

Broadband Over Power Line and Licensed Radio Services

**Ed Hare, W1RFI
ARRL Laboratory Manager
225 Main St
Newington, CT 06111
w1rfi@arrl.org
860-594-0318
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Rules of W1RFI's Presentations

- It is okay to get up and leave!
- Everybody has to laugh at my jokes!
- I am the only one allowed to tell any jokes!
- Ask questions any time.
- Falling asleep. . .

About your presenter

- **Ed Hare, W1RFI, has worked for ARRL since 1986**
- **He manages the ARRL Lab**
- **He has been ARRL's RFI "guru" for most of his career at ARRL HQ**
- **He is the author/editor of "The ARRL RFI Book" and "RF Exposure and You"**
- **He serves on a number of industry committees**

ARRL

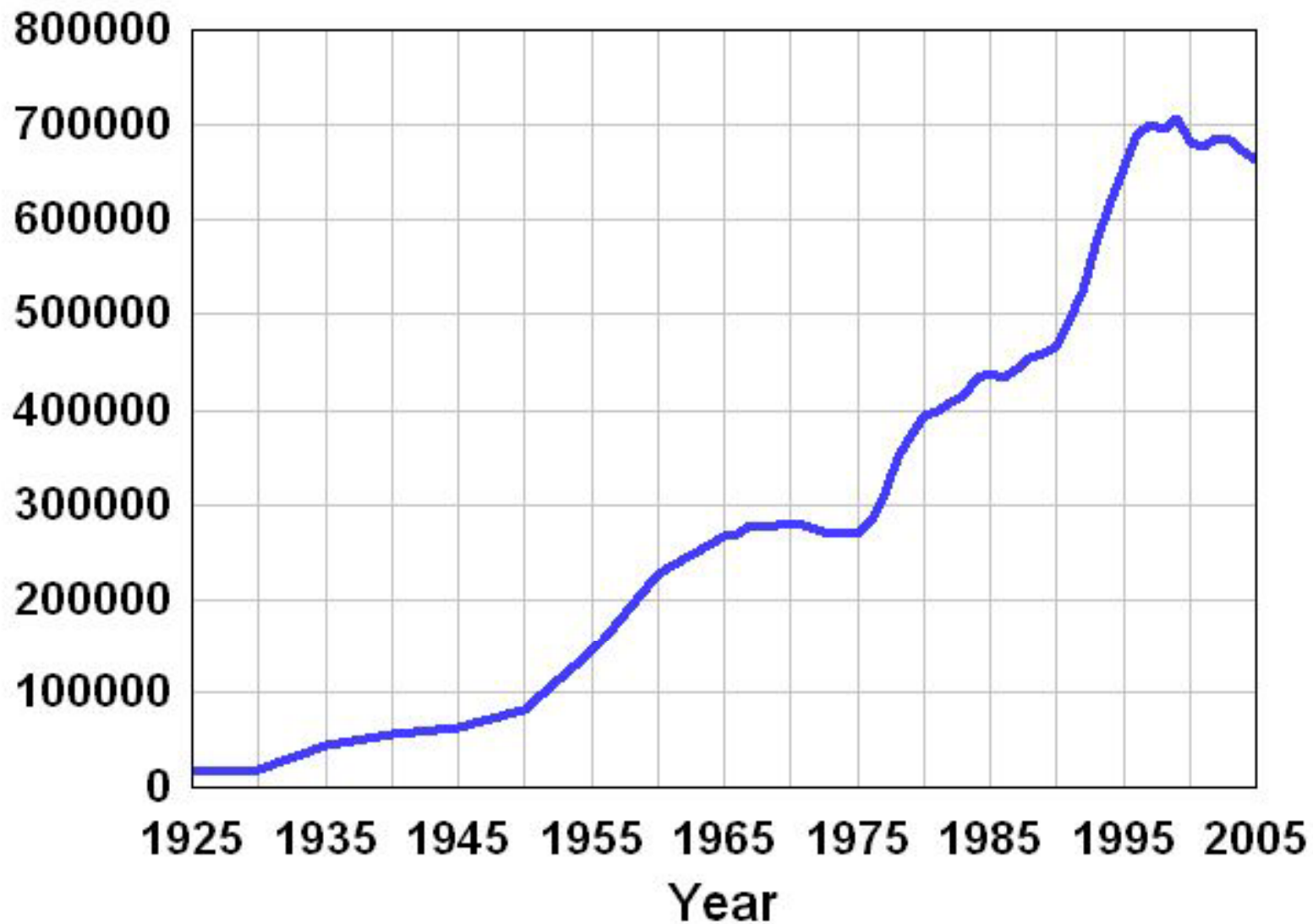
- **ARRL is the National Association for Amateur Radio**
- **Represents the interests of Amateur Radio in the US**
- **150,000 members**
- **650,000 licensed Amateur Radio Operators**

Value of Amateur Radio

“Amateur radio provides a vital public safety communications service to the public at no cost to taxpayers,” said Israel. “So-called ‘hams’ provide emergency communications when regular channels are disrupted or disabled. State and local governments, as well as disaster relief agencies, could not possibly afford to replace the services that radio amateurs dependably provide for free.”

Myth: Amateur Radio is dying

Number of Licensed US Amateur Licensees



Chapter 6

Other Radio Services

Amateur and Amateur-Satellite Services

The amateur service is defined internationally as "A Radiocommunications service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest." [EN574] Radio amateurs are trained and experienced in electronics, propagation theory, and communications techniques. [EN575] Amateurs also respond swiftly and effectively to calls for communications assistance when normal channels are lost. The amateur service has significantly contributed to the development of radio technology. Amateur operators continue to fulfill certain public service radiocommunications requirements, and increase their skills relating to emergency communications. During natural disasters such as hurricanes, floods, and other events, amateur radio communications have been particularly effective, and in many cases have been the sole means of communicating from the scene of a disaster.

The amateur-satellite service was formally created as a result of the 1971 World Administrative Radio Conference for Space Services. At that Conference and the 1979 WARC, both primary and secondary frequency allocations were granted to the service. Many of the secondary allocations are provided as a result of international Radio Regulation 664.

Amateur, or "ham" radio operators, have provided a unique service to the public while enjoying a popular, technical hobby. Many innovative uses of radio systems have been developed by amateurs for use in the amateur bands, such as packet-switched systems and amateur television. It is estimated that there are in excess of 632,000 amateur radio operators in the United States, and over 2.4 million worldwide. [EN576]

Myth: BPL users will outnumber Amateur Radio operators so BPL will be given priority

- **Under the FCC rules, licensed users are protected from unlicensed interference**
- **Cable TV users, telephone users, computer user and even electric-utility customers outnumber Amateur Radio**
- **The FCC has not taken any opportunity to change the rules governing the above users**
- **In the recent BPL Report and Order, the FCC did not change the rules that unlicensed operation must not interfere**
- **Giving unlicensed operation priority over licensed users would be a major paradigm shift**
- **If any in the industry are counting on such a rules change, that is a risky proposition**

ARRL and BPL

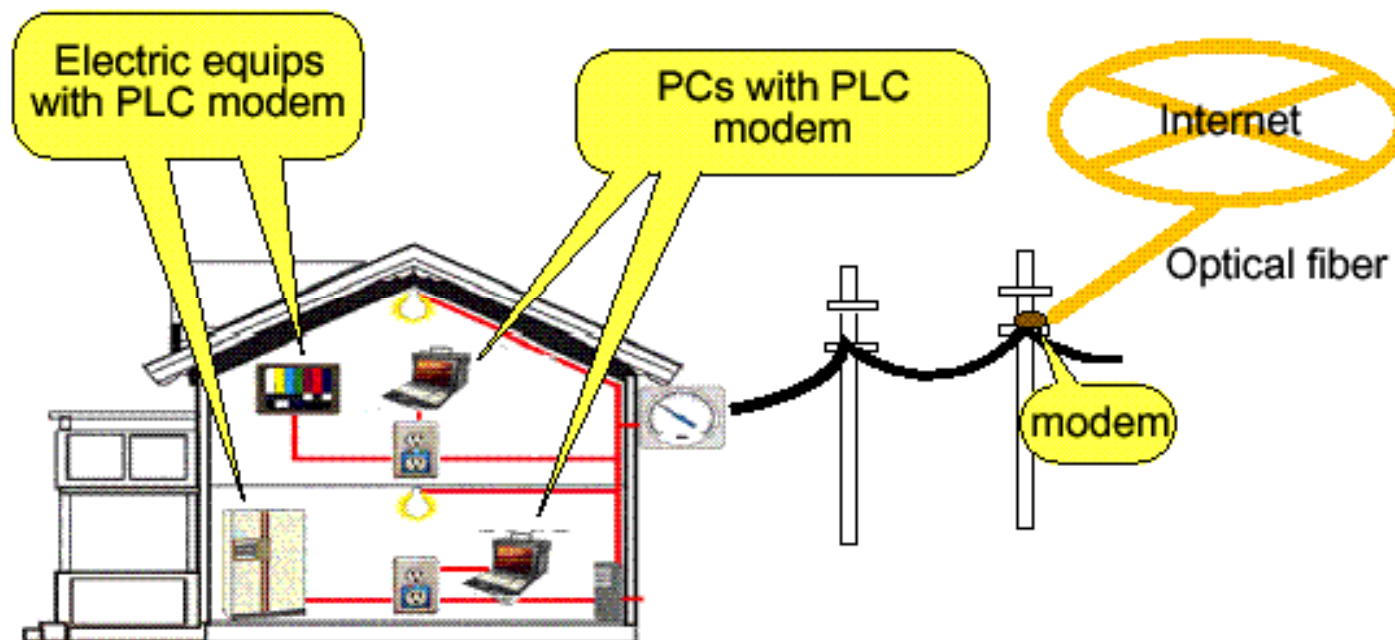
- **ARRL's interest in BPL is related only to its EMC aspects**
- **Other than EMC issues, BPL should be allowed to succeed or fail on its own merits**

Why BPL?

- **Manufacturers not here, so I will represent them**
- **Broadband at every outlet**
- **Electrical wiring not as good as coax and Cat 7 wiring**
- **Broadband to rural areas**
- **NARUC report notes that latency and costs may make that impractical, although rural communities can be networked**
- **Utility applications – Most valuable use of BPL**
- **In-premise, multi-dwelling unit**
- **Meter reading; voltage monitoring; equipment control; video monitoring**
- **ARRL helping BPL being successful**

What is HF PLC? (1)

Broadband Network Realization using Existing Power Line



In the US, Regulated by FCC

Part 15

- **On October 14, 2004 the FCC made significant changes to the rules governing BPL**
- **Although this was seen by some to mean that the FCC now allowed BPL, it had been legal all along under existing FCC rules**
- **The new rules place new restrictions on BPL that are intended to control its interference potential**

What Are the Rules?

- **BPL regulations apply to BPL operating between 1.7 and 80 MHz. Outside that range, BPL operates under general provisions of Part 15**
- **Absolute-maximum limits defined in Part 15**
- **Carrier-current must meet limits for intentional emitters**
- **Part 15 also is clear that unlicensed devices such as BPL must not cause any harmful interference and they must accept any interference caused to them**
- **Manufacturer responsible for FCC authorization and maximum limits**
- **Operator responsible for harmful interference**
- **Both components to the rules are necessary for Part 15 to work**

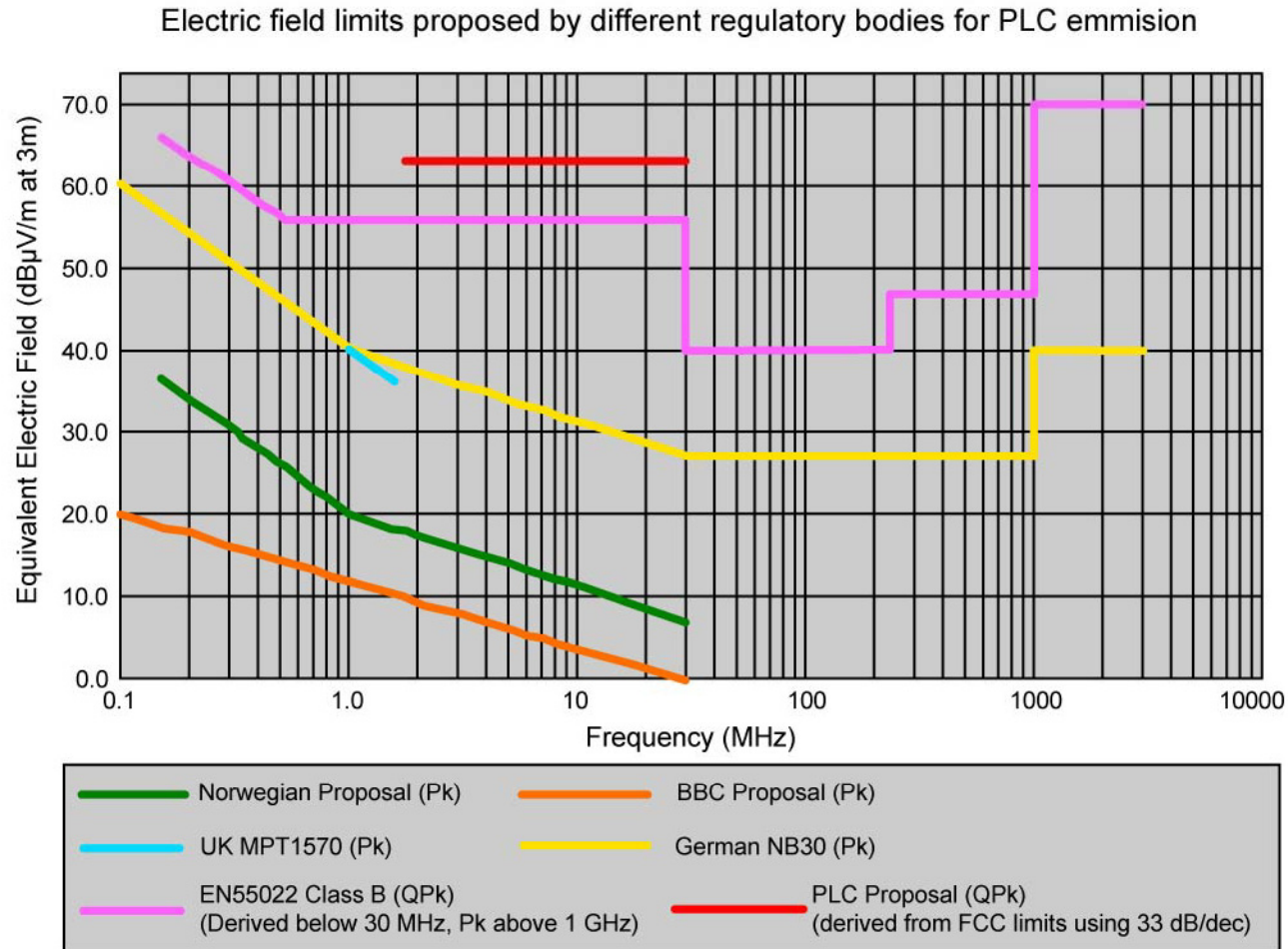
What is New?

- **Publicly accessible BPL-location database with ZIP code location and contact information**
- **Mandate to have ability to control frequency, power level and shut off**
- **Certification instead of Verification**
- **FCC said interference would be “very rare” but carved out 12 blocks of government spectrum that access BPL using overhead MV lines couldn’t use**
- **For BPL only, Mobile interference defined with a noise level of 20 dB lower than BPL limits**
- **Devil in details – will define what constitutes interference?**

Intentional Emitter Radiated Emissions Limits

- **Sec 15.209**
- **1.705-30.0 MHz -- 30 μ V/m at 30 meters, quasi-peak measured in 9 kHz**
- **30-80 MHz – 90 uV/m at 10 meters, quasi-peak measured in 120 kHz**
- **On VHF, Class A limits apply to medium-voltage, primary distribution lines, even in residential neighborhoods**
- **Class B limits apply to LV lines**
- **Hybrid devices that operate on both MV and LV lines use Class A limits**

Levels: International work in progress: FCC levels much higher than other nations or proposals



Will BPL limits protect radio services?

- **No!**
- **If the absolute emissions limits were set to offer unconditional protection to all radio services, the permitted levels would be unworkably low**
- **Amateur Radio Service, by design, uses sensitive equipment and weak signals**
- **The “legal limit” will result in a strong signal to nearby amateur HF installations**

Will BPL limits protect radio services?

- **On 3.5 MHz, a half-wave dipole placed in a $30\ \mu\text{V}/\text{m}$ field will receive a $-86.4\ \text{dBW}$ signal ($338\ \mu\text{V}$ across $50\ \text{ohms}$)**
- **To amateurs, this is S9+16 dB – clearly harmful interference to typical amateur communications!**
- **Harmful interference at even greater distances than the compliance distance is likely**
- **The absolute limits are not enough to prevent interference to nearby receivers**

Meeting the FCC emission limits is not enough to protect against causing harmful interference.

Interference to radiocommunications can occur from emissions that are 50 dB lower than the permitted levels.

Effectiveness of present rules for other unlicensed devices

- **They work – to a degree – to control interference from most unlicensed devices**
- **Most devices do not emit on wide range of frequencies**
- **Most do not emit all the time**
- **Most do not emit over large geographical area**
- **Examples: Computer birdies and outside lights**

How BPL is Different

- **Broadband**
- **Emit most of the time**
- **Emit over large area**
- **As built out, could be as big as an entire state?**
- **Significantly different interference potential**
- **Maintenance issues**

The Bottom Line

- **The legal limits result in strong signals to nearby receivers**
- **Nearby receivers that will receive interference if they are trying to receive signals on the same spectrum as analog signals**
- **In residential neighborhoods, the risk is typically to Amateur Radio, Citizens Band and international shortwave broadcast**
- **Other services are affected, but those services will have to speak for themselves and analyze BPL levels with respect to their own needs**

What is needed?

- **It is critical that all unlicensed emitters that operate anywhere near the FCC limits avoid locally used spectrum**
- **To avoid degrading a licensed service, typically, a 1 dB degradation is used**
- **This would require that noise be 6 dB lower than the desired signal**
- **If the median values of man-made noise are used for N , then the level of BPL emissions at the receive-system antenna on spectrum that must be protected would range from 0 dBuV/m on lower HF to -10 dBuV/m on upper HF**
- **This would generally protect mobile operation, and most fixed operation**

What is needed?

- **The values of man-made noise in ITU-R P378-2 are median values**
- **Lower noise levels are common in communications channels used by services with frequency agility**
- **At some stations in the Amateur Radio Service, field strength at the antenna of -20 dBuV/m in quiet areas and times of a given band are common**

How can compatibility be achieved?

- **Notching is a technique whereby BPL use of certain portions of spectrum is turned off**
- **Notching is typically 20 to 30 dB notch depth**
- **This is not enough to achieve the levels in the previous slide if starting at the FCC limits.**
- **To achieve compatibility with nearby radio services, operating at a lower emissions level and putting additional guard bands around spectrum that is being protected is necessary**

How can compatibility be achieved?

- **One way that the a lower operating level could easily be achieved with minimum changes to the rules would be to use a smaller distance extrapolation factor.**
- **A formula that used about 30 dB/decade at 1 MHz, decreasing to 20 dB/decade above 30 MHz would match modeled and measured results**
- **A simplification of this to 23 dB/decade would be a reasonable approach**
- **This would allow the typically achieved 25-30 dB notching to be adequate to protect HF and low-VHF mobile stations**

How can compatibility be achieved?

- Some fixed stations require additional notch depth
- One BPL manufacturer has shown that it is practical to do this with hardware filters
- These filters also help with ingress
- They can be used in all of a product line, or be applied on a case by case basis where need, if they are available

The goal is NOT to try to design systems or regulations that have no potential for interference. That would not be reasonable or practical. An attainable goal is to design systems that have a low-enough incidence of interference that it is practical to resolve that interference on a case-by-case basis. This requires the additional goals of having that practical solution available and to use those solutions where necessary.

Harmful Interference

- **Defined as the repeated disruption of radio communications or any disruption of certain emergency communications services**
- **Merely hearing a signal is NOT harmful interference**
- **$30\ \mu\text{V}/\text{m}$ at 30 m works to a degree for discrete frequency signals**
- **If from broadband device, however, will interfere with entire band(s)!**
- **$30\ \mu\text{V}/\text{m}$ works to a degree for isolated point sources**
- **If from PLC, level will occur for entire length of line in areas where access PLC is deployed!**

Harmful Interference – the BPL Perspective

"It is Progress Energy's position and interpretation of the FCC's rules with regard to 'harmful interference' that any interference that may still exist is not 'harmful' as that term is defined by the FCC's rules," Len Anthony, PEC's attorney for regulatory affairs, told James Burtles, chief of the FCC's Experimental License Branch. "This level of interference does not seriously degrade ham radio operation or transmissions or cause repeated interruptions."

The FCC defines as "harmful" any interference that "seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with the *Radio Regulations*."

Other BPL Industry Quotes

- **“Amateurs think that any interference is harmful.”**
- **“The FCC should determine that only interference that completely obliterates a signal is harmful interference.”**
- **“The BPL industry engineers are the experts, not armchair amateurs using vacuum-tube equipment.”**
- **Would they apply these same standards to the performance of their office telephone systems?**
- **One more quote: “We want to work with Amateur Radio to design a BPL system that will not cause interference problems for Amateur Radio.” – Motorola**
- **Some other BPL manufacturers working with ARRL to varying degrees.**

Probability

- **If a tree falls in the forest...**
- **BPL interference is local**
- **If it operates on spectrum not in use nearby, there will be no interference**
- **Low probability of interference?**
- **Most of the time, BPL won't cause interference because radio use is sporadic**
- **For individual user, high probability of interference**

Is it Interference?

Click on speakers to play sound

- 14 MHz Amateur
Band 5 miles from
BPL site



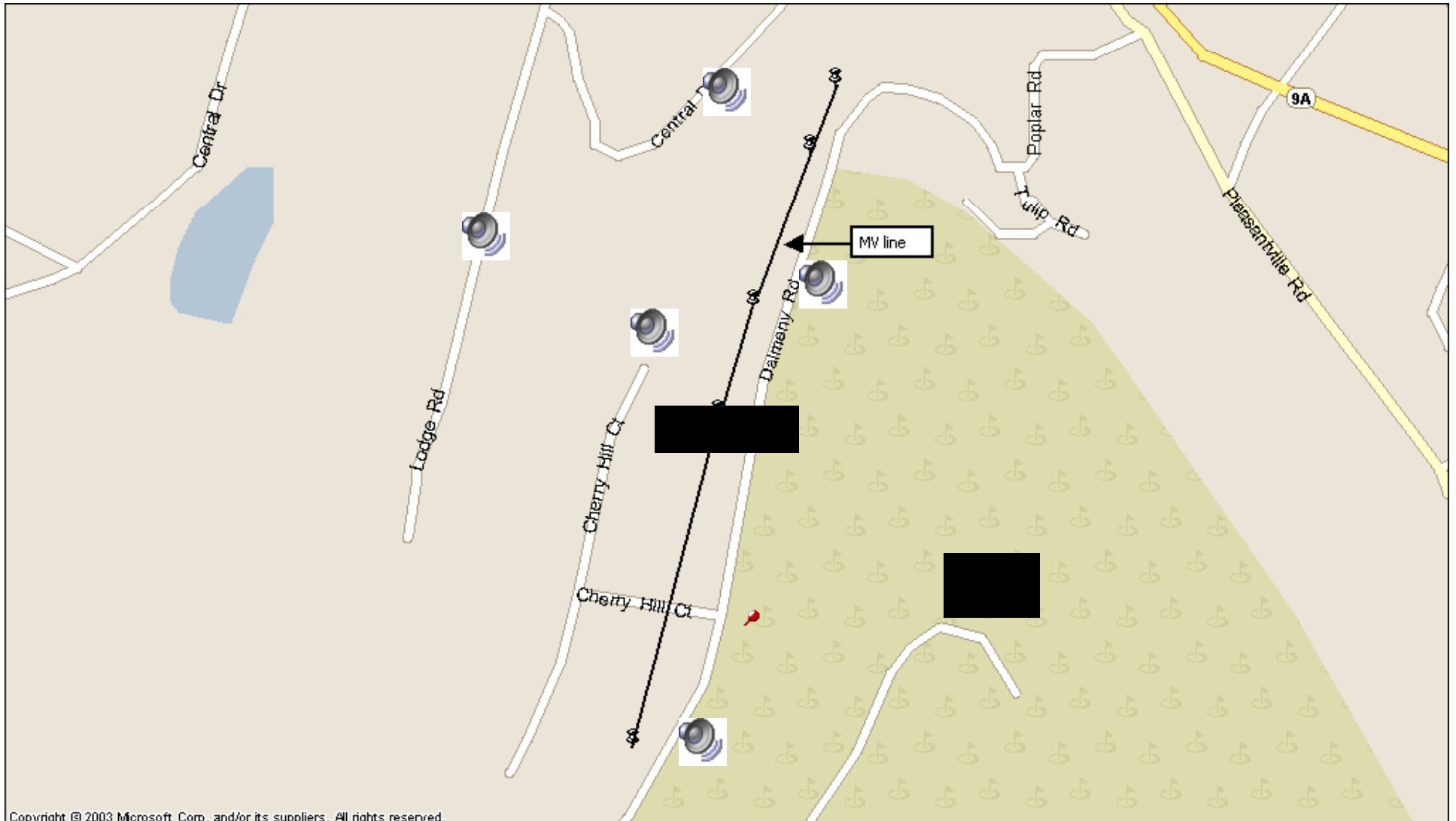
- Same communications
channel, same time,
within BPL area



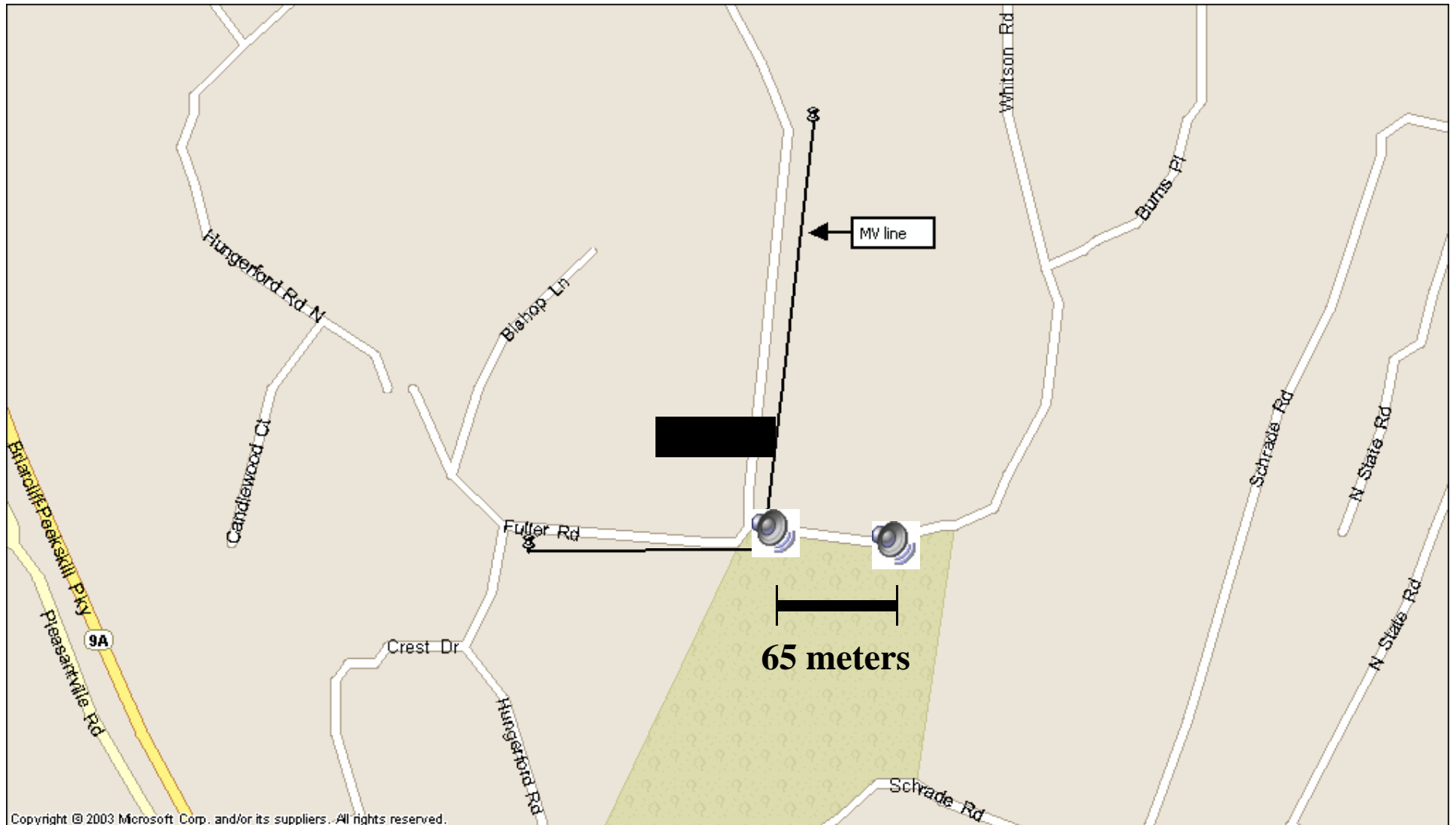
Distances From BPL Power Lines Within Which Interference Is Likely

Desired Signal Level Service		LOW – MODERATE	MODERATE – HIGH
Land Mobile Station		125 m	55 m
Fixed or Base Station (for Mobile)		770 m	450 m
Maritime Shipborne Station		135 m	85 m
Aircraft	6 km	33 km > 50 km	12 km -
alt: in Flight alt.	12 km		

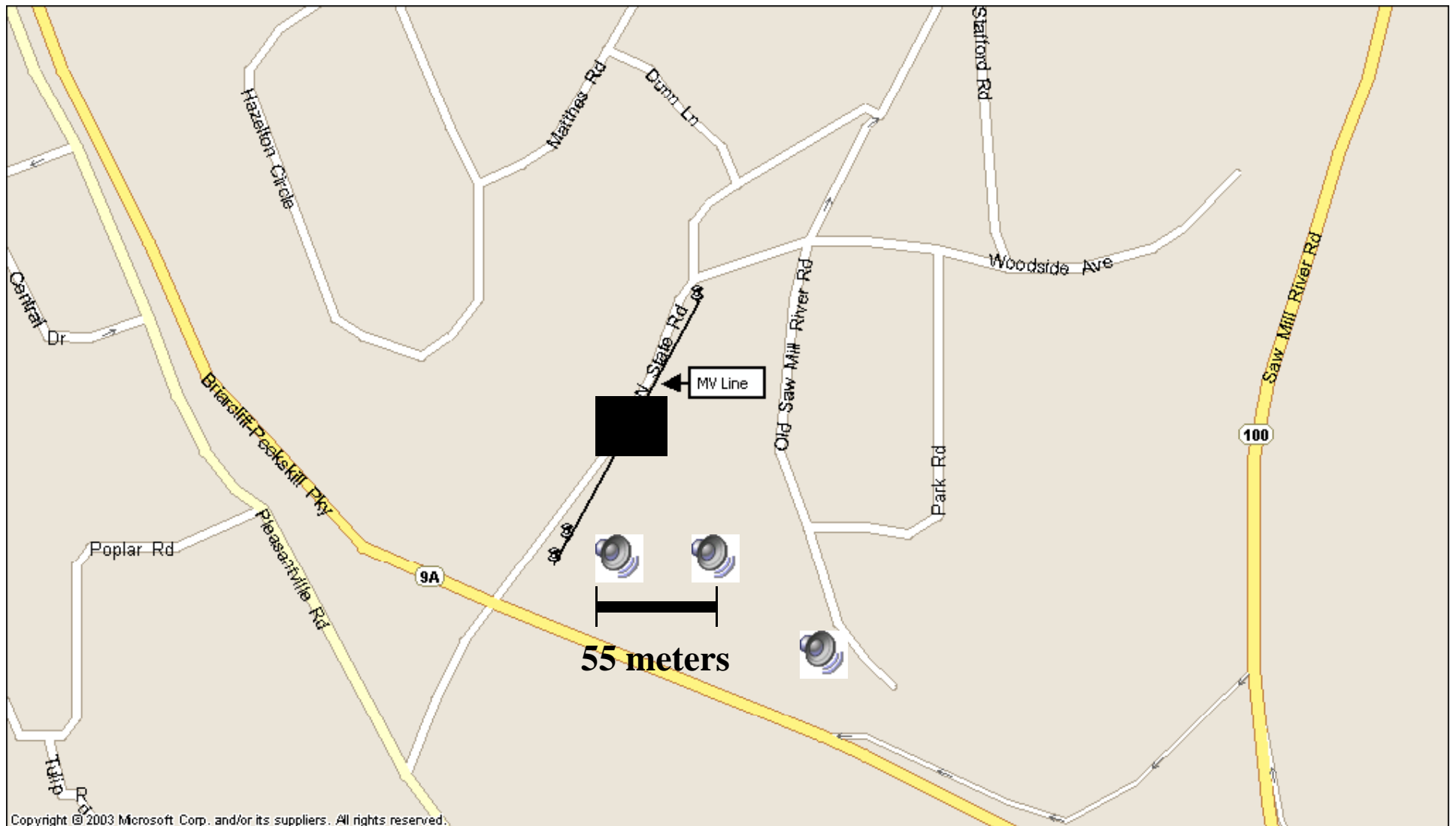
BPL at various locations in a BPL area. Injector is near point labeled “MV line” – Click speakers to play sound



The left speaker was recorded 10 meters from the BPL injector. The right speaker was recorded 75 meters from the injector. The power line does NOT run down the street where the recording was made.



This was recorded in a parking lot, with no power lines in the lot. The left speaker was 15 meters from the power line. The middle speaker was 70 meters from the power line and the right speaker 125 meters from the power line.



**Even if interference is rare, it must
be corrected when it occurs.**

To avoid interference, BPL must avoid locally used spectrum

- **Fixed and mobile commercial and military**
- **Fixed and mobile VHF public service**
- **In residential areas:**
 - **Amateur**
 - **CB**
- **International shortwave broadcast**
- **Fixed licensed stations relatively easy**
- **International shortwave broadcast receivers at unknown locations**
- **Mobile stations of all sorts impossible to predict**

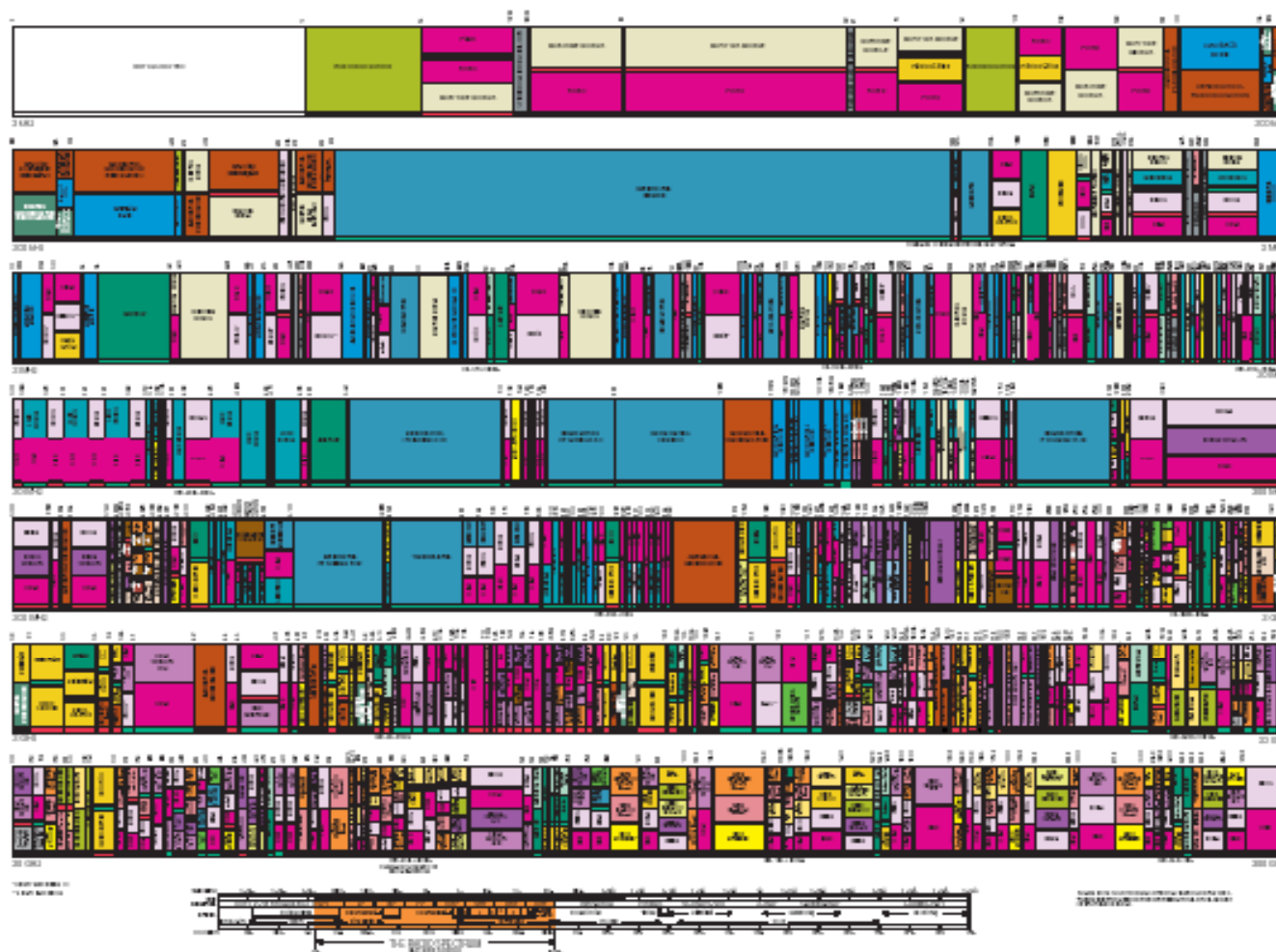
Amateur HF and VHF stations

- **Bands at 1.8, 3.5, 5.1, 7.0, 10.1, 14.0, 18.1, 21.0, 24.8, 28.0, 50 and 144 MHz**
- **Receiver sensitivity –165 dBW (0.04 uV)**
- **Ambient noise levels –155 dBW (0.1 uV)**
- **Antenna gain 2.14 dBi (F.S) on 3.5 Mhz**
- **Antenna gain 7.5 dBi (F.S) on 14-30 MHz**
- **EIRP >20 kW**

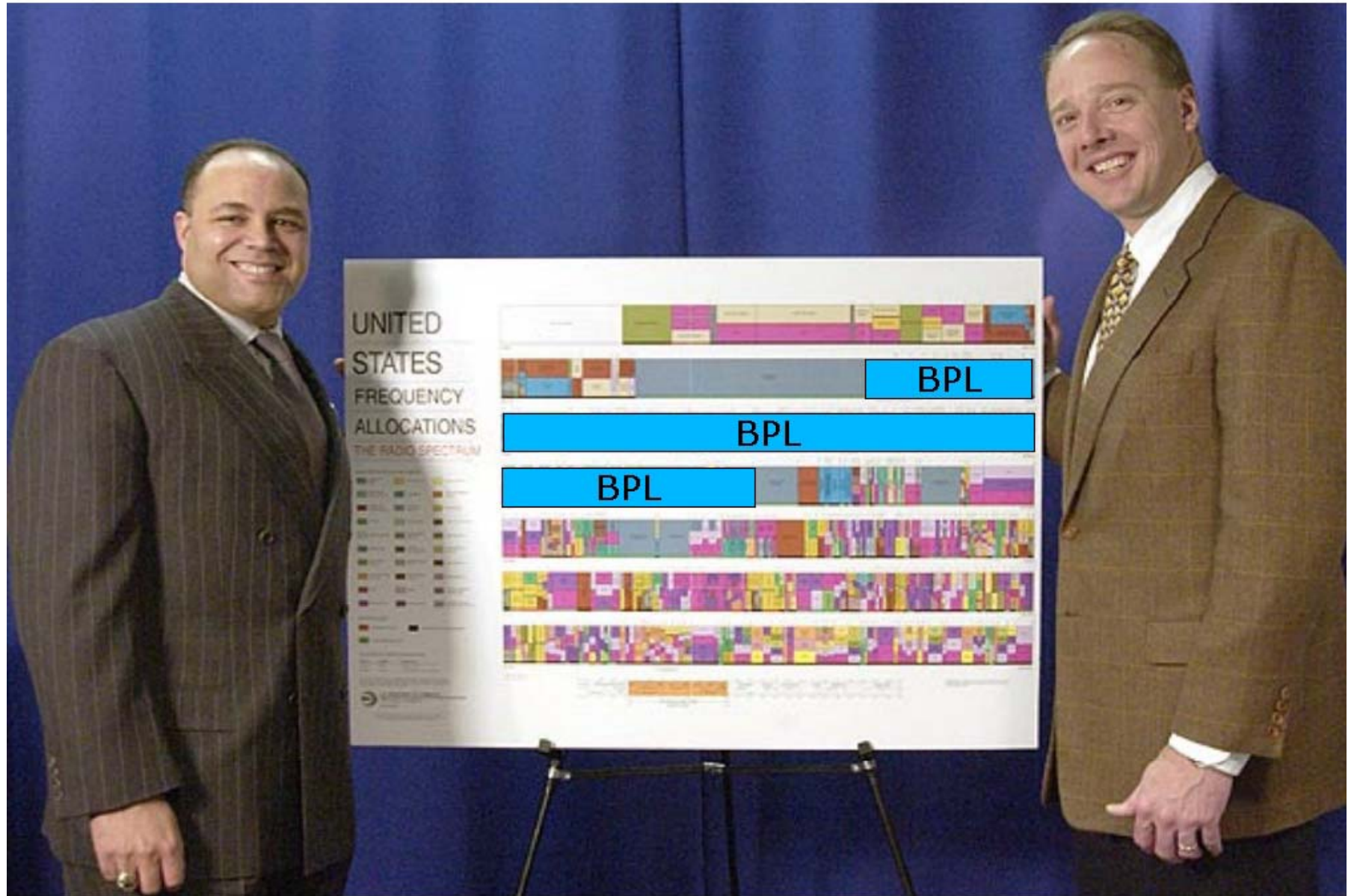
Some of the other radio services using the spectrum that BPL uses:

- **Emergency management**
- **National Guard**
- **US Coast Guard**
- **U.S. Military**
- **Fire Departments**
- **Law Enforcement**
- **CAP**
- **FAA**
- **FEMA**
- **NASA**
- **Voice of America**
- **TV stations**
- **Amateur and CB radio**

UNITED
STATES
FREQUENCY
ALLOCATIONS
THE RADIO SPECTRUM



Spectrum with BPL from 2-80 MHz:



Other spectrum users need to look closely at BPL

- **Notching and other mitigation aimed toward Amateur Radio**
- **Amateurs are knowledgeable users, well organized**
- **Other users potentially affected**
- **Most BPL systems, for example, use HF and 30-50 MHz**
- **They need to do what ARRL is doing and ensure that their interests are protected**

Other organizations that have shared ARRL's concerns:

- **Federal Emergency Management Agency**
- **National short-wave listener associations**
- **Short-wave broadcasters**
- **Aeronautical**
- **NTIA has done field measurements in Potomac, MD and Emmaus, PA**
- **They released a report on their findings**

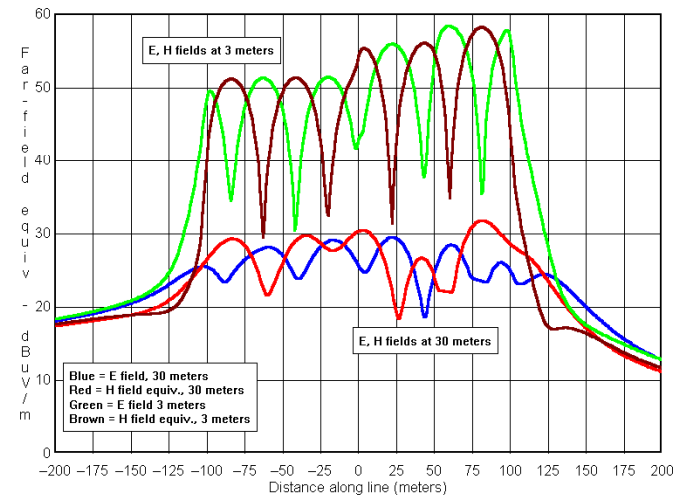
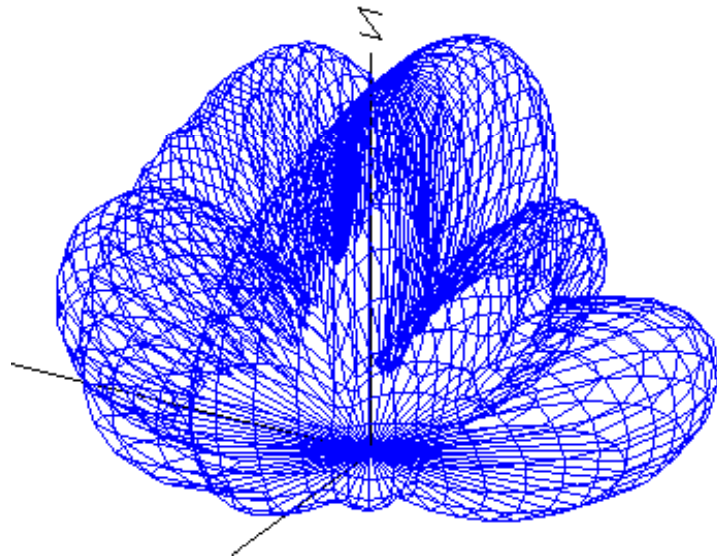
Federal Emergency Management Agency:

“This interference will severely impair FEMA’s mission-essential HF radio operations... The purported benefits of BPL... do not appear to outweigh the benefit... of radio capability as presently used by government, broadcasting and public-safety users.”

Disaster Emergency Response Association:

“DERA concludes that serious interference and disruption of critical emergency communications systems... would almost certainly result from BPL implementation as currently proposed.”

Examples from ARRL Filings



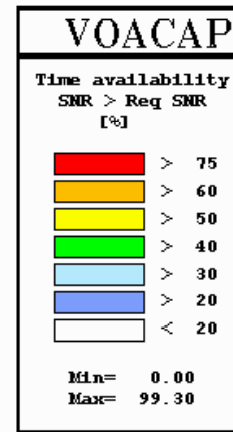
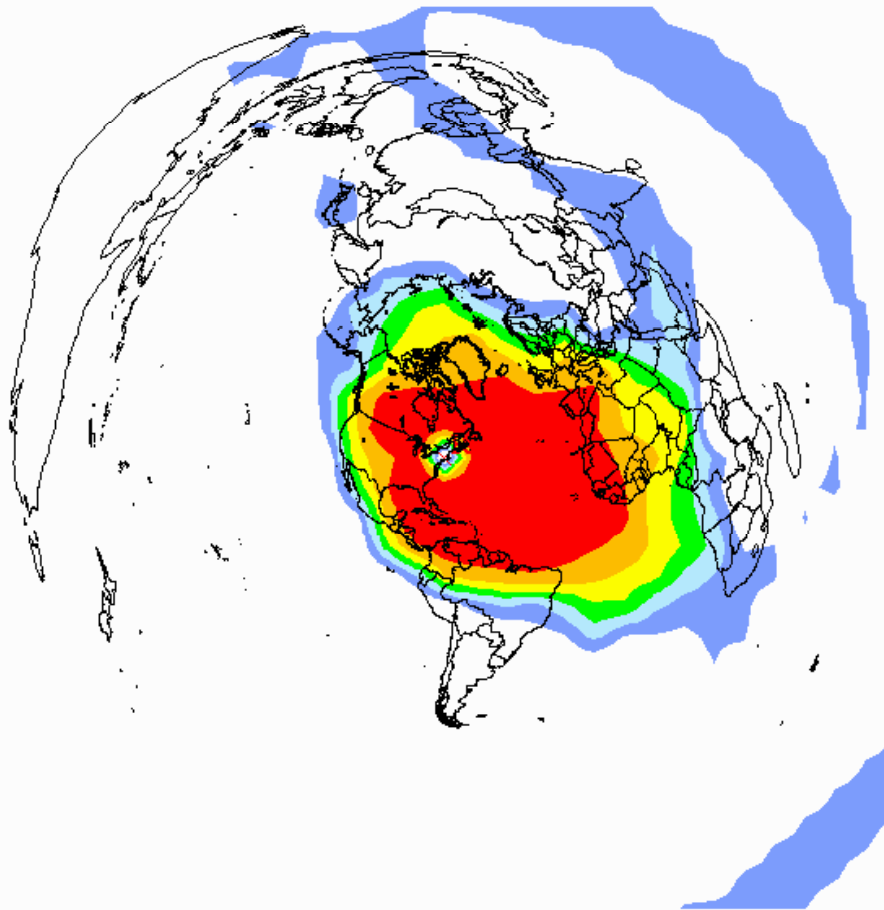
Residential Noise Levels

NEWINGTON [ISOTROPE] 1kW 1deg 20ut 14.000MHz Oct.01 50ssn

Rx location from grid of Tx

REL
AREA_INV\default\r-10-20.V11

Version 03.0408W



CCIR coefficients

NTIA/ITS

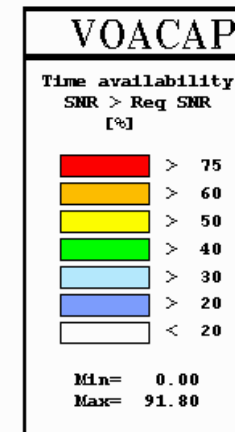
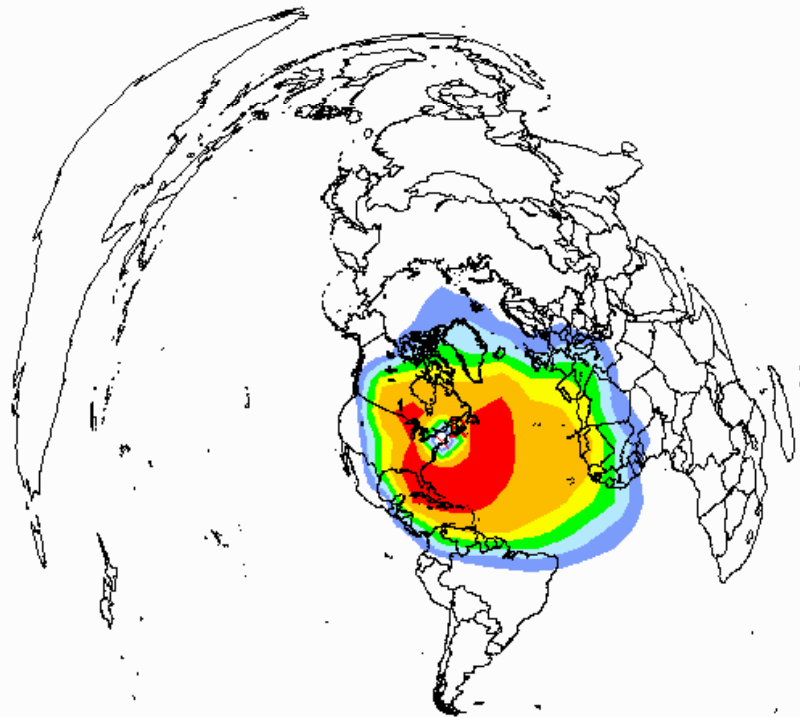
Residential Noise + 10 dB

NEWINGTON [ISOTROPE] 1kW 1deg 20ut 14.000MHz Oct.01 50ssn

Rx location from grid of Tx

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Version 03.0408W



CCIR coefficients

NTIA/ITS

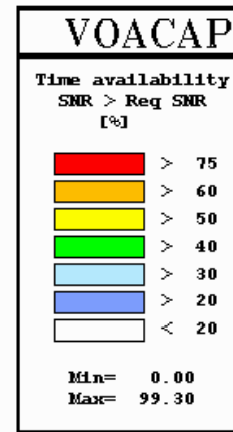
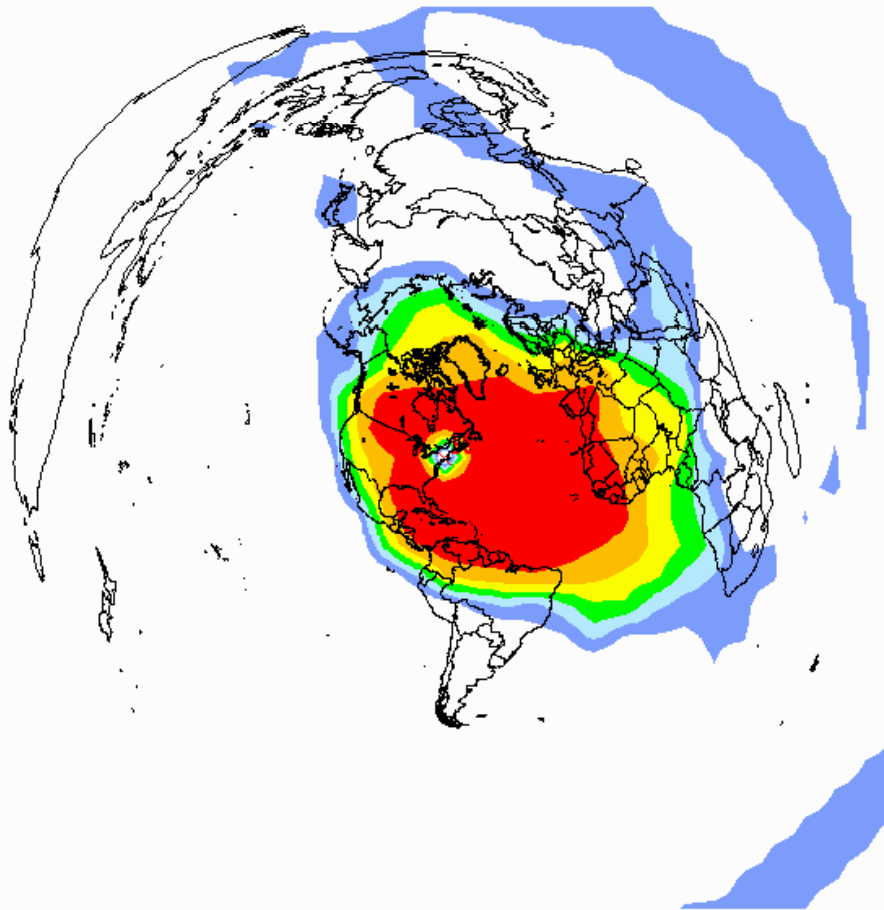
Residential Noise Levels

NEWINGTON [ISOTROPE] 1kW 1deg 20ut 14.000MHz Oct.01 50ssn

Rx location from grid of Tx

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CCIR coefficients

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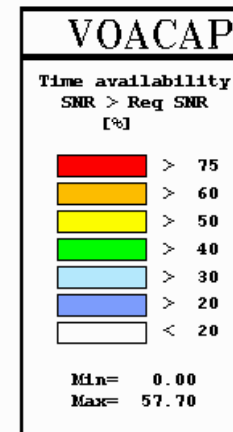
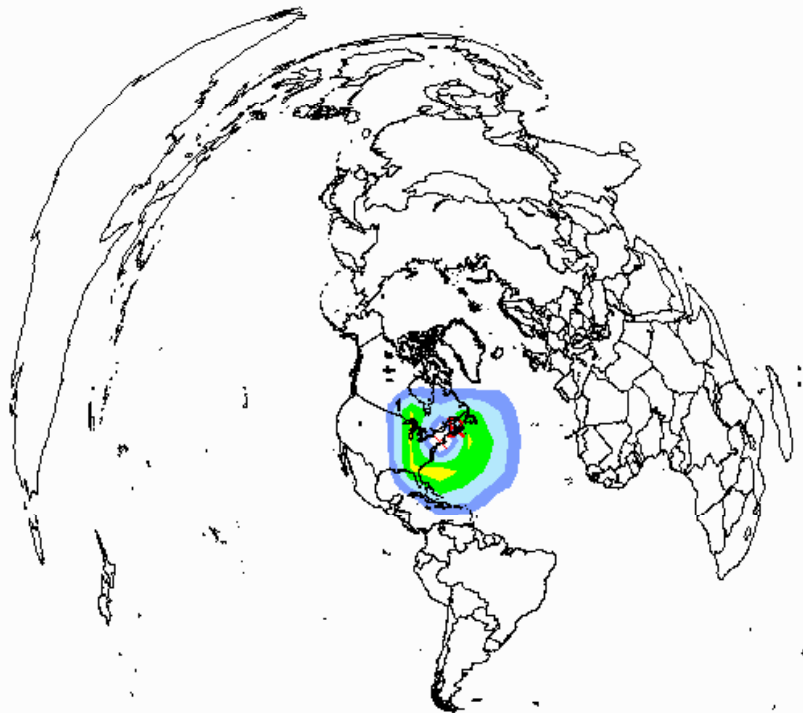
Part 15 Noise Levels

NEWINGTON [ISOTROPE] 1kW 1deg 20ut 14.000MHz Oct.01 50ssn

Rx location from grid of Tx

REL
AREA_INV\default\n-10-20.V11

Version 03.0408W



CCIR coefficients

NTIA/ITS

What Do the BPL Industry and Amateur Radio see differently?

- Interference is very rare vs interference will be everywhere
- BPL signals are very weak vs BPL signals are very strong
- BPL signals will be strong along miles of power line vs BPL signals are point sources that will be audible for only a short distance near the BPL device
- Mobile stations can just drive away from BPL interference vs mobile stations will experience BPL over large areas
- BPL is no different than other noises vs BPL is the worst noise we have ever heard
- Where do these differences come from?

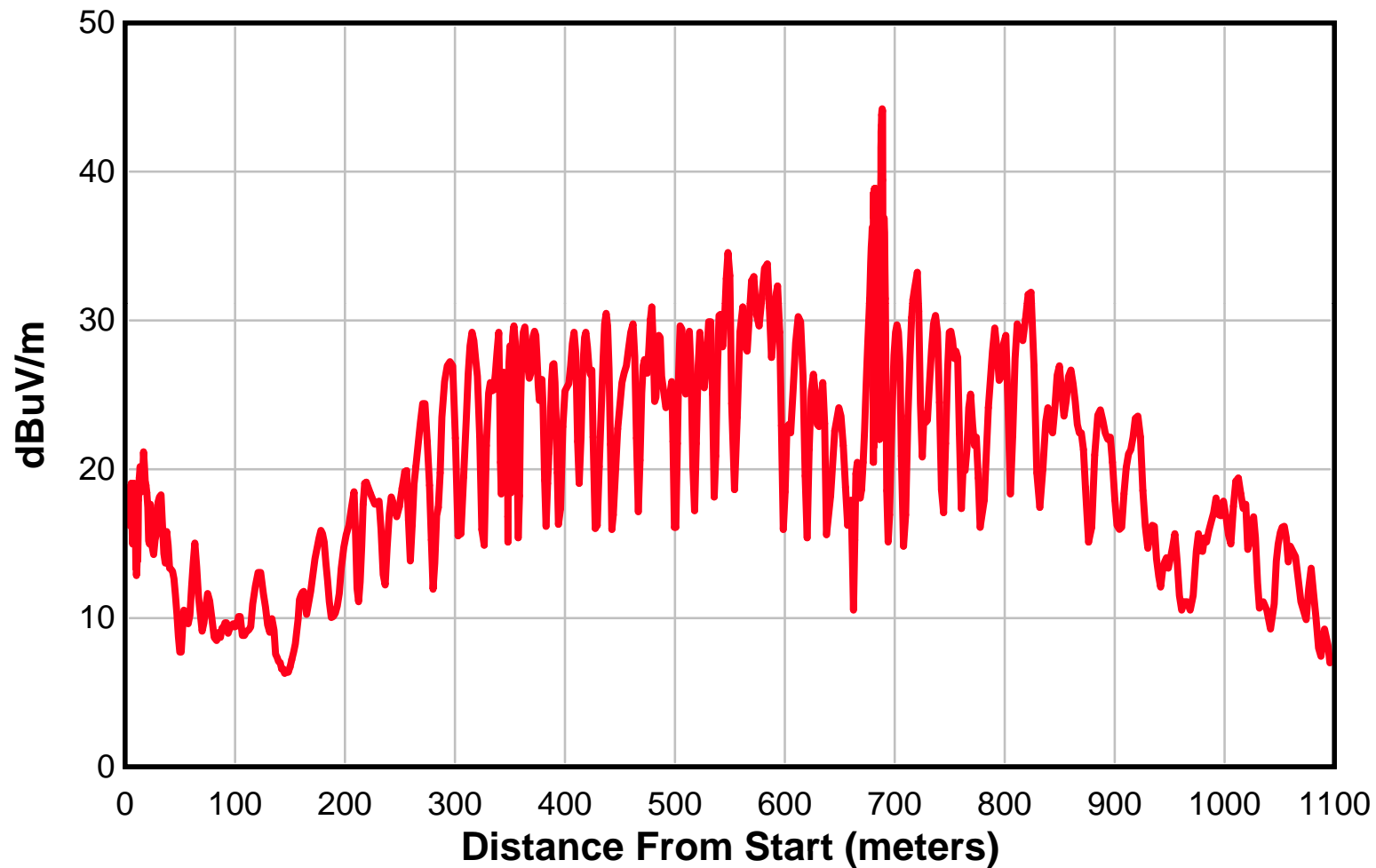
Possible Explanations

- The other side is lying to protect its own interests and can't be trusted!
- I don't believe it for a minute!
- However, all of our beliefs are shaped by our interests
- BPL manufacturers want an environment where they can manufacture and sell product
- Radio operators want an environment where their radio systems will not be degraded by external factors
- Utility engineers just want the stuff to work and not get fired for making the wrong decision!
- Everyone's perceptions are shaped by their viewpoint, experiences and what methods they use to investigate their environment

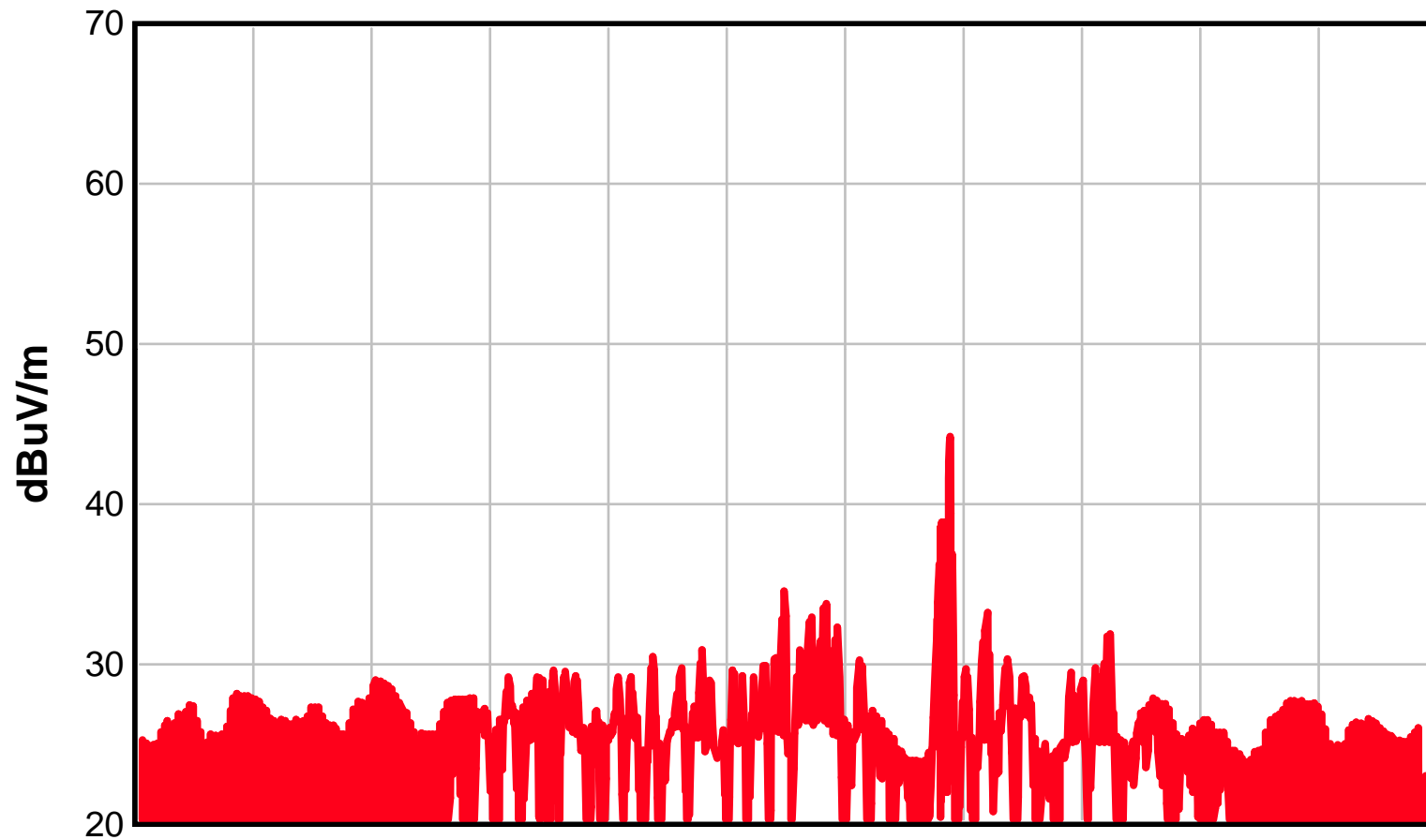
Receivers and spectrum analyzers see the world differently

- **Sensitivity**
- **Antenna gain**
- **Overload**
- **Those who use test equipment to analyze the EMC aspects of BPL will see the results differently than radiocommunications users**

14 MHz along a length of Road as seen by receiver



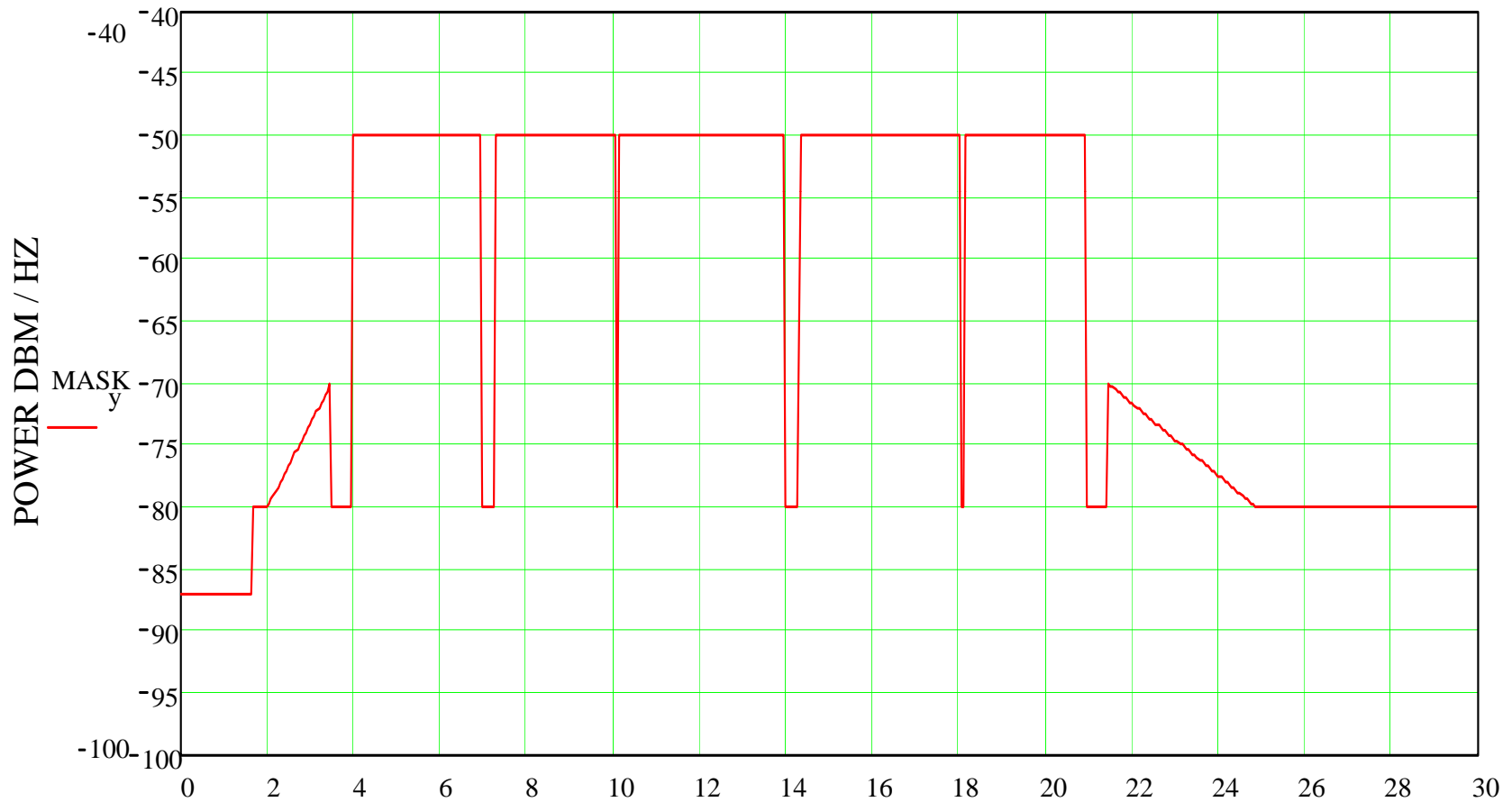
Same Data: Simulated Spectrum Analyzer



Cooperation

- **ARRL has a track record of working cooperatively with industry**
- **Over years, it has worked with the cable industry; VDSL; Home Phone Networking Alliance**
- **It has worked with HomePlug on their Version 1 standard and expects to work with them on the upcoming AV standard**
- **Within BPL industry, ARRL has worked effectively with many, but not all, of the BPL manufacturers**
- **It has also worked directly with electric utilities**
- **In other cases, manufacturers and utilities have chosen a more adversarial approach**
- **The door is still wide open for sincere cooperation**
- **ARRL and BPL industry will have differences, but there is common ground**

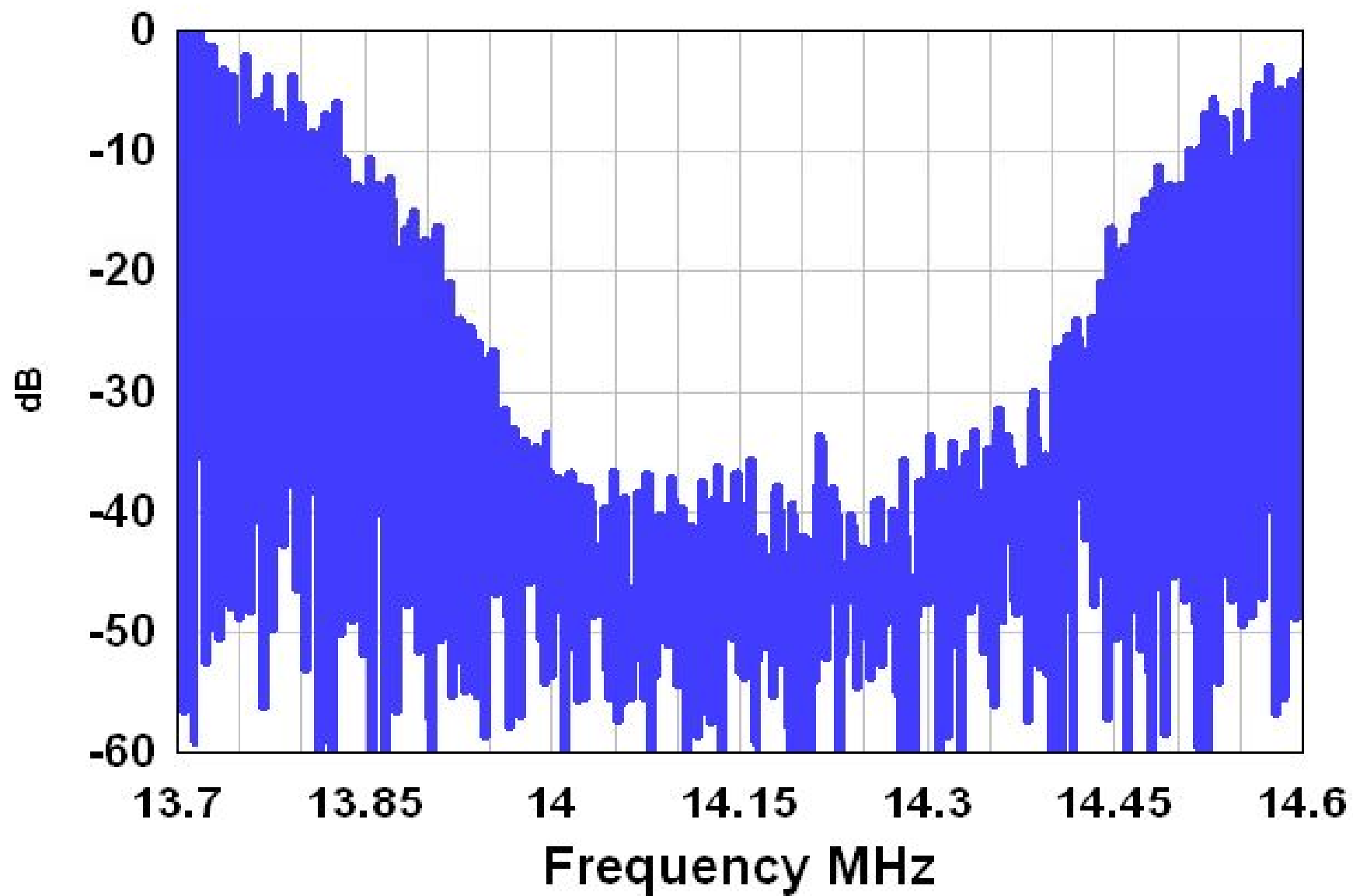
HomePlug – Final Specification



Some BPL Manufacturers are Actively Working with ARRL and Radio Users to Achieve Compatibility

- **At least for the Amateur bands...**
- **Two BPL manufacturers have designed their systems to completely avoid the use of Amateur Radio spectrum in their systems**
- **One manufacturer has taken this one step farther, with hardware filtering to improve notches**
- **Others are, by policy, notching the Amateur bands in all of their installations**
- **One of the chipset manufacturers 200 Mb/s technology has improved “notching” to -40 dB. This is an important improvement over existing technology**
- **The cable and DSL industries have effectively addressed EMC and if BPL is to compete, more BPL companies must follow the lead of the more progressive designs**

ARRL Lab 3/6/2006



BPL systems compared:

- **Motorola:** wireless backbone, HomePlug modems on premise wiring, with additional filters.
- **Amperion:**– Primary distribution backbone, 802.11 wireless to premises. DS2 chipsets. Involved in interference problems.
- **Current Technologies, IBEC:** 32-48 MHz on primary distribution, HomePlug modems on premise wiring. No major interference problems to date. May change to DS2 chipsets.
- **Ambient, Corinex, Mitsubishi:** Operate on 4 to 50 MHz range on primary distribution and premise wiring. DS2 chipset. Involved in interference problems.
- **Corridor Systems:** Microwave surface wave on primary distribution wiring – still very developmental.
- **Motorola, Current and Corinex** have active programs to work directly with ARRL to prevent and resolve interference
- In general, those companies working on EMC are doing better in the marketplace than those that are not

EMC Issues

- **Proper test methods**
- **Extrapolation vs height**
- **Extrapolation vs distance**
- **Compatibility with radio services**
- **Standards and good design practice must take over where regulations leave off**

Test methods

- **Standards for test methods are under development**
- **Measure at 1 meter height**
- **Below 30 MHz, extrapolate at 40 dB/decade “slant-range”**
- **Above 30 MHz, extrapolate at 20 dB/decade**
- **Above 30 MHz, add 5 dB for height**
- **Measure E field with magnetic loop**
- **Other than measuring an electric field with a magnetic loop in the near field, what is wrong with this test method?**
- **Actually, ARRL modeling showed good correlation between E and H peaks**

Test methods

- **Measure at 10 meters horizontal separation**
- **Measure at various distances along line**
- **Measure across entire frequency operating range**
- **Below 30 MHz – Q.P. in 9 kHz**
- **Above 30 MHz – Q.P in 120 kHz or average in 1 MHz**

Test Methods

- **Measure in situ for 3 typical overhead and underground wiring sites (6 sites)**
- **Measure for CPE, injector, coupler, repeater**
- **That's a lot of testing!**
- **At 10 distances along line for 4 different devices of 5 MHz bandwidth between 5 and 50 MHz, that is: 10 measurement points * 3 systems * 2 (overhead and underground) * 4 types of devices * 9 frequency segments = 2160 scans**

Test Methods (continued)

- **Good practice requires that the 6 strongest peaks be recorded and logged**
- **And in situ, ambients will kill you, and each “peak” must be demodulated and a determination made that it is a BPL signal, not an ambient**
- **This may require $2160 * 6 = 12,960$ demodulations**
- **Going from 10 meters horizontal to 3 meters horizontal doesn't buy much because the slant range changes little**

Extrapolation vs Distance

- **FCC rules specify that measurements made at other than compliance distance may be extrapolated to compliance distance**
- **Rules specify 40 dB/distance decade below 30 MHz and 20 dB/decade above 30 MHz**
- **This is a wide range of opinion on whether 40 dB/decade is appropriate for line emitters**
- **ARRL has provided FCC with antenna modeling and theoretical analysis showing why a power line is a line source**
- **Models show 40 dB/decade along ground**
- **Models show 20 dB/decade for measurement made at 1 meter to true maximum at height**

EMC Standards Work

- **IEEE Standards Association**
- **4 major standards under development**
- **Hardware and safety (P1675) (PES)**
- **EMC (P1775) (PES and EMCS)**
- **Protocols and interoperability (P1902) (ComSoc)**
- **By decision, EMC does not address compatibility with radio services**
- **IEEE EMC Society Standards Development Committee
EMC Study Project**
- **ANSI-accredited C63 BPL working group**

Calculations

- **Done with a variety of tools**
- **Simple calculators**
- **Show example**
- **Antenna modeling**

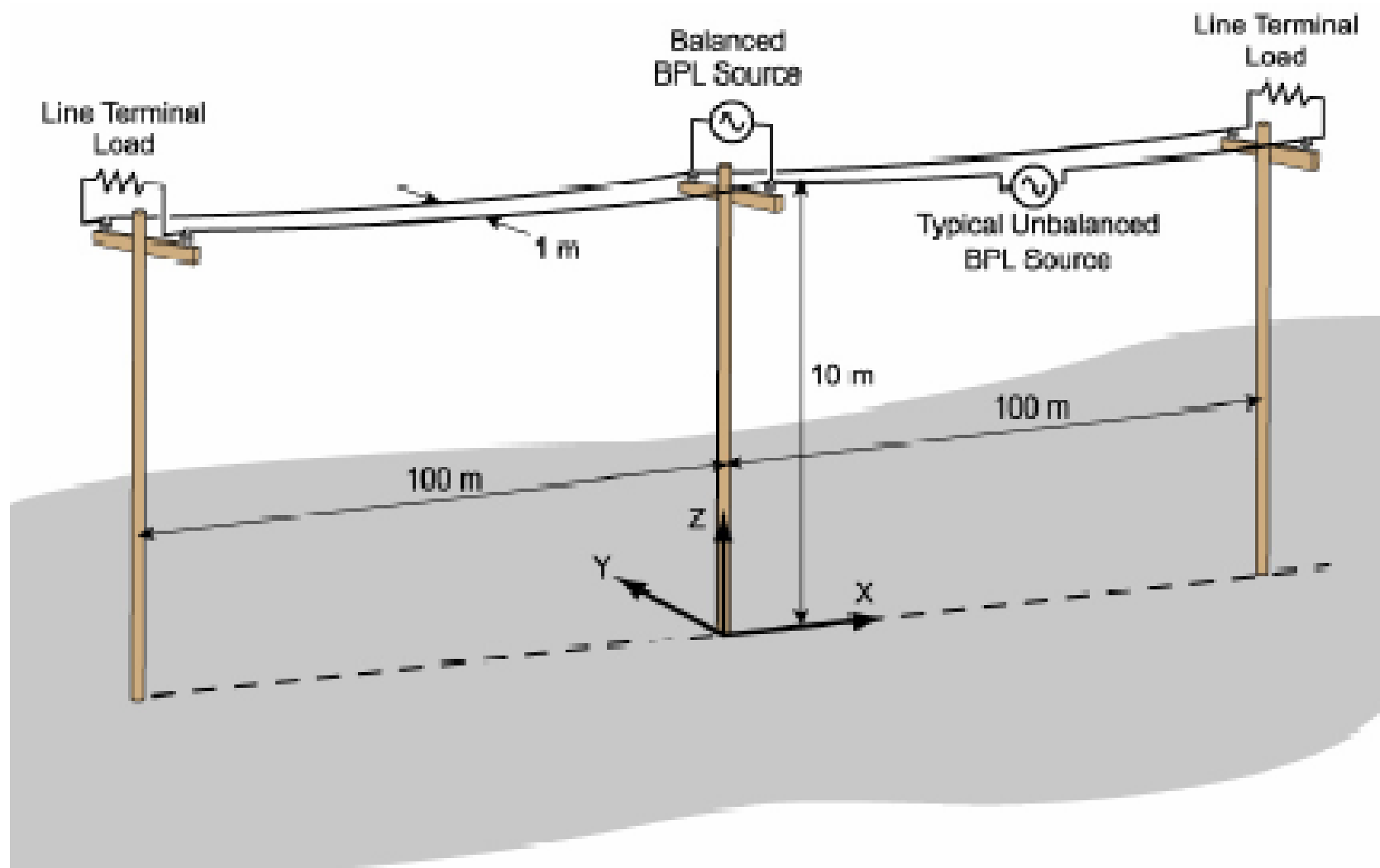
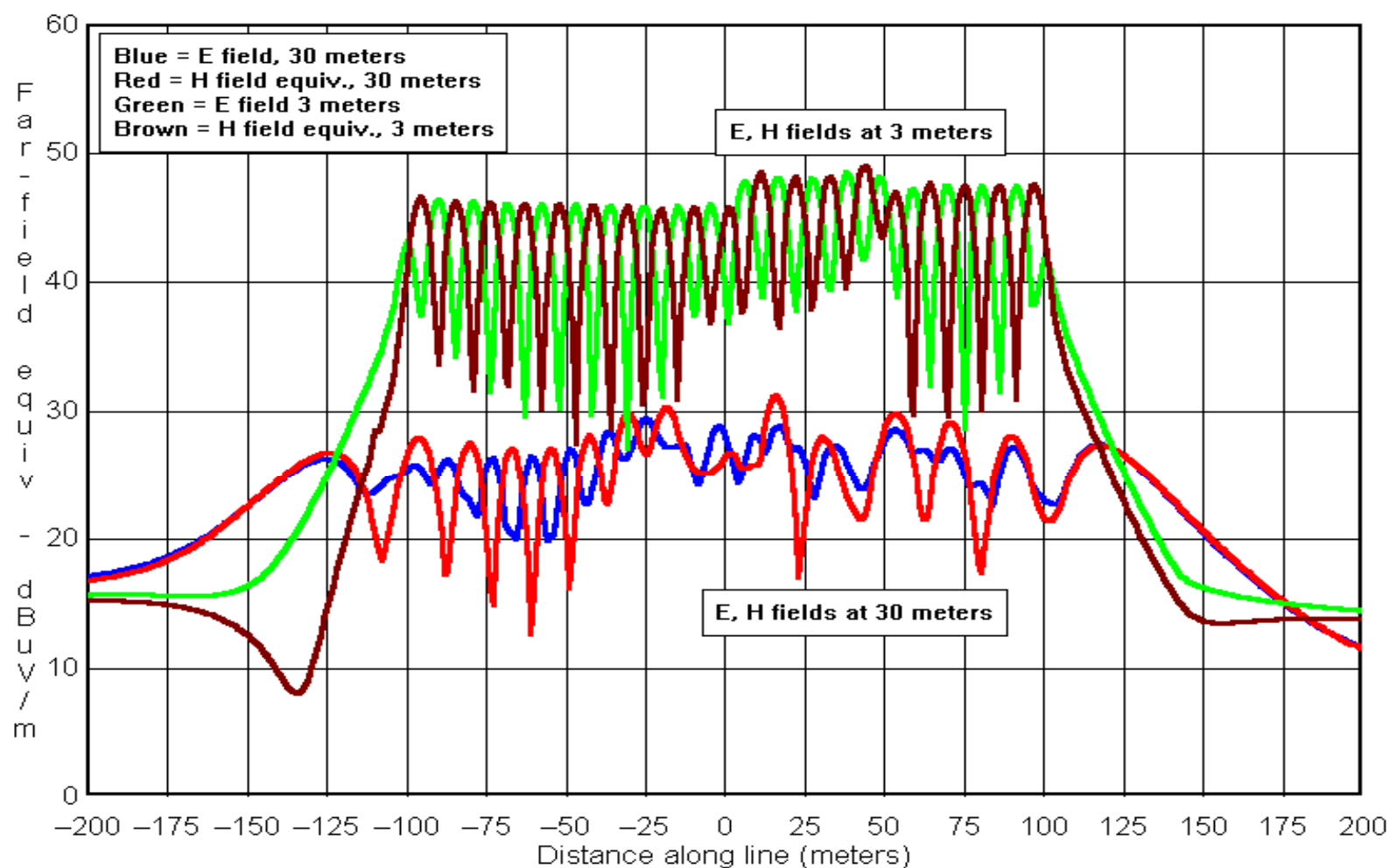


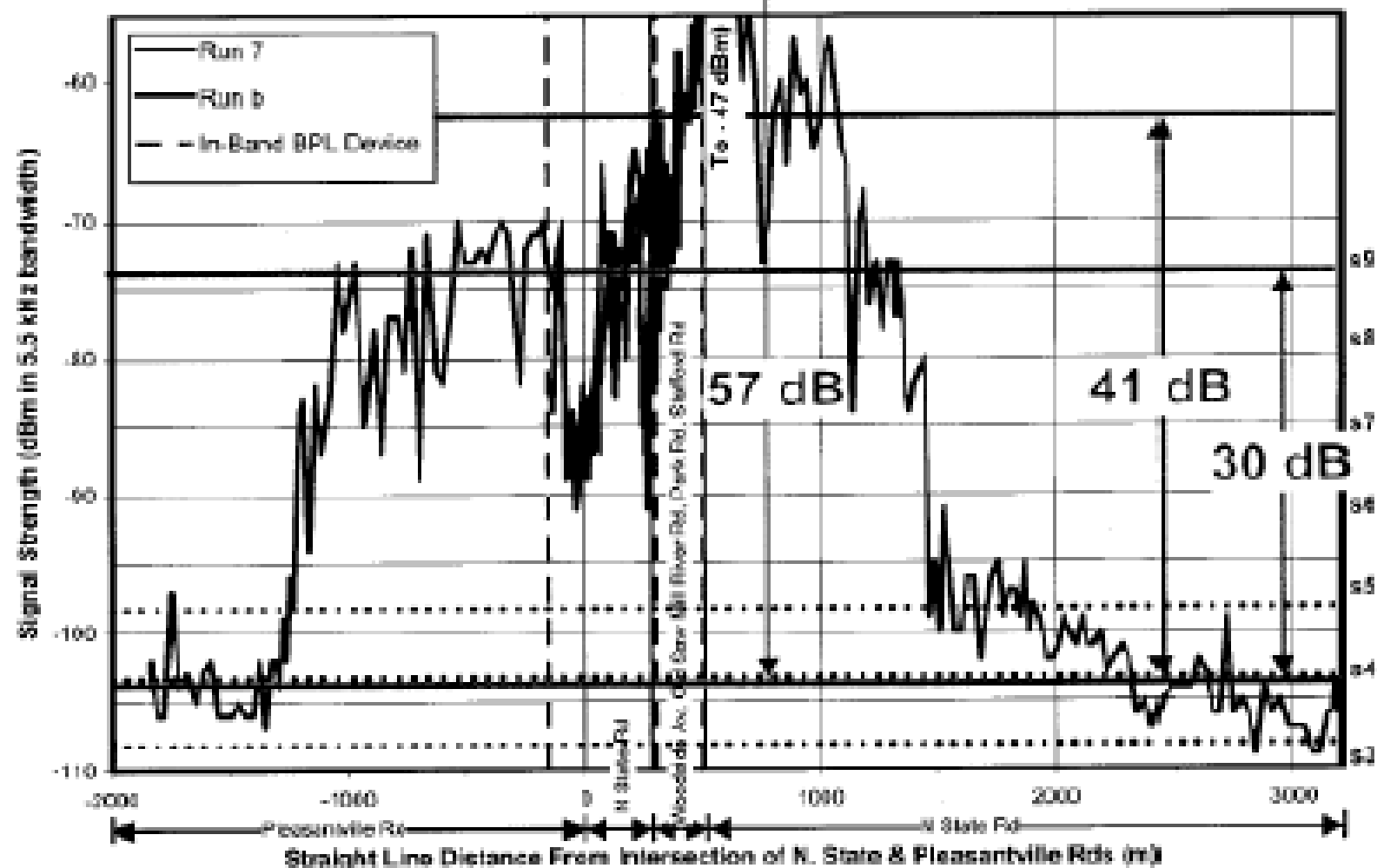
Figure A.1. ARRL used the dimensions of the model AEC described in its NPRM filing to model both the ideal balanced feed modeled by AEC and the typical unbalanced feed seen in present BPL systems.

Fields Near Large Radiators – 14 MHz

30 meter/3 meter ratio 16 dB



(Unnotched Amateur Band)



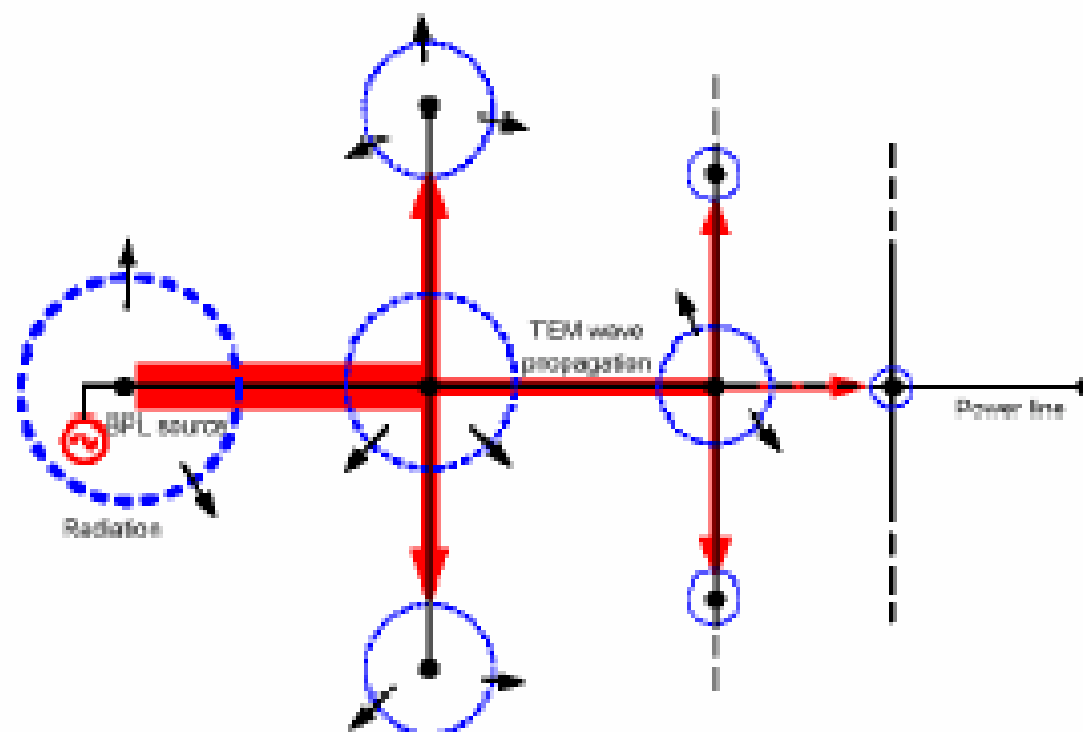


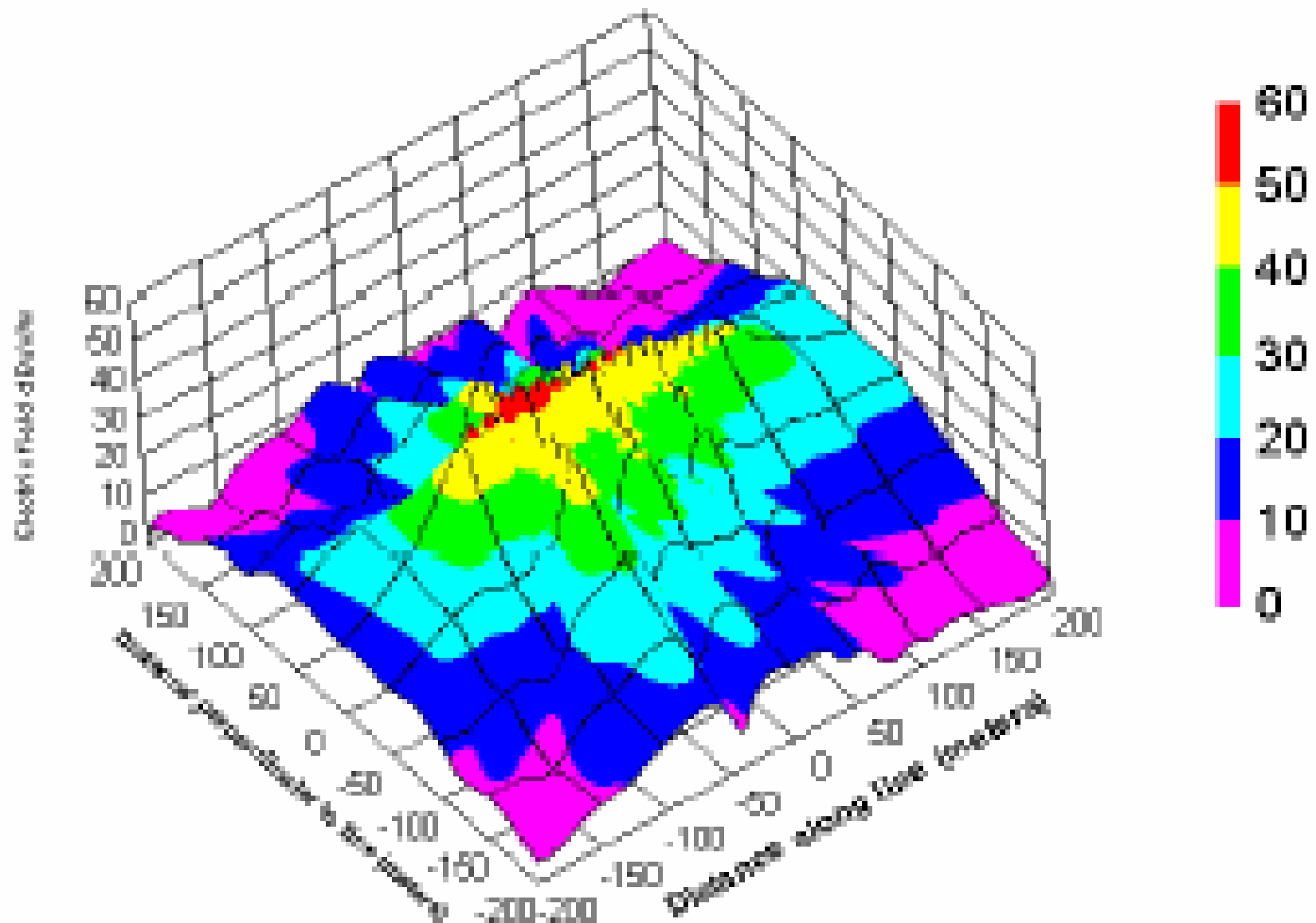
Fig. 3. Conceptual representation of the radiation from a single source BPL. Red line indicates the TEM wave path. Circles indicate the location and strength of radiation points.

Figure A.8. This line drawing was used by [REDACTED] to state that power lines radiate only as point sources.

Fields Near Power Line Antenna

Electric field at a height of 2 m

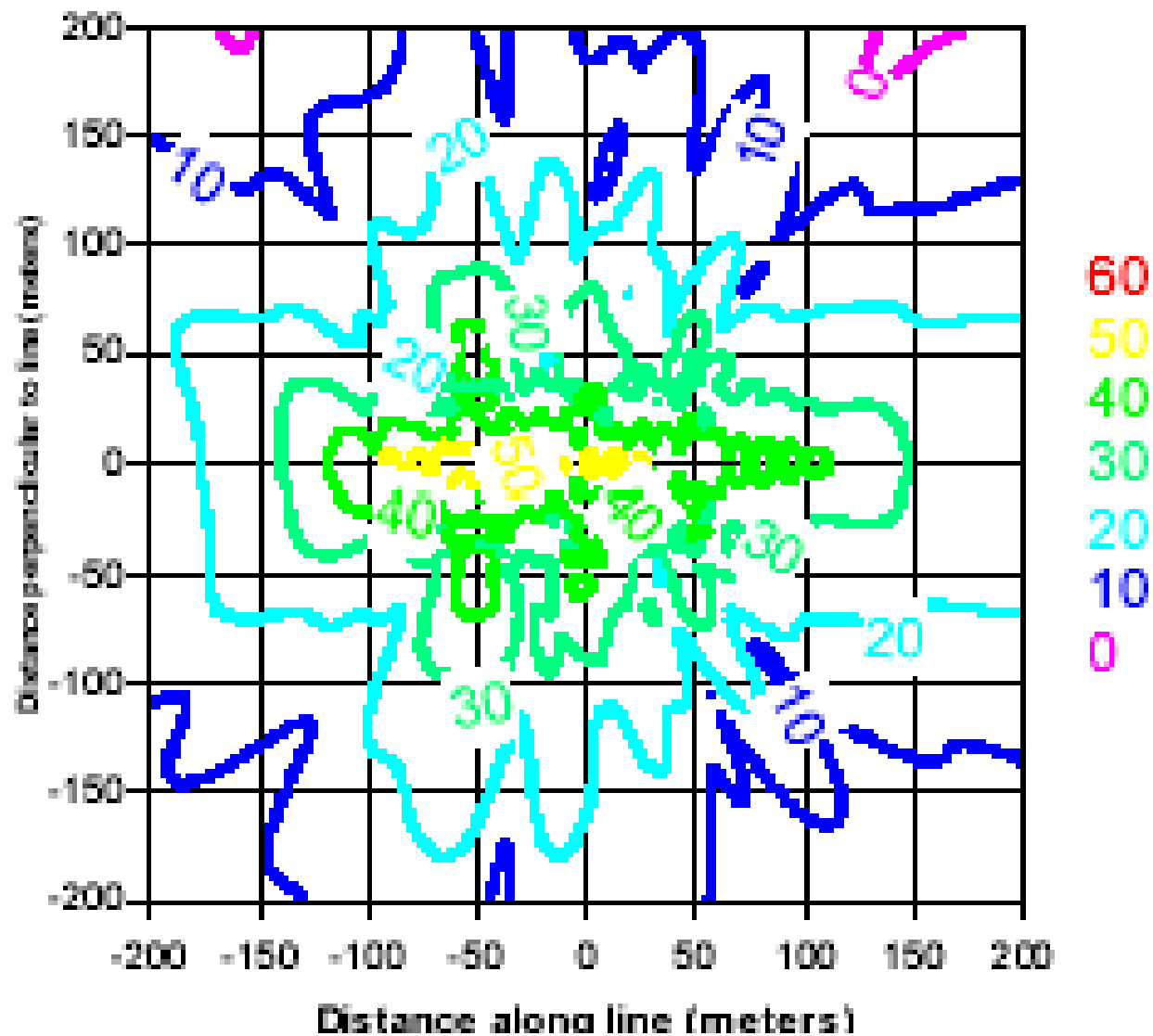
Normalized to 30 uV/m at 30 m



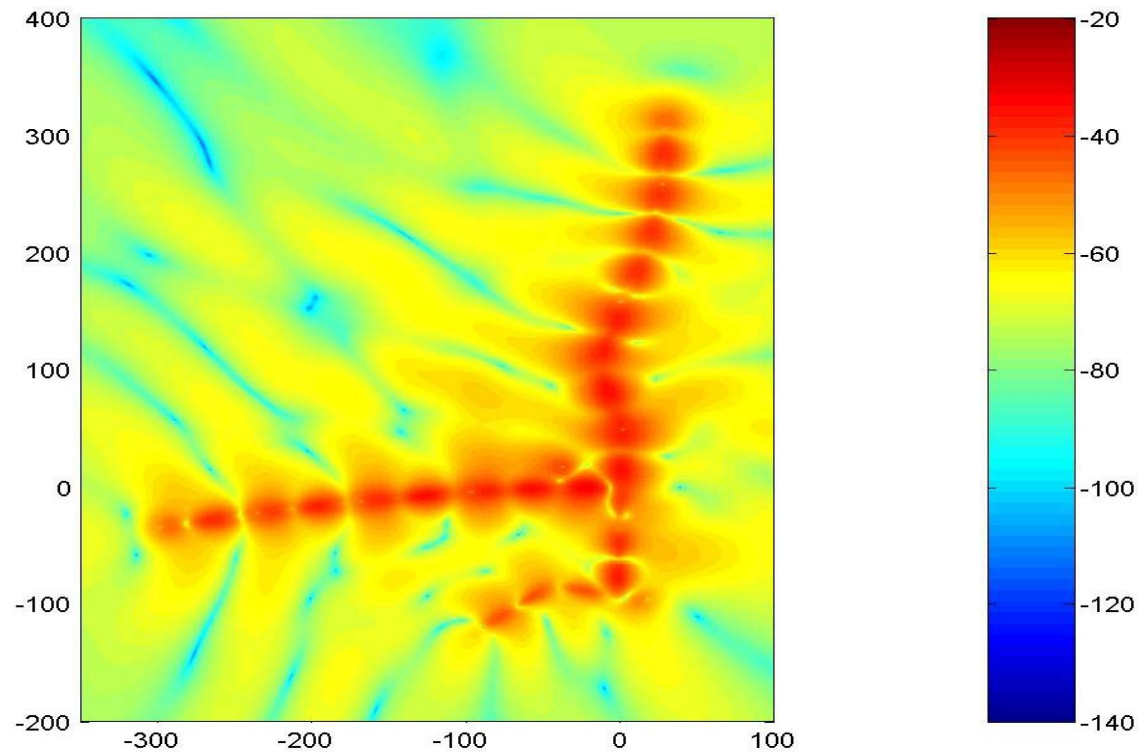
Fields Near Power Line Antenna

Electric field at a height of 2 m

Normalized to 30 uV/m at 30 m



Example NEC Analysis (Spatial Distribution of E Field)



**Measurements of field
strength in areas where
BPL is deployed**

Scope of ARRL testing

- **ARRL staff have done testing in 23 areas where BPL is located**
- **Other radio Amateurs have done testing in several other areas**
- **ARRL testing done for EMC assessment, not for compliance purposes**

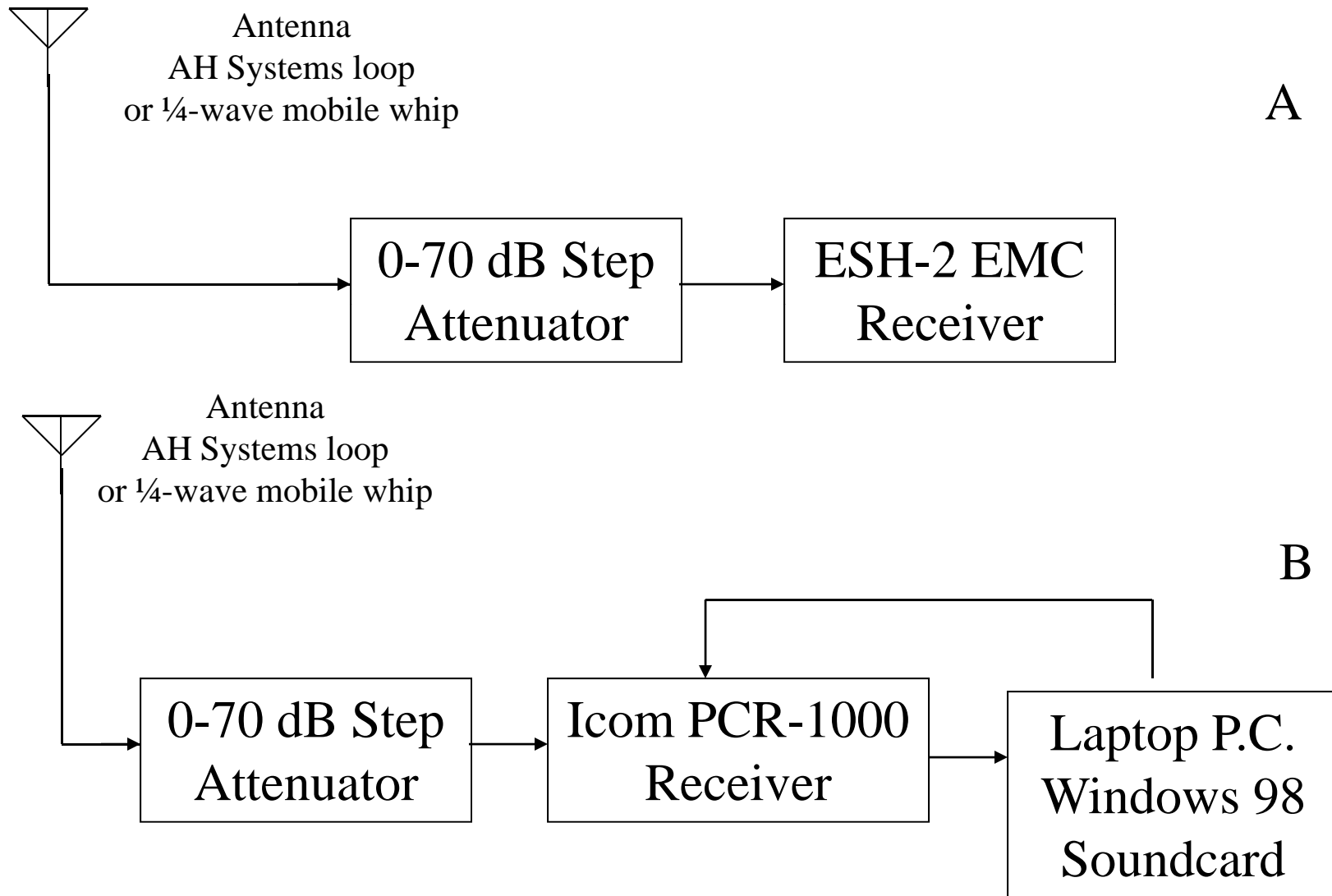
Types of ARRL testing

- **Computational, mainly using NEC-4**
- **Interference assessment**
- **Site survey, spectrum assessment**
- **Measurement of noise floor**
- **Measurement of ambient signal levels**
- **Relative measurements of noise-floor degradation**
- **Field-strength measurements**

Results of ARRL testing

- **247 pages of graphs and charts follow**
- **Findings have ranged from systems that exceed FCC emissions limits by 25 dB or more to systems operating 10 dB below the limits**
- **Findings have ranged from strong interference to systems that deployed without major interference problems**
- **Some systems in the middle, with interference problems that were corrected**

Field testing – typical test fixture



Measurement of noise floor

- **Ambient levels of man-made noise can range down to -20 dBuV/m at HF-station antennas**
- **It is not possible to measure this level with spectrum analyzer and typical EMC antenna**
- **Such measurements, even with active loops, are really measuring the noise floor of the test equipment**
- **Communications receivers and real-world antennas are much more sensitive than EMC test equipment**
- **To measure ambient levels, as a minimum, an EMC receiver and 8-foot monopole antenna, tuned to resonance with inductive loading, would be needed.**

Signals Measured in Amateur Radio Service Spectrum **14 - 14.35 MHz, October 1, 2004, 2220 UTC, Burlington, CT** **ESH-2 and Inductively Loaded Vertical Whip Antenna**

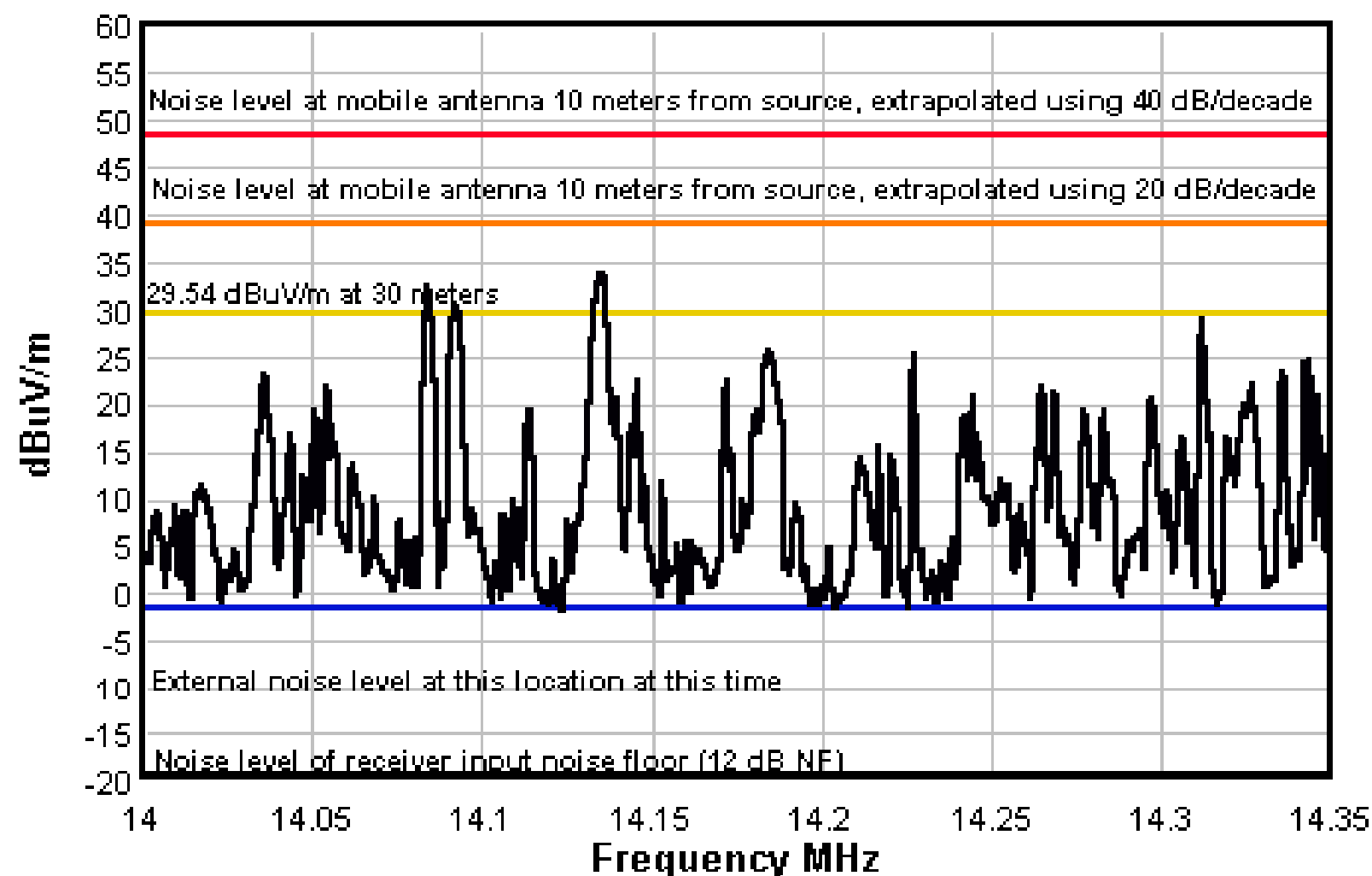
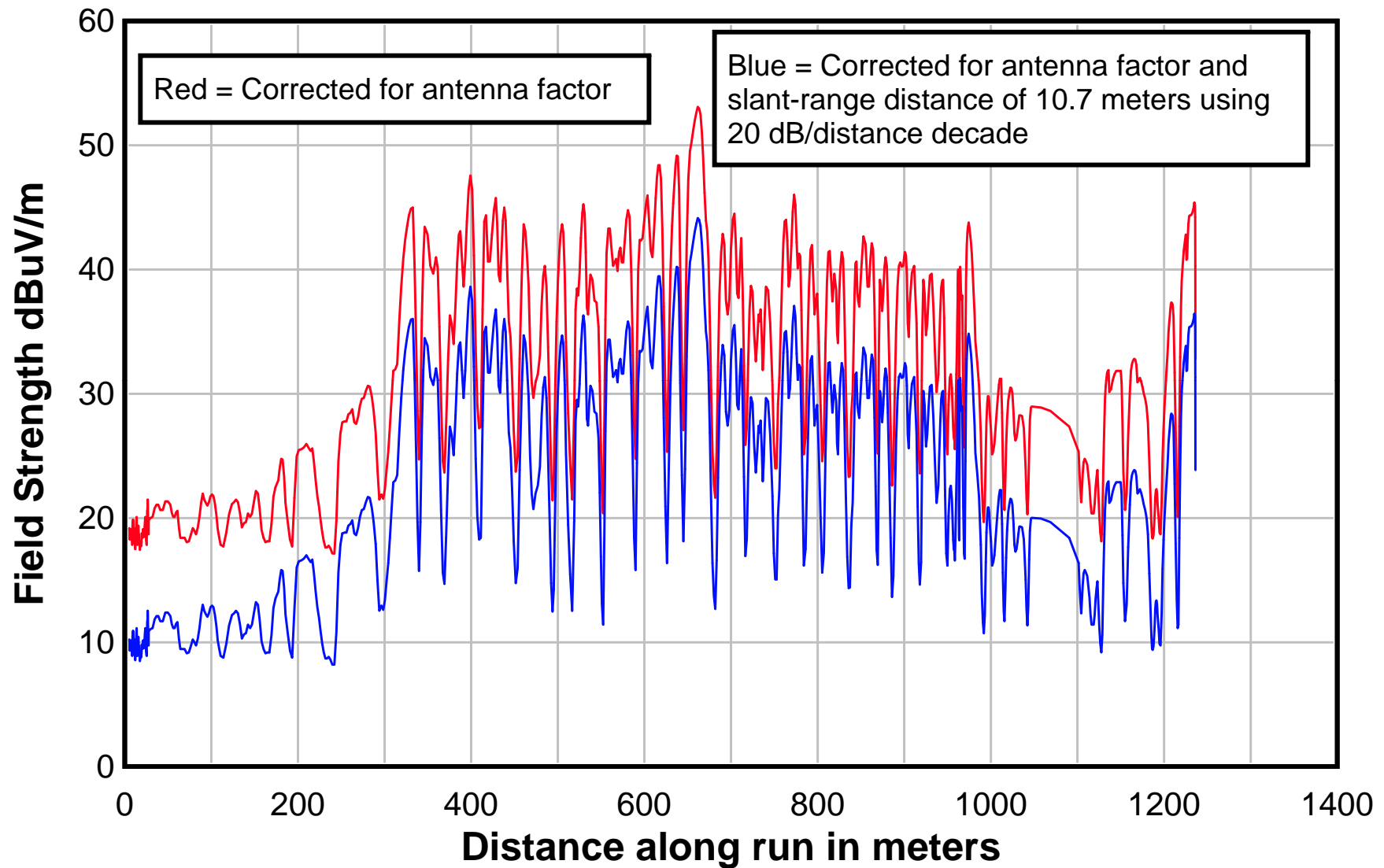


Figure 4 – These are the signals that were present on the 14-14.35 MHz Amateur band on October 1, 2004 at 2220 UTC. The lower line shows the sensitivity that would result from the use of a typical communications receiver with a 12 dB noise figure.

FCC Measurement Method

- **CISPR Q.P. 9 kHz<30 MHz; 120 kHz>30 MHz**
- **Measure 10 meters horizontal distance from line**
- **Measure 1 meter off ground**
- **Use magnetic loop**
- **30 uV/m 30 meters from source**
- **Extrapolate at $1/D^2$ <30 MHz to slant-range distance to power line**
- **Other than making a measurement of an electric field using a magnetic loop in the near field of the radiator what's wrong?**

September 21, 2004 1600 UTC



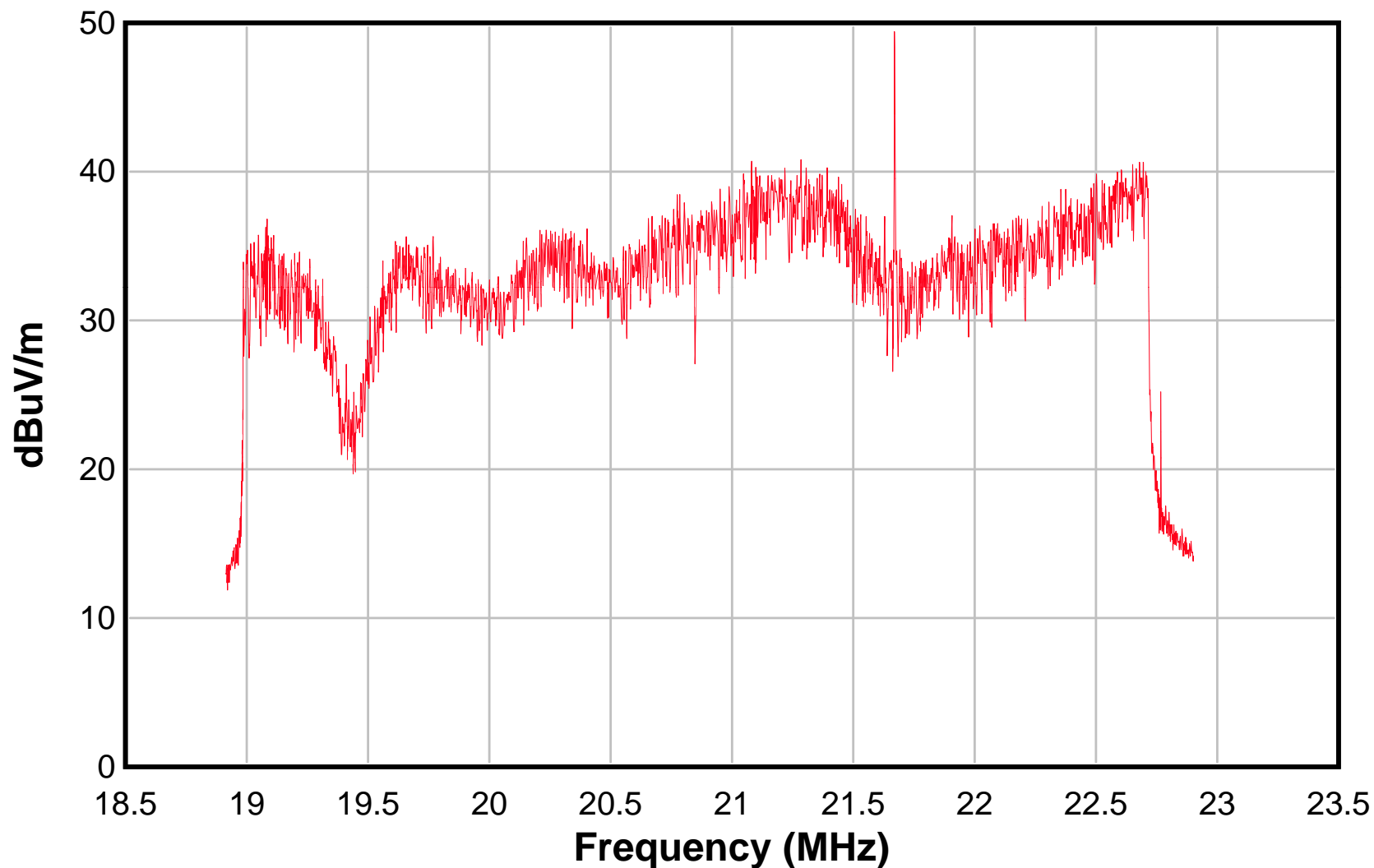
In addition to the mobile test run, tests were made at several fixed locations. The following show the actual measured signal levels at these points:

Test point	GPS coordinates	Frequency	Measured Field Strength
170 Dalmeny Road	41.14862° 73.83585°	14.588 MHz	36.9 dBuV/m at 30 m Extrapolated at 20 dB/decade
170 Dalmeny Road	41.14862° 73.83585°	14.345 MHz BPL on	22 dBuV/m Measured at mobile whip antenna
170 Dalmeny Road	41.14862° 73.83585°	14.345 MHz BPL off	8 dBuV/m ⁴ Measured at mobile whip antenna
Near corner of Dalmeny and Poplar	41.15156° 73.83231°	28.5 MHz	37.1 dBuV/m Measured at mobile whip antenna ⁵
67 Woodside Ave	41.15295° 73.82747°	3.85 MHz	37.5 dBuV/m at 30 m Extrapolated at 20 dB/decade
Park Road Behind police station	41.15201° 73.82778°	3.85 MHz	71.9 dBuV/m at 30 m Extrapolated at 20 dB/decade ⁶

These test data demonstrate significant, strong degradation of spectrum allocated to the Amateur Radio Service. In some cases, they show that the emissions are significantly greater than what is permitted by FCC Part 15 regulations. At the time these measurements were made, this system was not operating in compliance with Part 15.

Frequency sweep 18.9-22.9 MHz

October 3, 2004



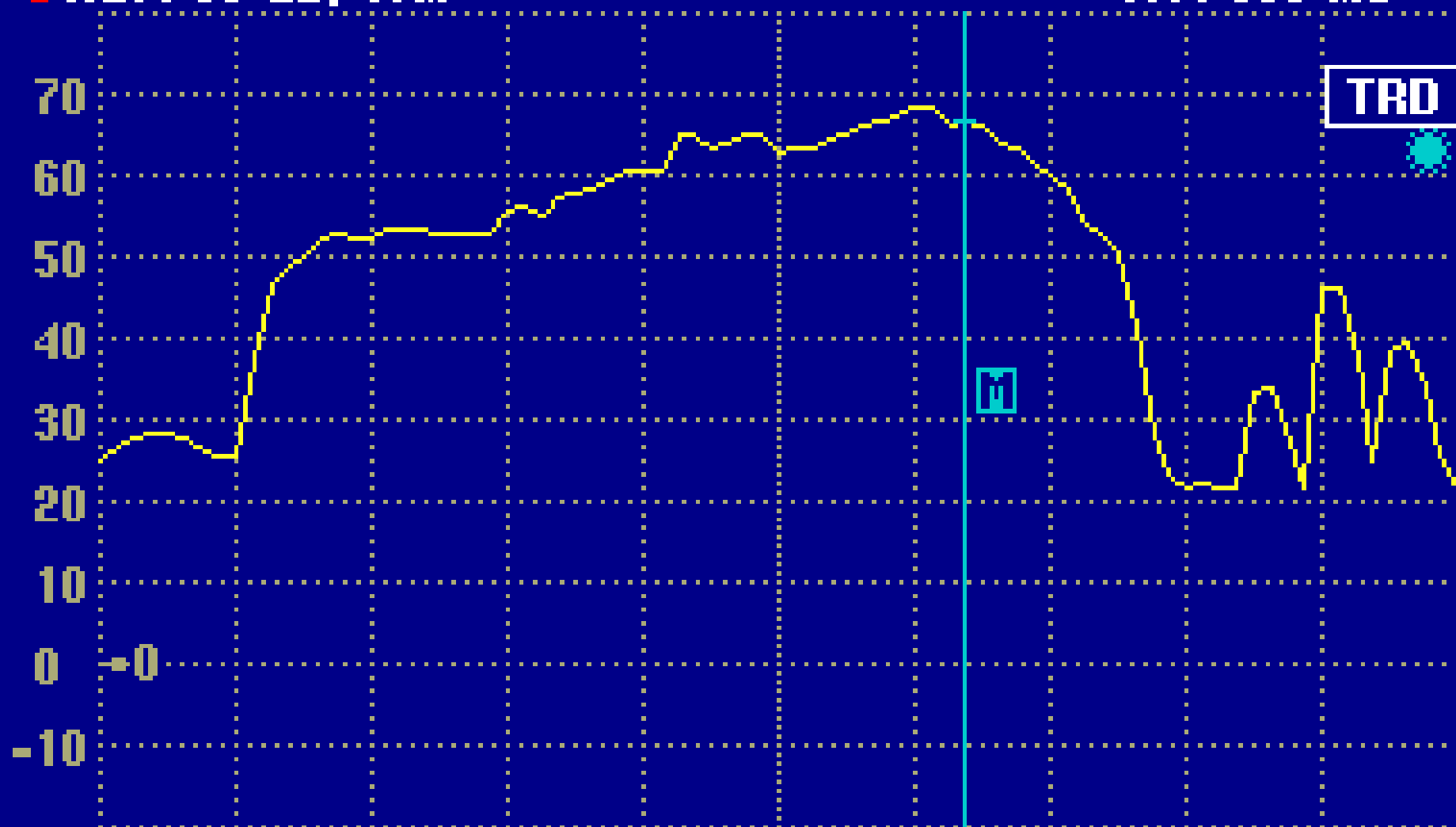
 : 16.55 MHz

66.4 dB μ V/m

RBW: 9 kHz

 Ref: 80 dB μ V/m

MT: 500 ms



Start: 14 MHz



Stop: 18 MHz

bcm.006

EXIT

ACTIVATE

SCREEN- \rightarrow
PRINTER

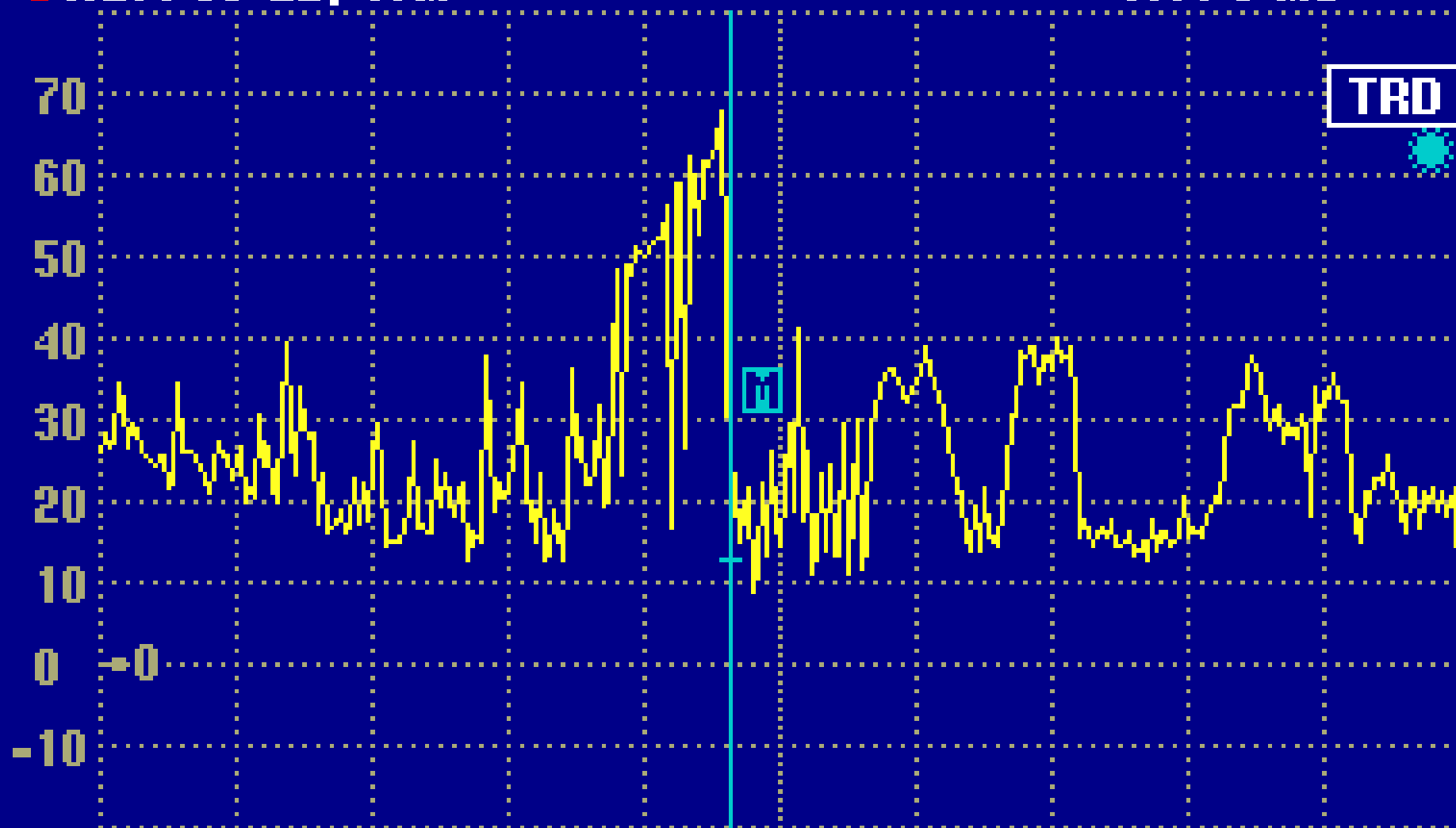
M : 16.6 MHz

12.7 dB μ V/m

RBW: 3 kHz

● Ref: 80 dB μ V/m

MT: 5 ms



Start: 5 MHz



Stop: 30 MHz

bcm.008

EXIT

ACTIVATE

SCREEN-
PRINTER

FCC Limits were apparently exceeded by at least 22 dB in this system:

The test fixture and measurement software made the following measurements, estimated as quasi peak field strength in a 9 kHz measurement bandwidth. These data are not extrapolated to distance.

3.52 MHz:

69.2 dBuV/m

68.7 dBuV/m

69.1 dBuV/m

69.0 dBuV/m

70.9 dBuV/m

Average: 69.4 dBuV/m



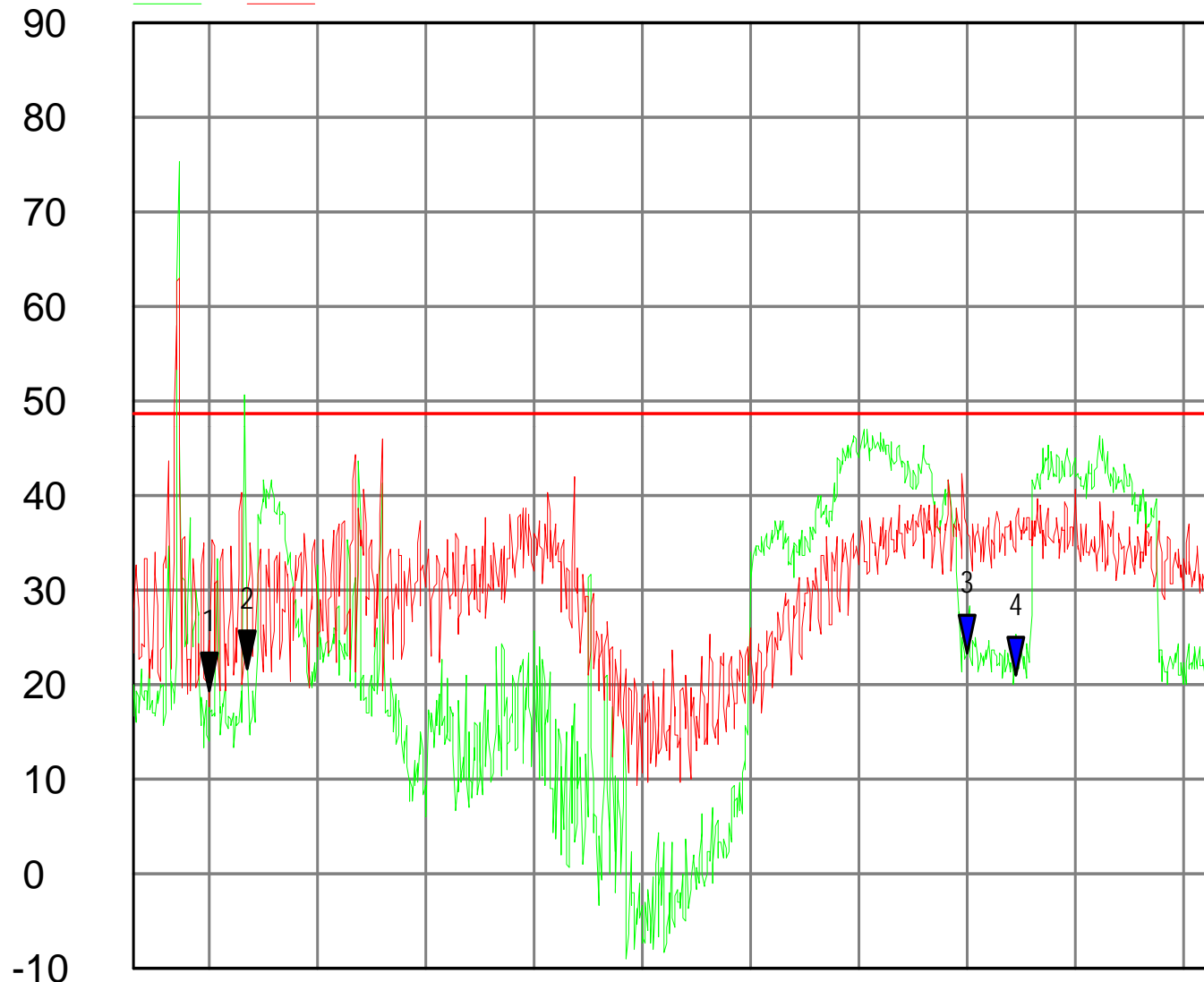
Bring the mountain to Mohammed

A number of BPL manufacturers have taken out experimental licenses. One of the conditions of their license is that they file 6-month reports with the FCC, showing the measurements they make to determine compliance with the emissions limits. The following are from some of their reports, or represent an ARRL analysis of same.

Sawmill Second Pole Mount

dBuV

PEAK OFF



- 1 PEAK
▼ 14.000 MHz
19.45 dBuV
- 2 PEAK
▼ 14.350 MHz
21.71 dBuV
- 3 PEAK
▼ 21.000 MHz
23.19 dBuV
- 4 PEAK
▼ 21.450 MHz
21.15 dBuV

Start: 13.300 MHz

Stop: 23.300 MHz

Res BW: 9 kHz

Vid BW: 3 kHz

Sweep: 1.20 s

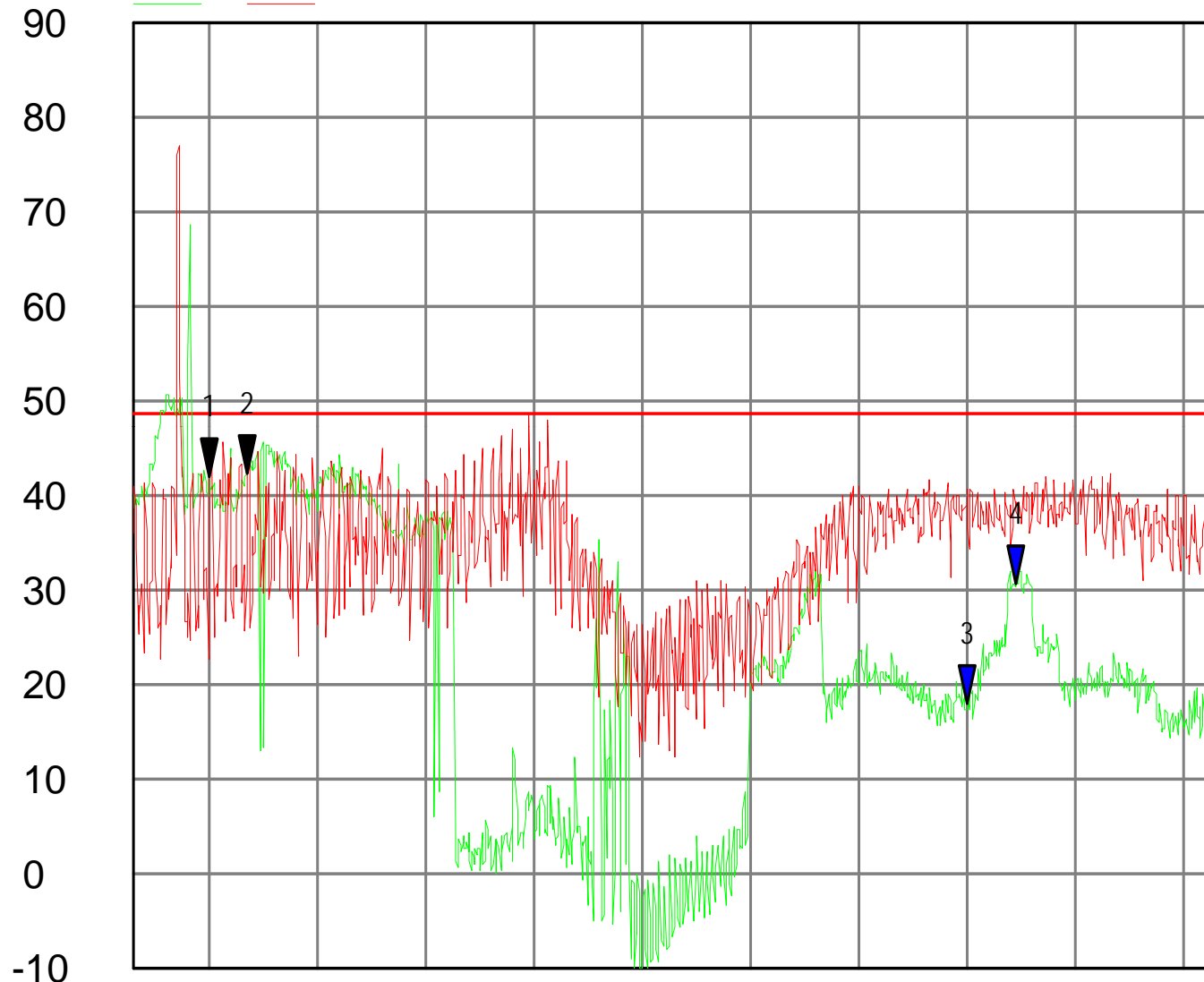
9/8/2004 7:10:26 PM 2N2 13_3 to 23.3.spt

R3132

Sawmill First Pole Mount

dBuV

PEAK OFF



- 1 PEAK
▼ 14.000 MHz
41.90 dBuV
- 2 PEAK
▼ 14.350 MHz
42.17 dBuV
- 3 PEAK
▼ 21.000 MHz
17.99 dBuV
- 4 PEAK
▼ 21.450 MHz
30.70 dBuV

Start: 13.300 MHz

Stop: 23.300 MHz

Res BW: 9 kHz

Vid BW: 1 kHz

Sweep: 3.40 s

9/8/2004 6:48:05 PM 2N1 13_3 to 23_3.spt

R3132

Interference to BPL

- **Initial tests show that BPL can be susceptible to ingress from nearby transmitters**
- **Amateur radio may use EIRPs of 20 kW or more**
- **Field strength at power lines may be 100 V/m**
- **Tests show as little as 2 watts can take it down**
- **Other tests show 75-500 watts needed to impact BPL**
- **ARRL working with Electric Power Research Institute on testing**
- **Results from testing of G2 BPL system**

Electric Utility Interests

- **Anyone from local utility industry here?**
- **Relationship not adversarial**
- **Electric utilities want to make money**
- **RF and digital signals are a far cry from 60 Hz**
- **PPL technology**
- **Interference and other issues can undercut profitability**
- **ARRL has 300 power-line cases**
- **ARRL/FCC cooperative program**
- **50 cases referred to FCC**
- **Cases have dragged on for years**
- **“Conventional” power-line noise has solutions**
- **What are the solutions for interference from BPL?**
- **Profitable?**

Questions Utilities Should Ask BPL Manufacturers

- **How does your technology deal with interference issues?**
- **What solutions do you have if notching doesn't work?**
- **What do you consider to be legitimate interference?**
- **Does the implementation notch all of the NTIA bands and frequencies that may be in use locally?**
- **If the answer doesn't include Amateur Radio, expect interference complaints if it is deployed where fixed or local Amateur operation is likely**
- **Ask them what they think of Ed. ☺**

Procedural issues in the rulemaking

- Procedural and technical flaws in the rulemaking
- FCC didn't follow its own rules
- Chairman Powell violated Ex Parte rules
- FCC concluded that interference potential low
- 650 pages of unreleased correspondence and test data
- This material showed unresolved interference and a considerable interference potential
- FCC's own testing supported ARRL's position
- ARRL filed an appeal in federal court
- Redaction in FCC material

NON-PUBLIC / FOR INTERNAL USE ONLY

New Information Arguing for Caution on HF BPL

FCC Laboratory

What can amateurs do?

- Be informed – <http://www.arrl.org/bpl>
- If local utility planning BPL, contact Ed Hare at ARRL, w1rfi@arrl.org
- Measurements of baseline noise levels
- Support ARRL's work with membership and contributions
- Get on the air

**The work being done by amateur
radio IS having an effect, and we
can continue to emphasize the
point to the FCC and to electric
utilities that power lines are not the
right place to put high-speed digital
signals operating on spectrum that
is used by licensed radio services
nearby**

I hear this noise... (How do I know it is BPL?)

- **It is possible to misidentify BPL**
- **Each BPL system has a unique sound**
- **Some are spread spectrum – broadband noise**
- **Some are OFDM, broadband noise or multiple carrier**
- **Onset vs spectrum is generally over about 100 kHz**
- **If the noise has a strong 60- or 120-Hz component, it is probably “regular” power-line noise**
- **If heard every 10-50 kHz, as a buzz or as birdies, it is probably a computer, TV set or switch-mode power supply**

Q&A
a.k.a. Stump the Speaker

MORE INFORMATION

**Ed Hare, W1RFI
ARRL Laboratory Manager
225 Main St
Newington, CT 06111
w1rfi@arrl.org
860-594-0318**

- **<http://www.arrl.org/bpl>**
- **BPLandHamRadio@yahoogroups.com**