

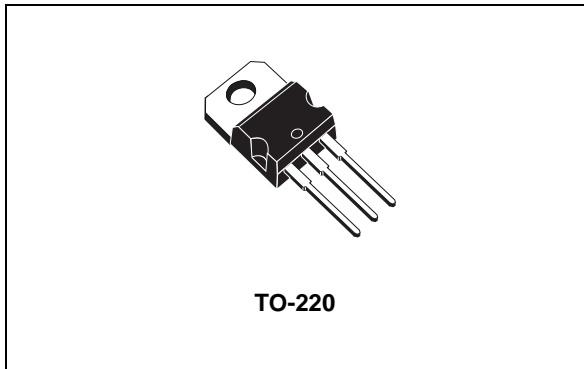


THE DATASHEET OF L78S09CV



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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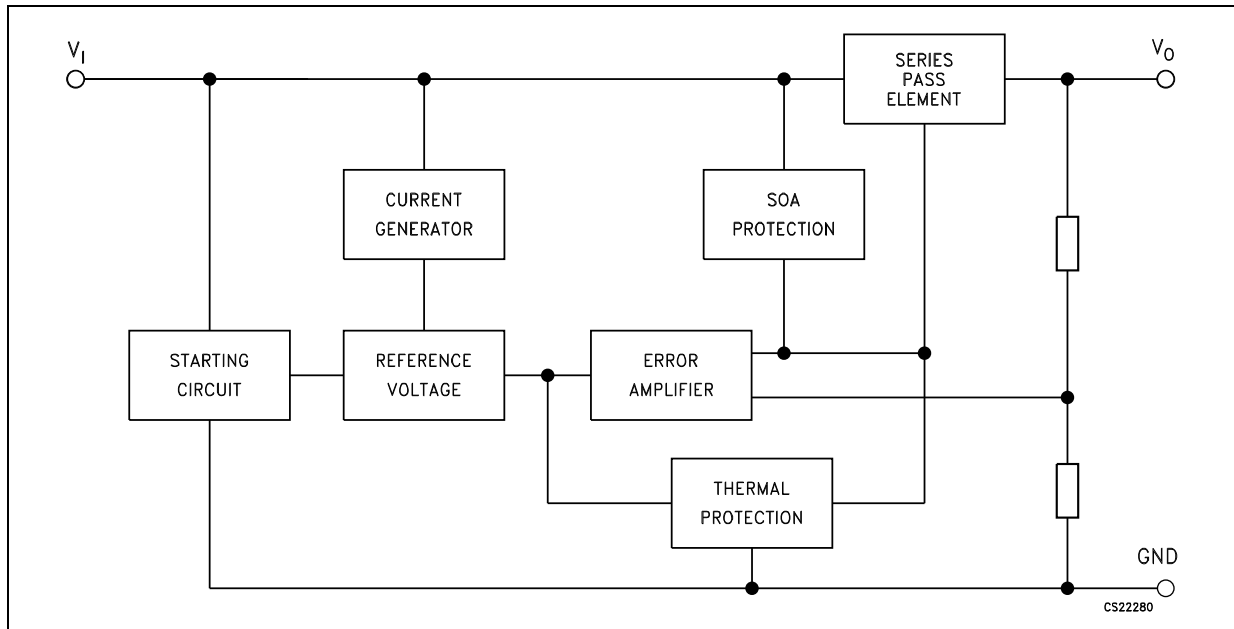
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1 Diagram

Figure 1. Block diagram



2 Pin configuration

Figure 2. Pin connections (top view)

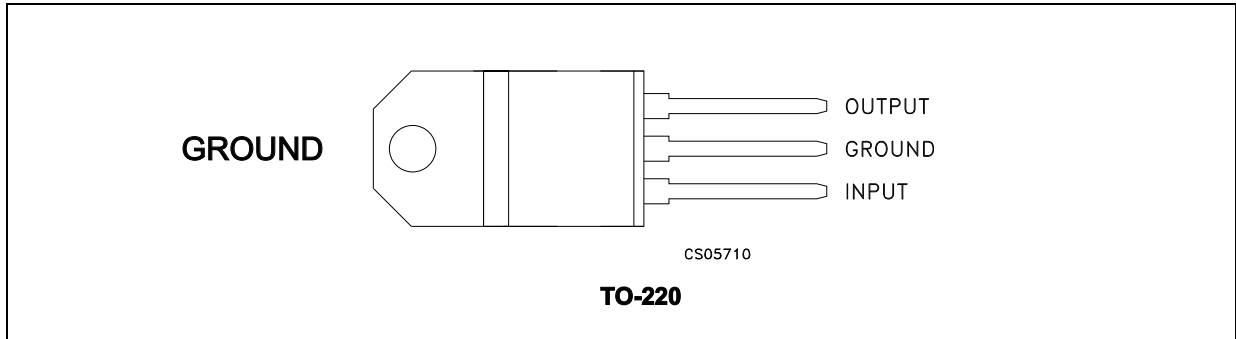
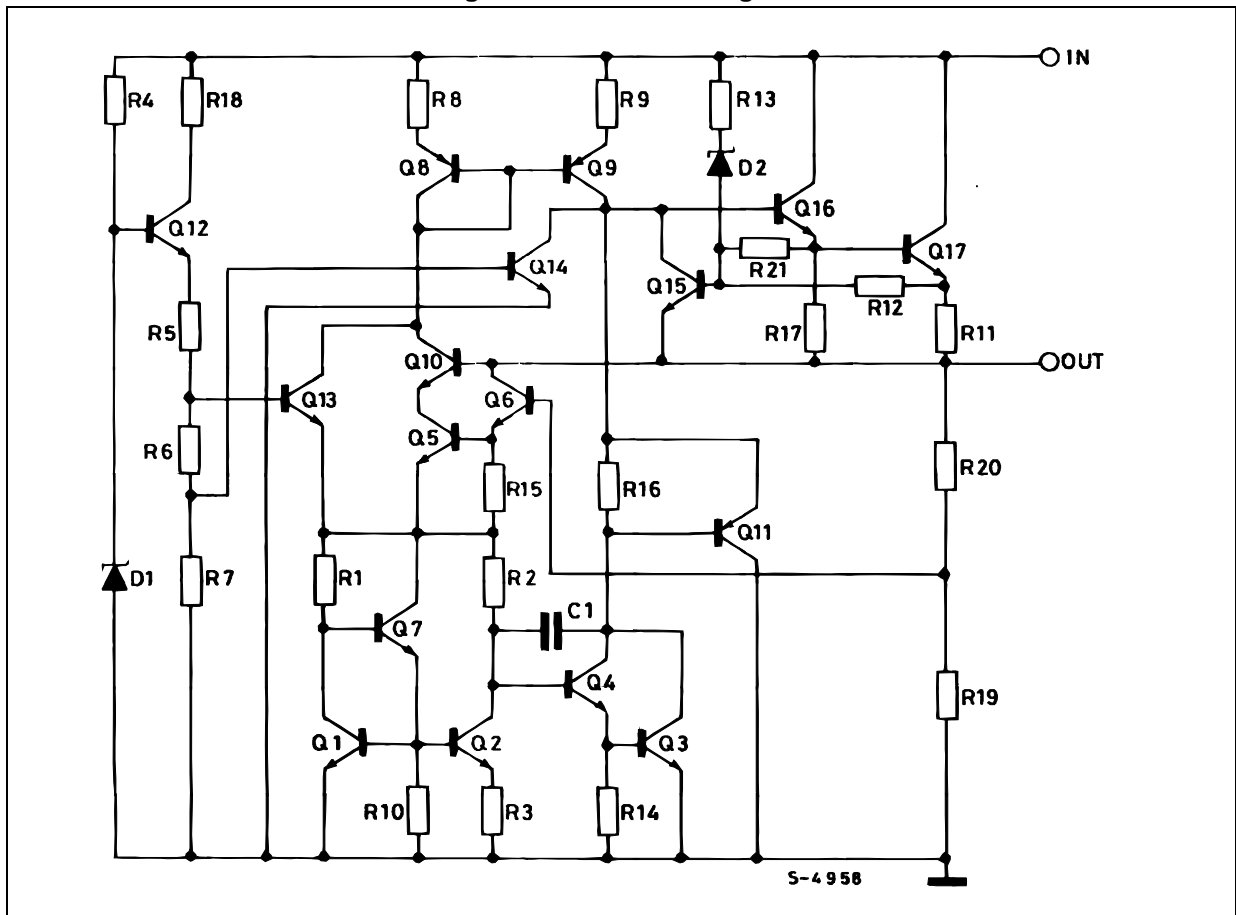


Figure 3. Schematic diagram



3 Maximum ratings

Table 2. Absolute maximum ratings

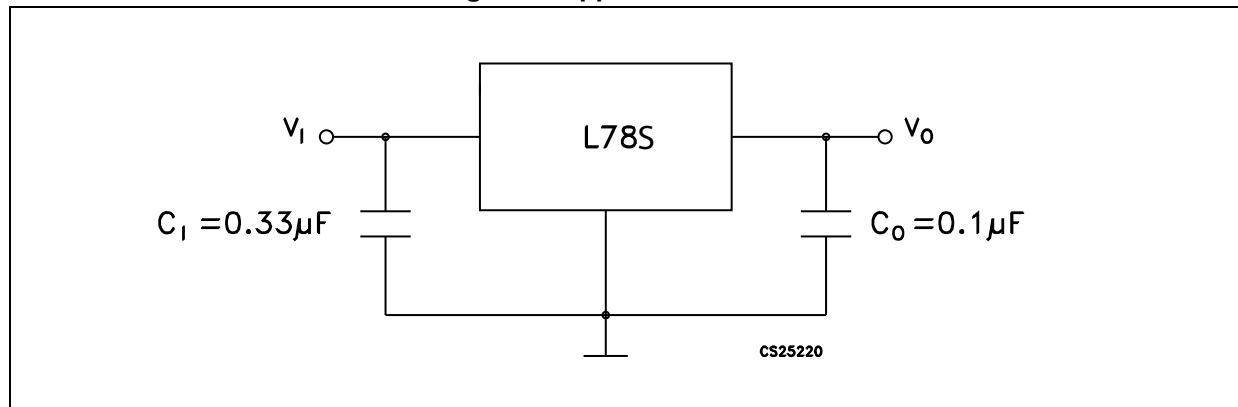
Symbol	Parameter		Value	Unit
V_I	DC input voltage	for $V_O = 5$ to $18V$	35	V
		for $V_O = 24V$	40	
I_O	Output current		Internally limited	
P_D	Power dissipation		Internally limited	
T_{STG}	Storage temperature range		-65 to 150	°C
T_{OP}	Operating junction temperature range		0 to 150	°C

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

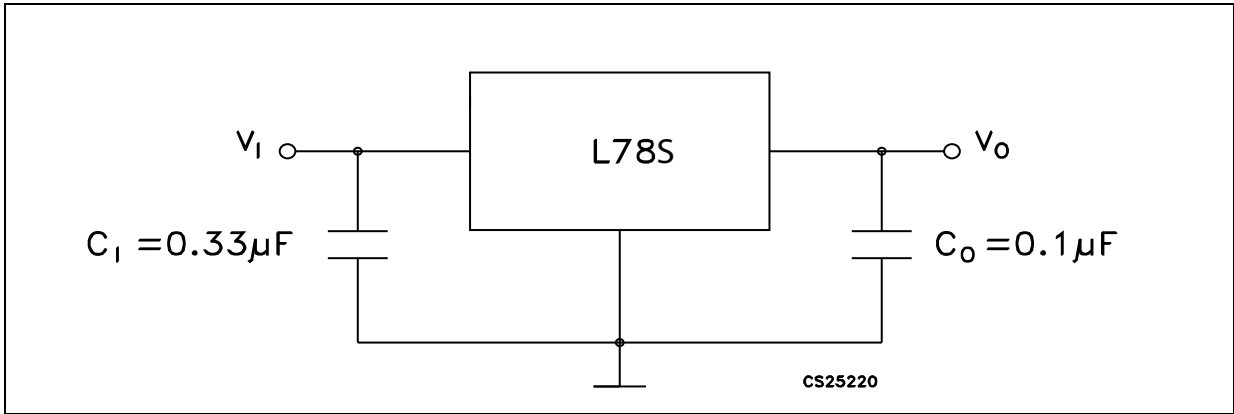


Figure 6. Load regulation

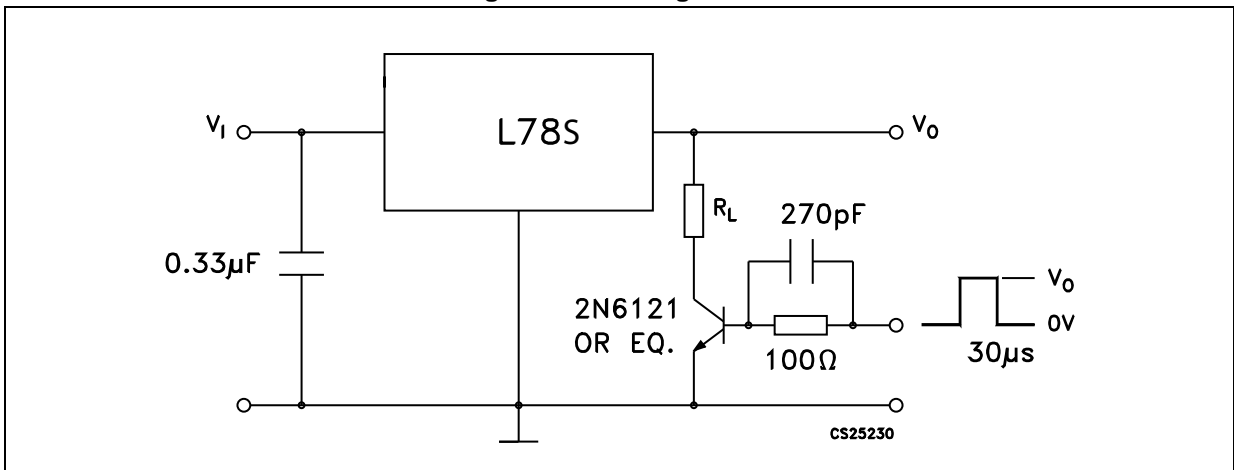
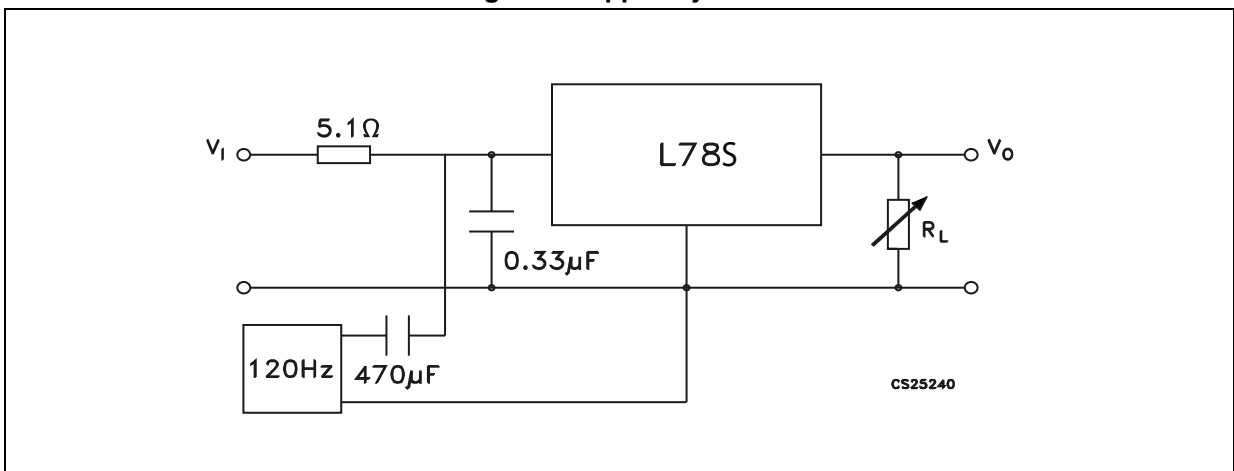


Figure 7. Ripple rejection



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
ΔV_O	Line regulation	$V_I = 7\text{ to }25\text{ V}$			100	mV
		$V_I = 8\text{ to }25\text{ V}$			50	
ΔV_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
ΔI_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		μV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	54 ⁽¹⁾			dB
V_I	Operating input voltage	$I_O \leq 1\text{ A}$	8			V
R_O	Output resistance	$f = 1\text{ kHz}$		17		m Ω
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
ΔV_O	Line regulation	$V_I = 9.5\text{ to }25\text{ V}$			120	mV
		$V_I = 10.5\text{ to }20\text{ V}$			60	
ΔV_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
ΔI_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 ⁽¹⁾			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
ΔV_O	Line regulation	$V_I = 11\text{ to }25\text{ V}$			130	mV
		$V_I = 11\text{ to }20\text{ V}$			65	
ΔV_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
ΔI_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		μV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	47 ⁽¹⁾			dB
V_I	Operating input voltage	$I_O \leq 1\text{ A}$	12			V
R_O	Output resistance	$f = 1\text{ kHz}$		17		m Ω
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
ΔV_O	Line regulation	$V_I = 12.5\text{ to }30\text{ V}$			200	mV
		$V_I = 14\text{ to }22\text{ V}$			100	
ΔV_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
ΔI_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 ⁽¹⁾			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
ΔV_O	Line regulation	$V_I = 14.5\text{ to }30\text{ V}$			240	mV
		$V_I = 16\text{ to }22\text{ V}$			120	
ΔV_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
ΔI_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	$B = 10\text{ Hz to }100\text{ kHz}$		75		μV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	47 ⁽¹⁾			dB
V_I	Operating input voltage	$I_O \leq 1\text{ A}$	15			V
R_O	Output resistance	$f = 1\text{ kHz}$		18		m Ω
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
ΔV_O	Line regulation	$V_I = 17.5\text{ to }30\text{ V}$			300	mV
		$V_I = 20\text{ to }26\text{ V}$			150	
ΔV_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
ΔI_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 ⁽¹⁾			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
ΔV_O	Line regulation	$V_I = 20.5\text{ to }30\text{ V}$			360	mV
		$V_I = 22\text{ to }28\text{ V}$			180	
ΔV_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
ΔI_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 ⁽¹⁾			dB
V_I	Operating input voltage	$I_O \leq 1\text{ A}$	21			V
R_O	Output resistance	f = 1 kHz		22		m Ω
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
ΔV_O	Line regulation	$V_I = 27\text{ to }38\text{ V}$			480	mV
		$V_I = 30\text{ to }36\text{ V}$			240	
ΔV_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
ΔI_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		μV
SVR	Supply voltage rejection	$f = 120\text{ Hz}$	42 ⁽¹⁾			dB
V_I	Operating input voltage	$I_O \leq 1\text{ A}$	27			V
R_O	Output resistance	$f = 1\text{ kHz}$		28		m Ω
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

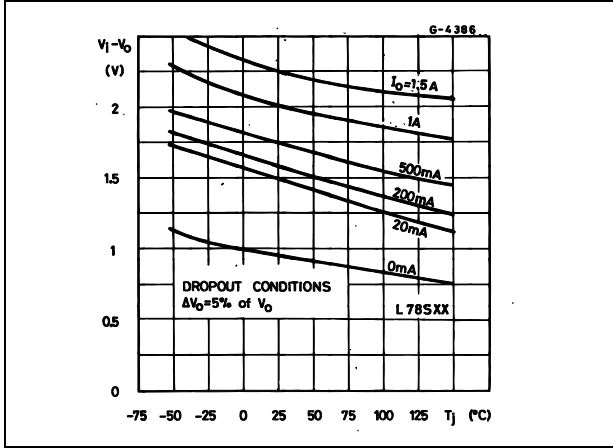


Figure 9. Peak output current vs. input/output differential voltage

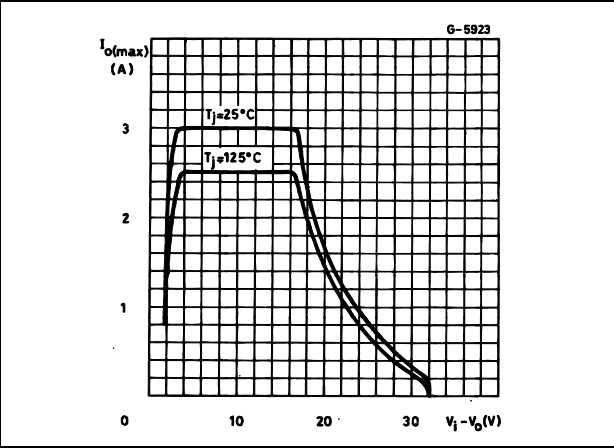


Figure 10. Output impedance vs. frequency

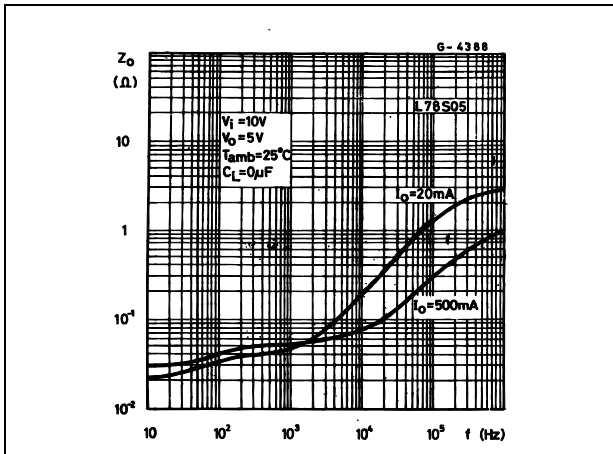


Figure 11. Output voltage vs. junction temperature

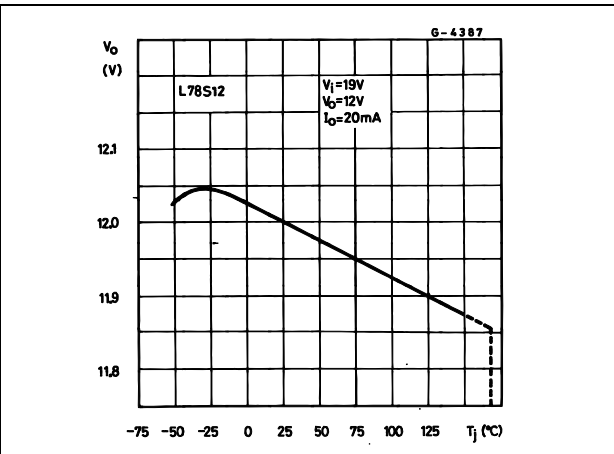


Figure 12. Supply voltage rejection vs. frequency

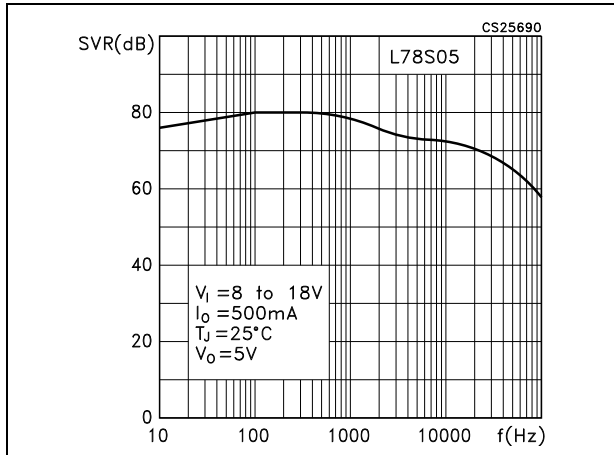


Figure 13. Quiescent current vs. junction temperature

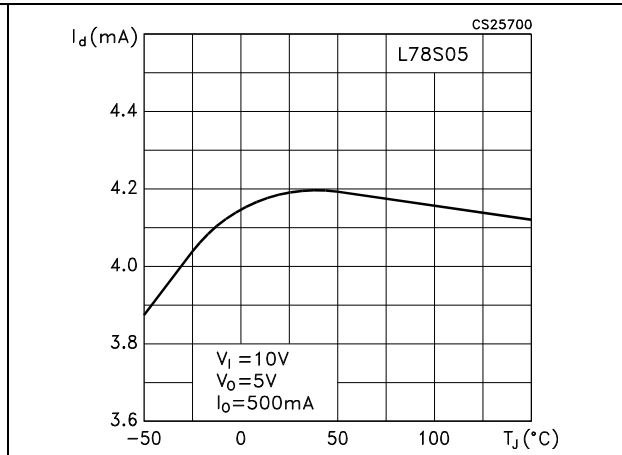


Figure 14. Load transient response

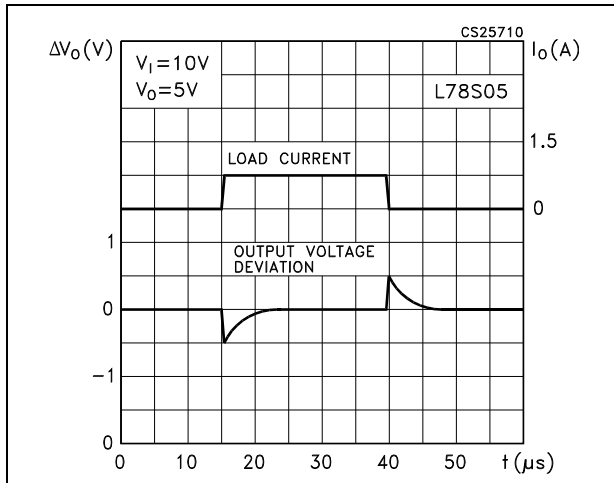


Figure 15. Line transient response

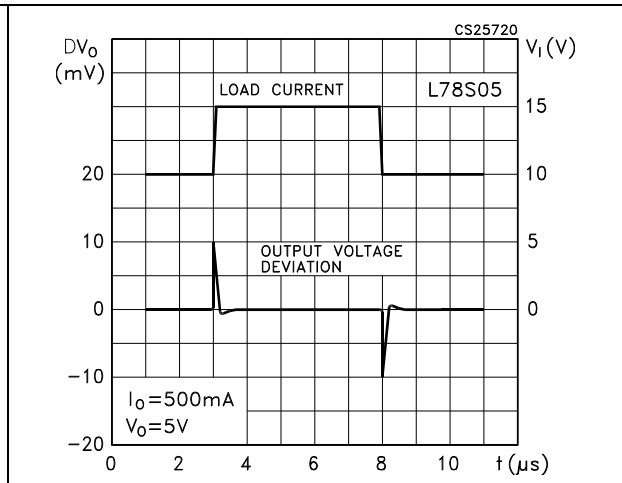


Figure 16. Quiescent current vs. input voltage

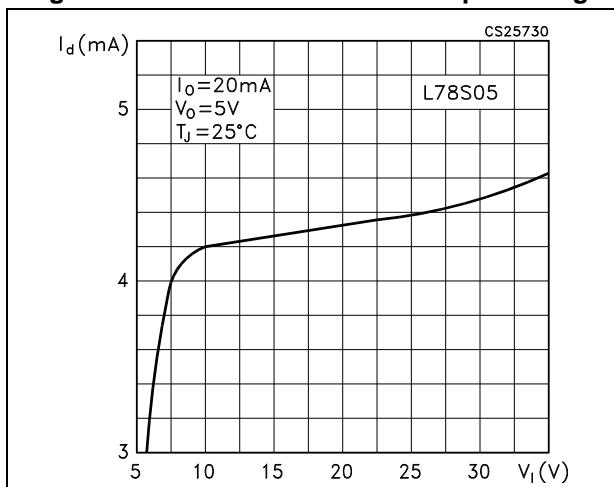
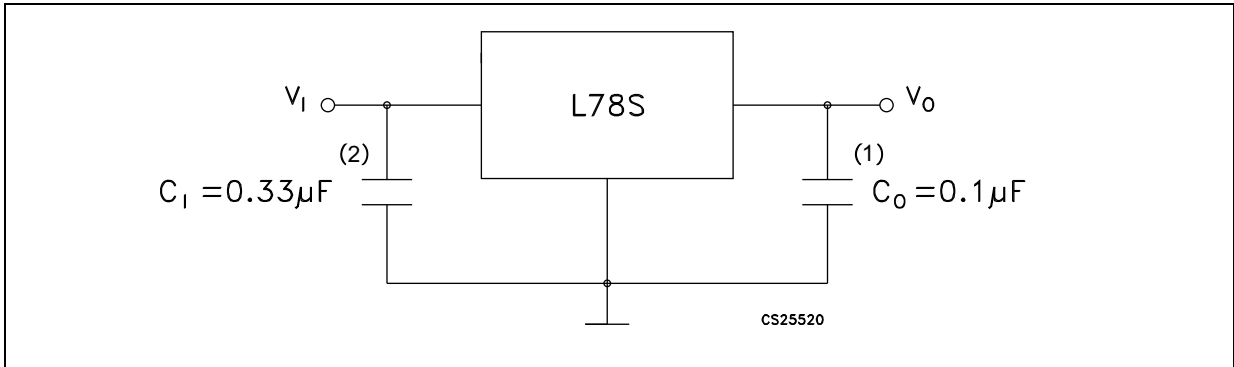
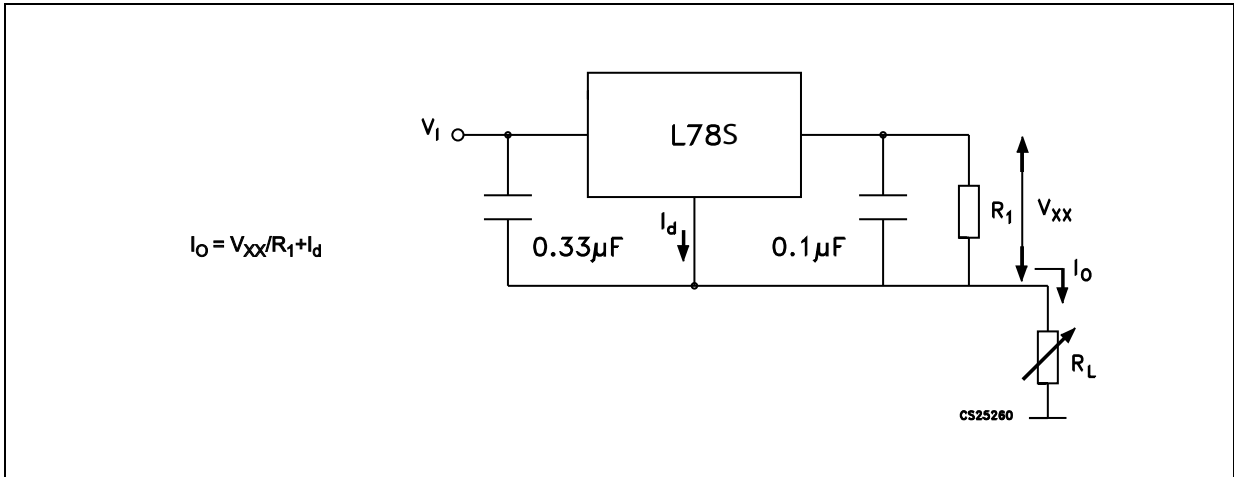


Figure 17. Fixed output regulator



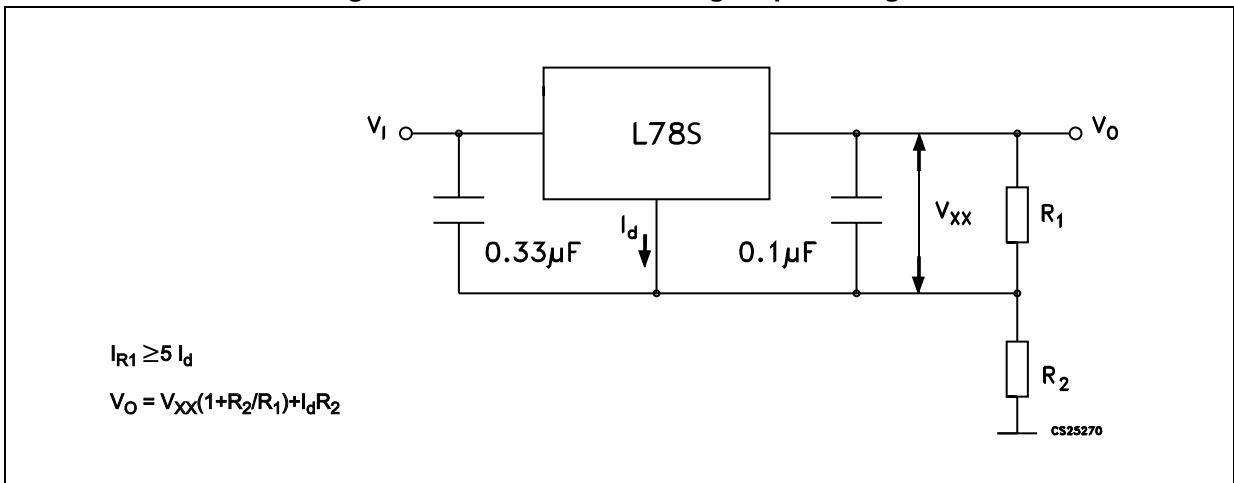
1. Although no output capacitor is need for stability, it does improve transient response.
2. Required if regulator is located an appreciable distance from power supply filter.

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)

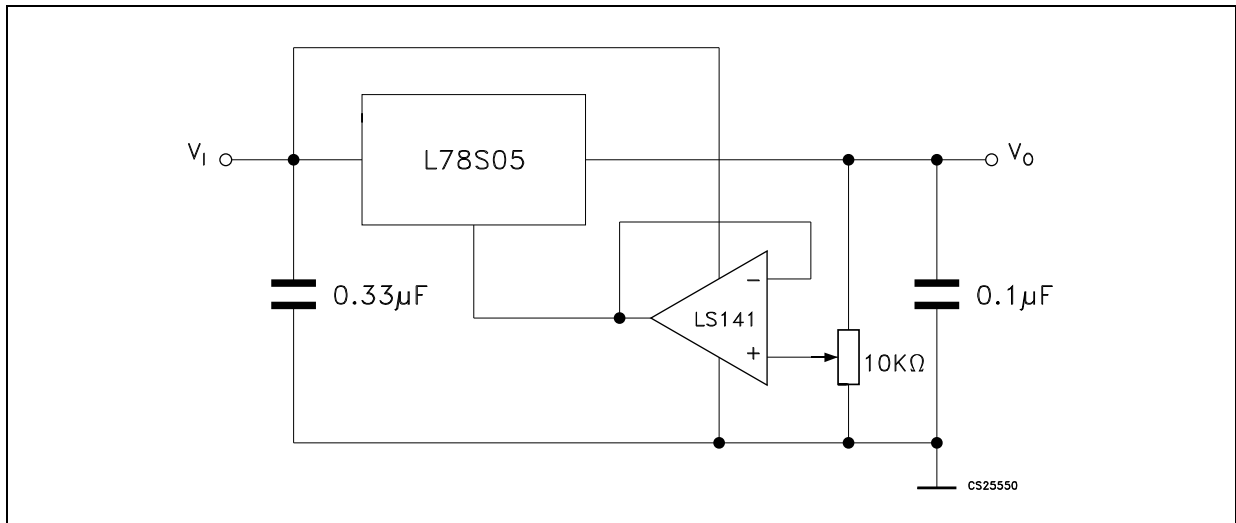


Figure 21. 0.5 to 10 V regulator

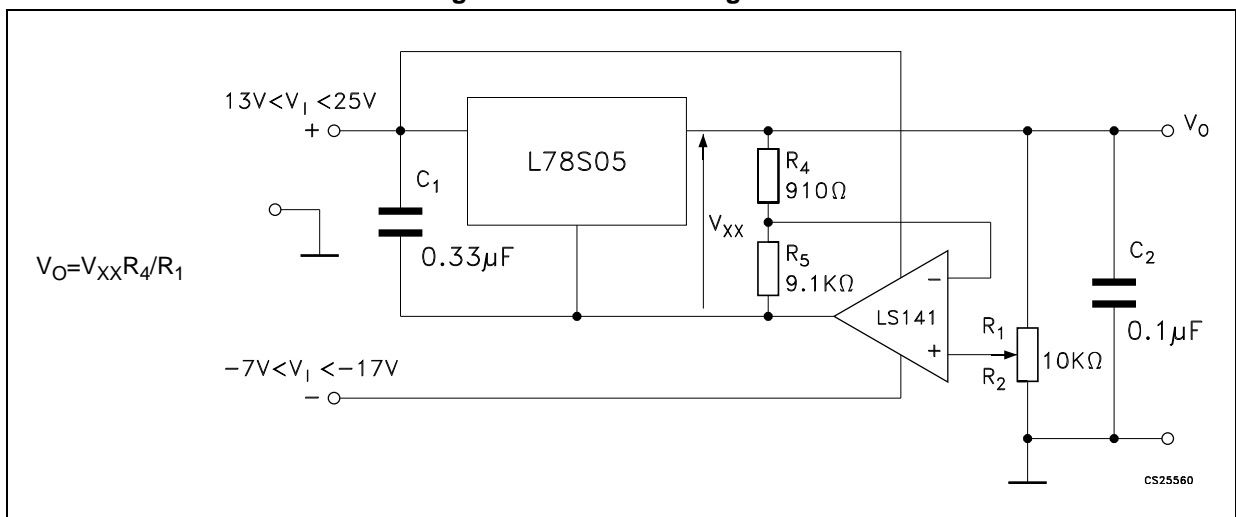


Figure 22. High current voltage regulator

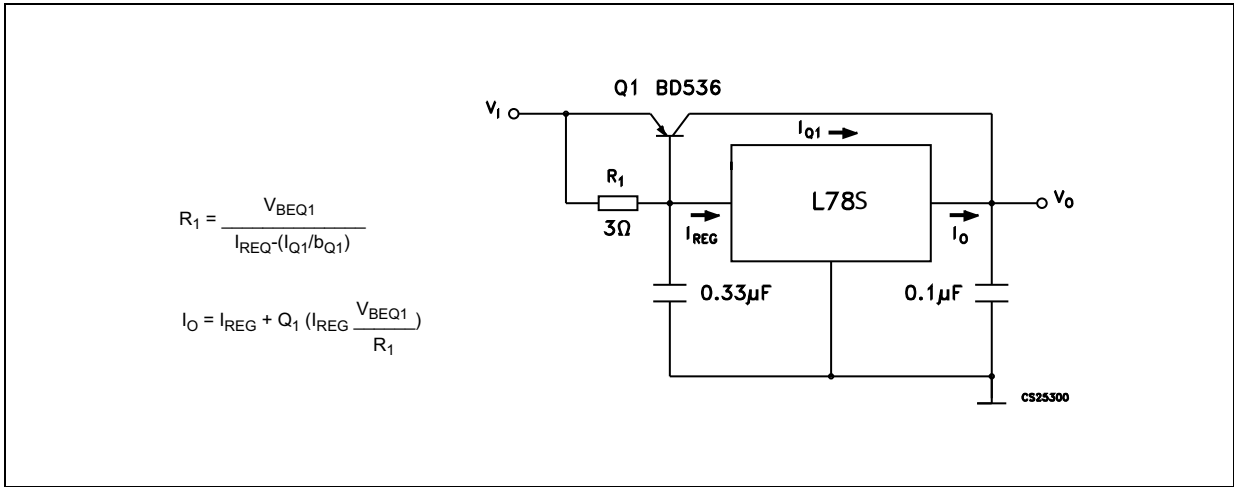


Figure 23. High output current with short circuit protection

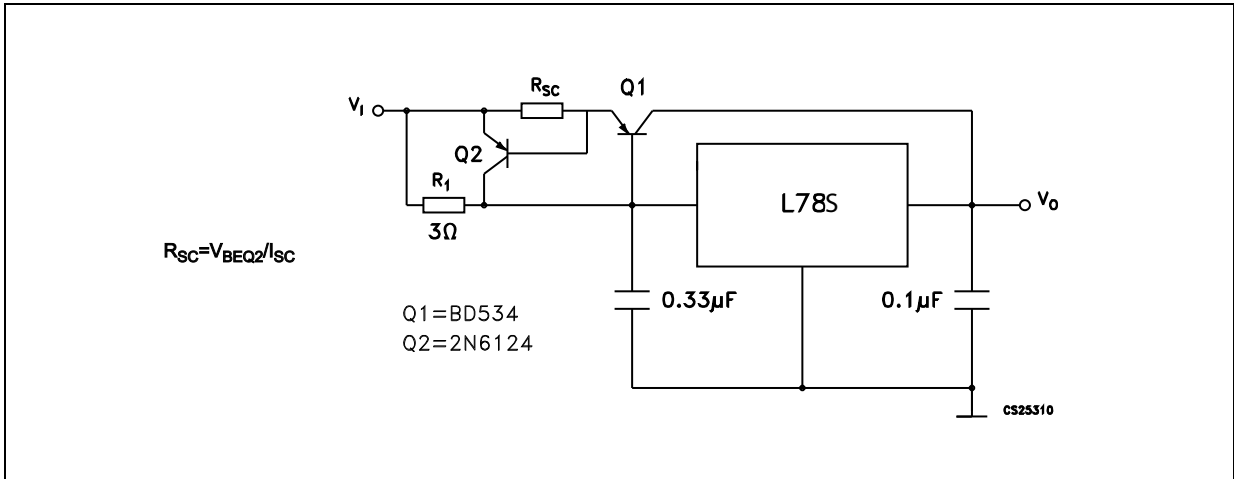


Figure 24. Tracking voltage regulator

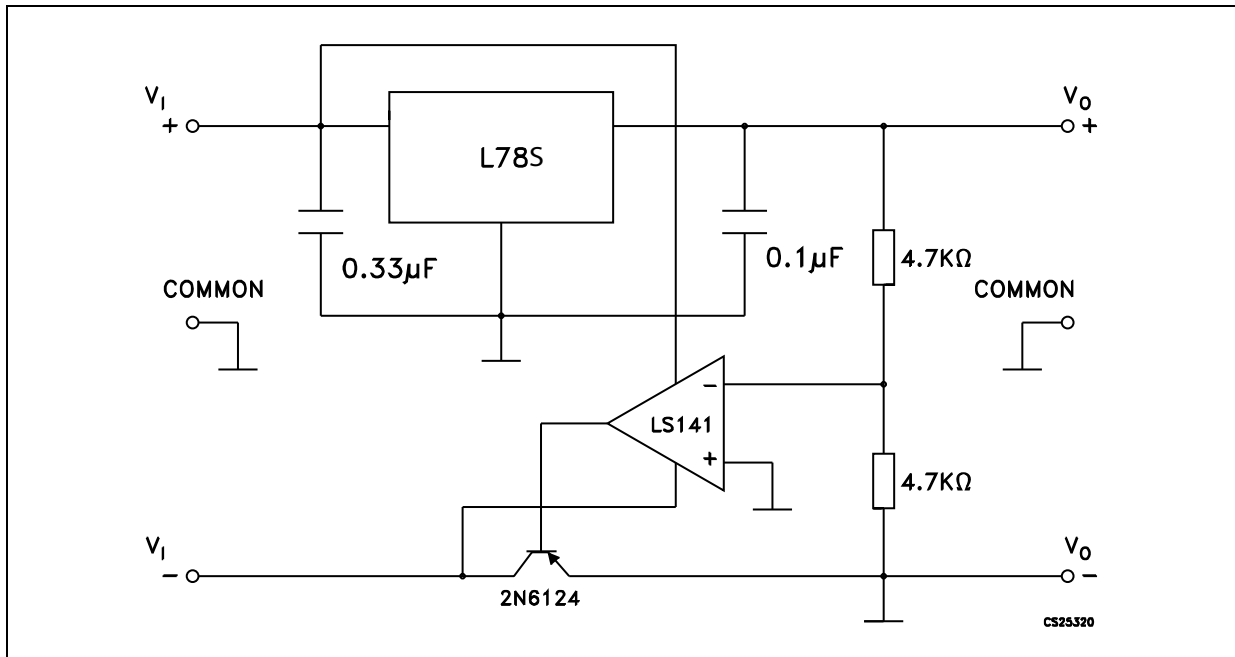


Figure 25. Positive and negative regulator

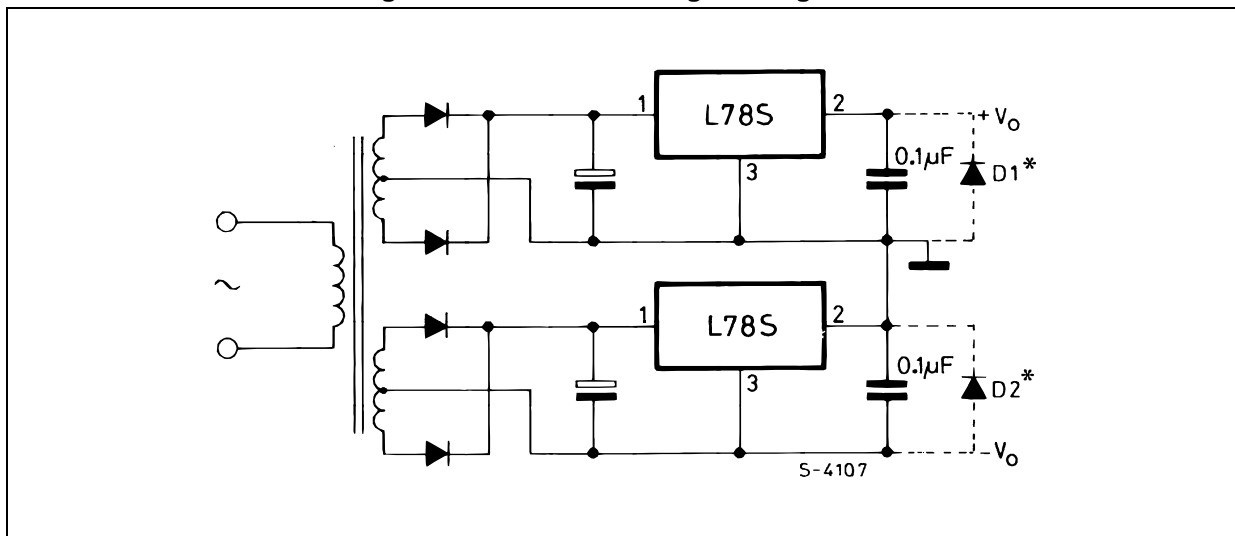


Figure 26. Negative output voltage circuit

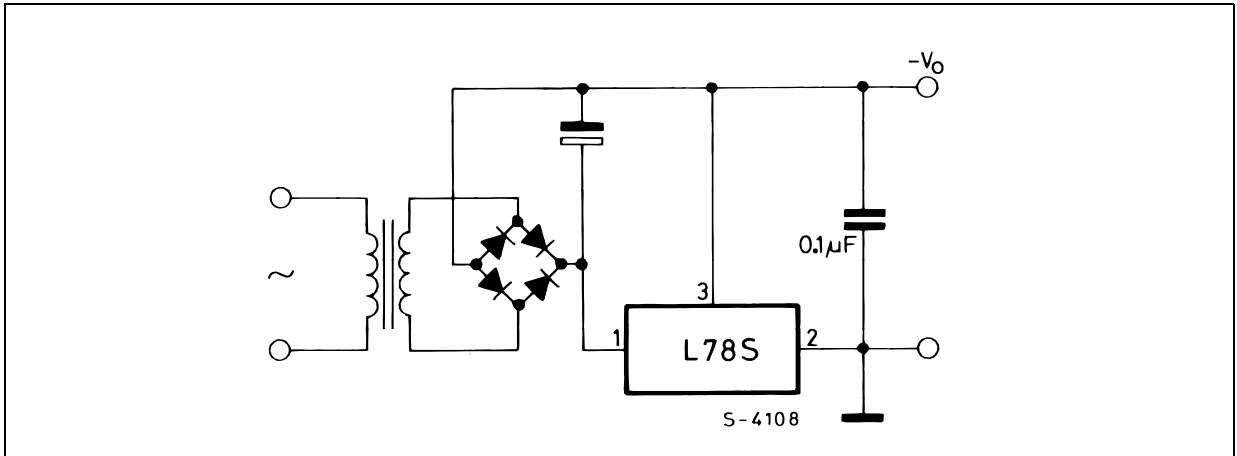


Figure 27. Switching regulator

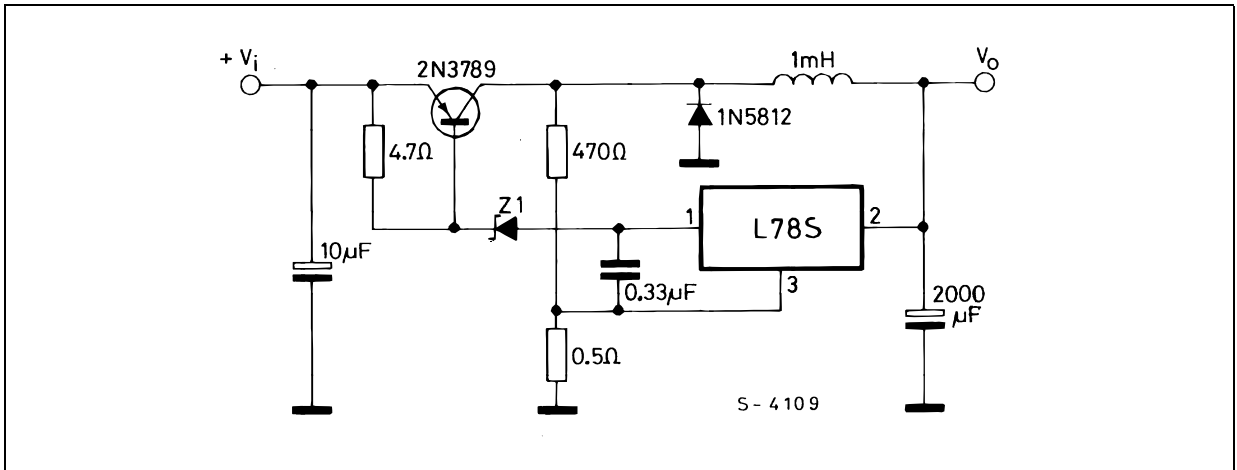


Figure 28. High input voltage circuit

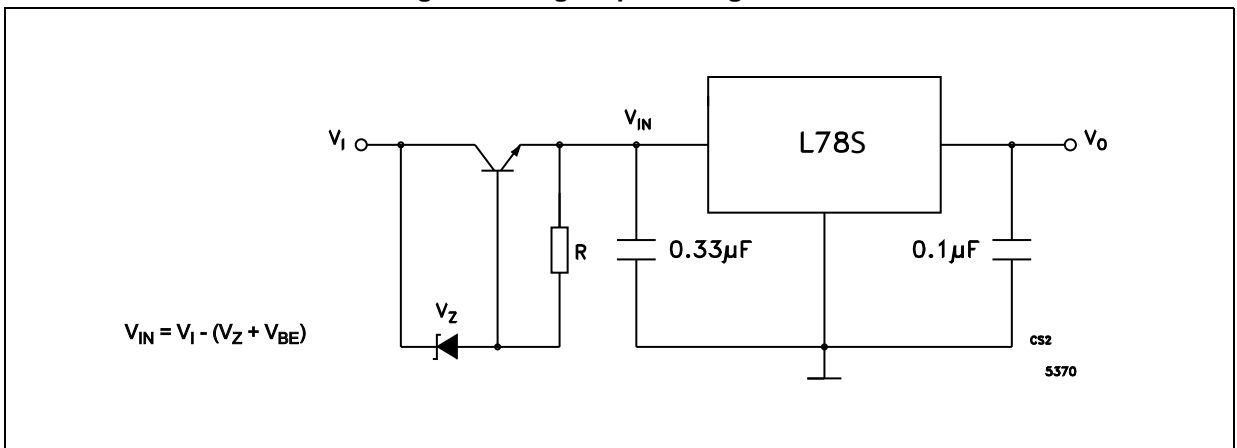


Figure 29. High input voltage circuit

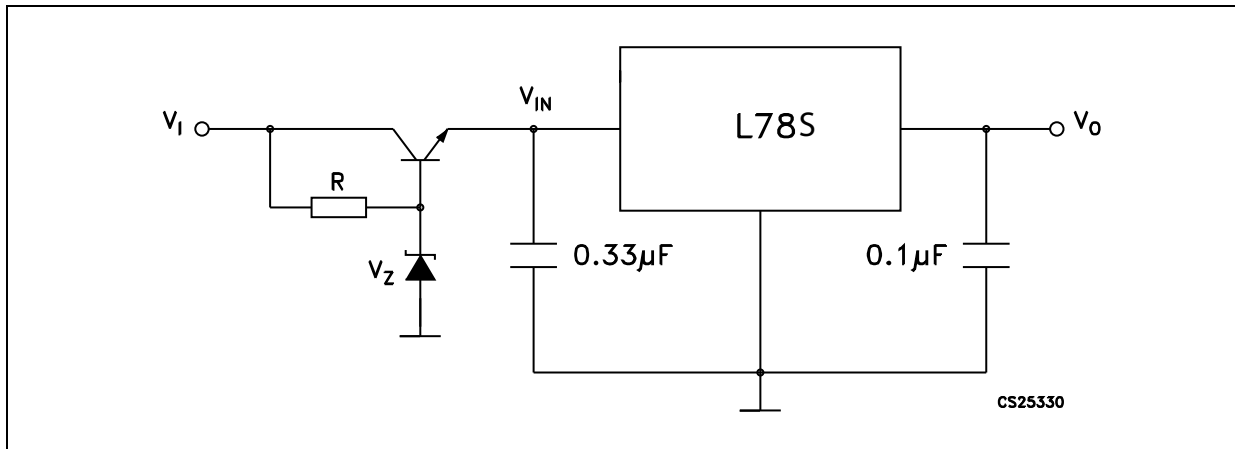


Figure 30. High output voltage regulator

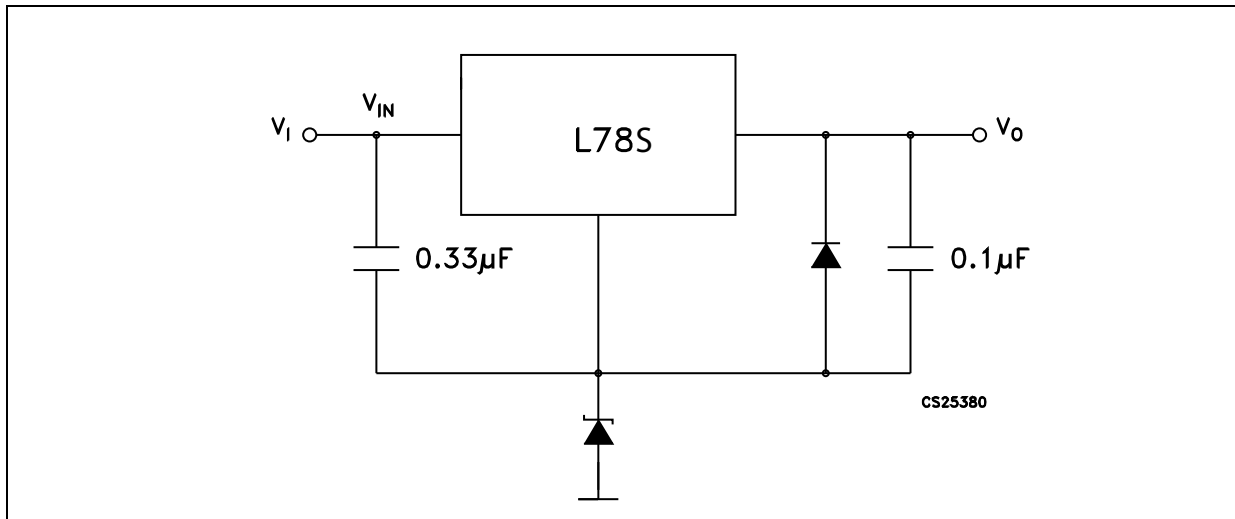


Figure 31. High input and output voltage

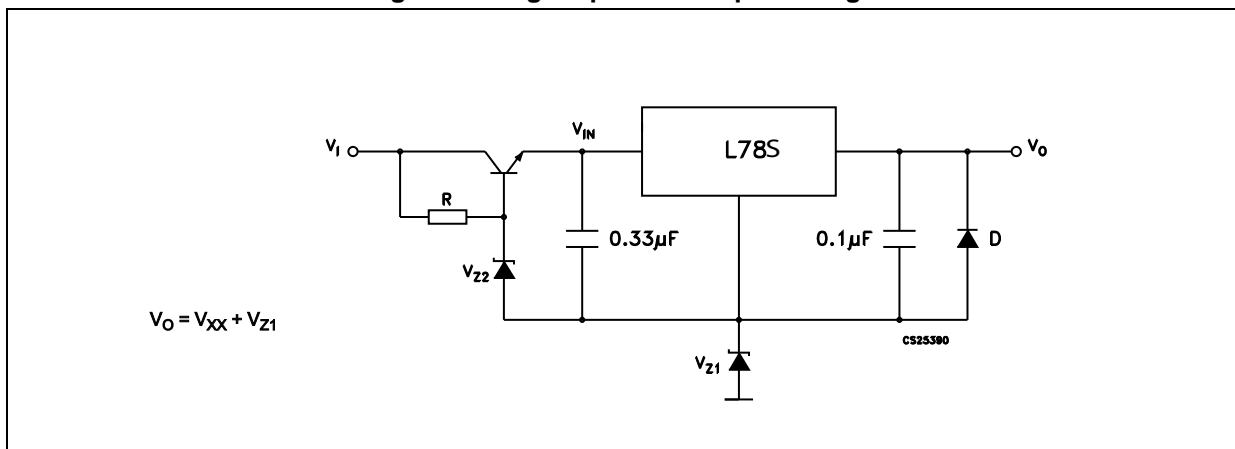


Figure 32. Reducing power dissipation with dropping resistor

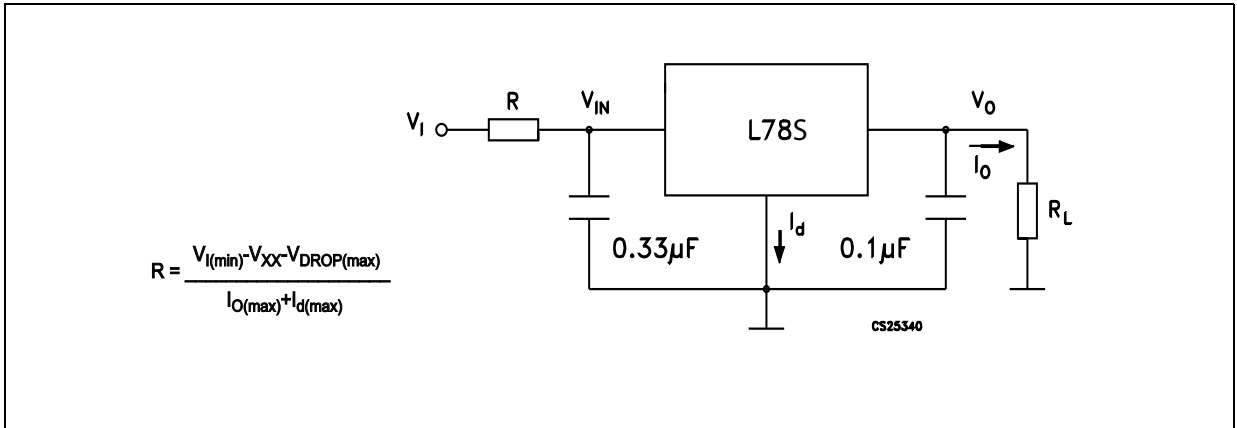


Figure 33. Remote shutdown

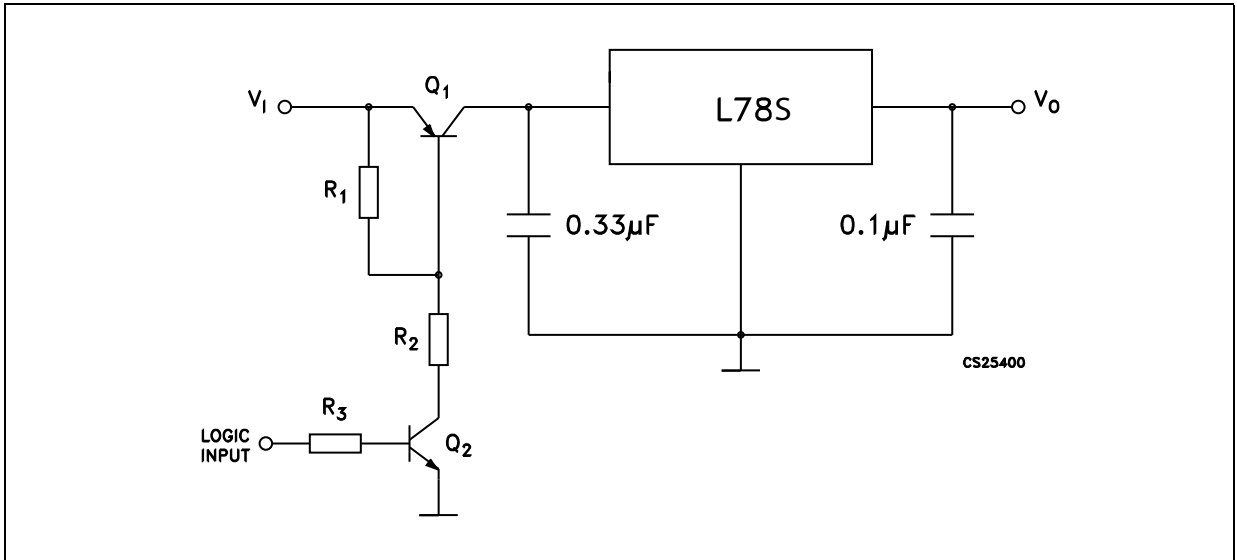
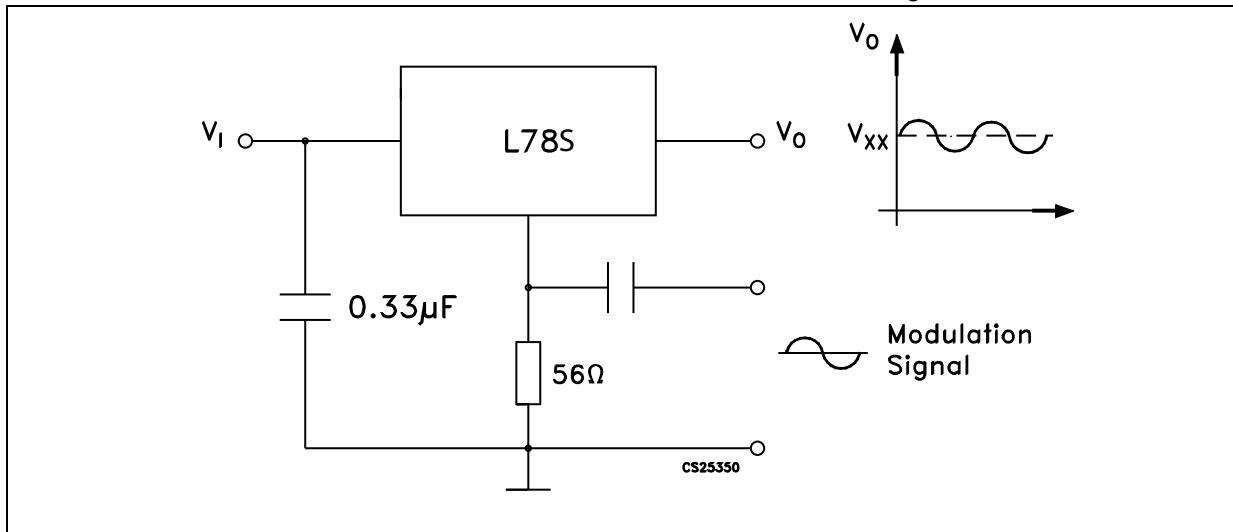
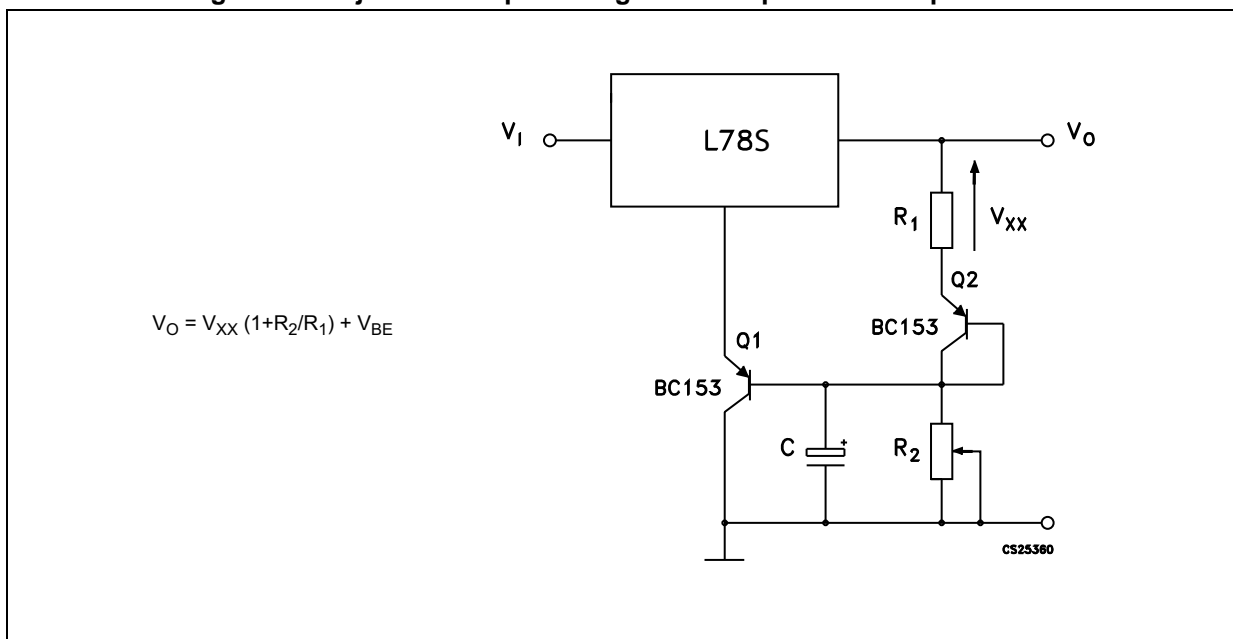


Figure 34. Power AM modulator (unity voltage gain, $I_O \leq 1\text{ A}$)



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 .

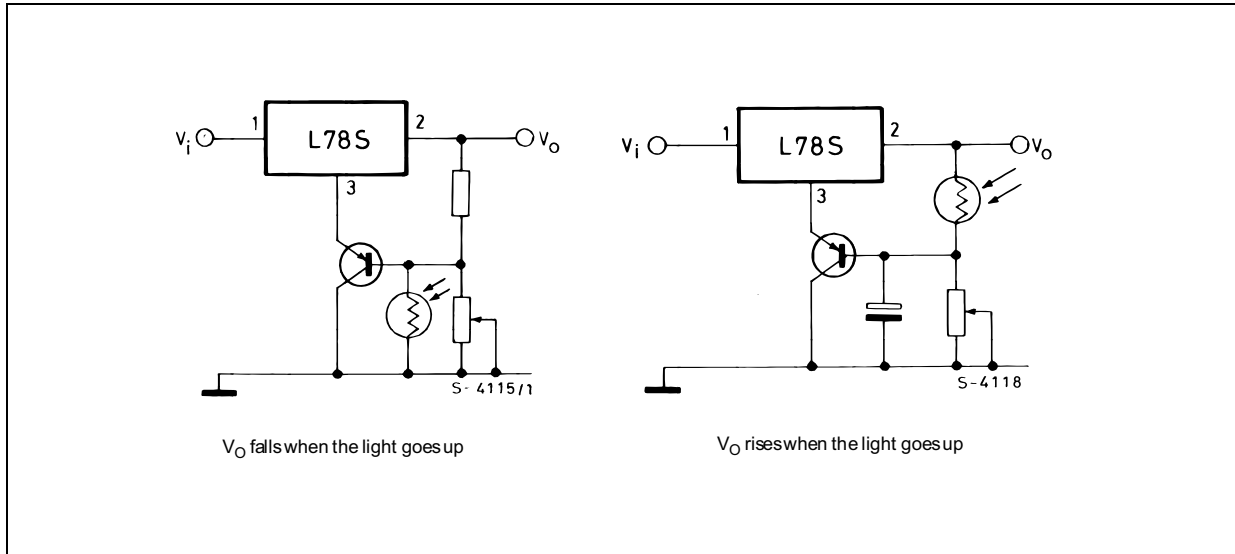
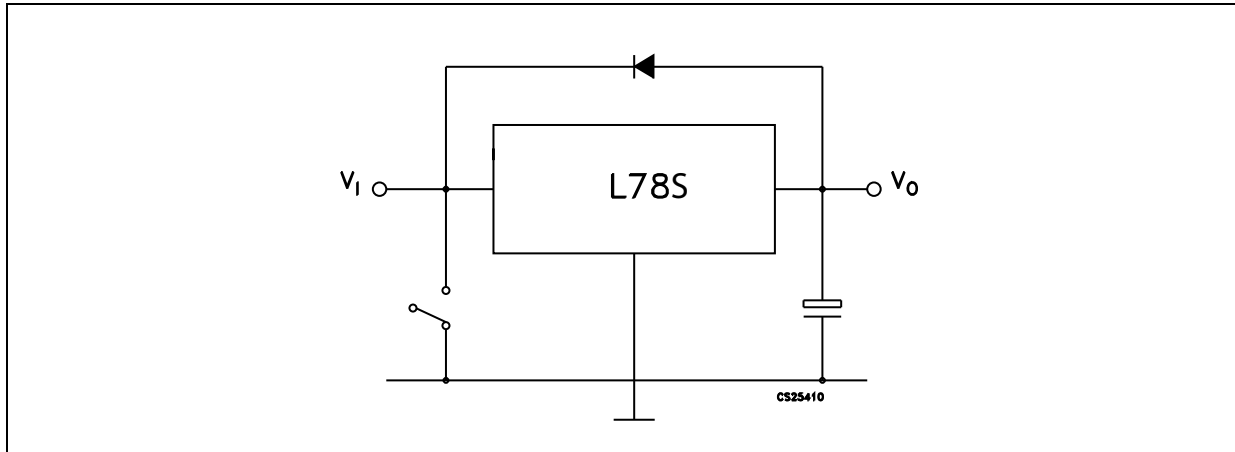
Figure 36. Light controllers ($V_{Omin} = V_{XX} + V_{BE}$)

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[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com. ECOPACK[®] is an ST trademark.

Figure 38. TO-220 (dual gauge) drawing

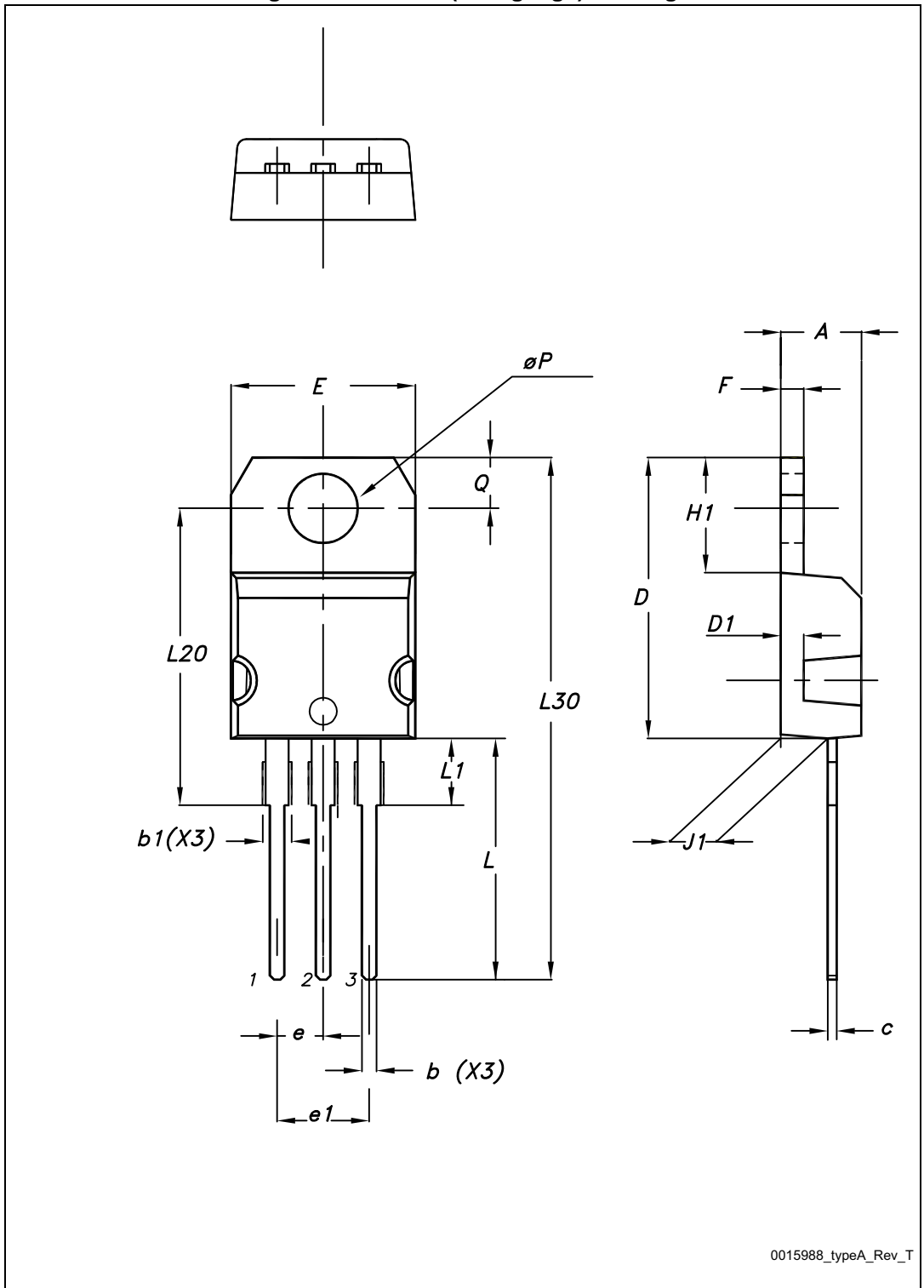


Table 12. TO-220 (dual gauge) mechanical data

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

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

9 Revision history

Table 14. Document revision history

Date	Revision	Changes
07-Sep-2006	2	Order codes updated.
20-Mar-2008	3	Added: Table 1 on page 1 .
22-Mar-2010	4	Added: Table 20 on page 32 , Figure 38 on page 33 , Figure 39 on page 34 , Figure 40 and Figure 41 on page 33 .
08-Feb-2012	5	Added: order codes L78S05CV-DG, L78S12CV-DG and L78S15CV-DG Table 13 on page 35 .
09-Mar-2012	6	Added: order codes L78S09CV-DG Table 13 on page 35 .
15-May-2012	7	Added: order codes L78S75CV-DG and L78S10CV-DG Table 13 on page 35 .
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 Table 1: Device summary , Section 2: Pin configuration , Section 3: Maximum ratings , Section 4: Test circuits , Section 5: Electrical characteristics , Section 6: Typical performance , Section 7: Package mechanical data , Section 9: Order codes . Added Section 8: Packaging mechanical data . Minor text changes.

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