Newell Acoustic Engineering

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Engineering task; Studio power network back-up system

Project; Gazprom Media – NTV-Kino film post production studios. Moscow

Engineering Brief

To provide a secure continuous power system for the film post production complex of NTV-Kino which will be totally reliable, easy to maintain, handle all current power demands and all future power demands with adequate headroom and reliability.

Problems to be Resolved

Audio power amplifiers have a heavy current demand which is a transient load and often many times the constant power demand.

The audio power system is incredibly sensitive to power system noise and interference.

Some audio and video equipment uses the power line frequency for signal synchronisation so the use of multi-phase systems is not possible as it will cause sync issues should items of this nature be used.

It is common in such studios for equipment to be constantly upgraded and added to.

Often temporary equipment is brought into the studios and connected to the power system by outside personnel.

Studios such as these often have a reasonably high turnover of technical staff so any complex operation or maintenance regime is likely to be overlooked by replacement staff unaware of any original staff training.

Any system must fully comply with local electrical regulations and not impact upon the normal functionality of the building electrical system or normal maintenance and inspection procedures.

For optimum system security all aspects must be tamper proof and resistant to untrained operatives connecting items related to their work.

The system must be resistant to the connection of unauthorised equipment and the occasional connection of heating, cleaning, or lighting equipment to the technical supply must not impact upon the normal operation of the system.

The Project Scope

The studios to be covered by the system incorporated the entire new-build post production facility, this consisted of a central machine room for data and audio systems, two full size sound dubbing theatres, a Foley effects recording studio, three voice-over studios, five audio editing suites, and ten video editing suites.

1 Studio reception area

Design Engineered Solutions

1 Investigation of the Suitability of Commercially Available Units.

In order to satisfy many of the identified problems it was decided at an early stage that the use of common commercial computer grade UPS (Uninterruptable Power Supplies) was not a sensible option. Common rack-mount units were unable to deliver both the large current capacity and massive transient loads we required for our amplification systems. It was also identified that system management and maintenance of a building wide distributed system was impractical and very much prone to omissions and mistakes by the operating staff. Tens of units would require careful inventory, inspection and monitoring. In the light of the high turnover of staff, and frequent need to add and remove equipment it was quickly decided that this option not only could not deliver the capacity that we needed but also would be prone to operator error and poor maintenance. The only remaining commercially available option was to investigate a central large scale computer grade UPS unit. The searches were eventually fruitless, no large scale single phase unit of adequate capacity was available within any reasonable budget or of a type which satisfied our needs.

The use of commercially available units was ruled out after a thorough search of the market.

2 Investigation of the Feasibility of a Central Single Unit.

In order to satisfy the need to maintain electrical system regulatory compliance and to keep to the concept of a simple to administer system it was decided to investigate a centrally located, single, building-wide back-up of the general technical power supply system. As a part of the standard process of studio system design that I usually implement all services that are not a part of the audio system are not supplied on the technical power system, thus things like offices, general lighting, HVAC, and machinery are all supplied separately to the technical services. It was soon decided that one very large heavy duty power back-up system could be custom engineered and inserted into the main building technical supply to provide secure power to the studio's systems. This solution would resolve the issues of complex maintenance and operation procedures by providing a single point of user interface and servicing. While solving some of the design problems it was noted that now the system had a single point of failure and that any system which was implemented would have to be of a completely failsafe nature.

2 Typical video suite

3 System Capacity

It now had to be investigated as to what system power capacity was adequate for the building as a whole. I was aware from previous projects that there were some modular off-grid power systems available that could deliver very substantial amounts of power reliably, these units could probably be used as a building block to achieve the specific requirements of this project. The aim now was to identify what power delivery capacity we would require. This could only be carried out by investigating what the final studio equipment specification would be. As I was also the principle project engineer for the whole studio design and construction I already had access to the provisional technical specifications. The power back-up systems were an integral part of the audio systems

and the power back-up project was a small sub-project of the bigger studio project. A week was spent obtaining every manufacturers power requirement specifications for all the items on the client's equipment list. Calculations of audio power amplifier peak demand and constant demand were made along with the theoretical possible additional temporary equipment lists. In addition to this a study of where the industry was heading and how past technologies had changed was carried out to investigate the possible future demand that would be placed upon the systems. System capacity was then calculated based upon these factors.

4 Engineering to Cope With and Avoid Misuse

Anybody with a reasonable amount of engineering experience will know that no matter how well a system is implemented there will be occasions where the user finds the most ingenious way to misuse the system. Intelligent engineering at the design stage can make a system more robust in these circumstances without resorting to excessive measures of control. Electrical systems are adequately protected from misuse through decades of development and are usually very resistant to such occurrences. The way that technical power systems most often become misused is by users connecting unauthorised foreign equipment such as domestic appliances and personal items, or by connecting items that should be power backed-up into power circuits that are not designated backed-up power outlets. I decided at a very early stage to remove all non-technical power outlets from technical rooms. This immediately resolves the issue of not powering important items from backed-up power supplies. Nobody can now inadvertently connect a critical item to a non-protected outlet. Only the issue of unauthorised appliances is now an issue. The only problem unauthorised equipment presents is extra system power required and the potential for it to introduce noise onto the sensitive supply. To counter these problems I ensured that the system power capacity included adequate provision for a few extra heaters and kettles to be used in people's workplaces. While these items should not be used in technical rooms experience has shown that it is human nature to smuggle in some comforts where possible and the system is engineered to cope with such instances. The issue of interference and noise is dealt with in the design of the electrical system independently of the power back-up systems. I was also the principle electrical design engineer for the whole project. All technical systems are designed to have extra low impedance circuits capable of conducting any noise or peaks back down to source. In addition to this all rooms are independently fed from an extremely low impedance power source and it is highly unlikely for any problem caused in one room, no matter how improbable, to feed back up into another room.

3Parallel isolation system for individual units allows any unit to be isolated for maintenance without shutting down the system

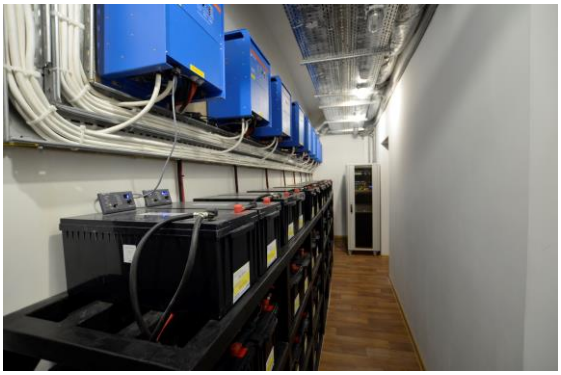
5 Dealing with a Single Point of Failure

Where the power back-up system would be installed at the initial point of distribution and supply the whole studio complex from one single point I had to make sure that there was no possible way for any component failure to cause a power failure. To deal with this issue a fail-safe multiple redundant parallel unit

configuration had to be implemented. A system was designed with redundant capacity where any unit failure would not result in an overload of the remaining units causing a domino effect failure of the entire system, plus all units had to have an individual electrical protection device to prevent the unit itself being overloaded by any external failure. An adequately safe system topology was arrived at without being excessively expensive by designing a highly parallel architecture within the system as a unit and ensuring additional fail-safe capacity over normal system headroom capacity.

6 Arriving at a Workable Solution.

The final system specification was to use nine 10KVA Victron Energy Quattro marine / off-grid power units in a parallel load sharing synchronised configuration. These units were carefully researched and suitability checked. Personal previous use of these units individually in smaller configuration had shown them to be capable of dealing with highly abnormal loads and shown, to date, a zero failure rate. Each of these units will deliver 10KVA continuously and a 100% over current for a substantial short term period of a few seconds without failure. The units will work in parallel and synchronise to either the grid or each other in off-grid mode. The units, in normal operation function in hard-bypass when the grid power is present and within specification. This delivers full advantage of the low impedance grid source to the electrical system and substantially reduces the potential for unit malfunction to cause problems in normal use. In the event of grid failure, or where grid power falls outside predetermined values all units take up the load with such speed as to not interfere with the operation of the most sensitive of equipment.



4 Nine Victron Energy power units

7 Dealing with Abnormal Loads

The system configuration with a single parallel massive back-up vastly reduces any issues with uneven transient current demands from studio power amplifiers. Where such an amplifier is connected to a smaller local back-up system the transient demand is a far greater percentage of the unit, and often exceeds the maximum deliverable power of the unit. It is not unusual for a group of power amplifiers to demand short term peaks of many tens of amps despite only having a continuous demand of four or five amps. In the system installed in the studios here we have a total studio constant current provision when off-grid of approximately 400A and a short term peak delivery capacity of 800A. This configuration ensures that even if the whole system is running with a heavy constant load there would be a peak reserve of 400A able to deal with abnormal peak demands.

8 System Headroom

The final specified system is able to deliver 400A of off-grid power. The actual calculated studio constant current draw for all systems operating was calculated to be somewhere in the region of 180A maximum at the point of initial system installation. And additional 40A was calculated for unauthorised personal equipment. 40A was allocated for temporary technical equipment such as rented or location gear, and a further 80A was set aside for future system upgrades and studio

expansion. This leaves a 60A safety margin with a fully loaded future system to allow for a unit failure while on load without risking a system shut-down. Additionally it is understood that future items may well be far more energy efficient allowing for greater system headroom as the general trend over the last 30 years has shown a constant reduction in energy consumption for technical equipment of similar specification, so while the system has future expansion capacity it may well be greater than actually required. In addition to the calculated constant current headroom the Victron Energy Quattro unit allows for a short term peak load of twice the specified unit capacity. This additional 400A supply ability enabled us to accommodate the power amplifier peak load demands without having to factor in any additional constant current supply capacity. With all studios running it was unlikely that short term instantaneous peak demand would ever exceed 100A.

9 System Run-Time and Batteries

Unlike conventional UPS units the modular system used an open architecture battery system. Batteries were external to the units and could be used in any quantity up to the maximum charging capacity of the unit. Each unit has a 140A charging capacity which can be paralleled with neighbouring units to deliver total of 1260A of 24V battery charge capacity. Building power supply has to be rated to accommodate this additional demand after the event of a power cut when the chargers are running at full capacity. With the chosen system charge current can be limited via software to accommodate for supply limitations. In the situation of the studios where we needed a super low impedance power source, extra current carrying capacity was pre-engineered into the system and could be utilised for the rare occasions a heavy charge was required to replenish the batteries. System load had to be calculated for events where the studios were required to run from battery power. This load had to be converted to Amp Hours at the battery voltage of 48V and the battery system specified to supply a minimum run time in these circumstances. It was decided that a whole 8 hour day should be covered so that a general local power fault would not stop important projects from being completed. A total of 72 12V deep cycle batteries were specified. This in itself produces its own engineering challenges. The weight of 72 lead-acid 180AH cells in the space available for the power system was in excess of the loading of the pre-cast concrete flooring units and a custom battery rack had to be designed and constructed which was bolted into the load-bearing wall onto which the power units had been mounted.

5 Custom Battery Rack Fabricated on Site

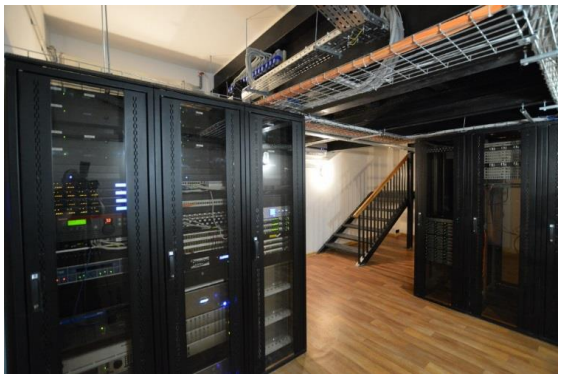
10 Ensuring Compliance with Local Regulations

Where such projects as this are installed under the jurisdiction of different national electrical codes it is imperative that I ensure that all aspects are compliant with the local

codes. For this purpose a local registered electrical engineer was contracted as a consultant for the purpose of ensuring all aspects of the work met local codes and were signed off by himself on my behalf. As electricity itself follows the same rules the world over, in these circumstances it is usually just a case of ensuring that any aspect which has to be tailored to local codes is done so with competence and knowledge. CAD drawings and schematics were produced and translated to Russian by the local engineer at our service.

11 Ensuring that the Equipment Keeps Running When the Lights Go Out

It is not only electrical power that is required for continual operation of systems during a power cut or fluctuation. Equipment has to be kept cool and certain areas kept ventilated. Working areas need minimum levels of work light. A study was carried out to ensure that where ventilation, air conditioning and lighting was essential to the safe continued operation of the studios working systems it was connected to the technical power system.



6 A Machine Room Where Cooling and Lighting Were Also Backed Up

12 Verification of Operation and Confirmation that the Project Brief Was Met

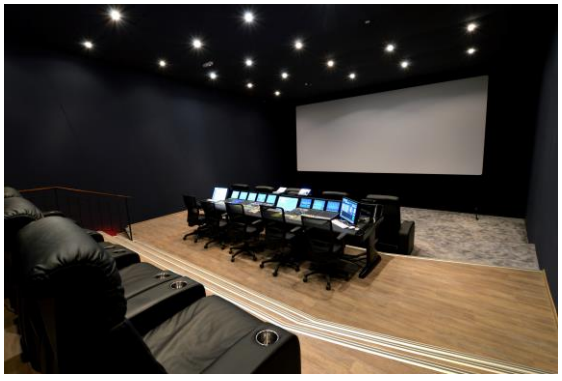
Upon commissioning of the entire studio systems the electrical system was tested to the highest applicable standards and documented on standard EU electrical inspection forms. All test were carried out through the custom power back-up system. The system operated and was verified by testing to be transparent in its presence. The extra-low impedance power source was maintained through the system and tested interference levels were well below acceptable limits. System operation and switchover on power failure was tested and proven to be invisible form the point of view of the studio equipment Load tests and run-time tests were carried out randomly during the month of systems commissioning.

Tests were carried out to ensure the project brief was met, and that all the problems the system had to resolve had been resolved adequately. The system was deemed to require no routine maintenance or human intervention for a period of the lifetime of the battery system which was 12 years, and at that point only replacement of the batteries would be required. Trials proved that the system worked perfectly without human intervention. Tests where unexpected loads were added and individual line faults simulated showed that no expected abuse would have a knock-on effect to systems sharing the back-up system. Audio system inspection and certification proved we had a clean solid power supply. The studios received Dolby Premier Certification which requires the highest standards of technical excellence to be inspected by the independent technical consultants from Dolby Laboratories.

13 The Project Revisited

Twelve months after the completion of the project the site was revisited and inspected. All power systems were working as specified. Additional technical systems had been added as expected and some operators were noted to have installed kettles and coffee machines in their rooms as predicted. There had been two notable power failures in this period that had not affected the operation of the studios. The first was a whole city block system blow-out when a local trolley bus driver had shorted out the lines on his bus and blown up the substation transformer. The second was a fire in a service area of the building which had burned through all the power cables to all floors of the building including the national satellite TV uplink station, although the satellite uplink station lost power briefly the studios covered by the scope of this project so no interruption of operations despite the huge electrical faults caused by cables burning through.

From the review of the system it was deemed that the system had been a total engineering success and should be used as a basis for any further projects of a similar nature.



7 Dubbing Theatre Number 1