Ken Stone CGS65 Tube VCA Mods by PrimateSynthesis:

I recently completed construction and initial testing of the CGS tube VCA using a 1SH24B tube. I built it in MOTM-format using a panel and bracket from Bridechamber.

The version I built is different than the original circuit. In order to avoid damaging the PCB from excessive unsoldering, I did not first build a stock unmodified version for comparison purposes. From what others had said, there were three issues: the output was noisy, there was a "high-pass effect" or "loss of bass", and there was a "thump" during the attack of the EG when used as a VCA. These modifications address those issues.

1. Remedy the noisy output
LED's are very noisy. Since the cathode is in the signal path, I eliminated the two signal diodes, the two LED's, and their 1.5K resistors. I connected a 1.2K 1/2W resistor between Pin 1 of the cathode-heater and ground.

2. Remedy the high-pass filter
In Ken's original circuit, the grid capacitor forms a high-pass filter with the (330K) grid resistor in parallel with the grid resistance of the tube. The grid resistance of the 1SH24B is specified as 100K. So the resulting corner frequency with a 220nF cap would be 9.4Hz -- not high enough to cause a problem, imho. However that specification is when the cathode-heater is run off 1.2V, which is not what we are doing here, so therefore the grid resistance is unknown. So I increased the two 220nF coupling caps to 470nF.

At audio frequencies, the effective impedance of the plate is the plate resistor (8K2) in parallel with the load resistor (100K). Imho, coupling caps sound better driving lower impedances. So I changed the plate resistor to 20K and the load resistor (connected to pin 5 of the OP275) to 33K. 20K||33K = 12.5K yielding a bit more gain than the stock circuit.

I was out of TL072's. In order to use a fast op-amp (which would not be an LM358 or LT1013) to drive the grid capacitor that was better suited for audio, I replaced it with an OP275. The OP275 requires power bypassing to operate within specification, and the stock 100nF bypass caps are too far away to be effective. Also, the stock 100nF cap on the positive supply looks like it forms ~15kHz LPF on the tube output. So I eliminated those caps, and underneath the PCB, added two .1uF ceramic caps with heat shrink tubing going from ground, with the capacitors as close as possible to the power pins on the socket.

The OP275 is designed to drive capacitive loads without requiring a feedback capacitor, and works better as a non-inverting amp if the parallel value of the gain resistors are less than 2K. So eliminated the 47pF cap. Originally, I simply replaced it with a resistor lead, and omitted RG. Later, I changed this for more gain, as posted below. The new values are shown on the schematic.

If I used a TL072, I would have made both RG and RL ten times as much.

While 330 Ohm is the minimum specified resistor for output protection of a TL072, and the OP275 has built-in protection against its output shorted to ground, I replaced it with 1K (outside the feedback path) to have the same output impedance as MOTM.

However, I do not think the "high-pass effect" noticed by others was largely due to the coupling caps. I think it was due to cathode depletion -- negative feedback that increases with lower frequencies. So I added a cathode bypass capacitor -- a 47uF axial electrolytic -- connected it between pin 2 of the tube (connected to the negative rail) and ground. Do not connect it to the ground side of the cathode or the in-rush current could burn out the heater.

While it likely varies from 1SH24B to 1SH24B, the tube I have installed is more than a bit microphonic. Clicking the bias switch is enough to produce ringing. So I stuffed some anti-static foam in between the tube and the board to minimize vibration.

These modifications seem to have worked very well. Without an input, the output is very quiet. I don't notice any noise, hiss, or hum.

While the LPF in the CV circuit is the same as the stock circuit, the cathode bypass cap improves the transient response of the tube itself. It seems likely that rapid changes in voltage on the control grid (eg. an envelope with a steep attack) would cause a sudden demand for plate current enough to deplete the cathode (if it were not bypassed), which then bounces back causing an unwanted noise.

3. Remedy the EG attack thump
There is a bit of a pop or click with a fast envelope, although it is not any worse than most solid-state VCA's. Changing the signal grid bias, and switching between the two settings, also effects its CV response. As such, it is possible to all but eliminate any bleed, such that there is only a boost at the initial transient for punchy basses and leads. I found this while experimenting with different values. It would increase the distortion from the "clean" setting, but it would still be a very nice feature. I might add that with a SP3T switch.

For those building this in other formats that might have he extra space, putting a bias rheostat on the panel would be a nice feature. Using a reversing attenuator for the second input/feedback control is another option, as negative feedback is also useful.

So with these modifications there is very little noise, sufficient bandwidth, and it works fine both as a "regular" VCA and a distortion/waveshaper module.

4. Other mods
a) I decreased the CV input resistor to 50K so a 0-5V EG it has about the same range as the Gain knob.

b) I wired up the SPDT bias switch -- using properly shielded cable -- to two settings:

For the "clean" setting, I wired a 1M pot as a rheostat to -Ve, then adjusted it by ear. After I found the appropriate range, I added a 20K multi-turn trimmer to the board. There is an area with some writing without any traces to the right of the -Ve hole for the stock 330K resistor, where I drilled two extra holes. With a roughly 10Vpp source, such that there is about 3.4 VAC RMS on pin one of the OP275, with the gain and input knobs at maximum, the adjusting the trimpot for almost no distortion resulted in around 1K. Although knowing that, I wouldn't use a fixed resistor as setting it just right requires a trimmer, imho. Three things are happening as resistor value becomes lower: the grid becomes more negative, the level of the AC signal decreases, and the frequency of the high-pass filter increases. As such, there is some loss of bass, which rolls off gently at low frequencies. With or without a signal, the grid bias is equal to -15V, due to the low impedance.

I would suggest using a 100K multiturn trimmer instead -- that way you could adjust a "clean" setting with the input potted down a bit for slightly better bass response. You also might want to try even larger values for the coupling caps.

For the "distortion" setting, I found that a smaller resistor to ground produced more distortion, but was far less interesting with feedback. Having a rheostat on the panel (for either setting) wouldn't be a bad idea for those of you building this in a format that has the extra panel space. So I arrived at a compromised setting of 475K. It produces obvious distortion, and still produces oscillations at various input and feedback settings. The low frequency response is well below the audio range. The AC voltage on the grid is about 3.3 RMS. With a signal the grid measures around -17.6 VDC (it varies with its frequency), and without a signal the bias is around -14.1V.

Regardless of the signal level on the grid, or the bias switch setting, the output of the tube, and therefore the module, is a bit below 1V RMS, as it seems that is the saturation limit of the tube. So while the signal on the grid is much higher for the distortion setting, the difference results in just that -- distortion. In fact, the "clean" setting measures just a bit more, although the "distortion" setting sounds louder to to the additional harmonics. Now 1V RMS is only about 2.8Vpp. Although it is enough on the mixing board, I might change the gain and feedback resistors to 2K (resulting in about 5.6Vpp) if it seems too low to work well with my other modules.

The suppression grid was connected to the negative rail.

c) After spending more time using the tube vca, I found the output was not high enough to work well with other modules. So I changed the feedback resistor of the output amp to 2.2K and added a 1K gain resistor resulting in an output of around 8.6Vpp. This also improved the range of sounds when using feedback (I normalled the output to the second input using a switched jack).

I used Bournes conductive plastic 50K linear pots for all four knobs.