

## Ultrahigh Threshold Voltage Depletion-Mode Power MOSFET

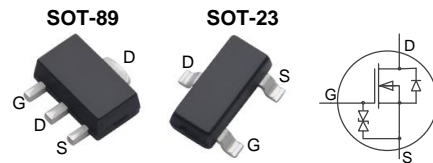
### General Features

- ESD improved Capability
- Depletion Mode (Normally On)
- Proprietary Advanced Planar Technology
- Proprietary Advanced Ultrahigh V<sub>th</sub> Technology
- RoHS Compliant
- Halogen-free available

|                         |                                |                            |
|-------------------------|--------------------------------|----------------------------|
| <b>BV<sub>DSX</sub></b> | <b>V<sub>GS(off),min</sub></b> | <b>I<sub>DSS,min</sub></b> |
| <b>70V</b>              | <b>-20V</b>                    | <b>120mA</b>               |

### Applications

- Quick Charge (QC4.0)/ Type C PD Charger or Adapter
- Current Source
- Voltage Source



### General Description

DMZ0615E / DMX0615E / DMZ0622E/ DMX0622E /DMX1015E- novel series of depletion mode MOSFETs are designed with ARK Microelectronics proprietary and patent ultrahigh threshold voltage technology. DMZ0615E is a wide range voltage (up to 70V) regulator. Its input voltage can be 70V high, and it also can provide stable output voltage from about 8V to 23V in accordance with different work conditions. It is very suitable for Quick Charge (QC4.0) / Type C PD Charger application which have variable charging voltage output (5V-20V).

By using the sub threshold characteristics, the depletion mode MOSFET DMZ0615E can provide stable power to the load, and the voltage of load can be clamped to protect the load without zener diode.

DMZ0615E can endure wide voltage input up to 70V, and can provide with proper voltage to the load. These characteristics are fit for the application of Quick Charge (QC4.0) /Type C PD Charger, and its PWM control IC need to be powered with stable voltage.

### Ordering Information

| Part Number | Package | Marking | Remark       |
|-------------|---------|---------|--------------|
| DMZ0615E    | SOT-23  | 0615    | Halogen Free |
| DMX0615E    | SOT-89  | 0615    | Halogen Free |

### Absolute Maximum Ratings

T<sub>A</sub>=25°C unless otherwise specified

| Symbol                              | Parameter   | DMZ0615E   | DMX0615E | Unit |
|-------------------------------------|---|------------|----------|------|
| V <sub>DSX</sub>                    | Drain-to-Source Voltage <sup>[1]</sup>                              | 70         |          | V    |
| V <sub>DGX</sub>                    | Drain-to-Gate Voltage <sup>[1]</sup>                                | 70         |          | V    |
| I <sub>D</sub>                      | Continuous Drain Current  | 0.1        |          | A    |
| I <sub>DM</sub>                     | Pulsed Drain Current <sup>[2]</sup>                                 | 0.4        |          |      |
| P <sub>D</sub>                      | Power Dissipation   | 0.5        | 1.0      | W    |
| V <sub>GS</sub>                     | Gate-to-Source Voltage  | ±30        |          | V    |
| V <sub>ESD(G-S)</sub>               | Gate Source ESD<br>IEC, C=150pF, R=330Ω                             | 400        |          | V    |
| T <sub>L</sub>                      | Soldering Temperature<br>Distance of 1.6mm from case for 10 seconds | 300        |          | °C   |
| T <sub>J</sub> and T <sub>STG</sub> | Operating and Storage Temperature Range                             | -55 to 150 |          |      |

Caution: Stresses greater than those listed in the "Absolute Maximum Ratings" may cause permanent damage to the device.

### Thermal Characteristics

| Symbol          | Parameter                               | DMZ0615E | DMX0615E | Unit |
|-----------------|---|----------|----------|------|
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 250      | 125      | K/W  |

### Electrical Characteristics

#### OFF Characteristics

 $T_A = 25^\circ\text{C}$  unless otherwise specified

| Symbol       | Parameter                         | Min. | Typ. | Max. | Unit          | Test Conditions   |
|--------------|-----------------------------------|------|------|------|---------------|---|
| $BV_{DSX}$   | Drain-to-Source Breakdown Voltage | 70   | --   | --   | V             | $V_{GS} = -30\text{V}$ , $I_D = 250\mu\text{A}$                             |
| $I_{D(OFF)}$ | Drain-to-Source Leakage Current   | --   | --   | 10   | $\mu\text{A}$ | $V_{DS} = 70\text{V}$ , $V_{GS} = -25\text{V}$                              |
|              |                                   | --   | --   | 1.0  | mA            | $V_{DS} = 70\text{V}$ , $V_{GS} = -25\text{V}$<br>$T_J = 125^\circ\text{C}$ |
| $I_{GSS}$    | Gate-to-Source Leakage Current    | --   | --   | 20   | $\mu\text{A}$ | $V_{GS} = +30\text{V}$ , $V_{DS} = 0\text{V}$                               |
|              |                                   | --   | --   | -20  |               | $V_{GS} = -30\text{V}$ , $V_{DS} = 0\text{V}$                               |

#### ON Characteristics

 $T_A = 25^\circ\text{C}$  unless otherwise specified

| Symbol        | Parameter                            | Min. | Typ.  | Max. | Unit     | Test Conditions                                 |
|---------------|--------------------------------------|------|-------|------|----------|---|
| $I_{DSS}$     | Saturated Drain-to-Source Current    | 120  | --    | --   | mA       | $V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$    |
| $R_{DS(ON)}$  | Static Drain-to-Source On-Resistance | --   | 10    | 15   | $\Omega$ | $V_{GS} = 0\text{V}$ , $I_D = 100\text{mA}$ [3] |
| $V_{GS(OFF)}$ | Gate-to-Source Cut-off Voltage       | -13  | -16.5 | -20  | V        | $V_{DS} = 20\text{V}$ , $I_D = 8\mu\text{A}$    |
| gfs           | Forward Transconductance             | --   | 130   | --   | mS       | $V_{DS} = 20\text{V}$ , $I_D = 5\text{mA}$      |

#### Dynamic Characteristics

Essentially independent of operating temperature

| Symbol    | Parameter                     | Min. | Typ. | Max. | Unit | Test Conditions   |
|-----------|-------------------------------|------|------|------|------|---|
| $C_{ISS}$ | Input Capacitance             | --   | 1.5  | --   | pF   | $V_{GS} = -30\text{V}$<br>$V_{DS} = 25\text{V}$<br>$f = 1.0\text{MHz}$                |
| $C_{OSS}$ | Output Capacitance            | --   | 2.6  | --   |      |   |
| $C_{RSS}$ | Reverse Transfer Capacitance  | --   | 0.74 | --   |      |   |
| $Q_G$     | Total Gate Charge             | --   | 9    | --   | nC   | $V_{GS} = -30\text{V} \sim 0\text{V}$<br>$V_{DS} = 30\text{V}$ , $I_D = 100\text{mA}$ |
| $Q_{GS}$  | Gate-to-Source Charge         | --   | 1.5  | --   |      |   |
| $Q_{GD}$  | Gate-to-Drain (Miller) Charge | --   | 2.3  | --   |      |   |

#### Resistive Switching Characteristics

Essentially independent of operating temperature

| Symbol       | Parameter           | Min. | Typ. | Max. | Unit | Test Conditions   |
|--------------|---------------------|------|------|------|------|---|
| $t_{d(ON)}$  | Turn-on Delay Time  | --   | 17   | --   | us   | $V_{GS} = -30\text{V} \sim 0\text{V}$<br>$V_{DD} = 35\text{V}$ , $I_D = 100\text{mA}$<br>$R_G = 20\Omega$ |
| $t_{rise}$   | Rise Time           | --   | 200  | --   |      |   |
| $t_{d(OFF)}$ | Turn-off Delay Time | --   | 11   | --   |      |   |
| $t_{fall}$   | Fall Time           | --   | 4    | --   |      |   |

#### Source-Drain Diode Characteristics

 $T_A = 25^\circ\text{C}$  unless otherwise specified

| Symbol   | Parameter             | Min | Typ. | Max. | Units | Test Conditions                                  |
|----------|-----------------------|-----|------|------|-------|--|
| $V_{SD}$ | Diode Forward Voltage | --  | --   | 1.2  | V     | $I_{SD} = 100\text{mA}$ , $V_{GS} = -30\text{V}$ |

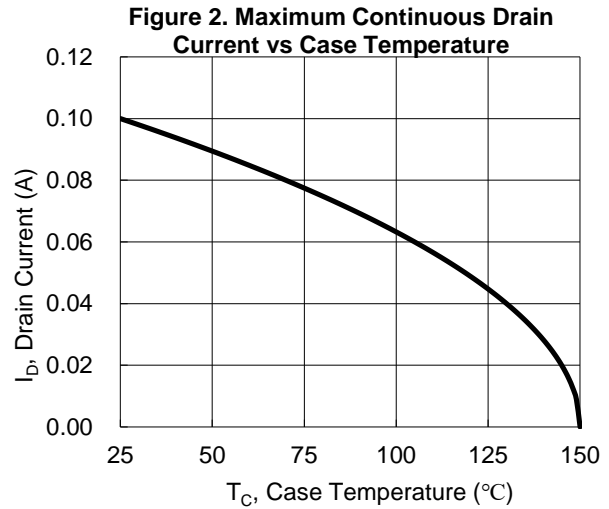
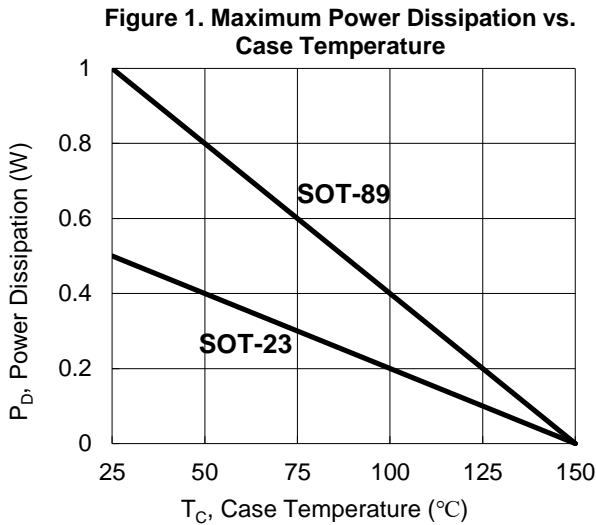
NOTE:

[1]  $T_J = +25^\circ\text{C}$  to  $+150^\circ\text{C}$ 

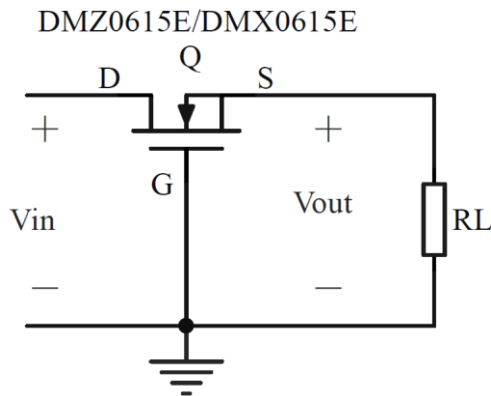
[2] Repetitive rating, pulse width limited by maximum junction temperature.

[3] Pulse width  $\leq 380\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

## Typical and highlight Characteristics



DMZ0615E/DMX0615E can be used as a current or voltage source to supply power to the load, as shown in Figure 3.

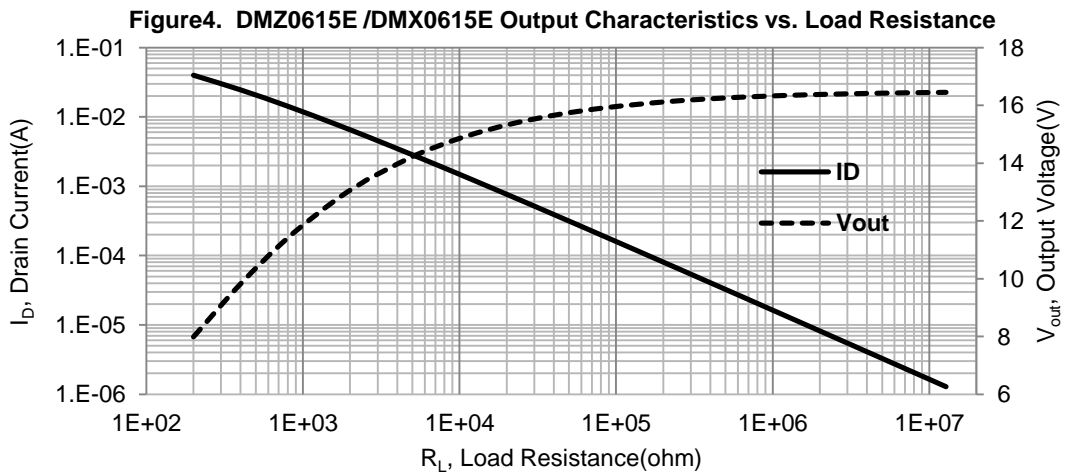


**Figure 3. DMZ0615E/DMX0615E as a Voltage Source**

The output voltage V<sub>out</sub> is determined by the load R<sub>L</sub>, current I<sub>D</sub> and V<sub>GS(OFF)</sub> :

$$I_D = I_{DSS} (1 + I_D R_L / V_{GS(OFF)})^2$$

$$V_{out} = -V_{GS} = I_D R_L$$



From the above function, we can see the depletion mode MOSFET operate in sub-threshold region, the  $V_{out}$  is always below or closed to the threshold voltage or Gate-to-Source Cut-off Voltage  $V_{GS(OFF)}$ , no matter how the input voltage  $V_{in}$  changes. Therefore, in addition to provide power for load like IC, the output voltage  $V_{out}$  can be clamped to the  $V_{GS(OFF)}$ , the IC is then protected from variable voltage or current. DMZ0615E/DMX0615E can support up to 70V input voltage.  $V_{out}$  and  $V_{in}$  have relations following the formulas:

**If  $V_{in} < |V_{GS(OFF)}|$ , then  $V_{out} \approx V_{in}$**

**If  $V_{in} \geq |V_{GS(OFF)}|$ , then  $V_{out} \leq V_{GS(OFF)}$**

The Ultrahigh Threshold Voltage Depletion Mode Power MOSFET--DMZ0615E/DMX0615E, was developed by ARK Microelectronics proprietary and patent technology. The threshold voltage  $V_{GS(OFF)}$  of DMZ0615E/DMX0615E is between -13V and -20V, can provide sufficient voltage for load such like a PWM IC in the primary side of a Flyback converter.

Since DMZ0615E/DMX0615E has a variation distribution of  $V_{GS(OFF)}$ , from -13V to -20V, so its output voltage is different with different  $V_{GS(OFF)}$ . Figure 5 shows the characteristics of output voltage  $V_{out}$  vs. junction temperature of two DMZ0615E/DMX0615E MOSFETS which has the highest  $V_{GS(OFF)}$ ,=-13V and lowest  $V_{GS(OFF)}$ ,=-20V respectively. This means the clamped voltage of  $V_{out}$  will also change with temperature and  $V_{GS(OFF)}$ .

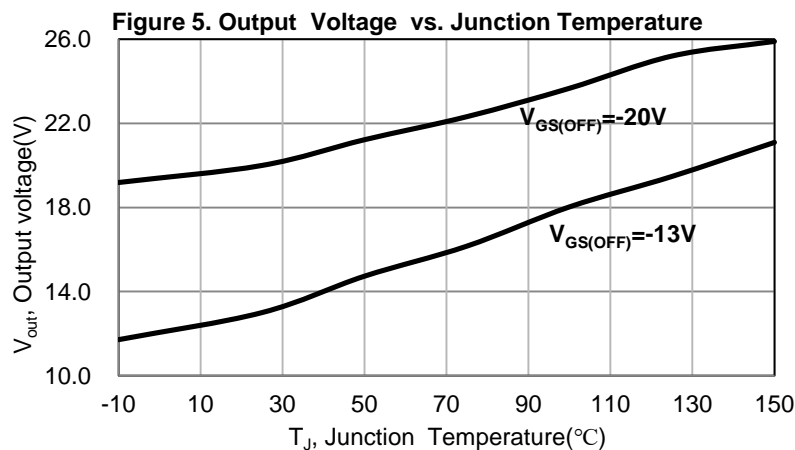
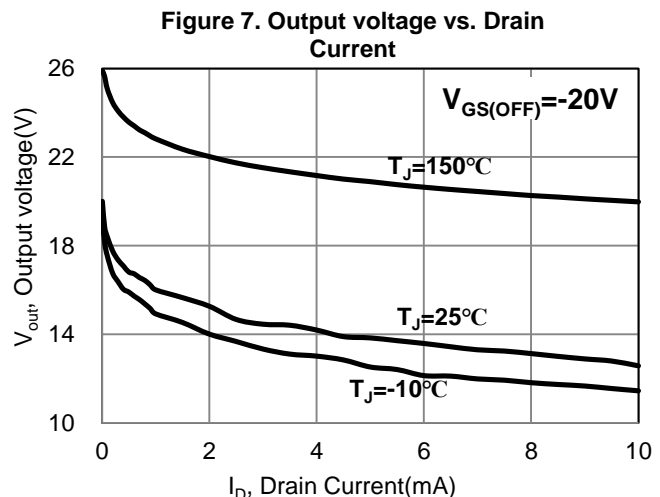
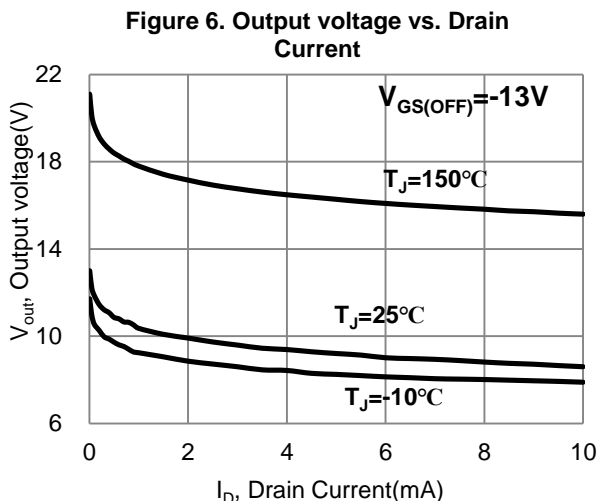


Figure 6 and Figure 7 shows the characteristics of output voltage  $V_{out}$  vs. load current  $I_{RL}$  and junction temperature  $T_J$  of two DMZ0615E/DMX0615E MOSFETS which has the highest  $V_{GS(OFF)}$ ,=-13V and lowest  $V_{GS(OFF)}$ ,=-20V respectively.

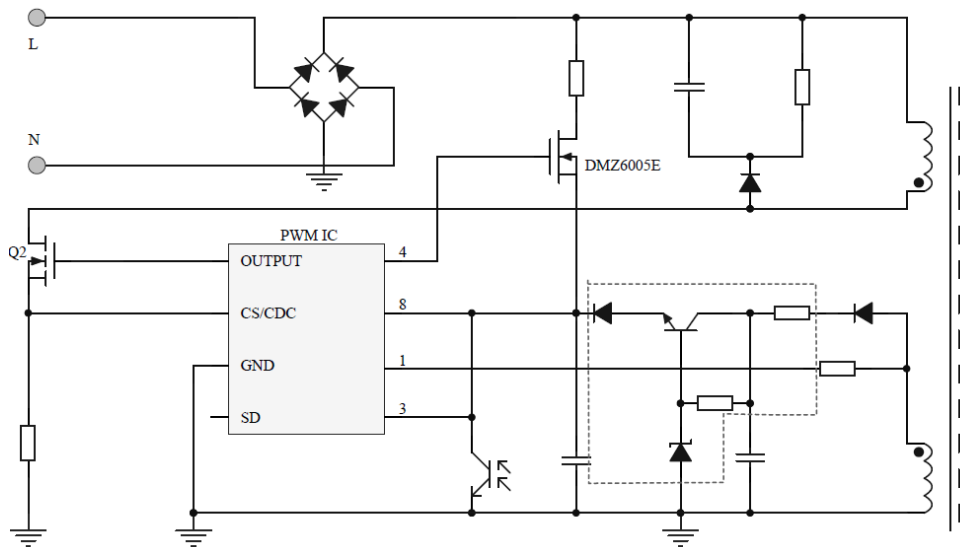


### Typical applications:

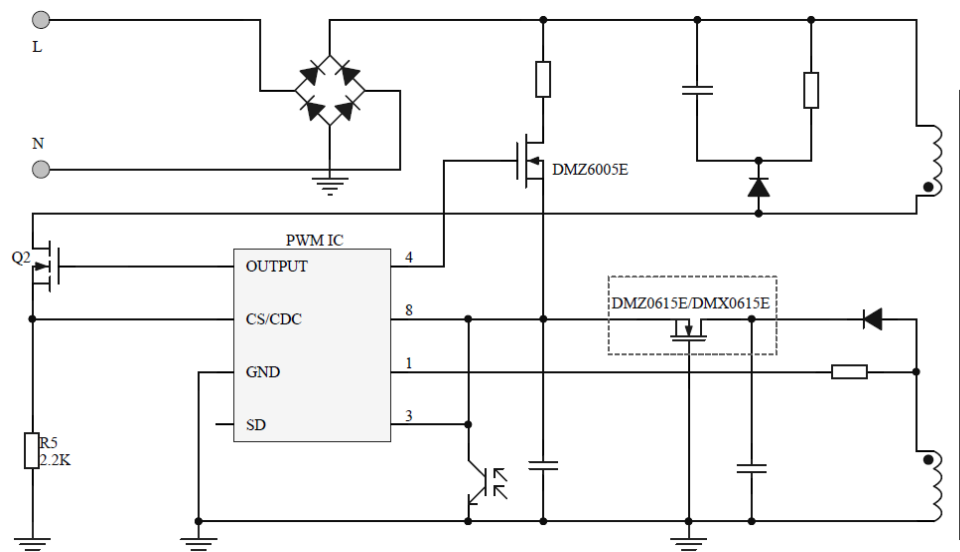
Figure 8. is a typical schematic of a primary side of a Flyback power source, it serves as a quick charger with TypeC PD or Quick Charge( QC) protocols. These kinds of quick chargers can provide variable charging voltage (from 5-20V) output, these voltages will turn back to the primary side, so that the voltage of auxiliary coil, which is used as a power source to PWM IC has to be changed in a wide ranges, even it can be too high to use for PWM IC. The normal solution is using a transistor and zener diode and some resistors to provide PWM IC with stable voltage. But the circuit is complicated and the BOM cost is higher.

The alternate cost effective solution is represent in Figure 9. The transistor, diodes and resistors in Figure 8 can be simply replaced with DMZ0615E/DMX0615E, then the space of PCB is saved with fewer components, and the cost will be down.

The depletion mode MOSFET DMZ6005E is used for start-up, when the charger start to work, the auxiliary coil will supply voltage for the PWM IC, then DMZ6005E is shut off, so that the standby power disipation of system will be significantly low. The documents of DMZ6005E can be accessed in ARK's website.

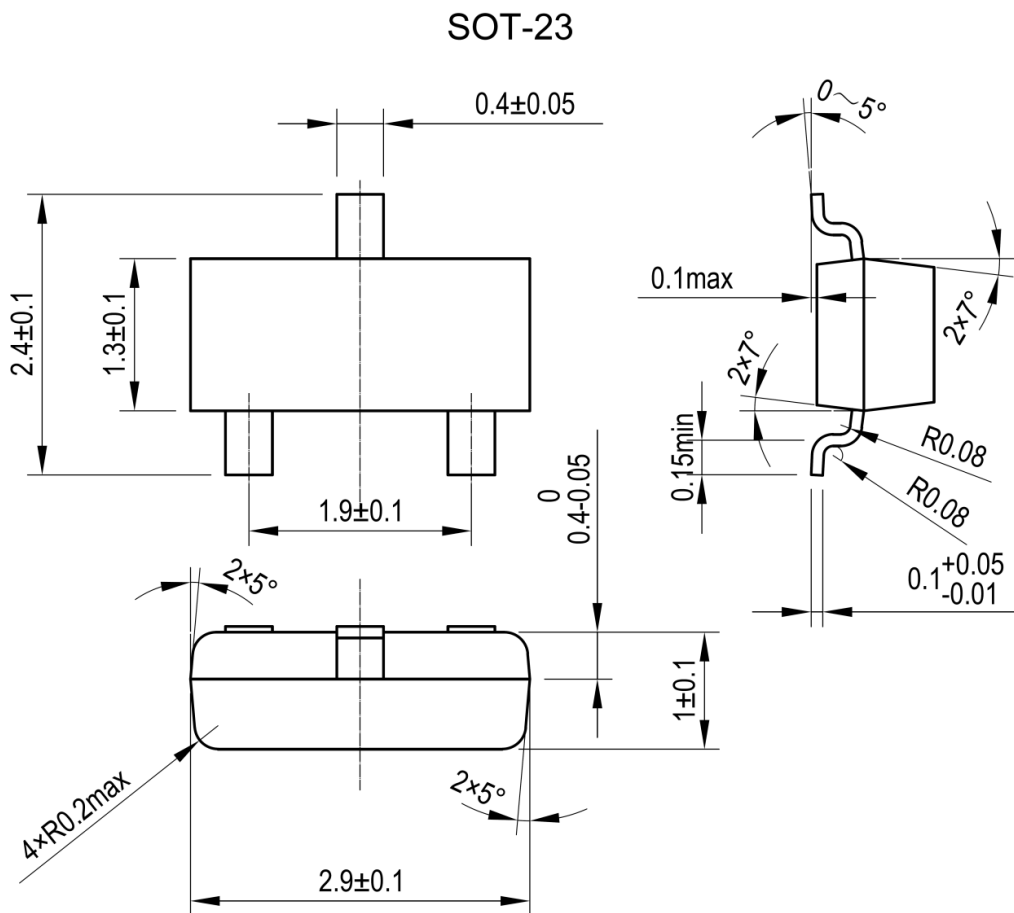


**Figure 8. Normal Circuit with Transistor and Diode**

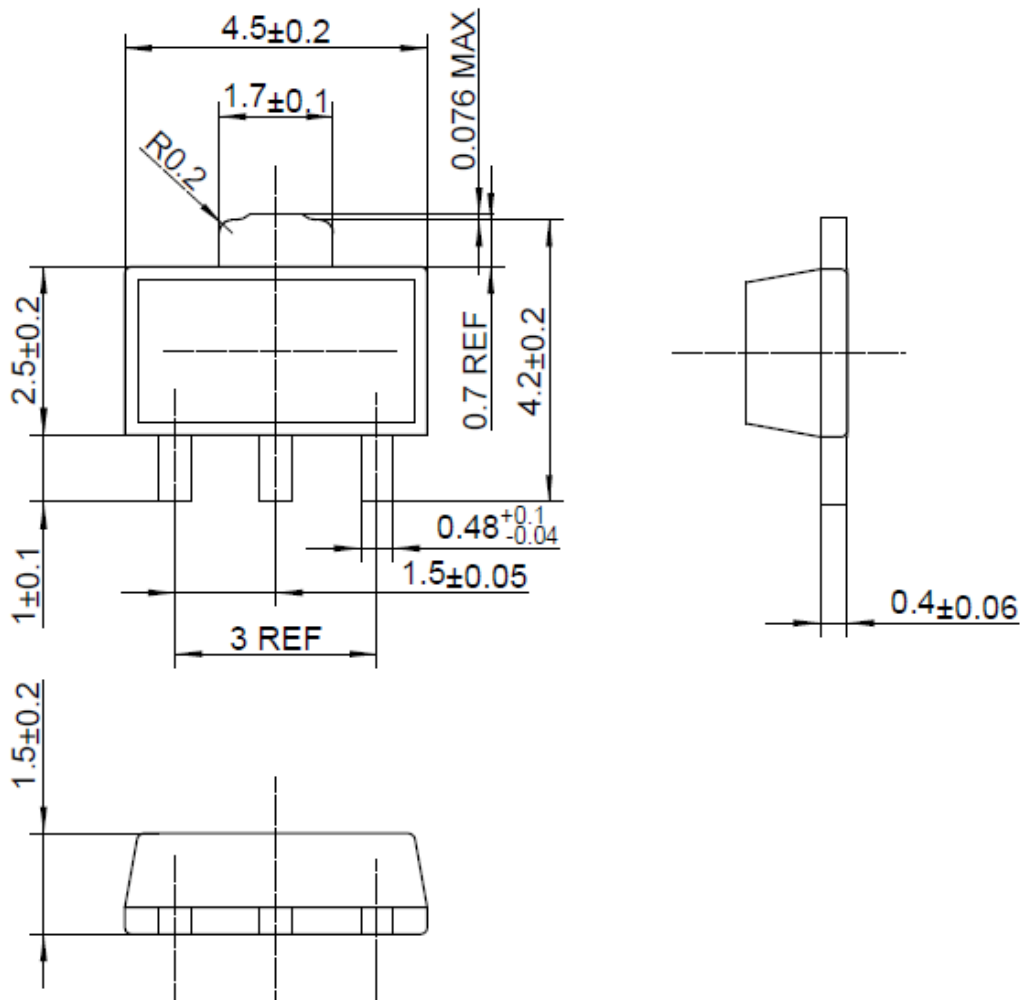


**Figure 9. Circuit with DMZ0615E/DMX0615E**

Package Dimensions



SOT-89



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