New Control and Monitor system for GMRT

R.Balasubramaniam, Charu Kanade, Raju Uprade, Naresh Sisodiya, Jitendra Kodilkar

NCRA-TIFR, Post Bag 3, Ganeshkhind Post office, Pune 411007, Maharashtra, India
(rbalu,cpk,rajsingh,naresh,jitendra@gmrt.ncra.tifr.res.in)

Abstract:

The development of the new **Control and Monitor system (CMS)** for GMRT envisages improved architectural functionalities compared to the present online system and is being developed using state-of-the-art approaches with available off-the-shelf hardware components and software solutions. We present the details of the upgrade undertaken to build a more powerful and sophisticated system. We also present the design and performance details of sub systems like Monitor and Control Module **(MCM)** and its associated software. The CMS system controls and monitors the working of all the telescope subsystems like Analog receiver, Digital receiver back ends, Optical Fibre systems, Electro-mechanical systems like Servo and Feed position system and Sentinel systems etc. This system establishes the command and voice communication link over a high speed **1 Gbits/s** digital optical fibre link between the Central building and the antennas over a distance of about 20 Kms. A new MCM card is being developed using a Rabbit 8 bit micro-processor with ADC support and **100 Mbits/s** Ethernet communication link. The RFI performance of this card is also being presented. **VOIP** phone and **Video** camera facility will also be available in all the antennas for voice communication and security purposes.

1. Introduction

The **GMRT** consist of 30 large and fully steerable parabolic dishes of 45 metres diameter, each in Alt-Azimuth mount, with 12 antennas in a compact **(1kmx1km)** array and 18 antennas in the "Y" shaped array as shown in Figure 1. It allows simultaneous low resolution imaging of extended emission as well as high resolution imaging of fine scale structure. The weight of the moving structure of each antenna is 82 tons and its counter weight is 34 tons.

The purpose of the CMS system is to **Control** and **Monitor** the working of all the GMRT subsystems like Analog receiver, Digital receiver back ends, Optical Fibre systems, Electro-mechanical systems like Servo and Feed Positioning systems **(FPS)** and Sentinel system.

It provides user interfaces for the Telescope Operators, Astronomers and maintenance personnel in the Central Electronics Building **(CEB)**. The operator is alerted in case any anomalous behaviour is detected. In case of severe fault conditions, safety procedures are also automatically initiated. Sufficient interlocks are implemented in the servo systems to avoid putting the telescope in a potentially dangerous situation due to human error. Safety precautions are also undertaken to automatically switch off the main AC power to the antenna shell if the temperature is beyond the normal set limit or if smoke or fire is detected by the sentinel system.

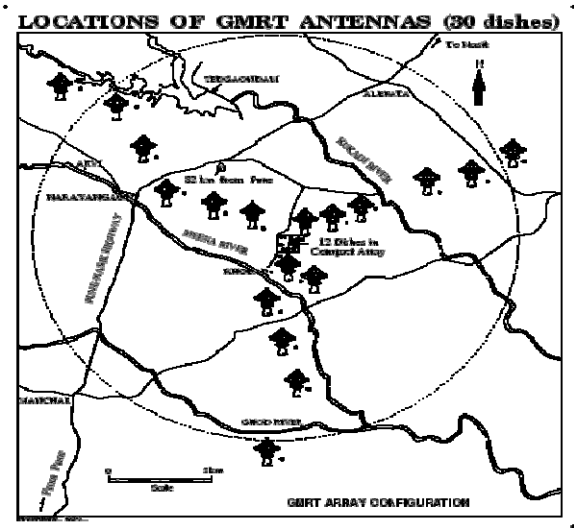

Figure 1. GMRT Array configuration.

2. Features of new CMS system [1]

- Dedicated high speed Ethernet/OF link to each antenna – 1 Gbits/s.
- High end PCs in CEB and each shell with proper EMI/EMC protection – Linux OS.
- Intelligent MCM using latest Micro-controller - Rabbit RCM 4300 series – High speed (~ 60 MHz).
- SD Memory – 2 GB, 2 MB of flash program memory, battery backed up SRAM of 512 KB, 12 bit ADC.
- Periodic Time synchronisation with NTP Server.
- Setting up of system parameters like Observing band, local oscillator frequency, system gain etc. in minimum possible time and facility for quick default setup.
- Sentinel system in each antenna to monitor temperature and to detect smoke and fire.
- VOIP phone for Voice communication and Video camera facility for security purposes.

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3. CMS Hardware & Software details

The prototype CMS programs developed using C and C++ consist of three modules with tightly coupled blocks to achieve various functions is running on high performance PCs under Fedora core 13 (Kernel version 2.6.36) as shown in Figure 2. These programs were previously using PC serial port-RS232 communication link @9600 bits/sec. New TCP/IP based socket program was developed to handle communication between CEB and the antennas using OF/Ethernet link @1 Gbits/sec and it supports multi-user and multi-sub array features. The CEB module, "Teleset", loaded in the CEB PC handles user interface for sending various commands to all the 30 antennas and for receiving the monitor information about the status of each and every sub-system from all the antennas sent by the "ABCcom" module loaded in the antenna PC. The TeleDisp module running in the CEB PC displays monitored data in a user friendly format retrieved from shared memory. It has been planned to procure high end PCs with sufficient EMI/EMC features.

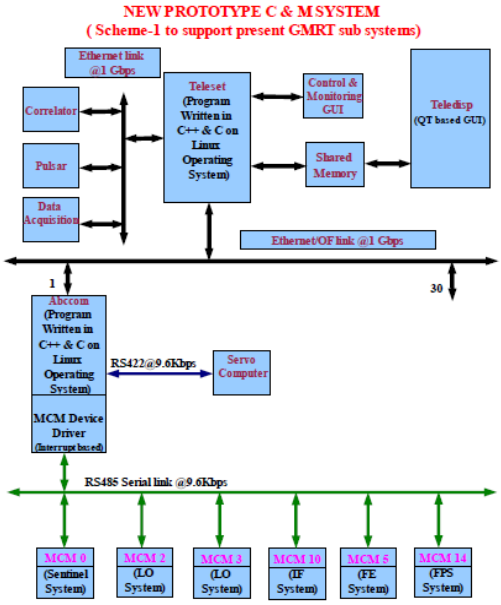

Figure 2. New Prototype CMS system (To support present GMRT sub systems)

Teleset [2]:

1. Provides a Console interface for sending various commands to move the antennas and set the various GMRT receiver parameters. It also provides a facility to run command script files.
2. Composes commands according to Teleset-ABCcom protocol and sends as simple ASCII characters.
3. Sends commands to ABCcoms connected in parallel through ethernet link and retrieves their responses.
4. Decodes ABCcom responses from all the antennas as per the protocol, fills shared memory and creates log files of each sub-system's status.
5. Supports multiuser configuration which divides GMRT into several sub arrays of antennas.

TeleDisp [2]:

TeleDisp is a graphical user interface to read the data from shared memory created by Teleset and to display various system parameters and monitored data received from the sub-systems of all the antennas.

ABCcom [3]:

1. Major part of intelligence has been shifted from Online system to ABCcom PC.
2. It receives GMRT receiver parameters (SET command) from Teleset and pass on the commands to relevant MCMs through RS485 link @9600 bits/sec or ethernet link @100 Mbits/sec and gets back the receiver status through monitoring information .
3. It receives antenna movement commands from Teleset and communicates with the servo system through RS422 link @9600 bits/sec or ethernet link @100 Mbits/sec to control the movement of antennas and get back the servo and mechanical system status.
4. The communication time between ABCcom and MCMs is reduced and so the monitored information is transferred faster to Teleset.

Key Features of Testing :

1. The Teleset and ABCcom software chain has been successfully tested using 3 antennas with 1 Gbits/sec ethernet link.
2. Setting of GMRT receiver parameters as well as controlling servo & FPS systems.
3. Status information is received from sub-systems of all the antennas with fast refreshing time of a few seconds.
4. Multi-sub array & Multi-user feature has been successfully tested in 3 antennas.
5. The software chain has also been successfully tested in the lab with the MCM program ported to the new MCM card and tested with RS485 serial communication @9600 bits/sec.
6. Figure 3 shows the snapshot of servo system status on TeleDisp window.

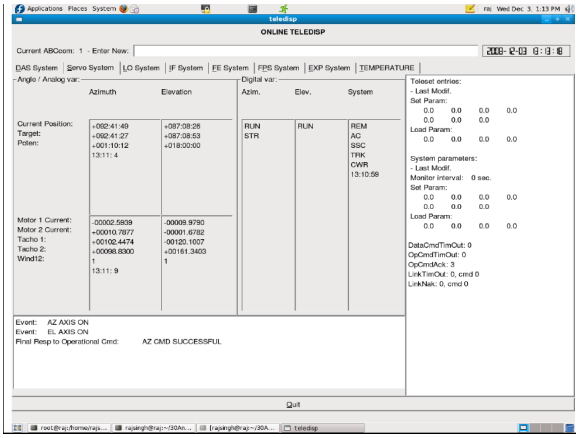

Figure 3. Snapshot of Servo status on TeleDisp

Figure 4 shows the block diagram of the new prototype CMS system being developed to support the new hardware sub-systems of GMRT as part of the upgrade plan activities. The CMS system in CEB and in the antenna as shown in the figure can use either Teleset and ABCcom modules explained elsewhere in the paper or Sensor Actuator and Control Element (SACE) based software modules, that are being developed by TRDDC, India [4] using open source tools like Java. The ABCcom module is being modified to communicate with the new Rabbit based MCM card through 100 Mbits/sec Eethernet link to provide support for the analog backend system in CEB and sentinel, front end and optical fibre systems in the antenna shell. The new scheme also provides the support for voice communication over VOIP and a video camera for security purposes.

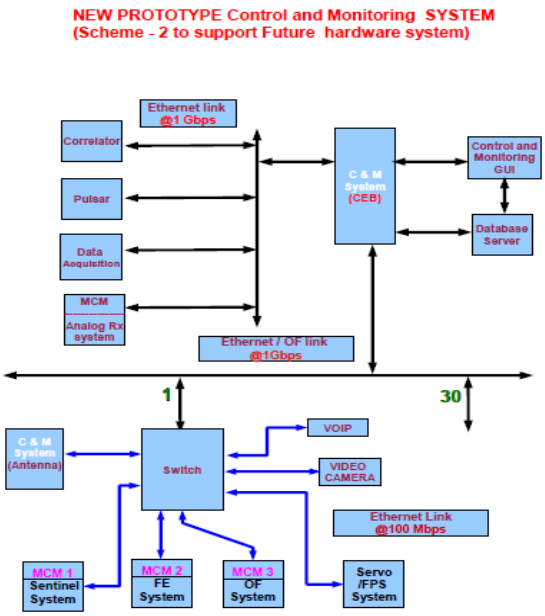

Figure 4. New Prototype CMS system (To support new hardware sub-systems of GMRT)

4. New MCM card hardware details

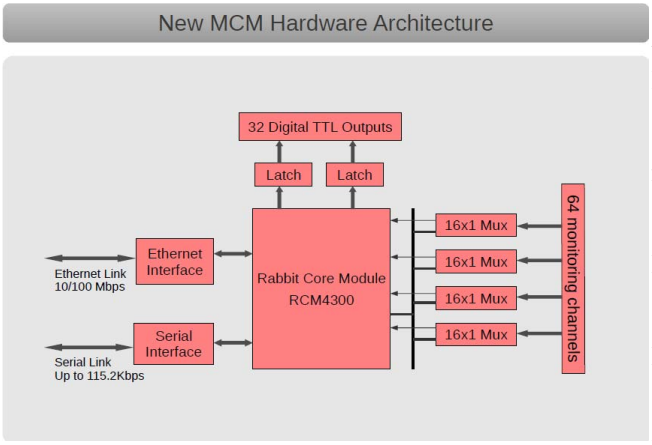

Figure 5. New MCM Hardware Architecture

Figure 6. RCM4300 Rabbit Core Module

The purpose of the MCM card is to **SET** various GMRT receiver parameters and **MONITOR** the status of any sub system. These cards are being used by all sub-systems except the Servo and FPS systems. The new MCM card can monitor 64 channels of +/- 5V range and can control 32 digital TTL outputs as shown in Figure 5. It provides ethernet link @100 Mbits/sec rate or RS485 link up to @115.2 Kbits/sec for communication purposes.

Figure 6 shows the RCM4300 Rabbit core module.

The specifications of the module are given below.

- Rabbit 4000 Microprocessor, 60 MHz Clock speed
- Supports up to 2GB mini SD™ memory card, 2MB Serial Flash Memory (program), 1MB SRAM for shared code, 512KB of battery-backed SRAM
- 10/100Base-T Ethernet port, 5 serial ports
- Configurable 35 general-purpose I/O lines
- 8-channel, 12 bits ADC, 52 KHz Throughput
- Real time Clock , Watch dog/Supervisor support
- Ten 8-bit Timers and one 16bit Timer
- 2 Ch input capture, 2 Ch Quadrature decoder
- Protocols supported – TCP/IP - Telnet, FTP, SMTP, HTTP.
- Clock modes – 1X, 2X, /2, /3, /4, /6, /8, Power down mode, Spectrum spreader for reduced EMI ~ 15 dB, < 10 dB µV/m @ 3 m
- Small Size 1.84" x 2.85" x 0.84”

5. New MCM card software details

Figure 7 shows the new MCM Software architecture. Dynamic "C" language is used to develop MCM programs. Telnet and web server programs have also been implemented and the MCM card was tested through 100 Mbits/sec ethernet link using a web browser and a Telnet client as shown in Figure 8. TCP/IP based Client-Server socket programs have also been developed to be integrated with CMS system software. The commands are in a simpler ASCII format like "DoSet IF XXXX" to SET any parameter in IF system or "DoMon LO SUM" to get summary of LO system status compared to the series of command bytes using proprietary protocol in Intel 9bit format used in the present system. 128 local oscillator system parameters in every antenna of GMRT can be monitored every 30 mSec. Higher Rabbit core CPU clock and ethernet connectivity have enhanced the overall performance of the MCM card.

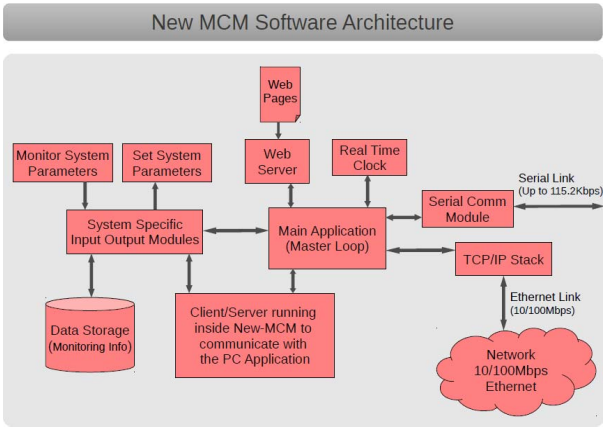

Figure 7. New MCM Software Architecture

6. RFI test results of MCM card

Rabbit 4000 series core module was tested for EMI/EMC [5]. The RFI test setup used was an HP Spectrum analyser kept inside a shielded box and the measurement was done at 3 meters using log periodic antenna and a 20dB amplifier.

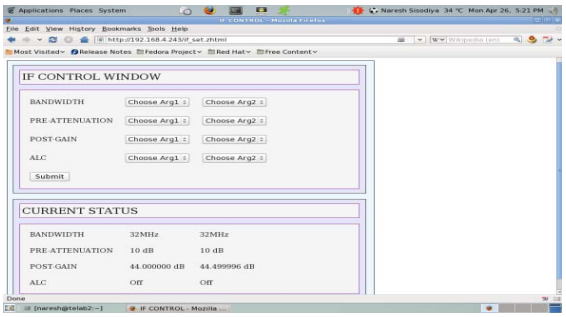

Figure 8. MCM testing using WEB browser

Figure 9 shows the RFI plot of the background noise of the test setup due to local environment when the Rabbit card was in OFF condition and Figure 10 shows the plot when the Rabbit card was ON with spectrum spreader OFF and frequency doubler ON. The plots show RFI from 100 MHz to 270 MHz with 5 to 10 dB increase in noise power level and spectral lines around 130, 150,170,380 and 640 MHz at -74 to -83 dBm. In order to reduce the EMI generated by the card, it is planned to enable the spectrum spreader. It is also planned to put the new MCM card into an RFI shielded box to reduce the unwanted spurious signals.

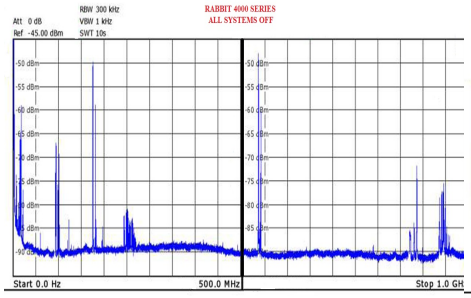

Figure 9. All systems OFF

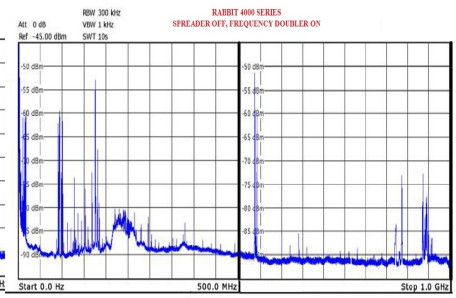

Figure 10. Spectrum Spreader OFF and Frequency doubler ON

7. Summary

The CMS system upgrade will certainly improve the performance of GMRT to meet world class standards and will be able to Control and Monitor all the sub systems in minimum time. High performance PCs with sufficient EMI/EMC capabilities will be used in the antenna shells. A feasibility study of the new CMS system using open source software has also been undertaken with reputed software companies as part of collaborative interaction with the industry.

8. References

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