KENWOOD TS-940 PAGE

One of the greatest transceivers ever produced.

This page provides:

· Some information not available anywhere else which should be useful to any TS-940 owner,
· Information at single web site, easy to follow, [no other site provides this about the 940]
· Information remaining available so more TS-940s will be repaired + functional, (and probably improved),

Version 2: 4 April 2005, Version 3: 25 April 2005, Version 4: 27 May 2005, Version 5: 31 May 2005, Version 6: 10 June 2005: Version 7: 16 June 2005: Version 8: 25 July 2005, Version 9: 30 July 2005. Version 10: 4 August 2005, Version 11: 13 Sep 2005, Version 12: 18 October 2005, Version 13: 23 October 2005, Version 14: 22 March 2006, Version 15: 8 April 2006, Version 16: 27 May 2006, Version 17: 12 July 2006 Version 18: 22 Aug 2006, Version 19: 23 Sep 2006, Version 20: 5 October 2006, Version 21: 7 Jan 2007, Version 22: 17 Jan 2007, Version 23: 5 Oct 2007, Version 24: 19 April 2008, Version 25: 27 July 08, , Version 26: 20 Sept 08

The intention is to acknowledge the person who discovered the information

When information is already well documented and reliably maintained on another site then a hyperlink is made to that site to avoid yet another slightly different version.

I will publish all email feedback of new information at the end of the page, so that whatever is discovered by others can be shared by all. Please email to jaking@es.co.nz

Yours sincerely
Jeff King ZL4AI / DU7 http://www.jking.kol.co.nz/ZL4AI.htm

Disclaimer: No liability or responsibility whatsoever is taken for any of the information on this site. You assume total liability for any modification you undertake.

See also TS-950sdx page which hold valuable information: http://homepages.ihug.co.nz/~jaking/TS-950sdx.htm

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TO ACCESS THE SECTIONS BELOW CLICK HERE ------>: www.jking.kol.co.nz/ts-940_02_part2.htm

PROMOTIONAL BROCHURE

TRIO

HF TRANSCEIVER

TS-940S

TS-940S

HF TRANSCEIVER

The TS-940S is a competition class HF transceiver having every conceivable feature, and is designed for SSB, CW, AM, FM and FSK modes of operation on all 160 through 10 metre Amateur bands, including the new WARC bands. It incorporates an outstanding 150 kHz to 30 MHz general coverage receiver having a superior dynamic range (102 dB typical on 20 meters, 50 kHz spacing, 500 Hz CW bandwidth).

Engineered with the serious DX'er/contest operator in mind, the TS-940S features a wide range of innovative interference rejection circuits, including SSB IF slope tuning, CW VBT (Variable bandwidth tuning), IF notch filter, AF tune circuit, Narrow/Wide filter selection, CW variable pitch control, dual-mode noise blanker, and RIT plus XIT. The use of a new microprocessor with advanced digital technology controlled operating features, plus two VFO's, 40 memory channels, programmable memory and band scans, a large fluorescent tube digital display with analogue-type sub-scale for frequency indication, and a new dot-matrix LCD sub-display for showing graphic characteristics and messages, all serve to provide maximum flexibility and ease of operation. In addition, a CW full break-in circuit, switchable to semi break-in, a built-in automatic antenna tuner, a solid-state final amplifier that is powered from a higher voltage source, a speech processor, all-mode squelch, and a host of other convenience features all add up to even greater versatility of use in fast-paced DX operations. With its power supply and antenna tuner built-in, and with its new whisper-quiet cooling system, the TS-940S is a complete, all-in-one type transceiver that brings tomorrow's sophistication to today's serious enthusiast. The unit may be ordered with the antenna tuner installed or available as an option.

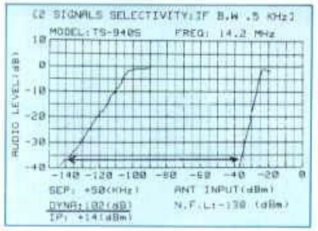
supplied by ZL4AI / DU7

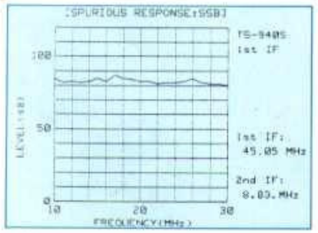
FEATURES

OUTSTANDING RECEIVER PERFORMANCE AND SENSITIVITY SPECIFICATIONS

Superior Dynamic Range Receiver Front End.

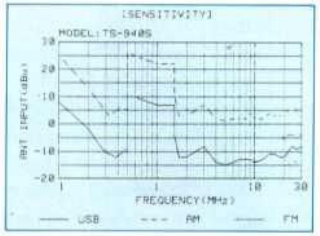
The TS-940S RF circuits have been specifically designed to provide the lowest noise floor level coupled with a superior dynamic range. Use of 2SK125 junction-type FET's wired in a cascode amplifier circuit, followed by two 2SK125's each in the first balanced mixer and in the push-pull gate grounded buffer amplifier, and working into a 2nd balanced mixer circuit, results in outstanding two-signal characteristics accompanied by a substantially improved noise floor level. The IM (intermodulation) dynamic range characteristic for the TS-940S receiver section is typically 102 dB (20 metres, 50 kHz spacing, 500 Hz CW bandwidth), with an overall intercept point of +14 dBm, noise floor level of −138 dBm and the blocking dynamic range at a point 200 kHz to either side of the centre frequency of the IF filter is −139 dB (typical).





160-m to 10-m Amateur Band Operation with 150 kHz to 30 MHz General Coverage Receiver.

The TS-940S covers all Amateur bands from 160 to 10 metres, including the new WARC 30, 17, and 12 metre bands. Its general conceived and engineered digital PLL circuit provides superior frequency accuracy and stability since only the standard frequency crystal oscillator determines those parameters. Selection of a specific Amateur band may be speedily and efficiently accomplished by the touch of the appropriate band access key (10 keys provided), or through use of the UP/DOWN 1 MHz step band switches, allowing easy access to all frequencies in the 150 kHz to 30 MHz range. Each of the two digital VFO's is continuously tunable from band to band across the full range of the transceiver.



All-Mode Operation.

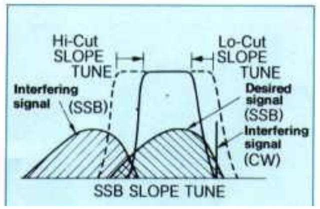
Modes of operation include USB, LSB, CW, AM, FM, and FSK. Mode selection is quickly effected through use of the proper front panel mode key. An adjacent LED confirms the selection. When a key is depressed, the first letter of the mode selected is announced in Morse code through the internal speaker, e.g., "L" for LSB, "F" for FM, etc. When FSK is selected, the Morse code letter "R" (for RTTY) is heard.

Superb Interference Reduction.

The TS-940S incorporates a number of special interference control circuits perfected by TRIO and described in the following paragraphs that give the operator maximum capability to minimize the effect of interference of all kinds.

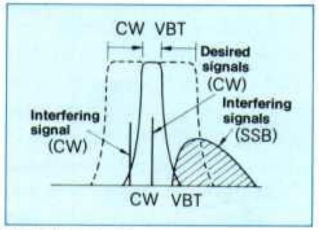
(1.) SSB IF Slope Tuning.

This feature operates in the LSB and USB modes. Front panel controls are provided to allow independent adjustment of either the low frequency or high frequency slopes of the IF passband. These HIGH CUT and LOW CUT controls permit the operator to easily and quickly define the most ideal IF passband width consistent with readability and interference rejection, and based on conditions as they exist at the time of the contact. The settings of the controls may be graphically illustrated on the LCD sub-display panel.



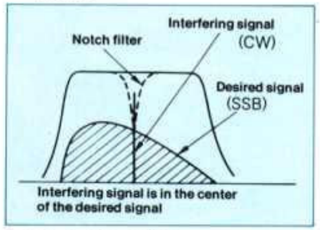
(2.) CW VBT (Variable Bandwidth Tuning.)

When all optional filters are installed, CW VBT operates in the CW, FSK and AM modes. When none of the optional filters are installed, CW VBT operates in the CW and FSK modes with the filter switch positioned at WIDE, and in the AM mode with the filter switch positioned at NARROW. In the CW mode of operation, the CW VBT and pitch control circuits are automatically enabled. The VBT control allows the passband width to be continuously varied within the range of the control without affecting the centre frequency. Graphic illustration of these adjustments is accomplished on the LCD sub-display panel.



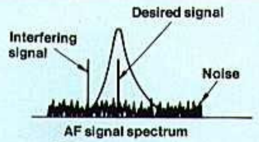
(3.) IF Notch Filter.

A tunable notch filter is located between the 4th receive mixer and the 100 kHz IF amplifier. The use of L-C-R components in a bridged-T filter circuit at the 100 kHz IF frequency results in deep, sharp notch characteristics that provide attenuation in the order of 40 dB to the interfering signal. As shown in the figure below, only the interfering signal is reduced while the desired signal remains unaffected. The resonant frequency of the filter is shifted by varying the voltage applied to the cathode of a vari-cap diode. The filter operates in all modes (except FM mode).



(4.) Audio Filter Built-in.

The next chart shows the principle of the AF-Tune feature, which reduces interfering signals and white noise, providing a peak tuning characteristic for the AF frequency response. When the front panel "AF-Tune" switch is depressed to the "ON" position, the "AF-Tune" circuit is activated, allowing operation only in the CW mode. The circuit consists of a three pole active filter located between the SSB/CW demodulator and the AF amplifier. It is



AF signal spectrum

AF tune operation

- The AF TUNE function reduces interfering signals and white noise.
- This function is normally used only during operation in the CW mode.

(5.) Narrow/Wide Filter Selection.

A front panel "NAR/WIDE" switch allows narrow/wide IF filter selection as required, based on interference conditions. The use of an 8.83 MHz 2nd IF, followed by a 455 kHz 3rd IF promotes excellent selectivity, with maximum potential for the use of various filter combinations to further enhance that important performance characteristic. The TS-940S comes with 2.7 kHz SSB filters (both 8.83 MHz and 455 kHz IF), and a 6 kHz AM filter (455 kHz IF), built-in. A selection of easily installed plug-in optional filters is available for the operator who requires maximum selectivity control.

W/N switch	WIDE		NARROW	
Mode	2nd IF filter	3rd IF filter	2nd IF filter	3rd IF filter
SSB	2.7 kHz*0	2.7 kHz*0	2.7 kHz*0	2.7 kHz*0
CW.FSK	2.7 kHz	2.7 kHz	0.5 kHz*2	0.5 kHz*3 or 0.25 kHz*4
AM	6 kHz*1	6 kHz	2.7 kHz	2.7 kHz
FM	Wide band	12 kHz	Wide band	12 kHz

*0: 2.7 kHz+2.7 kHz=2.4 kHz (Total selectivity)
*1: option YK-88A-1 installed
*2: option YK-88C-1 installed
*3: option YK-455C-1 installed
*4: option YK-455CN-1 installed

Built-in CW Variable Pitch Circuit.

The CW pitch control shifts the 4th IF passband in the demodulator circuit while, at the same time, raising or lowering the pitch of the audible beat frequency. This is very useful in avoiding interference or for changing the pitch tone to a frequency that is easier to copy, without moving the signal out of the IF filter pass band.

Dual-Mode Noise Blanker ("Pulse" or "Woodpecker".)

The noise blanker consists of two circuits, NB-1 and NB-2, each actuated by its own front panel switch. Noise sampled from the receive 2nd mixer output transformer is amplified approximately 70 dB by a noise amplifier. The NB level control adjusts the threshold level of the noise amplifier, allowing the operator to control the effectiveness of the noise blanker under specific noise and signal level conditions. Depressing the NB1 switch is most effective in suppressing pulse-type (ignition) noise. Depressing the NB2 switch is most effective in suppressing noise of a longer duty cycle, such as the so-called "woodpecker" type of interference. The threshold level in the NB2 position is factory optimized for maximum

Built-in RIT/XIT.

The front panel "RIT" (Receiver Incremental Tuning)/"XIT" (Transmitter Incremental Tuning) control shifts the receive or transmit frequency in 10 Hz steps across a range of ±9.99 kHz, using an optical encoder, to tune stations that are slightly off frequency, and without affecting the VFO transmit/receive frequency. RIT/XIT frequency shifts (0.0~±9.99 kHz) are displayed in the main display area. A "CLEAR" switch resets the RIT/XIT frequency to zero. The "RIT/XIT" control may be used in any mode of operation.

All-Mode Squelch Circuit.

The squelch circuit is effective in suppressing background noise in all operating modes.

RF Attenuator.

The meticulously engineered receiver section front end includes a 4-step, 0, 10, 20, or 30 dB RF attenuator, for optimum rejection of intermodulation distortion.

Switchable AGC Circuit (OFF/FAST/SLOW).

The automatic gain control (AGC) is activated by a 3-position (OFF/FAST/SLOW) switch, to provide optimum receiver operation in all modes, and under all signal strength conditions.

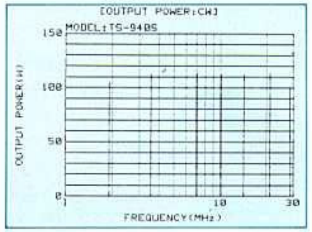
AUTOMATIC ANTENNA TUNER PLUS LOW DISTORTION, HIGH RELIABILITY TRANSMISSION

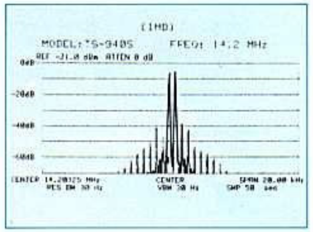
Automatic Antenna Tuner (160-10 metres) Built-In.

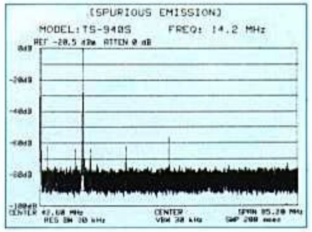
The TS-940S is available with a completely automatic antenna tuner covering all Amateur bands from 160 through 10 metres built-in, or may be ordered without the tuner installed. An AT-940 antenna tuner is available for future installation in transceivers initially ordered without the tuner. With the "AUTO/THRU" switch in the "AUTO" position, depressing the "AT.T" key sets up the automatic tune condition, which lasts for approximately 3 seconds. The LCD sub-display reads "ANTENNA TUNER AUTO-TUNE READY." Keying the transmitter while this message is being displayed initiates automatic tuning at the 50 watt RF output level, using high speed motors to reduce the tuning time. During the tuning cycle, the LCD sub-display indicates "ANTENNA TUNER TUNING . . . !!" When the SWR drops to its minimum value, a "motor-stop" signal is generated, instantaneously stopping the motors and the tuning action, and the LCD sub-display indicates "TUNING FINISHED TX-READY".

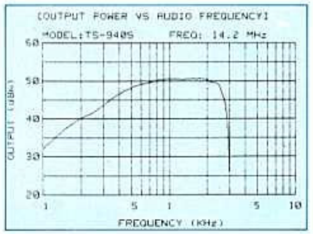
Low Distortion, High Reliability 28 Volt Powered Final Amplifier.

Through the use of a 28 volt power source, the quality of the transmitted signal has been measurably improved (3rd order intermodulation distortion better than −37 dB) compared to other contemporary designs. Two MOTOROLA MRF-422 (PD 290 watts each), operating push-pull, are used in the final amplifier. Temperature and VSWR monitoring circuits are incorporated in the final amplifier protection circuit to guard





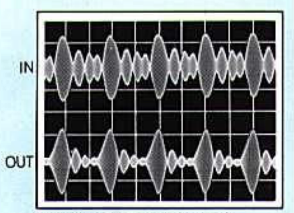




CW Full Break-in

Full break-in capability allows the DX or contest operator to respond more quickly to the calling station. To the "ragchewer", it means a more natural conversation. This capability is made possible through use of CMOS IC's in the timing logic circuitry. The actual switching is accomplished

Built-in Speech Processor.
The TS-940S employs speech processing circuitry based on RF clipping techniques. A marked improvement in the intelligibility threshold is attainable, depending on the positions of separate front panel "IN" and "OUT" controls. A higher average "talkpower" plus improved intelligibility makes for outstanding DX performance.



(Approx. 10 dB compression)

RF Output Power Control.
Using a front panel control, the RF output power may be continuously varied from 10 watts to the maximum power, in any mode of operation.

OPERATING FREQUENCY CONTROL USING NEW MICROPROCESSOR PLUS DIGITAL TECHNOLOGY.

The use of a new microprocessor plus advanced digital technology to control the various tuning functions, including the 2 digital VFO's, the 40 channels of memory, band scan and memory scan, etc., assures maximum flexibility and ease of operation under the most difficult operating conditions.

10 Hz Step Dual Digital VFO's with Optical Encoder.
Special tuning logic, working in conjunction with the basic 10 Hz step, high stability digital VFO design, provides a variable speed tuning characteristic that is directly related to the speed of tuning knob rotation. A large, die-cast tuning knob with moulded rubber cover, rotated at normal tuning speeds, results in a frequency shift in 10 Hz increments, or 10 kHz per tuning knob revolution. Rotation of the tuning control at speeds in excess of approximately 2 to 3 revolutions per second causes the tuning step size to be increased proportionally, speeding up the rate of frequency change. Each VFO tunes continuously across the full coverage of the transceiver, utilizing the TRIO engineered special optical encoder tuning system.

Built-in Dual VFO A/B Switching System.
An "A/B" switch allows the operator to specify the VFO to be used. A "SPLIT" switch is available for split frequency operations. An "A=B" switch makes it possible to quickly duplicate the tuning data (frequency, mode, RIT data) programmed into the active VFO, in the data banks of the inactive VFO. A "T-F SET" switch is provided to permit reversal of the transmit and receive frequencies during split frequency operations. All of these

40 Memory Channels.
For operating purposes, the 40 memory channels are divided into 4 groups of 10 channels each. Both mode and frequency data are stored, making all operations simple and convenient. The operator may select any 1 of the 4 memory groups for operations, using the 4 position memory bank switch located on the top panel. Depressing the "VFO/M" switch on the front panel permits selection of the memory channel, using the 10 band keys. The "M▶ VFO" switch is used to transfer memory data (frequency and mode) to the active VFO. Memory information is backed-up by an internal lithium battery. (Est. 5 yr. life.)

Built-in Scan Functions.
Memory scan is initiated by depressing the "MS" switch. Memories in which no data is stored are skipped. Programmable band scan is initiated by depressing the "PG.S" switch, and scans in 10 Hz (100 Hz in AM, FM modes) steps from the lowest frequency within the frequency limits specified in memory channels "9" and "0". A "HOLD" switch is provided to interrupt the scanning process during memory and program scan operations. When the "HOLD" switch has been depressed during program scan, the VFO operating frequency may be adjusted within the frequency limits established in memory channels "9" and "0".

Rapid Band Selection.
A specific Amateur band may be quickly selected by depressing the appropriate front panel band key. One MHz step "UP" and "DOWN" switches on the front panel allow rapid selection of shortwave broadcast frequencies. An "F.LOCK" switch prevents accidental loss of the selected frequency.

Direct keyboard entry of frequency
The dual function band selection keyboard is also used for direct entry of any frequency within the operating range of the TS-940S. Touching the ENT button transfers the TS-940S into direct entry mode. Any frequency can then be keyed into the main display, and a second touch of the ENT button, transfers this frequency into the operating VFO. The main tuning knob can then tune up or down from the entered frequency if required.

MULTI-FUNCTION MAIN DISPLAY AND SUB-DISPLAY.

The TS-940S incorporates a large fluorescent tube digital display with a unique analogue-type sub-scale, plus a new dot-matrix LCD sub-display that displays alpha-numeric information and graphic characteristics.

Large Fluorescent Tube Digital Main Display.
The large, built-in, multi-function fluorescent tube display and its analogue-type sub-scale provides improved readability and allows increased operating speed. Transmit/receive frequencies appear on a 7 numeral digital display/analogue sub-scale combination, indicating tuning across a selected 1 MHz/100 kHz band segment in 20 kHz/

memory "ON", memory channel number, "F.LOCK", and RIT/XIT "ON". The use of the fluorescent tube display makes reading easy, and minimizes eye fatigue. A "DIM" switch has been provided to allow dimming of the display and the meter illumination, if desired.

LCD Dot-matrix Sub-display.
The sub-display is capable of displaying a maximum of 16 digits and 2 lines of data. Frequency, graphic characteristics, messages, and clock time are the 4 different kinds of information that can be displayed.

■ **Frequency.**
The upper line shows frequency and mode of VFO "B" when VFO "A" is indicated on the main display. The lower line indicates memory group (1—4), memory channel (CH-1, 2, 3, ... 0), plus frequency and mode during VFO operations.

■ **Graphic Characteristics.**
Graphically indicates the effect on bandwidth when "SSB SLOPE TUNE" or "CW VBT" controls are operated.

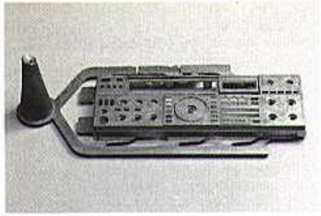
■ **Messages.**
Displays messages relating to operation of the Automatic Antenna Tuner, as follows:
1. "ANTENNA TUNER AUTO TUNE READY" when "AT.T" switch is depressed.
2. "ANTENNA TUNER TUNING" when transmitter is keyed within 3 seconds after pressing "AT.T" switch.
3. "TUNING FINISHED TX-READY" when automatic antenna tuner has finished tuning.

■ **Clock.**
Indicates the current time, or the preset timer time. The clock has a built-in battery back up. (Est. 3yr. life)

MECHANICAL DESIGN AND CONSTRUCTION TYPICAL OF COMPETITION-CLASS EQUIPMENT.

The clean, sharp, lines and functional stability so characteristic of die-cast construction are quickly recognized in the beautiful front panel and in the highly efficient heat sink design found on the rear of the unit.
Temperature control of critical components is accomplished with peak efficiency through use of a new air distribution system that allows operation on a 100% transmit duty cycle basis for periods of approximately one hour.
The high-density design concept enables the complete power supply circuitry and the automatic antenna tuner, as well as the balance of the transceiver electronics to be built into a compact cabinet normally needed for the transceiver electronics alone.

Rugged Zinc Die-cast Front Panel and VFO Control Knob.
The Zinc die-cast front panel assures maximum mechanical stability under even



Efficent Cooling System Allows 100% Transmit Duty Cycle.

The 100 W final amplifier stage is mounted directly on its die-cast aluminum heat sink and by using a ducted air-flow cooling system, provides maximum thermal conduction efficiency. The high efficiency of the cooling system permits continuous transmission at full power for periods of approximately one hour without thermal shut-down.

The power supply unit has its own independent cooling system and fan, also incorporating the ducted air-flow concept.

A VARIETY OF EXTRA, EASY-TO-OPERATE FUNCTIONS.

Built-in AC Power Supply and Speaker.

The TS-940S is a self-contained HF station, including a built-in power supply, and a rugged, top-mounted, high quality, 10 cm (4 inch) speaker. The power supply circuit provides ample capacity by use of a special, compact, laminated core transformer, assuring maximum stability of operation of the final transistor circuits. The correct AC circuit polarity is achieved through use of the 3-wire connector and cable assembly supplied with the unit.

Clock/Timer Function.

In addition to a 24-hour clock function, a single event timer is provided for scheduled un-attended recording of a specified transmission. Clock/Timer program data may be displayed on the LCD sub-display at the operator's option.

Transmission Monitor Circuit.

A built-in transmit monitor circuit operating in the SSB, FM, and FSK modes may be operator activated by depressing the front panel "MONI" switch. This circuit monitors the product detector signal from the output of the IF section during transmission, allowing the operator to check his audio quality, and the effectiveness of the speech processor.

High Stability RTTY Transmit Circuit.

The stability of RTTY transmissions is greatly improved through design that obtains the FSK signal information from the reference oscillator. The FSK shift width is 170 Hz.

Voice Synthesiser Unit (Optional).

An optional VS-1 "Voice Synthesiser Unit", which announces the operating frequency on demand by depression of the front panel "VOICE" key, is available. Installation within the cabinet is simple and easy.

Optional SO-1 TCXO "Temperature Compensated Crystal Oscillator".

An optional, high-stability TCXO, model SO-1, may be installed in place of the reference oscillator. This unit operates at a frequency of 20 MHz and has a thermal stability of $\pm 5 \times 10^{-7}$.

ADDITIONAL FEATURES, PLUS ACCESSORY TERMINALS.

Dimmer Switch

A front panel "DIM" switch permits selection of either normal or reduced intensity on the digital display and SWR/POWER meter.

100 kHz Marker.

A 100 kHz marker signal, controlled by a switch located under the sliding panel on top of the unit, is available for use in calibrating the fundamental oscillator against received standards such as WWV or MSF.

VOX Circuit.

The VOX gain, VOX delay, and Anti-VOX controls are located beneath the sliding panel on the top of the cabinet.

Meter Functions.

"COMP" (Compression), "ALC" (Automatic Level Control), "POWER" (RF Output Power), "SWR" (Standing-wave Ratio), "IC" (Final Amplifier Collector Current), and "VC" (Final Amplifier Collector Voltage.) S units and dB on receive.

LED Indicators for Miscellaneous Functions.

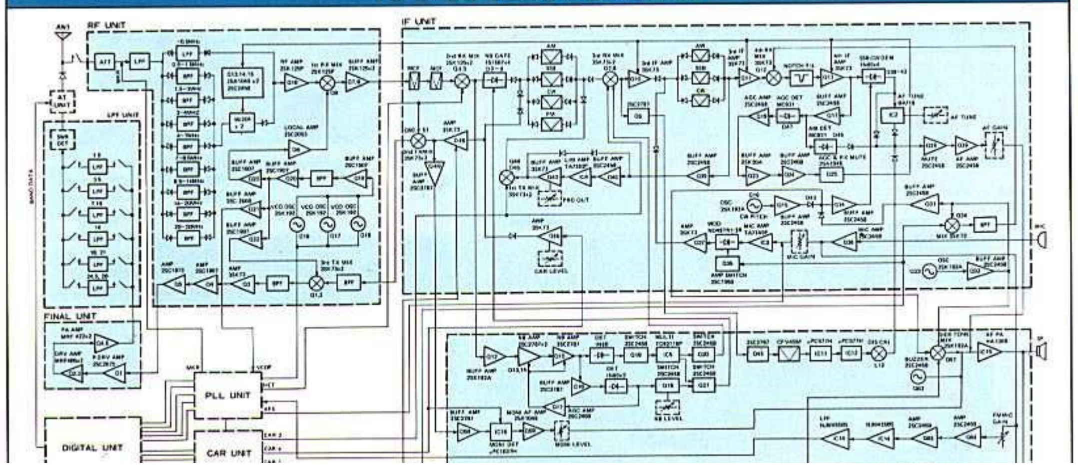
"ON AIR", "AT", "TUNE", "SPLIT", "NOTCH", "NAR".

Input/Output Terminals

RX antenna terminal and switch, transverter terminal, IF OUT 1 (For PAN-DISPLAY) and IF OUT 2 (Oscilloscope Modulation Monitor) terminals, phone patch IN/OUT terminals, accessory terminals 1 and 2, remote control terminal.

supplied by ZL4AI / DU7

TS-940S BLOCK DIAGRAM



CW break-in selector
During CW operation, selects either full break-in at FULL, or semi break-in at SEMI.

MONI (MONITOR)

ATT (RF attenuator)
(0, −10, −20, −30 dB)

DIM

PROC (processor) switch

SUB DISPLAY
Frequency/Graphic characteristics
Messages/Clock

MAIN DISPLAY
Frequency/VFO A, B
MCH (Memory Channel)/RIT, XIT

MEMORY function
Used to select memory scan, program scan VFO or memory operation.

BAND/KEY
- Selects Amateur bands

Ten keys: Used for direct frequency entry.

CLOCK/GRAPH
SCROLL • Recall frequencies in the memories.
SET • Used to set the "?" mark on the time display for setting time adjustment.
• Used when erasing time-controlled set time.

NOTCH -⊖- SQL controls

PITCH -⊖- AF TUNE controls

AF -⊖- RF controls

RIT/XIT control
Shifts the receive/transmit frequency in 10 Hz steps within a range of ±9.99 kHz when the RIT/XIT mode has been selected.

STAND-BY

NB 1/NB 2 switches

NAR/WIDE
Selects narrow or wide IF bandwidth.

AUTO/THRU
AUTO: Antenna tuner is ON.
THRU: Antenna tuner is OFF.

NB LEVEL control
Controls noise blanker operating level.

MODE switches
The first letter of the mode (FSK mode: "R") is announced in International Morse Code.

MIC (microphone gain) -⊖- PWR (RF power) controls
- Controls microphone amplifier gain for SSB operation.
- Controls the transmit power in SSB, CW and FM modes.

PROCESSOR-IN -⊖- PROCESSOR-OUT controls
Controls compression level, speech processor output level.

AT. T switch
Used when operating the transceiver in conjunction with the antenna tuner, when fitted.

CW VBT control
Continuously adjusts the IF filter bandwidth to eliminate interference from adjacent stations.

SSB SLOPE TUNE control
This permits independent variation of the high and low frequency slopes of the IF passband. High and low audio frequencies may be simultaneously cut.

UP/DOWN
Shifts 1 MHz up/down.

FUNCTION switches
- **T-FSET switch**
Depress this switch to "SPOT", or momentarily interchange reception frequency with transmission frequency. Frequency "SPOTTING" is possible only in receive and is ineffective during transmission.
- A/B — Selects VFO A or VFO B.
- SPLIT — For split frequency operations A-R, B-T or B-R, A-T.
- A=B — During VFO operation, press this switch to equalize the frequency and mode of the idle VFO to that of the active VFO.
- F. LOCK — Press this switch to lock the VFO and BAND switches.
- VOICE — Announces the frequency when an optional VS-1 is installed inside the cabinet.

PHONE PATCH jacks

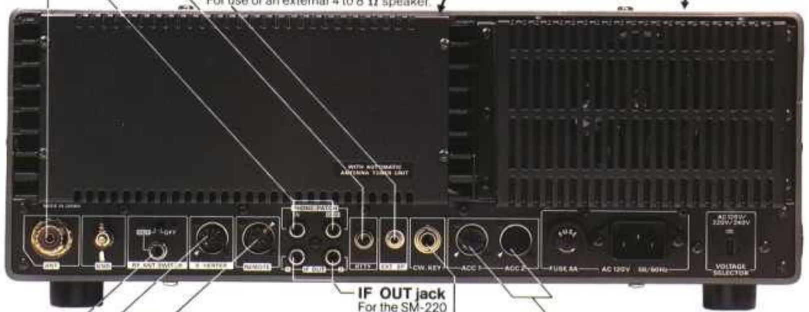
ANTENNA CONNECTOR
(50 Ω)

RTTY KEY jack
For FSK operation

Cooling fan (final section)
Electronically controlled automatic cooling fan for the final amplifier section.

EXT. SP (speaker) jack
For use of an external 4 to 8 Ω speaker.

Cooling fan (power supply)
Electronically controlled automatic cooling fan for the power supply section.



RX ANTENNA

REMOTE CONNECTOR

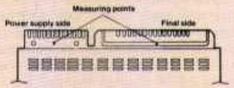
IF OUT jack
For the SM-220 station monitor.

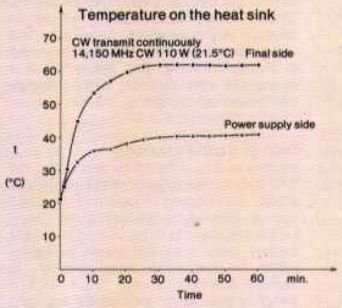
ACC1 For a computer interface.

Highly Efficient, Ducted Air-Flow, Cooling System

A new air distribution system allows operation on a 100% transmit duty cycle basis for periods of approximately one hour.

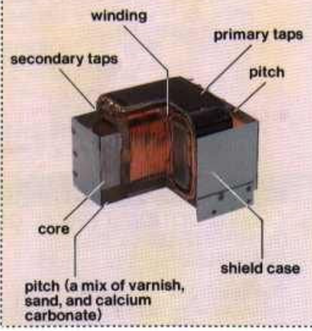
The heat sink cooling fins are designed to be an integral part of the ducted air-flow system, which is constructed in such a manner as to assure a continual flow of air across the front and rear surfaces of the heat sink, as well as over the fins themselves. Ports of varying sizes have been strategically located throughout the air-flow system to prevent dead-air pockets. Cooling air is drawn through the cabinet area by a quiet, two-speed fan that then directs its discharge air-flow into the ducting at a point immediately adjacent to the final amplifier transistors, assuring maximum heat transfer from these important components. Fan operation is controlled through use of automatic switching initiated by a detecting thermistor that senses final amplifier temperature.

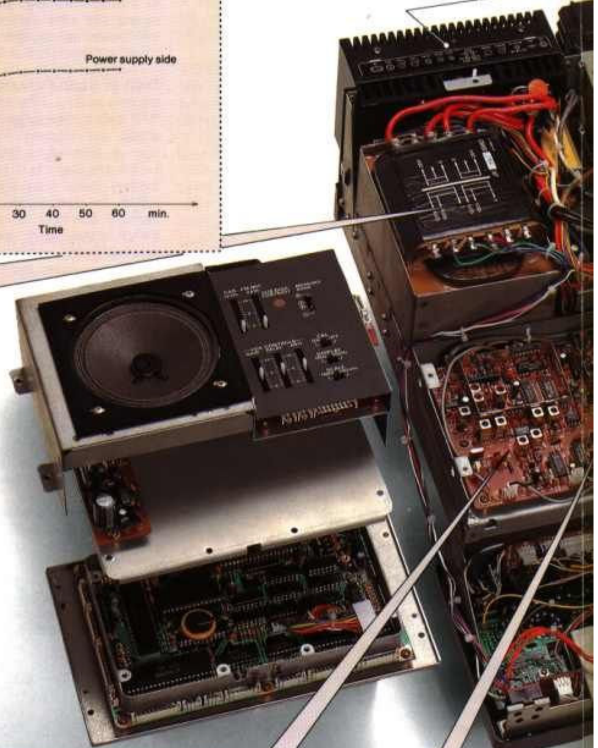


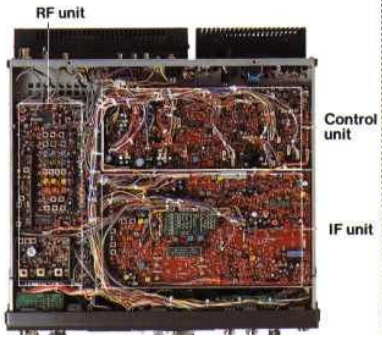


Laminated Core Transformer

The power transformer is high performance, shielded, and potted to protect the windings and connections from vibration and impact damage.

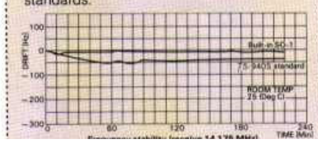






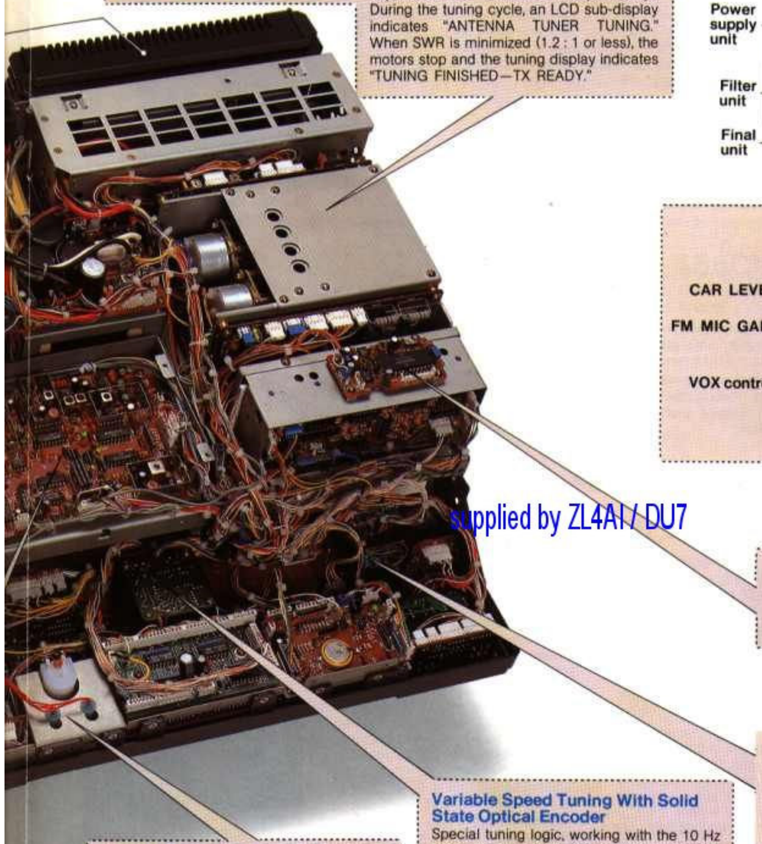
Optional SO-1 TCXO Temperature Compensated Crystal Oscillator.

An optional, high-stability TCXO, model SO-1, may be installed in place of the reference oscillator. This unit operates at 20-MHz with an accuracy of $\pm 5 \times 10^{-7}$ across a temperature range of −10 degrees C to +50 degrees C when installed inside the TS-940S. With the SO-1 installed, overall frequency stability is upgraded to a level approximating professional standards.



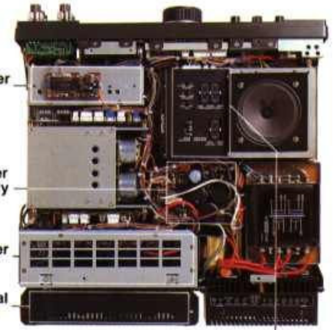
Phase Locked Loop (PLL) Circuit

This is a digital Variable Frequency Oscillator (VFO) covering 45.2—75.05 MHz in 10 Hz steps, in accordance with the TS-940S operating frequency of 150 kHz to 30 MHz. Three PLLs are linked in analogue mode. The dividing ratio data to each PLL is controlled by the microprocessor. Each PLL has a single-crystal frequency standard. The reference frequency is accurate to ±10 ppm between −10°C and +50°C.



Automatic Antenna Tuner

Forward and reflected power are detected by a directional coupler. Signals proportional to the antenna line voltage and current are processed for phase comparison. These signals are used to control servo motors which turn the two antenna tuner capacitors for minimum SWR. (The two variable capacitors are controlled independently.) During the tuning cycle, an LCD sub-display indicates "ANTENNA TUNER TUNING." When SWR is minimized (1.2 : 1 or less), the motors stop and the tuning display indicates "TUNING FINISHED—TX READY."



Voice Synthesizer Unit (option)

The optional VS-1 voice synthesizer is easily installed inside the cabinet, and announces the main display frequency on demand.

RIT/XIT Encoder Mechanism.

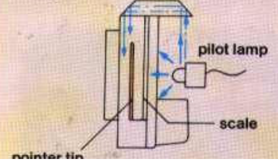
The RIT/XIT control employs a moulded optical encoder disk having fifty slits located along its outer circumference, providing a total of 2 kHz frequency shift in 10 Hz steps, for each 360 degrees of knob rotation.

Variable Speed Tuning With Solid State Optical Encoder

Special tuning logic, working with the 10 Hz step high stability digital VFO, provides frequency changes directly related to the speed of tuning knob rotation. The special TRIO-engineered Optical Encoder Tuning System provides smooth, backlash-free tuning. Rotating the VFO knob at normal tuning speeds shifts the frequency in 10 Hz increments, or 10 kHz per VFO knob revolution. Tuning the knob faster (approximately 2 to 3 revolutions per second), increases frequency step size proportionally.

Easy-To-Read, Illuminated Multi-Function Meter.

The front panel multi-function meter utilizes a black background colour selected to harmonize with the main display.
Backlighted calibration numerals, and a pointer tip coated with an orange fluorescent material, provide for superior readability and easy detection of minor variations in the reading.



supplied by ZL4AI / DU7

TS-940S OPTIONAL ACCESSORIES

SP-940

External Speaker

The SP-940 is a high class external speaker designed to match the TS-940S in size, colour and appearance. The SP-940 uses a panel made of reinforced ABS plastic and an expanded metal speaker grill to improve tone quality. It is a low-distortion speaker with selectable frequency response for high intelligibility in any mode. The frequency response is determined by the built-in audio filters, which are effective in improving signal-to-noise-ratio under certain interference conditions, or when receiving weak signals. On the front panel is a headphone connector, for listening to audio output passed through the filters. Also on the front panel is a switch for selecting either of two audio inputs to the SP-940.

SPECIFICATIONS

•Speaker Diameter: 100 mm (4 inch) •Input Power (max.): 1.5 W (3.0 W) •Impedance: 8 Ω •Frequency Response: 100 Hz~5 kHz •Filter Cut-off Frequency: LOW 430 Hz (−3 dB)/ HIGH1 1 kHz (−3 dB)/HIGH2 2.5 kHz (−3 dB)/ HIGH1 + HIGH2 730 Hz (−3 dB) •Filter Attenuation: −6 dB/OCT •Dimensions: 180 (7.01) W ×140 (5.51) H×290 (11.4) D mm (inch), (Projections not included) •Weight: 2 kg (4.41 lbs) approx.

AT-940

Automatic Antenna Tuner

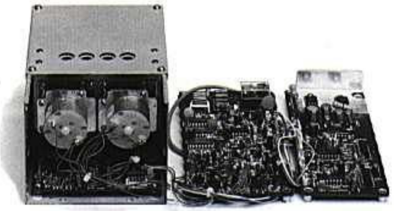
The AT-940 is an optional automatic antenna tuner that can be installed in the TS-940S.

FEATURES

- Full coverage of 160 through 10 meters, including the new WARC bands.
- Automatic motor speed control. The motor automatically stops when the SWR drops to its minimum value (1.2:1 or less).
- The AUTO-THRU circuit is disabled during transmission to protect the final transistors in case the AUTO-THRU switch is accidentally operated.
- The "tune" condition for automatic antenna tuning remains unchanged during transmission when the "AT.T" switch is depressed.

SPECIFICATIONS

•Frequency Range: All Amateur bands from 1.8 to 29.7 MHz •Input Impedance: 50 Ω unbalanced •Output Impedance: 20~150 Ω unbalanced •Insertion Loss: Less than 0.8 dB •Through Power: 150 W •Maximum Tuning Time: Less than 15 seconds.



SM-220

Station Monitor

Based on a wide-frequency-range oscilloscope (up to 10 MHz), the SM-220 station monitor features, in combination with a built-in two-tone generator, a wide variety of waveform-observing capabilities. When the BS-8 is installed in the SM-220 and connected to the transceiver, signal conditions in the vicinity of the receive frequency can be viewed over a ±20 kHz or ±100 kHz range. The SM-220 provides efficient station operation as it monitors transmitted waveforms, and it also serves as a high-sensitivity, wide-frequency range oscilloscope for various adjustments and experiments.

SPECIFICATIONS

(Transmit Signal Monitor Terminal) •Frequency range: 1.8~150 MHz •Maximum power: 1 kW (1.8~54 MHz), 50 W (150 MHz) •SWR: 1.2:1 or less •Deflection sensitivity: Better than 1 div. at 2 W input •Attenuator: 6 steps **(Trapezoid waveform observation)** •Frequency range: 1.8~30 MHz •Maximum power at DRIVE TERMINAL: 2~100 W •SWR: 1.2:1 or less **(Two-tone generator)** •Oscillator frequency: 1,000 Hz and 1,575 Hz •Output voltage: 10 mV/50 kΩ (at TWO TONE) **(Pan display unit)** •Input centre frequency: 8.830 MHz •IF frequency: 455 kHz •IF bandwidth: More than 1 kHz (−6 dB) •Input sensitivity: Better than 10 μV/div. •Scan width: ±20 kHz, ±100 kHz, switchable gain **(Horizontal amplifier)** •Deflection sensitivity: More than 300 mV/div. •Frequency response: DC−250 kHz or over (EXT GAIN at MAX); DC−40 kHz (EXT GAIN at 1/2) •Input resistance/capacitance: 1 MΩ (±20%)/35 PF or less (SYNC switch at INT) •Attenuator: Fully variable to 0 •Max. input voltage: 100 Vp-p **(Sweep circuit)** •Sweep frequency: 10 Hz~100 kHz (4 ranges, with fine adjustment) •Sweep linearity: Better than 5% •Sync system: Synchronized sweep, internal negative sync and external sync •Sync amplitude: Internal; Better than 1 div. on CRT, External; Better than 2 Vp-p **(Vertical amplifier)** •Deflection sensitivity: Better than 20 mV/div. •Frequency response: 2 Hz~10 MHz (−3 dB) •Input resistance/ capacitance: 1 MΩ / 40 PF •Overshoot: Less than 5% •Attenuator: 1, 1/10, 1/100 and GND/MONITOR (Error between steps: 5% max.) •Max. input voltage: 300 V (DC+AC peak) or 600 Vp-p •Power supply: 120/220/240 V AC±10%, 50/60 Hz 20 W •Dimensions: 215 (8.6) W×153 (6.1) H×335 (13.4) D mm (inch) •Weight: 5 kg (11 lbs.)

OPTIONAL ACCESSORIES

•BS-8....Pan Display for TS-830S/ TS-530S/TS-180S/TS-820 series/ TS-940S •BS-5 .... Pan Display for TS-520/TS-520SE

TL-922

HF Linear Amplifier

The TL-922 is class AB_2 grounded-grid linear amplifier developed by TRIO through advanced high-power technology using two high-performance EIMAC 3-500Z power tubes. They cover all bands 160 m through 10 m (except the three WARC Amateur bands) for SSB, CW and RTTY modes of operation. (not usable with full break-in, semi break-in only)

FEATURES

•Pair of EIMAC 3-500Z high performance transmitting tubes •Class AB_2 G-G circuit •Excellent IMD (intermodulation products distortion) characteristics •Perfect safety protection •Blower turn-off DELAY circuit •Variable threshold level type ALC circuit •Two easy-to-read meters •Attractive matching with TRIO HF transceivers.

MHz, 21.0~21.45 MHz, 28.0~29.7 MHz •Mode: SSB CW, RTTY •Drive power: 80 W or more for full output •RF input power: SSB= 2,000 W PEP, CW, RTTY=1,000 W DC •Circuitry: AB_2 class grounded-grid linear amplifier •Input impedance: 50 Ω •Output impedance: 50~75 Ω •Cooling: Forced air •Fan motor delay stop time: 140±30 seconds •ALC: Negative going adjustable threshold −8 V DC max. output (typical) •Tubes: 2×3-500Z (optional) •Power requirement: 220/ 240 V 14 A, 50/60 Hz type •Dimensions: 390 (15.4) W×190 (7.5) H×407 (16.0) D mm (inch) •Weight:

SW-200A, 2000

SWR/POWER Meter (supplied with a coupler)

SW-200A supplied with SWC-1
SW-2000 supplied with SWC-3
Selectable Peak-reading/RMS, SWR/POWER meters for base station use.

SPECIFICATIONS

•Impedance: 50~52Ω •Frequency range: 1.8~150 MHz (SW-200A) 1.8~54 MHz (SW-2000) •Power measuring range: 0~20/200 W (SW-200A) 0~200/2000 W (SW-2000) •Accuracy: Less than ±10% of full scale •Sensitivity: Less than 20W •Power supply: 12 VDC 100 mA •Dimensions: 193 (7.6) W×62 (2.4) H×79 (3.1) D mm (inch) •Weight: 0.7 kg (1.5 lbs.) approx.

YK-88A-1

6 kHz AM Filter for 8.83 MHz IF

•Centre Frequency: 8830.0 kHz •Selectivity: 6 kHz (−6 dB), 11 kHz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

YK-88C-1

500 Hz CW Filter for 8.83 MHz IF

•Centre Frequency: 8830.0 kHz •Selectivity: 500 Hz (−6 dB), 1.5 kHz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

YG-455C-1

500 Hz CW Filter for 455 kHz IF

•Centre Frequency: 455.0 kHz •Selectivity: 500 Hz (−6 dB), 820 Hz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

YG-455CN-1

250 Hz CW Narrow Filter for 455 kHz IF for 455 kHz IF

•Centre Frequency: 455.0 kHz •Selectivity: 250 Hz (−6 dB), 480 Hz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

SO-1

Superior Stability TCXO (Temperature compensated crystal oscillator)

(Requires modifications)
•Frequency Oscillator: 20 MHz •Frequency Stability: $\pm 5 \times 10^{-7}$ (−10°C~+50°C) •Frequency Correct Range: Better than ±60 Hz

VS-1

Voice Synthesiser unit

MC-42S (500 Ω)

UP/DOWN Hand Microphone (8 pin)

The MC-42S is a handy dynamic microphone with PTT switch and UP/DOWN switches.

MC-60A (50 kΩ/500 Ω)

Deluxe Desk-Top Microphone with built-in Preamplifier (8 pin)

The zinc die-cast base provides high stability, and the MC-60A is completed with PTT and LOCK switches, UP/DOWN switches, an impedance selector switch and a built-in pre-amplifier.

MC-85 (700 Ω)

Multi-function Desk-Top Microphone with built-in Audio Level Compensation (8 pin)

The MC-85 is an unidirectional high-class electret condenser microphone provided with an output select switch, audio level compensation circuit, low cut filter, level meter, PTT and LOCK switch.

MC-80 (700 Ω)

Desk-Top Microphone with built-in Preamplifier (8 pin)

The MC-80 is an omnidirectional electret condenser microphone provided with UP/DOWN switch, volume adjustment for output level, PTT and LOCK switch, and built-in pre-amplifier.

HS-4

Headphones
(8 Ω)

HS-5

Deluxe Headphones
(8 Ω)

HS-6

Light weight Headphones
(12.5 Ω)

HS-7

Micro Headphones
(16 Ω)

LF-30A

Low-Pass Filter

SPECIFICATIONS

•Cutoff frequency: 30 MHz •Attenuation: More than 90 dB between 90 and 300 MHz •Maximum input power: 1 kW PEP •Insertion loss: Less than 0.5 dB at 30 MHz •Input/output impedance: 50 Ω

TS-940S SPECIFICATIONS

[GENERAL]

Transmitter

Frequency Range ..... 160-m band 1.8~2.0 MHz
80-m band 3.5~4.0 MHz
40-m band 7.0~7.3 MHz
30-m band 10.1~10.15 MHz
20-m band 14.0~14.35 MHz
17-m band 18.068~18.168 MHz
15-m band 21.0~21.45 MHz
12-m band 24.89~24.99 MHz
10-m band 28.0~29.7 MHz

Receiver Frequency Range .... 150 kHz~30 MHz

Mode .... A3J (USB, LSB), A1 (CW) F1 (FSK), F3 (FM), A3 (AM)

Frequency Stability ... ±10×10⁻⁶ (−10°C~+50°C)

Frequency Accuracy .. ±10×10⁻⁶ (at normal temperatures)

Antenna Impedance... 50 Ω (20~150 Ω with the AT-940 antenna tuner installed, transmission only)

Power Requirements .. 120/220/240 VAC, 50/60 Hz

Power Consumption .. Max. transmit 510 W
Receive (no signal) 80 W

Dimensions .... 401 (15.79) W×141 (5.55) H×350 (13.78) D mm (inch) (Projections not included)

Weight .... 18.5 kg (40.78 lbs.) approx.
20 kg (44.09 lbs.) approx. (with antenna tuner)

[Transmitter]

Final Power Input ..... SSB/CW/FSK/FM=250 W PEP
AM=140 W

Modulation .... SSB=Balanced Modulation
FM=Reactance Modulation
AM=Low Level Modulation

FM Maximum Frequency Deviation .... ±5 kHz

FSK Shift Width .... 170 Hz

Carrier Suppression ... Better than 40 dB

Spurious Response ... Better than −40 dB (CW)

Unwanted Sideband Suppression .... Better than 50 dB
(Modulation frequency: 1.5 kHz)

Third Harmonic Intermodulation Distortion .... Better than −37 dB (at 14.2 MHz)
(based on single tone output)

Microphone Impedance .... 500 Ω~50 kΩ

Frequency Response (SSB) .... 400~2600 Hz (−6 dB)

[Receiver]

Circuitry .... SSB/CW/AM/FSK: Quadruple conversion system
FM: Triple conversion system

Intermediate frequency .... 1st IF 45.05 MHz
2nd IF 8.83 MHz
3rd IF 455 kHz
4th IF 100 kHz

Sensitivity .... at 10 dB (S/N) (0 dBμ=1 μV)

Mode \ Frequency	150~500 kHz	500 kHz~1.8 MHz	1.8~30 MHz
SSB, CW, FSK	Less than 1 μV	Less than 4 μV	Less than 0.2 μV
AM	Less than 10 μV	Less than 32 μV	Less than 2 μV
FM (SINAD 12 dB)	—	—	Less than 0.5 μV

Squelch Sensitivity ... Less than −10 dBμ (0.32 μV)

Image Ratio .... More than 80 dB (1.8~30 MHz)

IF Rejection .... More than 70 dB (1.8~30 MHz)

Selectivity .... SSB, CW, AM (Narrow), FSK
2.4 kHz (−6 dB)
3.6 kHz (−60 dB)
AM (Wide)
6 kHz (−6 dB)
15 kHz (−50 dB)
FM
12 kHz (−6 dB)
22 kHz (−60 dB)

Variable Frequency Range .... SSB slope tuning
High-cut=more than 1500 Hz
Low-cut=more than 700 Hz
CW VBT (without optional filter)
600 Hz~2.4 kHz (continuous)

RIT/XIT Variable Range .... ±9.99 kHz

Notch Filter Attenuation .... More than 40 dB

Audio Output Power ... 1.5 W (8 Ω at 10% distortion)

The equipment meets or exceeds published specifications.
Specifications are subject to change without notice due to advances in technology.

TRIO-KENWOOD CORPORATION
Shionogi Shibuya Building, 17-5, 2-chome Shibuya, Shibuya-ku, Tokyo 150, Japan

ALWAYS READ THIS SITE TO SEE THE UPDATES PLANNED TO BE PUBLISHED

From: "Vaso Nastasic" <vaso.yt5t@gmail.com>
To: <kenwood@mailman.qth.net>
Sent: Thursday, January 04, 2007 9:09 PM
Subject: [Kenwood] TS940S CW heterodyne tone

Hello from this part of world and HNY 2007! I have problem with ……
Anyone can help?
73s de Vaso YT1XX / YT6XX.

Hi Vaso,

did you find the home page of Jeff King ZL4AI,
http://homepages.ihug.co.nz/~jaking/TS-940_02.htm
Regards, Nermin S58DX

On Behalf Of Lynn Baustian
Sent: Friday, 5 January 2007 2:02 p.m.
To: kenwood@mailman.qth.net; 4i2benhad@comcast.net
Subject: [Kenwood] TS-940S

Does anyone happen to have all the info on Jeff Kings sight saved to a .pdf
It could be invaluable should his sight go down for any reason.
73.....Lynn WA7ADY
==

From: jaking [mailto:jaking@es.co.nz]
Sent: Saturday, 6 January 2007 10:48 a.m.
To: 'kenwood-bounces@mailman.qth.net'
Cc: 'Lynn Baustian'
Subject: RE: [Kenwood] TS-940S Page and updates

PDF of TS-940 page, or TS-950sdx page. If you really need this, print to a printer or a pdf writer and just print off your own version, Or just save the site as an html. Ihug is very reliable and this site is unlikely to go down. If that happened I would shift it to another ISP.

Taking a copy in any form is not recommended. because I update the TS-940 page regularly. I record my notes of working on the 940 on the site page. After that it takes about 5 minutes to post a new page. That way the site progressively becomes better.

The reason copies are not so good is they will not include improved / revised information. It is better to have just one authenticated source of information. For example I used to get lots of questions about how to follow circuit diagrams. Since I posted my ideas on how to read, all those questions seem to have stopped. If you have an old copy of the site you will not have that information. Ironically the reason I first published the site was I had collected the information and published it because I could see it would be helpful to others. Now I have to defend the advantages of keeping the information in just one place.

In the next years or longer as time permits I intend doing on both a late and an early 940

1. phase noise tests,
2. receiver tests, such as MDS [minimum discernable signal], IMD3 etc, because no source of this important information exists for modified or later 940s, [ZL4AI measured on his 20 mil unit MDS CW = -144 dBm, MDS SSB -139 dBm]
3. band filter adjustments / alignment
4. FET 2SK125 reversal with before and after laboratory MDS tests, to establish what the change in receive signal level is. Plus I intend telephoning Kenwood USA Amateur radio technical support on 001-310-639-4200, option 5, option 2, option 1, to find out what the real truth of Kenwoods official position on FET reversal is? I find it difficult to understand why reversing a single FET should overload or make the receiver unstable? I anticipate the measured change in MDS due to reversal will be only a couple of dBs.
5. possibly replacing 2SK125s with J310s to discover if later (year 2005 made) (of higher quality manufacturing standard) pre-amp FETs reduce the noise,
6. try installing better and additional shielding around the entire pre-amp sections to block out and reduce noise,

7. replacing band filter diode switches with relays to see if MDS and other receiver qualities improve,
8. Figure out the switching in and out of filters in SSB mode, so I can develop a rewiring of jumpers which allow switching in the empty CW filter bays while in SSB mode. Then try INRAD, and / or Kenwood AM 6K wide or other filters as additional or alternative switch ins, to enable filtering capability similar to the TS-950 and TS-850. [Measure receiver tests, for various combinations.]
9. publish audio spectrum graphical outputs of the 940 performance. [Possibly try replacing audio components such as capacitors to give a more hi-fi higher quality audio].
10. publish files of 940 performance with and without DSP filtering. Experience so far is 940 plus DSP is an exceptional improvement]
11. -evaluate and publish information on how to link 2 940s together so as to have and simultaneously use, a second 940 as a dual receiver,
12. Information about replacing bulbs with LEDs [published version 23]
13. Details on 28 volt crowbar circuit to protect the radio against power supply failure, [base data was published in Version 20]
14. An adjustable resistor for activating temperature of the power supply fan,
15. More experience on removing the very hot power diodes off the AVR board onto the heatsink
16. publish details of all the changes Kenwood made to the 940 between 1985 and November 1986. There are many more changes to the 940 than those on the published services bulletins.
17. publish info about filter input of SM-220 to remove ghost signals from 1 MHZ generated by the 940. [Published version 24]

All that information, should be of real interest to any 940 owner. For that reasons I suggest you keep reading the site.
[If anyone has done or undertakes any of the above earlier please send your results for publication. There are definitely more mods that can be undertaken to improve the 940.]

Jeff King ZL4AI

HUGE ADVANTAGE IS YOU CAN STILL SERVICE THE 940

Remember the only reason most 940 owners ever sell, is their radio has now developed faults, and they cannot bear the large cost of getting another person to repair the radio. So sadly they replace it with a radio that is working, for economic reasons. Most say if it had not developed faults I will still be using it because its performance is as good as all the latest models.

INRAD will soon release the 940 roofing filter [930 roofing filter came out recently].
http://www.qth.com/inrad/
For crowded bands, the roofing filter should provide the 940 receiver enhanced performance equivalent to the best current receivers.

Almost all radios after 1991 have been made using surface mount technology. The components are very small and difficult to work on.
For many amateurs servicing these radios is difficult, and requires soldering equipment with good temperature control, very fine tips and electrostatic safe.

The TS-940, (and others of the very early 1990s like the Icom 765, and Yaesu FT-1000D)
can still be serviced, and most parts are still readily available at local stores.

You can use standard off the shelf equivalent capacitors, resistors, ICs and often equivalent replacement transistors. The cost of these parts is low and they are readily easily available.

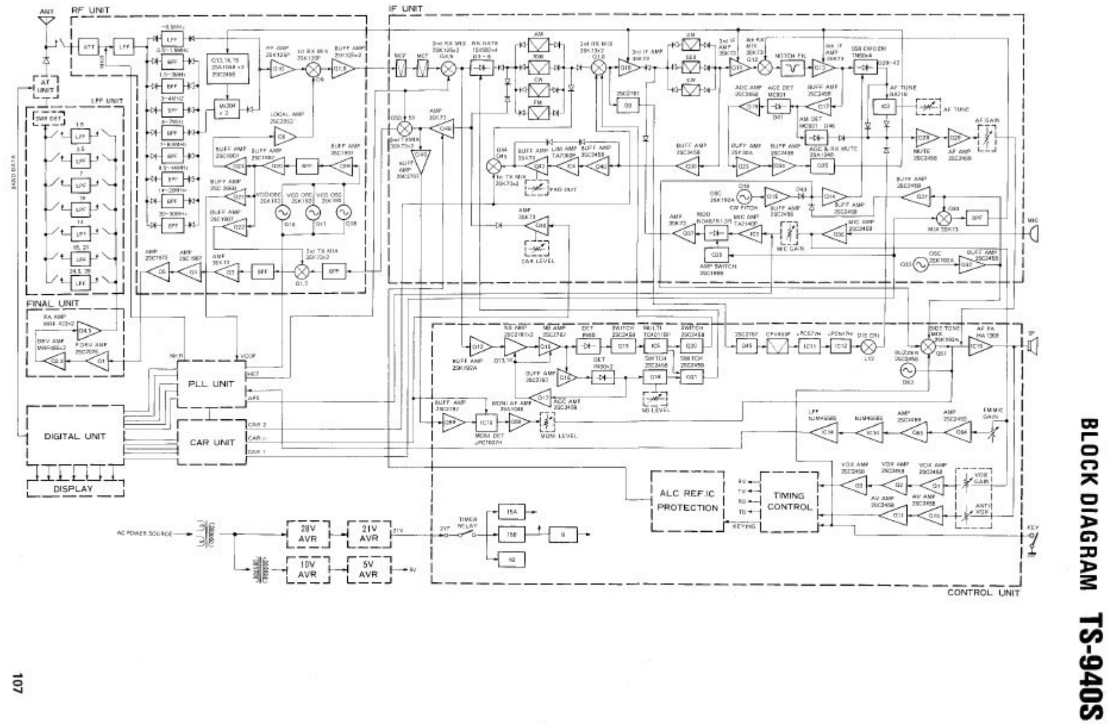
The only parts hard to get are ICs specially programmed by Kenwood [Only a few of these in the 940]
You can buy second hand TS-940 boards on EBay and elsewhere at very reasonable prices. With second hand boards and parts you can still obtain every component. Don’t sell your 940… Repair it.

If you like kit sets, you could say the 940 is like one large kit set, preassembled.

KEY TO SERVICING IS: HOW TO READ THE SERVICE MANUAL

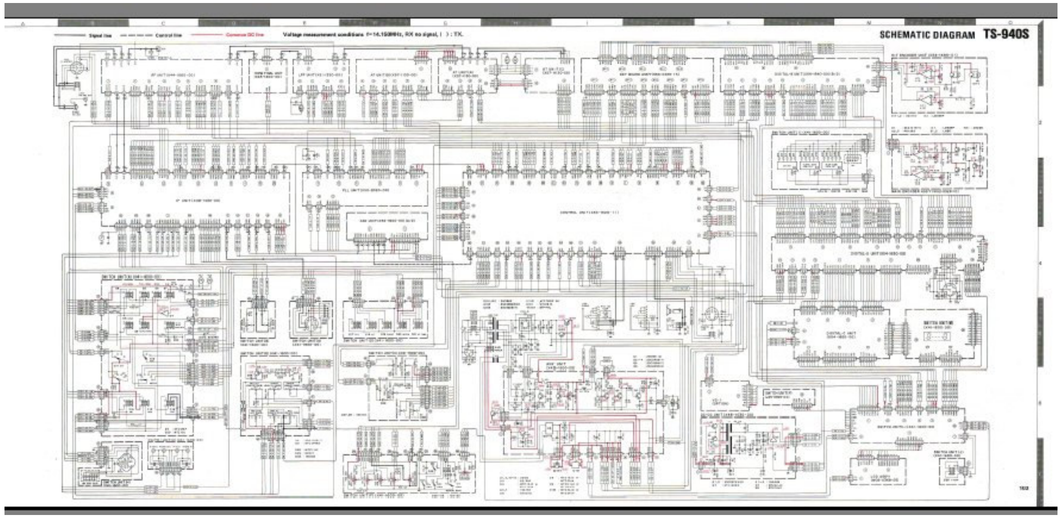
This section is first because it is key to working on the Ts-940. It is not explained in the service manual.
Once you understand this you can easily understand the TS-940.
First step is download the manual from www.mods.dk.com, or other sites.

On page 107 find the BLOCK DIGRAM. This is probably the most useful diagram in the book because it illustrates conceptually how the radio works.
It should have been at the very front of the manual. From this you can easily follow through where major signals and functions travel.

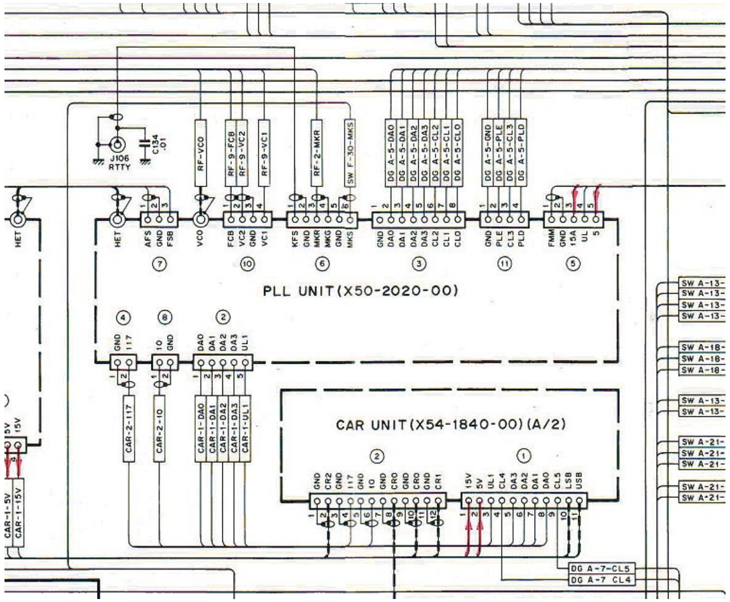


Then go to page 12 Receiver and page 17 transmitter and read through how the receiver / transmitter functions while following through the block diagram. This will give very good idea of how the radio works.

Then on page 103 find the overall schematic of the 940. This lays outs out all the major boards. There is a coding system, to trace between boards.



Now zoom into part of that schematic and look at example connectors:



Best illustrated by worked example.
On The PLL board X50-2020-00 find Connector Plug 2.
It has five wires:

Two example traces are shown below;

Wire 1-DA0 shown with a destination tag "CAR-1-DA0", whose destination is Carrier Board (X54-1840-00)(A/2) Connector Plug 1 –DA0 Wire 8,
Wire 2-DA1
Wire 3-DA2
Wire 4-DA3

Wire 5-UL1 shown with a destination tag "CAR-1-UL1", whose destination is Carrier Board (X54-1840-00)(A/2) Connector Plug 1 –UL1 Wire 4,

As you can see if you trace along all grouped wires through on the diagram, the grouped wire line leads from one board to another.

Using this system you can trace from any part of the 940 to any other part.

On each schematic or board layout diagram all you have to do is find the Connector Plug Number. Then you can easily trace through the board.

Page 83 to 89 of the service manual shows every Connector Plug on every board is listed out with description of its function. This helps identify what the wire function is doing.

Page 80 and 81 shows the physical location of most boards inside the radio.

WARNING: Please NOTE: There is no colour coding for wires listed in the service manual. IT IS VERY SAFE PRACTICE BEFORE TAKING A BOARD OUT TO DRAW A DIAGRAM OF THE BOARD SHOWING EVERY CONNECTOR PLUG AND THE COLOUR OF EEVRY WIRE. ONLY DOING THIS WILL GUARANTEE YOU PLUG THE WIRS BACK IN CORRECTLY. FOR THE IF BOARD AND CONTROL BOARD THERE ARE MULTIPLE WAYS TO PLUG IN WIRES, AND YOU COULD SERIOUSLY DAMAGE YOUR 940 IF YOU DONOTT DARW OUT WIRING COLOUR CODE PLUG IN DIAGRAMS.

Using the above decoding method solved the following problems.

From: W5EJ
Sent: Friday, 18 August 2006 7:45 p.m.
To: jaking@es.co.nz
Subject: RE: Need help on 940 Wires

Jeff, after seeing your documentation on the 940 I thought I'd send you a note and see if you could help me out.

I picked up a used 940 and appears whoever had it before me had replaced several connectors inside the unit with direct solder connections. (yes a mess).

Question. On the Speaker/internal switch unit (left front top with cover top off) there are 3 connectors that plug into the right side of the unit. One has three wires, red orange and black. All three of mine are disconnected and I cannot tell which connector terminal on the PCB to re-solder them too. (your wires would be in a connector)

I don't have another unit to reference and cannot find any pictures. do you have any pictures or 940's with the tops off could you let me know in what order front to rear the three wires are in your connector? (Of the three connectors on the right side facing the unit this is the connector towards the rear of the unit and only connector on that board with just three wires) Crazy question I know. …….

Any thoughts or help or pictures would be greatly appreciated.

thanks 73 - John (W5EJ)

From: jaking [mailto:jaking@es.co.nz]
Sent: Monday, 21 August 2006 8:59 a.m.
To: 'jwill@verizon.net'
Subject: RE: Need help on 940 Wires

John,

I don't have a TS-940 apart right now. But it is easy enough to figure out. Down load a service manual from www.mods.dk

Then on page 103 overall schematic, find those connections.
You may have to look at board layout middle of p 102 to identify the connector number and wire letter. Looks like connectors 48 29 and 30. You will see the letters for each number there.

Then find the same places on the schematic p 103.

Follow the wires through on the schematic to see which board and connector they end on another board.

Find that other connector inside the radio, and get the colour of the wire from where it connects to the other board.

Then use a multi meter to verify you have the same wire at both ends. You would be best to un-plug the other end connector, before measuring continuity, because that way you are 100% you are only measuring on that wire only.

Then you can reconnect.

There is no color coding in the manual so this is the only way to decode the wire colours.

For example ON PAGE 103 YOU WILL FIND 48 LG appears to connect to Switch L-49-LG

Or 28 CV1 connects to IF board 14-CV1

So find IF board 14-CV1, on the IF board and you will get the colour of that wire there. Un plug IF board 14-CV1, and use the meter to verify you have the same wire.

This decoding systems works right through all 940 connections.

Let me know how you get on.
73s
Jeff ZL4AI

From: W5EJ
Sent: Sunday, 20 August 2006 6:41 p.m.
To: jaking@es.co.nz
Subject: Re: RE: Need help on 940 Wires

Took your advise and downloaded the manual, had the unit fixed in 30 minutes. Thanks for the help - John

HOW TO FIND FAULTS AND FIX THE RADIO

I was initially lost about what and how to look for faults. Developed the following methodology. (All suggestions about repair methodology are welcome)

Step 1 is to download a service manual
www.mods.dk

Step 2: Read how radio works.
Read though the receiver and transmitter written explanations, and then follow those paths through on the circuit diagrams.
Easiest way to follow through is photocopy circuit pages and get a highlighter and highlight those paths on the circuits.
Only then you get feeling for where you look to find a particular fault.

Step 3:
Find the region of the radio responsible for the function causing your fault,
And locate that on the main wiring diagrams and detailed wiring diagrams.
Then progressively check every connection and component.
That is slow and tedious.
Write down every check you made.
By a process of logical and elimination you will find the fault.
It may take days or weeks, but if you are methodical you will find the fault.

Step 4:
In suspect region:

- Do go over and tighten all connectors. These white plugs have metal female clamps which get stretched open after many insertions. For each pin you need to take each connector out of the plastic sleeve and clamp it more closed with small pliers. [Female outers are only designed for so many insertions. After that they just become loose]
- Re-solder regions of boards where suspect components are located.

I would guess this would fix 80% of ts-940 faults, because the connectors and solder joints are the weak point of 940s

Step 6:
Using a digital volt meter continuity checker, verify all suspect connections are connected both inside and across boards.
(You can make your own RF volt meter for a couple of dollars by following articles in the ARRL Hand book.)

Step 7:
If you can locate replacement board for the suspect region and try that that will get fault absolutely defined to that board.
The fastest way and possibly cheapest way to fix is probably by elimination

All boards on the 940 are plug and play. When you put in replacement boards there are service adjustments to make afterwards , before seriously using the radio. But if the board is defective you can replace it and the radio should spring back to life.

For example your can buy a PLL and / or Digital A Board on EBay for between $50 and $100 each.

If you have problem in these regions I would suggest you buy, plug and play to eliminate if it is any of these boards.

You can always sell the boards you don't need again afterwards.

You can also probably sell your defective board as well for the parts on it. [Those parts are valuable to others]

Max cost is one board, plus postage plus eBay fees.
A lot cheaper than sending the radio away, and waiting and waiting.

Step 8:
To find the fault, with radio running
- Mechanical connection fault find by tapping components with plastic non conducting object.

- Fault that occurs as radio heats up. Use Freeze spray to cool suspect regions. If fault reappears when cooled you have found the region.
- Use a hair dryer to heat up regions to see if you can make a fault appear or dis-appear,
- Use shields make of cardboard around suspect commonest to try and isolate the cooling or heating to just one of two suspect components,
- Use digital volt meter to verify correct voltages shown on circuit diagrams,
- -Use oscilloscope to verify correct patterns as shown on circuit diagrams

Step 9:
Progressively replace components in suspect regions. Except for programmed ICs, You can use alternative parts,
From
www.Mouser.com

Find parts description on parts list in service manual,
Or more detail at
www.kenwoodparats.com

If you are methodical,
make written notes of everything you do,
re-think about what functions you have verified are working,
re-read the service manual, re-checking your understanding,
you will fix the 940.

This maybe safer than the risk of damage during shipping.

RECEIVER PERFORMANCE IMPROVEMENTS.

R1. KENWOOD PRODUCED 3 SERVICES BULLETINS which do considerably improve the receiver.

AGC circuit improvement

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=2d13f766bec08d9297b46280e3758b9b95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=d02a8b1ae4c8a39115ff83f169f65a1895e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

TS-940S Signal To Noise Ratio Improvement With Noise Blanker
http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=09b9d746891ed0281dcc8482861e53da08bf66aab282a3fe0ec52cce1a1412bab3177362513310ffd26e29ff6af16615

TS-940S VCO/Carrier To Noise Ratio Improvements
http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=57aa76a9447b3b37e1e9f60965f865a395e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=2e0ca5ad0e0e9060f7f850fe27f80b1a95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=55221dd570b7e465e5087cf67f5e71fa95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

KENWOOD TS-940S RECIPROCAL MIXING NOISE
In early March I [Rich Maher] talked to someone at International Radio regarding the reciprocal mixing noise problem with the Kenwood TS-940S. I had been in the process of installing the fix described in your newsletter (late 1986 issue) and found that it had already been installed on my TS-940S (S/N 7100269). The factory installation had one problem, the resistors used for R120/R129 were color coded for 900 ohm (close enough to the 1K in the newsletter), but in actuality measured 465 ohms. Apparently, Kenwood had gotten a bad batch of resistors from some supplier and had not discovered the problem.

At the time you indicated that was the first report you had received of the resistor value problem and recommended that I contact Kenwood. I called them and was told that they had not heard of the problem before. They also stated that a new fix for the reciprocal mixing noise problem had been developed and was described in a Service Bulletin dated March 2, l987. I requested a copy of the bulletin and have attached a copy of it to this letter for your information. (See Issue No. 76, Pg. 30 and 31 for Kenwood Service Bulletin No. 917 and schematics pertaining to this subject.)

Since receiving the bulletin from Kenwood, I have installed it on my TS-940S and found it to make a very significant improvement in weak signal handling in the presence of nearby strong signals. I would recommend highly that anyone experiencing reciprocal mixing problems install the new fix. It should be noted that some of the newer TS-940S have the fix installed. I was preparing to install the fix on a friends's TS-940 which had a serial number 100 lower than my own and found that the fix had been factory installed. Apparently, more than one manufacturing site is used and serial numbers are given to each in blocks. Consequently, it is possible for higher serial numbers to be produced at one location without the fix, while another site any have cut in the fix but is using numbers from a lower block.

The quickest way to verify whether the fix has been installed is to check R120 and R129 on the PLL Unit (X50-2020-00). If these two resistors are 3.3 ohms in value [*Editor correction Service Bulleting 917 says 3.3 Kilo-Ohms*], the fix is already installed. Do not depend on the on the absence of C176, C180 or C181 as an indication, as earlier attempts (factory or field) to correct the mixing noise problem may have removed these same capacitors. The instructions in the bulletin state that when making the modifications to the RF Unit (X44- 1660-00), it is easiest to move C132/C133 to the foil side of the board. As the component side of the section of the RF Unit containing these two capacitors has been filled with wax, it is definitely not easier. The factory installation of the fix left C132/C133 on the component side and installed the R154/C193 and R155/C194 series RC networks on the foil side. This is definitely easier. As a side note, the installation of the fix took me about 2 hours. Both the PLL Unit and RF Unit modifications must be completed before the transceiver is usable. If you install just the PLL Unit modifications and then try the receiver, CW signals will should like raw AC. Also, to make life simple, do not remove each of the boards above the PLL Unit individually. The easy way to gain access to the PLL Unit is to remove the top two screws (one on each side) holding the front panel and loosen the bottom tow screws. This allows the front panel to be tilted forward. The speaker assembly and all the boards above the PLL unit may then be removed as a unit by removing only 4 screws and tilting this unit towards the front of the TS-940S. No cables need be removed from the boards above the PLL Unit.

I hope the above information is helpful to you in dealing
with the reciprocal mixing noise problem. (Thanks, Rich
Maher, WZ4Z, 1117 NW 7th St., Boynton Beach, FL 33435)

RECEIVER 2. FIELD EFFECT TRANSISTORS AROUND THE WRONG WAY.

In September 2004 PY1NR announced he had discovered:
- -on RF board Preamp Q10 and
- -on the IF board 2nd balanced mixer Q4,

had been drawn on the circuit boards and mounted in the reverse orientation to that shown in the Kenwood Circuit Diagram.

See PY1NR web site www.guisard.com
and
http://www.eham.net/articles/9261

Initially ZL4AI found it hard to understand this website and actually what PY1NR had discovered. Starting with the circuit board layouts I tried to draw out the circuit: What I found was that apparently the FETS were mounted with the drain where the source was supposed to be and vice-versa.

As FETs normally allow current flow until the gate has a potential, I wonder if this really makes that much difference.

PY1NR suggest that reversing these transistors will provide 10 dB of gain. But this claim does not appear be based on before and after measurement. It would be useful to have some feedback on whether others have had much improvement by reversing the FETS.

<u>Garey Barrell provides Kenwood's advice</u>

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======================================================== =============================
From: kenwood-bounces@mailman.qth.net [mailto:kenwood-bounces@mailman.qth.net] On Behalf Of Garey Barrell
Sent: Wednesday, 9 March 20055:53 a.m.
To: Kenwood@mailman.qth.net
Subject: Re: [Kenwood] RE:TS-940 What is the correct FET direction?
Jeff -
OK..... Just in from Kenwood...
+++++++++++++++++++++++++++++++++++++++++++++++++++++
Dear Kenwood Customer:
This information pertains to the TS-940S component location.
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The circuit designer said the installation of Q10 in the actual TS-940S transceiver is correct.
The PCB view in the Service Manual is correct too. The schematic is the only section that is in error. The schematic indicates the drain of one FET connected to the source of the second FET. The correct
installation is to have the source of one FET connected to the source of the second FET.
In addition, testing at Kenwood Communications in Long Beach, CA showed poor results. Sensitivity can become unstable. The most important point about the Q10 pair is that both FET's must be replaced at the same
time (like a matched pair). Replacing only one FET at a time can affect sensitivity.
If you need further assistance, please e-mail us again.
Sincerely,
Kenwood Amateur Radio Customer Support
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
73, Garey - K4OAH
Atlanta
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From: Garey Barrell [k4oah@mindspring.com]
Sent: Friday, 11 March 2005 7:26 a.m.
To: jaking@es.co.nz
Subject: Re: [Kenwood] RE:TS-940 What is the correct FET direction?

Jeff -

OK. I just had a discussion via phone with the Amateur service department at Kenwood.

The Q4 situation is not quite as clear. The schematic appears to be correct, (sources tied together or push-pull,) and the board layout
drawing appears to be incorrect. According to a tech in Japan, the FET's in the actual unit are correct. They have not found any instance where they were reversed in the actual radio or any 'in-house' docs that could have resulted in such an error. *I guess someone is going to have to open one up and look at the traces! Looking at the board traces in the component layout, it certainly appears that one FET has the Source and Drain connections reversed if the FETs are installed in the orientation shown. Perhaps the board traces were changed? [ZL4AI editor comment: Boards made exactly as shown in the Service Manual]*

The guys at Kenwood, both in LA and Japan, are pretty frustrated with the whole mess! They tried to duplicate the Q10 situation, and found that performance was degraded considerably when the PY1 "correction" was made. They also mentioned that replacing one of the pair was not recommended. The original circuit used a matched pair and they recommended replacing them only with a matched pair. They were unable to describe the "matching" process, but we surmised they selected for Idss, and possibly transconductance.

The big question is, these transceivers have been working and meeting specs for 15+ years, so who cares!? :-)

73, Garey - K4OAH
Atlanta
==

```
-----Original Message-----
From: Traian Belinas [mailto:traian@deck.ro]
Sent: Tuesday, 5 April 2005 9:34 p.m.
To: jaking@es.co.nz
Subject: Re: Ts-940 All problems SOLVED .. Possibly for you too!

Hi Jeff,

The website is and will be great.
Will look carefully at.

I have two things to say.
First is that the second mixer Q4 JFET is indeed wrong mounted.
Here are attached pictures, you can use them on the website.
The PCB traces are symmetrical, the mixer should be balanced, and as the two
FETs are identical type, the way that they are mounted is obviously wrong.
As I said, I have reversed the Q4 and the improvement exist, but it is not
so great as other had reported (the sensitivity goes improved by 2 to 3 dB)
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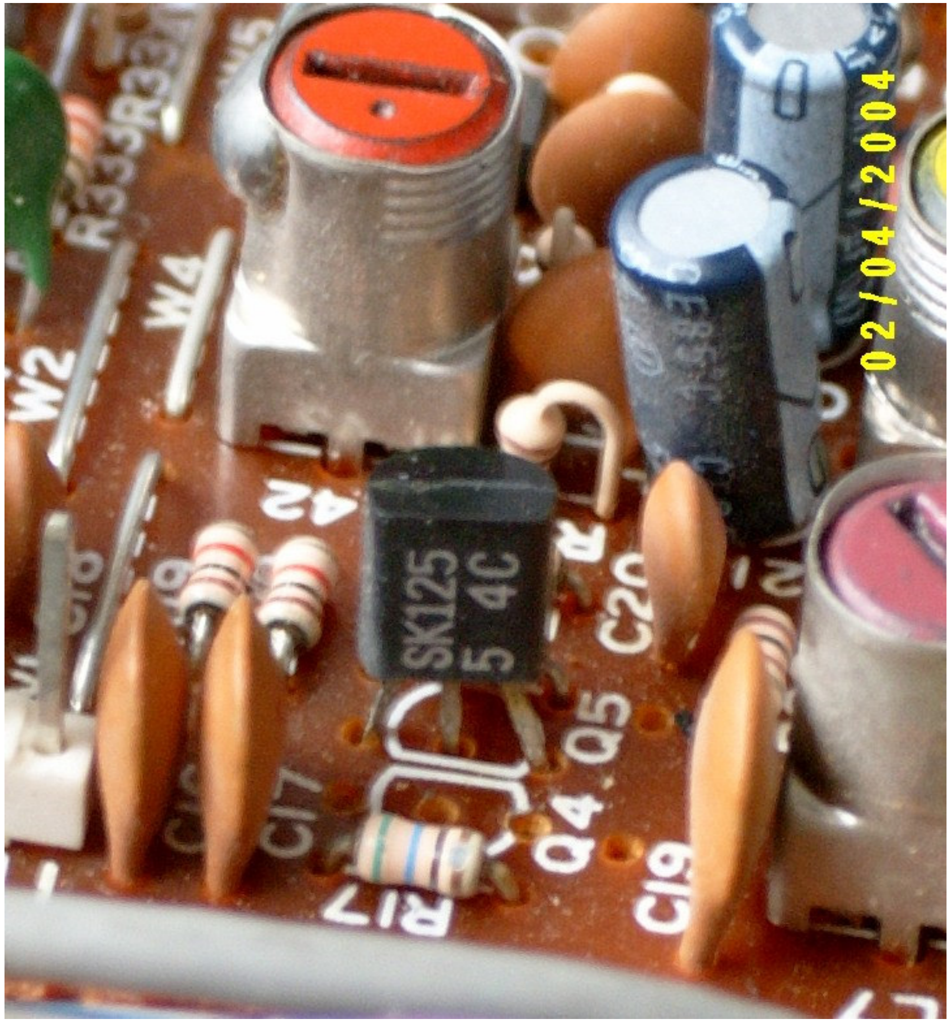
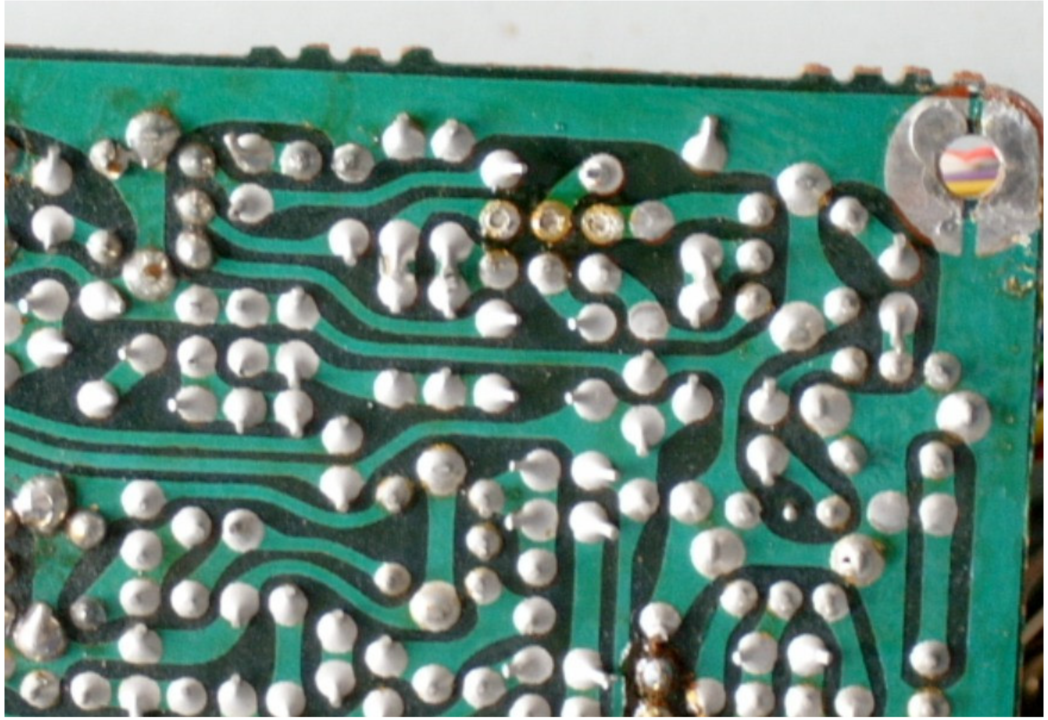
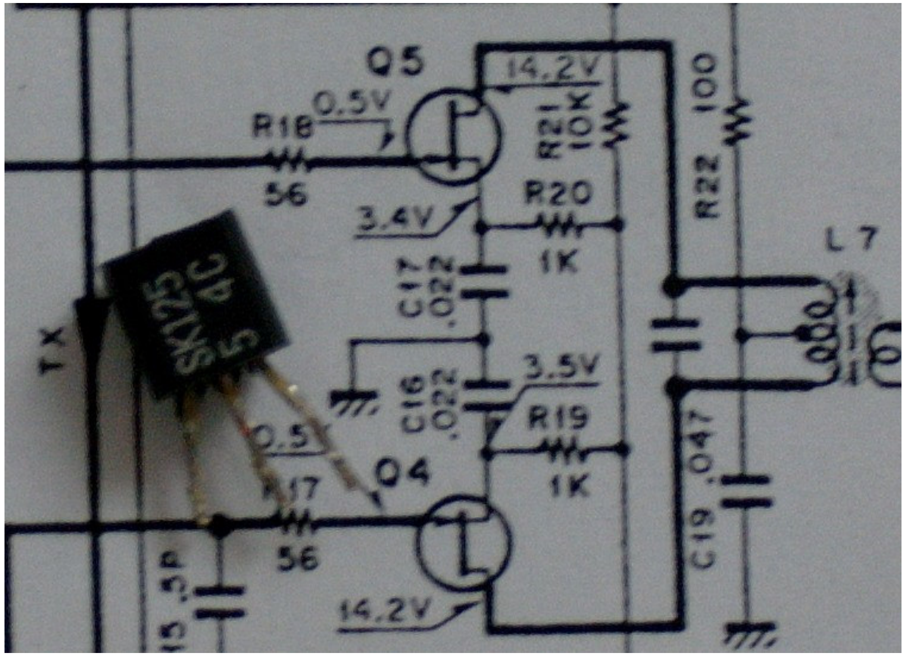

02/04/2004
SK125
5 4C
Q5
Q4
C20
C19
C17
R17
W4
W2





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After reading Kenwood's Garey's and Traian's advice, I turned around only Q4 on the IF board.
The result was a quieter receiver. I do not believe that there was any significant gain increase in the receiver.
I would appreciate (and will post on this page) emails describing others experience regarding this change.

From Kenwood.net on 25/4/05

Hi Dale

I also became interested in the RX mod you mention. Before opening my 940, I decided to first check whether drain and source of the 2SK125 are symmetrical or not. This was easy for me because I own a "dead" 940 RF board as a source of parts for future repair of my rig.

I collected one of the 2SK125s from this board and built a source-grounded test configuration with a 5K resistor connecting drain to +8V. Then, I fed a sawtooth test signal (about -6 to -1V) via 10K into the gate. U(drain) was recorded against U(gate) on a DSO (Tek 468). Thereafter, I repeated the measurement with drain and source exchanged.

I obtained the characteristical FET response curves and these were exactly (!) identical in both configurations. This did not change when the test frequency was increased to 10 MHz. It seems, therefore, that the 2SK125 is symmetrical.

As a consequence, i decided not to correct the layout error in my 940.

Like others, I also believe that there is not much to improve. My 940 has an RX sensitivity of about 0.15 µV (10 dB S/N) on all bands (well, I must say it was worse until I re-aligned the entire RX). The IP3 is +18 dBm (I once replaced the band switching diodes by PIN diodes).

Like others, I often had connector problems after working in the 940 - another reason only to go into this rig when necessary.

Best 73,
Thomas (DF5KF)

THEN TRAIAN PROVIDES MORE OVERVIEW

-----Original Message-----
From: Traian Belinas [mailto:traian@deck.ro]
Sent: Friday, 29 April 2005 2:05 a.m.
To: jaking@es.co.nz
Subject: Re: FW: ts-940

Regarding the TS940 2SK125 preamp, yes the FETs have this interesting
feature: for low signal/low freq and/or low DC, they are symmetric. This is why they are used as passive variable low resistance/attenuator/switching for low signal with rather good results. The things are changing at HF/VHF amplifiers where the interelectrode capacitances became important (do you remember about neutralising a FET preamp?), and these are not quite symmetrical, as the devices are manufactured so that the drain to gate capacitance to be as low as possible for obtaining lower out to in feedback when used for common source applications... So, even if symmetrical, why to use it as for having the greatest unwanted out ot in capacitance/feedback? The gain obtained by inverting the D/S for the TS940 Q10 may be still not high (I don't intend to do it because of the reason explained before), but the engineering feel tell us that something is not ok there... And regarding the second mixer, there it is obvious that it is not ok, even if it works... An counterexample is also the TS950 (both SD and SDX) which use the same Rx preamp as the TS940 with 2SK125 and 2SK520 (they are all FET cascade preamps) but for the 950 it is actually build as shown in the diagram, no drain/source inverting there (maybe the same for their second mixer), so which of them is the best regarding this, the 940 or the 950?!

Please let me know if any other new info about the 940/950.

Tnx,
73,
Traian

PY1NR provides feedback and re-endorses previous statements on turning the FETs around
PY1NRFeedback

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of John Rotondi
Sent: Friday, 17 March 2006 10:51 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] FET Reversal Fix Notes

Dear Fellow TS-940 users-

Just a quick post to let others know this information, which you can use as you see fit:

I have now fixed 2 TS-940SATs according to the findings of PY1NR who first detailed the reversal of 2 FETs in the TS-940, based on factory mistakes in the PCB silk-screening. After doing my own radio, I absolutely found a significant increase in received signal levels, with no audible increase in noise floor. I wondered why other users were not rushing to do the fix- and then saw several posts denying the validity of the fix. However, since I did not effectively document this in a scientific manner, I could not effectively offer valid 'proof' of the results.

When I mentioned this to one of my RACES group leaders- who also owns a TS-940- he decided that we would to do the 'fix' to his unit- but this time, we would document the results using a repeatable local test signal. The documented results: after each FET was reversed, we found a 1 S-unit improvement in received signal level using our local test signal in the 20 meter band, for a total of 2 S-units receive gain improvement.

Now, there is much conjecture regarding the dB value of S-units, and other TS-940 users may know what these 2 S-units on the TS-940 meter mean in terms of dB. Generally, from my research, each S-unit may represent 5 or 6 dB of signal, which means the fix has increased receive gain 10 to 12 db. Certainly nothing to sneeze at: being able to give one of the finest receivers made the full scope of RF gain that it was originally intended to have
- at no cost, and without negative repercussions? As the bands wane on the downside of the sunspot cycle, and running only a vertical 10 feet off the ground, I am finding I can use all the noise-free gain available to hear DX!

At any rate, this was my experience, which I humbly offer to the TS-940 user community.

Wishing you all good DX!
73,
John, WA2OOB
Ventura, CA

On Mar 19, 2006, at 1:53 AM, Jeff King wrote:

John,
found your report very very interesting.
Despite all the controversy, some of which I have reported on
http://homepages.ihug.co.nz/~jaking/TS-940_02.htm

I would appreciate if you could you please confirm you turned one FET around, ran signal test, identified improvement 1 S unit and then Turned other FET around and ran signal test, identified improvement 1 S unit?

You know it would be helpful if Kenwood would actually confirm their view of whether the FET in correct position results in too much gain.

hope to work you one day! and
73s
Yours sincerely
Jeff King zl4ai

From: John Rotondi, WA2OOB [mailto:wa2oob@earthlink.net]
Sent: Sunday, 19 March 2006 11:56 p.m.
To: jaking@es.co.nz
Subject: Re: [ts-940] FET Reversal Fix Notes

Hello Jeff!

Very nice to hear from you! Thank you for your interest in my posting on this topic.

I have seen your excellent website- thank you for providing such valuable information to the user community. I am still reading through all the information regarding PIN diodes, and may mod my radio in that area as well.

Just a bit on my background: I am a professional sound engineer, and have been designing/building/maintaining/operating professional music recording and TV/Film post production facilities for many years. When I first did the FET fix to my TS-940, the results were obvious to my ears. In doing the second radio with my friend, we systematically followed these steps to document the results relative to an external repeatable test signal, independent of band conditions, QSB, etc.:

1) Set up the signal source: my MFJ-259 antenna analyzer with whip antenna, to generate a signal near 14.200 MHz.
2) Set up the TS-940 with a small whip antenna on the work table, about 4 feet from the test source.
Note that the MFJ-259 RF test signal is fixed in level, so this would not be a variable in these tests.
3) Tuned the TS-940 to this test signal, peaking the carrier reception in USB mode, and recording the maximum S-meter reading.
Note that I moved the radio around a bit to ensure that the reading was stable and repeatable, and not sensitive to relative position.
4) Shut off the test source so as not to deplete the battery while working on the radio.
5) Reversed the first of the FETs, reinstalled it's PC board, installed the whip antenna, and positioned the radio as for the original measurement.
6) Powered up the test source, and tuned the TS-940 to it as before.
There was a full 1 S-unit increase in received signal level.
7) Shut off the test source.
8) Reversed the second of the FETs, reinstalled it's PC board, installed the whip antenna, and positioned the radio as for the original measurement.
9) Powered up the test source, and tuned the TS-940 to it as before.
There was now another full 1 S-unit increase in received signal level over the previous measurement, giving 2 full S-units total over the original base reading.

While this is probably not as sophisticated as if we would have used a Communications Monitor (IFR, Marconi, etc.) or other test system directly coupled to the receiver, with stepped calibrated attenuators, and RF voltmeters coupled to the IF of the TS-940, we felt that it would be a fast way to have valid empirical data to verify that we had created an improvement, rather than a disability, for the TS-940. BTW, post fix listening on air clearly showed the significant gain improvement.

In listening today on 10 meters on my own TS-940, I know that this additional gain has brought signals to the readable level that would otherwise have not been readable. I have also done extensive listening tests with extremely strong local broadcast signals to determine if this fix has compromised rejection of extraordinarily strong out-of-band signals, or has resulted in compromised receive RF or audio intermod or other non-linearities resulting from component saturation, imbalance, or interstage distortion- but have heard no such issues. I will mention that my recently purchased IC-706 MK II (for mobile use), of more recent design and with some DSP, totally folds up from same broadcast interference that has no effect on the 940!
The 940 receive audio quality remains exemplary. I have been pleased with the results of the fix, and feel it was worth the effort to realize the full potential of the original design intent.

I can only think that some amateurs did not have the same results because perhaps the FETs were not closely enough matched to begin with, or they had other problems, such as bad solder joints as often found in these units?

I hope this information is helpful to you! And yes- it would be nice if Kenwood would enlighten us on these issues- but as the radio is not a current product, and did quite well even with this 'defect', they have little motivation to do so.

I will look forward to a QSO with you on HF!
73,
John , WA2OOB

Editors Note:
John has undertaken some very useful measurements and it is very useful to have some measurements.
Measurement outcomes could be more factual if a change in signal to noise ratio was measured by laboratory methods described by the ARRL. For example MDS.
http://p1k.arrl.org/~ehare/aria/ARIA_MANUAL_TESTING.pdf
http://www.arrl.org/~ehare/testproc/testproc.pdf
If someone could do an MDS noise floor test before and after the FET swap, it would be more complete evidence of the assumed improvement.

Garey Barrell sensibly advises:
Even a good test, i.e., s+n / n measurements before and after, or _accurate_ noise figure measurements really wouldn't impress me that much, since a receiver meeting the Kenwood specs would be limited by external noise regardless!

I suspect Garey is correct about the noise floor: This is a less than 0.2 microvolt receiver: Maybe turning the FETS around produces more noise, [which of course lifts the S meter] but does it produce any more signal or better signal to noise ratio?
If first before an FET swap the S meter was calibrated against a signal generator, then signal strength against independent signal source measured, then an MDS measured, then after the FET swap the s meter was again re-calibrated, then a reading of the independent signal sourceand separately MDS again would show that it was just not an increase in noise.
I wish Kenwood would behave like a responsible manufacturer and explain the technical reasons they do not recommend turning the FETs around.

Have a look at the following links which show how measuring receiver improvement is a difficult undertaking. Even definition of what you are measuring requires some considerable reading and comprehension.

http://www.sherweng.com/table.html

http://www.rac.ca/opsinfo/smeters.htm

http://www.seed-solutions.com/gregordy/Amateur%20Radio/Experimentation/SMeterBlues.htm

http://www.w8ji.com/receivers.htm

RECEIVER 3. THERE IS NO AGC TIMING CORRECTION

Short (Simple) Version of What you need to verify on your TS-940 is the next 5 lines

Leave R 149 and R 150 in their original positions.

With the radio upside down and the front facing you,
R149 is on the right of the pair and should be 150K or 68K.
R150 is on the left of the pair and should be 2.2 meg.

If you want to upgrade (the way Kenwood changed the Service Manual), change R149 to 150K.

Thanks to Dennis WB8WTU who suggested a short Version of what to verify.

Now
If you are interested in the history of this Verification read the rest of this Section 3,
If you are NOT interested in the history of this Verification go to Section 4.

===
This R149, R150 issue was first discovered in about 1986, and is mentioned in International Radios Bulletins

STOP: This modification was suggested following Kenwood Japan's advice, that
"The I.F circuit diagram was correct and the I.F. board was labelled incorrectly."
Communications_1_2_with_Kenwood_Japan

Kenwood Japan have now changed their mind and confirmed
"The I.F circuit diagram is incorrect.
Communication 3 with Kenwood Japan

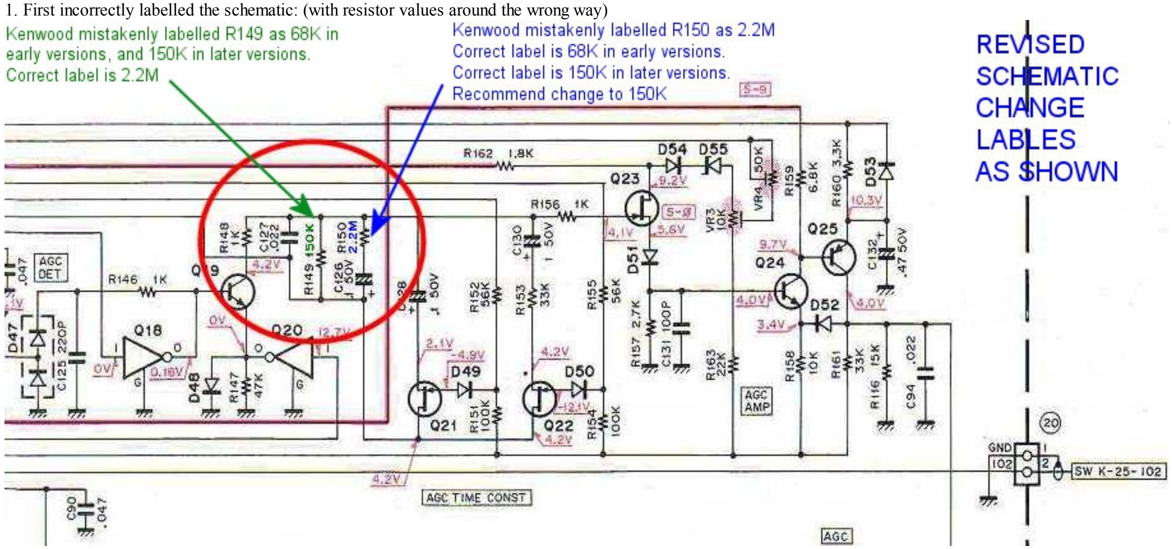
Swapping R149 and R150 probably increases sensitivity to similar degree as achieved by just turning the AGC off

Please review KI4NR's email below advising the (Kenwood intended) correct construction was electrical layout of the AGC identical to the TS-930.
KI4NR_email
KI4NR advises the rising S meter caused is leaking in C128 and C130. On the Editors radio C128 has been replaced and does not fix the rising S meter.
When time permits C130 [and / or other AGC capacitors] will be replaced and when replacement has been shown to remove the rising S meter this web page will be updated to confirm that. At that time this section of the web page will be restructured to separate communications about IF circuit diagram from the rising S meter problem.

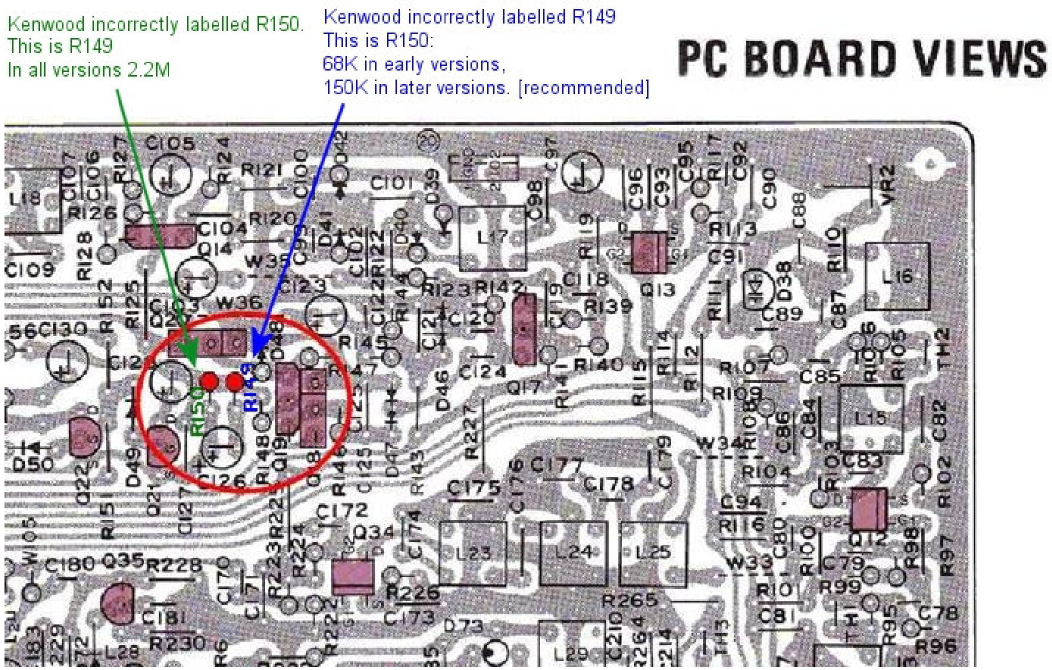
SUMMARY OF R149 AND R150 MIS-LABELLING

Kenwood appears to have done the following: **Please note there are 2 mistakes.**

1. First incorrectly labelled the schematic: (with resistor values around the wrong way)



2. Then incorrectly labelled the PC board [to correct the mistakes on the schematic] so correct resister values put in circuit.
(For example the position of R150 was labelled as R149 on the PC Board, which resulted in a 150K resistor being put at the R150 position.)



Areas in grey below should be disregarded.

Significantly improves the AGC timing function: After modification:

- You hear weak signals a lot better.
- S meter with AGC SLOW ON becomes quite responsive and lively in the region of S1 to S4 signals.

--Before S meter did not move much in S1 to S4 region.

--Before it would take a strong signal to lift the meter suddenly to S4.

I always wondered why the TS-940 behaved differently to other transceivers [TS-930S, TS950SDX] which react much faster over S1 to S4.

Mike KC8ZNW on 25/4/05 describes this same behaviour to the Kenwood.net.

Hello everyone I have a question about the movement of my 940's meter. It seems that it barely moves on some signals which are perfectly readable, other sigs give me 8 or 9 and I have even heard an occasional 10DB+ movement. My TS830S will give me a 2 or 3 s-unit increase when I switch the antenna to it for the same signal.
Is this an effect of the receive sensitivity of the receive section? Or do I have a malfunction? In addition my VFO exhibits the occasional hiccup on the last 2 digits on small movements of the knob. I understand this may be caused by solder joints.
TIA, Mike KC8ZNW

Executive Summary of AGC Mod

Its easy to modify a TS-940S to hear better (or as well as) a TS-950SDX.
When fixed, TS-940 really pulls out those very weak signals.
Simply swapping 2 resistors around, will enable this rig to hear as Kenwood designed and intended in Kenwood's original circuit diagram.

The error is on the IF board:
Kenwood printed labels for R149 and R150 around the wrong way!!!
As assembled by the factory, (the outcome is) in the main signal path, a 2,200 Kilo-Ohm resistor ends up where a 150 Kilo-Ohm Resistor should be.
Being 14 times larger the 2,200 Kilo-Ohm resistor (incorrectly) significantly degrades the signal.
Swap the resistors around and the receiver hearing improves significantly!!!

Kenwood have confirmed the resistors are in the wrong place. Their emails are below:
Probably "these resistors in the wrong place" occurs in every TS-940S produced.

Independent Feedback on how Receiver Improves

1.
From: Ed [mailto:ca.urso2@verizon.net]
Sent: Monday, 23 May 2005 7:18 a.m.
To: jaking@es.co.nz
Subject: TS-940S

Also, your AGC Timing Correction was applied on my rig (SN 806XXXX) and worked great! Sure enough, resistors R149 (68K on my equip) and R150 2.2Meg had been incorrectly installed by the Mfr. The board markings for those resistors were wrong.

73,
Ed Alves KD6EU
USA

Full email at: FeedbacK_3

2.
From: el34guy@aol.com [mailto:el34guy@aol.com]
Sent: Thursday, 23 June 2005 4:46 p.m.
To: jaking@es.co.nz
Subject: agc modification
Hi Jeff,
I was looking through the 940 page and found my feedback to you(regarding the AGC modification with resistors 149 and 150) under the alc setting portion. Im sure I mislabeled my original email to you on this(think *I wrote alc*). I am having some luck with changing out the 2.2 meg for a 1 meg resistor. Im thinking maybe a little lower value might be worthwhile to test also, like a 6-800k ohm value.
I know I received another email from you on this but I just wanted to let you know it looked like my feedback was in the wrong spot on your page.

-----Original Message-----
From: el34guy@aol.com [mailto:el34guy@aol.com]
Sent: Sunday, 12 June 2005 9:43 p.m.
To: jaking@es.co.nz
Subject: Re: alc mod
Jeff
I thought that mod might be a little better than it was for the alc. It made my radio appear as if it was in fast agc mode all the time. There wasnt a lot of smoothness in the ssb signal that Im used to. Like I said, maybe something like a 1.1 meg is worth considering in there. There isnt much room to solder at all in there. Geez, its tight.
73
Mark

[Editors Note: ZL4AI questions the validity of these observations but has included them to keep feedback information unbiased. Varying the resistors from Kenwoods values was never recommended or intended. With resistors changed around on the Editors 940 AGC slow is still very much slower than AGC fast.]

3.
-----Original Message-----
From: Michael Feryok II [mailto:mikeferyok@yahoo.com]
Sent: Saturday, 9 July 2005 9:57 a.m.
To: jaking@es.co.nz
Subject: AGC Mod

Hey Jeff,
Thanks so much for your TS940 page it helped a co-worker and I today to swap the R149-150 resistors for the AGC mod. Very apparent improvement in noise level and gain. I can hear stations that are buried into the noise floor now. Mike, KC8ZNW

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** mikeferyok
Sent: Saturday, 9 July 2005 9:53 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] AGC mod works great!!

My friend and I did the R149-R150 swap and it improved the gain and
noise level. Adjusted the VR3 for a proper zero on the meter and
worked LZ1YE and YV5YMA right after on 17 meters!
Very low noise compared to before the swap. I highly recommend it.
Thanks to everyone here, and Jeff ZL4AI, Mike KC8ZNW
I'm still debating the transistor gain swap.....????

4.
From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Dale
Sent: Tuesday, 12 July 2005 5:37 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: AGC mod works great!!

Hello Mike, I'm having both mods done to my 940 now and I hope the out
come is like yours. I'll post after I get my 940 back and let everyone
know how it goes. I have a very late model serial number which is
20700050 and it still had both mistakes in it, so I hope this will
improve on the already great recieve on the 940. 73 and enjoy your
improved TS-940S. Dale, KD5UVV

--- In ts-940@yahoogroups.com, "mikeferyok" <mikeferyok@y...> wrote:
> My friend and I did the R149-R150 swap and it improved the gain and
> noise level. Adjusted the VR3 for a proper zero on the meter and
> worked LZ1YE and YV5YMA right after on 17 meters!
> Very low noise compared to before the swap. I highly recommend it.
> Thanks to everyone here, and Jeff ZL4AI, Mike KC8ZNW
> I'm still debating the transistor gain swap.....????

5.
-----Original Message-----
From: Articles@eham.net [mailto:Articles@eham.net]
Sent: Sunday, 24 July 2005 3:52 p.m.
To: jaking@es.co.nz
Subject: [Articles] Improve TS-940 Receiver for Weak Signals

Posted By KB9IV
Well I finally got around to the AGC mod. What a fantastic difference.........it also improves CW to my ears. In addition the AGC mod also seems to improve useable weak sensitivity and decreases distortion.
Forget the "FET reverse" project. NO difference here, it's not worth the risk and time.
Best 73,
Bill KB9IV

-----Original Message-----
From: Bill & Becky [mailto:wmarvin@hickorytech.net]
Sent: Sunday, 24 July 2005 4:00 p.m.
To: jaking@es.co.nz
Subject: 940 AGC Change

Hello Jeff,

Thank you for the info on the "AGC" correction. What a fantastic difference here!!
Makes a good 940 a great 940........I can now hear much better not. I found the FET reversal change useless...........not worth the bother.

Have a Great Day!!

73
Bill KB9IV ....Minnesota

6.
http://www.eham.net/articles/11090

7.
-----Original Message-----
From: John [mailto:hydroaction@cfl.rr.com]
Sent: Friday, 29 July 2005 4:03 a.m.
To: jaking@es.co.nz
Subject: Your 940 observations

Jeff

I appreciate your efforts on the 940. I have to say the AGC deal is not quite right. I have work on more 940 that I can remember. I have known for years the silk screening of the numbers on the circuit board is wrong. but the resistor placement on the board is correct. also the service manual is wrong on the schematic. The 2.2 Meg ohm resistor is in parallel with C-127 .....the 68K or 150K resistor is in series with C-126 which give you the base line time constant when AGC switch is in the fast postion. This is the CORRECT arrangement. Also if you look at the TS -930 that has the identical AGC circuit this is how it is on that radio too. The reason why you get the AGC rise when the radio has been sitting is the Capacitors are leaky and by swapping the resistors around helps correct that problem. I have had 940's have the rising S meter problem and changing and the caps C128, C130 in the AGC fixed it. This circuit is a Hi impedance type with FET very sensitive and crazy things happen. I have check many, many 940 I have repaired new and old serial numbers and have not found one yet that had the resistors in wrong. Look at the TS-930 schematic to see what I am taking about.

73 John KI4NR

Editors note:
On the TS-930 signal board the equivalent AGC resistors to R150 and R149 are:
R730 2.2M
and
R710 68K

-----Original Message-----
From: LPC Wireless, KI4NR [mailto:lpcwireless@cfl.rr.com]
Sent: Friday, 29 July 2005 5:39 a.m.
To: jaking@es.co.nz
Subject: More Info ... Your 940 observations

Jeff

I forget to add something. When you swap the resistors around. you are putting the 2.2 Meg ohm in series with C-126. this effectively removes the Base line time constant to all AGC positions on the switch including AM even thou the switch does not function there. That why people say the meter is more jumpy. plus the 150 K or 68 K bias the gate of Q23 more heavy and allows the receiver to stay more sensitive to low level signals. if you look at the TS-930 schematic this is the correct circuit in every way and the way Kenwood intended it to work and how the 940 is

One other thing .....on all the older 940 4, 5 and early 6 mil serial number ...the IF board is different. The gain distribution in not the same. All the 940 ... late 6 and newer had better IF boards. They have more gain TX & RX the radio are hotter sensitivity wise, better AGC compression. I use a 5 mil TS 940 with a later model 8 Mil IF board in it ....much , much better !!

Also Kenwood put an S meter slam mod in those boards. all the older 940 when you shut the radio off, pin the S meter over. The newer boards are fix for that.

8.
From: Jeff King [mailto:jaking@es.co.nz]
Sent: Monday, 1 August 2005 8:01 a.m.
To: 'css@kenwood.co.jp'
Cc: 'lpcwireless@cfl.rr.com'
Subject: RE RE: Is your advice Correct about TS-940 R149 and R 150: being in wrong places???

Dear Mr T.Soranaka

Thank you so much for your 2 emails sent in March 2005 [attached as below].
COMMUNICATIONS_WITH_KENWOOD_JAPAN About R149 & R150
From your advice I understood:

“The I.F circuit diagram is correct about positions of R150 and R 149 and the I.F. board is labelled incorrectly.”

Because your advice was valuable I recorded this to a small web page:
http://homepages.ihug.co.nz/~jaking/TS-940_02.htm
This has been seen by some TS-940 enthusiasts. It enables one to adjust a TS-940 to operate as (you advised) Kenwood designers really intended.

A very experienced Kenwood repair expert from the USA very strongly suggests your advice may not be correct. The reasons he states sound correct and are very convincing: Those reasons are summarised below.

With the greatest of respect to Kenwood Corporation and yourself I ask please:
Could you please review your advice and advise again if R150 and R149 on the IF Board should be swapped around to make the TS-940 to operate as Kenwood designers really intended?

==
30 July 2005:
Abbreviated summary of key points in Emails from KI4NR Kenwood Repair Expert in USA

When R149 and R150 are swapped around the AGC does not function as Kenwood intended.

- The service manual is wrong on the schematic.
- The silk screening of numbers on the circuit board are reversed to the schematic and wrong in relation to the schematic (only).
- But the resulting resistor placement on the board is correct.

I believe the silk screening on the 940 IF board is correct and the IF schematic is wrong.

The 2.2 Meg ohm resistor is in parallel with C-127 .....the 68K or 150K resistor is in series with C-126 which gives the base line time constant when AGC switch is in the fast position. This is the CORRECT arrangement.

The 2.2 meg ohm resistors in both the TS-930 and TS-940 sets up the bias to the FET from the 3.2 volt AGC reference voltage. The 68k or 150k in series with the Cap set up the base time constant. The other FET switch in for slow AGC on SSB and Fixed AGC on AM.

Also if you look at the TS-930 (both schematic and signal board) that has the almost identical AGC circuit.
(R730 2.2M and R710 68K, are the equivalent resistors on the TS-930.) The TS-930 is the correct circuit in every way and the way Kenwood intended "the AGC of the TS-940" to work.

When you swap R149 and R150 around. you are putting the 2.2 Meg ohm in series with C-126.
This effectively removes the Base line time constant to all AGC positions on the switch including AM even thou the switch does not function there. That is why people say the meter is more jumpy. Plus the 150K or 68K bias the gate of Q23 more heavy and allows the receiver to stay more sensitive to low level signals.

73 John KI4NR

LPC Wireless
lpcwireless@cfl.rr.com
Phone: 386-774-9921

===

Mr T.Soranaka I look forward to receiving your advice.

Yours sincerely
Jeff King

9.
```
-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Tuesday, 2 August 2005 6:01 p.m.
To: jaking@es.co.nz
Subject: Re: RE RE: Is your advice Correct about TS-940 R149 and R 150: being in wrong places???


Dear Mr.King,

Please accept my apologies for having supplied incorrect information.
A very experienced Kenwood repair expert from the USA is right.
The service manual is wrong on the schematic.

Yours sincerely,

T.Soranaka
++++++++++++++++++++++++++++
Customer Support Center
Kenwood Corporation
(Japan)
URL:  http://www.kenwood.com/
Email:  css@kenwood.co.jp
++++++++++++++++++++++++++++
```

10.
From: John Brush [mailto:brushj@comcast.net]
Sent: Monday, 12 September 2005 2:29 p.m.
To: jaking@es.co.nz
Subject: TS-940S R149/R150 More Info

Jeff,

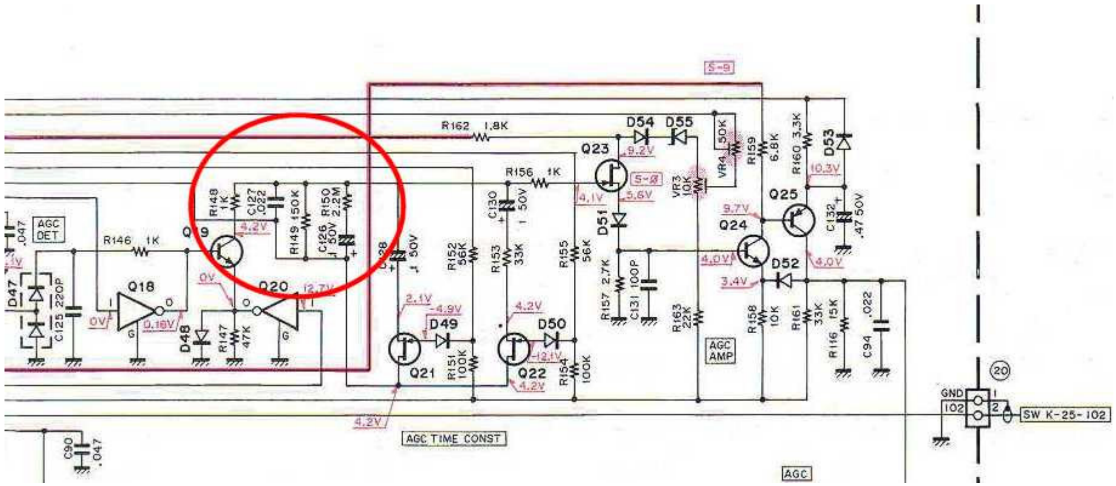
I absolutely agree with the comments made by John KI4NR. A rising S-meter reading is due to a leaking capacitor, and not the incorrect placement of R149/R150. In my case, I did the resistor swap and noticed that the S-meter's response was the same for both the AGC's Fast and Slow positions – not good. After undoing the resistor swap, I now had the rising S-meter problem (a problem I didn't have before the modification). In my case, the problem was resolved by replacing C126, the capacitor that is in series with R150 (2.2M) as shown on the schematic. Per John's advice, I also plan on replacing C128 and C130.

I must have one of those old IF boards, because my S-meter pegs when I turn the radio off.

73, John (WA3CAS)

THE PRODUCTION MISTAKE DESCRIBED:

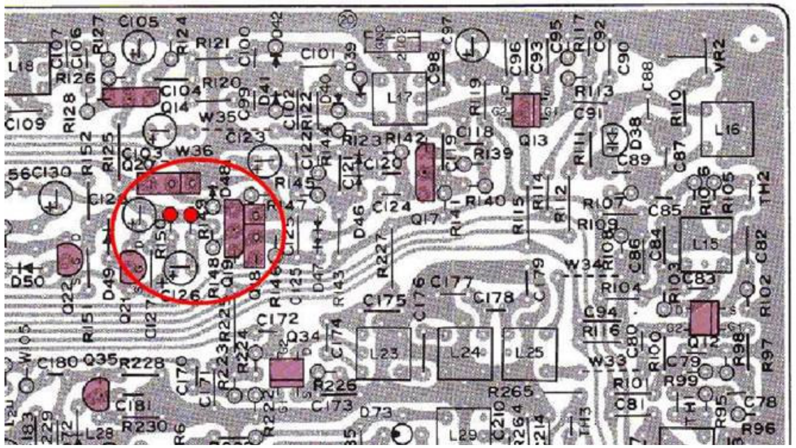
Below is Page 92 of the Revised Service Manual
Observe that:
-R 149 and R 150 are mounted between almost the same connections. I.e. between the junction of C127- R148 - C128 - C130 - R156 to-> C126 - Q21 - Q22
-The difference being that "additional C 126" is between R150 and C126 - Q21 - Q22



Below is page 93 of the Revised Service Manual

You will notice that R 149 is connected between C126 and the junction of C126 - Q21 - Q22. That is R149 has been mounted where R 150 should be.

PC BOARD VIEWS



Does putting the 2.2M ohm resistor where the 150 ohm Resistor should be make a difference. **Yes! You bet.** Change the 150 ohm back to the direct circuit and the AGC responds very quickly. [similar to the AGC in a TS-930]. AGC could not respond quickly before because it had to wait until C126 charged up.
This is in the heart of the AGC timing section.
Probably all TS-940s have R149 and R150 in the wrong place.
===

TO CHANGE THE RESISTORS

Change around is easy.
You will need to take the IF Board out.

The difficult part is removing and putting all the connectors off / on the board.
Before starting, draw a diagram of the board showing each connector and position and colour of its wires.
That makes it certain you put the right connectors back in the right places.
If you don't draw a diagram you will not know where all the connectors go back. Some two pin connectors could easily go in more than one place. That's could be disastrous
These colours are not shown in the service manual.

I suggest you put in new resistors, because with longer leads they will slightly easy to hold in place while soldering.

THE INITIAL PROBLEM SYMPTOMS:

ZL4AI discovered this while searching for the a fault described below
AGC:
Only happens in SSB:
If TS-940 left not running for a couple of days, when you turn it on,
with the AGC turned off or set in fast position, then the meter needle
goes to up 25db + 9 (approx). The signal is diminished like RF gain
turned up. Over the next 25 minutes the meter needle slowly moves it way

back to S0.
SSB in normal position, and TS-940 turned on this does not happen.
Needle is initially at s0.
During the first 25 minutes if you switch between off - fast - normal
then the needle goes back to zero in less time ... say 20 minutes.
If TS-940 left for a couple of months, and then turned on same behaviour
but worse.
Meter needle goes full scale right in all positions (off - fast -
normal)
It takes longer say 40 minutes for the needle to move to the s0. then
ts-940 functions as described above.
==

After R149 and R150 changed back to positions Kenwood intended in the circuit diagram, the result was:
-The fault of the rising S meter when cold disappeared.
- S meter dropped back to S1 on both AGC OFF and AGC SLOW, with no antenna signal. Needed to adjust VR3 to bring the S Meter to S0.

ACKNOWLEDGEMENTS TO PERSONS WHO HELPED SOLVE THIS

T.Soranaka Kenwood Japan was most helpful. You will see in the emails below Kenwood have readily confirmed that these components are around the wrong way. Then in a third communication (above) confirmed they are correctly installed.

Traian Belinas
traian@deck.ro
who diagnosed the problem and really understands these circuits. Traian appears to have amazing skill and after reading the symptoms pointed me to look at R149. From there it became obvious the circuit was not assembled according to the circuit diagram.

Garey Barrell
'k4oah@mindspring.com'
Who provide some very useful advice on functions of components and explanations how to read the circuit diagrams.
==

A CAUTION:

Not all IF boards are identical.
I installed another IF board installed as per factory spec with R149 and R 150 in their other components position in my TS-940. It did not have the rising S meter problem. But it was not sensitive to weak signals
==

COMMUNICATIONS WITH KENWOOD JAPAN BELOW:

-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Tuesday, 15 March 20057:11 p.m.
To: jaking@es.co.nz
Subject: Re: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Customer,

Thank you for your reply. I suppose that currently R149 and R150 are mounted correctly as the screen printing lettering R149 and R150 are reversed. Please confirm actual resistors comparing the circuit diagram.
The circuit diagram is correct.
Yours sincerely,
T.Soranaka
+++++++++++++++++++++++++++
CustomerSupportCenter
Kenwood Corporation
(Japan)
URL: http://www.kenwood.com/
Email: css@kenwood.co.jp
+++++++++++++++++++++++++++

----- Original Message -----
From: Jeff King
To: 'Customer Service Section'
Cc: k4oah@mindspring.com ; traian@deck.ro ; Bill Bailey ; Ken McVie
Sent: Tuesday, March 15, 20051:53 PM
Subject: RE: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear T.Soranaka
Thank you for your advice.
Could you please advise if it would be advisable to swap R149 with R 150 and vice versa, so the TS-940 functions in accordance with the circuit diagram?
Yours sincerely
Jeff King
-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Monday, 14 March 200510:29 p.m.
To: jaking@es.co.nz
Cc: kcc-amateur@kenwoodusa.com; sabura.tech@kenwood.com.au
Subject: Re: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Customer,
We are sorry for inconvnience. I have checked with our communication department as to R149 and R150. Unfortunately reference number of R149 and R150 on the borad are reversed. R150 and R149 are 2.2M and 68K or 150K respectively as shown in the Service Manual.
Yours sincerely,
T.Soranaka
+++++++++++++++++++++++++++
CustomerSupportCenter
Kenwood Corporation
(Japan)
URL: http://www.kenwood.com/
Email: css@kenwood.co.jp
+++++++++++++++++++++++++++

----- Original Message -----
From: Jeff King
To: css@kenwood.co.jp ; kcc-amateur@kenwoodusa.com ; sabura.tech@kenwood.com.au
Cc: k4oah@mindspring.com ; traian@deck.ro ; Bill Bailey ; Ken McVie
Sent: Saturday, March 12, 20056:41 AM
Subject: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Kenwood Customers Services,
I have found that when emailing Kenwood USA about a Kenwood USA product I got redirected to contact a Kenwood representative close to my home location. I am not sure who is best to send this to. So I am sending it onto to all Kenwood contacts.
Thank you for your recent replies.
While trying to find a fault in my TS-940 I have been going over the IF board. It appears to me when the board was made it was marked with the screen printing lettering of R149 being where R150 should be and vice versa. I have followed the board traces both in the Service Manual and on the back of a board, and these resistors both seem to be in the wrong place.
This means:
Specified in First Service Manual:
R149 68K
R150 2.2M
Specified in Revised Service Manual:
R149 150K
R150K 2.2M
Resistors as actually installed on my board if you follow the logic of the circuit diagram.
R149 2.2M
R150 150K

I have two IF boards here and they both have the resistors installed as required by the screen printing and hence on both boards both resistors are reversed. Possibly this is the case for every TS-940 ever made. I cannot understand how the circuits would function as the designer intended, as the installed resistors are very different to those shown on the schematic diagrams. Could you please advise if my observation is correct, and after later when Kenwood has investigated if it would be advisable to swap R149 with R 150 and vice versa?

At this time could you please just confirm that the question will be investigated?

I look forward to your reply.

Yours sincerely

Jeff King ZL4AI

RECEIVER 4. PIN DIODE IMPROVEMENTS

This improvement is not fully documented yet. Please send in information.

4.1: Background on how Pin Diodes were discovered to improve radios.

[TenTec] Pin Diodes / Paragon
Chester Alderman chestert@pressroom.com
Wed, 17 Sep 1997 17:14:45 -0400

TenTec builds a great amateur radio and obviously to give you a 'million dollar radio' that cost the user five bucks, economics really does have to enter the picture. PIN diodes have been around for many years, however they were initially invented, designed, manufactured, and sold to be micr

Dont quote me on this because I've been out of microwave design for too long. A regular diode is a piece of silicon (or germanium) that has a junction. One side of the junction is doped, during mfg process, to have an excess of electrons (+P) and the other side of the diode is doped to have an

What all of this means is that PIN diodes are relatively expensive. A regular PN junction diode (typically a 1N4148 for instance) may cost 5 cent apiece, however a 'cheap' true PIN diode will cost between one and three dollars apiece; and thats why you do not see them in very many amateur radios. ECONOMICS. (I'm not sure why it took that much verbage to explain, but it did.)

Corsair II's used a regular silicon switching diode, 1N4148 to switch the filters. The Omni 6 does use PIN diodes, but probably because of the above mentioned economics, TenTec uses diodes that 'will do the job' verses expensive PIN diodes.

I read Rhode's article on PIN diodes and decided I could improve the IM performance of my Omni 6 (it didn't need it!!), so I bought the expensive Hewlett-Packard PIN diodes that Rhode stated were the best, and installed them in my Omni 6. Over the past five years using my Omni, chasing DX and participating in some serious DX contest, I have yet failed to see where these expensive HP PIN diodes made any substantial improvement.

TenTec runs about 10ma of current through their production PIN diodes, in order to gain the full IM advantage of the HP PIN diodes, you must run 80ma through the HP PIN diodes!

So the bottom line is if you replace the PIN or silicon diodes in a rig, you will see (hear) practically no improvement, UNLESS you redesign the circuitry to utilize the diodes operating at their optimum design specifications. Probably if you find the filter switching diodes in your rig are running 'hot' to your touch, it probably means that someone has taken the time to change the current running through the switching diodes to really improve the IMD.

At 01:32 PM 9/17/97 -0400, you wrote:

>*H. M. 'Puck' Motley W4PM wrote:*
>> *I have the feeling that the pin diodes in question are a modification*
>> *suggested in an article by Ulrich Rhode (not sure of the spelling of his*
>> *name) a few years back concerning 2nd order IMD in modern rigs. One of*
>> *the rigs mentioned was the Paragon. The article stated that by replacing*
>> *the common switching diodes used to switch the receiver front end band*
>> *pass filters with a certain type of pin diode, 2nd order IMD could be*
>> *improved. Maybe some of our more technically oriented folks remember this*
>> *article and can comment in greater detail. This is all I remember so if*
>> *you have additional questions don't ask me!*
>*Thanks, Puck. I was certain it was something Rohde said, just wasn't*

>quite sure when or what the exact reason was. I just spoke to Ten Tec
>about this, and they actually said they had tested different types of
>diodes to switch the Paragon's receiver filters, and settled on regular
>switching diodes because there wasn't much difference with other types.
>So, I guess replacing the receiver filter switching diodes with PIN or
>other (hot carrier, etc.) types is probably a mod that some users have
>done themselves. At least I know for sure it's not a factory
>modification.

>Is there anyone out there who knows this for sure? Has anyone done the
>aforementioned mod? I know one fellow recently mentioned in a message
>that a rig he had for sale had the mod. Now I'll go search for the Rohde
>article. 8^)

>73, KE3KR

4.2 RadCom Technical Topics explains what Pin Diodes were supposed to achieve.

TECHNICAL TOPICS April 1995
RF SWITCHING I TUNING DIODES

TT FEBRUARY 1993 REPORTED briefly an important article by Dr Ulrich Noble, KA2WEU/DJ2LR, which was published simultaneously in English and German QST and *CQ-DL* November 1992) on "Recent advances in shortwave receiver design". He subsequently published a series of three articles (QST May, June and July 1994)on Key components of modem receiver design, and a recent follow-up Key components of modern receiver design: a second look" (QST, December 1994). In these articles he stressed that for receivers intended to have a very wide dynamic range, the intermodulation distortion that arises from the use of unsuitable RF switching and tuning diodes imposes an important limitation. He has recommended the use (or substitution) of such special-purpose RF diodes as the Hewlett-Packard HP5082-3081 PIN diodes.

Dr Rohde's articles encouraged Tom Thomson, WOIVJ, to investigate how bad in practice are the more distortion-prone switching diodes and how good are those designed for low distortion ('Exploring intermodulation distortion in RF switching and tuning diodes', QST, December 1994). He carried out laboratory tests on four types of diodes: The IN4153 generic PN switching diode: the Motorola MPN 3700 PIN diode intended for RF switching; the BAT-17 Siemens PIN switching diode; and the low-cost 1N4007 which is a generic 1 kV-PIV rectifier diode with a PIN structure but not intended for RF switching

He has tabulated results in terms of diode switch insertion loss (dB) at 1O MHz with 0, 5, 10 and 20mA bias currents; and similarly the second- and third-order intercept points (IP2, 1P3 and dBm). He draws the following conclusions: "RF-specified PIN diodes are the devices of choice for low-distortion switching at HF and above, for band pass filter selection and C switching in a narrow-band pre-selector. Although the presence of a PIN structure in the 1 N4007 makes it seem attractive as a low-cost alternative to RF-specified PIN diodes, its insertion-loss performance When unbiased and reverse-biased - and its IMD performance when unbiased - is demonstratively interior to RF-specified PIN diodes.

He adds: 'The manually switched and tuned front-end filters of the 1960s and 1970s had much to offer in terms of second-order IMD, but we need not retrogress to those techniques to achieve improved 1P2 and 1P3 performance today. More attention paid to front-end filtering in general can produce the improvement we need."

Dr Rohde in commenting on W0IVJ's finding, notes that many amateurs had reported difficulty in obtaining HP5062-3081 diodes. He recognises that even with the Motorola MPN3700 with a US price Of less than £11 replacing all 20-plus filter-switching diodes can be expensive. Nevertheless he recommends changing all the diodes between the antenna and the first mixer, which includes the diodes on both sides of the band pass filters of a transceiver but not the transmit/ receive switching diodes which typically are already high-quality PIN types. He also adds some notes on Japanese switching diodes which might be used to replace the 'bad' diodes seen in the past".

Pat Hawker's Technical Topics

PAT HAWKER, G3VA
London 37/SE22 8SS

RF SWITCHING DIODES CONTROVERSY

AN APRIL *TT* item ('RF Switching and Tuning Diodes', p63) drew attention to the series of QST articles by Dr Ulrich Rohde, KA2WEU/DJ2LR - recognised world-wide as a leading professional expert in HF receiver design - supplemented in a separate *QST* article by measurements made by Tom Thomson, WOIWJ. These highlighted the shortcomings of some general purpose PN and PIN diodes used for RF switching in some popular amateur HF transceivers. Dr Rohde pointed out that the second order IMD performance could be improved in such cases by substitution of PIN diodes specifically designed for RF purposes, and in particular recommended the Hewlett Packard HP5082-3081.

In part three of his article (*QST*, July 1994) Dr Rohde gave results of measurements made on unmodified and modified transceivers - an ICOM IC-765, a Yaesu FT890 and a Kenwood TS-50. These measurements suggested significant improvements in second and third order IMD performance. He also evaluated the second-order IMD performance of several other transceivers including Collins KWM-390, TS950SDX, Ten-Tec OMNI VI (second order intercept +43dBm) and FT-1000. But he did not appear to specify which, if any, of this second group would or would not benefit from diode replacement. As a result of his findings, ARRL decided that they would include second-order IMD measurements in future *QST* Equipment Reviews.

This is highlighted in a letter from Dave Farn, G4HRY, who reported the unfortunate experience of G4KPT who replaced all 40 switching diodes in his Omni VI only to find that sensitivity had suffered. As a result, G4HRY has now replaced the original diodes and believes that "the validity of the original articles is brought into doubt". G4HRY, however, was not able to check on second-order IMD performance before or aftermodification.

While I am sure that Dr Rohde could provide a convincing reply to his criticisms, G4HRY does make some comments that deserve to be aired. He writes:

"G4KPT read the *QST* articles and as the OMNI VI was specifically mentioned, decided to replace all of the switching diodes in the transceiver front end with HP5082-3081 types. He obtained 40 diodes at a cost of about £1 each and did the modification. This is where the trouble started.

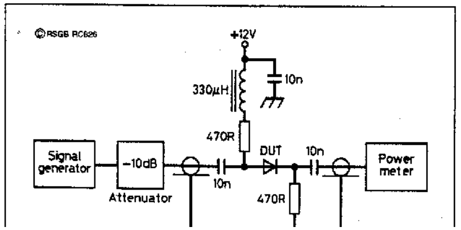
Freq	BA482	HP3081	BAT85	1N4148	BA439	IN4007
1.8MHz	-0.6	-0.9				
3.5MHz	-0.4	-0.75				
7MHz	-0.2	-0.7	-0.6	-0.7	-0.55	-0.5
10MHz	-0.3	-0.8				
14MHz	-0.2	-0.9				
18MHz	-0.3	-0.8				
21MHz	-0.3	-0.9				
24.5MHz	-0.3	-0.9				
28MHz	-0.3	-0.98	-0.6	-0.7	-0.55	-0.5

Table 1: G4HRY's measurements of diode loss (dB) in 50Ω transmission path with 10mA forward bias.

"After completing the modification he noticed that the receiver seemed a little deaf and the S-meter could no longer be calibrated. Thinking he had introduced a fault, he brought the set to me for a second opinion. Tests showed the sensitivity was at least 5dB worse than another OMNI VI. I could not find a hard fault with the rig and decided that, as it had worked well before modification, it was probably something to do with the new diodes. To prove this I built the small jig shown in **Fig 1**. This enabled diode through-loss to be measured in a 50Ω system which can be equated to diode RF resistance. The jig was used to measure the BA482 types and then the HP PIN diodes. Out of interest, I took a quick look at a variety of other general purpose diodes and this indicated that in respect of through-loss, the original diodes selected by Ten-Tec were a good choice: see **Table 1**.

"The receive RF path of the OMNI VI includes 5 diodes before the 1st RF amplifier. The first two isolate the transmitter from the receiver input, the next two select the appropriate bandpass filter. The final diode in the chain feeds the input of the RF amplifier in the Tx/Rx switching. The RF amplifier has 54 parallel-connected FETs with an input impedance of about 22Ω. The losses at this point would therefore be higher than those measured in 50Ω. Changing the diodes to HP 3091 types had introduced about 4dB additional loss which was clearly not acceptable. G4PKT had also changed diodes on the 1st IF board between the IF roofing filter and the narrow IF filters; this accounted for further losses.

"When all diodes were



ascribed to the switching diodes. My existing test equipment introduces more 2nd order products than the diodes. Better isolation is required between the test oscillators and the hybrid combiner and I hope to follow this up soon.

"As a result of this exercise, I came to the following conclusions:

(1) Owners should consider carefully before attacking expensive transceivers. Only consider making modification if technically competent and equipped to measure the results. The actual circuit configuration should be considered to judge the likely effects of a modification. It may prove to induce high losses and will almost certainly effect filter termination impedance's required realignment. Some modern filters have fixed values and therefore performance on receive and transmit could be compromised.

"(2) The validity of the original articles is brought into doubt. If the author did not consider the effect of an extra 4dB of loss inserted before the first mixer, the resulting improvement in intermod performance credited to the use of PIN diodes may be a false assumption. Building a 4dB input attenuator is much cheaper than changing all those diodes!

"(3) Considering specifically the OMNI VI, rather than changing diodes, performance would probably be enhanced by implementing better matching of the 1st mixer. The IF port has no diplexer and the buffer amplifier has only a 20dB return loss at 9MHz. The LO port is fed directly from the LO power amplifier without any attempt at matching. Better filtering at the RF signal input would reduce 2nd order effects."

G4HRY is particularly concerned by the unquestioning faith often put in published articles, including *QST* and *RadCom*. He urges others to follow his own philosophy and become professional sceptics!

In his three-part article, Dr Rohde noted that second-order IMD products change 2dB for every decibel of input-signal change, and appear at frequencies that result from the

Diode Type	Bias conditions per diode Reverse	0mA	5mA	10mA	20mA
1N4153	75	75	2	1	0.5
MPN3700	70	55	0.1	0.1	0.1
BAR17	75	70	0.3	0.1	0.1
1N4007	35	20	0.1	0.1	0.1

Table 2(a): WOIVJ's Diode Switch Insertion loss (dB) at 10MHz

Diode Type	Bias conditions per diode Reverse	0mA	5mA	10mA	20mA
1N4153	>80	>80	18	30	42
MPN3700	>80	80	66	70	72
BAR17	>80	>80	60	70	75
1N4007	>80	40	>80	>80	>80

Table 2(b): diode switch second-order intercept point (IP2) dBm

Diode Bias conditions per diode

simple addition and subtraction of input-signal frequencies. His introductory notes on switching diodes were as follows:

"The receiver sections of amateur MF/HF transceivers generally use diode-switched front-end filtering. The switching diodes used have low junction capacitance and can typically handle medium DC levels (10 to 100mA). These characteristics are important because we want these diodes to contribute minimal loss when turned on and leak very little RF when turned off.

"The two-tone, third-order MD dynamic-range testing routinely done to amateur transceivers seems to point up no weakness in these switching diodes. In real life, however, a huge number of signals simultaneously appear at a transceiver's antenna connector. Periodically, their voltages all sum in phase producing, for short durations, enough voltage to change the bias of the diode at the input of the filter in use. This causes intermodulation distortion - generally ,second-order IMD. This is ironic for twq reasons: First, this diode-generated IMD generates exactly the interference the filters switched by the diodes are supposed to prevent! Second, amateur radio equipment reviews have long let second-order front-end IMD go unmeasured because we have long assumed that our radios front-end filtering reduces this IMD to a non problem. Later, I will present measurement results that prove that second-order IMD is a very real problem today. (The test jig used by WOIVJ is shown in **Fig 2** with some of the results in **Table 2** - *G3VA*).

"The best way to avoid switching-diode IMD is to switch the filters with relays instead of diodes, and military and commercial gear generally take this approach. Relays are costly, however. A less expensive work-around that is acceptably good for amateur radio equipment is to use diodes - PIN diodes - designed for this application. The two best-known US manufacturers of PIN diodes for this type of low-frequency application are Hewlett-Packard and Alphas Industries. The best diode for the shortwave range is the HP 8052-3081 . . ."

Harry Leeming, G3LLL, was also concerned at the idea of using RF PIN diodes. He writes: "It is all very well testing equipment when new, but how well do the modem Schottky (hot-carrier) diodes stand up in service? Take, for example, the FT75. These have a reputation of being noisy on receive. Indeed, on many samples if you switch in the RF preamp, the noise comes up more than the signal. Check the dozen diodes around the input to the band pass filters and the Tx/Rx switching and up to half of them are likely to be found

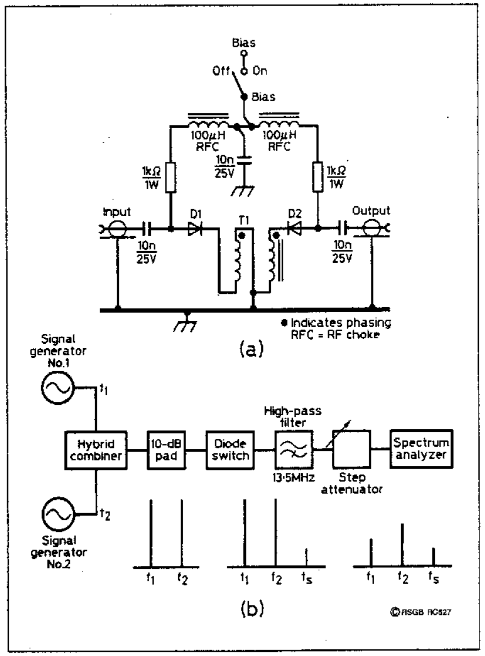


Fig 2: (a) The diode switch used by WOIVJ for his tests. D1 and D2, the diodes under test, included PN and PIN (power-rectifier and RF-specified) types. Capacitors are disc or monolithic ceramics. T1 consists of 11 bifiliar turns of Nr28 enamelled wire on an FT-37-43 ferrite toroidal form; the inductance of each winding is about 50uH. (b) Set up for measuring the diode switch's second - and third-order intercept points.

if anyone can suggest modest-priced diodes that are better than the 1N4148 and will stand up in service? Meanwhile, I am unable to detect any difference between a new FT757 and one that has had 1N4148s fitted".

My own feeling is that the experiences of both G4HRY and G3LLL highlight an increasingly serious problem involving modern technology. Without the most advanced (and expensive) laboratory test equipment, it is extremely difficult to evaluate fully the performance of equipment. With equipment which is new, or has been in service for some months, it is hard to assess how important these laboratory measurements are likely to prove in normal operational use on the amateur bands. In the case of HF receivers/transceivers, the 'old technology' of variable-capacitor tuned RF filtering with mechanical wavechange switching did have significant advantages over current broadband 'low-pass' or even sub-octave bandpass filtering. However, the 'old technology' was not without its own problems and costs.

DIODE TYPE	FREQUENCY 1.815MHz (dBm)	(dB)	FREQUENCY 7.015MHz (dBm)	(dB)	FREQUENCY 28.015MHz (dBm)	(dB)
BYD11M (@6 & 10mA)	38.0	1.16	45.0	1.23	35.5	1.93
IN4007 (@6 & 10mA)	38.0	0.25	42.0	0.97	37.0	2.0
HP3081 (@6mA)	38.0	3.82	37.0	3.9	36.0	3.36
HP3081 (@10mA)	35.5	2.68	41.0	2.5	35.5	2.84
BA482 (@14mA)	25.0	0.51	38.0	0.81	38.0	2.32
BA482 (@6mA)	18.5	3.49	23.5	0.71	36.0	2.0
IN4148 (@6mA)	21.2	6.61	19.0	7.47	17.3	5.83
IN4148 (@10mA)	12.5	3.61	15.0	4.1	16.5	2.84

Table 1: Third order intercept (dBm) and Test circuit insertion loss (dB)

DIODE TYPE	FREQUENCY 1.815MHz	FREQUENCY 7.015MHz	FREQUENCY 28.015MHz
BYD11m	73.9	53.9	50.0
1N4007	63.0	43.9	35.3
HP3081 @6mA	80.0	63.5	57.0
HP3081 @10mA	81.9	63.9	56.8
BA482 @14mA	80.0	65.0	57.0
BA482 @6mA	84.0	61.8	52.4

Table 2. Test circuit off isolation (dB).

ANOTHER LOOK AT RF SWITCHING DIODES

DAVE FAR, G4HRY, in 'RF Switching Diodes Controversy' (*TT*, July 1995, pp67-78) questioned the wisdom of wholesale substitution of HP 5082-3081 RF PIN diodes for the switching diodes fitted in the front-ends of typical modern HF transceivers. This item interested a number of readers concerned with the development of high-performance receivers including Colin Horrabin, G3SBI. He felt that the performance data provided by G4HRY and earlier by Tom Thomson, W0IVJ, in *QST*, December 1994 (summarised in *TT*, April 1995 with W0IVJ's measurement data in *TT*, July 1995, p67) deserved further investigation.

G3SBI writes: "**Tables 1** and **2** show some IP3 and RF isolation measurements on various diodes popularly used for low-level RF switching. This work was carried out by two vacation students - Mike Smith and Alex Macdonald - using test equipment in the RF laboratory of the SERC at Daresbury.

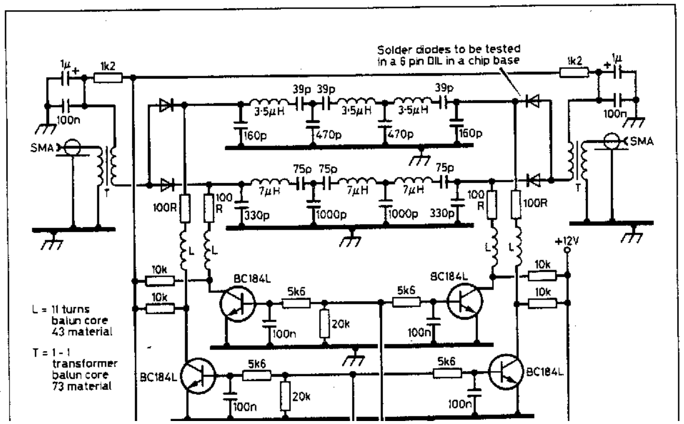
"The original test circuit (**Fig 3**) was designed to simulate different bandpass filters being switched in and switched out, permitting insertion loss and the isolation in the off condition also to be measured. Note that diodes in the off condition see about 12V reverse bias. In practice we abandoned the

that an important factor with some diodes is the sensitivity of insertion loss to forward current. The HP 3081 diode, severely criticised by G4HYR, shows a marked reduction of loss and hence improved performance as the forward current is increased from 6 to 10mA. As noted by G4HRY the Siemens BA482 (as used in the Ten Tec Omni) shows the lowest insertion loss (this would seem also to confirm G4HRY's view that it is inadvisable to replace BA482 diodes with HP3081 diodes - *G3VA*).

"Clearly anyone contemplating changing the RF switching diodes used in his transceiver must first estimate or measure the 'on' current used in the particular model concerned.

"All the measurements shown in Tables 1 and 2 were made in 50Ω systems. Some transceivers use 200Ω design impedances so that the insertion loss of the switching diode is of less consequence, but in this case the signal voltages are higher so that the IP3 intercept point may be lower.

"We could not achieve the sort of third order intercept figures reported by W0IVJ but it became clear that the IP3 performance of diodes is very much affected by the frequency. One is tempted to suggest that the designer of the 1N4007 diode must have been a radio amateur since its best performance seems to be around 7MHz where we measured an IP3 of +50dB. In fact, it is surprising how well the 1N4007 performs.



"The 1N4007 performance encouraged us to obtain some BYD11M diodes from RS Components (29p each). These are rated as 1000V PIV, 0.5A rectifier diodes and are the same physical size as normal signal diodes. Performance as switching diodes was good; relatively low insertion loss, good IP3 intercept point, and good degree of 'off-isolation' at 50MHz, even with a fairly low 'on' current: see **Fig 4 (a)** and **(b)**.

"It should be appreciated that a very high degree of 'off-isolation' between different bandpass filters is less important in up-conversion receivers (50dB is probably adequate) since the image frequency will be in the VHF region and will be largely taken out by low-pass filters before the mixer. However, in the case of a receiver with a 9MHz IF and a 5MHz local oscillator, the image will fall in the 3.5 and 14MHz bands. In this case, isolation between the filters should be greater than 90dB so that two diode switches in series with a shunt diode would be needed to achieve this degree of isolation. It would be better to use double-pole relays, one bandpass filter to ground. It may then be necessary to use the technique of 'DC-wetting' ie arranging to pass a few mA of direct current through the relay contacts, to improve long-term contact reliability."

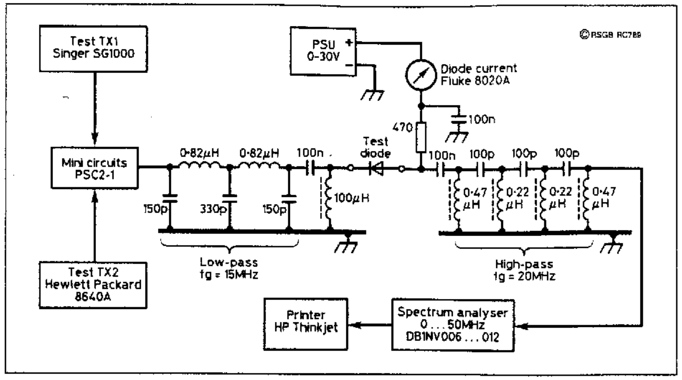


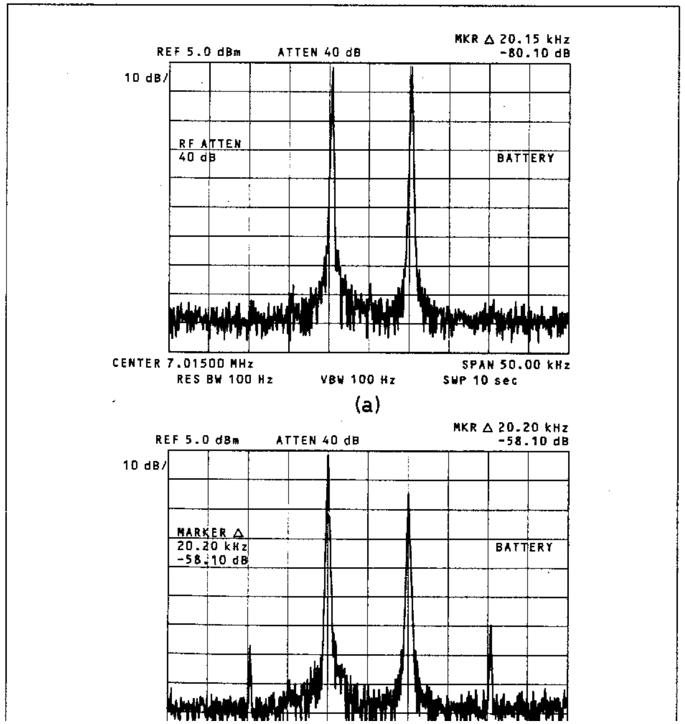
Fig 5: Test rig used by DB1NV for the measurement of intermodulation characteristics of switching diodes.

B J Mitchell, G3HJK, commenting on the strictures by G3LLL on the long-term reliability problems of RF switching by relays (*TT*, September, p68) also draws attention to the better reliability that can be achieved by DC-wetting, a long-established Post Office dodge, both in minimising oxidation and in reducing migration of contact material. This can be achieved with the aid of suitable blocking capacitors and resistors to feed DC across the contacts without changing the biasing of the active devices. G3HJK uses this technique with his FT102 and, despite being a pipe smoker, has not had to replace any of the six RF switching relays over years of use.

Another source of information on the 'Intermodulation properties of switching diodes' is an article which appeared in *VHF Communications* (Vol 26, Spring, 1/1994, pp12-18). Dr Ing Jochen Jirmann, DB1NV, used the measuring rig shown in **Fig 5** to measure intermodulation characteristics of a selection of switching diodes most of which have not been investigated by either W0IVJ or by G3SBI etc at SERC. DB1NV measured both IP2 and IP3. For the IP2 data he used test frequencies of 12 and 15MHz measuring IP2 at 27MHz while varying the diode DC from 2mA to 20mA: **Fig 6(a).** For IP3 he used test frequencies of 6 and 15.5MHz with the IM product evaluated at 25MHz with diode currents of 2mA and 5mA only: **Fig 6 (b).**

The conclusions drawn by DB1NV tend to differ in some respects from those of G3SBI. He wrote:

- Good repeatable intermodulation figures can be obtained only through the use of 'correct' PIN diodes, but they have their price. Miniature relays are even better, but more expensive and bigger.
- Universal diodes misused as HF switches can yield very good results (ISS53) or catastrophically poor results (1N4148). Moreover, it cannot be calculated what effect variations in the manufacturing parameters will have (different production lines, different production methods).
- The relatively good cut-off results obtained in practice from apparatus fitted with tuner switching diodes is not consistent with the poor measurement results from the BA244.
- The existing test rig of Fig 5 needs to be improved or re-constructed in order to check whether sufficient DC is flowing



DB1NV also investigated the IM products resulting from saturated ferromagnetic cores, as used in both the aperiodic case (RF chokes) and for tuned (resonant) circuits. He found, for example, that Amidon ring cores of various sizes and intended for HF applications were practically free from intermodulation effects under normal conditions. He did, however, provide some design tips "some of which are not new, but which have probably fallen into oblivion in Japan". He wrote:

(1) Input filters effectively resistant to IM can be produced only using sufficiently large iron powder ring cores as inductances. They offer the best compromise between the space requirement and the level controllability.

(2) In compact rigs, rod core chokes, such as the Siemens MCC, can be considered as alternatives.

(3) Chokes in the filter structure, eg on the operating voltage feed, are largely non-critical provided they do not resonate.

DB1NV recalled the band-pass filters using ring core coils that were publicised many years ago by VE3TP. He commented: "These were not exactly cheap to construct but . . . solved every receiver IM problem so far . . . (proving) that it is possible to produce receiver input components which can meet today's requirements in relation to sensitivity and high-level signal strength." Dr Rohde's reply to G4HRY's criticisms will be published next month.

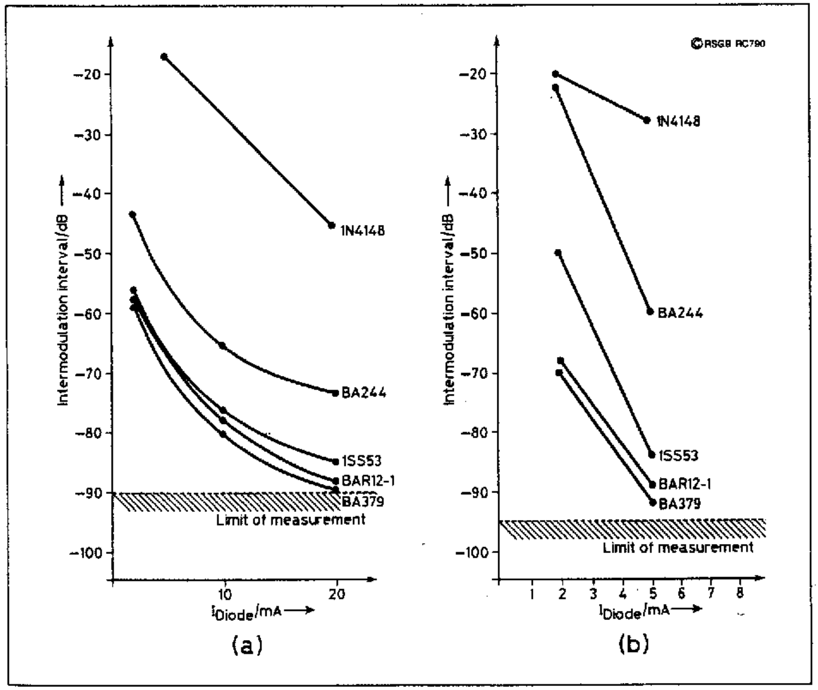


Fig 6: (a) Second-order IMP plotted by DB1NV against diode current (b) Third-order IMP plotted against 2mA and 5mA diode currents.

TECHNICAL TOPICS December1995
SWITCHING DIODES: DJ2LR/KA2WEUs REPLY

THE ITEM 'RF Switching Diodes Controversy 'TT, July 1995, included G4HRY's criticism of the advice given by Dr Ulrich Roinde, DJ2LR/KA2WIEU/4, in his excellent articles in OST that the second order IMD performance of several popular amateur HF transceivers could be improved by judicious substitution of PIN diodes, such as the Hewlett Packard HP5082-3081 , specifically intended as RF switching diodes. I pointed out that the criticisms were based solely on RF losses and that G4HRY had not made any IMD measurements. I added that I was sure that Dr Rohde could provide a convincing reply. However, in view of his experiences with GKPT's Omnii VI 1 felt it would be right to include G4HRY's view that it was unwise to put unquestioning faith in published articles including even those in OST and *RadCom.*

The detailed measurements provided by G3SBI (TT, November) and those published by DB1 NV in *VHF Communications* showed clearly that there is a wide difference between different diodes used for RF switching both in insertion loss and in IMD performance and that IMD is significantly affected both by the forward current through the diode and by frequency.

As a result of an unfortunate delay, the November item was written before I received a fax sent by Dr Rohde on July 18th. This, in a slightly abridged form, reads: I feel really concerned and sorry about G4KPT and the results of his experiments. As a matter of record, I would like to point out that intentionally
1 had not changed any of the diodes myself. but had the authorised service departments of AES, Milwaukee replace the diodes in the Yaesu FT890; ICOM changed the diodes in two IC765s; and Kenwood made the same changes in a TS50. The itemised ICOM repair bill shows 0.12uV for 12dB SINAD, I also had the other companies involved validate that following the diode changes, the receivers were within specifications.

'This validates my statement that this was a repeatable effort and the changes were not done at the expense of performance in any respect. It is also a matter of record that the HP5082-3081 diodes were used in the production of the Collins KWM380, one of which I still own and whose noise figure is on target with 0.3uV without a pre-amplifier and whose 2nd order IMD is superior to other diode applications. This should remove any doubts as to the correctness of my OST article.

1 have had no experience in modifying an Omni VI nor did I do any measurements or modifications with it. The ARRL edited in the Omni VI because it is a popular US-made transceiver and there had been some discussion as to whether or not the European version had different diodes or relays. Before fingers are pointed at specific diodes, I would like to examine the circuit diagram because there can be no need to change all 40 diodes. As an experiment, 1 may want to supply one set of more modem diodes.

"Everyone who has contacted me as the result of the OST articles had been advised not to use the HP 3081 (for reasons of cost and availability) but rather to use a Siemens BAR17 diode or M1204 diode, which is available through ICOM dealers/repair centres. Those diodes are much less expensive and more readily available.

"To the best of my knowledge, the companies who changed the diodes in the equipments involved did not change the diode bias. It is questionable why any one should wish to change diodes in the IF section; similarly diodes in the transmit / receive switches should not be touched.

"Finally, there is no question that relays provide the best of all worlds as far as IMD characteristics are concerned, but not necessarily the best solution in terms of space and costs. 1 have just tested a soon-to-be-re leased transceiver which uses PIN-type di odes and exhibits superb IMD characteristic while maintaining a good noise figure.

"As to multi-tone functionality, once 2n and 3rd order IMD tests have been done, on can predict the higher-order IMD effects, especially since they are based on diode characteristics and this type of test is a legitimate test to evaluate receivers.

"Hopefully, your readers will not deduct from this experiment that QST or other reputable magazines publish articles which are technically incorrect."

In a subsequent letter, dated September 19, 1995, Dr Rohde confirms that he has run into a lot of people who have modified their RF switching diodes and have been extremely happy with the results. Further, after refining his test set-up he finds the improvement is now slightly more dramatic than outlined in his QST article.

In regard to Dr Rohde's endorsement of the technical accuracy of articles, I would enter a caveat. While most writers strive lo complete accuracy. the mechanics an Murphy's Law of publication make it difficult to avoid some errors, particularly in column produced to a tight deadline. Many years ago I stressed that I regard Technical Topics as forum for new ideas, not all of which are likely to prove repeatable or even strictly accurate No guarantees can be given on experimental ideas still under development! I welcome comments from sceptical readers or those spotting printing errors etc. Fortunately, there is good evidence that the vast majority of 7T items do work as intended, and often provide useful additions to amateur lore!
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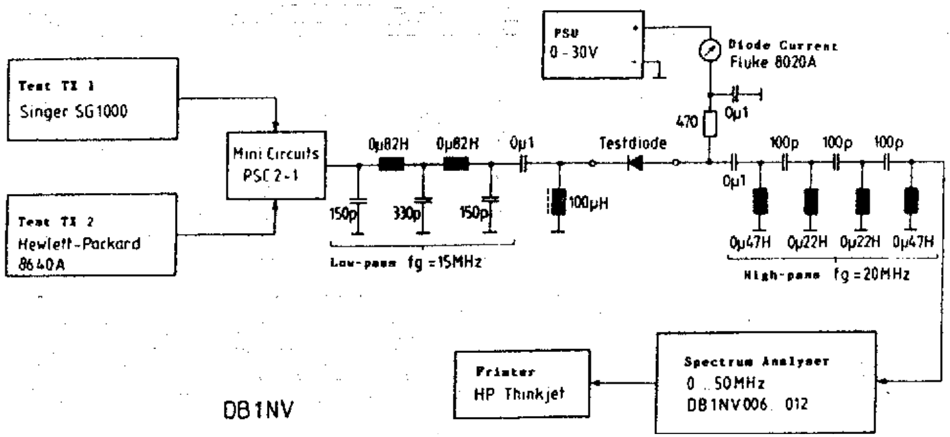
Intermodulation properties of switching diodes, by Dr. Ing. Jochen Jirmann, DB1NV

ZL4AI was contacted by a neighbouring ham, (known for many years). Peter Johnson ZL4LV. peter.Johnson@Paradise.Net.Nz
Peter designed and developed from scratch in the early 1970s an HF transceiver. (Actually it is still under development and may soon have BA479s installed.) The local Branch of the New Zealand Amateur Radio Transmitters Association under Peter's guidance sold this as a kitset. Peters design was the first use of diodes for band switching. Peter published this technique in English Radio magazines the early 1970s and thereafter the first commercial transceivers appeared with diodes switching bands. As the inventor of the concept Peter has collected articles on diode switches, and provided the following.

Dr. Ing. Jochen Jirmann, DB 1 NV

Intermodulation Properties of Switching Diodes

Some attempts to improve the intermodulation properties of short-wave receivers were described in (1). It was demonstrated there that the main reason for the moderate intermodulation properties of many short-wave receivers should be looked for in the use of unsuitable switching diodes for the switching of the input band pass filters. Following numerous enquiries, the intermodulation behaviour of commercially available high-frequency switching diodes was measured in a second investigation. The results were obtained using resources which were still almost on an amateur level, and should thus not be put down to the "dB scales". The comparison between the various diode types is actually more important than the absolute values.



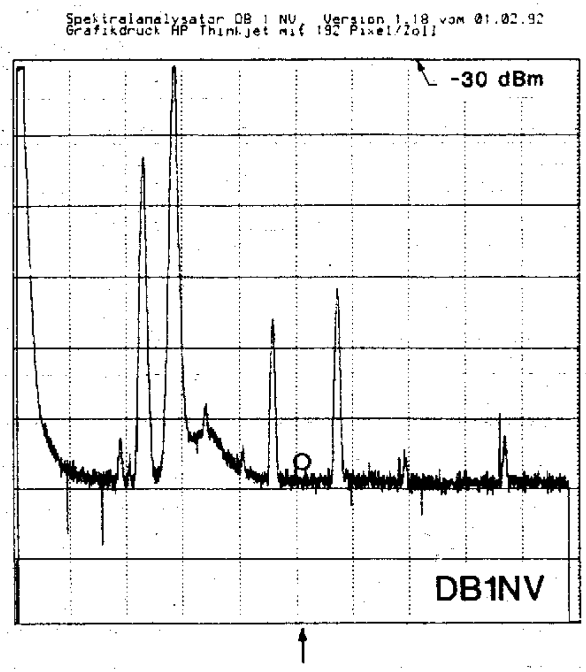


Fig.2: Measurement Curve without Diode (IM2 measurement). Circle shows location of Intermodulation Product
SA: centre 25 MHz; 5 MHz/div

1. THE MEASURING RIG

The previous experiments, using an IC765 from OM Hercher, DL8MX, had demonstrated that the critical level above which audible intermodulations arise should be sought at an aerial voltage of about 100mV. This corresponds to an output of -6dBm. By definition, an S1 signal has a level of -121dBm, so that the measuring rig must process a dynamic range of 115dB to detect weak IM products. This is just about possible using commercial measuring technology of the most expensive kind. In order to obtain usable results with amateur resources, measurements were carried out only at selected fixed frequencies, and the frequency diagram was drawn up in such a way that harmonics from the test transmitter can be separated from the IM products sought. With some filters, a measurement dynamic range could be usable at about 90dB. The measuring rig is sketched in Fig.1.

Two test transmitters act as signal sources, a Singer SG 1000 and a Hewlett-Packard 8640A, the outputs of which are combined by means of a power adder (Mini Circuits PSC2-1). The test transmitter power is 1mW or 0dBm. A simple low-pass filter made of proprietary chokes (Siemens MCC, 0.82 *H) with a limiting frequency of 15 MHz reduces the inherent intermodulation of the test transmitter to below -100dBm. The low-pass filter is fol-

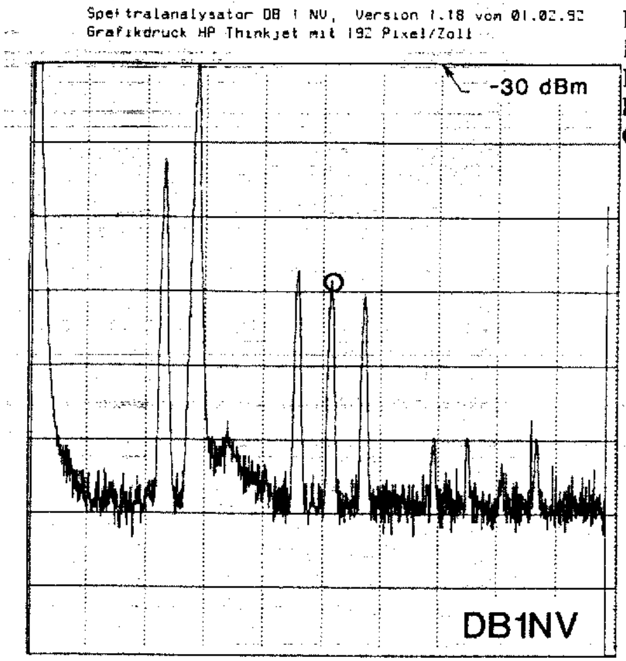


Fig.3: Measurement Curve: IM2 Spectrum of a BA379 with 2mA Diode Current

lowed by the test diode, which is biased with adjustable DC. A high-pass with a limiting frequency of 20 MHz relieves the spectrum analyser (home-made by the author) of the strong carrier wave signals from the test transmitter. The analyser was set to an average frequency of app. 25 MHz and to 5 MHz/div.

For the measurement of total frequencies (second-order intermodulation), the test transmitters operated at 15 and 12 MHz. The second-order mixed product at 27 MHz can thus easily be separated from the test transmitter harmonics at 24 and 30 MHz.

To measure third-order intermodulation, the test transmitters were set to 15.5 Hz and 6 MHz and the mixed product was measured at 25 MHz.

To check the measuring rig, the diode was short-circuited. Fig.2 shows the analyser screen print-out. The two test transmitter signals can be recognised (here 12 MHz and 15 MHz), together with their harmonics at 24, 30, 36 and 45 MHz. The reference level at the top edge of the screen was -30dBm here, so that the reduction of inherent intermodulation products could be estimated at better than 85dB. A circle marks the position of the IM product to be expected.

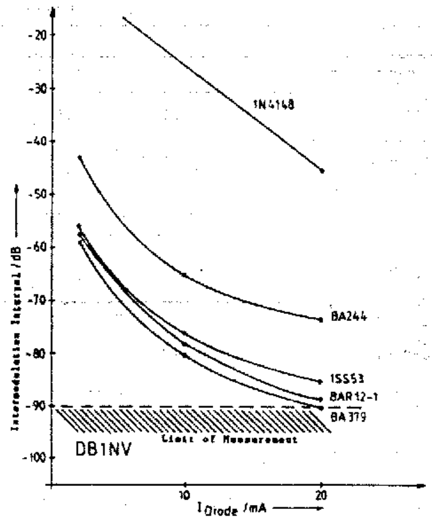


Fig.4: Second-order Intermodulation Products plotted against Diode Current

2. SECOND-ORDER INTERMODULATION

In this range, measuring frequencies of 12 and 15 MHz were used. The diode DC was varied from 2mA to 20mA. The test diodes used were a 1N4148, a 1SS53 (from an IC765), a BA379, a BAR12-1 and a BA244. A typical IM spectrum can be seen in Fig.3. Here a BA379 was operated at a low current of 2mA. The intermodulation signal can be clearly recognised at 27 MHz, with a level of -60dBm between the first harmonics of the test transmitter. The intermodulation intervals measured for various diodes are plotted against the diode DC in Fig.4. As can be seen, the first round in the IM contest goes to the BA379 from Siemens, followed by the BAR12-1 and the 1SS53. The good cut-off results from the 1SS53 universal diode are surprising. But since the diodes removed from the IC765 carried no type description, it might perhaps be conceivable that ICOM had secretly used improved diodes here. It isn't clear from the parts list. It can clearly be seen how important a sufficiently high level of DC through the diodes is, since at current levels below 10mA the intermodulation products increase greatly.

3. THIRD-ORDER INTERMODULATION

In this measurement range, the test transmitters were tuned to 6 and 15.5 MHz and the IM product was evaluated at 25 MHz. The diode DC was altered here at only two values, 2mA and 5mA, and the same diodes were used as in Section 2. Fig.5 shows the inherent interference spectrum for the measuring rig, Fig.6 the IM spectrum for a 1N4148 misused as a switching diode with a diode current of 5mA. The reference line is at -10dBm and the IM interval for third-order products is about 20dB! Fig.7 further shows the intermodulation intervals measured for the various diodes. As can be seen, the BA379 gives the best results here too, followed by the BAR12-1, whereas the 1SS53 falls off markedly.

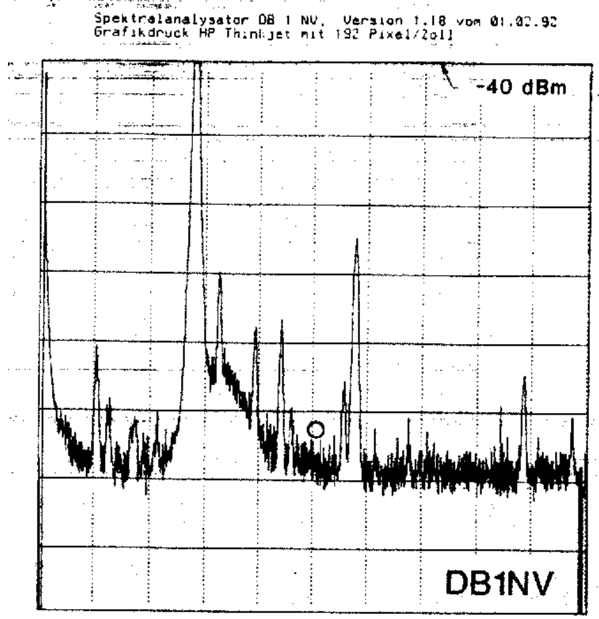


Fig.5:
Measurement Curve without Diode (IM3 measurement).
Circle shows location of Intermodulation Product

4. SUMMARY OF RESULTS SO FAR

The measurement results listed essentially show four things:

- Good, repeatable intermodulation intervals can be obtained only through the use of "correct" PIN diodes, but they have their price. Miniature relays are even better, but more expensive and bigger.
- Universal diodes misused as high-frequency switches can yield very good results (1SS53) or catastrophically poor results (1N4148). Moreover, it can not be calculated what effect variations in the manufacturing parameters will have (different production lines, different production methods).
- The relatively good cut-off results obtained in practise from the apparatus fitted with tuner switching diodes is not consistent with the poor measurement results from the BA244.
- The existing apparatus should also be improved or re-constructed in order to check whether sufficient DC is flowing through the diodes. An attempt should be made to set a value of about 20mA by altering the protective resistors. It can be concluded from the results that the main cause of intermodulation interference in short-wave amateur receivers should be sought in the area of the high-frequency input switching diodes.

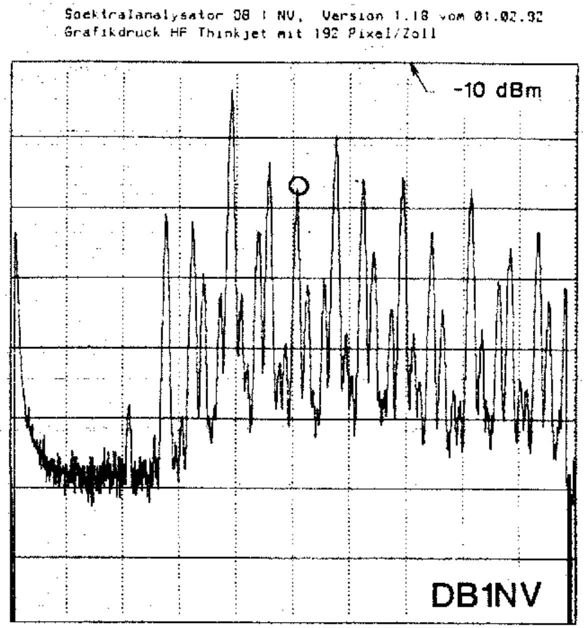


Fig.6: Measurement Curve: IM3 Spectrum of a 1N4148 with 5mA Diode Current

But since over-modulated coils with ferromagnetic cores can also generate intermodulation effects, the same measuring rig was used to classify inductive components.

5. INTERMODULATIONS IN INDUCTANCES

Here both the aperiodic case (coil as choke) and the resonance case were investigated. In the latter case, the coil was brought into series resonance with a high-quality foil trimmer at 15 MHz and subjected to 12 and 15 MHz measurement frequencies. Coils or series resonance circuits were inserted into the measurement circuit instead of the diodes. The following observations were made here:

- With a choke effect, intermodulation products above -110dBm were not detected either for rod core micro-chokes from the Siemens MCC range or for Neosid and TOKO ready-made coils selected at random. Only the "VK200" six-bore core choke from Valvo or Philips Components, a favourite with VHF Communications readers, yielded an IM level of between 85 and 95dBm, depending on the ferrite material. A DC level of 50mA did not influence the readings for any choke.
- In resonance mode, the Neosid and TOKO ready-made coils, together with some very small ferrite ring cores, came up with IM levels of -100 to -105dBm. The Siemens chokes stayed the course amazingly well. Their intermodulation could be placed at around -110dBm. Some

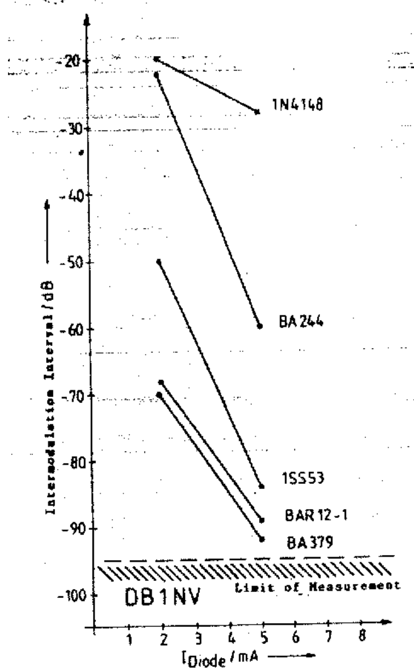


Fig.7: Third-order Intermodulation Products plotted against 2mA and 5mA Diode Currents

Amidon ring cores, suitable for short-wave use and of various sizes, were practically free from intermodulation.

The following design tips can thus be derived, some of which are in any case not new, but which have probably fallen into oblivion in Japan:

1. Input filters effectively resistant to IM can be produced only using sufficiently large iron powder ring cores as inductances. They offer the best compromise between the space requirement and the level controllability.

2. In compact rigs, rod core chokes, such as the Siemens MCC, can be considered as alternatives.

3. Chokes in the filter structure, e.g. on the operating voltage feed, are largely uncritical, as long as they do not resonate.

In this connection, we might recall the band-pass filters with ring core coils publicised many years ago by VE3TP, which were not exactly cheap to construct, but on the other hand have solved every receiver IM problem so far. This statement shows that, in spite of statements to the contrary from the industry and from a few, probably unqualified, "specialists", it is possible to produce receiver input components which can meet today's requirements in relation to sensitivity and high-level signal strength. Since in our hobby we don't need to worry about tenths of a penny, like industrial manufacturers, we can obtain results which are some orders of magnitude better for a slightly increased cost!

The author hopes that this account of his measurements will start people thinking about experiments of their own, and would be pleased to receive reports of their experiences.

6. LITERATURE

(1) Dr. Ing. J.Jirmann, DB1NV
Wilfried Hercher, DL8MX:
Improvement in Intermodulation Behaviour of Modern Short-wave Amateur Receivers
VHF Comm. 1/1993 pp. 38 - 43

FOR THE SUBSEQUENT SECTIONS CLICK HERE: www.jking.kol.co.nz/ts-940_02_part2.htm