IJITECH International Journal of Innovative Technologies
WWW.IJITECH.ORG
ISSN 2321-8665
Volume.08, Issue.01,
February, 2020,
Pages:17-22

LabVIEW Based MST Radar Transmitter Interlock Control Unit Health Monitoring and Control System

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Abstract: The paper describes the implementation of the real-time diagnostic monitoring system of the MST radar transmitters. For research and development purposes, the main goal of this work is to develop a cost effective and modern technique for Monitoring & Controlling of Radar Transmitters for safety management (WMCT) for MST Radar is described. It achieved the MST radar transmitters' remote supervisory, data logging and controlling activities. The system is developed using an ARM Cortex M3 processor to monitor and control the 32 triode-based transmitters of the 53-MHz Radar. The system controls transmitters via the network using an Ethernet client. In order to reduce off-site analysis effort, reports on Radar grid are generated on request for user defined time period by using HMI. HMI's provides information on Radar grid operation, displayed as digital values, slide bars and graphs. The whole interface contains different sub-screens which the operator can easily navigate and can perform test, analyze historical data and evaluate statistical information. The novelty of the system is that it can enable scientists to operate and control the radar transmitters from a remote client machine in the network using LabVIEW.

Keywords: Labview, MST Radar, ARM Cortex-M4 Processor And Ethernet.

I. INTRODUCTION

MST Radar located near Gadanki (13.5°N, 79.2°E) India is a prime instrument for atmospheric science research. The neutral atmosphere is classified as different regions according to the temperature profile, namely Troposphere, Stratosphere, Mesosphere and Thermosphere. To evaluate the characteristics of the regions, different techniques were developed. This radar is a prime instrument for atmospheric science research. The MST Radar triode facilitates controlling and monitoring 53-MHz, 2.5 Mega-watt peak power radar based transmitters via internet. These radars are capable of probing the atmosphere up to 100 km & ionization up to 650 km with good height and time resolution. It is capable of providing data continuously giving the information on the dynamics of atmosphere. The fig. 1 is the view of the radar antenna array and transmitter control rooms. MST Radar antenna array consisting of 1024 antennas arranged in 32x32 matrixes over an area of 130mx130m. Each array is fed from single transmitter with totally 32 transmitters sourcing the full array. All transmitter power levels and health condition can be monitored using "Centralized MST radar transmitter interlock control unit health monitoring system" developed in LabVIEW. Each transmitter can be monitored and operated in manual mode from the hut as well as in the 'Auto' mode.

Fig1. The radar antenna array and transmitter control rooms.

This data acquisition unit receives input from the sensors placed in the transmitter-amplifier cavities and monitors a total of 12 safety parameters. This unit logic circuit process sensor data for abnormal voltage, temperature and current deviations, and switches-off the Transmitter subsystems incase of any mall functions, with the help of Control unit. The Fig2 is the ARM cortex-m4 unit interface of radar transmitters and interlock control. This interlock control unit ensures the protection of the transmitters from any failure in the system. The transmitters can be operated in auto mode as well as in the manual mode (by using front panel switches). Auto mode allows scientists to operate and control transmitters through remotely using "Smart data acquisition system". Remote health monitor and controller system acts like the brain for radar transmitters. The centralized system monitors the status of all 32 transmitters remotely. The system also records sensors data using database technology in server. This data indicates for the number of transmitter's availability and their power level, It ensures the proper functioning of control and interlocking system in transmitters.

Fig2.The ARM cortex-m4 unit interface of radar transmitters.

II. EXPERIMENTAL SETUP

The methodology of this work is divided into two sections one is centralized MST radar health monitoring software implementation and the other is to establish communication with existing radar transmitter units. ARM cortex-m4 based customized data acquisition modules will be installed in MST radar Transmitter to transmit data to the application software. RM cortex-m4 is a low-power processor that features low gate count, low interrupt latency, and low-cost debug intended for deeply embedded applications that requires fast interrupt response features.

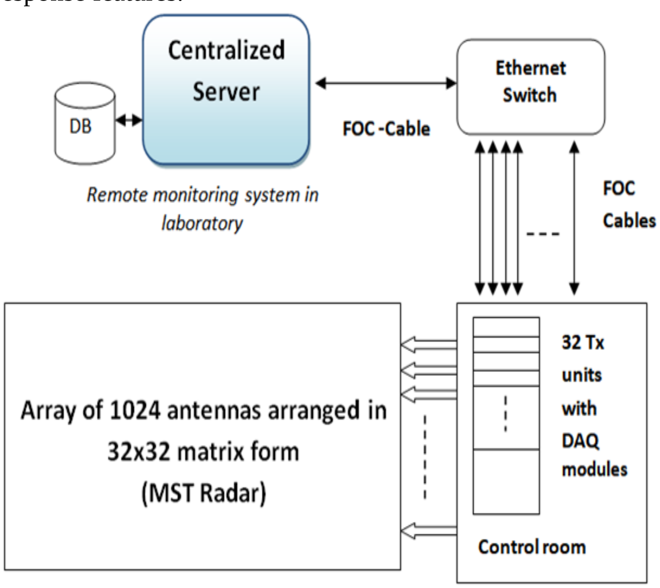


Fig3. The overall structure of control and monitoring system for transmitters.

ARM cortex-m4 is with ARMv7-M architecture. With the improved Thumb2 instruction set, cortex-m4 microcontrollers support a 4GB address space, provide bit-addressing (bit banding), and interrupts with at least 8 interrupt priority levels. The inbuilt Ethernet controller is used to send and receive the data or commands from embedded target board to a personal computer. The Transmitter amplifier sensors output interfaced to the ARM board and finally with centralized health monitoring and control system connected through the network. The software implementation is focused on GUI based user friendly application design with the help of LabVIEW, background TCP/IP network communication is programmed. Fig3 gives the overall structure of control and monitoring system for transmitters.

A. Software Design

The software implementation of the MST Radar TICU-HMS (Transmitter Inter lock Control Unit–Health Monitoring System) is developed using embedded LabVIEW and Microsoft Access database along with DB and visa drivers for labview. MST Radar TICU-HMS is centralized software which helps to monitor transmitter's health records from control room. Human mission interface (HMI), TCP/IP client and background controls are implemented developed in labview 2019. The sensors' data archive along with a time stamp is performed by Microsoft Access, a relational database management by microsoft. Data acquisition modules execute concurrently for monitoring and controlling MST Radar Transmitters. The system receives analog signals from transmitter, frames digitized data into ethernet packets for transmission to the centralized server. The server receives the digital data from the MCU using the TCP/IP protocol and analyzes data displays on the HMI page.

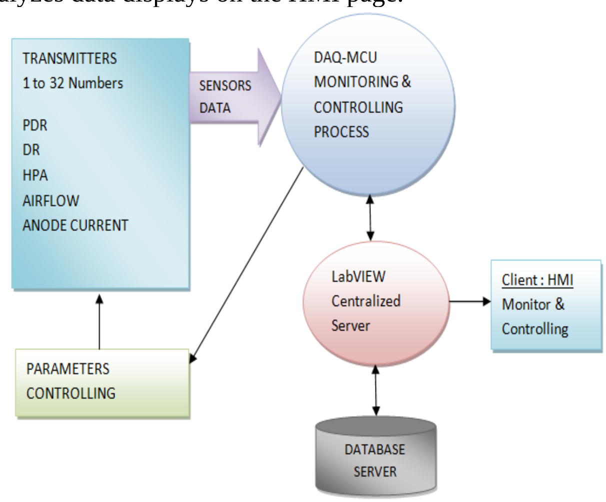
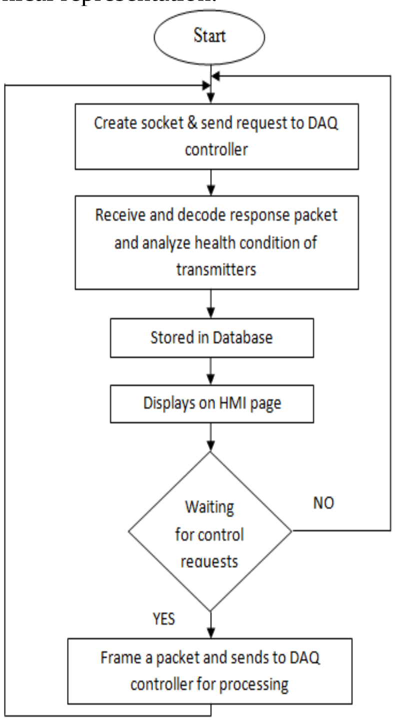


Fig4. Functional block diagram of TX monitoring and control system.

The system software is divided into two modules. The first module is for centralized server designing and TCP/IP communication implementation on the remote computer. The second module is routines for database handling and storing data in the database server.

B. Centralized Server

Centralized server module is software for getting data records from data acquisition modules connected to transmitters and to provide user interface to access transmitter health monitoring and controlling. It consists of IIS server with LabVIEW framework and connects to database server. The records will log on to database for further access of data. Under data analysis system calculates transmitter health/ working condition and notifications in case of any malfunctioning. The system is not only a one point access to all transmitter records and health monitoring it also configurable or customizable for operator requirement. The centralized server running on the personal computer takes sensor data in the form of packets. The packet splits into parameter wise and displays on home page continuously in digital and graphical representation.



Work Flow1. Centralized server-PC Logic.

C. DataBase Module

This software retrieves the sensed data of the parameters and stores the same in appropriate date and time. It also stores the user entered set of values in a separate table based on which parameter control action is initiated by the user. This software enables its user to generate reports on record parameters for particular time and days as well as generate graphs of the same, based on choice of user in the interactive general GUI page. The Microsoft Access 2007 is a relational database management system. As a database, it has a software function to store and retrieve data as requested by the front end application where both are running on the same computer. Data base has enhanced with new indexing algorithms, syntax and better error recovery systems. The data pages are check summed for better error resiliency and optimistic concurrency support has added for better performance. The permissions and access control have been made for more granularities and the query processor handles concurrent execution of queries in a more efficient way. The partitions on the tables and indexes are supported natively so that scaling out a database into a cluster is easier.

D. Software Implementation

To provide the flexibility and to reduce complexity, modularization programming method has been implemented. Modularizing the whole software resulted in flexibility of designing, testing, debugging and maintenance. The following two points are considered in program, first one is to distribute system resources by functionality i.e. hardware command communication, data analysis, health check, alert notifications and so on, second point is enhancing its universality and anti-jamming ability. LabVIEW 2019 is used for application program writing. LabVIEW is system engineering software for applications that require test, measurement, and control with rapid access to hardware and data insights. And offers TCP/IP programming of SOCKET grade and support various kinds of network protocols (such as HTTP, FTP, SMTP, PPP). With the development of network technology TCP/IP protocol has been written into the server system. As a result, System becomes a server which can communicate with all data acquisition units connected at transmitters.

E. Communication Module

The system turns into a miniature network server by creating single point daq module communication for all 32 transmitters. By this, the remote monitoring is indeed realized. Fig. 5 is the LabVIEW block diagram snippet for TCP/IP communication.

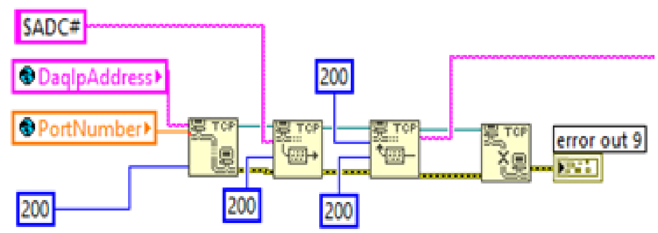


Fig5. LabVIEW block diagram snippet for TCP/IP communication.

E. Data Analysis and Health Check

This module computes the transmitter health of that movement including with power level details. In case of any power level or mal functioning will be represented to the user. Fig. 6 is the LabVIEW block diagram snippet for Tx Health Check calculation.

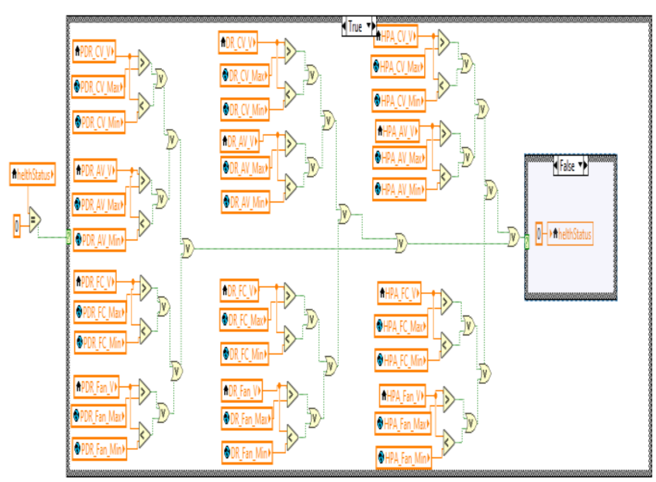


Fig6. LabVIEW block diagram snippet for Tx Health Check calculation.

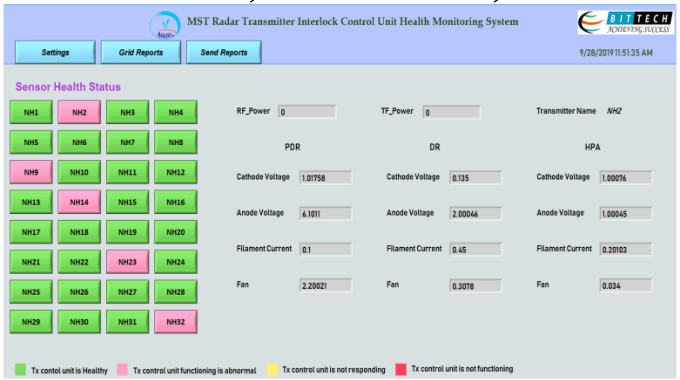


Fig7. GUI page for Tx Health and power level display.

F. Data logging

Data logging is the process of collecting and storing data over a period of time in order to analyze specific record or conditions. In this module continues transmitter records will save in database along with data and time. This module provides facility to get history of transmitter records. Fig. 8 LabVIEW block diagram snippet for data logging of Transmitter records.

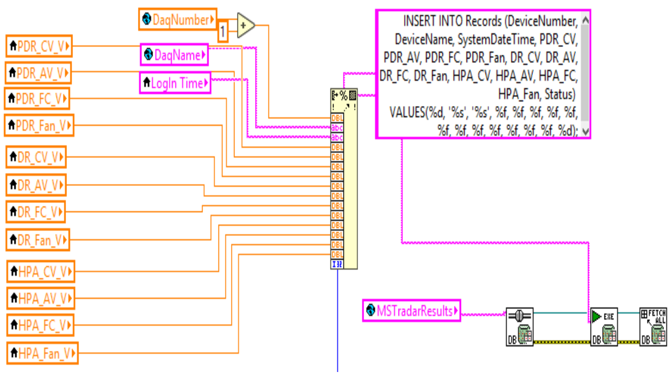


Fig8. LabVIEW block diagram snippet for data logging.

This module will also provide facility to save system configurations.

G. Reports

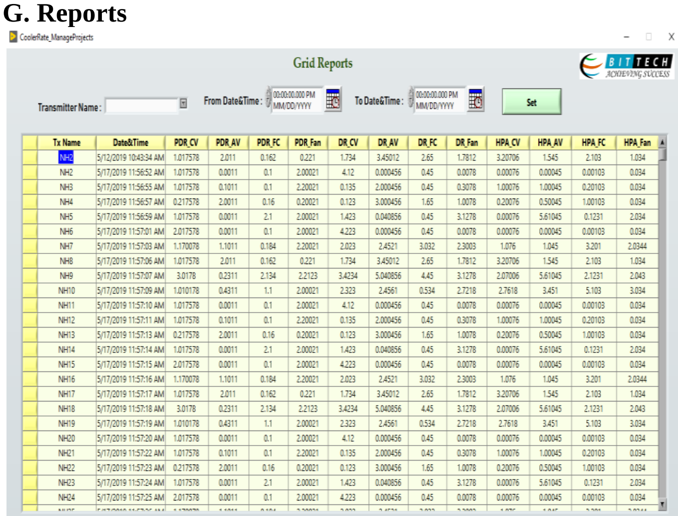


Fig9. GUI page for Transmitter records in form of grid View.

This module gives history of transmitter behavior along with power levels records. The reports will represented in grid and graph format Fig 9 and 10 is the GUI page for Transmitter records in form of grid and graphical representation.

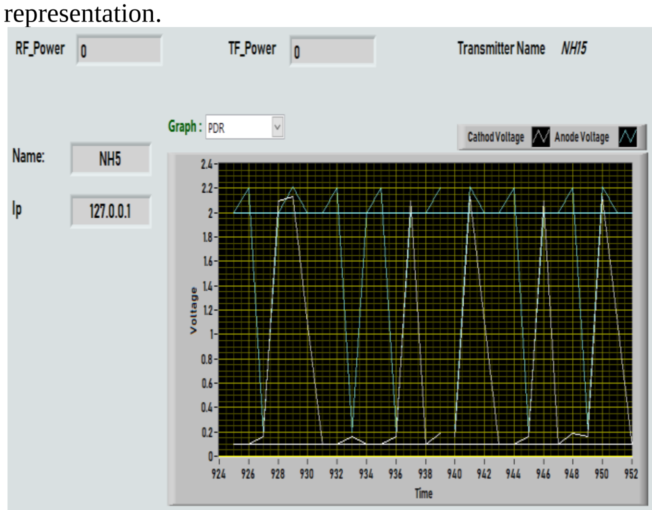


Fig10. GUI page for Transmitter records in form of Graph View.

H. Configuration

This module makes the application user friendly to scientist. It allows customizing the specific radar transmitter dynamic power-level thresholds for health indications and communication specifications. Authorized operator can also configure the Daq controller unit to uniquely identify the transmitter to program the transmitter data communication intervals.

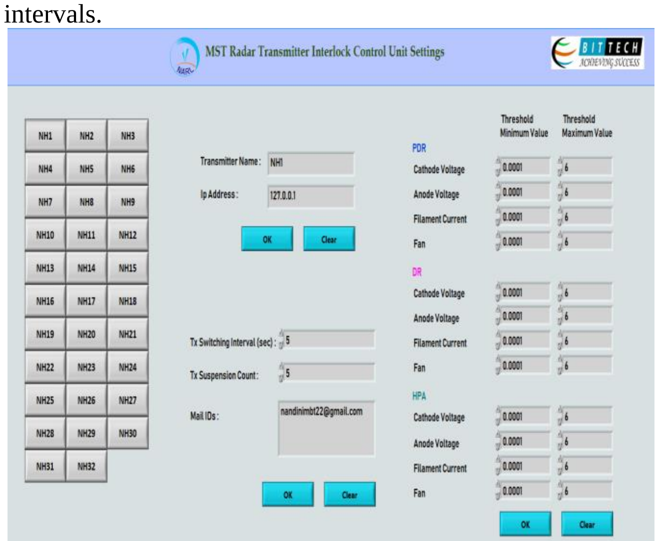


Fig11. GUI page for Application and Transmitter Configuration.

III. RESULTS AND DISCUSSIONS

The Indian MST Radar having 32 transmitter modules have been divided into six groups depending upon their power outputs. The outputs of all the transmitters in one group are same. The distribution of peak power outputs of the six groups is given in Table 1.

Table 1. Transmitters and their Peak power

Group	Number of Transmitters	Peak Power
1	12	120 KW
2	4	90 KW
3	4	71 KW
4	4	53 KW
5	4	36 KW
6	4	22 KW

In Fig7 the home page displays power readings of transmitter and its health levels like, Tx control unit is Healthy, Tx control unit functioning is abnormal, Tx control unit is not responding and Tx control unit is not functioning. The same page contains future to switch on/off the RF power circuitry on the transmitter. The health status of each parameter and voltage levels are mentioned in Tables 2, 3 and 4. Health status is good or bad is indicated asa colorful bubble. The RED is indicated as fault/bad condition of the corresponding parameter and GREEN indicates good condition.

Table 2. Fan sense signals

Amplifier	OFF	ON
PDR	4.67	0
DR	4.82	0
HPA	4.82	0

Table 3. Heater current Sense Voltages.

Amplifier	OFF	HALF HEATER POWER (1st 3min)	FULL HEATER POWER (after 3min)
PDR	0	2.4	3.4
DR	0.3	2.5	3.6
HPA	0	2.6	3.13

Table 4. Anode supply sense Monitor Voltages.

Amplifier	Anode supply OFF	Anode supply ON
PDR	2.7	3.1
DR	1.5	2.4
HPA	1.7	3.06

IV. CONCLUSION

The MST Radar Transmitter Interlock Control Unit Health Monitoring System proposed in this paper is intended to support the capabilities of the remote supervisory and controlling system based on IOT technology for Transmitters is designed and implemented. The system adopts Server mode and realizes the interconnection of the data acquisition devices like ARM Cortex-M4 Processor. Therefore, remote users can access, control and monitor the MST radar transmitters using application over the network. It has advantages of data analysis, data logger, system configuration and stable performance.

V. ACKNOWLEDGMENT

The authors express profound gratitude and thanks to the Director, National Atmospheric Research Laboratory at Gadanki for providing facilities, encouragement and guidance during the research period..

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