ARROWHEAD RADIO AMATEUR CLUB, INC. • DULUTH, MINNESOTA • WØGKP 1929

The RELAY

February 2024

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The Official Publication of the Arrowhead Radio Amateur Club

A.R.A.C. Inc. P.O. Box 7164 Duluth MN 55807-7164 http://www.thearac.org Dues: Member $20/Family $25

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2024

Join us on facebook!

Radio Frequency Energy

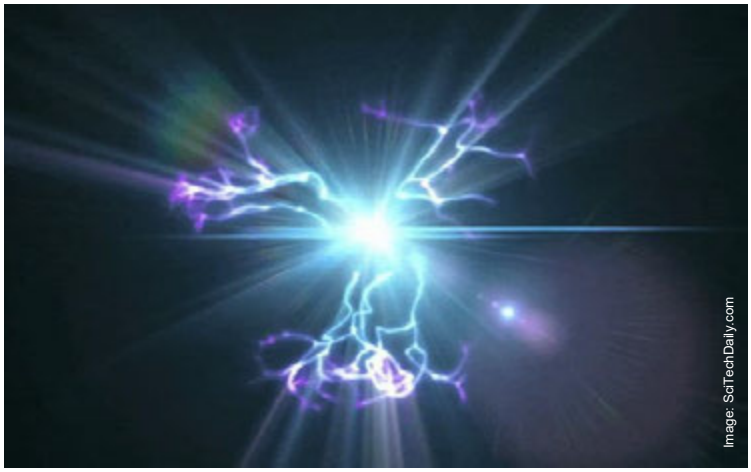
Harvesting RF as a Power Source

Nikola Tesla's work with radio-frequency waves laid the foundation for today's radio. He experimented with wireless transmission of electrical power, and received 112 patents for devices ranging from speedometers to extremely efficient electrical generators to a bladeless turbine still in use today. He suggested that it was possible to use radio waves to detect ships (later developed as RADAR), and his work with special gas-filled lamps set the stage for the creation of fluorescent lighting.

If you couldn't imagine life without your TV remote, thank Nikola Tesla for making it possible. Tesla invented, predicted or contributed to development of hundreds of technologies that play big parts in our daily lives -- like the remote control, neon lights, wireless transmission, computers, smartphones, laser beams, x-rays, robotics and, of course, alternating current, the basis of our present-day electrical system.

"Teslas," a unit used to measure the strength of magnetic fields, are named after Tesla. Another namesake is Tesla Motors, the electric vehicle company started by Elon Musk, in homage to Tesla's role in the invention of the electric motor.

Nikola Tesla was born on July 10, 1856, in the Austrian Empire, now Croatia. He was the fourth of five children. After a checkered academic career in Europe, he worked as a telegraph drafter and electrician before moving to the United States to work for Thomas Edison in 1884.



Spectacular energy image from SciTechDaily.com captioned as follows:
Radio Frequency Energy Harvesting
Technology could make it possible to use radio emissions from cell phone networks to wirelessly power sensors and LEDs

Innovation ran in Tesla's blood. Tesla once wrote: "My mother was an inventor of the first order and would, I believe, have had she not been so remote from modern life and its multi fold opportunities. She invented and constructed all kinds of tools and devices and wove the finest designs from thread which was spun by her." He credited both his parents' influence for his success.

During the war of the currents, alternating current (AC) -- favored by Tesla -- battled for wide acceptance with direct current (DC), favored by Edison. At stake was the basis for

Continued on Page 13

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KØDJP
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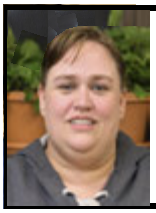

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Dave Davis

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1ST YEAR BOARD

PHOTO COMING SOON!

KD9VKI
Justin Cheever

Board Meeting Minutes - January 2, 2024

Present:
Board Members
Gene Ellefsen – N0VRM, Dave Pyrlik – K0DJP, Melinda Nelson – KF0GJW, Dave Davis – AA0AC, Doug Nelson - AA0AW, Sam Frey – KE0YTM, Justin Cheever – KD9VKI

Board Advisors (Non-Board Members)
Randy Wabik – KR0B, Grant Forsyth – KC0WUP

Guest:

Meeting called to order by President Gene – N0VRM at 18:40 (6:40 pm)

Minutes:
Minutes were sent via email. Motion to approve Dave Davis – AA0AC. Seconded by Doug Nelson – AA0AW, motion passed.

Treasurer's Report:

Checking:	$1,781.09
Savings:	$2,777.45
Repeater:	$2,070.60
Subtotal Cash	**$6,629.14**
Winter CD:	$1,748.93
Summer CD:	$0.00
Subtotal CD:	**$1,748.93**
Assets Subtotal:	**$8,378.07**

Motion to accept as presented by Melinda Nelson – KF0GJW, seconded by Justin Cheever – KD9VKI, motion passed.

Testing:
Big test session for the end of class on 1/16/2024 at the House of Refuge. 5:30 PM for registration, 6:00 PM for testing. As always if you are looking to test or upgrade, or know of anyone that is interested in testing please contact Doug Nelson at AA0AW@arrl.net

Repeater:
Dave Pyrlik – K0DJP Nothing at this time for the repeaters.

New Business:

Motion to adjourn by Melinda Nelson – KF0GJW. Seconded by Sam Frey – KE0YTM, motion passed at 19:03 (7:03 pm)

January 11, 2024

Present:
President: Gene Ellefsen – N0VRM
Vice President: Dave Pyrlik – K0DJP
Treasurer/Membership: Sam Frey – KE0YTM
Secretary: Melinda Nelson – KF0GJW
First Year Board: Justin Cheever – KD9VKI
Second Year Board: Dave Davis – AA0AC
Third Year Board: Doug Nelson – AA0AW
Special Events: Open/Gene Ellefsen – N0VRM (acting)
Parliamentarian: Grant Forsyth – KC0WUP
Testing: Doug Nelson – AA0AW
Repeater: Dave Pyrlik – K0DJP
Property/Picnic: Scott Ahlgren – N0VYU
HamFest/Education: Bob Schulz – KC0NFB

Absent:
Chaplin:
Web Site: Thomas Dorr – KE0RHA
Newsletter/Historian: Kim Waller – KE0NQS
Newsletter/Historian: Steve Waller – KE0NQT

Meeting called to order at 19:02 (7:02 PM) by President Gene Ellefsen – N0VRM. Thirty-seven (37) members were in attendance.

Minutes:
Minutes are posted on the website and in the newsletter. Motion to accept by Bob Schulz – KC0NFB, seconded by Grant Forsyth – KC0WUP Motion Passed.

Treasurer's Report:
Checking: $1,781.09
Savings: $2,777.45
Repeater: $2,070.60
Subtotal Cash $6,629.14

Winter CD: $1,748.93
Summer CD: $0.00
Subtotal CD: $1,748.93

Assets Subtotal: $8,378.07

Continued on Page 4

Motion to accept as presented by Mike Lovold – N0PDG, seconded by Paul Dallavia – KC0DWQ, motion passed.

Education:
Bob Schulz – KC0NFB nothing at this time. Diane Saunders – K0DSL will be starting a General Class sometime in March. The details will come out in a little while. If you are interested in upgrading to General Class please reach out to Diane.

Testing:
Doug Nelson – AA0AW we have a testing session next week on the 16th. As always if you are looking to test or upgrade, or know of anyone that is interested in testing please contact Doug Nelson at AA0AW@arrl.net

Repeater:

New Business:
Winter Field Day – January 27, 2024

Silent Key: (Please keep their family in your thoughts)

Door Prize was won by Gregory Scholz – KD0UYN

Motion to adjourn by Bill Fleischman – KC0ZZL, seconded by Justin Cheever – KD9VKI, motion passed at 19:11 (7:11 PM).

CLUB REPEATER
WØGKP
146.94 (-)
CTCSS TONE
103.5

Prez Sez ...

Hello Everyone,

Well another Winter Field Day has come and gone. It was a great time. We had about 25 people there on Saturday enjoying great fellowship and good food!! We made 468 contacts!! If you didn't make it this year plan to come next year. A big thank you to Robin and Dave Davis for hosting this event !!!!!

January is over and soon it will be May! You know what May brings: **The ARAC Swapfest** over in Superior, Wisconsin. This is our big fundraiser, so we will be again looking for help setting up, kitchen help and ticket sales. We are well-known as always having a good event, so please consider helping out. Also save your pennies if you are in the market for some used gear, as there is usually a good selection.

73's Gene Ellefsen NØVRM

LOOKING for an Amateur Radio License TESTING SESSION?

Schedule your own Testing Session TODAY!

Contact Doug Nelson-AA0AW at aa0aw@arrl.net or 218-391-5874

All Exam Candidates are REQUIRED to have an FCC Registration Number (FRN) before exam day, which will require your email address.

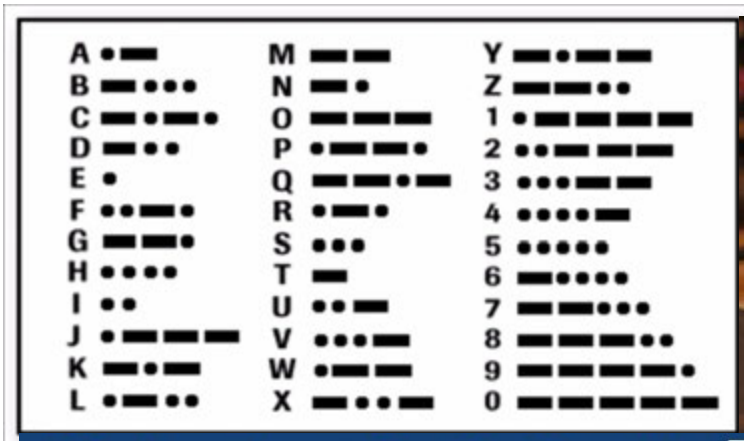
Not Currently Licensed? For New License Candidate FRN registration, go to:
www.fcc.gov/new-users-guide-getting-started-universal-licensing-system-uls

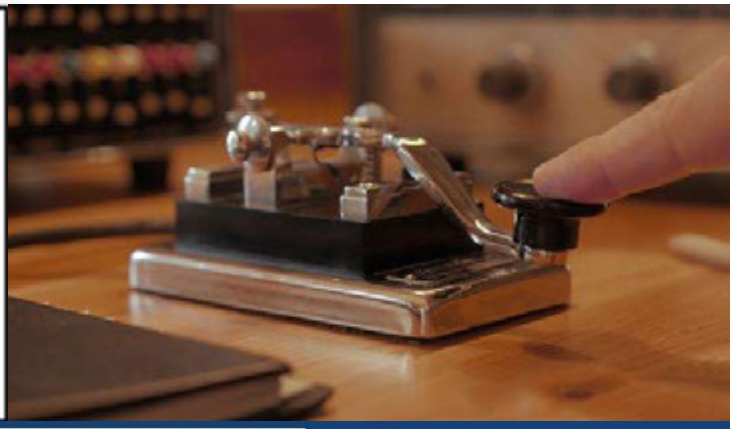
Upgrading to General or Expert Class & not sure you have an FRN number? go to
https://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp

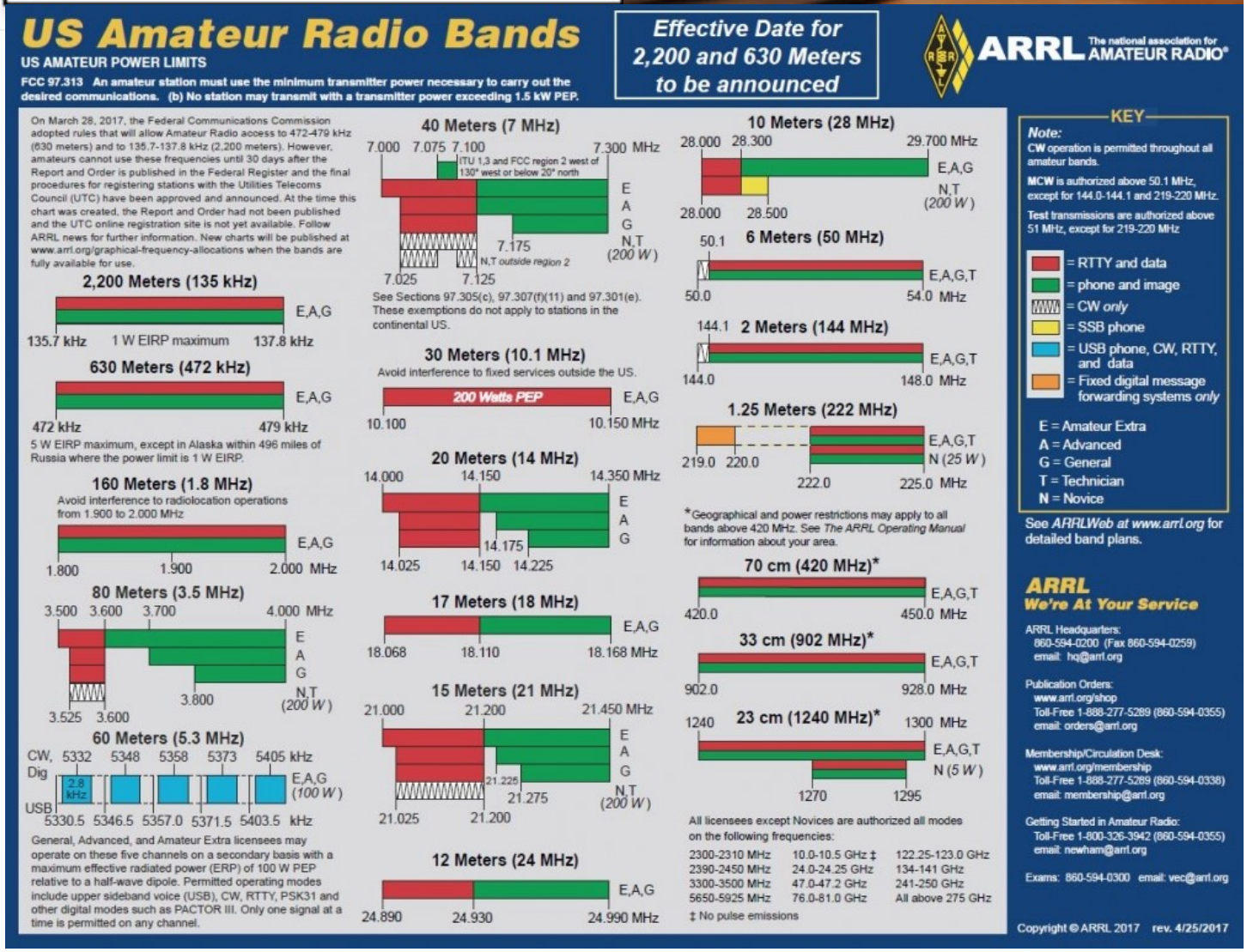
UPGRADE CANDIDATES:
Please bring a copy of your current license to the exam session.

CW Abbreviations

AR End of Message	AS Pse QRX	BK Back to You	SK End of Contact
TU Thank You	PSE Please	K Invite to Transmit	
QST Calling all Amateurs	QRL Are You Busy?	QRU Have anything for me	
QRV Are You Ready?	QRX Standby	QRS Transit Slower	







NETS

Have a favorite HF/6m/2m/1.25m/7Øcm net that you check into or listen in on? Also, please send corrections and we will add it to the list below - Kim KEØNQS at my email KEØNQS.mn@gmail.com.

- **Northland Weather Group Net:** Mondays 2ØØØ on the ARAC repeater (146.940 MHz with a tone of 103.5 and standard offset).
- **Minnesota D-Star Net:** Sundays at 19:3Ø on Reflector 53A
- **Minnesota Section Net** 12ØØ and 173Ø on 3.86Ø [Net Manager: NØYR] http://www.mn-section.org/dept_stm.html
- The non-non-net: Evenings 2ØØØ 144.2ØØ USB except for Sunday evenings.
- Badger WX Net: Ø5ØØ-Ø715 on 3.985. Give 24 hour high/low/current temperature, precipitation and snowfall.
- **PICONET**: 3.925 from Ø9ØØ-11ØØ CT Mon-Sat and 16ØØ-17ØØ CT Mon-Fri. Info at: http://www.piconet3925.com
- Michigan Upper Peninsula Net: 16ØØ (CST) on 3.921 MHz Sun-Sat and 12ØØ Sun. Info: http://www.michupnet.com
- Great Lakes Marine/Maritime Mobile Net: Morning Ø7:3Ø - 3.932; Ø8:15 - 7.261 MHz and evening 18:3Ø - 3.173Ø927; 19:15 - 7.268 MHz. Weekend extra net: 1Ø:ØØ - 7.261/7.268 MHz. All CST, LSB and +/- QRM. See: http://www.sailblogs.com/member/glmmnet/
- MIDCARS: Ø7:3Ø-13:ØØ - 7.258 MHz. See: http://www.midcars.net
- Iowa snowbird net on 14.257MHz, M-W-F at 1Ø:ØØ am Local Time. This is an open net.
- Spider Web Net (Marco Island FL) on 14.347 every morning at Ø73Ø CST/CDT: http://www.spiderwebnet.net
- Maritime Mobile Service Network: Daily at 11ØØ—21ØØ Central on 14.3ØØ. http://mmsn.org and http://www.143ØØ.net
- RV Radio Network: Every day at 19ØØ Central on 7.265 MHz. Web site: http://www.rvradionetwork.com
- Upper Midwest Ten Meter Net: Every Thursday Evening @ 8 PM – 28.48Ø MHz USB
- Wisconsin Sideband Net: Daily @ 5:15 PM – 3985 [or 3982.5] KHz LSB
- Hobby Helpers Net - Tuesday @ 8 PM – 28.33Ø MHz USB (Isanti MN) LSB [Net Manager: WOØA].
- Northstar Trader Net: 3.9Ø8 +/- at Ø83Ø CST Sundays
- WARFA: 3.9Ø8 +/- Sun/Tue/Thu nights at 22ØØ CST, http://warfa.org/
- Youth Net: 14.32Ø-1433Ø Sundays 18ØØ-19ØØ UTC, Net Control: AC8PI
- YACHT: Saturdays 19ØØ CST on EchoLink #481872, http://yachthams.webstarts.com
- Northwestern Ontario ARES Net: Evenings at 2Ø:15 (Central) on +/- 3.75ØMhz
- The Iron Range Net: Saturdays at Ø8ØØ Central time on or near 3.919 Mhz. Look them up on Facebook!
- FORX Net: Mondays at 19ØØ Central at 3.941 Mhz +/- QRM. WAØJXT — Grand Forks, North Dakota
- HF CW: Fridays Ø8:ØØ CST, 7.112 MHz. Informal slow speed CW Net. W8IRT NCS. Email: w8irt@aol.com
- Minnesota ARES Digital Net: Thursdays at 2ØØØ CST, 3.5835 MHz USB +/- QRM, Mode: Olivia 8/5ØØ.
- SARA Digital Net: Sundays at 19ØØ Local, 3.582.15Ø MHz USB +/- QRM, Mode: BPSK31/BPSK63
- Spider Web Net (Marco Island FL): 14.347 every morning at Ø73Ø CST/CDT: http://www.spiderwebnet.net
- Broadcaster Net: 7.231 or 3.855 M/W/F @ 15ØØ UTC. 14.255 M-F @ 213Ø UTC. http://www.cbsretirees.com/ham.htm
- Old Military Radio Net: 7.268 +/- nightly at Ø2ØØz. Other times/Frequencies too. See: http://www.mrca.ar88.net/
- Rag Chew Crew/Tailgaters/Freewheelers Nets: 3.916 +/- nightly at 19ØØ CST, http://www.tailgatersnet.com
- North South Net: 7.214.6 +/- at Ø7ØØ CST, Monday-Saturday

DULUTH AREA REPEATERS

ARAC System WØGKP

Frequency	Offset	Tone	Location
146.940	minus	103.5	Duluth
146.940	minus	107.2	Lakeside (recv)
146.940	minus	151.4	Two Harbors (recv)
146.940	minus	100.0	Gary-New Duluth (recv)
146.940	minus	110.9	Cloquet (recv)
147.000	minus	103.5	Mahtowa
444.100	plus	103.5	Duluth UHF Link

N9MMU/N9QWH System (WI)

145.310	minus	110.9	Duluth
145.490	minus	110.9	Solon Springs
147.255	plus	110.9	Hayward
145.110	minus	110.9	Rice Lake
147.345	minus	136.5	Holcombe
145.230	minus	110.9	Eau Claire

WECOMM – WI Statewide Linked System WE9COM

147.075	plus	110.9	Meteor Hill

(closest repeater to Duluth)

LSAC System # 1

147.330	plus	151.4	Proctor
147.330	plus	103.5	Duluth (recv for Proctor)
147.270	plus	114.8	Two Harbors
147.270	plus	103.5	Wales
147.090	plus	114.8	Silver Bay
145.410	minus	114.8	Finland
147.300	plus	114.8	Isabella
145.150	minus	103.5	Washburn, WI
146.700	minus	103.5	Bayfield, WI
443.850	+5.00	none	Bayfield, WI
147.165	plus	110.9	Hurley, WI
146.640	minus	151.4	Ely
443.500	+5.00	141.3	Gilbert
147.060	plus	103.5	Virginia
147.360	plus	162.2	Cook
147.165	plus	114.8	Coleraine
443.925	+5.00	110.9	Brainerd
443.200	+5.00	114.8	Tamarack
147.360	plus	203.5	Aitkin
146.865	minus	146.2	Giese
147.570	simplex	146.2	Hinckley
444.575	+5.00	146.2	Hinckley
443.325	+5.00	146.2	Isanti

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DULUTH AREA REPEATERS, continued

NARC System NAØRC

147.135 plus 103.5 Knife River
145.450 minus 114.8 Park Point (rcv)
147.135 plus 114.8 Knife River - Park Point (rcv)

Stand Alone Repeaters

145.210 minus 110.9 Clam Lake, WI
146.880 minus 123.0 Grand Rapids, MN
146.910 minus 146.2 Duxbury, MN
146.955 minus 146.2 Askov, MN
147.105 plus 110.9 Chaffey, WI
444.850 +5.00 141.3 Cloquet, MN

Fusion

Fusion **(**Analog has tone and C4FM digital with no tone)

147.150 plus 151.4 NTØB Gilbert. MN Fusion Repeater
145.170 minus 110.9 WA9KLM Superior, WI – Douglas County RACES/ARES Fusion Repeater (Digital only) Fusion Room 28373

145.250 minus 103.5 KBØYHX Cloquet, MN – Carlton County RACES/ARES Fusion Repeater

444.300 +5.00 103.5 NØEO Duluth, MN – Spirit Valley Amateurs Fusion Repeater WIRES-X NØEO (Analog only) Fusion Room 40494

444.400 +5.00 103.5 NAØRC Knife River, MN – Wires X Connected to NØEO Room 40494
444.500 +5.00 103.5 NØLCR Two Harbors, MN – Wires X Connected to NØEO Room 40494
444.600 +5.00 103.5 NØLCR Silver Bay, MN – Wires X Connected to NØEO Room 40494
444.800 +5.00 103.5 NØLCR Grand Marais, MN – Wires X Connected to NØEO Room 40494

D-Star

147.375 plus NØEO D Star
442.200 plus NØEO D Star

Rev. KCØWDQ as of 10/1/22 For ARAC Newsletter

Elmers

El-mer / ɛl-mər/ [el-mer]
1. a male given name: from Old English words meaning “noble” and “famous.”
2. an adhesive used to bond like or unlike materials
3. An experienced ham radio operator who mentors new and prospective hams.

Name	Call Sign	Expertise
Jeff Nast	KCØMKS	APRS, EchoLink, WinLink, Fusion, Contesting
Bob Schulz	KCØNFB	Contesting
Jim Anderson	NØJWA	QsoNet
Doug Nelson	AAØAW	HF, VHF/UHF, Contesting, Packet, APRS, Morse Code, VE testing, Echolink, Allstar, EmCom…

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Members, please check your name and email address for accuracy. If you are not on this list and want to be on the list, contact us with your info. If you need to make a change, please let us know at KEØNQS.mn@gmail.com OR KEØNQT@gmail.com

SUNDAY NIGHT NETS
193Ø - **CW - 28.125 MHz USB-CW**
2ØØØ -**USB 28.45Ø MHz**
21ØØ - **Southern St. Louis County Emergency Services Net**

MONDAY NIGHT NETS
2ØØØ- **Northland WX Net -** ARAC Repeater

FEBRUARY
CLUB EVENTS

TUESDAY NIGHT NETS
2ØØØ -**Douglas Cty 145.49Ø MHz**
2Ø3Ø -**Central Carlton County**

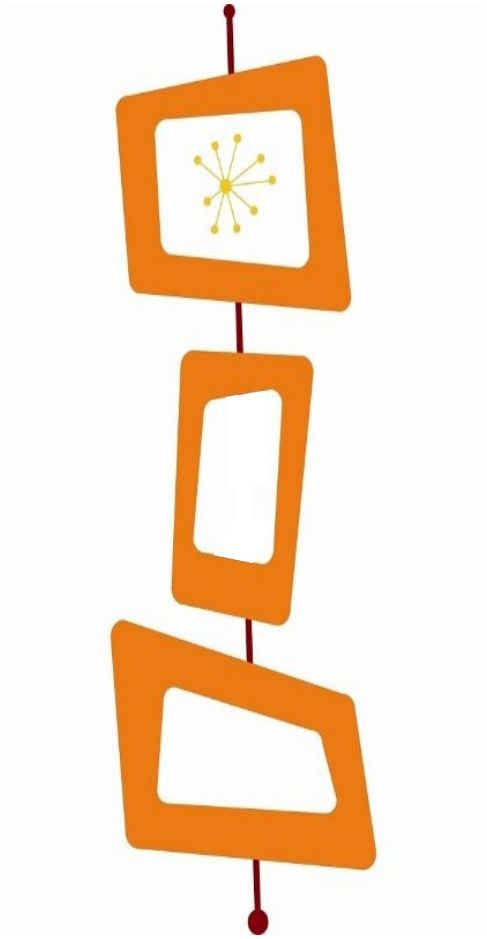
WEDNESDAY NIGHT NETS
19ØØ -**Lake County - LSAC1**
2nd & 4th Wednesdays
21ØØ -**BWAR**

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4 CW 1930 AAØAW USB 2000 NØPDG ES 2100 NØVRM	5 WX 2000 KCØMKS	6 ARAC BOARD MEETING Sammy's Pizza 6:30 pm DC Net 2000 CC Net 2030	7 21ØØ -**BWAR**	8 ARAC Club Meeting Coppertop Church 7:00 PM	9	10
11 CW 1930 NØPDG USB 2000 AAØAW ES 2100 KEØYTM	12 DC ARES/ RACES Mtg 1900 DC EOC WX 2000 KCØMKS	13 DC Net 2000 CC Net 2030	14 Happy Valentine's Day Lake County ARES/ RACES Meeting 1800 Lake County Net 1900 21ØØ -**BWAR**	15	16	17
18 CW 1930 AAØAW USB 2000 KB9WLB ES 2100 AAØAW	19 WX 2000 KCØMKS	20 DC Net 2000 CC Net 2030	21 St Louis County ARES/RACES Meeting 1800 21ØØ -**BWAR**	22 Carlton County ARES/RACES Meeting 1900 CC EOC	23	24 ARAC Club Breakfast The Chalet 8 am
25 CW 1930 NØPDG USB 2000 K9KDK ES 2100 KØDSL	26 WX 2000 KCØMKS	27 DC Net 2000 CC Net 2030	28 Lake County Net 1900 21ØØ -**BWAR**	29		

Get this newsletter *faster* via email!
Email Doug AAØAW at
aaØaw@arrl.net

Next Club Meeting:
Thursday,
February 8th, 2024 - 7 pm
at the Coppertop Church!

ARAC Committee Chairs



Club License Trustee:
Ray Barnes KEØZN

Control Operators:
AAØAW - NØKXT - KCØNFB

Newsletter/Historian:
Kim KEØNQS & Steve KEØNQT Waller

Education Chair:
Bob Schulz KCØNFB

Hamfest Chair:
Bob Schulz KCØNFB

Chaplain:
Rollie Bockbader KBØCK

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Property Chair:
Scott Ahlgren NØVYU

Testing:
Doug Nelson AAØAW

Field Day:

Picnic Chair:
Scott Ahlgren, NØVYU

Repeater Chairs:
Randy Haglin NØBZZ
Randy Wabik KAØJZV

Contest Calendar at www.contestcalendar.com

National Contest Journal at www.ncjweb.com

QSO Party Note: State/Province/National QSO Parties are abbreviated with the 2 or 3 letter abbreviation for the state/province/national designation followed by QP for QSO Party:

Examples: Minnesota QSO Party is MNQP
British Columbia QSO Party = BCQP

QRZ web site at www.qrz.com
VHF Propagation site at www.aprs.mountainlake.k12.mn.us

Reminder: The Contest Corral monthly listing of contests can be found in each issue of QST. ARRL sponsored contests can be found in Contest Corral, highlighted, or on the ARRL's web site at arrl.org.

the entire nation's electrical system. Edison launched a campaign against AC, claiming it was dangerous and could kill people; Tesla countered by publicly subjecting himself to 250,000-volt shocks to demonstrate AC's safety. Ultimately, Tesla's alternating current won the fight.

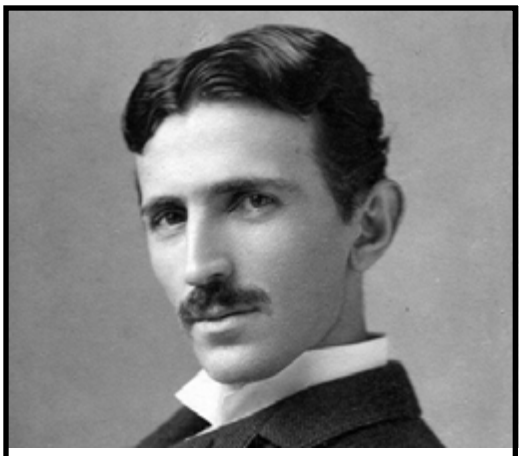
Tesla received his U.S. citizenship in 1891, the same year he invented the Tesla coil. Tesla coils are a type of electrical circuit used to generate low-current, high-voltage electricity. Today, they're widely used in radios, televisions and other electronics, and can be used for wireless transmission. A coil at Tesla's experimental station in Colorado Springs, Colorado, created 30-foot sparks that could be seen from 10 miles away.

Tesla designed the first hydroelectric power plant in Niagara Falls, New York, harnessing the power of the waterfalls he had marveled at since childhood. Construction took three years and power first flowed to homes in nearby Buffalo on Nov. 16, 1896. A statue of Tesla on Goat Island overlooks the falls today.

In 1901, Tesla received financial backing from J. Pierpont Morgan to build his Wardenclyffe laboratory in Shoreham, Long Island. The facility included the "Tesla Tower," a 185-foot high structure with a 65-foot copper dome transmitter on the top. Tesla's vision was to use the tower to transmit signals and free, unlimited wireless electricity all over the world.

Tesla was not a savvy businessman and suffered financially, despite his achievements. He lost financial backing from Morgan, who felt he couldn't profit from Tesla's wireless electricity concept, and sold his assets to make up for dual foreclosures on Wardenclyffe. The property was later sold to a film processing company. In 1917, the U.S. government demolished Tesla's partially completed tower because it worried German spies would use it to intercept communications during World War I.

Tesla lived in New York City for 60 years, and remnants of his time there still remain. The corner of 40th Street and 6th Avenue in downtown Manhattan has been designated "Nikola Tesla Corner" -- with its own street sign -- because of its proximity to Tesla's laboratory at 8 West 40th Street, where he worked in 1900 while building his now-infamous Tesla Tower on Long Island. At nearby Bryant Park Place, a plaque commemorates the Engineer's Club, which awarded Tesla the Edison Medal on May 18, 1917. During his later years, Tesla fed pigeons in nearby Bryant Park.



Nikola Tesla about 1890, in his mid-30s.
Image courtesy of the Library of Congress.

Photo is public domain, as is the source text about Tesla, which can be found at:

www.energy.gov/articles/top-11-things-you-didnt-know-about-nikola-tesla
and
www.eia.gov/kids/history-of-energy/famous-people/tesla.php

His long-abandoned Long Island laboratory Wardenclyffe is in the process of being restored and will become a Tesla museum & science education center. Last Fall a fire destroyed the progress made on the interior of Wardenclyffe, but the structure remains intact and the museum is committed to restoring the damage and moving forward with the project. You can donate to this important historical site by visting **https://teslasciencecenter.org** .

Thanks to Nikola Tesla's early work, wireless transfer of energy is finally being realized today -- from wireless chargers for electric toothbrushes and smartphones, to wireless electric vehicle charging, a technology being researched at the Energy Department's National Labs.

Tesla dreamed of free electricity for humanity and experimented with huge towers that would gather atmospheric electricity, then transmit it wirelessly to receivers in order to continuously supply electricity to all. He did not achieve that noble vision, but his lifetime of dedication to research inspires us today. This brings us to the topic of RF energy harvesting.

In June of 2023, **Saumitra Jagdale** authored an article in **Electrical Engineering Times** called ***Powering the Future Wirelessly with RF Energy Harvesting.*** Jagdale gives an overview of various aspects of the ***field*** of **energy harvesting** saying**:**

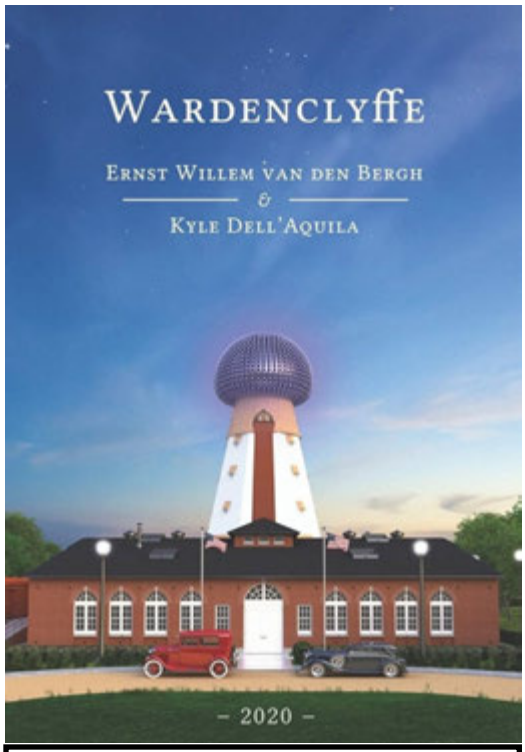
"Energy harvesting is a process of utilizing energy in the surrounding atmosphere for powering various portable devices. Energy can be harvested through different means—through wind, sun, radio frequency and so on. Amongst them, the RF energy-harvesting (RF-EH) system has received much popularity over recent years, as the method offers an alternative yet sustainable approach to supplying power to low-power electronic systems."

For the past decade, researchers from the Massachusetts Institute of Technology (MIT), Carnegie Mellon University,

Continued on Page 14

University of Central Florida UCF and several others, have sought to perfect methods in the concept of harvesting energy from radio waves to power everyday personal devices such as cell phones, smart watches, fitness trackers, coin-sized GPS tracking devices for pets & objects, GPS eyeglasses, sensors for IoT (Internet of Things) devices in general, and most important of all, implanted medical devices like pacemakers and insulin pumps. So far, excellent progress has been achieved in harvesting RF energy for low power devices. So what does the field of RF Energy Harvesing look like?

In the **EE Times** article, Jagdale explains:
"RF energy harvesting is the process of capturing and converting RF electromagnetic waves into usable electrical energy. It involves the use of specialized antennas and rectifiers that capture and rectify RF signals, transforming them into a direct-current (DC) power source.



"Wardenclyffe" researcher Ernst Van Den Bergh and illustrator Kyle Dell'Aquila reveal the theories, views, experiments and plans for Wardenclyffe – Nikola Tesla's greatest legacy. This combines research from Van Den Bergh's previous 4 books and is a must-have reference of Tesla history. Hardcover $48.39 at Amazon.com

"This harvested energy can then be utilized to power small electronic devices or stored in energy storage systems for later use. RF energy harvesting is a potential solution for powering wireless sensor networks, IoT devices and other low-power electronics. This can be done by harnessing energy from ambient RF signals already present in the environment.

"However, RF-EH (Radio Frequency Energy Harvesting) systems have a limited operating range, which necessitates the device requiring power to maintain close proximity to the RF broadcaster. The efficacy of RF energy harvesting diminishes considerably as the distance between the device and the RF source increases. Another challenge faced is the requirement of a specially designed antenna to receive or transfer RF signals."

Jagdale also does an excellent breakdown of three techniques in RF Energy Harvesting:

- **RF-EH from dedicated RF sources**
- **RF-EH from ambient RF sources**
- **RF energy transfer (RFET) between mobile devices**

RF-EH from dedicated RF sources

"RF-EH from dedicated sources enables high-power values compared with other methods. A circuit that harvests RF energy from a dedicated source over a short distance is expected to generate power levels in the range of 50 nW/cm^2. But such promising power levels are also accompanied by path loss, energy dissipation, shadowing and fading, all of which pose challenges. On the other hand, RFET shows promising advantages over non-radiative wireless energy transfer by providing more relaxed coupling and alignment specifications."

RF-EH from ambient RF sources is further categorized into two sub-parts: static and dynamic sources.

Static Sources

"These sources are characterized as stable-power transmitters. However, they aren't simplified. Signals are modulated—usually by adjusting the frequency and transmitted power—to power the sensor device. Ambient static sources include broadcast radio, mobile base stations and television."

Dynamic Sources

"These are transmitters that regularly broadcast RF in such a way that isn't monitored. To effectively harvest energy from such sources, an intelligent wireless energy-harvesting system is required to continuously monitor the channel for potential harvesting opportunities. Wi-Fi access points, microwave radio links, police radios and more are a few unnoticed examples of ambient dynamic sources."

RF energy transfer (RFET) between mobile devices

"RF energy harvesting between mobile devices enables stable power transfer among nearby devices. By utilizing power-splitting or time-switching techniques, these devices can operate sustainably without requiring any modifications to the transmitters. This approach allows for the use of a shared antenna or antenna array for both RF energy harvesting and information reception. For example, mobile devices can transfer RF energy based on information to relay nodes, preventing imbalanced energy consumption."

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A look at some pivotal research & development in Radio Frequency Energy Harvesting in the U.S.

Massachusetts Institute of Technology
Jennifer Chu reported in **MIT News**, what researchers are working on in the field of RF-EH:
"Researchers drew up a blueprint for a terahertz rectifier that consists of a small square of graphene that sits atop a layer of boron nitride and is sandwiched within an antenna that would collect and concentrate ambient terahertz radiation, boosting its signal enough to convert it into a DC current. Terahertz waves are electromagnetic radiation with a frequency somewhere between microwaves and infrared light.

"This would work very much like a solar cell, except for a different frequency range, to passively collect and convert ambient energy," said Liang Fu, Associate Professor of Physics

"The team has filed a patent for the new "high-frequency rectification" design, and the researchers are working with experimental physicists at MIT to develop a physical device based on their design, which should be able to work at room temperature, versus the ultracold temperatures required for previous terahertz rectifiers and detectors.

"If a device works at room temperature, we can use it for many portable applications," says Hiroki Isobe, a postdoc in MIT's Materials Research Laboratory. He envisions that, in the near future, terahertz rectifiers may be used, for instance, to wirelessly power implants in a patient's body, without requiring surgery to change an implant's batteries.

Professor Fu adds, "We are taking a quantum material with some asymmetry at the atomic scale, that can now be utilized, which opens up a lot of possibilities."

Carnegie Mellon University
Rose Eilenberg for Carnegie Mellon reports that researchers there created a flexible two-dimensional rectenna constructed in a layer of molybdenum disulfide (MoS2), with a thickness of 3 atoms.

"Such a design has allowed a fully flexible device that is fast enough to cover most of the radio frequency bands used by our daily electronics, including Wi-Fi, Bluetooth, cellular LTE, and many others," says first author Xu Zhang. Dr. Zhang, an assistant professor at Carnegie Mellon's Electrical and Computer Engineering department. The published research paper lists 15 other co-authors from MIT, Technical University of Madrid, the Army Research Laboratory, Charles III University of Madrid, Boston University, and the University of Southern California.

University of Central Florida
The UCF researchers created a technology that combines power scavenging and spectrum sensing capabilities for ultra-low power applications. As **Bethan Davies** reported in the December 2022 edition of **AZO Materials**:
"The power-hungry radio frequency sensing modules of conventional devices would no longer be required, thanks to the resulting passive module. [UCF's] innovation uses radio frequency electromagnetic waves, the most prevalent type of communication between IoT hubs and nodes, to harvest ambient energy. The radio frequency to direct current conversion operates in a sub-millimeter footprint and within a lithographically defined frequency range.

"The researchers enabled the invention to handle more intelligent data transmission between IoT nodes and hubs so that the IoT node "understands" the frequency occupancy in its immediate area in order to address the issue of spectrum availability. The UCF zero-power radio frequency-to-direct current conversion scheme could be used to build wake-up radios, which are inactive and ideally consume zero power before being activated. These radios would then scavenge energy from the radio frequency power emitted by nearby modules. Additionally, the module could scavenge the lost radio frequency energy and store it in a capacitor or a battery."

We hope you found this report on the exciting field of Radio Frequency Energy Harvesting interesting. There's so much more to learn about this growing field of technology, and it promises to significantly change the way we power our small devices in the not-so-distant future. We'll plan to report additional advances in RF-EH as they arise. As always, let us know your thoughts on the topic and we'll publish your comments in a future edition of the Relay.★

Contest Calendar - February 2024

+ CWops Test	0300Z-0400Z, Feb 1
+ CWops Test	0700Z-0800Z, Feb 1
	1800Z-1900Z, Feb 1 (CW) and
	1900Z-2000Z, Feb 1 (SSB) and
	2000Z-2100Z, Feb 1 (FM) and
	2100Z-2200Z, Feb 1 (Dig)
+ NRAU 10m Activity Contest	2000Z-2200Z, Feb 1
+ SKCC Sprint Europe	0100Z-0130Z, Feb 2
+ NCCC FT4 Sprint	0145Z-0215Z, Feb 2
+ Weekly RTTY Test	0200Z-0330Z, Feb 2
+ QRP Fox Hunt	0230Z-0300Z, Feb 2
+ NCCC Sprint Ladder	2000Z-2100Z, Feb 2
+ K1USN Slow Speed Test	0000Z, Feb 3 to 2400Z, Feb 4
+ Vermont QSO Party	0001Z, Feb 3 to 2359Z, Feb 4
+ 10-10 Int. Winter Contest, SSB	1200Z, Feb 3 to 1200Z, Feb 4
+ F9AA Cup, CW	1200Z, Feb 3 to 2359Z, Feb 4
+ Mexico RTTY International Contest	1200Z, Feb 3 to 1200Z, Feb 4
+ European Union DX Contest	1400Z-2400Z, Feb 3
+ FYBO Winter QRP Sprint	1400Z-2400Z, Feb 3
+ Minnesota QSO Party	1600Z, Feb 3 to 0359Z, Feb 4 and
	1600Z-2359Z, Feb 4
+ British Columbia QSO Party	1600Z-1900Z, Feb 3
+ AGCW Straight Key Party	0000Z-0359Z, Feb 4
+ North American Sprint, CW	0000Z-0100Z, Feb 5
+ K1USN Slow Speed Test	1300Z-1400Z, Feb 5
+ ICWC Medium Speed Test	1630Z-1729Z, Feb 5
+ OK1WC Memorial	1900Z-2000Z, Feb 5
+ ICWC Medium Speed Test	2000Z-2130Z, Feb 5
+ RSGB 80m Club Championship, SSB	0100Z-0159Z, Feb 6
+ Worldwide Sideband Activity Contest	0200Z-0400Z, Feb 6
+ ARS Spartan Sprint	0300Z-0400Z, Feb 6
+ ICWC Medium Speed Test	

Continued on Page 17

Contest Calendar - February 2024

+ QRP Fox Hunt	0200Z-0330Z, Feb 7
+ Phone Weekly Test	0230Z-0300Z, Feb 7
+ A1Club AWT	1200Z-1300Z, Feb 7
+ CWops Test	1300Z-1400Z, Feb 7
+ Mini-Test 40	1700Z-1759Z, Feb 7
+ VHF-UHF FT8 Activity Contest	1700Z-2100Z, Feb 7
+ Mini-Test 80	1800Z-1859Z, Feb 7
+ CWops Test	1900Z-2000Z, Feb 7
+ UKEICC 80m Contest	2000Z-2100Z, Feb 7
+ AWA Linc Cundall Memorial CW Contest	2300Z, Feb 7 to 2300Z, Feb 8 and 2300Z, Feb 10 to 2300Z, Feb 11
+ Walk for the Bacon QRP Contest	0000Z-0100Z, Feb 8 and 0200Z-0300Z, Feb 9
+ CWops Test	0300Z-0400Z, Feb 8
+ CWops Test	0700Z-0800Z, Feb 8
+ NCCC FT4 Sprint	0100Z-0130Z, Feb 9
+ Weekly RTTY Test	0145Z-0215Z, Feb 9
+ QRP Fox Hunt	0200Z-0330Z, Feb 9
+ NCCC Sprint Ladder	0230Z-0300Z, Feb 9
+ K1USN Slow Speed Test	2000Z-2100Z, Feb 9
+ FISTS Saturday Sprint	0000Z-2359Z, Feb 10
+ CQ WW RTTY WPX Contest	0000Z, Feb 10 to 2359Z, Feb 11
+ SARL Field Day Contest	1000Z, Feb 10 to 1000Z, Feb 11
+ Asia-Pacific Spring Sprint, CW	1100Z-1300Z, Feb 10
+ Dutch PACC Contest	1200Z, Feb 10 to 1200Z, Feb 11
+ SKCC Weekend Sprintathon	1200Z, Feb 10 to 2400Z, Feb 11
+ KCJ Topband Contest	1200Z, Feb 10 to 1200Z, Feb 11
+ OMISS QSO Party	1500Z, Feb 10 to 1500Z, Feb 11
+ RSGB 1.8 MHz Contest	1900Z-2300Z, Feb 10
+ CQC Winter QSO Party	0100Z-0259Z, Feb 11
+ Balkan HF Contest	1300Z-1700Z, Feb 11

Continued on Page 18

Contest Calendar - February 2024

+ K1USN Slow Speed Test	0000Z-0100Z, Feb 12
+ 4 States QRP Group Second Sunday Sprint	0100Z-0300Z, Feb 12
+ ICWC Medium Speed Test	1300Z-1400Z, Feb 12
+ ARRL School Club Roundup	1300Z, Feb 12 to 2359Z, Feb 16
+ OK1WC Memorial	1630Z-1729Z, Feb 12
+ ICWC Medium Speed Test	1900Z-2000Z, Feb 12
+ Worldwide Sideband Activity Contest	0100Z-0159Z, Feb 13
+ ICWC Medium Speed Test	0300Z-0400Z, Feb 13
+ PODXS 070 Club Valentine Sprint	0000Z-2359Z, Feb 14
+ NAQCC CW Sprint	0130Z-0330Z, Feb 14
+ QRP Fox Hunt	0200Z-0330Z, Feb 14
+ Phone Weekly Test	0230Z-0300Z, Feb 14
+ A1Club AWT	1200Z-1300Z, Feb 14
+ CWops Test	1300Z-1400Z, Feb 14
+ Mini-Test 40	1700Z-1759Z, Feb 14
+ VHF-UHF FT8 Activity Contest	1700Z-2100Z, Feb 14
+ Mini-Test 80	1800Z-1859Z, Feb 14
+ CWops Test	1900Z-2000Z, Feb 14
+ DARC FT4 Contest	1900Z-2000Z, Feb 14
+ RSGB 80m Club Championship, Data	2000Z-2130Z, Feb 14
+ CWops Test	0300Z-0400Z, Feb 15
+ CWops Test	0700Z-0800Z, Feb 15
+ NTC QSO Party	1900Z-2000Z, Feb 15
+ NCCC FT4 Sprint	0100Z-0130Z, Feb 16
+ Weekly RTTY Test	0145Z-0215Z, Feb 16
+ QRP Fox Hunt	0200Z-0330Z, Feb 16
+ NCCC Sprint Ladder	0230Z-0300Z, Feb 16
+ K1USN Slow Speed Test	2000Z-2100Z, Feb 16
+ YLRL YL-OM Contest	0000Z, Feb 17 to 2359Z, Feb 18
+ ARRL Inter. DX Contest, CW	0000Z, Feb 17 to 2400Z, Feb 18
+ Russian PSK WW Contest	1200Z, Feb 17 to 1159Z, Feb 18

Continued on Page 19

Contest Calendar - February 2024

+ Feld Hell Sprint	1900Z-2059Z, Feb 17
+ FISTS Sunday Sprint	0000Z-2359Z, Feb 18
+ Run for the Bacon QRP Contest	2300Z, Feb 18 to 0100Z, Feb 19
+ K1USN Slow Speed Test	0000Z-0100Z, Feb 19
+ ICWC Medium Speed Test	1300Z-1400Z, Feb 19
+ OK1WC Memorial	1630Z-1729Z, Feb 19
+ ICWC Medium Speed Test	1900Z-2000Z, Feb 19
+ Worldwide Sideband Activity Contest	0100Z-0159Z, Feb 20
+ ICWC Medium Speed Test	0300Z-0400Z, Feb 20
+ QRP Fox Hunt	0200Z-0330Z, Feb 21
+ Phone Weekly Test	0230Z-0300Z, Feb 21
+ A1Club AWT	1200Z-1300Z, Feb 21
+ CWops Test	1300Z-1400Z, Feb 21
+ VHF-UHF FT8 Activity Contest	1700Z-2100Z, Feb 21
+ Mini-Test 40	1700Z-1759Z, Feb 21
+ Mini-Test 80	1800Z-1859Z, Feb 21
+ AGCW Semi-Automatic Key Evening	1900Z-2030Z, Feb 21
+ CWops Test	1900Z-2000Z, Feb 21
+ Walk for the Bacon QRP Contest	0000Z-0100Z, Feb 22 and 0200Z-0300Z, Feb 23
+ CWops Test	0300Z-0400Z, Feb 22
+ CWops Test	0700Z-0800Z, Feb 22
+ RSGB 80m Club Championship, CW	2000Z-2130Z, Feb 22
+ NCCC FT4 Sprint	0100Z-0130Z, Feb 23
+ Weekly RTTY Test	0145Z-0215Z, Feb 23
+ QRP Fox Hunt	0200Z-0330Z, Feb 23
+ NCCC Sprint Ladder	0230Z-0300Z, Feb 23
+ K1USN Slow Speed Test	2000Z-2100Z, Feb 23
+ CQ 160-Meter Contest, SSB	2200Z, Feb 23 to 2200Z, Feb 25
+ REF Contest, SSB	0600Z, Feb 24 to 1800Z, Feb 25
+ UBA DX Contest, CW	1300Z, Feb 24 to 1300Z, Feb 25

Continued on Page 20

Contest Calendar - February 2024

+ South Carolina QSO Party	1500Z, Feb 24 to 0159Z, Feb 25
+ North American QSO Party, RTTY	1800Z, Feb 24 to 0559Z, Feb 25
+ NA Collegiate Championship, RTTY	1800Z, Feb 24 to 0559Z, Feb 25
+ World Wide Patagonia DX Contest	0000Z-2359Z, Feb 25
+ High Speed Club CW Contest	1400Z-1700Z, Feb 25
+ North Carolina QSO Party	1500Z, Feb 25 to 0100Z, Feb 26
+ K1USN Slow Speed Test	0000Z-0100Z, Feb 26
+ QCX Challenge	1300Z-1400Z, Feb 26
+ ICWC Medium Speed Test	1300Z-1400Z, Feb 26
+ OK1WC Memorial	1630Z-1729Z, Feb 26
+ QCX Challenge	1900Z-2000Z, Feb 26
+ ICWC Medium Speed Test	1900Z-2000Z, Feb 26
+ RSGB FT4 Contest	2000Z-2130Z, Feb 26
+ Worldwide Sideband Activity Contest	0100Z-0159Z, Feb 27
+ ICWC Medium Speed Test	0300Z-0400Z, Feb 27
+ QCX Challenge	0300Z-0400Z, Feb 27
+ SKCC Sprint	0000Z-0200Z, Feb 28
+ QRP Fox Hunt	0200Z-0330Z, Feb 28
+ Phone Weekly Test	0230Z-0300Z, Feb 28
+ A1Club AWT	1200Z-1300Z, Feb 28
+ CWops Test	1300Z-1400Z, Feb 28
+ Mini-Test 40	1700Z-1759Z, Feb 28
+ Mini-Test 80	1800Z-1859Z, Feb 28
+ CWops Test	1900Z-2000Z, Feb 28
+ UKEICC 80m Contest	2000Z-2100Z, Feb 28
+ CWops Test	0300Z-0400Z, Feb 29
+ CWops Test	0700Z-0800Z, Feb 29

Our thanks to Bruce Horn, WA7BNM for use of this calendar!
Visit Bruce at www.contestcalendar.com/contestcal.html

The ARAC RELAY

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