USB Type-C Source Controller with Integrated Power Switch

Hynetek Semiconductor Co., Ltd.

HUSB305_A01HB, HUSB305_A01TC

FEATURES

- **USB Type-C 2.0 Compliant**
- **Support BC1.2 DCP Protocols**
  - **BC1.2 DCP mode**
  - **Divider 3 mode**
- **Integrated 15mΩ N-MOSFET with Softstart**
- **Integrated OVP, UVP, UVLO, OCP, FOCP and TSD Protections**
- **9-Lead Panel Level DFN and Flip Chip DFN (3mm × 3mm) Package Available**
- **±2kV HBM ESD Rating for USB IO pins**

APPLICATIONS

AC-DC power adapter

Car charger

GENERAL DESCRIPTION

The HUSB305_A01XX is designed for a Type-C only product. The HUSB305_A01XX can perform as a Source only role with programmable Rp current source. Besides, the HUSB305_A01XX also supports Divider 3, BC1.2 DCP protocols.

The HUSB305_A01XX integrates the VBUS power switch and current sensing resistor to save board space and BOM cost.

The HUSB305_A01XX integrates all required protections such as Over Voltage Protection (OVP), Under Voltage Protection (UVP), Under Voltage Lock Out (UVLO), Over Current Protection (OCP), Fast Over Current Protection (FOCP) and Thermal Shut Down (TSD).

It is available in a PLDFN-9L and FCDFN-9L, 3mm x 3mm package.

TYPICAL APPLICATION CIRCUIT

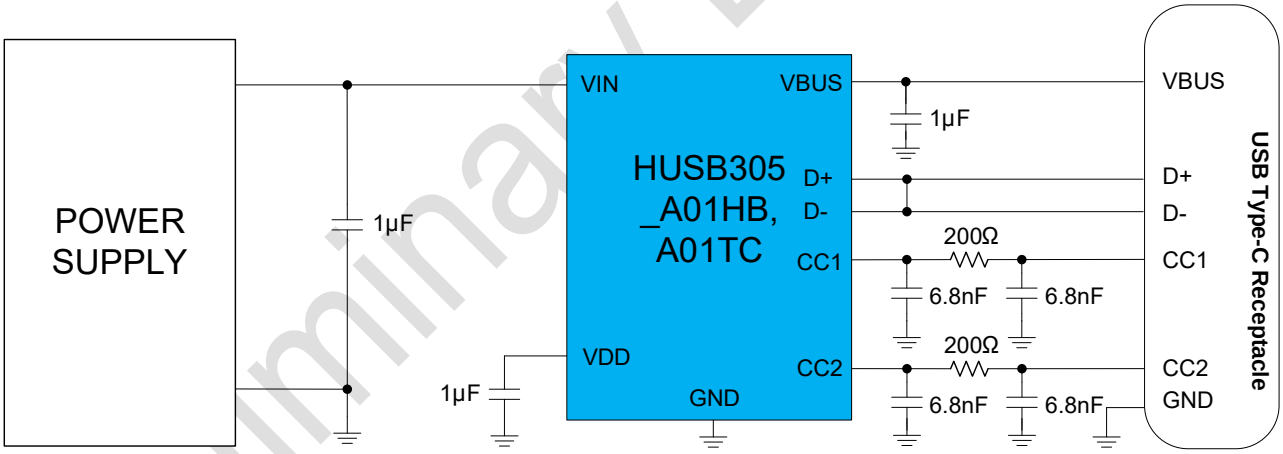

Figure 1. Typical Application Circuit

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REVISION HISTORY

Version	Date	Descriptions
Rev. 0.0	01/2022	Preliminary version
Rev. 0.1	05/2022	Revised ordering guide information
Rev. 0.2	09/2022	Revised packaging information

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PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

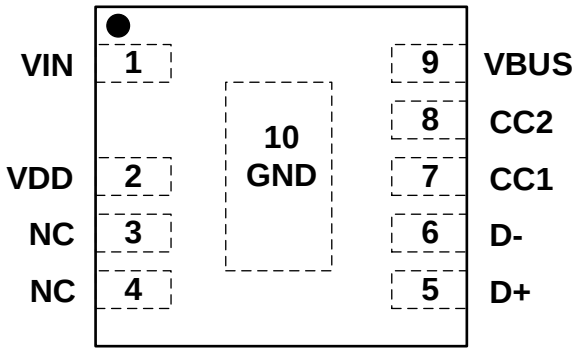

Figure 2. Pin Configuration (Top View)

Table 1. Pin Function Descriptions

Pin No.	Pin Name	Type[1]	Description
1	VIN	P	Supply voltage input. Connect this pin to GND via a recommended 1μF ceramic capacitor.
2	VDD	AO	Internal 3.3V regulator output for system power. Connect 1μF ceramic capacitor at this pin to ground.
3,4	NC	-	No Connection. Keep this pin floating.
5	D+	DIO	USB D+ line.
6	D-	DIO	USB D- line.
7	CC1	AIO	USB Type-C CC1 line.
8	CC2	AIO	USB Type-C CC2 line.
9	VBUS	P	Output of the integrated power switch. Connect this pin to USB Type-C connector.
10	GND	A	Exposed pad. Connect this pad to the ground of the system board.

1 Legend:
A = Analog Pin
P = Power Pin
D = Digital Pin
I = Input Pin
O = Output Pin

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SPECIFICATIONS

V_{IN} = 5V, T_A = 25°C, unless otherwise noted.

Table 2.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
POWER SUPPLY						
Supply Voltage	V_{IN}		3.15		12.6	V
Supply Voltage UVLO Threshold	V_{IN_UVLO}	Rising edge		3.0		V
Supply Voltage UVLO Hysteresis	$V_{IN\_UVLO\_HYS}$			300		mV
Supply Current	I_{CC}	CC is attached, normal operation		3		mA
Quiescent Current	I_Q	CC1 and CC2 pins are floating		300		μA
VDD						
Internal Regulator Output	V_{DD}			3.3		V
Type-C						
1.5A Mode Pull-Up Current Source	I_{RP_1P5}		166	180	194	μA
3.0A Mode Pull-Up Current Source	I_{RP_3P0}		304	330	356	μA
UFP Detection Threshold at 1.5A Current	$vR_{d\_OPEN\_1.5A}$			1.6		V
UFP Detection Threshold at 3.0A Current	$vR_{d\_OPEN\_3A}$			2.6		V
BC1.2 DCP MODE						
D+ and D- Shorting Resistance	R_{DPM_SHORT}	V_{D+} = 0.6V		20		Ω
D+ Leakage Resistance	R_{DP_LKG}	V_{D+} = 0.6V		800		kΩ
D− Leakage Resistance	R_{DM_LKG}	V_{D-} = 0.6V		800		kΩ
DCP Mode Entry Threshold	V_{SEL_REF}		1.8	2	2.2	V
DIVIDER 3 MODE						
D+ Output Voltage	V_{DP_APP}	V_{IN} = 5V		2.7		V
D− Output Voltage	V_{DM_APP}	V_{IN} = 5V		2.7		V
D+ Output Impedance	R_{DP_PAD}	I_{DP} = −5μA		30		kΩ
D− Output Impedance	R_{DM_PAD}	I_{DM} = −5μA		30		kΩ
POWER SWITCH						
ON Resistance		VIN pin to VBUS pin		15		mΩ
OVER VOLTAGE PROTECTION						
OVP Protection Threshold	V_{IN_OV}	Reference to 5V	115	120	125	%
OVP De-bounce Time	t_{OVP_DEB}			10		μs
UNDER VOLTAGE PROTECTION						
UVP Protection Threshold	V_{IN_UV}	Reference to 5V	75	80	85	%
UVP De-bounce Time	t_{UVP_DEB}			1		ms
OVER CURRENT PROTECTION						
OCP Protection Threshold	I_{IN_OC}	Reference to internal I_{IN} reference		125		%
OCP De-bounce Time	t_{OC_DEB}			2.5		ms
FOCP Protection Threshold	I_{IN_FOCP}			12		A
THERMAL SHUT DOWN						
Thermal Shut Down Threshold	T_{TSD}			150		ºC
Thermal Shut Down Hysteresis	T_{TSD_HYS}			20		ºC

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RECOMMENDED OPERATING CONDITIONS

Table 3.

Parameter	Rating
VIN Input Voltage	4.75V to 5.5V
Operating Junction Temperature Range (T_J)	−40°C to 125°C
Ambient Temperature Range (T_A)	-40°C to 85°C

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ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
VIN, VBUS, OPTO	−0.3V to +16V
CC1, CC2, D+, D−	−0.3V to +16V
Operating Temperature Range (Junction)	−40°C to +150°C
Soldering Conditions	JEDEC J-STD-020
Electrostatic Discharge (ESD)	
Human Body Model	±2000V
Charged Device Model	±500V

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Close attention to PCB thermal design is required.

θ_{JA} is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure.

θ_{JC} is the junction to case thermal resistance.

Table 5. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
PLDFN3x3-9L	75	54	°C/W
DFNFC3x3-9	87	56	°C/W

ESD CAUTION

Electrostatic Discharge Sensitive Device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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THEORY OF OPERATION

The HUSB305_A01XX is designed for a Type-C power adaptor under 15W. With power switch integrated inside the chip, the HUSB305_A01XX minimizes the quantities of external components and achieves highly integrated total system solution.

VIN AND VBUS PINS

VIN PIN

VIN pin is the power supply input, which is derived from the output of the AC-DC or DC-DC converter. Connect a 1μF decoupling MLCC between VIN pin and GND pin.

The VIN pin is also connected to the drain of internal power switch.

VBUS PIN

VBUS pin is the power output pin of the HUSB305_A01XX. When Type-C connection is established, the internal power switch is turned on with a soft start time of 1ms, and the VIN voltage is passed to VBUS pin.

The VBUS pin is connected to the source of internal power switch.

DISCHARGE FUNCTION

There are discharge circuits on both VIN pin and VBUS pin to help discharge the voltage quickly when any fault or a disconnection event happens.

During discharge mode, a typical 200Ω resistor is connected between VIN or VBUS pin to GND pin. The typical discharge time out is 300ms.

INTERNAL REGULATOR

An internal liner regulator is used to provide 3.3V for internal circuits. Connect a 1μF MLCC to VDD pin for decoupling.

CC1 AND CC2 PINS

CC1 and CC2 pins are used to detect Type-C connection.

TYPE-C CC FUNCTION

CC1 and CC2 are the Configuration Channel pins used for connection and attachment detection, plug orientation determination.

The HUSB305_A01XX monitors the status of CC1 and CC2 pins and decide which state should HUSB305_A01XX enter.

CC1 and CC2 are configured as Source only mode with 1.5A and 3A current advertising. The default Rp current on CC1 and CC2 is I_{CC_3P0}, which means 3A current advertising.

The CC1 and CC2 can tolerance a voltage up to 16V. This is helpful for the HUSB305_A01XX to survive in the failure when the CC1 or CC2 is shorted to the VBUS pin.

CHARGING PROTOCOLS AUTO SELECTION (D+ AND D- PIN)

The HUSB305_A01XX supports BC1.2 DCP and Divider 3 protocols. According to the different status of D+ and D- pins, the HUSB305_A01XX recognizes the attached Sinks and apply the fast charging protocol automatically.

DPDM_APP MODE

The DPDM_APP mode is the mode that the HUSB305_A01XX supports the Divider 3 charging protocol. In the DPDM_APP mode, the HUSB305_A01XX outputs 2.7 V DC voltage on both D+ and D- pins. The 2.7 V can be pulled down by the attached Sink. If D+ or D- pin is pulled down below V_{SEL_REF}, the HUSB305_A01XX exits the DPDM_APP mode and enters into DPDM_DCP mode.

DPDM_DCP MODE

The DPDM_DCP mode is the mode that the HUSB305_A01XX supports BC1.2 DCP protocol. The 2.7 V DC sources are removed and the D+ and D- pins are shorted through R_{DPM_SHORT} resistor. It is possible for the attached Sink to start primary, secondary and HVDCP detection processes when the HUSB305_A01XX is in DPDM_DCP mode.

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OVER VOLTAGE PROTECTION

The HUSB305_A01XX detects the VIN pin voltage to achieve over-voltage protection function. The threshold to trigger over-voltage protection has two options that is configured by internal fuse options. The default option is 120% of 5V. When the over-voltage condition occurs, the HUSB305_A01XX turns of the internal power switch and enters into discharge mode. When the over-voltage condition is removed, the HUSB305_A01XX performs re-connection with attached device.

UNDER VOLTAGE PROTECTION

The HUSB305_A01XX detects the VIN pin voltage to achieve under-voltage protection function. The threshold to trigger under-voltage protection is 80% of 5V. When the under-voltage condition occurs and the UVP function is enabled, the HUSB305_A01XX turns of the internal power switch and enters into discharge mode. When the under-voltage condition is removed, the HUSB305_A01XX performs re-connection with attached device.

OVER CURRENT PROTECTION AND CONSTANT CURRENT

The HUSB305_A01XX senses the current flowing through the internal power switch. This current information is used to perform the Over Current Protection (OCP) when current limit event happens.

There are four options of current limit thresholds that can be set by internal fuses and the default value is 120% of the rating current.

OCP

When the sensed current exceeds the internal current limit threshold, the over-current protection takes action and the HUSB305_A01XX turns off the internal power switch, resets internal status and performs re-connection with attached device.

FAST OVER CURRENT PROTECTION

The HUSB305_A01XX integrates FOCP protection function. When the VBUS is hard shorted by fault, the output current increases sharply. When the output current reaches the FOCP threshold, the protection circuit takes action and turns off the internal power switch after the FOCP de-bounce time. When the short condition is removed, the HUSB305_A01XX is reset to standby mode and will recover again.

The typical FOCP threshold is 12A to protect the internal power switch from being damaged.

THERMAL SHUT DOWN

The HUSB305_A01XX has internal temperature sensing circuit that monitors the junction temperature. When the junction temperature rises above 150°C, over-temperature protection takes action and the internal power switch is turned off immediately. When the junction temperature falls below 130°C, the HUSB305_A01XX is reset to standby mode and will recover again.

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TYPICAL APPLICATION CIRCUITS

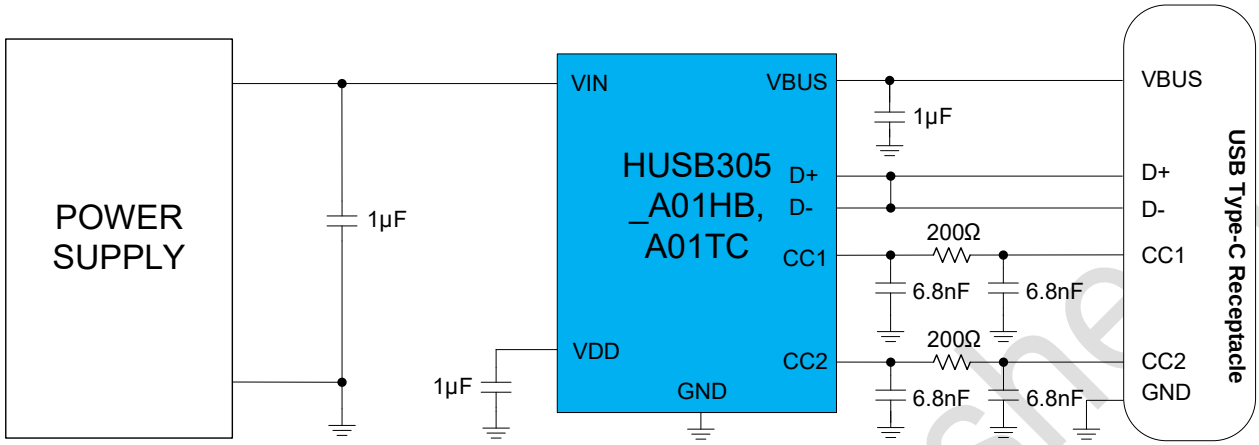

Figure 3. Travel Adaptor and Car Charger Application Circuit

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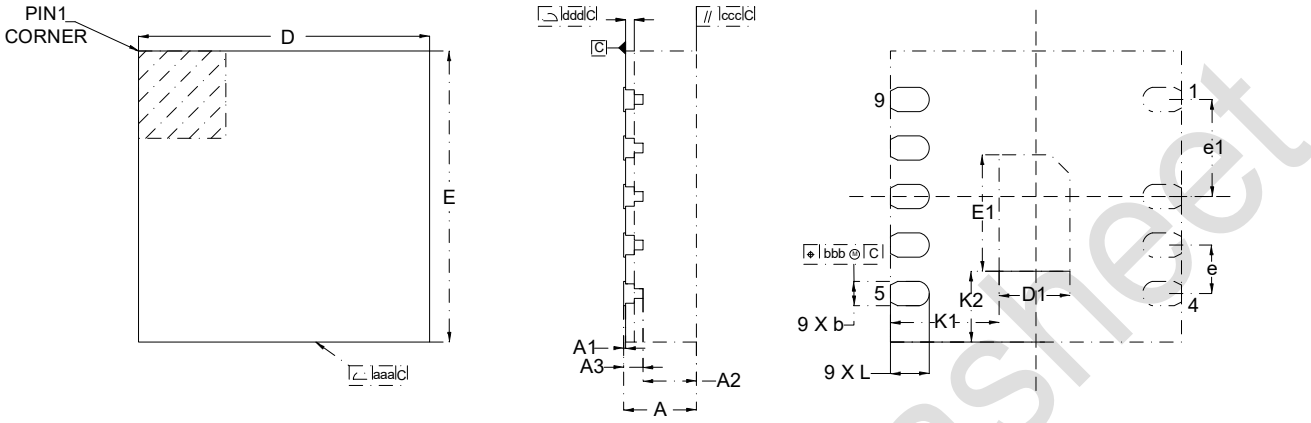
PACKAGE OUTLINE DIMENSIONS



TOP VIEW SIDE VIEW BOTTOM VIEW

	DIMENSION IN MILLIMETERS		
SYMBOLS	MIN	NOM	MAX
A	0.700	0.750	0.800
A1	0.000	0.020	0.050
A2		0.550	
A3		0.203 REF	
b	0.200	0.250	0.300
D		3.000	
E		3.000	
D1	0.630	0.730	0.830
E1	1.100	1.200	1.300
e		0.500	
e1		1.000	
L	0.350	0.400	0.450
K1		1.120 REF	
K2		0.730 REF	
aaa		0.100	
bbb		0.100	
ccc		0.100	
ddd		0.050	

Figure 4. FCDFN-9L Package, 3 mm × 3 mm

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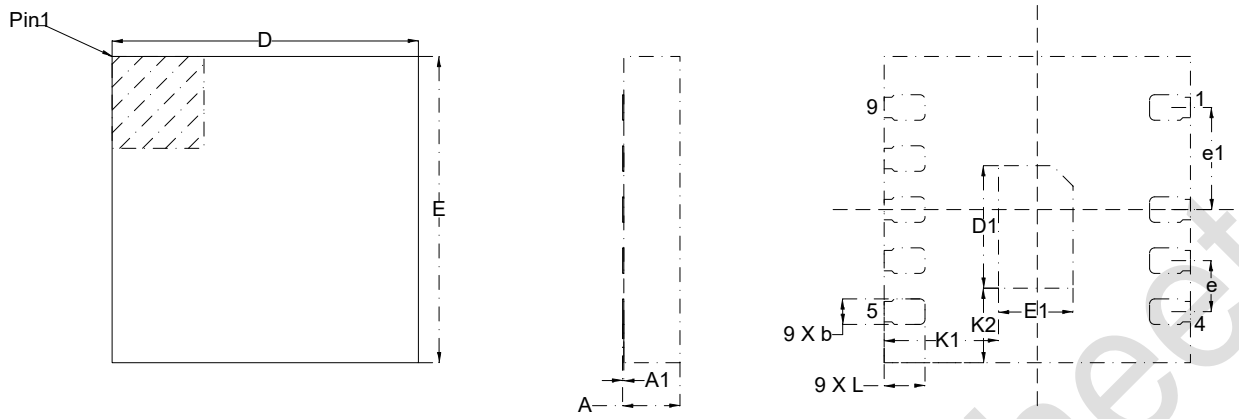

TOP VIEW SIDE VIEW BOTTOM VIEW

	DIMENSION IN MILLIMETERS		
SYMBOLS	MIN	NOM	MAX
A	0.512	0.562	0.612
A1	0.000	0.012	0.017
b	0.200	0.250	0.300
D	2.900	3.000	3.100
E	2.900	3.000	3.100
D1	0.630	0.730	0.830
E1	1.10	1.20	1.30
e	0.450	0.500	0.550
e1	0.950	1.000	1.050
L	0.350	0.400	0.45
K1		1.12	
K2		0.73	

Figure 5. PLDFN-9L Package, 3 mm × 3 mm

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PACKAGE TOP MARKING

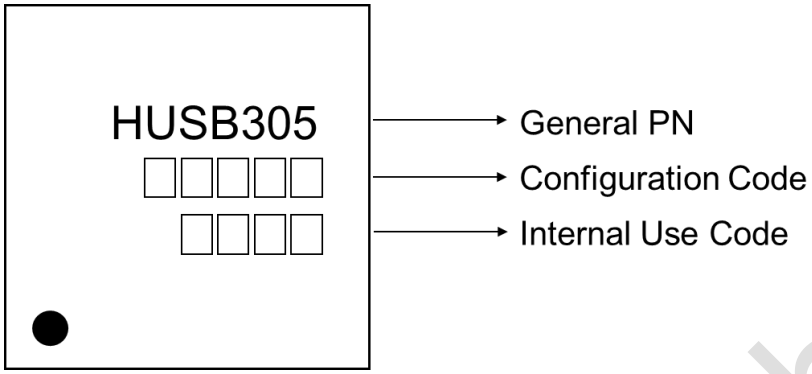

Figure 6. HUSB305_A01XX Package Top Marking

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ORDERING GUIDE

Model[1]	T_J Temp (℃)	Pkg Type	Pkg Opt	Pkg Qty
HUSB305_A01HB	-40 to 125	FCDFN3x3-9L	Tape & Reel	5000
HUSB305_A01TC	-40 to 125	PLDFN3x3-9L	Tape & Reel	4000

[1] Contact Hynetek for more configuration info.

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