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THE SCADA-READY FUNCTION OF AN IED

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INTRODUCTION

A vital part of any process control system is the initial and periodic point-to-point checkout of the system from process input values to the database and displays. Typically, this checkout is associated with a SCADA system, and a complete point-to-point check is very labor intensive. This paper describes a new concept that has the potential for greatly reducing the time and effort required to perform a point-to-point checkout; and as a result, insuring that the system database and overall operation meets the highest possible accuracy standards.

STATEMENT OF THE PROBLEM

An essential element of installing and periodically checking either the operation of an IED by itself, or as part of a SCADA system is the Point-to-Point Checkout. In its simplest form, a known quantity (analog value or its equivalent; or a status point, which can be defined by one or more binary bits) is injected into the measuring IED, and that quantity is verified as showing up in the correct location on all user displays, databases, and process programs. Further, the quantity may be varied so as to exceed defined alarm limits and therefore verify that the correct alarm and event messages are generated by the program(s) receiving the data.

A true and complete end-to-end point-to-point checkout requires that a known value of the primary signal be injected into the input circuit of the measurement and control chain, and that signal followed to its end location. For example, consider a simple current metering circuit in an electric power system:

1. A known 60Hz current is caused to flow on the phase wire being measured
2. The output of the current transformer connected to the phase wire is measured and checked to insure that it is scaled by the CT turns ratio and the phasing is correct.
3. The output of the transducer connected to the CT is measured and checked to insure that the milliamp dc signal is proportional to the known 60Hz current by the specified
scale factor.

4. The output of the analog-to-digital converter connected to the transducer is checked to insure that it is a correct digital representation of the known 60-Hz current.
5. The output of the alarm and event processing software that is logically connected to the a/d converter is checked to verify that it is producing the value of the 60Hz current in the appropriate (usually engineering units) numerical form.
6. All graphic and tabular displays that include the 60Hz current are checked to verify that the proper value shows in the correct location on the display.
7. The 60Hz current is varied to insure that the dynamic changes in the value are correctly transmitted to the end display or database.

In many cases, a point-to-point checkout bypasses the first two steps because most of the time adjusting the primary variable to a known quantity is difficult if not impossible and also because it is assumed that the current and voltage transformers (or other primary transformation devices) have been checked and calibrated by some other means at an earlier time. In an electric power system, for example, the transformers are checked out at the time of initial installation and commissioning of the IED (relay); and unless some part of the installation is physically modified, the connections should remain constant. Sometimes, of course, this assumption can lead to false conclusions, but on the whole, it is generally valid. In addition, the protection functions of the IED are checked and validated at the time of commissioning.

An essential part of point-to-point checkout is the ability to inject or trigger a single quantity as part of the checkout. This insures that the personnel performing the checkout (or the automatic checkout program) will have only a single data point to process, and can verify that the correct responses are received. The reason for restricting the injection to a single quantity is to eliminate any possible ambiguity that might result if multiple responses are observed. In other words, what is desired is a "go--no go" check.

When a Remote Terminal Unit (RTU) is involved in the SCADA system, the point-to-point checkout is typically divided into several parts. First, the chain from the primary measured variable to the output of the dc transducer is checked for the proper scale factor and calibration. Then, the dc transducer output is disconnected from the RTU analog input circuitry and a known dc milliamp value is applied to the terminals. Operators then verify that the resulting digital representation is passed through all processes and appears correctly in the database and on applicable displays. The operator at the RTU can vary the input dc signal to insure that proper alarms and other messages are produced at the receiving location. Likewise in the case of status points, the RTU input point is opened, or grounded, and the operators verify that the correct alarms and indications are produced.

For purposes of this paper, the following descriptions are provided in terms of the application of IEDs to electric power systems. However, it must be emphasized that the principles described herein are applicable to all process control systems that involve measurement and control functions.

Typical IEDs, such as microprocessor relays as applied to electric power systems, are complex devices that can have thousands of database points. Many, or all, of these points might be transmitted to a controlling device for further processing and/or display to users. Performing a point-to-point checkout involving these relays can be very difficult because of the complex interaction between the measurands and the resulting functions performed by the relay. For example, injecting a current greater than a specified value may cause the relay to operate and send a signal to its associated circuit breaker. This violates the "single quantity" concept of point to point checkout in that the injection of a single quantity (the current) will cause two (or more) indications (a digital representation of the current value, and a status change representing the signal sent to the controlled circuit breaker). The operator performing the checkout may infer that both results are expected, but must now verify that all alarms and messages relating to both events are generated and processed. This would not be too bad if only two quantities are generated, but in reality a single input current can result in additional indications like target information, fault records, operation records, etc. If more than one IED is involved in the process, the problem is compounded.

In addition to the requirement for "single quantity" checking, most methods for doing a point-to-point checkout require the following:

(a) A technician at the remote location to inject the single quantity into the IED

(b) A technician at the central location(s) to verify the correct processing and display of the injected quantity.

(c) Disabling or disconnecting the IED from the process so that the proper signals can be injected without interference to the process; or (preferably) a means to inject the proper signals without actually causing process control changes (breaker operations) to occur. The best overall solution would be the ability to check just the data communications functions without interfering with, or disabling, the other (protective) functions of the IED.

Conceptually, a relay contains circuits and programs that sample and calculate the digital representation of the input variables and all associated derivative variables (i.e., phase angles between voltage and current from the voltage and current inputs, calculated real and reactive power from the voltage and current inputs, frequency, etc.) Additional programs calculate relationships between the measured and calculated variables and various pre-defined sets of data. Based on the results of these calculations, the relay causes output contacts to open and/or close to perform various functions, typically tripping a breaker. Finally, there is a function, commonly called metering or output processing, which places the measured, calculated and all other pertinent data into a form that can be transmitted to, or read by, a user interface or external device.

In order for an IED to be "SCADA-READY ", it should be possible to override the communications portions of the metering function so that status and digital data can be directly loaded into the output processor. This status and digital data can be pre-defined values, or can be injected from the user interface or by an external process through one of the physical or logical ports. The other functions of the relay or IED should not be disabled or otherwise impaired. That is, a relay should continue to provide its intended protective functions at all times during the checkout. The metering function of the relay should continue to calculate the normal values of the metered quantities and status's, and store all or a selected set of such quantities in appropriate memory cells for later transmission to the process controller.

The metering function does not necessarily save instantaneous data for later transmission (but this function may be included if so desired), but would continue to calculate demand, maximum and minimum values, etc., which are normally stored in the IED. Likewise, if the protective function should be activated during the checkout, waveform capture and fault information should be captured and stored in the appropriate IED memory locations.

There are many methods for overriding the output portions of the metering function Typical methods include, but are not limited to, the following:

(a) Manipulation of the local user interface by a technician

(b) Local injection of data by a technician using an external computer connected to a logical or physical port on the IED.

(c) Remote injection of data by a technician using an external computer or the process control system itself connected to a logical or physical port on the IED.

(d) Automated checkout whereby the process control system is commanded to initiate a checkout sequence that includes injecting data into a logical or physical port of the IED and then compares the response with a pre-defined "correct" response by the process control system.

ADVANTAGES AND BENEFITS OF THE SCADA-READY CONCEPT

1. IEDs are normally tested and calibrated at the factory. Installation and connection of the IED will result in being able to verify that the primary inputs are being measured and calculated.

2. Point-to-point testing of an IED normally requires the use of complex, heavy and expensive test equipment in order to inject the necessary signals into the primary metering ports to achieve the desired indication (i.e., injecting the required currents to cause, in succession, a Phase A Overcurrent Trip, Phase B Overcurrent Trip, Phase C Overcurrent Trip, etc.) In other words, performing a SCADA point-to-point check requires the technician(s) to set up all the test equipment and essentially duplicate the work done to verify the relay settings and performance. To test all possible combinations of inputs and resulting outputs of a single IED could require several days. Using the SCADA-READY capabilities of a relay, it is estimated that two technicians, working

together, could verify the injection and correct processing of all possible signals in less than 4 hours per complex IED. If the process control system supports the SCADA-READY checkout procedures, the complete checkout could be run as a self-contained package. In other words, the technician at the process control system would initiate a checkout of a designated IED. The process control system would transmit known variables to the IED, and verify that the same known variables are received back from the IED through the defined communications channels. To insure independence, the channel from the process control system to the IED could be a separate communications channel. The savings in labor costs for automated checkout would be dramatic.

3. If communications channels are available, a point-to-point checkout can be performed without the necessity of a person at the substation site. Elimination of travel time would result in significant savings in travel time and material (primarily vehicle miles). In addition, there would no longer be a reluctance to perform a point-to-point checkout because of the technician time involved (or because the technicians are already fully loaded). Thus, any time a change, no matter how "trivial", is made to a display or process, an automated point-to-point check can be performed to insure the change was correctly implemented. This will eliminate the tendency to "save up" changes so as to minimize the need for frequent trips to the substations and technician time to perform the checkout. Over a period of time, this will insure the highest possible confidence in the integrity of the database and overall process.

4. Injecting a known number directly into the output process is inherently more accurate than trying to adjust complex test equipment to generate a set of input signals that will result in that number. All ambiguity is eliminated, and repetitive "adjustments" to the test setup are eliminated.

5. If the IED is designed such that it continues to perform its protective functions while the point-to-point checkout is taking place (as it should be), the overall safety, security and reliability of the power system is not compromised at any time during the point-to-point checkout.

While the above description used the example of a protective relay on an electric power system for illustrative purposes, it must be emphasized that the concepts discussed herein are equally applicable for all other applications where process data is measured and/or controlled and transmitted for short or long distances to a process control computer. The potential savings that can be accomplished when applied to a supervisory system that is monitoring and controlling a product or gas pipeline of great length are readily apparent. Similar examples can be provided for any industrial or commercial application.

SUMMARY

This paper has presented a new concept, called SCADA-READY , as an integral part of an Intelligent Electronic Device. SCADA-READY will permit the complete and detailed point-to-point checkout of an IED without compromising the other functions of the IED.

Using the capabilities of a SCADA-READY IED will insure that the SCADA database, displays, alarm limits, etc. as related to the IED are correct. At the same time, the current time-consuming methods of performing a point-to-point checkout will be basically eliminated, resulting in dramatic savings in technicians' labor and travel.

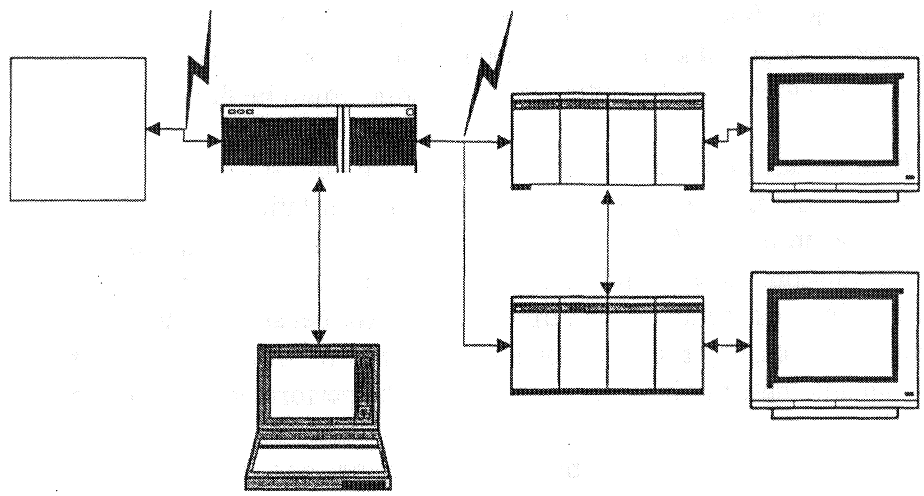

Figure 1 Diagram of a SCADA-READY System

Technical Biography of William J. Ackerman
Bill started work with Automatic Electric Company on the first solid-state SCADA systems (CONITEL-2000) after receiving his B.S. and M.S. degrees in Electrical Engineering. Since that time he has worked for Leeds & Northrup Company and Florida Power Corporation before joining ABB as a Project Manager in the Systems Control Division. Bill transferred to the Power Automation and Protection Division in 1996, where he is currently Manager of Substation Automation Systems. Bill is a Senior Member of the IEEE and the Power Engineering Society. He is past-Chairman of the Substations Committee of the PES and is a member of numerous committees and working groups developing IEEE and IEC standards. Bill has authored and co-authored numerous papers, including the IEEE Tutorial, Fundamentals of Supervisory Systems.

Technical Biography of Steven A. Kunsman
Steve joined the ABB Power T&D Company Inc., formerly know as Brown Boveri Corporation, in 1984 in the design support group. He graduated from NCC with an ASDT and continued his education through part-time classes graduating from Lafayette College with a BSEE. In 1992, Steve transferred into the microprocessor product development group and was a core team member in the development of the DPU2000 and later the 2000/R series product line. Another critical project was the implementation of the Modbus Plus™ communication's interface for the 2000R series product which contributed to the successful award of the Southern California Edison automation project. Steve presently holds the position of development manager for the ABB Power Automation and Protection Division's Allentown operation and is in pursuit of an MS in Management of Technology at Lehigh University. He is Member of the IEEE Power Engineering Society.

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