QRP Special

On the Cover: Robert Williams, N0QLR, operates a Summits on the Air (SOTA) station atop Mt. Herman, Colorado with "mountain goat" Steve Galchutt, WG0AT. Story on page 16, details on page 30.

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QRP SPECIAL ISSUE: Special things happen when you turn the power down less than 5 watts. Find out what happens on pages 8, 10, 16, 19, and 22. Plus ... love is in the air on pages 32 and 38.

FEATURES

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DEPARTMENTS

Yes, we know that February isn't outdoor operating time for many of us. So if you don't live in a warm-winter zone, hold onto this story and read it again when your world begins to thaw out!

QRP FT8 to the Field

Strategies on Operating Outdoors

BY GENE HINKLE,* K5PA

I have enjoyed building and operating QRP radios and enjoy the minimalist aspect of QRP. My QRP exploits began in the '70s with the Heathkit HW-7 QRP radio and culminated with the Elecraft KX3, a fully featured software-defined (SDR) transceiver. This last year, I had the opportunity to purchase the Icom IC-705 all-mode radio that features portability and operates over most ham bands (1.8-450 MHz). I figured the radio would serve as a very nice QRP CW transceiver to take to the field (*Photo A*), but could also provide SSB, FM, and data communications.

I also enjoy FT8/FT4 modes due to the homeowner's association (HOA) restrictions in our neighborhood. With a stealthy antenna and low power, I have found it easy to work the world on the HF bands. The combination of QRP power and FT8 seemed obvious and led to taking the Icom to the field. What I learned from my experiences can easily be applied to other transceivers in current production and some on the horizon.

There's Power in Signal Processing

QRP is normally rated in terms of RF output power. It is obvious through our experience that the greater the power is at the transmit end, the stronger the signal is heard at the receiving station. Thus, it is easier to make contacts using higher power. The QRP enthusiast, however, strives to use lower transmitter output power, such as 5 watts or less.

There are advantages in using digital coding techniques to increase the effectiveness of the communications using dig-

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Photo A. QRP FT8 in the field (Photos / diagrams by the author except as noted)
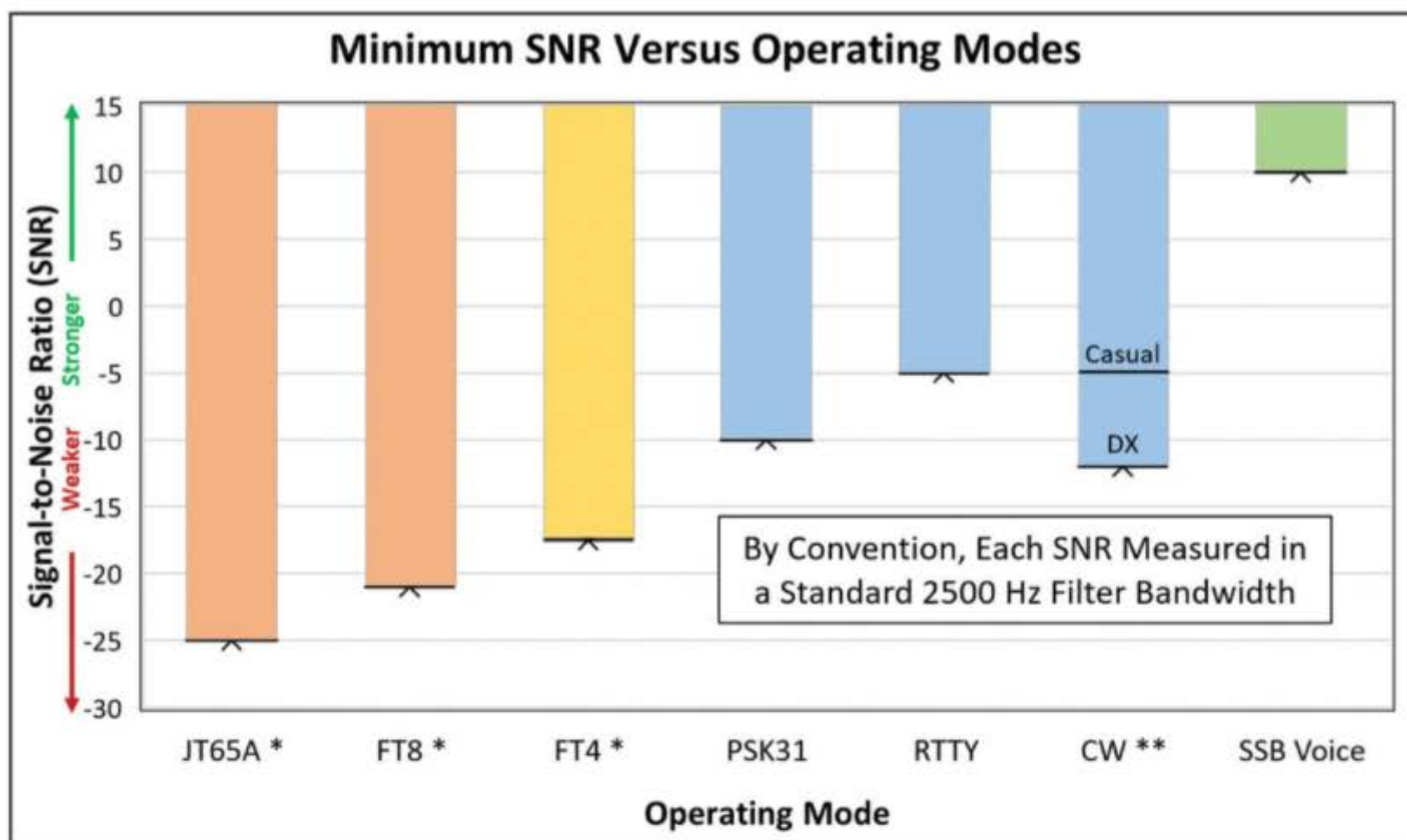
Figure 1. Minimum signal-to-noise ratio (SNR) thresholds versus operating modes [K5PA graph based on data from References 1, 2 (*), and 3 (**)]

ital signal processing (DSP). Interestingly, Morse code can be copied easily by ear but with the inherent limitations of the signal's power and background noise. Applying DSP techniques, this limitation can be extended to lower RF power levels, because it can lower the required signal-to-noise ratio (SNR) for communications. These DSP and coding techniques can make our communications more reliable, making them as effective as transmitting with higher RF power. Therefore, I say there is "real" power in signal processing.

The chart shown in *Figure 1* describes the minimum SNR necessary to communicate within a 2500-Hz filter bandwidth.[1,2,3] This represents the typical bandwidth of SSB filters for voice communications, 300-2800 Hz. The received desired-signal power when compared with the noise within this bandwidth defines this SNR. To the far right in the chart is single sideband (SSB) voice communication that shows the SNR needs to be higher than +10 dB for effective communications. On the far-left side is JT65A, where the SNR threshold for communications is -25 dB. FT8 (-21 dB) and FT4 (-17.5 dB) are also listed, along with CW, PSK31, and RTTY. The takeaway from this chart is recognizing the decrease in signal power that is needed to establish communication varies by operating mode.

What this means to the QRP enthusiast is communications can be readily made at lower RF transmit power if signal processing and coding are employed when using these different operating modes. For example, FT8, with a threshold of -21 dB SNR, when compared with working DX using CW, with a threshold of -12 dB SNR, requires a *9 dB* difference in necessary RF power given the same noise level. Think about that, a 100-watt CW transmitter at its threshold for communication would only need 12.5 watts if FT8 was being transmitted instead. To further explain how this is calculat-

ed, the 9-dB difference is equivalent to a factor of eight such that a 12.5-watt FT8 transmission would be equivalent to a 100-watt SSB transmission (8 x 12.5 watts = 100 watts). The difference in the RF power required is a direct result of the power of DSP and coding, all else being equal.

The story does not stop with raw RF power. For example, think about the amount of concentration that is needed to copy weak CW signals at the lowest SNR thresholds. The receiving station would normally want to copy stronger signals that provide a higher SNR approaching the causal CW copy level of about -5 dB. Digital modes such as FT8 provide weak-signal decoding improvements and they do not fatigue. They will produce the same result now or an hour from now. The operator becomes the conductor of the orchestra for selecting the decoded FT8 callsigns based on their location and measured SNR levels as measured by the FT8 program. This can add to the enjoyment of the operating session and can complement QRP CW operation.

Taking FT8 to the Field

I am using the Icom IC-705 portable transceiver as the center of a portable QRP operating station. It is capable of CW, SSB, FM, and digital modes such as FT8, FT4, D-Star, etc. The IC-705 is a SDR that uses DSP to convert the radio frequency energy into demodulated signals for speech and data. It also operates over most of the ham bands from 1.8-450 MHz. It includes a GPS receiver that can show satellite position, geo-location, and time display and it can transmit its decoded data to other software applications.

The transceiver has several wired and wireless interfaces to provide radio control and signal interfacing. It has a serial CIV radio control interface and audio sound card built into the architecture. This means that external software programs

that use a sound card interface can access the transceiver's built-in sound card for data communication modes. This is identical to how other Icom transceivers, the IC-7300 and IC-7610, operate for interfacing to digital modes.

Figure 2 shows the simplified connections from the IC-705 to the computer, external antenna tuner (optional), and battery power. There are just a few cables needed to carry the signals. A USB cable is used for data and digitized audio, a coaxial cable for the radio's antenna connection to the Elecraft tuner, and one battery cable. The built-in GPS antenna and receiver provide satellite position and time data that is displayed on the transceiver's front panel. There is also time and position data generated by the GPS receiver that can be sent to the station computer for adjusting the computer's time-of-day clock to within milliseconds. This is useful when operating software programs, such as WSJT-X FT8, that require time data to be accurate within a fraction of a second.

I use the Elecraft T1 as my tuner when using a non-resonant antenna. If your antenna already provides a 50-ohm match to the transceiver, then the tuner can be omitted. However, I find it is best to still include either an automatic or manual tuner in my go kit to address any antenna tuning problems when in the field.

Table 1 includes the equipment list organized by name, function, and a web link URL for gathering additional information.

The computer listed uses the Windows 10® operating system and all software is selected to run under it. *Table 2* lists the software programs I use by name, function, and where to find additional information. The basic program functions for my QRP FT8 operation are to run WSJT-X FT8 or FT4 modes, provide JTAlert to assist in keeping track of contacts by location, time syncronization, and contact logging. Since there are numerous other software programs that can be used for other modes (CW, RTTY, etc.), these can easily be integrated into the overall system. I also include a program called TimeFudge, which provides an easy way to nudge (fudge) the computer's time clock in fractional seconds (plus or minus) for synchronizing to within a split second while using digital modes. This is useful if the GPS signal is weak, such as when operating under a metal
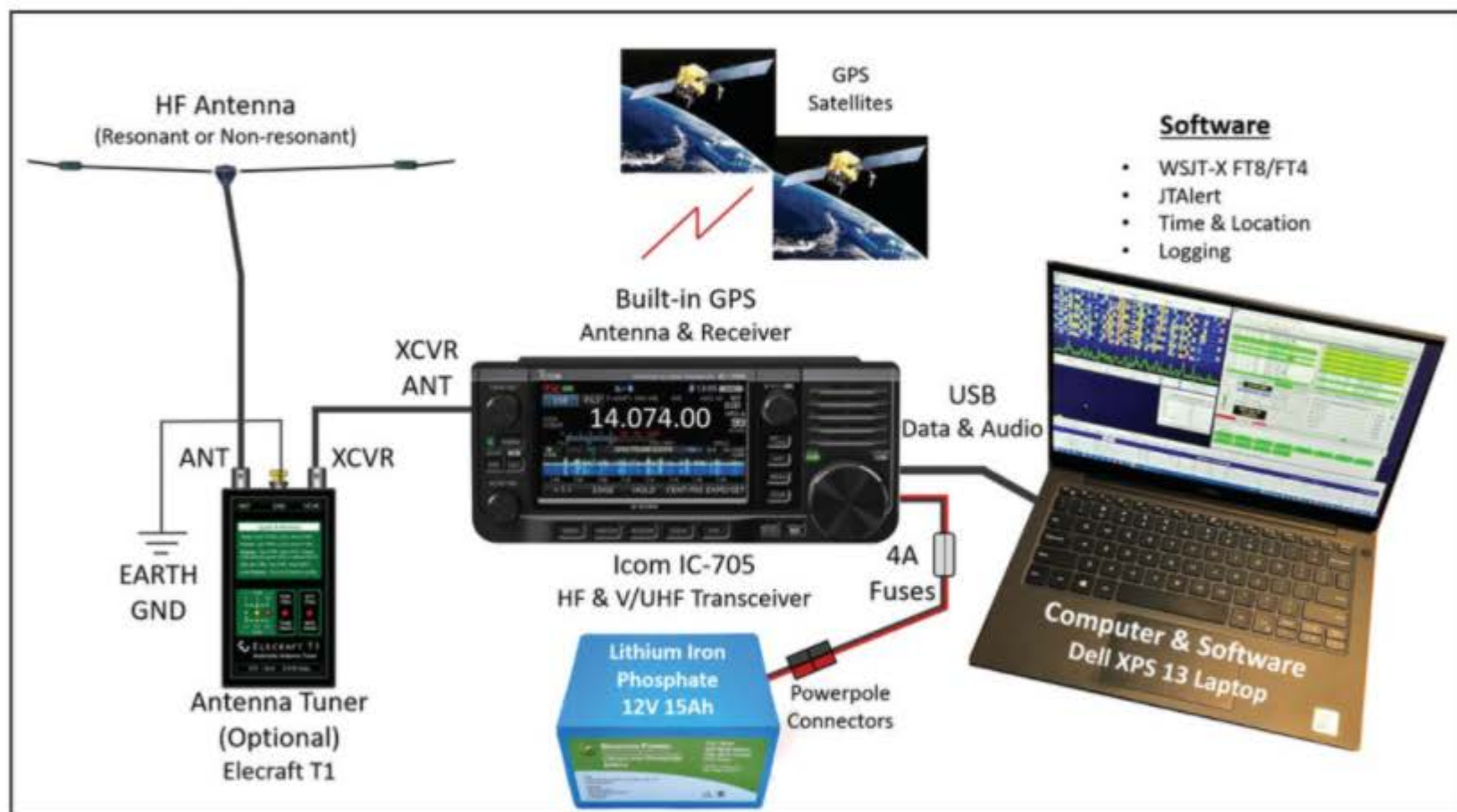
Figure 2. Connection of the IC-705 transceiver to other equipment.

Table 1		
Name	**Function**	**Download & Comments**
Icom IC-705	Transceiver, HF & V/UHF, USB audio, GPS, sound	<https://tinyurl.com/2p8498sn>
Bioenno Power BLF-1215A	Power source, 12-volts DC, 15-Ah capacity	<https://tinyurl.com/4f4vzax8>
Elecraft T1 autotuner (Optional)	Tune antenna to 1:1 VSWR	<https://tinyurl.com/yc3kz6hy>
HF antenna	80-10 meters or ither	Wire antenna, dipole or longwire, homemade
Dell XPS13 computer	Radio control, DSP, time, Logging, etc.	<www.dell.com/en-us/shop>

Table 1. The author's portable QRP FT-8 setup. Your details may vary depending on your available equipment.

Table 2

Name	Function	Download
WSJT-X v2.5.3 or higher	FT8, FT4 DSP	<https://tinyurl.com/26ft27rs>
JTAlert v2.50.9 or higher	Assist with contact goals	<https://hamapps.com>
NMEATime v2.2.1	GPS time and location	<https://tinyurl.com/4cxrjh5m>
N3FJP ACLog v.7.02	Logging contacts	<www.n3fjp.com/index.html>
TimeFudge v1.4.1	Time adjustment w/o GPS	<https://tinyurl.com/yckmr5j3>

Table 2. Software used at K5PA

roof or indoors, and alternate means must be used to provide time sync.

Use GPS for FT8 Time Sync

Software such as NMEATime can use the IC-705's internal GPS receiver to synchronize your computer clock to within a fraction of a second. But first, the menu settings of the IC-705 must be set so the radio can send position and time information to the computer using its built-in virtual serial com port. *Figure 3* lists the steps necessary to adjust the radio menus to have the GPS set the radio's time display, set up a data com port USB (B), and select data time transfer over the com port to your computer. At the computer, the GPS program NMEATime can connect to this virtual com port to read the GPS data sentences and then manage the computer clock to within a fraction of a second. The NMEATime program can provide a more accurate time sync when compared with using the GPS time of day clock.

Alternate Strategies

There are other solutions to operating QRP FT8 that merit discussion beyond the Icom IC-705. One of my favorite QRP transceivers, capable of 10-15 watts of RF power, is the Elecraft KX3 shown in *Figure 4*.[4] There is also its newer cousin, the KX2. These transceivers can be brought into service by interfacing them to the computer through their radio control interface. My KX3 was used for FT8 in earlier days and it was a joy to operate. Since the transceiver requires transmit and receiver audio, a sound card must be provided. There are numerous USB sound card solutions that can be put into service or the computer's internal sound card might be usable. Select one that can provide both input and output and provides a sampling rate of 48k samples / seconds. External sound cards are very affordable and easily interface to the computer and radio using the USB and 1/8-inch (3.5-millimeter) phone jacks.

New on the scene is the very affordable QDX (QRP Labs Digital Xcvr) transceiver also shown in *Figure 4*.[5] This design uses a unique interface to convert the FT8 audio tones to synthesized RF frequencies following the same data sequence patterns. The QDX is currently in high demand, but I am hopeful to have one assembled and fielded this year. The price point for this 4-band capable QRP transceiver is less than $100 U.S. The QDX includes a built-in sound card and radio control interface that should work as well as the Icom IC-705 interface. (*See this month's QRP column for more on the QDX – ed.*)

Another strategy is to use the Raspberry Pi 3 (RPi 3) computer board using the LINUX (Raspbian) operating system that runs WSJT-X FT8 and FT4.[6,7] During my early days of FT8, I integrated the Raspberry Pi computer as my FT8 proof-of-concept platform and found it worked rather well. There is a host of LINUX software programs available to serve the same functions as I have fielded with my IC-705. The beauty of this approach is the price declines significantly for building and fielding an FT8 QRP transceiver.

Lessons Learned Along the Way

I have found the simplified interfaces to the IC-705 for FT8 in the field make this rig a joy to use. The setup and takedown are very fast and easy due to the low number of cables and devices. As with most fielded systems, there can be challenges for successful operation.

1. Pay attention to RFI – The first challenge is to pay attention to cable routing and grounding. The IC-705 and the Elecraft T1 external tuner have grounding screws that should be bonded together and connected to a ground. This will help with static buildup and discharge from the antenna system or human contact. The IC-705 uses a plastic case (no EMI protection here) with the GPS receiver with antenna located under the case.

The plastic case of the IC-705 does not provide adequate shielding for keeping your transmitted RF from entering your transceiver. This can interrupt USB data communications

IC-705 Menu Setting

Let GPS Set IC-705 Time

TIME SET
(Source: Basic Icom Manual, Sec. 8, p. 18)
Menu >> SET > Time Set > Date/Time
Select **GPS Time Correct** (Auto)

Set Radio Virtual Com Port USB (B)

CONNECTORS
(Source: Basic Manual, Sec. 8, p. 14)
Menu >> SET > Connectors > USB (B) Function
Select **GPS Out** then **DATA -> USB (B): Output the position data to USB (B)**

Set Radio GPS Data Sentence to NMEA

TRANSMITTING NMEA DATA
(Source: Advanced Manual, Sec. 12, P. 17)
Menu >> GPS > GPS TX Mode > NMEA
Select **GPS Sentence** and **Select GGA**

Figure 3. IC-750 menu settings for using internal GPS

Elecraft - KX3 Transceiver
160-6 Meters
Up to 15 Watts RF Output
All Modes

QDX Digital Transceiver

QRP Labs

QRP Labs – QDX FT8 Transceiver
80, 40, 30, & 20 Meters Meters
Up to 5 Watts RF Output
FT8 Digital Only

Figure 4. The Elecraft KX3 and QRP Labs QDX digital transceivers.

between the radio and the computer. I have found it sometimes necessary to use clip-on ferrite cores to reduce RF coupling across the connections. The other mitigation technique is to keep the transmit antenna away from the IC-705 and your computer system. This will help reduce noise picked up by your receiver plus reduce the coupling of RF back into your equipment (*as well as minimizing potential exposure to RF – ed.*). The adage to keep your antenna away from your computer and equipment is certainly correct. For that rea-

son, I usually have a roll of coaxial cable available to add an additional length if necessary.

2. GPS and Time Sync Methods – The GPS antenna requires a clear view to the sky for successful satellite acquisition. In my case, I also use the TimeFudge program to adjust the computer's clock for time synchronization with the decoded FT8 signals. I can achieve less than ±0.2 seconds DT error (Differential Time value in WSJT-X FT8) using TimeFudge and watching the DT time decrease. But it helps to know the approximate time of day at the start of operating so signals are decoded showing their DT values. At first, it may be helpful to provide a sky view for GPS to set the computer clock and then use TimeFudge if the sky view cannot be maintained. Once TimeFudge has the proper correction value, it is easily tweaked in small intervals (plus or minus) to keep excellent synchronization. If the sky view is always present, then the time synchronization software, such as NMEATime, can be left running. One added benefit with NMEATime is that your current grid square is always calculated based on your latitude / longitude coordinates.

3. Manage Your Energy – The IC-705 transceiver transmitting 10 watts of RF power draws about 2 amps from your battery. I use the Bioenno Power Lithium Iron Phosphate battery (12 volt, 15 Ah) and I find it useful to manage the battery energy consumption by watching the energy drawn from the battery during operating sessions. A small energy meter with Powerpole connections is readily available for measuring the amp-hour usage.[8] You can watch the energy consumed and keep it below the rating of your batteries.

4. SNR is Not Bilateral – I find it interesting to monitor the sent / received SNR report during the FT8 / FT4 contacts. There are many factors that create the reports at your station and your QSO partner's station. Realize that the report consists of both your received signal level and your noise level. If your local interference level is high due to other transmitters (QRM) or atmospheric noise (QRN), the received noise power, which is measured during the dead period in the FT8 / FT4 cycle, will be high. Your QSO partner has his / her own received signal level and local interference or noise level. You should not expect both your SNR and his / her SNR to be equal. I do follow the trends between my different contacts to judge the

performance of my station and the effects of propagation. It is fun to watch the bands open during the day by monitoring the SNR reports sent to and received from various geographic areas.

5. Where are the Watering Holes? – Another question to consider is "what frequencies should be used for WSJT-X FT8 and FT4?" Considering the difference in RF power levels used by some home stations, you may be tempted to go outside the normal "watering holes" currently established. However, except for being on the edges of each sub-band, I would not recommend you do that. Most of the ham population you will be working will be in the established frequency sub-bands. You should keep to the sub-bands already established for FT8, FT4, Fox / Hound (a mode I do not recommended for QRP), or FT8 / FT4 contesting.

6. Call or Be Called? – Should you "call CQ" or "search & pounce" other stations? Running CQ on a specific frequency is best done when the bands are not fully populated to limit being interfered with. But on quiet bands, the Run CQ mode will draw out those who are monitoring. Of course, if you have been spotted on a certain frequency and are expecting callers, you could stay there and make your calls.

Search & Pounce is likely most successful in the general sense because those stations are calling CQ and listening for callers. You do not need to make the call on their frequency, however, for that is where many others might be calling. Instead, offset your call from the other callers to increase the odds that you will be decoded on the other end. You may want to call a few cycles to allow the current QSO to be completed and for you to become a tailgater to the current contact finishing up.

Summary

Taking FT8 QRP to the field has been very enjoyable and worthy of consideration. Over the last year, I assembled my station in various phases to provide the portability and capability presented. I am looking forward to new variations of operating FT8 using the new QDX radios currently under development. Since my current setup allows for new modes simply by changing software programs, I think it will serve me well into the future as a test bed for digital modes in the field. Plus, I still maintain my CW operating capability with the addition of support programs as they become updated and available.

The author would like to thank Tom Parish, KB5RF, for his insight into operating in the field on his recent trip to New Mexico. His exploits while in the field provided a fresh look at overcoming obstacles while operating outdoors and the focus needed during the planning phase.

References:
1. Signal/noise ratio of digital amateur modes, <https://tinyurl.com/n4a4anyh>
2. * WSJT-X User Manual, <https://tinyurl.com/yffzv8vp>
3. ** A Comparison of Common Digital Modes for Weak Signal VHF Communications, <https://tinyurl.com/2a9cj66y>
4. Elecraft KX3 SDR Transceiver, All Band, <https://tinyurl.com/bdh84ufj>
5. QDX Digital FT8 Transceiver, 80-20 Meters, <http://qrp-labs.com/qdx>
6. <https://tinyurl.com/3ys7fc4x>
7. <https://tinyurl.com/2p89n38b>
8. <https://tinyurl.com/ysrm7fe5>

Down

3. Quintessential name for an Italian cafe overlooking the Bay of Fundy
4. After poking a hive in Mauritania, the fennec fox's nose was covered with _____
6. The _____ on an object is equal to its mass times its acceleration in France
7. A humble home in Minnesota
8. Overactive Ego or custom callsign in Nova Scotia
9. Initials of the second-best grade of cognac in Namibia
12. Metal tossed in a fountain in Havana
13. Can cause "rusty" metals in Kalaallit Nunaat
15. The Greek LCD projector had inputs for VGA, HDMI and _____
16. Where the Siberian hockey club played all of its matches
20. The _____ oil passed through the Bosporus Strait
21. After robbing a bank in Wisconsin
23. In bad shape after heavy drinking in a Texas bar
24. Previous CCCP or USSR depending on the language of abbrev.
28. Reunion Island Ami
31. The yacht left Tripoli and _____ east to Alexandria
32. Burning strongly and brightly in Paris
34. When the wind blew through the graveyard, he thought he heard in Newfoundland
35. Eight in a cup and sixteen in a pound in Copenhagen
37. His old war _____ caused him to limp around his Kansas farm
41. Not harder in Barcelona
44. His midwestern friends said he was __ ____ to be around (2 words)
45. Bother in the Netherlands
46. Dostoevsky in French Guiana

(Answer Key on page 58)

Looking Ahead In

Here are some of the articles we're working on for upcoming issues of *CQ*:
- Results: 2021 CQ WW RTTY DX Contest
- HF Activities for Techs
- Profile: Southwest Ohio DX Association

Plus …
- The NinoTNC and Old-School Packet
- Updates on 630 / 2200 Meters and Crossing the Pond
- Using Vitamin K (as in Kirchhoff)

Upcoming Special Issues
June: Take it to the Field
October: Emergency Comm.
December: Technology

Do you have a hobby radio story to tell? Something for one of our specials? *CQ* covers the entire radio hobby. See our writers' guidelines on the CQ website at <http://bit.ly/2qBFOdU>.

BEHIND THE BYLINES...

... a little bit about some of this month's authors

James Green, WB9HDH ("Five Watts and a Dipole," p. 8), returned to active hamming last year after a 40-year absence from the bands, as he explains in his article. A retired technical writer, James operates exclusively QRP CW. He lives in Wauwatosa, Wisconsin.

Gene Hinkle, K5PA ("QRP FT8 to the Field," p. 10 and co-author of "Microphones and Audio Speech Processing for SSB," p. 45), is a regular contributor to *CQ*, often teaming up with other authors to share their joint projects. His many ham radio interests can be found on his webpage, <https://www.k5pa.com>.

Steve Galchutt, WGØAT ("QRP Quickies: A Great Introduction," p. 16), has been a ham since the 1950s and is well-known in the QRP and SOTA (Summits on the Air) communities for his goat-assisted hikes to operate from various mountain peaks in Colorado.

Paul Keon, AB4PP ("QRP Quickies: '35,000 Miles Per Watt' and 'Did I Mention it Was Raining?'" p. 17) is an active member and official storyteller ("scribe-meister") of the North Carolina-based Knightlites QRP Society. He is a retired state trooper and enthusiastic quilter as well as QRPer.

Zvi Segal, 4Z1ZV ("Love Island DXpedition – 4X100AI," p. 32), enjoys off-roading, photography, and 3D printing in addition to ham radio. Since 2019, he has been active on the geostationary QO-100 amateur satellite, which was a significant part of the expedition he writes about in this issue. He lives in Raanana, Israel.

Gary White, W5GW (co-author "Microphones and Audio Speech Processing for SSB," p. 45), is a retired Professional Engineer. His interests beyond ham radio include photography, astronomy, and fiction-writing. He has published a novel and won awards for his short stories. His webpage is <https://w5gw.com>.