Review of IC-9700 for Weak Signal Digital Modes

Note: This Review is based on only one radio and results could vary with different radios.

Pros:

1. An essentially flat passband from 100 Hz to 3000 Hz which is a useful advantage for wide bandwidth digital modes such as MSK441, ISCAT-B and QRA64-E.

2. Internal soundcard, PTT and CAT control all work over a single USB connection which avoids many cables and additional boxes for portable operation, the problem of using modern computers with combo ports (no separate line-in line-out), and reduces hum loops.

3. 1 Hz CAT control stepping for Doppler Correction on EME.

4. I nice feature is the Max power limit which can be set to say 1 watt (or lower) to feed transverters.

5. There is no evidence of ALC overshoot on my tests but I only have a Bird watt meter which is probably not fast enough to see them. VK3WRE has a faster power meter and also reports no overshoot. (It would be useful if others who have more appropriate equipment for testing for overshoot could let us know their results)

4. A generally very nice radio to use.

Cons:

1. It is not GPSDO lockable - despite having a 10 MHz reference input. This is used for calibration only. This is unlike the IC-7610 which does provide for GPS locking of the radio.

2. The stability is not satisfactory for most digital modes - for example up to 30 Hz drift on 144 MHz and 300 Hz on 1296 MHz within 4 minutes each time the fan comes on. These figures are less on VK3WRE's unit so they do vary from rig to rig.

3. The auto-calibration does not give consistent results. I have seen up to 4 Hz error on 144 MHz and up to 40 Hz error on 1296 MHz.

4. If one operates the radio via computer in USB-D mode you cannot just pick up the mike to work SSB such as with legacy radios like the IC-910.

PASSBAND

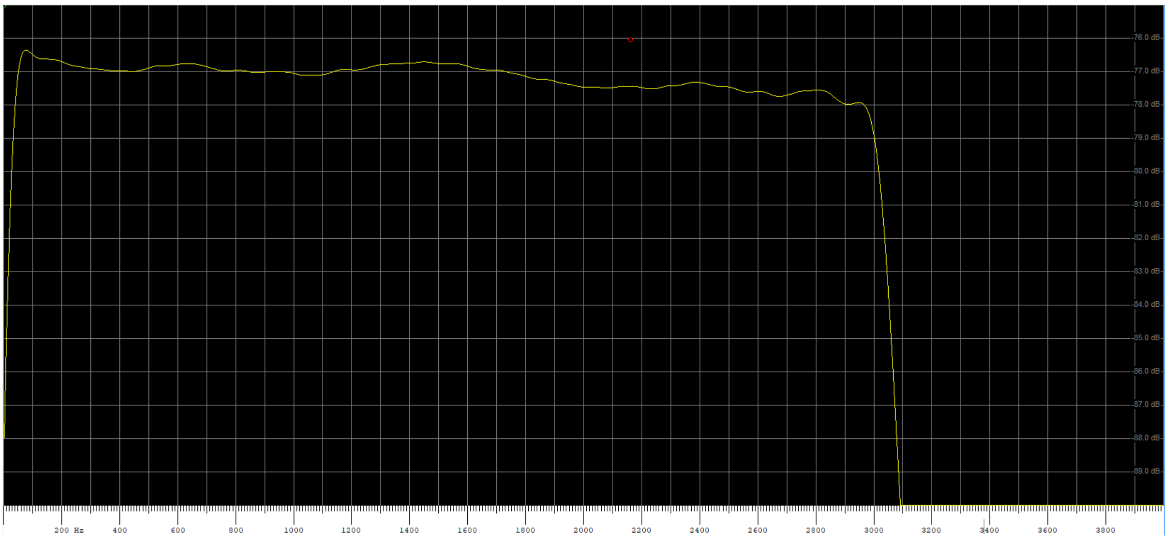

Fig 1: Passband for Filter 1 default setting of 3 KHz and "sharp". The vertical scale is 1 dB as indicated by the horizontal lines. The horizontal scale is 0 to 4 kHz.

Fig 1 shows that over the range 400 Hz to 2.8 kHz the passband is within +/- 0.5 dB which is excellent for the wider digital modes such as MSK441, ISCAT and QRA64-E. In case one is tempted to make it wider Fig 2 shows what happens if you increase the passband to the maximum of 3.6 kHz. Note that if you use the "soft" setting on the filter the response drops off significantly before each end and thus only the "sharp" filter is recommended.

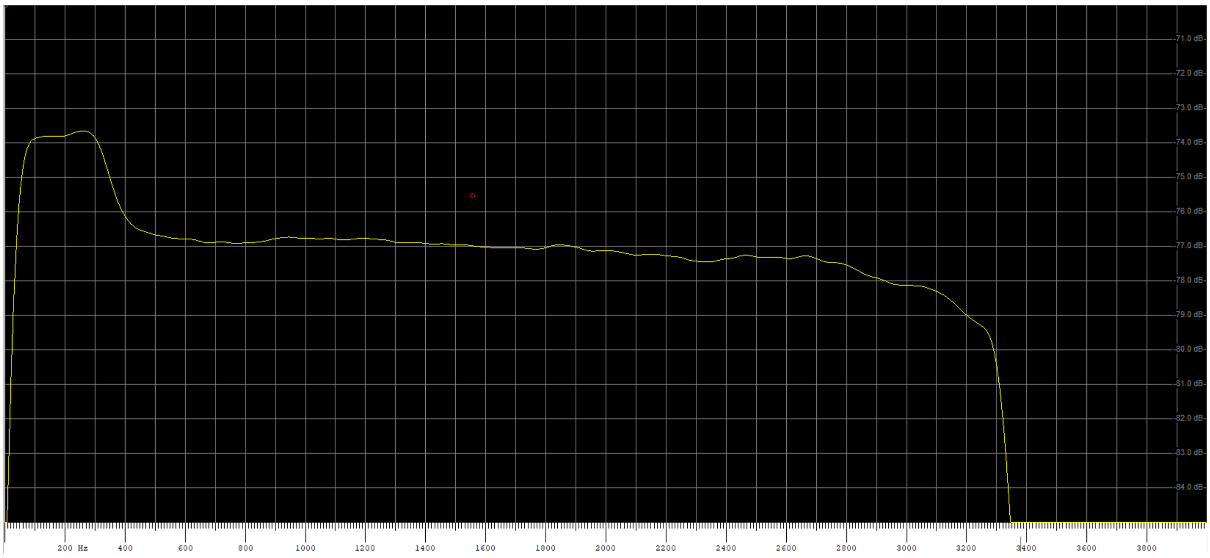

Fig 2: Passband increased to the maximum of 3.6 kHz

Fig 2 shows a 2 to 3 dB hump between 100 Hz and 400 Hz and while the passband does extend beyond 3 kHz the level is essentially no better at 3 kHz. Accordingly it is recommended that one keep the passband at the default value of 3 kHz.

STABILITY TESTS

Test Procedure

The test procedure for the stability tests below is based on the IC-9700 listening to a GPSDO locked signal source with an accuracy of 3 parts in 10^10. The IC-9700 is tuned 1 kHz below this to produce a 1 kHz tone which is fed to Spectrum Lab with a resolution of better than 1 Hz. Thus in most cases the drift that is seen is during the RX period. When the IC-9700 transmits there is a gap and thus the drift is measured between successive transmissions.

To check the actual drift during transmission with the IC-9700 one test was done (Fig 9) by listening to the transmissions with a separate GPSDO locked IC-9100 and this shows the drift on TX is similar to what is seen by looking at the gap between transmissions.

Examples of Drift

Fig 3 below is an example of the frequency stability on 144 MHz with the rig operating in a home environment and the case temperature varying by about 10 Degrees C.

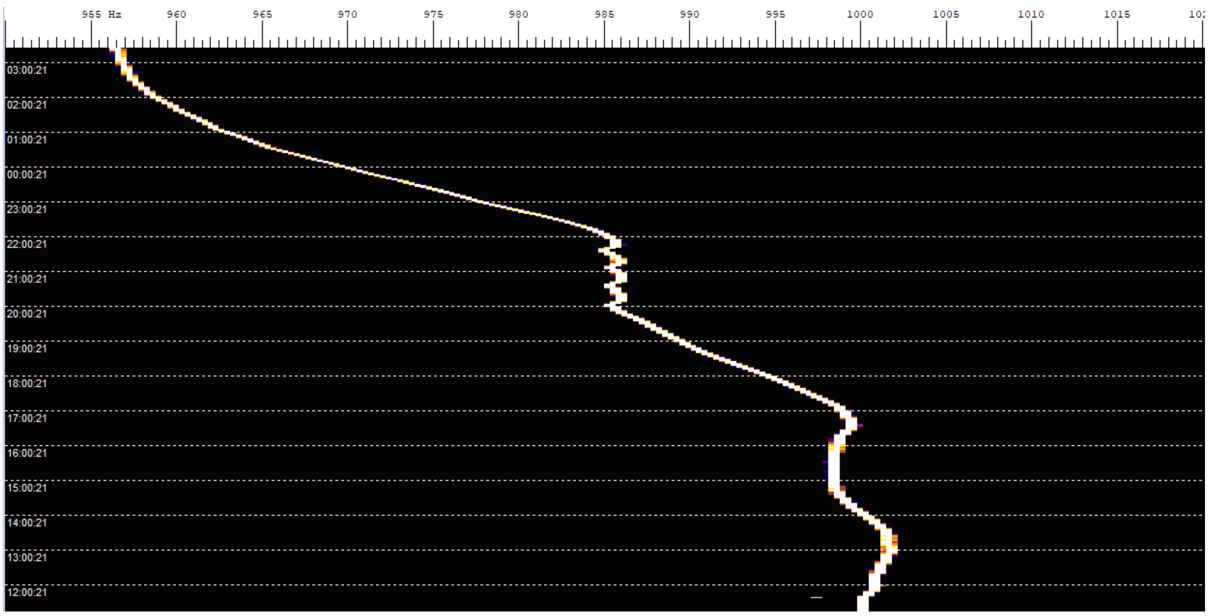

Fig 3: Frequency variation on 2 metres with a temperature variation of about 10 Degrees C over about 16 hours while not transmitting. The odd looking small ripple is due to the airconditioning system turning on and off and is not significant. Only the broad trend is relevant to the radio. The total frequency variation in a typcial home environment is around 40 Hz.

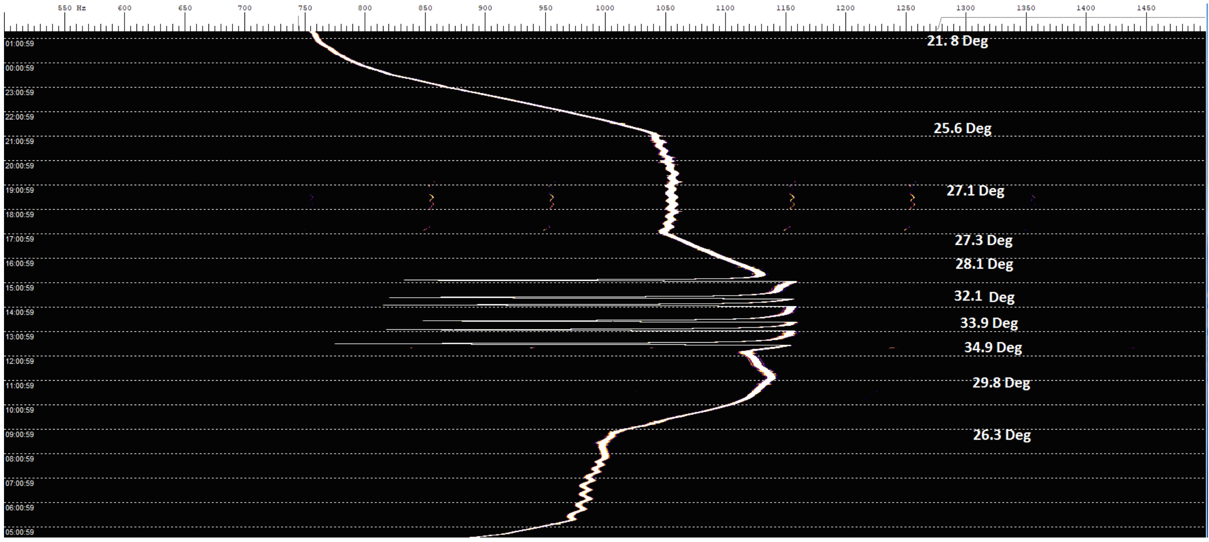

Fig 4: A similar test to Fig 3 on 1296 MHz.

Fig 4 shows frequency variations of over 300 Hz at 1296 MHz. The jumps occur when the temperature rises above about 30 degrees C and are related to the cooling fan turning on and off.

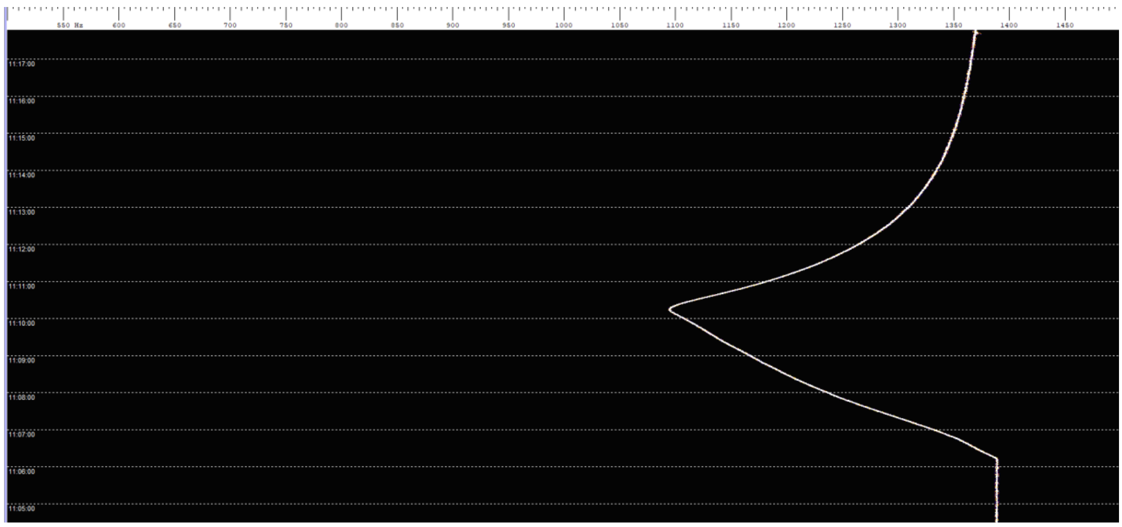

Fig 5: Example of a frequency jump at 2 metres scaled up. Vertical scale is indicated by the horizontal lines and is one 1 minute per division. Unless one is transmitting the case temperature needs to be above 30 degrees C to cause the jumps.

As seen in Fig 5 the jumps go low in frequency by around 30 Hz over about 4 minutes and exponentially return to the original frequency over another 10 minutes or so. I was able to correlate the downward jump in frequency with the fan turning on.

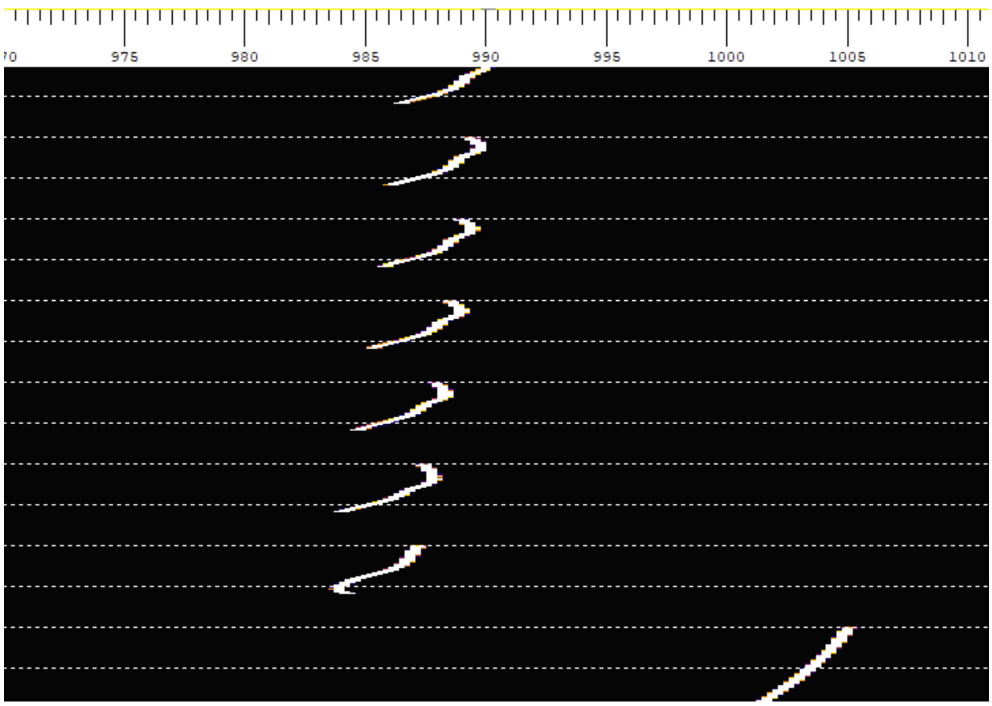

Fig 6: Shows frequency variations on 2 metres when transmitting the digital mode QRA64 C. The vertical scale is indicated by the horizontal lines which are 1 minute periods. The data is for the receive period after the completion of each transmission.

The bottom of Fig 6 starts at the time of a first transmission at 50 watts on 2 metres. It is seen that there is a frequency change of around 20 Hz on the first transmission but after that the changes reduce to around 4 Hz. It turns out that this occurs because the fan comes on several seconds after the start of each of each transmission and stops at the end of the transmission (unless the case temperature is above around 30 degrees C). The first transmission thus causes the largest jump until the fan comes on consistently and the drift reduces.

It is clear that the key stability problem relates to the fan turning on and off and thus one could expect a significant improvement if the fan ran all the time. In relation to the jump on this first transmission the size of the jump is not significantly affected by the power level during transmission. Nevertheless, one would expect significant changes over a longer time scale when transmitting at higher power.

Comparison with a GPSDO locked IC9100

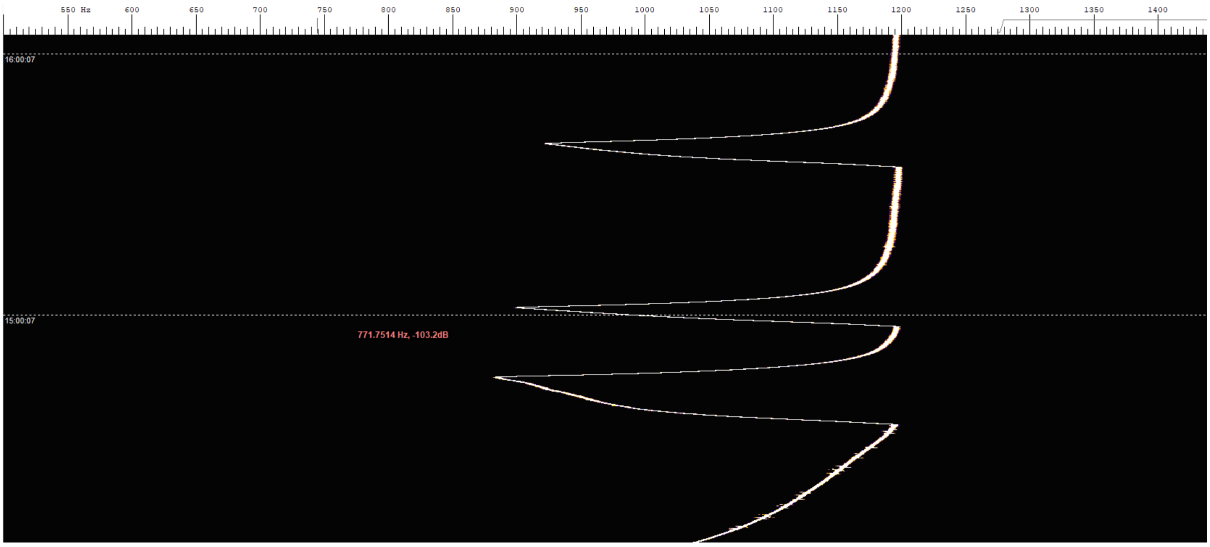

Fig 7: IC-9700 receiving from a GPSDO signal source. RX only but with case temperature above 30 degrees so the fan turns on and off.

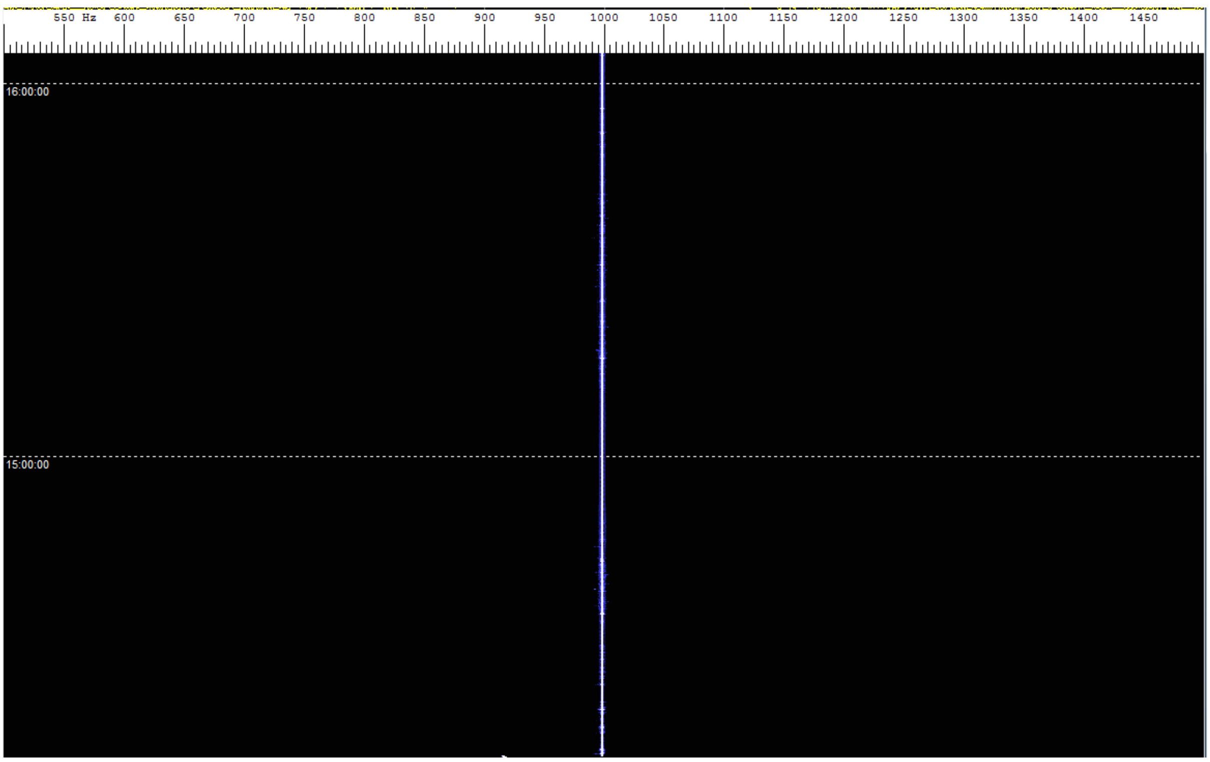

Fig 8: The same test at the same time and with the same scale as for Fig 7. But in this case the receiver is an IC9100 GPSDO locked with a VK3HZ unit.

As can be seen by comparing Figs 7 and 8, GPSDO locking provides a dramatic improvement in stability.

Test to confirm drift during transmission

The drift during transmission as measured on a GPSDO locked IC-9100 (Fig 9) is compared with that on the IC-9700 during the RX period (Fig 10). These tests are at 144 MHz with a transmitter power of 20 watts. There was a 10 minute break in transmission to show the increase in drift during the first period of transmission.

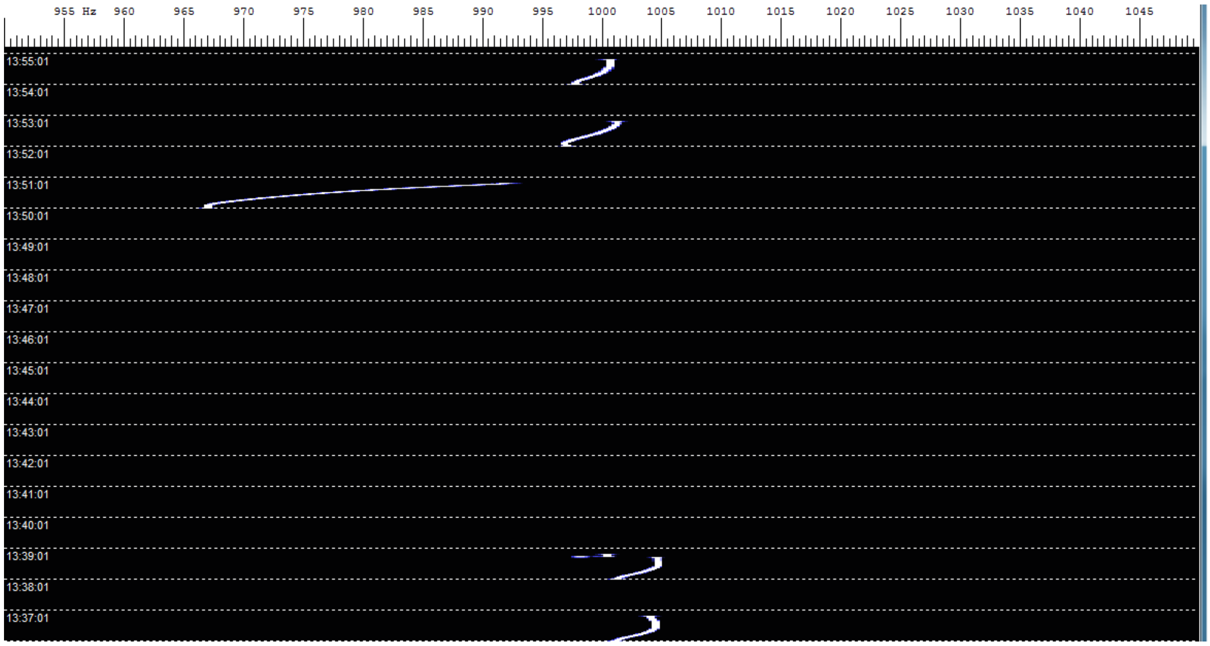

Fig 9: Drift with the IC-9700 transmitting as received on the GPSDO locked IC-9100. In this case transmission was stopped for 10 minutes to show a frequency variation of around 20 Hz on the first transmission due to the Fan coming on. If you look carefully at the start of the period at 13:50 there are few seconds where it is stable before the fan comes on.

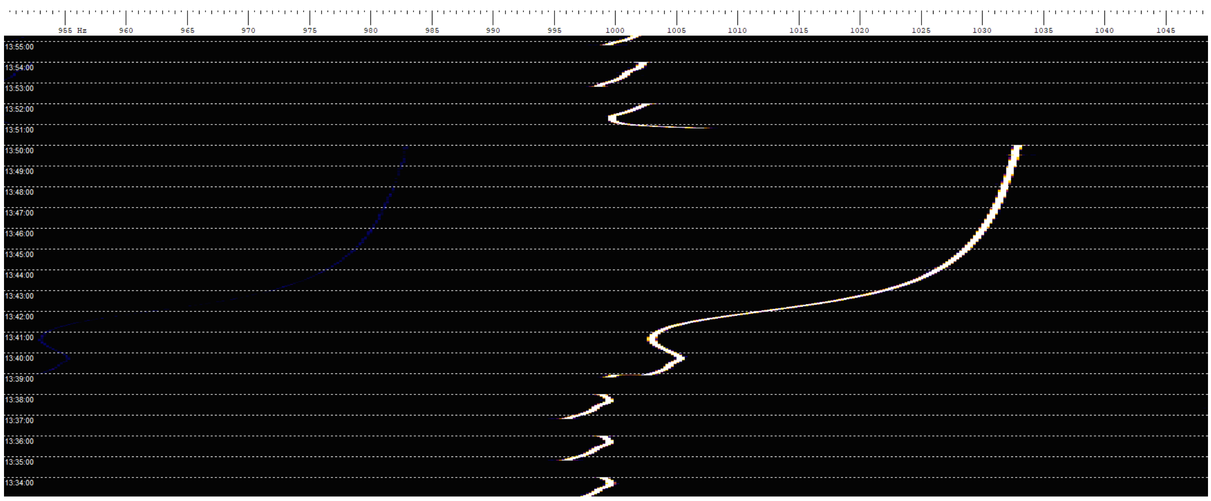

Fig 10: Drift on the IC-9700 at 2 metres during the RX period between transmissions. It is seen that when transmission is stopped for the 10 minute period for 13:39 to 13:50 the frequency increases by around 30 Hz which relates the Fan not being on.

As shown in Fig 9 and Fig 10 the drift is around 4 Hz providing one transmits regularly every second period (1 minute) on QRA64. However after a 10 minute break the effect of the fan going off 10 minutes and then on again increases the drift to around 30 Hz. The tests in both Fig 9 and Fig 10 show similar amounts of drift by both methods.

CALIBRATION FACILITY

The calibration facility has both a coarse and fine adjustment and this can allow calibrations to better than 1 Hz at 2 metres. But in addition to being able to apply an accurate 10 MHz signal to the Reference Input socket it does require an accurate and stable GPSDO locked source and a set-up such as Spectrum lab to adjust it.

There is also a Auto-Calibrate facility which makes the process much simpler as all you do is apply the 10 MHz reference and press the button to calibrate it. However this is not as accurate as using the fine adjustment and I have seen calibration errors of up to 4 Hz at 2 metres and 40 Hz at 1296 MHz.

Tests on WSPR at 2 metres

Tests transmitting WSPR at 50 watts on 2 metres show no decodes at all if running at a 10% duty cycle while it does decode (even if intermittently) if the WSPR duty cycle is increased to 50%. In effect by running at 10% duty cycle we let the fan stop for an extended period thus when it does transmit after an extended period this is equivalent to a first transmission as reported above. VK3WRE reports that his IC9700 does work on WSPR so it is likely that there are variations between IC-9700s.

Tests on QRA64 at 1296 MHz

Initial tests with VK7PD who has a GPSDO locked TS2000, showed no decodes at all on QRA64C as normally used on 1296 MHz. We then tried QRA64D which has twice the tone spacing VK7PD started to achieve decodes but it took several transmissions before VK7MO achieved decodes. It is considered that as seen on 144 MHz that decodes were only achieved when the fan is running consistently each transmission.

POSSIBLE SOLUTIONS

It is clear that a significant improvement in short term stability could be achieved if the fan was connected to run full time.   And this is certainly worth testing.

Another solution that has been considered is a software fix that continuously up-dates the auto-calibration function against the external reference. Unfortunately the errors in auto-calibration discussed above suggest that this would introduce random frequency jumps of up to 4 Hz on 2 meters and 40 Hz on 1296 MHz which would be mean it could not be used for digital modes with similar tone spacing. For this approach to work on digital modes like WSPR the accuracy of the auto-calibration function would have to be improved to a better than a Hz.

In my opinion the only reliable solution is to make provision for the radio to be phase locked to a GPSDO and this is likely to require a hardware fix along the lines that has been successfully applied to the IC-910 by the author and the IC-9100 and a wide range of radios by VK3HZ . Much of what is required is already included with the existing calibration facility but it would require an additional board to be developed and added by hams to the radio. I understand that there are concerns that people may lock the radio to a poor 10 MHz oscillator and that this will degrade the phase noise performance. However, most people who use digital modes on VHF and above use very high quality 10 MHz double oven GPSDOs. I consider this concern can be overcome by a note that the phase noise performance may degrade depending on the quality of any 10 MHz source used to lock the radio. Whether such a fix is even possible on an the IC-9700 can't be established until we have a service manual and go through extensive development and testing. Provision should be made for the radio to revert to its present mode of operation if the GPSDO is removed. This is standard practice on all the GPSDO locking systems designed by VK3HZ.

ICOM are listening to us on this issue and hopefully they can come up with an innovative solution.

CONCLUSIONS

While the IC-9700 is an major advance and an exciting new radio this particular IC-9700 is not suitable in its current form for weak signal digital modes. More test are required on a number of IC-9700s to establish if the stability issues found in this review relate to a general problem or only this one radio. While the stability should be improved by running the fan continuously the author considers that with increasing trend to digital modes, GPSDO locking is essential for any new radio at VHF and above where the effects of drift are many times worse than at HF.