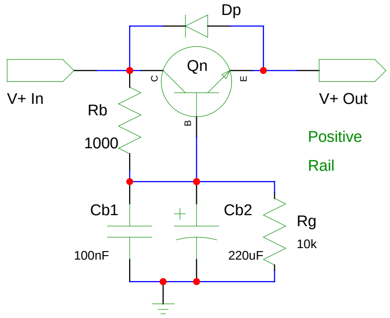
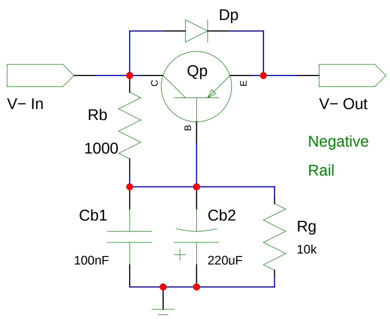
Transistor Voltage Regulators

2010−07−13





Dual Rail Floating Pre−Regulator Ripple Filters (~30−35db noise cut. Common Collector Amp configuration, load is after the emitter.)

These are also called "capacitance multipliers" and will seemingly increase capacitance by CbX * transistor beta.

A transistor in this configuration forms a type of variable voltage divider to keep the output voltage constant.

Effective drop out for usability is about 0.5v below the ripple (beta=100, Rload=100). 40Hz noise and below are reduced less.

For low ripple sources, Rb can be low wattage. For higher ripple sources, Rb should be a higher wattage and maybe used with a heat sink.

If Cb2 is electrolytic, observe polarity. Smaller capacitors can be paralleled for lower ESR. Cb1 should have a good HF response (ceramic).

The NPN one is for the positive rail. The PNP one is for the negative rail.

This is also a slow turn on with the capacitor charging up first before the transistor fully opens.

When ripple voltage swings high, the capacitor sinks it. When ripple voltage swings low, the capacitor sources the transistor base.

Rb+Cb1+Cb2 also forms a high pass zobel/snub filter to ground for noise.

For large capacitors, Dp protects against the possibility of reverse biasing the transistor.

Rb is a feedback resistor to essentially form a little BJT amplifier (provides negative feedback to the stable capacitor levels).

Rb size depends on the transistor beta. Lower beta, higher power models need more base current (lower value resistor).

Add large filter capacitors at V_in and V_out to handle peak current draw.

Higher Rb means more smoothing (to a point) and more voltage drop on output. Higher impedance means a slower Cb2 charge rate and slower turn on. Higher Cb2 means more low frequency smoothing. Too large will cause sluggishness and excessive turn on times.

CbX and Rb can be split into cascading RC filters for better performance (second order 12db/octave filter).

Rg is usually 10k−22k and stabilizes the circuit against variations in transistor gain. Lower Rg increases transistor dissipation and lowers V_out more (larger increase output noise). Choose this so that the voltage drop across the transistor is sufficient to handle noise.

Rb typical range: 100−3500. Cb2 typical range: 10−470uF.

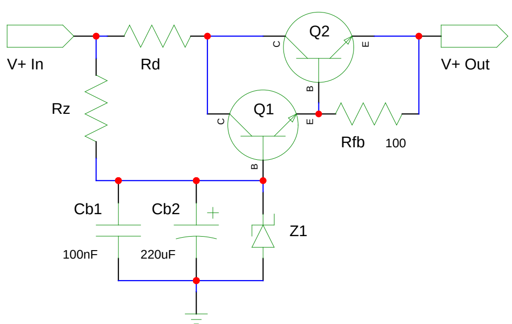
Option: split Rb to fixed + variable for an adjustable floating regulator.

Common transistors: BD139+TIP3055 NPN, BD140+TIP2955 PNP.

Set the output voltage about a half volt below the base of the ripple voltage.

Example Noise Reduction: Rb=1000, Cb=220uF, beta=100, Rload=100:

80Hz=58x, 70Hz=50x, 60Hz=43x, 50Hz=35x, 40Hz=27x, 30Hz=20x, 20Hz=13x, 10Hz=7x, 5Hz=3x



Simple Zener / Darlington Fixed Voltage Series Pre−Regulator (in series with the load)

This fluctuates much less than a lone zener shunt regulator. Good for clamping over voltages to the main regulator.

Problems. This design will fluctuate the output voltage under load transients (about 0.4v fluctuation). This design seems to have problems with zener voltages below 5v. This seems to do with the transistor's active base voltage range not being opened up enough(usually peaks at 5−6v). Use smaller Rz (<100ohms) to help compensate, but Rz will get quite hot with >10v inputs. Zeners also start partially conducting before reaching Vz (use a smaller watt zener?).

Z1 should be rated at a quarter watt and a few volts above the desired voltage if the main linear regulator that will follow.

A single transistor may be used instead of a darlington pair. A single transistor has a forward voltage drop of almost 0.6v.

A darlington configuration will be 0.6*2. An accordingly higher zener voltage will need to be chosen if this is a problem.

Darlington will be a little slower to respond to HF noise and may have oscillation issues.

The darlington transistor has a beta of around 1000. A single transistor usually has a beta of around 100.

Rz is a negative feedback resistor. Choose it accordingly so it gives 10−30mA to Q1 and Z1.

Rfb is an optional negative feedback resistor that is high enough to prevents Q1 from being loaded too heavily to the output.

Rfb (100−1k ohms) also helps increase switching speed of Q2. Q1 cannot actively inhibit the base current of Q2, so Q2 can be slow to switch off. Rfb provides a low impedance discharge path for Q2's B−E junction. If a Sziklai pair is used, Rfb still connects between Q2's emitter and base.

Cb1+Cb2 provide extra stability to the output. They should be rated for the zener voltage.

Rd is small and is sometimes used to split the heat load if Vin is high (watch the math for the downstream load current).

For a negative rail, flip Z1 and Cb2 and replace NPN's with PNP's. Keep the PNP's emitters on the output side of the circuit.

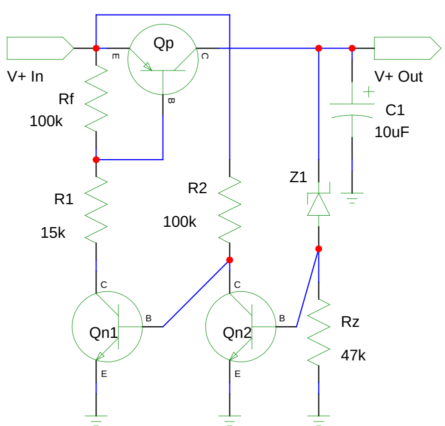
Equations: Rz = (Vin − Vzener) / (Iz + K * Ib). Ib = Iload / Beta_min. Iz is the needed zener current. Ib is the needed Q1 base current. K is 1.2 to 2 for headroom. Beta_min is the smallest usable DC current gain of the transistor.

Example Shown: 12v, 1 amp out, table:

Vmin =	15	17	23	34
Vmax =	30	40	50	60
Rz =	1.1k	3.6k	6.2k	8.9k
Rd =	0	0	10	20

Variation: A high voltage version can be made with an N−MOSFET replacing Rd, Q1, Q2, and Rfb. The drain is on Vin, source is Vout, and the gate connects to the zener. For very high voltages, Rhv will need to be added on the gate.

Add some kind of active current limiter instead of Rz for the zener current source?



Simple Low Drop Out Fixed Regulator (200mV drop at 10mA)

Qp needs to be power rated. Qn1 and Qn2 are signal level.

Z1+Rz sets Vout level and provides an output reference for Qn2.

Qn2+R2 provides an inverted reference signal to Qn1.

Qn1's base gets reference signal and Vin noise.

Qn1 reduces Qp base on fluctuations.

Rf+(R1+Qn1) forms a variable voltage divider.

Qp does the actual regulation and adjusts Vout accordingly.

Resistor values are not overly critical.

Tests. 3.3v zener outputs 1.5v. 5.6v zener outputs 4.4v. 13v zener outputs 14v. If Vin is less than 1v above Vz then there will be a 0.3v drop in Vout when under load. Higher voltages do not seem to have this problem and are stable. If Vin changes, Vout will fluctuate a little in the same direction (milliamp range).

???Why does a higher Vz have Vout above Vz?