

EMBEDDED CONTROL SYSTEM FOR HIGH POWER RF AMPLIFIERS

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Abstract

RF Power Devices are usually very sensitive to overheat and reflected RF power; hence a protective interlock system is required to be embedded with high power solid state RF amplifiers. The solid state RF amplifiers have salient features of graceful degradation and very low mean time to repair (MTTR). In order to exploit these features in favour of lowest system downtime, a real-time control system is embedded with high power RF amplifiers. The control system is developed with the features of monitoring, measurement and network publishing of various parameters, historical data logging, alarm generation, displaying data to the operator and tripping the system in case of any interlock failure. This paper discusses the design philosophy, features, functions and implementation details of the embedded control system.

Introduction

Due to the advancement in high frequency high power semiconductor device technology, RF transistors of power range of 1 kW are now available. The inherent advantages of solid state technology and the device availability are thrusting the development of high power solid state RF amplifiers for use in particle accelerators. We are developing high power solid state RF amplifiers working at various powers and frequencies to fulfil various needs of the centre. Each amplifier rack consists of a number of RF power amplifier modules, driver amplifier chain, DC bias power supplies, high power RF combiners and splitters, cooling system, mains powering system along with various monitoring, measurement and interlock components (Figure 1). Thus, to manage and diagnose such a complex system, an embedded monitoring and control system is required. Hence, all of the amplifiers racks have been embedded with a real time control system.

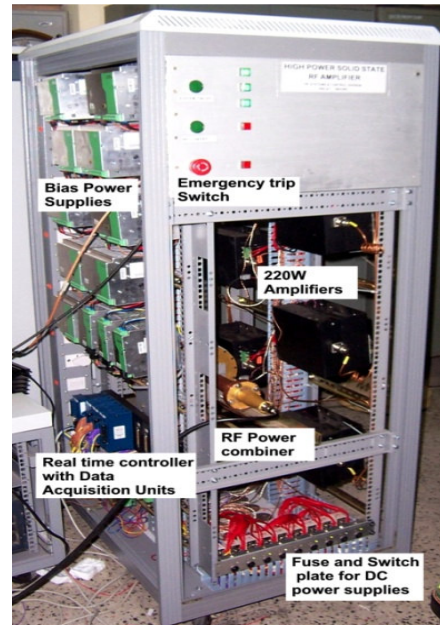


Figure 1: Photograph of solid state RF amplifier.

This paper describes the features and implementation of the control system by very briefly discussing various issues related with noise free data acquisition, historical data logging, alarm and trip generation, data and message management and presentation of data to the operator. Some new technologies of the field like shared variables and data socket along with new concepts and advanced features (like real time FIFO, functional shared variables) of graphical programming have been fully harnessed in the software design.

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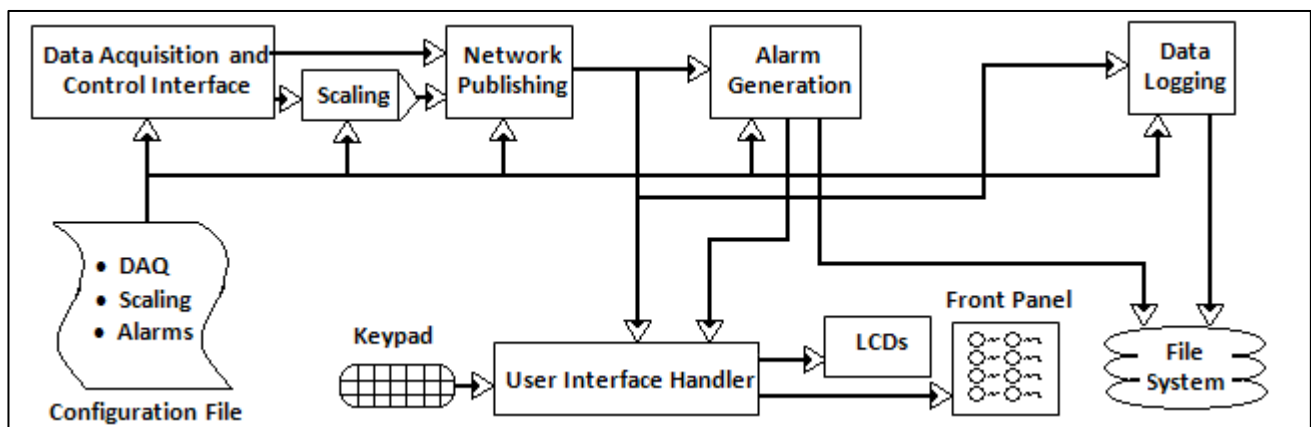


Figure 2: Logical block diagram of embedded control system software.

HARDWARE DESCRIPTION

The control system hardware mainly consists of RF detectors, current sensors, data acquisition modules, the controller, front panel, display and wiring hardware. Signals from amplifier modules, directional couplers and other components of the amplifiers are routed to acquisition modules. The data is acquired by the controller and then the scaled and processed information is communicated through network and is displayed on operator interface computers. The front panel of the amplifier consists of some switched, indicators, audio visual alarms, LCD displays and a keypad. This panel helps in easy control and monitoring of the amplifier in standalone mode.

Reducing the effects of noise has always been a big challenge in the measurement and control systems. In the presence of high power RF sources this problem is increased by an order of magnitude. To cope up with conducted and radiated EMI of our environment, due care has been taken right from system design to wiring and PCB layouts. For this purpose, all signals are carried with twisted pairs and shielded cables; common mode chokes and feed thru filters have been used properly. EMI performance of the running system is excellent.

SOFTWARE DESIGN

The embedded system software has been built on the LabVIEW real time environment running under real time operating system of the controller. The software development work was divided in multiple modules. Inter-module and intra-network data communication is done using data socket and real time FIFO. Figure 2 shows a block diagram of the software running on the controller.

Modular software

To simplify software development, modifications and fault finding processes, the control software is structured in small modules. For example, data logging module is responsible for data acquisition scaling and network publishing of various parameters. Alarm monitoring module receives data from data logger and checks various analog and digital signals for their value in the alarm range. The benefit of doing so is that if any part of the software needs to be changed; only a particular module will have to be modified slightly. It leaves rest of the program intact. Some of the software modules, developed for this system, are listed below.

Alarm monitor

In case of any signal exceeding its predefined values a system alarm is generated. These alarms are recorded and displayed to the operator. Depending upon the system requirements the alarms can be reconfigured.

Historical data logging

The historical data logger records various signal value change occurring in the amplifier systems. It is supported by an interactive historical data retrieval system.

Front panel server

The processed data is presented to operator with the help of LCD displays. Along with the data display, alarm messages and user configuration menus are displayed on the same LCD. Figure 3 shows front panel with displays.

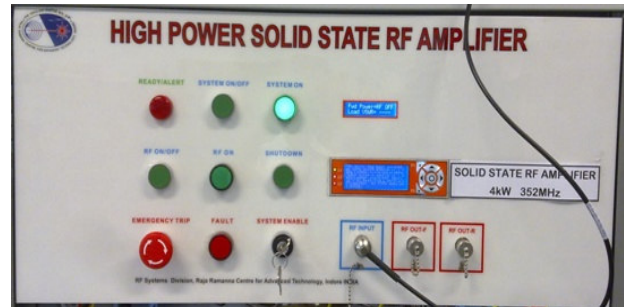


Figure 3: Photograph of front panel user interface.

CONCLUSION

The control system described in this paper has been developed and tested successfully. Presently, the system is being used for test runs and commissioning of solid state amplifiers. The system has undergone a successful time testing. User suggestions and comments have been adapted to enhance the system performance.

Acknowledgements

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