# Kenwood TS-940

## *Troubleshooting Hints and Updated Adjustment Procedures and Mods*

*Opinions, Notes, Corrections, Tricks and Hints from KB7JS*

*Revision 8.0.0*

***Many Thanks to all who provide critique, it helps make this document even better.***

If you are the proud owner of a Kenwood TS-940 you have one of the best performing desktop Amateur Radio transceivers ever manufactured. But it is not perfect, it is not new, and it has seen many hours of band chasing, so what do you do when it stops working? When it is time to take the covers off and go on the hunt for problems, you will need to consult the Kenwood TS-940 Service Manual for guidance. I recommend you tread lightly with a good sense of humor.

I have worked on these Kenwood models for several years now, and it has been both an enjoyable and painful experience. I have suffered many frustrations in the process, most of them due to the less than spectacular documentation.

The Kenwood TS-940 Service Manual Circuit Descriptions and Adjustment procedures have been a source of confusion and frustration for owners and technicians for many years. The Circuit Description is laced with design errata but lacks vital details and does not accurately describe how each circuit really works.

The Adjustments section is also seriously flawed. There are over 140 adjustments in the TS-940, but some of them are not included in the individual Adjustment procedures, some procedures are inadequate to achieve the desired result, and some necessary adjustment points are not even mentioned in the procedures. In addition, the procedures specify the use of test equipment and methods generally not available to most owners and technicians. Worst of all, the most critical problems with the procedures are several serious omissions and technical errors in the procedures. As a result, attempts by many owners and technicians to use the Service Manual as a guide have rendered many good radios with diminished performance or have outright failed in the attempt.

Kenwood attempted to improve on the content of the adjustment procedures by publishing three revisions of the stand-alone document "TS-940S Adjustment Instructions" but they only further exasperated this problem by repeating the inaccurate procedures while obfuscating or totally deleting some key steps.

Over the past few years, I have cluttered my shop with notes written in the margins, post-it's, and printed pages filed away in the folds of many copies of Service Manuals, forever lost in the chaos of my shop. So, I decided it was time to compile the notes and revisions that I have learned work with good results for me in my shop. This document will now try to formalize these notes.

This document is a work in-progress living document, updated whenever I encounter additional vague or misleading information while troubleshooting a customer's radio, so I will continue to update it in an on-going attempt to expand on and clarify the circuit description and adjustment procedures necessary to make a Kenwood TS-940 transceiver operate as it should. So far, I have not embarked on rewriting the entire TS-940 Service Manual, so the notes contained here should be used only as an addendum and guide to provide detail and clarity to the (*Kudo's to Byron, NF6M, for spotting my truncated grammatical error here*) *Kenwood documentation*.

Currently, this document focuses on the most problem prone areas of the problems and difficult adjustments in the TS-940 documentation:

1. PLL Troubleshooting and Adjustment. *Hint – The PLL & VCO adjustment procedures in the Kenwood Service Manual are vague, inaccurate, and typically lead to a seriously broken radio).*
2. ALC Adjustment (*Hint – The ALC adjustment procedure in the Kenwood Service Manual has a serious error that will render ALC inoperative.*)
3. S-Meter Adjustment (*Hint – The S-Meter adjustment procedure in the Kenwood Service Manual has serious errors that will result in severe S-Meter inaccuracy.*)
4. RX IF Trap Adjustment – Clarification and amendments to this procedure.

I have also included general technical comments on the Kenwood TS-940 documentation and some clarifications of the circuit design and operation. I sincerely hope these notes are helpful, but I caution that this is a work in progress, and undoubtedly will still be confusing to some. I invite critique or comments regarding its content or any possible improvement. Contact me at KB7JS@ARRL.Net .

# Table of Contents – *This may help you find what you want to know.*

# My Opinions - What were they thinking?

There is copious evidence that the Kenwood procedures were translated by the engineers from their native language to English, which often leaves much open for interpretation. I read these procedures in detail, once, twice, then, about twenty more times. I kept coming up with the same question,

***Karera wa nani o kangaete imashita ka?***

*"What were they thinking?"*

The following rambling discussion is an attempt at providing helpful hints and procedures to correct problems in your TS-940. These radios have been soldiering on now for up to 35 years, and, beyond the well-known problems and failures of the original Kenwood power supply, with only a few exceptions, many TS-940's have proven to be exceptionally reliable and are still in use today.

Obviously, the TS-940 is a complex implementation of electronics that can and probably will fail over time. The more frequent exceptions are a relatively small collection of common failures and misunderstandings due to some faulty manufacturing processes, but are also complicated by the omissions of detail and poor clarity of the Kenwood Service Manual, which contributes to incorrect repair attempts and maladjustment by technicians and owners, resulting in degraded performance, and alas, far too many of these fine radios getting sold for parts.

So, this is my attempt to pass on some hard-earned wisdom regarding the most frequent failures plaguing these great radios, while also hopefully shining some light on some of the obscure details of how they work as a good working knowledge of how the circuits work is important, especially with respect to the PLL Unit, so I strongly advise research to gain an understanding of each circuit before assuming that changing any adjustment will cure the problem. The PLL circuits have several inter-dependencies, a failure in one section can and will cause others to fail as well. Tread lightly, and use your thinker, test everything twice before fiddling with the adjustments. When in doubt, contact me, I will be happy to help.

Still, the general theory of a Phase Locked Loop is relatively simple, and there is some inherent logic to the overall behavior of the PLL system, especially when it fails. So, in this collection of technical babbles, I attempt to provide a logical approach to identifying failures in this circuitry. I will also attempt to identify where and why this circuit can fail and how to get it back operational again. I sincerely hope the following information simplifies its repair and adjustment by TS-940 owners.

## Troubleshooting and Adjusting the TS-940

This missive provides some technical insights on troubleshooting some of the well-known problems that may be encountered while servicing the Kenwood TS-940. That being noted, it does not even approach all the things that can and do go wrong. If you have any questions or would like my two cents worth opinion about problems in your radio, feel free to contact me at KB7JS@ARRL.NET.

Right off the top, I caution everyone that the TS-940 is a sophisticated and complicated design and a deep dive into RF theory is necessary to really understand how it all works to provide one of the most enjoyable operating experiences in Amateur Radio.

***Dave's hard learned Wisdom:*** This is not the type of radio that can be serviced with only a spanner, a hammer, and screwdriver, it requires patience, focus, good troubleshooting technique, experience with and knowledgeable use of test equipment and tools, and most importantly, gentle hands. Handle this radio delicately.

`The most important warning I can recommend is **NEVER PULL ON THE CONNECTORS WIRES TO UNPLUG THEM FROM THE CIRCUIT BOARD LEVEL CONNECTOR**. This type of abuse is the source of over half of the problems in radios that come to my shop for repair. The wires are typically 30 and 28 gauges, very fragile, and will easily separate from the pin crimp in the connector when pulled on. Always pull only on the connector itself, wiggle it, if necessary, but very gently since motion of the connector can transmit through the male connector on the board and break solder traces on its pins. You can use 45 degree bent tip miniature needle nose pliers for this but use great caution to not grip the board connector portion, and NEVER grip the connector too tightly, there is danger that your pliers will slip, jump up and grip the wires, smashing them or rip them out of the connector.

## About the Kenwood TS-940 Service Manual & Adjustment Procedures

Kenwood published extensive service information in the TS-940 Revised Edition that is for the most part very comprehensive, although some of the detailed circuit description is somewhat vague or simply wrong. Kenwood intended these procedures to be used by Kenwood technicians in Kenwood authorized service centers and it is apparent they never gave thought to the time-honored practice of Amateur Radio enthusiasts who maintain their own equipment. Kenwood also published a stand-alone TS-940 Adjustment Instructions guide, the most recent version of which is dated June of 1987. The adjustment procedures in this guide are almost identical to those in the Service Manual with the exception of a few minor differences.

Be aware that all these versions contain numerous errors and omissions of important technical information. I recommend you use my amended procedures in lieu of those in the SM. However, many of the procedures in the Kenwood SM are valid, though somewhat vague, and it is important to use my amendments only to add clarity or accuracy to your efforts. Please read the Kenwood procedures first, and then refer to these notes for clarification. I have made an attempt to provide additional clarity to both the Circuit Description and the Adjustment Instructions in this document in hopes that it will help others resolve these problems. In addition, I have provided some amended adjustment procedures intended to clarify or correct the existing adjustment procedures provided by Kenwood.

# Troubleshooting Common TS-940 Problems

## Digital Control Problems

The TS-940 employs Digital synthesis frequency synthesis and control to provide accurate and stable operation on all HF frequencies between 0.5 Khz and 30.0 MHz. All Digital control components are contained on three separate circuit boards, the Digital "A", Digital "B", and Digital "C" Units.

### Digital "A" Unit

This unit is mounted on the top left side of the chassis underneath the Speaker and Aux Control frame. It contains the primary microprocessor, its ROM and RAM memory, digital bus interfaces and I/O port controls. It also hosts an external data interface for control of the radio by a PC.

The microprocessor is the active heart of the TS-940. It continuously scans the I/O ports for changes in operational settings, e.g. Frequency and Mode and Status indicators, updates the settings in memory, and then downloads new digital control data to the PLL Unit and the Front Panel Frequency Display and controls.

The control program and default operational settings are contained in ROM memory. Dynamic operational parameters, e.g. Frequency, Mode, etc.: are maintained in RAM memory that is preserved by battery backup when the radio is powered off.

### Digital "B" Unit

The Digital "B" Unit is mounted on the top right of the chassis behind the Aux Display. It contains the interface to and control processing for all of the Front Panel controls, stores their status, and reports any changes via the data bus to the Digital "A" Unit.

### Digital "C" Unit

The Digital "C" Unit is mounted on the rear side of the Main Frequency Display. It contains all of the data driver logic for the main display and interfaces directly to the Digital "A" Unit.

### Digital Control System Problems and Maintenance

The Digital Control system of the TS-940 is pretty robust and reliable, but also known for having a few aggravating problems. Troubleshooting the Digital System can be challenging or even impossible without prior experience in microprocessor designs. However, this system seldom fails, and when it does, it is most often due to known problems.

The Main CPU chip is mounted in a socket, and several radios have suffered from intermittent problems due to poor solder flow on the pins of the socket, which need to bond to PC traces on both sides of the board. Kenwood issued a Service Bulletin (SB-951) recommending the removal of the socket and re-soldering of the ROM directly to the board. SB-951 is included in the "*Kenwood Service Bulletins*" section at the end of this document. This modification works well, but the work to accomplish it is not for the inexperienced or faint-hearted technician. Removing the socket can be difficult due to tight working conditions and the need to flow solder on both sides of the board. The easiest method to accomplish this is also the most destructive, first cut away the plastic of the socket, then heat each socket pin individually to flow the solder while pulling on the pin to extract it, then clean up any remaining solder around the hole on both sides of the board.

### *Compromised Wiring Connections*

Another common source of intermittent problems with the Digital "A" are the result of poor connections on the cable harness connectors, or worse, damage to the connectors or their wires due to previous attempts at maintenance. See my cautions at the beginning of this document on the best methods to handle these delicate connectors.

### *RAM Memory Content corruption*

And yet another typical source of intermittent problems with the Digital "A" is the degraded level of the RAM memory retention battery. If the battery voltage degrades below the threshold of @ 2.2V, it can begin to cause intermittent corruption of operational setting sored in RAM.

### *When to replace the RAM battery*

The RAM backup battery generally lasts for 10 ~ 20 years of normal operation before requiring replacement. If the battery voltage degrades to less than 2.2V, strange and intermittent behavior of the operational controls will become evident and may actually render the radio inoperable. To verify any anomalous behavior is the result of a low battery, the default factory settings can be restored from ROM memory by holding the "A=B" button down while powering on the radio. WARNING: This will delete all stored frequency memories. If this RESET operation restores normal operation, it's time to change the battery.

There are actually two batteries in the TS-940, one on the Digital "A", the other on the Sub-Display Module (a.k.a. Switch Unit "L") that serves to retain the 24-hour clock. Check both batteries, one on the Sub-Display and the other on the Digital "A" Unit. If either is less than 2.5V, it should be replaced.

These batteries are 23MM 255 mAh coin cell Lithium batteries with solder tabs, type **BR-2330/F3N**, obtainable from Digikey or Mouser.

## The TS-940 PLL System - The Ugly Details – A Deep Dive

### The Complicated Details of the PLL Unit

Well, if you arrived here, you want to know more about the Kenwood TS-940 frequency generation and PLL circuitry. Hopefully, you have attempted to read the circuit description in the Kenwood TS-940 Service Manual. I know, it doesn't really make much sense. It might be informative to some, but I sort of doubt it. If you want to skip the ugly details and go directly to troubleshooting hints and adjustment procedures, skip back to those sections.

Otherwise, I will try to fill in some gaps.

### TS-940 PLL Circuit Description – How it Works.

There are six Phase Locked Loops in the Kenwood TS-940. Each PLL drives a DC voltage that controls the frequency of a Voltage Controlled Oscillator. The PLL samples output frequency of the VCO, then divides it by a numeric value from the microprocessor that represents the current selected operating frequency. The PLL then compares the result against a fixed frequency reference, and any difference between the two signals results in an error voltage that is sent back to the VCO to change its frequency to correct the error. Once the error is eliminated, the PLL sets a LOCK DETECT output indicating its VCO is now locked on the target frequency.

The control voltage output of the PLL is limited in range, and if the error is greater than this range, the PLL cannot correct the error, and an UNLOCK condition exists.

#### *PLL Reference Oscillator Input ($OSC_{IN}$)*

In the TS-940, the reference frequency used by all PLL's is derived from a single fixed reference signal, which is designated the Frequency Standard (*fSTD*). The Kenwood documentation attempts to illustrate the operation of the PLL circuitry by using formula notations based on *fSTD*, which although accurate, is very confusing. So, the following dirty details is my attempt at making it less confusing.

Each PLL is paired with a Voltage Controlled Oscillator . The PLL samples the VCO frequency and compares it with a precision reference based on *fSTD* to produce a Control Voltage that adjusts the VCO frequency. The range of the Control Voltage is limited and optimally should be at its mid-range value when the desired output of the VCO is also midpoint in its range. Each PLL divides the frequency of the Reference Oscillator and the PLL's dependent VCO by digital values provided by the Digital "A" unit that represent the current value of the Main/RIT frequency selections. The two pre-scaled frequencies (reference & VCO) are compared and should be identical in frequency and phase. Any difference in phase is the amount of shift in the Control Voltage required to set the VCO to the proper frequency. Obviously, any inaccuracy in the Reference Oscillator can have an effect on frequency accuracy of the radio by offsetting the VCO tuning point within one full phase of each VCO oscillator.

Note that the precision of the TS-940 digital tuning dial step is 100 Hz (unless the 10Hz option is selected at the Aux Control Panel). If your radio is configured to display 100 Hz resolution, it potentially introduces a possible variance of +/- 50 Hz. The Reference Oscillator is the key to ensuring that each step is precisely centered in the 100 Hz increment.

Inaccurate adjustment of the Reference Oscillator can have serious side-effects since it will shift the phase comparison points from their optimum point and push the PLL Control Voltage toward its upper or lower limit. Adjusting the Master oscillator shifts the lock point of the PLL's and can result in a small inaccuracy, or even intermittent PLL Unlock (Dots on the Main Frequency Display). The Master Oscillator must be adjusted to precision prior to PLL Adjustment and should never be changed without repeating the entire procedure.

## 20 MHz Frequency Standard *ƒSTD*

The primary frequency standard reference **ƒSTD** is produced by a 20 MHz crystal oscillator on the PLL Unit. This reference is then pre-scaled to create additional reference frequencies by the PLLs and several other functions in the TS-940

| ***Reference Frequency*** | ***Designation*** | ***Source*** | ***Adjustment*** |
|---|---|---|---|
| 20 MHz | ƒSTD | Q1 | TC1 for +/- 10 Hz |
| 60 MHz | 3ƒSTD | Q16 | L20, L21 for Peak |
| 10 MHz | 1/2 ƒSTD | IC1 Pin 8/9 | Derived from ƒSTD |
| 5 MHZ | 1/4 ƒSTD | IC1 Pin 13/14 | Derived from 10 MHZ |
| 1 MHZ | 1/20 ƒSTD | IC2 Pin 11 | Derived from 5 MHZ |
| 100 Khz. | 1/200 ƒSTD - MARKER | IC3 Pin 11 | Derived from 1 MHZ |
| 2920/2125 Hz | FSK Shifts | IC2 Pin 12 & Q5 | Derived from 1 MHZ via IC4 |

Obviously, the calibration of the 20 MHz oscillator is critical to the operation of the TS-940. The Service Manual procedure uses a Signal Generator and O-Scope to achieve a heterodyne, then adjusting the oscillator for a stable wave form. While this may work, the percentage of errors hidden in the width of the trace lines on an O-Scope can exceed 5%, so the results are not as accurate as desired. A better method is to use an accurate Frequency Counter or Spectrum Analyzer to set the frequency as close as possible to 20.000.00 MHZ +/- 5 Hz.

## PLL-0 (PLL Unit IC19) - HET Oscillator

PLL-0 and VCO Q27 comprise the HET Oscillator VCO, which generates 36.22 MHz IF used in the Receive 2nd Mixer and the Transmit 2nd Mixer.

The frequency of the HET oscillator is critical to the accuracy of both Receive and Transmit signals, so it is important to adjust this PLL correctly. However, the proper procedure for adjusting this VCO/PLL is totally absent from the Kenwood adjustment procedures. .

## PLL-1 (PLL Unit IC9)- 100 ~ 110 MHz Reference

PLL-1 with VCO Q12 provides a 100 ~ 110 MHz reference frequency, which in turn is scaled by 1.0 ~ 1.1 MHz and mixed with the 11.7 MHz reference (see PLL-5), which in turn produces a 10.0 ~ 10.7 MHz reference which is then mixed with the output of PLL-2 (35.5 ~ 40.5 MHz) to provide a 46.2 ~ 51.1 MHz tracking reference.

It is important to note that the 110 MHz output from PLL-1 (IC19) is very low level at @-57 dBm (@3mV) and is too low to be detected by most frequency counters, so use of a RF Voltmeter, O-Scope, or Spectrum Analyzer is required to observe the output at TP1. It is easier to observe the output after it has been amplified by Q11 & Q12 and returned to the PLL (IC9 – Pin 16).

Of course, if PLL-1 fails to maintain lock, a failure at Q11, Q12, Q13, Q14, or IC9, should be considered and may require some serious troubleshooting.

## PLL-2 (PLL Unit IC8)

PLL-2 with VCO Q7 provides a 35.5 ~ 40.05 MHz output in 100 Hz steps Hz (unless the 10Hz option is selected at the Aux Control Panel). The output of Q7 is then fed to Q15/IC11 where it is prescaled to 3.5 ~ 4.05 MHz, the mixed with the 20 MHz ***ƒStd*** reference to produce 23.5 ~ 24.05 MHz , then mixed again with the 60 MHz reference to produce 83.55 ~ 84.05 MHz, which is mixed with the output of the Band VCO's (RF Unit) as the input reference frequency for PLL-3 at IC17.

Wow – that is a long complex chain of frequencies, but wait, there's more.

Note that PLL-2 is also complex in that it operates in two different frequency ranges. The PLL-2 loop controller (IC8) tracks the frequency range 46.2 ~ 51.1 MHz to drive the control voltage of Oscillator Q7, which operates in the frequency range of 35.5 ~ 40.5 MHz. produced by Oscillator Q7. The output of Q7 is then fed to mixer IC7, where it is mixed with the 10.6 ~ 10.7 MHz. output from IC6 to produce the 46.2 ~ 51.1 MHz tracking input to IC8.

The 10.6 ~ 10.7 mix reference produced by IC7 is the product of mixing the signals produced by two additional PLL's. PLL-1 (IC9) produces the 100 ~ 110 MHz. reference, and the combined outputs of PLL-5 and PLL-6 on the CAR unit produce the second reference of 117 Mhz. These two references are prescaled to 1.0 ~ 1.1 MHz. and 11.7 MHz., and when mixed in IC6 produces the 10.6 ~ 10.7 reference used by mixer IC7 to produce the tracking input to PLL-2.

## PLL-3 (PLL Unit IC17)

PLL-3 provides the tracking control of the three Band VCO's on the RF Unit. Its output is tracking voltage is used to control one of three VCO's on the RF unit. The VCO's are selected by digital control form the Digital "A" Unit when the frequency selection is within the following bands.

| Frequency | PLL-3 VCO Output |
|---|---|
| 30 Khz ~ 9.50 MHz | VCO1 – 45.05 ~ 54.55 MHz |
| 9.5 MHz ~ 19.5 MHz | VCO2 – 54.55 ~ 64.55 MHz |
| 10.5 ~ 30.0 MHz | VCO3 – 64.55 ~ 75.05 MHz |

An unlock condition at IC17 Pin 7 can be a bit confusing. This PLL is set with band selection information via serial data from the Digital "A" Unit. It then sets the control voltage for the VCO's located on the RF Unit. There are three sections used to cover the frequency bands 30 Khz. ~ 9.5 MHz, 9.5 MHz ~ 19.5 MHZ, and 19.5 ~ 30.0 MHZ.
The tricky part here is each of these VCO's must be on frequency, if one of them fails to stay on frequency, an UNLOCK condition occurs when the frequency selection is within its band. So, check the VCO Adjustment first.

Note that IC17 is the only PLL that receives its band data from the CPU on the Digital "A" unit as Serial Data. The other 5 PLL's use parallel data from the CPU. So, a problem with the Serial output from the Digital "A", or a broken wire, can cause this PLL to fail by itself. Check all the wiring first.

## *CAR Unit PLL's*

There are two PLL's located on the CAR Unit. These PLL's provide four separate outputs:

- A 117 MHz Reference
- CAR0 – 8.83 MHz IF
- CAR1 – 455 Khz IF
- CAR2 – 9.285 MHz IF

### PLL-4 (CAR Unit IC2).

PLL4 uses crystal oscillator Q1 and VCO Q4 combine to drive the 45.5 MHz. oscillator Q4.

### PLL-5 (CAR Unit IC2)

PLL5 uses crystal oscillator Q6 and VCO Q9 combine to drive the 71.5 MHz. oscillator Q9.

The two oscillators are then pre-scaled and/or mixed to produce the following outputs.

- 117 MHz Reference for the PLL Unit
- 455 KHz. CAR1 IF
  - The 45.5 MHz. from PLL4 is pre-scaled at IC5 to produce the 455 KHz. CAR1.
- 9.285 MHz CAR2 IF
  - The 71.5 MHz. from PLL5 is pre-scaled at IC3 to produce 715 KHz., then mixed with the 10Mhz *f*Ref from the PLL Unit to produce the 9.285Mhz CAR2.
- 8.83 MHz. CAR0 IF
  - The 9.285  CAR2 is mixed with the 455 KHz. CAR1 in IC6 to produce the 8.83 MHZ CAR0 IF

# Troubleshooting PLL Unlock Issues

## PLL Unlock - The Dreaded "Dots" on the Frequency Display

One of the most common problems encountered by owners of the Kenwood TS-940 are failures of the Phase Locked Loop (aka: PLL) frequency generation logic. Anyone who has read the "Frequency Configuration" section of the TS-940 Service Manual, or the expanded version in the addendum "TS-940 Technical Information", has probably had the same reaction I did, Huh?

### *The Problem*

To simplify the description, the TS-940 utilizes Voltage Controlled Oscillators (VCO's). Each Phase Locked Loop is comprised of a free running Voltage Controlled Oscillator (VCO) and a Phase Locked Loop (PLL) controller. The VCO frequency is set by the control voltage (CV) output of the PLL chip. This "Loop" maintains the VCO at a fixed frequency, automatically correcting for any drift. The result is very high accuracy, and unlike crystal driven oscillators, no drift. Each PLL receives digital data from the radio that specifies the frequency for the VCO. A standard reference frequency (a.k.a. ***fStd***), derived from a 20 MHz crystal, is also used. Each PLL pre-scales (divides) the VCO frequency and the ***fStd*** reference by a pre-set value, and then compares the two results. Any difference results in a change of the control voltage to drive the VCO to the "Lock" point. However, if the difference is too great, the CV from the PLL controller does not have sufficient range and cannot adjust the VCO beyond a limit.

### *Adjustment can change behavior but is seldom a cure.*

Despite the sage words of advice found in several Worldwide Disinformation Web Posts, I urge you to resist the temptation to adjust first and ask questions later. Yes, some people have done this and gotten lucky, but that does not make their chance achievement a universal cure. Blindly attempting to adjust the PLL Unit will almost always result in more pain.

Yes, the PLL system in the TS-940 is a complicated design, and the attempt by Kenwood to explain it through mathematical formulae in the Service Manual is, well, interesting, in an academic way, but wholly inadequate for most troubleshooting efforts. Even worse, the documentation is seriously incomplete and inaccurate. Although component drift with age can trigger the PLL Unlock problem, never "assume" that tweaking the adjustments will solve the problem.

**IMPORTANT - Don't Tweak - Troubleshoot First**

Drift in adjustments over time due to component aging is a common problem, and should be considered, but before you attempt to cure a problem first by tweaking an adjustment, I urge you to perform some due diligence research and troubleshooting to make sure you understand why. Although component aging can cause sufficient drift in values to cause a resonant circuit to drift, this is the exception and should never be your first assumption as the reason for PLL Unlock.

PLL Unlock is often the result of a failed component, or even more often, broken wiring connections and cold solder joints, both of which are exasperated by hands and fingers poking The display of a row of Dots on the Frequency Display in the Kenwood TS-940 is a pervasive problem indicating the frequency generation Phase Lock Loop (PLL) systems has suffered a "Un-Lock" condition. This may be an intermittent problem, but if so, it is bound to become more severe over time.

## Identifying the cause of PLL Unlock

PLL Unlock conditions in the TS-940 are typically first noted as intermittent or occasional blanking of the main Frequency Display, especially after warmup. This is an indication that Adjustment of the PLL is drifting out of spec and will only get worse over time.

Although this problem is almost always associated with the PLL Unit, there are a total of six PLL's in the TS-940, four of which are on the PLL Unit, and the additional two are located on the CAR Unit. The Unlock condition of all six loops is Or'ed into one signal, "UL", the common inverse of all Lock Detect outputs, so any one or more of the PLL's can cause the blanking of the display. Also, though rare, a failure in VCO circuitry on the RF Unit may also contribute to the same failure indication.

While PLL Un-lock conditions will always cause blanking of the Frequency Display, there are subtle differences in how this occurs based on which of the associated circuits is failing.

- Frequency Display blanks for only one or more operating modes (LSB/USB/CW)
    - PLL Unlock in Carrier Oscillators on the CAR Unit.
- Frequency Display blanks for only one on some, but not all, band segments
    - PLL Unlock due to VCO dropout on the RF Unit.
- Frequency Display is blank in all modes.
    - PLL Unlock on the PLL or CAR Unit.
- Frequency Display blanks but Receive and Transmit work normally.
    - False PLL Unlock due to signal "UL" high only at J4 Pin 1 on the Digital "B" Unit or J21 Pin 1 Control Unit.

### *Common Problems*

There are several common problems that have cropped up in the TS-940 over the years that may be the source of PLL Unlock Issues. Here are some hints.

#### 20 MHz (10 MHz) Reference Oscillator

Before diving in on troubleshooting PLL Unlock issues, it is important to always check the calibration of the reference oscillator.

The PLL system maintains frequency stability by continuous comparison of each VCO output with a known standard reference (***fStd)*** provided by a 20 MHz oscillator on the PLL Unit. The 20 MHz oscillator is the constant reference frequency and is also scaled to derive additional references of 10 MHZ ($^{1/2}$ ***fStd*)**, 5 MHz ($^{1/4}$ ***fStd***), 1 MHz ($^{1/20}$ ***fStd***), and 60 MHz ($^{3}$ ***fStd***). All crystal-based oscillators are subject to component aging that results in drift in the set point over time.

Maladjustment or drift with age in the 20 MHz reference oscillator will ripple through all the frequency generation logic of the TS-940. It is essential that the Reference Oscillator is calibrated accurately.
, preferably within +/- 5 Hz.

#### Intermittent PLL Unlock problems.

Intermittent failures are the most difficult problem to correct because they seldom exhibit their behavior when you have the radio open and the proper troubleshooting tools at hand.

It is common wisdom and practice in our hobby to attempt to induce some kind of external influence to force an intermittent problem to show its true nature and be more obvious. I have encountered dozens of intermittent problems in Kenwood radios, a good many caused by broken wiring, bent, twisted, damaged or outright broken components, some that have been struck so hard they have been pushed through the circuit board, causing broken circuit traces. All the result of the “Physical Inducement” method of troubleshooting. Yep, the old boot or hammer method, smack it to see if it will work better, or worse. Bad Idea, this can and will produce more problems and very seldom identify the original one.

Never attempt to make an intermittent problem a permanent one, it will lead you down a path of sorrow. Take your time, analyze the behavior, study the circuitry, and determine how the failure can occur, then go looking for the source.

### Broken Wires, Cold Solder Joints

Physical damage to wiring due to intrusions by our collective fat fingers is the most common problem I encounter in Kenwood radios. The very small wires used are prone to breakage at the pin crimp inside the connector. I have even seen cases where the wire has separated from the pin and pulled back inside the insulation, leaving no external indication that the connection is open. You should never pull on the wires to disengage a connector. Instead, use a small pair of needle nose pliers, preferably with a 45-degree bent tip, gently grip the connector, and leverage it free. Do not “wiggle” the connector, the movement will translate through the board connector pins to the circuit side and break the traces.

Manufacturing quality problems were common in Kenwood radios produced in the 80’s, including the TS-940. This is most commonly seen as poor flow and adhesion of solder on the trace side of circuit boards. Over years of environmental changes in temperature and humidity, these connections will begin to fail. I have often encountered solder points where the component lead, wire, or connector pin is freely floating in a hole surrounded by solder with poor continuity, resulting in intermittent contact and unstable operation due to variable conductivity at the connection.

For this reason, when faced with intermittent problems, it is always a good idea to carefully remove suspect boards and closely examine their trace side for any signs of cold connection points or corrosion. UNPLUG THE WIRE CONNECTORS CAREFULLY!!!!!

## *Service Bulletins*

Kenwood issued several Service Bulletins for the TS-940, two of which addressed intermittent PLL Unlock problems and another that addressed intermittent behavior of the display due to poor connections on the Digital “A” Unit ROM chip. If you have a relatively low serial number unit, it would be a good idea to check to make sure your radio has these remedies applied. See the Service Bulletin attachments at the end of this document.

## Wax in the PLL VCO’s

One reason for frequent failures in any of the VCO circuits is the result of a common 1980s Kenwood practice of encapsulating the components in a thick solution of wax or a substance commonly known as “*Sony Bond Clear*”, which is similar to silicon sealant. This practice is well known to cause problems in VCOs in many different Kenwood and ICOM radios. Oddly, a key feature of a PLL is its ability to track and remain stable on a target frequency without drifting, so thermal stability should not be a problem.

Wax encapsulation is found in three of the VCO’s on the PLL Unit and the in the three Band VCO’s on the RF Unit.

The encapsulating agent surrounding the VCO circuitry dries out and shrinks over time, suffers chemical breakdown, and becomes contaminated with ambient moisture and conductive dust particles, and will cause the VCO to fail.

To remove the Wax, a good heat gun on medium to low heat will dissolve the wax and allow it to flow. IMPORTANT, USE "**LOW HEAT**". The wax will melt at approximately 80 – 90 Deg F. Move the hot air over the area rapidly and do not get too close. Tip the PLL board on edge, heat the wax, and then GENTLY tap the board on a firm surface to dislodge the wax.

If you encounter "*Sony Bond Clear*" in your radio, it requires a dissolving agent to break it down for removal. "*3M Adhesive Remover*" is ideal for this task, although you can also use, carefully, Flux Solvent or Acetone, but use extreme care to not allow the solvent to contaminate the adjustable IF transformer in the VCO.

### *The Myth that a Tweak of the HET Oscillator (L34) Fixes it All.*

You can find many informed posts on the Worldwide Disinformation Web indicating all you need to do to correct the PLL Unlock problem in the TS-940 is tweak one coil on the PLL Unit, L 34. Don't go there.

**CAUTION**

***Beware of Fables, Sooth Sayers, and Tweakers***

It is always a mistake to believe the sole reason for PLL failure is simply an Adjustment issue. Attempting to blindly adjust in this circuitry without test equipment, also known as "Tweaking", will never produce reliable results.

L34 is the tuning inductor for the HET oscillator Q27, which is controlled by the PLL at IC19. It produces a standard reference frequency of 36.22 MHz used for IF mixing in the Receiver and Transmitter. Adjusting L34 will peak the output of the VCO, which should cause the PLL to lock at 36.22 MHz. However, that assumes that the associated PLL is working. Adjusting L34 will change the frequency of the oscillator. Yes, if it's on the edge, tweaking L34 may reign in the dreaded "Dots" problem for some radios, but it is a sure sign of Adjustment issues, and only one of several possible causes of the dreaded "Dots" problem.

BTW: This mysterious magical coil, L34, is not mentioned in the Kenwood TS-940 Adjustment instructions. *Sigh.*

### Identifying which PLL is Unlocked

PLL Unlock condition can be triggered by one or more individual PLL circuits. There is a total of six PLL's in the TS-940, four of which are located on the PLL Unit, and two more on the CAR Unit.

If you are experiencing PLL Unlock the first troubleshooting step is to determine if the fault is in the PLL Unit or the CAR Unit. The following tests will help determine where the problem is located.

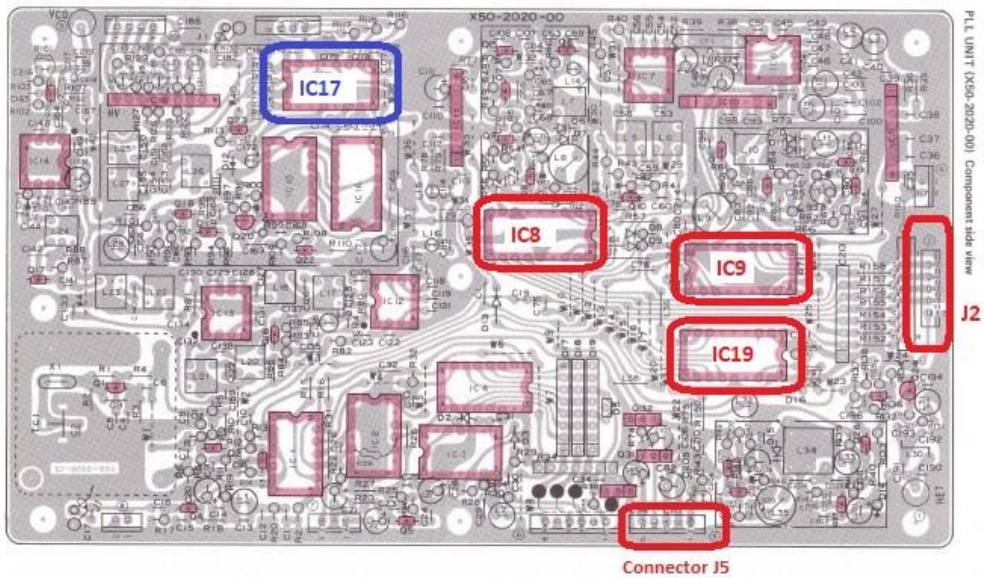
- Remove the top cover of the radio, then remove the Speaker Unit.

  **CAUTION**

  Take care when unplugging the connectors, I strongly advise avoiding pulling on the wires to unplug Kenwood connectors, I have seen a great many problems caused by stretched wires with broken connections at the connector pins, and sometimes the wire can break completely inside the insulation with no visible indication of the fault. It is best to use small needle nose pliers to gently wiggle the connectors to disconnect them.

  Next, remove the four screws anchoring the Digital "A" Unit, then gently lift it up and turn it over to rest on the top of the control panel. Take additional care not to stretch any of the wires.

The PLL Unit is now visible.  Refer to the following diagram for the location of Connector 5.




- Check voltages.  Connector 5 Pin 3 should be 15V, and Pin 5 should be +5V.   If either of these voltages is out of spec, determine why and correct the problem.

### *UNLOCK signal.*

Each individual PLL loop produces a LOCK DETECT (LD) output, measurable as a voltage of around +4.75V if it is in Lock and just above 0V if it is Unlocked. The LD output from all 6 PLL's are gated together using diodes to create a Logic inverted AND or "NAND" output to create the Unlock signal "UL".  Four of the inputs are from the PLL controllers on the PLL Unit, and two from the CAR Unit are pre-conditioned there as "UL1", forwarded to the PLL Unit via J2 Pin 5.  All six LD signals must be High to force the inverted AND output of "UL" low.  Any one PLL producing a low voltage on LD will produce a High level at "UL" which is then output from the PLL Unit at Connector 5, Pin 4.

### *Which PLL is Unlocked?*

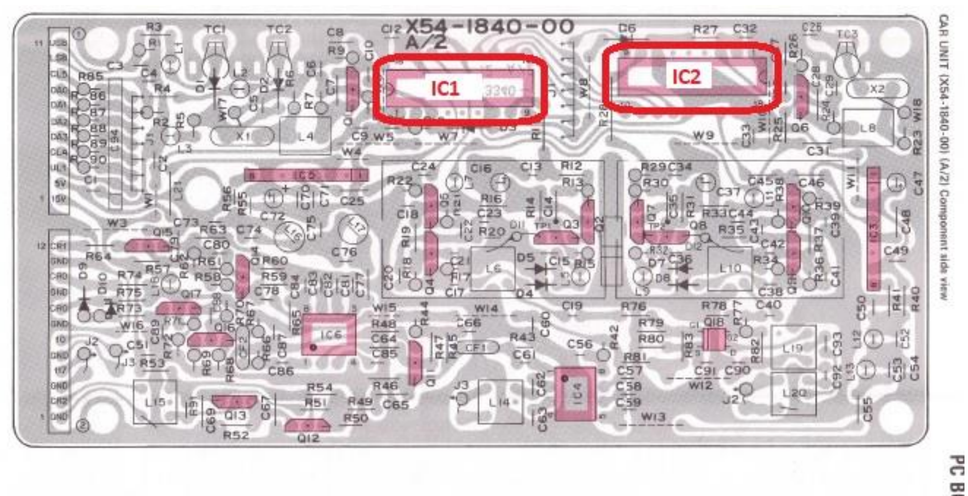
- Check Pin 4 of Connector J5 on the PLL Unit.   (Be careful, Pin 3 has 15V and Pin5 has +5V). This is the final lock/unlock signal "UL" for all 6 phase lock loops. If any loop is Unlocked, this voltage will read around 0 volts or just a few millivolts.
    - If Pin 4 of Connector J5 is High, unplug connector J2, which will disconnect the CAR Unit from the PLL Unit. This removes the influence of "UL1" from the ultimate "UL" output.
  - If the voltage on Pin 4 of connector 5 is still high, then one or more loops on the PLL Unit are unlocked. However, don't dismiss the CAR Unit yet.
    - Check the LOCK DETECT output on each of the PLL IC's.
      - IC8 pin 2
      - IC9 Pin 2
      - IC19 Pin 2\
      - IC17 Pin 7 (Yes, Pin 7)

      If any of these pins measure less than 4V, indicates the associated PLL is unlocked.

- **CAUTION:** While J2 is still unplugged, Check Pin 5 of J2 to see if the UL1 signal is high.  If it is, it can still be the source of the Unlock condition and should be addressed first.  The two PLL's on the CAR Unit produce 117 MHz.

reference used by PLL1 and PLL3, and a problem there can cascade to the PLL Unit. If Pin 4 of Connector J5 is low when connector 2 is unplugged, then the Unlock condition is being generated by one of the two PLL loops on the CAR Unit. This condition is rarely observed since an Unlock condition of either tow PLL's on the CAR Unit will typically result in failure of the 117 MHz. output used by the PLL Unit, causing additional Unlock conditions there. However, it is important to address this issue first before attempting to resolve problems on the PLL Unit.

The CAR Unit is a bit difficult to access. It is part of the Digital "B" unit, which has two circuit boards, identified as the CAR Unit A/2, and the Digital B Unit /B2. These two units are mounted together on the top right section of the main chassis. You must remove the screws that hold the Digital "B" unit and move it aside to gain access to the CAR Unit behind it.




- Check the LOCK DETECT outputs on the CAR Unit
  - IC1 Pin2
  - IC2 Pin 2.

A low voltage on either of these pins indicates the associated PLL in unlocked, and further troubleshooting is necessary to determine why.

## Ok, What's Next?

Ok, now you know which PLL(s) are failing to lock. Here are some hints about why this might happen. This will be the time to embark on hard core troubleshooting, circuit analysis, voltage measurement, scope probing, and serious thinking.

### Single Failures

If the unlock condition is isolated to only one PLL, then your troubleshooting efforts should be focused on that specific circuit. Each loop is relatively simple in that it derives its lock condition from digital data, a reference standard, and a sample of the output from the VCO it controls. Individual PLL chips have been known to fail, but that is rare. In most cases, the reason for the unlock condition can be found in the VCO failing to oscillate at its design frequency range. However, be aware there are some complications. PLL2 tracks its VCO not through its true output, but via an offset produced by mixing the VCO output with 10.6 ~ 10.7 Mhz. Since the mix is ultimately the product of multiple other PLL's, one on the PLL Unit and two on the CAR Unit, a failure to unlock in PLL2 can be difficult to identify, so check everything twice.

When only one PLL is failing, it is highly doubtful that the digital data from the Digital “A” unit is the problem since it is used by all the PLL’s. However, the Digital Data is sent to the PLL’s in a Parallel format to five of the PLL’s, and Serial format for one PLL (PLL-3 – IC17). so, problems with one Digital Output channel or the wiring between the Digital “A” Unit and the PLL or CAR Units may be suspect.

Single component failures in the VCO circuitry are always possible, but again, pretty rare. In my experience, a PLL failure is typically the result of deterioration on the board, cold solder joints, contamination ( see the discussion on *Wax in the PLL VCO’s*), corrosion, and broken or damaged wiring. However, as I have already mentioned, anything is possible.

### *HET Oscillator PLL Unlock (IC19)*

A frequent cause of PLL Unlock in the TS-940 is the HET Oscillator, PLL-0(IC19), which resonates at 36.22MHz. You will find many on-line posts that allude to this being the common PLL Unlock source, and that you can adjust this oscillator using a simple voltmeter to measure the PLL control voltage and “tweak” coil L34 to set the control voltage at 8 $V_{DC}$ to correct the problem. While that might cure the problem, it is far from optimum. L34 must be properly adjusted to achieve a stable lock at its design frequency.

**<u>Note</u>**

> **The Kenwood TS-940 Adjustment Instructions do not provide a procedure for adjusting the HET Oscillator.** See Step # 2 in the amended adjustment procedures below.

The HET Oscillator VCO for PLL-0 is isolated within a shielded area on the PLL Unit. The reason for frequent failures is the VCO circuitry for this loop are caused by a common 1980s Kenwood practice of encapsulating the components in a thick solution of wax or semi-solid glue HET Oscillator PLL Unlock (IC19).

A widely published PLL Unlock problem in the TS-940 is the HET Oscillator, PLL-0(IC19), which controls a VCO that resonates at 36.22MHz. You will find many on-line posts that allude to this being the common PLL Unlock source, and that you can adjust this oscillator using a simple voltmeter to measure the PLL control voltage and “tweak” coil L34 to set the control voltage at 8 $V_{DC}$ to correct the problem. That works, sometimes, enough that it has become a well-known resolution, but it is fable, untrue, and far from optimum. L34 must be adjusted properly to achieve a lock at its design frequency. When adjusted properly, this VCO will run at its design frequency, but there is considerable variance in the adjustment, so it is important get it just right.

### Wax in HET VCO

The HET Oscillator VCO for PLL-0 is isolated within a shielded area on the PLL Unit and may be a contributor to failure. A common failure of the HET is contamination of the circuit that affects the varicap diode tuning in the resonant loop. The Wax encapsulating agent surrounding the VCO circuitry dries out and shrinks over time, suffers chemical breakdown, and becomes contaminated with ambient moisture and conductive dust particles, and will cause the VCO to fail.

If the HET Oscillator is off frequency or PLL-0 fails to maintain lock, it may be due to contamination, so it is essential to remove the stabilizing material and clean the entire area around the components before proceeding with troubleshooting or adjustment of this VCO.

It is also a very good idea to inspect the circuit traces on the bottom of the PLL board for possible corrosion and re-solder them as necessary to improve thermal stability.

## Multiple Failures:

If more than one of the PLL's is Unlocked, a common failure affecting all should be suspect. Although the entire PLL system appears to be complex at first glance, multiple failures are almost always the product of a single problem. The TS-940 PLL loop system is interdependent so in this case, it is important to determine which of the loops is unlocked and if the failure is caused by a reference common to more than one or a cascade failure initiated by a single loop.

The TS-940 PLL loop system is interdependent, so it is also possible that a failure in one loop may result in more than one PLL becoming unlocked. Multiple failures can be caused by severe drift in the 20MHz reference oscillator on the PLL Unit. However, note that PLL-0 and its HET VCO (L34) is stand-alone and is only dependent on the 20MHz reference. However, the remaining five PLL's all have some interdependencies.

Multiple failures can also be the result of corrupted digital data from the Digital "A" Unit. Data is sent over two interfaces to the loops, one is interface is a 4-bit parallel bus (DA0- DA3 + Clocks CL0, CL1, CL2) used by five of the loops, the other is a serial interface (PL0, + Clock CL3 and Enable PLE) used by PLL-3. A component failure, or more common, a wiring problem, can result in one of these interfaces failing.

Do not forget that PLL-4 and PLL-5 on the CAR unit produce the mixing signals CAR1 (455KHz), CAR2 (9.285MHz), but also combine their outputs to produce both CAR0 (8.83 MHZ) and the 117 MHz reference used PLL-2 on the PLL Unit, which can cause a cascade failure of multiple PLL's.

### *Frequency Standard*

Verify that the 20 MHz Frequency Standard is on frequency and that all the pre-scaled products (60 MHz, 10 MHz, 5 MHz, and 1 MHz) are also present and are correct frequency.

### *Band Information Problems*

Each loop is programed with a digital count by the CPU on the Digital "A" Unit, and problems there can cause PLL failure. Digital "A" problems are usually noted by strange indications on the front panel, including a completely blank frequency display (NO DOTS) or the erratic operation of controls. If the Digital "A" unit is functioning properly, all front panel controls should continue to work properly, and the DOTS in the frequency display will be replaced by the frequency readout briefly every time the main dial is moved.

**Note**

> The Digital "A" unit has a memory backup battery installed, and if this battery is low, the behavior of the Digital "A" unit will be erratic.

### *Troubleshooting PLL-2 (IC8)*

#### PLL Interdependency #1 – PLL-2 (IC8)

A 117 MHz reference generated by PLL-4 (IC1 on the CAR Unit) and used by the PLL Unit as the basis of a cascade series of reference frequencies.

1. *The 117 MHz from PLL-4 is pre-scaled to 11.7 MHz by IC5.*
2. *The 100 ~110 MHz output of PLL-1 (IC9) is pre-scaled to 1 ~ 1.1 MHz in IC10.*
3. *The 11.7 MHz from IC 5 is mixed with 1 ~ 1.1 output of IC10 in IC 6, generating a 10.6 ~10.7 MHz. signal.*
4. *The 10.6 ~ 10.7 from IC6 is mixed with the output from VCO2 (35.5 ~ 40.5 MHz) in IC7 to create the 46.2 ~ 51.1 MHz. tracking input for PLL2 (IC8) to drive the VCO2 control voltage.*

Yep, it's complicated, but note that a failure of any one of these reference frequencies will result in an Unlock condition of PLL-2 (IC8).

### *Troubleshooting – PLL-3 (IC17)*

The Output of PLL-2 is also used by PLL-3. This creates an ugly chain on dependence, so it is a good idea to validate each point in the chain.

1. The output of PLL-2 is pre-scaled to 3.5 ~ 4.05 MHz by IC11
2. 3.5 ~ 4.05 MHz from IC11 is mixed with the 20 MHz reference at IC12.
3. The 23.55 ~ 24.05 MHz from IC12 is mixed with the 60 MHz reference at IC13
4. The 83.55 ~ 84.05 MHz from IC13 is mixed with the 45.05 ~ 75.55 MHz from the RF Unit VCOs at IC14
5. The 38.5 ~ 8.50 MHz output of IC14 is shaped in IC15 and pre-scaled (Divide by 3 or 4) in IC16. This becomes a digital pulse train tracking input to PLL-3 (IC17) Pin 8.

Yep, this one is even more complicated and difficult to troubleshoot without a very good frequency counter or spectrum analyzer. If PLL-3 (IC17) it UNLOCKED, there is a circular dependency since it tracks the RF VCO's on the RF Unit. Since there are three VCO's, failure of all 3 to be on frequency will most likely indicate the PLL is failing. Otherwise, the UNLOCK condition will occur only in the band segment of a failing VCO.

The primary source of the IC17 tracking reference is a mix of the RF VCO output with the result of dependent chain of mixing from PLL-2 (IC8) and the 20 MHz and 60 MHz frequency standards. So, if PLL-2 (IC8) is LOCKED, and PLL-3 (IC17) is UNLOCKED, the primary suspect will be the RF VCO's or the frequency conversions in IC11 → IC16.
However, as mentioned above, it is important to check each step in the chain to ensure that the input to PLL-3 is derived correctly before assuming the RF VCO is actually the problem.

### PLL-3 Troubleshooting Hints

#### *HINT #1*

- Pre-set the main dial to a good reference frequency. For these tests, I use 14.000.00. Engage the "Lock" function to keep it there.
- Check the input to Mixer IC14 at TP4 (C215). With the dial set to 14.000.00, this test point should be 83.55 MHz., if not, troubleshoot why. This point is originally derived from the output of PLL 2 (IC8) through several prior mixes at IC11, IC12, and IC13.

- Next, check TP5. At this point, the VCO frequency is derived from the base frequency of 45.05 MHz plus the selected dial frequency.

  So, with the dial set to 14.000.00, the RF VCO will be 59.05 MHz. (45.05 + 14.00 = 59.05). This is them mixed with the 83.55 MHz. to produce the 24.5 MHz VCO input to Pin 9 of IC15.

  Next, the 24.5 MHz is "shaped" at IC15 to create a TTL Level signal, which is then input to IC16 Pin1. The signal is divided again by either 4 or 3, dependent on the pulse swallow function output from IC17 Pin 12. For this test, expect this point to be 6.125 Mhz.

- If the RF VCO is on frequency, TP5 should be 24.5 MHz. (83.55 – 59.05 = 24.5). This will produce an input scaled input pulses at 500Khz IC17 Pin 8. However, the problem could also be in the pre-scaling of this input before it gets to IC17.

Since PLL-3 is unlocked, this test will probably fail because the control voltage to the VCO is either incorrect or is ineffective.

- Check the RF VCO CV reference voltage at J19 Pin 1 on the PLL Unit. This voltage should be @15.6V. If not, there is a problem in the RF VCO section on the RF Unit.

  - Check the voltages on R100 in the RF VCO section. The voltage drop across this resistor should be @ 2.0V. The input/output should be @17.5V on one side, 15.6V on the other side. If not, there may be a bad downstream component, e.g., capacitor C134 may be leaking, Zener Diode D34 (16V) may be bad, or another component is loading the 15.6V bias supply (Q16 ~ Q19).

    Disconnect the cable from J9, if the voltage comes up to 15.6V, then suspect IC18 on the PLL Unit. Otherwise, the problem is local to the RF VCO Circuit on the RF Unit.

### *HINT #2*

- The control voltage produced by IC17 is derived from the double-ended Phase Detector outputs øV & øR through a pair of comparator Op-Amps at IC18. If the CV output is at the right voltage but the VCO is not tracking, the problem could be IC17, IC18, the VCO's on the RF Unit, or the wiring between the two. When IC17 fails to lock, it is difficult to determine if the problem a failed output at øV & øR, the derived control voltage to the VCO from IC18, or the failure of the VCO to respond to it.

  - With the main dial set at 14.000.00, first measure the øV at IC17 Pin 15, and øR at IC17 Pin 16. Record these measurements.

    - Remove the VCO coax at the PLL connector and inject a fixed reference from a Signal Generator to emulate the correct output from the VCO for a given frequency setting on the Main Dial. For example, with the dial set to 14.000.00, the input VCO frequency should be 59.05 Mhz. When mixed with the 83.55 at TP4 it should result in 24.5 MHz. at TP5 .

    - Check the LD output of IC17 at Pin 7. If this results in a Lock Detect condition at IC17 Pin 7, check to see if the voltages at for øV & øR have changed.

      - If the øV & øR voltages are essentially the same as they were, IC17 may actually be bad provided the pre-scaled input to Pin 8 is correct (6.125 MHz.) and the 10 MHz. reference is present at Pin 1.

      - If the øV & øR voltages have changed, the PLL is reacting to the correct VCO input, so you can expect that the control voltage to the VCO's is not working, or the VCO is not responding to it correctly (VCO Adjustment). Check the operation of IC18, the VCO section on the RF Unit, or the wiring between the two.

### *HINT #3* - Alas, Maybe It's Not a PLL Problem

One consideration is failure of the digital band selection data input to one or more PLL's. This generally indicates a problem with the Digital "A" Unit, or the wiring between the Digital "A" and the PLL. Check all wiring connections carefully, then check the Digital "A" unit for possible bad solder pads.

Another problem can be caused by faulty ground connections for the Digital "A" or the PLL Unit. Both boards are mounted to the chassis using plated screws passing through grommets and brass stand-offs. The surface contact between these mechanical connections can become corroded, resulting in poor ground conductivity and can lead to intermittent behavior, especially with the Digital control circuitry.

**NOTE:**

> Early production units of the TS-940 had the ROM on the Digital "A" in a socket to facilitate ease up microcode update. The ROM socket was poor quality, and corrosion on its pins became a major problem over time. Kenwood issued a service bulletin stating the ROM socket should be removed and the ROM soldered back in its place.

## After the Unlock problem is fixed.

Hopefully, the information here has been helpful to you in resolving your PLL Unlock problem.

Once you have corrected any failures and cleared up the PLL Unlock problem, it is highly advisable to perform all of the adjustments to ensure it is operating at optimum efficiency. See the next section for information on how to properly adjust the PLL Unit.

# TS-940 Adjustment Procedure Updates

Before you dive into the TS-940 Service Manual Adjustment Procedures, you should be aware that they contain many errors and omissions that can lead you down the path to failure. I recommend you review those procedures documented in the Kenwood Manual, then read the amended procedures I have provided here.

The Kenwood Procedures also stipulate a rich assortment of test equipment that you may or may not have in your shop, so I have provided commentary in the "Technical Ramblings" section at the end of this document that may help rationalize what equipment you can use in instead to accomplish getting your radio operating as it should.

## Amendments and Updates to the TS-940 Adjustment Procedures

### Initial Setup

- Reset – Hold "A=B" while turning on Power.
- STBY : Receive
- Mode CW
- Wide/Narrow : ON
- Frequency - 14.000.00
- Test Equipment:
    - Frequency Counter
        - Note: Most Frequency Counters cannot detect weak signals below -40 dBm. Use RFVM/Scope/SA for observation of weak signals.
    - RF VM or O-Scope, or Spectrum Analyzer with Tracking Generator.
        - Optional - RMS/DC Voltmeter and RF Detector Probe
    - Sweep Generator – Optional, only necessary if bandpass filter adjustment is necessary.
    - Non-metallic or Ceramic adjustment tools
- Always perform the primary voltage checks as specified in the "VOLTAGE ADJUSTMENT AND CONFIGURATION" section of Service Manual prior to attempting any other adjustments.
- All signal levels noted in the following adjustment procedures are approximate – Adjust for best level (dBm or RMS Volts) at specified frequency.

## Voltage Adjustment and Configuration.

The "*VOLTAGE ADJUSTMENT AND CONFIGURATION*" section in the TS-940 Service Manual has errors and omissions. Notably, the adjustment for "RB" is at Connector J10 Pin 3 on the IF Unit, not Pin 5. Also, the procedure for setting the AGC Detector Gain bias was omitted from the Service Manual, and the S-Meter calibration procedure specified by Kenwood will erroneously adjust this control and never come back to make it right again.

The following steps should be more useful.

### Amended Voltage Adjustment and Configuration

| ***Item*** | ***Condition*** | ***Measurement*** | | | ***Adjustment*** | | | ***Specification/Remarks*** |
|---|---|---|---|---|---|---|---|---|
| | | ***Test Equipment*** | ***Unit*** | ***Terminal*** | ***Unit*** | ***Part*** | ***Method*** | |
| **1 – Voltage Adjustment and confirmation** | *POWER SW: ON<br>STBY : REC<br>MODE : CW<br>WIDE/NAR : NAR* | *DC V.M.* | *AVR* | *FB* | *AVR* | *VR1* | *Adjust to 28.5V* | ***After PS Upgrade – Adjust QUINT PS for 28.5V*** |
| | | | *IF* | *RV<br>©13 – 2* | | | *Confirm @14.0V* | ***14.0 ~ 16.0V*** |
| | | | | *RB<br>**©10–3*** | *CONT* | *VR1* | *Adjust to 2.1V* | ***2.1 + 0/01V*** |
| | | | *RF* | *AGC<br>©4 –2* | *IF* | *VR5* | *Adjust to 3.2V* | ***3.2V + 0.01V*** |
| | | | *IF* | *W31<br>W22<br>W21* | *IF* | | *Confirm<br>Confirm<br>Confirm* | *@14V<br>@ 12V<br>@11V* |
| | | | *RF* | ***Q13-B*** | *RF* | *VR1* | *13.9V* | ***Sets AGC Detector Gain*** |
| | MODE: USB<br>Meter: ALC<br>MIC VR : MIN<br>STBY: SEND<br>(After ADJ, Set STBY to REC) | | *CONT* | ***©2 -1*** | *CONT* | *VR3* | *3.2V +- 0.05V* | ***Sets ALC Reference Voltage*** |

## Adjusting the PLL and CAR Units

### Beware of the Kenwood Procedures

The Kenwood TS-940 Service Manual procedure for adjustment of the PLL Unit is seriously flawed and difficult to follow with reasonable outcome. The adjustment procedures in the Service Manual specify incorrect test points and values in several steps. These inaccuracies have led to a general ad-hoc practice in the field of simply adjusting the VCO level of each PLL to a fixed voltage of @ 8v to obtain a Lock condition for each loop. This approach has become “Common Wisdom” of many WEB posts but is in fact at best a flawed approach.

### Adjusting for Optimum Results

An important technical detail is three of the PLL’s output a variable frequency based on the current Main Frequency Dial selection and adjusting to simply peak the DC voltage level at the test point does not ensure the peak is obtained at the correct point to ensure the oscillator can operate properly across its variable range. The Main VFO frequency dial must be set precisely at a given frequency near the edge of the PLL tuning range for each specific PLL to obtain the correct adjustment.

The adjustment for each PLL sets the output level of the PLL control voltage, which in turn sets the frequency of the VCO in each loop. The level should be highest at the optimum resonant frequency point for each PLL. In most cases, the optimum adjustment is to obtain maximum output from the VCO when the TS-940 is tuned to a specific frequency. Using an Oscilloscope is an easy way to see the output level of the oscillator.

However, adjusting for max output is subject to errors. The adjustment point for each PLL is the resonant coil for its VCO, and some of the adjustments have two peaks, so adjusting the PLL solely based on the DC voltage measurement can cause the frequency to shift from the correct point even though the PLL may still obtain a lock. It is important to verify the frequency of each loop during the adjustment. A good frequency counter will help but note that most counters will not detect signal levels below @-45 dBm, so it is recommended to use an Oscilloscope, or better, a Spectrum Analyzer to ensure the loop output is correctly aligned to the correct frequency point.

# Revised Kenwood TS-940 PLL VCO, and CAR Unit Adjustments

## Important Adjustment Notes

The adjustment procedures below are amended from the original PLL adjustment steps in the Kenwood Service Manual. Note that the sequences of adjustment, test points, result, and pre-set conditions have been changed. This adjustment ensures the proper balance of the band pass filter and requires the use of an RF Sweep Generator.

**NOTE**

The correct setting of the Main Frequency dial is essential to ensure the adjustment is performed with each PLL operating at the correct frequency. The necessary frequencies are noted in the first column of each adjustment step in the following table.

If the main dial is bumped accidentally during the adjustment, it will cause inaccurate adjustment and can lead to intermittent PLL unlock and unstable operation and lead to incorrect Adjustment of downstream frequency dependent circuits. So, carefully set the main dial frequency for each step, then engage the "LOCK" function to prevent change. Yeah, you will LOCK/UNLOCK often, but the accurate results are worth the effort.

**CAUTION**

The adjustment procedures are performed by rotating the tuning cores of transformers on the PLL Unit. These cores are very fragile and can break easily if too much pressure is applied while attempting to rotate them. Please note the commentary in the Troubleshooting section regarding Wax potting in the VCO sections. If the wax has been allowed to flow into the transformer cores, the core slugs may be severely bound by wax in their threads and difficult to turn without damage.

Use a quality plastic or ceramic tool specifically designed for this task. **DO NOT ATTEMPT TO TUNE THE CORES WITH A METAL SCREWDRIVER**. The metal of the screwdriver will offset the coil tune point and can easily fracture the soft iron core.

## Detail Description of PLL/VCO Adjustment Steps

- **Step 1 – 10 MHz Reference Oscillator PLL Connector J8 Pin 1:** The 10 MHz reference is derived from a 20 MHz crystal oscillator on the PLL Unit (X1). This adjustment is critical for the accuracy and stability of all 6 PLL's. Note that the 10MHz output is derived from the 20 MHz Crystal Oscillator. Several other frequencies are also derived from this base reference. See note *"20 MHz Frequency Standard fSTD"* in "Appendix 1 -The Complicated Stuff".

- **Step 2 - PLL-0 HET Oscillator – TP6:** This is the output of the Heterodyne (HET) Oscillator, used by the 2nd RF Mixer; its output is fixed at 36.22 MHz and tracked by PLL-0 (IC19).

- **Step 3 - PLL 3 BPF – TP5:** This step is essential to ensure that PLL3 output is consistent across its entire bandwidth. The output of the PLL Band Pass Filter shifts from 8.5 MHz ~ 38.5 MHz for each 1 MHz band segment between 30 Khz. and 30 MHz (*e.g., 8.5 MHz at 30 Khz -> 38.5 MHz @ 30.000 MHz)*.

## NOTE:

Adjustment of the PLL BPF (L25, L26, and L27) should not be required unless it has been inadvertently changed after leaving the Kenwood factory, typically the result of someone attempting to "Tweak" the PLL. This adjustment requires an RF Sweep Generator. If adjustment of the PLL BPF is required, a 1 MHz ~ 50 MHz swept RF input is applied at TP4, the bandpass filter output is then observed on TP5.

- **Step 4 - PLL-1 - TP1:** The frequency shifts from 100 MHz -> 110 MHz for each 100 Khz. increase on the main tuning dial. For example, at 13.900.00 the frequency 100 MHz, at 13.999.99 MHz the frequency will be 110 MHz, and at 14.000.00 it will return to 100 MHz.

  The correct peak level of this loop should be adjusted at the 110 MHz point (e.g., Dial Frequency 13.999.99 MHz). Caution, L10 typically has two peaks. Normally, the correct peak will be near the top of L10. The level at the test point is very low, @-50 dBm and may be very difficult to observe. The output is amplified by Q11 and input to the PLL IC at IC9 Pin 16, and you can use this test point to adjust L10 for peak. It is very important to verify the correct frequency as well.

- **Step 5 - PLL-2 Input - TP3:** This is a bandpass filter adjustment, so it should be performed to achieve optimum signal level at both High and Low limits of the VCO span. The frequency at TP3 shifts for every 500 kHz on the Main Dial. Correct frequencies are 51.100.00 MHz (Display @13.999.99 MHz) and 46.200.00 MHz (Display @14.000.00). This is a level adjustment on the input to PLL-2, IC8 performed by adjusting L5-L6, and should first be performed at Dial Frequency 13.999.99 VCO Freq 51.1000.00 MHz) to achieve Max amplitude at TP3, then move the dial back and forth between 13.999.99 and 14.000.00 while re-adjusting L5-L6 for max but equal levels at both points.

- **Step 6 – PLL-2 Output – TP2**: This is a resonant amplifier on the output of PLL-2, IC8. The frequency at TP2 shifts between 35.5 – 40.5 MHz for each 500 kHz on the main tuning dial. This test point is not even mentioned in the Kenwood Service Manual procedures but can be used to monitor the peak output level of PLL-2 when adjusting L7. I recommend adjusting after first adjusting L5-L6 for peak level, then adjust L7 to obtain the maximum level for the output at 40.5 MHz (Dial Frequency 13.999.99 MHz). Then check the output at Correct frequencies is 35.500.00 MHz (Display @14.0000) to be sure the PLL remains locked.

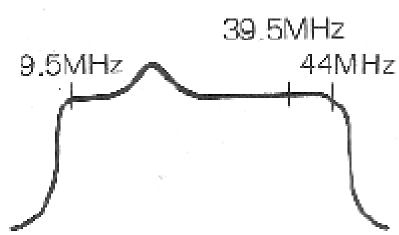
- **Step 7 – PLL3 Input - TP4 :** frequency shifts from 83.550 MHz to 84.050 MHz as main dial transitions from 13.999.99 to 14.000.00 Mhz. This is a level adjustment on the input to the Pre-scaler IC14. Adjust L17, L:18, and L22 – L24 for Max at 83.550 MHz.

## NOTE:

The output of the PLL-3 drives the three Band VCOs on the RF Unit. After completion of the PLL Adjustments, the VCO adjustments should also be checked – See Step 8 in the Kenwood Procedures.

## PLL Unit Adjustment Procedures

***See page 49 ~ 50 for test point and adjustment control locations for the PLL and CAR Units.***

| ***Item*** | ***Condition*** | ***Measurement*** | | | ***Adjustment*** | | | ***Specification/Remarks*** |
|---|---|---|---|---|---|---|---|---|
| | | ***Test Equipment*** | ***Unit*** | ***Terminal*** | ***Unit*** | ***Part*** | ***Method*** | |
| **1a– 10 MHZ Standard Oscillator** | ***Power: On<br>STBY: Rec*** | *Freq Counter* | *PLL* | *Connector 8 – Pin 1* | *PLL* | *TC1* | *ADJ for 10.0000.00 MHz* | ***+/- 5 Hz – I cannot overemphasize the importance of this level of accuracy. The tuning increment of the TS-940 is 100 Hz, and any error in this adjustment can result in an offset in tuning accuracy. For better accuracy, use the 10Hz accuracy setting at the Aux Control Panel.*** |
| **1b- 60 MHZ Reference** | ***STBY: Rec*** | *Scope* | *PLL* | *IC13 – Pin 2* | *PLL* | *L20 – L21* | *Adj for MAX @ 60.0000 MHz* | ***Adj for Max - @ -20dBm*** |
| **2 – PLL 0 - HET Oscillator** | ***STBY: Rec*** | * | *PLL* | *TP6 (R146)* | *PLL* | *L34* | *ADJ for 36.220.00 MHz* | *+/- 20 Hz*<br>*@**12.0 +/- 0.01V** at TP6*<br>***CAUTION: L34 has two peaks**. Start with slug at top of transformer, then Adj CW until signal dropout – then CCW to Peak, then continue for @ 1/8 turn.* |
| ***3– PLL 3 BPF*** | ***STBY: Rec<br>MODE: CW<br>WIDE/NAR: NAR<br>Disconnect VCO-Coax input to PLL<br>Re-connect VCO-Coax*** | *Sweep Gen*<br>*Scope or SA* | *PLL* | *TP4*<br>*TP5* | *PLL* | *L25 – L27* | *Sweep 1.0 MHz-> 50.0 MHz*<br>*Adjust as shown at right.* |  |
| **4 – PLL-1 Output: 100 – 110 MHz** | ***Display FREQ : 13.999.99 MHz<br>Display FREQ : 14.000.00 MHz*** | *RF V.M. / FREQ Counter Or Spectrum Analyzer* | *PL* | *TP1 (R8) Or IC9 – Pin 16* | *PLL* | *L10* | *ADJ for Max at 110 MHz*<br>*Check* | *@ -57 dBm or greater @ 110.000 MHz*<br>*@ 8.0 VDC*<br>*Note: TP1 level is very low amplitude. A better alternative is to observe the amplified output at IC9 Pin 16.*<br>*@ -62 dBm or greater @ 100.000 MHz*<br>*@4.0 ~ 5.5 VDC*<br>*This Voltage level is approximate* |
| **5 – PLL-2 Output: 46.2 – 51.1 MHz** | ***Display FREQ : 13.999.99 MHz<br>Display FREQ : 14.000.00 MHz*** | * | *PLL* | *TP3 (R42)* | *PLL* | *L5 – L6* | *ADJ For Max*<br>*Check* | *@ -35 dBm or greater @ 51.100 MHz*<br>*@10.7 VDC*<br>*@ -35 dBm or greater @ 46.2 MHz*<br>*@10.7 VDC*<br>*Voltage levels are approximate, adjust L5/L6 to ensure reliable PLL Lock at both frequencies* |
| **6 – PLL-2 Output: 35.5 – 40.5 MHz** | ***Display FREQ : 13.999.99 MHz<br>Display FREQ : 14.000.00 MHz*** | * | *PLL* | *TP2 (R53)* | *PLL* | *L7* | *ADJ for Max*<br>*Check* | *@-35 dBm or greater @ 40.499 MHz*<br>*@8.0 VDC*<br>*@-35 dBm or greater @ 35.500 MHz*<br>*@3.5 ~ 5.5 VDC*<br>*This Voltage level is approximate* |

| Item | Condition | Measurement | | | Adjustment | | | Specification/Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Test Equipment | Unit | Terminal | Unit | Part | Method | |
| **7 – PLL-3 Output: 83.55–84.05 MHZ** | ***Display FREQ : 13.999.99 MHz***<br><br>***Display FREQ : 14.000.00 MHz*** | * | *PLL* | *TP4 (C215)* | *PLL* | *L17 - L24* | *ADJ For Max –*<br><br>*Check* | *@-30 dBm or greater @ 84.05 MHz (@ 250mV P-P)*<br><br>*@-30 dBm or greater @ 83.55 MHz*<br>*Adjust L17 ~ L24 for Max level to ensure reliable PLL Lock at both frequencies* |

## RF VCO Adjustment Procedures

| Item | Condition | Measurement | | | Adjustment | | | Specification/Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Test Equipment | Unit | Terminal | Unit | Part | Method | |
| **8 – PLL-3 VCO Adjustment** | *VCO1 Display : 9.499.99 MHz* | *DC VM* | *RF* | *J9 – 4 (VC1)* | *RF* | *L65* | *ADJ to 12V & Confirm the VC1 voltage changes from 12V to @ 2.5V ~ 4.0V as Frequency varies 30KHz → 9.499 MHz.* | ***@12V +/- 0.01V*** |
| | *VCO2: Display: 19.4999.99 MHz* | | | | | *L68* | *Adj to 12V & Confirm the VC1 voltage changes from 12V to @ 2.5V ~ 4.0V as Frequency varies 9.500 MHz → 19.499 MHz.* | ***@12V +/- 0.01V*** |
| | *VCO3: Display: 30.000.00MHz* | | | *J9 – 2 (VC2 )* | | *L71* | *Adj to 12V & Confirm VC2 Voltage changes from 12V to @2.5V ~ 4.0V as Frequency varies from 20.0 MHz → 30.00 MHz* | ***@12V +/- 0.01V*** |

## CAR Unit Adjustment Procedures

| Step | Condition | Measurement: Test Equipment | Measurement: Unit | Measurement: Terminal | Adjustment: Unit | Adjustment: Part | Adjustment: Method | Specification/Remarks |
|---|---|---|---|---|---|---|---|---|
| **11 - CAR1 Adjustment** | MODE: USB | FREQ C | IF | CR1 J18 – Pin 2 | CAR | TC1 | ADJ to 453.50KHz | 453.50KHZ +/-50Hz<br>***NOTE: These are the "optimum" CAR1 set points. Due to minute variance in filter passbands, CAR1 must be refined as described in the "SSB Frequency Response" step in the TX Adjustments section.*** |
| | | FREQ C DC VM | CAR | TP1 | CAR | L6 | ADJ to 7.0V | 7.0V +/- 0.04V |
| | | FREQ C RF VM/ Scope | | J2 – Pin 4 | | L19-L20 | Adjust to Peak | Peak @ 117.000 MHz. |
| | STBY : SEND | FREQ C | IF | CR1 18 – 2 | | | Confirm | Same Frequency as RECV |
| | STBY: RECV<br>MODE: LSB | | | CR1 18 – 2 | | TC2 | ADJ to 456.50KHZ | 456.50KHZ +/- 50Hz |
| | STBY: SEND | | | | | | Confirm | Same Frequency as RECV |
| | MODE: CW<br>WIDE?NAR: WIDE<br>STBY: RECV | | | | | | Confirm at RECV & SEND | 454.30KHz +/-50Hz |
| | WIDE/NAR: NAR | | | | | | Confirm Green NAR LED on | 455.00KHz +/- 50Hz |
| | MODE: AM | | | | | | | |
| | MODE: FSK | | | | | | Confirm | 457.20KHz +/- 50Hz |
| **12 – CAR2 Adjustment** | MODE: CW<br>STBY: RECV | FREQ C DC VM | IF | W25 | CAR | TC3 | Adj to 9.285.00MHz | 9.285.00MHZ +/- 50Hz |
| | | | CAR | TP2 | | L10 | Adj to 7.0V | 7.00V +/-0.04V |
| | STBY: SEND | | IF | W25 | | | Confirm | Same Frequency as RECV |
| **13 – CAR 3 Adjustment** | MODE: CW | FREQ C DC VM | CONT | CR3 35 – 4 | IF | L20 | Adj to 100.00 KHz. | 100.00KHz +/- 20Hz |
| | MODE : USB<br>: LSB<br>: AM<br>: FM<br>: FSK | | | | | | Confirm | USB : 98.5KHz +/- 250Hz<br>LSB : 101.5KHz +/- 200Hz<br>AM : 100.0KHz +/- 100Hx<br>FM : 100.0KHz +/- 100Hx<br>FSK : 101.5KHz +/- 200Hz |
| **14 – CAR4 Adjustment** | MODE: CW | FREQ C DC VM | CONT | CR4 35 – 1 | IF | L19 | Adj to 99.20 K Khz | 99.20KHz +/- 20Hz |
| | CW PITCH : MAX | RF VM | IF | Q14€ | | L18 | Adj to MAX | @ 0.3vrms |

## More TS-940 Adjustments

### Receiver Adjustments

#### *Receiver Band Pass Filter, MCF, and RF Trap Adjustments (Rx Adjustment Steps 1 - 5)*

I recommend examining the RF Unit Schematic to understand what these adjustments achieve. The area of focus should be the Receive signal path beginning at the Antenna input and the Attenuator stage. From there, the Receive signal passes through band pass filters to the 1st Rx Amplifier and Mixer Stages.

NOTE: Some of the IF transformers in this path (L1, L42, T2) are shown on the schematic with symbology indicating they are adjustable but are actually fixed value.

#### Step 1 – Band Pass Filter

The Band Pass filter section is a collection of narrow band filters designed to isolate received signals within the selected band while sharply attenuating out-of-band signals, thus preventing IMD from harmonics of very strong primary and harmonic emissions originating at external transmitters . Each filter is comprised of two or three tuned coils that are adjusted to pass signals only for the selected band and severely attenuate all other frequencies. They are adjusted to optimize the peak range while also providing a sharp cutoff skirt to attenuate other frequencies. The Kenwood procedures to adjust them are documented in 9 individual sub-steps of the Rx Adjustments Step 1.

**NOTE**

> Adjustment of the Band Pass Filters is seldom necessary after their initial factory alignment unless they have been "fooled" with by owners and/or technicians over the years. To adjust properly requires the ability to introduce swept RF signals at the antenna port to stimulate each filter across the spread of frequencies it is designed to filter.

As noted in the Kenwood Procedures, the ideal adjustment of each filter establishes the peak passband and attenuation skirts over a range of frequencies. However, be aware that the examples are hand-drawn "ideal" results which do not represent the actual results that will be observed. Each filter will typically have a much broader response, so adjusting them for peak performance and reasonable skirts requires a bit of intuitive interpretation. An RF Sweep Generator or Spectrum Analyzer with Tracking Generator is required to adjust them properly, neither of which is commonly found on the average owner's workbench. Without the ability to sweep the filters, I recommend it is best to simply leave them alone unless specific attenuation is observed at some frequencies, especially the upper and lower limits of a specific band segment. Attempting to simply peak the filter coils to achieve maximum gain at a single frequency in the band segment can result in severe attenuation at the upper/lower skirts.

With respect to Kenwood's approach to adjusting these transformers, you should keep in mind that their procedures were written for the manufacturing environment where a unit was freshly assembled, so all of the adjustments were necessary. The best approach to adjust the receiver IF path for optimum performance would be to adjust each stage individually, from the Receive antenna input, monitoring the output of each stage individually. That is a long and tedious process, so Kenwood simplified the procedures to simply monitor the audio output level as an indications of changes in the receive signal strength. That works only if the entire Receiver IF chain is at least marginally functional.

To get this process started, Kenwood chose to make several adjustments (L2, L31-L33, L40, L44) in the very first step of the Rx BPF stage. Note that **L2**, **L40**, L44 are not integral to the BPF section. **L2** is a series trap filter inserted in the Rx signal path after the Attenuator, **L40** is a Trap Filter after the broad band Rx Amplifier (Q10), and L44 translates the balanced output of the 1st Rx Mixer (Q9) to a single-ended feed to the next stage.

As a result, a potential problem here is that sub-step 1 assumes it is possible to observe change in the audio level at the other end of the Rx IF Chain. If you are unable to see this, it is time to troubleshoot instead of adjust, selecting test-points throughout the IF chain to find out where the signal is being lost.

## Step 2 – Monolythic Crystal Filter

Step 2 refines the adjustment of the Monolythic Crystal Filter (MCF) which provides attenuation of mixing products produced by the 1st Rx Mixer to produce only the 44.05 MHz 1st IF frequency. Keep in mind that an RF Mixer produces four discreet output frequencies comprised of the two input frequencies and their Sum and Difference. A mixer is typically followed by a filter to attenuate everything but the desired Sum or Difference frequency.

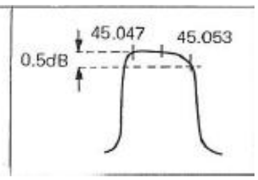
This procedure will first adjust the impedance matching transformers for the 1st RF Mixer and RF Amplifier on the RF Unit, then proceed to the actual MCF circuit which is located on the IF Unit to adjust the matching transformers on each of the three crystal filters.

Note that this procedure calls for a Swept input at 14.250 MHz but does not specify the bandwidth range of the sweep. The output of the 1st Rx Mixer is the 45.05 MHz 1st IF, the result of mixing the receive signal with the Band VCO, so the input frequency is not important as long as the receiver is tuned to the frequency of the signal inserted at the antenna port. Ideally, the sweep should be wide enough to detect any possible bleed through of unwanted mixer products. Note also that this procedure specifies the use of a Spectrum Analyzer to observe the results at TP1 on the IF Unit, which is important since the spectral output of the MCF can only be validated by an SA display.

The RF Unit adjustments are L44 – L46. L44 is a double-ended matching transformer on the output of the 1sr Rx Mixer (Q9) that converts the balanced dual-FET Mixer output to a single ended signal for impedance matching with L45, which is another double-ended transformer that converts the output again from single ended to balanced for input to the Rx Amplifier stage Q7/Q8. These adjustments simply balance the output of each stage, they are not actually filtering the 45.05 MHz 1st IF, which is then forwarded to the IF Unit as the Receive IF signal "RIF".

The IF Unit adjustments are L3, an impedance coupling transformer, L4, a Trap, and L5, another impedance coupling transformer.

The procedure provides an example of the spectral output of the MCF, but like those provided for the BPF stages, this is a hand drawn representation of ideal results and may not match the actual observed result.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2. MCF | 1) BAND : 14.250MHz<br>MODE : CW | SWEEP | RF | TP1 | RF | L44–46 | ADJ to MAX as shown at right.<br>Center frequency 45.050MHz |  |
| | | SPE-ANA | IF | TP1 | IF | L3–5 | | |



## Step 3 – Receive RF Amplifier

In Step 3, which optimizes the gain of the Rx IF Stages on the RF and IF Units.

This procedure stipulates setting VR2 to Mid-Point, then adjusts for **L44** – **L46** again for peak output. The intent is to establish peak output of the Rx Amp with input of the selected frequency of 14.175 MHz. This is counterproductive since it can compromise the **L44 – L46** adjustment for the MCF.

The only adjustment that should be performed here is VR2. However, the procedure stipulates setting VR2 to its center point and never returns to adjust it again. VR2 is intended to balance the parallel input levels to the dual-FET of the 1st Rx Mixer at Q9. The balance is necessary since the actual gain (hFe) of the two FET's may not be linear, so to prevent self-oscillation harmonics, their input levels should be adjusted to produce equal gain and a clean output to ensure uniformity without self-induced oscillation. Simply centering VR2 may not be sufficient to achieve optimal results. Again, observations with a Spectrum Analyzer at the output of Q9 will provide a far more accurate indication of the results of adjusting this stage.

The output of the 1st Rx Mixer then passes through L44 and L45 to the Rx Amplifier. If you examine the schematic, you will see that these two coils transform a balanced output from the mixer to a single ended signal and converted back to a balanced input for input to the dual-FET RF Amp stage at Q7/Q8. After the Rx Amplifier, the 45.05 MHz now becomes the 1st Rx IF signal "RIF", which is then passed to the IF Unit, where it is passes through the 45.05 MHz MCF filter comprised of three very narrow band crystal filters. Three more impedance matching transformers, L3, L4, L5, are inserted between the crystal filters and adjusted for optimum gain of the 1st IF Signal before it is then transformed again to a balanced feed by L6.

Again, I believe the only way to adjust these transformers accurately is to use an SA while monitoring the 45.05 MHZ RIF. Still, if an SA is not available, simply adjusting them for maximum gain will be sufficient to achieve good performance. A good universal test point to monitor while performing these adjustments is the input of the RIF signal to 2nd RX Mixer on the IF Unit at TP1.

### Step 4: Notch Filter

Step 4 adjusts the Notch Filter. This is basically an adjustable Trap filter that allows sharp attenuation of signals at or close to the selected receive frequency. The important point of this adjustment is to place the Notch control on the front panel in its center detent position prior to adjusting the trap.

Again, these coils seldom require re-adjustment, but I can rationalize the adjustment procedure a bit. Setting both all the way in will essentially null their effect. So, to limit the input of the 45.05 MHz signal, it makes sense to adjust L40 first to achieve the lowest possible result, then adjust L2 to refine the attenuation.

### Step 5 –Rx IF Trap

Step 5 stipulates setting the Receive frequency at 1.40 MHz, then injects a 45.05 MHz signal at the antenna port. Since that is well beyond both the selected Rx frequency and the maximum range of the TS-940 receiver, it helps to understand why they do that.

In TS-940, the 1st Receive IF is 45.05 MHz. If a signal input from the antenna at that frequency were to pass through to the Receive chain, it would result in a heterodyne with the internal IF frequency. Not good. Step 5 of the Rx Adjustments (*RX IF Trap*) is specifically intended to adjust the IF Trap to prevent bleed-over of any occurrence of a strong signal at the 1st IF frequency of 45.05 MHz from entering the receiver IF chain.

However, the adjustment procedures introduce confusion because of conflict with adjustments made in other steps of the Rx Adjustment procedures, and also fails to complete the adjustment properly.

So, it is helpful to understand what this adjustment step is attempting to achieve.

The SSG Injection level is specified at 80dB, this is confusing due to the notation convention used by Kenwood, as noted elsewhere in this document see ***Measuring Signal Levels*** on ***Page 50.***

The procedure step should specify 80 dBµ, and that is a very big difference.  The injected level at  80dBµ equates to 5.0mV (5000 µV), a whopping big signal (S-9 is only 50µV), equivalent to -33 dBm, or S9 + 60. This is a very high level intended to overload the receiver front end and generate IMD. The purpose of Step 5 is to adjust elements in the Receive IF chain to attenuate the IMD.

The receive signal from the antenna passes through one of nine bandpass filters depending on the current selected frequency. These filters serve to dramatically attenuate out-of-band signals to prevent receiver overload and improve sensitivity.   Note that the first of these filters, L5, L6, and L7, are selected when the selected frequency is 1.5 MHz or lower (0.5 MHz ~1.5 MHz). By design, the 45.05 MHz signal injected at the Antenna connector should be severely attenuated by the band pass filter at 1.4 MHz.  However, the significantly high level of the injected signal for this procedure will bleed through the filter.

Step 5 then specifies two adjustment points, L2 and L40 on the RF Unit.   Both of these are trap coils designed to attenuate a very narrow bandwidth centered at 45.05 MHz.    L2 is a common trap filter inserted in series ahead of the Bandpass filter stage of the receiver front end, and L40 is a post-amplifier filter transformer in the common signal path after the 1st RF Amplifier.  Both of these controls were previously specified for adjustment in the first sub-step of Step 1. Remember, they were adjusted there solely to provide peak performance of the Rx signal path.

*PROBLEM*: The adjustment procedure stipulates that both L2 and L40 should be pre-set to the bottom of their adjustment range.  After adjusting L40, the remaining adjustment procedures never return to re-adjust L2.  Obviously, this is wrong, L2 must also be adjusted in Step 5 after L40 to further attenuate the 45.05 MHz signal.

## Understanding and Adjusting the TS-940 S-Meter

By convention, we all tend to rely on the Signal Strength Meter, or S-Meter, provided with our radios as an accurate indication of received signal strength. We would all appreciate it if the S-Meter in our radio was accurate. Unfortunately, all S-Meters are not the same, and different radios vary widely in their representation of the same signal, so the indication is somewhat ambiguous. Often the correlation between a radio listener's qualitative impression of signal strength and the actual strength of the received signal is misinterpreted because the receiver's AGC inserts an arbitrary delay (SLOW FAST) that holds the audio output at a relatively constant level despite variable changes in input signal strength. This delay in AGC voltage dampens changes in the actual signal strength specifically to stabilize the S-Meter needle movement.

The procedure in the Kenwood TS-940 Service Manual for adjusting the S-Meter can be very confusing. Three controls are mentioned in the original Kenwood procedure, two of which share the same designation, VR1, one on the IF Unit, and another VR1 on the RF Unit. Adjusting the wrong one can cause serious problems.

It is important to understand that the S-Meter is driven by the AGC, and proper Adjustment of the AGC bias and threshold ensures the relative S-Meter accuracy. Incorrectly adjusted AGC threshold can make the S-Meter unresponsive, or aggressively non-linear.

The Kenwood S-Meter adjustment procedure is also incorrect. **The second step in the Kenwood procedure specifies setting VR1 on the RF Unit to fully CCW. This is wrong, VR1 on the RF Unit is the AGC Gain Threshold and setting if fully CCW essentially turns the AGC off. Even worse, the Kenwood adjustment procedures never again mention VR1 on the RF Unit.**

Accuracy of the S-Meter is subjective, no two radios will produce the exact same measurement across the full scale. Most S meters on traditional analog receivers are not calibrated, and in practice can only provide a relative measure of signal strength based on the receiver's AGC voltage. Complicating this is the S-Meter Adjustment procedures in the Kenwood documentation specify Signal Generator input levels as dB using a dBµV calibration baseline of *0dB = 0.5 µV*, a non-standard adopted only in Japan. The accepted conventional standard is *0dB = 1µV* . So, even if your SG supports selection of output levels as dBµV, the suggested signal levels often result in a "wacky S-Meter" because they are off by 100%. Most SG outputs are calibrated using dBm and µV, either of which is more directly applicable for adjustments.

For best results, the accepted IARU standard reference should be used to select signal levels for both S-1 and S-9. You can find the IARU standard levels for S-Meter calibration here:

### IARU S-Meter Calibration Standard

http://hamwaves.com/decibel/doc/iaru.region.1.s-meter.pdf

So, if you want your S-Meter to at least act in a conventional manner with as much accuracy as possible, it is important to ensure that the AGC is also calibrated to not be weak or too aggressive to obtain a reasonably accurate display of relative signal strength on the S-Meter.

### *Understanding AGC adjustment procedures*

The TS-940 AGC Adjustment procedures are "hidden" within the S-Meter adjustment, and they are not very clear as to what is being adjusted and why. The TS-930 procedure is a little bit better, but still does not clarify the purpose of the adjustments.

Before calibrating the S-Meter gain slope, the AGC threshold adjustment is set. The adjustment point for this in the TS-930 is VR1 on the Signal Unit, in the TS-940, it is VR1 on the RF Unit. The TS-930 procedure is a bit convoluted but worked. This same procedure works very well on the TS-940, just the adjustment points are different.

Still, the Kenwood procedures specify Signal Generator input levels based on a non-standard notation using dB/u calibrated as *0* dB/u = *0.5µV*, so before jumping into this procedure you will need to rationalize these levels to the conventional calibration of *0* dB/u = *1.0µV*.

For a detailed discussion on this oddity, see ***Measuring Signal Levels*** on ***Page50***.

The first step in accurately adjusting the AGC (S-Meter) is the Meter Zero scale adjustment, which establishes the baseline for the meter. Then, a weak signal is injected at the antenna port and the AGC threshold is adjusted to the point that a **decrease** in the AF Volume level is detected using an AF Voltmeter at the External Speaker output. This decrease indicates that the AGC is reducing the receiver gain to limit the signal from overloading the IF chain.

The level specified by Kenwood for this adjustment was 0dB/u, which converts to @0.50 µV(-113 dBm). So, basically, they were stipulating that the AGC turn-on point was -113 dBm. Next, they calibrated the S-1 point using an input of 8dB/u, which converts to @01.26 µV(-105 dBm). Finally, they set the S-9 level using 40dB/u, which converts to @50.0 µV(-73 dBm), and 100 dB/u (a Whopping 50mV (-13 dBm) to confirm the meter can reach full scale at S9 +60dB. This last check confirms the AGC slope is near linear.

For the Kenwood TS-940, calibration of the AGC and S-Meter is performed using five adjustments, none of which is well documented in the TS-940 Circuit Description or Adjustment Procedures.

| ***Location*** | ***Adjustment*** | ***Purpose*** | ***Adjustment Value*** |
|---|---|---|---|
| IF Unit | VR5 | AGC Bias Set Point | 3.2V +/- 0.01V RF J4 Pin 2 |
| RF Unit | VR1 | AGC Detector Gain | 13.9V @ Base of Transistor Q13 |
| IF Unit | VR3 | S-Meter Zero Set | S-Meter Mech Zero with AGC: OFF |
| IF Unit | VR1 | 3rd IF Amp Gain | S-Meter = S1 @ -105 dBm (1.26 µV) |
| IF Unit | VR4 | S-Meter Gain Slope | S-Meter = S9 @ -73 dBm (50µV) |

If your radio has never been serviced before, it would be best to simply leave the adjustment of VR1 on the RF Unit alone. However, there is no way to be certain that it has not been fooled with by a previous owner who followed the Kenwood procedure, so, here are three amended procedures that will improve your S-Meter performance.

The first procedure can be performed by using the built-in Calibrator of the TS-940 as a signal source and a voltmeter to set the AGC bias level. It will at least provide reasonable behavior although not too accurate.

The second procedure assumes the use of a calibrated signal generator and will provide accurate S-Meter performance compatible with the Kenwood specification.

A third procedure submitted by another Technician, Jeff Gagnon, refines this adjustment even further. Most traditional analog receivers are calibrated to read S9 for an input of -73 dBm (50 µV) but do not provide the correct 6 dB per S unit linear accuracy due to non-linearity in their AGC circuit. Jeff's procedure will fine-tune the AGC Gain Slope to better achieve this level of accuracy.

## The S-Meter "SLAM" Problem

Some TS-940s exhibit a disturbing behavior in the S-Meter where it will "Slam" to full deflection when the radio power is cycled. This problem is due to a timing delay in the switching of the +15V supply to the AGC Amplifier in the IF Unit. To correct this problem, Kenwood Service Bulletin 919 modifies the circuit to insert a blocking diode and delay capacitor. SB-919 can be found in the "***Kenwood Service Bulletins***" section at the end of this document.

## TS- 940 RX S-Meter Adjustment – Calibrator Method

The following procedure will produce the most consistent behavior if you do not have sufficient test equipment to generate accurate reference signals. This procedure uses the built-in Calibrator as a relative signal source, but remember it is not calibrated to any standard and will only get you somewhere in the ballpark.

| ***Item*** | ***Condition*** | ***Measurement*** | | | ***Adjustment*** | | | ***Specification/Remarks*** |
|---|---|---|---|---|---|---|---|---|
| | | ***Test Equipment*** | ***Unit*** | ***Terminal*** | ***Unit*** | ***Part*** | ***Method*** | |
| **6 – S-Meter** | 1)AGC: ON - FAST<br>CAL : OFF<br>MODE: CW<br>RF GAIN: FULL CW | VM | RF | Q13(B) or center pin of VR1 | RF | VR1 | Adjust to set Q13 Base @ 13.9V | Sets default AGC Level |
| | | | | | IF | VR3 | Adjust S-Meter needle to mechanical zero. | Sets S-Meter needle to mechanical zero. |
| | | | | | | VR1 | Pre-set to Full CCW | Pre-set S1 Level |
| | | | | | | VR4 | Pre-set to Full CCW | Pre-set S-9 Level |
| | 2)CAL: ON<br>MODE: CW<br>BAND: 14.000.00 | | | Speaker Out | | | | |
| | | | | | IF | VR1 | Adjust S-Meter to S-1, then reduce slightly. | Preset minimal S-Meter Level |
| | Set comfortable volume level and tune receiver to the CAL Signal to produce audio output of @1500 Hz. | | | | | VR1 | Repeat Adjust to S-1, then reduce slightly. | |
| | | | | | | VR4 | Adjust S-Meter to S-9 | Set S-Meter Gain for Strong Signal Reference point. |

## TS-940 RX S-Meter Adjustment – Signal Generator Method

The second procedure will produce the factory accuracy in both AGC and S-Meter performance.

Always check the calibration of the AGC Bias voltage.

| Item | Condition | Measurement | | | Adjustment | | | Specification/Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Test Equipment | Unit | Terminal | Unit | Part | Method | |
| **6 – S-Meter** | 1) AGC: FAST<br>CAL : OFF<br>MODE: CW<br>RF GAIN: FULL CW | VM | RF | Q13(B) or center pin of VR1 | **RF** | VR1 | Adjust to set Q13 Base @ 13.9V | Sets default AGC Level |
| | 2) | | | | **IF** | VR1<br><br>VR4 | Pre-set to Full CCW<br><br>Pre-set to Full CCW | Pre-set S1 Level<br><br>Pre-set S-9 Level |
| | 3)AGC: FAST<br>CAL: OFF<br>MODE: USB<br>BAND: 14.175 MHz<br>RF GAIN: FULL CW<br>**SSG: -130dBm (0.07µV** | | | S Meter | **IF** | VR3 | Adjust S-Meter needle to mechanical zero. | Sets S-Meter needle to mechanical zero (S-0).<br>NOTE: SG input signal at -130dBm establishes S-0 at the receiver noise floor. |
| | 4 )**SSG: -105dBm (1.26µV)** | | Front Panel | S-Meter | **IF** | VR1 | Adjust VR1 on IF Unit to set S-Meter to S-1 | S-Meter = S-1 |
| | 5**) SSG --72dBm (50.0µV**) | | Front Panel | S-Meter | **IF** | **VR4** | Adjust **VR4** on IF Unit to set S-Meter to S-9 | S-Meter = S-9 |

## *Improved S-Meter **Adjustment** (By Jeff Gagnon)*

Jeff Gagnon provided this very detailed amended procedure to adjust the S-Meter for better accuracy and linearity by adding additional steps that refine the adjustment of the AGC level and S-Meter Amplifier Gain slope to make it more accurate.

**TS-940S**

**ADJUSTMENT**

**On page 72 and 73, Adjustment 6. S meter - Revised procedure**

| Item | Condition | Measurement | | | Adjustment | | | Specification/Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Test equipment | Unit | Terminal | Unit | Part | Method | |
| 6. S meter | 1) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST | | Front panel | S meter | IF | VR3 | ADJ IF VR3 so S meter needle is at S0 with no signal on input | |
| | 2) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -113dBm (0.50μV) | SSG | RF | VR1 pin closest to L37 or Q13 base | RF | VR1 | ADJ for 13.9 Vdc | This presets a reasonable starting reference for AGC threshold adjustment |
| | 3) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -113dBm (0.50μV) | SSG<br>AF V.M<br>SP | Rear panel | SP out with 8Ω SP | RF | VR1 | (1) ADJ Front panel audio VR to a comfortable level. Note the AF V.M Vrms reading.<br>(2) ADJ RF VR1 down a bit, then up until AF V.M drops by approx 0.005Vrms | Set AGC threshold more precisely to point where it just begins to impose limiting on the AF output level, i.e. AGC turn-on point is at -113dBm |
| | 4) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -105dBm (1.26μV) | SSG | Front panel | S meter | IF | VR1 | ADJ IF VR1 so S meter needle is at S1 | |
| | 5) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -73dBm (50μV) | SSG | Front panel | S meter | IF | VR4 | ADJ IF VR4 so S meter needle is at S9 | |
| | 6) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -13dBm (50mV) | SSG | Front panel | S meter | IF | VR4 | ADJ IF VR4 so S meter needle is at S9+60dB | If this steps requires an adjustment then follow up with condition 7). Otherwise just recheck conditions 4) to 6) (when all good, skip condition 7). |
| | 7) MODE: CW<br>BAND: 14.175MHz<br>AGC: FAST<br>SSG: -105dBm (1.26μV) | SSG | Front panel | S meter | RF | VR1 | ADJ RF VR1 so S meter needle is at S1 --> Do this step only if required by remarks on condition 6): | Then redo conditions 5) to 6) |

## Transmitter Adjustments

### Tx Drive and IF Amp Adjustment Procedure (Tx Adjustment Steps 2 and 5)

The Tx Adjustment procedures steps 2 and 5 optimize the Tx IF Path for maximum gain. These adjustments are performed by monitoring the level of the DRV signal, which is the final drive input to the PA. Obviously, since these adjustments are performed while transmitting, disconnecting the DRV cable to the PA helps prevent undue stress while of the power transistors while performing the adjustments.

Step 2 optimizes only the maximum gain of the IF chain after the Tx Amplifier to peak the DRIVE signal to the PA Unit.

Step 5 optimizes the gain of the entire Tx IF Chain.

### *Error in the Transmitter Adjustment procedure step 5*

In Step 5 of the Transmitter adjustment procedures, L40 is included in the list of adjustments while transmitting in USB mode. This is incorrect, there is no output from Q46 in USB/LSB/FSK/AM Modes, so L40 has no effect/ Attempting to adjust L40 would degrade the DRIVE peak adjustment performed in Step 2.

## Understanding and Adjusting the ALC Meter for accuracy

The Kenwood TS-940 Service Manual procedure for adjustment of the ALC is wholly incorrect. As a result, it is often misaligned, which typically results in too much ALC action. This is easily identified by noting that the ALC meter deflection in SSB mode becomes highly active or even excessive with the MIC GAIN with control at or below the 12 O'clock position.

First, it is important to understand what ALC is and why. "Automatic Level Control", a.k.a. ALC, is a feature intended to ensure the RF drive of the transmitter Power Amplifier does not exceed optimum operating levels. Overdriving the transmitter Power Amplifier results in distortion of the transmitted signal and may even produce harmonic signals that result in interference. It is also hard on the amplifier transistors, which are designed to operate efficiently within a specific envelope of amplification and overdriving them causes the dissipation of lost power in the form of heat, the bane of all solid-state components. By design, ALC will reduce the transmitter output level to prevent this. ALC is important in SSB transmission since the power output is directly relative to the modulation amplitude, and voice peaks, which are not easily identified on a Watt Meter, can cause over-drive of the PA. Obviously, for optimum operation, we would not want our transmitter power reduced arbitrarily, so it is important that this circuit perform properly and the ALC level is kept at minimal levels while transmitting.

Popular "Common Wisdom" that the ALC meter should be deflecting near the top range of its scale while transmitting is a myth. This method has become popular as a method of increasing "Punch" in the signal by increasing the average power output, but in fact, as indicated by the ALC Meter deflection, it is only resulting in over-drive of the PA and is actually limiting of the peak power output. If you want to increase the average power in your SSB signal, use the Speech Processor, it is designed for exactly that purpose. Personally, I do not use one since the resulting audio is terrible and the added emphasis seldom makes a difference in your signal at the receiving station.

IMPORTANT: Adjusting the ALC Meter simply sets its linear range, it has absolutely no effect on the actual application of ALC. The adjustments for the ALC level, VR3, VR8, and VR9 on the Control Unit, all provide a relative calibration of the

ALC Meter indications, but they have absolutely no effect on the ALC Level used to control the gain of the Transmit RF Amplifier.

The ALC Amplifier circuit in the TS-940 is specifically designed to turn on when detected forward power exceeds 100 Watts.  Below that level, there will be no ALC action.  The adjustment for the ALC Amplifier turn- on point is the Max Power control, VR2 on the Control Unit.  Adjusting this control determines at what point the ALC circuit limits the Transmitter drive, thus limiting power output.

The Kenwood adjustment procedures specify setting the Max Power adjustment, VR2, to set a limit on power output in CW mode at 110 Watts.  Yes, you can adjust this control to get higher power output, as much as 125 Watts.  Believe me, that is a very bad idea. As the PA is driven beyond 110 Watts, the MRF-422 PA transistors begin to saturate, and the output signal wave form can be observed to be “Flat Topping”.  All that extra power is being lost in the form of heat Not only will the clarity of your SSB signal suffer from distortion because of this, it is a sure way to kill your PA.

The ALC provides a very useful indication of optimum operation of the transmitter, but only if it is calibrated correctly. The procedure provided below corrects the flawed procedure in the original Kenwood Service Manual.

The proper adjustment of the ALC is quite simple but requires the ability to insert precise levels of a 1500 Hz tone at the microphone input.  Basically, the circuit is first adjusted to establish the ALC base line with a minimal amount of modulation in SSB mode.  Then, the modulation level is doubled, and the ALC is adjusted to the high point in its zone.

The following amended procedure will calibrate the ALC properly.

### TX Adjustment

| ***Item*** | ***Condition*** | ***Measurement*** | | | ***Adjustment*** | | | ***Specification/Remarks*** |
|---|---|---|---|---|---|---|---|---|
| | | ***Test Equipment*** | ***Unit*** | ***Terminal*** | ***Unit*** | ***Part*** | ***Method*** | |
| **15 ALC Meter** | MODE: USB<br>Meter: ALC<br>MIC VR : MIN<br>STBY: SEND<br>(After ADJ, Set STBY to REC) | DVM | CONT | **J12** Pin 1 (ALC) | CONT | VR3 | 3.2V +- .05V | Set ALC Reference voltage. |
| | MIC VR : MIN<br>STBY: SEND<br>(After ADJ, Set STBY to REC) | | Meter | | CONT | VR8 | ADJ VR8 to set Meter at mechanical zero. |   |
| | AG Input: 1.5 kHz @ 5mV.<br>ADJ Mic Gain to Min ALC Zone<br>(After ADJ, set STBY to REC) | AG<br>AF V.M.<br>Dummy load. | | | Front Panel MIC GAIN | | ADJ Mic Gain to set ALC Meter at ALC Min | |
| | AG input: Increase level to 10mV<br>STBY : SEND<br>(After ADJ, set STBY to REC) | | | | CONT | VR9 | ADJ VR9 to set ALC Meter to ALC Max | |
| | MODE: FM<br>BAND: 29.25 MHZ<br>STBY : SEND | | | | IF | VR9 | ADJ VR9 to set ALC Meter to ALC Max. | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (After ADJ, set STBY to REC) | | | | | | | |

## Best Operating practices using the ALC Meter Indication.

It has been 'Common Wisdom" amongst Amateur Radio operators for some time that the ACL should be full scale while transmitting. This is ***absolutely not true***. Operating with the ALC meter deflection predominantly in the middle to high region of its scale is not efficient and does not improve the power or quality of your signal.

Obviously, since the ALC reduces transmitter drive to prevent distortion, then the optimum performance of the transmitter will be obtained when the ALC meter deflection is minimal. The higher the ALC indication on the meter, the more the transmitter drive is being reduced.

When operating the TS-940 in SSB/AM/FM or FSK Modes, it is advisable to set the MIC GAIN(FM MIC GAIN) or the PROCESSOR OUT controls to get maximum power output with minimal ALC indication.

Adjusting the optimum output in CW Mode is performed using the CAR LEVEL control. The TS-940 can produce excessive drive to the PA, especially in the CW mode. To prevent this, the CAR LEVEL control must be adjusted to obtain the maximum power output with minimal ALC. To achieve this, rotate the PWR control to full Clockwise position, press SEND, then adjust the CAR LEVEL control to obtain maximum power output with minimal ALC.

## General TS-940 Technical Notes and Observations

### Test Equipment –

Useful toys for keeping your TS-940 sailing and your bank account empty.

I have a lot of test equipment, acquired over years of horse trading and prospecting. However, I don't expect everyone to have such resources, but the better you are equipped, the more optimum your results will be.
I have added my musings about the required test equipment and the procedures where they are used in a section at the end of this document. Please read it at your convenience.

Proper adjustment of the Kenwood TS-940 requires test equipment specialized for performing measurements of RF signal levels. Specifically, an accurate Frequency Counter is a must for performing adjustment of the PLL circuitry.
Some of the adjustment steps in the Kenwood Service Manual specify voltage measurements using an RF Voltmeter, a specialized type of voltmeter not common to most Amateur Radio work benches. Although RF voltage measurement is essentially the same as measuring RMS levels, most Digital Voltmeters that do measure RMS do not have sufficient bandwidth for accuracy when measuring AC signals above 1 Mhz. Do not attempt to rationalize these adjustments with a Digital Voltmeter unless you are also using an RF Probe. You can use an Oscilloscope to determine Peak-to-Peak amplitude of RF signals, it is far less accurate. However, in most cases, the RF Voltage is specified as an approximate value to validate that a specific adjustment is at the optimum max scale, so most of these adjustments can be accomplished using an Oscilloscope to adjust for the maximum vertical deflection.

## What Test Equipment do you really need?

### Do you really need the "Required Test Equipment" listed in the Service Manual?

The Kenwood TS-940 Service Manual provides a list of the test equipment necessary to perform the adjustment procedures. Granted, it would be nice if everyone could afford to equip their workshop with all these items, but the expense, let alone the required real estate on your bench, is prohibitive, especially for the hobbyist. I have written the amended procedures in the same technical vernacular as the Kenwood original and specify the test equipment appropriate for each step. I realize that this may still be difficult or confusing since most technicians interested in performing these adjustments are not lucky, or wealthy enough to own all the necessary equipment. Don't worry, there are other ways, and where appropriate, I will mention alternative methods. Still, if you are stumped, contact me and I will try to help.

We should also realize that the Kenwood recommended test equipment list reflects the content of a professionally equipped radio repair shop of the 1980's, when virtually all communications equipment was of analog design. For Amateur Radio enthusiasts, while it would be nice to have all this equipment simply for its vintage collectability, it really is not practical.

However, there are a few instruments that are essential for any attempt at servicing radios, a good Voltmeter, and a good Oscilloscope with sufficient bandwidth provide display of waveforms up to @ 100 MHz, an RF Signal Generator, and a method of generating audio tones in the range of 300 Hz to 2900 Hz.

It is important to first understand the purpose of each adjustment procedure and how to observe the results to be confident that it is correct.  This may be difficult or impractical for many technicians who do not have the equipment specified as “Required” in the procedures.  Still, while accuracy is important, in the case of Adjustment of the TS-940, excellent performance can be achieved without need of many of these instruments.

For Example, while it would be nice to have the following test equipment on-hand, you really can get by without them.

## RF and AF Voltmeter

These are highly specialized meters that produce accurate level measurements of variable frequency (AC) waveforms at the native circuit impedance.  They are useful tools, but in almost all cases, the universal electronic technician tool, the Oscilloscope, will serve very well in this role.  Just remember that the Peak-to-Peak display of waveforms will not show the same values, but in most cases, the adjustment in question is simply to obtain a maximum possible value.

### *Measuring RF Voltages*

Most of the RF signals you will need to observe while adjusting the TS-940 will have very low levels, microvolts.  An RF Voltmeter is useful for this work as it allows accurate level display of these signals.  It also allows comparative measurements in decibels, useful when obtaining maximum gain of tuned circuits.

The most common tool for most of us is the Oscilloscope, which is very useful for both observation and level measurement of RF signals.  Keep in mind that accurate level measurements with respect to microvolts or dB are challenging, but seldom necessary anyway.

Alternatively, you can also use an RF Probe, which is a diode detector type of device that converts RF voltages to DC. They are a good alternative for measuring RF voltages using a common voltmeter, but level measurements will be less accurate.

### *Measuring AF Voltages*

Measuring the level of AF signals with precision accuracy is not necessary while adjusting the TS-940. Most measurements of AF signals will simply be observations to obtain a maximum gain of a received signal while performing adjustments.  A simple AC voltmeter will work fine. If you need or want some assurance of level accuracy, any meter used to observe these signals should be capable of displaying RMS scale.  Check the specifications of your meter, many commercial meters that support RMS measurements have limited bandwidth, typically between 50 Hz and @ 400 Hz, and will work reliably for Audio signals you will measure at the speaker output.  I have a Fluke 45 Meter that works very well for RMS measurements up to 100 Khz., but accuracy declines by as much as 5% of value as frequency increases.

### *Measuring Signal Levels*

Many technicians have encountered difficulty following the Kenwood adjustment procedures due to confusing notation and conventions in the specification of signal levels due to differences in Test Equipment calibration standards of Japanese test equipment versus those adopted by the rest of the world.  Most significant is the specification of signal levels in Decimal Units (dB) which often leads to confusion in understanding the circuit descriptions and mistakes in making adjustments.

Signal waveforms in any RF circuit are simply variable voltage levels when viewed with a voltage level instrument, O-Scope or RF VM. The RF VM will show the relative average signal strength and is useful in determining peak output level. However, with the exception of overall behavior of a signal swept across a specific bandwidth as it passes through a filter, the waveform shape on an O-Scope is non-descript since it only shows the varying level over time, and the most important primary attribute is its level at a specific frequency. This is where the Spectrum Analyzer is the most productive tool you can use when working on Radios as it reveals the signal waveform and level at a specific frequency.

With respect to measurement of signal levels and observing their profile properties, it is very useful to use values expressed in Decibels due to the potential wide range of values.

See the Wikipedia Page on Decibels: https://en.wikipedia.org/wiki/Decibel

Understanding Decibels (dB) is often a confusing subject, but if you take mathematics out of it, the concept is actually quite simple. For a helpful explanation, see the following link: Converting watts to dBm in radio and microwave transmitters (powerstream.com)

> *Decibels are dimensionless numbers used to represent the ratio of two quantities of power: dB. = log p1/p0. This is a base 10 logarithm. A common absolute unit of decibels, "dBm", is the reference of power defined as 1 milliwatt: dBm = log $P_1$/1mw. Likewise, dBμV is a relative measurement of intensity (level) in microvolts. To convert dBm to a dBμV relative voltage level, the equation is dBm+10·log10(Z)+90.*

If you don't really want to drag out your scientific calculator to do logarithmic calculations, you can find numerous useful on-line conversion calculators. Here is a link to a site that offers a complete set:

https://absolute-emc.com/calculator

## Obtaining the Correct Signal Levels for Adjustments

WARNING, the Kenwood Service Manual specifications for Signal Generator input levels for use in making adjustments are difficult to replicate.

By conventional standards, most RF test instruments are calibrated for measurement levels expressed in dBm or µV, although some also offer other level conversions, including dBμV. However, Japanese test equipment in use in the 70's-80's did not follow the "conventional" standard of calibrated output and stipulated their output as "dB" based on 0 dB = 0.5 µV. This odd non-standard convention was a carry carryover from earlier Kenwood hybrid equipment of the 70s and is documented quite well by Terry Wagoner, K9TW, at https://www.k9tw.com/

You can find his short version description in the Kenwood Hybrid group at https://kenwood-hybrids.groups.io/g/main/topic/japanese_db_standard/78897084

Unfortunately, the Kenwood TS-940 Service Manual appears to use this oddball convention. A clue that something is amiss can be found in the "Required Test Equipment" section of the Service Manual, where the specifications for the Standard Signal Generator (SSG) output levels are ***"-20 dB/0.1μV to 120 dB/1V***". Using the calculators referenced above will reveal these ranges are expressed in dBμV, and the reference relationship 0 dBμV = 1 µV = -107 dBm.

So, they meant dBμV, but there is still a serious problem with the levels specified in the Service Manual Procedures. The odd levels used by Kenwood result in confusion of what the proper level should be in adjustments. For example, Step 6 of the Receiver Adjustment procedures in the TS-940 Service Manual specifies an SSG output level of **8dB** to produce an indicated signal level of S-1, and ***40dB*** to produce S-9. Obviously, these levels are not dBm, and even if they were dBμV, using 8 dBμV for the S-1 level is equivalent to -99dBm or 2.5 µV, and using 40dBμV for the S-9 level is -67dBm or 100 µV.

Assuming these levels are calibrated dBμV can easily result in an S-Meter that is basically deaf. This is where the 0dB = 0.5μV confusion lies. The suggested values are off by 100%. But remember, dB measurements are based on Log 10, so simple division by 2 will not provide the correct compensation.

The accepted modern standard of 0db = 1.0µV will produce more accurate readings for S1 = -14 dBµV (0.2µV or -121 dBm) and S-9 = 34dBµV (50µV or -73dBm).

### Kenwood Signal Level notations for Signal Tracing

The charts on Page 82 of the Kenwood Service Manual illustrate expected signal levels at different stages through the RF path for both Transmit and Receive. In the Transmit Section, Kenwood chose to reflect the signal levels as RF Voltage, essentially VRMS. In the Receive path, Kenwood chose to stipulate the apparent gain of each stage over the previous stage in dB, so these are not a level measurement. Although informative, the levels documented here are only a representation, not absolute.

For the Receive IF path, these levels are based on the SSG signal input at the antenna terminal of 0dB, 15dB, 40 dB, 80dB, etc.:, but due to the confusion introduced by the 0dB = 0.5µV calibration reference noted above, the actual RF level necessary produce the expected stage gains is unspecified in measurable units. If we assume that it should be a relatively weak signal e.g., 0dB, then expect that it will have little to no visual S-Meter response or audio effect and will be difficult to observe with an SA without careful adjustment of the base reference level of the instrument.

For almost all receiver alignment tasks, I prefer to start with a relatively strong SSG input, e.g. -20dBm. This will be easy to measure or observe throughout the IF circuit but still so strong as to saturate or overload any of the amplifiers along the way.

Using the built-in calibrator as a signal source will work in a pinch for troubleshooting, but it is not a calibrated level source so do not assume it will produce accurate results for measurements.

Please, do not "Tweak". Although it is common practice to simply tweak the IF transformers to "Peak" the signal path, I am not a fan of this simplified approach as it leaves too much to guess based on the deviation of the S-Meter level or the audio output. Both are assumptions and will never produce optimum results. Trust your test equipment to indicate what is really happening.

Note that when observing and adjusting the IF signal path for optimal performance with signal detecting test equipment (O-Scope, RF VM, Spectrum Analyzer), with the exception of Band Pass Filter circuits, all adjustments should be made to obtain maximum measured level at the output of the circuit or the input to the next stage unless specifically stated otherwise in the adjustment procedure. The reason I emphasize the use of a spectrum analyzer is that both O-Scope and RFVM measurements are solely based on voltage level, so it becomes difficult to discern an adjustment that increases signal level versus noise. The Spectrum Analyzer will show you the actual signal.

Filters are Special. Do not attempt to "Tweak" filter circuits. Filters cannot be simply adjusted for maximum output at a single frequency. Band Pass Filter circuits are designed to pass a specific band of frequencies while sharply attenuating all signals outside of that band. Once adjusted when the radio was manufactured, they seldom drift with age and should only require proper alignment after somebody has "Tweaked" them in the past. These circuits must be adjusted using a swept RF input while observing the output to see the attenuation point at the frequency limits of the filter. This requires a Swept RF Generator, and an O-Scope or Spectrum Analyzer to perform the adjustment properly.

## Spectrum Analyzer

The RF Spectrum Analyzer is an essential tool for anyone who works with RF circuits. While an Oscilloscope is an excellent tool for observations of the varying levels of a signal over time, measuring frequency is difficult, and almost impossible with modulated RF waveforms. The Spectrum Analyzer allows us to observe waveforms in the frequency domain with relative level measurement in dB, so variations of frequency clearly visible.

However, for most of the adjustment procedures, a good RF frequency counter will suffice as well. However, the input sensitivity of most Frequency Counters is insufficient for in-circuit measurements due to very low signal levels present (-50dBm and lower).

## Do you really need a Spectrum Analyzer?

I find the ability to observe RF waveforms essential to understanding the behavior of any tuned circuit. I am lucky to be the owner of more than one Spectrum Analyzer, and I use one almost every day.

Spectrum Analyzers are highly specialized instruments, and, typically, also very expensive. Commercial models are particularly useful for observing very low-level signals. However, the recent evolution of high-speed digital signal processing electronics has made this capability accessible without excessive cost. Small hand-held units are readily available that will work just as well as commercial units for the Adjustment of your radio. Many of these can be found on eBay for less than $100.00. The “Nano VNA” is a good example. If you decide to add one to your shop, be aware that many of them are frequency limited, most at @35 MHz or higher, and do not support the lower frequencies used in HF Radio equipment, so shop carefully, choose one with a low-end range of @ 100 KHz.

## AF/RF Signal Generators

It will be exceedingly difficult to perform the Adjustment of any radio without the ability to input RF signals of known level at the antenna port, and to generate audio tones for input to stimulate transmitter modulation. The preferred equipment for these tasks is typically highly specialized, and expensive.

### AF Signal Generator:

The proper Adjustment of the transmitter will require audio tones input at known levels. This is especially true regarding the SSB linearity, which is best performed with a two-tone modulation input at a fixed level of 5 mV at the microphone input. The same is true for the proper Adjustment of the ALC. Although an accurate AF generator is nice have for this purpose, you can easily achieve the same results using PC based Audio Generator program, many of which are available for free download.

### RF Signal Generator:

For Adjustment of receiver circuits, the intent is, generally, to ensure the ability to reliably detect and receive a signal level of 0.2 $\mu V$ at the antenna terminal (signals as weak as S-1, or about -120 dBm). With exception to calibrating the S-meter on your radio, the primary intent here is to adjust the sensitivity of the receiver for maximum response, which can be performed by simply monitoring a readily available steady signal, such as WWV, or even the built-in calibrator.

However, there are exceptions where an accurate signal level is important. Some adjustments in the receiver are best performed with accurate RF signal levels. This includes the AGC, which ultimately determines the S-Meter response. Adjusting the S-Meter deflection accurately can only be performed with an RF Signal Generator with calibrated output. You can use a second receiver tuned to a known signal as an example to perform a rough calibration of the S-Meter scale. Still, it is important to understand that the S-Meter scale is non-linear, and the circuit that drives it has multiple adjustments that attempt to maintain accuracy over its full scale. Because of this the of S-Meter indications under real operating conditions are seldom identical in most radios, so this may be an adjustment that will meet your needs if it is "Close Enough".

### RF Sweep Generator:

The RF Sweep Generator is a specialized device used to generate RF signals at a fixed level that are periodically swept in frequency across a specified bandwidth. It is used to adjust Band Pass filters using a Spectrum Analyzer or Oscilloscope to observe and adjust the behavior of a filter.

Some RF Signal Generators provide this capability, others may have the ability to inject a sweep saw tooth wave from a function generator to change the output frequency over time. However, without the ability to sweep the bandwidth of a filter, any adjustment of a BPF should be avoided. Do not attempt to adjust them simply by peaking the measured strength of a fixed frequency signal as this will invariably lead to misalignment, causing attenuation on the band edges.

#### *Adjusting Band Pass and Monolithic Crystal Filters*

Band Pass and MCF filters are essentially passive circuits, once properly aligned, they seldom demonstrate drift with age. Adjusting them requires the use of an RF Sweep Generator. Do not attempt to "Peak" these adjustments, once that is done, there is no recourse but to go back and do it the right way. Unless you have had to replace damaged components or have specific knowledge of misalignment in any of the filter circuits in the TS-940, it is best to simply leave them alone and not attempt to adjust them.

## Probes for your test instruments:

### VOM Probes:

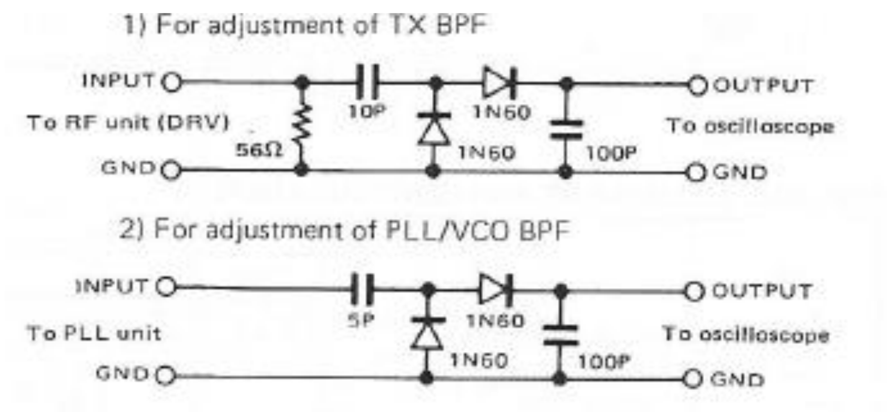
You should avoid using standard voltmeter probes when measuring RF voltages. The typical Voltmeter input impedance will load the signal being sampled and greatly skew the measurement or simply kill the signal entirely. Use VM probes only for measuring AD/DC voltage levels.

### Scope Probes:

An Oscilloscope probe makes an excellent tool for RF signal sampling but be aware that their typical input impedance (1 MOhm and 10 MOhm) may still induce attenuation when attempting to observe very low-level signals. An active Scope Probe, which utilizes a near infinite input impedance, is ideal for all RF signal sampling. However, if you have a decent 1:1 of 10:1 Passive Scope Probe, it will work fine in this application.

### RF Detector Probes

An RF Detector Probe is a device that rectifies RF voltages so they can be measured as a DC level on a common voltmeter. You can purchase dedicated RF Probe, the Fluke 81-85 series are excellent, and available on eBay for reasonable prices. Or you can simply build one. Kenwood specifies the construction of specialized adapter, useful to allow signal sampling while adjusting Band Pass filters, which uses Germanium Didoes. This is an example of an Old School RF detector and is the exact same circuit used in your TS-940 $4^{th}$ IF stage. You can still find 1N60 Germanium diodes, but you can also get excellent results using any good Schottky diode in place of the 1N60 Germanium diodes with only a minor reduction in sensitivity.

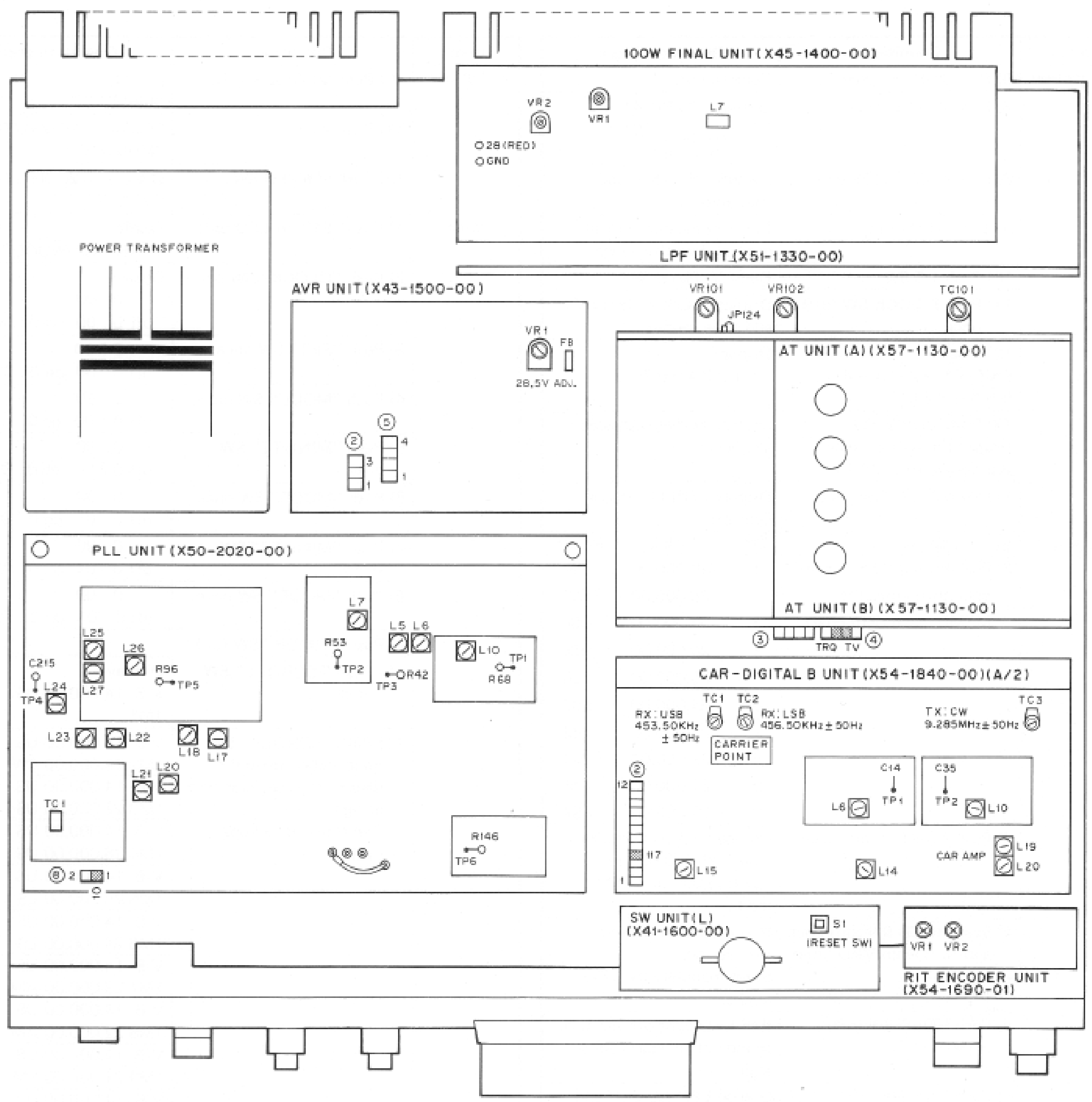

1) For adjustment of TX BPF
INPUT
To RF unit (DRV)
GND
56Ω
10P
1N60
1N60
100P
OUTPUT
To oscilloscope
GND
2) For adjustment of PLL/VCO BPF
INPUT
To PLL unit
GND
5P
1N60
1N60
100P
OUTPUT
To oscilloscope
GND

# TS-940 Adjustment Point Diagrams

## TS-940 Top Chassis Adjustment Points

### TS-940S ADJUSTMENT

TOP VIEW




**PLL UNIT (X50-2020-00)**
L5–7 : PLL-2 adj. (35.5–40.5MHz)
L10 : PLL-1 adj. (100–110MHz)
L17, 18, 20–24
: PLL IF adj.
L25–27 : PLL BPF adj. (9.5–44MHz)
TC-1 : STD freq' adj (20MHz)

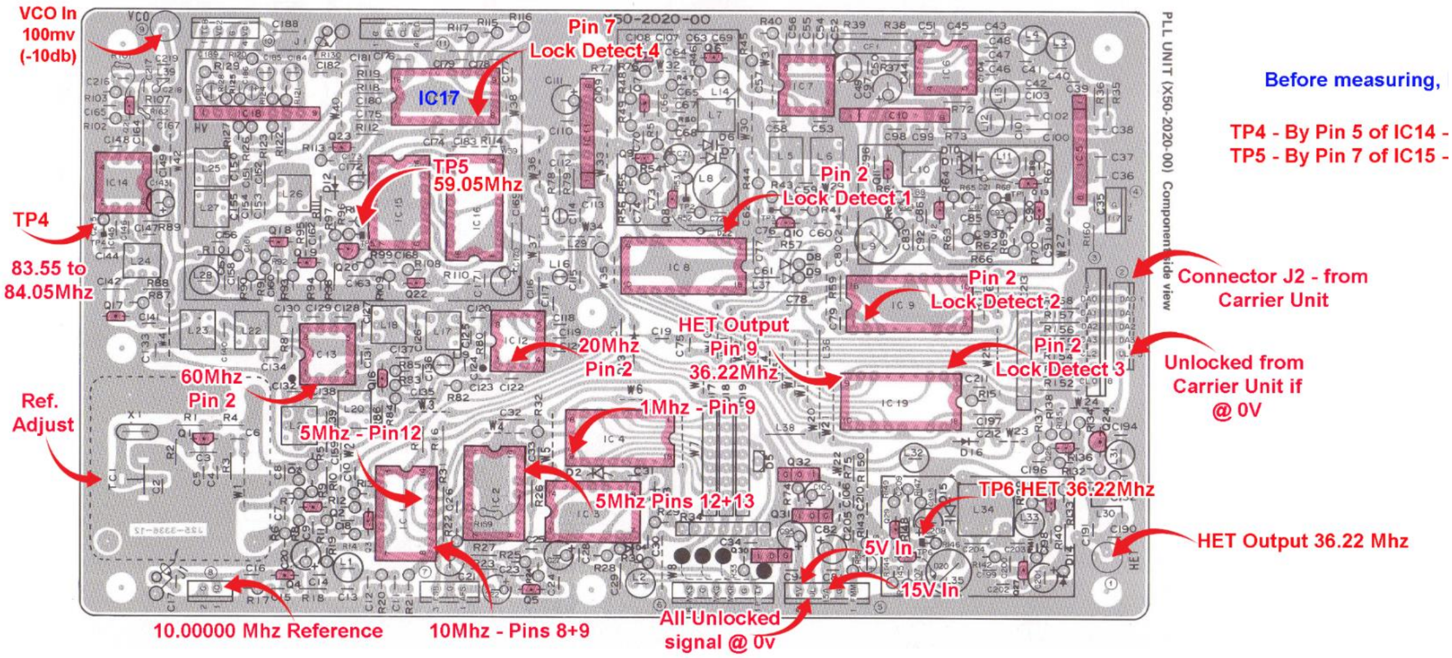
**AT UNIT (A) (X57-1130-00)**
VR101 : Waveform ratio (A=B)
VR102 : ANT TUNE indicator goes off

TC101 : Motor stop and SWR reads MIN

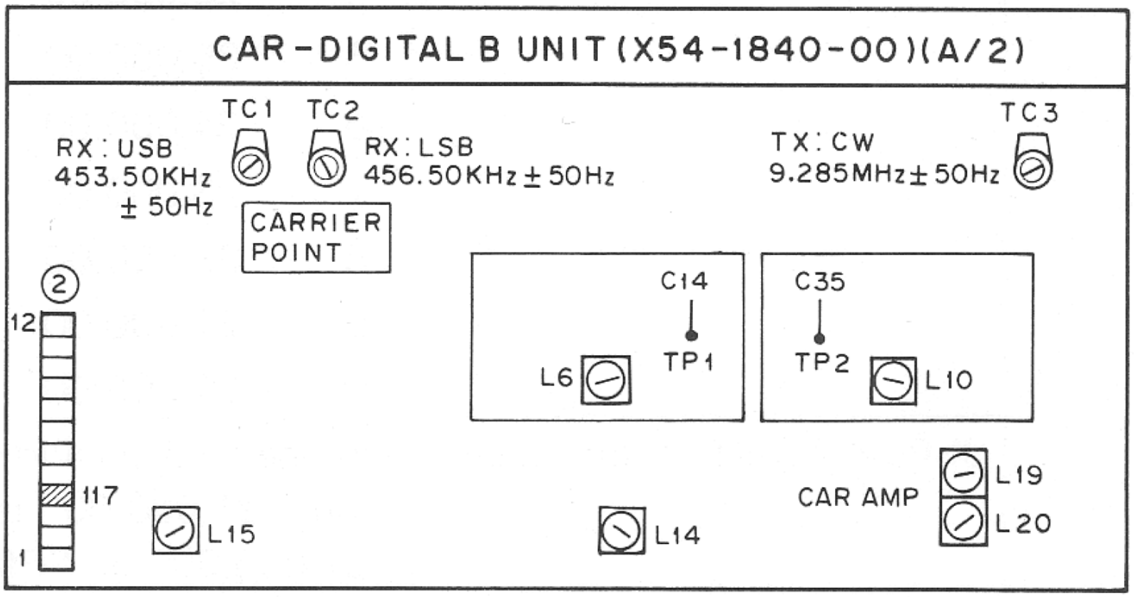
**100W FINAL UNIT (X45-1400-00)**
VR1 : 130mA +100mA, –50mA (100W Final bias)
VR2 : 50mA ± 10mA (10W Final bias)

## PLL Unit Test and Adjustment Points

***This** Excellent Detailed reference for PLL Unit testing is provided Courtesy of Jeff Hilliard*



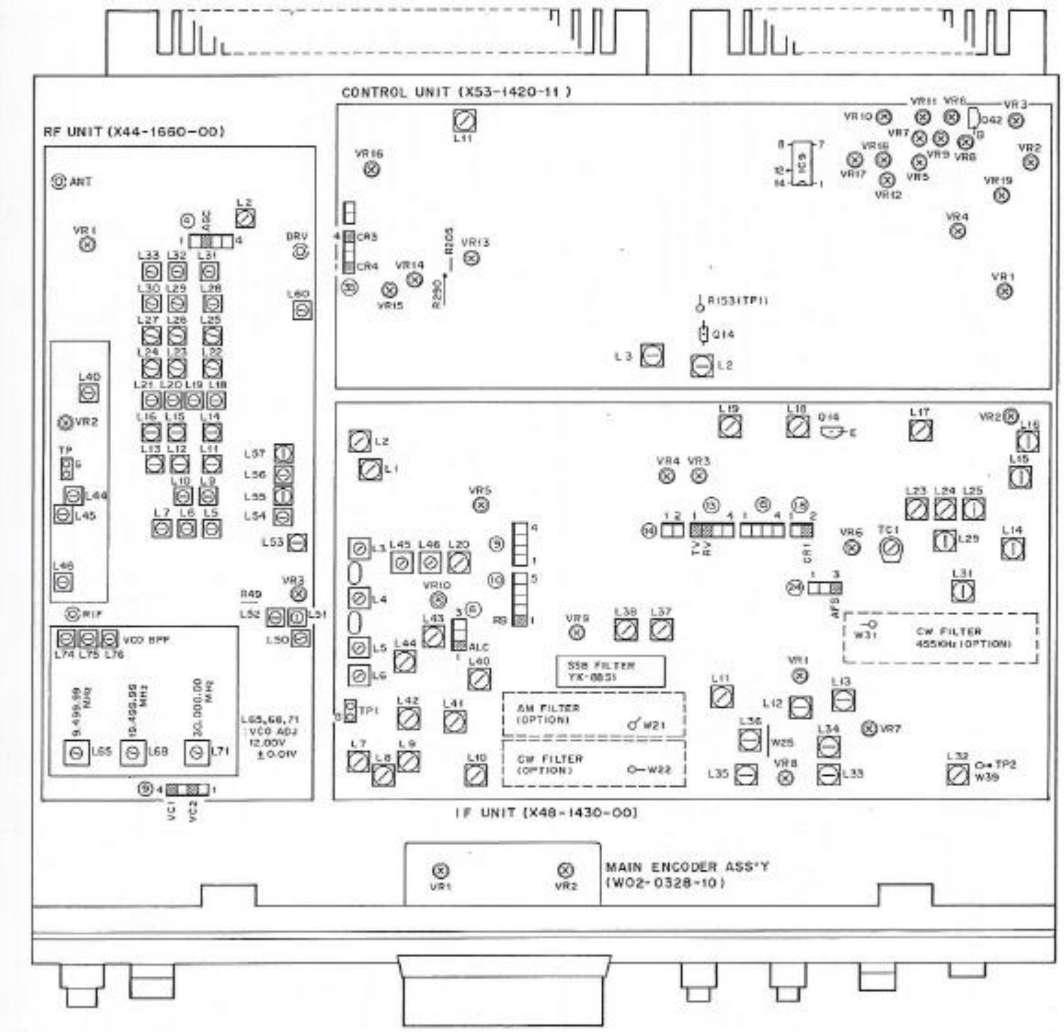
## TS-940 CAR Digital B Unit Test and Adjustment Points



# TS-940 Bottom Chassis Adjustment Points



BOTTOM VIEW




**RF UNIT (X44-1660-00)**

L2,40 : IF TRAP adj. (BAND 1.400MHz, SSG : 45.05MHz 80dB)
L5–7 : BPF 100–500kHz (Freq. : 300.0kHz)
L9,10 : BPF 0.5–1.5MHz (Freq. : 1,000.0kHz)
L11–13 : BPF 1.5–3.0MHz (Freq. : 1,900.0kHz)
L14–16 : BPF 3.0–4.0MHz (Freq. : 3,900.0kHz)
L18–21 : BPF 4.0–7.0MHz (Freq. : 6,900.0kHz)
L22–24 : BPF 7.0–8.5MHz (Freq. : 7,000.0kHz)
L25–27 : BPF 8.5–14MHz (Freq. : 10,000.0kHz)
L28–30 : BPF 14.0–20.0MHz (Freq. : 18,000.0kHz)
L31–33 : BPF 20.0–31.0MHz (Freq. : 29,500.0kHz)
L44–46 : MCF (Center freq. : 45.050MHz)
L50–52 : DRIVE adj.
L53,55,57 : TX BPF 1.7MHz Side (A)
L54,56,60 : TX BPF 30MHz Side (B)
L65 : VCO1 adj. (9.499.99MHz)
L68 : VCO2 adj. (19.499.99MHz)
L71 : VCO3 adj. (30.000.00MHz)
(L65, L68, L71: 12.00V±0.01V)
L74–76 : VCO BPF

VR1 : RF AGC adj. (AF output 0.2dB down)
VR2 : MIXER BALANCE adj.
VR3 : MIXER BALANCE adj. (CW 23.950MHz)

**IF UNIT (X48-1430-00)**

L1,2 : IF OUT adj. (8.83MHz)
L3–6 : MCF adj. (RF unit : L44–46)
L7–15,17,23–25 : SSB IF GAIN adj.
L16 : NOTCH adj.
L18,19 : CAR4 adj. (99.20kHz±20Hz)
L20 : CAR3 adj. (100.0kHz±20Hz)
L29,31,34–36,40–42,44–46 : DRIVE adj.
L32 : COMP LEVEL adj.
L33 : ALC LEVEL adj.
L43 : MONI LEVEL adj.
L37,38 : FM IF GAIN adj.

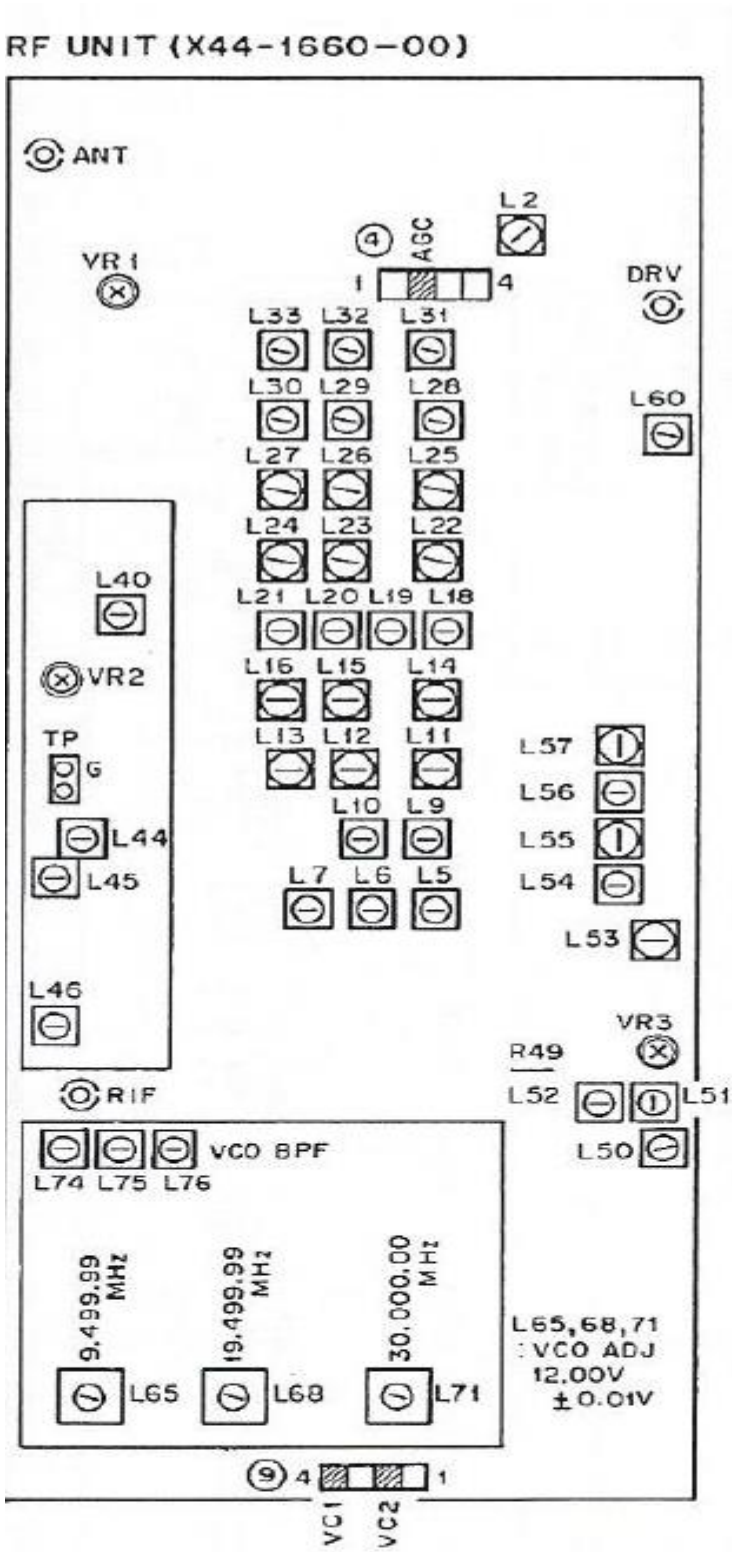
VR1 : RX S-meter Sens. S-1
VR2 : NOTCH adj. (VR2 and L16)
VR3 : RX S-meter ϕ adj.
VR4 : RX S-meter Sens. S-9
VR5 : AGC adj. 3.2V
VR6 : CARRIER SUPPRESSION adj. (VR6 and TC1)
VR7 : COM LEVEL adj. (VR7 and L32)
VR8 : MIXER BALANCE adj. 21.555MHz (AM 21.1MHz)
VR9 : ALC LEVEL adj. (FM 29.25MHz)
VR10 : MIXER BALANCE adj. (CW 29.930MHz)

**CONTROL UNIT (X53-1420-11)**

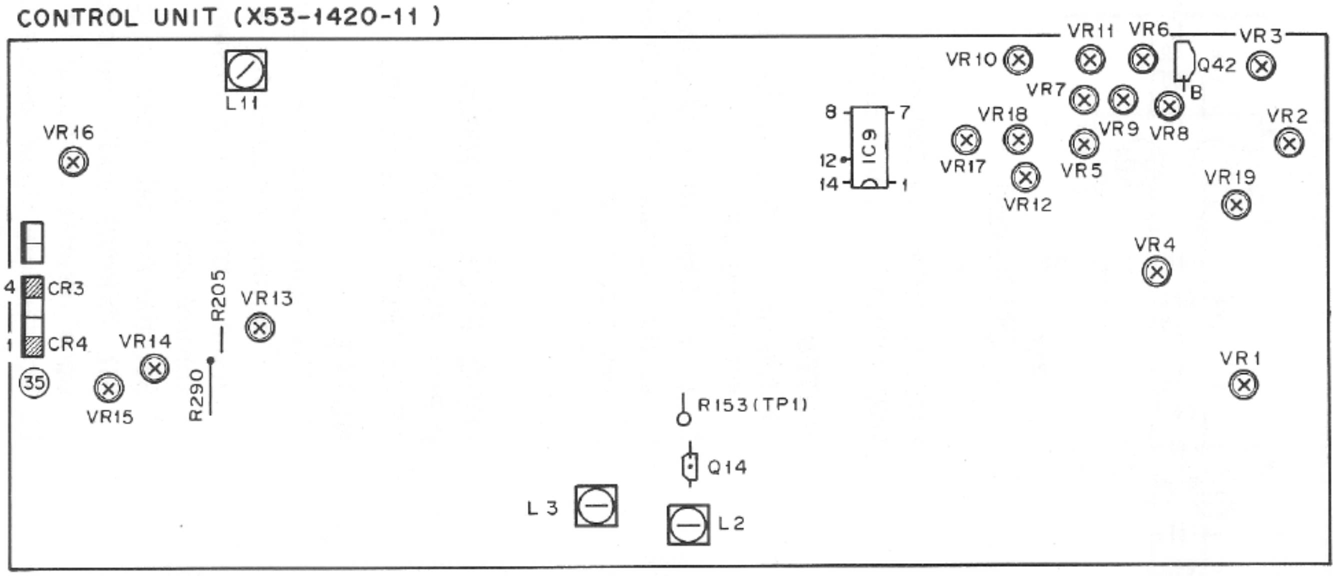
L2,3 : SSB IF GAIN (MIN. adj.)
L11 : FM IF GAIN

VR1 : RB adj. 2.1V
VR2 : MAX POWER adj. (110W)
VR3 : ALC adj. 3.2V
VR5 : SWR protection adj. (100W)
VR6 : Current protection adj. 14A
VR7 : IC meter adj. 10A
VR8 : ALC-ϕ adj.
VR9 : ALC meter adj.
VR10 : IC-ϕ adj.
VR11 : VC meter adj. 28.5V
VR12 : SWR standard adj. 0.5V
VR13 : MONITOR LEVEL adj.
VR14 : BUZZER LEVEL adj.
VR15 : Side tone level
VR16 : DEV.
VR17 : Power meter adj.
VR18 : SWR meter adj.
VR19 : MIN. power adj. (5W)

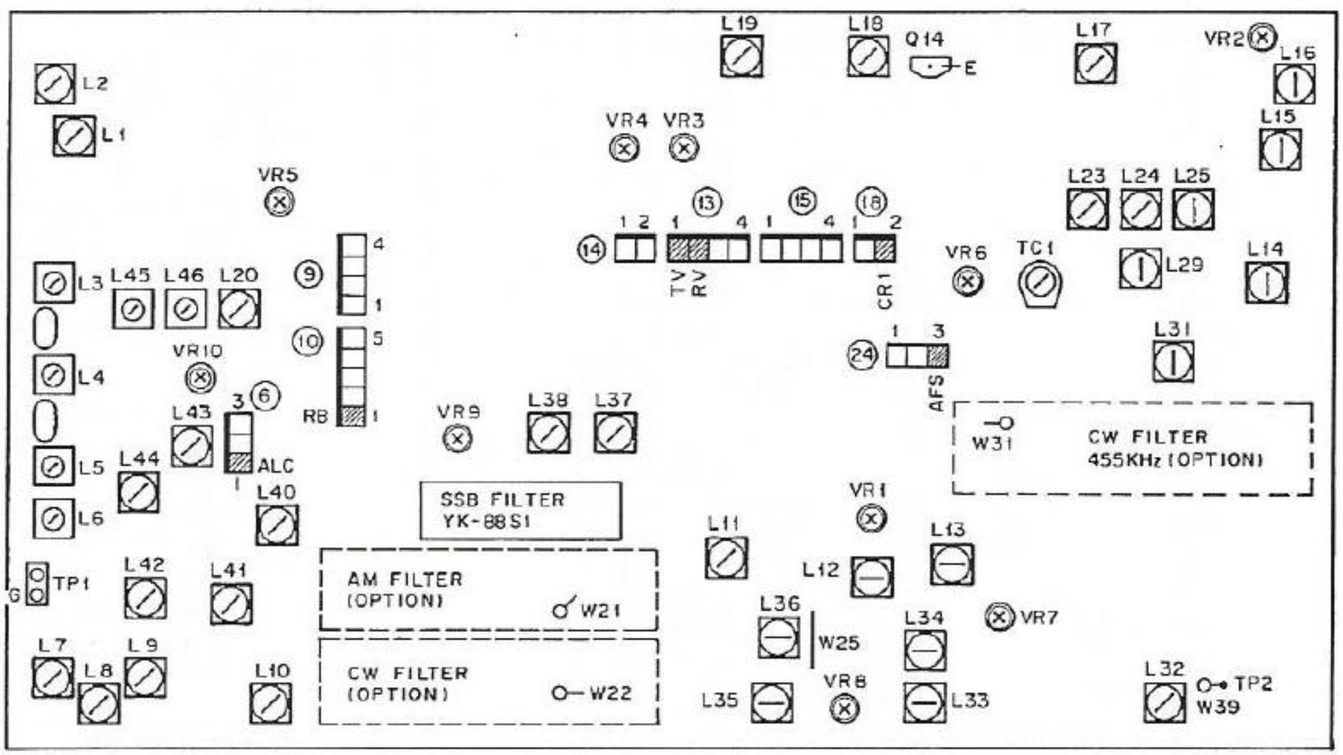
## TS-940 RF Unit Test and Adjustment Points



## TS-940 Control Unit Test and Adjustment Points




## TS-940 IF Unit Test and Adjustment Points



## Making the TS-940 “DIM” button work with LEDs in the Panel Meter

LED Meter Backlight Modification for the Kenwood TS-930 and TS-940

The Meter backlight circuit on Kenwood TS-930 and TS-940 includes series resistors that limit the current to the meter lamps, which enables the DIM switch on the front panel to change the brightness of the meter illumination.

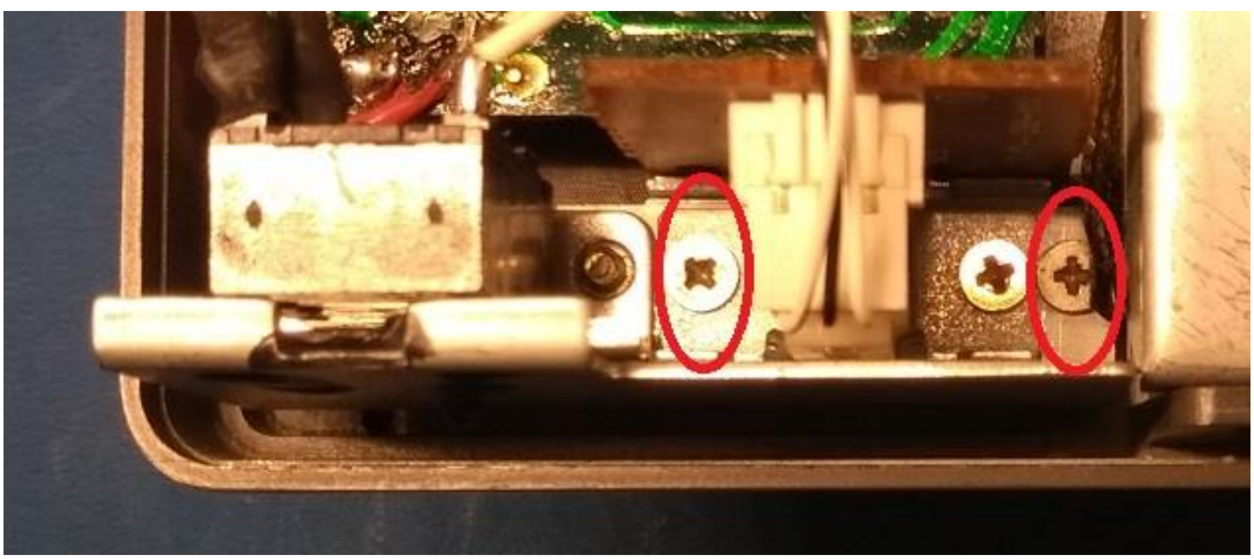
LEDs are constant current devices, so the limited resistance provided by Kenwood has no effect on their brightness. However, simply replacing one of the series resistors in this circuit enables the voltage to the LED’s to be changed enough to make the DIM feature work like it did with the incandescent bulbs.

The following are two separate procedures that show how to easily implement this modification when installing LED backlighting in your radio.

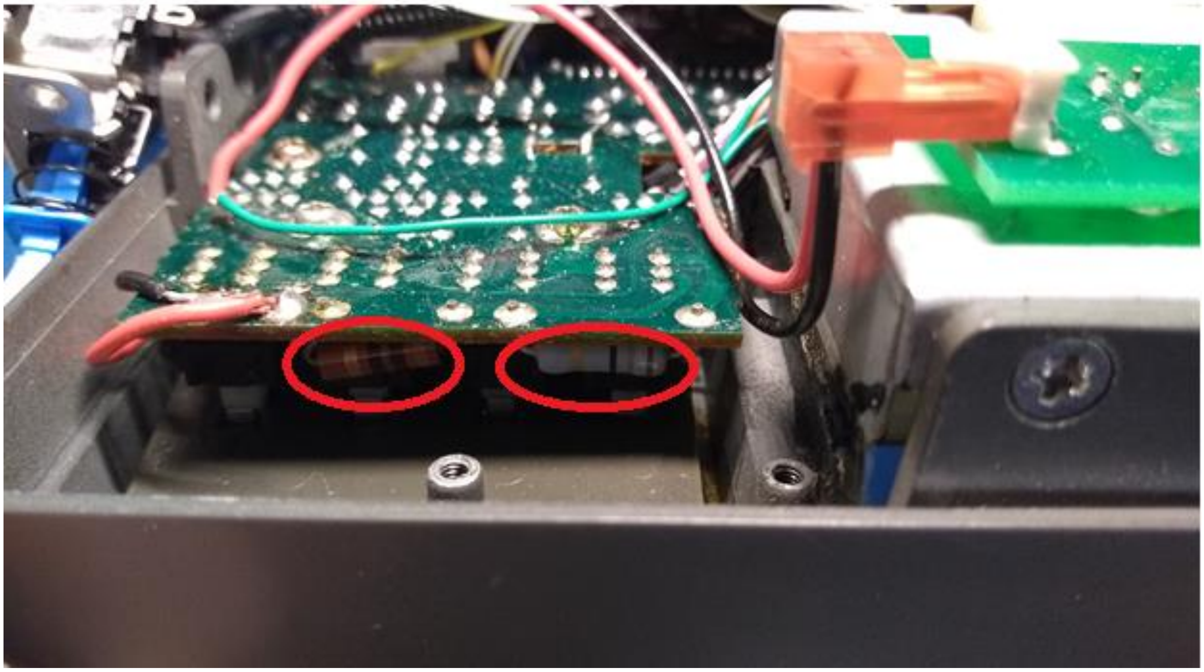
The procedure for making the DIM feature work with the K6IOK LED Upgrade is very similar, but in the TS-940, the meter lamp power supply is 15V instead of the 28V used in the TS-930.

The resistor that will be changed is R55, an 18Ω 1 Watt resistor. In this case, we will replace it with a 470Ω resistor.

To gain access to the switch unit (Switch Unit “A”) where the resistors are, it will be necessary to tilt the front panel forward, and then remove the two screws that retain the small bracket that holds the Power & Timer switches to the front panel. It is best to use a magnetized screwdriver for this to avoid losing the very small screws somewhere in the panel area. Remove only the left and right screws as shown highlighted in the photo below.

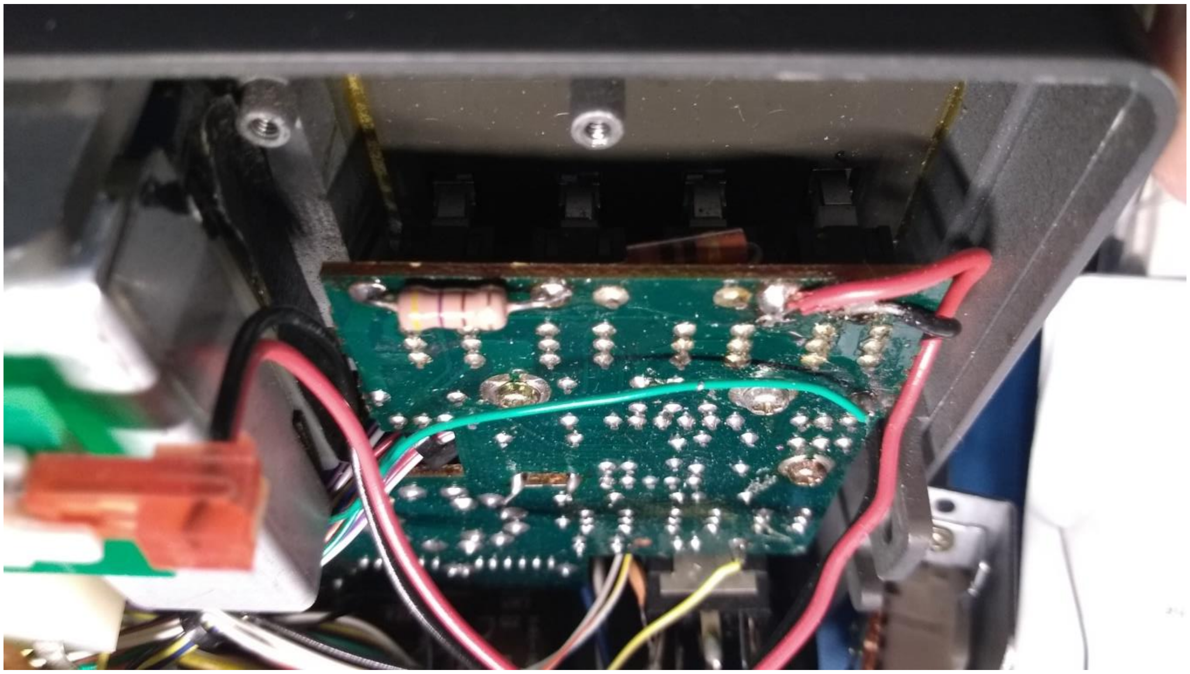


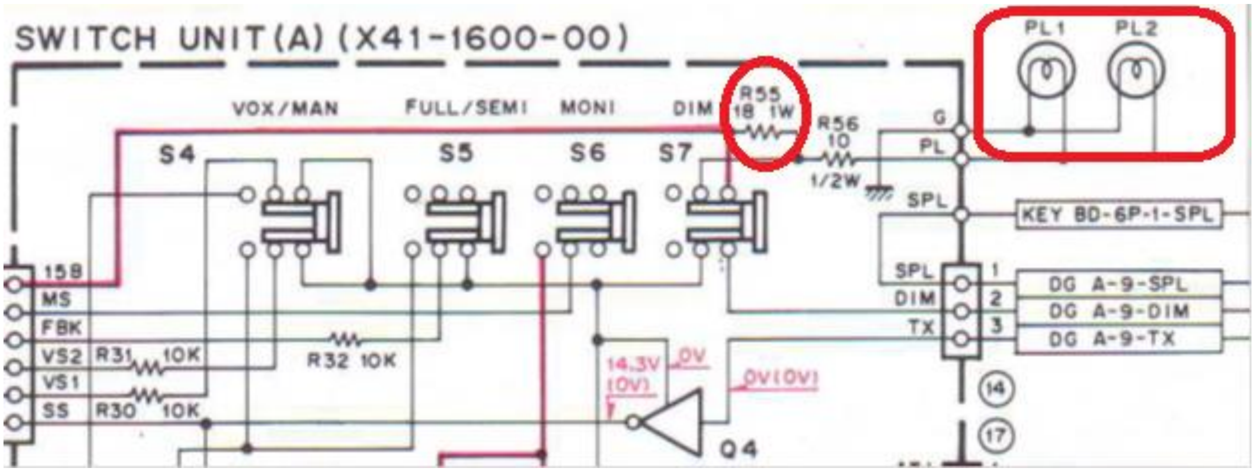
With the Power/Timer switch assembly set aside, now look at the Switch Unit “A” from above, you can see the two Lamp bias resistors, R55 and R56 on the edge of the circuit board side facing the front panel, highlighted on the photo below.  Their solder pads are easily accessible from the back side of the board.



Remove R55, the resistor on the right.   It is very difficult to clip its leads in the tight space between the board and the panel, so I recommend heating the pads with a soldering iron and, using fine point needle nose pliers, gently pry the resistor leads out.  Be careful, you can lose the resistor in the panel assembly if you lose grip on the last lead.

The replacement R55, a 470Ω resistor can now easily be inserted into the now vacant solder pads as shown in the photo  below.




SWITCH UNIT (A) (X41-1600-00)
PL1
PL2
VOX/MAN
FULL/SEMI
MONI
DIM
R55
18 1W
R56
10
1/2W
G
PL
SPL
S4
S5
S6
S7
KEY BD-6P-1-SPL
15B
MS
FBK
VS2
VS1
SS
R31
10K
R32 10K
R30
10K
SPL
DIM
TX
DG A-9-SPL
DG A-9-DIM
DG A-9-TX
14.3V
(0V)
0V
0V(0V)
Q4

## SB-900

# KENWOOD

900

## SERVICE BULLETIN

AMATEUR RADIO

| SUBJECT | DATE |
|---|---|
| TS-940S PLL UNLOCK | 10-18-85 |

Some users of the TS-940S have reported a blanking of the display accompanied by a loss of transmit and receive. Readjustment of the PLL unit will correct this tendency.

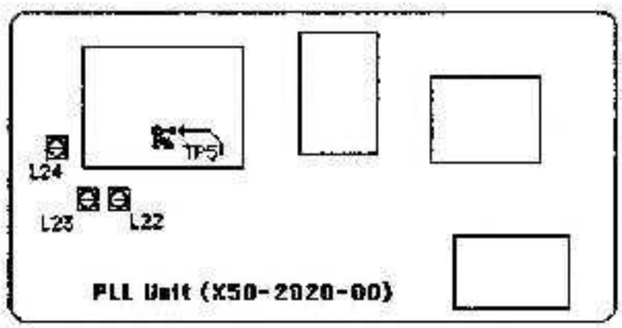
Procedure:

On the PLL Unit (X50-2020-00)

1. Set the Dial frequency for approximately 1.8 Mhz (inside the band).

2. Using an RF probe at TP #5 adjust L22, L23 and L24 for a maximum reading on the meter. You should see approximately 250 mV.

3. Adjustment of L24 will produce the greatest change, which may be up to a 90° adjustment from its present position.




Time required for this procedure is .5 hour or less. ©TKC101785
CLM

TRIO-KENWOOD COMMUNICATIONS
1111 WEST WALNUT STREET · COMPTON, CALIFORNIA 90220 U.S.A.
MAILING: P.O. BOX 7065 - COMPTON, CALIFORNIA 90224
TELEPHONE: (213)639-9000 SERVICE TELEPHONE (213) 639-7140

# KENWOOD

908

## SERVICE BULLETIN AMATEUR RADIO

SUBJECT: TS-940S PLL UNLOCK

DATE: 4-8-86

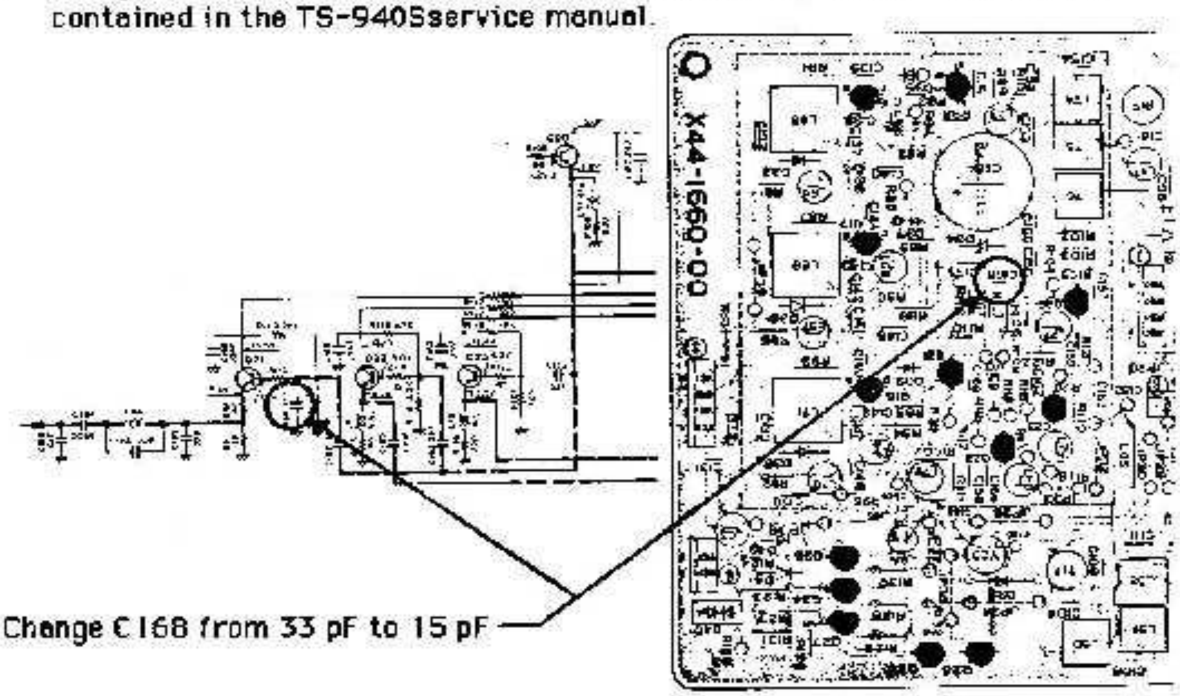
Reports of a PLL Unlock on the lower frequencies may be due to low VCO levels. The following change will increase the VCO level and should prevent reoccurance of this symptom.

Part Required

C168......................change to 15 pF 50 v (CC45SL1H150J)

Procedure:

1. On the RF Unit (X44-1660-00) change C168 from a 33 pF capacitor to a 15 pF 50 v capacitor.
2. Readjust the VCO BPF (RF unit L74-76) according to the instructions contained in the TS-940Sservice manual.




Change C168 from 33 pF to 15 pF

This change is applicable to units prior to serial number 606XXXX.

Time Required for this modification is 1 hour or less. ©TKC40886CLM

TRIO-KENWOOD COMMUNICATIONS
1111 WEST WALNUT STREET · COMPTON, CALIFORNIA 90220 U.S.A.
MAILING: P.O. BOX 7065 · COMPTON, CALIFORNIA 90224
TELEPHONE: (213) 639-9000 SERVICE TELEPHONE: (213) 639-7140

KENWOOD



# SERVICE BULLETIN

| TS-940 S-Meter Needle Slams to full scale during Power On/Off | 09/19/86 |
|---|---|
| Reports of the S-Meter needle slamming to full scale position on Power On/Off. This is due to the delayed switching of the +15V DC supply to the AGC Amplifier.<br><br>To correct this problem, perform the following modification.<br><br>IF Unit<br><br>Replace Jumper J5 with a 1SS133 Diode (Cathode towards R178).<br><br>Add a 100uf 16v cap between the junction of R178/1SS133 to ground.<br><br>Time to install this modification 1 hour or less. © TKCLM 91986 | |

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street Compton California90220 U.S.A
MAILING P.O. Box 7065 Compton, California 90224
TELEPHONE: (213) 639-9060 SERVICE TELEPHONE (213) 639-7140

KENWOOD

SB-951

# SERVICE BULLETIN AMATEUR RADIO

| SUBJECT | DATE |
|---|---|
| TS-940S ERRATIC DISPLAY | 01/20/89 |

Intermittent control or display problems that are difficult to correct with the reset procedure may be caused by a faulty ROM socket. The socket should be checked to insure that it makes good electrical contact with each pin of the ROM. If it is found to be intermittent, remove the socket and solder the ROM directly to the board. It should be noted that units between serial numbers 701XXXX to 811XXXX and from 903XXXX to 909XXXX are not likely to have this failure. In addition, units with a serial number of 909XXXX and above do not incorporate a socket.

**CAUTION**

Removing the socket requires good soldering skills. The ROM is mounted on the Digital A unit and is designated as IC2. The board, being double sided, has solder connections on both component and foil sides. When the socket is removed, it is very important to insure that each pin is completely solder free. Having to pry up on the socket means that it is not completely desoldered and will cause the circuit foils to tear.

When performing any work on the Digital A board, CMOS handling techniques must be observed. Such techniques include using a grounded or isolated soldering tip, avoid touching the pins of IC chips with your fingers, and ground yourself with a wrist ground strap.

To remove the socket:

1. Disconnect the power cord and antenna coax.
2. Remove the top and bottom covers from the transceiver.
3. Remove the 2 flat head screws from each side of the front panel chassis.
4. Loosen the round head screw on each side of the front panel chassis.
5. Carefully rotate the front panel forward. It will be necessary to unplug the VS-1 cable from the transceiver.
6. Remove the 4 screws from the speaker mount.

KENWOOD U.S.A. CORPORATION
2201 EAST DOMINGUEZ STREET · LONG BEACH, CALIFORNIA 90810
MAILING: P.O. BOX 22745 · LONG BEACH, CALIFORNIA 90801-5745
TELEPHONE: (213) 639-9000

7. Carefully pull up on the mount and rotate it toward the front panel. Swing the mount toward the right side of the transceiver and allow it to rest on the Digital B unit shield.

8. Remove the 8 screws from the Digital A unit shield plate.

9. Lift the plate and rotate it to the left side of the transceiver.

10. While avoiding contact with the pins, remove the ROM (IC2) and set it aside on anti-static foam.

11. Remove the 6 screws that mount the Digital A board. Rotate the board toward the front panel to expose the bottom side of the board.

12. Carefully desolder the socket and remove it from the board. Do not pry up on the socket. If it does not easily pull off the board, the top foils are still soldered to the socket.

13. Install the ROM in the board and solder it in place.

14. Assemble the transceiver by reversing steps 1 - 11. Do not pinch the power switch cables between the front panel and the body of the transceiver.

**This modification may be covered under warranty during the warranty period.
Time required for this modification is 1.5 hrs or less. (C) 011189TKC**