USB Type-A Port Controller with Power Switch

Hynetek Semiconductor Co., Ltd.

HUSB304

FEATURES

Integrated 15 mΩ Load Switch
Programmable Current Limit
Low Load Current Sensing
Automatic DPDM Detection

- **Apple 5 V 2.4 A Mode**
- **USB DCP Applying 1.2 V**
- **BC 1.2 DCP**
- **Chinese Telecommunication Industry**

Standard YD/T 1591-2009
Status Indication
Over Voltage and Over Current Protection
Low Operation Current
±8 kV HBM ESD Rating for USB IO pins

GENERAL DESCRIPTION

The HUSB304 is a USB port controller, which integrates common functions for a USB type-A port. There is an ultra-low Rdson (15 mΩ) N-channel MOSFET integrated. It is designed for a 5V USB type-A port application, which requires a high current switch. The programmable current limit provides an easy way to fine-tune the current limit through an external resistor. The can detect its load current and change its status output to notify that there is a load applied at the current USB type-A port. The output voltage and output current are both monitored by the HUSB304 so that it can performs an OVP, OCP, OTP.

The HUSB304 has Divider 3, USB DCP applying 1.2 V, BC 1.2 DCP and Chinese Telecommunication Industry Standard YD/T 1591-2009 protocols inside. It can automatically detect the attached devices and switch to the proper charging protocol.

Only 100 μA operation current is required for the HUSB304 to save the standby power loss of whole system.

APPLICATIONS

USB Type-A Adaptor

TYPICAL APPLICATION CIRCUIT

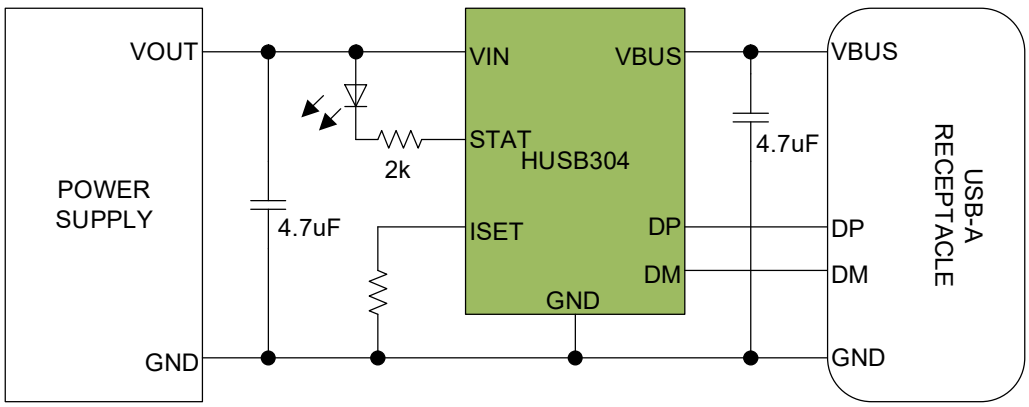

Figure 1. HUSB304 Typical Application

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REVISION HISTORY

Version	Date	Descriptions
Rev. 1.0	07/2020	Initial version
Rev. 1.1	11/2021	Add Block Diagram and Theory of Operation
Rev. 1.2	08/2022	Add PN: HUSB304-03
Rev. 1.3	09/2023	Change Divider 3 to Apple 5 V 2.4 A Mode in the description

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

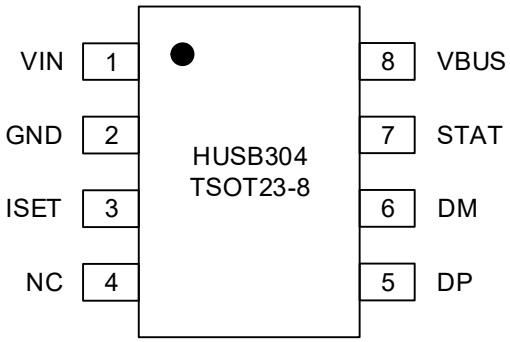


Figure 2. Pin Assignment

Table 1. Pin Function Descriptions

Pin No.	Pin Name	Type[1]	Description
1	VIN	PI	Input pin to power switch and internal circuit
2	GND	AO	Ground plane. All signals are referred to this pin
3	ISET	AI	This pin is used to set the constant current (CC) limit threshold. Tie a resistor to ground can vary the CC threshold. For HUSB304, it is trimmed at 2.8 A
4	NC	-	Not Connected Pin
5	DP	DIO	USB D+ line of type-A connector
6	DM	DIO	USB D- line of type-A connector
7	STAT	AO	Open drain output. It is a status indication. It is active Low to indicate the load current flowing this port is lower than Light Load Threshold in HUSB304-01 while high impedance (Hi-Z) in HUSB304-03. For HUSB304-02, this pin outputs blinking pulses when any fault is triggered
8	VBUS	PO	Output of USB Type-A port

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

SPECIFICATIONS

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

Table 2.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
VIN Input Supply						
Input Voltage Range	V_{IN_RG}		3		6.5	V
VIN UVLO Threshold	V_{IN_UVLO}	VIN Rising Edge to Clear UVLO		3.8		V
UVLO Hysteresis	V_{UVLO_HYS}			0.7		V
VIN Quiescent Current	I_Q	V_{IN}=5 V		100		μA
ISET						
Current Limit Threshold	I_{LIM}	R_{ISET}=200 kΩ		2.8		A
		R_{ISET}=348 kΩ		1.8		A
STAT						
Low load threshold	I_{LLD}	V_{IN}=5 V		40		mA
STAT Sink current	I_{STAT}	When STAT output Low		4		mA
Protections						
OVP Threshold	V_{OVP}		5.6	5.8	6	V
OVP Hysteresis	V_{OVP_HYS}			0.3		V
VBUS UVP Threshold	V_{VBUS_UV}	VBUS UVP and in CL mode		3.6		V
VBUS UVP Hysteresis	$V_{VBUS\_UV\_HYS}$			0.1		V
OTP Threshold	T_{OTP}			135		℃
OTP Hysteresis	T_{OTP_HYS}			20		℃
Fault recovery time	t_{try}			0.65		s
BC1.2 DCP Mode						
DP/DM shorted resistance	R_{DPM_SHORT}	V_{DP}=0.6 V		50		Ω
DP Leakage Resistance	R_{DP_LKG}	V_{DP}=0.6 V		1.05		MΩ
DM Leakage Resistance	R_{DM_LKG}	V_{DP}=0.6 V		1.05		MΩ
Divider 3 Mode						
DP output voltage	$V_{DP\_2.7V}$	V_{IN}=5 V		2.7		V
DM output voltage	$V_{DM\_2.7V}$	V_{IN}=5 V		2.7		V
DP output impedance	$R_{DP\_2.7V}$	I_{DP}=-5 μA		30		kΩ
DM output impedance	$R_{DM\_2.7V}$	I_{DM}=-5 μA		30		kΩ
USB DCP Applying 1.2 V						
DP output voltage	$V_{DP\_1.2V}$	V_{IN}=5 V		1.2		V
DP output impedance	$R_{DP\_1.2V}$	IDP=-5 μA		100		kΩ
Power FET						
Conduction Resistance	R_{DSON}			15		mΩ

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
VIN, VBUS, STAT to GND	−0.3 V to 7 V
DP, DM, ISET to GND	−0.3 V to 7 V
Operating Temperature Range (Junction)	−40°C to 150°C
Soldering Conditions	JEDEC J-STD-020
Electrostatic Discharge (ESD)	
Human Body Mode (VIN, ISET and STAT pin)	±4000 V
Human Body Mode (DP, DM and VBUS pin)	±8000 V

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 4. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
TSOT23-8	88	45	°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.

FUNCTIONAL BLOCK DIAGRAM

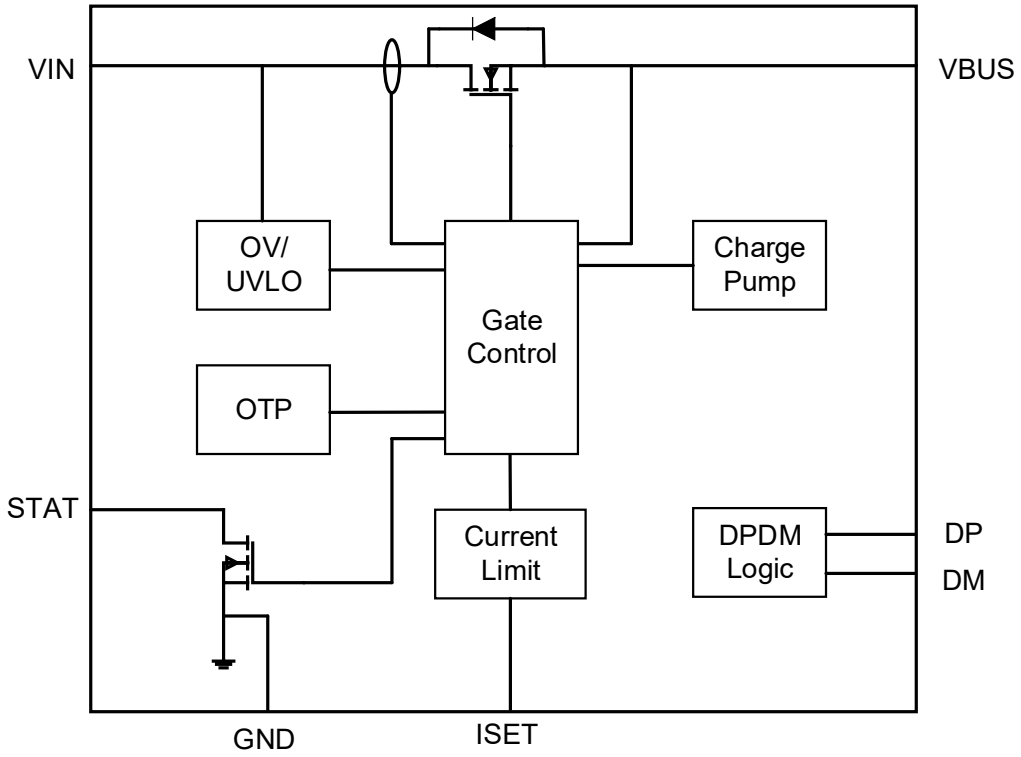


Figure 3. HUSB304 Functional Block Diagram

THEORY OF OPERATION

HUSB304 is a USB Type-A port controller that integrates multiples essential functions for a USB Type-A port. There is an ultra-low R_{DSON} (15 mΩ) N-channel MOSFET integrated as the VBUS load switch. It is designed for a 5 V USB Type-A port application that requires a high current switch with multiple charging protocols. The programmable current limit provides an easy way to fine-tune the current limit through an external resistor. HUSB304-01 and HUSB304-03 can detect its load current and change its STAT output to notify that there is a load applied at this port. HUSB304-02 employs STAT pin to indicate the fault status.

VIN AND POR

The VIN pin is the input source of internal circuit of HUSB304. There is a under voltage lockout (UVLO) circuit to control the internal circuit and the power switch. When the VIN reaches the V_{IN_UVLO}, the internal circuit works and is able to enable the output at VBUS pin. Built-in hysteresis of UVLO (V_{UVLO_HYS}) prevents unwanted ON/OFF cycling due to input voltage drop from large current surges. If VIN is lower than V_{IN_UVLO}- V_{UVLO_HYS} , the internal circuit is reset and Gate Control is disabled.

The VIN pin is also the input of integrated power FET. The load current flows from VIN pin to VBUS pin.

POWER SWITCH

HUSB304 integrates a power switch to block the voltage from VIN to VBUS. This power switch has low conduction resistance as low as to 15 mΩ. It is normally enabled to conduct the power from VIN pin to VBUS pin. Only a valid fault is detected at this USB port, the Gate Control is disabled.

ISET AND CURRENT LIMIT MODE

HUSB304 employs VIN and VBUS to sense the load current on the USB Type-A port. It can detect the ISET pin to determine the current limit threshold. The current limit threshold (I_{LIM}) is set by the resistor R_{ISET} across ISET pin and GND. The recommend R_{ISET} as show in Table 5.

Table 5.

R_{ISET} (KΩ)	Current Limit Threshold (A)
200	2.8
348	1.8

Once the load current flowing from VIN to VBUS exceeds the current limit threshold (I_{LIM}), HUSB304 tries to limit load current by reducing the VBUS voltage. If the load current continues to increase which results in the VBUS to be lower than V_{VBUS_UV}, the VBUS UVP fault is triggered. HUSB304 enters hiccup mode until the VBUS UVP fault is cleared.

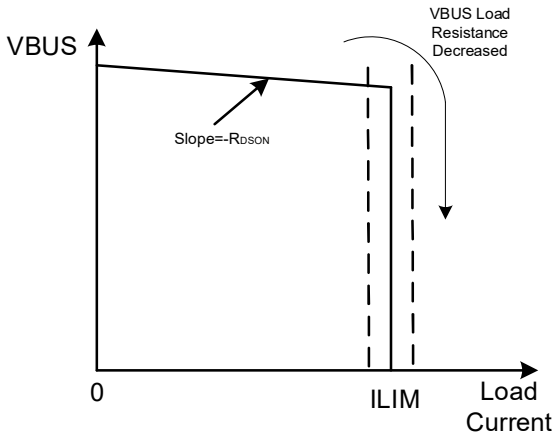


Figure 4. HUSB304 Output IV Characteristics

The HUSB304 may enter hiccup mode if an overload condition is present long enough to activate OTP fault during the Current Limit Mode. This is due to the relatively large power dissipation [(VIN – VBUS) × I_{LIM}] driving the junction temperature up. HUSB304 turns off power FET when the junction temperature exceeds OTP threshold (T_{OTP}) and remains power FET off until the junction temperature cools 20°C. After that, HUSB304 enters hiccup mode.

STAT

The STAT pin is an open-drain output. HUSB304 monitors the load current from VIN to VBUS. In HUSB304-01 and HUSB304-03, STAT is employed to indicate load current is lower than I_{LLD}. The STAT pin is pulled down when the load current condition is met in HUSB304-01 or high impedance in HUSB304-03. Similarly, when the load current is higher than I_{LLD}, the STAT pin returns to Hi-Z in HUSB304-01 or be active low in HUSB304-03.

In HUSB304-02, STAT is configured as fault status indication, it outputs blinking pulses under an OTP, OVP or VBUS UVP fault condition, as well as the following hiccup mode. When the device in UVLO, STAT is Hi-Z.

CHARGING PROTOCOLS AUTO SELECTION (DP AND DM PIN)

The HUSB304 supports 3 USB charging protocols including Divider 3, USB DCP applying 1.2 V, BC1.2 DCP. According to the different status of DP and DM pins, the HUSB304 recognizes the attached device and switches to the correct charging protocol automatically.

DPDM_APP MODE

The DPDM_APP mode is the mode that the HUSB304 supports the Divider 3 charging protocol. In the DPDM_APP mode, the HUSB304 outputs 2.7 V DC voltage on both DP and DM pins. The DP and DM voltage may be changed by attached device and then the HUSB304 enters USB DCP Applying 1.2 V Mode.

USB DCP APPLYING 1.2 V

The USB DCP Applying 1.2 V mode is the mode that the HUSB304 supports a specified DCP protocol. In this mode, the 2.7 V DC sources are removed and the DP and DM pins are shorted through R_{DPM_SHORT} resistor. Another 1.2 V DC voltage is applied at DP and DM pin.

DPDM_DCP MODE

The HUSB304 supports BC1.2 DCP protocol. The DP and DM pins are shorted through R_{DPM_SHORT} resistor. It is possible for the attached Sink to start primary, secondary detection processes when the HUSB304 is in DPDM_DCP mode.

VBUS

The VBUS pin is the output of power FET. It is connected to the USB Type-A connector. During hiccup mode, VBUS may be 0 V during t_{try} since the internal power switch is disabled by Gate Control.

FAULT RESPONSE

The HUSB304 monitors the VIN voltage, VBUS voltage, load current from VIN to VBUS and the internal junction temperature.

Once VIN is above OVP threshold (V_{OVP}), OVP fault is triggered. The internal power FET shuts down. Only after the OVP fault is cleared, the HUSB304 enters hiccup mode.

The VBUS voltage is also monitored. There is a VBUS UVP fault mechanism implemented for VBUS voltage, see the section of “ISET AND CURRENT LIMIT MODE” for more details.

The HUSB304 has internal over-temperature protection, OTP. It is used to protect the internal FET from damage and assist with overall safety of the system. OTP fault is triggered when the junction temperature exceeds T_{OTP}.

The hiccup mode is applied for the VBUS UVP, OTP and OVP, when the VBUS UVP, OTP and OVP flags are cleared, the HUSB304 is going to perform restart after t_{try}.

TYPICAL APPLICATION CIRCUITS

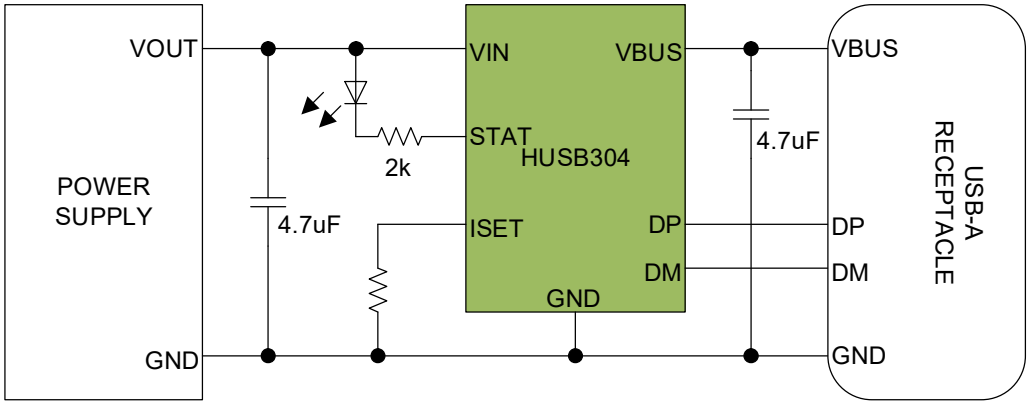
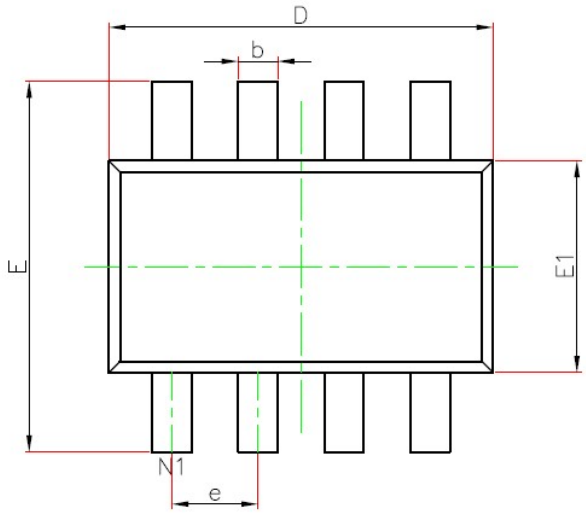
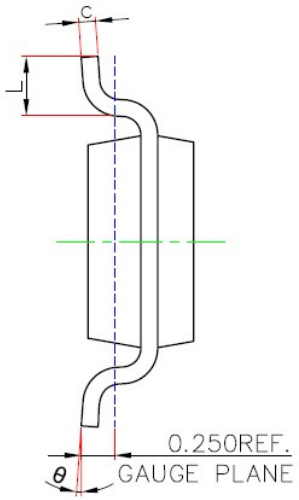


Figure 5. USB Type-A 5V2.4A Port

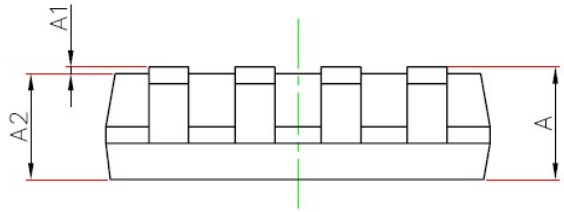
PACKAGE OUTLINE DIMENSIONS



TOP VIEW



SIDE VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	------	1.100	-------	0.043
A1	0.000	0.100	0.000	0.004
A2	0.700	1.000	0.028	0.039
D	2.850	2.950	0.112	0.116
E	2.650	2.950	0.104	0.116
E1	1.550	1.650	0.061	0.065
b	0.200	0.400	0.008	0.016
c	0.080	0.200	0.003	0.008
e	0.650(BSC)		0.026(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Figure 6. TSOT23-8 Package

PACKAGE TOP MARKING

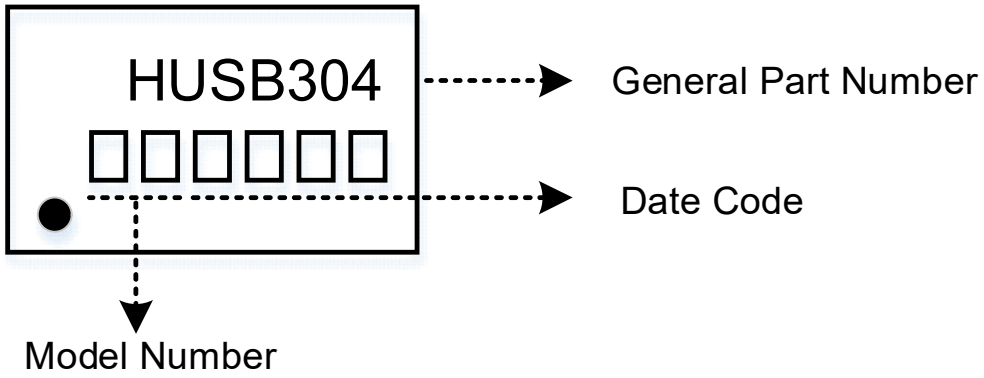


Figure 7. HUSB304 Package Top Marking

ORDERING GUIDE

Model	Temperature Range (°C)	STAT Configuration	Package Option	Quantity
HUSB304-01	-40 to 125	LLD Indication, active low	TSOT23-8L	Tape & Reel, 4k
HUSB304-02	-40 to 125	Fault Indication, blinking pulses	TSOT23-8L	Tape & Reel, 4k
HUSB304-03	-40 to 125	LLD Indication, active Hi-Z	TSOT23-8L	Tape & Reel, 4k

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