

### TL431 Adjustable Reference Source

#### TL431

Adjustable Accurate Reference Source

#### DEVICE DESCRIPTION

The TL431 is a three-terminal adjustable shunt regulator offering excellent temperature stability. This device has a typical dynamic output impedance of  $0.2\Omega$ . The device can be used as a replacement for zener diodes in many applications.

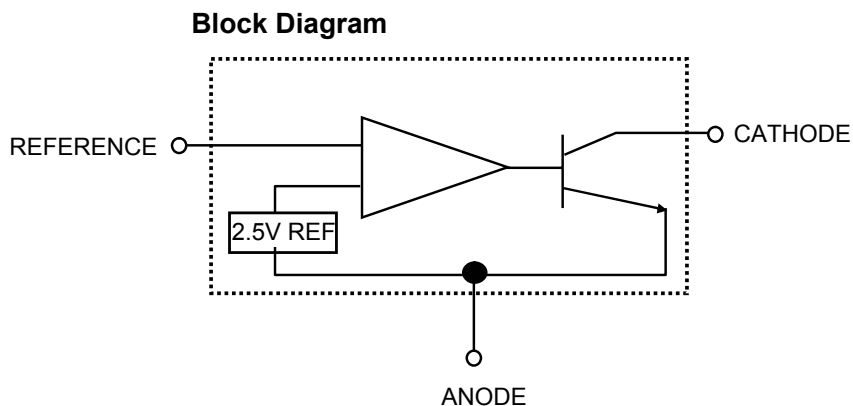
#### FEATURES

- The output voltage can be adjusted to 36V
- Low dynamic output impedance, its typical value is  $0.2\Omega$
- Trapping current capability is 1 to 100mA
- Low output noise voltage
- Fast on-state response
- The effective temperature compensation in the working range of full temperature
- The typical value of the equivalent temperature factor in the whole temperature scope is  $50 \text{ ppm}/^\circ\text{C}$

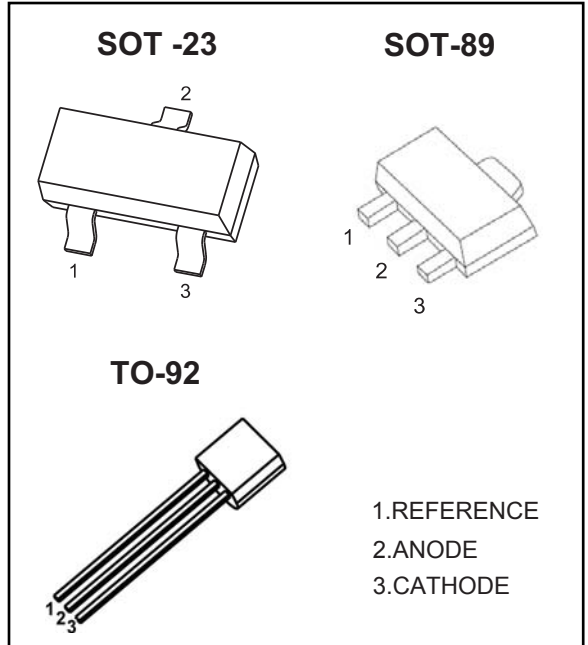
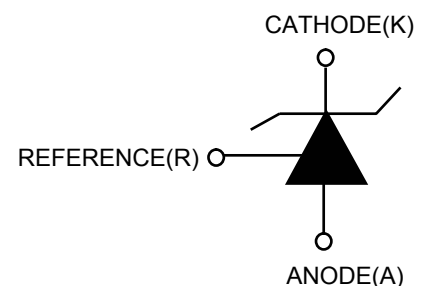
#### APPLICATION

- Shunt Regulator
- High-Current Shunt Regulator
- Precision Current Limiter

#### FUNCTION BLOCK DIAGRAM



#### Equivalent Circuit





### ORDERING INFORMATION

| Part Number | MARKING <sup>(1)</sup>      | Package | Packing Method | Pack Quantity |
|-------------|-----------------------------|---------|----------------|---------------|
| TL431       | 431                         | SOT-23  | Reel           | 3000pcs/Reel  |
| TL431       | 431                         | SOT-89  | Reel           | 1000pcs/Reel  |
| TL431       | TL431<br>XXX <sup>(2)</sup> | TO-92   | Bulk           | 1000pcs/Bag   |
| TL431       | TL431<br>XXX <sup>(2)</sup> | TO-92   | Tape           | 2000pcs/Box   |

Notes: (1). Solid dot= Green molding compound device, if none, the normal device.

(2). XXX=Code

### ABSOLUTE MAXIMUM RATINGS (Operating temperature range applies unless otherwise specified)

| Parameter                                   | Symbol          | Value     |        |       | Unit |
|---------------------------------------------|-----------------|-----------|--------|-------|------|
|                                             |                 | SOT-23    | SOT-89 | TO-92 |      |
| Cathode Voltage                             | $V_{KA}$        | 37        |        |       | V    |
| Cathode Current Range (Continuous)          | $I_{KA}$        | -100~+150 |        |       | mA   |
| Reference Input Current Range               | $I_{ref}$       | 0.05~+10  |        |       | mA   |
| Power Dissipation                           | $P_D$           | 300       | 500    | 770   | mW   |
| Thermal Resistance from Junction to Ambient | $R_{\theta JA}$ | 417       | 250    | 162   | °C/W |
| Operating Temperature                       | $T_{opr}$       | -25~+85   |        |       | °C   |
| Junction Temperature                        | $T_J$           | 150       |        |       | °C   |
| Storage Temperature Range                   | $T_{STG}$       | -65~+150  |        |       | °C   |

### TL431-0.3% ELECTRICAL CHARACTERISTICS ( $T_a=25^{\circ}\text{C}$ unless otherwise specified)

| Parameter                                                                   | Symbol                         | Cir-Cuit | Test conditions                                                                                         | Min   | Typ   | Max   | Unit          |
|-----------------------------------------------------------------------------|--------------------------------|----------|---------------------------------------------------------------------------------------------------------|-------|-------|-------|---------------|
| Reference input voltage                                                     | $V_{ref}$                      | 1        | $V_{KA}=V_{REF}$ , $I_{KA}=10\text{mA}$                                                                 | 2.487 | 2.495 | 2.502 | V             |
| Deviation of reference input voltage over temperature (note)                | $\Delta V_{ref}/\Delta T$      | 1        | $V_{KA}=V_{REF}$ , $I_{KA}=10\text{mA}$<br>$T_{MIN}\leq T_a\leq T_{MAX}$                                |       | 3     | 17    | mV            |
| Ratio of change in reference input voltage to the change in cathode voltage | $\Delta V_{ref}/\Delta V_{KA}$ | 2        | $I_{KA}=10\text{mA}$<br>$\Delta V_{KA}=10\text{V}\sim V_{REF}$                                          |       | -1.4  | -2.7  | mV/V          |
|                                                                             |                                |          | $\Delta V_{KA}=36\text{V}\sim 10\text{V}$                                                               |       | -1    | -2    | mV/V          |
| Reference input current                                                     | $I_{ref}$                      | 2        | $I_{KA}=10\text{mA}$ , $R_1=10\text{k}\Omega$<br>$R_2=\infty$                                           |       | 1.8   | 4     | $\mu\text{A}$ |
| Deviation of reference input current over full temperature range            | $\Delta I_{ref}/\Delta T$      | 2        | $I_{KA}=10\text{mA}$ , $R_1=10\text{k}\Omega$<br>$R_2=\infty$<br>$T_a=-25\text{ to }85^{\circ}\text{C}$ |       | 0.4   | 1.2   | $\mu\text{A}$ |
| Minimum cathode current for regulation                                      | $I_{KA(min)}$                  | 1        | $V_{KA}=V_{REF}$                                                                                        |       |       | 0.15  | mA            |
| Off-state cathode current                                                   | $I_{KA(OFF)}$                  | 3        | $V_{KA}=36\text{V}$ , $V_{REF}=0$                                                                       |       | 0.2   | 1     | $\mu\text{A}$ |
| Dynamic impedance                                                           | $Z_{KA}$                       | 1        | $V_{KA}=V_{REF}$ , $I_{KA}=1\text{ to }100\text{mA}$<br>$f\leq 1.0\text{kHz}$                           |       | 0.2   | 0.5   | $\Omega$      |

Note:  $T_{MIN}=-25^{\circ}\text{C}$ ,  $T_{MAX}=+85^{\circ}\text{C}$



### TL431-0.5% ELECTRICAL CHARACTERISTICS (Ta=25°C unless otherwise specified)

| Parameter                                                                   | Symbol                         | Cir-Cuit | Test conditions                                                           | Min                              | Typ   | Max   | Unit     |
|-----------------------------------------------------------------------------|--------------------------------|----------|---------------------------------------------------------------------------|----------------------------------|-------|-------|----------|
| Reference input voltage                                                     | $V_{ref}$                      | 1        | $V_{KA}=V_{REF}, I_{KA}=10mA$                                             | 2.482                            | 2.495 | 2.507 | V        |
| Deviation of reference Input voltage over temperature (note)                | $\Delta V_{ref}/\Delta T$      | 1        | $V_{KA}=V_{REF}, I_{KA}=10mA$<br>$T_{MIN} \leq T_a \leq T_{MAX}$          |                                  | 3     | 17    | mV       |
| Ratio of change in reference Input voltage to the change in cathode voltage | $\Delta V_{ref}/\Delta V_{KA}$ | 2        | $I_{KA}=10mA$                                                             | $\Delta V_{KA}=10V \sim V_{REF}$ | -1.4  | -2.7  | mV/V     |
|                                                                             |                                |          |                                                                           | $\Delta V_{KA}=36V \sim 10V$     | -1    | -2    | mV/V     |
| Reference input current                                                     | $I_{ref}$                      | 2        | $I_{KA}=10mA, R_1=10k\Omega$<br>$R_2=\infty$                              |                                  | 1.8   | 4     | $\mu A$  |
| Deviation of reference input current over full temperature range            | $\Delta I_{ref}/\Delta T$      | 2        | $I_{KA}=10mA, R_1=10k\Omega$<br>$R_2=\infty$<br>$T_A=-25$ to $85^\circ C$ |                                  | 0.4   | 1.2   | $\mu A$  |
| Minimum cathode current for regulation                                      | $I_{KA(min)}$                  | 1        | $V_{KA}=V_{REF}$                                                          |                                  |       | 0.15  | mA       |
| Off-state cathode current                                                   | $I_{KA(OFF)}$                  | 3        | $V_{KA}=36V, V_{REF}=0$                                                   |                                  | 0.2   | 1     | $\mu A$  |
| Dynamic impedance                                                           | $Z_{KA}$                       | 1        | $V_{KA}=V_{REF}, I_{KA}=1$ to $100mA$<br>$f \leq 1.0kHz$                  |                                  | 0.2   | 0.5   | $\Omega$ |

### TL431-1% ELECTRICAL CHARACTERISTICS (Ta=25°C unless otherwise specified)

| Parameter                                                                   | Symbol                         | Cir-Cuit | Test conditions                                                           | Min                              | Typ   | Max  | Unit     |
|-----------------------------------------------------------------------------|--------------------------------|----------|---------------------------------------------------------------------------|----------------------------------|-------|------|----------|
| Reference input voltage                                                     | $V_{ref}$                      | 1        | $V_{KA}=V_{REF}, I_{KA}=10mA$                                             | 2.47                             | 2.495 | 2.52 | V        |
| Deviation of reference Input voltage over temperature (note)                | $\Delta V_{ref}/\Delta T$      | 1        | $V_{KA}=V_{REF}, I_{KA}=10mA$<br>$T_{MIN} \leq T_a \leq T_{MAX}$          |                                  | 3     | 17   | mV       |
| Ratio of change in reference Input voltage to the change in cathode voltage | $\Delta V_{ref}/\Delta V_{KA}$ | 2        | $I_{KA}=10mA$                                                             | $\Delta V_{KA}=10V \sim V_{REF}$ | -1.4  | -2.7 | mV/V     |
|                                                                             |                                |          |                                                                           | $\Delta V_{KA}=36V \sim 10V$     | -1    | -2   | mV/V     |
| Reference input current                                                     | $I_{ref}$                      | 2        | $I_{KA}=10mA, R_1=10k\Omega$<br>$R_2=\infty$                              |                                  | 1.8   | 4    | $\mu A$  |
| Deviation of reference input current over full temperature range            | $\Delta I_{ref}/\Delta T$      | 2        | $I_{KA}=10mA, R_1=10k\Omega$<br>$R_2=\infty$<br>$T_A=-25$ to $85^\circ C$ |                                  | 0.4   | 1.2  | $\mu A$  |
| Minimum cathode current for regulation                                      | $I_{KA(min)}$                  | 1        | $V_{KA}=V_{REF}$                                                          |                                  |       | 0.15 | mA       |
| Off-state cathode current                                                   | $I_{KA(OFF)}$                  | 3        | $V_{KA}=36V, V_{REF}=0$                                                   |                                  | 0.2   | 1    | $\mu A$  |
| Dynamic impedance                                                           | $Z_{KA}$                       | 1        | $V_{KA}=V_{REF}, I_{KA}=1$ to $100mA$<br>$f \leq 1.0kHz$                  |                                  | 0.2   | 0.5  | $\Omega$ |

Note:  $T_{MIN}=-25^\circ C$ ,  $T_{MAX}=+85^\circ C$

### CLASSIFICATION of $V_{ref}$

| Rank  | 0.3%        | 0.5%        | 1%        |
|-------|-------------|-------------|-----------|
| Range | 2.487-2.502 | 2.482-2.507 | 2.47-2.52 |

### Test Circuit

Fig. 1 Test Circuit for  $V_{KA} = V_{REF}$

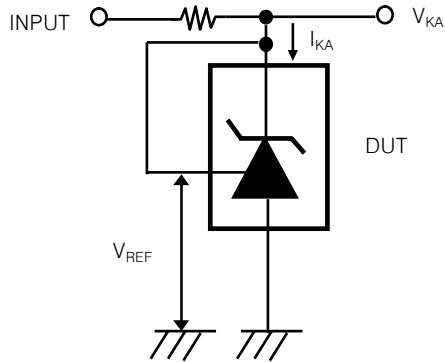


Fig. 2 Test Circuit for  $V_{KA} \geq V_{REF}$

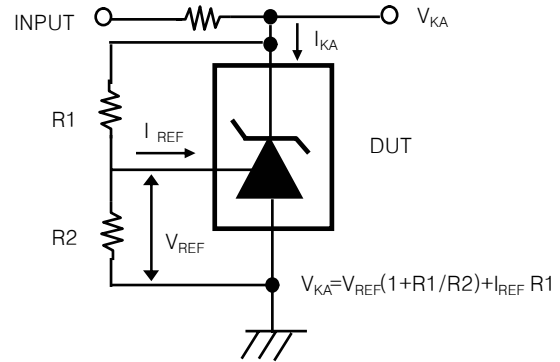
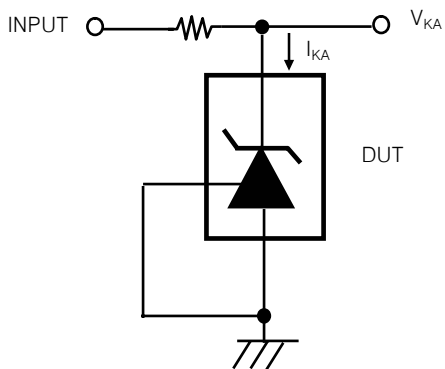


Fig. 3 Test Circuit for  $I_{KA}$  (off)



### Typical Performance Characteristics



Figure 4.

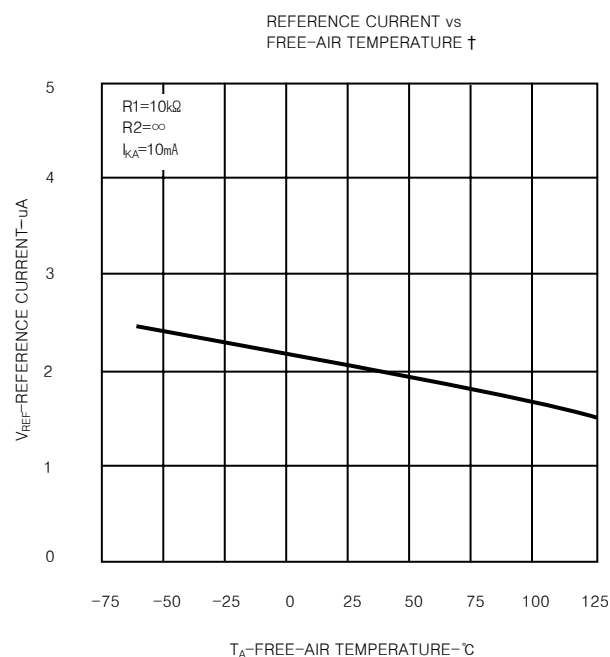


Figure 5.

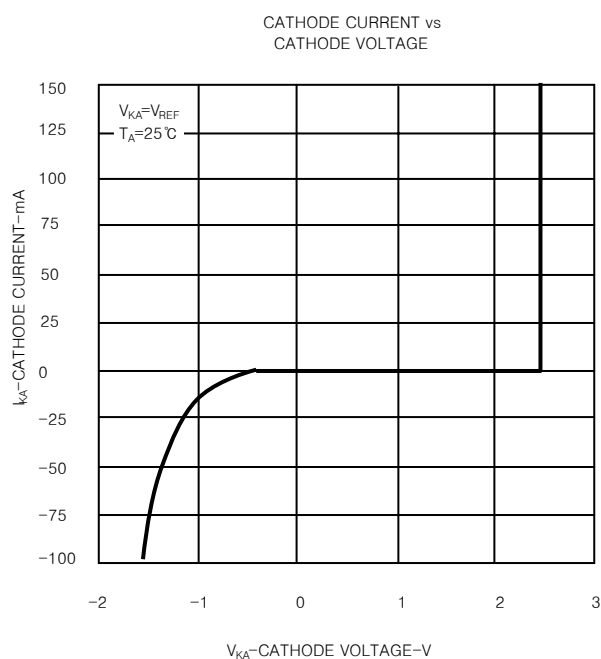


Figure 6.

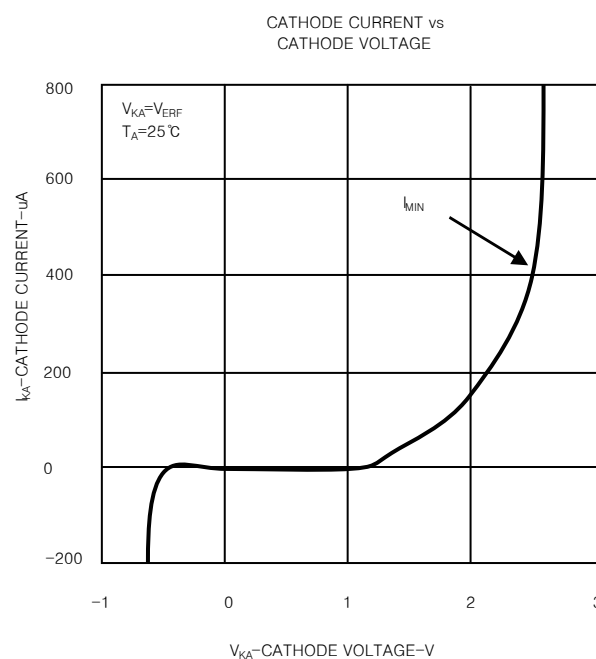
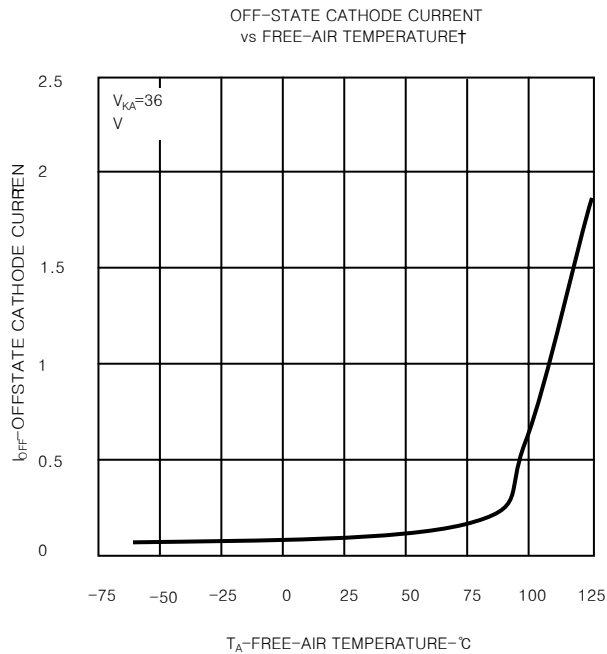


Figure 7.

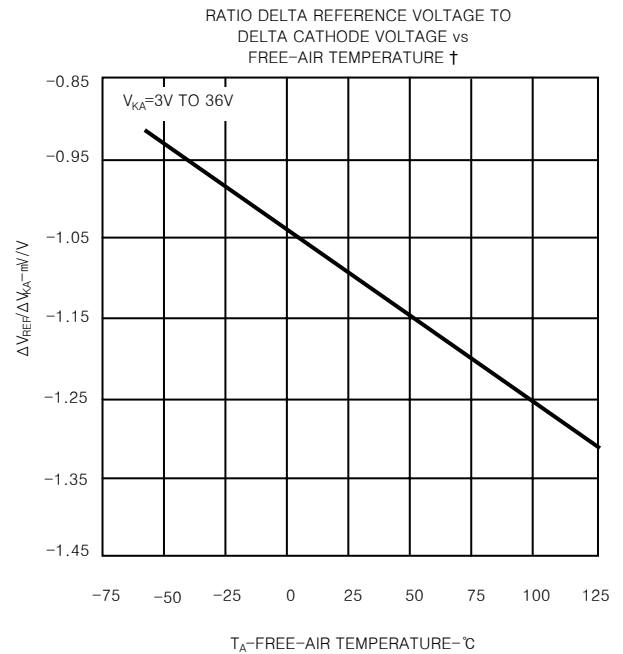
The curve above is for reference only.

### Typical Performance Characteristics



† Data is applicable only within the recommended operating free-air temperature ranges of the various devices.

Figure 8.



† Data is applicable only within the recommended operating free-air temperature ranges of the various devices.

Figure 9.

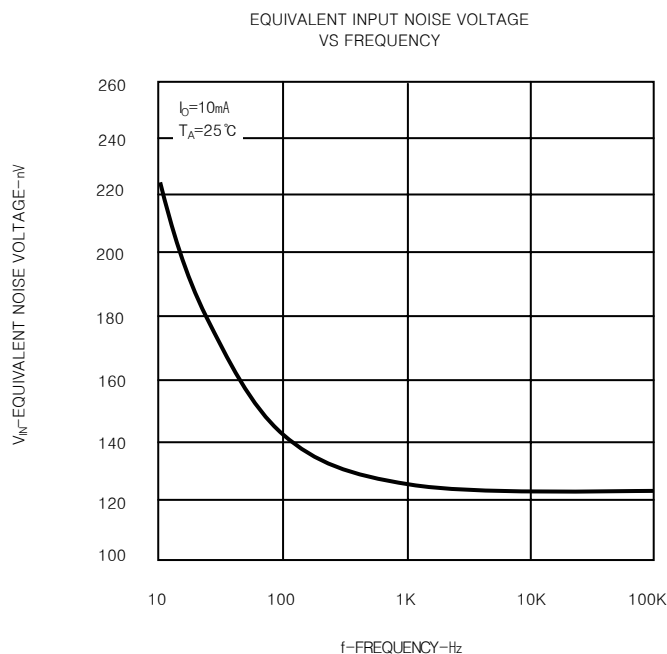
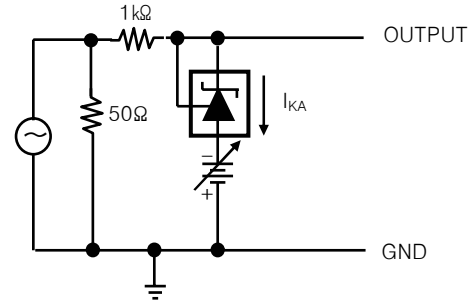
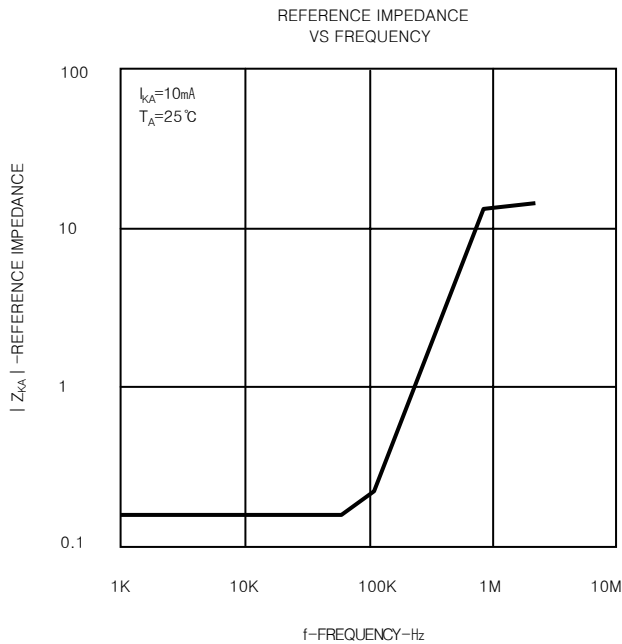


Figure 10.

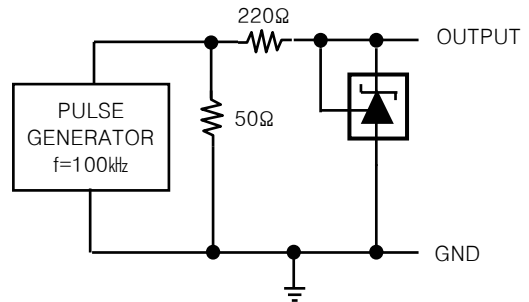
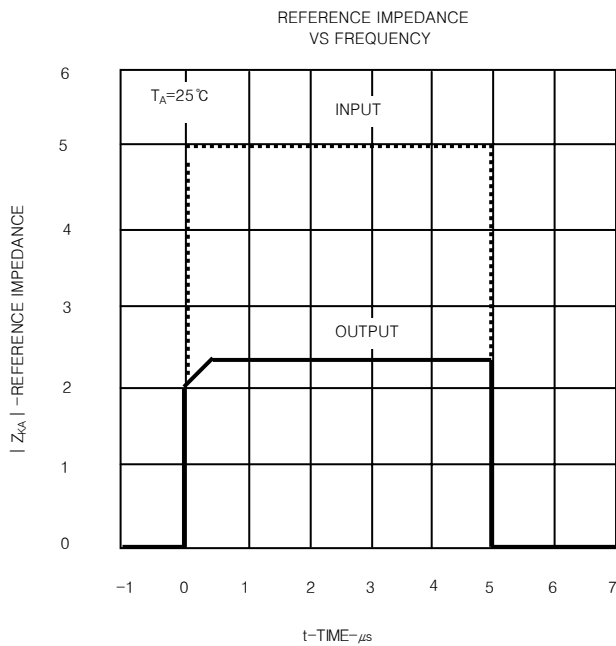
The curve above is for reference only.

### Typical Performance Characteristics



Test Circuit for Reference Impedance

Figure 11.

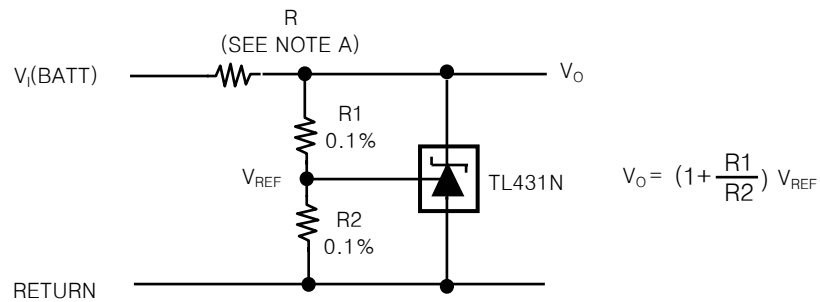


Test Circuit for Pulse Response

Figure 12.

The curve above is for reference only.

### Application Information



NOTE A : R Should provide cathode current  $\geq 1\text{mA}$  to the TL431N at minimum  $V_I(BATT)$

Figure 13. Shunt Regulator

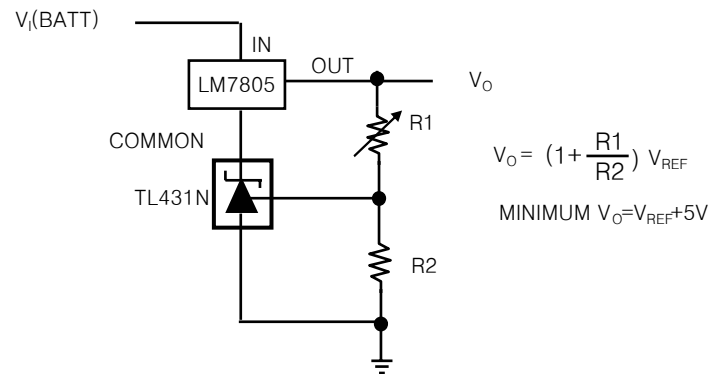


Figure 14. Output Control of a 3-Terminal Fixed Regulator

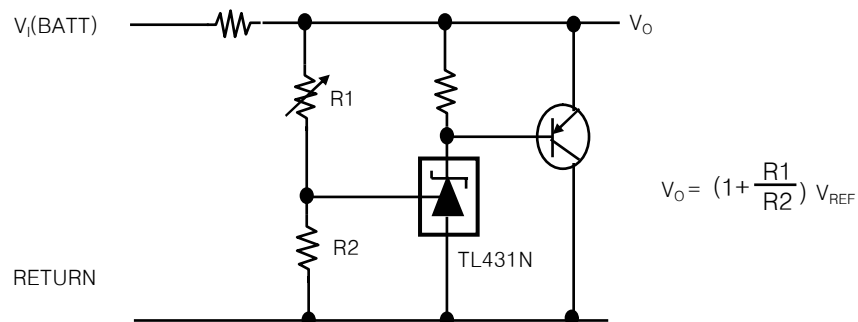
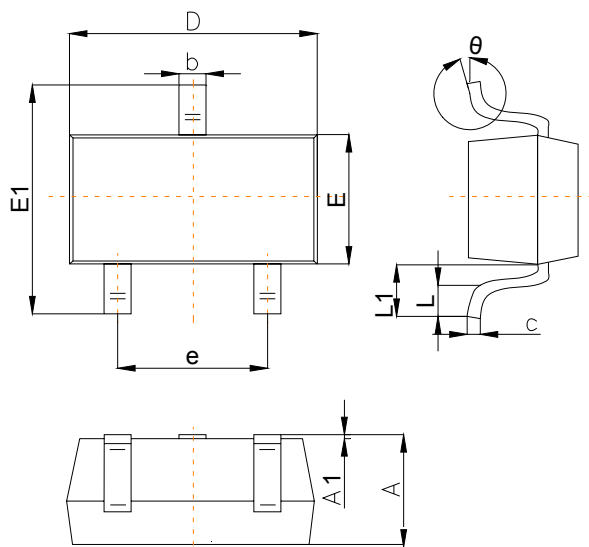


Figure 15. High-Current Shunt Regulator

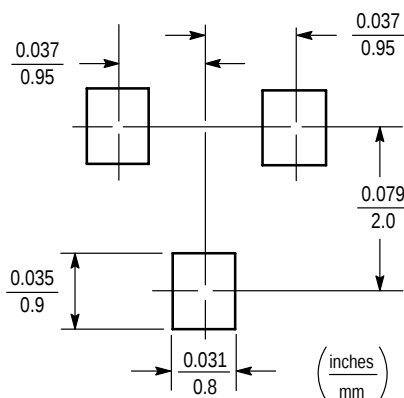
### SOT-23 Outlitne Drawing

#### SOT-23 Package Outline Dimensions



| Symbol | Dimensions In Millimeters |      |      |
|--------|---------------------------|------|------|
|        | Min                       | Typ  | Max  |
| A      | 0.90                      |      | 1.40 |
| A1     | 0.00                      |      | 0.10 |
| b      | 0.30                      |      | 0.50 |
| c      | 0.08                      |      | 0.20 |
| D      | 2.80                      | 2.90 | 3.10 |
| E      | 1.20                      |      | 1.60 |
| E1     | 2.25                      |      | 2.80 |
| e      | 1.80                      | 1.90 | 2.00 |
| L      | 0.10                      |      | 0.50 |
| L1     | 0.4                       |      | 0.55 |
| θ      | 0°                        |      | 10°  |

### SOT-23 Suggested Pad Layout

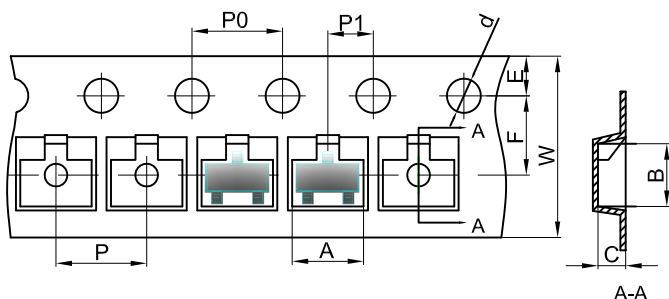


Note:

1. Controlling dimension: in/millimeters.
2. General tolerance:  $\pm 0.05\text{mm}$ .
3. The pad layout is for reference purposes only.

### SOT-23 Tape and Reel

#### SOT-23 Embossed Carrier Tape

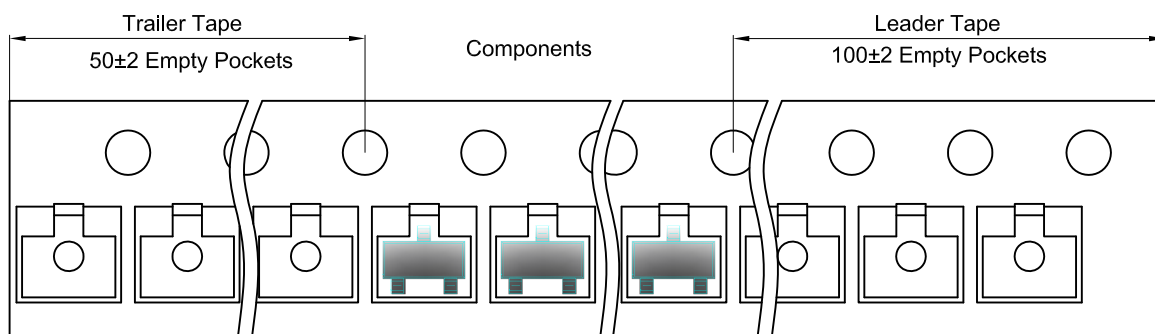


#### Packaging Description:

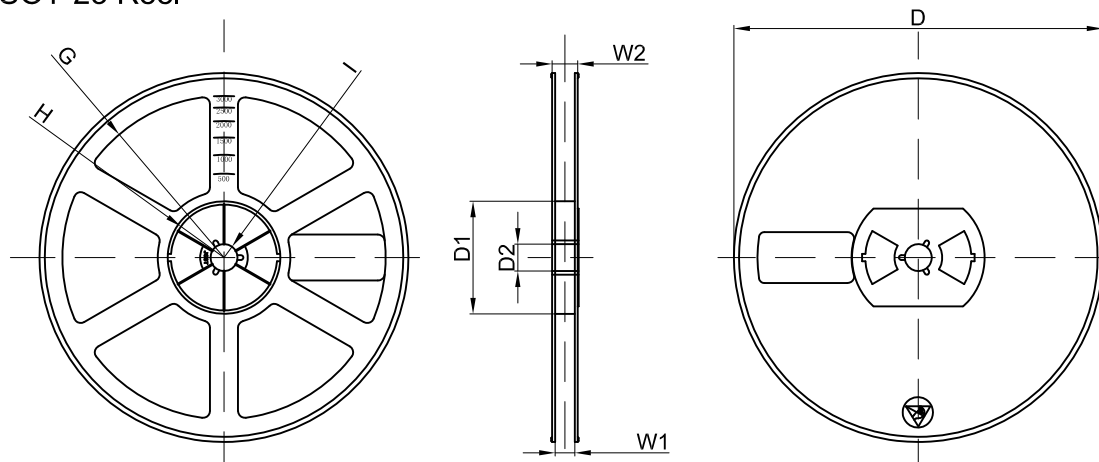
SOT-23 parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 3,000 units per 7" or 17.8cm diameter reel. The reels are clear in color and are made of polystyrene plastic (anti-static coated).

| Dimensions are in millimeter |      |      |      |       |      |      |      |      |      |      |
|------------------------------|------|------|------|-------|------|------|------|------|------|------|
| Pkg type                     | A    | B    | C    | d     | E    | F    | P0   | P    | P1   | W    |
| SOT-23                       | 3.15 | 2.77 | 1.22 | Ø1.50 | 1.75 | 3.50 | 4.00 | 4.00 | 2.00 | 8.00 |

#### SOT-23 Tape Leader and Trailer



#### SOT-23 Reel

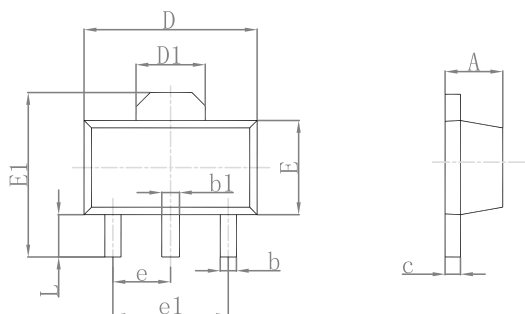


| Dimensions are in millimeter |         |       |       |        |        |       |      |       |
|------------------------------|---------|-------|-------|--------|--------|-------|------|-------|
| Reel Option                  | D       | D1    | D2    | G      | H      | I     | W1   | W2    |
| 7"Dia                        | Ø178.00 | 54.40 | 13.00 | R78.00 | R25.60 | R6.50 | 9.50 | 12.30 |

| REEL     | Reel Size | Box        | Box Size(mm) | Carton      | Carton Size(mm) | G.W.(kg) |
|----------|-----------|------------|--------------|-------------|-----------------|----------|
| 3000 pcs | 7 Inch    | 45,000 pcs | 203×203×195  | 180,000 pcs | 438×438×220     |          |

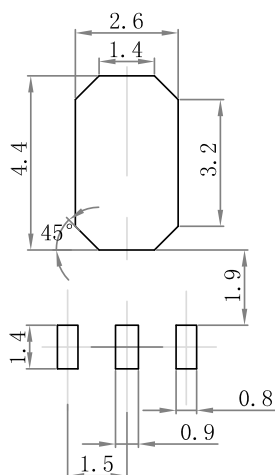
### SOT-89-3L Outline Drawing

#### SOT-89-3L Package Outline Dimensions



| Symbol | Dimensions in Millimeters |       | Dimensions in Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 1.400                     | 1.600 | 0.055                | 0.063 |
| b      | 0.320                     | 0.520 | 0.013                | 0.020 |
| b1     | 0.400                     | 0.580 | 0.016                | 0.023 |
| c      | 0.350                     | 0.440 | 0.014                | 0.017 |
| D      | 4.400                     | 4.600 | 0.173                | 0.181 |
| D1     | 1.550 REF.                |       | 0.061 REF.           |       |
| E      | 2.300                     | 2.600 | 0.091                | 0.102 |
| E1     | 3.940                     | 4.250 | 0.155                | 0.167 |
| e      | 1.500 TYP.                |       | 0.060 TYP.           |       |
| e1     | 3.000 TYP.                |       | 0.118 TYP.           |       |
| L      | 0.900                     | 1.200 | 0.035                | 0.047 |

### SOT-89-3L Suggested Pad Layout

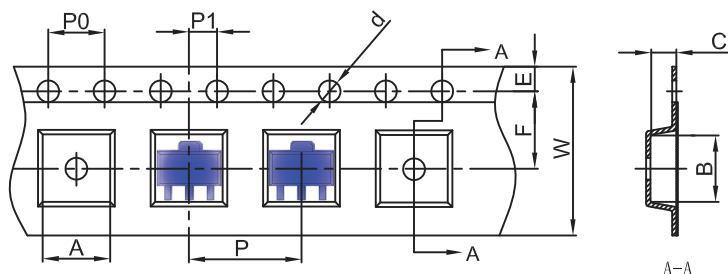


#### Note:

1. Controlling dimension: in/millimeters.
2. General tolerance:  $\pm 0.05\text{mm}$ .
3. The pad layout is for reference purposes only.

### SOT- 89-3L Tape and Reel

#### SOT-89-3L Embossed Carrier Tape

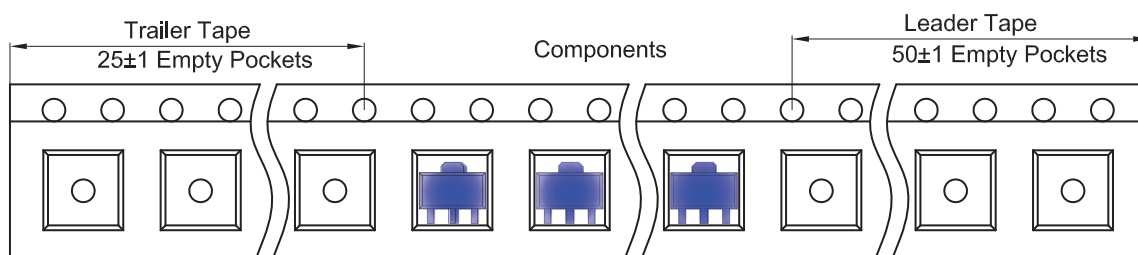


#### Packaging Description:

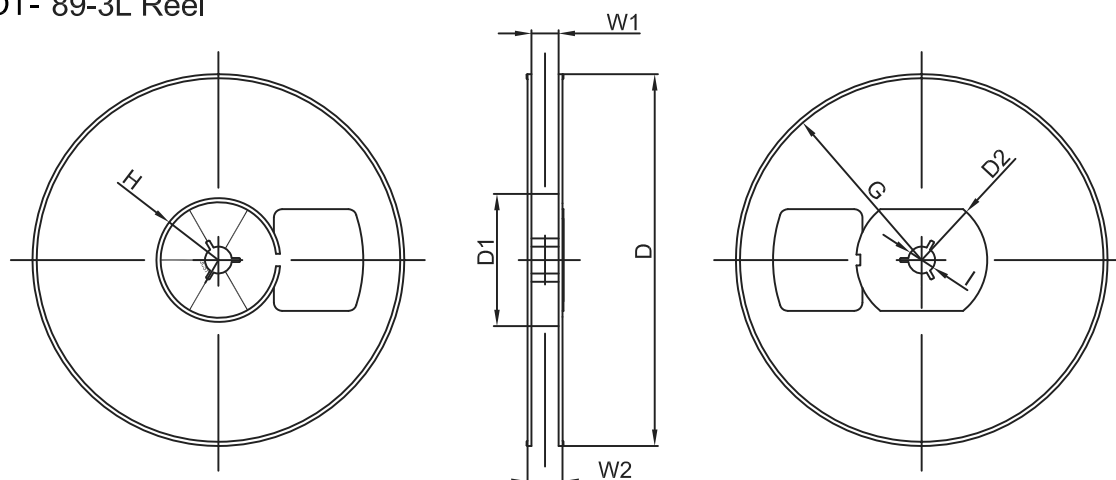
SOT-89-3L parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 1,000 units per 7" or 18cm diameter reel. The reels are clear in color and is made of polystyrene plastic (anti-static coated).

| Dimensions are in millimeter |      |      |      |       |      |      |      |      |      |       |
|------------------------------|------|------|------|-------|------|------|------|------|------|-------|
| Pkg type                     | A    | B    | C    | d     | E    | F    | P0   | P    | P1   | W     |
| SOT-89-3L                    | 4.85 | 4.45 | 1.85 | Ø1.50 | 1.75 | 5.50 | 4.00 | 8.00 | 2.00 | 12.00 |

#### SOT-89-3L Tape Leader and Trailer



#### SOT- 89-3L Reel

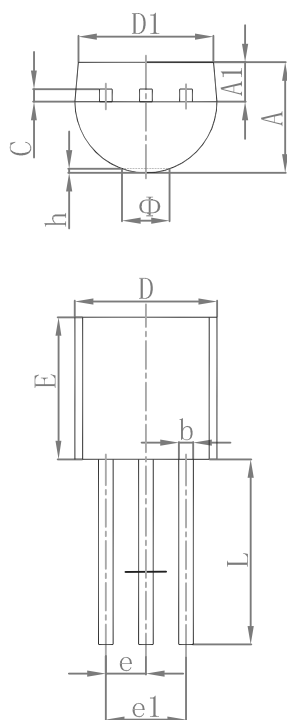


| Dimensions are in millimeter |         |       |        |        |        |        |       |       |
|------------------------------|---------|-------|--------|--------|--------|--------|-------|-------|
| Reel Option                  | D       | D1    | D2     | G      | H      | I      | W1    | W2    |
| 7"Dia                        | Ø180.00 | 60.00 | R32.00 | R86.50 | R30.00 | Ø13.00 | 13.20 | 16.50 |

| REEL     | Reel Size | Box        | Box Size(mm) | Carton     | Carton Size(mm) | G.W.(kg) |
|----------|-----------|------------|--------------|------------|-----------------|----------|
| 1000 pcs | 7 Inch    | 10,000 pcs | 203×203×195  | 40,000 pcs | 438×438×220     |          |

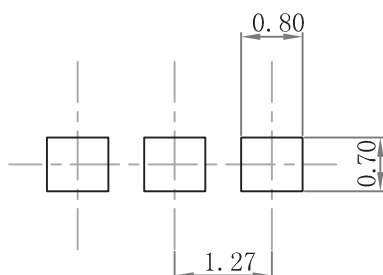
## TO-92 Outlitne Drawing

### TO-92 Package Outline Dimensions



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min                       | Max    | Min                  | Max   |
| A      | 3.300                     | 3.700  | 0.130                | 0.146 |
| A1     | 1.100                     | 1.400  | 0.043                | 0.055 |
| b      | 0.380                     | 0.550  | 0.015                | 0.022 |
| c      | 0.360                     | 0.510  | 0.014                | 0.020 |
| D      | 4.300                     | 4.700  | 0.169                | 0.185 |
| D1     | 3.430                     |        | 0.135                |       |
| E      | 4.300                     | 4.700  | 0.169                | 0.185 |
| e      | 1.270 TYP                 |        | 0.050 TYP            |       |
| e1     | 2.440                     | 2.640  | 0.096                | 0.104 |
| L      | 14.100                    | 14.500 | 0.555                | 0.571 |
| Φ      |                           | 1.600  |                      | 0.063 |
| h      | 0.000                     | 0.380  | 0.000                | 0.015 |

## TO-92 Suggested Pad Layout

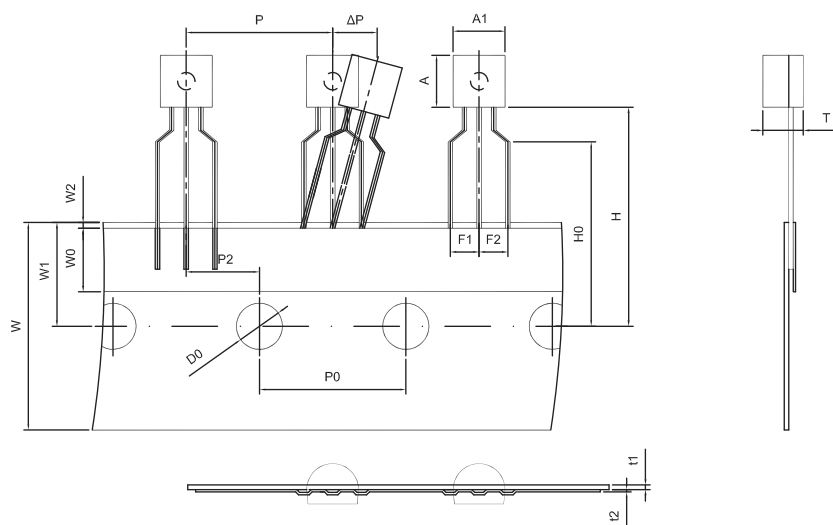


#### Note:

1. Controlling dimension: in/millimeters.
2. General tolerance:  $\pm 0.05\text{mm}$ .
3. The pad layout is for reference purposes only.

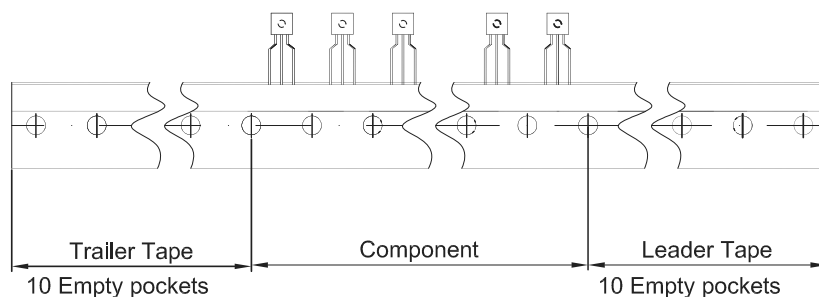
# **TO-92 Tape and Reel**

## TO-92 Package Tapeing Dimension



Dimensions are in millimeter

| A1  | A   | T        | P    | P0   | P2   | F1  | F2  | W    |
|-----|-----|----------|------|------|------|-----|-----|------|
| 4.5 | 4.5 | 3.5      | 12.7 | 12.7 | 6.35 | 2.5 | 2.5 | 18.0 |
| W0  | W1  | W2       | H    | H0   | D0   | t1  | t2  | ΔP   |
| 6.0 | 9.0 | 1.0 MAX. | 19.0 | 16.0 | 4.0  | 0.4 | 0.2 | 0    |



| Package | Box       | Box Size(mm) | Carton     | Carton Size(mm) | G.W.(kg) |
|---------|-----------|--------------|------------|-----------------|----------|
| TO-92   | 2,000 pcs | 333×162×43   | 20,000 pcs | 350×340×250     |          |