



Integration of Automation Devices in Hydro Plants on a Highest Level

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Abstract:

HIPASE- Highly Integrated Protection Automation Synchronization Excitation integrates the specific requirements of the different fields in one single device. This paper presents the overview and construction details of the newly developed integrated devices which is very reliable and high performing device used in automation of Hydro Power plants.

Keywords: Protection, Automation, Synchronization, Excitation and communication.

I. INTRODUCTION

BACKGROUND-

The new and innovative HIPASE platform has especially been developed for the dedicated use in hydroelectric power plants and covers the many applications like Excitation, Protection, Turbine and Control. These functions can be performed by one device or individual device for each application. All devices are based on identical hardware modules and use the same engineering tool. Dedicated electronic boards are used for specific requirements resulting in perfectly fitting devices for applications like voltage regulators or generator protection functions.. "This platform based idea results in various advantages. First of all spare part handling is a lot easier when various systems of a hydroelectric power plant share the same electronic boards. Second of all as the HIPASE Engineering Tool is the same for all applications it is a lot easier for engineers to handle different systems as the all HIPASE applications are handled with the same PC program"

AUTOMATION IN HYDRO POWER PLANTS

The traditional way of automation in hydro power plant is to provide the different devices having different kind of hardware and software levels. However this innovation will enhance the level of automation in hydro power plant by using one device for all the major automation applications or different set of devices for each application with common hardware and software logics. Other advantages like more efficient maintenance, easier training and the ability to have similar looks on the integrated touch panels of the devices for different applications are more examples where the HIPASE platform shines during the lifetime of the system.

1. ONE PLATFORM FOR DIFFERENT DEVICES

HIPASE devices usually carry four boards combined according the needs of the application. The processor board is the core component providing system tasks, the calculation of dedicated programs and also acting as a standard communication interface (e.g. IEC 61850, IEC 60870-5-103, IEC 60870-5-104 and Modbus) to other devices or SCADA systems in the plant. For processing analog and digital information dedicated I/O boards are provided. HIPASE devices consist of a half size 19" housing incorporating up to

32 digital inputs and outputs as well as 12 current and 8 voltage transformer inputs. For all applications with extensive signal requirements (e.g. 6-system differential protection) a full size 19" housing can be used. A key characteristic of the HIPASE platform is its architecture. HIPASE ensures both the protection of humans and property (safety) and data integrity (security) by hardware and software measures.

1.1 FUNCTIONAL SCOPE

The functional scope of the new HIPASE platform consists of state-of-the-art and innovative technology like a fully graphical colour touch panel, multiple open communication features, certified safety and security features as well as a simple plant specific configuration of the devices. As a result of predefined functions included in HIPASE all devices can easily be fitted to the dedicated demands and plant specific requirements. Due to the complex interconnection between the overall infrastructure of power generation and distribution, the issue of "cyber security" has become increasingly important. This importance particularly becomes clear in the related policies of key power utilities (e.g. the White Paper of German BDEW and the North American NERC CIP Standard).

1.2 HARDWARE

HIPASE consists of a series of hardware modules which are developed for the dedicated use in hydroelectric power plants. They are specially designed to full fill the requirements and support a safe and proper operation of the applications they are used for. HIPASE devices come in two sizes. There is a medium housing (Half 19") and a large housing (Full 19"). Both housings can be mounted in a (swing) frame and can also be mounted on the rear side of a cubicle with a detached touch panel. It is anticipated that the data volume transferred from a household for simple metering is less than 100 kB³ per day and firmware upgrades may require 400 kB of data to be transferred.



Figure.1. Hardware variants – Medium and large device

1.3 FEATURES

PROCESSOR BOARD CP-300

Features the central processors, the interface to the other boards in the device and connects to the process network and other communication media. This board takes care of the execution of the software functions (like protection functions, regulators and others) and serves as the main boards of a HIPASE device.

TRANSFORMER BOARD TR-310

This board features 12 current transformer inputs (1/5 Ampere) and 8 voltage transformer inputs (100 VAC) which are sampled and transferred to the software functions every 1ms.

POWER SUPPLY BOARD PS-300 / PS-500

This board features the power supply for the HIPASE device. It can either be 24-60VDC (PS-300) or 110-220VDC (PS-500). Additional there are 4 fail safe digital output channels available on this board. The Power Supply Boards can be equipped with additional digital input / outputs modules to suit the intended application. Available modules are: 16DI (DI-010), 16DO (DO-010), 8DI+8DO (DX-010).

APPLICATION BOARD EXCITATION AB-310

This board features dedicated channels and functions for the excitation application like the regulation of the trigger angles and the connection to the Thyristor Bridge. It can be equipped with an additional module (AM-010) providing 6 analog input channels (4-20mA), 4 analog output channels (4-20mA) and 4 input channels for temperature measurement (PT100 sensors).

APPLICATION BOARD PROTECTION AB-320

This board features dedicated channels and functions for specific protection functions like the earth fault protection. It can be equipped with an additional module (AM-010) providing 6 analog input channels (4-20mA), 4 analog output channels (4-20mA) and 4 input channels for temperature measurement (PT100 sensors).

TOUCH PANEL TP-900

The integrated touch panel of HIPASE devices provides state-of-the-art technology for displaying and manipulating process data. It is freely configurable in terms of optical representation and in terms of the kind and amount of data points which should be displayed. The HIPASE touch panel offers a leap forward to all existing protection devices and excitation controllers with an intuitive user interface and easy to use handling. HIPASE complies with a number of different national and international standards. These are amongst IEC 60255-26 Measuring relays and protection equipment IEC 61131-2 Programmable controllers IEC 61850-3 Ed 2.0 Communication networks and systems for power utility automation.

2. HEART OF DEVICE- SOFTWARE.

HIPASE devices feature a powerful platform built on state-of-the-art microprocessor technology for calculating tasks and executing functions necessary for protection and excitation of hydroelectric power plants.

2.1 PROCESSOR BOARD

A) MODULE TO MODULE COMMUNICATION

The processor board acts as the center point for all calculations in a HIPASE device. It features dual CPU design. One CPU is

designed to do all tasks necessary to guarantee a proper operation of all functions the HIPASE device was loaded with. This includes all protections functions and functions for the regulators of excitation applications as well as system tasks like the operating system and Watchdog functionality. The execution of the user program can be separated into three tasks. This ensures the possibility to achieve different cycle times for different parts of the application. This especially helps when several parts (for instance control algorithms) of a program need to be calculated faster than other parts. With this an overall better performance of the system can be achieved. Besides this there is a second CPU on the processor board dedicated for communication interfaces. The advantage of this design is that the external and internal Ethernet networks are separated. This means that no external influence can harm the internal communication of HIPASE devices. Even if the external communication breaks down, the local functionality of the device is ensured. This measure underlines the security aspects which were put into the design of HIPASE.

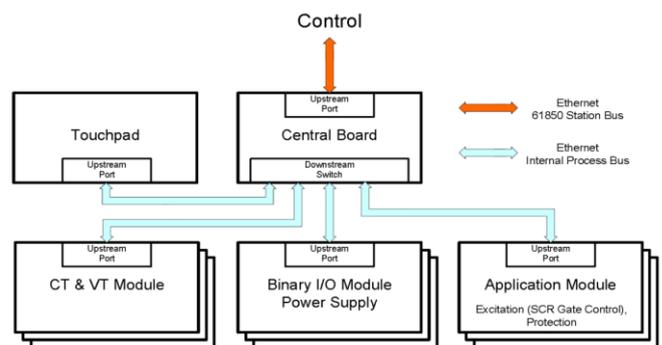


Figure.2. Block architecture of HIPASE software

These two CPUs on the processor board together with all other boards and the integrated touch panel of every HIPASE device do communicate via an internal Ethernet Bus. This ensures a safe, stable and fast transport of all data throughout the system.

B) COMMUNICATION PROTOCOLS

HIPASE devices support the following international communication protocol standards:

IEC 61850 Ed 2.0 IEC 60870-5-104 Ed 2.0 IEC 60870-5-103 Mod Bus TCP The engineering of these protocols is done in HIPASE Engineering Tool. A mapping feature provides the possibility to connect map all internal information to a data point of the communication protocol and vice versa freely. With the help of this a powerful interface can be engineered for connecting HIPASE devices to control systems or SCADA systems within the hydroelectric power plant. Recording analog and digital values and providing this information as a set for further analysis is another feature of the HIPASE device software. The channels to be recorded can be defined freely and therefor can be customized to the needs of specific applications. Additionally to that disturbance records are also recorded and stored in the device and can be read out with the help of HIPASE Engineering Tool and then saved in standard COMTRADE format. Loading new user programs, parameters or even a new firmware is handled by the device software in combination with HIPASE Engineering Tool. Every data download to a HIPASE device is verified and will only be executed if the transmission went without error. The data transfer from the HIPASE Engineering Tool to the HIPASE device is encrypted and therefor secure. These measures

ensured that no corrupt files can harm the functionality or availability of the system. Additional functionality of the device software contains

features like:

Time management

HIPASE devices get their time from external time servers like for instance an NTP Server. This time information is used for time stamping of entries in chronological event lists or protocol telegrams.

Self-diagnostic and Watchdog

HIPASE devices feature powerful self-diagnostic capabilities. Hardware and software monitoring is implemented on system level and monitors a wide variety of functions. Any detected error will put the HIPASE device into a so-called "safe state" where additional damage on the system itself and of course damage on the equipment it controls can be excluded.

Logging

An internal logging mechanism ensures a gap free log for all occurrences in the system. Loading processes restarts and parameter changes are only a small part of events which are recorded and logged in the system. This log can be read out and analysed with the help of HIPASE Engineering Tool.

C) ENGINEERING TOOL

HIPASE Engineering Tool is state-of-the-art PC software for engineering all HIPASE devices. It features a modern user interface and a new quality of working with tools of such kind. The user is guided through the whole engineering process, an efficient way of working is guaranteed. HIPASE Engineering Tool is fully multilingual and offers a wide variety of customization options. It follows the platform idea of HIPASE. Similar tasks are handled in a similar way, like the placement of the hardware boards or setting an IP address. Special tasks like for instance the definition of the trip matrix for protection devices can be done with dedicated designed user interfaces to provide the best way of working for each and every task.

The main functions of HIPASE Engineering Tool are:

Defining the hardware configuration of HIPASE devices an easy and intuitive way of placing boards to match the configuration of the HIPASE device to be engineered. All available boards are presented in a library view and can be placed by the user. Additionally a live update of all input and output channels is provided in this view. Setting the parameter for input and output channels. Parameters like thresholds, input filters and others can easily be adjusted here to fit the requirements of the different applications possible. Programming and parameter setting of device function with an integrated IEC 61131-3 compliant Function Block Editor a quick and standardized way of working is assured. Predefined functions like protection functions or voltage regulators can be mixed with user defined functions to fully customize the needs for every application possible. Parameters for these functions can be directly set in the program or can be set via the integrated touch panel. In addition also the configuration of communication interfaces takes place within HIPASE Engineering Tool. Drawing process display for the integrated touch panel of HIPASE devices. HIPASE Engineering Tool offers an easy to use full graphical editor for drawing the process displays for the integrated touch panel of HIPASE devices. The configuration is done via predefined templates which can be adopted freely to fit the needs of specific

configurations. The touch panel offers integrated parameter setting capability which means that all parameters of all functions can directly be entered on the device without the need on an engineering tool. HIPASE Engineering Tool also features a simulation mode for the integrated touch panel. This means that you can run the complete functionality of the touch panel right on the PC you are working on without having a HIPASE device attached. Commissioning, service and maintenance of HIPASE devices. During the commissioning HIPASE Engineering Tool supports the user with a lot of tailor made functions for this task. For instance a fully featured online test for the Function Block Diagram with forcing and blocking of all parameters and internal values helps a lot during this phase of a project. A table view with live updates of a user defined set of parameters, input and output channels or even internal variables helps to have a detailed look into the functions of a HIPASE device. The definition and the read back of curves and disturbance records can also be done with dedicated designed user interfaces within the program. Additionally a built in documentation feature ensures an easy way of documenting all parts of a project.

D) AUTHENTICATION

In order to ensure a safe and controlled way of operating HIPASE devices they are equipped with a state-of-the-art licensing system. In general this means that for all software functions the device is asked to execute a valid license has to be provided. As a result of this the operator can be sure that all functions were commissioned properly and that he has legally purchased the desired functions. ANDRITZ HYDRO on the other hand can be sure that only released functions are executed at a specific plant. Besides the hardware configuration also the desired software functions have to be specified during the order process of a HIPASE device. The list of software functions available contains for example protection functions, standard and advanced functions for the voltage regulator of excitation applications or protocols for communication to other control devices or SCADA systems in the hydroelectric power plant. After selecting the proper housing of the HIPASE device and the amount and types of the I/O boards based on the input and output channels needed for the desired application you also have to choose the necessary software functions. All this combined results in a HIPASE device perfectly fitting for the application you need. Every HIPASE shipment contains license information as well as the device itself. The software licenses are tied to the device they were ordered for and can therefore not be transferred from one device to another. This helps to have a consistent database of where specific software functions are implemented and ensures that functions are used as intended. The license information can be transferred into the device via HIPASE Engineering Tool.

2.2 AREA OF APPLICATION

A) PROTECTION APPLICATION

HIPASE-P provides an optimal solution for a state-of-the-art and efficient generator- and transformer protection used in Hydro and thermal power plants. The internal logic of the protection function is made with function block diagram. It can easily be back traced or expanded using a fully graphical function block editor. Windows PC based software HIPASE Engineering Tool supports the protection engineer with well-known and proven tools such as software output matrix, test inputs for each protection function or simple interface testing. A parameter window for each protection function provides the

user with clear and straightforward information for parameter setting in on-line or off-line mode. In addition a fully graphical colour touch display of 7 inch is available for local operation. Standardized process displays such as protection functions, measured values, protection function parameters, test of digital I/O's alarm list or software LED protection status information are designed to reduce complexity of operation and increase efficiency of testing. Numerous hardware supervision functions enable detailed analysis in case of relay failure. Information is given per hardware module. There are two failure output relays available. Each of them provided with a normally closed and a normally open contact. They are designed to signalize a device failure with two stages such as device fault and device halt.

B) EXCITATION APPLICATION

HIPASE- E provides the reliable solution with single and redundant channel features based Automatic voltage regulators systems for Exciter of Hydro and thermal generators. The exciter cubicle contains all required power circuits (except excitation transformer/s), the automatic voltage regulator and the complete sequencer, which is necessary to control the individual components. The system also comprises a local operating Touch panel with alarm indication, which enables local operation and quick systems analysis and repair in case of excitation failures.

C) TURBINE GOVERNOR APPLICATION

HIPASE- T provides the reliable solution for turbine controlling of any type i.e. single regulated, double regulated, Pelton and pump turbines. These turbines may be connected to any type of grid i.e. single unit, isolating grid, frequency support and large grids. It also support different operating modes i.e. Speed regulation, power regulation, opening regulation and flow regulation.

D) SYNCRONISATION APPLICATION

HIPASE-S provides the solution to synchronize and parallel synchronous or asynchronous three phase or single phase systems being either in an energised and/or de-energised state. There are up to five different synchronizing modes for altogether ten different parameter settings blocks available. In addition the circuit breaker closing time function i.e. CB dead time compensation is also included. It contains features such as the synchronizing check operating mode and measuring of the circuit breaker closing time. The relay is applied as a manual closing interlock when paralleling two systems or as an additional safety interlock in automatic transfer control circuits.

It also covers 6 synchronising modes:

- Mode 1: Generator to bus bar or power line
- Mode 2: Synchronous or asynchronous power systems or lines
- Mode 3: Synchronous or asynchronous power systems or lines similar to mode 2, however with additional dead line or dead bus charging
- Mode 4: Synchronizing check for manual closing operations
- Mode 5: Fast automatic transfer of bus bar systems
- Mode 6: Measuring of the circuit breaker closing time

II. CONCLUSION

It is a dedicated product for the use in the power plants (Hydro power and thermal power) for all unit types and unit sizes. One platform for the protection, excitation, synchronisation and turbine controller and it reduces the complexity of traditional automation solution used the Hydro and thermal

power plants. The device has the best performance and high reliable in all kind of environmental conditions of power plants. The software is very easy to use and can be changed into any type of application by single click. The programming of the device is simple and user friendly.

III. ACKNOWLEDGEMENT

I am very thankful to Mr. Sanjev Handoo, Member, Advisory Committee, EA, Alternate Hydro Energy Centre (AHEC), Indian Institute of Technology, Roorkee for guiding me to publish this paper. I am also thankful to Mr. Kapil Mangla, Head, Department of Electronics & Communication, SATYA College of Engineering & Technology Palwal, for the motivation and inspiration that triggered to me for the thesis work.

IV. REFERENCES

- [1]. According to the article 10 of the EU Directive 73/23/EEC.
- [2]. International Standard of the Series IEC 60255 and the National Standard DIN VDE 57 435 Section 303 (September 1984) according to the Stipulations of the Low Voltage Directive 2006/95/EC of the European Community of February 19th 1973.
- [3] The new product line by ANDRITZ HYDRO Automation. <<http://www.andritz.com/en/hy-24-03-hipase>>
- [4]. 421.1-2007 - IEEE Standard Definitions for Excitation Systems for Synchronous Machines. < <http://ieeexplore.ieee.org/document/4274782/>>.
- [5]. Development and supply of five electronic/digital governor PID design and implementation – Pradeep Digital Private Ltd. – 1990.

V. BIOGRAPHIES



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