PS-15D-25A Repeater Power Supply

JL Keith 7-30-22

Introduction.

Once our club obtained coordination for moving its repeater to a near by mountain and installing a 75W transmitter, a new power supply was required. The following data and drawings document the 13.8 VDC power supply that is rated to provide 0 to 25 ADC at 100% duty cycle.

Figure 1. is the schematic. Note the regulator assembly is a PS15D102 and contains all the low power components. High power components are mounted on the rack panel which is shown in Figure 2.

This design is a high performance CC CV power supply with fold-back current limiting. The simple design is deceiving, making one think the performance will also be simple, but far from that, as can be seen from the following performance data.

Theory of operation.

Theory of operation is easy to understand, but one needs to realize all measurements are measured with respect to the POSITIVE output terminal. D202 provides a 5.4V reference for Q201, again with respect to the positive output terminal.

The divider network of R201, 202 and 203 provides Q201 a base voltage (to compare to its emitter voltage) that is a sample of the negative output terminal voltage compared to the positive terminal. When the negative terminal becomes more negative with respect to the positive terminal, Q201 collector current will increase.

Q201 collector current flows through Q203 base-emitter junction causing Q203 collector current to increase. Q203's collector load resistor, R214, is connected to the positive output terminal, which if Q203 is not conducting, will turn on Q1. But as Q203 conducts more, its collector voltage will go negative turning off Q1.

Q1 source current flows through Q2 - Q4 base-emitter junctions causing them to conduct. Q1 drain current is from the negative output terminal and so is part of the supply's output current. As Q2 - Q4 conduct more, the output negative terminal becomes more negative. As this happens, the above description reduces the base current to the pass transistors and the negative terminal voltage is reduced, as it should be for regulation.

At power ON, R214 turns on Q1 which then turns on Q2 - Q4. As the negative terminal voltage increases, it will reach a value that will cause Q201 to turn on and regulation is achieved. This allows the power supply to start up in any condition, even for intermittent incoming power loss.

Q202 provides current limiting. The current induced voltage developed across R208 is applied to Q202 via two resistor networks. R206 and 207 which set a threshold voltage for Q202 base. This voltage is approximately 0.41V more negative than the positive output terminal. This is the current limit reference voltage.

R209 and R 210 supply Q202 emitter voltage which is comprised of the positive voltage developed across R208 as current flows through it and a sample of the negative output voltage. When the output voltage is normal, indicating no current limiting, the negative output voltage offsets R208 current induced voltage.

Thus the output current can increase to the limit set by Q202 base voltage. Once current limit is reached, Q202 will take over the control loop from Q201 and shut down the pass transistors. As the load current continues to increase, Q202 emitter voltage will become more positive causing Q202 to further shut down the pass transistors.

Thus the current will fold-back to about 25% of the current limit point. This protects the pass transistors for loads up to and including shorts on the output terminals. The design of this fold-back function allows the power supply to start up under full load and with a tungsten load, which many Amateur Radio market power supplies will not. However, it will not start up into a pure constant current load nor will any fold-back supplies.

Fortunately about the only place one runs into true constant current loads is when testing with an electronic load. Most, and all good ones, have a constant resistance mode which can be used for testing start up with full load.

This simple design is insensitive to RF fields, reactive loads, power line perturbations and step function loads. The control loop is unconditionally stable and noise is extremely low, partially due to no excess gain or complex op amp devices.

Performance.

Output voltage adjust range is 10.37 to 14.46 VDC.

Load Regulation (from 0 to 15 ADC) is 0.033%.

Output nose (from 0 to 15 ADC) is <0.5 mVpp.

Output voltage temperature coefficient is -1.3 mV/^{o}C.

Line regulation (at 15 ADC load and 105 to 125 VAC) is 0.023%.

Current limit is 33 ADC.

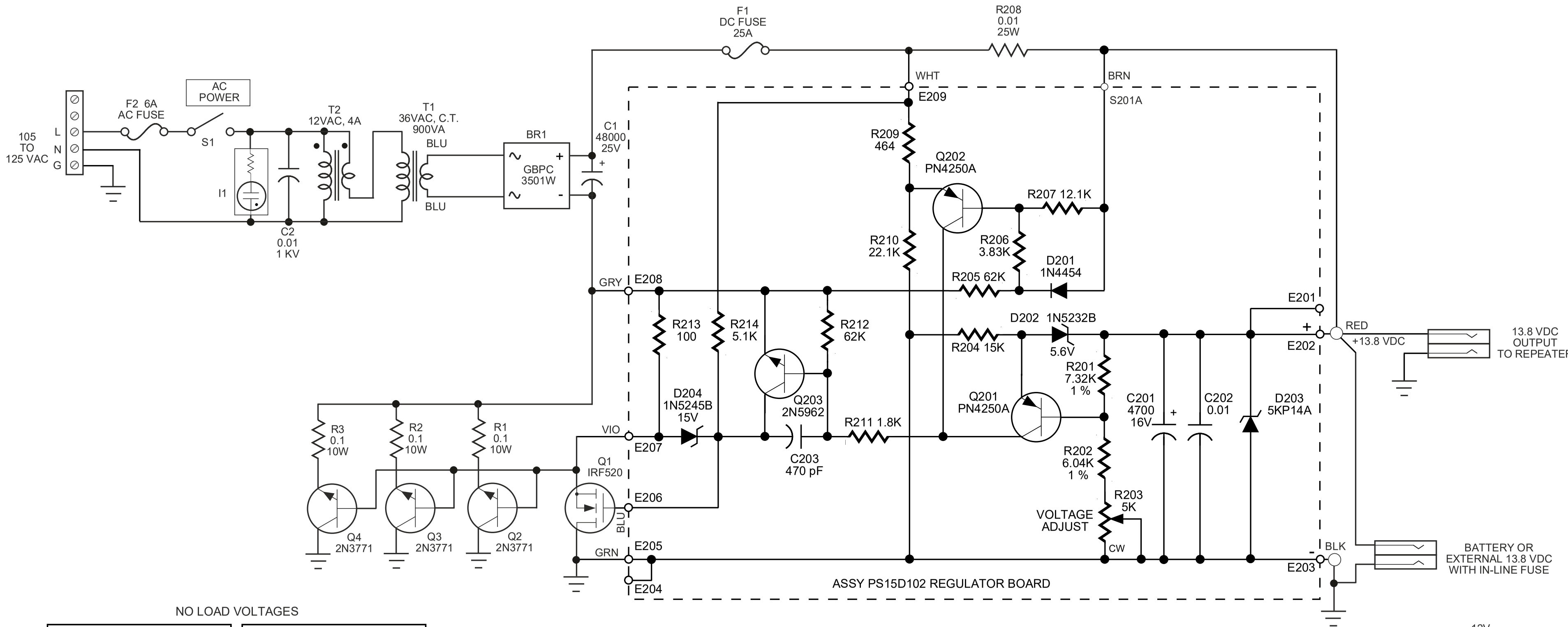
Fold-back is 8.25 ADC.

100% duty cycle output current (t_a < 40^{o}C) is 25 ADC.

AC line, no load current is 0.50 Amp.

AC line, 15 ADC load current is 3.62 Amps.

AC line, 25 ADC load current is 5.52 Amps.



NO LOAD VOLTAGES

VOLTAGE CHART (VDC) (REFERENCED TO E202 POSITIVE OUTPUT)		
Q201	E	-5.4
	B	-5.8
	C	-22.6
Q202	E	-0.28
	B	-0.41
	C	-22.6

VOLTAGE CHART (VDC) (REFERENCED TO E202 POSITIVE OUTPUT)		
Q203	E	-23.0
	B	-22.6
	C	-20.8
Q1	S	-23.0
	G	-20.8
	D	-13.8

INPUT RANGE 107 VAC TO 125 VAC AT 15 ADC LOAD

AC LINE CURRENT NO LOAD = 0.50 AMP (60VA)

AC LINE CURRENT 15 ADC LOAD = 3.62 AMPS (434.4 VA)

EFFICIENCY = 48%, PD = 227W AT 120 VAC AND 15 ADC LOAD

OUTPUT LOAD RANGE 0 TO 25 ADC

CURRENT LIMIT 33 ADC

VOLTAGE ADJUST RANGE 10.37 TO 14.46 VDC

RIPPLE AND NOISE 0 TO 25 ADC < 0.5 mVpp

REGULATION FOR 107 TO 125 VAC = 0.023%

REGULATION FOR 0 TO 15 ADC = 0.033%

OUTPUT VOLTAGE TEMPERATURE COEFFICIENT = -1.3mV/°C

REVERSE CURRENT DRAWN FROM BATTERY WITH
AC POWER OFF IS 2 mADC.

PS-15D-25A
13.8 VDC AT 25 ADC
JL KEITH 6-27-22

Figure 1. PS-15D-25A Power supply schematic.

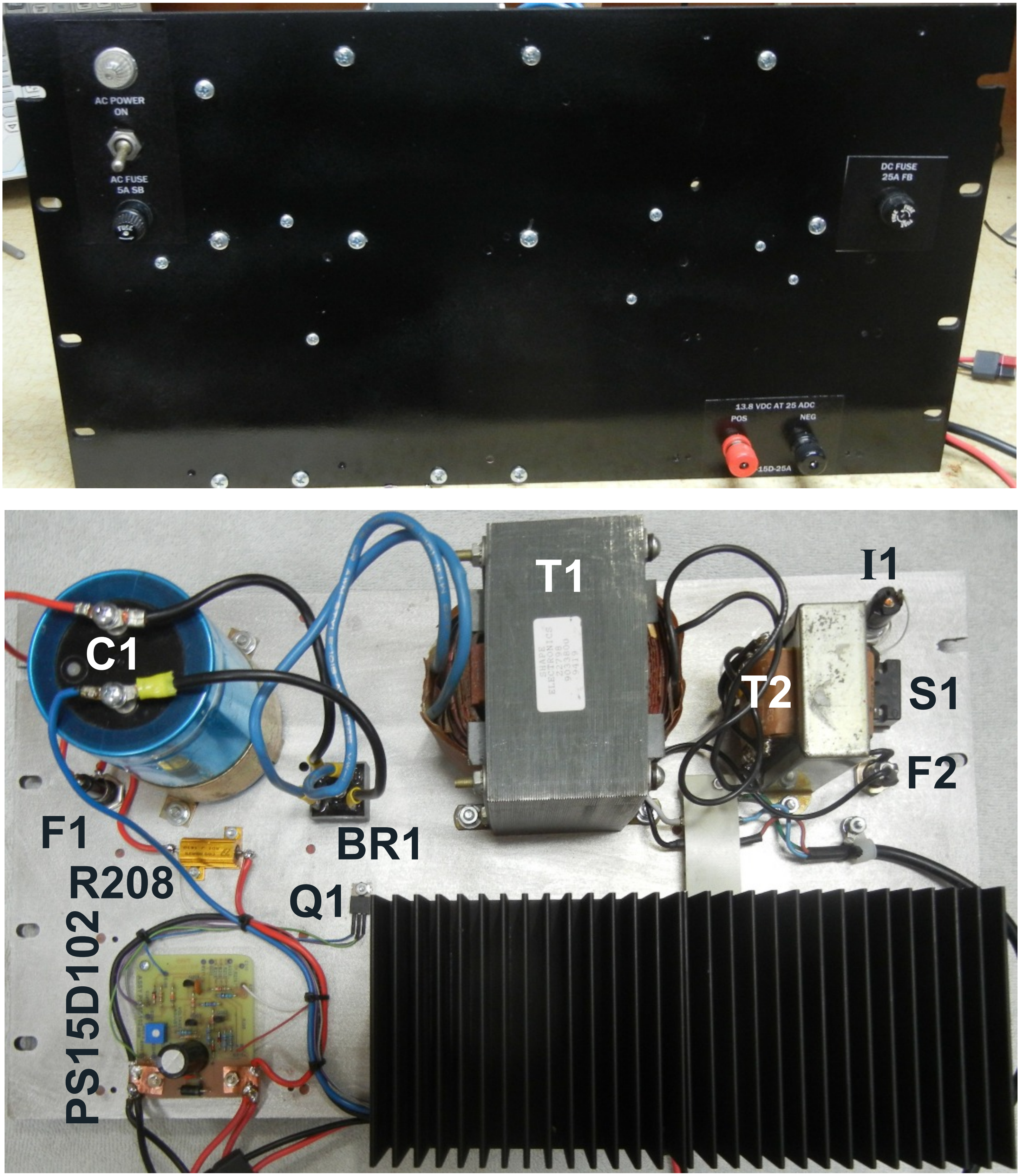


Figure 2. PS-15D-25A Front and back views.