ON-LINE CONDITION ASSESSEMENT OF HIGH VOLTAGE CURRENT TRANSFORMERS IN SOUTH AUSTRALIA

Terry Krieg
Manager Substation Maintenance and Technology Services
ElectraNet SA

Abstract

This paper describes experience in the introduction of on-line monitoring techniques for current transformers and bushings. Changes in monitoring practices for high voltage assets have been influenced by external environment and legislative changes including a more competitive national electricity market in Australia. A range of new on-line, continuous monitoring systems has been introduced to improve the information available for strategic and operational decision making. Following failure of a 275kV current transformer in a critical location in the ElectraNet network in 1997, a bushing and current transformer monitoring system was installed to provide early warning of imminent failure. This system is described briefly together with operational experience.

Background

ElectraNet SA is the trading name of ETSA Transmission, previously a subsidiary to ETSA Corporation a state owned authority in South Australia. The Corporation was formed from the Electricity Trust of South Australia (or ETSA) a statutory authority established in 1946 by the then Premier of the state, Thomas Playford. In 1996, ETSA celebrated its 50th anniversary. In October 2000 as part of government debt restructuring the Corporation was sold to a consortium comprising ABB, Powerlink, Queensland and the Macquarie Bank.

ElectraNet SA operates the South Australian Transmission network comprising voltages to 275kV. The table below summarises the key statistics of the Transmission system.

Main Voltages	275, 132, 66kV
Peak Demand	[1]2649 MW
Substations	68
Lines & Cables	5,575 km
Telecom	88 sites
Value	[2]$729 m
Personnel	173

Maintenance contractors carry out all maintenance in ElectraNet SA and no staff are directly employed for line or substation maintenance. The Corporation has retained Contract management and the core functions of strategic planning, maintenance management and policy development.

Asset Management

Asset management has been referred to as the "catchword of the nineties" and many organisations have implemented an asset management approach. This essentially involves consideration of the asset over its entire life cycle to ensure that the plant is safe, performs required service with minimum whole of life cost. This cost must include the capital cost as well as maintenance and operating costs and the whole of life cost of risk for that plant.

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[1] February 2, 2000

[2] ElectraNet SA 2000 Annual Report

In ElectraNet a risk based asset management philosophy has been adopted that takes account of the nature of the network, the large geographic area covered, unmanned stations, maintenance outsourcing and cost drivers.

Failure of a Current Transformer

In February 1997 mid summer temperatures in Adelaide, South Australia reached 40C for a period of a week. In the early morning at the end of that week, a current transformer in a vital power station switchyard failed catastrophically. The current transformer was one of a population of more than 60 installed over a period from 1976. One similar failure had occurred with this live head design at another substation some years previously.

Fig 2: Failed Current Transformer

The investigation concluded that the most likely cause of failure from the meagre evidence was quality control and design. Thermal runaway triggered by the excessive ambient heat and possible moisture ingress were considered as other likely contributing causes. The unit had been tested for dissolved gas-in-oil less than 3 months prior to the failure and the results showed no problems. Figure 2 shows the remains of the transformer. Very little evidence was available to indicate a definite cause of failure.

It was decided that a number of suspect units of the failed type and batch be replaced but that units of other batches of that type be retained after installation of a suitable continuous monitoring system. The AVO system was selected and commissioned in May 1999. The system was justified as a lower cost option to replacement of the entire population of this type of current transformer.

One of the strong drivers for this decision was the need to address safety issues for personnel working in the yard. The original failure had resulted in debris up to 50 metres from the original site.

Substation On-Line System

The AVO SOS system is designed to provide continuous on-line monitoring of insulation condition by comparative measurement of insulation capacitance and dielectric dissipation factor. The system consists of the following main components.

Connections are made to the test tap of each device to be monitored. A capacitor divider unit is used to develop a 40V Pk signal that is wired by twisted pair cable to the central control unit via a central marshalling box. A personal computer fitted with a high-speed data acquisition board is used to analyse signals, calculate comparative results, monitor trends, display and archive results. User configurable multi-stage alarms are wired from the computer to station alarms and SCADA system. The unit can be accessed remotely via a modem using standard remote control protocols and software. The computer display features a graphical representation of the monitored plant. Key conditions including warnings and alarms are shown graphically using coloured icons. This method of representing the information enables the condition of the equipment to be assessed by operating and other staff at a glance. More detailed analysis is possible using alternative views. The system enables reporting by exception as the system can be used to only report operating problems.

Alarm conditions are notified to the office by use of regular facsimiles generated by the SOS software.

Fig 3: Central Marshalling and Control PC

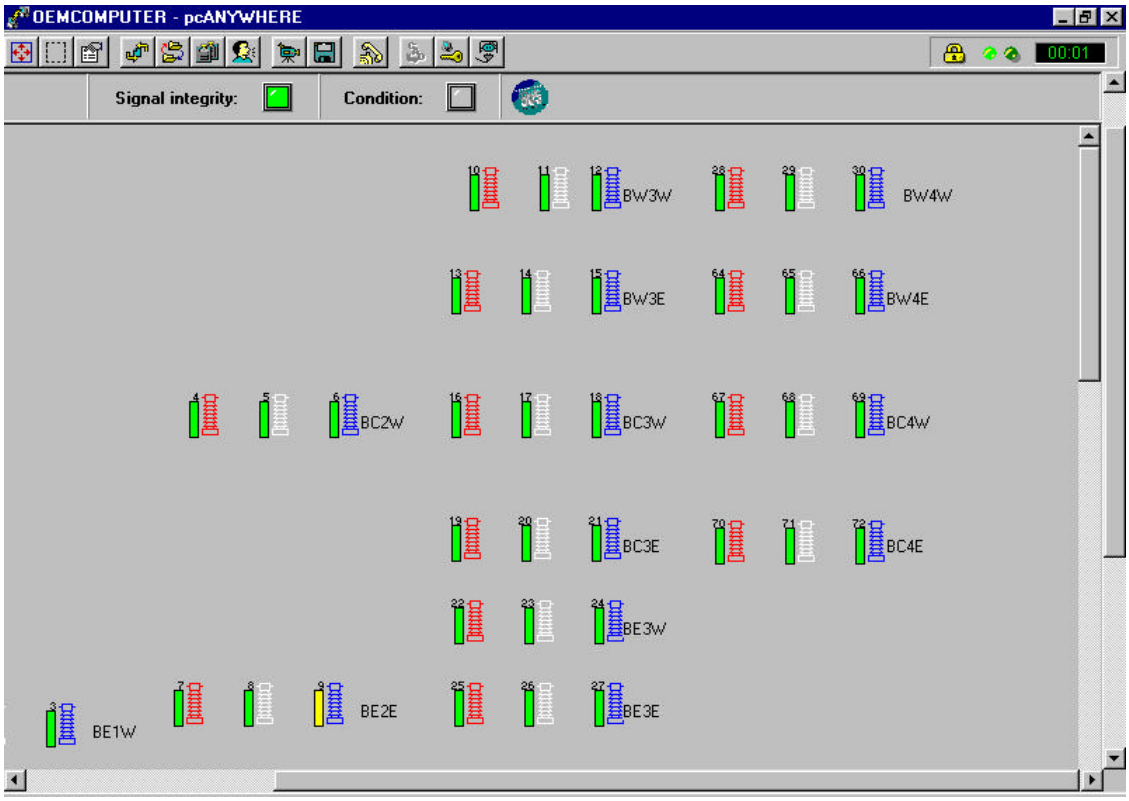

Fig 4: Screenshot of the Torrens Island Monitoring System

Service Experience

The Torrens Island monitoring system was commissioned in May 1999. The system has detected a potentially faulty unit (warning level) and the unit is being monitored more closely for signs of further degradation. Some problems have been associated with upgrading SOS software to latest versions.

Key Advantages of the System for ElectraNet

The current transformer and bushing monitoring system has a number of advantages over discrete, traditional monitoring including:

Application – ElectraNet have adopted a risk-based approach to the selection of equipment to be fitted with continuous monitoring. It is important that the system can be used with a range of plant types and designs.

Exception Reporting – Reduced numbers of personnel and cost pressures mean that the number of staff to sift data and determine condition of plant is minimum. The system is designed so that staff are only notified when there is a problem with the plant being monitored.

Expandability – This includes the ability to add other forms of transducers and monitoring (example Transformer gas-in-oil monitoring.

Early Warning – Instrument transformer design means that failure gestation time is short. The system provides early detection of potential failures.

Future Directions

It is difficult to predict the future in the changing electricity utility industry in Australia. It is certain in the medium term that monitoring and diagnostics will continue to play a major part in providing the information necessary to make strategic decisions particularly in the environment where out-sourcing and competitiveness are key factors.

In ElectraNet, a number of additional monitoring systems for key plant will be installed to provide comprehensive information on network performance and condition. A risk-based approach that identifies the most critical locations is used to assess new projects. This will lead to better strategic decision making especially for refurbishment and replacement decisions but also as an aid to operations. These systems will enable ElectraNet to better service customer needs by improving reliability and safety.

Important directions for ElectraNet in monitoring systems will be reducing the cost of installation. One of the major costs associated with the systems installed to date has been cabling. We are currently examining the use of a wireless option for our next major installation. In addition ElectraNet are examining expanding the SOS systems to include transformer monitoring functions and it is understood that this has been included in more recent designs.

Integration with Substation automation for our newer substations will be a consideration for the future and the use of standardized communication protocols and architecture such as UCA will be essential to ensure that our monitoring systems are closely integrated with overall station information management and control.

Conclusion

Changes to the Corporate environment and increased competition as part of participation in the National Electricity market has increased awareness of the benefits of on-line and continuous forms of monitoring to management in ElectraNet SA. Where previously systems were implemented as part of research and development projects, decreased personnel, out-sourcing of maintenance and increased awareness of the need to reduce whole of life costs with minimised risk, have resulted in an asset management strategy that includes implementation of comprehensive and detailed monitoring systems. There has been significant expenditure in developing necessary infrastructure and in ensuring that the information collected is at sufficient level and quality to enable strategic decision making for operations, plant refurbishment and replacement decisions. The installation and commissioning of a bushing and current transformer monitoring system has provided ElectraNet with a low cost alternative to replacement of a population of ageing instrument transformers.

References

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