

## 1.2 V to 37 V adjustable voltage regulators

### Features

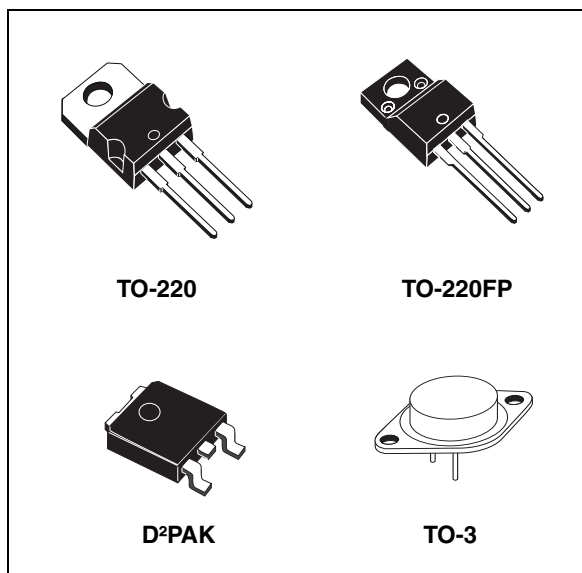
- Output voltage range: 1.2 to 37 V
- Output current in excess of 1.5 A
- 0.1% Line and load regulation
- Floating operation for high voltages
- Complete series of protections: current limiting, thermal shutdown and SOA control

### Description

The LM117, LM217, LM317 are monolithic integrated circuits in TO-220, TO-220FP, TO-3 and D<sup>2</sup>PAK 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**

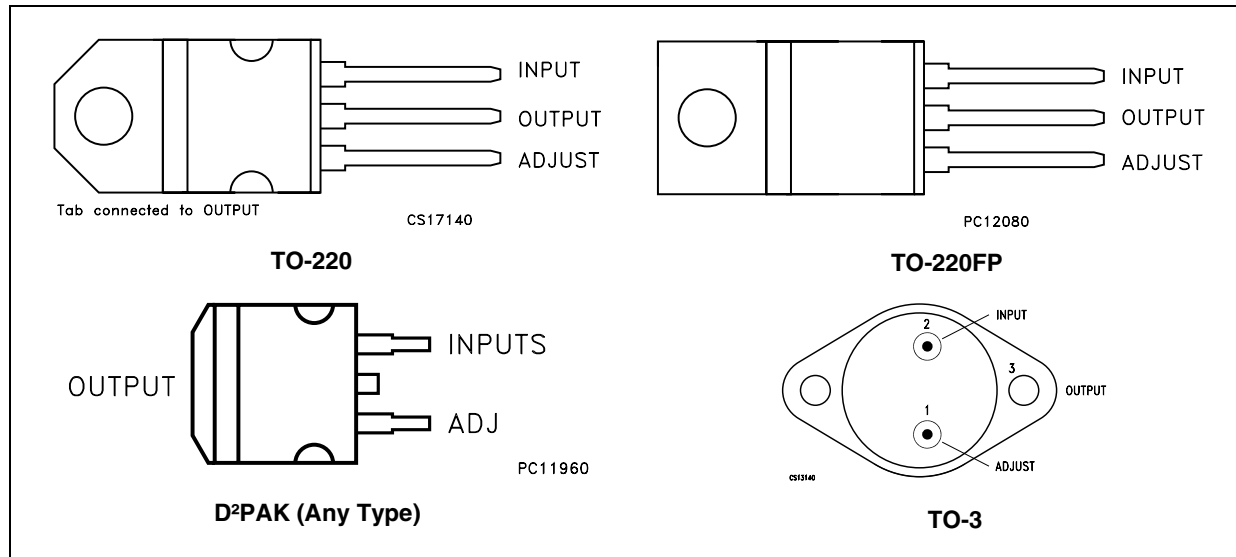
Order codes			
TO-220	D <sup>2</sup> PAK (tape and reel)	TO-220FP	TO-3
			LM117K
LM217T	LM217D2T-TR		LM217K
LM317T	LM317D2T-TR	LM317P	LM317K

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# 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

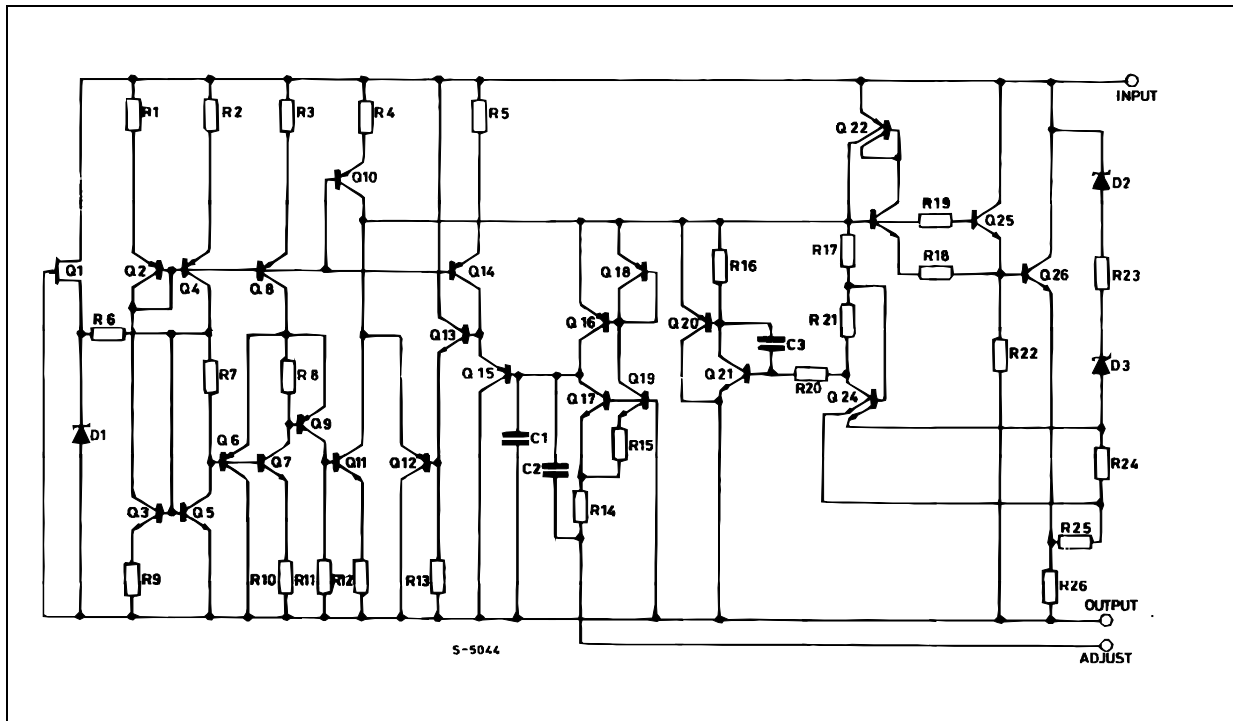
*Note:* Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

**Table 3. Thermal data**

Symbol	Parameter	D <sup>2</sup> PAK	TO-220	TO-220FP	TO-3	Unit
$R_{thJC}$	Thermal resistance junction-case	3	3	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
$\Delta V_O$	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	
$\Delta V_O$	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	$\mu\text{A}$	
$\Delta I_{ADJ}$	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	$\mu\text{A}$
$V_{REF}$	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 = 10Hz to 100kHz, $T_J = 25^\circ\text{C}$			0.003		%
SVR	Supply voltage rejection <sup>(1)</sup>	$T_J = 25^\circ\text{C}$ , $f = 120\text{ Hz}$	$C_{ADJ}=0$		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
$\Delta V_O$	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	
$\Delta V_O$	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	$\mu\text{A}$	
$\Delta I_{ADJ}$	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	$\mu\text{A}$
$V_{REF}$	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 <sup>(1)</sup>	$T_J = 25^\circ\text{C}$ , $f = 120\text{Hz}$	$C_{ADJ}=0$		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

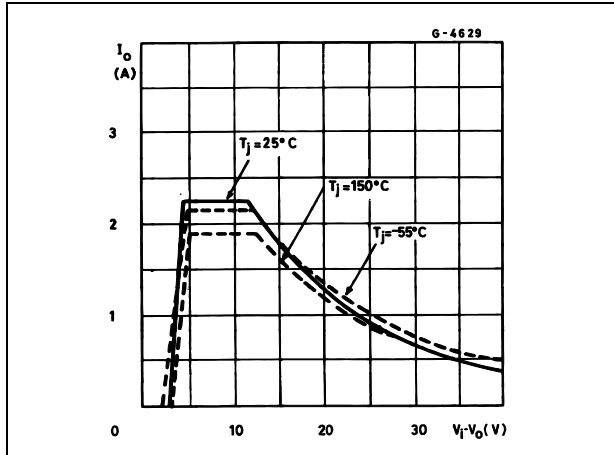


Figure 4. Dropout voltage vs. junction temperature

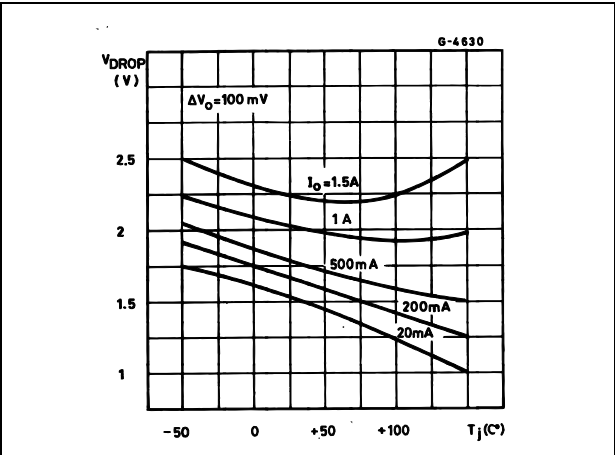


Figure 5. Reference voltage vs. junction

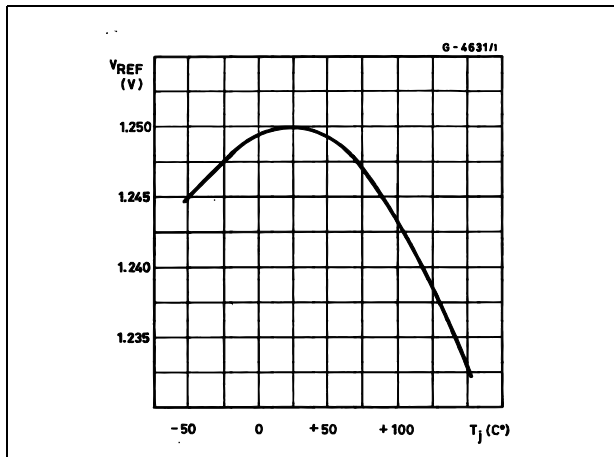
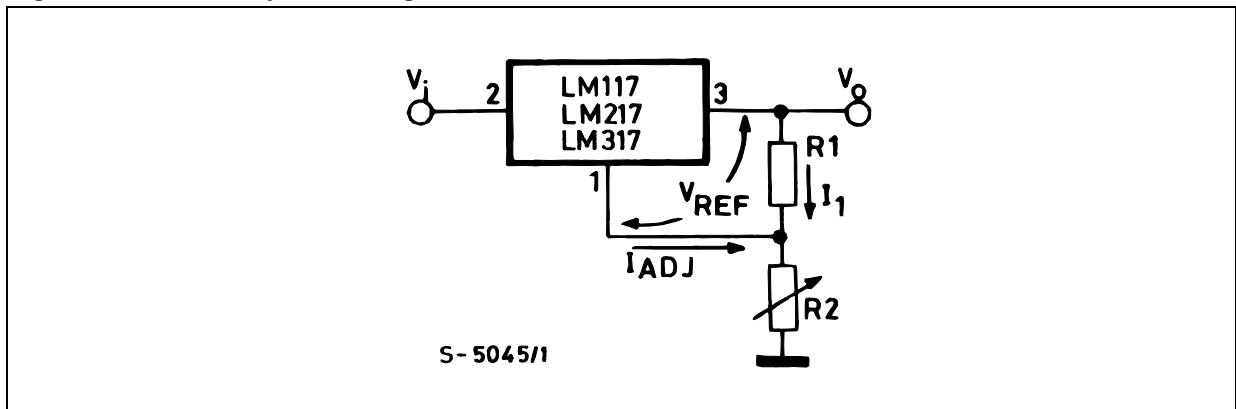


Figure 6. Basic adjustable regulator





## 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  $\mu$ 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.

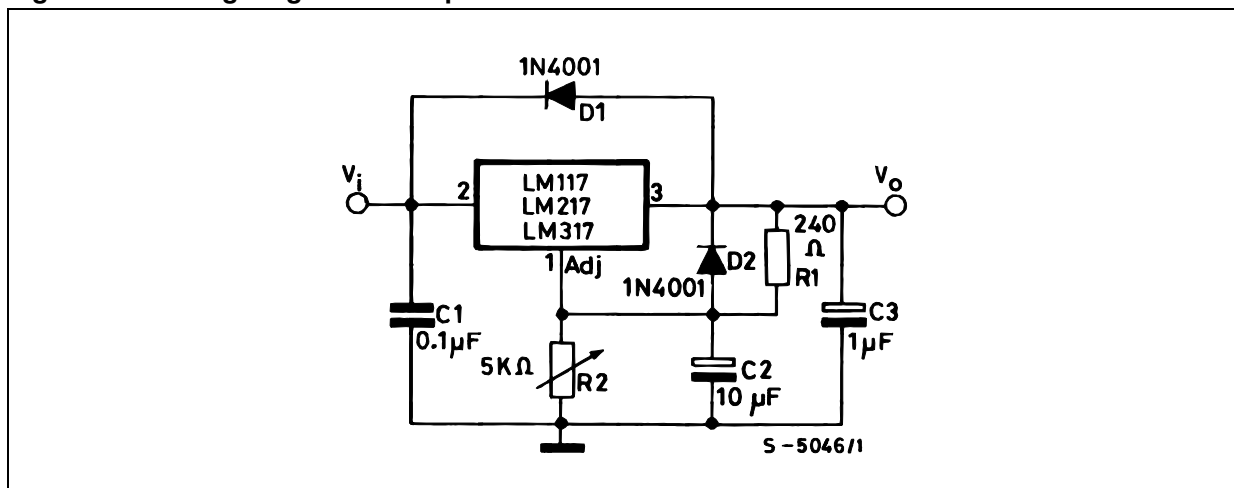
Furthermore, programmable regulator are easily obtainable and, by connecting a fixed resistor between the adjustment and output, the device can be used as a precision current regulator. In order to optimize the load regulation, the current set resistor  $R_1$  (see [Figure 3](#)) should be tied as close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

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

An 1  $\mu$ F tantalum (or 25  $\mu$ F 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

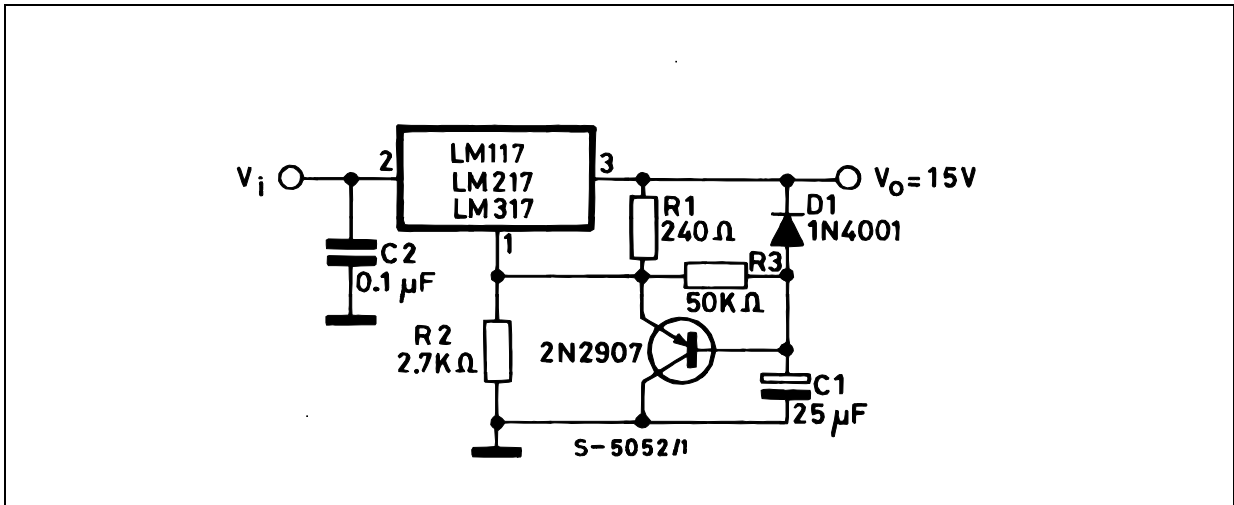
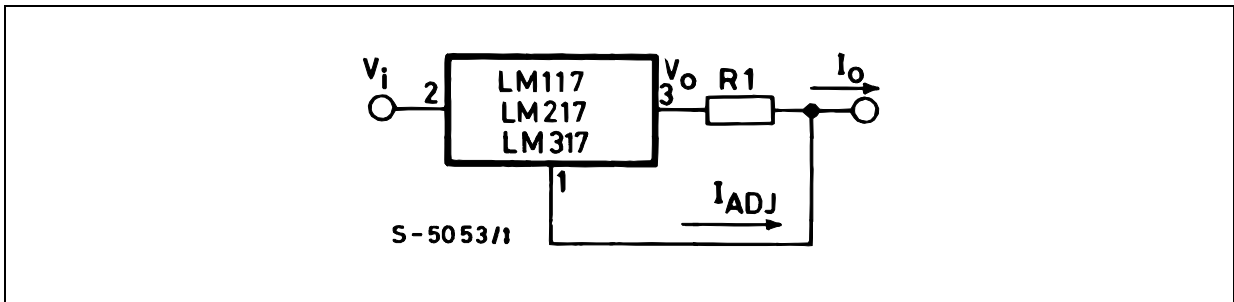


Figure 9. Current regulator



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

Figure 10. 5 V electronic shut-down regulator

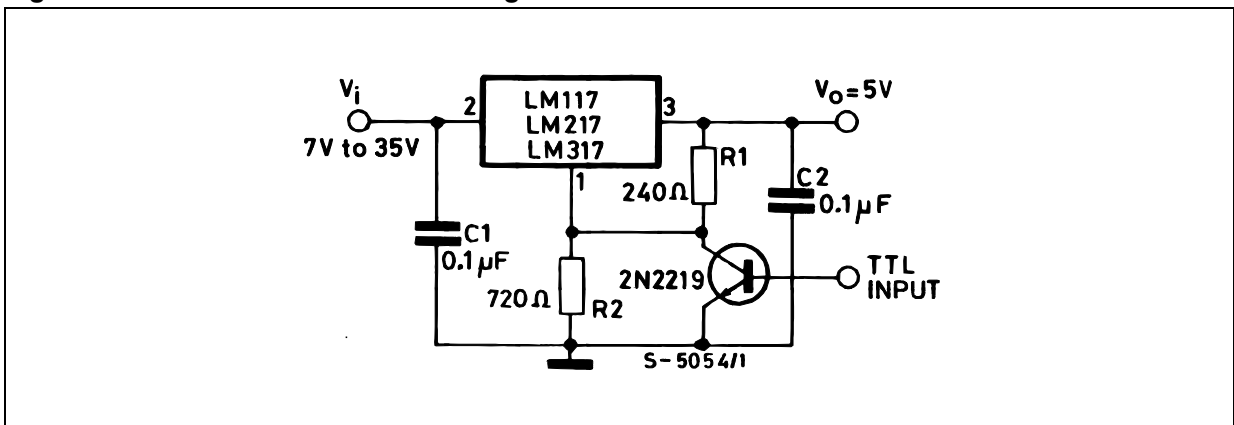
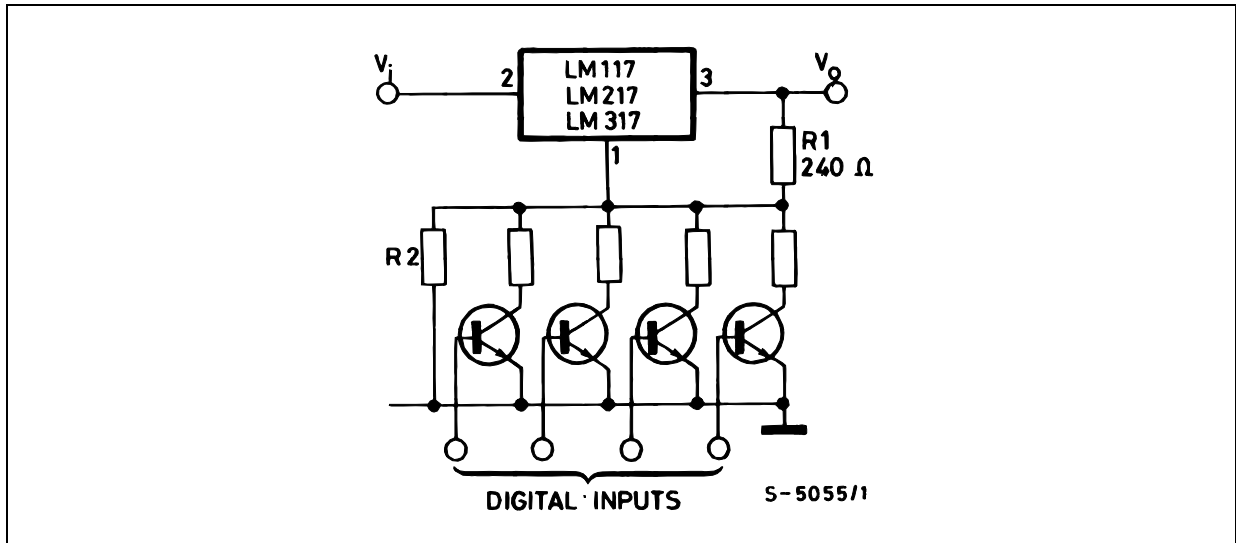
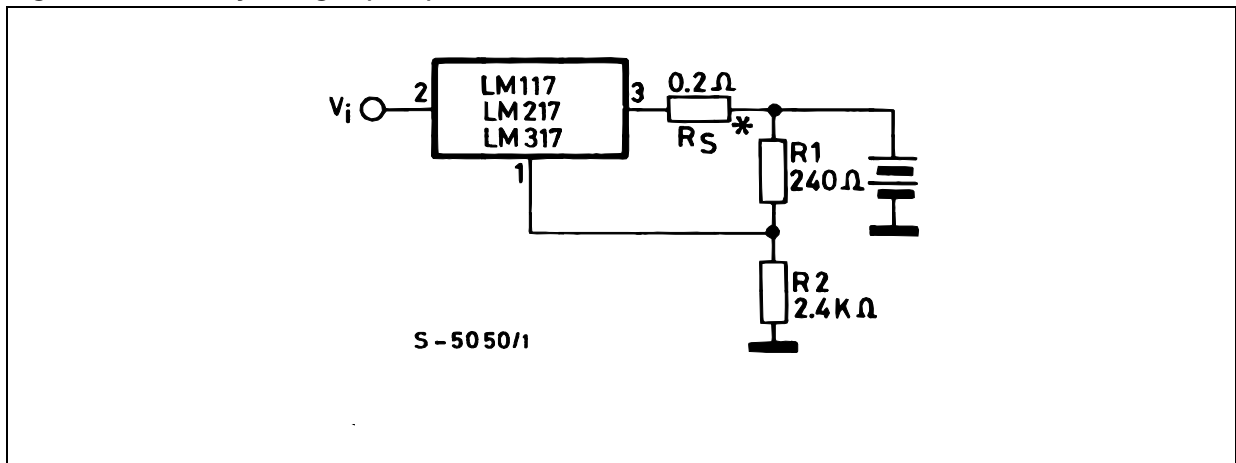


Figure 11. Digitally selected outputs



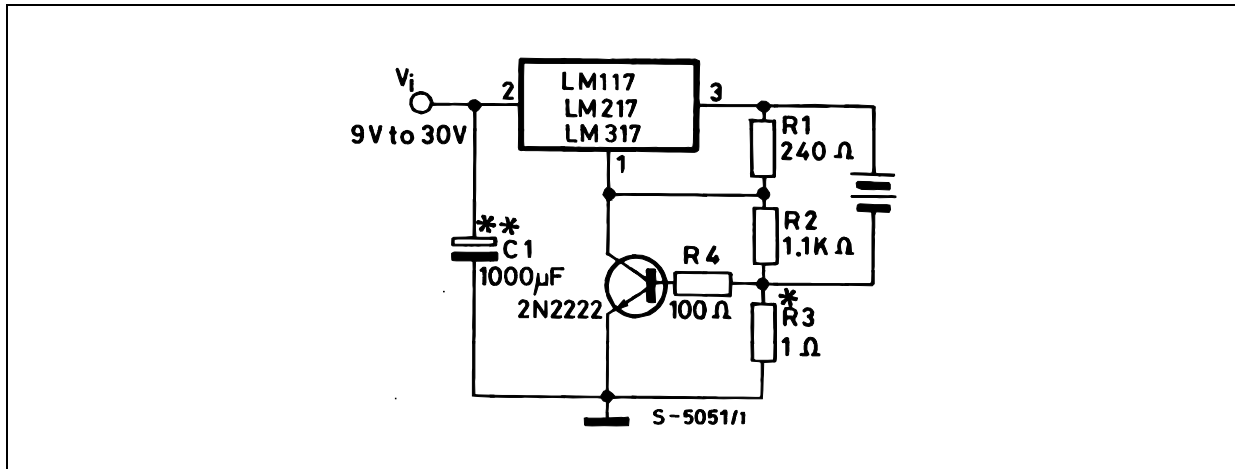
( $R_2$  sets maximum  $V_O$ )

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  $\Omega$ ).

\*\* C1 recommended to filter out input transients.

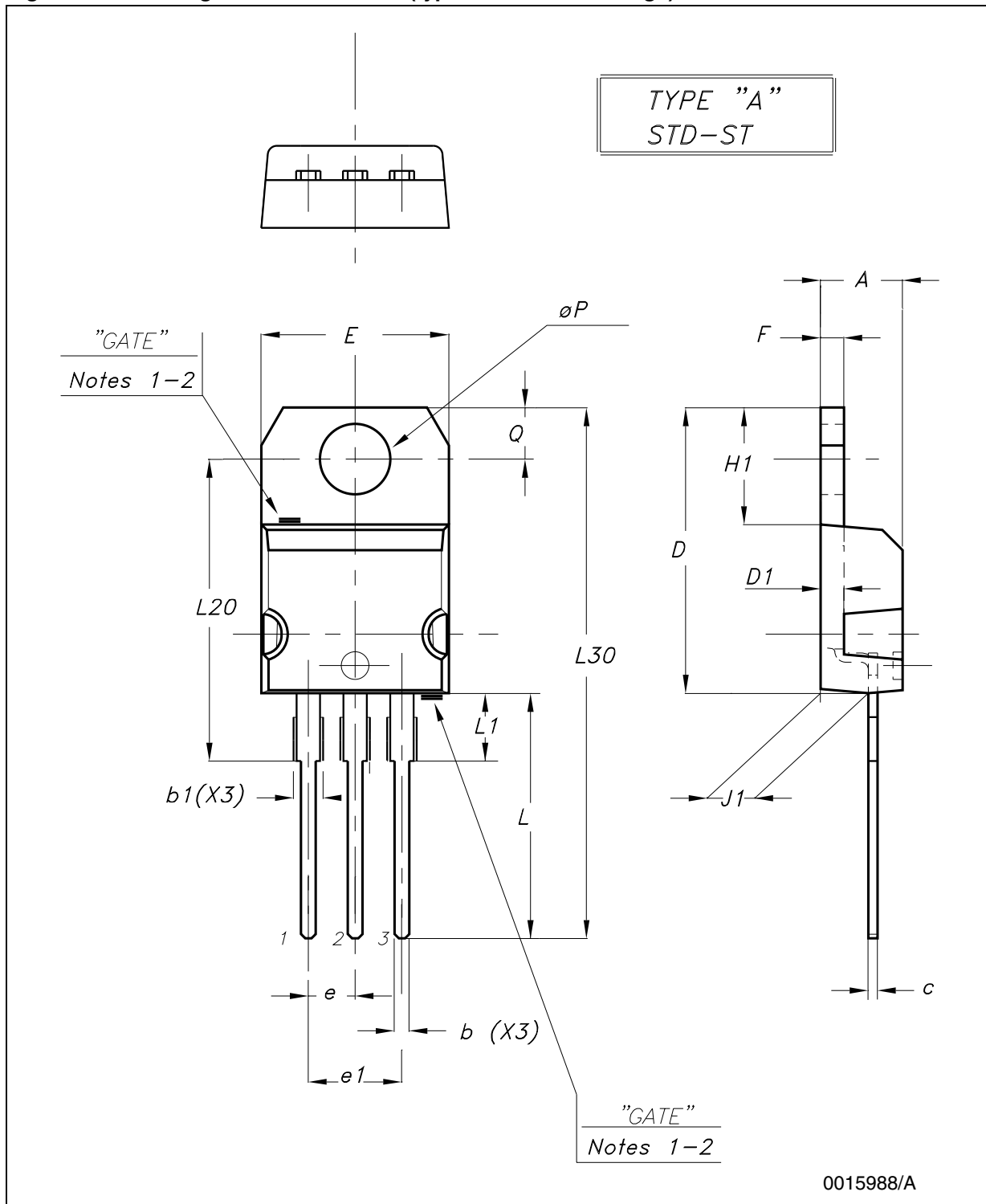
## 7 Package mechanical data

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

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

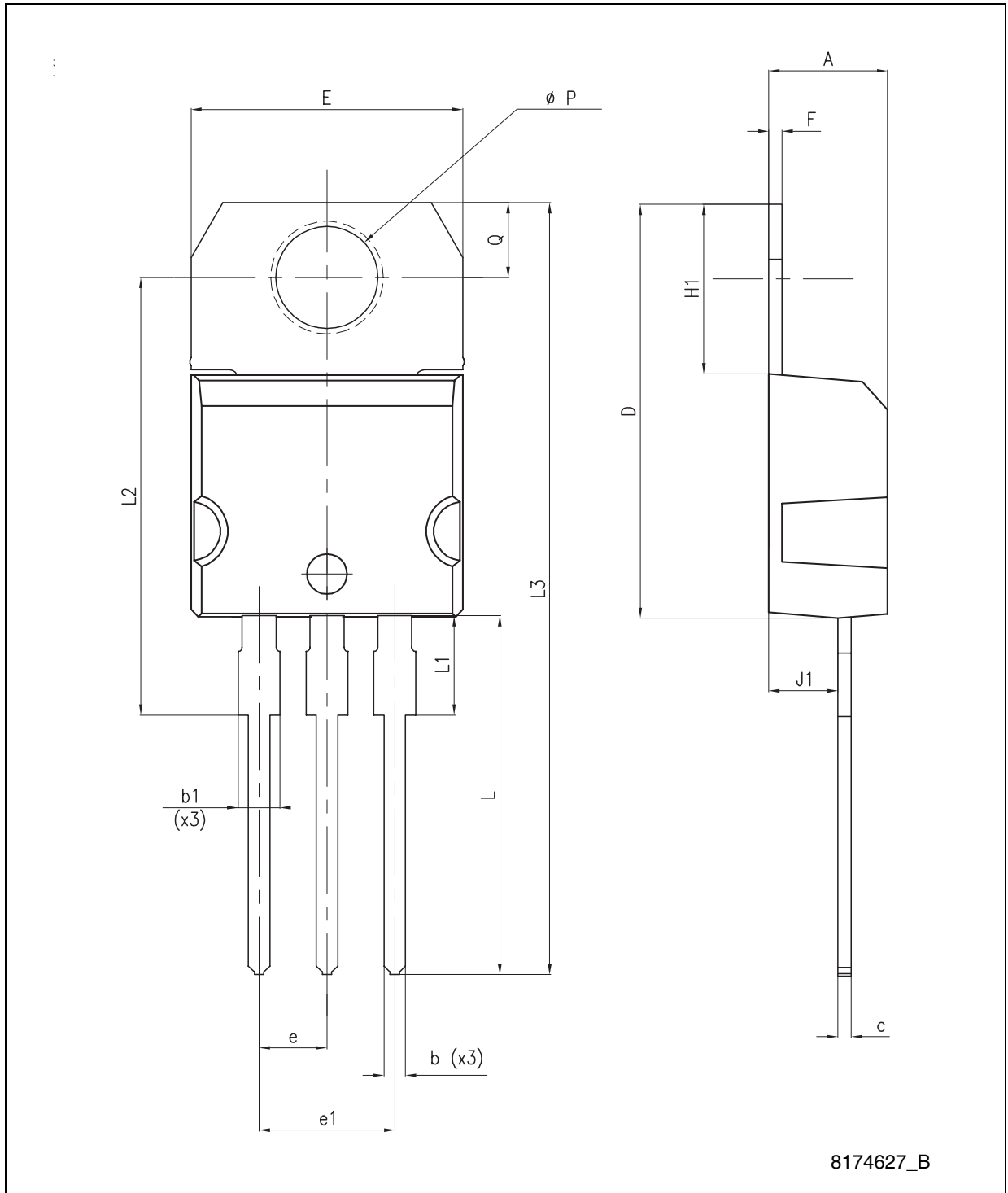
Dim.	Type STD - ST Dual Gauge			Type STD - ST Single Gauge		
	mm.			mm.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.40		4.60	4.40		4.60
b	0.61		0.88	0.61		0.88
b1	1.14		1.70	1.14		1.70
c	0.48		0.70	0.48		0.70
D	15.25		15.75	15.25		15.75
D1		1.27				
E	10.00		10.40	10.00		10.40
e	2.40		2.70	2.40		2.70
e1	4.95		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 dwg, 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.)

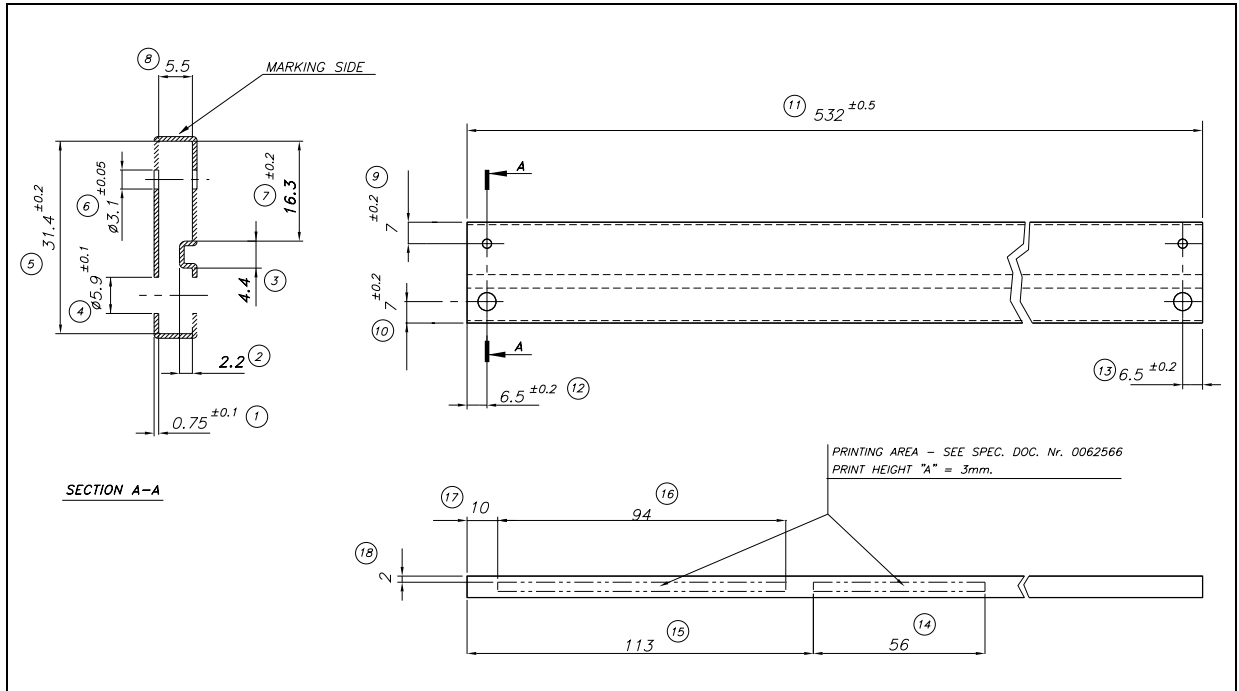
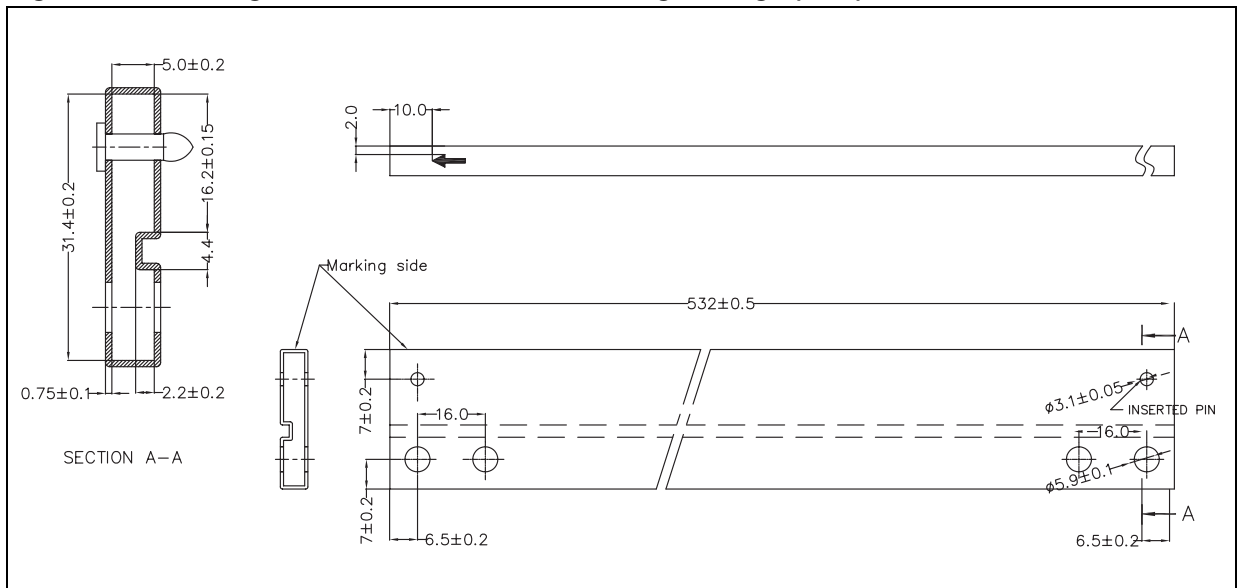


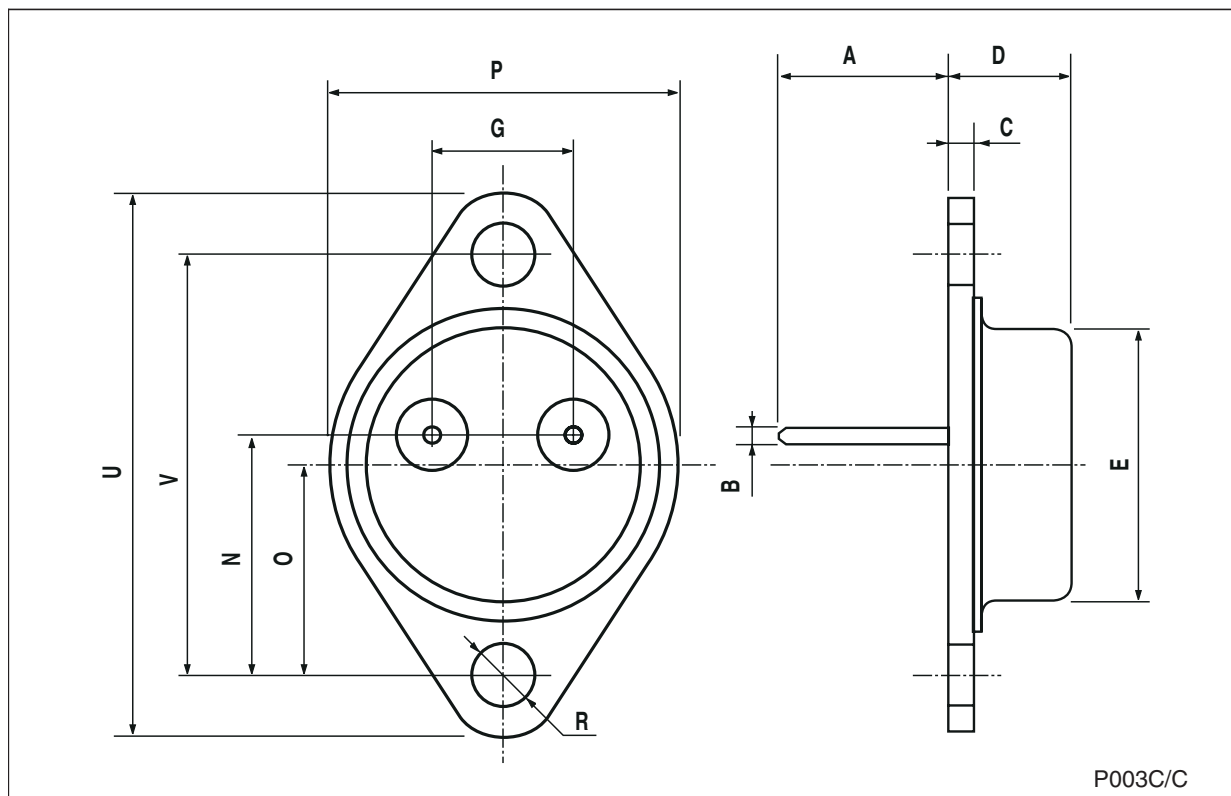
Figure 17. Drawing dimension tube for TO-220 Single Gauge (mm.)





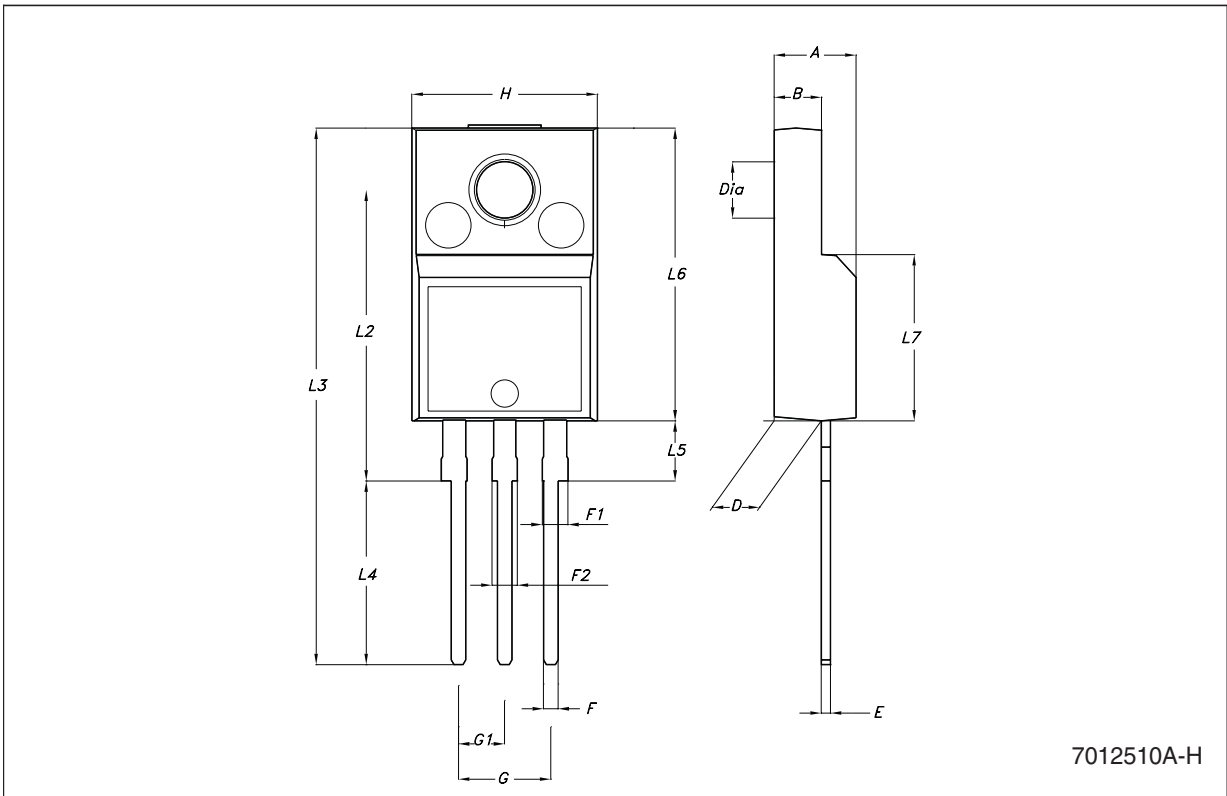
## TO-3 mechanical data

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	



**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 D<sup>2</sup>PAK (type STD-ST)

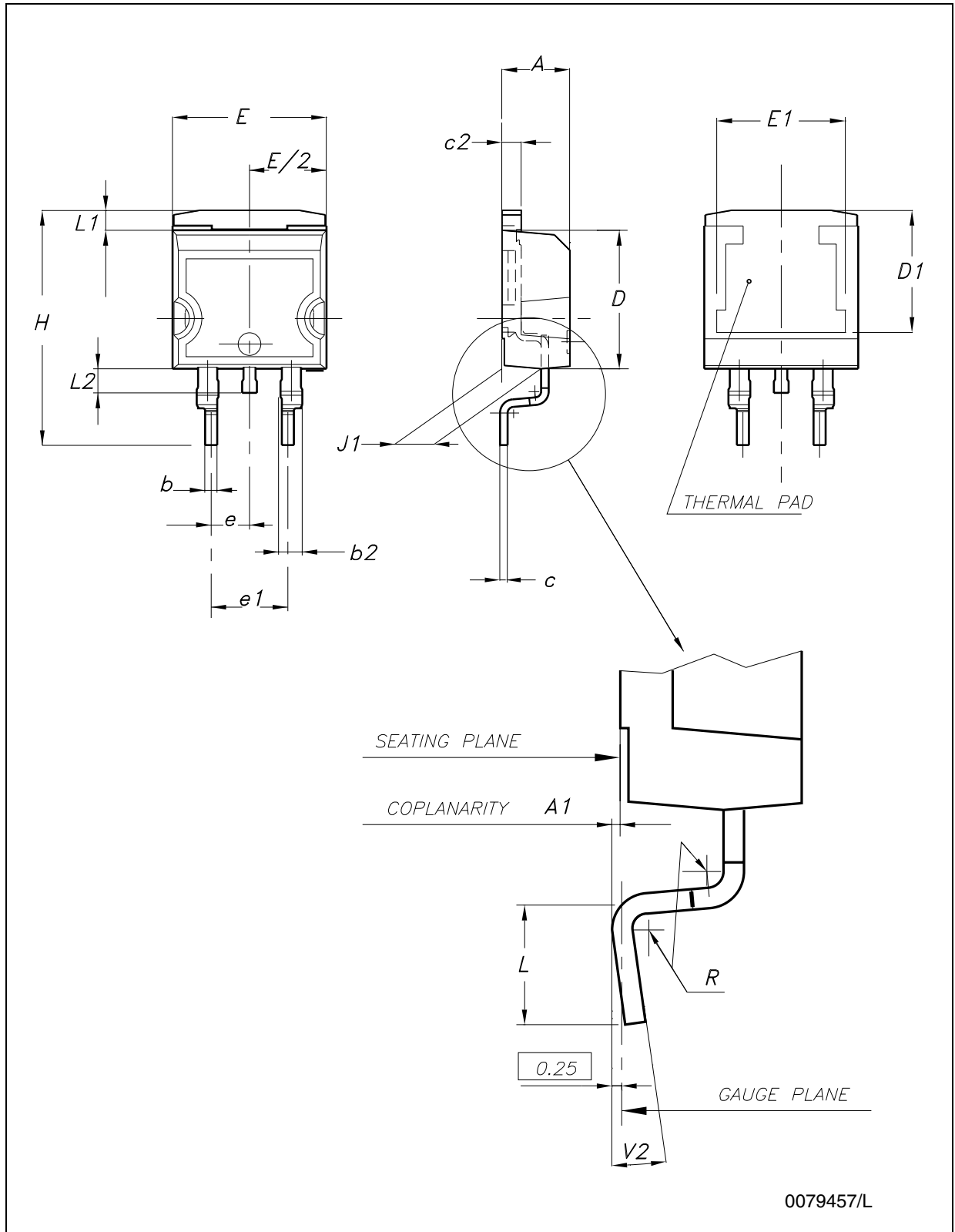
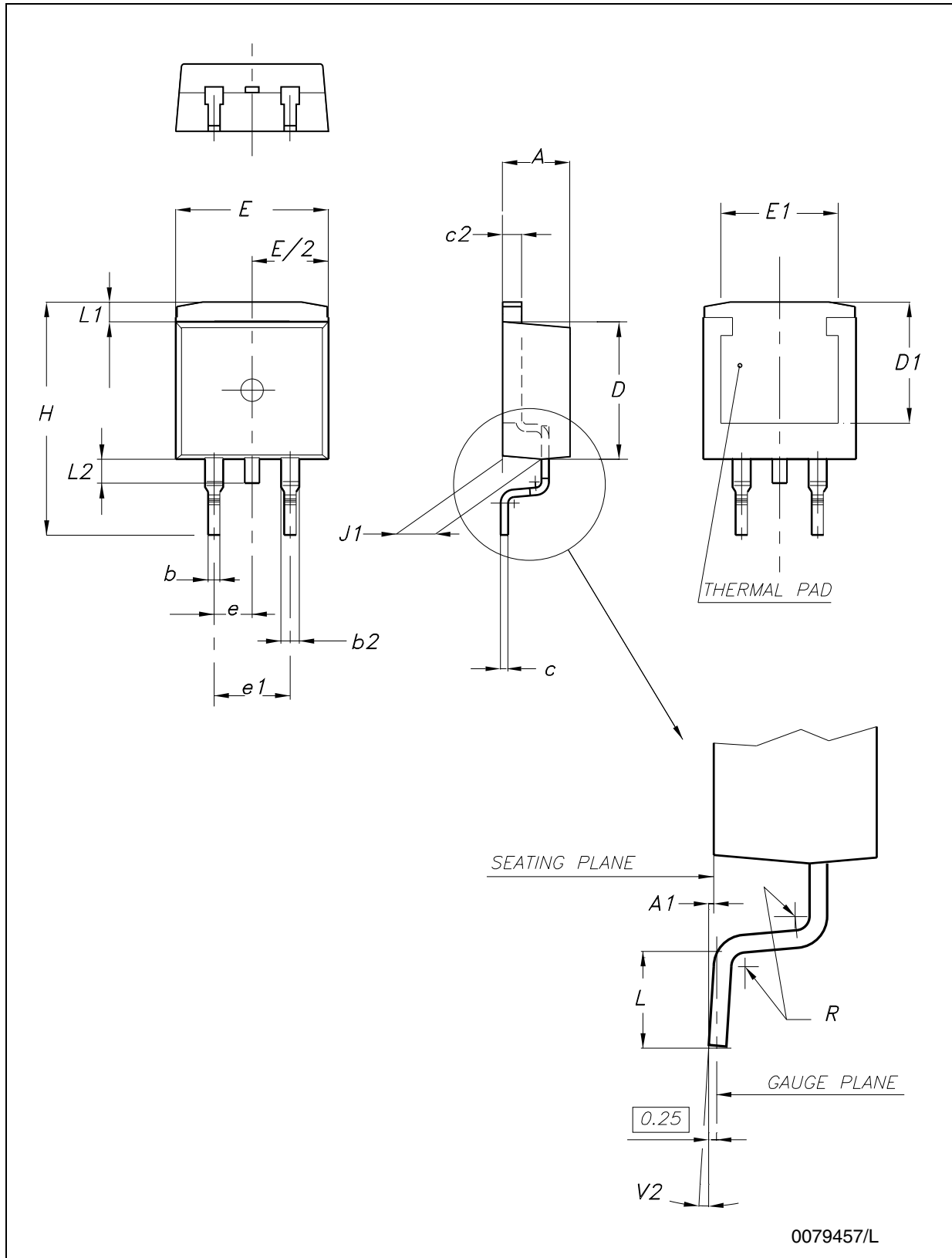


Figure 19. Drawing dimension D<sup>2</sup>PAK (type WOOSEOK-SUBCON.)



0079457/L

Table 7. D<sup>2</sup>PAK 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 D<sup>2</sup>PAK package coming from the subcontractor Wooseok is fully compatible with the ST's package suggested footprint.

Figure 20. D<sup>2</sup>PAK footprint recommended data

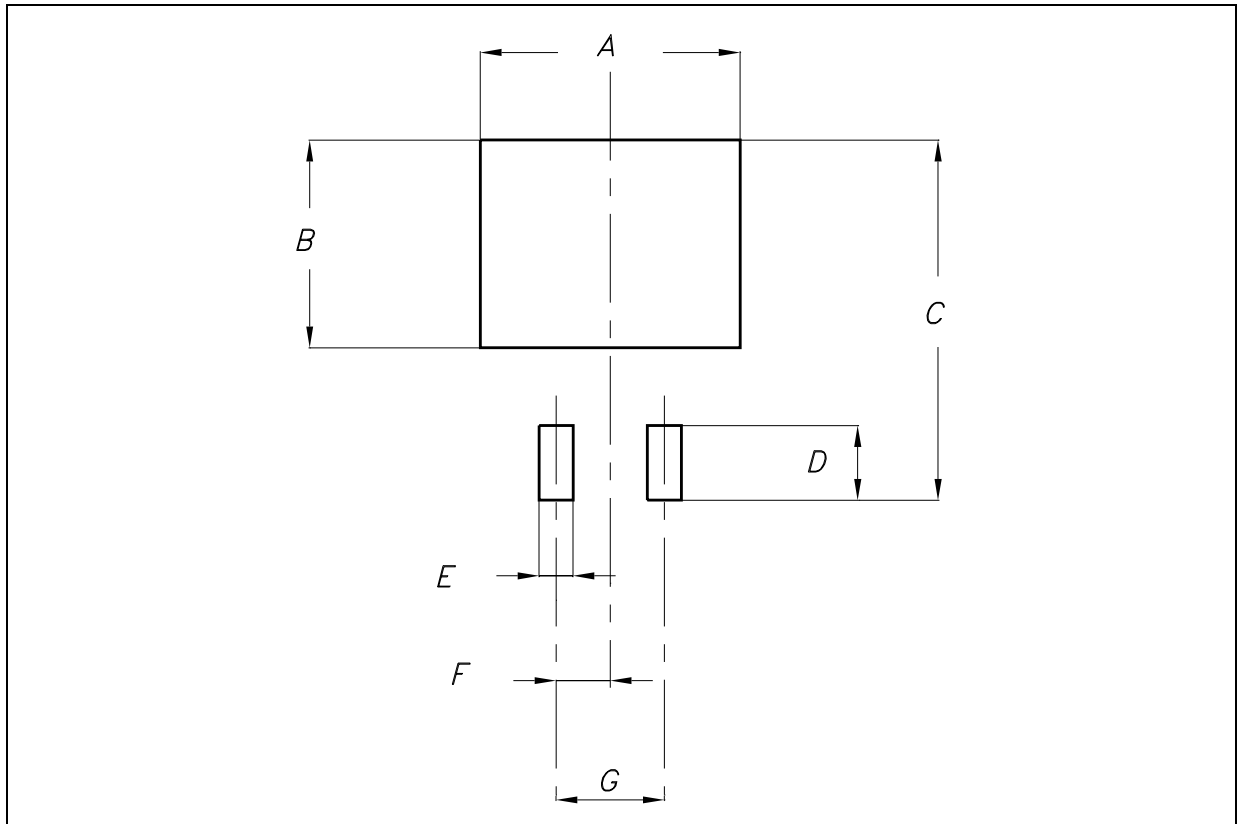
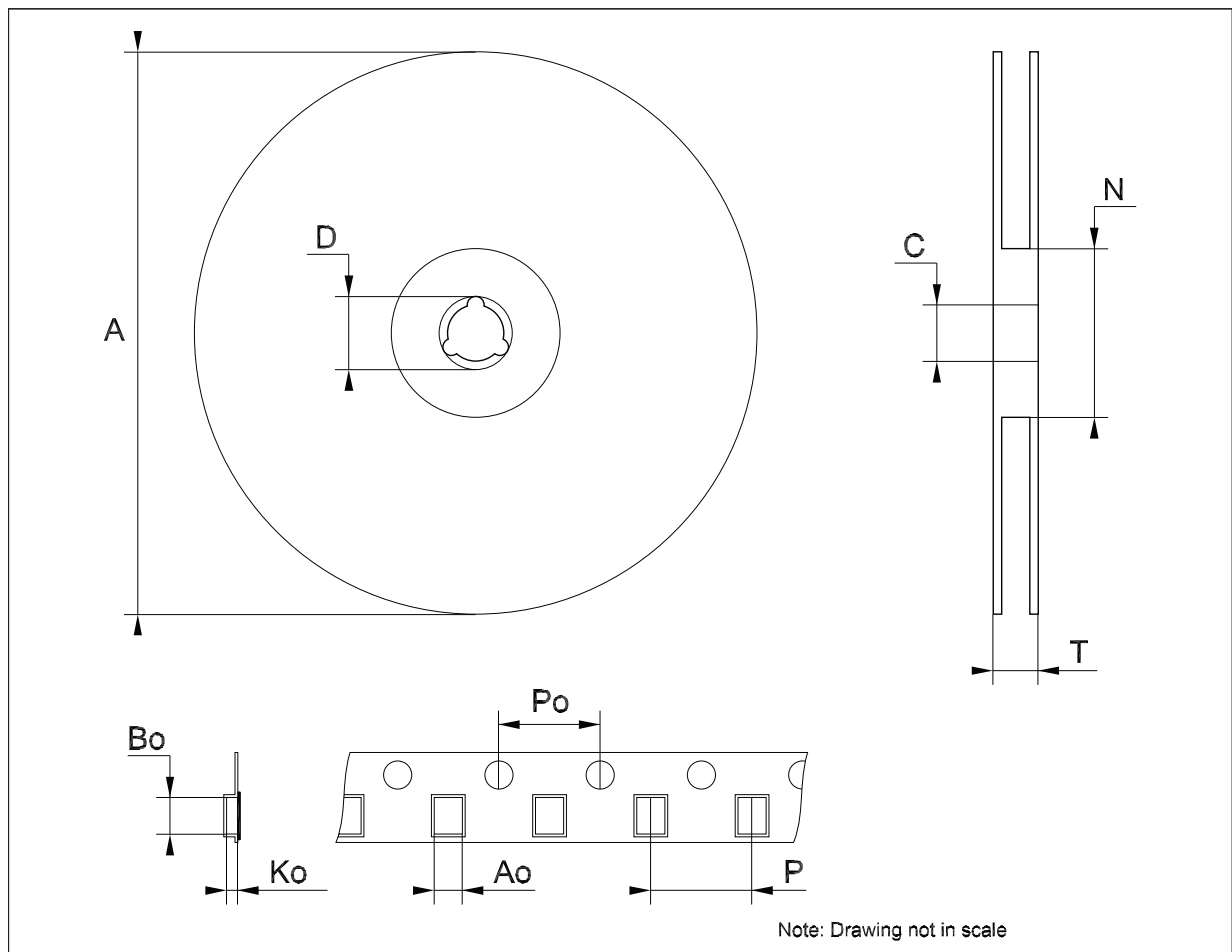


Table 8. Footprint data

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 D<sup>2</sup>PAK-P<sup>2</sup>PAK-D<sup>2</sup>PAK/A-P<sup>2</sup>PAK/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 <sup>2</sup> PAK 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 $I_O = 10 \text{ mA}$ to $I_{MAX} \Rightarrow I_O = 10 \text{ mA}$ to 500 mA on <a href="#">Table 5</a> .
23-Nov-2007	13	Added <a href="#">Table 1</a> .
06-Feb-2008	14	Added: TO-220 mechanical data <a href="#">Figure 14 on page 14</a> and <a href="#">Table 6 on page 13</a> .
02-Mar-2010	15	Added: notes <a href="#">Figure 14 on page 14</a> , <a href="#">Figure 15 on page 15</a> , <a href="#">Figure 16</a> and <a href="#">Figure 17 on page 16</a> .



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