4 Amp Over-Voltage Protection IC with Sense Output

Features

- Wide Input voltage range: 2.3V to 30V
- Up to 4A Continuous current capability
- Integrated 38mΩ (typ) N-Channel MOSFET
- Wide Over-Voltage threshold range
  - ▶ Fixed internal: 13.75V
  - ▶ Adjustable: 4V to 22V
- Fast OVP response time: 0.1µs (typ.)
- Microphone Mode for audio signal on IN
- Internal 15ms Startup Debounce
- Integrated Surge Protection up to 100V
- Low Quiescent Current: 70µA (typ.)
- Thermal Shutdown and Short Circuit Protection
- Compliance to IEC61000-4-2 (Level 4)
  - ▶ Contact: ±8kV
  - ▶ Air Gap: ±15kV
- ESD Protection
  - ▶ Human Body Model: ±2kV
- Pb-free Package: 12-Bump WLCSP
- -40°C to +85°C Temperature Range

Applications

- Smartphones
- Tablet
- Mobile Internet Devices, Peripherals

Brief Description

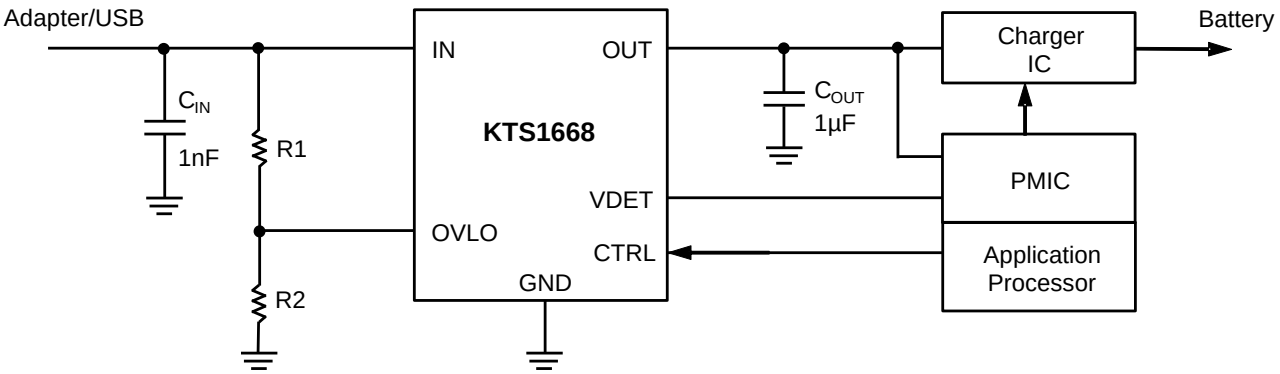
The KTS1668 over-voltage protection (OVP) device features an ultra-low 38mΩ (typical) on-resistance high current integrated MOSFET which actively protects low-voltage systems from voltage supply faults up to +28V_{DC}. An internal clamp protects the device from surges up to 100V.

An input voltage exceeding the over-voltage threshold will cause the internal MOSFET to turn off, preventing excessive voltage from damaging downstream devices. When the OVLO input set below the external OVLO select voltage, the KTS1668 automatically chooses the internal fixed OVLO threshold, preset to 13.75V (typical). The over-voltage protection threshold can be adjusted with optional resistor divider to a voltage between 4V and 22V.

The device features a microphone mode which disables the OVP switch and allows the microphone signal present on the input to be output at VDET pin without an additional multiplexer circuit. The KTS1668 is protected against over-current faults by an internal over-temperature protection shutdown feature.

The KTS1668 is available in a RoHS and Green compliant 12-Bump 1.288mm x 1.988mm x 0.64mm WLCSP.

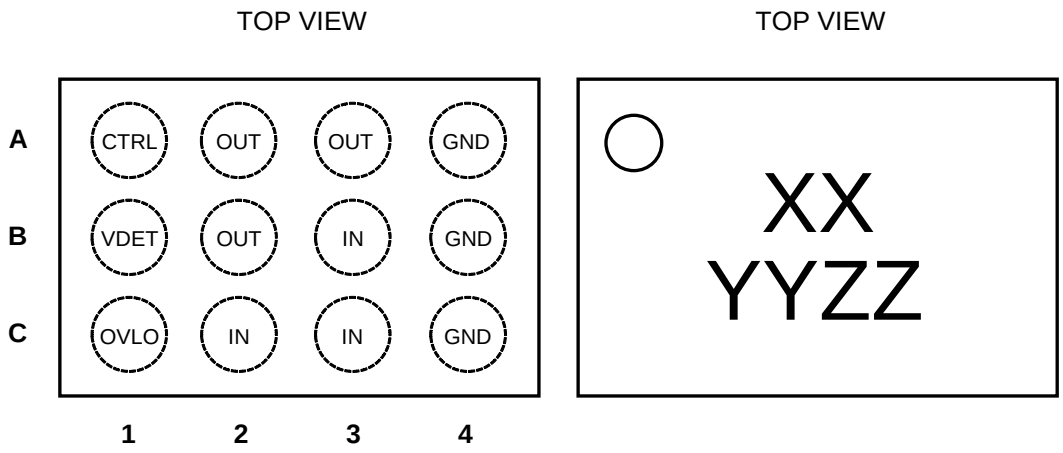
Typical Application



Pin Descriptions

Pin #	Name	Function
A1	CTRL	Active-Low Enable Input. IN to OUT power path switch is Enabled when CTRL is logic Low, and is disabled when CTRL is logic High.
A2, A3, B2	OUT	Output of internal main high-current power switch. Connect OUT pins together in the PCB for proper operation.
A4, B4, C4	GND	Ground. Connect GND pins together in the PCB for proper operation.
B1	VDET	Output from IN pin, with internal protection clamp. V_{DET} can source 1mA.
B3, C2, C3	IN	Voltage Input. Connect IN pins together in the PCB for proper operation.
C1	OVLO	External OVLO Adjustment. Connect OVLO to GND when using the internal fixed threshold. Connect a resistor-divider to OVLO to set the adjustable OVLO threshold. The optional external resistor divider is unrelated to the internal threshold.

WLCSP-12



12-Bump 1.288mm x 1.988mm x 0.64mm
WLCSP Package
Top Code
XX = Device Code
YY = Date Code, ZZ = Assembly Code

Absolute Maximum Ratings[1]

(T_A = 25°C unless otherwise noted)

Symbol	Description	Value	Units
IN[2], OUT	Input, output Voltages	-0.3 to 30	V
OVLO, VDET	OVLO, VDET Pins	-0.3 to 7	V
CTRL	Control Pin	-0.3 to 6	V
IN, OUT Current	Continuous Current	4.5	A
	Peak Current (10msec)	8.0	A
C_{LOAD}	OUT Load Capacitance	0.1 to 100	µF
T_J	Operating Temperature Range	-40 to 150	°C
T_S	Storage Temperature Range	-65 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	260	°C

Thermal Capabilities

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance – Junction to Ambient[3]	73	°C/W
P_D	Maximum Power Dissipation at $T_A \le 25°C$	1.09	W
$\Delta P_D/\Delta T$	Derating Factor Above T_A = 25°C	-13.7	mW/°C

Recommended Operating Range

Description	Value
Input Voltage Range	2.3V to 28V

Ordering Information

Part Number	Marking[4]	OVLO Threshold	Operating Temperature	Package
KTS1668EAY-TR	KPYYZZ	13.75V	-40°C to +85°C	WLCSP-12

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.
2. Survives burst pulse up to 100V with 2Ω series resistance.
3. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board. Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board.
4. "KPYYZZ" is the device code, date code and assembly code.

Electrical Characteristics[5]

V_{IN} = +2.3V to +28V and C_{IN} = 1.0nF. Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of -40°C to +85°C, while *Typ* values are specified at room temperature (25°C). V_{IN} = 5V, $I_{IN} \leq$ 3A.

Symbol	Description	Conditions	Min	Typ	Max	Units
Charging Mode (VCTRL = 0V)						
V_{IN}	Input Voltage Range		2.3		28	V
V_{IN_CLAMP}	Input Clamp Voltage	I_{IN} = 10mA, T_A = +25°C		32		V
I_{IN}	Input Supply Current	V_{IN} = 5V, $V_{IN} < V_{OVLO}$		100		µA
OVP						
V_{IN_OVLO}	Internal Overvoltage Trip Level	V_{IN} rising, T_A = +25°C	13.50	13.75	14.00	V
$V_{IN\_OVLO\_HYS}$	OVLO Hysteresis	V_{IN} falling, T_A = 25°C		0.2		V
V_{OVLO_TH}	OVLO Set Threshold		1.19	1.21	1.23	V
V_{OVLO_EXT}	Adjustable OVLO Select Threshold		4		22	V
V_{OVLO_SEL}	External OVLO Set Threshold range		0.2		0.3	V
R_{ON}	OVLO Switch On-Resistance	V_{IN} = 5V, I_{OUT} = 1A,T_A = +25°C		38	53	mΩ
I_{OUT_LEAK}	OUT Leakage Current	$V_{IN} = V_{IN\_OVLO}$, V_{OUT} = 5V		8	12	µA
I_{OVLO}	OVLO Input Leakage Current	$V_{OVLO} = V_{OVLO\_TH}$	-100		100	nA
CTRL						
V_{CTRL_H}	CTRL logic high threshold		1.4			V
V_{CTRL_L}	CTRL logic low threshold				0.4	V
VDET						
R_{VDET}	VDET Switch On-Resistance	V_{IN} = 4.0, V_{CTRL} = 0V, I_{VDET} = 1mA		40	75	Ω
V_{VDET_OUT}	VDET Clamp Voltage	V_{IN} = 20V, V_{CTRL}= 0V	4.5	5.0	5.5	V
I_{VDET_LIM}	VDET Current Limit			30		mA
Microphone Mode (VCTRL = 3V)						
I_{VDET}	VDET Input Current	IN unconnected, V_{CTRL} = 3V,VDET = 2.5V		6	28	µA
V_{VBUS_MIC}	Microphone Mode VDET Clamp Voltage	V_{IN} = 20V, V_{CTRL} = 3V,VDET loaded by 1MΩ		5.0		V
R_{MIC}	Microphone Mode VDET On-Resistance	I_{IN} = 1mA, V_{CTRL} = 3V,V_{IN} = 0V or 2.5V			120	Ω
I_{CTRL_H}	CTRL Input High Current	IN unconnected, V_{CTRL} = 3V, VDET = 2.5V		2	4	µA
I_{CTRL_L}	CTRL Input Low Current	V_{CTRL} = 0V	-1	0	1	µA

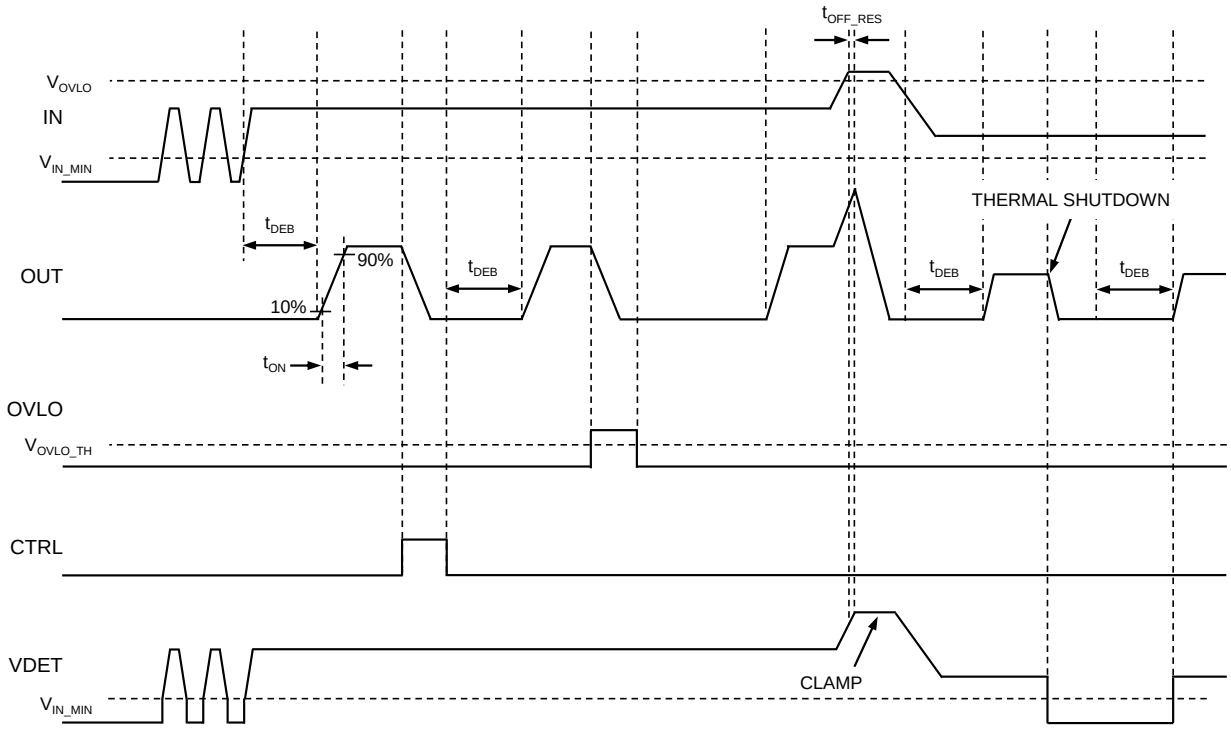
5. All specifications are 100% production tested at TA = +25°C, unless otherwise noted. Specifications are over -40°C to +85°C and are guaranteed by design.

Electrical Characteristics[6] (continued)

V_{IN} = +2.3V to +28V and C_{IN} = 1.0nF. Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of –40˚C to +85°C, while *Typ* values are specified at room temperature (25°C). V_{IN} = 5V, $I_{IN} \leq$ 3A.

Symbol	Description	Conditions	Min	Typ	Max	Units
Timing Characteristics (Figure-1)						
t_{DEB}	Debounce Time	Time from 2.1V < V_{IN} < V_{IN_OVLO} to V_{OUT} = 10% of V_{IN}		15		ms
t_{ON}	Ramp Time	V_{OUT} = 10% of V_{IN} to 90% of V_{IN}		2		ms
t_{OFF_RES}	Switch Turn-Off Response Time	V_{IN} > V_{OVLO} to V_{OUT} stop rising		100		ns
Thermal Protection						
T_{SHDN}	IC junction thermal shutdown threshold			130		°C
T_{HYST}	IC junction thermal shutdown hysteresis			20		°C
ESD Protection						
V_{ESD}	IEC 61000-4-2 Contact Discharge	IN pin		±8		kV
	IEC 61000-4-2 Air-Gap Discharge	IN pin		±15		kV
	Human Body Model (HBM) Model = 2	All Pins		±2		kV

6. All specifications are 100% production tested at TA = +25°C, unless otherwise noted. Specifications are over -40°C to +85°C and are guaranteed by design.



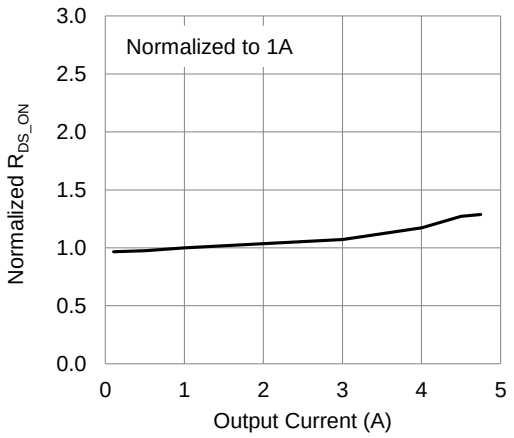
* NOTE: WAVEFORMS ARE NOT TO SCALE

Figure 1. Timing Diagram

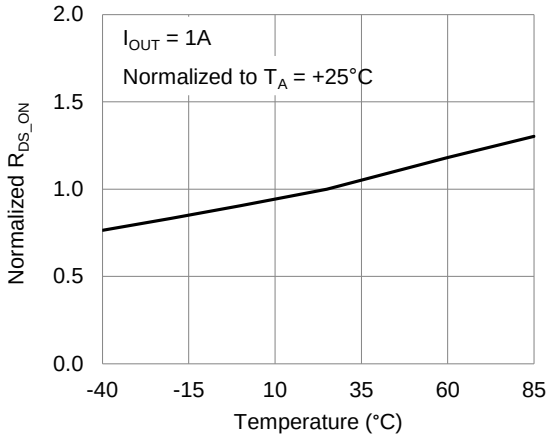
Typical Characteristics

V_{IN} = 5V, C_{IN} = 0.1µF, C_{OUT} = 1µF, OVLO pin = GND, CTRL = GND, Temp = 25°C unless otherwise specified.

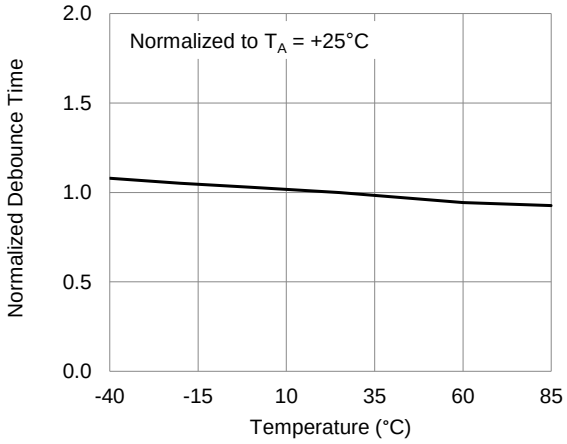
Normalized R_{DSON} vs. Output Current



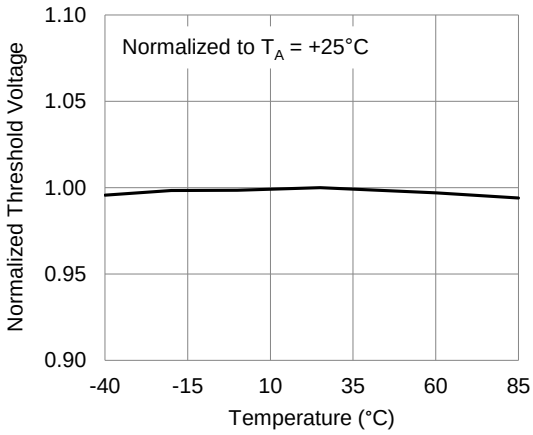
Normalized R_{DSON} vs. Temperature



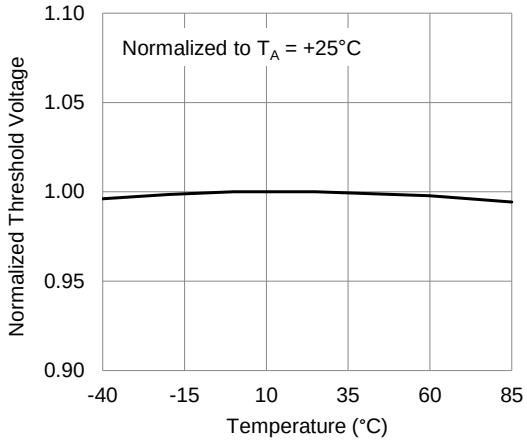
Normalized Debounce Time vs. Temperature



Normalized Fixed OVLO vs. Temperature (OVLO pin GND)



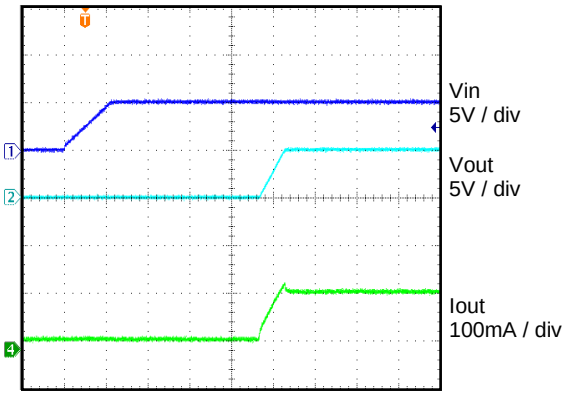
Normalized Adjustable OVLO Threshold vs. Temperature



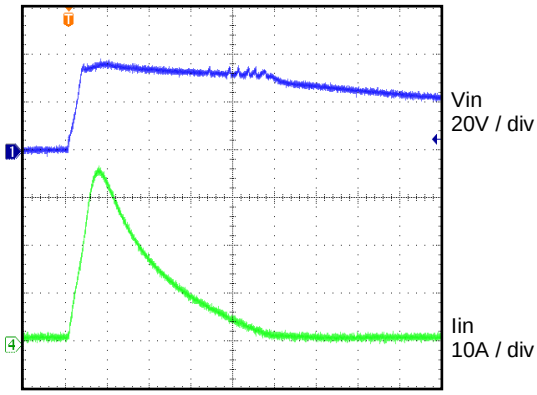
Typical Characteristics (continued)

V_{IN} = 5V, C_{IN} = 0.1µF, C_{OUT} = 1µF, OVLO pin = GND, CTRL = GND, Temp = 25°C unless otherwise specified.

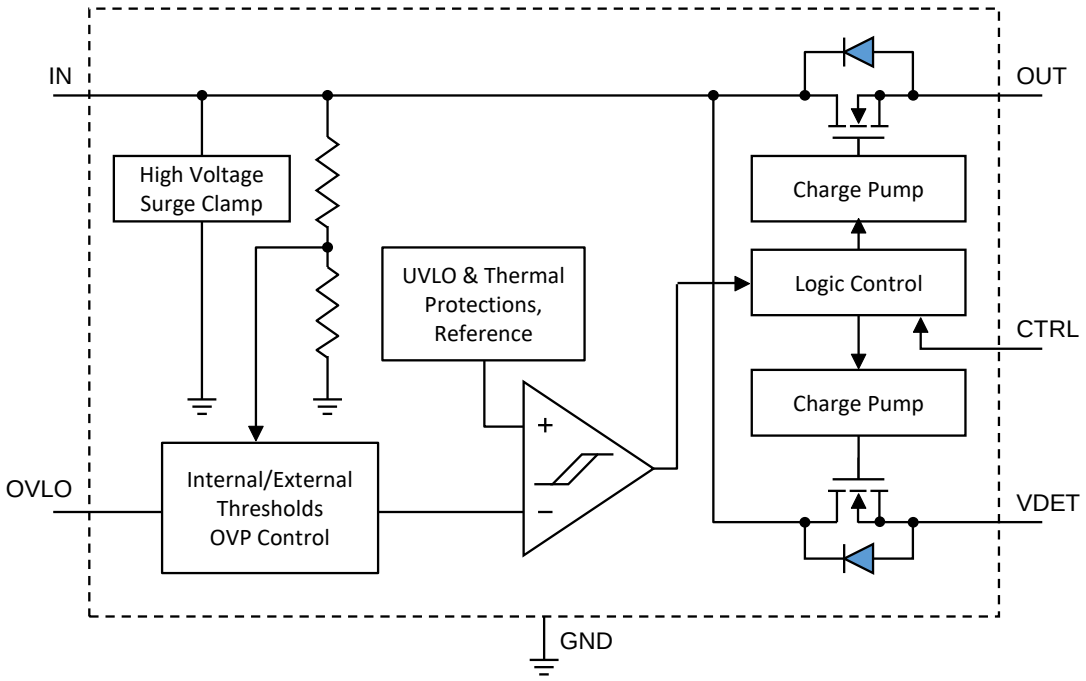
Power-up (C_{OUT} = 10µF, 100mA load)



Surge Transient (110V)



Functional Block Diagram



Functional Description

The KTS1668 is inserted between the power supply or charger source and the load to be protected. The overvoltage protection (OVP) switch features an ultra-low 38mΩ (typical) on-resistance MOSFET and protects low-voltage systems against voltage faults up to +28V_{DC}. An internal clamp also protects the device from input surge transients up to 100V. If the input IN pin voltage exceeds the overvoltage threshold, the internal MOSFET is turned off to prevent damage to any downstream components connected to the output. A 15ms debounce time built into the device delays the internal MOSFET turn on time.

The overvoltage protection threshold can be externally programmed with an optional resistor divider to set a threshold between 4V and 22V. With the OVLO input pin tied to GND (or below the external OVLO select voltage), the KTS1668 automatically selects the internal OVLO threshold. The internal overvoltage threshold (V_{IN_OVLO}) is preset to 13.75V typical.

KTS1668 also features a microphone mode which turns off the main power switch allowing the microphone signal from IN pin to be output at VDET pin without an additional multiplexer circuit.

Device Operation

During normal operation, with CTRL input low, once IN voltage is present, the main power switch connecting IN and OUT turns on after a 15ms debounce delay (see Functional Diagram). After the debounce delay, a soft-start limits the inrush current for 2ms (typical), during that time OUT voltage ramps up to IN voltage.

The main power switch turns off, OUT disconnected from IN, if one of the following fault condition becomes true. The fault conditions are:

- Overvoltage protection mode (OVP) when either $V_{IN} > V_{IN\_OVLO}$ or OVLO pin voltage $V_{OVLO} > V_{OVLO\_TH}$ (if a resistor divider is used to program OVLO).
- Undervoltage lockout when VIN below the normal operating range.
- Thermal shutdown.

Internal Main MOSFET Switch

In normal operating mode (main power switch turned on), the CTRL input must be set to the logic low state (CTRL = GND). The KTS1668 integrates an N-Channel power MOSFET with ultra-low 38mΩ (typical) on-resistance between IN and OUT. The MOSFET is internally driven by an internal charge pump supply rail that generates the gate voltage (V_{GS}) greater than IN.

Overvoltage Lockout (OVLO)

The KTS1668 has a 13.75V (typical) overvoltage threshold. If the IN input voltage is above this threshold, the internal MOSFET is turned off and OUT is disconnected from IN.

Protected Bus Voltage

The KTS1668 passes a protected VIN voltage through to VDET. The VDET pin can provide up to 1mA of DC current. VDET contains an internal 5.0V clamp to protect devices connected to VDET, while still allowing the devices to operate from the VDET voltage. The voltage at VDET is not present while the KTS1668 is in thermal shutdown or IN is lower than the input operating range.

Microphone Mode

The KTS1668 features a microphone mode which turns off the internal main MOSFET and allows a microphone signal at IN to pass through to the VDET pin. This enables the user to select the path of IN without an additional multiplexer circuit. The CTRL input recommended voltage is 3V or higher in order to put the device in microphone mode.

Thermal-Shutdown Protection

Both the internal main MOSFET and VDET switches are turned off when the junction temperature exceeds +130°C (typ). The device exits thermal shutdown after the junction temperature cools by +20°C (typ).

Application Information

Input Capacitor

For most applications, connect a 1nF ceramic capacitor as close as possible to the device from IN to GND. During surge voltage transients, the internal input clamp keeps the input IN pin voltage below 40V, so 50V rated capacitors are ideal for most OVP applications.

OUT Output Capacitor

The internal soft-start function allows the KTS1668 to charge an output capacitor up to 100μF without turning off due to overcurrent.

External OVLO Adjustment Functionality

If the OVLO pin is connected to ground, KTS1668 uses the factory programmed OVLO value for its internal OVLO comparator.

If an external resistor-divider is connected to OVLO and V_{OVLO} exceeds the OVLO select voltage, V_{OVLO_SELECT}, the internal OVLO comparator reads the IN fraction fixed by the external resistor divider. Starting with R1 = 1MΩ to minimize current consumption, R2 can be calculated from the following formula:

$$V_{OVLO\_EXT} = V_{OVLO\_THRESH} \times (1 + \frac{R_1}{R_2})$$

This external resistor-divider is separate from the internal resistor-divider circuit. An external resistor-divider could slow the OVLO response time, affecting the surge protection. An RC divider can be used to improve response speed. The capacitor can be calculated as follows:

$$C_1 > 5 \times t_R \times \left[\frac{R_1 + R_2}{R_1 R_2} \right]$$

Where t_R is the rise time of the worst-case transient at IN pin (measured from the start of rising edge to the point where IN reaches V_{IN_OVLO}). See Figure 2.

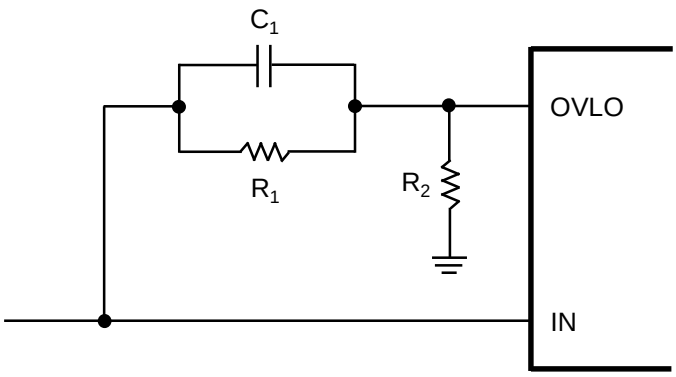


Figure 2. External OVLO Set Circuit

USB On-The-GO (OTG) Operation

When used in an OTG application the KTS1668 can provide power from OUT to IN regardless of the condition of the CTRL pin.

When the CTRL pin is LOW (power switch automatically enabled), initially, the OTG voltage applied at OUT will forward bias the power switch bulk diode and present a voltage drop of approximately 0.7V between OUT and IN. The maximum current in this mode is limited by the thermal performance of the device and at an ambient temperature of 25^{O}C

$$\mathbf{I_{MAX}} = \frac{\mathbf{1.09W}}{\mathbf{0.7V}} = \mathbf{1.56A}$$

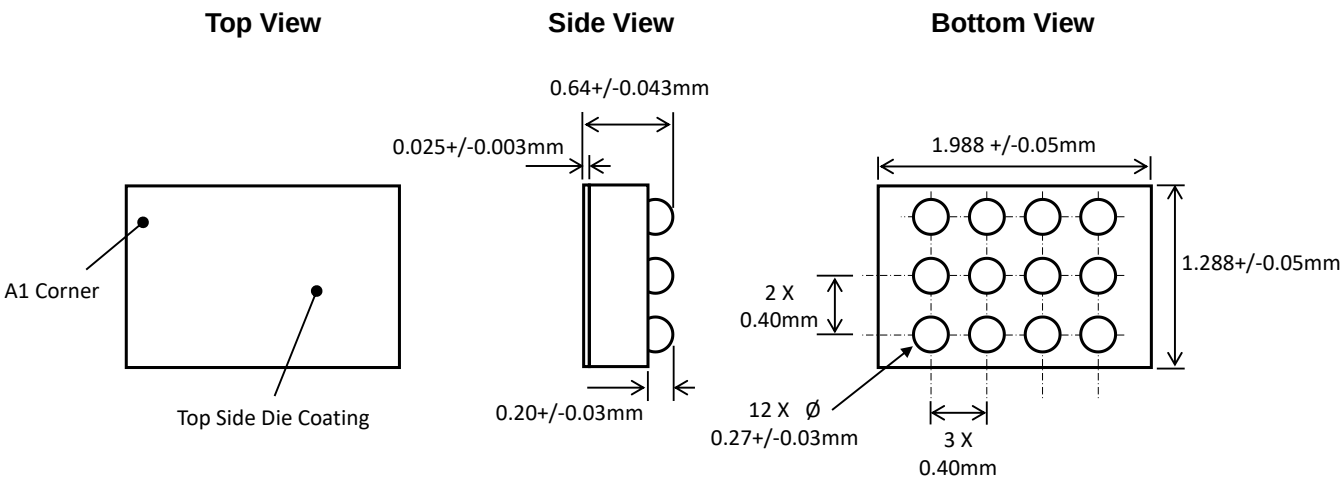
This is purely a transitionary condition as once the voltage at IN exceeds 2.1V and the debounce time of 15ms has elapsed, the main power switch will turn fully ON, significantly reducing the voltage drop from OUT to IN.

When the CTRL is HIGH (power switch is OFF), the OTG voltage applied at OUT will also forward bias the power switch bulk diode, but as the switch will not turn ON unless CTRL is pulled LOW, the high forward voltage drop of 0.7V and consequent high power dissipation will remain. For this reason, it is highly recommended to pull CTRL LOW in all OTG applications.

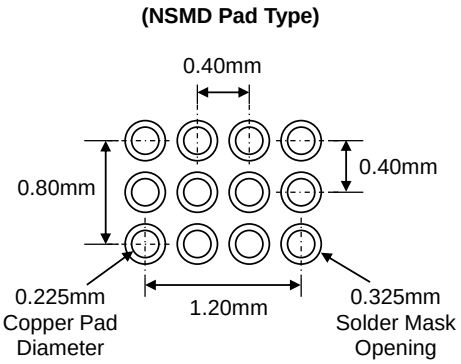
Please note in OTG mode, under no circumstance should any load, or any voltage be connected to VDET.

Packaging Information

WLCSP-12, 1.288mm x 1.988mm x 0.64mm



Recommended Footprint



* Dimensions are in millimeters.

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