6BF5 vs. 6AQ5
in Collins 75S-3,B,C Receivers

Editor's note: Contributed by Jay Rusgrove in early 2014, this work brings some good data and factual info to the long standing suggestion that the 6AQ5 be substituted for the 6BF5 that runs so hot in our S-Line receivers. The facts show a rather substantial increase in distortion and a reduction in available gain and output power – as one might suspect. However, from an overview standpoint, this substitution works well in receivers where the filaments are not in a series string and practically, the ¾ watt available Pout is more than adequate for most rooms and good listening volume. I do not notice the distortion increase at normal volumes. . . . Let the facts speak and we thank Jay for this effort.

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A recent thread on the Collins e mail reflector suggested the possible substitution of a 6AQ5 in place of the 6BF5 audio output tube to reduce heat generation. There's no denying that the 6BF5 runs HOT in those receivers! The tube manual specifications, recommendations and curves indicated a significant difference between the two tubes. A 75S3-C and the test equipment necessary to make the measurements was handy so I decided to collect the data.

Details of the test setup are as follows: receiver audio output (4-ohm speaker jack) was terminated with a non-inductive resistance of 4 ohms and a scope across the resistor monitored the output power level. An HP339A distortion analyzer was used to measure frequency response and total harmonic distortion (THD). Audio output from the 339A audio generator was applied to the cw sidetone jack (a convenient entry point into the audio system) and the 339A analyzer to the 4-ohm load resistor.

Three each 6BF5 and 6AQ5 that tested good on a TV-7D/U were used for the tests. All three tubes of a given type produced essentially identical results. Voltage and resistance checks on the receiver audio stages were normal.

The first test compared amplifier gain. The audio signal generator of the HP339A and receiver volume control were set and left in position while swapping tubes (turning the receiver on and off, of course).

The 6AQ5 consistently showed -6dB relative to the 6BF5.

The second test compared audio frequency response. Results were virtually identical between the two tube types with a fraction of a dB difference here and there.

Audio Frequency Response:

Tube	100 Hz	200 Hz	400 Hz	600 Hz	800 Hz	1 kHz	2 kHz	3 kHz	4 kHz	5 kHz
6BF5	-3 dB	-1 dB	0 dB	0 dB	0 dB	0 dB	0 dB	-1 dB	-2 dB	-3 dB
6AQ5	-3 dB	-1 dB	0 dB	0 dB	0 dB	0 dB	0 dB	-1 dB	-2 dB	-3 dB

The next test was for Total Harmonic Distortion (THD) and was measured at 1 kHz at a number of different power levels. Other frequencies were spot checked and found to be in close agreement with the measurement at 1 kHz. Maximum 'usable' output is in the eye (or ears) of the beholder ... but THD levels above 10% are noticeable to most listeners.

Total Harmonic Distortion (THD):

Tube	.125 W	.25 W	.5 W	1 W	1.5 W	2.5 W
6BF5	2.0%	2.5%	4.0%	6.3%	11.2%	15.9%
6AQ5	11.2%	15.9%	22.4%	-	-	-

The 6BF5 topped out at just shy of 3 watts with significant levels of distortion. The 6AQ5 topped out at about 0.75 watts, again with significant levels of distortion. Roughly .5 watt of audio power into a Collins 4 ohm speaker produces adequate volume for an 'average' room.

The final test looked at distortion when using headphones only. Headphones of choice here are the Sony MDR7506. With both earpieces in parallel the impedance is approximately 35 ohms. With these headphones, milliwatts of power produce ample volume for normal listening. Not surprisingly, both tubes performed well at these low power levels with THD measurements in the 2% or less range.

It's possible that circuit modifications could be made to improve the performance of the 6AQ5 in these receivers, however that is beyond the scope of this project. Based on the measurements I'm planning to stick with the 6BF5 audio output tube.

de W1VD, Jay Rusgrove

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Related test and non-invasive modification of 6AQ5 Bias with tack in resistor:

Suggested by Dick, W5IU in an email: Jay responds to Dick's suggestion to slightly change the stage bias with a tack-in resistor

(Jay wrote to Dick)

Thanks for your input.

Since the test setup was still in place it was easy to make the bias change and run the measurements again. I tried several values of resistors and 390k worked best for 'centering' the waveform so that onset of clipping was equalized top and bottom of the waveform. Test results are as follows:

Gain: 6AQ5 gain -5 dB when referenced to 6BF5

Frequency response: same

THD:

.125 W 3.6%

.25 W 4.5%

.5 W 8.0%

.75 W 15.6%

Maximum output power only slightly higher

It's apparent that the bias change is worthwhile in reducing THD when using a 6AQ5. If it's okay with you I'll add this information to the webpage giving you credit for the modification.

Jay W1VD