海外における PLT による妨害例

2012 年 1 月 13 日　国立天文台

2011 年 11 月 8 日に開催された第 5 回作業班において、海外における PLT による妨害例を紹介してほしいとの要望があった。そこで、多数ある報告のうち、いくつかを紹介する。

1. オーストリア主管庁による測定報告（別紙 1）
   公開 URL：
   http://www.bmvit.gv.at/telekommunikation/funk/plt/download/etsijwg16td09.pdf
   リンツ近郊で実測を行い、CEPT ECC/REC(05)04 に定める制限値をおよそ 42dB 超過する妨害波を測定したことを CENELEC の JWG に報告したもの。

2. オーストラリア主管庁による測定報告（別紙 2）
   公開 URL：
   http://reast.asn.au/2007/ACMA_Measurement_Day_Report_20070111__Final_.pdf
   メルボルン近郊で、PLT 利用による妨害波に対する苦情が上がり、主管庁として測定を実施したもの。34〜53dBμV/m の妨害波を実測。

3. 英国主管庁による妨害波報告（別紙 3）
   公開 URL：
   http://stakeholders.ofcom.org.uk/binaries/research/technology-research/ds2.pdf
   スコットランド　カーディフにおいて、DS2 社製 PLT モデムを用いた実測を行ったもの。送信電力は-62dBm/Hz で、漏洩電界レベルが NB30 を 15dB ほど超過する例が報告されている。

4. ARRL が FCC に提出した妨害波報告（別紙 4）
   公開 URL：http://fjallfoss.fcc.gov/ecfs/document/view?id=7021024871
   IBEC 社の PLT (BPL) モデムによる妨害波レベルを測定し、全ての測定において FCC 許容値を超過することを報告。

なお、これらの報告例にある数値をみるだけでは、妨害波がいかに酷いかが実感しづらい。妨害波を受信した場合の動画や音声が公開されているので、これらのファイルを開いてみると、その妨害問題を実感することが容易となる。

PLT による妨害例の動画や音声：
http://www.arrl.org/video-and-audio-recordings-of-bpl-interference
http://www.arrl.org/files/file/bpl/CorinexDS2.wmv
http://www.youtube.com/watch?v=x7a1-zFwLiY
http://www.youtube.com/watch?v=dK3MuTPlHS0&feature=related
http://www.youtube.com/watch?v=NuD92VYPSM4

その他にも多数がインターネット上に公開されている。

以　　上

別紙 1

オーストリア主管庁による測定報告

CENELEC/ETSI JOINT WORKING GROUP ON
EMC OF CONDUCTED TRANSMISSION NETWORKS

16th MEETING TO BE HELD ON 21 & 22 February 2006 at ETSI, SOPHIA ANTIPOLIS

Source: **Federal Ministry for Transport, Innovation and Technology (Austria)**

Date: **16 February 2006**

Title: **PLC interference;**
Report about measurements concerning power line communication systems (PLC), and harmful interference caused by PLC in the HF bands 2000 – 30000 kHz.

Background

In Austria, broadband services via PLC are being provided in some regions. Since the first trials of PLC technology in Austria, which commenced in 2001, radio amateurs, and various public safety organizations using radio services in bands below 30 MHz, periodically reported harmful interference in these frequency bands, which were, according to the opinion of these spectrum users, caused by PLC operation in the concerned region.

In order to verify the complaints of these various users of HF systems, the Austrian Telecommunication authority carried out relevant investigations in the region Linz (Upper Austria) in May 2004, April 2005 and November 2005, where a PLC system is operated on a commercial basis. It turned out that the measured emission of PLC installations in the region of Linz is much higher (approximately 42 dB) than the relevant limit according to CEPT ECC/REC(05)04 which reflects the state-of-the-art in Austria.

Results of these measurements are presented in the Annexes.
Annex 1 contains measurement results of emissions in the HF spectrum from a PLC repeater mounted on an open-wire power grid (first part), measurement results of emissions in the HF spectrum of PLC signals from a transformer and from a terminal box (second part), and emissions of mercury vapour lamps induced by a PLC signal (third part). It should be noted that

- Emissions from PLC modems installed inside of buildings (e.g. within a flat) are quite the same as emission from PLC repeaters mounted on an open-wire power grid (see first part of Annex 1).
- Mercury vapour lamps (which are in many cases used for street lighting) obviously emit signals in the frequency band below 30 MHz up to at least 3 GHz which are induced by PLC signals carried on the power grid. This effect was detected quite recently and is still under investigation. At present, it is supposed that the plasma of mercury vapour lamps, is triggered by high-frequency PLC pulses. Obviously, the mercury vapour plasma, being an element with a non-linear characteristic, spreads the PLC signal into a very large bandwidth, and amplifies/radiates this signal as broadband radio emissions with rather high field strength (see Annex 1 part 3). It was not yet possible to investigate whether these broadband radio emissions cause harmful interference to radio stations using the subject frequency bands in the vicinity of such mercury vapour lamp street lighting installations. Other administrations are encouraged to also investigate this effect and to exchange relevant results.

The characteristics of measured PLC signals are available in Annex 2 of this document.

Proposal:

This report is intended to inform the “CENELEC/ETSI JOINT WORKING GROUP ON EMC OF CONDUCTED TRANSMISSION NETWORKS” about measurements concerning power line communication systems (PLC) and harmful interference caused by PLC in the HF bands 2000 – 30000 kHz and to trigger a discussion to adopt the ECC/REC/(05)04 as the document describing the state-of-the-art for wire-line telecommunication networks such as PLC networks within Europe.

Annex 1

Measurement results

Measurement on	Location	Measurement date	Frequency of Field strength maximum	Measured field strength (Peak) in 3 m distance	Permissible field strength (Peak) according to ECC/REC/(05)04	Ppermissible field strength is exceeded by
Part 1						
PLC repeater mounted on an open-wire power grid	Ansfelden, Neubaustraße (Traunuferstraße)	23.11.2005	**8 000,0 kHz**	78,5 dBµV/m	32,1 dBµV/m	**46 dB**
	Pregarten, Mitterfeld	24.11.2005	**5 141,0 kHz**	80,9 dBµV/m	33,7 dBµV/m	**47 dB**
	Linz, Plesching	22.11.2005	**8 747,0 kHz**	82,2 dBµV/m	31,7 dBµV/m	**50 dB**
Part 2						
PLC repeater in transformer-station	Linz, Im Schlantenfeld	22.11.2005	**4 738,0 kHz**	54,7 dBµV/m	34,1 dBµV/m	**21 dB**
	Luftenberg, Statzingerstraße	22.11.2005	**21 842,0 kHz**	51,8 dBµV/m	28,2 dBµV/m	**24 dB**
	Pregarten, Trafo Heimstätte	24.11.2005	**8 002,0 kHz**	68,2 dBµV/m	32,1 dBµV/m	**36 dB**
	Steyregg, Bergsiedlung	29.11.2005	**4 753,0 kHz**	73,0 dBµV/m	34,0 dBµV/m	**39 dB**
PLC repeater in terminal box	Linz, Galvanistraße	22.11.2005	**4 648,0 kHz**	66,9 dBµV/m	34,1 dBµV/m	**33 dB**
	Linz, Im Schlantenfeld/Pulvermühlstraße	24.11.2005	**4 349,0 kHz**	69,1 dBµV/m	34,4 dBµV/m	**35 dB**
	Linz Dornach, Glaserstraße	24.11.2005	**6 460,0 kHz**	65,9 dBµV/m	32,9 dBµV/m	**33 dB**
	Luftenberg, Statzingerstraße	25.11.2005	**21 549,0 kHz**	56,3 dBµV/m	28,3 dBµV/m	**28 dB**
	Neumarkt, Feldstraße	30.11.2005	**6 858,0 kHz**	69,3 dBµV/m	32,6 dBµV/m	**37 dB**
Part 3						
Mercury vapour lamp used for street lighting	Linz, Karl Renner Straße	22.11.2005	**8 946,0 kHz**	87,4 dBµV/m	31,6 dBµV/m	**56 dB**

Figure 1: PLC signal injected from PLC modem into artificial grid according to EN55022

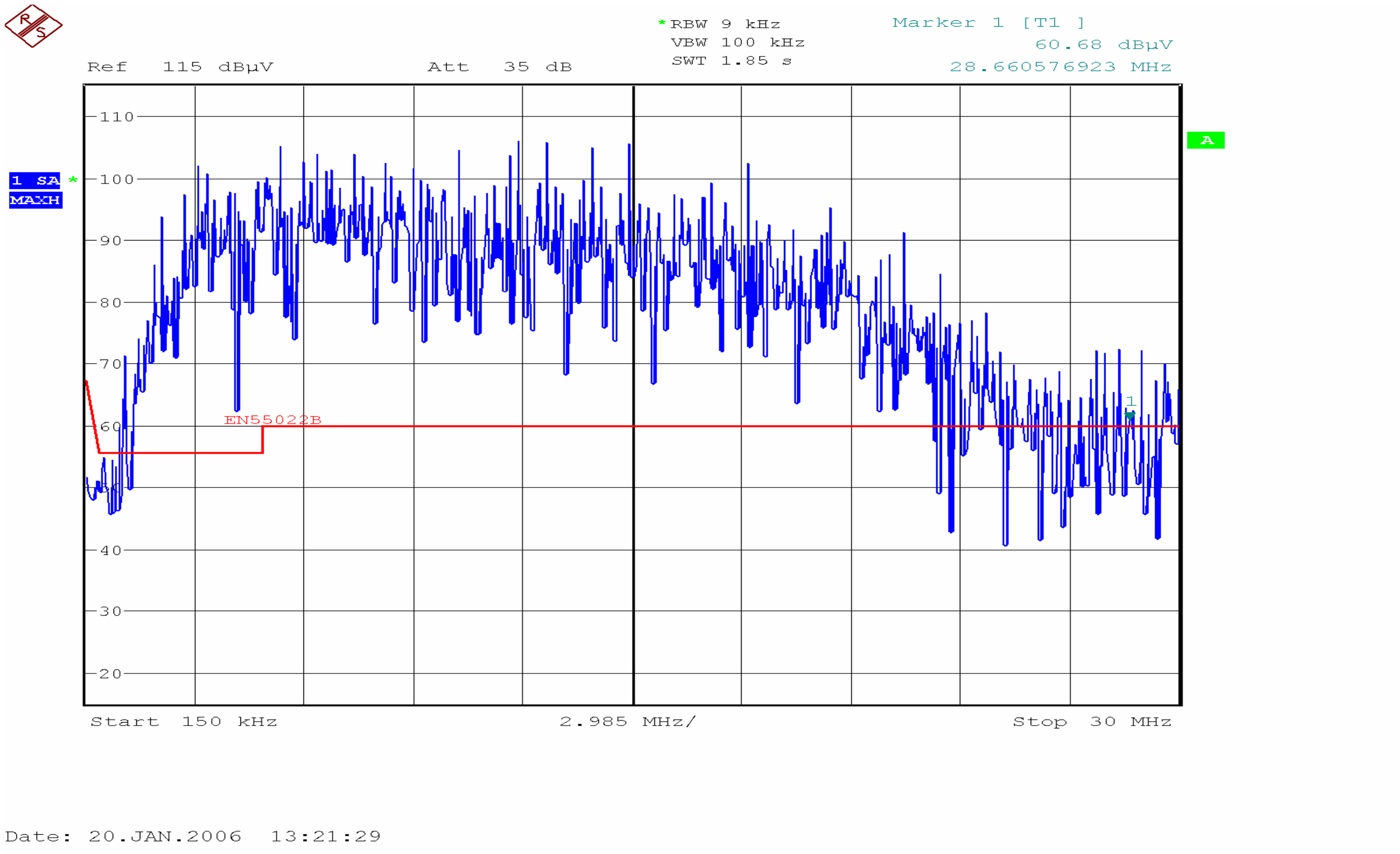
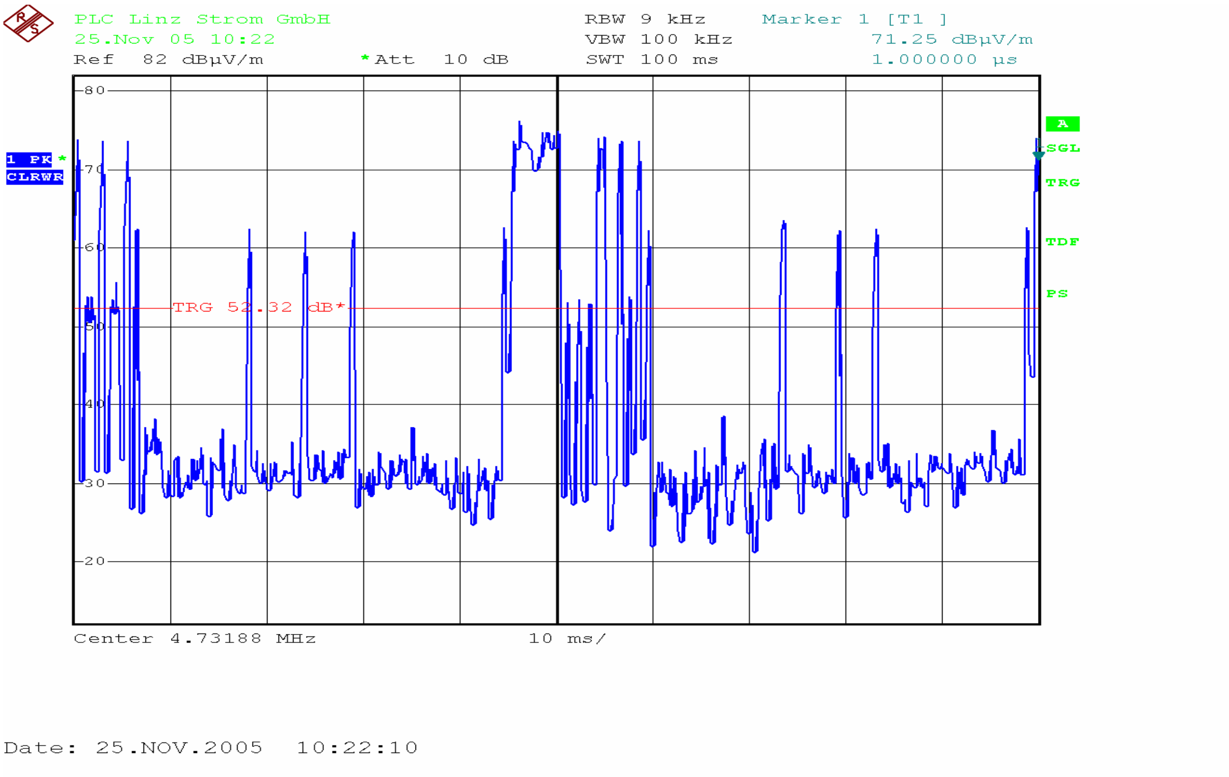


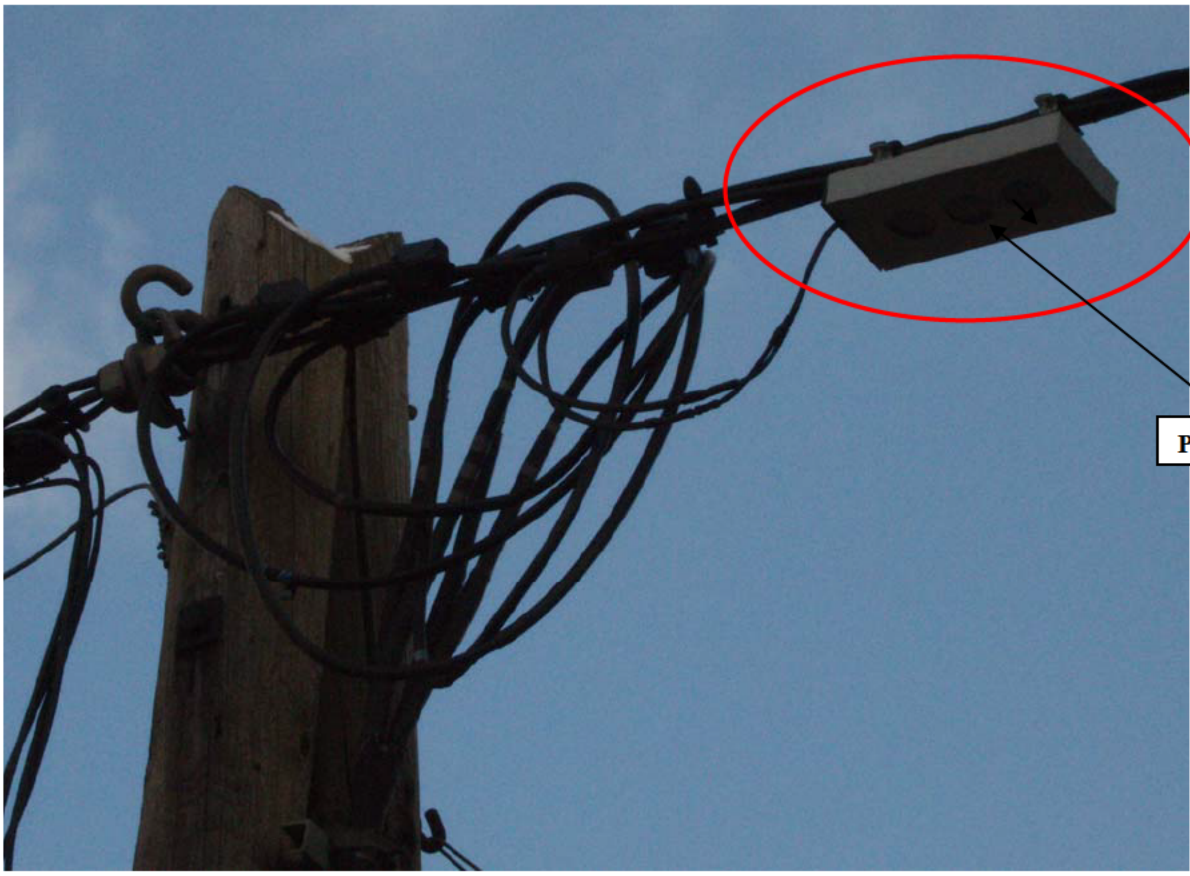
Figure 2: Radio spectrum emitted by PLC installation (measured in open area in a distance of 3 m from open-wire power grid line carrying PLC signals. Spikes are intended radio signals emitted by licensed radio transmitters. The line on the bottom presents the limit according to CEPT ECC/REC/(05)04).

Figure 3: PLC emission on the frequency 4731.88 kHz in the time domain (sweep time 100 milliseconds).
In particular, this figure shows, as an example, the interfering signals (i.e. the spikes) caused by PLC emissions.

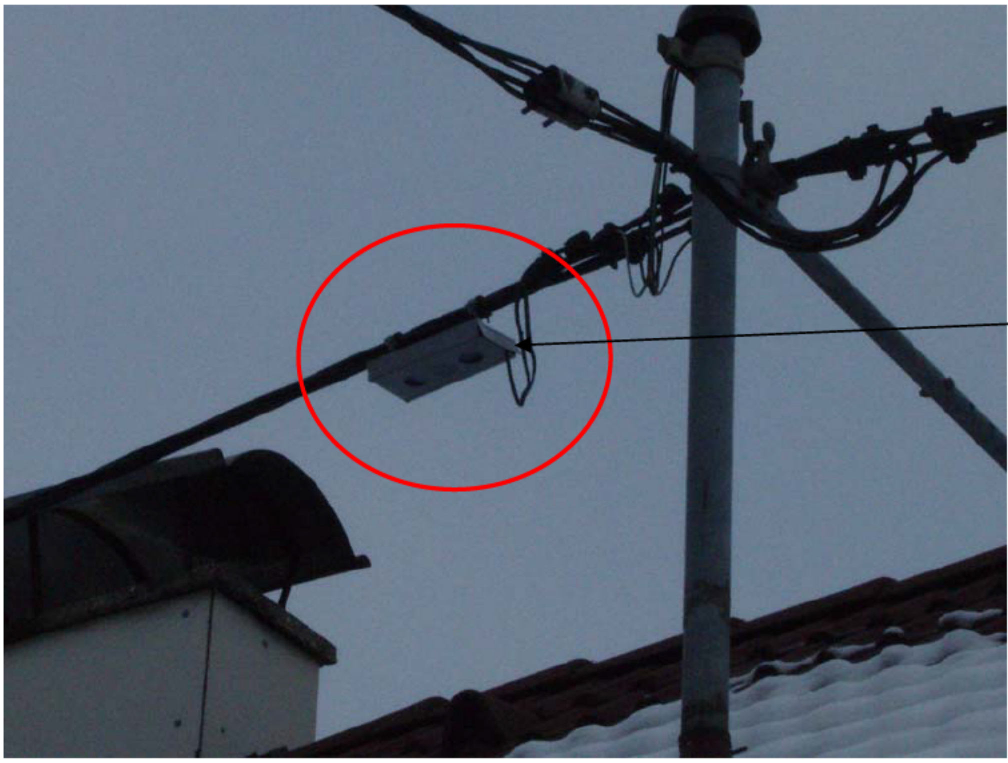


Annex 3

Typical installation of a PLC repeater on an open-wire power grid



PLC repeater



PLC repeater

Measurement situation

Annex 5

Electronic Communication Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

ECC RECOMMENDATION (05)04

CRITERIA FOR THE ASSESSMENT OF RADIO INTERFERENCES CAUSED BY RADIATED DISTURBANCES FROM WIRE-LINE TELECOMMUNICATION NETWORKS

Recommendation adopted by the Working Group "Spectrum Engineering" (SE)

INTRODUCTION

In individual cases radiated disturbances from wire-line telecommunication networks can cause (harmful) interference[1] to radiocommunications applications even if the relevant part of the network meets all relevant EMC requirements. The elimination of such interference cases becomes particularly difficult if also the individual radiocommunications application meets the provisions of its harmonised EMC and functional standards and is operating within the coverage area of the relevant radiocommunications system.

In order to resolve such individual interference cases to the best interests of both parties involved, CEPT recommends that it is useful to have a set of common criteria to assess such cases of radio interference. CEPT administrations are encouraged to use these criteria as a guideline for eliminating individual interference cases.

It is considered appropriate that this Recommendation be reviewed every three years, in the light of changing technologies and regulatory requirements. This review should involve consultation with the relevant technical and working groups within CEPT, ETSI and CENELEC.

"The European conference of Postal and Telecommunications Administrations,

considering

a) that the radio frequency spectrum is a common resource and that it is essential to minimise unnecessary interference by making the best use of the most modern and cost-effective techniques;

b) that harmonised standards for radiocommunications equipment and other electrical/electronic apparatus are established in order that such products, systems and installations operate as intended in the majority of application cases and under normal operation conditions;

c) that meeting the requirements of harmonised EMC standards may not prevent an individual apparatus, system, installation or network from causing harmful radio interference under certain operation and environmental conditions;

d) that protection from radiated disturbances from telecommunications networks is specifically called for in ITU-R RR 15.12[2] and provided for in Council Directive 89/336/EEC[3];

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[1] For ITU definitions on interference and harmful interference see RR articles 1.166 and 1.169

[2] ITU-R RR No. 15.12:"Administrations shall take all practicable and necessary steps to ensure that the operation of electrical apparatus or installations of any kind, including power and wire-line telecommunication networks, but excluding equipment used for industrial, scientific and medical applications, does not cause harmful interference to a radio communication service and, in particular, to a radio-navigation or any other safety service operating in accordance with the provisions of these Regulations"

[3] It is expected that the new version of the EMC Directive will be in force in 2007

e) that Article 6 (art 4.2 new EMC Directive, see note 3) of the Council Directive 89/336/EEC provides special measures with regard to the taking into service and use of apparatus taken for a specific site in order to overcome an existing or predicted electromagnetic compatibility problem;

f) an assessment of disturbances from wire-line telecommunication networks in accordance with the provisions of harmonised standards or other EMC specifications only is not sufficient to resolve in an appropriate manner individual cases of harmful radio interference;

g) that the ECC Report 24 "PLT, DSL, cable communications (including cable TV), LANs and their effect on radio services" addresses the compatibility between data communication systems and radiocommunications services. It also describes in detail the various radiocommunications services potentially affected by unwanted radiation from telecommunications networks and it describes the associated protection requirements. The ECC Report 24 also provides evaluation of radiation limit examples and examples of measurements.

h) that CEPT and ETSI have developed a Memorandum of Understanding describing the mutual responsibilities of the two bodies. The MoU text is available from ERO, further information available from ETSI[4];

i) that the R&TTE Directive 1999/05/EC, in force since 8th April 2000, has been implemented in EU Member States and also followed by most other CEPT member countries;

j) that further steps should be taken to harmonise the resolution of interference cases through a more formalised framework;

k) that the European Commission is preparing a Recommendation on broadband communications through Power-lines[5];

l) that the European Commission has issued the standardisation mandate M/313 under EMC Directive 89/336/EEC to CEN, CENELEC and ETSI to produce harmonised EMC standards for telecommunications networks. This mandate concerns the preparation of harmonised standards covering EMC aspects of wire-line telecommunication networks and their in-house extensions. These standards should cover the types of networks, which are currently operational or which are under development, including, but not limited to those using power lines, coaxial cables and classical telephone wires.

recommends

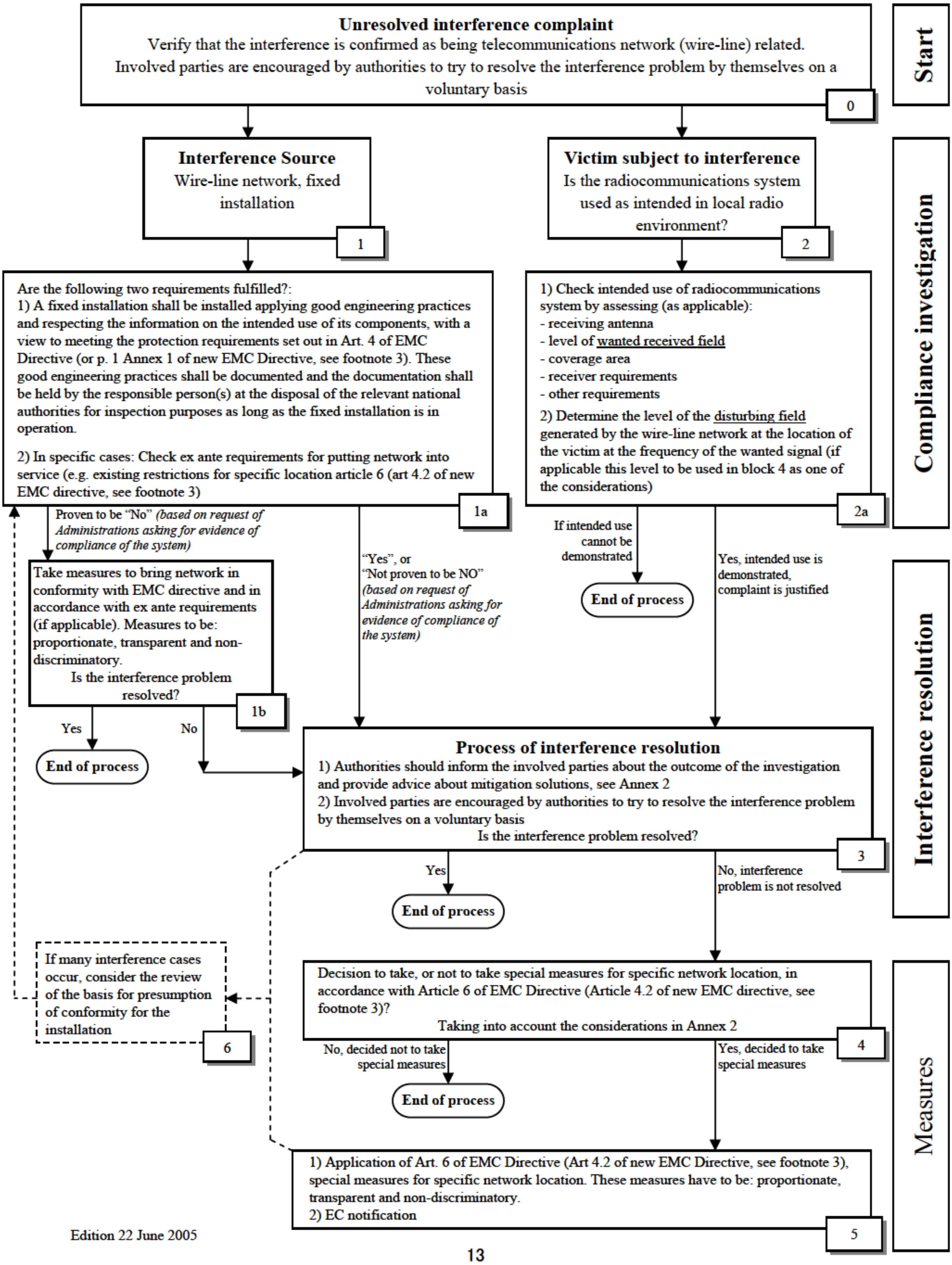
1. that when examining cases of interference complaints, caused by radiated disturbances of wire-line telecommunications networks, CEPT Administrations or National Authorities consider the use of the framework described in Annex 1 as a guideline for the process of resolving these interference cases in a transparent, proportionate and non-discriminatory way;

2. that the set of criteria for the assessment of interference, which includes reference field strength limits, as given in the Annex 2, should be used in order to investigate the case and to address all necessary measures to resolve the interference in a proportionate, non-discriminatory and transparent manner."

[4] http://portal.etsi.org/erm/kta/emc/clc_agree_emc.asp
[5] This recommendation was in draft form as of August 2004

Annex 1

GUIDELINES FOR THE ASSESSMENT OF RADIO INTERFERENCE CASES CAUSED BY DISTURBING RADIATIONS GENERATED BY WIRE-LINE TELECOMMUNICATIONS NETWORKS



Addendum

Explanation of flowchart in Annex 1

0		**Starting point** The process starts with an unresolved interference case complaint involving a radiocommunications system and a wire-line network. Involved parties are encouraged by authorities to try to resolve the interference problem by themselves on a voluntary basis
1		**Gathering information about the interference source** • Determine if the wire-line telecommunications network causes the interference • Request evidence of presumption of conformity of the network. Wire-line telecommunications networks are considered to be fixed installations and can only be put into service if they comply with the essential requirements of the EMC Directive
	1a	The following requirements have to be assessed by the national authority: • A fixed installation shall be established applying good engineering practices and respecting the information on the intended use of its components, with a view to meeting the protection requirements set out in Art. 4 of EMC Directive (P. 1 of Annex 1 of new EMC Directive, see footnote 3). Those good engineering practices shall be documented and the documentation shall be held by the responsible person(s) at the disposal of the relevant national authorities for inspection purposes as long as the fixed installation is in operation. • In addition, ex ante requirements might be applicable for a specific location, e.g. if prior EMC Directive's Art. 6 procedure (Art. 4.2 of new EMC Directive, see footnote 3) was used to forbid the putting into service or use of a wire-line network in an certain area in order to overcome an existing or predicted EMC problem in that area.
	1b	If network is NOT in conformity with EMC directive: • Wire-line communications networks are considered to be fixed installations and can only be put into service if they comply with the essential requirements of the EMC Directive. So the network must be brought in conformity with the EMC Directive. Measures should be: - proportionate; - transparent; - non-discriminatory.
2		**Gathering information about the radiocommunications system which suffers interference** Is the radiocommunications system used as intended in local radio environment?: • Investigate the radiocommunications system • Obtain information and evidence of compliance of the radiocommunications system with the relevant requirements.
	2a	1) Check intended use of radiocommunications system by assessing (as applicable): • Receiving antenna • Receiver requirements • Coverage area • Level of wanted received field • Distance between the source and victim • Does the victim radiocommunications system suffer from a structural defect or other inner malfunction? • Are the operating conditions in accordance with the specification? • Do the operating conditions (such as location and type of antenna) fulfil the minimum relevant requirements for reliable signal reception? • Other requirements that are applicable 2) Determine the level of the disturbing field generated by the wire-line network at the location of the victim at the frequency of the wanted signal (if applicable this level to be used in block 5 as one of the considerations)

3	**Process of interference resolution** - Authorities should inform the involved parties about the outcome of the investigation and provide advice about mitigation solutions, Annex 2 refers - Involved parties are encouraged by authorities to try to resolve the interference problem by themselves on a voluntary basis
4	Process of taking a decision to take or not to take special measures for this specific location of the network (in accordance with Art. 6 of EMC Directive, Art. 4 of new EMC Directive), taking into account the considerations given in Annex 2 like: - the importance of the radiocommunications service - the importance of the network - technical aspects - economic aspects and other aspects
5	Taking specific measures on the basis of Art. 6 of EMC Directive, Art. 4 of new EMC Directive (see footnote 3). Special measures for a specific location of a network have to be: - proportionate; - transparent; - non-discriminatory. Special measures should be notified to the European Commission. Those that have been recognized as justified must be contained in an appropriate notice made by the Commission in the *Official Journal of the European Union*.
6	If many interference cases occur, administrations are urged to consider the review of the basis for the presumption of network conformity.

Annex 2

MITIGATION TECHNIQUES AND CONSIDERATIONS, INCLUDING LIMITS OF THE DISTURBANCE FIELD STRENGTH,

APPLICABLE TO BLOCKS 3 AND 4 OF FLOWCHART IN ANNEX 1

Mitigation techniques (Ref. Block 3, Annex 1)

Some examples of possible mitigation techniques are:

- Change of receiving antennas and/or their siting for the victim radiocommunications system
  Note: other antenna types or a better antenna siting could be an efficient mitigation technique. However this may not always be possible in a given location and could involve significant costs if the antenna site is high above the ground.
- Change in the geometrical structure of the wire-line network
- Frequency notching by the operator of wire-line network
  Note: the notching of specific frequencies may not be possible with some modulation schemes. Notching is an effective technique to mitigate specific cases of interference. If there are multiple cases of interference, multiple notches will seriously reduce the bandwidth available to the network operator.
- Use more repeaters in the wire-line network to reduce peak power
  Note: this will tend to increase the bandwidth used by a network operator in a locality as many repeaters employ a frequency-shift. A wire-line telecommunications network operator will wish to minimise the number of repeaters on economic grounds.
- For the case of Power Line Communication systems, other techniques such as the use of filters and signal terminations, differential mode signal injection, adaptive filtering and power control can be considered.

Criteria to decide whether special measures should be taken (Ref. Block 4, Annex 1)

These special measures refer to Art. 6 of the EMC directive (Art 4.2 of new EMC directive, see footnote 3) which are meant to overcome an existing or predicted electromagnetic compatibility problem at a specific site regardless of the fulfilment by the involved equipment (interference source and victim) of the requirements of the EMC Directive.

Criteria to decide whether special measure should be taken should contain the following aspects:

1. Technical aspects

- Level of the disturbance field strength generated by the network at the location of the victim at the frequency of the (disturbed) wanted signal. Examples of practical measurement procedures[6]: for each scenario and network different measurement methods should be used as appropriate, for example: in-situ measurements of the disturbance emission or conducted disturbance measurements.

- Recommended field strength level for assessing the level of the disturbance emission generated by the wire-line network at the location of the victim at the frequency of the (disturbed) wanted signal is stated in the following table:

[6] CENELEC TLC/prTS50271; RegTP 322 MV 05

Frequency f [MHz]	Limit of the interfering electric field strength in dB(µV/m) (peak detector) at the location of the victim and at the distance of 3 meter from the source	Measurement Bandwidth
0.009 to 0.15	40 - 20·$\log_{10}$(f/MHz)	200 Hz
0.15 to 1	40 - 20·$\log_{10}$(f/MHz)	9 kHz
Above 1 to 30	40 - 8.8·$\log_{10}$(f/MHz)	9 kHz
Above 30 to 1000	27 (1)	120 kHz
Above 1000 to 3000	40 (2)	1 MHz

(1) This corresponds to an effective radiated power of 20 dBpW.
(2) This corresponds to an effective radiated power of 33 dBpW.

- National Administrations could decide to take special measures regardless of the level of disturbing field if it is justified by the importance of the victim radiocommunications service, e.g. for safety and/or emergency services (see section 2 of this annex).

- Field strength measurements at the interference site will show if a decrease in the unwanted field strength might improve the interference scenario

2. Economic and political aspects

- Burden of costs to achieve compatibility for the victim and interferer (note: Administrations should have to take account of the proportionalities of the costs)

- Importance of the victim service (safety related services etc.)
  Setting more stringent parameters or limits for particular devices or frequency bands.
  Note: This is a political rather than an economic aspect. The need to protect special services (e.g. safety related services) should not be influenced by an economic argument.

- Alternative delivery of the service
  Note: This is a political decision. Freedom of access to existing sources may potentially be restricted if alternative delivery is by a non-radio medium. An alternative delivery of a service will also have an economic impact for the operator and the user of this service.

- Number of interference complaints
  Note: The number of interference complaints may be far below the number of interference events. A user subject to interference may not recognise the cause as interference from a wire-line network. As a result an interference complaint is not made to the Administration. Administrations are expected to intervene only when interference complaints are notified.

- Perspectives for the future
  - New radio technologies
  Note: New technologies may not improve the interference scenario. New technologies are usually introduced for economic reasons.

- New users to take account of existing users ("First come - first served" principle)
  Note: This principle provides a general protection of existing services. However Administrations have to assess if this general principle has to be maintained under all circumstances.

3. Regulatory aspects

- Responsibility
  Note: The responsibilities of the interferer and the victim have to be identified.
- Administrations may invoke coordination procedures between the affected parties to solve a case of interference.

4. Assessment of all criteria and circumstances

Administrations should assess all criteria in a balanced and proportional way. Especially in a “Conflict of Standards” case, Administrations are expected to avoid any unnecessary burden for the victim service.

別紙 2

オーストラリア主管庁による測定報告

ACMA – BPL Measurement Day Report

11 January 2007

By Justin Giles-Clark VK7TW

Attendees:

- Colin Payne – ACMA Regulation and Compliance Branch Melbourne
- David Long – ACMA Regulation and Compliance Branch Hobart
- Phil Wait VK2DKN – WIA
- Justin Giles-Clark VK7TW – REAST
- Conrad Kley VK7HCK - Complainant
- Greg Todd VK7YAD - Observer
- Harvey Skegg VK7HK - Observer

Background:

Mr Kley made an initial complaint of unacceptable levels of interference from BPL emissions in November 2005 and then again on the 11 September 2006, and these have been the subject of ongoing investigation by ACMA. ACMA detected emissions at the Quoin Ridge ITU monitoring station (20km away) in November 2005, however that is no longer the case possibly due to the use of wireless technology for the BPL back-haul network. ACMA staff also undertook further measurements at Mt Nelson on 24/11/05, 28/06/06 and 14/07/06.

Following Mr Kley's follow-up complaint of 11/09/06 the ACMA compiled their measurement results into a report which was released at the end of November 2006. The following is a short summary of ACMA's 14 July 2006 measurement results showing emission levels in the bands Mr Kley's complaint related to:

Frequency (MHz)	14/07/06 measurements		Analyser Range	Comment
	dBuV/m	MHz		
3.5-3.7	34.1 64.0[1]	3.53 3.56	Wideband span 2-6Mhz span	BPL is above the noise in this band.
7.0-7.3	51.1 42.4	7.22 7.25	Wideband span 6-10MHz span	BPL emission across whole band
14.0-14.35	40.3 43.9	14.28 14.34	Wideband span 10-16MHz span	If software notching is in use it is ineffective BPL detected across whole band
21.0-21.45	46.5 34.3	21.44 21.44	Wideband span 16-23MHz span	Notching deployed however upper end of notch not effective
28.0-29.7	52.6 53.3	29.1 29.0	Wideband span 23-30MHz span	Narrow notch employed remainder of the band has high level BPL emissions.

At the time ACMA suggested that Aurora was not utilising the Jeizer network management software which would ensure the BPL system operated at the lowest practical power levels in the vicinity of Mr Kley's residence.

[1] Large Spike, similar to the spike at 2.81MHz – may not be BPL.

The Ionospheric Prediction Service's ionosonde emissions were detectable at 11.3MHz but were masked by the BPL emissions from 14MHz upward.

ACMA commented in the report that receiver selectivity must be considered when a vendor is deciding the degree of software notching to implement and the use of sensitive communications receivers may require front-end filters to reduce or prevent front-end overloading, inter-modulation distortion and desensing.

The ACMA report substantiates the claims made by Mr Kley that the Aurora BPL system is causing interference and greatly reducing his ability to operate licenced amateur radio equipment.

Latest Series of Measurements:

On 11 January 2007 ACMA undertook another round of measurements with the assistance of Colin Payne who is an EMC measurement specialist within the ACMA Regulation and Compliance Branch. Measurements were undertaken at Mr Kley's residence using equipment flown in from Melbourne.

David & Colin observing the HF spectrum with test equipment and test loop antenna.

Measurements were taken using a flat-response loop antenna and also using Mr Kley's quad and vertical antennas so a comparison could be made between the calibrated professional antenna and tuned amateur antennas.

Initial findings indicated that higher frequency signals were showing lower levels using the calibrated antenna compared to the tuned amateur antennas, possibly due to the different locations and heights of each antenna.

There was correlation between what Mr Kley was reporting using the “S” signal strength scale and what was measured using the test equipment on the same antenna.

Notch measurements showed about a 20dB notch depth which still resulted in about an S3-4 being experienced by Mr Kley within a notch. There also appeared to be remnant carriers within the notch.

David, Colin and Conrad discussing the results using Conrad’s antennas to measure emission levels.

It was acknowledged that Aurora has through notching and wireless backhaul reduced the level of emissions over the period of the trial. Conrad has requested further reductions in emission levels including the widening of notching in various bands and notching of the 10m band.

We await with interest the release of measurement results from this round of testing.

別紙 3

英国主管庁による妨害波報告

DS2 PLT Measurements in Crieff

Publication date: 11 May 2005

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Summary

This project was designed to update Ofcom on the nature and extent of the unavoidable radio frequency leakage emissions that radiate from modern Power Line Telecommunications networks. Particular interests were the rate at which PLT leakage emission levels decay with distance from their source and the effectiveness of any mitigation measures that can be applied by PLT manufacturers and operators to reduce any adverse impact of these leakage emissions on radio reception.

This report covers the second part of the project and is specific to the situation at Crieff in Scotland where Scottish and Southern Energy plc were undertaking a commercial trial of a DS2 access PLT product that is based on multi-carrier OFDM signal architecture.

A significant feature of the DS2 access PLT product is a built-in capability of having programmed notches inserted within the broadband downstream spectrum for the purpose of reducing launch power levels, within specified frequency bands, by up to 30dB. This aspect was the main focus of this work.

Swept frequency measurements of the conducted output of the DS2 Head End modem were made to characterise the broadband downstream spectrum and to examine the notching capabilities. It was found that both the 20dB and 30dB notches performed as claimed but that the application of the 30dB notch resulted in an appreciable loss of wanted bandwidth.

A low noise loop antenna was used to make swept frequency measurements of radiated leakage emissions within the Ancaster Road area of Crieff, where the DS2 PLT network was deployed. It was found that, even at the maximum power setting of the Head End modem, the notched spectrum bandwidth and depth remained unchanged when measured as a radiated emission.

The practical benefits of the notching technique have been shown in this report as several simple examples where radio signals, previously buried under DS2 leakage emissions, were uncovered by notching.

Leakage emission levels were generally found to be in accordance with expectations having regard to the measurement position, distance from the source, power applied and in particular, the results of previous work on radiated emissions from PLT networks.

The flexibility of the DS2 product, with its programmable spectrum mask and downstream notching capability, represents a significant step towards a more EMC friendly PLT solution.

Section 1

Background

Power Line Telecommunications (PLT), Power Line Communications (PLC) and Broadband *over* Power Line (BPL) are all terms used to refer to the process of delivering high frequency broadband data over existing electricity supply cables, on a secondary use basis. The generic term PLT will be used in this report.

PLT products are designed to provide broadband internet access using electricity distribution networks as a transmission medium. In concept, PLT has some similarities with ADSL that also delivers high frequency broadband data, using existing infrastructure cables on a secondary use basis.

Access PLT networks feature high frequency internet signals that are passed between an electricity sub-station and all the PLT customers connected to it. A typical 500 kVA substation can serve up to about 200 electricity users, situated within a 200 metre radius, with the potential PLT customer base being a small percentage of these. To serve these customers, each PLT enabled electricity sub-station must be connected to an ISP via a dedicated high capacity link.

In principle, PLT is in competition with ADSL and Cable although, in practice, the PLT market share in the UK is currently extremely small as there are only a few isolated commercial trial networks in operation. One reason for this is concern over leakage emission levels. Although efficient for their primary purpose, electricity supply cables are not designed, screened or balanced for high frequency use and in this application they produce significant leakage emissions. These emissions have the potential to interfere with the reception of radio communication services, including short wave broadcasts.

This potential for interference from PLT networks was first raised by RA during 1997 as a result of leakage emission measurements taken at the first UK trials of PLT, by United Utilities, in Manchester. The interference aspect of PLT has been widely debated in many discussion groups since. The PLT industry has participated in these discussions from the outset and responded to the interference issue by focussing on more efficient modulation techniques. These permit operation over a wider bandwidth with less power spectral density than some early PLT deployments. Other measures, such as the use of quasi-balanced signal coupling and the use of intermediate repeaters have also reduced leakage emission levels in some applications.

The PLT interference issue is contentious and remains under discussion within the EC and elsewhere. Various radiated emission limits have been proposed, either for system compliance or for the purposes of adjudication in cases of reported interference, but currently none can satisfy a dual objective of protecting radio reception whilst, at the same time, allowing PLT to operate in a commercially viable manner.

The advent of multi-carrier PLT signal architecture has lead to a comparatively recent development in which pre-defined frequency bands within the broadband PLT spectrum can be notched to lower the launch power spectral density. The notched frequency bands have significantly reduced leakage levels. This technique is being promoted by

PLT manufacturers and operators as a useful mitigation measure in cases where nearby radio receivers are experiencing interference from PLT signal leakage even though the unnotched leakage levels may be within the currently proposed emission limits.

The second generation DS2 PLT equipment, deployed by S&SE at Crieff, has a notching capability that is examined in this report.

Section 2

Introduction

Scottish and Southern Energy's PLT Trials

Scottish and Southern Energy plc, a major UK power utility, is currently conducting several trials of access PLT products. Small scale trials are in place at Crieff and Campbeltown in Scotland with larger trials underway at Stonehaven in Scotland and at Winchester in England.

S&SE's promotional material for their PLT based broadband products can be found at:

http://www.hydro.co.uk/broadband/index.asp

http://www.southern-electric.co.uk/broadband/

Some of these trials are receiving external support, including that from central government through the DTI broadband fund. More details can be found at:

http://www.ssetelecom.co.uk/news/index.asp

http://www.scottish-enterprise.com/sedotcom_home/services-to-business/broadband/broadband-news/power_line_trial.htm

Access PLT Networks in Crieff

S&SE are currently using and evaluating equipment from three different PLT manufacturers, Ascom, MainNet and more recently DS2.

The Ascom equipment uses GMSK signal architecture, MainNet equipment uses DSSS signal architecture and the DS2 equipment uses OFDM signal architecture. The RA had previously undertaken leakage emission measurements at S&SE's trial PLT network at Crieff when both Ascom and MainNet PLT equipment were in use. (**Ref 1**) In a later development, S&SE has installed multi-carrier PLT equipment using a chipset developed by the Spanish company DS2. Measurement of the DS2 based access PLT network at Crieff is the subject of this work.

Measurement Objectives

Project 793 was designed to update Ofcom on the nature and extent of the unavoidable radio frequency leakage emissions that radiate from modern Power Line Telecommunications networks.

Particular interests were the rate at which PLT leakage emission levels decay with distance from their source and the effectiveness of any mitigation measures that can be applied by PLT manufacturers and operators to reduce any adverse impact of these leakage emissions on radio reception.

This second part of project (793/2) is specific to the situation at Crieff where Scottish and Southern Energy plc are currently undertaking a commercial trial of the DS2 access PLT product that is based on multi-carrier OFDM signal architecture.

The primary objective of this work was:

1.) To examine the DS2 PLT spectrum and characterise the notching capabilities provided by the chipset in order to assess its potential usefulness as an interference mitigation measure.

Other objectives were:

2.) To measure the level of leakage emissions in the immediate vicinity of both the DS2 access PLT network and PLT customer premises.

This information was required in order to compare PLT leakage emission levels with those measured elsewhere and to make comparisons with emission limits under discussion within Europe.

3.) To assess the effect of DS2 leakage emissions on short wave broadcast reception within the domestic environment.

It is considered that short wave broadcast reception within the domestic environment is the most likely interference scenario to occur due to PLT deployment. To address this issue, it was agreed that the BBC would be invited to use the two PLT customer premises, made available by S&SE, to continue their previous work on the effect of PLT leakage emissions on both AM broadcast reception and reception of the new Digital Radio Mondiale services. (**Ref. 2**)

The BBC took up this invitation and a recent BBC R&D White Paper on the compatibility between PLT and Broadcast reception contains some references to this work. (**Ref 3**)

A further BBC report, specific to their recent work at Crieff, is expected.

Section 3

Summary of findings

Notching

The notches requested by Ofcom were applied to both the downstream access spectrum transmitted from the Head End master unit in Ancaster Road substation and separately to the downstream in-house spectrum transmitted from the Home Gateway master units in PLT customer premises. Notches could not be applied to the upstream spectrum.

Measurements of the conducted DS2 signal at Ancaster Road substation confirmed that the depth of both 20dB and 30dB notches, was as claimed but that the application of the 30dB notch resulted in an appreciable loss of wanted bandwidth.

A low noise loop antenna was used to make swept frequency measurements of radiated leakage emissions within the Ancaster Rd area of Crieff where the DS2 PLT network was deployed. It was found that, where there were sufficient leakage levels above the measuring system noise floor to demonstrate it adequately, the DS2 notched spectrum performance remained unchanged, even at the maximum power setting of the Head End modem. This aspect addresses some speculation that intermodulation may occur within a PLT network and cause spectral re-growth within the notches.

Further work, to examine the practical benefits of the notching technique has been demonstrated in several simple examples where radio signals, previously buried under DS2 leakage emissions, were uncovered by notching.

DS2 were unable to apply notching in an upstream direction from either of the slave units. This is presumably because it would have conflicted with the dynamic power control of the slave units by the master units. It does, however, represent a significant shortcoming in the general concept of notching as an interference mitigation measure.

Launch power levels

DS2 stated that the PLT network at Ancaster Road was operating satisfactorily at a downstream launch power of -62dBm/Hz. This level was claimed to be sufficient to provide the advertised broadband service to S&SE's 6 customers, one as far as 230 metres from the launch point, without the use of intermediate repeaters.

Leakage emission levels

The leakage emission levels measured were as expected, having regard to the measurement position, distance from the source, power applied and the results of previous work.

There were two locations where it was possible to make a close approximation to a standard 3 metre regulatory measurement. At both of these, leakage emissions resulting from the Link 2 Home Gateway downstream spectrum, radiated by in-house wiring, were at levels close to the German NB30 radiated emission limit. (**Ref. 4**)

At one of these locations the Link 1Home Gateway upstream spectrum, also radiated by in-house wiring exceeded the German NB30 radiated emission limit by up to 15dB.

Section 4

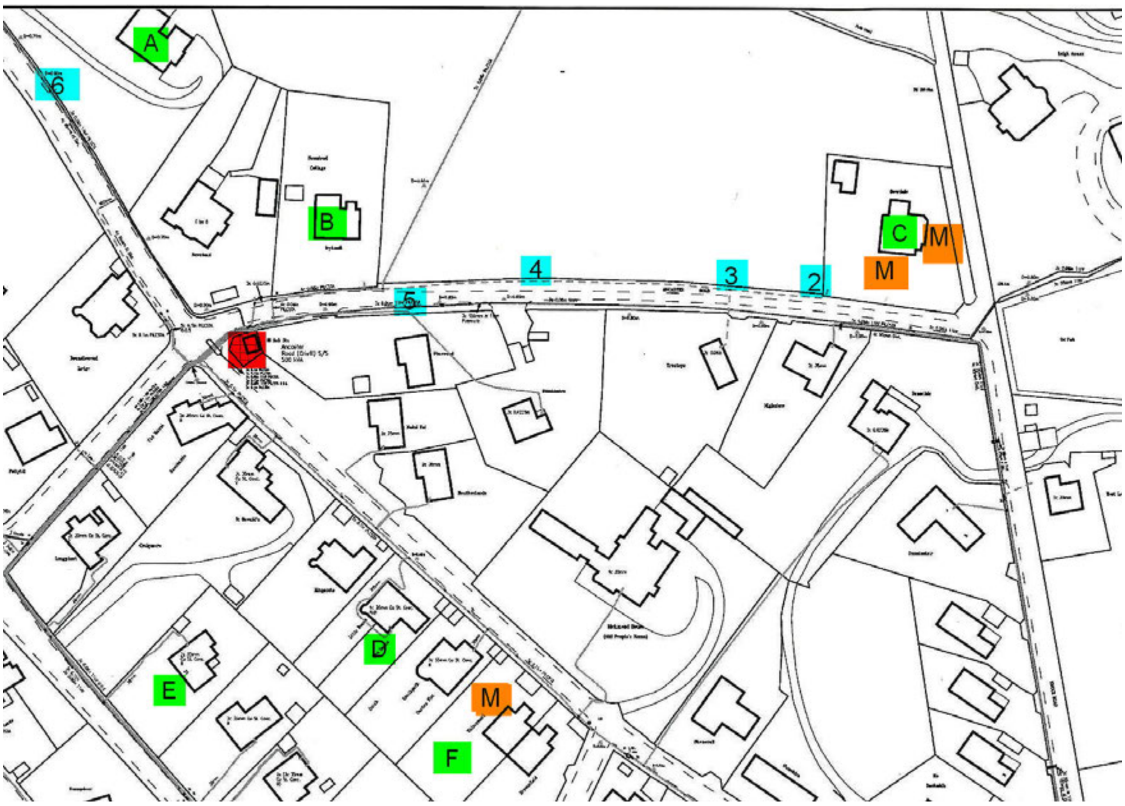
Test Notes

Measurement Location

At the time of testing, the Crieff DS2 deployment from Ancaster Road substation served 6 PLT customers, the most distant of which were over 200 metres from the substation.

The map below, provided by S&SE, shows that the area consists mainly of large residential properties arranged in a low density format.

Figure 1   Ancaster Road PLT Network



Approximate Scale: 100 metres

Key:

Red		**Ancaster Road electricity substation**
Green	**A, B, C, D, E, F**	**PLT Customer Premises**
Blue	**1, 2, 3, 4, 5, 6**	**Access network - measurement positions**
Orange	M	In-house network - measurement positions

The DS2 PLT system

DS2 based PLT equipment uses 1280 carrier OFDM signal architecture delivering a total data rate, per network, of 27 Mbps downstream and 18 Mbps upstream. Features of the system include fully programmable spectrum ranges operating between 1 and 38 MHz and a programmable transmission power mask to facilitate notching.
This and more information, can be found at: http://www.ds2.es/home/index_total.php

For network operators, a PLT management and monitoring solution, optimised for the DS2 product range, is available from Jeizer.™ This information, can be found at: http://www.jeizer.com/webjeizer/WEB_JEIZER/english/template_E.html

DS2 Network Architecture

Each DS2 PLT cell consists of two networks. The 'access' or outdoor part that comprises the LV 3 phase distribution network associated with a single electricity substation and the 'in-house' part that comprises the single phase internal electricity wiring in a PLT user's premises. The networks, known as Link 1 and Link 2 are integrated to provide the end to end functionality of the product.

To provide full duplex operation, the substation to house 'access' spectrum (Link 1) is divided into upstream and downstream blocks. The Link 1 Head End master unit is situated in an electricity sub-station and communicates with the 'slave' units installed in PLT customer premises using the LV 3 phase distribution network as a transmission medium.

Except for PLT customers very close to the substation, where low attenuation renders this unnecessary, a similarly divided higher frequency spectrum is used for the 'in-house' network (Link 2) The transition between the Link 1 and Link 2 spectrum blocks is carried out by a Home Gateway unit located near the electricity meter in a PLT user premises. The Home Gateway unit acts as a slave for the Link 1 access network and a master for the Link 2 spectrum which uses the in-house electricity wiring as a transmission medium to carry PLT signals to and from a modem, normally situated by the user's computer.

Crieff DS2 PLT Deployment

Link 1 (Access PLT Network)			
Downstream (head end to home gateway)	7.8 to 11.3 MHz	Master	(768 carriers)
Upstream (home gateway to head end)	2.5 to 5.0 MHz	Slave	(512 carriers)
Link 2 (In-house PLT Network)			
Downstream (home gateway to computer)	19.0 to 22.75 MHz	Master	(768 carriers)
Upstream (computer to home gateway)	13.8 to 16.3 MHz	Slave	(512 carriers)

The downstream spectrum from both Link1 and Link 2 master units is continuous. The upstream spectrum from the slave units transmits only when allowed by the Head End master unit.

Transmit Power Spectral Density (PSD) can be varied in 6 dB steps, known as Levels. Level 1 represents the minimum value of -74dBm/Hz and Level 5 represents the maximum value of -50dBm/Hz. The power of the slave units is under dynamic control of the Master units in order to achieve a satisfactory signal to noise ratio.

The Ancaster Rd PLT enabled substation

At the time of testing, this PLT enabled 500 kVA substation supplied approximately 6 PLT customers with symmetrical broadband connections of up to 1Mbit/s using a Head End modem fitted with the DS2 chipset that is based on OFDM signal architecture.

Figure 2 Ancaster Road Sub-Station

The underground LV electricity distributors, carrying the PLT signals, exit the sub-station close to the lower ventilation grille shown on the left hand side of the picture.

PLT backhaul is provided by an overhead SDSL feed from the telegraph pole on the right hand side of the picture.

A small programme of conducted measurements was made inside the sub-station and the initial radiated measurements were made just outside it.

Test Equipment

Some conducted current measurements inside the substation were made with a Schaffner SMZ11 current clamp and a Rohde & Schwarz FSU3 spectrum analyser. All other measurements were made with a Rohde & Schwarz ESCS30 EMI measuring receiver.

Except where stated in section 5, all the radiated leakage emission measurements were made using a Rohde & Schwarz HM525, low noise, magnetic loop antenna. Both the antenna and the measuring receiver were battery powered to allow portability and to eliminate the possibility of ground loop currents adversely affecting the measurements. With the 9 kHz bandwidth and peak detector settings used, the magnetic field measuring system had a noise floor of approximately 10dBµV/m. This is up to 20 dB lower than can usually be achieved with measuring systems employing the standard 60cm loop antenna specified in CISPR 16.

DS2 & S&SE support during the measurements

Engineering representatives from both DS2 and S&SE were present throughout the test period to adjust the network settings, implement spectrum notches, to liaise with PLT customers and to witness the measurement processes.

Downstream Power Settings for the Access Network
It was emphasised by DS2 that a significant feature of their PLT product was its ability to function at a low signal to noise ratio allowing the use of a PSD of -62dBm/Hz at Crieff.

DS2 representatives were resistant to the idea that the PLT network should be tested at its full power settings in case the lower PSD benefits of the DS2 equipment were not clearly evident in this report. It was agreed that, in accordance with normal practice, the power setting in use would be recorded and shown in the results but that the full power capabilities of the product would be clearly indicated in this report.

It some instances it was necessary to operate the downstream access network at its full power setting of -50dBm/Hz in order to properly demonstrate the notching capabilities of the product but for most other measurements a power setting of -62dBm/Hz was used.

Leakage Emission Measurements from In-house Networks
It was DS2's stated view that initial proposals to make leakage emission measurements inside a PLT user premises were unfair to their product as they could not be expected to 'protect' the reception of radio broadcasts in that environment.

It was argued by Ofcom that, in-house PLT leakage emissions are a potentially problematic issue both within multiple occupancy premises housing a PLT user and for premises immediately adjoining a PLT user. It was further argued that information about the level and extent of these emissions was important and would be required before decisions about emission limits could be made.

All parties to these measurements were, however, appreciative of the degree of customer premises access, already negotiated on our behalf by S&SE. In order to minimise further disruption and inconvenience to those customers it was agreed that measurements would be made at 1 & 3 metres from the outside walls of those premises but where possible, adjacent to the rooms containing PLT equipment.

Section 5

Measurement results

DS2 Link 1 Conducted Downstream Spectrum

The Head End downstream access spectrum was plotted at Ancaster Road substation.

The spectrum was characterised by measuring the common mode current on the cables joining the PLT couplers to the substation LV bus bars as shown below.

Figure 3   Substation Bus Bars with PLT signal coupler.

Coupling
S&SE apply PLT signals to the bus bars using the black coupler shown at the top middle of the picture. Coupling is symmetrical between the Red and Yellow phases with no neutral connection.

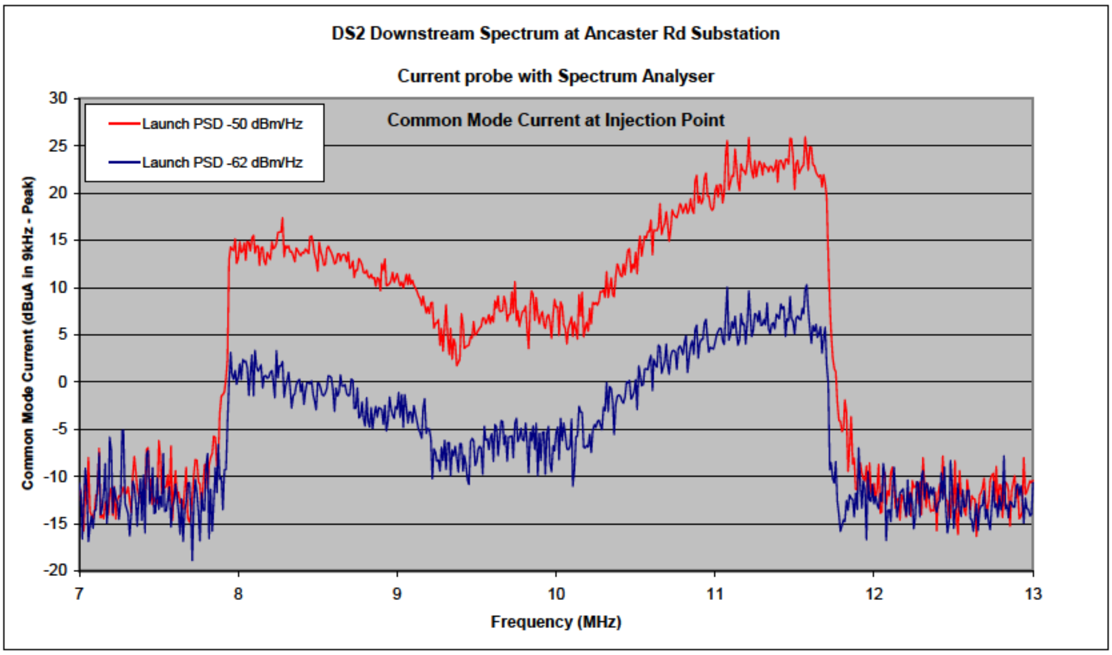
Measurements
A Schaffner SMZ11 current clamp is shown on the bus bar side of the PLC coupler. The measurement was of common mode current injected directly into the network.

Safety Note
As these measurements were made on the live electricity network, the current clamp was installed by qualified S&SE staff. A rubber insulation blanket and shrouding for the current clamp feeder cable can be seen in the photograph.

DS2 Conducted Downstream Spectrum – Spectrum Analyser Measurements

The charts that follow show the result of swept frequency measurements across the DS2 downstream access spectrum using a Rohde & Schwarz FSU3 Spectrum Analyser.

Figure 4 DS2 Conducted Downstream Spectrum – Power Settings



The chart shows the 7.8 to 11.3 MHz downstream spectrum used to transfer data from the substation to the home gateway units over the access part of the PLT network.

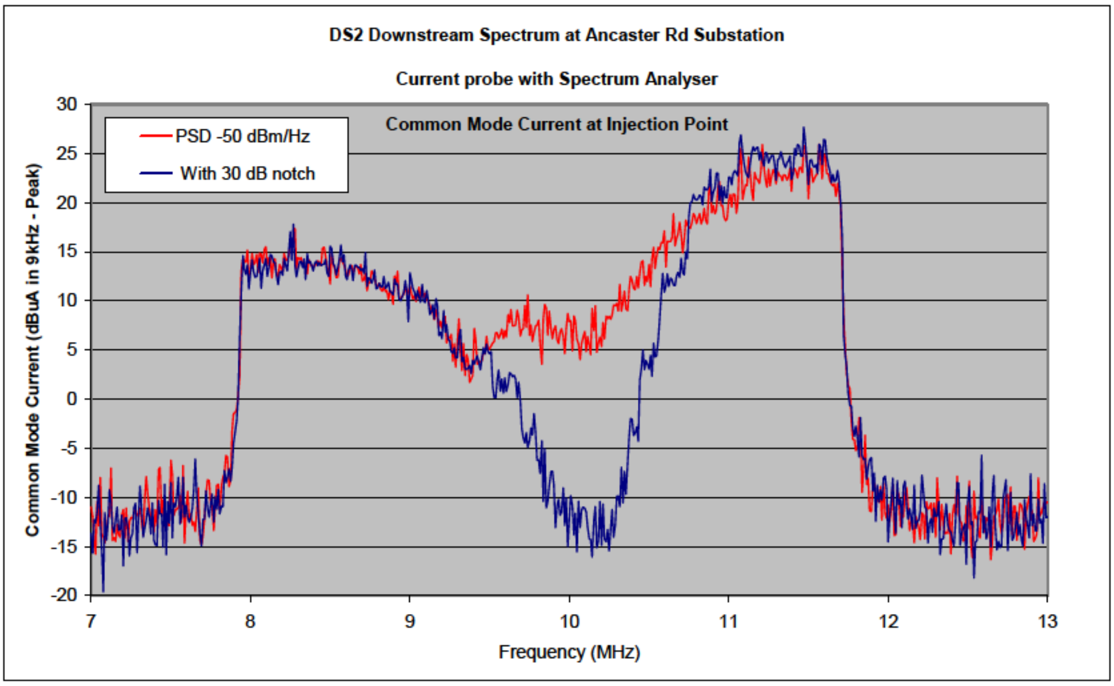
Both the 'normal' and the full power condition have been shown.

It can be seen that, unlike some first generation PLT equipment, the spectrum envelope has an extremely sharp roll-off at both sides of the operating band.

The shape of the amplitude curve is the result of variations in the common mode impedance of the electricity network and the frequency response of the PLT coupler.

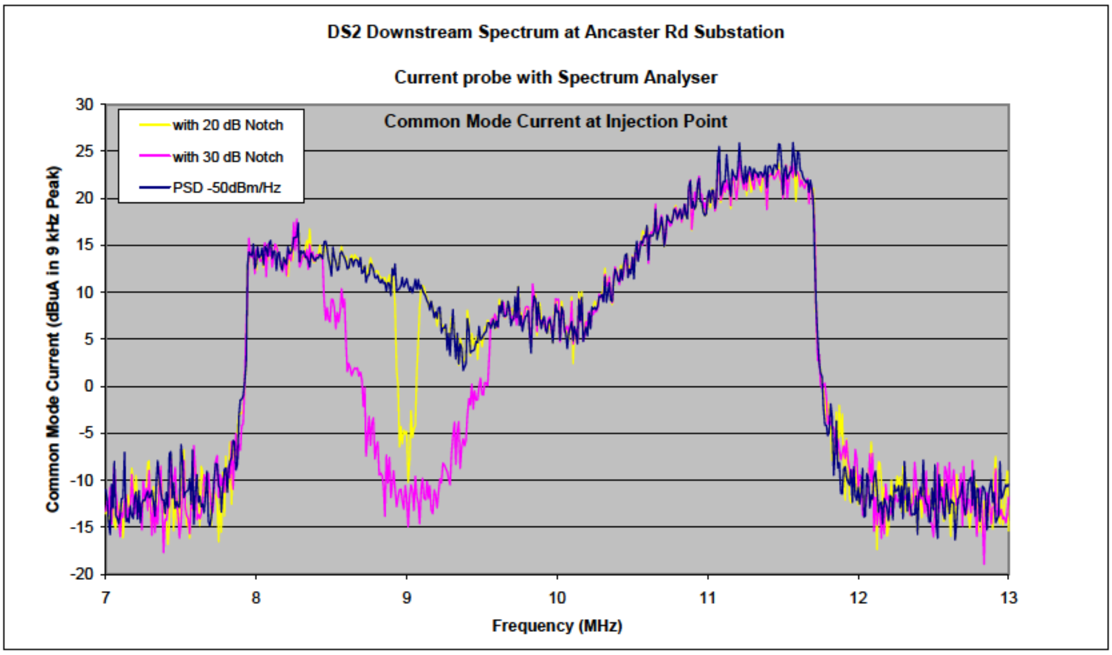
If it had been possible to make the measurements with the Head End unit connected to a constant impedance wideband load, then the in-band amplitude level would have been flat on the assumption that all carriers were being transmitted at the same power.

Figure 5 DS2 Conducted Downstream Spectrum – with notch at 10.125 MHz



The chart shows a '30dB' notch centred on the 10.1 to 10.15 MHz Amateur Radio Band

Figure 6 DS2 Conducted Downstream Spectrum – with notch at 9 MHz

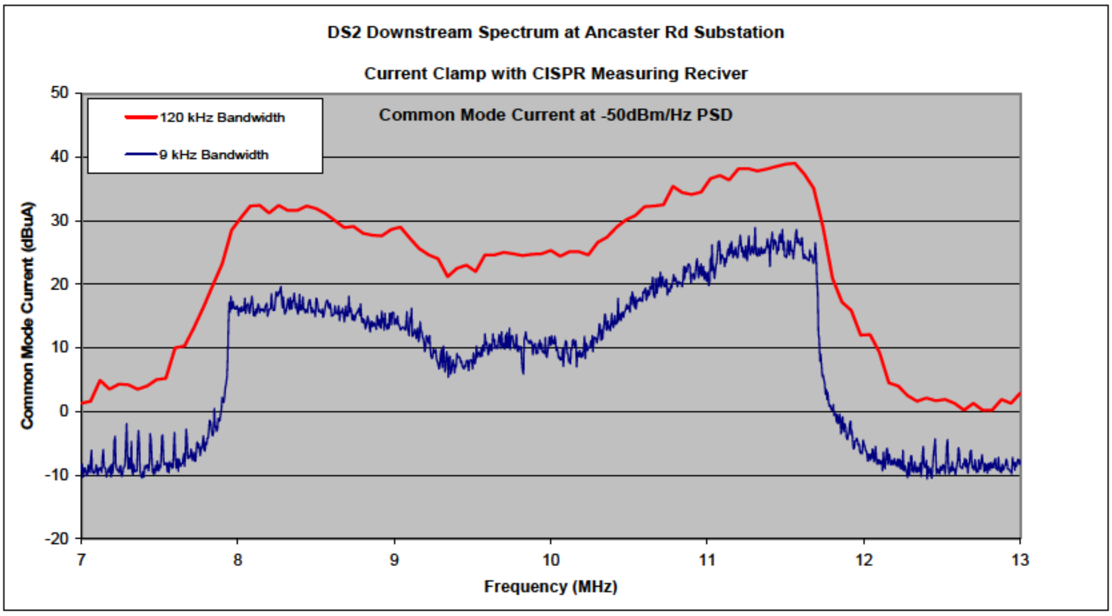


The plot shows a, sharp sided, 20 dB deep notch applied between 8.965 & 9.040 MHz by DS2 engineers.

Also shown, is a 30 dB deep notch specified for the same frequencies. As can be seen the extra 10dB notch depth has resulted in a substantial loss of wanted bandwidth.

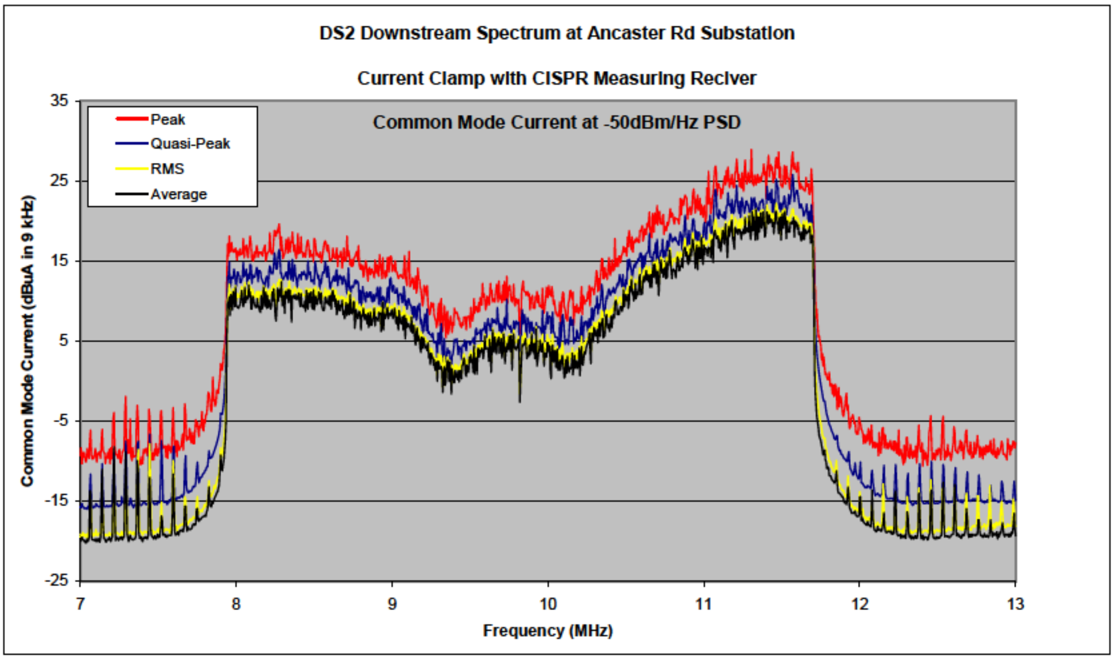
DS2 Downstream Spectrum – ESCS30 Measuring Receiver Responses

Figure 7 Measuring Receiver Bandwidth Response to DS2 signal



It can be seen that the difference in peak level is approximately 11dB [10 log (120k/9k)] indicating the noise like structure of the DS2 OFDM signal.

Figure 8 Measuring Receiver Detector Response to DS2 signal



Taking the Peak Detector reading as a reference, the approximate response of the receiver's detectors to the DS2 OFDM signal is:

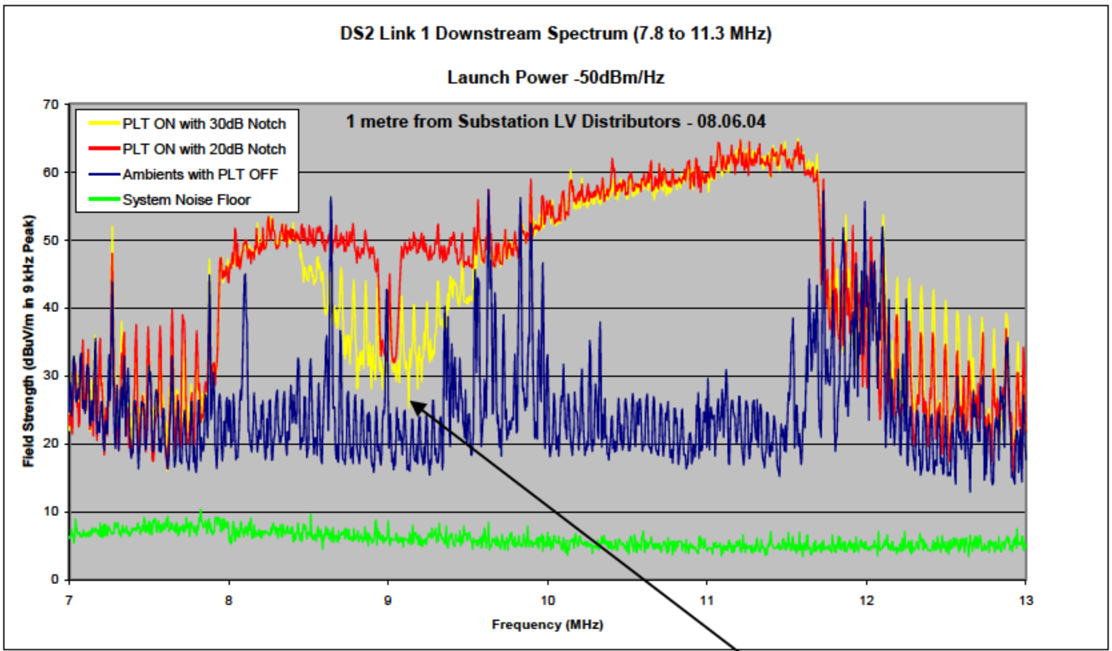
Quasi-peak -3 dB
RMS -5 dB
Average -6 dB

Radiated Emission Measurements in Ancaster Road

The chart below shows a 'worst case' radiated emission level measurement made at approximately 1 metre from the underground LV distributors leaving the Ancaster Rd substation.

The measurement was made with a Rohde & Schwarz HM525 loop antenna and ESCS30 measuring receiver.

Figure 9 Leakage Emissions outside Ancaster Rd Sub-Station (location 1)



The plot shows notches between 8.965 & 9.040 MHz.

Both 20 dB and 30 dB notches were individually applied and the effect of these can be seen.

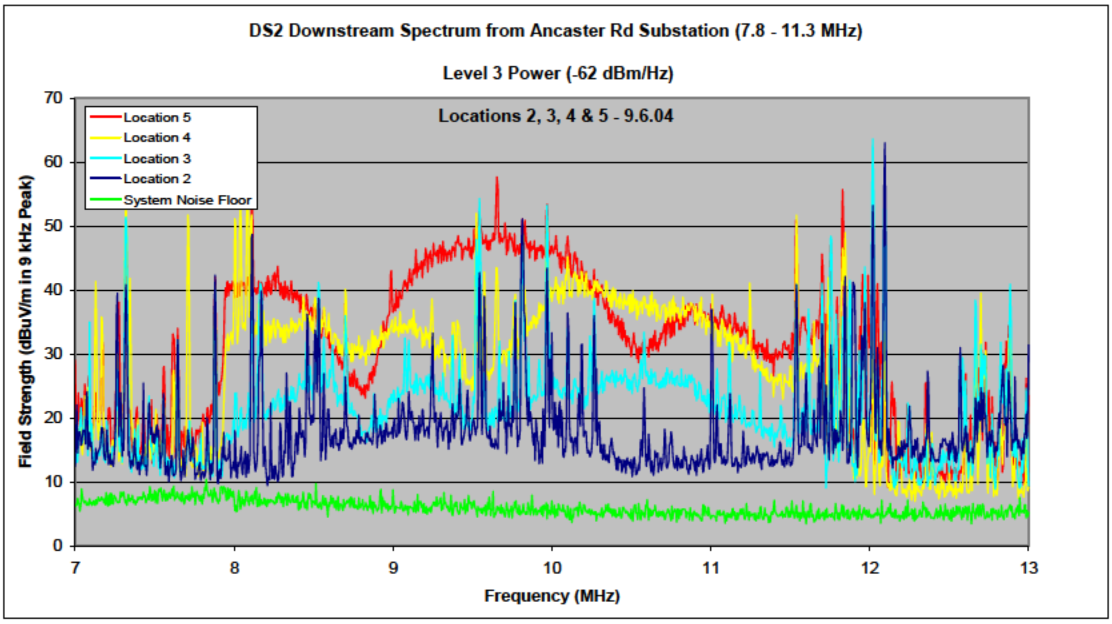
It appears that the 30dB notch is not significantly deeper than the 20dB notch, but the chart shows noise spikes both within the 30 dB notch and at either side of the DS2 downstream spectrum block. These spikes were found to be coming from the switch mode power supply unit in the DS2 modem and have led to a false impression about the depth of the 30dB notch.

It can also be seen that some lower level spikes, of unknown origin, were evident in the 'PLT OFF' plot when the DS2 Modem was not operating.

Downstream Leakage Emission Measurements in Ancaster Road

Measurements at positions 2 to 5 along Ancaster Road have been grouped together to provide a quick overview of the leakage emission situation. Photographs of these measuring locations appear in **Annex B**

Figure 10 DS2 Downstream Spectrum leakage in Ancaster Road



The leakage emissions shown are due to the DS2 access PLT spectrum transmitted from the Head End unit in Ancaster Road substation.

The measurements were made with the loop antenna placed directly over the underground cables supplying electricity to the houses shown in the table below. The positions used were close to where the single phase house supply feeders were jointed to the main underground 3 phase LV distributor running along Ancaster Road.

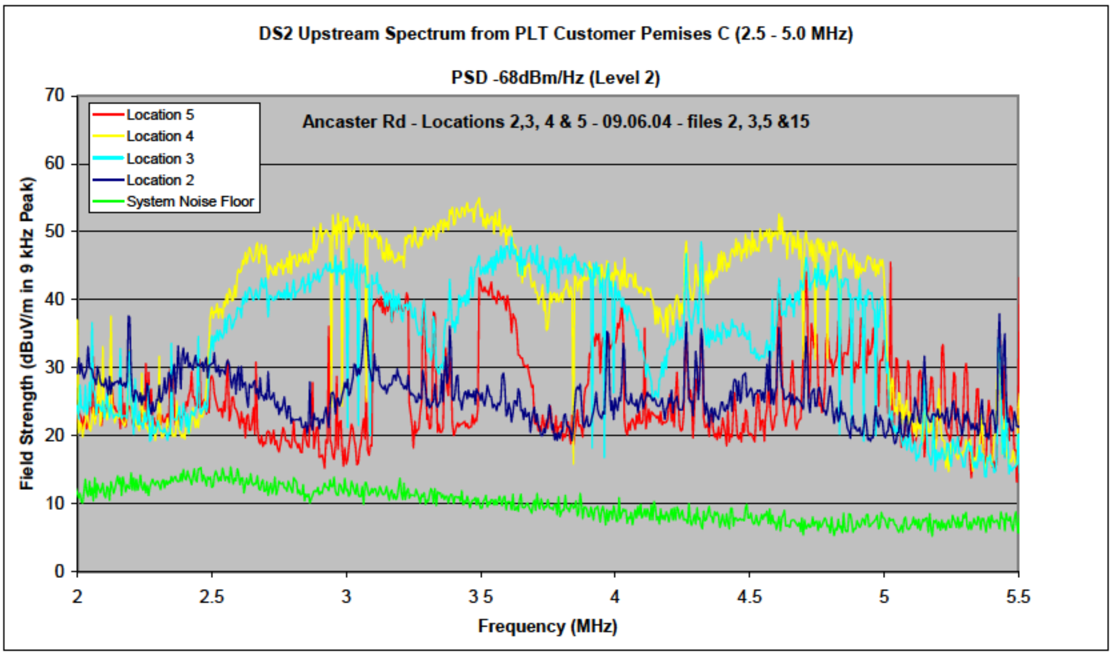
Figure 11 Ancaster Road Measurement Locations – Table 1

Map Location Number	Description	PLT Customer Premises	Approximate cable distance from substation injection point
2	Outside 'Overdale'	Yes **(see note)**	190 metres
3	Outside 'Treetops'	No	160 metres
4	Outside 'Rumbleden'	No	110 metres
5	Outside 'Pinewood'	No	55 metres

Note: *Overdale was at the end of the Ancaster Road LV distributor and had a 3 phase supply. It was unclear whether there was any separate joint underneath the measuring position, at the external boundary of the property, or whether the 3 phase LV distributor ran in a continuous length up to the house.*

The results show that, as expected, the leakage emissions radiated from the cables generally decrease in level as the distance from the substation is increased.

Figure 12 Upstream Spectrum



The leakage emissions shown above are due to the DS2 upstream access spectrum transmitted from the Home Gateway slave unit in 'Overdale' at the far end of the Ancaster Road section of the PLT network.

In order to produce a continuous spectrum, the Home Gateway unit was exercised by DS2 engineers to produce a data transfer rate of 800kb/sec. The upstream PSD of all Home Gateway units is automatically controlled by the head-end master unit with the setting used in this case being shown in the chart above.

Figure 13 Ancaster Road Measurement Locations – Table 2

Location Number	Description	PLT Customer Premises	Approximate cable length to nearest PLT customer Home Gateway unit
2	Outside 'Overdale'	Yes **(see note)**	30 metres
3	Outside 'Treetops'	No	60 metres
4	Outside 'Rumbleden'	No	110 metres
5	Outside 'Pinewood'	No	100 metres

Note: Overdale was at the end of the Ancaster Road LV distributor and had a 3 phase supply. It was unclear whether there was any separate joint underneath the measuring position, at the external boundary of the property, or whether the 3 phase LV distributor ran in a continuous length up to the house.

The upstream levels at position 2 were much lower than expected. This is likely to have been due to the beneficial effect of PLT signal balance within the 3 phase feeder to the house and possibly also to the absence of a joint at the measurement position.

5.3 Notched Spectrum Measurements in Ancaster Road

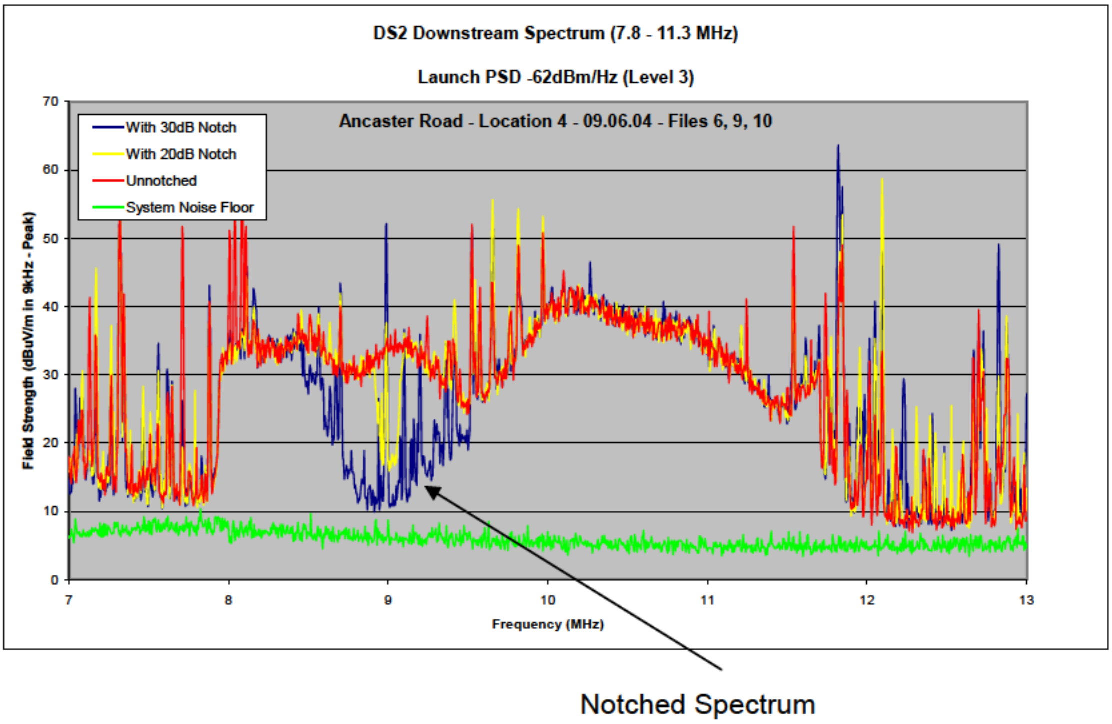
Radiated emission measurements of notched DS2 downstream spectrum were made at location 4, about halfway from the substation to the furthest point of the Ancaster Road PLT network.

All notches were applied directly by DS2 engineers at the Ancaster Road substation rather than remotely by S&SE, using the management software available to them at their PLT control centre in Perth.

The equipment has downstream notching capabilities within both the access spectrum from the Head End unit and the in-house spectrum from the Home Gateway units installed in each customer premises.

Notching is not supported in the upstream spectrum.

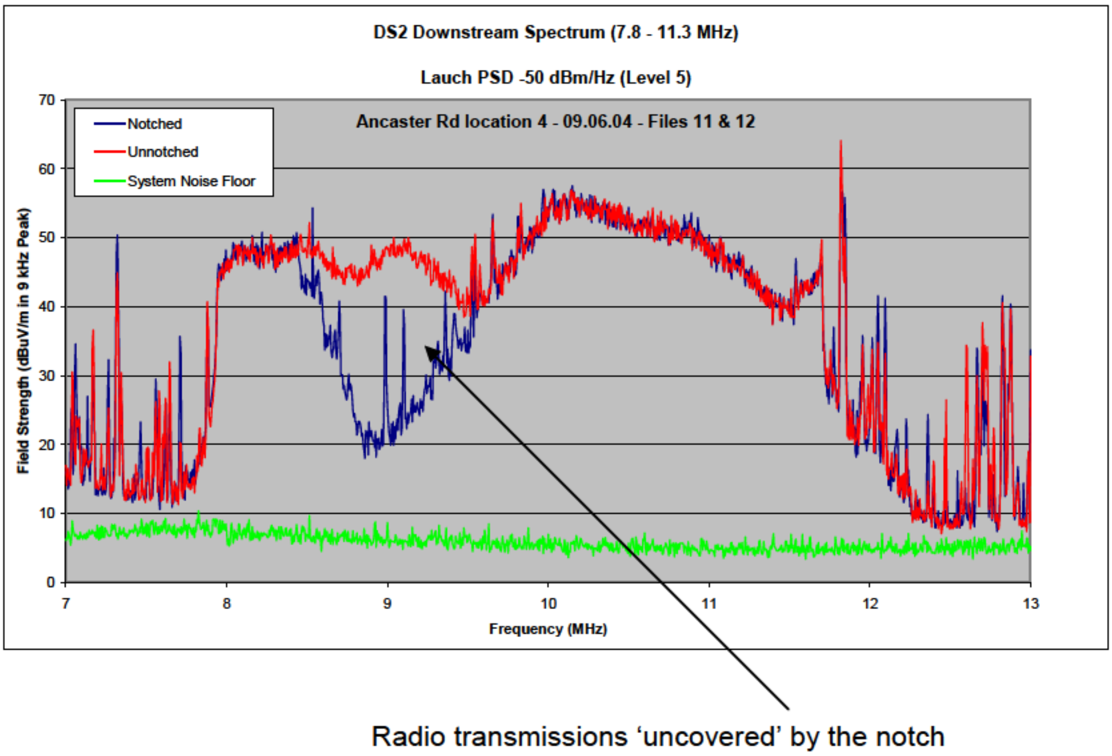
Figure 14 DS2 Downstream Spectrum with notch between 8.965 and 9.040 MHz



In this part of the DS2 spectrum the unnotched level was only 25dB above the ambient noise floor. In order to display the full 30dB notch depth an increase in launch power was required.

For this measurement the Head End unit in Ancaster Road substation was set to maximum power in order to generate a sufficient level of leakage emissions to demonstrate the full performance of the notching technique.

Figure 15 Downstream Spectrum with 30 dB notch between 8.965 and 9.040 MHz



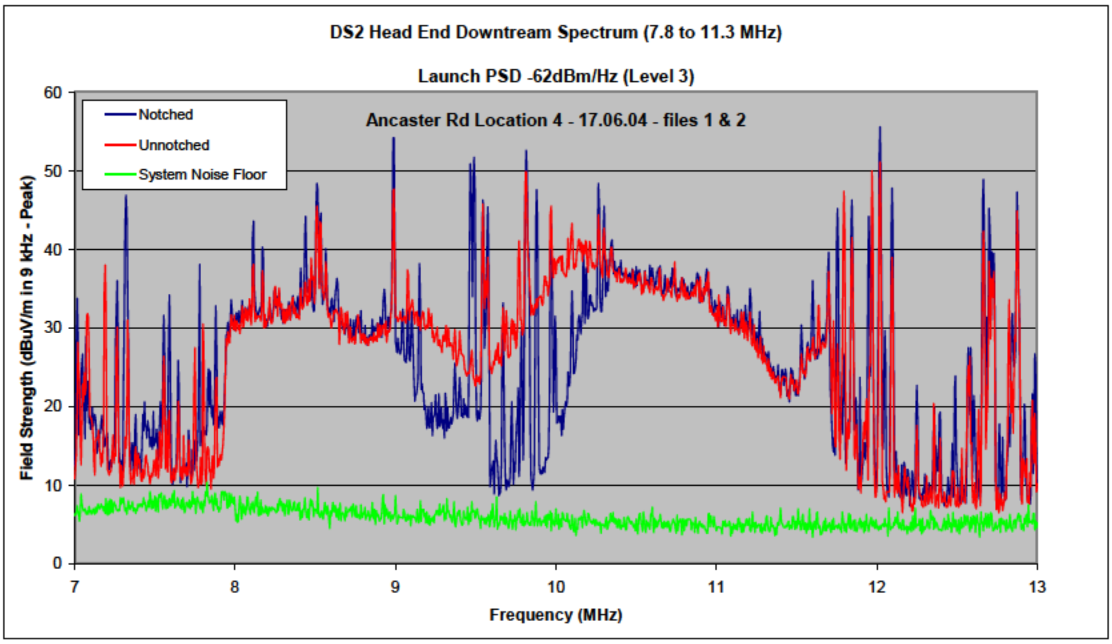
The chart shows the DS2 downstream access spectrum with the deepest notch that can be applied.

It can be seen that the notch was effective in uncovering, part of, two radio transmissions that would otherwise have been completely buried beneath the PLT signal.

A point to note is the substantial loss of downstream bandwidth that has occurred despite the 30 dB notch requested being only 75 kHz wide.

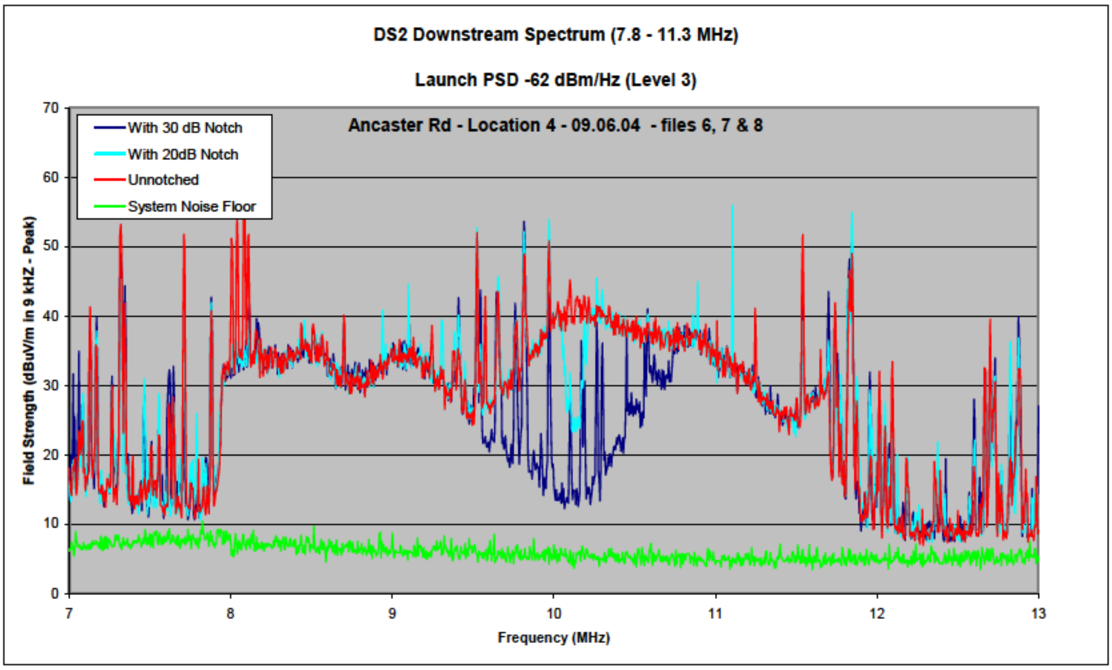
Further notches within this spectrum block were examined and these are shown overleaf.

Figure 16 Downstream Spectrum with 30 dB notch between 9.4 and 9.9 MHz



This notch covers the 9.4 to 9.9 MHz broadcast band.

Figure 17 DS2 Downstream Spectrum with notches between 10.10 and 10.15 MHz



These notches were specified to cover the 10.1 to 10.15 MHz Amateur Radio band.

The notch bandwidth specified was the same in both cases. There was insufficient launch power to demonstrate the full depth of the 30dB notch as a radiated measurement at this location.

Leakage Emission Measurements in Drummond Terrace

This measurement location was chosen to supplement the Ancaster Rd leakage emission measurements because it was outside a PLT customer premises that had a conventional single phase supply rather than the PLT customer in Ancaster Road (location 2) that had a 3 phase supply.

Figure 18 Location 6 – Outside PLT Customer Premises A (Tom an Oir)

The location shown is a grass verge outside the boundary wall of PLT customer premises A.

The Rohde & Schwarz HM525 loop antenna (**see note**) can be seen in position over the underground single phase electricity feeder where it enters the grounds of the premises.

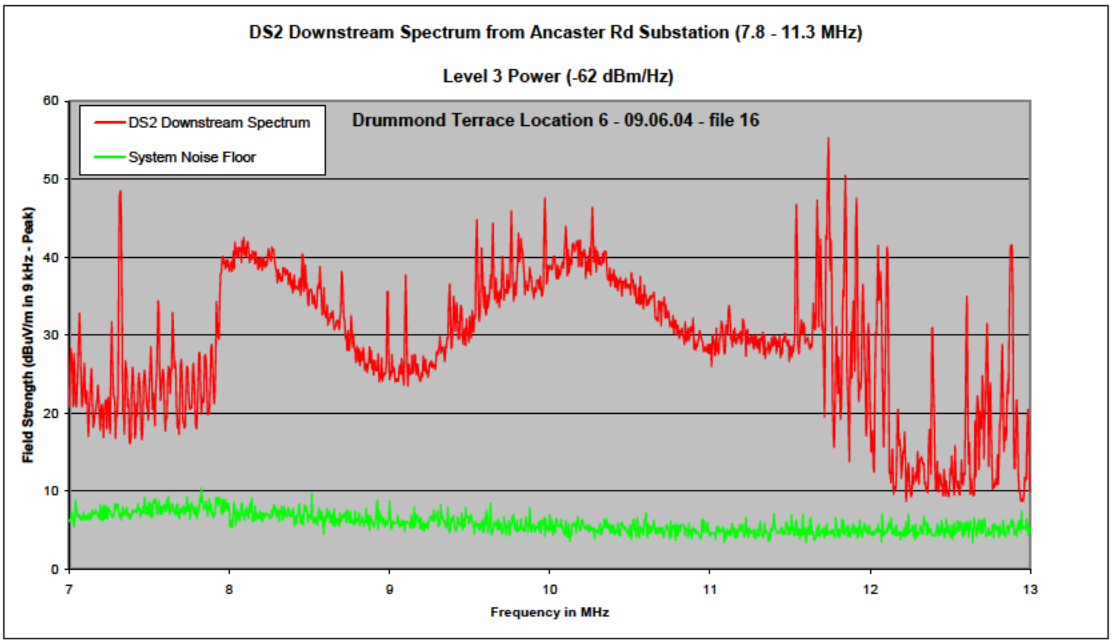
The distance to Ancaster Rd substation injection point is approximately 100 metres

The distance to the customer premises is approximately 30 metres

Measurement distance from antenna to the underground LV feeder is between 1 & 2 metres.

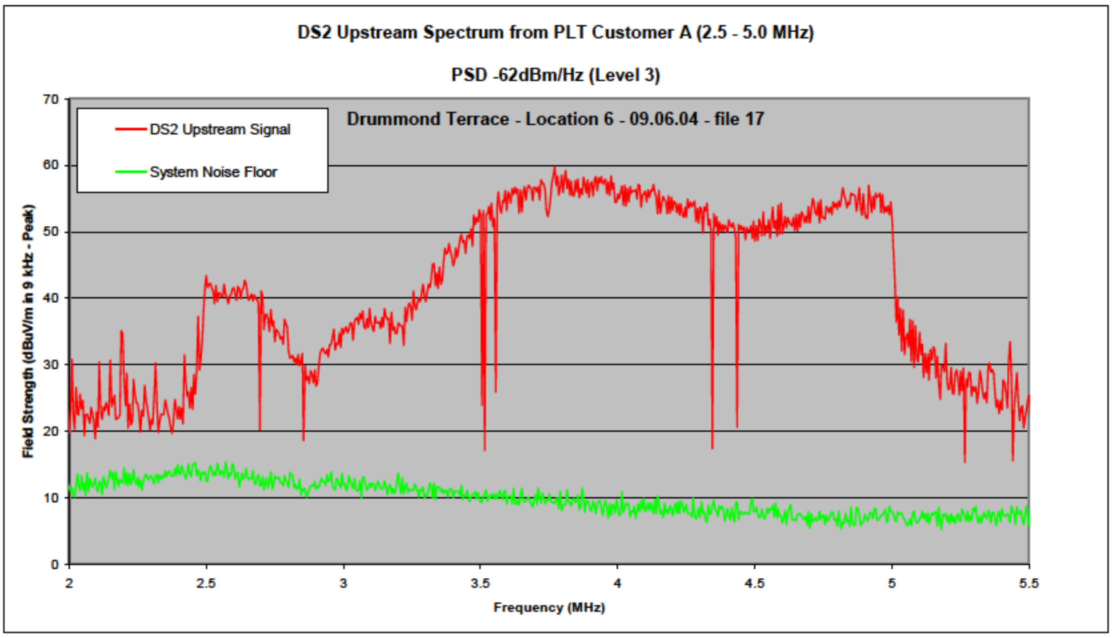
Note:
The Rohde & Schwarz HM525 low noise loop antenna is designed for laboratory use but has been housed in a weatherproof fibreglass enclosure to facilitate external use.

Figure 19 Drummond Terrace - Location 6 – Link 1 Downstream Spectrum



These levels are consistent with those measured at location 4 in Ancaster Road, also approximately 100 metres from the substation and shown in Figure 10.

Figure 20 Drummond Terrace - Location 6 – Link 1 Upstream Spectrum



In order to produce the continuous upstream spectrum shown, the Home Gateway unit was exercised by DS2 engineers to produce a data transfer rate of 750kb/sec

Note the significant difference in the upstream leakage emissions from this customer's Home Gateway unit compared with that measured at location 2 in Ancaster Road which is shown in Figure 12.

The chart below shows the Link 2 downstream leakage emissions from the PLT customer's Home Gateway unit being 'conducted backwards' and radiated by the incoming single phase service cable.

Figure 21 Drummond Terrace Location 6 – Link 2 Downstream Spectrum

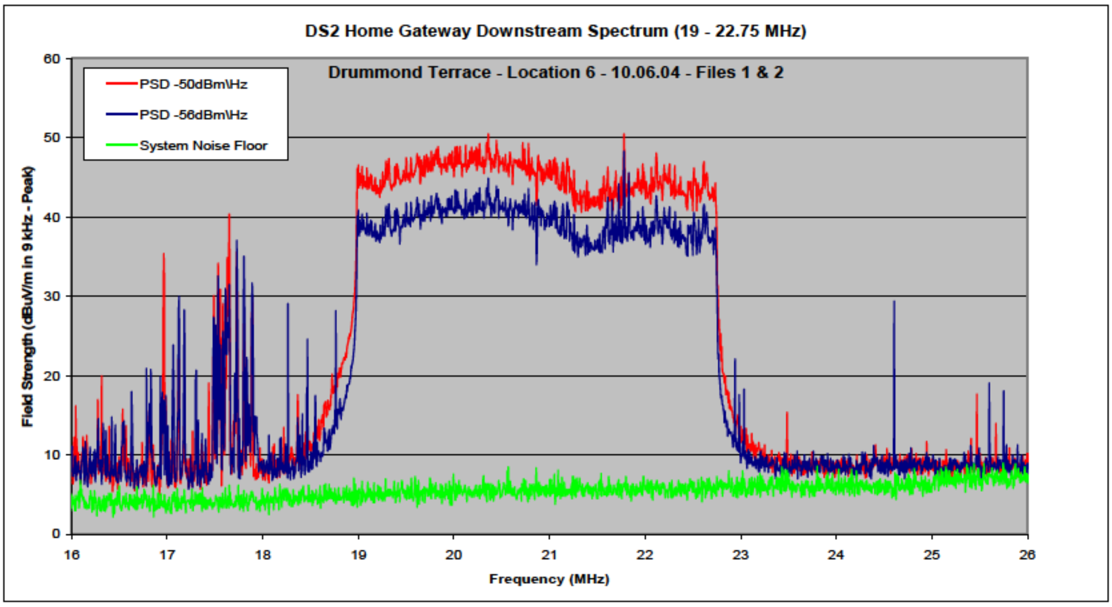
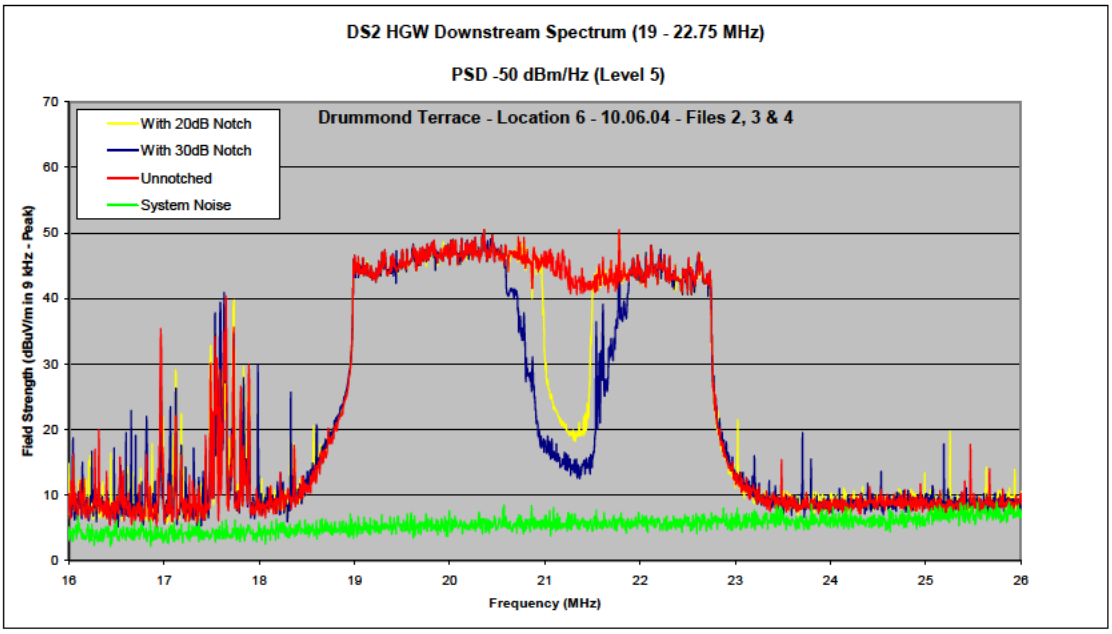


Figure 22 Link 2 Downstream Spectrum with notch between 21 & 21.45 MHz



This chart shows notches in the 21 to 21.45 MHz Amateur Radio band.

It can be seen that, in this instance, the 30dB notch has been implemented with less loss of wanted bandwidth than has occurred with other 30dB notches. The reason for this is unknown.

Notched Spectrum Measurements in Drummond Terrace

Figure 23 Link 1 Downstream Spectrum with notch between 9.4 & 9.9 MHz

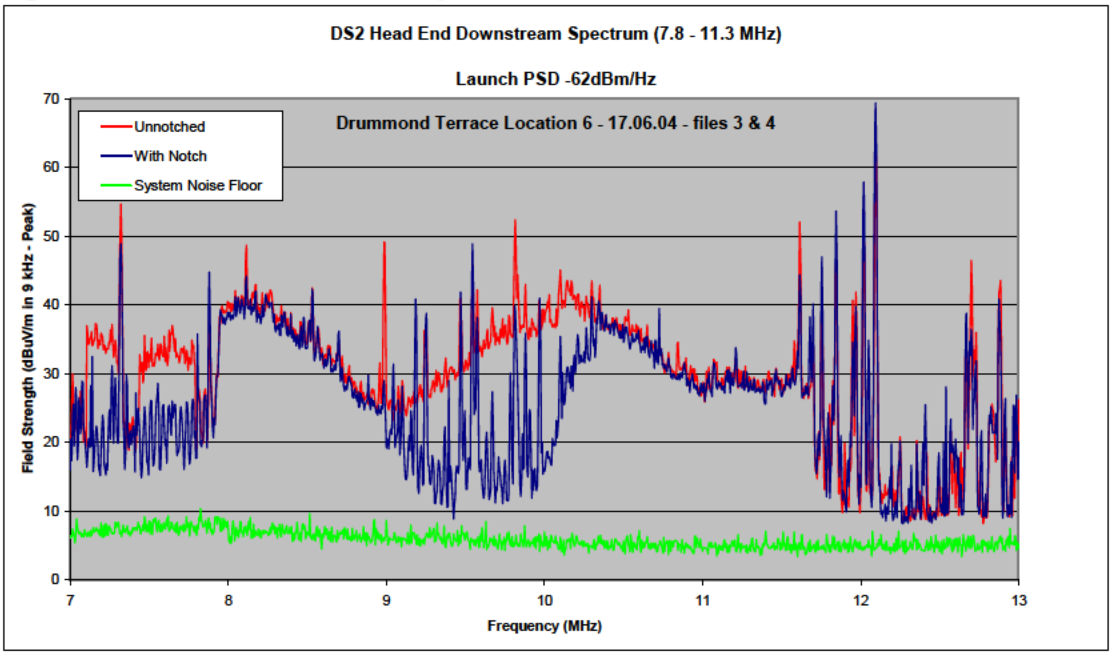
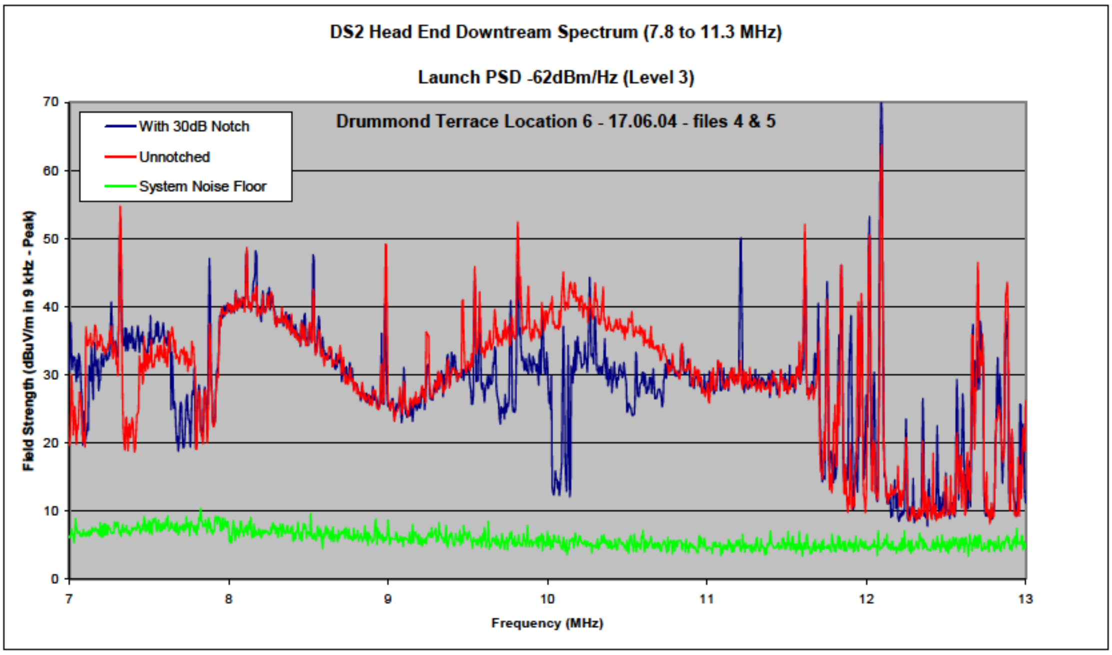


Figure 24 Link 1 Downstream Spectrum with notch between 10.1 & 10.15 MHz

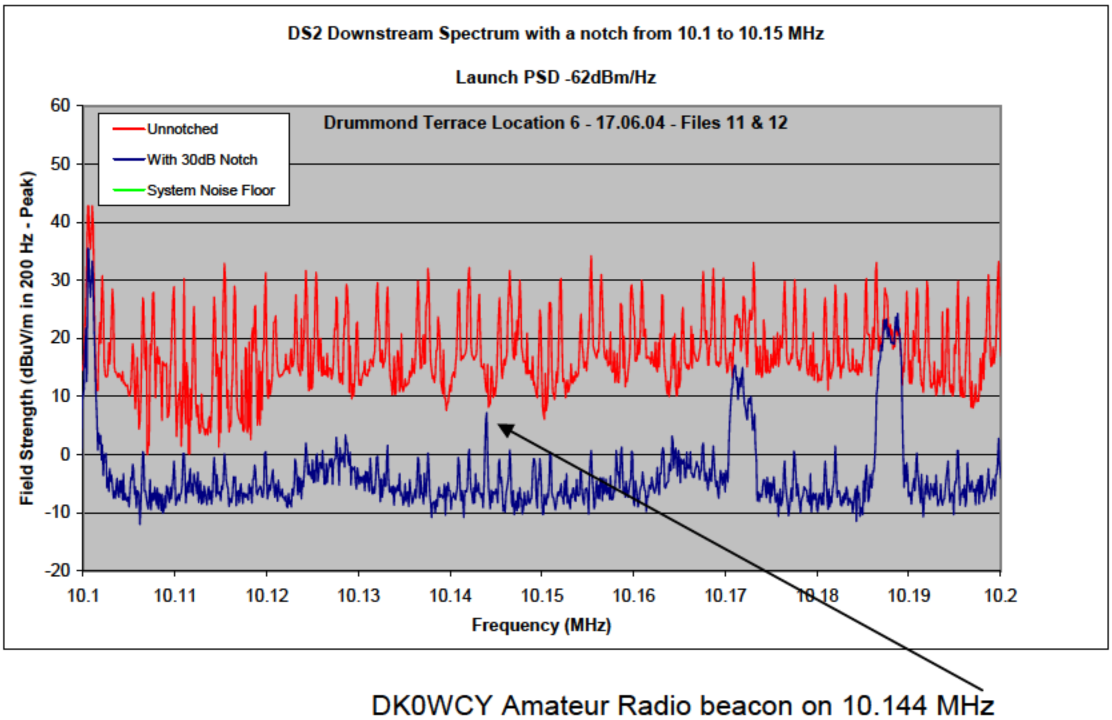


This chart shows the only sharp sided 30dB notch seen. The reason for the difference between this notch and other, much wider, 30dB notches is unknown.

To examine the effectiveness of notching on the reception of a weak signal, a high resolution frequency scan was made using a 200 Hz receiver bandwidth with 100 Hz frequency increments.

These measurements were made in the 10.1 to 10.15 MHz Amateur Radio band and the results are shown below.

Figure 25 Link 1 Downstream Spectrum with notch between 10.1 & 10.15 MHz



The top trace is the unnotched DS2 spectrum that shows OFDM carriers with 1.1 kHz spacing.

The lower trace shows the notched spectrum with the OFDM carriers reduced by 30dB.

Also shown within the notched spectrum, is the German Amateur Radio beacon DK0WCY being received at a level of 7dBµV/m. This beacon transmits its call sign identification in Morse code and this was clearly audible on the measuring receiver.

Leakage Emissions from PLT Customer Premises C

This House is located at the far end of the Ancaster Road section of the PLT network approximately 220 metres from the substation. The house has a 3 phase electricity supply to power an outside workshop. This is most unusual for domestic premises.

Figure 26 Ancaster Road PLT Customer Premises C – Position 1

The picture shows the battery powered measuring receiver and loop antenna in position 1, a location 1 metre from the wall of the house. Although not usually specified below 30 MHz, some Electric Field measurements were made at this house. There were several reasons for this initiative:

1.) There has been much speculation about the nature of PLT networks as radiating sources. In particular, whether magnetic or electric fields predominate at the sort of measurement distances usually specified in radiated emission standards.

2.) Broadcast reception in this frequency range usually involves the use of a portable receiver with a whip antenna responding predominantly to the electric field component of an electromagnetic wave. Should there prove to be any significant difference between the magnetic and electric fields radiated, then an electric field measurement would be more representative of the situation faced by a listener using such a receiver.

3.) Electric field measuring antennas, suitable for this frequency range, usually comprise a 1 metre rod mounted over a ground plane but this arrangement does not readily lend itself to changes of height and polarisation. More recently, a new design of electrically short active dipole antenna has become available. This antenna has a relatively low noise performance together with extremely compact dimensions. Such an antenna seemed ideal for this exercise, particularly for in-house measurements.

Leakage Emissions from PLT Customer Premises C – Position 1

The leakage emissions shown on this page are due to the upstream spectrum from the Home Gateway unit being radiated by the house wiring.

Figure 27 Link 1 Upstream - House C – Position 1 - Magnetic Field

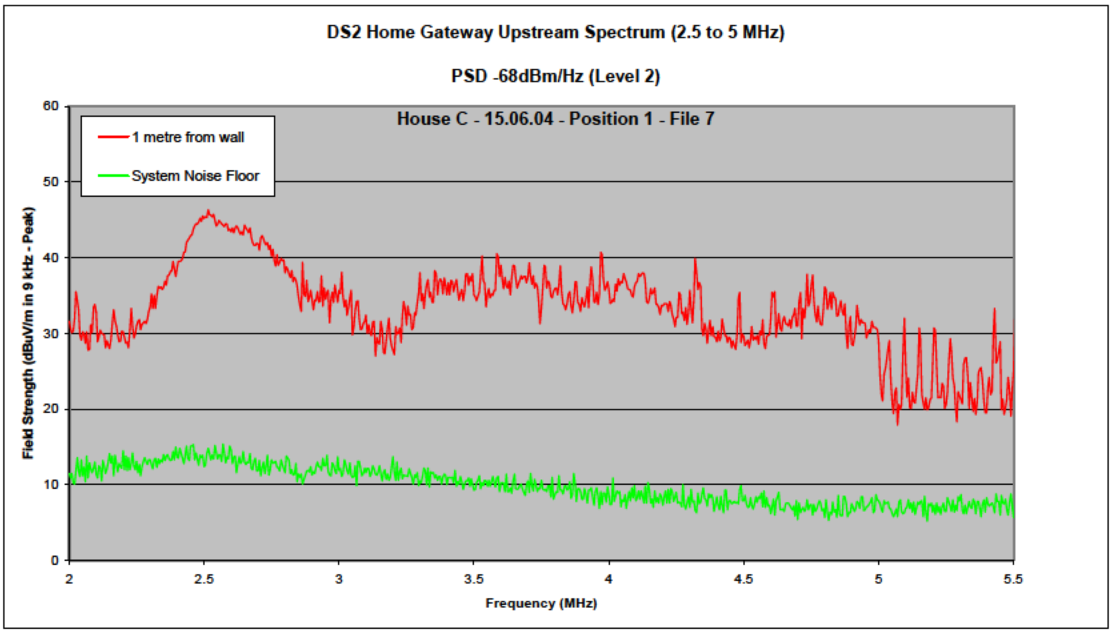
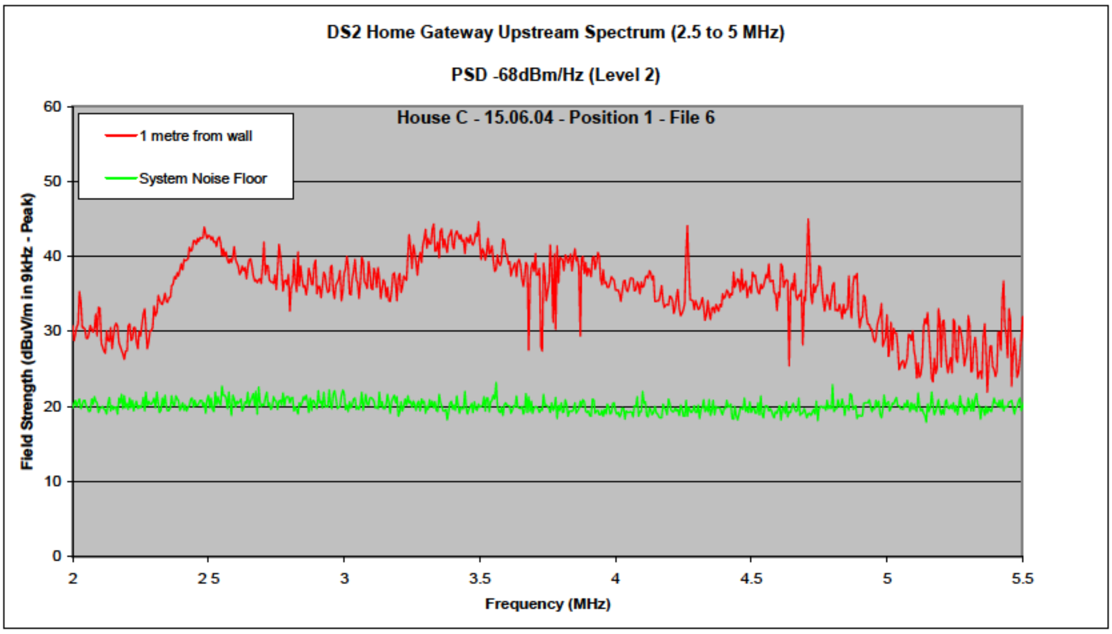


Figure 28 Link 1 Upstream - House C – Position 1 - Electric Field



Measured with a vertically polarised Schwarzbeck EFS 9219 short active dipole antenna mounted 2 metres above ground.

It can be seen that the magnetic and electric field measurements have shown very similar results.

The leakage emissions shown on this page are due to the downstream spectrum from the Home Gateway unit being radiated by the house wiring.

Figure 29 Link 2 Downstream - House C – Position 1 - Magnetic Field

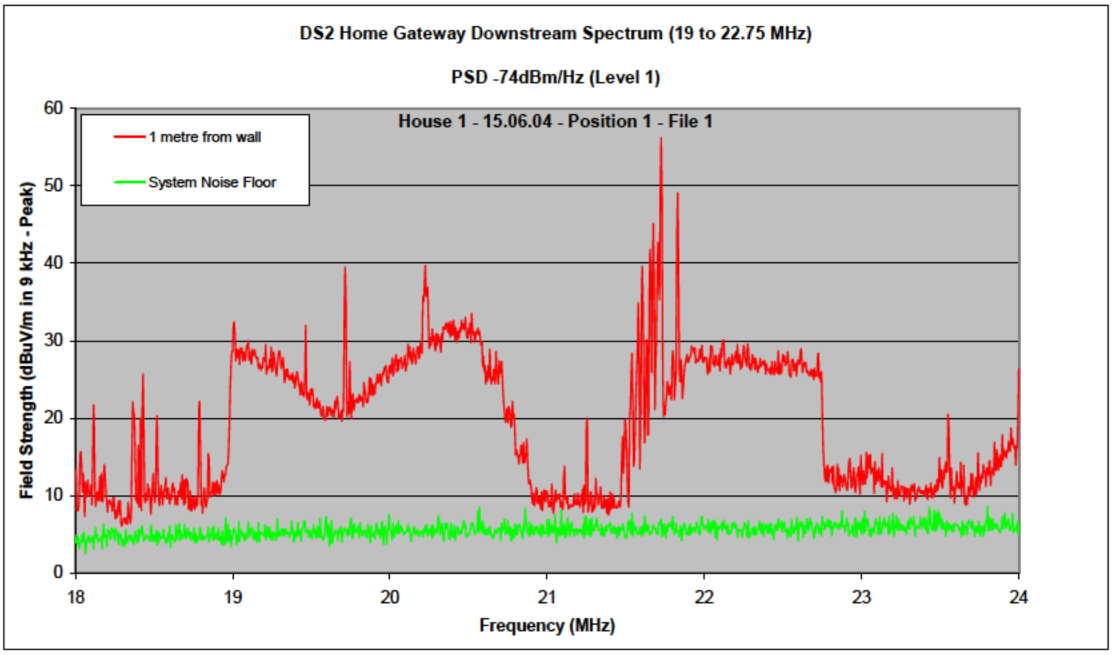
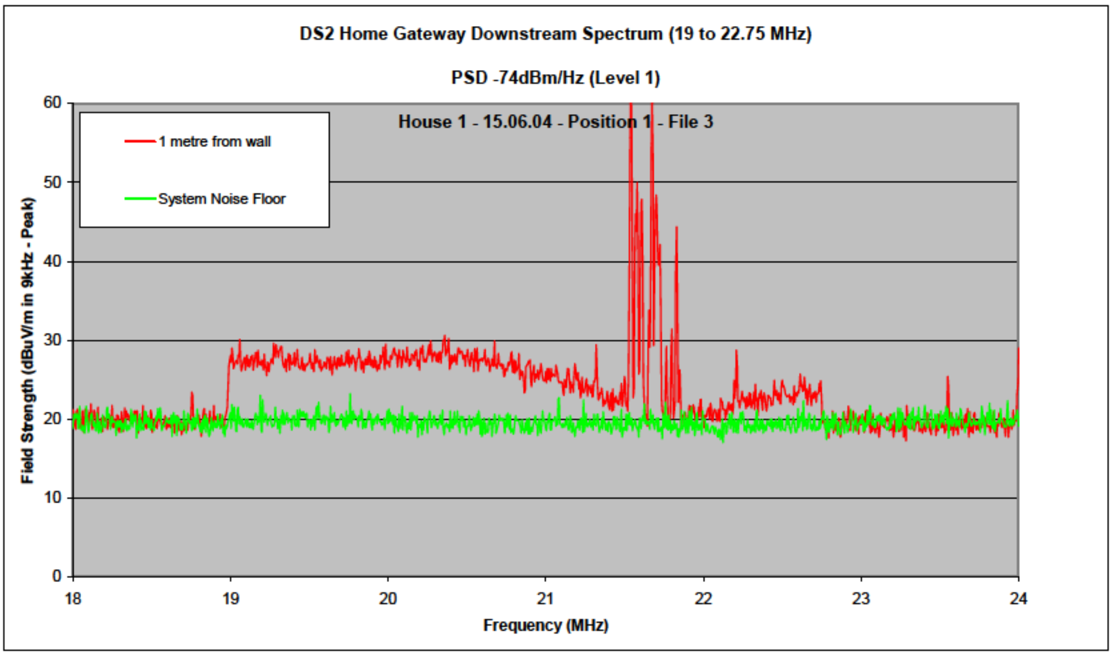


Figure 30 Link 2 Downstream - House C – Position 1 - Electric Field



Measured with a vertically polarised Schwarzbeck EFS 9219 short active dipole antenna mounted 2 metres above ground.

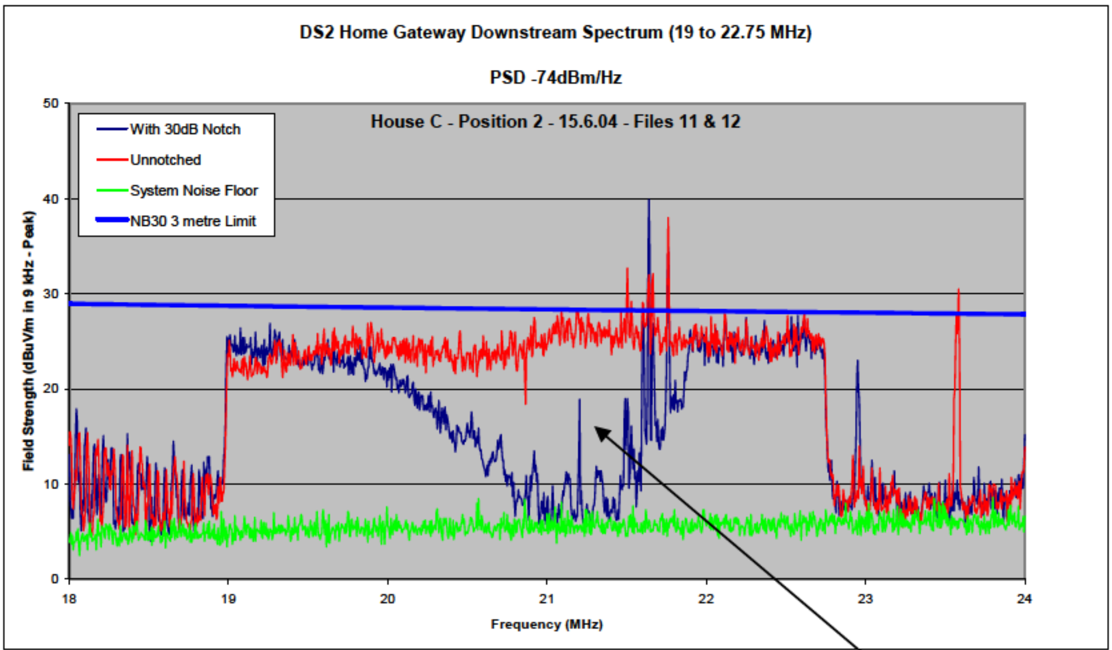
The second measurement position, shown below, was 3 metres outside the window of the room containing the customer's computer.

Figure 31   Ancaster Road PLT Customer Premises C – Position 2

Link 1 and Link 2 upstream measurements, were abandoned at this position due to intermittent emissions from an unidentified switch mode power supply unit located within the customer's premises.

The Home Gateway downstream spectrum was unaffected by these emissions and is shown in the chart below.

Figure 32   Link 2 Downstream - House C – Position 2 - Magnetic Field



The chart shows a notch in 21 MHz Amateur Radio band with an Amateur Radio signal on 21.205 MHz being clearly visible.

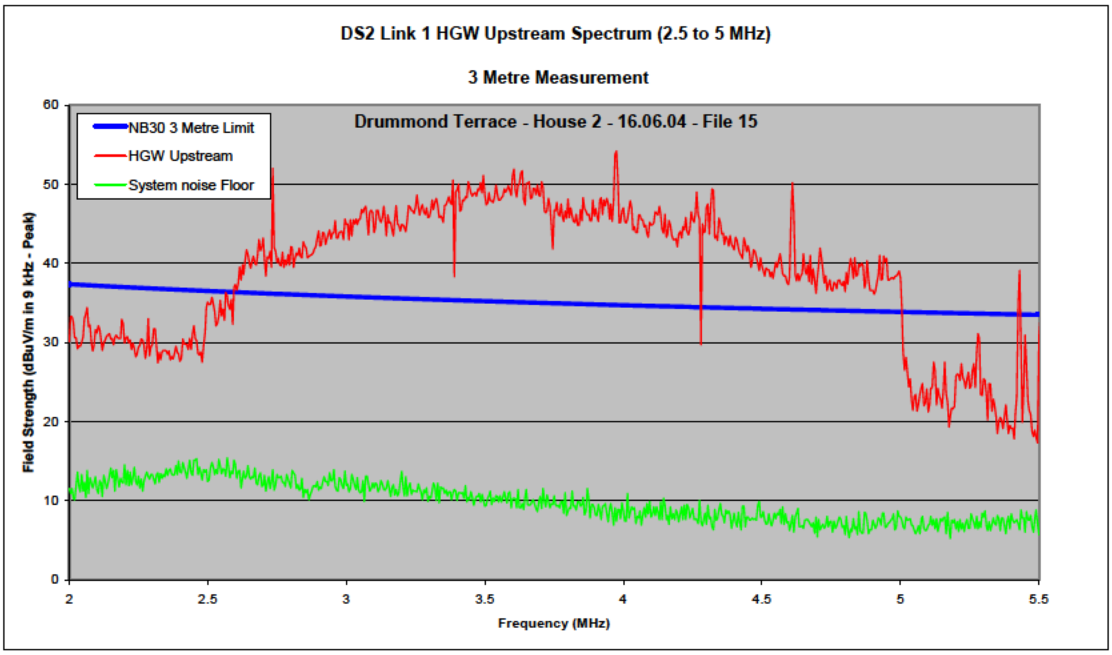
The German NB30 3 metre PLT limit, of 40-(8.8 log f), is not applicable in the UK but is shown here for comparison purposes.

Leakage Emissions from PLT Customer Premises F

This location is approximately 180 metres from the Ancaster Road substation. All measurements were made at the single location shown below which was 3 metres from the outside wall of the premises

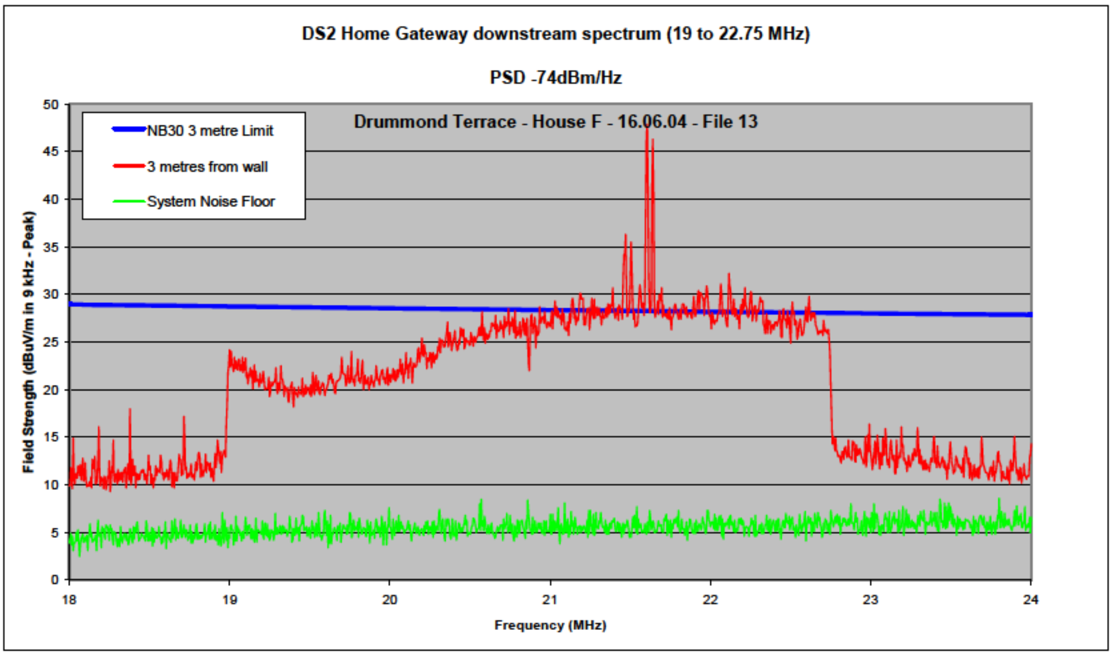
Figure 33 PLT Customer Premises F in Drummond Terrace

Figure 34 Link 1 Upstream Spectrum - House F - Drummond Terrace



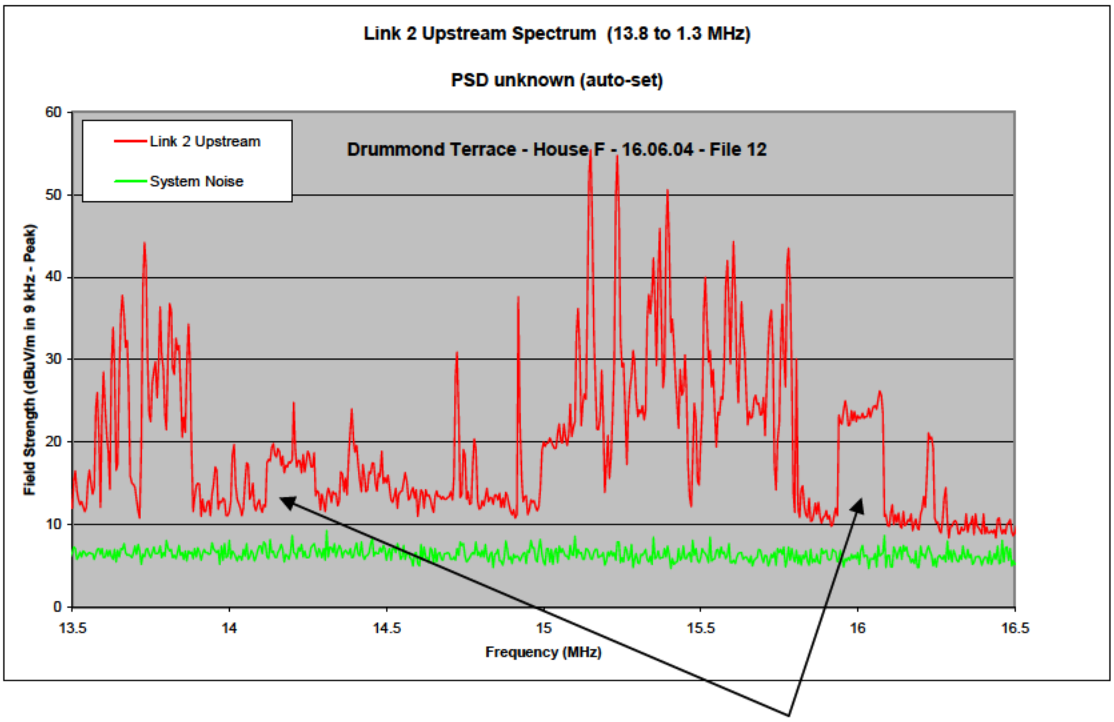
Upstream PSD is under control of the Head End master unit and was unconfirmed in this case. The German NB30 3 metre PLT limit, of 40-(8.8 log f), is not applicable in the UK but is shown here for comparison purposes.

Figure 35 Link 2 Downstream Spectrum - House F - Drummond Terrace



The German NB30 3 metre PLT limit, of 40-(8.8 log f), is not applicable in the UK but is shown here for comparison purposes.

Figure 32 Link 2 Upstream Spectrum - House F - Drummond Terrace



Truncated PLT spectrum due to upstream data bursts from the customer's modem to the Home Gateway unit.

Section 6

Observations & conclusions

Notching

The notches required by Ofcom were applied to both the downstream access spectrum transmitted from the Head End master unit in Ancaster Road substation and separately to the downstream in-house spectrum transmitted from the Home Gateway master units in customer premises. Notches were not applied to the upstream spectrum – *see later*.

S&SE have Jeizer™ network management software, or similar, that enables them to apply notches on demand from their PLT control centre. However, the notches required for this work were requested in advance by DS2, pre-programmed and applied during the testing by their on-site representatives. It is not known whether the two processes are essentially different but if there are differences, it must be presumed that the DS2 method, used for this work, has given the best results currently obtainable.

Measurements of the conducted DS2 signal at Ancaster Road substation confirmed that the depth of both 20dB and 30dB notches, was as claimed. It was found that these values were maintained when the notched spectrum was measured as a radiated leakage emission in other parts of the Ancaster Road network. This aspect addresses some speculation that intermodulation may occur within a PLT network and cause spectral re-growth within the notches. There was no obvious evidence of this.

The 20dB notches appeared to be relatively straightforward to implement and had a sharp cut-off with minimal unintended loss of spectrum bandwidth.

This contrasts with the 30dB notches that required the calculation and application of an algorithm to modify the characteristics of individual carriers within the OFDM spectrum. Although the 30dB notch depth was always achieved, the notch shape appeared more variable and in most cases resulted in a very substantial loss of wanted bandwidth.

At the time of these tests, the calculation and application of the 30dB notch algorithm had not been automated and was carried out on a case by case basis, by DS2 at their Spanish headquarters. It seems likely that, due to the substantial loss of wanted bandwidth and algorithm complications, the 30dB notch will be reserved as an interference mitigation measure of last resort rather than being something that could be more readily used by network operators.

It should be noted that DS2 were unable to apply notching in an upstream direction from either of the slave units. Whilst this is presumably because it would have conflicted with the dynamic power control of the slave units by the master units, it does nevertheless represent a very significant shortcoming in the general promotion of notching as an interference mitigation panacea.

It is understood that later generation PLT products, based on DS2's 'Wisconsin' chipset will be significantly more configurable and will support upstream notching. This appears to be a promising development which may warrant future testing if deployed in the UK.

Launch Power Levels

The PLT launch power levels quoted in this report are those stated by DS2 at the time each measurement was made. They are believed to be correct but, as with all previous measurements of PLT networks by Ofcom and RA, it was not possible to confirm the launch power by calibrated measurement. This has been due to the lack of any standardised interfacing network designed specifically to connect calibrated test equipment to the output ports of PLT modems or couplers.

DS2 stated that the PLT network at Ancaster Road was able to operate satisfactorily at a fixed downstream launch power of -62dBm/Hz due to the low signal to noise ratio performance of their product. This level was claimed to be sufficient to provide S&SE's broadband service to 6 PLT customers, one as far as 230 metres from the launch point. If confirmed, this would appear to be a significant advance on earlier generation PLT products that have required up to 12dB more power to produce the same performance.

It is clear, however, that even if all 6 customers on the Ancaster Road network had been using their broadband service to its full potential at the same time, this would have required only a small percentage of the available bandwidth of the DS2 product. Were the network to have been operating near to its maximum capacity, then it follows that most of the bandwidth would have been required. In these circumstances it is likely that a higher launch power would have been needed to account for signal to noise ratio problems arising in those parts of the DS2 access spectrum that are occupied by, and suffer ingress from, high level broadcast band signals.

In considering the potential for radio interference that leakage emissions from any PLT network represent, it is not the launch power used for a small scale well controlled measurement programme that is of primary importance, but rather the launch power that will be used by network operators on an everyday basis in order to ensure a reliable service to their paying customers in the face of intermittent wide band noise due to arcing thermostats and switch mode power supplies. For this reason leakage emission level measurements are normally carried out at maximum system power because this will be what operators will want to use.

It is recommended that any future measurements are made at the maximum power capability of the product.

Outdoor Leakage Emission Levels.

Except where noted in the results, the leakage emission levels measured and presented in this report were as expected having regard to the measurement position, distance from the source, power applied and the results of previous work. **(Refs 1, 5, 6, 7, 8 & 9)**

There were two locations where it was possible to make close approximations to a standard 3 metre regulatory measurement. At these, the leakage emissions radiated from in-house wiring, due to the Home Gateway downstream spectrum, were at levels very close to the German NB30 radiated emission limit. **(Figures 32 & 35)** These levels were those obtained with the Home Gateway units set at their minimum downstream power setting of -74dBm/Hz. It should be noted that 24dB more power is available if needed. At one location **(Fig 34)** a 3 metre measurement of the Home Gateway upstream spectrum radiated from in-house wiring exceeded the German NB30 limit by approximately 15dB. The power setting in use, under automatic control of the Head End master unit to achieve a satisfactory signal to noise ratio, was unconfirmed.

Indoor Leakage Emission levels

No measurements were made inside a PLT customer premises or inside adjacent premises, but in their absence some simple deductions can be made.

As a starting point it is reasonable to assume that leakage emission levels measured inside a PLT customer premises would be higher in level than those measured outside at 3 metres from the wall. Previous work has shown that a 20dB/decade distance correction factor is applicable between 1 and 3 metre measurements. **(Ref 5)**

Taking account of the 3 metre measurements of the Home Gateway downstream leakage levels, from this report, **(Figures 32 34 & 35)** and adding 9.54 dB (20 log 3/1) would give the minimum levels likely to be seen in positions within a PLT user premises that a victim radio receiver might be located. The level in directly adjoining premises, that are not PLT customers, is likely to be similar.

Measurement Considerations

The low noise floor of the measuring antenna used for this work was the key to securing the results presented.

Had a typical standard 60cm CISPR loop antenna been used, the measuring system noise floor would have been around 30dBµV/m. The charts produced for this report show that, in those circumstances, it would not have been possible to demonstrate the full depth of the notches, as a radiated measurement.

It can also be seen that many of the charts would not have displayed much useful information had the system noise floor been 30dBµV/m and in some cases, all the information contained was at a lower level than that, so a chart would have shown nothing at all.

This situation illustrates the misleading inadequacy of a standard CISPR loop antenna for the EMC compatibility analysis of PLT leakage emissions when the ambient noise floor is often 20 to 40dB below the level that can be measured with it.

It is recommended that for research purposes all future PLT leakage emission measurements, made by or on behalf of Ofcom, use a low noise antenna having similar performance to the product used for this work.

Section 7

Calibrated measuring equipment

DESCRIPTION	MANUFACTURER	Model Number	RTCG Plant
EMI Measuring Receiver	Rohde & Schwarz	ESCS30	2840
EMI Measuring Receiver	Rohde & Schwarz	ESCS30	3178
60cm Active Loop Antenna	Rohde & Schwarz	HFH2-Z2	2115
Low Noise Active Loop Antenna	Rohde & Schwarz	HM525	Ex Contract
Short Active Dipole Antenna	Schwarzbeck	EFS9219	On loan from BT Exact
RF Current clamp	Schaffner	SMZ11	Ex Contract
Spectrum Analyser	Rohde & Schwarz	FSU3	3287

Section 8

References

1. **PLT Measurements at Crieff.**
RA / Baldock Report No. ML2 014/02 November 2002
http://www.ofcom.org.uk/research/industry_market_research/technology_research/emc/?a=87101

2. **The effects of power-line telecommunications on broadcast reception:**
BBC R&D White Paper 67
http://www.bbc.co.uk/rd/pubs/whp/whp067.shtml

3. **PLT and broadcasting - can they co-exist?**
BBC R&D White Paper 99
http://www.bbc.co.uk/rd/pubs/whp/whp099.shtml

4. **'Specification for the Measurement of Disturbance Field from Telecommunication Systems and Networks in the Frequency Range 9 kHz to 3 GHz'**
RegTP 322MV05 (part 1) October 2001
http://www.regtp.de/en/index.html

5. **Ascom PLT Measurements in Winchester**
Ofcom Report 793 (part 1) November 2004

6. **Ascom PLT installation at S&SE Maidenhead**
RA / RTCG Whyteleafe Report 612 September 2002

7. **PLT Measurements at Campbeltown**
RA / Baldock Report No. ML2-017-03 June 2003

8. **The compatibility of VDSL and PLT with radio services in the range 1.6 to 30 MHz**
RA Report of the UK Technical Working Group October 2002
http://www.ofcom.org.uk/static/archive/ra/topics/interference/documents/twg-finalreport.pdf

9. **Leakage Emissions from ADSL and PLT Networks**
RA Presentation to the RRAC annual open forum November 2003
http://www.ofcom.org.uk/research/industry_market_research/technology_research/rrac/rr_forum2003/?a=87101

Section 9

Acknowledgements

Ofcom would like to thank the following organisations for their support during the course of this work.

Scottish & Southern Energy plc:

for hosting this work, permitting controlled access to the PLT equipment in Ancaster Road substation and for negotiating access for measurements at two of their PLT customer’s premises.

DS2:

for providing technical information on the operation of their product, for scripting the spectrum notches required during the course of this work and for providing on-site assistance during the measurement phase.

BBC R&D:

for undertaking an on-site assessment of the effect of DS2 PLT leakage emissions on sound broadcast reception in the short wave spectrum.

DTI CII division:

for sending a representative to witness some of the measurements.

Annex A

List of abbreviations

ADSL	**Asymmetric Digital Subscriber Line**
BPL	Broadband (over) Power Line (USA)
CISPR	International Committee for the study of Radio Interference
DTI	Department of Trade & Industry (UK)
DRM	Digital Radio Mondiale
DSSS	Direct Sequence Spread Spectrum
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
GMSK	Gaussian Minimum Shift Keying
LV	Low Voltage
OFDM	Orthogonal Frequency Division Multiplex
PLC	Power Line Communications
PLT	Power Line Telecommunications
PSD	Power Spectral Density
RA	Radiocommunications Agency (subsumed into OFCOM UK Jan. 2004)
Reg TP	Regulator of Telecommunications & Posts (Germany)
RMS	Root Mean Square
RTCG	Radio Technology & Compatibility Group
SDSL	Symmetrical Digital Subscriber Line
S&SE	Scottish & Southern Energy plc (Major UK Power Utility)

Annex B

Measurement location photographs

Location 2 – Outside 'Overdale'

Location 3 – Outside 'Treetops'

Location 4 – Outside ‘Rumbleden’

Location 5 – Outside ‘Pinewood’

別紙 4

ARRL が FCC に提出した妨害波報告

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December 29, 2010

Via Courier to the Office of the Secretary
and Via E-mail

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Mr. Julius Knapp, Chief
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Re: Interference Complaint: IBEC Access Broadband Over Power Line System at Central Virginia Electric Cooperative, Arrington, VA; BPL Operation in Violation of FCC Regulations, BARC Electric Cooperative, Fairfield, Virginia; Somerset Rural Electric Cooperative, Somerset, PA; and Lake Edgewood Water District Office, Martinsville, IN.

Greetings:

ARRL, the national association for Amateur Radio, formally known as the American Radio Relay League, Incorporated (ARRL), hereby submits, on behalf of its members and other licensed Amateur Radio operators in the vicinity of Lovingston, Virginia; Fairfield, Virginia; Somerset, Pennsylvania and Martinsville, Indiana a complaint of ongoing harmful interference and of numerous, ongoing violations of the Commission's Rules regarding the operation of several IBEC Broadband over Power Line (BPL) systems in those communities. The attached reports concern an ongoing interference complaint involving IBEC, Inc. BPL systems operated in and near Arrington, Virginia), and the results of measurements and observation of other BPL systems using IBEC's BPL technology. These violations include overpowered BPL operation, BPL database violations, and operation on prohibited Federal government frequencies in violation of Section 15.615(f)(1) of the Commission's rules. Each of the subject BPL systems discussed in this letter and in the attached Exhibits is operated by IBEC.

Based on the two Exhibits attached to this letter[1], ARRL respectfully requests that the Commission initiate immediately an enforcement proceeding regarding these BPL systems, and cause them to cease operation until such time as they are each in full compliance with the Commission's Rules. In the case of the Lovingston, Virginia system, resumption of the operation of this system should be predicated on satisfactory resolution of the harmful interference complaint discussed in ***Exhibit A*** attached.

The report of harmful interference to ongoing Amateur Radio operation is with respect to the IBEC BPL system in the vicinity of Lovingston, Virginia using power lines owned by the Central Virginia Electric Cooperative at Arrington, Virginia. The interference complainant is Mr. Kevin Ward, K4BDR, of Afton, Virginia. This BPL system was measured on two separate occasions by ARRL Laboratory Manager Ed Hare, in March and in December of 2010. Mr. Ward had noted harmful interference to his Amateur station at his home and as well to his mobile Amateur Station during his regular commutes to work. Upon complaining to IBEC with respect to the mobile interference, IBEC told him that there was "nothing that could be done" to correct that interference. Mr. Ward's interference problems at his home Amateur station are a "moving target" because IBEC apparently is resolving interference complaints by notching particular segments of its system at subscriber's sites in the immediate vicinity of the interference complainant, but the problem resurfaces with each new subscriber near the Amateur station.

IBEC had previously represented to ARRL (and separately to a local Amateur group) while negotiating a contract with the Central Virginia Electric Cooperative in this area that it was universally notching Amateur bands, and as well all bands required to be notched by virtue of Section 15.615(f)(1) of the Commission's rules. Indeed, in the BPL Database, IBEC makes the specific representation that "All appropriate Amateur Radio and Public Safety Frequencies are Notched in Compliance with FCC Part 15 Requirements." [2] This statement is false and misleading. As can be seen from the attached Exhibit A, not only is IBEC's BPL system at Lovingston, Virginia not notched in all areas on Amateur bands, neither is it notched on the bands specified in Section 15.615(f)(1). Furthermore, the system is overpowered in bands below 30 MHz, and apparently the power levels are not diminished above 30 MHz. As noted by Mr. Hare at pages 2 and 3 of Exhibit A, this is significant in terms of interference avoidance:

---

[1] ***Exhibit A*** attached is the report prepared by ARRL Laboratory Manager Ed Hare of measurements and observations of the IBEC BPL systems at Arrington, Virginia; Fairfield, Virginia; and Somerset, Pennsylvania during the times indicated in the report. ***Exhibit B*** attached is the report prepared by the engineering firm of ARC Technical Resources, which conducted the measurements of the IBEC BPL system at Martinsville, Indiana in March of 2010.

[2] See Page 26 of Exhibit A.

ARRL has noted that in similar systems operated by other BPL entities, effective notching by systems that are generally operating at the emission limits has proven sufficient to generally protect Amateur fixed, portable and mobile operation, coupled with a case-by-case approach to resolving any remaining harmful interference problems. In all three IBEC systems tested, neither mobile nor fixed operation is reasonably protected from the operation of a system that is operating well outside its limits in several different respects.

The Lovingston, Virginia IBEC BPL system using the Central Virginia Electric Cooperative lines is registered in the BPL database. The same is *not* true with respect to the IBEC BPL systems at Fairfield, Virginia and Somerset, Pennsylvania. Both systems are in commercial deployment but neither appears in the BPL database at all in violation of Section 15.615(a) of the Commission's Rules.

At the Lovingston, Virginia and Fairfield, Virginia locations, as can be seen from Exhibit A attached, the systems were operated well above radiated emission maxima at the sites measured. Though some potential test areas were inaccessible due to private property, the sites measured were sufficient to establish that (1) IBEC is operating these systems well in excess of maximum radiated emission limits;[3] (2) the system did not notch Amateur bands nor the Section 15.615(f)(1) prohibited bands; and (3) the combination of these factors contributed to a very high noise environment between 1.7 and 30 MHz.

Mr. Hare's investigation of the Somerset, PA IBEC BPL site did not involve specific measurements due to an exceptional snowfall in the area during his December 8, 2010 visit to that area. However, his mobile survey using the same communications-grade receiver demonstrated field strength levels similar to those measured at the Lovington and Fairfield, Virginia BPL sites. It was also apparent that the Somerset system (1) was operating well above permitted radiated emission levels; (2) did not notch either the Amateur allocations or the Section 15.615(f)(1) prohibited bands. It was also apparent that the Somerset IBEC system was operating with power levels above 30 MHz that approximated those below 30 MHz.

Exhibit B attached, the report on radiated emissions testing of the IBEC BPL system at Martinsville, Indiana prepared by the engineering firm of ARC Technical Resources reveals essentially the same results as did the Ed Hare studies in Exhibit A. This system does not notch Amateur allocations; it is operated at levels well in excess of permitted radiated emission maxima; and it radiates in the Section 15.615(f)(1) prohibited bands.

Accordingly, based on the ARRL and ARC Technical Resources studies, ARRL requests that the Commission immediately cause each of these BPL systems to cease

[3] It is unknown how overpowered BPL modems were able to be certified under the Commission's equipment authorization program.

operation system until (1) the Lovingston system is operating in accordance with all applicable BPL rules, and that it is operating without causing harmful interference to licensed Amateur Radio stations; (2) Thirty days after all required information about the Fairfield, VA and Somerset, PA BPL systems is available in the UTC database, as required by §15.615(a); and (3) that all systems are shown to be operating in accordance with all Part 15 regulations, including Section 15.615(f)(1).

In addition, the Commission should determine other appropriate sanctions against IBEC as a result of the multiple rule violations noted herein. ARRL notes that the information contained in these reports amply justifies the modifications of the BPL rules urged by ARRL in ET Docket 04-37, including the mandatory, full-time notching of all Amateur Radio allocations by BPL systems, to a notch depth of at least 30-35 dB.

Kindly address all communications on this subject to the undersigned counsel.

Yours very truly,

Christopher D. Imlay

Attachments
Exhibit A
Exhibit B

Exhibit A

ARRL The national association for AMATEUR RADIO™
ADMINISTRATIVE HEADQUARTERS
225 Main Street, Newington, Connecticut, USA 06111-1494
Telephone: 860-594-0200 ■ FAX: 860-594-0259
www.arrl.org

Broadband over Power Lines (BPL) Simplified Radiated Emissions Testing[1] (Access Overhead and Underground) FCC Method (1m measurement height)

EUT INFORMATION	
Type of Device being tested	IBEC BPL system, generation 2
Serial Number	Unknown, multiple
Model Number	IBEC, model unknown
Modulation type	OFDM, DS2 chipset
Lowest external frequency used	1.7 MHz
Highest external frequency used	34 MHz
Power setting during tests	Unknown
Rep rate of data	Not measured

Cumulative Test Results:	FAIL
Name & Location of Testing Organization:	**ARRL Laboratory,** Newington, CT
Test Engineer's Signature:	Ed Hare, ARRL Laboratory Manager
Testing date(s):	March 5-8, 2010, December 6-8, 2010
Report date:	December 13, 2010

Locations:

This report describes the results of in-situ testing of IBEC BPL systems at the following locations:

- Central Virginia Electric Cooperative[2] in and near Arrington, VA (CVEC)
- BARC Electric Cooperative[3] in and near Fairfield, VA (BARC)
- Somerset Rural Electric Cooperative[4] in Somerset, PA (SREC)

Executive Summary:

The IBEC Corporation is the manufacturer of all three systems tested. The systems use Orthogonal Frequency-Division Multiplexing (OFDM) technology, using the DS2 200 MB/s chipset.

This testing was initiated in the Lovingston, VA area by ARRL staff in response to a report of harmful interference to Amateur Radio by Kevin Ward, K4BDR, of Afton, VA[5]. Mr. Ward reported partially resolved interference to his home Amateur station, with a continuing need for resolution of new instances of harmful interference as new

[1] As described in IEEE Draft Standard for Broadband Power line Communication Equipment – Electromagnetic Compatibility (EMC) Requirements – Testing and Measurements Methods, Annex A

[2] Central Virginia Electric Cooperative, 800 Cooperative Way, Arrington, VA 22922-3300, Tel (434) 263-8336, Internet: http://www.forcvec.com/about_us/index.html

[3] BARC Electric Cooperative, 84 High St., Millboro, VA 24460-0264, Tel (800) 846-2272, Email: co-op@barcelectric.com, Internet: www.barcelectric.com

[4] Somerset Rural Electric Cooperative, 233 Industrial Park Rd., Somerset, PA 15501, Tel: (814) 445-4106, Internet: http://www.somersetrec.com, Info: http://www.prea.com/Content/somerset.asp

[5] Kevin Ward, K4BDR, 351 Mountain Rd., Afton, VA 22920-5008

neighbors obtained the BPL service. He also reported that within the Amateur bands notched near his station location, the BPL noise level is significantly above the quiet rural noise level previously enjoyed during local use of Amateur spectrum. Mr. Ward also reported that reported interference to his mobile Amateur operation to and from work and during his travels within his community was unresolved, with IBEC, the BPL manufacturer involved, informing him that there is “nothing they can do” to correct interference to his mobile station.

ARRL’s testing in March and December 2010 shows that IBEC equipment as deployed is capable of and actually does significantly exceed the radiated emission limits for BPL. It also shows that Amateur band notching and the protection of spectrum required by §15.615(f)(1) is not generally implemented.

During the time it was negotiating a contract with CVEC, IBEC had previously demonstrated to ARRL staff and separately to local amateurs that it was *universally* notching the Amateur allocations and the bands in which BPL is prohibited pursuant to §15.615(f)(1) of the FCC’s rules. Once IBEC secured that contract, based in part on findings of the local Amateur community, IBEC *ceased* notching the Amateur bands and the spectrum described in §15.615(f)(1) . This demonstration of Amateur band notching was documented in two Exhibits[6], [7] provided by ARRL as part of its November 30, 2010 Ex Parte filing in the ET Docket 04-37 rulemaking proceeding dealing with BPL rules.

In its measurements of the CVEC system made during 3 days in March 2010 (and confirmed in further testing in December, 2010 of the CVEC, BARC and SREC systems in Virginia and Pennsylvania), ARRL found that the operating frequency of these systems was *not* in accordance with the frequency-use information that IBEC has entered into the BPL industry database. In December 2010, IBEC made changes to the contact information in the BPL database, so the substantial and continued misrepresentation of frequency use is not a simple oversight.

Notching of the Amateur bands and notching of federal spectrum as required by §15.615(f)(1) of the FCC’s rules is not implemented in most areas of the three systems tested.

The March 2010 testing included measurements below and above 30 MHz. In the December 2010 testing, measurements were not made above 30 MHz, but it was observed that there was no reduction in noise level when tuning below and then significantly above 30 MHz. The system is operating at the same level above 30 MHz as it is operating below 30 MHz in all cases spot checked during testing. Especially in cases where the emissions below 30 MHz exceeded the emissions limits, this is a certain indication that the emissions above 30 MHz are significantly exceeding the limits. This is what *was* measured in the March 2010 measurements made by ARRL staff.

Although it was somewhat difficult to obtain access to parts of these rural systems due to the general rural practice of running power lines directly between houses or groups of houses and through posted private land, ARRL consistently found that in location after location for which access could be obtained, the systems are operating above the permitted maximum radiated emission limits.

ARRL was not able to make measurements of the IBEC system in Somerset, PA due to an ongoing lake-effect snowstorm and hazardous parking conditions. However, the levels shown on the signal-strength indicator on the communications receiver employed were consistent with the high levels seen on the same communications receiver and measured, at the sites of the other systems.

Testing was also done by staff from ARC Technical Resources of the smaller system in Martinsville, IN. ARC Technical Resources had findings similar to those of ARRL: an absence of notching in the Amateur bands; an absence of notching in the spectrum protected from BPL by §15.615(f)(1); and emissions exceeding the FCC limits. The results of this testing are provided separately.

ARRL has noted that in similar systems operated by other BPL entities, effective notching by systems that are generally operating at the emission limits has proven sufficient to generally protect Amateur fixed, portable and mobile operation, coupled with a case-by-case approach to resolving any remaining harmful interference

[6] “Albermarle Amateur Radio Club report on notching before system-wide notching was removed by IBEC subsequent to this testing.” See http://fjallfoss.fcc.gov/ecfs/document/view?id=7020921740

[7] “Field Test Report: Broadband over Power Line (BPL) Communications Interference Test for International Broadband Electric Communications, Inc. (IBEC), January 7, 2004.” See http://fjallfoss fcc.gov/ecfs/document/view?id=7020921739.

problems.   In all three IBEC systems tested, neither mobile nor fixed operation is reasonably protected from the operation of a system that is operating well outside its limits in several different respects.

The system in Arrington, VA and environs[8] is registered in the FCC-mandated BPL database at http://www.bpldatabase.org. The systems in Fairfield, VA[9] and Somerset, PA[10] are both in commercial deployment, but have no entries in the BPL database.

Applicable Standards:	
ANSI C63.4 (2003)	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
47CFR15 subpart G (2004)	Specified in FCC Report & Order 04-245 “Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems” released October 28, 2004
IEEE-P1775 / D5 (2010)	Draft Standard for Broadband Power line Communication Equipment – Electromagnetic Compatibility (EMC) Requirements – Testing and Measurements Methods (June, 2010)

TEST EQUIPMENT				
Manufacturer	**Description**	**Model Number**	**Serial Number**	**Calibration**
Rohde & Schwarz	EMC Spectrum Analyzer	FSH3 opt. K1, K3, Z21, Z25	102393	(yearly)
ETS-Lindgren	Active loop antenna (internal preamplifier)	6502	00051644	(biannual)
ETS-Lindgren	Biconical antenna	3104C	N/A	(as needed)
Not specified	Non-metallic tripod	N/A	N/A	N/A
Ben Meadows	Optical range-finder	--	--	N/A
Lufkin	Non-conductive tape measure	100’	N/A	N/A
ICOM America	Communications transceiver	IC-756Pro II	03651	N/A
Yaesu	Communications transceiver	FT-817	4HB70017	N/A
Kenwood	Communications transceiver	TS-480SAT	7070030	N/A
MFJ	Adjustable 8’ mobile whip antenna	MFJ-1662	N/A	N/A
Iron Horse	Monoband mobile whip antennas	N/A	N/A	N/A

RG-223/U CABLE LOSS vs. FREQUENCY				
Loss /100 ft. (dB)	0.4 dB	1.2 dB	3.2 dB	4.8 dB
Frequency (MHz)	2MHz	10MHz	50MHz	100MHz
Loss of actual cable used:	0.1	0.1	0.3	0.3

[8] See http://www.facebook.com/notes/central-virginia-electric-cooperative/a-quick-update-on-the-broadband-over-powerline-project-bpl/404695293898.
[9] See http://www.barcelectric.com/index.php?option=com_content&view=article&id=73&Itemid=88.
[10] See http://www.somersetrec.com/wpi/?p=156.

EMISSIONS LIMITS (United States)		
Test	**Frequency Range**	**Field Strength Limit**
Radiated Emissions	1.705 MHz – 30 MHz	**29.5 dBμV/m** @ 30 meters*
	30 MHz - 80 MHz	**39.1 dBμV/m** @ 10 meters*

***** Installations are measured at slant-range distances other than those listed. The dB value to subtract from the measured values in the United States are calculated using these formulas:

$40\log_{10} 30m/d_n$ for frequencies below 30MHz

$20\log_{10} 10m/d_n$ for frequencies above 30MHz

BPL Testing Methodology below 30MHz:

Initial frequency survey: Spectrum analyzer

Set spectrum analyzer to PEAK detection, 10 kHz IF bandwidth, 15 MHz center frequency, 100 kHz/div. Evaluate the band from 1.705 to 30MHz looking for BPL signals, demodulate and analyze signature to verify candidates. (Center frequencies of 2, 3, 4, 5, 6, etc. selected every 1MHz from 2 to 30MHz)

Initial frequency survey: Communications receiver

As an alternative to the use of a spectrum analyzer, or to aid in demodulation of received signals, a communications receiver may be used. Tune across the band of interest, determining by ear the presence of signals with known BPL characteristics or the known characteristics of licensed radio signals.

Measurement procedure:

Utilize the simplified test procedure for BPL systems outlined in the draft IEEE P1775 BPL EMC standard. It is based on the test procedure specified in Measurement Guidelines for Access Broadband over Power Line (BPL) Systems.[11] To the extent practical, measurements should be made at a horizontal distance of 10 meters from the equipment under test (EUT) or the exterior of a premise with wiring carrying BPL signals, or a BPL coupler connected to overhead power lines or a step-down transformer.

Below 30 MHz, the results shall be extrapolated to the limit distance of 30 meters using a 40 dB/decade extrapolation factor, based on the slant-range distance to the EUT wiring. Measurements shall be made with a magnetic loop antenna, applying antenna factors expressed in terms of electric field strength in dB/m. The antenna shall be oriented with the loop vertical, at a height of 1 meter. The loop shall be rotated through 180 degrees and the maximum value obtained at each distance and frequency shall be reported.

BPL Testing Methodology above 30MHz:

Initial frequency survey: Spectrum analyzer

Set spectrum analyzer to PEAK detection, 100 kHz IF bandwidth, 55 MHz center frequency, 100 kHz/div. Evaluate the band from 30 to 80 MHz, looking for BPL signals, demodulate and analyze signature to verify candidates.

Initial frequency survey: Communications receiver

As an alternative to the use of a spectrum analyzer, or to aid in demodulation of received signals, a communications receiver may be used. Tune across the band of interest, determining by ear the presence of signals with known BPL characteristics or the known characteristics of licensed radio signals.

Measurement procedure:

[11] This is available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-245A1.pdf.

Utilize the simplified test procedure for BPL systems outlined in the draft IEEE P1775 BPL EMC standard.   It is based on the test procedure specified in Measurement Guidelines for Access Broadband over Power Line (BPL) Systems. To the extent practical, measurements should be made at a horizontal distance of 10 meters from the equipment under test (EUT) or the exterior of a premise with wiring carrying BPL signals, or a BPL coupler connected to overhead power lines or a step-down transformer.

Above 30 MHz, the results shall be extrapolated to the limit distance of 10 meters using a 20 dB/decade extrapolation factor, based on the slant-range distance to the EUT wiring. Measurements shall be made with a bi-conical antenna. Measurements shall be made at each location and frequency with the antenna oriented horizontally, broadside to the EUT and vertically. The maximum value obtained at each distance and frequency shall be reported.

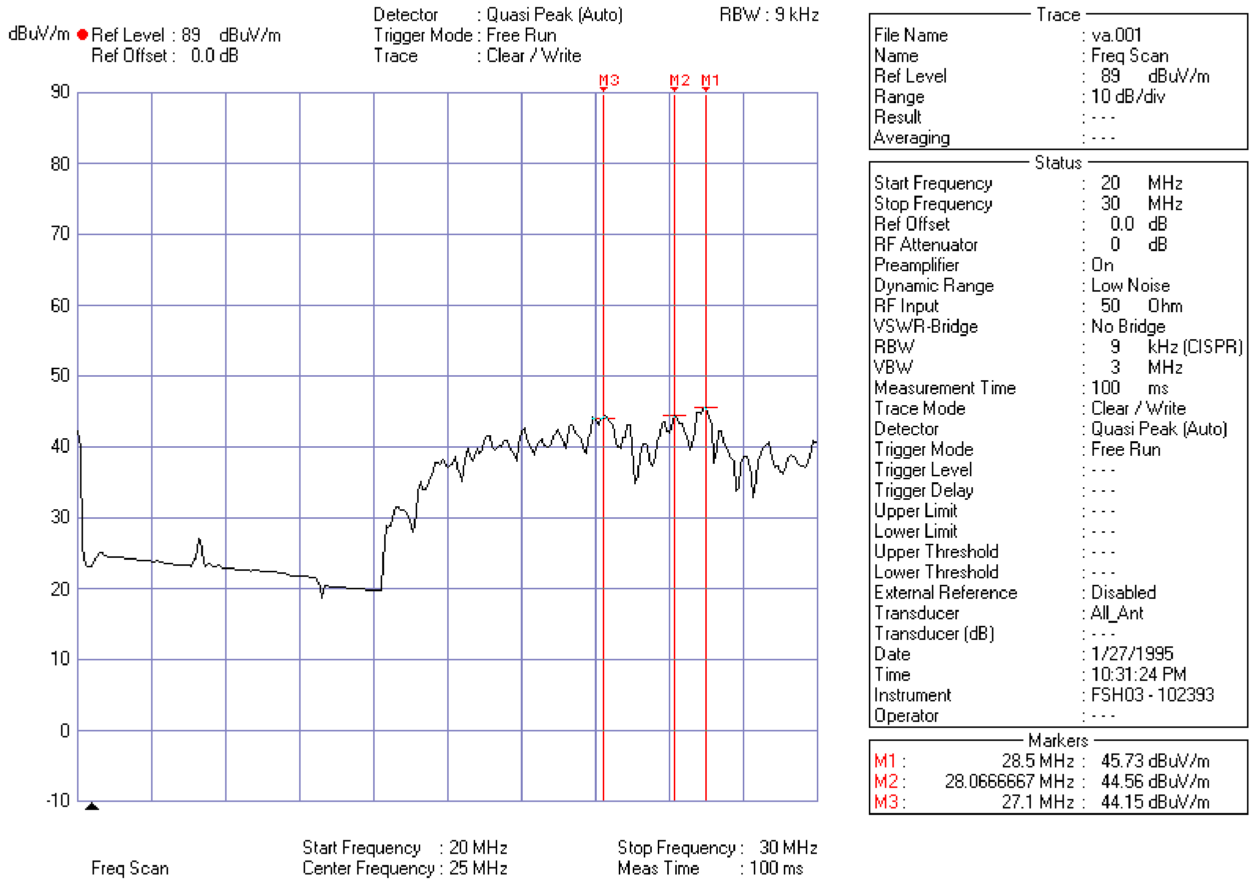
Measurement Results:

Location #1 – Stephen's Cove Road, Lovingston, VA

Photo/map of test site

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Stephen's Cove Road, Lovingston, VA, no houses, BPL repeater visually observed on pole supporting power lines in the woods.
Date: December 6, 2010
Horizontal distance to EUT, premise or overhead line: 11.3 meters (approximate)
Height of overhead line (if applicable): 15.7 meters
Slant range distance: 18.5 meters
Slant range distance correction (40 log): -8.4 dB

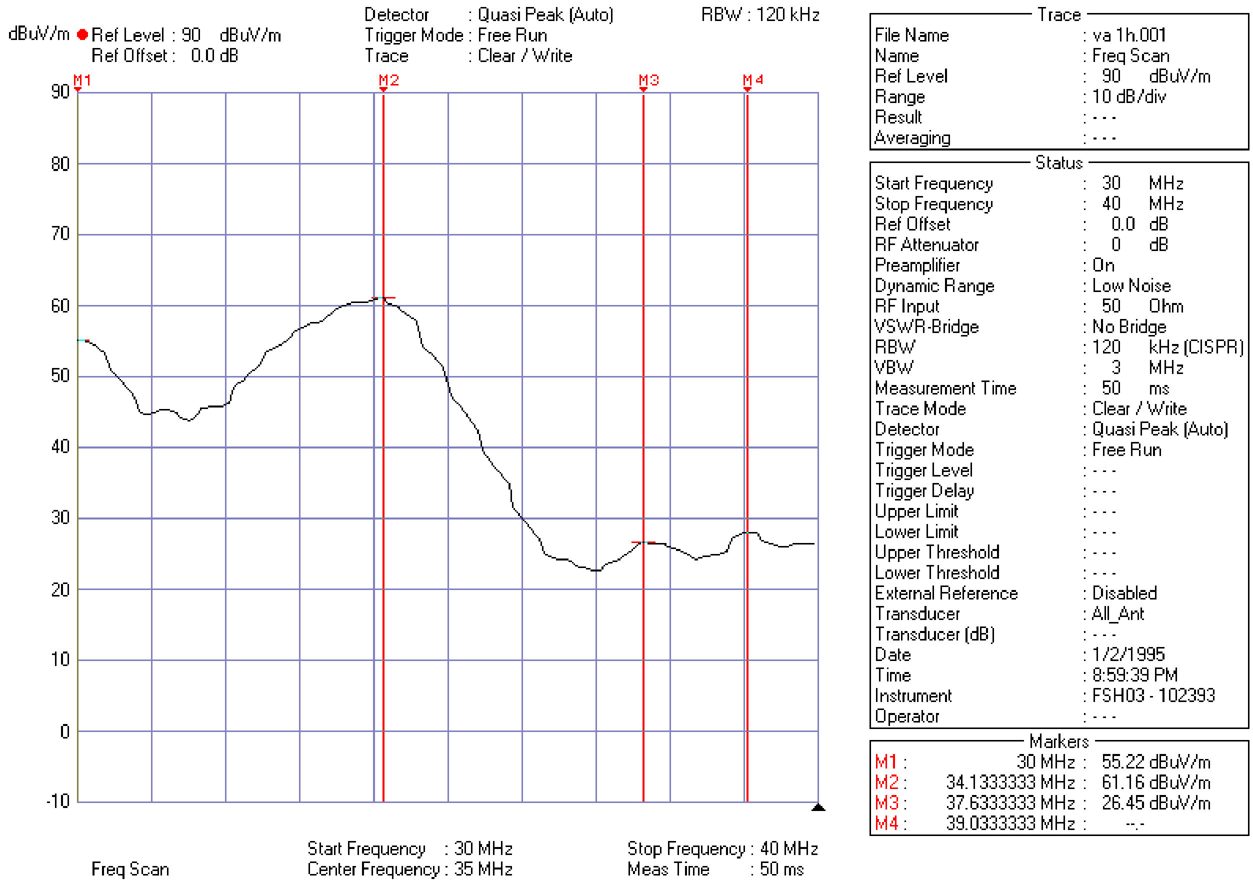


Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 3 highest readings (MHz)	28.4	28.1	27.1	--	--	--
Quasi peak spectrum analyzer voltages (dBµV)	45.7	44.5	44.5	--	--	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	--	--	--
Antenna Factor@measurement frequency (dB/m) [12]	n/a	n/a	n/a	--	--	--
Slant range distance correction (40log 30/X) (dB)	-8.4	-8.4	-8.4	--	--	--
Corrected E-Field Strength (dBµV/m @ 30m)	37.4	36.2	36.2	--	--	--
Test margin (dB)	+7.9	+6.7	+6.7	--	--	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	--	--	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	--	--	--

Measurement results: 30 to 1000 MHz:

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Stephen's Cove Road, Lovingston, VA, no houses, BPL repeater visually observed on pole supporting power lines in the woods.
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height of overhead line (if applicable): 15.7 meters
Slant range distance: 17.8 meters
Slant range distance correction (20 log): +5.0 dB

[12] For all tables in this report, the spectrum analyzer used has all antenna factors pre-programmed into memory, so all reported results in dBµV include the antenna factor.



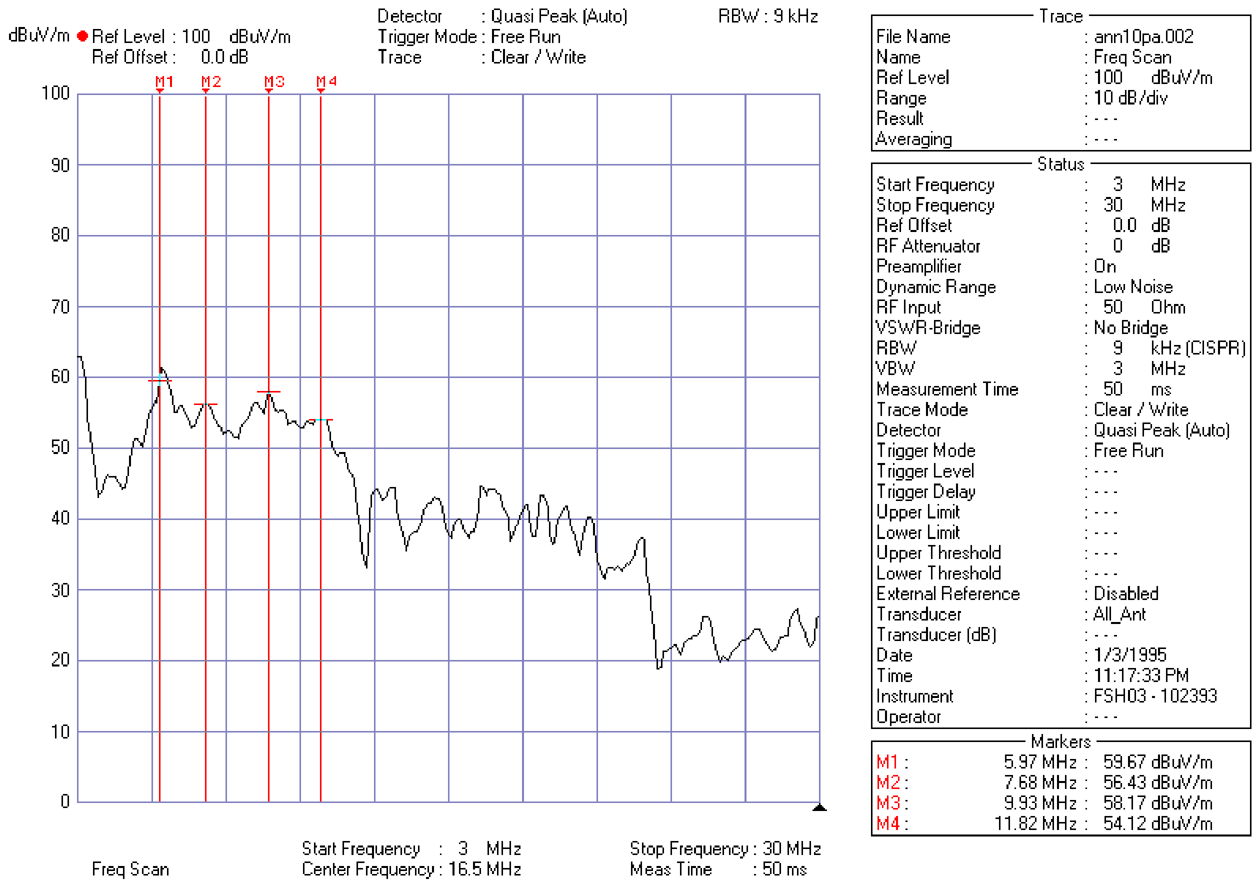
Field Strength 30 MHz to 1000 MHz (from spectral plot)						
Frequencies of 4 highest readings (MHz)	30.0	34.1	37.6	39.0	--	--
Quasi peak spectrum analyzer voltages (dBµV) (Indicate Horizontal or Vertical polarization)	55.2 H	61.2 H	26.4 H	27.8 H	--	--
Cable loss at the measurement frequency (dB)	0.3	0.3	0.3	0.3	--	--
Antenna Factor @ measurement frequency (dB/m)					--	--
Height conversion E-Field (+5 dB overhead only)	+5.0	+5.0	+5.0	+5.0	--	--
Slant range distance correction (20log 10/X) (dB)	+5.0	+5.0	+5.0	+5.0	--	--
Corrected Worst Case Field (dBµV/m @ 10m)	65.5	71.5	36.7	38.1	--	--
Test margin (dB)	+26.5	+32.4	-2.4	-1.0	--	--
FCC Limit Field Strength (dBµV/m @ 10 meters)	39.1	39.1	39.1	39.1	--	--
Test Results: FAIL	**FAIL**	**FAIL**	PASS	PASS	--	--

Location #2 – 1170 Thomas Nelson Highway, Arrington, VA (parking lot)

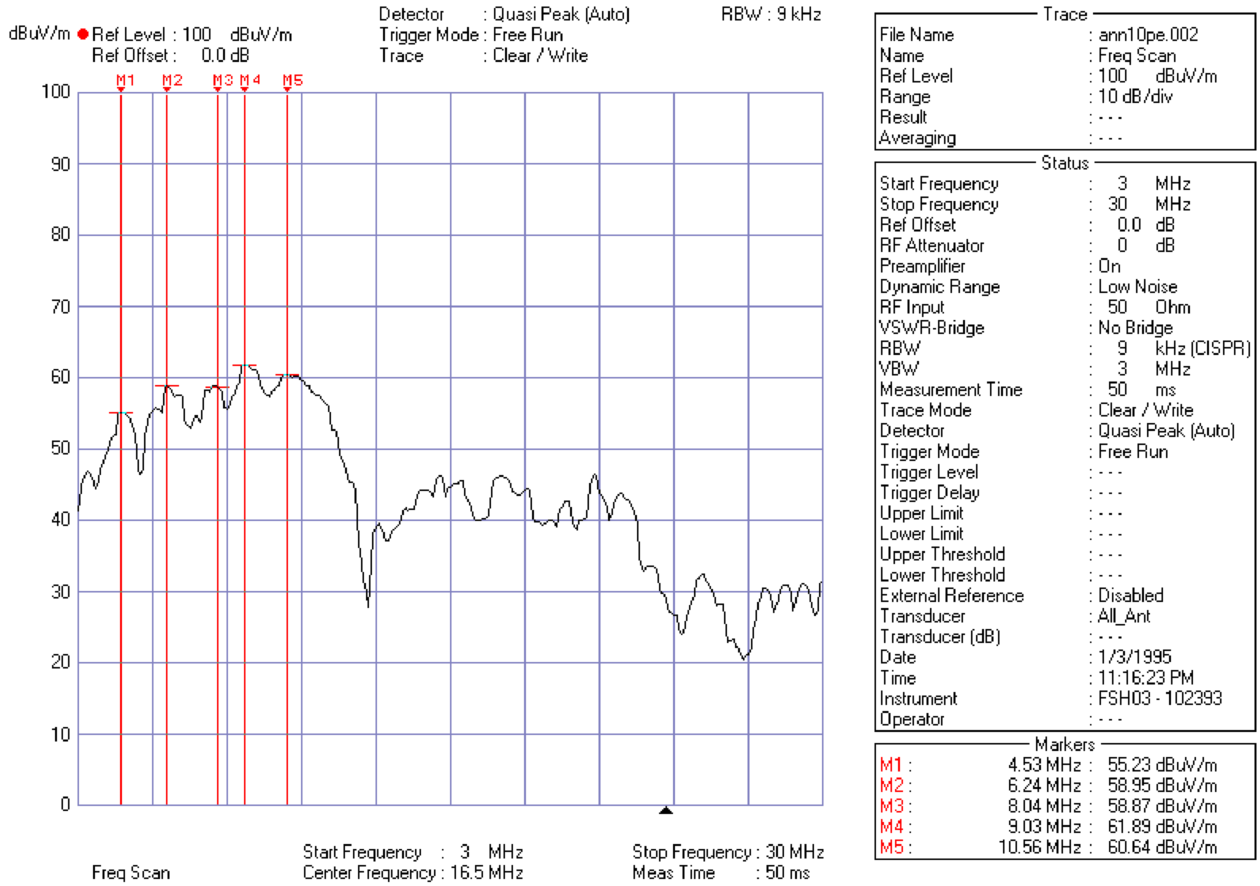
Photo/map of test site

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: 1170 Thomas Nelson Highway, Arrington, VA (parking lot)
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height over overhead line (if applicable): 12 meters (approximate)
Slant range distance: 14.9 meters
Slant range distance correction (40 log): -12.2 dB



Field Strength 1.705 MHz to 30 MHz (from spectral plot) 10 meters horizontal distance, loop parallel to overhead power lines						
Frequencies of 5 highest readings (MHz)	3.0	6.0	7.7	9.9	11.9	--
Quasi peak spectrum analyzer voltages (dBµV)	63.0	58.7	56.4	58.2	54.1	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	--
Slant range distance correction (40log 30/X) (dB)	-12.2	-12.2	-12.2	-12.2	-12.2	--
Corrected E-Field Strength (dBµV/m @ 30m)	50.9	46.6	44.3	46.1	42.0	--
Test margin (dB)	+21.4	+17.1	+14.8	+16.6	+12.5	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--



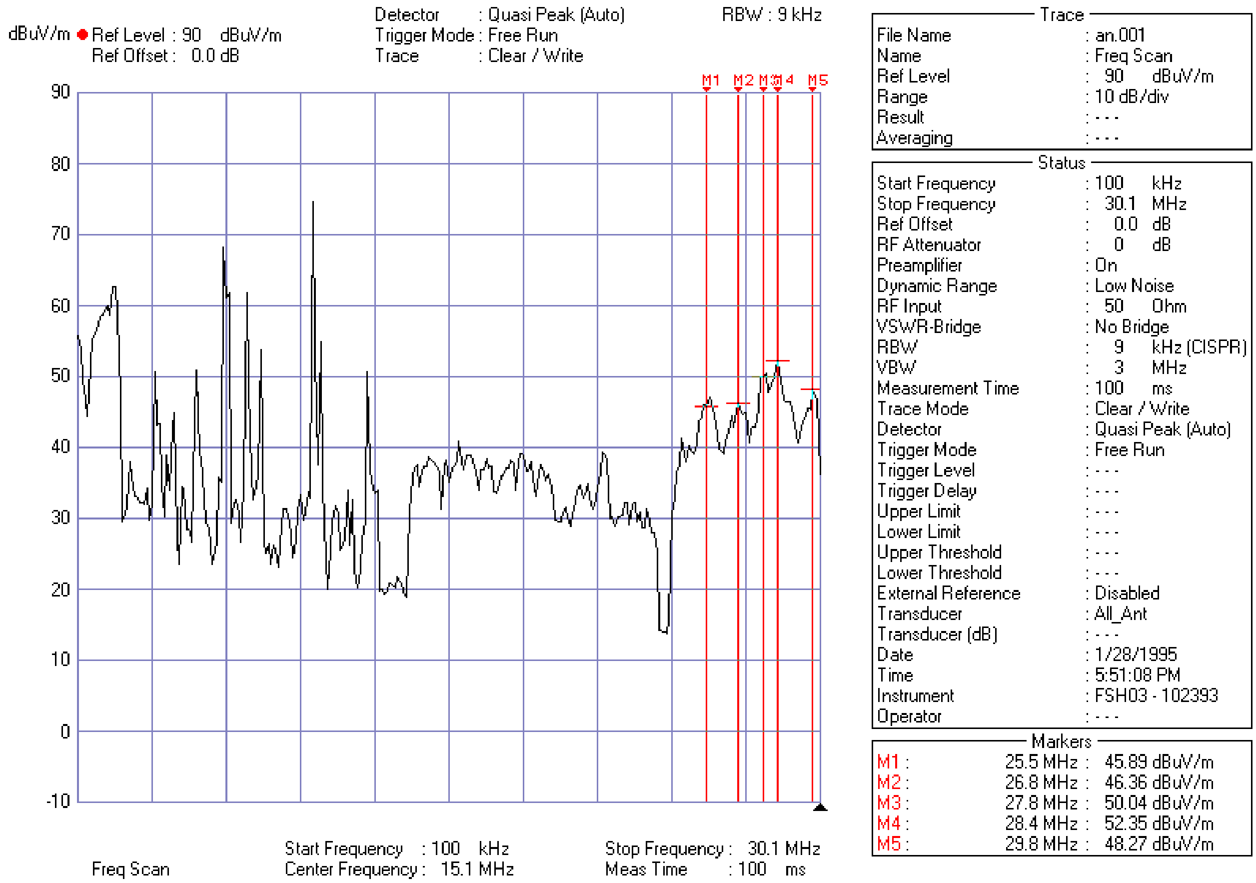
Field Strength 1.705 MHz to 30 MHz (from spectral plot) 10 meters horizontal distance, loop perpendicular to overhead power lines:						
Frequencies of 4 highest readings (MHz)	4.5	6.2	8.0	9.0	10.6	--
Quasi peak spectrum analyzer voltages (dBµV)	55.2	59.0	58.9	61.9	60.6	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	--
Slant range distance correction (40log 30/X) (dB)	-12.2	-12.2	-12.2	-12.2	-12.2	--
Corrected E-Field Strength (dBµV/m @ 30m)	43.1	46.9	46.8	49.8	48.5	--
Test margin (dB)	+13.6	+17.4	+17.3	+20.3	+19.0	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--

Re-measurement results – December 6, 2010

Measurement results: 1.705 to 30 MHz

Note: This location was re-measured on December 6, 2010. The levels at this location had decreased from prior measurements, but were still above the limits.

Test description: Measurement of overhead MV line carrying BPL signal
Test location: 1170 Thomas Nelson Highway, Arrington, VA (parking lot)
Date: December 6, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height over overhead line (if applicable): 12 meters (approximate)
Slant range distance: 14.9 meters
Slant range distance correction (40 log): -12.2 dB



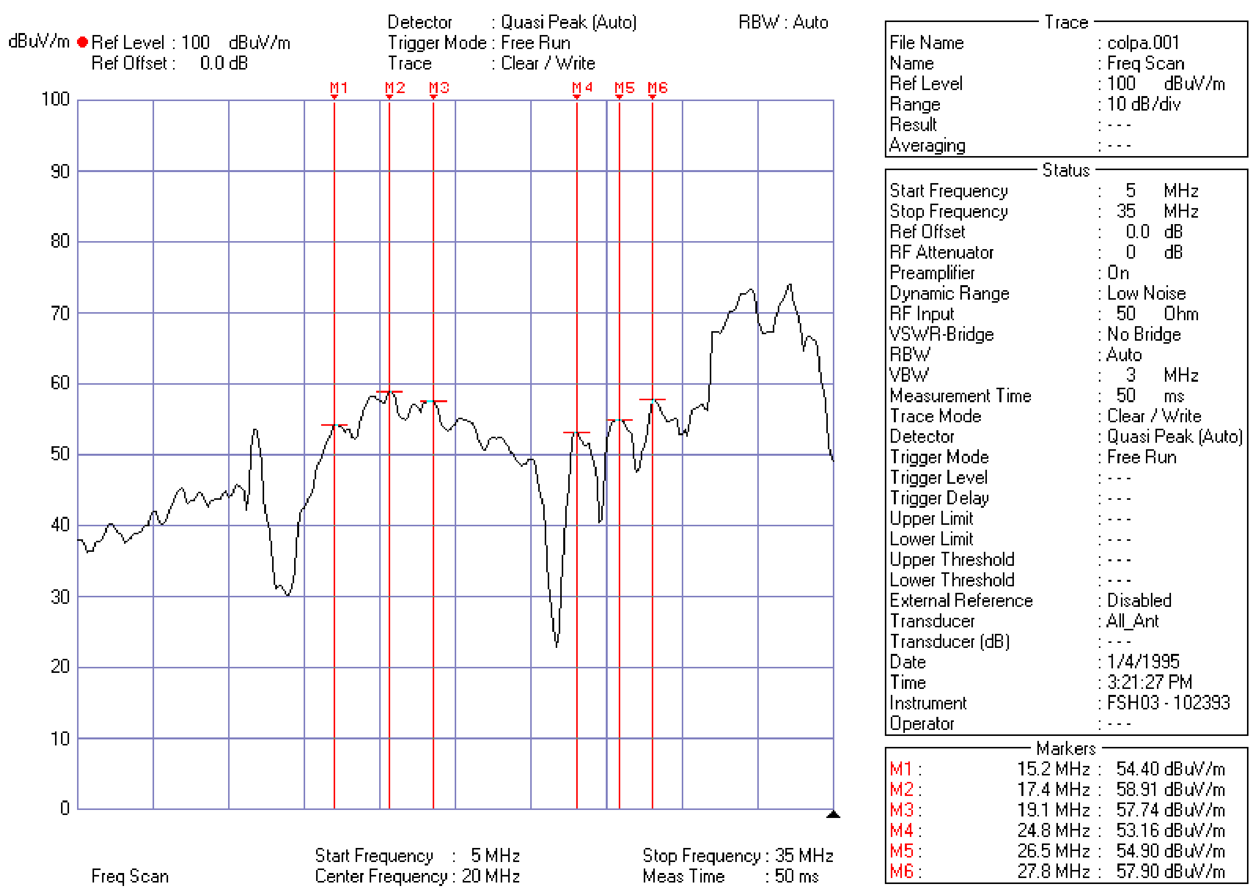
Field Strength 1.705 MHz to 30 MHz (from spectral plot) 10 meters horizontal distance, loop perpendicular to overhead power lines:						
Frequencies of 4 highest readings (MHz)	25.5	26.8	27.8	28.4	29.8	--
Quasi peak spectrum analyzer voltages (dBµV)	45.9	46.3	50.0	52.3	48.3	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	--
Slant range distance correction (40log 30/X) (dB)	-12.2	-12.2	-12.2	-12.2	-12.2	--
Corrected E-Field Strength (dBµV/m @ 30m)	33.8	34.2	37.9	40.2	36.2	--
Test margin (dB)	+4.3	+4.7	+8.4	+10.7	+6.7	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--
					--	--

Test location #3 – Cooperative Way, VA – near CVEC administrative offices

Photo/map of test site

Measurement results: 1.705 to 30 MHz:

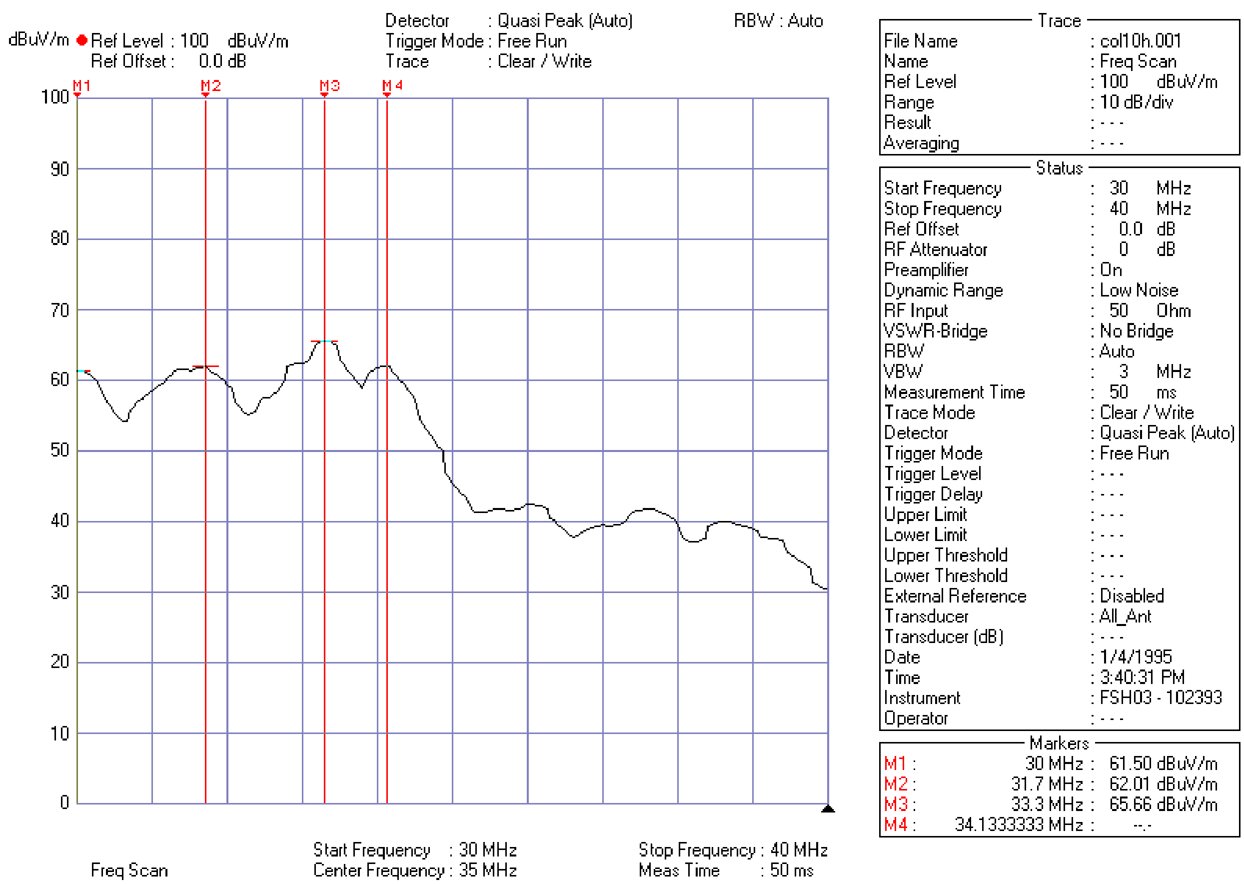
Test description: Measurement of overhead MV line carrying BPL signal
Test location: Cooperative Way, Arrington, VA – near CVEC administrative offices
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height of overhead line (if applicable): 12 meters (approximate)
Slant range distance: 14.9 meters
Slant range distance correction (40 log): -12.2 dB



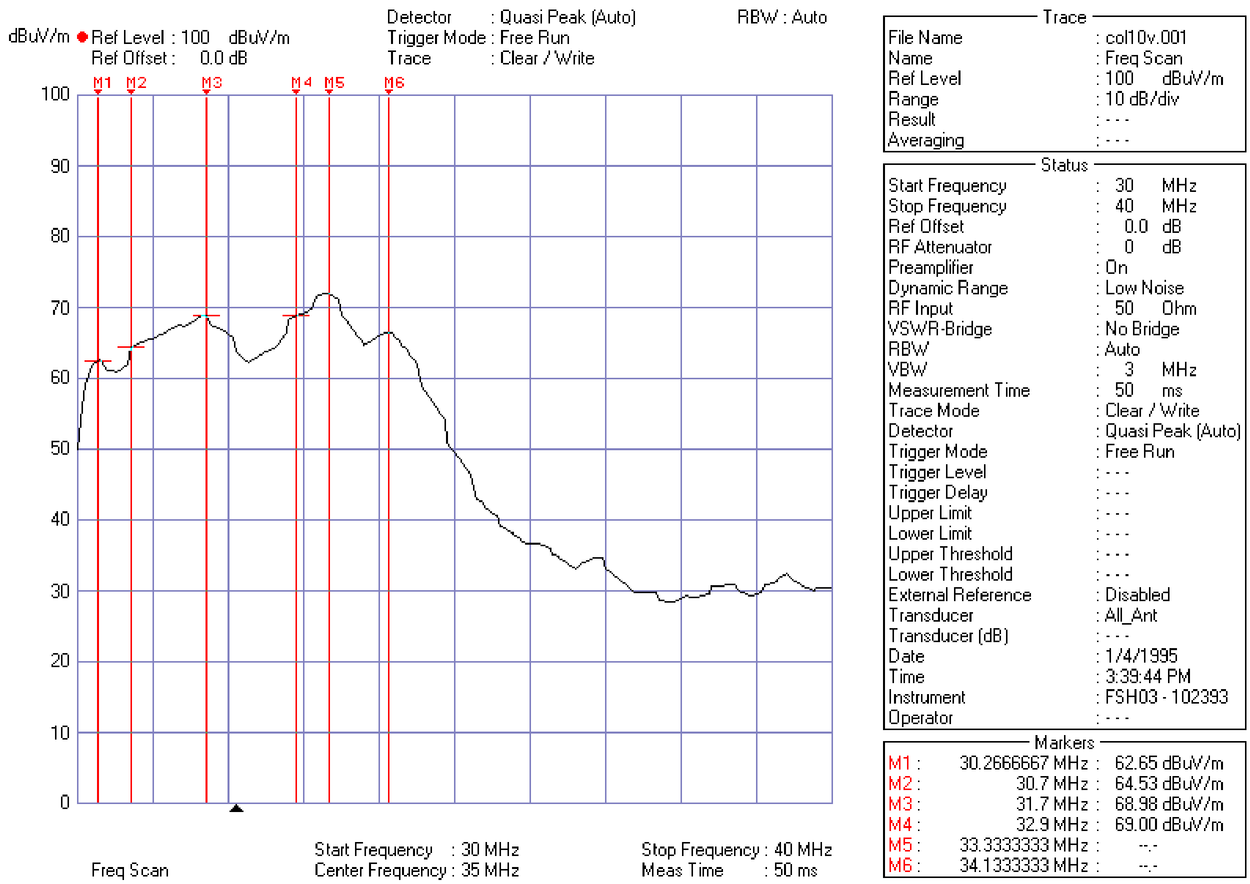
Field Strength 1.705 MHz to 30 MHz (from spectral plot) Horizontal distance: 10 meters, loop oriented for maximum						
Frequencies of 6 highest readings (MHz)	15.2	17.4	19.1	24.8	26.5	27.8
Quasi peak spectrum analyzer voltages (dBµV)	54.4	58.9	57.8	53.2	54.9	57.9
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	0.1
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Slant range distance correction (40log 30/X) (dB)	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2
Corrected E-Field Strength (dBµV/m @ 30m)	42.3	46.8	45.7	41.1	43.8	45.8
Test margin (dB)	+12.8	+17.3	+16.2	+11.6	+13.3	+16.3
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

Measurement results: 30 to 1000 MHz:

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Cooperative Way, Arrington, VA – near CVEC administrative offices
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height of overhead line (if applicable): 12 meters (approximate)
Slant range distance: 14.9 meters
Slant range distance correction (20 log): +3.5 dB



Field Strength 30 MHz to 1000 MHz (from spectral plot) Horizontal distance: 10 meters, bi-conical antenna horizontally polarized						
Frequencies of 4 highest readings (MHz)	30	31.7	33.3	34.1	--	--
Quasi peak spectrum analyzer voltages (dBµV)	61.5	62	65.7	62.1	--	--
Cable loss at the measurement frequency (dB)	0.3	0.3	0.3	0.3	--	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	--	--
Height conversion E-Field (+5 dB overhead only)	+5.0	+5.0	+5.0	+5.0	--	--
Slant range distance correction (20log 10/X) (dB)	+3.5	+3.5	+3.5	+3.5	--	--
Corrected Worst Case Field (dBµV/m @ 10m)	70.3	70.8	74.5	70.9	--	--
Test margin (dB)	+31.2	+31.7	+35.4	+31.8	--	--
FCC Limit Field Strength (dBµV/m @ 10 meters)	39.1	39.1	39.1	39.1	--	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--	--



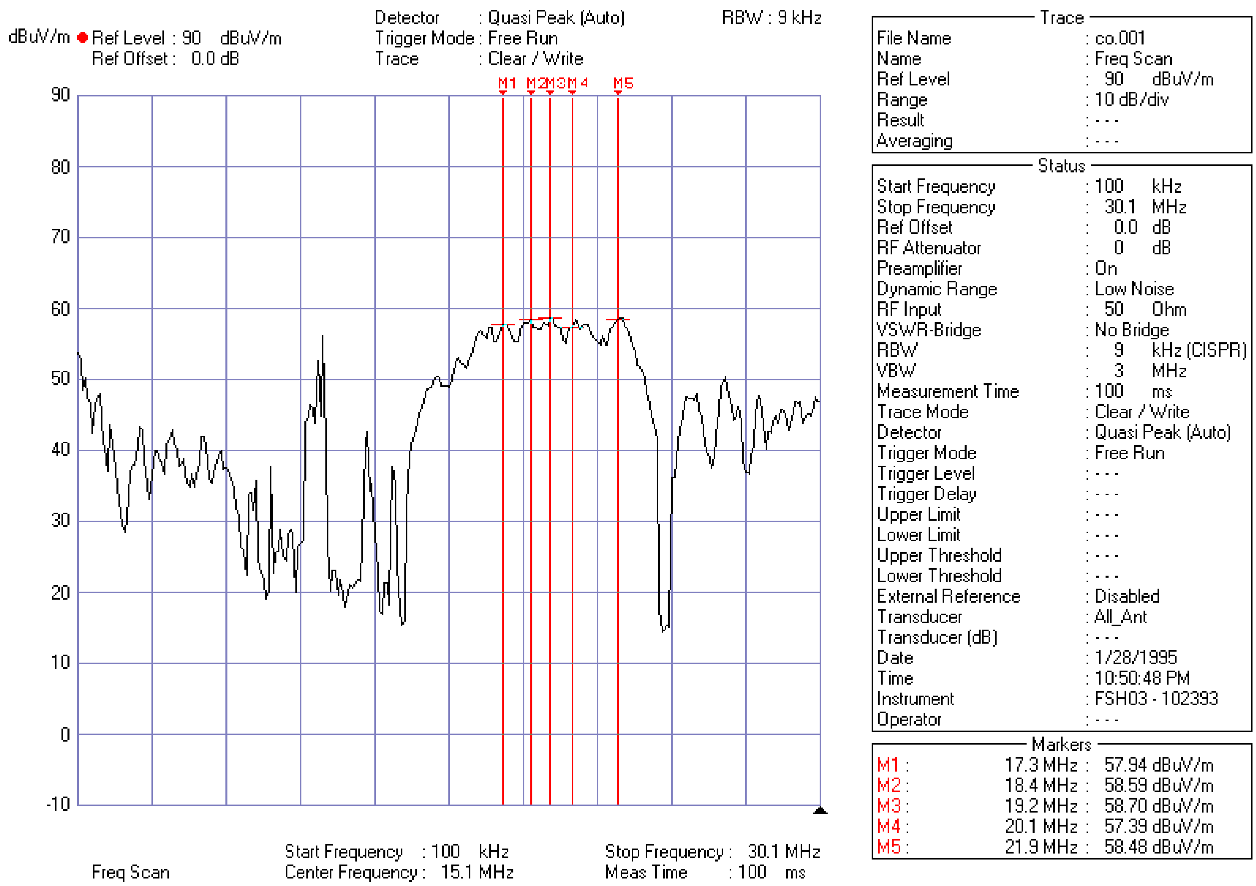
Field Strength 30 MHz to 1000 MHz (from spectral plot) Horizontal distance: 10 meters, bi-conical antenna vertically polarized						
Frequencies of 6 highest readings (MHz)	30.3	30.7	31.7	32.9	33.3	34.1
Quasi peak spectrum analyzer voltages (dBµV)	62.7	64.5	69.0	69.0	72	66.7
Cable loss at the measurement frequency (dB)	0.3	0.3	0.3	0.3	0.3	0.3
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Height conversion E-Field (+5 dB overhead only)	+5.0	+5.0	+5.0	+5.0	+5.0	+5.0
Slant range distance correction (20log 10/X) (dB)	+3.5	+3.5	+3.5	+3.5	+3.5	+3.5
Corrected Worst Case Field (dBµV/m @ 10m)	71.5	73.3	77.8	77.8	80.8	75.5
Test margin (dB)	+32.4	+34.2	+38.7	+38.7	+41.7	+36.4
FCC Limit Field Strength (dBµV/m @ 10 meters)	39.1	39.1	39.1	39.1	39.1	39.1
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

Re-measurement results – December 6, 2010

Measurement results: 1.705 to 30 MHz

Note: This location was re-measured on December 6, 2010. Below 30 MHz, the levels at this location were approximately the same as they had been in the March 2010 testing. Measurements were not made above 30 MHz in the December 2010 testing.

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Cooperative Way, Arrington, VA – near CVEC administrative offices
Date: December 6, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters
Height of overhead line (if applicable): 12 meters (approximate)
Slant range distance: 14.9 meters
Slant range distance correction (40 log): -12.2 dB



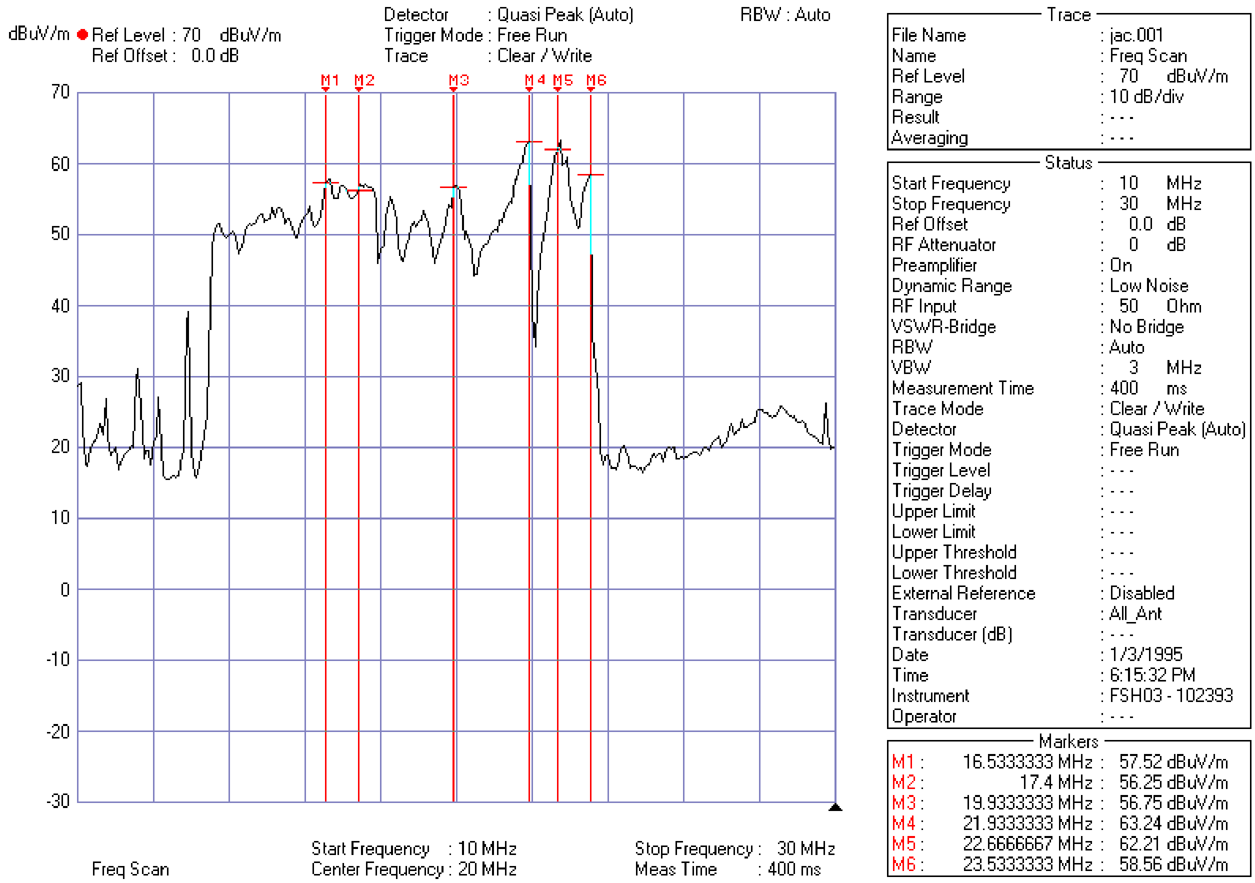
Field Strength 1.705 MHz to 30 MHz (from spectral plot) Horizontal distance: 10 meters, loop oriented for maximum						
Frequencies of 6 highest readings (MHz)	17.3	18.4	19.2	20.1	21.9	--
Quasi peak spectrum analyzer voltages (dBµV)	58.0	58.6	58.7	57.4	58.5	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	--
Slant range distance correction (40log 30/X) (dB)	-12.2	-12.2	-12.2	-12.2	-12.2	--
Corrected E-Field Strength (dBµV/m @ 30m)	45.9	46.5	46.6	45.3	46.4	--
Test margin (dB)	+16.4	+17.0	+17.1	+15.8	+16.9	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--

Test location #4 – private residence

Photo/map of test site

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Private residence
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 8 meters (approximate)
Height of overhead line (if applicable): 10 meters (approximate)
Measurement height: 2 meters
Slant range distance: 11.3 meters
Slant range distance correction (40 log): -16.9 dB



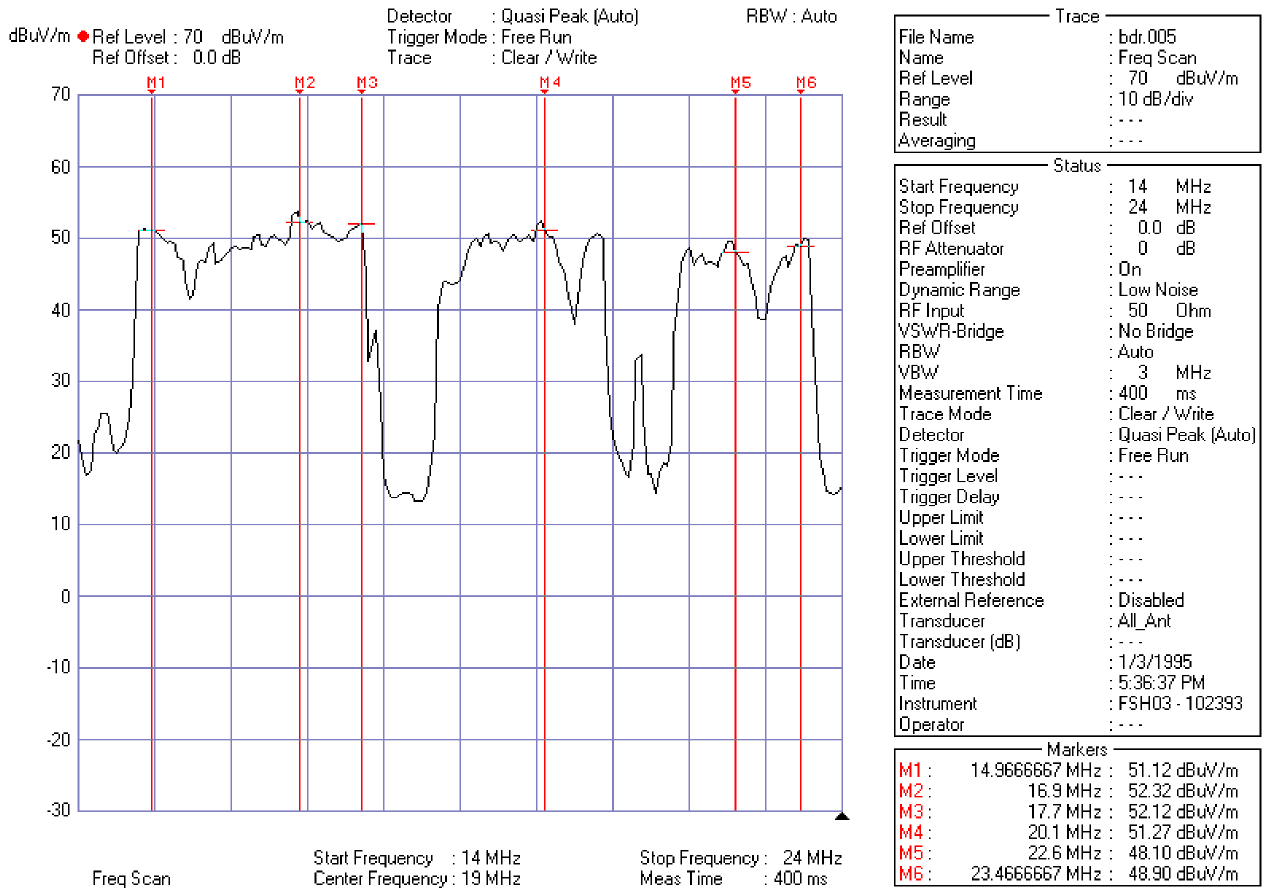
Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 6 highest readings (MHz)	16.5	17.4	19.9	21.9	22.7	23.5
Quasi peak spectrum analyzer voltages (dBμV)	57.5	56.2	56.8	63.2	62.2	58.6
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	0.1
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Slant range distance correction (40log 30/X) (dB)	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9
Corrected E-Field Strength (dBμV/m @ 30m)	40.7	39.4	40.0	46.4	45.4	41.8
Test margin (dB)	+11.2	+9.9	+10.5	+16.9	+15.9	+12.3
FCC Limit Field Strength (dBμV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

Test location #5 – K4BDR, Afton, VA

Photo/map of test site

Measurement results: 1.705 to 30 MHz:

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Kevin Ward, K4BDR, 351 Mountain Rd, Afton, VA
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 50 meters (approximate)[13]
Height of overhead line (if applicable): 10 meters (see footnote)
Slant range distance: 50.8 meters (see footnote)
Slant range distance correction (20 log): + 4.6 dB



Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 6 highest readings (MHz)	15.0	16.9	17.7	20.1	22.6	23.5
Quasi peak spectrum analyzer voltages (dBµV)	51.1	52.3	52.1	51.3	48.1	48.9
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	0.1
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Slant range distance correction (20log 30/X) (dB)[14]	+4.6	+4.6	+4.6	+4.6	+4.6	+4.6
Corrected E-Field Strength (dBµV/m @ 30m)	55.8	57.0	56.8	56.0	52.8	53.6
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test margin (dB)	+26.3	+22.8	+27.3	+26.5	+23.3	+24.1
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

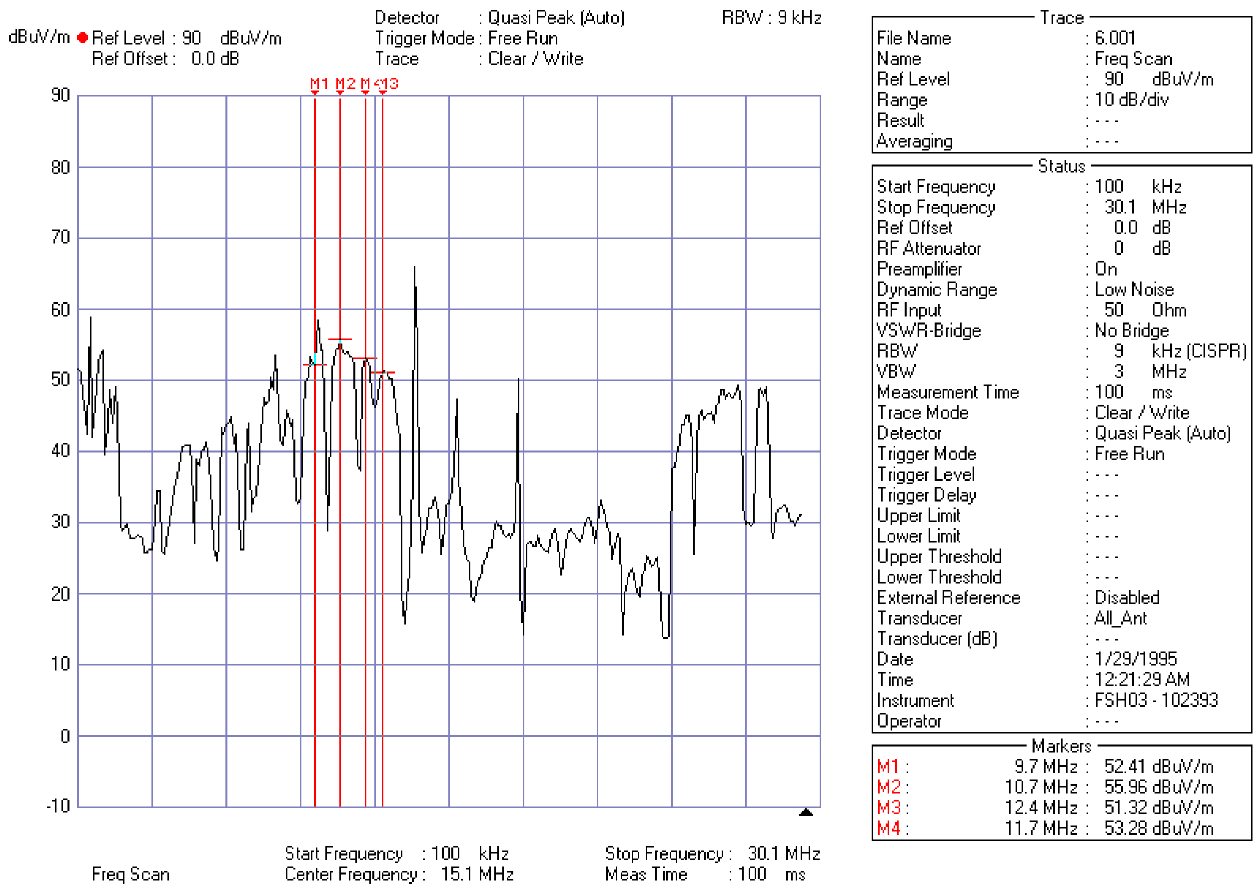
[13] The nearest lines carrying BPL were on private property and not accessible. The estimate of distance is very approximate.
[14] Because the distance to the line is greater than 30 meters and the frequency is in the upper part of the frequency range, ARRL applied a 20 log extrapolation factor, resulting in an estimate of field strength that is somewhat lower than would be obtained with a 40 log factor.

Re-measurement results – December 6, 2010

Measurement results: 1.705 to 30 MHz

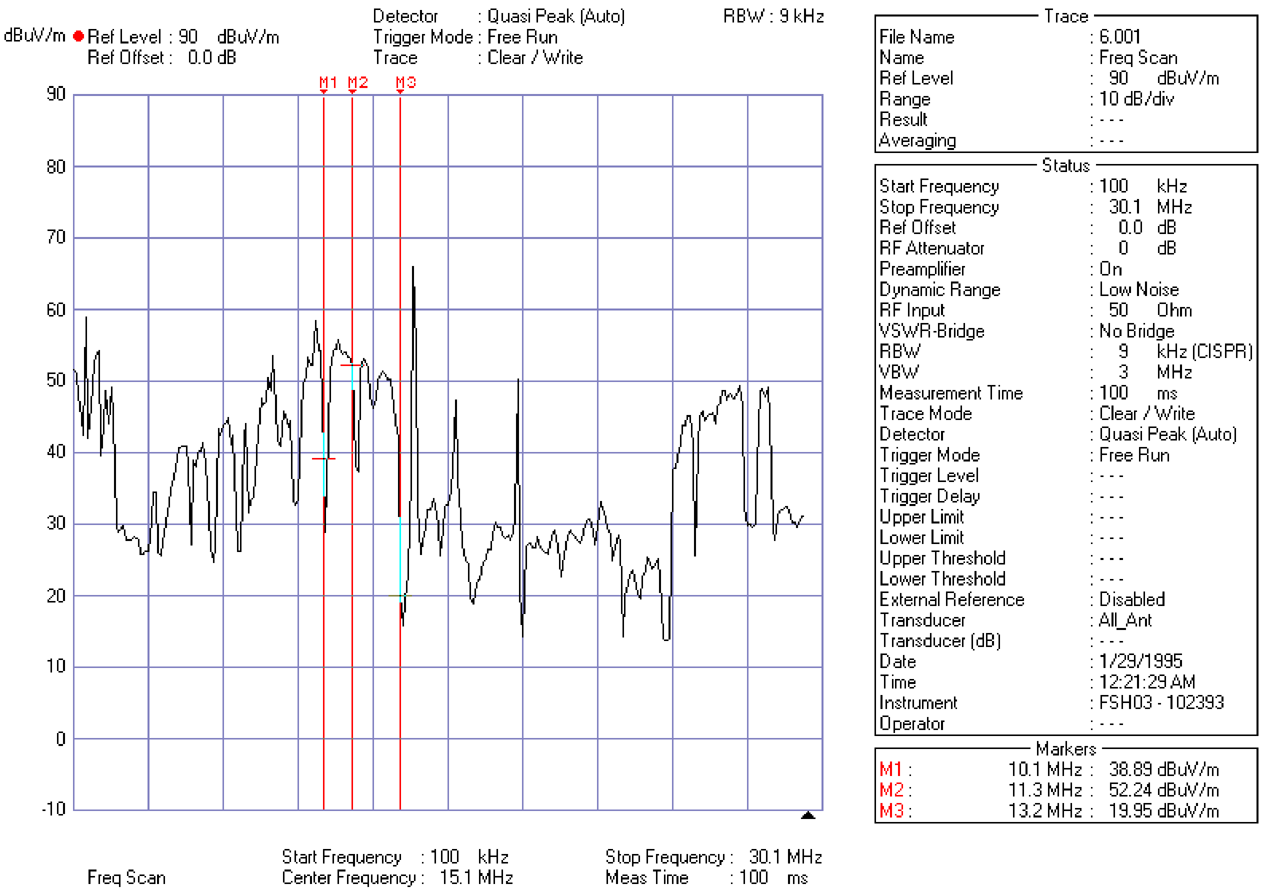
This general area was re-tested on December 6, 2010, at a location on Mountain Road, Afton, VA.

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Mountain Rd, Afton, VA
Date: December 6, 2010
Horizontal distance to EUT, premise or overhead line: 8 meters (estimate)
Height of overhead line (if applicable): 10 meters (estimate)
Slant range distance: 12.2 meters
Slant range distance correction (40 log): -15.6 dB



Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 6 highest readings (MHz)	9.7	10.7	12.4	11.7	--	--
Quasi peak spectrum analyzer voltages (dBµV)	52.4	56.0	51.3	53.3	--	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	--	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	--	--
Slant range distance correction (40log 30/X) (dB)	-15.6	-15.6	-15.6	-15.6	--	--
Corrected E-Field Strength (dBµV/m @ 30m)	36.9	40.5	35.8	37.8	--	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	--	--
Test margin (dB)	+7.4	+11.0	+6.3	+8.3	--	--
Test Results: FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	--	--

As seen in the graph below, this was the only location tested in the area that showed evidence of an attempt to notch the bands protected by §15.615(f)(1).



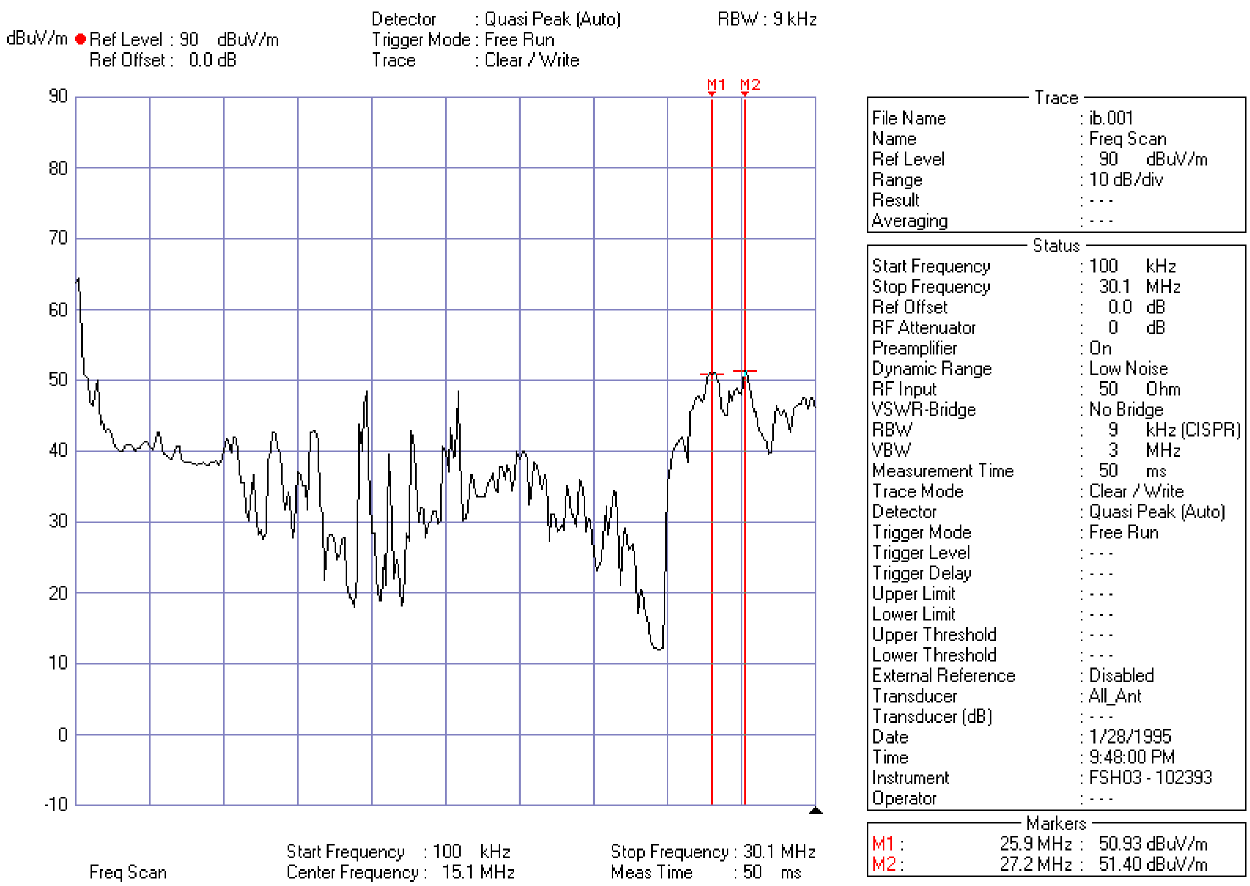
Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 6 highest readings (MHz)	10.1	11.3	13.2	--	--	--
Quasi peak spectrum analyzer voltages (dBµV)	38.9	52.4	20.0	--	--	--
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	--	--	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	--	--	--
Slant range distance correction (40log 30/X) (dB)	-15.6	-15.6	-15.6	--	--	--
Corrected E-Field Strength (dBµV/m @ 30m)	23.4	36.9	4.5	--	--	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	9.5	9.5	9.5	--	--	--
Test margin (dB)	+13.9	+27.4	-5.0	--	--	--
Test Results: FAIL	**FAIL**	**FAIL**	**PASS**	**--**	**--**	**--**

Location #6 – 2417 Cove Mountain Road, Lovingston, VA

Photo/map of test site

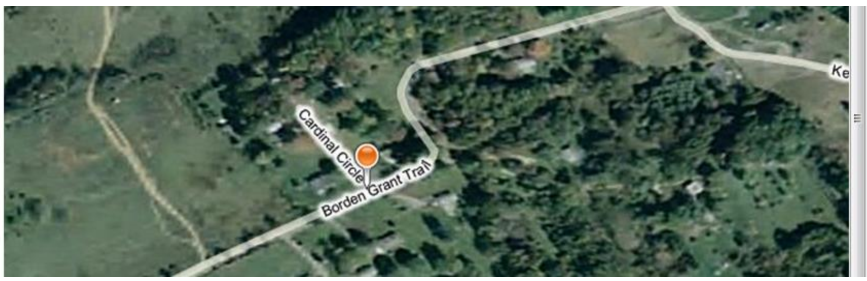
Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: 2417 Mountain Cove Rd, Lovingston, VA
Date: December 7, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters (estimate)
Height of overhead line (if applicable): 8 meters (estimate)
Slant range distance: 12.2 meters
Slant range distance correction (40 log): -15.6 dB



Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 2 highest readings (MHz)	25.9	27.2	--	--	--	--
Quasi peak spectrum analyzer voltages (dBµV)	50.9	51.4	--	--	--	--
Cable loss at the measurement frequency (dB)	0.1	0.1	--	--	--	--
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	--	--	--	--
Slant range distance correction (40log 30/X) (dB)	-15.6	-15.6	--	--	--	--
Corrected E-Field Strength (dBµV/m @ 30m)	35.4	35.9	--	--	--	--
Test margin (dB)	+5.9	+6.4	--	--	--	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	--	--	--	--
Test Results: FAIL	**FAIL**	**FAIL**	**--**	**--**	**--**	**--**

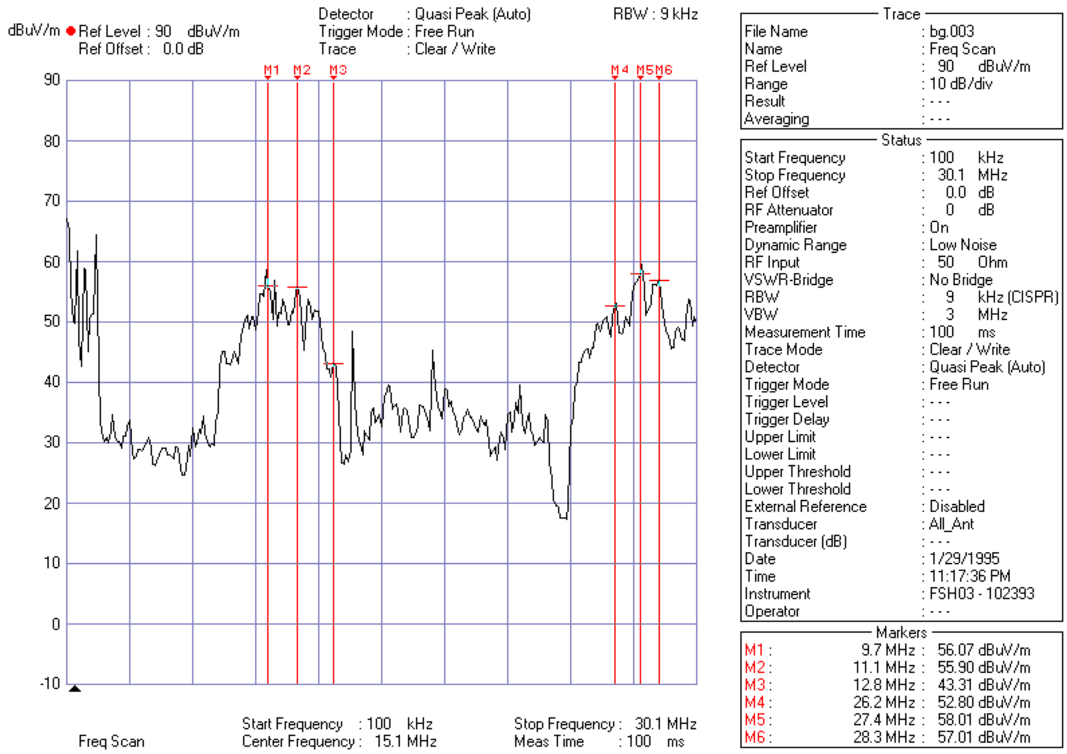
Location #7 – Borden Grant Trail and Cardinal Circle, near Fairfield, VA



Photo/map of test site

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Intersection of Borden Grant Trail and Cardinal Circle, near Fairfield, VA
Date: December 7, 2010
Horizontal distance to EUT, premise or overhead line: 10.1 meters
Height of overhead line (if applicable): 8 meters (estimate)
Measurement height: 2 meters
Slant range distance: 11.7 meters
Slant range distance correction (40 log): -16.4 dB



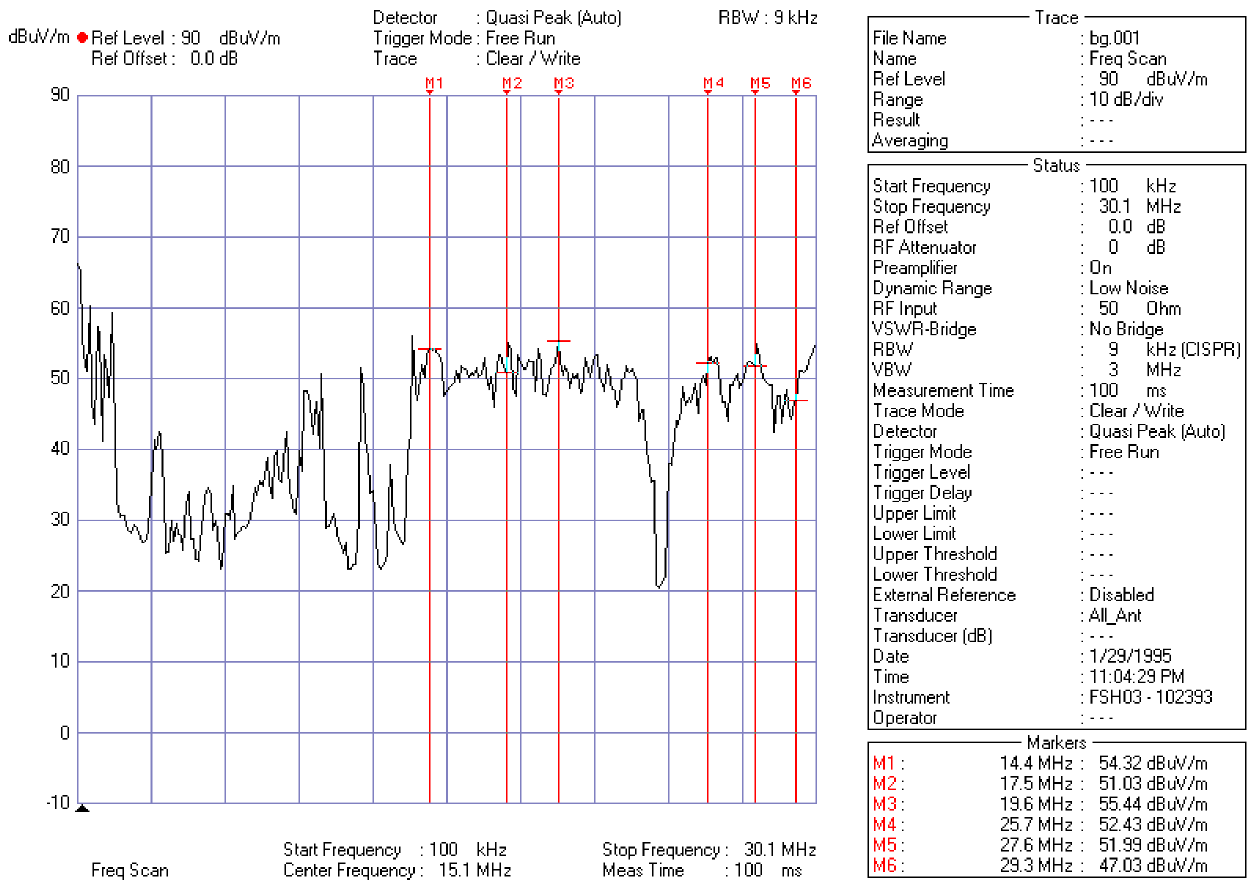
Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 3 highest readings (MHz)	9.7	11.1	12.8	26.2	27.4	28.3
Quasi peak spectrum analyzer voltages (dBµV)	56.1	55.9	43.3	52.8	58.0	57.0
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	0.1
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Slant range distance correction (40log 30/X) (dB)	-16.4	-16.4	-16.4	-16.4	-16.4	-16.4
Corrected E-Field Strength (dBµV/m @ 30m)	39.8	39.6	27.0	36.5	41.7	40.7
Test margin (dB)	+10.3	+10.1	-2.5	+7.0	+12.2	+11.2
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: FAIL	**FAIL**	**FAIL**	**PASS**	**FAIL**	**FAIL**	**FAIL**

Location #8 – 4516 Borden Grant Trail, Fairfield, VA

Photo/map of test site

Measurement results: 1.705 to 30 MHz

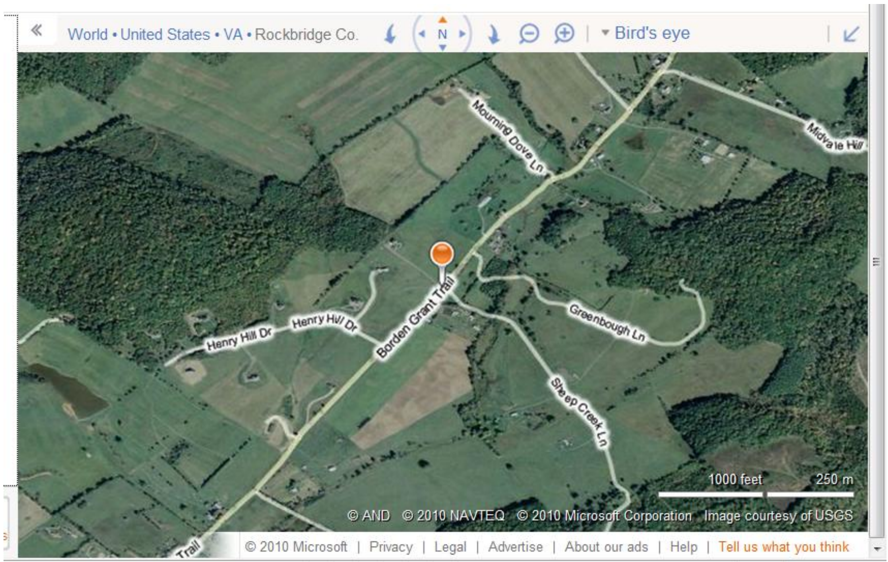
Test description: Measurement of overhead MV line carrying BPL signal
Test location: 4516 Borden Grant Trail, Fairfield, VA
Date: December 7, 2010
Horizontal distance to EUT, premise or overhead line: 8 meters (estimate)
Height of overhead line (if applicable): 8 meters (estimate)
Measurement height: 2 meters
Slant range distance: 10 meters
Slant range distance correction (40 log): -19.1 dB



Field Strength 1.705 MHz to 30 MHz (from spectral plot)						
Frequencies of 3 highest readings (MHz)	14.4	17.5	19.6	25.7	27.6	29.3
Quasi peak spectrum analyzer voltages (dBµV)	54.3	51.0	55.4	52.4	52.0	47.0
Cable loss at the measurement frequency (dB)	0.1	0.1	0.1	0.1	0.1	0.1
Antenna Factor @ measurement frequency (dB/m)	n/a	n/a	n/a	n/a	n/a	n/a
Slant range distance correction (40log 30/X) (dB)	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1
Corrected E-Field Strength (dBµV/m @ 30m)	35.3	32.0	36.4	33.4	33.0	28.0
Test margin (dB)	+5.8	+2.5	+6.9	+3.9	+3.5	-1.5
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: FAIL[15]	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**PASS**

[15] For this measurement distance and extrapolation, this location's emissions are within a reasonable measurement uncertainty of meeting the limits.

Location #9 – 2178 Borden Grant Trail, Fairfield, VA



Photo/map of test site

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: 2178 Borden Grant Trail, Fairfield, VA
Date: December 7, 2010
Horizontal distance to EUT, premise or overhead line: 8 meters (estimate)
Height of overhead line (if applicable): 8 meters (estimate)
Measurement height: 2 meters
Slant range distance: 10 meters
Slant range distance correction (40 log): -19.1 dB

<No spectral sweep was performed at this location>

Field Strength 1.705 MHz to 30 MHz (from single measurement)						
Frequencies of 1 highest reading (MHz)	5.6	--	--	--	--	--
Quasi peak spectrum analyzer voltages (dBµV)	58.5	--	--	--	--	--
Cable loss at the measurement frequency (dB)	0.1	--	--	--	--	--
Antenna Factor @ measurement frequency (dB/m)	n/a	--	--	--	--	--
Slant range distance correction (40log 30/X) (dB)	-19.1	--	--	--	--	--
Corrected E-Field Strength (dBµV/m @ 30m)	39.5	--	--	--	--	--
Test margin (dB)	+10.0	--	--	--	--	--
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	--	--	--	--	--
Test Results: FAIL	**FAIL**	**--**	**--**	**--**	**--**	**--**

Note: At this location, vehicle parking did not appear to be safe. A single measurement was made along the power line, while in motion, recording the level of the strongest emission along the line, within 10 meters of the BPL injection coupler.

Test Location #10 – Other areas in the environment of Fairfield, VA

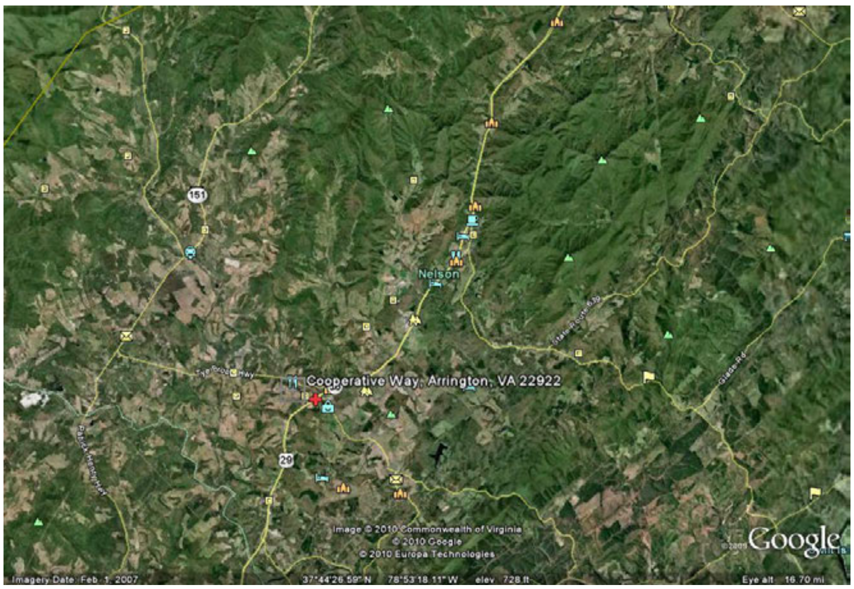
In addition to the measured points, the use of spectrum by BPL was investigated in the general vicinity. Strong noise in the Amateur bands and in the prohibited bands from BPL radiated emissions along sections of Borden Grant Trail and South River Road, and connecting cross roads was observed. There was no evidence of Amateur or §15.615(f)(1) notching in any part of this system.

Test Location #11 – Somerset, PA and environs

On December 8, 2010, a site visit to Somerset, PA was performed. There was heavy lake-effect snow occurring at the time, with approximately 8" of snow on the ground. Road conditions were somewhat slippery and with the snow plowed to the side of the road, side of road parking was not possible. For that reason, no measurements were performed at this location at this time. A drive-around survey showed strong noise in the Amateur bands and in the prohibited bands from BPL along sections of Water Level Road, Chickentown Road and other roads in the vicinity. The levels observed on the signal-strength meter of the communications receiver used for the testing were consistent with those noted in the areas measured in the Lovingston, VA area. There was no decrease in signal strength in those parts of the system that operated above 30 MHz, so it is presumed that this system is operating significantly above the radiated emission limits above 30 MHz.

There was no evidence of Amateur band notching, nor the notching required by §15.615(f)(1) of the FCC rules in any part of this system.

Test location #12 – Unspecified location along I-28



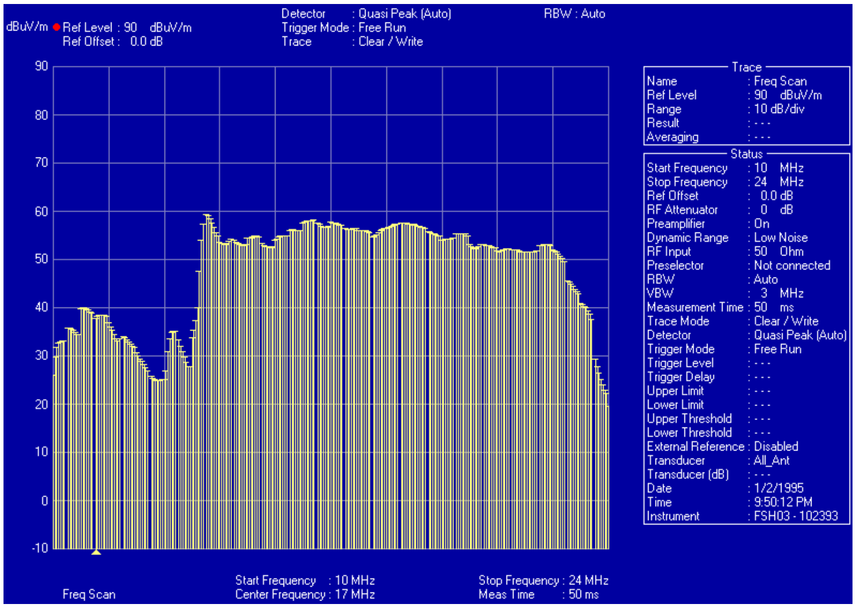
Photo/map of test area

Measurement results: 1.705 to 30 MHz

Test description: Measurement of overhead MV line carrying BPL signal
Test location: Unspecified location along I-29, north of the CVEC administrative building
Date: March 5, 2010 through March 8, 2010
Horizontal distance to EUT, premise or overhead line: 10 meters (approximate)[16]
Height of overhead line (if applicable): 10 meters (see footnote)
Slant range distance: N/A

Note: The following graph is representative of the lack of notching of the Amateur bands and the spectrum protected by §15.615(f)(1) throughout the three IBEC BPL installations. Measurements or estimates of slant-range distance were not made, although from the signal levels, this level is consistent with the excessive emissions at other locations. The lack of notches was widespread throughout all three systems.

[16] The nearest lines carrying BPL were on private property and not accessible. The estimate of distance is approximate.



The graph that shows the lack of notching shows frequency use significantly different from the information IBEC and CVEC have entered into the BPL database, shown below for ZIP code 22922. The system is not notched on the frequencies the database claims to be notched:

Found Active Companies

We found **1** company listed as operating within zip code *22922*

IBEC Inc.

Contact Name: Steve Turner

Phone: 256-492-1000

Email: steven.turner@ibec.net

Street Address: P. O. Box 2042
Gadsden, AL 35903

Operational Zip: 22922

Details:

Frequency	Manufacturer	Model	Start Date
2.0 - 34.0	Corinex Communications; Kaicom Communications; IBEC, Inc.	Corinex Medium-Voltage Gateway; Kaicom Medium-Voltage Equipment Models 2210, 2220E, & 2330; IBEC Customer Access Unit and BPL Regenerator Unit	2006-06-17

Notes: Corinex Medium-Voltage Gateway FCC ID: QIUCXP-MVA-GWY, granted Part 15G Certification on 09/28/2006. Kaicom Medium Voltage Equipment 2210 - FCC ID: UGN-KPI-2210, granted Part 15G Certification on 03/08/2007; 2220E - FCC ID: UGN-KPI-2220E, granted Part 15G Certification on 01/12/2007; and 2330 - FCC ID: UGN-KPI-2330, granted Part 15G Certification on 01/09/2007; IBEC Customer Access Unit FCC ID: U9TLCCAU10007, granted Part 15G Certification on 08/24/07; IBEC BPL Regenerator Unit FCC ID: U9TBRUG320007, granted Part 15G Certification on 10/01/07. All appropriate Amateur Radio and Public Safety Frequencies are Notched in Compliance with FCC Part 15 Requirements.

47 C.F.R. Section 15.615(f)(1) reads as follows:

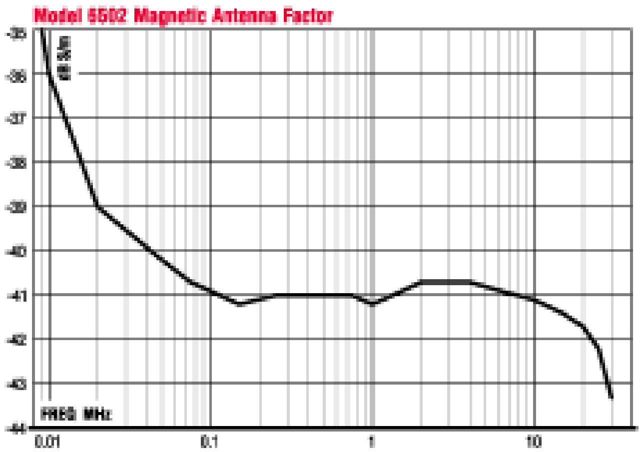
(1) *Excluded Bands.* To protect Aeronautical (land) stations and aircraft receivers, Access BPL operations using overhead medium voltage power lines are prohibited in the frequency bands listed in Table 1. Specifically, such BPL systems shall not place carrier frequencies in these bands

.

TABLE 1—EXCLUDED FREQUENCY BANDS

Frequency band
2,850–3,025 kHz
3,400–3,500 kHz
4,650–4,700 kHz
5,450–5,680 kHz
6,525–6,685 kHz
8,815–8,965 kHz
10,005–10,100 kHz
11,275–11,400 kHz
13,260–13,360 kHz
17,900–17,970 kHz
21,924–22,000 kHz
74 8–75 2 MHz

Antenna factors:



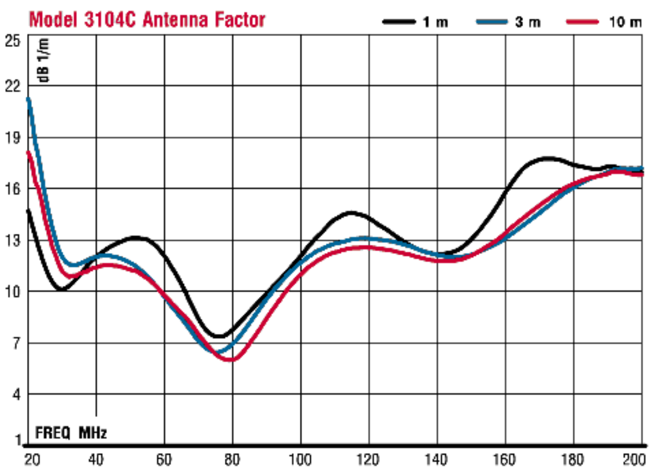


Exhibit B

arc technical resources
engineering services

2006 Lockwood Drive, San Jose, CA 95132

www.arctechnical.com
(408) 263-6486

03/26/10

Broadband over Power Lines (BPL)
Simplified Radiated Emissions Testing
(Access Overhead)
FCC Method (1m measurement height)

Access BPL Equipment Under Test: (EUT) Lake Edgewood Access Overhead Injector – Head End near Water District Office; Martinsville, IN

Applicable Standards:	
ANSI C63.4 (2003)	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
47CFR15 subpart G (2004)	Specified in FCC Report & Order 04-245 “Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems” released October 28, 2004
IEEE-P1775 / D2 (2006)	Draft Standard for Broadband Power line Communication Equipment – Electromagnetic Compatibility (EMC) Requirements – Testing and Measurements Methods (June, 2006)

EUT INFORMATION	
Type of Device being tested	Corinex Medium-Voltage Gateway FCC ID: QIUCXP-MVA-GWY
Serial Number	
Model Number(s)	Models 2210, 2220E, & 2330
Designation	DS2 gateways, regenerators & bridges, typical in this deployment
Modulation type	OFDM
Number of carriers	
Carrier spacing	1.1kHz
Upstream / Downstream Channels	
Lowest external frequency used	2MHz
Highest external frequency used	34MHz
Carrier On-Off capable?	
Power setting during tests	Operational
GPS location of device	N39° 26.9826´ W86° 26.7947´
Rep rate of data	
IBEC, Inc. claims:	*“All appropriate Amateur Radio and Public Safety Frequencies are Notched in Compliance with FCC Part 15 Requirements.”*

EMISSIONS LIMITS (United States)		
Test	**Frequency Range**	**Field Strength Limit**
Radiated Emissions	1.705 MHz – 30 MHz	**29.5 dBuV/m** @ 30 meters*
	30 MHz - 80 MHz	**39.1 dBuV/m** @ 10 meters*

***** Installations are measured at slant-range distances other than those listed. The dB value to subtract from the measured values in the United States are calculated using these formulas:
$40\log_{10} 30m/d_n$ for frequencies below 30MHz
$20\log_{10} 10m/d_n$ for frequencies above 30MHz

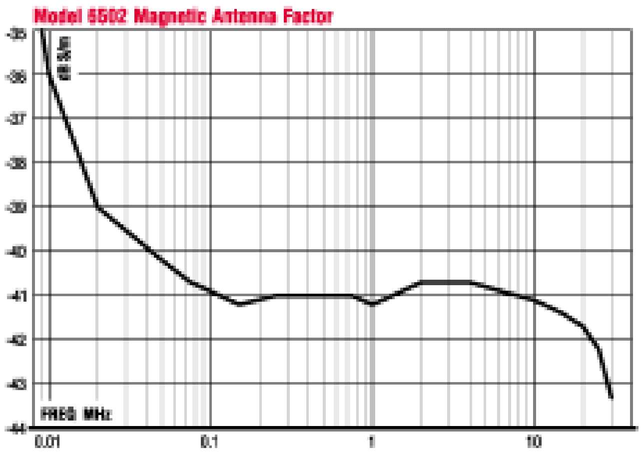
TEST EQUIPMENT				
Manufacturer	**Description**	**Model Number**	**Serial Number**	**Calibration**
Rohde & Schwarz	EMC Spectrum Analyzer	FSH3 opt. K1, K3, Z21, Z25		(yearly)
Yaesu	Portable receiver	FT-817		N/A
ICOM	Portable receiver			N/A
MFJ	HF whip antenna w/ tuner			N/A
	RG-58/U cable (25' spool)			N/A
ETS	Active loop antenna (internal preamplifier)	6502		(yearly)
ETS	Biconical antenna	3104C		(yearly)
	Non-metallic tripod		N/A	N/A
Stanley	Optical range-finder			N/A
Lufkin	Non-conductive tape measure	100'	N/A	N/A

Supporting Documentation:

Cable Loss Table
Transducer Name,25F
Description,25-foot RG-58
Unit,dB
1, 1000000, .1
2, 2000000, .1
3, 5000000, .2
4, 10000000, .4
5, 15000000, .4
6, 20000000, .5
7, 30000000, .5
8, 50000000, .65
9, 100000000, 1.1
10, 200000000, 1.6
11, 300000000, 2
12, 500000000, 2.6

Electric Antenna Factor for 6502:
```
Description,6502 and 3104C
#,(Hz),dBuV/m
1, 9000, 19.5
2, 10000, 18.7
3, 20000, 14.1
4, 50000, 11.2
5, 75000, 10.9
6, 100000, 11
7, 150000, 10.9
8, 250000, 10.9
9, 500000, 10.9
10, 750000, 10.9
11, 1000000, 11
12, 2000000, 10.8
13, 3000000, 10.5
14, 4000000, 10.4
15, 5000000, 10.4
16, 10000000, 9.8
17, 15000000, 9.4
```

```
18, 20000000, 8.9
19, 25000000, 8.1
20, 30000000, 6.8
```



Testing below 30MHz:

Set spectrum analyzer to PEAK detection, 9kHz IF bandwidth, 2MHz center frequency, 100kHz/div. Tune across band from 1.705 – 30MHz looking for BPL signals, demodulate and analyze signature to verify candidates. (Center frequencies of 2, 3, 4, 5, 6, etc. selected every 1MHz from 2-30MHz)

Distance Correction Table

$40\log_{10} 30\text{m}/d_n$ for frequencies below 30MHz

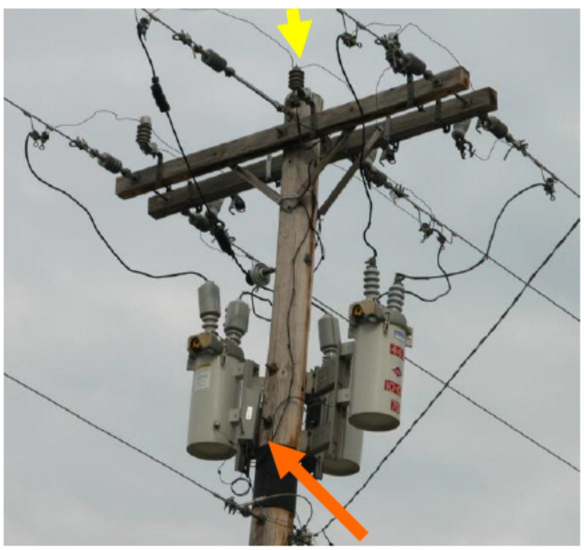
Slant-Distance to wires or transformer (Meters)	**English Equivalent distance (Feet & Inches)**	**Distance Extrapolation Factor (dB)**
3	9’ 10”	40 dB
5	16’ 5”	31.1 dB
10	32’ 10”	19.1 dB
11	36’ 1”	17.4 dB
12	39’ 4”	15.9 dB
13	42’ 8”	14.5 dB
14	**45’ 11”**	**13.2 dB**
15	49’ 3”	12.0 dB
16	52’ 6”	10.9 dB
17	55’ 9”	9.9 dB
18	59’ 1”	8.9 dB
19	62’ 4”	7.9 dB
20	65’ 7”	7.0 dB

Field Strength 1.705 MHz – 30 MHz @ 10 meters lateral distance						
Frequencies of six (6) highest readings: (**MHz**)	**3.24**	**3.91**	**5.20**	**9.80**	**29.34**	**29.96**
Receiver voltages (dBuV) (**QUASI-PEAK**)	39.0	42.8	40.2	47.0	39.2	41.0
Cable loss at the measurement frequency: (dB)	+0.2	+0.2	+0.2	+0.4	+0.5	+0.5
Antenna Factor @ measurement frequency: (dB)	-41.0	-41.1	-41.1	-41.7	-44.7	-44.7
E-Field conversion of magnetic loop readings (dB)	+51.5	+51.5	+51.5	+51.5	+51.5	+51.5
Slant range distance correction (40log 30/X) (dB)	-13.2	-13.2	-13.2	-13.2	-13.2	-13.2
(subtract distance correction) **Corrected E-Field Strength (dBuV/m @ 30m)**	**36.5**	**40.2**	**37.6**	**44.0**	**33.3**	**35.1**
FCC Limit Field Strength (dBuV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: PASS / FAIL	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

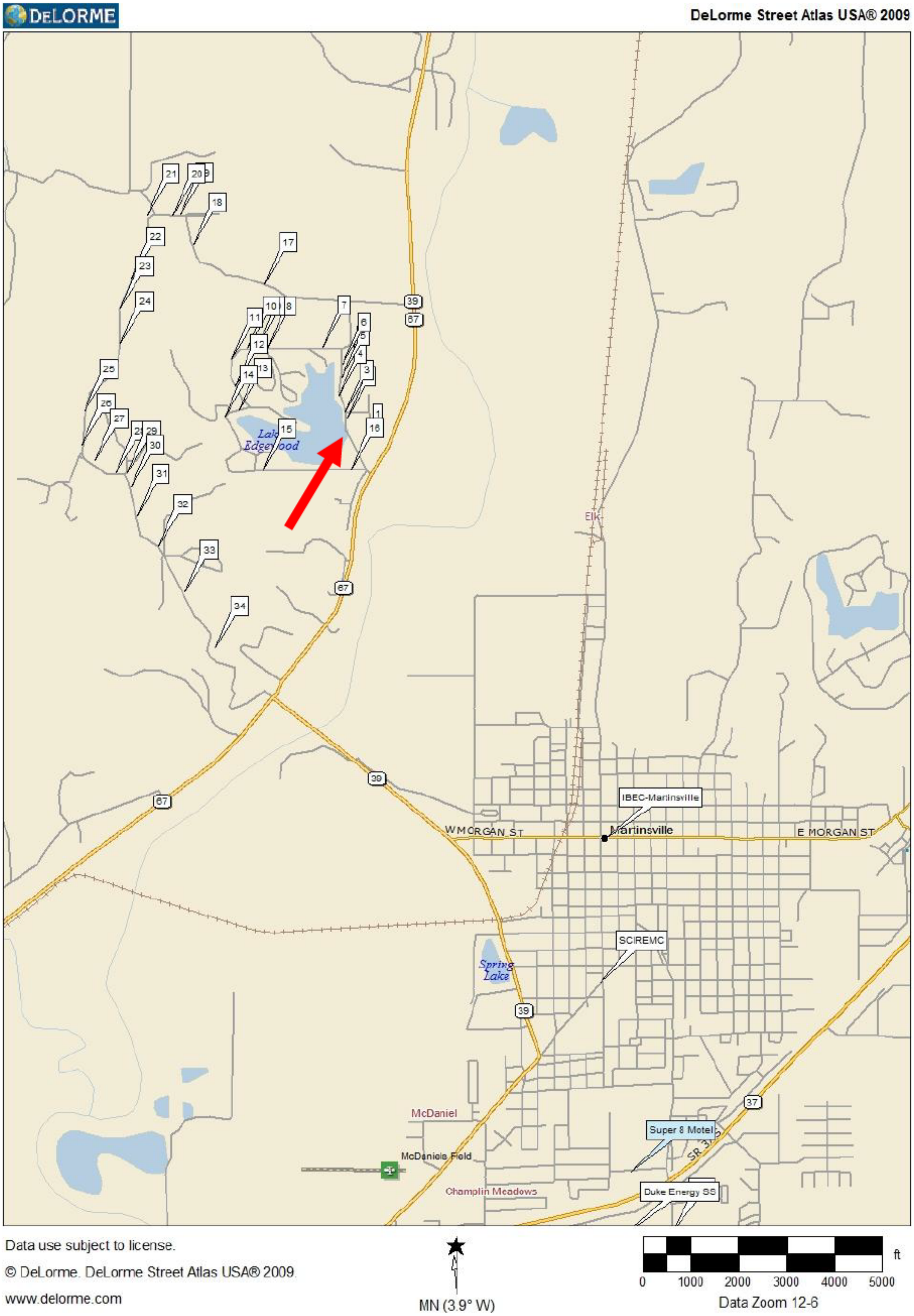
Field Strength 1.705 MHz – 30 MHz @ 27 meters lateral distance						
Frequencies of six (6) highest readings: (**MHz**)	**3.24**			**9.80**		**29.96**
Receiver voltages (dBuV) (**QUASI-PEAK**)	26.9			28.5		28.7
Cable loss at the measurement frequency: (dB)	+0.2			+0.4		+0.5
Antenna Factor @ measurement frequency: (dB)	-41.0			-41.7		-44.7
E-Field conversion of magnetic loop readings (dB)	+51.5			+51.5		+51.5
Slant range distance correction (40log 30/X) (dB)	-0.0			-0.0		-0.0
(subtract distance correction) **Corrected E-Field Strength (dBuV/m @ 30m)**	**37.6**			**38.7**		**36.0**
FCC Limit Field Strength (dBuV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: PASS / FAIL	**FAIL**			**FAIL**		**FAIL**

Orange arrow shows BPL gateway, yellow arrow shows capacitive coupler.

Blue arrow shows antenna position at 10m lateral distance, green arrow shows position for 27m distance.



GPS map of measurement location: (tag #1 at end of red arrow)



Assessment of BPL Operation in Excluded Frequency Bands

EXCLUDED FREQUENCY BAND	CONTENT
2,850 – 3,025 kHz	**BPL**
3,400 – 3,500 kHz	Power line gap noise
4,650 – 4,700 kHz	Power line gap noise
5,450 – 5,680 kHz	**BPL**
6,525 – 6,685 kHz	Power line gap noise
8,815 – 8,965 kHz	Power line gap noise
10,005 – 10,100 kHz	Power line gap noise
11,275 – 11,400 kHz	Power line gap noise
13,260 – 13,360 kHz	Power line gap noise
17,900 – 17,970 kHz	Power line gap noise
21,924 – 22,000 kHz	Power line gap noise
74.8 – 75.2 MHz	Not assessed

Field Strength in Exclusion Bands @ 10 meters lateral distance						
Frequencies of six (6) highest readings: (**MHz**)	**2.88**		**5.63**			
Receiver voltages (dBµV) (**QUASI-PEAK**)	35.1		26.2			
Cable loss at the measurement frequency: (dB)	+0.2		+0.2			
Antenna Factor @ measurement frequency: (dB)	-41.0		-41.1			
E-Field conversion of magnetic loop readings (dB)	+51.5		+51.5			
Slant range distance correction (40log 30/X) (dB)	-13.2		-13.2			
(subtract distance correction) **Corrected E-Field Strength (dBµV/m @ 30m)**	**32.6**		**23.6**			
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5		29.5	29.5	29.5	29.5
Test Results: PASS / FAIL	**FAIL 4dB notch**		**FAIL 14dB notch**			

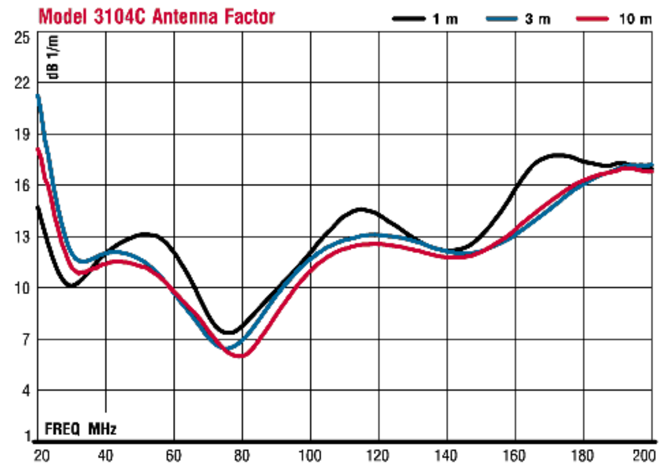
Assessment of BPL Operation in Amateur Bands

AMATEUR BAND	CONTENT
160 Meters (1.8-2.0 MHz)	S5 gap noise
80 Meters (3.5-4.0 MHz)	S5 gap noise
40 Meters (7.0-7.3 MHz)	S5 gap noise
30 Meters (10.1-10.15 MHz)	S5 gap noise
20 Meters (14.0-14.35 MHz)	S5 gap noise
17 Meters (18.068-18.168 MHz)	S5 gap noise
15 Meters (21.0-21.45 MHz)	**BPL**
12 Meters (24.89-24.99 MHz)	**BPL**
10 Meters (28-29.7 MHz)	**BPL**

Field Strength in Amateur Bands @ 10 meters lateral distance						
Frequencies of six (6) highest readings: (**MHz**)				**21.20**	**24.98**	**28.37**
Receiver voltages (dBµV) (**QUASI-PEAK**)				27.0	36.6	40.3
Cable loss at the measurement frequency: (dB)				+0.5	+0.5	+0.5
Antenna Factor @ measurement frequency: (dB)				-41.7	-44.7	-44.7
E-Field conversion of magnetic loop readings (dB)				+51.5	+51.5	+51.5
Slant range distance correction (40log 30/X) (dB)				-13.2	-13.2	-13.2
(subtract distance correction) **Corrected E-Field Strength (dBµV/m @ 30m)**				**24.1**	**30.7**	**34.4**
FCC Limit Field Strength (dBµV/m @ 30 meters)	29.5	29.5	29.5	29.5	29.5	29.5
Test Results: PASS / FAIL				**FAIL 9dB notch**	**FAIL <3dB notch**	**FAIL No notch**

Testing above 30MHz:

Set spectrum analyzer to PEAK detection, 120 kHz IF bandwidth, 35MHz center frequency, 1MHz/div. Tune across band from 30 – 80 MHz looking for BPL signals, demodulate and analyze signature to verify candidates. (Center frequencies of 35, 45, 55, 65, 75 MHz) Measure both vertically and horizontally, report worst case.



Electric Antenna Factor for 3104C @ 10 meters

```
21, 30000000, 11
22, 35000000, 11
23, 40000000, 11.4
24, 45000000, 11.4
25, 50000000, 11.1
26, 55000000, 10.5
27, 60000000, 9.7
28, 65000000, 8.6
29, 70000000, 7.5
30, 75000000, 6.4
31, 80000000, 6.1
32, 85000000, 6.9
33, 90000000, 8.3
34, 100000000, 9.6
35, 105000000, 10.9
36, 110000000, 11.7
37, 115000000, 12.3
38, 120000000, 12.6
39, 125000000, 12.7
40, 130000000, 12.6
41, 135000000, 12.5
42, 140000000, 12.2
43, 145000000, 12
44, 150000000, 12
45, 155000000, 12.1
46, 160000000, 12.5
47, 165000000, 13.2
48, 170000000, 13.9
49, 175000000, 14.6
50, 180000000, 15.4
51, 185000000, 16
52, 190000000, 16.5
53, 195000000, 17
54, 200000000, 16.9
55, 3000000000, 16.9
```

Distance Correction Table

$20\log_{10} 10m/d_n$ for frequencies above 30MHz

Slant-Distance to wires or transformer (Meters)	**English Equivalent (Feet & Inches)**	**Distance Extrapolation Factor (dB)**
3	9’ 10”	10.5 dB
5	16’ 5”	6 dB
10	32’ 10”	0 dB
11	36’ 1”	-0.8 dB
12	39’ 4”	-1.6 dB
13	42’ 8”	-2.3 dB
14	**45’ 11”**	**-2.9 dB**
15	49’ 3”	-3.5 dB
16	52’ 6”	-4.1 dB
17	55’ 9”	-4.6 dB
18	59’ 1”	-5.1 dB
19	62’ 4”	-5.6 dB
20	65’ 7”	-6 dB

Field Strength 30 MHz– 80 MHz @ 10 meters lateral distance						
Frequencies of six highest readings: (**MHz**)	**30.14**	**30.55**	**31.45**	**31.57**	**31.82**	**31.98**
Receiver voltages (dBuV) (**QUASI-PEAK**)	36.2	37.0	37.0	36.8	36.7	37.8
Cable loss at the measurement frequency: (dB)	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5
Antenna Factor @ measurement frequency: (dB)	+11.0	+11.0	+11.0	+11.0	+11.0	+11.0
Height conversion E-Field (+5 dB overhead only)	+5.0	+5.0	+5.0	+5.0	+5.0	+5.0
Slant range distance correction (20log 10/X) (dB)	+2.9	+2.9	+2.9	+2.9	+2.9	+2.9
(subtract distance correction) (subtracting a negative = adding a positive) **Corrected Worst Case Field (dBuV/m @ 10m)**	**55.6**	**56.4**	**56.4**	**56.2**	**56.1**	**57.2**
FCC Limit Field Strength (dBuV/m @ 10 meters)	39.1	39.1	39.1	39.1	39.1	39.1
Test Results: PASS / **FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**	**FAIL**

Cumulative Test Results:	**FAIL**
Name & Address of Testing Organization:	**ARC Technical Resources, Inc.** 2006 Lockwood Drive San Jose, CA 95132-1322 (408) 263-6486 jramie@arctechnical.com
Test Engineer’s Signature: Jerry Ramie	**Jerry Ramie** President NARTE-certified EMC Technician # EMC-002600-NT Certification Expires 11/30/11
Date:	**03/26/10**