The Internet and broadband society needs a new form of power distribution.

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Abstract:
Nearly all aspects of public and commercial life depend on electrical power and telecommunications. Internet technology will become the means by which critical communication services, e.g. telephony, 112, etc. are distributed. The customers of broadband services will get telephony over IP at low extra cost and will not pay for the old telephony service any more. Gradually, all buildings that are fully broadband connected will be disconnected from the old fixed line telephone network. This means that the availability and reliability of the Internet access must be dramatically improved. IP technology requires high electric power locally at every active point in the access network, including the IP telephone. Telecommunications and the Internet are most likely to fail us when we need them the most, during a power cut. It would be a maintenance logistic, an operating and environmental nightmare to try to provide each and every one of the billions of electronic devices that make up the Internet with small batteries that can last for 8 hours, which is the target of the telephone network,.

It is therefore clear that the mains electricity network, needs an upgrade of integral reserve power supply for the powering of Internet and other critical systems.

This upgrade to the power distribution network could be rapidly implemented by using power cables made to the same dimensions as optical fibre cables. Power cables can be natural conveyers of optical fibre making up hybrid optical power metropolitan area networks. An estimate of the operational reliability of such a system would suggest that this new power would be unavailable for less than 15 sec/year, which is the target for power supply of telecommunications.

This paper will suggests a solution of this challenge and proposes a new power distribution system with integral reserve power.

1.0 Introduction

All activity and business in modern society have become almost complete dependent on the sustainable supply of electric power and communication. It is not any longer real mission critical systems, but also normal life functions that suffer heavily in case of interruption of power supply and communications. Companies responsible for energy supply and telecommunication must from now on plan and construct the infrastructure for these systems in joint action to obtain co-operative systems, which can support each other fully.

Because of Internet there is a great change in paradigm for the power supply and safe operation of telecommunications. The old telephone system is independent for 8 hours or more of public power supply and can be used as restoring tool to restart the disturbed technical systems including the power distribution during mains failure. The public can use the telephone as a lifeline service to call for help and report power failures and to ask for information.

The Internet development is defined by the ever increasing use of computers and communication and the ambition of Internet to take over the telephony service by IP-telephony. This shift in technology makes the public power supply system directly responsible for the power supply of telecommunication. Internet cannot use the centralised reserve power system for telecommunications that now is in operation as its computers in the access network requires too much power of normal AC voltage. The local conventional battery back up by UPS systems is because of many aspects not a sufficient solution.

The new IT infrastructure required for broadband consists of national and international telecommunications backbone networks, MAN-networks (Metropolitan Area Networks) and LAN-access networks (Local Area Networks) as well as new 3G wireless access networks.

Broadband offers many advantages in an ever expanding range of applications, many of which are business critical, e.g. payment systems or literally vital e.g. in telemedicine or domiciliary healthcare. This inevitably means that as we become more dependent on such applications we become more vulnerable when they do not function. Power cuts have immediate and serious consequences. The rollout of systems for secure power supply and telecommunications must therefore be coordinated.

1.1 Increasing vulnerability

We have every good reason to review the vulnerability of these modern systems in general and the security measures that are needed to ensure high operational reliability in particular. All these networks require a lot of electronic devices, present in every building and widely dispersed throughout an entire country. These will need a significant amount of energy, that must be in constant supply at the point of demand. The power demands made on the electricity network by Internet and broadband access only are estimated to be at least 300 MW per approx. 10 million people, and the annual energy requirement at least 2 TWh.

Logistics, maintenance and control of industrial processes, and monitoring of electricity and telecommunications networks etc. are to a great extent carried out remotely nowadays, something that demands reliable telecommunications and power supply. Computers in management, control- and supervision systems and information systems need to communicate with one another and this what makes society vulnerable.

The need for secure supply, demands in turn greater network resilience and availability of reserve power sources and new enabling technologies

2.0 Demand for more secure availability is the inevitable consequence of Internet

The established fixed line telephone system has one great advantage. It can function for at least 8 hours independent of

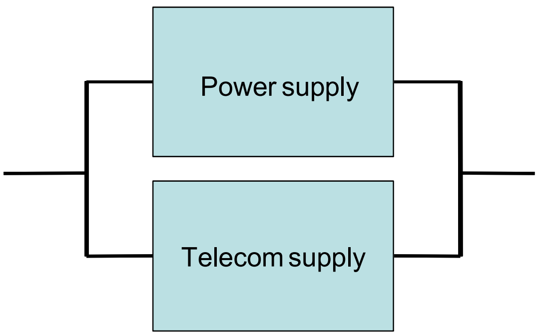

Fig. 1. The logic reliability scheme of today's situation, whereas power and telecom serve society independently and in parallel during 8 hours.

mains electricity, maintaining the functionality of each fixed telephone through the use of its own power distribution with integral reserve power.

This means that fixed line telephony remains a reliable lifeline, available for emergency calls by members of the public in all sorts of crises, even when the utility supply is down, Fig 1.

This feature implies that technical faults can be quickly identified and the restoration of failed technical systems, e.g. the electricity supply network or other technical systems, is made efficiently with the use of voice communication between technicians. It is an invaluable asset for society, providing support at those times when the need for reliable voice communication is greatest. The fixed line telephone network is also the foundation on which wireless telephony is built. Wireless networks rarely manage a power outage for more than an hour or so without special solutions such as the installation of small transportable electricity generators in base stations. 3G networks have even more base stations, so such solutions are hardly feasible, particularly in cities.

The advent of the Internet and broadband has led to the loss of this independence from the electricity grid. The Internet enabled computer powered by mains electricity and using IP-telephony has superseded the traditional fixed telephone, which receives its power via the telephone line. IP-telephony is an integrated part of Internet access via a local network in a property with many users. It is a completely computerised communications network for broadband, which, is powered by mains electricity at every active point, including the telephone. Power and telecom supply are put in series, Fig 2.

More and more buildings that become fully connected to the Internet via broadband will be disconnected from the old telephone network, which will inevitably wither away and eventually disappear. An ever increasing proportion of voice and data telephony is being transmitted via the Internet, resulting in ever increasing demand for better Internet access, which is technically relatively easy to achieve as regards the computer equipment used.

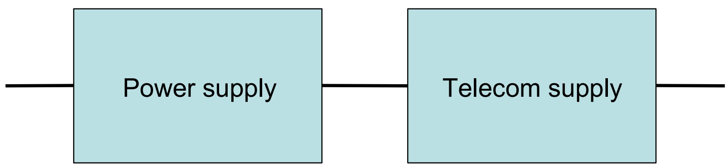

Fig.2. The logic reliability scheme of the "Internet-situation" when society is served by power and telecom in series.

2.1 Traditional reserve power solutions

Energy supply is less straightforward to deal with for both operators and consumers. Traditional solutions involving local battery systems or reserve generators are not easy to operate or maintain. They are expensive, difficult to operate and undesirable from an environmental point of view. The investment cost required for the necessary level of availability and required reserve time is very high in decentralised systems compared to those in centralised. Also maintenance is more complicated to organise. Located in great numbers, distributed in all buildings this solution represents a giant maintenance task and cost. To be fit for intervention having the availability required in case of mains failure all individual plants need regular supervision, test running and battery control. As for the environment, increased use of lead in batteries is not recommendable. Lead is coming up as a heavy metal, which will be banned by legislation. Having diesel fuel tanks in great numbers distributed in many buildings is not a desirable circumstance, considering the risk for leakage to the ground and risk for unpleasant smell from the petrol and diesel fumes and noise coming from often occurring test runs. Also fuel cells installed locally in buildings will have the same maintenance and cost circumstance. However centralised in a bigger plant would be the best option for future use.

3.0 Required availability level

The Internet now challenges the old telecommunications infrastructure in the field of voice communication, which is the most mission critical of services. This means that the availability and reliability of the Internet must be improved dramatically. The old telephony infrastructure has since a century been constructed with the most stringent reliability and availability design requirements. These can be expressed in a number of different ways.

A telephone station is designed with the requirement on its accumulated down time to be less than 2 hours in 40 years, which is equivalent of 3 minutes average per year. This is the level of 99,9999 % availability or 6 9:s. So when it comes to power supply it is required to be at least 10 times better, which implies 7 9:s in every active point. In practice the requirement on power has been an unavailability better than $5x10^{-7}$, which is equivalent to an accumulated downtime of less than 15 seconds per year. These are figures, which are defakto standard and used in practice by the telecom industry. They are verified and reality in fixed telecommunication systems worldwide today. This is the foundation for the high reliability in service, that today's telecommunications systems show.

Telephony and the Internet share a common backbone network. They differ, however, at the level of local and access networks. The telephone network has a centralised structure and service organisation, while those of the Internet are decentralised. This difference has great relevance for the provision of reserve power during mains outage. The fixed-line network has its own power distribution system and provides each telephone with power from reserve batteries and generators located up to 5 km away at exchanges.

If the Internet is to take over responsibility for vital emergency and other telephone services from the fixed line network with the same degree of operational reliability, the reserve power capacity of the old system must be replaced. Ordinary power distribution networks have approximately an average level of outage of about ½ - 1 hour per year in urban areas in industrialised countries. This level of availability cannot comply with the requirements put on power for voice service and other mission critical services planed for Internet. The operational reliability in mains distribution systems cannot be significantly improved upon without structural changes.

To make this challenge a success, Internet access needs the support of a highly sustainable mains distribution system. The logical conclusion is that electricity distribution must be restructured in order to meet the new demands for dependable supply made by the Internet society. It however only needs to be improved to the extent made necessary by the needs of the Internet and other critical uses. It implies that the mains electricity network, like the telephone network, needs an integral reserve power supply for the powering of Internet and other critical systems.

4.0 A new mains distribution system

The main philosophy behind high availability performing systems is the use of always active parallel operating units and diversified transmission routing. Consequently the major measures to adopt in restructuring local mains distribution infrastructure would be to use integral reserve power, diversified routing and always active parallel operation.

4.1 The overlay power network

The need for a new highly available mains supply for Internet and society's other mission critical systems can be met by linking reserve power stations into a new local electricity distribution system. It should be used to normally power the Internet and the IT-infrastructure in parallel with the ordinary mains electricity supply. The new reserve power stations would be located in urban population centres, and the network would normally form a supplemental part of ordinary mains electricity distribution, assuming the role of a reserve network only when the reserve generators are started.

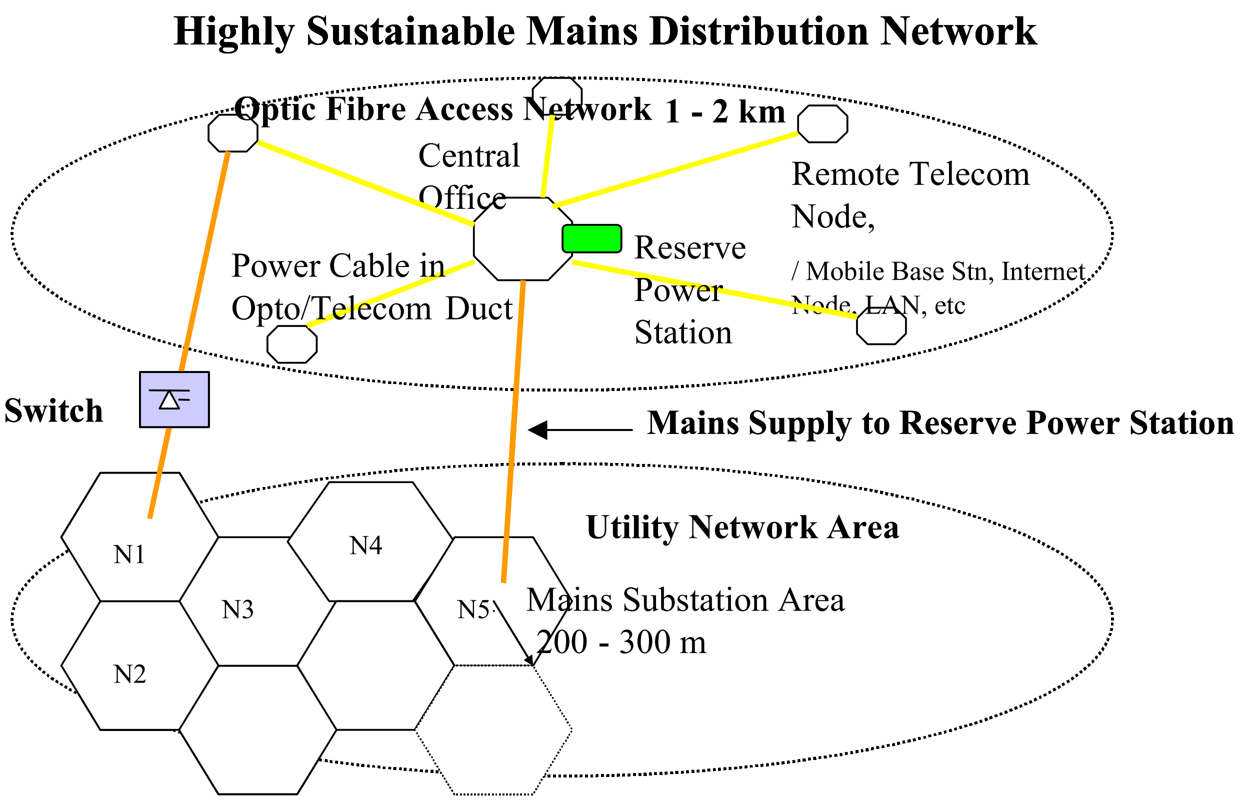

Fig.3. The ordinary mains network and overlay mains distribution network.

This upgrade of the existing power distribution network could be rapidly implemented by using the existing infrastructure of the telecommunications network or new optical metropolitan area networks, such as buildings, underground channels and reserve generators. Thus forming a joint overlay mains power distribution cell with a radius of maybe 10 times the normal, covering parts of metropolitan areas, city centre, industrial- and office parks or campus areas etc, Fig. 3 and Fig. 5.

Power cables can be made to the same dimensions as fibre optic cables and be the natural conveyers of optic fibre. They can be laid using the same methods and equipment for compressed air technique. In this way a dual power supply can be created, with two separate networks operating simultaneously. A new product - electricity with a high guarantee of supply - would become available. It should for many reasons be logical to introduce in conjunction with the building up of the new optical infrastructure.

5.0 Hybrid optical power cables, makes possible construction of MAN hybrid optical power networks.

New cable technology allows integration of optical fibres into power cables as well as dimensions similar to optical cables. By this approach using collocation of a metropolitan area network (MAN), and a power distribution network in the same cable, a dual functionality network is achieved. The dimensions allow installation in standard optical fibre ducts. These hybrid optical power cables can be in two designs, either with the optical fibres integrated in production, or

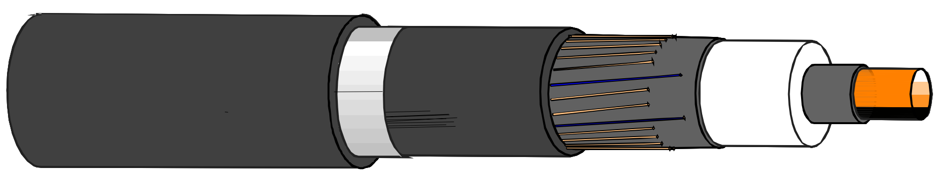

Fig. 4. Hybrid-power optical fibre cable 7 kV 10 mm^2

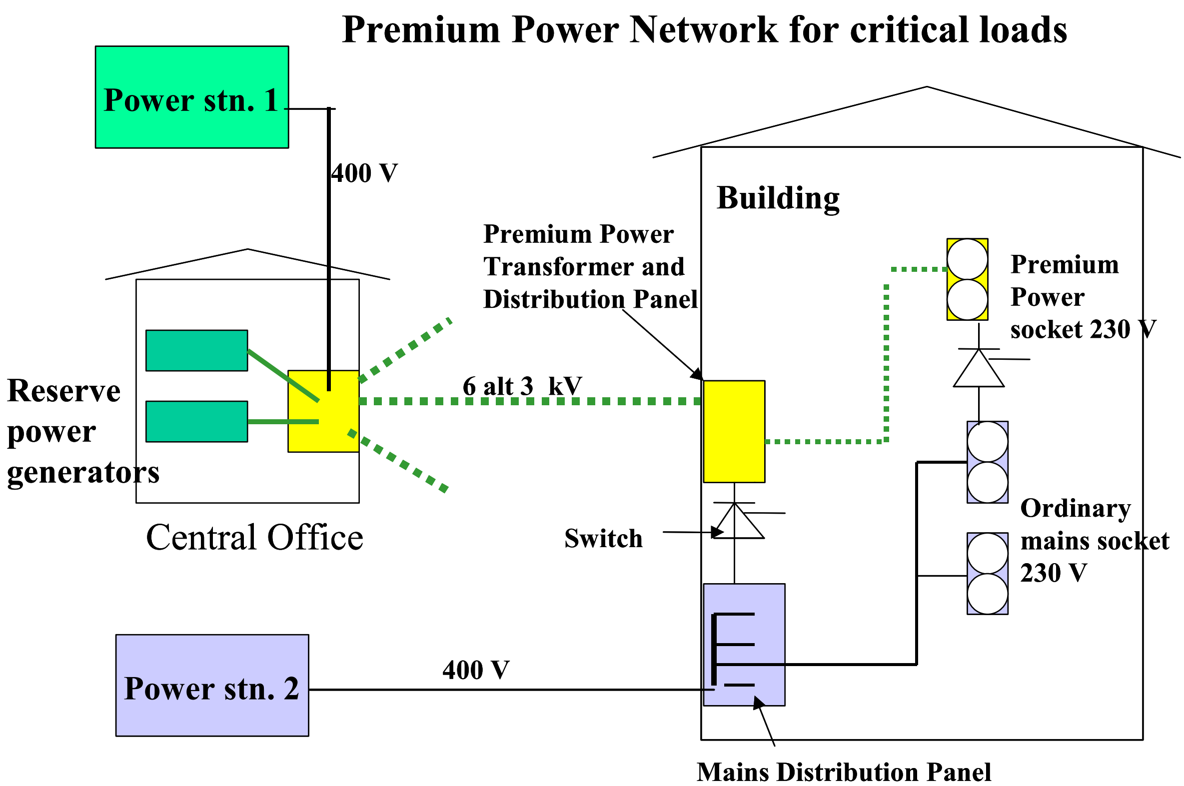

Fig. 5. A new mains distribution system.

cables equipped with micro ducts, which allow the lay on of optical fibre later. Both single phase and three phase cables are in suitable dimensions.

5.1 Single phase AC or DC cables

Fig. 4 shows a single phase cable, which is available in 10 mm^2 Cu conductor for 7 kV and 6 mm^2 Cu conductor for 5 kV. Between the screen conductors optical fibres are located in so called loose tubes. Present designs allow 48 fibres put in symmetrically around the cable. The diameter is 20 mm for the 7 kV type and 13 mm for the 5 kV type.

5.2 Three phase AC cables

A three phase line can be made by the use of three single-phase cables in a three-phase connection. Standard voltages 12 kV, 6,6 kV and 3,3 kV can be used.

The ordinary three phase cable design, Fig 6, contains 3 micro ducts for optical fibre. The fibres are installed when suitable in the micro ducts with compressed air technique. The diameter of a three phase 5kV cable is 22 mm.

All cable types can be installed in a standard 40/32 mm optical fibre duct. These plastic tubes used for ducts, represents an extra isolation layer, which increases safety in the system. It also adds an extra mechanical protection to the cable system against digging damages.

The standard three and single phase 12 kV, 7 kV, 5 kV cables without optical fibre are products, which are produced in big volume for use in ordinary electricity distribution and can be of use when high power is needed in an overlay distribution network as described.

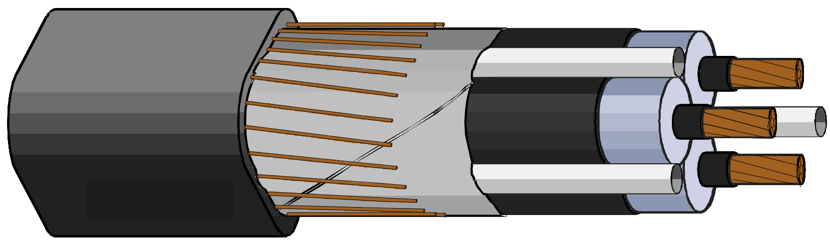

Fig. 6. Three phase cable with integrated micro duct.

5.2 Installation cables for buildings

For installation of optical local area networks (LAN), for broadband in buildings, a new type of installation power cable is available, Fig 7, It shows a cable with an integral micro duct for optical fibre.

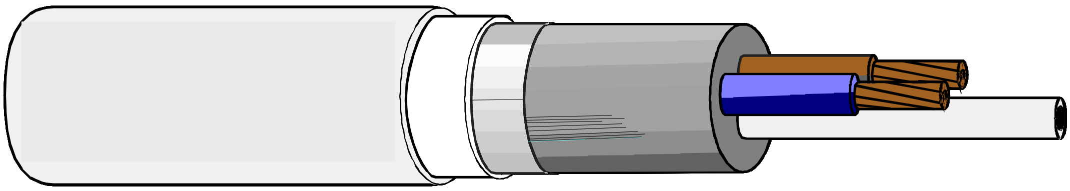

Fig 7 Single phase installation cable with integrated micro duct.

The copper areas of the conductors are 2x1,5 mm^2 plus 1,5 mm^2 PE conductor and screen. The level of isolation is 1 000 V AC.

In this manner a new section for distribution of highly sustainable electric power, reserve power for mission critical equipment in buildings can be a reality simultaneously with the rollout of broadband in fibre to the office and home and with only limited extra cost, Fig 5.

6.0 The development in optronics is exceptional.

New optical transmission technology now has 16 (or more) synthetic wavelengths (colours), which can be injected in one single fibre string. All wavelengths can be operated in Gigabit speed simultaneously. These advanced systems are now for sale at low cost for use in metropolitan area networks. This means that one fibre can do the job, which earlier required 16 fibres. Thus the need for optical fibres cables with a great number of fibres will reduce. And cables like hybrid power optical cables can compete even when there is a need for great data transmission capacity.

The difference in cost between standard optical cables and hybrid cables is not critical, considering other cost. The direct cable cost compared to other project costs does not dominate a typical metropolitan area network project for broadband. Adding fibre to a power cable do not add much as fibre is cheap.

7.0 Conclusion

The development of new generating techniques and cables to be used in existing ducts and infrastructure has come to a point where it is possible to distribute highly reliable power to support optical fibre networks. Environmental constraints on lead batteries, stand-by diesel generation make a joint-overlay network a very interesting solution. The joint overlay network makes it possible to distribute mains power of high availability and integral reserve power to a broader range of customers, especially smaller. The suppliers of Internet broadband and the utilities should offer this new service and product to the market and the customers. All of us in society would become winners, enjoying a more resilient and less vulnerable society, as dependence on broadband Internet and mobile systems increases.

IPR

The method and system for distribution of standby electric power according to this description is covered by a number of patents in Sweden and US. These are SE516 059, SE516 756, SE517 112 and patent application Nr 9602319-7 and US6498966. John Akerlund is inventor and co-inventor of these patents.

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