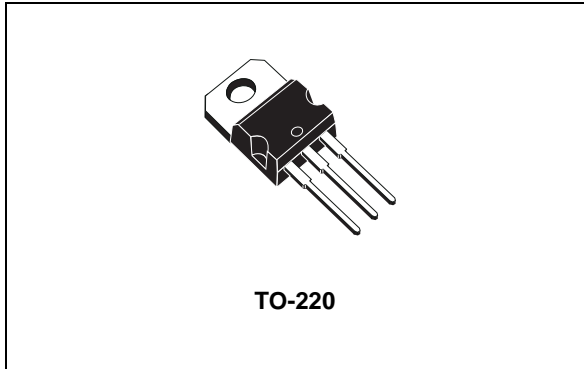


## 2 A positive voltage regulator IC

Datasheet - production data



### Description

The L78S series of three-terminal positive regulators is available in TO-220 package 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 embeds internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 2 A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

### Features

- Output current up to 2 A
- Output voltages of 5; 7.5; 9; 10; 12; 15; 18; 24 V
- Thermal protection
- Short circuit protection
- Output transition SOA protection

**Table 1. Device summary**

Part numbers	TO-220 packages		Output voltage
	Dual gauge	Single gauge	
L78S05C	L78S05CV-DG	L78S05CV	5 V
L78S75C	L78S75CV-DG	L78S75CV	7.5 V
L78S09C	L78S09CV-DG	L78S09CV	9 V
L78S10C	L78S10CV-DG	L78S10CV	10 V
L78S12C	L78S12CV-DG	L78S12CV	12 V
L78S15C	L78S15CV-DG	L78S15CV	15 V
L78S18C		L78S18CV	18 V
L78S24C		L78S24CV	24 V

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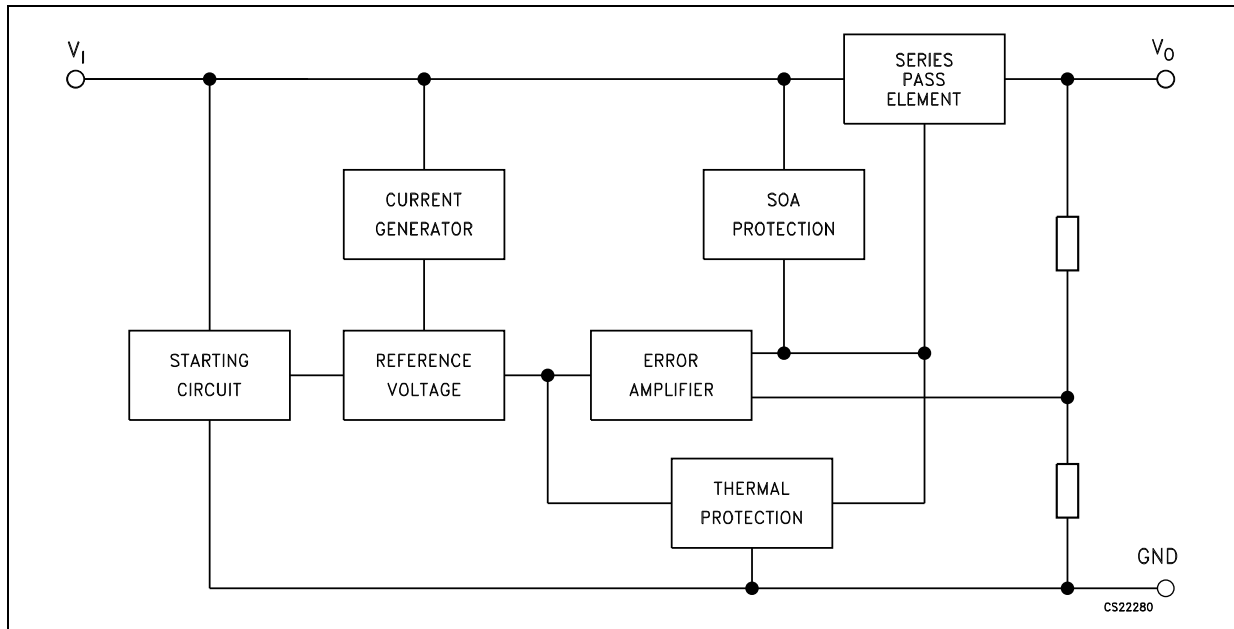
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# 1 Diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)

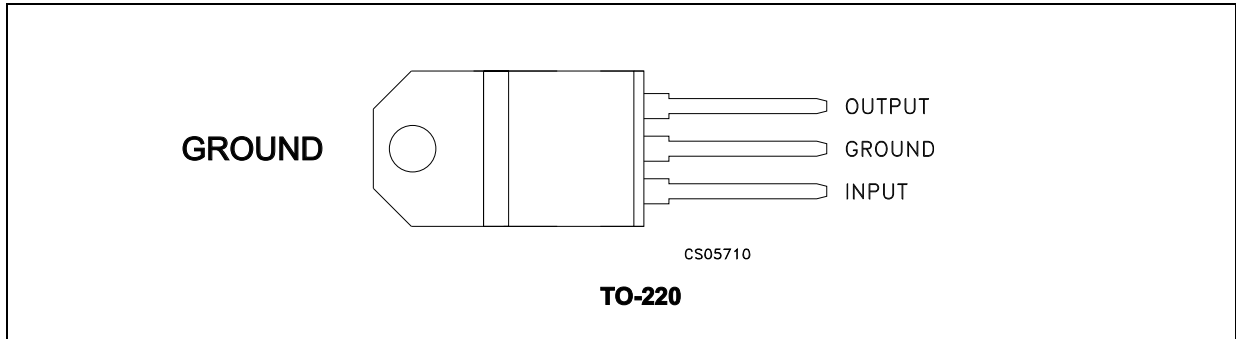
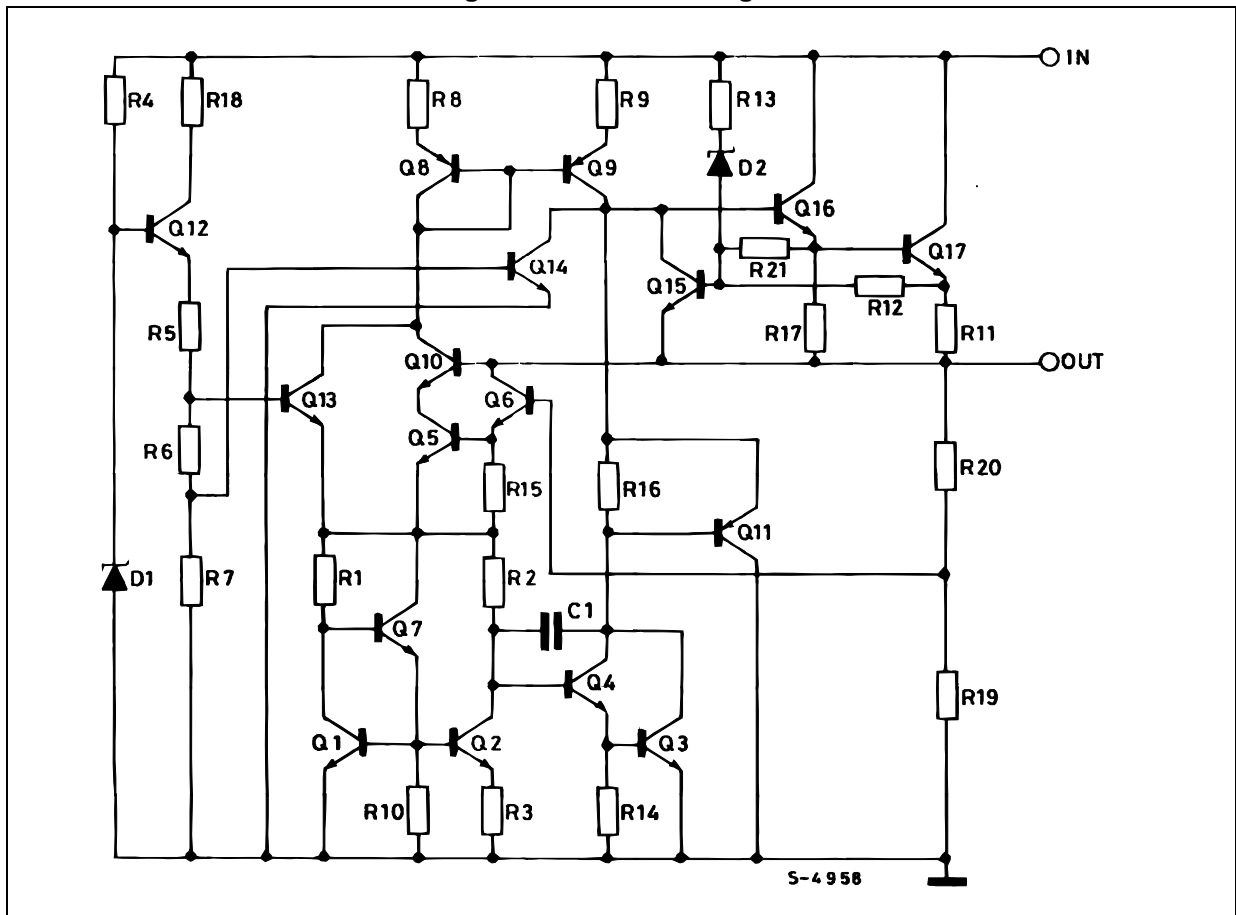


Figure 3. Schematic diagram



### 3 Maximum ratings

Table 2. Absolute maximum ratings

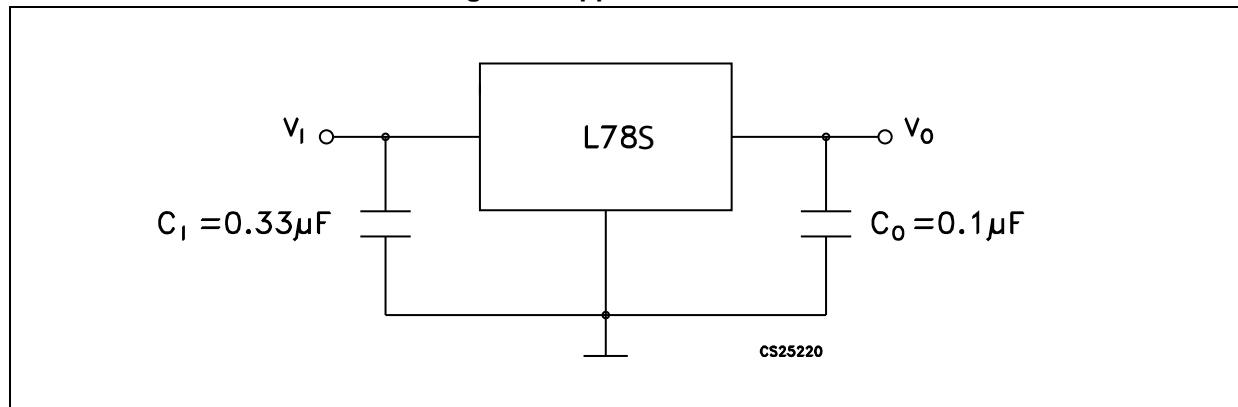
Symbol	Parameter		Value	Unit
$V_I$	DC input voltage	for $V_O = 5$ to $18V$	35	V
		for $V_O = 24V$	40	
$I_O$	Output current		Internally limited	
$P_D$	Power dissipation		Internally limited	
$T_{STG}$	Storage temperature range		-65 to 150	°C
$T_{OP}$	Operating junction temperature range		0 to 150	°C

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

Table 3. Thermal data

Symbol	Parameter	TO-220	Unit
$R_{thJC}$	Thermal resistance junction-case	5	°C/W
$R_{thJA}$	Thermal resistance junction-ambient	50	°C/W

Figure 4. Application circuits



# 4 Test circuits

Figure 5. DC parameter

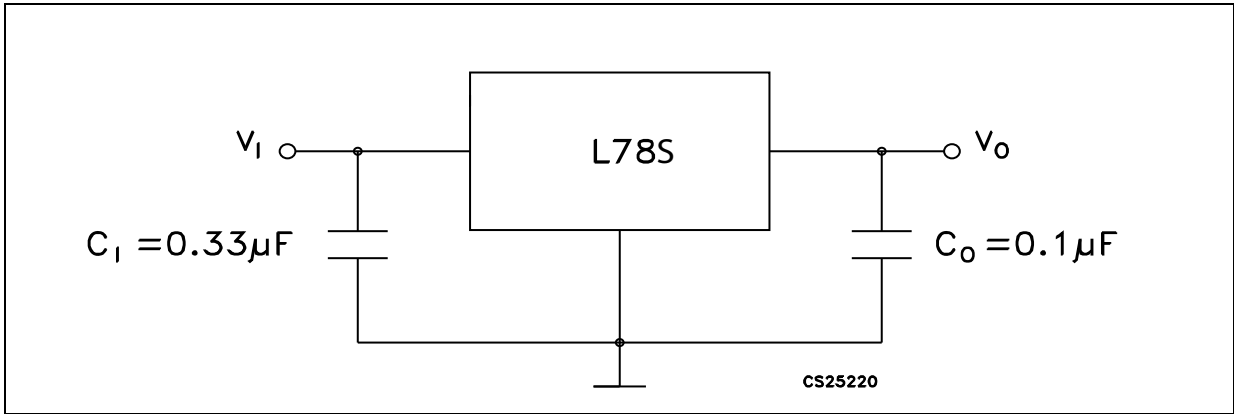


Figure 6. Load regulation

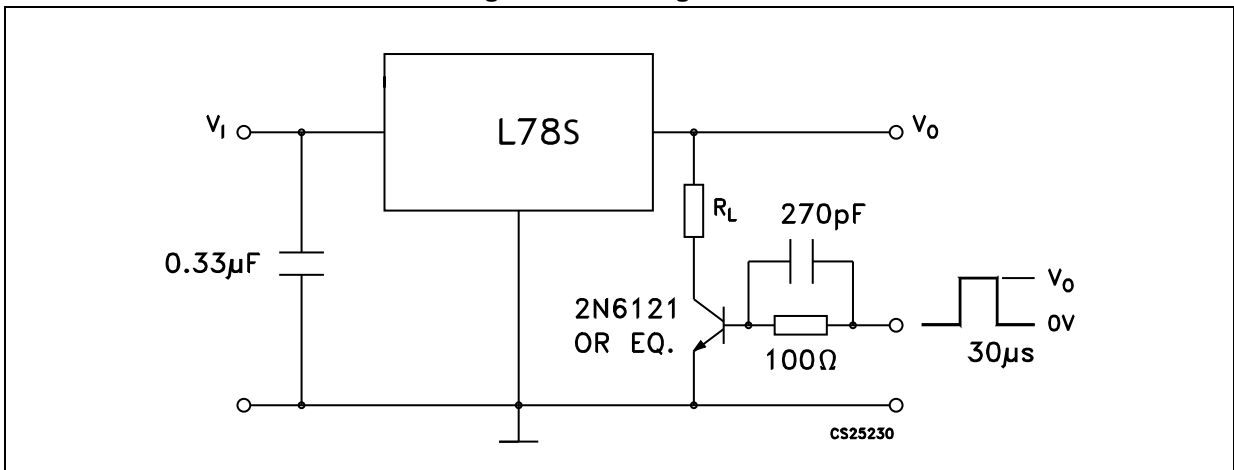
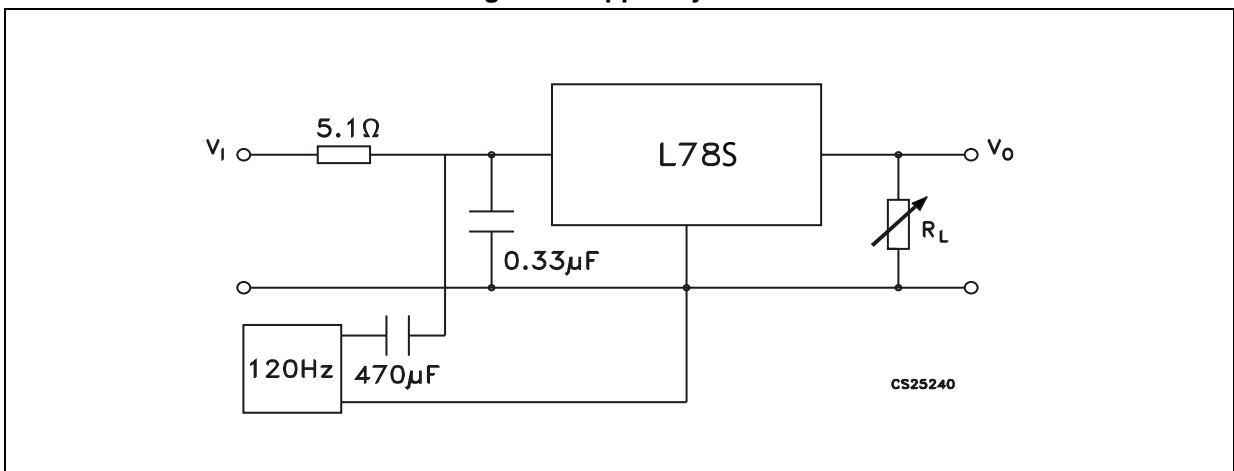


Figure 7. Ripple rejection





## 5 Electrical characteristics

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 10\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 4. Electrical characteristics of L78S05C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		4.8	5	5.2	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 7\text{ V}$	4.75	5	5.25	V
$\Delta V_O$	Line regulation	$V_I = 7\text{ to }25\text{ V}$			100	mV
		$V_I = 8\text{ to }25\text{ V}$			50	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			100	mV
		$I_O = 2\text{ A}$		80		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 7\text{ to }25\text{ V}$ , $I_O = 20\text{ mA}$			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1.1		mV/°C
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$		40		$\mu\text{V}$
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	54 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	8			V
$R_O$	Output resistance	$f = 1\text{ kHz}$		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 12.5\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 5. Electrical characteristics of L78S75C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		7.15	7.5	7.9	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 9.5\text{ V}$	7.1	7.5	7.95	V
$\Delta V_O$	Line regulation	$V_I = 9.5\text{ to }25\text{ V}$			120	mV
		$V_I = 10.5\text{ to }20\text{ V}$			60	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			140	mV
		$I_O = 2\text{ A}$		100		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 9.5\text{ to }25\text{ V}$ , $I_O = 20\text{ mA}$			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-0.8		mV/°C
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$		52		μV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	48 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	10.5			V
$R_O$	Output resistance	$f = 1\text{ kHz}$		16		mΩ
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 14\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 6. Electrical characteristics of L78S09C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		8.65	9	9.35	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 11\text{ V}$	8.6	9	9.4	V
$\Delta V_O$	Line regulation	$V_I = 11\text{ to }25\text{ V}$			130	mV
		$V_I = 11\text{ to }20\text{ V}$			65	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			170	mV
		$I_O = 2\text{ A}$		100		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 11\text{ to }25\text{ V}$ , $I_O = 20\text{ mA}$			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1		mV/°C
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$		60		$\mu\text{V}$
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	47 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	12			V
$R_O$	Output resistance	$f = 1\text{ kHz}$		17		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 15\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 7. Electrical characteristics of L78S10C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		9.5	10	10.5	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 12.5\text{ V}$	9.4	10	10.6	V
$\Delta V_O$	Line regulation	$V_I = 12.5\text{ to }30\text{ V}$			200	mV
		$V_I = 14\text{ to }22\text{ V}$			100	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			240	mV
		$I_O = 2\text{ A}$		150		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 12.5\text{ to }30\text{ V}$ , $I_O = 20\text{ mA}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1		mV/°C
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$		65		µV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	47 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	13			V
$R_O$	Output resistance	$f = 1\text{ kHz}$		17		mΩ
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 19\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 8. Electrical characteristics of L78S12C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		11.5	12	12.5	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 14.5\text{ V}$	11.4	12	12.6	V
$\Delta V_O$	Line regulation	$V_I = 14.5\text{ to }30\text{ V}$			240	mV
		$V_I = 16\text{ to }22\text{ V}$			120	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			240	mV
		$I_O = 2\text{ A}$		150		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 14.5\text{ to }30\text{ V}$ , $I_O = 20\text{ mA}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		75		μV
SVR	Supply voltage rejection	f = 120 Hz	47 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	15			V
$R_O$	Output resistance	f = 1 kHz		18		mΩ
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 23\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 9. Electrical characteristics of L78S15C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		14.4	15	15.6	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 17.5\text{ V}$	14.25	15	15.75	V
$\Delta V_O$	Line regulation	$V_I = 17.5\text{ to }30\text{ V}$			300	mV
		$V_I = 20\text{ to }26\text{ V}$			150	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			300	mV
		$I_O = 2\text{ A}$		150		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 17.5\text{ to }30\text{ V}$ , $I_O = 20\text{ mA}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		90		μV
SVR	Supply voltage rejection	f = 120 Hz	46 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	18			V
$R_O$	Output resistance	f = 1 kHz		19		mΩ
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 26\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 10. Electrical characteristics of L78S18C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		17.1	18	18.9	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 20.5\text{ V}$	17	18	19	V
$\Delta V_O$	Line regulation	$V_I = 20.5\text{ to }30\text{ V}$			360	mV
		$V_I = 22\text{ to }28\text{ V}$			180	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			360	mV
		$I_O = 2\text{ A}$		200		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 20.5\text{ to }30\text{ V}$ , $I_O = 20\text{ mA}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		110		μV
SVR	Supply voltage rejection	f = 120 Hz	43 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	21			V
$R_O$	Output resistance	f = 1 kHz		22		mΩ
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits,  $T_J = 25\text{ °C}$ ,  $V_I = 33\text{ V}$ ,  $I_O = 500\text{ mA}$ , unless otherwise specified.

**Table 11. Electrical characteristics of L78S24C**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_O$	Output voltage		23	24	25	V
$V_O$	Output voltage	$I_O = 1\text{ A}$ , $V_I = 27\text{ V}$	22.8	24	25.2	V
$\Delta V_O$	Line regulation	$V_I = 27\text{ to }38\text{ V}$			480	mV
		$V_I = 30\text{ to }36\text{ V}$			240	
$\Delta V_O$	Load regulation	$I_O = 20\text{ mA to }1.5\text{ A}$			480	mV
		$I_O = 2\text{ A}$		300		
$I_Q$	Quiescent current				8	mA
$\Delta I_Q$	Quiescent current change	$I_O = 20\text{ mA to }1\text{ A}$			0.5	mA
		$V_I = 27\text{ to }38\text{ V}$ , $I_O = 20\text{ mA}$			1	
$\Delta V_O/\Delta T$	Output voltage drift	$I_O = 5\text{ mA}$ , $T_J = 0\text{ °C to }70\text{ °C}$		-1.5		mV/°C
eN	Output noise voltage	$B = 10\text{ Hz to }100\text{ kHz}$		170		$\mu\text{V}$
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	42 <sup>(1)</sup>			dB
$V_I$	Operating input voltage	$I_O \leq 1\text{ A}$	27			V
$R_O$	Output resistance	$f = 1\text{ kHz}$		28		m $\Omega$
$I_{sc}$	Short circuit current	$V_I = 27\text{ V}$		500		mA
$I_{scp}$	Short circuit peak current			3		A

1. Guaranteed by design.



# 6 Typical performance

Figure 8. Dropout voltage vs. junction temperature

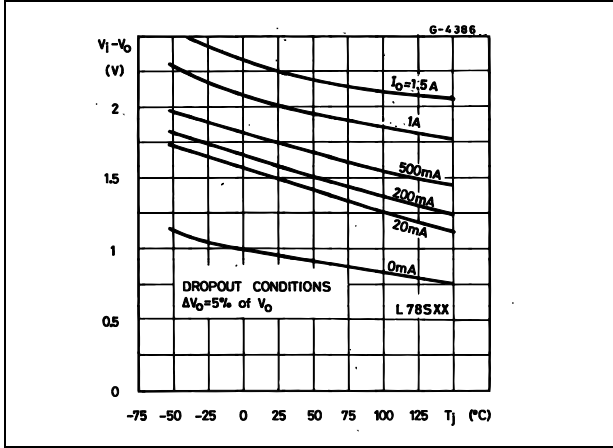


Figure 9. Peak output current vs. input/output differential voltage

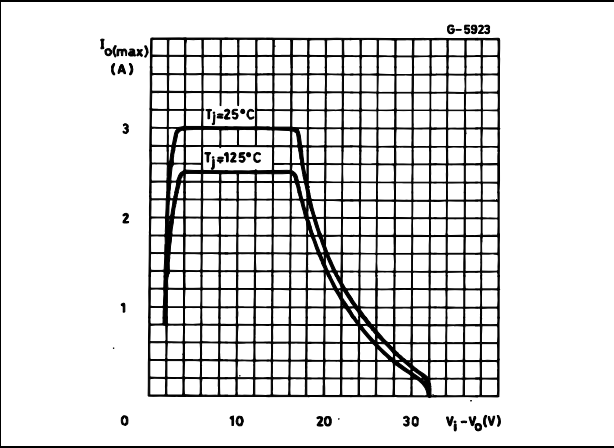


Figure 10. Output impedance vs. frequency

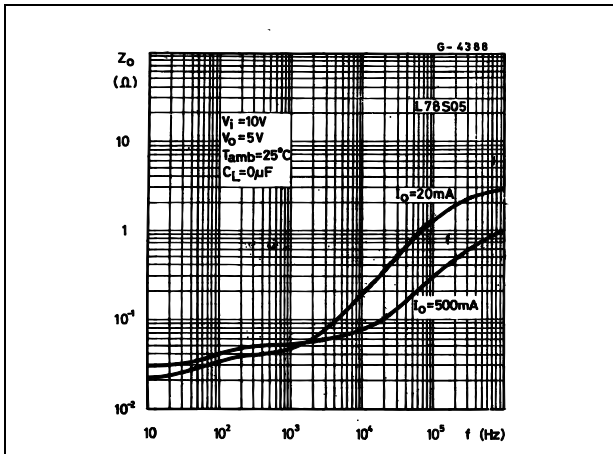


Figure 11. Output voltage vs. junction temperature

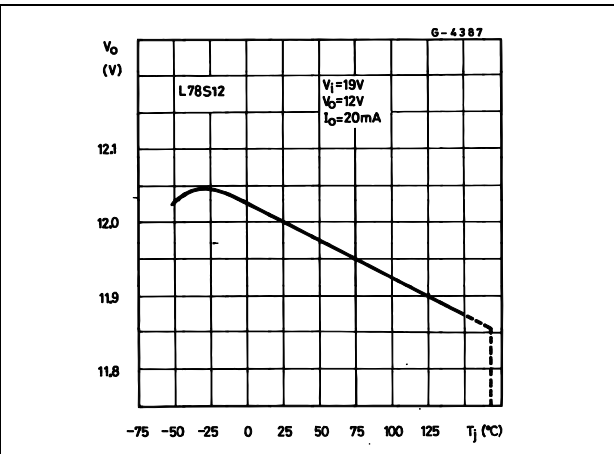


Figure 12. Supply voltage rejection vs. frequency

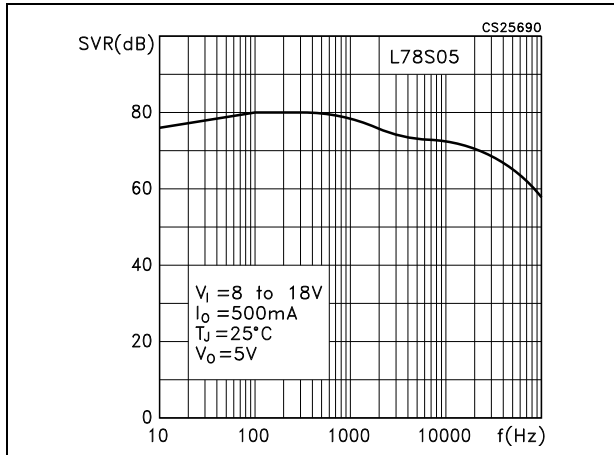


Figure 13. Quiescent current vs. junction temperature

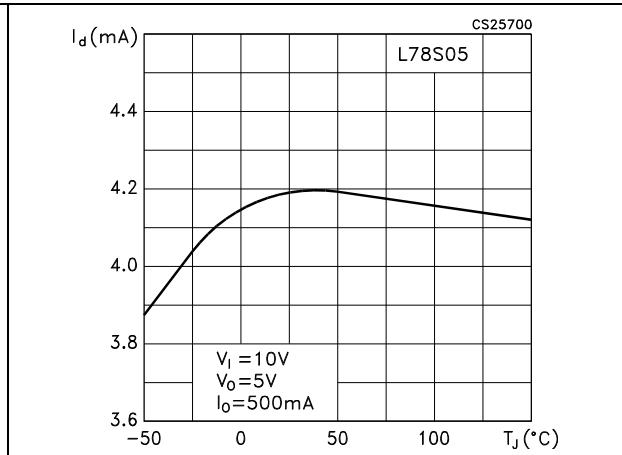


Figure 14. Load transient response

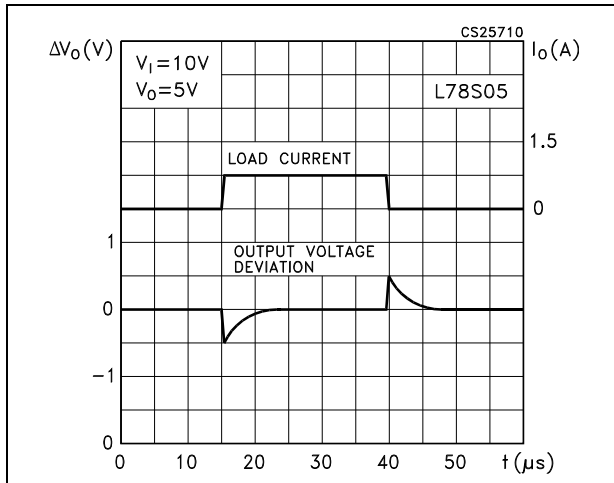


Figure 15. Line transient response

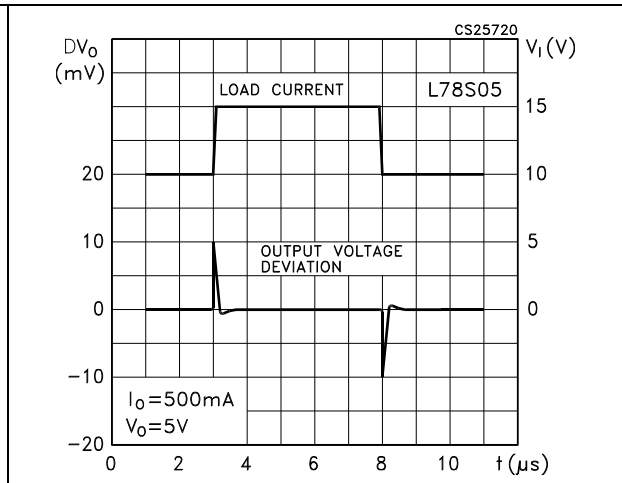


Figure 16. Quiescent current vs. input voltage

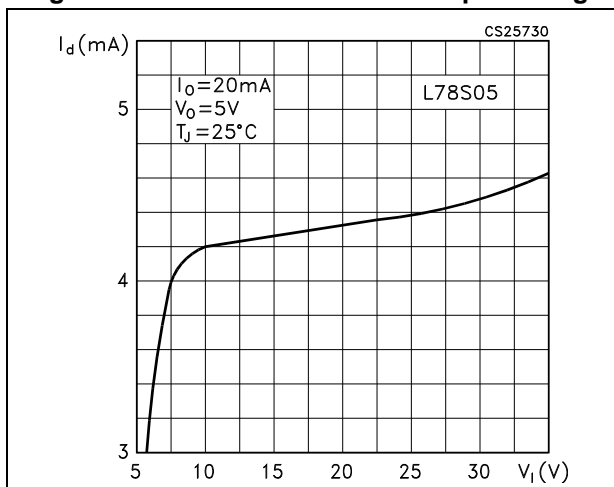
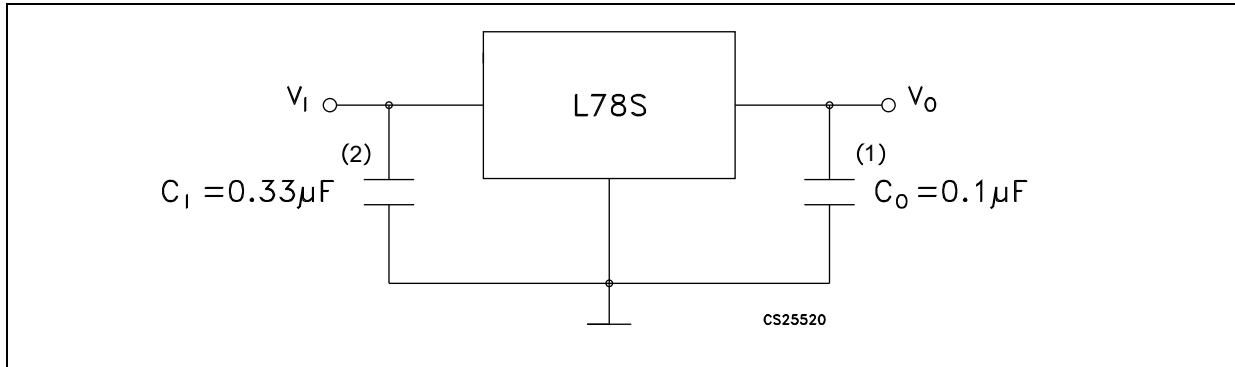
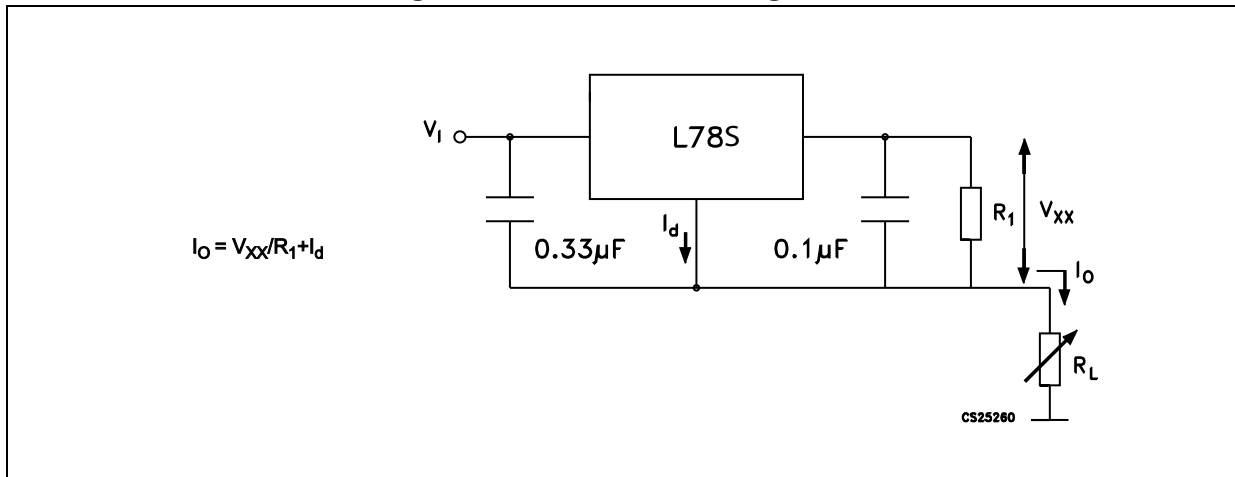


Figure 17. Fixed output regulator



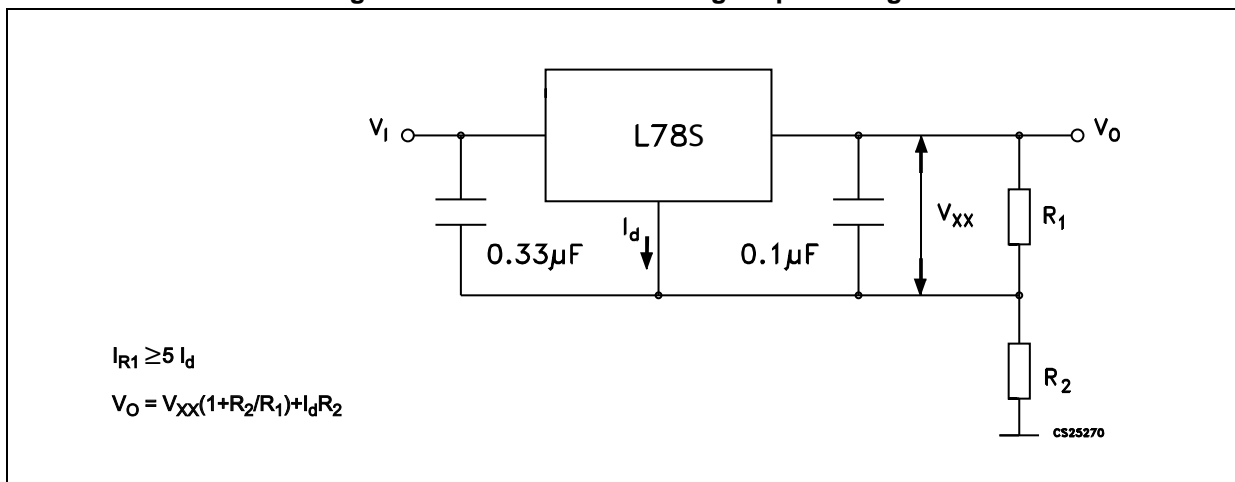
1. Although no output capacitor is need for stability, it does improve transient response.
2. Required if regulator is located an appreciable distance from power supply filter.

Figure 18. Constant current regulator



$$I_o = V_{xx}/R_1 + I_d$$

Figure 19. Circuit for increasing output voltage



$$I_{R1} \geq 5 I_d$$

$$V_o = V_{xx}(1 + R_2/R_1) + I_d R_2$$

Figure 20. Adjustable output regulator (7 to 30 V)

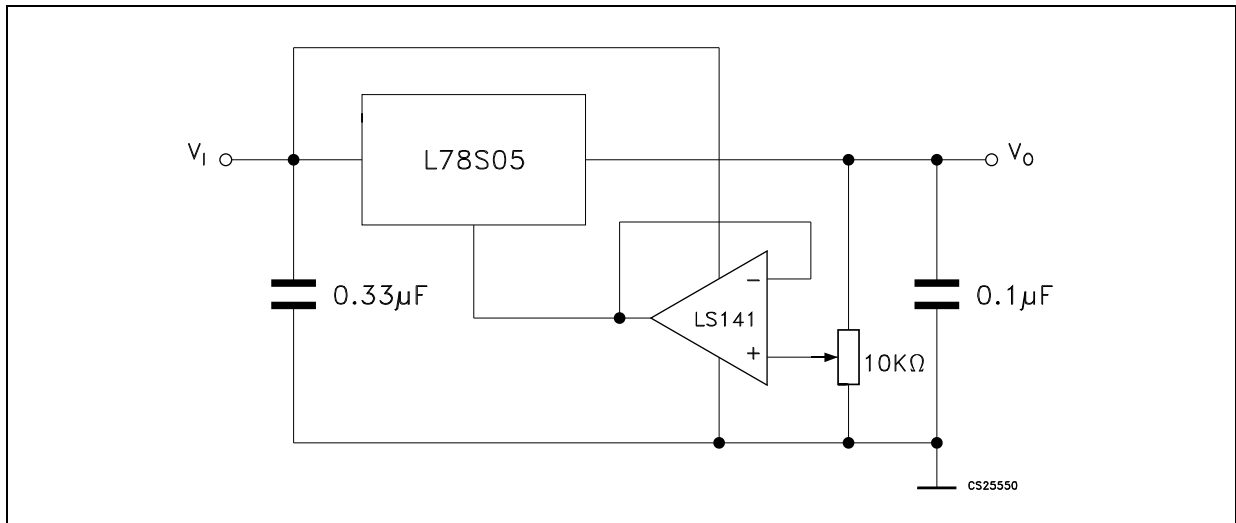


Figure 21. 0.5 to 10 V regulator

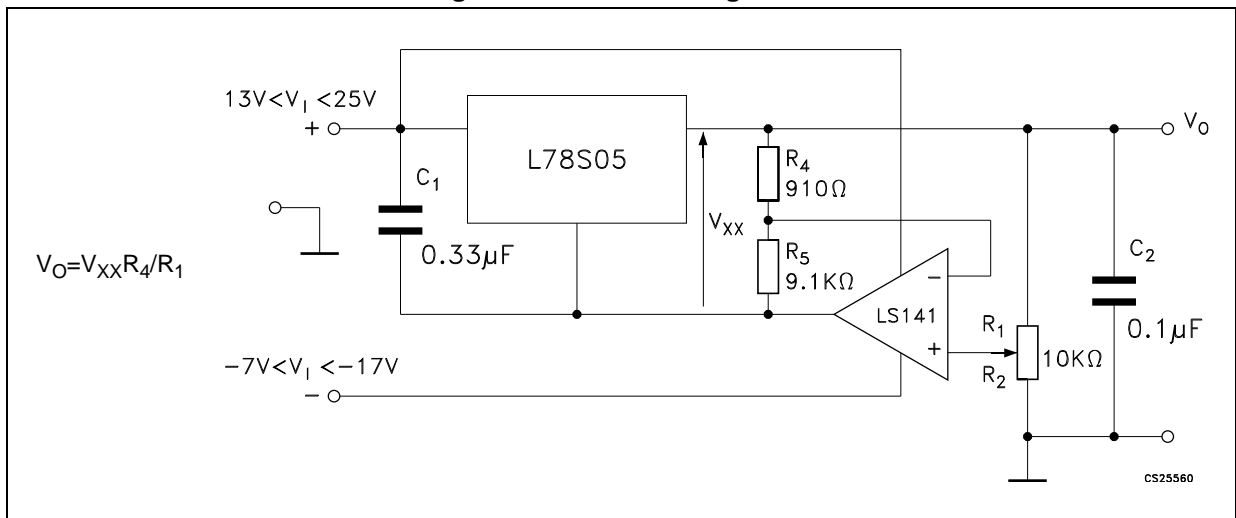


Figure 22. High current voltage regulator

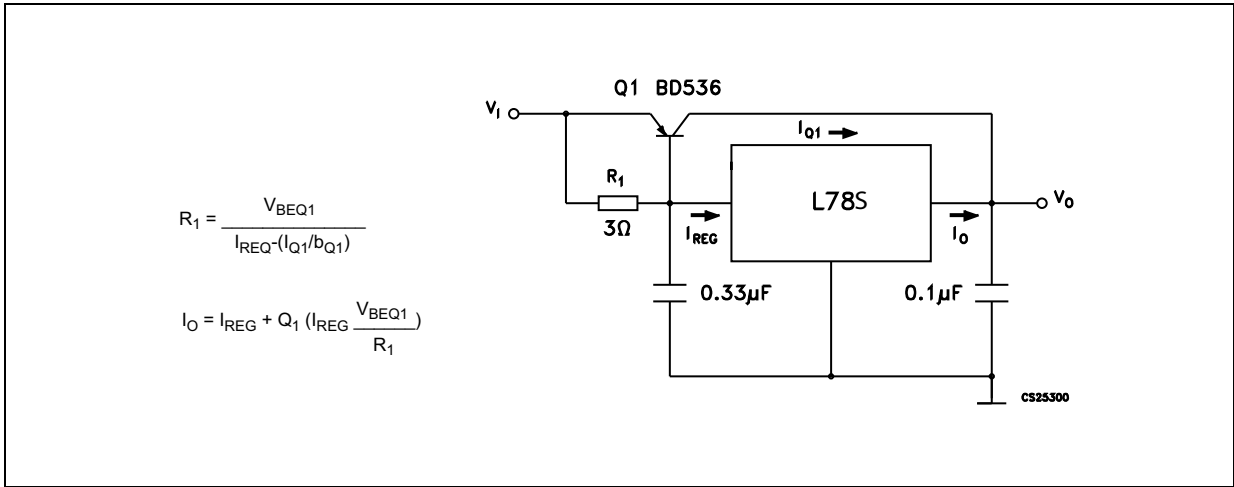


Figure 23. High output current with short circuit protection

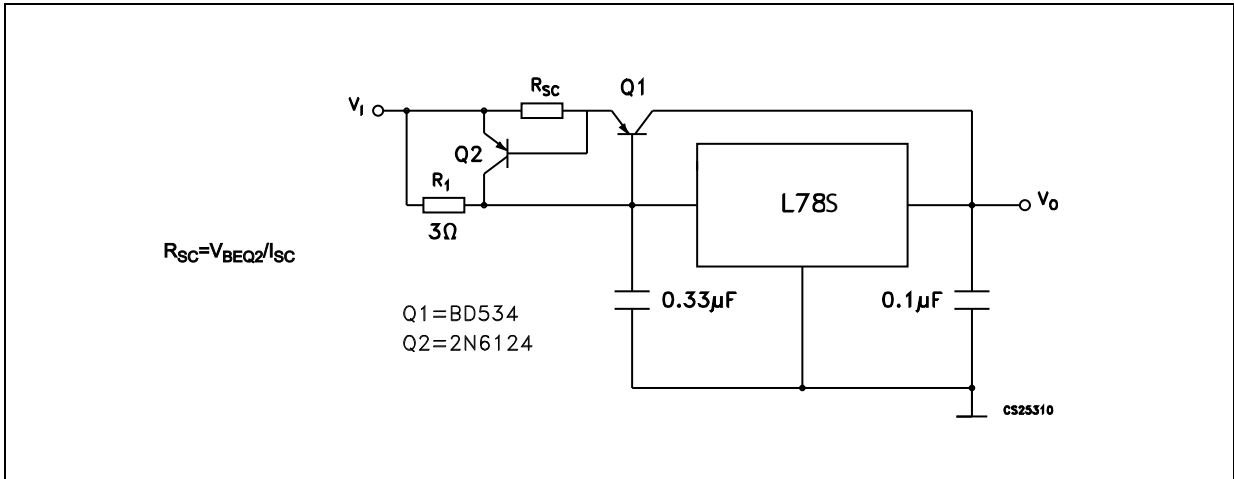


Figure 24. Tracking voltage regulator

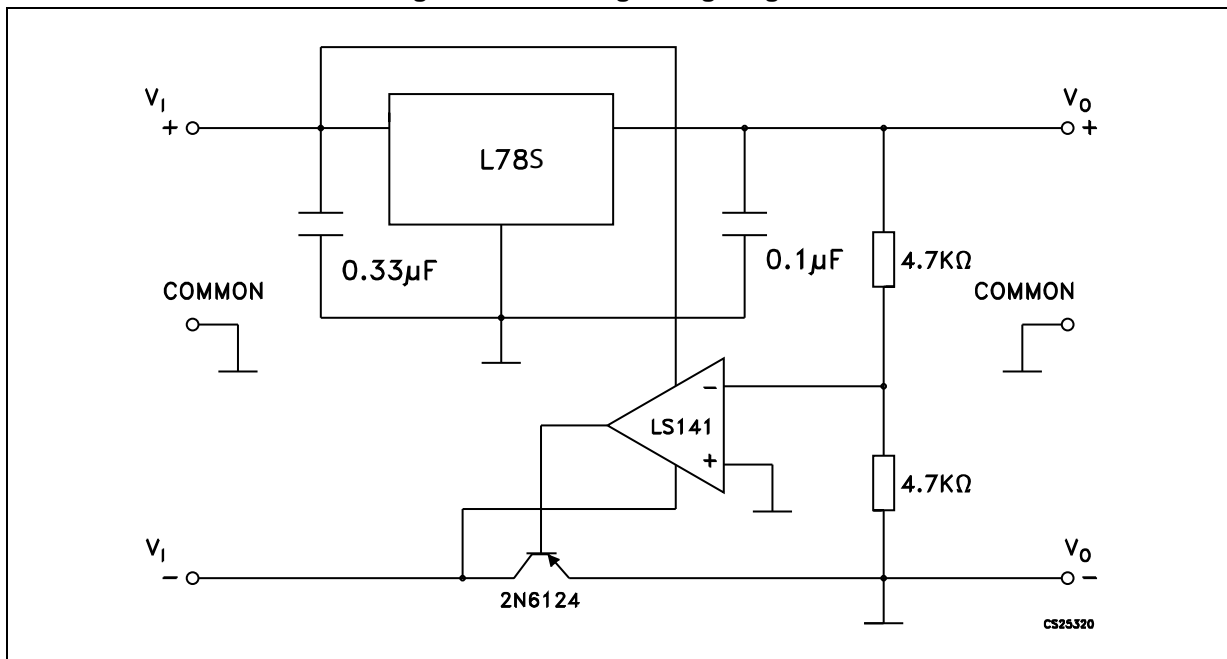


Figure 25. Positive and negative regulator

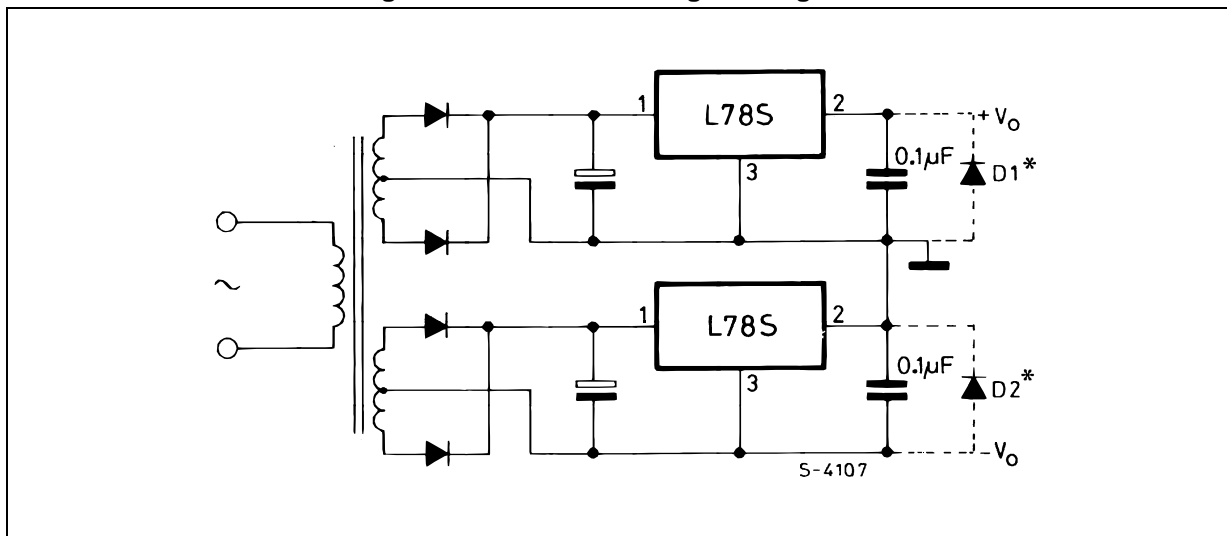


Figure 26. Negative output voltage circuit

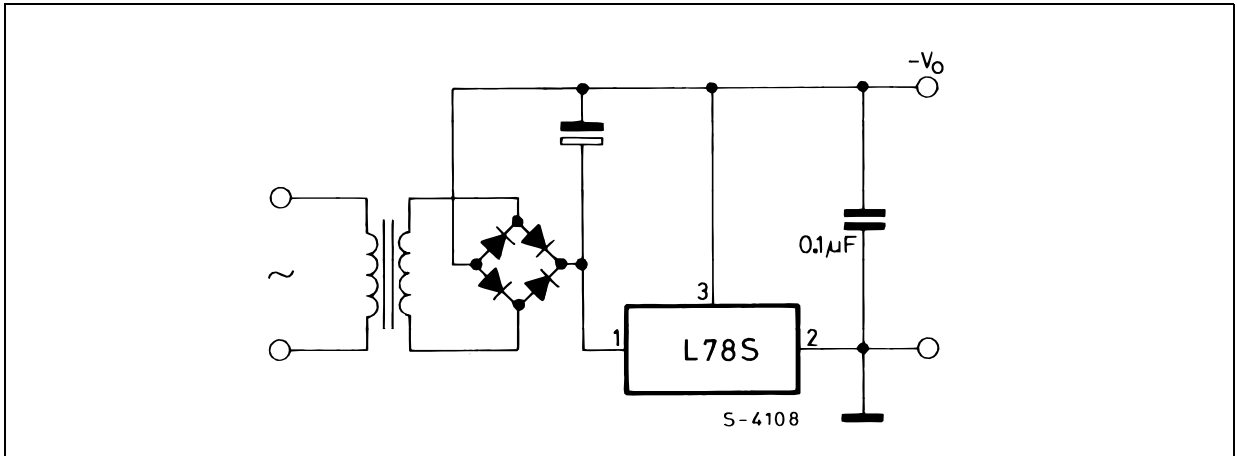


Figure 27. Switching regulator

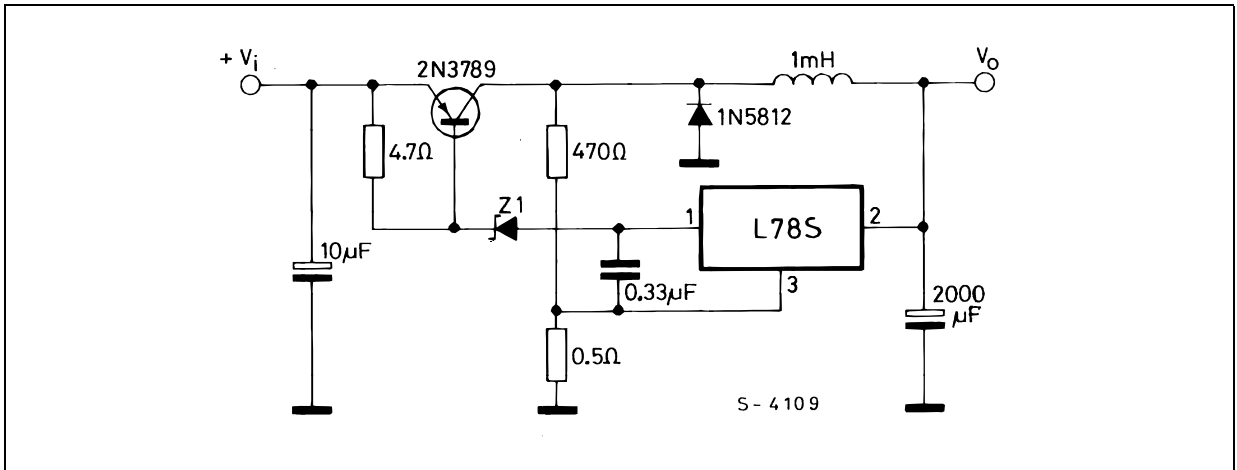


Figure 28. High input voltage circuit

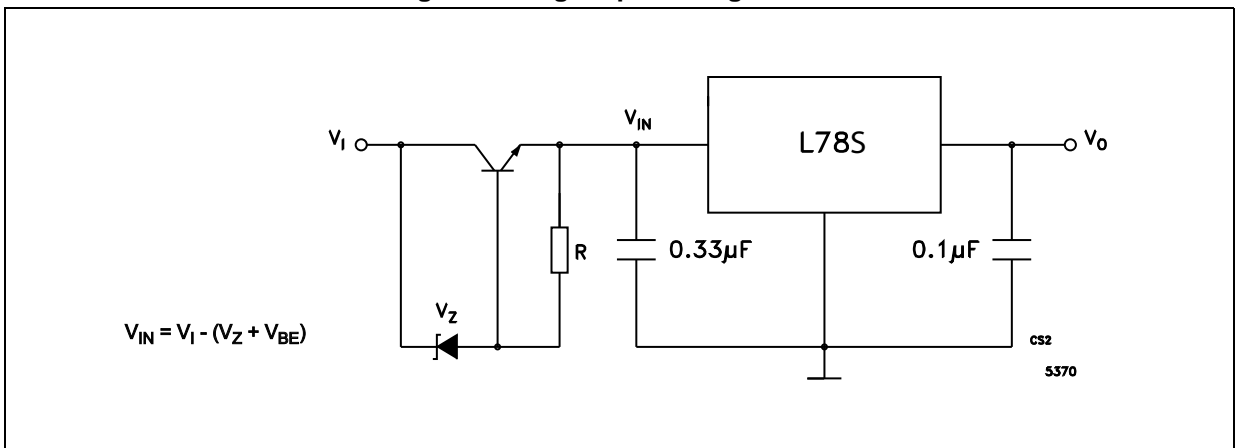


Figure 29. High input voltage circuit

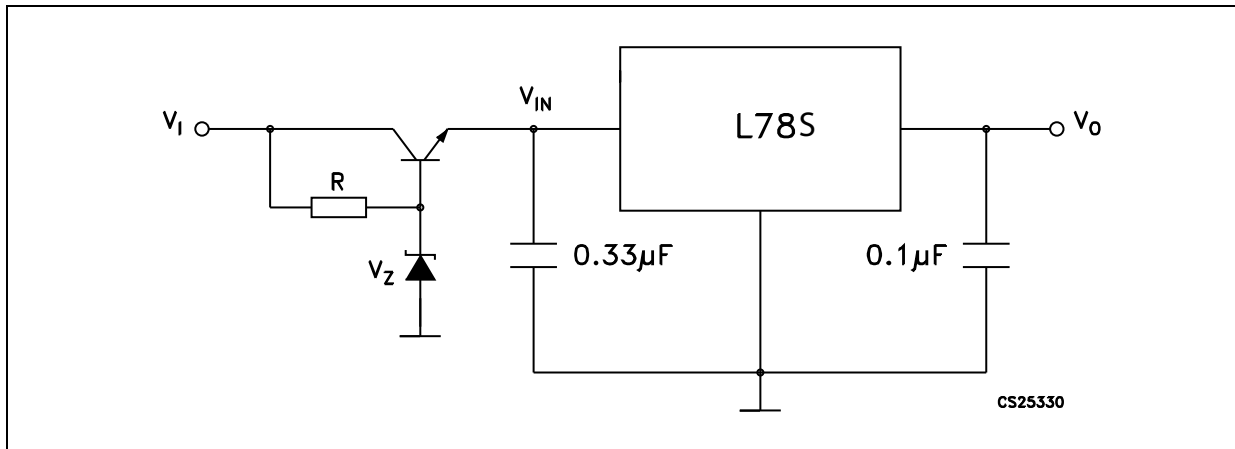


Figure 30. High output voltage regulator

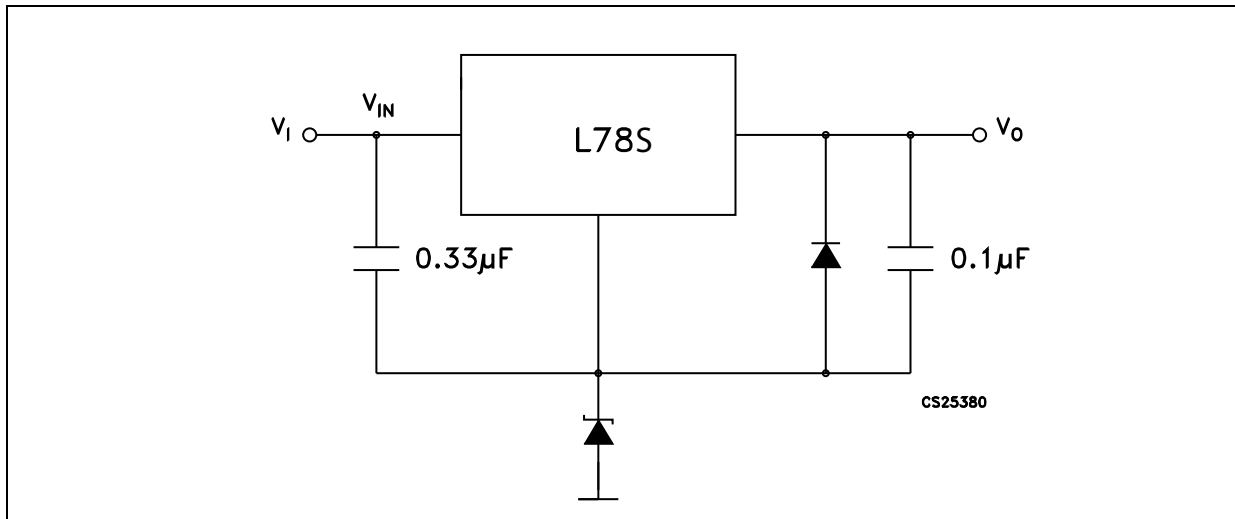


Figure 31. High input and output voltage

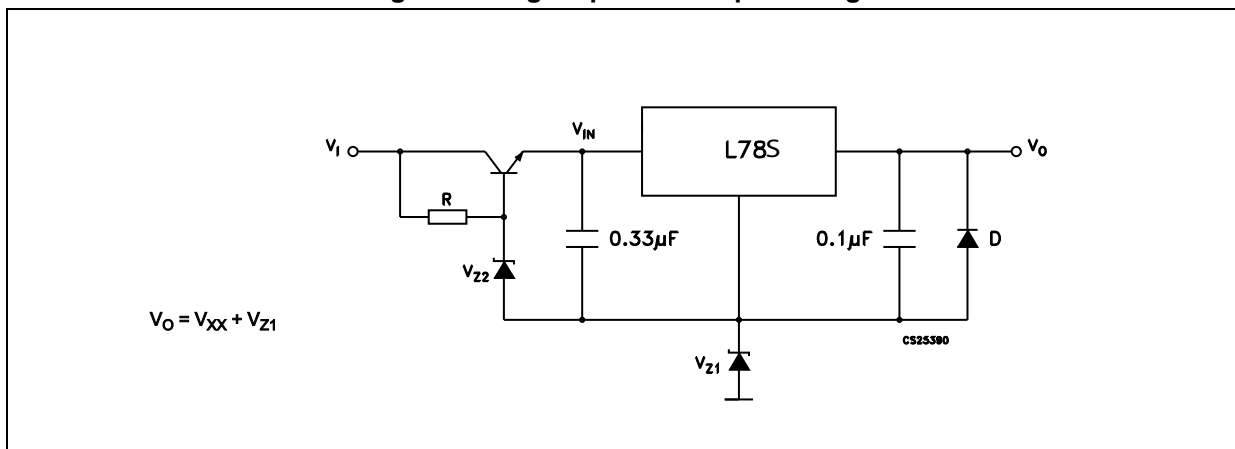




Figure 32. Reducing power dissipation with dropping resistor

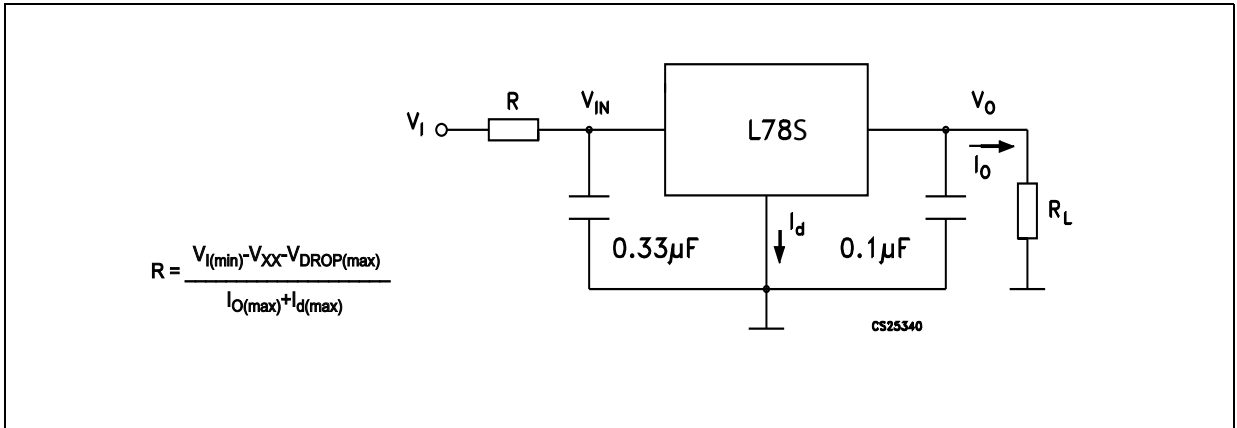


Figure 33. Remote shutdown

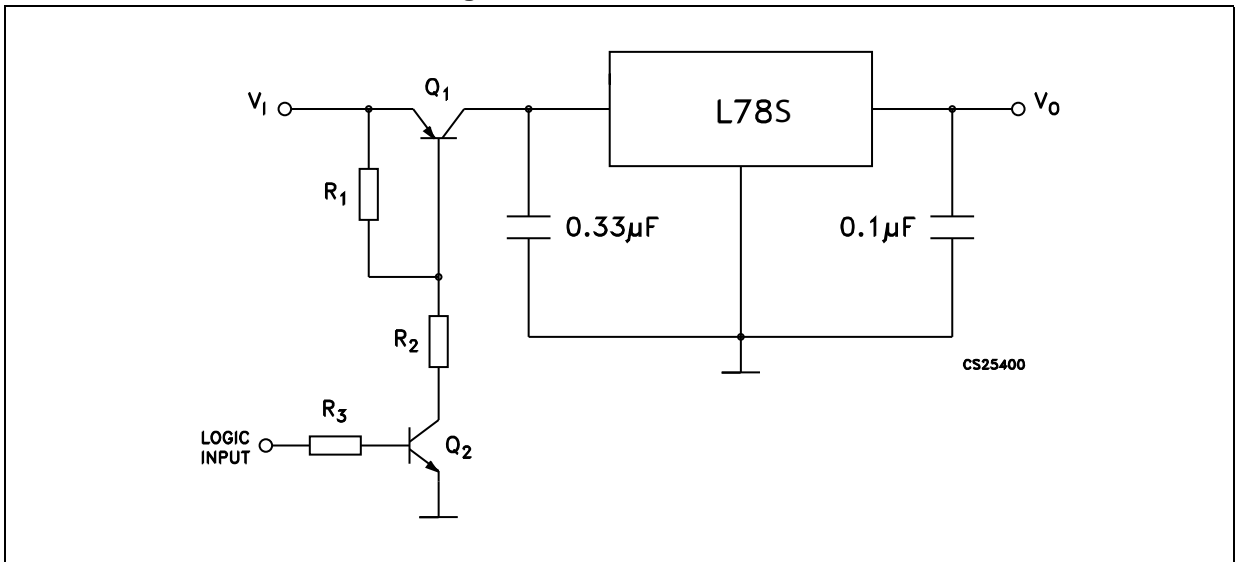
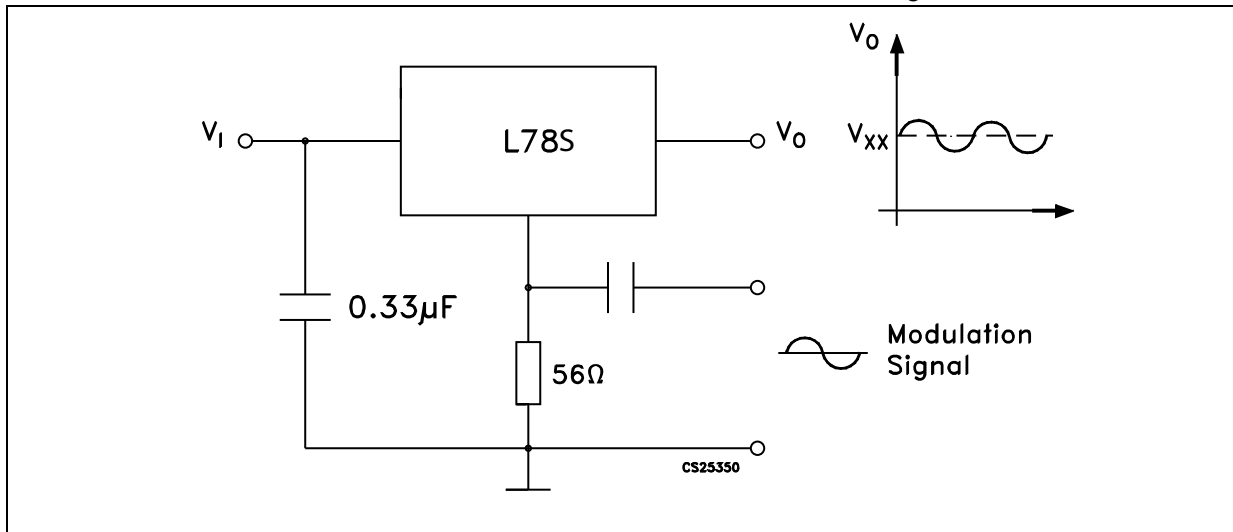
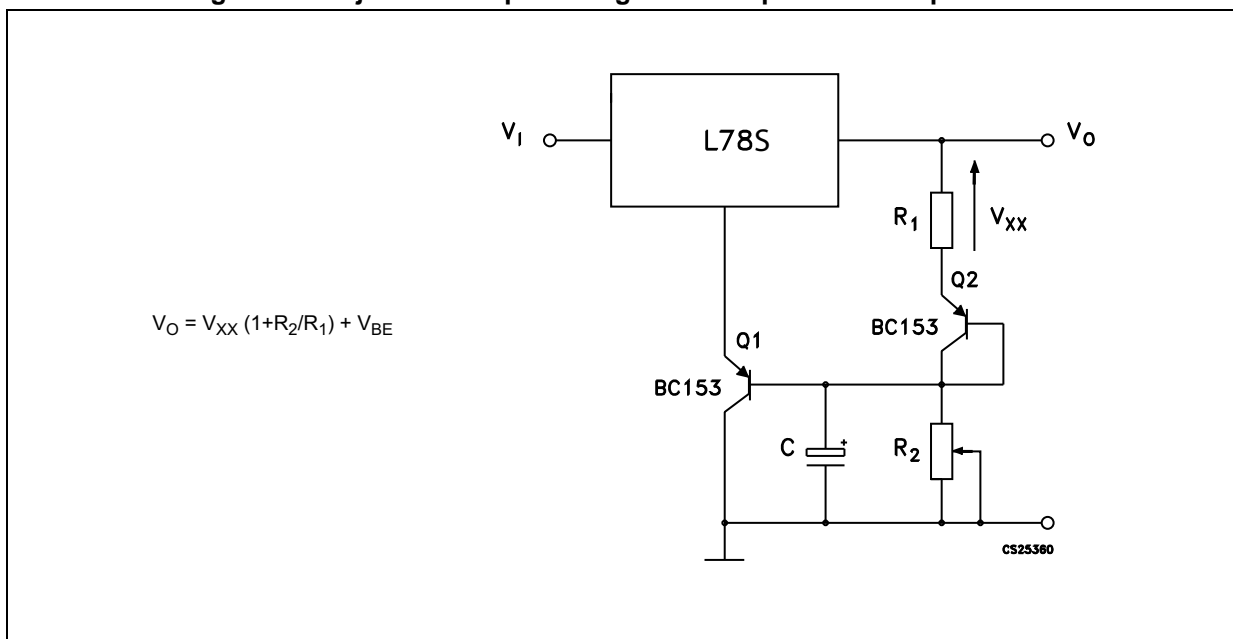


Figure 34. Power AM modulator (unity voltage gain,  $I_O \leq 1\text{ A}$ )



Note: The circuit performs well up to 100 kHz.

Figure 35. 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  $V_O$ .

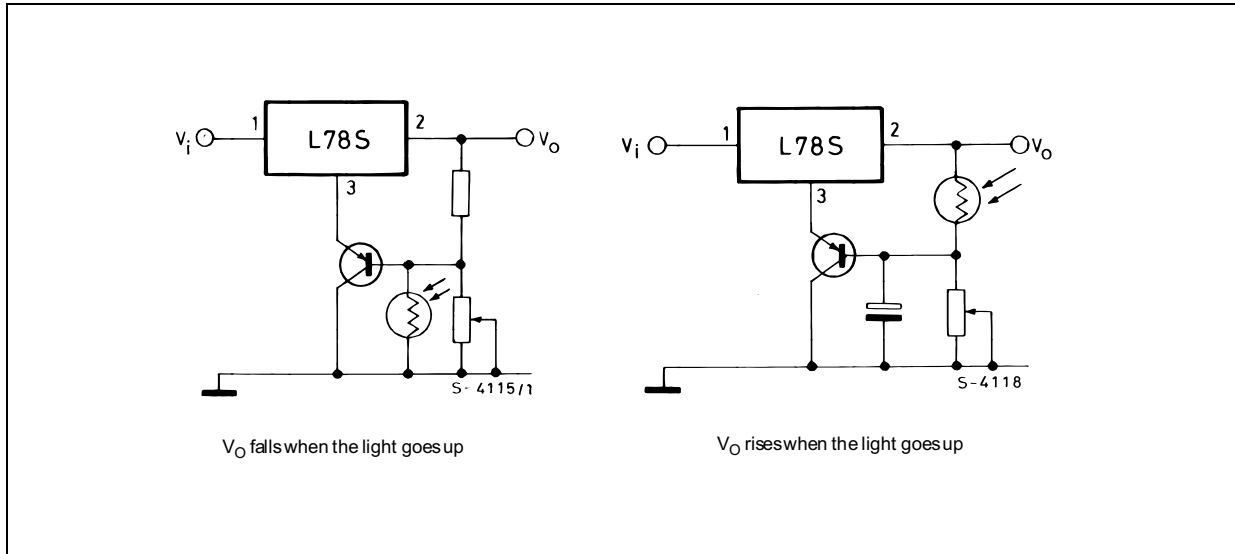
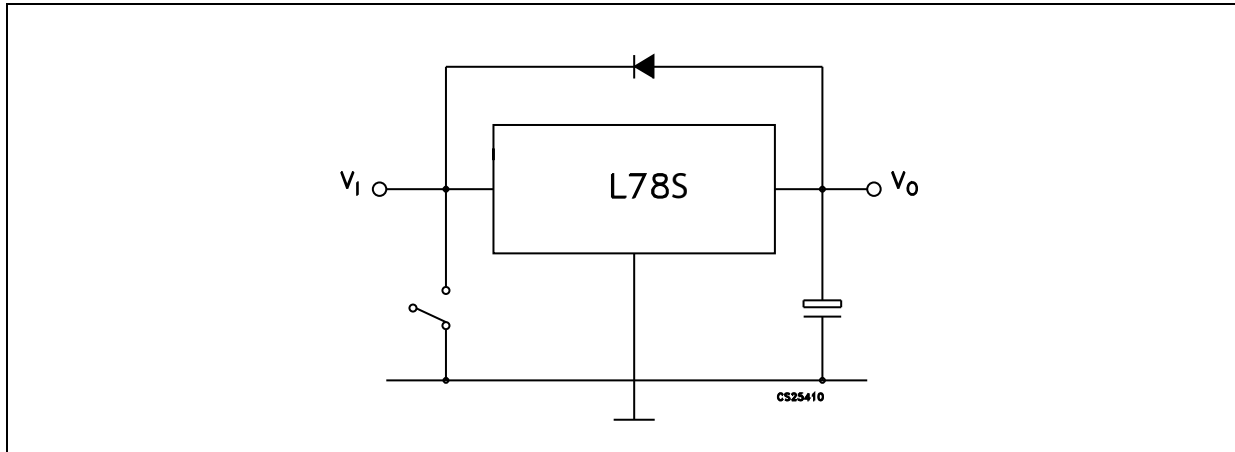
Figure 36. Light controllers ( $V_{Omin} = V_{XX} + V_{BE}$ )

Figure 37. Protection against input short-circuit with high capacitance loads



1. Application with high capacitance loads and an output voltage greater than 6 volts need an external diode (see [Figure 30 on page 24](#)) 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 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.

Figure 38. TO-220 (dual gauge) drawing

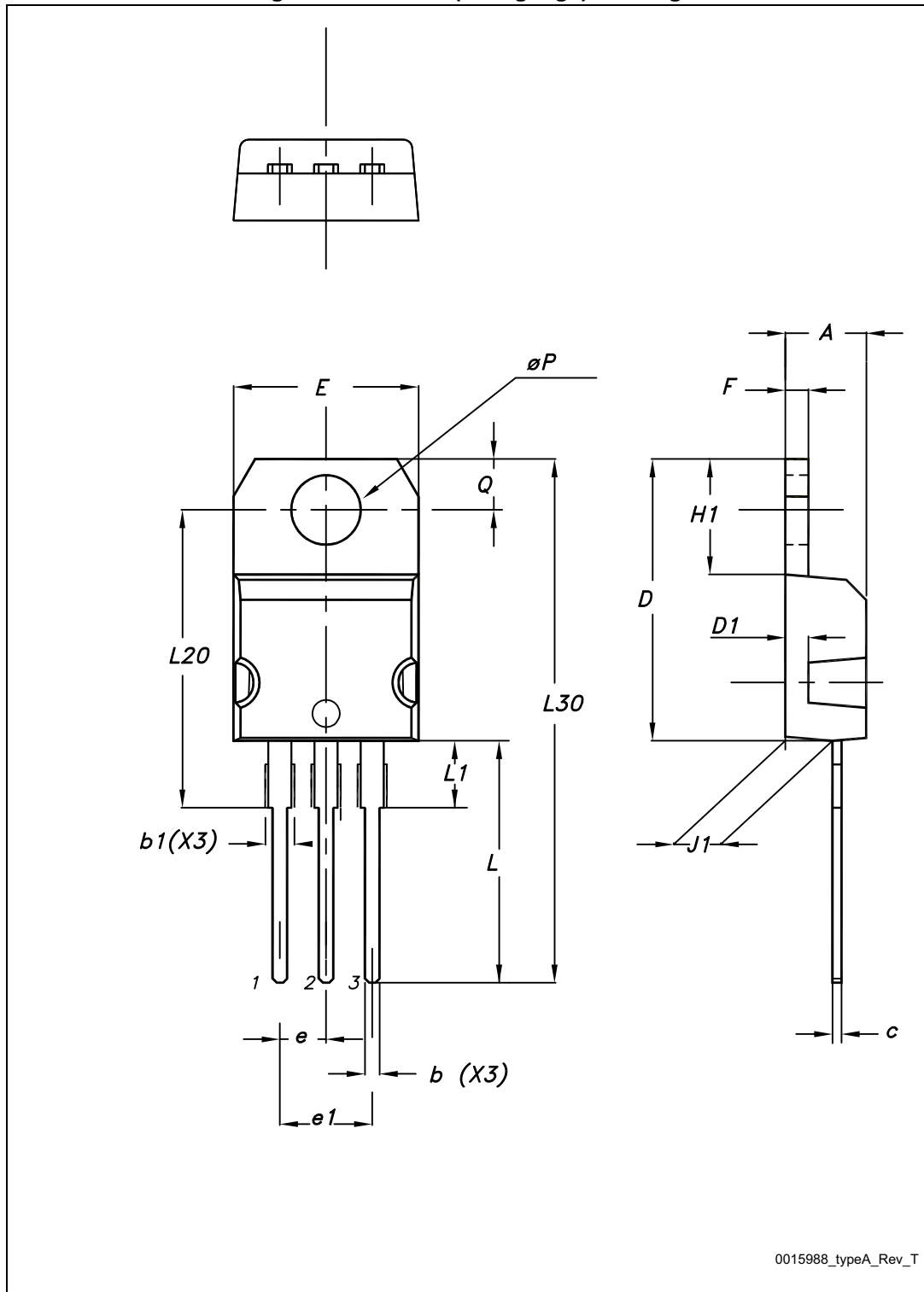


Table 12. TO-220 (dual gauge) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10		10.40
e	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

Figure 39. TO-220 SG (single gauge) drawing

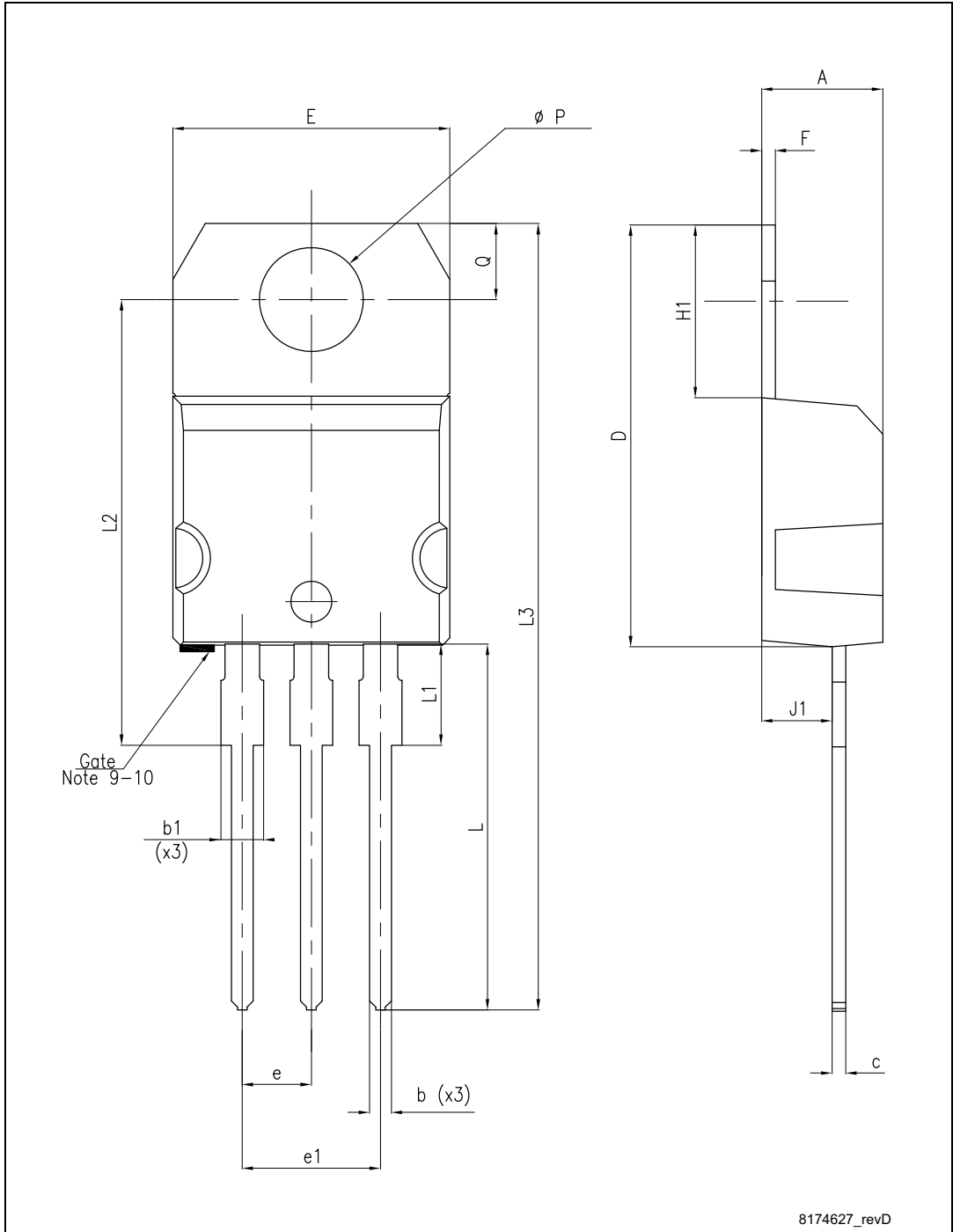


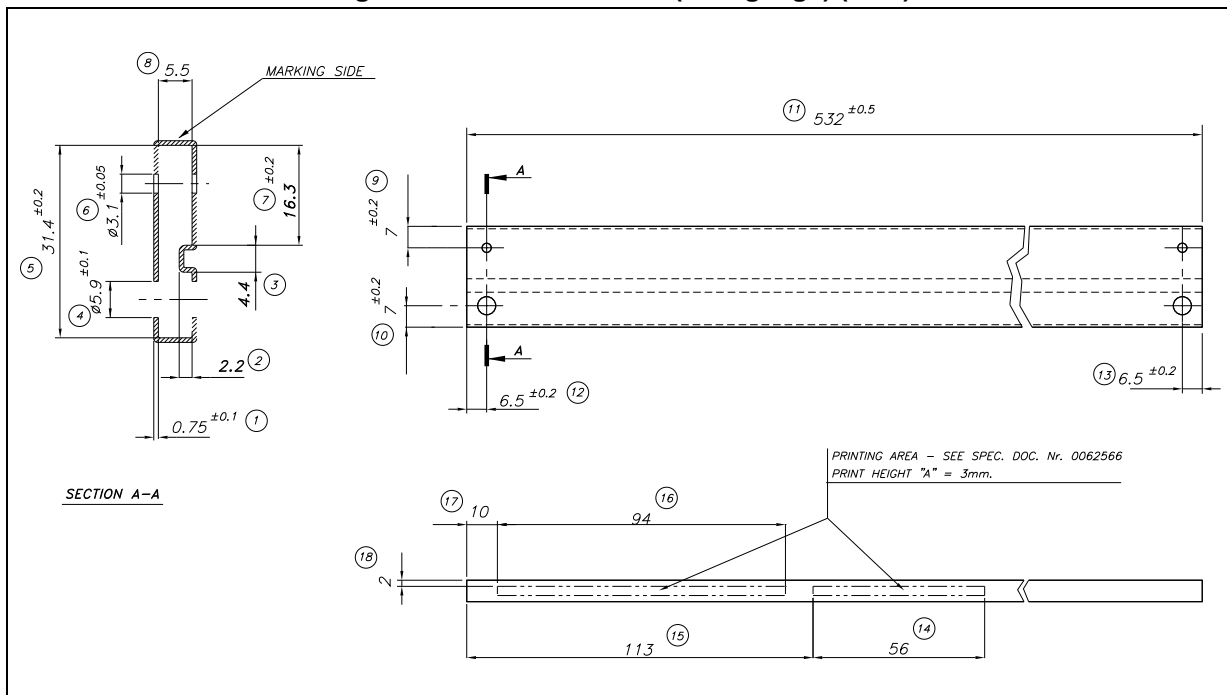
Table 13. TO-220 SG (single gauge) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
c	0.48		0.70
D	15.25		15.75
E	10		10.40
e	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		14
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95

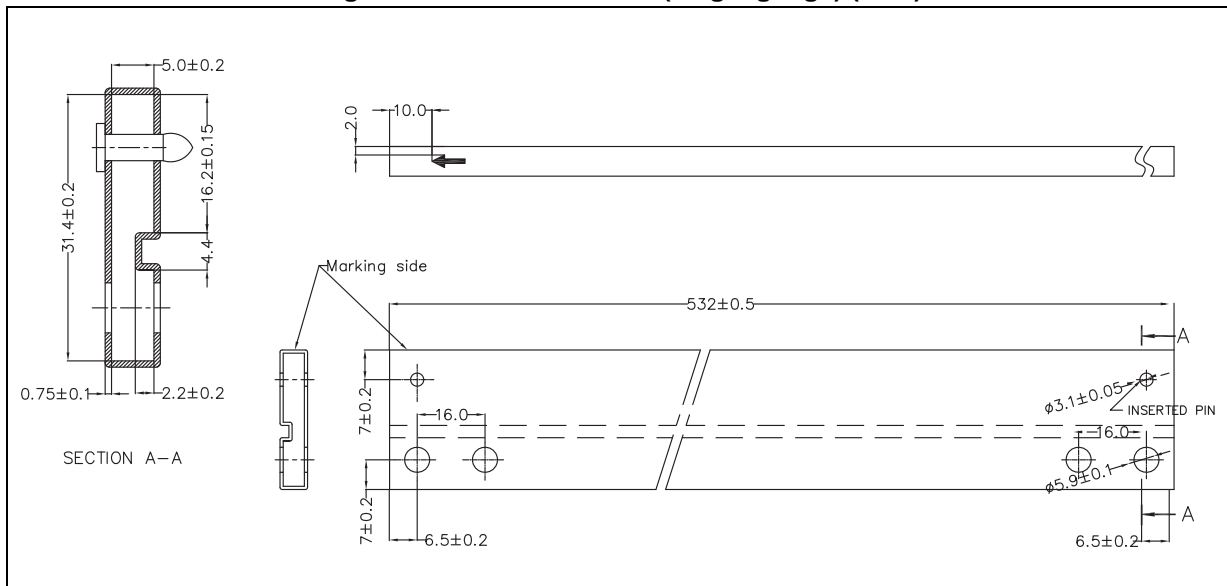


### 8 Packaging mechanical data

**Figure 40. Tube for TO-220 (dual gauge) (mm.)**



**Figure 41. Tube for TO-220 (single gauge) (mm.)**



## 9 Revision history

**Table 14. Document revision history**

Date	Revision	Changes
07-Sep-2006	2	Order codes updated.
20-Mar-2008	3	Added: <a href="#">Table 1 on page 1</a> .
22-Mar-2010	4	Added: <a href="#">Table 20 on page 32</a> , <a href="#">Figure 38 on page 33</a> , <a href="#">Figure 39 on page 34</a> , <a href="#">Figure 40</a> and <a href="#">Figure 41 on page 33</a> .
08-Feb-2012	5	Added: order codes L78S05CV-DG, L78S12CV-DG and L78S15CV-DG <a href="#">Table 13 on page 35</a> .
09-Mar-2012	6	Added: order codes L78S09CV-DG <a href="#">Table 13 on page 35</a> .
15-May-2012	7	Added: order codes L78S75CV-DG and L78S10CV-DG <a href="#">Table 13 on page 35</a> .
10-Mar-2014	8	Part numbers L78Sxx and L78SxxC changed to L78S. Modified the title, the features and the description in cover page. Removed TO-3 package. Updated <a href="#">Table 1: Device summary</a> , <a href="#">Section 2: Pin configuration</a> , <a href="#">Section 3: Maximum ratings</a> , <a href="#">Section 4: Test circuits</a> , <a href="#">Section 5: Electrical characteristics</a> , <a href="#">Section 6: Typical performance</a> , <a href="#">Section 7: Package mechanical data</a> , <a href="#">Section 9: Order codes</a> . Added <a href="#">Section 8: Packaging mechanical data</a> . Minor text changes.

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