PALAS – Powerline as an Alternative Local AccesS
IST-1999-11379

D2: PLC Technology Inventory and Development Roadmap

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Authors: HINES, David (Electricom Ltd.)
DICKINSON, John (Electricom Ltd.)
NICHOLSON, Peter (Electricom Ltd.)
LEHNERT, Ralf (Dresden Technical University)
HRASNICA, Halid (Dresden Technical University)
HAIDINE, Abdelfatteh (Dresden Technical University)
STANTCHEVA, Mariana (Dresden Technical University)
LANGHOF, Marco (RegioCom GmbH)
LEICHT, Uwe (Teleport Sachsen-Anhalt GmbH)

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1 Introduction

1.1 Objective and goal of the document

1.1.1 Primary audience: Utilities and Telecom Operators

The main intention of this document is to give an overview of
- technical issues which have to be addressed by PLC solutions,
- utility and user driven requirements to potential solutions,
- existing technical approaches and
- relevance and implication of approaches chosen.

A basic understanding of technical terms and dependencies shall be given with the aim to understanding the advantages and the trade-offs of solutions provided by technology providers. It shall be pointed out, which technical questions have to be addressed by a complete technical solution that fits into a utility's operating environment. That way, utilities get a guideline to evaluate at least the completeness of a technical PLC solution, which is a pre-requisite for a solid business decision and business plan. In addition utilities and potential Powerline Telecom Operators are able to judge on the technical ability of an approach or of a system to support certain types of services and service performance parameters.

1.1.2 Secondary audience: Technology developers

By giving an overview about technical issues to be addressed, technology providers can use this document in order to look at the completeness of their system. They may use this document as a neutral basis for discussion with utilities and as a kind of co-ordinate system for the presentation of their system. It also helps to identify technological gaps, such as coupling, fusing and conditioning in order to start a technical development of appropriate technical solutions. This is particularly important since a substantial part of the technology providers concentrate on modem technology only. Therefore it is important to foster an early discussion about complete technical solutions and systems.

1.2 How to use this document

This document represents an overview of known problems and possible solutions. On the other hand, this document addresses some fundamental areas and issues as well as a set of well understood approaches to overcome known problems.

This document cannot be used to judge existing technical approaches and real solutions. The dynamic nature of the market and the confidential status of the majority of information in the market makes it difficult to acquire and to utilise information on existing and upcoming solutions. However, this document may give a basic qualification that enables the audience to look at technical features of existing solutions and to formulate the requirements of potential operators.

Of course there cannot be any hard-coded procedure to give an absolute answer on the appropriateness of a given solution. This answer always depends on technical, regulatory and market circumstances. On the other hand these parameters have to be known in order to 'solve the equation' and to look at the result for a certain operator.

Utilities and potential Powerline Telecom Operators:
should use this document to formulate their operational requirements both regarding the electro-mechanical perspective and taking into account the operational telecommunication circumstances.

They should evaluate
- the completeness of a solution as well as
- the need for additional components, work-around solutions etc.
- the suitability of a system to support the required services in terms of quality, performance, interfaces etc.
- the implication of a given system on total cost of ownership such as installation, maintenance, service administration and replacement

As technical progress goes on, new solutions and new technology providers will appear in the market. It will be easy to evaluate their unique selling propositions by simply mapping their new approaches against the set of areas addressed in this document.

PLC Technology Providers
should sharpen the profile of their system and adjust the position of their system as regards
- the target application,
- the standard environment (DIN, TAB etc.) they target at,
- strengths and weakness of their system

In addition to that the authors hope that – as a result of a discussion amongst utilities and technology providers – new and complete solutions will be developed and brought into the market more quickly.

2 Communication on 50 Hz Electrical Networks: Overview on PLC technology classes

2.1 Motivation

At present, there is strong development in the PLC Market. Beside the fact, that nearly every day new trials are announced, there are a growing number of new players in the community of technology providers. On the other hand there is confusion about basic terms and about the real content of trials. That is the case due to the use of the item PLC for a number of applications which can be better summarised as '(digital) communication using 50Hz electrical networks'.

Classification takes part regarding

Voltage level of the network

Due to different physical behaviour and due to different operational circumstances of these types of networks it makes sense to differentiate between them by defining the areas of PLC as: Low-voltage, medium voltage and high voltage.

Ownership of the network

Particularly in the low voltage network, but partly also in the medium voltage network parts of the electrical grid are not owned the utilities. That technically makes no difference, it does however require different procedures and concept on the operational level.

In-house and access network

Although these parts of the network are connected and influence each other it is very useful to distinguish between them due to different physical behaviour. In many cases the In-house networks are not under the ownership of the utilities.

Low bit rate (also CENELEC compliant) and high bit rate PLC

Independent from ownership and voltage level the frequencies used for the transmission of signals differentiate both the regulatory circumstances as well as the maximum transmission performance of PLC systems.

Since this classification does not follow an 'orthogonal' approach – this means that you can combine different parameters to classify a system – it is very important to ask for all aspects of classification in order to understand the abilities and the target of a given PLC system. In this chapter the implications of the different parameters will be described in order to sensitise utilities for aspects to take into account when thinking about getting a certain PLC system into operation.

2.2 Low voltage and medium voltage

A clear classification can be given to differentiate the different voltage layers.

Low voltage

generally means the voltage level that is actually delivered to the customer.

Medium voltage

Generally used for voltage levels between 6.6 and 30 kV. The medium voltage lines feed the low voltage transformer stations. The respective topology changes with the geographical location.

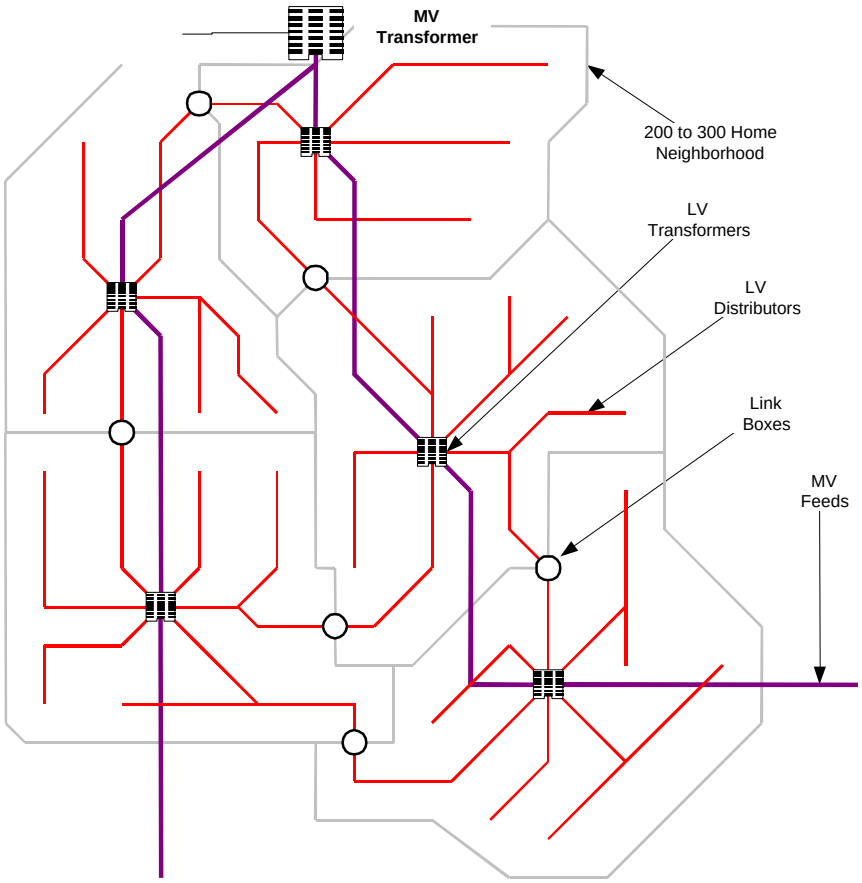

Figure 1: Typical German medium/low voltage network topology

Implications

Due to the fact that low voltage PLC takes place directly on the network where most of the electrical appliances are operated, the noise and distortion level on those networks can be high. Also, connected houses and street lights can be considered as transmitting and receiving antennas. Another important issue is, that the physical behaviour of the network changes with every load that is switched on or off, this is why low voltage PLC has to provide solutions for a number of physical problems.

Comparing the physical behaviour of low voltage and medium voltage networks, it turns out that medium voltage networks are easier to handle for PLC in terms of noise/distortion, radiation and impedance variations.

To understand the implication of physical network behaviour it is necessary to refer to the section ‘Physics’.

2.3 Low bit rate and high bit rate

Low bit rate PLC

The first upcoming PLC solutions were dedicated to the Power automation area. In this area only low bit rates were required. For that reason and for regulatory reasons it was decided to define a frequency range which can be used for power automation and home automation demands. That covers the range from 3 to 148,5 kHz as described in the figure below.

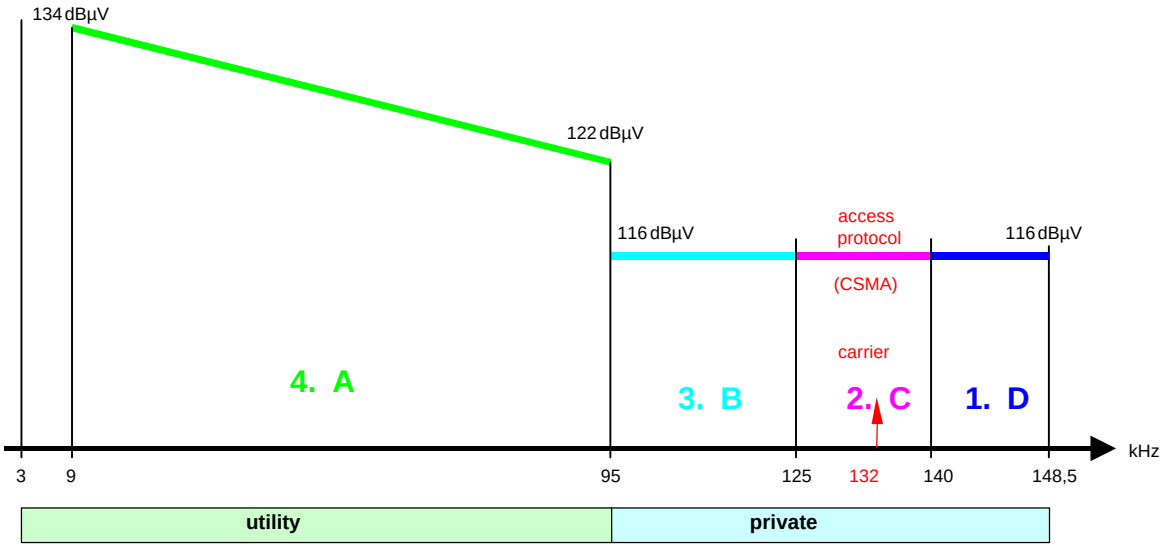

Figure 2:Use of CENELEC Frequencies (Source VDEW)

High bit rate PLC

Since the frequency range regulated by CENELEC will only allow transmission at comparatively low bit rates, a technological move towards higher frequencies took place. A number of technical issues needed to be addressed as a consequence.
One fundamental problem of this frequency range is, that a high frequency signal placed on a wire tends to leave the conductor – to radiate. This effect is higher in the MHz range than in the CENELEC bands.
The MHz range conflicts with a number of frequencies used for different services such as security and air traffic control. That is why it needs to be subject to regulation.

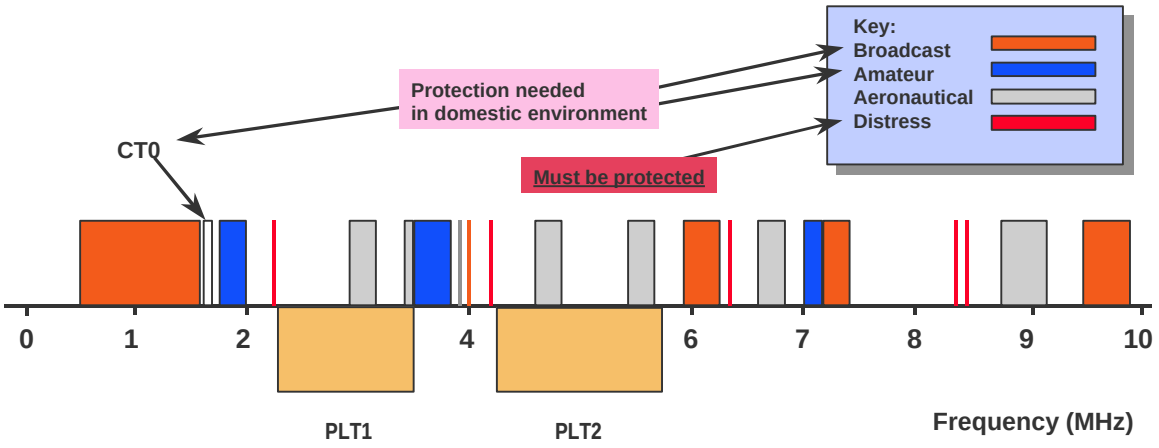

Figure 3: Key Spectrum Usage 0-10 MHz for ITU Region 1 (Source: NOR.WEB)

2.4 In-house and 'Last mile' PLC

In-house PLC

Since the item 'access' is not clearly defined, it simply makes sense to decide, whether or not the PLC system exclusively operates within a building. If this is the case, then the PLC system can be called an In-house system. In-house systems are using the in-house electrical cabling to carry the signals between the different PLC devices.

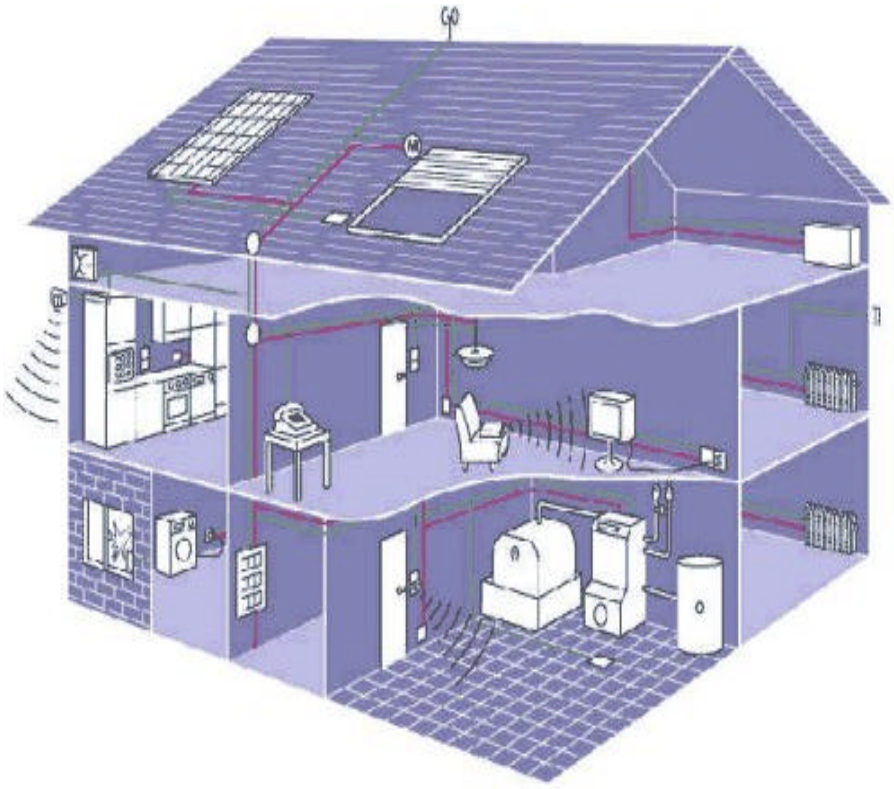

Figure 4: In-house PLC (Source: SIEMENS)

Last Mile PLC

LMPLC connects a backbone connection point where the telephony and data traffic is fed in, with a connection point at the respective customer's electrical feeding point. In many cases the low voltage transformer station will be used as the backbone connection point and the low voltage distribution network will be used as the connection to the customer's building. Backbone connection points can also be organised at the medium voltage transformer or at other appropriate points.

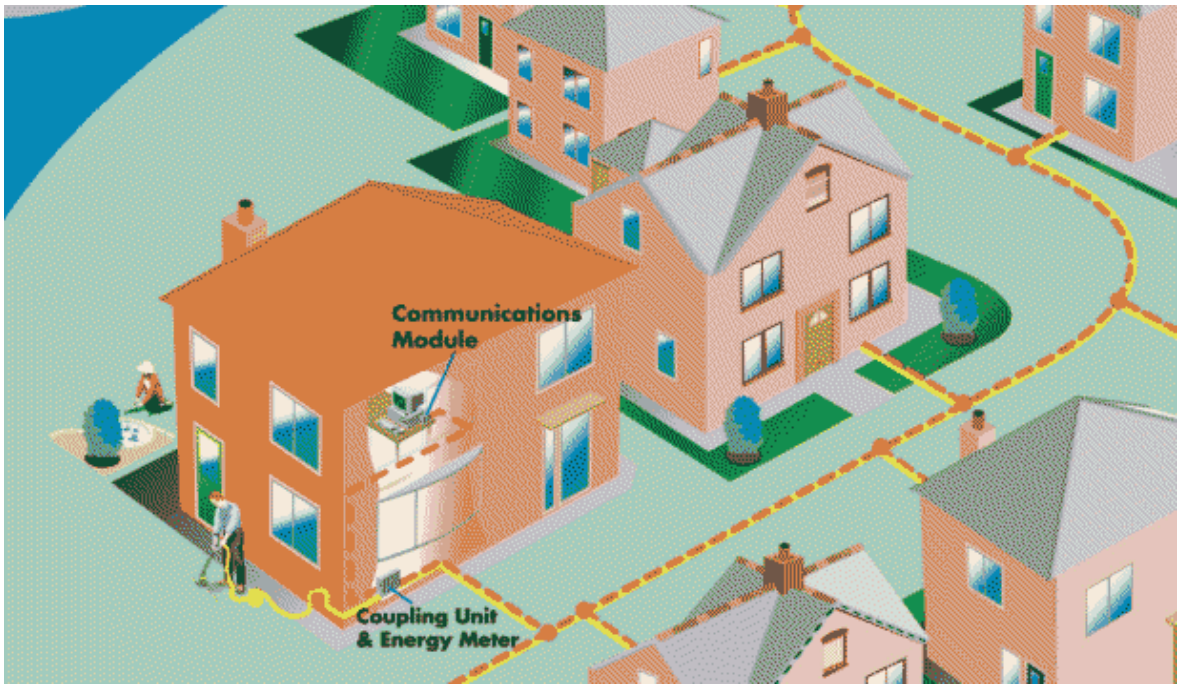

Figure 5: Last Mile PLC (Source: NOR.WEB)

Implications

An in-house PLC system can be operated as a private network without any additional outdoor connectio. In-house PLC systems are in many cases operated on networks not owned by the utilities, but owned by the customer. However they may influence a 'last mile' PLC solution operated by the utility. A number of technology providers offer integrated 'last mile' – in-house solutions.
Last mile PLC is often equated with low voltage PLC. Depending on the business and operational concept that may be feasible. However, including e.g. medium voltage PLC it is possible to concentrate more customers onto one backbone connection point.

2.5 Inventory of technology providers

As an orientation, an overview of PLC technology providers is given in Annex 2. In addition to that, Annex I includes a series of interviews carried out with technology providers in spring 2000.
Please take into account, that this information represents a snap-shot and may change very quickly.

2.6 Guideline for identifying a suitable system and related considerations

Item	Option	System indication	Further considerations
Services	Internet and Telephony to the customer's home (gateway)	- High bit rate - Last mile	- Regulation on a European level is still not finalised - Connection to customers computer / telephone has to be solved
	Internet and Telephony to industrial customer	- High bit rate - Last mile	- Regulation on a European level is still not finalised - Requires, that customer has a LV transformer station at his premises - Commercial system available (e.g. ALCATEL)
	Power automation	- low bit rate (+) - medium voltage	- commercial systems available - for high bit rate, regulation on a European level is still not finalised
	Remote meter reading	- low bit rate (+) - Last mile	- Commercial systems available - for high bit rate, regulation on a European level is still not finalised
	Demand side management	- Last mile - In-house - Low bit rate (+)	- Ownership of the electrical network - for high bit rate, regulation on a European level is still not finalised
Commercial status	Operational business	- Low bit rate (all voltage levels)	- Systems available e.g. SIEMENS, ABB
	Trial operation	- High bit rate - all voltage levels - last mile and in-house	- Trials can be carried out with systems commercially available - for high bit rate, regulation on a European level is still not finalised - test licence often required

2.7 Usage scenarios for systems offered

System feature	Potential usage	Examples
Medium voltage / low bit rate (+)	Power automation	ABB, SIEMENS
Last mile / low bit rate (+)	Meter reading	ABB, SIEMENS
In-house / low bit rate (+)	Home automation / demand side management In-house computer networks (low bandwidth)	SIEMENS Polytrax,
Medium voltage / High bit rate	Telephony / Internet B2B	ALCATEL
Last mile / high bit rate	Telephony / Internet (private customers)	ONELINE, ASCOM
In-House / high bit rate	In-house computer networks (low bandwidth) Connection of Last mile gateway to customer premises	ENIKIA, INTELLON ONELINE

2.8 Scope of PALAS

PALAS as a project concentrating on the Last mile aspect as an alternative local access technology. That approach requires to exclude all kind of low bit rate solutions. In all other terms the focus of PALAS is not restricted.

3 Physics

3.1 Motivation

It is not the intention of this chapter to present an in-depth description of issues to be addressed on the physical layer. However it is important to understand the physical nature of the electrical network in order to understand certain technical approaches. Based on technical approaches chosen implications on potential performance and limitation of a PLC system can be identified. Those are finally very important in order to design proper expectation on economical potential of PLC operational schemes.

3.2 Issues to be addressed on the physical layer

In order to understand the need for complex technical solutions it is useful to ask why PLC requires special and normally expensive approaches. As well an understanding of reliability of approaches shall be given that helps to understand the choice of major PLC technology providers.
The signal transmitted through a electrical network is caused by a number of independent reasons which are described below briefly.

3.2.1 Noise / Signal-Noise-Ratio

Each electrical network receives electrical signals radiated by appliances on the network itself and emitted by other sources. That is why every electrical network can be characterised by a certain so called noise level. It depends on a number of circumstances such as natural and artificial sources of electromagnetic radiation as well as on the physical structure and parameters of the network.
Like in an acoustical conversation between two persons in the real life, the noise level influences the acoustical level of understanding. To acoustically overcome a certain distance between two peoples in a given noisy environment, the ‘sender’ must speak with a certain loudness – this can be compared with the signal level. The minimum loudness the speaker can choose in order to be understood, needs to be a little louder than the noise at the receiver side. This minimum distance between transmitted signal and the so called noise floor is called signal-noise-ratio.

Implications

If we – in one of the following chapters – look into different modem technology and schemes the parameter ‘signal-noise-ratio’ becomes very important. For a given distance and a given noise floor it finally indicates the signal level to be fed onto the network in order to achieve comparable bandwidth and quality. In the figure below an example of signal-noise-ratio is shown.

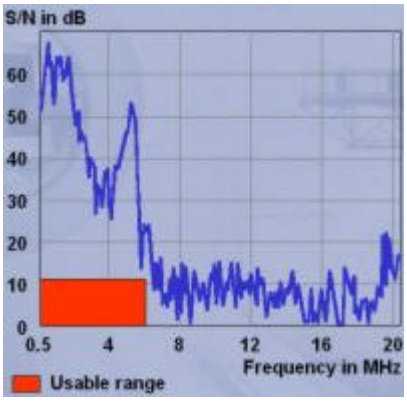

Figure 6: Example of a signal-noise-ratio measurement (Source: SIEMENS)

3.2.2 Distortion

Another problem that has to be managed on the power network is distortion. Without going too deep into any academic discussion it can be summarised that distortion can be caused by natural and artificial sources. Distortions can appear for timeframes of milliseconds up to several minutes. Typical distortions are caused by electrical appliances such as drilling machines, microwave ovens and blenders, but also by street lights and lamps switched on and off.

Implications

The influence of distortions on services delivered via PLC depends on the nature of distortion, the ability of the respective PLC system to handle distortions and finally on the quality parameters required for a certain service. As regards typical www internet traffic a distortion of one second may not even be detected by the user whereas the same distortion in a telephone call is a clear lack of quality.
Regarding PLC systems the question of distortions has to be evaluated as concerns two perspectives:

- how typical distortions influence the service quality parameters and
- how PLC systems can handle different types of distortion

For utilities it is useful to evaluate the behaviour of the a PLC in a typical distorted environment.

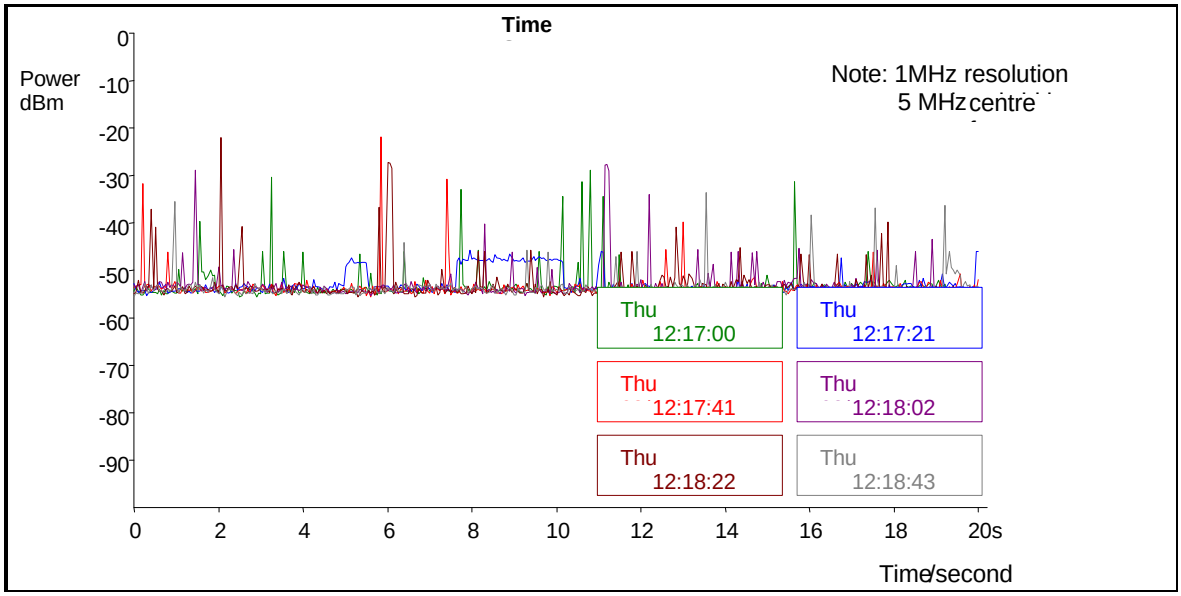

Figure 7: Distortions - 24 Hour Noise Monitoring, Time Domain (Source: NOR.WEB)

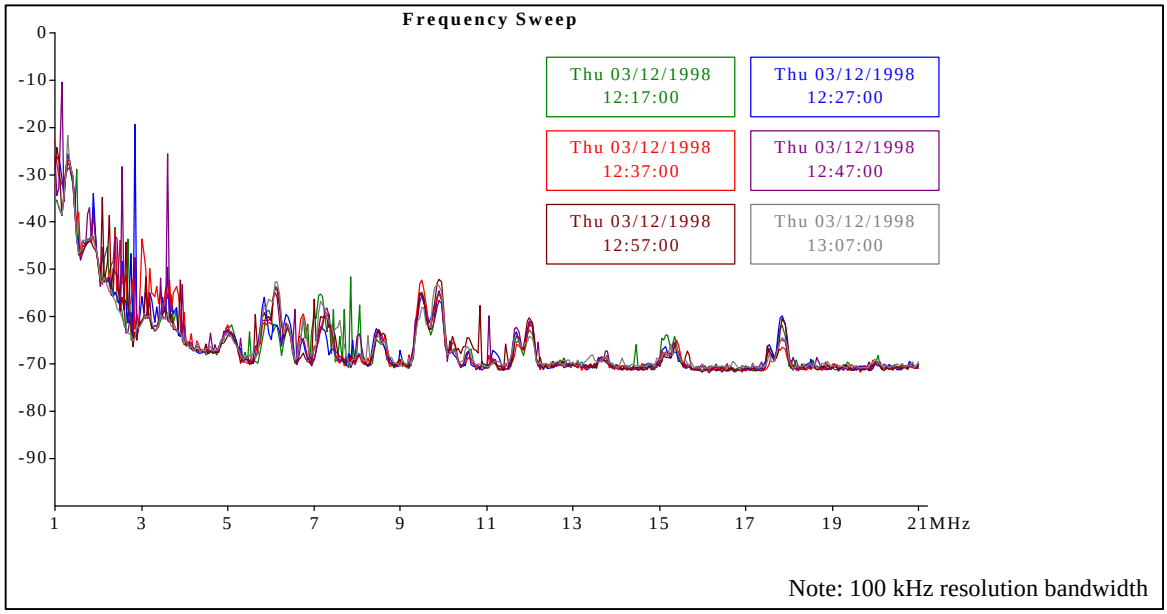

Figure 8: Distortions - 24 Hour Noise Monitoring, Frequency Domain (Source: NOR.WEB)

3.2.3 Attenuation

The attenuation defines the property of a network to decrease the signal level over a certain distance. Amongst other factors this property varies depending on

- the cabling material used
- network elements involved (bus bars etc.)
- the frequency ranges used
- the impedance of the network

As regards the cabling material, network elements and the frequency ranges, a table of typical attenuation values can be evaluated.
A particularly complicated dependency exists between attenuation and the load of the network, because the load may change depending on the usage of the electrical grid.

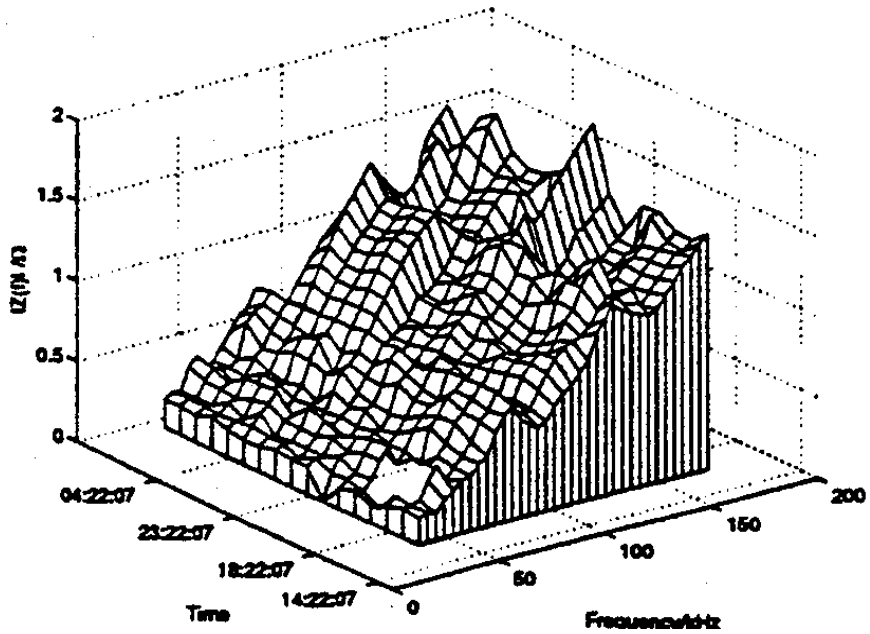

Figure 9: Time and Frequency Dependency of Network Impedance

Implications

Utilities should evaluate typical attenuation values of their network as concerns different frequency ranges in order to estimate the behaviour of a PLC system for utility's typical network arrangements.

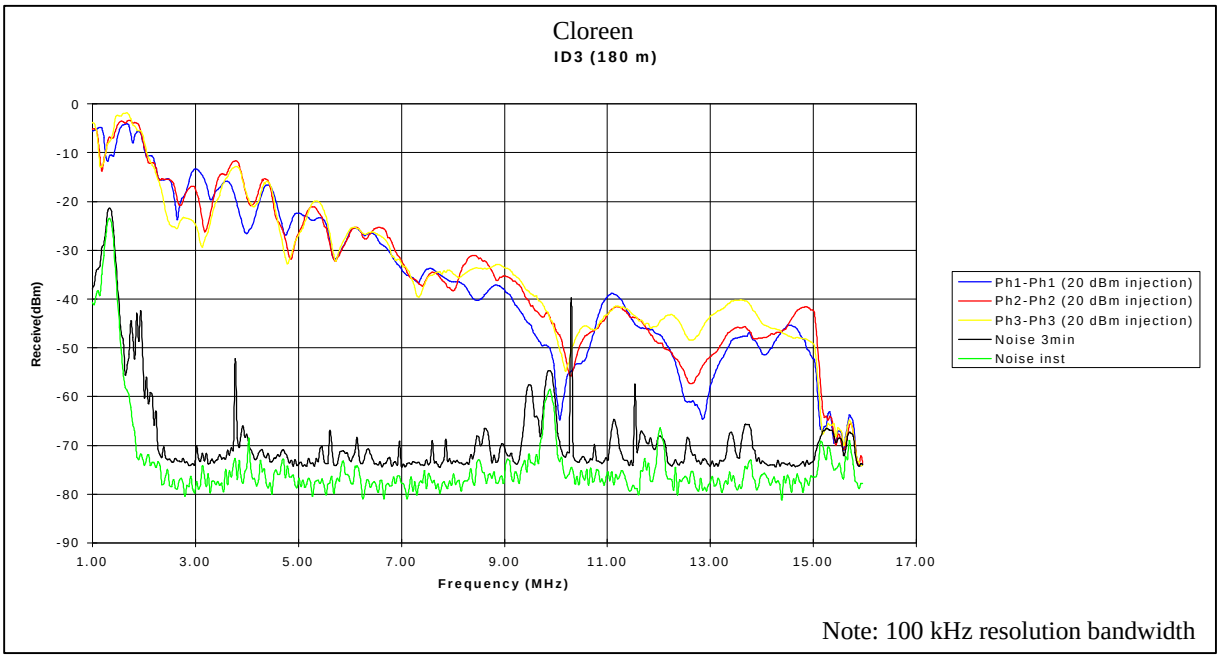

Figure 10: Attenuation- Example of Attenuation Measurement: Low Attenuation (Source: NOR.WEB)

3.2.4 Reflections

Another undesired property of the electrical network as concerns PLC is that signals injected into the network will be reflected at certain network elements. This behaviour is not very predictable.

Implications

In general, the ability of a PLC system to handle network reflections can best be evaluated by real tests of the respective system.

3.3 Discussion of transmission methods used

3.3.1 Economy of frequency and its implication

Since a PLC network is normally organised as a bus system – all users are jointly accessing the same overall network performance – the overall system bandwidth is a very important parameter.

Basic Principles

In order to gain a certain transmission bandwidth a relationship between bandwidth, frequency use and signal-noise ratio has to be considered. As a simplified rule it can be said, that for a higher bandwidth either the required frequency range must be increased or the signal/noise ratio has to be improved. Both approaches have their limitation.

Beside the fact that the frequency range allocated for PLC as a whole is limited from 1 to 30 MHz, we have to keep in mind that a co-existence of in-home and last mile PLC must be organised as well in the same frequency range.

The other option - the improvement of the Signal/Noise Ratio - for a given noisy network requires a higher signal injection level. That strongly influences the regulatory issues pointed out in other parts of this document.

Demand for bandwidth

One thing has to be clear in advance: there must be a balance between

- number of customers connected to a PLC segment and the services used respectively,
- the ability of a PLC system to concentrate and transport the traffic created by services used and traffic profiles and
- the economically considerable bandwidth to be provided at the backbone

All that can be judged best by using a business plan tool that enables to adjust

- market estimations,
- services and their traffic profile as well as the
- estimated statistical bandwidth of a service,
- products to be offered and
- prices for bandwidth to be purchased

Typical voice and data bandwidth estimations are

	Bandwidth (kb/s)	Parallel activities on 8 Mb/s	Type of usage	Comments
Telephone	64	125	Continual for length of call	Standard Telephony packet switching implies more phone calls
Web users (slow)	28,8	278	Browse and read	Periods of activity followed by very low usage
Web users (medium)	128	63	Browse and read	Periods of activity followed by very low usage
High Speed Web	1024	8	Browse and read	Periods of activity followed by very low usage
Downloading	128	63	Continual	Requires continual bandwidth
Internet Music	128	63	Continual	Requires continual bandwidth
Internet Video	1024	8	Continual	Requires continual bandwidth (crucial that there is no drop in bandwidth)
DVD Standard Video	10240	0	Continual	Needed for high quality video on demand

Source: Deutsche Bank AG: Powerline Technology – Hype or Hope?

In the following sections two approaches are discussed which are very much in the discussion process. Of course there is no judgement on the 'right' approach and there is no limitation of transmission principles to these two. On the other hand these approaches represent important options for the further development of PLC.

3.3.2 Spread spectrum / low transmission level approaches

Spread spectrum is a type of modulation that scatters data transmissions across the available frequency band in a pseudo-random pattern. Spreading the data across the frequency spectrum makes the signal resistant to noise, interference, and snooping. Spread spectrum approaches are principally designed to use low and very low transmission levels. To detect and to decode these very low level signals there are two aspects used

- high redundancy in the transmitted signal
- high effort in accuracy and sensitivity of technology used

Spread spectrum approaches require comparatively low signal-noise-levels. As a result spread spectrum approaches have less problems with radiation, but need in most of the cases a broad frequency range in order to transmit a certain bandwidth. That causes a comparatively bad **modulation efficiency.**

3.3.3 OFDM

OFDM (Orthogonal Frequency Division Multiplexing) is an approach which is chosen by a few of the PLC technology providers. OFDM is a method that allows to transmit high data rates over extremely hostile channels. The main properties of OFDM from the perspective of a utility are:

- very stable and reliable approach, particularly for hostile channels
- high modulation efficiency up to 5 bit per Hertz
- comparatively high signal-noise-ratio is required
- potential problems with radiation under certain regulatory circumstances

For a relatively long time, the practicality of the OFDM concept appeared limited. The increase of complexity in integrated circuits and the respective price declining makes it possible to use that approach on a useful economical basis.

In the following table the decision of a certain PLC technology provider (SIEMENS) has been made transparent.

	QPSK	OFDM	FSK	CDMA
Bandwidth efficiency	~ 2 bit/s/Hz	~ 2 bit/s/Hz	~ 1 bit/s/Hz	< 0.1 bit/s/Hz
E_b/N_0 for 10^{-7}	11.5 dB	11.5 dB	14.5 dB	< 6 dB
Linear analog processing	no	yes	no	no
Sensitivity for impulse noise	yes	no	no	?
Sensitivity for phase distortion	yes	no	yes	no
Sensitivity for frequency attenuation	no	no	no	yes

Figure 11: Decision Table for a Modulation Scheme (Source: SIEMENS)

Implications

Of course there is no ‘better’ and ‘worse’ approach. However it should be understood that there are different degrees of freedom depending on each other:

Low level / low radiation approaches such as spread spectrum show a comparatively low modulation efficiency. That means that in a given high bit rate frequency range between 1 and 30 MHz the transmittable bandwidth will be rather low.

High modulation efficiency approaches generally need a comparatively high signal-noise ratio and have to solve regulatory problems. On the other hand the comparatively high modulation efficiency enables the high-bit-rate frequency range to theoretically transport bandwidth up to about 100MHz. For practical

implementations the complexity of such broadband PLC systems is to high and therefore to expensive.

Practical questions to PLC technology suppliers may be

- How does the transmission methods behave as concerns respective regulatory issues?
- What is the actual used frequency range of for transmission the bandwidth of the PLC system?
- What is the (theoretically) broadest bandwidth that can be transmitted in the 30 MHz high bit rate PLC Frequency range?

3.3.4 Innovations

In the following section only a few items are described, which are actually in discussion or even already implemented into PLC systems:

Automatic signal level control

A very basic feature is the automatic control of the transmission level as a dialog between transmitter and receiver. It enables to optimise the transmission power and helps to reduce the radiation levels

Channel adaptation technology

The idea is to collect information about every channel of the network and to do an overall PLC network optimisation regarding the transmission behaviour of all parts of the network.

Error-control

Error control is a continuous innovation area in PLC. That includes channel dependent carrier management as well as redundancy mechanism at the physical layer.

4 PLC modem technology

After the physical parameters of the network and some basic considerations about transmission principles are discussed, the actual implementation of those schemes shall be looked at. It is the intention to give an overview about basic items and questions which very often appear in discussion of PLC technology.

This information will help utilities to better understand the technology and the roadmaps of PLC technology developers.

4.1 Principal scheme

Principle

A principle scheme of a PLC modem is presented below. The actual **modem** can also be surrounded by a **system** that may fulfils additional tasks such as service management and interface adaptation. The system functionality will not be discussed here.

Technical and economical challenges

If the modem consist of standard components it normally contains programmable logic devices, carrying parts of the interface coding, of the error correction and sometimes some external circuitry of the modulation component. The actual modulation component can also be a programmable logic, but it is more often a Digital Signal Processor (DSP). Whereas the components and interface adaptation are comparatively inexpensive, the modulation block is in most of the cases still the most expensive block of the modem. Also, analogue RF components are required in many cases.

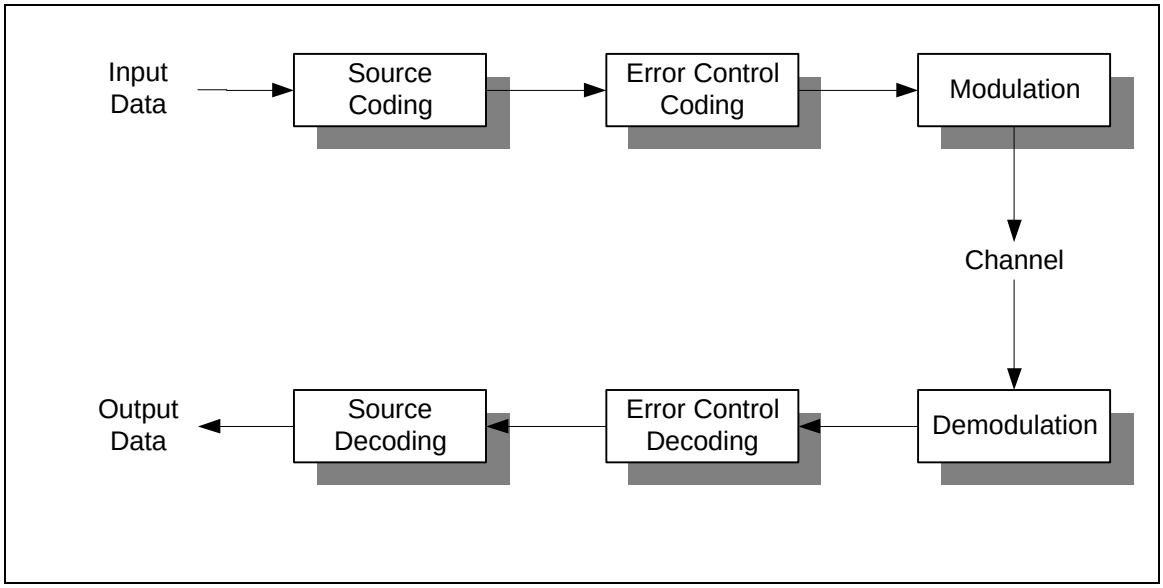

Figure 12: Principle Modem Scheme (Source: WestEnd)

4.2 Standard Components vs. Application Specific Integrated Circuits (ASIC)

Due to the high costs of modulation components, very many modem manufacturer and chip designer / manufacturers tend to develop so called application specific Ics (ASICs). This allows a drastic reduction of the price.

However, for a number of manufacturers this is still in the planning stage. Reasons therefore might be

- the solution developed still needs testing in order to ensure reliability
  once an ASIC has been developed and broad into the production process it is not possible to change something in that ASIC – DSPs allow to change software and even to change the overall modulation approach for existing devices
- the regulatory boundary conditions are still not clear; therefore it would be a risk to start ASIC production
- to start a real ASIC production requires a certain amount of money; normally series of at least 10.000 dies are required for useful economic conditions

Implications

In very many cases the actual design of PLC modems represents a useful and reasonable application of a certain modulation scheme. It normally does not represent the mostly cost effective solutions due to a number of potential reasons

- boundary conditions for the operation of the device are not fixed
- the number of devices is still too small to produce it in a cost-effective manner

Information on further modem development should include the question of the further development path towards a cost effective solution. In addition the question can be asked how the price with first real scale effects can be expected - about 10.000 devices – can be expected to be.

Also, in many cases utilities are confronted with chip designers, who do not actually offer a modem nor a system. Therefore the so called ‘reference design’ – the description of all needed external components and circuitry – is required, This is a basis to evaluate potential system designs, prices and development cycles.

4.3 Innovations

4.3.1 Repeating

Particularly for high bit rate PLC systems with higher signal-noise ratio requirements long distance transmission and the respective radiation might become a problem. Some of the technology providers have decided to use a so called repeating concept. It is partly based on different technical application, in principle however, it follows the same pattern:

The signal will be taken up and repeated by every modem in a given network segment. On one hand, that allows to do ‘hopping’ throughout the electrical

network, on the other hand that approach reduces the average transmission distance drastically. In this case the signal levels as well as the potential radiation is also reduced.
The disadvantage is that additional modem functionality has to be put into the modems.

4.3.2 Self organising routing topology for repeater stations

Based on the repeater concept it becomes important to organise the network according to the customer and service structure. This might be needed when a new customer has to be involved into the network.

4.3.3 Self learning systems

Principally, PLC systems need to be adaptive to the given networks. From the PLC perspective there is little existing knowledge about electrical networks. This is why the development of a 'plug and play' system, which does not need intensive measurement and planning in advance, is essential.

4.3.4 Path redundancy and device failure detection

In order to achieve high quality services it is needed to think more about fall back and redundancy solutions. Problems to be addressed are:

- switching activities in the power network
  at least in Germany the typical household is switched off between 10 and 100 minutes per year
- power down scenarios
  although – from the statistical point of view - this event does not take place very often, it regularly causes peoples to try to use the phone. Particularly for those technology providers who are offering telephony services via PLC the problem has to be solved.

4.4 Regulatory boundary conditions[1]

This document shall be used as a handbook for the evaluation of PLC systems. Therefore there is included, a short overview about the present regulatory situation. However this overview concentrates on the European level. It is known, that different European countries have different approaches.

4.4.1 Narrow band systems

CENELEC EN 50.065

Since the beginning of the 1990-ies the standardisation body SC 205 A of CENELEC has been busy standardising the transfer of information on low voltage networks in public distribution networks or within customer systems in the frequency range of 3 to 148.5 kHz. Part 1 of the concerning standard 50.065 "General Requirements, Frequency Ranges, and electromagnetic compatibility" developed in 1991 assigns frequency ranges for the different applications and

[1] Source: VDEW Position paper on communication via 50Hz electrical networks

defines measurement procedures. The standard aims to limit interactions between devices for signal transmittance in electric installations and the influence of such devices on sensitive electronic devices.
There are basically three different possibilities for the de-coupling of PowerLine systems:

1. Physical separation by using filters or varying signal injection systems
2. Separation based on frequency bands dedicated to certain applications (e.g. depending on utility or private customer system)
3. Definition of a general protocol addressing mechanisms depending on the application

CENELEC – basically but not exclusively following the second of the above options – defines a frequency range for utilities of 3 to 95 kHz and for private customer systems of 95 to 148.5 kHz.

Band	Frequency range (kHz)	Maximum transmission level (V)	[dBµV]	Access protocol CSMA*	user
A	9 – 95	10	134 – 122	-	Utility
B	95 – 125	1.2	116	-	Private
C	125 – 140	1.2	116	132 kHz	Private
D	140 – 148.5	1.2	116	-	Private

*CSMA: Carrier Sense Multiple Access

EN 50.065 also states that conformity with this norm does not a priori determine the acceptance of a certain system to an electricity distribution network and that the use of the 3 to 9 kHz frequency band for the transmission of data is only permitted after the utility's approval .

IEC 61.000-3-8

Five years after the European norm 50.065 the IEC 61.000-3-8 " Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels" was published. This international standard builds on work of the IEC SC 77BWG5. It distinguishes from the European 50.065 by enlarging the frequency range to 525 kHz which is driven by the fact that radio broadcast in regions 2 and 3 of the ITU definition starts at a frequency of 525 kHz whereas it begins at 148.5 kHz in region 1 of the ITU, i.e. Europe. Following the above difference in the three ITU regions IEC 61.000-3-8 defines diverse specifications of the use of frequency, transmission and disturbance levels for Europe.

IEC 61.334

Aiming at the PowerLine systems of utilities in the low and medium voltage area WG 09 of the IEC TC 57 (Power Control and Associated Communications) developed the standard IEC 61.334. It deals with communication protocols for distributed automation systems (DAS) and customer automation such as remote metering and amends the low voltage oriented standards of CENELEC SC 205A and IEC SC 77B. IEC 61.334-3-1 "Distribution automation using distribution line carrier systems – Part 3: Mains signalling requirements – Section 1: Frequency bands and output levels" describes criteria and requirements of DAS on low and medium voltage networks for the frequency range of 3 to 500 kHz, following IEC 61.000-3-8. For low voltage systems it again refers to IEC 61.000-3-8 and thus for Europe to EN 50.065. For medium voltage systems it – following ITU rules – prohibits disturbing priory wireless services.

4.4.2 Broad band systems

Overcoming initial problems CENELEC in 1990 succeeded in forming WG 10 which deals with standardisation in broad band (high bit rate (HBR)) PowerLine. Although CEPT is not counted as a standardisation organisation, it – as well as the spectrum management activities of CEPT (TC ERM) – are to be mentioned here. ETSI, too, has now started a "Powerline Telecommunication" project.
Following interface problems between CENELEC and ETSI about the distribution of tasks, the insight – found in fierce discussions with representatives of the authorities administering wireless services in SC 205A WG10 – that electromagnetic compatibility is a rather complex problem and with CEPT claiming the sole right of discussion with regard to frequency management, an agreement between CENELEC, ETSI, and CEPT about structuring the work in the PowerLine area was reached in January 2000. However, it merely focuses on low voltage networks.

4.4.3 Summary

Standardisation of narrow band applications of PowerLine technology in the low voltage networks follows EN 50.065-1 of CENELEC. Except for some individual amendments to be finalised in the near future, standardisation in this area is solid.

Standardisation of medium voltage networks is ensured by IEC 61.334-3-1 which was agreed both by IEC and CENELEC. As there has been a technical problem and general conflict with EN 50.065-1, CENELEC has in December 1998 withdrawn from a harmonisation defining IEC 61.334-3-1 as a European standard and delegated the norm back to TC 210 (electromagnetic compatibility) and SC 205A (Mains signalling).

Standardisation of broad band applications does right now not have any normative basis or specification in the sense of a technical system of rules. Work has begun only recently, a distribution of work in system technical aspects, electromagnetic compatibility, and spectrum management between CENELEC, ETSI, and CEPT has taken place.

Given the absence of European standards in the field of frequency allocation and transmission levels of high bit rate PowerLine systems the German Regulierungs-behörde fuer Telekommunikation und Post (RegTP) started discussing the draft of a regulation which by limiting the level of disturbance resulting from the radiation of high bit rate PowerLine systems will allow the general use of such systems.

The fact that the standardisation process is not finished yet currently represents one of the biggest obstacles to a wide range use of PowerLine systems as it increases the risk of mislead investments of PowerLine providers.

5 Implication of MAC Layer Specifications

5.1 Development of MAC Layer for PLC

Low-voltage power supply networks connect several users to the transformer station over an energy cable. In the case of usage of the supply networks for the telecommunications (PLC network), the cable represents a transmission medium for the information transfer between the users and the transformer station. This means, that the communication in the PLC network is transported over only one physical transmission medium – the energy cable. The transmission medium is used by all subscribers of the PLC network. Because of that, there is a need for an access organisation of many users, to the transmission medium.

The organisation of the multiple access is defined in MAC (Media Access Control) network layer. The MAC layer is first sub-layer of so called data link layer of the OSI (Open System Interconnection) reference model for communication networks. The MAC layer receives data to transmit from the second sub-layer of the data link layer, called logical link control (LLC) layer. The task of the MAC layer is to deliver the data prepared for the transmission to the physical network layer, which simply transmits a bit stream over a transmission medium. Also in the other transmission direction, the data has to be received from the physical layer by MAC layer and prepared and delivered to the LLC network layer.

There are several factors in any communication system and also in PLC systems to be considered for the development of MAC layer. In the case of an access network like PLC access systems, the following features have to be investigated:

- Structure of PLC access networks
- Telecommunication services to be applied in the PLC
- Strategy for the connection of the PLC access networks to the backbone and wide area communication networks (WAN)

After a consideration of the PLC network structures a reference network structure (reference model) for the development of MAC layer should be defined. This makes possible a further investigation of the MAC layer independently to the reality of very different structures of low-voltage supply networks.

The specification of telecommunication services for the investigation of the MAC layer helps to specify the features of the MAC layer and the MAC protocol to be implemented in PLC system. The feature of a PLC system to carry/serve a possibly high number of telecommunication services with both weak and very strong transmission demands is very important as a competitive factor against other communication technologies applied in the access area.

PLC networks will exist together with other transmission technologies and both PLC and classical communication networks will be interconnected. For the organisation of the powerline MAC layer it is also very important to investigate a future interconnection of PLC networks to a backbone transmission system. Powerline MAC layer and MAC protocol have to be able to carry out efficient

communications with its backbone networks and to ensure the interconnections with possibly high number of different communication systems.

There are also some specific features to be considered in the case of PLC systems:

- Characteristics of the PLC transmission system (for which the MAC layer has to be developed)
- Impact of disturbances in PLC networks on MAC layer

The PLC physical layer has some specifics comparing with other communication technologies. Because of that the usage of special PLC transmission systems is expected. As we stated, MAC layer uses the services of the physical layer for transmission and reception of the data. Because of that the characterisation of PLC transmission systems is very important as an input for the development of MAC layer.
Another important peculiarity of PLC systems is the frequent occurrence of various kind of disturbances in the network. Low-voltage networks are not built up for data transmission and there are many disadvantages for their usage in telecommunications. Because of that, PLC networks seems to be more disturbed than any other wired communication network. Additionally, because of very strong regulation rules for electromagnetic radiation from PLC network to the environment , PLC systems have to work with very low signal power. That makes PLC systems more sensitive to the disturbances and PLC transmission systems have to deal with this problem. Beside the functionality of the network physical layer to deal with the disturbances, it is also task to be done in the MAC layer of PLC systems.
As we said, the MAC layer is used by other transmission techniques and has been developed for numerous communication systems. That makes possible usage of this experience for the development in PLC networks. Especially, the transmission systems used in the access or local communication area are very interesting for PLC, which will be inserted at first in the access area, too. There are also several similarity between PLC and mobile networks (which normally operate in an access or local area) like used transmission methods, modulation and disturbance sensitivity of both technologies. Because of that, organisations of a MAC layer for mobile networks and MAC protocols developed for this transmission systems seem to be an interesting point of analysis for the development of MAC layer for PLC.

5.2 PLC Network and Service Structure

5.2.1 Topology of Low-Voltage Supply Networks

It is well known that the structures of low-voltage supply networks are very different. It depends on several factors:

- Location of the PLC network
  - Urban residential area
  - Rural residential area
  - Industrial area
  - Business area
- User density
  - Number of users in PLC network (small – middle – large)

  - User Concentration (single houses - small blocks – towers)
- Network length (short – middle – long)
- Network design – number of network sections

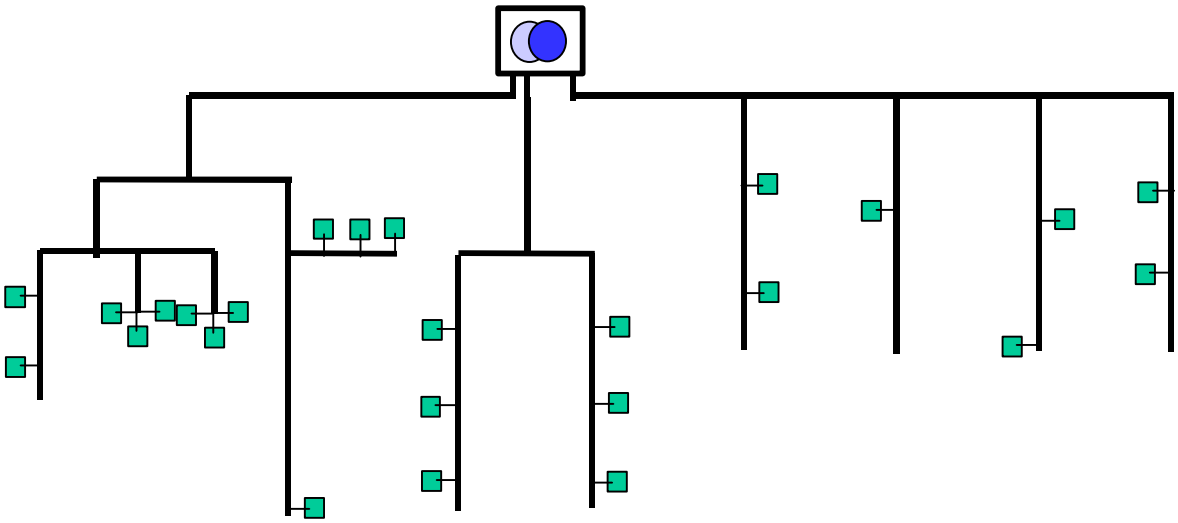

Figure 13: PLC Network Structure

The above figure shows a possible structure of a PLC Network. As we see, there are generally several network sections from the transformer station to the users. Each section (and also each low-voltage supply network) can have a different structure. There could be various number of connected users in different networks and of course in different network section. The users can be more concentrated or not and they can be distributed in a symmetric or in an asymmetric way. There is also a difference between network lengths and between lengths of network sections. However, we are able to define some characteristic values describing the middle structure of a typical PLC network:

- Number of users in the network: 250 ~ 400
- Number of network sections: ~ 5
- Number of users in a network section: 50 ~ 80
- Network length: ~ 500

5.2.2 Network Model for Development of MAC Layer

Generally, a PLC access network is connected to its backbone network over a base/main station. That means all communication between the users of a PLC network and the world is carried out over a base station. Also the internal communication between users of a PLC network is done via the base station.

We can differ two transmission directions in a PLC network:

- Downlink/downstream from the base station to the users
- Uplink/upstream from users to the base station

If we take the network structure of the above figure and assume that the base station is placed in the transformer station (it is also valid if the base station is placed in any other station in the network) we can conclude following transmission features:

- Information sent by the base station in downlink direction is transmitted to all network subsection and is received by all users in the network

- In uplink direction, information sent by an user is transmitted not only to the base station, but also to all users in the network

That means the PLC transmission medium/cable holds in principal a bus structure in spite of the fact that the low-voltage supply networks have a tree topology. It is also valid if we consider only one network section or any other part of the PLC access network. Because of that it is possible to consider the PLC network structure as a bus system, at least in the investigations of the powerline MAC layer.

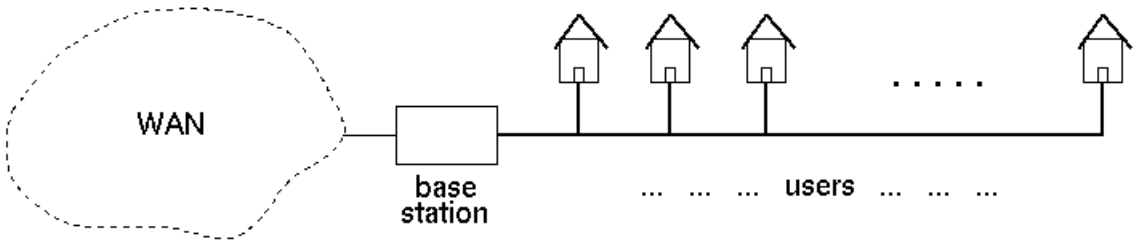

Figure 14: Model of PLC network

5.2.3 Service Specification for MAC Layer

The users of a PLC network will use services. It is already a very important competition factor. In the development of the MAC layer the following four basic group of telecommunication services have to be considered:

- Connection oriented services like telephony and other CBR (constant bit rate) services
- Connection less services like data transmission without QoS guarantees
- Specific PLC services
- Data transmission with QoS guarantees (like VBR – variable bit rate – services)

PLC networks must support the classical telephone service, because of its importance and its big penetration in the communications world. Further requirement will be a CBR service with higher transmission capacity like video. Another important service is data transmission, which allows the usage of the internet.

The powerline MAC layer and MAC protocol have to be able to deal with both of the previous mentioned services to ensure an initial position of the PLC systems against other technologies. Also, a possibility to transmit more sophisticated services (like VBR) should be included into the powerline MAC layer.

In the consideration of the MAC layer in the PLC networks special emphasis has to be given to the specific PLC services (home automation, energy management, security, ...). Most of this services can be covered by other previous considered kind of services, especially with connection less data transmission. In spite of that, there can be some special requirements of the PLC services which need some QoS guarantees and transmission priorities and this features have to be also included in the functionality of the MAC layer.

5.3 PLC Transmission System

There are several multiplex schemes which are investigated for their application in PLC transmission systems. Two of them are market out as suitable for PLC networks:

1. CDM – Code Division Multiplexing
2. OFDM – Orthogonal Frequency Division Multiplexing

In this section OFDM is considered as an example for the specification of PLC transmission system in sense of the development and investigation of MAC layer for PLC networks. As we will show, there are also some general principals of its consideration which can be applied to CDM based and other techniques .

5.3.1 MAC Layer in OFDM Based PLC System

OFDM transmission systems use a number of sub-carriers distributed in a frequency spectrum for the data transmission. Each sub-carrier has a transmission capacity and it is possible to make a groups of the sub-carriers to build up transmission channels (see the below figure).

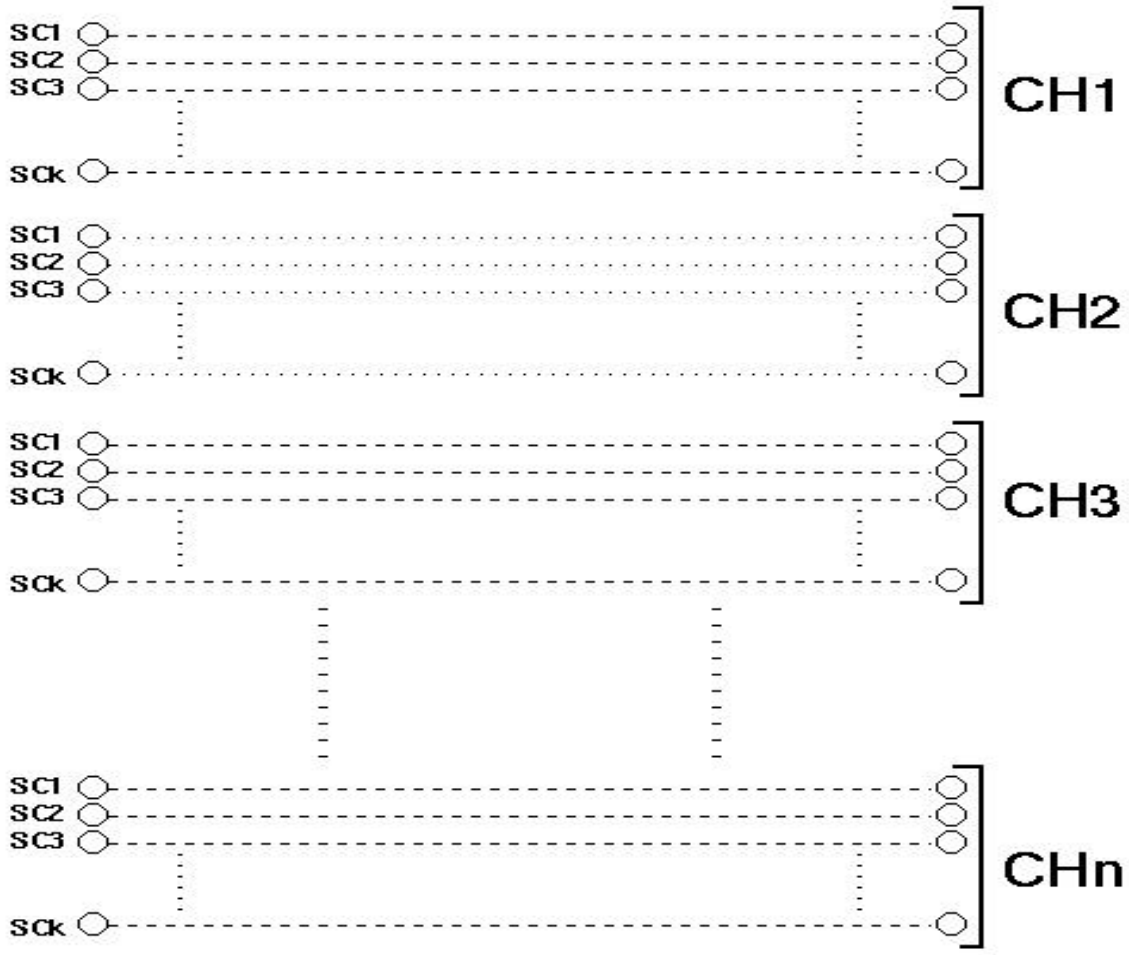

Figure 15: OFDM channel structure

MAC layer and MAC protocol have to manage data transmission over the transmission channels which means channel allocation/re-allocation between a number of PLC network user and transmission of different kind of services. In this

case, because of a frequency distribution of the transmission channel, it concerns a kind of FDMA (Frequency Division Multiple Access). Because of the OFDM structure and a number of sub-carriers in each of the transmission channels this multiple access method is called OFDMA (OFDM access).

There are following three possibilities for the capacity management it the OFDM system to be considered in the development of the MAC layer:

A) The transmission channel, (each channel includes a defined number of sub-carriers – sub-channels) has a fixed transmission capacity (e.g. 64 kbps/s)
B) The transmission channel has a variable capacity
C) A sub-carrier management ensures a build up of the transmission channels with a pre-defined transmission capacity

In case A) the MAC layer deals always with the transmission channels having a same transmission capacity. The transmission channels include always the same sub-channels. That is to say, if one of the sub-channels is not available (a sub-carrier is disturbed) the transmission channel can not be used despite the fact that other sub-channels are available.

OFDM systems can react with a reduction of transmission capacity of the sub-channels according to the disturbance situation (case B). In this case, a transmission capacity of a transmission channel is also reduced and it could be a problem for the service using the channel. Of course, a possibility to allocate the transmission channels to the particularly services according to the available capacity exists if we deal with the channels with a variable transmission capacity.
In case C), all available sub-channels are summarised into a number of transmission channels with a firm transmission capacity. In this case a management of the transmission channels with variable capacity could be also possible.

5.3.2 Logical Structure of MAC Layer

As we saw in subsection 5.3.1 there is a channel structure of a OFDM based transmission system. The channels can be used with a constant or variable transmission capacity. Such channel structure is not a peculiarity of the OFDM system. Similar structures can be also found in other transmission technologies.
If we consider CDMA as another candidate for PLC systems we can find a similar channel structure as in OFDM based systems. In this case the whole available transmission spectrum is divided by orthogonal codes which can be allocated to the particular users or services. With a possibility for usage of a code an user has a opportunity to send or receive data with a certain transmission speed. That means, a transmission capacity is allocated to the user also like a transmission channel. Because of that we are able to recognise a channel structure in CDMA systems, too.
In CDMA systems the users are able to use a whole frequency and time spectrum for the transmission. The transmissions from various users differs with applied code. We can also imagine a system which use all sub-carriers of a OFDM system for each transmission. To avoid collisions between different users, some kind of access organisation has to be done. In this case it could be done occasionally which means that each user receives a part of time to transmit its data. This kind of access organisation is TDMA (Time Division Multiple Access). In TDMA systems there are a number of time slots which repeat during the time (in frames).

The time slots offer also a transmission capacity and they can be compared with OFDM or CDMA transmission channels.

We can conclude that the PLC transmission system seems to have a channel structure independent on used transmission technology. Accordingly, in the development of MAC layer it is possible to deal with logical channels which are managed by MAC protocol. The logical channels have other meanings for each considered transmission method, but the principal investigations, done on the logical level, can be applied to any of the methods, of course always considering their particularities.

5.3.3 Impact of Disturbances on MAC Layer

As we already mentioned, an influence of disturbances in the PLC transmission systems play a very important roll. In this section we consider the impact of the disturbances on MAC layer and its development.

PLC transmission system will work with predefined signal power which has to be under a limited value defined by regulation organisations. On the other hand, the signal level has to keep data transmission over PLC network possible. That means there should be a SNR (Signal Noise Ratio) level in the network making the communication possible. So far that SNR is sufficient to avoid the disturbances in the network there is no need for application of other special methods against the disturbances. SNR has to be able to avoid an influence of the background noise.
More difficult for PLC transmission systems are pulse disturbances which have much higher power than the background noise. In this case SNR is not enough to avoid the disturbance and following data damage (transmission error). But if the duration of a disturbance is enough short, which means shorter than the duration of a symbol transmitted over physical layer of a PLC system, there is no influence of the disturbance on the transmission. E.g., typical duration of an OFDM symbol is 500 µs and a pulse disturbance shorter than 500 µs should not damage transmitted data.

In many transmission systems forward error correction (FEC) mechanisms are applied to avoid an influence of the disturbances. That means that the transmission system are able to manage a situation when a number of bits is damaged and in spite of that to correct a data contents and to make possible correct data transmission. FEC mechanisms are expected to be implemented also in PLC systems.

All three methods for the disturbance avoidance mentioned below (SNR, symbol duration, FEC) are realised in the physical layer of a communication system like PLC. That does not mean that the data transmission is carried out without any influence of the disturbances and that the powerline MAC layer does not have to deal with this problem. Firstly, the MAC layer has to include a functionality to communicate with the physical layer according to applied FEC mechanism and its format and data overhead. Secondly, in spite of the applied FEC mechanism it is possible that the data contest transmitted by MAC layer is damaged. In following we describe shortly possible inserts which have to be provided by MAC protocol.
Data transmitted by MAC layer is delivered to the next network layer – Logical Link Control (LLC). On this point it can be recognised if a data contest is error free. In case of errors the damaged data has to be transmitted again. There are some

methods for data retransmission in this case called ARQ (Automatic Repeat Request). Insert of ARQ mechanisms can reduce error probability to a very low value and it is only limited by rest error probability of CRC code used for error recognising. Because of the additional end-to-end transmission delay due by transmission of the acknowledgements and data retransmissions ARQ is not suitable for the voice.

ARQ mechanism deal with relative short duration which occur on one or several data units. MAC layer has to react also to long term disturbances which make one or more transmission channels unavailable for a longer time. In this case, the disturbed channels will not be used until the disturbance disappears. That means, a kind of channel re-allocation has to be done to make possible a further transmission of affected connections, now using other transmission channels.

5.4 Analysis of MAC Protocols for PLC

In previous subsections we mentioned several factors to be considered in the development of MAC layer for PLC networks. At this time there is no any standardisation of the powerline MAC layer. There is of course need for the consideration of MAC and in this section we give some guidelines for this development.

The development of MAC layer and of MAC protocol can be divided in following investigation subtasks:

- Organisation of MAC Layer
- Signalling – definition of MAC protocol
- Duplex Procedure
- Error Handling

The organisation of MAC layer includes principals of data transmission to be done in the PLC system and also basic reflection of signalling, error handling and duplex procedure to be implemented in the system. It should be decided if a collision free or a collision transmission will be carried out and also how the various services will be mixed in the network. An organisation of data transmission has to be also defined as well as transmission capacity which will be used for the signalling in the MAC layer.

A MAC protocol to be implemented in PLC systems should serve for an efficient signalling. There are two task of MAC protocol for the signalling in PLC networks:

- Efficient transmission of connection requests from the users to the base station in the uplink direction
- Optimal utilisation of signalling transmission capacity in the downlink direction

Organisation of a duplex procedure is also a task to be defined in the MAC layer. Use of the PLC systems in the access telecommunication area causes probably an asymmetric traffic in the PLC network. That means, the network load will be more larger in the downlink transmission direction than in the uplink. Because of that it should be decided between following basic methods for the organisation of the duplex procedure:

- Static and the same transmission capacities in both downlink and uplink transmission direction
- Static transmission capacities but with larger capacity in the downlink
- Dynamic transmission capacity which change depending on traffic situation

As we already mentioned in subsection 5.3.3 the MAC protocol has to include an interface to the physical layer and its error correction mechanism and also to provide an ARQ mechanism for retransmission of damaged data as well as a mechanism for channel reallocation in case of long term disturbances.

6 Access to the electrical network: Coupling and Fusing

From the perspective of a utility, the coupling to the electrical network is one of the more interesting issues. It influences the operational procedures and also influences security issues. The operational boundaries are between the backbone's access point and the demarcation point in the customer's building. The PLC System may not influence the operation of the electrical network and in particular, the PLC system must not influence meters and connected appliances.
Coupling in the low voltage segment must be possible without interrupting the power for a certain house. Standard components are highly appreciated.
Particularly for the German market coupling solutions for the transformer station, for the demarcation point in the customer's house and for the metering cabinet were developed and introduced into the market.

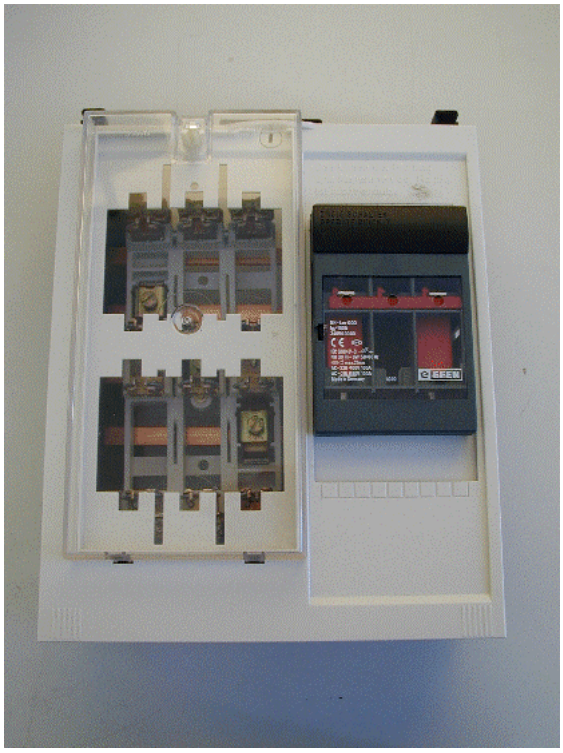

Figure 16: PLC Coupler, Circuit breaker and Fuse Block (Source EFEN GmbH)

As regards medium voltage couplers, a number of systems are available on the market both for core injection and coupling onto the shielding.

Figure 17: PLC Medium Voltage Coupler (Source SIEMENS)

If the power supply of the PLC system is connected to the un-metered part of the network, that it has to be fused. Fusing has to follow the rules of the respective utility. In many cases the theft of electricity must be avoided; the sealing of the coupling unit must be possible.

7 Connection to service providers

Although utilities are not directly involved into the telecommunication business, they need to take that point into consideration. Especially the additional need for additional equipment may influence business plans drastically.
In general it will be appreciated by utilities not to install any other additional equipment in transformer stations.

The WAN – wide area network – is in many cases owned and operated by the utility itself. Minimum and in most of the cases standard interfaces are 2 Mbps lines. The technology provider should suggest one standard solution that can be operated without any additional equipment.

Especially if utilities want to deliver telephony services it has to be taken into account that the transfer of the telephone number in some countries must be carried out.

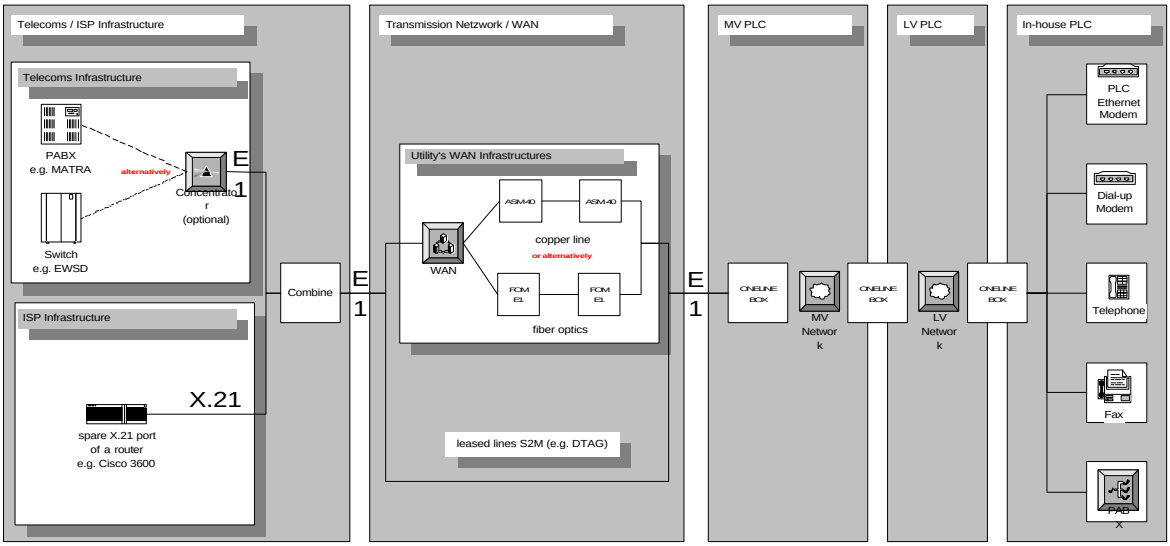

Figure 18: Connection to backbone scenario (Source ONELINE)

8 Disturbances in Powerline Communication Transmission System

8.1 Introduction

In order to communicate reliably on power distribution networks, there are many difficult technical challenges to overcome, such as, unstable transmission characteristics, very low impedance channel, etc. Among these technical issues, one of the most important is the design of a communication system that considers the unique features of noise.
The noise on power-lines is mainly caused by electrical appliances connected to these lines. So the statistical behavior of this man-made noise is quite different from that of stationary white Gaussian noise and its characteristics may change in very short time periods. Therefore, a model which can describe the statistics of the instantaneous value of the noise is needed. Thus, after making a classification to the disturbances in the PLC network, we propose to give their three important properties, the magnitude, the duration and the inter-arrival time. These are the three random variables defining the basis of the disturbance model.

8.2 Disturbance Classification

In contrast to many other communication channels the powerline channel does not represent an additive white Gaussian noise (AWGN) environment. According to different papers, supported by some recorded measurements, the additive noise in broadband powerline communication channels can be considered to be the summation of five noise types, as shown in Figure 19.

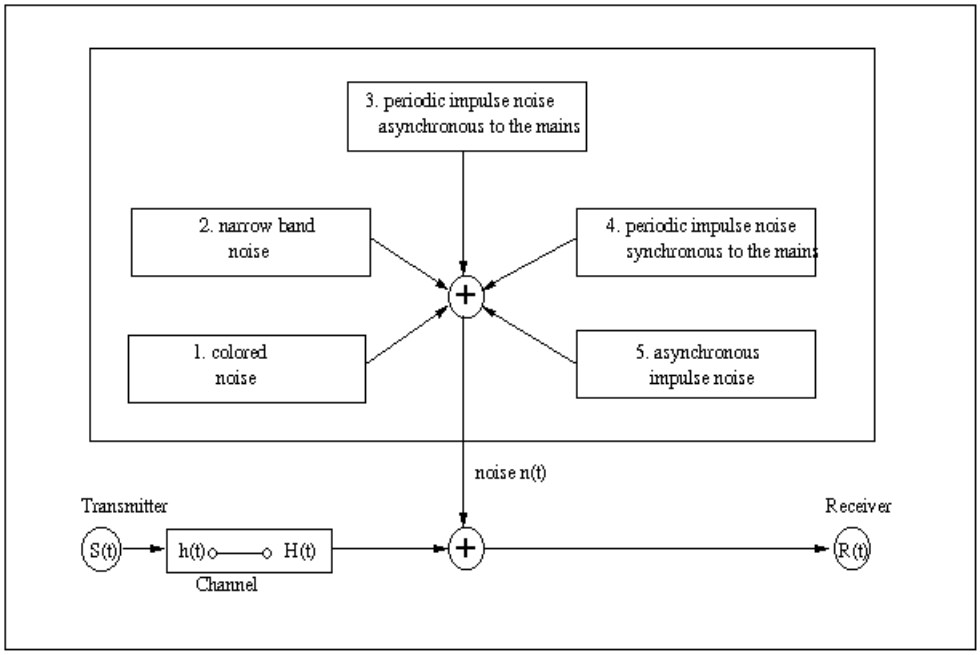

Figure 19 Classification of noise in a powerline environment

1. Coloured background noise (also called type 1): mainly caused by summation of numerous noise sources with low power. Its power spectral density (psd) is decreasing with frequency. Its level varies slightly over time in terms of minutes or even hours.

2. Narrowband noise (type 2): as the name implies this is noise confined to a narrow portion of the frequency band, over which the level is approximately constant. This type of noise is mainly caused by ingress of broadcast stations in the medium and short wave broadcast bands. The level is generally varying with time of day (high in the evening and much lower during daylight hours).

3. Periodic impulsive noise, asynchronous to the mains frequency (or type 3): most of the time, this type of noise is caused by switching power supplies. These pulses have in most cases a repetition rate between 50 kHz to 200 kHz, which results in a spectrum with discrete lines whose frequency spacing is dictated by the repetition rate.

4. Periodic impulsive noise, synchronous to the mains frequency (noise type 4): these impulses have a repetition rate of 50 Hz or 100 Hz and are synchronous to the mains cycle. They are of short duration (some microseconds) and have a psd decreasing with frequency. This type of noise is caused by power supplies operating synchronously with the mains cycle.

5. Asynchronous impulsive noise : this type of impulsive noise is caused by switching transients on the network. These impulses have duration from microseconds up to a few milliseconds with arbitrary arrival time. The psd of this type of noise can reach values of more than 50 dB above the background noise.

In order to make the investigations of the disturbances more clear, a general classification of this noise can be done based on their behavior over time. The measurements show that these five types can be classified into two categories, background noise including the first three types and the impulsive noise, which represents the two last.

8.3 Background noise

According to the disturbances histogram, two assumptions can be made. On one hand, as the level of the narrowband noise is generally varying with the time of day (day or night), OFDM systems consider this type as background by either, avoiding the use of the frequency ranges or by attaching to these frequencies a small bit-loading rate. On the other hand, due to the high rate repetition of the impulses (type 3) and their behavior in the frequency domain, this noise is also seen as a background noise. In fact, the occurrence of such noise results in a spectrum with a comb, disturbing by that, a wide frequency range. So, the first three noise types are categorized as a background noise, whose spectral analysis is shown in Figure 20 [1].

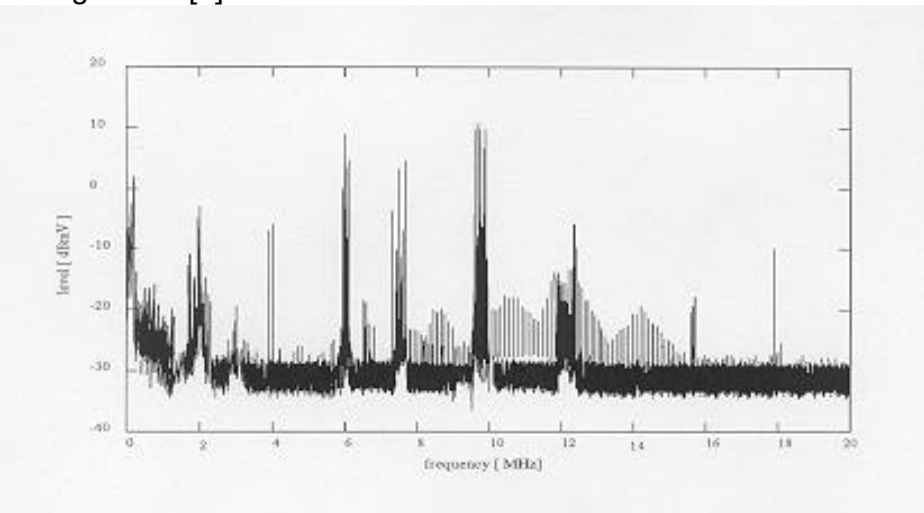

Figure 20 Spectral analysis of the background noise

In some ways, the background noise psd may be considered as constant over different frequency ranges. Hence, the basis of one noise model are sources of white noise which must be defined separately for different adjacent, non-overlapping frequency band. For each range, the bandwidth and the noise amplitude have to be defined.
This property may be used for the conception of the physical layer, for example: to define the bit-loading algorithm, the suitable interleaving used sometimes with trellis coding for the channel coding.

8.4 Impulsive noise

While background noise is stationary over seconds, minutes or even hours, the short time variance in the powerline environment is mostly introduced by noise types 4 and 5, which have durations in terms of microseconds and milliseconds. According to the measurements, the noise type 4 has a psd decreasing with frequency, a low rate repetition (50 or 100 Hz) and some microseconds of duration. Because of the short duration, we consider that these noise impulses can not introduce any error in the interpretation of an OFDM symbol, which has a duration of 500 microseconds. However, the noise duration of type 5 can reach several milliseconds or seconds with a psd up to more than 50 dB above the background noise.
The following subsections present measurements, in both frequency and time domains, of asynchronous impulsive noise (called type 5), which is considered as the main reason for bit error occurrences in powerline communications.

8.4.1 Power spectral density

The psd of noise impulses is important for the characterization of the impact on a communication system. The (average) psd of a noise impulse, as plotted in Figure 21 [1], gives an idea of the actual change in the noise scenario during the occurrence of such noise impulse, the psd of the background noise measured at the same location is also plotted in this figure.

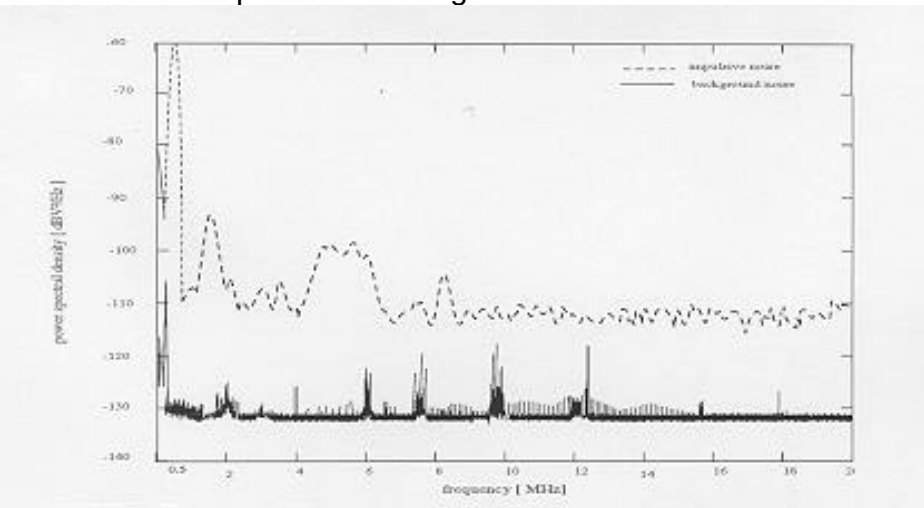

Figure 21 Power spectral analysis of background and impulsive noise

It is quite obvious that the psd of the noise scenario during the occurrence of impulses is 20- 60 dB above the level of the periods that are free of impulse noise. It is very likely that such impulses will introduce bit errors.

8.4.2 Impulsive noise characteristics

Due to the high impact of impulse noise on data transmission it is essential to gain statistical information about the probability distribution of impulse magnitude, impulse width and interarrival time, the distance between two impulses. The curves of different measurement results show the distribution of these three random variables. The magnitude distribution is represented by Figure 22. It shows that most of the impulses have an amplitude between 100 mV and 200 mV and that they are exponentially distributed.

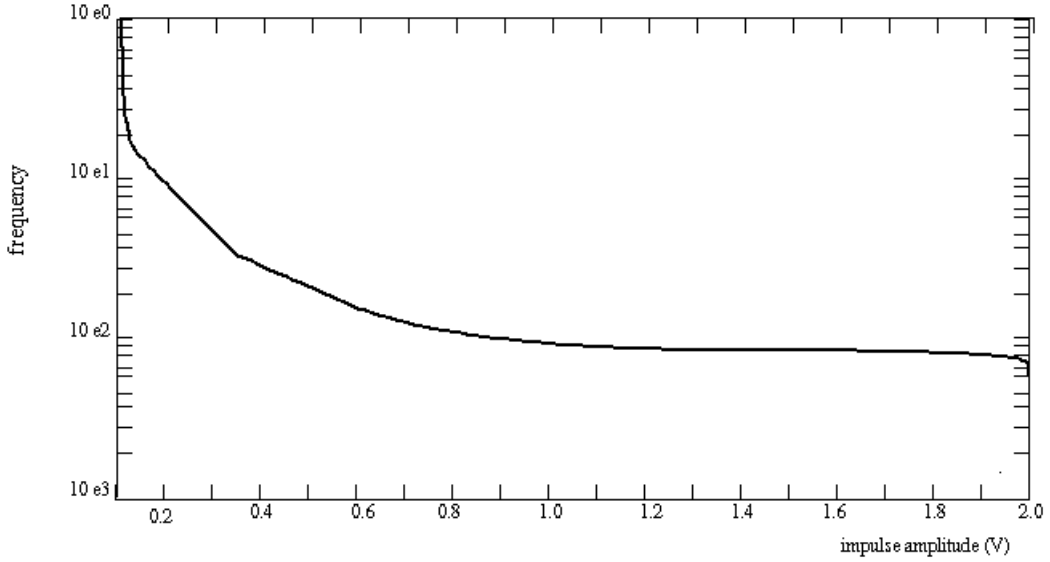

Figure 22 Measured frequency of impulse amplitude

It can be seen that the impulse width, of which the probabilities are plotted into Figure 23 [1], can be modeled by a random variable that has an exponential distribution, with an approximated mean value m equal to 108.46 µs.

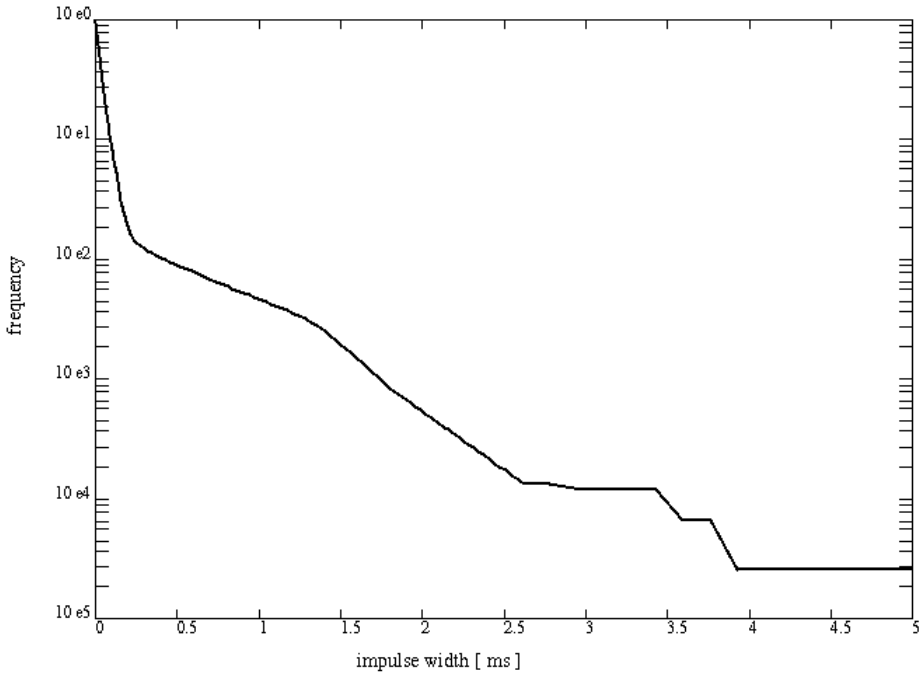

Figure 23 Measured frequency of impulse width

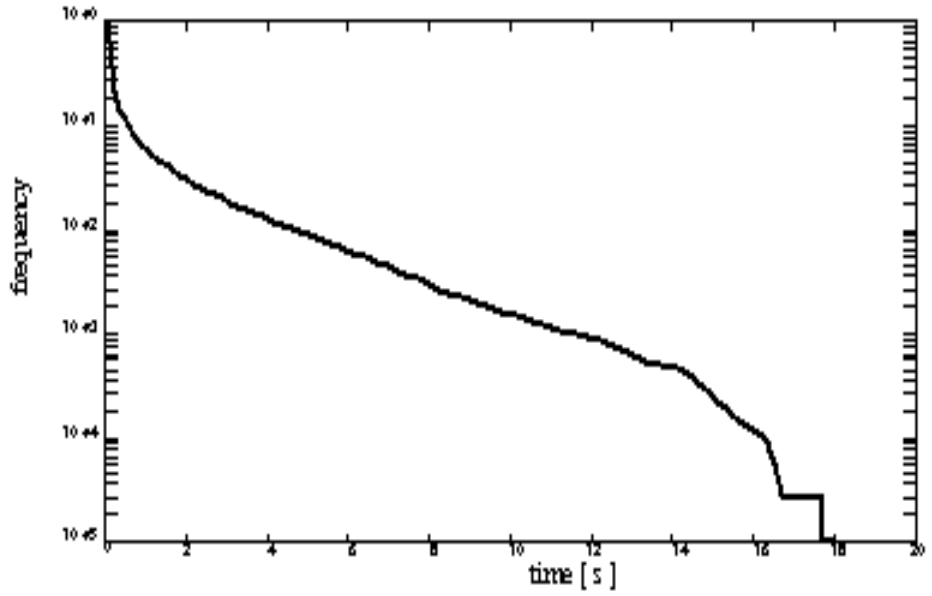

Figure 24 Measured frequency of impulse interarrival time

The results of the measured interarrival times between two impulses are shown in Figure 24 [1]. Also these times seem to follow an exponential distribution, whose parameter can be taken to be approximately equal to 1.67 seconds.

[1] M. Zimmerman, K. Dostert
An Analysis of the Broadband Noise Scenario in Powerline Networks
ISPLC 2000

9 The way forward – developments and trends

9.1 Comparison of competing access technologies

Why PLC?, the obvious answer is that because utilities are operating the electrical networks and not the cable TV networks...

If we compare PLC with other serious access technologies, it is clear that all those technologies (PLC, UMTS, CATV, XDSL) are all operating in the same class of services and service parameters. On the other hand it can be shown that -except CATV - all other technologies are using hostile channels in media (air, telephone line, power line) not designed for these kind of signals.
The complexity of the modulation schemes used and therefore the cost are similar for these alternative access technologies.
The advantage of PLC is that the investment in central technical premises is comparatively low. Investments can strictly follow user acquisition and up-front investment will be kept low.
Anyone who believes in the success of alternative access technologies must see PLC as a significant part of that success. From the material contained in this document it is clear that electricity distribution networks can, in general, provide a workable platform for “powerline as an alternative local access”. There are many technical, regulatory and commercial challenges that remain to be more clearly defined and addressed. The PALAS project partners are continuing to investigate and report on many of these issues and will point to possible solutions.

9.2 Moore’s law – implications and adjustment of hopes

Looking at the history of the development of communication solutions and especially looking into the history of PLC, there is one trend that has helped to solve most of the problems. We can observe that problems will be solved with an increasing amount of processing power. Looking at the number of transistors that can be used to solve a certain communication problem, for the same price the number of transistors doubles every two years. Looking at OFDM it can be observed, that the principle itself has been known for more than 50 years. Only after a series of DSPs processors appeared on the market were technologists able to apply the complex algorithms to practical systems, as a result of this, OFDM started a very successful career.
Since it is possible, in principal, to double the bandwidth simply by doubling the number of modems used (as long as there are available frequencies) it could be expected that the bandwidth available on the PLC bus could double every two years.

But there are still two limitations. First, the frequency range available for PLC is limited. Of course if it is possible to use the whole frequency range form 1 to 30 MHz, with a modulation efficiency of 5 Bit/Hz this would return PLC into a 150 Mbps system.

On the other hand not all frequencies can be used. In addition to that, it has to be expected that in-house and access PLC have to define their co-existence. This will also diminish the overall estimated bandwidth.

9.3 Conclusion – The way forward

The time has come for utilities to help to vigorously develop the PLC platform. It is in their best interests to organise a strong market pull and to influence specifications and developments in a way that future solutions can be made to fit precisely the utility's requirements. This is particularly true for coupling to the electrical network. The PALAS partners are working to facilitate a workable Utility/technology interface in activities planned for the remainder of the PALAS project.

Utilities and technology developers must embrace the fact that they both have a lot to learn. Every trial, every installation, is vital to generate a sound knowledge base for future developments. It is unrealistic to believe that a complete solution will appear on the market overnight.

To develop the PLC market to realise the benefits of the information society for Europe both by accelerating its emergence and by ensuring that the needs of individuals and participating enterprises are met, requires that all potential and actual users take part in practical exercises and trials. Powerline communications holds an enormous potential for our community, which will be unlocked through the co-operative efforts of both the Utility and technology sectors working toward a common goal.

10 *Annex I*: Interviews with PLC technology providers

10.1 Observations concerning current technology developers

The work in producing this initial Technology Inventory has highlighted the highly dynamic nature of the PLC industry and the importance of remaining current with the many significant changes in emphasis, regulatory impact, technological approach, commercial casualties, births and rebirths. All but for a few notable exceptions, the PLC industry appears to have been under-resourced, being based largely on start-up companies working on seed capital, meeting the needs or attempting to attract equity investors and driven hard to follow a strategy which would ensure short-term survival and not necessarily serve the best interests of the power utility industry**.** Against this background and in view of the unwillingness of companies to release prototype equipment for Independent public domain evaluation, the inventory represents the best available public domain information which is available at the present time. It has been obtained using a combination of in-depth face-to-face interviews, telephone interviews, e-mail correspondence and searches of available public domain resources. Participants were selected from research of available data bases initially provided by the International Powerline Communications Forum supplemented by further research.

10.2 Technology developers questionnaire

The following was presented to each of the technology contributors:

Electricom Ltd is a member of a European Commission funded study consortium (PALAS) investigating Powerline as an alternative access technology. In addition Electricom has been commissioned to write a number of reports and articles for Power Economics and other publications which will reach a wide audience. You are invited to participate initially by responding to the following from David E Hines. deh@electricom.co.uk

Questions asked:

1. Are you intending to enter the Powerline access or in home market?
2. Which other companies are you associated with in terms of Ownership, Partnering, Sponsors and Investors?
3. What is the name of your Chief Executive in your Powerline Business (to be quoted in any articles written)?
4. What is the contact name for E-mail or further information?
5. What is the number of employees in your Powerline communications related business, and or what is the market capitalisation if public company?
6. Will your system/equipment co-exist without change with other technologies or with new or proposed standards in your chosen market territory?
7. Is your system easily changed to allow it to co-exist with other technologies / new standards?
8. Are you ready to go to market? If not what are your projected time scales and initial projected levels of sales?

9. What is your product, chip, system, services?
10. Who are your competitors with respect to your chosen market?
11. What is your projected data rate?
12. What is your projected frequency band?
13. What is your target price range?
14. Where are your chosen market territories?
15. Who is your customer?
    - Computer or other equipment manufacturer
    - Electricity Utility
    - Telecommunications operator
    - ISP
    - End User
16. Any other comments you would like to add?

10.3 In-depth Interviews.

Transcripts of in-depth interviews concerning developing technologies, roadmaps and strategic approaches. In-depth interviews concerning roadmaps and strategic approaches

10.3.1 Question 1: "Are you intending to enter the Powerline access or in-home market?"

DS2:
Both of them.

Ascom:
Ascom Powerline Communications is a system for access (last mile) and in-house which can be installed combined and stand alone as a access or in-house system.

Enikia:
ENIKIA: Yes to both of those.
QUESTION: Enikia emerged as an in-home company so there have obviously been some changes. Can you describe how Enikia are getting into the access market.
ENIKIA: Enikia has been in business for 3 years and we originally started our studies based upon in-home technologies. Then as we watched the access market evolve, and with NOR.WEB efforts going forth then with the demise of NOR.WEB, we saw an opportunity there because there were a lot of people that were counting on that technology to work, and it did work in many cases. But with the demise of NOR.WEB they were asking us whether our technology could be applied to that and we believe that it can. So approximately 6 months ago we began to undertake a study to figure out how we would do this, as a technology supplier, not as a systems supplier.
QUESTION: To the Power Distribution Executive he might say, this is fools rushing in where angels fear to tread. What would you say to him?
ENIKIA: I think that the biggest challenge that we run into overall is that there have been a lot of very good companies who have tried to solve the powerline communications problem. I think that just by taking a look around here (Ce-BIT) with the number of companies here, that many people are now reaching the conclusion that someone is going to solve it very soon, if it hasn't already been solved. Naturally we would like to think that Enikia has a special edge on it because we've learnt a lot about communication over the past few years, especially with cellular network and with the activities that NOR.WEB had, so there has been a great deal of discussion and understanding. I think that people have sussed it out a little bit better than they had earlier.
QUESTION: So the fact that the big boys walked away from it has not deterred you then?
ENIKIA: Well I think that, to the best of my understanding, the reason the big boys walked away from it was a short-term issue, that naturally they were focussed on profitability and they had to have an immediate return. And to the best of my understanding, as I talk to some of the people in Northern Telecom they said that the whole problem that they had was that they had to be able show they could return a profit in 18months.

NAMS:
NAMS: We are in the layer of system level, we intend to approach the market in 4 layers; 1 is how to market meter reading which is the very basic because we are already, for many years, doing electronic metering, so we have a communication group and we are now enhancing our activity into PowerLine communication. We already have systems which are doing automatic meter reading, not necessarily through the PowerLine. So it's either radio, or smart-cards, three phase systems and so forth and this is something that is very straight forward to us to look into the PowerLine communication. But this is not our aim - our aim is to go far beyond that. So there is a command and control which is the second layer. The uniqueness of command and control and AMR is actually the need for limited bandwidths. So this is something which is available existing and could be implemented in a very short time. We are aiming towards the third level which is the access for the ability to bring on the PowerLine network, to bring in communication in speeds which will allow voice, internet, data, and so on. So this is the third layer. The fourth layer is also to allow the in-home or in-house networking. We are not manufacturing the components, so we are not the company that's doing what you can see around here (Ce-BIT). We are approaching this market as a system company using those components, and we are trying to bring them together so at least they will be able to talk to each other so, we as a system providers will be able to provide systems that will be approaching the market of the ESP's for the benefit of the ESP's and the customers.
QUESTION: I understand that those are some of the things for the future. Currently I would imagine that your first offerings would be meter reading using the PowerLine communications systems, am I right about that?
NAMS: We are doing everything in such a way that it won't be contradicting so it is a layer after layer, having additional added values to the customer and the ESP's, so once we are starting such programme it will be continued by adding a PC Board or replacing a PC Board, but not changing dramatically the whole infrastructure.

Alcatel KE:
ALCATEL: We have done the development on the middle voltage range from 4 to 20 kilowatts.
QUESTION: Would you call that the "back-haul", more than the access market?
ALCATEL: Yes. Also we are providing the access for the industry, which has direct connection to the middle voltage range, like banks or something like this. People who have direct access to the middle voltage range and are able to have data transmission to these big customers. Energy customers.
QUESTION: So this is quite different?
ALCATEL: I think so.

ITRAN:
We have solutions for both. We might create a different group that will take care of outside the home maybe, but definitely we have approached both markets and come up with solutions from the physical level up to the networking level.

Keyin:
Yes we are doing both of them.

Oneline:
ONELINE: Both. What we're trying to do is create a platform for our service portfolio, with whom we want to enter the market, so it's not a technology-driven approach, it's a service-driven approach.
QUESTION: So it's a service-driven approach covering the whole spectrum of the Powerline communications industry from the substation to the socket on the wall?
ONELINE: Exactly.

Polytrax:
We are in the in-home networking market. Currently we have no plans to enter the Powerline Access market.

Tesion:
TESION: For us both possibilities are very interesting. Mainly for Tesion as a telecommunications provider, the access system is very interesting, but also in addition with other access systems like ADSL or Point-to-Multipoint or other technologies, the in-house Powerline systems are also very interesting.
QUESTION: Is that something which you might actually produce and sell, or something you might buy from other people and sell to your customers?
TESION: It's written in the newspapers that we have a partnership with Siemens, with a possibility to have our own company for production of in-house and access technologies. But we also are open and not fixed to Siemens to use also other equipment for in-house or access technologies.

Siemens:
QUESTION: I see that you are developing for both in home and access. Are you concentrating more on inhome than access.
SIEMENS: Both sides, equally.

Cogency Semiconductor:
QUESTION: Are you still going in for access or have you quit that market?
COGENCY: I wouldn’t say we’ve quit it completely but we’re not really doing it in the short term.
QUESTION: Nothing in the short term.
COGENCY: Primary focus is to do home networking first.

Electricom:
Our primary focus is Powerline access solutions.

10.3.2 Question 2: "Which other companies are you associated with in terms of Ownership, Partnering, Sponsors and Investors?"

DS2:
The reply to this question is confidential, although we will be able to tell more during the coming weeks.

Ascom:
The project is a 100% Ascom Powerline Communications AG project, incl. the patents.

Enikia:
ENIKIA: We are private company, which has been privately funded up to this time.
QUESTION: In terms of partnering, I see that you have an announcement with ONELINE. Can you describe that to us?
ENIKIA: We have just announced at the show (Ce-BIT) our relationship with ONELINE. In this case ONELINE had done an investigation of the technology that is on the market, and as I said our focus is on being on a technology supplier. So in this they have chosen our technology as being the technology they wanted to introduce for the in-home and we've based the structure on that basis because they will be supporting our in-home technology for provision in systems that they service for customers.
QUESTION: So your in-home technology will have to interface with their existing access technology. Is that correct?
ENIKIA: That is correct.
QUESTION: Does that not produce some kind of conflict between your now stated position of moving into the access market. Are you going to use ONELINE's access technology, or how are you going to deal with it?
ENIKIA: We are in discussions with ONELINE at this time as to how we will take a look at the technologies and learn from the best of both of them. In this case there may be aspects of our technology that get developed into ONELINE's and there maybe aspects of theirs that come into ours.
QUESTION: So you don't see a conflict then?
ENIKIA: No, as a matter of fact the biggest challenge which we really run into is that they have to be compatible between the in-house and the outside, and so ultimately the same problem will occur with anybody that is trying to do it, so why not try to solve it ourselves.
QUESTION: So getting those two systems to work together happily is the next little challenge to be dealt with then.
ENIKIA: Yes that’s exactly what we are trying to do.

NAMS:
NAMS: We are talking just about those companies who are doing PowerLine communication interface and they are using the same technology as Texas Instrument, as IBM, Intel and others. OK, so we are trying to be very open to all of them and we are trying to get the best out of what is available. It might happen that we might be more involved with one of the providers. We are part of a group, there is a group called NISKO, its a company in Israel, the stock exchange market, and we are now approaching the private placement, we are aiming for public placement later on. I believe it will be within a year.

QUESTION: You are private company? Owned by a public company, and the private company will go to market in about 1 year – under the name of NAMS. And are there any other companies that you are associated with in terms of technology partnering, do you have any associations that you can speak about in the public domain?
NAMS: At this point of time, no.
QUESTION: But you expect that might change.
NAMS: Yes, we are working on it.
QUESTION: Do you have any private investors other than your public company.
NAMS: At this moment we have the owners of the company and we are in the process of having private equity investors coming in.

Alcatel KE:
QUESTION: And which other companies are you associated with, or is there another company that owns Alcatel?
ALCATEL: No, it is Alcatel.
QUESTION: A public company.
ALCATEL: A public company. We are from Alcatel Kommunikations-Elektronik here in Hannover, but we are a direct daughter from Alcatel.
QUESTION: In this business of medium voltage access technologies are you partnering with any other companies at all, are you doing it entirely on your own?
ALCATEL: No, we have done it always on our own.

ITRAN:
ITRAN: We are a private company owned by shareholders, which are comprised from the founders and the employees of the company. We have private equity invested in the company, and lately Microsoft has invested in Itran too.
QUESTION: Are you able to tell me the size of that or the percentage?
ITRAN: Most of it was by Microsoft, so it was Microsoft and internal investors. I can tell you that Microsoft are far from having any control on anything.
QUESTION: We did wonder, I must say!
ITRAN: But we do have a Microsoft board member - one.
QUESTION: Which is usual when you have a substantial equity partner, they usually like to put someone there to look after that. In terms of technology or partnering, are you working with any other company, particularly with regard to your technology?
ITRAN: No, we are discussing quite a lot and trying to bring partners into what we are trying to do. We feel that we have a unique solution, especially on the price point here, so we are of course attracted by a lot of semiconductor companies and by major OEMs. Nothing has been signed yet but I hope to see things coming soon.

Keyin:
It is a private company. Our CEO is a major shareholder, and we have certain funds from venture capitalists. We don't have any technology partners, we develop everything by ourselves.

Oneline:
Our main shareholder in this is Preussen Electra, which is 100 percent owned by VEBA, and it's VEBA's power company.

Polytrax:

POLYTRAX: We are a privately held company. We have a partnership with Texas Instruments.
QUESTION: Do they have some investment in your company?
POLYTRAX: No.
QUESTION: Is it the intention to have a public offering at some point?
POLYTRAX: This I can't tell you - it might be, I don't know!
QUESTION: I ask that question because we get an awful lot of interest in terms of investors who are looking to put money into PoweLine companies.
POLYTRAX: We are a venture-capital funded company...
QUESTION: So obviously that's the ultimate exit route for your venture-capitalist friends?
POLYTRAX: Yes.

Tesion:
TESION: Tesion is owned by EnBW - Energie Baden Württemberg, the south-western electricity utility in Germany and Swisscom the Swiss telecoms company, both 50%.
QUESTION: And when was that formed?
TESION: Tesion was formed in 1997 together with Swisscom, without Swisscom it was formed in 1995.
QUESTION: So you are currently in the telecommunications business and you are providing real customers with real services and you're probably better placed than most people to understand some of the problems.
TESION: Yes, let us say that we think we are an experienced telecommunications provider, we have glass-fibre rings with 3600 km distance, 200 GHz bandwidth and we offer a data service, we offer voice services and we offer the full service portfolio in Internet services from Internet surfing to e-commerce housing and so on.
QUESTION: So PowerLine really is just a small part of your portfolio?
TESION: That is correct, PowerLine is one portfolio with the target groups between Home customers, the Small Office/Home Office and the Small to Medium Enterprise.
QUESTION: And you're partnering at the moment with Siemens as a supplier, they are presumably a supplier to you?
TESION: Yes.
QUESTION: Do you have any other official supplier partnerships or anything of that nature?
TESION: This is the only alliance we have, we have other suppliers and in the test other equipment under use, but the only strategic is now with Siemens.
QUESTION: What is the logic behind that alliance?
TESION: The problem was that our manufacturer last year stopped producing the equipment because of its own strategic aspects. Powerline was in competition with other access technologies, mainly to the glass fibre and the glass fibre market assures more revenue this year and next year than Powerline, because Powerline will come perhaps next year and the revenue will come in two-years Because of that the problem is I can understand for a manufacturer who has not enough man-power that he stops the activities on Powerline to use this man-power in that businesses he can earn at once money. That is the logic.
QUESTION: Many people who are in the power distribution industry look at that and they say there must be something wrong with this business if those guys walked away, what would you say to that?

TESION: That is the problem where activities are over-interpreted - in many cases industrial strategic decisions are made from strategic political aspects not from technological, and because of that, for instance, we have had many developments in digital television, but up to now we have not the success to position it or develop other developments in consumer electronics.

Siemens:
SIEMENS: We have published our co-operation with EnBW which is our preferred partner.

Cogency Semicondutor:
COGENCY: Not public information.

Electricom: We have a mutually exclusive design/manufacturing agreement with BICCGeneral who manufacture PowerLine access coupling devices and ancillary equipment.

10.3.3 Question 3: "What is the name of your Chief Executive in your Powerline Business? (To be quoted in any articles written)"

DS2:
Jorge Blasco

Ascom:
Daniel Martinez, CEO
Marcel Graber, Head of Marketing & Sales
Dr. Weilin Liu, Head of R&D.

Enikia:
Bob Dillon

NAMS:
Rom Gamfni, CEO
Igal Karny, Vice President for PLC Business Development

Alcatel KE:
Enno Borchers

ITRAN:
Avner Matmor

Keyin:
Dr. Lee

Oneline:
Dick Mensing

Polytrax:
Dr. Werner Pohl

Tesion:
Jürgen Unfried

Siemens:
Ludwig Hiebinger.

Electricom:
David E Hines, CEO
Dr. John Dickinson, Head of R&D

10.3.4 Question 4: "What is the contact name for E-mail or further information?"

DS2:
ann.whyte@ds2.es
jvbc@ds2.es

Ascom:
marcel.graber@ascom.ch

Enikia:
bdillon@enikia.com

NAMS:
i_karny@niskometering.com

Alcatel KE:
enno.borchers@kecam-han.de

ITRAN:
avnerm@itrancomm.com

Keyin:
shlee@keyintelecom.com

Oneline:
mensing@oneline-ag.de

Polytrax:
werner.pohl@polytrax.com

Tesion:
juergen.unfried@tesion.net

Siemens:
ludwig.hiebinger@icn.siemens.de

Cogency Semiconductor:
gwilson@cogency.com

Electricom:
deh@electricom.co.uk
jd@electricom.co.uk

10.3.5 Question 5: "What is the number of employees in your Powerline communications related business, and or what is the market capitalisation in public company?"

DS2:
23 employees, growing to 40 by YE-2000 and 60 by 2001.

Ascom:
Today, about 35 employees are related to the project, but this number will shortly be increased. – (No answer given to the market capitalisation question).

Enikia:
ENIKIA: We currently are employing about 45 people.
QUESTION: Where are those 45 people based?
ENIKIA: The vast majority of them are in the United States, right now, we have 2 employees in Europe and we are looking to staff up.
QUESTION: Enikia is a private company. Am I right in assuming that you would at some point go to IPO, in what, what kind of timeframe?
ENIKIA: That would be a target for us. Effectively Enikia's goal is to broaden the market for this technology and we believe that with our technology that there be the opportunity for moving to IPO or acquisition.
QUESTION: You probably have some equity partners?
ENIKIA: We have some investors that have made in but a lot of that hasn't gone public at this time.
QUESTION: I get constant enquiries from investor groups who are looking for funding.
ENIKIA: Enikia right now is going through a round of venture funding, and it should close very quickly, but there will be additional funding required because ultimately a lot depends on the philosophy of the people you are talking to when you go IPO. It used to be that you had to have 18 months of sales and profitable and we won't have products to ship until at least third quarter of this year (2000) and that would put it 18 months beyond that, but I don't think it will take that long.

NAMS:
NAMS: The company as a whole has between 50 and 60 employees, and out of them directly connected to the PowerLine communication is about 12.
QUESTION: What would the market capitalisation of NISKO be? Do you know?
NAMS: No

Alcatel KE:
Less than 20.

ITRAN:
ITRAN: We have 45.
QUESTION: OK. You're not public so you've no market capitalisation.

Keyin:
20 to 25.

Oneline:
ONELINE: At present, around 30. And it will be between 30 and 50 people in the short term.
QUESTION: This presumably is a private company not a public company?
ONELINE: It's a private company.
QUESTION: OK. So it doesn't have a market capitalisation at the moment?
ONELINE: Not yet. Of course, it has, but not calculated yet.
QUESTION: And would the prospect be to take that to I.P.O.?
ONELINE: Yes, within two years.

Polytrax:
Currently it's a little bit above 20.

Tesion:
TESION: All in all, about 50 to 60 persons.
QUESTION: And are you a public company or a private company?
TESION: Tesion is privately owned by EnBW, but EnBW or Swisscom is in the majority a public owned company.
QUESTION: But in terms of Tesion it is a private company that could be floated at some point in the future. Do you imagine that company would be floated? Will Tesion always be a private company?
TESION: No, it is more possible that Tesion gets more a private company, that for instance the shareholders Swisscom and EnBW brings the company to the stock market and then takes in private finances. It would be possible.
QUESTION: I ask that question because there is a lot of interest in companies which are currently private in the Powerline business that will ultimately float and go on the stock market. People are looking for the companies to buy shares in and so on, and I just wondered if Tesion might be one of those. Most people say that they are going public in one or two years
TESION: It is not planned.

Siemens:
QUESTION: Number of employees that you are involving?
SIEMENS: This is something that is not for public information

Cogency Semiconductor:
COGENCY: Approximately 35

Electricom: 20

10.3.6 Question 6: "Will your system/equipment co-exist without change with other technologies or with new or proposed standards in your chosen market territory?"

DS2:
Yes.

Ascom:
The co-existence of our system with other PLC technologies is a project target.

Enikia:
ENIKIA: Well at least all of the systems and equipment need to be able to co-exist because they have everything from X10 and CEBUS devices out, other people are apparently selling meter reading, automatic meter reading capabilities and so the technology has to be compatible with those things as it moves on. And it needs to be done without change to the technology.
QUESTION: But can it, that's the question, we know it should, but my question to you is, because things have moved on so quickly, do you see that the technology that you are bringing to market is future proof, or do you have to go back to make another chip or do you fix it in the software?
ENIKIA: At this time I believe that through our studies with the technologies that are available today that we are fully compatible with all the technologies that I know of, including those that are proposing to come out.
QUESTION: If it turns out that its not?
ENIKIA: Maybe I should restate that because when I am saying compatible it doesn't mean it works with it, it means its non-interference.
QUESTION: So it's compatible but not interoperable.
ENIKIA: Right, and I think the next big step for the PowerLine technology will be to make it compatible and interoperable. There will have to be standards to be borne. The real challenge in this is that, having taken a page out of the home phone line network alliance, I believe that the standards will be established much more from a commercial standpoint rather than the traditional standards committees - just because they occur much more quickly. They will then be followed up by standards groups, who I believe will tidy up and improved upon.

NAMS:
NAMS: Very simple. For the first 2 layers, which I mentioned before, which is the AMR command and control? we are within Europe, we are within CENELEC. So it is within the standard, We are within the limit. Regarding the wider bandwidth, which we are aiming towards 10 Mbit per second, there is a process of regulation. There is already some suggestions to allow transmission over that frequency, since this is a common thing for the whole PowerLine communication industry, I believe at the end of the day there will be some new standards which will allow to transmit on the PowerLine.
QUESTION: How will that affect your product, will you have to redesign to make it function within those, if people are putting those signals on the same connections that you are using?
NAMS: Not really, as I mentioned before, since we are a system company, we are relying on the PowerLine front-end, which has actually to comply with those standards, so whenever those components at the front end will comply with the

standards, our system will comply with the standards. So from our perspective we are not so sensitive about that.

Alcatel KE:
N/A

ITRAN:
ITRAN: Well you know that we have two lines of product, one is the low speed and the other one is the high speed. The low speed works in the United States within the frequencies allowed for the utilities for use by Powerline. We did design our chip to be compatible with CEBUS that's our low speed. And we will also design it to at least co-exist with X10 so it won't interfere with X-10. Regarding the high speed, there's nobody there that dominates the market.
QUESTION: It's difficult to say?
ITRAN: It is difficult to say. I can only tell you this, Itran has a positive approach towards standardisation. We're not forcing our solution, we think our solution is the best, it's a low cost and so-forth, but we believe that in order to bring a product to market, there has to be a standard. A mass-market, I mean a big market. We want to participate and contribute to the standard, because we feel we have a lot to say, unlike some of our competitors. We want to see a democratic forum created. We are sure that whatever the standard will be in Europe and so-forth we will be there with a solution, it will be a good solution, it will be low in cost. So I don't have a problem with it, I hope that they will adopt whatever I have right now so it will save me some time, but I'm 100% behind the initiative to have a standard.

Keyin:
KEYIN: I believe that we are very dominant for the market, we have Malaysia, we have RWE, we have Korea, so we have more pretty soon. So why do we want to co-exist with the other technologies, I don't think so.
QUESTION: You don't need to co-exist?
KEYIN: No I don't think so, our company is the standard.
QUESTION: Your company is the standard for your chosen market?
KEYIN: It's the de-facto standard.
QUESTION: The de-facto standard in your chosen market, you've got it, that's it.
KEYIN: Why we have to follow the other companies and then, you know?, we can open our standard to them, they can follow us.
QUESTION: Well, it's a good tough strategy, it's what NOR.WEB did, yes, do it, go for it!

Oneline:
ONELINE: When you talk about end-user equipment or customer premise equipment, then our technology is fully capable of handling every existing equipment there is. When you talk about co-existence with other Powerline technologies, I certainly hope so it can! The question is the other way round.
QUESTION: It's very difficult because it starts to tease out the real problems which are standards of course, because here we are, people are going to ASIC and building chips and putting millions of dollars into that, into an industry, and they don't really know whether they're going to clash or whether it's going to be a disaster or whatever - it's a real gamble.
ONELINE: Yes, but that's the main reason we chose not to develop a Powerline modem - we're not interested in the modem part, we created the system around it to implement all modem technologies in the world, so when there’s somebody who

makes a better modulation technology, we can implement that. It's just a software upgrade.

Polytrax:
POLYTRAX: We think that inter-operability will be very important and we take this very seriously. There are various competing technologies. We think some of them are rather complementary, for example we are talking about some wireless technologies, so we believe that inter-operability will be very important.
QUESTION: What about other Powerline technologies? What about for instance the relationship between "Access" Powerline and "In Home" Powerline and the necessity of those to co-exist very closely together.
POLYTRAX: Yes, what we are doing in home networking is distributing data in the home and, OK, there are various access technologies - could be phone line, could be access PLC, satellite, could be wireless local loop. For us this doesn't make really a difference, we want to talk to all of them.
QUESTION: And do you think they would be able to co-exist without making any major changes to your product? I suppose what I'm driving at is, how future-proof your offerings actually are in terms of whether you're locked into a chip which is.….
POLYTRAX: No, our implementation is software centric so this gives us a lot of flexibility both in terms of reacting to changing regulations, to make sure we are inter-operable with other technologies, so we decided not to do something which is hard-wired but truly software-centric.

Tesion:
TESION: The actual equipment is not finally developed, that is the first point. It is necessary to reduce the size of the equipment together with Siemens, because of that it is the possibility to change something with the equipment. But up to now we have succeeded in the standardisation and in the Powerline Telecommunications Forum, in the standardisation organisations that we can have a co-existence between in-house and out-house systems. We also think that it is necessary that there exists a co-existent inter-working between different equipment.
QUESTION: And at the moment this sharing the frequency range is the one which you are working with, is that the one you favour or is it one you are stuck with, how do you see that?
TESION: The frequencies?
QUESTION: The in-home range and the access range.
TESION: OK, the idea is that above 10 MHz, in-house applications are good and below 10 MHz the out-house access systems.
QUESTION: And is that sufficient for access? Are you happy with that?
TESION: Yes, yes, that would be sufficient because there exists some access systems, like Alcatel KE's, and this equipment has 500 kHz about 2 megabits and that is very good frequency-bandwidth relation, and if we have such a relationship also in the high bit-rate access systems, we will have the possibility between 3 and 10 MHz to have between 50 to 80 megabits and that is more than enough.
QUESTION: In the United States they talk about "Regulatory Capture" where before the power utility companies awaken to the reality of Powerline that the regulations will be set before they even get a chance to even discuss the matter. Do you have any comment on that? There are very few power companies at ETSI for instance...
TESION: I think this shows the difference in our strategy, we started discussions with the German regulator in January 1998. They recommended how we should work and how to develop equipment, because we are determined to assure that

this investment is not a stranded investment, we tried to use the recommendations of the regulator, he recommended to use dedicated frequencies and we used that, and perhaps have regions with different dedicated frequencies.
QUESTION: But nevertheless the same principle applies?
TESION: Correct. And then we have no collisions with other systems, because of that we think we are in that situation a little bit more successful.
QUESTION: Are you leading the way?
TESION: We have in Germany the experience with the cable TV. We called it the "Wild West" method - nobody cares about that and they offered the services and now there is a strong competition between different interests. We wanted to avoid that because the problem is, if you don't realise that or don't avoid that, you have stranded investment if the other is more successful.

Siemens:
QUESTION: Will your system co-exist without change with other technologies?
SIEMENS: It depends on the other technologies. I think we have quite a valuable solution for co-existence because we have a very bandwidth efficient technology, but of course if the other technology covers the whole bandwidth, then we can’t co-exist.

Cogency Semiconductor:
QUESTION: To what degree are you building an intelligent modem?
COGENCY: Certainly co-existence, what we are building right now is the homeplug 1 compliant chip and coexistence has been built in quite a bit in the planning and the writing of the spec. co-existence with other technologies as a whole, X10, CeBUS - that has been taken care of, tested and it has been proved that it coexists.

Electricom: Yes the coupling unit is invisible to such standards and protocols that are generally expected to be used on power line networks.

10.3.7 Question 7: "Is your system easily changed to allow it to co-exist with other technologies / new standards?"

DS2:
Yes.

Ascom:
Relatively easily.

Enikia:
(See answer to Question 6)

NAMS:
QUESTION: Is it easy to change your system or is it software changeable, do you have to go back to the chip, or how do you change it?
NAMS: As a system it is very flexible and as I mentioned before from day one we were looking for the final destination and trying to see that we were going through several stages which were implementing those layers that I mentioned before.

Alcatel KE:
N/A

ITRAN:
ITRAN: You know, it's difficult to have a future proof technology, There has to be some way that these guys will work together, and my guess is it will have to be one sort of a signal or something very close. It is also possible to address the inter-operability problem by higher layers. If you just fix the channel access mechanism to be common, then the data channel could be different.
ITRAN: But it will bring the total solution higher in cost probably to have a lot of modulation.
QUESTON: No, it's not going to be like that.

Keyin:
(See answer to Question 7)

Oneline:
ONELINE: Very future-proof! All algorithms used to handle the networks are software based, so we can actually embed any modulation technique or new future-proof or other future-proof systems.

Polytrax:
You asked about how flexible or future-proof is the technology. Due to the software centric implementation you can have the same box also running in U.S. or Asia/Pacific where you have the dedicated frequency range below 500 kHz, there it would run perhaps 10 times this speed - same hardware!

Siemens:
QUESTION: To what degree is your equipment intelligent enough to understand the conditions it is working on.

SIEMENS: We have basically bought this idea of adaptability services with the so-called chimney approach, so we have promised the chimney approach, so in our eyes due to the network conditions, we are obliged to be adaptable to the network conditions, so definitely we will have the means and algorithms in our transmission system which provide adativeness for the PLC transmission system to the network conditions.

Electricom:
(same as previous question.)

10.3.8 Question 8: "Are you ready to go to market. If not what are your projected time scales and initial projected levels of sales?"

DS2:
Pilots by mid 2000. The highest performance, lowest-cost chipset by the 3Q/2000.

Ascom:
The project launch is scheduled for CeBIT 01. This summer, we are installing 14 field trials in 12 countries (500 households, buildings and approx.1000 adapters).

Enikia:
ENIKIA: We are forecasting product for third or fourth quarter of the year 2000. Our goal is to be able to have products in the market that are using our technology by the end of the year.
QUESTION: And that would also apply to equipment which would support ONELINE's initiative in terms of them moving forward, would that be the same?
ENIKIA: At this time I can't really quote on some of the details that are going on within ONELINE and their exact timing.
QUESTION: We have already had an in-depth interview with Dick Mensing.
ENIKIA: Dick has been directly involved in discussions and negotiations and I haven't.
QUESTION: All I am looking at is that they are looking to you as a partner to provide an aspect of their offerings. Obviously it is important that you understand when those products are going to be available.
ENIKIA: Dick and I have had many conversations, but I don't know what his public position is, so therefore I would choose not to make ours, but other than to say that we fully intend to support their requirements.
QUESTION: What about the projected levels, are they ones and twos, are we talking about volume?
ENIKIA: We have had a half dozen people come to us and tell us they would purchase everything that we could make. So I don't think that there is really an issue as to the volume. I think the biggest challenge would be the productisation - how quickly we could scale up and produce those.
QUESTION: Where would you produce that, in the States or in the Far East.
ENIKIA: We have the opportunity to work with fabs throughout the world, and indeed part of our philosophy is also to licence our technology so that through discussions with numerous semiconductor partners - it could be just about anywhere depending on where negotiations are.

NAMS:
NAMS: Today we are not ready to go to market. We are aiming towards 1 year.
QUESTION: What sort of level of sales would you project on that, could you tell me about that?
NAMS: I wouldn’t like to give you figures because there are a lot of approaches that you can take, and I mentioned 4 layers. I think that each layer, by itself, is a big market, by itself. I think that the nice thing about it is that it comes together in one package. If we are going to just talk about AMR, I believe that just look at the numbers of new meters that are coming in, you will see that we are talking about big, big figures, and this is just for AMR.
QUESTION: Will you manufacture in Israel or outside?

NAMS: We are manufacturing in Israel, we have also joint ventures in other companies, we invested in some of them in order to manufacture those components.

Alcatel KE:
QUESTION: Are you ready to market what you have?
ALCATEL: Yes!
QUESTION: When can you go to market?
ALCATEL: As soon as possible.
QUESTION: OK, so in three months time if I wanted to order some of this, you could start thinking about delivering?
ALCATEL: Yes, we can.
QUESTION: And if I were to order, what about being a little bit future-proof, what is likely to happen if you then come up with a 10 megabit system, am I then having to buy it all again, or can it be modified? How can I be sure that I am not wasting money buying 2 megabits today?
ALCATEL: Ah, with 2 megabits you don't waste money if you are using 2 megabits at the time because a 2 megabits leased line is very expensive, as you know. Therefore you don't really lose money, you are using 2 megabits and in the next steps will be maybe to increase the data rate.

ITRAN:
We are going to start to sell 2.5 megabit/second in Q2. Our chip is in the "fab", we were expecting it to be earlier in the market. It took a little bit more time. In Q2 we will start shipping the 2.5 megabit/second. We are waiting for the samples any day.

Keyin:
KEYIN: Yes we are ready for market. We already have some chip-sets.
QUESTION: You do? All ready?
KEYIN: So we developed them, and our own chip-set you put into there (points at product), you see the chip-set there? That's the pre mass-production model, so we are ready to go, and we have new designs for mass production.
QUESTION: Time-frame?
KEYIN: July time-frame.
QUESTION: Obviously you're projecting quite big levels of production. Your sales levels will be quite substantial?
KEYIN: You can say so.

Oneline:
ONELINE: I think we're ready to go to market in the sense that everything we need is there. In terms of production capacity that's one of the things we have to solve, we're addressing now. The second thing of course is regulatory issues which have to be cleared.
QUESTION: With regard to regulatory issues, you know full well that that's not likely to be sorted out for a couple of years.
ONELINE: No, in Germany it's a little bit different. We have a de-facto regulation already in place, which is used by the regulatory bodies, and it's now within the main Chancellor's office to be decided within the next two months.
QUESTION: And you are fitting within those standards / limits?
ONELINE: Oh yes, absolutely.

QUESTION: How do you see it beyond, in terms of going out to Britain and beyond to America and suchlike?
ONELINE: We already did some testing in some networks abroad where we had very good results from that, so our aim is in the very short term to make our system work in other countries as well.
QUESTION: Time-scales, with regard to Germany it is right away, time-scales with regard to places abroad, maybe roll out later this year perhaps?
ONELINE: Roll out will start next month (March 2000). When we go to the large trial we will address a territory of approximately 400 households, starting now until the end of the year and our intention is to even increase that.
QUESTION: Tell us about the trial you are proposing.
ONELINE: The trial we are proposing now is under discussion with the power utility. We're investigating the networks, feasibility of networks, not to select the best network but to see that we have a large variety of networks, and that we can very broadly test the acceptance and technical features of the products.
QUESTION: That's here in Germany?
ONELINE: That's here in Germany.
QUESTION: Can you tell us the name of the utility you're working with?
ONELINE: Yes, Avacon, it's the largest regional distribution company.
QUESTION: Where are they based?
ONELINE: They're based in Helmstadt - it's the largest utility, 1.1 million direct addressed customers. We have some potential there!

Polytrax:
POLYTRAX: We are very, very close to market.
QUESTION: So if there was a customer you could supply them in six months?
POLYTRAX: Yes, sure! Most probably earlier.
QUESTION: Any feel for your projected levels of sales? Do you see this being a sharp take-off or a shallow take-off, where do you see that?
POLYTRAX: We think it will follow the trend, which some analysts are forecasting for the overall home networking market.
QUESTION: Which is?
POLYTRAX: Which is significant growth. Very steep, all the forecasts.
QUESTION: So you believe that forecast?
POLYTRAX: Not the exact figures but the trend.
QUESTION: Have you done your own research?
POLYTRAX: Yes.
QUESTION: Does that confirm that belief?
POLYTRAX: Yes, otherwise we wouldn't have that focus on home networking.

Tesion:
QUESTION: You've already told me you're not ready to go to market, you'll be ready in about a year, six months?
TESION: We think and hope that in a year we are ready for market.
QUESTION: And that would be with the Siemens equipment would it?
TESION: Yes, we concentrate now on the joint development and we say we are focused on Siemens not fixed on Siemens.
QUESTION: Right, so Siemens are on the critical path now, are they?
TESION: Yes.
QUESTION: So all the pressure is on Siemens to come up with the hardware and the software to make it work?

TESION: Correct. We think we are the most experienced network provider or grid user, electricity utility or telecoms provider in the framework of Powerline because we've about ten different many different systems.
QUESTION: So you can compare?
TESION: We can compare, but due to the stop of activities in NOR.WEB we realised that it is not only necessary to have that experience, it's also necessary to give the manufacturer the security that we are interested in the success of him and because of that we have that alliance.
QUESTION: OK, give me some feel for the projected levels of sales, what are you looking at? Have you some projections, can you tell me anything, is this going to go slowly, quickly or dare you say anything at all?
TESION: The services we want to offer are in mainly different areas, from automated meter reading for new tariffs and new services of electricity to telemetric data in the energy surroundings at a local power plant. We have spent one and a half years on this test.
QUESTION: I mean there are huge savings to be made in the industry by managing it more intelligently.
TESION: Yes, correct, and also to offer a central service, technical service, with de-central equipment.
QUESTION: Just going off at a tangent at that point, obviously the intelligent management of the power system was the original purpose of the development of Powerline technology, that is why it was developed originally, and then of course telecommunications became the flavour of the year and it became the thing to do. We've just seen this enormous increase in the value of VEBA for instance, relative to their recent announcement. Do you feel that the same thing would happen to other power companies that actually announce themselves moving into the Internet world?
TESION: Yes I can imagine because the Powerline business has a great opportunity, a great chance, it is in my eyes more an addition to the existing access technologies than an alternative, but it is a real alternative for Internet business because existing dedicated access systems are not really optimal adopted to Internet business. With Powerline you have more of a LAN or a Wide Area Network and that is ideal for electronic commerce and, because of that, many interested people know about this chance it's because of that they think this is a great field, a successful field for business. The public strategy of our company is now more oriented that we offer in this situation when we have directly in front with a fixed date this service, when we can start.

Siemens:
QUESTION: When will you be ready to go to market?
SIEMENS: Yes, first half next year (2001)

Cogency Semiconductor:
QUESTION: When will you be able to go to market?
COGENCY: We are talking silicon in the beginning of 2001.

Electricom: coupling units are currently available for trial purposes on a short run build basis. Custom products are available to order on approximately 10-week delviery, and volume product with commensurate savings in price require orders in excess of $300K.

10.3.9 Question 9: "What is your product, chip, system, services?"

DS2:
* Broadband PowerLine access chipset
* Narrowband PowerLine access chipset
* LAN PowerLine chipset

Ascom:
We are designing our own Chip. The business mission includes selling systems and in addition act as a system integrator as well as a solution provider.

Enikia:
ENIKIA: We are a semiconductor manufacturer and we also licence our intellectual property with other semiconductors, because we think that this will be a way to achieve standardisation in a very broad scale acceptance of the technology.

NAMS:
NAMS: What we are providing is a system, and the system is divided into several elements and those elements are implemented either into separate units at home somewhere on the net, but definitely also electronic meters. This is where we are starting, so it will be integrated within the electronic meter, it will be on the net as a concentrator and gateway and it will be in-house with equipment which is going to use this kind of communication.
QUESTION: You are not actually manufacturing a chip, you are going to buy that from third parties?
NAMS: We do design chips. We do have some chips that we implemented in some of our equipment. For the purpose of PowerLine communication we are not designing the chip. We are incorporating, by integrating some of the chips on the market.
QUESTION: And the chips that you have seen, will they do the job or do they need to be modified to do your job?
NAMS: As of today the chips are still in development phase. We are working together with those companies, we are bringing them knowledge and our needs in order to modify and to adapt to our requirements. I think we are very close to first generation of such components.

Alcatel KE:
ALCATEL: What we are selling is the transmission system of the data, we are selling also for the installation of the coupling units and so on.
QUESTION: So there's the coupling units, the modem...
ALCATEL: The modem, the management system...
QUESTION: Are you buying the modem or are you building it?
ALCATEL: No, we are also building the modems in our own company.
QUESTION: So they have chips in them, do you make the chips as well?
ALCATEL: Yes, as well.
QUESTION: So you're very vertically integrated aren't you? You're not dependent on anyone else at all?
ALCATEL: For the time being we're not dependent.

ITRAN:
ITRAN: Right now our business model is to sell chips, do some licensing in some cases and sell reference designs.
QUESTION: So the board that we've seen, will that be something that someone else would construct?
ITRAN: It is kind of a reference design, and if we get the price lower and [at] some point customers might want it. We don't know, but this is a board that is particularly more for evaluation and a kind of first version of a reference design for USB.

Keyin:
KEYIN: Everything! We have a chip-set, a design for the modem, the in-home coupler and a Powerline hub.
QUESTION: So you go all the way to the sub-station?
KEYIN: Exactly, so that's why we put in the whole system at RWE.
QUESTION: What about medium voltages, have you anything on the medium voltage?
KEYIN: Not at this moment.

Oneline:
ONELINE: Both, a system and service.
QUESTION: A system and service but not a chip?
ONELINE: Not a chip.
QUESTION: No, you'll buy the chip from [who]?
ONELINE: We have a chip product as well but the question is always "Everyone is working on a chip", so whether ours is the best... may the best man win!

Polytrax:
POLYTRAX: Some kind of mixture. But first of all it's a technology.
QUESTION: Well, first of all, are you making a chip?
POLYTRAX: We decided all the important things are on a DSP.
QUESTION: DSP, right, and will it always be so?
POLYTRAX: I can't tell you, I don't have a crystal ball!
QUESTION: And so, what is it you are actually selling?
POLYTRAX: Our business model is "business to business". We don't intend to manufacture products for the consumer, for the end-user.
QUESTION: For them to build that into their product? So your customer then would be a computer or other equipment manufacturer?
POLYTRAX: Right.

Tesion:
QUESTION: You're not offering a chip, that would come from Siemens. Presumably Siemens would also build that into a system, then you would offer the service? Just dropping to (Question 15), who would your customer be then, are you looking to start selling your services to other electricity companies or are you going to remain offering your service to your local end users? Where do you see yourself in two years time?
TESION: We think it will be a very wide range of customers. It will be targeting end users in the field of private customers, SOHO's and Small-Medium Enterprises but also we want to offer it to carriers, to electricity utilities, but also we can imagine that ISPs are an interesting user group for PowerLine to assure them the possibility of access to their customers. Last, but not least, also we think that the

other telecommunications operator, mobile or fixed, are interested in an additional access system.

Siemens:
QUESTION: Are you producing a complete product or chip set?
SIEMENS: A system solution.
QUESTION: So a power utility could come to Siemens and get a complete solution?
SIEMENS: Yes, yes.
QUESTION: Would that include the apparatus for in home would it, or would you be selling that separately.
SIEMENS: We will be able to provide a complete solution. It depends on the customer's interest, if he wants to buy an in-house solution from us, or if there is another one, and so we have to check if this co-exists with our solution. We are flexible of course, but we are able to provide a complete solution.

Cogency Semiconductor:
QUESTION: Are you developing chips or systems?
COGENCY: Definitely just chips. So what we are developing is chip set for a total integrated solution, low cost.
QUESTION: So you are looking to manufacturers to buy the chips aren't you?
COGENCY: That's right.

Electricom: Coupling units, technical training courses and consultancy.

10.3.10 Question 10: "Who are your competitors with respect to your chosen market?"

DS2:
Siemens, Ascom and, others, although their data rates and R&D are well behind that of DS2. They are more potential customers than competitors. In the LAN area the competitors are Intellon, Enikia and others, though their solutions are more expensive, have lower performances and higher radiation levels.

Ascom:
All world-wide PLC manufacturers.

NAMS:
NAMS: I think that the PowerLine communication market is not yet there and for that purpose I am very sympathetic to every company who is within this business and is able to have market share. We are not competing between ourselves yet, we are competing to have market. We are actually competing with communication companies. Communication companies at this moment do not see us as a threat, the moment we have something that will be competitive, there will be competition between types of technology, PowerLine versus other type of telecommunication. As of now, I think it is not worth to discuss competition between the companies in PowerLine communication.
QUESTION: I am thinking of Schlumberger for instance, they have been looking at PowerLine communications as a means of working with metering and so on for some time. I met them back in 1994 and they were looking at it then, so obviously they are a serious competitor in that marketplace.
NAMS: Schlumberger, Aberger, all of these companies could be there in the future, but as of today its a little bit difficult to talk about competition. Once the PowerLine communication is a normality, the same as having energy in your socket to also have communication in your socket, then we will be able to start talking about competition and market-share.

ITRAN:
ITRAN: We don't have competitors! As I said before we started the company, there was always Intellon there, I don't know the position Intellon has regarding the low speed today, it seems that they gave it up or something. So at the low speed I don't see a big competitor really because we came up with a reliable solution, it goes between phases, doesn't need any phase coupling, and it's still at the low cost at the CeBUS, it is CeBUS compatible, so I don't see much of a competition. On the high-speed I don't exactly know what everybody has, but there's Intellon, Enikia, Intelogis, some companies in Europe of course, Siemens, DS2 and Ascom.
QUESTION: So you're quite well aware of the situation on competition?
ITRAN: Sure, sure. I'm reading their announcements every week!

Keyin:
We don't have any other competitor in the PowerLline area at this moment but we have competitors in other media like ADSL or cable modem, that's why we have to be competitive.

Oneline:

At this time I can't see any competitors in this chosen market because we go into the service industry together with utilities. At the moment what I can see is that most people in the PowerLine industry are working on technology, not in the service part, so I cannot yet see the competition - perhaps it's there, but who knows.

Tesion:
TESION: The situation with competitors has to be analysed due to the target groups. We have Point-to-Multipoint for the customers above 2 megabits, that means there we have no competitors to the PowerLine, where with ADSL or with unbundled access with ISDN with some mobile offers the providers of that services are regarded as competitors. The situation is that many of these competitors are only acting regionally and the national owned Deutsche Telekom is the only competitor who wants to offer access totally covered the whole area.
QUESTION: So he's your competitor?
TESION: Mainly a competitor in telecoms, but perhaps not a competitor, it is also possible that like Tesion buys bandwidth from Tesion, it would be also possible that Deutsche Telekom buys bandwidth for ADSL or others from us over the PowerLine.
QUESTION: So we'll see a kind of a merging, it just becomes a bandwidth market really doesn't it? Who cares how you generate that bandwidth it's just bandwidth really.
TESION: Correct, as in the glass fibre market, we have joined glass fibre lines, built up together between competitors, the competitors co-operate to reduce their infrastructure costs. The competition is then in defining products, in defining services, in defining market plans, prices and so on. That is the difference.

Siemens:
QUESTION: Looking around the market I don’t see anyone else offering a complete solution, would you say you had any direct competitors? I am thinking that most of the people who are developing technologies are developing chip sets and then it gets into a very small group of people.
SIEMENS: We should mention Ascom.

Electricom:
We currently do not recognise any direct competitors in this field.

10.3.11 Question 11: "What is your projected data rate?"

DS2:
50 Mbits

Ascom:
The projected data rate for the first product generation are:
- outdoor: > 3 Mbit/s (real through-put)
- indoor: > 5 Mbit/s (real through-put)

Enikia:
ENIKIA: Right now our focus is in the 10 - 20 Mbit per second rate - in home.
QUESTION: And what about access?
ENIKIA: Frankly it is too early to tell on the access standpoint. I believe that similar ranges will be possible in that arena.

NAMS:
We are aiming to have 10 Mbits per second, which is something that is reasonable. We are trying to see the whole package because we are trying to bring, as a first layer, AMR, Command and Control and other applications, which is straight forward, the technology is ready and the bandwidth is not a limitation as it is in the high speed data rate. But we are aiming towards 10 Mbits. We also have to mention that we are not talking here about point to point. We are talking about a topology which is a tree topology and over there we have to share between the users and it depends how many users are linked, how many of them are using high speed data and so forth.

Alcatel KE:
Projected rate is 2 megabits and faster if needs demand.

ITRAN:
So far we're showing here the 2.5 megabit/second which is done already. The other solution that we're bringing in is the 12 megabit/second. We're showing now at this show (Ce-BIT) for the first time, the first evaluation board of this technology. This chip is going to go to the "fab" at the end of this year, I'm not sure exactly what month. If we do it right we're expecting to start shipping somewhere around Q2 next year. Hopefully experience with our first chip will help us, although it's using a different modulation. We couldn't just go with the same modulation as the other one, we needed to make some changes, it will be done to be compatible to the first one. Again it will be a very low cost solution, so it's not going to be a high cost solution. We are going to increase the speed of course, we are now considering doubling the speed for the next generation.

Keyin:
Our data rate at the moment is, our chip-set is 2 megabits/second.

Oneline:
The present system that we have, and I explicitly say the present, because that's the first release of the commercial product, has 8 megabit per second capacity on the line, 10 megabit on the in-house part. We very soon want to step that up in

small steps, but that's of course inter-linked to the regulatory question. As soon as we step higher in bandwidth we have to expand the frequency range.

Polytrax:
POLYTRAX: Yes, what we have here are running at 230 kilobits per second, under European regulations, under CENELEC regulations.
QUESTION: But what about in terms of the in-home marketplace, we're hearing numbers of 10, 15, 20, in fact today we heard 25 megabits or some figure, it's astonishing.
POLYTRAX: No, as long as you have to stay within the CENELEC park it's simply impossible. If we are going to megahertz then double-digit data rates are possible.
QUESTION: But that's not what you're offering at the moment?
POLYTRAX: At the moment no.
QUESTION: But they'll run at 2 megabits...
POLYTRAX: Yes 2, 2.5 megabits in the frequency range below 500 kHz.
QUESTION: Below 500.
POLYTRAX: Yes that's the dedicated frequency range. You know of course that in the U.S. you can use up to 30 MHz, as long as you don't disturb other services. With the technology itself you can also go into the megahertz range.
QUESTION: Right, I'm aware of what can be done I'm interested in what you're going to do really.
POLYTRAX: It's limited to the regulations really.
QUESTION: Yes, but outside the regulations, what is possible?
POLYTRAX: Double-digit megabits is possible out of our equipment.
QUESTION: Right, this is where I'm coming from, because this has not been settled yet properly, there is, as you know, a lot of talk about "Regulatory Capture", the fact that the people who really matter still haven't wakened up to the fact that it's going on.
POLYTRAX: For us it's important that we are developing something that's a high priority, that you can use immediately, and with something which offers you the possibility to extend services like ISDN or something like this in the home, that's fine, the speed is OK. For other systems you most probably would need the 10 megabits. If you would like to have streaming media, uncompressed, of course then you need it - then 10 megabits most probably is not good enough at all.

Tesion:
We think that 1.3, 1.5 megabits per second on the access, is enough for the first start-up. We think in three or four years it has to go up a little bit. In the in-house systems we think 10 megabits is more than enough because it's very similar to the 10 Base T Ethernet, and that was considered more than enough. We have for instance in my home Fast Ethernet, but I never use it, and I don't know of any application that could, besides perhaps a large company with thousands of employees.

Siemens:
QUESTION: What are the projected data rates, net to the customer?
SIEMENS: 2 Mbit.

Cogency Semiconductor:
QUESTION: What sort of data rates are you going to be announcing then?

COGENCY: Public information about homeplug is talking about 10Mbit plus, the spec expects it to be 14, so whether we come out with say 14M bit - but its in that 10 – 14Mbit range.

10.3.12 Question 12: "What is your projected frequency band?"

DS2:
1 to 30 Mhz

Ascom:
The projected frequency bands are:
- outdoor: 1-10 MHz
- indoor: 15-30 MHz
based on international discussions.

Enikia:
At this time we don't publish our frequency information. We are currently going through the final patent applications.

NAMS:
We are aiming towards 10 to 20 MHz, not necessarily using all of that, but this is approximately what we are talking.

Alcatel KE:
N/A

ITRAN:
Working on the high speed from 4 to 20 MHz.

Keyin:
3 to 8 MHz.

Siemens:
QUESTION: What is your projected frequency band?
SIEMENS: According to the chimney proposals, this is not just one frequency band, this is a model dividing the access into at least 3 bands, to be used depending on the network conditions.
QUESTION: Do you know what those bands are?
SIEMENS: One is 1.6 to 3.5MHz, the next is 4.5 to 6.5MHz, the third is 7.4 to 9.4MHz.

Cogency Semiconductor:
QUESTION: Projected frequency band, that’s already been designated?
COGENCY: 4 – 24, that’s in-home.

Electricom:
1 – 50 MHz

10.3.13 Question 13: "What is your target price range?"

DS2:
By the end of the learning curve below $10 per node.

Ascom:
Our benchmarks are focussed on alternative access & in-house solutions as well as on main competitor prices.

Enikia:
QUESTION: You are producing chips, so therefore we are looking at price ranges and so on, but chips are chips are chips aren't they?
ENIKIA: Initially they are always more expensive than anybody wants because if you sell more then they are a lot cheaper.
QUESTION: The quick answer is, “Give me an order for 5 million…”

Alcatel KE:
ALCATEL: A few thousand German marks, about a few thousand for the whole system. For one 2 megabit line.
QUESTION: Point to point, 2 Km, a few thousand, done! Finished, no more costs. And is the cost the same for a second one, or do you use the same management system?
ALCATEL: It depends, the cost depends on the numbers of systems sold.

Keyin:
KEYIN: It's difficult to say for the public.
QUESTION: But you’re looking to get a low cost solution?
KEYIN: Right, so we're very competitive against the other media. We don't have any other competitor in the PowerLine area at this moment, but we have competitors in other media like ADSL or cable modem, that's why we have to be competitive.
QUESTION: That's the competition, yes. The status-quo is the competition.
KEYIN: Yes.

Tesion:
QUESTION: Obviously price is a difficult one, you know, sell me a million units and you'll tell you the price...
TESION: Yes, correct!

Cogency Semiconductor:
QUESTION: Do you have a target price?
COGENCY: No I don’t, I would rather comment on the price of the end product - $79 - $99 per unit = 1 modem, 1 coupler, like a netcard.

Electricom:
In volume production between $200 - $500 dependent upon specification and quantity. LV coupling units to be advised.

10.3.14 Question 14: "Where are your chosen market territories?"

DS2:
Worldwide

Ascom:
Outdoor and indoor systems - Europe, South America, Asia and Africa. In-Home only - North America and Japan

Enikia:
What we believe is that PowerLine has huge opportunities, both in the US and outside the US. We believe that PowerLine will move very quickly in the US but we actually see a greater need in Europe, and indeed in the Far East to some degree because of the structure of phone lines. As you may know, the home phone-line network alliance has put in numbers from I believe 4 or 5, on average, telephone jacks in the home in the US, yet typically I hear numbers 1 -2 in places throughout Europe. As such the phone line does not provide an opportunity, so I see that while the authorities that are pulling market numbers will say that US will be a very large market, they typically talk about the rest of the world being at least as large, if not larger, in the PowerLine arena. So our target is to initially introduce things both in the US and Europe and then expand as quickly as we can.

Alcatel KE:
At first we are trying to do the business in Europe and in Germany because we have to get some experiences on this market, and for the technology and so on. I think our business will develop all over the world.

ITRAN:
We’re doing it everywhere.

Keyin:
KEYIN: Everywhere!
QUESTION: Where are you going to start?
KEYIN: We're starting from RWE in Germany and then also we have Korean Electric Power Corporation and then also we have signed contracts in Malaysia.
QUESTION: You've signed?
KEYIN: Yes. And the others we didn't sign yet, so that's why I can't comment.

Polytrax:
We want to be present world-wide. We started in Germany first, as it just happened that the founders of the company are German.

Tesion:
QUESTION: Chosen market territories, at the moment I assume you're sticking in Germany?
TESION: Baden Württemberg, yes correct.

Cogency Semiconductor:
QUESTION: Presumably your chosen market territories, initially the Americas, what about Europe?
COGENCY: We see ourselves in it but that comes second because of the different regulatory regime, emission levels being a bit lower. We have some experience in

that, the homeplug group as a whole has that experience and hasn't quite got their head around, is it still a 14Mbit spec or is it now a 8Mbit spec?

Electricom:
Worldwide

10.3.15 Question 15: Who is your customer?"

DS2:
Computer or other equipment
Electricity Utility
Telecommunications operator
ISP
End User

Ascom:
Electricity utilities
Telecom Operators and CATV operators
OEM: Computer, Brown and White Good manufacturers,

Enikia:
QUESTION: So your customer then is the systems builder, the equipment manufacturer?
ENIKIA: Yes
QUESTION: So there is an intermediate process, or an intermediate space between your stated business and the business of ONELINE who are in the 'service business', Somewhere in-between there, somebody has actually got to put your chip into a piece of kit that actually works and then sell it to them or make it available to them to be able to provide a service. Do you see that there is a gap there?
ENIKIA: As you know, when you start introducing technology, you end up having to deal with system level problems, so ultimately, what has happened is that both ONELINE and Enikia take a look at it from a systems level issue, and work together to help solve the problem in the very short term. And then we went back and took a look at our core competencies and there appear to be a lot of good equipment manufacturers that will want to provide systems for ONELINE to implement. That's not Enikia's position. We would love for our technology to be used by a whole range of equipment manufacturers that are vying for the best system for access.
QUESTION: You want them to buy your chip and put it into their kit don't you? So we have already said, your customer is the computer or other equipment manufacturer. That's your direct customer.
ENIKIA: Because of the way PowerLine technologies evolve, our customer base - we have actually separated into 4 different areas, because we started off with the computer equipment manufacturer and the network equipment manufacturers. We see the consumer electronics manufacturers coming along very soon. Ultimately there will be appliance manufacturers that will want to do this, but then also there are service providers that play a very large part in this because for the home networking aspect, they are the ones that are trying to sell. So ultimately once they put a pipe up to the home, they are going to put a little digital meter reader on the outside and try to get that thing turning as quickly as possible. So it's in their interests, and therefore they would ultimately be driving the market. So they will be creating the demand. We had significant conversations with those total communication suppliers, the RSP's, and now more lately with the activities in the access market, we have been contacted by dozens of utilities here.

QUESTION: Yes, although utilities are very confused, I mean they start talking to chip manufacturers and they should be talking to people to hold their hand to put systems in.
ENIKIA: It used to be that all the people here (Ce-BIT) would be talking about providing systems that go from soup to nuts, and then a few months later, a few years later, people begin to specialise on equipment. And traditionally, from a computing standpoint you do systems, then you did boards, and then you did motherboards and then you did chips. What has happened is that everything has accelerated so fast that Enikia originally developed systems. We learned very quickly that that's not going to be our capability but you need to have a systems appreciation. And so effectively what you end up doing is partnering with OEM's and so we've had numerous discussions with OEM's, that if we find utilities who have the proper telecommunications understanding, and the PowerLine technology and then you also have the OEM's who are able to do it. At that point you will have a true partnership.

NAMS:
QUESTION: So your customer is?
NAMS: Our customer is the electricity utility.
QUESTION: OK, so I'm an executive of a power utility and I've heard about remote meter reading, and it all seems a bit too high-tech for a steady utility company. Why should I be taking you seriously at all, why should I come and talk to you?
NAMS: If I were not able to show you, or you were not aware that there is an added value for yourself or ISP using this technology, then perhaps it will not take off. It has to make sense, it has to have added value to ISP, it has to have added value to the customer in the new deregulated market, where people will be able to select their own energy supplier. Perhaps the revenues that you can have on the added value services will be a good reason for you to come and say, yes, I would like to have PowerLine communication on my existing network.
QUESTION: OK, at the moment there is a cost to perform meter reading, if the utility installs remote metering he has to have some saving on that, of course he makes some capital expenditure and so his cash flow becomes affected, he gets some more capital equipment out there and then he is looking for a return on what is a known cost at the moment. Are you saying he has to wait until he adds other services until it becomes viable?
NAMS: I think that there is a direct return on the investment, which is just by AMR command & control, reducing the cost. Or you may have real time picture of the power consumption - you are able to reduce significantly any losses of energy, which, I don't know how much is today in Europe but I do know that some of the companies do not know how much energy is not collected, or money is not collected. I believe there is an economical basis to return investment just on the very basic 2 layers, the applications you have just with AMR should be enough to make an economical reason. And if you add, on the same layer, command and control like fire alarms, like street lighting control, I think that you have significant added value. And as I said, we are looking for wide-band applications. There is competition, by the way, and if the PowerLine communication goes too slow, there will be alternative solutions which will not allow PowerLine communications to take off.

Alcatel KE:
QUESTION: Who would your customer be?

ALCATEL: Our customer would be local carriers, fixed carriers, who are often subsidiaries of energy companies, and they have the access through the middle voltage range cables and this is the target area for us.
QUESTION: OK, so if I'm an executive in a power distribution company and I'm reading about PowerLine telecommunications and I'm thinking I need to get into this business, and I can see that there are in-home people, there are access people, should I speak with you?
ALCATEL: Yes, yes of course.
QUESTION: And what would you be able to give them?
ALCATEL: We can bring the data to the access people. That's the main subject here we have done.
QUESTION: Over what kind of distances can you do that?
ALCATEL: We have two different technologies, for the coupling, the data to the middle voltage cable, we have the shield coupling.
QUESTION: So you're sending it down the shield?
ALCATEL: Yes, this is the shield coupling technology, where you can reach about 400 - 500 metres, this is 2 megabits data transmission from point to point. It's not a point to multipoint transmission. And very new, for the time being, we have here at CeBIT the new version of the coupling to the core and we are transmitting the data between the shield and the core also at 2 megabits over a transmission distance of about 2 Km.
QUESTION: Well, I am using maybe 10 megabits between the home and the sub-station in the low voltage, and then we're going to go up onto the medium voltage, but we can only go at 2 megabits..
ALCATEL: I think also for the first low voltage systems, they will have lower data rates.
QUESTION: So you are expecting to increase your data rate?
ALCATEL: We are also expecting to increase, but now we are waiting for the market at first. So let's wait for the market, find out what the demand of the market is, and then after selling the 2 megabits systems, waiting for the next, maybe 10 megabits or so. The next possibility is for concentrating the data, it's also possible you don't need 10 megabits data to the home, not for everyone at the same time.
QUESTION: So you're sharing bandwidth using statistical multiplexing. You're not working on increasing the data rate until you see what the lower voltage market requires?
ALCATEL: For the time being, no.
QUESTION: So your competitor really is fibre I suppose, isn't it?
ALCATEL: Yes!
QUESTION: That's a big competitor!
ALCATEL: But it depends on the companies who'd like to use our systems. The energy companies don't have fibre in the middle voltage range, they have fibre in the high voltage range for transmitting the data.
QUESTION: And your customer is the electricity utility or their telecommunications partners?
ALCATEL: Yes.
QUESTION: And your competitors, you don't have any at the moment?
ALCATEL: For the time being we have no competitors.

ITRAN:
QUESTION: Is your customer the computer or other equipment manufacturer?
ITRAN: Well the computer manufacturer, but not only them, you're talking about the consumer market, you're talking about home appliances. So we're talking

about the consumer appliance manufacturers, companies like Panasonic and others. For the low speed you're talking about all the electric switches, how do you call it in general - electric devices,
QUESTION: Yes, consumer goods really, brown goods.
ITRAN: Brown goods no, but white goods of course. But all these electric switches and companies of course like Panasonic, Matsushita, are very good in there too.
QUESTION: The utilities would tend to buy from people who put things together rather than try and do it themselves.
ITRAN: Well, so we will work with the OEMs who supply the utilities. I'm talking about the utilities market in general.

Keyin:
QUESTION: So your customer could be a computer or equipment manufacturer, it could be an electric utility?
KEYIN: All of them!
QUESTION: It could be all of them, couldn't it?
KEYIN: All of them, because we are in the Powerline access and in-home market.

Oneline:
QUESTION: So your chosen customer then is the electricity utility, not the computer manufacturer.
ONELINE: Yes.
QUESTION: Not the end user?
ONELINE: No. Not directly.
QUESTION: It's a business to business package for the electricity utility.
ONELINE: Package itself - yes. The outcome of the package - no, it's a direct private business. So what we do together with the utility is private business, what we do with the utility is a business to business.
QUESTION: So in other words you are looking to get access to the end user in partnership with the electricity utility?
ONELINE: Exactly.
QUESTION: Will you bill the end user or will the electricity company bill the end user?
ONELINE: It will be a joint venture between the electricity company and Oneline.
QUESTION: And so your customer base then are all the electricity distribution companies in the world?
ONELINE: Yes.
QUESTION: 18,000 customers. Right. That's a big job!
ONELINE: We've got a lot to do!
QUESTION: Where does the ISP fit into all this, would you become an ISP?
ONELINE: No. First of all we do the same things as a normal local telephone operator does, so we have local calls, we have data services. The ISP for us is just a kind of partner in the whole concept, where we buy in ISPs for data access. And whether that's an ISP or a data network, a big data network or big data company, that doesn't matter.
QUESTION: Utilities are looking to leverage their poor position with regard to getting more revenue from their fixed assets. Do you see a future in power utilities moving towards becoming an ISP in order to provide services on that network?
ONELINE: Sure, I think that the main issue is that electricity companies are not forced to get into things like e-commerce as well, and for that they need much more information about their present customer base than they have now. So what we offer is a platform for e-commerce services where we actually offer the plug to

the electricity utility to put their service platforms on them. And that's one of the things we're integrating now with Preussen Electra. So we offer the plug to our trial area and Preussen Electra uses it for their e-commerce.

Siemens:
QUESTION: Your direct customer would be primarily the electric utility?
SIEMENS: Yes that is correct.
QUESTION: In terms of the electric utility or telecoms operator, I suppose that would be a kind of partnership really, how do you see that working?
SIEMENS: A kind of partnership I agree. You have missed one of our customers, it is the network owner, the so-called city carrier; he owns the network inside this city. Certainly in Germany, he is basically a very valuable customer for us because the city utilities here are very interested to have now the so-called “additional value” compared to utilities that will enable them a better position in the market.

Cogency Semiconductor:
QUESTION: What would be a good customer for you?
COGENCY: There’s a bunch of top networking companies, if you look at some of the other home networking solutions, like net card, ethernet cards, the top ones are Intel.
QUESTION: Do they generally multi-source, typically how many chip manufactures would they source from?
COGENCY: They probably sign up one and look for compatible chip as a back up, second sourcing.

Electricom:
The power utility, systems constructor, telco.

10.3.16 Question 16: Additional Comments:

DS2:
Further information re questions 6 & 7.
DS2 is committed to working in partnership with potential clients which has the effect of promoting a “de-facto” standard, mutually beneficial to both. While no regulations yet exist, current standardisation work going-on in the IPF PTF, CENELEC and ETSI is defining bands for the use of power line in the access network. In the near future, OFDM will be confirmed as the modulation scheme, and procedures for upstream-downstream transmission, as well as for sharing of the spectrum between several users will be defined. DS2 is very active in all the major standardisation bodies (through its participation in CENELEC, SG 206, WG 10 and ETSI power line projects). DS2 takes an active leadership role in the main industry representative bodies namely the PTF and IPCF (now PLCforum), where the idea of an open standard is also gaining support. The technology being developed by DS2 is adaptable in power and frequency in such a way that it can comply with any regulation that finally might apply.

Alcatel KE:
ALCATEL: I think the main thing for the whole Powerline market in my opinion is the EMC requirements we have here in the European Community and so on, and I think that's a very good advantage of our system, we are acting on cable with the shield and so on, so we have no problems with this EMC. That's our biggest advantage, and I think that's a very big problem for in the low voltage area.

ITRAN:
ITRAN: I would like to ask you how long would you think it will take for a standard to be created in Europe? That's a big question!
QUESTION: Two years.
ITRAN: Two years, you sure? OK, just promise me because it's a big stumbling block compared to how the U.S. is working, if you keep it longer and longer it might never happen. It's a big problem for companies like ourselves and the others this is crucial.
QUESTION: This needs to be fast-tracked.
ITRAN: It needs fast-tracking. It's also frustrating for companies like Siemens who want to come with products but they need to wait.
QUESTION: Yes that's it, they daren't. They're a stranded investment.

Keyin:
QUESTION: Have you got any plans to increase the data rate?
KEYIN: Yes, sure.
QUESTION: You are working in that area?
KEYIN: Yes, we are working towards 10 Mbits as well. It will be available at this year's COMDEX. Prior to this we spent two years taking our prototype product to various test sites around the world, we committed to completion, and did so on time.
QUESTION: Yes, so you delivered what you said you were going to deliver, when you said you were going to deliver.
KEYIN: Exactly, that was our strength. That's why we got the contract with RWE.
QUESTION: Because you're reliable.

KEYIN: Yes, that's our strength. So that's why I really wanted to say we can deliver whole things as a product. It's very important. Nowadays nobody has a product. There's no market for the Powerline communications, for the high speed, that's what I'm saying.
QUESTION: So now you see there is a market.
KEYIN: Exactly, right. If they can not deliver it on time, imagine!
QUESTION: Yes, it goes the other way?
KEYIN: That's the point. We announced some big announcement one month ago with the Korean government. The Korean government funded us to commercialise our technology, as a part of the information-superhighway project. And then after that, the press announcement, our telephone was totally jammed! People just believe, "If I can buy one modem I can easily connect to the power line". They should be very careful. I don't like that kind of thing. We have to carefully prepare everything.
QUESTION: Isn't that dangerous?
KEYIN: Yes, very dangerous.

Oneline:
QUESTION: Your share price just had a major increase, what do you see as the cause of this?
ONELINE: I think mainly the direction of the stock markets have to do with the speculation in the Internet market. What you can see is that the hi-tech companies, the Internet companies are positioned very high on the stock market, power companies are more valued in a steady area of the market, so what happened was we mixed the two and you got an increase, a cross-over in the other business.
QUESTION: The identity of VEBA suddenly changed overnight, in so far as in the eyes of the investment community.
ONELINE: Yes, sure, because actually going into a new innovative business area is of course a drive forward for markets to react on that, and that's exactly what happened.
QUESTION: Can you give me any numbers?
ONELINE: Well, so far as I can see it was 11% in the first day.
QUESTION: What would that mean in terms of market capitalisation. How much money did it put on the company?
ONELINE: I would say it's somewhere in the area of 3 billion D-Marks.
QUESTION: One billion pounds in three days!
ONELINE: The last time it happened was with RWE and - 7%, what happened with the share price of VEBA in total was really incredible because in the second day it went up to even 15%. It was not the intention to increase the share price, it was the intention to introduce Powerline.
QUESTION: But that was an inevitable consequence of that?
QUESTION: Has this changed your business plan?
ONELINE: No, none whatsoever. No, it's exactly the same. I think we have the right concept, I think we have the right plan and the right way forward, so we should not get over-enthusiastic about any market speculation because nobody knows what will happen tomorrow.
QUESTION: Here I am in my power distribution utility, with my very poor return on capital, my very poor market capitalisation, I'm a little afraid of getting into the telecoms business, what should I do?
ONELINE: I would say give me a ring!
QUESTION: So they should come to you?

ONELINE: Yes, what we offer are the business concepts to do it, but low risk in the whole, like I said we offer the plug for the utilities.
QUESTION: Traditionally there's been a lot of resistance within the utility companies, they're very very resistant to change. This is seen within the industry as being a greater obstacle than the technology itself, how would you comment on that?
ONELINE: I would say that there are certain market dynamics in telecoms, which are different from the utility market. This is changing very rapidly, but still taking the risk of going into a new core business is a decision which has to be made, and if we can offer a low risk solution with low risk in making the decision, low risk in capital investment, I think we have a good deal!
QUESTION: Is it going to cost them a lot of money up front to get into that business?
ONELINE: No.
QUESTION: Why not?
ONELINE: We have anticipated, we're first of all making a technology which is linearly upgradeable, which means no up-front investment, we can "Pay as you grow". Secondly, of course, we need some up front investments, but it's not comparable to any other telecoms venture, where you have to build up networks.
QUESTION: How much would someone have to put on the table to get started in this business with you?
ONELINE: I think this depends a little bit on the area, the size of the area, and you can't estimate that because of the difference between countries, difference between areas. In Germany we have a lot of small areas, in other countries we have one big utility and their demands are completely different.
QUESTION: But it's not a lot, comparatively?
ONELINE: No, comparatively it's a very small amount, for a utility it's very small.
QUESTION: What are the risks for them?
ONELINE: The risks are very low, probably the only risk they have is that the regulatory body does decide not to go along with it and then the business stops, but we're not talking about losing billions here.
QUESTION: The industry has been talking a lot about "Regulatory Capture", the fact that the telecoms businesses are capturing the regulatory position before the power utilities even wake up to the reality of Powerline. What would you invoke them to do to stop their options being curtailed by this? Is the answer to mobilise themselves and to become part of the regulatory process by becoming members of ETSI, PLC*forum* and other such organisations?
ONELINE: Yes, but I think there's a second part in that, it's that the regulatory bodies need facts, what's happening is that a lot of people are talking about the issue of Powerline Telecommunications but nobody's really doing it at the moment because they're waiting for the regulatory body and the regulatory body's waiting for the industry to start. I think we will now start in Germany to break this circle and just put the facts on the table, facing the risk that the regulatory body might decide differently. But we will take that risk.

Annex II: Compilation of results of in-depth interviews.
See Annex II, Compilation of results of in-depth interviews.

To provide an overview of the current status of visible entities within Access PowerLine, we have assembled the key issues and responses in a comparative table to highlight basic technology parameters, future plans, strategic decisions, commercialisation strategies, strategic partnerships and availability of products and services. It is essential that reference is made to the incorporated in-depth interview transcripts and company published material, in addition to visiting the appropriate websites, in order to gain a full understanding of the comparative position. It is also essential to follow updates of this document due to the highly dynamic nature of the PLC access industry.

NAME	MAX. DATA RATE (Mbit/s)	NAME OF TECHNOLOGY	VOICE	NETWORKING	INTERNET	CHANNEL	Chip Set	ACCESS
DS2	50							YES
ASCOM	5		YES	YES	YES	IN HOME + ACCESS		YES
COGENCY SEMICONDUCTOR	10 - 14						YES	LATER
ELECTRICOM	NA		NA	NA	NA	NA	NA	YES
ENIKIA	>10	Information Appliance Network (IAN)			YES			YES
NAMS	10	NisCom	YES	YES	YES			YES
ALCATEL	2	LineRunner PDSL	YES	YES	YES	SCREEN & CONDUCTOR		YES (MV) "Backhaul"
ITRAN	2.5 Currently, 12 Third Quarter2000	ITM1 & ITM10	YES	YES	YES		YES	YES
KEYIN	2	Keyin	IP		Yes		YES	YES
ONELINE	ACCESS 8, INHOME 10	ONELINE	YES		YES			YES
POLYTRAX	0,025		YES	YES	YES			
TESION								Yes
M@IN.NET	10	PLUS	YES	YES	YES			YES
PHONEX BROADBAND	10		WIRELESS PHONE	END 2000	WIRELESS MODEM LINK			
SIEMENS	2			YES	YES	IN HOME + ACCESS		YES
INTELLON	11	PowerPacket		YES	YES			

NAME	INHOME	TRIALS	DISTANCE	INTERFACES	SERVICES
DS2	Yes				
ASCOM	YES		350 METERS	A/B ETHERNET INTERFACE	INTERNET METER READING, APPLCANCE STATUS, TELEPHONY, PLC LAN, ENERGY MANAGEMENT + SECURITY
COGENCY SEMICONDUCTOR	YES				
ELECTRICOM	NO	NA	NA	NA	NA
ENIKIA	YES			ETHERNET	
NAMS	YES		0.5 - 1KM		TELEMETRY, COMMAND + CONTROL, AUTOMATCI METER READING
ALCATEL		RWE & ENBW	UP TO 2KM	G.703, V.35, V.36, V.11/X.21, ETHERNET	LOAD MANAGEMENT, TELECONTROL
ITRAN	YES				
KEYIN	YES	RWE		ETHERNET + USB	LAN
ONELINE	YES	VEBA, Avacon		ETHERNET, USB, RS232, A/B, ISDN, E1	REMOTE METER READING
POLYTRAX	YES				LAN, HOME CONTROL + SECURITY
TESION	Yes				
M@IN.NET	YES			ETHERNET, RS232, PSTN, USB	REMOTE METER READING, HOME AUTOMATION
PHONEX BROADBAND	YES			ETHERNET	
SIEMENS	YES	EnBW			
INTELLON	YES				

NAME	WEBSITE	COMPONENT	REGULATIONS	No OF NODES	COVERAGE	FREQUENCY BAND
DS2	www.ds2.es		Meets all current and expected regulations			1 Mhz to 30 Mhz
ASCOM	www.ascom.com			250		1 MHz to 10 MHz
COGENCY SEMICONDUCTOR	www.cogency.com					4 - 24 MHz
ELECTRICOM	www.electricom.co.uk	coupling units	LV Directive & EC Mark	NA	NA	1 - 50 MHz
ENIKIA	www.enikia.com		Meets FCC Part 15	256	DESIGNED TO SUPPORT HOMES UP TO 5,000 SQ FT	Confidential
NAMS	www.nisko-metering.com		CONFORMS			10 MHz to 20 MHz
ALCATEL	www.alcatel.com	COUPLING UNIT + EXTERNAL BOX	MEETS ALL CE REQUIREMENTS			NA
ITRAN	www.itrancomm.com	NA	Meets FCC Part 15			4 Mhz - 20 Mhz
KEYIN	www.keyintelecom.com					3 Mhz - 8 Mhz
ONELINE	www.oneline-ag.de		NA			1.5 - 30 MHz
POLYTRAX			CE CERTIFIED			
TESION	www.tesion.de, www.enbw.com					
M@IN.NET	www.mainnet.co.il					4 - 25 MHz
PHONEX BROADBAND	www.phonex.com					
SIEMENS	www.siemens.de					1.6 to 3.5MHz, 4.5 to 6.5MHz, 7.4 to 9.4MHz
INTELLON	www.intellon.com		Meets FCC Part 15		Designed to support homes up to 7,000 sq ft	3.5 MHz - 16.5 MHz

NAME	MODULATION	COST	Customer	Parent companies
DS2		$10 per node	Computer or other equipment, Electricity Utility, Telecommunications operator, ISP, End User	Confidential
ASCOM			Computer or other equipment, Electricity Utility, Telecommunications operator	Ascom
COGENCY SEMICONDUCTOR	OFDM	$79 - $99 for product	Equipment Manufacturers	
ELECTRICOM	NA		PLC Vendors & utilities	NA
ENIKIA			OEM	
NAMS	SPREAD SPECTRUM		Electricity Utility	
ALCATEL		125 EURO'S PER METRE ONCE DISTANCE EXCEEDS 75METRES	Local carriers often daughters of energy companies	Alcatel
ITRAN	ACSK		Manufacturers	Itran
KEYIN			Everyone	Keyin
ONELINE	MODIFIED OFDM		Utilities	Preussen Electra which is 100% owned by VEBA
POLYTRAX	FSK/PSK		Manufacturer	Polytrax
TESION			Telecommunication operator, ISPs, utilities, private customers, SO-HO's and Small-Medium Enterprises.	EnBW and Swisscom
M@IN.NET	DSSS			
PHONEX BROADBAND				
SIEMENS	Chimney modem	will compete with ADSL	Electric Utility	Siemens
INTELLON	OFDM			

NAME	PLC?	Partners	Contact	No. of employees	Compatibility	Ready to market?
DS2		CISCO, EDF	ann.whyte@ds2.es	23, 40 YE 2000, 60 2001	Yes through standards	Pilot by mid 2000, chip set by Q3 2000
ASCOM		RWE AG	marcel.graber@ascom.ch	35		Launch Cebit 2000
COGENCY SEMICONDUCTOR		[Shortly to be announced]	gwilson@cogency.com	35	HomePlug Standard	End of Q1 2001
ELECTRICOM	No	BICCGeneral	deh@electricom.co.uk	20	NA	YES
ENIKIA		Oneline	bdillon@enikia.com	45		month 8, 2000
NAMS		None	I_karny@niskometering.com	55		Feb,2001
ALCATEL	Yes	None	ennoborchers@kecam-han.de	Less than 20	Perceived as a problem for the access market not backhaul	Yes
ITRAN	No	Microsoft	avnerm@itrancomm.com	45	Don't know, are willing to adapt if need be.	2.5 Mb/s Q2 2000. 12 Mb/s Q2 2001.
KEYIN		None	shlee@keyintelecom.com	20 - 25	Keyin believe they have the de-facto standard, all others must follow.	Yes
ONELINE	No	None	mensing@oneline-ag.de	30	Compatibility not an issue	Yes (trials)
POLYTRAX	No	Texas Instruments	werner.pohl@polytrax.com	20	Unclear, although conforms to CENELEC bands.	Close, prototype ready
TESION	No	Siemens, not exclusive.	juergen.unfried@tesion.net	50 to 60	Sees the market as still developing, looking for standardisation for final solution.	Need another year
M@IN.NET						
PHONEX BROADBAND						
SIEMENS	YES	EnBW	Ludwig.Hiebinger@icn.siemens.de	no information given	adopting chimney approach	1st half of year 2001
INTELLON						

NAME	Product	Competitors	Rollout	Comments
DS2	Chips	Siemens, Ascom	World wide	Active in standards bodies.
ASCOM		All PLC vendors		
COGENCY SEMICONDUCTOR	Chips	Other chip-set manufacturers	U.S. primarily, Europe secondary	
ELECTRICOM	Coupling units		World wide	In addition to coupling units, Electrocm offer technical training courses, network measurement and evaluation, independent evaluation of modem technologies on test network and consultancy.
ENIKIA				
NAMS		Communication companies		
ALCATEL	Whole System	None perceived	Germany first	Regulatory issues considered to be big problem for LV technologies but not for MV
ITRAN	Chips	None	World Wide	The need for European standards is seen as critical. Slow speed version works in CENELEC range. CEBus, X-10 compatible
KEYIN	Whole system, including chips.	ADSL, Cable modem	Germany, Korea, Malaysia then world wide.	
ONELINE	ill-defined (system and a service)	None	Germany	Trying to do is create a platform for a service portfolio, it's not a technology-driven approach.
POLYTRAX	System		Germany, world wide	Polytrax have no plans to enter the "access" market. High speed data not an issue until regulations in place.
TESION	Service	None	Germany	
M@IN.NET				
PHONEX BROADBAND				
SIEMENS	System	Ascom		
INTELLON				