# <u>28V Over-Voltage Protection Power Distribution</u> <u>Switch</u>

### ✤ GENERAL DESCRIPTION

The AX8733 is an integrated power switch for self-powered and bus-powered Universal Serial Bus (USB) applications with high output absolute rating of 28V.

A built-in charge pump is used to drive the N-channel MOSFET that is free of parasitic body diode to eliminate any reversed current flow across the switch when it is powered off. FLAG is an open-drain output report over-current or over-temperature event and has typical 9ms deglitch timeout period. When the output voltage/current is higher than input voltage, the power switch is turned off by internal output reverse-voltage/current comparator. Several Protection features include current limiting and thermal shutdown to prevent catastrophic switch failure caused by increasing power dissipation when continuous heavy loads or short circuit occurs.

### ✤ FEATURES

- $50m\Omega$  High-Side MOSFET
- Operating Range:2.7V to 5.5V
- Available with Current Limits with Foldback
- 28V Absolute Ratings at VOUT
- 1.5mS Typical Rise Time
- Logic Level Enable Pin, Available with Active-High or Active-Low Version
- Under voltage Lockout
- Fast Overcurrent Response -1.5µs (TYPICAL)
- VOUT OVP: 5.6V(TYPICAL)
- Output Reverse-Voltage/Current Protection
- Deglitched Open-Drain Over-Current Flag Output (FLAG)
- Available with or without Output Shutdown Pull-low Resister
- Fast Role Swap Support
- No Reverse Current when Power Off
- TSOT-23-5 and TSOT-23-6 Package
- RoHS and Halogen free compliance

#### ✤ FEATURES

- High-Side Power Protection Switch
- USB Power Management
- USB Host and Self-Powered Bubs
- USB Bus-Powered Hubs
- Battery-Charger Circuits

### **\* BLOCK DIAGRAM**



\*: AX8733B only

### **\* PIN ASSIGNMENT**



F	PIN		FUNCTION				
TSOT-23-5	TSOT-23-6		FUNCTION				
1	1	OUT	Switch Output: Output MOSFET Source of switch. Typically connect to switched side of load.				
2	2	GND	Ground				
3	3	FLAG	Over-Current: Open-Drain FLAG output.				
4	4	EN( EN )	<b>Enable</b> : Logic level enable input. Make sure EN pin never floating.				
5	6	IN	<b>Input Supply</b> : Output MOSFET Drain, which also supplies IC's internal circuitry. Connect to positive supply.				
	5	SET	Current limit set input				

## **ORDER INFORMATION**

ORDER NUMBER	ENABLE	Current Limit	Output Shutdown Resistor	Fast Role Swap	TEMP. RANGE	PACKAGE
AX8733AHBTA	Active High	3.5A	YES	NO	-40°C to +85°C	TSOT-23-5
AX8733ALBTA	Active Low	3.5A	YES	NO	-40°C to +85°C	TSOT-23-5
AX8733ANBTA	Active High	3.5A	NO	NO	-40°C to +85°C	TSOT-23-5
AX8733AGBTA	Active Low	3.5A	NO	NO	-40°C to +85°C	TSOT-23-5
AX8733BHCTA	Active High	RSET	YES	NO	-40°C to +85°C	TSOT-23-6
AX8733BLCTA	Active Low	RSET	YES	NO	-40°C to +85°C	TSOT-23-6
AX8733BNCTA	Active High	RSET	NO	NO	-40°C to +85°C	TSOT-23-6
AX8733BGCTA	Active Low	RSET	NO	NO	-40°C to +85°C	TSOT-23-6
AX8733CHBTA	Active High	2.5A	YES	NO	-40°C to +85°C	TSOT-23-5
AX8733CLBTA	Active Low	2.5A	YES	NO	-40°C to +85°C	TSOT-23-5
AX8733DHBTA	Active High	3.5A	YES	YES	-40°C to +85°C	TSOT-23-5
AX8733DLBTA	Active Low	3.5A	YES	YES	-40°C to +85°C	TSOT-23-5
AX8733DNBTA	Active High	3.5A	NO	YES	-40°C to +85°C	TSOT-23-5
AX8733DGBTA	Active Low	3.5A	NO	YES	-40°C to +85°C	TSOT-23-5

#### Table 1. Current Limit RSET Value for AX8733B

RSET(kΩ)	Current Limit Min (A)	Current Limit Typ (A)	Current Limit Max (A)
6	3.1	3.5	4
7	2.7	3	3.3
10.5	1.7	2	2.3
21	0.8	1	1.2

Note: The Relationship between RSET (KΩ) and Typical Current Limit (A) is about Current Limit =21/RSET

### **♦ MARKING INFORMATION**



### **\* ABSOLUTE MAXIMUM RATINGS**

/ to 6V
′ to 28V
nally Limited
/ to 6V
/ to V <sub>IN</sub> +0.3V
/ to 6V
)*
C/W
).8W
°C/W
0°C
5°C to +150°C
260°C
2kV
2.5kV
15kV
8kV

#### **Operating Ratings**

Supply Voltage (VIN)	2.7V to 5.5V
Output Voltage (VOUT)	4V to 22V
Operating Temperature (T <sub>A</sub> )	40°C to +85°C

\*HBM: JESD22-A114, CDM: JESD22-C101, SYSTEM LEVEL: IEC61000-4-2. \*Please refer to Minimum Footprint PCB Layout Section.

### **Minimum Footprint PCB Layout Section**



### **\* ELECTRICAL CHARACTERISTICS**

 $V_{IN} = 5V$ ,  $C_{IN} = 1\mu$ F,  $C_{OUT} = 1\mu$ F,  $R_L = 10\Omega$ ,  $T_A = 25^{\circ}$ C The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	SYMBOL	CONDITION		MIN	TYP	MAX	UNIT
Input Voltage Rage	V <sub>IN</sub>			2.7		5.5	V
		AX8733A/C		100	160	μA	
Quiescent Current	la	4.20200	$R_{SET}$ =6k $\Omega$		150	200	μA
		AX0733B	$R_{\text{SET}}=21k\Omega$		120	180	μA
Off Supply Current	I <sub>Q(OFF)</sub>	$V_{IN}=5V, EN(\overline{EN})=Inactive$			4	10	μA
V <sub>IN</sub> Under Voltage Lockout	V <sub>UVLO</sub>			2.0	2.2	2.4	V
V Over Veltage Bretestien(OV/D)	N/	VOUT Rising Threshold			5.6		V
	VOUT_OVP	VOUT Falling Threshold			5.5		V
Vout OVP Hystersis	$V_{\text{OUT}_{HYS}}$	VOUT Falling Threshold			0.1		V
OVP Response Time	t <sub>OVP</sub>	Vout=5.5V to 6V			1		μs
		AX8733A, I <sub>OUT</sub> =3A			50		mΩ
	D	AX8733B	<sub>ET</sub> =6kΩ		50		mΩ
	RDS(ON)	lout=0.8A with F	R <sub>SET</sub> =21kΩ		50		mΩ
		AX8733C, I <sub>OUT</sub> =1.5A		50		mΩ	
		AX8733A		3.1	3.5	4	A
Over Current Trigger Point	I <sub>LIM</sub>	AX8733B	R <sub>SET</sub> =6kΩ	3.1	3.5	4	A
			0.8	1	1.2	A	
		AX8733C	1.6	2.0	2.4	A	
		AX8733A, VIN>3.5V and VOUT<1V			2.3		A
Short-Circuit Fold-Back Current	I <sub>SFB</sub>	AX8733B	R <sub>SET</sub> =0KΩ		2.3		A
		AV07220 \/>2 E\/ and \/		0.07		A	
EN Input Threshold High VIII	V		v	1.0	1.5		A
	V EN(H)			1.2			V
	VEN(L)	D -10 0 -10F	11 -51			0.6	V
Output Turn-on Rising Time	Tr	$R_{\text{LOAD}}=10$ , $C_{\text{OUT}}=10\mu$ F, $V_{\text{IN}}=3V$		16	1.5	2	ms
ELAC Deglitch	True	ELAC assortion or deassortion	VIN-0.0V	6	0	12.0	me
Shutdown OUT Pull Low Resistance	' FLAG			0		225	0
too Response Time to Short Circuit	tion	Vw=5V see figure 1.2			15	220	115
	403	EN-"0" Vour-5\/			0.5	1	μ3
Output Leakage Current throshold		EN= U, VOUT=5V		0.2	0.5	1	μ
Output Neverse-Outrent threshold		Vw=5V AX8733A/B/C		0.2	5		ms
Output Reverse-Current Deglitch Time	T <sub>OCP</sub>	V <sub>IN</sub> =5V, AX8733D		1.5		ms	
Thermal Limit	ОТ				140		°C
Thermal Limit Hysteresis	OT <sub>HYS</sub>				20		°C
Discharge Time	T <sub>DS</sub>				130		ms
Fast Role Swap Repose Time	T <sub>FSR</sub>	V <sub>IN</sub> =5V, C <sub>OUT</sub> =100uF, R <sub>L</sub> =50Ω, A	X8733D		150		μs



Figure 1



#### Note:

To exactly identify the short circuit characteristic of IC, avoid the test result interfered by parasitic inductor, output capacitor, and contact resistor. It is necessary to follow the recommendation as follows.

#### Please,

- 1. Add  $1000\mu F$  of capacitor between V<sub>IN</sub> and GND, and close to IC.
- 2. Remove output capacitor.
- 3. Shorter the short circuit device wire.
- 4. Measure output current (I<sub>OUT</sub>).

### **\*** FUNCTIONAL DESCRIPTION

#### Input and Output

IN (input) is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT (output) is the source of the output MOSFET. In a typical application, current flows through the switch from IN to OUT toward the load. Both OUT pins must be connected together to the load.

#### Thermal Shutdown

Thermal shutdown protects AX8733 from excessive power dissipation. If the die temperature exceeds aforementioned OT spec., the MOSFETS switch is shut off. The hystersis prevents the switch from turning on until the die temperature drops to  $OT_{HYS}$ . Thermal shutdown circuit functions only when the switch is enabled.

#### Undervoltage Lockout

UVLO (undervoltage lockout) prevents the output MOSFET from turning on until IN (input voltage) exceeds 2.2V typically. After the switch turns on, if the voltage drops below 2.2V typically, UVLO shuts off the output MOSFET.

#### **Over Current Trigger Point**

The typical over current trigger point of AX8733A/C is 3.5A/2A. There is short-circuit fold-back current when VIN>3.5V and  $V_{OUT}$ <1V. (See Typical Performance Characteristics)

The AX8733B over current trigger point is programmed with a resistor from SET to ground. The typical value is determined by RSET. We can choose the proper RSET by Table1 There is short-circuit fold-back current limit when VIN>3.5V and VOUT<1V.

#### **Output Reverse-Voltage/Current Protection**

The output reverse-voltage protection turns off the MOSFET switch whenever the output voltage is higher than the input voltage by 40mV (typ) for 5ms (AX8733A/B/C)/1.5ms (AX8733D) (typ) and the MOSFET switch will turn on when output reverse-voltage/current condition is removed for 5ms (AX8733A/B/C)/2us (AX8733D) (typ).

#### V<sub>OUT</sub> Over-Voltage Protection (OVP)

When output voltage is higher than 5.6V (typ), the MOSFET switch is turned off to prevent IN from high-voltage stress.

#### **FLAG** Function

The FLAG open-drain output is asserted (active low) when an over current condition is encountered after a 9-ms deglitch timeout. The output remains asserted until the overcurrent condition is removed. Over temperature condition is also reported immediately by FLAG open-drain output.

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#### **Over Current Regulation and Protection**

In over current condition, the temperature of the chip will rise. It results in thermal shutdown of the MOSFETs switch as over current condition is not removed. Then, the device enters in over current regulation and protection modes. In over current regulation mode, the current is regulated to the desired over cur- rent level and the MOSFETs switch is turned off in over current protection mode. The over current regulation and protection modes allow the device to release high thermal dissipation within temperature operation condition.

#### Fast Role Swap

AX8733D supports fast role swap function. When AX8733D is under output reverse-voltage/current protection, MOSFET switch is off. When  $V_{OUT}$  drops lower then  $V_{IN}$ ,  $V_{OUT}$  is recovered to 4.75V (typ) within 150us (typ).

### **\*** APPLICATION INFORMATION

#### Supply Filtering

A 1µF bypass capacitor from IN to GND, located near the AX8733, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Input transients must not exceed the absolute maxi- mum supply voltage ( $V_{IN max} = 6V$ ) even for a short duration.

#### EN, the Enable Input

EN must be driven logic high or logic low for a clearly defined input. Floating the input may cause unpredictable operation. EN should not be allowed to go negative with respect to GND.

#### **Test Circuit**



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#### **Timing Diagrams**



Switch Delay Times

**\* APPLICATION CIRCUIT** 



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## **\* TYPICAL PERFORMANCE CHARACTERISTICS**

AX8733A, VIN= 5V, CIN=10 $\mu$ F, COUT=100 $\mu$ F, TA=25°C, unless otherwise noted.















Enable Input Threshold vs. Temperature







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## **TYPICAL PERFORMANCE CHARACTERISTICS (continued)**



ON-Resistance vs. Temperature







**Overcurrent Protection Characteristics** 









**Overcurrent Protection Characteristics** 



Rev.1.1 Nov.20, 2019

## **\* TYPICAL PERFORMANCE CHARACTERISTICS (continued)**



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AX8733A, VIN= 5V, CIN=10µF, COUT=100µF, TA=25°C, unless otherwise noted.



Inrush Current with Load Capacitance

















## **\* TYPICAL PERFORMANCE CHARACTERISTICS (continued)**



#### Short-Circuit Current, Device Enable into Short



#### Capacitance Load Inrush Response





Short Circuit Response at Start up



Capacitance Load Inrush Response



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## **\* TYPICAL PERFORMANCE CHARACTERISTICS (continued)**





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## **\*** TYPICAL PERFORMANCE CHARACTERISTICS (continued)

AX8733D, VIN= 5V, CIN=10µF, COUT=100µF, TA=25°C, unless otherwise noted.



#### Fast Role swap Response

YM	130us	
VOUT		
FLAG <sub>D</sub>		
IOUT		RL=50Ω



# 8733



## **♦ PACKAGE INFORMATION**

**TSOT-23-5** 







				-			
0. mahal		IMENSION IN MI	M	DIMENSION IN INCH			
Symbol	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
A	0.70	0.80	0.90	0.028	0.031	0.035	
A1	0.00	0.05	0.10	0.000	0.002	0.004	
A2	0.70	0.75	0.80	0.028	0.030	0.031	
D	2.80	2.90	3.00	0.110	0.114	0.118	
E	2.70	2.80	2.90	0.106	0.110	0.114	
E1	1.50	1.60	1.70	0.059	0.063	0.067	
с	0.08	0.15	0.25	0.003	0.006	0.010	
b	0.30	0.40	0.50	0.012	0.016	0.020	
е	0.85	0.95	1.05	0.033	0.037	0.041	
L	0.30	0.45	0.60	0.012	0.018	0.024	

#### **Taping Specification**



PACKAGE	Q'TY/REEL
TSOT-23-5	3,000 ea

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**TSOT-23-6** 







Cump al	D	IMENSION IN MI	м	DIMENSION IN INCH			
Symbol	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
A	0.70	0.80	0.90	0.028	0.031	0.035	
A1	0.00	0.05	0.10	0.000	0.002	0.004	
A2	0.70	0.75	0.80	0.028	0.030	0.031	
D	2.80	2.90	3.00	0.110	0.114	0.118	
E	2.70	2.80	2.90	0.106	0.110	0.114	
E1	1.50	1.60	1.70	0.059	0.063	0,067	
с	0.08	0.15	0.25	0.003	0.006	0.010	
b	0.30	0.40	0.50	0.012	0.016	0.020	
е	0.85	0.95	1.05	0.033	0.037	0.041	
L	0.30	0.45	0.60	0.012	0.018	0.024	

## **Taping Specification**



PACKAGE	Q'TY/REEL
TSOT-23-6	3,000 ea

## **\*** Carrier tape dimension

TSOT-23-5L





Α	Н	T1	С	d	D	W	E1	F
178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
P0	P1	P2	D0	D1	T	A0	B0	K0
4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)







Α	Н	T1	С	d	D	W	E1	F
178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
P0	P1	P2	D0	D1	T	A0	B0	K0
4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)