Integrated Voltage Regulators

- flexible voltage regulator, adjustable voltage, more than 3 terminals
- three-terminal regulators: - fixed regulator
  - adjustable regulator
- …….

Data sheet features:

- v_I range
- V_O range
- I_{omax}
- P_{dmax}
- performance parameters

Performance parameters

- line regulation:

$$\left(\frac{\Delta V_O}{V_O} \Big/ \frac{\Delta V_I}{V_I} \right) \cdot 100\,[\%] \quad @\ I_O$$

$$\%\ V_O \text{ for } \Delta V_I\ @ V_O\ ,\ I_O$$

$$\Delta V_O \text{ for } \Delta V_I\ @ V_O, I_O$$

- load regulation:

$$\left(\frac{\Delta V_O}{V_O} \Big/ \frac{\Delta I_O}{I_O} \right) \cdot 100\,[\%] \quad @\ V_I$$

$$\%\ V_O \text{ for } \Delta I_O\ @ V_O\ ,\ V_I$$

$$\Delta V_O \text{ for } \Delta I_O\ @ V_O, V_I$$

- thermal regulation:

The 723 integrated voltage regulator

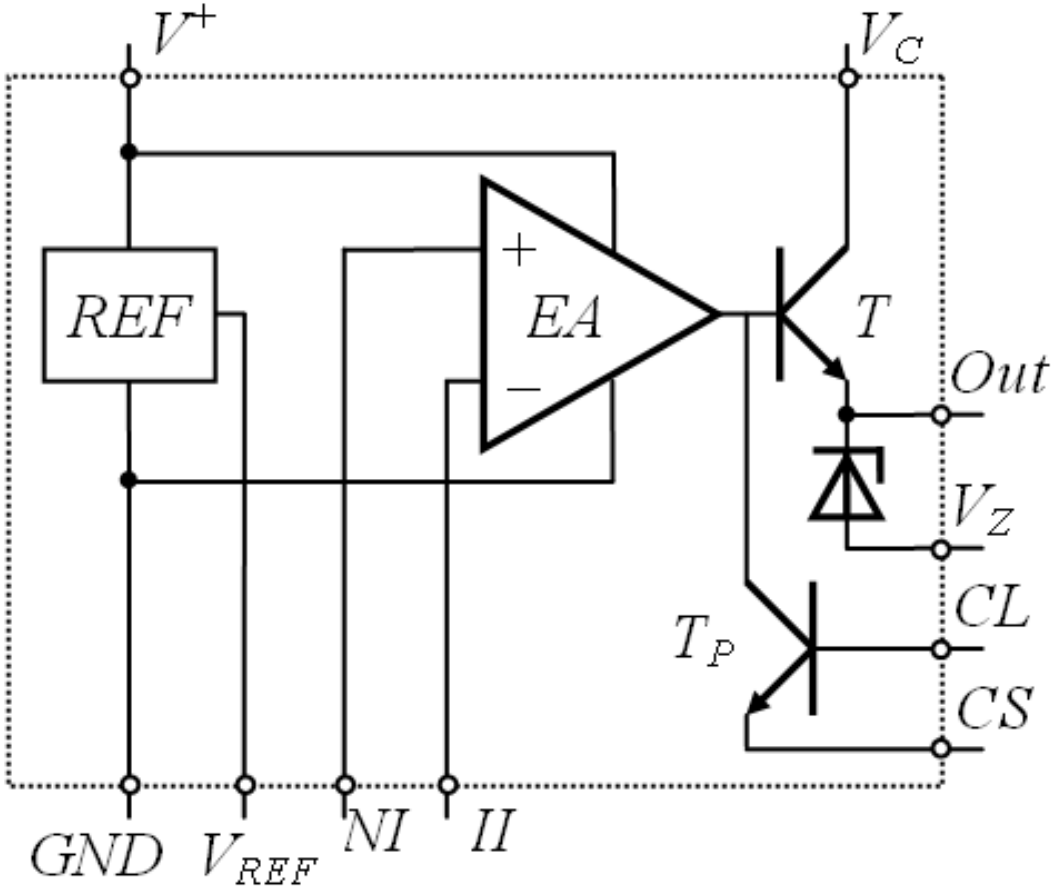
LM723/LM723C National Semiconductor Data Sheet

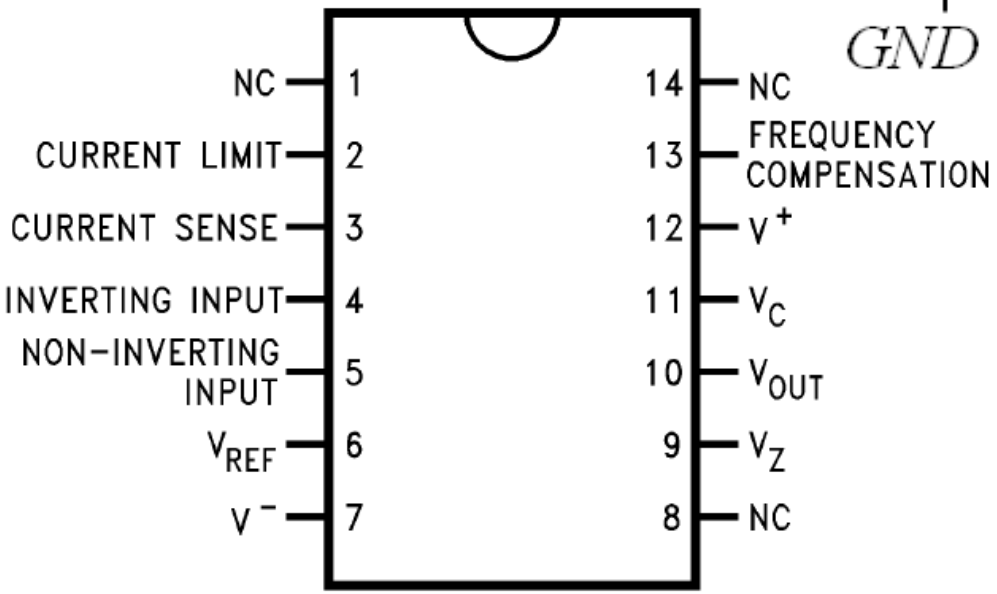
Features:

- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	V_{IN} = 12V to V_{IN} = 15V		0.01	0.1		0.01	0.1	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.3				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.3	% V_{OUT}
	V_{IN} = 12V to V_{IN} = 40V		0.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	I_L = 1 mA to I_L = 50 mA		0.03	0.15		0.03	0.2	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.6				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.6	% V_{OUT}
Average Temperature Coefficient of Output Voltage (Note 8)	−55°C ≤ T_A ≤ +125°C		0.002	0.015				%/°C
	0°C ≤ T_A ≤ +70°C					0.003	0.015	%/°C
Short Circuit Current Limit	R_{SC} = 10Ω, V_{OUT} = 0		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V

Block diagram





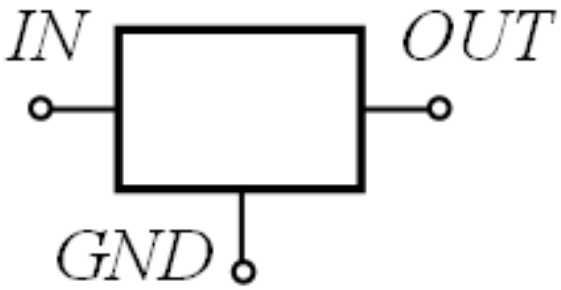
Build a voltage regulator:

$V_O \in (3;12)\text{V}$

$I_{O\max} = 50\text{mA}$

$I_{O\max 1} = 500\text{mA}$ external transistor

Three-terminal fixed voltage regulator



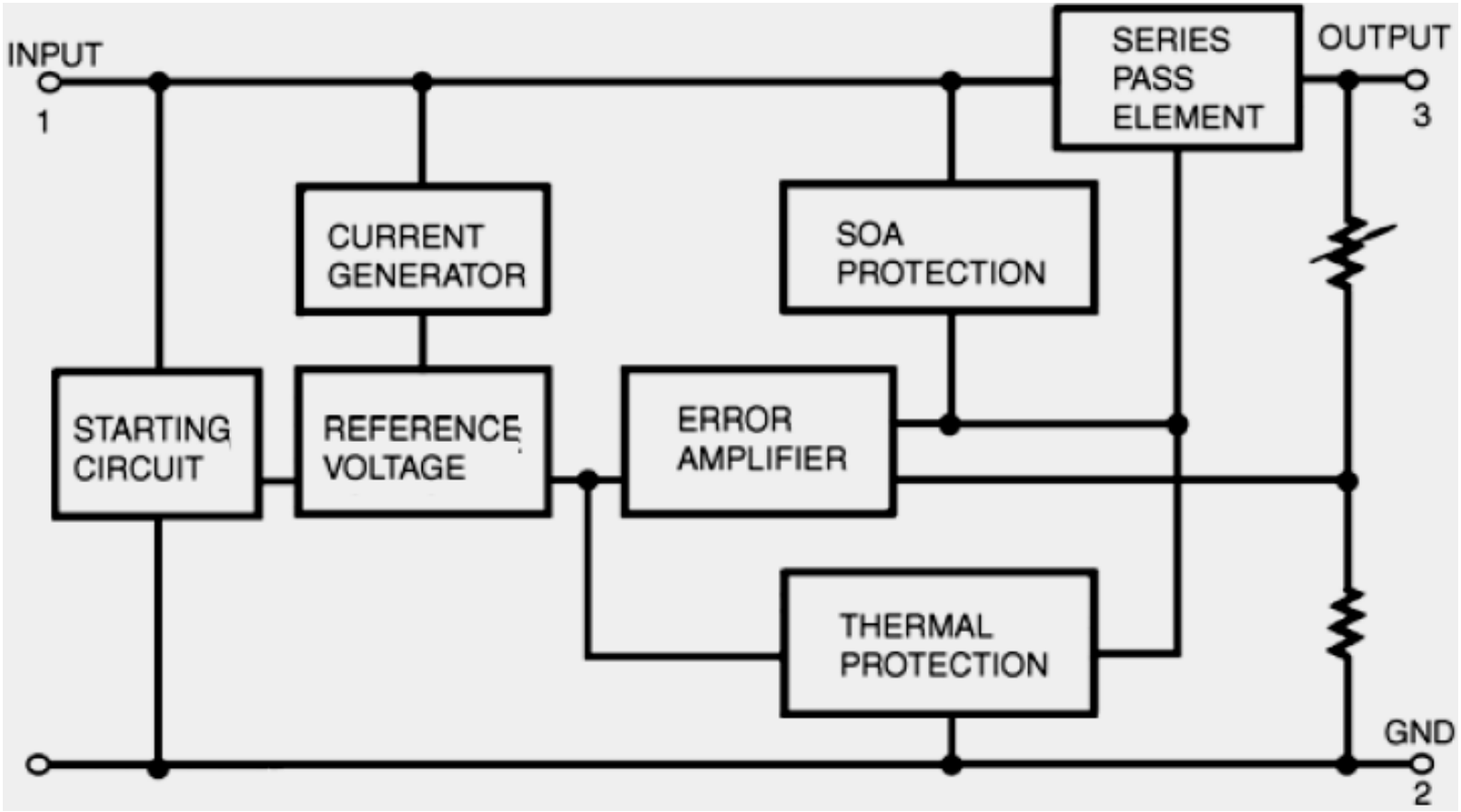
Factory trimmed to provide a fixed output.

Positive voltage regulators:

- **7805**
- **7806**
- **7808**
- **7809**
- **7810**
- **7812**
- **7815**
- **7818**
- **7824**

Negative voltage regulators:
LM79xx

Block diagram of LM78xx



Electrical characteristics: LM 7805

FAIRCHILD SEMICONDUCTOR®

LM78XX/LM78XXA
3-Terminal 1A Positive Voltage Regulator

Absolute Maximum Ratings

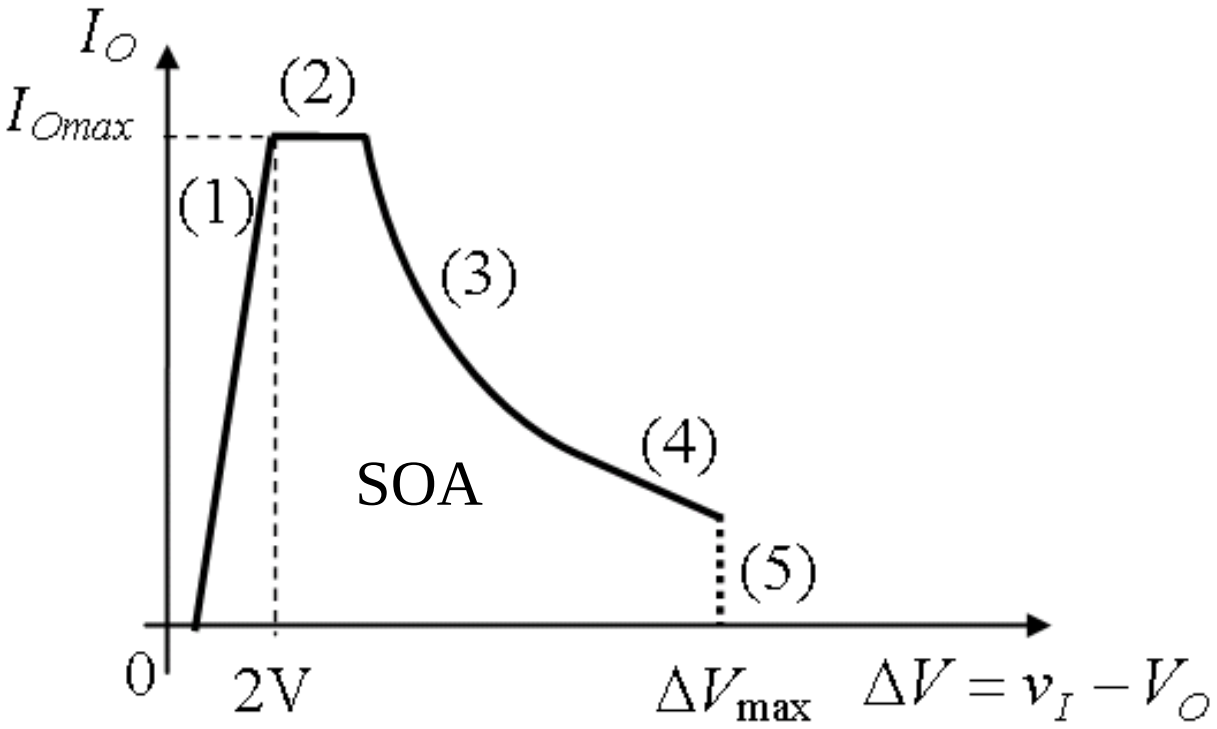
Symbol	Parameter		Value	Unit
V_I	Input Voltage	V_O = 5V to 18V	35	V
		V_O = 24V	40	V

Electrical Characteristics (LM7805)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		4.8	5.0	5.2	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 7V to 20V		4.75	5.0	5.25	
Regline	Line Regulation(1)	T_J = +25°C	V_I = 7V to 25V	–	4.0	100	mV
			V_I = 8V to 12V	–	1.6	50.0	
Regload	Load Regulation(1)	T_J = +25°C	I_O = 5mA to 1.5A	–	9.0	100	mV
			I_O = 250mA to 750mA	–	4.0	50.0	
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA

Safe Operating Area



(1) Minimum dropout voltage

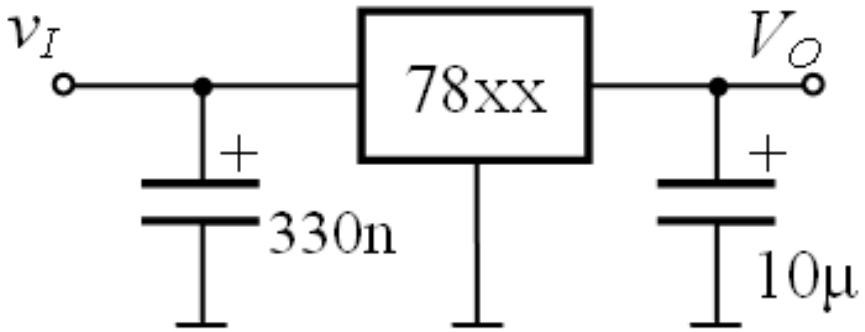
(2) Maximum output current – peak current (overcurrent protection)

(3) Maximum power dissipation (thermal protection)

(4) Secondary breakdown ("hot spots" in the junctions of the trans.)

(5) Maximum input voltage

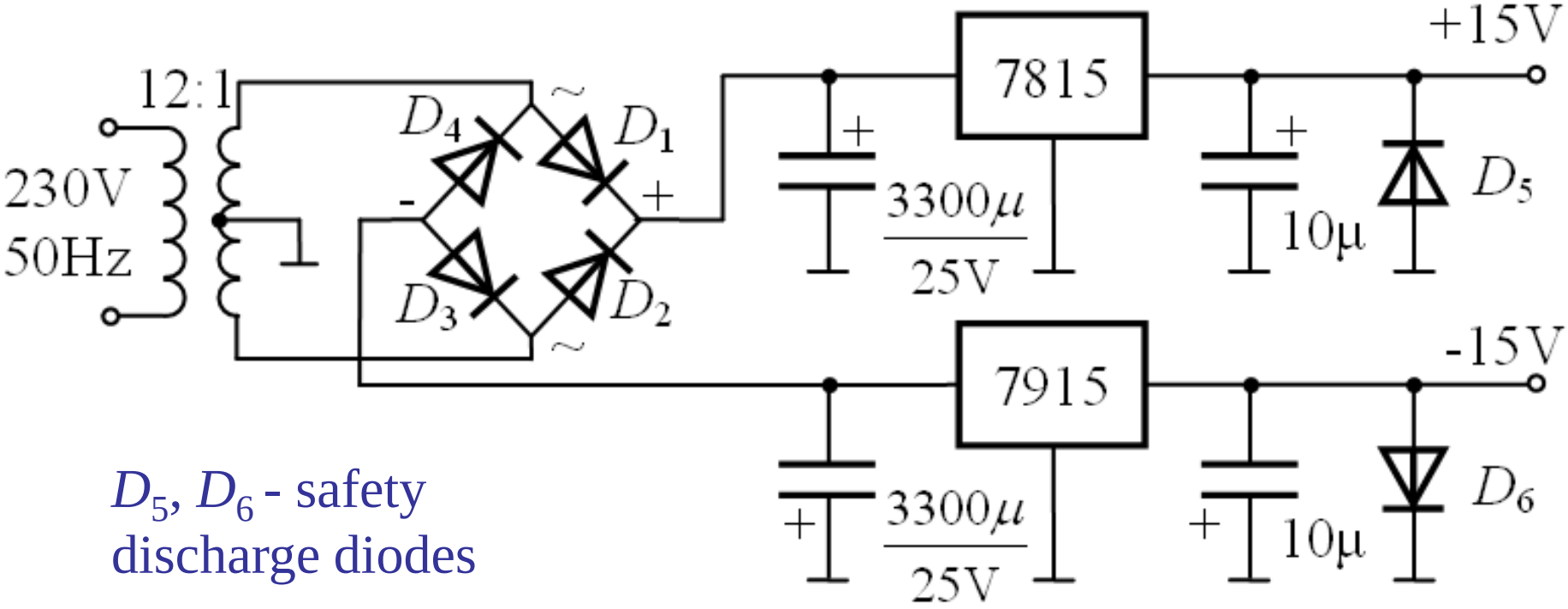
Fixed voltage regulator



C_O improves transient response and keeps the output impedance low for high frequency

$$V_O \geq v_I + 2\ \text{V}$$

Dual power supply

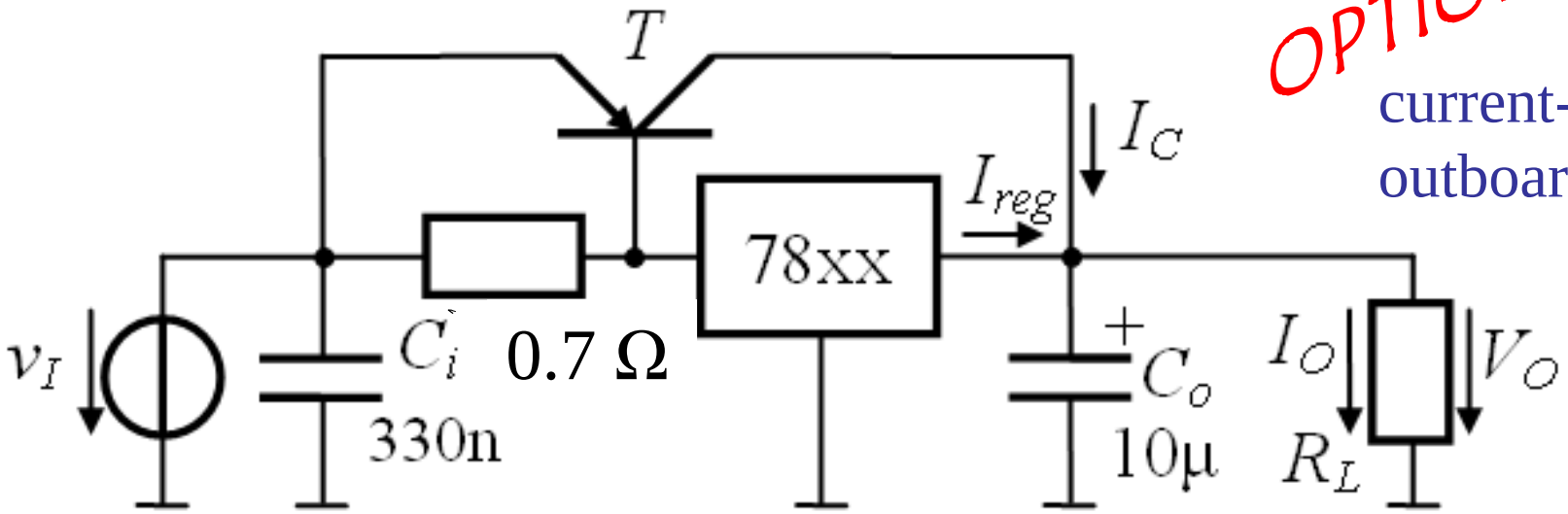


D_5, D_6 - safety discharge diodes

High current voltage regulator

OPTIONAL

current-boosting outboard transistor



$I_O < 1\ \text{A},\ T-(off),\ I_O = I_{reg}$

$I_O > 1\ \text{A},\ T-(a_F),\ I_O = I_{reg} + I_C$

The circuit should be improved to provide current limiting for *T* (protection of *T*)

E.g. 7805 ; $V_o = 5V$; $V_I \geq 7.7V$

$R_L = 3.3\,\Omega$

$I_o = \frac{V_o}{R_L} = \frac{5V}{3.3\,\Omega} = 1.5A$

$I_{reg} = 1A$

$I_C = I_o - I_{reg} = 1.5 - 1 = 0.5A$

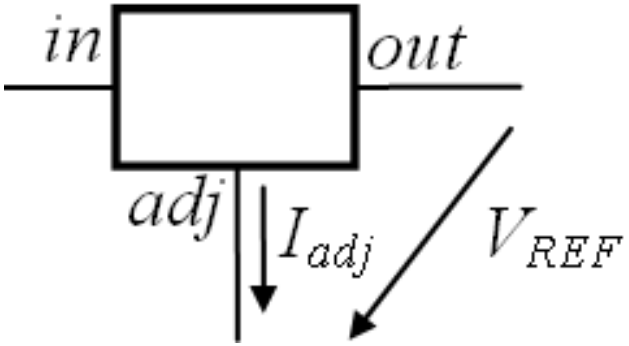
$R_L = 2\,\Omega$

$I_o = 2.5\ A$

$I_{reg} = 1A$

$I_C = 1,5\ A$

Three-terminal adjustable regulators



LM 317 positive voltage

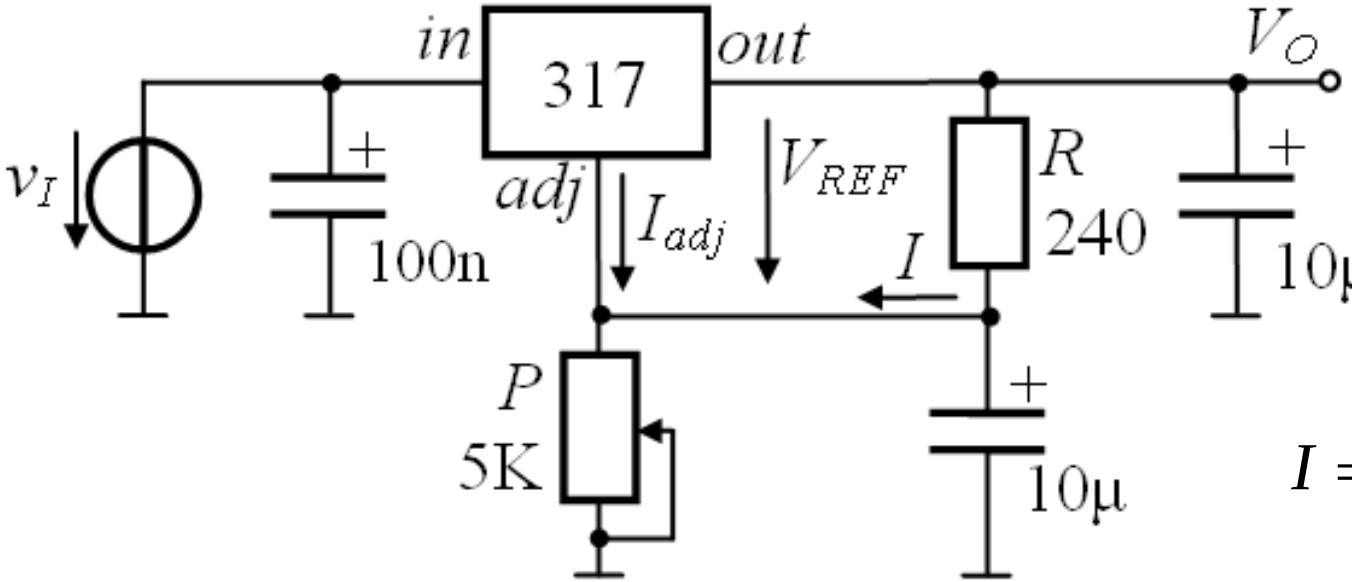
LM 337 negative voltage

$V_O \in (1.25; 37)\text{V}$

$V_{REF} = 1.25\text{V}$

$I_{O\max} = 1.5\text{A}$

$I_{adj} = 50...100\mu\text{A}$



$I >> I_{adj}$

$$I = \frac{1.25\text{V}}{240} = 6.25\text{mA}$$

$$V_{O\min} = 1.25\text{V}$$

$$V_{O\max} = \left(1 + \frac{5}{0.24}\right) \cdot 1.25\text{V}$$