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Field Day Interference Management

Operating ARRL Field Day using multiple radios at the same site can result in RF interference problems, especially if some of the radios are operated simultaneously on the same band or on harmonically related frequencies and with antennas separated by only a few hundred feet. Simultaneous same-band operation may also occur for QSO parties with multiple radios at the same site.

Interference-management techniques, measurements, and results are presented from the Field Day 2021 operations of W3CWC, the club station of the Antietam Radio Association (ARA) of Hagerstown, Maryland. Simultaneous operation of CW, digital, and SSB radios on the same HF band without significant interference was a key goal for the club, and it was achieved in 2021 for the first time in many years.

Radios with good transmit and receive performance, antenna isolation methods including cross-polarization, and ultra-sharp filters to separate signals on the same band were used to mitigate same-band interference. Listening and measurement test results showed that by combining these techniques, same-band interference was well controlled on HF for Field Day.

Existing Work on Field Day Interference

The book[1] *Managing Interstation Interference with Coaxial Stubs and Filters* by George Cutsogeorge, W2VJN, is a great resource on the problem of interference between stations in close proximity, such as occurs on Field Day. A two-part series by Barrett Milliken, KC9CHG, and Tim Toman, N9TO, on Field Day inter-station interference, appeared in the September/October and November/December 2010 issues of *NCJ*. It addresses antenna orientation using cross-polarized antennas or end-to-end dipoles to maximize isolation between antennas. Cross-polarization techniques with some extensions are key elements in the set of techniques that W3CWC used for Field Day 2021. One extension was a wide-spaced fan inverted V for 80, 40, and 20 meters with movable leg end-points on each band to optimize isolation or cross-polarization in the field. Other extensions involved using a tilted dipole and using filters designed for same-band signal separation.

Several top Field Day clubs published their techniques [2, 3] in 2009 at Dayton Hamvention®. W3AO operated with 23 transmitters in 2008 using Elecraft K3s, which provide very good transmit noise and receiver blocking performance. Rob Sherwood, NCØB, presented a discussion on rig performance and contests at Contest University 2021[4].

To manage inter-station interference on Field Day with operations on the same band, transmitter purity and low composite transmit noise are very important as well as receiver dynamic range and reciprocal mixing dynamic range (RMDR).

A key technique at W3AO was to employ directional (Yagi) antennas on 40 through 10 meters at 50 feet, with all antennas facing west from the east coast sited along a line running north-south, placing them in each other's side lobes. End-to-end dipoles were used for 80 meters. Some clubs have used a separate receive antenna placed to maximize isolation with transmitting antennas for Field Day.

Good grounding and bonding are important. Any coaxial cable feed line radiation will distort antenna patterns and create RF leakage paths between antennas, so baluns for dipoles, RF chokes at antenna feed points, and related measures are recommended. An open, flat field is desirable for siting Field Day antennas to minimize signal reflections that can leak RF between antennas oriented for low signal coupling. Placing individual radios near their respective antennas with no connections to other radios can eliminate potential paths for conducted RF leakage.

Transmitter and Receiver Performance

Radio performance is key to mitigating Field Day Interference. *QST* "Product Review" articles publish many measured performance metrics for both receivers and transmitters. For Field Day 2021, W3CWC used Yaesu FTDX10 transceivers for digital and CW, and Kenwood TS-2000 transceivers for SSB. Among the most important performance points for interference on Field Day are transmitter phase noise, transmitter composite noise, RMDR, and blocking gain compression dynamic range (BGCDR).

ARRL defines BGCDR as blocking level – noise floor. The FTDX10 set to 14.020 MHz has a noise floor of –127/–136/ –139 dBm for preamp settings of off, 1 and 2, and the corresponding BGCDR values are >137/147/140 dB. Hence, the respective blocking levels for the FTDX10 are > +10/+11/+1 dBm. The TS-2000 set to 14.020 MHz has a noise floor of –129/–137 dBm for the preamp off/on positions, respectively, and the BGCDR values are 126/121 dB. Hence, the blocking levels for the TS-2000 are –3/–16 dBm. At these blocking levels for 14 MHz, assuming power levels of 100 W or +50 dBm, the FTDX10 requires antenna isolations exceeding 40/39/49 dB, respectively, and the TS-2000 requires antenna isolations greater than 53/66 dB, respectively.

The FTDX10 RMDR is 124/122/118

dBc for 14 MHz. The TS-2000's RMDR may be 10 to 20 dB lower based on the transmitter phase noise measurements. A margin of 20 dB on RMDR may be a good target for a desired signal at –107 dBm (this is equivalent to a 20 dB signal-to-impairment ratio). For the FTDX10, the preamp set to 1 results in a maximum nearby signal of –107 dBm (desired weak signal level) +122 dB (RMDR value) –20 dB (desired margin) = –5dBm (maximum nearby interference level) corresponding to 55 dB of isolation. Hence, the antenna isolation requirement is driven by the RMDR for the FTDX10. With the FTDX10 preamp set to 1 and the TS-2000 preamp set to ON, consideration of both receiver blocking and RMDR suggests targeting 55 dB of isolation and 65 to 75 dB of isolation for these radios, respectively, limited by receiver performance.

Transmitter composite (or total) noise can easily result in interference on Field Day for nearby radios operating on the same band. This problem cannot be addressed by improving receiver performance — barring some form of noise cancellation — so it must be addressed by either reducing transmitter noise at the interfering radio or increasing isolation. For the FTDX10, the composite noise, as measured by NCØB,[4] as –135 dBc at 100 kHz offset at 14 MHz. Transmitter noise measurements by the ARA for the FTDX10 and the TS-2000 showed levels of –133 and –123 dBc respectively using a spectrum analyzer and a sharp notch filter to attenuate the strong transmit signal. Assuming that an impairment level that is –20 dB compared to a weak desired signal at –107 dBm is required in a 500-Hz bandwidth, then the required antenna isolations are 71 dB and 81 dB respectively for the FTDX10 and the TS-2000.

For example, for the FTDX10:

–133 dBc (transmitter noise at 200 kHz offset from the carrier at 1 Hz bandwidth)

+27 dB at 500 Hz bandwidth

+50 dB for a carrier level of 100 W

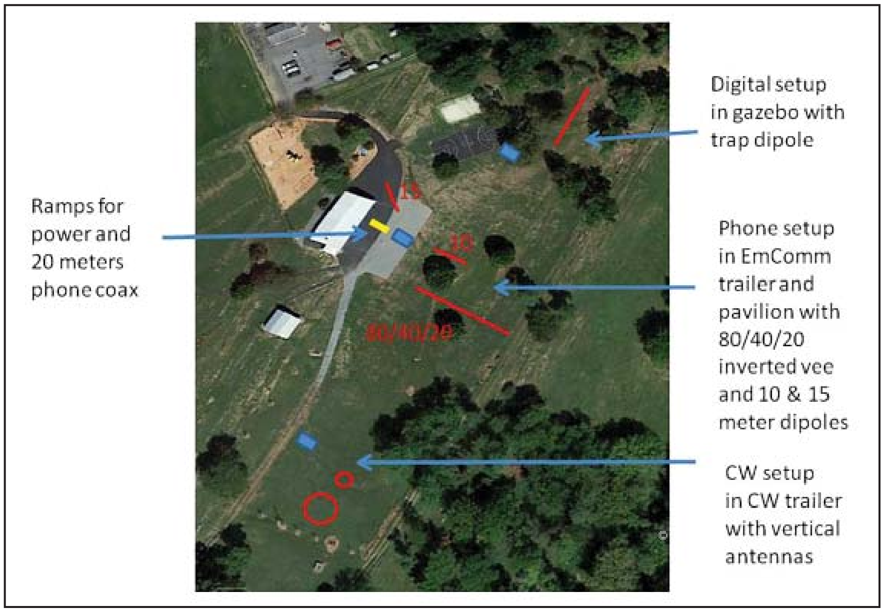

Figure 1 — W3CWC Field Day 2021 antenna layout.

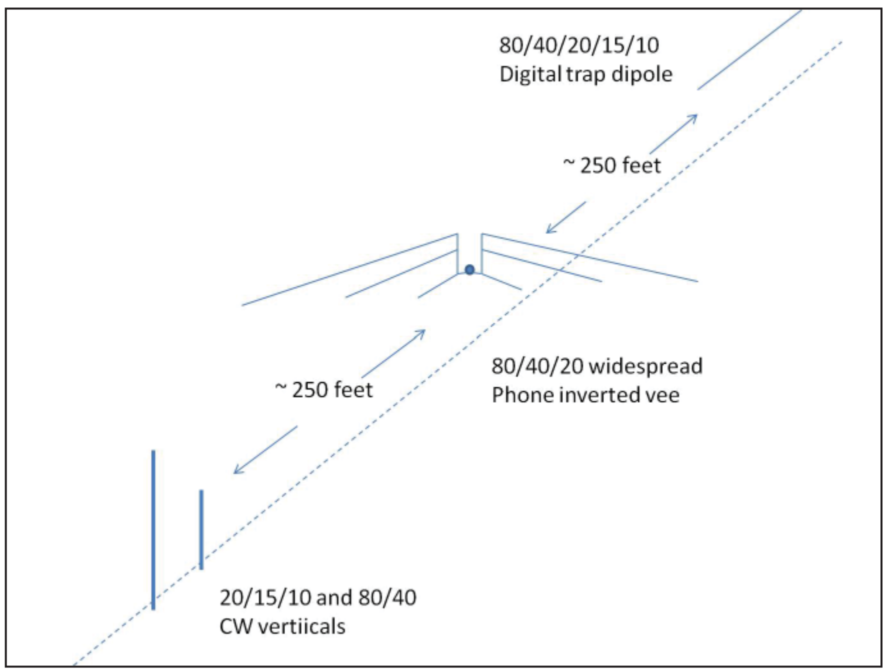

Figure 2 — W3CWC Field Day 2021 antenna diagram.

– (–107 dBm) for the desired weak-signal level

– (–20 dB) for the desired margin is 71 dB required antenna isolation.

From these measurements and calculations, the required antenna isolations are dominated by transmitter composite noise. For typical recent low-to-modestly priced and older radios, isolations of 70 to 80 dB may be needed to avoid noticeable interference, although lower isolation levels may be okay with some better radios. CW interference was generally more problematic for W3CWC than digital or phone interference.

Antenna Design for Isolation

Figures 1 and 2 show the W3CWC antenna layout/diagram for Field Day

2021. Club members spent about 8 hours on Friday prior to Field Day setting up and testing the antennas. For CW, phone, and digital, three clusters of antennas plus some miscellaneous antennas were set up along a line with about 250 feet between clusters. The three clusters were arranged in mutual cross-polarization.

Two verticals were set up at the southern end of the field for CW using a Cushcraft R5 vertical on 20, 15, and 10 meters and a 33-foot fiberglass pole with attached antenna wire and eight radials laid on the ground for 40 meters (with a switchable loading coil for 80 meters). An RF choke was used at the feed point of the verticals to minimize any coaxial radiation. Also, the CW radio was located near the antennas and powered by a small, dedicated 1-kW generator/inverter to avoid any possibility of conducted interference from the CW radio to the digital and phone radios.

At the northern end of the field, a home-brew coaxial trap dipole for 80 – 10 meters was set up for digital, placed with one end facing the verticals with the radio placed nearby. Since digital operates very close to CW frequencies, the CW and digital antennas were placed with maximum separation allowed by the site to optimize isolation.

In the middle of the field, a wide-spaced inverted V was set up for 80-, 40-, and 20-meter phone. The inverted V was set perpendicular to a line running from the digital trap dipole to the CW verticals.

These arrangements placed the three clusters of antennas for digital, phone, and CW mutually in cross-polarization to maximize isolation. Dipoles were also erected for 15- and 10-meter phone that were not cross-polarized, and an alternative portable end-fed antenna was set up for digital. Only one digital and only one CW radio were operated for FD, but W3CWC used four radios for phone dedicated for 40, 20, and 15 meters, and one radio switchable between 80 and 10 meters. To allow simultaneous operation on 80, 40, and 20 meters, a triplexer with high-performance band-pass filters was used with the phone 80-, 40-, and 20-meter inverted V.

The inverted V for 80, 40, and 20 meters used a wide-spaced configuration (see Figure 2). The center insulator used a 2 × 4-foot rectangular PVC pipe spacer for the center of the inverted V legs, which widely separates the center points for the three bands, and then individual wires for each band slope down in a fan arrangement.

This arrangement offers several advantages. The wide spacing improves performance of the antenna in terms of SWR bandwidth and reduced tuning interactions compared to a typical multi-band HF fan dipole. This arrangement also allows the antenna element ends for the different bands to be adjusted independently in position to maximize isolation. A 1:1 balun and an RF choke were used at the antenna center feed point to minimize any coaxial radiation.

The trap dipole for digital was tilted to maximize isolation. The mast support closest to the other antenna clusters was 30 feet, while the other mast was 25 feet.

EZNEC modeling shows that tilting dipoles over Earth can increase isolation with other antennas by balancing near-field, far-field, and ground reflections. A 1:1 balun and an RF choke were used at the dipole center feed point to minimize any coaxial radiation.

Ultra-Sharp Filters for Same-Band Signal Separation

Two types of filters were used in addition to band-pass filters. Ultra-sharp receive (USRX) filters that suppress the CW band by 20 to 40 dB and pass the phone band with only a few decibels of loss were designed and built. The USRX filters were used with the 80, 40, and 20-meter phone radios[5]. These filters include relays that can bypass the filters while transmitting (see Figure 3).

A second type of filter was designed for both transmitting and receiving to separate signals on the same band[6]. These ultra-sharp low-loss (USLL) filters must handle 100 W and suppress transmitter composite noise, a dominant interference factor for the W3CWC Field Day setup. These USLL filters were placed on the CW radio to suppress composite noise on 80-, 40-, and 20-meter phone. In addition, a USLL filter was built for 15-meter phone (see Figures 4 and 5). The USLL filters for 80, 40, and 20 were placed on the trailer floor beside the operating table with the FTDX10 and CW equipment. The

Figure 3 — The 80-meter phone setup for the TS-2000. The larger aluminum box is the USRX filter for 80 meters and the smaller aluminum box is a band-pass filter for 80 meters.

smaller aluminum boxes are band-pass filters for 80, 40, 20, 15, and 10 meters.

Measurement and Operating Results

After setting up the antennas for Field Day 2021, club members performed a series of listening and measurement tests to measure isolation among the three antenna clusters for 80, 40, 20, 15, and 10 meters. In the first set of tests, the CW radio transmitted a series of test signals at 100 W on each band at about 35 kHz from the lower band edge. The digital radio operator listened near standard digital frequencies for any interference, and the phone radio operators listened on the phone band for any interference. On the phone radios, no interference could be heard while listening on the same bands, except when listening fairly close to the CW band edge, where weak interference was detectable. This appeared to be transmitter composite noise that was leaking through the USLL filters at the CW radio due to the transition band in the filter near the CW band. For the digital radio, no interference was heard except for very weak interference on 80 meters.

In a second set of tests, CW test signals were sent, while a small portable oscilloscope measured the signal levels at the inverted V for 80, 40, and 20 phone. Then the end points of the inverted V were moved one at a time in two dimensions to minimize the interference signal levels. This work was performed starting on 80 meters, then 40 meters, and finally 20 meters. The results: 3.5 MHz — 180 mVp –p or 60 dB; 7.0 MHz — 700 mVp-p ➔ 300 mVp-p or 56 dB; and 14.0 MHz — 4,000 mVp-p ➔ 600 mVp-p or 50 dB. The 20 meters signal was 4,000 mVp-p before adjustments reduced it to 600 mV-p-p.

These are the measured signal levels into a 50-Ω load at the inverted V, given 100 W transmitter power at the CW radio, which is about 200 Vp-p. For earlier tests in an open field, isolations of close to 70 dB were achieved on 80, 40, and 20 meters from CW verticals to phone inverted V at about 300 feet spacing. These results fall 10 to 20 dB short of the desired isolation of about 70 dB but are fair results for cross-polarized antennas only separated by 250 – 300 feet with obstructions in the area, including large metal buildings. Closing the gap in desired isolation required adding the ultra-sharp filters.

A third set of tests was performed to measure isolation from the CW verticals to the digital trap dipole on 80, 40, 20, 15, and 10 meters. Here are the results: 3.5 MHz — 100 mVp-p or 66 dB; 7.0 MHz — 75 mVp-p or 69 dB; 14.0 MHz — 50 mVp-p or 72 dB; 21.0 MHz — 25 mVp-p or 78 dB; and 28.0 MHz — 25 mVp-p or 78 dB.

During the contest, the results were consistent with the pre-contest tests with no interference observed on 80-, 40- and 20-meter phone and no interference observed on the digital or CW radios. At the phone radio on 15 meters, some weak CW and some weak digital interference was heard. However, the 15-meter phone dipole was not in a cross-polarized configuration.

Conclusion

Interference on Field Day between radios operating within a few hundred feet of each other is a common problem. This is especially a problem when operating CW, phone, digital, and/or GOTA radios on the same band where band-pass filters are not helpful. To achieve interference-free operation, a number of key issues must be addressed including antenna

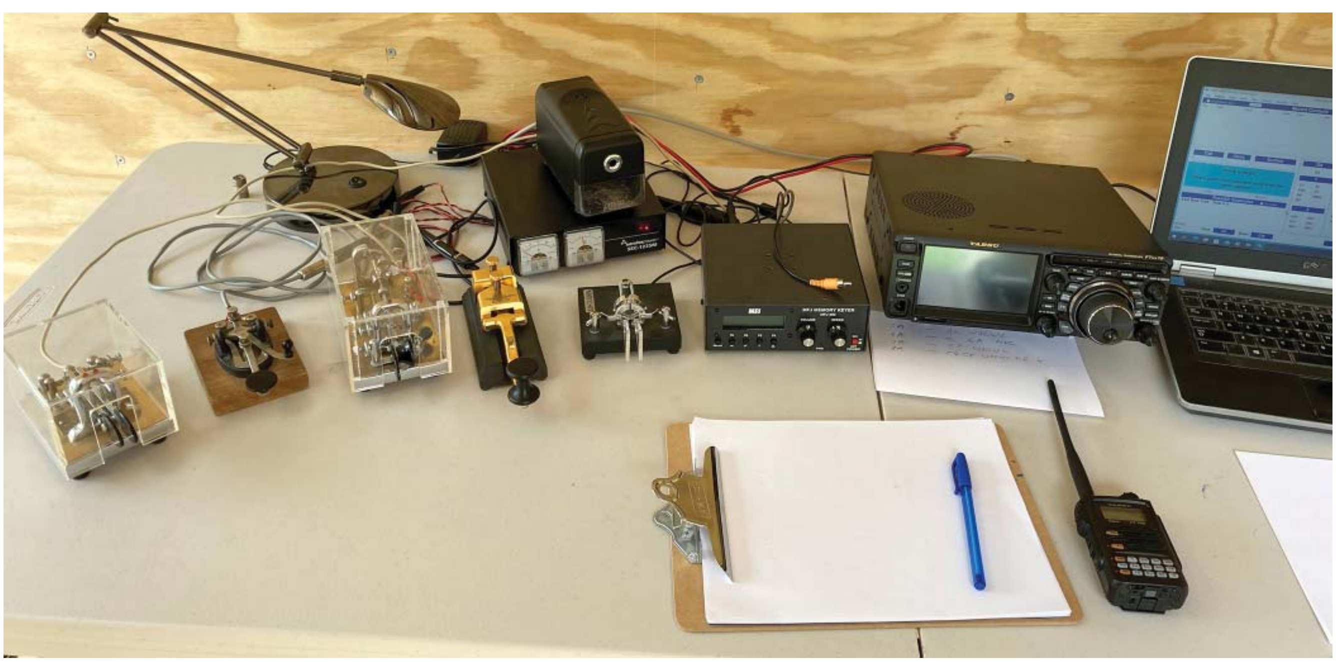

Figure 4 — The FTDX10 CW setup.

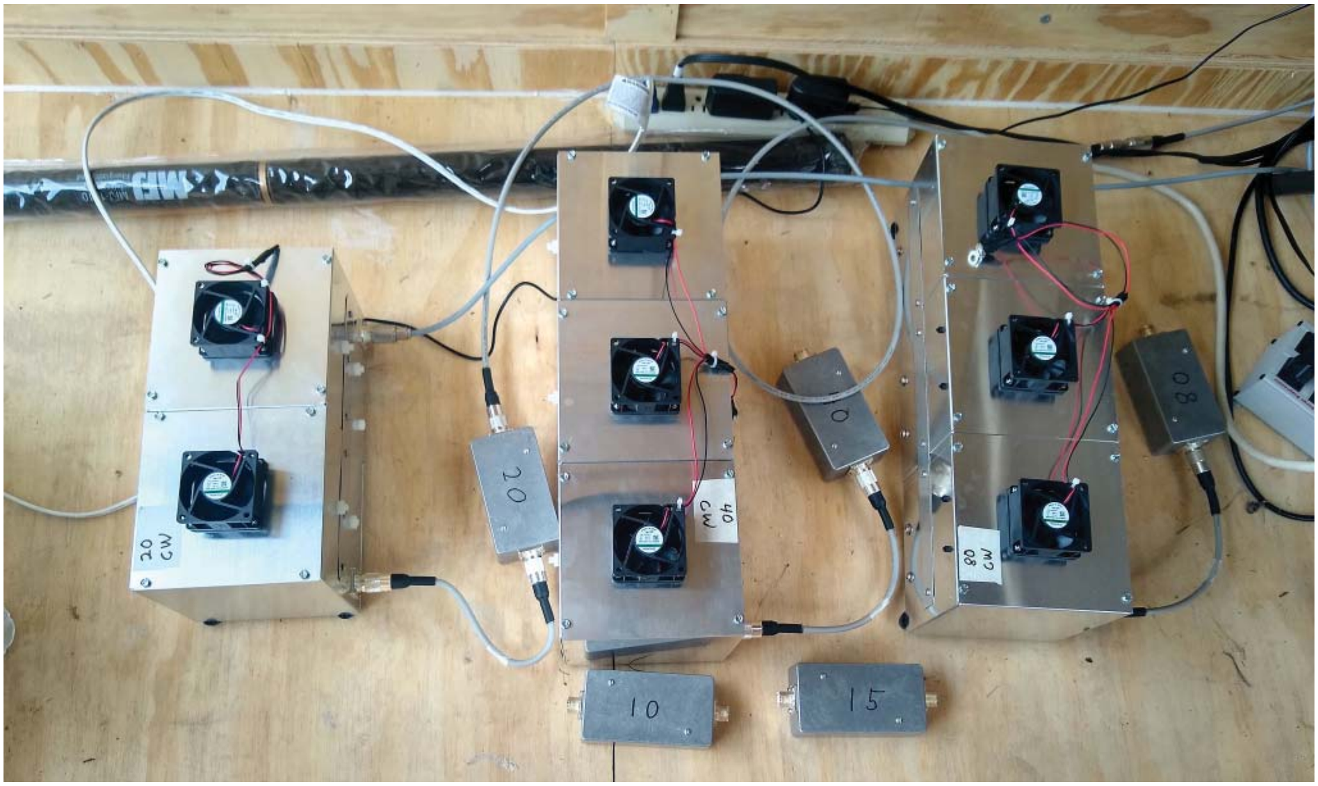

Figure 5 — The CW filter bank.

isolation and radio performance as well as such items as power supply isolation, bonding, and grounding.

If addressing these issues through direct radio performance metrics and achieved antenna isolation is inadequate, then USRX and USLL filters that can separate signals on the same HF band can provide large additional levels of isolation. W3CWC used filters capable of separating signals on the same band combined with other techniques to address these problems resulting in almost no interference during Field Day operations. Operating without interference definitely makes Field Day more fun.

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Notes

1 **www.vibroplex.com/techdocs/INRAD/MII_W2VJN.pdf**

2 **www.kkn.net/dayton2009/W3AO_2009.pdf**

3 **www.kkn.net/dayton2009/Dayton_FD_W2RDX.pdf**

4 **www.contestuniversity.com/wp-content/uploads/2021/05/Transceiver-Performance-for-the-HF-Contest-and-DX-Operator-CTU-2021-NC0B.pdf**

5 **www.ka2c.com/wp-content/uploads/2021/01/Field-Day-Ultra-Sharp-RX-Filters.pdf**

6 "Filters to Separate Signals on the Same HF Band for Field Day," Sollenberger, Nelson (KA2C), *NCJ*, Nov/Dec 2021.

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