The Signal

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COLLINS COLLECTORS ASSOCIATION
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The Collins 32S Series

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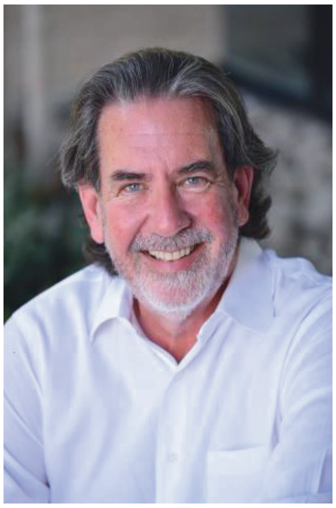
Collins Collectors Association

From the President's Desk...



This is a busy time for the CCA leadership team. Dayton is fast approaching and this is the time of the year to finalize all the Dayton plans. We will be at the same location as we have been each year at Xenia. It is a busy traffic area so we expect lots of visitors - but this year I am trying to get a 20 meter inverted V up outside the building and am bringing two Collins suitcases with a KWM-2/PM2 and a 30L-1. We are going to run a special event on Friday and Saturday afternoon on 14.263. Should be a lot of fun and we will try and get as many of you as possible to run the station. This should be a great way to show off Collins gear to the Dayton attendees.

Friday night we will have our annual CCA banquet at the Miami Valley Golf Club. This has been a nice venue for us with great food and service. Social hour will begin at 6pm and dinner at 7pm.

Rod Blocksome, K0DAS will be our speaker this year. Rod is an ex Collins Engineer/ Product lead. Rod was responsible for the development of the 8023 1KW Solid State amp and also the 3KW 8021 Amp. Since retiring from Collins, Rod has been involved with the search for the answers to Amelia Earhart's disappearance and also a board member of the Arthur A. Collins Legacy Association - AACLA. The AACLA has been producing several videos on the history of Collins Radio and he will be showing the second video 'Moon Talk' and discussing the production of the third video titled 'Live From The Moon'. Rod is an engaging speaker and it should be a fun evening.

Francesco and I are on the way back from California and we have had a whirlwind trip. First a stop at Wayne, W6IRD and Sharon, K6IRD Spring's home. Always a great time with this wonderful couple — Wayne volunteered to be on the board last year and his wisdom and knowledge is invaluable to us — his vast knowledge of Collins and restoration is amazing. We visited and played with radios until Ron Mosher, K0PGE, our treasurer, showed up and the group drove over to Huntington Beach to see Pete Zilliox, K5PZ, and his shack. Pete spent many years as the CCA membership chairman and the CCA owes Pete big time for his years of service. He has lots of Collins and other restorations in his shack and each one is a piece of art and used on a regular basis. Pete loves restoring radios and it shows!!

Saturday morning, we drove up to Santa Clarita to see Jim Stitzinger, WA3CEX and were able to spend a couple of hours with Jim and Debbie. I know everyone is concerned for Jim and I can say that both Francesco and I were excited to see the progress that Jim has made. Lots of hard work in rehab seems to be paying off and we hope to see Jim back on his feet and at Dayton soon. We also had the opportunity to spend some time looking through Jim's incredible collection of radios, memorabilia, and literature. Going to Jim's always makes me sinfully green with envy - hey - at least I admit it!

Then off to the desert to see Dennis W6DQ and Lisa Kidder. Lisa just got her General - congrats! - and she will have lots of radios to play with. By the time you read this, the Kidder's will have tied the knot - again Congrats!! Dennis has an eclectic collection of the old and new with some really unique and one of a kind radios, again, another shack to make any collector green with envy.

Now it is Sunday afternoon and, on a jet, headed back to Dallas. This weekend has reminded me that the CCA is much more than the love of Collins - it is about the comradery of a bunch of guys that are passionate about ham radio and the equipment that Collins brought us. Join us on one of our many nets or, better yet, pack a bag and head to Dayton this May.

Francesco has embraced his job as Signal editor and has worked diligently to produce these last two issues. This issue covers important information about the 32S-3 transmitter. In addition to this, there is important 30L-1 info posted on the CCA website at www.collinsradio.com that every S-Line user needs to read.

Looking forward to seeing everyone at Dayton!!

- Scott, KE1RR
President, CCA
president@collinsradio.org

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You can renew your membership or join the CCA on our website using the "JOIN US" link.

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*Sunday 14.263 MHz at 2000Z
*Tuesday 3805 kHz at 8pm CST
*Thursday 3805 kHz at 8pm CST
*Friday [West Coast] 3895 kHz at 10pm CST
*Sunday 29.050 MHz at 10am CST

From the Editor

Dear Friends,

In this issue we cover a serious problem that may arise from a modification that was often applied to the 32S-3 to increase the Grid Drive. It was recently discovered that this mod introduces some non-linearities that produce unwanted frequency spurs. In his article, Don shows the effects with clear spectral measurements. If you have a 32S-3, the CCA recommends that you investigate if this modification was done to your rig and, if it was, return your 32S-3 to the original factory configuration.

The second article from Asa Jay Laughton, W7TSC covers remote control of the more modern and popular HF2050.

We also have an article on the 32S-3 SYNC function, which has never been described in detail nor thoroughly analyzed. Bob Jefferis, KF6BC, has definitely filled this technical void with his article.

We are looking for new contributors and new ideas for future issues to the Signal magazine. If you are interested in contributing an article or have a suggestion for an article or topic you would like to see in Signal, please drop me a line.

Special thanks to my partner editor Buzz Beitchman, W3EMD and all contributors to this issue.

Best Regards,
Francesco Ledda, K5URG
Editor & Vice President, CCA
k5urg@yahoo.com

The C20 Modification for the 32S-3/3A Transmitter

By Don Jackson, W5QN

Many years ago, this modification started circulating while the 32S-3 was still in production. Its origin is unclear, but it has been performed on countless 32S-3 transmitters. This was refreshed and exacerbated when Bud Whitney, K7RMT - without benefit of a Spectrum Analyzer - picked up the modification as a commonly accepted one and started both doing it and recommending it in his writings. In addition, the modification has been made available in other media and performed by numerous repair shops while doing a series of common modifications. As you will see in this article, the recommendation is that this mod be promptly removed and the transmitter returned to its original, as manufactured configuration (regarding this change only).

A few weeks ago I had my 32S-3 out of its cabinet, so I thought it would be a good time to install some of the common modifications often recommended. Among the modifications is a recommendation to change C20 from .01uF to .001uF to increase grid drive. C20 couples the BFO signal into the 1st Mixer cathode (V4), when in TUNE, LOCK KEY or CW modes. After doing this modification, I tuned up the rig at the bottom end ("0" logging scale) of the 14.0 MHz segment. I happened to be looking at my RF output signal on my spectrum analyzer and noticed two rather large spurious outputs on either side of the desired carrier. Their amplitudes were large enough to exceed the 32S-3 specification of -50 dBc. Much worse, the lower frequency spur was outside the 20m band! Alarmed, I changed C20 back to .01uF, and the spurs dropped down by 30 dB or so.

What Is Going On?

A few more measurements showed that the problem was the worst at the bottom end of all the bands, meaning that the spurs were being generated in the 1st Mixer. The 1st Mixer combines the crystal BFO with the VFO signal when in TUNE, LOCK KEY or CW modes. The spurs do not occur in SSB modes because the crystal BFO is applied to the balanced modulator, allowing the 455 kHz mechanical filter to clean up the 455 kHz input to the 1st Mixer.

So, in order to fully understand these observations, I needed to determine what combinations of the BFO and VFO signals and their harmonics could produce spurious signals that would fall in the vicinity of the 2.955-3.155 MHz IF bandpass filter. Spurious signals that fall within, or close to, the IF passband will be converted to the RF output, regardless of the selected band segment. A little number crunching with my old spur calculator program yielded the following possibilities:

> Spur #1: 7th harmonic of the crystal BFO: (7 x .45635 MHz = 3.19445 MHz)
> Spur #2: Mixing of the 2nd VFO harmonic with the 5th BFO harmonic: 2 x 2.69865 MHz – 5 x .45635 MHz = 3.11555 MHz
> Spur #3: Intermodulation of the desired IF output 2nd harmonic, and Spur #2: 2 x 3.155 MHz - 3.11555 MHz = 3.19445 MHz

Interestingly, Spur #1 and Spur #3 are on the same frequency. In practice, Spur #1 is much lower in amplitude than Spur #3, so Spur #1 can be ignored for all practical purposes.

For the 14.0 MHz band segment, we can translate these IF frequencies into transmitted RF output frequencies by subtracting the IF frequency from the appropriate XTAL OSC frequency:

> RF Spur #2: 17.155 MHz – 3.11555 MHz = 14.03945 MHz
> RF Spur #3: 17.155 MHz – 3.19445 MHz = 13.96055 MHz (out of band!)

A chart generated from a spreadsheet calculator is shown in Figure 1. These frequencies are for a typical 32S-3. (Let me know if you would like a copy of this Excel spreadsheet.)

Observing Spur #3 on a spectrum analyzer, you will notice that it does not vary in frequency as the VFO is tuned, whereas Spur #2 and the desired RF output frequency will vary. This is an important point because it means that the out of band spur at 13.96055 MHz remains at this frequency, regardless of the setting of the VFO.

Inputs			
BFO Frequency	=	0.45635	**MHz**
VFO Frequency	=	2.69865	**MHz**
HF XTAL Osc.	=	17.15500	**MHz**
IF Frequencies			
Desired Output		3.15500	**MHz**
Spur #1 (7*BFO)		3.19445	**MHz**
Spur #2 (2*VFO-5*BFO)		3.11555	**MHz**
Spur #3 (IMD w/RF out)		3.19445	**MHz**
RF Out Frequencies			
Desired Output		14.00000	**MHz**
Spur #1 (7*BFO)		13.96055	**MHz**
Spur #2 (2*VFO-5*BFO)		14.03945	**MHz**
Spur #3 (IMD w/RF out)		13.96055	**MHz**

Figure 1 – Typical 32S-3 Spur Chart

Figures 2 and 3 show the RF output on a spectrum analyzer for C20 values of .001uF and .01uF respectively. The 32S-3 was tuned up for an RF output frequency of 14.000 MHz. "0 dBm" represents 100W RF output power.

As can be seen in Figure 2, the spurs do not meet the 32S-3 specification of -50 dBc with a C20 of .001uF. Worse, the lower spur will be stationary, about 40 kHz out of band, regardless of the selected transmitter RF output frequency. (Note: The spur occurring at approximately 14.080 MHz is a spur generated by mixing the 11th harmonic of the BFO with the 3rd harmonic of the VFO, but it still meets the 32S-3 specification.)

Figure 3 with the original C20 value of .01uF nearly eliminates those spurs, with remaining spurs well below the -50 dBc spec.

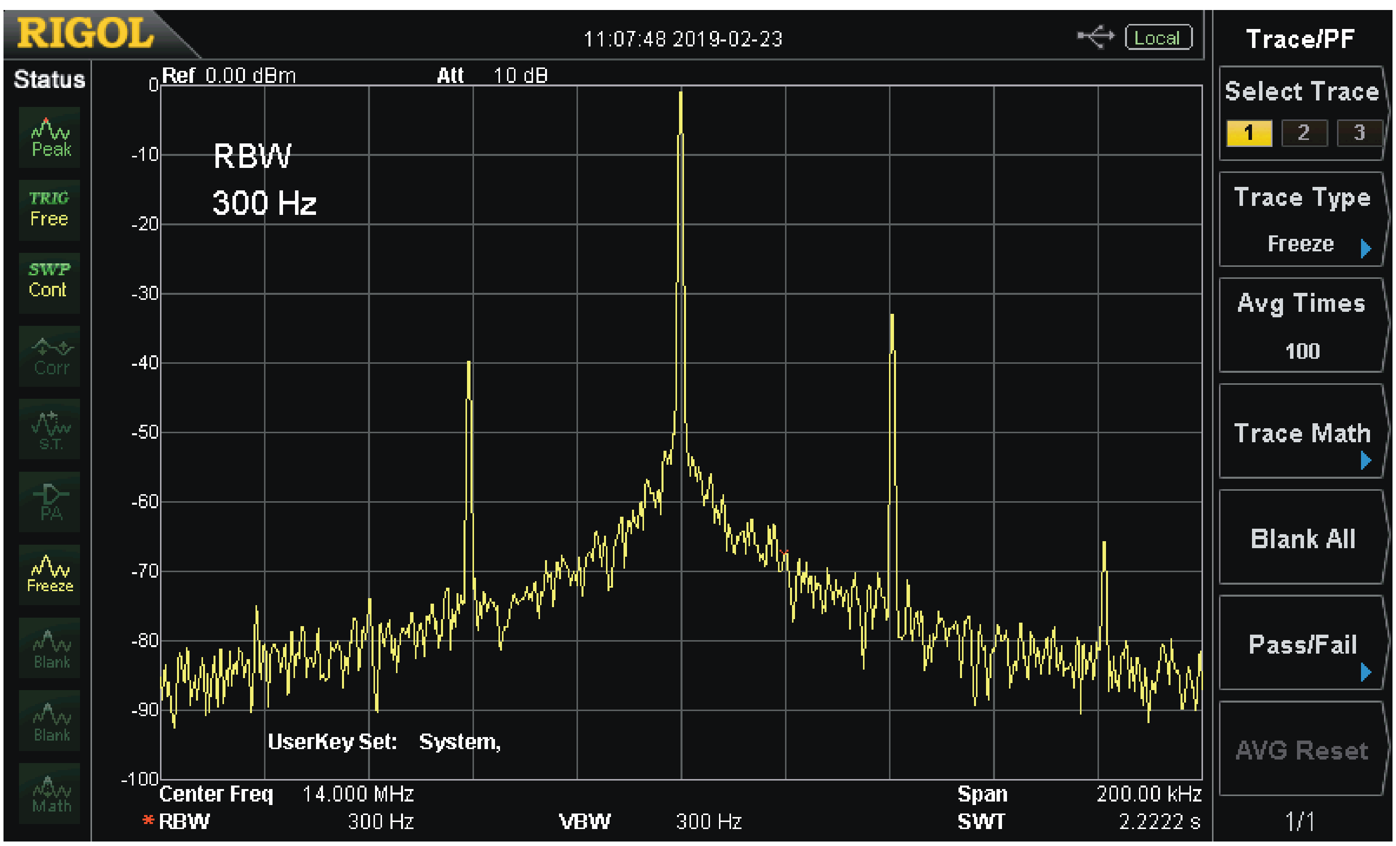


Figure 2 – RF Spectrum with .001uF C20

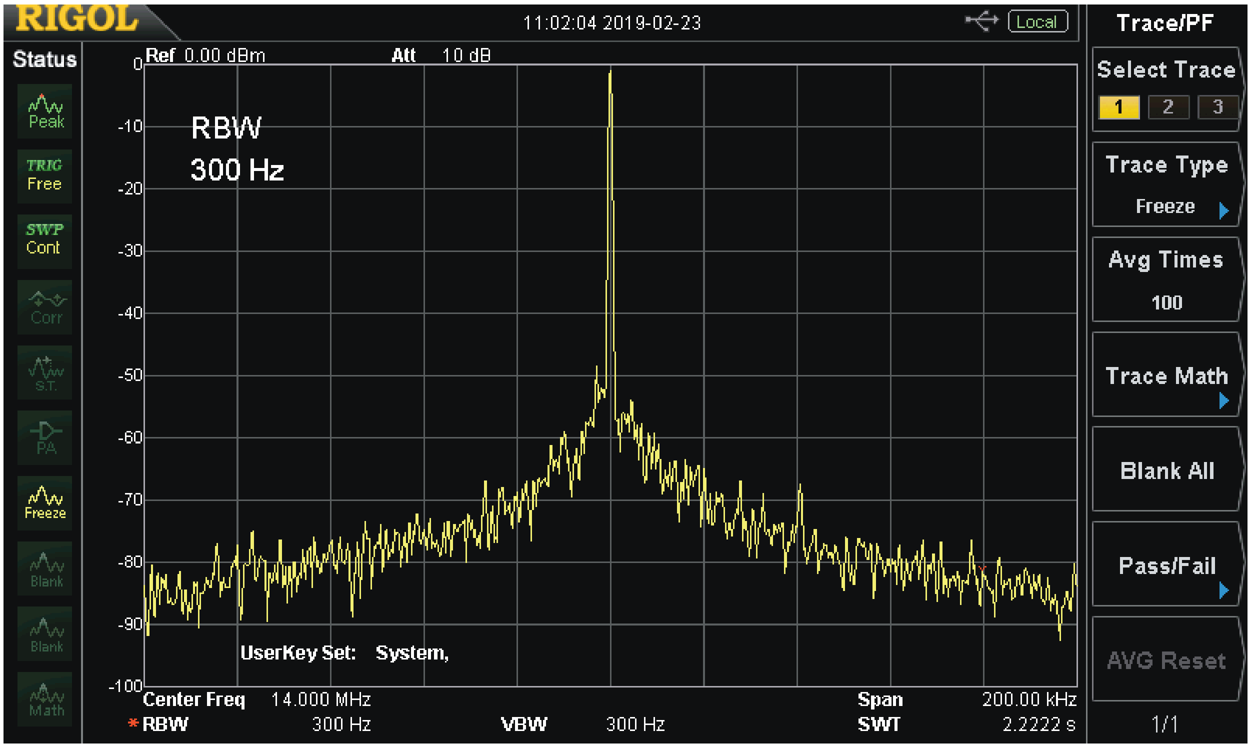


Figure 3 – RF Spectrum with .01uF C20

Why Does a .001uF C20 Cause These Spurs?

Determination of the precise cause is not a trivial task. Analysis and measurements indicate that the problem is likely associated with increase in BFO harmonic content with the .001uF installed. Increased BFO signal may cause this, and another possibility is the terminating impedance the 1st Mixer sees with a .001uF C20 vs. a .01uF C20. The cause is likely a combination of factors. A likely "smoking gun" can be seen in Figures 4 and 5. These are spectral plots of the crystal BFO signal as measured at the 1st Mixer BFO input port, V4 Pin 3. Figure 4 was with a .001uF, and Figure 5 is with a .01uF.

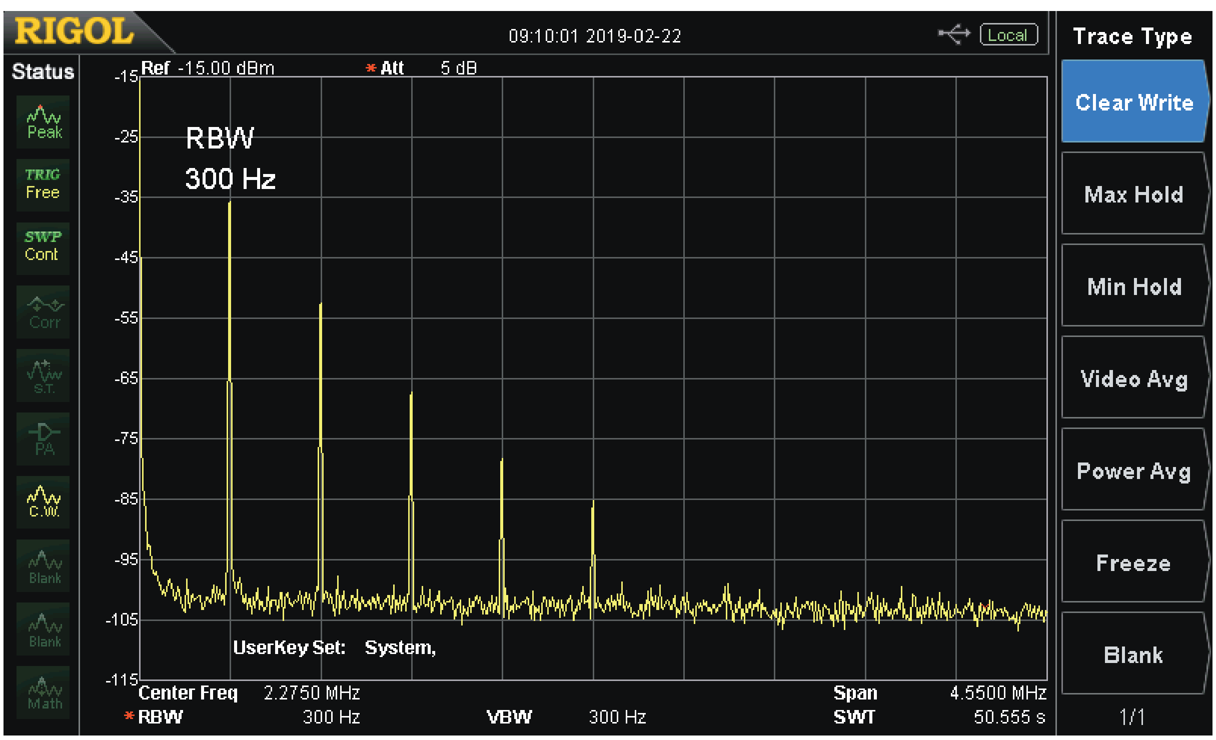


Figure 4 – BFO Signal with .001uF Showing Increased 5th Harmonic Level

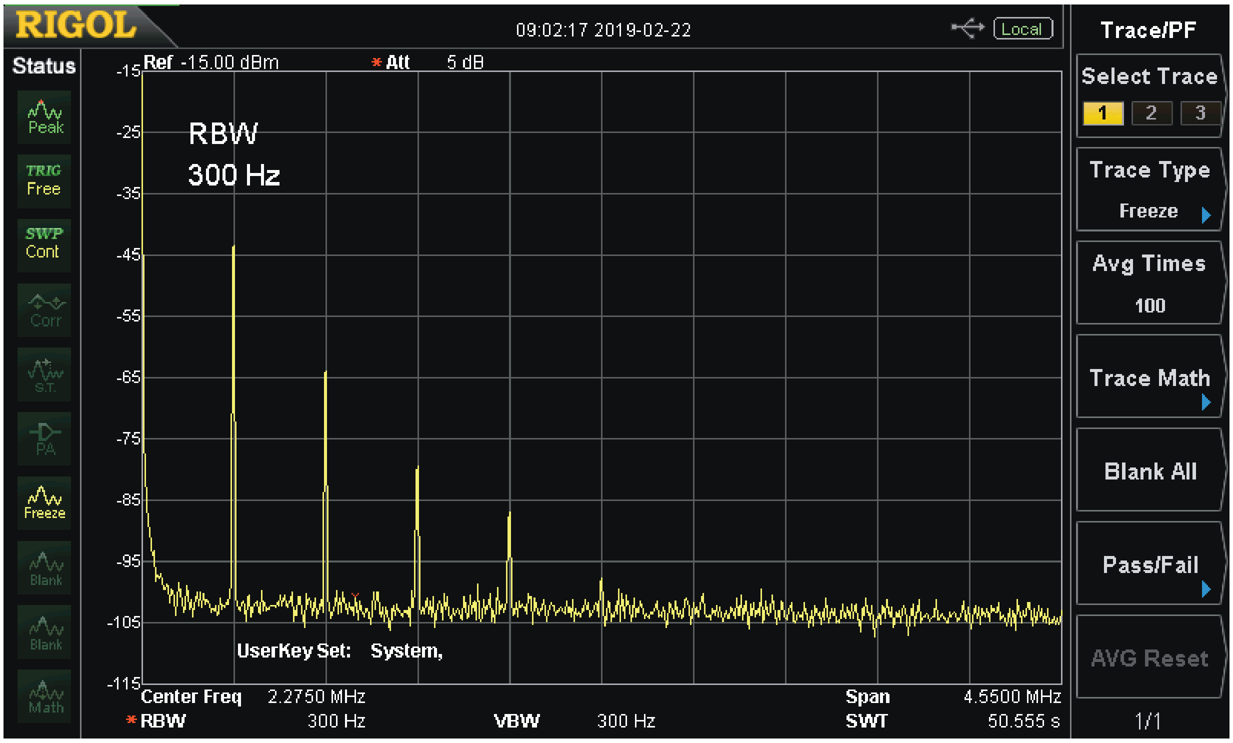


Figure 5 – BFO Signal with .01uF C20

Note that the fundamental of the BFO is about 8 dB higher with the .001uF installed. This higher BFO level with the .001uF is due to the lighter loading of the BFO oscillator. The lower level of the BFO with the .01uF installed likely contributes to the lower spur level. Of particular importance is the magnitude of the 5th harmonic. Recall from earlier in this article that the 5th harmonic of the BFO is a key contributor to the 2*VFO minus 5*BFO mixing spur. In the above figures, we can see that the 5th harmonic of the BFO is about 13 dB lower with the .01uF than with the .001uF.

The 32S-3 Drive Increase with the .001uF Modification

One of the initial questions I had about the C20 modification was how changing from a .01uF value to a .001uF value could increase the 32S-3 grid drive. On the surface, that seemed counter intuitive. In order to determine what might be happening, I resorted to a Spice model of the circuitry between the BFO tube plate and the 1st Mixer tube grid. It turned out that this circuitry has a bandpass characteristic, primarily due to the LC network at the BFO plate. The maximum response of this network is normally around 410 kHz or so with a C20 of .01uF. However, when C20 is changed to .001uF, the response peak moves up to around 445 kHz, increasing the 455 kHz output. Figure 6 shows the two scenarios.

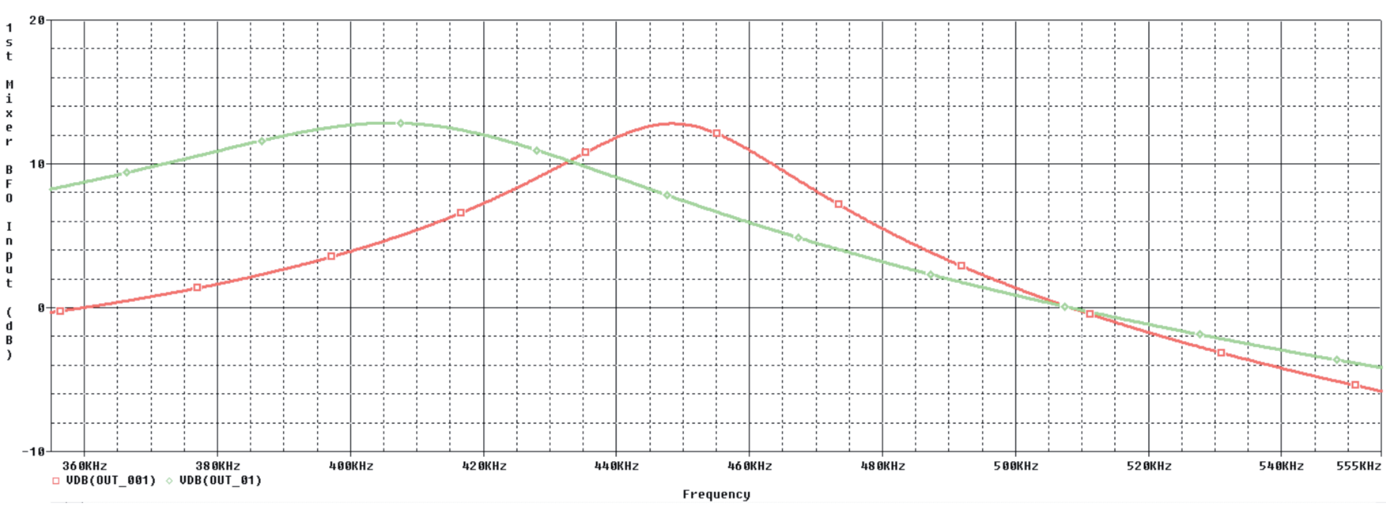


Figure 6 – Spice Simulation of the BFO Plate to 1st Mixer Grid Circuitry

As Figure 6 indicates, the simulation predicts that changing C20 to a .001uF increases the BFO drive to the mixer by about 5 dB at 455 kHz. Note that this is only a simulation, and behavior in the actual 32S-3 is highly dependent on the exact component values, particularly the LC components connected to the plate of the BFO tube.

How to Replace C20

First, determine if you need to replace C20. You can do this by taking the 32S-3 out of its cabinet and checking the value of C20. It should be .01uF. Alternatively, if you have a spectrum analyzer, tune the unit up at the low end of a band, and observe the output signal. If it is similar to Figure 3, you are ok. If it looks more like Figure 2, it's time to replace C20. The good news is that this is an easy fix.

Figure 7 shows the location of C20 under the chassis. It is relatively easy to get to, and can be replaced with careful soldering techniques. If you aren't comfortable with complete replacement, the spur problem can be solved by simply soldering a .01uF capacitor to the leads of the existing .001uF capacitor. The C20 shown is a .01uF with value code "103". A .001uF capacitor would have a value code of "102".

I recommend that the First Mixer Balance Adjustment (4.5.7 in the 32S-3 manual) be performed after installing the .01uF capacitor. In fact, I was concerned that installing the .001uF capacitor without performing this alignment might actually be a contributing factor to the spur problem. However, experiments showed that the First Mixer Balance has virtually no affect on these spurs.

For those of you with 32S-1 transmitters, this particular spur problem does not apply to that unit. In the 32S-1, the CW mode is not implemented by direct application of the crystal BFO to the 1st Mixer. All 455 kHz energy is passed through the mechanical filter, so the spur problem discussed in this article is not an issue.

Figure 7 – Location of C20

Conclusions

The spur issue with a .001uF C20 has been demonstrated on the four 32S-3 units tested. All units worked properly with a .01uF C20, and every unit had the spur problem with a .001uF installed. In every case, the C20 modification caused the 32S-3 to fail its 50 dBc spurious specification. Much more importantly, it significantly strengthens a spurious output that falls outside the ham bands. Since the spurs are generated in the 1st Mixer, RF output spurs are created on all band segments, although they are most noticeable toward the low end of each 200 kHz band segment.

These spurs only show up in TUNE, LOCK KEY and CW modes. In SSB modes, the spurs do not occur because the mechanical filter cleans up the 455 kHz signal.

The bottom line is, if you have a .001uF installed for C20, replace it as soon as you possibly can. The slight increase in grid drive from the .001uF is certainly not worth the unintended consequences.

A big thank you to Bob Jefferis, KF6BC, Dick Weber, K5IU and Bill Carns, N7OTQ for their help with this article.

Cheers,
Don, W5QN

Collins HF-2050 Receiver Remote Control

By Jay Laughton, W7TSC

After purchasing a Collins HF-2050 Receiver at a Hamfest in Spokane Washington, I proceeded to get it working and then wondered about remote control. The right-most button on the front panel, [CNTL], toggles between LCL and RMT. Since it looked like remote was possible and having used the remote software for controlling HF-80 radios, I thought there might be software available for it.

I searched the Internet and was given contacts through the CCA to investigate. My efforts didn't turn up any existing software but I was given encouragement that it wasn't hard to do. With the receiver technical manual in-hand, and a desire to see what could be done, I charged ahead.

This article will focus on how remote serial control can be made with the HF-2050 receiver. The information presented here is from my own experience with the radio, limited as it may be. Some technical information displayed in this article is extracted from the HF-2050 manual:

C-51-534-000/MS-001
Radio Receiver
R-5099/U, R-5099A/U, AND R-5104/GRC-508

Addressing, Baud Rates, and Serial Standards

The HF-2050 can be configured with any one of 16 addresses ranging from 0-15. This allows the control of several radios independently from a single remote source. However, address 0 is used as a broadcast address to all radios, so it's not recommended to strap the radio as address 0 (though apparently, it's possible). All radios come defaulted to address 15. To strap for a different address, a user must ground pins on J6, the Remote Control connector, at the left-rear corner of the radio.

Baud rate can be set to any one of 16 speeds, most of which are supported by modern serial communications. The Baud rate is set using four switches that make up the DIP U39 on the A2 board; inside the radio near the rear panel connectors. See the chart below for Baud Rate and Address strapping.

The final item a user needs to be aware of, is the part number of the radio to note the serial option installed: RS-232 or RS-422. Several models of HF-2050 were produced containing different configurations. The following chart can be used to identify what options should be found for each part number listed. Most radios found during the investigation for this article, were -001 and -002 with RS-422 configurations. The impetus for finding other radios was due to the trouble found with mine while trying to remotely communicate with it; more on that later.

BAUD RATE

BAUD RATE	HEX DIGIT			
	SW4	SW3	SW2	SW1
75	0	0	0	0
110	0	0	0	1
150	0	0	1	0
300	0	0	1	1
600	0	1	0	0
800	0	1	0	1
1 200	0	1	1	0
1 600	0	1	1	1
1 829	1	0	0	0
1 920	1	0	0	1
2 400	1	0	1	0
3 200	1	0	1	1
4 800	1	1	0	0
9 600	1	1	0	1
12 800	1	1	1	0
19 200	1	1	1	1
A2U39 SWITCH NO	4	3	2	1
Note: 1 = open circuit; 0 = closed (ground). A2U39 switch 1 is nearest the rear of the receiver.				

ADDRESS

ADDRESS	HEX DIGIT			
	ADDR4	ADDR3	ADDR2	ADDR1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1
RS-232	12	11	10	9
RS-422	18	17	16	15
	J6 pin no			
Note: 1 = open circuit; 0 = ground				

Table 1-1. Equipment Features.

FEATURE	RADIO RECEIVER 622-6577-( )								
	-001 Note 1	-002 Note 1	-003 Note 1	-004	-005	-006	-007	-008	-009
Remote control:									
RS-232C						X	X	X	X
RS-422	X	X	X	X	X				
Preselector port	X			X	X	X	X	X	X
Front panel color:									
Gray	X	X		X	X	X	X	X	X
Beige			X						
Preset channels:									
30	X	X	X						
100				X	X	X	X	X	X
Independent sideband	X			X		X		X	
Scan								X	X

Note 1. The following receiver statuses have been assigned Canadian military nomenclature:
-001 -- R-5099A/U Radio Receiver
-002 -- R-5099/U Radio Receiver
-003 -- R-5104/GRC-508 Radio Receiver

The RS-422 Standard

Most people are familiar with the RS-232 standard used with various devices including radio controls, computer mice, scanners and other equipment to a DB9 port. In the last two decades, the DB9 serial port has been replaced by USB. However, USB-to-Serial converter cables and modules can be found so we can still control our older devices. The RS-422 standard isn't much different and can be used today.

"RS-422 (EIA RS-422-A Standard) is the serial connection historically used on Apple Macintosh computers. RS-422 uses a differential electrical signal, as opposed to unbalanced signals referenced to ground with the RS-232. Differential transmission uses two lines each for transmit and receive signals which results in greater noise immunity and longer distances as compared to the RS-232. These advantages make RS-422 a better fit for industrial applications." (National Instruments [online]. Available from http://www.ni.com/white-paper/11390/en/#toc3. Accessed 2019 February 2.)

Using RS-422 with the HF-2050 Receiver makes a lot of sense if you want to remotely control several radios at long distances. I can picture many of these in a rack, all controlled remotely from a single source. Now that I knew my radio was optioned with RS-422, it was time to "cable-up" and try it out.

Cabling the Radio

I don't have RS-422 ports on any of my computers, and I needed a solution. I quickly found a method to configure a system starting with USB on my computer and ending in a 37-pin connector mated to J6 of the radio. I determined to buy the following parts:

- USB-to-Serial converter (this is the typical USB to RS-232 DB9 standard)
- RS-232-to-RS-422 converter, with breakout connector/circuit board (DTech)
- 37-pin breakout connector/circuit board

One of my habits for creating cables is to use breakout connectors allowing me to wire one connector to another using screw-down terminals. This facilitates making sure I have a cable wired correctly, pin-to-pin, before I solder the final cable, connector and cover. Figure 1 shows my test setup; the larger DB37 connector board goes to the J6 connector on the back of the radio.

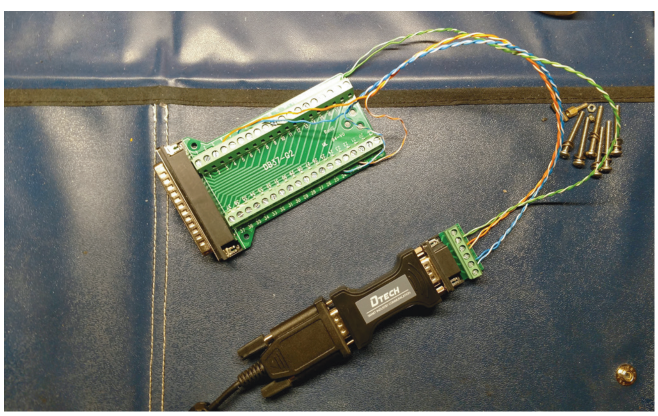


Figure 1 - USB-to-Serial cable, RS-232-to-RS-422 converter, breakout connectors

I might note here I only use USB-to-serial cables and converters using an FTDI chipset. I've found FTDI to be the most reliable, with great drivers and support. I wouldn't use anything else, unless I had to, and then I would complain loudly.

The RS-422 standard contains two lines for transmit and two lines for receive. Each pair contain a positive and negative line (+ and -). The standard calls for wiring the control device to the remote device from plus-to-plus and minus-to-minus, as illustrated in figure 2.

As illustrated here, and with the paperwork received with the RS-232-to-RS-422 converter, the TX+ of the Host is wired to the RX+ of the remote device. Similarly, the TX- goes to RX-.

The HF-2050 J6 Remote Control connector is wired for RS-422 using the following Pinout found in the manual.

J6p4	Send Data +
J6p6	Receive Data +
J6p22	Send Data -
J6p24	Receive Data -

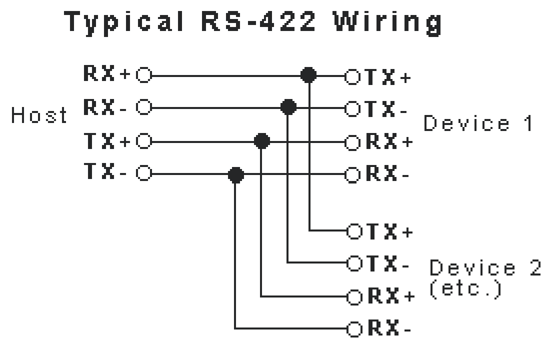


Figure 2

Turns out, this is WRONG!

Uh-Oh! -- Time for a Detour

During my initial attempts to control the radio, I began to get frustrated with the lack of actual connection. I wasn't seeing any response from the radio at all. Even after double-checking all the settings, looping back the comms from the computer and making sure the wiring was correct, the radio simply wasn't responding. It was then I decided to tone the lines from the DB37 connector to their respective locations on the A2 board, prior to grabbing my oscilloscope.

What I found surprised me. The wiring diagram provided in the manual is wrong. All the callout references for the Send Data and Receive Data + and – lines in the manual are wrong. The Send Data lines are indeed the transmit lines, and the Receive Data lines are indeed the receive lines. However, their respective + and – polarities are swapped. In other words, the Send Data + line is really the Send Data - line.

Figure 3 is the Send Data path. You'll note U36 pin 15 crosses over the line for U36 pin 14 and leads to the Send Data + on J6 pin 4. This is wrong. The wiring actually goes from U36 pin 15 to J6 pin 22. Therefore, Send Data + appears on J6p22.

Similarly, in the receive path illustrated in Figure 4, the data coming on J6 pin 6 (Receive Data +) is going to U38A pin 4. This is wrong. The actual wiring goes from J6 pin 6 to U38A pin 2.

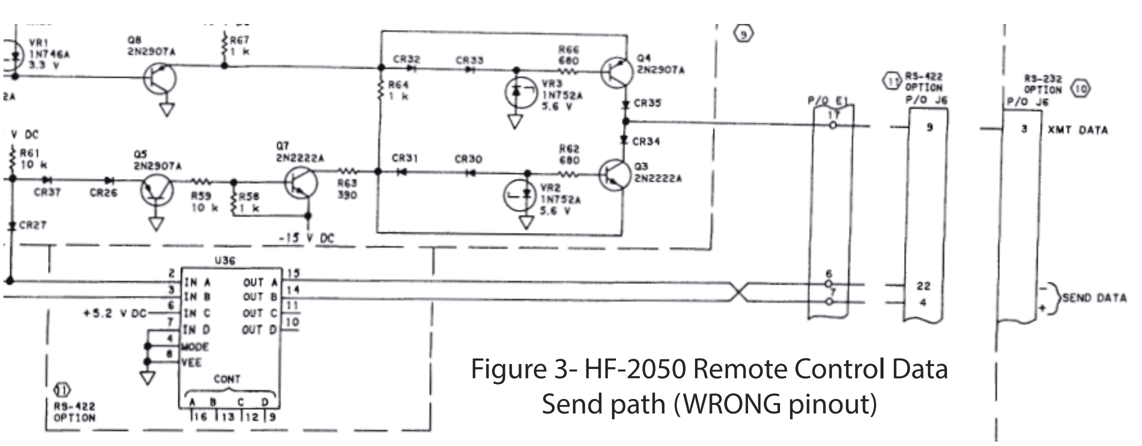


Figure 3- HF-2050 Remote Control Data Send path (WRONG pinout)

The labeling of U36 and U38 is correct when comparing to their respective data sheets. However, the labelling of the J6 connector for the send and receive data + and – is incorrect. For proper operation, these lines must be swapped.

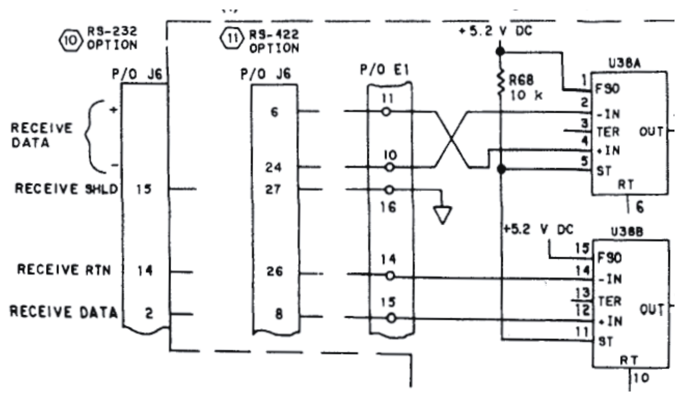


Figure 4 - HF-2050 Remote Control Data Receive path (WRONG pinout)

The correct pinout for the RS-422 lines on the HF-2050 Receiver are as follows:

J6p4	Send Data -
J6p6	Receive Data -
J6p22	Send Data +
J6p24	Receive Data +

During manufacturing, changes were made to the A2 board to create the wiring connections listed above. Interesting enough, prior to the on-board wiring changes, the pinout matched the wiring diagrams found in the manual. Why this was changed is unknown. Perhaps the manual most of us are using, is an early, unchanged manual.

During this phase of my investigation, I was sent photos of the wiring changes from two other HF-2050 owners, one from a -001 model and one from another -002 model. Both A2 circuit boards, like mine, had the same changes which conflicted with the wiring diagram. You can trace these changes for yourself, see figure 5.

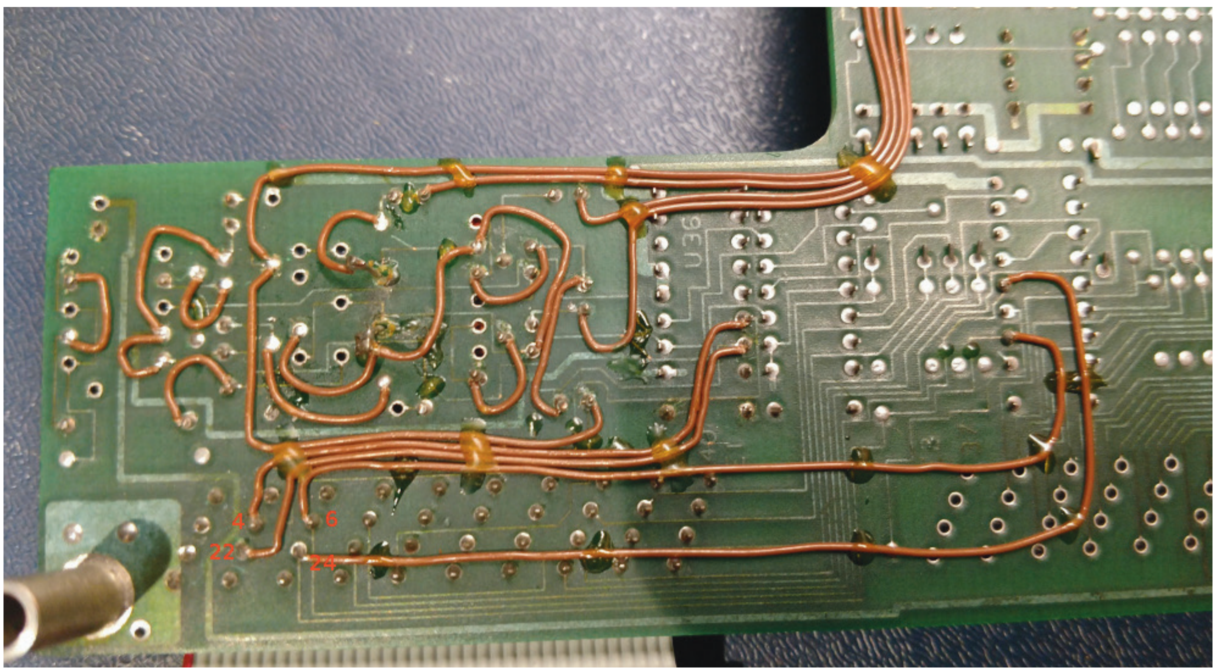
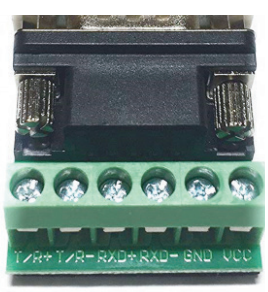


Figure 5 - A2 backside wiring, note J6 pins 4, 6, 22, 24 are labeled for easy reference

To make sure the signaling labeled on my RS-422 breakout board (supplied with the converter, see figure 6) was correct, I toned the connections as follows:



DB9 Pin	Signal as labeled
1	T/R+
2	T/R-
3	RXD+
4	RXD-

With the breakouts properly wired such that I was successfully communicating to the Radio, the cable pinout for my converter and radio worked out to be:

Note, I haven't found consistent information on the proper pinout for a DB9 connector using RS-422. It appears the actual pinout may be dependent on the manufacturer of the RS-422 device using the DB9. If you construct your own cable, I strongly encourage you to use a breakout board to confirm wiring prior to cable assembly.

DB37 Male pin	DB9 Female pin	Signaling
22	3	Send Data + to RXD +
4	4	Send Data - to RXD -
24	1	Receive Data + to T/R+
6	2	Receive Data - to T/R-
19	5	Signal Return

Figure 6

Many converters come with a breakout board for direct wiring which can make this job easier.

Terminal Control

The HF-2050 uses a communication protocol of seven data bits, odd parity and one stop bit. Most RS-232 communications I'm familiar with use 8-N-1, so this was a departure from the norm. I set my terminal program for 7-O-1.

I use a freeware program called TeraTerm (https://osdn.net/projects/ttssh2/releases/). Ever since Microsoft pulled Hyperterminal from Windows, this has been my go-to program for simple keyboarding through a serial or Internet connection.

Configuring TeraTerm for the HF-2050 was easy enough. I first found the specific com port my USB-to-Serial cable was on (COM3 in my case). I then set the serial port (via TeraTerm) to 7-O-1. On the front of the powered-on HF-2050, I changed [CNTL] to RMT. Now it's a matter of sending the right commands and looking for the right responses.

The HF-2050 Command Set

The HF-2050 uses the standard US ASCII character set for sending and receiving data. This makes it extremely easy for a layman to send commands to the radio via a terminal, and since the radio responds using the same character set, it makes it very easy to read what the radio is telling you.

The remote commands cover most, but not all, front panel operations. Things you can't change from the remote include [DIAL], [TUNE], [AUDIO], [CNTL], [SCAN], [AUX], [GROUP], and [DWELL]. Everything else is controllable from the remote using short, simple commands.

The entire listing of commands including examples can be found in the manual, Table 3-3 beginning on page 3-12. Figure 7 is an example of the command set used with the HF-2050.

Table 3-3. Remote Control Commands.

COMMAND	DESCRIPTION
UNIT ADDRESS COMMAND	
UNit NN<-	Selects receiver unit (NN = 1 thru 15). No receiver responds to any commands until it receives a UNit address command which matches its hardwired strapped address, or until it receives the broadcast UNit address (NN = 0). Examples: UNIT 5<- Selects receiver number 5 for control. Receiver 5 accepts all subsequent commands until another UNIT command is issued. UNIT 0<- Selects the broadcast address to which all receivers respond. UNIT 8<- Selects receiver number 8 for control. UNIT ?<- Requests a UNIT response readback from the currently active unit. This command is ignored when UNIT 0 (broadcast address) is currently active. UNIT: 8 Receiver number 8 responds with its unit number as the currently active receiver.
FREQUENCY COMMAND	
FRequency NNNNN.NN<-	Specifies receiver operating frequency (N = 0 to 29 999.99 kHz). If the decimal point is absent, kHz is assumed. Examples: FR 12345.67<- Sets the receiver frequency to 12 345.67 kHz.

Figure 7 - An example command set from the manual

To establish a connection with the radio from the terminal program, the unit must first be identified and addressed. This is done using the simple command "UNIT NN" or "UN NN" for short. Although each command can be spelled out fully, the radio will only interpret the first two characters, then look for a space, then the setting you wish to make. In other words, you might type "UNIT 15" but the radio will only see "UN 15." Note the commands must be sent in capital letters; the radio will not interpret lowercase. Each command sent must end with a carriage return. Most terminal programs will automatically add a carriage return when you press the [Enter] key, but you may need to check.

Once the radio has been addressed, it will not respond until asked to do so. The simplest command to send is a question mark "?" which asks the radio to send its entire status. The return string includes all current settings the radio is operating in. Figure 8 is an example status return and how it's interpreted. Note that if a radio is in LCL control, you will only be able to query status and not be able to send commands to change any setting.

Figure 9 illustrates an example session with my HF-2050 radio. Note how you can change many different settings, then request a full status line, or request status of individual settings.

Once you send Unit NN from the terminal program, that unit will be the only one responding. If you have more than one radio on the same control bus, you can address each one individually by prefacing commands with the unit number.

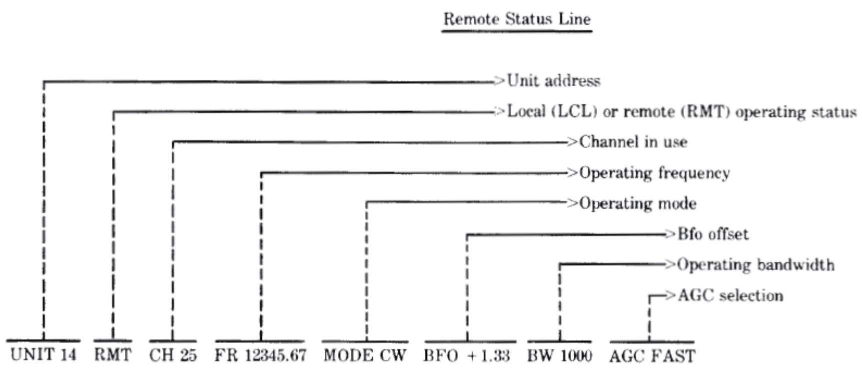
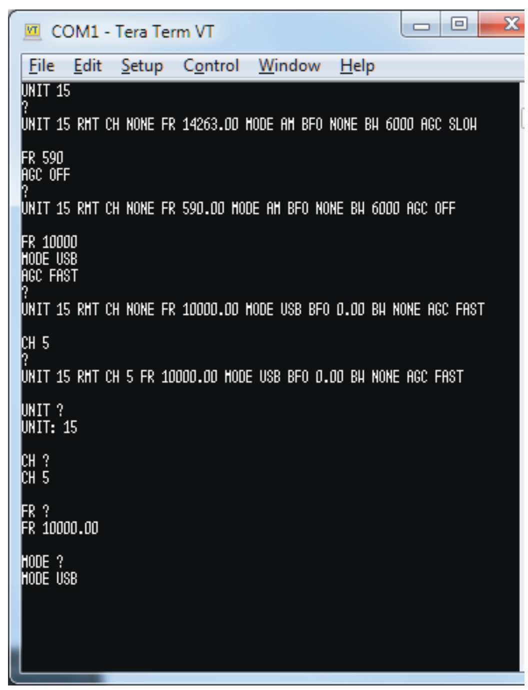


Figure 8 - Example Status return line with explanation

For example, if you are currently working with Unit 15 and want to get a status on Unit 7, you would send the command "UNIT 7; ?" Afterward Unit 7 would be the controlled radio until you sent another unit change.

To know the active unit, you can send "UNIT ?"

All these details, and more, are contained in the technical manual.



Summary

I've shown how the Collins HF-2050 Receiver can be remotely controlled once everything is in place. I've shown how the Send and Receive lines in the radio are not exactly how they are depicted in their associated wring diagrams from the technical manual. I've shown some simple tools for breaking out the connectors for easy troubleshooting and sample wiring prior to building a cable. I've also shown a quick example of how to use commands in a terminal program to control the radio remotely. Armed with this knowledge, the proper parts and the technical manual, you can control your HF-2050 remotely.

The Future? - Non-Terminal Software Control

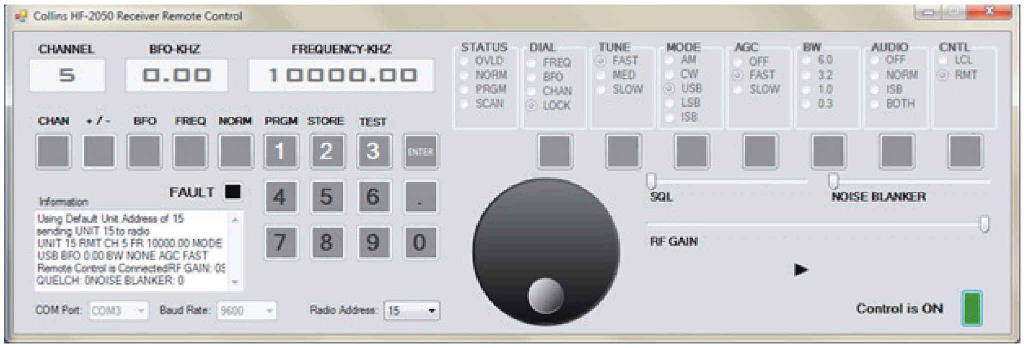
I started down this adventure with the idea of building a simple DOS-based control program similar to what I have in the TSC-60 for the HF-80 radios. That idea took a turn toward Windows (without ever trying DOS), probably because I thought it might be easier. Hi-Hi! My objective is to create user interface that mimics the radio itself. Further, I'd like to add as much functionality as possible, including the use of the [DIAL] and [TUNE] buttons. Although these items aren't remotely controlled to the radio, they can be locally programmed similarly in order to use a dial control for tuning. I'm certainly not there yet, but I'm getting closer. I would say over a hundred hours have been put into this so far and I'm still a long way off. However, it's making progress. Figure 10 is the latest screenshot.

Eventually, I'll be looking for beta testers. If you have an HF-2050 and wish to control it remotely, you should first get started with a terminal program as outlined in this article to make sure you have it cabled correctly and have a basic understanding of how it all works.

Thank you to the following individuals who provided input and additional information used to help me in writing this article: Jim Stitzinger, Francesco Ledda, Jim Jones, and Bill Carns.

73,
Asa Jay Laughton, W7TSC

Below: Figure 10 - W7TSC's Windows application for Remote Control of the Collins HF-2050 Receiver (under construction)



Collins 32S Series Frequency Synchronization

By Bob Jefferis, KF6BC

The frequency synchronization or SYNC function of 32S-1/2, and 32S-3/3A transmitters enables close matching of transmitter carrier frequency Ft to a companion 75S series receiver carrier frequency Fr in SSB emission modes. Acoustic feedback sound is the tuning queue. SYNC is only functional when operating the transmitter (TX) and receiver (RX) as "separates". This note describes SYNC characteristics and offers an approach to familiarization for quick and reliable synchronization.

Basic Characteristics

Referring to 32S-3 schematics, placing the "FREQ CONTROL" switch in SYNC position does the following:

1. The TX internal power amplifier (PA) is disabled by removing PA tube screen voltage at switch S9E-4.
2. The TX internal VFO output is routed to the first mixer via S9B-4.
3. The TX is placed in transmit mode by grounding the push-to-talk (PTT) line at S9J-8.
4. RX muting is given a hard override by grounding the TX mute line at S9G-10.
5. TX baseband audio from the 2nd audio amplifier cathode is summed with RX anti-VOX audio via S9F-12.
6. RX RF input is capacitively coupled to TX RF output by the open TX K2 relay contact wired to J11 ($C \approx 0.1$ pf).
7. TX RF output at J12 is connected to the RF load. SYNC tuning is on-the-air at very low power levels if J12 is connected to an antenna.

This setup creates a closed loop sound system depicted in Figure 1. Together, the TX and RX serve as an audio amplifier with two volume or gain controls: TX microphone gain (MG) and RX audio gain (AG). The active frequency range is approximately 300 Hz to 2400 Hz. If MG is shut off, there is normally enough carrier leakage from the TX balanced modulator to be heard in the RX passband. It is weak and typically below RX automatic gain control (AGC) threshold but it can be used for somewhat coarse matching of Ft and Fr.

Now increase amplifier gain until acoustic feedback starts (oscillation). If Ft = Fr the oscillation frequency will be constant somewhere within the active frequency range. If there is a carrier frequency difference Δf = Ft-Fr , $|\Delta f| > 0$, the amplifier adds a frequency shifting sound effect. Once oscillation starts, acoustic signal energy entering the mic at frequency Fx exits the speaker at a new frequency Fx + Δf . Frequency shifting continues until the system no longer sustains oscillation. The period of sustained oscillation depends strongly on $|\Delta f|$. Oscillation restarts shortly after the previous oscillation decays. This repetitive frequency shifting cycle creates "chirping canary" sounds mentioned in 32S manuals. As a side note, the British Broadcasting Corp. developed a SSB modulation based audio frequency shifter to combat acoustic feedback in live broadcast studios sometime around 1960.

There is no standard or unique SYNC sound signature. Dominant starting pitches, the number of tones heard within chirp cycles, harmonic content, and appropriate gain setting range will be slightly different in each S-line station. You must become familiar with SYNC sounds your particular room, speaker, microphone (mic), and physical equipment arrangement produces.

Getting Started

The following familiarization strategy assumes a stationary desktop or boom mounted mic. Successful synchronization requires stable VFOs, VFO tuning hardware in good operating condition, a steady hand, and a little practice. If you are trying this for the first time or have experienced difficulty using SYNC, I suggest creeping up on it with practice sessions aimed at exploring SYNC sounds and reasonable MG and AG setting ranges. Let's put the good equipment status and steady hand requirement into perspective by noting that the 32S series VFO tuning rate is approximately 22.5 kHz per 360° of tuning knob rotation.

Figure 1, The 32S-3

Satisfactory SSB synchronization requires a Δf limit of about ± 25 Hz which translates to ± 0.4° of tuning knob rotation. There is not much slop or jitter room for any synchronization method.

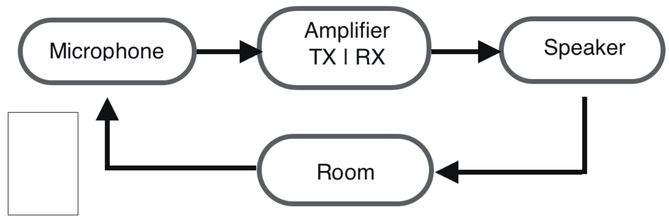


Figure 2, SYNC Sound System

Start by setting up for SSB operation without an external PA. If high frequency oscillator and VFO RF cables are installed between TX and RX for transceiver operation, leave them in, it makes no difference.

Otherwise, all the interconnect cables shown in Figure 1-2 or Figure 1-3 of the TX manual must be in place. Make the room environment as quiet as practical and place the mic in its usual operating position. Let the equipment warmup as long as necessary for good VFO stability. Select the same TX and RX frequency band and sideband. Pick a receive frequency, set RX RF gain at maximum, select AGC "Slow", and peak the RX preselector. Place the TX tuning dial where you think it will match RX frequency, the FREQ CONTROL switch in "TRANS VFO" position and execute normal TX SSB tuneup. When finished, place the TX meter switch in ALC position and MG at minimum (not off).

Caution:

1. Some microphones with integrated PTT switches inhibit audio output until the PTT switch is activated. Obviously, this requires PTT switch activation when SYNC is selected.
2. The TX PA driver works hard in all transmit modes. Limit continuous SYNC operation to about a minute or less with no more than a 25-35% duty cycle.

Add these steps to practice sessions for initial TX dial calibration and some assurance, but not a guarantee, that Δf is small enough to produce typical SYNC sounds. Hereafter, all references to "the knob" mean the TX VFO tuning knob. Set AG at its normal listening level. Leaving MG at minimum, switch to SYNC and slowly rotate the knob back-and-forth while listening for the residual TX carrier. Once you find it, rotate the knob from high pitch to low pitch until the carrier tone barely vanishes. You may need to increase AG to accomplish this. When finished, exit SYNC mode, return AG to normal listening position and set the TX dial hairline to match the RX dial.

Now go back to SYNC and increase MG until you hear something other than RX background noise. It might be a buzz, warbling, chirping, or a slowly varying tone depending on how lucky you were with the previous spotting step. Rotate the knob back and forth SLOWLY until you hear definite chirping. Adjust MG to produce about 2-4 units of peak RX S-meter activity and look for TX ALC activity. You absolutely do NOT want ALC intervention. It wreaks havoc on the SYNC mechanism with spurious tones and strong pulsating audio burps or pops at a slow rate related to ALC and AGC time constants. This erratic system gain pumping is easily mistaken for a slow chirp rate and a false sense of synchronization. If you see ALC meter movement or hear the popping, reduce MG just enough to eliminate it. At this point amplifier gain is in a reasonable range so you can twiddle the knob and practice synchronizing. The goal is well defined periodic chirping at any chirp rate (Fc) less than about 5 chirps per second. Even a warbling sound means that Δf is probably less than 10-12 Hz. With care and good short-term VFO stability you can probably get a nearly constant tone and S-meter reading for a few seconds. This degree of accuracy might be gratifying, but is unnecessary and needlessly time consuming. Any periodic chirp rate indicates that Δf is small enough. Don't work too hard!

Each time you set Fc between about 1 and 4 Hz, take your hand off the knob and listen for a short time to become familiar with the range of sounds and Fc changes that occur as the VFOs drift relative to one another. You may hear chirp direction change as the sign of Δf changes. Alternating high and low cycle starting pitches as well as tone stepping within cycles might also be heard. For entertainment and an appreciation of room reverberation influence, try moving your hand and arm slowly around the mic and speaker. Resulting sound changes can be interesting. Play with MG and AG combinations systematically to define approximate range limits for your station. You want enough overall gain for reliable oscillation and chirp sound clarity, but not enough to create obvious distortion or ALC action. There is normally a wide range of MG and AG control settings that fill the bill. An ideal setup does not require any change to mic position, MG, or AG controls. My station arrangement calls for reducing MG a known amount to dodge the ALC problem but I do not have to move the mic or change AG. Not quite ideal, but easy to accomplish quickly.

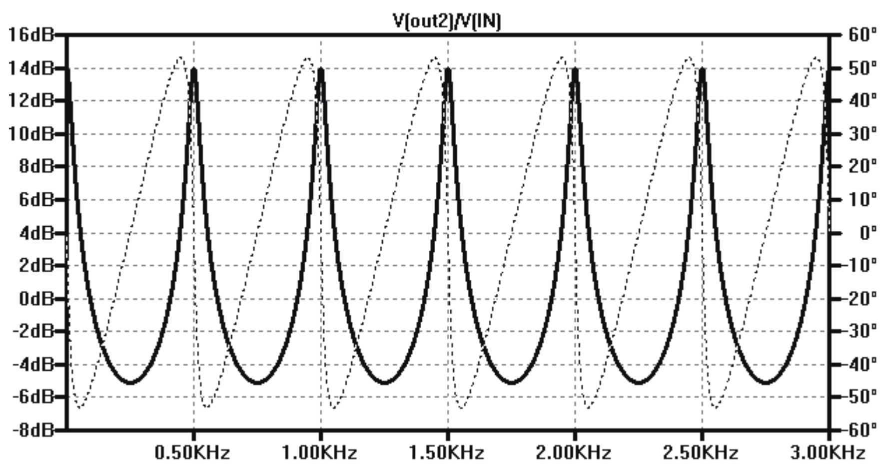
If the canary proves elusive or you consistently hear irritating high pitch cycles, try changing something like speaker placement or mic type.

Is SYNC useless when headphones are used? Certainly not! The acoustic link is open so the headphones become a transmit sound monitor. Simply speak into the mic and adjust the knob until your voice sounds right in the headphones. If this is awkward for you (it is for me), try singing a sustained constant pitch vowel sound like "short A" or "long O" into the mic with constant pitch. Soft constant pitch whistling will also work. It is easy to match headphone reproduction pitch to your voice stimulus pitch for excellent synchronization.

A Closer Look

Section 2 of 32S-X instruction books implies that Fc = |Δf|. After using SYNC for years, I became curious and a little suspicious about this relationship. On several occasions when Fc had been set in the range of 1-2 cycles/sec I had noted that the short term rate of Fc change seemed larger than I knew the combined TX and RX VFO drift rates could be in my equipment. Direct measurement or precise experimental control of Δf is not practical. So, for some insight I applied Spice computer models and indirect measurement data to a partial canary dissection.

Mathematically, the structure in Figure 2 forms a "feedback comb filter". Such filters are well documented in technical literature. In this application the feedback path time delay $T_{fn} = T_i + T_{An}$ where T_i is absolute time delay within the amplifier (≈1.6 ms, measured) and T_{An} is acoustic path delay set by the speed of sound in air and effective acoustic path length between speaker and mic. n is a path index number. Feedback loop gain A_{Ln} is controlled by AG, MG. and AGC. Assume for a moment that magnitude of the system open loop frequency response is constant (flat), phase response is linear, and there is only one direct acoustic signal path between speaker and mic (n = 1). Given linear phase, group delay, i.e., signal envelope transit time around the loop is constant and equals T_{f1}. Steady state transfer functions can be confusing in this arena but for concept illustration, Figure 3 shows magnitude and phase of the closed loop voltage transfer function when T_{f1} = 2 ms and A_{L1} = 0.8. The magnitude curve (solid line) has local maxima and minima at $1/T_{f1}$ = 500 Hz intervals and the round trip phase change at each maximum is 0°. Therefore, each maximum represents a potential oscillation frequency. If T_{f1} is doubled to 4 msec by moving the mic farther away from the speaker, peak spacing decreases to 250 Hz for twice as many possible oscillation frequencies. Oscillation occurs when $|A_{L1}| >= 1$ (0 dB).



Left: Figure 3 - Sound Reinforcement and Attenuation vs. Frequency

Continuing with Figure 3, assume that oscillation starts at 1 kHz and introduce Δf. Initially, oscillation amplitude will build at the rate A_{L1} / T_{f1} dB/second. Each pass around the loop shifts the oscillation frequency Δf Hz to a new point on the curves having lower gain and a phase shift farther away from 0°. Amplitude growth stops when the gain reaches 0 dB and decays rapidly as system gain goes into negative dB territory. This process defines the chirp oscillation period Tosc. Let S represent frequency span between the starting and termination frequencies. The shape of the transfer function magnitude curve dictates that S is inversely proportional to T_{f1}. If oscillation restarts as soon as the previous cycle ends we can relate Fc to Δf as follows:

$$Fc = 1 / Tosc = |\Delta f| / ST_{f1} = K |\Delta f| \quad (1)$$

Does K = 1, and is it constant? The short answer is: no. The real relation is a little more complicated. Frequency response of the amplifier. speaker, and mic is not flat and phase response is not quite linear. These details are small potatoes. The biggest factor controlling closed loop response is sound reflections. These depend on room reverberation characteristics, speaker radiation pattern, mic radiation pattern, and proximity of the operator's body to the mic and speaker. Each reflection reaching the mic constitutes an additional feedback path in the filter model with its own T_{An} and A_{Ln} contribution. Each one modifies Figure 2 with closer peak spacing. Reinforcement peaks and valleys are no longer uniform either. Theoretically, there are an infinite number of reflection paths in any room. However, SYNC operation is only influenced by a small number of strong first order reflections. Then, we are not talking about an oscillator constrained by design to a specific operating frequency. As long as the amplifier stays within its linear operating range, oscillation occurs at all frequencies where loop gain is greater than 0 dB and the phase change is close to 0°. AGC adds loop gain variation in the time domain on a scale that modifies chirp cycles. Oh, did I mention memory effects? If the delay associated with any significant reflection path is more than twice that of T_{f1} or any other T_{fn} the system will have a short term frequency memory. Good grief, it's an intricate process. In light of these complications I knew that any meaningful attempt to describe Fc(Δf, x,y,z, ...) mathematically would either be a fool's errand or create an esoteric Ph.D thesis. So much for theory. Let's proceed with plan "B"!

Connecting a deep memory digital oscilloscope to RX audio output at the anti-VOX port enabled direct measurement of Fc, Tosc, and S. Δf can be computed from S, Tosc, and T_{f1}. Figure 4 presents an example of well behaved chirping. The yellow trace is audio voltage. The blue trace is voltage at the negative S-meter terminal of my 75S-3A which provides a useful indication of AGC buss voltage activity without loading the buss. Decreasing voltage indicates decreasing RX gain. Note how the main Tosc bursts and chirp cycles are framed by AGC cycles. Each tall burst has a low amplitude tail. This is caused by rising AGC voltage that sustains oscillation until Δf gain reduction finally kills the feedback. Well behaved chirp envelopes are not the norm. Low amplitude spurious bursts like those in Figure 4 are just one simple example of fascinating and sometimes puzzling cycle details. Since AGC and Δf effectively limit oscillation amplitude, the amplifier remains linear so Tosc usually is a multi-tone signal to varying degrees. At times it seems as though there are stochastic variables influencing the behavior. My shack is a large acoustically "live" room. Moving the mic just an inch or two changes burst envelope and overall cycle detail. Therefore, I am confident that most of the variance is caused by reverberation and ambient noise. Nonetheless, in terms of audible signal characteristics, the ear perceives colorful and sometimes dissonant periodic chirps.

I analyzed about 30 recordings like Figure 4 using two different mics, three speaker to mic spacings in the range 6-24 inches, and several AG/MG combinations. With reference to equation (1), the data yielded K values between 0.6 and 2.8. By far, the predominant range was 1.4 to 2.6. The multi-tone nature of chirp bursts renders extraction of Δf from scope data challenging and rather uncertain. To validate the measurements I assembled an equivalent baseband system model with LTSpice but limited its fidelity with a maximum of three sound reflection paths (n=4, max) and a simple AGC time constant network consistent with 75S-3 receivers. The model also sends simulated speaker drive voltage to "sync.wav" audio files that can be played back for comparison with reality.

Spice model vetting began with trivial single path cases. To my amazement, model plots and audio files consistently produced K = 1, precisely, with any T_{f1} value and a wide range of A_{L1} values. After studying some acoustics literature on room reverberation and sound absorption coefficients of common wall, window, and furnishing materials, I introduced reflections and ran simulations with a reasoned collection of [Δf , T_{fn} , A_{Ln},] test vectors (sets). By the time I grew weary of this exercise, K values between 0.5 and 2.0 had been captured and many of the sync.wav files sounded remarkably real. My conclusion is that 0.5 and 2.2 are realistic bounds for the ratio Fc/Δf. In most situations you can expect it to be between 1 and 2.

The R.L. Drake Company employed the same technique for "Spotting" in its T-4/R-4 series equipment. They offered a more realistic assessment of spotting accuracy on page 18 of the T-4XB manual: "When the two units are near the same frequency, a chirping sound will be heard very much like the sound of a canary. When the 'tweets' occur only a few times per second, the transmitter is within a very few cycles of the receiver frequency."

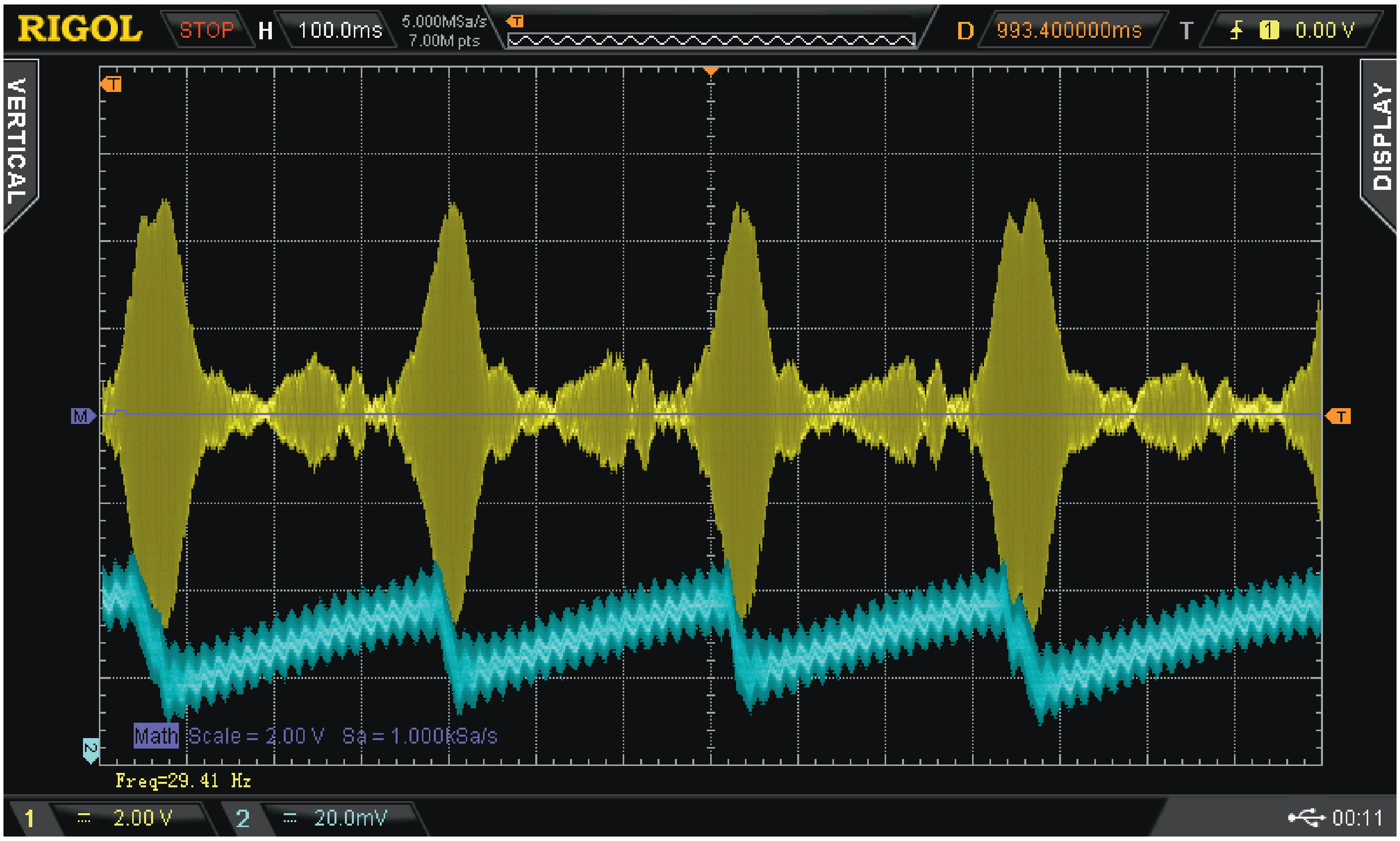


Figure 4 - Chirp Cycle Example: Equipment; 32S-3, 75S-3A, 312B-4 speaker, Shure 522 mic.
Conditions; speaker to mic separation = 24 inches, AG = 9:15 O'clock, MG = 9:00, Fr = 21.3 MHz.
Statistics; Fc = 3 Hz, Δf = -1.4 Hz, Tosc = 144 msec

Concluding Remarks

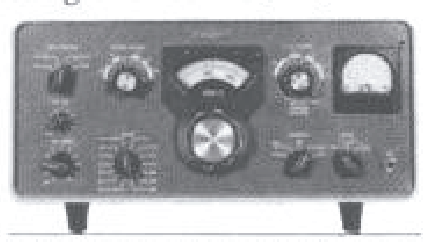
Several more pages replete with equations and diagrams would be needed to describe how the variables change K and how AGC influences Tosc and K. I will simply say that the AGC attack time constant is most important. AGC release time constants are not critical. I want to thank Don Jackson (W5QN) for graciously performing SYNC experiments with his 75S-3B that has been modified with a long SSB release time constant.

I use dynamic element desktop mics having cardioid radiation patterns with 32S transmitters. High sensitivity omnidirectional mics or handheld mics might present a steeper learning curve.

Synchronization became second nature to me through regular use. It rarely adds more than 6-8 seconds to TX tuneup which is a small price to pay for the flexibility of separate operation. I never hear comments like: "Hey OM, you're off frequency" when joining nets or responding to CQ transmissions.

Even though Collins put considerable thought and switch circuit complexity into its SYNC implementation, the instruction books devote precious little space to it. They are silent on the subject of headphone use as well. Perhaps this supplement will help demystify SYNC mode and encourage wider use.

73, Old Man. You've worked another good one. With the clean voice signal of Collins 32S-3 transmitter. It gives you a lot to work with. Nominal output of 100 watts—175 watts PEP input on SSB and 160 input on CW. Gives you superior stability, transceive operation, mechanical filter sideband generation. And there's automatic load control, permeability-tuned VFO and crystal-controlled HF oscillator. With Collins 32S-3 there's no telling where you'll work your next QSO. See your authorized Collins distributor today.



Be sure to see the S/Line at the SSB show during New York IEEE.