

# Power Architectures for Telecommunications - A Review

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**Abstract**— This paper gives a brief review of various power architectures suggested through years of research and implementation in various countries, by various firms and individuals for achieving low emission, high quality, minimal battery storage, high reliability, low operating cost, rapid Return of Investment (ROI), alternative sources of energy during long power outages, size of the telecom facility, modularity, redundancy, maintainability, Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR)

**Keywords**- Power Architecture of telecommunication, Base station Power supplies, telecom energy schemes, power distribution for telecommunication equipment, telecommunication power system

## I. INTRODUCTION

There are six billion mobile subscribers worldwide. Growth is led by urban areas of developing countries. For example: India has an average population of 7935 per Sq Km in urban areas [1]. The number of mobile phone subscribers in India rose to 893.84 million in Dec 2011 registering a growth rate of 1.07 % every month, and the land line subscribers' number is steady at 33 million [2].

The fixed line broad band internet users are shifting to WiFi, 3G / 4G services from their mobile devices. There are now 1.5 billion mobile Web users worldwide and ever increasing [3], to reduce call drop / discontinuity in data streaming due to poor signal strength in urban areas, due to reflection /absorption of radio energy by buildings. All these are forcing the TSPs to shift their focus on to enhancing number of BTS. TSPs are mounting sector type antennas on a tower / walls on high raised buildings and installing Omni antenna in atrium of big buildings. Further to escalate the problem, each TSP is providing various wireless communication technologies like GSM, CDMA, WLL, WAN, WiFi, WiMAX, etc.

## II. MPPDRS -1978

The Modular Power Plant with Dual Reserve Sets (MPPDRS) is designed by British Post Office in 1970, it standardized the design keeping in view of inter changeability of equipment, low initial cost, low annual maintenance etc [4].

The MPPDRS is a (4+1) rectifier sub-system shown in Fig 1, MPPDRS is powered by 50Hz, 415/240 V ( $\pm 6V$ ) via

11kv from national grid system, with a air cooled transformer (600KVA) sub-station facility on the premises for supplying both essential and non essential loads. Two Standard Diesel generator (DG) plants of 180KW (300A /phase) mounted on a transportable base provide reserve power. A Standard Rectifier cubicle which is fully automatic and self contained with a 25 cell battery that operates at 50 V.

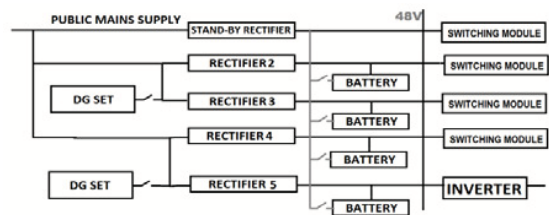


Figure 1. A modular power plant with dual reserve sets

MPPDRS achieved the policy target of (200-500) MTBF for the complete system and an availability of  $10^{-5}$  [4].

The MPPDRS design did not considered optimal component packing density on panels/racks and consequent high heat dissipations, and the reliability issues arising due to ventilation / chilling systems were not addressed.

## III. DPS - 1982

Distributed Power System (DPS) use the battery as a flexible short-term redundant module and is preferred to the over-provision of redundant rectifiers.

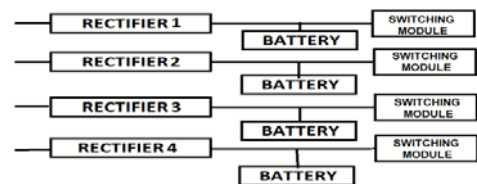


Figure 2. A distributed power system

In DPS the D.C. distribution is sub-divided as shown in Fig 2, this scheme reduced the rectifier provision by up to 20% [5]. The reduction in number of rectifiers employed has reduced the initial cost and did not alter the availability. If the number of parallel power paths is increased, the switching equipment overprovision diminishes. Since cost of switching equipment is appreciably higher than power equipment cost, total exchange cost yields to minimum.

#### IV. GEODE – 1983

Energy management and optimisation of equipment (GEODE) describes a large electrical supply characterized by its very high availability. GEODE architecture grouped certain number of important auxiliary systems to be built around the current generator providing some critical functions like fuel supply, starter, cooling, and regulation.

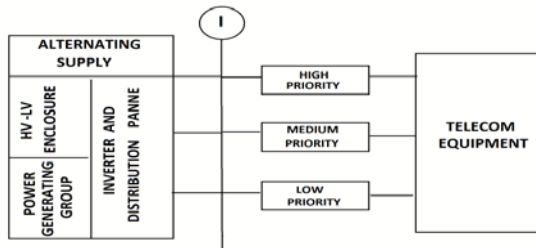


Figure 3. A grouped architecture

Its aim is to stop the group when critical conditions have been reached which could cause irreversibly damage. GEODE design implemented twin independent busbar panel, isolated neutral operation to improve service continuity, use of an isolation controller for each panel and a computerized surveillance system [6]. All this suggestions resulted in increase of availability to  $10^{-6}$  and increase in reliability of the reserve power generation group.

#### V. ALFATEL -1984

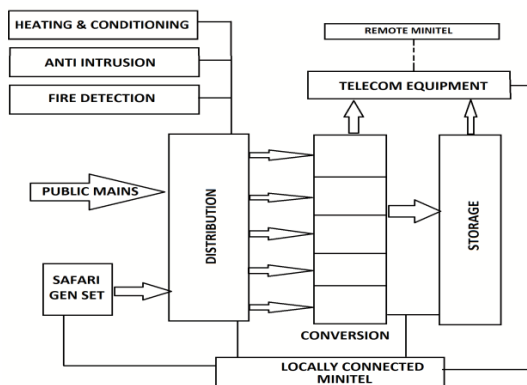


Figure 4. typical architecture of ALFATEL

Reliable power supply for telecommunications (ALFATEL) shown in Fig 4, system addresses the crucial problem faced by TSPs in rural/isolated areas i.e., where there is lack of grid connectivity and absence of onsite maintenance staff. To meet the rural/remote telecom policy target, ALFTEL suggested that a generating set must be designed to have the same rate of maintenance as the telecommunications system.

ALFATEL uses SAFARI (reliable alternative source with integrated fuel tank) a Diesel Electric Generator (DEG)

set enclosed in a compact sound proof cabinet with its control, protection devices and information sensors connected to a computer for remote data processing, ALFATEL uses a "Video text" terminal connected to the telecommunications network for communication.

The computer selects between normal and emergency power supplies. When power is supplied by the generating set, only the exact number of switching mode power rectifier modules will be in service. The energy for emergency requirement is stored in a UCM module containing batteries which give autonomy of almost 3 hours with a useful power output of 3 kW in the absence of mains / reserve power [7].

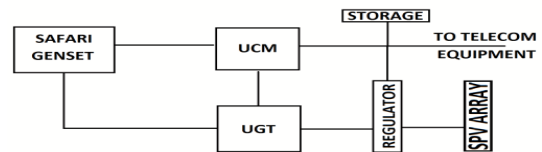


Figure 5. A hybrid ALFATEL

To enhance the availability in remote located BTS, where main electricity supply is not available AFATEL system can be used in combination with solar PV cell array or an extra SAFARI module to increase redundancy as shown in Fig 5.

#### VI. CO DC POWER PLANT – 1984

In this architecture intended for Central Office (CO) the power processing equipment are moved closer to the electronic equipment in telecommunication exchange serving area as shown in Fig 6. due to the development of micro controllers and microprocessors “smart plants” capable of presenting status reporting and tracking alarms, collecting maintenance information and triggering automatic transfer from utility main to back up power were used [8].

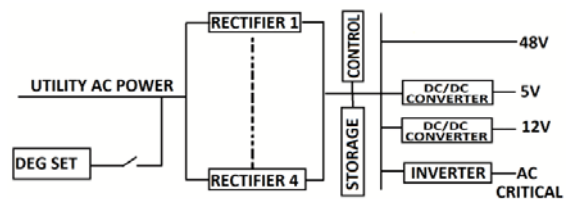


Figure 6. Central office power plant

#### VII. GEODE -1987

The general structure of the GEODE source remains unchanged; a new improved DC/DC converter with a wide input voltage range is used. The high reliability of the AC source is guaranteed by an improved Diesel Engine Generator (DEG) and a new type of AC distribution board well suited to high reliability constraints. Critical circuits

such as the starting circuit, cooling circuits are doubled; the switching over of the source between DEG and AC boards is made highly reliable. The AC distribution is divided into several circuit breakers to avoid common mode failure. The AC board, the DEG and the DC racks are controlled by individual computers linked to an alarm and energy managing network [9].

### VIII. A.R.E -1991

A.R.E (Alimentation a Reserve d Energie) distributes 230 V AC everywhere in the system and secondly it assumes that the power consumption of each electronic board is reduced because of technological advancements.

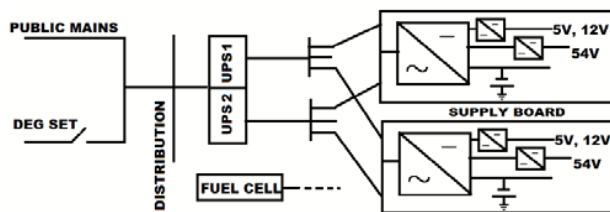


Figure 7. Integrated back-up on supply board

A.R.E is a power supply board with direct AC plug in, AC/DC converters and associated battery backup as shown in Fig 8. A.R.E uses a complementary local backup comprising of NI H / LI-polymer as close as possible to the system. A.R.E uses back connectors to plug-in the board, which are easy to replace on site and can carry up to 40amps [10].

### IX. TENOR -1993

The TENOR architecture unifies two uninterrupted power sources DC 48 V and AC 230 V, with a single AC interface applicable to any size of installation as shown in Fig 8.

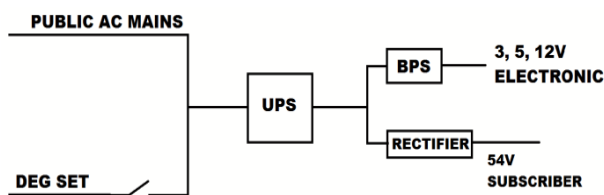


Figure 8. Unified power supplies architecture

With clear idea of decreasing importance of the 48 V DC, due to reduction in power demand of telecom equipment and availability of small power rectifiers controlled by using high frequency (20KHz) power chopping techniques were available in single/three phase AC input with 54V/25A -100 Amps as DC output. These plug-in modules are light and easy to replace compared to

centralized high power rectifiers build with thyristor and their cost is very attractive.

The important achievement of TENOR architecture was decentralized rectifying and storage equipment, due to the distribution of storage equipment in 3 levels higher rate of power availability is achieved with minimum redundant equipment [11]. An important aspect of TENOR is Back-up Power Supply is in parallel with the output of power supply, this optimized the reliability while powering new telecommunication system and preserved compatibility with the older one (GEODE-1987).

### X. RAMO -1993

RAMO (Management Network for Telecommunications Environment Equipment) is an addition to existing GEODE and ALFATEL architectures, it monitors functions such as power supply, cooling system, building surveillance, access control, security, EMC and electrostatic environment, hence it is possible to analyse the quality of the equipment's performance in operation and to precisely identify equipment failures to reduce their MTTR [12]. In RAMO an X.25 interface is used to connect with the regional and remote supervisors and to send alarms as they arise.

### XI. ASCETE – 1998

Architecture of a Simplified Concept for Energy and the Technical Environment (ASCETE) is an extension of the TENOR concept as shown in Fig 9; it consists in calling on the UPS to undertake the automatic starting of the replacement source (RS). Conversely, the replacement source is drawn on directly to recharge the batteries incorporated in the UPS. Power can be supplied downstream of the UPS to the air conditioning, and without the UPS having to be of too large a design. In the event of failure of the local electricity grid, the climate control is powered by the redundancy module of the UPS in case necessary. It is assumed that the reserve source (RS) is a fuel cell and requires less than 10% of the rated power of UPS to start [13].

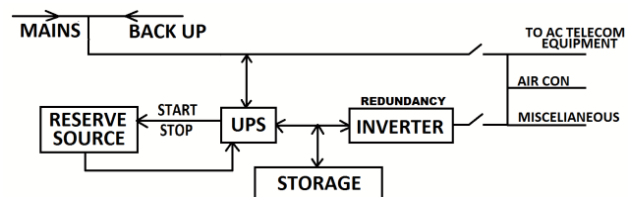


Figure 9. The ASCETE architecture

### XII. ITALTEL – 2000

ITALTEL introduced architecture for both highly distributed low power telecom sites and to the old large power central offices /data centres. ITALTEL technical

solution is a single compact cabinet which may house a combination of complete DC system, AC system and battery strings. ITALTEL achieved modularity, scalability and built-in intelligent capability. To reduce the cost of management and maintenance ITALTEL has designed a new supervision and control system, named RetEnergy [14].

### XIII. EFHQ & HA TPPA – 2002

In this proposed Environment Friendly High Quality, High Availability Telecom Power Plant Architecture (EFHQ & HA TPPA) shown in Fig 10, the DEG set and the Automatic Transfer Switch (ATS) are eliminated, the battery size is reduced and a micro turbine is added in lieu of the DG set. The micro turbine is connected to the DC bus of a UPS for improved availability.

Inclusion of micro turbine resulted in low initial cost, low maintenance cost and low emissions. Since micro turbine has less number of moving parts the reliability has considerably increased [15].

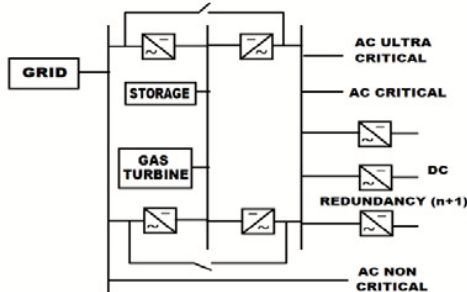


Figure 10. An architecture with out auto transfer switch

### XIV. RAID -2002

RAID (Redundant Array of Independent Devices) is a novel system approach to provide a high availability 48V DC power supply without batteries and with distributed energy resources (DER) as shown in Fig 11. In this architecture a dual DC bus Architecture is proposed in which the distributed array of DER and utility grid are terminated to high capacity independent rectifiers, whose DC outputs are connected to rungs of ladder DC distribution system.

The rungs of the ladder are then connected to two buses, either of which can provide dc power to other rungs of the ladder. Because of the redundant array of primary power engine-alternators and high capacity DC output rectifiers the system can tolerate individual and multiple failures without affecting service to the customer. The switchgear and switchboards are intentionally eliminated in this architecture to achieve a higher level of availability.

There is enough redundancy of each element in the system which was determined through a probabilistic risk

analysis (PRA); hence failure of any single device will not affect the critical load [16].

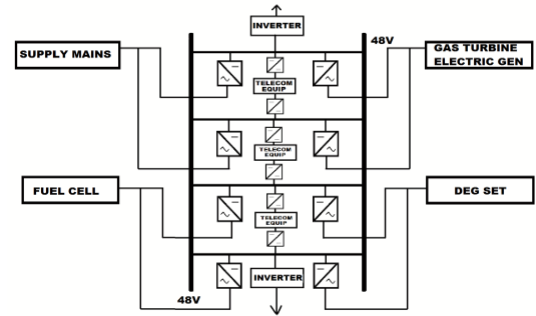


Figure 11. Dual bus architecture

### XV. MICRO SOURCE FEED - 2008

In this architecture shown in Fig 12, micro-sources such as Micro-Turbine (MT) and Fuel Cell (FC) is used in lieu of a DG set and battery storage, micro-sources respond slowly during starting, so an ultra- capacitor is added to supply power in the absence of AC utility grid. The automatic transfer switch is replaced with multiple input buck boost converter (MIBBC) [17].

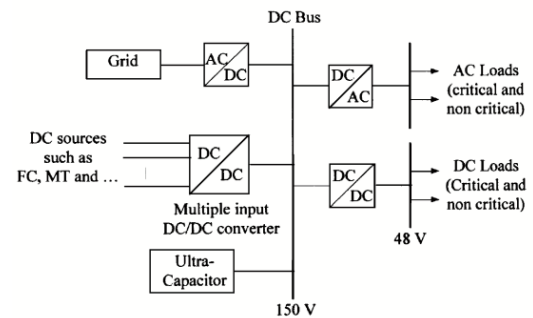


Figure 12. Architecture with MIBBC

### XVI. HYBRID STAND ALONE TPS – 2009

In this proposed hybrid energy system for standalone Telecom Power System (TPS) architecture as shown in Fig 13, an SPV-FC-Battery system is optimized, analysed, compared and simulated in Hybrid Optimization Model for Electric Renewables (HOMER) [18].

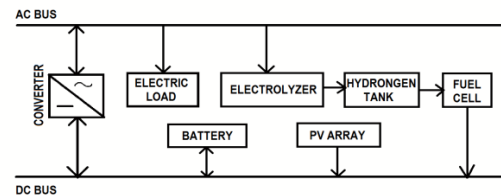


Figure 13. Architecture powered by fuel cell

### XVII. WIND– PV STAND ALONE TPS - 1997 & 2011

This architecture meant for remote BTS, consists of a 1500 W wind turbine and a 900Wp photovoltaic array supplying energy to a telecommunication system, the dimension of the storage unit is done by considering several unproductive days, reliability and the cost. The overall system is designed to supply energy throughout the year. The two energy sources complement each other to suit the need of load. The developed system is test in NESL test facility for one year [19]. The battery consists of a bank formed by 24 lead-acid cells with a rated capacity of 450 Ah, The DC-AC PWM converter of 1500 W is used.

In another case of wind-PV power plant meant for remote BTS. The existing equipment were resized and optimized by using HOMER [20].

### XVIII. THE FUTURE

Telecommunication industry is experiencing a tremendous growth with continuous expansion of BTS, which lead to increase in energy consumption.

The importance of reducing the energy consumption and running cost is attracting all TSPs. In the highly competitive telecom environment TSPs are sharing the infrastructure i.e., various TSPs are mounting their equipment on a single BTS tower at a particular site/area, and reserve power source (DEG set) is shared by all the TSPs and runs on Biodiesel, this has reduced the capital cost and rents up to some extent.

Power system availability, redundancy, operating & maintenance cost and emissions will drive future research to create new and amicable solutions.

There are millions of people living in remote villages where the grid power supply is available for few hours in a day; with high diesel prices the focus is now on wind and solar power.

In the past 20 years we can see miniaturization of telecom equipment and increase in reliability of power conversion equipment due to availability of improved solid state power devices, but the main power source has always been the public mains in urban areas and DEG sets for remote BTS. These two energy sources dominated for more than 3 decades coz of their low capital investment. Now all the TSPs are looking towards solar in case of urban and wind in case of remote areas.

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