USB Type-C Source Controller with Power Switch

Hynetek Semiconductor Co., Ltd.

HUSB305

FEATURES

- **Integrated 15mΩ Power Switch**
- **Programmable Current Limit**
- **Low Load Current Sensing**
- **Integrated USB Type-C R_p Current Source**
- **Automatic USB Type-C R_p 1.5A/3A Switching**
- **Status Indication**
- **Over Voltage and Over Current Protection**
- **Low Operation Current**
- **±8kV HBM ESD Rating for USB IO pins**

GENERAL DESCRIPTION

HUSB305 is a USB Type-C Source port controller, which integrates multiples essential functions for a USB Type-C source port. There is an ultra-low conduction resistance (15mΩ) N-channel MOSFET integrated. It is designed for a 5V USB Type-C source 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. HUSB305 can detect its load current and change its status output to notify that there is a load applied at the current USB Type-C port. The output voltage and output current are both monitored by HUSB305 so that it can performs an OVP, OCP, OTP.

HUSB305 has USB Type-C 1.5A/ 3A protocols integrated. It can automatically switch different R_p per the ISET setting.

Only 150μA operation current is required for HUSB305 to save the standby power loss of whole system.

APPLICATIONS

USB Type-C Adaptor

USB A to C Conversion Connector

TYPICAL APPLICATION CIRCUIT

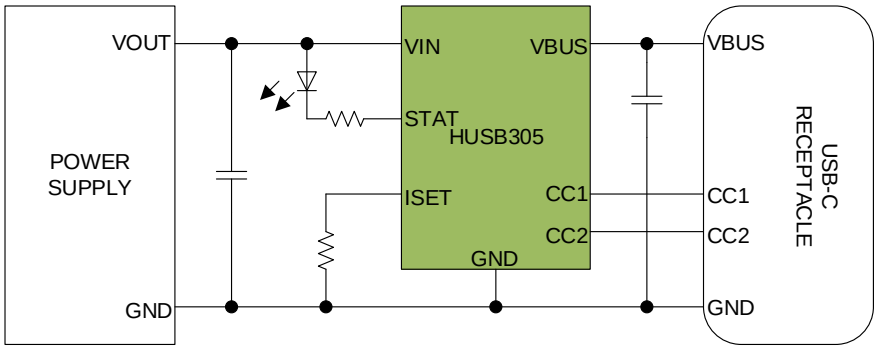

Figure 1. HUSB305 Typical Application

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REVISION HISTORY

Version	Date	Owner	Descriptions
Rev. 1.0	07/2020	Yingyang Ou	Initial version
Rev. 1.1	07/2021	Yingyang Ou	Add Block Diagram and Theory of operation
Rev. 1.2	10/2021	Yingyang Ou	Update Top Marking Update Ordering Guide

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

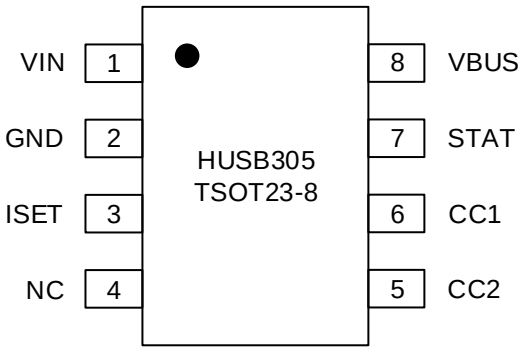


Figure 2. Pin Assignment

Table 1. Pin Function Descriptions

Pin No.	Pin Name	Type[1]	Description
1	VIN	P	Input pin to power switch and internal circuit
2	GND	A	Ground plane. All signals are referred to this pin
3	ISET	I	This pin is used to set the constant current (CC) limit threshold. Tie a resistor to ground can vary the CC threshold. For HUSB305, it is trimmed at 3.6A
4	NC		Not Connected Pin
5	CC2	A	Configuration line 2 of USB Type-C connector
6	CC1	A	Configuration line 1 of USB Type-C connector
7	STAT	O	Open drain output. It is active low to indicate the port is active in HUSB305-01 or output blinking pulse when any fault is triggered in HUSB305-02
8	VBUS	P	Output of USB Type-C 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	VIN=5V, CC is NOT attached		150		μA
ISET						
Current Limit Threshold	I_{LIM}	R_{ISET}=150K		3.6		A
		R_{ISET}=200K		2.8		A
		R_{ISET}=348K		1.8		A
STAT						
Low load threshold	I_{LLD}	VIN=5V		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
Type-C Pull up Current Source						
3A Current Source	I_{RP_3A}			330		μA
1.5A Current Source	$I_{RP\_1.5A}$			180		μA
3A Rp EN Rising threshold	$I_{LIM\_CC\_R}$	3A Rp current source is enabled		2.5		A
3A Rp EN Falling threshold	$I_{LIM\_CC\_F}$	3A Rp current source is enabled		2.4		A
Rd detection threshold 1	$vR_{d\_OPEN\_1.5A}$	1.5A Rp current source is enabled		1.6		V
Rd detection threshold 2	$vR_{d\_OPEN\_3A}$	3A Rp current source is enabled		2.6		V
Ra detection threshold 1	$vR_{a\_OPEN\_1.5A}$	1.5A Rp current source is enabled		0.4		V
Ra detection threshold 2	$vR_{a\_OPEN\_3A}$	3A Rp current source is enabled		0.8		V
Connection Wait Deglitch	$t_{CCdebounce}$	Time to wait before entry of Attached.src		150		ms
VBUS						
VBUS Discharge Resistance	R_{DSCG}	When Power Switch is off, VIN=5V		300		Ω
Power FET						
Conduction Resistance	R_{DSON}	VIN=5V, HUSB305 is in Attached.src		15		mΩ

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
VIN, VBUS, STAT to GND	−0.3 V to +7 V
CC1,CC2, 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 (CC1, CC2 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

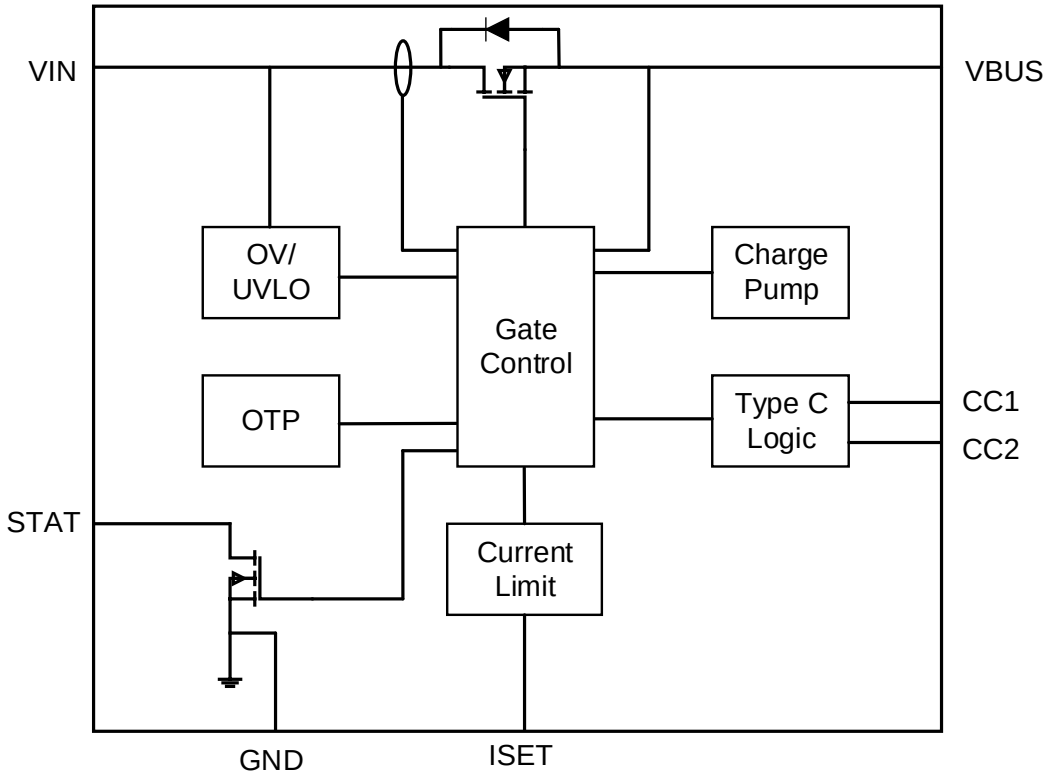


Figure 3. HUSB305 Functional Block Diagram

THEORY OF OPERATION

HUSB305 is a USB Type-C source port controller that integrates multiples essential functions for a USB Type-C source port. There is an ultra-low R_{DSON} (15mΩ) N-channel MOSFET integrated as the VBUS load switch. It is designed for a 5V USB Type-C port application that requires a high current switch up to 3A. The programmable current limit provides an easy way to fine-tune the current limit through an external resistor. HUSB305-01 can detect its load current and change its STAT output to notify that there is a load applied at this port. HUSB305-02 employs STAT pin to indicate the fault status.

VIN AND POR

The VIN pin is the input source of internal circuit of HUSB305. 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 detect the connection of external device. 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

HUSB305 integrates a power FET to block the voltage from VIN to VBUS. This power FET has low conduction resistance as low as to 15mΩ. It is turned off when there is NOT a Sink device attached at CC1 or CC2 pin. Only a valid USB Type-C connection is established between HUSB305 and a Sink, the power FET is turned on.

ISET AND CURRENT LIMIT MODE

HUSB305 employs VIN and VBUS to sense the load current on the USB Type-C 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)
150	3.6
200	2.8
348	1.8

Once the load current flowing from VIN to VBUS exceeds the current limit threshold (I_{LIM}), HUSB305 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. HUSB305 enters hiccup mode until the VBUS UVP fault is cleared.

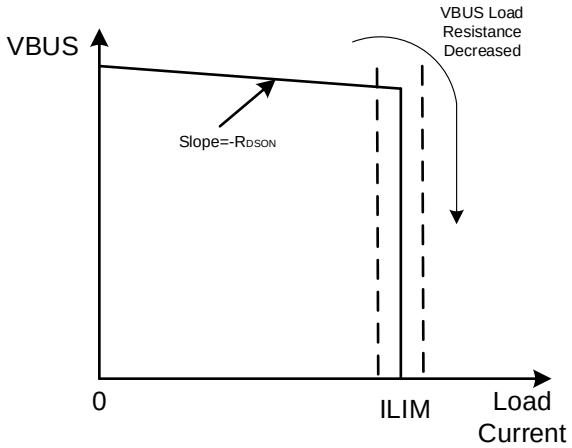


Figure 4. HUSB305 Output IV Characteristics

The HUSB305 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. HUSB305 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, HUSB305 enters hiccup mode.

STAT

The STAT pin is an open-drain output. HUSB305 monitors the load current from VIN to VBUS. In HUSB305-01, STAT is employed to indicate load current is higher than I_{LLD}. The STAT pin is pulled down when the load current condition is met. Similarly, when the load current is lower than I_{LLD}, the STAT pin returns to HIZ.

In HUSB305-02, 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 HIZ.

TYPE-C MODE (CC1 AND CC2)

HUSB305 is used for a USB Type-C source controller. HUSB305 checks the status of CC1 and CC2 before it is going to work. HUSB305 also checks the current limit set by I_{SET} pin and determines the advertised R_p at both CC pins.

After R_p is set, HUSB305 is able to detect a possible connection of a USB Type-C Sink, as shown below.

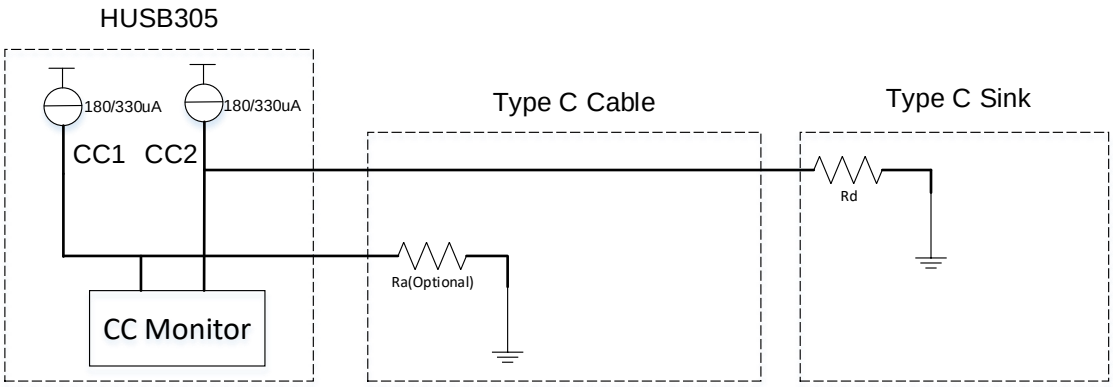


Figure 5. USB Type-C Source Connection with a Sink

The connected CC pin is monitored to check whether a valid USB Type-C attachment or detachment happens.

VBUS

The VBUS pin is the output of power FET. It is connected to the USB Type-C connector. During detachment or hiccup mode, an integrated R_{DSCG} is enabled to dissipate the energy at VBUS pin timely.

FAULT RESPONSE

HUSB305 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 HUSB305 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.

HUSB305 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 HUSB305 is going to perform restart after t_{try}.

TYPICAL APPLICATION CIRCUITS

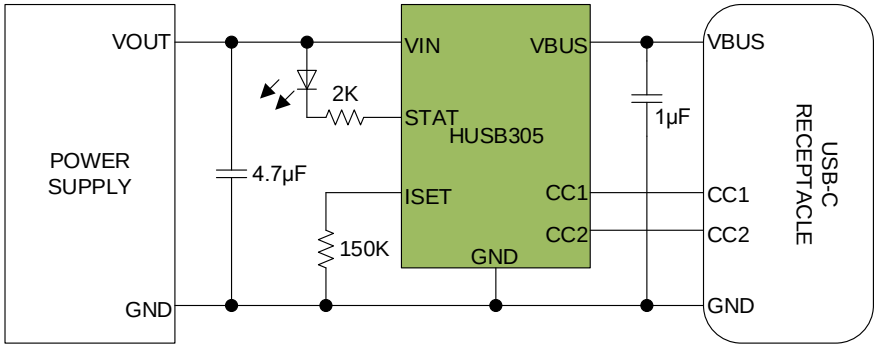


Figure 6. USB Type-C 5V3A Single Source Port

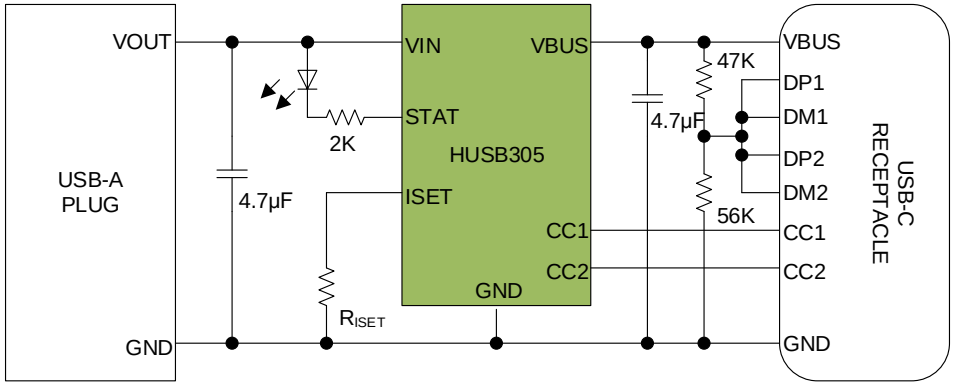
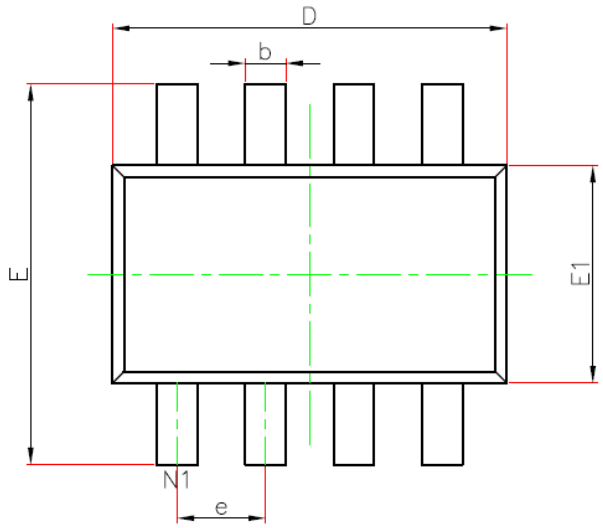
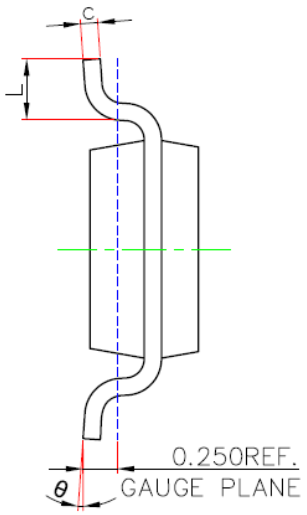


Figure 7. USB A to C Conversion Connector

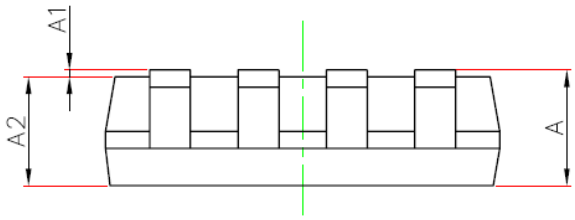
PACKAGE OUTLINE DIMENSIONS



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 8. TSOT23-8 Package

PACKAGE TOP MARKING

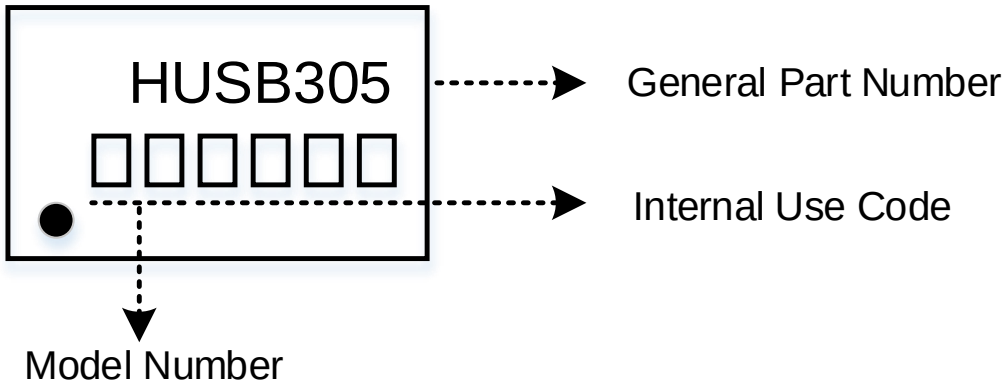


Figure 9. HUSB305 Package Top Marking

ORDERING GUIDE

Model	Temperature Range (℃)	STAT Configuration	Package Option	Quantity
HUSB305-01	-40 to 135	LLD Indication	TSOT23-8L	Tape & Reel, 4K
HUSB305-02	-40 to 135	Fault Indication	TSOT23-8L	Tape & Reel, 4K

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