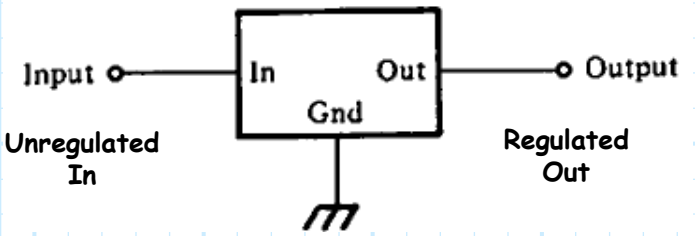
Fixed (Three Terminal) Regulators

In many applications you may want to use a three-terminal regulator. These devices save the engineer a lot of time in designing power supplies, but you must be careful when using them.

These are linear regulators, so their internal circuitry is very similar to the 723 in function. They are not used in conjunction with an external pass transistor so the device itself must dissipate any unused power. Use good heat management techniques with these devices.



Why use a three-terminal regulator?

- Cheap and easy to use.
- Available mostly below 5 A.
- Reduces coupling between supply voltages.
- More efficient. Allow central PS to be unregulated. Regulators can be placed on each PC board.

Characteristics of these devices:

- V_{out} is fixed
- $|V_{in}| \geq |V_{out}| + 2\ \text{V}$
- I_{out} can vary from zero to the max current rating. A heat sink may be necessary.
- Device usually has thermal protection. It shuts down then the internal temperature reaches 125 °C.

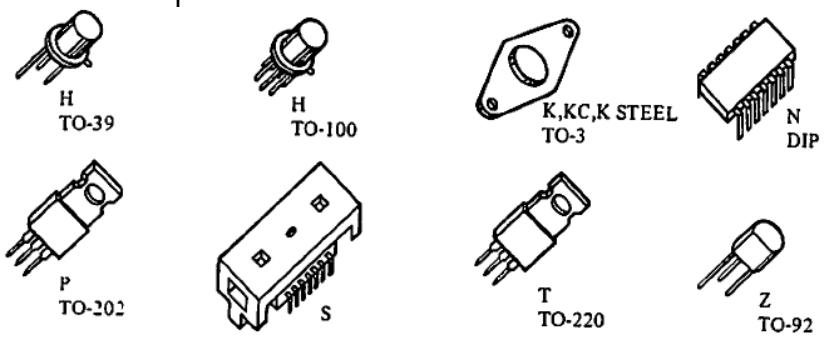
Important parameters for this device are shown in the table below (from H & H):

TABLE 6.8.
FIXED VOLTAGE REGULATORS

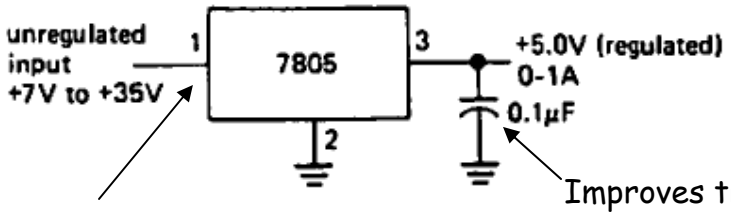
Type	Pkg	V_{out} (V)	Accuracy (%)	Output current (max)[a] @75°C case I_{out} (A)	No heatsink[b] I_{out} (A)	No heatsink[b] P_{diss} (W)	Regulation (typ) Load[c] (mV)	Regulation (typ) Line[d] (mV)	Θ_{JC} (°C/W)	Input voltage min[i] (V)	Input voltage max (V)	120Hz ripple reject typ (dB)	Temp stab[e] typ (mV)	Long-term stab[f] max (%)	Output impedance 10Hz (Ω)	Output impedance 10kHz (Ω)
Positive																
LM2950CZ-5.0	TO-92	5	1	0.08	0.1	0.5	2	1.5	160	5.4	30	70	10	–	0.01	0.5
LM2931Z-5.0	TO-92	5	5	0.1	0.1	0.5	14	3	160	5.3	26	80	–	0.4[t]	0.1	0.2
LM78L05ACZ	TO-92	5	4	0.1	0.1	0.6	5	50	160	7	35	50	–	0.25	0.2	0.2
LM330T-5.0[g]	TO-220	5	4	0.15	0.15	1.5	14	20	4	5.3	26	56	25	0.4[t]	0.1	0.2
TL750L05	TO-92	5	4	0.15	0.15	0.6	20	6	160	5.6	26	65	50	–	–	–
LM2984CT	TO-220[h]	5	3	0.5	0.5	2	12	4	3	5.5	26	70	3	0.4[t]	0.01	0.02
LM2925T	TO-220	5	5	0.75	0.5	2	10	8	3	5.6	26	66	–	0.4[t]	0.2	0.2
LM2935T	TO-220	5	5	0.75	0.5	2	10	8	3	5.5	26	66	–	0.4[t]	0.02	0.02
LM309K	TO-3	5	4	1	0.6	2.2	20	4	3	7	35	80	50	0.4	0.04	0.05
LT1005CT	TO-220	5	2	1	0.5	2	5	5	3	7	20	70	25	–	0.003	0.01
LM2940T-5.0	TO-220	5	3	1	0.5	2	35	20	3	5.5	26	72	20	0.4[t]	0.03	0.03
LM7805CK	TO-3	5	4	1	0.6	2.2	10	3	3.5	7	35	80	30	0.4	0.01	0.03
LM7805CT	TO-220	5	4	1	0.45	1.7	10	3	3	7	35	80	30	0.4	0.01	0.03
LM7815CT	TO-220	15	4	1	0.15	1.7	12	4	3	17	35	70	100	0.4	0.02	0.05
LT1086-5CT	TO-220	5	1	1.5	0.5	2	5	0.5	3	6.3	30	63	25	1	–	–
LAS16A05	TO-3	5	2	2	0.75	2.8	30[m]	100[m]	2.5	7.6	30	75	–	–	0.002	0.02
LM323K	TO-3	5	4	3	0.6	2	25	5	2	7	20	70	30	0.7	0.01	0.02
LT1035CK	TO-3	5	2	3	0.8	3	10	5	1.5	7.3	20	70	25	–	0.003	0.01
LT1085-5CT	TO-220	5	1	3	0.5	2	5	0.5	3	6.3	30	63	25	1	–	–
LAS14A05	TO-3	5	2	3	0.8	3	30[m]	50[m]	2.3	7.5	35	70	100[m]	–	0.001	0.003
LT1003CK	TO-3	5	2	5	0.8	3	25	5	1	7.3	20	66	25	0.7	0.003	0.02
LT1084-5CK	TO-3	5	1	5	0.8	3	5	0.5	1.6	6.3	30	63	25	1	–	–
LAS19A05	TO-3	5	2	5	0.8	3	30[m]	50[m]	0.9	7.6	30	70	150[m]	–	0.01	0.2
LT1083-5CK	TO-3	5	1	7.5	0.8	3	5	0.5	1.6	6.3	30	63	25	1	–	–
LAS3905	TO-3	5	5	8	0.8	3	20[m]	100[m]	0.7	7.6	25	60[m]	100	–	0.004	0.01

$$V_{ripple\ out} = V_{ripple\ in} \times 10^{-\left[(dB - 20\log V_{out})/20\right]}$$

Example: a 2 Vp-p input ripple will be reduced to 1.002 mVp-p when this spec is 80 dB.



How do we use a 3-terminal regulator?

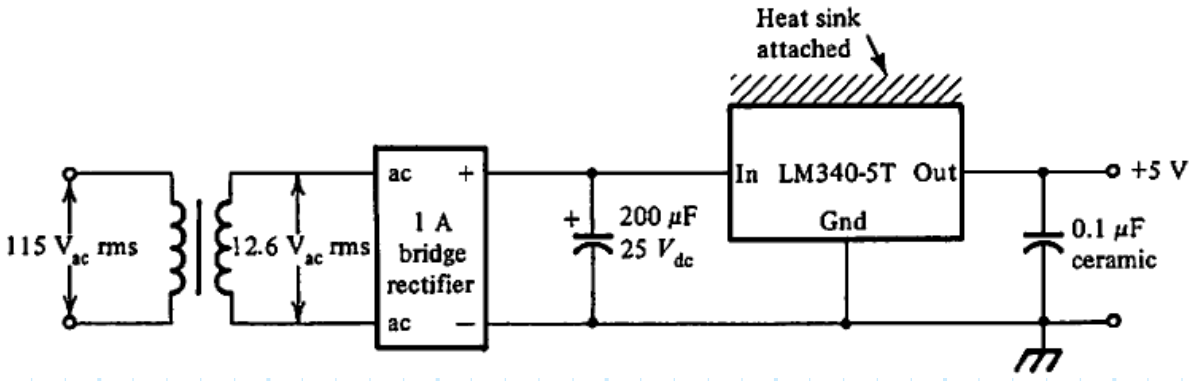


a large electrolytic capacitor is a good idea here. Keep the value greater than 1 μF.

Also, keep Vin within the proper bounds:

$$V_{out} + 2\ \text{V.}\Big|_{I_L=\max} < V_{in} < V_{in(\max)}\Big|_{I_L=0}$$

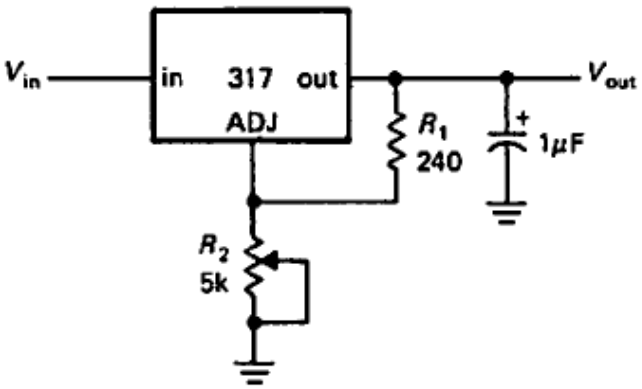
Here is how a power supply circuit might be designed using a 3-terminal regulator:



Three terminal regulators also are available as adjustable regulators. These devices do not have a ground connection. These are used when

- Nonstandard voltages are needed.
- Greater % accuracy is needed than available from fixed 3-terminal regulators.

An example is shown below with the LM317:



The regulator places a constant 1.25 V (bandgap potential) across R_1 which forces a fixed current to flow into R_2. The output voltage is,

$$V_{out} = 1.25\left(\frac{R_1 + R_2}{R_1}\right) \text{ Volts}$$

Here's an example of a complete circuit. Be sure to use the diode if the "adj" terminal is bypassed by a large capacitor.