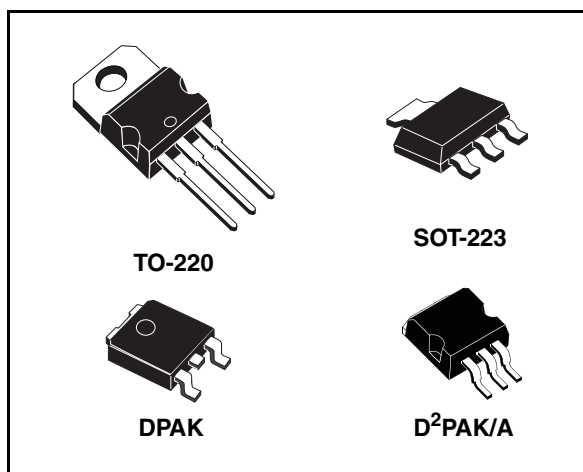


## Low drop fixed and adjustable positive voltage regulators

### Features

- Low dropout voltage  
(1.15 V typ. @  $I_{OUT} = 1\text{ A}$ , 25 °C)
- Very low quiescent current  
(5 mA typ. @ 25 °C)
- Output current up to 1 A
- Fixed output voltage of: 1.2 V, 1.8 V, 2.5 V, 3.3 V
- Adjustable version availability ( $V_{REL} = 1.25\text{ V}$ )
- Internal current and thermal limit
- Only 10  $\mu\text{F}$  for stability
- Available in  $\pm 2\%$  (at 25 °C) and 4 % in full temperature range
- High supply voltage rejection:
  - 80 dB typ. (at 25 °C)
- Temperature range: 0 °C to 125 °C



stability. Only chip trimming allows the regulator to reach a very tight output voltage tolerance, within  $\pm 2\%$  at 25 °C.

### Description

The LD1117A is a low drop voltage regulator able to provide up to 1 A of output current, available even in adjustable version ( $V_{REF} = 1.25\text{ V}$ ).

Concerning fixed versions, are offered the following Output Voltages: 1.2 V, 1.8 V, 2.5 V and 3.3 V. The device is supplied in: SOT-223, DPAK, D²PAK/A and TO-220. Surface mount packages optimize the thermal characteristics even offering a relevant space saving effect. High efficiency is assured by NPN pass transistor. Only a very common 10  $\mu\text{F}$  minimum capacitor is needed for

**Table 1. Device summary**

Part numbers	
LD1117AXX12	LD1117AXX33
LD1117AXX18	LD1117AXX
LD1117AXX25	

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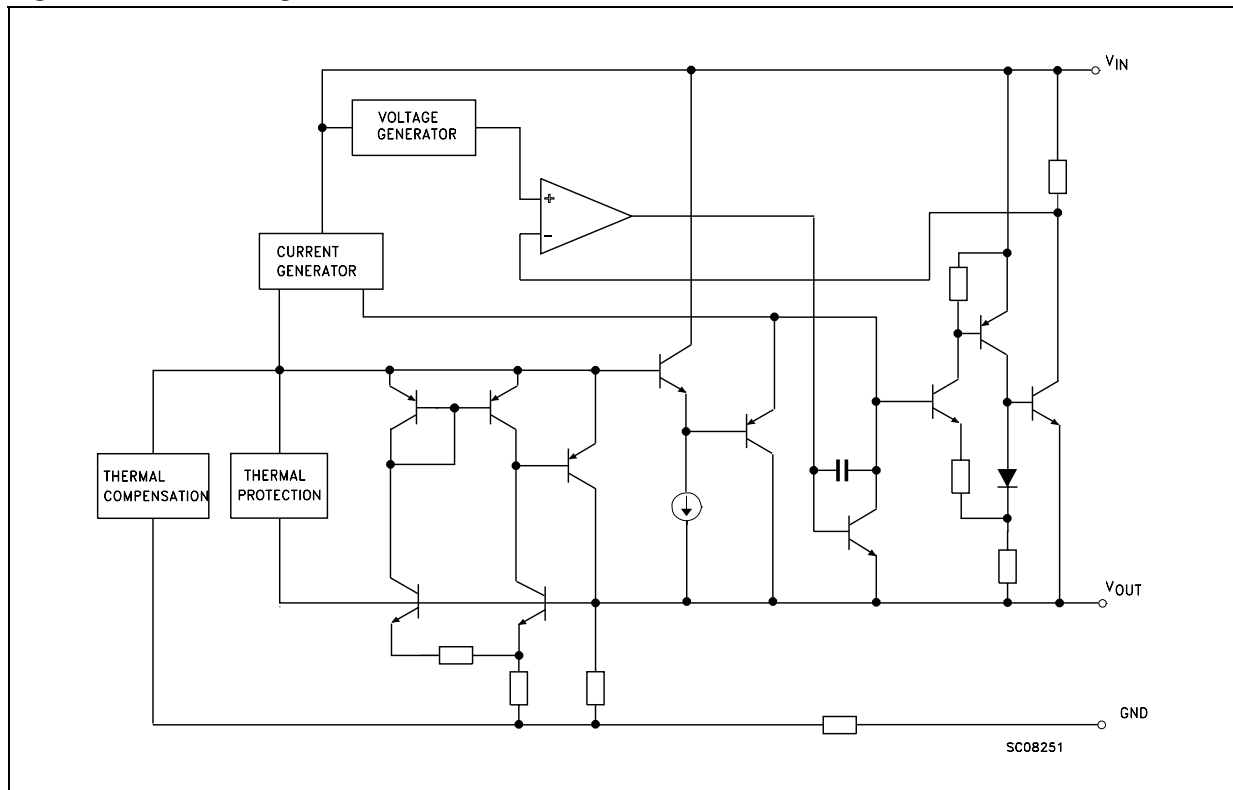
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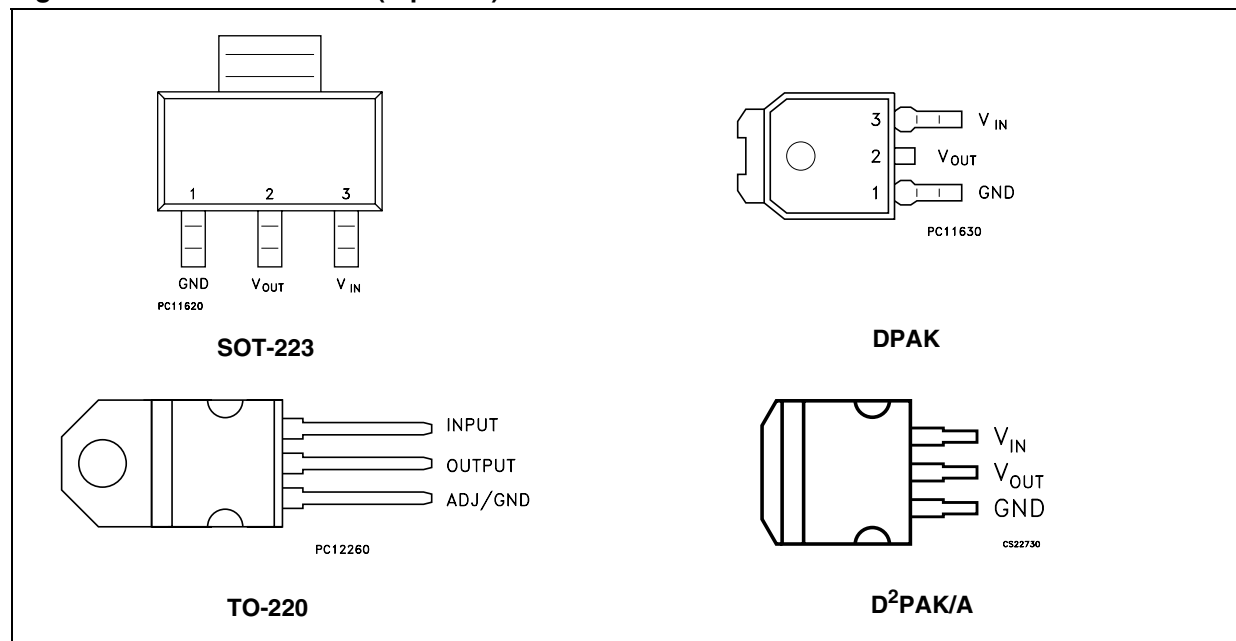
# 1 Diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)



*Note:* The TAB is connected to the  $V_{OUT}$ .

### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{IN}$	DC input voltage	15	V
$P_D$	Power dissipation	12	W
$T_{STG}$	Storage temperature range	-40 to +150	°C
$T_{OP}$	Operating junction temperature range	0 to +125	°C

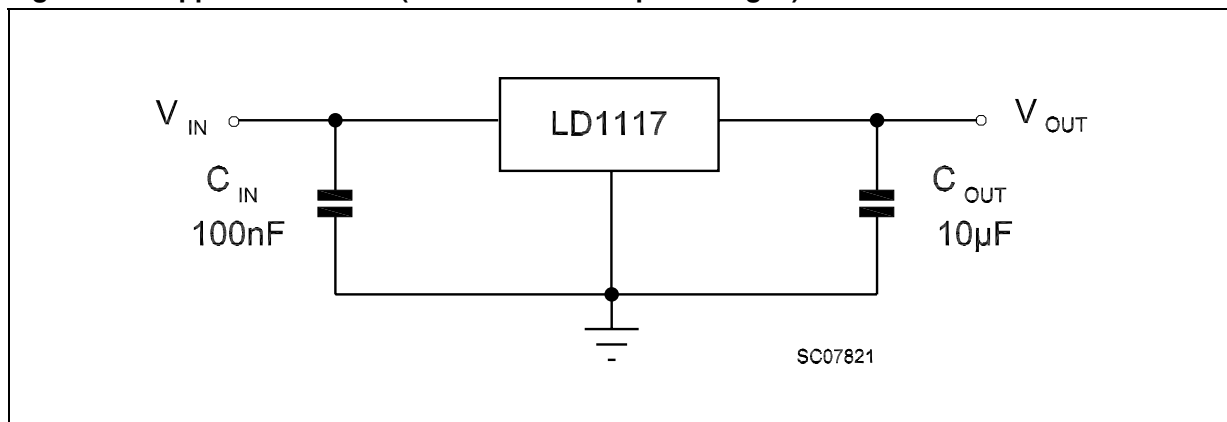
*Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied. Over the above suggested max power dissipation a short circuit could definitively damage the device.*

**Table 3. Thermal data**

Symbol	Parameter	SOT-223	D <sup>2</sup> PAK/A	DPAK	TO-220	Unit
$R_{thJC}$	Thermal resistance junction-case	15	3	8	3	°C/W
$R_{thJA}$	Thermal resistance junction-ambient				50	°C/W

## 4 Schematic application

Figure 3. Application circuit (for other fixed output voltages)



## 5 Electrical characteristics

**Table 4. Electrical characteristics of LD1117A#12**

(refer to the test circuits,  $T_J = 0$  to  $125^\circ\text{C}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C_I = 10\ \mu\text{F}$ ,  $R = 120\ \Omega$  between OUT-GND, unless otherwise specified).

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$V_I = 5.3\text{V}$ , $I_O = 10\text{mA}$ , $T_J = 25^\circ\text{C}$	1.176	1.2	1.224	V
$V_O$	Output voltage	$I_O = 0$ to $1\text{A}$ , $V_I = 2.75$ to $10\text{V}$	1.152	1.2	1.248	V
$\Delta V_O$	Line regulation	$V_I = 2.75$ to $8\text{V}$ , $I_O = 0\text{mA}$		1	6	mV
$\Delta V_O$	Load regulation	$V_I = 2.75\text{V}$ , $I_O = 0$ to $1\text{A}$		1	10	mV
$\Delta V_O$	Temperature stability			0.5		%
$\Delta V_O$	Long term stability	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
$V_I$	Operating input voltage	$I_O = 100\text{mA}$			10	V
$I_d$	Quiescent current	$V_I \leq 8\text{V}$ , $I_O = 0\text{mA}$		5	10	mA
$I_O$	Output current	$V_I - V_O = 5\text{V}$ , $T_J = 25^\circ\text{C}$	1000	1200		mA
eN	Output noise voltage	$B = 10\text{Hz}$ to $10\text{kHz}$ , $T_J = 25^\circ\text{C}$		100		$\mu\text{V}$
SVR	Supply voltage rejection	$I_O = 40\text{mA}$ , $f = 120\text{Hz}$ $V_I - V_O = 3\text{V}$ , $V_{\text{ripple}} = 1V_{\text{PP}}$	60	80		dB
$V_D$	Dropout voltage	$I_O = 100\text{mA}$		1	1.10	V
		$I_O = 500\text{mA}$		1.05	1.15	
		$I_O = 1\text{A}$		1.15	1.30	
$\Delta V_{O(\text{pwr})}$	Thermal regulation	$T_a = 25^\circ\text{C}$ , 30ms Pulse		0.08	0.2	%/W

**Table 5. Electrical characteristics of LD1117A#18**

(refer to the test circuits,  $T_J = 0$  to  $125^\circ\text{C}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C_I = 10\ \mu\text{F}$  unless otherwise specified).

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$V_I = 3.8\text{V}$ , $I_O = 10\text{mA}$ , $T_J = 25^\circ\text{C}$	1.764	1.8	1.836	V
$V_O$	Output voltage	$I_O = 0$ to $1\text{A}$ , $V_I = 3.3$ to $8\text{V}$	1.728		1.872	V
$\Delta V_O$	Line regulation	$V_I = 3.3$ to $8\text{V}$ , $I_O = 0\text{mA}$		1	6	mV
$\Delta V_O$	Load regulation	$V_I = 3.3\text{V}$ , $I_O = 0$ to $1\text{A}$		1	10	mV
$\Delta V_O$	Temperature stability			0.5		%
$\Delta V_O$	Long term stability	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
$V_I$	Operating input voltage	$I_O = 100\text{mA}$			10	V
$I_d$	Quiescent current	$V_I \leq 8\text{V}$ , $I_O = 0\text{mA}$		5	10	mA
$I_O$	Output current	$V_I - V_O = 5\text{V}$ , $T_J = 25^\circ\text{C}$	1000			mA
eN	Output noise voltage	B = 10Hz to 10kHz, $T_J = 25^\circ\text{C}$		100		$\mu\text{V}$
SVR	Supply voltage rejection	$I_O = 40\text{mA}$ , $f = 120\text{Hz}$ $V_I - V_O = 3\text{V}$ , $V_{\text{ripple}} = 1V_{PP}$	60	80		dB
$V_D$	Dropout voltage	$I_O = 100\text{mA}$		1	1.10	V
		$I_O = 500\text{mA}$		1.05	1.15	
		$I_O = 1\text{A}$		1.15	1.30	
$\Delta V_{O(pwr)}$	Thermal regulation	$T_a = 25^\circ\text{C}$ , 30ms Pulse		0.08	0.2	%/W



**Table 6. Electrical characteristics of LD1117A#25**

(refer to the test circuits,  $T_J = 0$  to  $125^\circ\text{C}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C_I = 10\ \mu\text{F}$  unless otherwise specified).

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$V_I = 4.5\text{V}$ , $I_O = 10\text{mA}$ , $T_J = 25^\circ\text{C}$	2.45	2.5	2.55	V
$V_O$	Output voltage	$I_O = 0$ to $1\text{A}$ , $V_I = 3.9$ to $8\text{V}$	2.4		2.6	V
$\Delta V_O$	Line regulation	$V_I = 3.9$ to $8\text{V}$ , $I_O = 0\text{mA}$		1	6	mV
$\Delta V_O$	Load regulation	$V_I = 3.9\text{V}$ , $I_O = 0$ to $1\text{A}$		1	10	mV
$\Delta V_O$	Temperature stability			0.5		%
$\Delta V_O$	Long term stability	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
$V_I$	Operating input voltage	$I_O = 100\text{mA}$			10	V
$I_d$	Quiescent current	$V_I \leq 10\text{V}$ , $I_O = 0\text{mA}$		5	10	mA
$I_O$	Output current	$V_I - V_O = 5\text{V}$ , $T_J = 25^\circ\text{C}$	1000	1200		mA
eN	Output noise voltage	$B = 10\text{Hz}$ to $10\text{kHz}$ , $T_J = 25^\circ\text{C}$		100		$\mu\text{V}$
SVR	Supply voltage rejection	$I_O = 40\text{mA}$ , $f = 120\text{Hz}$ $V_I - V_O = 3\text{V}$ , $V_{\text{ripple}} = 1V_{PP}$	60	80		dB
$V_D$	Dropout voltage	$I_O = 100\text{mA}$		1	1.10	V
		$I_O = 500\text{mA}$		1.05	1.15	
		$I_O = 1\text{A}$		1.15	1.30	
$\Delta V_{O(pwr)}$	Thermal regulation	$T_a = 25^\circ\text{C}$ , 30ms Pulse		0.08	0.2	%/W

**Table 7. Electrical characteristics of LD1117A#33**

(refer to the test circuits,  $T_J = 0$  to  $125^\circ\text{C}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C_I = 10\ \mu\text{F}$  unless otherwise specified).

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$V_I = 5.3\text{V}$ , $I_O = 10\text{mA}$ , $T_J = 25^\circ\text{C}$	3.234	3.3	3.366	V
$V_O$	Output voltage	$I_O = 0$ to $1\text{A}$ , $V_I = 4.75$ to $10\text{V}$	3.168		3.432	V
$\Delta V_O$	Line regulation	$V_I = 4.75$ to $8\text{V}$ , $I_O = 0\text{mA}$		1	6	mV
$\Delta V_O$	Load regulation	$V_I = 4.75\text{V}$ , $I_O = 0$ to $1\text{A}$		1	10	mV
$\Delta V_O$	Temperature stability			0.5		%
$\Delta V_O$	Long term stability	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
$V_I$	Operating input voltage	$I_O = 100\text{mA}$			10	V
$I_d$	Quiescent current	$V_I \leq 10\text{V}$ , $I_O = 0\text{mA}$		5	10	mA
$I_O$	Output current	$V_I - V_O = 5\text{V}$ , $T_J = 25^\circ\text{C}$	1000	1200		mA
eN	Output noise voltage	$B = 10\text{Hz}$ to $10\text{kHz}$ , $T_J = 25^\circ\text{C}$		100		$\mu\text{V}$
SVR	Supply voltage rejection	$I_O = 40\text{mA}$ , $f = 120\text{Hz}$ $V_I - V_O = 3\text{V}$ , $V_{\text{ripple}} = 1V_{PP}$	60	75		dB
$V_D$	Dropout voltage	$I_O = 100\text{mA}$		1	1.10	V
		$I_O = 500\text{mA}$		1.05	1.15	
		$I_O = 1\text{A}$		1.15	1.30	
$\Delta V_{O(pwr)}$	Thermal regulation	$T_a = 25^\circ\text{C}$ , 30ms Pulse		0.08	0.2	%/W

**Table 8. Electrical characteristics of LD1117A (Adjustable)**  
 (refer to the test circuits,  $T_J = 0$  to  $125^\circ\text{C}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C_I = 10\ \mu\text{F}$  unless otherwise specified).

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$V_I = 5.3\text{V}$ , $I_O = 10\text{mA}$ , $T_J = 25^\circ\text{C}$	1.225	1.25	1.275	V
$V_O$	Output voltage	$I_O = 0$ to $1\text{A}$ , $V_I = 2.75$ to $10\text{V}$	1.2		1.3	V
$\Delta V_O$	Line regulation	$V_I = 2.75$ to $8\text{V}$ , $I_O = 0\text{mA}$		1	6	mV
$\Delta V_O$	Load regulation	$V_I = 2.75\text{V}$ , $I_O = 0$ to $1\text{A}$		1	10	mV
$\Delta V_O$	Temperature stability			0.5		%
$\Delta V_O$	Long term stability	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
$V_I$	Operating input voltage	$I_O = 100\text{mA}$			10	V
$I_{\text{adj}}$	Adjustment pin current	$V_{\text{in}} \leq 10\text{V}$		60	120	$\mu\text{A}$
$\Delta I_{\text{adj}}$	Adjustment pin current change	$V_{\text{in}} - V_O = 1.4$ to $10\text{V}$ , $I_O = 10\text{mA}$ to $1\text{A}$		1	5	$\mu\text{A}$
$I_{O(\text{min})}$	Minimum load current	$V_{\text{in}} = 10\text{V}$		2	5	mA
$I_O$	Output current	$V_I - V_O = 5\text{V}$ , $T_J = 25^\circ\text{C}$	1000	1200		mA
eN	Output noise voltage	$B = 10\text{Hz}$ to $10\text{kHz}$ , $T_J = 25^\circ\text{C}$		100		$\mu\text{V}$
SVR	Supply voltage rejection	$I_O = 40\text{mA}$ , $f = 120\text{Hz}$ $V_I - V_O = 3\text{V}$ , $V_{\text{ripple}} = 1V_{\text{PP}}$	60	80		dB
$V_D$	Dropout voltage	$I_O = 100\text{mA}$		1	1.10	V
		$I_O = 500\text{mA}$		1.05	1.15	
		$I_O = 1\text{A}$		1.15	1.30	
$\Delta V_{O(\text{pwr})}$	Thermal regulation	$T_a = 25^\circ\text{C}$ , 30ms Pulse		0.08	0.2	%/W

## 6 Typical application

Figure 4. Negative supply

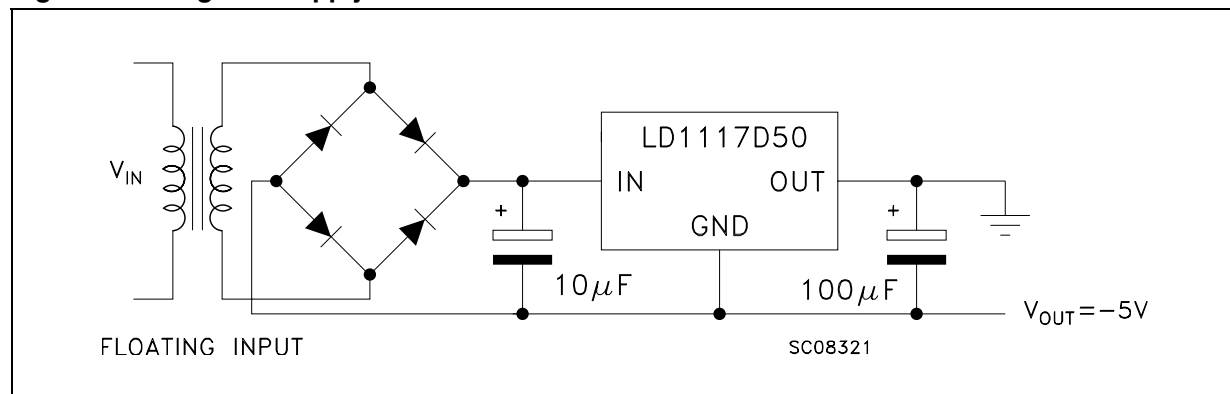


Figure 5. Active terminator for SCSI-2 bus

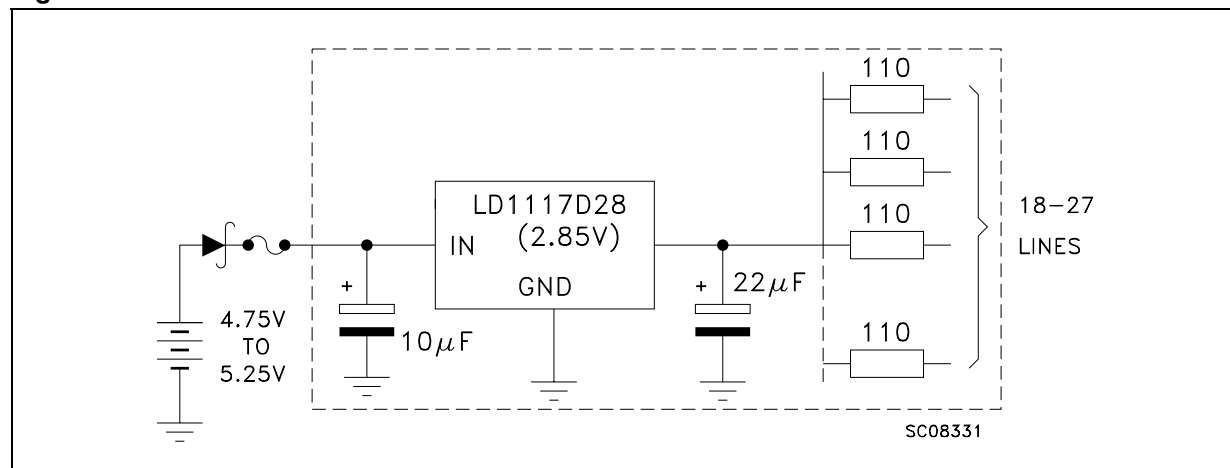
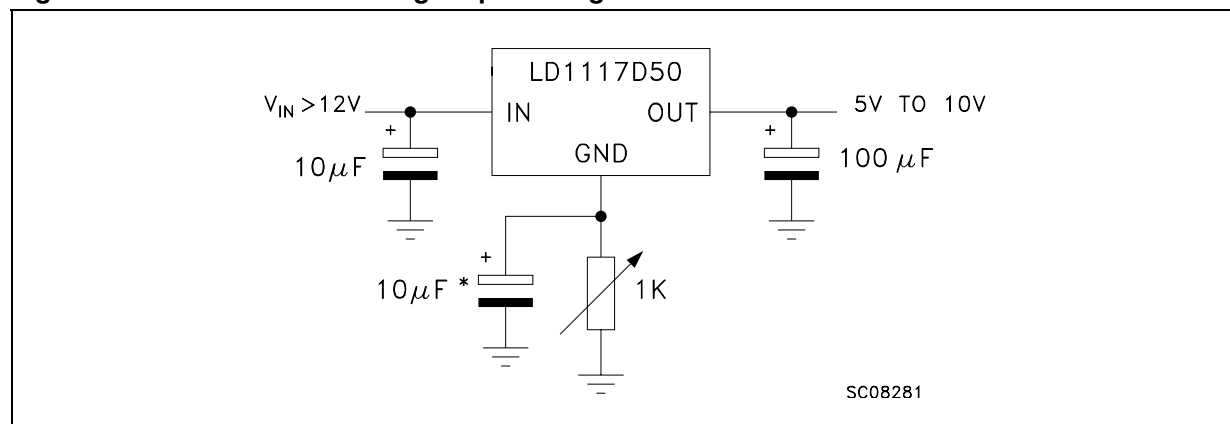


Figure 6. Circuit for increasing output voltage



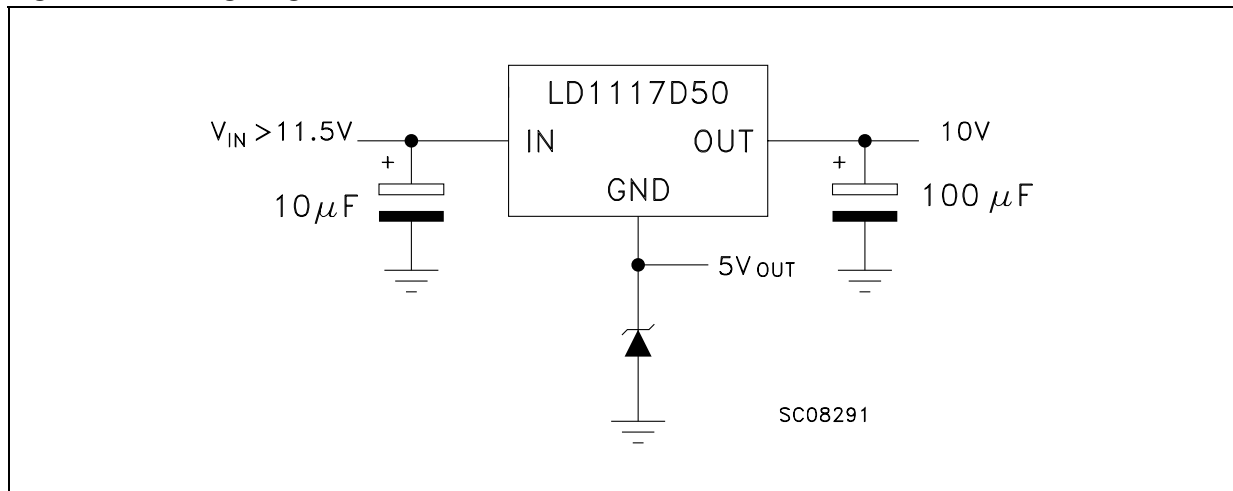
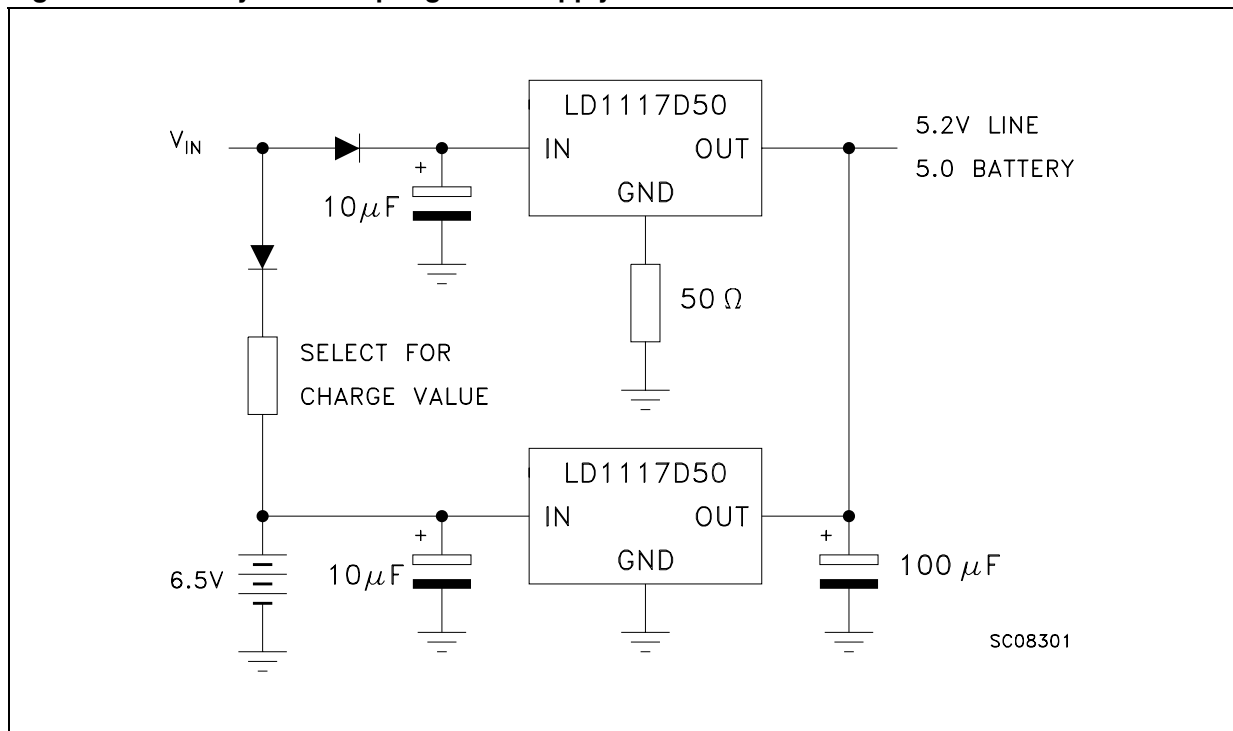
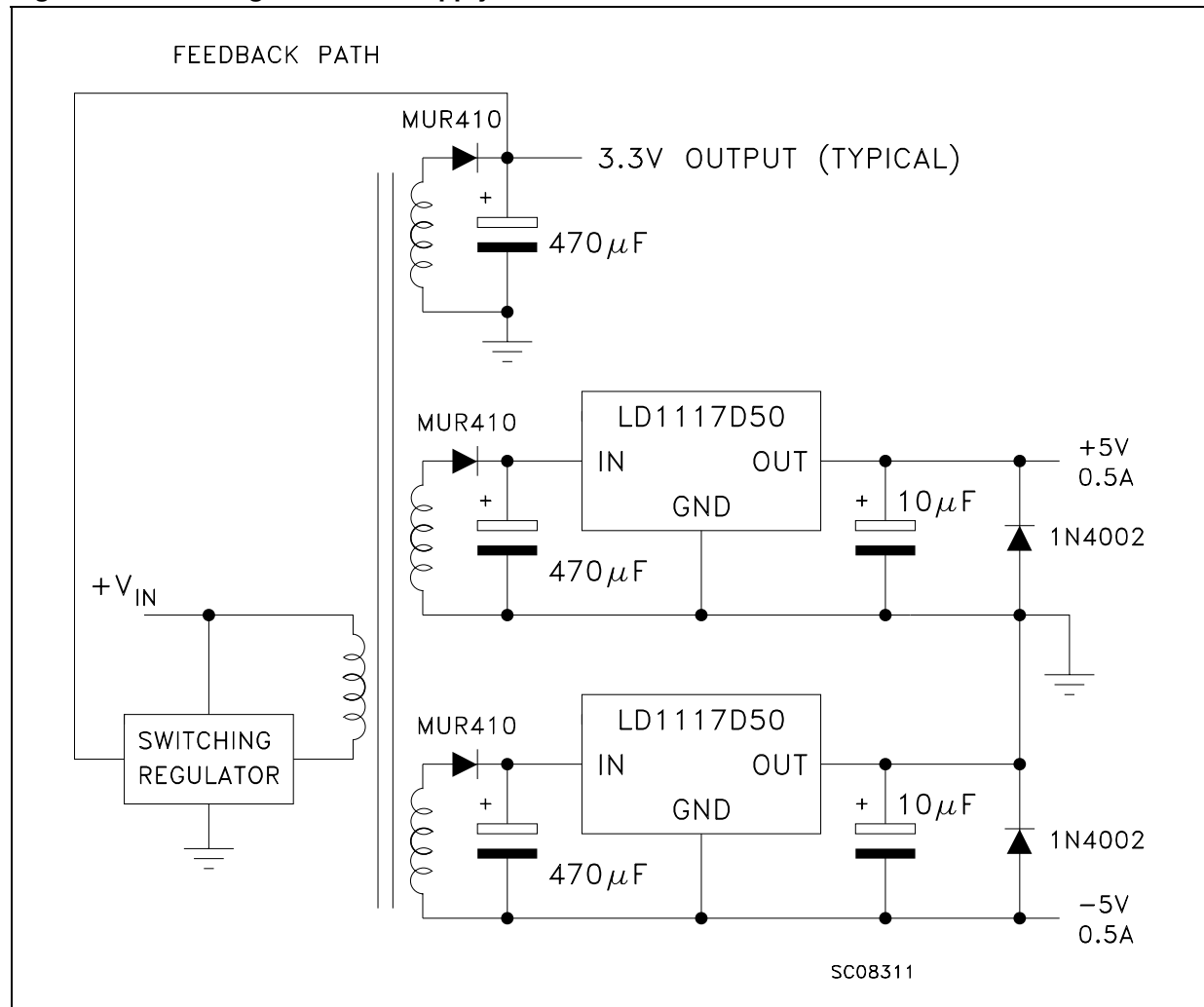
**Figure 7. Voltage regulator with reference****Figure 8. Battery backed-up regulated supply**

Figure 9. Post-regulated dual supply



## 7 LD1117A adjustable: application note

The LD1117A adjustable has a thermal stabilized  $1.25 \pm 0.012$  V reference voltage between the OUT and ADJ pins.  $I_{ADJ}$  is 60  $\mu$ A typ. (120  $\mu$ A max.) and  $\Delta I_{ADJ}$  is 1  $\mu$ A typ. (5  $\mu$ A max.).

$R_1$  is normally fixed to 120  $\Omega$ . From [Figure 7](#) we obtain:

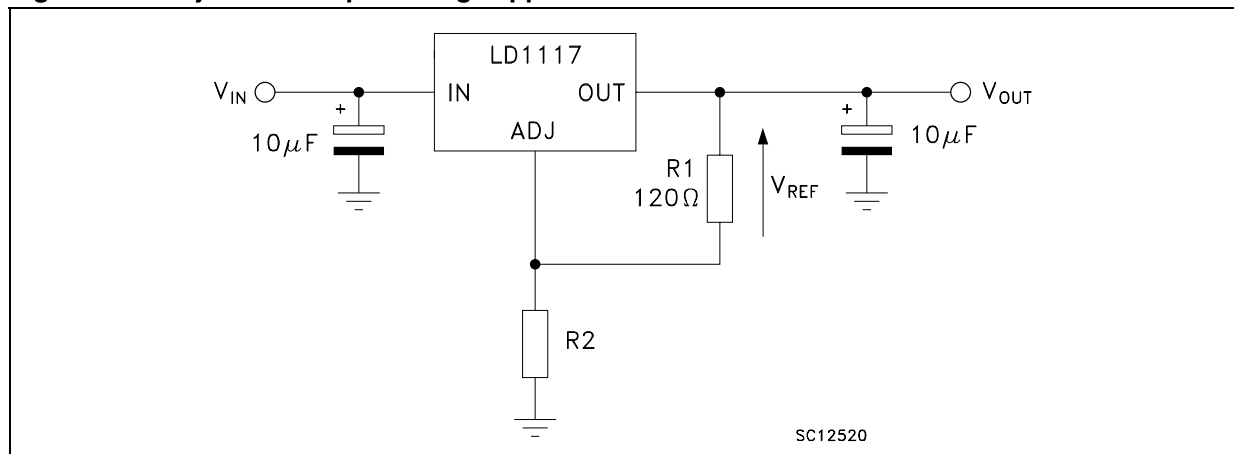
$$V_{OUT} = V_{REF} + R_2 (I_{ADJ} + I_{R1}) = V_{REF} + R_2 (I_{ADJ} + V_{REF} / R_1) = V_{REF} (1 + R_2 / R_1) + R_2 \times I_{ADJ}$$

In normal application  $R_2$  value is in the range of few  $k\Omega$ , so the  $R_2 \times I_{ADJ}$  product could not be considered in the  $V_{OUT}$  calculation; then the above expression becomes:

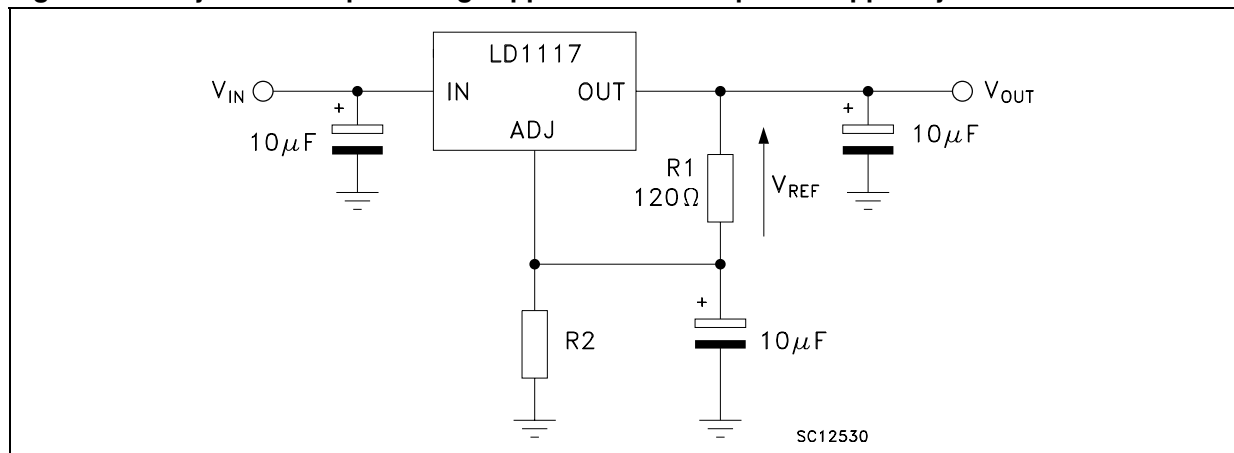
$$V_{OUT} = V_{REF} (1 + R_2 / R_1)$$

In order to have the better load regulation it is important to realize a good Kelvin connection of  $R_1$  and  $R_2$  resistors. In particular  $R_1$  connection must be realized very close to OUT and ADJ pin, while  $R_2$  ground connection must be placed as near as possible to the negative Load pin. Ripple rejection can be improved by introducing a 10  $\mu$ F electrolytic capacitor placed in parallel to the  $R_2$  resistor (see [Figure 10](#)).

**Figure 10. Adjustable output voltage application**



**Figure 11. Adjustable output voltage application with improved ripple rejection**



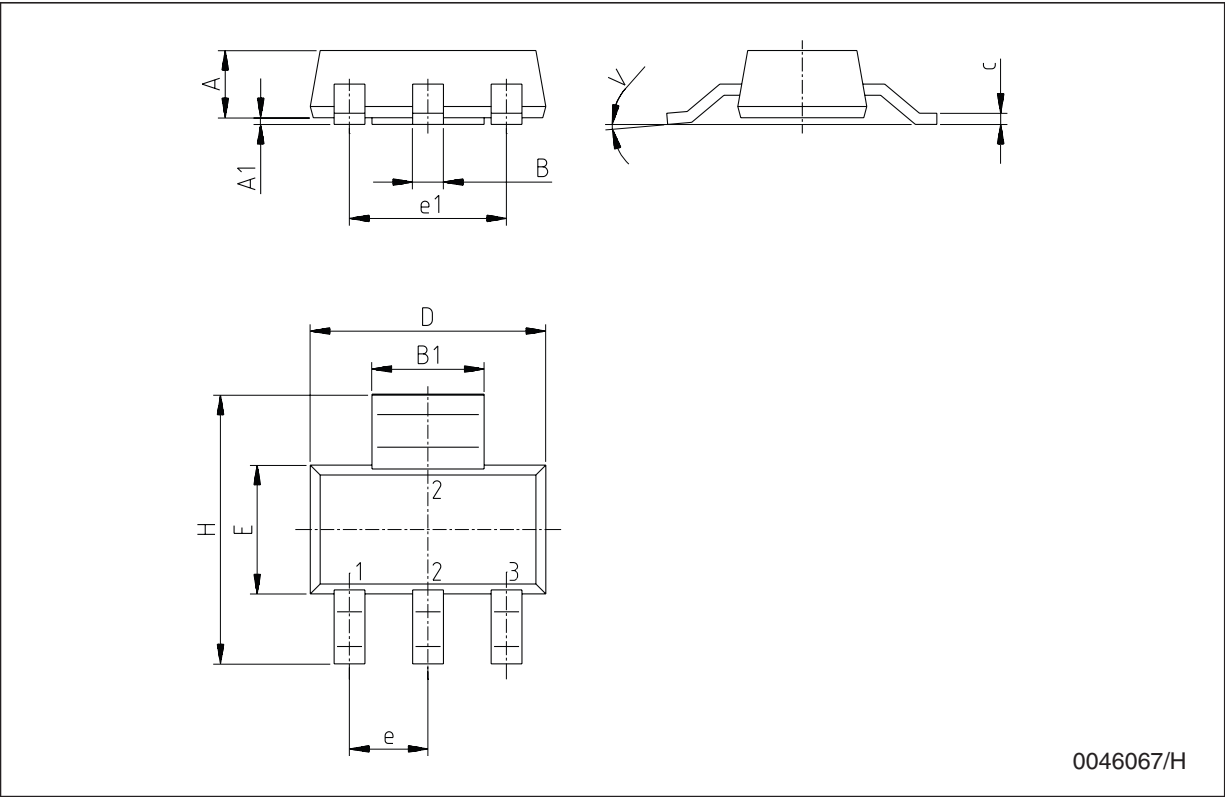
## 8 Package mechanical data

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).



SOT-223 mechanical data

Dim.	mm.			mils.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.8			70.9
A1	0.02		0.1	0.8		3.9
B	0.6	0.7	0.85	23.6	27.6	33.5
B1	2.9	3	3.15	114.2	118.1	124.0
c	0.24	0.26	0.35	9.4	10.2	13.8
D	6.3	6.5	6.7	248.0	255.9	263.8
e		2.3			90.6	
e1		4.6			181.1	
E	3.3	3.5	3.7	129.9	137.8	145.7
H	6.7	7	7.3	263.8	275.7	287.5
V			10°			10°



TO-220 mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151

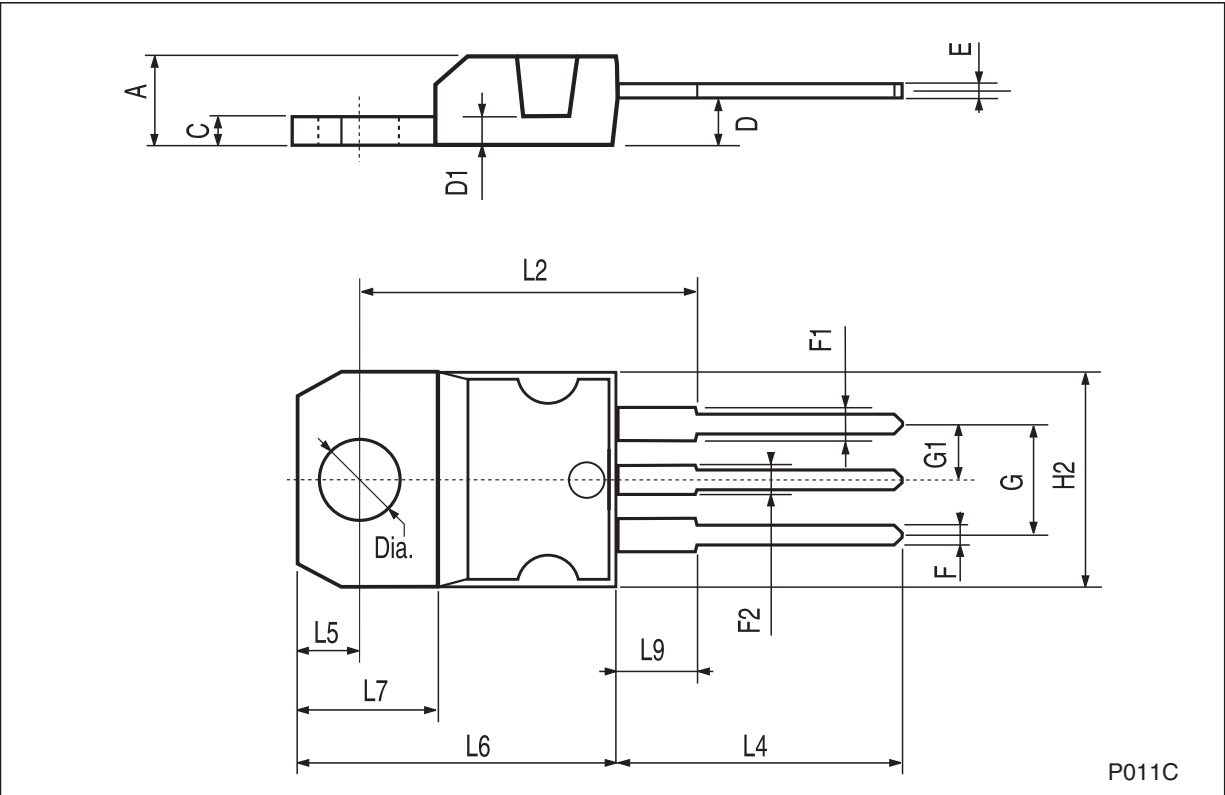


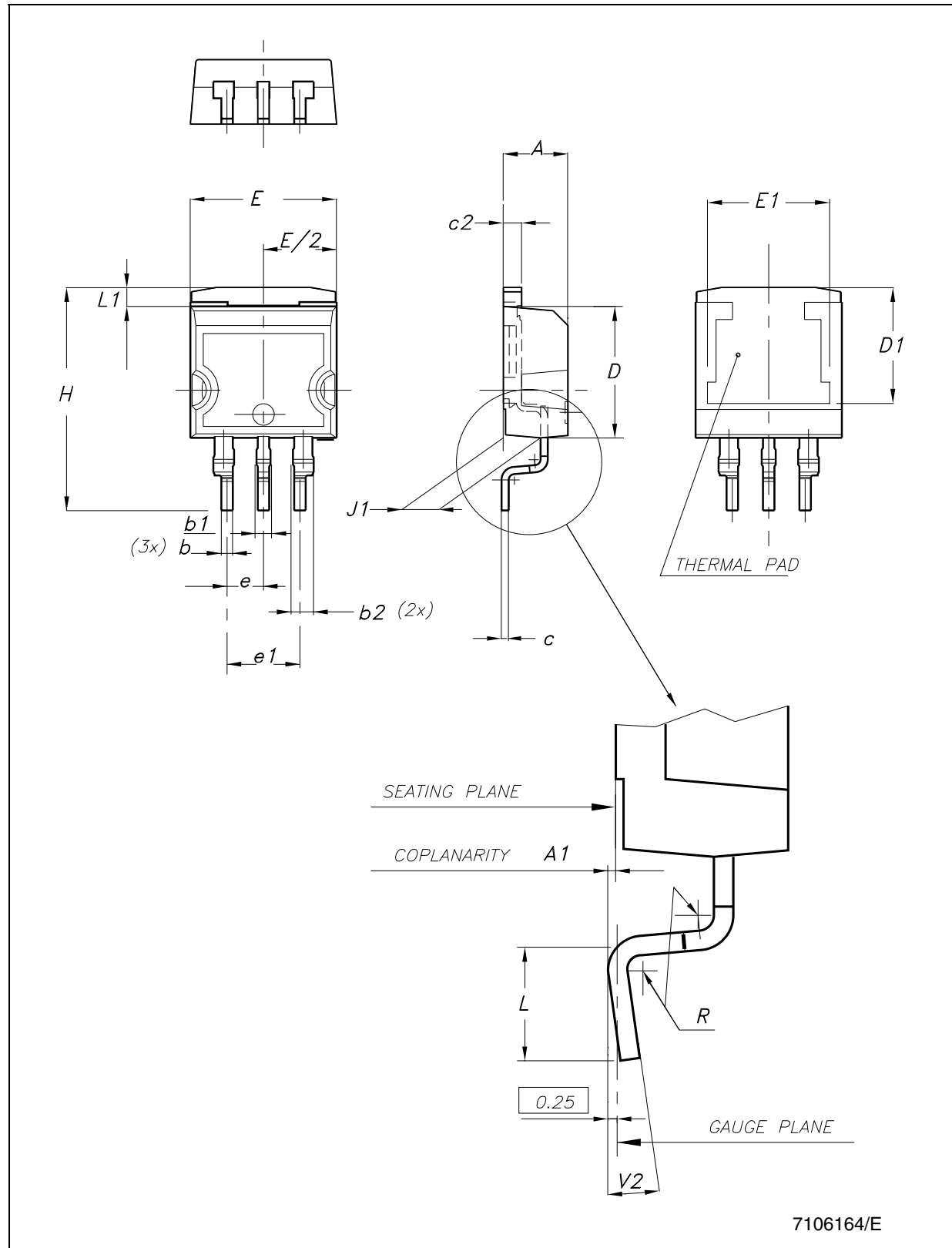
Figure 12. Drawing dimension D<sup>2</sup>PAK/A (type STD-ST)

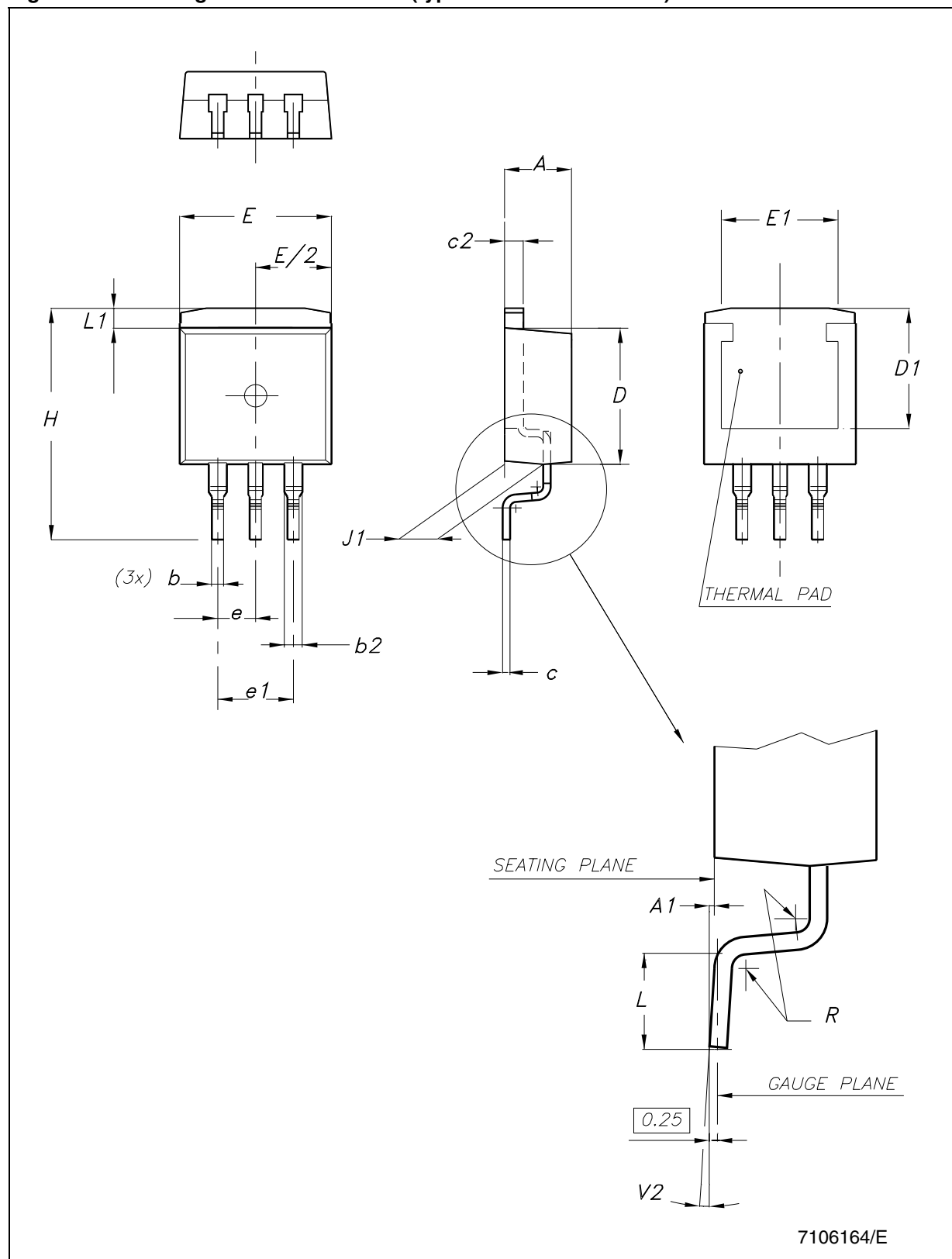
Figure 13. Drawing dimension D<sup>2</sup>PAK/A (type WOOSEOK-Subcon.)

Table 9. D<sup>2</sup>PAK/A 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
b1	0.80		1.30			
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
R		0.4			0.30	
V2	0°		8°	0°		3°

**Note:** The D<sup>2</sup>PAK/A package coming from the subcontractor Wooseok is fully compatible with the ST's package suggested footprint.

Figure 14. D<sup>2</sup>PAK/A footprint recommended data

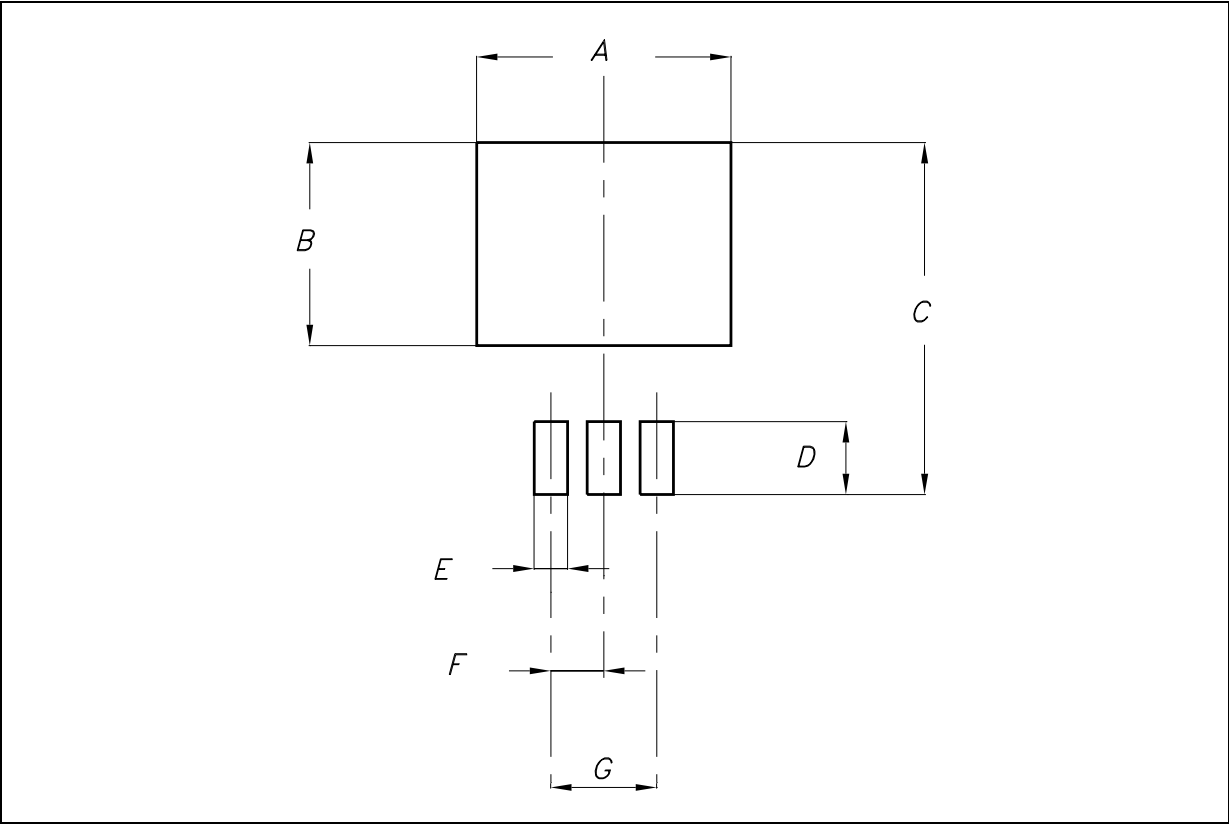
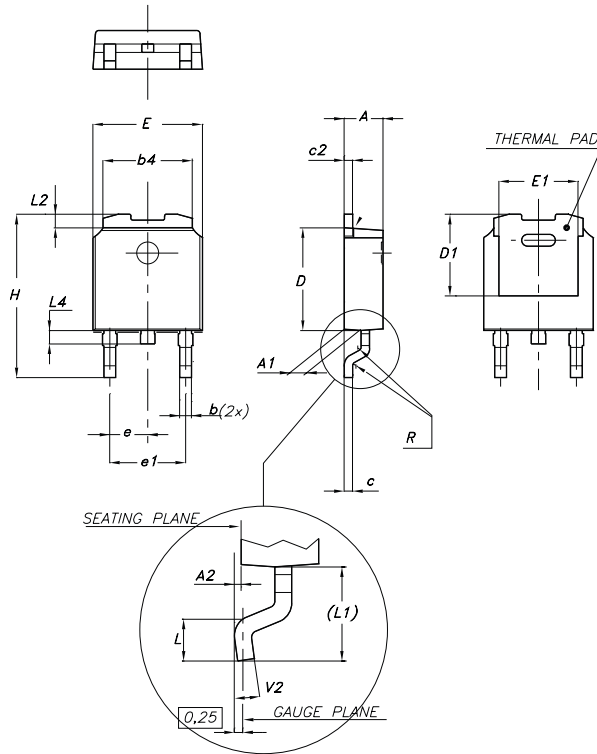


Table 10. Footprint data

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

**DPAK mechanical data**

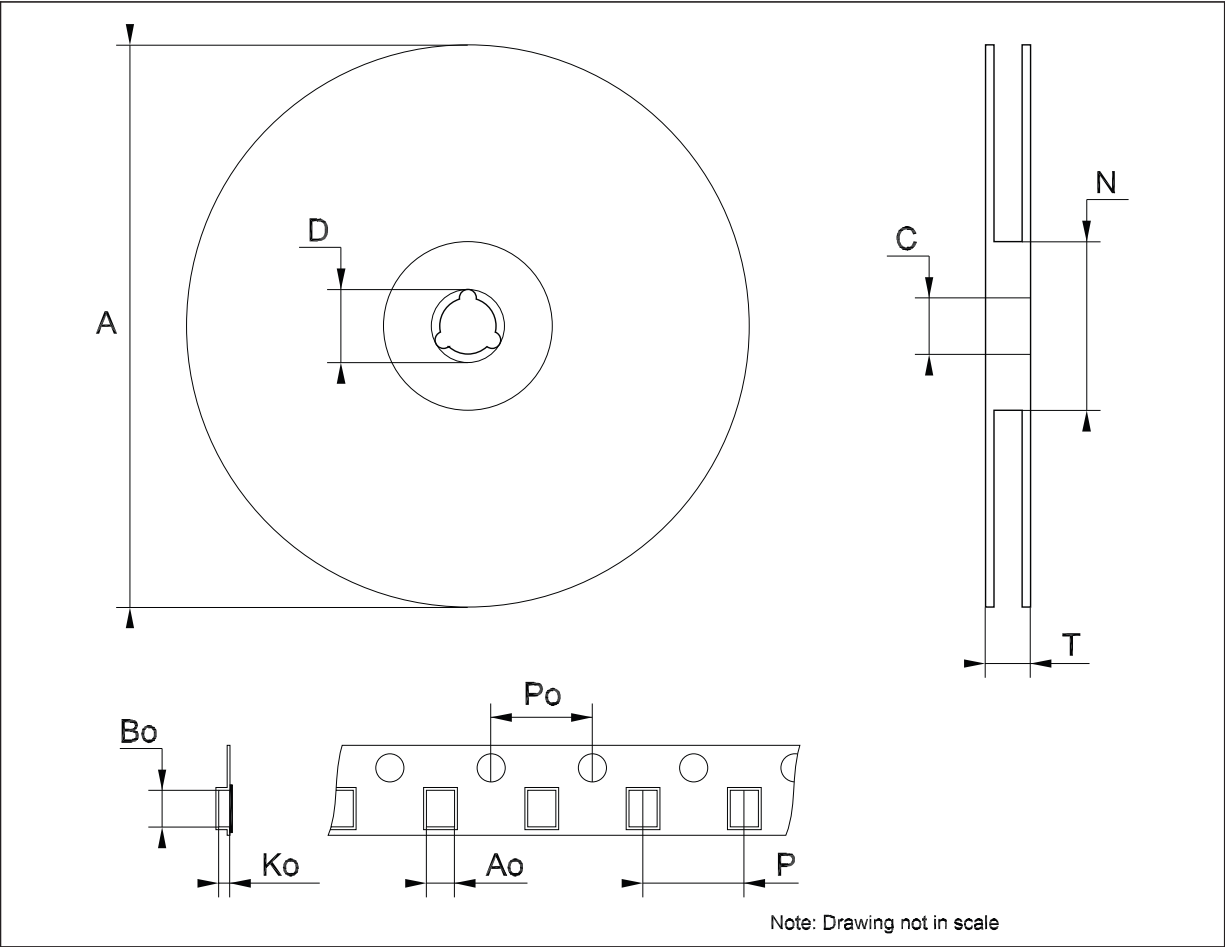
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.2		2.4	0.086		0.094
A1	0.9		1.1	0.035		0.043
A2	0.03		0.23	0.001		0.009
B	0.64		0.9	0.025		0.035
b4	5.2		5.4	0.204		0.212
C	0.45		0.6	0.017		0.023
C2	0.48		0.6	0.019		0.023
D	6		6.2	0.236		0.244
D1		5.1			0.200	
E	6.4		6.6	0.252		0.260
E1		4.7			0.185	
e		2.28			0.090	
e1	4.4		4.6	0.173		0.181
H	9.35		10.1	0.368		0.397
L	1			0.039		
(L1)		2.8			0.110	
L2		0.8			0.031	
L4	0.6		1	0.023		0.039
R		0.2			0.008	
V2	0°		8°	0°		8°



0068772-F

Tape & reel SOT223 mechanical data

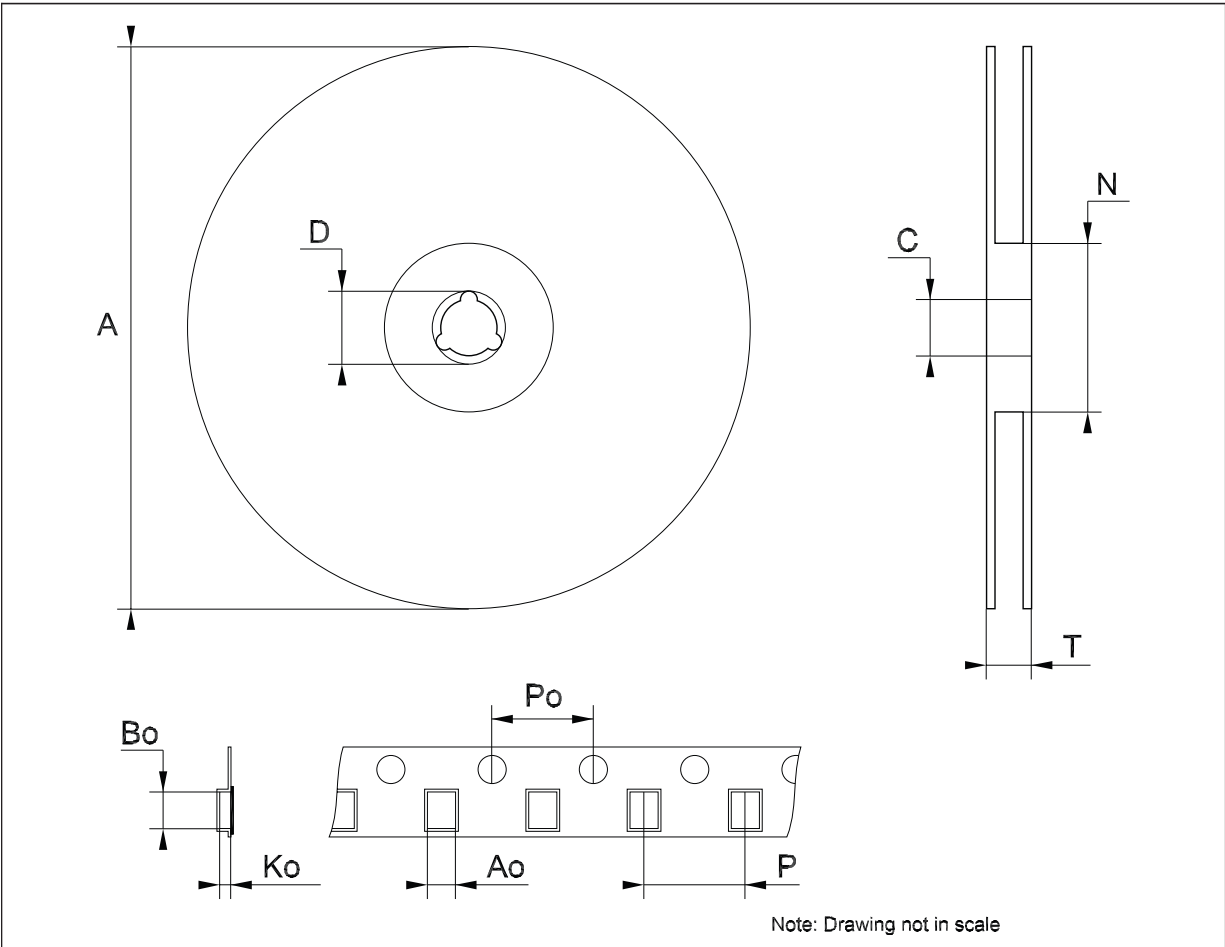
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8	13.0	13.2	0.504	0.512	0.519
D	20.2			0.795		
N	60			2.362		
T			14.4			0.567
Ao	6.73	6.83	6.93	0.265	0.269	0.273
Bo	7.32	7.42	7.52	0.288	0.292	0.296
Ko	1.78		2	0.070		0.078
Po	3.9	4.0	4.1	0.153	0.157	0.161
P	7.9	8.0	8.1	0.311	0.315	0.319





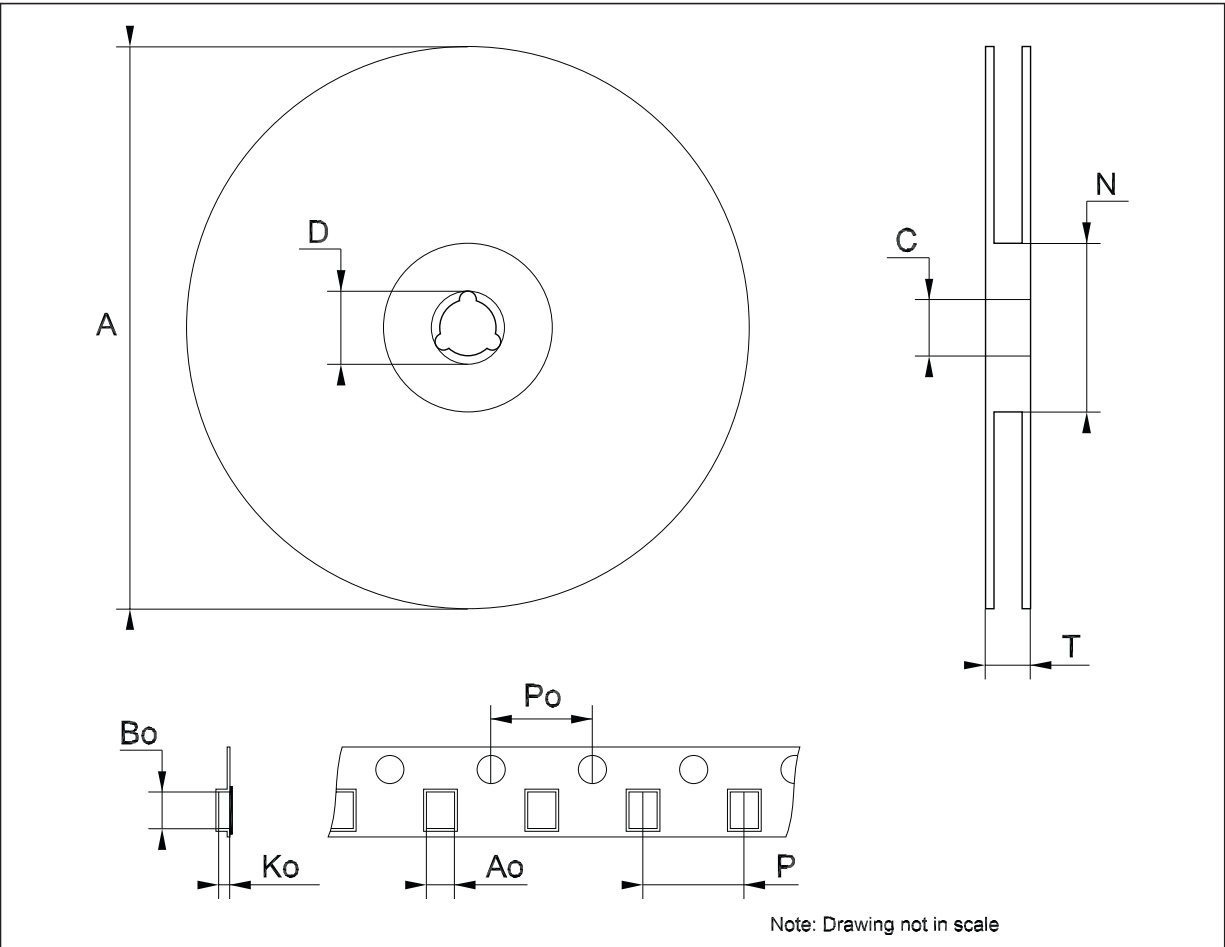
Tape & reel DPAK-PPAK mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8	13.0	13.2	0.504	0.512	0.519
D	20.2			0.795		
N	60			2.362		
T			22.4			0.882
Ao	6.80	6.90	7.00	0.268	0.272	0.276
Bo	10.40	10.50	10.60	0.409	0.413	0.417
Ko	2.55	2.65	2.75	0.100	0.104	0.105
Po	3.9	4.0	4.1	0.153	0.157	0.161
P	7.9	8.0	8.1	0.311	0.315	0.319



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



## 9 Order codes

Table 11. Order codes

Packages				Output voltage
SOT-223	DPAK	D <sup>2</sup> PAK/A	TO-220	
LD1117AS12TR	LD1117ADT12TR			1.2 V
LD1117AS18TR	LD1117ADT18TR		LD1117AV18	1.8 V
LD1117AS25TR	LD1117ADT25TR		LD1117AV25	2.5 V
LD1117AS33TR	LD1117ADT33TR		LD1117AV33	3.3 V
LD1117ASTR	LD1117ADT-TR	LD1117AD2MTR	LD1117AV	Adjustable from 1.25 to 15 V

## 10 Revision history

**Table 12. Document revision history**

Date	Revision	Changes
29-Sep-2004	11	Add new part number #12.
12-Oct-2004	12	Mistake $V_O$ max. - Table 4.
21-Apr-2005	13	Add new package - D <sup>2</sup> PAK/A.
05-Jul-2005	14	The DPAK mechanical data updated.
10-Feb-2006	15	Add new package - D <sup>2</sup> PAK/A (B Type).
20-Dec-2006	16	Change value $V_{IN}$ on <a href="#">Table 2</a> .
19-Jan-2007	17	D <sup>2</sup> PAK/A mechanical data updated and add footprint data.
28-May-2007	18	Add $I_{ADJ}$ and $\Delta I_{ADJ}$ values on <a href="#">Table 8</a> .
07-Jun-2007	19	Add $I_{O(min)}$ value on <a href="#">Table 8</a> .
15-Apr-2008	20	Modified: <a href="#">Table 11 on page 27</a> .

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