Powering the Internet – Broadband Equipment In All Facilities - the Need For a 300V DC Powering and Universal Current Option

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Abstract:

There are big opportunities to replace the present AC -UPS systems by introducing 300V Single mode parallel operating system in telephone exchange facilities. In doing this, one can expect higher accessibility and extended back-up times. As an extension of this, all 48V system can eventually be abandoned at a pace when servers and routers will handle a greater part of the telephone traffic.

To ease the implementation, a unanimous view regarding the necessity of having a standardised interface is needed, as well as a certification for 300VDC of today's AC fed equipment.

1.0 Introduction/Background

The use of IP telephony, broadband and datacom via internet is increasing worldwide. This has resulted in a transformation of the old telephone exchange stations for voice telephony to a mix between telecom and datacom. That has not been completely simple because most of the servers, routers and modems in the market are fed from AC source. The work to introduce -48V supplied equipments has not been a success because the development in this area is driven by the data industry and it has been oriented towards the AC supplied mass market. The mix of different power solutions for telecom and datacom in the same building is not simple to handle because of maintenance problems and cost.

We propose to introduce a new power system strategy in the telecom business. How to implement same quality, reliability and cost effective as in the old type has become an urgent topic and been discussed more frequently during the recent years.

Until now the only possibility to guarantee safe and reliable AC source has been with UPS systems in combination with diesel generators. There are substantial problems related to complex UPS systems. High cost, low flexibility for expansion and sensitivity for load with high distortion.

One important factor when looking for a better solution is that most of the modern datacom equipment can be fed with universal current without any problems. That has been addressed in the new ETSI standard EN300 132-3. Telecommunication equipment is specified to operate from single phase 240V systems as rectified current, alternating current or direct current source up to 400Vdc.

The power 300V DC can be realised in different ways depending on what aspect are important.
The specifications of data com equipment as described in ETSI EN300 132-3 is basically the same as what servers, routers and modems already today fulfils regarding mains variations and EMC.
With that in mind we have three possible ways to feed the datacom equipment. Using UPS systems as today, direct rectification (rAC) of the mains or using 300V rectifiers.

We have found many advantages to use the system with 300V rectifier modules and have investigated how such a system can be built.
Such a system is possible to build up in the same way as the traditional –48V system with a higher voltage and achieve the same performance.

2.0 Technical Solution

2.1 *System*

The proposed system is a (n+1) single mode parallel operating system with the same structure and philosophy as 48 systems.

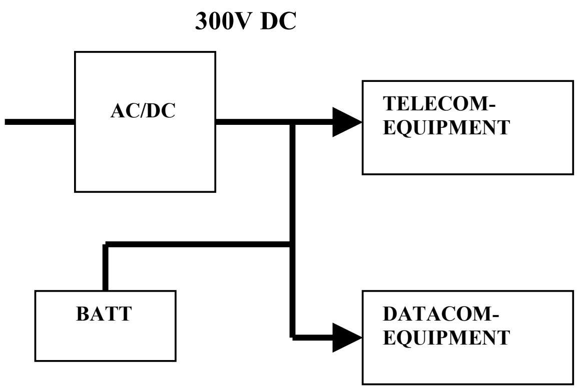

Fig 1. Single mode parallel operating system

This redundant system contains several rectifier modules and batteries and is modular expandable.
The rectifying modules are single or three-phase fed and in addition of transferring energy to the telecom system they also act like an isolation barrier between the primary and secondary side.
More cabinets, batteries and rectifying modules can easily be added when demand so requires. This gives a high degree of flexibility, a prerequisite in today's fast paced data com environment. The basic building blocks contain rectifying modules, cabinets, including distribution cabling, and battery banks. Each block carries a close resemblance with present 48V systems, main difference being the higher system voltage.

A mains fed**,** single mode parallel operating system is a relatively simple way to solve the many demands that exists in powering telecom equipment.
Greatest need is the replacement of the UPS-systems but even replacement of the 48V systems is feasible.

During a transitional period both 48V and 300V, have to operate side by side at the same site. When the 48V part is diminishing, there is a possibility to feed a small 48V system from 300V and achieving a suitable backup system.
By only having one type of system to support in stead of several different, service and maintenance is simplified and cost reduced.

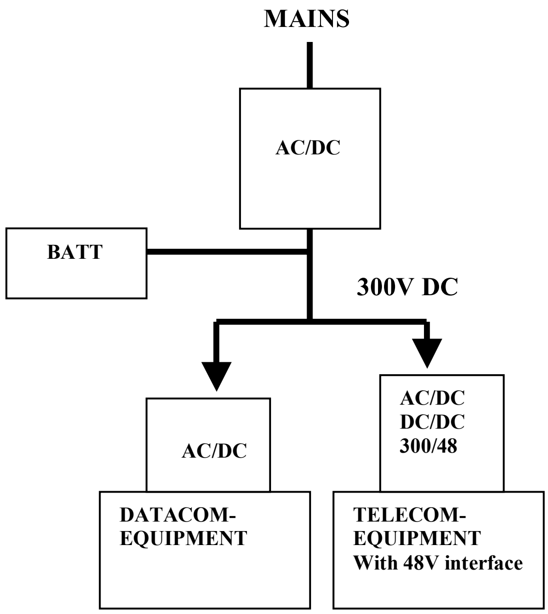

Fig 2. 300V DC or AC load is dominating

2.1.1 *Batteries*

Universal fed Telecom equipment has an input voltage range, which according to ETSI EN 300 132-3, is defined for a maximum peak voltage of 375V and a lowest rms voltage of 188V. As a consequence, the system voltage must be chosen according to this.
With 156 cells, and a maximum cell voltage of 2.35V, a system voltage of 367V is achieved, i.e. well below 375V.

Disconnection of batteries is set to a cell voltage of 1.75V which gives a system voltage of 273V. Converted, it gives an rms voltage of $(273/\sqrt{2})$= 193V, well above 188Vrms.

It means that universal fed units have an input voltage window corresponding to a fully utilised battery system.

Following this, the nominal system voltage @20degC will be 351V with 26 serially connected blocks with 6 cells each.
There are no objections to use more or fewer cells per block. It is more a practical issue.

The total number of cells in a system for a given energy content is the same on a comparison between 48 and 300V.
The difference being that the 300V system has more cells connected in series.
This will not influence the system reliability negatively since the batteries are only used as back up during mains failure.
A prerequisite is that the batteries are monitored.
For system maintenance purposes, the batteries should furthermore be divided at least into two strings.

2.1.2 Rectifiers

In principal, the rectifiers can be either isolated or non-isolated between the primary and secondary side. The determine factor in this case is how to handle system earth and immunity. With non-isolated rectifiers, both forward and return path has a voltage potential to earth. This requires a two-pole fuse and even security measures of encapsulation of the battery bank. If the rectifiers are isolated, the system can have a simpler design, since the +300V side can be connected to earth directly. This eases handling at short circuit and enhances the immunity of the system for externally generated interference i.e. lightning pulses.

The system should be completely comparable with a 48V system concerning grounding. The earth is connected to the battery's +pole. This facilitates problems with EMC, electrical safety and earth failures etc.
Service technicians will also recognise the resemblance with the 48V systems, which will minimise risk for possible human errors.

The choice of the power capability per rectifier is dependent upon the total system power requirement. A small system will probably be designed with rectifiers at 2.7kW to be able to use 16A fuses at the lowest input voltage. With 10 modules, one can achieve 27kW in a cabinet with the dimensions 2100x600x400mm including fuses for distribution and batteries. With (n+1) redundancy, the system will be able to handle 24kW practical usable power including extra capacity for charging.
If higher power requirements are needed, it is advisable to use rectifiers with a capacity of 5kW, and to use separate cabinets for the rectifiers and distribution.
A cabinet with above dimensions can then be equipped with eight 5kW rectifiers, delivering a total of 40kW.

In order to be able to expand the system and to optimise the life cycle, the rectifiers should use active load sharing. By choosing the correct system for load sharing there is no real upper limit for how many rectifiers that can be connected together.

2.1.3 *Cabinets*

A 300V system differs from a 48V regarding system voltage requirement for electrical safety and the gauges of system cabling.
Installations do not require any special cables but can be designed with standard AC installation wiring. Isolation must be done with the higher system voltage in mind since it is higher than the SELV-level.

2.1.4 Fuses

The distribution fuses must be rated for DC voltage. One possibility is to use standard diazed melting fuse with the ratings of 500VDC.

2.2 *Transient Limiting*

At short circuit, the transient attenuation is relatively easy to achieve in a 300V system. Which measures that are necessary depend upon battery size and cabling.
To use electrolytic capacitors close to the loads is one way to improve transient attenuation. The energy charging capacity per volume unit is better the higher the system voltage used. For a given capacitor size the product $\frac{1}{2}CU^2$ doubles (which represents the energy content) on a comparison between a 64V and a 400V capacitor. This implies that the need for capacitors is considerable less compared to a 48V system.
AC-UPS systems and direct rectification (rAC), will have neither the same possibilities nor the flexibility to handle these issues.

2.3 *Harmonic Contents*

A problem related to AC-fed units is the harmonic content of the load.
The requirements of harmonics contents are specified in EN61000-3-2. That's not a problem in those cases where the loads have PFC (Power Factor Correction) on the input. Power below 75W is excluded in the standard and a large amount together can cause high harmonics contents. This is a problem when using AC-UPS and even with direct rectification (rAC).
In DC-fed systems, no harmonics are generated.

The rectifiers on the primary side must certainly fulfil these requirements, but there, it will be dealt with at one single interface.

2.4 *Terminals*

A practical useable and internationally standardised DC terminal that can be used for universal fed tele/datacom equipment is missing. This requires an international standardisation in co-operation with the datacom manufactures.
To certify the rectifiers ought to be only a formality as these units already handles DC-feeding.

2.5 *Distributed Power Back-Up*

One important advantage by using 300VDC is the fact that the system power cabinets and batteries can be placed at a long distance from the datacom equipments. That can be utilised in an office building with many datacom users to achieve power back-up.

3.0 Reliability and Cost

Historically, powering a telephone facility has been guided by high reliability and at a lowest possible cost. An aiming value on inaccessibility used in dimensioning the system has been $5x10^{-7}$, which corresponds to an accumulated downtime of 15 seconds per year. The development towards using AC-fed equipment with UPS has not been favourable in this respect. According to INTELEC white book "Powering the Internet" a fulfilment of the requirements can only be achieved with duplicate systems. This is an important factor, and should be taken into account in the cost comparison.
In our investigation of the rectifier cost for 48V and 300V they end up approximately the same in $/W. Even cabinets, batteries, monitoring and distribution fuses are regarded in this survey to have the same cost level.

In a comparison between AC and DC UPS systems one need to take into consideration the cost to include feeding distribution fuses. These must be quadrupled because of the need of bypass and duplicate AC UPS systems.

3.1 *Cost for Single AC UPS System*

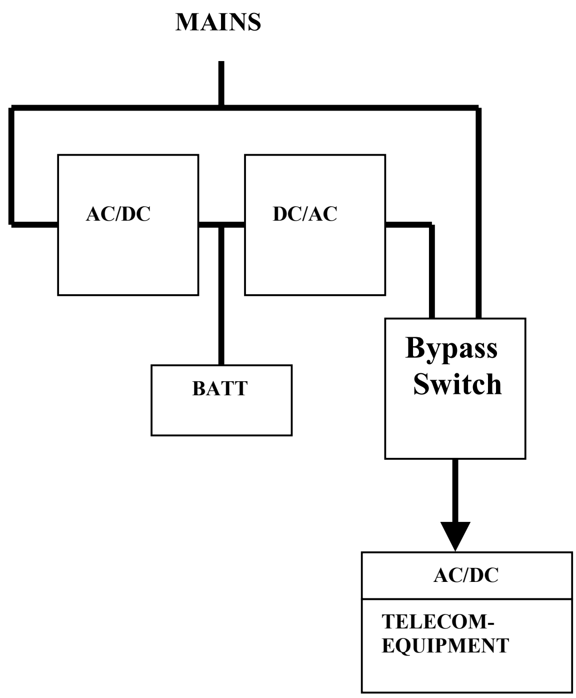

Fig 3. Single AC UPS System

Prerequisites:
System will not meet the inaccessibility demand of 5×10^{-7}.
Batteries with a reserve capacity of 30 minutes are including in the cost.
For longer periods a stand by generator is needed.

Power level kW	Number of distribution Points	Total system cost compared to 300VDC UPS
2,5	10	100%
5	20	107%
10	30	75%
20	50	85%
30	60	73%
60	120	58%

Table 1. Cost for Single AC UPS System

3.2 *Cost for Double AC UPS System with A- and B Distribution*

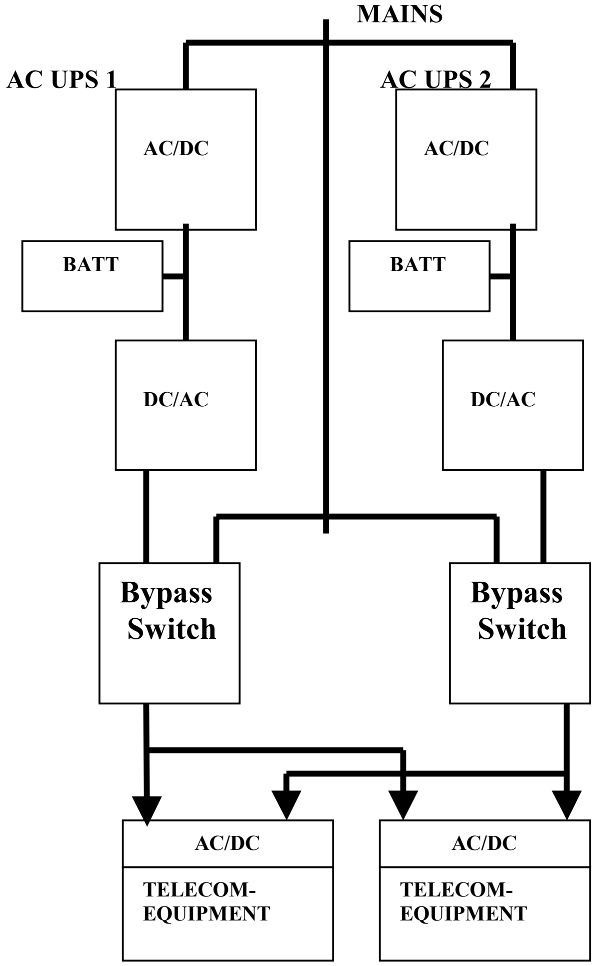

Fig 4. Double AC UPS System with A- and B Distribution

Prerequisites:
System meets the inaccessibility demand of 5 x 10^{-7}.
Batteries with a reserve capacity of 2x30 minutes are included in the cost.
For longer periods, a stand by generator is needed.
Servers and routers with A and B inputs are required.

Power level kW	Total system cost compared to 300VDC UPS
2,5	243%
5	200%
10	157%
20	134%
30	113%
60	95%

Table 2. Cost for Double AC UPS System with A- and B Distribution

3.3 *Cost for Single AC UPS System together with a Standby Diesel Generator.*

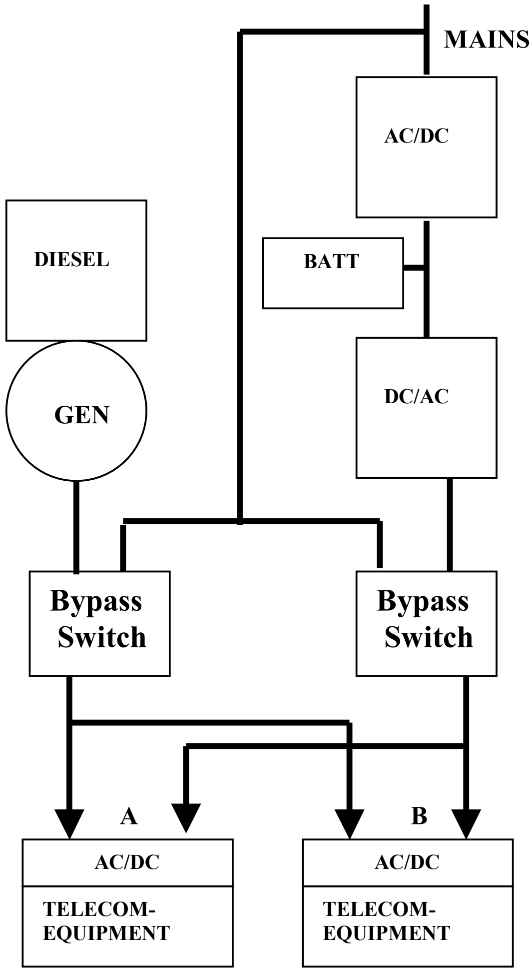

Fig 5. Single AC UPS System together with a Standby Diesel Generator

Prerequisites:
System meets inaccessibility demand of 5 x 10^{-7}
Batteries with a reserve capacity of 30 minutes are included.
System is able to handle long reserve time.

Power level kW	Standby generator kVA	Total system cost compared to 300DC UPS
2,5	15	322%
5	15	253%
10	30	186%
20	60	163%
30	100	142%
60	150	113%

Table 3. Cost for Single AC UPS System together with a Standby Diesel Generator.

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