

WS4612

60mΩ, Current Limited, Power Distribution Switch

Descriptions

The WS4612 is a high-side switch with ultra-low ON resistance P-MOSFET. Integrated current-limit function can limit inrush current for heavy capacitive load, over load current, and short-circuit current to protect power source.

The WS4612 is also integrated reverse protection function to eliminate any reverse current flow across the switch when the device is off. Output auto-discharge function makes output voltage off quickly while the device shutdown. Thermal shutdown function can protect the device and load.

The WS4612 is available in SOT-23-5L packages. Standard product is Pb-free and Halogen-free.

Features

- Input voltage range : 2.5-5.5V
- Main switch R_{ON} : 60mΩ@VIN=5.0V
- Adj. current limit range : 0.1A-2.5A(Typ.)
- Quiescent Supply Current : 26μA
- Under Voltage Lockout
- Auto discharge
- Reverse block (No “body diode”)
- Over temperature protection

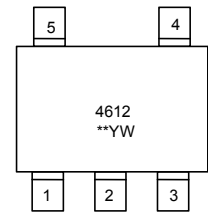
Applications

- USB peripherals
- USB Dongle
- USB 3G data card
- 3.3V or 5V Power Switch
- 3.3V or 5V Power Distribution

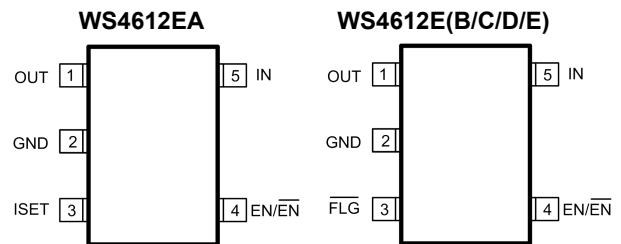
[Http://:www.sh-willsemi.com](http://www.sh-willsemi.com)



SOT-23-5L



Marking



Pin configuration (Top view)

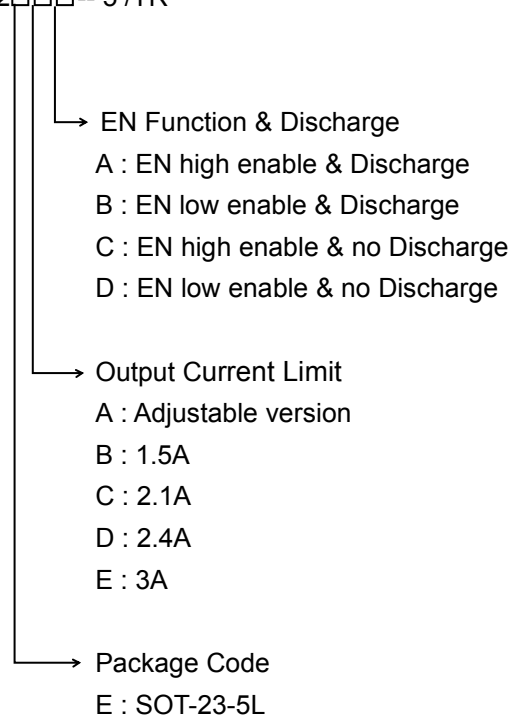
For detail marking information, please see page 14.

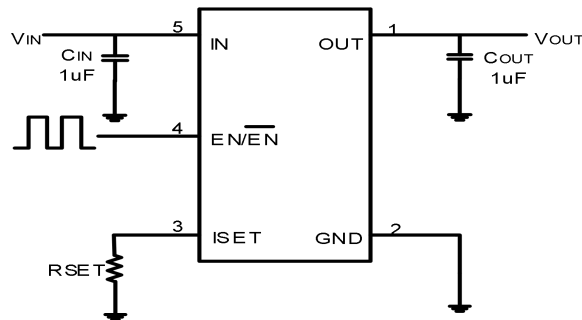
Order Information

For detail order information, please see page 14.

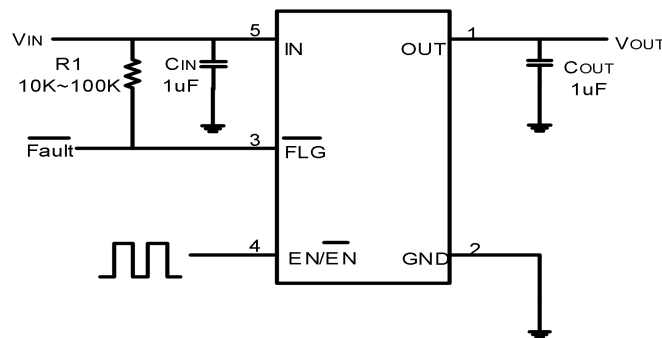
Ordering Information

WS4612□□□-- 5 /TR

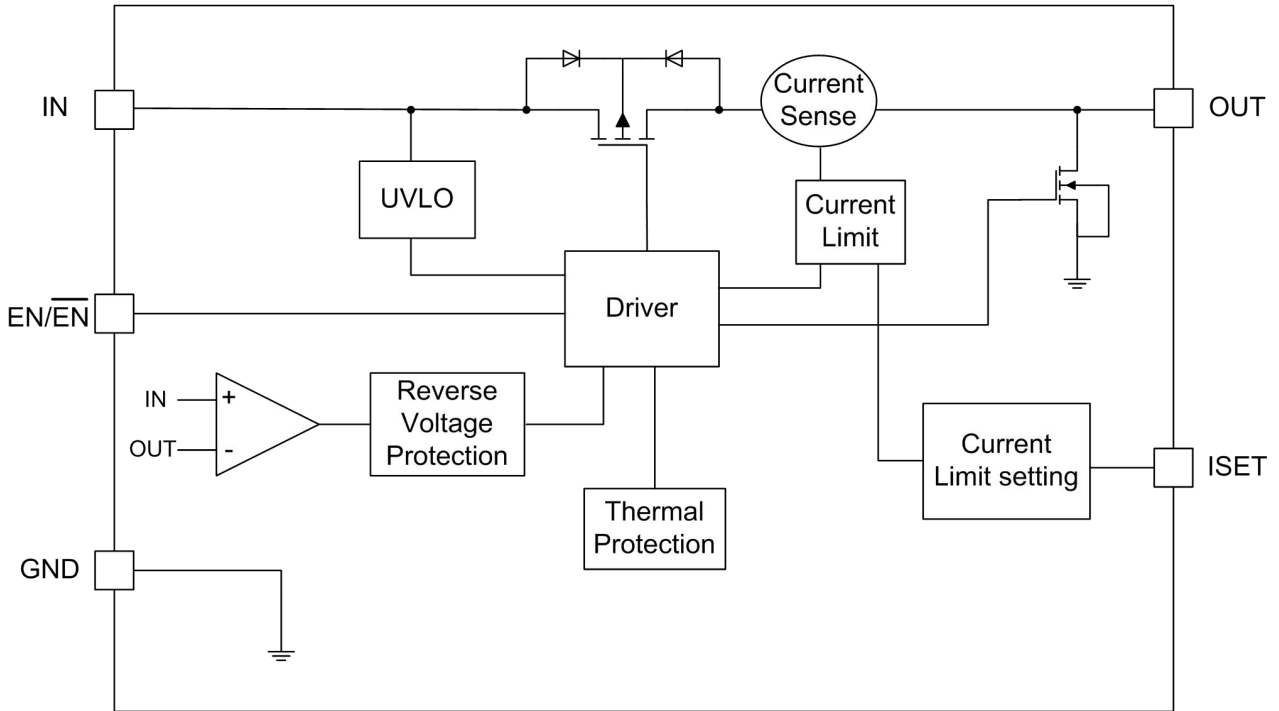
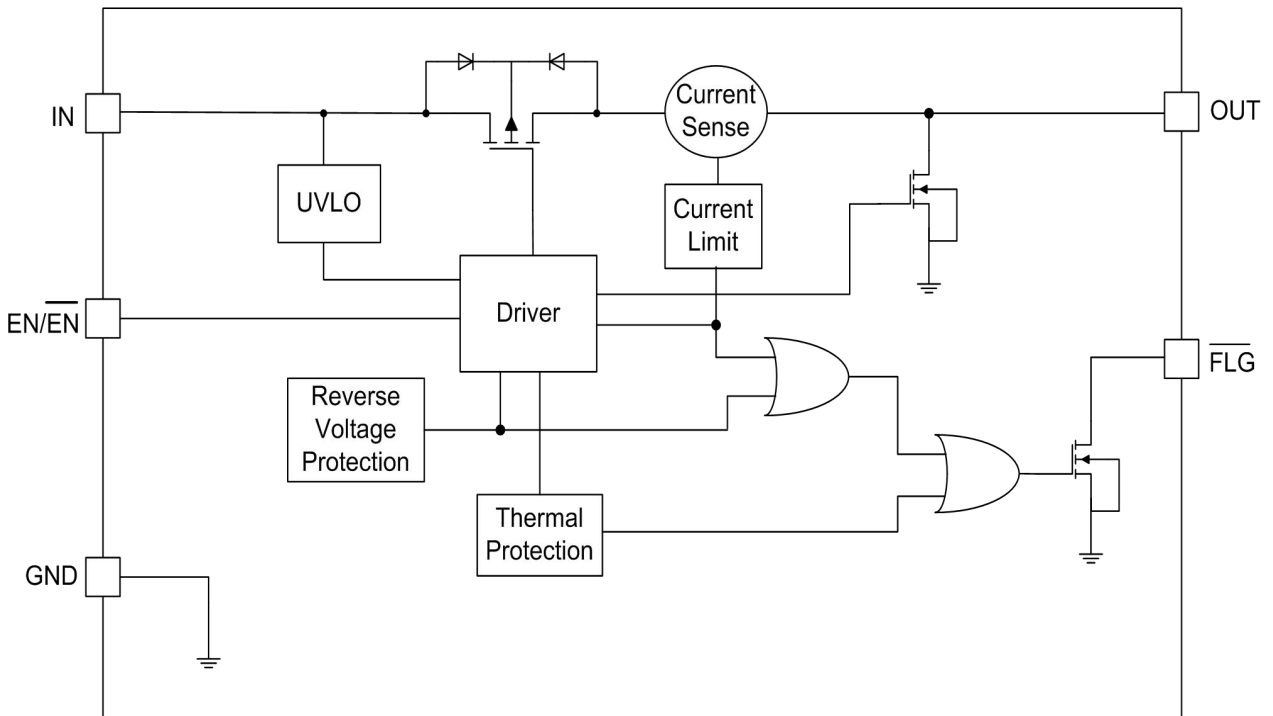


Typical Applications
WS4612EA

Pin Descriptions

| WS4612EA | | |
|------------|----------------------------|--|
| Pin Number | Symbol | Descriptions |
| 1 | OUT | Output Pin |
| 2 | GND | Ground |
| 3 | ISET | Current limit setting |
| 4 | EN/ $\overline{\text{EN}}$ | Enable Pin must be driven logic High or Low for a clearly defined input. Floating the input may cause unpredictable operation. |
| 5 | IN | Input Pin |

WS4612E(B/C/D/E)

Pin Descriptions

| WS4612E(B/C/D/E) | | |
|------------------|----------------------------|--|
| Pin Number | Symbol | Descriptions |
| 1 | OUT | Output Pin |
| 2 | GND | Ground |
| 3 | $\overline{\text{FLG}}$ | Fault Flag Pin, Open-Drain, Active Low |
| 4 | EN/ $\overline{\text{EN}}$ | Enable Pin must be driven logic High or Low for a clearly defined input. Floating the input may cause unpredictable operation. |
| 5 | IN | Input Pin |

Block Diagram(WS4612EA)

Block Diagram(WS4612E(B/C/D/E))


Absolute maximum ratings

| Parameter | Symbol | Value | Unit |
|------------------------------------|----------------------|----------|------|
| IN pin voltage range | V_{IN} | -0.3~6.5 | V |
| OUT pin voltage range | V_{OUT} | -0.3~6.5 | V |
| ISET pin voltage range | V_{ISET} | -0.3~6.5 | V |
| \overline{FLG} pin voltage range | $V_{\overline{FLG}}$ | -0.3~6.5 | V |
| EN pin voltage range | V_{EN} | -0.3~6.5 | V |
| Junction temperature | T_J | -40~150 | °C |
| Lead temperature(Soldering, 10s) | T_L | 260 | °C |
| Storage temperature | T_{stg} | -55~150 | °C |
| ESD Ratings | HBM | 2000 | V |
| | CDM | 2000 | V |

These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Recommend Operating Conditions

| Parameter | Symbol | Value | Unit |
|-------------------------------|-----------------|---------|------|
| Supply input voltage range | V_{IN} | 2.5~5.5 | V |
| Operating ambient temperature | T_A | -40~85 | °C |
| Thermal Resistance | $R_{\theta JA}$ | 250 | °C/W |
| Thermal Resistance | $R_{\theta JC}$ | 58 | °C/W |

Surface mounted on FR-4 Board using 2 oz, 1*1 square inch Cu area. PCB board size 1.5*1.5 square inches.

Electronics Characteristics(WS4612EA)
Ta=25°C, V_{IN}=5V, C_{IN}=C_{OUT}=1μF, unless otherwise noted

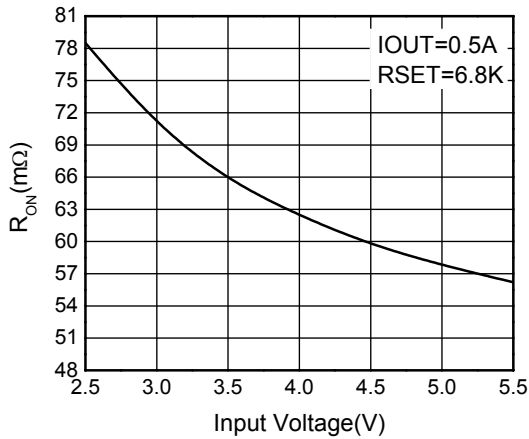
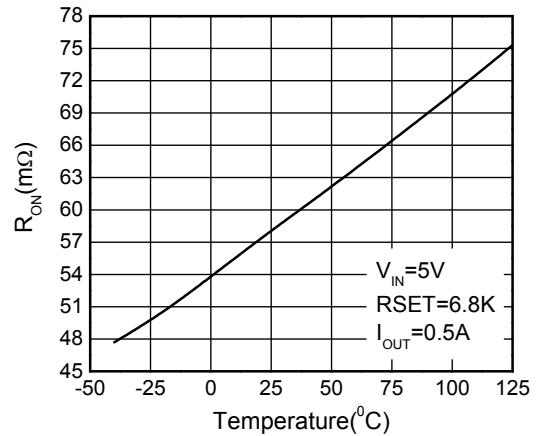
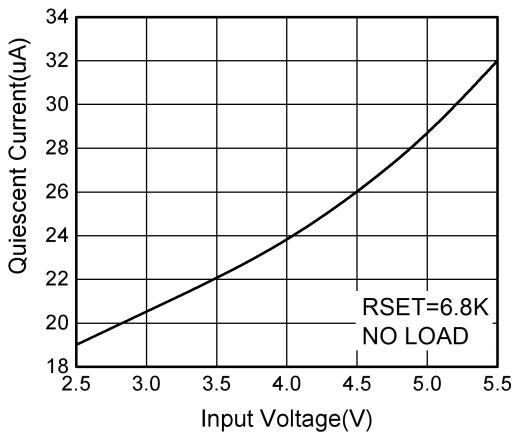
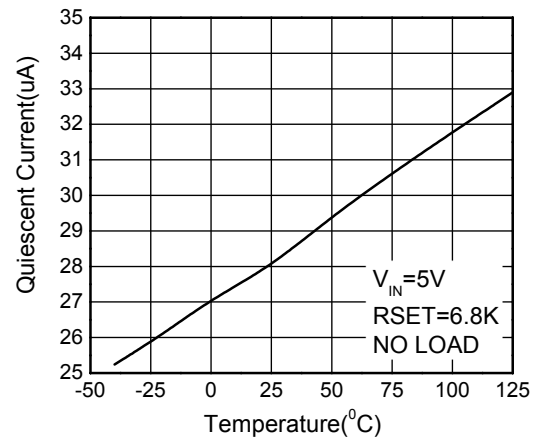
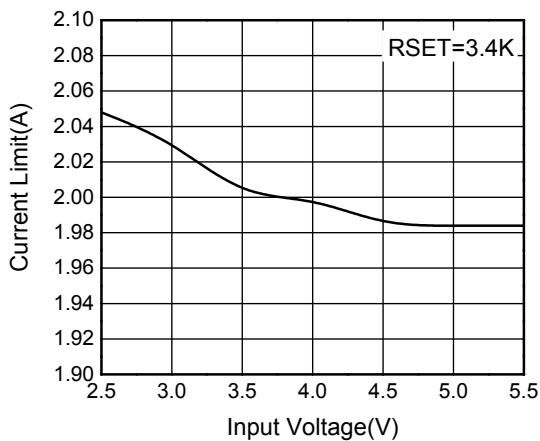
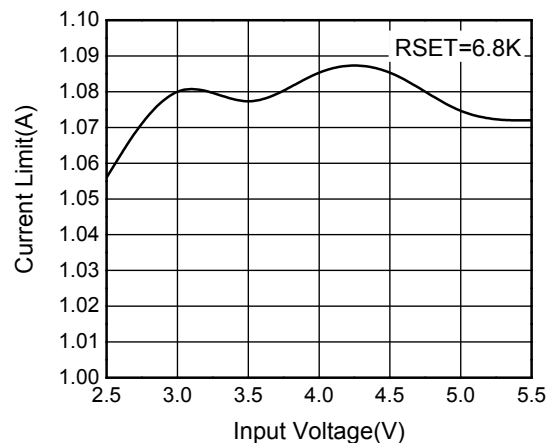
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|-----------------------|--|------|------|------|-------|
| Quiescent supply current | I _Q | I _{OUT} =0, V _{IN} =5V, V _{EN} =enable | | 26 | 50 | μA |
| Shutdown current | I _{SD} | V _{EN} =disable | | | 1.0 | μA |
| Reverse current | I _{REV} | V _{IN} =0V, V _{EN} =disable, V _{OUT} =5V, Current flow to V _{IN} | | | 1.0 | μA |
| Main-FET ON resistance | R _{ON} | V _{IN} =5V, V _{EN} =enable, I _{OUT} =500mA | | 60 | 70 | mΩ |
| Auto-discharge FET ON resistance | R _{DCHG} | V _{EN} =disable, V _{IN} =5V, V _{OUT} =2V | | 50 | 100 | Ω |
| Current Limit ⁽¹⁾ | I _{LIM} | R _{SET} =2.72 kΩ | 2.15 | 2.5 | 2.85 | A |
| | | R _{SET} =6.8 kΩ | 0.86 | 1.0 | 1.14 | A |
| | | R _{SET} =13.6 kΩ | 0.40 | 0.50 | 0.60 | A |
| | | R _{SET} =68 kΩ | 0.05 | 0.1 | 0.15 | A |
| Short-circuit output current | I _{OS} | OUT shorted to GND, Rset=6.8kΩ | | 0.65 | | A |
| Short circuit current limiting response time | t _{SHORT} | OUT connected to GND, C _L =1μF | | 1.0 | | μs |
| EN input low voltage | V _{IL} | V _{IN} =5V | | | 0.4 | V |
| EN input high voltage | V _{IH} | V _{IN} =5V | 1.2 | | | V |
| OUT pin turn-on time after EN ON | t _{ON} | C _L =1μF, R _L =5ohm | | 700 | | μs |
| Fault flag output blanking time | t _{BLANK} | V _{IN} =5.0V | | 7.5 | | ms |
| Over-temperature shutdown threshold | T _{SD} | | | 160 | | °C |
| Over-temperature threshold hysteresis | T _{HYS} | | | 20 | | °C |
| Under voltage lock out threshold | V _{UVLO} | | | 2.25 | 2.4 | V |
| Under voltage lock out hysteresis | V _{UVLO-HYS} | | | 250 | | mV |

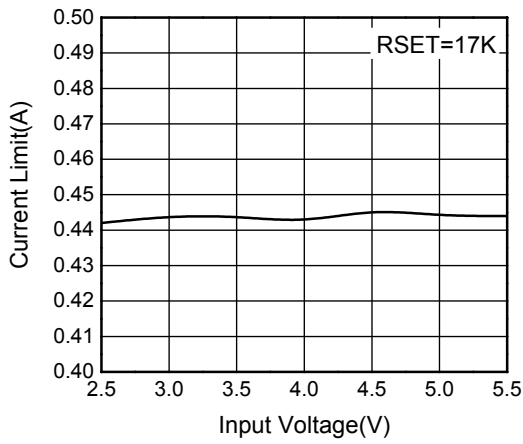
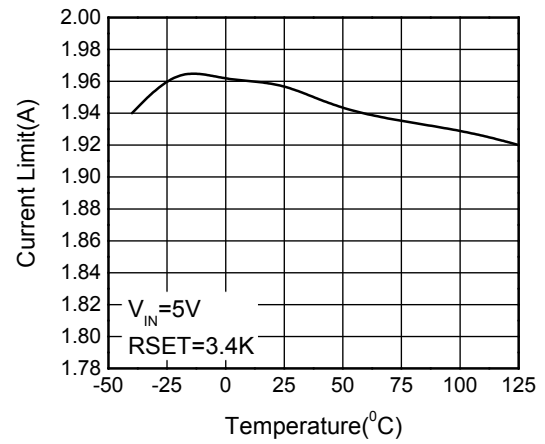
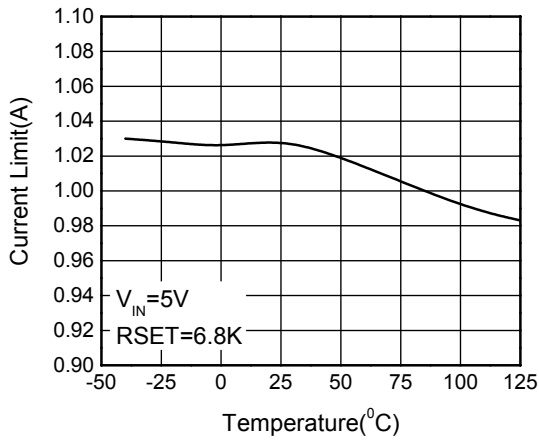
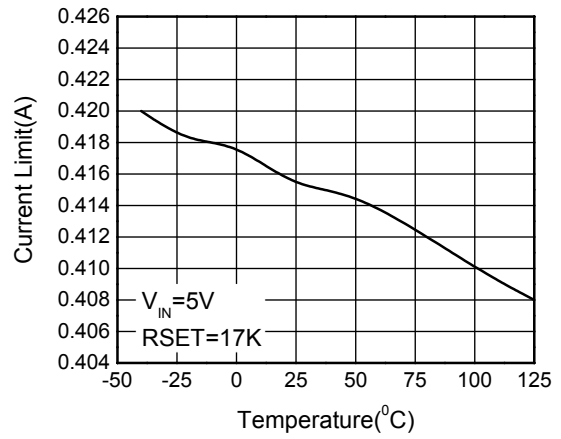
(1) Pulse test, Period=10mS, Duty cycle=4%

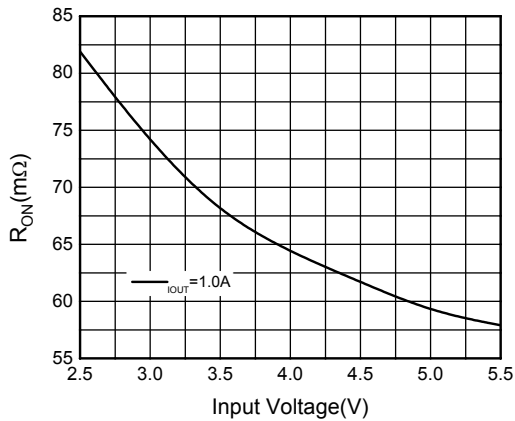
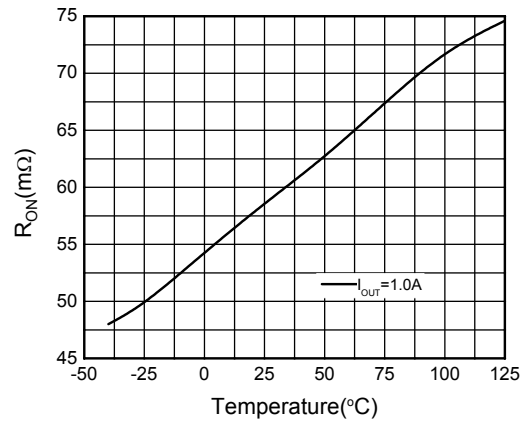
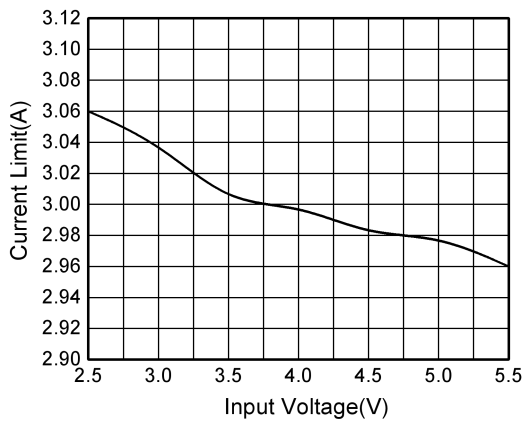
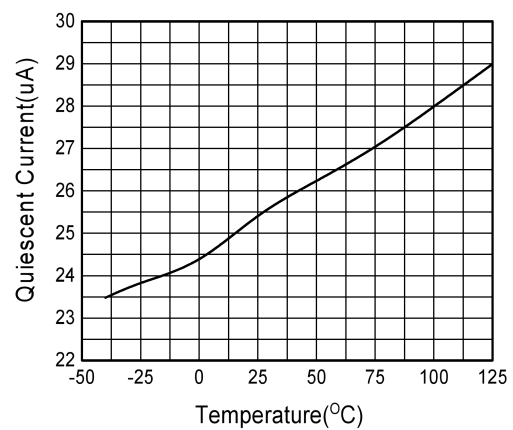
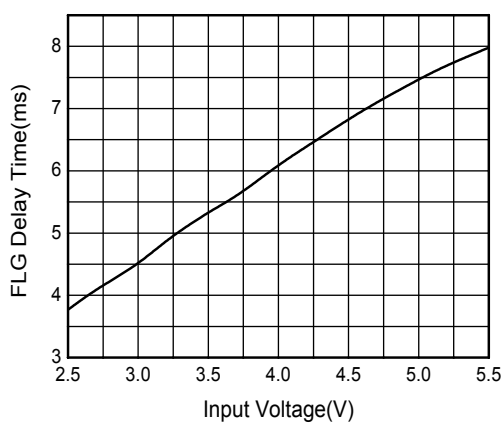
Electronics Characteristics(WS4612E)
Ta=25°C, V_{IN}=5V, C_{IN}=C_{OUT}=1μF, unless otherwise noted

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|--|-----------------------|--|------|------|------|-------|
| Quiescent supply current | I _Q | I _{OUT} =0, V _{IN} =5V, V _{EN} =enable | | 26 | 50 | μA |
| Shutdown current | I _{SD} | V _{EN} =disable | | | 1.0 | μA |
| Reverse current | I _{REV} | V _{IN} =0V, V _{EN} =disable, V _{OUT} =5V, Current flow to V _{IN} | | | 1.0 | μA |
| Main-FET ON resistance | R _{ON} | V _{IN} =5V, V _{EN} =enable, I _{OUT} =500mA | | 60 | 70 | mΩ |
| Current Limit ⁽¹⁾ | I _{LIM} | WS4612EB | 1.2 | 1.5 | 1.6 | A |
| | | WS4612EC | 1.8 | 2.1 | 2.4 | A |
| | | WS4612ED | 2.1 | 2.4 | 2.7 | A |
| | | WS4612EE | 2.6 | 3 | 3.4 | A |
| Auto-discharge FET ON resistance | R _{DCHG} | V _{IN} =5V, V _{EN} =disable, V _{OUT} =2V | | 50 | 100 | Ω |
| Short circuit current limiting response time | t _{SHORT} | OUT connected to GND, C _L =1μF | | 1.0 | | μs |
| EN input low voltage | V _{IL} | V _{IN} =5V | | | 0.4 | V |
| EN input high voltage | V _{IH} | V _{IN} =5V | 1.2 | | | V |
| OUT pin turn-on time after EN ON | t _{ON} | V _{IN} =5V C _L =1μF R _L =5ohm | | 600 | | μs |
| Fault flag output blanking time | t _{BLANK} | V _{IN} =5.0V | | 7.5 | | ms |
| Over-temperature shutdown threshold | T _{SD} | | | 160 | | °C |
| Over-temperature threshold hysteresis | T _{HYS} | | | 20 | | °C |
| Under voltage lock out threshold | V _{UVLO} | | | 2.25 | 2.4 | V |
| Under voltage lock out hysteresis | V _{UVLO-HYS} | | | 250 | | mV |

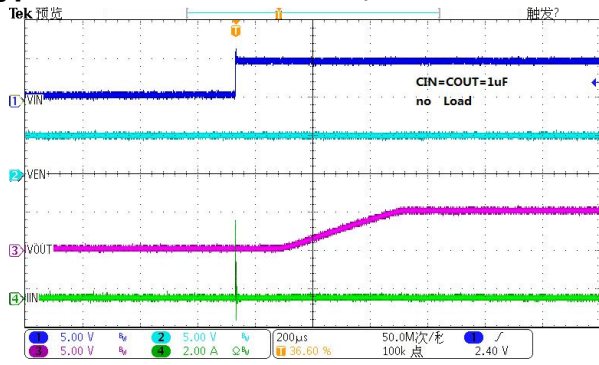
(1) Pulse test, Period=10mS, Duty cycle=4%.

Typical Characteristics (WS4612EAA, Ta=25°C, unless otherwise noted)

ON Resistance vs. Input Voltage

ON Resistance vs. Temperature

Quiescent current vs. Input Voltage

Quiescent current vs. Temperature

Current Limit vs. Input Voltage

Current Limit vs. Input Voltage

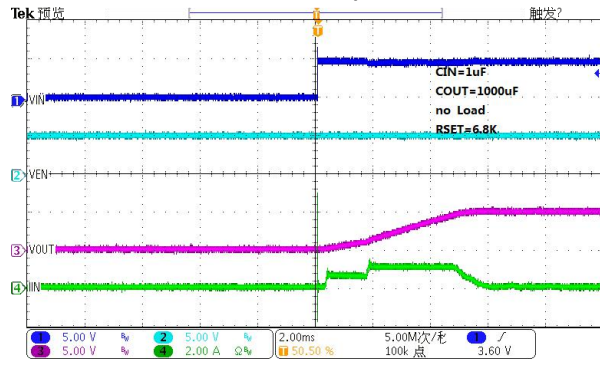

Current Limit vs. Input Voltage

Current Limit vs. Temperature

Current Limit vs. Temperature

Current Limit vs. Temperature

Typical Characteristics (WS4612EE, Ta=25°C, unless otherwise noted)

ON Resistance vs. Input Voltage

ON Resistance vs. Temperature

Current Limit vs. Input Voltage

Quiescent current vs. Temperature

FLAG delay time vs. Input Voltage

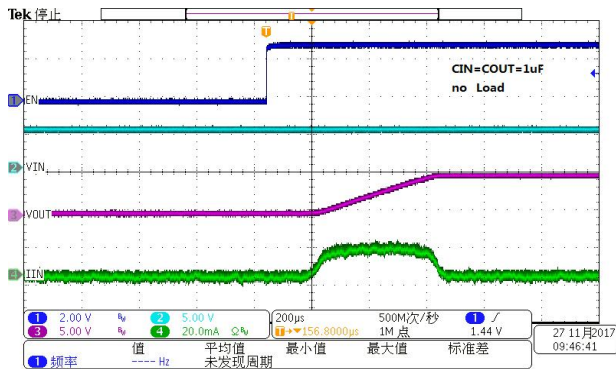
Typical Characteristics (WS4612EAA, Ta=25°C, unless otherwise noted)



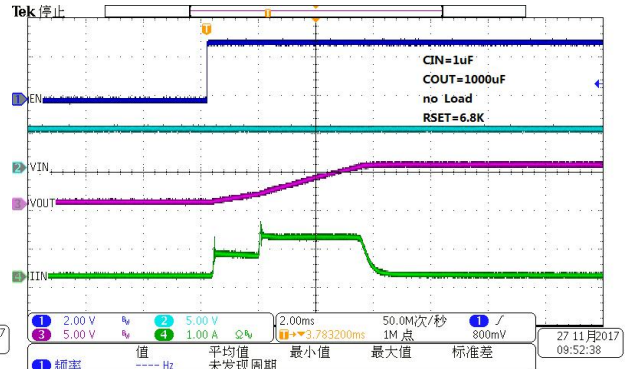
Startup from Power ON



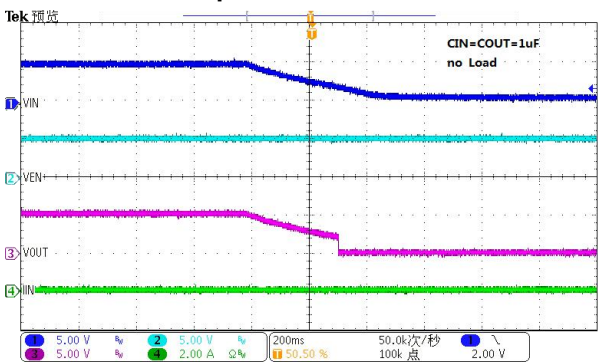
Startup from Power ON



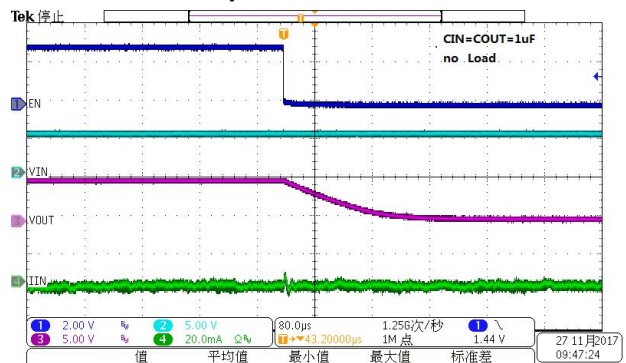
Startup from Enable ON



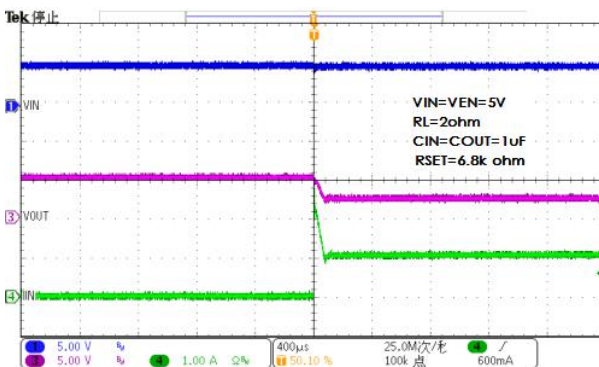
Startup from Enable ON



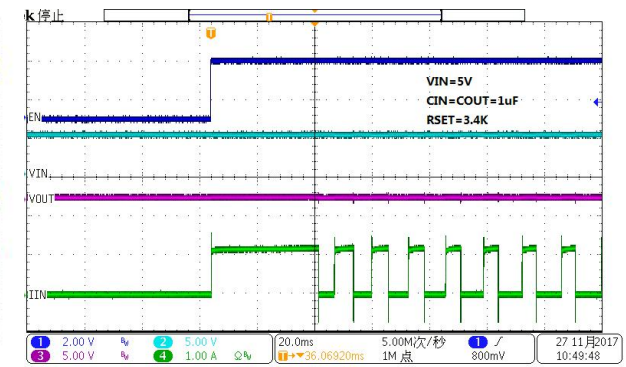
Shutdown from Power OFF



Shutdown from Enable OFF

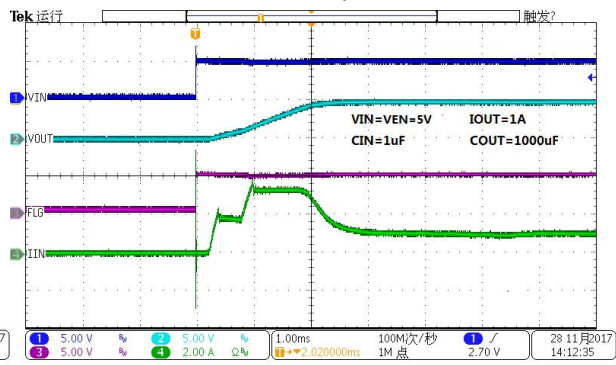
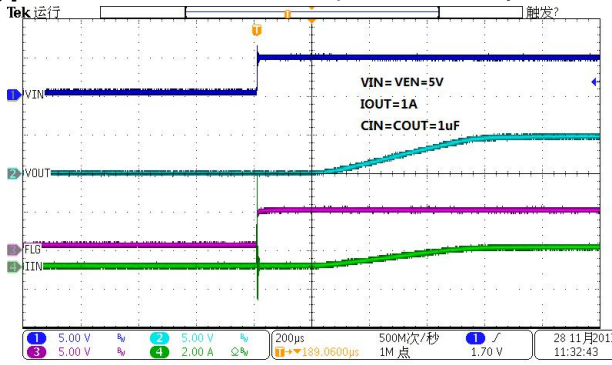


Current Limit Response



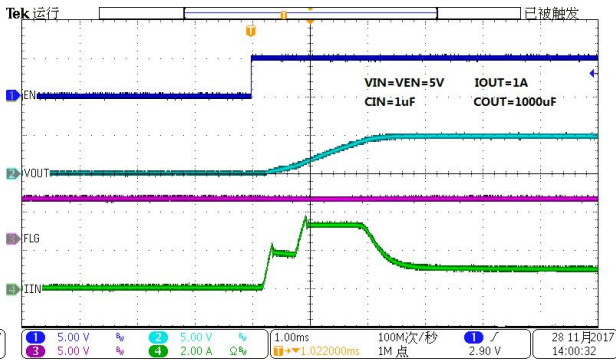
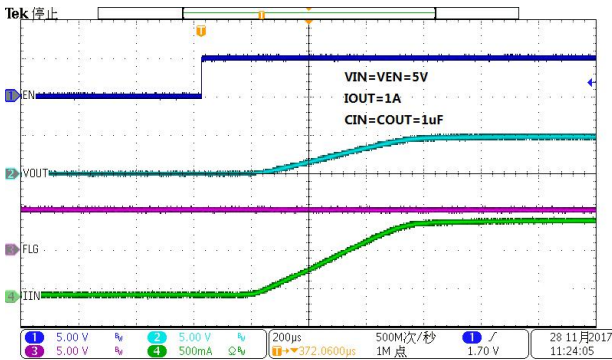
Short Circuit Response

Typical Characteristics (WS4612EEA), Ta=25°C, unless otherwise noted)



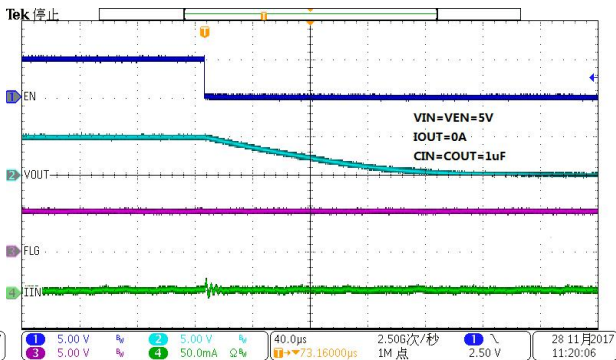
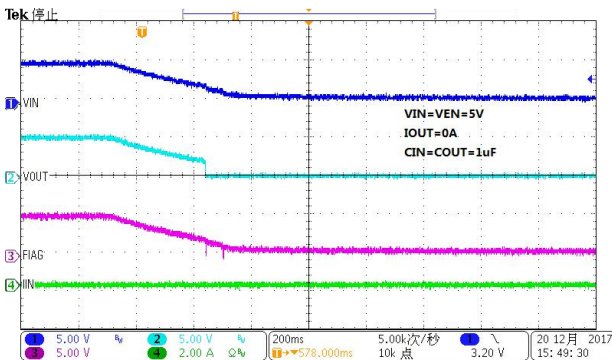
Startup from Power ON

Startup from Power ON



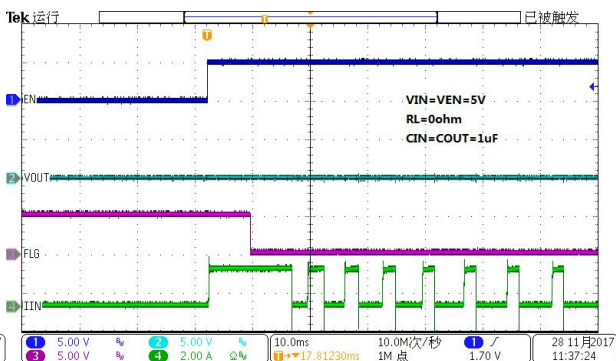
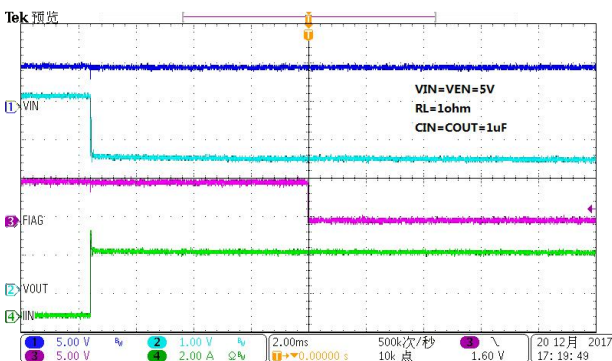
Startup from Enable ON

Startup from Enable ON



Shutdown from Power OFF

Shutdown from Enable OFF



Current Limit Response

Short Circuit Response

Operation Information

Power Switch

The power switch is a P-channel MOSFET with low $R_{DS(ON)}$ for power management or USB power distribution applications. The WS4612 has reverse voltage protection to prevent current flow from OUT to IN and IN to OUT when the device is off.

Current-Limit Protection(WS4612EA)

The WS4612 provides current limit protection function to protect the power source when an over-current condition occurs. The current limit I_{OC} can be adjusted by an external resistor connected between ISET pin and GND. The I_{OC} typical value can be calculated using the following equation:

$$I_{OC}(A) = \frac{6.8K}{R_{SET}}$$

Current-Limit Protection(WS4612E(B/C/D/E))

The WS4612 provides current limit protection function to protect the power source when an over-current condition occurs. The typical current limit threshold is set internally to approximately 1.5A(WS4612EB), 2.1A(WS4612EC), 2.4A(WS4612ED), 3A(WS4612EE).

Short-Circuit Protection

The WS4612 provides short circuit protection function. The output current will be limited to a safe level. The short-circuit protection is used to reduce power dissipation of the device and protect the power source during short-circuit condition.

Fault Indicate(WS4612E(B/C/D/E))

The \overline{FLG} open drain output is asserted (active low) with 7.5ms(Typ.) delay when an over-current or over-temperature condition is encountered. The \overline{FLG} signal will remain asserted until the over-current or over-temperature condition is removed.

UVLO Protection

To avoid malfunction of the WS4612 at low input voltages, an under voltage lockout is included that disables the device, until the input voltage exceeds 2.25V (Typ.)

Shutdown Mode

Drive EN to place the WS4612 in shutdown mode. In shutdown mode, input current falls to smaller than 1 μ A.

Thermal Shutdown

As soon as the junction temperature (T_J) exceeds 160°C (Typ.), the WS4612 goes into thermal shutdown. In this mode, the device is turned off and will turn on again until the junction temperature falls below 140°C (Typ.).

Application Information

Input Capacitor

A 1 μ F input bypass ceramic capacitor(C_{IN}) from IN to GND, located near the WS4612 is strongly recommended to suppress the voltage overshooting during short circuit fault event. Without the bypass capacitor, the output short may cause sufficient ringing on the input (from supply lead inductance) to damage the device.

Output Capacitor

A low ESR, 150 μ F aluminum electrolytic or tantalum between OUT and GND is strongly recommended to reduce the voltage droop during hot-plug of downstream peripheral. Higher value output capacitor is better when the output load is heavy. Additionally, bypassing the output with a 1 μ F ceramic capacitor improves the immunity of the device to short-circuit transients.

PCB Layout consideration

The PCB layout should be carefully performed to maximize thermal dissipation and to minimize voltage drop. The following guidelines must be considered:

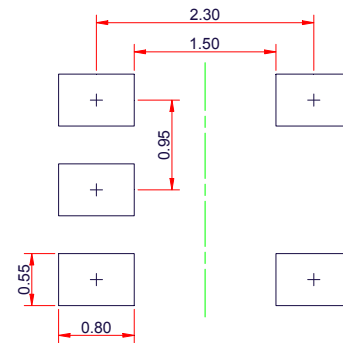
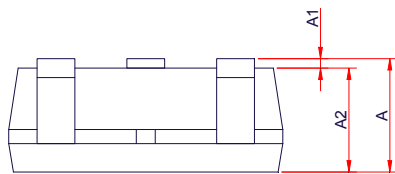
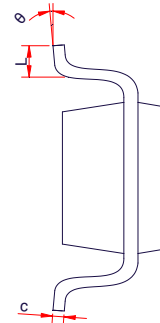
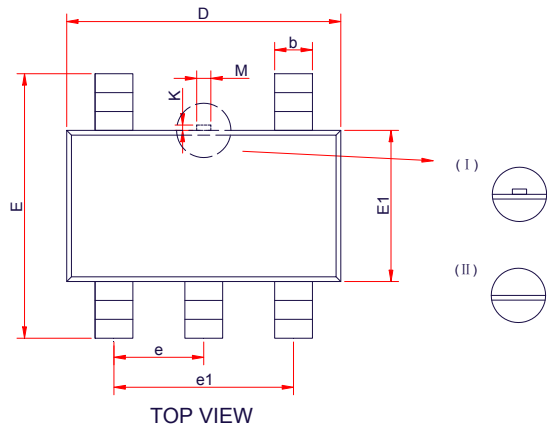
1. Please place the input capacitors near the IN pin as close as possible.
2. Output decoupling capacitors for load must be placed near the load as close as possible for decoupling high frequency ripples.
3. Locate WS4612 and output capacitors near the load to reduce parasitic resistance and inductance for excellent load transient performance.
4. The negative pins of the input and output capacitors and the GND pin must be connected to the ground plane of the load.
5. Keep IN and OUT traces as wide and short as possible.

Order Information

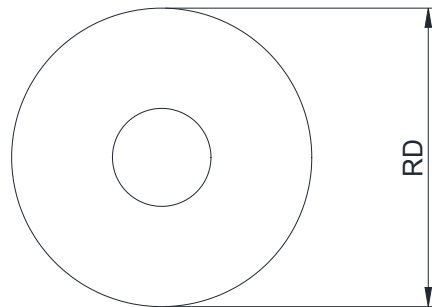
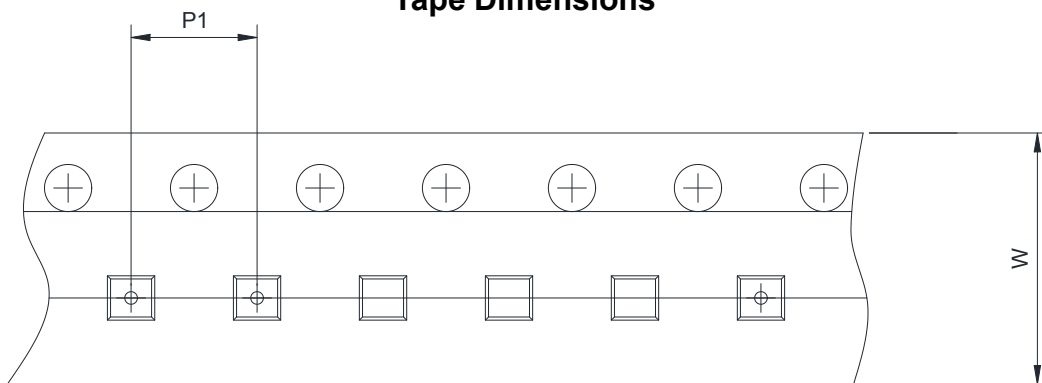
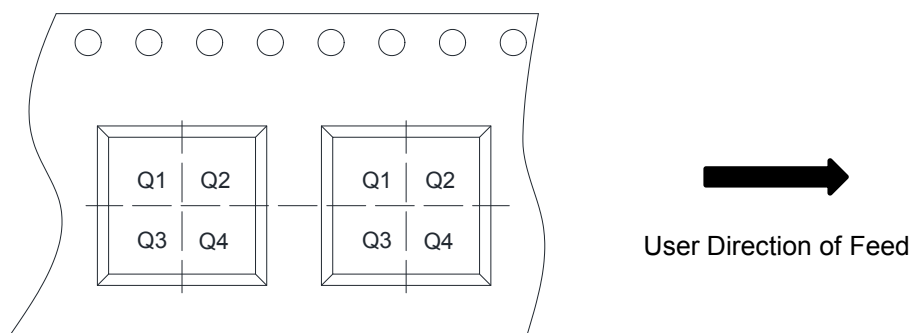
| Ordering No. | Continuous Current | Enable | Output Shutdown Resistor | Package | Operating Temperature | Marking | Shipping |
|----------------|--------------------|-------------|--------------------------|-----------|-----------------------|--------------|----------------|
| WS4612EBA-5/TR | 1A | Active High | Yes | SOT-23-5L | -40~85°C | 4612 BAYW | 3000/Reel&Tape |
| WS4612EBB-5/TR | 1A | Active Low | Yes | SOT-23-5L | -40~85°C | 4612 BBYW | 3000/Reel&Tape |
| WS4612ECA-5/TR | 1.5A | Active High | Yes | SOT-23-5L | -40~85°C | 4612 CAYW | 3000/Reel&Tape |
| WS4612ECB-5/TR | 1.5A | Active Low | Yes | SOT-23-5L | -40~85°C | 4612 CBYW | 3000/Reel&Tape |
| WS4612ECC-5/TR | 1.5A | Active High | No | SOT-23-5L | -40~85°C | 4612 CCYW | 3000/Reel&Tape |
| WS4612EDA-5/TR | 2A | Active High | Yes | SOT-23-5L | -40~85°C | 4612 DAYW | 3000/Reel&Tape |
| WS4612EDB-5/TR | 2A | Active Low | Yes | SOT-23-5L | -40~85°C | 4612 DBYW | 3000/Reel&Tape |
| WS4612EEB-5/TR | 2.5A | Active Low | Yes | SOT-23-5L | -40~85°C | 4612 EBYW | 3000/Reel&Tape |
| WS4612EEA-5/TR | 2.5A | Active High | Yes | SOT-23-5L | -40~85°C | 4612 EAYW | 3000/Reel&Tape |
| WS4612EAA-5/TR | ADJ | Active High | Yes | SOT-23-5L | -40~85°C | 4612 AAYW | 3000/Reel&Tape |
| WS4612EAB-5/TR | ADJ | Active Low | Yes | SOT-23-5L | -40~85°C | 4612 ABYW | 3000/Reel&Tape |
| WS4612EAC-5/TR | ADJ | Active High | No | SOT-23-5L | -40~85°C | 4612 ACYW | 3000/Reel&Tape |

Marking Information

4612 = Device code
****** =Special code
Y = Year code
W = Week code
Marking

PACKAGE OUTLINE DIMENSIONS
SOT-23-5L


| Symbol | Dimensions in Millimeters | | |
|--------|---------------------------|------|------|
| | Min. | Typ. | Max. |
| A | - | - | 1.25 |
| A1 | 0.00 | - | 0.15 |
| A2 | 1.00 | 1.10 | 1.20 |
| b | 0.30 | 0.40 | 0.50 |
| c | 0.10 | - | 0.21 |
| D | 2.72 | 2.92 | 3.12 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.40 | 1.60 | 1.80 |
| e | 0.95 BSC | | |
| e1 | 1.90 BSC | | |
| L | 0.30 | 0.45 | 0.60 |
| M | 0.10 | 0.15 | 0.25 |
| K | 0.00 | - | 0.25 |
| θ | 0° | - | 8° |

TAPE AND REEL INFORMATION
Reel Dimensions

Tape Dimensions

Quadrant Assignments For PIN1 Orientation In Tape


| | | | |
|------|---|---|--|
| RD | Reel Dimension | <input checked="" type="checkbox"/> 7inch | <input type="checkbox"/> 13inch |
| W | Overall width of the carrier tape | <input checked="" type="checkbox"/> 8mm | <input type="checkbox"/> 12mm <input type="checkbox"/> 16mm |
| P1 | Pitch between successive cavity centers | <input type="checkbox"/> 2mm | <input checked="" type="checkbox"/> 4mm <input type="checkbox"/> 8mm |
| Pin1 | Pin1 Quadrant | <input type="checkbox"/> Q1 | <input type="checkbox"/> Q2 <input checked="" type="checkbox"/> Q3 <input type="checkbox"/> Q4 |

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