

## 1.2 V to 37 V adjustable voltage regulators

### Features

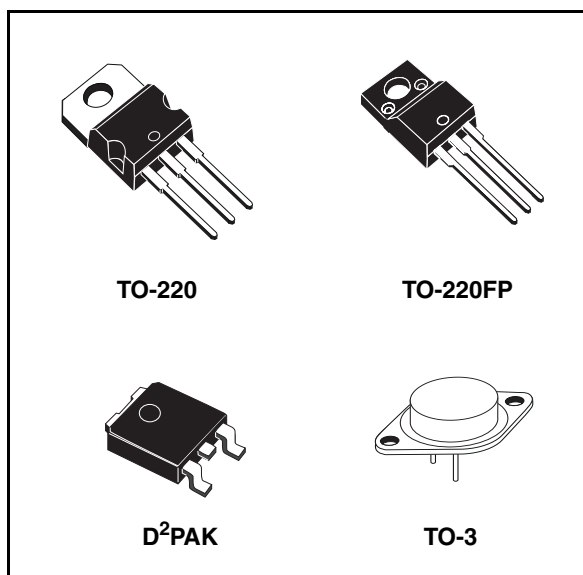
- Output voltage range: 1.2 to 37 V
- Output current in excess of 1.5 A
- 0.1% Line and load regulation
- Floating operation for high voltages
- Complete series of protections: current limiting, thermal shutdown and SOA control

### Description

The LM117/LM217/LM317 are monolithic integrated circuit 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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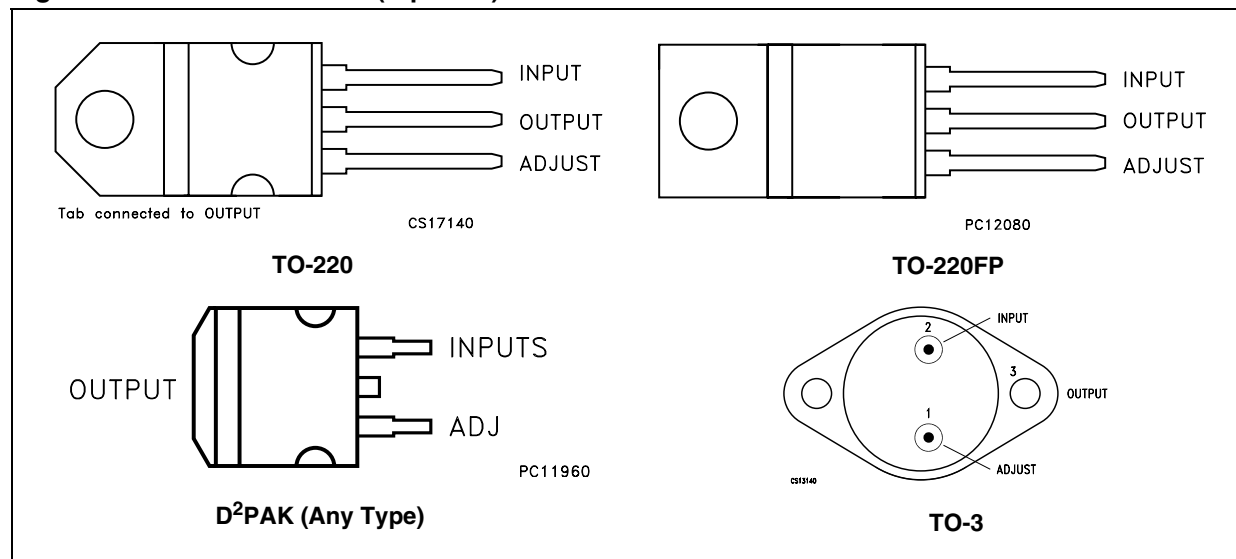
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# 1 Pin configuration

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

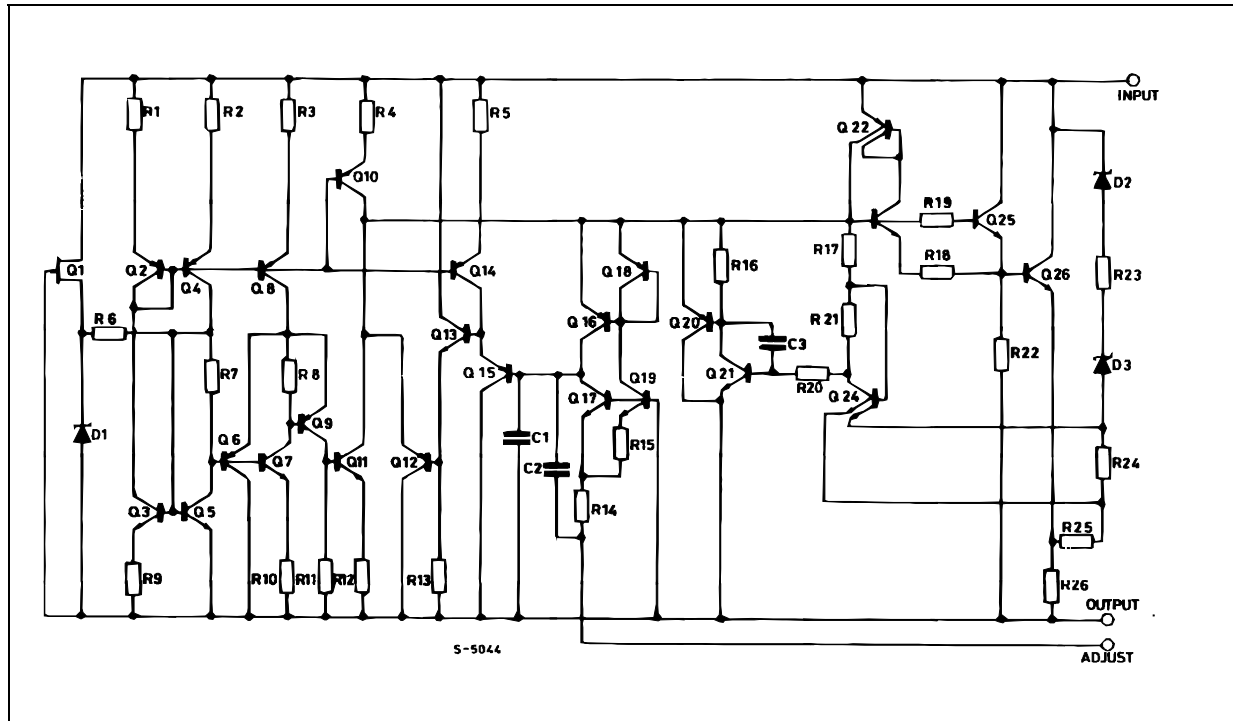
*Note:* Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

**Table 3. Thermal data**

Symbol	Parameter	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

**Table 4. Electrical characteristics for LM117/LM217** ( $V_I - V_O = 5\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $I_{MAX} = 1.5\text{ A}$  and  $P_{MAX} = 20\text{ W}$ ,  $T_J = -55\text{ to }150^\circ\text{C}$  for LM117,  $T_J = -25\text{ to }150^\circ\text{C}$  for LM217, unless otherwise specified)

Symbol	Parameter	Test conditions		Min.	Typ.	Max.	Unit
$\Delta V_O$	Line regulation	$V_I - V_O = 3\text{ to }40\text{ V}$	$T_J = 25^\circ\text{C}$		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	$V_I - V_O = 2.5\text{ to }40\text{ V}$ $I_O = 10\text{ mA to }I_{MAX}$			0.2	5	$\mu\text{A}$
$V_{REF}$	Reference voltage (between pin 3 and pin 1)	$V_I - V_O = 2.5\text{ to }40\text{ V}$ $I_O = 10\text{ mA to }I_{MAX}$ $P_D \leq P_{MAX}$		1.2	1.25	1.3	V
$\Delta V_O/V_O$	Output voltage temperature stability				1		%
$I_{O(min)}$	Minimum load current	$V_I - V_O = 40\text{ V}$			3.5	5	mA
$I_{O(max)}$	Maximum load current	$V_I - V_O \leq 15\text{ V}$ , $P_D < P_{MAX}$		1.5	2.2		A
		$V_I - V_O = 40\text{ V}$ , $P_D < P_{MAX}$ , $T_J = 25^\circ\text{C}$			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.

**Table 5. Electrical characteristics for LM317** ( $V_I - V_O = 5\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $I_{MAX} = 1.5\text{ A}$  and  $P_{MAX} = 20\text{ W}$ ,  $T_J = 0\text{ to }125^\circ\text{C}$ , unless otherwise specified)

Symbol	Parameter	Test conditions		Min.	Typ.	Max.	Unit
$\Delta V_O$	Line regulation	$V_I - V_O = 3\text{ to }40\text{ V}$	$T_J = 25^\circ\text{C}$		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	$V_I - V_O = 2.5\text{ to }40\text{ V}$ , $I_O = 10\text{ mA to }500\text{ mA}$			0.2	5	$\mu\text{A}$
$V_{REF}$	Reference voltage (between pin 3 and pin 1)	$V_I - V_O = 2.5\text{ to }40\text{ V}$ , $I_O = 10\text{ mA to }500\text{ mA}$ $P_D \leq P_{MAX}$		1.2	1.25	1.3	V
$\Delta V_O/V_O$	Output voltage temperature stability				1		%
$I_{O(min)}$	Minimum load current	$V_I - V_O = 40\text{ V}$			3.5	10	mA
$I_{O(max)}$	Maximum load current	$V_I - V_O \leq 15\text{ V}$ , $P_D < P_{MAX}$		1.5	2.2		A
		$V_I - V_O = 40\text{ V}$ , $P_D < P_{MAX}$ , $T_J = 25^\circ\text{C}$			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

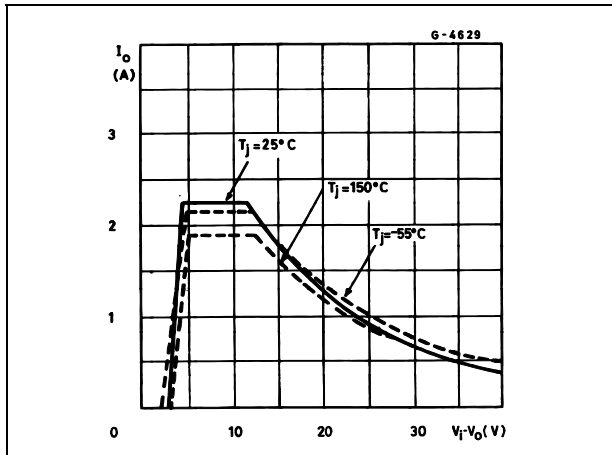


Figure 4. Dropout voltage vs junction temperature

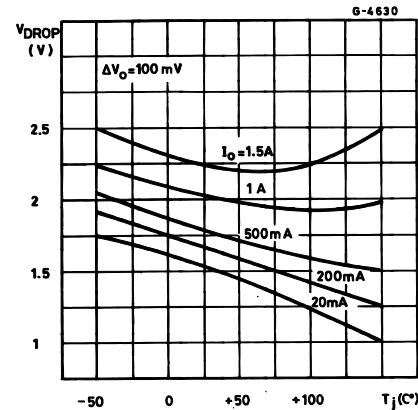


Figure 5. Reference voltage vs junction

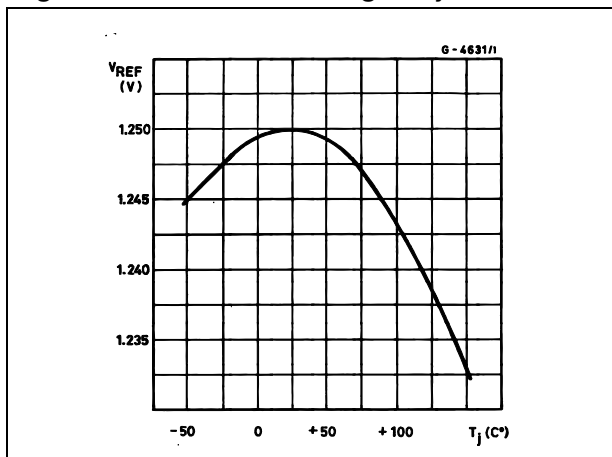
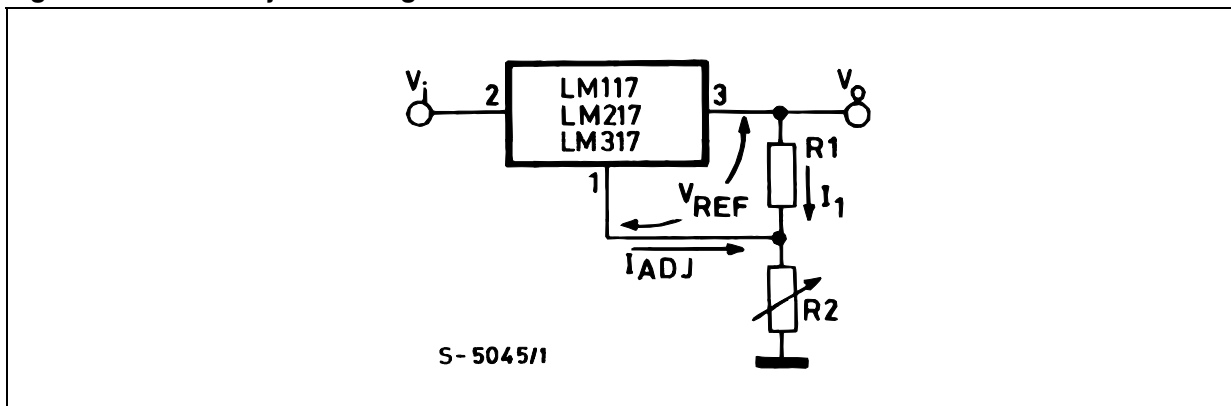


Figure 6. Basic adjustable regulator





## 6 Application information

The LM117/217/317 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:

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

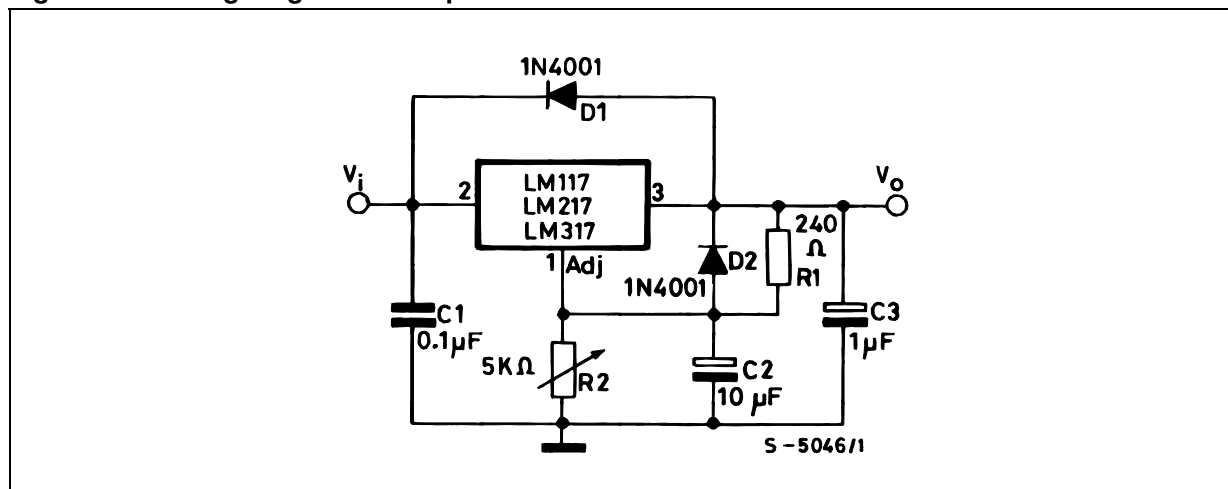
The device was designed to minimize the term  $I_{ADJ}$  (100  $\mu$ A max) and to maintain it very constant with line and load changes. Usually, the error term  $I_{ADJ} \times R_2$  can be neglected. To obtain the previous requirement, all the regulator quiescent current is returned to the output terminal, imposing a minimum load current condition. If the load is insufficient, the output voltage will rise. Since the LM117/217/317 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 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

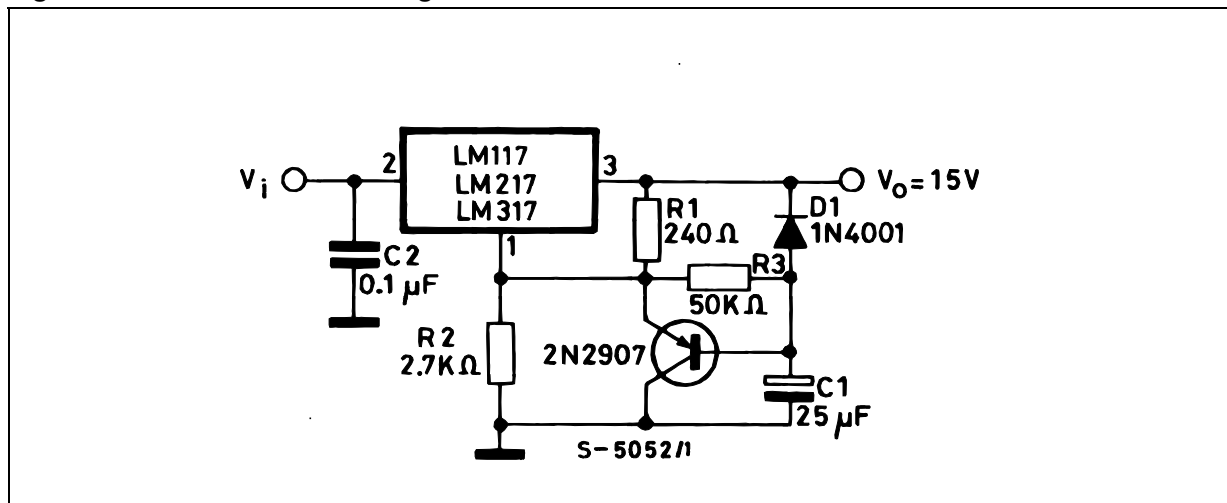


Figure 9. Current regulator

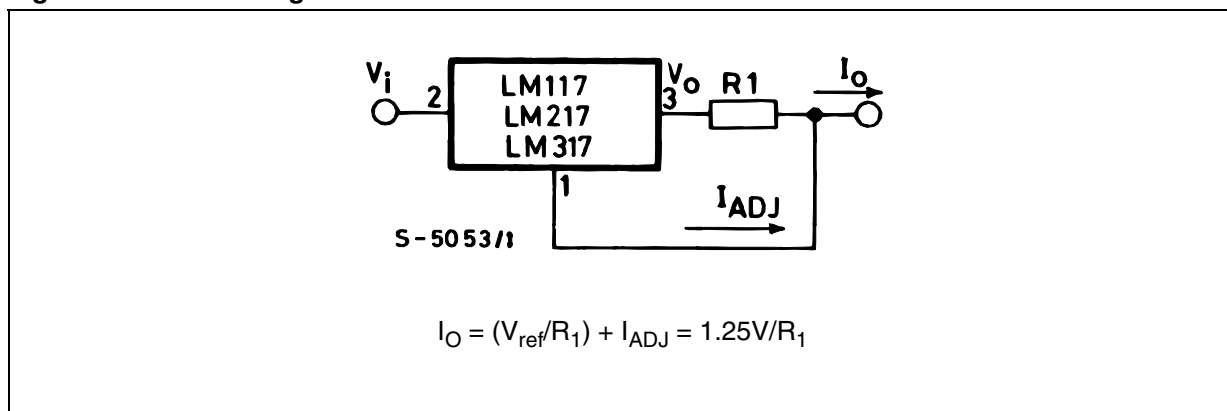


Figure 10. 5 V electronic shut-down regulator

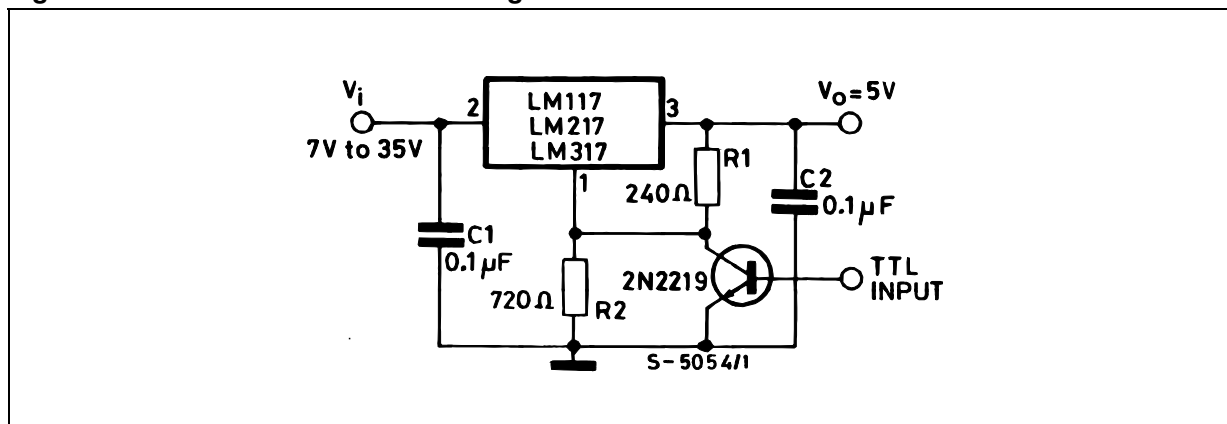
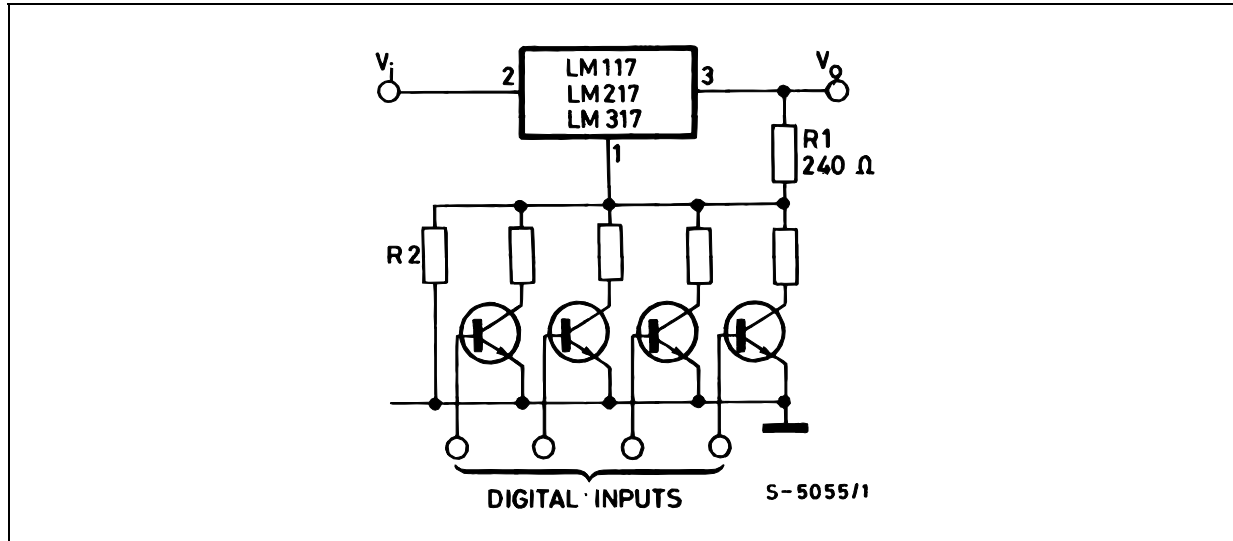
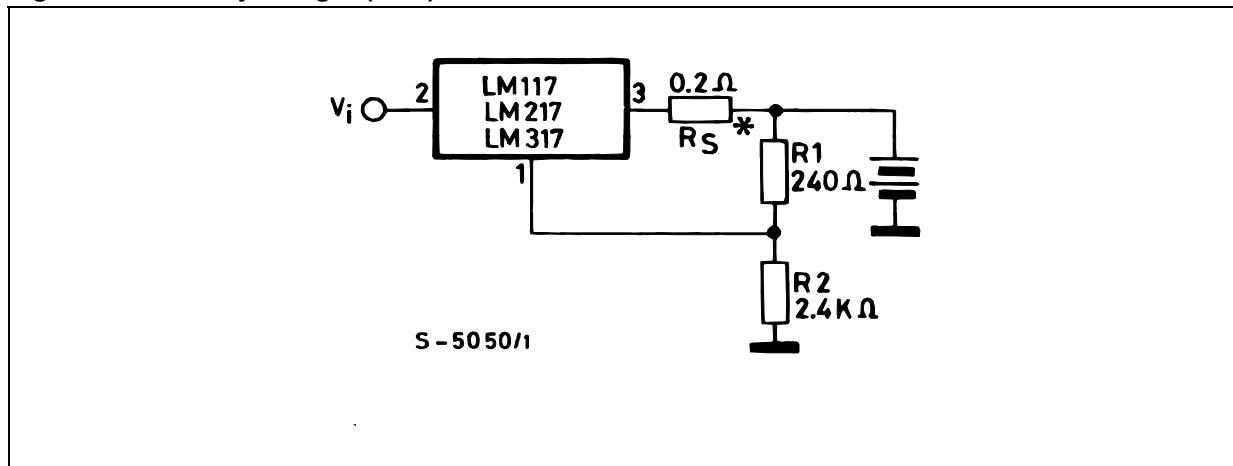


Figure 11. Digitally selected outputs



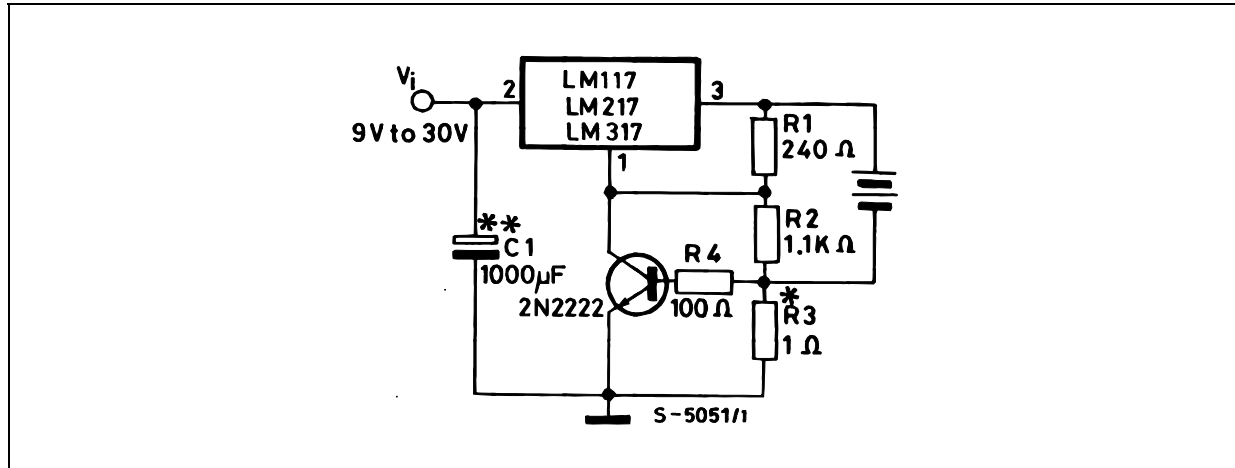
( $R_2$  sets maximum  $V_O$ )

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



\*  $R_3$  sets peak current (0.6 A for 1  $\Omega$ ).

\*\*  $C_1$  recommended to filter out input transients.

## 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. These packages have a lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

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	

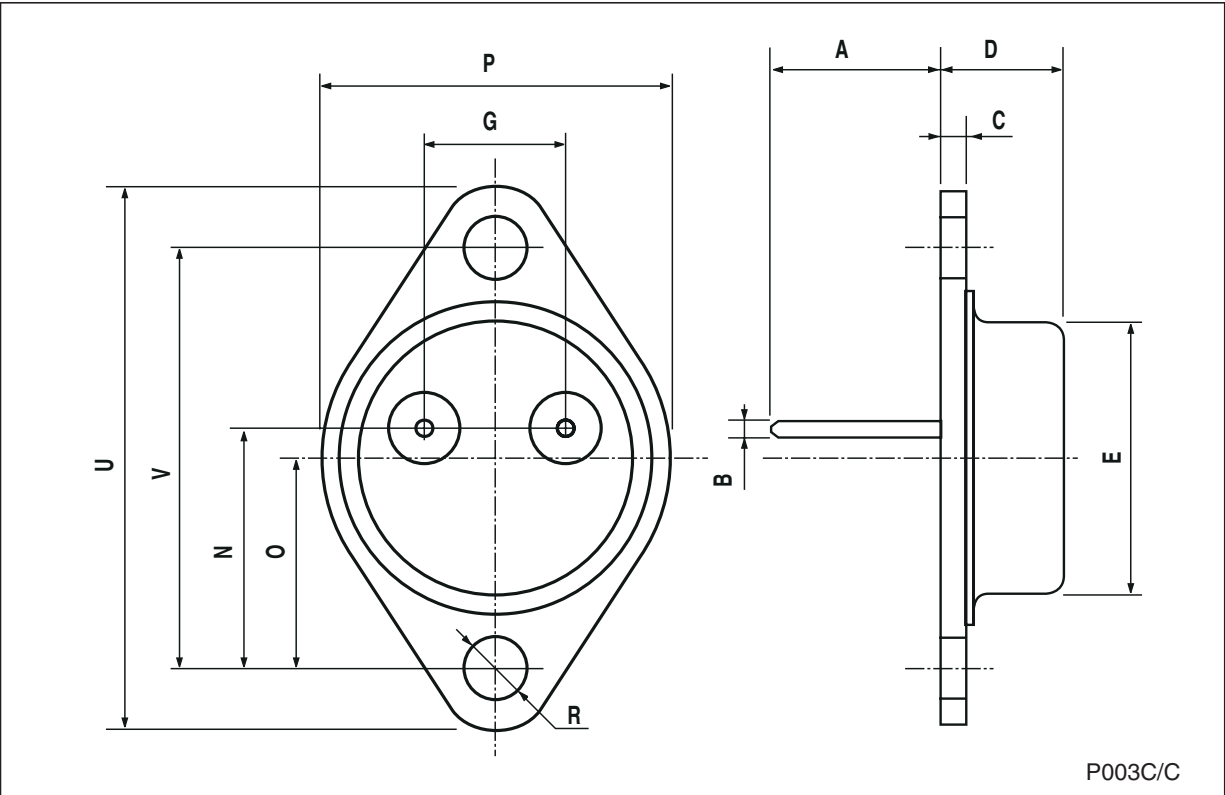


Figure 14. Drawing dimension TO-220 (type SMIC-subcon.)

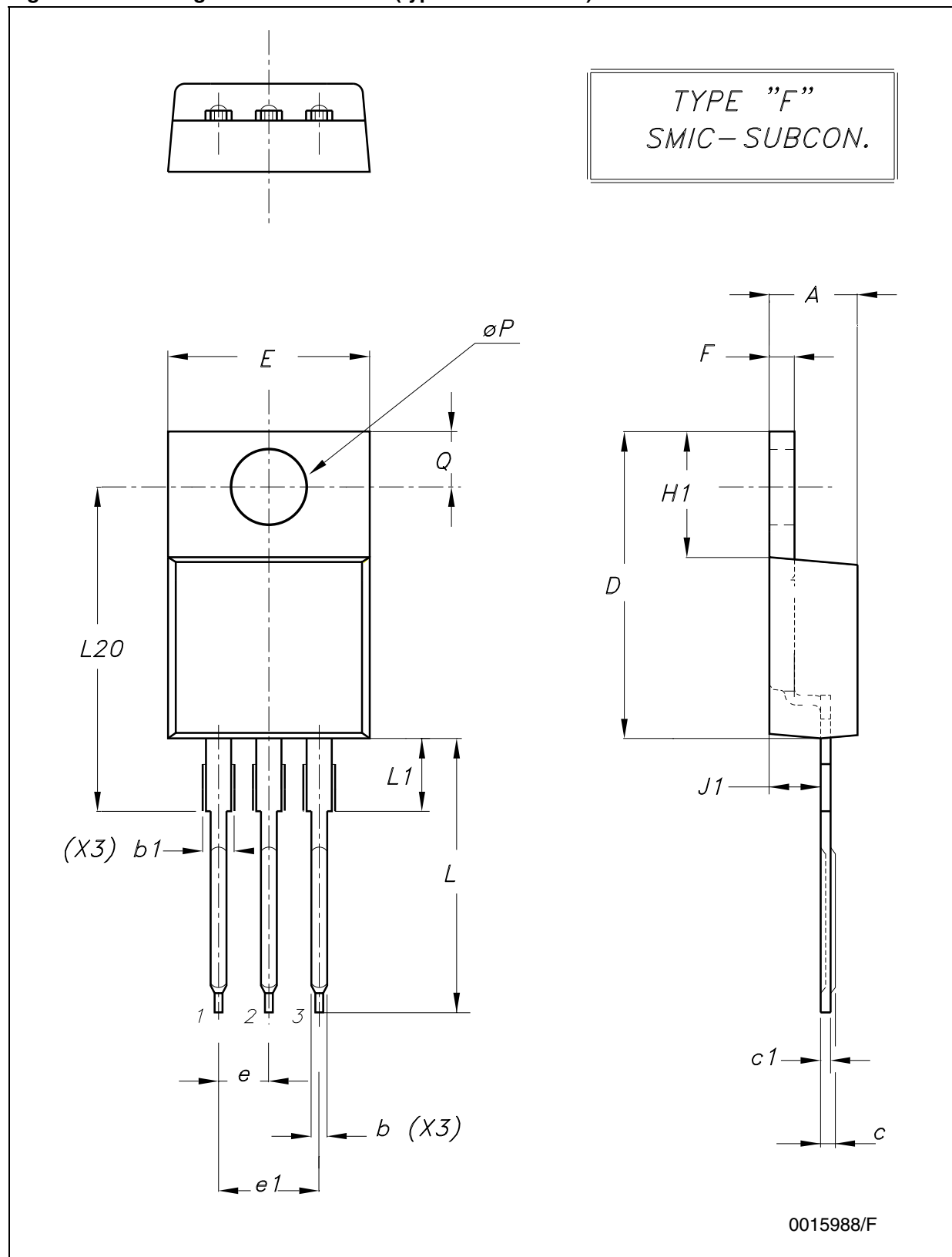


Figure 15. Drawing dimension TO-220 (type STD-ST)

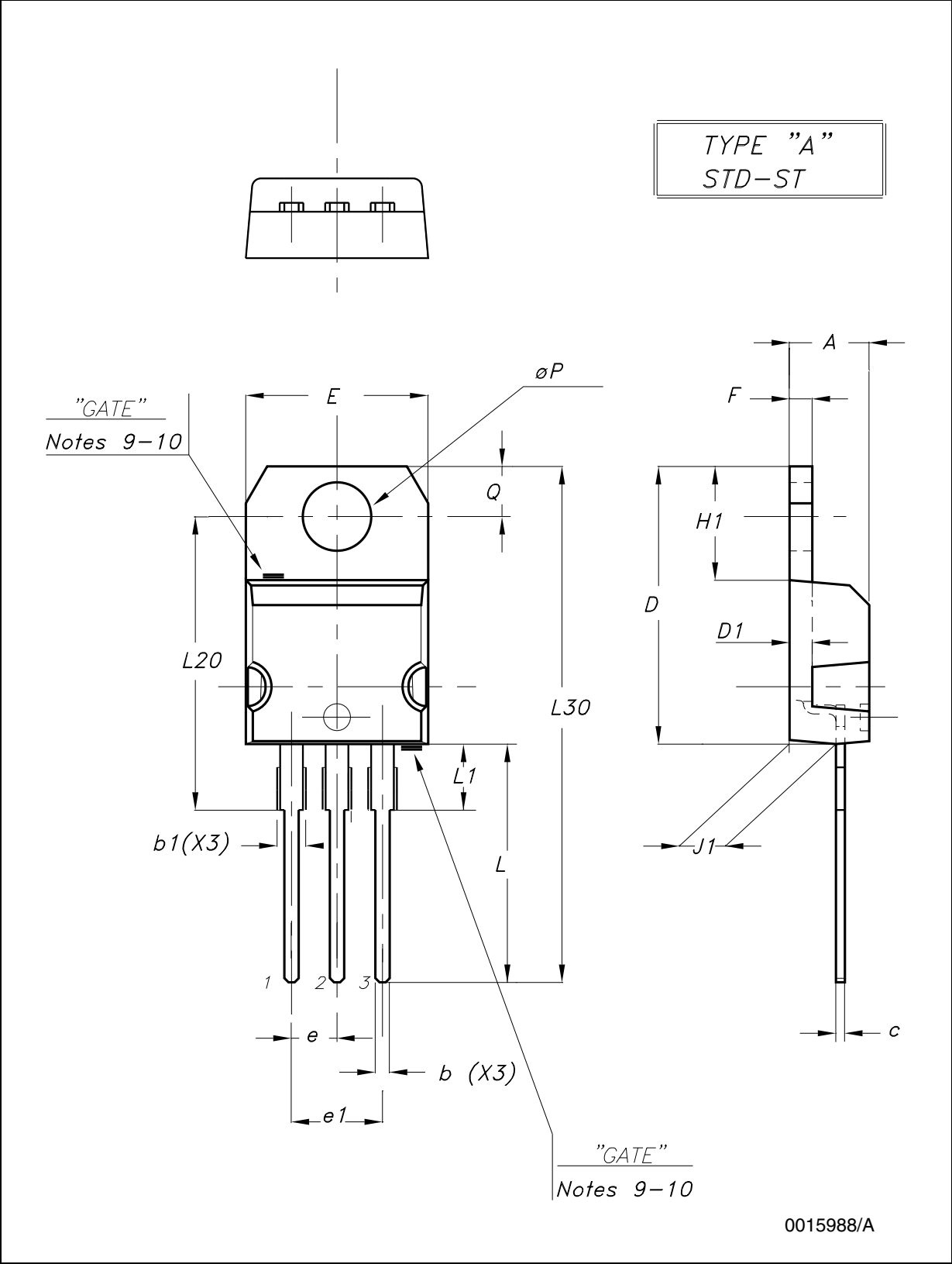




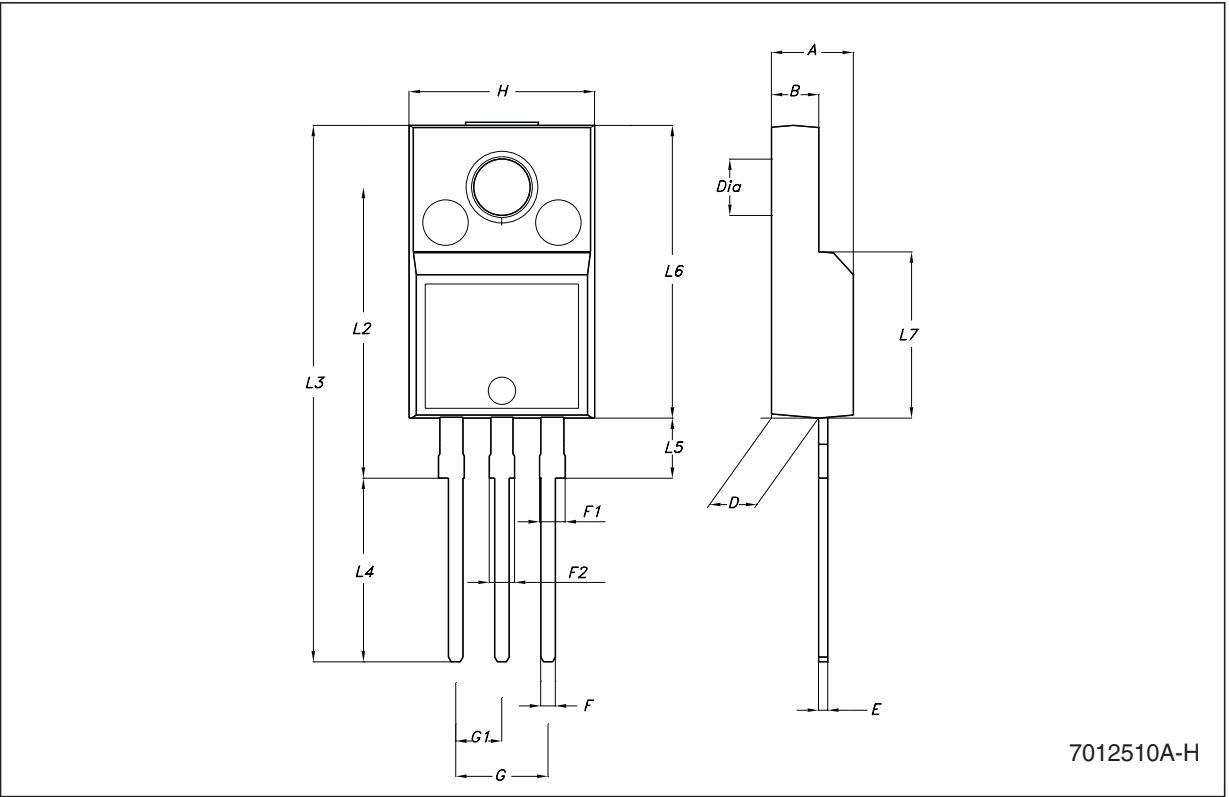
Table 6. TO-220 mechanical data

Dim.	Type STD-ST			Type SMIC-Subcon.		
	mm.			mm.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.40		4.60	4.47	4.57	4.67
A1	0.61		0.88	0.80	0.81	0.86
b1	1.14		1.70	1.15		1.44
c	0.49		0.70		0.56	
c1					0.38	
D	15.25		15.75	15.07	15.24	15.45
D1		1.27				
E	10.00		10.40	10	10.15	10.30
e	2.40		2.70	2.29	2.54	2.79
e1	4.95		5.15	4.83	5.08	5.33
F	1.23		1.32		1.27	
H1	6.20		6.60		6.24	
J1	2.40		2.72	2.04	2.67	2.92
L	13.00		14.00	13.35	13.50	13.65
L1	3.50		3.93		3.90	
L20		16.40		16.25	16.40	16.55
L30		28.90			28.74	
ØP	3.75		3.85		3.83	
Q	2.65		2.95	2.72	2.74	2.80

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

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



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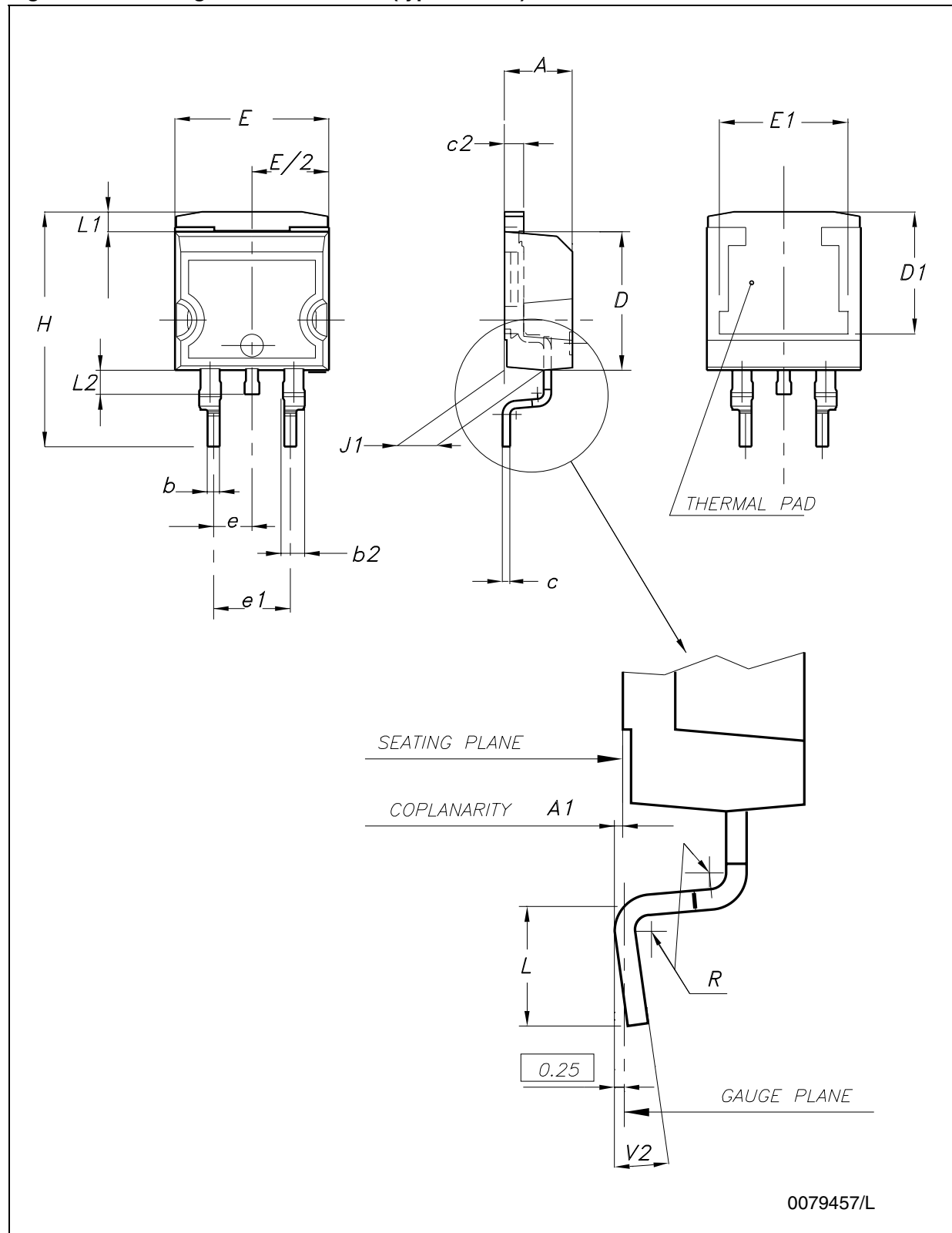
Figure 16. Drawing dimension D<sup>2</sup>PAK (type STD-ST)

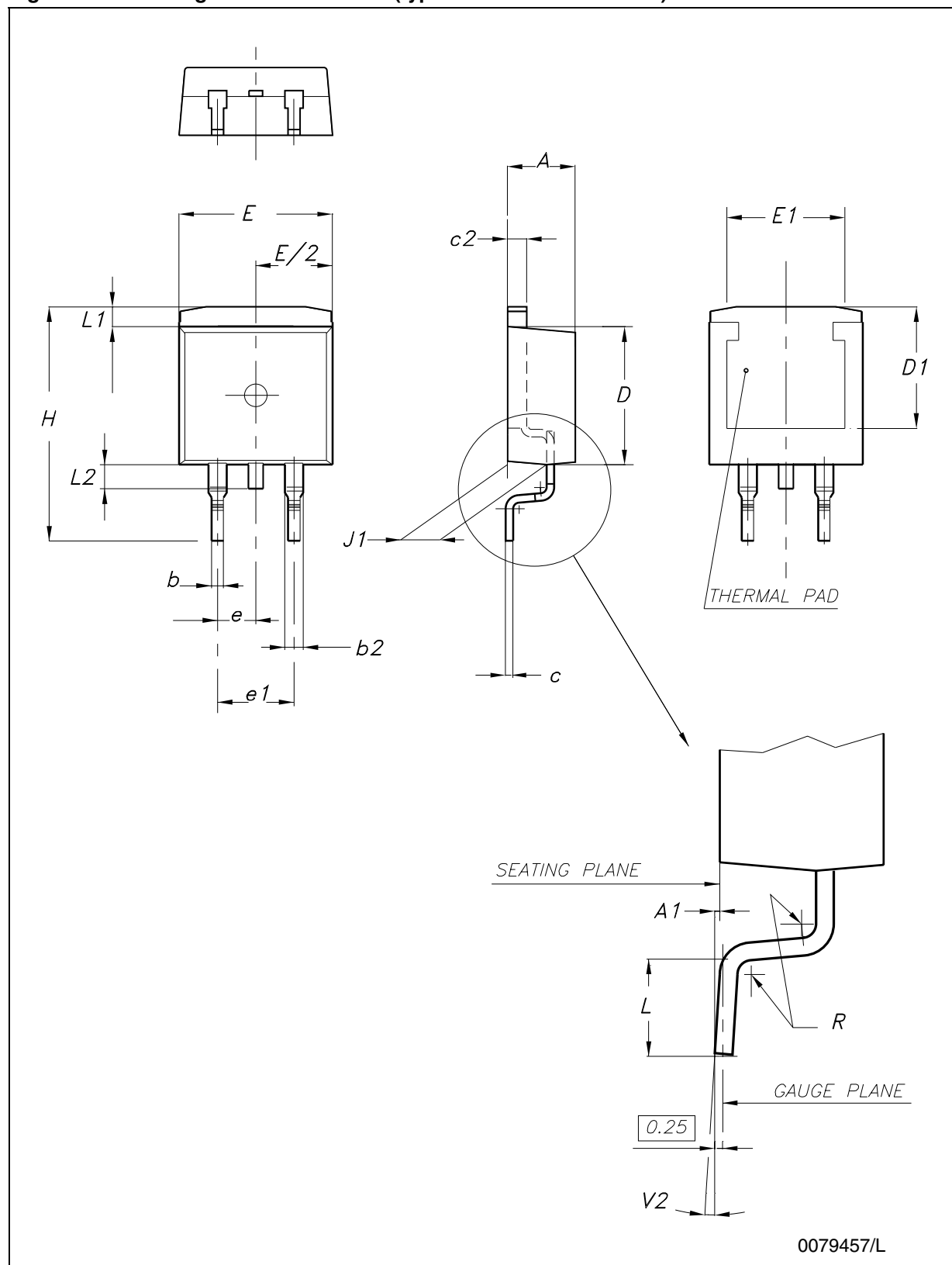
Figure 17. Drawing dimension D<sup>2</sup>PAK (type WOOSEOK-SUBCON.)

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 18. D<sup>2</sup>PAK footprint recommended data

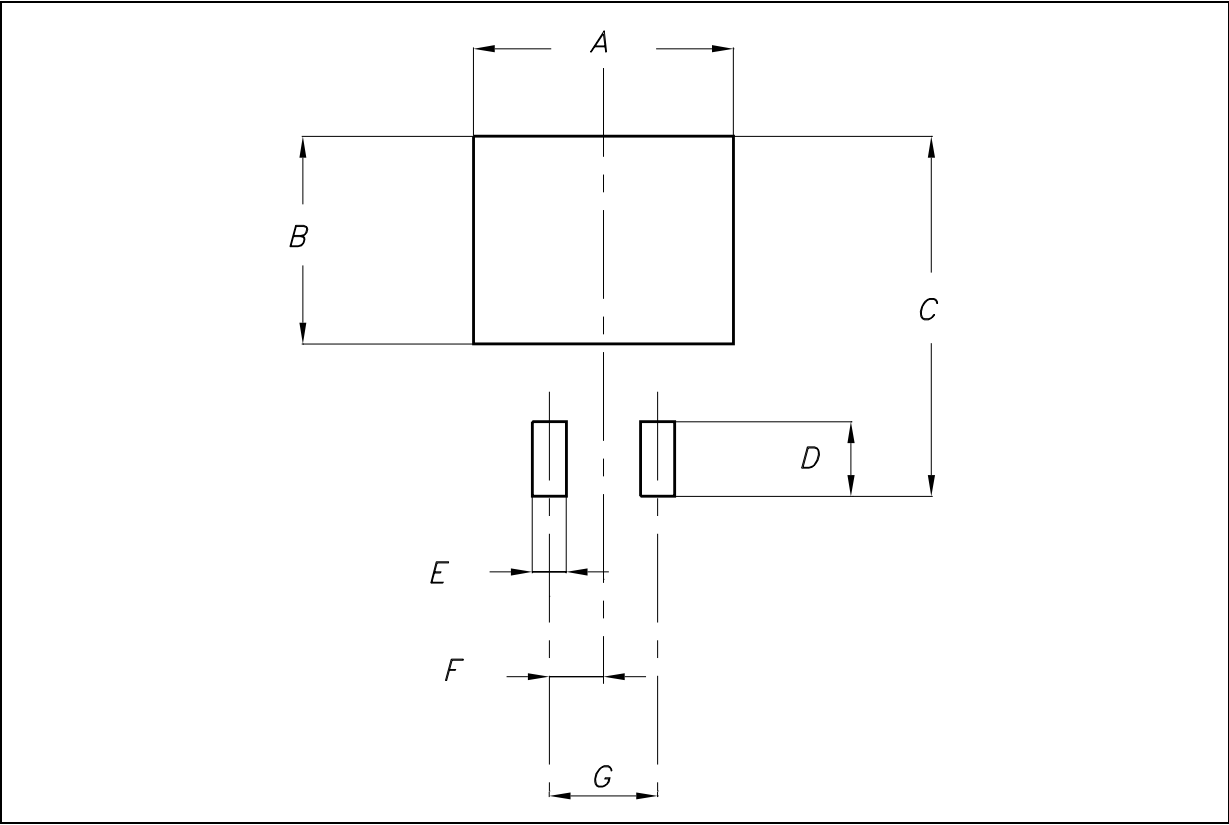
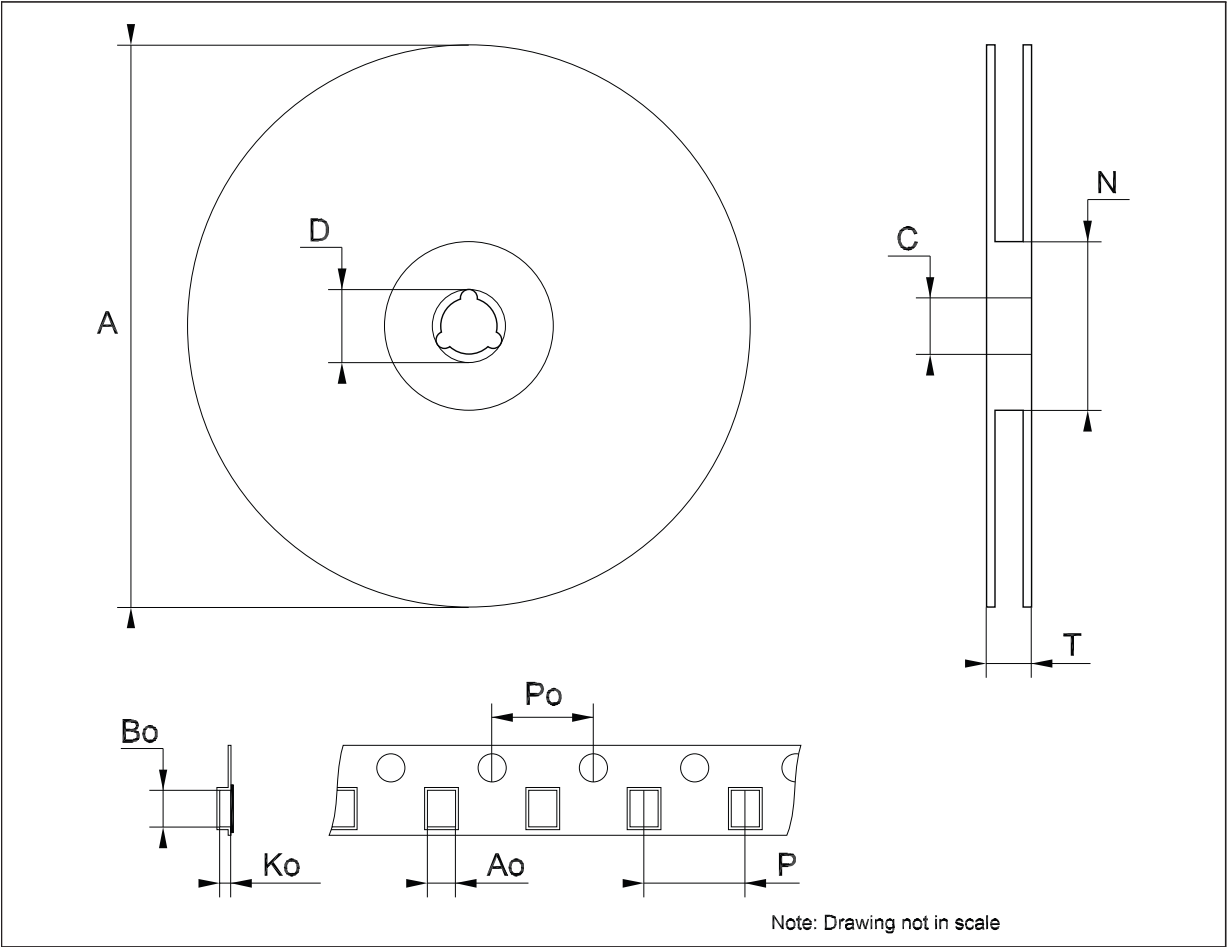


Table 8. Footprint data

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 500mA 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 15</a> , <a href="#">Figure 15 on page 16</a> and <a href="#">Table 6 on page 17</a> .



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