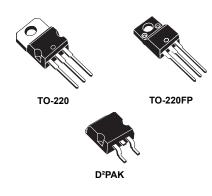




#### 1.2 V to 37 V adjustable voltage regulators



#### **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**

lectronics sales office

The LM217, LM317 are monolithic integrated circuits in TO-220, TO-220FP 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.

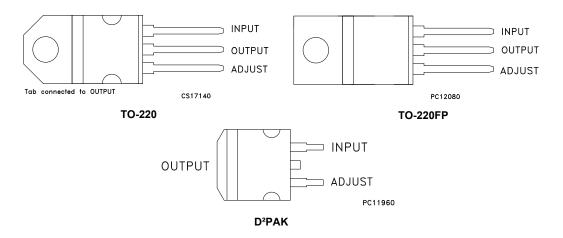
The nominal output voltage is selected by means of a resistive divider, making the device exceptionally easy to use and eliminating the stocking of many fixed regulators.

Maturity status link
LM217
LM317



# 1 Pin configuration

Figure 1. Pin connections (top view)





# 2 Maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter		Value	Unit	
V <sub>I</sub> - V <sub>O</sub>	Input-reference differential voltage	Input-reference differential voltage			
I <sub>O</sub>	Output current		Internally limited	Α	
		LM217	- 25 to 150		
T <sub>OP</sub>	Operating junction temperature for:	LM317	0 to 125	°C	
		LM317B	-40 to 125		
P <sub>D</sub>	Power dissipation		Internally limited		
T <sub>STG</sub>	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 2. Thermal data

Symbol	Parameter	D <sup>2</sup> PAK	TO-220	TO-220FP	Unit
R <sub>thJA</sub>	Thermal resistance junction-ambient	62.5	50	60	°C/W
R <sub>thJC</sub>	Thermal resistance junction-case	3	5	5	°C/W

DS0433 - Rev 20 page 3/32



# 3 Diagram

Figure 2. Schematic diagram

DS0433 - Rev 20 page 4/32



#### 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, unless otherwise specified.

Table 3. Electrical characteristics for LM217

Symbol	Parameter	Test conditions		Min.	Тур.	Max.	Unit
Δ۷ο	Line regulation	line regulation $V_1 - V_0 = 3 \text{ to } 40 \text{ V}$		0.01	0.02	%/V	
Δν0		V  - V() = 3 to 40 V			0.02	0.05	70/ V
		V <sub>O</sub> ≤ 5 V	T <sub>J</sub> = 25°C		5	15	mV
ΔVO	Load regulation	$I_O = 10 \text{ mA to } I_{MAX}$			20	50	IIIV
700	Load regulation	V <sub>O</sub> ≥ 5 V,	T <sub>J</sub> = 25°C		0.1	0.3	%
		$I_O = 10 \text{ mA to } I_{MAX}$			0.3	1	70
I <sub>ADJ</sub>	Adjustment pin current				50	100	μA
Δl <sub>ADJ</sub>	Adjustment pin current	$V_I - V_O = 2.5 \text{ to } 40 \text{ V } I_O = 10 \text{ m/s}$	A to I <sub>MAX</sub>		0.2	5	μA
V <sub>REF</sub>	Reference voltage	$V_I - V_O = 2.5 \text{ to } 40 \text{ V } I_O = 10 \text{ mA to } I_{MAX}$ $P_D \le P_{MAX}$		1.2	1.25	1.3	٧
ΔV <sub>O</sub> /V <sub>O</sub>	Output voltage temperature stability				1		%
I <sub>O(min)</sub>	Minimum load current	V <sub>I</sub> - V <sub>O</sub> = 40 V			3.5	5	mA
	Marianonalandarona	$V_{I} - V_{O} \le 15 \text{ V}, P_{D} < P_{MAX}$		1.5	2.2		
I <sub>O(max)</sub>	Maximum load current	$V_{I} - V_{O} = 40 \text{ V}, P_{D} < P_{MAX}, T_{J} = 25^{\circ}\text{C}$		0.4			Α
eN	Output noise voltage (percentage of $V_O$ )	B = 10 Hz to 100 kHz, T <sub>J</sub> = 25°C			0.003		%
C) /D	Supply voltage rejection $^{(1)}$ $T_J = 25^{\circ}C$ , $f = 120 \text{ Hz}$	T 25°C f - 120 U-	C <sub>ADJ</sub> = 0		65		4D
SVR		IJ = 25 C, I = 120 HZ	C <sub>ADJ</sub> = 10 μF	66	80		dB

<sup>1.</sup>  $C_{ADJ}$  is connected between adjust pin and ground.

DS0433 - Rev 20 page 5/32

 $V_I$  -  $V_O$  = 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 4. Electrical characteristics for LM317

Symbol	Parameter	Test conditions		Min.	Тур.	Max.	Unit
۸۱/ -	Line regulation	$V_1 - V_0 = 3 \text{ to } 40 \text{ V}$			0.01	0.04	%/V
ΔV <sub>O</sub>	Line regulation	v <sub>1</sub> - v <sub>0</sub> - 3 to 40 v			0.02	0.07	%/V
		V <sub>O</sub> ≤ 5 V	T <sub>J</sub> = 25°C		5	25	mV
۸۱/ -	Lood regulation	$I_O$ = 10 mA to $I_{MAX}$			20	70	IIIV
ΔV <sub>O</sub>	Load regulation	V <sub>O</sub> ≥ 5 V,	T <sub>J</sub> = 25°C		0.1	0.5	%
		$I_O$ = 10 mA to $I_{MAX}$			0.3	1.5	70
I <sub>ADJ</sub>	Adjustment pin current				50	100	μA
Δ1	A discrete and win assume of	V <sub>I</sub> - V <sub>O</sub> = 2.5 to 40 V		0.0	0.0	5	
Δl <sub>ADJ</sub>	Adjustment pin current	$I_O$ = 10 mA to $I_{MAX}$	ΛX		0.2	J	μA
		$V_{I} - V_{O} = 2.5 \text{ to } 40 \text{ V}$					
V <sub>REF</sub>	Reference voltage (between pin 3 and pin 1)	$I_O = 10 \text{ mA to } I_{MAX}$			1.25	1.3	V
		$P_D \le P_{MAX}$					
ΔV <sub>O</sub> /V <sub>O</sub>	Output voltage temperature stability				1		%
I <sub>O(min)</sub>	Minimum load current	$V_{I} - V_{O} = 40 \text{ V}$			3.5	10	mA
1	Maximum load current	V <sub>I</sub> - V <sub>O</sub> ≤ 15 V, P <sub>D</sub> < P <sub>MA</sub>	Х	1.5 2.2	2.2		A
I <sub>O(max)</sub>	Maximum load current	V <sub>I</sub> - V <sub>O</sub> = 40 V, P <sub>D</sub> < P <sub>MAX</sub> , T <sub>J</sub> = 25°C		0.4			- A
eN	Output noise voltage (percentage of $V_{\rm O}$ )	B = 10 Hz to 100 kHz, T <sub>J</sub> = 25°C			0.003		%
SVR	Cumply voltage rejection (1)	T <sub>.1</sub> = 25°C, f = 120 Hz	C <sub>ADJ</sub> = 0		65		dB
SVK	Supply voltage rejection (1)	1J - 20 C, I - 120 HZ	C <sub>ADJ</sub> = 10 μF	66	80		uв

<sup>1.</sup> C<sub>ADJ</sub> is connected between adjust pin and ground.

DS0433 - Rev 20 page 6/32



 $V_I$  -  $V_O$  = 5 V,  $I_O$  = 500 mA,  $I_{MAX}$  = 1.5 A and  $P_{MAX}$  = 20 W,  $T_J$  = -40 to 125 °C, unless otherwise specified.

Table 5. Electrical characteristics for LM317B

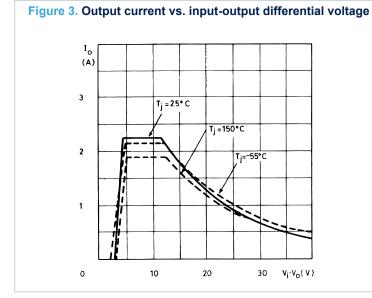
Symbol	Parameter	Test conditions		Min.	Тур.	Max.	Unit
ΔV <sub>O</sub>	Line regulation	V <sub>I</sub> - V <sub>O</sub> = 3 to 40 V	T <sub>J</sub> = 25°C		0.01	0.04	%/V
Δν0	Line regulation	V  - V() = 3 to 40 V			0.02	0.07	%/V
		V <sub>O</sub> ≤ 5 V	T <sub>J</sub> = 25°C		5	25	mV
ΔVO	Load regulation	$I_O = 10 \text{ mA to } I_{MAX}$			20	70	IIIV
ΔνΟ	Load regulation	V <sub>O</sub> ≥ 5 V,	T <sub>J</sub> = 25°C		0.1	0.5	%
		$I_O = 10 \text{ mA to } I_{MAX}$			0.3	1.5	70
I <sub>ADJ</sub>	Adjustment pin current				50	100	μA
Λ1	A disconnection as a second	V <sub>I</sub> - V <sub>O</sub> = 2.5 to 40 V		0.2	_		
Δl <sub>ADJ</sub>	Adjustment pin current	$I_O$ = 10 mA to 500 mA			0.2	5	μA
		V <sub>I</sub> - V <sub>O</sub> = 2.5 to 40 V					
V <sub>REF</sub>	Reference voltage (between pin 3 and pin 1)	I <sub>O</sub> = 10 mA to 500 mA			1.25	1.3	V
		$P_D \le P_{MAX}$					
ΔV <sub>O</sub> /V <sub>O</sub>	Output voltage temperature stability				1		%
I <sub>O(min)</sub>	Minimum load current	$V_{I} - V_{O} = 40 \text{ V}$			3.5	10	mA
	Marine and a second	V <sub>I</sub> - V <sub>O</sub> ≤ 15 V, P <sub>D</sub> < P <sub>MA</sub>	Х	1.5 2.2	2.2		
I <sub>O(max)</sub>	Maximum load current	V <sub>I</sub> - V <sub>O</sub> = 40 V, P <sub>D</sub> < P <sub>MAX</sub> , T <sub>J</sub> = 25°C		0.4			_ A
eN	Output noise voltage (percentage of V <sub>O</sub> )	B = 10 Hz to 100 kHz, T <sub>J</sub> = 25°C			0.003		%
C) /D		T = 25°C f = 120 H=	C <sub>ADJ</sub> = 0		65		40
SVR	Supply voltage rejection (1)	T <sub>J</sub> = 25°C, f = 120 Hz	C <sub>ADJ</sub> = 10 μF	66	80		dB

<sup>1.</sup> C<sub>ADJ</sub> is connected between adjust pin and ground.

DS0433 - Rev 20 page 7/32



# 5 Typical characteristics



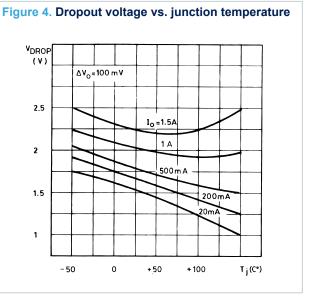
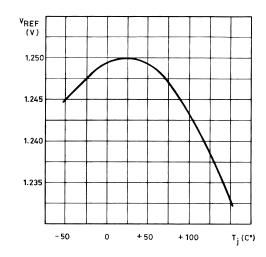


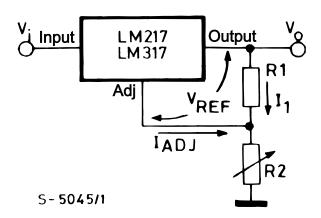
Figure 5. Reference voltage vs. junction



DS0433 - Rev 20 page 8/32



Figure 6. Basic adjustable regulator





#### 6 Application information

The 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 6. Basic adjustable regulator), giving an output voltage  $V_O$  of:

$$V_0 = V_{REF} (1 + R_2/R_1) + I_{ADJ} R_2$$

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 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 regulators 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 6. Basic adjustable regulator) 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 (C<sub>ADJ</sub>).
- An 1 μF tantalum (or 25 μF 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 below D1 protect the device against input short circuit, while D2 protect against output short circuit for capacitance discharging.

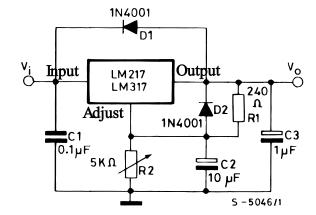


Figure 7. Voltage regulator with protection diodes

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

DS0433 - Rev 20 page 10/32



Figure 8. Slow turn-on 15 V regulator

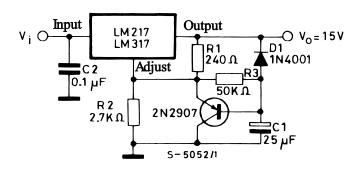
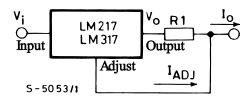
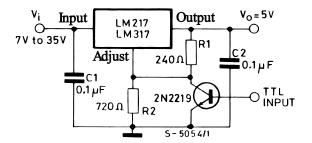


Figure 9. Current regulator



 $I_{O} = (V_{REF} / R_{1}) + I_{ADJ} = 1.25 \text{ V} / R_{1}$ 

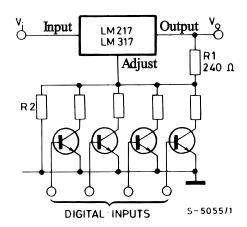
Figure 10. 5 V electronic shut-down regulator



DS0433 - Rev 20 page 11/32

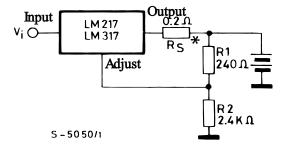


Figure 11. Digitally selected outputs



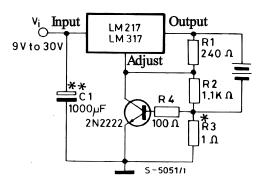
(R<sub>2</sub> sets maximum V<sub>O</sub>)

Figure 12. Battery charger (12 V)



<sup>\*</sup>  $R_S$  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



<sup>\*</sup> R3 sets peak current (0.6 A for 10).

DS0433 - Rev 20 page 12/32

<sup>\*\*</sup> C1 recommended to filter out input transients.



## 7 Device summary

**Table 6. Device summary** 

Order codes						
TO-220 (single gauge)	TO-220 (double gauge)	D <sup>2</sup> PAK (tape and reel)	TO-220FP			
LM217T	LM217T-DG	LM217D2T-TR				
LM317T	LM317T-DG	LM317D2T-TR	LM317P			
LM317BT						

DS0433 - Rev 20 page 13/32



## 8 Package information

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.

DS0433 - Rev 20 page 14/32

8174627\_5



# 8.1 TO-220 (single gauge) package information

Α Ε øΡ F  $\Xi$ L20 L30 J1 Gate Note 9-10 b1 (x3) С b (x3) e1

Figure 14. TO-220 (single gauge) package outline

DS0433 - Rev 20 page 15/32



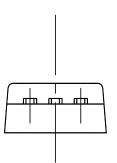
Table 7. TO-220 (single gauge) mechanical data

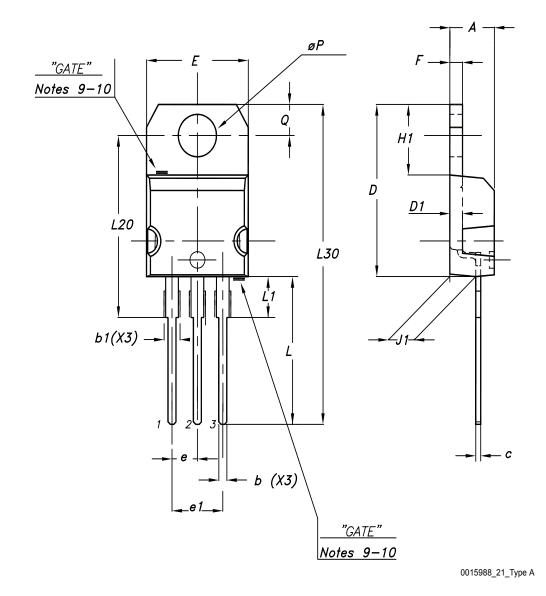
Dim.		mm	
Dilli.	Min.	Тур.	Max.
А	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
С	0.48		0.70
D	15.25		15.75
Е	10.00		10.40
е	2.40		2.70
e1	4.95		5.15
F	0.51		0.60
H1	6.20		6.60
J1	2.40		2.72
L	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95



### 8.2 TO-220 (dual gauge) package information

Figure 15. TO-220 (dual gauge) package outline





DS0433 - Rev 20 page 17/32



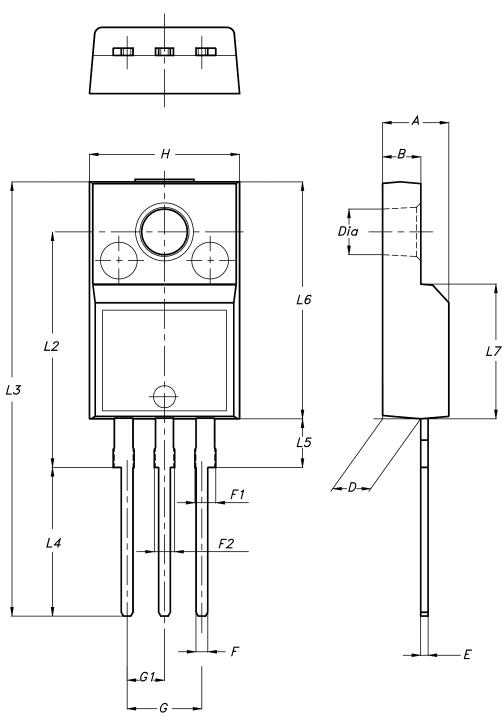
Table 8. TO-220 (dual gauge) mechanical data

Dim.		mm	
Dilli.	Min.	Тур.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
С	0.48		0.70
D	15.25		15.75
D1		1.27	
Е	10		10.40
е	2.40		2.70
e1	4.95		5.15
F	1.23		1.32
H1	6.20		6.60
J1	2.40		2.72
L	13		14
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95



### 8.3 TO-220FP type A package information

Figure 16. TO-220FP package outline



7012510\_type\_A



Table 9. TO-220FP package mechanical data

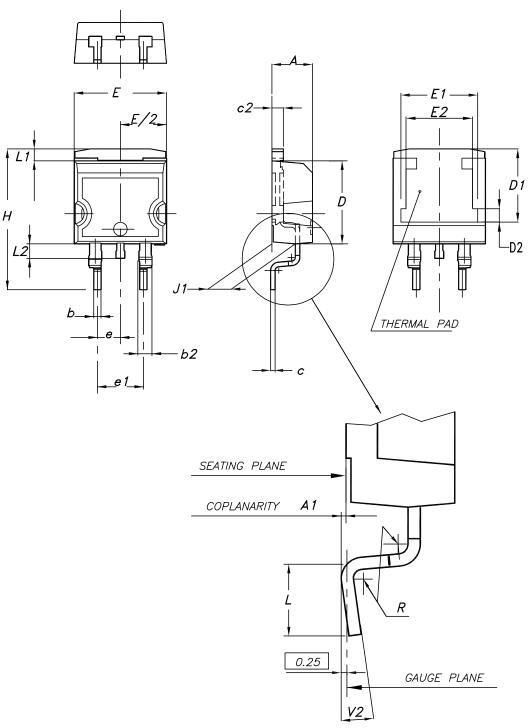
Dim.		mm	
Dilli.	Min.	Тур.	Max.
А	4.4		4.6
В	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
Н	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

DS0433 - Rev 20 page 20/32



#### 8.4 D<sup>2</sup>PAK (SMD 2L STD-ST) type A package information

Figure 17. D<sup>2</sup>PAK (SMD 2L STD-ST) type A package outline



0079457\_22\_type A

DS0433 - Rev 20 page 21/32



Table 10. D<sup>2</sup>PAK (SMD 2L STD-ST) mechanical data

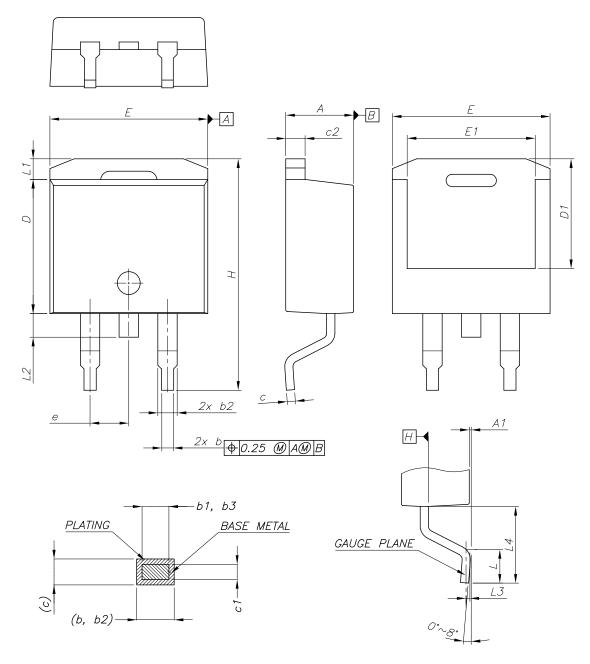
Dim.		mm	
Dim.	Min.	Тур.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
С	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50	7.75	8.00
D2	1.10	1.30	1.50
E	10		10.40
E1	8.50	8.70	8.90
E2	6.85	7.05	7.25
е		2.54	
e1	4.88		5.28
Н	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

DS0433 - Rev 20 page 22/32



### 8.5 D<sup>2</sup>PAK (ASE) type B package information

Figure 18. D<sup>2</sup>PAK (ASE subcon) type B package outline



0079457\_23\_type B



Table 11. D<sup>2</sup>PAK (ASE) type B mechanical data

Dim.		mm	
Dim.	Min.	Тур.	Max.
Α	4.36		4.56
A1	0		0.25
b	0.70		0.90
b1	0.51		0.89
b2	1.17		1.37
b3	1.36		1.46
С	0.38		0.694
c1	0.38		0.534
c2	1.19		1.34
D	8.60		9.00
D1	6.90		7.50
E	10.15		10.55
E1	8.10		8.70
е		2.54	
Н	15.00		15.60
L	1.90		2.50
L1			1.65
L2			1.78
L3		0.25	
L4	4.78		5.28

DS0433 - Rev 20 page 24/32



9.75

16.9

2.54

Footprint\_0079457

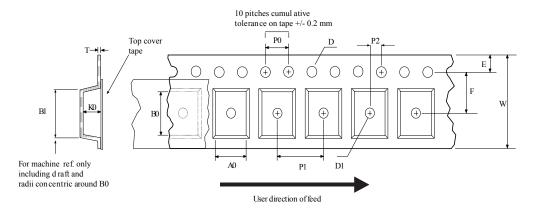
Figure 19. D<sup>2</sup>PAK recommended footprint (dimensions are in mm)

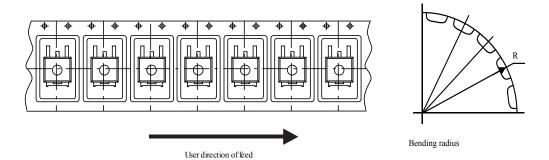
DS0433 - Rev 20 page 25/32



### 8.6 D<sup>2</sup>PAK packing information

Figure 20. D<sup>2</sup>PAK tape outline





DS0433 - Rev 20 page 26/32



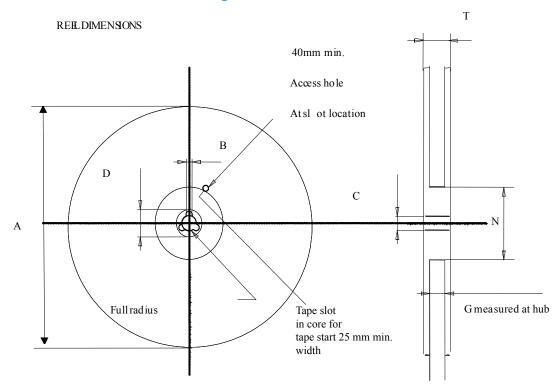


Figure 21. Reel for D<sup>2</sup>PAK

Table 12. D<sup>2</sup>PAK tape and reel mechanical data

Таре		Reel			
Dim.	mm		Direc	mm	
	Min.	Max.	Dim.	Min.	Max.
A0	10.5	10.7	Α		330
В0	15.7	15.9	В	1.5	
D	1.5	1.6	С	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	Т		30.4
P0	3.9	4.1			
P1	11.9	12.1	Base qty		1000
P2	1.9	2.1	Bulk qty		1000
R	50				
Т	0.25	0.35			
W	23.7	24.3			

DS0433 - Rev 20 page 27/32



### **Revision history**

Table 13. Document revision history

Date	Revisio n	Changes
01-Sep-2004	10	Mistake VREF==> V <sub>O</sub> , 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 <sub>thJC</sub> valuefor 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.
		The part number LM117 has been moved to a separate datasheet. Removed TO-3 package.  Updated the description in cover page
12-Mar-2014	19	Modified Table 1: Device summary, Table 3: Thermal data, Figure 1: Pin connections (top view), Section 4: Electrical characteristics, Section 5: Typical characteristics, Section 6: Application information, Section 7: Package mechanical data.
		Added Section 8: Packaging mechanical data. Minor text changes.
28-May-2018	20	Updated Section 8.5 D²PAK (ASE) type B package information.

DS0433 - Rev 20 page 28/32



### **Contents**

1	Pin	configuration	2
2	Max	imum ratings	3
3		yram	
4	Elec	trical characteristics	5
5	Турі	cal characteristics	8
6	Арр	lication information	10
7	Dev	ice summary	13
8	Pac	kage information	14
	8.1	TO-220 (single gauge) package information	14
	8.2	TO-220 (dual gauge) package information	
	8.3	TO-220FP type A package information	18
	8.4	D²PAK (SMD 2L STD-ST) type A package information	20
	8.5	D²PAK (ASE) type B package information	
	8.6	D²PAK packing information	25
Rev	ision	history	28



### **List of tables**

Table 1.	Absolute maximum ratings	. 3
Table 2.	Thermal data	. 3
Table 3.	Electrical characteristics for LM217	. 5
Table 4.	Electrical characteristics for LM317	. 6
Table 5.	Electrical characteristics for LM317B	
Table 6.	Device summary	
Table 7.	TO-220 (single gauge) mechanical data	
Table 8.	TO-220 (dual gauge) mechanical data	18
	TO-220FP package mechanical data	
	D²PAK (SMD 2L STD-ST) mechanical data	
	D <sup>2</sup> PAK (ASE) type B mechanical data	
Table 12.	D <sup>2</sup> PAK tape and reel mechanical data	27
Table 13.	Document revision history	28



# **List of figures**

Figure 1.	Pin connections (top view)	. 2
Figure 2.	Schematic diagram	. 4
Figure 3.	Output current vs. input-output differential voltage	. 8
Figure 4.	Dropout voltage vs. junction temperature	. 8
Figure 5.	Reference voltage vs. junction	. 8
Figure 6.	Basic adjustable regulator	. 9
Figure 7.	Voltage regulator with protection diodes	10
Figure 8.	Slow turn-on 15 V regulator	11
Figure 9.	Current regulator	11
Figure 10.	5 V electronic shut-down regulator	11
Figure 11.	Digitally selected outputs	12
Figure 12.	Battery charger (12 V)	12
Figure 13.	Current limited 6 V charger	12
Figure 14.	TO-220 (single gauge) package outline	15
Figure 15.	TO-220 (dual gauge) package outline	17
Figure 16.	TO-220FP package outline	19
Figure 17.	D <sup>2</sup> PAK (SMD 2L STD-ST) type A package outline	21
Figure 18.	D <sup>2</sup> PAK (ASE subcon) type B package outline	23
Figure 19.	D <sup>2</sup> PAK recommended footprint (dimensions are in mm)	
Figure 20.	D <sup>2</sup> PAK tape outline	26
Figure 21.	Reel for D <sup>2</sup> PAK	27



#### **IMPORTANT NOTICE - PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2018 STMicroelectronics - All rights reserved

DS0433 - Rev 20 page 32/32