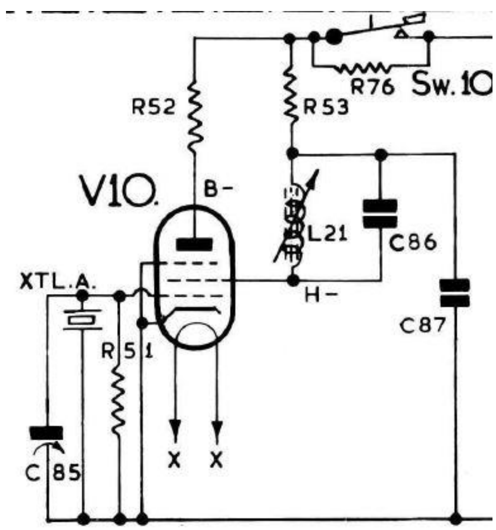
Installing a 500KHz Crystal Calibrator Unit in an Eddystone S.940 – Gerry O'Hara

While I was raking about in my Eddystone spares box looking for the S640, S750 and S940 parts, I came across a small, grey diecast box with no lid that had two valve sockets mounted on it, a few components inside, including a coil and variable capacitor, and a pigtail of wires hanging out of one end. Next to it was a small cardboard box containing a valve (6AM6) and a 500KHz crystal mounted in a B7G valve envelope wrapped in cotton wool, together with two valve shields. I realised these belonged together, and what I was looking at was an Eddystone crystal calibrator unit (photos below).

Checking through various Eddystone models, I concluded that it had most likely belonged to a model in the S730 series, eg [S730/4](S730/4) (schematic on page 2). How I came to own this is a mystery to me – forgotten in the 'sands of time' – as I have never owned an S730, nor even had one on my bench.

I was about to put these parts back in the box, when I thought – why not fit the calibrator to the S940 I had been working on? (photo, top of page) – I may as well put it to use rather than it sit in a box in the garage for ever. The S940 has reasonable scale accuracy, claimed to be 0.5% on all ranges in the specifications - sounds ok, but that's 150KHz at 30MHz, so it would be useful to have a calibration signal ('pip') to inject when needed. For such a receiver, a 500KHz interval calibrator is probably more useful than the more usual 100KHz calibrator, as it would normally be used to check the scale accuracy on the



higher frequencies, when 100KHz markers can become confusing, ie. it can be difficult to tell which 100KHz marker is which.

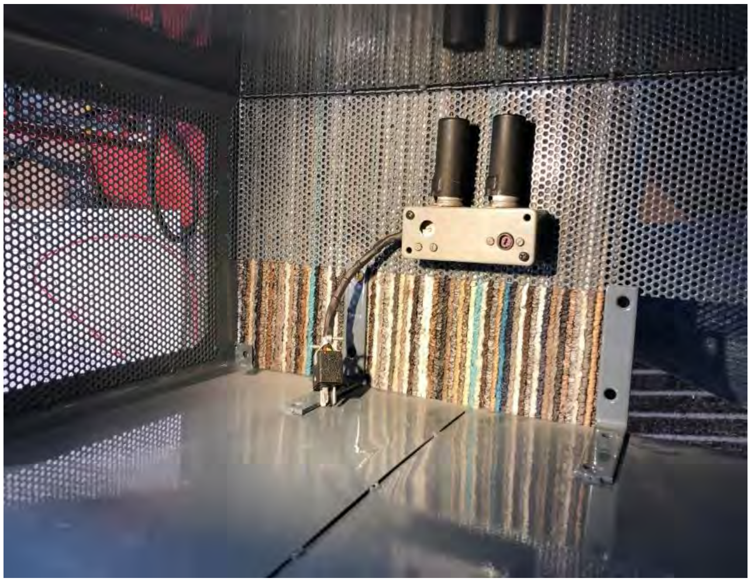
Best use is made of a calibrator when the relative pointer-scale alignment to be can be adjusted 'on the fly', as in the Eddystone S730 and S830 series, with a small mechanical adjuster (circled yellow on photo, right, here on my S830/4). This facility allows the pointer to be moved relative to the scale by a small amount to bring it in-line with the calibrator signal, thus bringing the section of dial in use into higher accuracy. The S940 does not have this 'refinement' (its really a kludge), but a calibrator can still be usefully deployed to check the scale accuracy during listening sessions.

My S940 was still on the bench after installing the new vernier scale and fixing the BFO/product detector unit. I decided to jury-rig the calibrator unit to the S940 to check its functionality. First, I checked the components and, although they were not perfect – the resistors had drifted high in value and the tubular paper capacitor was leaky, I decided they were good enough to test the unit out. So, I connected the heater (yellow) lead to the heater supply, the HT+ (red) lead to the 240vDC ('HT1') supply, ground (black) lead to the chassis, and the output (green) lead to the antenna. There was actually two heater leads (both yellow) in the pigtail: as one side of the 6.3vAC heater supply in the S940 is grounded, I simply connected one of the yellow wires to the black (ground) lead. Doing this would allow a 4-pin connector to be used during installation in the receiver.

On powering-up the S940, sure enough, the calibrator unit was working, with distinct markers at 500KHz intervals. These were strong at lower frequencies, but faded out around 15MHz. On checking the output lead in the diecast box, I realised it was merely wrapped around the 100Kohm anode resistor of the 6AM6 valve, ie. an extremely low level of coupling – probably less than 1pF. I decided to rebuild the unit, replacing the three resistors and one paper capacitor (in the S730 parts list this is given as a moulded mica type – it was not – and it measured more like a 100Kohm resistor…). I also added a 10pF 500vw silver mica cap from the anode of the 6AM6 to the output lead to increase the available calibrator output signal (photo, above).

I did not want to damage the chassis by installing a switch for the calibrator. A few 'non-invasive' options to install a switch were considered, including:

- A push-switch with a shaft passed through the 'phones socket hole (which I never use):
- Remove the 'phones socket, retaining it behind the front panel ready for re-installation if ever it was ever wanted, and install a switch through the 'phones socket hole;
- Install an AF gain pot with a push-switch (I remembered that I have one of these in my junk box), ie. simply push the AF gain knob to activate the calibrator; and
- Install a small switch on the rear of the cabinet - there are some spare holes (this would mean reaching around the receiver to operate the calibrator – not that convenient).



While I was pondering this, I proceeded with mounting the calibrator unit inside the rear panel of the home-made steel cabinet – this comprises a perforated steel panel that would allow 6BA screws to pass through the perforations. The calibrator unit has four holes that would normally, eg. as in the S730/4, allow the unit to be bolted to the top of the tuning gang cover. These holes aligned ok with the perforations, so attachment was straightforward (photo, right). There is also a convenient space on the chassis behind the tuning gang that the calibrator unit would occupy once the chassis was installed in the cabinet.

Although the wires forming the short 'pigtail' of wires exiting the calibrator were cord-tied, I installed a length of heat-shrink over the pigtail to provide additional support and protection. I then connected the pigtail from the calibrator unit to a polarized 4-pin 'Jones' ('Cinch') plug, noting that the pin-out was 1) ground, 2) heater, 3) HT+ and 4) output (signal). Luckily I had some of these connectors in my junk box, along with some suitable multi-core cable. The line plug was mounted onto the calibration units' pigtail,

and the line socket mounted on the multi-core cable from the chassis so no 'live' connections would be exposed when it was disconnected. An adequate length of cable was used such as to allow connection with the plug on the calibrator pigtail when installing the chassis in the cabinet. I installed an (open) 'P-clip' on the inside of the rear panel so any excess cable length could be secured once the Jones plug/socket had been connected and the chassis was in the cabinet. The multicore cable was run along the top of the chassis (follow arrow in photo, left), secured by two more P-clips, then to underneath the chassis (power supply

compartment) via the gap between the front of the chassis and the rear of the front panel, and secured under the chassis with another P-clip (arrow in photo, left). The wire colours in the multi-core cable were different to that used in the calibrator unit (standard Eddystone colour code: ground/black, heater/yellow, HT+/red and signal/green). I therefore connected wires of these colours to the wires in the multi-core cable corresponding to these colours in the calibrator unit, so they matched the colour-coding of the receiver chassis, the joins being secured and insulated with heat-shrink. These wires were then run under the chassis, connecting to the appropriate points: black (ground) to a nearby chassis ground lug, yellow (heater) to the 6.3vAC heater tap on the power transformer, red (HT+) to the calibrator on-off switch, and green (signal) to the injection point in the coil box (see below). I checked that the additional heater current (0.3A) would be handled ok by the transformer – it was, but just (4.065A v. 4.2A rating on the 6.3VAC tap used), but that's ok – I was assured by Bill Cooke many years ago that these transformers are "good for at least a 15% overload". There is a second 6.3VAC tap (unused), rated at only 0.3A, so I left it alone.

Having given the options I listed above for a switch to operate the crystal calibrator some thought, I first tried fitting a small push-button switch through a hole in the rear apron of the chassis (vacated when someone had installed a jack socket audio input instead of the original terminal posts). I used this to function-test the calibrator now it was installed in the receiver – it was working ok, however, I felt a switch in this location was too inconvenient for use while operating the receiver. Another of my ideas was then considered – that of replacing the AF gain control with one that had a push-switch incorporated on its shaft. However, the only control I had like this was a 1Mohm unit, and the S940 specifies a 500Kohm part. While the 1Mohm part would likely have worked ok, while I was considering this, I had another thought – why not use the 'Standby' switch for this purpose? (circled in photo, right). This switch is a double pole double throw switch, which uses only one pole to de-sensitize (mute) the receiver by switching in a 47Kohm resistor into the cathode circuits of the 1st and 2nd RF amplifier stages and the 1st IF stage. The other pole on the switch is unused as supplied by Eddystone to the customer, but could be connected such as to operate a relay or other circuit to switch a transmitter on and throw a transmit/receive antenna relay when in the 'Standby' position. To re-purpose this switch to operate the calibrator, I simply added a shorting resistor across the 47Kohm resistor so the receiver would not be de-sensitized when the calibrator was switched

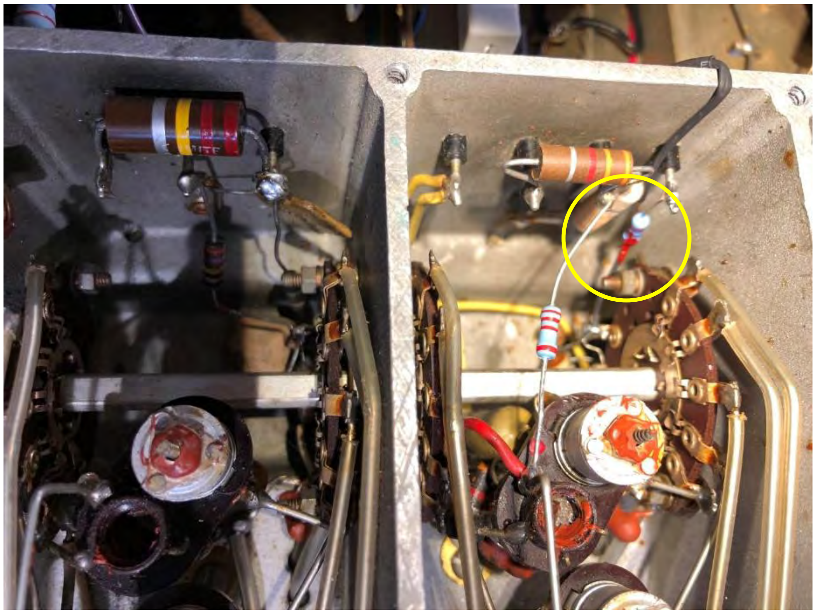
on (switch thrown to 'Standby'), connected the red (HT+) wire from the calibrator and from the receiver HT+ (240vDC supply) to the other pole of the switch, such as when the switch was thrown to 'Standby', the HT+ was connected to the calibrator. A 2.4Mohm resistor was connected across the HT+ connections at the switch to both provide a small leakage current to the calibrator when the HT+ is switched off, to mitigate 'cathode poisoning' of the 6AM6 valve during long periods when the calibrator is not in use (heater on with no HT applied to the valve), and help protect the switch contacts by reducing arcing of the switch contacts. The value of this resistor is not critical – anything from 1.5 to 3.5Mohms should do the job (a resistor like this is used in the S730/4 – see schematic on page 2).

Next, I tried different injection points for the calibrator signal in the RF section (coilbox). In the S730/4, injection is by stray coupling from the signal lead - though I don't have an S730/4 to check exactly how this was achieved. Playing around with 'stray coupling' for a while, I found that this was not very effective, especially on Band 1 (13 – 30MHz). Other Eddystone models (loosely) couple the calibrator into the grid of the Mixer valve, thus, if the RF amplifier stages are de-sensitized, the calibrator signal can still be heard without the signal masking it on the weaker harmonics. In the S940, I thought some experimentation was needed:

- I started by loosely coupling the calibrator output signal to the Mixer valve grid by simply placing the output wire near the grid connection to this valve. This worked ok at lower frequencies (stronger harmonics), but at high frequencies the calibrator signal disappeared into the noise. I tried increasing the 10pF coupling capacitor from the anode of the calibrator valve to its output lead, but even with 1000pF in its place, and still loosely coupled into the receiver (calibrator signal wire placed near the mixer grid connection), the calibrator signal was too weak above around 15MHz, so I swapped the coupling capacitor back to 10pF. I did not want to increase the coupling from the calibrator output lead onto the valve grid with a 'hard' connection (say another 10pF capacitor), so next I checked the calibrator output signal with a 'scope'[1]. I thought perhaps the crystal 'activity' was poor, as after all, it is dated 1959 (photo, right), so its getting on a bit (but not quite as much as me!) - or the valve was weak, however both seemed to be working fine. I noted that the output waveform is not exactly a sine-wave – more triangular in form, but I think that is intentional to encourage generation of harmonics;

- Having established the calibrator was working well, I then tried moving the calibrator injection point to the grid of the 1st RF valve, again loosely-coupled with the calibrator signal wire close to the grid of the valve. This provided better results, with harmonic marker pips being found up to around 27MHz;
- I then added a length of 26 gauge enamelled copper wire ('magnet wire') to the end of the calibrator signal wire and wrapped a couple of turns of the enamelled copper wire around a resistor wire connected to the valve grid, secured with a spot of nail polish - the enamel coating

[1] I used my recently-acquired Siglent 'scope for this – it includes a hardware frequency counter, so I took this opportunity to tweak the calibrator frequency to exactly 500KHz using the trimmer across the crystal. The calibrator also includes an adjustable slug in the screen circuit – this does not affect the output frequency, but can be adjusted to maximise harmonic output



insulating the magnet wire from the grid wire. With this closer coupling, I could easily hear the 500KHz harmonic market pips right up to 30MHz. However, with an antenna connected, marker pips above around 20MHz were often difficult to locate amongst the noise and signals (I live in a very noisy location);

- Then I decided to re-wire the 'Standby' switch again – this time, such that it de-sensitized the 1st RF amplifier stage when switched to 'Standby', ie. the 47Kohm resistor was placed in the 1st RF amplifier stage cathode circuit only, leaving the 2nd RF and 1st IF amplifier stages at normal sensitivity, and move the calibrator injection point, again using the enamelled wire coupling method, to the grid of the 2nd RF amplifier (circled in the photo, above). I thought that doing this would remove the background noise when the calibrator was switched on as the 1st RF stage would be de-sensitized, but the 2nd RF stage onwards would still amplify the calibrator signal. I tried this method out and it worked very well, so I stuck with that. I don't condone modifying radios, especially Eddystone sets, but these minor mods are very easily reversed if ever I wanted to (less than an hours work).

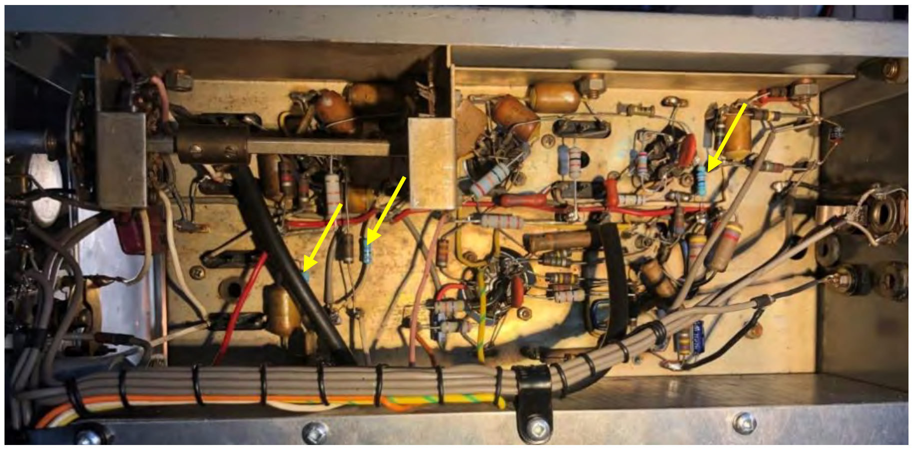
With the calibrator injection methodology optimized, I secured the calibrator unit back into the inside of the cabinet as described above, installed the chassis into the cabinet, hooked the excess cable into the open P-clip to secure it, switched the receiver on and checked all was well.

Alignment Checks and AGC Problem

I left the receiver on 'soak test' with the calibrator operating for several hours and then checked the S940 calibration accuracy. This had not been done for 13 years, and, although it was within specification across most of the scale on each band, I noted it was a little out on all bands, especially Bands 1 and 2. This was just enough to be annoying - so I removed the cabinet again, intending to just tweak Bands 1 and 2. Then I thought I may as well do a full alignment of IF and RF while I had the set on the bench. With the receiver coupled up to a signal generator I noted that the sensitivity was down a bit overall, and that the AGC line was only hitting around -4.5vDC on a strong signal (measured with a VTVM). This was accompanied by some distortion on strong signals that could be resolved by backing off the RF gain. I decided to investigate this before I continued with the alignment:

- The first thing to check on a faulty AGC circuit is the decoupling capacitor. In this S940 it's a 0.1uF disc ceramic of 'Erie' manufacture. I disconnected one end of this, expecting it to have developed a leak (though disc ceramics are generally very reliable), but it tested good – no measurable leakage at 30vDC and a capacitance value of 0.12uF. I even tried subbing with a new poly film capacitor, but that made no difference;

- I then tested the AGC diode (one half of a 6AL5), and although that was also ok, I subbed it for a NOS one anyway that had higher emission;
- I disconnected the AGC diode end of the 50pF tubular ceramic capacitor that passes the IF signal to the AGC diode from the anode of the 2nd IF stage valve and tested that capacitor – no measurable leakage and it measured 52pF. Hmmm, so that was also ok, but I tried subbing with a 50pF silver mica anyway. That made no difference, so I reconnected the tubular ceramic;
- I disconnected the AGC diode from the AGC line and measured the resistance of the AGC line to ground – open circuit, as it should be. Now I was getting a bit desperate(!);



- I measured all the 470Kohm and 270Kohm grid resistors, they had all drifted high, some 270Kohm parts to well over 300Kohms, and 470Kohm parts to over 550Kohms. This would not affect the AGC performance, and I would normally have left them in place, but I decided to change them out anyway (photo, above, with the arrows showing the grid resistors changed out in the IF/AF compartment). As expected, this made no change to the AGC voltage, but at least I felt like I had done something! Hmmm – time to 'think outside the box' Gerry…;
- I disconnected the AGC diode from the AGC line again and now measured -5V on the AGC line – what? - without the AGC diode connected(!)? Could it be a valve problem? – secondary emission on one of the grids perhaps? - or maybe a faulty valve socket, eg. a high resistance conducting path from an anode or screen pin to the grid pin?;

- I decided to check the valves first: all the RF and IF valves tested ok on my tester. Having been caught out by this before, ie. a valve testing good on the tester and still having issues, I decided to sub each valve with another known good NOS one. The 6BA6's (2nd RF and 1st/2nd IF amplifier stages) were subbed first – no change, the voltage was still present on the AGC line. Then I subbed the ECC189/6ES8 (1st RF amplifier), again, no change. I left the NOS 1st RF amplifier valve in place as I had noticed the ECC189/6ES8 that had been in the set was a little low emission on one of its triodes. Last, I subbed the Mixer (6AJ8) valve for a NOS 'International' (Sylvania) one – that was it, now there was no voltage on the disconnected AGC line;
- I reconnected the AGC diode to the AGC line and the set was now generating almost -9vDC on a strong signal and the distortion was gone. This fault was a first for me. The 6AJ8 removed, a Westinghouse branded one of Japanese manufacture – photo, right, tested very good on my tester,

but obviously had an internal fault, possibly some form of secondary grid emission, that was causing the strange IF 'mystery voltage' issue.

I then proceeded with the IF and RF alignment. Only one of the IF cores (T2) really needed a tweak, and some tweaks on Bands 1 and 2 to bring the set onto specification. I also fitted a terminal to the rear apron (through an existing hole) and connected this to the AGC line to allow this to be monitored with the received in its cabinet (photo, left).

That done, the receiver was 'boxed-up' and is now doing stalwart service again, albeit on the corner of my workbench for the time being at least (photo, below). The calibrator is a definite improvement to the S940s functionality, even without a scale-adjustment knob, especially on Bands 1 and 2. A brief demo of the calibrator in operation can be viewed here[2].

Now, I wonder what else is lurking in that Eddystone spares box of mine….? Hmmm, what's this small box with a knob on it and a pigtail of wires connecting to an Octal plug and a meter? – oh, could that be the guts of an S-Meter circuit? Perhaps that could be used on my S.640…? - maybe another day!

Gerry O'Hara VE7GUH, Victoria, BC, April 2020

[2] Please note that I mumble something about tweaking the vanes on the mixer section of the tuning gang to fine-tune the scale alignment (at around 5:04mins in) - of course I should have said "local oscillator section of the tuning gang...". It had been a long day!