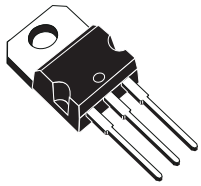
L78S

2 A positive voltage regulator IC

Datasheet - production data



TO-220

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

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.

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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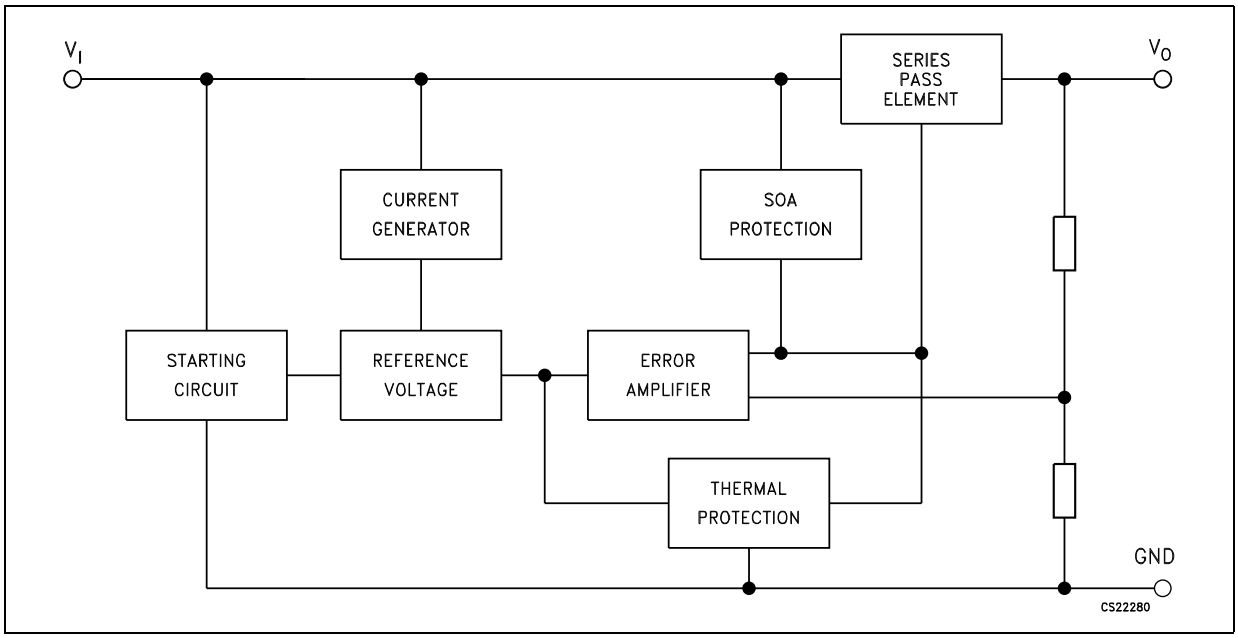
Figure 1. Block diagram



2 Pin configuration

Figure 2. Pin connections (top view)

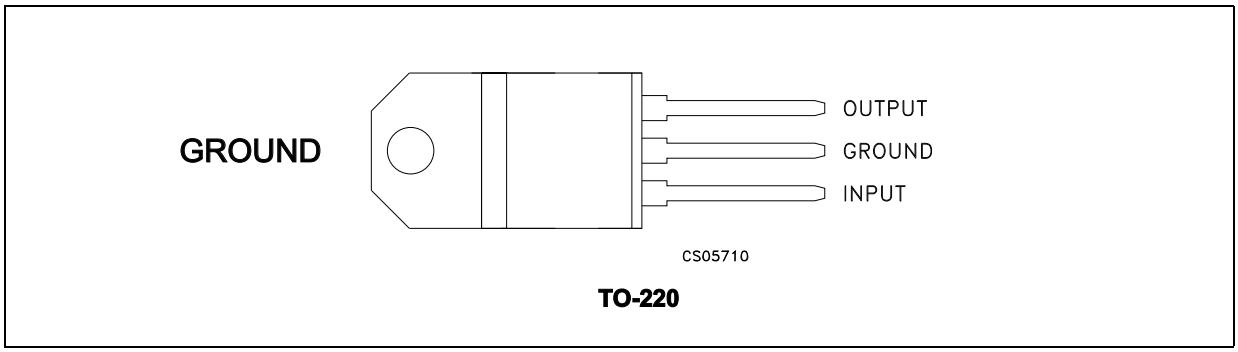
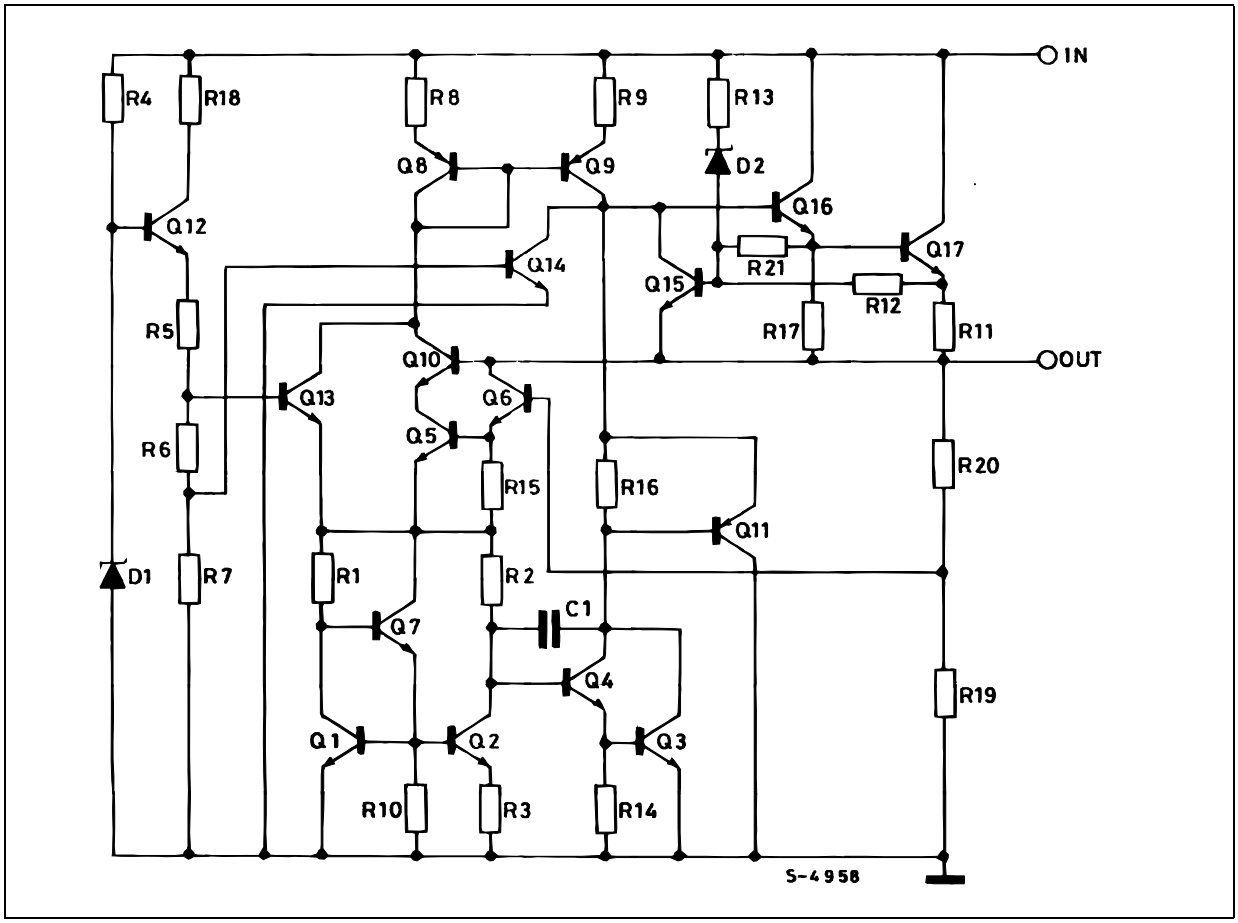


Figure 3. Schematic diagram



3 Maximum ratings

Table 2. Absolute maximum ratings

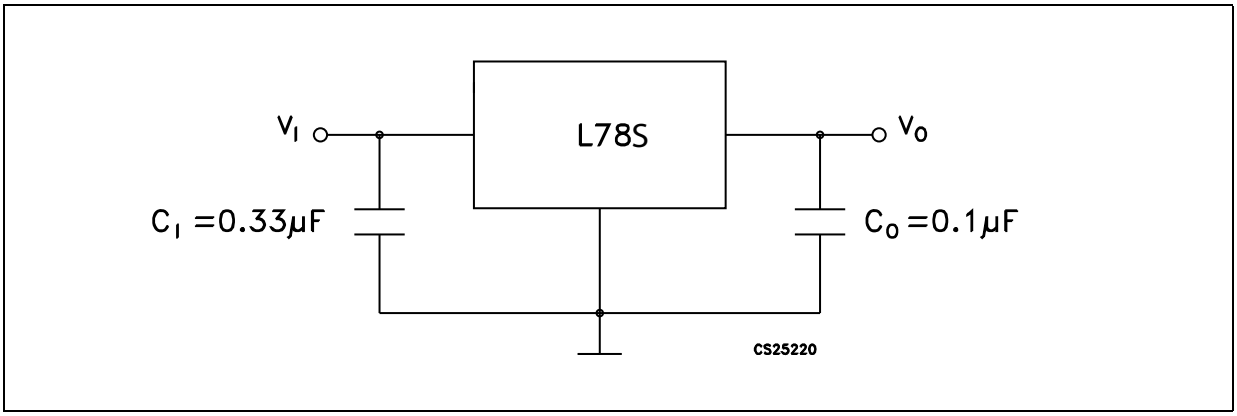
Symbol	Parameter		Value	Unit
V_I	DC input voltage	for V_O= 5 to 18V	35	V
		for V_O= 24V	40	
I_O	Output current		Internally limited	
P_D	Power dissipation		Internally limited	
T_{STG}	Storage temperature range		-65 to 150	°C
T_{OP}	Operating junction temperature range		0 to 150	°C

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

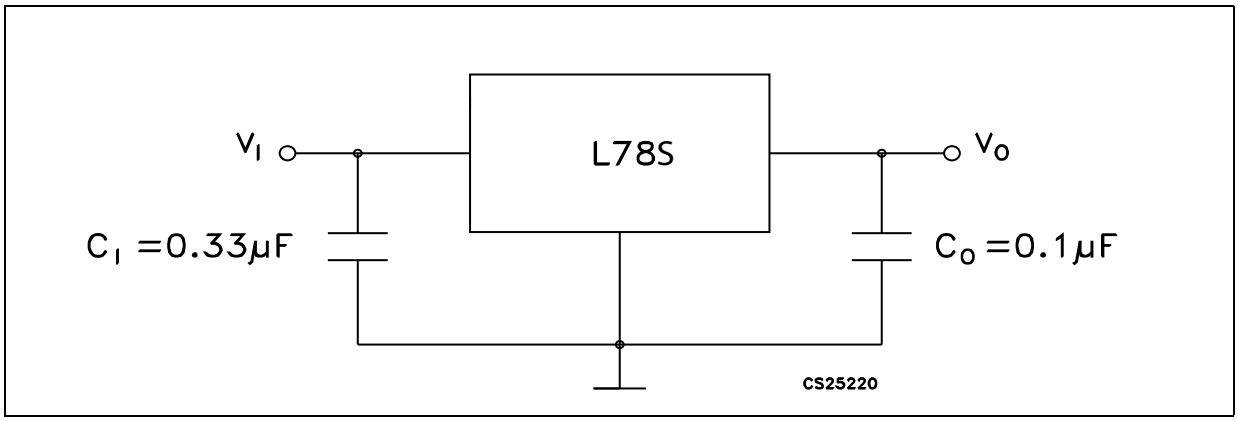


Figure 6. Load regulation

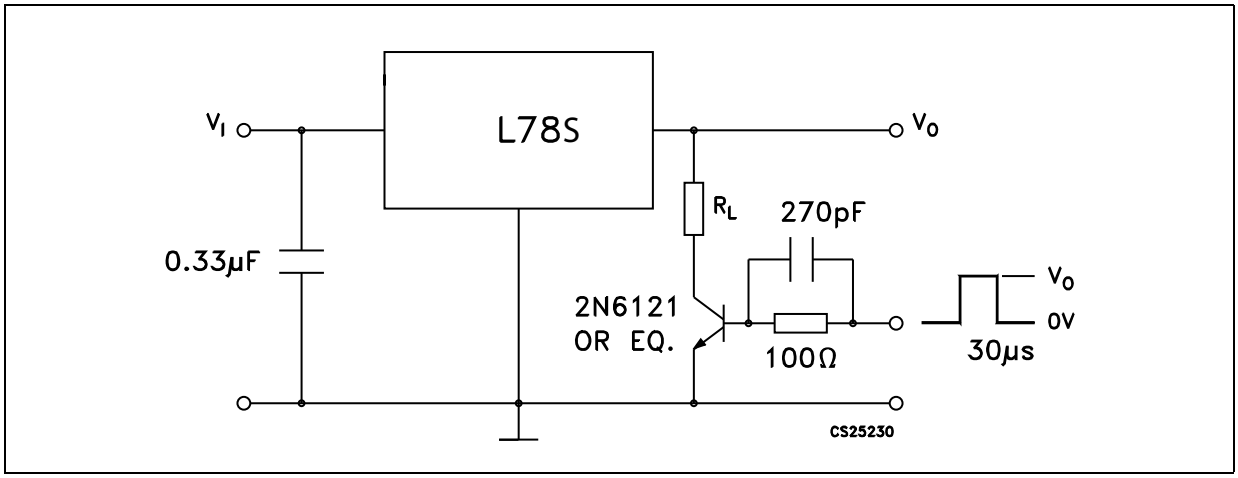
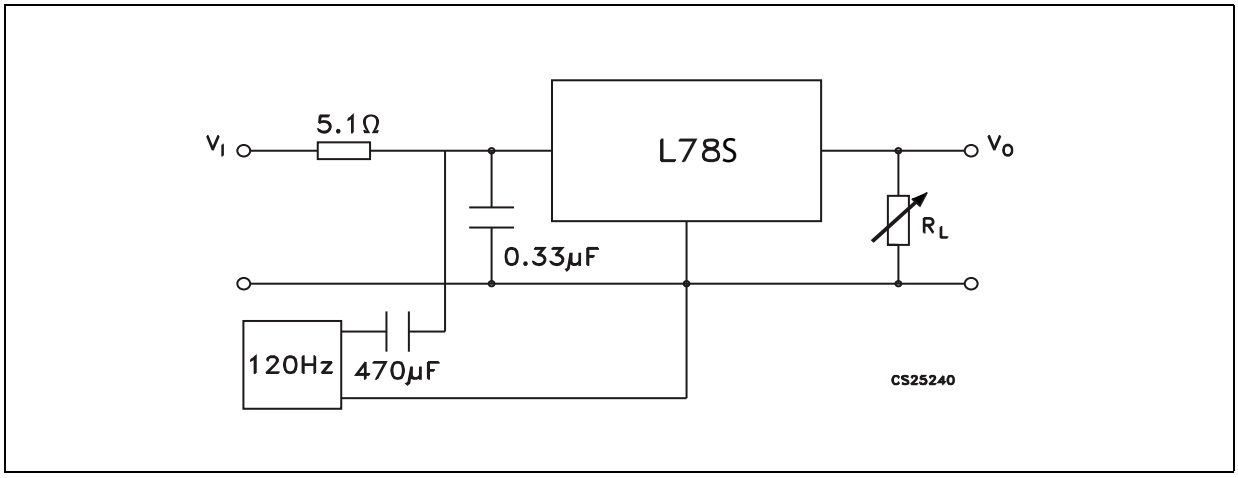


Figure 7. Ripple rejection



5 Electrical characteristics

Refer to the test circuits, T_J = 25 °C, V_I = 10 V, I_O = 500 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 A, V_I = 7 V	4.75	5	5.25	V
ΔV_O	Line regulation	V_I = 7 to 25 V			100	mV
		V_I = 8 to 25 V			50	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			100	mV
		I_O = 2 A		80		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 7 to 25 V, I_O = 20 mA			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-1.1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		40		µV
SVR	Supply voltage rejection	f = 120 Hz	54(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	8			V
R_O	Output resistance	f = 1 kHz		17		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 12.5 V, I_O = 500 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 A, V_I = 9.5 V	7.1	7.5	7.95	V
ΔV_O	Line regulation	V_I = 9.5 to 25 V			120	mV
		V_I = 10.5 to 20 V			60	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			140	mV
		I_O = 2 A		100		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 9.5 to 25 V, I_O = 20 mA			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-0.8		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		52		µV
SVR	Supply voltage rejection	f = 120 Hz	48(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	10.5			V
R_O	Output resistance	f = 1 kHz		16		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 14 V, I_O = 500 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 A, V_I = 11 V	8.6	9	9.4	V
ΔV_O	Line regulation	V_I = 11 to 25 V			130	mV
		V_I = 11 to 20 V			65	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			170	mV
		I_O = 2 A		100		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 11 to 25 V, I_O = 20 mA			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		60		µV
SVR	Supply voltage rejection	f = 120 Hz	47(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	12			V
R_O	Output resistance	f = 1 kHz		17		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 15 V, I_O = 500 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 A, V_I = 12.5 V	9.4	10	10.6	V
ΔV_O	Line regulation	V_I = 12.5 to 30 V			200	mV
		V_I = 14 to 22 V			100	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			240	mV
		I_O = 2 A		150		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 12.5 to 30 V, I_O = 20 mA			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-1		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		65		µV
SVR	Supply voltage rejection	f = 120 Hz	47(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	13			V
R_O	Output resistance	f = 1 kHz		17		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 19 V, I_O = 500 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 A, V_I = 14.5 V	11.4	12	12.6	V
ΔV_O	Line regulation	V_I = 14.5 to 30 V			240	mV
		V_I = 16 to 22 V			120	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			240	mV
		I_O = 2 A		150		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 14.5 to 30 V, I_O = 20 mA			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-1		mV/°C
eN	Output noise voltage	B =10 Hz to 100 kHz		75		µV
SVR	Supply voltage rejection	f = 120 Hz	47(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	15			V
R_O	Output resistance	f = 1 kHz		18		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 23 V, I_O = 500 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 A, V_I = 17.5 V	14.25	15	15.75	V
ΔV_O	Line regulation	V_I = 17.5 to 30 V			300	mV
		V_I = 20 to 26 V			150	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			300	mV
		I_O = 2 A		150		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 17.5 to 30 V, I_O = 20 mA			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °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 A	18			V
R_O	Output resistance	f = 1 kHz		19		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 26 V, I_O = 500 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 A, V_I = 20.5 V	17	18	19	V
ΔV_O	Line regulation	V_I = 20.5 to 30 V			360	mV
		V_I = 22 to 28 V			180	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			360	mV
		I_O = 2 A		200		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 20.5 to 30 V, I_O = 20 mA			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °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 A	21			V
R_O	Output resistance	f = 1 kHz		22		mΩ
I_{sc}	Short circuit current	V_I = 27 V		500		mA
I_{scp}	Short circuit peak current			3		A

1. Guaranteed by design.

Refer to the test circuits, T_J = 25 °C, V_I = 33 V, I_O = 500 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 A, V_I = 27 V	22.8	24	25.2	V
ΔV_O	Line regulation	V_I = 27 to 38 V			480	mV
		V_I = 30 to 36 V			240	
ΔV_O	Load regulation	I_O = 20 mA to 1.5 A			480	mV
		I_O = 2 A		300		
I_Q	Quiescent current				8	mA
ΔI_Q	Quiescent current change	I_O = 20 mA to 1 A			0.5	mA
		V_I = 27 to 38 V, I_O = 20 mA			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA, T_J = 0 °C to 70 °C		-1.5		mV/°C
eN	Output noise voltage	B = 10 Hz to 100 kHz		170		µV
SVR	Supply voltage rejection	f = 120 Hz	42(1)			dB
V_I	Operating input voltage	$I_O \leq$ 1 A	27			V
R_O	Output resistance	f = 1 kHz		28		mΩ
I_{sc}	Short circuit current	V_I = 27 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

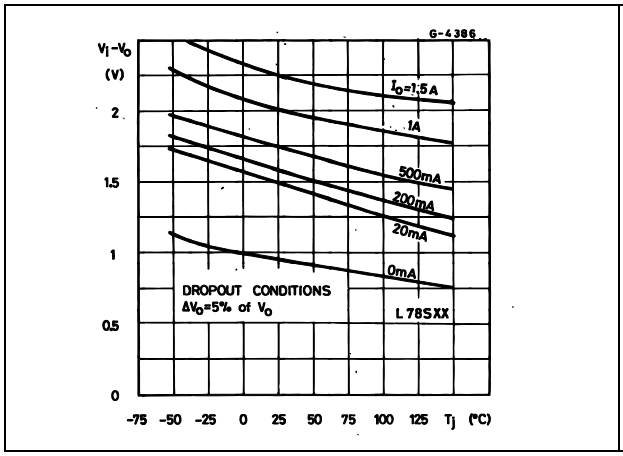


Figure 9. Peak output current vs. input/output differential voltage

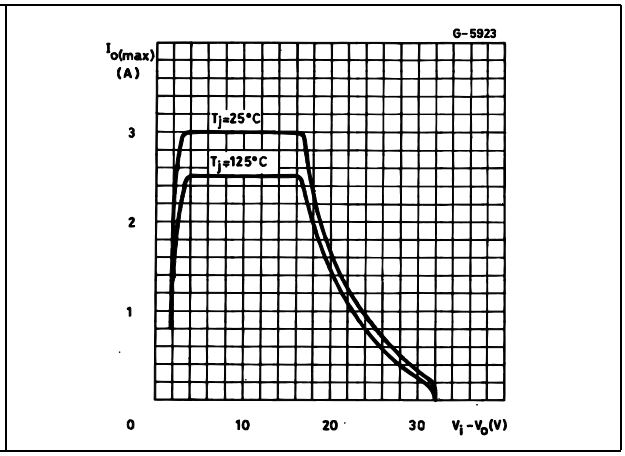


Figure 10. Output impedance vs. frequency

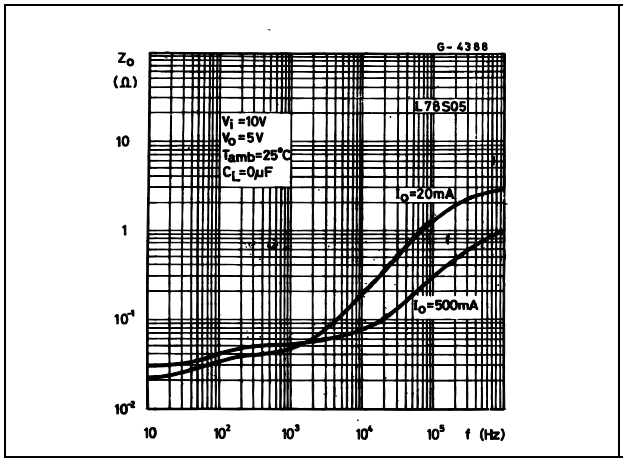


Figure 11. Output voltage vs. junction temperature

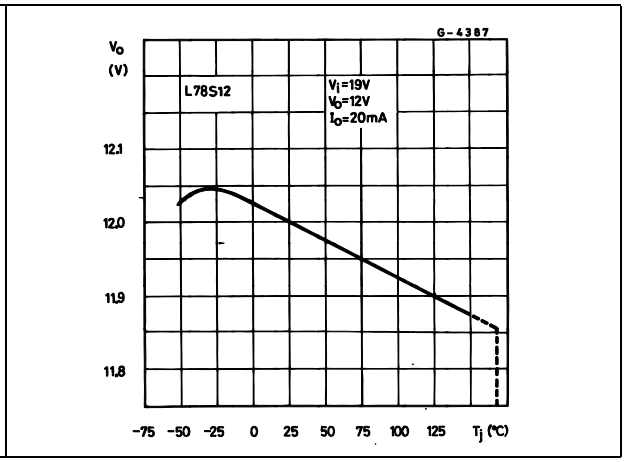


Figure 12. Supply voltage rejection vs. frequency

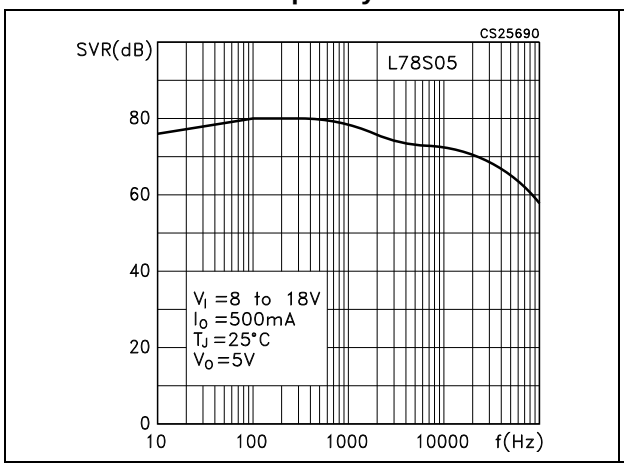


Figure 13. Quiescent current vs. junction temperature

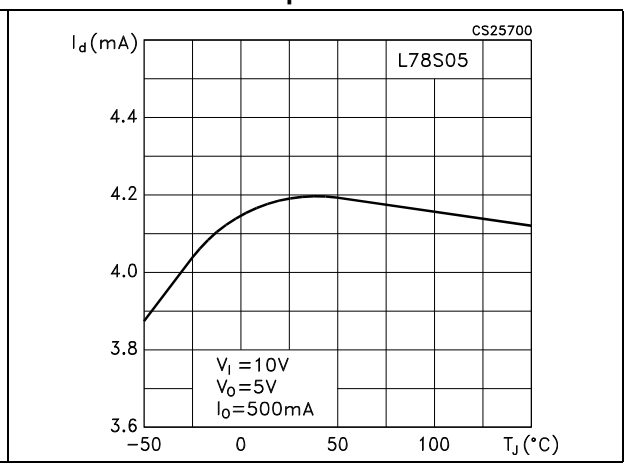


Figure 14. Load transient response

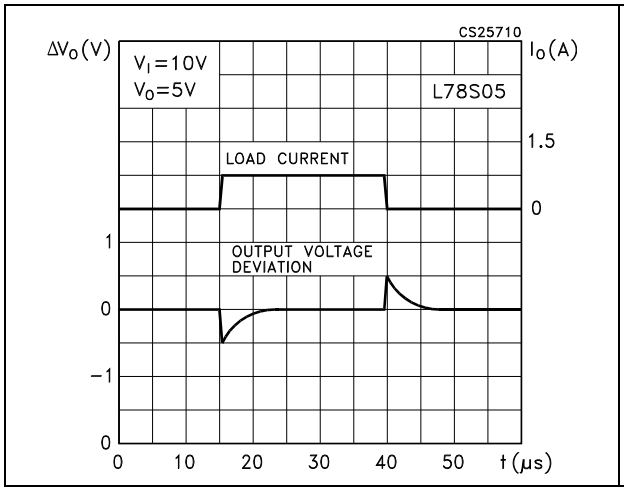


Figure 15. Line transient response

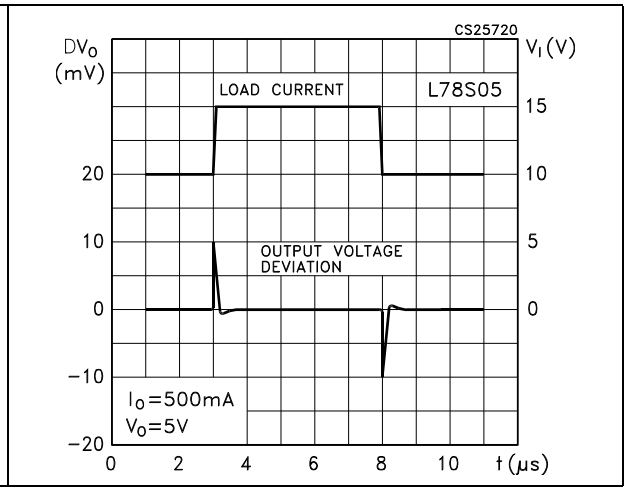


Figure 16. Quiescent current vs. input voltage

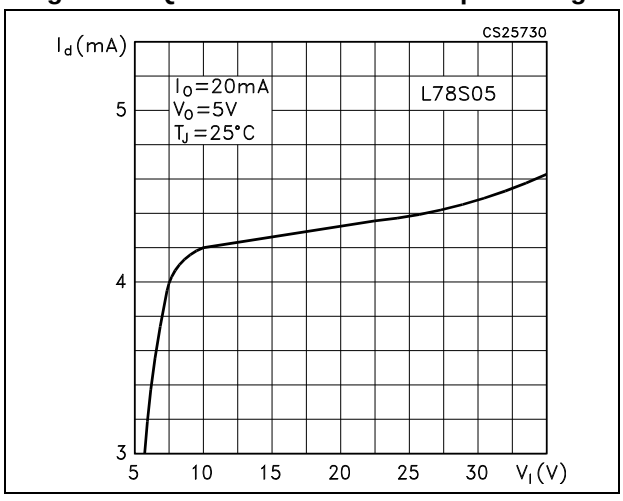
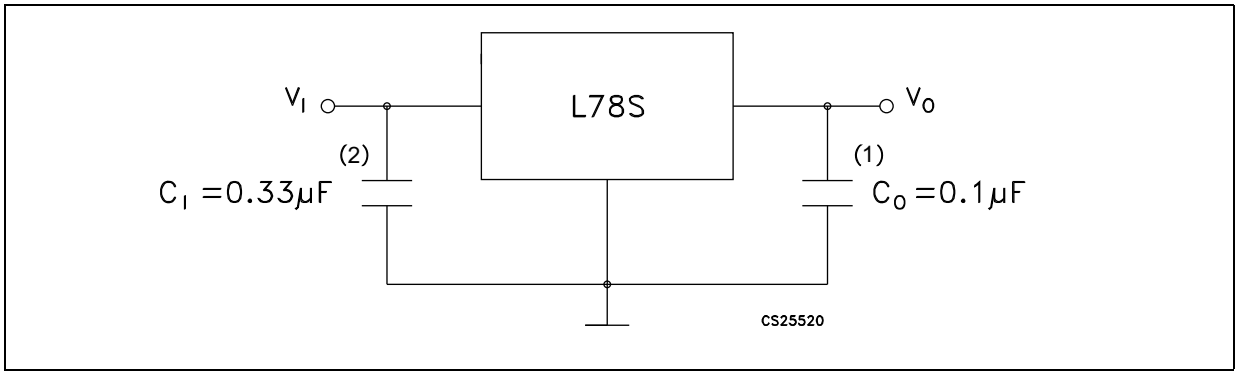


Figure 17. Fixed output regulator



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

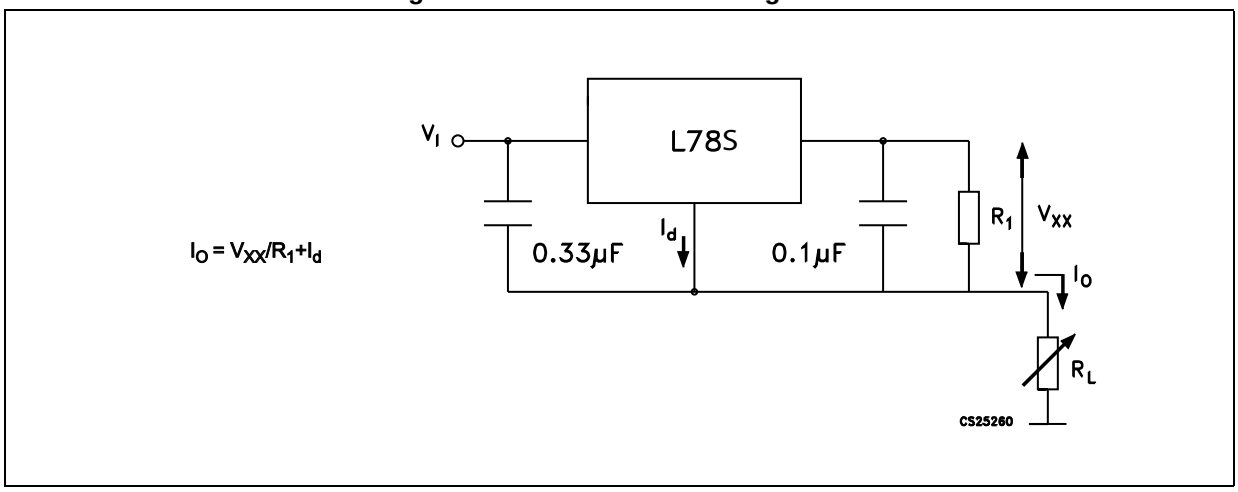


Figure 19. Circuit for increasing output voltage

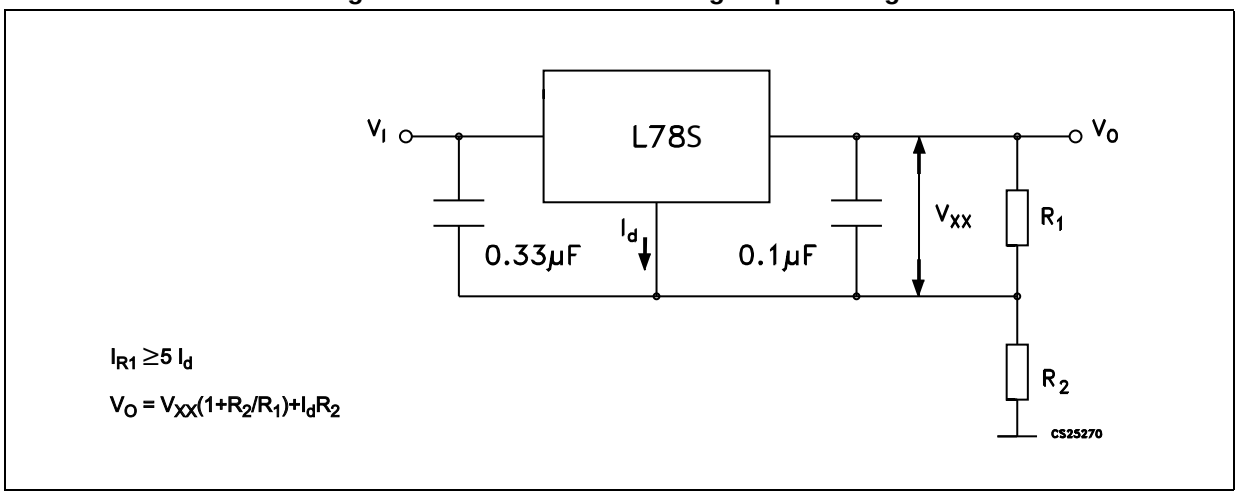


Figure 20. Adjustable output regulator (7 to 30 V)

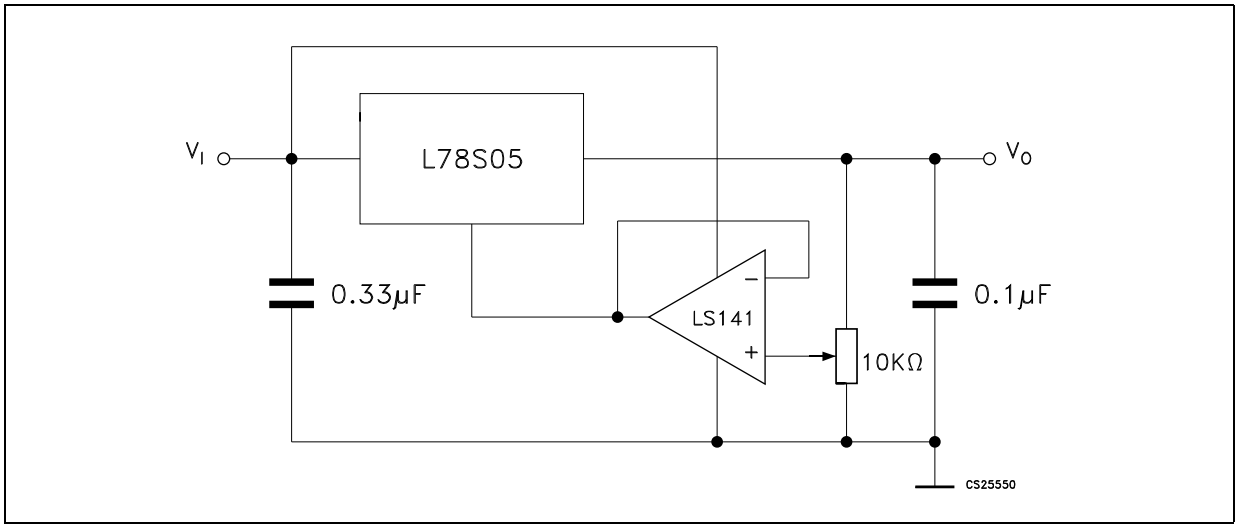


Figure 21. 0.5 to 10 V regulator

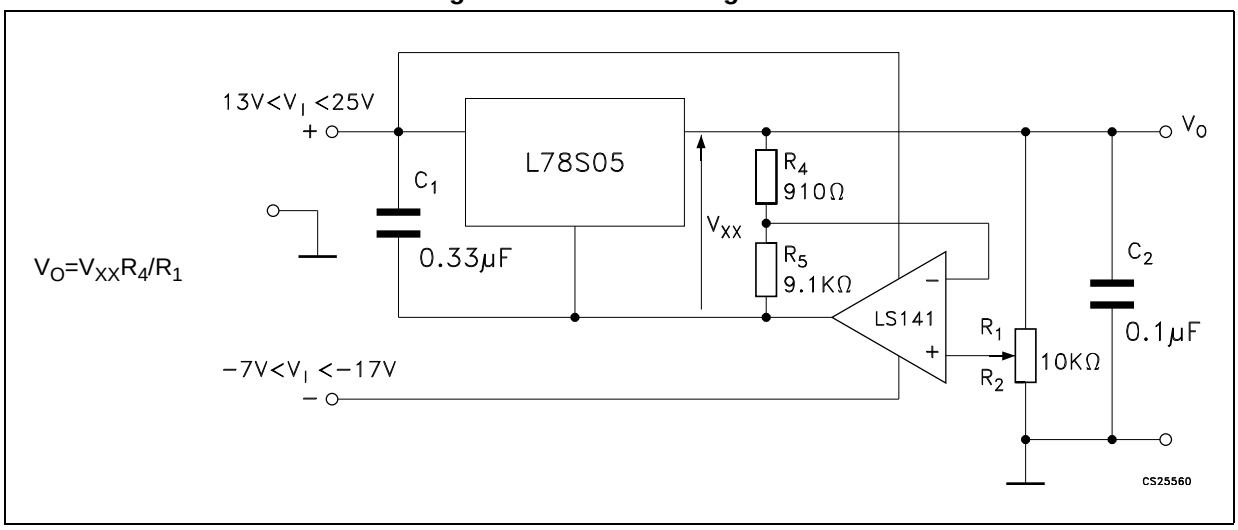


Figure 22. High current voltage regulator

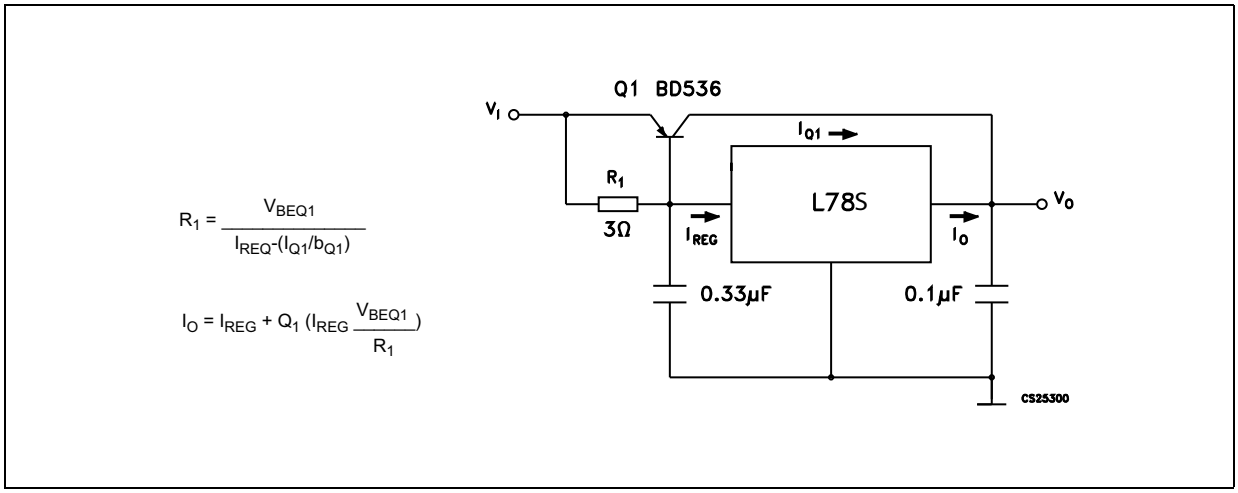


Figure 23. High output current with short circuit protection

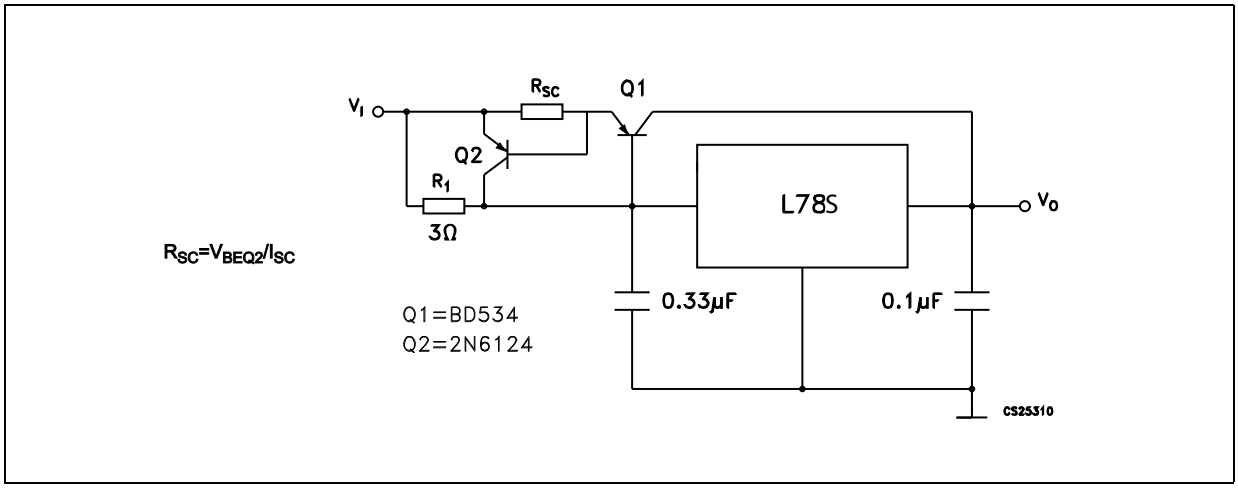


Figure 24. Tracking voltage regulator

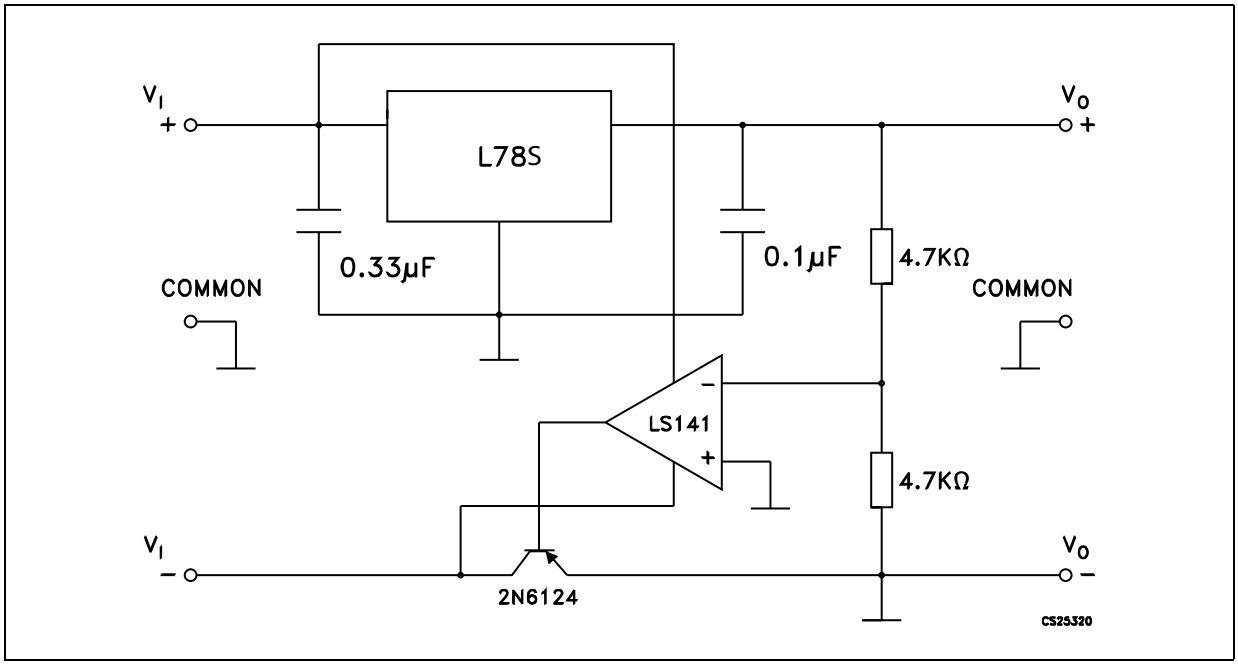


Figure 25. Positive and negative regulator

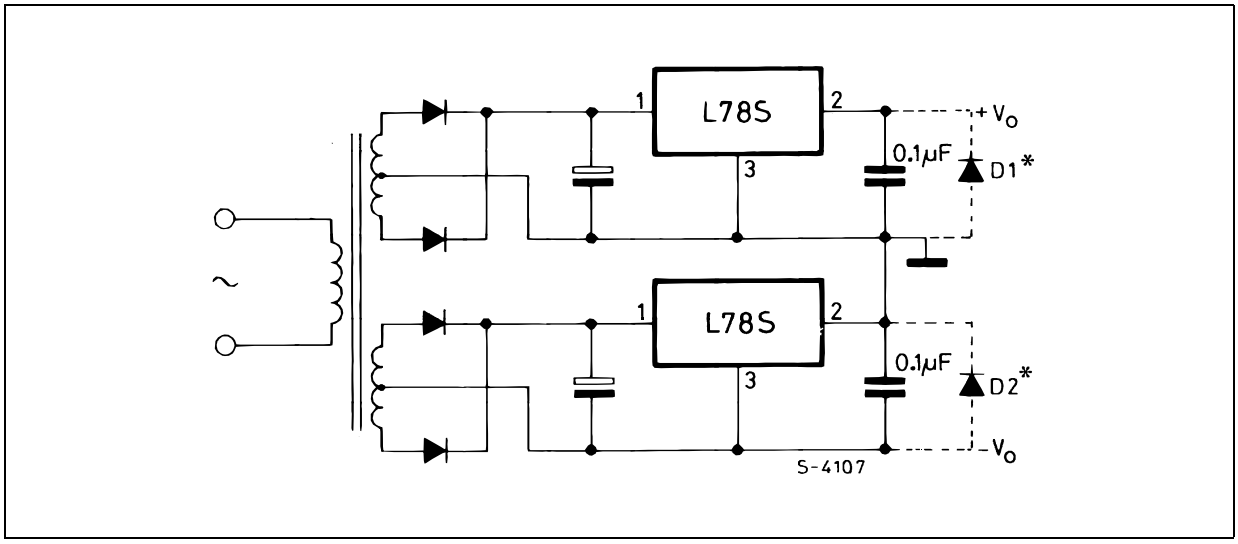


Figure 26. Negative output voltage circuit

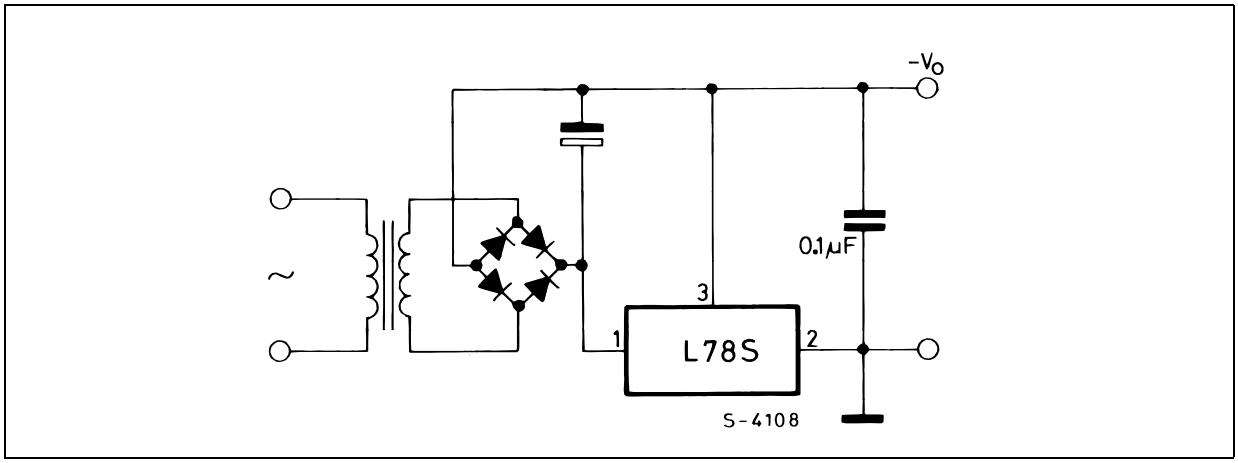


Figure 27. Switching regulator

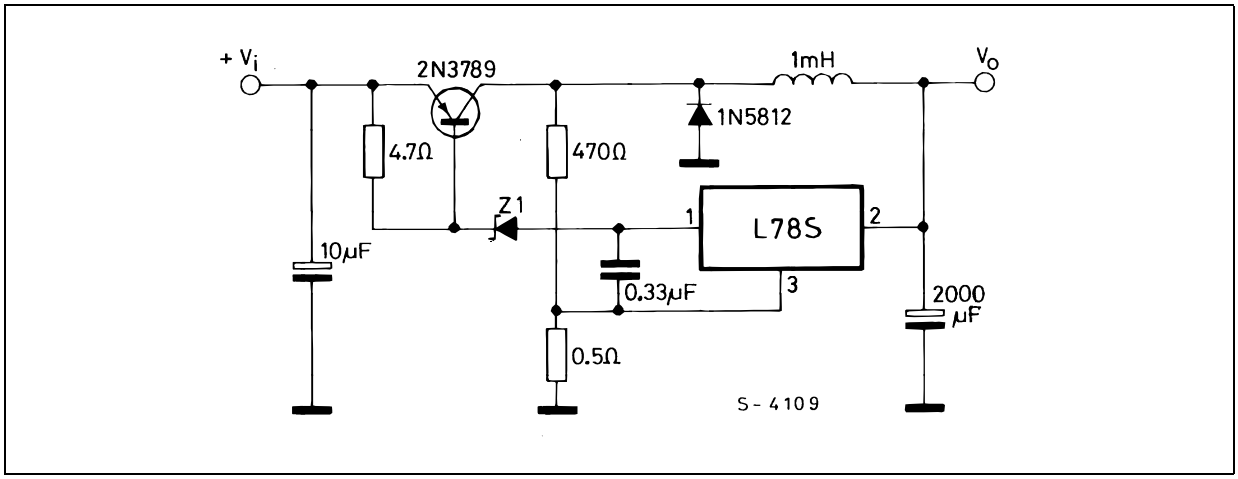


Figure 28. High input voltage circuit

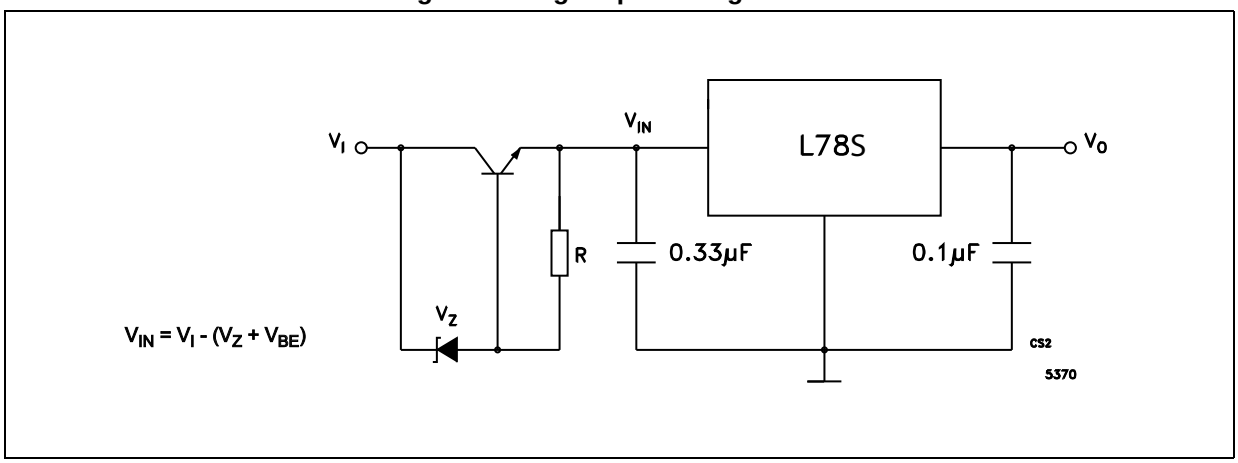


Figure 29. High input voltage circuit

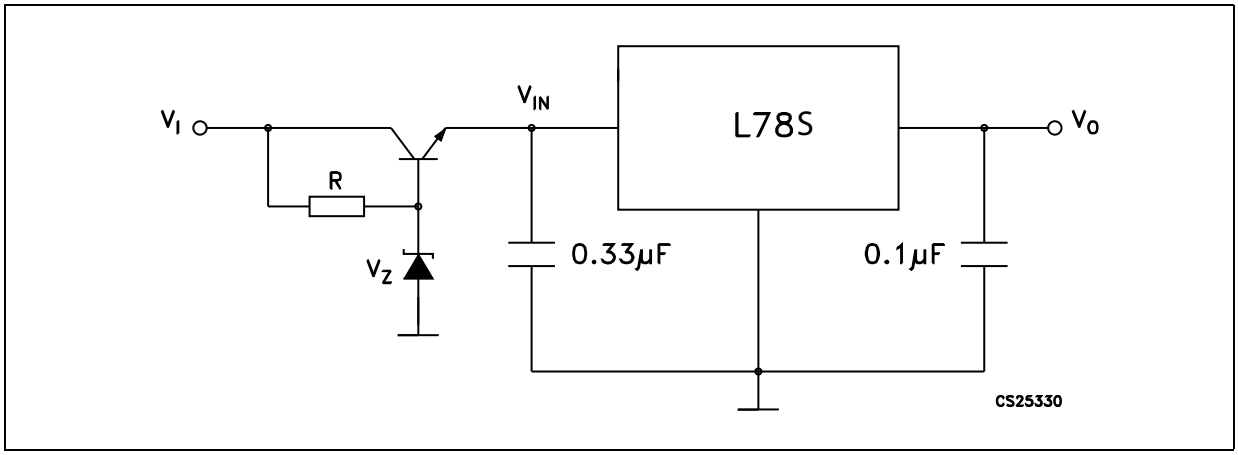


Figure 30. High output voltage regulator

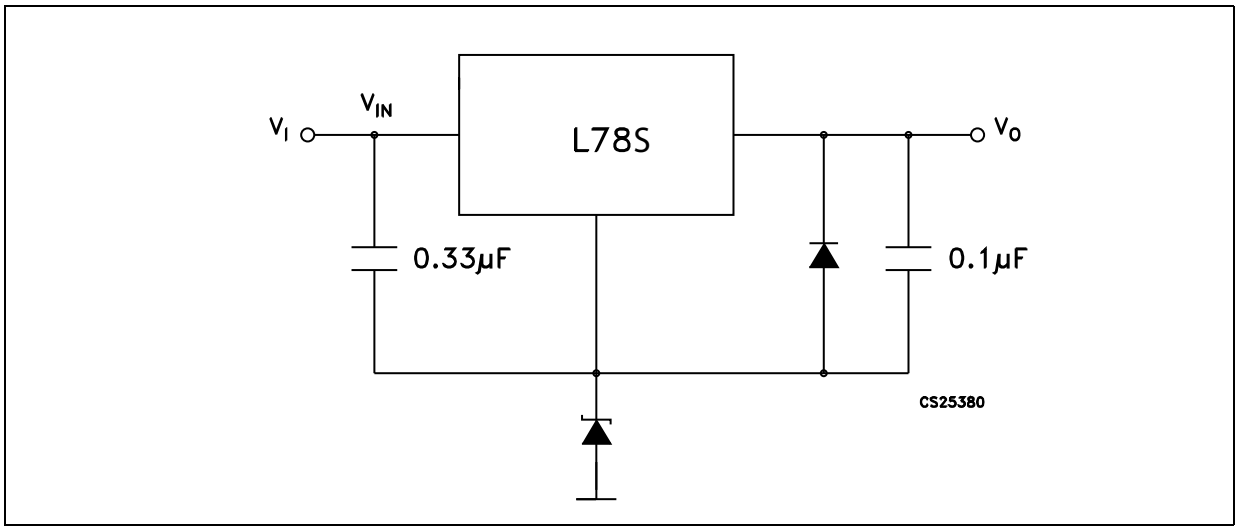


Figure 31. High input and output voltage

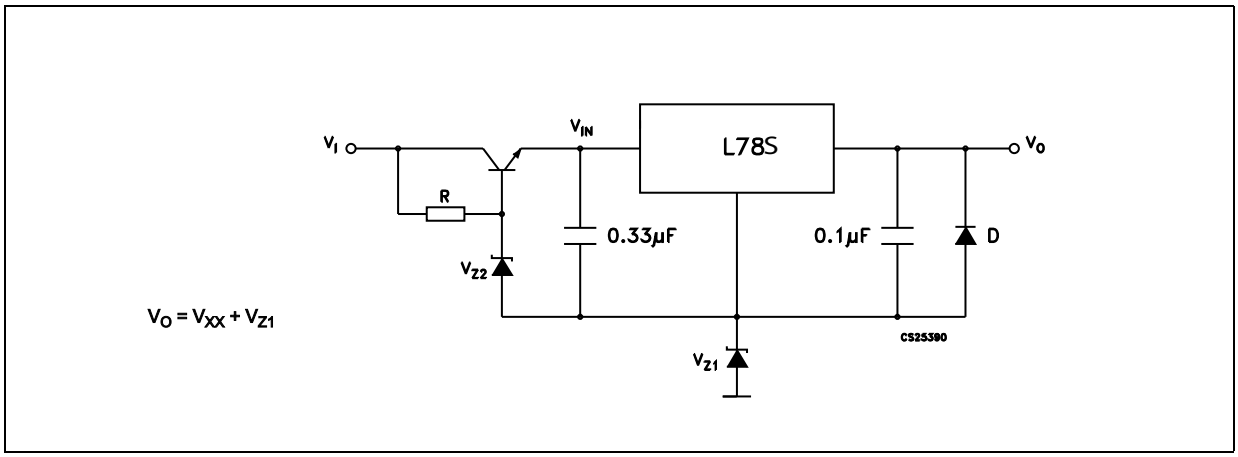


Figure 32. Reducing power dissipation with dropping resistor

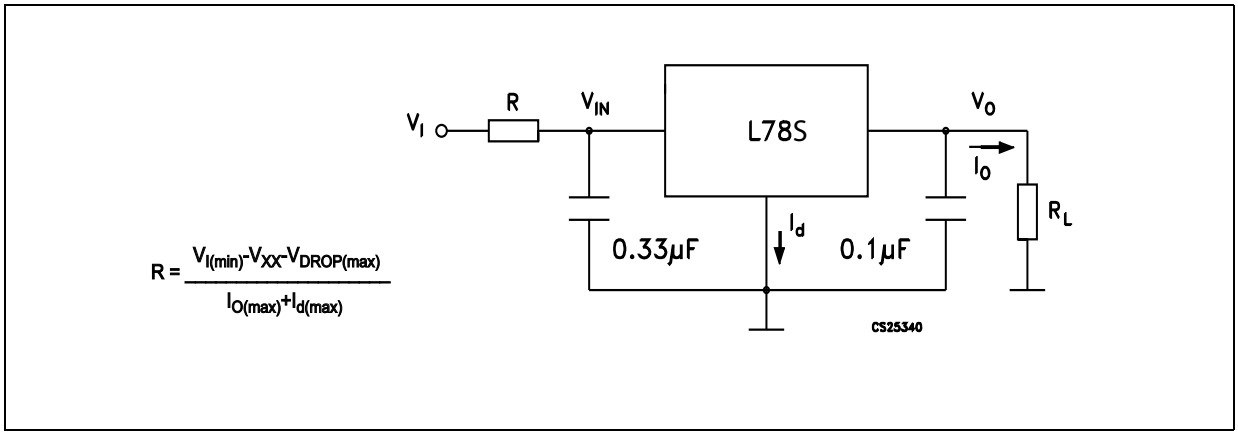


Figure 33. Remote shutdown

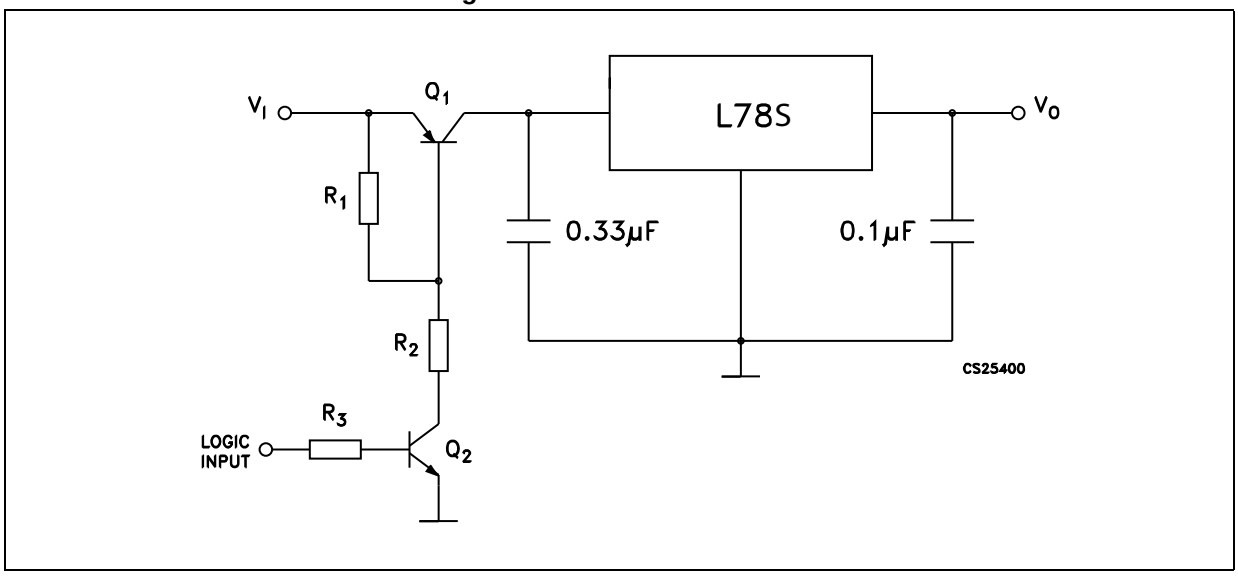
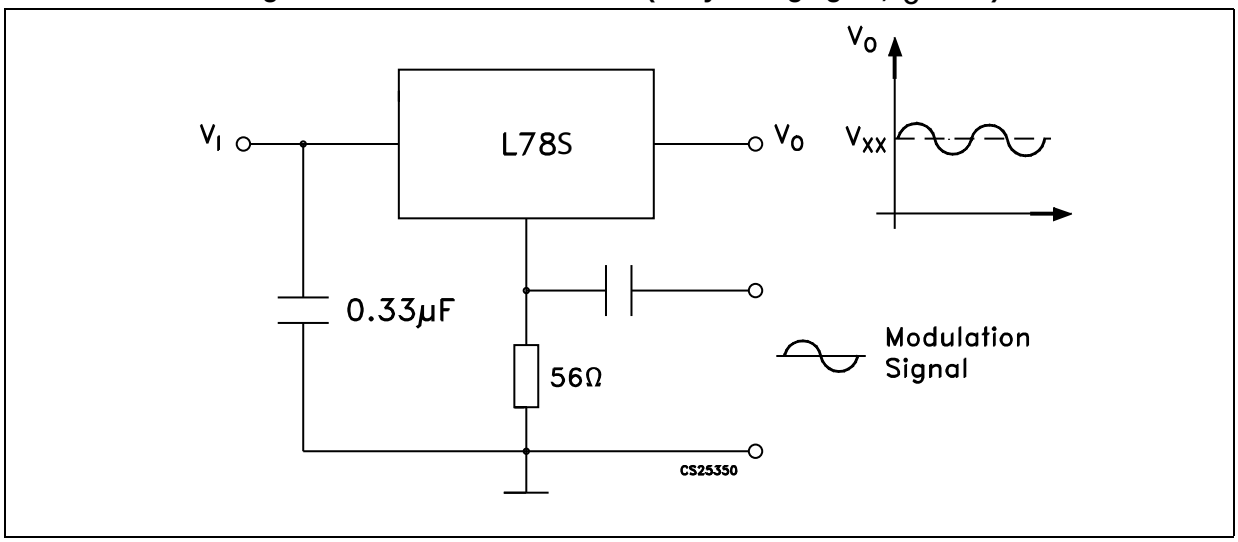
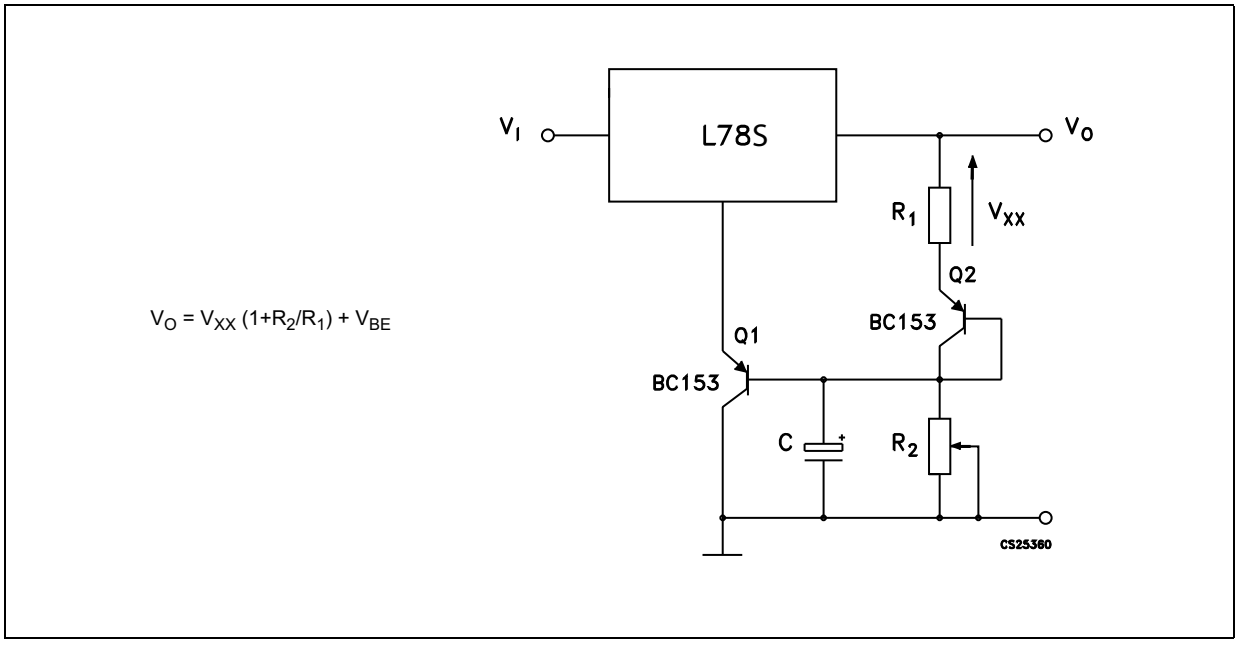


Figure 34. Power AM modulator (unity voltage gain, $I_O \leq 1$ A)



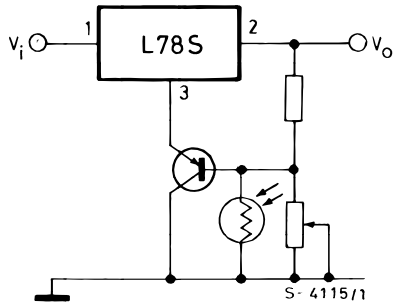
Note: The circuit performs well up to 100 kHz.

Figure 35. Adjustable output voltage with temperature compensation

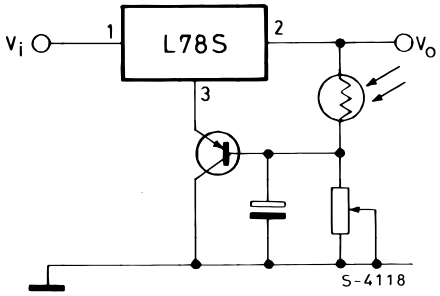


Note: Q_2 is connected as a diode in order to compensate the variation of the Q_1 V_{BE} with the temperature. C allows a slow rise time of the V_O.

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

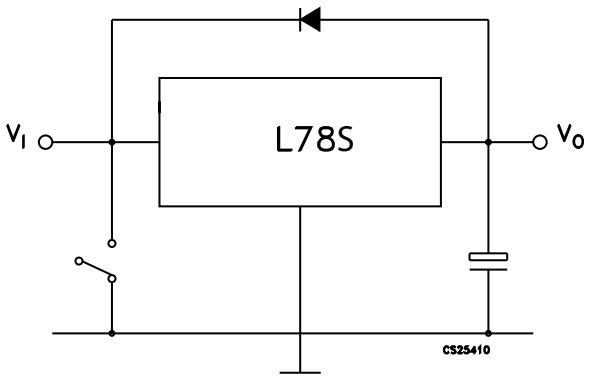


V_O falls when the light goes up



V_O rises when the light goes up

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

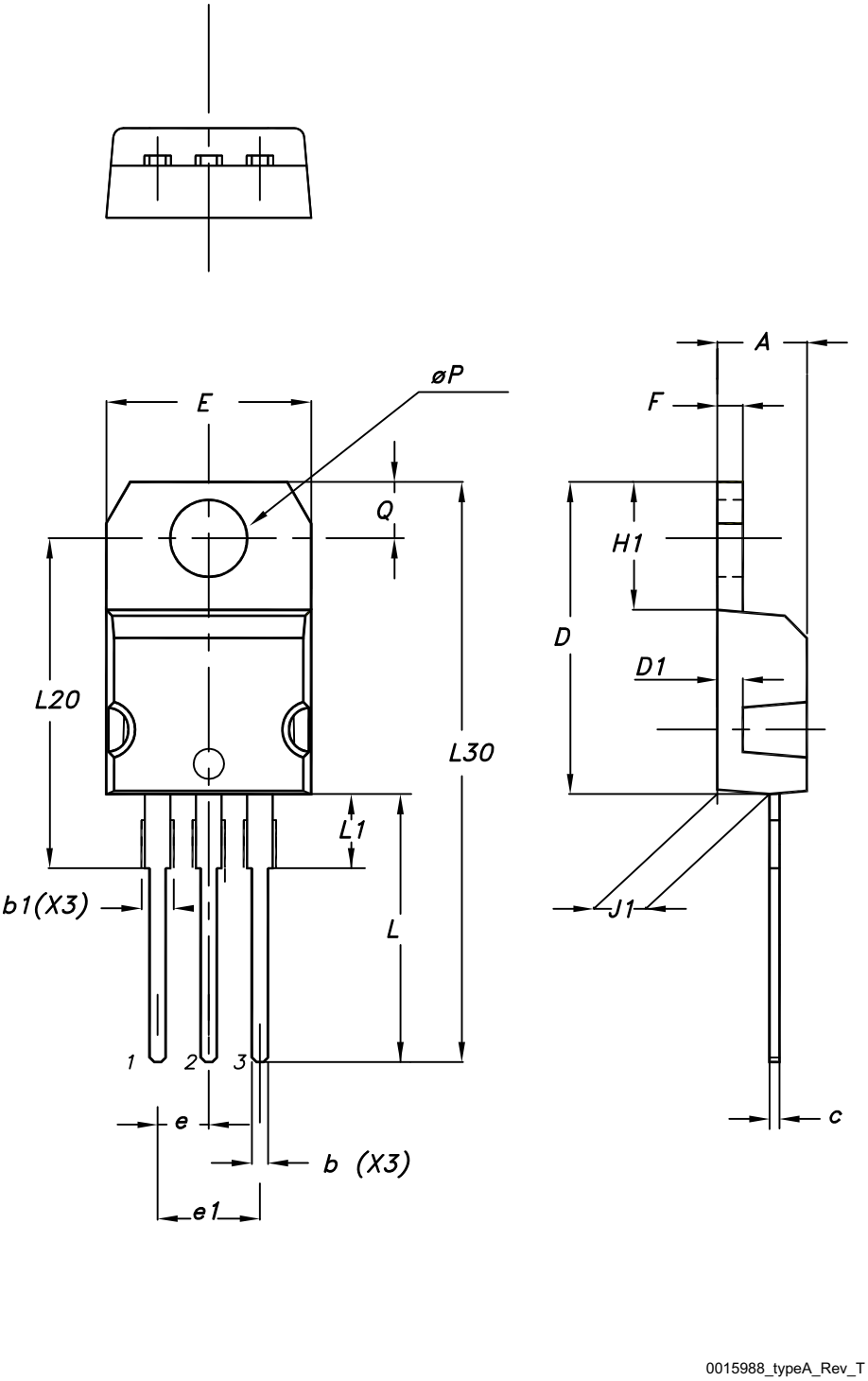


Table 12. TO-220 (dual gauge) mechanical data

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	
∅P	3.75		3.85
Q	2.65		2.95

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

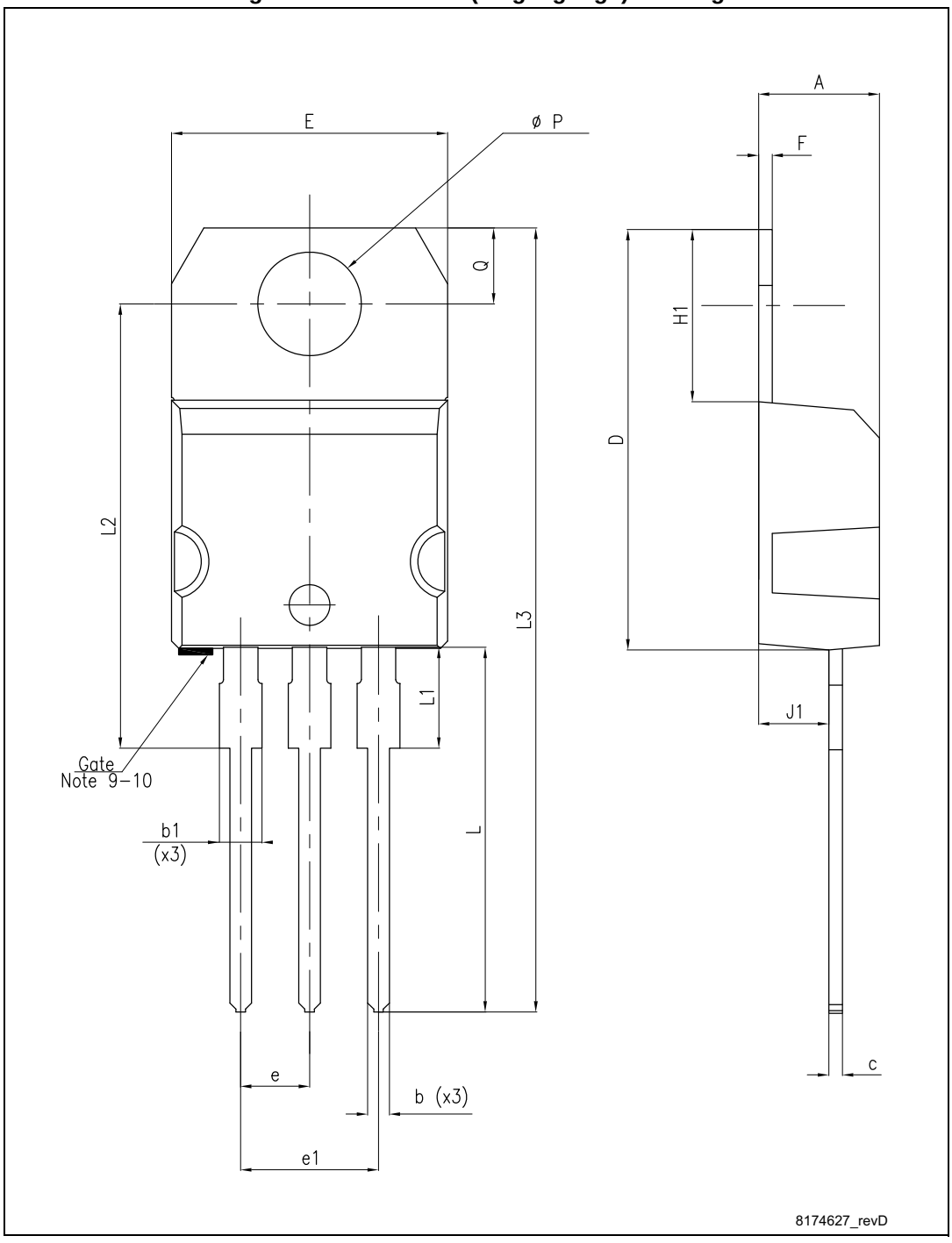


Table 13. TO-220 SG (single gauge) mechanical data

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	
∅P	3.75		3.85
Q	2.65		2.95

8 Packaging mechanical data

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

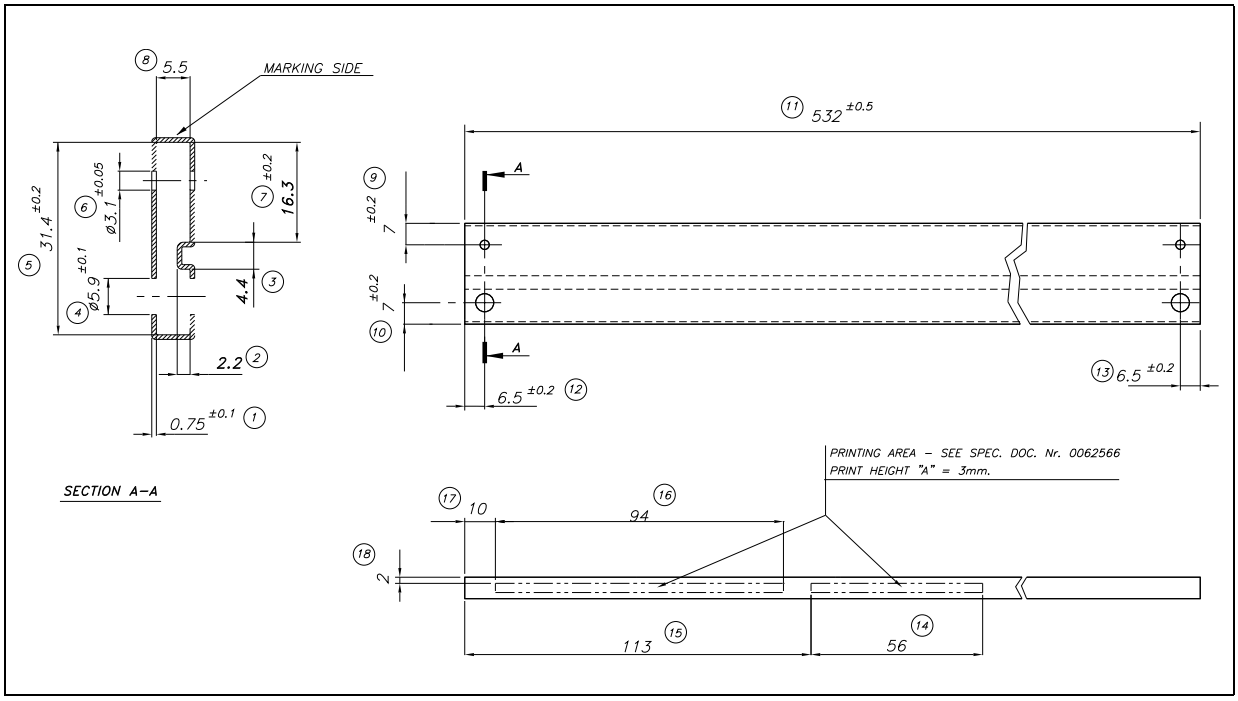
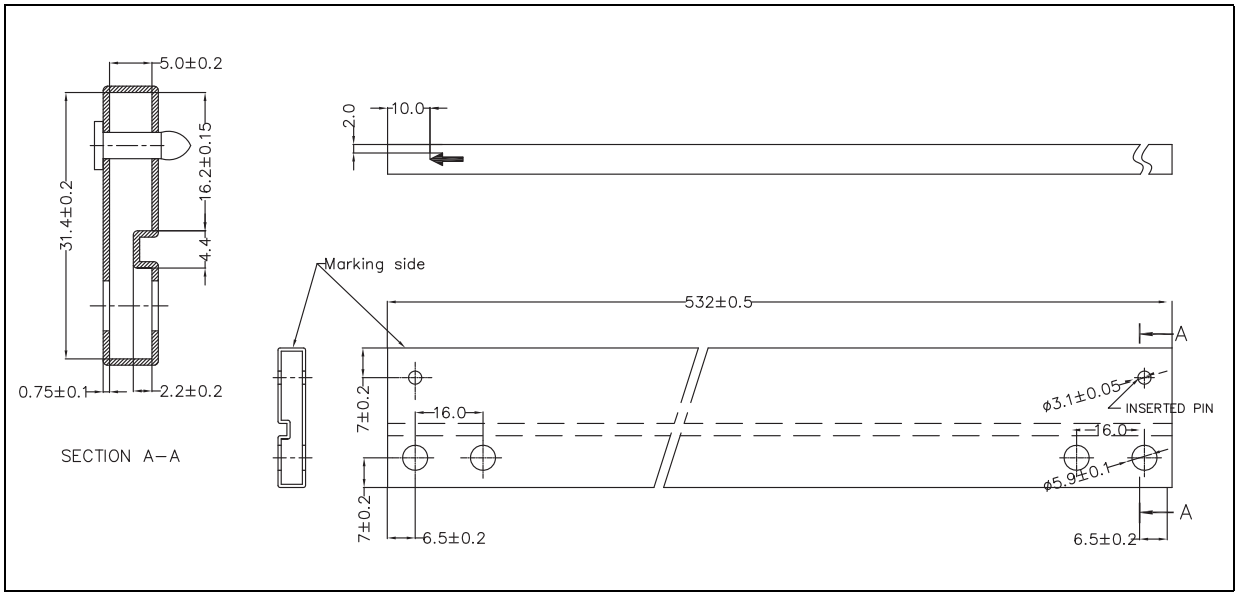


Figure 41. Tube for TO-220 (single gauge) (mm.)



9 Revision history

Table 14. Document revision history

Date	Revision	Changes
07-Sep-2006	2	Order codes updated.
20-Mar-2008	3	Added: *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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