# Automotive Load Switch with OVP and RB Protection

## Features

- Wide input operating range from 4V to +40V DC Input
- Low resistance MOSFET Switch typ. 41mΩ
- Reverse Battery Protection to -28V
- Fixed over-voltage protection.
- Fixed: 20.3V ± 0.8V
- Fast OVP response time typ. 360ns
- Continuous output current up to 6A
- Over-temperature Protection with Auto-Retry
- Open drain fault flag
- Shutdown pin with low shutdown current
- Battery detection output
- Input ESD protection to IEC61000-4-2 (Level 4)
  - Contact: ±8kV
  - Air: ±15kV
  - Other pins HBM: ±2kV to AEC Q100-002
- EN or $\overline{EN}$ Enable Logic Input Versions
- AEC-Q100 Qualified
- Meets automotive ISO7637 transient requirements with suitable external TVS diodes.
- Pb-free TDFN44-12 package.
- -40°C to +125°C operating temperature range.

## Applications

- Automotive Load Switching
- Reverse Power Supply Protection
- Telecom/Server/Networking System
- Industrial and Medical Systems
- Portable Instrumentation

## Brief Description

The KTS1642Q is low-resistance, electronically controlled load switches, with enhanced protection features, used to protect loads from abnormal power supply or load problems. Operating from a wide input supply voltage of between 4V and 40V, the KTS1642Q protects the system from reverse input supplies down to -28V.

Integrating two N-Channel MOSFETs, the device includes fixed over-voltage protection of 20.3V along with over-temperature protection with auto-retry. Following an over-voltage condition only, KTS1642Q will automatically resume operation, when the over-voltage condition is removed.

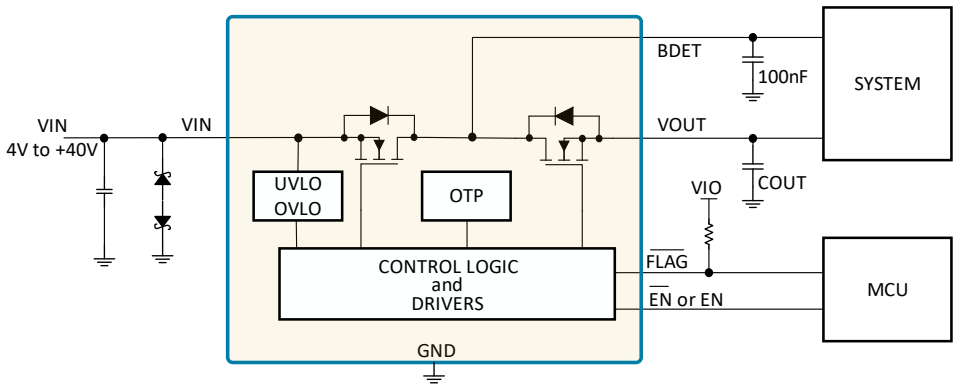
An ENABLE pin allows the MOSFET switch to be enabled or disabled, placing the device in a low current shutdown mode. System monitoring is provided by a fault $\overline{FLAG}$.

To inform the system that the battery or power supply is connected, BDET mirrors the input voltage less the drop across the reverse battery protection MOSFET and sources up to a maximum of 500mA.

Further protection includes over-temperature shutdown, and the input pin is fully ESD protected to comply with the IEC61000-4-2 (Level 4) specification.

The KTS1642Q is packaged in an advanced, fully green compliant, TDFN44-12 package.

## Typical Application



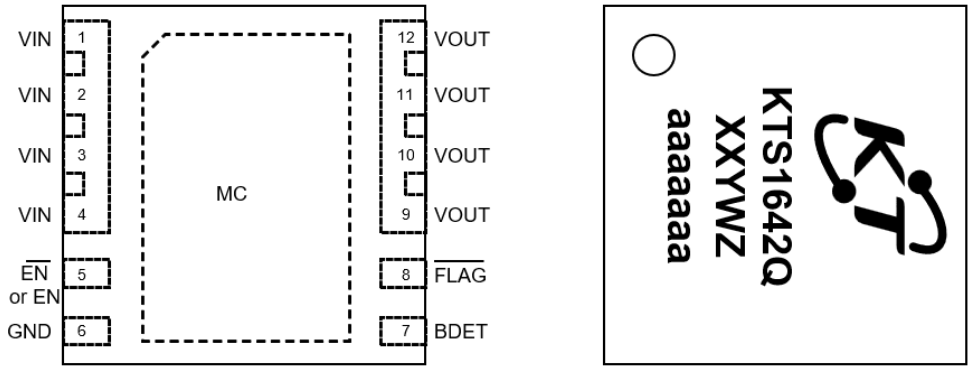
## Ordering Information

| Part Number | Marking[1] | OVP | Enable Polarity | Fault Response | Ambient Operating Temperature | Package |
|---|---|---|---|---|---|---|
| KTS1642QGDV-TR | TDYWZ<br>aaaaaaa | 20.3V | $\overline{EN}$ | Auto Retry | -40°C to +125°C | TDFN44-12 |
| KTS1642AQGDV-TR | TTYWZ<br>aaaaaaa | 20.3V | EN | Auto Retry | -40°C to +125°C | TDFN44-12 |

## Pinout Diagram

**TDFN44-12**

Top View




12-Lead 4.00mm x 4.00mm x 0.75mm
TDFN Package

**Top Mark**

KT Logo

KTS1642Q or KTS1642AQ = Part Number
XX = Device ID Code, YWZ = Assembly Date Code
aaaaaaa = Assembly Lot Tracking Code

1. TD or TT = Device ID Code, YWZ = Assembly Date Code, aaaaaaa = Assembly Lot Tracking Code.

## Pin Descriptions

| Pin # | Name | Function | | |
|---|---|---|---|---|
| 1, 2, 3, 4 | VIN | Input to the power switch and device supply. The VIN pins must be decoupled to GND via a minimum 1µF ceramic capacitor. To be compliant to the ISO7326 Automotive Transient specification, this pin should also be protected by two suitable external TVS diodes. | | |
| 5 | $\overline{EN}$ | Active LOW logic input pin with 1Mohm pull down resistor. (KTS1642Q) | | |
| | EN | Active HIGH logic input pin with 1Mohm pull down resistor. (KTS1642AQ) | | |
| 6 | GND | Ground | | |
| 7 | BDET | Battery Detection, and supply. Should be decoupled by a 100nF capacitor to GND | IC is disable | BDET = VIN - 0.7V |
| | | | IC is enabled | BDET = VIN – ($r_{DS}$ x $I_D$) |
| 8 | $\overline{FLAG}$ | Active LOW, open drain fault pin. Connect an external pull-up resistor to the system logic supply. $\overline{FLAG}$ is asserted during any fault condition. | | |
| 9, 10, 11, 12 | VOUT | Power switch output to the load. The VOUT pins must be decoupled to GND via a minimum 1µF ceramic capacitor. | | |
| MC | MC | Metal chassis. Connect to ground for electrical and thermal usage. MC is internally connected to GND. | | |

## Absolute Maximum Ratings[2]

($T_A$ = 25°C unless otherwise noted)

| Symbol | Description | Value | Units |
|---|---|---|---|
| VIN | Input Voltage to GND | -30 to 42 | V |
| VIN to VOUT | Input voltage to VOUT | -30 to +42 | V |
| VOUT, | Output Voltage to GND | -0.3 to +30 | V |
| BDET | BDET output voltage to GND | -0.3 to +42 | V |
| $\overline{FLAG}$, $\overline{EN}$ or EN | $\overline{FLAG}$, $\overline{EN}$ or EN pins to GND | -0.3 to 7 | V |
| IBDET[3] | Battery Detect Continuous Current | 510 | mA |
| IOUT | VIN to VOUT Continuous Current | 6 | A |
| $T_{STG}$ | Storage Temperature Range | -55 to 150 | °C |
| $T_J$ | Junction Operating Temperature | -40 to 150 | °C |
| $T_{LEAD}$ | Maximum Soldering Temperature (at leads, 10sec) | 260 | °C |

## ESD Ratings[4]

| Symbol | Description | Conditions | Value | Units |
|---|---|---|---|---|
| $V_{ESD}$ | IEC61000-4-2 Air Discharge | VIN Only | ±15 | kV |
| | IEC61000-4-2 Contact Discharge | | ±8 | kV |
| | Human-body Model (HBM), per AEC Q100-002[5] | All Pins | ±2 | kV |
| | Charged-device Model (CDM), per AEC Q100-011[6] | | ±1 | kV |

## Thermal Capabilities[7]

| Symbol | Description | Value | Units |
|---|---|---|---|
| $\theta_{JA}$ | Thermal Resistance, Junction−to−Air | 38 | °C/W |
| $P_D$ | Maximum Power Dissipation at 25℃ | 3.29 | W |
| $\Delta P_D/\Delta_T$ | Derating Factor Above $T_A$ = 25℃ | -26.3 | mW/°C |

2. 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.

3 Maximum output current pin limited. Output does not short-circuit protected.

4. ESD Ratings conform to JEDEC and IEC industry standards. Some pins may actually have higher performance. Surge ratings apply with chip enabled, disabled, or unpowered, unless otherwise noted.

5. Follows ANSI/ESDA/JEDEC JS-001

6. Follows ANSI/ESD S5.3.1-2009.

7. 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.

## Recommended Operating Conditions[8]

| Description | System Condition | Value |
|---|---|---|
| Input Voltage | NORMAL | 4V to OVP |
| | PROTECTED | -28V to +40V |
| Continuous Output Current | NORMAL | Up to 6A |
| BDET Output Current[9] | NORMAL | 500mA max |
| Operating Temperature | ALL | -40°C to +125°C |

8. The recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Kinetic does not recommend exceeding them or designing to Absolute Maximum Rating.

9. Output not short circuit protected.

## Electrical Characteristics[10]

Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of -40°C to +125°C. Typical values are specified at room temperature (25°C) with VIN = 14V, IOUT ≤ 5A, $\overline{EN}$ = LOW, $\overline{FLAG}$ = OPEN, CIN = 1.0µF, COUT = 1.0µF, CBDET = 100nF and $T_A$ = 25°C.

| Symbol | Description | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **INPUT** | | | | | | | |
| $I_Q$ | Input Quiescent Current | | | | 145 | 200 | µA |
| $I_{LK}$ | Input Leakage Current | $\overline{EN}$ = HIGH, No load | | | 5 | 8 | µA |
| $I_{LK\_RB}$ | Input Leakage Current in Reverse Battery | $V_{IN}$ = -28V, $\overline{EN}$ = HIGH, No load | | | 52 | 70 | µA |
| $I_{OVLO\_Q}$ | Input Supply Current in Over-voltage mode | KTS1642Q | $V_{IN}$ = 20.3V | | 150 | 180 | µA |
| $V_{IN\_UVLO}$ | Under Voltage Lockout | $V_{IN}$ Rising | | 3.4 | 3.6 | 3.8 | V |
| | | $V_{IN}$ Falling | | 2.9 | 3.2 | 3.4 | V |
| **OUTPUT** | | | | | | | |
| $R_{ON\_OUT}$ | On-resistance VIN to VOUT | $I_{OUT}$ = 1A | $T_A$ = 25°C | | 41 | 50 | mΩ |
| | | $I_{OUT}$ = 5A | | | 44.5 | | mΩ |
| $V_{OUT\_OVLO}$ | Over-Voltage Trip Level | $V_{IN}$ Rising | | 19.5 | 20.3 | 21.1 | V |
| | | $V_{IN}$ Falling | | 17.9 | | | V |
| $I_{OUT\_RC}$ | OUT Reverse Current | $V_{IN}$ = 0V, $V_{OUT}$ = 28V, $T_A$ = 25°C | | | 38 | | µA |
| **DIGITAL SIGNALS ($\overline{FLAG}$, $\overline{EN}$, EN)** | | | | | | | |
| $V_{FLAG\_OL}$ | $\overline{FLAG}$ Output Low Voltage | $V_{IO}$ = 5V, sinking 1.0mA | | | | 0.5 | V |
| $I_{FLAG}$ | $\overline{FLAG}$ Leakage Current | $V_{IO}$ = 5V | | | | 1 | µA |
| $V_{EN\_IH}$ | $\overline{EN}$, EN High Voltage | $V_{IO}$ = 5V | | 1.2 | | | V |
| $V_{EN\_IL}$ | $\overline{EN}$, EN Low Voltage | $V_{IO}$ = 5V | | | | 0.35 | V |
| $I_{EN}$ | $\overline{EN}$ Leakage Current | $V_{IO}$ = 5V | | | | 4 | µA |
| **TIMING CHARACTERISTICS (Figures 1 – 3)** | | | | | | | |
| $t_{OUT\_DB}$ | VOUT Debounce Time | Time from $V_{IN}$ = $V_{IN\_UVLO}$ to 10% of $V_{OUT}$, | | | 2 | | ms |
| $t_{ON\_OUT}$ | OUT Switch Turn-on Time | $V_{OUT}$ from 10% of $V_{IN}$ to 90% of $V_{IN}$, $R_L$ = 100Ω, $C_L$ = 22µF | | | 10 | | ms |
| $t_{OFF\_OUT\_F}$ | OUT Switch Turn-Off Time Under Fault Conditions or by $\overline{EN}$ [11] | $V_{IN}$ > $V_{OUT\_OVLO}$ to $V_{OUT}$ Stop rising, $R_L$ = 100Ω, No $C_L$, $\overline{EN}$ = Low | | | 360 | | ns |

10. Device is guaranteed to meet performance specifications over the -40°C to +85°C operating temperature range by design, characterization, and correlation with statistical process controls.

11. Guaranteed by characterization and design.

## Electrical Characteristics (continued)[12]

Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of -40°C to +125°C. Typical values are specified at room temperature (25°C) with VIN = 14V, IOUT ≤ 5A, $\overline{EN}$ = LOW, $\overline{FLAG}$ = OPEN, CIN = 1.0µF, COUT = 1.0µF, CBDET = 100nF and $T_A$ = 25°C.

| Symbol | Description | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **TIMING CHARACTERISTICS Cont. (Figures 1 – 3)** | | | | | | |
| $t_{EN(ON)}$ | Switch Turn-ON | $\overline{EN}$ High to Low, VOUT | | 14 | | ms |
| $t_{EN(OFF)}$ | Switch Turn-OFF | $\overline{EN}$ Low to High, $V_{OUT}$ falls to 90% $V_{OUT}$, $R_L$ = 100Ω, No $C_L$ | | 350 | | ns |
| **THERMAL SHUTDOWN[13]** | | | | | | |
| $T_{SHDN}$ | Shutdown Temperature | | | 165 | | °C |
| | Shutdown Temperature Hysteresis | | | 20 | | °C |

12. Device is guaranteed to meet performance specifications over the -40°C to +85°C operating temperature range by design, characterization, and correlation with statistical process controls.

13. Guaranteed by design, characterization, and statistical process control methods; not production tested.

## Timing Diagrams[14]

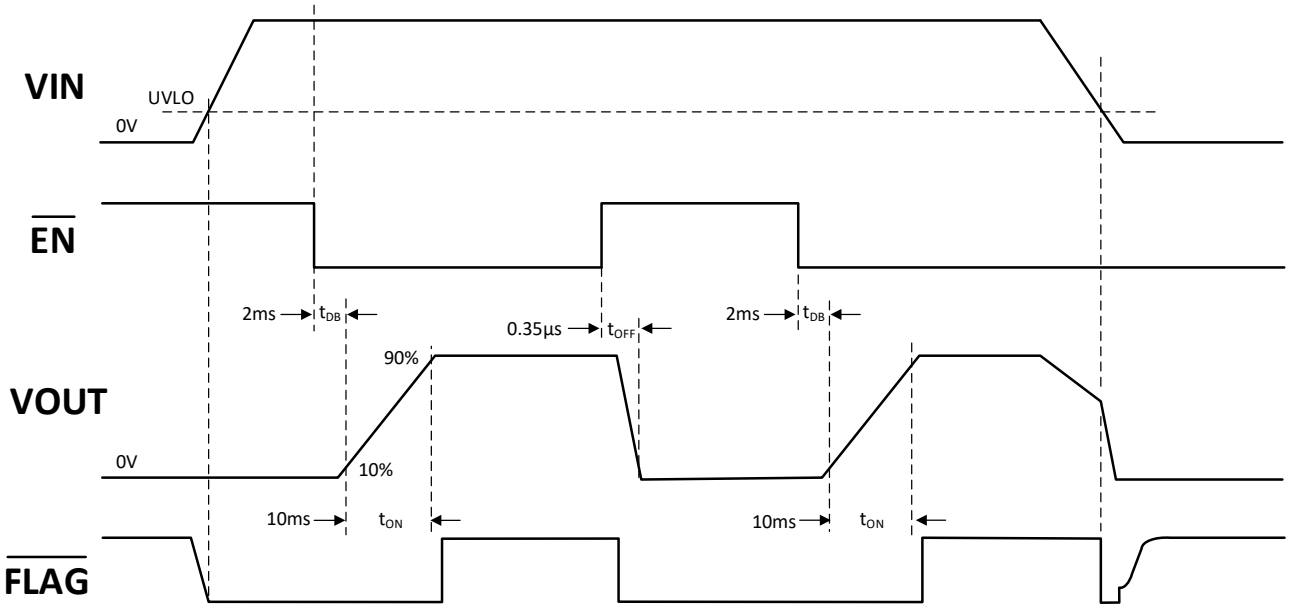



**Figure 1. TURN-ON/TURN-OFF, When initially VIN = 0V, $\overline{EN}$ = H**

14. All timing diagrams are for illustration purposes only and not to scale.

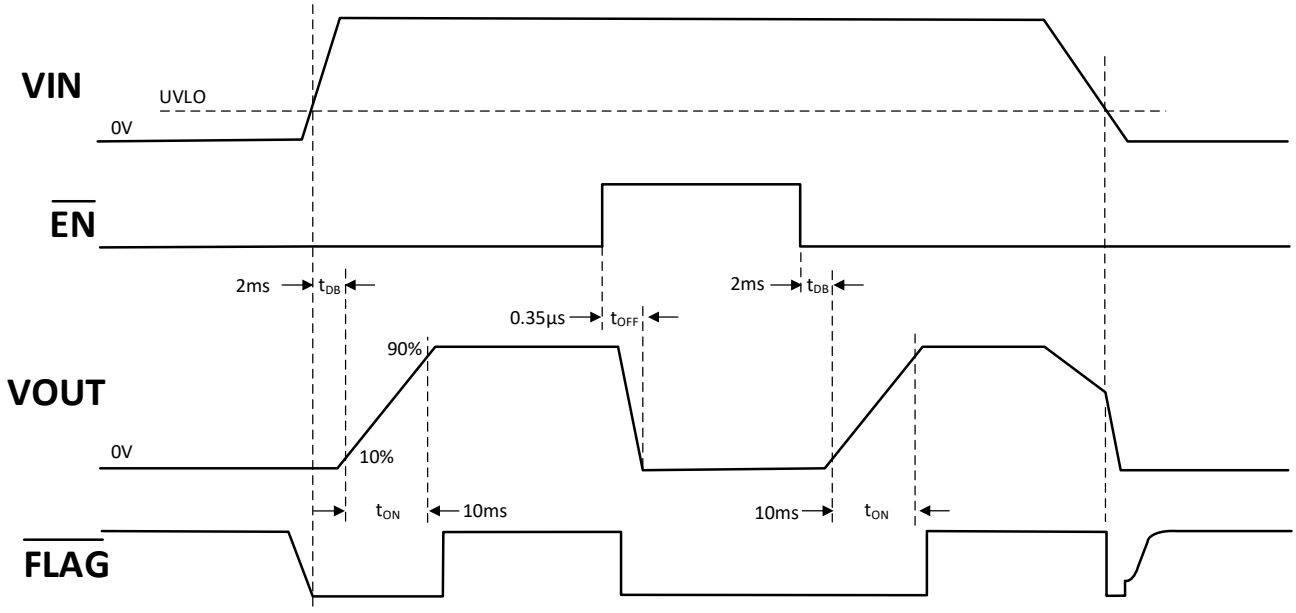



**Figure 2. TURN-ON/TURN-OFF, When initially VIN = 0V, $\overline{EN}$ = L**

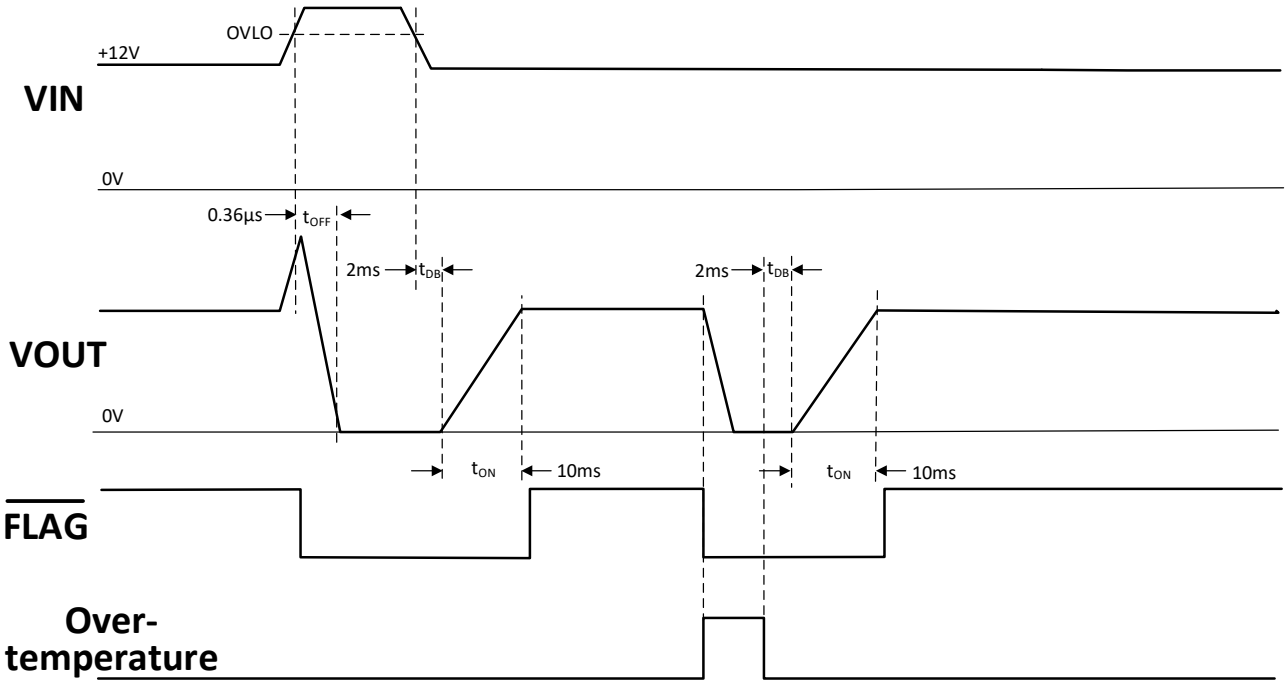
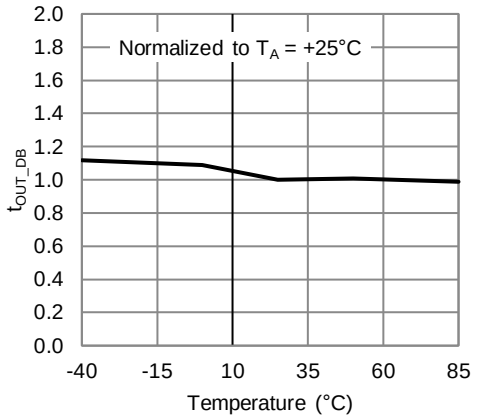



**Figure 3. Over-voltage and Over-temperature, $\overline{EN}$ = L**

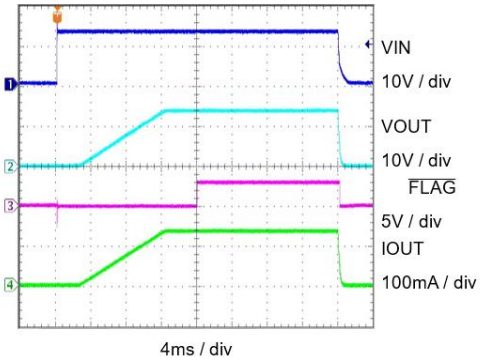
## Typical Characteristics

VIN = 14V, $\overline{EN}$ = LOW, CIN = 1µF, COUT = 1µF, CBDET = 100nF, $T_A$ = 25°C unless otherwise specified.

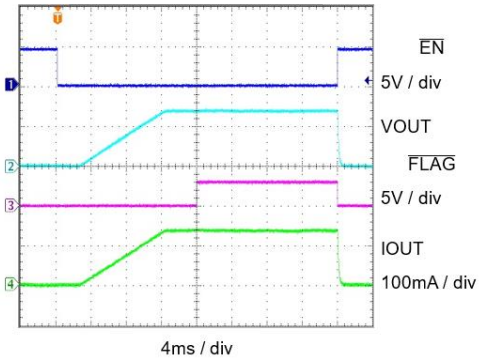
**Normalized Debounce Time vs. Temperature**



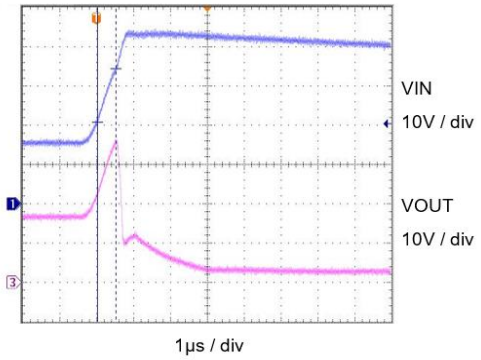

**Power Up and Down (100Ω load)**



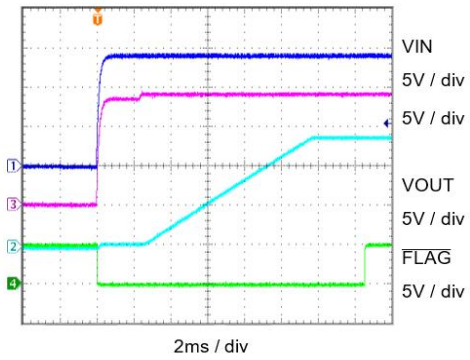

**Turn On and Off by Enable**



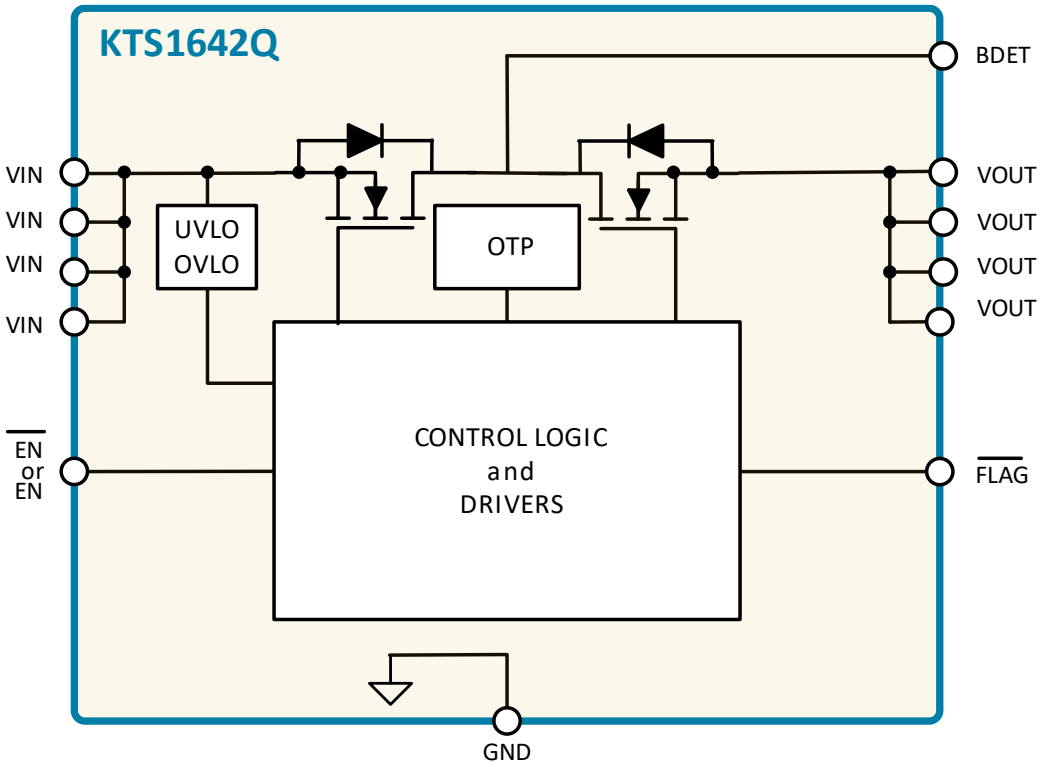

**OVP Transient**




**Power-up with BDET**



## Functional Block Diagram




## Functional Description

The KTS1642Q is low-resistance, electronically controlled load switches, with enhanced protection features, used to protect loads from abnormal power supply or load problems. Operating from a wide input supply voltage of between 4V and 40V, the KTS1642Q protects the system from reverse input supplies down to -28V, over-voltage conditions, over-temperature and output short-circuits.

The KTS1642Q integrates two low-resistance, active LOW enabled, N-Channel MOSFETs, in common drain configuration. The first MOSFET will provide protection to the system if the battery supply is accidentally reversed. The second MOSFET provides the controlled turn-on and protection of the battery voltage to the system load. The KTS1642Q includes fixed over-voltage protection of typical 20.3V±0.8V. It also includes over-temperature protection with auto-retry[15].

An ENABLE pin allows the MOSFET switch to be enabled or disabled, placing the device in a low current shutdown mode. System monitoring is provided by a digital output fault $\overline{\text{FLAG}}$. When a fault condition occurs, the fault $\overline{\text{FLAG}}$ is pulled down to GND. An external pull-up resistor connected to the system power supply is required.

Further protection includes ESD protection, and the input pin is fully protected to comply with the IEC61000-4-2 (Level 4) specification.

15. For an alternative response to fault conditions, please contact marketing.

### Internal MOSFET Switch

In normal operating mode (main power switches turned on), for KTS1642Q, the $\overline{EN}$ input must be set to the logic low state ($\overline{EN}$ = LOW); for KTS1642AQ, the EN input must be set to the logic high state (EN = HIGH). The KTS1642Q integrates two N-Channel power MOSFETs in a back-to-back configuration with ultra-low 41mΩ (typical) on-resistance between VIN and VOUT. The MOSFETs are internally driven by a charge pump supply that generates a gate voltage (VGS) greater than VIN.

To prevent downstream systems from being damaged by a reverse battery condition, the KTS1642Q include an integrated synchronous MOSFET diode to protect against voltages down to -28V.

### Under-voltage Lockout

When the input voltage VIN is below the normal operating range, either during operation or start-up, the internal switch will turn-off and the fault flag asserted low. The UVLO is internally set to 3.6V typical with 400mV hysteresis.

### Over-voltage Lockout Protection

The KTS1642Q features a fixed over-voltage threshold of 20.3V typical. If VIN is above this threshold, the internal MOSFET switches are turned OFF and VOUT is disconnected from VIN, protecting the load. $\overline{FLAG}$ is asserted low during the over-voltage period. Once the over-voltage condition is removed the switch will automatically restart.

### Battery Present Output

BDET provides an unregulated output, whenever VIN is present. When the switch is enabled, BDET is equal to VIN less the voltage dropped across the input MOSFET ($V = r_{DS} \times I_{SW}$). When the switch is disabled, BDET is equal to VIN less one diode drop, due to the reverse battery protection MOSFET ($BDET = V_{IN} – V_F$ (~0.7V)). This output is capable of supplying up to a maximum of 500mA output current. However, care should be taken not to exceed this value as this pin is not short-circuit protected.

### Over-temperature Protection

During an over-temperature event, KTS1642Q will immediately turn OFF both switches and $\overline{FLAG}$ will be asserted low. The over-temperature threshold is 165°C typical.

Once $T_J$ falls by 20°C the device automatically retries and will continually retry indefinitely.

The $\overline{FLAG}$ signal remains asserted low until the fault condition is removed and the device resumes normal operation.

## Applications Information

### Input Capacitor

A 1µF or larger capacitor is typically recommended for $C_{IN}$. $C_{IN}$ should be located as close to the device VIN pin as practically possible. 50V rated capacitors are recommended to support input voltage up to 40V.

### Output Capacitor

The soft-start function provides a slow turn-on that allows the device to charge large output capacitors with minimum in-rush current. It is recommended to bypass VOUT pin with a 1µF minimum ceramic capacitor with 35V rating.

### Recommended PCB Layout

For high output current, the power dissipation may be large. The TDFN package allows to dissipate well the heat to the PCB when using proper PCB layout technic. To improve the board thermal conductivity, large copper area around GND, VIN and VOUT pins are recommended. Thermal vias under the package exposed center pad help to spread the heat throughout the board ground plane.

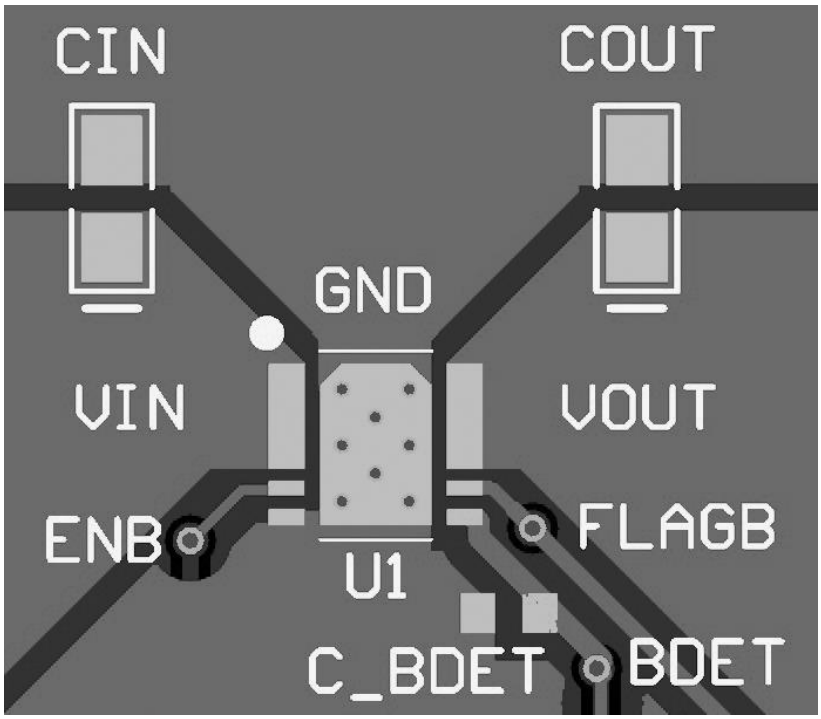
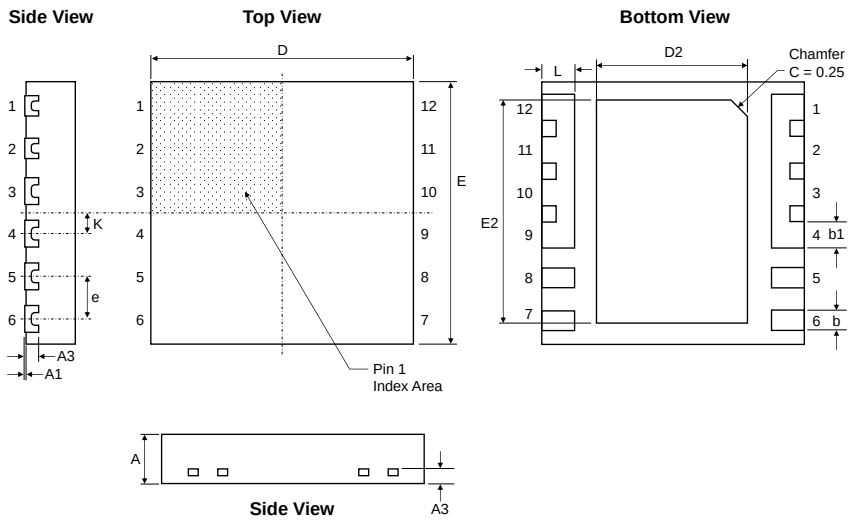



**Figure 4. Recommended PCB Layout**

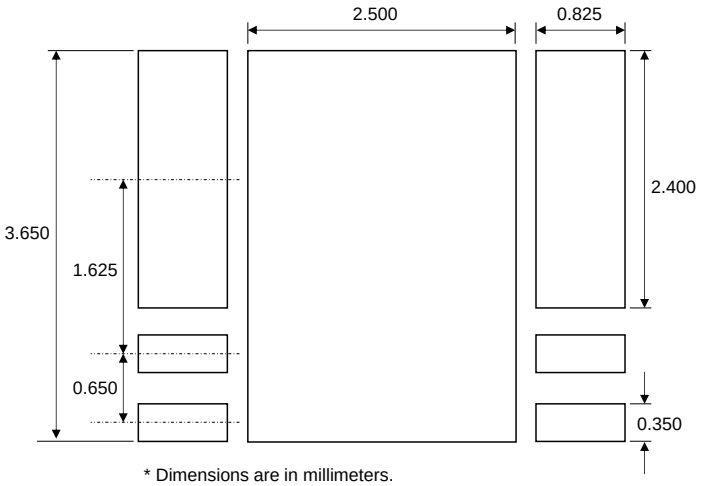
# Packaging Information

## TDFN44-12 (4.00mm x 4.00mm x 0.75mm)




| Dimension | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | 0.02 | 0.05 |
| A3 | 0.203 REF | | |
| b | 0.25 | 0.30 | 0.35 |
| b1 | 0.35 | 0.40 | 0.45 |
| D | 3.90 | 4.00 | 4.10 |
| D2 | 2.25 | 2.30 | 2.35 |
| E | 3.90 | 4.00 | 4.10 |
| E2 | 3.35 | 3.40 | 3.45 |
| e | 0.650 BSC. | | |
| L | 0.45 | 0.50 | 0.55 |
| K | 0.035 REF | | |

### Recommended Footprint




* Dimensions are in millimeters.