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Future talk

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Abstract

The paper is divided into two distinct parts. The first part deals with a look at the progress made to date in the VRLA battery technology that has established itself as the primary source of emergency standby power within the BT network. This will include a review of maintenance procedures and the specifying of such products for central office and local switching centres, and will be discussed alongside an appreciation of how telecommunications networks are changing. The second part includes an assessment of future technology developments and how these changes will increase demand upon suppliers of battery power for network and hand-held devices of the future. The paper will conclude with a light-hearted look at potential technological developments of the future that will revolutionise the way we communicate with each other and our environment. © 2001 Published by Elsevier Science B.V.

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1. Introduction

Standby power, in the form of battery technology, is used throughout the telecommunications industry either as a means of portable power for hand-held devices or for providing emergency power in central office applications. This paper will describe the incredible and rapid change that is effecting the telecommunications industry, and review the progress made over the last 15 years in valve-regulated lead-acid (VRLA) battery technology. The author will also take a light-hearted look at future technological and social change that will continue to place great demands upon the battery industry to solve the insatiable appetite for power solutions that will make these products of the future a reality.

With so much of commerce reliant on their IT infrastructure, it is essential that any telecommunications network is resilient against the possibility of a mains power outage. At the same time, commercial pressure within the telecommunications industry is demanding a greater return on its network investment, and in particular questioning many aspects of the traditional way to power and maintain network equipment. This paper will review many of the standby power initiatives that have been introduced over the previous 20 years, and take a look at current and future network technologies and the challenges that these represent for the standby power community.

2. Telecommunications technology review

2.1. Changes in the telephone network

The current digital telephone network was introduced in the UK only 20 years ago, replacing the then decaying electro-mechanical analogue system, and it was thought at the time that this would be the network to meet all of the demands of the future. How wrong we were and how rapidly things have changed! The explosion of demand for broadband services fuelled by growth in the Internet and mobile communications has eaten into all of the available digital capacity and required a rapid reassessment of technology and infrastructure investment plans.

Powering these networks has seen a similar revolutionary change, as many operators found the world decided that their large-scale centralised dc power systems were too cumbersome for the digital age. Available technology had also changed, and the introduction of switch-mode rectifiers and valve-regulated lead-acid batteries enabled network operators to introduce smaller end-of-suite distributed power systems. The introduction of rapidly deployed Internet protocol (IP) equipment is also producing an intense debate within the telecommunications power community as

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to whether the future of power equipment should be from a standby ac or dc platform.

2.2. Changes in mobile communications

Over the last 10 years, mobile hand-held devices have also changed out of all recognition. From the old style bulky handsets owned by the few, to today's wireless application protocol (WAP) miniature devices. The changes in technology have been surpassed only by the volume in use and this trend is set to continue for many years to come, as wireless bandwidth becomes cheaper and mobile Internet service providers exploit the potential of the new 3G networks.

Powering hand-held devices has also improved significantly with the introduction of new battery technologies (nickel/metal hydride, lithium-ion, lithium polymer) and sensible power control built into the handset. Improvements in radio technology, micro-electronics and smaller digital radio cells has also reduced the demand on the battery pack, correspondingly lower tariffs have increased talk time considerably and this has again burdened the power pack. Battery performance has and remains an inconvenience for the mass of users of mobile telephony despite the changes to more reliable battery technology and improved energy density. The future for mobile telephony is even more challenging, as greater reliability and higher power densities will be required for the next generation of always-on communicators that will transform all aspects of our lives.

3. Standby power: background and architecture

BT introduced VRLA battery designs to its network in 1984 as a means of simplifying its dc power system. Previously, the older centralised power plants consisted of large rectifier modules, some as large as 3000 A and associated large-scale, flooded electrolyte, Planté batteries. As the network evolved to the digital platform, it became clear that this type of dc infrastructure could not be built at the same speed as the telecommunications switching equipment, and therefore a new architecture was designed incorporating a rack-mounted power system installed alongside the switching equipment. This was made possible by recent improvements in smaller switch-mode rectifier designs.

Recombination VRLA battery technology was chosen because of its reduced gassing levels enabling the rack to be positioned in the switch room. Due to this close proximity of the power system to the switching equipment, distribution costs were reduced as the voltage drop from the battery was minimised and improved system reliability was anticipated due to the modular design of the new dc power system, both at component and system level. By comparison, failures of large central power plants, although rare, would be catastrophic over a large geographic area, as all switching and transmission units are connected to this one source.

As part of its modernisation plan for the digital network, BT also installed automatic-start diesel engine generator sets at all network sites. As these generators start within 27 s of the failure of the public electricity supply, battery autonomy times were reduced to a minimum of 1 h.

3.1. Reliability of VRLA batteries

Initially, all seemed well with the new battery technology. Then 4–5 years after their introduction, BT along with other network operators experienced increasing battery failures that primarily fell into two groups. The most serious were sudden and catastrophic failures caused by an open circuit battery and the second a premature reduction in battery capacity.

Investigations by BT and their battery suppliers identified one manufacturer whose products sometimes suffered severe corrosion of the interconnecting group-bar or top lead. At this time, most manufacturers employed a manual process to burn or form the group-bar onto the plate lugs. Subsequently, it became clear that the VRLA design was far more susceptible to manufacturing quality control than other lead designs and as a result BT introduced a monitoring programme and supported the introduction of the BSI standard (BS) 6290 pt 4 (1997).

Between 1989 and 1996, VRLA reliability became a major concern to BT and its battery suppliers, although it must be said that not all designs suffered from the same failure modes and there were also many examples of products that met their anticipated design life. Of notable merit were VRLA designs made from a pure glead prismatic plate that achieved an in-service life of 10 years. It became clear that there was nothing fundamentally wrong with the basic VRLA design other than the issue of quality control during manufacture, and BT's battery suppliers responded by introducing new automated manufacturing techniques that dispensed with the variability caused by older manual techniques. The group-bar problems were eradicated by the introduction of the automated cast-on-strap process, and incidences of premature capacity loss were reduced by improved active material mixing and pasting techniques.

As a result, BT has become increasingly satisfied by the performance of the VRLA product, and 98% of it is now meeting the 6-year-life criterion for lead–calcium–tin designs installed in an average equipment room temperature of 2°C. However, not all telecom operators feel the same, and there is move in some circles to go back to the older style centralised systems and flooded battery designs.

3.2. Monitoring

Due to our early experience with the VRLA product and with the number of monoblocs installed in the network now approaching 1 million units, it became essential to introduce a reliable monitoring programme. Even more essential was the need to register the make, age and location of each battery on a network-wide inventory system. The basic fact that all batteries, especially lead-acid types, will ultimately require replacement means that a monitoring and replacement strategy is an essential service requirement of all network operators. Sadly (and this must be of some concern to the battery industry), many of the VRLA products installed within private networks have now decayed beyond their useful life and will ultimately present a safety hazard to the end user.

Automated power system controllers that can periodically perform a maintenance check by discharging batteries to the equipment load are a recent innovation, and until now manual methods had to be used. With so many batteries in a modem telecommunication network, it can prove to be an expensive time-consuming task if traditional discharge techniques are used. As a result, many batteries may remain untested and therefore their condition remains unknown. With so many batteries deployed within the BT network, it became necessary to introduce a faster manual method whilst continuing to deploy our ultimate strategy of automated battery testing for all modern power systems. To this end, BT introduced conductance/impedance testing as the primary annual maintenance check for all VRLA batteries. Initial scepticism over this method by industry was soon replaced by a better understanding of the limitations and advantages, coupled to the knowledge that BT's environmental control is within acceptable limits for a VRLA product (life is halved for every 10°C rise above 20°C).

Each field technician has a Midtronics conductance tester that uses a four wire ac signal method to measure and display the inverse of the impedance, conductance, of the monobloc under test. This is then compared to a reference figure for this type of battery. As BT is primarily interested in only potentially gross failures, due in part to the provision of an emergency engine generator, the chosen failure thresholds are purposely set outside of the scatter which is commonly seen around the 70–80% capacity value. In this way, only fully charged batteries are tested and a large variation in conductance can be identified as a problem battery. The technician can then choose either to subject this battery to a discharge test or replace it under warranty.

Careful monitoring of conductance trends and warranty replacements ensure that replacement strategies can be built with confidence.

BT is currently embarking on a further enhancement to its battery maintenance strategy by introducing automated battery capacity tests. This method exploits the potential of the power system controller to initiate an automated timed-battery discharge to the equipment load. This is a simplistic test to ensure that the battery can supply the equipment load for a predetermined time down to a minimum of 46 V. Once again, the test is only performed on a fully charged battery and the frequency of the test is designed to capture any significant degradation in battery capacity without any necessary cycling of the battery. In the event that a failure has been determined, a technician will only then attend and perform a system load check and conductance test to further diagnose the problem and effect a repair.

Early indications of this method are suggesting that maintenance costs will be reduced by a further 15%, and those batteries that are exceeding their design life can remain in the network longer, thereby deferring capital replacement costs.

3.3. Specification, national and international battery standards

An appreciation and understanding of the battery application and environment is essential to successfully specify the appropriate battery. A suitable National Standard for telecommunications batteries within the UK is BS 6290 pt4 (1997). This standard has been designed to assist in the formulation of a procurement specification and requires the user to specify the performance classification required to meet his requirements. The classification includes sections on safety, performance and durability. The user must specify a performance classification in each section.

Safety tests include container flammability and mechanical integrity tests as well as gas emission and high current endurance tests. These can be used by the designers of equipment cabinets to ensure that adequate ventilation and overcurrent protection can be built in from the start.

Performance tests confirm rated capacity tests between durations of 5 min and 10 h, as well as cyclic endurance, charge retention (for storage calculations) and internal resistance.

The durability classification is based upon elevated temperature tests in the laboratory that have been proven to relate to anticipated life at normal temperatures. The high temperature accelerates the corrosion of the lead plates and through a mathematical relationship (the Arrhenius equation); the high temperature life can be used to predict life at the actual temperature.

Work is also in progress on a new International Standard to reflect the global aspirations of telecommunications companies. This standard is an attempt to amalgamate National Standards from America, Japan and Europe, including BS 6290 pt4. If successful, IEC 60896-2 will be welcomed by many in the telecommunications industry, and simplify the global procurement of VRLA telecom batteries.

4. Future telecom platforms

4.1. Network elements

The real telecommunications revolution is only just beginning. The arrival of the Internet means that all networks are being forced to change beyond all recognition. A broadband network based on the new datacoms Internet switching protocol (IP) enables voice, data or video streams to be sent at low cost over the high-speed part of the PSIN network. Advances in datacoms switching speeds enables vast amounts of data to be sent anywhere in the world, effectively by-passing the lower-order PSTN elements. The requirement to send and receive large amounts of data is enhanced further down-stream by cable TV networks, domestic modem or direct server access or by emerging XDSL platforms that can operate at increased speeds over a normal twisted-pair telephone line.

Commerce and Governments are demanding cheaper access to the Internet in order to benefit from the potential productivity gains of e-business within a society that embraces e-commerce. This will become a reality as Internet connections become affordable and are always on.

One of the most significant developments of this new IP network will be the emergence of voice over IP (VOIP) or video over IP. This is where voice or video data is transmitted over the IP network at a fraction of the cost of the PSTN network. These technology changes will force network operators to dispose-off assets that are not part of their new core businesses, and as a result the provision and maintenance of network power will move to external businesses. As a result, battery standby reverses may be reduced further and procurement pressure will see price as the dominating factor.

The reducing cost of bandwidth and the convergence of datacoms and telephony is making the traditional network operators move into media content as information service providers (ISPs) for their own products or as third party providers. The reliability of the necessary datacoms equipment will become increasingly important to these organisations and to their customers, as will the provision of standby power to backup the servers and routers.

In power and reliability terms, the convergence of the datacoms and telecoms networks will cause its own problems, as traditionally datacoms equipment has been fed from an ac source with limited backup power being provided from UPS systems having typical autonomy times of 5–30 min.

Safety and working practices are different too, with telecommunications equipments being the safer option using the traditional dc voltage of 48 and employing specific high impedance separation between ac protective and dc signalling earths.

4.2. Wireless elements

Mobile networks will also be transformed with the introduction of 3G networks that will enable high bandwidth transmission via the newly licensed radio spectrum. This will require an increase in base stations, as the 3G network utilises smaller radio cells and each miniature radio base station will require its own backup battery. As these base stations will be subjected to varying environmental conditions, the chosen battery technology will have to be robust enough to give reasonable life at summer temperatures in excess of 30°C. The downside to this rapid deployment of 3G infrastructure is cost, and therefore network providers will be reluctant to increase investment levels, and a fear exists that purchasing pressure could outweigh the use of a more suitable battery technology despite its superior engineering qualities.

The growth in personal communications is set to continue well into the next decade as mobile phone density rivals fixed network devices and the successful deployment of 3G networks enables a new range of personal communicators. Some operators believe that wireless networks will become the number one broadband access platform and that, despite the initial heavy costs of the 3G platform, will retain a significant cost-efficiency over rival fixed network. The evolution into higher speeds will also provide the opportunity to re-define basic telecommunications services. Always-on connectivity, bandwidth-on-demand and mobility will become the norm rather than the exception with speeds in excess of 64,000 bits/s becoming possible.

5. Futurology

In order to visualise the impact of these dramatic technology changes and the convergence of multimedia platforms, BT employs the services of a futurologist — a person who attempts to predict the endless possibilities of emerging technology, and how this will change and impact upon society. These predictions help technologists to develop new applications and devices that may well spin-off into commercial reality.

Futurologists have both optimistic and pessimistic views of the future. Optimistically, new technology will become all embracing and be a true commercial success that will change our human behaviour for the better, and will have an impact across all aspects of society. Pessimistically, the belief is that basic human needs of food, shelter, love, status and self-fulfilment cannot be altered by technology and are written deep into our DNA.

Clearly, the most rapid change is being experienced by the computer-based industries. This will continue with rapid advances being made in software developments that are not constrained to bandwidth. Personal computers, containing their own software packages, will be replaced by Internet software portals personalised to restrict unwanted junk mail and enhance speed of access to items of interest. Voice communication and recognition will rapidly prove to be a major success, and instantaneous multi-lingual translations will make the world seem even smaller.

Interactive software will develop personalities and synthetic talking life forms called *avatars* will add that personal touch when obtaining access to services or buying products on-line. By the year 2005, there will be more than 2 billion voice portals or voice-enabled web-sites. These devices will exploit Internet-based e-commerce and solutions to customer/management relationships. The most popular avatars will have legal rights and some of our friends will be synthetic creations only existing in cyber space. All learning will become web-based and experience will be gained from time spent in a holographic simulator.

There will become one universal electronic currency accepted by any shop or web-site in the world with crediting and debiting performed instantaneously via your personal communicator. By 2003, there will be more than 350 million smart phones or personal communicators in use. The integration of GPS technology into these devices will create myriad opportunities for location-based content and services. These personal communicators will also be able to monitor basic health functions and automatically alert your doctor, who may automatically e-mail a prescription or request a consultation.

These are just some of the views of our changing world, illustrations purely to remind the battery technologist that reliable portable and standby power will become essential part of our everyday life.