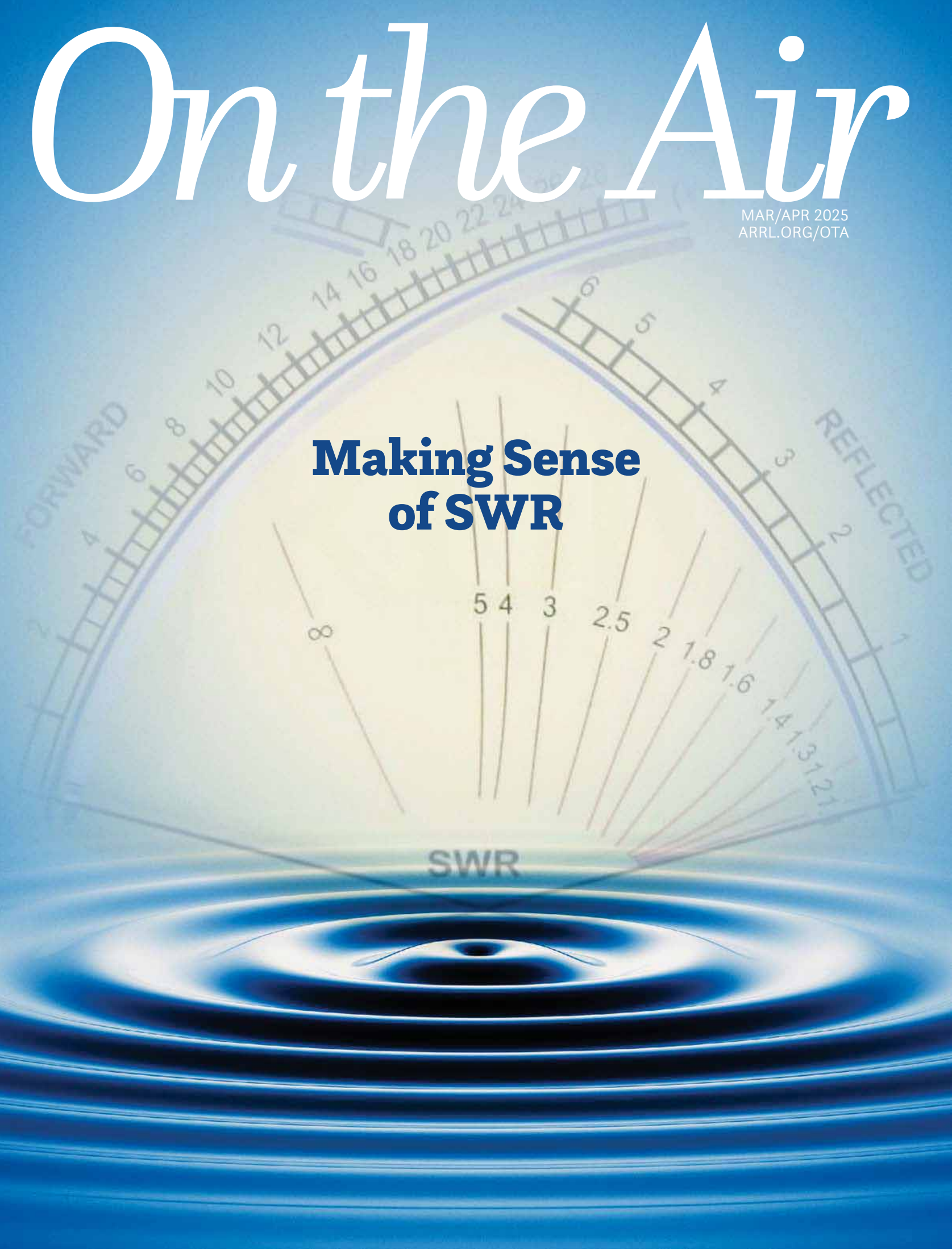


On the Air

MAR/APR 2025
ARRL.ORG/OTA

Making Sense of SWR



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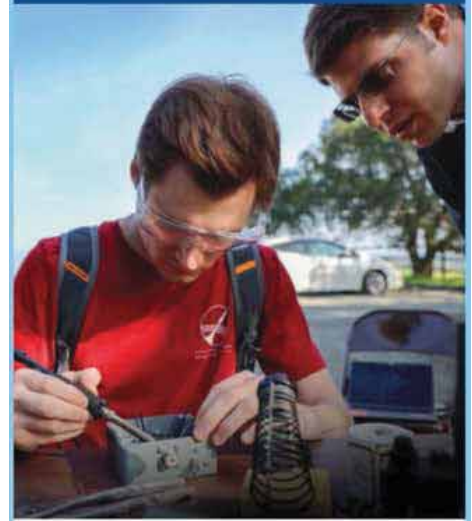
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On the Cover: Many hams are concerned with their setup's SWR, or standing wave ratio. Read "When Good SWR Goes Bad" to learn why SWR is important, and just how much you should worry about yours.

On this Page: Robert Wood's, W5AJ, portable setup deployed in rare grid DM83 (part of which is in New Mexico and part of which is in Texas) during the Quadrantid meteor shower on January 3, 2025. [Robert Wood, W5AJ, photo]



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From the Editor

100 Years of the IARU

The amateur radio community has a big milestone coming up in April — the 100th anniversary of the International Amateur Radio Union (IARU). Founded in Paris on April 18, 1925, the IARU is a federation of national amateur radio organizations from around the world that works collaboratively with organizations that influence radio spectrum allocations, as well as other organizations related to amateur radio's objectives. One of the IARU's first actions was to fight for the existence of the Amateur Radio Service in a post-World War I setting in which wireless technology was relatively new, and governments were suspicious of hams — to the point where amateur radio was shut down for a period during and even after the war. Thanks to the efforts of the IARU, amateur radio survived and thrived.

Today, the IARU is made up of more than 160 “member-societies” from all over the world, organizations that protect the interests of amateur radio and its practitioners, in a manner similar to what ARRL does for amateur radio in the US. The member-societies work under the auspices of the IARU to continue to represent the interests of the Amateur Radio Service, helping to secure new frequency bands, protecting access to our existing frequency bands, and representing amateur radio at events such as the World Radio Conference, which plays a critical role in determining wireless regulations.

As licensed hams, we may not spend much time thinking about the IARU while we're setting up an antenna or tuning up and down the band to find our next contact, but the truth is, we owe a lot — perhaps everything — to the organization's tireless work.

The IARU celebrates its 100th anniversary on April 18th this year. You can learn more about how to join in the celebration in the article “Get Ready for Ham Radio Open House” in this issue.

73,

Becky W1BXU



Resources

On the Air Information and Archive
arrl.org/ota

On the Air Podcast
blubrury.com/arrlontheair
podcasts.apple.com

On the Air Blog
arrl.org/ota-blog

ARRL Learning Network
arrl.org/ARRL-Learning-Network

Technical Information Service
tis@arrl.org

New Ham Group
groups.arrl.org/g/ARRL-New-Hams

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arrl.org/class

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IARU: A Century of Global Service

April 2025 marks the 100th anniversary of the creation of the International Amateur Radio Union



The 1920s were an exciting time in radio. For amateurs, the transition from spark-gap to continuous wave transmitters using vacuum tubes led to the first two-way transatlantic contact in November 1923, followed by a flurry of achievements as the “short waves,” or frequencies above 3 MHz, began to be explored.

ARRL founding president Hiram Percy Maxim, seeing the need for an international organization to promote and protect amateurs’ access to the radio spectrum, conferred with leaders of the European radio community in March 1924. A committee was formed to organize a Congress with the goal of establishing an International Amateur Radio Union. The April 1925 Congress in Paris was a success, with attendees

from 25 countries. Today, 100 years later, the IARU has 170 member-societies across three Regions.

The primary mission of the IARU is to maintain, and if possible to expand, useful access to the radio spectrum by licensed radio amateurs. This requires representation at the International Telecommunication Union (ITU), regional telecommunications organizations, and other standards-setting bodies.

The IARU has achieved significant successes. Here are some highlights:

- New band at 21 MHz (1947)
- Recognition of the amateur-satellite service (1971)
- New high frequency (HF) bands at 10, 18, and 24 MHz and improvement of the 1.8 MHz band (1979)
- Additional amateur-satellite and microwave allocations (1979)

- Successful defense against HF broadcasting expansion (1992)
- Major improvement of the 7 MHz band (2003)
- Easing of some restrictions to facilitate disaster communications (2003)
- New band at 136 kHz (2007)
- New band at 472 kHz (2012)
- New band at 5 MHz (2015)
- Major improvement of the 50 MHz band in Region 1 (2019)

With the radio frequency spectrum fully allocated up to 275 GHz, opportunities for additional gains are limited. However, given the pressure for greater commercial utilization of the spectrum it is essential for the IARU to remain active.

Spectrum allocations are only half the battle. A growing threat comes from manmade sources of interference. The IARU works through the ITU, standards organizations, and with national regulators and representatives of other radio services, such as broadcasters, to make the case for limits on sources of spectrum pollution.

Telecommunications developments offer new challenges and opportunities for amateur radio. With that in mind, a plan for restructuring the IARU is underway to improve the speed of decision making and efficiency, and to make the best possible use of resources.



IARU Centenary

Any organization that is still healthy at the age of 100 deserves a party! In late April IARU officials, member-society representatives, and invited guests will gather in Paris to celebrate the Centenary as well as the 75th anniversary of IARU Region 1. Several member-societies are organizing special on-air events during the month, including for World Amateur Radio Day (WARD) on April 18 — see the article about WARD in this issue. You can earn more about the IARU by visiting iaru.org.



Upcoming Contests

Springtime QSO parties offer opportunities to hone your skills, rack up some contacts, and have fun.

Date	Contest	Rules
March 8-9	Idaho QSO Party	idahoqsoparty.org
March 9	North American RTTY Sprint	ncjweb.com/Sprint-Rules.pdf
March 9-10	Wisconsin QSO Party	warac.org/wqp/wqp.htm
March 15-16	Virginia QSO Party	qsl.net/sterling/VA_QSO_Party/2024_VQP/2024_VQP_Main.html
March 23	North American SSB Sprint	ssbsprint.com/rules/
March 29-30	CQ WPX SSB Contest	cqwpx.com/rules.htm
April 12-13	Georgia QSO Party	gagsoparty.com/
April 19	Michigan QSO Party	miqp.org/index.php/rules/
April 19-20	Ontario QSO Party	va3cco.com/oqp/rules.htm
April 20	ARRL Rookie Roundup – SSB	arrl.org/rookie-roundup



Past and Future *On the Air Live* Episodes

If you didn't make it to the filled-to-capacity launch of *On the Air Live* on January 28, you can still watch the recording of the session to learn all about slow-scan television (SSTV). Log into learn.arrl.org, and click on "Courses," then navigate to "On The Air Live Recordings."

By the time you read this, the recording of the February 25 session, "How to Use Your Handheld Radio," may also be posted.

To get the full *On the Air Live* experience, register for these upcoming livestreams at learn.arrl.org/events

March 25: Digital Modes

April 22: The Automatic Packet Reporting System (APRS)

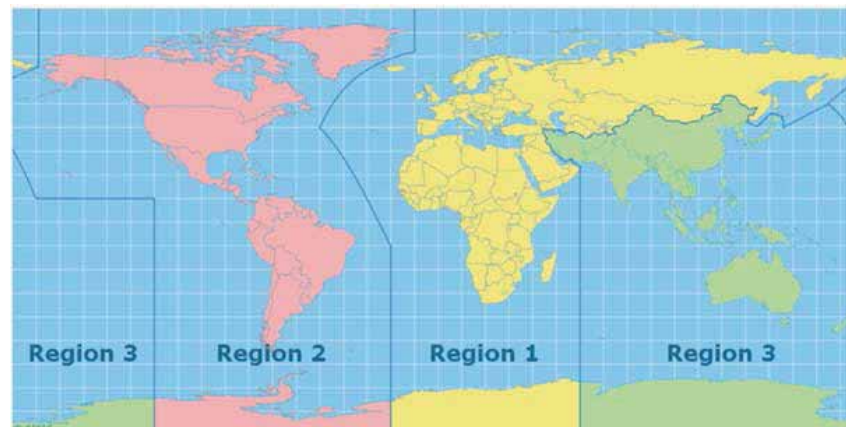
IARU Regions

The three IARU Regions correspond to the three Regions defined by the International Telecommunication Union (ITU) for frequency allocations purposes:

Region 1: Europe, Africa, northern Asia, and the Middle East

Region 2: The Americas

Region 3: The remainder of Asia and the Pacific



From Our Readers

Recommendations for Training and Field Day

I hope future issues will expand on the use of the ARES task book (“Emergency Management Task Book Updates,” September/October 2024). It is a great starting point for those new to our hobby.

I also encourage *On the Air* readers to complete FEMA’s course IS-317.A: Introduction to Community Emergency Response Team (CERTs). Our EMA Director has added this course to our ARES task book, and I found it beneficial.

On another topic, for many years, my group has held a licensing session just before the start of our Field Day operation. In 2024, three young men traveled almost 2 hours to our VE session, passed their exams, and were excited to make their first contacts on our GOTA (Get On the Air) station. I encourage all Field Day operations to take an hour or so out of Field Day work to hold a licensing session and put their GOTA station to good use with their newly licensed hams.

Joe Tokarz, KB9EZZ
Ottawa, IL

Understanding the ICS

The November/December 2024 issue of *On the Air* ranked as the best yet, in my opinion. In particular, the article “Understanding the ICS: It Starts with Training” spread the word of the importance of amateurs without alienating those who fill the roles professionally. Knowledge is power, and knowing where the resources exist opens the avenues for both awareness and participation — well done!

Joe Anderson, KB9UJL
Chicago, IL



Talk to us!

Send letters and other comments about *On the Air* to ota@arrl.org or *On the Air*, ARRL, 225 Main St., Newington, CT 06111.

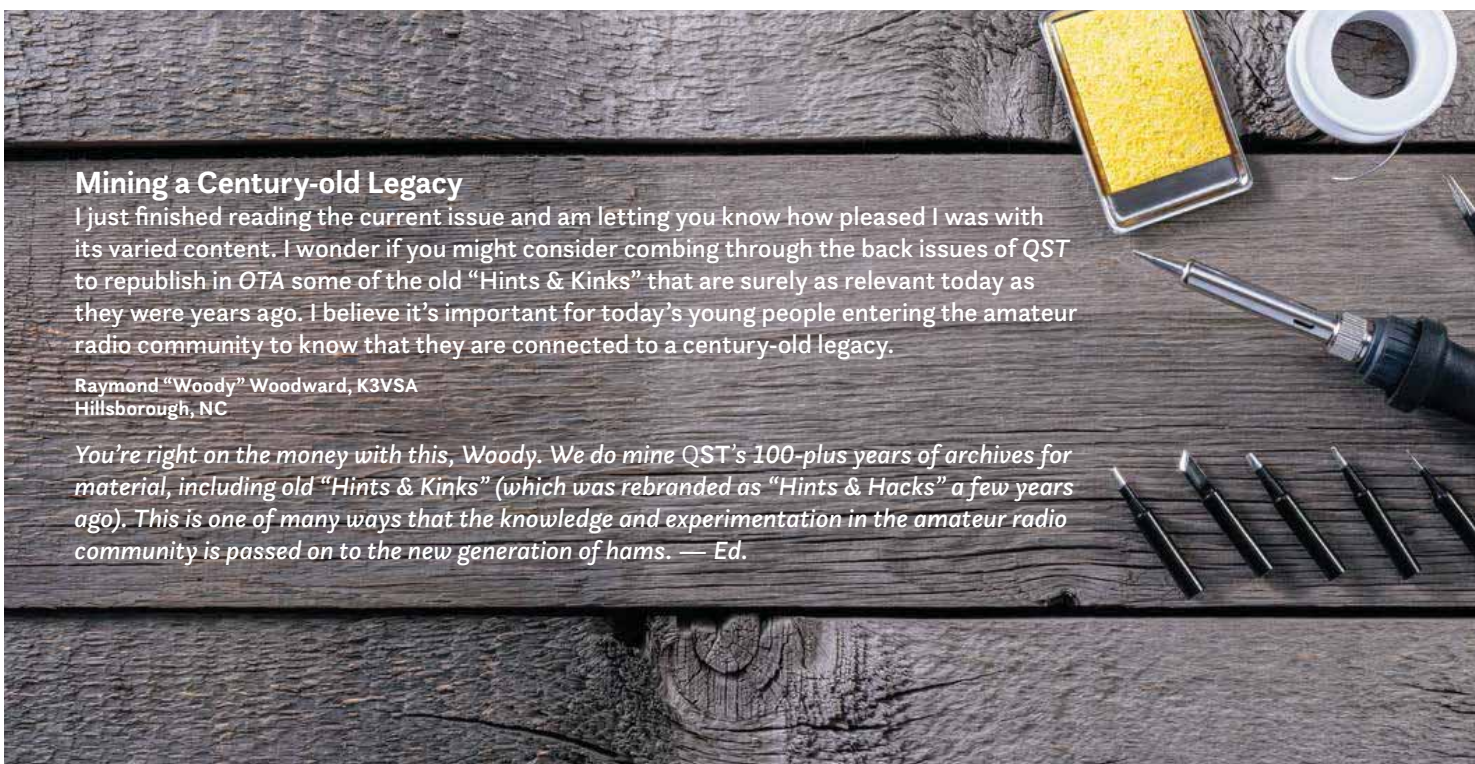
“Knowledge is power, and knowing where the resources exist opens the avenues for both awareness and participation.”

Mining a Century-old Legacy

I just finished reading the current issue and am letting you know how pleased I was with its varied content. I wonder if you might consider combing through the back issues of *QST* to republish in *OTA* some of the old “Hints & Kinks” that are surely as relevant today as they were years ago. I believe it’s important for today’s young people entering the amateur radio community to know that they are connected to a century-old legacy.

Raymond “Woody” Woodward, K3VSA
Hillsborough, NC

You’re right on the money with this, Woody. We do mine QST’s 100-plus years of archives for material, including old “Hints & Kinks” (which was rebranded as “Hints & Hacks” a few years ago). This is one of many ways that the knowledge and experimentation in the amateur radio community is passed on to the new generation of hams. — Ed.



Reaching Out to Youth

Nic Wall, KY4OP

Age 36, Brightwood, VA

Credentials: First licensed in October 2020, upgraded to General in December of that year. Achieved Amateur Extra in 2022.

Q: What led you to get licensed?

I wanted to do something technical in my free time outside of my work in cybersecurity. I was also working with people who had their license or a background in HF communications systems and I was curious to learn more.

Q: What were the first things you did after you got licensed?

I was the stereotypical new ham with a handheld, barely making it into the local repeater and learning on the fly. Fortunately, my local mentor, K1HTV, was on the repeater to welcome me, make suggestions to improve my setup, and invite me to the weekly net.

Q: What do you currently do with ham radio?

A little of everything: DX, digital modes, satellites, Summits on the Air (SOTA) and Parks on the Air (POTA), antenna builds, and the occasional contest. My favorite thing is introducing young people to ham radio. I lead our local 4-H Ham Radio Club, N4HKZ, for youths ages 9 – 18, so I experiment with many different aspects of the hobby, so I have new things to share with them.

Q: Biggest ham-related embarrassment?

I think the most embarrassing thing was when I first upgraded to General and was learning FT8. I was running through a SignalLink and misconfigured it. I was making contacts, but then I suddenly heard someone calling my call sign on the local repeater. When I came back to them, it turned out my FT8 signal was splattered all over the frequency with harmonics on top of harmonics. Fortunately, the mentor who called me out did it very respectfully and was interested in helping me learn from the experience and fix my station.

Q: Biggest ham-related success?

The 4-H Ham Radio Club of Fauquier County, Virginia, N4HKZ. We've got about 20 kids exploring STEAM through amateur radio because of the club. I started with my daughter, KO4NLR, and we've introduced hundreds of kids with our community outreach trailer at local fairs, events, and field days over the years.

Q: Finish the sentence: "People say I am..."

Smart, but really, I'm just curious and like to learn new things.

Q: What do you, personally, get out of being an ARRL member?

ARRL has made some great progress in education with things like the Teachers Institute and efforts to attract and retain young hams. That and ARRL's advocacy for hams with the FCC and legislators are why I am an ARRL member.



KY4OP's three must-have tools for ham radio:

Antenna analyzer: Whether it's troubleshooting an existing antenna or building a new one, I think having a good antenna analyzer is a great investment.

Dual-band handheld Yagi: An Arrow (or similar) portable Yagi antenna for 2 meters/70 centimeters opens some cool possibilities for any ham, like foxhunting, satellites, and some directional gain for SOTA.

A good Li-ion battery (or two): While I enjoy being in my shack, I really enjoy being able to operate portable.

Q: How do you think the ham radio community can attract and retain new hams?

I think we often overlook what makes amateur radio different from other radio classes. An amateur radio license allows you to experiment, explore, create, and invent across a wide range of RF bands. The ability to do that is very appealing to youth, the creator community, STEM educators, and others.



Getting Started with Data Modes — About Sound Cards

Wayne Greene, KB4DSF

Data modes are very popular, offering some of the best and most efficient communications links even in poor signal-to-noise ratio conditions. Register for the March 25 *On the Air Live*, which digs into data modes, at learn.arrl.org.

A transceiver, computer, monitor, data mode software, and a sound card are needed to set up a data mode-capable station. Depending on the data mode, one could use a VHF/UHF FM handheld radio as the transceiver. The computer need not be very powerful. If you have an old laptop or Raspberry Pi sitting in the corner, it will likely be more than sufficient. The sound card, however, is a critical component, so we'll spend some time on them now.

Recommended External Sound Cards:

Tigertronics Signalink USB
tigertronics.com/slusbmain.htm

West Mountain Radio RIGblaster
westmountainradio.com/rigblaster.php

microHAM external sound card devices
microham.com/contents/en-us/d200_radio_interfaces.html



The Tigertronics Signalink with the cover removed to show the inner workings.

Sound Card

All data modes require a *sound card*. The sound card translates the digital signal from your computer to analog audio that is sent to your transceiver and converts received analog audio to digital data that is processed by your computer and the data mode software. The computer you have chosen for data mode operation likely has an internal sound card, but I prefer to use external sound cards for data modes, as this prevents the possibility of accidentally transmitting any sounds from your computer (including system sounds) onto the airwaves.

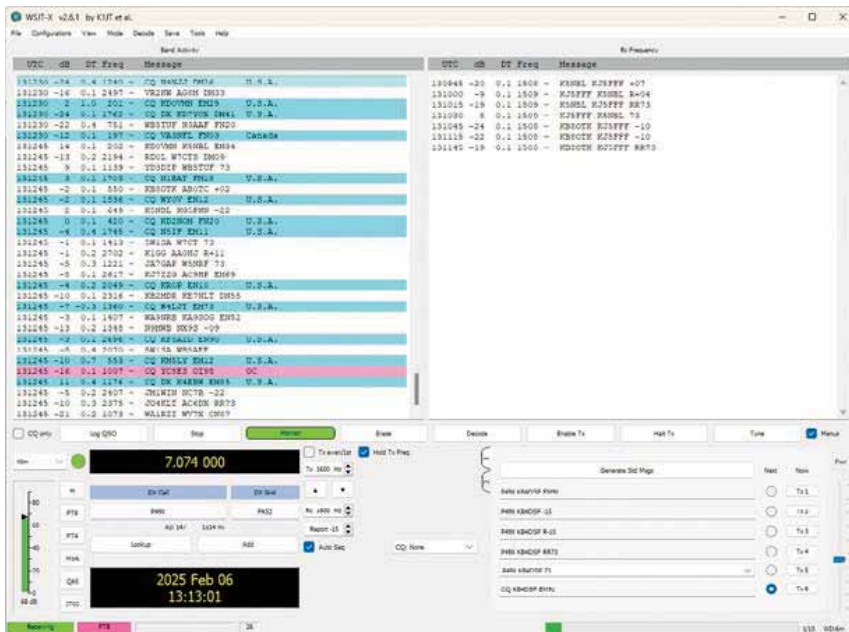
There are some great external sound cards available. I prefer the Signalink USB from Tigertronics, but there are other excellent options such as the RIGblaster from West Mountain Radio, and the external sound card devices from microHAM.

You connect the sound card's audio output to your transceiver's audio input and your transceiver's audio output to the sound card's audio input. This means you will need interface cables to connect your sound card to your computer and your transceiver. You can build your own, but I buy my mine from the company from which I purchased my sound card.

Many newer handheld radios have an internal sound card, which is an excellent option. In this case, the only interface cable you will need is a USB cable directly from your computer to your transceiver. One USB cable will also likely handle Computer Assisted Transceiver, or CAT, control.

Audio Settings

Setting up your sound card's audio settings properly will ensure that your transmitted signals aren't distorted and that the input signals received by your transceiver are sufficient for your data mode software to correctly decode the received signal.



Sound card output audio adjusted for minimum ALC while producing enough audio into the transceiver for transmitting at the desired RF output of 10 watts.

Adjusted sound card output audio producing enough input audio into the transceiver to transmit at the desired RF output power of 10 watts.

On the right, the audio drive level (PWR) adjusted for minimum ALC while producing the desired RF output power. On the left, the audio input bar is green, indicating sufficient audio input from the transceiver without overdriving the software.

The *Automatic Level Control (ALC)* is the transceiver's transmit circuitry that maintains a consistent output power level despite changing input audio signals from your sound card. If the input audio is too high, however, the ALC circuit will limit the transceiver's power output to prevent damage to the power amplifier. The higher the overdriven signal, the more the ALC will limit the power output, potentially leading to a distorted output signal that will be difficult, if not impossible, for a receiver to process. Properly setting the audio input level from the sound card to the transceiver will ensure a clean output signal. The sound card audio output level can be adjusted either at the sound card or via the drive level found in the data mode software.

Each transceiver manufacturer has a way of indicating whether the ALC circuit is being activated. If your rig has an LED ALC indicator, ensure it is not lit while you're transmitting. If it is lit, lower the audio output from your sound card until the LED is no longer lit. Most newer transceivers have a meter indicator that gives more information about the audio output level coming from your sound card. Use the meter to adjust your sound card so you have the lowest ALC meter deflection possible while ensuring your transceiver's power output is consistent with your desired power output.

I'm going to refer to the WSJT-X software for purposes of this article, but the information will be consistent with many other data mode software packages. For my FT-710, which has an internal sound card, I adjust the appropriate sound card device in my computer's audio settings to maximum audio output and use the WSJT-X drive level (Pwr) slider to adjust the audio output level from the sound card to the rig while ensuring minimum ALC. I keep an eye on the FT-710's ALC meter while adjusting my output sound levels. For my rigs that require an external sound card, I set their output power level to maximum, such as 100 watts, disable any audio enhancement settings, and adjust the audio output level of my sound card to set the rig's actual RF output, usually 25 watts or less, while ensuring minimum ALC.

Automatic Gain Control (AGC) is the circuitry in your transceiver's receive audio despite varying receive audio signal strength differences. Transceivers normally have three AGC settings: fast, medium, and slow. Other transceivers may have a fourth option: automatic. Each affects how quickly or slowly the AGC responds to strong or weak incom-

ing signals. A properly set AGC will allow your transceiver to perform well even in environments where signal strengths vary widely. I generally keep my AGC set to automatic, but I have adjusted it in complex environments, such as contesting.

Data mode software packages will provide an input audio indicator. Adjusting the input audio is another important step to ensure the best receive audio input of the data mode software. The data mode software must have sufficient audio input for accurate decoding, but too much audio input may cause errors during the decode process. For WSJT-X, that indicator is on the left-hand side. If the audio level is sufficient, the bar indicator will be green, but it will change to red if the level is too high. I adjust my software to receive the highest amount of audio input while ensuring the bar indicator does not turn red. When using rigs with internal sound cards, the audio input can be adjusted either through your computer's audio settings. If you are using an external sound card, the input audio setting can be adjusted via the sound card's controls. My strategy for external sound cards is to adjust the appropriate sound card's audio setting via my computer audio settings to maximum, disable any audio enhancement setting, and then I use the external sound card's controls to adjust the input audio.

Join the Livestream on March 25!
 Register at learn.arrl.org to tune in to *On the Air Live* on March 25, where I'll be explaining more about how to get set up for digital modes!

When Good SWR Goes Bad

Steve Ford, WB8IMY



Hams seem to be obsessed with *standing wave ratio*, or *SWR*. Listening to some amateurs, you may gather the impression that the SWR at your station must be a flat 1:1, or “one to one.” Even a smidge more is cause for deep concern. And don’t even speak of SWRs above 2:1.

But let’s take a deep breath. Is SWR evil, regardless of the value? Are there truly “good” or “bad” SWRs? The honest answer is, “it depends.”

Before we can confront evil, we must first understand it. Look at Figure 1 and imagine a bucket filled with water. In the center of the bucket, there’s a tiny motor that vibrates at a fixed rate. Let’s say it oscillates back and forth at a rate of 60 times per second.

When you switch the motor on, you will see little waves moving away from the center. As the waves reach the sides of the bucket they bounce back toward the center. Of course, the motor is still vibrating, creating new waves all the time, and these will collide with the waves returning from sides of the bucket.

As the waves merge, they add or subtract from each other, and something strange occurs. The waves are still flowing back and forth within the bucket, but now it suddenly looks as though they are frozen in place. We call these *standing waves*. What appears “frozen” is the amplitude variation due to constructive and destructive interference between the two waves.

Replace the motor with a transceiver and imagine the sides of the bucket have transformed into an antenna system (see Figure 2). The transceiver generates radio frequency (RF) energy, which moves in *forward waves* along the feed line (such as a coaxial cable) until they reach the antenna. Some of the energy is radiated away, but a portion of it is reflected down the feed line like the waves of water bouncing off the sides of the bucket. These *reflected waves* mix with the forward waves and, once again, the result is standing waves in the feed line.

There are devices that can measure the ratio of the maximum amplitude of a standing wave to its minimum amplitude. That’s the *standing wave ratio* and it indicates whether there is an impedance mismatch between the transceiver and the antenna system. The higher the ratio, the greater the mismatch. Some of these measurement devices are built into transceivers or antenna tuners, while others are separate meters.

So now that you know what SWR is, there remains an unanswered question: What does it mean for you?

Neither Good Nor Evil

First the good news: There is no such thing as an inherently good or bad SWR. An SWR can only be considered good or bad according to how it affects your station.

An amateur’s obsession with SWR rests on a foundation of truth. A high SWR (above 2:1 or 3:1) can cause large voltages to develop in the output circuitries of transceivers, amplifiers, or antenna tuners, especially when you are operating at power levels of 100 W and up. These voltages can harm your equipment.

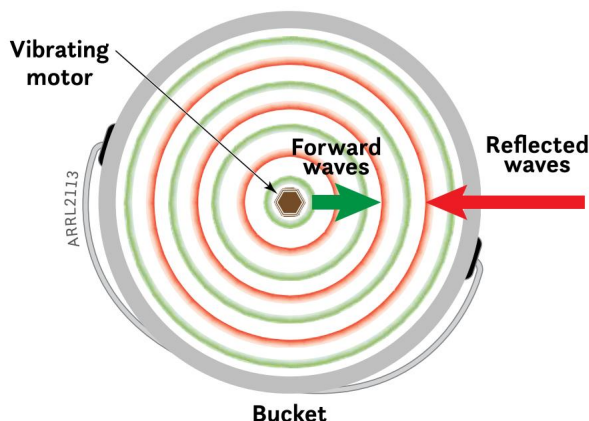
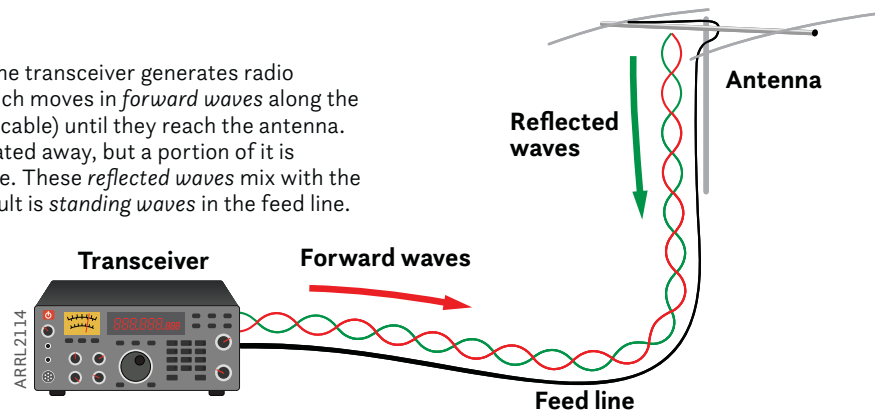


Figure 1: Imagine staring into a bucket filled with water. In the center of the bucket, we’ve placed a tiny motor that vibrates at a fixed rate. When you switch the motor on, you will see little waves moving away from the center. As the waves reach the sides of the bucket they bounce back toward the center. Of course, the motor is still vibrating, creating new waves all the time, and these will collide with the waves returning from sides of the bucket. As the waves merge, they add or subtract from each other and create *standing waves*.

Figure 2: In this example, the transceiver generates radio frequency (RF) energy, which moves in *forward waves* along the feed line (such as a coaxial cable) until they reach the antenna. Some of the energy is radiated away, but a portion of it is reflected down the feed line. These *reflected waves* mix with the forward waves and the result is *standing waves* in the feed line.



Modern transceivers often include special circuits that detect high SWRs and automatically reduce the output power to safe levels. These circuits can be rather conservative, however, which means they will cause power reductions in the presence of even a mediocre SWR of about 1.5:1. The philosophy is that it is better to be safe than sorry, but it can drive some amateurs to worry about SWR excessively.

Another way in which an elevated SWR can become problematic is *feed line loss*. Higher SWRs cause more energy to dissipate in the form of heat between the radio and the antenna. This effect becomes especially pronounced at higher frequencies such as VHF and UHF.

However, SWR losses can be mitigated by using high-quality, low-loss cables, and by keeping the cables as short as reasonably possible. At HF frequencies, you'll often find hams using a type of feed line known as *windowed ladder line* because its losses can be exceedingly low, regardless of the SWR. In fact, once upon a time amateurs used this type of feed line exclusively and, as a result, they didn't worry very much about SWR at all.

SWR: Bottom-Line Bullet Points

- * It is always a good idea to be aware of your SWR. If your HF transceiver lacks an SWR meter, invest in an external meter. You'll find SWR meters in antenna tuners as well.

Many VHF/UHF radios include SWR metering. Those that don't will still offer some sort of power output indicator. If you notice that the radio has reduced its output, that's a sure sign that the SWR on the feed line has become unacceptably high.

- * If you are operating at HF frequencies and using low-loss coaxial cable or windowed line, and if you are using an antenna tuner to match the output of your transceiver to your antenna

system, the only SWR that should concern you is the one between the antenna tuner and your radio. (If the tuner includes an SWR meter, that is exactly what it is showing you.) The SWR needs to be low enough to avoid triggering the transceiver's protection functions. Anything below about 1.5:1 will do. Some transceivers are even more generous and won't begin penalizing you until the SWR exceeds 2:1.

- * If you are operating at HF frequencies and you don't have an antenna tuner to match the transceiver to the antenna system, you'll still need to adjust the antenna until the SWR is 1.5:1 or less. Don't obsess over this value, though. If your transceiver generates the output you desire at an SWR of 1.5:1 or even 2:1, don't waste time trying to reduce the SWR to a flat 1:1.

- * At VHF or UHF frequencies, you're not likely to have an antenna tuner in the line between the antenna system and your transceiver. Once again, you will need to adjust your antenna to get the SWR at the radio down to 1.5:1 or less to keep your radio at full output and to minimize SWR loss in your feed line.

- * Speaking of feed lines, purchase the lowest-loss cables you can afford. (Cable losses are rated in decibels per 100 feet at various frequencies — the lower these numbers, the better.) Your investment will pay dividends by keeping any SWR losses as low as possible, especially at VHF and UHF.

- * Beware of bargain transceivers or amplifiers that lack SWR protection circuitry. For example, even a 60 W amplifier without SWR protection can suffer severe damage if the SWR rises above 1.5:1. You'll often see warnings about elevated SWR included with sales descriptions of imported amplifiers. To keep costs down, the manufacturers may not have added such protections, so *you're* responsible for keeping the SWR in check!



Above: A dedicated external SWR/power meter. Right: Windowed ladder line has extremely low RF loss, even when the SWR is quite high. [DX Engineering photos]

-Input power: 1~5W
 -Output power: 40~60W
 -Working frequency: 3-21Mhz
 -Working Voltage: 12V-13.8V

Package Included:

-1 x Main Unit
 -1 x Power Cable

Note: Before use, you need to use a NanoVna or similar tools to measure the antenna to 50Ω. The standing wave should be less than 1.5, otherwise the power amplifier tube will be burned due to the mismatch of the output!

In this real-life example, the text in red warns that even a modest SWR can damage this 60 W amplifier, likely because the design lacks SWR protection circuitry. The mistranslated warning references potential harm to the "tube," but it actually means "transistor."

Get Ready for Ham Radio Open House



About World Amateur Radio Day

World Amateur Radio Day, held on April 18 each year, is celebrated worldwide by radio amateurs and their national associations, which are organized as member-societies of the IARU. It was on this day in 1925 that the IARU was formed in Paris. ARRL co-founder Hiram Percy Maxim was its first president. ARRL is the Secretariat of the IARU.

To help promote amateur radio science and technology, and to honor the 100th anniversary of the International Amateur Radio Union (IARU), ARRL invites radio clubs and schools to organize a Ham Radio Open House in April 2025.

The event is intended to highlight the Amateur Radio Service for its development and practice of the latest radio communications and technology, and as a hands-on pathway into science, technology, engineering, and mathematics (STEM) fields for the next generation. Read on to find out how your club or school can get involved.

This April, amateur radio clubs, school stations, and other groups will have the opportunity to advance public knowledge about ham radio by welcoming their communities into their stations for the Ham Radio Open House, as part of World Amateur Radio Day (see the sidebar, “About World Amateur Radio Day” for more information about this observance). The focus will be on scientific advancement and demonstrating cutting-edge technology. This is a chance to not only shape the conversation about modern ham radio but also show how it serves as a stepping stone and test bed for many young people pursuing future STEM education and high-tech careers.

One Million Acts of Science

ARRL has teamed up with Ham Radio Science Citizen Investigation (HamSCI) and the science community organization SciStarter to invite the public to participate in One Million Acts of Science during April, which is Citizen Science Month. By hosting a Ham Radio Open House at your group’s station this April, you’ll introduce individuals who might never otherwise find out about today’s amateur radio, where science and technology intersect with fun and learning.

Clubs are encouraged to showcase the latest weak-signal modes, such as FT8, using WSJT-X or other digital modes. This could be a great opportunity to explore new areas of amateur radio and demonstrate how the service is at the cutting edge of electrical engineering.

HamSCI and SciStarter Collaborations

HamSCI (hamsci.org) has built a community by connecting radio amateurs and citizen scientists in ionospheric research.



Lead HamSCI Organizer Dr. Nathaniel Frissell, W2NAF, shows a visitor WSJT software at W3USR, The University of Scranton amateur radio station. [Photo courtesy of University of Scranton]

The Solar Eclipse QSO Parties held during the 2023 annular eclipse and the 2024 total solar eclipse (see “The April 2024 Solar Eclipse QSO Party” in the March/April 2024 issue for more information) provided significant data for researchers studying the ionosphere’s response to the eclipses, wrapped into fun operating events.

SciStarter is working to engage people from all walks of life in one million acts of science during Citizen Science Month in April (scistarter.org/citizensciencemonth), to promote public participation in scientific research. ARRL’s Ham Radio Open House provides a unique opportunity to help achieve that goal.

Imagine your open house visitors seeing a software-defined radio (SDR) waterfall display and then hearing what the signal they see on the screen sounds like — that’s an act of science! Taking it a step further, let them take a standing wave ratio (SWR) measurement of an antenna, modify it slightly, and take another reading. They’ve just gathered data, made a physical change, and measured the impact of their modifi-

cations. Not only is that an additional act of science, but it’s also a great way to engage people in hands-on learning about ham radio. With this kind of involvement, visitors will be more likely to return for a club meeting or participate in future events.

Clubs will be asked to track those acts of science and submit a report to ARRL detailing the number of acts and the total number of visitors. Find details and information for reporting at arrl.org/world-amateur-radio-day.

Preparing Your Open House

Enlist the Nearest Club Station. Clubs and schools are encouraged to welcome visitors to their existing club station or organize some other comfortable indoor space (ideal for April weather). This is a different approach than the readiness demonstrations for ARRL Field Day.

A Focus on Innovation. Show off the cutting-edge science and technology behind amateur radio. Create a “wow” factor and be prepared to describe what visitors are

seeing and hearing. It’s all about highlighting technical advancements and innovations that make ham radio so exciting today.

Make It Modern. Aim to counter the misconception that ham radio is “old” technology. Showcase the high-tech aspects of amateur radio. Think satellite communications, HF weak-signal modes, VHF/UHF/microwave stations, computer networking and integrated devices, constructing antennas, and test and measurement equipment.

Welcome the Community. The Ham Radio Open House should be held in a public space, such as a club or school station, library, or municipal building. If your club doesn’t have a facility, consider partnering with local astronomy clubs or other science-minded groups.

ARRL, HamSCI, and SciStarter are working to help local clubs engage in community outreach for the Ham Radio Open House. Visit the World Amateur Radio Day website at arrl.org/world-amateur-radio-day for more resources.

The Radio Amateur's Code

THE RADIO AMATEUR IS:

CONSIDERATE...

He/She never knowingly operates in such a way as to lessen the pleasure of others.

LOYAL...

He/She offers loyalty, encouragement and support to other amateurs, local clubs, the IARU Radio Society in his/her country, through which Amateur Radio in his/her country is represented nationally and internationally.

PROGRESSIVE...

He/She keeps his/her station up to date.
It is well-built and efficient.
His/Her operating practice is above reproach.

FRIENDLY...

He/She operates slowly and patiently when requested; offers friendly advice and counsel to beginners; kind assistance, cooperation and consideration for the interests of others.

These are the marks of the amateur spirit.

BALANCED...

Radio is a hobby, never interfering with duties owed to family, job, school, or community.

PATRIOTIC...

His/Her station and skills are always ready for service to country and community.

Nearly a century old, the Code is still good, relevant advice.

It has been almost a century since Paul Segal, W9EEA, first drafted what was to become the Radio Amateur's Code. Paul's original 1928 version has changed only slightly over the years and the "modern" version, which itself is decades old, is still regarded as the gold standard.

Why the Code Still Matters

The Radio Amateur's Code remains relevant today because its guidance has withstood the test of time. In fact, you'll occasionally still see the Code included in social media posts as well as in books (including some published by ARRL).

As you read through the Code, note that the need to be considerate tops the list of admirable qualities. In real life this boils down to simple actions such as listening before transmitting to make sure a frequency is clear, or avoiding frequencies that others use for specific activities. (Many of these frequencies are spelled out in ARRL's Considerate Operators Frequency Guide, which can also be found online at arrl.org/files/file/conop.pdf)

Next, the Code discusses loyalty, but not necessarily the kind you might imagine. Segal isn't suggesting that a loyal ham should be blindly obedient. He is appealing for hams to support the organizations that have made amateur radio possible and still defend it today. For American hams, these include local clubs, ARRL, and the International Amateur Radio Union (see the sidebar "What is the IARU?").

What follows is a call for amateurs to be "progressive." This is an admonition to avoid living in the past. Ideally, amateurs should always be willing to explore innovative technologies, or at least not condemn those who might choose to do so.

The Code's appeal for friendliness speaks for itself, and the Code advocates this both on and off the air. One example is a kind, helpful attitude toward newcomers. Friendliness also means mature, collegial on-air conduct that reflects well on the ham community. Always remember that non-hams — including government authorities — may be listening!

Segal's inclusion of "balance" was every bit as important in 1928 as it is now. As much as we all love amateur radio, there are other important concerns in life. Maintain a reasonable perspective and never allow your passion for the hobby to consume you. Sadly, there are amateurs who invest in their hobby to the point where they neglect the needs — financial and otherwise — of their families. Balance was important in 1928, and it's important today.

Finally, the Code's mention of patriotism is a reference to the importance of service. It is a call to remember that hams enjoy their privileges at the pleasures of their governments. We weren't given these valuable privileges just to pursue an enjoyable hobby, and we could lose them at a moment's notice. There is always the expectation that we will set aside our hobby activities and use our radio skills to assist communities and nations whenever the need arises.

What is the IARU?

The International Amateur Radio Union (IARU) is a federation of national amateur radio organizations from around the world. There are more than 160 societies that comprise the IARU.

The IARU was founded in 1925, just as amateur radio activity was surging around the globe. Wireless technology was in its infancy and many governments were suspicious of amateur radio in general and hams in particular. Some nations wanted to outlaw amateur radio completely. It was a narrow escape, but thanks to the efforts of the IARU, amateur radio survived.

Today the IARU continues to represent the interests of the Amateur Radio Service. In late 2023, for example, an IARU team was present at the World Radio Conference in Dubai, United Arab Emirates. This conference plays a critical role in determining wireless regulations, so it is important that the IARU had a seat at that table.

Over the years the IARU has worked diligently to expand amateur radio privileges. The organization was instrumental in securing new frequency bands at 136 and 472 kHz, as well as at 10, 18, and 24 MHz.

The IARU celebrates its 100th anniversary this year. You can learn more by visiting the IARU website at iaru.org.



A VHF/UHF Antenna Menagerie

Steve Ford, WB8IMY

VHF and UHF antennas come in every shape and size imaginable. Even so, each antenna must satisfy the same requirement: it must radiate and receive radio frequency (RF) energy. How an antenna goes about doing this will change according to the application and the design.

Let's look at some of the more common VHF/UHF antenna designs you're likely to encounter and take inventory of their advantages and disadvantages.

Rubber Ducks (Helical Whips)

These antennas are standard equipment on handheld transceivers. They are called *rubber ducks* because they consist of little more than a coil of wire embedded in rubber or plastic.



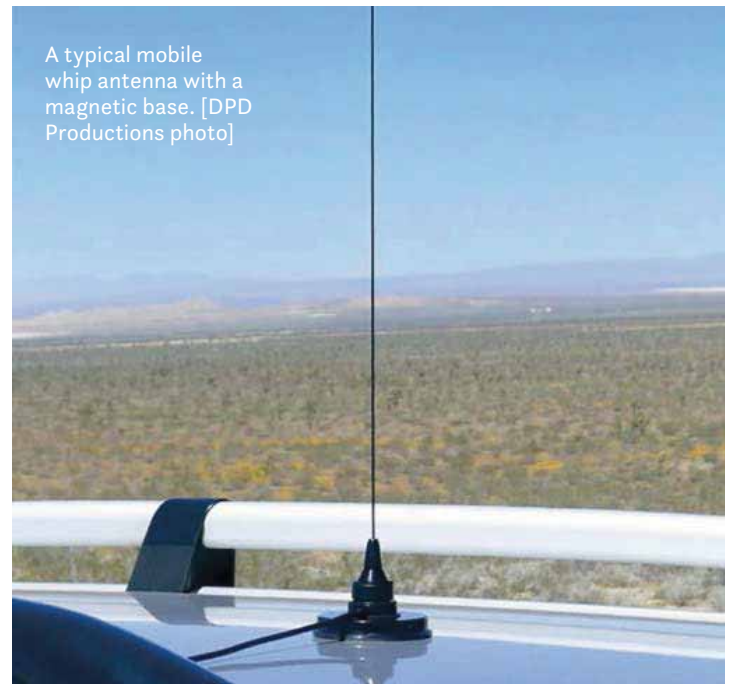
A so-called *rubber duck* antenna is just a wire coil encased in rubber or plastic.

Advantages:

- Compact size. Most rubber ducks are less than a foot in length.
- Durable construction. You can bend these antennas to extreme angles without damage.
- Lightweight. They weigh less than a few ounces.
- Inexpensive. Materials and manufacturing costs for these antennas are minimal, so their price tags are low.
- No setup required. You never “tune” a rubber duck antenna. Just attach it and go.

Disadvantages:

- Poor efficiency. When it comes to radiating your signal, rubber ducks are among the worst antennas around. A significant portion of the RF energy generated by your transceiver is lost as heat within a rubber duck.
- Limited communication range thanks to the sub-par efficiency.
- The antenna's meager performance can be made even worse by the effects of nearby objects, including your body.



A typical mobile whip antenna with a magnetic base. [DPD Productions photo]

Mobile Whips

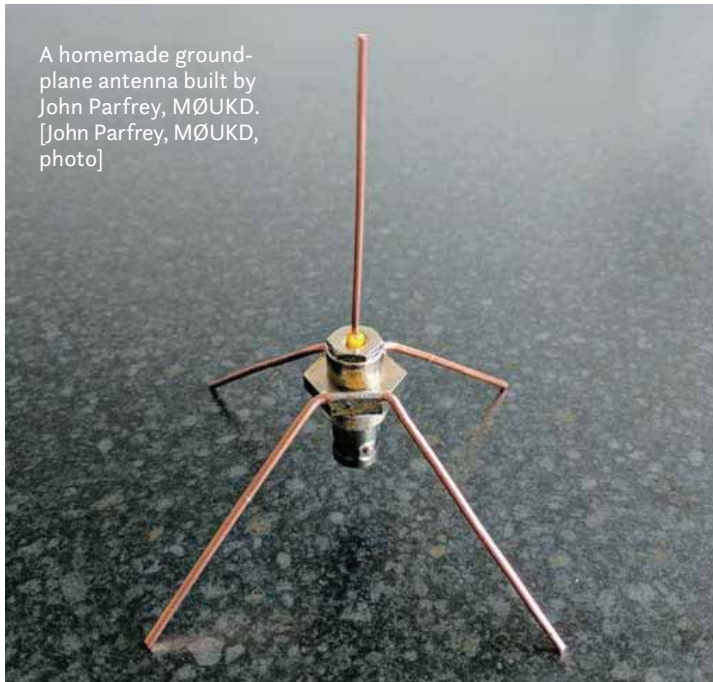
These antennas are intended for use on vehicles, so they are designed with slender profiles to minimize wind resistance at highway speeds. Some are mounted permanently on the vehicle body, while others are held in place with clips or magnets.

Advantages:

- Durable, flexible construction to withstand collisions with low ceilings, such as underpasses and parking garages.
- Easy mounting, with the exception of permanent mounts that require drilling holes in the vehicle body.
- Many models are capable of use on two or more frequency bands.

Disadvantages:

- Limited efficiency. They are vastly superior to rubber ducks, but still less than optimal.
- For a mobile whip to perform well, its base must be electrically attached to as much metal as possible, creating what is known as a *ground plane* beneath the antenna. The metallic body of the vehicle and its chassis serves this purpose, but finding a good attachment point in a car with a plastic or composite body can be challenging.



A homemade ground-plane antenna built by John Parfrey, MØUKD. [John Parfrey, MØUKD, photo]



A J-pole antenna built out of copper pipes. Note the distinctive "J" shape that gives the antenna its name. [Juan Prieto, KM4HLF, photo]

Quarter-Wavelength Ground Planes

These antennas have been staples at VHF/UHF for many years. They are among the best *omnidirectional* antennas (antennas that radiate in all directions).

Advantages:

- Simple to build and maintain. You can build a ground-plane antenna out of almost anything, even metal clothing hangers. A basic design consists of a vertical portion known as the *radiator* surrounded by several wires called *radials* that make up the ground plane.
- Inexpensive.
- Good efficiency for local communications. Install a ground-plane antenna as high as possible and its performance may surprise you.

Disadvantages:

- Limited *gain*. An antenna's gain is its ability to focus power in specific directions, but since a ground-plane antenna is omnidirectional, its gain is minimal.

J-Poles

This is another popular omnidirectional design. It is more difficult to build than a quarter-wavelength ground plane, but it is easier to install within restricted spaces because it does not have radials.

Advantages:

- J-poles can be built from low-cost materials including short lengths of 300- or 450-ohm cable.
- They can be easily disassembled and packed for portable operating. J-poles built from cables can be rolled up and stuffed into bags.

Disadvantages:

- More complex to build than quarter-wavelength ground planes.
- The lack of radials means that J-poles must use the outer shields of their coaxial feed lines as ground planes. Although this approach obviously works, it is not ideal and the efficiency of the antenna can suffer as a result.

A loop antenna for 50 MHz. Circular loops for VHF/UHF are often referred to as *halos*. Square loops like this one are sometimes called *squalos*. [Steve Ford, WB8IMY, photo]



A typical UHF Yagi antenna. [Ephraim Gariguez, DW1ZWS, photo]



Loops

A loop antenna is about as simple as it gets: It is merely a loop of wire or metal tubing that connects the “hot” side of the antenna feed line to the ground side. If you think this is a short circuit, you’re right. In a dc circuit, this connection would be highly undesirable, to say the least. But when you apply RF energy, the loop responds as a radiating “load,” not a short circuit.

Like the other omnidirectional antennas we’ve discussed so far, loops tend to be low-gain radiators. However, they can be combined or “stacked” to achieve greater gain.

Advantages:

- Compact size. Individual loop antennas are small at VHF/UHF frequencies, making them attractive for limited-space environments.
- Relatively inexpensive.

Disadvantages:

- Reduced efficiency compared to a quarter-wavelength ground plane.
- More critical tuning requirements. They can be tricky to adjust for the lowest standing wave ratio (SWR).
- They have narrower bandwidths. The usable bandwidth tends to be more restricted compared to other omnidirectional antennas.

Yagis

A Yagi is among the most effective directional antennas. Its ingenious design focuses most of your RF energy in the direction in which the antenna is pointed, and it concentrates received signals in the same way.

Advantage:

- It’s a superb antenna for long-distance communication. This is especially true when a Yagi is installed at high elevations. When connected to a good transceiver and feed line, a VHF/UHF Yagi can provide reliable communication over substantial distances — even hundreds of miles in some cases.

Disadvantages:

- Because a Yagi is highly directional, you must be able to aim it. This usually requires an electric motor known as an *antenna rotator*. Adding a rotator complicates the installation and adds to the cost.
- Larger physical size. Yagis are made of several metal tubes (or stiff wires) known as *elements*. Depending on the frequency, these elements can be sizable. In addition, elements must be supported by a boom. High-gain Yagis require long booms with many elements.
- More complex assembly and tuning. Yagis require more time to assemble, and you must be careful to place all of the elements in their proper positions. Once the antenna is assembled, it must be adjusted for the lowest SWR.
- Because of their size and significant surface areas, Yagis are susceptible to wind damage, as well as damage caused by snow and ice loading.

Less Common Antennas

There are other VHF/UHF antennas that you are less likely to see, but their interesting designs still turn up in amateur radio applications.



This handheld LPDA antenna is used for satellite operating. [Steve Ford, WB8IMY, photo]

Log Periodical Dipole Arrays (LPDAs)

These antennas may look like Yagis, and they are directional like Yagis, but they lack the same amount of gain. An LPDA functions in a complex way that we won't describe here, but suffice to say that it essentially behaves like a collection of dipole antennas.

Advantages:

- A single LPDA can operate on separate frequency bands using only one coaxial feed line. This is the primary benefit of the LPDA design.
- Lightweight versions can be quickly deployed during portable operations.

Disadvantages:

- As mentioned, LPDAs have less gain than similarly sized Yagis.
- Because these antennas are directional, you'll need rotators to aim them.



A quadrifilar antenna for 2 meters. [Phil Harris, photo]

Quadrifilar Helixes

Yagis are ideal for satellites, but not every station can accommodate a cumbersome set of Yagi antennas, not to mention the rotators necessary to keep them pointed at spacecraft. The exotic-looking quadrifilar antenna offers a simpler alternative by creating a uniform overhead pattern, which is exactly what you need when a satellite is flying above your location. A quadrifilar lacks the gain of a Yagi, but unlike a Yagi, it does not have to be moved.

Advantages:

- One of the best omnidirectional antennas for satellite operating.
- Performs well even when installed close to the ground.

Disadvantages:

- It is a complex and challenging to build correctly.
- Somewhat larger than other omnidirectional antennas.
- Susceptible to wind and ice damage.
- Can be expensive when purchased commercially.



A dual-band Moxon antenna. [EAntenna photo]

Moxons

Invented by the late Les Moxon, G6XN, these directional antennas have a distinctive rectangular shape.

Advantages:

- Compact design. The Moxon is known for its relatively small footprint compared to traditional full-size beam antennas. This makes it particularly attractive for those with limited space.
- Directional performance. Despite its compact size, the Moxon antenna offers good directional characteristics. It provides moderate gain and excellent *front-to-back rejection*, which means it can effectively receive signals from one direction while minimizing interference from the opposite direction.
- Simple construction. Compared to more complex antenna designs, the Moxon is relatively straightforward to build. It typically consists of two main elements and can be constructed using simple materials like aluminum tubing or even wire.

Disadvantages:

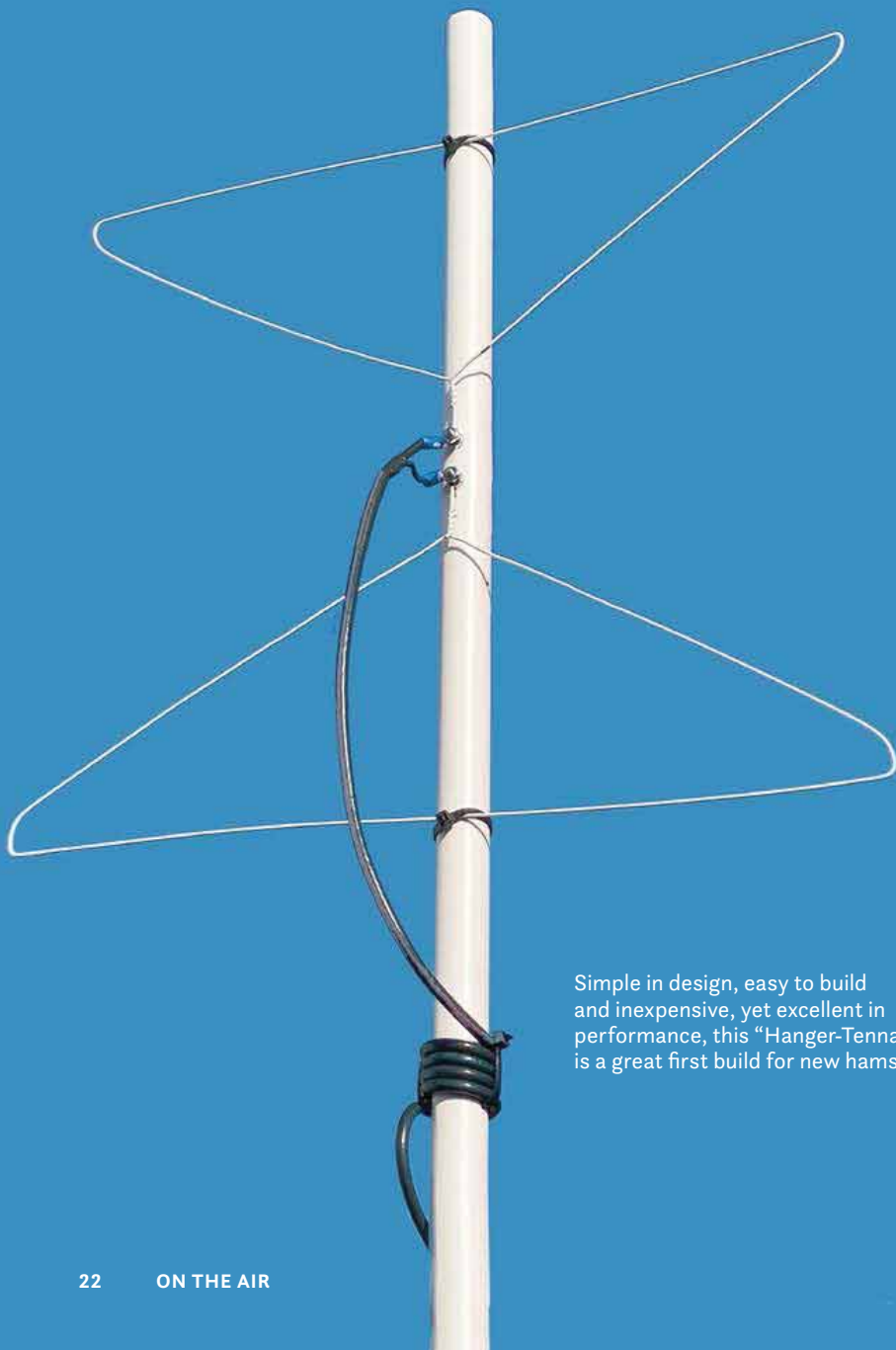
- Bandwidth limitations. One of the primary drawbacks of the Moxon is its relatively narrow bandwidth. The antenna performs optimally within a specific frequency range, but performance degrades quickly outside this range.
- Mechanical sensitivity. The precise geometry of a Moxon antenna is critical to its performance. Even small variations in element spacing or length can significantly impact its radiation pattern.
- Lower gain compared to Yagis.
- Rotators required for aiming. Like the Yagi or LPDA, a Moxon is most effective when you can point it in the desired direction. This entails the added cost and complexity of a rotator.



Build an Ultra-Simple 2-Meter Coat Hanger Antenna

This easy-to-build gem is made from not much more than a pair of common dry-cleaner wire coat hangers and a few feet of hardware store PVC pipe, yet it can hold its own alongside commercially built antennas.

John Portune, W6NBC



Simple in design, easy to build and inexpensive, yet excellent in performance, this “Hanger-Tenna” is a great first build for new hams.

This coat hanger antenna transmits and receives in all directions toward the horizon and is vertically polarized, ideal for contacting repeaters. *Polarization* is the direction in which an antenna’s radio waves vibrate in space as they propagate. Both a repeater and a ham’s radio must have the same direction of polarization. A horizontally polarized version of this antenna is also practicable. Just add a PVC T-fitting to the boom to mount the antenna horizontally.

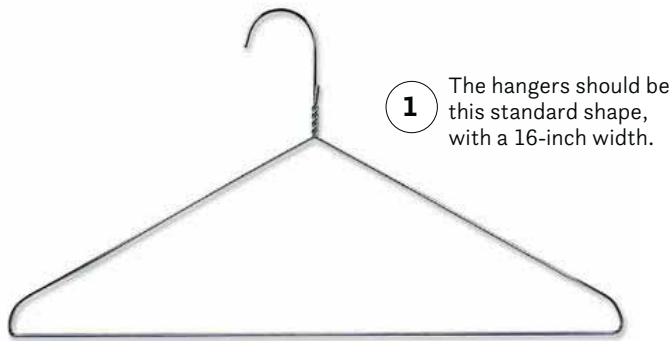
This antenna’s advantages are that it is relatively inexpensive to build and only 17 inches tall — neighbors will hardly notice it. Furthermore, the antenna is also very *broad banded*; it works on the entire 2-meter band without re-tuning, and has a good SWR of under 2:1.

Notes on Selecting the Hangers

Check your closet for ordinary wire coat hangers, the inexpensive kind you get from the dry cleaner. Be sure that they’re 16 inches wide, as 18-inch hangers cannot be tuned to the 2-meter band.

The finish on the hanger is not important; generally, they’re white powder coated. As to wire diameter, you’ll need common 13-gauge (0.075 inches) hangers. Use a caliper or a micrometer to measure the wire. Other diameters will work, but the antenna dimensions shown here may require small adjustments.

For indoor use, steel hangers and galvanized steel hardware are fine. For outdoor use, apply a coat of paint and use brass or stainless hardware. Stainless-steel hangers are available on the internet but are not necessary for this project.



Tools and Materials

- Heavy-duty pliers
- Needle-nose pliers
- Screwdrivers
- Heavy-duty wire cutters
- Hobby or box knife
- Pipe/dowel center drilling guide block (optional)
- Caliper or micrometer
- Soldering iron and solder (as needed)
- Wire terminal crimper (as needed)
- 3 ft. or more 3/4 in. hardware store PVC pipe (1/2 in. is okay)
- (2) 16 in. 13-gauge wire hangers from the dry cleaner
- (2) 8-32 x 1 1/2 in. stainless or brass machine screws
- (4) 8-32 stainless or brass nuts
- (1) 10-15 ft. small-diameter coax, e.g. RG-8X Mini-8 or LMR-200 or similar
- (1) RF connector that fits your radio (such as a PL-239)
- 6 in. small-diameter heat-shrink tubing
- (2) Ring terminals, crimp or solder, for #8 lug
- 1/8 in. zip-ties

Construction

Step One

Use heavy pliers to bend the hangers to eliminate any misshaping or extra bends, if necessary. The hangers should have the simple shape shown in (1). Be sure, however, to maintain the 16-inch width.

Step Two

Look closely at the twist of wire at the apex of the hanger. There's a small excess amount of wire at the end of the shorter twisted wire. Cut it off. Then reduce the length of wire in the main hanger hook wire to 1 3/8 inch from to the twisted wires, and bend a small connection hook in the end as shown in (2). The hook should fit closely but freely around an 8-32 machine screw. The distance from the center of the hook to where the wires fan out to form the hanger should be 1 1/2 inch (see (2)). Scrape the paint/coating off of the small hook.

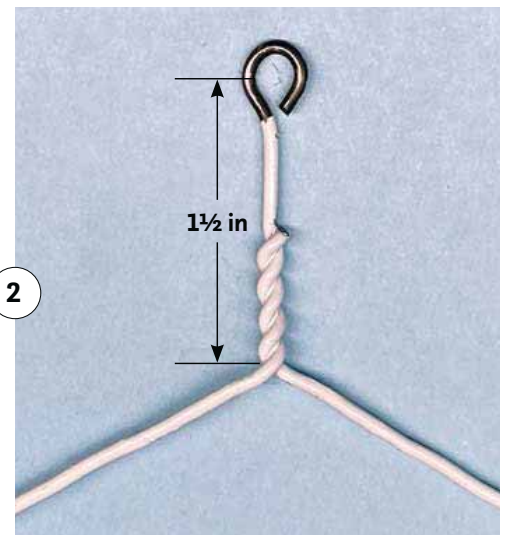
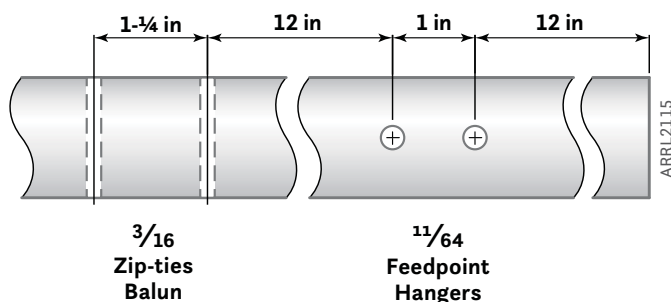
Step Three

Prepare an antenna mast using 30 inches minimum length of 3/4-inch PVC pipe. Drill 1 1/64-inch holes for two feed-point screws, and 3/16-inch holes to accommodate four balun zip-tie holes (see diagram below). Note that the zip-tie holes are rotated 90 degrees respective to the feed-point holes.

Take care to drill the holes straight through the pipe. A pipe/dowel hole drilling block, available inexpensively from the internet, is recommended. It is a useful tool to have in your toolkit.

Mast drilling guide

Follow this guide for drilling the necessary holes in the 3/4-inch PVC mast.



The feed-point screw connection hook for an 8-32 screw.

Continues on following page.



3

Steps in preparing the feed-point end of the coaxial cable.

Step Four

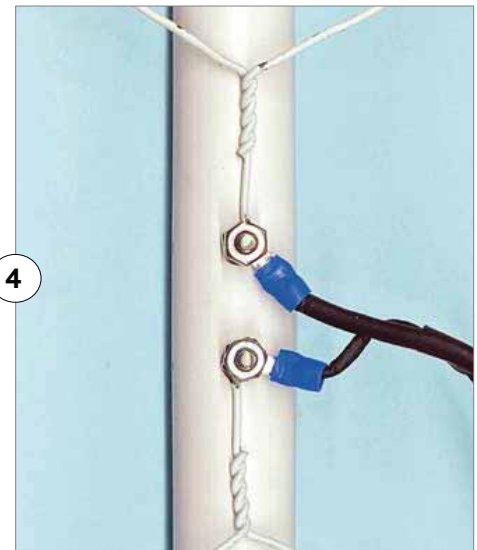
Follow the images in ③ to prepare one end of a length of small-diameter coax feed line (e.g. RG-8X Mini-8, LMR-200, or similar).

Use a hobby/box knife to carefully remove 2 inches of the plastic coax jacket, being careful not to nick the braid. It is soft copper and easily cut. Bend the coax away from you as you gently cut through the jacket to allow it to split. Pull off the short jacket end.

Then unbraid the exposed shield into individual wires by pulling the fine wires outward between your thumbnail and index finger (see the first image in ③). Do not remove the plastic dielectric from the center conductor of the coax.

Twist the fine wires of the braid into a single separate conductor (see the second image in ③). Strip ¼ inch of the dielectric from the end of the center conductor. Tin the ends of the separated coax conductors with solder. Apply heat-shrink tubing for weather protection (see the third image in ③).

Crimp or solder a #8 lug ring terminal onto each of the two separated coax wires (see the fourth image in ③).



4

The hangers and feed-line coax, attached to the mast.

Step Five

Install two 8-32 x 1½ screws and nuts in the mast, in the 1¼-inch holes you drilled in Step 3. Attach the hangers and the coax lug rings to the same screws with a second nut, as shown in ④.

Step Six

Loop the coax down to the balun location on the mast, near the 3/16-inch holes that you drilled in Step 3. Adjust the ends of the coax so that they stand out and away from the hangers by at least 2 inches.

At the balun location, make five tight wraps of coax around the mast to form the choke current balun, as shown in ⑤. Secure the turns with a zip-tie through the four 3/16-inch holes in the mast.

Lastly, add a connector of your choice to the end of the coax. For final mounting, secure the coax to the mast below the balun with additional zip-ties.



5

Coax looped down and formed into a balun.

Tuning

The antenna is *broad banded*, that is, it has a low SWR over a wide range of frequencies. Consequently, if built as illustrated, and from the same coat hangers, both the SWR and the frequency should be acceptable without adjustment.

However, antenna frequency and SWR are easily fine-tuned by bending the longer 16-inch sections of the hangers inward or outward in small increments. For frequency, bend both sides of one hanger equally. For SWR, bend only one side of one hanger. In ⑥, we see one of the two hangers bent inward equally to raise frequency. To lower the frequency, bend the hanger outward equally.

If you have built the antenna from hangers of a different wire diameter than what is indicated here, you may have to modify the hangers with a different distance from the small feed-point connection loop in ② to where the wires fan out.

Finally, after you have mounted the antenna in its operating location, secure the top and bottom (the 16-inch sections) of the antenna to the mast with zip-ties, as shown in the lead photo.

John Portune, W6NBC, is a frequent contributor to On the Air and QST. He has been licensed for more than 50 years, and has held an Amateur Extra-class license since 1972. You can reach John at w6nbcmail@gmail.com.



One of the two hangers bent equally inward to raise the antenna's frequency (bend it outward to lower the frequency).

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Basic Gear for the Public Service Ham

Arc Thames, W4CPD

Whether you're new to public service or re-evaluating your collection of gear, there are some things a public service ham can't do without — and they don't have to cost a lot.

I've been re-evaluating my gear following the communications outages that were experienced from Hurricane Helene, and I was reminded of a phrase that you may have heard: *two is one and one is none*. If I'm in a critical situation where I need communications and the one handheld radio that I brought breaks, or the battery dies, then I'm left with no communications at all (assuming traditional communications methods are down). In an emergency, I just need a way to communicate. It doesn't have to be the best or the fanciest, it just has to work. Here are the basics.



The Icom IC-T10 Dual Band Handheld Transceiver and the AnyTone AT-D878 UVI Plus DMR/FM Handheld Transceiver are just two of many options to choose from when buying a handheld radio.

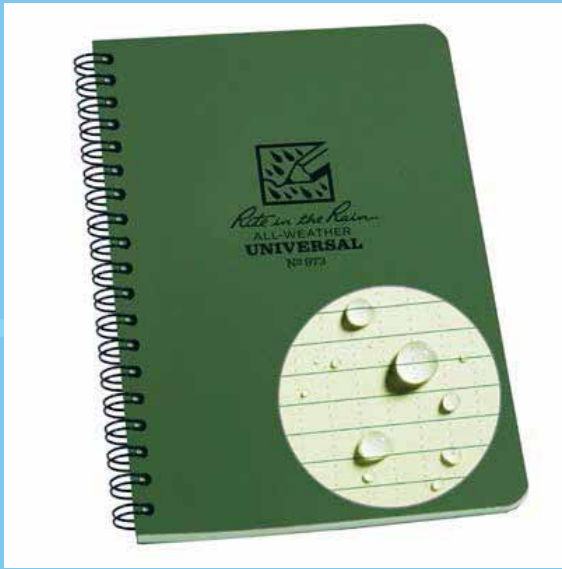
Handheld Radios

When communications matter in a crisis, we are generally going to default to good old FM. Digital radios that operate on C4FM, D-STAR, DMR, etc. are advantageous for many things but, for communicating with random individuals in a disaster scenario you're mostly going analog. By all means, continue to carry your digital handheld with you. Most of them can still operate analog. I would however, going back to *two is one and one is none*, also keep with me a cheap \$25-50 analog handheld as a backup. I keep one in my truck that I charged when I first got it and so far, every time I've needed it when I've forgotten my main handheld, it's still been charged and ready to go. (I do recommend charging your batteries regularly, I'm just demonstrating why it's good to have a backup radio lying around.)

HF Radios

If you need long-range communications, you'll want to invest in a good portable HF radio. Again, if having redundancy is important to you, have some sort of backup HF radio. There are many QRP (low power) radios available for less than \$500 that are ultra-portable. While they may only put out 10 watts of power, with the right antenna, you can still reach a long distance. While I'm not advocating that you carry two HF radios everywhere you go, if I were deploying to an area with no traditional communications and knew I was having to provide comms, I absolutely would bring at least one backup HF radio. And keeping a QRP radio in your vehicle is also handy for last-minute POTA (Parks on the Air) activations!

Rite in the Rain makes notebooks of water-resistant paper in many sizes, as well as a variety of writing instruments that produce water-resistant writing.



A bag with MOLLE straps on the outside makes it easier to attach additional bags or other items.

Antennas

You're going to want a good selection of antennas for your handheld as well as your HF radio. For your handheld, the stock antenna is generally good enough to keep around in case your primary antenna fails, but for that primary antenna you're going to want something with higher gain. I'm a fan of fold-over tactical whip antennas because you can keep it folded over when you're near the repeater or person you're trying to contact, and then extend it if you get farther away.

The same thing goes for HF antennas. I like to have a selection of them in my go-bag. I lean toward antennas that are resonant on a particular band or several bands, to keep me from having to carry an antenna tuner. A lot of modern full power (100 watt) radios will have an antenna tuner built in that can handle a 3:1 SWR or lower, but most QRP radios in the 10 watt range won't have a built-in tuner, and the tuner just becomes one more thing you must carry — and that can break. A few companies like Chameleon and TN07 offer antennas that are broadband and can be used without a tuner. You can also make your own wire antennas for bands that you will need. The most common bands I see used in statewide emergency communications are generally 40 meters for daytime and 80 meters for nighttime. Several manufacturers make a dual band 40/80-meter dipole antenna.

Tools for Documentation and Messaging

For documentation and other tools to interface with your radio, you'll want a basic, affordable laptop or tablet. *Winlink*, software that allows you to utilize your radio to send messages over the air with or without internet, is one of the primary software programs used to communicate during a disaster or incident. *Winlink* was primarily written for Windows, but there are Linux versions, as well as apps like *Radio Mail* on iOS or *WoAD* for Android devices that can interface with a supported radio over Bluetooth. This capability is incredibly handy for being able to send ICS forms, radiograms, and other formal messages without having to read them aloud over the air.

A laptop or tablet also allows you to keep any necessary ICS forms, radio manuals, or other documents you may need, saved and readily available. You can get usable tablets for less than \$100 online, and there are generally good deals on refurbished laptops under \$500. Most amateur radio software doesn't require anything super powerful, so you can keep a laptop or tablet in your bag without having to spend a lot.

Don't forget old-fashioned pen and paper. So often, I just revert to a legal pad to quickly write down information that I may need to later transfer to an official form. If you're going to be outside a lot, it's worth investing in a Rite in the Rain notebook and pen/pencil (riteintherain.com). There's even a tactical notebook sold by a company called Off Grid WX (offgridweather.com) that includes reference cards for amateur radio band plans and other useful tactical information.

A Bag for Carrying It All

I've covered suggested items to keep in a go-bag in a previous article (see "Basic Gear for Public Service" in the September/October 2022 issue), but what we haven't talked about is the bag itself. I won't even begin to suggest brands, as there are far too many, but there are a few key things I would look for.

First of all, find a bag that is the right size for the gear you actually need to carry. Everyone tends to rush to the biggest bag, but that's not always the right choice, especially if it becomes so heavy that you can't carry it. Don't be afraid to split gear into multiple bags or cases so you can add or take away things you may not need for a particular scenario.

MOLLE straps on the outside make it easier to add on additional bags or hook-on items like carabiners and paracord. MOLLE (pronounced "molly") stands for "modular, lightweight load-carrying equipment," and a MOLLE system on a bag can make it more versatile. It also might be nice to have EMP/RF shielded interior compartments to protect your gear from anything that might harm it.

Ham Media Playlist

1:20

73:00

Presenting highlights from the growing community of YouTubers who focus on ham radio, to help you build a Ham Media Playlist of content creators who can help you learn and grow in the ham radio hobby and service.

Ham Radio 2.0 — Keeping Costs in Mind



Jason Johnston, KC5HWP, shows ham radio operators how to participate in POTA at Galveston Island State Park (US-3013).

Jason Johnston, KC5HWP, was licensed in 1994 and never truly had a mentor in the hobby. His engagement with amateur radio came and went as time and finances allowed, and he and his friends learned what they could together. While attending a hamfest in 2012, he found that amateur radio didn't have to be expensive.

Walking the hamfest aisles, Jason stumbled upon a Wouxun handheld radio for \$99. He was amazed at the low cost and advertised features. Once Jason had used the radio for some time and got a feel for its operation, it sparked enough of an interest that he eventually became an online reseller of low-cost radios and equipment.

The Beginning of Ham Radio 2.0

Jason was getting questions about programming a TYT mobile radio that he had sold several of, so he created a low-budget video about programming it and uploaded it to YouTube (tinyurl.com/kc5hwb-first). While he didn't know it at the time, that was when his channel, "Ham Radio 2.0" (youtube.com/@hamradio2) was born.

When Jason looked at the analytics for the video, he was shocked to see that it had amassed nearly 6,000 views in just a few months. Jason saw the possibility of using YouTube to help hams find answers. He then created his second video, which was the first with the name "Ham Radio 2.0" attached to it.

Jason has always had an affinity for demonstrating that amateur radio does not have to be expensive, and many of his videos reflect this. This is, in part, a way to help new and potential radio amateurs get on the air and experience radio without a large initial monetary investment.

While Jason certainly creates videos on many of the more expensive radios, his channel has always steered hams to lower-priced equipment that suits their needs. He regularly hosts livestreams, during which he features equipment that is on sale. As the holiday sales ramp up, Jason shares the available deals and where to get them.

Helping Hams

Ham Radio 2.0 is about more than just radio. Jason is a lover of the outdoors, and his Parks on the Air (POTA) and Field Day videos make that obvious. Jason typically participates in ARRL Field Day and Winter Field Day from his hunting camp. He also activates parks not only all over his home state of Texas, but across the country. One of his regular spots is in Galveston, Texas. In one such video, titled "POTA Happy New Year 2022 from Galveston Island State Park" (tinyurl.com/kc5hwb-fieldday), Jason not only has a great time with his activation, but he also takes the time to teach a first-timer how to activate a park for POTA. His own operating often gets set aside when the opportunity to help someone get on the air presents itself.

With almost 1,400 videos, Ham Radio 2.0 has amassed a staggering 13.8 million views. Numbers like that make it clear that the amateur radio community appreciates Jason's dedication to creating the kind of content they are looking for.



In the first YouTube video he ever created, Jason Johnston, KC5HWP, shows viewers how to program a mobile radio.



From the Podcast

Unique content to help you get more out of the magazine.

arrl.org/On-the-Air-Magazine

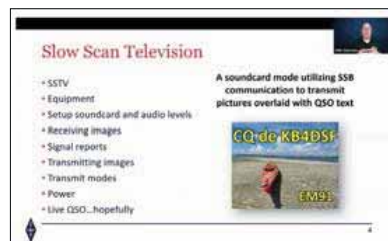
arrl.org/On-the-Air-Podcast

youtube.com/ARRLHQ

Every month, the editors of *On the Air* release a companion podcast that extends the features, projects, and experiences presented in the magazine. Hosted by Becky Schoenfeld, W1BX, and sponsored by Icom, the 15-minute podcast takes a deeper dive into an issue of *On the Air* to offer additional resources, techniques, and hints to help you get the most from the magazine's content.

The *On the Air* podcast is now available as a video! Visit ARRL's YouTube channel at youtube.com/ARRLHQ to watch the video version of our monthly podcast.

Here's an overview of recent episodes:



January 2025: Steve Ford, WB8IMY, author of “SSTV: When a Picture is Worth a Thousand Words” in the January/February 2025 issue, joins the podcast to share the basics of SSTV. This podcast is a companion to the January 2025 *On the Air Live* class about SSTV, which you can watch at learn.arrl.org.



February 2025: World Amateur Radio Day (WARD) is April 18 every year, and in 2025, WARD is extra special. ARRL invites radio clubs and schools to organize a Ham Radio Open House in April, to highlight the Amateur Radio Service for its development and practice of the latest radio communications and technology, and as a hands-on pathway into STEM fields for the next generation. ARRL Public Relations and Outreach Manager Sierra Harrop, W5DX, and Associate Professor of Physics and Engineering at the University of Scranton Nathaniel Frissell, W2NAF, join the podcast to talk about what a Ham Radio Open House might include, and how your club or group can start organizing one.

You can subscribe to the *On the Air* podcast in Apple iTunes (podcasts.apple.com) or on Stitcher (app.stitcher.com). If you're using an RSS client, the feed URL is feeds.blubrry.com/feeds/arrlontheair.xml.

Share your hints (or hacks) with fellow hams by sending them to ota@arrl.org or *On the Air*, ARRL, 225 Main St., Newington, CT 06111.



Figure 1: The soldering iron in its completed antioxidant holder.

A small, clean, and properly tinned soldering iron tip is a must.

HINT

Soldering Iron Antioxidant

It can seem like a constant battle to keep the tip of your soldering iron clean of oxidation (the hard black scale that builds up). When building with larger components, it can be fairly easy to find a clean spot on the tip to heat the component and solder simultaneously. Working with SMD (surface mount devices) and small printed circuit boards is quite different, however. The component terminals and solder pads are small. Soldering such devices requires that the heat transfer from the soldering iron to the component or pad happen very quickly. A small, clean, and properly tinned soldering iron tip is a must, which was a problem with my old 12 and 25 watt irons. I keep a wet sponge handy and was constantly cleaning the tip with it, but I found another way, described here.

Keeping Out the Air

Oxidation is a result of the hot metal coming into contact with oxygen in the air. It occurred to me that oxidation could be reduced if the tip was not exposed to the air while in the holder. I had the idea to keep the tip buried in a pool of molten solder, so that it wouldn't come into contact with the air.

The cup to hold the molten solder would have to be small, shallow, inexpensive, and able to withstand substantial heat. I started walking the aisles of my home improvement store and found a solution: a $\frac{3}{8}$ inch zinc-plated steel axle cap nut (Lowe's part #008236768541). They are used on kids' toys to keep the wheel on the axle. I bought a package of two.

I found a piece of oak board about an inch thick, cut it to size and bored a shallow hole to hold the cup and another hole to support a soldering iron holder formed from a coat hanger. I put a couple of screws through the base for my 25 watt soldering iron into the wooden block, and my new soldering station was complete (see Figure 1).

First Heat

As my 25 watt iron was heating up, I used my 300 watt soldering gun to melt enough solder to fill the cup. I cleaned the tip of the soldering iron and stuck it in the homemade holder. Then I withdrew the iron and the bottom 1/8 inch of the tip was clean and perfectly tinned, with no hard scale. I grabbed a few pieces of wire and a printed circuit board and soldered and desoldered a bunch of connections without ever touching the cleaning sponge.

The original holder for my 12 watt iron was a small piece of angled aluminum. It didn't have an existing base to work with, so that holder was built completely from scratch. All it took was a scrap piece of wood, the other cup, a formed section of coat hanger, a few minutes, and this project reached a successful conclusion (see Figure 2).

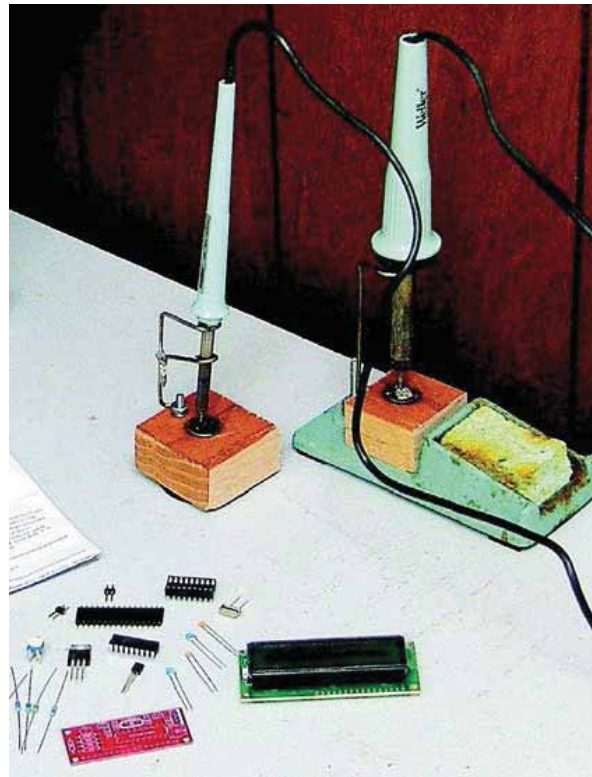


Figure 2: Some metal cups, a piece of wood, and a coat hanger are all you need to keep the tip of your soldering iron shiny.

Safety

Remember, even low-wattage soldering irons are *hot*! So is the liquid solder in the cup. Don't use this setup around children or others who could be burned by the molten solder or iron. Even though the amount of solder in the cup is small, it's enough to cause a serious burn if spilled. The base of my 25 watt iron is heavy enough to resist tipping over. Not so for the 12 watt iron. For safety purposes, it is attached to the workbench with industrial-strength hook-and-loop fastener. Always use soldering equipment in a proper work area and take steps to keep hot items away from yourself and others.

The solder cups are held in the wooden blocks with epoxy, as well as the lower coat hanger

support of the 12 watt iron. Be careful to use an epoxy that can tolerate the heat, such as J-B Weld, which can withstand 600°F.

From a cold start it takes about 10-12 minutes for the solder in the cup to liquefy. A dark layer of rosin will form on the top, but it does not stick to the tip of the iron.

Wayne Smith, WA4WZP

[Note that eventually the solder in the cup will become contaminated and will need to be disposed of. Check your local regulations regarding proper disposal. Also, some modern soldering iron tips are plated with a protective layer of iron. The tin in the molten solder can dissolve this layer and cause premature failure of the tip. Finally, the cup solder will be an additional heat load on the iron and many shorten its life. — Ed.]

US Amateur Radio Bands

Operator license classes: **E** = Amateur Extra **A** = Advanced **G** = General **T** = Technician **N** = Novice
 CW operation is permitted throughout all amateur bands. Except as noted, all frequencies are in megahertz (MHz).

■ = RTTY, data, phone, image
 ■ = USB phone, RTTY, data and CW
 ■ = RTTY and data
 ■ = phone and image
■ = SSB phone
 = CW only

LF – Low Frequency band

2200 Meters (135 kHz) E,A,G
 1 W EIRP maximum



Amateurs wishing to operate on **2200 or 630 meters** must first register with the Utilities Technology Council online at <https://utc.org/plc-database-amateur-notification-process/>. You need only register once for each band.

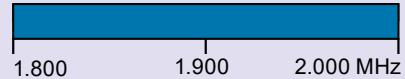
MF – Medium Frequency bands

630 Meters (472 kHz) E,A,G

5 W EIRP max, except in Alaska within 496 miles of Russia where the limit is 1 W EIRP

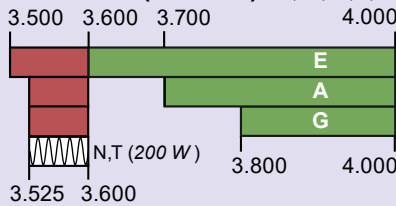


160 Meters (1.8 MHz) E,A,G

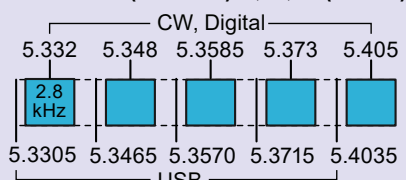


HF – High Frequency bands

80 Meters (3.5 MHz) E,A,G,T,N

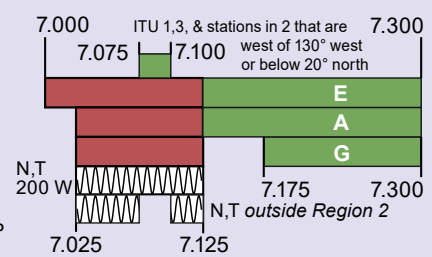


60 Meters (5.3 MHz) E, A, G (100 W)



General, Advanced, and Extra licensees may operate on a secondary basis with a maximum ERP of 100 W (relative to a half-wave dipole antenna).

40 Meters (7 MHz) E,A,G,T,N



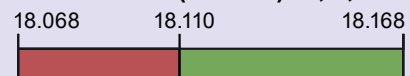
30 Meters (10.1 MHz) E,A,G



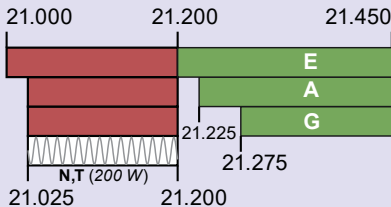
20 Meters (14 MHz) E,A,G



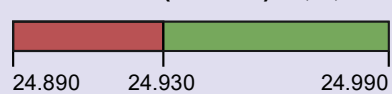
17 Meters (18 MHz) E,A,G



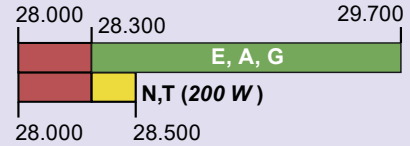
15 Meters (21 MHz) E,A,G,T,N



12 Meters (24 MHz) E,A,G

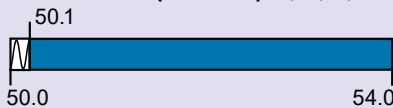


10 Meters (28 MHz) E,A,G,T,N

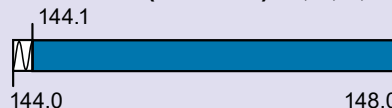


VHF – Very High Frequency bands

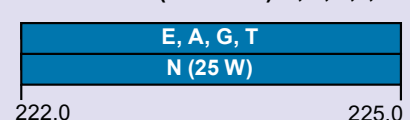
6 Meters (50 MHz) E,A,G,T



2 Meters (144 MHz) E,A,G,T



1.25 Meters (222 MHz) E,A,G,T,N



UHF – Ultra High Frequency bands

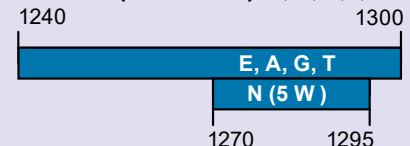
70 cm (420 MHz) E,A,G,T



33 cm (902 MHz) E,A,G,T



23 cm (1240 MHz) E,A,G,T,N



SHF&EHF – Super and Extremely High Frequency bands

All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz	3400-3450 MHz	10.0-10.5 GHz	47.0-47.2 GHz	122.25-123.0 GHz	241-250 GHz
2390-2450 MHz	5650-5925 MHz	24.0-24.25 GHz	76.0-81.0 GHz	134-141 GHz	All above 275 GHz

See www.arrl.org/band-plan for detailed band plans.

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 OTAbands rev. 07/25/2024

The Next Steps

Try your hand at a couple of questions you may encounter on your upgrade exams.

General

Question G5A01

What happens when inductive and capacitive reactance are equal in a series LC circuit?

- A. Resonance causes impedance to be very high
- B. Impedance is equal to the geometric mean of the inductance and capacitance
- C. Resonance causes impedance to be very low
- D. Impedance is equal to the arithmetic mean of the inductance and capacitance

The correct answer is C. In a series LC circuit, when inductive and capacitive reactance are equal, resonance causes the impedance to be very low.

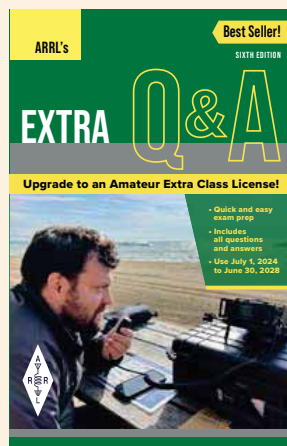
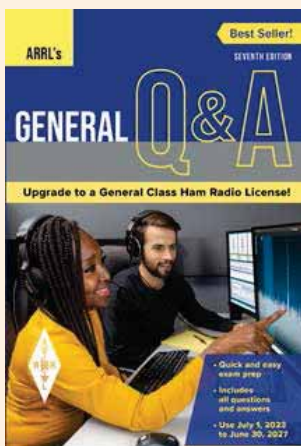
Amateur Extra

Question E6F03

What is the most common configuration of an optoisolator or optocoupler?

- A. A lens and a photomultiplier
- B. A frequency-modulated helium-neon laser
- C. An amplitude-modulated helium-neon laser
- D. An LED and a phototransistor

The correct answer is D. An optoisolator or optocoupler is an LED and a phototransistor in a single IC package. Light from the LED shines on the phototransistor, allowing current to flow in the output circuit.

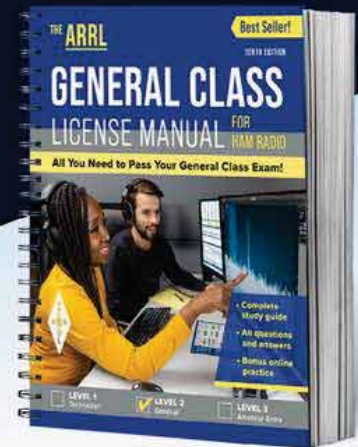


For Further Study

For the entire General or Amateur Extra question pools, along with simple answers like the ones shown here, pick up a copy of ARRL's *General Q&A* or *Extra Q&A*. For in-depth explanations of the answers, get a copy of *The ARRL General Class License Manual* or *Extra Class License Manual*. These resources are available from the ARRL online store (arrl.org/shop), Amazon, or your favorite ham radio dealer.

As you're studying, take free practice exams at arrl.org/exam-practice.

The ARRL General Class License Manual For Ham Radio



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- Enjoy access to major portions of all amateur HF bands.
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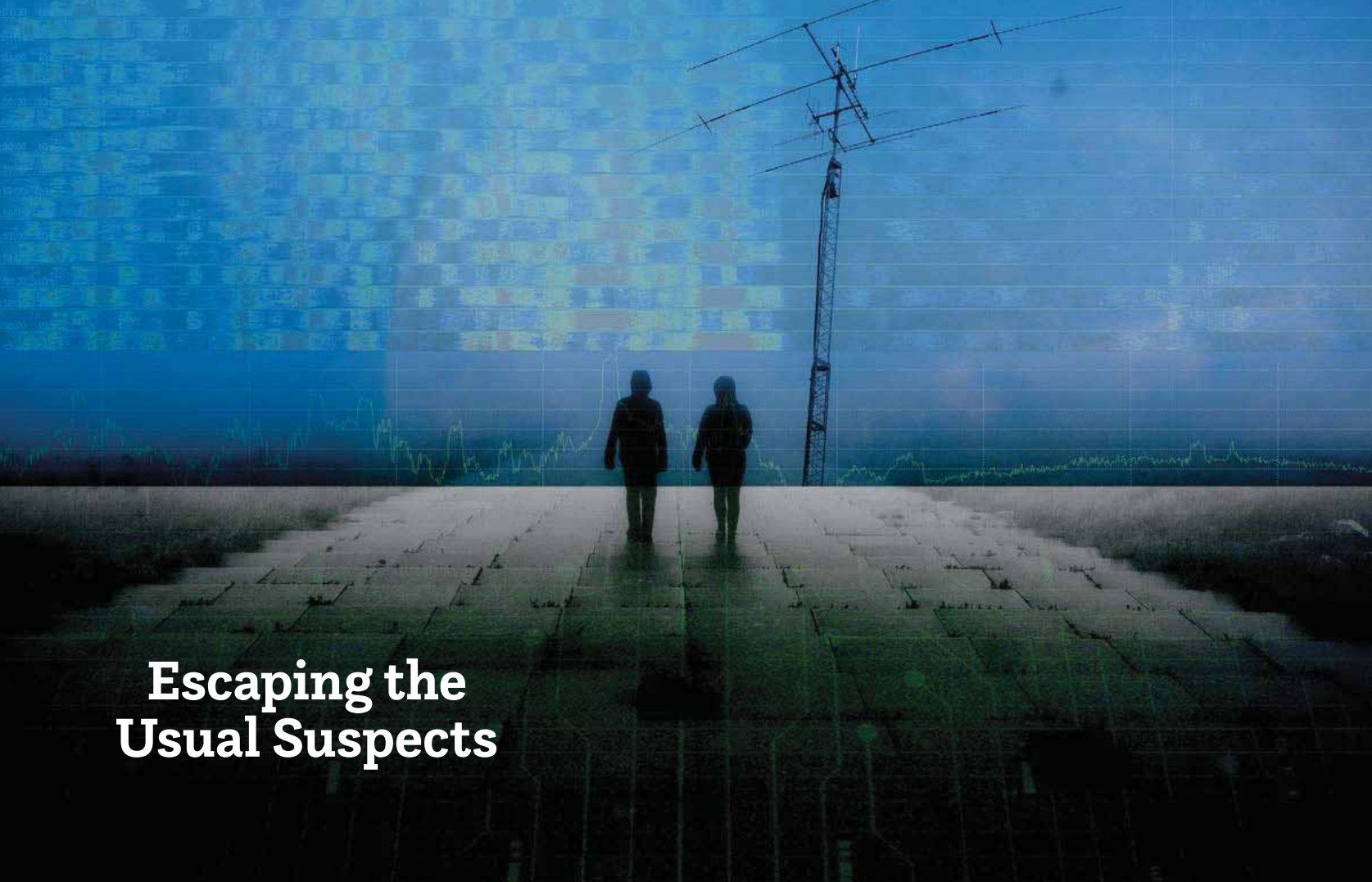
Use this manual to pass the 35-question multiple-choice examination. Upgrading to General class will increase your capabilities dramatically, making it possible to communicate with other hams across the country and around the globe!

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Escaping the Usual Suspects

73 LAST WORD

Patrick Hamel, W5THT

The phrase “the usual suspects” has existed in American memory for quite a while, certainly ever since Rick Blaine and the inspector walked off into the fog to freedom in the classic 1942 film *Casablanca*. Each of us has our own “usual suspects” to avoid or overcome in life, and they aren’t necessarily people. Our lives seem busier than ever, our attention is pulled in a million directions at once, and balancing work, family, and our personal interests can seem impossible.

The potential for feeling overwhelmed makes it that much more important that we take the time to do things we enjoy and that give us a feeling of fulfillment. Ham radio, on the air and on the workbench, offers us many pursuits that we can choose to follow as our interests mature, such as relaxed conversations on the local repeater, or a certain net that always seems to bring people together. There’s always another group on another repeater or another net on another frequency, and banishing boredom or loneliness requires only turning the dial.

Hams wanting to feel accomplished can set goals for operating or building hardware on any number of bands. You need at least two stations for a contact, and any licensed ham, no matter their age, can get on the air at any time and find an entirely new group of people to contact, as the propagation will be different.

The advent of FT8 and other modes available in WSJT-X has enabled goal-seeking by band and mode, with colored lines that show the status of our station and the others on the air. When

we start operating a band and mode, all the lines are purple. When we have contacted everyone within propagation range, the lines are all green, and the call signs are red — it can give a real feeling of accomplishment to watch those colors change.

We can build an antenna from scraps and use it to contact the big stations with massive, permanent antennas, or even bounce our signal off the moon. The million smaller hobbies that make up ham radio have so much power to meet our emotional needs and help us escape “the usual suspects.”

Pat Hamel, W5THT, has an Extra-class license and has been on the air since 1967. Primarily an experimenter, builder, and Heathkit repairman, his most recent operation has been with WSJT-X modes.

bhi

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- Use with any radio including SDR
- Three different options available



Dual In-Line

- Fully featured dual channel DSP noise cancelling in-line module
- 8 Filter levels 9 to 40dB
- 3.5mm speaker level input
- Line level input for SDR radio and headphone output
- Easy-to-use controls



Compact In-Line

- Powerful audio processor
- Removes noise and interference
- Hear weak signals clearly
- Easy to use with "real-time" audio adjustment
- Use with headphones or a loudspeaker



NES10-2 MK4

- 5W amplified DSP noise cancelling speaker
- 8 to 40dB noise cancelling
- Audio bypass feature
- Use mobile or base station
- Supplied with integral 2M audio lead, fused DC power lead & manual



DESKTOP MKII

- 10W Amplified DSP noise cancelling base station speaker
- Easy-to-use controls
- 8 DSP filter levels
- "Real-time" adjustment
- Suitable for all radios including SDR
- Loudspeaker and line-level inputs
- H:200mm x D:160mm x W:150mm



In-Line Module

- 5W amplified DSP noise cancelling In-Line Module
- 8 filter levels 8 to 40dB
- Use in-line with a loudspeaker
- Audio bypass feature
- 3.5mm mono inputs and outputs
- Supplied with a fused DC power lead & 3.5mm mono jack plug lead

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