INSTRUMENTATION FOR POWER SYSTEM DISTURBANCE MONITORING, DATA ACQUISITION AND CONTROL IN NIGERIA

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ABSTRACT

In this paper, the level of instrumentation for power system disturbance monitoring, data acquisition and control in Nigerian Electric Power System; National Electric Power Authority (NEPA) is presented. The need for accurate power system disturbance monitoring is highlighted. A feature of an adequate monitoring, data acquisition and control system is discussed. The state of the art in NEPA is focused and the attendant inadequacies highlighted. Finally, ways of improving NEPA monitoring, data acquisition and control are suggested.

INTRODUCTION

In order to reduce the risk, extent and duration of bulk power supply outages, different preventive (protective), corrective and restorative measures are taken respectively. A lot of researches and studies have been carried out in these areas, but the 'coordinating link' of these measures is neglected. It is therefore important that studies be directed toward this area.

In recent times, adequate power system monitoring and data acquisition, partly for triggering of the protective and corrective schemes, and partly for analysis of the performance of electric power system during appreciable disturbances have attracted some interests [1,2,3]. These recent interests may be ascribed to the high reliability requirement of the present day power systems predicated by emergence of critical loads based on microprocessor technology, and also to the fact that power systems are becoming more complex and vast with increased interconnections. In addition, the analysis of system's response to disturbances helps a lot in the understanding of system dynamic characteristics and consequently assists in the assessment of the models used for system's operation studies. The result is improved system stability measures vis-a-vis adequate sizing of protective and corrective schemes.

In the face of the present worldwide economic depression, attention have been directed towards the most economic ways of achieving desired goals via optimisation processes. The major effect on power systems is that they are not operated closer to their stability limits. In addition, the efficiency of the control logic for maintaining system stability is largely dependent on the adequacy of the models used in system's operation studies predicated by proper monitoring and data acquisition of the system characteristics under disturbances. Therefore there is an overt need for effective and accurate monitoring, data acquisition and control of the performance of electric power system during disturbances.

A recent research carried out on NEPA generation adequacy [4] revealed that the current generation capacity of NEPA is adequate for its load, yet in Nigeria, blackout phenomenon is a regular event. The blackout phenomenon is therefore an operational problem. This usually results from voltage collapse caused by overloading of some injection substations and occasionally short circuit faults on the transmission and distribution lines. Most of these blackout situations would have been forestalled if adequate monitoring scheme and control of the performance of NEPA system have been established. The voltage collapse problem caused by overloading of an injection substation for instance could have been avoided if proper monitoring of system voltage at the substation is carried out and the resulting data used to switch on adequate V AR support

In this paper, the requirements for

adequate monitoring, data acquisition and control system are focused, and the state of the art in Nigeria highlighted. The remedies to the attendant inadequacies in the NEPA system are proffered.

2. MONITORING, DATA ACQUISITION AND CONTROL SYSTEMS

Generally, a generation of equipment is developed to perform the monitoring, data acquisition and control functions in power systems. These sets of instruments are known as Supervisory Control and Data Acquisition (SCADA) systems. A SCADA system is generally a combination of hardware and software systems providing a flexible set of functions. The actual application of a particular SCADA system is specified by the parameters defined in the data base of the system, which provides for future expansion of the power system network. This is achieved by the use of advanced real time data base techniques which constantly updates the data base of the system to suit the prevailing conditions of the power system.

Monitoring, data acquisruon and control systems can be used for two major purposes; off- line analysis, and real time sampling of distinct electrical quantities for potential corrective control actions. The first purpose is necessary for analysis of the dynamic performance of the power system under disturbances in order to assist in;

i) control system development.
ii) system identification, like system oscillation and damping modes;
iii) validation of existing system model

The second purpose makes it possible to 'quarantine' system disturbances and thus avoid global blackouts.

2.1 Data Acquisition

The basic information in power system is measured and collected by equipment in the various substations and power stations. Distributed system equipment enables remote data acquisition. The measured values are mainly current and voltage levels, active and reactive powers, and frequency. The status of the circuit breakers, tap- changing transformers and other signals are monitored. The status indications are usually transmitted when a status change occurs.

Two systems of recording significant disturbance data are possible; triggered recording system, and continuous recording system. In the triggered system, recording is automatically started by a detection of any appreciable system disturbance. The type of disturbances to be recorded is incorporated in the triggering algorithm of the recording system. Such disturbances may include the following:

i) voltage deviation of about 5 %
ii) operation outside the statutory frequency range of 49.5 to 50.5 Hz for a 50 Hz system.
iii) loss of synchronisation in any part of the system.
iv) presence of power oscilIations on the system.
v) loss of generation
vi) large area blackout.

In the continuous recording system, monitored data are recorded continuously. The problem is in the choice of a recording equipment capable of storing data for a few days. This is overcome by the use of high density tape cartridges placed on different cartridge decks and the data recorded and cycled around the cartridges, such that they are overwritten after a few days. If there is any disturbance of interest, the relevant cartridge is removed and data of interest retrieved. This is difficult since large quantities of data are involved and there is the need to search the cartridge for the period of interest.

2.2 Monitoring and Control

Generally, the basic system data are automatically monitored through appropriate transducers/sensors for adequate control actions. The control action could be in the form of any of the following:

i) Adequate V AR switching.
ii) Turbine-governor system control action.
iii) Under load tap-changing transformer's operation
iv) Circuit breakers' operation leading to either load shedding or loss of generation

The status indications are also monitored

3. STATE-OF-THE-ART IN NIGERIA

The National Control Centre (NCC) Oshogbo, was established with sole responsibility of controlling the operation of the entire NEPA system. This became important with establishment of the National Grid whereby every power station generates into the Grid. Thus there is the need to control the amount of generation coming from each power station to the national Grid depending on the status of the Grid. The NCC Oshogbo employs a DASA system, a German, acronym simply meaning Data Exchange and Control system, for this purpose. A DASA system is made up of a master station and remote stations. The NCC is the master station while the 330/132 KV substations in Nigeria are the remote stations. The outputs of the transducers *(CT* -Current Transformer or VT-Voltage Transformer) and the status of the circuit breakers at the remote stations are monitored and transmitted to the master station. The internally computed real and reactive powers are plotted by the chart recorders. The outputs of the measured values are shown by the DASA measure and while the status of the circuit breakers is indicated by the DASA status and alarm indications.

3.1 System Configuration

The NCC is made up of five DASA systems, connected in radial/in-line configurations as shown in Figure I. Each DASA system has a number of remote stations identified by addresses such as 00, 0 I, 02, etc that it is controlling. Power Line Carrier (PLC) is used as the communication medium between the master station and the remote stations. Data transmitted between the two stations are the measured values, and status and alarm indications. The DASA facility of the NCC Oshogbo allows many signals to be received simultaneously without loss of identity. Facility for recording data during disturbances is provided by the chart recorders which record continuously the real and reactive powers at the remote stations.

4. DISCUSSION

Analysis of the performance of the NEPA system monitoring, data acquisition and control facilities in serviceable condition reveals that the instrumentation level is barely adequate for only monitoring of the system operation status for off- line control of the system. The data acquisition is only by the chart recorder. This is very cumbersome since the chart recorders plot continuously the real and reactive powers at the remote stations and make the search for any data of interest very laborious. Moreover, for appreciable system disturbances, the need to obtain sufficient data to accurately simulate the disturbance and investigate into the possibility of minimizing the risk and severity of any further occurrences has placed a special requirement on the instrumentation and logging procedures of the data acquisition system. This requirement is met by the development of on-site recording and measurement (OSRM) equipment. This has been implemented in Central Electricity Generation Board (CEGB), London [I]. The control facility is grossly inadequate since it should be based on proper Energy Management System (EMS), which in the case of NEPA is not incorporated in the control facility. The energy management aspect of

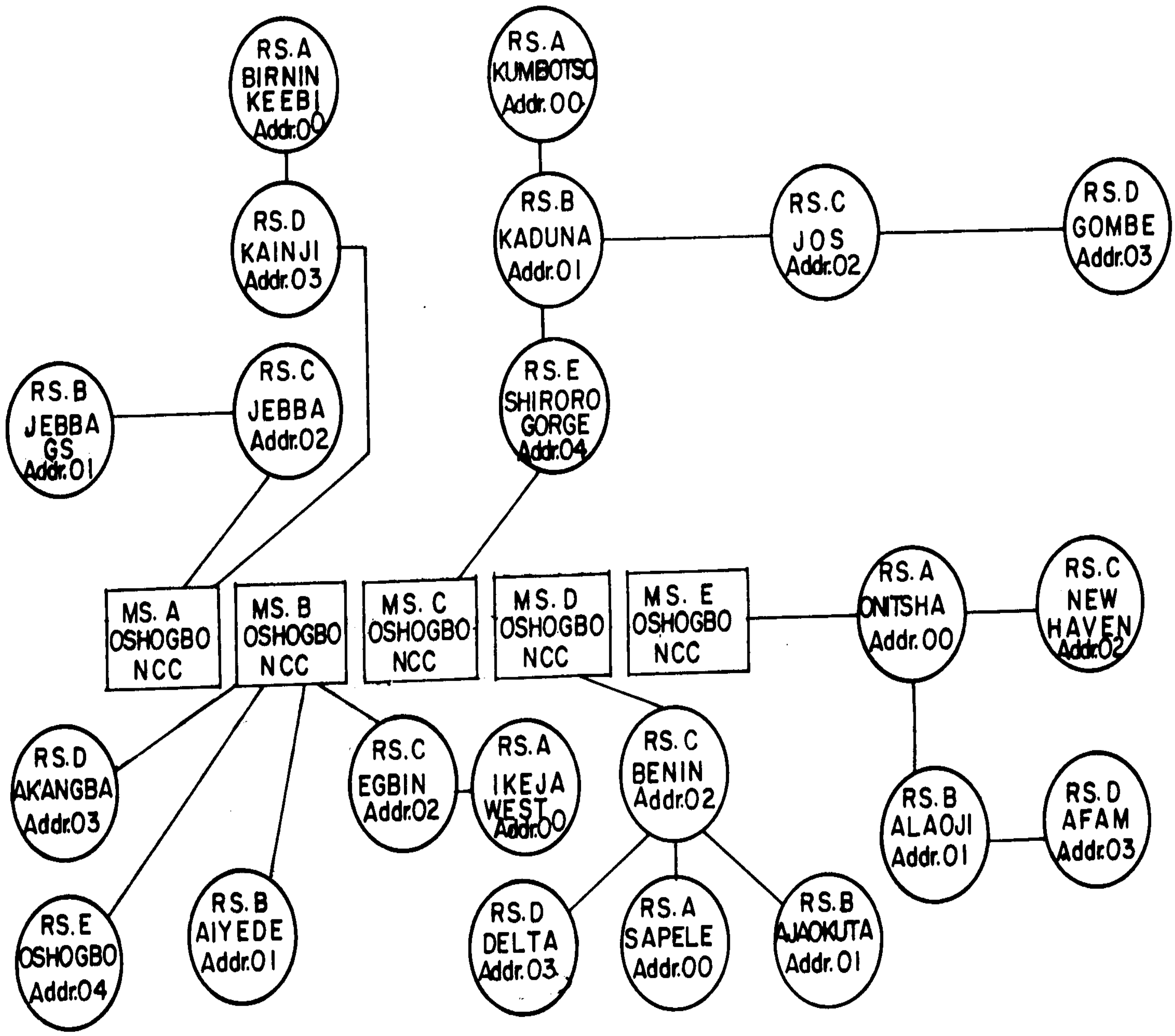

FIG. 1. NEPA DASA SYSTEMS CONFIGURATIONS

the control is therefore performed by the operator on duty, which now depends on the expertise of the operator. This sometimes makes the control command inadequate.

A technical report issued by the NCC Oshogbo [5] revealed that by the close of 1986, only status and alarm indications of the DASA system for few remote stations were functional, and a recent visit revealed that the situation has remained the same to date. Hence, the existing telephone, telex and radio facilities remained the main prop of NCC system control function. This has resulted in the crucial decision on real and reactive powers dispatch being dependent on hourly collection of data from remote stations by telephone, telex and radio messages. This makes such decision to be often times slow and hence inaccurate.

5. CONCLUSION

This paper has presented the instrumentation level for power system disturbance monitoring, data acquisition and control in Nigeria. The analysis of the existing monitoring, data acquisition and control facilities of the NEPA system revealed a lot of inadequacies in the system. A practice where information crucial for control action is received partly by telex, telephone and radio messages and partly from returns sent through postal and courier services is considered not only inadequate but obsolete. Oddly enough, the only data acquisition tools available; the chart recorders, are in a state of disrepair.

No modern power system with the number of interconnections as in NEPA system can operate near satisfactorily without a well integrated monitoring, data acquisition, control and energy management system. The trend is towards digital computer based monitoring and real time data based on-line control of power system. A situation in which a computer based on-line monitoring and data acquisition system and energy management system are incorporated into the existing DASA system, such that given information on the status of the system, appropriate control command is automatically issued is recommended.

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