Goran Finnberg's AG440 Power Supply Modification

Circuit description and redrawing by Rick Chinn.

Overview

Goran sent me this circuit in 2002 after some discussion on the list about the stock AG440 power supply. I agreed to redraw the circuit and to post it. This modification is applicable to all variants of the AG440. The circuitry involved is located on PWA 4050432.

This modification to the AG440's 39V regulator accomplishes several things:

- Higher loop gain in the regulator, leading to better regulation and lower output impedance.
- Improved short circuit protection
- More protection for various circuit elements.

Figure 6-22 from the AG440B manual is included with this document.

For starters:

- Q705 is the series pass element. It is a power transistor.
- Q704 is darlington connected to Q705.
- Q703 is a current source
- Q1 is a protection transistor. It shuts down current source Q703 in the event of overcurrent through Q705. The current limit is now about 2x what it was originally.
- Q2 and Q706 are the error amplifier
- VR702 is a 24V zener diode. It is the voltage reference for the regulator.
- Where possible, reference designators match those on the original Ampex schematic.

Theory of Operation

Q705 and Q704 are Darlington connected transistors used as an emitter follower. Q704's base is pulled towards the raw supply via current source Q703. Using a current source for the pullup increases the gain of the error amplifier (Q706 and Q2) and isolates the error amplifier from the ripple content of the raw supply.

Q703, the current source, uses the reference voltage developed by constant current diode IS1 causing a constant voltage drop across forward biased diodes CR705 and CR706. Since CR704 cancels the V_{be} drop of Q703, the resulting 0.7v across R708 sets the current source output to 4 milliamps. The constant current diode Is1 further isolates the current source from the ripple in the raw supply because it presents a high AC impedance and its constant current output filters out the AC component of the raw supply.

At turn-on, Q703 biases the pass transistors ON and the voltage across C3 starts to rise until it approaches 39V. Once this happens, Q706 starts to be forward biased, turning on Q2 (which is compound connected with Q706 to make a high gain NPN transistor) and reducing the voltage at Q706's base. Ultimately the output voltage settles at 39V, which is the voltage of the zener diode multiplied by the division ratio of the voltage divider formed by R713 R712, and R711 (because that divider sets the gain of the regulator).

For a midrange setting of R712, the division ratio is:

$$k = 1 + \frac{(R713 + (0.5 * R712))}{(R711 + (0.5 * R712))}$$

$$k = 1 + \frac{(2k2 + 500R)}{(3k9 + 500R)} = 1.6136$$

$$Vo = Vz * k = 24 * 1.6136$$

$$Vo = 38.73V$$

This agrees well with the Ampex design philosophy that setting any variable component to the midrange of its mechanical setting range should give approximately correct results.

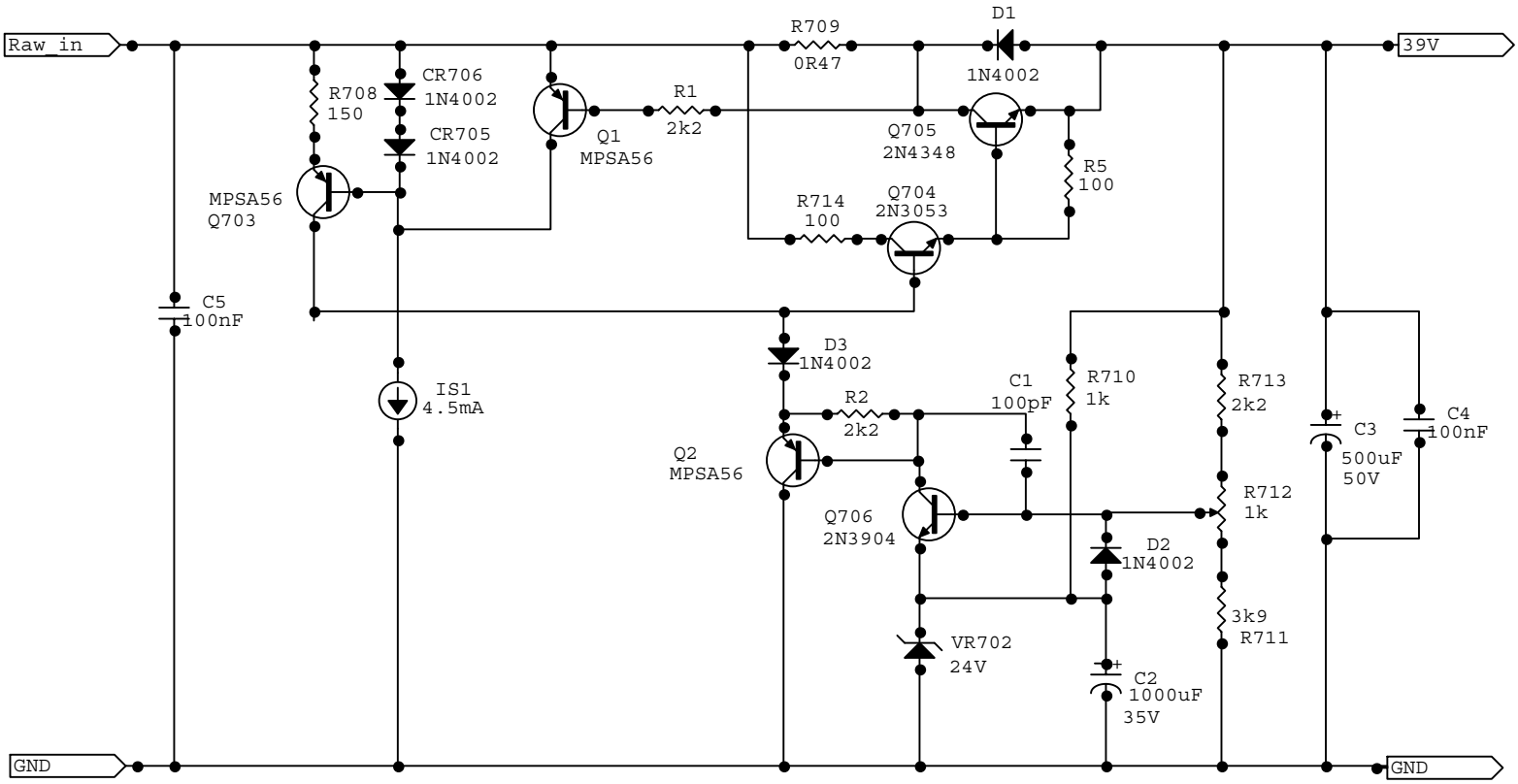
When the current thorough R709 exceeds about 0.7V, Q1 disables current source Q703 by shorting out its reference voltage, starving the error amplifier and consequently the base drive to the output pass transistors, reducing the output voltage of the regulator to zero

C1 sets the dominant pole in the open loop frequency response of the regulator, ensuring HF stability. D2 protects the EB junction of Q706 during startup of the regulator. R710 ensures that sufficient current flows thru VR702 to stabilize its operating point, which is further enhanced by R710 drawing its input from the regulated output of the supply. C2 bypasses/filters any noise output from VR702. C3 and C4 further ensure that the output impedance of the regulator remains low at all frequencies through and above the audio range.

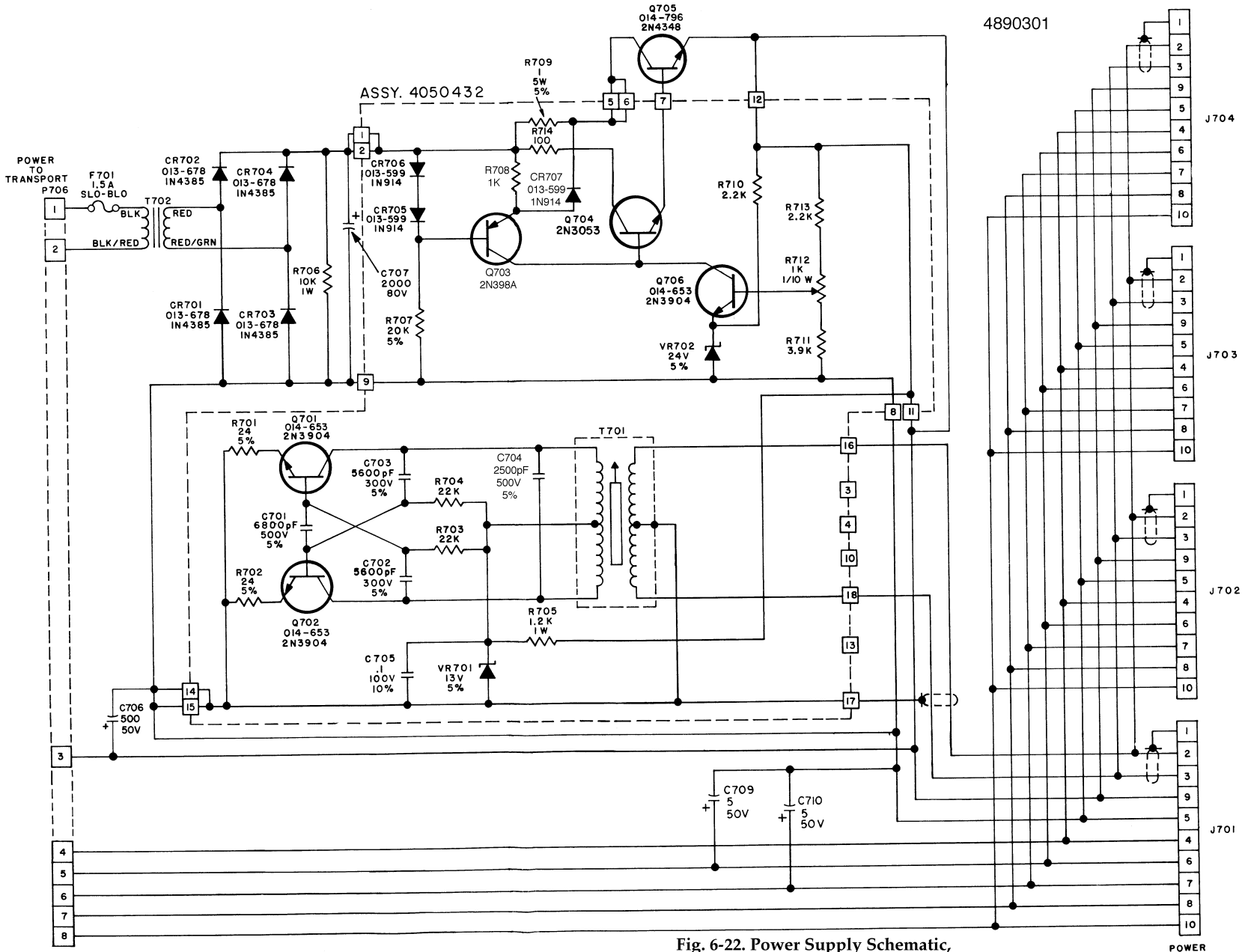
To further enhance the isolation of the zener voltage reference from transients at the output of the regulator, substitute two or three paralleled 4.7ma current regulator diodes for R710 (two if R710 is 2k2, three if R710 is 1k0).

In Europe, you can get suitable current regulator diodes from Elfa:
http://www.elfa.se/elfa/produkter/en/2009907.htm

In the United States, Mouser has suitable parts from Siliconix:
http://www.mouser.com/catalog/616/294.pdf



R710 = 2k2 (some versions)



Unless otherwise specified, All capacitor values are in MicroFarads, ratings as indicated All Resistor Values are in Ohms, 1/2 Watt, 10%.

Fig. 6-22. Power Supply Schematic, Record / Reproduce