

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

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.

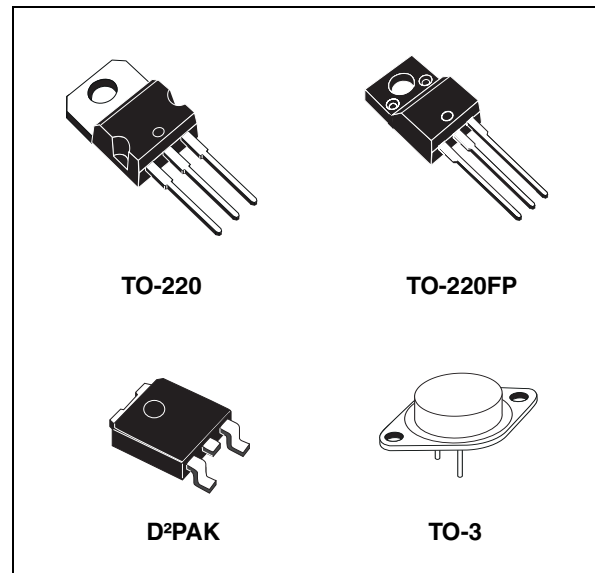


Table 1. Device summary

| Order codes | | | | |
|-------------|--------------------------|------------------------------------|----------|--------|
| TO-220 | | D ² PAK (tape and reel) | TO-220FP | TO-3 |
| | | | | LM117K |
| LM217T | LM217T-DG ⁽¹⁾ | LM217D2T-TR | | LM217K |
| LM317T | LM317T-DG ⁽¹⁾ | LM317D2T-TR | LM317P | LM317K |

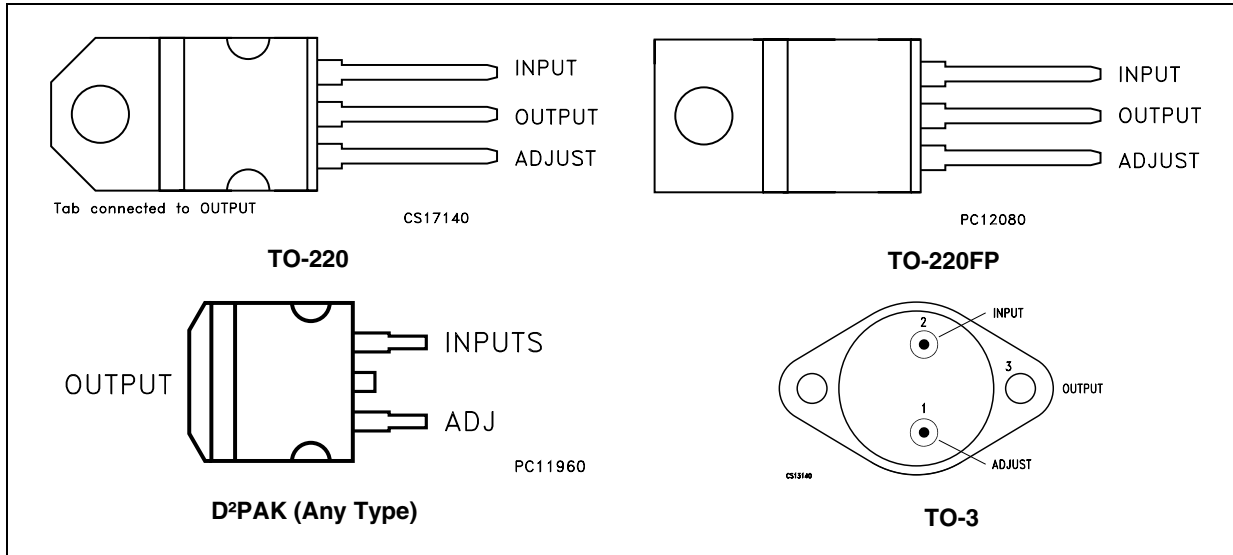
1. TO-220 Dual Gauge frame.

Contents

| | | |
|---|----------------------------------|----|
| 1 | Pin configuration | 3 |
| 2 | Maximum ratings | 4 |
| 3 | Diagram | 5 |
| 4 | Electrical characteristics | 6 |
| 5 | Typical characteristics | 8 |
| 6 | Application information | 9 |
| 7 | Package mechanical data | 13 |
| 8 | Revision history | 24 |

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 |
| | | LM217 | - 25 to 150 |
| | | LM317 | 0 to 125 |
| P_D | Power dissipation | Internally limited | |
| T_{STG} | Storage temperature | - 65 to 150 | °C |

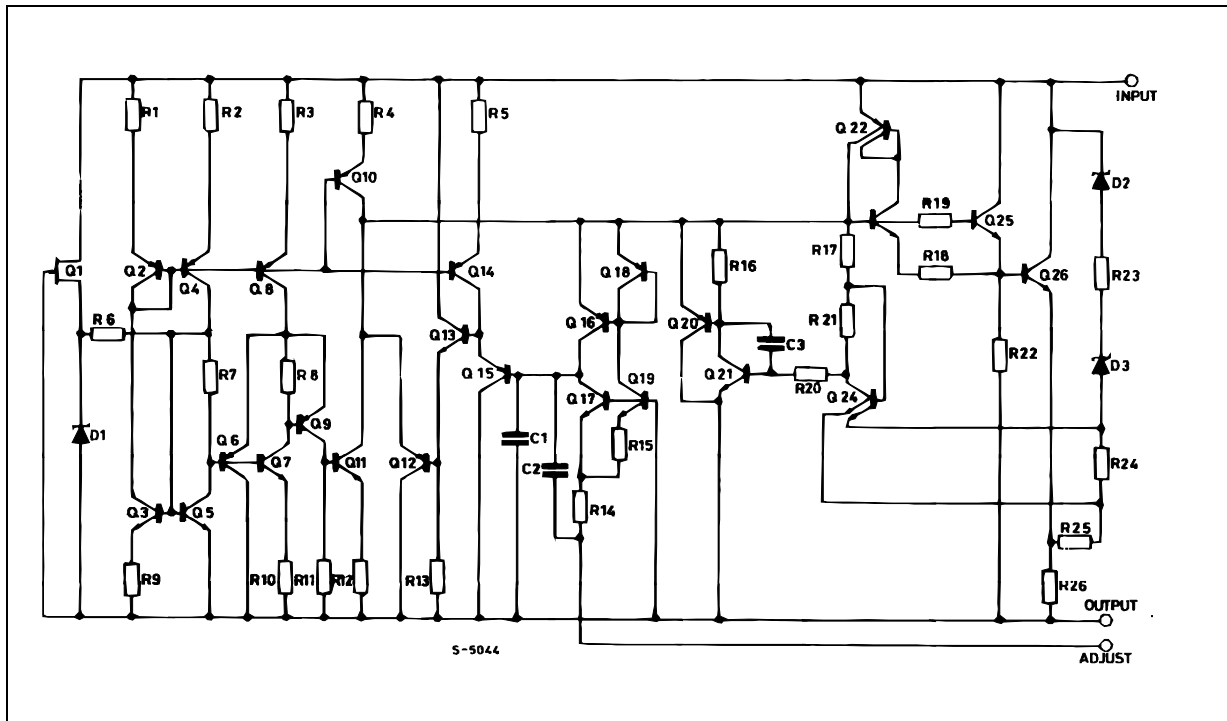
Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

Table 3. Thermal data

| Symbol | Parameter | D ² PAK | 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

$V_1 - V_O = 5\text{ V}$, $I_O = 500\text{ mA}$, $I_{MAX} = 1.5\text{ A}$ and $P_{MAX} = 20\text{ W}$, $T_J = -55\text{ to }150\text{ }^\circ\text{C}$ for LM117, $T_J = -25\text{ to }150\text{ }^\circ\text{C}$ for LM217, unless otherwise specified.

Table 4. Electrical characteristics for LM117/LM217

| Symbol | Parameter | Test conditions | | Min. | Typ. | Max. | Unit |
|------------------|--|--|---|------|-------|---------------|---------------|
| ΔV_O | Line regulation | $V_1 - V_O = 3\text{ to }40\text{ V}$ | $T_J = 25^\circ\text{C}$ | | 0.01 | 0.02 | %V |
| | | | | | 0.02 | 0.05 | |
| ΔV_O | Load regulation | $V_O \leq 5\text{ V}$ $I_O = 10\text{ mA to }I_{MAX}$ | $T_J = 25^\circ\text{C}$ | | 5 | 15 | mV |
| | | | | | 20 | 50 | |
| | | $V_O \geq 5\text{ V}$, $I_O = 10\text{ mA to }I_{MAX}$ | $T_J = 25^\circ\text{C}$ | | 0.1 | 0.3 | % |
| | | | | | 0.3 | 1 | |
| I_{ADJ} | Adjustment pin current | | | 50 | 100 | μA | |
| ΔI_{ADJ} | Adjustment pin current | $V_1 - V_O = 2.5\text{ to }40\text{ V}$ | $I_O = 10\text{ mA to }I_{MAX}$ | | 0.2 | 5 | μA |
| V_{REF} | Reference voltage (between pin 3 and pin 1) | $V_1 - V_O = 2.5\text{ to }40\text{ V}$ | $I_O = 10\text{ mA to }I_{MAX}$ $P_D \leq P_{MAX}$ | 1.2 | 1.25 | 1.3 | V |
| $\Delta V_O/V_O$ | Output voltage temperature stability | | | | 1 | | % |
| $I_{O(min)}$ | Minimum load current | $V_1 - V_O = 40\text{ V}$ | | | 3.5 | 5 | mA |
| $I_{O(max)}$ | Maximum load current | $V_1 - V_O \leq 15\text{ V}$, $P_D < P_{MAX}$ | | 1.5 | 2.2 | | A |
| | | $V_1 - V_O = 40\text{ V}$, $P_D < P_{MAX}$, $T_J = 25^\circ\text{C}$ | | | 0.4 | | |
| eN | Output noise voltage (percentage of V_O) | $B = 10\text{ Hz to }100\text{ kHz}$, $T_J = 25^\circ\text{C}$ | | | 0.003 | | % |
| SVR | Supply voltage rejection ⁽¹⁾ | $T_J = 25^\circ\text{C}$, $f = 120\text{ Hz}$ | $C_{ADJ}=0$ | | 65 | | dB |
| | | | $C_{ADJ}=10\mu\text{F}$ | 66 | 80 | | |

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

$V_1 - V_O = 5\text{ V}$, $I_O = 500\text{ mA}$, $I_{MAX} = 1.5\text{ A}$ and $P_{MAX} = 20\text{ W}$, $T_J = 0\text{ to }125^\circ\text{C}$, unless otherwise specified.

Table 5. Electrical characteristics for LM317

| Symbol | Parameter | Test conditions | | Min. | Typ. | Max. | Unit |
|------------------|--|---|--------------------------|------|-------|---------------|---------------|
| ΔV_O | Line regulation | $V_1 - V_O = 3\text{ to }40\text{ V}$ | $T_J = 25^\circ\text{C}$ | | 0.01 | 0.04 | %V |
| | | | | | 0.02 | 0.07 | |
| ΔV_O | Load regulation | $V_O \leq 5\text{ V}$ $I_O = 10\text{ mA to }I_{MAX}$ | $T_J = 25^\circ\text{C}$ | | 5 | 25 | mV |
| | | | | | 20 | 70 | |
| | | $V_O \geq 5\text{ V}$, $I_O = 10\text{ mA to }I_{MAX}$ | $T_J = 25^\circ\text{C}$ | | 0.1 | 0.5 | % |
| | | | | | 0.3 | 1.5 | |
| I_{ADJ} | Adjustment pin current | | | 50 | 100 | μA | |
| ΔI_{ADJ} | Adjustment pin current | $V_1 - V_O = 2.5\text{ to }40\text{V}$, $I_O = 10\text{ mA to }500\text{mA}$ | | | 0.2 | 5 | μA |
| V_{REF} | Reference voltage (between pin 3 and pin 1) | $V_1 - V_O = 2.5\text{ to }40\text{V}$ $I_O = 10\text{ mA to }500\text{mA}$ $P_D \leq P_{MAX}$ | | 1.2 | 1.25 | 1.3 | V |
| $\Delta V_O/V_O$ | Output voltage temperature stability | | | | 1 | | % |
| $I_{O(min)}$ | Minimum load current | $V_1 - V_O = 40\text{ V}$ | | | 3.5 | 10 | mA |
| $I_{O(max)}$ | Maximum load current | $V_1 - V_O \leq 15\text{ V}$, $P_D < P_{MAX}$ | | 1.5 | 2.2 | | A |
| | | $V_1 - V_O = 40\text{ V}$, $P_D < P_{MAX}$, $T_J = 25^\circ\text{C}$ | | | 0.4 | | |
| eN | Output noise voltage (percentage of V_O) | $B = 10\text{Hz to }100\text{kHz}$, $T_J = 25^\circ\text{C}$ | | | 0.003 | | % |
| SVR | Supply voltage rejection ⁽¹⁾ | $T_J = 25^\circ\text{C}$, $f = 120\text{Hz}$ | $C_{ADJ}=0$ | | 65 | | dB |
| | | | $C_{ADJ}=10\mu\text{F}$ | 66 | 80 | | |

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

5 Typical characteristics

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

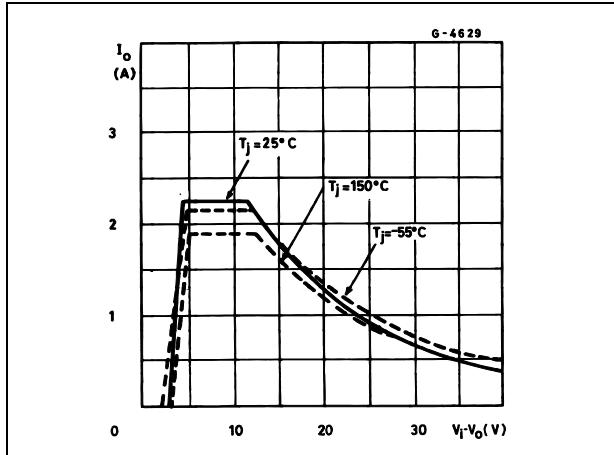


Figure 4. Dropout voltage vs. junction temperature

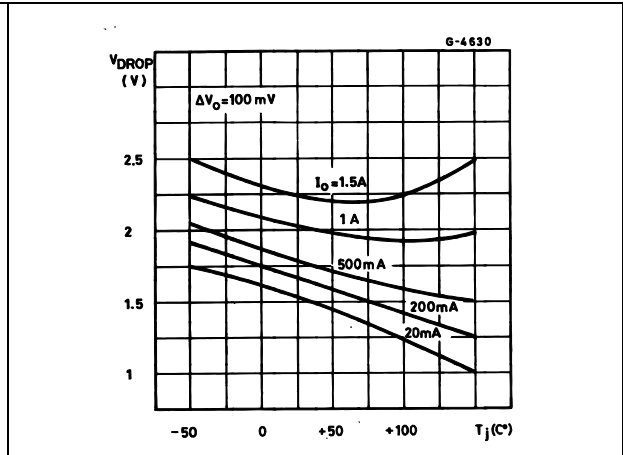


Figure 5. Reference voltage vs. junction

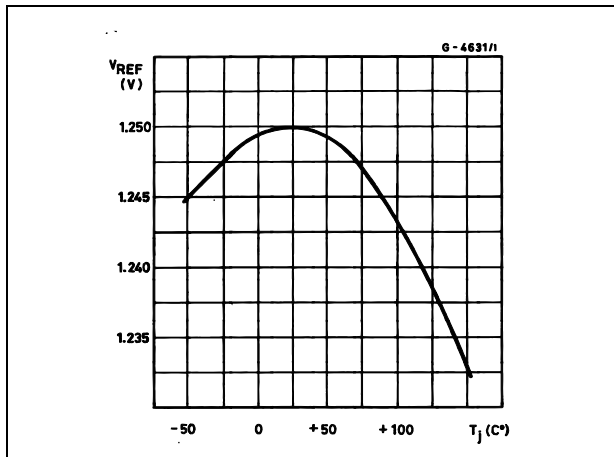
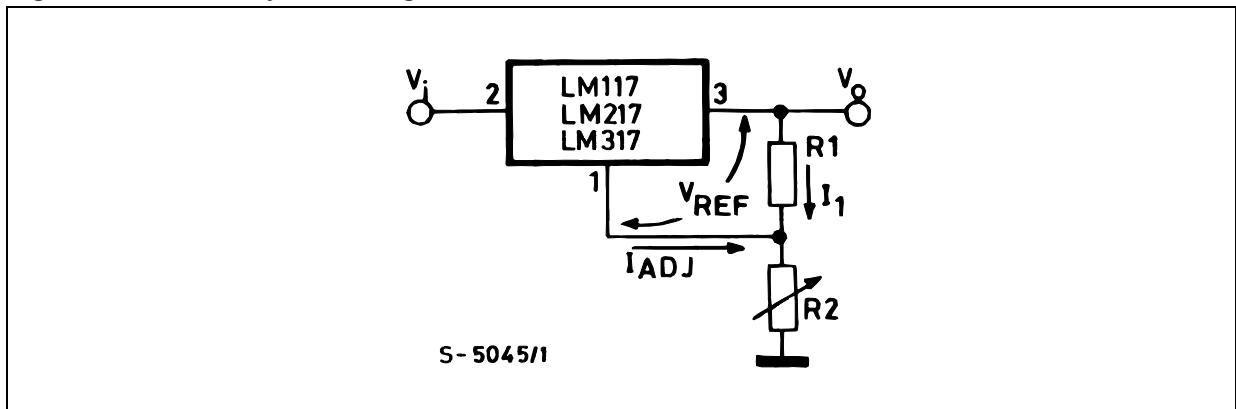


Figure 6. Basic adjustable regulator



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 μ A 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.

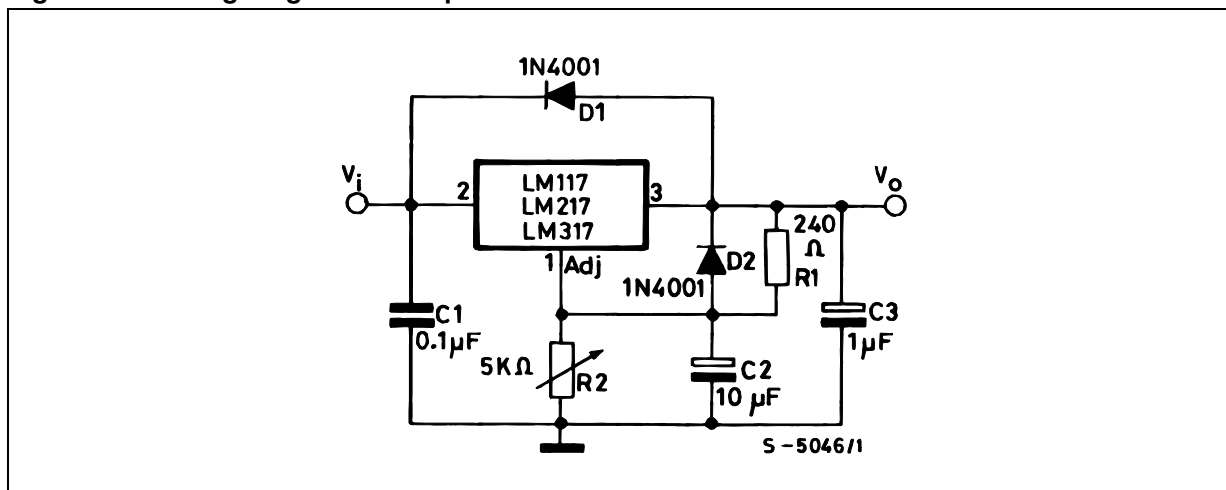
Furthermore, programmable regulator are easily obtainable and, by connecting a fixed resistor between the adjustment and output, the device can be used as a precision current regulator. In order to optimize the load regulation, the current set resistor R_1 (see [Figure 3](#)) should be tied as close 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 μ F

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

An 1 μ F tantalum (or 25 μ F Aluminium electrolytic) capacitor on the output to improve transient response. In addition 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

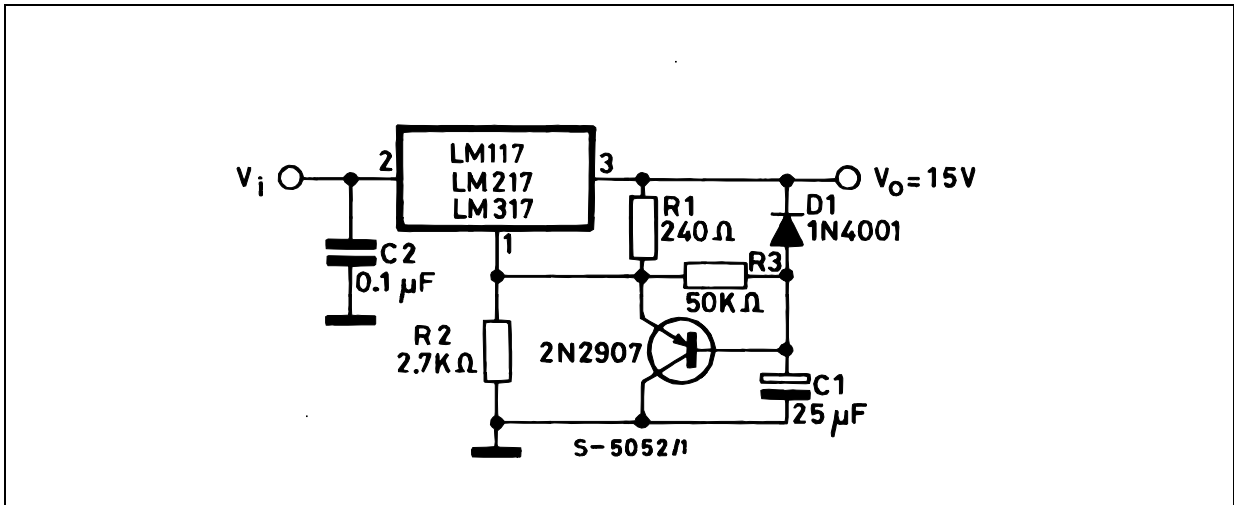
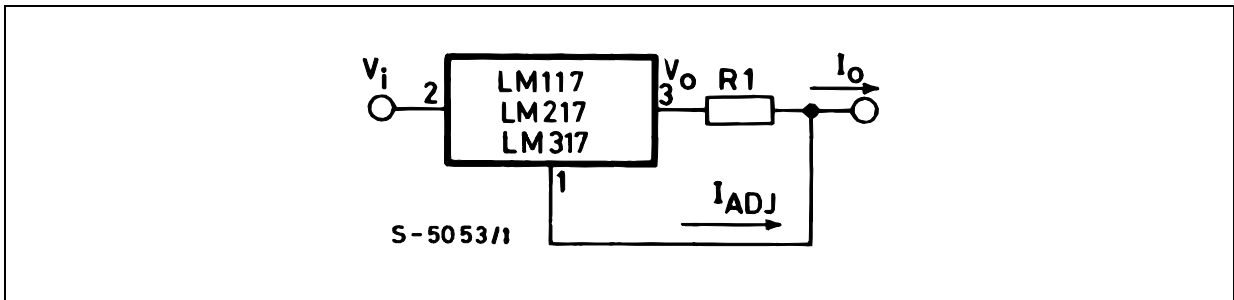


Figure 9. Current regulator



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

Figure 10. 5 V electronic shut-down regulator

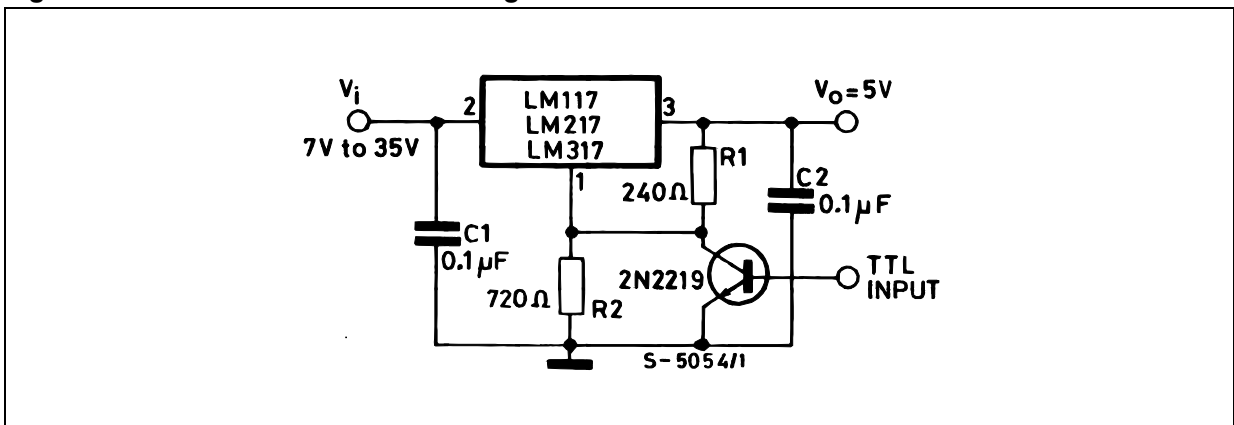
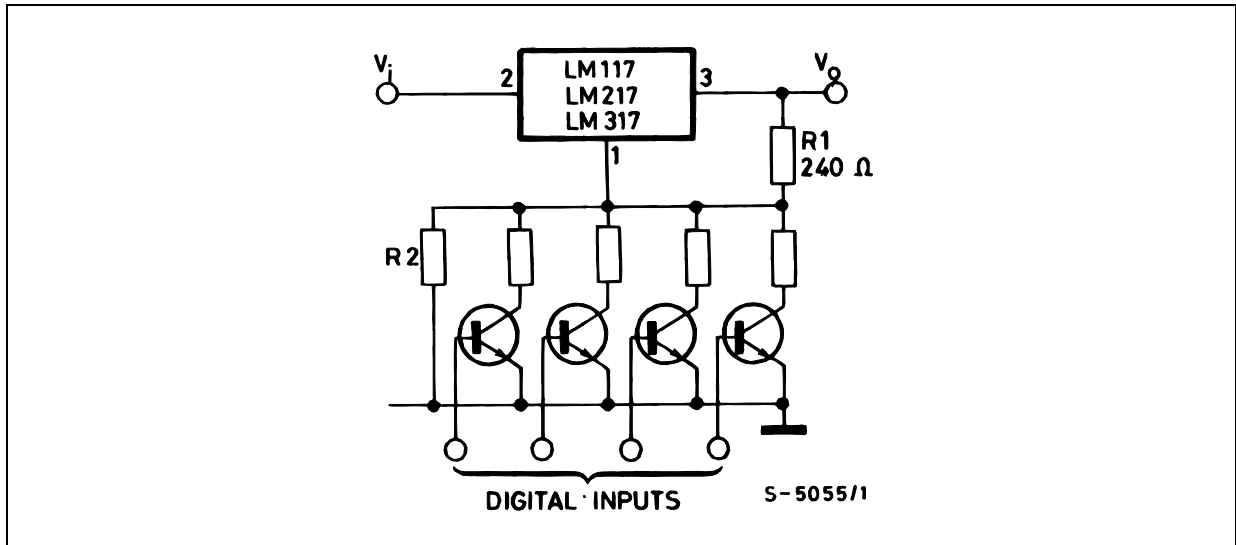
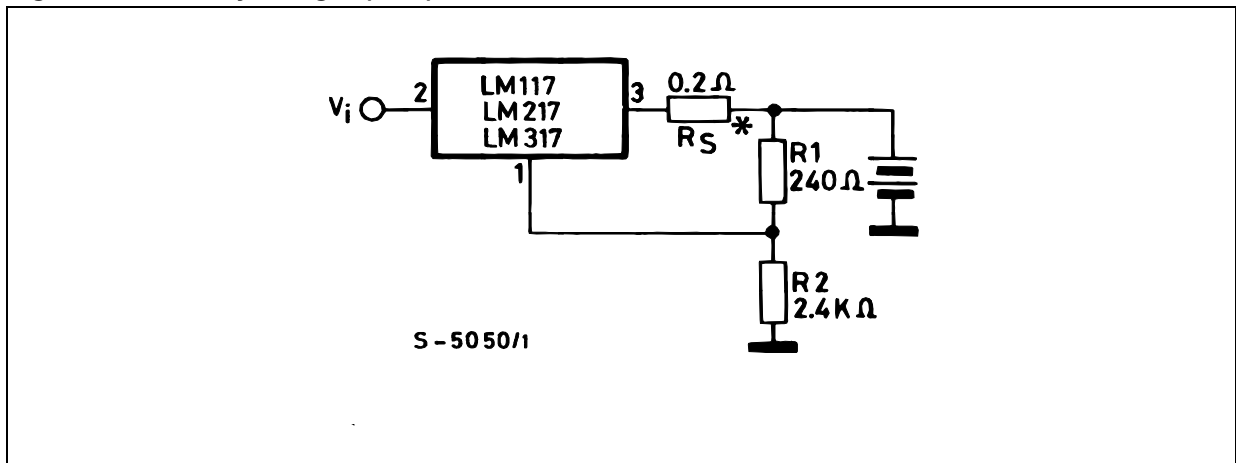


Figure 11. Digitally selected outputs



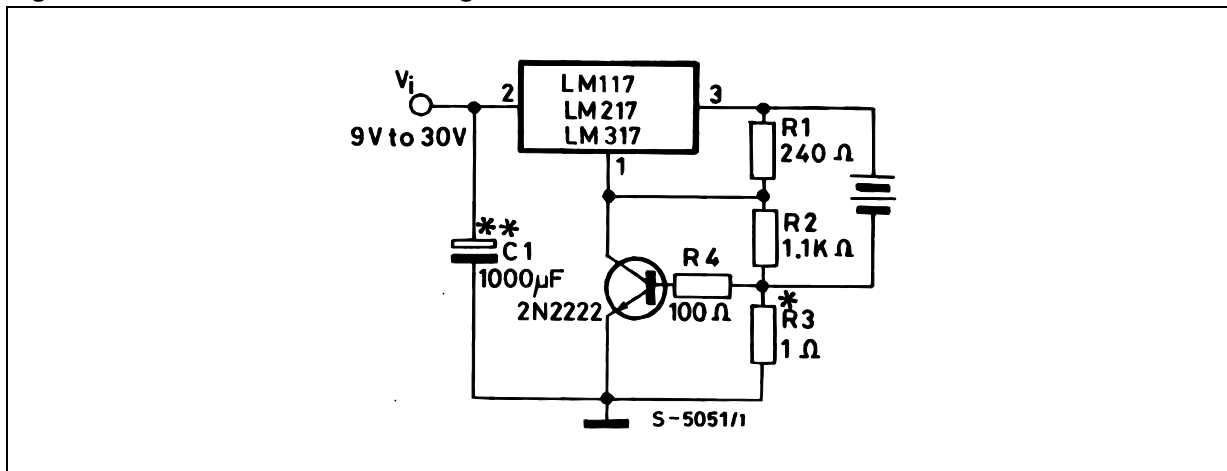
(R_2 sets maximum V_O)

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 Ω).

** C1 recommended to filter out input transients.

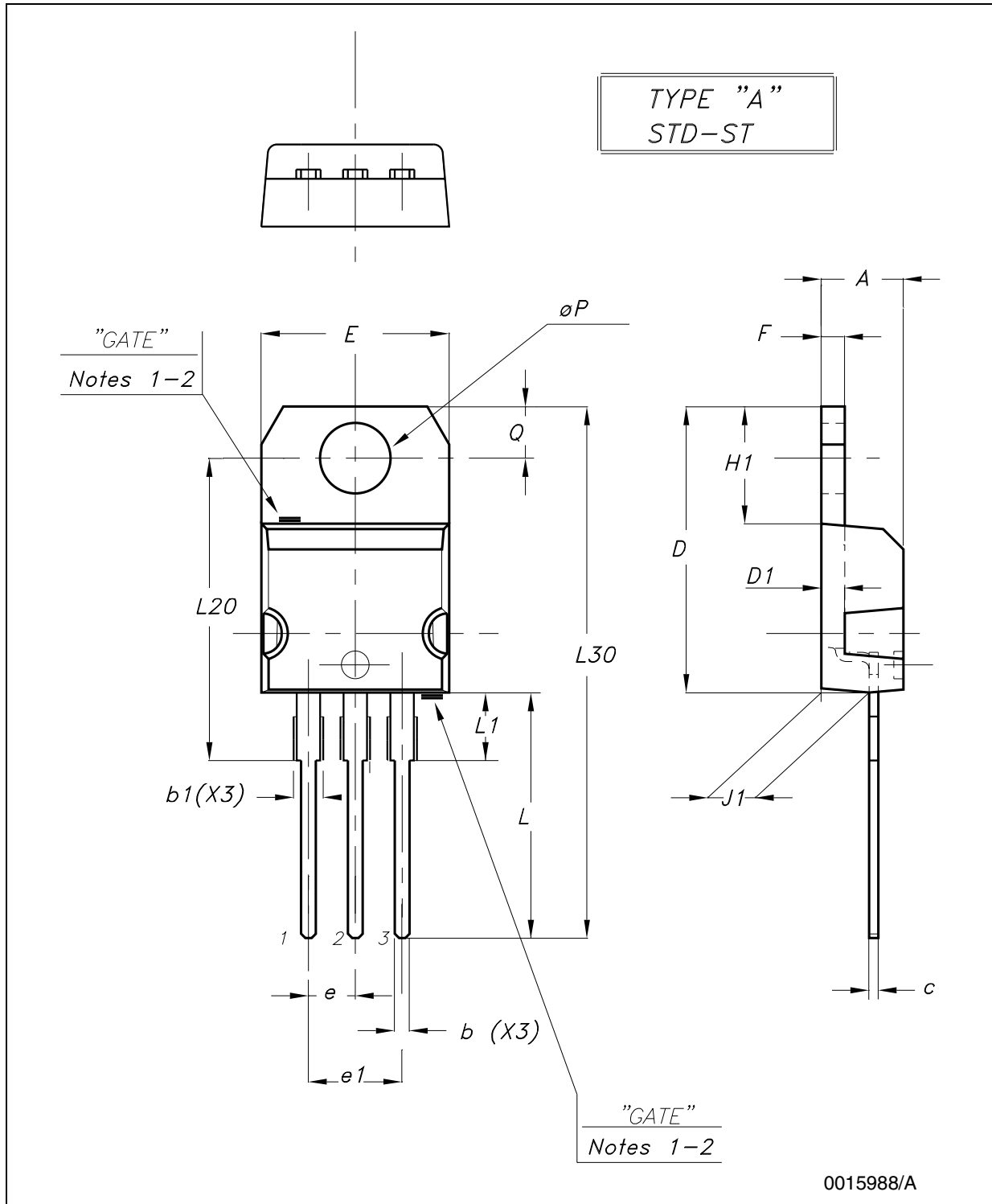
7 Package mechanical data

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 |

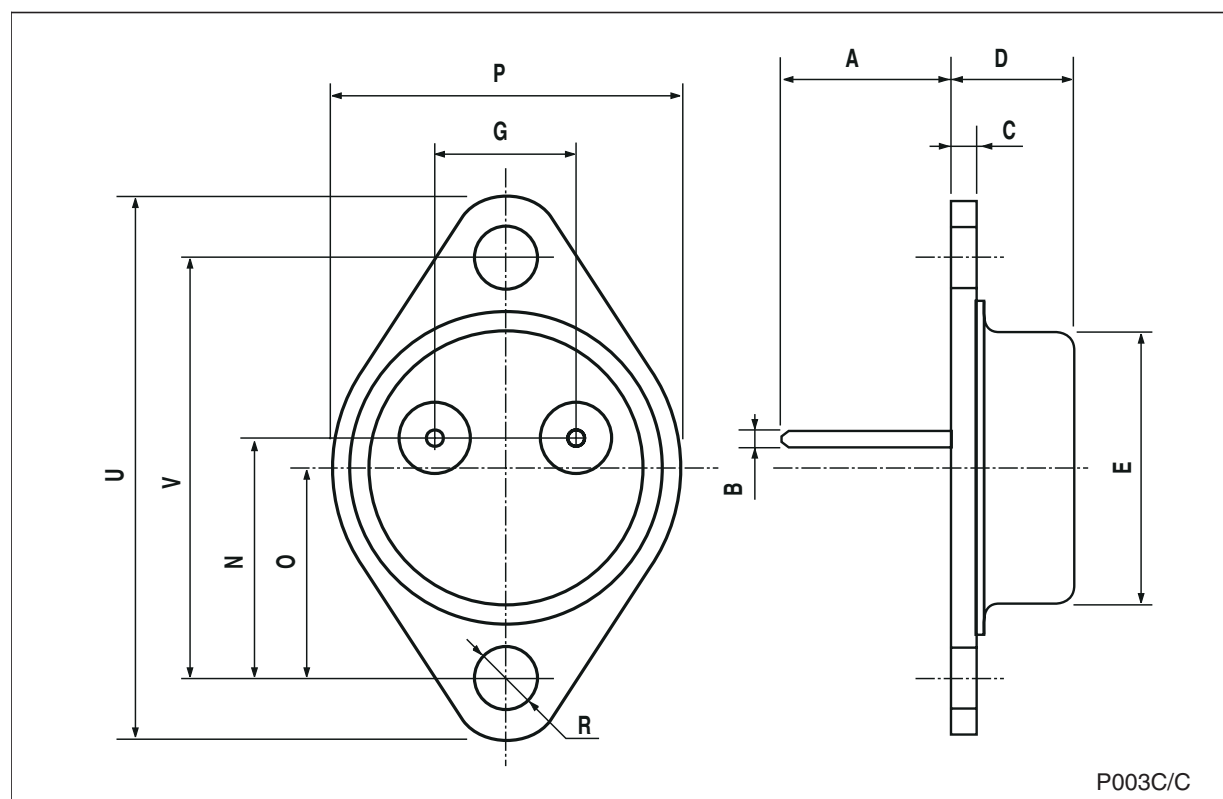
Figure 14. Drawing dimension TO-220 (type STD-ST Dual Gauge)



- 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.

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 | |



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 |

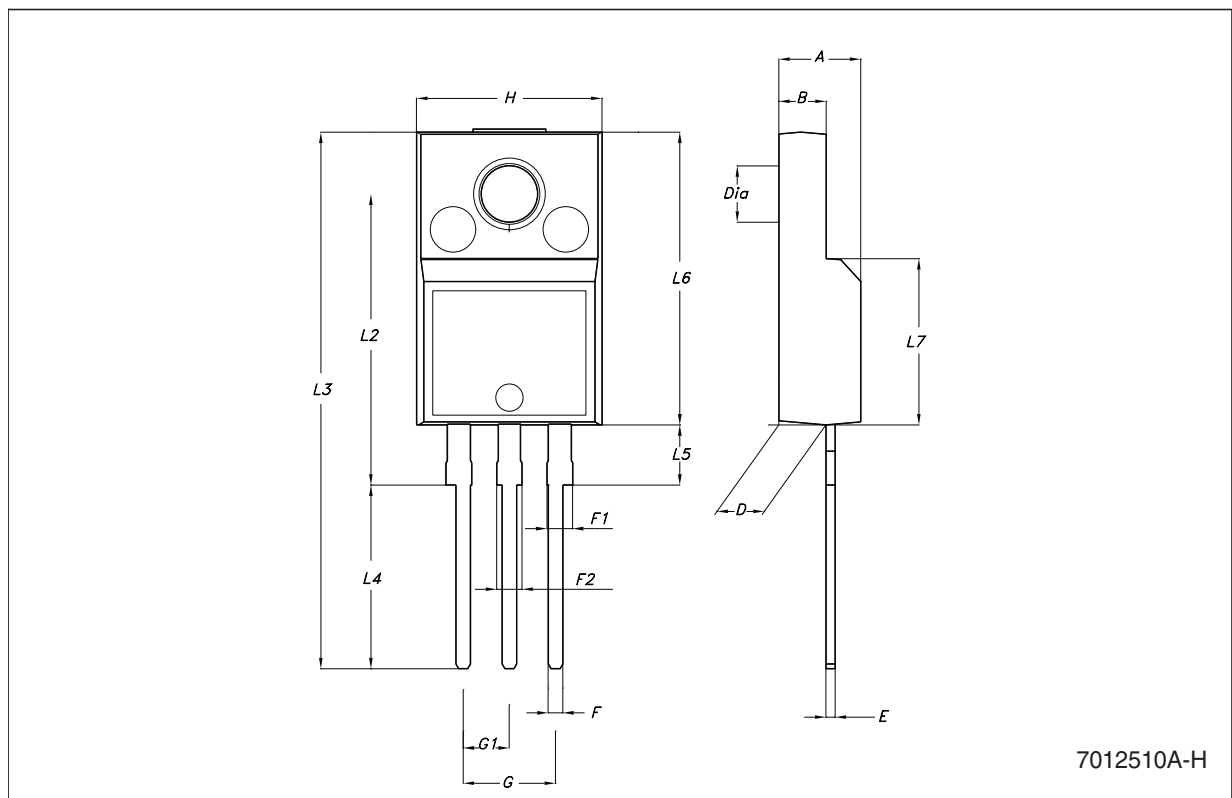


Figure 18. Drawing dimension D²PAK (type STD-ST)

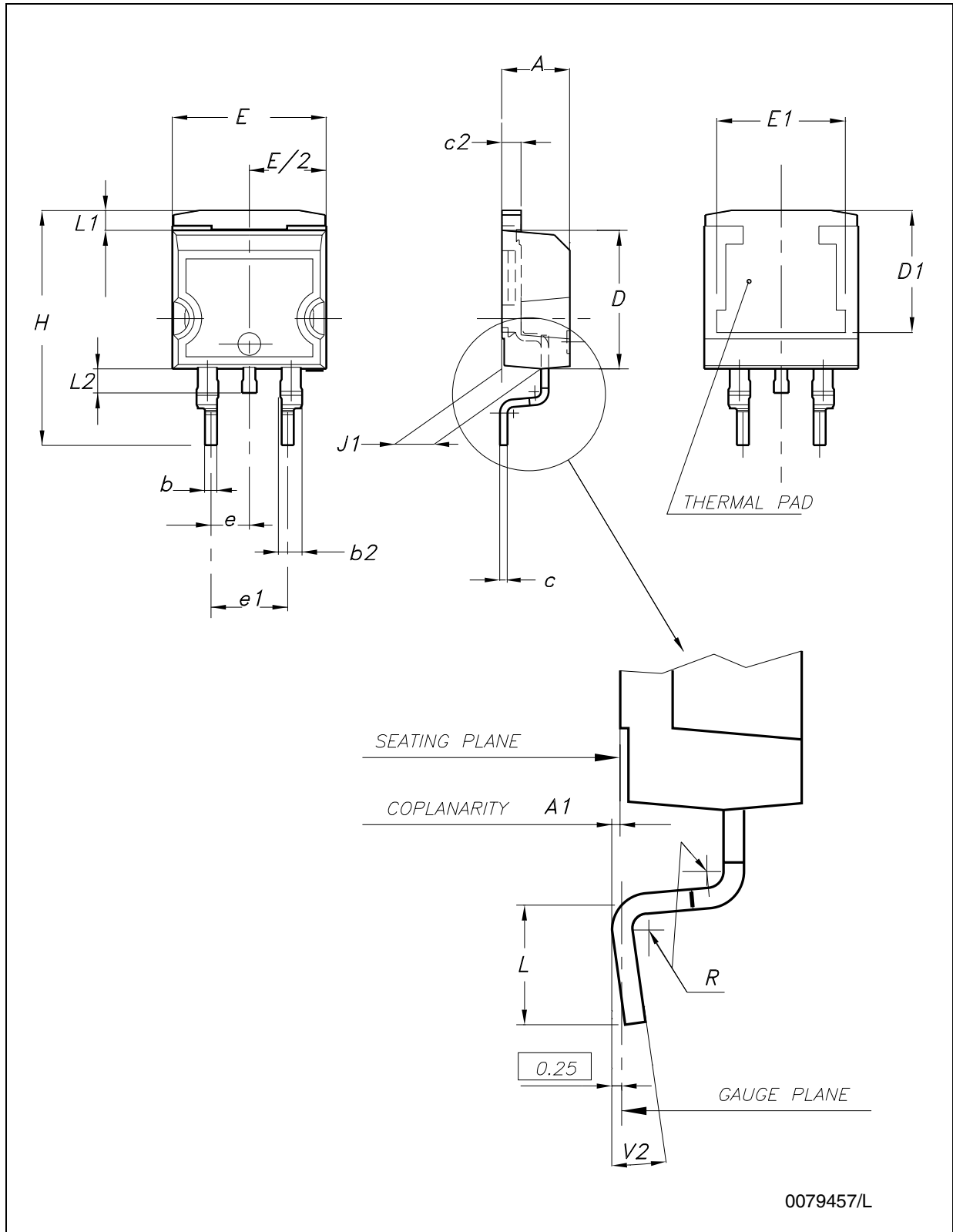
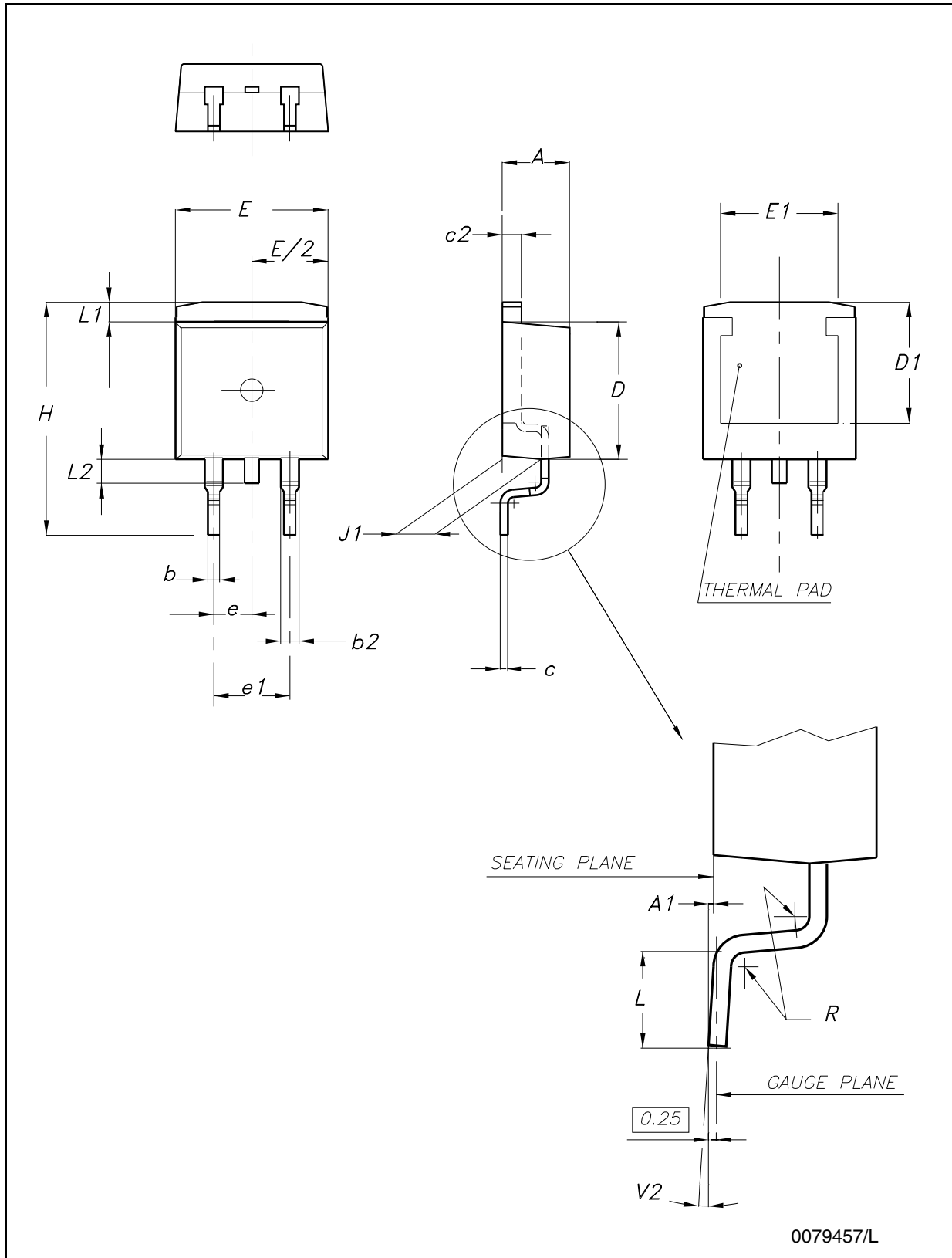


Figure 19. Drawing dimension D²PAK (type WOOSEOK-SUBCON.)



0079457/L

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

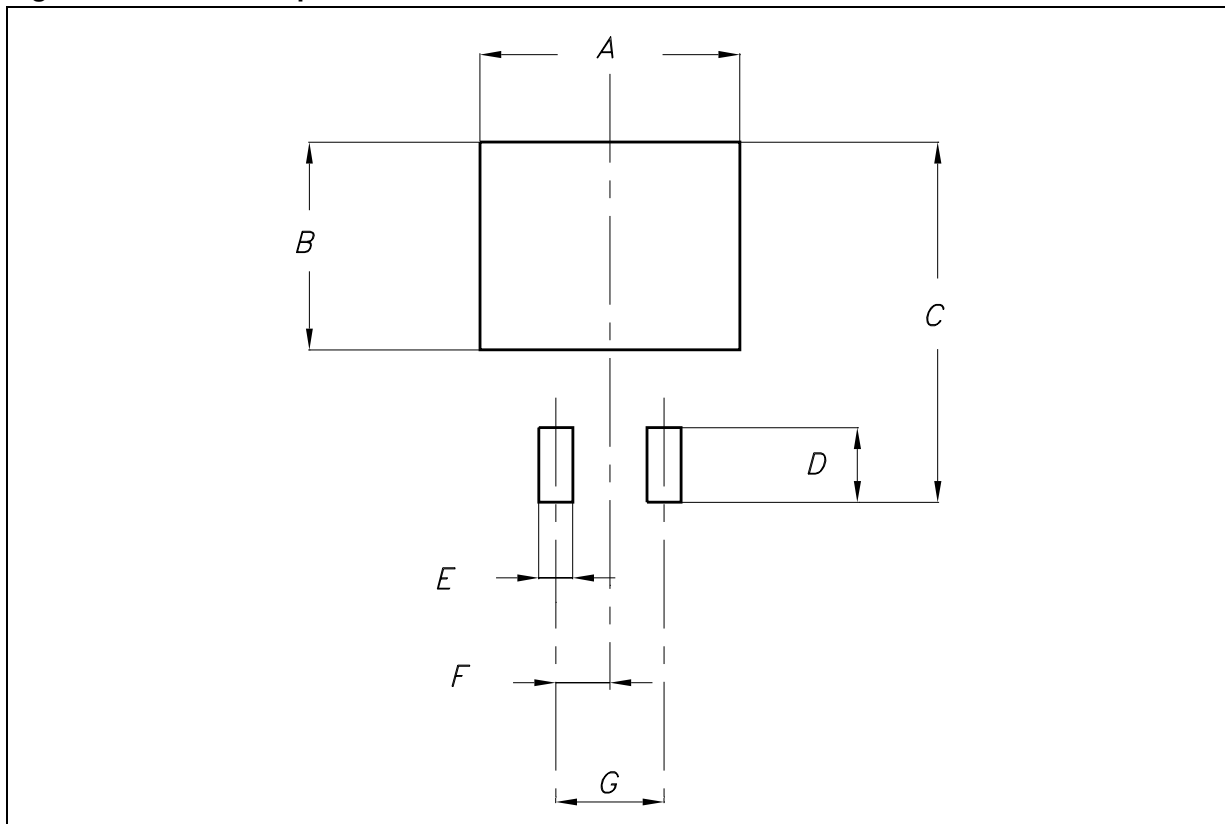
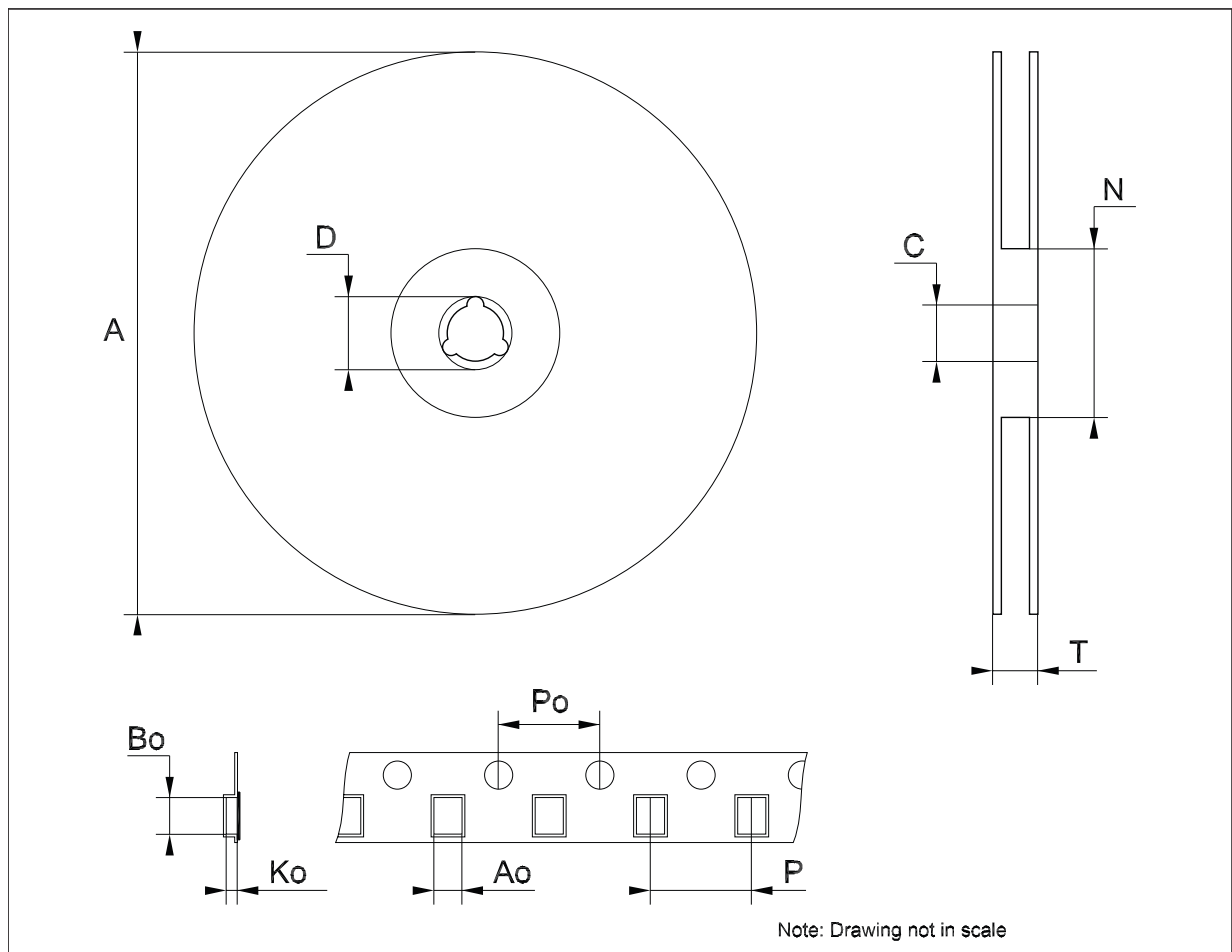


Table 8. Footprint data

| Dim. | Values | |
|------|--------|-------|
| | 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 D²PAK-P²PAK-D²PAK/A-P²PAK/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 |



8 Revision history

Table 9. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 01-Sep-2004 | 10 | Mistake $V_{REF} \Rightarrow V_O$, tables 1, 4 and 5. |
| 19-Jan-2007 | 11 | D ² PAK mechanical data has been updated, add footprint data and the document has been reformatted. |
| 13-Jun-2007 | 12 | Change values ΔI_{ADJ} and V_{REF} test condition of $I_O = 10 \text{ mA}$ to $I_{MAX} \Rightarrow I_O = 10 \text{ mA}$ 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 . |
| 18-Nov-2011 | 17 | Added: order code LM317T-DG Table 1 on page 1 . |
| 13-Feb-2012 | 18 | Added: order code LM217T-DG Table 1 on page 1 . |

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