

RESTORING AND ALIGNING THE AMAZING SAILOR 66T NAVIGATION RADIO. S.P RADIO, AALLBORG – DENMARK.

(H. Holden. Sept. 2025)



Advertising images



Introduction:

The Sailor 66T Radio was a very popular unit in the 1960's to 1980's era. Primarily it was deployed for Radio Navigation in the North Sea between Norway and Scotland and used in the North Atlantic, prior to modern GPS navigation systems.

This article is more about the radio itself, than its Radio Direction Finding (RDF) applications. However, it is of interest there were once a number of radio navigation and radio direction finding systems that existed in the past and no longer do, because Satellite/GPS has taken over.

The RDF system being briefly discussed here was called Consol. The Navigator takes a direction reading by rotating their radio's direction finding (DF) antenna, to receive and null signals received from a specific fixed Radio Beacon on land. The Navigator, by taking bearings from only two known radio Beacons, then plotting those on a chart, locates the Vessel's position.

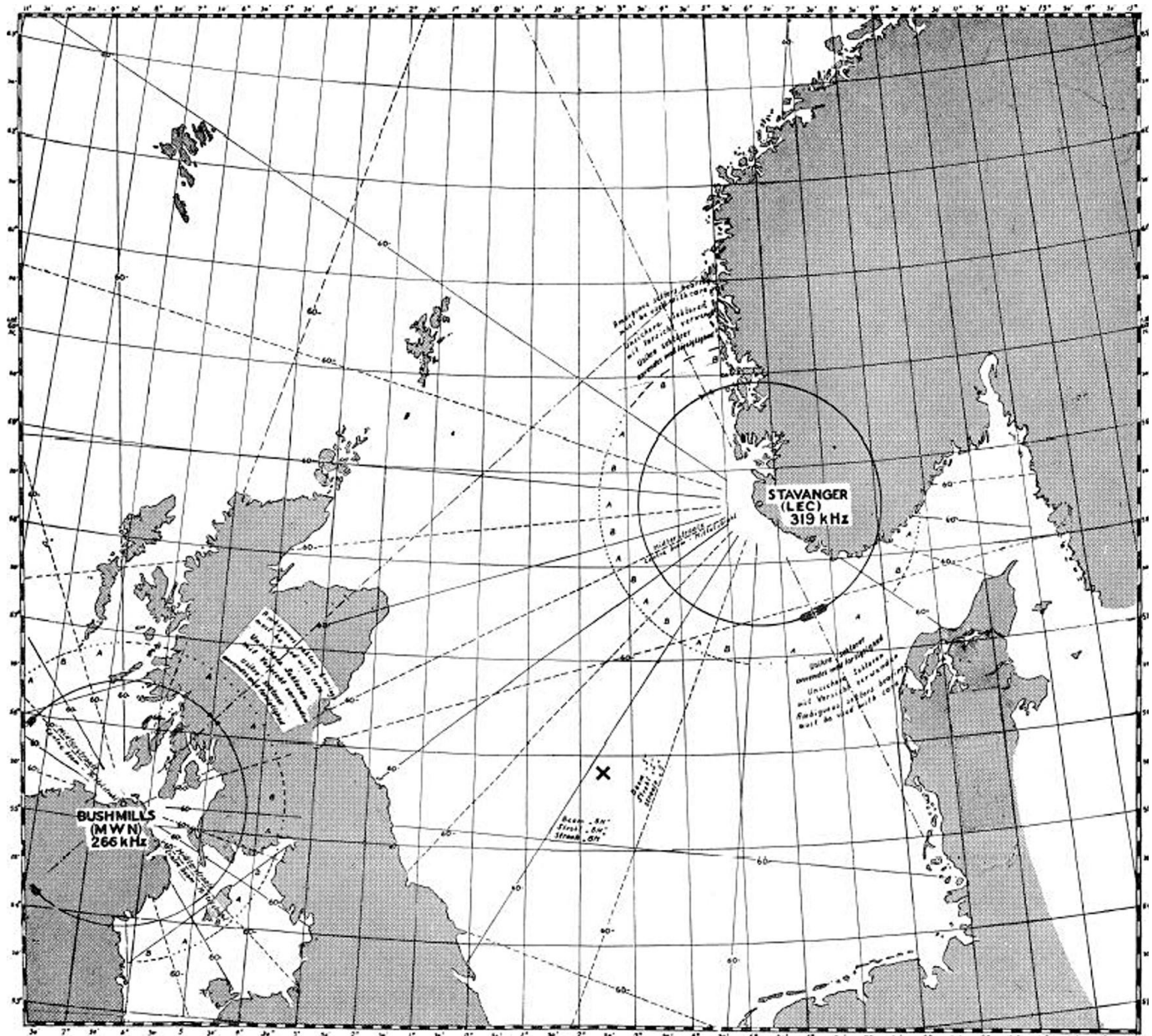
The DF Antenna typically consisted of a Ferrite Rod & tuned coil that could manually be rotated. Loops can also be used. This arrangement could be pressed onto the paper Navigation chart. When the long axis of the Ferrite Rod is aligned with the axis of the beam from the Beacon, there is a signal null. This is called a "Relative Bearing" The direction though, pointing toward the actual Beacon, with that alignment, could be 180 degrees either way because it is determined by a symmetrical figure of 8 sensitivity pattern from the rod.

To get around this 180 degree direction finding ambiguity and make a "Relative Determination" there is a "Sense Switch" on the radio's front panel. When deployed the switch combines some of the received signal from the main antenna which is omnidirectional in character with the DF antenna signal. This creates a Cardioid sensitivity pattern. Therefore, when the Ferrite rod is rotated 90 degrees for a signal maximum, the combined result is more sensitive in one direction than the other. The received signal's strength in one direction, versus the other, solves the 180 degree ambiguity of the Beacon's direction. The Navigator can combine the information with compass readings too.

There were Radio Navigation Beacons, one on 266 kHz in Bushmills on the North coast of Northern Ireland and another at Stavanger on the coast of Norway on 319 kHz which "beamed" radio signals across the North Sea. Typically they had a transmission range in the order of 1000 Nautical miles.

The Beacons transmitted their carrier waves as dots in one sector (Sector A) and dashes transmitted in sector B during the direction finding transmission period. The transmission period for the direction finding is 60 seconds with a one second pause, then the station call sign is transmitted for 6 seconds and the most of the remainder is a long dash (heard as a long tone due to the radio's BFO) for 50 seconds and a pause of 3 seconds. The DF information repeats again, so the entire cycle takes 120 seconds. The speed of the rotation is one sector width per 120 seconds.

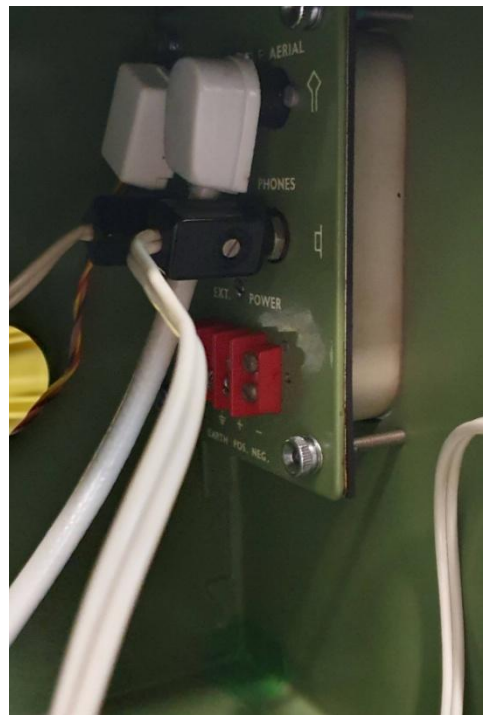
For example referring to the map below, if you were in the position marked X in the North Sea you would hear from the Stravanger Beacon in Norway 48 dots of the remaining A sector and 12 dashes from the B sector as the beam passes by your location. On the other hand the Beacon from Bushmills you would hear 28 dashes and after that 32 dots will be heard when its beam passes.



Features of the 66T receiver:

Apart from the RDF capabilities of the 66T it is a highly sensitive and capable radio receiver. It can be powered from an internal battery pack of 6 D cells in a battery box on the right side of the radio's housing.

When the attached speaker box option is not used, the radio's power input panel is simply screwed onto the left hand side of the radio. This panel is shown below. However, when the accessory speaker box is used, this panel sits on standoffs that attach the speaker housing to the radio's housing and is attached with thumb nuts. To remove these, the speaker itself and the front panel retaining it must be removed:



The speaker box has a hole in its rear to allow the main antenna connection to pass through.

The speaker itself is shown below, it is a high quality 4 inch unit and interestingly is mounted on a wooden baffle which I think likely improves the damping in the cabinet a little:



The radio has a number of DC power options aside from the internal battery pack, which can be selected from an internal rotary switch 12V, 24V or 32V operation.

The radio also sports a very nice audio amplifier with two good sized Philips transformers with a 10mm x 10mm cross sectional core area the Driver & Output transformer shown below the power select switch in the photo upper right. Just beside the upper (output transformer) on each side are the two AC128 Output transistors mounted in heat conducting fins. The audio output is rated at 1.8 Watts.

Also shown in the Photo upper right, at the very bottom, is a large power stud mounted BZZ19, which is a 9.1V power Zener diode mounted on a 6cm x 8cm, 4mm thick black painted Aluminium Heatsink. This is because the voltage regulator design for the external power option for this radio is a Shunt Regulator design. The excess input voltage is dropped across a substantial ceramic wire wound power resistor. While that might seem inefficient to some, the beauty of it is that it makes the power supply and radio highly resistant to electrical abuse such as high voltage transients on the DC supply because the Zener snubs them off. The Zener also prevents accidental reverse polarity accidents because it conducts in the forward direction in that case. More complex series pass voltage regulator circuits are more easily damaged, often requiring TVS protection devices or other protective parts.

The radio has 4 bands:

LW- LONG WAVE BAND, 150 - 285 kHz

NW- NAVIGATION BAND 255 - 425 kHz - uses the DF Antenna input.

MW- MEDIUM WAVE BAND 425 - 1600 kHz

SW- SHORT WAVE BAND 1.6MHz - 4.2MHz

The 66T also has a very attractive glass dial with a well calibrated scale for each band.

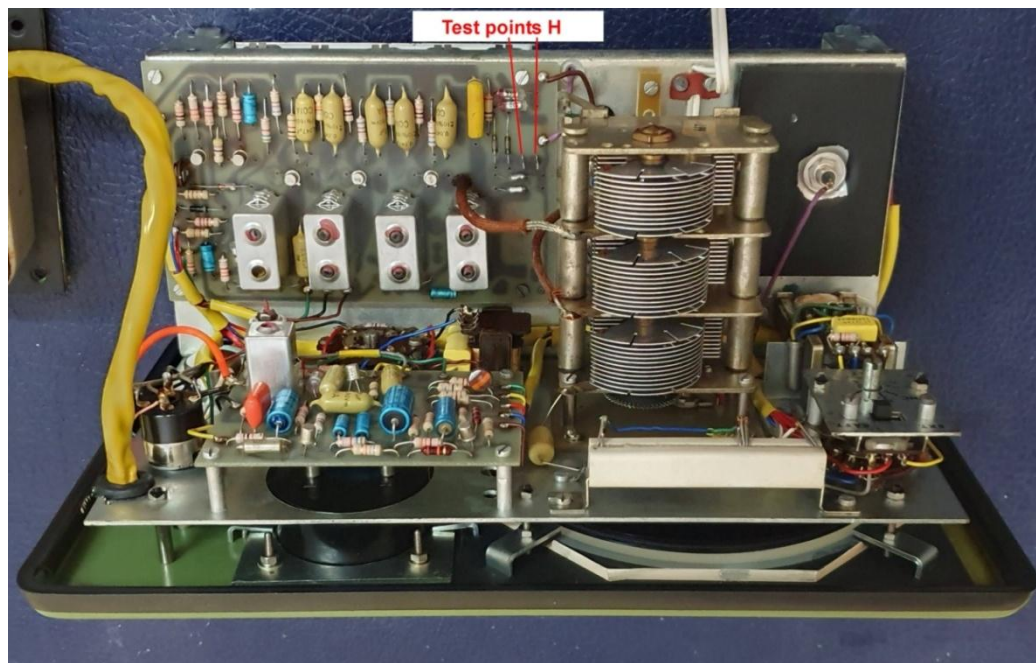
(However this particular radio was miles off correct alignment and this will be explained on the section below on radio alignment)

The dial contains some additional markings that are very helpful in performing an alignment (Calibration) of the radio. The calibration frequencies were mentioned in the manual, I could not find any mention of the critical Index Mark in the text, although I did not have a fully translated manual. This mark controls the mechanical relationship of the dial pointer to the 3 gang variable capacitor. That relation in my radio was badly off making calibration and tracking impossible until it was corrected. This is discussed in the section on alignment.



The photo below shows the general architecture of the radio. Of note the rear section of the 3 Gang Variable Capacitor (V/C) is the one that tunes the set's local oscillator and its associated inductances for each band. The middle section tunes the inductances associated with the RF stage and the front section tunes the inductances associated with the Antenna circuit.

Notice the bends in the outer adjustment Wings of the rear (oscillator) section of the variable capacitor, these are discussed later.



Another notable feature of this radio is the 470 kHz IF amplifier board. This uses double tuned IF transformers. One of the interesting things done on some versions of this IF board, was that the first IF transformer had an additional small coil added to its primary. It was a signal injection point labelled H. This was so that a low output resistance sweep generator could easily be connected without damping the tuning on the first IF coil.

However, in later versions, such as my radio, that coil was dispensed with and instead two test points, corresponding to "Test point H" were provided across the 1st IF transformer primary. This is a very high impedance zone. I had to make a special adapter to drive it, as will be shown in the alignment section. Also there was a note in the manual: "Never touch the intermediate frequency alignment unless proper measuring equipment is available" (by this they mean a sweep generator and scope) In this radio, if the IF tuning slugs are simply peaked on the 470kHz frequency, the overall bandwidth is far too low and the recovered audio modulation is therefore very muffled and lacking in high frequency components.

General Specifications of the 66T:

The sensitivity of this radio is very good on SW band at 50mW output for only 3uV RF input, specified with 30% audio modulation.

The IF bandwidth specified at 6.5kHz. This can only come about with correct tuning of the double tuned IF transformers, as will be outlined in the alignment section.

The image suppression specified at an excellent 50dB or better at 2.2 MHz.

The audio frequency specification is 100Hz to 3000Hz (without the filter switched in) I found this a little restrictive and as will be explained. I reduced the value of a filter capacitor to widen the frequency response in the audio section. This made music listening better.

In keeping with many transistor radios like this, the current consumption is amazingly low at around 40mA to 150mA depending on the volume setting. The 6 D cells in the battery carrier have a very long life. On external power, due to the nature of the shunt Zener voltage regulator, the current consumption is 400mA. The radio weighs in at 8kg.

The radio's signal to noise ratio was specified in the manual. To measure this it requires an output signal from a low impedance source (25 Ohms) and the use of a Dummy Antenna. This Dummy Antenna will be described in the alignment section.

The radio also contains 5 Quartz crystals for fixed frequency reception. In my radio the crystals fitted were for 2182 kHz, 1792 kHz, 1834 kHz, 1841 kHz and 1848 kHz reception. The crystals are housed in a row on the lower rear chassis:



The 66T Schematic & Factory Modifications:

There were a number of revisions of the schematic by the manufacturer.

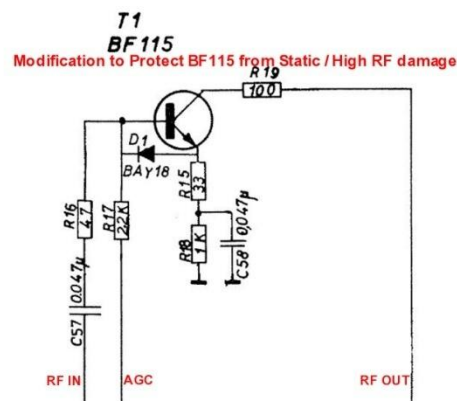
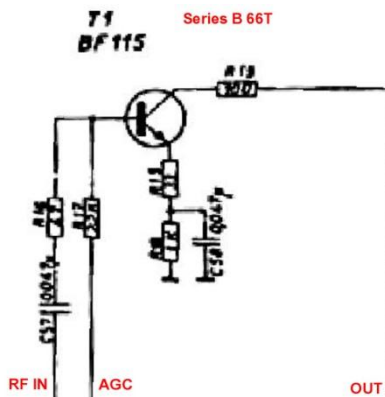
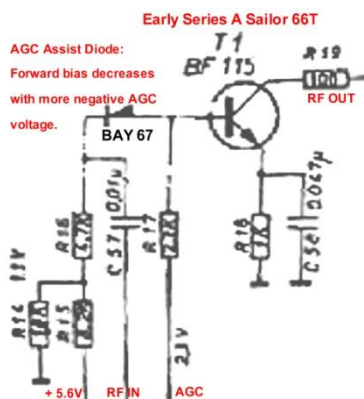
The first 66T set was Series A, then going all the way to series K with small changes. After series A though, most of the schematics are very similar. Except that after series A, an extra switch gang was added to switch the two local oscillator signals (Crystal versus the 4 tuned Bands) as separate signals into the Mixer circuit.

And after series B the RF amplifier got modified. It turned out that either electrostatic discharges (Lightning) or RF output power from the Ship's Transmitter, via the Antenna could fry the BF115 RF amplifier transistor. This sort of effect is not unheard of. For example there were a number of radios where if an operator even walked across carpet and their body charged up to a high voltage, that touching the radio's antenna conveyed enough energy to the RF amplifier transistor junction to destroy it. The general approach is to use diodes to protect the transistor.

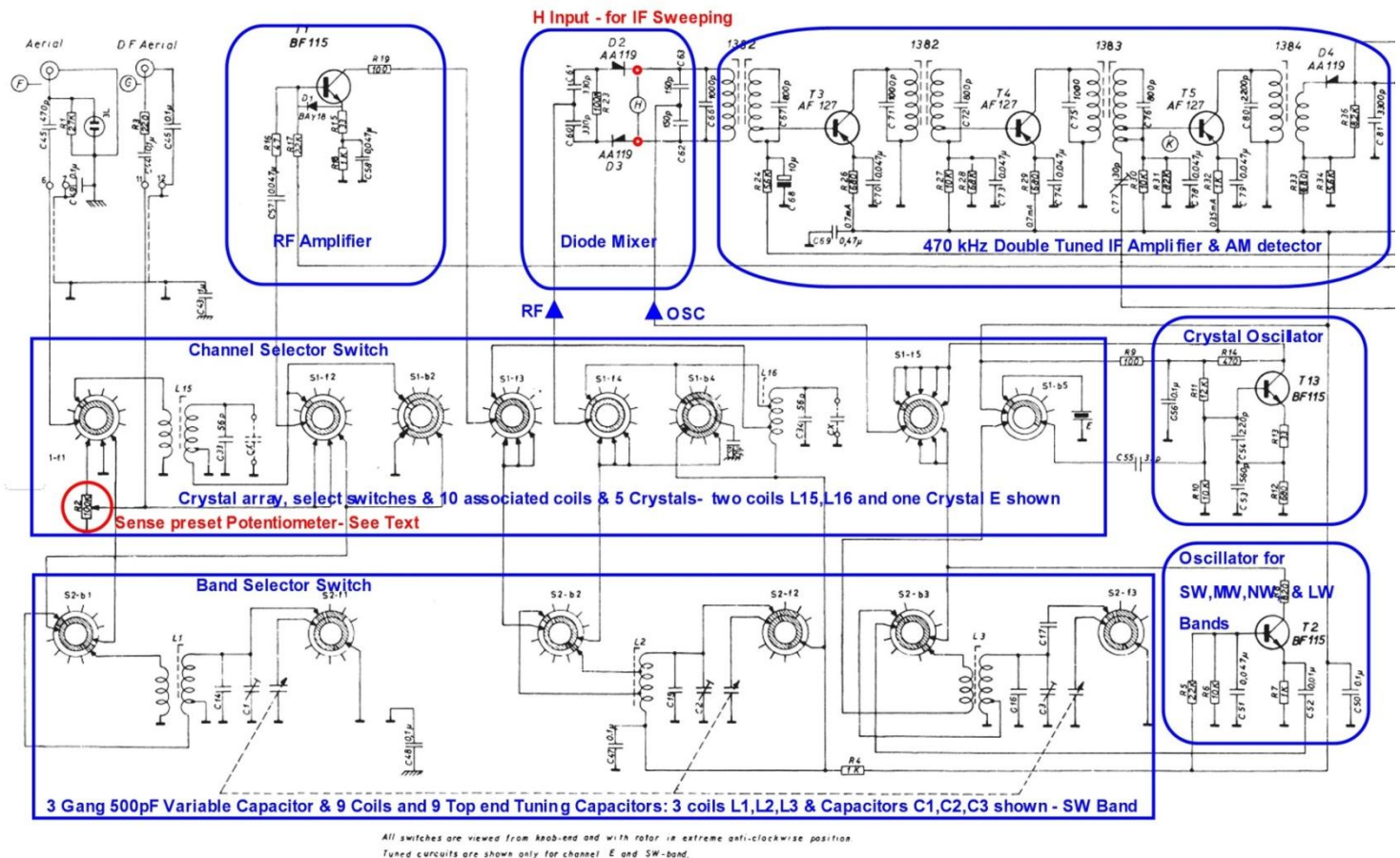
Sailor made a modification to prevent this event. Interestingly in some of their earlier versions, they had a diode in the Base circuit of the RF amplifier transistor, but in series with the base. The circuit there suggested it was not to protect the BF115 RF transistor, but rather to augment the AGC. Although a large positive signal impulse would tend to, reverse bias the diode, the diode's reverse breakdown voltage is not enough to protect from very high voltages. Later no diode at all was used in series B. Then they moved a diode on the B-E junction of the BF115. The explanation in the manual was this (If you OCR this and convert to English) you will find that it is consistent with the above explanation:

Vedr. HF-transistor.

Da vi har modtaget klager over, at HF-transistoren i nogle modtagere brænder af på grund af statisk elektricitet på antennen eller HF-spænding fra senderen, har vi i de kommende serier indført en beskyttelse af transistoren. Beskyttelsen består af en siliciumdiode monteret over base-emitter strækningen på HF-transistoren.



The series C schematic is shown below. This one corresponds to my radio. For the schematics below, I have broken them into blocks. The partial schematic below shows the arrangements in the radio frequency sections.



The potentiometer R2 is the “Sense–Balance” preset which is accessible through a hole in the front panel, just beside the Sense Switch. However, interestingly, in my radio, a green LED power light had been placed in that hole. The appearance of that and the wiring to it, suggest it was done by the manufacturer, but it was only operational on external power.

I switched the LED over so that it runs whenever the radio is powered from any source, it draws about 4mA. It is a good idea to have it, because when the radio is powered by batteries, it is all too easy to leave it accidentally switched on.

As noted previously, the Sense system creates a mix between the signal received by the DF antenna and the main Antenna, so as to create an asymmetry in the reception sensitivity, so that it can be determined the direction of the Beacon, otherwise there is a 180 degree ambiguity.

The Test inputs H are to couple in the sweep signal for aligning the IF amplifier. This arrangement is not as ideal as the circuit version where instead there is a small coupling coil in the 1st IF transformer's primary. How this was dealt with is explained in the alignment section.

The schematic above shows the coil sets and the top end tuning capacitor for the SW- band. The other coil sets and tuning capacitors for the other bands, 3 for each band, being the Antenna coil, RF coil and Oscillator coils are connected to the empty positions on the rotary switches.

For the fixed crystal reception frequencies, there are 5 Crystals and an Antenna coil and an RF coil associated with each crystal channel. In this case fixed Polystyrene tuning capacitors are used for the Antenna and RF stages. The arrangement here accounts for 10 coils in total and 10 fixed tuning capacitors associated with them. These capacitors, two for each of the Crystal Channels, are mounted vertically on the side of the chassis:



Regarding the basic overall design of the radio frequency sections Silicon transistors (The BF115) are used for both of the oscillators and for the RF amplifier. Germanium transistors, the AF127, are used for the IF amplifier. The specifications for both of these parts are excellent.

The BF115 is a spectacularly good Silicon Planar Epitaxial Transistor. Its transition frequency is in the order of 230 MHz and it has a low noise figure at 1MHz of 1.2dB.

The AF127 belongs to a family of parts that replaced the AF11x series of transistors, which are now prone to failure from Tin Whiskers. Fortunately the AF12x series of parts do not suffer from these problems.

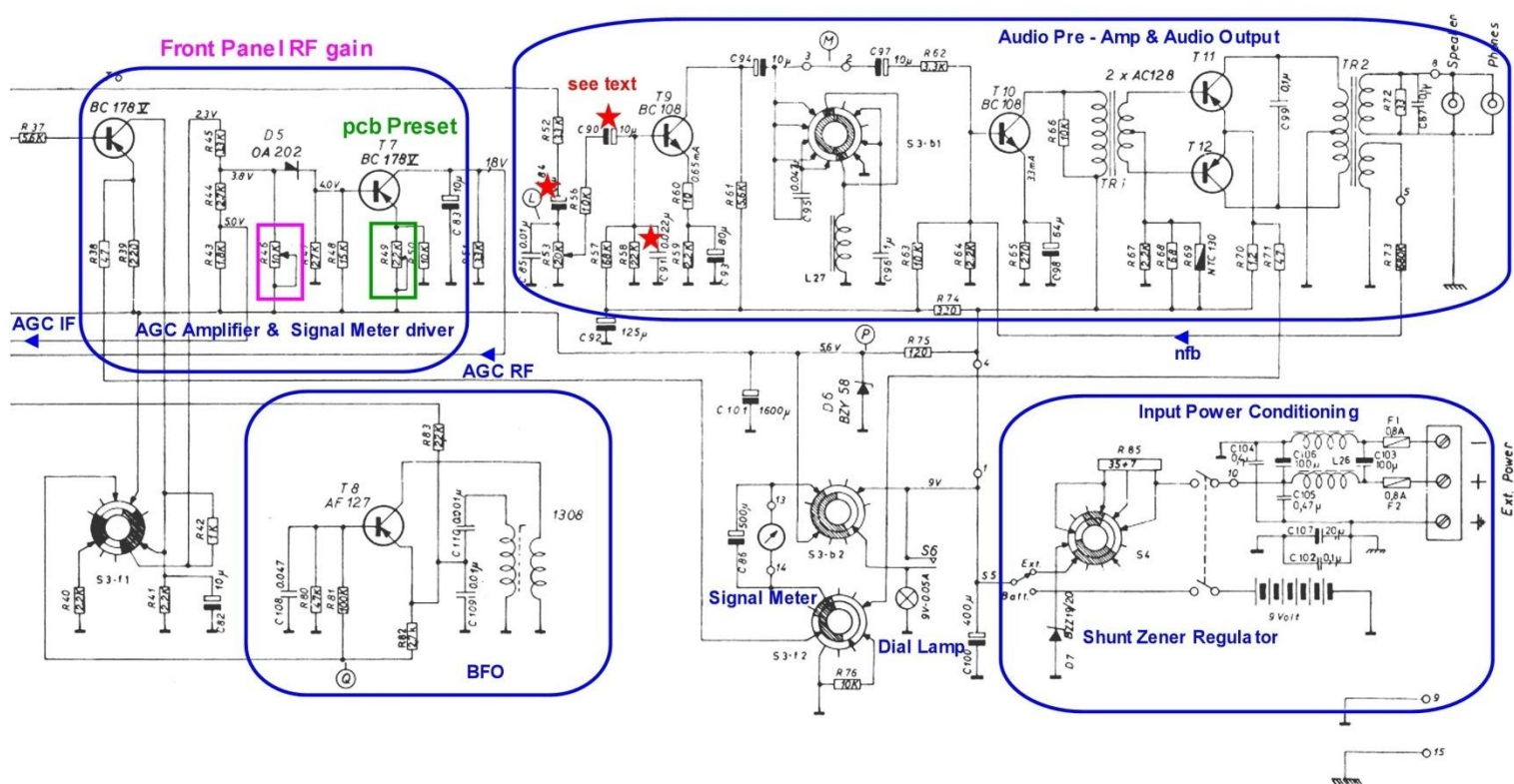
The AF127 is a diffused alloy transistor and it has a transition frequency of 75MHz, it is a very capable part for RF and radio work and with a low noise figure of 1.5dB. One of its very useful features is in IF Amplifier applications, because it has a very low feedback capacitance, only in the order of 1.5pF. This means it can work as a stable IF amplifier, without requiring Neutralisation. On the other hand, older generation Germanium RF parts, such as the OC45, had

feedback capacitances in the order of 10pF and always required neutralisation feedback components added, so as to be stable in an IF amplifier application.

One would therefore expect the performance (Noise and Sensitivity figures) for a radio such as the 66T to be very good on account of the very capable RF & IF & Oscillator transistors.

Certainly the sensitivity figure specified for the SW band being less than 3uV input for 50mW output is very good. The S/N ratio is specified at 10dB, below 1MHz with a 10uV signal and a Dummy Antenna (see section on alignments which require a Dummy Antenna) and for the SW band, from a low Z generator source of 25 Ohms at 1uV signal level.

The AGC system shown on the schematic below, feeds a separate line to the RF amplifier and the first IF amplifier. A separate pcb preset is used to help adjust the AGC to the RF amplifier. The front panel RF gain control affects both the AGC to the IF & the RF amplifier. The AGC performance is specified that an increase in RF input voltage from 31uV to 100mV will increase the output by less than 10dB.



The radio's metal chassis is independent of the actual positive and negative supply power system, only bypassed to those with capacitances. So the radio itself could be mounted in a vessel that had either a positive or negative ground power supply system.

In my radio I made some modifications (shown with the red stars on the diagram above) to three capacitor values in the Audio system. One problem I encountered was a noisy volume control, which persisted even after substituting in a new control and renewing the coupling capacitors. I changed both the capacitors around the volume control both to low leakage 1uF axial Tantalum capacitors. I could have used Film capacitors, but I had no axial types of that value which would fit the pcb well. Reducing the 10uF capacitor, leading away from the control, to 1uF substantially reduced low frequency noise with control rotation. It did not degrade the audio's low frequency response. In this circuit the resistances are such that the frequency response, even with a 1uF capacitor (rather than the 10uF value) does not -3dB roll off the audio signal until it is below about 20Hz.

The 0.022uF capacitor in the base circuit of T9 resulted in fairly heavy audio high frequency roll off, muffling the sound to a degree. That may well have been ok for voices, not so much music though. For a better tone balance for music I reduced that value to 1.5nF.

I could not find anything else that required changing. In terms of faulty parts, the only capacitor which required replacing was C100, a 400uF part which I replaced with two parallel axial 220uF parts. The original part had gone high ESR and it resulted in a Motor-boating effect with low frequency oscillations in the audio.

The audio amplifier in the radio is quite capable and gives a good sound with the 4 inch speaker in the speaker box. The amplifier has negative feedback to reduce distortion and good sized iron cored audio transformers.

Conveniently, S.P Radio provided the results of injecting signal voltages at different test points in the radio, under the condition that 50mW is being produced with a 30% modulation at 400Hz. This is helpful to verify that the radio is working to specifications.

P_{out} 50mW:	F. 2.2 m c/s (m 0.3-400 c/s)	1 μ V
	320 kc/s (m 0.3-400 c/s)	10 μ V
	G. 320 kc/s (m 0.3-400 c/s)	1 μ V
	H. 470 kc/s (m 0.3-400 c/s)	20 μ V
	K. 470 kc/s (m 0.3-400 c/s)	500 μ V
	L. 800 c/s	1 mV
	M. 800 c/s	25 mV

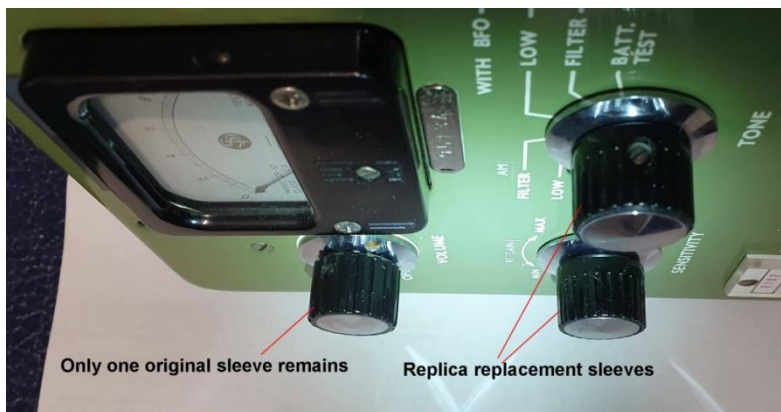
When I checked the radio initially I found that that none of the received station frequencies were close to the dial markings. Sailor went to the trouble of making a very precise looking dial, suggesting the unit should have good calibration. This is unlike some domestic radios with poor dial markings without graduations between them and somewhat loosely spaced dial legends.

On SW band, it was not possible to receive the high frequencies at all above about 3.6 MHz. The radio was significantly out of alignment.

Although many radio restorations are done, replacing various parts such as Electrolytic Capacitors, faulty Transistors & Resistors one of the true arts of radio restoration occurs after all of that. It is in the alignment of the radio. It might not be so important in some radios, such as pocket transistor radios, with single tuned IF transformers and limited dial markings, but in Commercial types such as Communications Receivers, or other functions, such as Navigation, calibration was seen to be, and is, very important. It is often clear from inspecting a Radio's Tuning Dial, whether the manufacturer thought of it as more of a domestic product or more of a scientific instrument where the dial information was expected to be reasonably accurate and meaningful.

Mechanical Repairs:

One curio is that this model radio has a peculiar failure rate of the Black Phenolic sleeves which were placed over the Chromed knobs. They have a habit of splitting and falling off and getting lost. They were all missing on this radio, except one. This required some donor phenolic knobs which were machined out with an internal taper to create a sleeve or shell, so they would slip over the original chrome metal knobs to act as a reasonable replacement. As can be seen these have finer finger grip grooves to the original sleeve, but they were as close as I could find.



Replica Sleeve made from a Donor knob.

Another mechanical issue cropped up related to the signal meter, it was sticking. Investigation revealed that some Rust Crystals had projected out of the side wall of the laminated Iron pole pieces and were catching on the meter's coil form. These were removed by slipping in strips of sticky tape to extract them. Some people have attempted to blow out debris from meter movements with compressed air. This is always better avoided as it normally destroys the hair springs and movement.

Alignment of the 66T Radio - Required Tools and Accessories:

To help with radio alignments I have a number of useful tools and equipment. One is the Philips PM5326 RF Generator. This generator has an accurate frequency counter. This unit puts out exactly 50mV rms into a 75 Ohm load on 0dB attenuation. It has an excellent shielded RF Attenuator that goes beyond -80dB. A -80dB output corresponds to a voltage delivered across a 75 Ohm load as 5uV rms.

In most radios, the local Oscillator runs the IF frequency above the received station frequency. To examine the local oscillator I have a Frequency Counter with a programmable offset value, in this case set to subtract 470 kHz, which is the set's IF frequency. Therefore, as the photo shows, with no signal input applied to the counter, its display reads 99.5300 MHz. It has an input sensitivity in the range of 10mv to 40mV and its maximum counting frequency is about 48MHz.

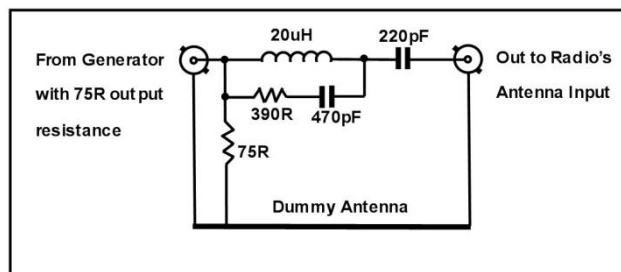


The input impedance (in common with many counters) is too low and its input capacitance too high to directly connect to a radio's oscillator circuitry without loading it and causing a large frequency shift. This issue is addressed in this article, how to solve that problem.

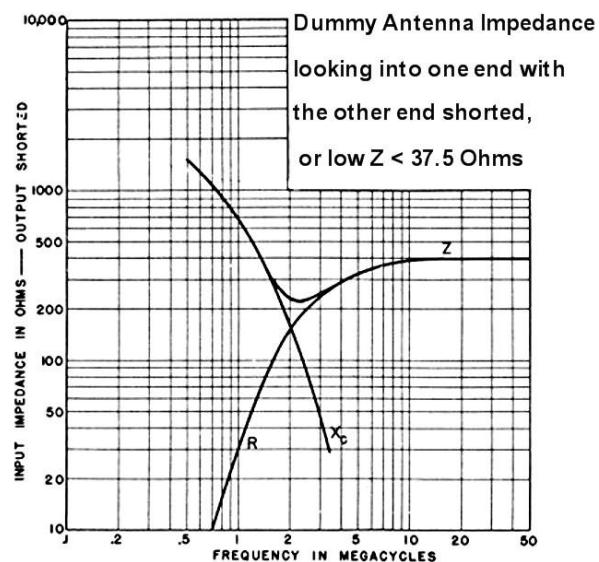
Dummy Antenna:

The IEC Dummy Antenna was suggested in the Sailor 66T manual to interface the RF generator with the Radio. It was said to use it with a Generator with a 25 Ohm output resistance (This is a 50 Ohm output generator with a 50 Ohm Terminator applied to bring the output Z down to 25 Ohms) And to use this for the LW, NW & MW bands. But not the SW band, where they suggested using the 25 Ohm generator signal source directly.

A typical Dummy Antenna is meant to be driven by a low source resistance of 25 Ohms or less, but there is little practical difference using a 37.5 Ohm source. This is a Terminated 75R source. It has the following circuit, this one conforms fairly closely to the American IRE circuit:



The performance of this circuit is shown graphically here:



Unfortunately the IRE version of the Dummy Antenna does not suit the Sailor radio especially on the LW band 150 to 280 kHz. The IRE circuit suits radios with MW and SW bands. The circuit for the recommended IEC Dummy antenna is not readily available.

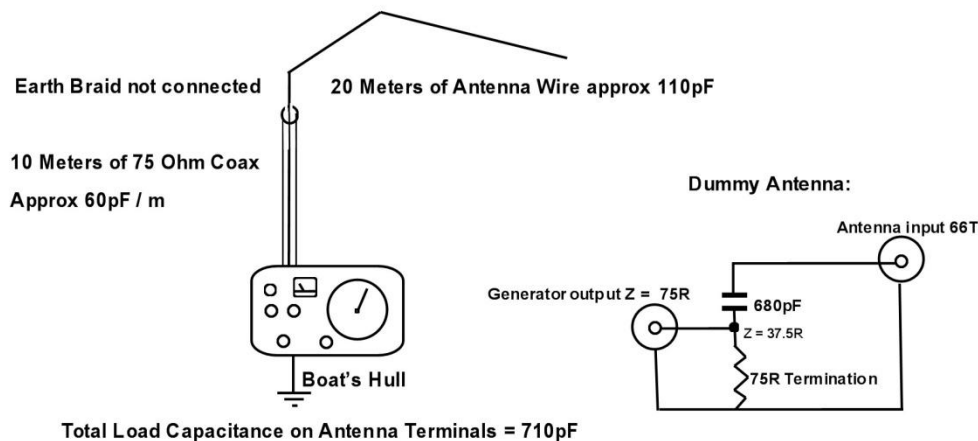
Since in the UK & Europe, Long Wave transmissions were very popular, it is highly likely the IEC Dummy antenna would suit the LW band too and it was recommended by Sailor.

In the case of attempting the alignment with the IRE Dummy Antenna, the Antenna coil on LW would not come into range on its tuning slug. The reason for this is that at the frequency of 170 kHz, the IRE dummy does not apply enough load to the primary circuit of the Antenna coil. Its load is in the order of nearly 5k capacitive reactance at 170 kHz on account of the 220pF capacitor. As a result of this, and the mutual coupling, the tuned secondary resonant frequency of the LW Antenna coil was too low. Even with the ferrite slug removed from the former, it still only came up to a maximum of around 160 kHz.

The actual Antenna arrangement for the 66T radio, when fitted into a Vessel was specified in the Manual. Therefore as a solution to the above problem, I made an adapter to emulate the capacitance of that system. This capacitance is present regardless of what Band on the radio is being used, so it is suited to adapt the generator to the radio for alignment purposes on all bands.

Since the length of the wire antenna is relatively short, compared to the wavelengths involved, there is no requirement to model the antenna's inductance or the transmission line properties of the Coax. The antenna system is essentially a capacitive load. The relatively low load of 37.5 Ohms (the terminated generator) placed in series with the load capacitance, has negligible effects on the total load, but it allows signal injection in series with the 680pF load capacitance. With this arrangement the Antenna coil's tuning slug, for all Bands closely matches the original manufacturer's slug positions (they were locked with red paint of which most remained) At 170 kHz the capacitive reactance of the 680pF capacitor is in the order of 1.4k Ohms. At 4 MHz on SW is it low at around 58 Ohms, this low range load being suited to the SW band as recommended by Sailor.

Recommended Antenna Configuration.



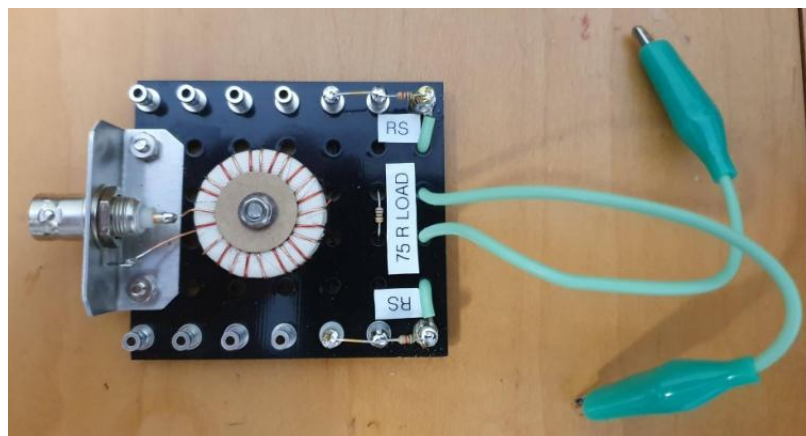
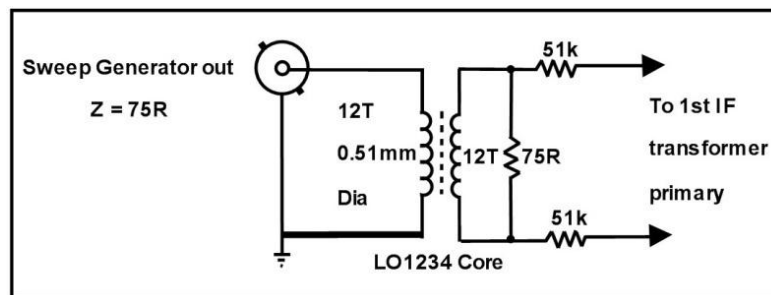
IF Signal Injector Adapter:

Another adapter required in this particular radio alignment case, was a device to allow the output from the RF Generator to be turned into a differential signal with a very high impedance, so as to allow coupling into the first IF transformer without damping its primary coil. This is for the purpose of using the RF generator in Sweep Mode, to sweep the IF's 470 kHz band-pass frequency response.

For many transistor radios, a sweep generator is not required. This is because all of coils can be peaked on the centre IF frequency (Typically 455 kHz in most Transistor radios) and the IF's are designed to have the correct overall band-pass response in that single peaked condition. However this is not always the case for radios with double tuned IF transformers, such as the Sailor 66T.

The circuit for the adapter I made uses a Jaycar Toroidal Ferrite core part LO1234, with two 12 turn windings. Each winding has an inductance in the order of 200uH. In the unloaded condition (without the 75R termination resistance on the secondary) the loading on the generator's 75R output resistance at 470 kHz is negligible. The 75R termination resistor on the secondary makes sure that there are no spurious resonances. The high value series resistors ensure that the primary of the first IF transformer is not damped or affected by the connection of the adapter.

One thing that helps significantly, in winding Toroidal cores, is to wrap Scotch 27 cloth (fibreglass) tape around the core. It stabilizes the position of the wires and makes for a much better result.



The Frequency Counter Interface - Adapter:

One of the major issues in Superhet receiver alignment, especially when one wants to examine the Tracking, is accurate counting of the radio's local oscillator with a frequency counter, in a way that does not significantly alter the oscillator's operating frequency.

I became interested in this topic when interfacing Digital Frequency Counters to vintage Communications Receivers. In this scenario, the digital counter has an offset equal to the IF frequency, so that the counter displays the tuned frequency. This is also a handy way to arrange things when testing the radio's alignment and tracking.

Even attaching a 1 foot long wire, which has a capacitance of about 4 or 5pF, can have de-tuning effects. And that is even with no test apparatus connected to the other end of that wire. This is enough to de-tune the local oscillator especially at the high end of the band where the oscillator's Variable Capacitor (V/C) gang is at its minimum value.

I found while experimenting with x10 Oscilloscope probes, that if the probe tip was clipped onto the plastic (typically PVC) insulation of a wire in the oscillator circuit, this created about a 0.7pF to 1pF "gimmick capacitor" This forms a voltage divider with the scope probe's 30pF input capacitance.

This low value of capacitance, being right at the probe tip largely isolates the circuit being monitored via the wires leading to it, as well as the input capacitance of the test device connected to that. The 0.7pF is generally not enough to de-tune the oscillator to any significant extent in MW or SW band radios, at least below the very top of the band.

Typical measurements show that if the conductor inside the insulation has a 3Vpp Sine Wave, the combination of the small metal surface area of the probe tip or clip, of about 0.7pF and the 30pF probe input capacitance results in approximately 70mVpp (about 25mV rms) being measurable at the scope.

The question therefore became how to utilize this basic approach with a custom interface adapter to drive a frequency counter. The voltage level is almost enough to drive some frequency counters with input sensitivities in the 10mV to 50mV region.

Therefore I designed a unit for the task of interfacing the frequency counter. It uses a standard Test clip with the Phosphor Bronze wire formed into a partial loop, so that it can grab onto the plastic insulation of a wire in the radio's oscillator circuit. One location to *place it* (not connect it, there is no Galvanic connection) is on the PVC insulation of the wire leading to the Oscillator Gang of the variable capacitor. However there is a better place.

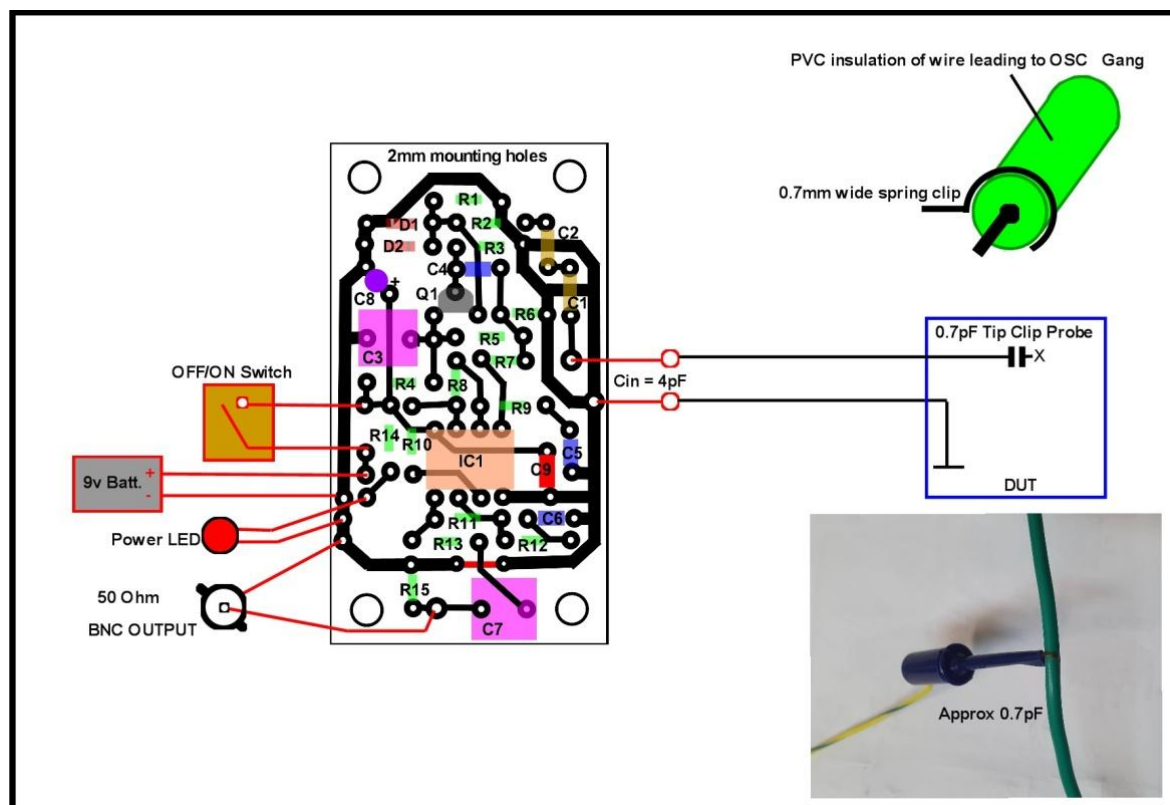
Normally, for most transistor radios there is a 3Vpp or more sine wave on the conductor inside the wire that leads to the oscillator's V/C gang (it is much higher in tube radios). If there is no wire present, say if it's a pcb, you can tack on a ¼" length of insulated wire. If there is a bare

wire available, you can put a split section of insulating sleeve on it, and clip the probe tip over that.

The required circuit, for low noise, is 9V battery operated and placed in a small box.



The device itself has a low input capacitance on its terminals at around 4pF, but, it still has to be much lower, on account of the wires leading to it, so it is used in conjunction with the clip around the PVC wire insulation. This cuts the total added capacitive load down to less than 1pF:



capacitances, to close to 16mVpp. That is amplified by the two OP amps by a factor of 37, but divided down by 2, when the output is terminated into 50 Ohms. The voltage supplied to a 50 Ohm output load is close $18.5 \times 0.016 =$ approximately 300mV pp.

Most radios have a higher the 1V pp voltage on the conductor leading to the Oscillator gang of the Variable capacitor. In the Sailor 66T radio for example, the Terminated pp voltage when the 0.7pF clip is applied to the insulation on the oscillator section of the V/C, the voltage output from this unit into a 50 Ohm load is close to 1.5V pp, because the voltage on the actual conductor is in the order of 6V pp.

Even with a low input capacitance, the isolation is not 100%, so the test clip will load the Oscillator a little. The effect is greatest on the radio's SW band at the top end around 4 MHz in this set, where the 0.7pF load can lower the oscillator frequency by as much as 5kHz or about a 0.1% frequency shift. Not a lot in the scheme of things.

However, the unit shown gives a good result with near zero detectable loading, with less than a 100 Hz shift in the L/O, if the clip is instead connected onto the RF Gang (either directly or via its connecting wire's plastic sleeve) of the V/C instead. This is because enough of the oscillator's signal finds its way from the Mixer back to that point. This method provides further isolation.

Apart from driving a frequency counter with minimal loading effects, the adapter unit is also helpful to view signals on any circuit point without any significant loading.

The adapter has a double use. It is also used as a buffer for the scope, to check the Antenna & RF stage tuning and its correlation with the dial markings, without de-tuning (see below)

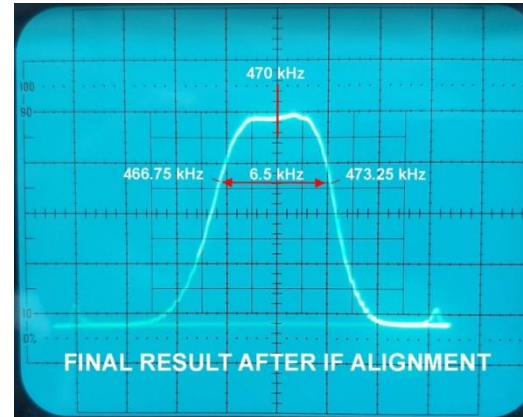
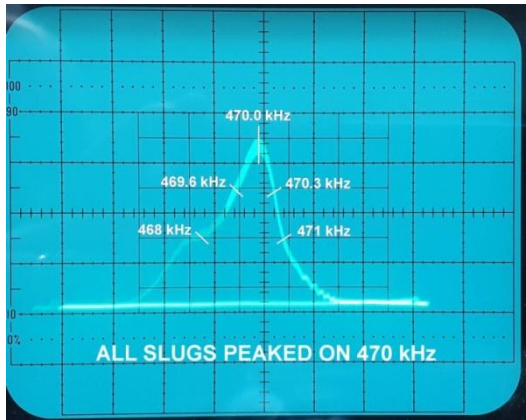
The IF Amplifier:

It is the Gain and Bandwidth of the IF stages in a Superhet radio which confers much of the radio's Selectivity and Sensitivity. There is less selectivity in the RF and Antenna circuits, as these have to be wide enough in bandwidth to accommodate the Tracking Errors.

One first and basic principle of normal Superhet radio alignment is to make sure the IF stages are correctly set up with the correct centre frequency and bandwidth (if the latter is adjustable)

With this particular IF amplifier in the 66T, if all of the IF slugs are peaked to the same frequency, the band-pass response is far too narrow. The result is a muddy sound with loss of the treble response. The sweep result is shown below for the case where these particular IF transformers are peaked all on 470kHz, it results in a narrow bandwidth response which also has an asymmetrical skirt.

The manufacturers specified a bandwidth of 6.5 kHz, meaning that the response should be -3dB down at ± 3.25 kHz around the 470 kHz centre frequency. This was easily achieved by adjusting the IF slugs and using the Sweep Generator with the sweep generator adapter:



Indexing:

One important issue, aside from the IF being correctly adjusted, prior to any other alignment processes, is that when the dial pointer is pointing to a specific legend at the low frequency end of the dial, the mechanical angle of the variable capacitor (V/C) is in the correct position.

This is so that over the tuning range the minimum & maximum capacitances of the V/C run over the correct range to suit the coil set.

The question is where is that position? It may not be explicitly stated, or for that matter even present on some dials.

It was once a historical custom for a manufacturer to put an Index Mark on the dial. In most cases the pointer should be aligned with this mark with the V/C fully meshed, or close to that. In the Sailor 66T manual I could find no mention of this mark, though one was clearly evident on the actual Dial. This setting for my radio was so far off that, the V/C had completely un-meshed by about 3.6 MHz on the short wave band dial markings and it was therefore impossible to tune in any frequencies above that.

Standard Textbook Alignments:

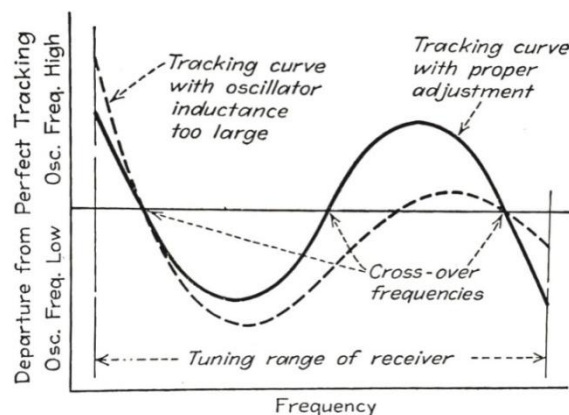
In typical alignments, after the IF alignment has been attended to, the manufacturer recommends that the dial pointer is set to a specific Pointer & Dial Marking location on the low end of the band. The Oscillators coil's tuning slug (or its adjustable padder capacitor if there is one) is set to receive the tone modulated test frequency for maximum signal out of the IF's detector or the audio amplifier stages. The dial pointer is moved to an instructed position near the high end of the band and the generator set to that frequency and the oscillator's Trimmer Capacitor, in parallel with the oscillator's V/C gang, is moved to tune that in for a peak signal. And the process is repeated a few times because they interact.

After that, the Antenna & RF coil slugs are peaked at the low end of the band at the same dial locations and the trimmer capacitors associated with those coils are peaked at the recommended high end frequency.

With this common alignment method the tracking of the oscillator's frequency, running the IF frequency value above the received carrier frequency, turns out to be exactly correct at the upper and lower points that were adjusted by the technician and at some intermediate point in the mid band, that the Technician is not aware of. These three frequencies are called "Cross Over Frequencies" At any other tuned frequencies, a suitable name for the *areas* could be "Tracking Zones"

In the tracking zones around the cross over frequencies, the local oscillator runs a little faster, or slower, than ideal with respect to the tuned centre frequencies of the RF and Antenna stages tuned by the other two gangs of the V/C. These errors are shown diagrammatically below and are called "Tracking Errors"

These tracking errors do not definitely relate to relative positions of markings or legends printed on the radio's dial around the upper & lower cross over frequencies, but are intrinsic to the design of a Superhet radio where the V/C's oscillator and Antenna (and RF tuning gangs if present) have the the same capacity and the oscillator Gang has the required Padder Capacitor in series to reduce its overall capacitance. The dial markings in the tracking zones and the relative position of the dial pointer to them are a different type of error, not to be confused with Tracking errors.



When the Padder capacitor is the correct value for the associated V/C capacitance and oscillator coil inductance combination, for the band being tuned (and the manufacturer usually makes sure it is) the magnitude of the + and – tracking errors, at their worst, are about equal. You could say these tracking errors, which occur in the tracking zones, of which there are 4 zones, could be called “Tracking Zone Errors”

The tracking zone errors themselves, if significant enough, can result in reduction in sensitivity of the radio and or reduction in the image rejection in those zones.

The other set of errors is related to the position of the dial’s markings or legends, in that the dial pointer’s relative position to the dial’s markings anywhere other than the upper and lower frequency calibration points, set by the Technician, might not “tell the exact truth” about the received radio station’s frequency.

In other words, if you monitored the oscillator’s frequency, with a frequency counter which subtracted the IF frequency from it, that the dial pointer would not be pointing to a dial legend at that exact frequency the counter was displaying anywhere other than the upper and lower frequency calibration points. Or, that the tuned RF frequencies of the Antenna & RF stage anywhere, other than the two calibration points where they were set to match the dial’s markings, might not exactly match the dial legends elsewhere either.

Tracking Alignment:

There is an alternative Alignment method to adjust a radio to ensure that both the dial markings match the received frequencies as closely as possible and that the tracking errors are as minimal as possible, all at the same time. No modulation is required on the carrier from the RF generator in this process.

In this alternative alignment method it does not involve relying on the IF amplifier at all and it can also be used to check and measure the magnitude of the tracking errors too, as will be explained below. Although the IF amplifier must be properly setup for a final result.

Once the IF has been set up correctly with the sweep generator and marker generator (it is best to disable the oscillator for this process) and the mechanical relationship of the V/C angle and dial pointer are set up on the Index mark, these things are then ignored.

Firstly the oscillator transistor stage in the radio is disabled (I do this by shorting out the base to emitter of the oscillator transistor with a 100 Ohm resistor in the case of a separate oscillator transistor) and examining the RF output from the RF stage. In Mixer/Oscillator designs, shorting out the oscillator’s resonant coil also works.

Then, for each Band the cores in the RF and Antenna coils are peaked on the manufacturer recommended low frequency end and the capacitor trimmers at the upper band end in the usual way, but in this case by monitoring the output of the antenna/RF tuned circuit (if present) where it feeds into the mixer, or on the RF amplifier's V/C gang.

One way to keep the detuning effects extremely low is to use 1pF capacitor. Insulate one of its leads with heat-shrink sleeving and hook its other bare lead as a small loop around the insulation of the wire leading to the RF stage's V/C gang. Then clip the spring hook of the adapter unit described above to the heat-shrink insulation. That keeps the added load capacitance below 0.5pF and then feed the output of the adapter unit to the scope, instead of the frequency counter. This way the tuned carrier can be seen on the scope with negligible detuning effects on the RF stage's resonant circuit. In essence this part of the radio is now being treated as a TRF circuit.

Once the upper and lower frequency points are set for the Antenna & RF stages, and done a few times because of interactions, the positions of all other Dial markings with respect to the dial pointer (representing the V/C's angle) can be checked, to see how closely the Dial markings & Pointer match the applied carrier frequencies.

This is why an RF generator with a built in frequency counter is very helpful. In the Sailor radio, it turned out that the antenna & tuned RF stages were closely correlated with the V/C's pointer and the Dial markings. In this case there is no requirement to adjust the wings on the variable capacitor gangs associated with those two radio frequency stages.

The glass dial's markings had clearly been created from a law defining the tuned frequencies when a SLW (straight line wavelength V/C was used). Though rather than calibrating the dial in Wavelength, which would have more evenly spread the values, it is calibrated in frequency. This may have been due to the availability of SLW V/C's being better than SLF types. When this scenario is the case, as it was in the 66T, it is very convenient because any adjustments to the oscillator's fine tuning in the tracking zones can then be targeted to match the dial markings as closely as possible too. This way, both tracking errors and dial marking/pointer errors for tuned stations can be simultaneously minimised.

NOTE: If it were the case that the dial markings closely followed the Oscillator's tuning in the tracking zones, then the Wings of the Oscillator's variable capacitor should never be altered from standard. Only the wings of the RF and Antenna sections adjusted (with the oscillator disabled) if required, to better match the dial/pointer relationship.

Setting up the Oscillator:

The oscillator is re-enabled and this time its frequency is monitored with the offset frequency counter with the low coupling method and adapter unit. The oscillator is set on the low and high recommended frequency points on the dial with the tuning Slug and Trimmer capacitor respectively. It pays to do it a few times because they interact.

Then the points on the dial in the tracking error zones can be checked by disabling the oscillator and tuning the antenna and RF system for a peak and then re-enabling the oscillator. Then using the adapter and the offset frequency counter to see how the oscillator frequency varies from the RF frequency value from the RF generator's digital display. If required, the adjustment vanes on the oscillator gang of the V/C can be altered to improve the tracking.

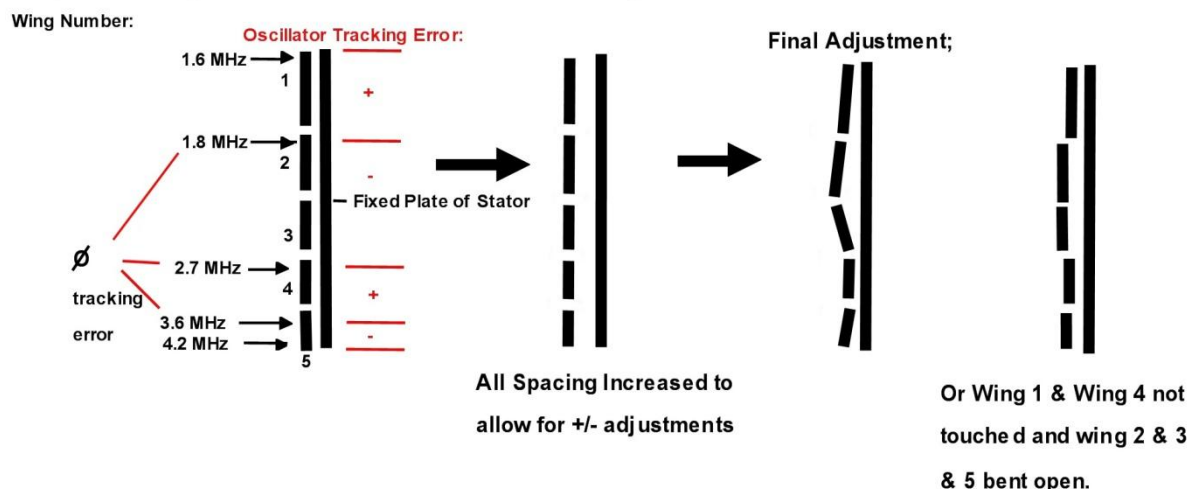
Due to the fact that the capacitance of the V/C gang can only be reduced by bending the wing outwards, then to gain full control, all of the vanes would have to be bent outward initially, so that bending one in can increase the capacitance and bending one out decreases it further. But this does not always need to be done. Every time Wings are adjusted though, both the oscillator's Tuning slug and the trimmer capacitor have to be reset at the upper and lower frequency points, to correct the upper and lower set frequencies.

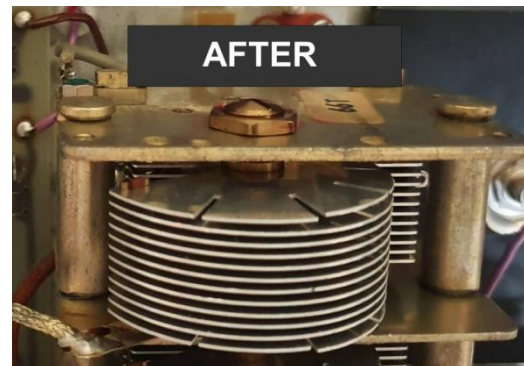
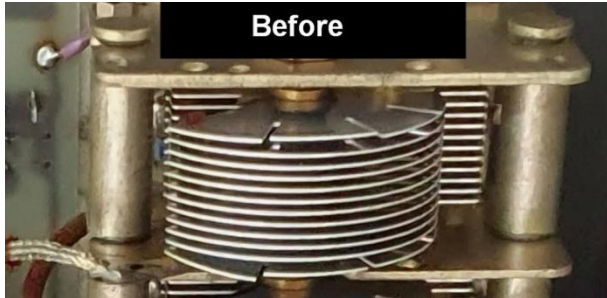
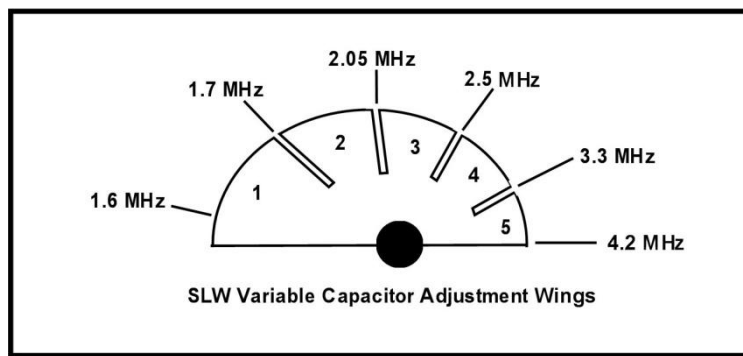
Ideally before starting you create a tracking error map, this is done by disabling the oscillator as noted above, tuning in to the RF signal for a peak at each major dial frequency step then re-starting the oscillator and inspecting its deviation. Using the offset frequency counter, you simply see a value that is higher or lower than what the frequency counter on the RF generator is displaying. Indicating that the oscillator is running a little slower or a little faster than it ideally should in the tracking error zones. This is one reason it is much easier to have a counter that subtracts the IF frequency for you.

Interestingly, as one might expect, the ideal format of the adjustment wings would be an S curve, reminiscent of the tracking error curve itself. However it is compressed due to the nature of the SLW variable capacitor vane profile. To get an actual curve the vanes would require twisting as well as bending outward.

Another approach, as the diagram shows, is to bend them directly outwards. This can also mean that Wing 1 and Wing 4 can and mostly wing 5 can be left alone. There are not enough adjustment wings to acquire a super accurate result, 10 wings would be better. The oscillator tracking error shown below; the + means the oscillator is running fast in those zones and the – means its running slow:

5 Adjustable Wings on Each side. One side shown for clarity.





With the wings untouched and matching those of the antenna and RF stage gangs, in the zone between 1.8 MHz and 2.7 MHz the oscillator is running a little more slowly than ideal and requires a little less capacitance, this is why the wings in that zone Wings 2 & 3 are better bent outwards. In the zone between 2.7 MHz and 3.6 MHz the oscillator is running a little faster and requires more capacitance.

It was found with this radio, that the appropriate Wing adjustment, if performed on the SW band, was also as ideal as possible on the other three bands. The SW band was the most convenient one to use for the tracking adjustment because the outer dial scale & pointer has a larger range of relative motion for a small change in angle of the V/C and the dial marking details are very helpful. The maximum mechanical error in the position of the pointer, with respect to a dial marking in the tracking zones in SW mode, when all is set in proper alignment, is in the order of about 1 to 1.5 x the width of the actual pointer.

Fortunately, in the scheme of things, the effects of tracking errors in single conversion Superhet radios are generally small. This is because of the relatively wide bandwidth of the tuned RF stages and Antenna stages, being significantly broader than the oscillator's tracking errors, so there is no significant loss of sensitivity or image rejection. It is the IF stage in the radio which confers the selectivity to the receiver as a whole. Still, it is good to have the radio in good alignment as well as the dial pointer giving a good representation of the received stations frequency.

Summary:

The Sailor 66T is a remarkably well made radio. It lives up to its sensitivity specifications on testing. And it sports a very attractive well calibrated dial and its direction finding capabilities are quite remarkable. In the days prior to GPS navigation, it probably saved a number of Sailor's livelihoods and lives too, in the treacherous North Sea. In addition it sports a very satisfactory speaker and audio system and with only a very change to a capacitor value makes a very pleasant sounding radio to listen to music stations on the MW band.
