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The Collins KWM-2: Curing T/R Switching Transients

Unexpected Service Bulletin Side Effects

When I am in a QSO using my KWM-2 and when I switch from receive to transmit, either by VOX or PTT, my partner will hear a click and bump. This noise may be masked by my first spoken syllable and it sounds a bit like mechanical noise from the relays, entering via a microphonic tube. But even when I set the Mic Gain control to "off", it is still noticeable and a bit annoying, unless we take it as a special characteristic of this fine piece of Collins equipment.

Where does it come from? Well, most of the KWM-2's circuits come from the separate 32S-1 transmitter and 75S-1 receiver, but you won't find this click and bump sound there. So the root cause must lie in the receiver-transmitter switching circuits within the KWM-2.

But, didn't they find this when they designed the KWM-2? Oh yes, they did. And they designed a remedy into its circuits: C264, R176, R177 and CR10 in the anode supply of V3A.

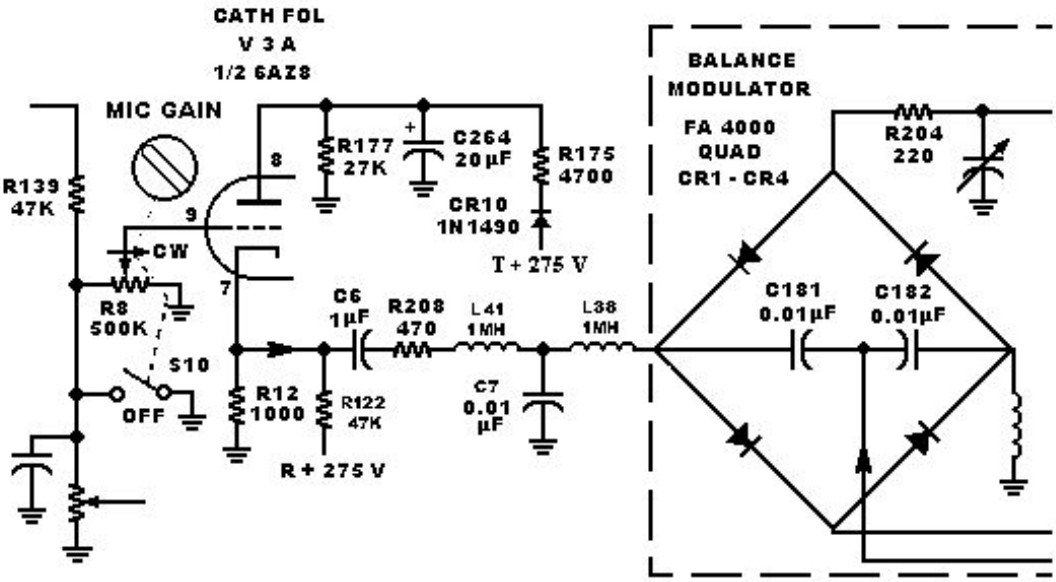

Fig. 1 Components around V3A in a Collins KWM-2

Let's look at the circuit diagram in Fig. 1 and temporarily pretend that C264 and R122 are not there. First, in receive mode, the junction of C6 and R12 in the cathode of V3A is at zero volts. After switching to transmit, V3A gets its anode voltage from the T+275V supply, immediately starts to draw current through R12 and quickly charges C6 from zero to a few volts. This causes a large bump that goes via R208, L41 and L38 directly into the balanced modulator, and from there it gets converted into an RF signal at the PA output.

You can clearly see this in Fig. 2. This oscilloscope trace has been triggered when the PTT line was actuated. The trace below shows the voltage at the cathode of V3A. After about 12 ms, when the T+275V supply has been switched on, it quickly rises from zero to about 8 volts. The upper trace shows the RF output into a dummy load. You can see a corresponding signal spike of about 5 ms duration, which has full peak-to-peak PA output.

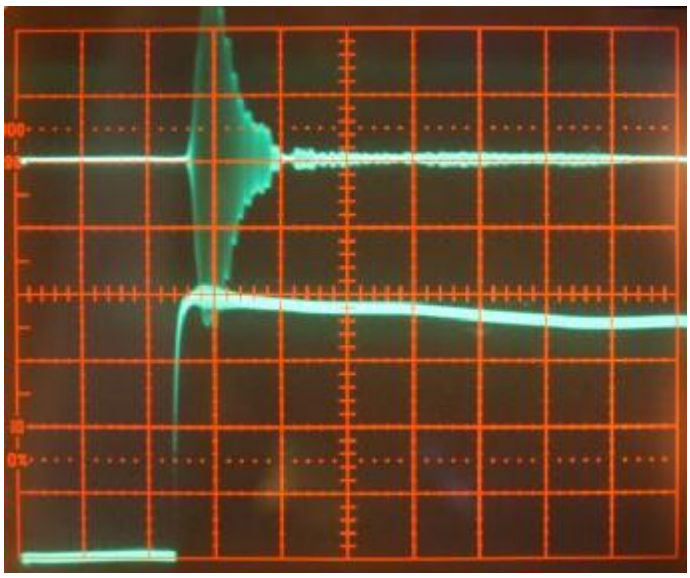

Fig. 2 RF output (top) and voltage at cathode of V3A (bottom),
when switching from receive to transmit,
Mic Gain off, **without C264 and without R122**
horizontal resolution 5 ms / division

When you compare the circuitry in Fig. 1 (without C264 and R122) with the corresponding circuit in a KWM-1, you can see that this bump is probably also present in a KWM-1. So at design time for the KWM-2 this effect must have been known and a remedy was searched for. As a consequence C264 and R176 have been put in the anode circuit of V3A. Now, when the T+275V line is switched on, the anode voltage of V3A is rising much slower and the current change through R12 is also slowed down. Thereby the bump into C6 is reduced. The result can be seen in Fig. 3.

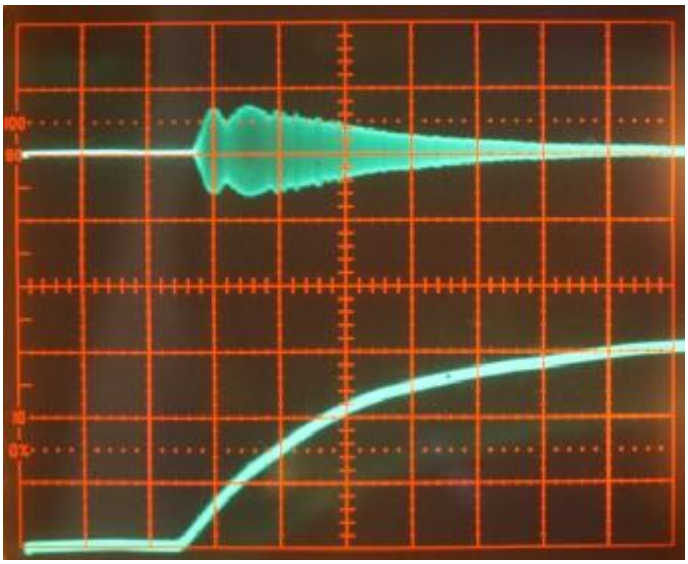

Fig. 3 RF output (top) and voltage at cathode of V3A (bottom),
when switching from receive to transmit,
Mic Gain off, **with 4µF for C264 and without R122**
horizontal resolution 5 ms / division

Initially C264 had a value of 4µF, which must have been a compromise between slowing down the current increase through R12 and at the same time preventing a new side-effect that happened when the KWM-2 was switched back from transmit to receive. The charge on C264 keeps the T+275V supply line high for a short moment, when the R+275V receiver supply is already on. And although R177 has been added to quickly discharge C264, the small remaining charge is enough to cause regeneration around receiver stages. This oscillation can easily be seen at the anode of V3B, the second IF amplifier (see Fig. 4).

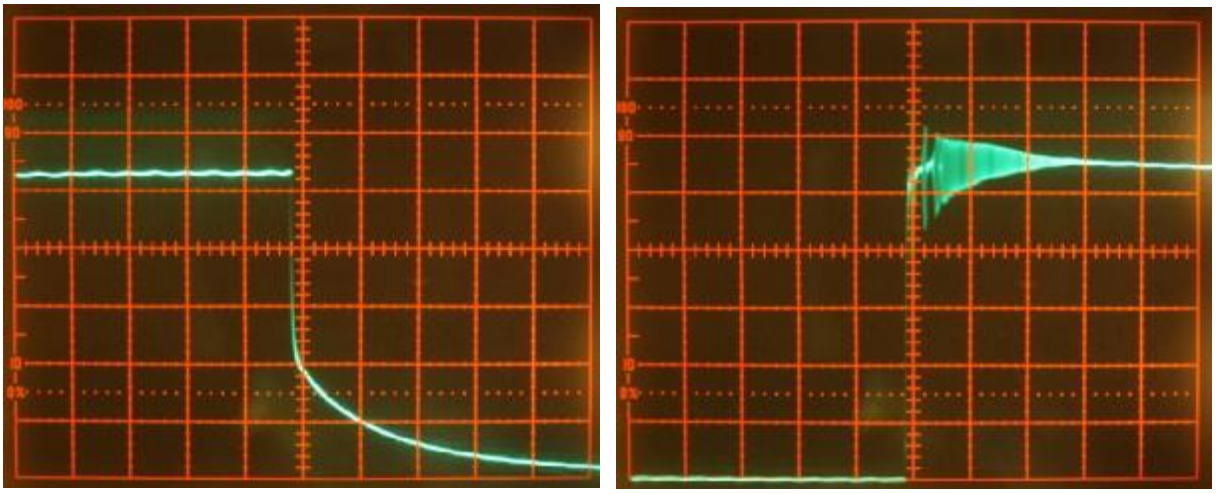

Fig. 4 Voltage on T+275V line (left) and voltage at anode of V3B (right),
when switching back from transmit to receive,
Mic Gain off, **with 4µF for C264 and without CR10**
horizontal resolution 20 ms / division

Of cause, this oscillation enters the AVC circuit and causes the S-meter on my KWM-2 to jump to nearly S9, every time I switch back from transmit to receive.

This adverse effect was only cured after diode CR10 was introduced in October 1965 by Amateur Service Agency Bulletin ASAB 1016. Now the charge on C264 can no longer flow back unto the T+275V line and it is therefore possible to increase C264 to the later value of 22µF. This further reduces the bump into C6 and in the RF output, as can be seen in Fig. 5.

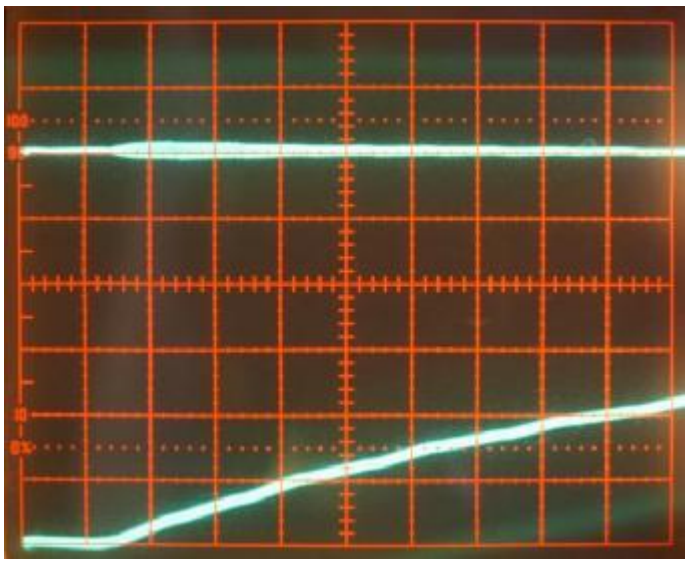

Fig. 5 RF output (top) and voltage at cathode of V3A (bottom),
when switching from receive to transmit,
Mic Gain off, **with 22µF for C264 and without R122**
horizontal resolution 10 ms / division

Not a bad result, but why does my KWM-2 still exhibit such a loud noise in the output when I switch from receive to transmit?

Again, let's look at the circuit diagram in Fig. 1. There still is R122, connected between the R+275V supply line and C6. This resistor was introduced in May 1961 by Amateur Service Agency Bulletin ASAB 1006 to prevent an "audio squeal" when switching from transmit to receive. R122 is supposed to put a positive voltage on the cathode of V3A in receive mode, thus better cutting off V3A and preventing possible audio feed through.

The service bulletin further states "This change will have no effect on the audio voltage to the vox circuitry." That is certainly true, but there is another effect and it seems that it was not detected at that time, nor any time later.

Here is what happens when a KWM-2 switches from receive to transmit, step by step:

- First relay K2 is activated and switches over. It first activates the RX mute line.
- On closing, K2 releases the TX mute line and activates relays K3 and K4.
- Then, after about 10 ms, the armature of K4 starts to move and first cuts off the R+275V receiver supply.
- And then, after a further 2 ms, K4 switches the T+275V transmitter supply on. This supply also feeds the PA screen grids.

What happens on C6?

- Before K4 is activated, C6 is charged to about 5V via R122 from the R+275V supply.
- Then, 10 ms after K2 is activated, when K4 starts to move, R122 loses its R+275V supply. So C6 is quickly discharged by R12 with a sharp negative transient.
- Then, a further 2 ms later, the anode voltage for V3A slowly comes on and the current through V3A and R12 again charges C6 to a few volts with a relatively slow positive transient.

As TX mute has already been released when K2 closes, the bumps and noise caused by these two transients at C6 are delivered to the PA. Luckily, the PA only starts working when its screen supply is established by K4. So the very first part of bumps and noise is cut off, but the largest part still gets out to the antenna.

Fig. 6 is a further oscilloscope screen shot that shows the result. You can clearly see the new sharp negative transient at C6 and the corresponding large click at the RF output, which on my KWM-2 has about 60% of full peak-to-peak output.

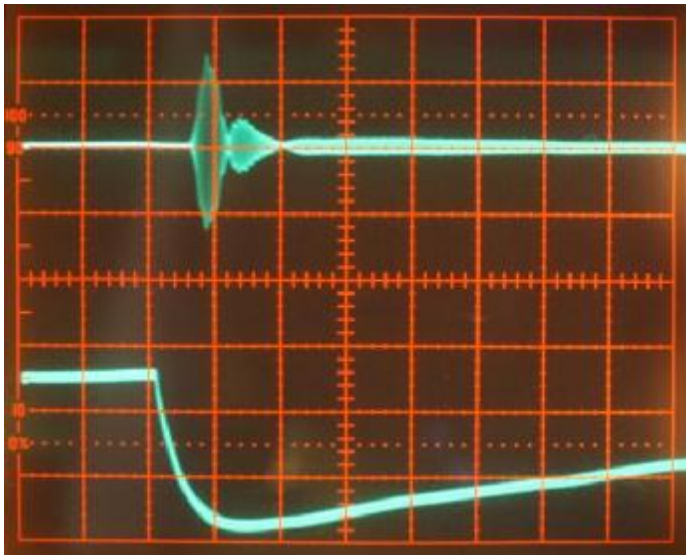

Fig. 6 RF output (top) and voltage at cathode of V3A (bottom),
when switching from receive to transmit,
Mic Gain off, **with 22µF for C264, CR10 and original R122**
horizontal resolution 5 ms / division

So the root cause for the bump noise is found: The addition of R122 according to ASAB 1006 may have solved one problem, but it clearly has aggravated a problem that once seemed to be solved.

Convinced? Then give it a try, remove R122 (47 KΩ) between V3 and turret E40. Check whether the problem described in ASAB 1006 exists for your KWM-2. If not - leave it that way. I can promise you, most of the noise when switching from receive to transmit will be gone. But also gone will be the click sound of a true Collins KWM-2, so it's up to you what you want.

In closing I should not forget to mention that the typical click at the end of a transmission, when releasing PTT with Mic Gain open, has a completely different story. This has been dealt with by Billy Burke, WA6Q, in Electric Radio magazine #260, January 2011.

Furthermore, I am grateful that Serge, VA3SB, and Stefan, DO3SPR have taken their time to discuss my findings and confirm my measurements.

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