Overview

Woomera Online undertook trials of Broadband over Power Line (BPL) in Moruya between October and December 2004. The ACA was invited to attend the trials to collect measurements of the electro-magnetic field strengths attributed to BPL signals injected onto the power lines. Woomera Online in partnership with Country Energy, Optus, ByteCan, InovaTech and Imagine Telecommunications plans to provide a permanent internet access facility in the area.

The ACA ran two sets of tests: the first prior to Woomera's system management software being installed displayed high levels of emissions within the area of the BPL deployment; the second after management software had been implemented enabling 'notching' and control of injection power levels.

PLC Equipment

The InovaTech[i] system utilises the DS2 9011[ii] third generation chipset which uses OFDM[iii] technology and is capable of providing a data speed of 45Mbps (using less than 10 MHz of spectrum per segment) over the low voltage mains network. At the head hnd an outdoor, pole mounted *MultiCAT* connected the WAN to the LV network, *PurCAT*s repeaters were used to avoid PBXs, and *IPCAT*s connect the customer premises equipment (CPE).

The system separates frequencies into 4 Links as shown in appendix D. The Woomera BPL system utilised Link 4 for communications between the Head End and Repeaters, and Link 2 for communications between the Repeaters and the CPE.

Trial Details

The trial site was Moruya Industrial Estate, 3Km north of the south coast NSW township; (see map on page 4).

The BPL carrier was injected into the Low Voltage (LV) network between phases from the head end modem to the repeater, and between phase and neutral from the repeater to the CPEs. Capacitive coupling units were used to couple to the LV conductors at the head end and repeater at test site 6. Inductive couplers were used at the repeater used at subscriber Staples Waste Removals.

The ACA supplied Woomera with a list of frequencies that were to be 'notched' out to reduce the possibility of interference to maritime and other emergency services. The most notable change to the system was the implementation and installation of Jeizer BPL management software. The Jeizer Network Management[iv] tool has been specifically optimised for DS2 products so that the service provider can be able to configure the network devices, maintain the network, control and manage the quality of service, monitor line quality, adjust power levels, notch[v] out carriers for interference management etc.

For the duration of the testing a system 'power mask' was set for various channels within link 4. This power mask comprised of notching on various Aeronautical and Maritime frequencies.

The LV network predominantly consisted of bundled conductors. One span of conventional open wire conductors was used between the head end unit and Staples Waste Removals where a repeater was used to couple around their switch board. A second repeater was mounted on a transformer pole closer to the Woomera Kiosk (refer area layout diagram).

Two subscribers including the Woomera Kiosk were connected to the BPL system during the first two days of testing with access to the internet, VoIP and video movies. A third subscriber was connected on the 29 October. Access to the Internet and VoIP was supplied by Optus V-Sat while video movies were stored on an 'Apple Mac' computer co-located with the V-Sat terminal, both of which were connected to the head end modem by Cat 5E UTP.

Measurements

The location of the trial site made measurements relatively easy. Seven locations were chosen as outlined in Appendix a for the first series of measurements. Due to adverse weather only four of these were used for the second series.

The measurements were taken using a Rohde & Schwarz Model ESPC 150 kHz to 1000 MHz Field Strength Meter with a Rohde & Schwarz Model HFH2 – Z2 9 kHz to 30 MHz H-Field Magnetic Loop Antenna. The measurement process was carried out using Rohde & Schwarz ESPC-K1 Version 2.20 EMC measurement software, the ESPC Field Strength Meter is GPIB controllable, and a National Instruments USB – B to GPIB Converter was used to control it via a laptop computer. Both laptop and measuring receiver were powered by battery only.

The measurement convention used for taking measurements in the x, y, and z planes was:

- X Plane – Loop antenna was vertically polarized and parallel to the line
- Y Plane – Loop antenna was vertically polarized and perpendicular to the line
- Z Plane – Loop antenna was horizontally polarized (rotated 90° from Y Plane)
- S Plane – The 3 planes above were computer generated using the formula $\sqrt{(x^2 + y^2 + z^2)}$ and presenting the final plot.

The R&S HFH2-Z2 H-Field Loop antenna used to perform these measurements is an active antenna with a frequency compensated response across the range 9kHz to 30 MHz, as such it has a constant antenna factor of k=20 (giving a flat frequency response). The measurement result is automatically compensated by 20 dB on the R&S ESPC field strength meter and the units are displayed as dBµA/m.

To convert to electric field voltage dBµV/m, 51.5 dB can be added to the electric field current dBµA/m.

Summary of Results

Appendix C detail site location and parameters

Test Results October 2004

Table 1

Test Site	Horizontal distance from cable (m)	Diagonal Distance from cable (m)	Max Signal S Plane (dBuA/M)
1	0	6.5	29
2	15	16.4	28
3	3	7.2	23
4	15	16.4	12
5	30	30.7	8
6	3	7.2	29
7	10	12	15
8	100	100	11
9	3	3	11
10	10	10	20

Table 1: Summary of maximum levels encountered at each test site location. Note: The measurements quoted are not related to the same frequency points, a maximum was picked from each plot.

Notes: To convert electric field voltage dBμV/m, 51.5 dB can be added the to electric field current dBμA/m ie. dBμV/m = dBμA/m + 51.5

Where the constant 51.5 is a conversion of the characteristic impedance of free space (120π or 377Ω) into decibels: 20 log(120π) = 51.5

The 240 volts ac power cable height was typically 8 meters above ground level.

The loop antenna measurement height (centre of loop) was 1.5 meters above ground level.

Test Results December 2004

Table 2

High Power Setting (15)

Test Site	Horizontal distance from cable (m)	Diagonal Distance from cable (m)	Max Signal S Plane (dBuA/M)
3	3	7.2	29
4	15	16.4	5
7	10	12	15

Table 3

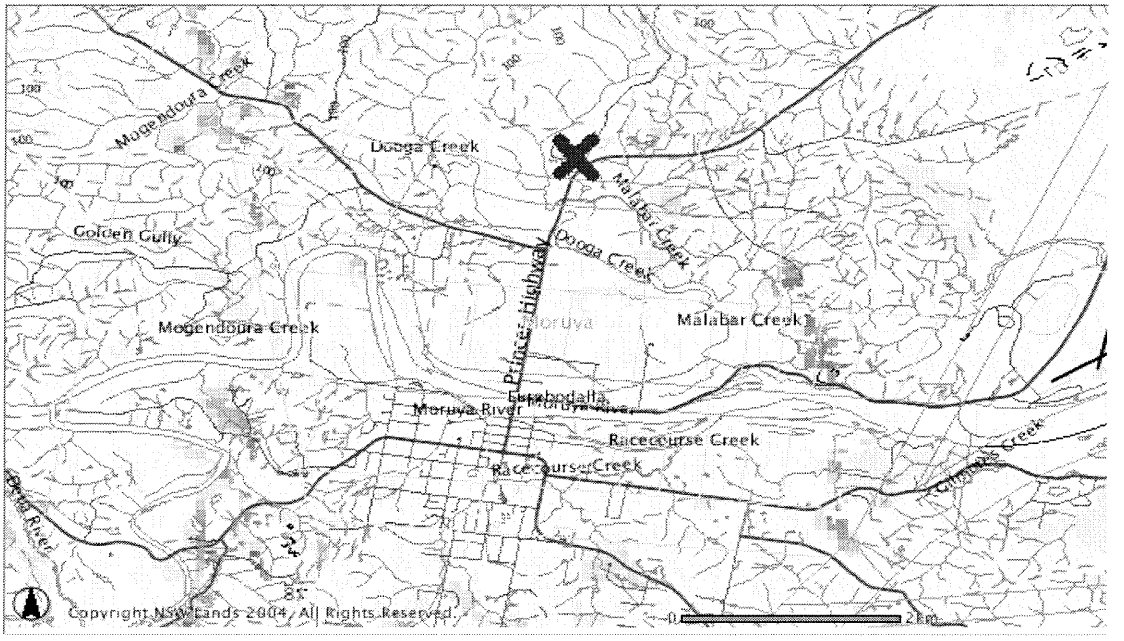
Low Power Setting (2)

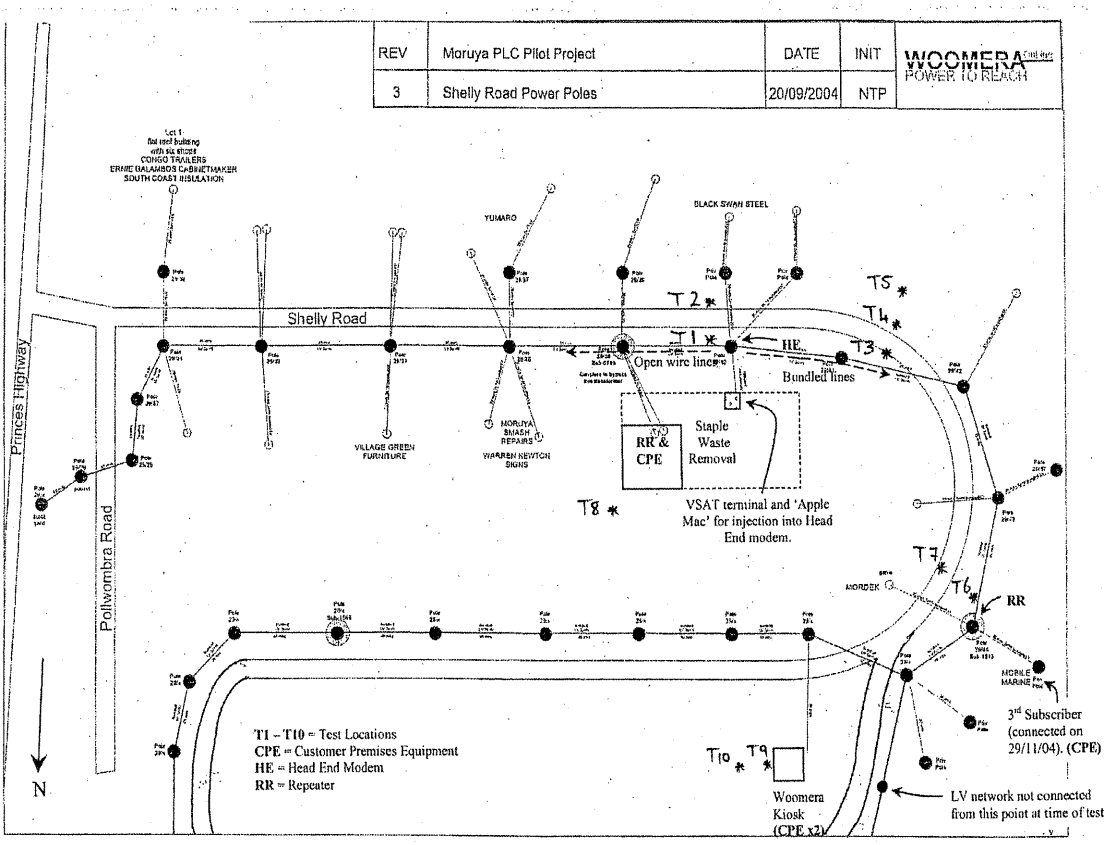
Test Site	Horizontal distance from cable (m)	Diagonal Distance from cable (m)	Max Signal S Plane (dBuA/M)
3	3	7.2	- 3
4	15	16.4	- 7
7	10	12	10

***Table 2 & 3**: Summary of maximum levels encountered at each test site location. Note: The measurements quoted are not related to the same frequency points, a maximum was picked from each plot.*

Appendix A - Moruya Business Park

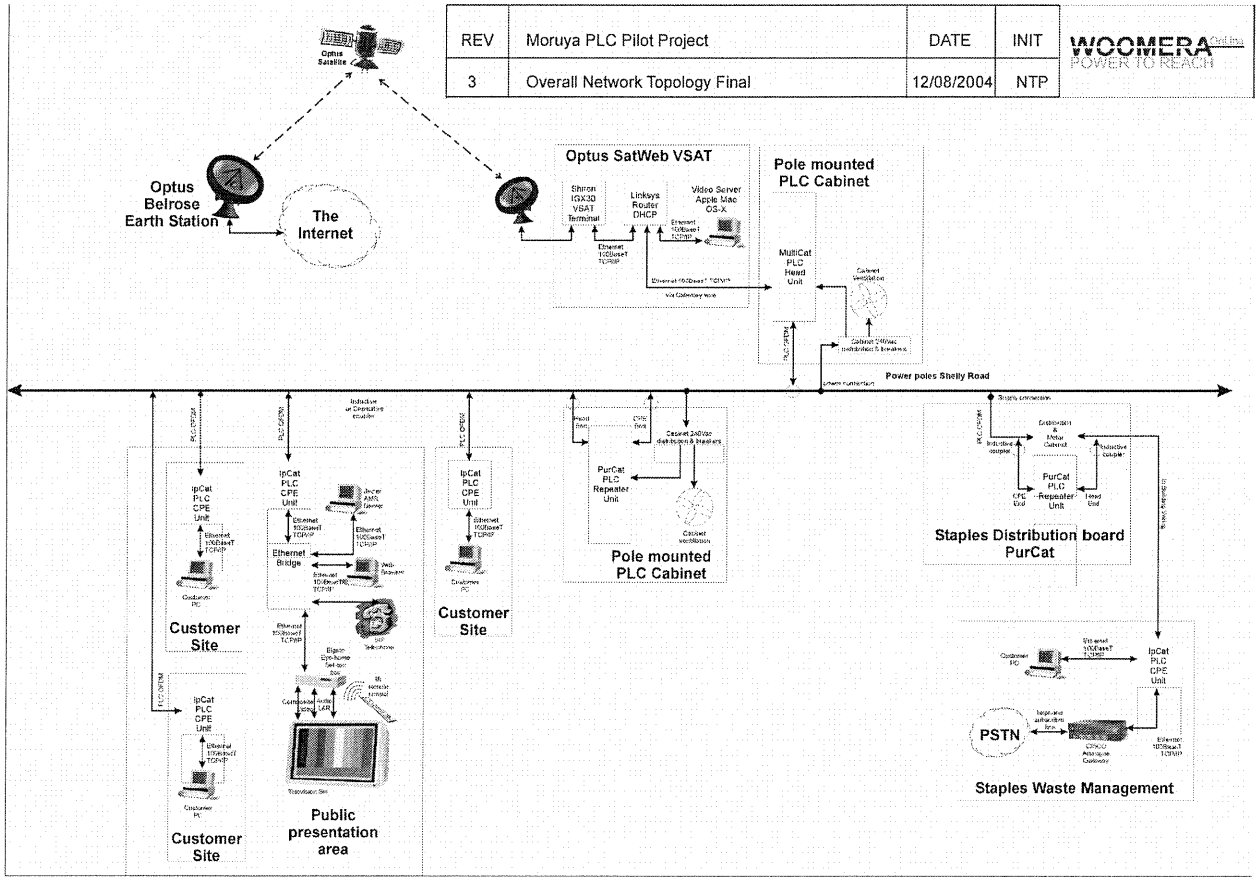
Source: © DEPARTMENT OF LANDS
PANORAMA AVENUE BATHURST 2795
www.lands.nsw.gov.au





Map of Test Site locations at Moruya Industrial Park.

Appendix B - System Diagram



Courtesy Woomera Online

Appendix C - Test Location Descriptions

Site No.	*Antenna position relative to power lines and PLC system components*	*Power line/pole characteristics*	*Included in second test*
1	0m horizontal dist. from lines; ~7m from nearest pole which supported Head End modem.	Mix of open and bundled conductors extending in opposite directions; 2x 3 Ø premises feeds, 1x single Ø premises feed branching from pole.	No
2	15m horizontal dist. form lines.	As for test site 1	No
3	3m horizontal dist. from lines.	Bundled conductors, approx. middle of span.	Yes
4	15m horizontal dist. from lines.	As for test site 3.	Yes
5	30m horizontal dist. from lines.	As for test site 3.	Yes
6	3m horizontal dist. from lines; ~5m from pole.	Bundled conductors; MV – LV transformer on pole; Repeater mounted on pole. 2x 3 Ø premises feed branching from pole.	No
7	10m horizontal dist. from lines.	As for test site 6.	Yes
8	~100m horizontal dist. form lines directly connected to Head End.	Test set up in vacant lot behind Staples Waste Removals.	No
9	3m from Woomera Kiosk	Closest line was premises feed for Kiosk; ~30m from main LV line.	No
10	10m from Woomera Kiosk	As for test site 9.	No

Appendix D

Links		Frequency Range Used (MHz)		
L1	Upstream	2.460	to	4.960
	Downstream	7.925	to	11.725
L2	Upstream	13.800	to	16.300
	Downstream	19.000	to	22.800
L3	Upstream	26.700	to	29.200
	Downstream	34.200	to	38.000
L4	Upstream	8.575	to	11.075
	Downstream	2.460	to	6.260

Appendix F – Test Plots Sites Test Site 3

High Power (15)

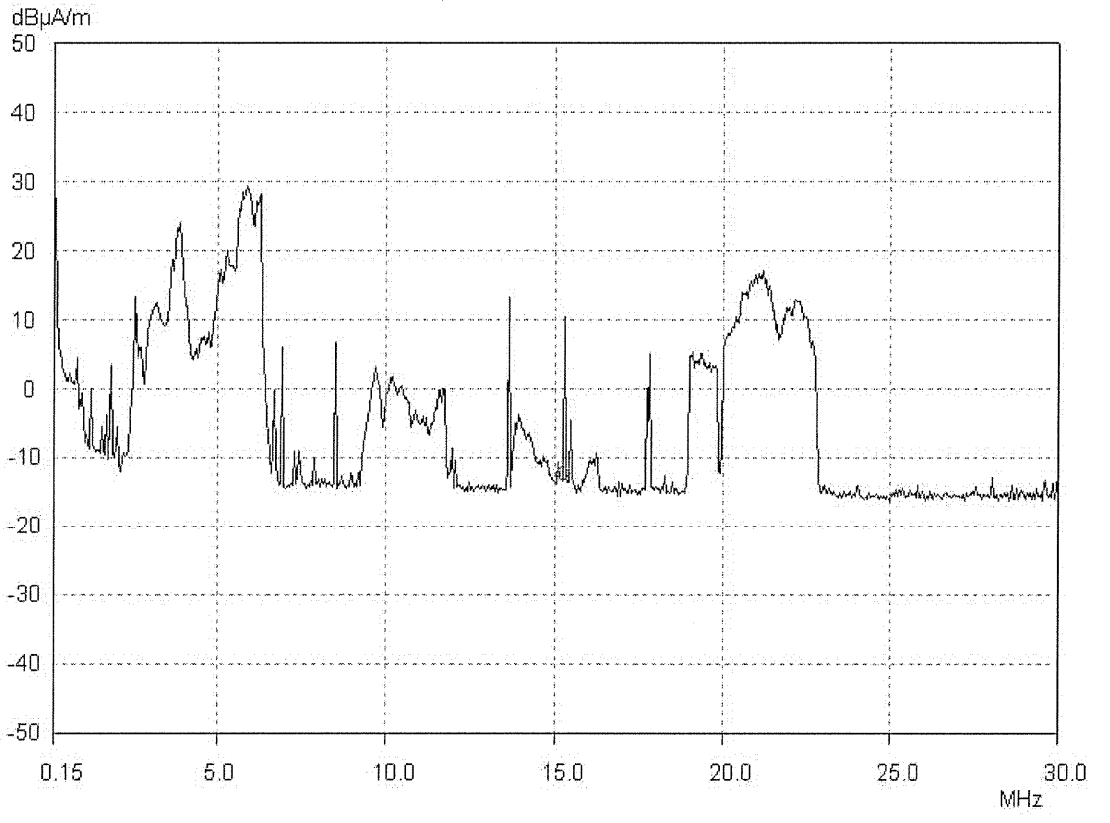
Test Site 3

3 meters horizontal

Bundled conductors

"S" Plane

Receiver settings: IF BW = 10kHz Detector = PK M-Time = 50 msec Atten = Auto OpRge = 60db



Low Power (2)

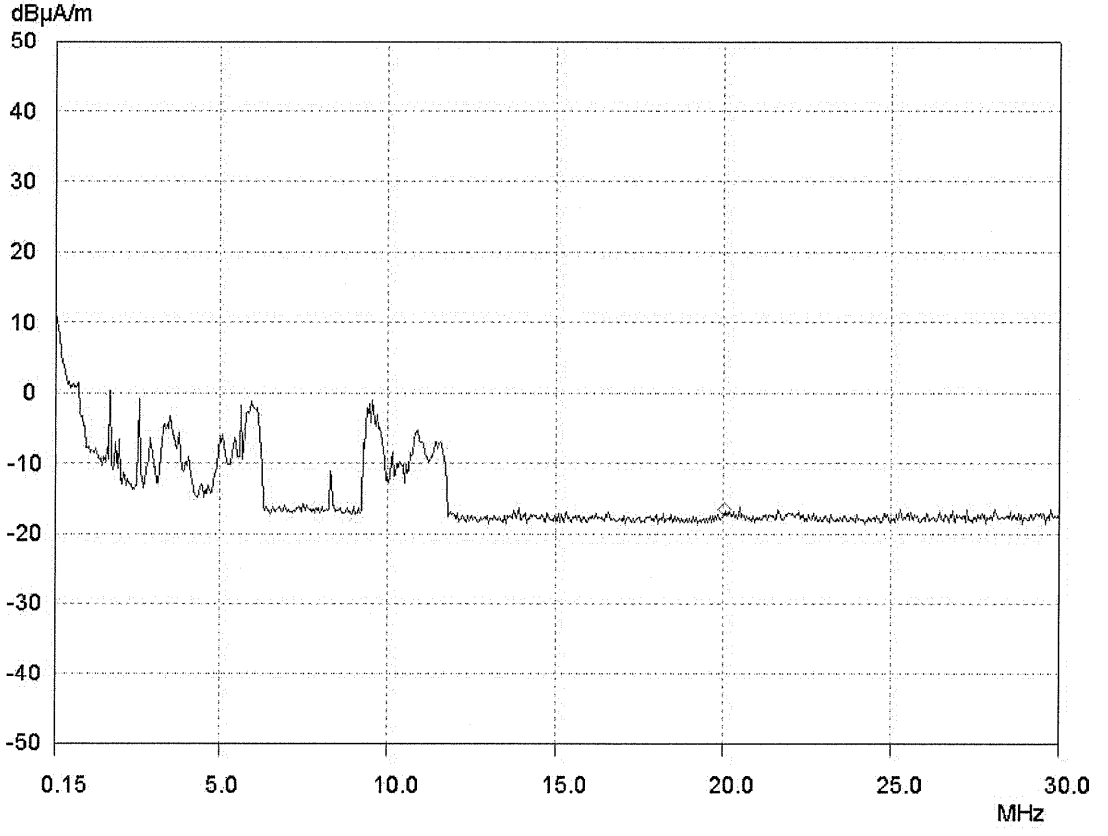
Test Site 3

3 meters horizontal

Bundled conductors

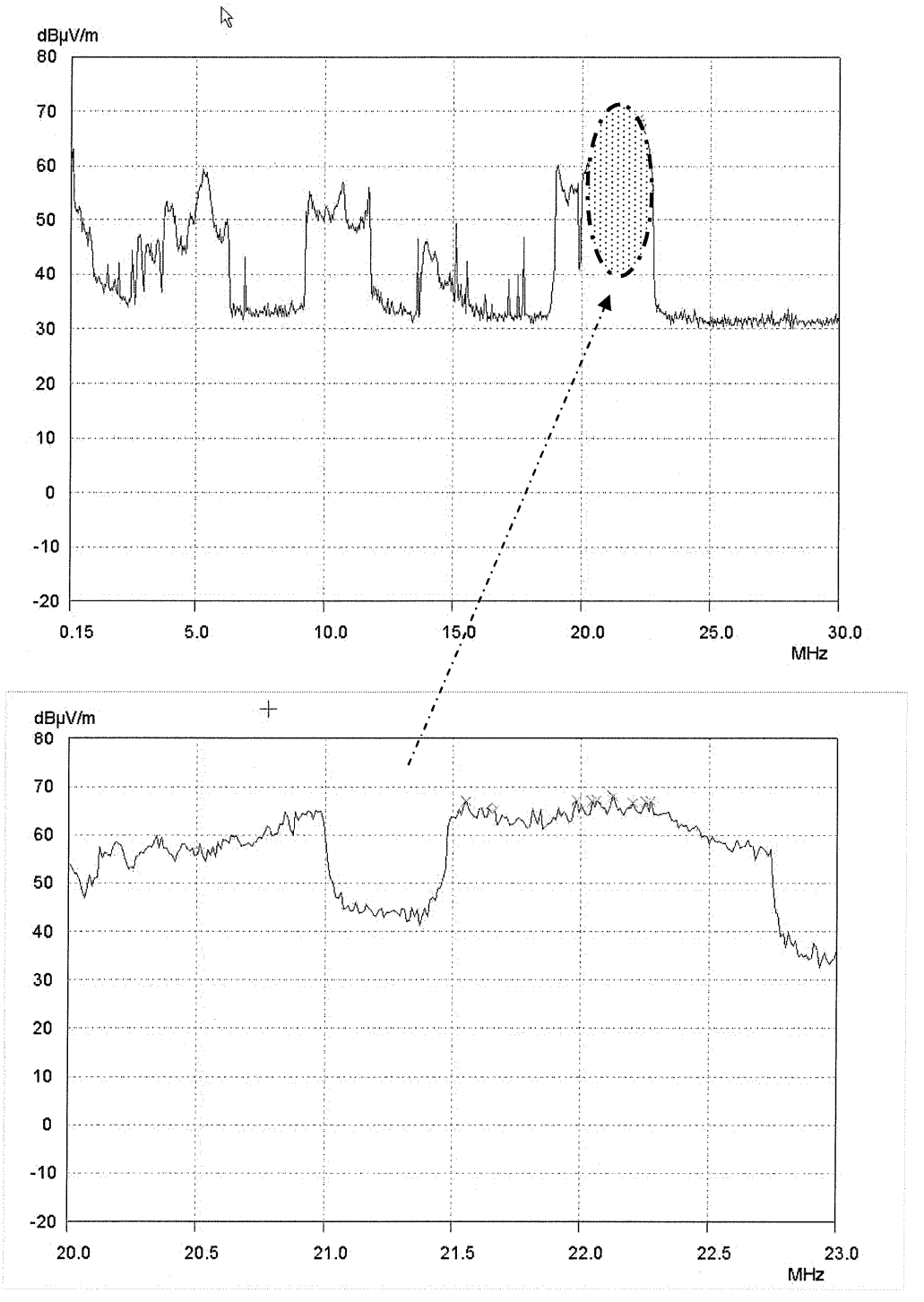
"S" Plane

Receiver settings: IF BW = 10kHz Detector = PK M-Time = 50 msec Atten = Auto OpRge = 60db



Appendix F – Test Readings

Field Strength example with notching



"Notch" employed in the L2 Downstream band

Endnotes

[i] An Australian company specialising in the design of BPL equipment see www.inovatech.com.hk

[ii] DS2 – Design of Systems on Silicon: a Spanish company specialising in chip design for the BPL industry, see www.ds2.es. The DSS9011 is a low-cost solution designed for BPL audio networks..

[iii] OFDM - Orthogonal Frequency Division Multiplexing: a spread spectrum technique which distributes the data over a large number of carriers that are spaced apart at precise frequencies.

[iv] JEIZER is a Spanish company. Their Jeizer BPL product is dedicated to the monitoring and management of the different elements and services that integrate a whole BPL Network. It provides a different level views and control of the states, events and relationships of the elements deployed over a BPL network topology. See www.jeizer.com.

[v] Notching – a technique of filtering transmission so as to not use specified frequencies.