ARRL EMC Committee Semi-Annual Report

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For The
American Radio
Relay League

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Submitted By
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Chairman, ARRL EMC Committee

Mission Statement:

The EMC Committee monitors developments in the Electromagnetic Compatibility (EMC) field and assesses their impact on the Amateur Radio Service. The Committee informs the ARRL Board of Directors about these activities and makes policy recommendations for further action, if appropriate.

The overall goals of the committee are:

- Advise the ARRL Board about issues related to radio-frequency interference
- Advise the ARRL HQ staff on the content of its publications
- Make recommendations to the ARRL Board and HQ staff
- Maintain contact with other organizations involved in EMC matters through established liaison individuals

Members of the Committee:

- Mr. Kermit Carlson, W9XA, ARRL Central Division Vice Director, EMC Committee Chairman
- Mr. Phil Barsky, K3EW, Engineering/Management Consultant, retired
- Mr. Gordon Beattie, W2TTT, Principal Technical Architect, AT&T Enterprise IT Service Assurance
- Mr. Jody Boucher, WA1ZBL, RFI troubleshooter, Northeast Utilities, retired
- Mr. Brian Cramer, PE, W9RFI, Electrical Interference Solutions, Inc.
- Mr. Mike Gruber, W1MG, ARRL Lab RFI Engineer, HQ Staff Liaison
- Mr. Ed Hare, W1RFI, ARRL Laboratory Manager
- Mr. Ron Hranac, N0IVN, Technical Leader, Cisco Systems; past member of the Board of Directors, Society of Cable Telecommunications Engineers
- Mr. Richard D. Illman, AH6EZ Senior Engineer, Motorola Solutions
- Mr. Steve Jackson, KZ1X, VDSL and wireless communications
- Mr. John M. Krumenacker, KB3PJO Design Engineer

- Dr. Ron McConnell, W2IOL, T1E1.4 VDSL Standards Committee
- Mr. Jerry Ramie, KI6LGY, ARC Technical Resources, Inc.
- Mr. Cortland Richmond, KA5S, EMC Engineer
- Mr. James Roop, K9SE, past FCC District Director
- Mr. Mark Steffka, WW8MS, Automotive EMC engineer
- Dr. Steve Strauss, NY3B, Home Phone Networking Alliance Technical Committee

HQ Staff:

The role of the ARRL HQ staff consists of the following:

- Answer individual inquiries from hams (and sometimes their neighbors) about RFI problems
- Write and publish articles about RFI
- Write and publish the ARRL RFI Book
- Design and update ARRL's RFI web pages
- Maintain a database at ARRL to facilitate EMC case tracking and reporting
- Work with ARRL's D.C. office on various spectrum and RFI-related filings
- Maintain contact with industry
- Participate in standards and industry groups, as a voting member or as a liaison. This includes ANSI accredited C63®, Society of Automotive Engineers EMC and EMR committees, Home Phone Networking Alliance, VDSL, HomePlug, FCC and individual companies.

Mr. Gruber handles the majority of the staff work on EMC matters. In the 2nd half of 2015, he also continued with work in a number of key areas:

- Adding updates and revisions to the ARRL RFI Web pages.
- Facilitating and providing assistance on resolving long standing power line noise cases with the FCC.
- Testing the conducted emissions of suspect consumer electronic and electrical devices. Devices that exceed FCC specified absolute limits can be identified and reported to the FCC. Of particular concern are:

    1) Large grow lighting devices used for indoor gardening. Fortunately complaints from these devices seem to be on the decline. Mr. Gruber is happy to report that the last grow light tested in the Lab was labeled as a Part 18 non-consumer device and generally met the limits. As such, these grow lights are not intended to be marketed or sold for residential purposes. While this continues to be an obvious marketing violation, the interference potential is much less than grow lights in previous FCC complaints.

        As previously reported, earlier grow lights grossly exceeded the FCC limits. The Lab has purchased and tested four separate ballast units and each exceeds the applicable Part 18 consumer limits by a significant margin – nearly 60 dB in one case. Also as previously reported, one of these cases has was submitted

as a complaint to the FCC March 12, 2014. The remaining three cases were submitted to the FCC by General Counsel Chris Imlay on June 30, 2015.

It must be emphasized that these devices are being heard at much greater distances than normally expected from an otherwise legal device. In some cases, we have received reports of interference from devices that were found to be over ½ mile away.

Hams affected by grow light interference have found this problem to be particularly difficult to solve for several reasons:

1. Because of the abnormal distances over which this interference can propagate, hams often find it difficult to find the source. An otherwise legal device at the FCC limits is typically a few hundred feet or less, thus limiting the scope of the problem to one that can be located by sniffing with a portable shortwave receiver. This is often not practical in the case of a grow light.

2. Once the source residence is located, hams are often not comfortable approaching the homeowner or filing a complaint. He or she may no longer be a neighbor, and given the nature of what they might be growing, hams often fear for their personal safety.

It must be emphasized that these grow lights are not only the worst devices we've ever tested in the Lab for conducted emissions; they often are difficult if not impossible to resolve. As previously reported, in an effort to help hams locate these problems, Mr. Gruber helped Thompson, Tom, W0IVJ write his article, Locating RF Interference at HF, which appeared on page 33 in the November 2014 issue of QST. This article specifically addresses several aspects of the grow light problem. Mr. Thompson reports that the response to his article has been very favorable.

2) LED Part 15 Bulbs have so far not proven to be a significant source of RFI complaints in household environments. Nonetheless, Mr. Gruber continues to recommend cautious optimism. These devices still have the potential to become a serious problem without a practical solution. If we consider bulbs that are at or near the FCC limits in a typical suburban environment, the affected ham could easily be within range of 150 or more bulbs from just two neighboring homes. Attempting to find and fix this many sources is obviously not a practical or realistic solution for the ham. Mr. Gruber also notes that he did receive one complaint of RFI from a 2-meter repeater site in Georgia.

3) Non-consumer Part 18 electronic ballasts being marketed and sold for consumer and residential purposes. Note: Both the consumer and non-consumer limits Part 18 limits were exceeded in the case of all four ballasts tested by the ARRL Lab.

4) Variable speed pulsed DC motors now appearing in such things as washing machines, HVAC systems and pool pumps. Furnaces and air conditioners seem to be particularly problematic and difficult to resolve.

- Working with AT&T engineering staff to help resolve RFI issues with U-Verse and other broad band systems.

- Reviewing proposed EMC related material for ARRL publications.

Summary of Recent and Ongoing Lab Activities

Working Group for Recommended Practice of Locating Power Line Noise

Mr. Gruber now serves as Chairman of a Working Group to develop a Recommended Practice for Location of Power Line Gap Noise. See **Committees** section for additional details.

Grow Lights

As previously reported in this document, Mr. Gruber tested four sample grow lights for conducted emissions. They were purchased from both local retailers and on-line sources. Three different manufacturers were included in this survey – Lumatek, Quantum and Galaxy. They were selected on the basis of complaints that from the field. Not surprisingly, each was also considerably over the FCC limits. The worst case measured 58 dB over the applicable Part 18 consumer limits.

ARRL General Counsel Chris Imlay used the resulting Lab report as the basis for an FCC complaint on March 12, 2014, which was covered in the ARRL News. See Appendix 1 in the July 2015 EMC Committee report for this article and Mr. Imlay's complaint. The three remaining FCC complaints were filed on June 30, 2015. See Appendices 1, 2 and 3 of this report for copies of these filings.

Although the first complaint was submitted to the FCC nearly two years ago, and these devices measured way over the applicable FCC limit, there does not yet appear to have been any enforcement action taken by the FCC. Mr. Gruber believes that this lack of enforcement is simply unacceptable. He further advises that enforcement issues such as this be treated with a higher level of urgency within the ARRL.

Other Lighting Devices

As previously reported, Mr. Gruber tested a number of energy saving Part 15 & Part 18 Lighting Devices for conducted emissions. It should be emphasized that LED bulbs operate under are Part 15, while CFL's and electronic fluorescent light ballasts typically Part 18. In this case, there is an important distinction between these two rules - *Part 18 limits for consumer RF lighting device are considerably lower than applicable Part 15*

limits. As a consequence, the ARRL Board has previously asked us to consider a proposal to reduce Part 15 limits to Part 18 levels for lighting devices. This concern was included in FCC comments filed by ARRL on October 8 on a *Notice of Proposed Rule Making* (NPRM) in ET Docket 15-170 and RM-11673. The ARRL News covered the story on October 13, 2015. Here is the URL:

www.arrl.org/news/arrl-asks-fcc-to-clarify-that-hams-may-modify-non-amateur-gear-for-amateur-use

Mr. Gruber is happy to report that there continues to be few complaints of RFI from these bulbs. However, these bulbs could still be legally marketed and sold if their emissions were close to the FCC limits. The emissions in this case would be high enough to create interference issues even from nearby residences in a typical suburban neighborhood. If and when such interference occurs, the burden then falls on the device *operator* to correct problem. While this rule may work on a case-by-case basis involving a small or limited number of sources, it is not practical should many bulbs in several houses be contributing to a wide spread problem. This concern was also included in the previously mentioned NPRM comments filed by ARRL on October 8, 2015.

An additional problem involves the sale and marketing of non-consumer rated ballasts to consumers in hardware and big box stores. These ballasts are being sold to unsuspecting consumers and have been the subject of interference complaints to the ARRL Lab. ARRL General Counsel Chris Imlay first filed a complaint concerning Home Depot on July 14, 2015. This complaint concerned the improper marketing of such devices. See Appendix 4 for this report.

Two additional filings by Mr. Imlay occurred on December 28, 2015 against Lowes and Walmart. These complaints noted similar marketing issues as the one filed against Home Depot. The resulting news story and complaints are included as Appendices 5 and 6 in this report.

Arc Fault Current Interrupter AFCI Breaker Immunity Issues

As previously reported, Mr. Gruber began receiving a few reports of "tripping breakers" from hams in early 2013. Specifically, these complaints concerned AFCI breakers, or Arc Fault Circuit Interrupter type breakers. These breakers are designed to trip if they sense an arc, and are now required by the electrical code in some specified rooms for residential wiring.

In response to these complaints, Mr. Gruber with invaluable help from W1AW Station Manager Joe Carcia built a "universal" circuit breaker test fixture. Using this fixture, he and Mr. Carcia tested as many breakers as they could find during W1AW broadcasts and other transmissions. The final results of this testing indicated that most of the AFCI breakers were surprisingly robust. The only problem breakers were the new – and only the new - model Eaton breaker at the time. Note: Eaton and Cutler Hammer are both

part of the same company. Some Cutler Hammer breakers may have also had RFI issues, but the samples we tested were not a problem.

As previously reported, Mr. Gruber worked with Eaton to identify and test prototype breakers. As of early 2015, only the new Eaton breakers are now being manufactured and the problematic breakers have been discontinued. Based on initial reports from members, these new breakers were not tripping in response to Amateur transmissions.

In cases where older breakers are improperly tripping, Eaton continues to provide assistance. The ham or homeowner can call one of two individuals at Eaton and they have been replacing the old breakers on a one-for-one basis free of charge. Complete details, including name and contact information, appeared in the November 19, 2013 ARRL news story, *ARRL Helps Manufacturer to Resolve Arc Fault Circuit Interrupter RFI Problems*.[1]

While it had been hoped that the new Eaton breakers would finally end this matter, problems are still being reported in an area of Florida called "The Villages." We've received reports that some of the new breakers are still tripping. Some breakers also appear to be tripping for unknown reasons but hams are still being blamed. In other cases, multiple breaker changes have tried the patience of neighbors of hams. So far, estimates of at least 6,000 breakers have been changed in The Villages by Eaton.

While this matter may not be completely resolved in The Villages, Eaton seems to have fixed the vast majority of cases in other parts of the country. Additional testing is also planned at W1AW.

Power Supply Conducted Emissions Investigation

As previously noted, Mr. Gruber noted a significant increase in conducted emission from an EtherWAN "ethernet switch" when an unterminated CAT5 cable was connected to it. This device could test very quiet in a lab, but be very noisy when used in actual practice. It should also be noted that the power supply was internal to the device, and the problem went away when an outboard power supply was used in place of the internal switching supply.

A subsequent investigation with EMC Committee member Gordon Beattie also resulted in a similar observation. Mr. Beattie reported that a number of power supplies had apparently met Part 15 emissions limits but generated more noise than expected in an actual residential environment. Messer's Beattie and Gruber subsequently investigated this phenomenon in the ARRL Lab. They concluded it is caused by relatively low RF impedance at the load side of the power supply. In an actual real world environment, cables and wires connected to the load side of the power supply can cause this phenomenon to occur.

[1] The URL is www.arrl.org/news/arrl-helps-manufacturer-to-resolve-arc-fault-circuit-interrupter-rfi-problems.

This phenomenon has now been observed in other products and power supplies. Although this investigation remains ongoing, Mr. Beattie now reports that these findings have already helped improve response to members concerns with regard to xDSL and power supply issues.

Status on FCC Enforcement and Outstanding EMC Cases

Mr. Gruber reports that the FCC has been sending letters to utilities (and consumers) with regularity. Meaningful enforcement beyond that has historically been very disappointing. To the best of his knowledge, no previously reported longstanding power line noise case has been resolved during the second half of 2015 due to enforcement. While some cases have been closed, many cases can drag on indefinitely. Protracted cases are often caught in an endless loop or letter writing campaign. As a result, new cases develop faster than old cases are resolved. There has been little or no change from the previously reported statics in this regard. The FCC has yet to issue even one NAL in a case of interference to Amateur Radio from a Part 15 or Part 18 device.

As previously reported, the FCC is not pursuing amateur related EMC enforcement issues in a meaningful way. At the present time, three examples of particular concern include:

1. On March 14, 2014, the following story appeared in the ARRL News: ARRL to FCC: "Grow Light" Ballast Causes HF Interference, Violates Rules.[2] This story reported a formal complaint made by the ARRL to the FCC concerning grow light ballasts that were considerably over the applicable FCC Part 18 limits. Since these devices are being marketed and sold in shops across America, and given the incredible margin by which they exceed the limits, this was a slam dunk case for FCC enforcement. Yet, at the time of this report, no enforcement has taken place. In fact, to the best of Mr. Gruber's knowledge, the FCC has yet to even respond to the ARRL's complaint.

   While it may be understandable for the Commission not to comment on an ongoing investigation, it is clear that timely FCC enforcement is not happening. It has now been almost two years since the ARRL's news story on this matter. It would appear that the FCC is either unable or unwilling to provide timely and meaningful enforcement, even in a clear and egregious case such as this. Mr. Gruber fears that if this should continue, it has the potential to compromise the FCC's credibility as an enforcement body. Meaningful FCC enforcement when warranted is essential toward protection of all spectrum, not just the ham bands.

   It has also been reported by EMC Committee members who are professionally employed electrical engineers in the cable-TV/cable-modem area that grow light ballast have been found to cause serious harmful interference to the operation of cable systems; Electro-Magnetic Interference from grow-light ballasts enters the

[2] The URL is www.arrl.org/news/arrl-to-fcc-grow-light-ballast-causes-hf-interference-violates-rules. Included at the end of this report as Appendix 1A.

cable system in the downstream end and causes interference to subscribers in a relatively large areas. As previously noted in the Summer-2014 EMC Committee report, emissions from some grow-light ballasts have measured 58 dB above the FCC limits. In other words, these devices are presenting problems to cable distribution systems often with coupling to the ground and power of residences with the conducted levels far in excess of what is encountered in typical amateur installations.

2. On April 24, 2014, the following story appeared in the ARRL News: ARRL FCC Cites Washington Resident for Causing Interference on Amateur Frequencies.[3] This article describes a case in Woodinville, Washington in which the FCC conducted a field investigation. Although this investigation resulted in a finding of harmful interference from a nearby property, possibly caused by a lighting device, the property owner subsequently failed to respond to the Commission. As a result, the Commission released a Citation & Order on the 24th of April, the same day as the ARRL News article[4]. However, as of December 2015, the interference was confirmed to be ongoing.

   The noise in this matter is consistent with a grow light. At this point, it appears that the property owner has simply ignored the FCC's Citation and Order and no formal enforcement has taken place after almost two years. Mr. Gruber believes that this is the best case for an NAL that he has seen in quite a while.

Historically, meaningful FCC enforcement beyond an advisory letter has been and continues to be disappointing. So far, most cases involving Amateur radio have been argued on the basis of harmful interference as opposed to exceeding the FCC emissions limits. The FCC rules place the burden to correct harmful interference on the *operator* of the offending device – not the distributor or manufacturer. Device operators in a typical RFI case include a power company or neighbor.

In a typical case, one or more letters will be sent by the FCC in Gettysburg to an offending device operator. Beyond that, a typical case will be referred to the local FCC field office for an investigation. From what we've seen, most field investigations result in a conclusion of convenience. As a typical example, the agent may conclude that the noise is insufficient to meet the criteria for harmful interference, thus ending the case. Other complainants have reported a lack of follow-up after an investigation, especially if the source was not active during the initial field investigation.

Also from what we've seen, FCC field agents often do not have the proper training or equipment to correctly identify and locate power line noise. Their equipment seems better suited for locating such things as transmitters. Even if the source is known, or if the source is a consumer device in a nearby home, we've yet to see one in which the FCC

[3] The URL is www.arrl.org/news/fcc-cites-washington-resident-for-causing-interference-on-amateur-frequencies.
[4] The URL is http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0424/DA-14-536A1.pdf.

issued an NAL or forfeiture. Some cases like this have dragged on for a considerable period of time with no resolution.

FCC Enforcement Concerns

While a lack of meaningful enforcement in cases involving device operators has been the norm for a considerable period of time, the two examples described in the previous section plus a third appear to demonstrate an alarming trend.

In summary:

1. The first involves grow light manufacturers. The ARRL has so far filed four complaints of devices that were grossly over the applicable FCC limits. Although the first complaint was filed on March 14, 2014, so far there has been no apparent enforcement action by the Commission. **In fact, the Commission has yet to even acknowledge or respond to any of these complaints.**
2. The second is an apparent lack of response to an FCC Citation & Order that was issued on April 24, 2014. The Citation and Order was ignored by the recipient and he interference continues unabated. **The FCC has yet to take any meaningful action in the matter after nearly two years.**
3. The third example concerns the three illegal marketing of Part 18 non-consumer lighting devices. The first Home Depot complaint was filed by the ARRL on July 14, 2015. The Lowe's and Walmart complaints were filed on December 28 and 29, respectively. Although the first complaint was filed six months ago, the FCC has failed to take any action problem continues. **In fact, the Commission has yet to even acknowledge or respond to any of these complaints. At the time of this report, the only response has been from Walmart seeking to rectify the problem.**

It must be emphasized that even if there is an ongoing FCC effort in any of these matters, they have now been ongoing for a considerable period of time with no known formal FCC action. Even if there was to be an FCC action at this point, it would not be timely enough to achieve maximum impact as a future deterrent.

With the proliferation of new types of lighting devices, including grow lights, not to mention such things as switching mode power supplies, battery chargers, pulsed dc motors in appliances, etc., meaningful enforcement is badly needed. A lack of it in RFI matters would no doubt be disastrous for both hams and other services as well. If the FCC does nothing about something as egregious as a grow light, proper follow-up it to a Citation & Order, or illegal marketing of industrial devices, it would fundamentally call into question the FCC's credibility as an enforcement body. It would also seem unlikely that t meaningful enforcement could be expected in other interference matters as well.

Second Half 2015 Year Total RFI-Case Statistics:

New RFI Cases – 82
New electrical power-line cases – 22

- ARRL Letters sent – 17
- FCC 1st Letters submitted – 5 (Note: Laura Smith may have issued FCC letters based on need and input from the ARRL. These letters were not formally submitted by ARRL and therefore not included in this total. Many of these letters could possibly be follow-up in nature and therefore require custom legal language. The effectiveness of these letters has yet to be determined.)
- FCC 2nd Letters submitted – 0

Electric Utilities:

Power-line interference has continued to be the single number one known interference problem reported to ARRL HQ. It can also be one of the most difficult to solve. Fortunately, Laura Smith clearly remains interested in RFI matters and continuing with the Cooperative Agreement; and there has been no change to the process of processing cases presented through the Agreement. Although none of the previously reported cases have been successfully resolved as a result of FCC enforcement, the Committee is continuing in the process of addressing this issue.

KI6IBS Power Line Noise Investigation

In an effort to develop a power line noise case for ARRL consideration as a higher level FCC complaint, Messer's Gruber and Ramie investigated the case of Eric Schreiber, KI6IBS, in March and April of 2015. This case is located in Pleasant Hill, CA and first reported to ARRL on April 24, 2012. The utility in this matter is PG&E.

Since first reported to us, PG&E has responded to numerous FCC and ARRL communications. PG&E also claims to have made significant effort toward resolving it. Although the noise at KI6IBS is intermittent and primarily active at higher temperatures, it was severe and not particularly difficult to find when using proper modern methods and equipment. The people that PG&E were sending out did not have the right equipment, or if they did, they didn't know how to use it.

Complete details on this investigation appear as Appendix 8 of this report. Although Mr. Gruber has forwarded this report to PG&E's attorney Jonathan Pendleton on June 12, 2015, the problem remains ongoing. Laura Smith at the FCC was also a CC recipient of this report. While there was a subsequent attempt to fix this problem, it was unsuccessful. PG&E failed to conduct a technically competent RFI investigation in response to Mr. Gruber's report.

Mr. Gruber reports that this case is solid. The only potential issue might be the intermittent nature of the noise in cooler weather. Given the extraordinary effort it requires to groom and develop a case to this level, Mr. Gruber recommends to the Board that it be used for a timely and higher level complaint at the FCC. He also notes that Mr. Schreiber continues to periodically ask about the status of his case with the ARRL. Since his case is being handled at a higher level within the ARRL, he has been unable to advise Mr. Schreiber in this regard. Since it has now been nine months since his investigation, Mr. Gruber suggests that a higher level decision be made as to what we tell Mr. Schreiber.

K7GMF Power Line Noise Complaint

Tom Lopez of Cochise Arizona first reported his power line noise problem to ARRL over ten years ago. Despite numerous FCC letters and an investigation by Mike Martin, the problem continues. A brief timeline is as follows:

- 02-18-04 – Complainant first reports interference problem to ARRL
- 03-20-06 – ARRL sends letter to Sulphur Springs Valley Electric Cooperative (SSVEC), the utility in this matter.
- 03-16-09 – FCC sends 1st FCC letter to utility.
- 08-17-09 – FCC sends 2nd FCC letter to utility.
- 05-10-10 – RFI investigator Mike Martin, whose services were obtained by the Utility, reports that he investigated the problem. There were numerous staples in a desert environment contributing to the problem. The primary source was found to be associated with 69 kV transmission lines about six miles away. This problem could not be fixed at the time of Mr. Martin's investigation.
- 03-01-11 – FCC sends 3rd FCC letter to utility.
- 07-08-14 – Mr. Carlson contacts Mr. Lopez to ascertain the current state of harmful interference to K7GMF from powerline noise.
- 08-18-14 – Mr. Gruber requests 4th FCC letter.
- 12-05-14 – Laura Smith reports that she had sent the utility a letter in August but did not receive a reply. She indicated that she would send to the field if nothing after the Holidays.
- Present – Mr. Lopez reports the problem continues and he has not heard from the field. He asks Mr. Gruber for help and provides him with a package of recent documents related to his case.

Mr. Gruber reports that he did have contact with FCC staff about this particular case at the beginning of July, 2015. Later that month, Laura Smith responded that she had asked the Field Office to put it on their schedule. She also added that they can only make the site visit when they can bundle it with other Arizona matters. She noted that they are coming from CA and the FCC front office will only approve travel for a case like this if they can kill multiple birds with that one stone. She will let Mr. Gruber know once they have a trip planned.

Although Mr. Gruber has concerns about the complexity of the case with over five years since the professional investigation began, Mr. Gruber is now grooming this as one of the cases that the Committee still believes should be used as a higher level complaint with the FCC.

Additional ARRL Power Line Noise Investigations by Kermit Carlson

Vice director and EMC Committee Chairman Kermit Carlson continues to perform follow-up on the status of the 74 open cases of power line noise that had been previously referred to the FCC. The purpose of this inquiry was to determine the status of harmful interference from Power Line Noise for cases that had been reported in the past 5 years but for which the League had an unknown remediation status.

Of the 74 cases that Mr. Carlson investigated, fourteen were closed as a result of the inquiry. The harmful interference issue had been resolved and that no follow-up is necessary.

Out of the 41 unresolved cases identified by the follow-up several cases have been selected for further preparation for presentation to the Commission as long-term unresolved problems:

Along with the KI6IBS, Pleasant Hills, California and the K7GMF, Cochise, New Mexico situations few cases of persistent powerline noise have been as problematic as the K9XD powerline noise case in Warrenville, Illinois. This case is remarkable because the complainant, Mr. David Janiec, K9XD, has gone to the extreme extent of purchasing his own Radar Engineers RFI locating equipment and has actually been able to present credible and accurate location information of the noisy and failing equipment to the responsible utility, Commonwealth Edison.

K9XD Power Line Noise Complaint

In 2015 Mr. Janiec was able to eventually contact the proper person within the Commonwealth Edison who was able help resolve the interference. Using the list of sources identified as causing interference to K9XD, Commonwealth Edison seems to have been able to resolve the issue of harmful interference. His case demonstrates the powerline gap noise can be solved but only if the utility becomes a willing participant in the remedy.

As demonstrated in the K9XD case, the lack of any substantial consequence for inaction by a utility does continue to confound suitable progress towards resolution in a number of cases. Unfortunately, with a Federal Communications Commission that appears to have completely abandoned most enforcement, there would seem to be little more that can be produced by Commission involvement for these cases that remain unresolved. Although it would be extremely helpful for future efforts if the Commission were to levy a substantial fine in at least one egregious power line noise case of harmful interference, it appears that this would not be a realistic expectation of Commission action.

W9TS – Powerline Noise Complaint

Shortly after K9XD's problems were solved, Mr. Paul Kasley, W9TS, of Hillside, Illinois approached the ARRL EMC Engineer seeking help with powerline gap noise from the same electrical utility, Commonwealth Edison. The quickest and first step was to lodge a complaint with the utility. Given that it had been reported over one year ago that Commonwealth Edison had instituted new guidelines internally to handle powerline gap noise complaints for radio, television and amateur radio, this was one of the first opportunities to monitor the progress from start to resolution. Although the complainant was told that he should expect some resolution within 45 days, the utility investigated the noise within 2 weeks and seems to have resolved the issue to the satisfaction of W9TS. Given the intermittent nature of gap-noise producing powerline faults the optimism is guarded. The experience between Commonwealth Edison and Mr. Kasley does indicate that at least in the service area on the West area of Chicago that Commonwealth Edison is responsive and does assign qualified employees and equipment to investigate the problem. It is important to note that this case demonstrates that the most expedient resolution is achieved with the help of the utility, and positive results are achieved without any need for letters or action by the ARRL or any regulatory agency. We could only hope that this paradigm would become more common throughout the country.

Case of Reported interference to two amateur station by an AM broadcast station

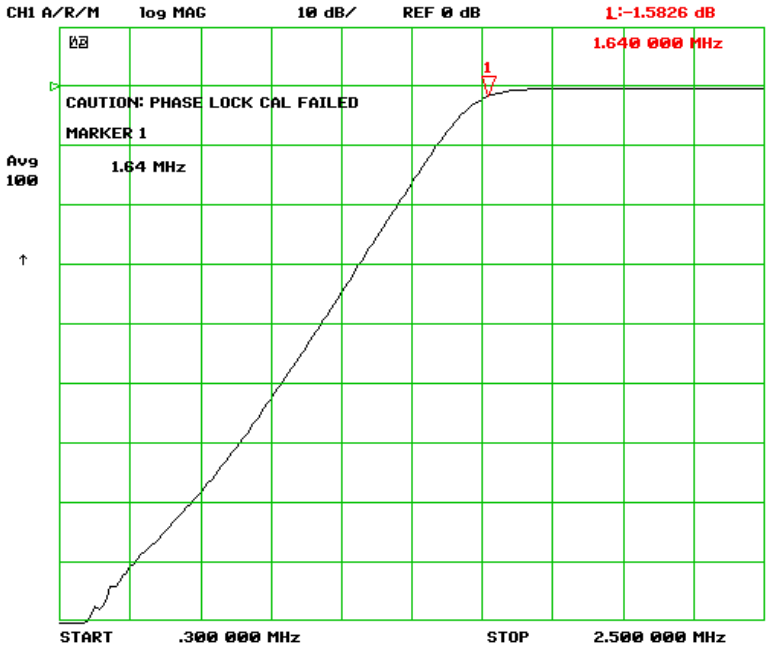
Mr. Carlson investigated complaints near Milwaukee, Wisconsin from two active ARRL members of interference arising from an AM Broadcast station operating on 1640 kHz. Both operators had asked the ARRL EMC Engineer for FCC intervention on their behalf to resolve the interference. Although both amateur stations were using commercially sold Broadcast Band (BCB) filters that should have provided several 10's of dB of attenuation, both amateur stations had reported significant issues.

A check of the operating parameters of the AM stations' license indicated a power of 5 kW into a 1/4λ vertical antenna with 120 ground radials. Receiver overload was suspected since one amateur station was located 330 yards from the broadcast station's antenna while the other amateur was within 1 mile. A computation of field strength at the closest amateur station predicted a field strength of 25 Volts/Meter while the second station was located within the 2 Volt/Meter contour.

A visit to the site of both amateurs on the first Saturday in November 2015 confirmed the level of field strength with a quick measurement by Mr. Carlson. The station located closest to the AM transmitter site was investigated first for the interference, a spectrum sweep at the 25 Volt/Meter contour with an ALR-52 loop antenna proved that there was no emission from the station that was responsible for the issues seen at either station. This first amateur station had a good layout with sufficient and proper installation of antennae lead-in, grounding and power. The presence of the commercial BCB filter was noted in the output lead of the transmitter, and yet severe interference to the amateur receiver was noted.

The first step was to remove the filter and replace it with a calibrated switchable attenuator to test at what level the noise caused by the transceiver's front end would cease. An attenuation of 10 db would completely eliminate the front-end overload that was giving rise to the received "interference". The next step was to measure the response of the BCB filter was made with the portable spectrum analyzer and integral tracking generator, this measurement proved that the commercial obtained BCB filter had in fact less than 1.6 dB of attenuation, while the advertised value was well in excess of 20 dB for the frequency of 1640 kHz. Similar results were obtained when the second station was visited.

One week after the site visit both operators mailed their BCB filters to Mr. Carlson who measured the response curves with an HP-8753C network analyzer. The filters were then sent to the ARRL lab where similar results were confirmed. The filters have been returned to the two operators who will seek a remedy directly with the manufacturer.



A plot of response from the Morgan M-402 Broadcast Band Filter that exhibits 1.58 db rejection at 1.64 MHz, significantly less than advertised. Attenuation of 10 db would have eliminated receiver overload at the amateur station located 330 yards from a 5 kilowatt AM transmitter site. Measurement by Kermit Carlson W9XA HP-8753C Network Analyzer - 20Nov15

The result of the investigation was that the 'interference' was not a problem with the broadcast station's transmitter but receiver overload at the amateur's station. Mr. Carlson has recommended that a short article appear in QST about the methods that can used to remedy receiver overload issues absent the availability of expensive equipment; also, he has asked that a product review of such BCB filters be considered if it becomes evident that the response of such filters is being misrepresented. This case also demonstrates the importance of ascertaining the validity of any reported interference case before it is elevated to regulatory agencies for action and resolution.

Marketing of Drone TV transmitters that operate on Amateur and FAA radar frequencies.

In the early days of November 2015, the ARRL EMC Engineer Mike Gruber, W1MG, was made aware of the marketing of video transmitters for installation on airborne **drones** that operate on amateur radio frequencies. The marketing of radio equipment that had obviously not been tested for FCC rules compliance is nothing new but besides being a nuisance for the operators on the 23 cm band the operation of these transmitters does carry the distinct possibility of causing harmful interference which would result in a serious safety of flight issue for aircraft operations.

The Lawmate 1.2 GHz 8-channel 1000 mW (1-watt) AV transmitters for drones which is marketed by hobbyking.com (information copied below) is capable of operating on the following frequencies; 1010 1040 1080 1120 1160 1200 1280 MHz Although 1280 is in the amateur band, the 1200 MHz channel would be in conflict with the GLOSSNASS (Russian GPS) CDMA 1202.5 MHz channel. This frequency is in commercial use within the US for radiolocation. Operation on three of the other "channels" have a far more significant impact. For instance, 1010 MHz is used for aeronautical guidance in the TACAN/DME aircraft radio navigation band, and it is the potential use of 1040 and 1080 MHz that represents the greatest threat to the safety of flight. These two frequencies are in direct conflict with the ATC (Air Traffic Control) transponder frequencies used to interrogate aircraft transponders (1030 MHz) and for the responding transmission from aircraft (1090 MHz) when those aircraft are operating in what is termed MODE-A or MODE-C transponder. The use of transponders is required on these frequencies by all aircraft operating above 18,000 feet and within 30 miles of all major airports. Additionally, the newest form of digital ATC information for aircraft is transmitted on 1082 MHz . Since the TACAN/DME system and the ATC Transponder systems operate with 10Mhz bandwidth the use of a unlicensed drone transmitter can cause serious issues with the integrity of the ATC radar system.

The channels chosen for operation of these airborne transmitters demonstrate a complete disregard by the manufacturer of the established and legal assignments of frequency allocations. It is the recommendation of the EMC Committee Chair, Mr Carlson, W9XA that the ARRL should formally object to FCC about the marketing of these transmitters. The several facts that support a complaint are; that the target market is the drone hobbyist, not the radio amateur; that the transmitter in the example (shown below) is not appropriate for unlicensed Part 15 use on any of the available channel settings; that the use of these devices will cause undue interference to properly licensed amateur stations. Further, given the capability to cripple the operation of the ATC secondary target/ transponder systems, these illegal transmitters do represent a significant hazard to public safety in general and the safety of flight specifically. While these transmitters are marked as appropriate for "ham" use, it is quite apparent that these devices have not received proper FCC equipment authorization under Part 15. The rules require low power transmitters such as these to be Certificated. While the state of FCC equipment authorization is not known for certain, the specified frequencies of operation would make the required FCC Certification highly improbable.

These transmitters and amplifiers are being offered online by a number of internet vendors. A quick online perusal of vendors indicates that there is no shortage of suppliers of these devices:

www.getfpv.com/fpv.html

www.readymaderc.com/store/index.php?main_page=index&cPath=11&zenid=8be5bec447599f85ef884721a0c92d8e

www.hobbyking.com/hobbyking/store/__540__543__FPV_Aerial_Video_Telemetry-Video_Tx_Rx.html

It is only a matter of time until amateur operations will be affected by these transmitters, but if such a device ever does interfere with the integrity of the FAA's ATC transponder radar system it would be beneficial to be able to show that we had warned the Commission of the nature and dangerous potential that these transmitters represent. Although the response to any complaint of improper marketing of non-compliant devices is likely to ignored by the Commission, it does warrant consideration for filing a complaint.

An example of the internet direct marketing of transmitters for drone television transmitters one only has to look as far as the "Hobbyking.COM" the website where the Lawmate transmitter is available for $89, a companion 6-watt amplifier is available for $79.

www.hobbyking.com/hobbyking/store/__77815__Lawmate_1_2GHz_8CH_1000mW_Wireless_AV_Transmitter_for_FPV_CCTV_Camera.html

webpage information

A compact 1000mW 1.2GHz A/V transmitter module designed for FPV use. An excellent quality unit that has 8 selectable frequencies and audio/video outputs. This transmitter will give you excellent range and very good video clarity.

It utilizes a "Digital Phase Lock-Loop Circuit" without temperature drifting problems. It also features a highly integrated circuit board for ultimate reliability.

Selectable channels: 1080 1120 1160 1200 1010 1040 1280 1280GHz

Features:
• Compact size
• Exceptional range
• Excellent video clarity
• Highly integrated circuit
• Uses "Digital Phase Lock-Loop Circuit" with no temperature drift.

Specs:
Transmission Frequency: 1.2GHz
Output Power: 1000mW

Channels: 8
Input Voltage: 5V
Modulation Deviation: 2.8MHz FM modulation
Sub-Carrier Frequency: 5.5MHz
Video Input: Impedance = 75ohms
Audio Input: Vp-p
Operating Temperature: -10C~+40C
Weight: 27.5g (transmitter only)
Weight: 76g (transmitter, antenna and supplied A/V lead)
RF Output Connector: SMA
Dimensions: 60 x 25 x 11mm

Note:
Please check with your local authorities regarding operation of this equipment before you purchase. Regulations on power output, usable frequencies and licenses to operate vary from region to region.

end

Noise Monitoring; a suggestion is now an action item

Dr. Greg Lapin, N9GL, the Chair of the ARRL RF Safety Committee contacted Mr. Hare and Mr. Carlson prior to the November EMC Committee meeting to suggest that the EMC Committee consider undertaking a the creation of a program to measure and monitor trends for background noise in the HF spectrum.

The EMC Committee and Mr. Hare are in the process of developing suitable approaches to the concept of enlisting volunteers of internet-connected amateur stations that would use their stations to monitor the HF bands for changes in noise levels, both long-term and short-term, for the purpose of documenting HF noise levels.

Smart Grid & EMC Standardization Efforts

Mr. Ramie (KI6LGY) expands on his efforts in these four areas:

1) **Update to IEEE-1613.1(2013)** - This work was terminated early in 2015 to begin transferring the work to the update needed for IEEE-1613(2009), which will be withdrawn soon. (5 years) The PAR for the new work on IEEE-1613(2016) will be considered in two weeks at the Power & Energy Society C0 Substation meetings in Memphis. We have three sponsoring Committees within P&E; Substations, T&D and Relaying. We expect that a PAR will be approved and are encouraged by the fact that we are not encountering any opposition to including the same immunity tests and levels we included in 1613.1. The new 1613 will cover all Intelligent Electronic Devices (IEDs) whether they communicate or not. In effect, if it has a microprocessor inside and is purchased by an electric utility for a substation or for use out in distribution, IEEE-1613 will cover it for EMC immunity (including resistance to HF emanations) and will harmonize with IEC 61850-3 as well.

2) **SGIP2** - The Smart Grid Interoperability Panel hosts the EMI Issues Working Group to address EM interference issues to/from utility equipment. The new Chairman, Don Heirman, wants to move towards further work in ground potential rise from solar storms and mass coronal ejections and their effects on the power system. Dr. Bill Radasky, a leading expert on the topic for the US Congress, has joined the working group. Mr. Ramie has been asked to become the Vice Chair and is considering it. We would need to pay membership dues for another year, however. (about $750)

3) **Public Speaking about Smart Grid EMC Standards Harmonization** - Mr. Ramie spoke at the IEEE - EMC Symposium in March about IEEE-1613.1(2013) and discussed the disbandment of the working group assigned to update it. Since the group is re-forming under IEEE-1613, Mr. Ramie will still act as the liaison between the P&E Society and the EMC Society (SDE-Com) to keep both Societies informed. For public outreach, Mr. Ramie solicited every EMC, Communications and Power/Energy chapter in the US and has given nine Presentations on ***Smart Grid EMC Standards Harmonization*** to good reviews. The opening slide of his Presentation shows the ARRL logo to acknowledge the support of the League and the comments Mr. Ramie delivers describe these efforts. The presentation was recently given again at ElectroRents in Van Nuys to instrument rental agents who view this utility EMC market as an emerging opportunity.

4) **Support the ARRL Lab** - The IEEE - EMC Society Standards Development & Education Committee met in March, 2015 and approved the PAR authorizing work to begin on a sparking gap noise Recommended Practice (IEEE - P1897) to showcase industry best practices. Mr. Ramie is the working group Secretary and work has begun on this important document. A utility procedures task group, Chaired by Brian Cramer, will meet by webinar next week.

Automotive EMC:

The Headquarters staff continues to send all reports of automotive EMC problems to interested people in the automotive industry. While these reports are advisory, they are helpful to the industry in planning for future designs. Mr. Steffka continues to help prepare automotive related responses to Technical Information Services (TIS) questions for ARRL members.

Cable Television:

As a whole, the cable industry continues to do a good job at adhering to the FCC's regulations about signal leakage and interference. During the past six months, ARRL received two reports of problems, and our cable liaison, Mr. Ron Hranac (N0IVN), received one report directly, indicating that most cable systems are either clean or are addressing complaints effectively.

The first case, in September, had to do with service quality issues (data outages, etc.) in a Comcast cable system in Palm Beach, FL, and miscommunication by a Comcast tech that the complainant's radio "was the problem." Comcast resolved the service disruption issues, and advised the complainant that his radio was not causing problems.

The second case, in early November, involved a complaint that the intermediate frequency (IF) of Scientific Atlanta set-top boxes was in the 2 meter band and causing interference. Mr. Hranac checked with his company's set-top division and found that the STBs in question have dual IFs, with the first IF above 1 GHz and the second IF below 50 MHz, neither of which is in or near the 2 meter amateur band. That information was relayed to the complainant by ARRL, but no further response was received from the complainant.

The third case, also in November, came directly to Mr. Hranac via the complainant, who said that he was receiving suspected cable interference in the roughly 46 MHz to 52 MHz frequency range. Mr. Hranac advised the complainant that North American cable networks don't carry signals in that frequency range (it's in the cable amplifier diplex filter crossover region), and suggested that the noise might possibly be from a Part 15 device coupled to the cable shielding via code-required neutral bonds. The complainant was working directly with Seattle-area Comcast technical staff to determine whether local signal leakage existed. Resolution uncertain – there was no further response from the complainant after Mr. Hranac explained the possible interference source.

DSL, U-Verse & Home Phone Networking Alliance

Mr. Beatty continues to assist with broadband service complaints to the ARRL. Very few complaints were received since July. In addition, Mr. Beatty has been working toward formalizing the process that AT&T uses to address these issues with ARRL.

Based on a complaint from Arizona, Mr. Beatty also reports that CenturyLink is doing something different than other xDSL carriers. Specifically, they are increasing their DSLAM in the specific spectrum where the interference is occurring. If the source is an Amateur station in the transmit mode, it can create interference to that same station when in the receive mode.

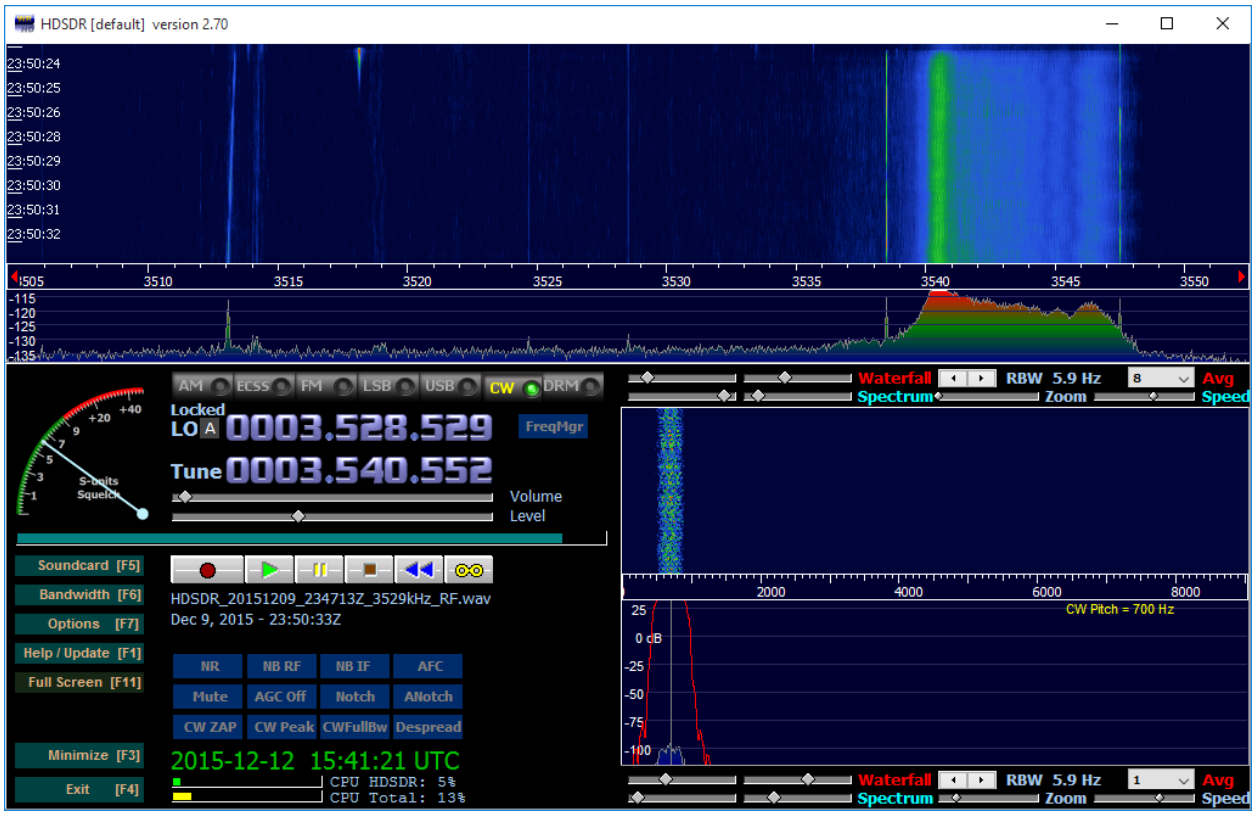
Miscellaneous Reports from Committee Members

Mr. Roop submits the following report:

Power Line Communication Devices

The Wireless Modem and Telephone Jack information at www.arrl.org/wireless-modem-and-telephone-jacks remains of current interest and not just a historical footnote.

Interference from Phonex PX-421 power line communication devices remains a current source of interference to the low end of the 80 meter band.



The device appears to have a failing power supply since the frequency modulated carrier is modulated by 60 Hz hum. The occupied bandwidth is in excess of 15 kHz and the noise floor of the lower 25 kHz is raised by 6 dB over the ambient noise level.

The resolution of the interference remains ongoing. The device appears to have been installed by DirectTV.

Multiple sources have been observed at multiple locations.

FCC Amateur Radio Complaint Processing

Harmful interference from a power line communication device provided an opportunity for an EMC committee member and retired Enforcement Bureau (EB) supervisory electronics engineer to submit a complaint on the (new) FCC.gov website. The experience documented significant issues with the Commission's Consumer and Governmental Affairs Bureau (CGB) to input and process complaints from licensed entities. The filed complaint was not processed by CGB and forwarded to EB for resolution.

The underlying Commission deficiency lies in CGB's failure to recognize that there are basically two categories of FCC consumers: licensed entities and all others. CGB,

heretofore, assumed that interference complaints from FCC consumers would only be broadcast related, i.e., Part 73 broadcast or Part 27 SDARS. Licensee entities filing interference complaint at the Consumer Help Center website was required to input one of two choices, Broadcast or Satellite for their "Radio Method." A complaint from a licensed entity had little chance being properly characterized and subsequently forwarded to EB.

As of December 22, 2015, Amateur Radio has been added as one of the "Radio Methods" when filing a "Radio" interference complaint. It is too early to know if this will result in newly entered amateur radio complaints being automatically flagged for referral to the Enforcement Bureau.

FCC Enforcement Bureau Priorities

Improvements in a radio amateur's ability to file a complaint of interference with the FCC are tempered by the reduction in field technical assets. Even though the FCC Chairman asserts that ". . . interference resolution anywhere in the country is and will remain a top FCC priority . . . .[5]" we will have to wait to see how this plays out after the field is finally reorganized.

In the meantime, many experienced field engineers are retiring ahead of the purge and morale with the agency continues to decline.[6]

LED Part 15 Bulbs – Personal Experience

I replaced all the lamps in the (basement) room where the amateur radio station is located. No noise has been observed between 160 and 6 meters.

[5] FCC Chairman Tom Wheeler letter to Chairman Greg Walden, Subcommittee on Communications and Technology, Committee of Energy and Commerce, U.S. House of Representatives dated April 2, 2015.
[6] Partnership of Public Service, "The Best Places to Work in the Federal Government", Online: Partnership of Public Service, http://bestplacestowork.org/BPTW/rankings/detail/FC00, accessed January 3, 2016.

RFI-Case Database:

The ARRL HQ staff maintains a database of RFI reports and cases. This is used primarily as a case-management tool for the several hundred RFI cases ARRL handles every year, but the information the Lab staff are gathering about types of interference cases, involved equipment and frequencies will provide a wide range of reporting capability. Here are some statistics from the database for 2015 and compared to the previous five years:

Category of Case Reported to ARRL Lab/EMC Engineer	2010	2011	2012	2013	2014	2015
BPL	3	0	0	0	0	0
Unknown Unintentional Radiators	57	78	66	68	81	49
CABLE TV	8	7	3	4	4	4
Satellite TV				2	3	1
Computing Devices and Modems	4	7	3	5	6	8
Power Line Noise	90	65	53	52	51	43
Plasma TV Receivers	10	14	5	3	5	1
Other Broadcast Receivers	7	0	4	4	4	0
Other Receivers	8	3	1	1	4	1
Other Transmitters	2	9	2	2	4	3
Broadcast Transmitters	3	4	6	6	2	5
Lighting Devices	15	13	4	10	15	7
Confirmed & Suspect Grow Lights[7]	---	---	---	2	16	6
Fence Systems	4	2	0	3	3	0
Battery Chargers / Power Supplies	1	1	3	4	5	7
Wheelchair	1	1	0	0	0	0
Water Pump Systems	3	2	1	2	2	0
HVAC Systems	11	6	3	10	6	5
Alarm Systems including detectors	6	0	4	2	4	2
Other Appliances	3	8	7	7	4	3
GFIC / AFCI	1	1	5	7	25	6
AUTOMOBILE Systems	4	3	2	7	1	1
Manufacturing and Retail Generated Noise	1	0	0	1	2	0
AT&T U-Verse Systems	10	8	8	3	4	6
PV Systems	---	---	---	2	1	3
Doorbell Transformers	---	---	---	2	3	0
Other			36	16	16	15

[7] It can be difficult to confirm a Grow Light. As a result, a number of other grow lights may appear as Unknown Sources. Based on their signatures, a number of Unknown Sources are most likely Grow Lights but remain unconfirmed.

It is important to note that power line noise has consistently been the most reported and problematic RFI problem reported to the ARRL Lab. As Committee member Ed Hare indicted, ***more hams suffer from power line noise right now than will ever suffer from BPL.***

ARRL RFI Forums:

The two RFI forums remain ongoing in the ARRL forums pages. These forums provide self-help and discussion for members. They are monitored and moderated by HQ Lab staff and other volunteers. The pages are:

- RFI - Questions and Answers
  - RFI questions and are answered by other members and RFI experts. Members can post questions and read answers about solutions to an RFI problem they are having. The link is: www.arrl.org/forum/categories/view/20

- RFI - General Discussion
  - This forum is a place to discuss technical issues associated with RFI and Amateur Radio. The link is: www.arrl.org/forum/categories/view/21ssion

Committees:

ARRL continues to be represented on professional EMC committees. Messrs. Hare and Carlson continue to represent the interests of Amateur Radio on the ANSI ASC C63® EMC committee. The C63® committee is working on developing industry standards for immunity, emissions and testing of electronic devices. ARRL serves as a resource to the committee to protect the interests of Amateur Radio.

Mr. Hare is the Primary ARRL C63® representative; Mr. Carlson is the Alternate. Mr. Hare serves as the Vice Chair of Subcommittee 5, Immunity. Mr. Hare also serves on Working Groups developing standards for the measurement of LF and HF wireless power-transfer devices, lighting devices and a Working Group writing recommended procedures to test various forms of Industrial, Scientific and Medical devices.

Mr. Ramie serves as the C63® Secretary and as a member of Subcommittee 5. Subcommittee 1 continues to work on a variety of EMC projects, primarily related to test site standardization. Subcommittee 5 deals with immunity and immunity measurement issues. Subcommittee 8 deals with various types of medical equipment. The multiple ARRL EMC-Committee representation on C63 watches immunity and testing developments.

Mr. Hare also serves on the IEEE EMC Society Standards Development and Education Committee (SDECom). SDECom serves as the EMC Society standards board, overseeing the development of all IEEE EMC Standards. He was also elected to serve a two-year term, starting January 1, 2015, on the on the IEEE EMC Society Board of Directors.

Related to committee work, Mr. Hare also maintains informal contact with a number of industry groups, including HomePlug, Society of Cable Telecommunications Engineers, Society of Automotive Engineers and the Electric Power Research Institute, as a few examples.

A list of the planned, recent and ongoing EMC activities at the ARRL Laboratory includes:

- Identification of several companies marketing industrial lighting ballasts for use in residential areas. The Lab helped Chris Imlay draft formal complaints to the FCC. To date, the FCC has not responded to any of ARRL's complaints about illegal emissions limits (grow lights) or to the complaints ARRL has filed about marketing. In early 2016, one of the marketers did respond favorably to Mr. Imlay.
- Continue to identify and test devices that operate above the FCC limits, including new grow-light devices.
- Develop standardized methods of locating RFI sources of harmful interference to Amateur Radio stations. Work with other Industry Groups to develop methods of best practices for location sources such as lighting controls, motor controls and power line noise.
- Investigate and document pulse-width specific radiated and/or conducted emissions limits for certain incidental emitters motor controllers used in appliances.
- Test a number of devices that belong to staff and/or local hams that have caused instances of harmful interference.

Mr. Gruber now serves as Chairman of a Working Group to develop a Recommended Practice for Location of Power Line Gap Noise. Additional EMC Committee members in this group include Messrs. Raimie, Carlson, Cramer and Boucher. This p1897 Working Group is sponsored by the EMC Society. The first formal meeting was held on December 10, 2015.

The Future of EMC and Amateur Radio:

Interference to hams appears to be the present major work of the committee. Although immunity problems still do occur, this is being addressed at the national and international standards level. RFI from unlicensed devices poses a major real threat to Amateur Radio at this time. This will continue to require significant Committee and ARRL staff attention. To the extent possible with existing staff, or with additional resources, the ARRL should increase its contact with standards organization, industry groups and individual companies, and continue to work on all aspects of RFI problems and solutions.

ARRL's information about RFI can be read at:

www.arrl.org/radio-frequency-interference-rfi.

As the Chair of the ARRL EMC Committee I am very honored to welcome Mr. James Roop, K9SE, to the ARRL EMC Committee as a new member, all of us on the EMC Committee look forward to working with Mr. Roop on the issues of Electromagnetic Compatibility as they apply to Amateur Radio.

As a note of personal thanks, I would like to recognize Mr. Hare, W1RFI, Mr. Raime, KI6LGY; Mr. Gruber, W1MG; Mr. Roop, K9SE; Mr. Hranac, N0IVN; Mr. Beatty, W2TTT ; and Mr. Steffka, WW8MS, for their authorship of material for this report, and to all of the EMC Committee members for their ongoing service to the ARRL and the Amateur Radio community.

Respectfully Submitted,

Kermit A Carlson W9XA
EMC Committee Chairman
Vice Director Central Division

List of Appendices