Treetop Circuits

Owner's Manual for PD3 Product Detector Version 8

The PD3 Product Detector *(Fig. 1)* from Treetop Circuits is designed specifically as an accessory for the Collins R-388 and 51-J series receivers. It provides enhanced performance in SSB and CW modes. Performance in AM mode is largely unchanged. A 12-volt DC supply for the receiver's muting relay is incorporated as an added convenience.

To maintain consistency with the receiver documentation, and in deference to the distinguished history of these receivers, we use 1950's terminology -- for example "megacycles", not "MHz" -- in this document.

The unit plugs into the radio in place of the detector/AVC tube V110 *(Fig. 2)*, and most connections are made through the tube socket. In addition, two wires are connected from the PD3 to the radio, three components are removed, and one wire moved. With the PD3 installed, all controls operate as before, but performance in SSB and CW modes is markedly improved.

To achieve this improved performance, the PD3 replaces the diode detector with a high-level product detector, and provides a fast-attack slow-return dual-time-constant AVC circuit patterned after late-production KWM-2's. These circuits are automatically switched in when the receiver's BFO is turned on. With the BFO turned off, AM detector and AVC circuits which closely mimic the original circuits are switched in.

The PD3 comes as a PC board, ready to install and operate.

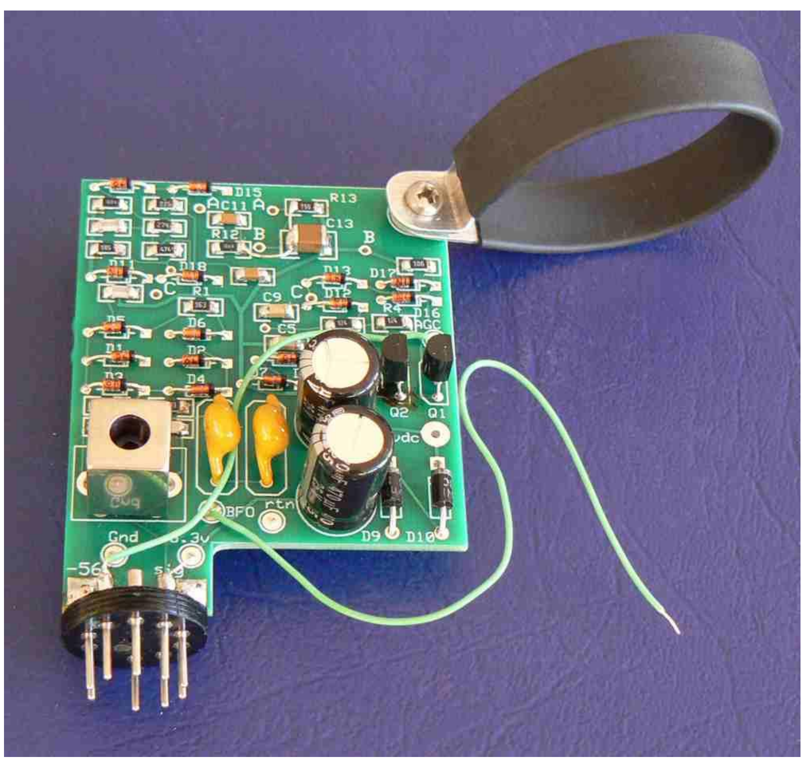

Fig. 1 –The product detector with clamp.

Fig. 2 – As installed in the receiver. The white wire supplies 12 volts to the muting relay. You can also leave it out, or route it below the chassis and solder to the terminal inside the receiver.

Degree of Difficulty
Installation will present no problem for an experienced technician or hobbyist. However, it does require some skill, and should not be undertaken as a "first project". If you are uncertain about this, the best bet is to read the instructions thoroughly and make sure you are comfortable with all the steps. Treetop Circuits can provide clarification on specific points, so please do not hesitate to e-mail. But please also bear in mind that there is no substitute for basic electronic skills and good workmanship. And as always, remember that ***voltages approaching 300 volts are present in this receive***r.

Before Proceeding
We recommend that you check our web page http://treetopcircuits.com/docs for the latest version of this manual. Do not hesitate to e-mail us at radio@treetopcircuits.com if you need assistance.

Preparing the Radio
The radio should be in good operating condition and properly aligned. If this is not the case, it is recommended that a performance check and alignment be performed before proceeding.

Complete documentation for the R-388A/51J-4 can be downloaded from the Collins Collectors Association website at www.collinsradio.org at no charge; this organization is authorized by Collins to disseminate Collins documentation. Membership is not required in order to access the website, the reflector, or other services. However, Collins enthusiasts are encouraged to join.

The BFO alignment instructions in parts 5.3.5 (g) and 5.3.6 of the Collins document ensure that the BFO is centered at 500 kilocycles. This is adequate for CW because it generally does not matter whether the BFO is above or below the IF passband. With an SSB signal, best performance requires that the BFO be placed on the correct side of the passband, and ideally just outside it. Correct settings can be found by trial and error, but these will vary in a complex manner from band to band.

The situation arises because these receivers use different conversion schemes on different bands, so the signal in the second IF is sometimes inverted and sometimes not. Also, by convention, the lower sideband is almost always used below 10 MHz and the upper sideband above 10 MHz.

To help resolve this situation, stickers are provided with the unit. These are applied to the skirt of the BFO PITCH knob *(Fig. 3, 6, and 7)*. You can use either the ham band sticker (yellow highlights) or the general coverage sticker (blue highlights), or both. The extra stickers provided are spares -- do not use two stickers of the same type together.

Fig. 3 – The BFO PITCH knob with stickers.

You can safely ignore the band designations on the stickers at this point. A detailed explanation is given in the section on Operation.

The easiest way to proceed is to remove the knob using the appropriate Bristol spline key. Cut out the sticker(s), as shown and apply to the knob skirt. You may need to give them a final trimming with a sharp knife. Orientation on the knob does not matter from a functional point of view, but you may prefer to align the yellow or blue radial line with the white line on the skirt for best appearance.

Alternatively, rather than remove the knob, you can leave it in place and apply the sticker(s) at the end of the procedure.

If you have access to a frequency counter with a high-impedance probe, you can skip steps 3 to 6 and instead measure the BFO frequency at pin 5 of V114. Remember to use a blocking capacitor. Tune the BFO PITCH control for the highest frequency, which should be around 503 kilocycles, and fasten the knob in the position shown in *Fig. 3*. The BFO range should be roughly 497-503 kilocycles.

1. Set the receiver controls as follows:
   CRYSTAL FILTER SELECTIVITY – *0*
   CRYSTAL FILTER PHASING – *CENTERED*
   BFO – *ON*
   Mechanical Filter (R-388A and 51J-4 only) – *6 KC*
   OFF–STANDBY-ON – *ON*
   RF GAIN – *10*
   CALIBRATE – *ON*
   AVC – *OFF*
   LIMITER – *OUT*
   AUDIO GAIN – *ADJUST AS REQUIRED*
   BAND CHANGE –*3.5–4.5 MEGACYCLES*

2. If you removed the knob, put it back on and temporarily tighten one setscrew. Orientation doesn’t matter at this stage. Disconnect the antenna and tune across the band. You should hear a tone from the calibrator near each 100 kilocycle point.

3. Tune to approximately 3820 kilocycles, then tune down slowly until you hear a high-pitched tone. To confirm that this is the calibrator signal, turn the CALIBRATE control off. The tone should disappear. Turn the CALIBRATE control back on.

4. Tune as needed until the tone is fairly high. Adjust the BFO PITCH to increase the pitch slightly. Adjust the main tuning slightly to keep the pitch in the audible range. Continue to adjust these controls alternately, in small increments, until the BFO PITCH control will not increase the pitch any further.

5. To check, tune up to 3820 kilocycles again and tune down until you hear the high-pitched tone. Move the BFO PITCH control back and forth slightly to make sure that you have the highest possible pitch.

6. Now, being careful not to rotate the shaft, loosen the setscrew so the knob rotates freely. Rotate the knob to the position shown in *Fig. 3* and tighten both setscrews. Alternatively, if you did not remove the knob, apply the sticker(s) in the position shown in *Fig. 3*.

Installation

Unplug the receiver from the power source. Do not trust the switch.

Refer to *Fig. 4* and *Fig. 5* for the following steps.

Be particularly careful not to contact the insulation on the wires with the soldering iron. It melts and burns more easily than modern insulation.

Remove or disconnect C206 (the small capacitor from V114 pin 5 to V110 pins 6 and 7).

Remove or disconnect C204. (100 pF capacitor from pins 6 and 7 to pin 3 of V110).

Remove or disconnect R145 (100k resistor from pin 3 to pins 1 and 2 of V110).

Disconnect the wire from C205B (the middle terminal on the triple capacitor at lower center in *Fig. 4*). The best way to do this is to clip the wire next to the terminal. Then clean up the terminal. Otherwise, the insulation will overheat and turn into a sticky mess as you try to get the wire off the terminal. Strip and tin the end of the wire and connect it to V110, pin 3 (red-white-blue wire in *Fig. 5*). This leaves C205B disconnected and shorts out R144. There is no need to remove these components.

Remove V110 and its shield. In most radios, the shield base can remain in place, but remove it if there is insufficient clearance. Mount the clamp as in *Fig. 1*. The lockwasher goes under the nut. Remove the hold-down from the large capacitor and slide the clamp down over it as you seat the PD3 in the socket. Tighten the clamp and replace the hold-down.

Route the short green wire through the chassis as shown, and connect to V114, pin5.

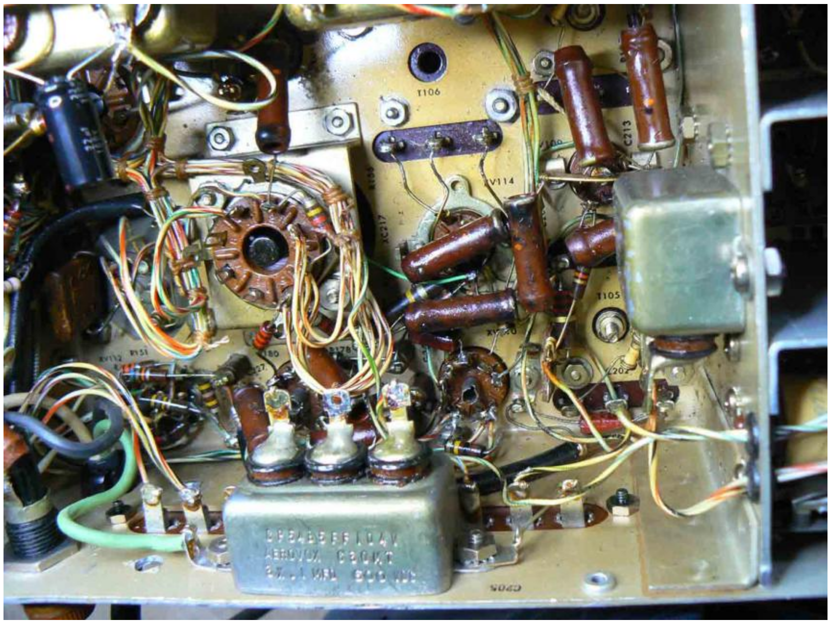

Fig. 4 –The wire has been removed from C205B (the middle terminal on the triple "bathtub" capacitor near bottom center). You can also see the green wire from the PD3, which has been routed beside the large filter capacitor (in the octal socket) to V114, pin 5.

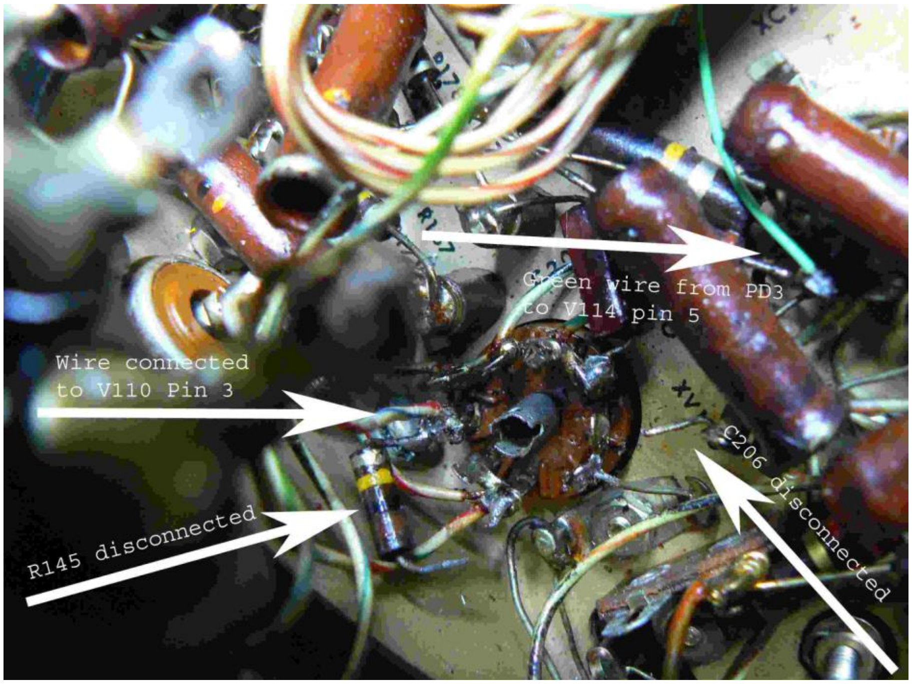

Fig. 5 – The red-white-blue wire that was disconnected from C205B has been connected to V110, pin 3. The green wire from the PD3 is connected to V114, pin 5. C206 and R145 are shown disconnected but not removed. C204 has been removed.

If you want to use the 12-volt supply to operate the muting relay K101, connect a wire from the 12vdc point on the PD3 to terminal 3 on "REMOTE" terminal strip E101 on the rear of the chassis (*Fig. 2*). This wire can be routed below the chassis and soldered to the terminal, or brought through one of the slots in the side of the receiver and fastened under the screw on the terminal strip. With this in place, a ground applied to terminal 2 (typically from an associated transmitter) will mute the receiver. Please note that this relay does not replace the antenna relay in the transmitter.

Operation
Now you can connect an antenna and try it out.

Operation of the receiver is mostly unchanged. In particular, AM operation is completely unaffected. On SSB, the receiver will be much easier to operate. In most situations, you can leave the RF gain turned up and the AVC on. It will no longer be necessary to "ride" the RF gain control.

The band designations on the BFO pitch knob are mostly self-explanatory, but the following notes may be helpful.

The sticker with yellow highlights is marked for the ham bands. Setting the knob according to the sticker automatically selects LSB for bands below 10 megacycles, and USB above 10 megacycles. Since portions of the 10 meter band fall in three different bands in this receiver, things get a bit more complicated. The portion from 28 to 28.5 megacycles is designated 10A, the portion from 28.5 to 29.5 megacycles is 10B, and the portion from 29.5 to 29.6 megacycles is 10C.

If you never need to listen to SSB outside the ham bands, you can skip the next two paragraphs, and ignore the "blue" settings. But they'll come in handy if there's an interesting SSB signal around (for example) 13 megacycles.

To provide for general coverage, we take advantage of the fact that there are actually two positions of the BFO PITCH control which will produce a given frequency. The sticker with the blue highlights uses these "extra" positions. The section marked "3, <10 EVEN, >10 ODD" is used for Band 3 (2.5 to 3.5 MHz) and for bands 2, 4, 6, 8, and the lower half of Band 10. This automatically gives LSB operation. Above 10 MHz, USB is normally used, so the same setting would be used for odd Bands 11, 13, …..29.

The other section of this sticker applies to bands 1, 2, 3, 5, 7, 9, the upper portion of Band 10, and Bands 12, 14, …..30.

You'll need to establish the best BFO PITCH settings for your particular receiver. To get started, turn the SELECTIVITY control to 0 and set the mechanical filter switch (if present) to 6 kc. Turn the AVC and BFO on. Choose a band where there will be lots of SSB signals, and set the BFO PITCH control to the position shown in Fig. 3, or the diametrically opposite position, depending on the band you're using. For instance, on 20 meters, you'd use the opposite position. With a bit of careful tuning, you should be able to receive SSB stations. You'll find the tuning a bit more critical than with many receivers; this is because the tuning rate is 100 kilocycles per revolution, as opposed (for instance) to 25 in the Collins S-line radios.

With these settings, the BFO PITCH adjustment is not very critical. However, you'll want to be able to use the crystal and/or mechanical filters in crowded band conditions. In general, as you move to narrower bandwidths, you will find that the best setting is closer to the center of the range, as in Fig. 6 or 7.

Fig. 6 – A typical ham-band setting for a narrow-band filter.

Fig. 7 – This setting actually produces the same result as Fig.. 6. You'd use it for Band 13, which is >10 megacycles and odd-numbered.

The required setting is a function of the filter, not the band. So once you've found the best point for, say, 80 meters with a given filter, the same setting will work for the other bands in the same portion of the label.

Circuit Description:
In the following description, references to components on the PD3 circuit board are shown in bold (**C1**, etc.), and those in the receiver are in normal text.

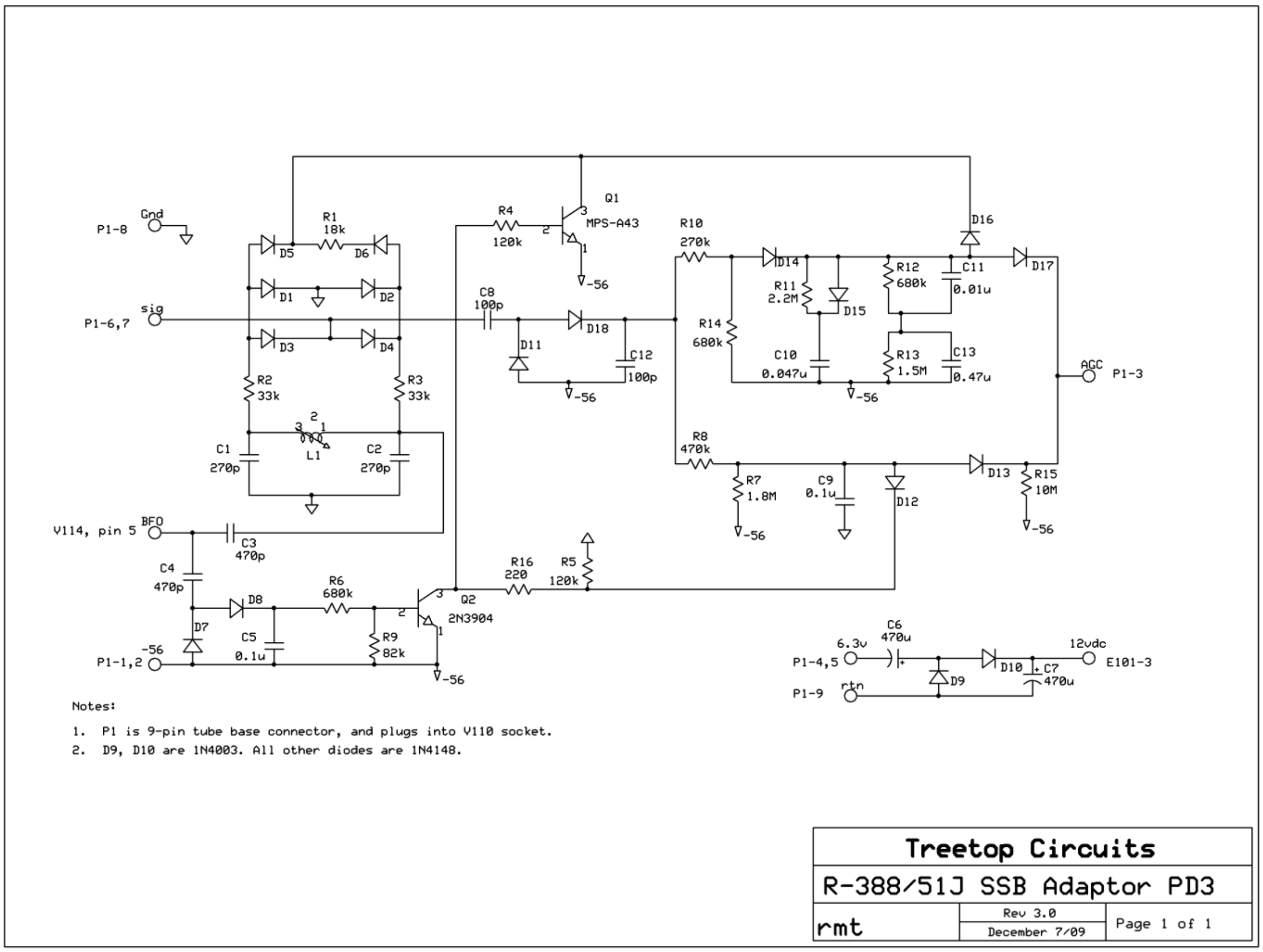

Fig. 8 – PD3 schematic.

The signal from the IF amplifier comes into the PD3 on pins 6 and 7 of **P1**. The BFO signal from the plate of V114 comes in through a wired connection, and the –56 volt supply from the receiver comes in via pins 1 and 2 of **P1**.

In SSB or CW reception, the BFO voltage is applied via **C4** to a doubling rectifier which keeps **Q2** saturated as long as the BFO voltage is present. This keeps **Q1** cut off so that **D5** and **D6** do not conduct.

Diodes **D1-D4** and associated components form a high-level single-balanced mixer. The BFO voltage (about 35 volts RMS, 497 to 503 kilocycles) is applied via **C3** to the resonant circuit consisting of **C1**, **C2**, and **L1**. **C3** blocks the DC component, so the voltage on **C2** swings above and below ground. Due to the resonant circuit, the voltage on **C1** is equal to that on **C2** but in opposite phase. When the voltage on **C2** is negative, the voltage on **C1** is positive, so current flows through **R2**, **R3**, and **D1**-**D4**. This forces the IF signal line to ground. On the alternate half-cycle, diodes **D1**-**D4** are reverse-biased, so they present an open circuit to the IF signal. The path from ground via pins 1 and 2 and T105 to C202 is thus interrupted at the BFO rate, causing the demodulated audio signal to appear on C202.

If the BFO is switched off, **Q2** goes into cutoff and **Q1** saturates, applying nearly –56 volts to the anodes of D1 and D3 so they do not conduct. Current flows through **D6** and **D2** to ground. Additional current flows through **D2** to ground via the path **D5-R2-L1-R3**.This keeps its cathode, and the cathode of **D4**, at an essentially constant voltage of about 0.7 volts below ground.**D4** then acts as a pre-biased diode detector, replacing one section of V110 as an AM detector.

The AVC signal is developed using a doubling rectifier consisting of **D11**, **D18**, and associated components. The resulting roughly-filtered AVC voltage is applied to the AM time-constant circuit via **R8** and also to the SSB time constant circuit via **R10**. The unwanted time-constant circuit is shorted to –56 volts via **D12** and **Q2** (in SSB mode) or **D16** and **Q1** (in AM mode). The appropriately filtered AVC voltage is then applied to the AVC amplifier V111 via **D17** or **D13**.

The SSB time-constant circuit approximates the circuit used in late-model KWM-2's, with **D14** providing the fast-attack slow-return feature. Due to the presence of the AVC amplifier with its sharp threshold and high gain, overall circuit behavior is, inevitably, substantially different from the KWM-2; however, good results are obtained in a wide variety of situations. In AM mode, the attack and decay time constants are nearly symmetrical and roughly equivalent to the original circuit.

The voltage dividers **R10**/**R14** and **R8**/**R7** are set so that the AVC regulates the signal at a somewhat lower level than the original. This reduces the probability of overloading the product detector on fast signal peaks, and linearity on AM is slightly improved.

The +12 volt DC supply for the muting relay is derived from the 6.3 volt AC filament supply by a doubler consisting of **D9**, **D10**, **C6**, and **C7**. The RTN connection goes to ground via pin 9 of **P1**, so the supply is ground-referenced.

Warranty and Return Policy
If you are not satisfied with the product for any reason, you can ship it back to us. Provided that it is shipped within 30 days of your receiving it, and we receive it in good shape, we will credit your PayPal account with the amount you paid us – that is, full purchase price including shipping one way.

If the product fails in normal use within one year from when you received it, return it to us at your expense. We will repair it and ship it back to you at no charge or replace it (our option).“Normal use” means that it is installed in a correctly functioning Collins R-388, R-388A, 51J-3, or 51J-4 receiver, according to the instructions provided and using good workmanship. Also, we will not be responsible for damage caused by receiver malfunction or other events beyond our control, including (but not limited to) power surges and lightning hits.

Non-warranty repairs will be carried out for a flat fee of $20 U.S. plus shipping both ways. We reserve the right to refuse to repair heavily damaged units under this policy.

You can modify the unit without automatically voiding the warranty. However, you must tell us in detail what changes were made, the workmanship must be good (in our judgment), and we have the final word on whether your actions caused the failure.
We make this provision so that knowledgeable owners can alter the AVC time constants and other properties according to individual preferences.

73,

Bob Thomas VE3TOU
Owner, Treetop Circuits