SCM9601BTA Ultra-high Voltage Start-up Controller

Features

- Ideal for applications requiring an ultra-wide input voltage range (16VDC to 700VDC)
- Low-cost design featuring large starting current in small physical package
- The output short circuit rest time can be programed by an external VDD bypass capacitor.
- Charging voltage limit of VDD
- It can be used in parallel to realize high current charging

Applications

- Used for converters with ultra-wide input voltage of 16VDC to 700VDC.

Package

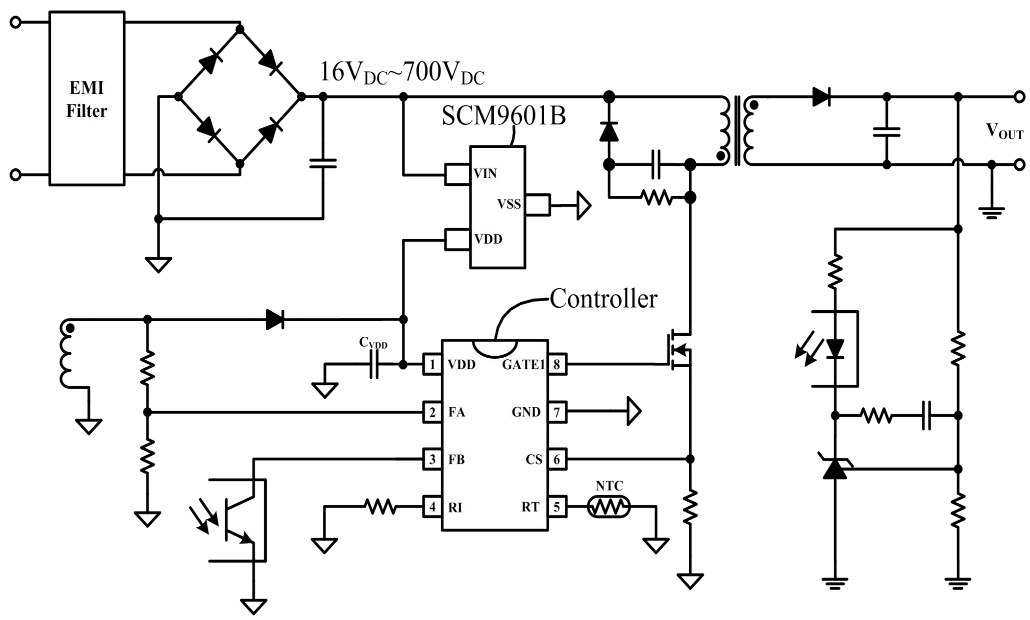
Mechanical package: SOT-23
(see "Ordering information" for details).

Functional Description

The SCM9601BTA has a built-in 700V high voltage transistor that can operate with an input voltage from 16VDC up to 700VDC. The output is a constant charging current into the bypass capacitor of the switching power supply to start the controller chip. After the controller started up, the starter continues to deliver power for some time and increases the capacitive load capability of the power supply. In addition, SCM9601BTA can be used in combination with our SCM9602B to increase the input voltage even further covering a range from 40VDC up to 5,000VDC.

To avoid damage to the controller and the power system, the SCM9601BTA can sense the appropriate fault protection mode if the VDD bypass capacitor is too small or when the power supply output is in short circuit condition.

Typical Application Circuit

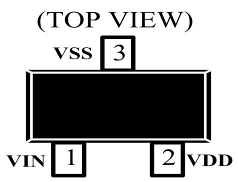


Application shown with an Input Voltage range of 16VDC to 700VDC where SCM9601BTA is used individually

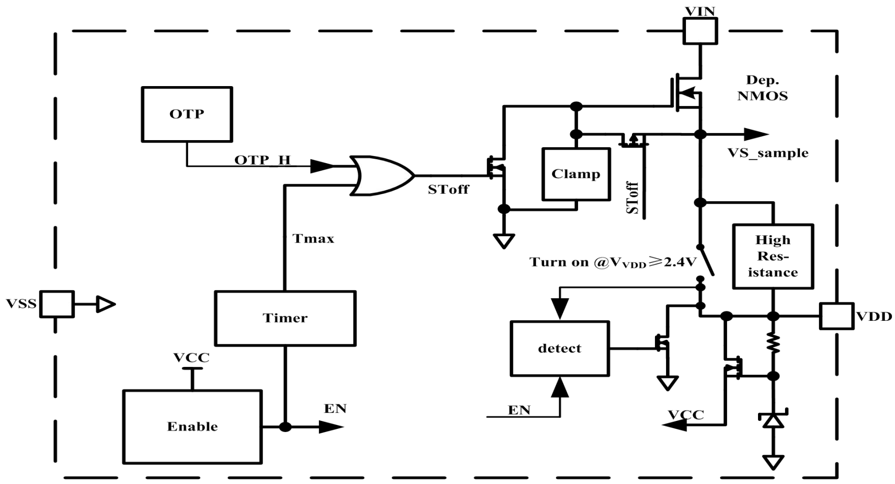
Note:Schottky diode D1 is only used in the aoolication where the VDD voltage is greater than the busbar.

Contents

Pins



Internal Block Diagram



Pin Descriptions

Pin No.	Pin Name	I/O	Description
1	VIN	P	The high voltage input obtains power from the input voltage and charges the bypass capacitor of the VDD pin to start the controller.
2	VDD	P	Powers controller. This pin requires to be connect to GND via an external bypass capacitor.
3	VSS	P	IC Ground connection

Absolute Maximum Ratings

General test conditions: Free-air, normal operating temperature range (unless otherwise specified).

Parameter	Symbol	Min	Max	Unit
Bias mains voltage	V_{VDD}		40	V
Voltage at the VIN pin	V_{VIN}		700	
Operating junction temperature	T_J	-40	150	℃
Storage temperature	T_{STG}	-40	150	
Welding temperature (the temperature at which the chip is allowed to over-reflow for 10 seconds)			260	
Electrostatic Discharge (ESD) rating	Human body model (HBM)		1500	V
	Charging device model (CDM)		1000	

Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit
Bias mains voltage	V_{VDD}	9	20	V
VDD bypass capacitance	C_{VDD}	5	30	uF
Operating junction temperature	T_J	-40	125	℃

Note:The maximum value of Cvoo here is the recommended value for the conventional system. The specific application should be selected according to the VDD voltage window and the power consumption of VDD. The minimum value should be adjusted according to the actual situation, considering the starting and rest time under specific circumstances.

Electrical Characteristics

General test conditions: Free-air, normal operating temperature range, V_{SS}=0V

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
POWER						
I_{STL}	Minimum charging current of VDD	V_{VIN}=16V，V_{VDD}=0V	200	400	600	uA
I_{STH}	Maximum charging current of VDD	V_{VIN}=40V，V_{VDD}=12V	0.9	1.2	2.4	mA
I_{VIN_OFF}	VIN turn-off current	Current flows in from the VIN at the end of charging		1	5	uA
I_{VDD}	Operating current	I_{VIN}=0,V_{VDD}=12V	40		200	uA
V_{CM}	Charging voltage limit	C_{VDD}=47nF	21.2	22	24.8	V
V_{VDD_START}	Oscillation voltage of oscillator		7.36	8	8.64	V
V_{VDD_TRANS}	Timing switching voltage		11	12	13	V
V_{VDD_RESET}	Reset voltage of start-up circuit		4.6	5	5.4	V
V_{VDD_PULL}	VDD pull voltage		5.52	6	6.48	V
T_{J_SHUT}	Heat off temperature	Internal junction temperature	138	146	154	°C
$T_{J\_RESTART}$	Restart temperature	Internal junction temperature	114	122	130	°C
TIMING						
T_{OSC}	Oscillation period of oscillator	V_{VDD}=8V	18.7	22	25.3	uS
T_{CH1}	Duration of high-voltage power supply1	V_{VDD}≤12V		40960		T_{OSC}
T_{CH2}	Duration of high-voltage power supply2	V_{VDD}>12V		24576		T_{OSC}

Note : T_{CH1}=40960*T_{OSC} T_{CH2}=24576*T_{OSC}

Typical Performance Curves

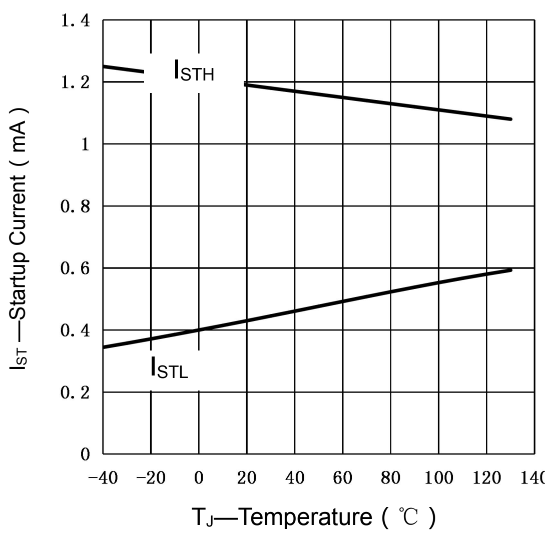


Fig. 1 Starting Current versus Temperature

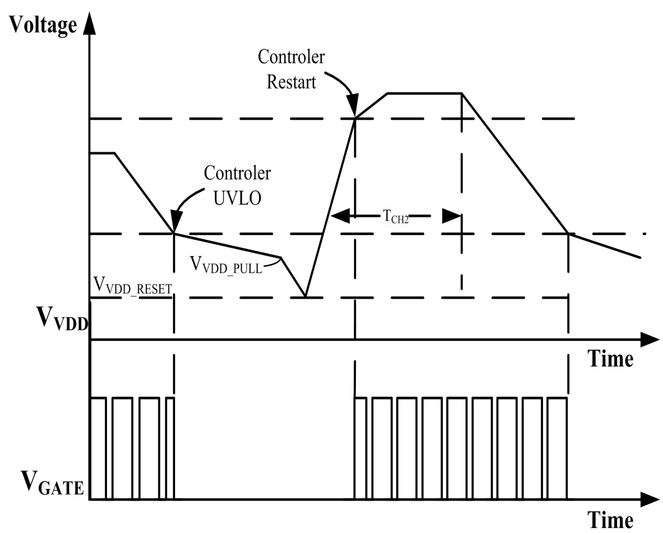


Fig. 2 Time versus VDD Supply Voltage(Short circuit)

Parameters Test Circuit

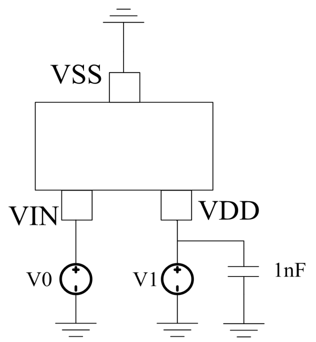


Fig. 3 Maximum Starting Current Test Circuit

Start-up Sequence,Input connected with the VIN pin

The converter input voltage powers the SCM9601BTA which charges the bypass capacitor C_{VDD} to start the controller. Once the switching power supply is on, SCM9601BTA keeps running for some time. It continues obtaining power from the input voltage to maintain normal operation of the controller and to improve the capacitive load capability of the switching power supply. As shown in Fig.4, after power on, the start-up circuit of the SCM9601BTA charges the bypass capacitor C_{VDD} with the minimum current I_{STL} while V_{VDD} remains below 2.4V. When V_{VDD} exceeds the 2.4V level, the start-up circuit of the SCM9601BTA starts charging the bypass capacitor C_{VDD} with the maximum current I_{STH}. At the point where V_{VDD} is close to 8V, the internal oscillator of the SCM9601BTA starts and closes the start-up circuit after T_{CH1} time elapses. When Vvo-12V, TCH2 is timed again, TCH2<TCH1. After the timing ends, VDD no longer draws power from the input voltage, and Voo gradually decreases to equal to the auxiliary winding voltage VA. During the timing, SCM9601BTA will still supply power to the controller. If the current required to work after the controller is started is greater than ISTH, the VDD pin voltage will drop (not shown in Figure 4); If not, as shown in Figure 4, the VDD pin voltage continues to rise and approaches the charging limit voltage VCM.

Refer to the “Electrical characteristics” table for I_{STL}, I_{STH}, T_{CH1} and V_{CM} values.

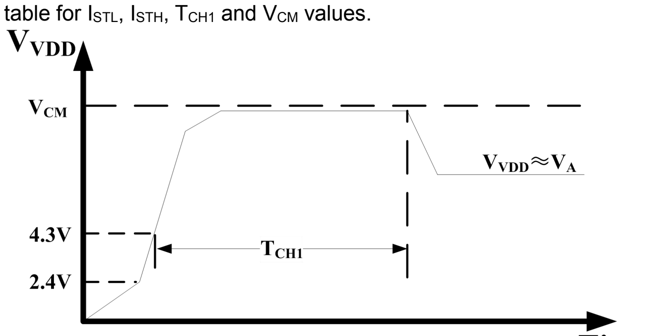


Fig. 4 Waveform of VDD Pin during Start

Parallel use

When two SCM9601BTA are used in parallel, the two starting chips can charge the bypass capacitor of the main control chip together to provide a large charging current during high-limit charging, as shown in Figure 5. In the case of fault protection of VDD, when the power failure reaches the pull voltage of VDD (typical value 6V), power will be pumped to VDD. When the power failure reaches the reset voltage (typical value 5V), the pull operation of VDD will be released, so as to ensure that each startup chip can be reset and realize the high current charge of restart. See Fault Protection for the protection sequence

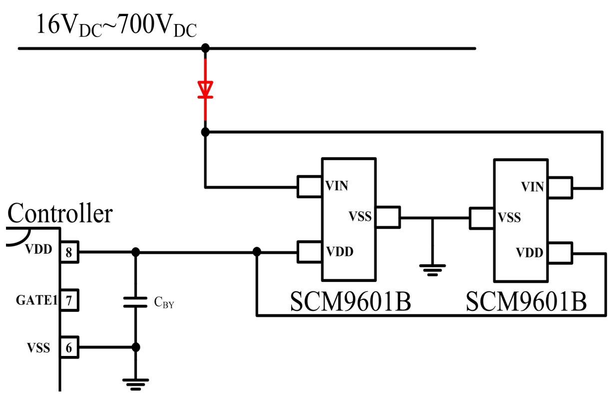


Fig. 5 Charging schematic diagram of two startup chips

Fault protection

The SCM9601BTA can sense the appropriate protection mode for following two fault conditions:

1.Bypass capacitance at VDD pin too small;

2. Output of the power supply in short circuit condition.

The following is a detailed description based on the attached figure. The attached figure shows the fault situation and the corresponding protection mode after the controller starts and works for a period of time. For ease of description, the graph is not drawn in strict voltage to time ratio, where GATE is the grid drive voltage signal of the main power switch tube.

Bypass capacitance at VDD pin too small

If the bypass capacitance is too small, the VDD pin voltage will have steep rising slope during start, resulting in VDD pin voltage overshoot which could potentially damage the post-stage controller if not properly handled. Therefore the SCM9601BTA limits V_{VDD} to V_{CM} during start, which is the safety voltage range of the controller, hence protecting the controller from damage by overvoltage due to a too small bypass capacitance C_{VDD} or due to a timing duration that is too long.

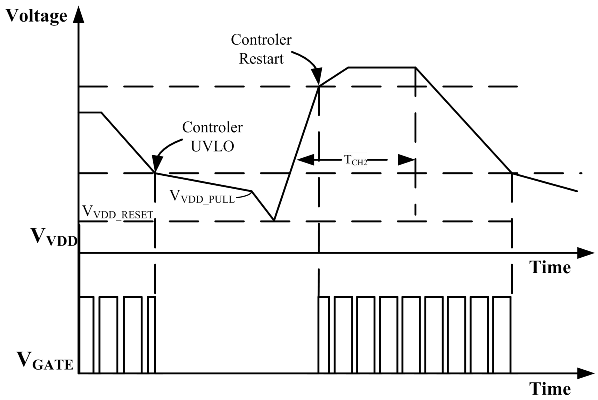


Fig. 6 Waveform and Time Sequence of Output Short Circuit Protection Mode

Output of the power supply in short circuit condition

Please refer to Figure 6, stage 1: When the output of the switching power supply is short circuited, the Controller will not be able to obtain the energy to maintain normal operation from the auxiliary winding, and the voltage Vvoo will continue to drop until the controller is locked under voltage (please refer to Controller·UVLO in Figure 6). Of course, during this process, the controller will still have GATE signal output.

Stage 2: At the undervoltage lockout stage, the controller does no longer consume any energy from the bypass capacitor C_{VDD}, only the SCM9601BTA chip does. The bypass capacitor C_{VDD}'s discharge current I_{VDD} becomes relatively small and therefore voltage V_{VDD} of the bypass capacitor takes more time to drop to V_{VDD_RESET} level.

Stage 3:When V_{VDD_PULL}, SCM9601BTA starts to pump the VDD voltage inside until VDD is powered off to V_{VDD_RESET}.

Stage 4: When V_{VDD} is equal to V_{VDD_RESET}, SCM9601BTA again begins to charge the bypass capacitor C_{VDD} with the maximum current I_{STH} until the time T_{CH1} elapses. In the process, the controller is restarted (Controller Restart in Fig.6), re-enabling the GATE driving signal output. This is basically assuming, that the necessary current for the controller operation is smaller than the maximum current I_{STH}, so V_{VDD} can keep rising and approaching the charging voltage limit V_{CM}. If an output short circuit condition remains at the end of time T_{CH1}, VDD will drop once again back into stage 1 and starts a new cycle of output short circuit protection until the output short circuit is no longer present.

The time between controller undervoltage and controller restart is also called "short circuit protection sleep time" during which the switching power supply can run a cooling cycle. This time can be adjusted by means of the bypass capacitor C_{VDD} value.

Application Circuit

1.When the maximum input voltage is lower than 700VDC, the SCM9601BTA can be used as the high-voltage startup circuit. For details, please refer to the typical application circuit.

2.When applied to a higher input voltage range, it is recommended to use our SCM9602A, please refer to Fig.7. C1 and C2 are input high-voltage storage capacitors to slow the fluctuation of input voltage; R1 and R2 are equalization Resistance, avoiding the uneven voltage problem caused by the difference between C1 and C2 leakage current; D1, D2 and D3 are used to solve the current backflow problem caused by the large difference between C1 and C2 leakage current.

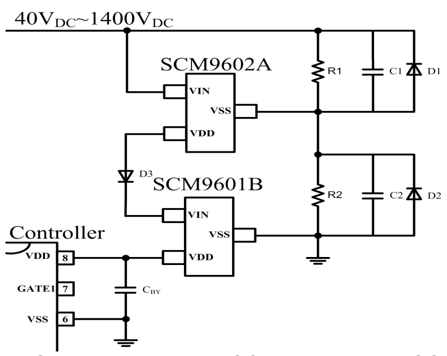


Fig. 7 Input 40VDC~1400VDC application circuit (SCM9601BTA and SCM9602A are used in series)

Power Supply Recommendations

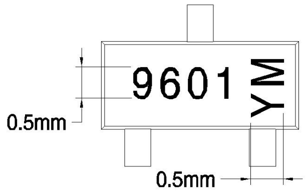
1. When the SCM9601BTA draws power from the input terminal and charges the VDD bypass capacitor, the capacitor CVDD is recommended to be below 30uF.
2. When SCM9601BTA and SCM9602A are used in series, the leakage current difference between capacitors C1 and C2 should be considered.

Ordering Information

Part number	Package	Number of pins	Product Marking	Tape & Reel
SCM9601BTA	SOT-23	3	9601 YM	3K/REEL

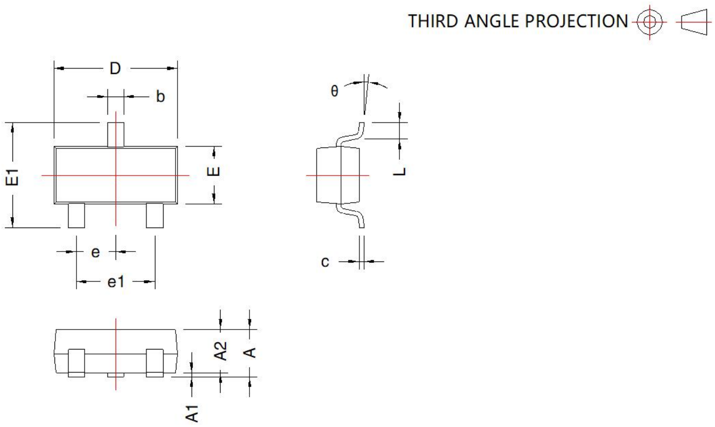
Product model number and screen printing instructions
SCM9601XYZ:
(1) SCM9601 = Product designation.
(2) X = Version code information (A-Z).
(3) Y = Packaging definition code; T for SOT package,
(4) Z = Operating temperature range (C = 0℃ to +70℃, I =-40℃ to +85℃, A =-40℃ to +125℃, M = -55℃ to +125℃) .
(5) YM: Date code for product traceability; Y = code for production year; M = code for production month

Silk Screen Information



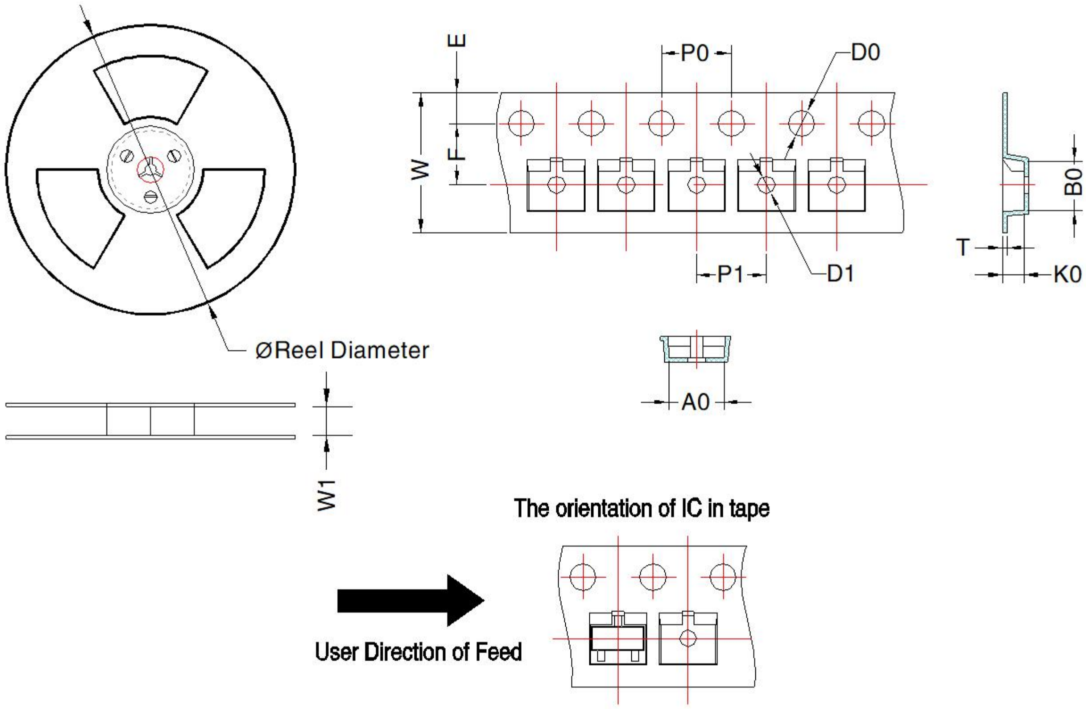
Note：
1、Typeface：Arial；
2、Character size：
Height：0.5mm，Spacing：0.1mm

Package Information (SOT-23)



SOT−23				
Mark	Dimension(mm)		Dimension(inch)	
	Min	Max	Min	Max
A	0.90	1.15	0.035	0.045
A1	0.00	0.10	0.000	0.004
A2	0.90	1.10	0.035	0.043
D	2.80	3.00	0.110	0.118
E	1.20	1.40	0.047	0.055
E1	2.25	2.55	0.089	0.100
L	0.30	0.50	0.012	0.020
b	0.30	0.50	0.012	0.020
e	0.95 TYP		0.037 TYP	
e1	1.80	2.00	0.071	0.079
c	0.132	0.202	0.005	0.008
θ	0°	8°	0°	8°

Tape & Reel Information (SOT-23)



Device	Package Type	MPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	T (mm)	W (mm)	E (mm)	F (mm)	P1 (mm)	P0 (mm)	D0 (mm)	D1 (mm)
SCM9601BTA	SOT-23	3000	180.0	8.5	3.15 ± 0.1	2.77 ± 0.1	1.22 ± 0.1	0.25 ± 0.03	8.0 ± 0.3	1.75 ± 0.1	3.5 ± 0.1	4 ± 0.1	4 ± 0.1	1.5 ± 0.1	1.0 ± 0.1

Note: The minimum order quantity is the minimum packing quantity, and the order quantity shall be an integral multiple of MPQ.

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