National Centre for Radio Astrophysics

Internal Technical Report
GMRT/ R-266

Technical Report On New MCM & Qt/QML based GUI

Naresh M Sisodiya

Email: *naresh@gmrt.ncra.tifr.res.in*

Revision	Date: 12 Dec. 2014	Modification/ Change
Ver. 1		Initial Version R-266

INDEX

New Monitoring & Controlling Module – New MCM

1.1 Introduction :

New Monitoring and Controlling Module – New MCM is the general purpose card, designed using RCM4300 core module as processing unit. It has a motherboard, on which hardware for Multiplexing, Signal conditioning Digital data latching and serial communication is placed. On top of the motherboard, RCM4300 as daughter-board is placed.

New MCM will be directly interfaced with other systems of GMRT like Front End, Fiber Optics, Analog Back End, Sentinel etc. New MCM will monitor as well as control the various parameters of such systems. It will also generate the alarm in the erroneous condition and it will take immediate precautionary action.

As compared to existing MCM, this New MCM is more powerful in terms of computing power, operating frequency, memory and the other features. Moreover it is more intelligent in terms of its software capabilities and command structure.

As New MCM is more powerful than previous one, most of the higher level intelligence has been shifted from Online and ABCCOM software to New MCM card.

In this document I have explained Hardware and Software architecture of New MCM. Various New MCM software programs are also explained in detail in this document.

1.2 Motivation for changing the old MCM :

It has been 15 years since last MCM was designed, during that technology has been advanced dramatically. Now a days we have more powerful processors in-terms of bits as well as operating frequency. To keep pace with new technology and next generation Online system we need more powerful hardware at every stage.

Also we wanted to provide more functionalities in terms of processing power, communication channels, monitoring channels, controlling channels, intelligent command structure, data storage etc. In short we wanted to make it more and more powerful to support requirement of Online as well as other GMRT subsystems with which New MCM will be interfaced.

1.3 Criteria for designing New MCM Card :

The design criteria for New MCM is as follows :

- Software development using higher level language
- Ethernet Support
- Serial as well as SPI interface support
- Low EMI from card
- On-board data storage
- 64 analog monitoring channels
- Monitoring signal range : +/- 5V.
- 32 TTL compatible output channels

1.4 Criteria for using RCM 4300 and Rabbit 4000 processor :

Nowadays Embedded Development Kits includes all the tools necessary to complete embedded network design, including a world class IDE, Graphical Debugger, Real Time Operating System, and TCP/IP Stack. Every kit includes Integrated peripherals include 10/100 Ethernet, SPI Bus and/or CAN Bus, A/D inputs, PWM outputs, USB and more.

The available options for Embedded Development Kits were from various companies like Rabbit Semi conductor, NetBurner, PIC etc. As far as hardware features and price is concerned, most of them are equal.

The Rabbit Core Module 4300 has few advantages over others.

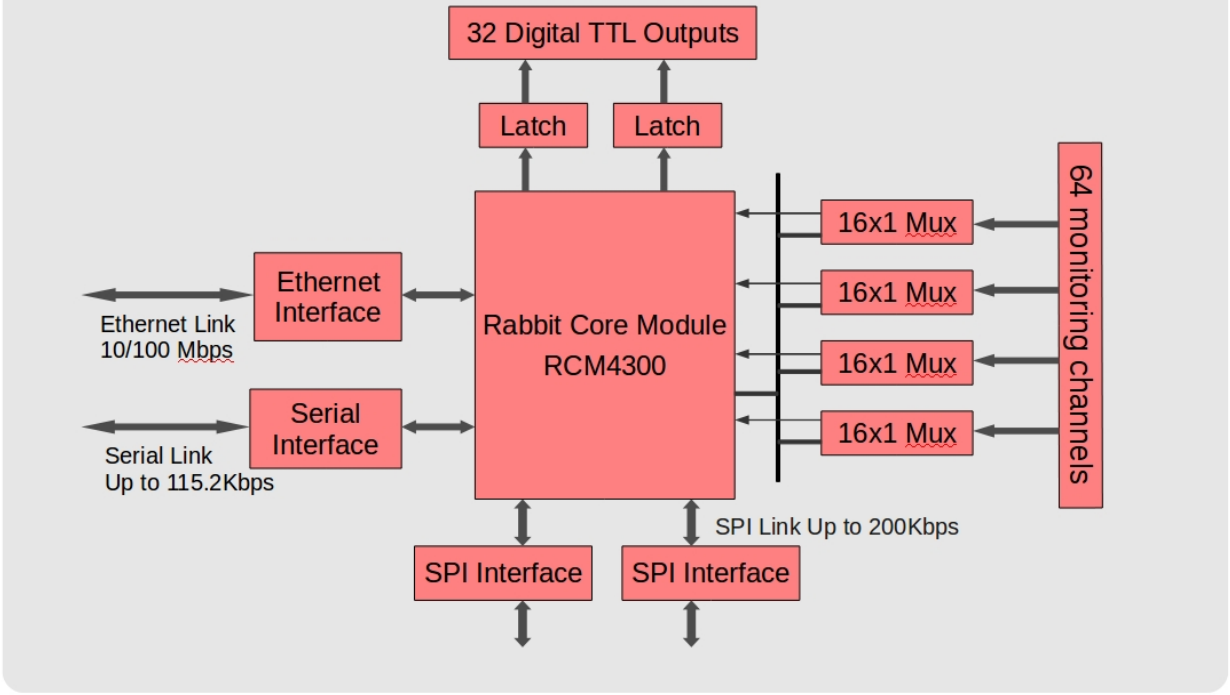
- “Dynamic C” IDE for software development, that supports co-operative multitasking with C language.
- On board Ethernet Hardware.

- Inbuilt EMI reduction hardware and software control, also called as the Spectrum Spreader which reduces EMI by 10dB.
- More General purpose I/O pins are available for design to the user.
- The GPIO pins have up-to FOUR multi function feature.
- Rabbit semiconductor offers variety of products and long term support.
- The rabbit processor series Rabbit 2000,3000,4000,5000 are still in use.

1.5 New MCM Hardware :

New MCM hardware has been built around powerful rabbit core module RCM 4300, which has Rabbit-4000 processor on board. New MCM has been designed using *Altium Designer 6.7* software. The PCB is double layered which includes four 16X1 multiplexing, Signal conditioning to convert +/-5V to 0-5V, RS-485 Serial Communication, 2 SPI ports and 32 bits Data latching. Most of the components are SMD to make New MCM very compact.

New MCM Hardware Architecture



Above figure shows block diagram of Hardware architecture of the New MCM. Block diagram has been described below.

RCM 4300 Core Module :

The RCM4300 series of RabbitCore modules is one of the next generation of core modules that take advantage of new Rabbit 4000 features such as hardware DMA, clock speeds of up to 60 MHz, I/O lines shared with up to six serial ports and four levels of alternate pin functions that include variable-phase PWM, auxiliary I/O, quadrature decoder, and input capture. Coupled with more than 500 new opcode instructions that help to reduce code size and improve processing speed, this equates to a core module that is fast, efficient, and the ideal solution for a wide range of embedded applications. The RCM4300 also features an integrated 10/100Base-T Ethernet port, an optional A/D converter, and removable ("hot-swappable") memory cards.

The RCM4300's mass-storage capabilities make them suited to running the optional Dynamic C FAT file system module where data are stored and handled using the same directory file structure commonly used on PCs. A removable *microSD™ Card* can be hot swapped to transfer data quickly and easily using a standardized file system.

Description of Rabbit 4000 processor :

The Rabbit Semiconductor has designed the *Rabbit 2000*, the *Rabbit 3000* the *Rabbit 4000* and the Rabbit 5000 microprocessors for use in small- and medium-scale single-board computers over period of time. The *Rabbit 2000*, the *Rabbit 3000* do not support Ethernet port and SPI Bus. The Rabbit 5000 supports 10/100Base-T and 802.11b/g Wi-Fi network interfaces and CPU clock frequency of 100 MHz. But Wi-Fi network interface makes it unsuitable for use in New MCM card.

The Rabbit 4000 is a 8-bit high-performance microprocessor with low electromagnetic interference (EMI), and is designed specifically for embedded control, communications, and Ethernet connectivity. Extensive integrated features and glue-less architecture facilitate rapid hardware design, while a C-friendly instruction set promotes efficient development of even the most complex applications.

The Rabbit 4000 is fast, running at up to 60 MHz, with compact code and support for up to 16 MB of memory. Operating with a 1.8 V core and 3.3 or 1.8 V I/O, the Rabbit 4000 boasts an internal 10Base-T Ethernet interface, eight channels of DMA, six serial ports with IrDA, 40+ digital I/O, quadrature decoder, PWM outputs, and pulse capture and measurement capabilities. It also features a battery – backed real-time clock, glue-less memory and I/O interfacing, and ultra-low power modes. Four levels of interrupt priority allow fast response to real-time events. Its compact instruction set and high clock speeds give the Rabbit 4000 exceptionally fast math, logic, and I/O performance.

Analog Multiplexer :

The 64 input monitoring signals are handled by FOUR, 16 to 1 Analog multiplexers. Outputs of the FOUR multiplexer are connected to four input pins of 8 channel ADC .

Level Shifter Circuit :

The input voltage range of ADC used on RCM 4300 is from 0 V to +2V. The Level shifter circuit maps input signal voltage range of +/- 5 V to 0 to 2 V.

32 bit Output Port :

The 32 output lines of Output Port are TTL compatible for interacting with GMRT subsystems. All output lines are latched before appearing on output Connector.

Ethernet Interface :

New MCM has got an integrated 10/100 Based-T Ethernet Port.

Serial Interface :

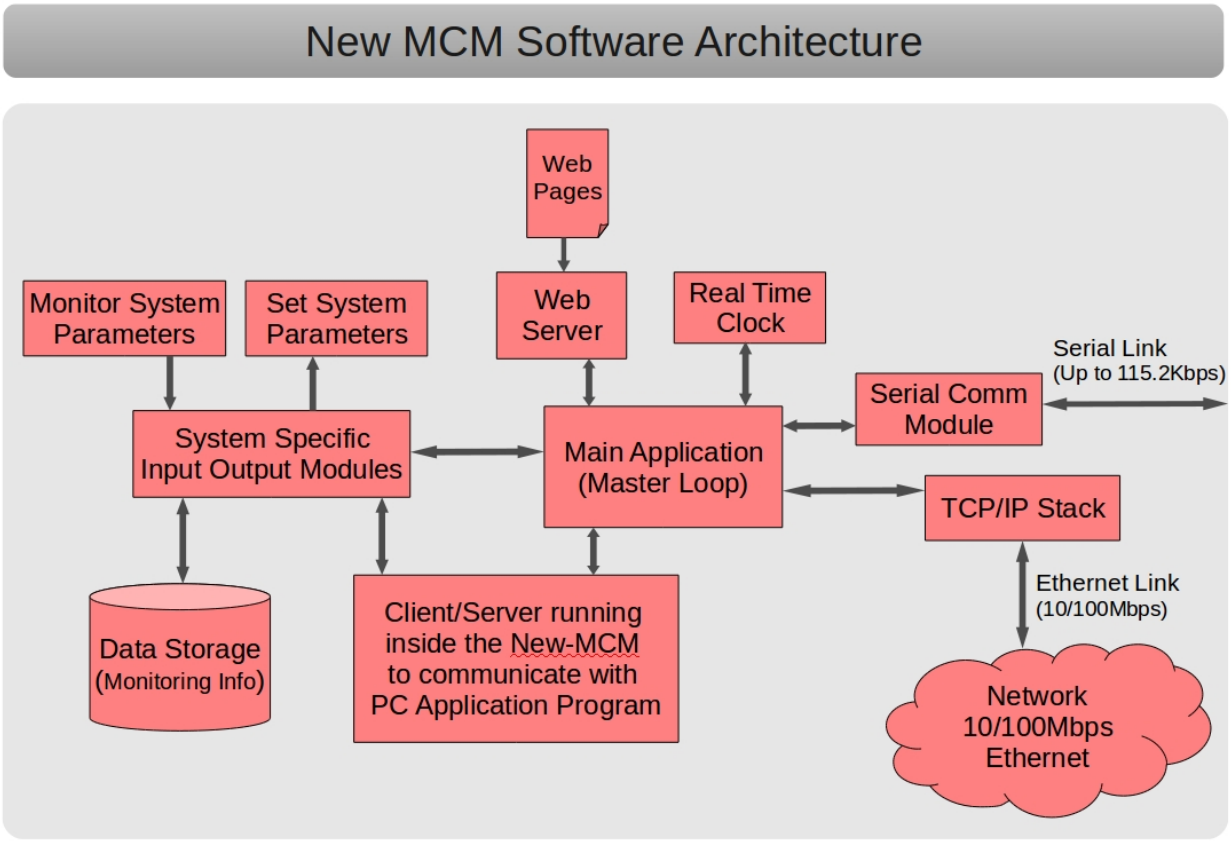
To support existing GMRT subsystems the Serial Interface at baud rate of 9600 bps. It supports RS485 in Half Duplex, multi-drop mode, differential transmission line.

SPI Bus :

The New MCM card supports SPI Bus to interface with FSW based new LO system. The SPI Bus speed is 200 Kbps. Two SPI ports are provided on the MCM card.

1.6 New MCM Software :

New MCM software has been developed from the scratch using dynamic C, which supports co-operative multitasking. It uses the infinite while loop approach instead of using the OS. Moreover, the New MCM software has been designed carefully, so it can include all necessary features and exhibit good performance.



Software architecture of New MCM supports the Communication over the Ethernet as well as Serial link, 64 channel monitoring, 32 bit controlling, up to 1Gb data storage using FAT-16 file system. Furthermore, it will have Real Time Clock and Web server running inside.

- Main Application or Master loop takes care of entire new MCM software, it handles all the parallel tasks to be done by New MCM, like to establish connection with remote device, listen for command over either Ethernet or serial link, to do background monitoring, to serve web pages etc.

- Client/Server running inside new MCM establishes socket connection with Server/Client running on remote PC on particular port address.
- System specific input/output modules looks at received command, It looks for the
    1. System name like ; IF, LO, FE, Sentinel etc.
    2. Operation to be performed like ; Set, Monitor Raw data/Summery
    3. Parameters to be set like ; Attenuation, Bandwidth, LO frequency, Filter selection etc
    4. Arguments to the parameters
- Monitoring system parameters actually performs the monitoring task by running the ADC operations. First raw data is generated by scanning all 64 monitoring channels. Summery is prepared based on gathered raw data. Raw count 0 is generated for +5V, 1000 for 0V and 2000 for -5V.
- Set system parameters generates 32 bit patterns for setting the system specific parameters. Unlike old MCM, New MCM has inbuilt logic that reads the intelligent command and internally generates 32 bit pattern rather then receiving it from higher level application.
- Data storage modules stores monitoring data as well as keeps the log of command received and executed by MCM. FAT 16 file-system is used to manage stored data in directories and files.
- New MCM supports HTTP protocol so we can run web server on it. This can be useful to host web pages for monitoring and controlling of GMRT subsystems. We can put web pages that show current status of New MCM - like RTC time, 64 channel raw data, local system summery etc. Moreover we can use such web pages for system debugging. The web pages provides very good user interface to set system parameters. For security reasons setting of parameter will support lab testing only. We have used HTML, CSS, JavaScript, XML and AJAX for web development.
- RTC module reads as well as sets real time clock of New MCM. RTC is used for synchronizing MCM with higher level application.
- TCP/IP stack is provided by Dynamic C. New MCM software calls library

function of the TCP/IP stack for establishing socket communication between the New MCM and the higher level application at 10/100 Mbps Ethernet link.

- Serial communication Module is used to do communication over serial link at 9600bps. It supports communication of New MCM with existing system over RS-485 serial communication link.

Moreover, Command structure for communication between MCM and higher level application is designed intelligently so that it can carry all the necessary information in one go and with minimum command length. Command are pure ASCII characters bound in command structure.

1.7 Various New MCM Programs :

As part of New MCM software development I have developed various New MCM softwares which are as follow :

- For In House CMS
- For GAB MCM
- For various 15m dish antenna system
- MCM Debug Software MCM Debug

- New MCM program for In House CMS :

  I have designed full fledge MCM program to connect MCM with In House CMS called as Online_V2. MCM program opens client socket which connects with core online software which is server application. On other hand core online will be connected to GUI or Python environment or terminal to receive user input. However as complete chain MCM can be directly accessed from GUI. Efficient command structure has been designed to communicate with the core application. This program Supports both web and socket version.

  This MCM program is designed to perform various operations like : Monitoring, Controlling, Preparing Summery, Do background monitoring, Listening over socket to receive various commands from higher level application, Serve Web-page etc.

I have implemented support for various systems like : Sentinel, Front End, Fiber Optics, Analog Back End, MCM Self Test.

To perform system specific tasks various commands for such systems are implemented like : Monitoring, Setting, Initialize, Reset.

- New MCM Program for 15m Dish Antenna MCM :

  After doing certain level of development in Lab, I gain enough confidence to put New MCM in actual system. I got an opportunity to test MCM by interfacing it with Sentinel and GAB system of 15m dish NCRA. This MCMs are running very smooth since they have been interfaced.

  This MCM supports only socket communication, through which MCM communicates wrapper program on the “Atithi” machine, which ultimately connects MCM with CMS developed by PSPL, through which user can fire command to MCM. For making communication more generic, a common communication protocol was decided and followed.

  I have implemented various commands for Sentinel system like : domon, setcmd, init and reset

  Various commands implemented for GAB system are like : domon, set attn, set lo, set reflo, init and reset

- New MCM Program for GAB system :

  New MCM for GAB system uses same software architecture and communication protocol as 15m dish MCMs. Along with that this MCM program provides web interface to monitor local condition of MCM.

  This MCM communicates with GAB server on loconf machine, which ultimately connects MCM with existing online.

  This MCM program performs various operations like : Listening over socket to receive various system commands from higher level application, Doing background monitoring, Pinging to check server reachability, Monitoring, Controlling, Preparing Summery, Serving Web-page etc.

  I have implemented various commands for GAB system like : set dmask, set lo, set reflo and mon

  This MCM program is also being used for testing with TCS.

- New MCM Program for MCM debugging & Troubleshooting - MCM Debug :

  Before giving New MCM to user, it is required to test various features of New MCM as well as tune analog channels in lab. I have developed New MCM Testing Software called MCM Debug for debugging and maintenance purpose. Using this software user can test various features of New MCM like Ethernet communication, LO setting through SPI bus, setting 32 control bits and 64 monitoring channels before its release.

  MCM Debug is web based test software, so user need only browser to test New MCM functionalities. New MCM can be put into network or it can be connected directly to PC. Each MCM has its own IP address, so to test New MCM user has to type IP address of MCM into address bar of the web browser to initiate testing.

  By default MCM serves Monitoring page which shows all 64 monitoring channels raw data & voltage information, system status and LO frequency. By clicking “SET New MCM” button user can navigate to setting page. At setting page user can set 32 digital bits, LO frequency through SPI bus and RFI testing parameters.

1.8 Testing of New MCM :

- More than 30 MCMs are running continuously in GAB system since 2012.
- 8 MCMs in local lab test set up are running continuously since 2012. MCMs are running without any issue because of robust software architecture.
- Tested Sentinel and Fiber Optics systems of C01, C04, C06 antennas
- Before that we also tested single antenna single MCM at C01, C04, C06, C09, C12 , S02, S04
- MCM Debug is extensively being used by lab members for tuning 64 monitoring channels and testing MCM features before its release.
- MCMs are interfaced with Sentinel and GAB system of 15m dish Antenna at NCRA are running very smooth since 2011.

Qt/QML Based Online_V2 GUI Design

2.1. Introduction :

Existing online runs on terminal based applications, which requires little bit tedious tasks to be performed by operator and user. To reduce this efforts, since starting of Online_V2 development, need for GUI was felt. After defining criteria and deciding technology to use, we design Qt/QML based Online_V2 GUI.

2.2. Criteria :

After deciding to design GUI for the Online_V2, we defined criteria, like :

- User Friendly
- Use of known technology
- Run on Linux
- Easy to Port

We also wanted to design GUI using technology from which most developer are familiar with. So we decided to design Online_V2 GUI using Qt/QML, as it supports C++ programming and QML, which provides easy integration of logic and graphics.

Graphics of Online_V2 GUI is written in QML, which is very similar to CSS, while Logic is implemented using JavaScript and C++. Data communication between GUI and core application has been achieved by various methods. We have tried three different approaches : using XML files, over Socket and Direct database access.

As most of the people are familiar with Linux, we have developed the GUI as well as other Online_V2 applications, which can run on Linux OS.

Online_V2 GUI is network application, so it can be straight away ported to any Linux machine. However GUI has been written in Qt, so porting to other Operating System will be easier.

2.3. Design :

Online_V2 GUI is very easy to operate, easy to port application. Tabbed navigation is provided to make GUI user friendly as much as possible. Main menu tabs are horizontally tabbed, while sub menus are vertically tabbed.

At present Online_V2 GUI has four types of horizontally tabbed main menu interfaces : Monitoring, Controlling, Engineering and User Management.

- Monitoring Interface : Monitoring Interface is designed to display current status of radio telescope. Various monitoring tools are grouped together in similar windows. As of now monitoring interface have five vertically tabbed windows as follow :
  - Graph Window : To display various zoom-able graph
  - System monitoring window : To display all parameters of all system of particular antenna.
  - Quick View window : To display critical parameters of all antennas like Temperature, Wind speed
  - Antenna Device window : To display all network device at antenna and at receiver room. Networked device may be Antenna based Machine, New MCM, PC104, Switch, IP Phone etc.
  - Alarm window : To display all system alarm with priority and level. From warning to critical alarm can be displayed.

In following pages I have attached screen-shots of various windows of Monitoring Interface - Online_V2 GUI.

ONLINE V2
Control and Monitoring system - GMRT

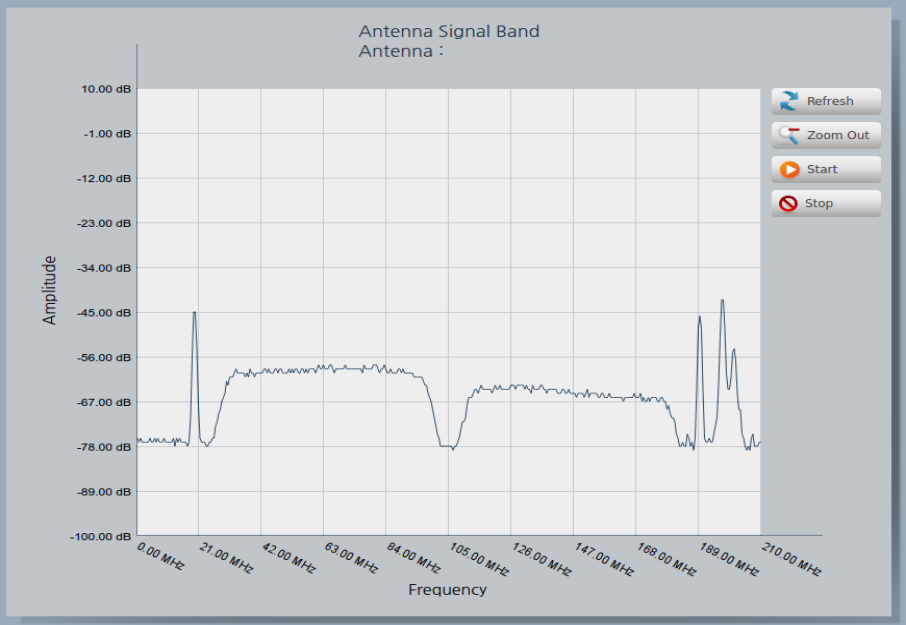
Naresh Sisodiya

Monitoring Window | Controlling Window | Engineering Interface | User Log In | How to Use

- Graph Window
- System Monitoring
- Quick View
- Antenna Devices
- Alarm Window
- Antenna SubArray

Live Updates

Graph Span



ONLINE V2
Control and Monitoring system - GMRT

Naresh Sisodiya

Monitoring Window | Controlling Window | Engineering Interface | User Log In | How to Use

- Graph Window
- System Monitoring
- Quick View
- Antenna Devices
- Alarm Window
- Antenna SubArray

Live Updates

C00 C01 C02 C03 C04 C05 C06 C08 C09 C10 C11 C12 C13 C14 W01 W02 W03 W04 W05 W06 E02 E03 E04 E05 E06 S01 S02 S03 S04 S06

Front End

Frequency Band	330 MHz	330 MHz
Solar Attenuation	10 dB	14 dB
Filter	1	1
L Band Filter	1060	1170
Calibration Noise	Low	Low
RF Power	Off	Off
Channel	Unswap	

Fiber Optics

RF Attenuation	4 dB	6 dB
Bias Voltage	-3.1 V	-1.1 V
Supply Voltage	12.0 V	
Temperature	22.1 C	

Servo

Axis State	STRL	STRL
Current Position	-127.34 a	+234.78 e
Target Position	+67.72 a	+56.46 e
Break	Applied	Released
Stow	--	Released
Position Error	0.04 al	2.32 el
Encoder Offset	NIL	NIL
Axis Speed	20 d/M	20 d/M
LH Motor Current	1.1 Amp	1.2 Amp
RH Motor Current	1.2 Amp	1.0 Amp
Wind Velocity	24 mph	

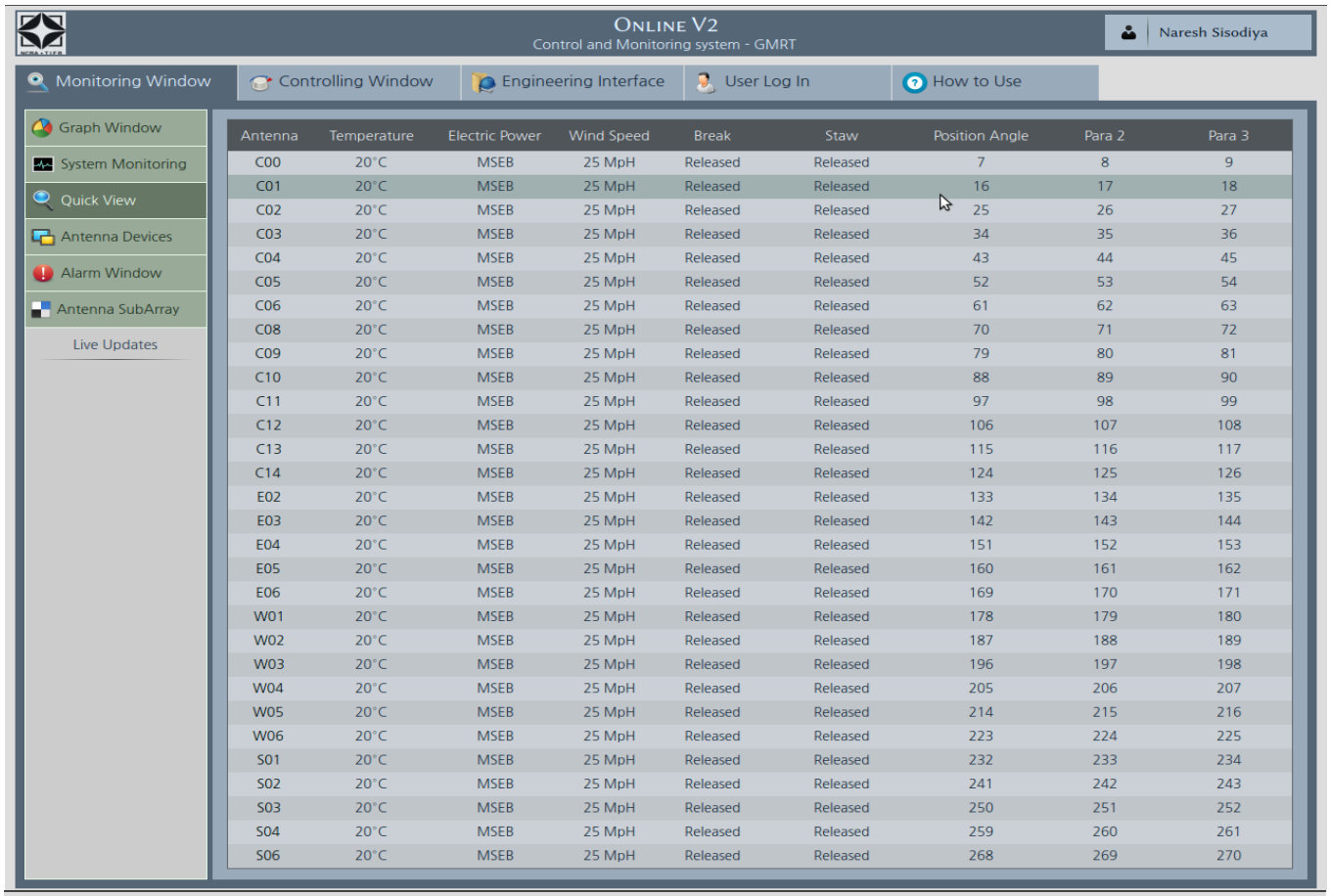
FPS

Analog Back End

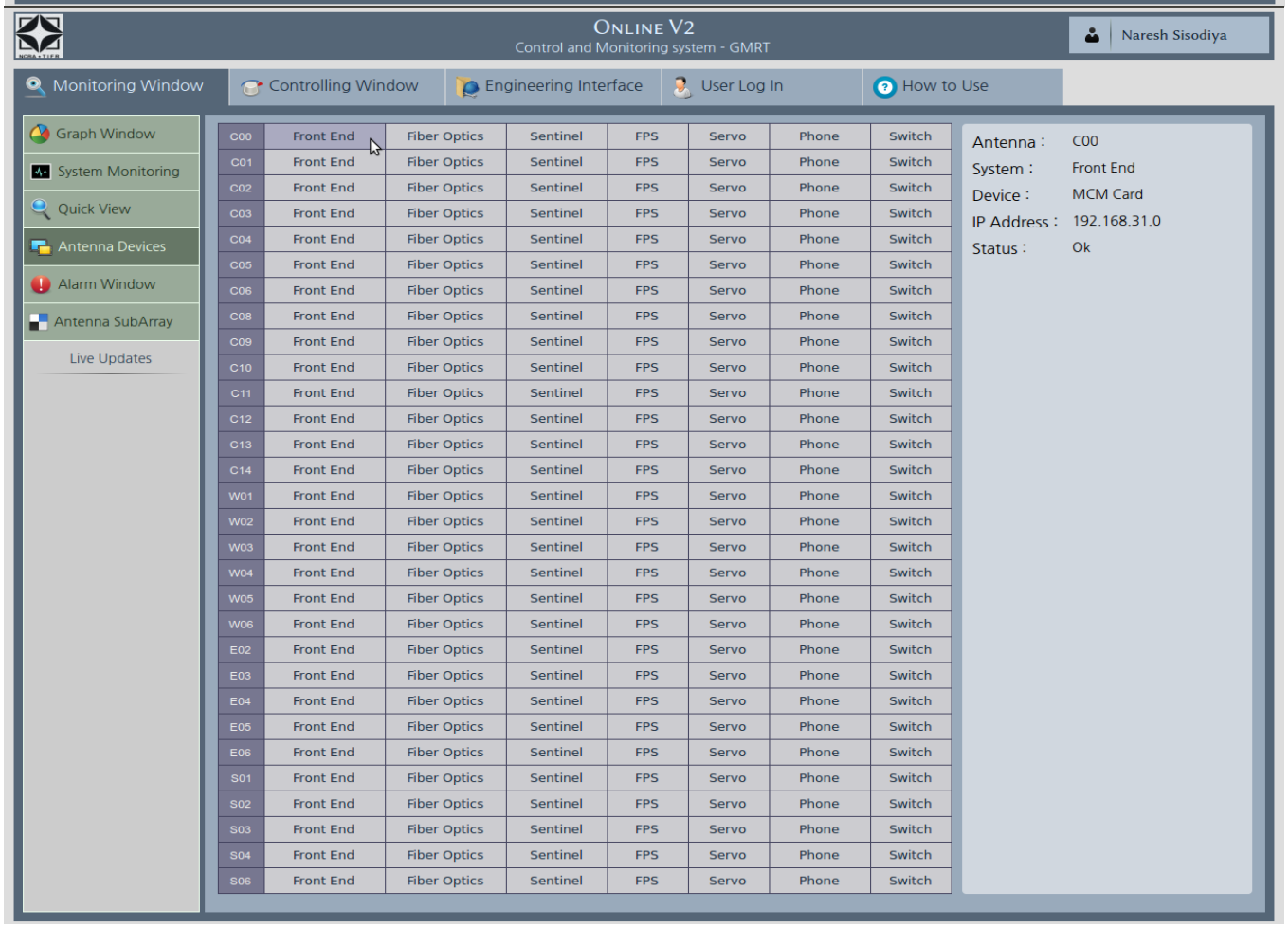
LO Frequency	700 MHz	700 MHz
Attenuation	10 dB	14 dB
Filter	1	2
Low Pass Filter	4	2
Path	Direct	Direct
Source	SigGen	SigGen
Signal	Antenna	Antenna
Channel	1	

Digital Back End

Frequency Band	330 MHz	330 MHz



Antenna	Temperature	Electric Power	Wind Speed	Break	Staw	Position Angle	Para 2	Para 3
C00	20°C	MSEB	25 MpH	Released	Released	7	8	9
C01	20°C	MSEB	25 MpH	Released	Released	16	17	18
C02	20°C	MSEB	25 MpH	Released	Released	25	26	27
C03	20°C	MSEB	25 MpH	Released	Released	34	35	36
C04	20°C	MSEB	25 MpH	Released	Released	43	44	45
C05	20°C	MSEB	25 MpH	Released	Released	52	53	54
C06	20°C	MSEB	25 MpH	Released	Released	61	62	63
C08	20°C	MSEB	25 MpH	Released	Released	70	71	72
C09	20°C	MSEB	25 MpH	Released	Released	79	80	81
C10	20°C	MSEB	25 MpH	Released	Released	88	89	90
C11	20°C	MSEB	25 MpH	Released	Released	97	98	99
C12	20°C	MSEB	25 MpH	Released	Released	106	107	108
C13	20°C	MSEB	25 MpH	Released	Released	115	116	117
C14	20°C	MSEB	25 MpH	Released	Released	124	125	126
E02	20°C	MSEB	25 MpH	Released	Released	133	134	135
E03	20°C	MSEB	25 MpH	Released	Released	142	143	144
E04	20°C	MSEB	25 MpH	Released	Released	151	152	153
E05	20°C	MSEB	25 MpH	Released	Released	160	161	162
E06	20°C	MSEB	25 MpH	Released	Released	169	170	171
W01	20°C	MSEB	25 MpH	Released	Released	178	179	180
W02	20°C	MSEB	25 MpH	Released	Released	187	188	189
W03	20°C	MSEB	25 MpH	Released	Released	196	197	198
W04	20°C	MSEB	25 MpH	Released	Released	205	206	207
W05	20°C	MSEB	25 MpH	Released	Released	214	215	216
W06	20°C	MSEB	25 MpH	Released	Released	223	224	225
S01	20°C	MSEB	25 MpH	Released	Released	232	233	234
S02	20°C	MSEB	25 MpH	Released	Released	241	242	243
S03	20°C	MSEB	25 MpH	Released	Released	250	251	252
S04	20°C	MSEB	25 MpH	Released	Released	259	260	261
S06	20°C	MSEB	25 MpH	Released	Released	268	269	270



C00	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C01	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C02	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C03	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C04	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C05	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C06	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C08	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C09	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C10	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C11	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C12	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C13	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
C14	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W01	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W02	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W03	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W04	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W05	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
W06	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
E02	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
E03	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
E04	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
E05	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
E06	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
S01	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
S02	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
S03	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
S04	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch
S06	Front End	Fiber Optics	Sentinel	FPS	Servo	Phone	Switch

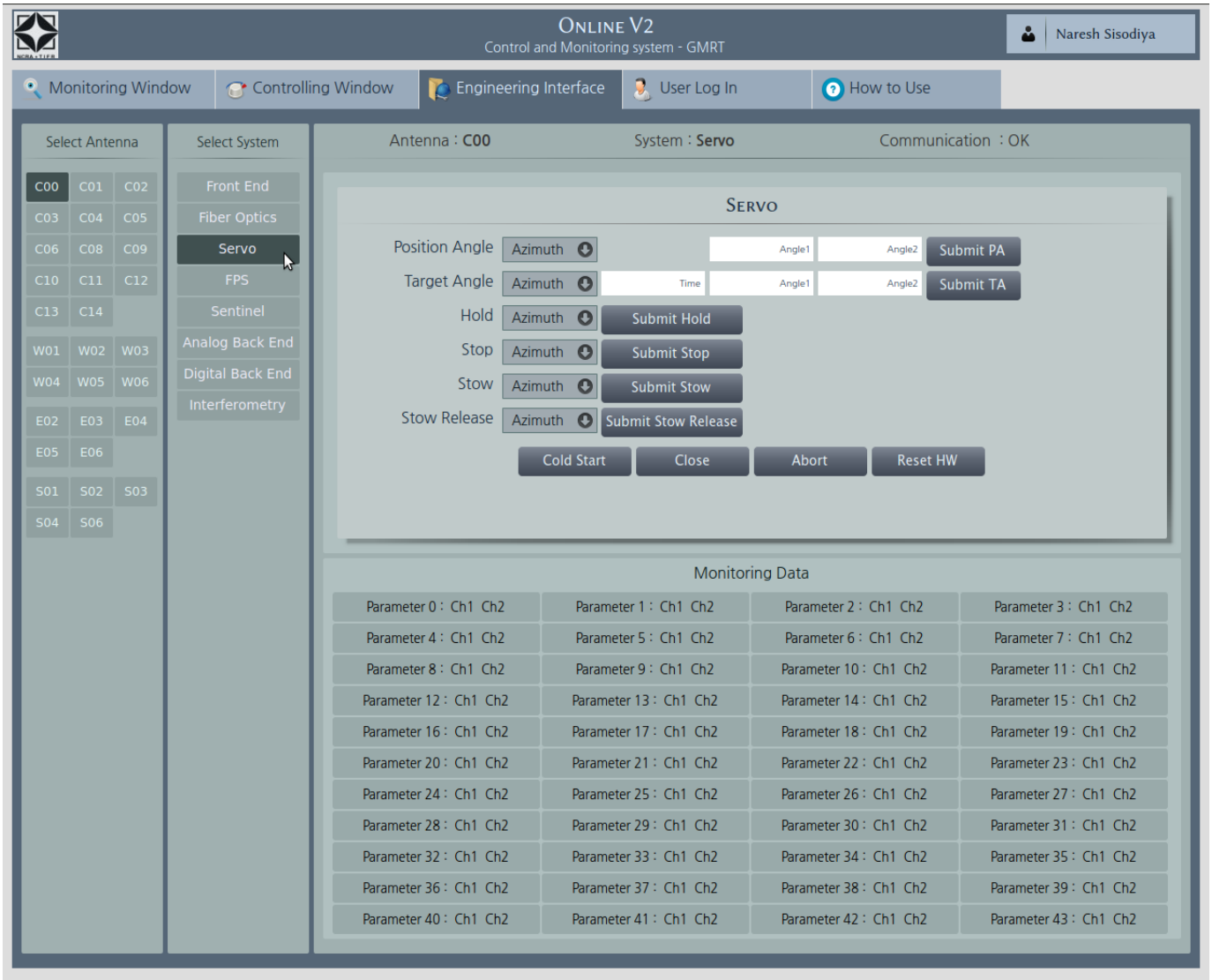
Antenna : C00
System : Front End
Device : MCM Card
IP Address : 192.168.31.0
Status : Ok

- Controlling Interface : Controlling GUI includes various windows to control various systems of GMRT radio telescope. All parameters required by telescope operators will be included here. Control windows are designed for various systems like :
    - Front end
    - Fiber Optics
    - Sentinel
    - Servo
    - FPS
    - GAB
    - GSB

- Engineering Interface :

  Engineering Interface provides setting of particular system in more detail. Functions which are very system specific will be included here, which will be accessible to only system experts for testing their own system.

  For Example Engineering Interface for Servo system has been shown as below.



- User Management Interface : It is designed to manage various User, their authority and credentials.

Other Activities

3.1 Setting Lab Test Set Up :

After designing prototype software for New MCM we required Lab test set up for continuous development of mature New MCM as well as core Online application.

I have programmed and tested total 8 MCMs - for 2 Antenna, 4 Systems, by putting them in Local Area Network created in telemetry lab.

Since 2012 after putting 8 MCMs in lab test set up, all eight MCMs are working fine.

For testing purpose MCMs can be grouped together either as single antenna – single system, or single antenna – multiple system.

3.2 Setting Vanilla Discussion Forum :

After staring development of Online_V2 we needed a common forum on which all user can upload their contribution. After doing brief search for suitable application we decided to use web based vanilla forum.

I have searched and installed vanilla forum on vanilla machine in telemetry lab. All Online_V2 team members are given authorized access to this forum. This forum is being used to store MOM of weekly meeting, Development Reports, Test Results etc.

3.3 Web Page Design For Monitoring Tools :

In order to bring all monitoring tool under single page I was asked to design a web-page which can link and group similar category monitoring tools. Designed web-page can be found at : http://www.gmrt.ncra.tifr.res.in/~naresh/index_new.html