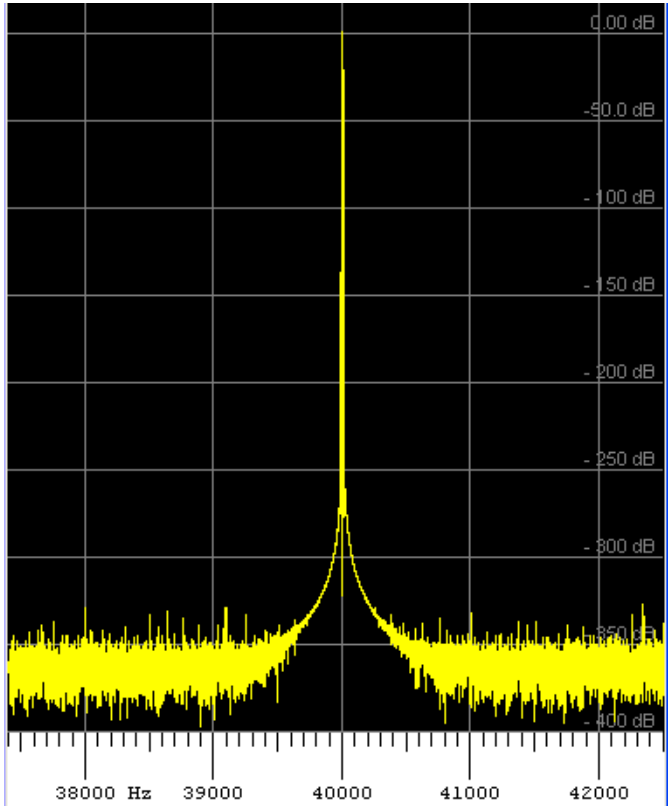


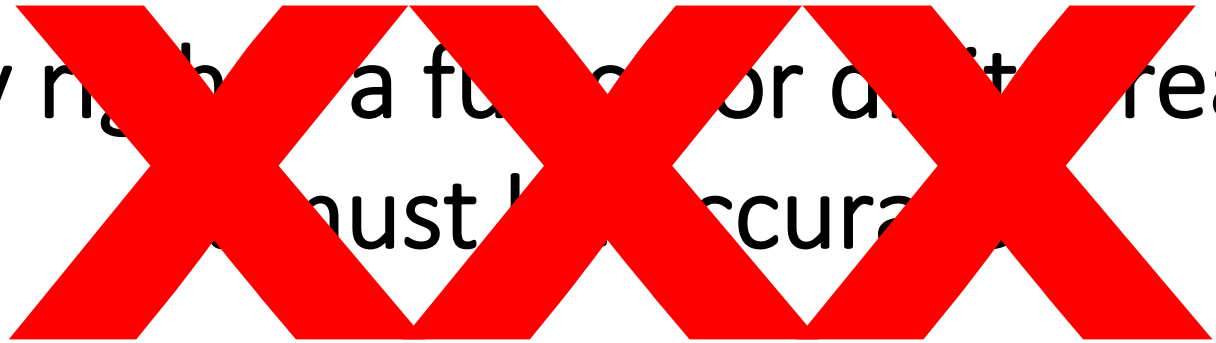
Transceiver Calibration, Precision Frequency Measurement, and The Frequency Measuring Test

George, K1IG
K1IG@arrl.net

PART of WESTFORD

Transceiver Calibration

- Be sure you're on the right frequency - avoid an FCC QSL
- DX spots are accurate
- Does your net complain that you're off frequency?
- Digital modes (FT-8, WSPR…) require frequency accuracy
- Drift with age
- Know your rig and be able to optimize its performance
- Participate in ARRL Frequency Measuring Test
  - Science fair project!

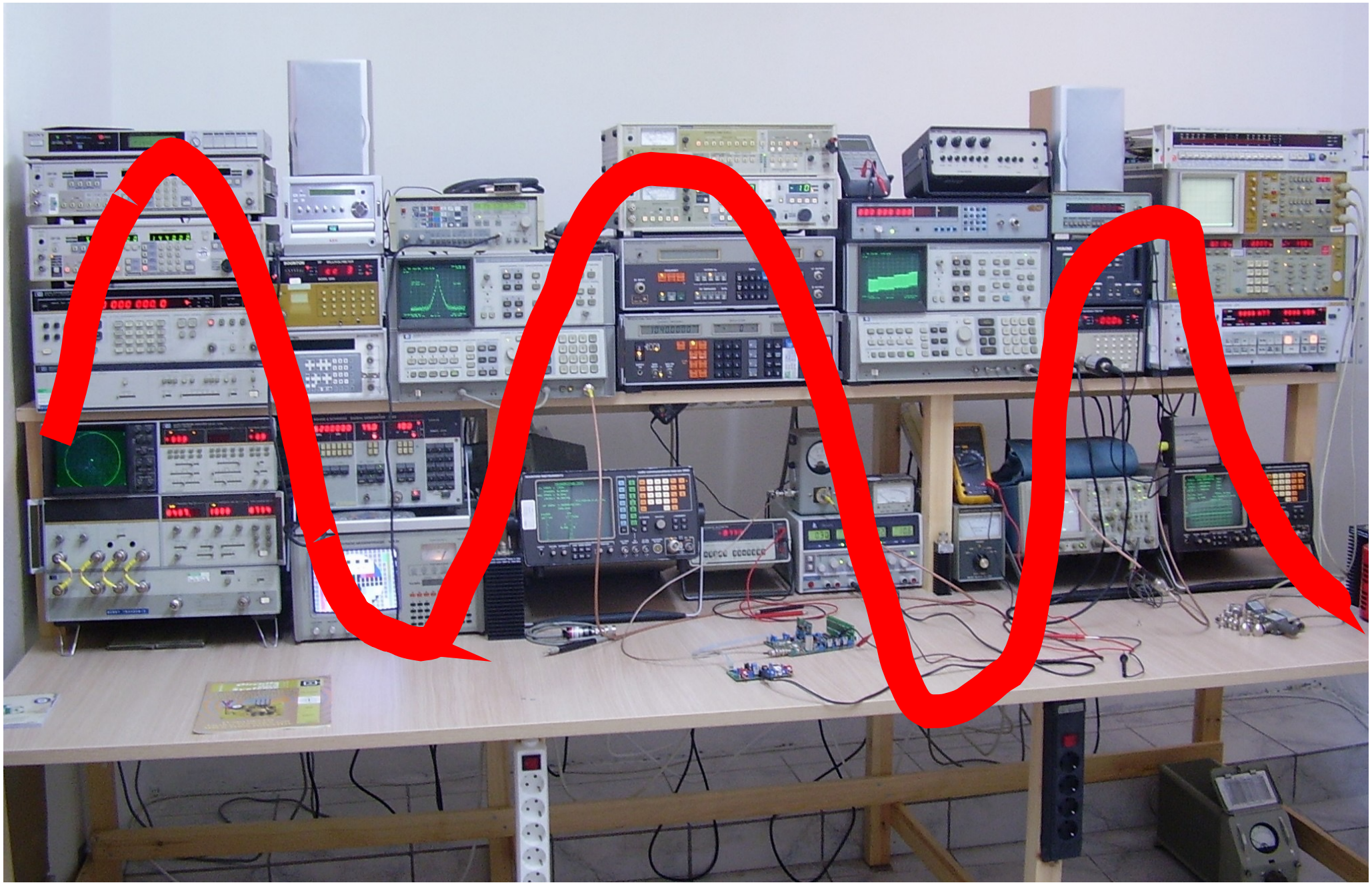


ARRL Frequency Measuring Test

- Began in 1931 – Over 90 years old!
- Measure frequencies over the air – was an Official Observer requirement
- Twice a year — April and November
- 100 - 130 participants worldwide
- Goal is 1 Hz or better accuracy — measure and report to the nearest 0.01 Hz

One Hundredth of a Hertz???

Minimum Setup?



What You Need

Transceiver

Computer

Connecting Cable

Anyone can participate – Equipment isn't important!

Three Step Process

1. Load software and set it up
2. Calibrate your computer
3. Calibrate your transceiver

Total Time = One Hour

Free Software

Windows

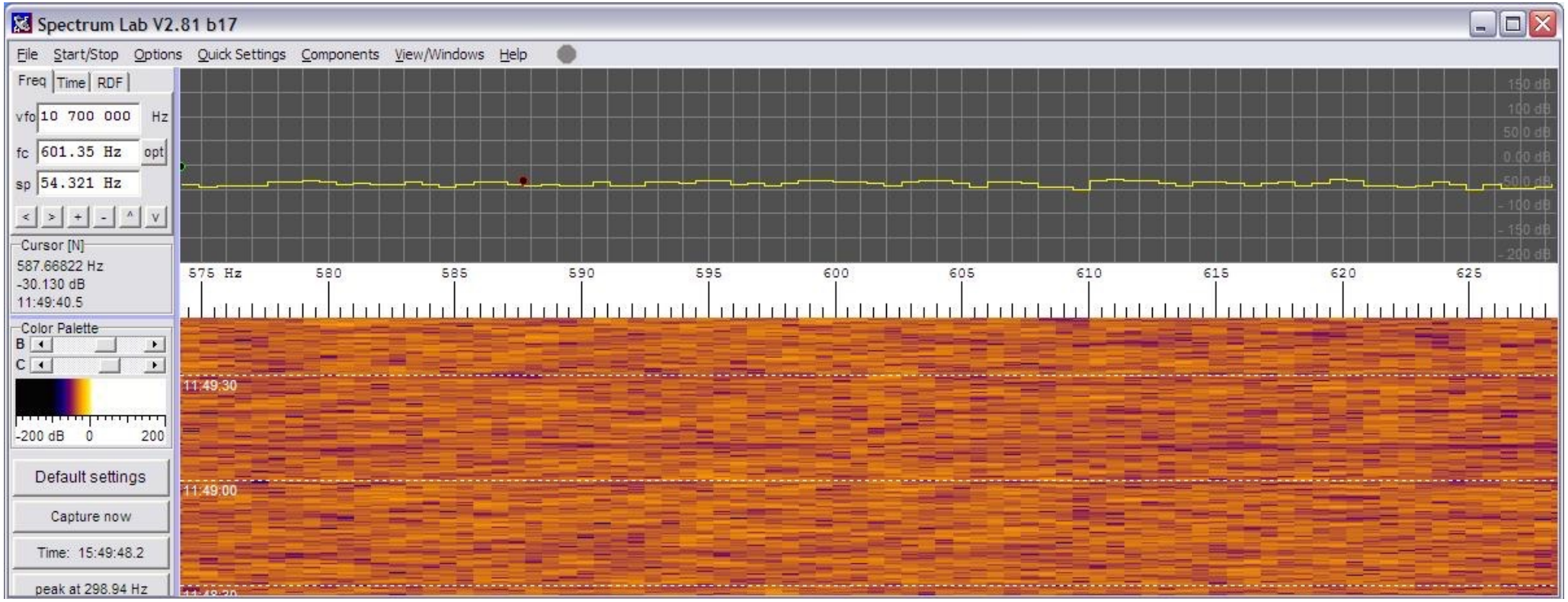
- Spectrum Lab
  - http://www.qsl.net/dl4yhf/spectra1.html
- Installation tutorial at:
  - http://www.ve2azx.net/technical/FMT/SpecLabInfo.pdf

Mac/Linux/Windows

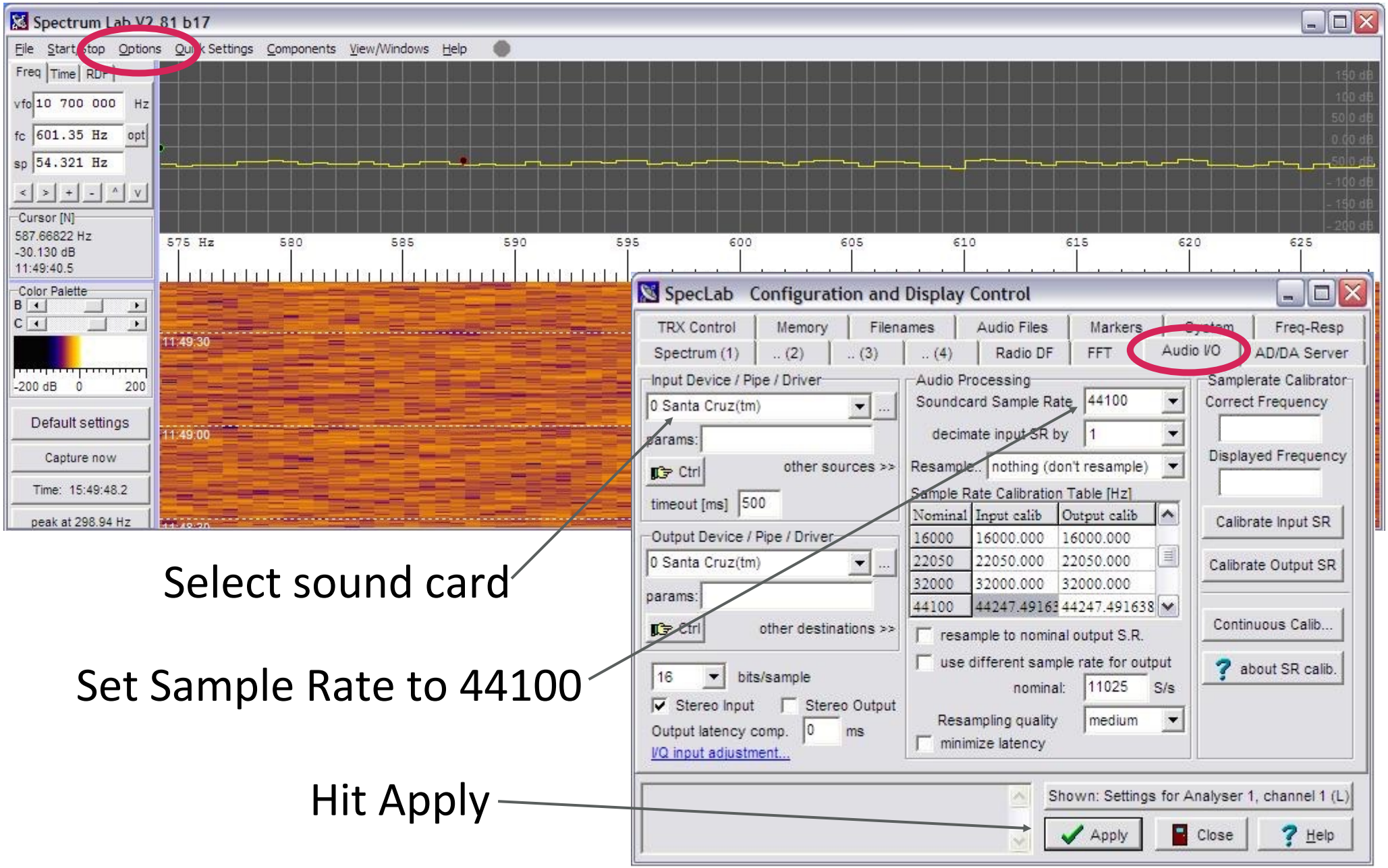
- Fldigi
  - http://www.w1hkj.com/index.html
  - Download, installation and help files on main webpage
- WSPR
  - http://physics.princeton.edu/pulsar/K1JT/wspr.html

Spectrum Lab

- Very powerful, versatile, and accurate
- Will run in Linux/Wine or Mac/Parallels at reduced capability



Spectrum Lab Setup

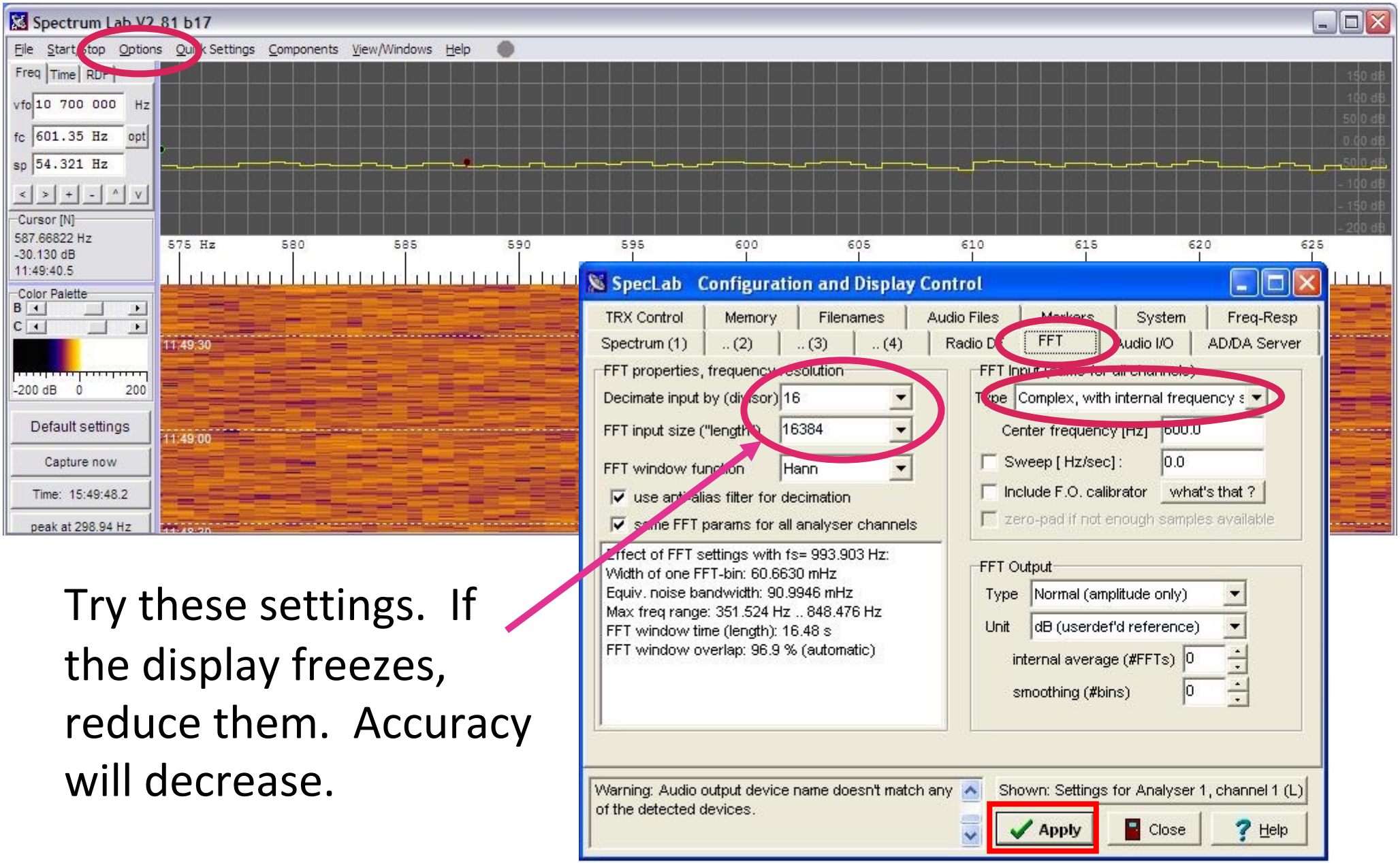


Select sound card

Set Sample Rate to 44100

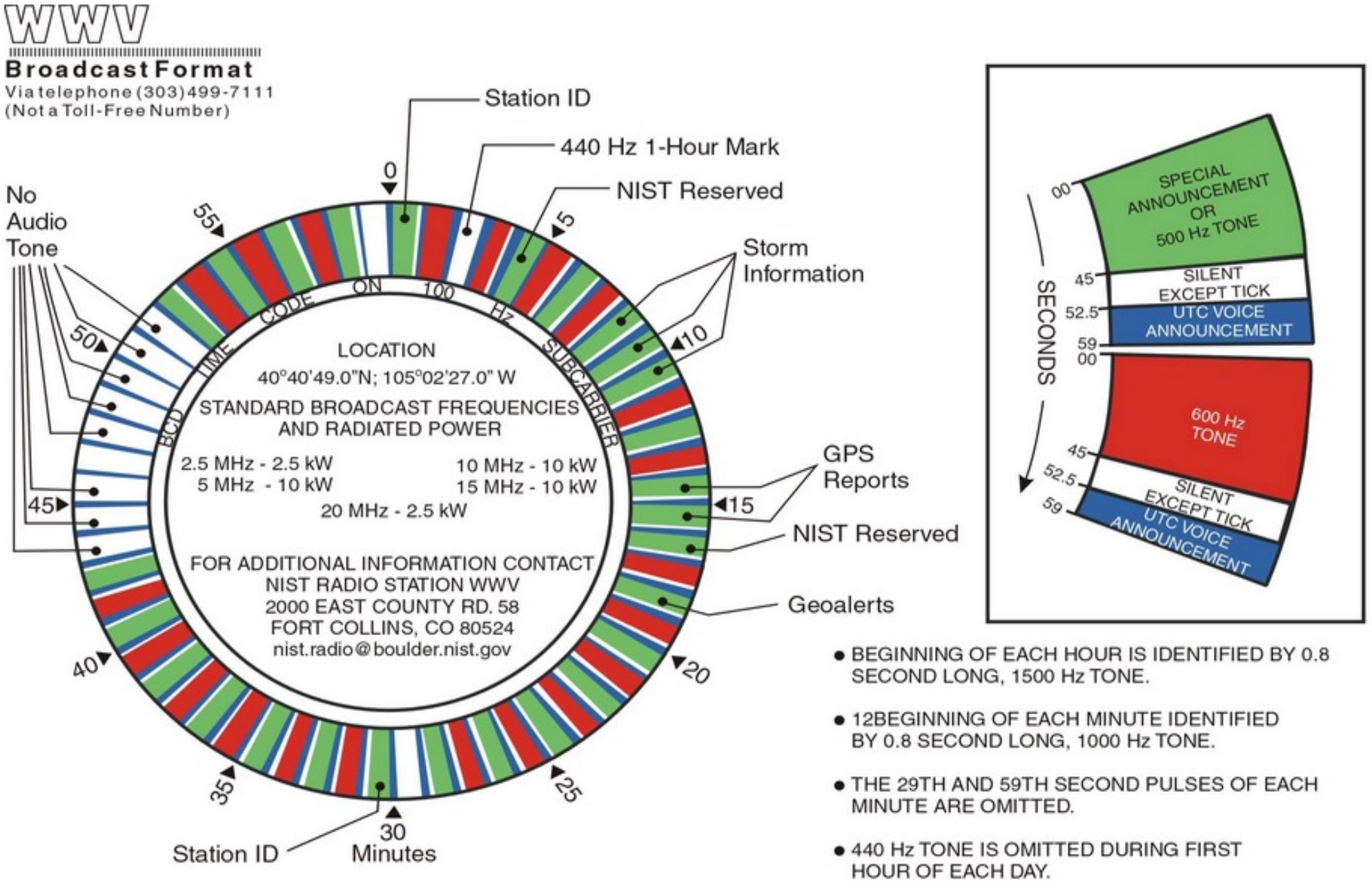
Hit Apply

Spectrum Lab Setup



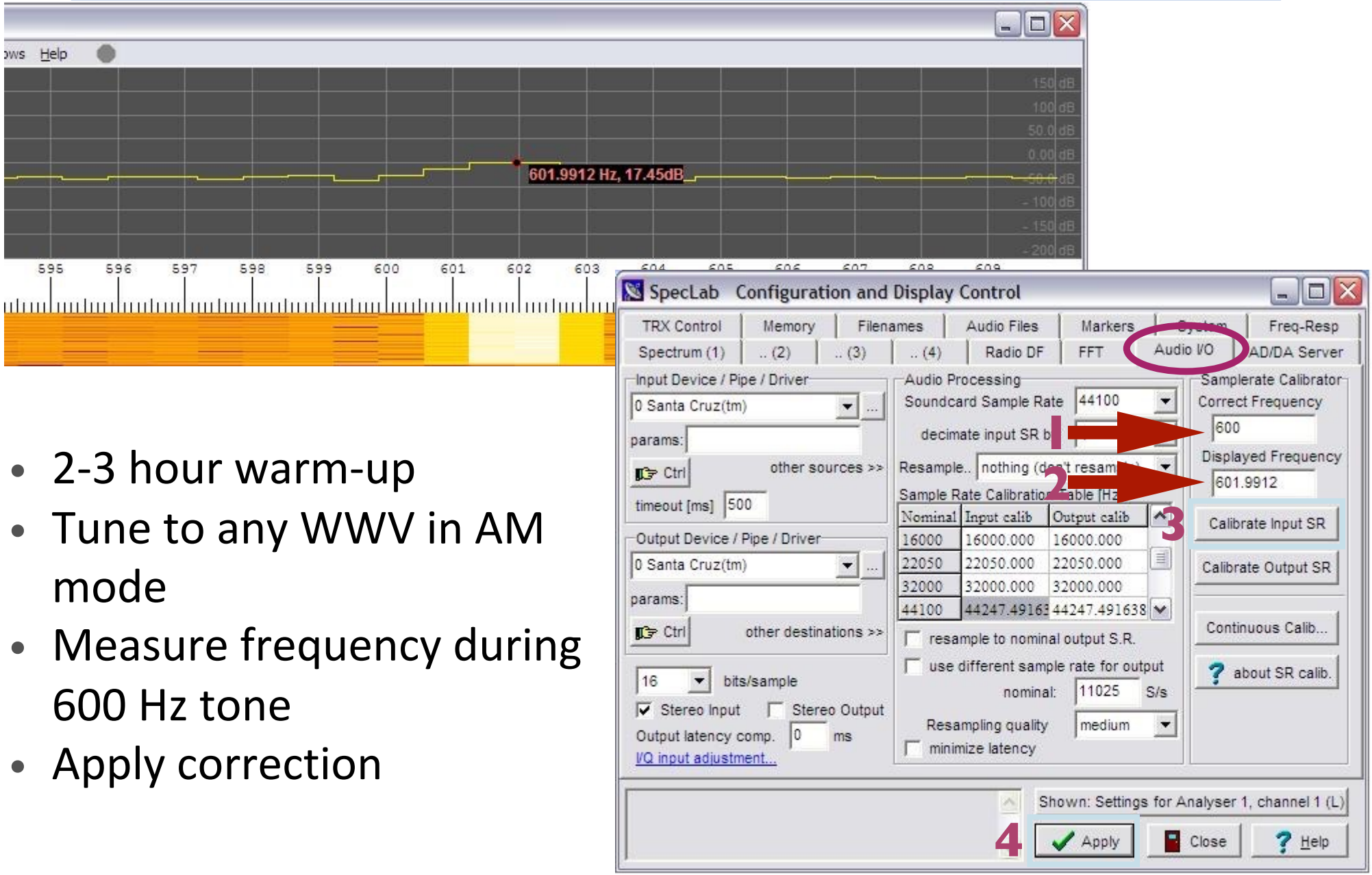
Try these settings. If the display freezes, reduce them. Accuracy will decrease.

WWV



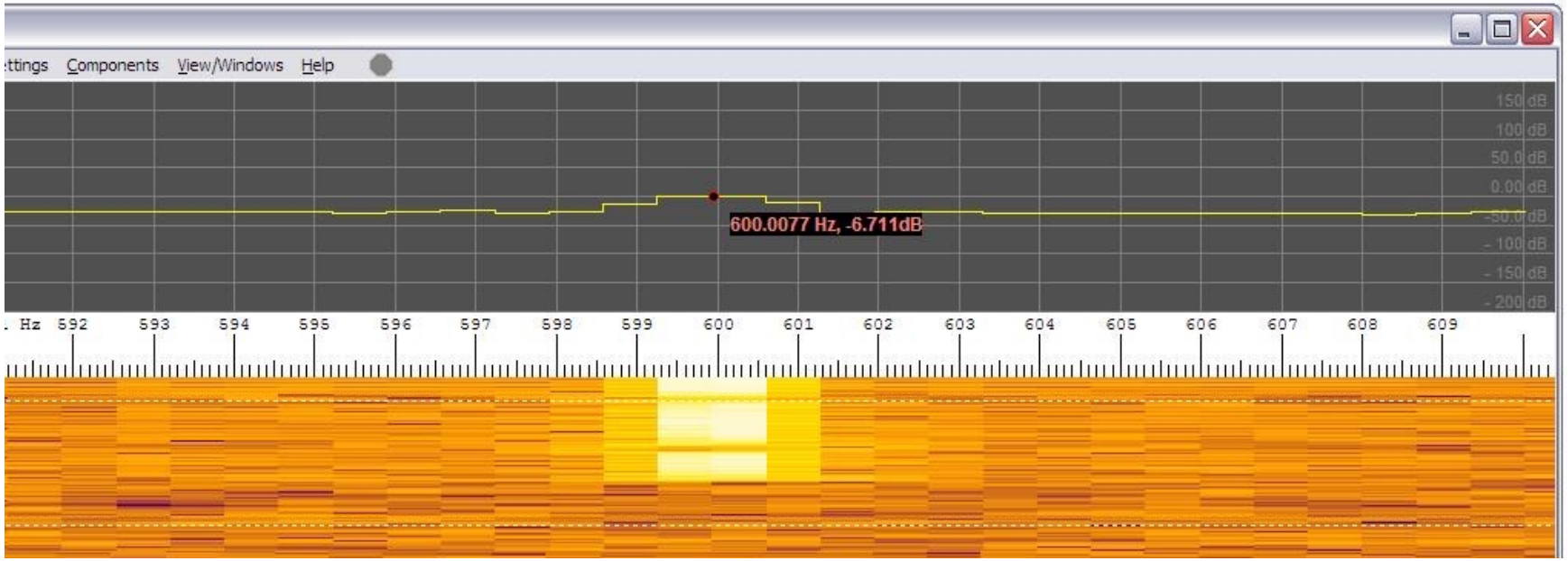
- BEGINNING OF EACH HOUR IS IDENTIFIED BY 0.8 SECOND LONG, 1500 Hz TONE.
- 12BEGINNING OF EACH MINUTE IDENTIFIED BY 0.8 SECOND LONG, 1000 Hz TONE.
- THE 29TH AND 59TH SECOND PULSES OF EACH MINUTE ARE OMITTED.
- 440 Hz TONE IS OMITTED DURING FIRST HOUR OF EACH DAY.

Computer Calibration



- 2-3 hour warm-up
- Tune to any WWV in AM mode
- Measure frequency during 600 Hz tone
- Apply correction

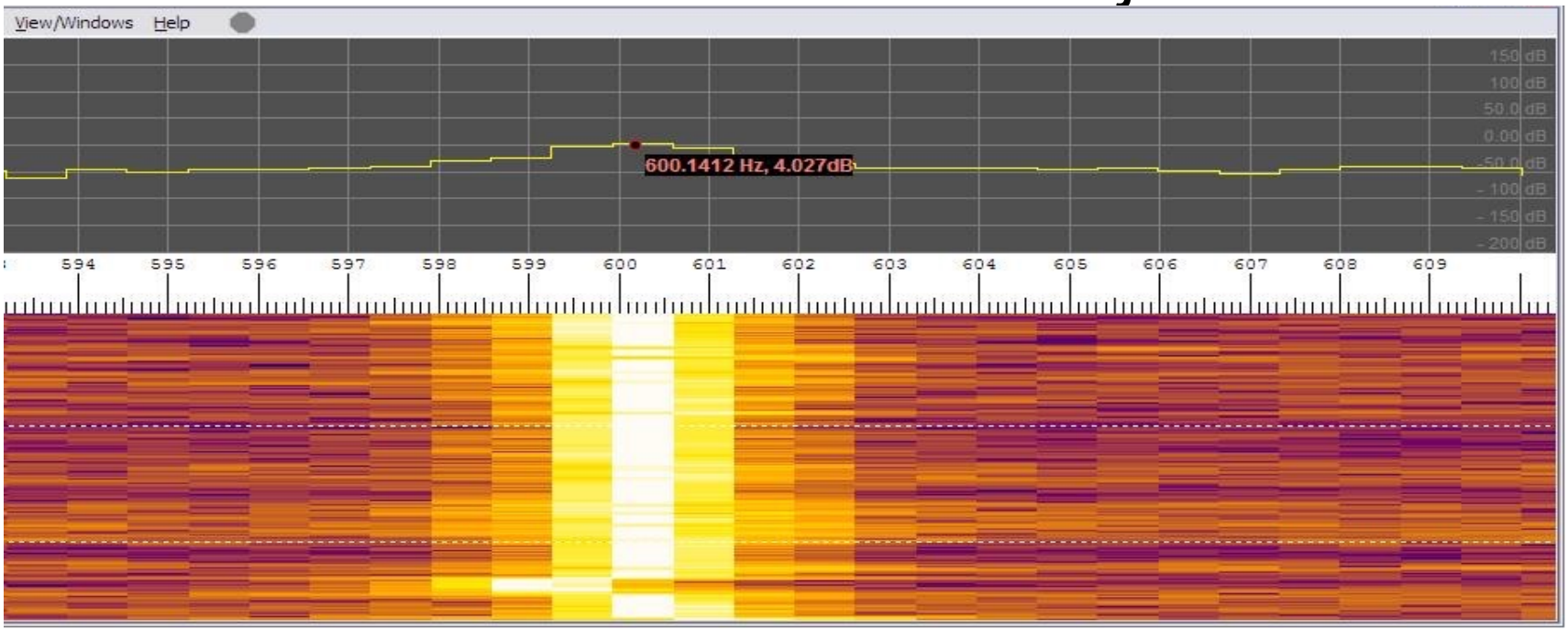
Computer Calibration



After calibration, we're within 0.0077 Hz

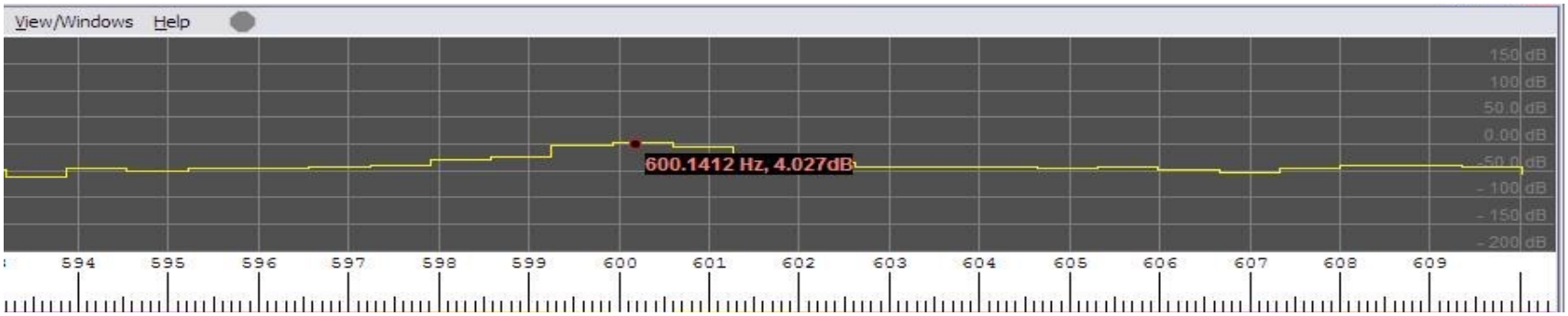
Rig Calibration – Spectrum Lab

1. Set rig to USB ⟵ **All measurements are in USB mode**
2. Tune to any WWV ⟵ **Avoid sunrise/sunset**
3. Re-tune to WWV - 600 Hz
4. Measure the frequency of the tone
5. Adjust your rig (if possible) to center the tone at 600 Hz — consult manual for adjustment



Frequency Measurement – SL

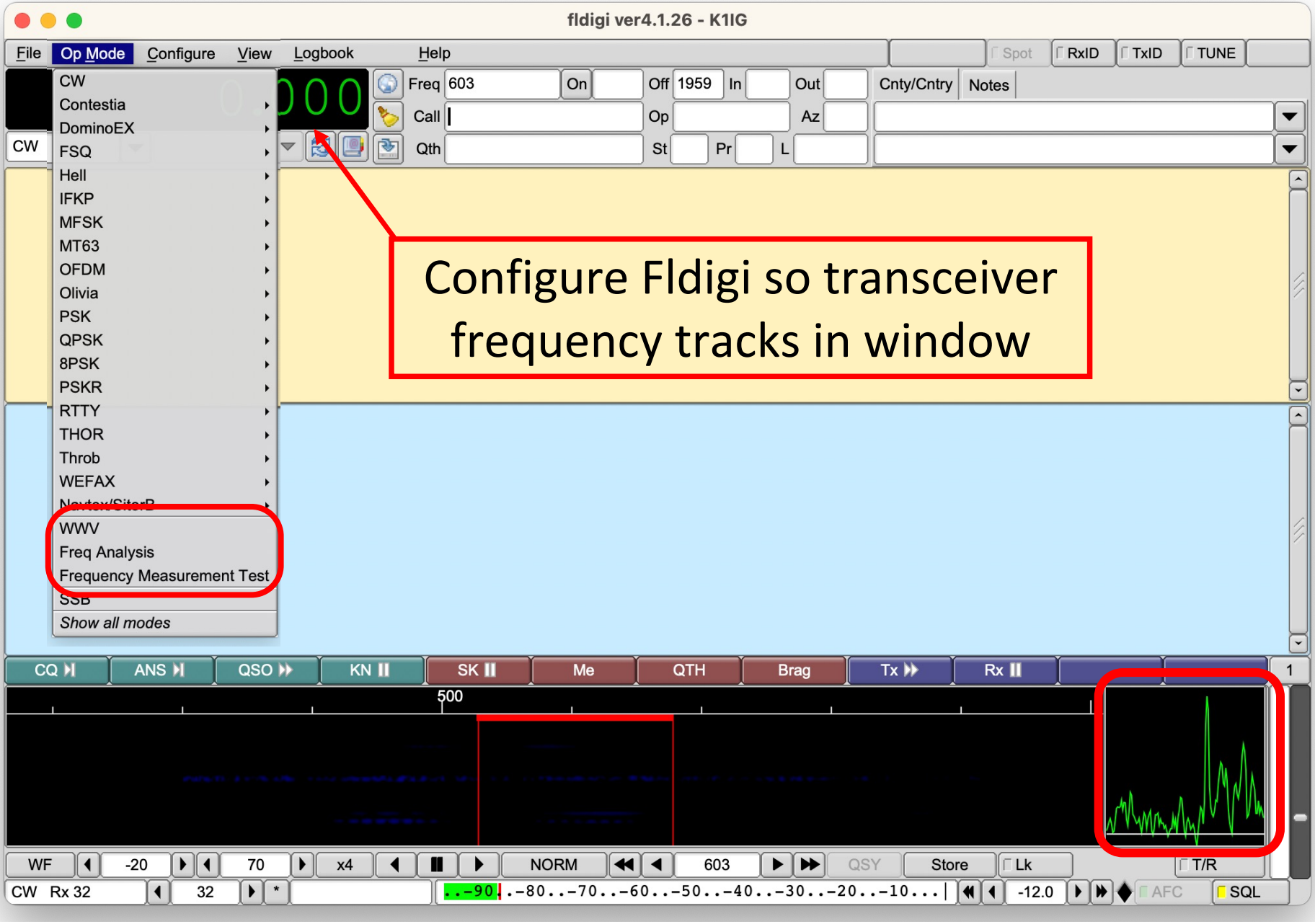
1. Set rig to USB ⟵ **All measurements are in USB mode**
2. Tune rig until carrier tone is near 600 Hz
3. Record tone frequency
4. Add tone frequency to dial frequency



Example:

- Dial freq = 3544.227 kHz = 3,544,227 Hz
- SL tone measurement = 600.1412 Hz
- Measured frequency = 3,544,827.1412 Hz

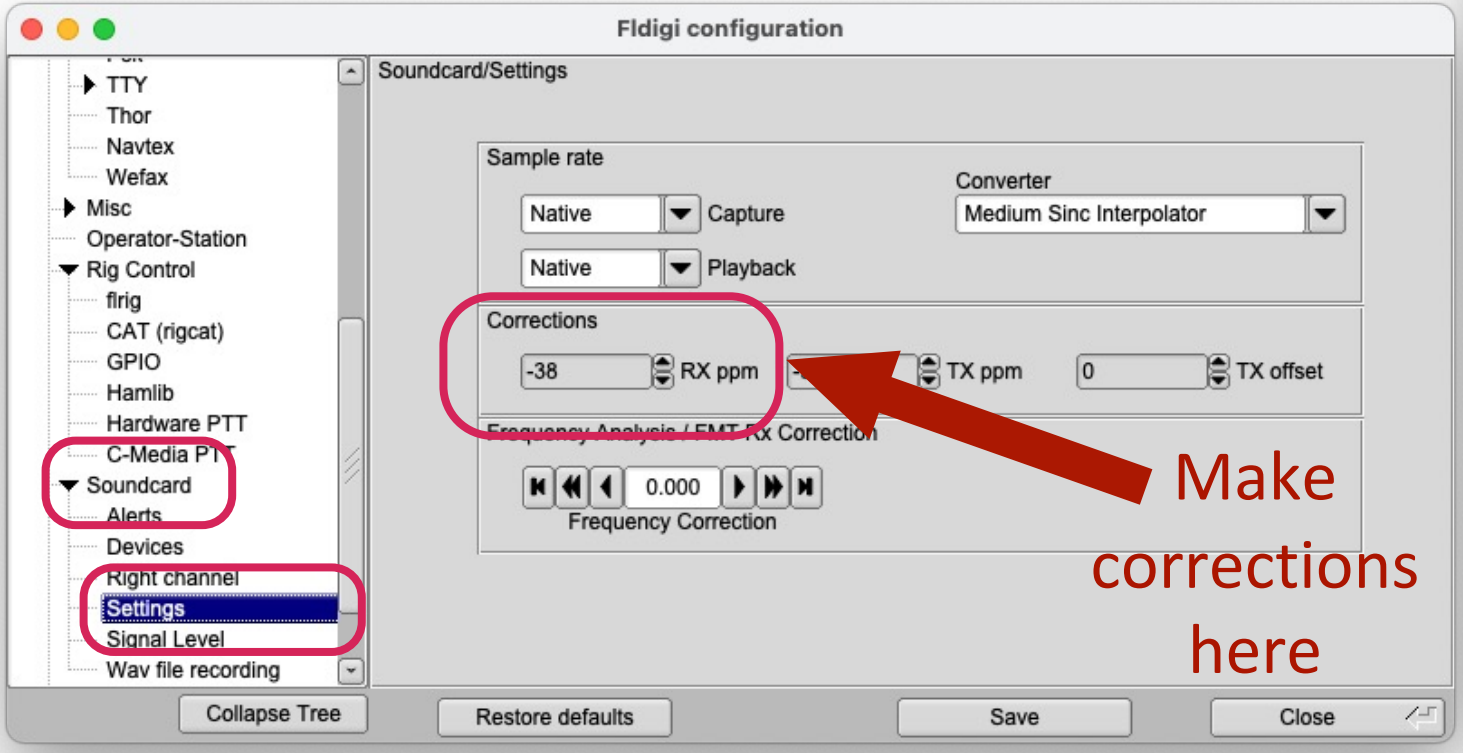
Fldigi


fldigi ver4.1.26 - K1IG
File
Op Mode
Configure
View
Logbook
Help
Spot
RxID
TxID
TUNE
CW
Contestia
DominoEX
FSQ
Hell
IFKP
MFSK
MT63
OFDM
Olivia
PSK
QPSK
8PSK
PSKR
RTTY
THOR
Throb
WEFAX
WWV
Freq Analysis
Frequency Measurement Test
SSB
Show all modes
Freq 603
On
Off 1959
In
Out
Cnty/Cntry
Notes
Call
Op
Az
Qth
St
Pr
L
Configure Fldigi so transceiver frequency tracks in window
CQ
ANS
QSO
KN
SK
Me
QTH
Brag
Tx
Rx
500
WF
-20
70
x4
NORM
603
QSY
Store
Lk
T/R
CW Rx 32
32
-90
-80
-70
-60
-50
-40
-30
-20
-10
-12.0
AFC
SQL

Fldigi Setup

Computer Calibration — Part I

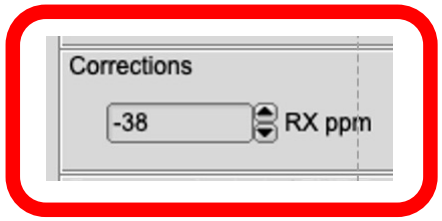
1. Select Op Mode - WWV
2. Select View - Floating Scope (Stretch it)
3. Select Configure - Sound Card - Settings



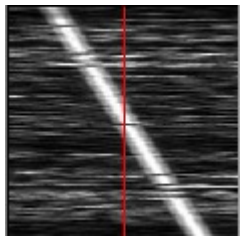
Fldigi Setup

Computer Calibration — Part II

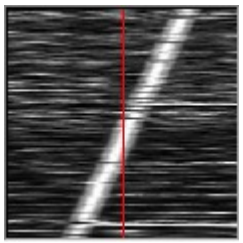
1. Set Rig to AM — tune to any WWV
2. Apply “RX ppm” corrections to make the scope line vertical



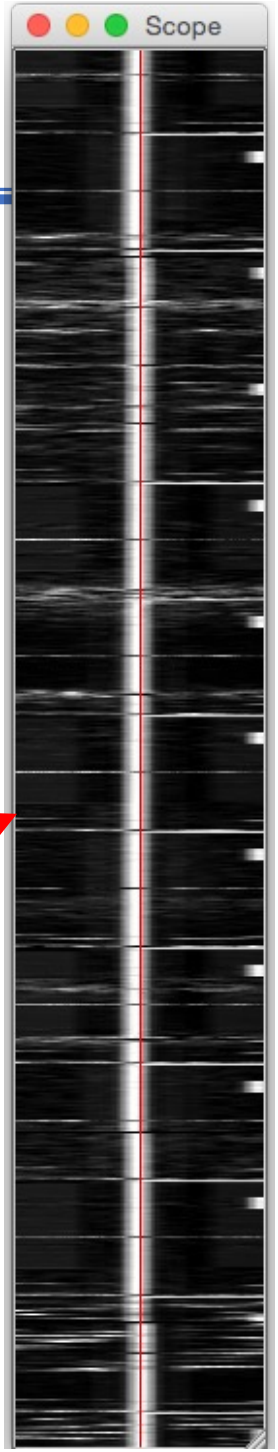
Left-Click on line to center it
Right-Click on window for resolution.



-1000 ppm



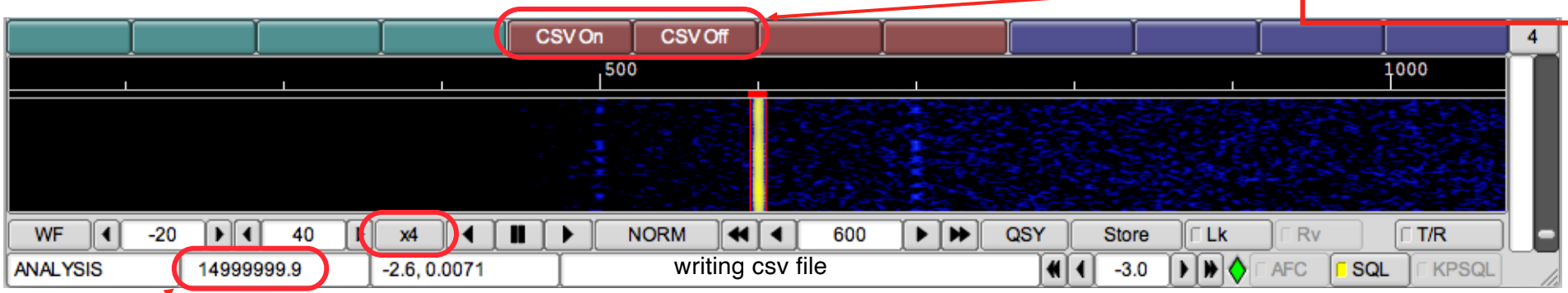
+1000 ppm



Fldigi Transceiver Calibration

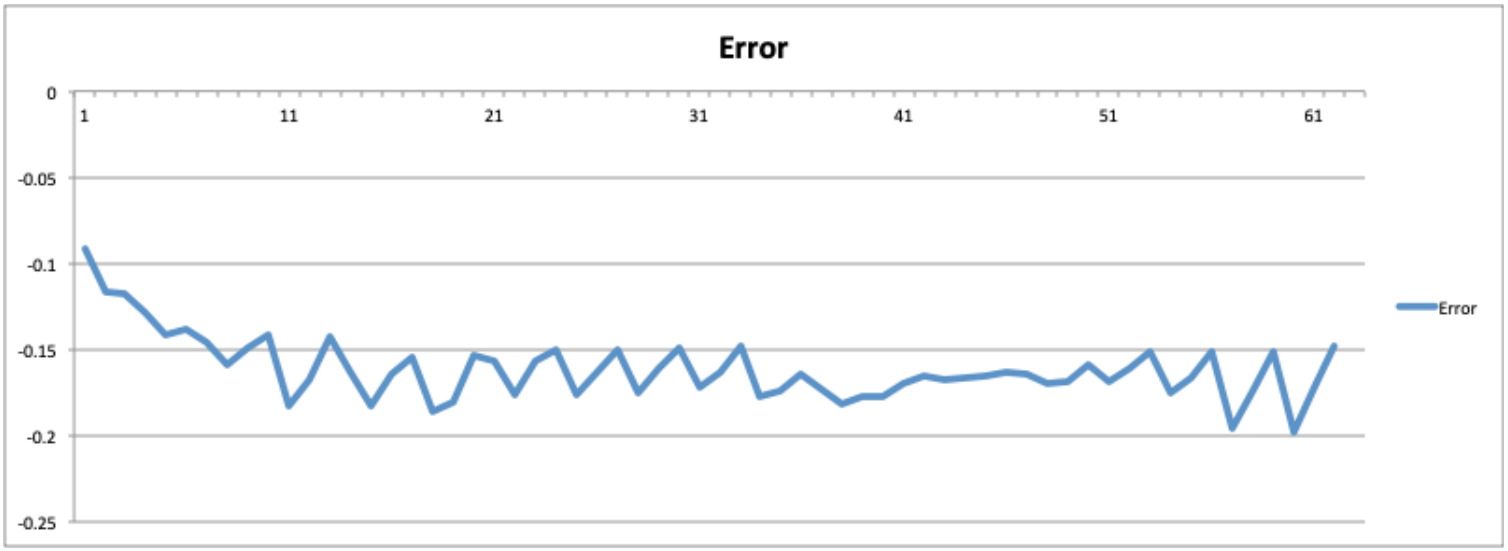
1. Set Rig to USB — tune to WWV - 600 Hz
2. Select Op Mode - Freq Analysis
3. Adjust rig so waterfall is at 600 Hz

Use these two macros to turn data collection on and off

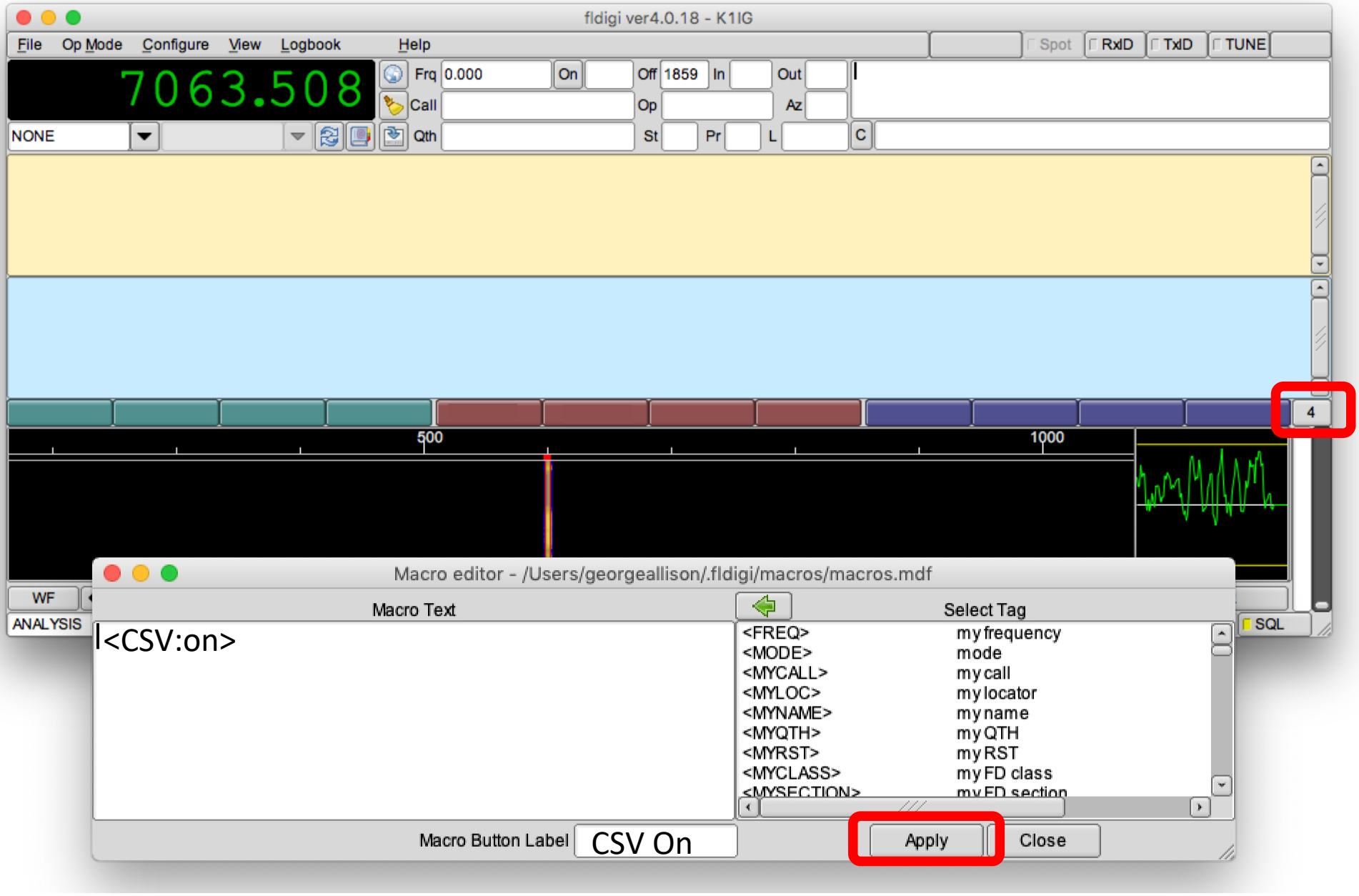


Computed freq

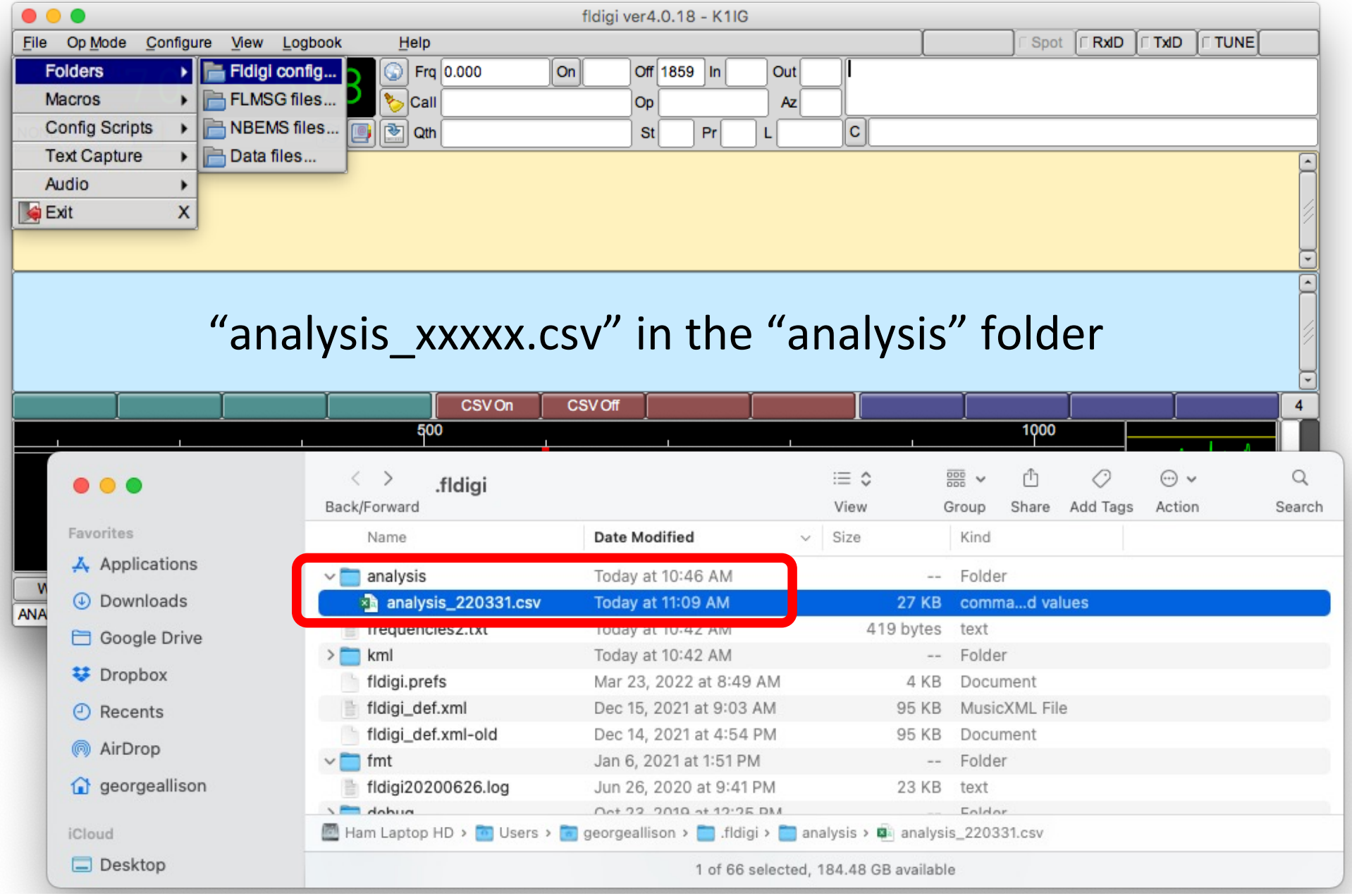
You'll get a data file that you can import into a spreadsheet



Fldigi Macros



Fldigi Data File



Frequency Measuring Test

- April and November
- Test announcement in QST and:

  http://fmt.arrl.org
- Data entry page and previous results are at:

  http://www.b4h.net/fmt/

Frequency Measuring Test

April 2023 Frequency Measuring Test

There will be two transmitting stations for the April Frequency Measuring Test (FMT) — W8RKO in Ohio and K5CM in Oklahoma. Transmissions will be made on 40 and 80 meters (in that order). The FMT will start with a "call up" by K5CM at 0300 UTC April 21 (Thursday evening in North America). If the scheduled frequency is busy, transmissions will be on frequencies close to the published frequency, so be prepared to tune.

Measure the transmitted frequency and report your results at **http://fmt.arrl.org**. Results must be submitted by 0200 UTC on April 24, at which time they'll be published on the website. Stations submitting measurements within ± 1 Hz for all transmissions from K5CM or W8RKO will be listed in the "Green Box" in the results.

The call-up frequency may not be the same exact frequency as during the key-down measurement period (it may shift as much as ± 10 Hz). Although the call up is scheduled to start at a specific time, both stations will try to start earlier. Every effort will be made to start key down at the published time. The key-down period will be 1 minute.

K5CM

40 meters near 7064 kHz
03:00 Call up
03:03 Key down
03:04 End 40-meter run

W8RKO

40 meters near 7065 kHz
03:15 Call up
03:18 Key down
03:19 End 40-meter run

K5CM

80 meters near 3598 kHz
03:30 Call up
03:33 Key down
03:34 End 80-meter run

W8RKO

80 meters near 3599 kHz
03:45 Call up
03:48 Key down
03:49 End 80-meter run

QST April 2023, page 73

Frequency Measuring Test

K5CM

40 meters near 7064 kHz
03:00 Call up
03:03 Key down
03:04 End 40-meter run

W8RKO

40 meters near 7065 kHz
03:15 Call up
03:18 Key down
03:19 End 40-meter run

K5CM

80 meters near 3598 kHz
03:30 Call up
03:33 Key down
03:34 End 80-meter run

W8RKO

80 meters near 3599 kHz
03:45 Call up
03:48 Key down
03:49 End 80-meter run

These times are UTC!

Local start time is
11:00 PM EDST on
Thursday, April 20

Entries are due no later than
9:00 PM, Sunday, April 23

Frequency Measuring Test

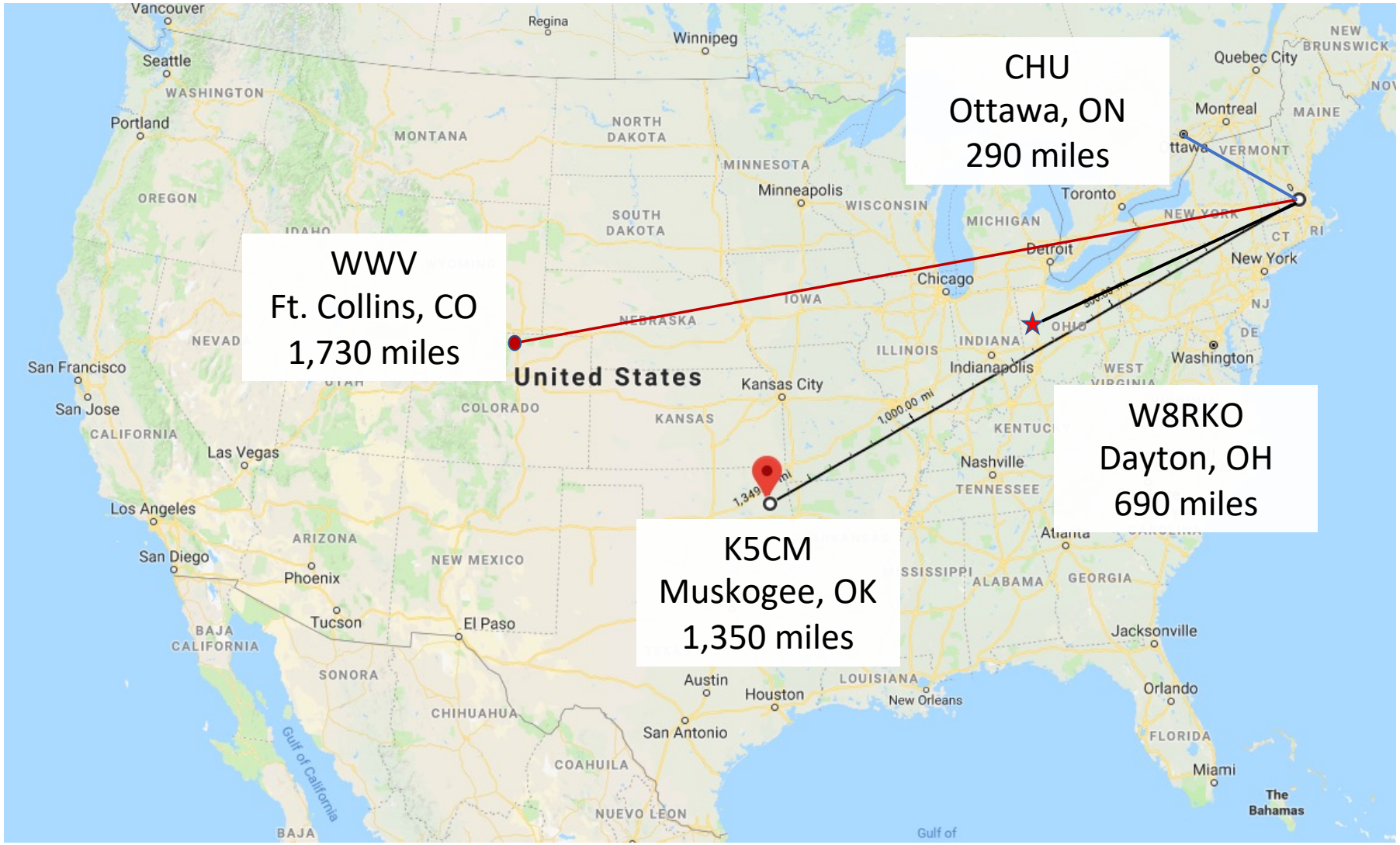
Test Procedure:

1. Measure WWV frequency
2. Measure test signal
3. Measure WWV frequency

We have to correct for Ionospheric Doppler Shift

Frequency Measuring Test

Ionospheric Doppler Shift Measurements



Frequency Measuring Test

Preparations

- Warm up at least two hours – no xmit
- Climate control in shack
- Check computer calibration
- Check transceiver calibration
- Preset transceiver memories
- Prepare a written plan/log
- Fldigi: Analysis mode, “x4”, “CSV Off”, “analysis” folder open, floating scope

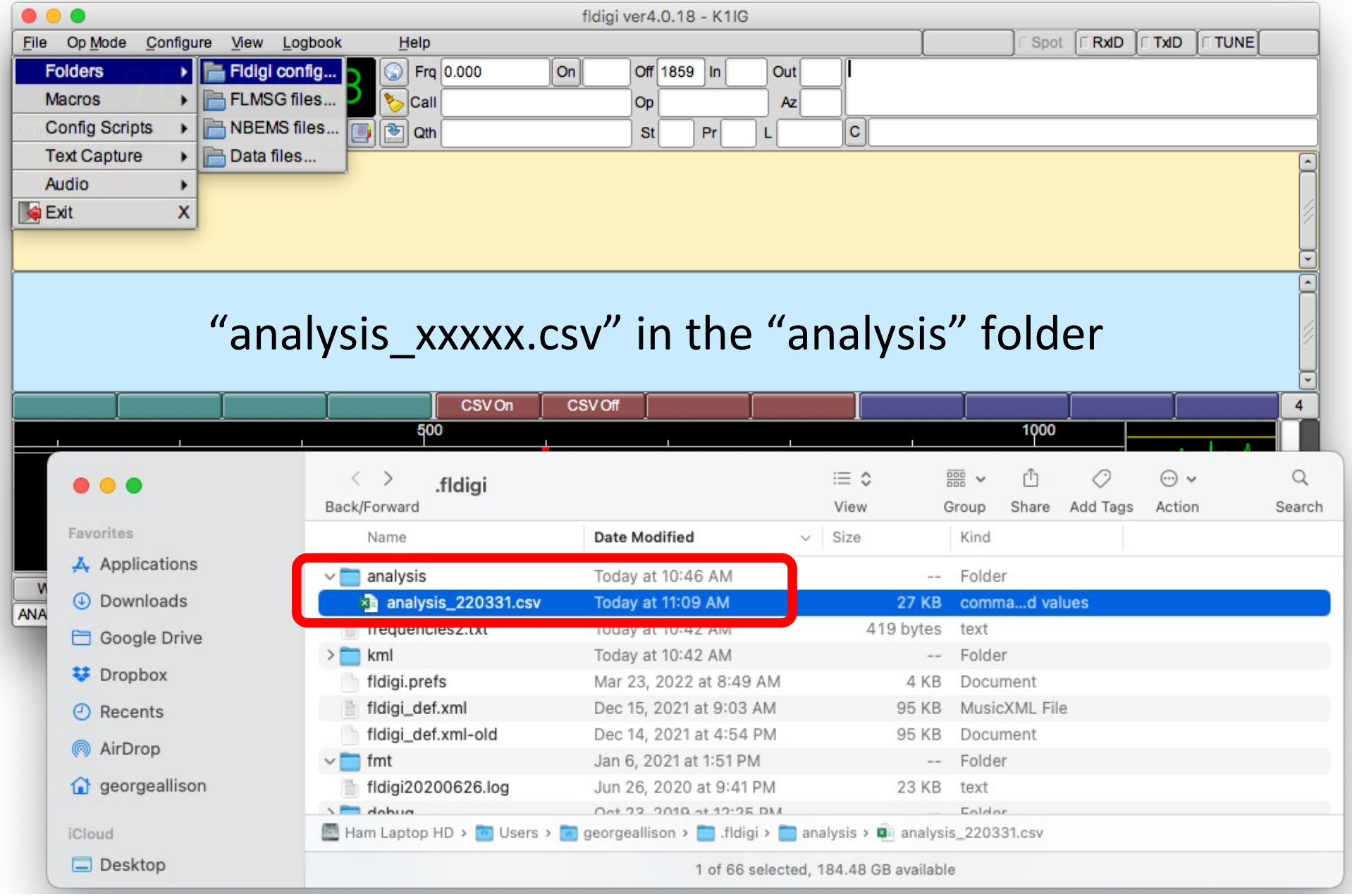
Frequency Measuring Test

Conducting the test

1. Transceiver in USB mode!
2. WWV pre-test data collection(s)*
3. Collect data from test transmission*
4. WWV post-test data collection(s)*
5. Graph data from all collections
6. Analyze data and apply WWV correction
7. Enter data in online form

* Immediately re-name data files!!!!

Fldigi Data File



Frequency Measuring Test

Data Collection Schedule

K5CM #1 run: 40-meters near 7064 kHz

- 10:55 PM: WWV at 10 and 5 MHz
- 11:00 PM: Call up
- 11:03 PM: Key Down
- 11:04 PM: End 40 meter run
- 11:04 PM: WWV at 10 and 5 MHz

K5CM #2 run: 80-meters near 3598 kHz

- 11:25 PM WWV at 5 MHz and 2.5 MHz
- 11:30 PM: Call up
- 11:33 PM: Key Down
- 11:34 PM: End 80 meter run
- 11:34 PM: WWV at 5 MHz and 2.5 MHz

W8RKO #1 run: 40-meters near 7065 kHz

- 11:10 PM WWV at 10 MHz and 5 MHz
- 11:15 PM: Call up
- 11:18 PM: Key Down
- 11:19 PM: End 40 meter run
- 11:19 PM: WWV at 10 MHz and 5 MHz

W8RKO #2 run: 40-meters near 3599 kHz

- 11:40 PM WWV at 5 MHz and 2.5 MHz
- 11:45 PM: Call up
- 11:48 PM: Key Down
- 11:49 PM: End 80 meter run
- 11:49 PM: WWV at 5 MHz and 2.5 MHz

Five Data Collections for Each Run

Frequency Measuring Test

Keep a written log as a sanity check and fallback if the computer logging fails

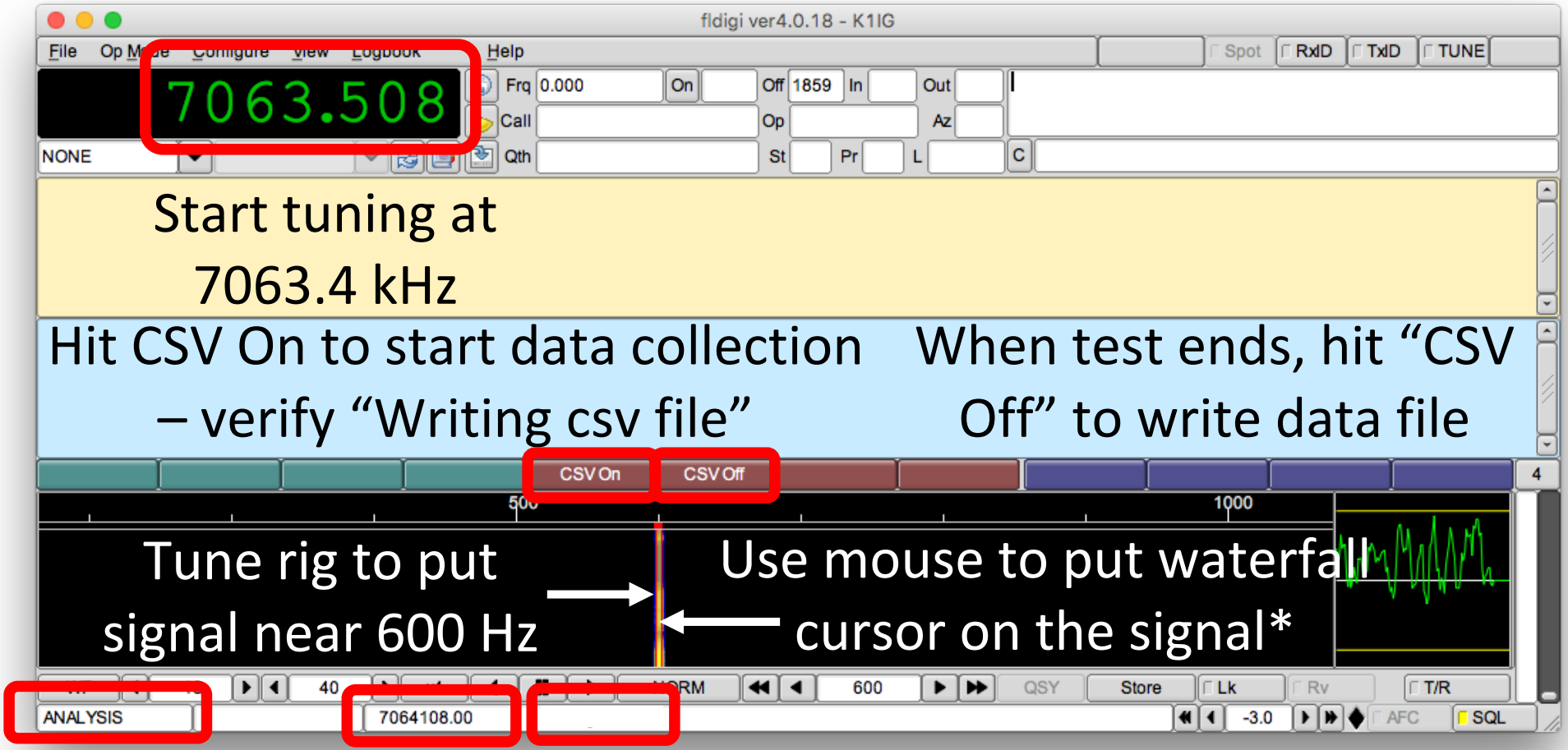
First Run: K5CM 40 Meter Band		✓
Fldigi WWV 10 MHz Est:		USB
WWV 10 MHz Filename:	WWV_10_1.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_1.csv	
Approximate Frequency:	7064 MHz (7063.4)	USB
Dial Frequency:		USB
Offset:	(600 Hz)	
Fldigi Estimate:		
Measurement Filename:	FMT_40_1.csv	
Fldigi WWV 10 MHz Est:		USB
WWV 10 MHz Filename:	WWV_10_2.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_2.csv	

Second Run: W8RKO 40 Meter Band		✓
Fldigi WWV 10 MHz Est:		USB
WWV 10 MHz Filename:	WWV_10_3.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_3.csv	
Approximate Frequency:	7065 MHz (7064.4)	USB
Dial Frequency:		USB
Offset:	(600 Hz)	
Fldigi Estimate:		
Measurement Filename:	FMT_40_21.csv	
Fldigi WWV 10 MHz Est:		USB
WWV 10 MHz Filename:	WWV_10_4.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_4.csv	

Third Run: K5CM 80 Meter Band		✓
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_5.csv	
Fldigi WWV 2.5 MHz Est:		USB
WWV 2.5 MHz Filename:	WWV_25_1.csv	
Approximate Frequency:	3598 MHz (3597.4)	USB
Dial Frequency:		USB
Offset:	(600 Hz)	
Fldigi Estimate:		
Measurement Filename:	FMT_80_1.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_6.csv	
Fldigi WWV 2.5 MHz Est:		USB
WWV 2.5 MHz Filename:	WWV_25_2.csv	

Fourth Run: W8RKO 80 Meter Band		✓
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_7.csv	
Fldigi WWV 2.5 MHz Est:		USB
WWV 2.5 MHz Filename:	WWV_25_3.csv	
Approximate Frequency:	3599 MHz (3598.4)	USB
Dial Frequency:		USB
Offset:	(600 Hz)	
Fldigi Estimate:		
Measurement Filename:	FMT_80_2.csv	
Fldigi WWV 5 MHz Est:		USB
WWV 5 MHz Filename:	WWV_5_8.csv	
Fldigi WWV 2.5 MHz Est:		USB
WWV 2.5 MHz Filename:	WWV_25_4.csv	

Fldigi Frequency Measurement



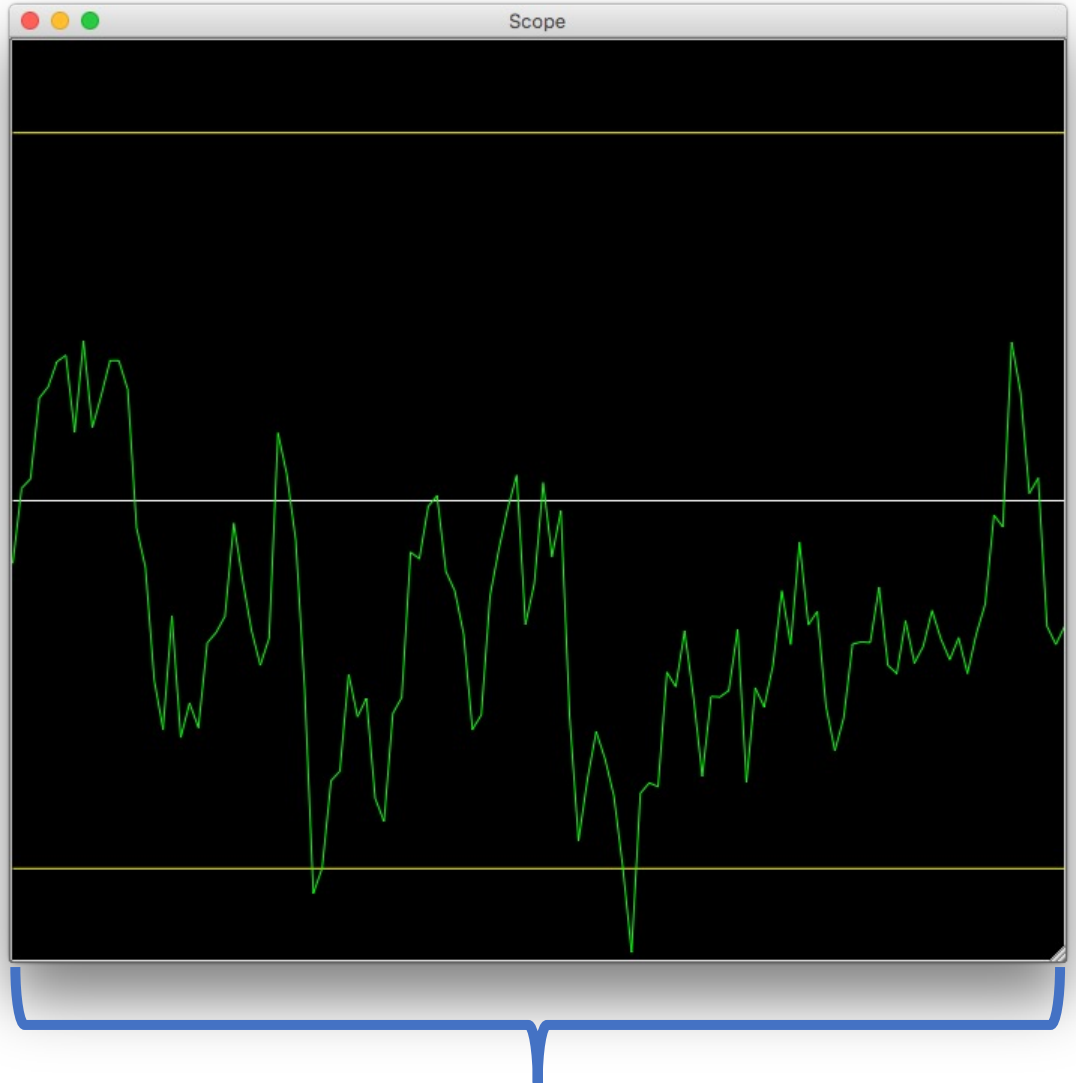
Analysis Mode

Fldigi computes the carrier freq "Fldigi Estimate"

*When waterfall cursor is moved, data collection starts automatically. Hit "CSV Off" to stop it.

Rename data file at the end of each measurement!

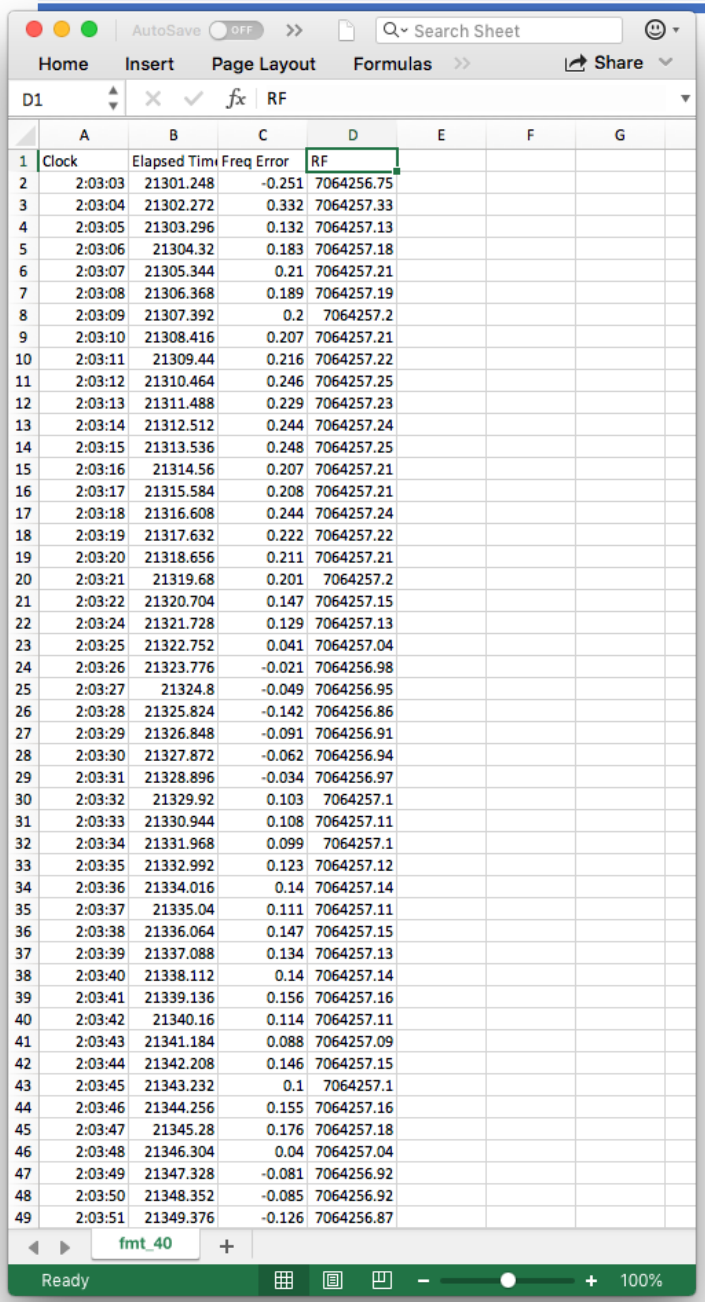
Fldigi Floating Scope



2 Hz

2 Minutes

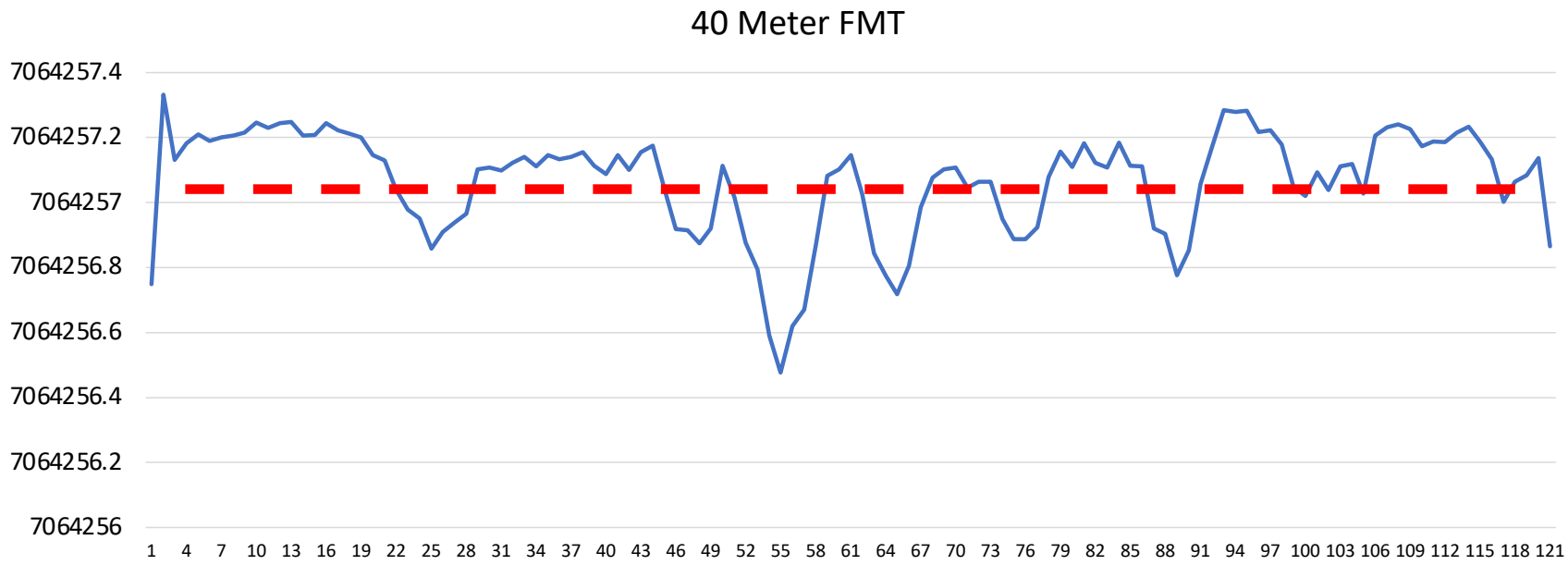
Fldigi Frequency Analysis



	A	B	C	D
1	Clock	Elapsed Tim	Freq Error	RF
2	2:03:03	21301.248	-0.251	7064256.75
3	2:03:04	21302.272	0.332	7064257.33
4	2:03:05	21303.296	0.132	7064257.13
5	2:03:06	21304.32	0.183	7064257.18
6	2:03:07	21305.344	0.21	7064257.21
7	2:03:08	21306.368	0.189	7064257.19
8	2:03:09	21307.392	0.2	7064257.2
9	2:03:10	21308.416	0.207	7064257.21
10	2:03:11	21309.44	0.216	7064257.22
11	2:03:12	21310.464	0.246	7064257.25
12	2:03:13	21311.488	0.229	7064257.23
13	2:03:14	21312.512	0.244	7064257.24
14	2:03:15	21313.536	0.248	7064257.25
15	2:03:16	21314.56	0.207	7064257.21
16	2:03:17	21315.584	0.208	7064257.21
17	2:03:18	21316.608	0.244	7064257.24
18	2:03:19	21317.632	0.222	7064257.22
19	2:03:20	21318.656	0.211	7064257.21
20	2:03:21	21319.68	0.201	7064257.2
21	2:03:22	21320.704	0.147	7064257.15
22	2:03:24	21321.728	0.129	7064257.13
23	2:03:25	21322.752	0.041	7064257.04
24	2:03:26	21323.776	-0.021	7064256.98
25	2:03:27	21324.8	-0.049	7064256.95
26	2:03:28	21325.824	-0.142	7064256.86
27	2:03:29	21326.848	-0.091	7064256.91
28	2:03:30	21327.872	-0.062	7064256.94
29	2:03:31	21328.896	-0.034	7064256.97
30	2:03:32	21329.92	0.103	7064257.1
31	2:03:33	21330.944	0.108	7064257.11
32	2:03:34	21331.968	0.099	7064257.1
33	2:03:35	21332.992	0.123	7064257.12
34	2:03:36	21334.016	0.14	7064257.14
35	2:03:37	21335.04	0.111	7064257.11
36	2:03:38	21336.064	0.147	7064257.15
37	2:03:39	21337.088	0.134	7064257.13
38	2:03:40	21338.112	0.14	7064257.14
39	2:03:41	21339.136	0.156	7064257.16
40	2:03:42	21340.16	0.114	7064257.11
41	2:03:43	21341.184	0.088	7064257.09
42	2:03:44	21342.208	0.146	7064257.15
43	2:03:45	21343.232	0.1	7064257.1
44	2:03:46	21344.256	0.155	7064257.16
45	2:03:47	21345.28	0.176	7064257.18
46	2:03:48	21346.304	0.04	7064257.04
47	2:03:49	21347.328	-0.081	7064256.92
48	2:03:50	21348.352	-0.085	7064256.92
49	2:03:51	21349.376	-0.126	7064256.87

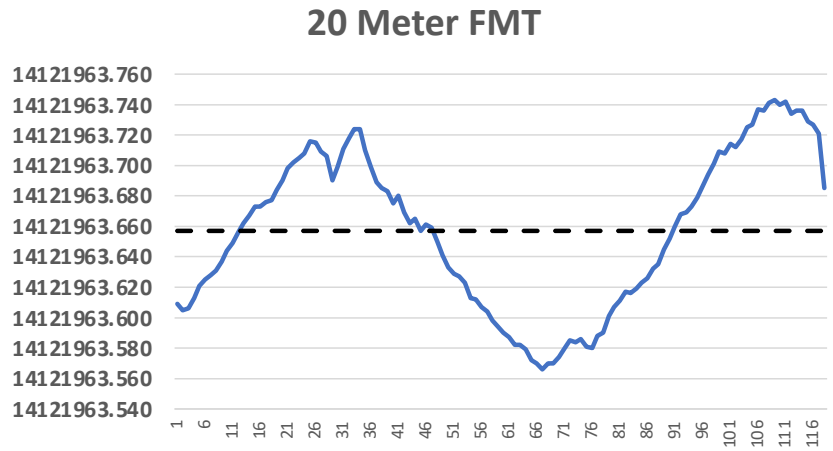
Open the data file with your spreadsheet. Select the “RF” column data and draw a line graph.

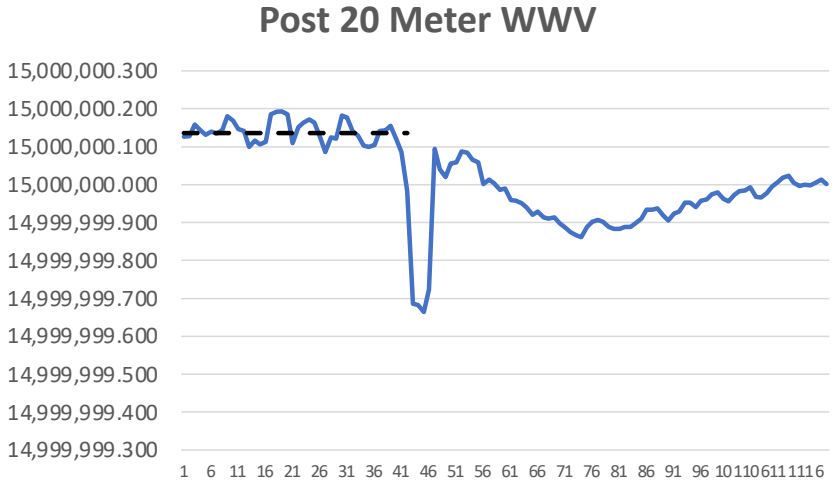
Fldigi Frequency Analysis

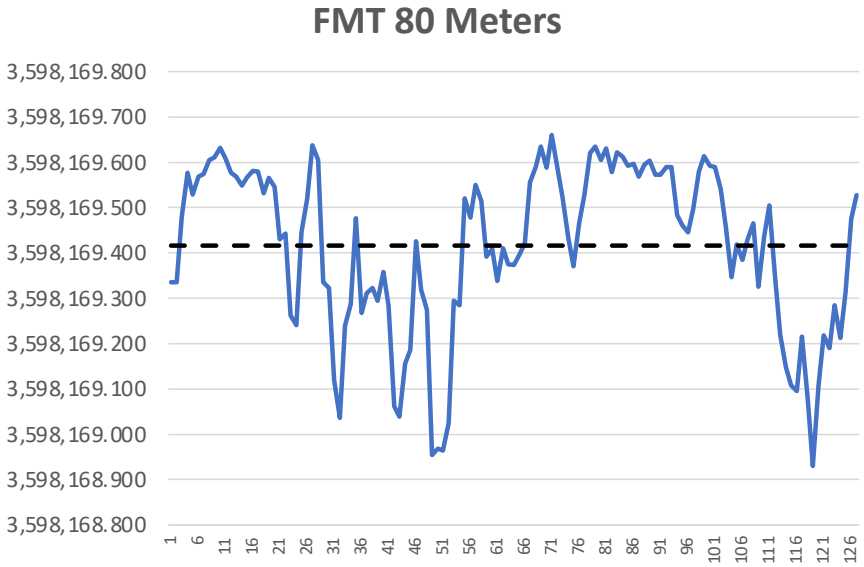


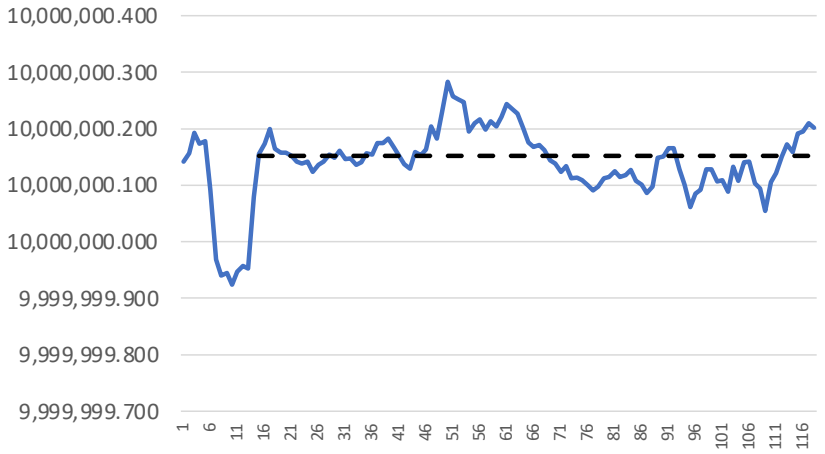
Throw out the first few seconds of data. Look for areas of stability. Eyeball an average value. Use spreadsheet to calculate average over stable areas.

Fldigi Frequency Analysis









Frequency Calculation

- Take the before and after WWV data and average them to compute a correction value. The WWV correction will normally be less than 0.5 Hz.
- Apply the correction to your measured frequency.

Example:

- WWV before: 5,000,000,000.103 Hz
- WWV after: 5,000,000,000.119 Hz
- Average: 5,000,000,000.111 Hz
- WWV Correction = - 0.111 Hz

Check the sign!

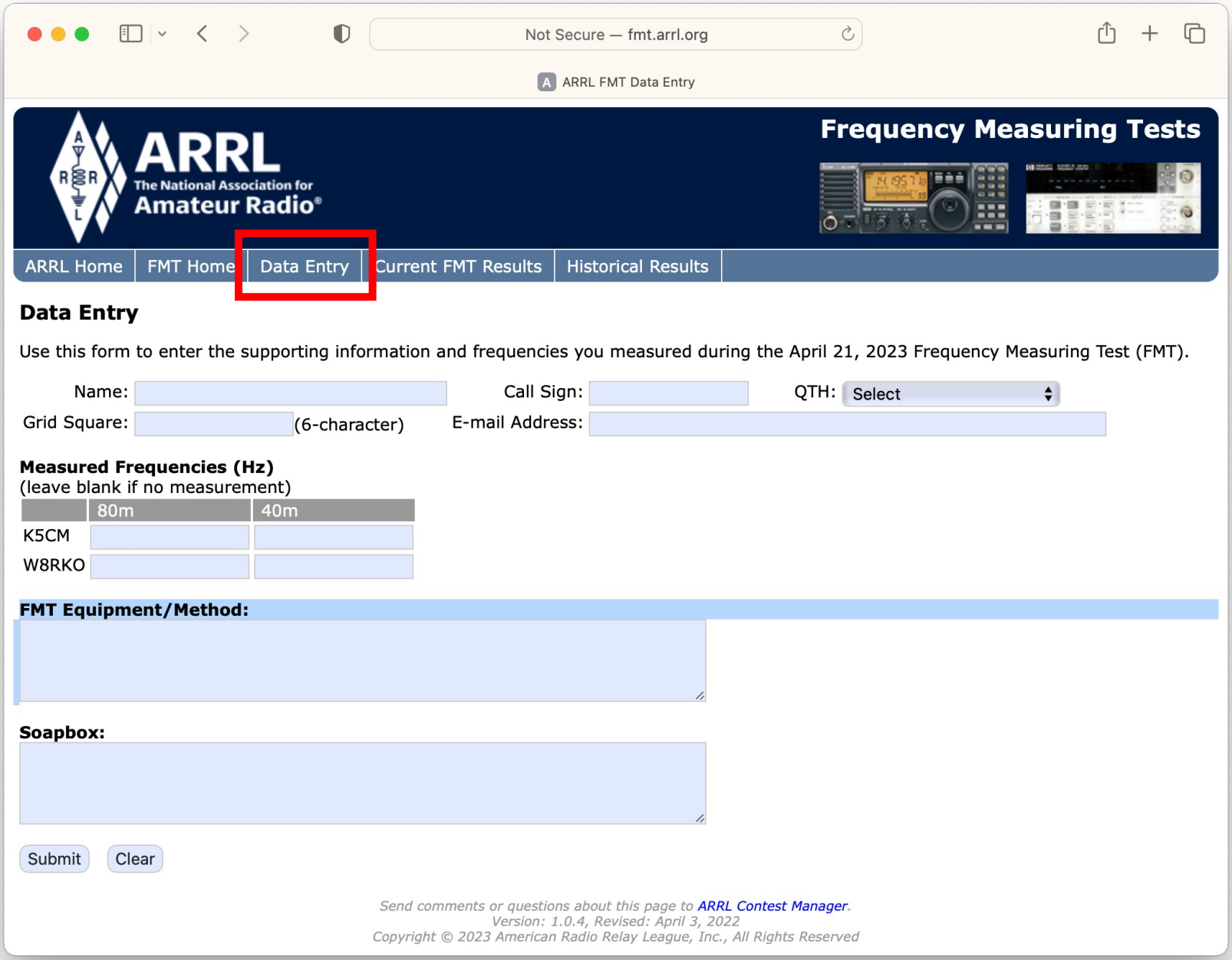
Frequency Calculation

Example:

- Fldigi measurement = 7,064,108.483 Hz
- WWV correction = - 0.111 Hz
- Frequency = 7,064,108.372 Hz

Final frequency = 7064108.37 Hz

Data Entry


Not Secure — fmt.arrl.org
ARRL FMT Data Entry
ARRL
The National Association for Amateur Radio®
Frequency Measuring Tests
ARRL Home
FMT Home
Data Entry
Current FMT Results
Historical Results
Data Entry
Use this form to enter the supporting information and frequencies you measured during the April 21, 2023 Frequency Measuring Test (FMT).
Name:
Call Sign:
QTH:
Select
Grid Square:
(6-character)
E-mail Address:
Measured Frequencies (Hz)
(leave blank if no measurement)
80m
40m
K5CM
W8RKO
FMT Equipment/Method:
Soapbox:
Submit
Clear
Send comments or questions about this page to ARRL Contest Manager.
Version: 1.0.4, Revised: April 3, 2022
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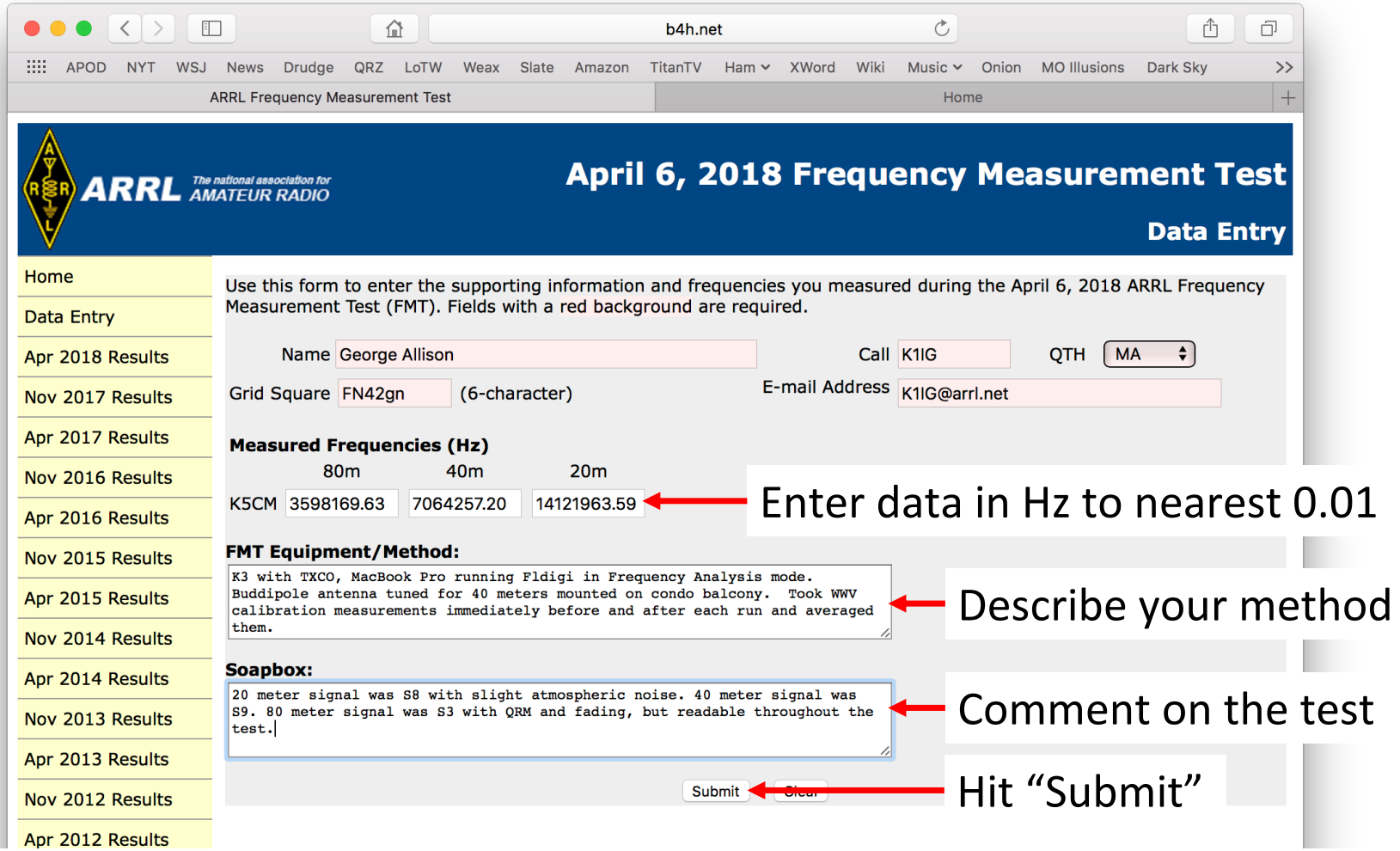
Data Entry



Data MUST be entered by 9:00 PM Sunday night. Results will be published a few seconds later. If you make an error in your data entry, you can bring up a new form and re-enter everything.

Data Results

K0WM	CO	W0		80m	40m	20m	**Method:** Yaesu FT-1000 MP Mark V + 40 meter dipole
			K5CM	3,598,357.20 **0.04**	7,055,773.71 **0.12**		**Soapbox:** Remarkably strong, stable signal on 40 meters, good signal on 80 meters, no signal on 20 meters.
			W6OQI				
K1GGI	MA	W1		80m	40m	20m	**Method:** Heterodyne with LO referenced to GPS, detect beat with SpectrumLab.
			K5CM	3,598,357.15 **-0.01**	7,055,773.48 **-0.11**		**Soapbox:** Tnx to the organizers, always fun.
			W6OQI			14,121,545.58 **-0.08**	
K1IG	MA	W1		80m	40m	20m	**Method:** K3, FLDigi, and MacBook Pro. Made two minute WWV measurements before and after each signal measurement and averaged to get applied offset. Graphed two minute signals at one second intervals and averaged.
			K5CM	3,598,357.11 **-0.05**	7,055,773.60 **0.01**		
			W6OQI			14,121,545.51 **-0.15**	**Soapbox:** First 20 meter signal was about S2-S3, but very stable. Unable to detect second 20 meter signal. 40 and 80 meter signals were very loud. Band conditions in the afternoon were terrible, but improved greatly after dark; this is the first FMT in over a year that I've been able to hear all three signals.
K1JT	NJ	W2		80m	40m	20m	**Method:** TS-2000X with WSPR "fmtest" tools.
			K5CM	3,598,357.00 **-0.16**	7,055,773.61 **0.02**		**Soapbox:** W6OQI antenna has good directivity: signal was inaudible when he turned toward JA. My software measured its frequency anyway: 14121544.836 Hz, about 0.9 Hz lower than when he was beaming east. No estimates or corrections for Doppler shifts have been applied. I simply report frequency measurements of the signals "as received". Estimated uncertainties are around 0.3 Hz for each signal.
			W6OQI			14,121,545.77 **0.11**	
K3JQ	MD	W3		80m	40m	20m	**Method:** Equipment used: HP 3586B Selective Level Meter, Trimble Thunderbolt GPS Receiver, Spectrum Lab FFT Program running on Windows 7 PC, SoundBlaster Sound Card. Antenna: Carolina Windom 80 Short, 60 feet high. Procedure: HP 3586B locked to Thunderbolt GPS Receiver. Audio output of 3586B fed to line-in of sound card. Sound card audio recorded by Spectrum Lab starting with 10 MHz WWV at 22:10 EDT, W6OQI at 22:15, 15 MHz WWV at 22:31, 10 MHz WWV at 22:35, 5 MHz WWV at 22:40, K5CM 40m at 22:45, 5 MHz WWV at 22:54, 2.5 MHz WWV at 22:57, K5CM 80m at 23:00, 2.5 MHz WWV at 23:08, 5 MHz WWV at 23:11. During this session, I located each FMT transmission to within a few Hz aurally and visually with Spectrum Lab (FFT set to decimate by 4, Hann window 8192), set the 3586B 20 Hz filter, and recorded the frequency setting of the 3586B. Next day, analyzed the Spectrum Lab wav file (decimate by 4, Hann window 131072), exported results to Microsof Excel, calculated frequencies, standard deviations with Excel functions using measured WWV signals for comparison.
			K5CM	3,598,357.19 **0.03**	7,055,773.45 **-0.14**		
			W6OQI			14,121,545.29 **-0.37**	

Data Results

ARRL The national association for AMATEUR RADIO

April 2018 Frequency Measurement Test

Results

- Home
- Data Entry
- Apr 2018 Results
- Nov 2017 Results
- Apr 2017 Results
- Nov 2016 Results
- Apr 2016 Results
- Nov 2015 Results
- Apr 2015 Results
- Nov 2014 Results
- Apr 2014 Results
- Nov 2013 Results

April 6, 2018

Actual Radio Frequencies (Hz):

	80m	40m	20m
K5CM	3,598,169.73	7,064,257.06	14,121,963.34

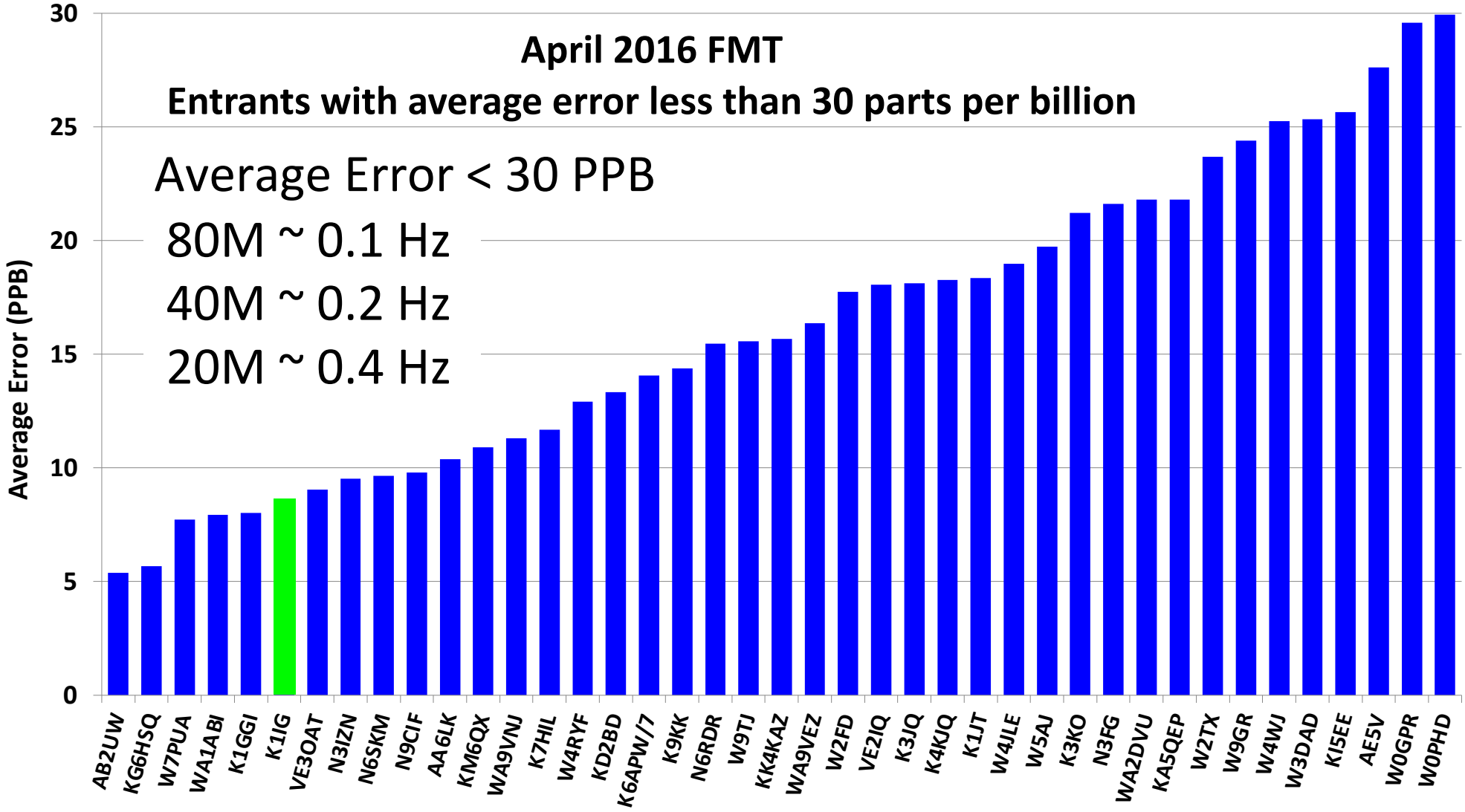
Green Box!

K5CM All (<=1 Hz):
AA6E, AA6LK, AB1UY, AB2UW, AC6SL, AF9A, K1IG, K4BYN, K4CXX, K5ND, K5RKS, K5XL, K6APW, K7KMQ, K8CT, K8DJR, KA1BQP, KA5QEP, KD5MMM, KF7NP, KG5X, KJ6HYC, KM6QX, KN1H, N1IRO, N2GL, N3FG, N3SXI, N6SKM, N7EP, NK6P, VE2IQ, VE3OAT, VE3YX, VE6GRT, W2FD, W2JTM, W2TX, W3DAD, W3JW, W4IVF, W4VU, W4WJ, W5LAC, W6BM, W6DSR, W6OQI, W7DMR, W7GW, W8BL, W8XN, W9GR, W9INE, WA1ABI, WA2DVU, WA4FJC, WA7BNM, WA7IRW, WA9VNJ, WB0OEW, WB4SON, WB8TFV, WD4IYE

K5CM 80 (<=1 Hz):
AA6E, AA6LK, AB1UY, AB2UW, AB9TX, AC6SL, AF9A, K1GGI, K1IG, K4BYN, K4CXX, K5ND, K5RKS, K5XL, K6APW, K6UM, K7HKR, K7KMQ, K8CT, K8DJR, KA1BQP, KA5QEP, KB1OIQ, KC8BNP, KD2BD, KD5MMM, KF7NP, KG5X, KI5EE, KJ6HYC, KM6QX, KN1H, N1IRO, N2GL, N3FG, N3SXI, N4VSD, N5DM, N5LUL, N6SKM, N7EP, N7WS, N8OB, N8OOU, NK6P, SV8QG, VE2IQ, VE3OAT, VE3YX, VE6GRT, W1LMT, W2FD, W2JTM, W2TX, W3DAD, W3JW, W4IVF, W4VU, W4WJ, W5LAC, W6BM, W6DSR, W6OQI, W7DMR, W7GW, W7KPZ, W8BL, W8EDU, W8XN, W9GR, W9INE, W9ZB, WA1ABI, WA2DVU, WA2IKL, WA4FJC, WA6VPJ, WA7BNM, WA7IRW, WA9VNJ, WB0LXZ, WB0OEW, WB4SON, WB8TFV, WD4IYE, WQ8T

K5CM 80 (>1 to <=5 Hz):
KD5FX, KQ2RP, VE9DAN

Data Results



Techniques for the **FANATICAL***

- Record the test as a WAV file and play it back on other computers for analysis
- Feed a 10 MHz GPSDO (GPS Disciplined Oscillator) signal into your receiver and computer for nanosecond accuracy
- Warm up receiver for 48 hours in a temperature controlled blanket

* No guarantee of accuracy improvement

Smartphone Rig Calibration

- Smartphones are surprisingly accurate, but need good signals
- Look for “Piano Tuning” or “Guitar Tuning” in your app store - several free apps give 0.1 Hz readout
- Hams have successfully participated in the FMT with Android tablets

Lessons Learned

- Test equipment is not required
- Dumb errors ruin many scores
  - USB mode
  - Sign of WWV & rig corrections
  - Check spreadsheet numbers against your log
- You'll improve with practice
- With a little experience, rig calibration is easy

Resources

- Groups.io: FMT-Nuts
- http://www.k5cm.com/
- QST April 2015, p. 37
- http://www.ka7oei.com/fmt.html
- http://www.febo.com/time-freq/fmt/
- http://fmt.arrl.org

Rig Calibration

■ Calibration the Frequency (approximate)

EXACT!

A very accurate frequency counter is required to calibrate the frequency of the transceiver. However, a rough check may be performed by receiving radio station WWV, WWVH, or other standard frequency signals.