



# L78xx, L78xxC L78xxAB, L78xxAC

## Positive voltage regulator ICs

Datasheet – production data

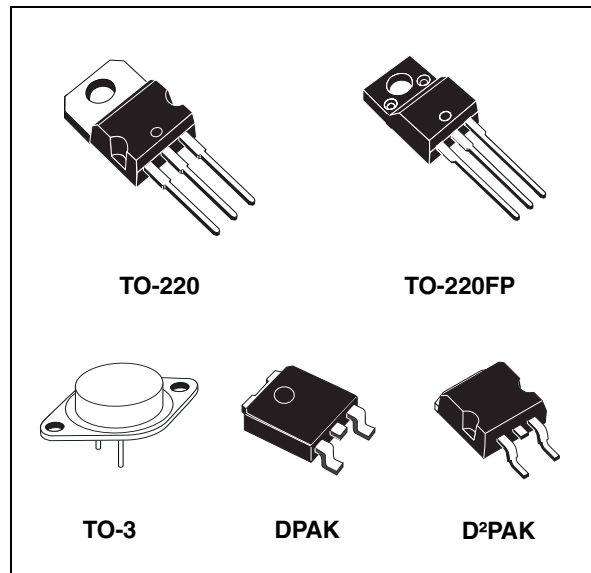
### Features

- Output current up to 1.5 A
- Output voltages of 5; 6; 8; 8.5; 9; 12; 15; 18; 24 V
- Thermal overload protection
- Short circuit protection
- Output transition SOA protection
- 2 % output voltage tolerance (A version)
- Guaranteed in extended temperature range (A version)

### Description

The L78xx series of three-terminal positive regulators is available in TO-220, TO-220FP, TO-3, D<sup>2</sup>PAK and DPAK packages and several fixed output voltages, making it useful in a wide range of applications.

These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1 A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.



**Table 1. Device summary**

Part numbers			
L7805	L7806AC	L7809AB	L7815AB
L7805C	L7808C	L7809AC	L7815AC
L7805AB	L7808AB	L7812C	L7818C
L7805AC	L7808AC	L7812AB	L7824C
L7806C	L7885C	L7812AC	L7824AB
L7806AB	L7809C	L7815C	L7824AC

# Contents

1	<b>Diagram</b> .....	5
2	<b>Pin configuration</b> .....	6
3	<b>Maximum ratings</b> .....	7
4	<b>Test circuits</b> .....	8
5	<b>Electrical characteristics</b> .....	9
6	<b>Application information</b> .....	28
	6.1 Design consideration .....	28
7	<b>Typical performance</b> .....	37
8	<b>Package mechanical data</b> .....	39
9	<b>Order codes</b> .....	54
10	<b>Revision history</b> .....	56

## List of tables

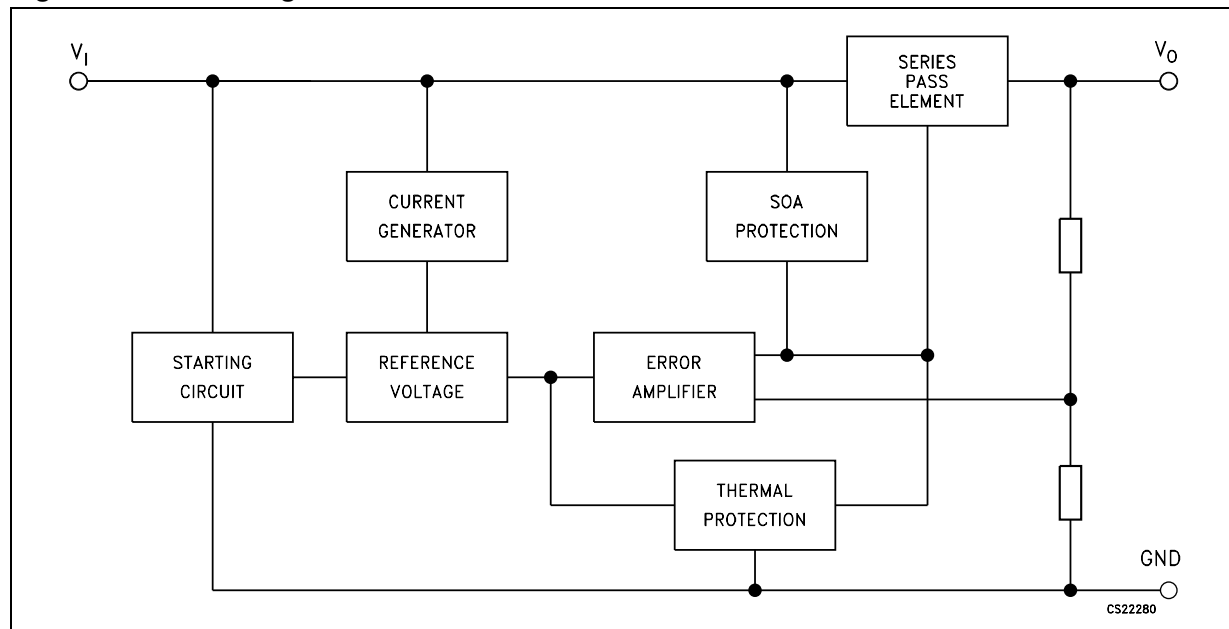
Table 1.	Device summary . . . . .	1
Table 2.	Absolute maximum ratings . . . . .	7
Table 3.	Thermal data . . . . .	7
Table 4.	Electrical characteristics of L7805 . . . . .	9
Table 5.	Electrical characteristics of L7805A . . . . .	10
Table 6.	Electrical characteristics of L7806A . . . . .	11
Table 7.	Electrical characteristics of L7808A . . . . .	12
Table 8.	Electrical characteristics of L7809A . . . . .	13
Table 9.	Electrical characteristics of L7812A . . . . .	14
Table 10.	Electrical characteristics of L7815A . . . . .	15
Table 11.	Electrical characteristics of L7824A . . . . .	16
Table 12.	Electrical characteristics of L7805C . . . . .	17
Table 13.	Electrical characteristics of L7806C . . . . .	18
Table 14.	Electrical characteristics of L7808C . . . . .	19
Table 15.	Electrical characteristics of L7885C . . . . .	20
Table 16.	Electrical characteristics of L7809C . . . . .	21
Table 17.	Electrical characteristics of L7810C . . . . .	22
Table 18.	Electrical characteristics of L7812C . . . . .	23
Table 19.	Electrical characteristics of L7815C . . . . .	24
Table 20.	Electrical characteristics of L7818C . . . . .	25
Table 21.	Electrical characteristics of L7820C . . . . .	26
Table 22.	Electrical characteristics of L7824C . . . . .	27
Table 23.	TO-220 mechanical data . . . . .	39
Table 24.	TO-220FP mechanical data . . . . .	44
Table 25.	TO-3 mechanical data . . . . .	45
Table 26.	DPAK mechanical data . . . . .	47
Table 27.	Tape and reel DPAK mechanical data . . . . .	48
Table 28.	D <sup>2</sup> PAK mechanical data . . . . .	51
Table 29.	D <sup>2</sup> PAK footprint data . . . . .	52
Table 30.	Tape and reel D <sup>2</sup> PAK mechanical data . . . . .	53
Table 31.	Order codes . . . . .	54
Table 32.	Document revision history . . . . .	56

## List of figures

Figure 1.	Block diagram . . . . .	5
Figure 2.	Pin connections (top view) . . . . .	6
Figure 3.	Schematic diagram . . . . .	6
Figure 4.	Application circuits . . . . .	7
Figure 5.	DC parameter . . . . .	8
Figure 6.	Load regulation . . . . .	8
Figure 7.	Ripple rejection . . . . .	8
Figure 8.	Fixed output regulator . . . . .	28
Figure 9.	Current regulator . . . . .	29
Figure 10.	Circuit for increasing output voltage . . . . .	29
Figure 11.	Adjustable output regulator (7 to 30 V) . . . . .	29
Figure 12.	0.5 to 10 V regulator . . . . .	30
Figure 13.	High current voltage regulator . . . . .	30
Figure 14.	High output current with short circuit protection . . . . .	30
Figure 15.	Tracking voltage regulator . . . . .	31
Figure 16.	Split power supply ( $\pm 15\text{ V} - 1\text{ A}$ ) . . . . .	31
Figure 17.	Negative output voltage circuit . . . . .	32
Figure 18.	Switching regulator . . . . .	32
Figure 19.	High input voltage circuit (configuration 1) . . . . .	32
Figure 20.	High input voltage circuit (configuration 2) . . . . .	33
Figure 21.	High output voltage regulator . . . . .	33
Figure 22.	High input and output voltage . . . . .	33
Figure 23.	Reducing power dissipation with dropping resistor . . . . .	34
Figure 24.	Remote shutdown . . . . .	34
Figure 25.	Power AM modulator (unity voltage gain, $I_O \leq 0.5$ ) . . . . .	34
Figure 26.	Adjustable output voltage with temperature compensation . . . . .	35
Figure 27.	Light controllers ( $V_{O(\min)} = V_{XX} + V_{BE}$ ) . . . . .	35
Figure 28.	Protection against input short-circuit with high capacitance loads . . . . .	36
Figure 29.	Dropout voltage vs. junction temperature . . . . .	37
Figure 30.	Peak output current vs. input/output differential voltage . . . . .	37
Figure 31.	Supply voltage rejection vs. frequency . . . . .	37
Figure 32.	Output voltage vs. junction temperature . . . . .	37
Figure 33.	Output impedance vs. frequency . . . . .	37
Figure 34.	Quiescent current vs. junction temp. . . . .	37
Figure 35.	Load transient response . . . . .	38
Figure 36.	Line transient response . . . . .	38
Figure 37.	Quiescent current vs. input voltage . . . . .	38
Figure 38.	Drawing dimension TO-220 (type STD-ST Dual Gauge) . . . . .	40
Figure 39.	Drawing dimension TO-220 (type STD-ST Single Gauge) . . . . .	41
Figure 40.	Drawing dimension tube for TO-220 Dual Gauge (mm.) . . . . .	42
Figure 41.	Drawing dimension tube for TO-220 Single Gauge (mm.) . . . . .	42
Figure 42.	Drawing dimension TO-220FP . . . . .	43
Figure 43.	Drawing dimension TO-3 . . . . .	45
Figure 44.	Drawing dimension DPAK . . . . .	46
Figure 45.	Drawing dimension tape and reel for DPAK . . . . .	48
Figure 46.	Drawing dimension D <sup>2</sup> PAK (type STD-ST) . . . . .	49
Figure 47.	Drawing dimension D <sup>2</sup> PAK (type WOOSEOK-Subcon.) . . . . .	50
Figure 48.	D <sup>2</sup> PAK footprint recommended data . . . . .	52
Figure 49.	Drawing dimension tape and reel for D <sup>2</sup> PAK . . . . .	53

# 1 Diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)

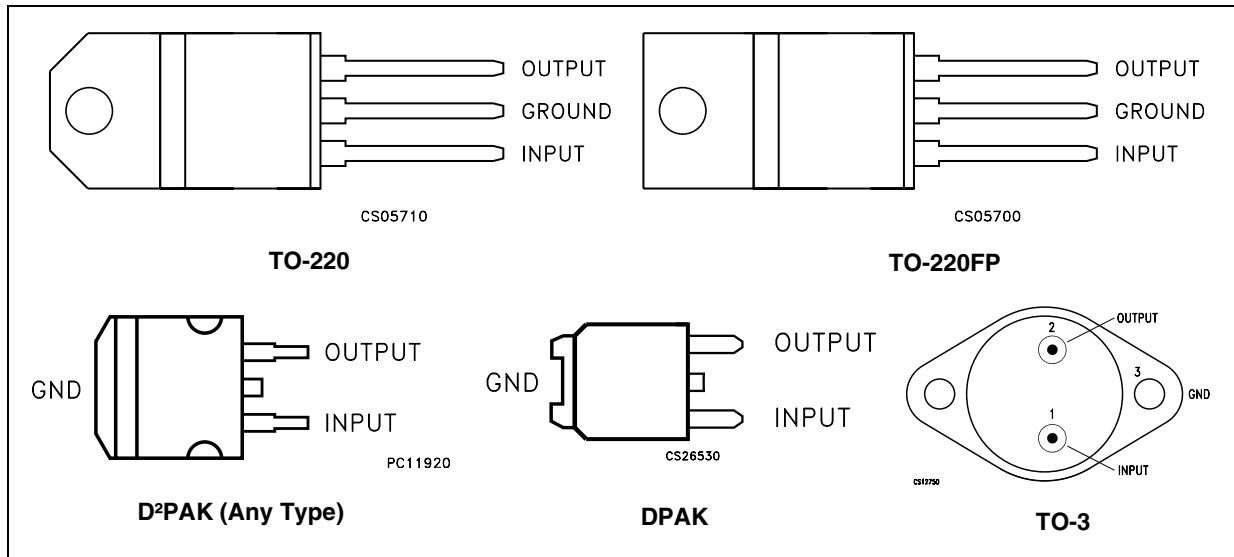
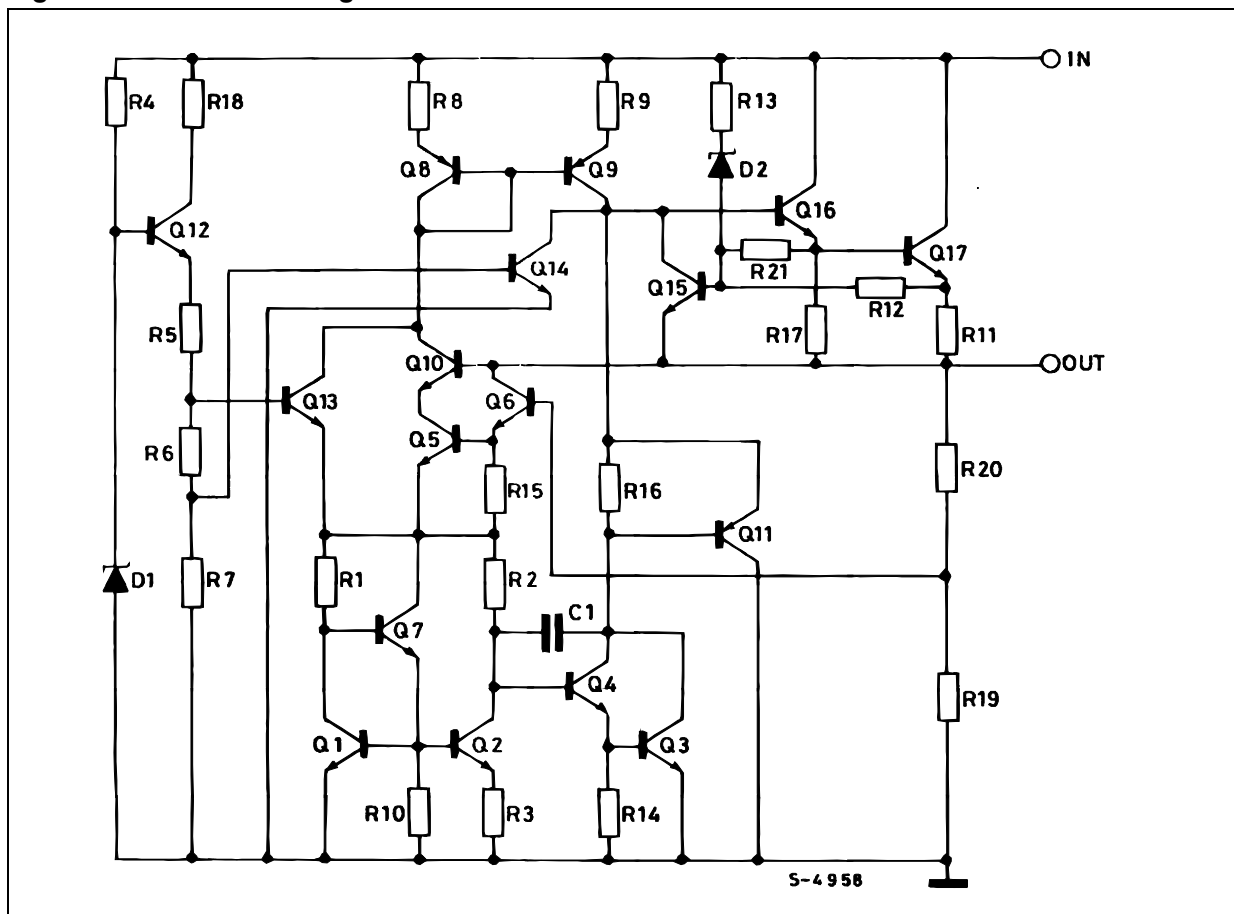


Figure 3. Schematic diagram



### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

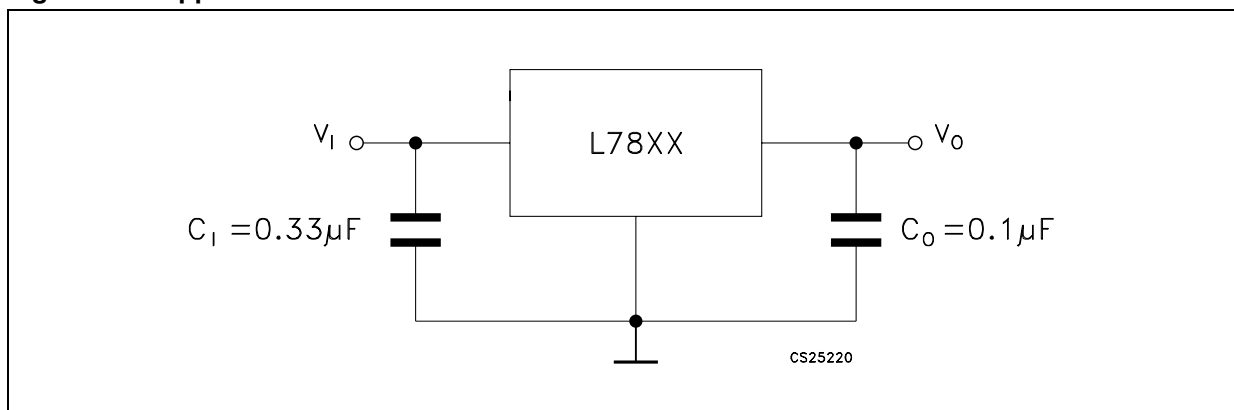
Symbol	Parameter		Value	Unit
$V_I$	DC input voltage	for $V_O = 5$ to $18$ V	35	V
		for $V_O = 20, 24$ V	40	
$I_O$	Output current		Internally limited	
$P_D$	Power dissipation		Internally limited	
$T_{STG}$	Storage temperature range		-65 to 150	°C
$T_{OP}$	Operating junction temperature range	for L78xx	-55 to 150	°C
		for L78xxC, L78xxAC	0 to 125	
		for L78xxAB	-40 to 125	

*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	DPAK	TO-220	TO-220FP	TO-3	Unit
$R_{thJC}$	Thermal resistance junction-case	3	8	5	5	4	°C/W
$R_{thJA}$	Thermal resistance junction-ambient	62.5	100	50	60	35	°C/W

**Figure 4. Application circuits**



## 4 Test circuits

Figure 5. DC parameter

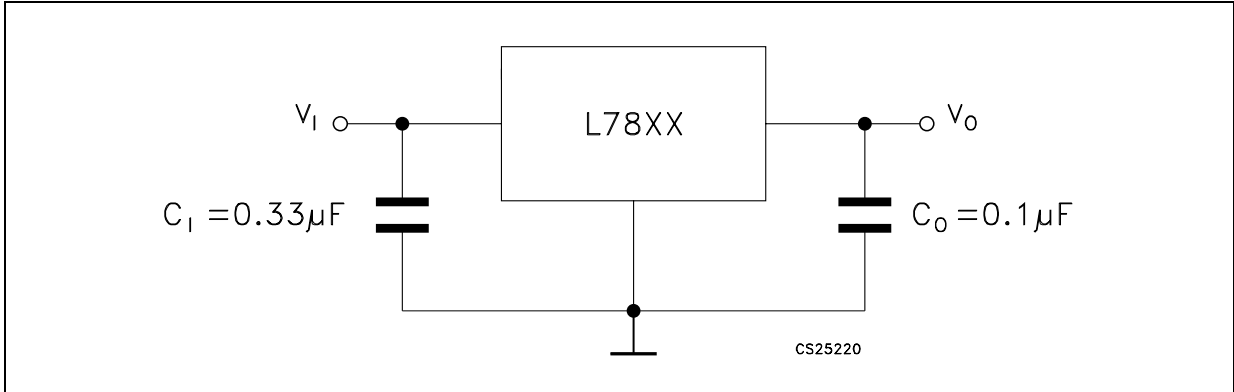


Figure 6. Load regulation

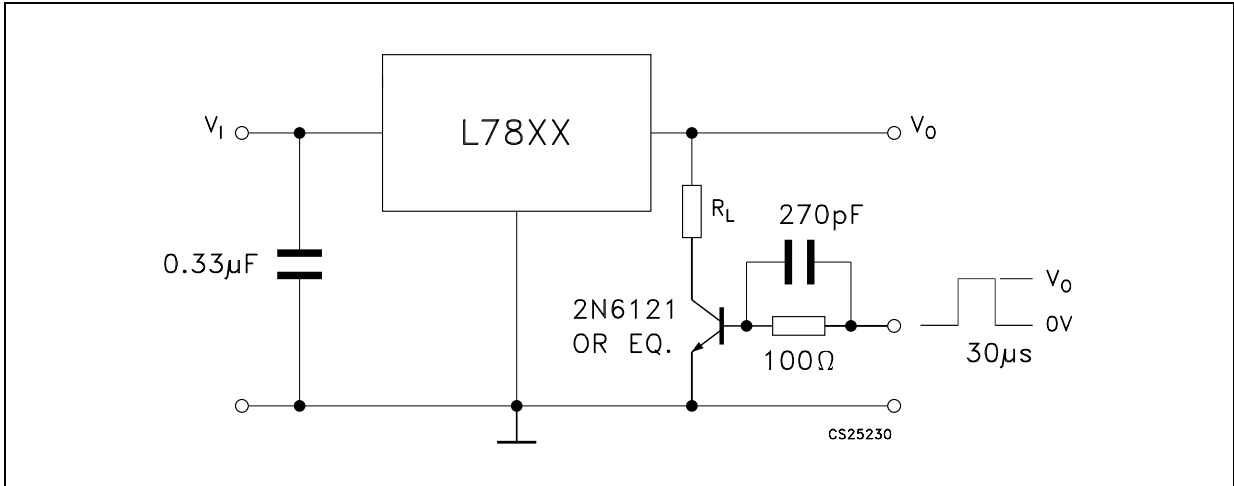
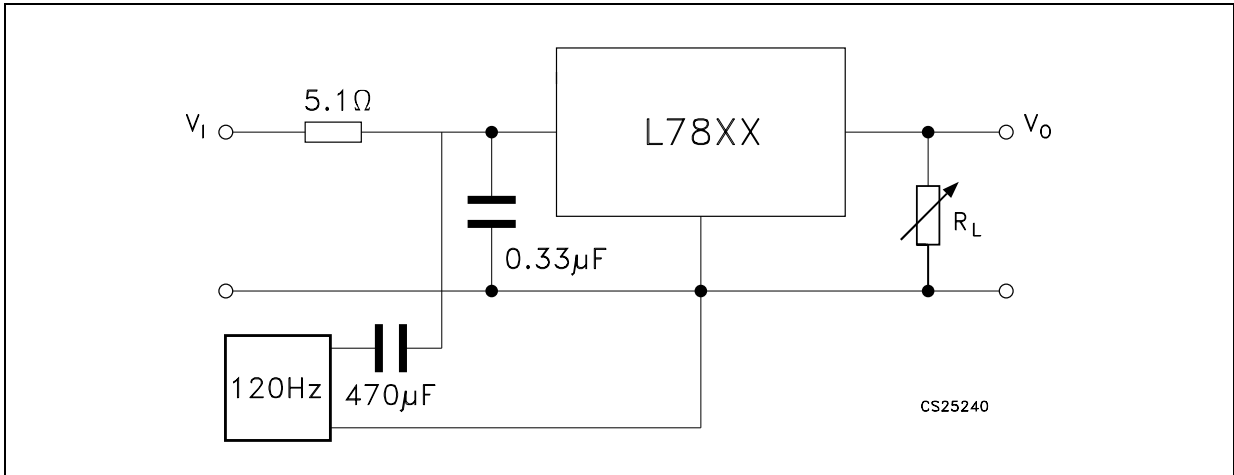


Figure 7. Ripple rejection





## 5 Electrical characteristics

Refer to the test circuits,  $T_J = -55$  to  $150$  °C,  $V_I = 10$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 4. Electrical characteristics of L7805**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	4.8	5	5.2	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 8$ to 20 V	4.65	5	5.35	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 7$ to 25 V, $T_J = 25^\circ\text{C}$		3	50	mV
		$V_I = 8$ to 12 V, $T_J = 25^\circ\text{C}$		1	25	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			100	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			25	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			6	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 8$ to 25 V			0.8	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		0.6		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz, $T_J = 25^\circ\text{C}$			40	$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 8$ to 18 V, $f = 120$ Hz	68			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2	2.5	V
$R_O$	Output resistance	$f = 1$ kHz		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.75	1.2	A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$	1.3	2.2	3.3	A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 10\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7805AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7805AB), unless otherwise specified.

**Table 5. Electrical characteristics of L7805A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	4.9	5	5.1	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 7.5\text{ to }18\text{ V}$	4.8	5	5.2	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 18\text{ to }20\text{ V}$ , $T_J = 25\text{ °C}$	4.8	5	5.2	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 7.5\text{ to }25\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		7	50	mV
		$V_I = 8\text{ to }12\text{ V}$		10	50	mV
		$V_I = 8\text{ to }12\text{ V}$ , $T_J = 25\text{ °C}$		2	25	mV
		$V_I = 7.3\text{ to }20\text{ V}$ , $T_J = 25\text{ °C}$		7	50	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		8	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.3	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 8\text{ to }23\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 7.5\text{ to }20\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 8\text{ to }18\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		68		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-1.1		mV/°C

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 11\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7806AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7806AB), unless otherwise specified.

**Table 6. Electrical characteristics of L7806A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	5.88	6	6.12	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 8.6\text{ to }19\text{ V}$	5.76	6	6.24	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 19\text{ to }21\text{ V}$ , $T_J = 25\text{ °C}$	5.76	6	6.24	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 8.6\text{ to }25\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		9	60	mV
		$V_I = 9\text{ to }13\text{ V}$		11	60	mV
		$V_I = 9\text{ to }13\text{ V}$ , $T_J = 25\text{ °C}$		3	30	mV
		$V_I = 8.3\text{ to }21\text{ V}$ , $T_J = 25\text{ °C}$		9	60	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.3	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 9\text{ to }24\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 8.6\text{ to }21\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 9\text{ to }19\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		65		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		17		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-0.8		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 14\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7808AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7808AB), unless otherwise specified.

**Table 7. Electrical characteristics of L7808A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	7.84	8	8.16	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 10.6\text{ to }21\text{ V}$	7.7	8	8.3	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 21\text{ to }23\text{ V}$ , $T_J = 25\text{ °C}$	7.7	8	8.3	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 10.6\text{ to }25\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		12	80	mV
		$V_I = 11\text{ to }17\text{ V}$		15	80	mV
		$V_I = 11\text{ to }17\text{ V}$ , $T_J = 25\text{ °C}$		5	40	mV
		$V_I = 10.4\text{ to }23\text{ V}$ , $T_J = 25\text{ °C}$		12	80	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.3	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 11\text{ to }23\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 10.6\text{ to }23\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 11.5\text{ to }21.5\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		62		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		18		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-0.8		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 15\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7809AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7809AB), unless otherwise specified.

**Table 8. Electrical characteristics of L7809A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	8.82	9	9.18	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 10.6\text{ to }22\text{ V}$	8.65	9	9.35	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 22\text{ to }24\text{ V}$ , $T_J = 25\text{ °C}$	8.65	9	9.35	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 10.6\text{ to }25\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		12	90	mV
		$V_I = 11\text{ to }17\text{ V}$		15	90	mV
		$V_I = 11\text{ to }17\text{ V}$ , $T_J = 25\text{ °C}$		5	45	mV
		$V_I = 11.4\text{ to }23\text{ V}$ , $T_J = 25\text{ °C}$		12	90	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.3	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 11\text{ to }25\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 10.6\text{ to }23\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 11.5\text{ to }21.5\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		61		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		18		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-0.8		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 19\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7812AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7812AB), unless otherwise specified.

**Table 9. Electrical characteristics of L7812A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	11.75	12	12.25	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 14.8\text{ to }25\text{ V}$	11.5	12	12.5	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 25\text{ to }27\text{ V}$ , $T_J = 25\text{ °C}$	11.5	12	12.5	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 14.8\text{ to }30\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		13	120	mV
		$V_I = 16\text{ to }12\text{ V}$		16	120	mV
		$V_I = 16\text{ to }12\text{ V}$ , $T_J = 25\text{ °C}$		6	60	mV
		$V_I = 14.5\text{ to }27\text{ V}$ , $T_J = 25\text{ °C}$		13	120	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.4	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 15\text{ to }30\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 14.8\text{ to }27\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 15\text{ to }25\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		60		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		18		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-1		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 23\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7815AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7815AB), unless otherwise specified.

**Table 10. Electrical characteristics of L7815A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	14.7	15	15.3	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 17.9\text{ to }28\text{ V}$	14.4	15	15.6	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 28\text{ to }30\text{ V}$ , $T_J = 25\text{ °C}$	14.4	15	15.6	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 17.9\text{ to }30\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		13	150	mV
		$V_I = 20\text{ to }26\text{ V}$		16	150	mV
		$V_I = 20\text{ to }26\text{ V}$ , $T_J = 25\text{ °C}$		6	75	mV
		$V_I = 17.5\text{ to }30\text{ V}$ , $T_J = 25\text{ °C}$		13	150	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.4	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 17.5\text{ to }30\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 17.5\text{ to }30\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 18.5\text{ to }28.5\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		58		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		19		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-1		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

$V_I = 33\text{ V}$ ,  $I_O = 1\text{ A}$ ,  $T_J = 0\text{ to }125\text{ °C}$  (L7824AC),  $T_J = -40\text{ to }125\text{ °C}$  (L7824AB), unless otherwise specified.

**Table 11. Electrical characteristics of L7824A**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25\text{ °C}$	23.5	24	24.5	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 27.3\text{ to }37\text{ V}$	23	24	25	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 37\text{ to }38\text{ V}$ , $T_J = 25\text{ °C}$	23	24	25	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 27\text{ to }38\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = 25\text{ °C}$		31	240	mV
		$V_I = 30\text{ to }36\text{ V}$		35	200	mV
		$V_I = 30\text{ to }36\text{ V}$ , $T_J = 25\text{ °C}$		14	120	mV
		$V_I = 26.7\text{ to }38\text{ V}$ , $T_J = 25\text{ °C}$		31	240	mV
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1\text{ A}$		25	100	mV
		$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25\text{ °C}$		30	100	
		$I_O = 250\text{ to }750\text{ mA}$		10	50	
$I_q$	Quiescent current	$T_J = 25\text{ °C}$		4.6	6	mA
					6	mA
$\Delta I_q$	Quiescent current change	$V_I = 27.3\text{ to }38\text{ V}$ , $I_O = 500\text{ mA}$			0.8	mA
		$V_I = 27.3\text{ to }38\text{ V}$ , $T_J = 25\text{ °C}$			0.8	mA
		$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
SVR	Supply voltage rejection	$V_I = 28\text{ to }38\text{ V}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$		54		dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25\text{ °C}$		2		V
eN	Output noise voltage	$T_A = 25\text{ °C}$ , $B = 10\text{ Hz to }100\text{ kHz}$		10		$\mu\text{V}/V_O$
$R_O$	Output resistance	$f = 1\text{ kHz}$		20		$\text{m}\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_A = 25\text{ °C}$		0.2		A
$I_{scp}$	Short circuit peak current	$T_J = 25\text{ °C}$		2.2		A
$\Delta V_O/\Delta T$	Output voltage drift			-1.5		$\text{mV}/\text{°C}$

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.



Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 10$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 12. Electrical characteristics of L7805C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	4.8	5	5.2	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 7$ to 18 V	4.75	5	5.25	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 18$ to 20V, $T_J = 25^\circ\text{C}$	4.75	5	5.25	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 7$ to 25 V, $T_J = 25^\circ\text{C}$		3	100	mV
		$V_I = 8$ to 12 V, $T_J = 25^\circ\text{C}$		1	50	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			100	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			50	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 7$ to 23 V			0.8	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1.1		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		40		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 8$ to 18 V, $f = 120$ Hz	62			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.75		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 11$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 13. Electrical characteristics of L7806C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	5.75	6	6.25	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 8$ to 19 V	5.7	6	6.3	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 19$ to 21 V, $T_J = 25^\circ\text{C}$	5.7	6	6.3	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 8$ to 25 V, $T_J = 25^\circ\text{C}$			120	mV
		$V_I = 9$ to 13 V, $T_J = 25^\circ\text{C}$			60	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			120	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			60	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 8$ to 24 V			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-0.8		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		45		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 9$ to 19 V, $f = 120$ Hz	59			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		19		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.55		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 14$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 14. Electrical characteristics of L7808C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	7.7	8	8.3	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 10.5$ to 21 V	7.6	8	8.4	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 21$ to 25 V, $T_J = 25^\circ\text{C}$	7.6	8	8.4	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 10.5$ to 25 V, $T_J = 25^\circ\text{C}$			160	mV
		$V_I = 11$ to 17 V, $T_J = 25^\circ\text{C}$			80	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			160	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			80	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 10.5$ to 25 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-0.8		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		52		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 11.5$ to 21.5 V, $f = 120$ Hz	56			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		16		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.45		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125\text{ }^\circ\text{C}$ ,  $V_I = 14.5\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $C_I = 0.33\text{ }\mu\text{F}$ ,  $C_O = 0.1\text{ }\mu\text{F}$  unless otherwise specified.

**Table 15. Electrical characteristics of L7885C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	8.2	8.5	8.8	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 11\text{ to }21.5\text{ V}$	8.1	8.5	8.9	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 21.5\text{ to }26\text{ V}$ , $T_J = 25^\circ\text{C}$	8.1	8.5	8.9	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 11\text{ to }27\text{ V}$ , $T_J = 25^\circ\text{C}$			160	mV
		$V_I = 11.5\text{ to }17.5\text{ V}$ , $T_J = 25^\circ\text{C}$			80	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25^\circ\text{C}$			160	mV
		$I_O = 250\text{ to }750\text{ mA}$ , $T_J = 25^\circ\text{C}$			80	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 11\text{ to }26\text{ V}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$		-0.8		mV/ $^\circ\text{C}$
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$ , $T_J = 25^\circ\text{C}$		55		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 12\text{ to }22\text{ V}$ , $f = 120\text{ Hz}$	56			dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1\text{ kHz}$		16		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_J = 25^\circ\text{C}$		0.45		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 15$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 16. Electrical characteristics of L7809C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	8.64	9	9.36	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 11.5$ to 22 V	8.55	9	9.45	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 22$ to 26 V, $T_J = 25^\circ\text{C}$	8.55	9	9.45	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 11.5$ to 26 V, $T_J = 25^\circ\text{C}$			180	mV
		$V_I = 12$ to 18 V, $T_J = 25^\circ\text{C}$			90	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			180	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			90	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 11.5$ to 26 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		70		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 12$ to 23 V, $f = 120$ Hz	55			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.40		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 15$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 17. Electrical characteristics of L7810C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	9.6	10	10.4	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 12.5$ to 23 V	9.5	10	10.5	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 23$ to 26 V, $T_J = 25^\circ\text{C}$	9.5	10	10.5	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 12.5$ to 26 V, $T_J = 25^\circ\text{C}$			200	mV
		$V_I = 13.5$ to 19 V, $T_J = 25^\circ\text{C}$			100	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			200	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			100	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 12.5$ to 26 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		70		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 13$ to 23 V, $f = 120$ Hz	55			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.40		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 19$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 18. Electrical characteristics of L7812C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	11.5	12	12.5	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 14.5$ to 25 V	11.4	12	12.6	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 25$ to 27 V, $T_J = 25^\circ\text{C}$	11.4	12	12.6	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 14.5$ to 30 V, $T_J = 25^\circ\text{C}$			240	mV
		$V_I = 16$ to 22 V, $T_J = 25^\circ\text{C}$			120	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			240	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			120	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 14.5$ to 30 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		75		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 15$ to 25 V, $f = 120$ Hz	55			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		18		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.35		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125\text{ }^\circ\text{C}$ ,  $V_I = 23\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $C_I = 0.33\text{ }\mu\text{F}$ ,  $C_O = 0.1\text{ }\mu\text{F}$  unless otherwise specified.

**Table 19. Electrical characteristics of L7815C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	14.5	15	15.6	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 17.5\text{ to }28\text{ V}$	14.25	15	15.75	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 28\text{ to }30\text{ V}$ , $T_J = 25^\circ\text{C}$	14.25	15	15.75	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 17.5\text{ to }30\text{ V}$ , $T_J = 25^\circ\text{C}$			300	mV
		$V_I = 20\text{ to }26\text{ V}$ , $T_J = 25^\circ\text{C}$			150	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25^\circ\text{C}$			300	mV
		$I_O = 250\text{ to }750\text{ mA}$ , $T_J = 25^\circ\text{C}$			150	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 17.5\text{ to }30\text{ V}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$		-1		mV/ $^\circ\text{C}$
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{kHz}$ , $T_J = 25^\circ\text{C}$		90		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 18.5\text{ to }28.5\text{ V}$ , $f = 120\text{ Hz}$	54			dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1\text{ kHz}$		19		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_J = 25^\circ\text{C}$		0.23		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.2		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.



Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 26$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 20. Electrical characteristics of L7818C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	17.3	18	18.7	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 21$ to 31 V	17.1	18	18.9	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 31$ to 33 V, $T_J = 25^\circ\text{C}$	17.1	18	18.9	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 21$ to 33 V, $T_J = 25^\circ\text{C}$			360	mV
		$V_I = 24$ to 30 V, $T_J = 25^\circ\text{C}$			180	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			360	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			180	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 21$ to 33 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		110		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 22$ to 32 V, $f = 120$ Hz	53			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		22		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.20		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.1		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125\text{ }^\circ\text{C}$ ,  $V_I = 28\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $C_I = 0.33\text{ }\mu\text{F}$ ,  $C_O = 0.1\text{ }\mu\text{F}$  unless otherwise specified.

**Table 21. Electrical characteristics of L7820C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	19.2	20	20.8	V
$V_O$	Output voltage	$I_O = 5\text{ mA to }1\text{ A}$ , $V_I = 23\text{ to }33\text{ V}$	19	20	21	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 33\text{ to }35\text{ V}$ , $T_J = 25^\circ\text{C}$	19	20	21	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 22.5\text{ to }35\text{ V}$ , $T_J = 25^\circ\text{C}$			400	mV
		$V_I = 26\text{ to }32\text{ V}$ , $T_J = 25^\circ\text{C}$			200	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5\text{ mA to }1.5\text{ A}$ , $T_J = 25^\circ\text{C}$			400	mV
		$I_O = 250\text{ to }750\text{ mA}$ , $T_J = 25^\circ\text{C}$			200	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 23\text{ to }35\text{ V}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$		-1		mV/ $^\circ\text{C}$
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$ , $T_J = 25^\circ\text{C}$		150		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 24\text{ to }35\text{ V}$ , $f = 120\text{ Hz}$	52			dB
$V_d$	Dropout voltage	$I_O = 1\text{ A}$ , $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1\text{ kHz}$		24		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35\text{ V}$ , $T_J = 25^\circ\text{C}$		0.18		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.1		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Refer to the test circuits,  $T_J = 0$  to  $125$  °C,  $V_I = 33$  V,  $I_O = 500$  mA,  $C_I = 0.33$   $\mu$ F,  $C_O = 0.1$   $\mu$ F unless otherwise specified.

**Table 22. Electrical characteristics of L7824C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$	23	24	25	V
$V_O$	Output voltage	$I_O = 5$ mA to 1 A, $V_I = 27$ to 37 V	22.8	24	25.2	V
$V_O$	Output voltage	$I_O = 1$ A, $V_I = 37$ to 38 V, $T_J = 25^\circ\text{C}$	22.8	24	25.2	V
$\Delta V_O^{(1)}$	Line regulation	$V_I = 27$ to 38 V, $T_J = 25^\circ\text{C}$			480	mV
		$V_I = 30$ to 36 V, $T_J = 25^\circ\text{C}$			240	
$\Delta V_O^{(1)}$	Load regulation	$I_O = 5$ mA to 1.5 A, $T_J = 25^\circ\text{C}$			480	mV
		$I_O = 250$ to 750 mA, $T_J = 25^\circ\text{C}$			240	
$I_d$	Quiescent current	$T_J = 25^\circ\text{C}$			8	mA
$\Delta I_d$	Quiescent current change	$I_O = 5$ mA to 1 A			0.5	mA
		$V_I = 27$ to 38 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5$ mA		-1.5		mV/°C
eN	Output noise voltage	$B = 10$ Hz to 100 kHz, $T_J = 25^\circ\text{C}$		170		$\mu\text{V}/V_O$
SVR	Supply voltage rejection	$V_I = 28$ to 38 V, $f = 120$ Hz	50			dB
$V_d$	Dropout voltage	$I_O = 1$ A, $T_J = 25^\circ\text{C}$		2		V
$R_O$	Output resistance	$f = 1$ kHz		28		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 35$ V, $T_J = 25^\circ\text{C}$		0.15		A
$I_{scp}$	Short circuit peak current	$T_J = 25^\circ\text{C}$		2.1		A

1. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## 6 Application information

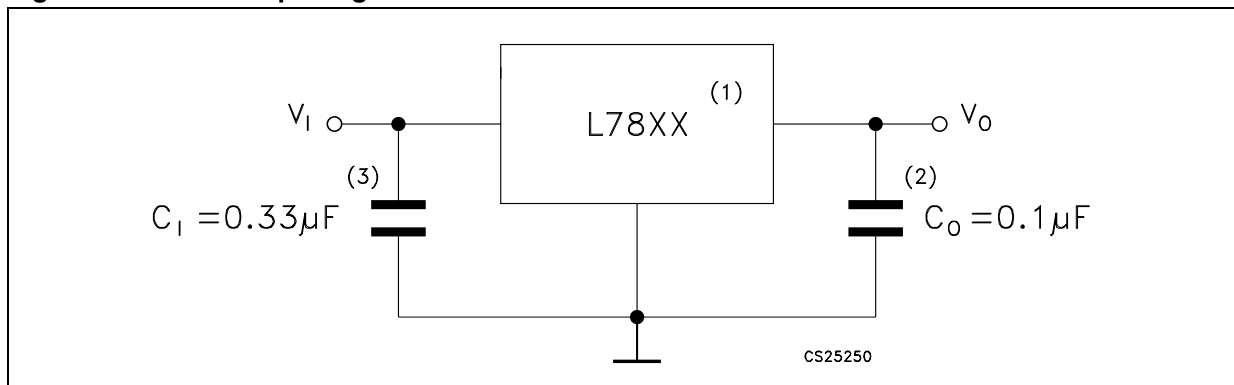
### 6.1 Design consideration

The L78xx Series of fixed voltage regulators are designed with thermal overload protection that shuts down the circuit when subjected to an excessive power overload condition, internal short-circuit protection that limits the maximum current the circuit will pass, and output transistor safe-area compensation that reduces the output short-circuit current as the voltage across the pass transistor is increased. In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with capacitor if the regulator is connected to the power supply filter with long lengths, or if the output load capacitance is large. An input bypass capacitor should be selected to provide good high frequency characteristics to insure stable operation under all load conditions. A 0.33  $\mu\text{F}$  or larger tantalum, mylar or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulators input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead.

The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtained with the arrangement is 2 V greater than the regulator voltage.

The circuit of [Figure 13](#) can be modified to provide supply protection against short circuit by adding a short circuit sense resistor, RSC, and an additional PNP transistor. The current sensing PNP must be able to handle the short circuit current of the three terminal regulator. Therefore a four ampere plastic power transistor is specified.

**Figure 8. Fixed output regulator**



1. To specify an output voltage, substitute voltage value for "XX".
2. Although no output capacitor is need for stability, it does improve transient response.
3. Required if regulator is locate an appreciable distance from power supply filter.

Figure 9. Current regulator

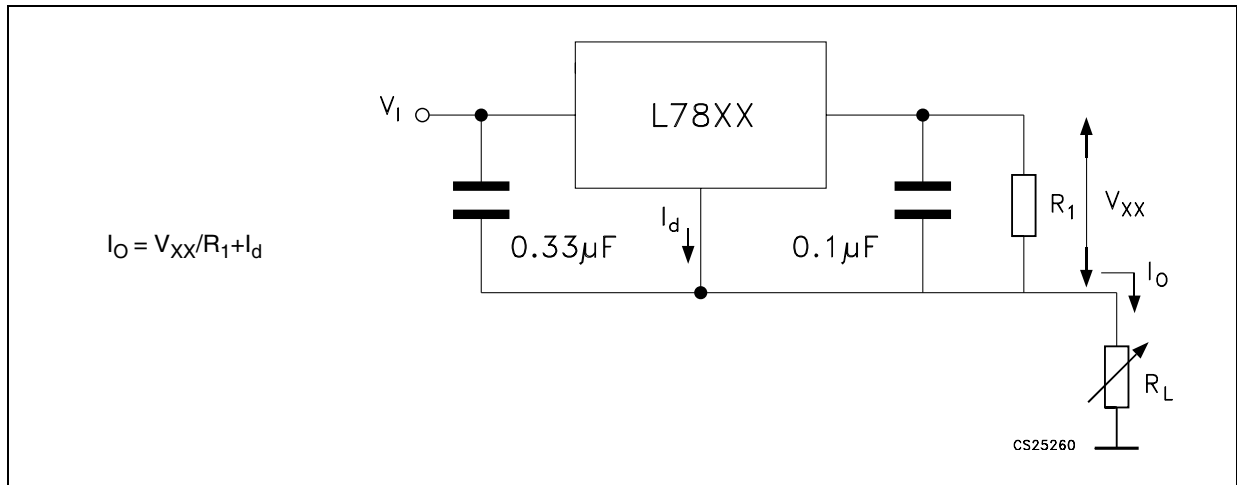


Figure 10. Circuit for increasing output voltage

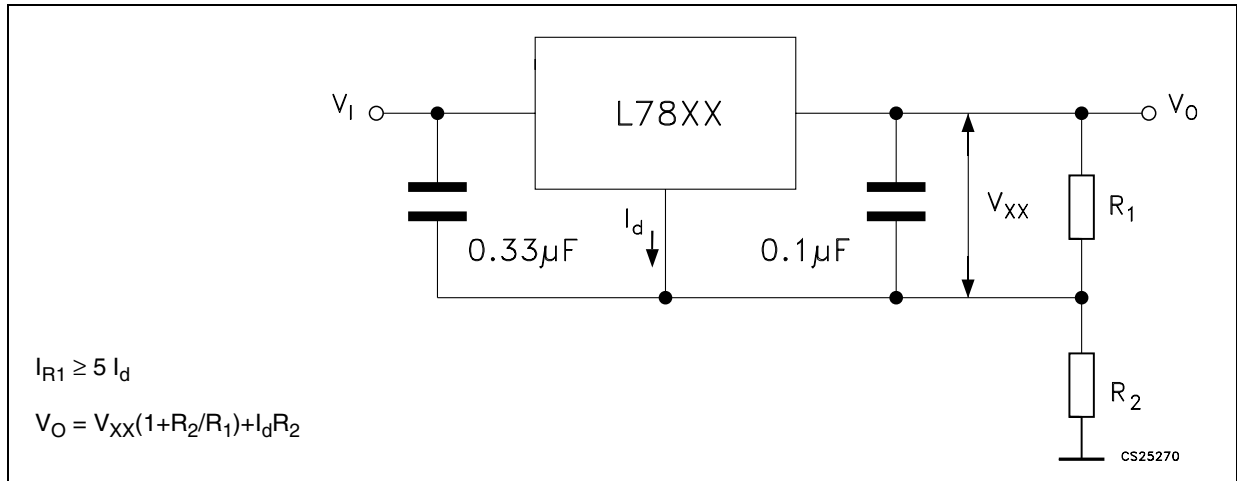


Figure 11. Adjustable output regulator (7 to 30 V)

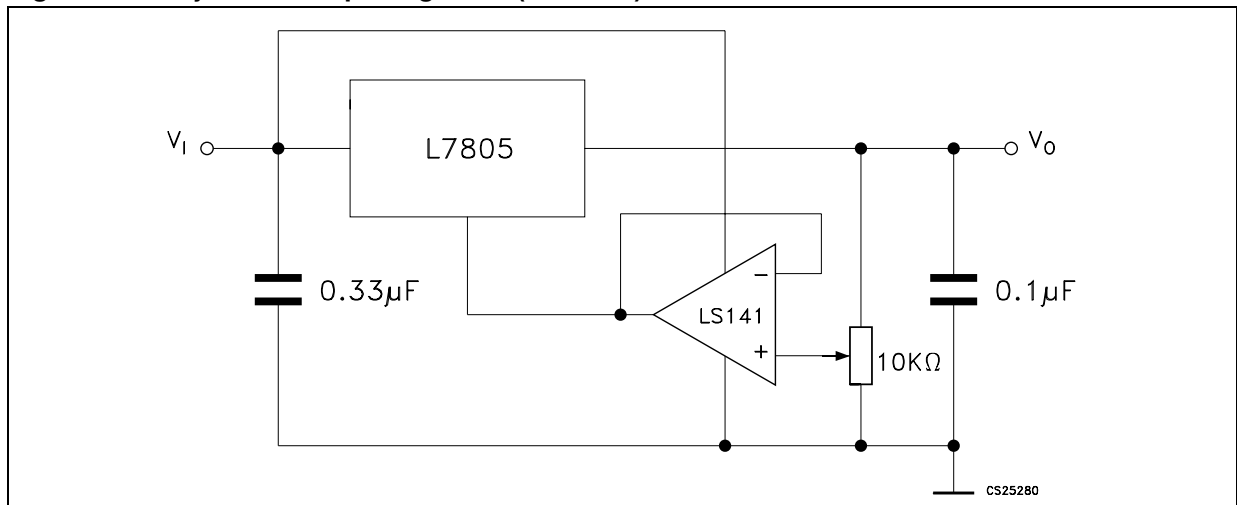


Figure 12. 0.5 to 10 V regulator

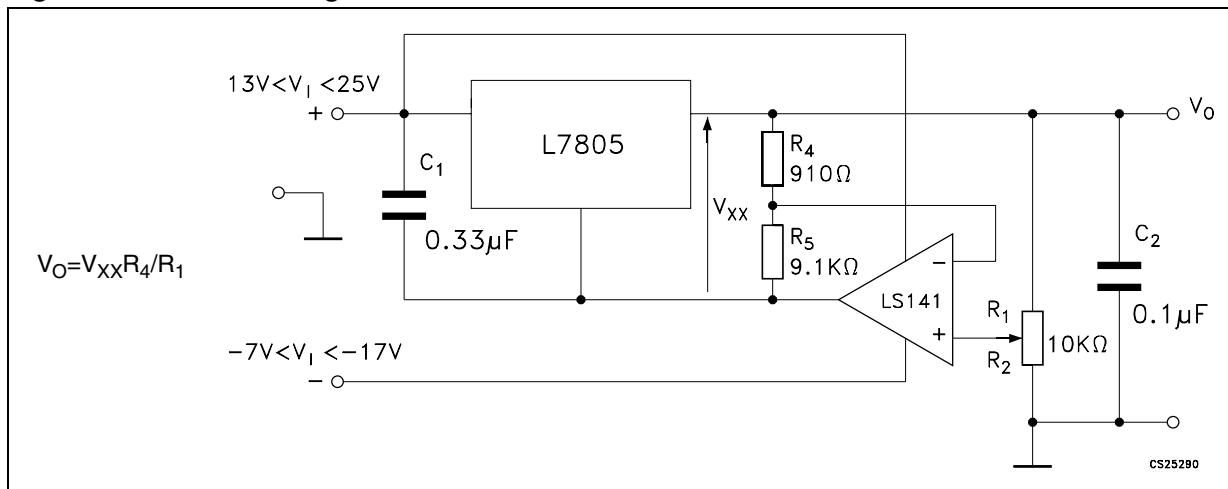


Figure 13. High current voltage regulator

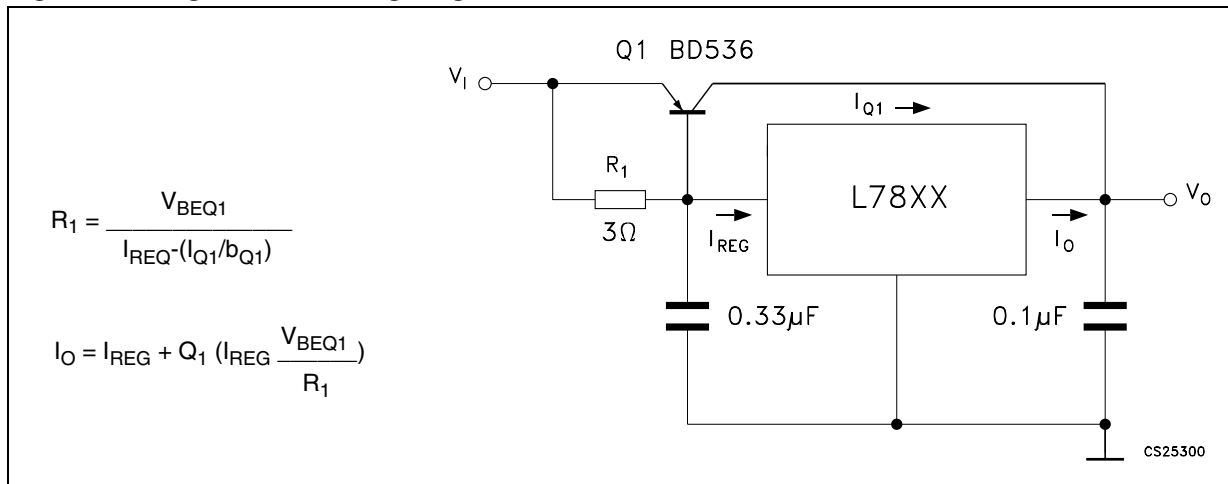


Figure 14. High output current with short circuit protection

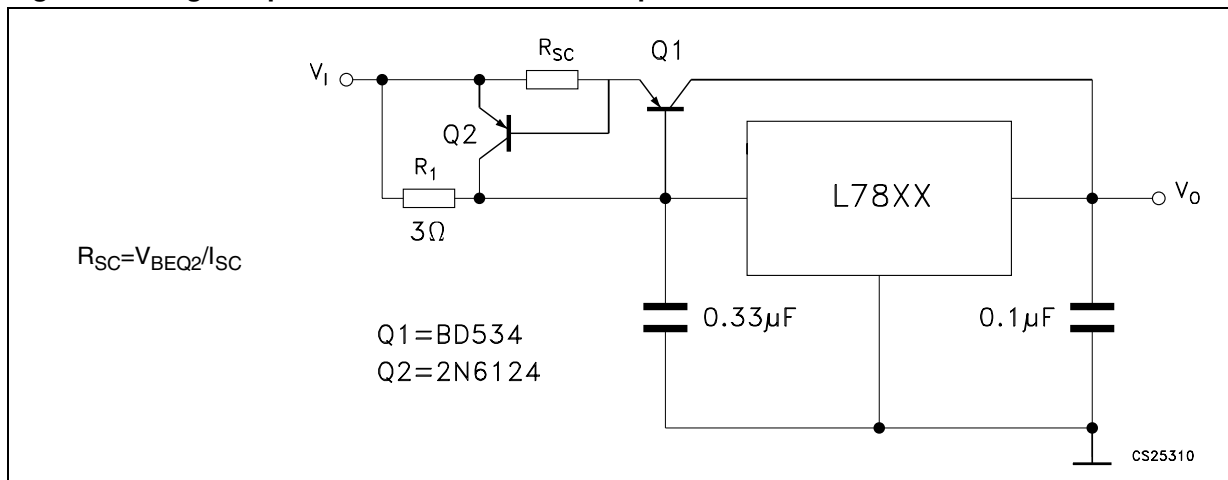


Figure 15. Tracking voltage regulator

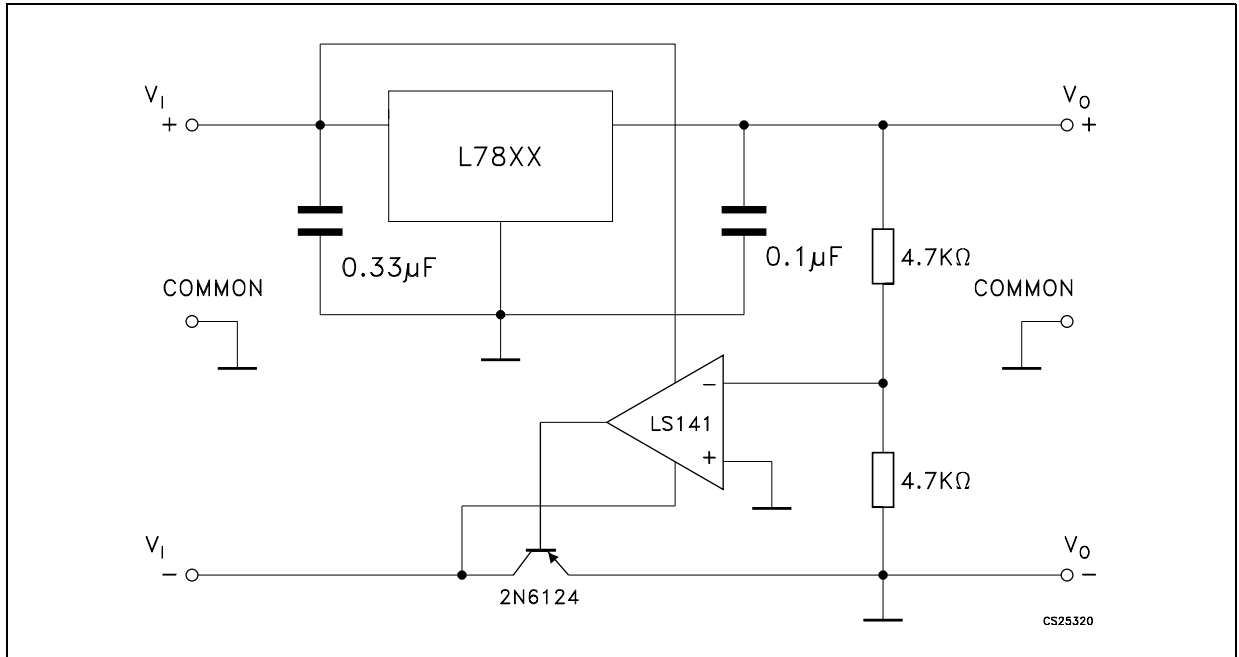
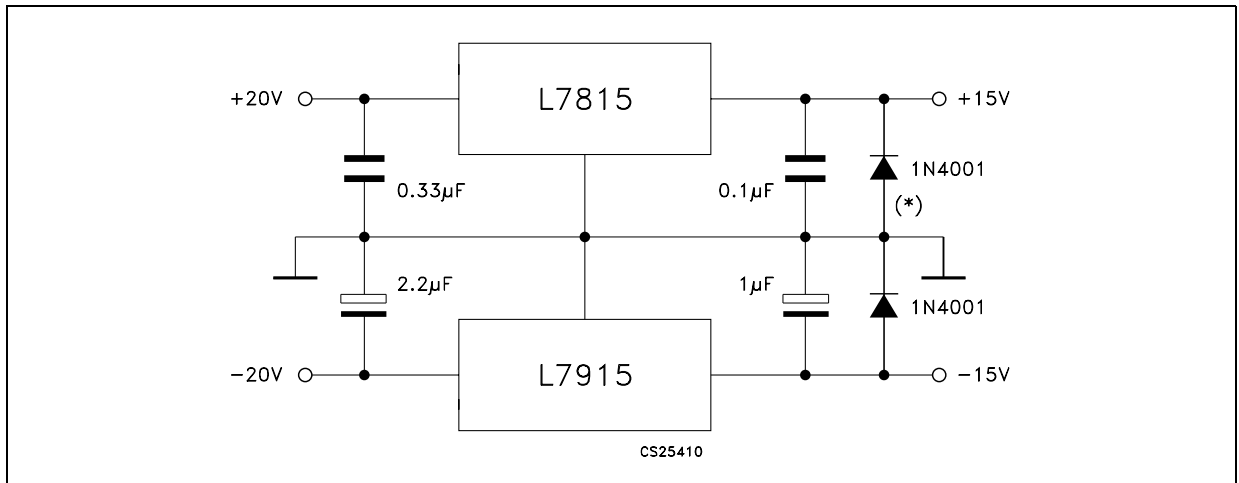


Figure 16. Split power supply ( $\pm 15\text{ V} - 1\text{ A}$ )



\* Against potential latch-up problems.

Figure 17. Negative output voltage circuit

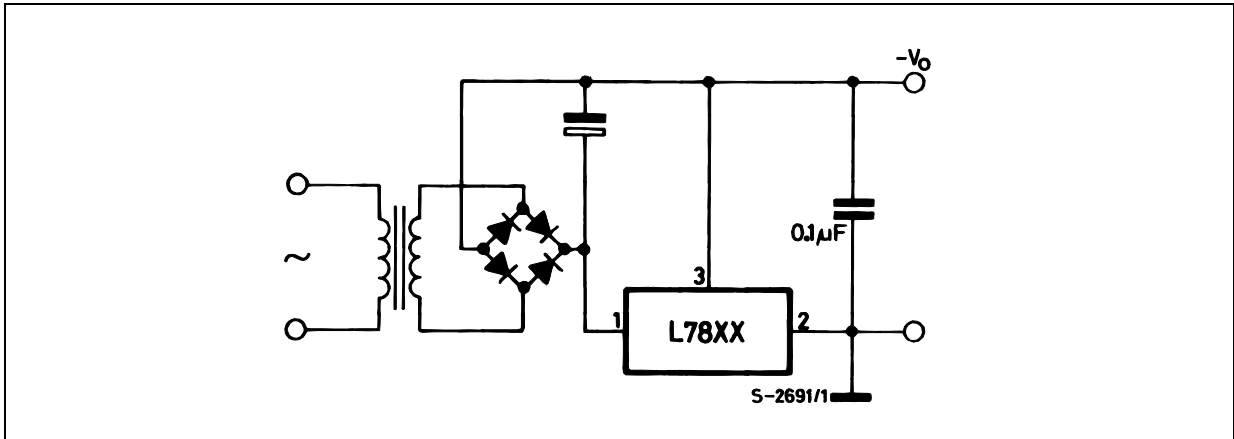


Figure 18. Switching regulator

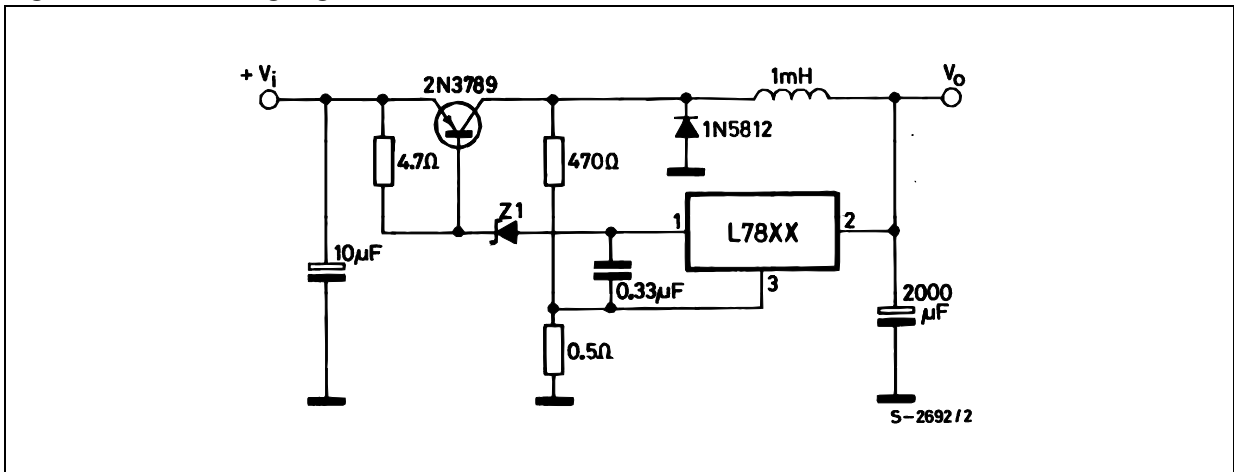


Figure 19. High input voltage circuit (configuration 1)

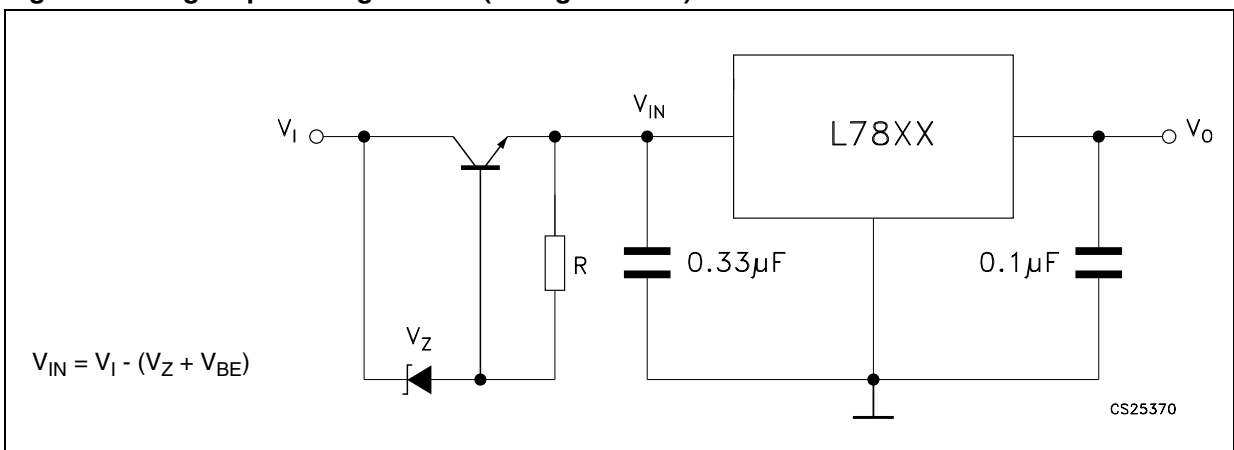




Figure 20. High input voltage circuit (configuration 2)

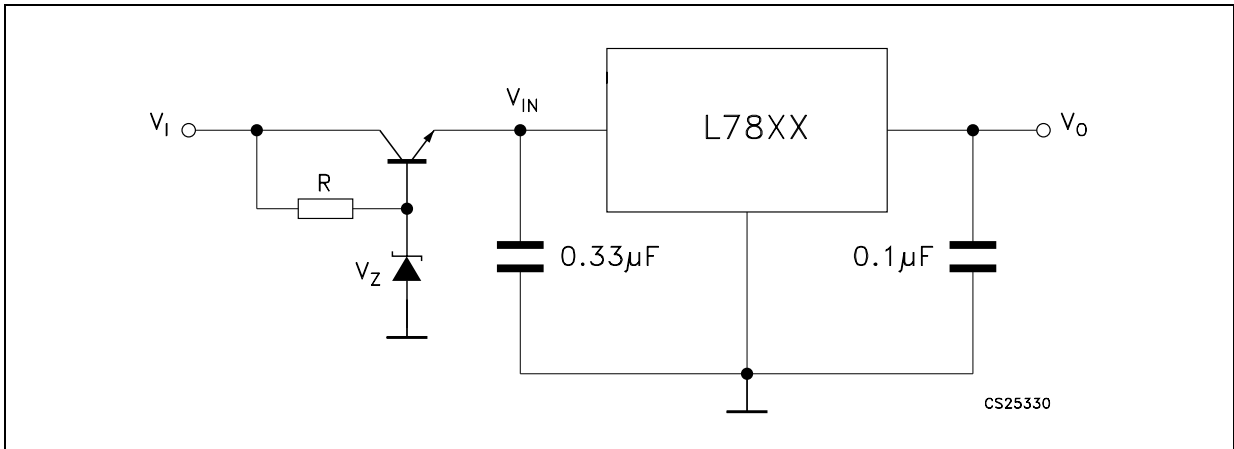


Figure 21. High output voltage regulator

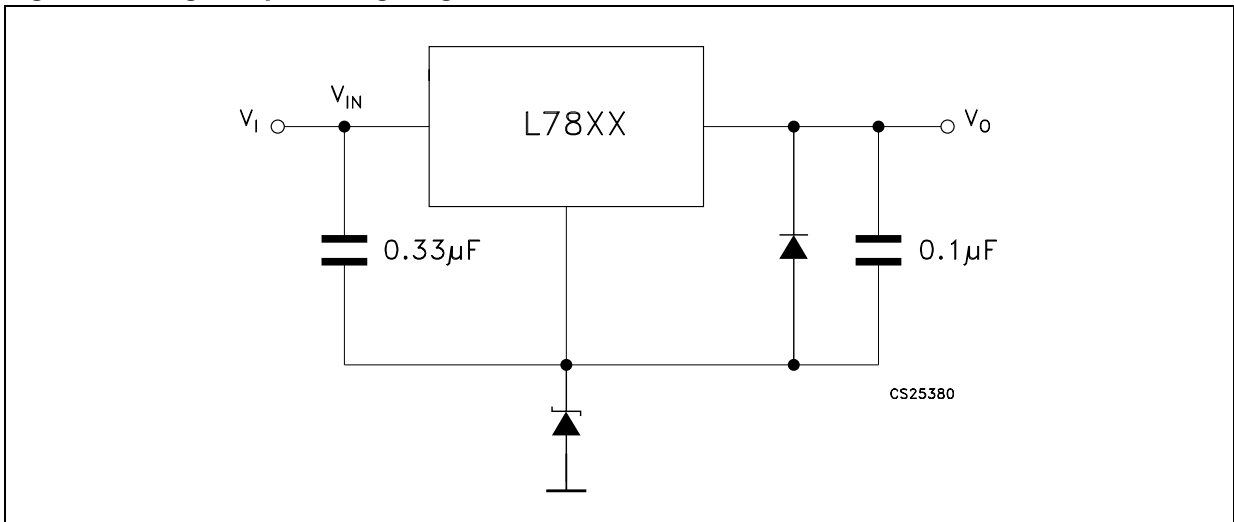


Figure 22. High input and output voltage

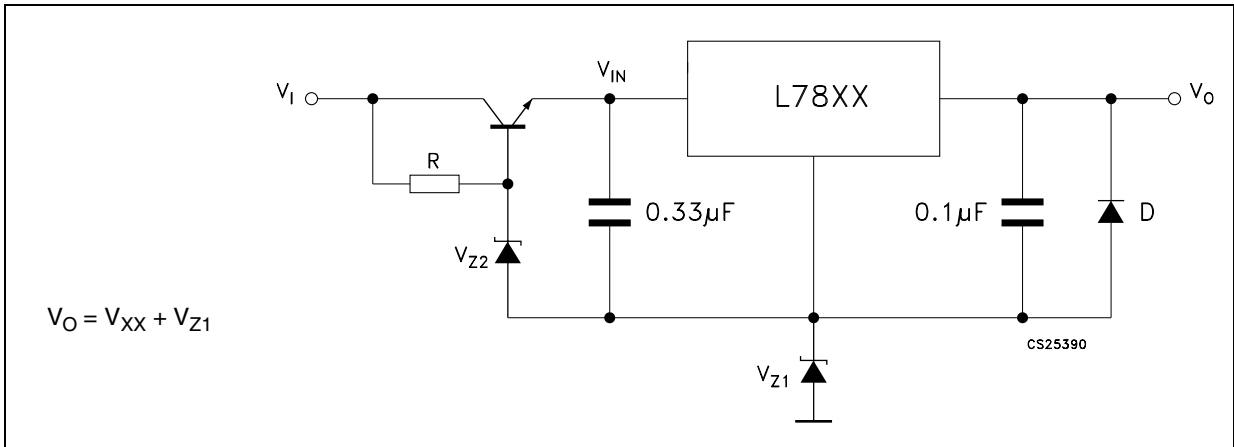


Figure 23. Reducing power dissipation with dropping resistor

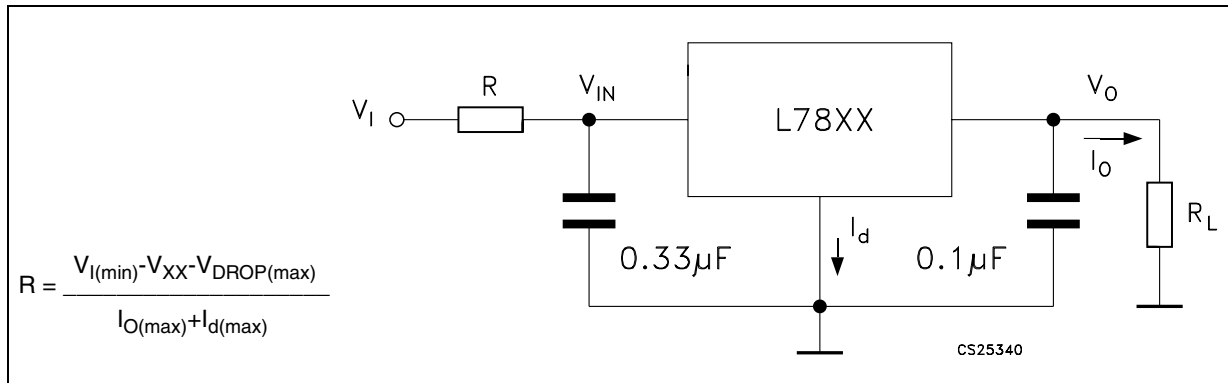


Figure 24. Remote shutdown

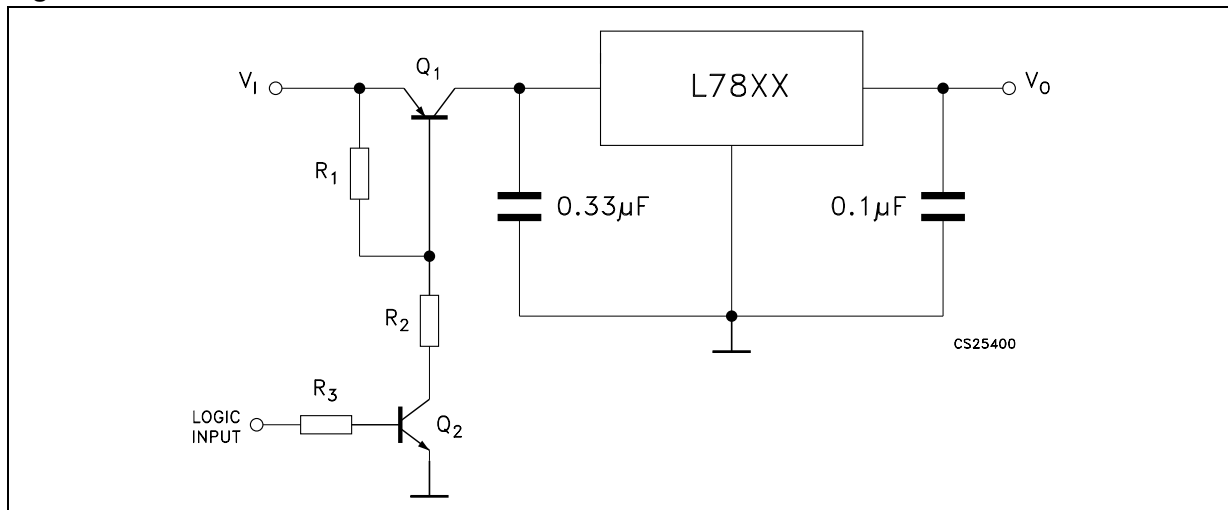
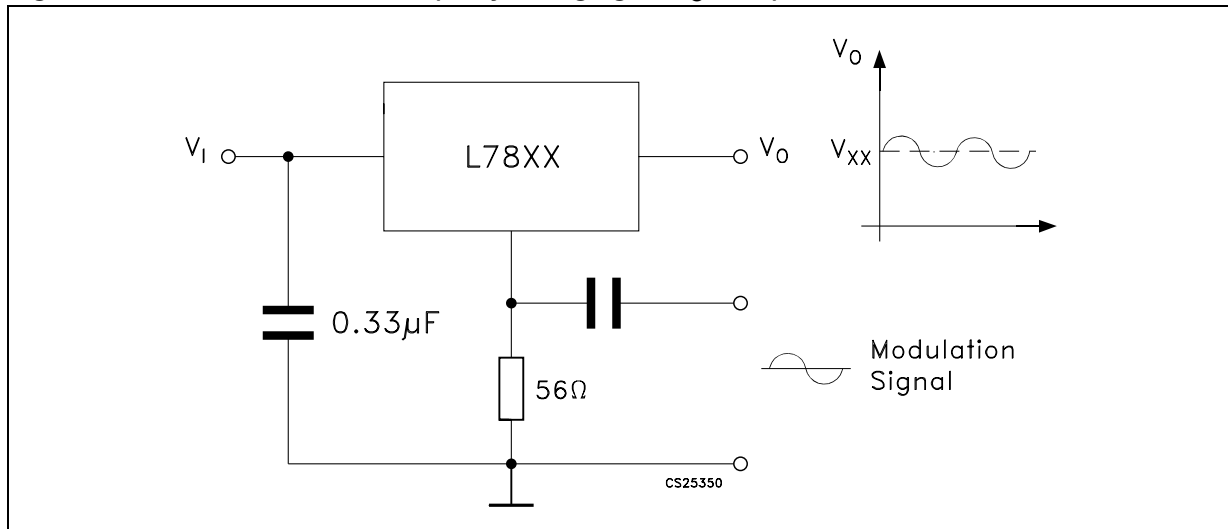
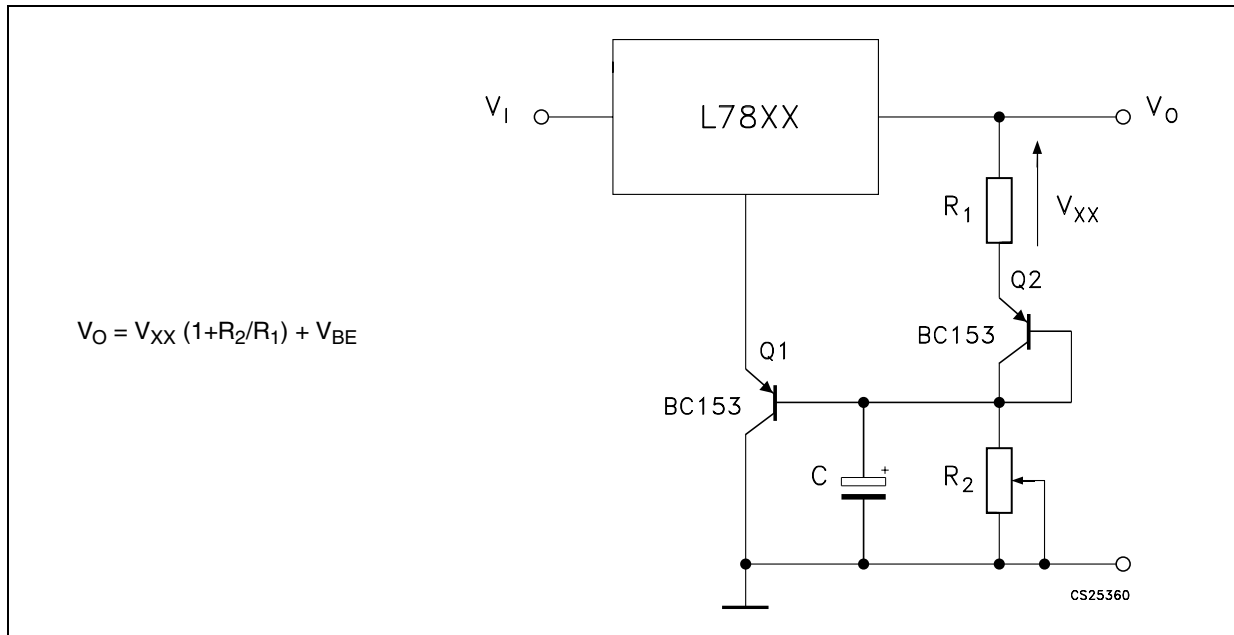


Figure 25. Power AM modulator (unity voltage gain,  $I_O \leq 0.5$ )



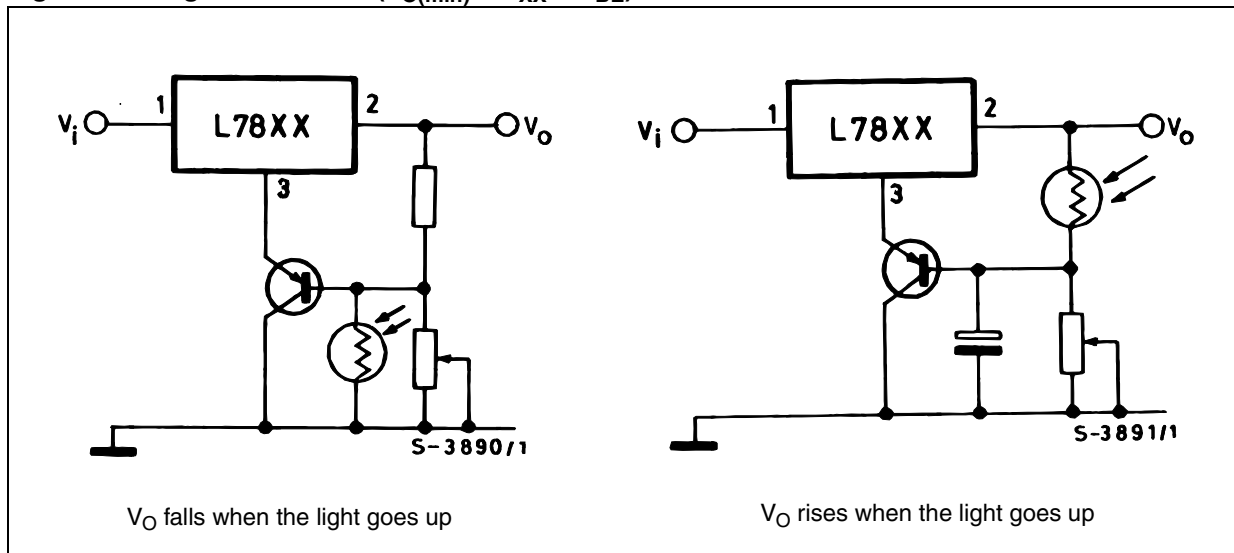
Note: The circuit performs well up to 100 kHz.

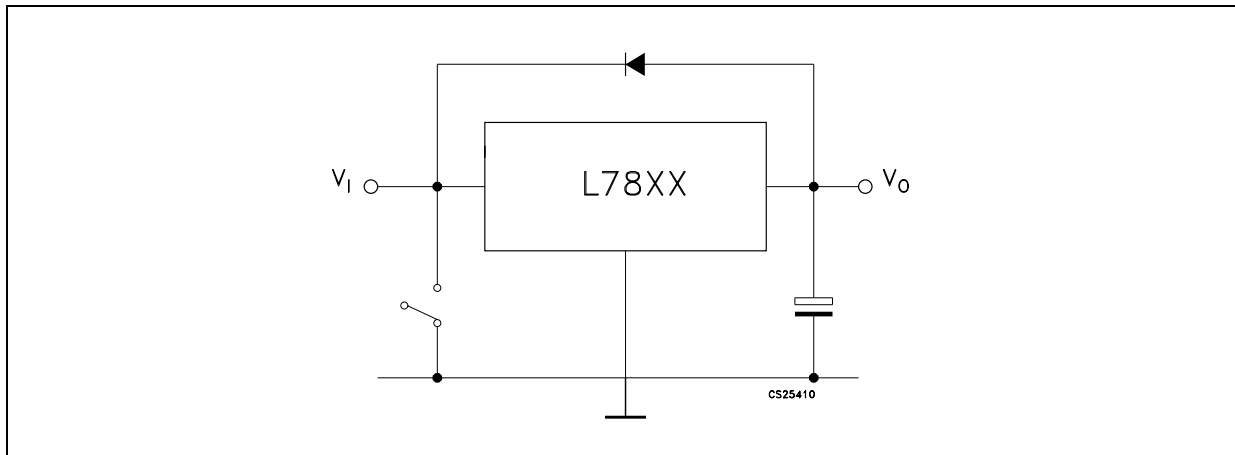
Figure 26. Adjustable output voltage with temperature compensation



Note:  $Q_2$  is connected as a diode in order to compensate the variation of the  $Q_1$   $V_{BE}$  with the temperature.  $C$  allows a slow rise time of the  $V_O$ .

Figure 27. Light controllers ( $V_{O(min)} = V_{XX} + V_{BE}$ )



**Figure 28. Protection against input short-circuit with high capacitance loads**

**Note:** Application with high capacitance loads and an output voltage greater than 6 volts need an external diode (see [Figure 23 on page 34](#)) to protect the device against input short circuit. In this case the input voltage falls rapidly while the output voltage decrease slowly. The capacitance discharges by means of the base-emitter junction of the series pass transistor in the regulator. If the energy is sufficiently high, the transistor may be destroyed. The external diode by-passes the current from the IC to ground.

# 7 Typical performance

Figure 29. Dropout voltage vs. junction temperature

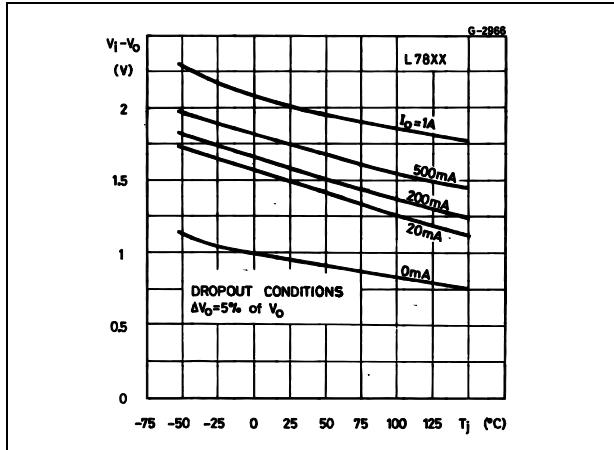


Figure 30. Peak output current vs. input/output differential voltage

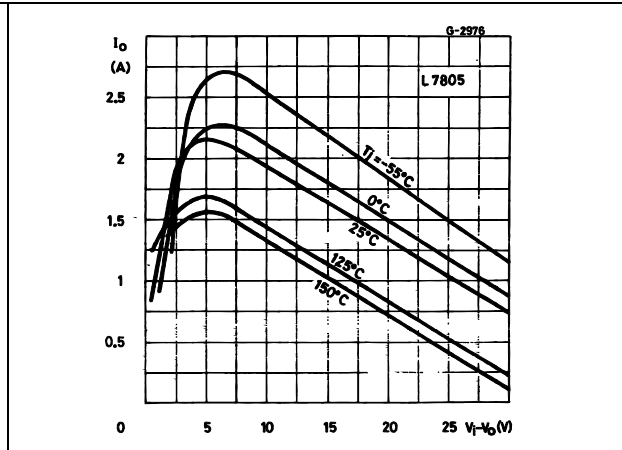


Figure 31. Supply voltage rejection vs. frequency

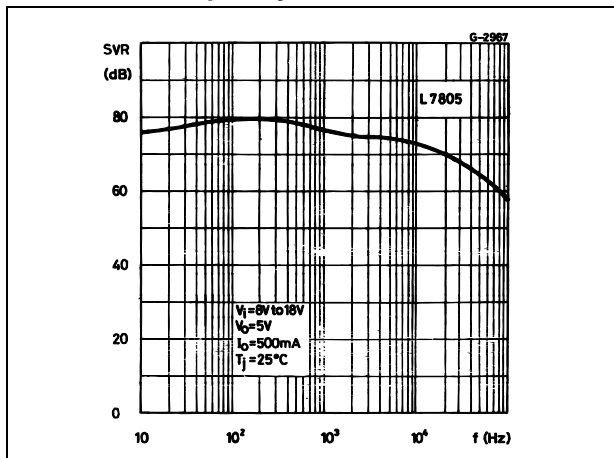


Figure 32. Output voltage vs. junction temperature

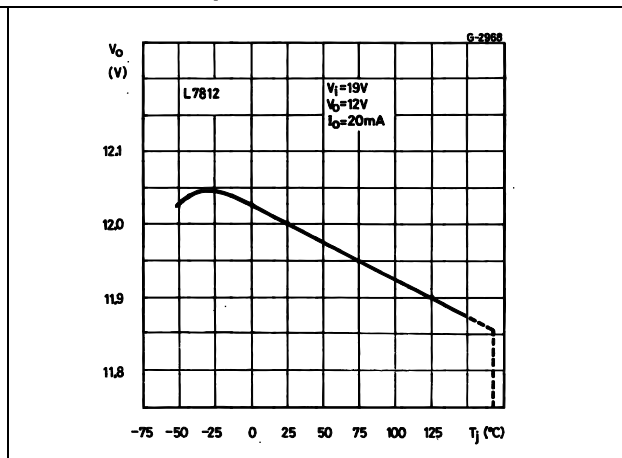


Figure 33. Output impedance vs. frequency

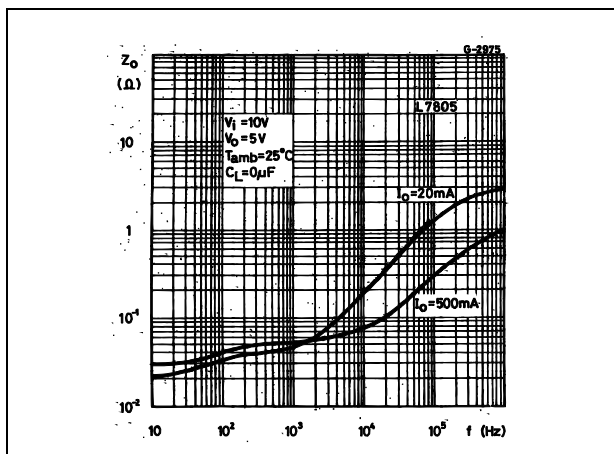


Figure 34. Quiescent current vs. junction temp.

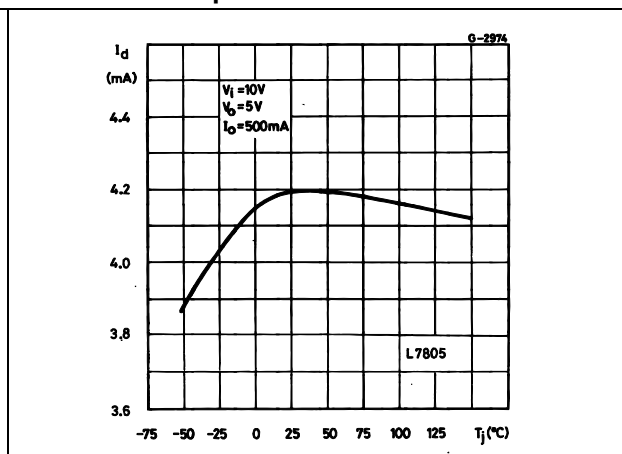


Figure 35. Load transient response

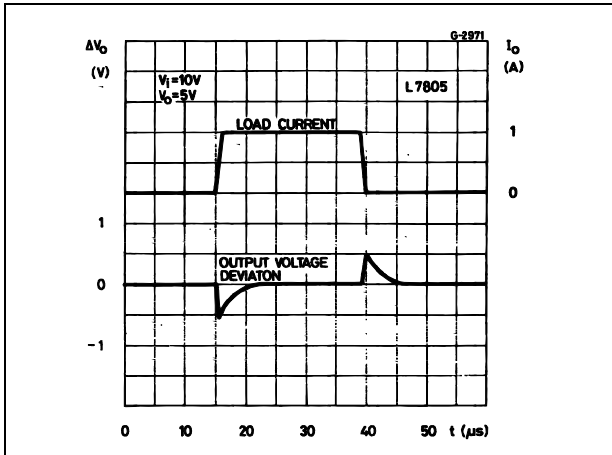


Figure 36. Line transient response

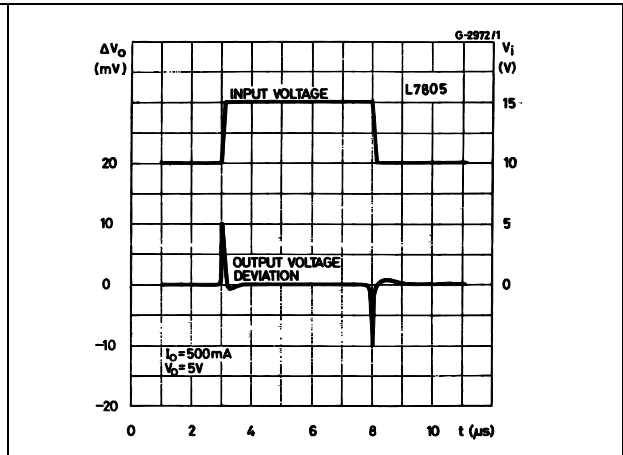
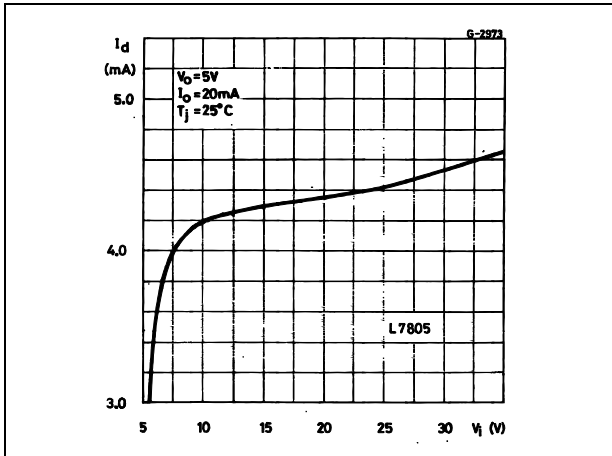


Figure 37. Quiescent current vs. input voltage



## 8 Package mechanical data

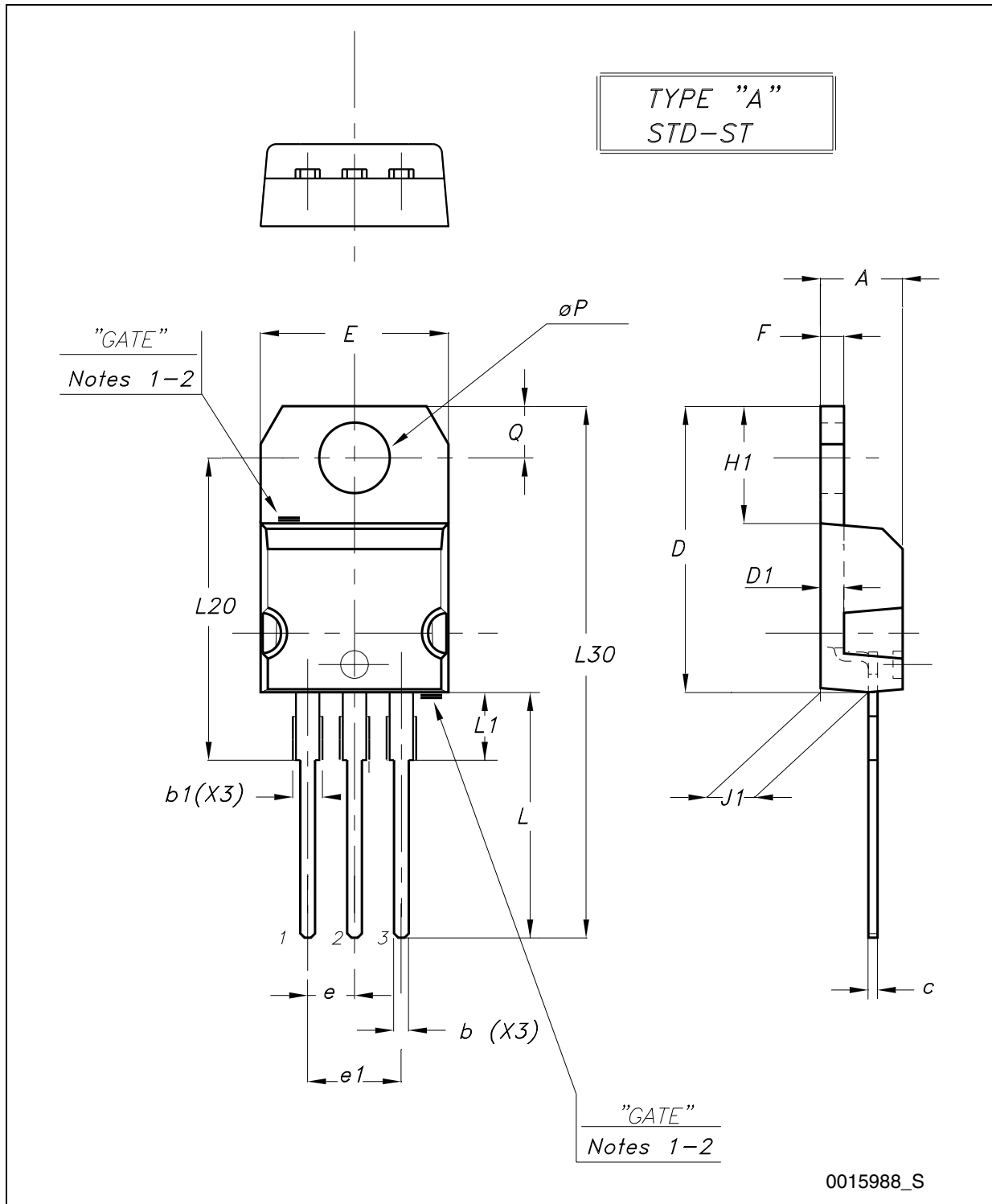
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK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

**Table 23. 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

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

Figure 38. Drawing dimension TO-220 (type STD-ST Dual Gauge)



- Note: 1 Maximum 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.







Figure 42. Drawing dimension TO-220FP

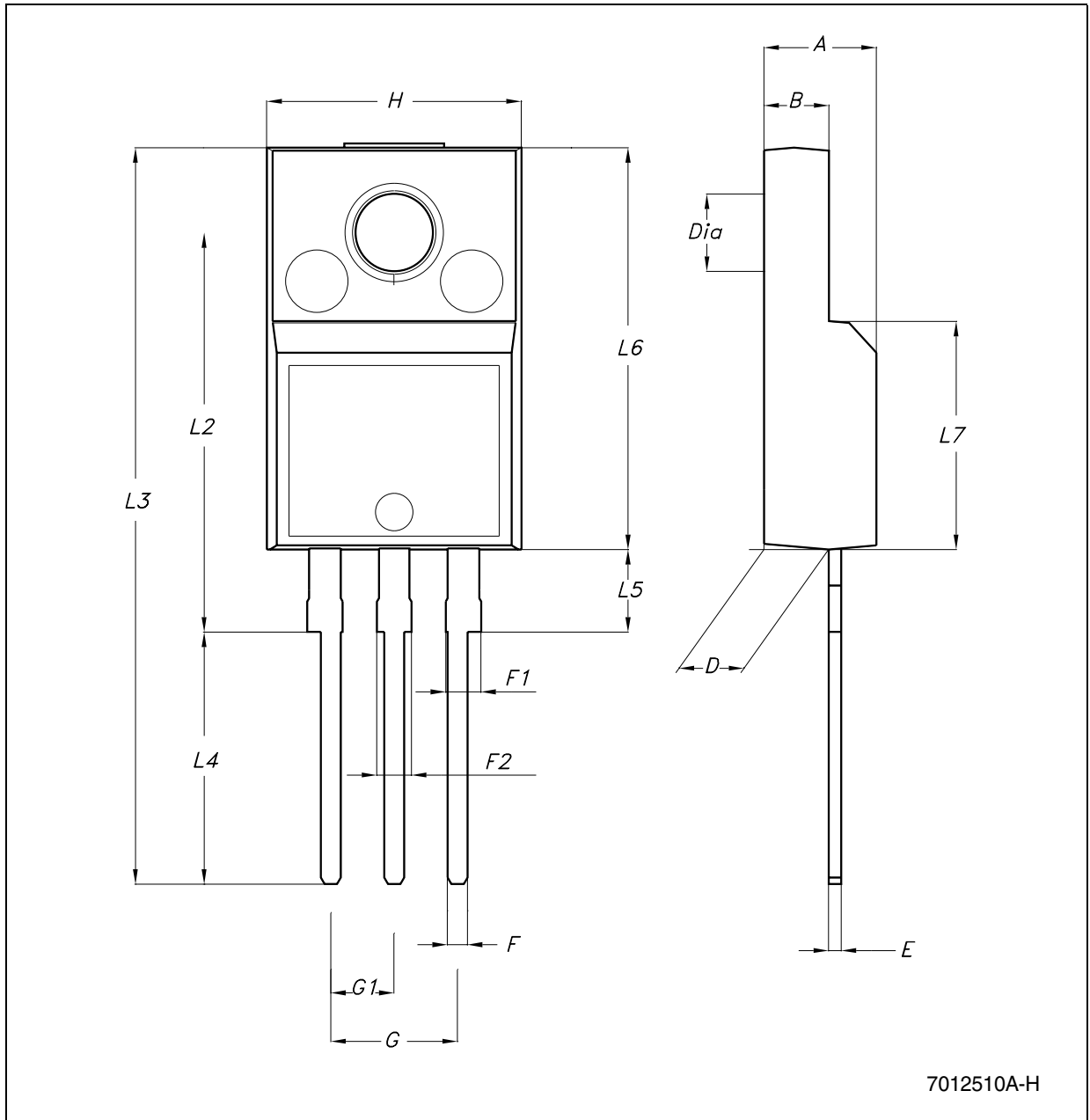


Table 24. TO-220FP mechanical data

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 43. Drawing dimension TO-3

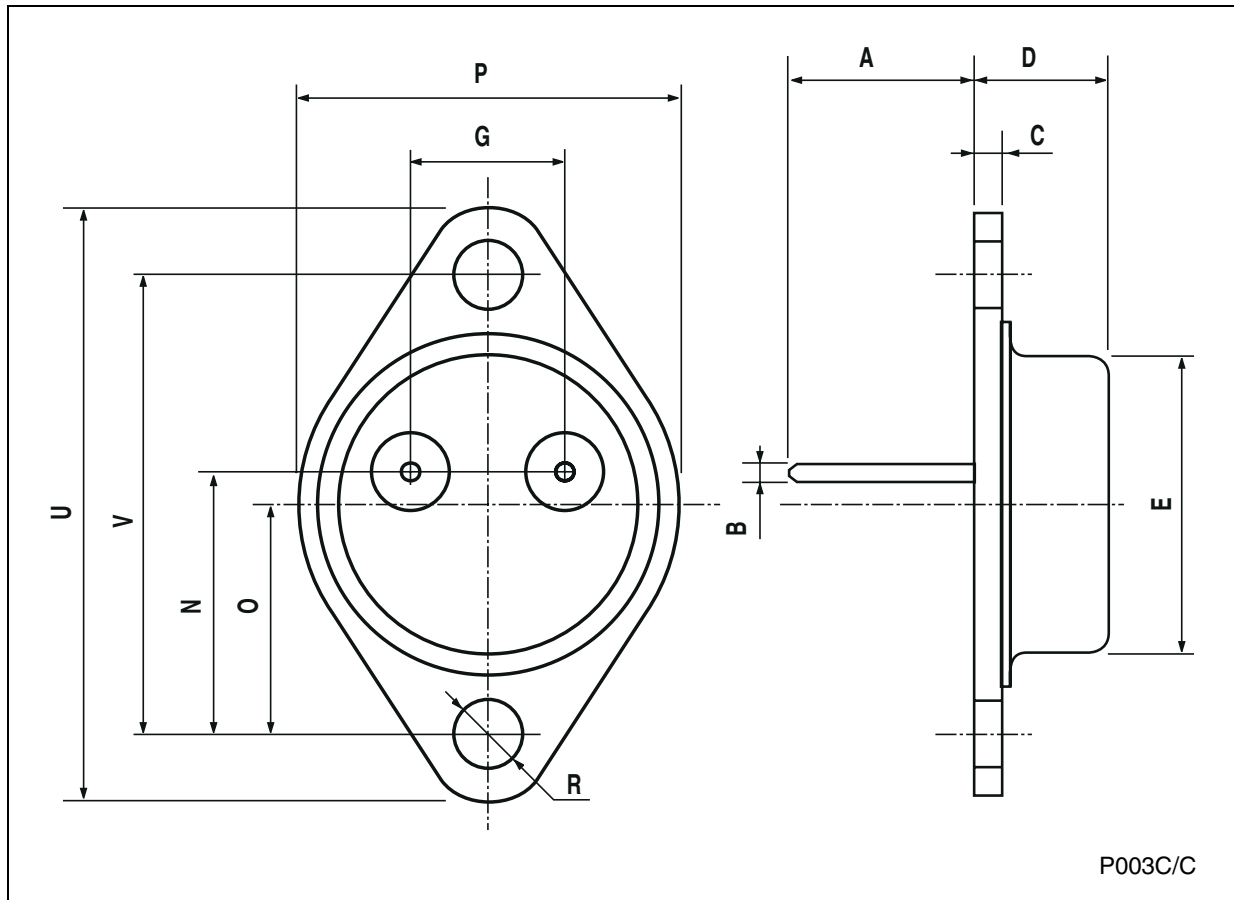


Table 25. TO-3 mechanical data

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 44. Drawing dimension DPAK

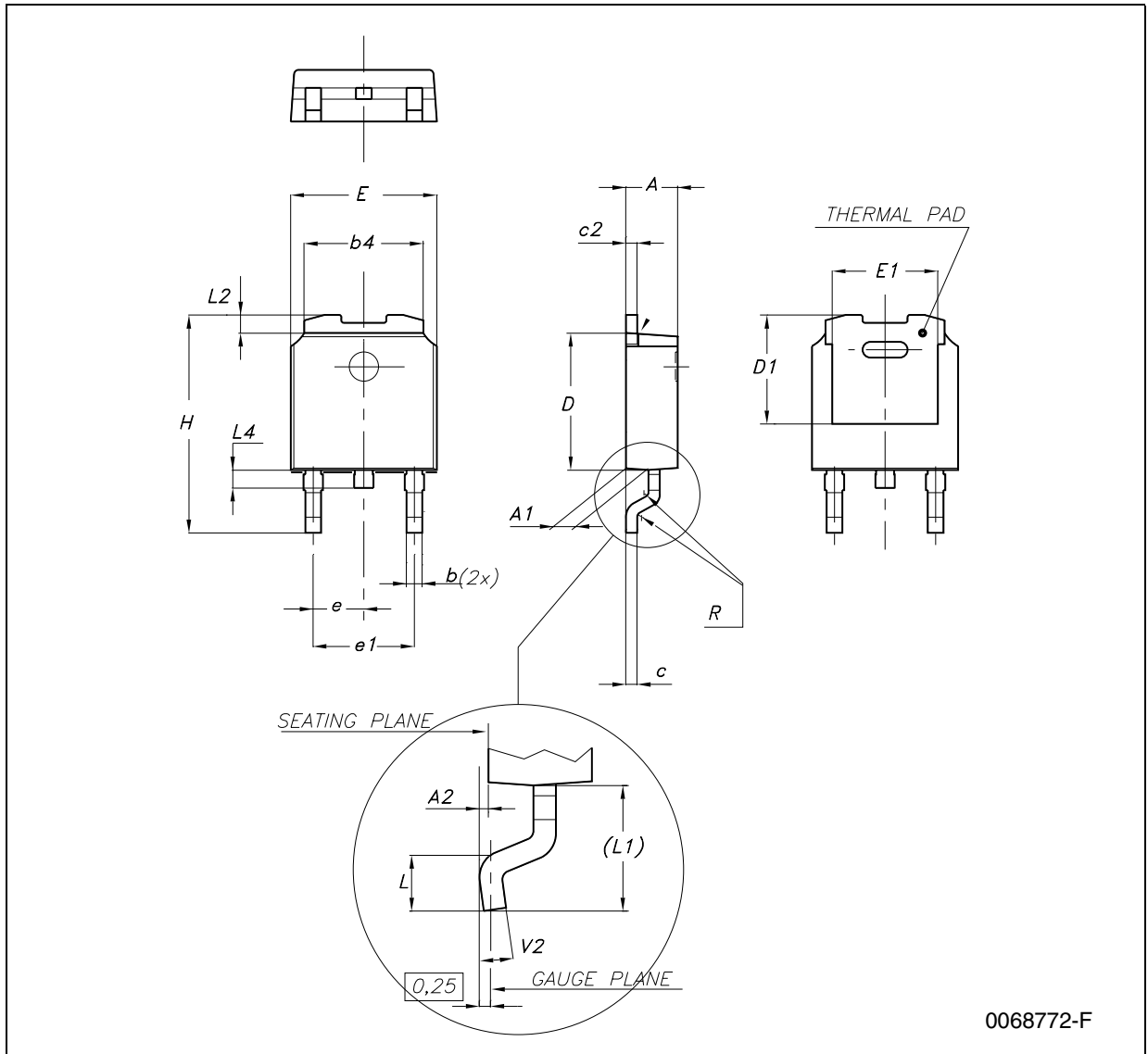


Table 26. DPAK mechanical data

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°

Figure 45. Drawing dimension tape and reel for DPAK

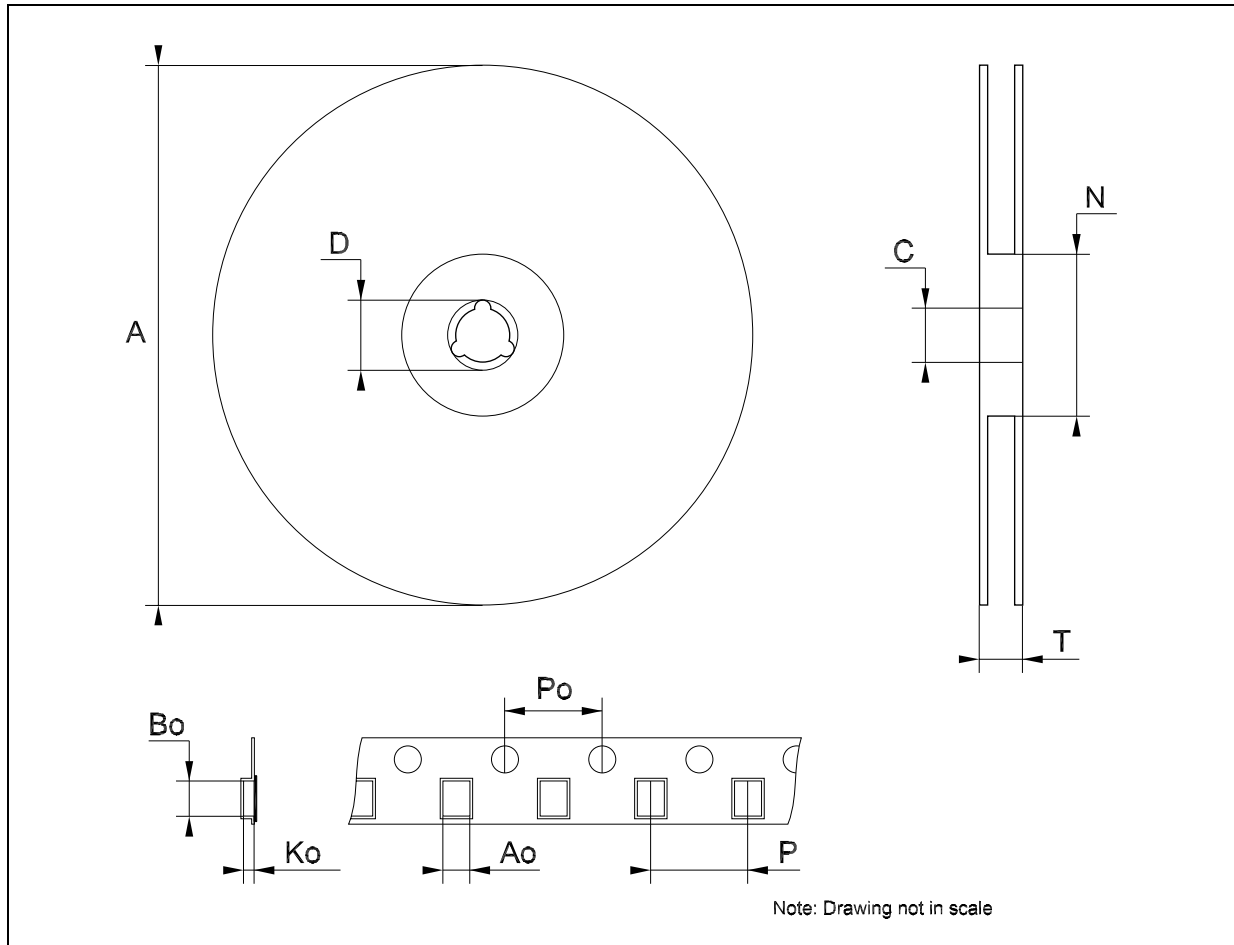


Table 27. Tape and reel DPAK mechanical data

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



Figure 46. Drawing dimension D<sup>2</sup>PAK (type STD-ST)

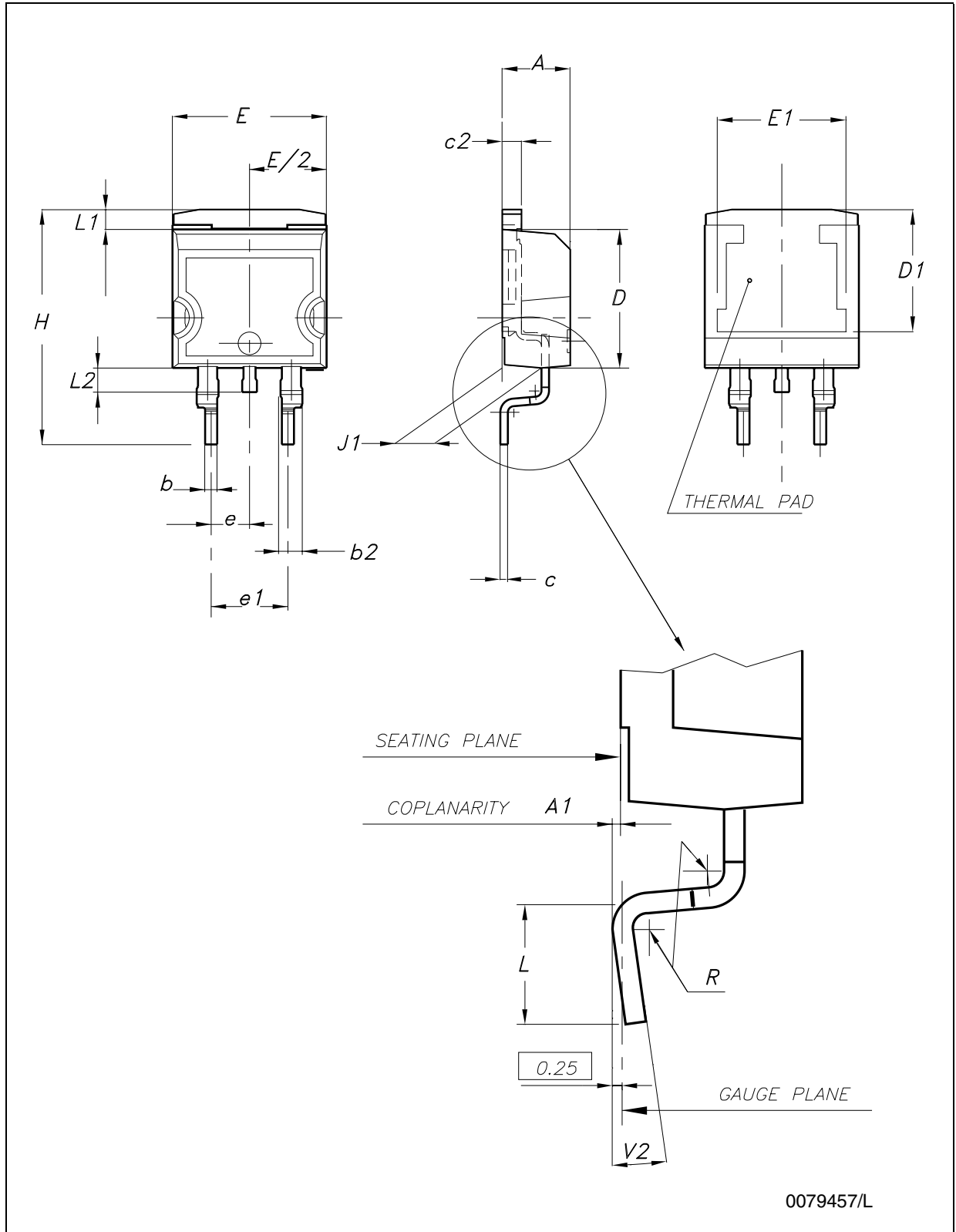


Figure 47. Drawing dimension D<sup>2</sup>PAK (type WOOSEOK-Subcon.)

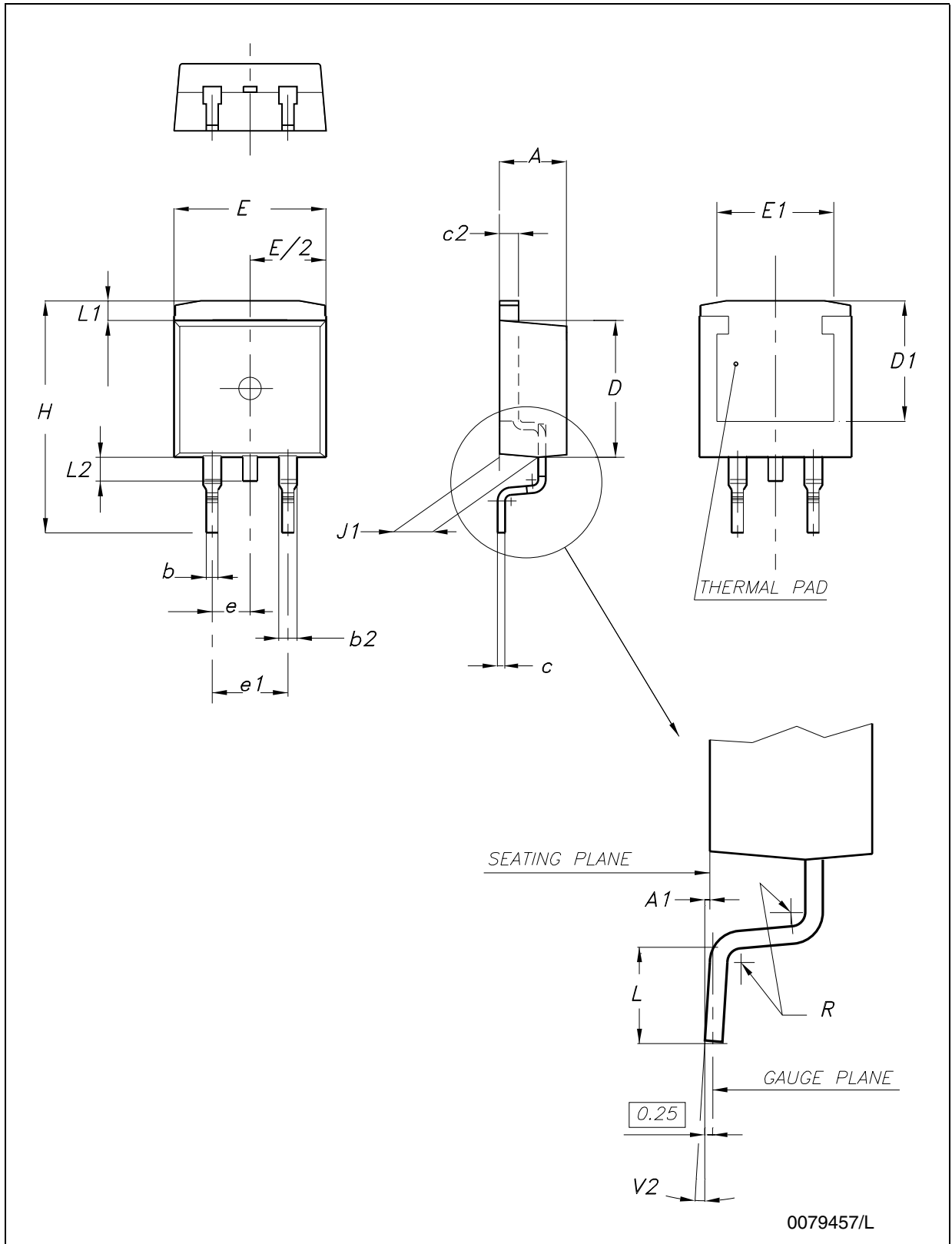


Table 28. D<sup>2</sup>PAK mechanical data

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

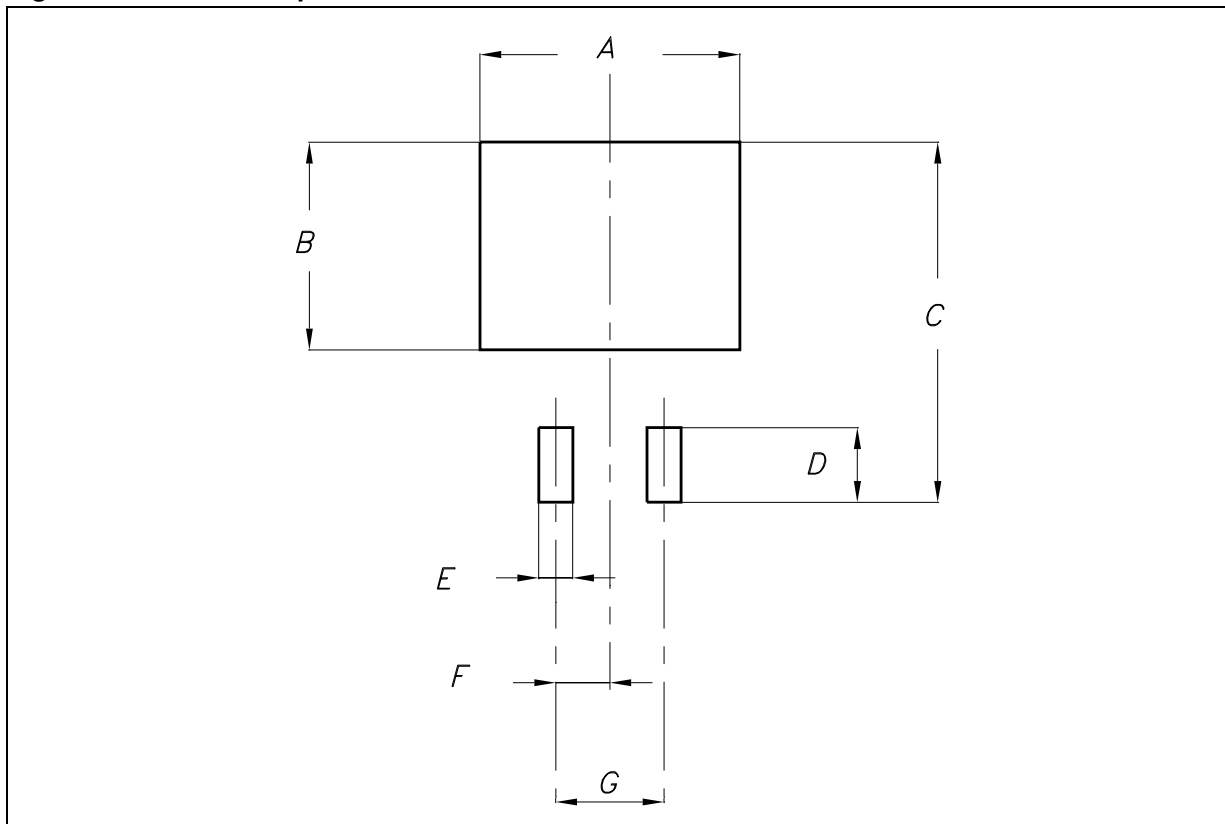


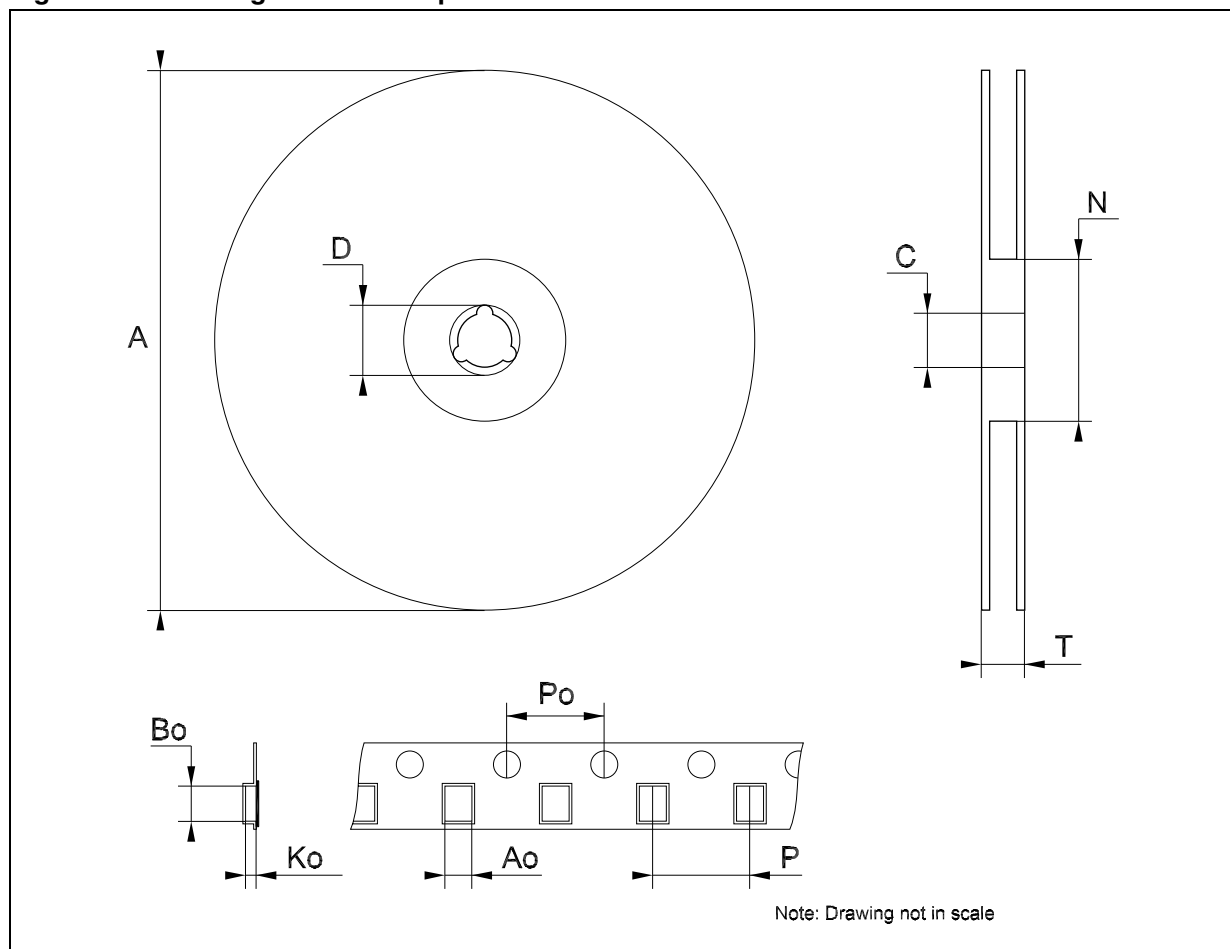
Table 29. D<sup>2</sup>PAK footprint data

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

Table 30. Tape and reel D<sup>2</sup>PAK 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

Figure 49. Drawing dimension tape and reel for D<sup>2</sup>PAK



## 9 Order codes

Table 31. Order codes

Part numbers	Order codes					
	TO-220	DPAK	D <sup>2</sup> PAK	TO-220FP	TO-3	Output voltages
L7805					L7805T	5 V
L7805C	L7805CV	L7805CDT-TR	L7805CD2T-TR	L7805CP	L7805CT	5 V
	L7805CV-DG <sup>(1)</sup>					5 V
L7805AB	L7805ABV		L7805ABD2T-TR	L7805ABP		5 V
	L7805ABV-DG <sup>(1)</sup>					5 V
L7805AC	L7805ACV		L7805ACD2T-TR	L7805ACP		5 V
	L7805ACV-DG <sup>(1)</sup>					5 V
L7806C	L7806CV		L7806CD2T-TR		L7806CT	6 V
	L7806CV-DG <sup>(1)</sup>					6 V
L7806AB	L7806ABV		L7806ABD2T-TR			6 V
	L7806ABV-DG <sup>(1)</sup>					6 V
L7806AC	L7806ACV					6 V
	L7806ACV-DG <sup>(1)</sup>					6 V
L7808C	L7808CV		L7808CD2T-TR			8 V
	L7808CV-DG <sup>(1)</sup>					8 V
L7808AB	L7808ABV		L7808ABD2T-TR			8 V
	L7808ABV-DG <sup>(1)</sup>					8 V
L7808AC	L7808ACV					8 V
	L7808ACV-DG <sup>(1)</sup>					8 V
L7885C	L7885CV		L7885CD2T-TR <sup>(2)</sup>	L7885CP <sup>(2)</sup>	L7885CT <sup>(2)</sup>	8.5 V
L7809C	L7809CV		L7809CD2T-TR	L7809CP		9 V
	L7809CV-DG <sup>(1)</sup>					9 V
L7809AB	L7809ABV		L7809ABD2T-TR			9 V
L7809AC	L7809ACV					9 V
L7812C	L7812CV		L7812CD2T-TR	L7812CP	L7812CT	12 V
	L7812CV-DG <sup>(1)</sup>					12 V
L7812AB	L7812ABV		L7812ABD2T-TR			12 V
	L7812ABV-DG <sup>(1)</sup>					12 V
L7812AC	L7812ACV		L7812ACD2T-TR			12 V
	L7812ACV-DG <sup>(1)</sup>					12 V

Table 31. Order codes

Part numbers	Order codes					
	TO-220	DPAK	D <sup>2</sup> PAK	TO-220FP	TO-3	Output voltages
L7815C	L7815CV		L7815CD2T-TR	L7815CP	L7815CT	15 V
	L7815CV-DG <sup>(1)</sup>					15 V
L7815AB	L7815ABV		L7815ABD2T-TR			15 V
	L7815ABV-DG <sup>(1)</sup>					15 V
L7815AC	L7815ACV		L7815ACD2T-TR			15 V
	L7815ACV-DG <sup>(1)</sup>					15 V
L7818C	L7818CV		L7818CD2T-TR <sup>(2)</sup>		L7818CT	18 V
	L7818CV-DG <sup>(1)</sup>					18 V
L7824C	L7824CV		L7824CD2T-TR	L7824CP	L7824CT	24 V
	L7824CV-DG <sup>(1)</sup>					24 V
L7824AB	L7824ABV					24 V
	L7824ABV-DG <sup>(1)</sup>					24 V
L7824AC	L7824ACV					24 V
	L7824ACV-DG <sup>(1)</sup>					24 V

1. TO-220 Dual Gauge frame.

2. Available on request.

## 10 Revision history

**Table 32. Document revision history**

Date	Revision	Changes
21-Jun-2004	12	Document updating.
03-Aug-2006	13	Order codes has been updated and new template.
19-Jan-2007	14	D <sup>2</sup> PAK mechanical data has been updated and add footprint data.
31-May-2007	15	Order codes has been updated.
29-Aug-2007	16	Added <a href="#">Table 1</a> in cover page.
11-Dec-2007	17	Modified: <a href="#">Table 31</a> .
06-Feb-2008	18	Added: TO-220 mechanical data <a href="#">Figure 38 on page 40</a> , <a href="#">Figure 39 on page 41</a> , and <a href="#">Table 23 on page 39</a> . Modified: <a href="#">Table 31 on page 54</a> .
18-Mar-2008	19	Added: <a href="#">Table 26: DPAK mechanical data on page 47</a> , <a href="#">Table 27: Tape and reel DPAK mechanical data on page 48</a> . Modified: <a href="#">Table 31 on page 54</a> .
26-Jan-2010	20	Modified <a href="#">Table 1 on page 1</a> and <a href="#">Table 23 on page 39</a> , added: <a href="#">Figure 38 on page 40</a> and <a href="#">Figure 39 on page 41</a> , <a href="#">Figure 40 on page 42</a> and <a href="#">Figure 41 on page 42</a> .
04-Mar-2010	21	Added notes <a href="#">Figure 38 on page 40</a> .
08-Sep-2010	22	Modified <a href="#">Table 31 on page 54</a> .
23-Nov-2010	23	Added: T <sub>J</sub> = 25 °C test condition in ΔV <sub>O</sub> on <a href="#">Table 5, 6, 7, 8, 9, 10</a> and <a href="#">Table 11</a> .
16-Sep-2011	24	Modified title on page 1.
30-Nov-2011	25	Added: order codes L7805CV-DG, L7806CV-DG, L7808ABV-DG, L7812CV-DG and L7815CV-DG <a href="#">Table 31 on page 54</a> .
08-Feb-2012	26	Added: order codes L7805ACV-DG, L7805ABV-DG, L7806ABV-DG, L7808CV-DG, L7809CV-DG, L7812ACV-DG, L7818CV-DG, L7824CV-DG <a href="#">Table 31 on page 54</a> .
27-Mar-2012	27	Added: order codes L7812ABV-DG, L7815ABV-DG <a href="#">Table 31 on page 54</a> .
27-Apr-2012	28	Modified: V <sub>I</sub> = 10.4 to 23 V ==> V <sub>I</sub> = 11.4 to 23 V test conditon value Line regulation <a href="#">Table 8 on page 13</a> .
10-May-2012	29	Added: order codes L7806ACV-DG, L7808ACV-DG, L7815ACV-DG, L7824ABV-DG and L7824ACV-DG <a href="#">Table 31 on page 54</a> .
19-Sep-2012	30	Modified load regulation units from V to mV in <a href="#">Table 5</a> to <a href="#">Table 11</a> .



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