Power Frequency Ripple Reduction in B+ Supplies John L Stewart P.Eng

This note describes a simple, low cost power supply improvement. It allows reduction of the power frequency ripple component (60 Hz in North America & 50 Hz in Europe) by up too 20 db. The problem this modification resolves occurs only in center tapped, full wave rectifier circuits. The conditions described are not found in a full bridge configuration. The experimenter needs to be extremely careful. Deadly voltages are present.

The article was originally published in Glass Audio Volume 10, Number 3, 1998.

A shorter version appeared in June 1998 edition of Electronics World.

The test circuit I used for this modification is an amplifier I built in the early 1960's. It uses a Hammond 273BZ power transformer. Nominal HV is 375 volts each side of center tap. The choke is a Hammond 156R, which along with the 35-microfarad capacitor forms the filter section at the output of the capacitor input rectifier. Load used during testing is a 5k, 50 watt resistor.

We would assume that the ripple would be predominantly even order harmonics (2nd, 4th, 6th, etc. However, because power transformers are wound serially, one side of the high voltage winding has a higher resistance than the other. This results in a significant ripple at the power frequency.

The LC filter network following the rectifier is only one-quarter (-12 db) as effective at the power frequency as at the main ripple frequency. The DC available at the filter output could contain ripple at the power frequency as large or greater then that of the main ripple frequency.

All of this is of little importance to pushpull amplifiers since they have large immunity to power supply ripple (see Note). However, the single ended amplifier & particularly the triode amplifier (SET & SEUL) are adversely affected.

Depending on the loading conditions of a triode power stage, from 2/3 to 4/5 of this ripple voltage will be

applied to the load. Unfortunately, most loudspeaker systems have one or two resonance's below 100 HZ. One of these could be at or near the power frequency. Presto!! We have objectionable hum in the listening room.

Figure One illustrates an ordinary center tapped full wave power supply. Two sides of the HV winding measured 38 & 40 ohms. Four resistors have been added. The purpose of R1, R2 & R3 is to apply a small AC voltage in series with the DC output voltage at the break point B1. By selecting the polarity the connection provides series aiding for the high resistance side of the HV winding & series bucking for the low resistance part. R4 is a current sampling resistor used during adjustment. The large dots shown on the transformer secondaries are polarity indicators.

Setting for optimum results is made by adjusting R2 while monitoring the current charging pulses with a scope at test point C (TPC). R2 must be wirewound since the current pulses are large. I used a Clarostat A4320. Adjust for equal size of the current pulses. An example of how they should appear is shown in Figure 2.

To get consistent information from the test scope it is important to use line triggering. The power cord on the test power supply should be polarized. A X10 probe AC coupled at the scope will keep the trace on the screen.

The diagram shows a solid state rectifier. I used an octal replacement unit from New Sensor Corp for these trials. Several vacuum rectifiers were tried with varying results. Their heaters were connected to the 5 volt winding in the normal way. Socket pin connections are shown.

Similar results could be had by using the 6.3 volt winding. In that case the mod could be inserted at break point B2. These same fixes could be applied to a power supply using a choke input filter.

C3 & C4 are ceramic & must be rated for direct connection to the power line. Mallory makes a capacitor approved by Underwriters Labs for this service. The part number is UN103M.

The ripple components at the input & output of the filter section were measured using an HP302A Wave Analyzer. The results in Table One show the reduction in the 60 Hz component. Higher odd order harmonics are also reduced.

Figure 3 is an FFT comparison of the output of the power supply before and after adjustment. The lower trace shows an improvement of about 20 db of the power frequency ripple.

For some there is an even easier fix. If the power supply uses a directly heated rectifier such as a 5R4WGB then it is possible to simply reverse the 5 volt heater transformer leads. No extra parts are needed. The difference will be very obvious when looking at the trace at test point C. The FFT measured about 15 db improvement. This is shown in Figure 4. By the laws of chance 1/2 of these rectifiers will already be properly connected.

A simpler fix is possible by adding a 2 ohm resister in series with the 38 ohm winding. Results will depend on the rectifier used. But easy to do at very little expense.

Note- Since doing this work in 1996/1997 I've had a closer look at some PP amps. If the PS is unfiltered then 120Hz sidebands are clearly visible on the test signals used. This could explain the so-called muddiness, Etc in the rendering of program material by some amplifiers. Some reputed to be high class at that. For those spectrums I was using a Pico Technology ADC-216, so 96 db resolution.

Table One- Reduction of the Ripple Frequency Component by Circuit Modification

Ripple Frequency	TPA		TPB	
HZ	Before	After	Before	After
	Millivolts		Millivolts	
60	800	95	75	8.5
120	4000	3800	95	92
180	240	85	2.5	1.0
240	1500	1450	10	9.5
300	110	53	-	-
360	600	540	-	-

File- Power Frequency Ripple Reduction Z

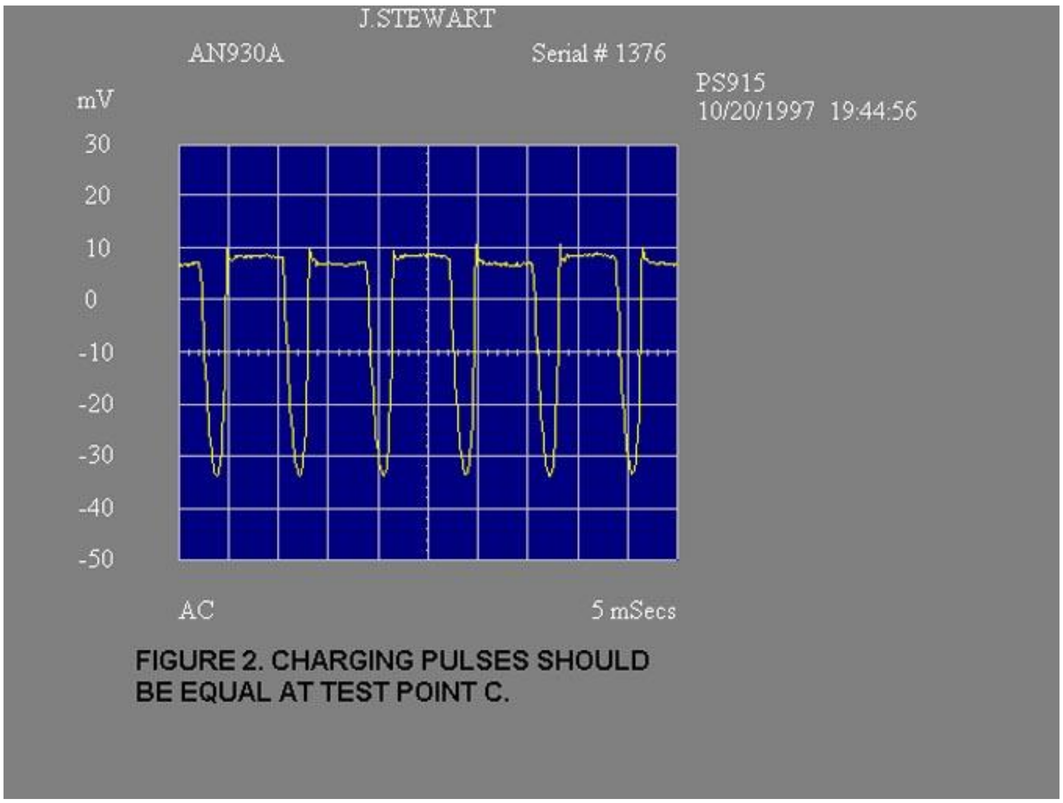
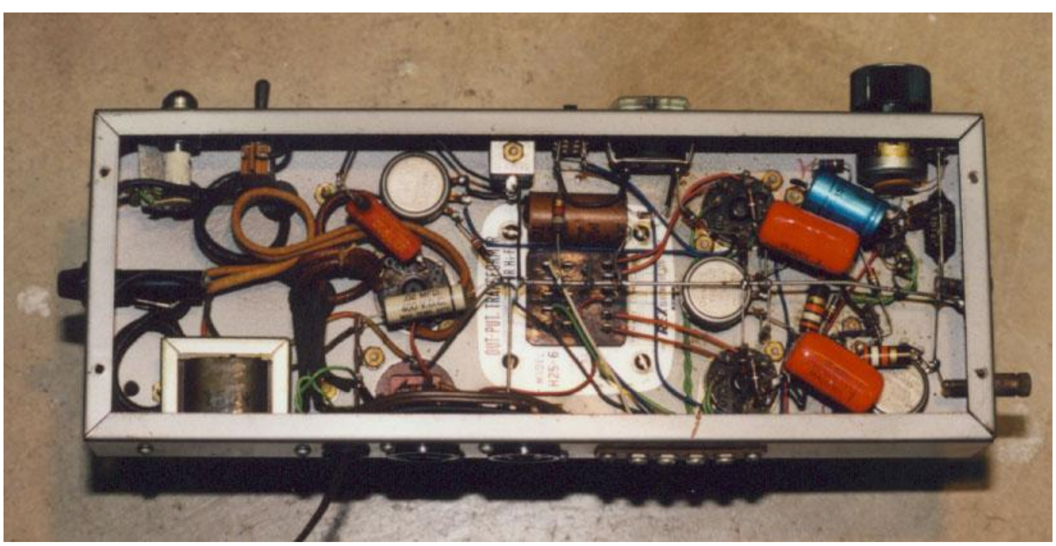
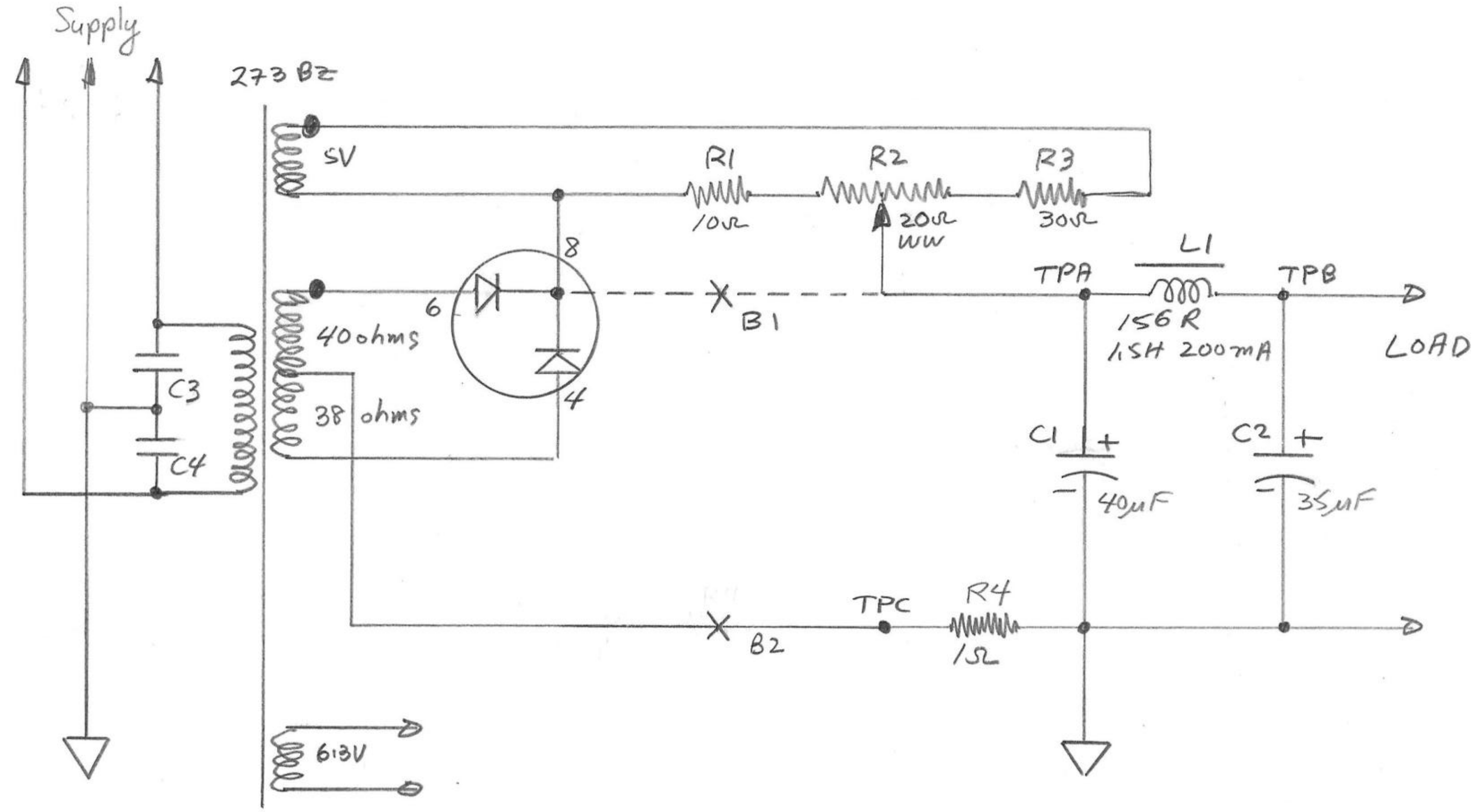


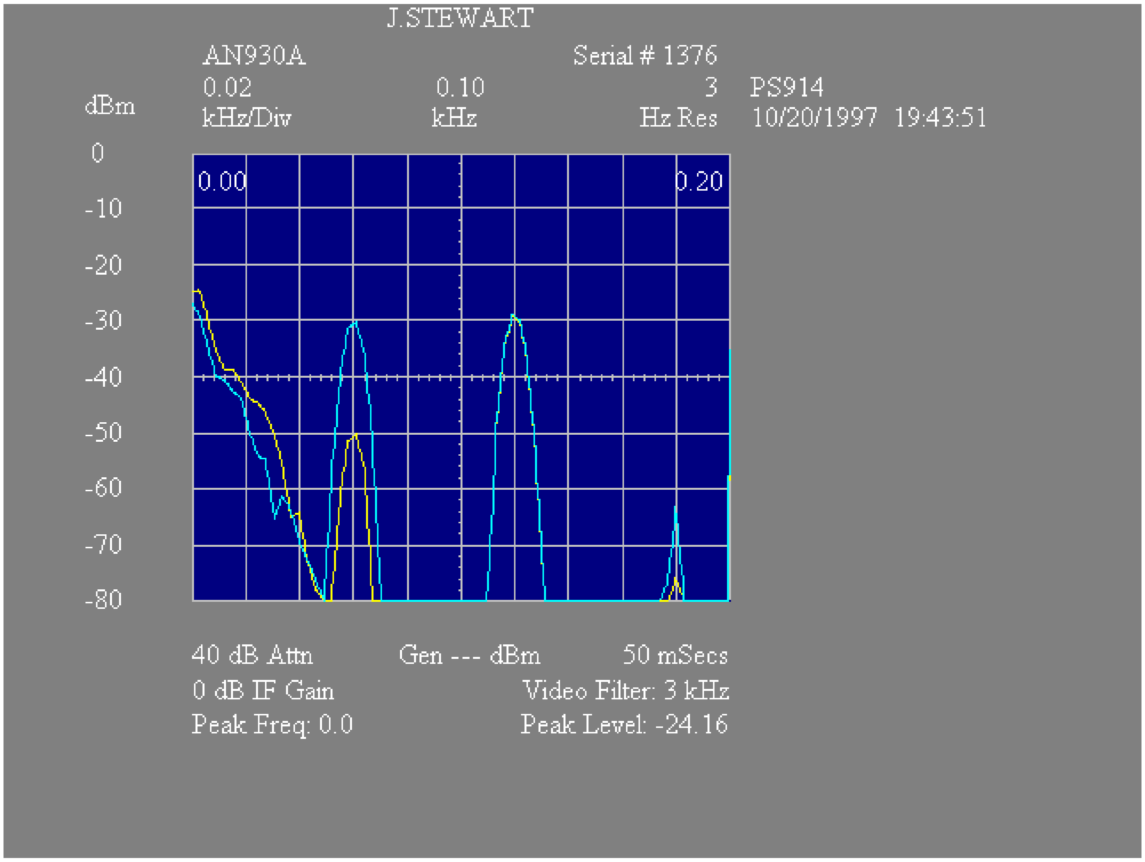
FIGURE 2. CHARGING PULSES SHOULD BE EQUAL AT TEST POINT C.

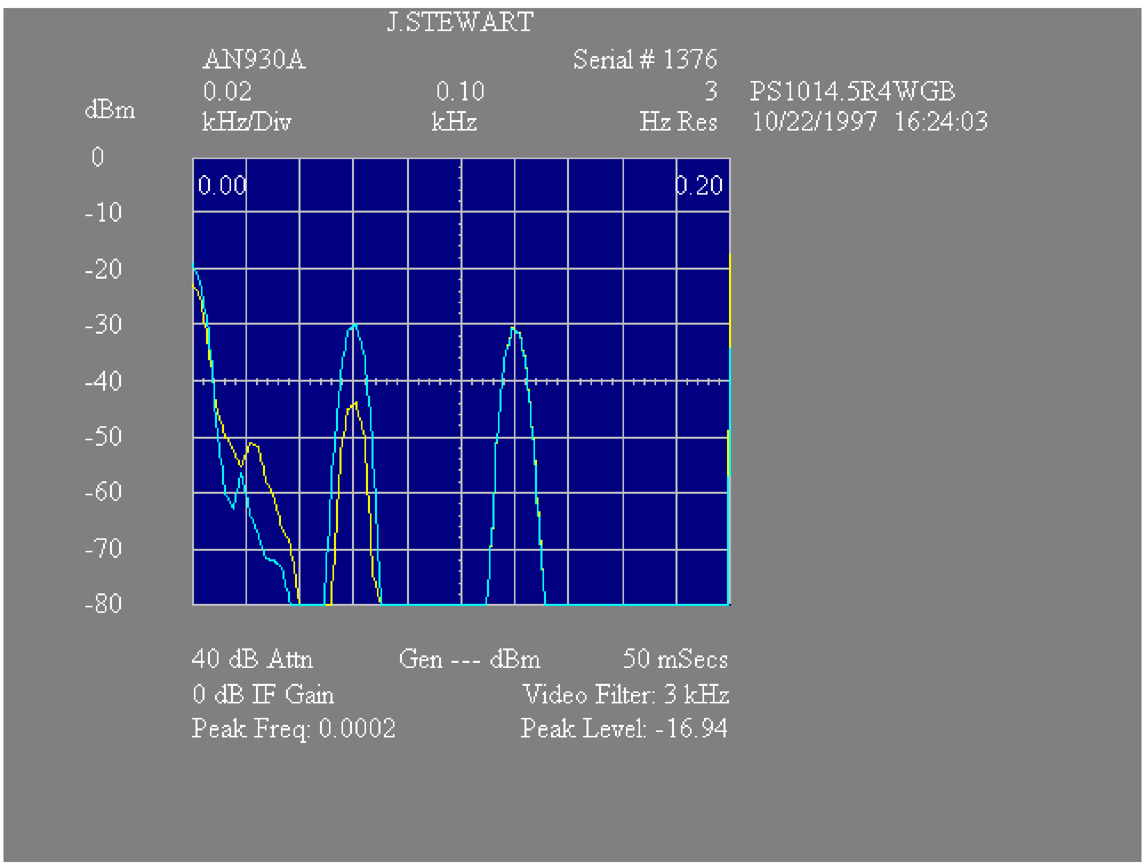




Supply
273 BZ
5V
R1
10Ω
R2
20Ω
WW
R3
30Ω
8
6
4
40 ohms
38 ohms
B1
B2
TPA
TPB
TPC
L1
156R
1.5H 200mA
LOAD
C1
40μF
C2
35μF
C3
C4
R4
1Ω
6.3V

FIGURE ONE


J.STEWART
AN930A
Serial # 1376
0.02
0.10
3
PS914
dBm
kHz/Div
kHz
Hz Res
10/20/1997 19:43:51
0
-10
-20
-30
-40
-50
-60
-70
-80
0.00
0.20
40 dB Attn
Gen --- dBm
50 mSecs
0 dB IF Gain
Video Filter: 3 kHz
Peak Freq: 0.0
Peak Level: -24.16


J.STEWART
AN930A
Serial # 1376
0.02
0.10
3
PS1014.5R4WGB
dBm
kHz/Div
kHz
Hz Res
10/22/1997 16:24:03
0
-10
-20
-30
-40
-50
-60
-70
-80
0.00
0.20
40 dB Attn
Gen --- dBm
50 mSecs
0 dB IF Gain
Video Filter: 3 kHz
Peak Freq: 0.0002
Peak Level: -16.94