L7800 Series

POSITIVE VOLTAGE REGULATORS

- OUTPUT CURRENT UP TO 1.5A
- OUTPUT VOLTAGES OF 5; 6; 8; 12; 15; 18; 20; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSISTOR SOA PROTECTION

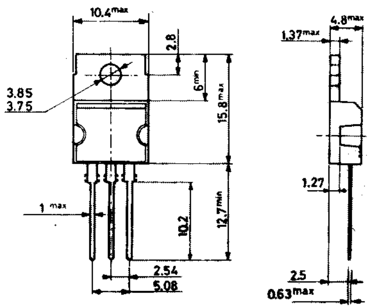
The L7800 series of three-terminal positive regulators is available in TO-220 and TO-3 packages and with several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single 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 1A 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

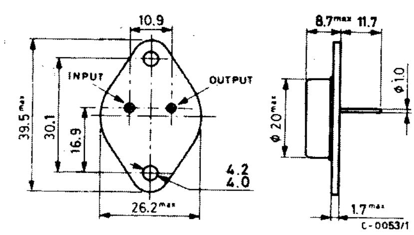
V_i	DC input voltage (for V_o = 5 to 18V)	35	V
	(for V_o = 20, 24V)	40	V
I_o	Output current	internally limited	
P_{tot}	Power dissipation	internally limited	
T_{op}	Operating junction temperature (for **L7800**)	-55 to +150	°C
	(for **L7800C**)	0 to +150	°C
T_{stg}	Storage temperature	-65 to +150	°C

MECHANICAL DATA

Dimensions in mm

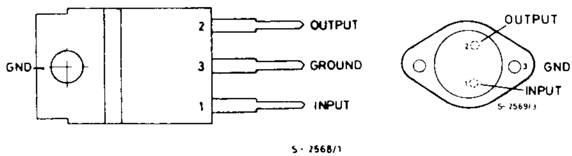


TO-220



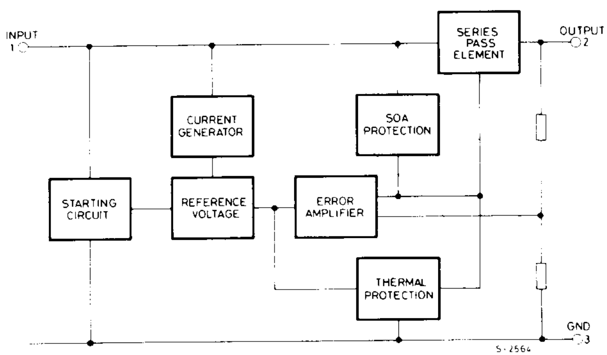
TO-3

CONNECTION DIAGRAMS AND ORDERING NUMBERS
(top views)

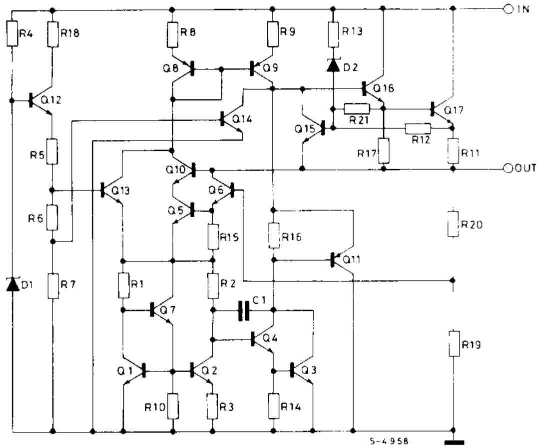


Type	TO-220	TO-3	Output voltage
L 7805	–	L 7805T	5V
L 7805C	L 7805CV	L 7805 CT	5V
L 7806	–	L 7806T	6V
L 7806C	L 7806 CV	L 7806CT	6V
L 7808	–	L 7808T	8V
L 7808C	L 7808 CV	L 7808CT	8V
L 7812	–	L 7812T	12V
L 7812C	L 7812CV	L 7812CT	12V
L 7815	–	L 7815T	15V
L 7815C	L 7815CV	L 7815CT	15V
L 7818	–	L 7818T	18V
L 7818C	L 7818CV	L 7818CT	18V
L 7820	–	L 7820T	20V
L 7820C	L 7820CV	L 7820CT	20V
L 7824	–	L 7824T	24V
L 7824C	L 7824CV	L 7824CT	24V

BLOCK DIAGRAM



SCHEMATIC DIAGRAM



TEST CIRCUITS

Fig. 1 - DC parameters

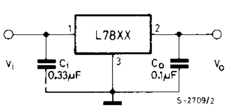


Fig. 2 - Load regulation

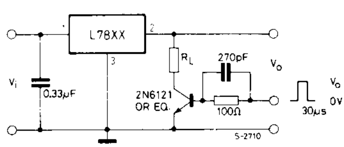
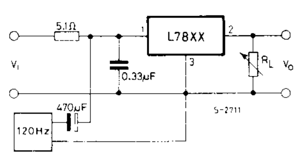


Fig. 3 - Ripple rejection



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 L 7800 (Refer to the test circuits, T_j= -55 to 150°C, I_o = 500 mA, C_i = 0.33 μF, C_o= 0.1 μF unless otherwise specified)

OUTPUT VOLTAGE			5			6			8			12			Unit
INPUT VOLTAGE (Unless otherwise specified)			10			11			14			19			
Parameter		Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o	Output voltage	T_j= 25°C	4.8	5	5.2	5.75	6	6.25	7.7	8	8.3	11.5	12	12.5	V
		I_o= 5 mA to 1A, $P_o \leq$ 15W	4.65	5 (V_i= 8 to 20V)	5.35	5.65	6 (V_i= 9 to 21V)	6.35	7.6	8 (V_i= 11.5 to 23V)	8.4	11.4	12 (V_i= 15.5 to 27V)	12.6	V
ΔV_o	Line regulation	T_j= 25°C		(V_i= 7 to 25V)	50		(V_i= 8 to 25V)	60		(V_i= 10.5 to 25V)	80		(V_i= 14.5 to 30V)	120	mV
				(V_i= 8 to 12V)	25		(V_i= 9 to 13V)	30		(V_i= 11 to 17V)	40		(V_i= 16 to 22V)	60	mV
ΔV_o	Load regulation	T_j= 25°C, I_o= 5 mA to 1.5A			100			100			100			120	mV
		T_j= 25°C, I_o= 250 to 750 mA			25			30			40			60	mV
I_d	Quiescent current	T_j= 25°C			6			6			6			6	mA
ΔI_d	Quiescent current change	I_o= 5 mA to 1A			0.5			0.5			0.5			0.5	mA
				(V_i= 8 to 25V)	0.8		(V_i= 9 to 25V)	0.8		(V_i= 11.5 to 25V)	0.8		(V_i= 15 to 30V)	0.8	mA
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift	I_o= 5 mA		0.6			0.7			1			1.5		mV/°C
e_N	output noise voltage	B= 10Hz to 100KHz, T_j= 25°C			40			40			40			40	$\mu V / V_o$
SVR	Supply voltage rejection	f = 120 Hz	68	(V_i= 8 to 18V)		65	(V_i= 9 to 19V)		62	(V_i= 11.5 to 21.5V)		61	(V_i= 15 to 25V)		dB
V_d	Dropout voltage	I_o= 1A, T_j= 25°C		2	2.5		2	2.5		2	2.5		2	2.5	V
R_o	Output resistance	f = 1 KHz		17			19			16			18		mΩ
I_{sc}	Short circuit current	V_i= 35V, T_j= 25°C		0.75	1.2		0.75	1.2		0.75	1.2		0.75	1.2	A
I_{scp}	Short circ. peak current	T_j= 25°C	1.3	2.2	3.3	1.3	2.2	3.3	1.3	2.2	3.3	1.3	2.2	3.3	A

ELECTRICAL CHARACTERISTICS L 7800 (continued)

OUTPUT VOLTAGE		15			18			20			24			Unit
INPUT VOLTAGE (Unless otherwise specified)		23			26			28			33			
Parameter	**Test conditions**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	
V_o Output voltage	T_j = 25°C	14.4	15	15.6	17.3	18	18.7	19.2	20	20.8	23	24	25	V
	I_o = 5 mA to 1A, $P_o \leqslant$ 15W	14.25	15	15.75	17.1	18	18.9	19	20	21	22.8	24	25.2	V
			(V_i = 18.5 to 30V)			(V_i = 22 to 33V)			(V_i = 24 to 35V)			(V_i = 28 to 38V)		
ΔV_o Line regulation	T_j = 25°C			150 (V_i = 17.5 to 30V)			180 (V_i = 21 to 33V)			200 (V_i = 22.5 to 35V)			240 (V_i = 27 to 38V)	mV
				75 (V_j = 20 to 26V)			90 (V_i = 24 to 30V)			100 (V_i = 26 to 32V)			120 (V_i = 30 to 36V)	mV
ΔV_o Load regulation	T_j = 25°C, I_o = 5 mA to 1.5A			150			180			200			240	mV
	T_j = 25°C, I_o = 250 to 750 mA			75			90			100			120	mV
I_d Quiescent current	T_j = 25°C			6			6			6			6	mA
ΔI_d Quiescent current change	I_o = 5 mA to 1A			0.5			0.5			0.5			0.5	mA
				0.8 (V_i = 18.5 to 30V)			0.8 (V_i = 22 to 33V)			0.8 (V_i = 24 to 35V)			0.8 (V_i = 28 to 38V)	mA
$\frac{\Delta V_o}{\Delta T}$ Output voltage drift	I_o = 5 mA		1.8			2.3			2.5			3		mV/°C
e_N output noise voltage	B = 10Hz to 100KHz, T_j = 25°C		40			40			40			40		$\frac{\mu V}{V_o}$
SVR Supply voltage rejection	f = 120 Hz	60 (V_i = 18.5 to 28.5V)			59 (V_i = 22 to 32V)			58 (V_i = 24 to 35V)			56 (V_i = 28 to 38V)			dB
V_d Dropout voltage	I_o = 1A, T_j = 25°C		2	2.5		2	2.5		2	2.5		2	2.5	V
R_o Output resistance	f = 1 KHz		19			22			24			28		mΩ
I_{sc} Short circuit current	V_i = 35V, T_j = 25°C		0.75	1.2		0.75	1.2		0.75	1.2		0.75	1.2	A
I_{scp} Short circ. peak current	T_j = 25°C	1.3	2.2	3.3	1.3	2.2	3.3	1.3	2.2	3.3	1.3	2.2	3.3	A

ELECTRICAL CHARACTERISTICS L 7800C (Refer to the test circuits, T_j = 0 to 125°C, I_o = 500 mA, C_i = 0.33 μF, C_o = 0.1 μF unless otherwise specified)

OUTPUT VOLTAGE		5			6			8			12			Unit
INPUT VOLTAGE (Unless otherwise specified)		10			11			14			19			
Parameter	Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o Output voltage	T_j = 25°C	4.8	5	5.2	5.75	6	6.25	7.7	8	8.3	11.5	12	12.5	V
	I_o = 5 mA to 1A $P_o \leq$ 15W	4.75	5 (V_i = 7 to 20V)	5.25	5.7	6 (V_i = 8 to 21V)	6.3	7.6	8 (V_i = 10.5 to 25V)	8.4	11.4	12 (V_i = 14.5 to 27V)	12.6	V
ΔV_o Line regulation	T_j = 25°C		3 (V_i = 7 to 25V)	100		(V_i = 8 to 25V)	120		(V_i = 10.5 to 25V)	160		(V_i = 14.5 to 30V)	240	mV
	T_j = 25°C		1 (V_i = 8 to 12V)	50		(V_i = 9 to 13V)	60		(V_i = 11 to 17V)	80		(V_i = 16 to 22V)	120	mV
ΔV_o Load regulation	T_j = 25°C I_o = 5 mA to 1.5A			100			120			160			240	mV
	T_j = 25°C I_o = 250 to 750 mA			50			60			80			120	mV
I_d Quiescent current	T_j = 25°C			8			8			8			8	mA
ΔI_d Quiescent current change	I_o = 5 mA to 1A			0.5			0.5			0.5			0.5	mA
			(V_i = 7 to 25V)	1.3		(V_i = 8 to 25V)	1.3		(V_i = 10.5 to 25V)	1		(V_i = 14.5 to 30V)	1	mA
$\frac{\Delta V_o}{\Delta T}$ Output voltage drift	I_o = 5 mA		-1.1			-0.8			-0.8			-1		mV/°C
e_N Output noise voltage	B = 10Hz to 100KHz T_j = 25°C		40			45			52			75		μV
SVR Supply voltage rejection	f = 120 Hz	62	(V_i = 8 to 18V)		59	(V_i = 9 to 19V)		56	(V_i = 11.5 to 21.5V)		55	(V_i = 15 to 25V)		dB
V_d Dropout voltage	I_o = 1A		2			2			2			2		V
R_o Output resistance	f = 1 KHz		17			19			16			18		mΩ
I_{sc} Short circuit current	V_i = 35V T_j = 25°C		750			550			450			350		mA
I_{scp} Short circ. peak current	T_j = 25°C		2.2			2.2			2.2			2.2		A

ELECTRICAL CHARACTERISTICS L 7800C (continued)

OUTPUT VOLTAGE			15			18			20			24			Unit
INPUT VOLTAGE (Unless otherwise specified)			23			26			28			33			
Parameter		Test conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_o	Output voltage	T_j= 25°C	14.4	15	15.6	17.3	18	18.7	19.2	20	20.8	23	24	25	V
		I_o= 5 mA to 1A P_o ≤ 15W	14.25	15 (V_i= 17.5 to 30V)	15.75	17.1	18 (V_i= 21 to 33V)	18.9	19	20 (V_i= 23 to 35V)	21	22.8	24 (V_i= 27 to 38V)	25.2	V
ΔV_o	Line regulation	T_j= 25°C			300 (V_i= 17.5 to 30V)			360 (V_i= 21 to 33V)			400 (V_i= 22.5 to 35V)			480 (V_i= 27 to 38V)	mV
					150 (V_i= 20 to 26V)			180 (V_i= 24 to 30V)			200 (V_i= 26 to 32V)			240 (V_i= 30 to 36V)	mV
ΔV_o	Load regulation	T_j= 25°C I_o= 5 mA to 1.5A			300			360			400			480	mV
		T_j= 25°C I_o= 250 to 750 mA			150			180			200			240	mV
I_d	Quiescent current	T_j= 25°C			8			8			8			8	mA
ΔI_d	Quiescent current change	I_o= 5 mA to 1A			0.5			0.5			0.5			0.5	mA
					1 (V_i= 17.5 to 30V)			1 (V_i= 21 to 33V)			1 (V_i= 23 to 35V)			1 (V_i= 27 to 38V)	mA
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift	I_o= 5 mA		-1			-1			-1			-1.5		mV/°C
e_N	Output noise voltage	B= 10Hz to 100KHz T_j= 25°C		90			110			150			170		µV
SVR	Supply voltage rejection	f = 120 Hz	54			53			52			50			dB
V_d	Dropout voltage	I_o= 1A		2			2			2			2		V
R_o	Output resistance	f = 1 KHz		19			22			24			28		mΩ
I_{sc}	Short circuit current	V_i= 35V T_j = 25°C		230			200			180			150		mA
I_{scp}	Short circ. peak current	T_j = 25°C		2.1			2.1			2.1			2.1		A

Fig. 4 - Dropout voltage vs. junction temperature

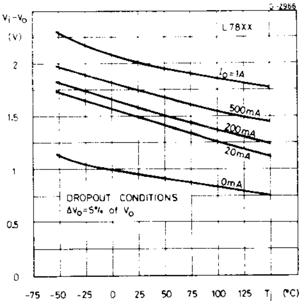


Fig. 5 - Peak output current vs. input/output differential voltage

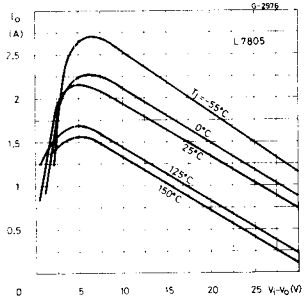


Fig. 6 - Supply voltage rejection vs. frequency

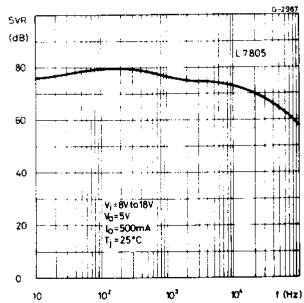


Fig. 7 - Output voltage vs. junction temperature

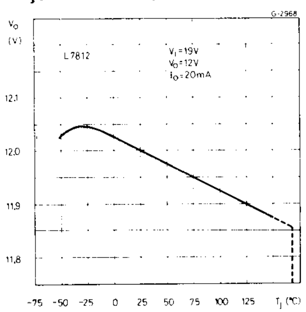


Fig. 8 - Output impedance vs. frequency

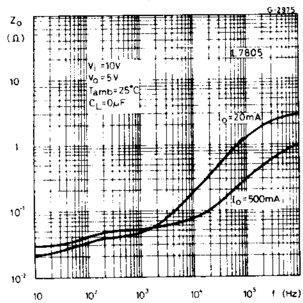


Fig. 9 - Quiescent current vs. junction temperature

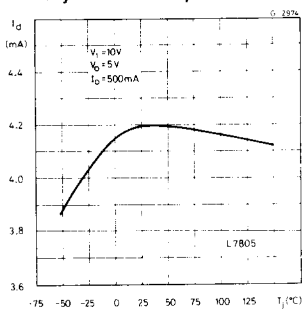


Fig. 10 - Load transient response

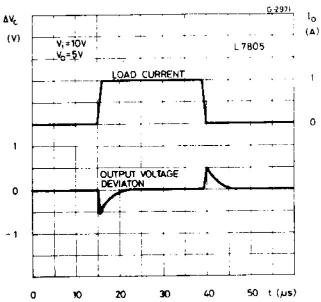


Fig. 11 - Line transient response

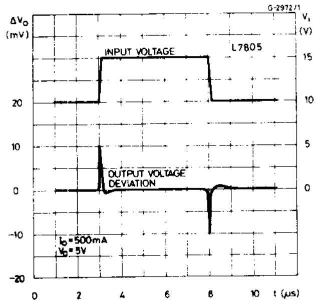
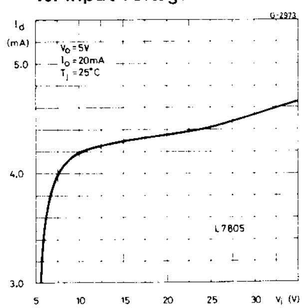
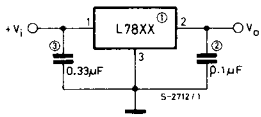


Fig. 12 - Quiescent current vs. input voltage



APPLICATION INFORMATION (continued)

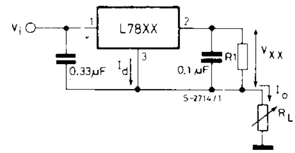
Fig. 13 - Fixed output regulator



Notes:

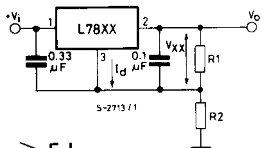
(1) To specify an output voltage, substitute voltage value for "XX".
(2) Although no output capacitor is needed for stability, it does improve transient response.
(3) Reouired if regulator is located an appreciable distance from power supply filter.

Fig. 14 - Current regulator



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

Fig. 15 - Circuit for increasing output voltage



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

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

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

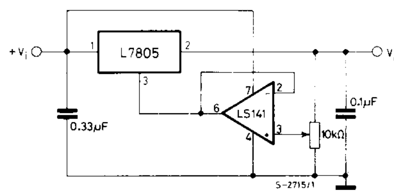
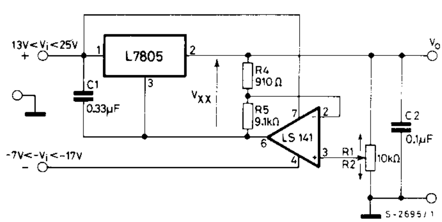
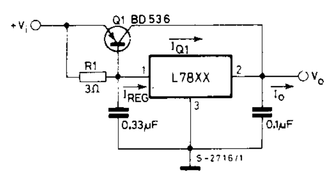


Fig. 17 - 0.5 to 10V regulator



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

Fig. 18 - Hiqh current voltage regulator

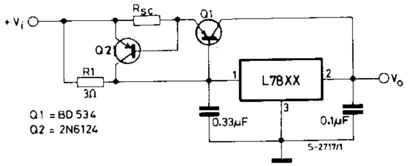


$$R_1 = \frac{V_{BEQ_1}}{I_{REG} - \frac{I_{Q_1}}{\beta_{Q_1}}}$$

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

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

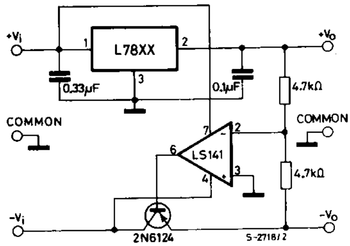
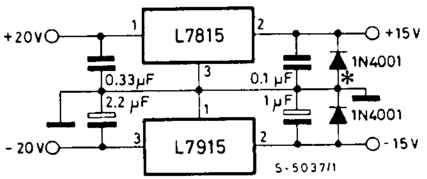


Fig. 21 - Split power supply (±15V - 1A)



* Against potential latch-up problems

Fig. 22 - Negative output voltage circuit

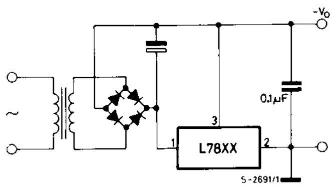


Fig. 23 - Switching regulator

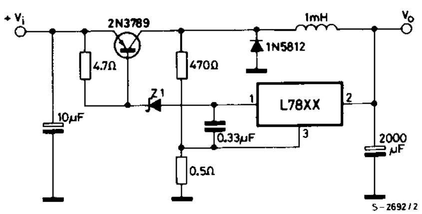
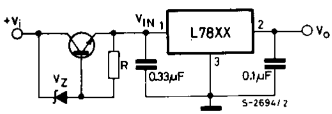


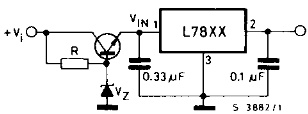
Fig. 24 - High input voltage circuit



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

APPLICATION INFORMATION (continued)

Fig. 25 - High input voltage circuit



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

Fig. 26 - High output voltage regulator

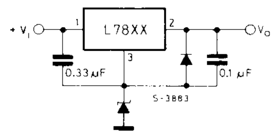
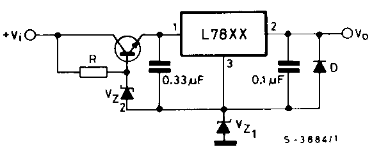
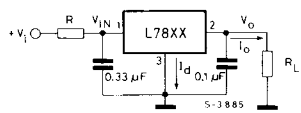


Fig. 27 - High input and output voltage



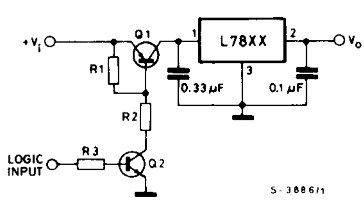
$$V_O = V_{XX} + V_{Z1}$$

Fig. 28 - Reducing power dissipation with dropping resistor



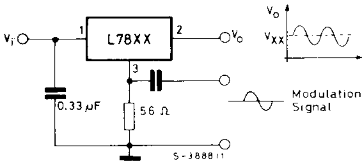
$$R = \frac{V_{i(min)} - V_{XX} - V_{DROP(max)}}{I_{o(max)} + I_{d(max)}}$$

Fig. 29 - Remote shuntdown



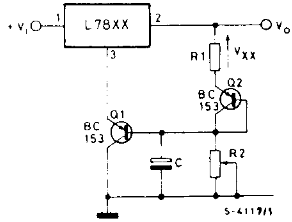
APPLICATION INFORMATION (continued)

Fig. 30 - Power AM modulator (unity voltage gain, $I_o \leq 1A$)



Note: The circuit performs well up to 100 KHz.

Fig. 31 - Adjustable output voltage with temperature compensation

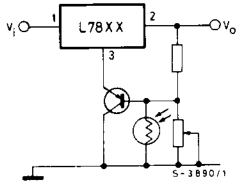


Note: Q_2 is connected as a diode in order to compensate the variation of the Q_1 V_{BE} with the temperature. C allows a slow rise-time of the V_o

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

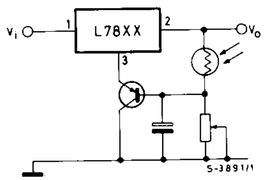
Fig. 32 - Light controllers ($V_{o\,min} = V_{XX} + V_{BE}$)

(a)



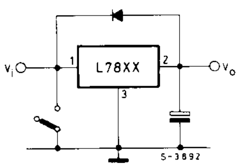
V_o falls when the light goes up

(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.