

# DC Powering of Internet certifies for telephony

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## Abstract

Telephony faces new great changes. One paradigm, still current, was established at the beginning of automation in the 1920s. That was when the central battery system was introduced, enabling telephones to be powered over large distances, 3 – 5 km from the telephone exchange. The customers did not have to deal with local batteries anymore.

The central battery system was a great step forward, leading to a dramatic increase of service level, availability performance and reliability in telephony. It helped subscribers to make their calls without the need of public power supply or local batteries and at the same time made the telephony system into a very reliable, life-saving, emergency and safety system of great benefit to the entire society. The "lifeline" was born. This excellent quality of telephone technology, simple as it is, must not be underrated. If possible, it should be defended and maintained, see Figure 1. This can be achieved at low costs when constructing Internet, laying data cables for LANs into almost any building.

The present technical development, with datacom, broadband, IP telephony via the Internet, PCs and optical fibre etc., decreases availability performance, reliability and if not independently powered, the "lifeline" function. From the point of view of performance availability and power supply, the present technological development will bring us back to the times of the local battery unless the power people take action.

This paper describes a possible solution to this problem, and shows what to do to give Internet and IP telephony the same functionality and availability as Plain Old Telephony Service (POTS), when it comes to power supply.

"Require the universal current feature from the datacom industry!"

"Move the central battery system out to the buildings!"

"Combine the laying of data cables with a laying of DC supply cables!"



Figure 1

## 1. General

There is widespread concern about society's increasing vulnerability, as it becomes more and more dependent on technology. It is understandably accompanied by a demand for more robust, simple and reliable powering systems. Improved availability performance and economy are also on request. Other examples are improved electrical efficiency and quality by means of a sustainable power supply system. Effective measures capable of reducing our vulnerability and sensitivity to disturbances in public power supply systems and telecommunications should be welcomed.

The purpose of this paper is to describe whether the desired effects could be achieved by partly going back to DC powering systems. The basic conditions of using DC powering of electric equipment like light fittings, computers, telecommunications equipment, office machines, domestic electronic appliances and other consumer products in residential and office buildings is discussed.

## 2. Historical review

### 2.1. Public electricity

During the early electrification period all electricity was DC. Initially 2x110 V and later 2x220 V were the first standard voltages.

In the cities where it all started, each block or number of blocks had its own power station powered by steam engines. The distribution cables covered an area with radius from a couple of hundred meters up to about maximum 500 meters. The same area of distribution or smaller is normal today because of the allowed voltage drop. At the power station there were accumulator batteries to provide load levelling. This was the normal concept at the time being and it delivered uninterruptible power to the consumers. That was a system that we today would call a DC UPS system and it would have been great to have it to power Internet and other critical loads for the benefit of us all.

When the use of electricity expanded the local power generation became too expensive and environmentally unacceptable. The next step was to move the power stations out of the city centre and at that time the 3-phase AC transmission system was invented. By means of high voltage transmission (6 kV) it was possible to transfer the required power to the places where earlier the steam engine generators were located. So they were changed to converter plants equipped with rotary converters, which transformed the high voltage AC to low voltage DC to be distributed as before and still backed up by batteries. In the city of Stockholm, for example, DC distribution areas existed in parallel with AC distribution areas for a period

of 50 years. The last area of DC distribution in the city of Stockholm was closed as late as 1974.

The great drawback and problem in conjunction with DC and in comparison with the AC system was the difficulty to break the current. This problem caused trouble with the electric switches and breakers and caused risk for fire. The batteries in the system caused high maintenance costs together with the switching troubles. The risk for fire was always a reality. The AC system is more favourable as the current is easy to break. It almost eliminates the risk for fire and simplifies the switching and transmission of power. So AC became the dominant system as it gave the safest and cheapest solution to distribution of electric power to the public

### 2.2 Public telephony

Similar to the public electricity system in the early nineteen hundreds was a DC UPS system developed for use in public telephony. It has been used in telecommunications since the 1920s when the so-called central battery system was deployed for powering telecommunications systems and telephone sets. It is a very reliable system independent of public electricity. It can supply telephone sets at a distance of up to 5 km, reaching a whole city from one plant. In its simplicity and without much notice it is the foundation of society's biggest safety and security system: the emergency service number 112. Thanks to this system, the ordinary citizen can use the telephone to call for help in emergency situations, also when or because there is a mains failure, see Figure 2.



Figure 2

The new Internet technology needs to be powered locally from the mains. The telephone, which in future will be a PC-type device, can no longer be powered via the telecom line, and so the eminent lifeline function collapses. It is a social benefit that should be maintained.

### 3. Powering modern telecommunications systems

Old telecommunications systems started with manual switching and were powered with DC, which was the standard and suitable source of power. When automation of telecommunications systems started, the technology was electromechanical and based on relays. These systems also required DC as source of power.

Modern telecommunications started to develop when computers were introduced. Some of the first computerised switches were powered by AC systems. However, AC distribution within telecommunications switches turned out to be a disaster and these systems very soon turned back to DC the safest way of powering for high reliability. Also when mobile telephone systems were introduced the first radio base stations were powered by AC. Now DC, the standard option, powers all mobile systems because of its reliability and efficiency.

Internet is now becoming a public telecommunications system rather than more or less a private data communications network. This changes the prerequisites in many aspects, among them the requirement on reliability in service and also the reliability in power supply. As traffic escalates in Internet this change will take place gradually and the public's demand of uninterrupted service will rise continuously. The natural and logical choice of power supply for Internet would be DC

### 4. Modern electronics

One other great change in prerequisites compared to old-time conditions in the comparison of DC and AC is the change of rectification method. The dominant technology, before, was the use of low frequency rectification. Today however, the technological development has made it possible to use high frequency rectification instead. This has introduced new technological prerequisites and conditions, which open up new advantageous features that are especially attractive for the operators and customers.

#### 4.1 Universal current apparatus

More specifically, this means that the modern high frequency rectifier includes a DC/DC-converter. See Figure 3. This rectifier can operate on 230 V AC as well as on 340 V DC. So it is a universal current apparatus unlike the low frequency type, which is a true AC/DC converter. This new situation creates great opportunities and flexibility in design and selection of powering methods. It makes possible to reduce elements in series in the traditional concept, i.e. the AC UPS, and simplify UPS system design. It gives higher efficiency and higher availability. Lower energy losses reduce the need and

cost for cooling. All together the new technology brings significantly lower cost both for investment and operation, lower life cycle cost, ref. [1].

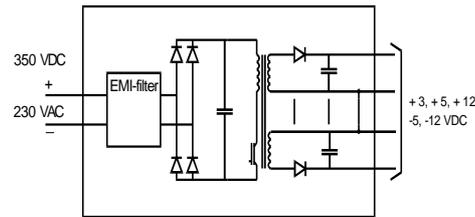


Figure 3

### 4.2 AC versus DC

The old argument against DC is based on the fear of fire connected to the old problem of breaking direct current. This is true especially when the load and cables have large inductance and was truly a problem in the old DC times. Modern conditions, however, have changed this circumstance drastically. Modern power electronics and micro-power electronics have altered the typical load from inductive to capacitive or resistive. Almost 100 % of all electronic AC-loads, including low energy bulbs, have now some sort of power electronics included for conversion or regulating purposes. So if powered by DC, the DC power source looks into a capacitance or resistance. The problem of breaking the current has become much easier as only the cable inductance is included, when breaking the current. Also micro-power electronics can be used in a modern DC distribution system integrated in devices such as circuit breakers, fuses, socket outlets etc. to master the current breaking problems. The general conditions to use DC safely and reliably has improved fundamentally by the existence of micro-power electronics.

Interestingly, the capacitive character of the loads causes new problems that affect the AC system negatively. These are power quality problems such as harmonic distortion and other EMC problems. These problems are especially critical for AC UPS systems since they are not low-impedance power sources.

### 5. Increased need for UPS

The increasing use of telecommunications and the Internet induces many owners of office and residential buildings to build local area networks (LAN) to enable Internet and broadband access on their premises. These proprietary telecommunications networks, often with integrated safety, security and monitoring systems, are subject to stringent requirements on availability, of importance to both daily and working life and for safety and security considerations. Consequently, this type of plant needs a powering system more reliable than the public mains. This is where DC powering has its

advantages, not least when it comes to simplified designs of uninterruptible power supply (UPS).

## 6. A comparison of reliability

The requirements imposed by telecom systems on the power supply system and the portion of unavailability that may be allocated to the power supply system of a telecom installation is  $5 \times 10^{-7}$ , which is 0.26 minutes or 15 seconds of service disruption per year. This requirement is derived from the service level needed for telephony service. In the INTELEC® white paper from 1998, "Powering the Internet, Datacom Equipment in Telecom Facilities", ref. [2], a comparative calculus of unavailability was made comparing the AC UPS with the DC UPS as used in their respective standard configurations.

### Reliability Model AC UPS

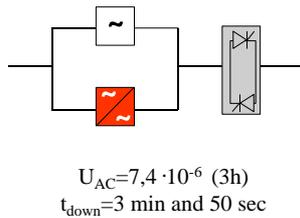


Figure 4

### Reliability Model DC UPS

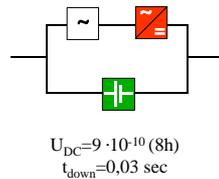


Figure 5

It showed the difference being as large as 7600 times in advantage for the DC UPS. In large-scale operation and use, this difference will give a valuable contribution to overall performance and economy on system level for the end user and consumer, you and me, when using Internet. See Figure 4 and 5.

## 7. Electrical safety, legislation and standards

### 7.1 Electrical safety

From the point of view of personal safety, DC is safer than AC, ref., [3]. Clean DC power through the body does not cause cramps as a result of the effects on the nervous systems of the muscles and the heart as provided by AC power. The shock perceived in contact with a cable is an electrostatic shock. The reaction is a reflex movement away from the conductor to break the contact. The possible resulting harm is secondary injuries from falling or bumping against other objects. If worst comes to worst, burn injuries may result from a plasma arc burning against the body for quite some time. Serious injuries of this kind may also occur in connection with AC power.

In connection with short-circuits and ground faults, fire hazards are greater with DC power than with AC power as there is no zero crossing capable of turning the current off. Minors short-circuit or ground fault may be in progress for a long time, causing heating and eventually fire. It should be possible though, by means of modern power electronics and ground fault monitoring, to develop means of protection and breaking elements to reduce these problems to a minimum.

### 7.2 Legislation and standards

According to present laws and regulations, there are no obstacles to a low-voltage installation with a DC powering system instead of an AC powering system, or a combination of both. In the safety instructions (and the EU low-voltage directive), both DC voltage and AC voltage are indicated, with a maximum voltage of 1500 V DC and 1000 V AC, respectively. According to the regulation, terminals or socket outlets from different voltage systems shall be designed so as to prevent mistakes and be non-interchangeable.

The requirements to be met for connection of equipment to 230 V AC are common knowledge and well documented. For DC voltage, the corresponding requirements and standards must be better established. Technically it is no problem as most of it is well known. A voltage of 170/340 V DC will make it easy to connect all peak value detecting equipment to both 110/230 V AC and 170/340 V DC. Such a system voltage will make all electronic equipment universal. The tolerances of equipment connected to the mains is often  $\pm 10\%$ , which should of course apply also to the DC voltage value. The requirements for immunity to brief deviations from the nominal value specified for AC power operation should be sufficient for DC power operation as well.

## 8. DC power distribution in office and residential buildings

### 8.1 General

All residential and commercial buildings in Europe are connected to 400/230 V AC. The connection terminates at the local power distributor with a franchise. The connection is performed via a service centre designed according to current standard, with a service fuse, main switch and distribution fuses.

For flats, regulations in force prescribe lighting and terminals to be divided between at least two groups in each room. In office buildings, there are several power supply solutions available according to needs, type of tenant, etc. Where computer equipment is extensive, the installation often already includes separate cabling and fuse panels for the connection of computer equipment. At the tenant's request, the power supply system for computer equipment may be provided with some kind of protective equipment against voltage breaks or other voltage fluctuations.

Very often there is no clearly defined, regulated limit of responsibility between the equipment installed by the property owner and the needs of the tenant/user. The landlord/property owner only provides "standard" installations, and the tenant/user must procure and operate his own equipment. The main lighting often consists of low-energy lamps and HF fluorescent lamps.

### 8.2 Emergency lighting

According to current building regulations, emergency lighting along escape routes is required in buildings of more than eight floors. According to these requirements, the emergency lighting shall be connected to a separate power supply source. To ensure proper evacuation, a system of electric emergency fittings and illuminated/fluorescent signs are installed for guidance. Depending on the situation, they are powered centrally by AC or DC systems or by means of built-in power supplies with local battery backup.

### 8.3 A possible system structure for the future

All buildings offer possibilities of installing a separate distribution for DC powering of computers. Terminals, fuse panels and connectors can all be adapted. Existing networks or network sections should also be possible to adapt or rebuild for DC operation. With a voltage level for DC of 170/340 V the same cables that are used for normal AC installations can very well be used.

When planning for new installations, the possibility exists of co-ordinating the needs of UPS for datacommunications, telecommunications, fire alarms, access control systems etc. This offers an opportunity of building up a more reliable and economical system. The

powering of numerous different security systems, now with separate power supply installations within the same building, could be co-ordinated. Much money could be saved on purchasing, installation, operation and maintenance.

The traditional AC power distribution network has its given place. A DC network for distribution of uninterruptible direct current to communications systems, locks, alarms, surveillance, security and emergency lighting systems in the building may very well exist in parallel. See Figure 6

Ordinary buildings for office and residential purposes will in the future be very much like today's telephone stations when it comes to power- and communications networks installations. These must be constructed based on practices elaborated and adopted for telecommunications buildings to ensure safe and disturbance-free operation, protection against lightning and EMC etc.

## 9. Conclusion

You should always go for the best solution, in any situation. I do not propose DC powering as a universal solution. But I still believe it is the best solution if you want to achieve high availability performance and sustainable economy for vital functions like communications, security and safety systems.

Future powering systems in buildings could very well be the traditional AC powering system for general consumption purposes like heating and housekeeping needs, in combination with a separate and partly redundant DC powering system for communications, security and safety needs. Most electronic equipment could universally use outlets from both systems. The DC powering system can and should easily be provided with reserve power from batteries or other reserve power sources for backup availability.

With a new structure of powering systems in proprietary networks and the introduction of DC powering, a new and much better power quality may be achieved for specific and vital applications.

Using DC powering in the manner described above will help us to considerably reduce social vulnerability due to fast growing reliance on electricity and communications. We will achieve a society more robust and sustainable and better equipped to overcome various kinds of crises. Business and life in general can go on as usual. Internet will by the use of DC get the same service level that telephony has.

# On the premises telecom and data network

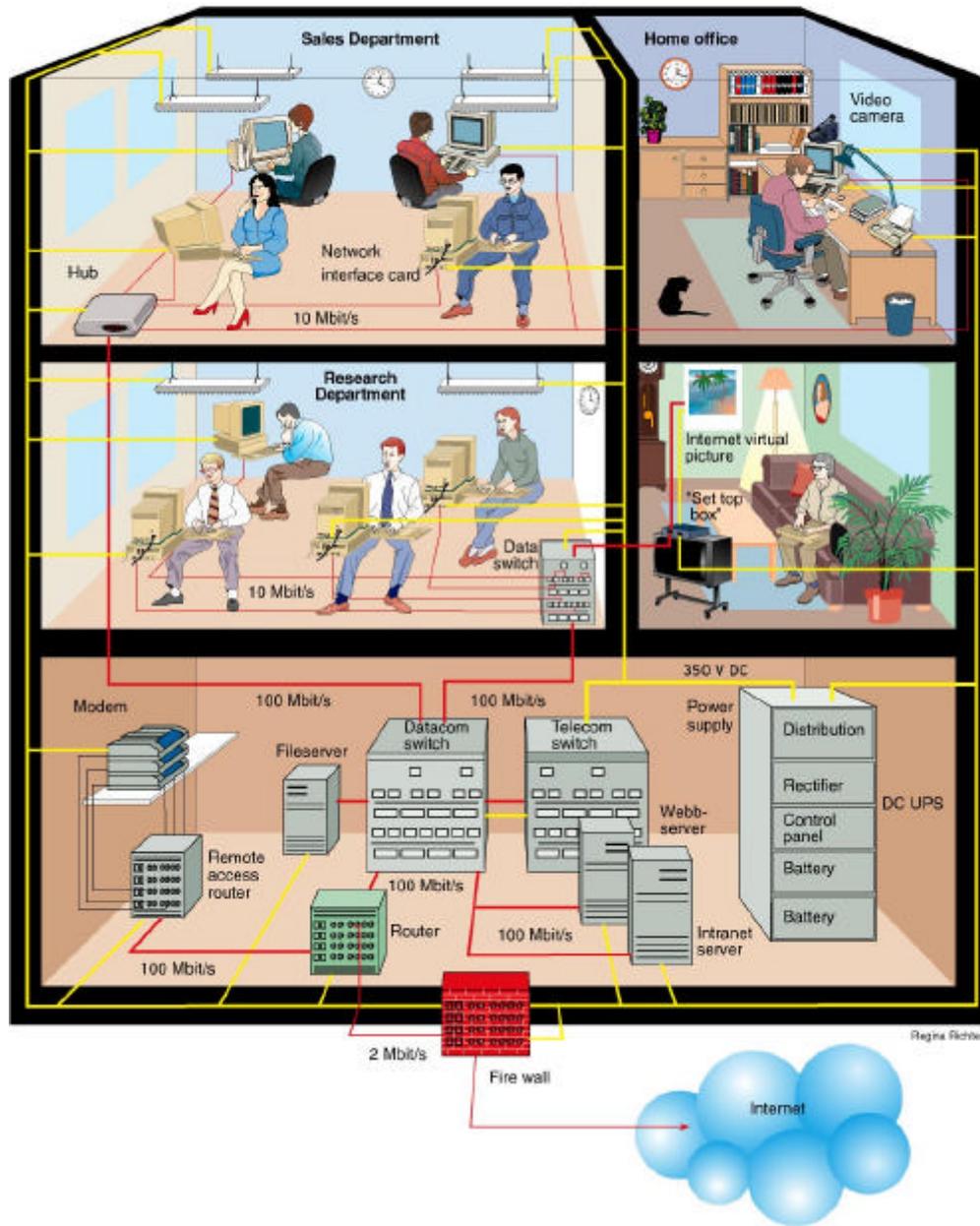


Figure 6

## **10. Action plan**

- Require the universal current feature from the datacom industry.
- Move the central battery to the buildings.
- When installing datacom networks in buildings, also install or prepare for a separate backup power distribution for the critical loads.

## **Acknowledgement**

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## **References**

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