit		130		℃
T_{hys}	Hysteresis temperature	Temperature falling after OT		20		℃
t_{iOS}	Response time to short circuit	V_{IN}=5V		3		μs
V_{OUT_HICCUP}	V_{OUT} voltage threshold while going to hiccup mode	V_{IN}=5V	3.8	4.0	4.2	V
T_{HICCUP_ON}	Switch on time of hiccup mode	V_{IN}=5V, while V_{OUT}< V_{OUT_HICCUP}		6.4		ms
DPDM FUNCTIONALITY						
V_{DP_2V7}	DP output voltage	VIN=5V	2.5	2.7	2.9	V
V_{DM_2V7}	DM output voltage	VIN=5V	2.5	2.7	2.9	V
R_{DP_2V7}	DP output resistance	IDP=-5μA	24	30	36	kΩ
R_{DM_2V7}	DM output resistance	IDM=-5μA	24	30	36	kΩ

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Parameters	Descriptions	Test conditions	Min.	Typ.	Max.	Unit
V_{DP_1V2}	DP output voltage	V_{IN}=5V	1.05	1.2	1.3	V
V_{DM_1V2}	DM output voltage	V_{IN}=5V	1.	1.2	1.3	V
R_{1V2_GND}	DP/DM output resistance	I_{DP}=-5μA	80	105	130	kΩ
R_{SHORT_DPDM}	DP and DM short resistance	V_{DP}=0.8V, I_{DM}=1mA		100	150	Ω
R_{DCP_GND}	Resistance between DP/DM and GND	V_{DP}=0.8V	550	700	850	kΩ
V_{DPL_DETACH}	Voltage on DP while device goes back to divider mode		0.31	0.33	0.35	V
SUPPLY CURRENT						
I_{VIN_IDLE}	VIN current while no loading on VOUT	V_{IN}=5V		150		μA

TYPICAL CHARACTERISTIC DIAGRAM

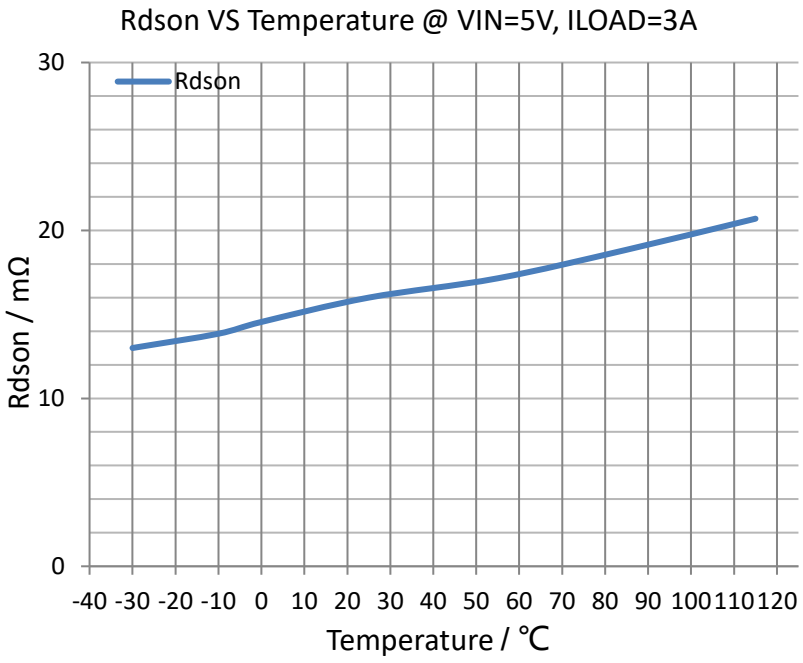

Figure 2 On-resistance of load switch VS ambient temperature

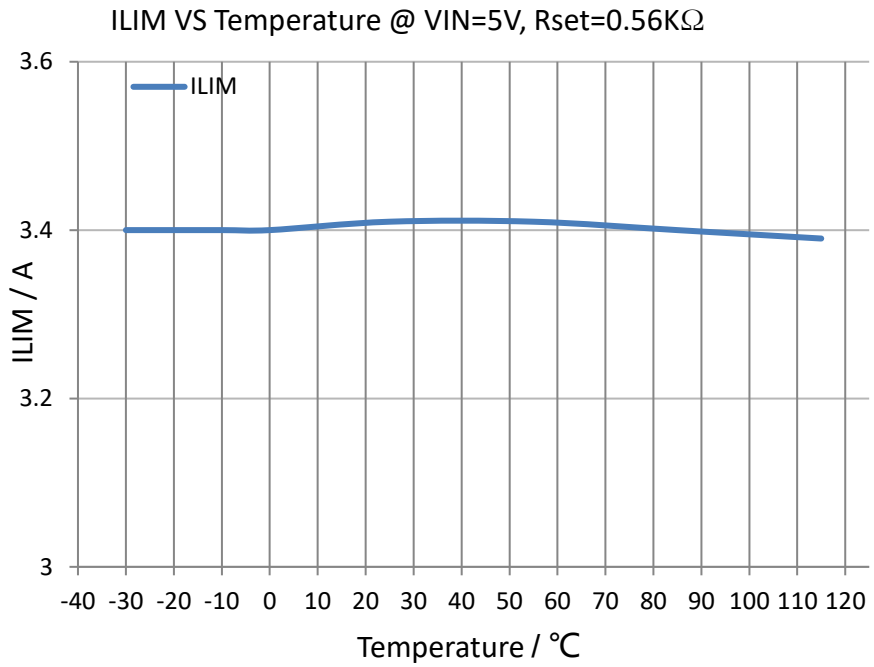

Figure 3 Limitation current of load switch VS ambient temperature

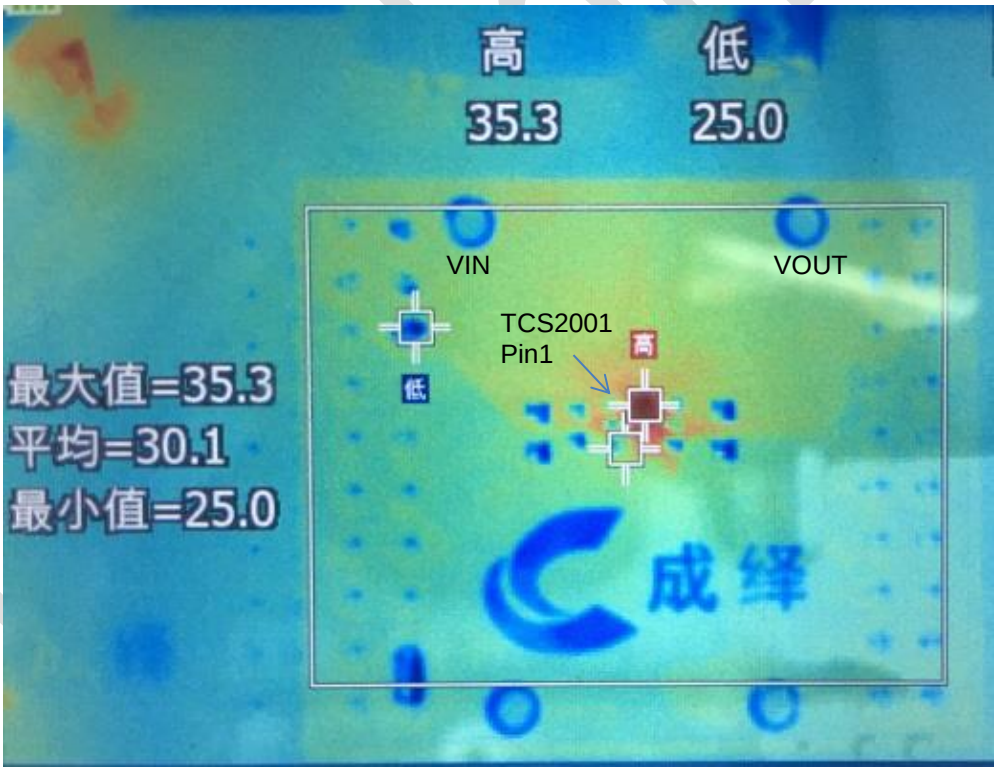

Figure 4 Thermal performance image (ΔT=10℃) while ILOAD=3A @ T_A=25℃

9. Application Notes

9.1 Programming the Current limit Threshold

The user-programmable R_{SET} resistor on the ISET pin sets the current limit threshold of the load switch. The TCS2001 uses an internal regulation loop to sense output current flowing through the switch. The current-limiting threshold is proportional to the current sourced out of the ISET pin, which is also a sensitive node regarding loop stability.

The recommended 1% resistor range for R_{SET} is between 480 Ω and 3800 Ω to ensure loop stability. Equation 1 shows the calculation of current limit threshold:

$$I_{SET} = \frac{1905}{R_{SET}} \quad \text{----------} \quad \text{Equation 1}$$

The following table shows the recommended resistance:

R_{SET} / Ω	1050	790	680	530
I_{SET} /A	1.8	2.4	2.8	3.6

9.2 Layout Guidelines

- TCS2001 placement: Place at least 22-μF low ESR capacitor on VOUT pin for filtering. And the capacitor should be placed between TCS2001 and USB receptacle.
- VIN to VOUT current path: Take special care on the critical path from VIN to VOUT (VBUS of USB). The copper for this path should be as wide as possible to reduce the conducting resistance and help dissipating heat of chip.
- I_{SET} pin: Ensure that there is adequate spacing between VIN pin copper/trace and I_{SET} pin trace to prevent contaminant buildup during the PCB assembly process. To reduce parasitic effects on the current-limit accuracy, R_{SET} resistor should be placed as close to TCS2001 as possible. The 10nF filtering capacitor should be X5R ceramic placed beside the R_{SET} resistor.

10. Mechanical, Packaging, and Ordering Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document.

10.1 Ordering Information

Part number	Top side Marking	Package		
		Name	Description	Version
TCS2001DDCR	2001	SOT236	SOT23-6L	A

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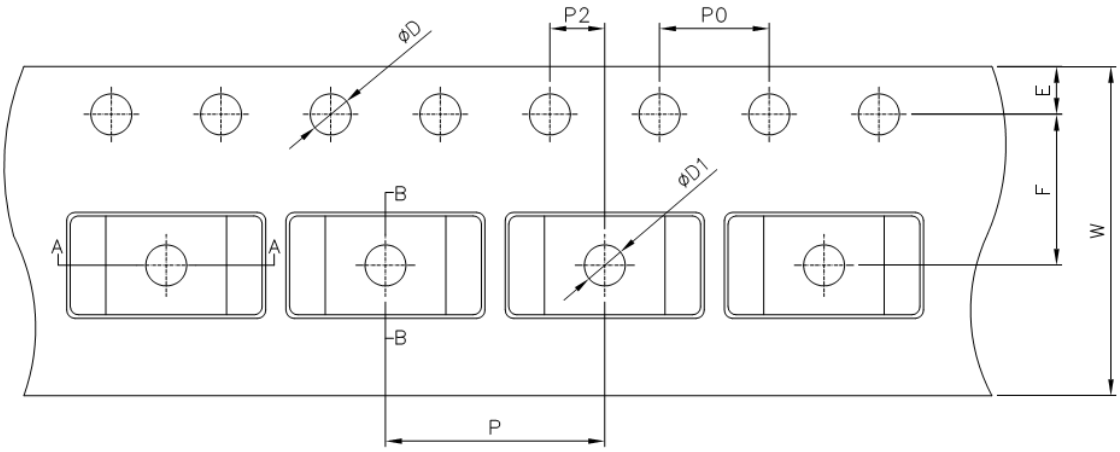
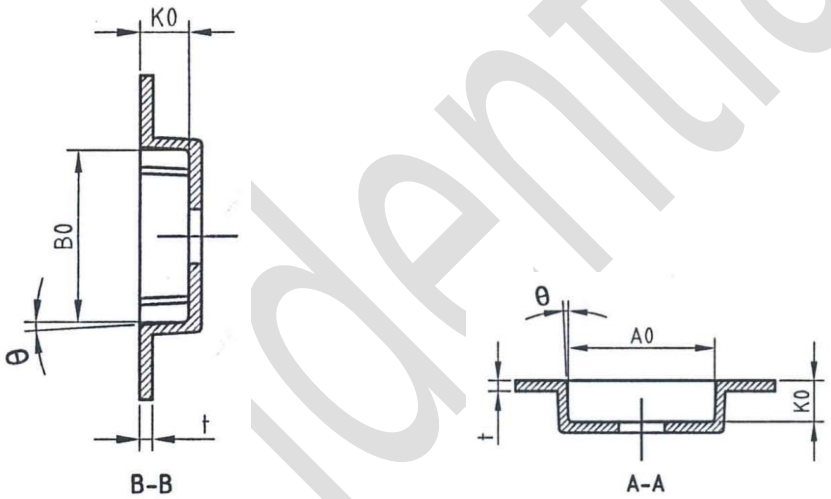
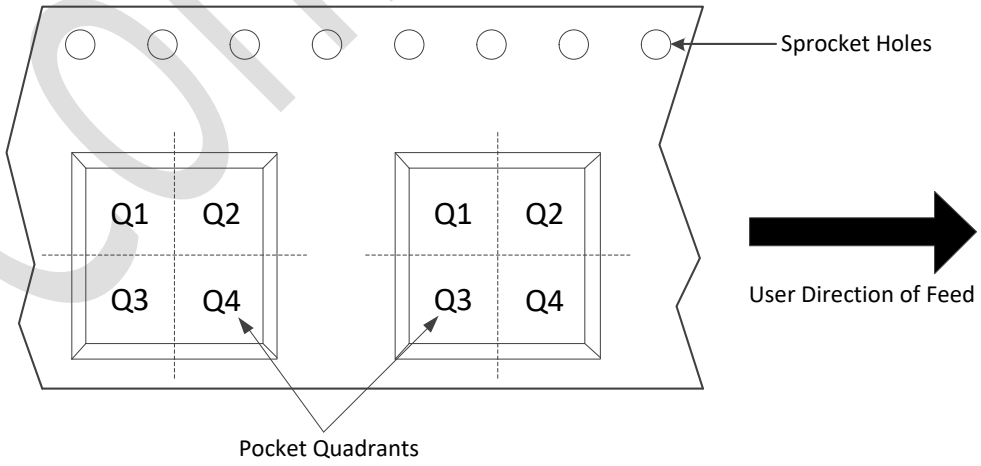
10.2 Tape and Reel Information



Device	Package Type	Pins	SPQ	E (mm)	F (mm)	P2 (mm)	D (mm)	D1 (mm)	P0 (mm)	10P0 (mm)
TCS2001DDCR	SOT23-6	6	3000	1.75	3.5	2.0	1.55	1.05	4.0	40.0



QUADRANT ASSIGNMENTS FOR PIN1 ORIENTATION IN TAPE



Device	W (mm)	P (mm)	A0 (mm)	B0 (mm)	K0 (mm)	t (mm)	θ (mm)	Pin1 Quadrant
TCS2001DDCR	8.0	4.0	3.26	3.23	1.05	0.2	5° MAX	Q1

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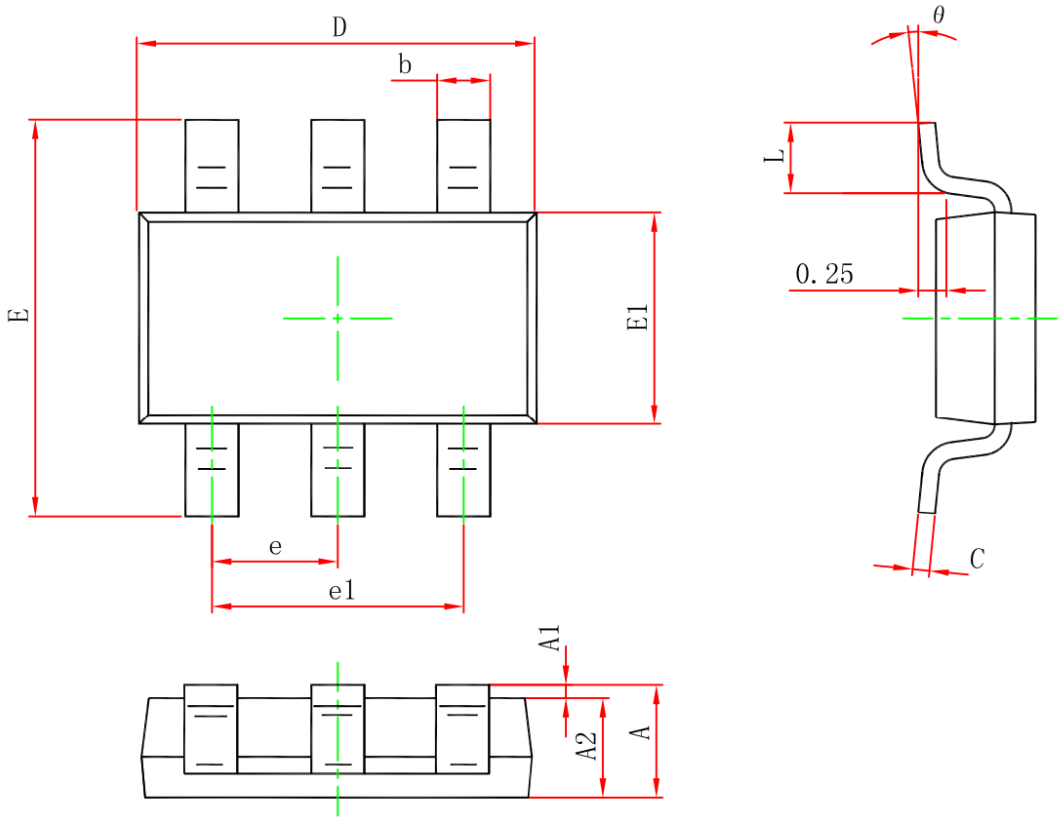
10.3 Package description



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	---	0.900	---	0.035
A1	0.000	0.100	0.000	0.004
A2	0.700	0.800	0.028	0.031
b	0.350	0.500	0.014	0.020
c	0.080	0.200	0.003	0.008
D	2.820	3.020	0.111	0.119
E1	1.600	1.700	0.063	0.067
E	2.650	2.950	0.104	0.116
e	0.95（BSC）		0.037(BSC)	
e1	1.90（BSC）		0.075(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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