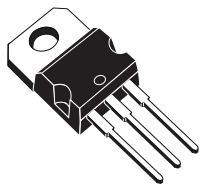
# LM117
# LM217, LM317

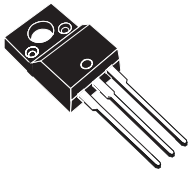
## 1.2 V to 37 V adjustable voltage regulators

## Features

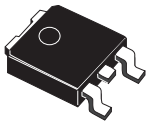
- Output voltage range: 1.2 to 37 V
- Output current in excess of 1.5 A
- 0.1 % line and load regulation
- Floating operation for high voltages
- Complete series of protections: current limiting, thermal shutdown and SOA control



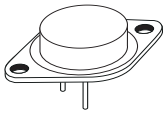
TO-220



TO-220FP



D²PAK



TO-3

## Description

The LM117, LM217, LM317 are monolithic integrated circuits in TO-220, TO-220FP, TO-3 and D²PAK packages intended for use as positive adjustable voltage regulators. They are designed to supply more than 1.5 A of load current with an output voltage adjustable over a 1.2 to 37 V range. The nominal output voltage is selected by means of only a resistive divider, making the device exceptionally easy to use and eliminating the stocking of many fixed regulators.

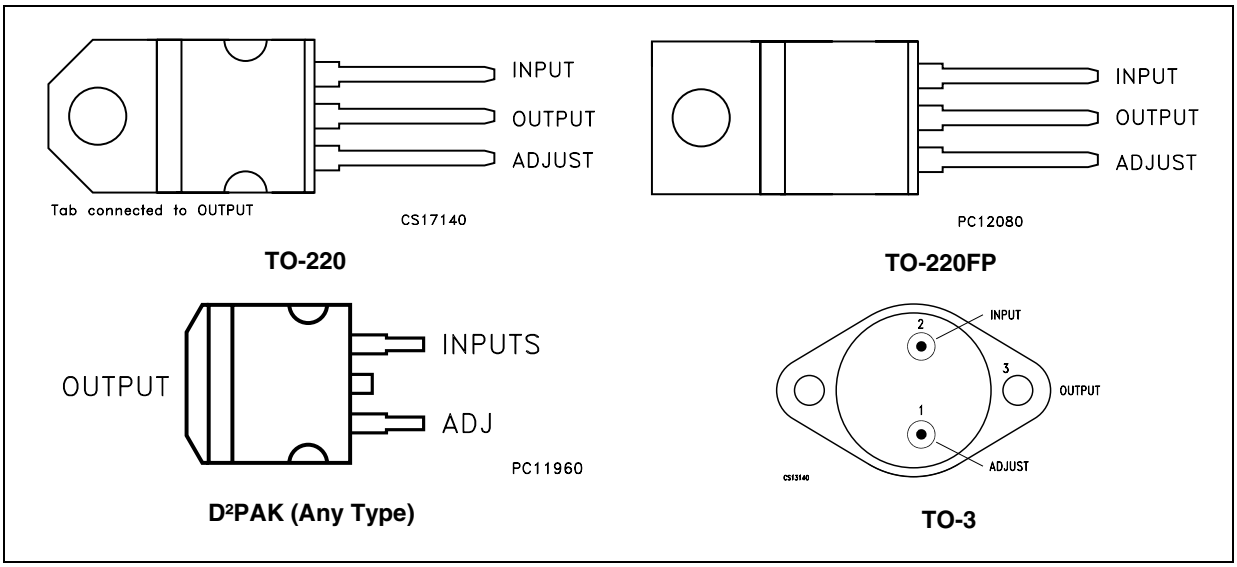
**Table 1. Device summary**

| Order codes | | | |
|---|---|---|---|
| **TO-220** | **D²PAK (tape and reel)** | **TO-220FP** | **TO-3** |
| | | | LM117K |
| LM217T | LM217D2T-TR | | LM217K |
| LM317T | LM317D2T-TR | LM317P | LM317K |

# Contents

# 1 Pin configuration

**Figure 1. Pin connections (top view)**



# 2 Maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_I - V_O$ | Input-reference differential voltage | | 40 | V |
| $I_O$ | Output current | | Internally limited | |
| $T_{OP}$ | Operating junction temperature for: | LM117 | - 55 to 150 | °C |
| | | LM217 | - 25 to 150 | |
| | | LM317 | 0 to 125 | |
| $P_D$ | Power dissipation | | Internally limited | |
| $T_{STG}$ | Storage temperature | | - 65 to 150 | °C |

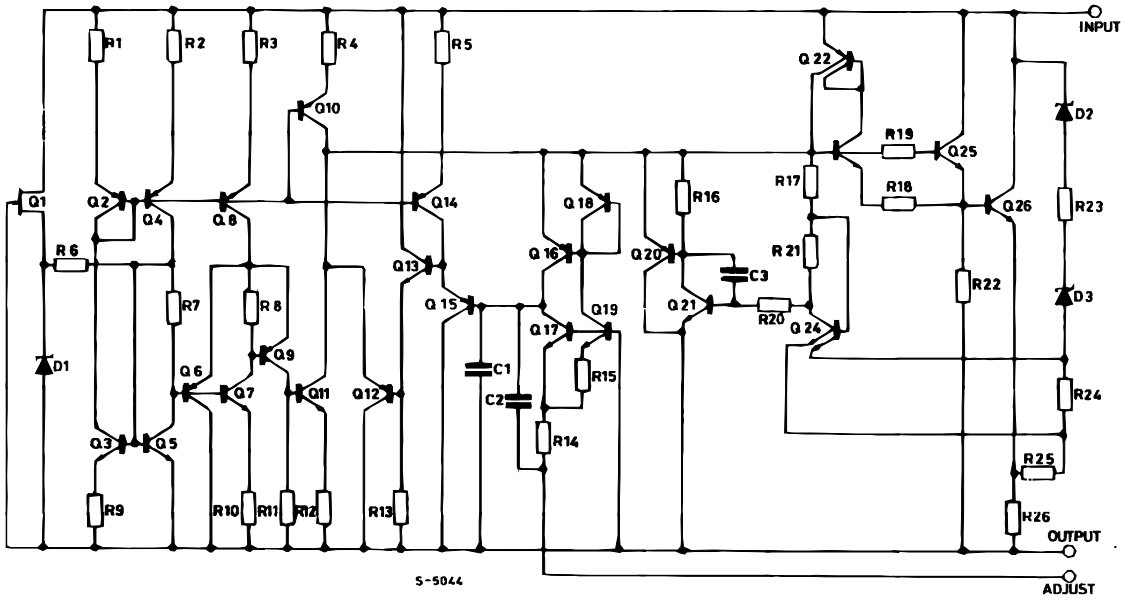
*Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.*

**Table 3. Thermal data**

| Symbol | Parameter | D²PAK | TO-220 | TO-220FP | TO-3 | Unit |
|---|---|---|---|---|---|---|
| $R_{thJC}$ | Thermal resistance junction-case | 3 | 5 | 5 | 4 | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 62.5 | 50 | 60 | 35 | °C/W |

# 3 Diagram

**Figure 2. Schematic diagram**



# 4 Electrical characteristics

$V_I$ - $V_O$ = 5 V, $I_O$ = 500 mA, $I_{MAX}$ = 1.5 A and $P_{MAX}$ = 20 W, $T_J$ = - 55 to 150 °C for LM117, $T_J$ = - 25 to 150 °C for LM217, unless otherwise specified.

**Table 4. Electrical characteristics for LM117/LM217**

| Symbol | Parameter | Test conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $\Delta V_O$ | Line regulation | $V_I$ - $V_O$ = 3 to 40 V | $T_J$ = 25°C | | 0.01 | 0.02 | %/V |
| | | | | | 0.02 | 0.05 | |
| $\Delta V_O$ | Load regulation | $V_O \leq$5 V<br>$I_O$ = 10 mA to $I_{MAX}$ | $T_J$ = 25°C | | 5 | 15 | mV |
| | | | | | 20 | 50 | |
| | | $V_O \geq$5 V,<br>$I_O$ = 10 mA to $I_{MAX}$ | $T_J$ = 25°C | | 0.1 | 0.3 | % |
| | | | | | 0.3 | 1 | |
| $I_{ADJ}$ | Adjustment pin current | | | | 50 | 100 | µA |
| $\Delta I_{ADJ}$ | Adjustment pin current | $V_I$ - $V_O$ = 2.5 to 40V $I_O$ = 10 mA to $I_{MAX}$ | | | 0.2 | 5 | µA |
| $V_{REF}$ | Reference voltage (between pin 3 and pin 1) | $V_I$ - $V_O$ = 2.5 to 40V $I_O$= 10 mA to $I_{MAX}$<br>$P_D \leq P_{MAX}$ | | 1.2 | 1.25 | 1.3 | V |
| $\Delta V_O/V_O$ | Output voltage temperature stability | | | | 1 | | % |
| $I_{O(min)}$ | Minimum load current | $V_I$ - $V_O$ = 40 V | | | 3.5 | 5 | mA |
| $I_{O(max)}$ | Maximum load current | $V_I$ - $V_O \leq$ 15 V, $P_D < P_{MAX}$ | | 1.5 | 2.2 | | A |
| | | $V_I$ - $V_O$ = 40 V, $P_D < P_{MAX}$, $T_J$ = 25°C | | | 0.4 | | |
| eN | Output noise voltage (percentage of $V_O$) | B = 10Hz to 100kHz, $T_J$ = 25°C | | | 0.003 | | % |
| SVR | Supply voltage rejection (1) | $T_J$ = 25°C, f = 120Hz | $C_{ADJ}$=0 | | 65 | | dB |
| | | | $C_{ADJ}$=10µF | 66 | 80 | | |

1. $C_{ADJ}$ is connected between pin 1 and ground.

$V_I$ - $V_O$ = 5 V, $I_O$ = 500 mA, $I_{MAX}$ = 1.5 A and $P_{MAX}$ = 20 W, $T_J$ = 0 to 125°C, unless otherwise specified.

**Table 5. Electrical characteristics for LM317**

| Symbol | Parameter | Test conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $\Delta V_O$ | Line regulation | $V_I$ - $V_O$ = 3 to 40 V | $T_J$ = 25°C | | 0.01 | 0.04 | %/V |
| | | | | | 0.02 | 0.07 | |
| $\Delta V_O$ | Load regulation | $V_O \leq$ 5 V<br>$I_O$ = 10 mA to $I_{MAX}$ | $T_J$ = 25°C | | 5 | 25 | mV |
| | | | | | 20 | 70 | |
| | | $V_O \geq$5 V,<br>$I_O$ = 10 mA to $I_{MAX}$ | $T_J$ = 25°C | | 0.1 | 0.5 | % |
| | | | | | 0.3 | 1.5 | |
| $I_{ADJ}$ | Adjustment pin current | | | | 50 | 100 | µA |
| $\Delta I_{ADJ}$ | Adjustment pin current | $V_I$ - $V_O$ = 2.5 to 40V,<br>$I_O$ = 10 mA to 500mA | | | 0.2 | 5 | µA |
| $V_{REF}$ | Reference voltage (between pin 3 and pin 1) | $V_I$ - $V_O$ = 2.5 to 40V $I_O$ = 10 mA to 500mA<br>$P_D \leq P_{MAX}$ | | 1.2 | 1.25 | 1.3 | V |
| $\Delta V_O/V_O$ | Output voltage temperature stability | | | | 1 | | % |
| $I_{O(min)}$ | Minimum load current | $V_I$ - $V_O$ = 40 V | | | 3.5 | 10 | mA |
| $I_{O(max)}$ | Maximum load current | $V_I$ - $V_O \leq$ 15 V, $P_D < P_{MAX}$ | | 1.5 | 2.2 | | A |
| | | $V_I$ - $V_O$ = 40 V, $P_D < P_{MAX}$, $T_J$ = 25°C | | | 0.4 | | |
| eN | Output noise voltage (percentage of $V_O$) | B = 10Hz to 100kHz, $T_J$ = 25°C | | | 0.003 | | % |
| SVR | Supply voltage rejection (1) | $T_J$ = 25°C, f = 120Hz | $C_{ADJ}$=0 | | 65 | | dB |
| | | | $C_{ADJ}$=10µF | 66 | 80 | | |

1. $C_{ADJ}$ is connected between pin 1 and ground.

# 5 Typical characteristics

**Figure 3. Output current vs. input-output differential voltage**

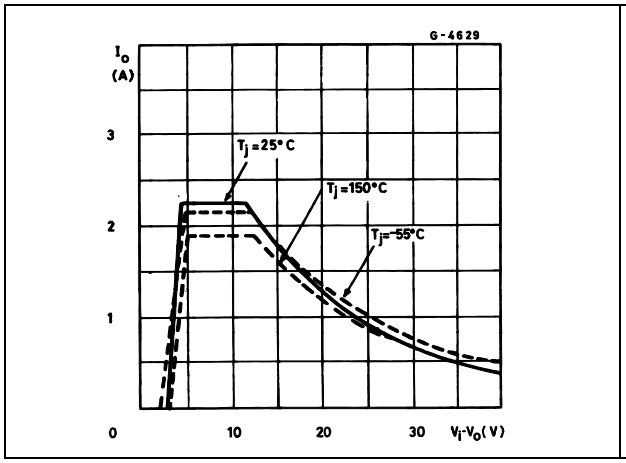



**Figure 4. Dropout voltage vs. junction temperature**

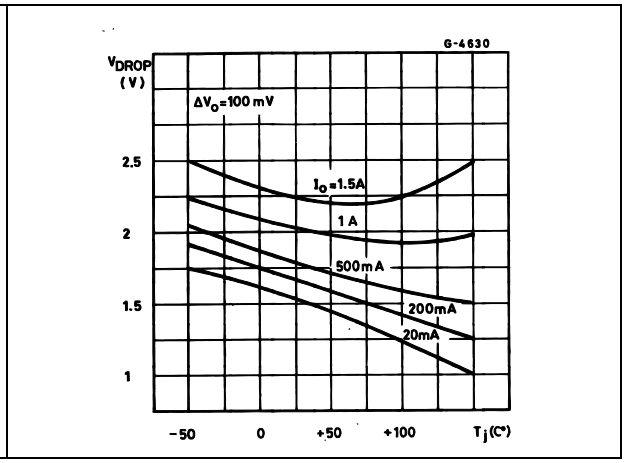



**Figure 5. Reference voltage vs. junction**

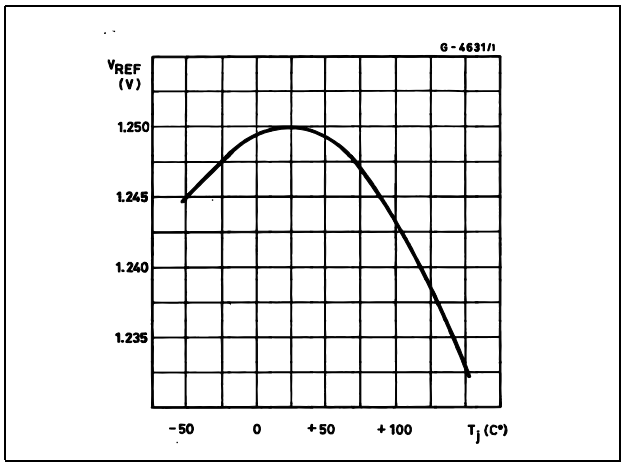
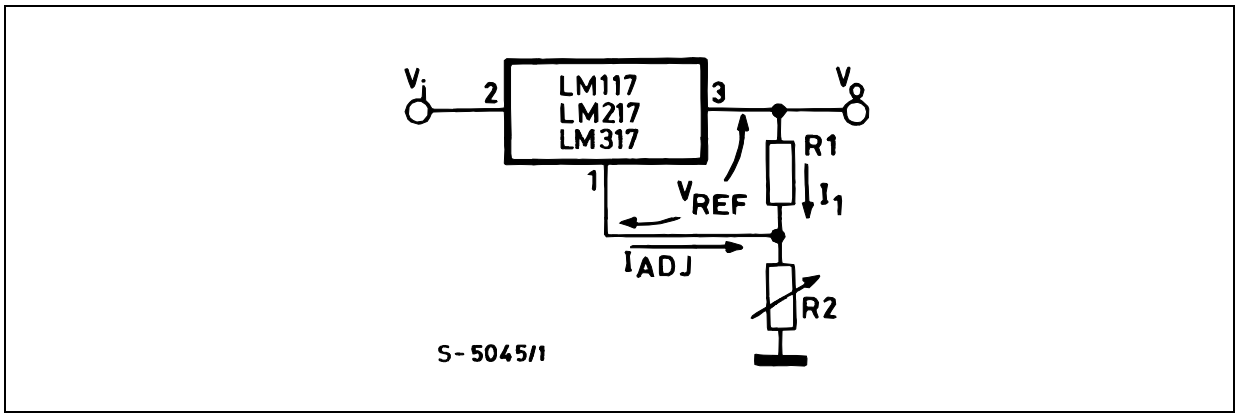



**Figure 6. Basic adjustable regulator**



# 6 Application information

The LM117, LM217, LM317 provides an internal reference voltage of 1.25 V between the output and adjustments terminals. This is used to set a constant current flow across an external resistor divider (see *Figure 3*), giving an output voltage $V_O$ of:

$V_O = V_{REF} (1 + R_2/R_1) + I_{ADJ} R_2$

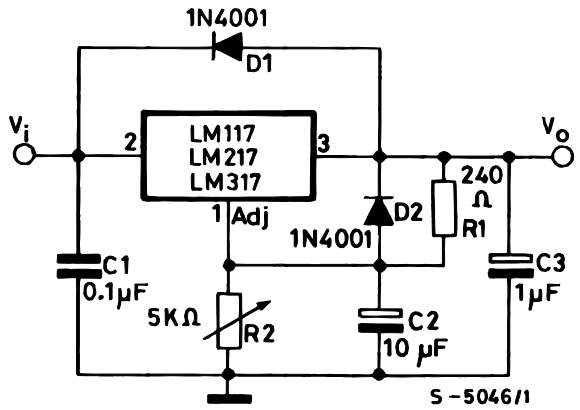
The device was designed to minimize the term $I_{ADJ}$ (100 µA max) and to maintain it very constant with line and load changes. Usually, the error term $I_{ADJ} \times R_2$ can be neglected. To obtain the previous requirement, all the regulator quiescent current is returned to the output terminal, imposing a minimum load current condition. If the load is insufficient, the output voltage will rise. Since the LM117, LM217, LM317 is a floating regulator and "sees" only the input-to-output differential voltage, supplies of very high voltage with respect to ground can be regulated as long as the maximum input-to-output differential is not exceeded. Furthermore, programmable regulator are easily obtainable and, by connecting a fixed resistor between the adjustment and output, the device can be used as a precision current regulator. In order to optimize the load regulation, the current set resistor $R_1$ (see *Figure 3*) should be tied as close as possible to the regulator, while the ground terminal of $R_2$ should be near the ground of the load to provide remote ground sensing. Performance may be improved with added capacitance as follow:

An input bypass capacitor of 0.1 µF

An adjustment terminal to ground 10 µF capacitor to improve the ripple rejection of about 15 dB (CADJ).

An 1 µF tantalum (or 25 µF Aluminium electrolytic) capacitor on the output to improve transient response. In additional to external capacitors, it is good practice to add protection diodes, as shown in *Figure 4* D1 protect the device against input short circuit, while D2 protect against output short circuit for capacitance discharging.

**Figure 7. Voltage regulator with protection diodes**




*Note: D1 protect the device against input short circuit, while D2 protects against output short circuit for capacitors discharging.*

**Figure 8. Slow turn-on 15 V regulator**

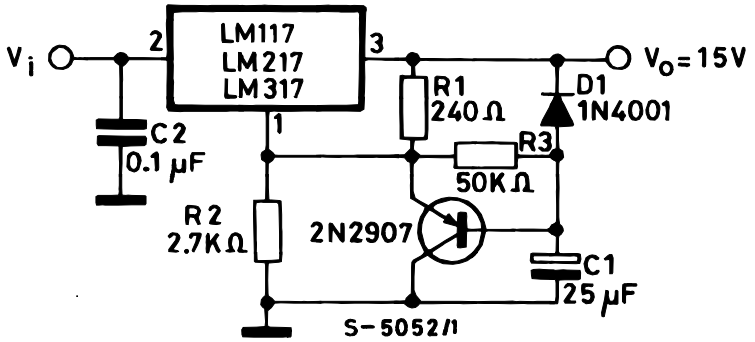
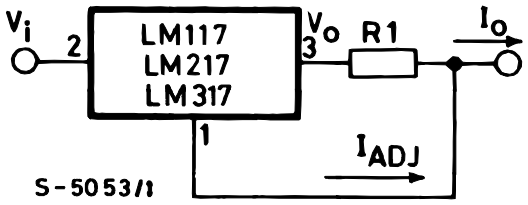



**Figure 9. Current regulator**




$I_O = (V_{REF} / R_1) + I_{ADJ} = 1.25\ V / R_1$

**Figure 10. 5 V electronic shut-down regulator**

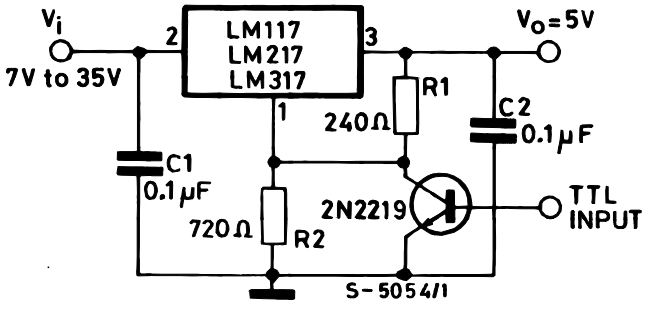
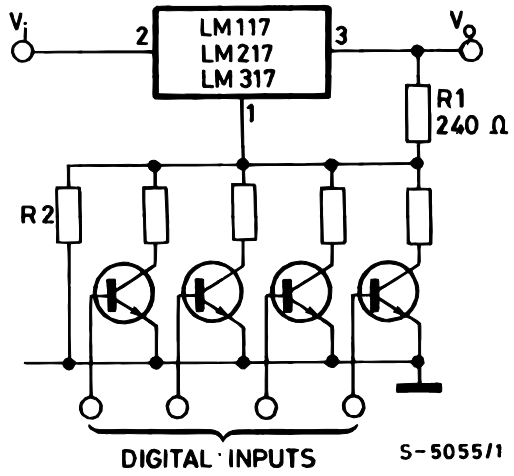
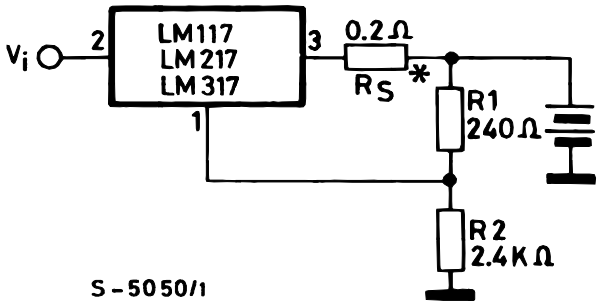


**Figure 11. Digitally selected outputs**



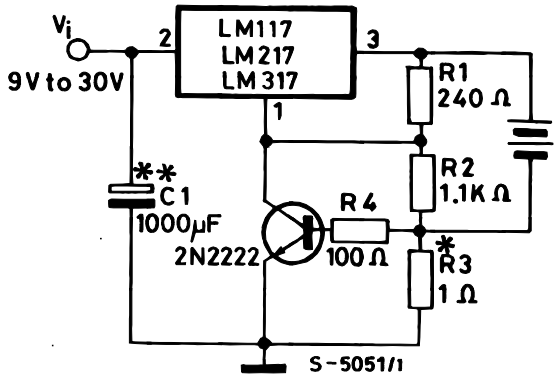

($R_2$ sets maximum $V_O$)

**Figure 12. Battery charger (12 V)**




* $R_S$ sets output impedance of charger $Z_O = R_S (1 + R_2/R_1)$. Use of $R_S$ allows low charging rates whit fully charged battery.

**Figure 13. Current limited 6 V charger**




* R3 sets peak current (0.6 A for 1 0).

** C1 recommended to filter out input transients.

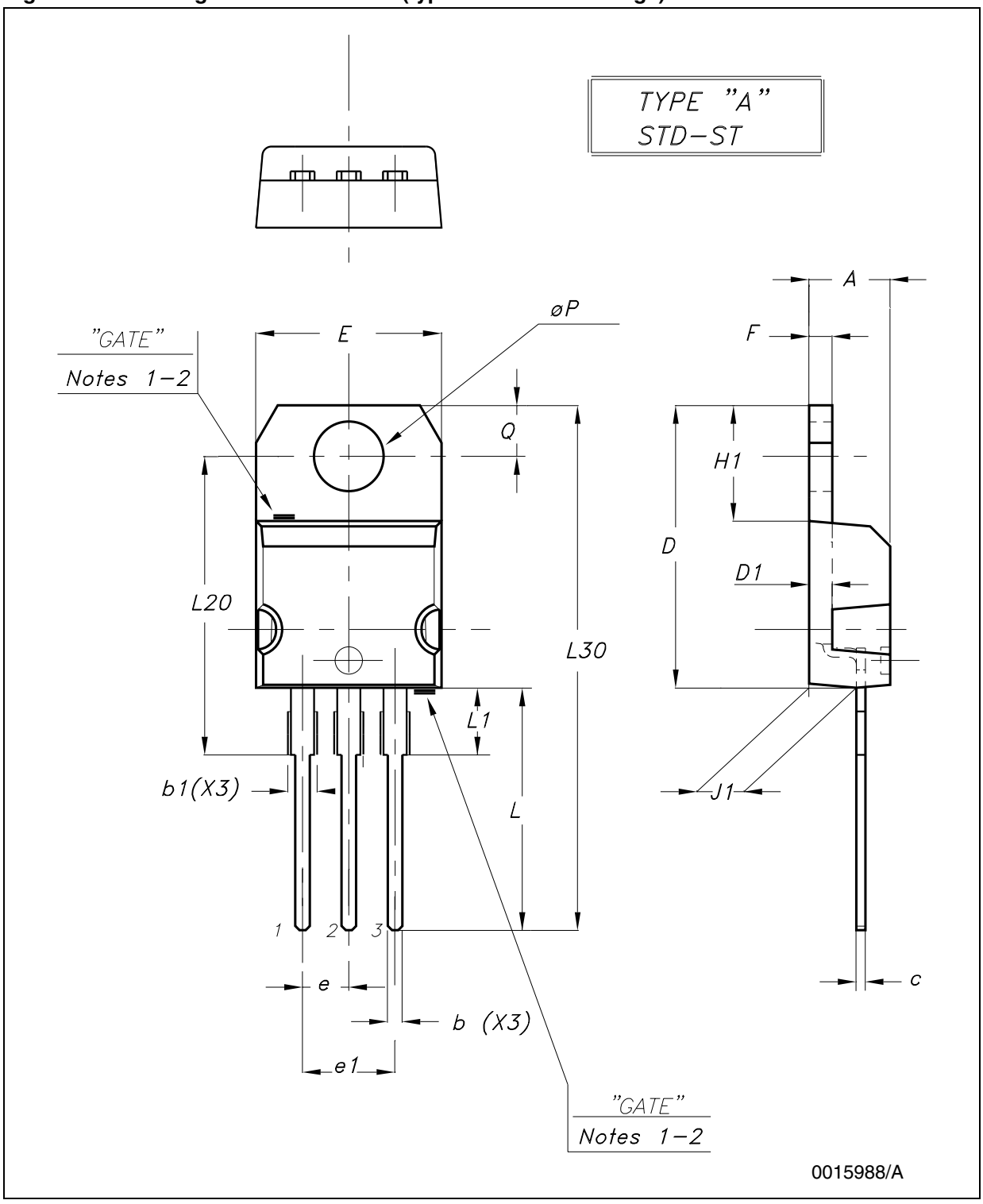
# 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

**Table 6. TO-220 mechanical data**

| Dim. | Type STD - ST Dual Gauge | | | Type STD - ST Single Gauge | | |
|---|---|---|---|---|---|---|
| | mm. | | | mm. | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 | 1.14 | | 1.70 |
| c | 0.48 | | 0.70 | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 | 15.25 | | 15.75 |
| D1 | | 1.27 | | | | |
| E | 10.00 | | 10.40 | 10.00 | | 10.40 |
| e | 2.40 | | 2.70 | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 | 4.95 | | 5.15 |
| F | 1.23 | | 1.32 | 0.51 | | 0.60 |
| H1 | 6.20 | | 6.60 | 6.20 | | 6.60 |
| J1 | 2.40 | | 2.72 | 2.40 | | 2.72 |
| L | 13.00 | | 14.00 | 13.00 | | 14.00 |
| L1 | 3.50 | | 3.93 | 3.50 | | 3.93 |
| L20 | | 16.40 | | | 16.40 | |
| L30 | | 28.90 | | | 28.90 | |
| ∅P | 3.75 | | 3.85 | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 | 2.65 | | 2.95 |

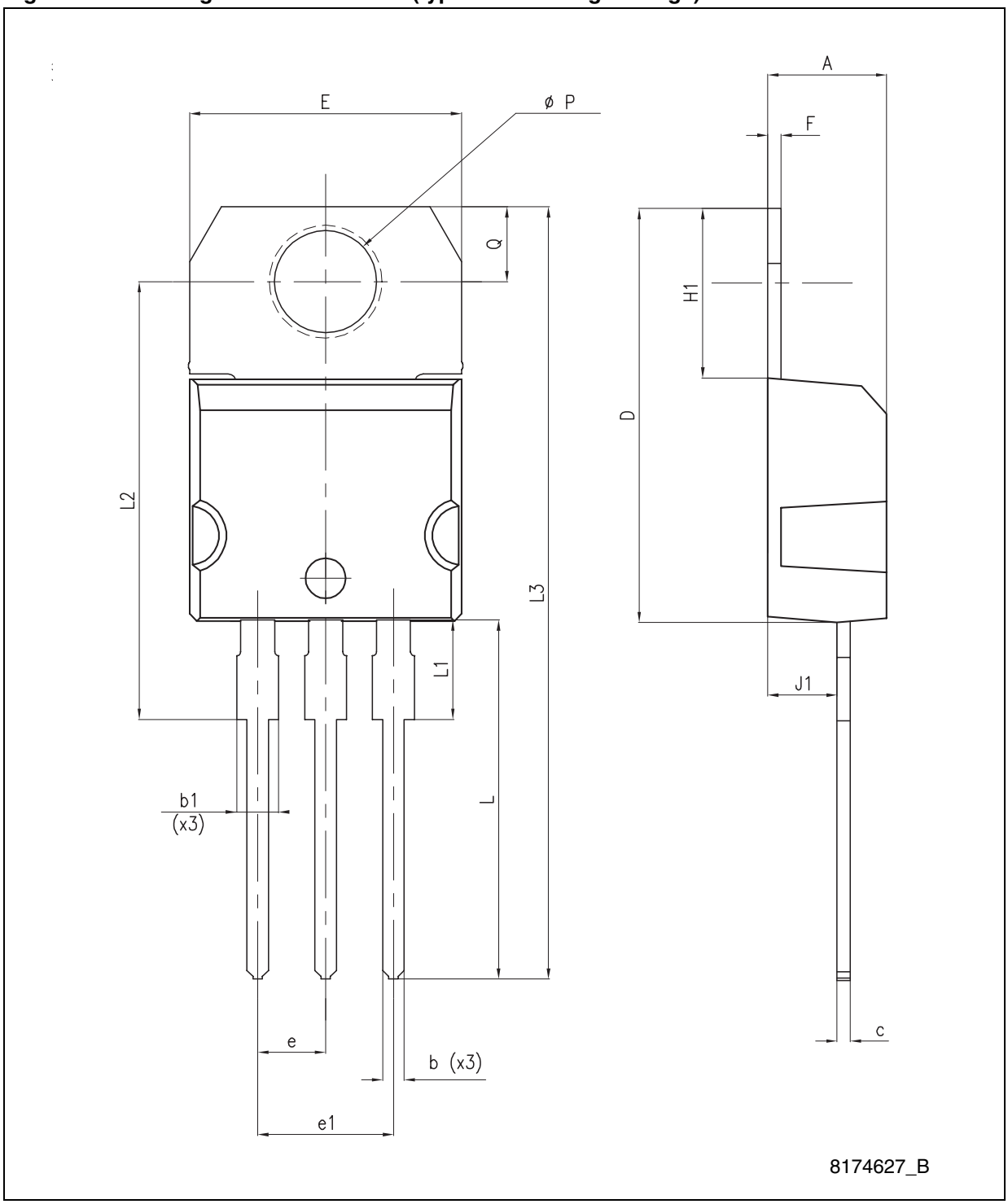
**Figure 14. Drawing dimension TO-220 (type STD-ST Dual Gauge)**




*Note: 1 Max resin gate protrusion: 0.5 mm.*

*2 Resin gate position is accepted in each of the two positions shown on the drawing, or their symmetrical.*

**Figure 15. Drawing dimension TO-220 (type STD-ST Single Gauge)**




*Note: In spite of some difference in tolerances, the packages are compatible.*

**Figure 16. Drawing dimension tube for TO-220 Dual Gauge (mm.)**

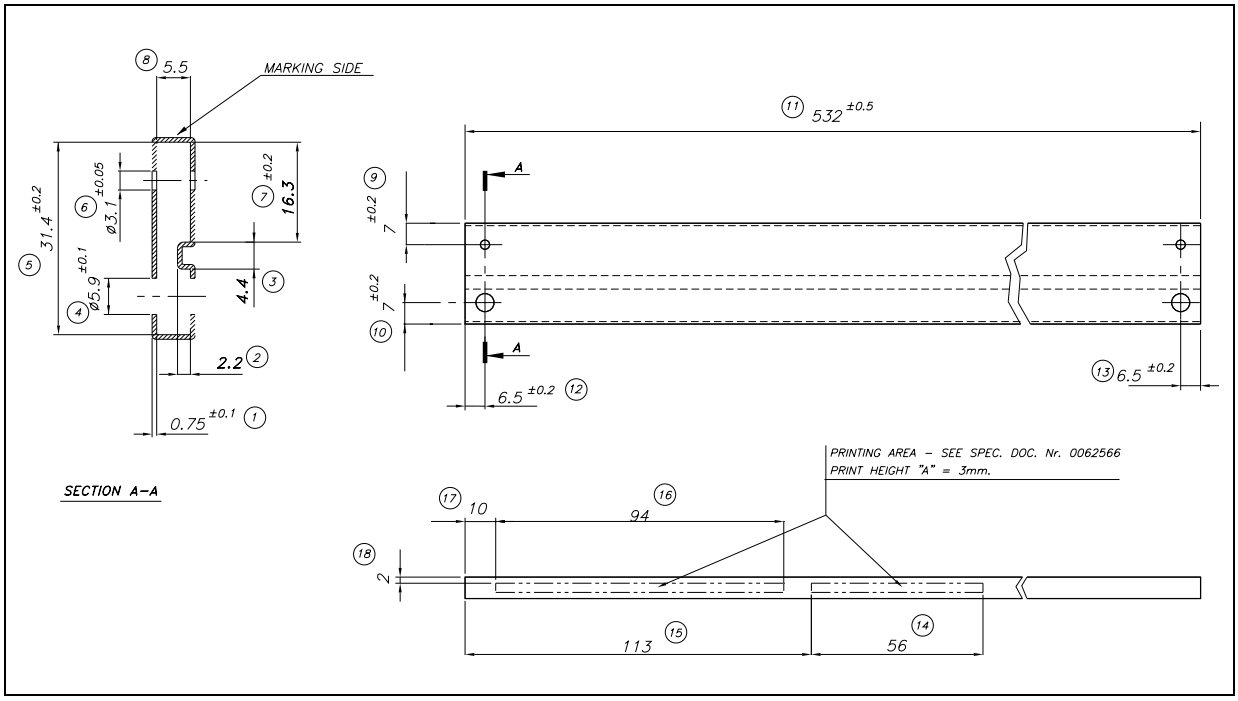
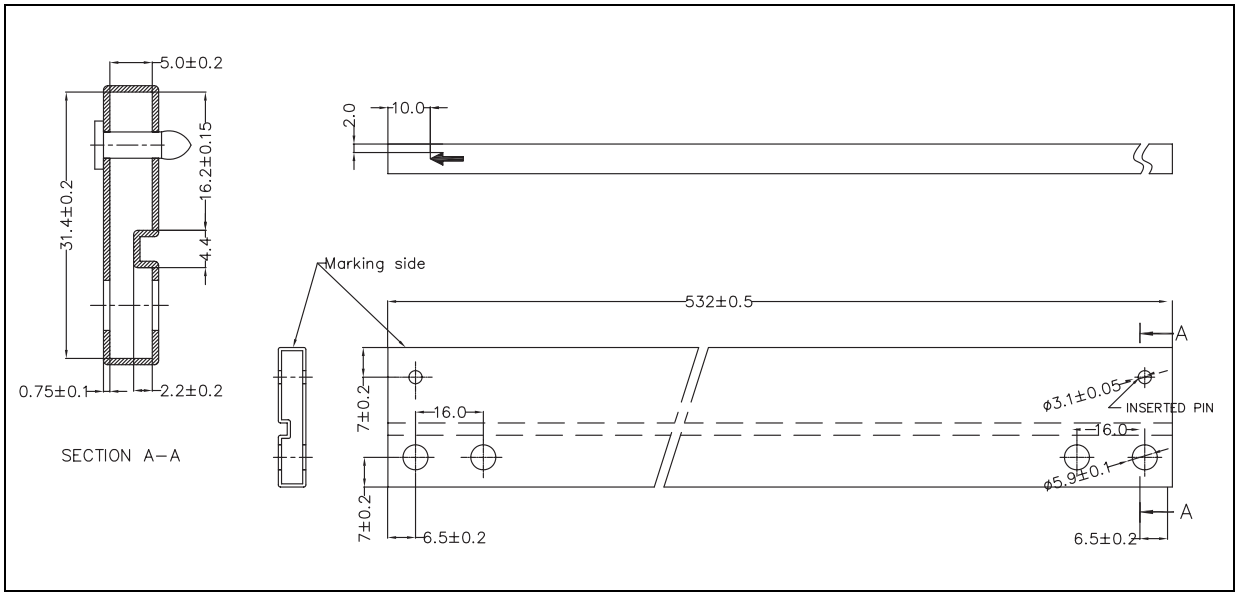
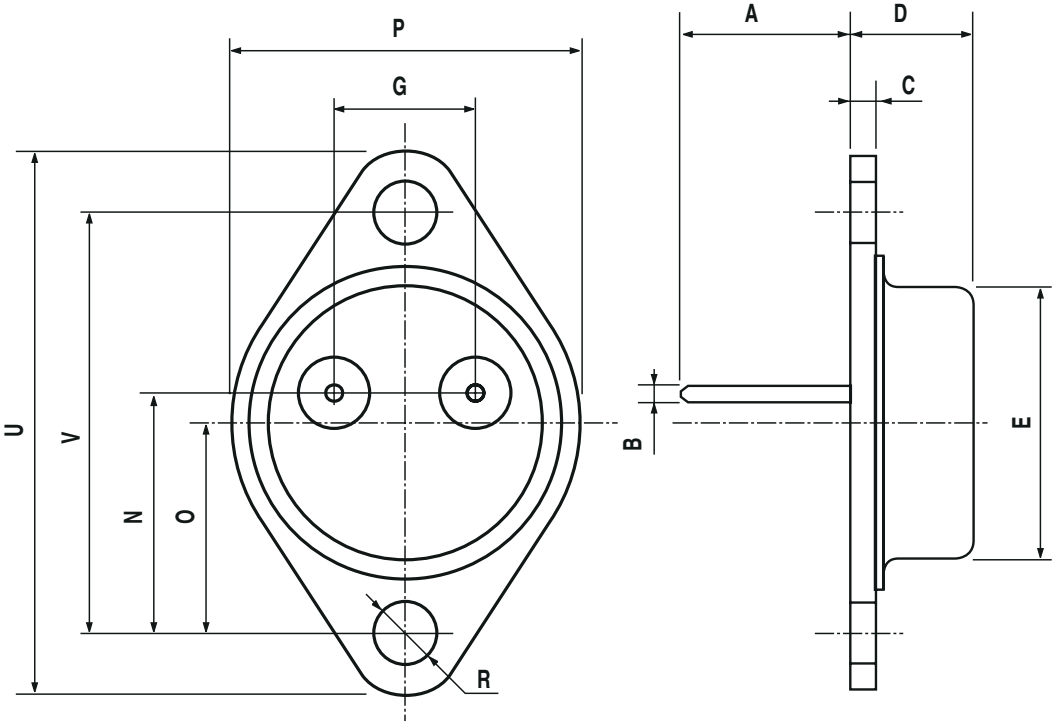



**Figure 17. Drawing dimension tube for TO-220 Single Gauge (mm.)**



## TO-3 mechanical data

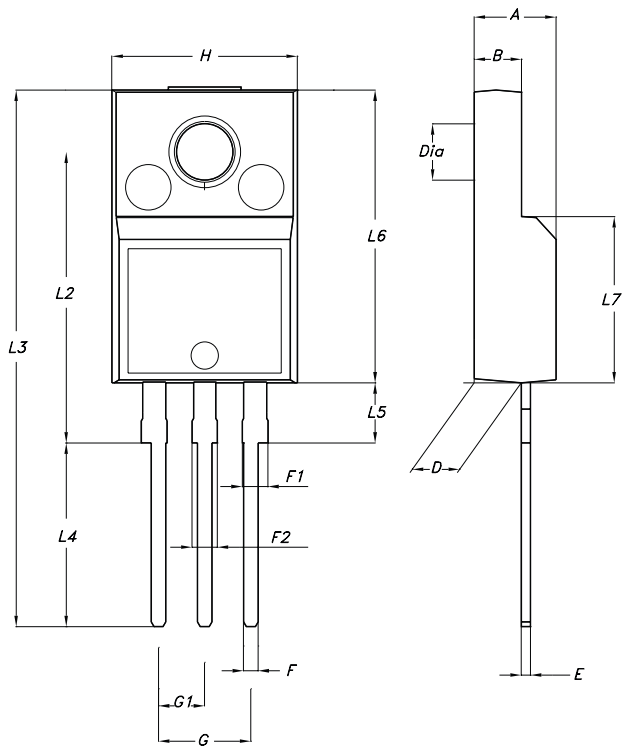
| Dim. | mm. | | | inch. | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | 11.85 | | | 0.466 | |
| B | 0.96 | 1.05 | 1.10 | 0.037 | 0.041 | 0.043 |
| C | | | 1.70 | | | 0.066 |
| D | | | 8.7 | | | 0.342 |
| E | | | 20.0 | | | 0.787 |
| G | | 10.9 | | | 0.429 | |
| N | | 16.9 | | | 0.665 | |
| P | | | 26.2 | | | 1.031 |
| R | 3.88 | | 4.09 | 0.152 | | 0.161 |
| U | | | 39.5 | | | 1.555 |
| V | | 30.10 | | | 1.185 | |




P003C/C

## TO-220FP mechanical data

| Dim. | mm. | | | inch. | | |
|---|---|---|---|---|---|---|
| | Min. | Typ | Max. | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 | 0.173 | | 0.181 |
| B | 2.5 | | 2.7 | 0.098 | | 0.106 |
| D | 2.5 | | 2.75 | 0.098 | | 0.108 |
| E | 0.45 | | 0.70 | 0.017 | | 0.027 |
| F | 0.75 | | 1 | 0.030 | | 0.039 |
| F1 | 1.15 | | 1.50 | 0.045 | | 0.059 |
| F2 | 1.15 | | 1.50 | 0.045 | | 0.059 |
| G | 4.95 | | 5.2 | 0.194 | | 0.204 |
| G1 | 2.4 | | 2.7 | 0.094 | | 0.106 |
| H | 10.0 | | 10.40 | 0.393 | | 0.409 |
| L2 | | 16 | | | 0.630 | |
| L3 | 28.6 | | 30.6 | 1.126 | | 1.204 |
| L4 | 9.8 | | 10.6 | 0.385 | | 0.417 |
| L5 | 2.9 | | 3.6 | 0.114 | | 0.142 |
| L6 | 15.9 | | 16.4 | 0.626 | | 0.645 |
| L7 | 9 | | 9.3 | 0.354 | | 0.366 |
| DIA. | 3 | | 3.2 | 0.118 | | 0.126 |




7012510A-H

**Figure 18. Drawing dimension D²PAK (type STD-ST)**

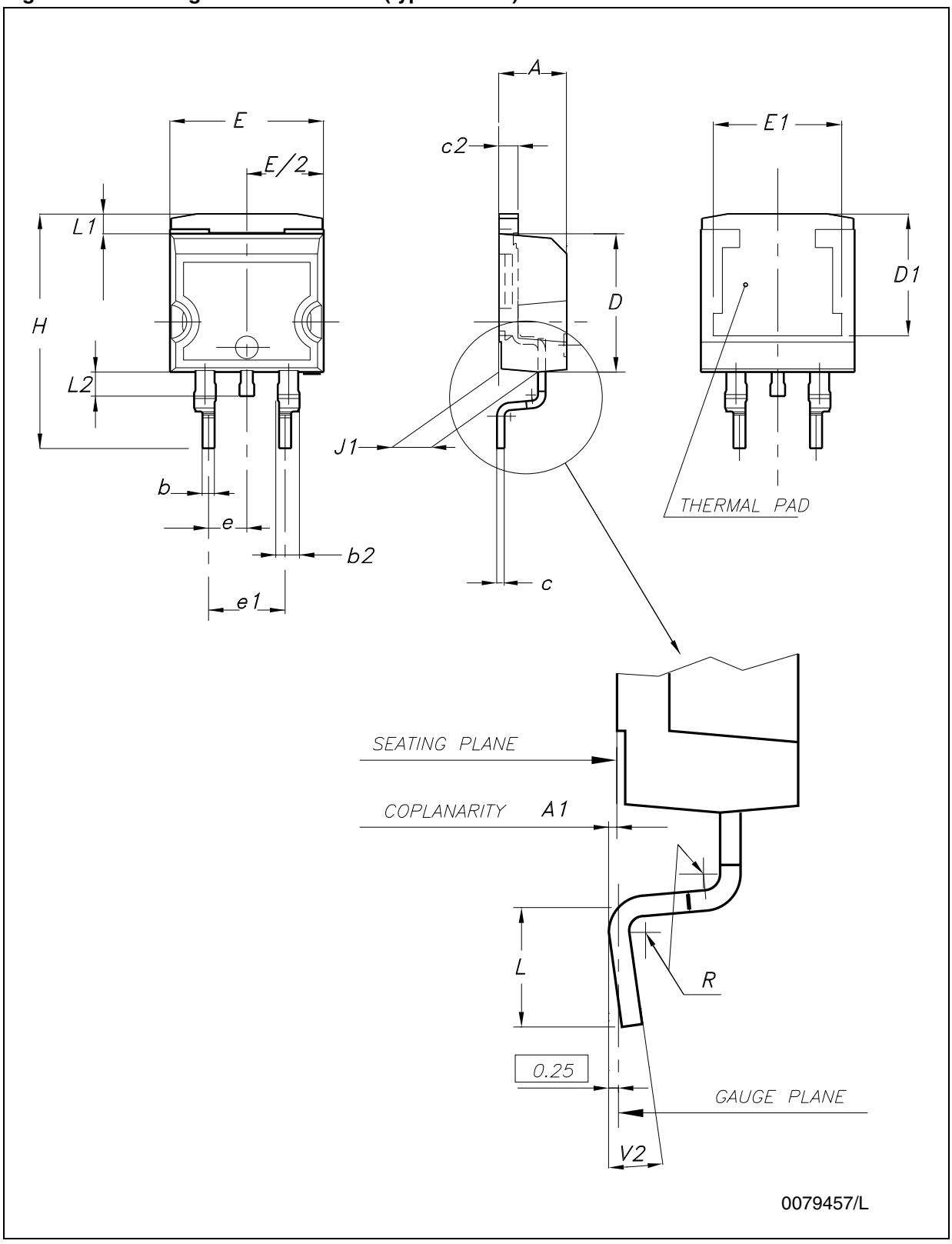


**Figure 19. Drawing dimension D²PAK (type WOOSEOK-SUBCON.)**

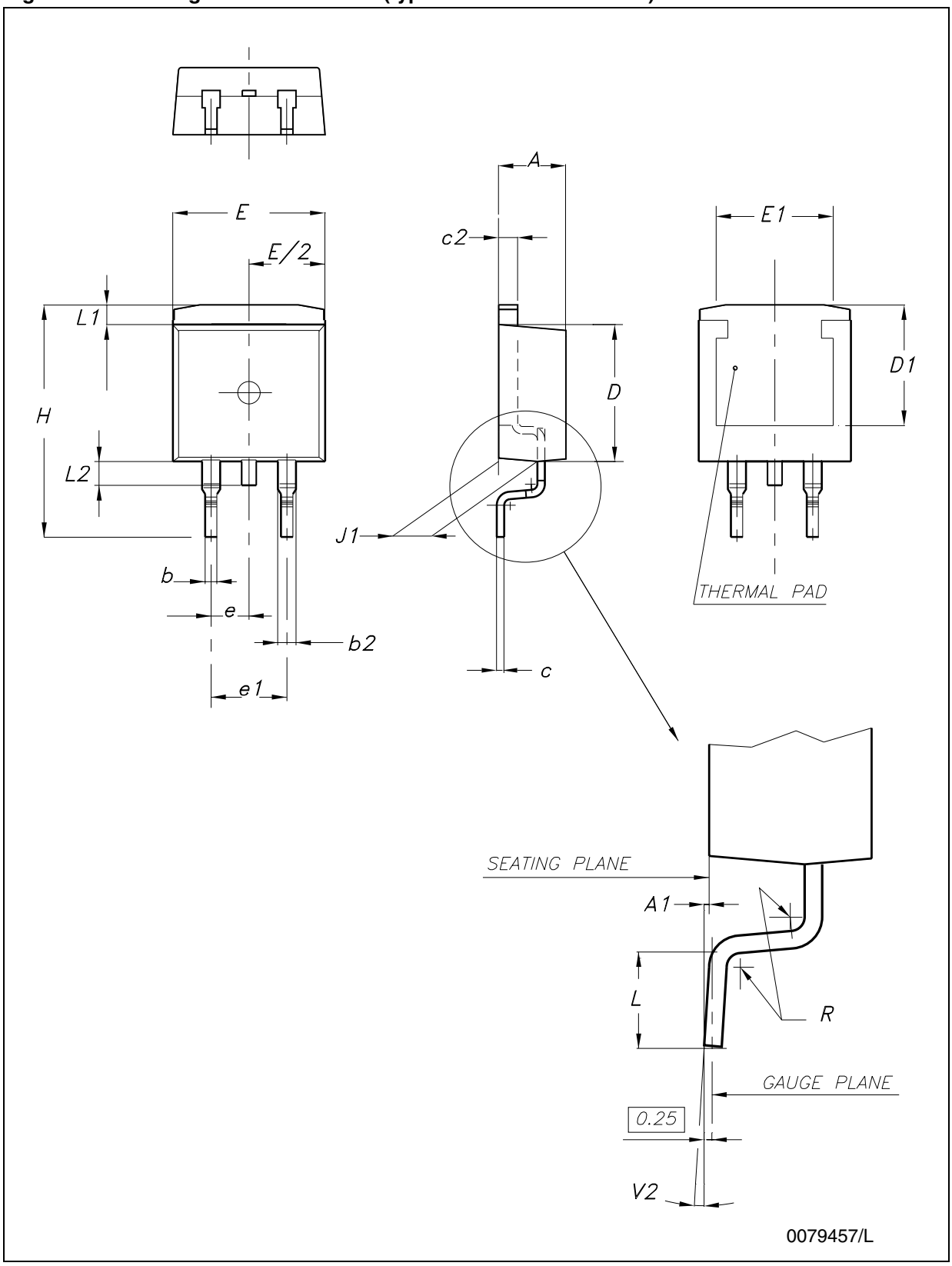


**Table 7. D²PAK mechanical data**

| Dim. | Type STD-ST | | | Type WOOSEOK-Subcon. | | |
|---|---|---|---|---|---|---|
| | mm. | | | mm. | | |
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | 4.40 | | 4.60 | 4.30 | | 4.70 |
| A1 | 0.03 | | 0.23 | 0 | | 0.20 |
| b | 0.70 | | 0.93 | 0.70 | | 0.90 |
| b2 | 1.14 | | 1.70 | 1.17 | | 1.37 |
| c | 0.45 | | 0.60 | 0.45 | 0.50 | 0.60 |
| c2 | 1.23 | | 1.36 | 1.25 | 1.30 | 1.40 |
| D | 8.95 | | 9.35 | 9 | 9.20 | 9.40 |
| D1 | 7.50 | | | 7.50 | | |
| E | 10 | | 10.40 | 9.80 | | 10.20 |
| E1 | 8.50 | | | 7.50 | | |
| e | | 2.54 | | | 2.54 | |
| e1 | 4.88 | | 5.28 | | 5.08 | |
| H | 15 | | 15.85 | 15 | 15.30 | 15.60 |
| J1 | 2.49 | | 2.69 | 2.20 | | 2.60 |
| L | 2.29 | | 2.79 | 1.79 | | 2.79 |
| L1 | 1.27 | | 1.40 | 1 | | 1.40 |
| L2 | 1.30 | | 1.75 | 1.20 | | 1.60 |
| R | | 0.4 | | | 0.30 | |
| V2 | 0° | | 8° | 0° | | 3° |

*Note: The D²PAK package coming from the subcontractor Wooseok is fully compatible with the ST's package suggested footprint.*

**Figure 20. D²PAK footprint recommended data**

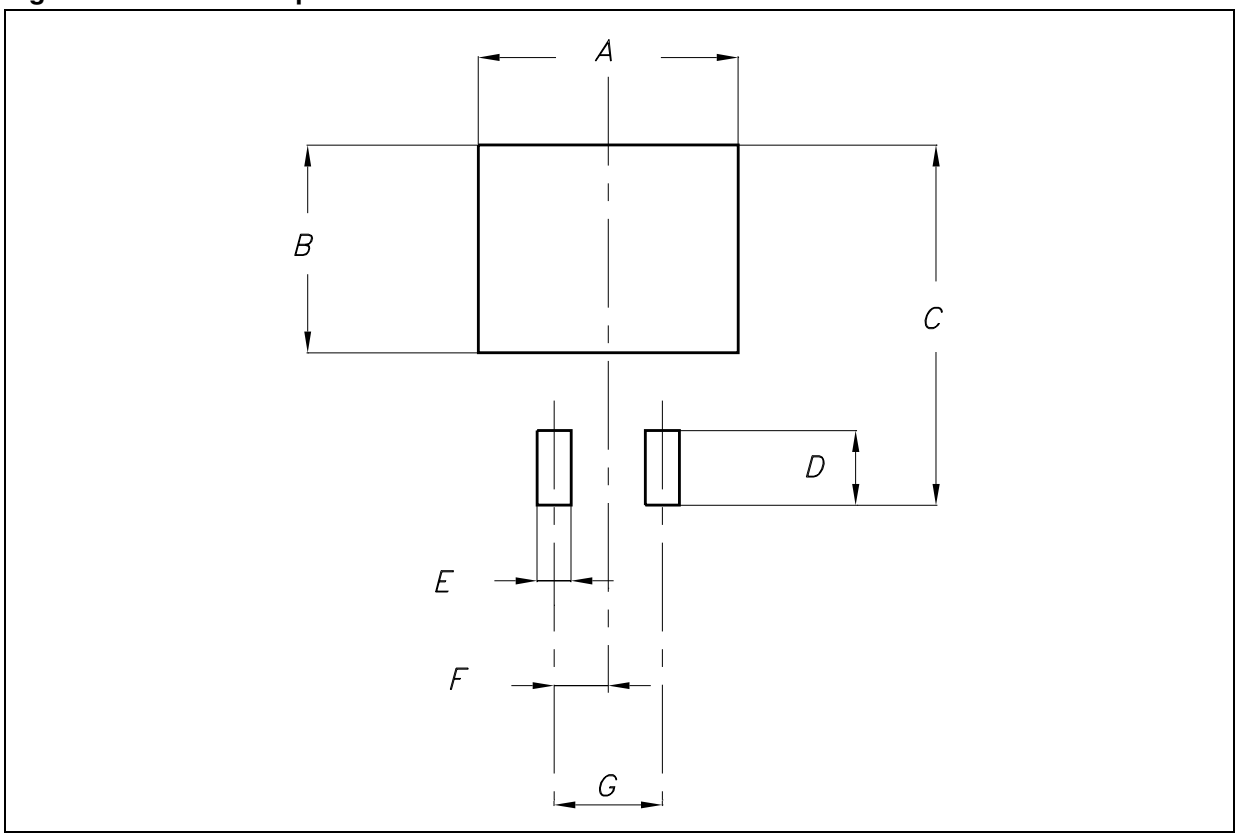
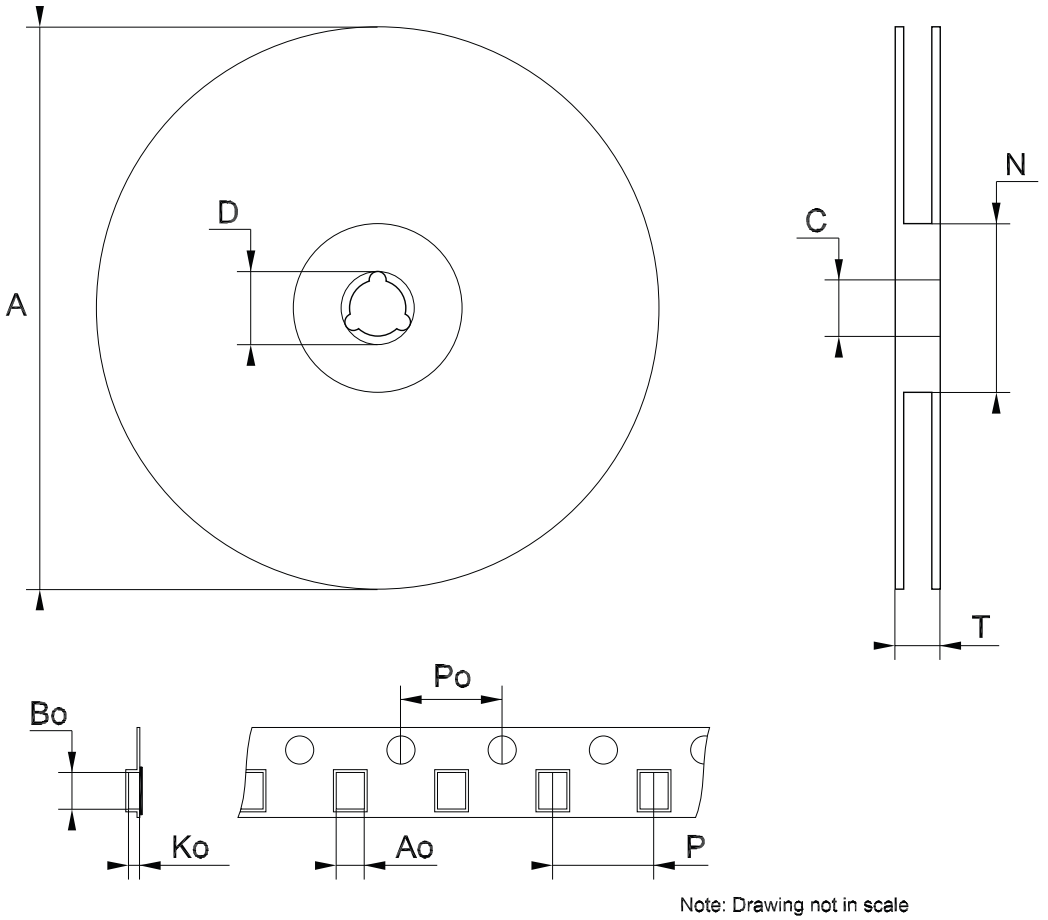



**Table 8. Footprint data**

| Values | | |
|---|---|---|
| **Dim.** | **mm.** | **inch.** |
| A | 12.20 | 0.480 |
| B | 9.75 | 0.384 |
| C | 16.90 | 0.665 |
| D | 3.50 | 0.138 |
| E | 1.60 | 0.063 |
| F | 2.54 | 0.100 |
| G | 5.08 | 0.200 |

## Tape & reel $D^2PAK$-$P^2PAK$-$D^2PAK/A$-$P^2PAK/A$ mechanical data

| Dim. | mm. | | | inch. | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 180 | | | 7.086 |
| C | 12.8 | 13.0 | 13.2 | 0.504 | 0.512 | 0.519 |
| D | 20.2 | | | 0.795 | | |
| N | 60 | | | 2.362 | | |
| T | | | 14.4 | | | 0.567 |
| Ao | 10.50 | 10.6 | 10.70 | 0.413 | 0.417 | 0.421 |
| Bo | 15.70 | 15.80 | 15.90 | 0.618 | 0.622 | 0.626 |
| Ko | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| Po | 3.9 | 4.0 | 4.1 | 0.153 | 0.157 | 0.161 |
| P | 11.9 | 12.0 | 12.1 | 0.468 | 0.472 | 0.476 |




Note: Drawing not in scale

# 8 Revision history

**Table 9. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 01-Sep-2004 | 10 | Mistake $V_{REF}$ ==> $V_O$, tables 1, 4 and 5. |
| 19-Jan-2007 | 11 | D²PAK mechanical data has been updated, add footprint data and the document has been reformatted. |
| 13-Jun-2007 | 12 | Change values $\Delta I_{ADJ}$ and $V_{REF}$ test condition of $I_O$ = 10 mA to $I_{MAX}$ ==> $I_O$ = 10 mA to 500 mA on *Table 5*. |
| 23-Nov-2007 | 13 | Added *Table 1*. |
| 06-Feb-2008 | 14 | Added: TO-220 mechanical data *Figure 14 on page 14* and *Table 6 on page 13*. |
| 02-Mar-2010 | 15 | Added: notes *Figure 14 on page 14*, *Figure 15 on page 15*, *Figure 16* and *Figure 17 on page 16*. |
| 17-Nov-2010 | 16 | Modified: $R_{thJC}$ value for TO-220 *Table 3 on page 4*. |

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