

TS78L00 Series

3-Terminal 100mA Positive Voltage Regulator

TO-92

Pin Definition:

1. Output
2. Ground
3. Input



SOT-23

Pin Definition:

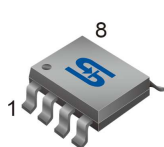
1. Output
2. Input
3. Ground



SOP-8

Pin Definition:

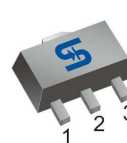
1. Output
2. Ground
3. Ground
4. N/C



SOT-89

Pin Definition:

1. Output
2. Ground
3. Input



General Description

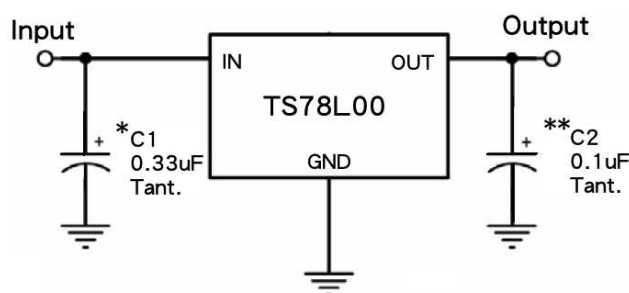
The TS78L00 Series of positive voltage Regulators are inexpensive, easy-to-use devices suitable for a multitude of applications that require a regulated supply of up to 100mA. Like their higher power TS7800 and TS78M00 Series cousins, these regulators feature internal current limiting and thermal shutdown making them remarkably rugged. No external components are required with the TS78L00 devices in many applications.

These devices offer a substantial performance advantage over the traditional zener diode-resistor combination, as output impedance and quiescent current are substantially reduced.

Features

- Output Voltage Range 3.3 to 24V
- Output current up to 100mA
- No external components required
- Internal thermal overload protection
- Internal short-circuit current limiting
- Output transistor safe-area compensation
- Output voltage offered in 4% tolerance

Standard Application Circuit



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the Input ripple voltage.

XX = these two digits of the type number indicate voltage.

* = C_{in} is required if regulator is located an appreciable distance from power supply filter.

** = C_o is not needed for stability; however, it does improve transient response.

Ordering Information

| Part No. | Package | Packing |
|---------------|---------|--------------------|
| TS78LxxCT B0 | TO-92 | 1kpcs / Bulk |
| TS78LxxCT A3 | TO-92 | 2kpcs/ Ammo |
| TS78LxxACY RM | SOT-89 | 1kpcs / 7" Reel |
| TS78LxxCS RL | SOP-8 | 2.5kpcs / 13" Reel |
| TS78LxxCX RF | SOT-23 | 3kpcs / 7" Reel |

Note: Refer to detail ordering information table.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

| Parameter | Symbol | Limit | Unit |
|--------------------------------------|------------------|------------------|------|
| DC Input Voltage | V _{IN} | 30 | V |
| | | 35 | |
| | | 40 | |
| Power Dissipation | P _D | Internal Limited | W |
| Operating Junction Temperature Range | T _J | 0 ~ +150 | °C |
| Storage Temperature Range | T _{STG} | -65~+150 | °C |

Thermal Performance

| Parameter | Symbol | Limit | Unit | |
|--|-----------------|--------|------|---------------|
| Thermal Resistance - Junction to Case | $R_{\theta JC}$ | TO-92 | -- | $^{\circ}C/W$ |
| | | SOT-23 | 120 | |
| | | SOT-89 | 15 | |
| | | SOP-8 | 20 | |
| Thermal Resistance - Junction to Ambient | $R_{\theta JA}$ | TO-92 | 230 | $^{\circ}C/W$ |
| | | SOT-23 | 330 | |
| | | SOT-89 | 55 | |
| | | SOP-8 | 55 | |

Note: Considering 6 cm² of copper board heat-sink

TS78L03 Electrical Characteristics

($V_{IN}=8.3V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|-------|---------|----------|-----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 3.173 | 3.3 | 3.432 | V |
| | | $5.8V \leq V_{IN} \leq 20V$, $5mA \leq I_{OUT} \leq 100mA$ | 3.142 | 3.3 | 3.465 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $5.8V \leq V_{IN} \leq 20V$ $I_{OUT}=40mA$ | -- | 50 | 150 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 15 5 | 60 30 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 3 | 6 | mA |
| Quiescent Current Change | ΔI_Q | $5.8V \leq V_{IN} \leq 20V$ | -- | -- | 1.5 | |
| | | $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 0.1 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 40 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $5.8V \leq V_{IN} \leq 20V$ | 41 | 49 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 2 | -- | V |
| Peak Output Current | $I_{o peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -0.2 | -- | mV/ $^{\circ}C$ |

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TS78L05 Electrical Characteristics

($V_{IN}=10V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|------|----------|----------|----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 4.80 | 5 | 5.20 | V |
| | | $7.5V \leq V_{IN} \leq 20V$, $5mA \leq I_{OUT} \leq 100mA$ | 4.75 | 5 | 5.25 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $7.5V \leq V_{IN} \leq 20V$ $I_{OUT}=100mA$ | -- | 50 | 150 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 20 10 | 60 30 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 3 | 6 | mA |
| Quiescent Current Change | ΔI_Q | $7.5V \leq V_{IN} \leq 20V$ | -- | -- | 1.5 | |
| | | $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 0.1 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 40 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $7.5V \leq V_{IN} \leq 20V$ | 41 | 49 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 1.7 | -- | V |
| Peak Output Current | $I_{o\ peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -0.65 | -- | $mV/^{\circ}C$ |

TS78L09 Electrical Characteristics

($V_{IN}=15V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|------|----------|----------|----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 8.65 | 9 | 9.36 | V |
| | | $11.5V \leq V_{IN} \leq 23V$, $5mA \leq I_{OUT} \leq 100mA$ | 8.57 | 9 | 9.45 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $11.5V \leq V_{IN} \leq 23V$ $I_{OUT}=40mA$ | -- | 90 | 180 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 30 15 | 90 45 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 3 | 6 | mA |
| Quiescent Current Change | ΔI_Q | $11.5V \leq V_{IN} \leq 23V$ | -- | -- | 1.5 | |
| | | $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 0.1 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 60 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $11.5V \leq V_{IN} \leq 23V$ | 37 | 57 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 1.7 | -- | V |
| Peak Output Current | $I_{o\ peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -0.9 | -- | $mV/^{\circ}C$ |

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TS78L12 Electrical Characteristics

($V_{IN}=19V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|-------|------|-------|-----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 11.53 | 12 | 12.48 | V |
| | | $14.5V \leq V_{IN} \leq 27V$, $5mA \leq I_{OUT} \leq 100mA$ | 11.42 | 12 | 12.60 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $14.5V \leq V_{IN} \leq 27V$ $I_{OUT}=40mA$ | -- | 120 | 240 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 40 | 120 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 3 | 6.5 | mA |
| Quiescent Current Change | ΔI_Q | $14.5V \leq V_{IN} \leq 27V$ $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 1.5 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 80 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $14.5V \leq V_{IN} \leq 27V$ | 37 | 42 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 1.7 | -- | V |
| Peak Output Current | $I_{o\ peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -1.0 | -- | mV/ $^{\circ}C$ |

TS78L15 Electrical Characteristics

($V_{IN}=23V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|-------|------|-------|-----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 14.42 | 15 | 15.60 | V |
| | | $17.5V \leq V_{IN} \leq 30V$, $5mA \leq I_{OUT} \leq 100mA$ | 14.28 | 15 | 15.75 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $17.5V \leq V_{IN} \leq 30V$ $I_{OUT}=40mA$ | -- | 150 | 300 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 50 | 150 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 3 | 6.6 | mA |
| Quiescent Current Change | ΔI_Q | $17.5V \leq V_{IN} \leq 30V$ $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 1.5 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 90 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $17.5V \leq V_{IN} \leq 30V$ | 34 | 39 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 1.7 | -- | V |
| Peak Output Current | $I_{o\ peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -1.3 | -- | mV/ $^{\circ}C$ |

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TS78L24 Electrical Characteristics

($V_{IN}=33V$, $I_{OUT}=40mA$, $0^{\circ}C \leq T_J \leq 125^{\circ}C$, $C_{IN}=0.33\mu F$, $C_{OUT}=0.1\mu F$; unless otherwise specified.)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------------------------|--|-------|----------|------------|----------------|
| Output voltage | V_{OUT} | $T_J=25^{\circ}C$ | 23.07 | 24 | 24.96 | V |
| | | $27V \leq V_{IN} \leq 38V$, $5mA \leq I_{OUT} \leq 100mA$ | 22.85 | 24 | 25.20 | |
| Line Regulation | REG_{LINE} | $T_J=25^{\circ}C$ $27 \leq V_{IN} \leq 38V$ $I_{OUT}=40mA$ | -- | 200 | 400 | mV |
| Load Regulation | REG_{LOAD} | $T_J=25^{\circ}C$ $5mA \leq I_{OUT} \leq 100mA$ $5mA \leq I_{OUT} \leq 40mA$ | -- | 80 40 | 240 120 | |
| Quiescent Current | I_Q | $I_{OUT}=0$, $T_J=25^{\circ}C$ | -- | 4 | 7 | mA |
| Quiescent Current Change | ΔI_Q | $27V \leq V_{IN} \leq 38V$ | -- | -- | 1.5 | |
| | | $5mA \leq I_{OUT} \leq 40mA$ | -- | -- | 0.1 | |
| Output Noise Voltage | V_N | $10Hz \leq f \leq 100KHz$, $T_J=25^{\circ}C$ | -- | 200 | -- | μV |
| Ripple Rejection Ratio | RR | $f=120Hz$, $27V \leq V_{IN} \leq 38V$ | 31 | 45 | -- | dB |
| Voltage Drop | V_{DROP} | $I_{OUT}=100mA$, $T_J=25^{\circ}C$ | -- | 1.7 | -- | V |
| Peak Output Current | $I_{o\ peak}$ | $T_J=25^{\circ}C$ | -- | 0.15 | -- | A |
| Temperature Coefficient of Output Voltage | $\Delta V_{OUT} / \Delta T_J$ | $I_{OUT}=5mA$, $0^{\circ}C \leq T_J \leq 150^{\circ}C$ | -- | -2.0 | -- | $mV/^{\circ}C$ |

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

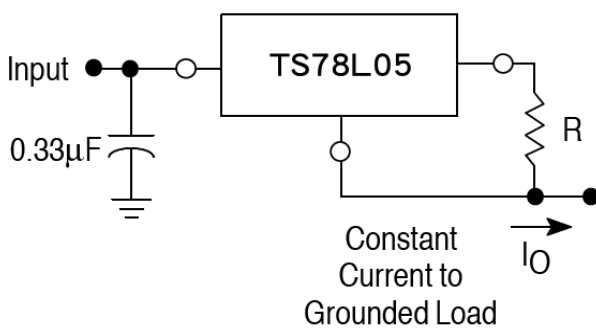
Application Information

Design Considerations

The TS78L00 Series of fixed voltage regulators are designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition. Internal Short Circuit protection Limits the maximum current the circuit will pass.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. The input bypass capacitor should be selected to provide good high-frequency characteristics to insure stable operation under all load conditions. A 0.33µF or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulators input terminals. Good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead. Bypassing the output is also recommended.

FIGURE 1 – Current Regulator



The TS78L00 regulators can also be used as a current source when connected as above. In order to minimize dissipation the TS78L05 is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5.0V}{R} + I_B$$

$I_B = 3.8mA$ over lined and load changes

For example, a 100mA current source would require R to be a 50Ω, 1/2W resistor and the output voltage compliance would be the input voltage less 7V.

FIGURE 2 – ±15V Tracking Voltage Regulator

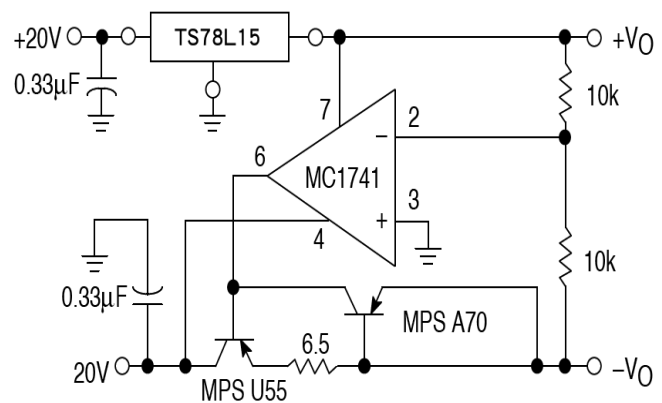
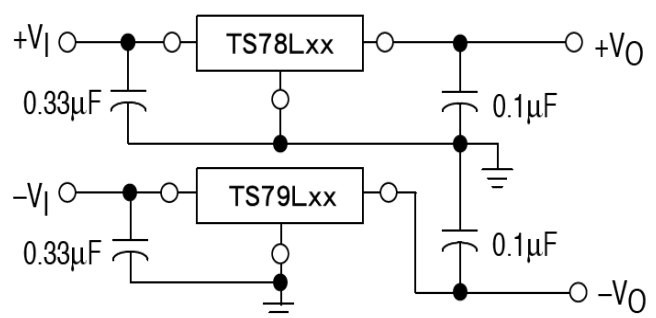


FIGURE 3 – ±15V Tracking Voltage Regulator



TS78L00 Series

3-Terminal 100mA Positive Voltage Regulator

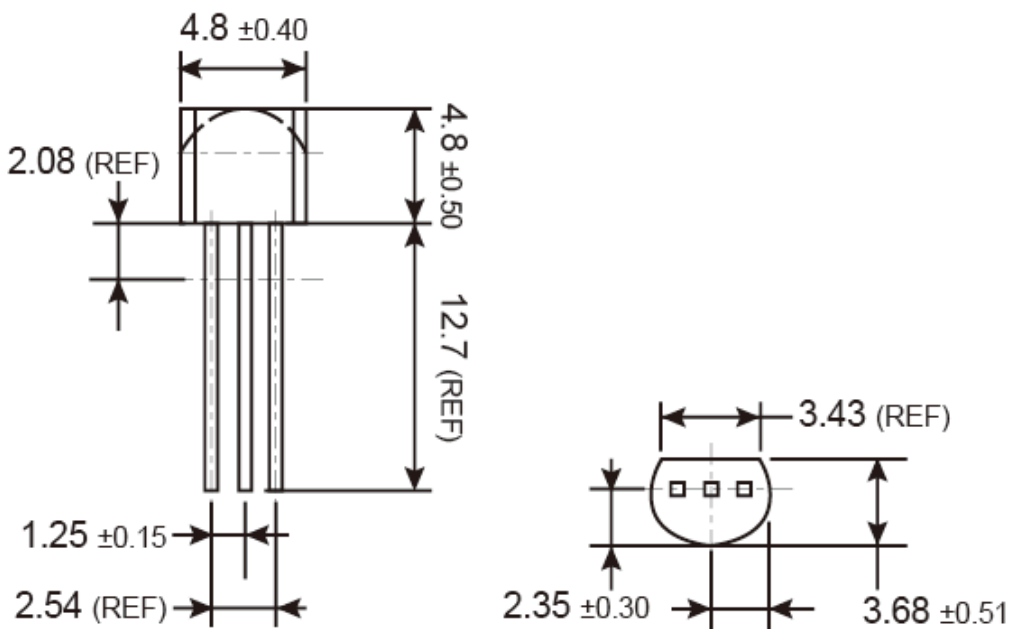
Ordering information

| Voltage | TO-92 | SOT-89 | SOP-8 | SOT-23 |
|---------|------------------------------|---------------|--------------|--------------|
| 3.3V | TS78L03CT B0 TS78L03CT A3 | TS78L03ACY RM | TS78L03CS RL | TS78L03CX RF |
| 5V | TS78L05CT B0 TS78L05CT A3 | TS78L05ACY RM | TS78L05CS RL | TS78L05CX RF |
| 9V | TS78L09CT B0 TS78L09CT A3 | TS78L09ACY RM | TS78L09CS RL | TS78L09CX RF |
| 12V | TS78L12CT B0 TS78L12CT A3 | TS78L12ACY RM | TS78L12CS RL | |
| 15V | TS78L15CT B0 TS78L15CT A3 | TS78L15ACY RM | TS78L15CS RL | |
| 24V | | | TS78L24CS RL | |

Packing code information

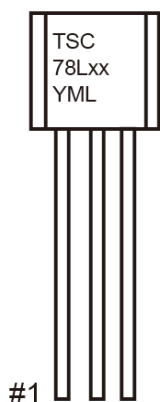
| Packing | B0: 1kpcs / Bulk A3: 2kpcs / Ammo | 1kpcs / 7" Reel | 2.5kpcs / 13" Reel | 3kpcs / 7"Reel |
|---------|--------------------------------------|-----------------|--------------------|----------------|
| | | | | |

TO-92 Mechanical Drawing



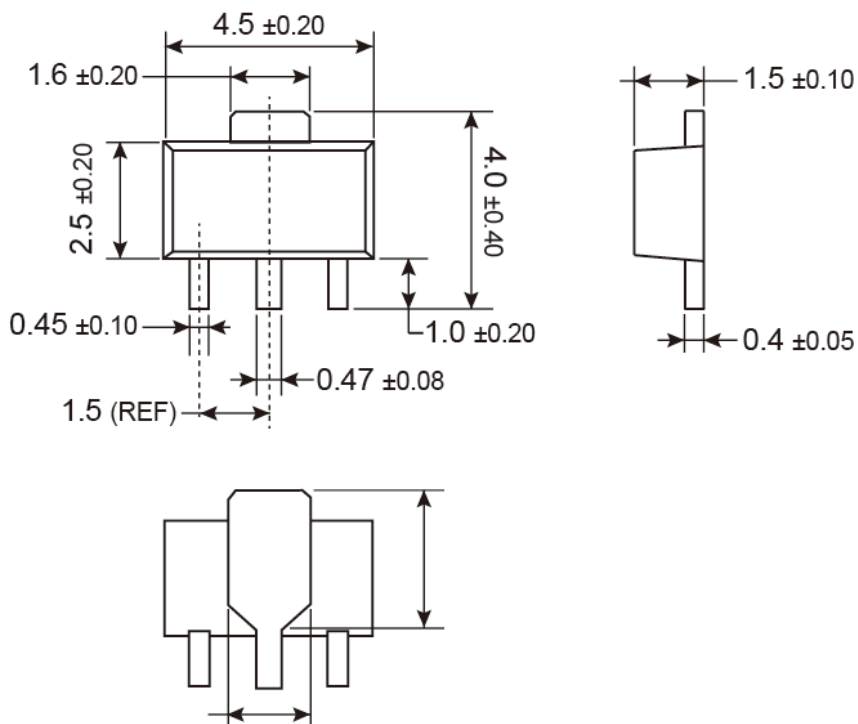
Unit: Millimeters

Marking Diagram



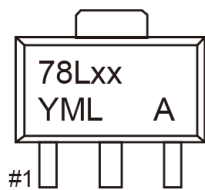
- XX** = Output Voltage
(03=3.3V, 05=5V, 09=9V, 12=12V, 15=15V)
- Y** = Year Code
- M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apr, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
- L** = Lot Code

SOT-89 Mechanical Drawing



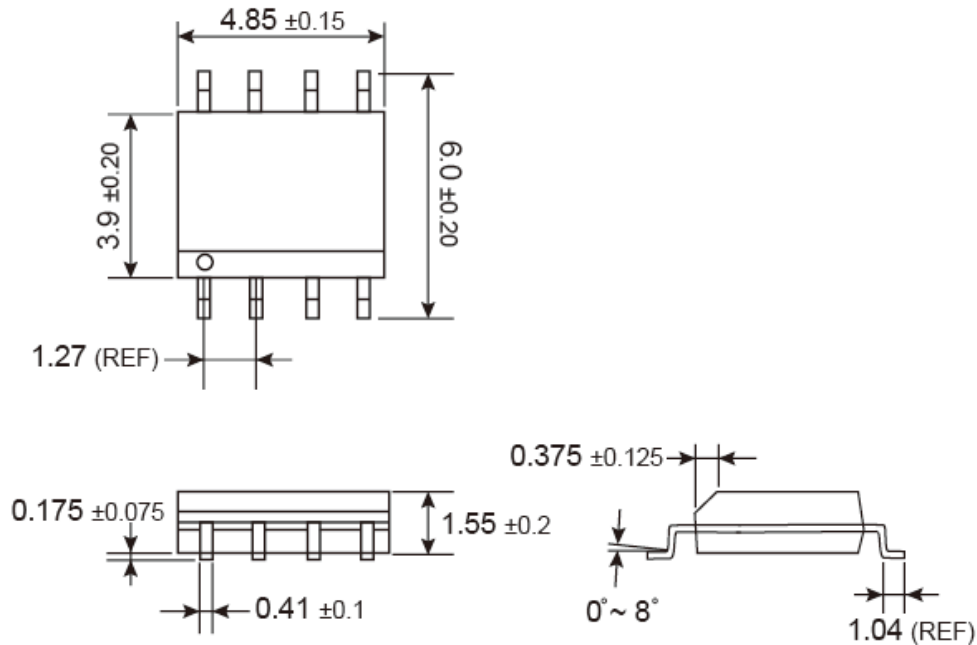
Unit: Millimeters

Marking Diagram



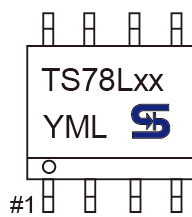
- XX** = Output Voltage
(03=3.3V, 05=5V, 09=9V, 12=12V, 15=15V)
- Y** = Year Code
- M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apr, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
- L** = Lot Code
- A** = TS78LxxACY

SOP-8 Mechanical Drawing



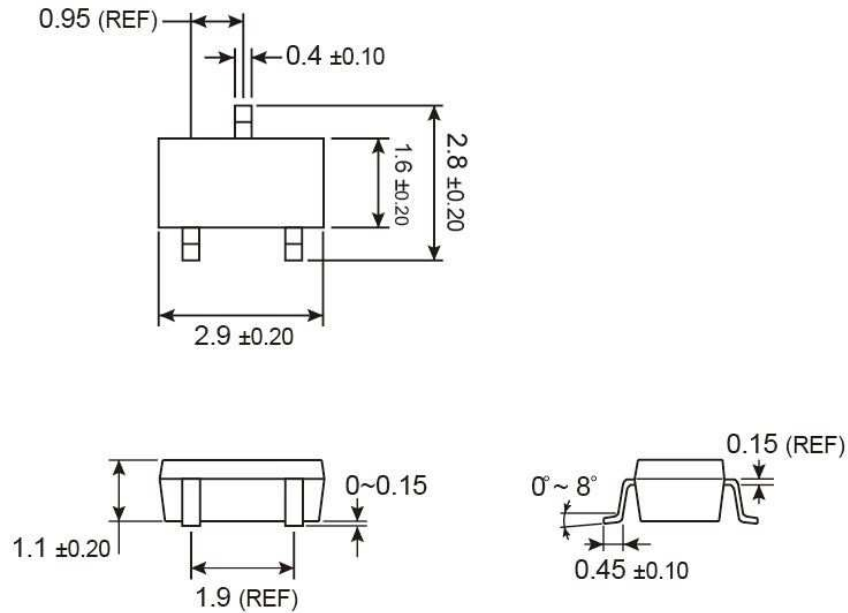
Unit: Millimeters

Marking Diagram



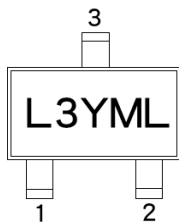
- XX** = Output Voltage
(03=3.3V, 05=5V, 09=9V, 12=12V, 15=15V, 24=24V)
- Y** = Year Code
- M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apr, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
- L** = Lot Code

SOT-23 Mechanical Drawing



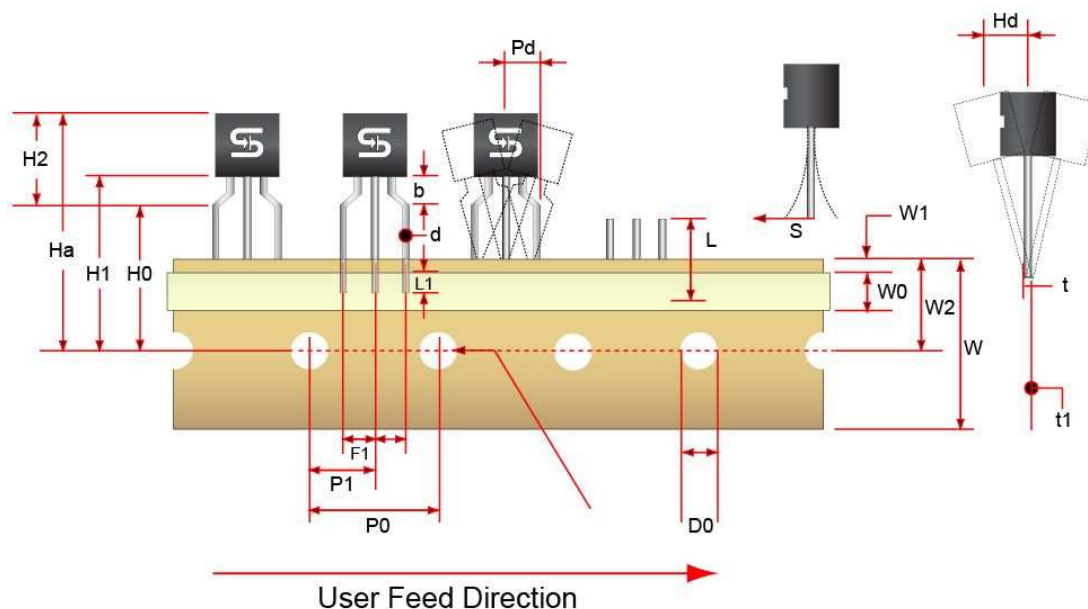
Unit: Millimeters

Marking Diagram



- L** = Device Voltage Code
- 3** (L3=3.3V, L5=5V, L9=9V)
- Y** = Year Code
- M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apr, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
- L** = Lot Code

TO-92 Ammo Pack Mechanical Drawing



Tape Dimension

| Item Description | Symbol | Dimension |
|------------------------------------|--------|--------------|
| Base of Package to Lead Bend | b | 3.0 (typ.) |
| Component Height | Ha | 23.57 (typ.) |
| Lead Clinch Height | H0 | 16.0 ±0.5 |
| Component Base Height | H1 | 19.0 ±0.5 |
| Component Top to Lead Bend | H2 | 8.0 (max) |
| Component Alignment (side / side) | Pd | 1.02 (max) |
| Component Alignment (front / back) | Hd | 0.79 (max) |
| Feed Hole Pitch | P0 | 12.7 ±0.3 |
| Hole Center to Component Center | P1 | 6.25 ±0.4 |
| Lead Spread | F1 | 2.5 ±0.3 |
| Lead Thickness | d | 0.46 (typ.) |
| Cut Lead Length | L | 10.9 (max) |
| Taped Lead Length | L1 | 5.31 (typ.) |
| Taped Lead Thickness | t | 0.81 ±0.2 |
| Carrier Tape Thickness | t1 | 0.5 ±0.2 |
| Carrier Tape Width | W | 18.0 ±0.5 |
| Hold – down Tape Width | W0 | 0.5 ±0.2 |
| Hold – down Tape position | W1 | 9.0 ±0.7 |
| Feed Hole Position | W2 | 6.0 ±0.2 |
| Sprocket Hole Diameter | D0 | 4.0 ±0.2 |
| Lead Spring Out | S | 0.1 (max) |

Note: All dimensions are in millimeter.

TS78L00 Series

3-Terminal 100mA Positive Voltage Regulator

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