# TOPFET high side switch SMD version

# BUK215-50YT

## DESCRIPTION

Monolithic single channel high side protected power switch in **TOPFET2** technology assembled in a 5 pin plastic surface mount package.

## APPLICATIONS

General controller for driving lamps, motors, solenoids, heaters.

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | MIN. | UNIT |
|---|---|---|---|
| $I_L$ | Nominal load current (ISO) | 9 | A |
| **SYMBOL** | **PARAMETER** | **MAX.** | **UNIT** |
| $V_{BG}$ | Continuous off-state supply voltage | 50 | V |
| $I_L$ | Continuous load current | 20 | A |
| $T_j$ | Continuous junction temperature | 150 | ˚C |
| $R_{ON}$ | On-state resistance $T_j = 25˚C$ | 38 | mΩ |

## FEATURES

- Vertical power TrenchMOS
- Low on-state resistance
- CMOS logic compatible
- Very low quiescent current
- Latched overtemperature protection
- Load current limiting
- Latched short circuit load protection
- Overvoltage and undervoltage shutdown with hysteresis
- Diagnostic status indication
- Voltage clamping for turn off of inductive loads
- ESD protection on all pins
- Reverse battery, overvoltage and transient protection

## FUNCTIONAL BLOCK DIAGRAM

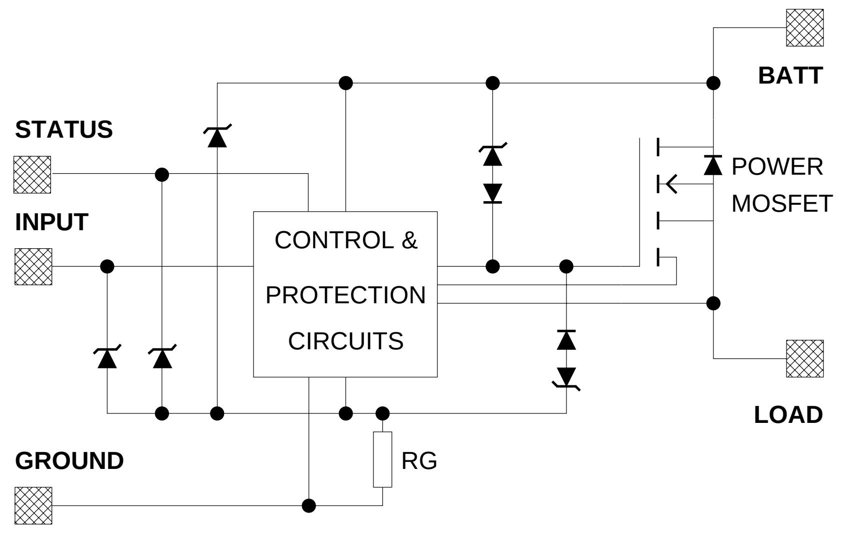



Fig.1. Elements of the TOPFET HSS with internal ground resistor.

## PINNING - SOT426

| PIN | DESCRIPTION |
|---|---|
| 1 | **G**round |
| 2 | **I**nput |
| 3 | (connected to mb) |
| 4 | **S**tatus |
| 5 | **L**oad |
| mb | **B**attery |

## PIN CONFIGURATION

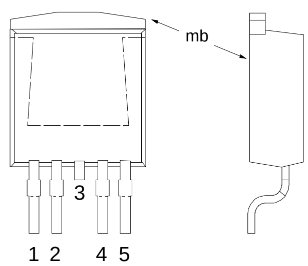



*Fig. 2.*

## SYMBOL

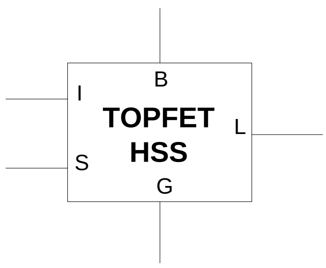



*Fig. 3.*

## LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{BG}$ | Continuous supply voltage | | 0 | 50 | V |
| $I_L$ | Continuous load current | $T_{mb} \leq 95˚C$ | - | 20 | A |
| $P_D$ | Total power dissipation | $T_{mb} \leq 25˚C$ | - | 67 | W |
| $T_{stg}$ | Storage temperature | | -55 | 175 | ˚C |
| $T_j$ | Continuous junction temperature[1] | | - | 150 | ˚C |
| $T_{sold}$ | Mounting base temperature | during soldering | - | 260 | ˚C |
| | **Reverse battery voltages[2]** | | | | |
| $-V_{BG}$ | Continuous reverse voltage | | - | 16 | V |
| $-V_{BG}$ | Peak reverse voltage | | - | 32 | V |
| | **Application information** | | | | |
| $R_I$, $R_S$ | External resistors[3] | to limit input, status currents | 3.2 | - | kΩ |
| | **Input and status** | | | | |
| $I_I$, $I_S$ | Continuous currents | | -5 | 5 | mA |
| $I_I$, $I_S$ | Repetitive peak currents | $\delta \leq 0.1$, tp = 300 µs | -50 | 50 | mA |
| | **Inductive load clamping** | $I_L$ = 10 A, $V_{BG}$ = 16 V | | | |
| $E_{BL}$ | Non-repetitive clamping energy | $T_j \leq 150˚C$ prior to turn-off | - | 150 | mJ |

## ESD LIMITING VALUE

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_C$ | Electrostatic discharge capacitor voltage | Human body model; C = 250 pF; R = 1.5 kΩ | - | 2 | kV |

## THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| | **Thermal resistance[4]** | | | | | |
| $R_{th\ j\text{-}mb}$ | Junction to mounting base | - | - | 1.52 | 1.86 | K/W |

**1** For normal continuous operation. A higher $T_j$ is allowed as an overload condition but at the threshold $T_{j(TO)}$ the over temperature trip operates to protect the switch.

**2** Reverse battery voltage is allowed only with external resistors to limit the input and status currents to a safe value. The connected load must limit the reverse load current. The internal ground resistor limits the reverse battery ground current. Power is dissipated and the $T_j$ rating must be observed.

**3** To limit currents during reverse battery and transient overvoltages (positive or negative).

**4** Of the output power MOS transistor.

## STATIC CHARACTERISTICS

Limits are at -40˚C ≤ $T_{mb}$ ≤ 150˚C and typicals at $T_{mb}$ = 25 ˚C unless otherwise stated.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| | **Clamping voltages** | | | | | |
| $V_{BG}$ | Battery to ground | $I_G$ = 1 mA | 50 | 55 | 65 | V |
| $V_{BL}$ | Battery to load | $I_L$ = $I_G$ = 1 mA | 50 | 55 | 65 | V |
| $-V_{LG}$ | Negative load to ground | $I_L$ = 10 mA | 18 | 23 | 28 | V |
| $-V_{LG}$ | Negative load voltage[1] | $I_L$ = 10 A; $t_p$ = 300 µs | 20 | 25 | 30 | V |
| | **Supply voltage** | battery to ground | | | | |
| $V_{BG}$ | Operating range[2] | | 5.5 | - | 35 | V |
| | **Currents** | 9 V ≤ $V_{BG}$ ≤ 16 V | | | | |
| $I_B$ | Quiescent current[3] | $V_{LG}$ = 0 V | - | - | 20 | µA |
| | | $T_{mb}$ = 25˚C | - | 0.1 | 2 | µA |
| $I_L$ | Off-state load current[4] | $V_{BL}$ = $V_{BG}$ | - | - | 20 | µA |
| | | $T_{mb}$ = 25˚C | - | 0.1 | 1 | µA |
| $I_G$ | Operating current[5] | $I_L$ = 0 A | - | 2 | 4 | mA |
| $I_L$ | Nominal load current[6] | $V_{BL}$ = 0.5 V; $T_{mb}$ = 85˚C | 9 | - | - | A |
| | **Resistances** | $V_{BG}$; $I_L$; $t_p$[7]; $T_{mb}$ | | | | |
| $R_{ON}$ | On-state resistance | 9 to 35 V; 10 A; 300 µs; 25˚C | - | 28 | 38 | mΩ |
| | | 150˚C | - | - | 70 | mΩ |
| $R_{ON}$ | On-state resistance | 6 V; 10 A; 300 µs; 25˚C | - | 36 | 48 | mΩ |
| | | 150˚C | - | - | 88 | mΩ |
| $R_G$ | Internal ground resistance | $I_G$ = 10 mA | 95 | 150 | 190 | Ω |

**1** For a high side switch, the load pin voltage goes negative with respect to ground during the turn-off of an inductive load.

**2** On-state resistance is increased if the supply voltage is less than 9 V.

**3** This is the continuous current drawn from the supply when the input is low and includes leakage current to the load.

**4** The measured current is in the load pin only.

**5** This is the continuous current drawn from the supply with no load connected, but with the input high.

**6** Defined as in ISO 10483-1. For comparison purposes only. This parameter will not be characterised for automotive PPAP.

**7** The supply and input voltage for the $R_{ON}$ tests are continuous. The specified pulse duration $t_p$ refers only to the applied load current.

## INPUT CHARACTERISTICS

9 V ≤ $V_{BG}$ ≤ 16 V. Limits are at -40˚C ≤ $T_{mb}$ ≤ 150˚C and typicals at $T_{mb}$ = 25 ˚C unless otherwise stated.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $I_I$ | Input current | $V_{IG}$ = 5 V | 20 | 90 | 160 | µA |
| $V_{IG}$ | Input clamping voltage | $I_I$ = 200 µA | 5.5 | 7 | 8.5 | V |
| $V_{IG(ON)}$ | Input turn-on threshold voltage | | - | 2.4 | 3 | V |
| $V_{IG(OFF)}$ | Input turn-off threshold voltage | | 1.5 | 2.1 | - | V |
| $\Delta V_{IG}$ | Input turn-on hysteresis | | - | 0.3 | - | V |
| $I_{I(ON)}$ | Input turn-on current | $V_{IG}$ = 3 V | - | - | 100 | µA |
| $I_{I(OFF)}$ | Input turn-off current | $V_{IG}$ = 1.5 V | 10 | - | - | µA |

## STATUS CHARACTERISTICS

The status output is an open drain transistor, and requires an external pull-up circuit to indicate a logic high. Limits are at -40˚C ≤ $T_{mb}$ ≤ 150˚C and typicals at $T_{mb}$ = 25 ˚C unless otherwise stated. Refer to TRUTH TABLE.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $V_{SG}$ | Status clamping voltage | $I_S$ = 100 µA | 5.5 | 7 | 8.5 | V |
| $V_{SG}$ | Status low voltage | $I_S$ = 100 µA | - | - | 1 | V |
| | | $T_{mb}$ = 25˚C | - | 0.7 | 0.8 | V |
| $I_S$ | Status leakage current | $V_{SG}$ = 5 V | - | - | 15 | µA |
| | | $T_{mb}$ = 25˚C | - | 0.1 | 1 | µA |
| $I_S$ | Status saturation current[1] | $V_{SG}$ = 5 V | 2 | 7 | 12 | mA |
| | **Application information** | | | | | |
| $R_S$ | External pull-up resistor | | - | 47 | - | kΩ |

**1** In a fault condition with the pull-up resistor short circuited while the status transistor is conducting. This condition should be avoided in order to prevent possible interference with normal operation of the device.

## UNDERVOLTAGE & OVERVOLTAGE CHARACTERISTICS

Limits are at -40˚C ≤ $T_{mb}$ ≤ 150˚C and typicals at $T_{mb}$ = 25 ˚C. Refer to TRUTH TABLE.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| | **Undervoltage** | | | | | |
| $V_{BG(UV)}$ | Low supply threshold voltage[1] | | 2 | 4.2 | 5.5 | V |
| $\Delta V_{BG(UV)}$ | Hysteresis | | - | 0.5 | - | V |
| | **Overvoltage** | | | | | |
| $V_{BG(OV)}$ | High supply threshold voltage[2] | | 40 | 45 | 50 | V |
| $\Delta V_{BG(OV)}$ | Hysteresis | | - | 1 | - | V |

## TRUTH TABLE

| INPUT | ABNORMAL CONDITIONS DETECTED | | | | | LOAD OUTPUT | STATUS | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| | SUPPLY | | LOAD | | | | | |
| | UV | OV | LC | SC | OT | | | |
| L | X | X | X | X | X | OFF | H | off |
| H | 0 | 0 | X | 0 | 0 | ON | H | on & normal (LC not detected!) |
| H | 1 | 0 | X | X | X | OFF | H | supply undervoltage lockout |
| H | 0 | 1 | X | 0 | 0 | OFF | H | supply overvoltage shutdown |
| H | 0 | 0 | 0 | 1 | 0 | OFF | L | SC protection |
| H | 0 | 0 | X | X | 1 | OFF | L | OT shutdown |

## KEY TO ABBREVIATIONS

L logic low
H logic high
X don't care
0 condition not present
1 condition present

UV undervoltage
OV overvoltage
LC low current or open circuit load
SC short circuit
OT overtemperature



**1** Undervoltage sensor causes the device to switch off and reset.

**2** Overvoltage sensor causes the device to switch off to protect its load.

## OVERLOAD PROTECTION CHARACTERISTICS

5.5 V ≤ $V_{BG}$ ≤ 35 V, limits are at -40˚C ≤ $T_{mb}$ ≤ 150˚C and typicals at $T_{mb}$ = 25 ˚C unless otherwise stated.
Refer to TRUTH TABLE.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| | **Overload protection** | $V_{BL} = V_{BG}$ | | | | |
| $I_{L(lim)}$ | Load current limiting | $V_{BG} \geq 9$ V | 34 | 45 | 64 | A |
| | **Short circuit load protection** | | | | | |
| $V_{BL(TO)}$ | Battery load threshold voltage[1] | $V_{BG}$ = 16 V | 8 | 10 | 12 | V |
| | | $V_{BG}$ = 35 V | 15 | 20 | 25 | V |
| $t_{d\,sc}$ | Response time[2] | $V_{BL} > V_{BL(TO)}$ | - | 180 | 250 | µs |
| | **Overtemperature protection** | | | | | |
| $T_{j(TO)}$ | Threshold junction temperature[3] | | 150 | 170 | 190 | ˚C |

## SWITCHING CHARACTERISTICS

$T_{mb}$ = 25 ˚C, $V_{BG}$ = 13 V, for resistive load $R_L$ = 13 Ω.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| | **During turn-on** | from input going high | | | | |
| $t_{d\,on}$ | Delay time | to 10% $V_L$ | - | 40 | 60 | µs |
| $dV/dt_{on}$ | Rate of rise of load voltage | 30% to 70% $V_L$ | - | 0.35 | 1 | V/µs |
| $t_{on}$ | Total switching time | to 90% $V_L$ | - | 140 | 200 | µs |
| | **During turn-off** | from input going low | | | | |
| $t_{d\,off}$ | Delay time | to 90% $V_L$ | - | 55 | 80 | µs |
| $dV/dt_{off}$ | Rate of fall of load voltage | 70% to 30% $V_L$ | - | 0.6 | 1 | V/µs |
| $t_{off}$ | Total switching time | to 10% $V_L$ | - | 85 | 120 | µs |

## CAPACITANCES

$T_{mb}$ = 25 ˚C; f = 1 MHz; $V_{IG}$ = 0 V. *designed in parameters*.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $C_{ig}$ | Input capacitance | $V_{BG}$ = 13 V | - | 15 | 20 | pF |
| $C_{bl}$ | Output capacitance | $V_{BL}$ = 13 V | - | 250 | 350 | pF |
| $C_{sg}$ | Status capacitance | $V_{SG}$ = 5 V | - | 11 | 15 | pF |

**1** The battery to load threshold voltage for short circuit protection is proportional to the battery supply voltage.After short circuit protection has operated, the input voltage must be toggled low for the switch to resume normal operation.

**2** Measured from when the input goes high.

**3** Latched protection. After cooling below the threshold temperature the switch will resume normal operation only after the input has been toggled low.

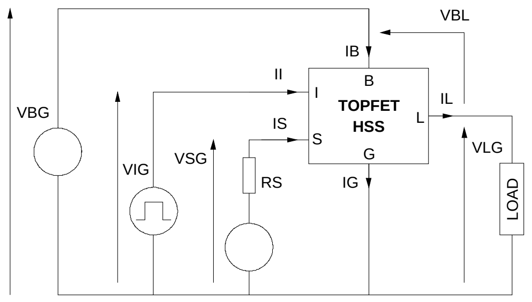



Fig.4. High side switch measurements schematic. (current and voltage conventions)

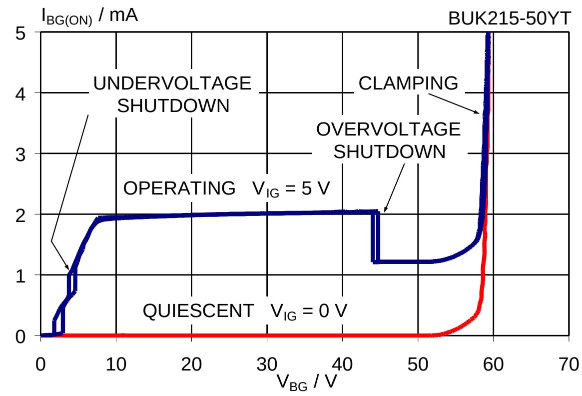



Fig.7. Typical supply characteristics, 25 ˚C. $I_G = f(V_{BG})$; parameter $V_{IG}$

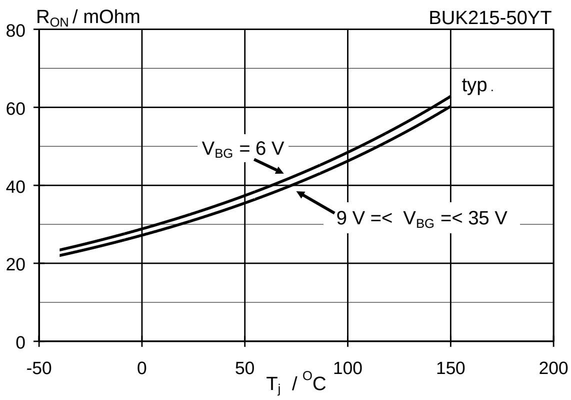



Fig.5. Typical on-state resistance, $t_p$ = 300 µs. $R_{ON} = f(T_j)$; parameter $V_{BG}$; condition $I_L$ = 10 A

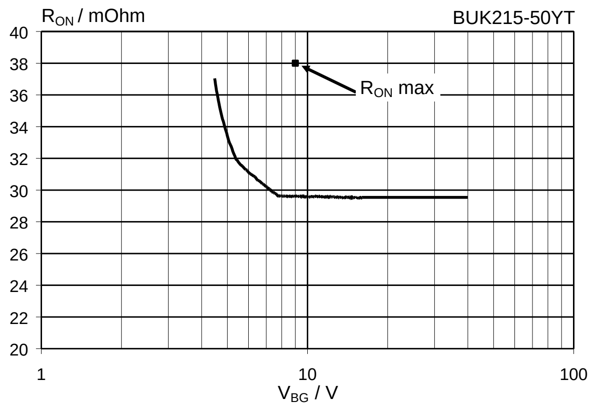



Fig.8. Typical on-state resistance, $T_j$ = 25 ˚C. $R_{ON} = f(V_{BG})$; condition $I_L$ = 10 A; $t_p$ = 300 µs

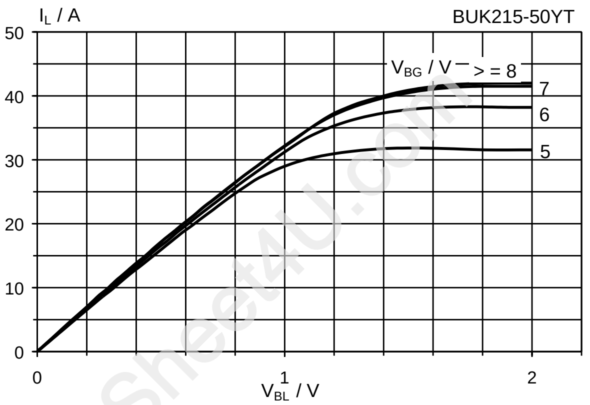



Fig.6. Typical on-state characteristics, $T_j$ = 25 ˚C. $I_L = f(T_j)$; parameter $V_{BG}$; $t_p$ = 250 µs

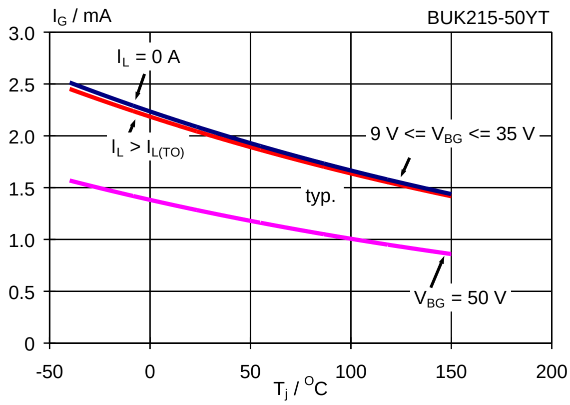



Fig.9. Typical operating supply current. $I_G = f(T_j)$; parameters $I_L$, $V_{BG}$; condition $V_{IG}$ = 5 V

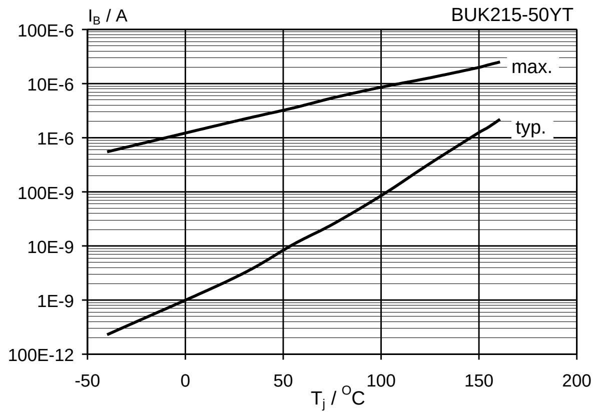



Fig.10. Typical supply quiescent current.
$I_B = f(T_j)$; condition $V_{BG} = 16$ V, $V_{IG} = 0$ V, $V_{LG} = 0$ V

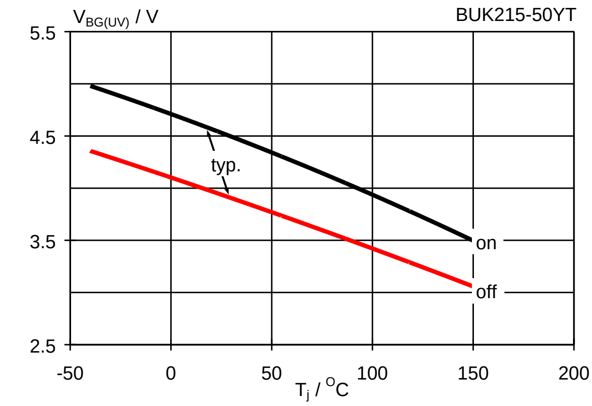



Fig.13. Supply undervoltage thresholds.
$V_{BG(UV)} = f(T_j)$; conditions $V_{IG} = 5$ V; $V_{BL} \leq 2$ V

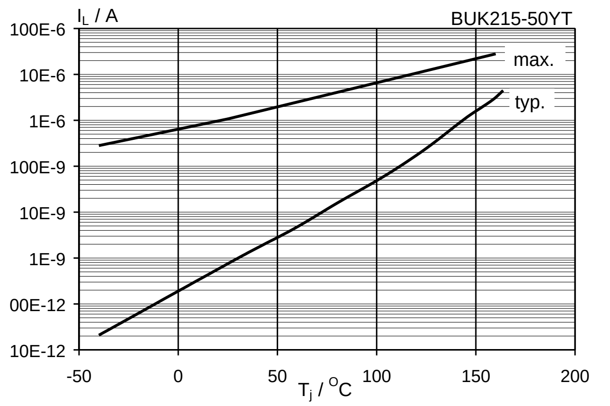



Fig.11. Typical off-state leakage current.
$I_L = f(T_j)$; conditions $V_{BL} = 16$ V $= V_{BG}$, $V_{IG} = 0$ V.

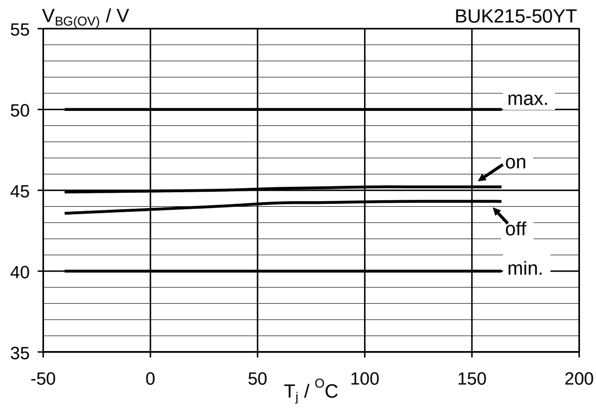



Fig.14. Supply overvoltage thresholds.
$V_{BG(OV)} = f(T_j)$; conditions $V_{IG} = 5$ V; $I_L = 100$ mA

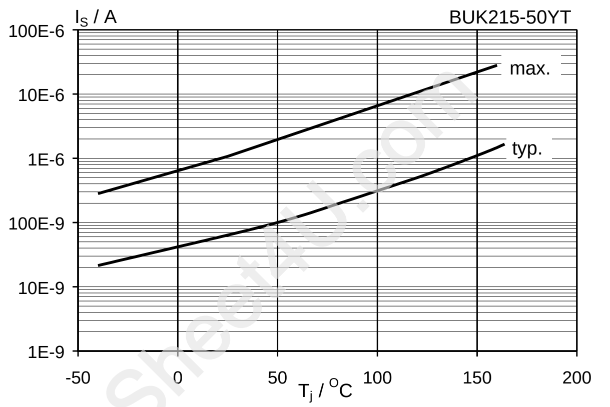



Fig.12. Status leakage current.
$I_S = f(T_j)$; conditions $V_{SG} = 5$ V, $V_{IG} = V_{BG} = 0$ V

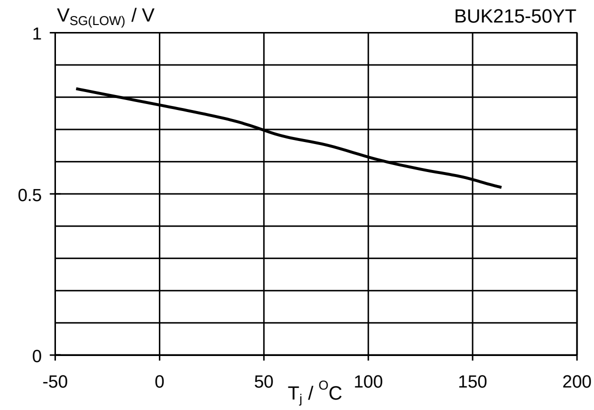



Fig.15. Typical status low characteristic.
$V_{SG} = f(T_j)$; conditions $V_{BG} \geq 9$ V, $I_S = 100$ µA

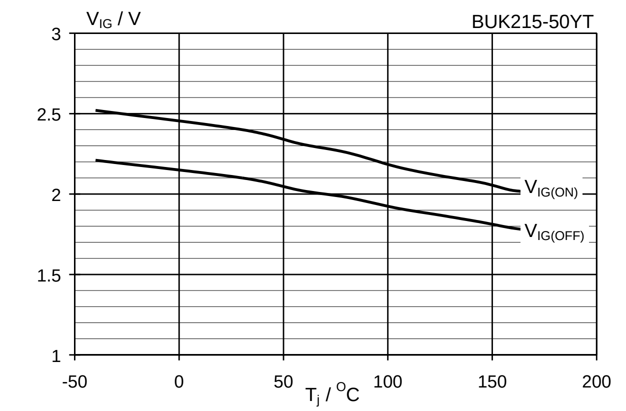



*Fig.16. Typical threshold voltage characteristic.*
*$V_{IG} = f(T_j)$; condition $9V \leq V_{BG} \leq 16V$*

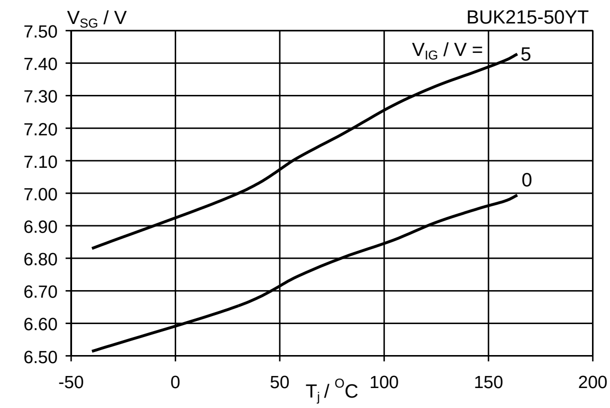



*Fig.19. Typical status clamping voltage.*
*$V_{SG} = f(T_j)$; condition $I_S = 100\mu A$, $V_{BG} = 13V$*

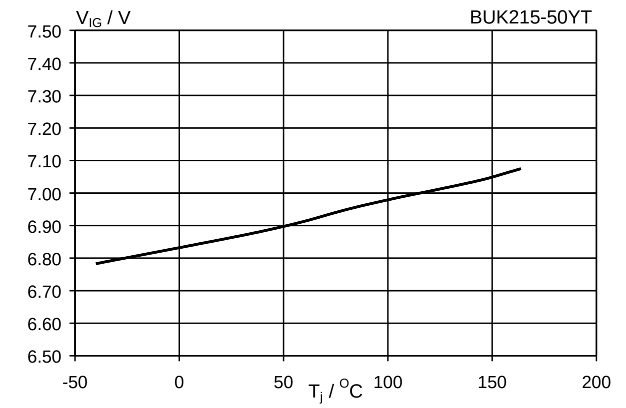



*Fig.17. Typical input clamping voltage.*
*$V_{IG} = f(T_j)$; condition $I_I = 200\mu A$, $V_{BG} = 13V$*

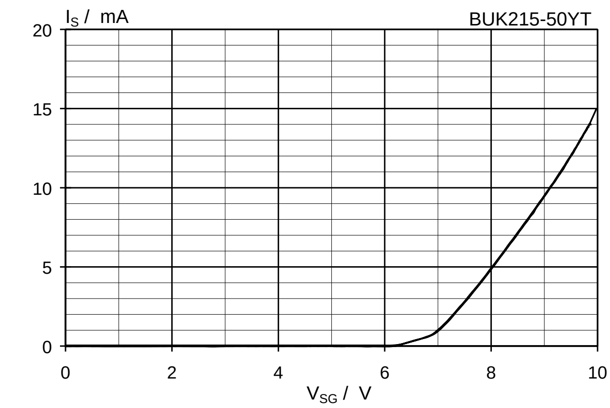



*Fig.20. Typical status characteristic, $T_j = 25$ ˚C.*
*$I_S = f(V_{SG})$; conditions $V_{IG} = V_{BG} = 0V$*

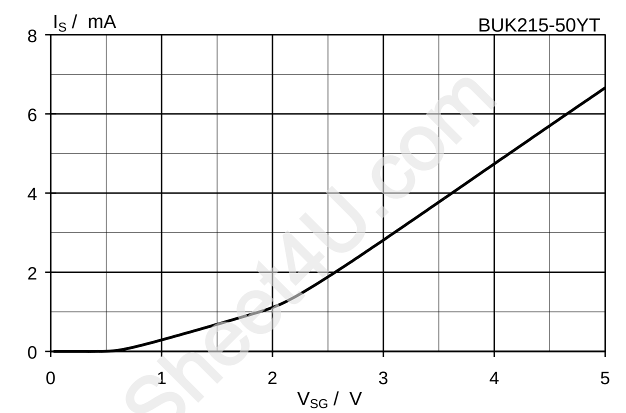



*Fig.18. Typical status low characteristic, $T_j = 25$ ˚C.*
*$I_S = f(V_{SG})$; conditions $V_{IG} = 5V$, $V_{BG} = 13V$, $I_L = 0A$*

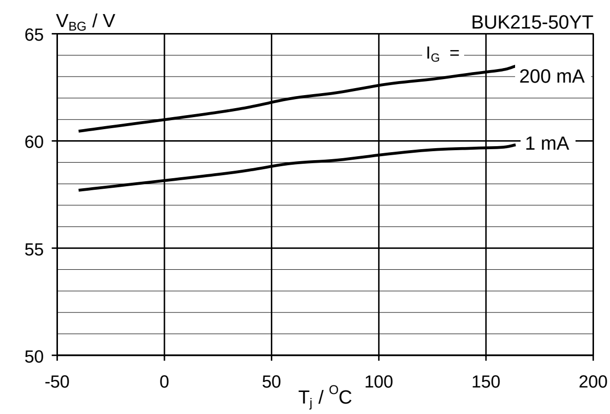



*Fig.21. Typical battery to ground clamping voltage.*
*$V_{BG} = f(T_j)$; parameter $I_G$*

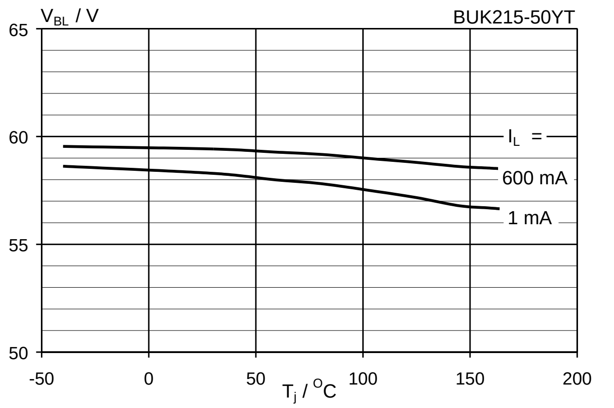



Fig.22. Typical battery to load clamping voltage. $V_{BL} = f(T_j)$; parameter $I_L$; condition $I_G = 10mA$

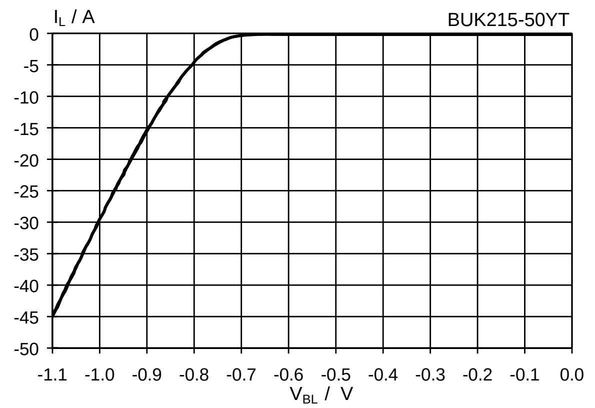



Fig.25. Typical reverse diode characteristic. $I_L = f(V_{BL})$; conditions $V_{IG} = 0$ V, $T_j = 25$ °C

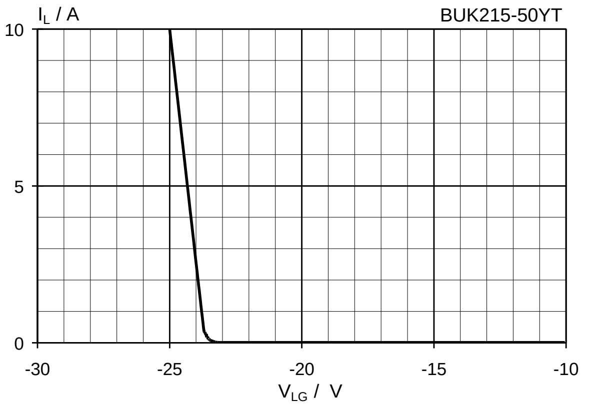



Fig.23. Typical negative load clamping. $I_L = f(V_{LG})$; conditions $V_{IG} = = 0V$, $T_j = 25$°C

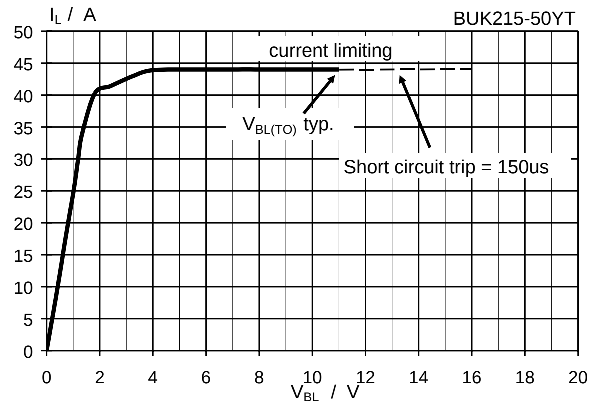



Fig.26. Typical overload characteristic, $T_{mb} = 25$ °C. $I_L = f(V_{BL})$; condition $V_{BG} = 16$ V; parameter $t_p$

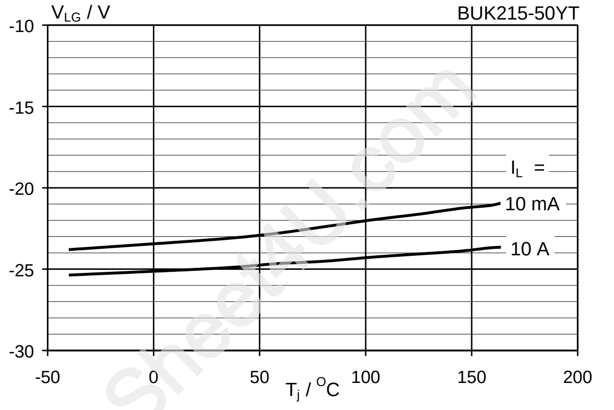



Fig.24. Typical negative load clamping voltage. $V_{LG} = f(T_j)$; parameter $I_L$; condition $V_{IG} = = 0V$

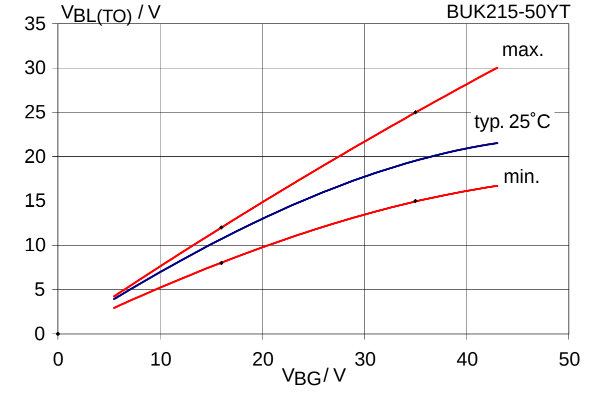



Fig.27. Short circuit load threshold voltage. $V_{BL(TO)} = f(V_{BG})$; conditions -40˚C ≤ $T_{mb}$ ≤ 150˚C

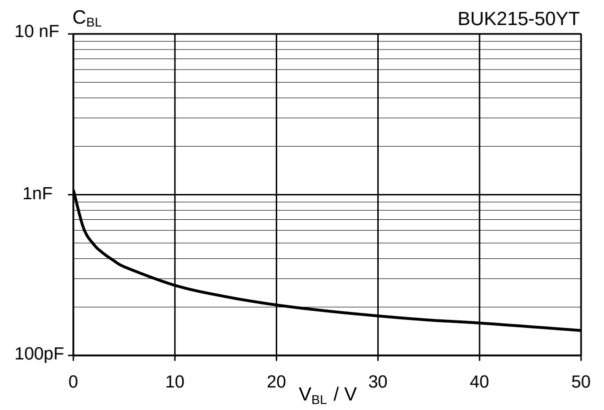



*Fig.28. Typical output capacitance. $T_{mb}$ = 25 ˚C*
*$C_{bl} = f(V_{BL})$; conditions f = 1 MHz, $V_{IG}$ = 0 V*

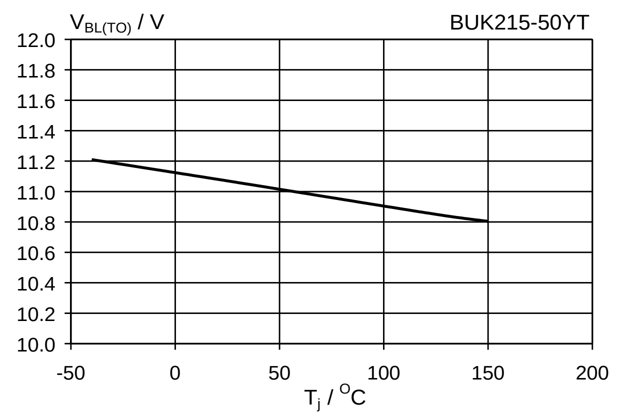



*Fig.31. Typical short circuit load threshold voltage.*
*$V_{BL(TO)} = f(T_j)$; condition $V_{BG}$ = 16 V*

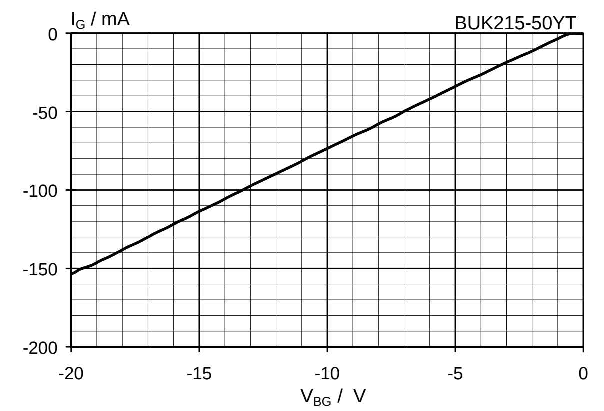



*Fig.29. Typical reverse battery characteristic.*
*$I_G = f(V_{BG})$; conditions $I_L$ = 0 A, $T_j$ = 25 ˚C*

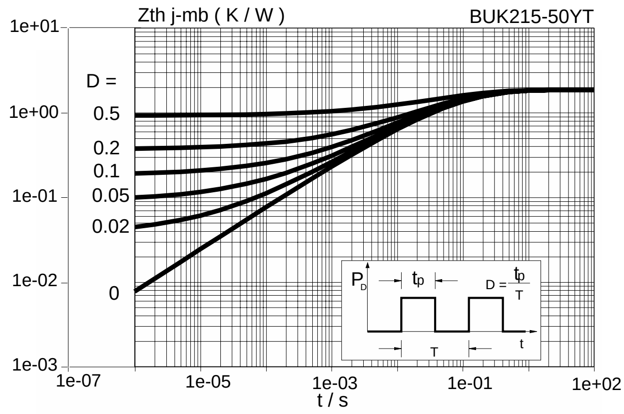



*Fig.32. Transient thermal impedance.*
*$Z_{th\ j\text{-}mb} = f(t)$; parameter $D = t_p/T$*

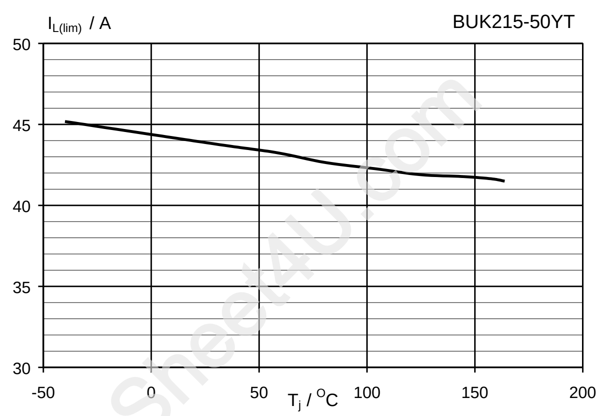
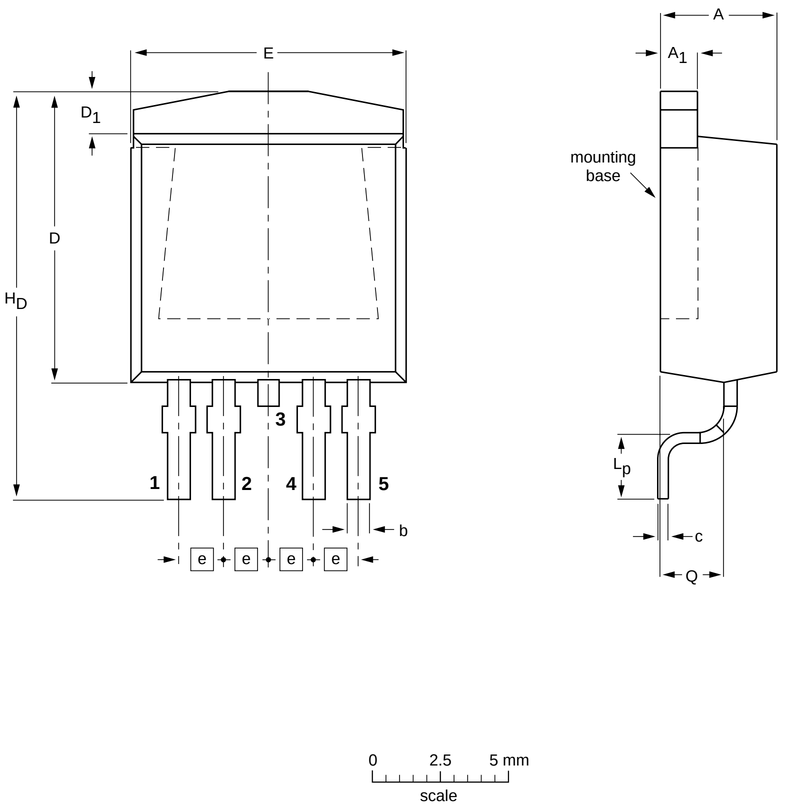



*Fig.30. Typical overload current, $V_{BL}$ = 8V.*
*$I_L = f(T_j)$; parameter $V_{BG}$ = 13V;$t_p$ = 300 µs*

## MECHANICAL DATA

**Plastic single-ended surface mounted package (Philips version of D2-PAK); 5 leads (one lead cropped)** **SOT426**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ | b | c | D max. | $D_1$ | E | e | $L_p$ | $H_D$ | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.50<br>4.10 | 1.40<br>1.27 | 0.85<br>0.60 | 0.64<br>0.46 | 11 | 1.60<br>1.20 | 10.30<br>9.70 | 1.70 | 2.90<br>2.10 | 15.80<br>14.80 | 2.60<br>2.20 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | EIAJ | | | |
| SOT426 | | | | | | ~~98-12-14~~<br>99-06-25 |

*Fig.33. SOT426 surface mounting package[1], centre pin connected to mounting base.*

**1** Epoxy meets UL94 V0 at 1/8". Net mass: 1.5 g.
For soldering guidelines and SMD footprint design, please refer to Data Handbook SC18.

## DEFINITIONS

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|---|---|---|
| **DATA SHEET STATUS**[1] | **PRODUCT STATUS**[2] | **DEFINITIONS** |
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| Limiting values are given in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of this specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | | |
| **Application information** | | |
| Where application information is given, it is advisory and does not form part of the specification. | | |
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