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Sustainable benefits of power line carrier systems

Task Force Power Line Carriers

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Task Force Power Line Carriers

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Sustainable benefits of power line carrier systems

Task Force Power Line Carriers

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EXECUTIVE SUMMARY

UNIPEDE Domain III "Products, Markets and Customers" commissioned a task force during the early part of 1998 to make an assessment of the current status and future of Power Line Carrier Systems from both a technical and economic view point and to provide an overview of customer related products and services which are, or are to become, available using this technology.

This report has been prepared to address these issues and the following is a summary of the major findings.

Different utilities and companies may, due to the heterogeneous liberalisation process in the energy market, have different requirements (technical, commercial and legal) and different criteria in determining the features and facilities required of a power line carrier system and the cost benefits and commercial advantages which might follow the introduction or expansion of such technology.

For any such communication system or concept to become widely acceptable, it must be seen to be cost effective for individual electricity distribution or supply businesses, or indeed other third party communication service providers, to operate and to offer a range of medium to long term sustainable benefits which would justify the considerable extra investment for over laying the power line carrier or communication system over the power distribution system and the possible need for re-organisation of existing operating practices and routines and the introduction of telecommunication service and operation management procedure.

Communication systems using the electricity distribution system present a new management system challenge, in particular if they are to be competitive with other telecommunication providers or if their facilities are contracted out to third party service providers. A crucial issue is to determine the level of bit rates that PLC systems may be capable of achieving in the future and if this level would be cost effective against future telephony or data technologies. A major challenge for any such communication operation is that the power line carrier system must not put any unacceptable operating constraints on the electricity distribution network, where the prime purpose is the delivery of electricity to the customer. Therefore it is essential for the power line carrier system to co-exist or be automatically reconfigured to ensure that communication access is maintained to the customer, irrespective of changes to the electricity distribution network due to power system faults or temporary or permanent operational rearrangements of the network.

Commercial systems for two-way communication over the electricity supply system exist and system are in operation in a number of European countries, some for 20 years or more, as in France where EDF has used Power Line Carriers on a large scale but at very low bit rate for transmitting tariff signals all over France from mains substations through medium and low voltage systems to customer metering points. Many experiments of new system are being conducted throughout Europe and developments have reached very advanced stages with several system suppliers.

For example in France, EDF have been engaged in a 2300 customer experiment to evaluate both the PLC technical solution and new customer services. This experiment called SYNCRONIA, is taking place in NANTERRE (near Paris) and NANTES, and has been designed to provide information on consumption levels and load switching facilities.

Many utilities have considerable knowledge and experience in the specification and the operation of low bit rate PLC which in general provides sufficient capability to enable billing services, tariff control, home automation and other services connected with Electricity Supply applications and where low bit rate PLC has been used when its application has been cost justified.

The continued evolution of electronic technology has now presented new possibilities for P.L.C communication at high bit rates enabling new and existing applications both before and beyond the point of the customers metering. One such development is taking place in the UK with 'Digital Power Line' which is a portfolio of products developed by Nortel (Northern Telecom) and Norweb Communications (a business unit of United Utilities plc). This system allows data to be transferred over electric power line into customers premises at speeds of up to one megabit per second and provides a communication service giving access to the Internet.

Thus PLC may be considered as a shared communication media and although low bit rate and high bit rate applications may be implemented simultaneously on the same electrical power network, the applications and opportunities offered by each have to be considered separately.

Low bit rate PLC is a well tried and proven technique and new services are being developed for application using its capability.

Whereas although the potential of HBR PLC is seen to provide a new factor in telecommunications business competition, a number of areas may need to be further investigated and resolved before wide spread implementation is considered, they include the following factors:

- Further information on the performance, capability and its potential to be gained by progressive experiments under all electrical network conditions.

- Clarification of the regulatory requirement and constraints in various countries.

- The kind of operating constraints which the operation of a HBR PLC system, and power distribution networks might place on each other and are such constraints acceptable.

- The Electricity Industry has achieved a high level of standard in its activities, does this need to be reflected in the telecommunications PLC application.

Perhaps there is an opportunity for Unipede members to work together on the above factors, in particular on the regulatory aspects of PLC, mainly to protect the classic capability of the electric power network, and further to open new value-added application for communication systems using the electrical network.

From the Electricity Utility or Companies customers perspective traditionally power line carrier

systems have been used to control public lighting and provide energy management by switching on and off electric space and water heating and in some countries by the provision of two part or multi part tariff. Such systems have provided benefits for both the utilities and the customers with little or no interaction required by the customer, perhaps only initially to contract to take such a service.

The advent of more comprehensive services with 'smart' meters providing access to a wide range of electricity related information has enabled survey's to be carried out to determine what the customers requirements and usage of information might be, a factor enabling cost effective design of equipment.

One such survey undertaken with customers indicated that the awareness of the information made available on 'smart' metering equipment was high ranging from over 70% aware of information on tariffs and over 90% aware of information about electricity bills and over 80% on how much electricity their homes used. The most commonly used information was that relating to the electricity bill. Customers undoubtedly perceived this information and in particular an estimated prediction amount of the next bill to be the most pertinent information as this allowed customers to budget effectively.

Modern technical developments make the possibility of using the electricity distribution network to reach customers premises both for low speed utility application and high-speed telecommunication channels very attractive. When extended through gateway to reach the customers installations, appliances and system supports services requiring information or data exchange for Home Automation, business, education and entertainment applications, they must be competitive in a rapidly expanding market place.

New customer trends and technological developments have and will continue to present new opportunities and challenges to the Electricity Utility, these include the implementation of today's technology, and preparation for tomorrows technology and customer requirements and trends. With this in mind it is recommended that UNIPEDE members give consideration for this survey to be repeated at twelve-month intervals both to monitor developments in technology, customer requirements and results of trials and installations in current operation.

1. Scope of Work

The Terms of Reference of the Task Force "Power Line Carriers" were to analyse the evolution of the technology using electricity cables for the transmission of telecommunication signals and in particular:

- make an assessment of the current status and future of Power Line Carriers from a technical and economic point of view;
- give an overview of customer related products and services based on Power Line Carriers.

2. Introduction

The Electricity Industry has for some considerable time, both been aware and taken advantage of the technical opportunities offered by communication systems operating over the electricity distribution network connecting 'suppliers' and their customers. Traditionally communication from the customer to a central location allows electricity companies to remotely read meters, to obtain information about customer loads for network management and to monitor the security of their equipment on customers' premises; communications outwards to the customer would allow electricity companies to implement direct load control schemes, to trim demand during peak times, to offer automatic control of certain loads to suit both the customer and commercial and operational needs and to operate flexible and variable tariffs by signaling to the customer changes in the cost of electricity and the time of availability of the tariffs etc.

New customer trends and technological developments have and will continue to present new opportunities to the Electricity Utility these include today's technology, that allows data to be transferred over the distribution network at speeds of over one mega bite to satisfy a requirement for Internet service in the home, and preparation for tomorrows technology and customer trends and requirements.

This short report presents an overview of the technology available, some economic considerations, some results of customer surveys and customer related products and services which are or about to become available.

3. Overview

- Technical Issues

Distribution Line Carrier (DLC) technology makes it possible to use MV/LV distribution networks and LV mains as data transmission media. This technology is referred to also with a rather similar attribute, Power Line Carrier (PLC), having the same meaning, even if slightly more generic. Either terms identify a set of methods and techniques used to implement a multidrop channel, not split into a cascade of point to point links with adapted impedance. If compared with

the traditional approach of HV networks, this solution is less expensive, but requires appropriate injection techniques.

The first industrial DLC implementation dates back to almost two decades, the technology has become mature in recent years; but it is not yet in widespread use. Since the late 80's, the relevance of this technology has been recognised, mainly with reference to distribution automation and home-building automation. To promote developments in these emerging application areas, several initiatives have been undertaken, most of them aimed at proposing international standards for low speed channels.

The need to cover the so-called "last mile" without installing new cables has been perceived in more recent years, when the deregulation of telephony and telecommunication markets has been envisaged. The possibility of using electricity wires to reach customers' premises inside with high-speed channels is attractive, but the DLC technology has to be explored in much more complex directions.

- Low Speed Channels

The utility side of the communications protocol has been standardised, and the customer side complete architectures have been designed, including protocols and application functions. In Europe, significant research effort has been funded by the ESPRIT Programme through projects focussed on EHS (European Home Systems) standard, producing the implementation of a true "open" platform and the development of various applications compliant with this architecture.

Because electric power lines and cables are usually not shielded nor twisted in the way appropriate to inhibit emission of electromagnetic fields, interference with other use of the same frequencies can occur. To prevent such situations, a CENELEC standard defines allowed frequency bands and related voltage limits. To avoid the conflicting use of frequencies and the need of filters, this standard assigns the available bands separately to electricity suppliers and to consumer use.

In Europe, two main frequency bands are identified: band (3-95) kHz attributed to utilities, band (95-148.5) kHz attributed to consumers. For the band (125-140) kHz the use of an access protocol is prescribed.

The reason of such band limitation lies in the radio transmissions on long waves, still used in European countries. In other countries, for instance North America or Japan, the maximum frequency limit is higher, because it is related to the radio transmissions in the medium wavelength range. However, it is still possible to transmit in the forbidden frequencies, but within very low power limits, so that the produced electromagnetic noise is below the values prescribed in the appropriate CISPR standard.

The well known narrow band modulation techniques (amplitude, frequency, phase modulation) offer solutions of moderate complexity and costs: they are also useful to implement low speed DLC channels (in the baud rate range of few kHz). Even if severe conditions can dynamically occur, producing sharp changes in the signal attenuation, or in the noise levels, or in the standing waves, the average availability figure remains acceptable (90% or more) to be employed in the low cost automation systems. In more sophisticated solutions a simplified version of spread spectrum technique has been adopted to obtain higher availability.

In LV networks the signal is injected between phase and neutral (phase to phase in MV networks). The cross talk assures that all the three phases are involved, even when only one is used for injection. The coupling device of narrow band channels is simple, but it must assure a rather high output impedance. Otherwise, the insertion of hundreds of such devices, placed in clusters along the channel, will seriously reduce the line impedance. Even if the line is partially equipped, its impedance is still affected in significant way.

In situations with a number of variable parameters, the transmitter range can, permanently or occasionally be less than the distance from the receiver. To overcome the problem, some communication protocols implement proper mechanisms, such as “store and forward”, which make use of intermediate receivers (if any) to repeat messages. The channel of the utility can propagate beyond the electricity meter on the customer’s wires arriving, for instance, at the gateway to the channel of the user. Under certain conditions, filters can be required, but only to separate channels of different users which, otherwise, could produce mutual interference. The proper filter position is across the gateway, but, even if not necessary, it stops the further propagation of the utility channel inside the house.

- High Speed Channels

The techniques set up for implementing ADSL communications can be moved to the DLC field. Studies done to build a high speed channel in the utility band show that it is possible for a single channel at a baud rate not exceeding (100-200) kHz with availability figure comparable to that of the low speed channel. If the channel is shared among all the customers (normally about 50) connected to the distribution cable, the bandwidth per customer is enough only for telephony. The complexity of terminal devices, and therefore their costs, are much higher in this case than for the low speed channel. The possibility to combine either type of channels has not yet investigated nor is it explored whether the marginal use of “over voice” channels for low speed data transmission is equally convenient.

Very recently, the industrial implementation of wide band channels has been announced in UK by Nortel (in co-operation with Norweb).

This solution appears finalised to offer access to Internet, but the dynamic control of up and down streams can probably be directed to support telephone link requirements. In this case, the termination will have to supply two connections, one for Internet and the other for a telephone circuit. The competitive position of this technology is due to the ability to serve the traffic peak demand assuring an acceptable throughput to each user, never below a certain limit; in indirect demand control, based on time of day tariffs, is not necessary.

- Services

The communication infrastructures based on DLC technologies have intrinsic strength and weakness, both related to the media they use. The MV electricity networks reach primary and secondary distribution substations, the LV networks link secondary substations to buildings and houses, i.e. meters, appliances, sockets and all the devices supplied through electricity. Moreover, in a deregulated market they offer new business opportunities to electricity utilities. Of course, this type of connections, not designed to become a telecommunication circuit, requires more complex techniques, balanced by the exceptional advantage of avoiding new wires.

The application areas of low spread channels are in automation systems:

. Distribution Automation Systems (DAS), for remote monitoring of substations.
. Energy Customer Service Automation Systems (ECSAS), for remote meter reading, demand side management, monitoring of quality of service, anti-fraud control, device diagnostics,
. Home and Building Automation Systems (HBAS), for energy management, monitoring of safety related events, security functions, etc.

ECSAS and HBAS need to be interconnected, if they have to co-operate in providing customer interface and remote services to the same end user.

High-speed channels, now oriented to telephony and Internet, could coexist or, instead, be overlapped in the future to the low speed channels. In the present trend all these application areas are moving from vertical integration to a layered composition of systems, so that DLC communications can become a real backbone able to remain for long term, evolving as necessary along the years.

4. Economic Considerations

Electricity companies share with other businesses the need to match supply with demand. Electricity has the additional feature that it cannot be easily stored and therefore, supply and demand must be continually in balance.

In normal business terms, in a competitive environment, where the customer has a choice of supplies an obvious way of matching supply and demand is by competitive price adjustment, over production or by simply leaving some demand unsatisfied. For products such as electricity, stopping a customer's supply is not an acceptable course of action, although some controllable loads such as space heating, water heating and refrigeration etc. may be interrupted for short periods without inconvenience to the customer and to the mutual advantage of the supplier and the customer.

Competitive pricing to encourage consumption at one time rather than another is a familiar business strategy and is used by electricity suppliers worldwide in time of day tariffs. In the future electricity suppliers may consider point-of-use control, pricing, billing, different methods of payment and the use of different tariffs at different times together with other commercial or marketing incentives - areas which will give rise to greater control to the supply business, notwithstanding the requirements of distribution and generating companies to satisfy their business drivers and produce a cost-effective service and competitive product for the supply customer.

Against a background of considerable and continuous change within the Electricity Industry and in order to understand in practice the opportunities which continued development in technology and high volume production techniques present and in order to meet the challenges of such change, the Electricity Industry has over the past decade, with the close collaboration of manufacturers carried out trials and evaluations at a number of locations and installed various systems. The purpose has been not only to determine the technical performance of the system and technology but also to quantify the likely benefit to both the customer and the utility that utilisation of such systems might provide.

Different utilities and companies have different requirements (technical, commercial and legal) and different criteria in determining the features and facilities required of a power line carrier system and the cost benefits and commercial advantages which might follow the introduction or expansion of such technology.

It might be noted that, whatever the commitment by the utilities and the advances in technology, the implementation of such communication services is a massive task and it would seem unlikely that the full potential and cost effectiveness of systems based on the use of the electricity distribution system could be realised for a high proportion of a utility or electricity companies customer in less than 7 to 10 years.

For any such communication system or concept to become widely acceptable, it must be seen to be cost effective for individual electricity distribution or supply businesses or indeed other third party communication service providers to operate and to offer a range of medium to long term sustainable benefits which would justify the considerable extra investment of over laying the power line carrier or communication system over the power distribution system and the possible need for re-organisation of existing operating practices and routines and introduction of telecommunication service management procedures.

Communication systems using the electricity distribution system present a new management system challenge, in particular if they are to be competitive with other telecommunication providers or if their facilities are contracted out to third party service providers. A crucial issue is to determine the level of bit rates that PLC systems may be capable of achieving in the future and if this level would be cost effective against future telephony technologies such as ADSL. The challenge is that the power line carrier system must not put any operating constraints on the electricity distribution network where the prime purpose is the delivery of electricity to the customer, therefore it is essential for the power line carrier system to coexist or be automatically reconfigured and communications access to be maintained between the distribution/supply company and its customer, irrespective of changes to the electricity distribution network due to power system faults or temporary or permanent operational rearrangements.

The present range of systems used in residential premises to effect Home Automation and enable the use of smart information systems - Internet, etc - is increasing, however, for a utility or electricity company to offer and manage such system via their own communication system or network, particularly if this is Mainsborne or Power Line Carrier based, requires considerable investigation and a cautious approach, to ensure that the capacity and resilience of the system is not exceeded and that the purpose of the utilities needs of communication system is not forgotten or weakened by the commercial opportunities, which are and will be exploited.

In the case of low speed channels exclusively connecting secondary substations and meters, the utilities are the only possible users: they have to exploit, within their application, a set of profitable functions in terms of costs and benefits. If gateways are added so that customer's HBAS are linked, services can be offered at reasonable prices. Moreover, two way transport of information can be made available to connect external providers for further services, such as the remote monitoring of safety related events (see chapter 8).

This communication infrastructure, extended through gateways to reach the customer side, supports services requiring data exchange at low traffic. To state the competitive position, specific cost / benefit figures must be identified for customers (sometimes acting as consumers, not as investors), utilities and other service providers. Because the level of benefits for each category is relatively low, the level of costs (mainly related to the devices) must be kept low using the latest technology.

The high-speed channels on LV networks are implemented to support the provision of telephony and telecommunication services, in competition with other communication infrastructures . These services must be provided by bodies or branches, separated ("unbundled") from their mother utilities who obtain profits simply by lending the use of their cables and lines as media of new communication infrastructures.

In this way, the value of the distribution networks can be increased, one scenario could be as follows. The increment can be estimated considering, for instance, a yearly subscription of 100EURO per customer (for telecommunication services) and a minimum rent of the wires per year of (1-5) % ie. (1-5) EURO per year customer; at the interest rate of 5% per year, the increase of value is (20-100) EURO per customer; in an urban area, for a LV network connecting 400 customers to a secondary substation, the increment of value is (8-40) kEURO.

A second cost scenario could be if it is assumed that (broadband) PLC is in direct competition with other telecommunication services e.g. WLL, POTS/ISDN, XDSL, GSM, etc then costs have to be competitive with these technologies.

For example in Germany, the proposed cost for an unbundled access to a POTS line is in the order of 10 Euro/month per subscriber and the cost of a point to multipoint WLL high speed DECT link to customs (2 Mbit) is in the order of 400 Euro.

Thus comparing the cost of the POTS and a PLC application and allowing for a return on investment of 15% the cost of the PCL should not exceed 720 Euro (i.e. 10 Euro x 12 month x 6 years). Assuming a reduced quality for a PLC based local access then a further reduction of 40% is assumed.

Therefore in order to be cost effective with competing communication services the cost of the PLC connection should not exceed 400 Euro. This figure would include the cost of coupling, devices, installation at the customer site and the device to perform coupling to an existing high speed communication backbone, but excluding line terminations units/modems etc, and assumes there is an asset (or tax) value for the lv network of 0 Euro.

In the chapter 8, the remote meter reading and the tariff control, but also the limiting switch control or the monitoring of service quality parameters, are functions to be referred to the utility interest. The availability of gateway between low traffic channels of customers and utilities make possible and very useful the data exchange with the HBAS where load control, customer assistance and other functions will be provided. The availability of Internet is related to high-speed channels and completely independent on low traffic network services.

5. Communication Media and Systems

Communication over the electricity supply system is an obvious solution for electricity power companies since they own the communication path. Many experiments of new systems are being conducted throughout Europe and developments have reached very advanced stages with several system suppliers.

For example in France, EDF have been engaged in a 2300 customer experiment to evaluate both a PLC technical solution and some new customer services. This experiment called SYNCRONIA is taking place in NANTERRE (nr Paris) and NANTES, to provide information on consumption levels and a load switching facility.

Systems are in operation in various European countries, some for 20 years or more, as in France where EDF has used Power Line Carrier on a large scale but at a very low bits/second rate for transmitting tariff signal all over France from mains substations through medium and low voltage systems to customer metering points. So commercial systems for two-way communication over the electricity supply system exist. Some systems use both the medium-voltage, and the low-voltage networks. Other systems use only the low-voltage system. Most of the communication systems use two-way communication. The various systems operate in different frequency ranges, varying from 3 to 95 kHz. The transmission distance decreases as the frequency increases. This is why low-voltage-based systems, which collect and transfer large amounts of information, work in conjunction with local and regional concentrators.

The use of interactive communication systems and interfaces inside the customer's premises requires the appliances in the home to be capable of being connected together and working together. This interconnection can be made via a local-area network in the building. This may use the existing electricity mains cabling or a bus system (a separate internal communications network) which makes data collection significantly easier.

Via the bus system data is brought to a concentrator to be transmitted further via another communication network. Measurement data can be sent by wireless transmission or through the electricity mains cabling to a centrally located concentrator.

Data is transmitted from the local area network to the communications network outside the house through a gateway. This is a module which can perform the conversion between the two protocols used in either side of the unit.

The following examples are presented to give a picture of systems which are available or are being developed and Appendix 1 gives details of several other systems, a list is not exhaustive and the fact that omission of a product, equipment, manufacturer or supplier from the report does not mean that it or they do not provide or produce alternative products.

ABB

ABB has a distribution line carrier system for medium and low voltage. It calls it Dart Net. Dart Net is a two-way system mainly for distribution automation and demand side management applications. ABB says, the liberalisation of the energy market asks for more data as well in between transformer stations and control centres as in between customers and the utility. They say, that although the number of data per data point will be less than in the high voltage, because of the much higher number of data points the number of data to be transmitted in both directions grows.

Dart Net mainly consists of three elements. Novel modems, intelligent node controllers and couplers. The novel modems consist of digital signal processors with novel modulation techniques and micro controllers for higher protocol and application levels. ABB says, they can transfer data in the frequency range of 22.5 to 95 kHz according to the ITY-T requirements at data rates of 33.6 kbps.

The Thorn/Mainsborne System
(Mainsborne Communications International)

Mainsborne is a two-way signaling system which uses HF Spread Spectrum techniques to overcome the effects of variable noise and attenuation, for communication over the electricity distribution networks which places Distribution and/or Supply Companies in direct communication with customers for Remote Meter Reading, Load Management and other services.

The Thorn/Mainsborne Telecontrol system comprises of three main elements:

- equipment at the customer's premises, the Home Unit and Customer Display to receive and send information, connected by the electricity distribution main to.

- equipment situated in an MV/LV substation, the Central Controller (CC) to send and receive information and to manage communications with those customers in its area of supply connected by telephone line to.

- equipment sited centrally in a distribution or supply company, the Data Control Centre (DCC) to send and receive information and to manage communications with all MV/lv substations.

Therefore using the above system components as the building blocks, a direct communication path can therefore be established between a utility or supplier central point and each customer, which can be used either to reach individual customers or to "broadcast" to groups of customers. It should be noted that the system allows for collection and exchange of data by other Utilities (water and gas), by supply companies, meter collection agencies etc. independently if required of the Host Electricity Distribution Company and with complete separation of each organisation's data to satisfy commercial and data protection requirement.

Electricity mains communication systems present new management system challenges, in the need for the communication system to be automatically reconfigured and access to be maintained between Supply Company and customer, irrespective of changes to the electricity distribution network due to system faults or temporary or permanent operational rearrangements.

This ability is enhanced by an Automatic Network Management Module ANMM. The total requirements of the Management Computer System at the DCC are therefore to manage the Mainsborne Communication System, to determine the priority of the required

communications, to re-route the message in the case of power system faults or reconnecting with which the CC cannot cope, to repeat messages when interference from normal electrical sources (harmonics, noise, etc) is detected, to maintain a history of usage of the system by the Distribution or Supply Company and other connected Utilities and to act as store and forward facility for the main business, accountancy, technical and other computer systems.

Operational functions offered by the system to the Distribution and Supply Company by the Mainsborne system are:-

. Remote reading of the electricity meter and the opportunity to remotely adjust tariff rate/time matrices, price messages and other data including half hour meter reading.

. Remote load and energy management, including remote setting and resetting of customer subscribed load.

. Prepayment metering or setting of credit limits.

. Customer Care facilities such as “heat for rent”.

. Detailed customer and system performance data.

. Interface with the customer’s appliances and interactive home systems.

. Gateway for data services to the customer.

Each of these can be evaluated by the Company at time of communication system specification and implemented if required, to ensure that the system meets the particular needs of its customers.

In the ultimate, whatever benefits are seen by the Electricity Company in implementing a Mainsborne system, operation of such system must be acceptable to the customer and should offer him improved facilities and services. The direct interface between the end customer and the system is through a Customer Display, and great care has been taken in its design so that it is understandable, easy to use and complements other services offered.

Benefits to the customer include:-

. Remote reading of meters hence no estimated bills and no problems of needing to provide access for the meter reader.

. The possible availability of flexible tariffs to which he could respond to reduce his overall bill, if offered by the Distribution/Supply Company.

. The opportunity to “pay as you go” or to limit credit to a pre-agreed amount.

. The automatic economical control of space and water heating by the Distribution

Supply Company, but with the opportunity of override or of resetting time periods to suit individual requirements.

The Mainsborne system thus offers Distribution Supply Companies a powerful yet flexible system with which to address the demands of their customers for improved tariff related information and services, together with the opportunity to offer other data services, all within a system totally under their control.

The PowerNet System

In other areas, systems tested have included the PowerNet® system, which was developed by RMS Communications Systems Ltd, to enable high-speed, two-way data communications, over both the Low Voltage (240, 415V) and Medium Voltage (10-30kV) networks. The system is fully compliant with all European and international standards, including EN50065.

PowerNet is a hierarchical communication system that can be broken down into at least four basic levels:- Central Controller, Area Controller, Local Controller and Terminal Units. Communication occurs at speeds of up to 19,200 bits/sec across both the Medium Voltage and Low Voltage networks.

The Central Controller is the user interface to the PowerNet® system that can allow real time communications with any node on the system. It is generally located at the Electricity Company's office and communicates to the rest of the PowerNet® system via conventional communication's media, such as leased line. Requests for information or actions to be undertaken by a node can be initiated either on a routine or ad hoc basis. The Central Controller can 'map' the system beneath it and authenticate newly installed nodes once they have been located.

The Area Controller is based at the Primary Substation (e.g. 33kV/11kV) and is the principal injection point for power line carrier signals on the PowerNet® system. Receiving information from the Central Controller, the Area Controller induces a signal directly onto the cores of the MV network ensuring strong, reliable communications to a number of Local Controllers (and vice versa). The Area Controller uses a non-invasive transducer to induce the signal and this can be easily installed, usually without any modifications to the power system.

The Local Controller exists in two forms, for underground and overhead Medium Voltage networks and acts as a bridge between the Medium Voltage and the Low Voltage distribution network. Like the Area Controller, both the Local Controller Unit (for underground cables) and the Network Coupler Unit (for overhead lines) can generally be installed without any major modifications to the current network and, if the working practices permit can often be installed using live line techniques. The Local Controller is generally used to pass information between the Area Controller and the Terminal units, but it is an intelligent device and can be used to store data, 'repeat' signals and execute background processes.

Terminals Units are the receivers of communications from the Central Controller and they either provide the information or act upon instructions given. RMS Communications Systems Ltd currently have two types of Terminal Units, the PowerScan® meter and the Mains Modem. The PowerScan® meter is, an 'Offer' approved, single-phase Class 2 electricity meter, which was specifically developed by RMS Communications Systems Ltd to demonstrate the many capabilities of the PowerNet® system and was therefore built to the highest specifications. It supports/or has the potential to support remote disconnection/connection, two rate tariffing, detailed consumption profiles, Voltage Current, Power measurement, customer messages, prepayment and act as an interface for other Multi-utility metering.

The Mains Modem is an adaptable interface that can already connect to many existing meters and can be adapted to interface with any other meter that has a suitable data interface (including pulse output). The Mains Modem can also be used to communicate with other devices including water meters, Switchgear, street lighting equipment etc. and in this way the PowerNet® system can be described as a data communication tool and not just as an automated meter reading system.

Other Major Developments

Many European electricity companies are now investigating the use of Power Line Carrier techniques utilising high transmission rates. The investigations, both technical and economic have indicated some of the following factors:-

- High bit rates of transmission with Power Line Carriers is possible.

- This offers the possibility of new services, in the telecommunications domain, but would require the utility to provide a high-speed telecommunication network to each MV/LV substation.

- Such a service might be offered to third party telecommunication providers or operated by a separate structure within the host electricity company.

- Early in such application the utility has to determine what kind of services are possible and the most important factor, 'DOES THE CUSTOMER REQUIRE THEM' from the electricity industry in this very competitive market place.
- Electricity companies can work together on the necessary work in the areas of standardisation and regulation to both protect and ensure this new method of using electricity distribution network.

- One technical point to be identified is the amount of variation in the level of communication performance, with different types of LV networks and hour by hour variations in load characteristics.

NORWEB/NORTEL Systems

One such system designed to enable electricity companies to add value to this power distribution infrastructure has been developed by Nortel (Northern Telecom) and Norweb Communication. The system (see Appendix 1, Section 11) uses mains communication on the LV distribution network between the substation transformer point and the residential or commercial premises. Communications between the substation and the central backbone can optionally use a variety of communication media, copper, fibre etc and a variety of conventional communication systems.

Initially trials concentrated on using the technology to provide a telephone service to residential premises. More recently the emphasis has moved to providing a high-speed Internet service. The first public installation is within the UK at Seymour Park Primary School in Trafford, Greater Manchester, where 12 personal computers have been connected to the Internet by powerline. All 12 computers can operate concurrently from just one connection, from which they obtain permanent access to the Internet at speeds of up to 1 megabit per second.

In addition to educational uses, the greater capacity offered by this technology may facilitate Internet based applications including, electronic commerce, teleworking, entertainment and Internet telephone to be available on a wider scale.

One technical feature of this new product which enables data to be transmitted at rates of more than one megabit per second is the use of a patented technology that screens the data from electrical interference on the host powerline.

6. Standardisation Which Relates To Power Line Carrier Communication Technology

Standards of particular interest are IEC TC13 - Equipment for electrical energy measurement and load control, and IEC TC57 - Telecontrol, teleprotection and associated telecommunication for electric power systems, and CISPR.

TC13, which deals with the standardisation of electricity meters and associated equipment, has appointed a working group, WG14, which works on matters relating to data communication. Examples of standards already produced are IEC1107 and IEC1142, which describe data protocols and physical interfaces for reading electricity meters via serial interfaces, and over a data bus respectively.

IEC TC57 has appointed a working group, WG9, which is concerned with carrier-frequency systems. A Special Joint Working Group, SJWG 13/57, with members from both TC13 and TC57, coordinates the work between these two working groups.

CEN TC294 - Communication Systems for, and Remote Reading of, Meters - has two working groups, WG1 and WG2, which work on the standardisation of data protocols for reading water meters, gas meters and calorimeters. A Joint Working Group (JWG) coordinates the work with IEC TC13.

A common problem today is that there are several system solutions and data protocols for meters, and above all for customer communication systems. This means that systems and components from different suppliers cannot easily be integrated.

In addition to the differences in equipment from various suppliers, a given supplier may use different protocols depending on the type of unit and the year of manufacture.

The primary reason for this is the lack of international standardisation in this particular area of data communication. In addition, national regulations have influenced developments in particular directions. The consequence has been that manufacturers have developed their own technical system solutions and protocols. Another reason for this can be found in the fact that development in this field has been, and still is, remarkably rapid. This has led to the development of so many different technologies for communication that standardisation has not been able to keep pace.

One way of coping with this situation has been to design 'drivers' (bridges) to translate the protocol of one system into the protocol of another. This has made it possible to mix and use hardware from different suppliers.

In the field of carrier technology, work is in hand within CENELEC TC105A and TC57 to arrive at standardisation, and supplier-independent interfaces, for communication across the electricity supply system. As a general rule, standardisation of interfaces must comply with the applicable CENELEC standards.

In order to create a communication system that is as flexible and as open as possible, the universal architecture for the communication protocols of transmission systems based on the OSI model, with layered interfaces, is proposed. The proposal is for a simplified form with three levels of protocols instead of the seven used in the OSI model. The three levels are:

. The application interface: the highest level, where the actual application is situated.
. The data link layer: functions by moving data to the physical link. This layer is divided into two underlying layers called MAC and LLC. These handle, among other things, error detection and the link to the physical layer, and the addressing and sending of data, respectively.
. The physical layer: acts as an interface between the communication equipment and the transmission medium, in this case the electricity distribution system.

The model describes the interfaces between the layers, but not how data is handled within each layer.

TC105A of CENELEC has produced the standard EN50065-1. This specifies which frequency bands may be used for carrier technology (communications impressed on the electricity system) for different purposes within the frequency range 3kHz to 48 kHz. It also specifies the permitted signal levels and maximum interference levels. The frequency band between 3 and 95 kHz is reserved exclusively for electricity distributors whilst that

from 95 kHz to 148.5 kHz is reserved for use by consumers.

7. Customer Requirement Survey

Traditionally power line carrier systems have been used to control public lighting and provide energy management by switching on and off electric space and water heating and in some countries by the provision of two part or multi part tariff. Such systems have provided benefits for both the Utility and the customer with little or no interaction required by the customer, perhaps only initially to contract to take such a service.

The advent of more comprehensive service with smart meters providing access to a wide range of electricity related information has enabled survey's to be carried out to determine what the average customer usage of information might be, a factor enabling cost effective design of equipment.

One such survey indicated that awareness of the information made available on the metering equipment was high ranging from over 70% aware of information on tariffs and over 90% aware of information about the electricity bill and over 80% on how much electricity their home used.

The most commonly used information was that relating to the electricity bill. Customer's undoubtedly perceived this information and in particular an estimated prediction amount of the next bill to be the most pertinent information. The reason given was the ability to budget effectively using this information was perceived to be an important advantage.

8. Customer Related Products and Services

General

There are many potential commercial and technical benefits for the Utility when considering extending its activity beyond the traditional input metering equipment within residential and commercial property. However, there are four main areas, which complicate decisions when consideration is given on extending Electricity Utility communication systems and associated customer services into the home, i.e. Home Automation.

- The different and complex interaction required between the customer acting in a decentralised mode and the Utility whose decisions are centralised.

- The wide range of techniques and technology available and becoming available and the lack of adequate standards in many areas.

- The capability, resilience and cost of the communication systems and the Utility and customer interface required to carry a significant amount of Utility data together with further data required for home automation and control.

- The possible different and often conflicting expectations of the customer, Utility,

Regulator and Government in the implementation of any comprehensive system.

Present Facilities Developed for Home Automation

The following list contains those applications which may fall into the category of Home Automation and which are presently available as Customer Service Facilities or have been trailed as part of Pilot Projects by the Utilities. In each case either one-way or two-way communication is require between the Utility and the customer to enable the concepts to be realised effectively and commercially. Many systems trialed have the technical capability but the economic case has still to be proven.

- **Remote Meter Reading - Two-way Communication**

  Electricity
  Gas
  Water
  Telephone
  TV Channel
  etc.

- **Tariff Control - One-way Communication**

  Time of Day
  Interruptible
  Night Rate
  Multi-Rate Tariff
  Prepayment or Token Operated (one-way or two-way)

- **Subscribed Management Load Control - One-way Communication**

  At a communicated electrical load or financial credit limit

- **Price Information - One-way Communication - Two-way (if available)**

  Credit Control
  Reactive and Contract Price Control

- **'Usage' Information - One-way Communication - Two-way (if available)**

  Cost of Current Account
  Prediction of Monthly, Quarterly or Annual Account

- **Load Control - One-way Communication**

  Command Mode Communication
    Load Shedding
    Emergency Disconnection

  Load Management (Demand Side) with Customer Override
    Space Heating
    Water Heating
    Electricity or Gas Water Boilers for Residential Complexes
    Remote Setting and Resetting of Customer Subscribed Loads

  Disconnect -Two-way Communication
    Remote Disconnect (Credit)
    Change of Tenancy
    Heat for Rent Schemes and other Social Benefits

- **Alarms - Two-way Communication**

    Fire Alert
    Security Alert
    Earth Leakage Electrical Detection
    Gas Leakage Detection
    Fraud and Utility Tamper Alerts
    Out of Limit Voltage Detection

- **Account Payment - Two-way Communication**

  Remote Fund Transfer
    Electricity
    Gas
    Water
    Telephone Usage
    TV charging and Channel Enabling

- **Customer Information via Comprehensive Display and Control Panel - One or Two-way Communication**

  Fuel Costs
    Electricity
    Gas (Gas Calorific Value)
    Water
    Telephone

Tariff in Operation
- Tariff Times
- Tariff Prices
- Tariff Costs

Meter Reading
- Total Usage
- Units Used in Billing Period
- Cost to Date
- Bill Prediction
- Account Balance
- Bill Period Start Date
- Bill Period End Date

Standing Charge

Automatic Manual Control
- Water Heating
- Space Heating
- Lighting
- Refrigeration

- **Utility Facilities (Statistical) - Two-way Communication**

  Detailed Customer and System Performance Data

Gateway Service

Present designs of Power Line Communication Systems offer two address facilities. The first is primarily to communicate with those traditional Utility services as outlined above, this communication is effected by data communication to the customer's metering and control equipment which in turn activates relays or contactors or electronic equipment to effect control within the residential or commercial premises.

The second facility provided is a "gateway service", communicating directly through the customers metering and communication equipment and making available a digital port for connection to a 'Home Automation Bus' system or a logical or computer interface or interfaces or hardware or fibre optic connection. Thus a digital service is available for pro-active or reactive measurements, control or for alarm and alert within the commercial or residential premises giving access to and enabling many facilities including:

- Internet services,

- choice of fuel for space, water heating, dependent on fuel availability and cost, ie. gas, electricity, oil, coal, solar, etc;

- electronic mail;
- remote fund transfer automatic or manually instigated;
- security, fire and elderly person emergency alarms;
- minimal heating systems for second and holiday homes (with wake up);
- control of individual devices, consumer appliances, etc;
- customer communication systems for voice, data video;
- programmable service to allow customers to request or a Utility to provide, a range of requirements in the future.

This latter facility is perhaps the most important and it is expected that the Utility will wish to install equipment with a cost effective life of 5 to 10 years minimum, and within this period it is to be expected that technology will make available many new devices or systems for the potential customer of the future.

9. Conclusion

This short report presents an overview of the technology available or being developed, some economic considerations, results of customer surveys and customer related products and services which are or are about to become available.

The possibility of Power Line Carrier technology providing high bit rates of transmission enables new services to be offered in the telecommunication domain but would require the utility to provide high speed telecommunication network to each MV/LV substation. Such a service might be offered to third party telecommunication providers or operated by a separate structure within the host electricity company.

Traditionally surveys have indicated that the customer would wish to have information on his electricity consumption and a prediction of the cost of his next bill, with regard to other services telephony etc, the most important factor is to determine if the customer requires the services to be provided by the power utility or the telecommunication operator in this very competitive market place.

With regard to economic considerations, different utilities and companies have different requirements (technical, commercial and legal) and different criteria in determining the features and facilities required of a power line carrier system and the cost benefits or otherwise and commercial advantages which might follow the introduction or expansion of such technology. However there is considerable agreement that in terms of today's commercial world, whatever the commitment by a utility, and the advances in technology, the installation and implementation of such communication services is a massive task and it would seem unlikely that the full potential and cost effectiveness of

system based on the use of the electricity distribution system could be realised for a high proportion of a utility or electricity companies customer in less that 7 to 10 years.

However, specific application, in certain areas involving new service introduction, such as provision of Internet services, will achieve significant market penetration and other services, will be able to be introduced to complement the main service.

Notwithstanding the above, modern developments make the possibility of using electricity distribution network to reach customer premises both for low speed utility application and high speed telecommunication channels very attractive and it is recommended that UNIPEDE members give consideration for this survey to be repeated at twelve month intervals both to monitor developments in technology, customer requirements and results of trials and installations in current operation.

APPENDIX 1, COMMERCIALLY AVAILABLE COMMUNICATION SYSTEMS

This Appendix lists some commercially available communication systems that are used or are under development in the electricity sector.

1. Automatic Meter Reading Association

   Trials and Installation Report 1998

   General
   The January 1998 report is available from AMRA, 60 Revere Drive, Suite 500, North Brook IL 60062 - Fax 847/480-9282.

   The report gives general detail of some 211 projects with installations comprising 8.6 million units located in some 188 Utilities.

   The report details communication media which include Power Line Carrier and radio.

2. ABB, S.P.I.D.E.R. DSM 100

   General
   S.P.I.D.E.R. DSM 100 has been developed by ABB Energi A/S in Norway in collaboration with ABB Metering in the USA and 30 Norwegian power companies. DSM 100 is a system for controlling and turning energy flows between the supplier and the customer.

   System Design
   DSM 100 comprises a central computer, concentrators and customer terminals. The central computer, MCU 100, automatically collects hourly readings and cumulated readings for reporting. It also provides functions for automatic load control and event reporting. The central computer software runs on an IBM-compatible PC under Windows.

   During communication from the same central computer, data can be retrieved from the terminals via various communication paths, such as a dial-up connection, a fixed line, INFRANET or communication via the high- and low-voltage distribution systems. The communication paths can also be combined to give an optimal network in terms of cost and transmission speed. It is also possible to define alternative communication paths for the terminals.

3. ABELKO - PDK AXESS

   General
   The system was developed by Abelko in collaboration with Vattenfall Norrbotten. It uses two-way communication on the Telia MiniCall network and the public telephone network. The system is designed for collecting readings and for internal and external load control. The central equipment comprises a PC, a modem and modular software. The customer

terminal has a three-phase supply and contains all the functions, including a multi call receiver and telephone modem.

System Features
Signaling via MiniCall is used for communications from the central computer, e.g. for load control. Since the customer terminal has a three-phase supply, it is accessible even in the event of failure of one or two phases. The terminals can be called and controlled individually, in groups, or all in the same call. Readings are collected via the public telephone network.

Duplicated program memories which can be re-programmed via the modem permit a completely different software function to be in service, without interfering with the collection of the readings.

System Functions
The system operates by two-way communication, with prices, tariff changes, control orders etc being transmitted via MiniCall. Readings, status and alarms are retrieved with a built-in modem via the public telephone network. This arrangement makes it possible to share an existing telephone line without inconveniencing the customer. Calls are made from the customer terminal to the central computer on a command from MiniCall or at a time programmed into the terminal.

4. CEWE Instrument - The DIN-EL System

General
With the DIN-EL energy metering system a complete system for individual electricity metering can be installed in both new or existing buildings.

System Features
The system requires only a four-wire cable from the top storey of the building to the basement and a cable from the distribution board in each apartment connecting to it. Consumption can be read off by the customer directly on the electricity meter and at the same time the information is sent to the receiver in the basement. This continuously stores information from all the apartments in the building.

Information from up to 48 electricity meters can be stored at the same time in one measuring unit. As many as 63 measuring units can be connected in a loop providing data from a total of 3024 customer distribution boards. The information is transmitted to a personal computer which prints out the bills to be sent to the customer. Several loops can be combined to form a larger system.

5. The ENEL System

The Italian energy company ENEL has developed a system which is based on the transmission of data on the high and low-voltage systems. The communication speed is 1200 bit/s and the carrier frequency is 72 kHz on the high-voltage network and 600 bit/s and 82 kHz on the low-voltage network. The system works on the ‘store-and-forward’

principle. This means that every electricity meter passes on the information and serves as a form of amplifier, so that the transmitter output is only 1 W.
The future trend is towards increased communication with customers via TV and with customers responding via a teletext terminal over the electricity distribution system.

6. ENERMET, MELKO 4000

General
The MELKO 4000 (based on the Centralpuls and MELKO 3000 systems) is available for both one-way and two-way communication but these options use alternative communication media. Two-way communication is via the electricity distribution system, medium- and low-voltage systems and signal cable network.

System Features
The product concept comprises a number of standard components, hardware and software blocks. By combining the components a user can expand the system as required to provide the desired functions.

Programs for terminal configuration and other utility programs are grouped in the Enermet Tool-box. The programs were developed under Windows with a graphical user interface (GUI) with mouse support.

The MH40 house terminal has two-way functions developed for the detached-house customer sector. The system is used to transfer information which enables the customer to read on the display such information as the current energy price, cost of consumption (including the fixed charge), energy tax and VAT. As an option the terminal can be fitted with a serial interface for distribution relay functions, kitchen display etc.

7. Flex Products, FLEXTAR

General
Flex Products A/S is a Danish company which was set up in 1991 and is owned by the distribution company EASV, Partner Electric A/S and Tele Søderjylland A/S. The company has developed a customer communication system which uses the Danish OPS public paging service. In Sweden the MiniCall system can be used.

System Features
All control is exercised from a simple base station comprising a PC with a modem. The PC is programmed with different parameters for tariffs, prices, statistics etc. The OPS paging system is used for remote control of technical function commands. The transmitter frequency is in the range 140-165 MHz or 469-471 MHz.

8. Landis & Gyr, AMDES

Introduction
AMDES is Landis & Gyr's system concept for creating new opportunities for energy distributors, based on modern communication solutions. The system enables the energy distributor to automate the flow of data from the meter to the finished bill.
AMDES is a two-way customer communication concept designed to meet the needs that exist in the fields of electricity, gas, direct heating and water distribution. It must, for instance, be possible to send commands with top priority and to transport readings data on the same system.

System Description
The system is comprised of the following parts:

- a central system unit DCC; which monitors and controls objects on the network and collects readings which are transferred to existing billing systems;
- a regional concentrator RC; which serves as a master for the relevant LV DLC network and as a bridge to the central system unit;
- a customer communication unit MCU which interconnects different types of control objects and meters to the DLC system;
- an electronic/Ferrari electricity meter with pulse output, or a modern DFS meter fitted with a tariff register.

9. Mainsborne Telecontrol - Thorn Security (now Mainsborne)

General
The Mainsborne Telecontrol system was developed in England by Thorn Security. It has existed since 1984.

System Features
Mainsborne is a two-way communication system which uses the electricity distribution system as the transmission medium. The signals are fed into the low-voltage network. In order to secure signal transmission, a broad-spectrum signaling technology was developed. The frequency range used is 45-90 kHz and the transmission speed is 300 baud.

System Design
The system has a central unit, DCC, matched to the billing and customer management system of the energy company. The central unit communicates over the telephone network with local area units, CC's which handle up to 1023 customers in the same substation area. The customer units have inputs to measure the consumption of gas, heat and electricity. There is also a contactor unit with two outputs for load control. The customer unit can be fitted with a display for reading registers and controlling the contactor unit.

In the simplest case, the central unit is based on a PC. For major customers the PC is matched to the customer's system environment, billing system and network monitoring system.

Possible system functions can be summarised as follows:

- multi-tariff metering
- automatic remote reading
- load control
- alarms from customer units

The monitoring unit controls time-multiplexing between local control units to ensure that signals do not merge. In practice it also has address tables for all local units and customer units. These are maintained manually or automatically.

Communication with local control units is via a telephone modem, which has a call-back function to secure the connection. Passwords provide separate access to meters for gas, heat and electricity.

10. Metric FA System

General
The system is manufactured by CB Svendsen A/S, Vaerlose, Denmark, and is marketed by VMC-Elteknik of Mariefred, Sweden.

System Features
The FA system is controlled by FA-BAs, PC and a telephone modem, located at the distributor. Communications go via the public telephone network to remote meter reading units. Folke Andersson 10, or directly to a portable PC at the point of consumption. The Folke Andersson 10 unit is connected directly to an existing telephone line which can then be used for ordinary conversions, faxes or data traffic without disturbance. The Folke Andersson 10 unit continuously collects pulses from the transmitter/meters. The pulses are weighted and stored as consumption or meter readings, which are then synchronised with the counter of the master transmitter. Instantaneous and maximum power, and the times of these, are calculated on the basis of this data. For district heating metering, the drop in water temperature and its instantaneous values can be determined in addition to energy, flow, and the values at maximum power.

11. NORTEL/Northern Telecom

Introduction
Digital Power Line is a portfolio of products developed by Nortel (Northern Telecom) and Norweb Communications, a business unit of United Utilities plc UK. The system allows data to be transferred over electricity power lines into the home at speeds of more than one megabit per second.

System Features

Digital Power Line enables electricity companies to add value to their power distribution networks by using them as information access networks to provide a communication service that gives electricity companies access to the Internet through their existing electricity network. The system offers permanent on-line connection with the potential for lower charges and enables data to be transmitted at rates of more than one megabit per second by using a patented technology that screens data from electrical interference on the host power line.

System Functions

A base station, using a specialised signalling scheme, turns the low voltage distribution system into a Local Area Network (LAN) to carry data traffic between the substation and home. Each base station is linked by copper or fibre optic circuits; using standard technologies, to a network node and then to worldwide communication facilities.

The technology makes a variety of new broadcast and interactive multi-media services possible and cost effective including the delivery of CD-quality audio, video clips, animation, high speed gaming and video conferencing, further the emerging potential of Internet to transmit voice is expected to be a market driver.

12. RMS Communication Systems Limited

General

RMS Communications Ltd have developed the PowerNet® system that enables fast, reliable two-way communications over both Low Voltage and Medium Voltage distribution networks. The system is capable of transmitting at speeds of up to 19,200 bits/sec.

System Features

PowerNet® uses non-invasive coupling devices to induce a signal directly onto the cores of the MV power cables. Providing the relevant infrastructure is in place, the PowerNet® system has the ability to reach every residential and business property. The Mains Modem acts as an interface to non- PowerNet® equipment allowing the system to have the capability to be utilised for a wide range of applications i.e. street lighting, security systems, Multi-utility meter reading, traffic light control etc.

System Functions

The system is controlled using the Central Controller, which is generally located at the Utility's office. As well as supporting the traditional AMR functions of routine and ad hoc meter readings, the Central Controller can carry out specific requests such as tariff changes and supply disconnection/connection. Any node on the system can be used as a 'repeater' to send messages to other more remote nodes, in order to optimise system performance in terms of efficiency and reliability.

PowerNet® is intended for use as a general-purpose data communications system as well as an AMR system. As such. RMS intend to develop)or support the development of) a wide range of functions and applications in the future.

13. Schlumberger ETS II

General
The system uses two-way communication o n the low-voltage network. From there, communication with the central computer goes via the telephone network or a dedicated signal cable. As an alternative, the data can pass through a transformer stage and reach the central computer via the medium-voltage network.

System Features
Information is transmitted on the electricity network with a narrow-band carrier frequency of 70-80 kHz at a data rate of 600 baud.

The system is designed to automate the management of most of the functions related to electricity meters and the remote reading of other meters, such as those for water, gas and district heating.

In addition to the remote reading functions mentioned above, the Schlumberger Industries system includes typical functions for managing the distribution network with regard to remote programming facilities, tariffs, automatic management of customer consumption with freezing of values at the predetermined date/time, detection of current leakage or malfunction with the aid of energy balance, load disconnection by commends from the central computer or tariff changing.

System Design
The design is level-based and modular so that the system can be upgraded and expanded. The levels, starting with the lowest, are:

1 meter level
2 transformer level
3 central computer level

14. SENEA - CUSTCOM

General
The system uses several frequencies in the 9-95 kHz frequency range specified by CENELEC. This two-way system is based on the master-slave principle, where the maser (the collector) is located in the network station and the slave (the counter) is on the customer's premises. The master polls the slaves cyclically.

System Features
CUSTCOM is based on the frequency jump principle. Four different channels with frequencies between 16 and 90 kHz are used. With this technique if transmission is blocked, by interference or damping in one frequency region, the system switches (jumps) automatically to another frequency region.
The circuits have built-in functions which adapt the transmission automatically to changes in the characteristics of the electricity network. Currently the maximum transmission speed

is 3200 bits/second. To enable the high quality communication, the system contains a function which detects faulty data packets and merges them to produce correct data packets.

The system allows both cyclically-polled and directly-connected transmission.

When new customer terminals are installed they are automatically logged on to the system. The system includes functions for broadcast control.

15. Siemens Measurements, Mains Metering System

General
Siemens Measurements Ltd (formerly Ferranti) is part of the Siemens Group and is based in Manchester, England. The main product line is electricity meters for the UK market.

The system uses two-way communication over the electricity network within the 40-90 kHz frequency band.

One of the system features is that the frequency is automatically matched to the impedance of the network in order to minimise the attenuation of the signals. Phase-shift modulation is used.

The customer terminal is a tariff computer (MDS), with an integral communication interface for transmission on the low-voltage network. Connection to electricity meters are made via an SO interface. Alarm inputs and outputs for control can also be provided.

The information to and from the customers is collected on the low-voltage side of the distribution transformer in a data collection unit (DDC). From there, communication with the cental unit goes via a modem over the public telephone network. The DDC on the low-voltage side can hold data for more than 1000 customers.

At the central unit, information is collected in the database of the regional data collector (RDC) for further processing and distribution.

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