ARRL EMC Committee Report

Document # 16

For the
ARRL Board of Directors Meeting
July 16-17, 2021

Submitted by
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Chairman, ARRL EMC Committee

EXECUTIVE SUMMARY:

Three significant EMC issues have arisen as major challenges to continuation of interference-free access to the amateur radio spectrum. Two are sources of potential harmful interference which has been measured, researched, and documented by EMC Committees of the ARRL and the EMC Committees of other national amateur organizations. The emissions of these systems are subject to regulation in most countries. One of these types of potential interference sources, WPT-EV Wireless Power Transfer – Electric Vehicles, is in an experimental status with its governing regulations currently under development while PV, Photo Voltaic or "solar power", is being currently deployed under existing regulations.

The issue of WPT-EV presents the potential for harmful interference from what could become a ubiquitous presence of wireless vehicle charging systems. WPT-EV is notable because FCC and international rulemaking is underway. In the US, this is covered by FCC Docket 19-226. The ARRL has filed Comments and Reply Comments in the Docket 19-226 proceedings which are now part of the record. The League is also working with the IARU on the international rulemaking proceedings. Two main concerns are that first, no amateur bands be used for the fundamental frequency for power transfer and that second, that any impact to amateur operations by spurious and harmonic emissions cause less than a 1-dB increase to the background noise floor within the amateur bands.

The second issue, that of harmful interference to amateur operations regarding the installation of residential solar power systems, is the other main potential source of great concern. For installation into a residential setting such devices are regulated under FCC Part-15. There are rules for the standards that these devices must meet in order to protect licensed users of the spectrum within this residential setting. However, the only standards that apply in FCC Part-15 below 30 MHz are for conducted emissions into the AC Mains. There are no applicable limits that apply for radiated emissions below 30 MHZ, and there is no regulation of conducted RF between the solar panels, power optimizers and the power converter. The only applicable regulatory limit regulates that conducted RF from the power converter back into the AC Mains.

More and more states are legalizing recreational and/or medical marijuana. This is leading to an increase in the number of commercial "grow lights" being used in residential neighborhoods.

In past EMC Committee reports, ARRL has documented that many of the controllers for these lights significantly exceed the FCC emissions limits. The resolution of the resultant RFI cases represent significant challenges, with both technical and social issues making these cases more difficult.

The ARRL Laboratory and the EMC Committee has been working with industry both directly with manufacturers and standards committees for both issues. In the case of the solar panel industry the work by the ARRL Laboratory with the manufacturers has proven quite effective. This began with ARRL's cooperation with Solar Edge in the design improvements of that manufacturer's roof-top mounted optimizers. This work is ongoing. Due to the publicity that ARRL and others have generated regarding noise from solar systems, other solar companies have also contacted ARRL to discuss EMC issue and to discuss solutions and improvements they are making. This includes Generac, LG, Delta and EnPhase.

With regards to the potential for harmful interference arising from WPT-EV charging systems for transportation, the ARRL has been working with our sister EMC organizations, within industry standards groups and directly with manufacturers at some of the first deployments of WPT-EV systems in test range environments. This almost invisible and highly technical involvement in the establishment and refinement of standards produces a great impact on reducing the potential for harmful interference. The standards being proposed presently are for a field strength that combined with a typical reduction of un-necessary emission still creates a signal far above the noise background found at most amateur stations.

In the case of what was seen at one test of a WPT-EV the charging system covered the 40-meter band with noise that registered S7 at a distance of 32 feet to typical mobile amateur radio installation.

Each of the various issues addressed in this report could at minimum present the possibility for a 20-page synopsis for the Board. My suggestion is that at a future time that the Board be invited to meet with the members of the Committee in an electronic forum to discuss in more detail each of the issues regarding the known potential sources of harmful interference to amateur radio.

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 Director, EMC Committee Chairman
- Mr. Ed Hare, W1RFI, ARRL Laboratory Manager, Staff Liaison
- Mr. Paul A. Cianciolo W1VLF, ARRL Lab RFI Engineer
- Mr. Mike Gruber, W1MG ARRL Volunteer and past ARRL Laboratory EMC Engineer
- Mr. Riley Hollingsworth, K4ZDH, ARRL Volunteer Monitor Program Coordinator
- Dr. Gregory Lapin, N9GL, Chair ARRL RF Safety Committee
- Ms. Kristen McIntyre, K6WX. ARRL Pacific Division Director
- Mr. Bud Hippisley, W2RU, ARRL Roanoke Division Director
- Mr. Carl Luetzelschwab, K9LA, ARRL Central Division Vice Director
- Mr. Ed B. Hudgens, WB4RHQ, ARRL Delta Division Vice Director
- Mr. Ned Sterns, AA7A, ARRL South West Division Vice Director
- Mr. James Roop, K9SE, Supervisory Electronics Engineer, FCC, retired
- Dr. Richard E. DuBroff, W9XW, Professor Emeritus at Missouri University of Science & Technology
- Mr. Brian Cramer, PE, W9RFI, Commonwealth Edison
- Mr. Ron Hranac, NØIVN, past member of the Board of Directors, Society of Cable Telecommunications Engineers
- Mr. Jerry Ramie, KI6LGY, ARC Technical Resources, Inc.
- Mr. Gordon Beattie, W2TTT
- Mr. Ghery Pettit, N6TPT, Chair of CISPR Subcommittee I, past President IEEE EMC Society

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, review and publish articles about RFI
- Write and publish the ARRL *RFI Book*
- Design and update ARRL's RFI web pages
- Produce video content pertaining to RFI
- 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 but is not limited to the ANSI accredited C63® and the IEEE EMC Society Board of Directors.
- Work with the FCC Enforcement Bureau on RFI cases that require FCC intervention and to help resolve RFI cases sent to ARRL by the FCC.

In the first half of 2021, Mr. Cianciolo handled most of the staff work on EMC matters. He has assumed the duties of ARRL Product Review test engineer. Mr. Hare will assume the duties of ARRL RFI engineer until a replacement can be hired. The duties of the test engineer are:

- Responding to member inquiries about RFI issues and problems
- Adding updates and revisions to the ARRL RFI Web pages.
- Facilitating and providing assistance on resolving long standing power line noise and other RFI 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 lighting devices, including LED and grow lights. Issues concerning grow lights have been discussed in previous EMC Committee reports.
- Working with SolarEdge, Generac, Enphase, LG and Delta to resolve RFI from both PV panel optimizers, microinverters, and line tie inverters
- Reviewing proposed EMC related material for ARRL publications.

EMC Committee Participation in Industry and Standards Associations

The EMC Committee Members work on several Industry and Standards group such as IEEE and ANSI. The C63 Committee is mentioned several times in this report. As an answer to the question, "What is the C63 Committee?", the following section is included in this report.

Scope of C63®

C63® is an ANSI accredited standards committee that develops North American EMC standards. It included the following Subcommittees. Each Subcommittee has one or more working groups maintaining or developing various standards in its areas of expertise.

The Subcommittees and Chairs that report to the Main Committee include:

- SC-1 – Measurement and Instrumentation, Zhong Chen, ETS Lindgren
- SC-2 – Definitions, Marcus Shellman, US Dept. of Defense
- SC-3 – International Standardization, Ross Carlton, ETS Lindgren
- SC-4 – Wireless and ISM Equip. and Msrmnts, Bob DeLisi, Underwriters Lab
- SC-5 – Immunity Testing, Ed Hare, ARRL
- SC-6 – Laboratory Accreditation, Randy Long, ANSI Nat. Accreditation Board
- SC-7 – Spectrum Etiquette, Jason Coder, National Inst. Stds and Technology
- SC-8 – Medical Equipment Testing, Stephen Berger, independent consultant

Several of the standards developed by C63® are adopted by the FCC and FDA by reference in their rules.

The C63® membership is diverse, including manufacturers, industry groups, regulators, independent consultants. In this venue, ARRL is a representative of both a

radiocommunications service and a user of standards and products affected and controlled by them. More information on C63® and the scope of its work can be found on its web page[1].

Origin of C63®

The origin of the C63® Committee is still being researched, but its existence goes back at least as far as 1936. It may have existed earlier. Some of its earliest work was not only oriented toward American standards, but also focused on international standardization, through entities such as CISPR. Over the years, its stature has steadily increased, and although its focus is North American, its work is often harmonized internationally.

A good article describing more of the history of C63®is available at the link in Footnote 2[2].

Importance of C63® to amateur radio

A quick review of the list of C63® Subcommittees and membership shows a wide range of interests. ARRL's participation in this arena broadens ARRL's contact with key players in industry and with regulators. ARRL also brings the value of amateur radio to this professional table. Based on appreciation expressed by many participants and their desire to elevate ARRL participants to positions of leadership are yet another example of the value of ARRL's work with standards in general.

Although all industry standards are of importance to amateur radio, C63® may be one of the most important. C63® develops American standards that are often incorporated by reference into the rules by the FCC. At this time, this includes the following standards

Standard	**Brief description**
C63.4	Measurement methods
C63.10	Measurements of intentional unlicensed emitters
C63.26	Measurement of licensed transmitters
C63.19	Hearing aid compatibility with transmitting devices

The C63.10 standard on unlicensed emitters is of particular import because its section on distance extrapolation measurement methods is scientifically accurate. This was a major contention between ARRL and the FCC during the BPL proceeding. What was not won in that proceeding was ultimately won in the standards arena, as industry and regulators alike recognized the importance of scientifically accurate test methods. Achieving this in the C63.10 standard was a major step forward that is being adopted and refined into other standards. The task group that wrote this section of the standard was chaired by Mr. Hare.

[1] http://www.c63.org

[2] https://incompliancemag.com/article/the-ansi-asc-c63-committee-on-electromagnetic-compatibility/

ARRL Participation in C63®

ARRL's participating in C63® became especially important when Public Law PL-97.259 was adopted in 1982. This law gave the FCC the authority, but not the mandate, to regulate the immunity of consumer devices to strong RF signals. The FCC chose to implement that law by allowing the industry to create and adopt industry standards to regulate the immunity of devices. C63® undertook this work, forming a subcommittee on immunity that monitored progress in the industry to that end. ARRL became an active voting member of both C63 and the subcommittee on immunity, represented by then Atlantic Division Director Hugh Turnbull, W3ABC (SK).

ARRL has been a voting member of C63® ever since, with strong participation in the Main Committee activities, and participation in most subcommittees and a number of its working groups. As is often the case, as ARRL brings information and the value of amateur radio to industry standards groups, not only is the importance of amateur radio elevated in the perception of industry and regulators, ARRL staff are elevated to positions of leadership within these committees. ARRL is current represented by Mr. Hare as the primary representative and Mr. Carlson as the alternate. Mr. Hare is the Chairman of Subcommittee 5, Immunity and a voting member of the C63® Steering Committee (its ExCom).

SUMMARY OF RECENT AND ONGOING ARRL LAB EMC ACTIVITIES:

COVID 19 has impacted EMC problem resolution during 2020 and to some extent into 2021 in several ways.

- Workload has significantly increased due to many more amateur operators restricted to their homes. This has prompted an increase in cases being brought to the attention of the ARRL and the forwarded by the FCC.
- Response time from various utilities has been slower than in the past due to the lack of available staff, and qualified personnel to work on RFI problems.
- The general increase in the level of anxiety has been a factor between neighbor interactions when an RFI problem is being addressed.

Power-Line Noise:

Power line noise remains a significant problem facing hams today. Cases can drag on for years without meaningful FCC enforcement, often leading to frustration on the part of the ham. Much of the time ARRL spends on a case involves helping the Amateur understand the issues and how-to best work with his or her local power company and, most important, how the Amateur can correctly identify noise as being caused by electric- utility equipment and how to correctly identify the source. Although in theory, if power- company equipment causes interference, it is the responsibility of the power company to fix it, they can generally do so much faster if the complainant is able to identify the pole from which the noise is coming. The ARRL EMC desk has noticed a trend for amateurs to locate several possible RFI sources(poles) and report them

all to the utility, who will then address them only to find this has not resolved the amateurs line noise problem. The cost involved makes them hesitant to work further with that amateur. This an issue that HQ staff has been trying to resolve through education when speaking with the amateur, emphasizing the importance of signature analysis. Signature analysis is the correct manner to determine which noise source is the cause of the harmful interference experienced by that amateur's station.

P1897 Recommended Practice for handling Sparking Gap Noise complaints:

This IEEE Working Group continues developing an IEEE standard on the best practices for electric utilities to use to resolve power-line radio and television noise complaints. The group, chaired by Mr. Gruber, formerly an ARRL staffer, now an ARRL consultant, has been working cooperatively for over four years on this document. It is remarkably close to being finished.

The EMC Committee recognizes the staff and volunteer efforts of Mr. Gruber, the Chair of the WG. He is primarily responsible for the successful creation of this important industry standard. The standard is expected to be in ballot early in 2021 and should be published by the end of the year.

Mr. Cramer is the Vice Chair of the P1897 Working Group Additional EMC Committee members in the Group also include Mr. Carlson; Mr. Ramie, who serves as its secretary; Mr. Hare; Mr. Gordon Beattie; Mr. Hranac and Mr. Hollingsworth. The electric-utility industry is also heavily represented in this working group, helping to ensure acceptance and adoption of the standard when adopted. An important goal in developing this standard is to achieve the consensus with the utility industry, to ensure adoption and use of the standard.

Photo-Voltaic (PV) Systems (Solar Panels)

The California mandate:

It is extremely important to note that California has a mandate for new homes to include solar power PV as a power source. The California solar mandate is a relatively new building code that requires new construction homes to have a solar photovoltaic (PV) system as an electricity source. This code, which went into effect on January 1, 2020, applies to both single-family homes and multi-family homes that are up to three stories high. This appears to be only the beginning of a trend, that has the potential to become a problem nationwide.

Complaints involving residential solar PV systems continue to be on the rise and are, in fact, the dominant RFI issue ARRL staff has dealt with in recent months. ARRL has received multiple complaints involving several new manufacturers of solar equipment. SolarEdge, Generac, LG, Enphase, and Delta have been identified as major RFI contributors. Although all these manufacturers have Part15B certification, the problem of RFI continues. FCC Part 15B addresses conducted emission's concerning the AC line but does nothing to address the emissions from the DC side wiring to the PV panels and optimizers. There are two sources of RFI that have been identified ARRL concerning PV panel installations. The line inverter that

converts the DC output of the PV panels, typically 400 Volts to synchronous 220-volts AC, and the optimizers which are essentially a DC to DC converter that extracts maximum power from the PV panel while providing NEC rapid shutdown capabilities. Even with the PV system is shut down, the optimizers still generate RFI whenever sunlight is impinging on the PV panels. The severity of RFI is case dependent.

The ARRL is working with several of the manufacturers to resolve these issues. SolarEdge, LG, Delta, Enphase and Generac have been responsive in discussions on methods of RFI mitigation. SolarEdge has retrofitted in excess of 250 systems to the satisfaction of the amateurs afflicted. The resolution consists of replacing the AC inverter, the optimizers, rewiring the panels using twisted-pair wiring and adding ferrite common-mode chokes.

There is at least one case that appears to be difficult to resolve, though, with some residual noise present even after the retrofit has been completed. Resolving these RFI cases becomes challenging when several homes in a given area have implemented solar power near an Amateur operator. In many areas, homes are closely- spaced and Amateur antennas may be only 15 to 30 feet away from a neighbor's solar array. These retrofits are very time consuming and expensive. ARRL has reports from Solar Edge that indicate that as many as 9 systems needed to be retrofitted in the vicinity of a single Amateur operator in order to mitigate harmful interference.

Here again COVID has hampered efforts to retrofit systems, this was due to limited parts availability and travel restrictions. These delays are obviously not a welcome news for the affected parties.

Grow Lights:

Grow lights cases continue to increase as a source of RFI being second only to solar power. Many states have adopted various degrees of marijuana legality for both medicinal and adult recreational use. The typical grow light installations vary, but most grow lights operate between the 600 watt and 1000-watt level. The largest home grow light system Mr. Cianciolo has delt with is comprised of six 1000-watt ballasts. Most grow light ballast are imported and have no EMC filtering between the device and the AC mains. RFI varies on a case-by-case basis but S-9 noises levels within a one-mile radius have been noted in extreme situations.

In addition to RFI issues, once a source has been identified, the neighbor interaction can be difficult due the stigma attached this issue. It is not uncommon to hear stories of guard dogs and firearms when speaking with amateurs who have confronted neighbors on the issue of grow light RFI.

Other Lighting Devices:

Mr. Cianciolo reports that interference from lighting devices seems to be on the rise. Much of the problem to be caused by switching mode power supplies in low voltage lighting products. Some states mandate efficient lighting in new construction. Leading to wholesale installation of LED bulbs Another issue has been dimmers for LED bulbs. The solid-state drivers/ballast are

the chief causes. Commercial establishments wishing to lower energy costs are moving toward utility subsidized LED lighting fixtures. Some of which are causing RFI. These are being handled by ARRL staff, but the EMC Committee is continuing to monitor this as a potential threat to Amateur Radio.

An additional problem involves the sale and marketing of non-consumer rated ballasts to consumers in hardware and big box stores. These ballasts are still being sold to unsuspecting consumers and have been the subject of interference complaints to the ARRL Lab.

HVAC Equipment:

ARRL has received complaints involving several different types of HVAC equipment. One of these companies is Mitsubishi, the manufacturer of the HVAC system used at ARRL HQ. Resolution of these problems is still in progress. The ARRL Lab has devised filtering that can be added to the wiring of the system in operation at ARRL. This will be completed in the summer of 2021.

Other Appliances:

Residential devices are experiencing RFI from amateur radio operators as well. One such case involved a Samsung gas oven/stove which would mysteriously turn on the oven in the middle of the night. The cause was found to be a local amateur operator working 20 meters CW getting into the microprocessor control circuitry. Samsung replaced the oven with another unit and returned the problem unit to the factory for study.

Update on Samsung gas range. Since the January 2020 EMC report 5 more cases have been reported. RF immunity in these appliances appear to be severely lacking. Reported faults with these appliances range from erratic displays to stove turning on without input by the owner. Contact has been made with the Samsung engineering and several emails have been passed. Samsung did finally respond to ARRL's emails and phone calls but would not work with the ARRL. Samsung company policy dictates that communications will only be conducted with the customer. So far only one of the five afflicted amateurs has been contacted.

Wireless Power Transfer Systems:

Wireless Power Transfer (WPT) systems. WPT is used in two ways. The first is already widely deployed, through low-powered wireless chargers used to charge cell phone and similar devices. While there haven't been any reported cases of interference from low-powered WPT chargers so far, this emerging technology in the use or WPT for high-powered chargers for electric vehicles (WPT-EV) could have the potential to cause significant interference problems. This may be particularly true in cases involving high power, such as in a system used to charge an electric vehicle. We continue to monitor WPT development using industry contacts.

The most recent challenge to Amateur Radio spectrum is from potential interference from WPT-EV (Wireless Power Transmission – Electric Vehicles) systems. Appendix #1 shows the block diagram of one such system under development. This rapidly developing threat has been understood to be a large potential issue that must be addressed at national and international levels. ARRL staff is working the IARU on an ongoing basis. In 2020 and again in early 2021, Mr. Hare worked with Don Beattie, G3BJ and other IARU representatives, and ARRL's Jon Siverling, WB3ERA, to refute findings that WiTricity, a WPT-EV manufacturer, has been presenting into various international standards and regulatory proceedings (ITU, CISPR, CENELEC, etc).

The largest concern is that of harmonics and noise related to a high-power system where those emissions fall onto Amateur Radio spectrum. There is no doubt that there will be harmonics and noise arising from the use of such devices. In earlier testing, Mr. Hare and Mr. Don Beattie measured a WPT-EV system and found that it did meet FCC limits, but were at a level significantly above the median values of man-made noise described in the ITU-R Recommendation P.372-14. It was the conclusion of both representatives that this high level would cause significant harmful interference to amateur radio. The test site at this commercial EMC facility was located in a light industrial and commercial area. It had a noise level significantly higher than the median levels in P.372-14.

Since the coupling between the charging power source primary coil and the vehicle's receiving secondary coil will form an imperfect coupling system, the radiative leakage from this type of system has the potential to create harmful interference to nearby receivers. A misalignment between the two coils could also provide for the potential of power coupling to material other than the target of intended coil on the vehicle. The amount of stray field is particularly important since the estimated power transfer for a typical residential WPT charger system is expected to be in range of 10-15 kW.

The report that resulted from these measurements was ultimately compiled by the WPTEV manufacturer into a report that is has been using in various international regulatory and standardization efforts.

2nd Half of 2020RFI cases reported to the ARRL Lab:

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. In addition, over 150 phone calls were taken from members concerning RFI issues, that do not rise to the level of cases to be added to the data base.

Here are some statistics from the database for entire year 2020 compared to the previous six years. Data for 2021 are for year to date:

Case Type	2014	2015	2016	2017	2018	2019	2020	2021
Unknown Unintentional Radiators	81	49	70	73	56	47	60	40
CABLE TV	4	4	2	2	3	2	4	
Satellite TV	3	1	0	2	0	1	1	
Computing Devices and Modems	6	8	3	12	5	0	4	
Power Line Noise	51	43	47	44	47	28	32	22
Plasma TV Receivers	5	1	3	1	1	1	1	0
Other Broadcast Receivers	4	0	1	1	1	0	0	0
Other Receivers	4	1	6	5	0	0	1	0
Other Transmitters	4	3	3	2	13	5	5	0
Broadcast Transmitters	2	5	1	3	3	1	2	7
Lighting Devices	15	7	19	6	8	6	4	2
Confirmed & Suspect Grow Lights	16	6	12	11	10	6	9	8
Fence Systems	3	0	2	0	2	0	1	0
Battery Chargers / Power Supplies	5	7	9	6	1	3	4	0
Water Pump Systems	2	0	0	1	1	3	6	2
HVAC Systems	6	5	12	6	3	4		1
Alarm Systems including detectors	4	2	3	4	2	0	1	0
Other Appliances	4	3	10	7	5	3	3	0
GFCI / AFCI	25	6	5	6	6	7	10	0
Automobile Systems	1	1	3	5	1	1	1	0
Manufacturing Generated Noise	2	0	0	0	0	1	1	0
AT&T U-Verse Systems	4	6	1	2	0	0	1	0
PV Systems	1	3	10	24	10	12	24	17
Doorbell Transformers	3	0	2	2	1	1	1	0
Other	16	15	30	16	12	10	10	1

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

Messrs. Hare and Cianciolo are also regular participants in the RFI email list hosted by contesting.com.

FCC Enforcement Concerns:

While a lack of meaningful enforcement in cases involving operators of interfering Part 15 devices has been the norm for a considerable period of time, the issues described in the previous EMC Committee reports remain ongoing. A brief summary includes but not limited to:

- Grow lights and other devices being marketed and sold that exceed the FCC limits, in some cases by a considerable margin.
- Illegal marketing of Part 18 non-consumer lighting devices. Non-consumer devices are being marketed to consumers for residential environments. These devices are only intended for commercial and industrial environments.
- Field investigations are almost non-existent with abnormally long waiting times.
- Field investigations being conducted in such a way that the outcome will not be favorable to the Amateur. Examples include cases in which the investigation took place at times when the source was known to be off, checking for noise at random (unaffected) frequencies, etc.
- There is a growing proliferation of imported handheld VHF transceivers that are presenting problems for amateur radio. Some of these devices are not FCC certificated. Others are sold "wide open," to all comers, operating on the full VHF and/or UHF range**. A separate report of the findings of the ARRL Lab and recommendations is appended to this report.**

It must be emphasized that any FCC enforcement effort in any of these matters will have the maximum impact if it takes place in a timely fashion. Some cases have been ongoing for a considerable period 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 electronic devices and technology, some of which have the potential to cause a considerable interference problem, some meaningful FCC enforcement

is badly needed. A lack of enforcement 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 grow lights, or 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 meaningful enforcement could be expected in other interference matters as well.

SMART GRID AND EMC STANDARDIZATION MONITORING:

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The EMC Committee is also closely monitoring the development and proliferation of the Smart Grid. Mr. Ramie is involved in developing and promoting EMC Standards for the Smart Grid as the liaison between the IEEE-EMC Society and the Power & Energy Society of the IEEE. In that role, Mr. Ramie reports to Mr. Hare, the VP of Standards for the EMC Society. Here's a summary of recent activity:

P1613 - EMC Immunity testing of Communicating Devices - This is becoming the controlling EMC immunity document for any smart grid device in a substation blockhouse or out on a pole that has a communications port, including an antenna. Almost all smart grid controllers will communicate, so the COM port was used as a hook to attach immunity requirements to these products. (It calls out the three C37.90.x Standards below, all of which are under revision) This document is nearing completion and only requires text explaining the involvement of the EMC Society with the Power & Energy Society before it's done and ready for MEC and balloting.

PC37.90.1 - SWC & EFT Testing of Protective Devices (controllers for protective relays) – The Surge Withstand Capability (tolerance of switching transients) in this document is already harmonized with Europe under IEC 61850-3 and IEC 60255-26 draft. The Electrical Fast Transients (EFT) section will have the 100kHz rep rate added to address this frequency region that is filled with switch-mode power supply noise. Mr. Ramie reports that he is not expecting problems with moving this document forward. Mr. Raime expects to have a draft in 2 years or less.

PC37.90.2 - Radiated RF Immunity testing of Protective Devices: Changes made to this document, in response to Mr. Ramie's presentation to this working group, used Mr. Hare's ARRL modeling software to develop four Use Cases to justify the highest test level in the industry, at 35V/m peak (20V/m before modulation is applied). Mr. Ramie donated custom photography to make this section more compelling. This is a realistic level that was widely supported and not any higher than the previous version of this document. This document is very near completion and should go to MEC editing and formal balloting later this year.

PC37.90.3 - Electrostatic Discharge (ESD) testing of Protective Devices – This document is undergoing significant revision in response to Mr. Ramie's input. Controversy over the suggested edits seems to have died down and the working group is in the process of implementing Mr. Ramie's suggested text changes into the first working draft, which should be

ready before the end of 2021.

It is expected to take 2-3 years to complete this work. Mr. Ramie reports that cooperation is much improved now that TVA supports our efforts.

INDUSTRY CONTACT AND 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 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 is in his final term as the IEEE EMC Society Vice President for Standards. As the Vice President for Standards, he will be using an IEEE WebEx account to host the virtual meetings of about a dozen of the Working Groups at IEEE virtual symposium that will be held in August.

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.

Some of the testing of noisy devices that the ARRL could have done was put on hold due to COVID-related issues, the Lab will continue to identify and test noisy devices. A list of the planned, recent and ongoing EMC activities at the ARRL Laboratory includes:

- Continue to identify and test devices that operate above the FCC limits, including lighting 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.
- Test several devices that belong to staff and/or local hams that have caused instances of harmful interference.

HF NOISE FLOOR MEASUREMENT

During the World Radio Conference in the fall of 2019, there were several comments made by participants from other delegations that opined that the noise floor in rural areas was the same as that found in suburban and urban areas. This has immediate. implications should this inference be accepted as fact, absent any quantitative measurements since it has the possibility of allowing regulators to provide lower level of protection to sources from EMI sources in low-noise areas. Should the level of protection afforded to spectrum users be established at the level of the higher urban noise level environment, it would be at the detriment to the noise floor in suburban and rural areas. With the future now presenting the possibility of many high-power potential noise sources being introduced into common usage, there is a very real need to protect users of the amateur spectrum from a detrimental increase in "background noise".

Sources of the man-made portion of the radio background noise have been made as far back as the 1920's when there was noted to be a significantly higher background in urban and suburban areas attendant with the-then new modern use of electrical devices. There have been few measurements in the modern era since the mid-1970's. While most amateur stations have experienced some increase in the noise background experienced during normal operation, the evidence is extremely anecdotal. There is a serious need to replicate as best as possible the methodology used in the mid-70's to benchmark the noise background with qualified and calibrated receivers and antennas in an effort to determine the amount of increase over the past 50 years. Further, the methodology of any noise measurement effort should be established for an on-going long-term gathering and analysis of collected data.

For the past two years a sub-group of EMC Committee has been studying the various methods and technical issues that arise when making qualified noise measurements with calibrated antennas. The immediate goal has been to measure the noise floor of one remote site with defensible and technically correct methods of analysis, and to use the results of that analysis to refute the assertion that noise in rural areas is at the same level as urban locations. It is the hope to be able to eventually establish a network of noise measurement sites to measure long-term changes to the radio noise floor.

Members of the EMC Committee Noise-Measurement group are participating in the efforts of other similar monitoring and research system such as HAMSci and the TangerineSDR initiative. While the TangerineSDR/DASI does have a system parallel to the technical needs of the Noise-Measurement group, the TangerineSDR system is still at the board design level of development. The Noise Study group decided to proceed with the establishment of a noise measurement effort at an existing location in order to gain experience with the technical

challenges of establishing a noise measurement effort. While the TangerineSDR receiver would be a great tool, there are countless issues that need to be accomplished before the EMC Committee's Noise-Measurement group could ever consider adding a large base of monitoring receiver locations, not to mention the yet-to-be-accomplished final of the design for the TangerineSDR device.

The ARRL Laboratory will participate in the ENAMS noise measurement program that has been established by the DARC (Deutscher Amateur-Radio-Club). It was expected that there would be 50 such systems installed world-wide by the end of 2020 however the deployment was delayed for a variety of reasons. Two receivers and active antennas are expected to arrive in Newington soon. DARC (Germany) developed the ENAM system which can provide measurements close to the ITU-R methods and report measurements to a remote server. ENAMS uses an active vertical antenna (active E-field probes). The receivers are based on a Red Pitaya (https://www.redpitaya.com/). A technical description of the ENAMS receiver can be found here; (https://vienna.iaru-r1.org/wp-content/uploads/2019/05/VIE19-C7-datasheet-ENAMS-RX_2.pdf).

Mr. Hare has outfitted a mobile van with a loop antenna located on a trailer, a spectrum analyzer, computer and test receiver to make measurements of noise in the field. Initial tests indicate that this set-up can be used to measure noise in the field both at specific locations and in motion.

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 a note of personal thanks, I would like to welcome Mr. Ghery Pettit, N6TPT, who is the Chair of the CISPR Subcommittee I. My sincere thanks to Mr. Hare, W1RFI; Mr. Ramie, KI6LGY; Mr. Gruber, W1MG; Mr. Cianciolo, W1VLF; and Ms. Kristen McIntyre, K6WX for their contribution of material for this report. Thank you 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
ARRL EMC Committee Chairman
Director, ARRL Central Division

APPENDICIES

1. **ENAMS RECEIVER DATA SHEET** (https://vienna.iaru-r1.org/wp-content/uploads/2019/05/VIE19-C7-datasheet-ENAMS-RX_2.pdf)

ENAMS-receiving system

EMV-Referat, Joerg Logemann, DL2NI, Machtolsheim Feb.19th 2019

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ENAMS-receiving system

EMV-Referat, Joerg Logemann, DL2NI, Machtolsheim Feb.19th 2019

1. Antenna

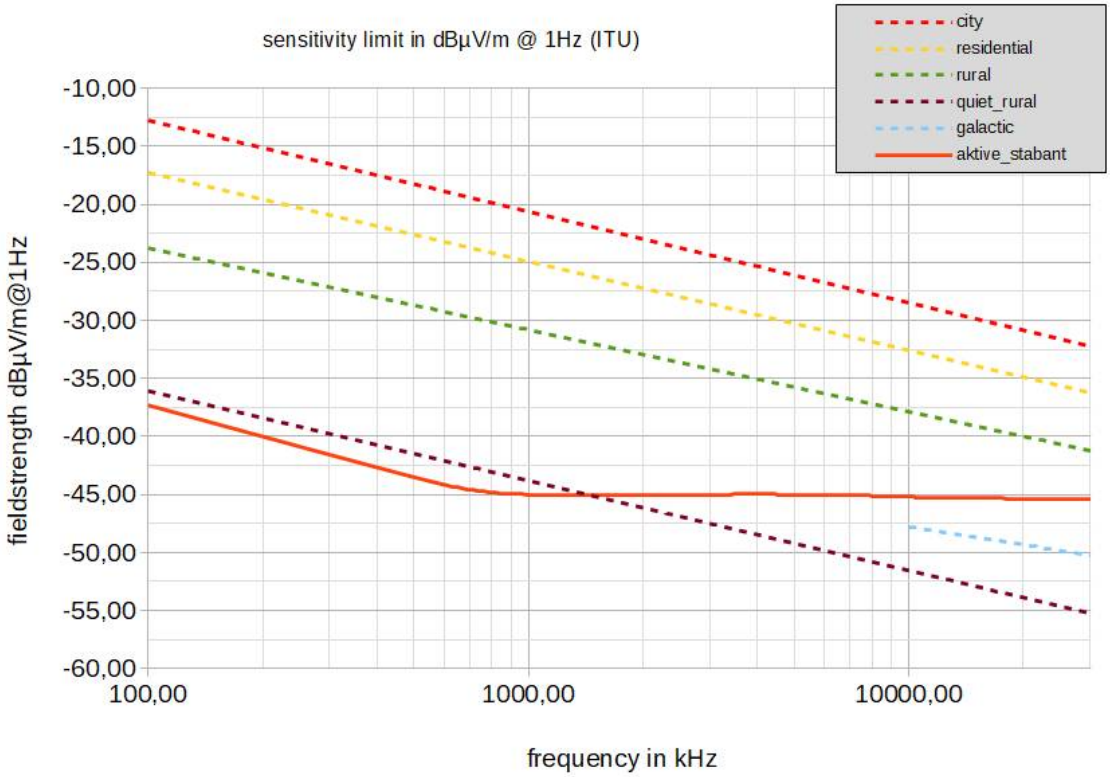
Principle: active e-field sensor, k-factor=1 (variable by changing resistor values), power supply via coaxial cable

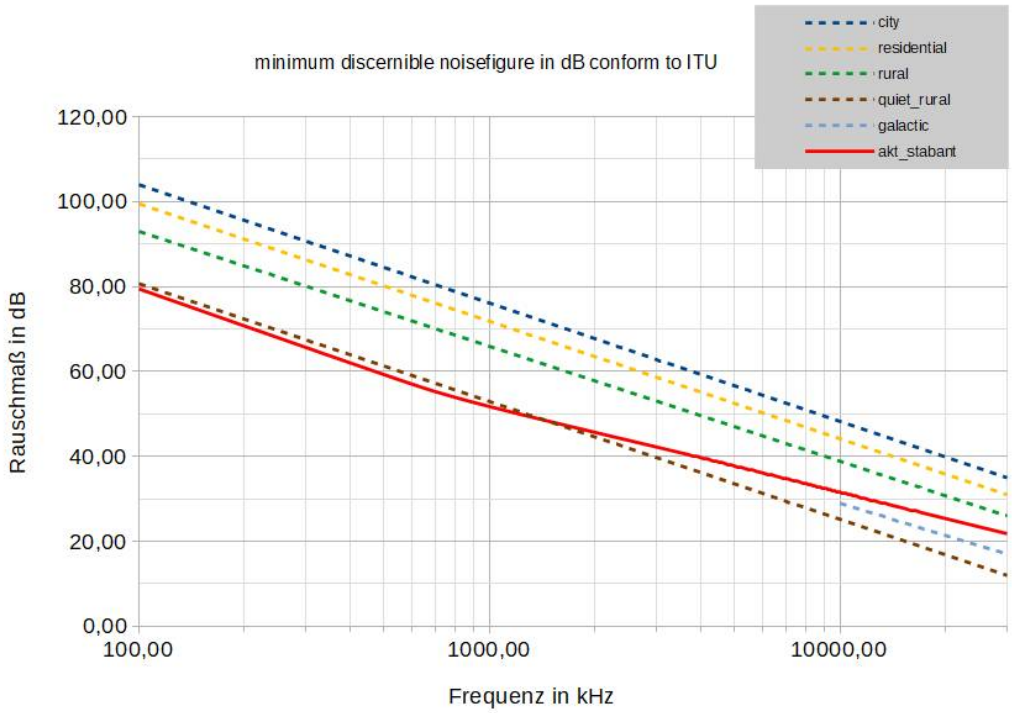
1.1. Measured Values

effective height by mechanical dimensions, 1m radiator, 1m stand, 8 radials	h_N = 1,5 m
electrical gain at 50 Ω load und 9pF antenna substitute	v = -3.5 dB
resulting k-factor	k = 1.0 m^{-1}
k-factor logarithmic	k‘ = 0 dB/m
input capacity	C_i = 8,6 pF
input resistance	R_i = 5 MΩ
output resistance	R_A = 50 Ω
OPIP2	+56 dBm
OPIP3	+43 dBm
1dB-compression (output)	+11 dBm

note: gain and k-factor can be changed by replacing resistors

1.2. Sensitivity Diagrams





2. Receiver

A Red Pitaya 14bit is being used as receiver supplemented by a diplexer network, a lowpass and 2 preamplifiers forming the frontend. For dynamic improvement purposes the 2 available A/D-channels of the red pitaya are used in 2 frequency ranges with different gains. The diplexer cutoff frequency is 8MHz, thus a range up to 8MHz and another 8MHz to 30MHz is implemented. The frontend also contains a 32MHz lowpass of 5th order. The gain of the 2 preamplifiers can be dimensioned independently to optimize dynamic, 10dB (low band) and 20dB (high band) are used momentary. Furthermore the frontend contains a bias-T and a current limiter for the 15V supply of the active antenna.

Attention when measuring the frontend: the antenna input is connected to the $15V_{DC}$ powersupply for the antenna permanently! Use a DC-Block!

2.1 Red Pitaya

Software: HDSDR, input attenuator of RP deactivated (jumper in middle position), external 50Ω load applied (with T-connector)

2.1.1. Intermodulation, f1=11,05MHz, f2=11,1MHz (RP only)

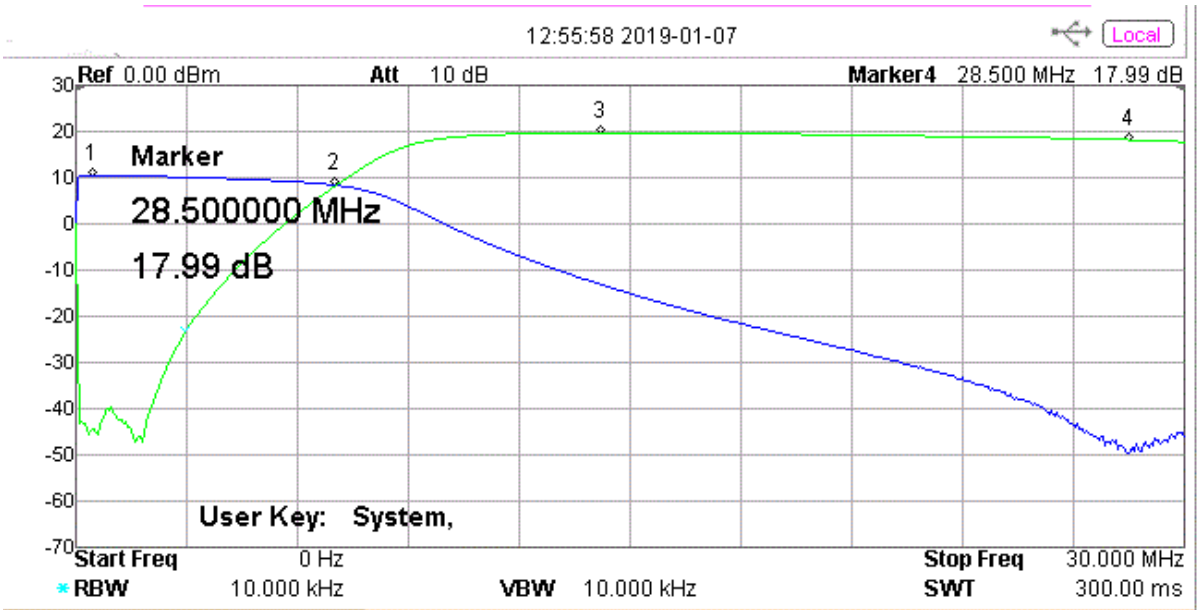
input level	measured	IM	IP3
2 x -30dBm	2 x -42dBm	68dB	+4dBm
2 x -20dBm	2 x -32dBm	72dB	+16dBm
2 x – 10dBm	2 x -22dBm	71dB	+25,5dBm
2 x -3dBm	2 x -15dBm	65dB	+29,5dBm

2.1.2. Noisefigure and Dynamic

The noise figure was measured with the noise generator SUF2 (R&S). A noise level of -133.9dBm/Hz caused a noise increase of 3dB. Thus the resulting noise figure is **F=40.1dB**. For comparison: ELAD FDMS2: F=18.1dB, Perseus: F=23.1/25.5dB with and without preamp. Maximum input level (fullscale A/D converter) is +5dBm.

2.2 Red Pitaya + Frontend (complete receiver)

2.2.1. Frequency Response and Gain of Frontend



Marker Table

Marker	Trace	Type	X Axis	Amp
1D	1	Frequenz	450.000 kHz	10.34 dB
2D	1	Frequenz	7.000000 MHz	8.20 dB
3D	2	Frequenz	14.200000 MHz	19.55 dB
4D	2	Frequenz	28.500000 MHz	17.99 dB

2.2.2. Noise at Output of Frontend with and without Antenna

noiselevel at output, lowband (5MHz) without antenna P_R = -158,6dBm/Hz

noiselevel at output, lowband (5MHz) with antenna P_R = -142,6dBm/Hz

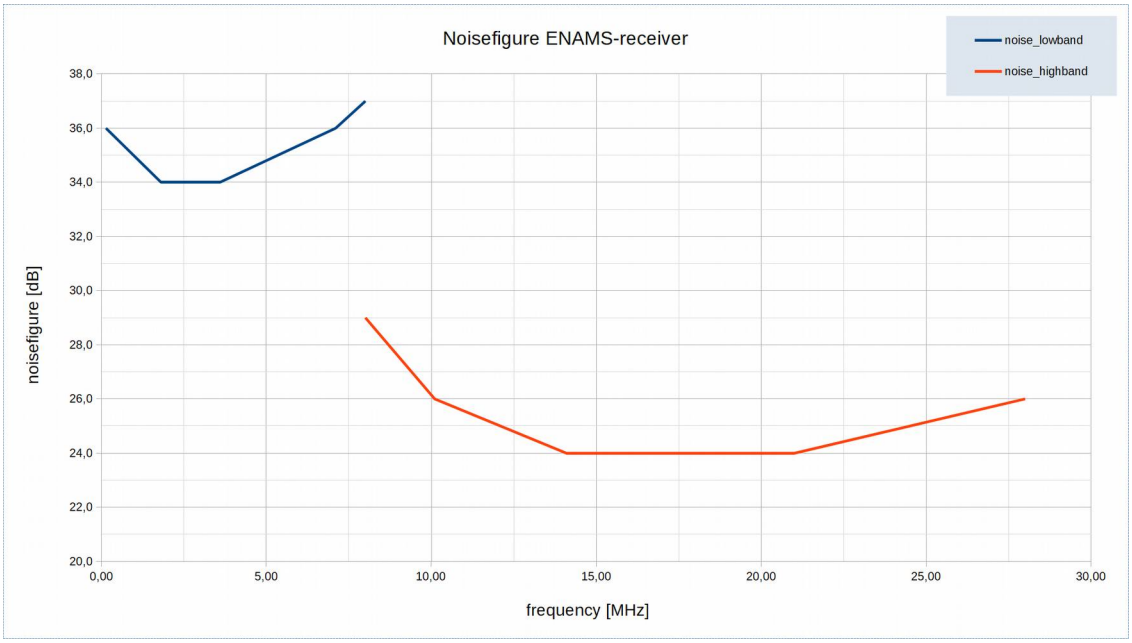
noiselevel at output, highband (14MHz) without antenna P_R = -148,6dBm/Hz

noiselevel at output, highband (14MHz) with antenna P_R = -130,5dBm/Hz

When measuring „with antenna“ the radiator was removed and substituted by an equivalent load (9pF).

2.2.3. Noisefigure with Preamp

noisefigure complete RX:



2.2.4. Input Level Limit (Fullscale) with Preamp

lowband	-2dBm
highband	-13dBm

2.2.5. Intercept Point

lowband (6,0 / 6,5MHz)

IP2 @ 2 x -20dBm	+52dBm (summ) / +56dBm (diff.)
IP3 @ 2 x -20dBm	+20dBm

highband (10,0 / 19,0MHz)

IP2 @ 2 x -20dBm	+37dBm (summ) / +49dBm (diff.)
IP3 @ 2 x -20dBm	+10dBm

2.2.6. Spurious

Frequency [MHz]	level [dBm]
0,110	-115
0,220	-113
2,148	-115
2,258	-116
11,303	-116
13,566	-117
18,088	-116
25,000	-118
29,395	-116