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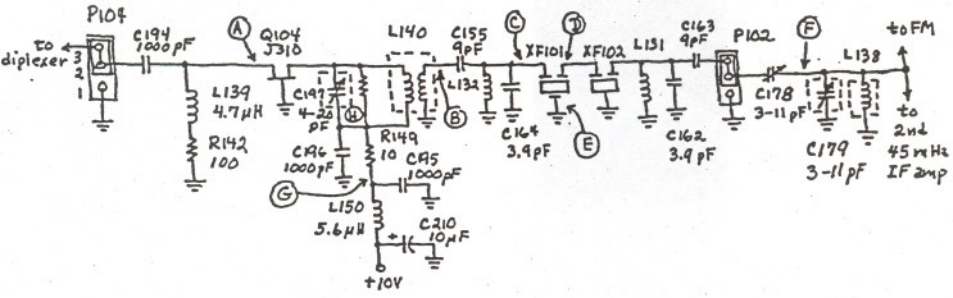
Drake R8: More On Improving Image Rejection

Dallas Lankford, 2 II 95

In my recent article (DX News, Vol. 61, No. 28 - July 18, 1994), "Drake R8: Increased Dynamic Range, Mod 2," I described how the 50 kHz image rejection could be improved from about 80 dB to over 94 dB by removing the R8 image reject circuit, and removing the 45 mHz crystal filter XF100 and moving it to just ahead of the 2nd mixer, SBL-1X. As I pointed out in that article, those changes to the image reject circuit and crystal filter were done in conjunction with a replacement of the 1st 45 mHz IF amplifier by a common base transformer feedback amplifier, and that it was not know whether the improved image rejection could be obtained without replacing the 1st 45 mHz IF amplifier. All of the mods mentioned above were done with prototype PC boards, which were anything but attractive. A few days ago I decided to replace the prototype PC board circuits with attractive and thoughtfully laid out PC board circuits, so that the finished circuits would be professional in appearance as well as performance.

You can imagine my surprise when I measured the 50 kHz image rejection of my R8 RF boards with their pretty new PC board mods and found that the image rejection at ±100 kHz had fallen off to about 86 dB. This caused me to make additional changes at various points in the 45 mHz signal path to determine why the image rejection was degraded, and how to restore the image rejection to over 94 dB. Based on a number of changes and measurements, which I will not relate here, the 94 dB or greater image rejection which I obtained previously was due in part to circuit layout and parts positions of the prototype PC boards. The solution to this problem, which will be described in detail below, involved removal of header plug P102 and development of a new matching network between the output of crystal filter XF102 and the high impedance 45 mHz IF transformer consisting of C179 and L138.



The original R8 45 mHz IF signal path from P104 to the 45 mHz IF transformer consisting of C179 and L138 is given above. If you compare the partial schematic sketch above with the R8 service manual schematic, you will notice three differences (1) the 4.7 H choke L139 and 100 ohm resistor R142 are reversed in my sketch above, to reflect the actual R8 RF PC board layout, and (2) C179 is shown with a shield, as is the case on the R8 RF PC board, and (3) C197 is also shown with a shield, as is the case on the R8 RF PC board.

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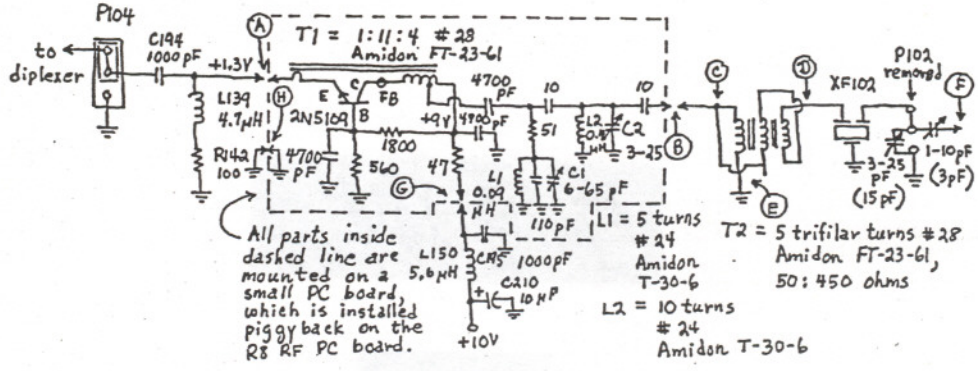
The final modifications to my R8 RF board (excluding replacement of the RF amplifier, removal of the image reject circuit, and addition of crystal filter XF101 immediately ahead of the 2nd mixer, which were described in detail in the DX News article mentioned above) are given below. Upper case letters A - H are given on both schematics for certain important reference points.



As can be seen, most of the original R8 parts between the junction of C194 and L139 and crystal filter XF102 were removed. C210, L150, and C195 were retained for the positive voltage feed of the new common base IF amplifier. The common base IF amplifier was built on a small PC board and mounted piggy back on the R8 RF board. The 47 ohm resistor shown on the common base IF amp board may alternately be mounted on the R8 RF board. Surface mount resistors and surface mount capacitors were used throughout the common base IF amp board to conserve space. Note that a ground connection from the common base IF amp board to the R8 RF board is required, and labeled point H on the modification schematic above (which is a ground pad for the shield of C197 which had been removed). Points A, B, and G are the other three connections required by the common base IF amp piggy back board. These four connections were made with short (about 0.50 inch) lengths of #22 solid tinned copper wire which had been press fitted into PC board pads of the common base IF amp board (so that the short wires would not fall out when they were soldered to the R8 RF board pads).

The 9 pF capacitors C155 and C163 were not present on my R8 RF board, and there were no PC board pads to accomodate such capacitors. Apparently these two capacitors existed only in some R8 prototypes, and were not included in any production R8's as far as I know.

And the two inductors L132 and L131 and two capacitors C164 and C162 were also not present on my R8 RF board. Instead, three surface mount devices (perhaps capacitors) were used in my R8. These three surface mount devices were removed.

Also, XF101, P102, C178, the shield of C179, and C179 were removed.

T2 was mounted one the R8 RF board in the holes vacated by XF102, a small jumper made from #24 solid tinned copper wire was added between the two indicated holes vacated by P102, a modified Mouser # 24AA0022 3-25 pF ceramic trimmer

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capacitor was added between the two indicated vacated holes of P102, a Mouser # ME242-1810 2-9 pF ceramic trimmer was added in place of C178, and a Mouser # 24AA021 2-14 pF ceramic trimmer was added in place of C179. The shield for C179 was not restored. When installing trimmer capacitors which are grounded at one end, be sure that the grounded end is the rotor lug. Drake production line workers did not always adhere to this standard practice, which can make peaking tuned circuits difficult.

Removal of some of the parts above, especially XF101 and P102, is not easy, and should not be attempted by a novice. I've said it before and I'll say it again, ChemWik Lite 0.100 desoldering braid is the only desoldering braid which works really well. The PC board holes and pads for XF101 are very small and easily lifted if too much heat is applied. I used a 23 watt soldering iron for all these modifications.

The PC board holes for P102 are also very small, so small that the lugs of a Mouser #24AA0022 3-25 pF ceramic trimmer will not fit. The lugs must be made smaller by cutting off the flanges and reducing the lug width with an India stone deburring stone. After the lug widths have been reduced, the lugs must be bent for the narrower spacing required.

Note on the modification schematic above that the 3-25 pF capacitor mounted at P102 and the 1-10 pF capacitor mounted in place of C178 should be set approximately to 15 pF and 3 pF respectively. This can be done before installation with a accurate capacitance meter, of after installation by setting the "plates" about half meshed for the 3-25 pF trimmer, and near minimum capacitance for the 1-10 pF capacitor. If the value of the 1-10 pF capacitor is set too low, C179 will not be able to peak L138 to as high as normal. The value of the 1-10 pF capacitor should be set as low as possible without reduction of signal level when C179 is peaked.

Two R8 RF boards have been modified in the manner described above. For one such modified R8 RF board, the 50 kHz image rejection (at ± 100 kHz) was 94 dB, and for the other R8 RF board, the image rejection was 97.5 dB. Such slight variation in image rejection from one RF board to another is to be expected because of variations in the 45 mHz crystal filters from one board to another.

As pointed out in the DX News article mentioned above, the original R8 image reject circuit was a bad idea because the amount of image rejection available from that approach depends on the geometry of the PC board layout and the geometry of the IF transformer windings, which in turn determines the amount of phase cancellation, and hence the amount of image rejection. Previously I thought I had avoided the phase cancellation problem with my modifications, but apparently that was not the case. Whether the above changes solve the phase cancellation problem is not known. I suppose it does not matter. My goal was to improve the R8 image rejection substantially, and that has been accomplished. Hopefully, these notes will provide the determined builder with sufficient information to duplicate my R8 image rejection improvements.