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In Partnership with

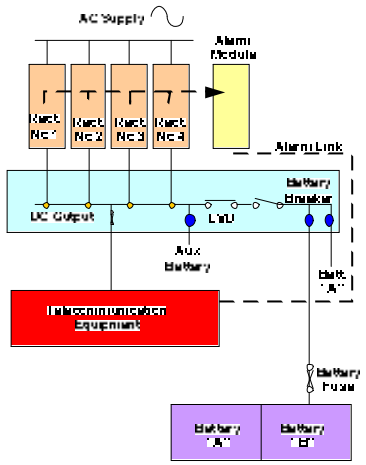
are expanding their Global Telecommunication Network on a dynamic front.

As part of this expansion and ongoing commitment to customers to maintain a secure Telecommunication system, the Verizon DC power systems and support batteries are constantly reviewed to ensure optimum performance when required during "Mains" failure.

has retained the services of Eta Projects Ltd the specialist power company to provide power support services including design, product evaluation and power management on the Customers Sites. This service provides an important back up to their in-house power team as part of their expansion programme.

This paper details the design and configuration of the DC power system which provides support to their telecommunications network at various Point of Presence (POP) Sites, otherwise know as "Customers Sites". These sites are located within the UK and Europe (EMEA and currently number in excess of 1300 in the UK alone

The DC power system are specifically designed to provided a Positive Earthed (- 48volt) DC supply to telecommunications equipment while at the same time maintain a battery system fully charged.



DC System (Typical)

Figure 1.

DC System

The DC systems are designed for N+1 rectifier configuration with the facility to replace a single rectifier, whilst other rectifiers remain in service. This replacement operation can be carried out without interruption of the DC supply with or without a battery connected.

Facilities are included to automatically control all rectifiers to maintain DC output and to trickle charge a -48 volt battery. The DC output is calibrated to provide -54.4volts output, continuously both under normal conditions and when on battery re-charge after the restoration of loss of "Mains" supply.

Rectifiers

Rectifiers are designed for load sharing and are configured to provide N+1 redundancy. Rectifier modules are self-monitoring and include protection facilities to isolate an individual rectifier module under fault condition.

Rectifiers are designed for cool running to minimize heat buildup in the telecom section of the cabinet. Rectifiers are specified to operate at efficiency greater than 90% and are fitted with power factor correction to ensure primary energy is taken at a power factor at 0.95 or above.

The rectifiers are designed for hot replacement without the need for disconnection of any electrical or communication leads either by hand or tools. Removal of any one rectifier does not affect normal operation of the system. Reliability of each rectifier are specified at 120,000hrs calculated Mean Time before Failure (MTBF)

The rectifiers are complete with visual LED indication to indicate healthy status and modular failure mode.

The power cabinets, cabling and batteries are tested and commissioned as a complete assembly when installed on site. Test certificates for all tests are included in the Operation and Maintenance Manuals.

Chassis

The rectifiers are housed within a purpose designed and constructed 19" chassis arrangement. They are designed to ensure that potential failures do not occur on the chassis, thereby necessitating the isolation and removal of the complete system for repair.

Alarm Module

The alarm module plays a critical part of the DC system as it is designed to detect an abnormal condition on either the incoming supply or the DC System itself.

The alarm module is designed for hot replacement without the need for disconnection of any electrical or communication leads either by hand or tools.

The alarm modules provide specific alarms for the following abnormal conditions -

- *High Volts" (-56 volts)*
- *Low Volts" (-48.3 volts)*
- *Battery Fuse/breaker open"*
- *Battery disconnect "(43.2 volts)*
- *Mains" failure.*
- *Rectifier failure".*
- *High temperature".*

These alarms are presented on the front of the alarm module system in the form of LED's.

The alarms are also remotely monitored via the International communication network. Alarm conditions triggered ares relayed back to the Verizon Central24-Hour command INOC centre in

Carey in the US. The alarm status is assessed and a local field engineer dispatched to the affected site.

The alarms are grouped to alarm as follows:-

- *Alarm 1 "Mains" failure*
- *Alarm 2 All other alarms except*
- *Alarm 3 Rectifier failure*

On receipt of an alarm, the 24-hour operate field engineering team located the closest to the site under alarm is dispatched to site to identify and resolve the problem.

The alarm module/system an all new sites are complete with a digital display module with the following parameters: -

- *DC load amps*
- *DC output volts*
- *Battery temperature*

A Manual alarm reset facility is provided on the alarm module. Alarms can only be re-set when the alarm condition has cleared. A manual alarm test button facility is also provided to test the alarm indication and at the same time activate the alarm indication to the remote INOC centre in Carey.

The alarm module has a facility for showing "Historic" alarms. When a fault is cleared, the led indicating the fault changes from constant illumination to flashing illumination, until manually reset. This indicates to the engineer which alarm was activated.

<u>DC Distribution Frame</u>

The final connections to the Telecommunications equipment is made via a dedicated DC distribution frame separate from the DC rectifier chassis. It is complete with the following facilities: -

- *Plug-in Connection for an "A" and a "B" dual string battery (30amps minimum)*
- *Plug-In Connections for an Auxiliary battery to enable testing of main battery*
- *D type connector for outgoing alarms to Telecommunication network*
- *16No fused outputs minimum with 0-20amp range of fuses.*

Due to the Positive Earth mode of the DC systems, the connections for the batteries are marked to ensure no confusion is experienced with the battery connections. The colour coding and labelling is currently as follows

+ Ve Black
- Ve Blue

The positive bus-bar of the DC distribution rail is grounded solidly to Earth and. each individual DC output on the distribution rail is complete with an in-line LED, which is load dependant i.e. LED illuminates when fuse operates.

Batteries

The standby batteries are critical to the security of the Telecommunications system on each site. These provide standby support during a mains born disturbance such as transient sags or surges. In addition, they provide support during any planned power outages on Customers premises during essential maintenance work.

Verizon provide 4-hours battery back up as a standard design commitment to their customers. This battery autonomy time can be extended if requested either on a permanent basis or alternatively on a temporary basis to cover planned shut down works where a power outage in excess of 4-hours is envisaged.

Eta Projects *were commissioned by*  *to identify the optimum battery to support the Verizon Telecommunication system. Extensive discharge and recharge tests were carried out on various batteries submitted by manufacturers. In addition, the construction of the proposed batteries was considered to suit the various power applications required.*

Two battery manufacturers were short-listed and batteries were selected from the Hawker SBS40 battery range and from the Yuasa NPL range of batteries.

The batteries are generally installed in the base of the Telecommunication cabinets and connected to the DC system battery breaker, using double insulated multi-strand cable, protected at the battery end with in-line fuse on the negative lead.

The battery DC breaker is fitted with an auxiliary contact (Volt Free) to provide an alarm signal via the alarm module of battery breaker operation. This triggers an alarm to the central INOC centre in Carey.

In addition, a temperature sensing transducer on a flexible lead is supplied on all recent DC systems for monitoring the temperature of the battery cells and is set to alarm at temperatures in excess of 25^0 *C.*

Automatic and manual battery discharge facilities are provided on all new systems

The DC distribution rail is also fitted with an automatic battery disconnect relay and this automatically disconnects the battery from the load when the battery output voltage reaches 43.2volts. This facility protects the battery from a deep rooted discharge form which the battery may never recover.

The auxiliary battery is connected to the load side of the main battery breaker at all times when diagnostic or maintenance work is been undertaken. This enables the main battery breaker to be tested without risk to business.

Battery Testing

A battery can only be guaranteed to operate in the event of a "Mains" failure if subjected to regular and appropriate testing. The optimum test to prove the integrity of a lead acid battery is to subject it to a full discharge/re-charge cycle in accordance with manufacturer's recommendations. Also it is important not to totally discharge the battery (full deep rooted discharge) otherwise the battery may not re-charge. Hence, the manufacturer discharge rates (current) were applied based on an end voltage of 1.8volt/cell. This equates to 10.8v (minimum voltage/12v battery) or 43.2 on a 48v system battery. Over the years 2000 – 2005 Verizon implemented a nationwide programme of battery testing/replacement across all its European sites. All batteries were subjected to a full discharge test on an annual basis. This programme enabled all suspected/or near end of life batteries to be removed from their network without affecting customer service.

The results of each battery test were recorded each year on a central database. As the battery testing/replacement programme progressed over the years, the level of battery failure decreased the need for regular discharging.

Therefore, this enabled the implementation of a level one test procedure which was regular impedance testing of the batteries and only if a battery results failed a specific impedance test, then the overall battery system would be subjected to a full discharge test. All the results are recorded on the central database. Figure No 2 shows a typical graph from a battery impedance test where one cell if found to have failed.

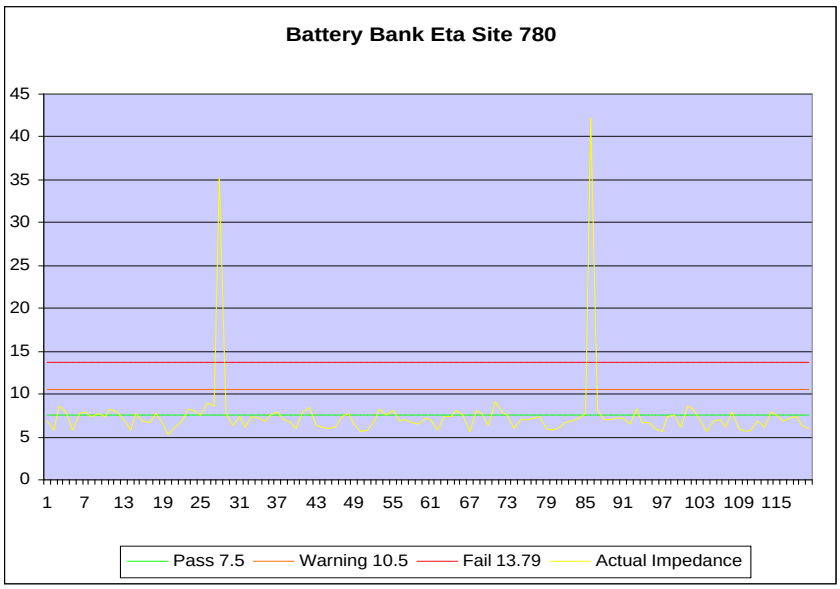


Figure 2.
(Impedance graph with failed battery)

The impedance tester comes with software which enable all battery impedance tests to be recorded to a central database where historical information can be retained for all their customer sites. Figure No 3 highlights a battery system whre cell 2 on one cabinet has failed the test and in the case of the other cabinet, one cell has failed with an other cell highlighting a warning.

Therefore, it is essential that all communication systems are fitted with dual string batteries to provide optimum support in the event of a power failure.

CAB No	Cell 1			Cell 2			Cell 3			Cell 4		
.	m Ohm	Volts	P/F/W	m Ohm	Volts	P/F/W	m Ohm	Volts	P/F/W	m Ohm	Volts	P/F/W
P1-1	5.52	13.52	Pass	6.15	13.45	Pass	6.87	13.52	Pass	7.39	13.51	Pass
P1-2	5.88	13.62	Pass	6.38	13.52	Pass	6.54	13.24	Pass	6.05	13.64	Pass
L2-1	6.25	13.60	Pass	26.90	15.94	Fail	6.97	13.39	Pass	5.72	13.47	Pass
L5-1	9.00	14.25	Warn	6.81	13.93	Pass	42.10	12.16	Fail	6.87	14.12	Pass

Figure 3.
(Individual battery results of failed cells)

Recommendations

To provide secure power supplies for your telecommunication systems, we recommend the following:-

- *Install 10-year design life batteries to BS6290*
- *Install dual string batteries*
- *Install fuse links on negative of -48volts DC battery systems*
- *Carry out Annual Discharge test*
- *Carry out routine impedance tests on batteries*
- *Install good quality DC systems with N+1 redundancy*