LINEAR INTEGRATED CIRCUITS

SGS **L78S00 Series**

3-TERMINAL POSITIVE VOLTAGE REGULATORS

- OUTPUT CURRENT UP TO 2A
- OUTPUT VOLTAGES OF 5; 7.5; 9; 10; 12; 15; 18; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSISTOR SOA PROTECTION

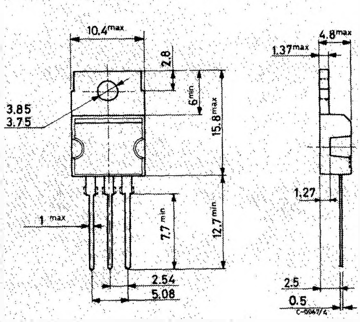
The L78S00 series of three-terminal positive regulators is available in TO-220 and TO-3 packages and with several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single 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 2A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

ABSOLUTE MAXIMUM RATINGS

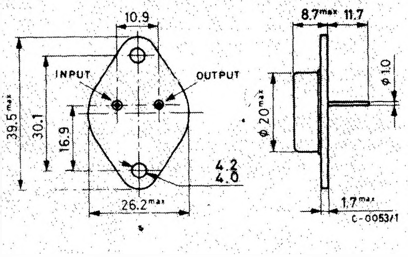
V_i	DC input voltage (for V_o = 5 to 18V)	35	V
	(for V_o = 24V)	40	V
I_o	Output current	internally limited	
P_{tot}	Power dissipation	Internally limited	
T_{stg}	Storage temperature	-65 to +150	°C
T_{op}	Operating junction temperature (for **L78S00**)	-55 to +150	°C
	(for **L78S00C**)	0 to +150	°C

MECHANICAL DATA

Dimensions in mm

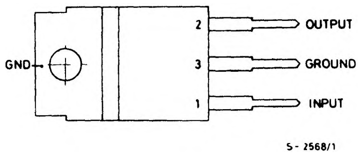


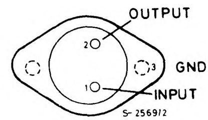
TO-220



TO-3

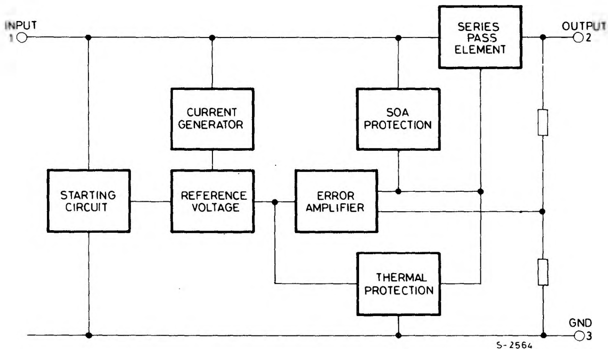
CONNECTION DIAGRAMS AND ORDERING NUMBERS
(top views)



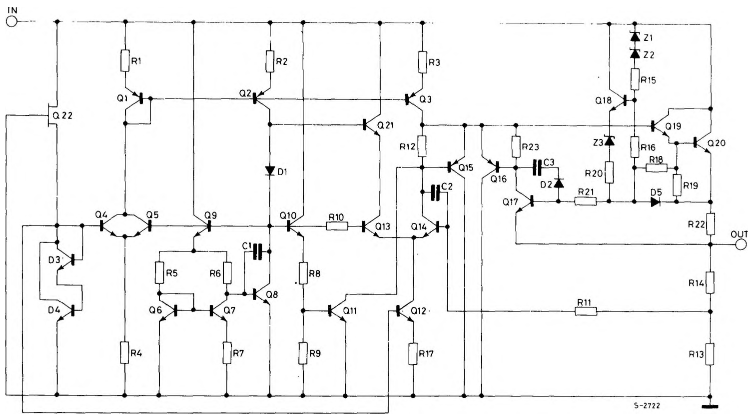


Type	TO-220	TO-3	Output voltage
L 78S05	–	L 78S05T	5V
L 78S05C	L 78S05CV	L 78S05CT	5V
L 78S75	–	L 78S75T	7.5V
L 78S75C	L 78S75CV	L 78S75CT	7.5V
L 78S09	–	L 78S09T	9V
L 78S09C	L 78S09CV	L 78S09CT	9V
L 78S10	–	L 78S10T	10V
L 78S10C	L 78S10CT	L 78S10CT	10V
L 78S12	–	L 78S12T	12V
L 78S12C	L 78S12CV	L 78S12CT	12V
L 78S15	–	L 78S15T	15V
L 78S15C	L 78S15CV	L 78S15CT	15V
L 78S18	–	L 78S18T	18V
L 78S18C	L 78S18CV	L 78S18CT	18V
L 78S24	–	L 78S24T	24V
L 78S24C	L 78S24CV	L 78S24CT	24V

BLOCK DIAGRAM



SCHEMATIC DIAGRAM



TEST CIRCUITS

Fig. 1 - DC parameters

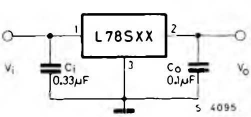


Fig. 2 - Load regulation

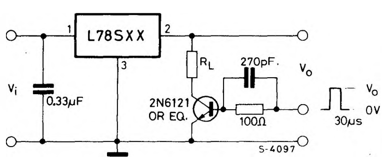
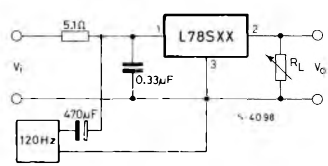


Fig. 3 - Ripple rejection



THERMAL DATA

			TO-220	TO-3
$R_{th\ j\text{-}case}$	Thermal resistance junction-case	max	3 °C/W	4 °C/W
$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	50 °C/W	35 °C/W

ELECTRICAL CHARACTERISTICS L78S00 (Refer to the test circuits, T_j= 25°C, I_o= 500 mA unless otherwise specified)

OUTPUT VOLTAGE			5			7.5			9			10			Unit
INPUT VOLTAGE (Unless otherwise specified)			10			12.5			14			15			
Parameter		Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o	Output voltage		4.8	5	5.2	7.15	7.5	7.9	8.65	9	9.35	9.5	10	10.5	V
		I_o= 1A	4.75	5 (V_i= 7V)	5.25	7.1	7.5 (V_i= 9.5V)	7.95	8.6	9 (V_i= 11V)	9.4	9.4	10 (V_i= 12.5V)	10.6	V
ΔV_o	Line regulation				100 (V_i= 7 to 25V)			120 (V_i= 9.5 to 25V)			130 (V_i= 11 to 25V)			200 (V_i= 12.5 to 30V)	mV
					50 (V_i= 8 to 12V)			60 (V_i= 10.5 to 20V)			65 (V_i= 11 to 20V)			100 (V_i= 14 to 22V)	mV
ΔV_o	Load regulation	I_o= 20 mA to 2A			100			120			130			150	mV
I_d	Quiescent current				8			8			8			8	mA
ΔI_d	Quiescent current change	I_o= 20 mA to 1A			0.5			0.5			0.5			0.5	mA
		I_o= 20 mA			1.3 (V_i= 7 to 25V)			1.3 (V_i= 9.5 to 25V)			1.3 (V_i= 11 to 25V)			1 (V_i= 12.5 to 30V)	mA
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift	I_o= 5 mA, T_j= -55 to 150°C		-1.1			-0.8			-1			-1		mV/°C
e_N	Output noise voltage	B= 10Hz to 100KHz		40			52			60			65		µV
SVR	Supply voltage rejection	f = 120 Hz	60			54			53			53			dB
V_i	Operating input voltage	$I_o \leq$ 1.5A	8			10.5			12			13			V
R_o	Output resistance	f = 1 KHz		17			16			17			17		mΩ
I_{sc}	Short circuit current	V_i = 27V		500			500			500			500		mA
I_{scp}	Short circ. peak current				3.5			3.5			3.5			3.5	A

ELECTRICAL CHARACTERISTICS L78S00 (continued)

OUTPUT VOLTAGE			12			15			18			24			Unit
INPUT VOLTAGE (Unless otherwise specified)			19			23			26			33			
Parameter		Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o	Output voltage		11.5	12	12.5	14.4	15	15.6	17.1	18	18.9	23	24	25	V
		I_o = 1A	11.4	12 (V_i = 14.5V)	12.6	14.25	15 (V_i = 17.5V)	15.75	17	18 (V_i = 20.5V)	19	22.8	24 (V_i = 27V)	25.2	V
ΔV_o	Line regulation				240 (V_i = 14.5 to 30V)			300 (V_i = 17.5 to 30V)			360 (V_i = 20.5 to 30V)			480 (V_i = 27 to 38V)	mV
					120 (V_i = 16 to 22V)			150 (V_i = 20 to 26V)			180 (V_i = 22 to 28V)			240 (V_i = 30 to 36V)	mV
ΔV_o	Load regulation	I_o = 20 mA to 2A			160			180			200			250	mV
I_d	Quiescent current				8			8			8			8	mA
ΔI_d	Quiescent current change	I_o = 20 mA to 1A			0.5			0.5			0.5			0.5	mA
		I_o = 20 mA			1 (V_i = 14.5 to 30V)			1 (V_i = 17.5 to 30V)			1 (V_i = 22 to 33V)			1 (V_i = 28 to 38V)	mA
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift	I_o = 5mA, T_{amb} = 0 to 70°C		-1			-1			-1			-1.5		mV/°C
e_N	Output noise voltage	B = 10Hz to 100KHz		75			90			110			170		µV
SVR	Supply voltage rejection	f = 120 Hz	53			52			49			48			dB
V_i	Operating input voltage	$I_o \leq$ 1.5A	15			18			21			27			V
R_o	Output resistance	f = 1 KHz		18			19			22			23		mΩ
I_{sc}	Short circuit current	V_i = 27V		500			500			500			500		mA
I_{scp}	Short circ. peak current				3.5			3.5			3.5			3.5	A

ELECTRICAL CHARACTERISTICS L78S00C (Refer to the test circuits, $T_j = 25°C$, $I_o = 500mA$ unless otherwise specified)

OUTPUT VOLTAGE			5			7.5			9			10			Unit
INPUT VOLTAGE (Unless otherwise specified)			10			12.5			14			15			
Parameter		Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o	Output voltage		4.8	5	5.2	7.15	7.5	7.9	8.65	9	9.35	9.5	10	10.5	V
		$I_o = 1A$	4.75	5 ($V_i = 7V$)	5.25	7.1	7.5 ($V_i = 9.5V$)	7.95	8.6	9 ($V_i = 11V$)	9.4	9.4	10 ($V_i = 12.5V$)	10.6	V
ΔV_o	Line regulation				100 ($V_i = 7$ to 25V)			120 ($V_i = 9.5$ to 25V)			130 ($V_i = 11$ to 25V)			200 ($V_i = 12.5$ to 30V)	mV
					50 ($V_i = 8$ to 12V)			60 ($V_i = 10.5$ to 20V)			65 ($V_i = 11$ to 20V)			100 ($V_i = 14$ to 22V)	mV
ΔV_o	Load regulation	$I_o = 20$ mA to 2A			100			140			170			240	mV
I_d	Quiescent current				8			8			8			8	mA
ΔI_d	Quiescent current change	$I_o = 20$ mA to 1A			0.5			0.5			0.5			0.5	mA
		$I_o = 20$ mA			1.3 ($V_i = 7$ to 25V)			1.3 ($V_i = 9.5$ to 25V)			1.3 ($V_i = 11$ to 25V)			1.0 ($V_i = 12.5$ to 30V)	mA
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift	$I_o = 5$ mA $T_{amb} = 0$ to 70°C		-1.1			-0.8			-1			-1		mV/°C
e_N	Output noise voltage	B = 10Hz to 100KHz		40			52			60			65		µV
SVR	Supply voltage rejection	f = 120 Hz	54			48			47			47			dB
V_i	Operating input voltage	$I_o \leq 1.5A$	8			10.5			12			13			V
R_o	Output resistance	f = 1 KHz		17			16			17			17		mΩ
I_{sc}	Short circuit current	$V_i = 27V$		500			500			500			500		mA
I_{scp}	Short circ. peak current				3.5			3.5			3.5			3.5	A

ELECTRICAL CHARACTERISTICS L78S00C (continued)

OUTPUT VOLTAGE		12			15			18			24			Unit
INPUT VOLTAGE (Unless otherwise specified)		19			23			26			33			
Parameter	Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o Output voltage		11.5	12	12.5	14.4	15	15.6	17.1	18	18.9	23	24	25	V
	I_o= 1A	11.4	12 (V_i= 14.5V)	12.6	14.25	15 (V_i= 17.5V)	15.75	17	18 (V_i= 20.5V)	19	22.8	24 (V_i= 27V)	25.2	V
ΔV_o Line regulation				240 (V_i= 14.5 to 30V)			300 (V_i= 17.5 to 30V)			360 (V_i= 20.5 to 30V)			480 (V_i= 27 to 38V)	mV
				120 (V_i= 16 to 22V)			150 (V_i= 20 to 26V)			180 (V_i= 22 to 28V)			240 (V_i= 30 to 36V)	mV
ΔV_o Load regulation	I_o= 20 mA to 2A			240			300			360			480	mV
I_d Quiescent current				8			8			8			8	mA
ΔI_d Quiescent current change	I_o= 20 mA to 1A			0.5			0.5			0.5			0.5	mA
	I_o= 20 mA			1.0 (V_i = 14.5 to 30V)			1.0 (V_i = 17.5 to 30V			1.0 (V_i = 20.5 to 30V)			1.0 (V_i = 27 to 38V)	mA
$\frac{\Delta V_o}{\Delta T}$ Output voltage drift	I_o= 5mA T_{amb}= 0 to 70°C		-1			-1			-1			-1.5		mV/°C
e_N Output noise voltage	B= 10Hz to 100KHz		75			90			110			170		µV
SVR Supply voltage rejection	f = 120 Hz	47			46			43			42			dB
V_i Operating input voltage	$I_o \leq$ 1.5A	15			18			21			27			V
R_o Output resistance	f = 1 KHz		18			19			22			28		mΩ
I_{sc} Short circuit current	V_i = 27V		500			500			500			500		mA
I_{scp} Short circ. peak current				3.5			3.5			3.5			3.5	A

Fig. 4 - Dropout voltage vs. junction temperature

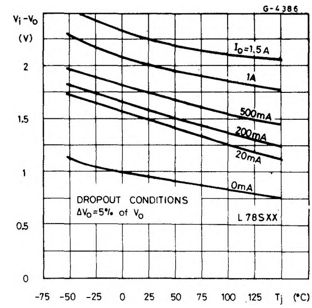


Fig. 5 - Peak output current vs. input/output differential voltage

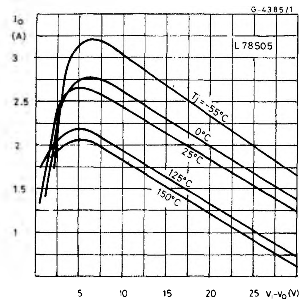


Fig. 6 - Supply voltage rejection vs. frequency

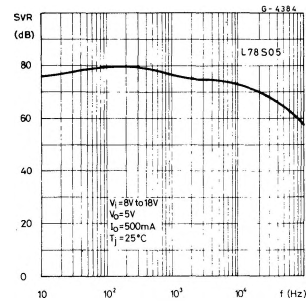


Fig. 7 - Output voltage vs. junction temperature

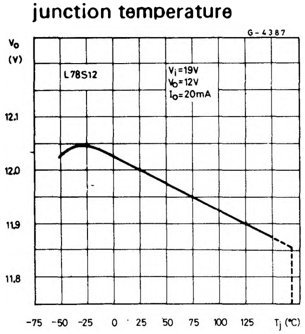


Fig. 8 - Output impedance vs. frequency

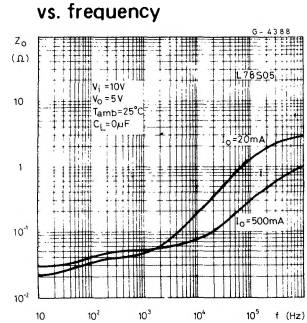


Fig. 9 - Quiescent current vs. junction temperature

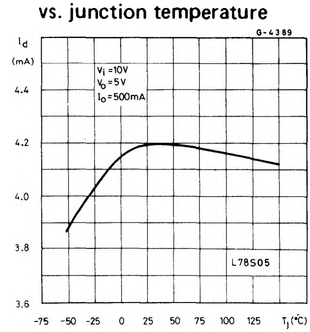


Fig. 10 - Load transient response

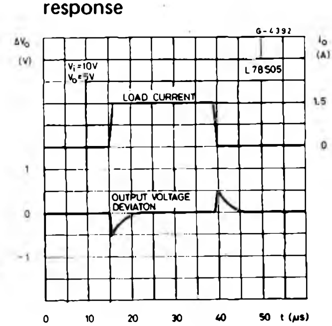


Fig. 11 - Line transient response

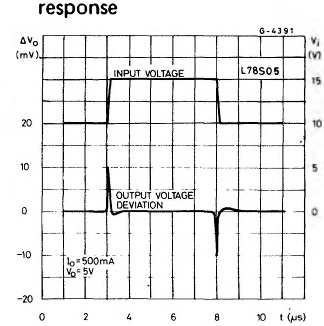
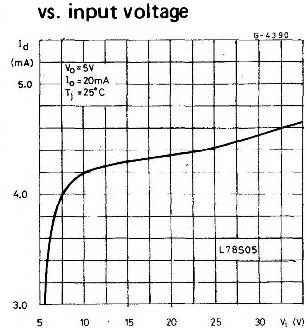
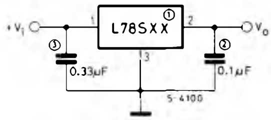


Fig. 12 - Quiescent current vs. input voltage



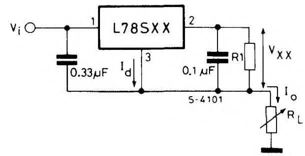
APPLICATION INFORMATION (continued)

Fig. 13 - Fixed output regulator



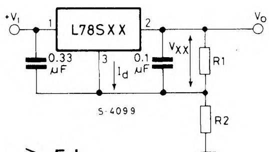
Notes:
(1) To specify an output voltage, substitute voltage value for "XX".
(2) Although no output capacitor is needed for stability, it does improve transient response.
(3) Required if regulator is located an appreciable distance from power supply filter.

Fig. 14 - Costant current regulator



$$I_o = \frac{V_{XX}}{R_1} + I_d$$

Fig. 15 - Circuit for increasing output voltage



$$I_{R_1} \geqslant 5\, I_d$$

$$V_o = V_{XX} \left(1 + \frac{R_2}{R_1}\right) + I_d\, R_2$$

Fig. 16 - Adjustable output regulator (7 to 30V)

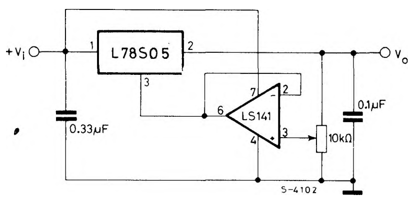
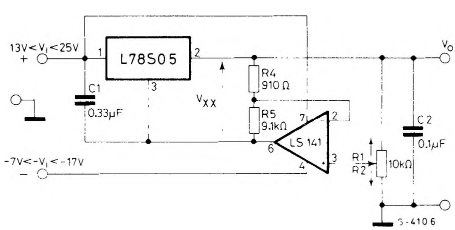
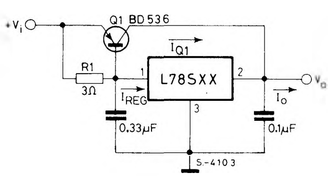


Fig. 17 - 0.5 to 10V regulator



$$V_o = V_{XX} \frac{R_4}{R_1}$$

Fig. 18 - High current voltage regulator

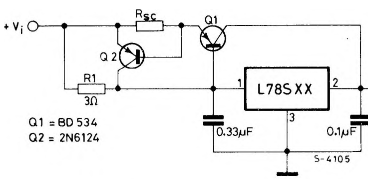


$$R_1 = \frac{V_{BEQ_1}}{I_{REG} - \frac{I_{Q_1}}{\beta_{Q_1}}}$$

$$I_o = I_{REG} + \beta_{Q_1} \left[I_{REG} - \frac{V_{BEQ_1}}{R_1}\right]$$

APPLICATION INFORMATION (continued)

Fig. 19 - High output current with short circuit protection



$$R_{SC} = \frac{V_{BEQ_2}}{I_{SC}}$$

Fig. 20 - Tracking voltage regulator

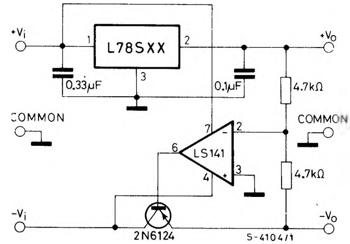
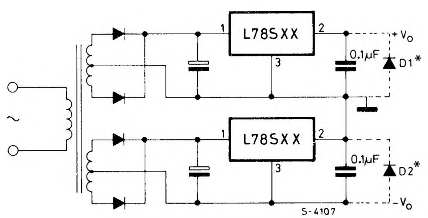


Fig. 21 - Positive and negative regulator



(*) D_1 and D_2 are necessary if the load is connected between + V_o and – V_o

Fig. 22 - Negative output voltage circuit

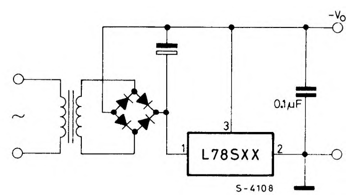


Fig. 23 - Switching regulator

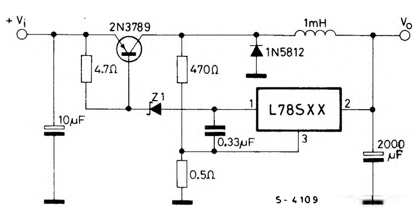
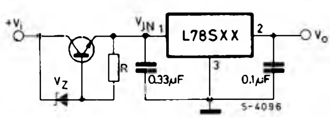


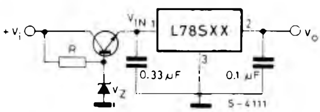
Fig. 24 - High input voltage circuit



$$V_{IN} = V_i - (V_Z + V_{BE})$$

APPLICATION INFORMATION (continued)

Fig. 25 - High input voltage circuit



$V_{IN} = V_Z - V_{BE}$

Fig. 26 - High output voltage regulator

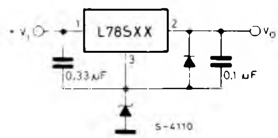
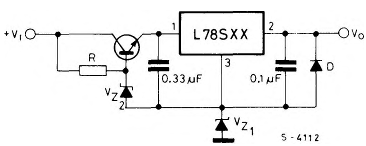
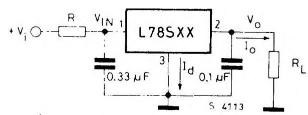


Fig. 27 - High input and output voltage



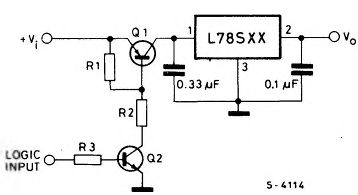
$V_O = V_{XX} + V_{Z1}$

Fig. 28 - Reducing power dissipation with dropping resistor



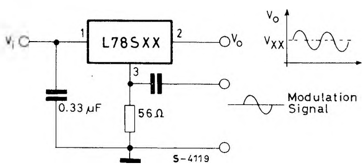
$$R = \frac{V_{i(min)} - V_{XX} - V_{DROP(max)}}{I_{o(max)} + I_{d(max)}}$$

Fig. 29 - ·Remote shuntdown



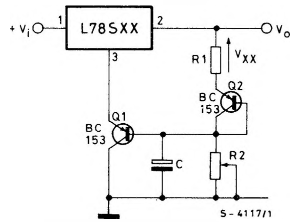
APPLICATION INFORMATION (continued)

Fig. 30 - Power AM modulator oscillator (unity voltage gain, $I_o \leqslant 1.5A$)



Note: The circuit performs well up to 100 KHz.

Fig. 31 - Adjustable output voltage with temperature compensation

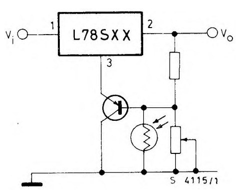


Note: Q_2 is connected as a diode in order to compensate the variation of the Q_1 V_{BE} with the temperature. C allows a slow rise-time of the V_o

$$V_o = V_{XX} \left(1 + \frac{R_2}{R_1}\right) + V_{BE}$$

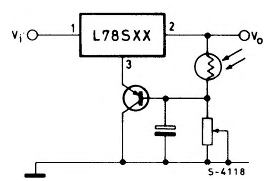
Fig. 32 - Light controllers ($V_{o\ min} = V_{XX} + V_{BE}$)

(a)



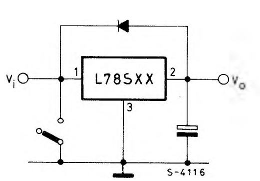
V_o falls when the light goes up

(b)



V_o rises when the light goes up

Fig. 33 - Protection against input short-circuit with high capacitance loads



Applications with high capacitance loads and an output voltage greater than 6 volts need an external diode (see fig. 33) to protect the device against input short circuit. In this case the input voltage falls rapidly while the output voltage decreases showly. 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.