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Ethernet Enabled Rabbit MCM0 for uGMRT

Authors: Charudatta Kanade, Raju Uprade

Email: cpk@gmrt.ncra.tifr.res.in, rajsingh@gmrt.ncra.tifr.res.in

Telemetry Lab, GMRT

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Ver 1.0	11/08/2023	Initial version
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1. Introduction

The Control and Monitor System of a Radio Telescope is required to provide the necessary coordination between the various building blocks of the receiver system. This system is used for Controlling the activities of the various building blocks of GMRT like FE, LO, IF, BB, SERVO, FPS, etc, and Monitoring the healthiness of the same in each of the antenna shells and CEB. It provides the human interface to persons like Telescope Observers, Scientists, and maintenance personnel for operating all the antennas from CEB. It has to monitor all parts of the telescope system for correct operation and alert the operator in case of any anomalous behavior. And in the case of severe fault conditions, safety procedures have to be initiated locally. It has also prevented human error from placing the telescope in a dangerous situation. This Control and Monitor System for GMRT tries to meet all the points mentioned above.
ANTCOM is the vital Antenna base computer located in each of the antenna shells. It receives various parameters sent by COMH and performs all the tasks and passes the vital information to various systems like Servo Control Computer, MCMs, and FPS thro' the following three communication links.

- Main FSK communication link between COMH & ANTCOM at 250 Kbits/sec using the OF system.
- Asynchronous data communication link between ANTCOM & SERVO thro' RS 422 link.
- Asynchronous data communication link between ANTCOM & MCMs thro' RS 485 link.

MCM is a general purpose Microcontroller based card that provides 16 TTL Control O/Ps and monitors 64 analog signals. Antcom communicates with MCMs thro' the RS485 communication link @ 9.6 Kbaud rate and sets various FE, LO, and IF system parameters.

Nowadays, It is most challenging to maintain the old system, as both Microcontroller Chips used inside ANTCOM (Antenna Base Computer) are obsolete from the market. Also, it is necessary to upgrade the old system with new technology. The operations group has upgraded the old Controller and Monitoring software with a new TANGO-based C&M. On the hardware side, Mr. Charudatta Kanade designed the Rabbit RCM4300-based Control and Monitor module which is used to set antenna base systems like Front End system, Optical Fiber system and CEB system like GMRT analog backend. As per the final part of the upgrade phase, We planned to replace the ANTCOM unit with a Rabbit-based MCM0 and also provide MCM4 functionalities like MCM5 On/Off, Noise setting, and Walsh setting inside the Rabbit MCM0. Mr. Charu wrote firmware code that can perform functionalities of MCM0, MCM4, SERVO, and FPS

system RESET, etc. It can also perform monitoring of various parameters of subsystems. A new command, “rabbit_reset” has been introduced in the TGC GUI to reset the RCM4300 Core Module , if it gets hung during the course working.

2. Motivation for Ethernet Enabled Control and Monitor System for uGMRT

- Ethernet-based system for improved communication and ease of implementation.
- Replacing Legacy Telemetry system with New Control and Monitor Hardware.
- To reduce the hardware at the antenna base which will reduce the RFI footprint at the Antenna base.

3. Current Status : Seamless Switchover between Legacy and TGC system

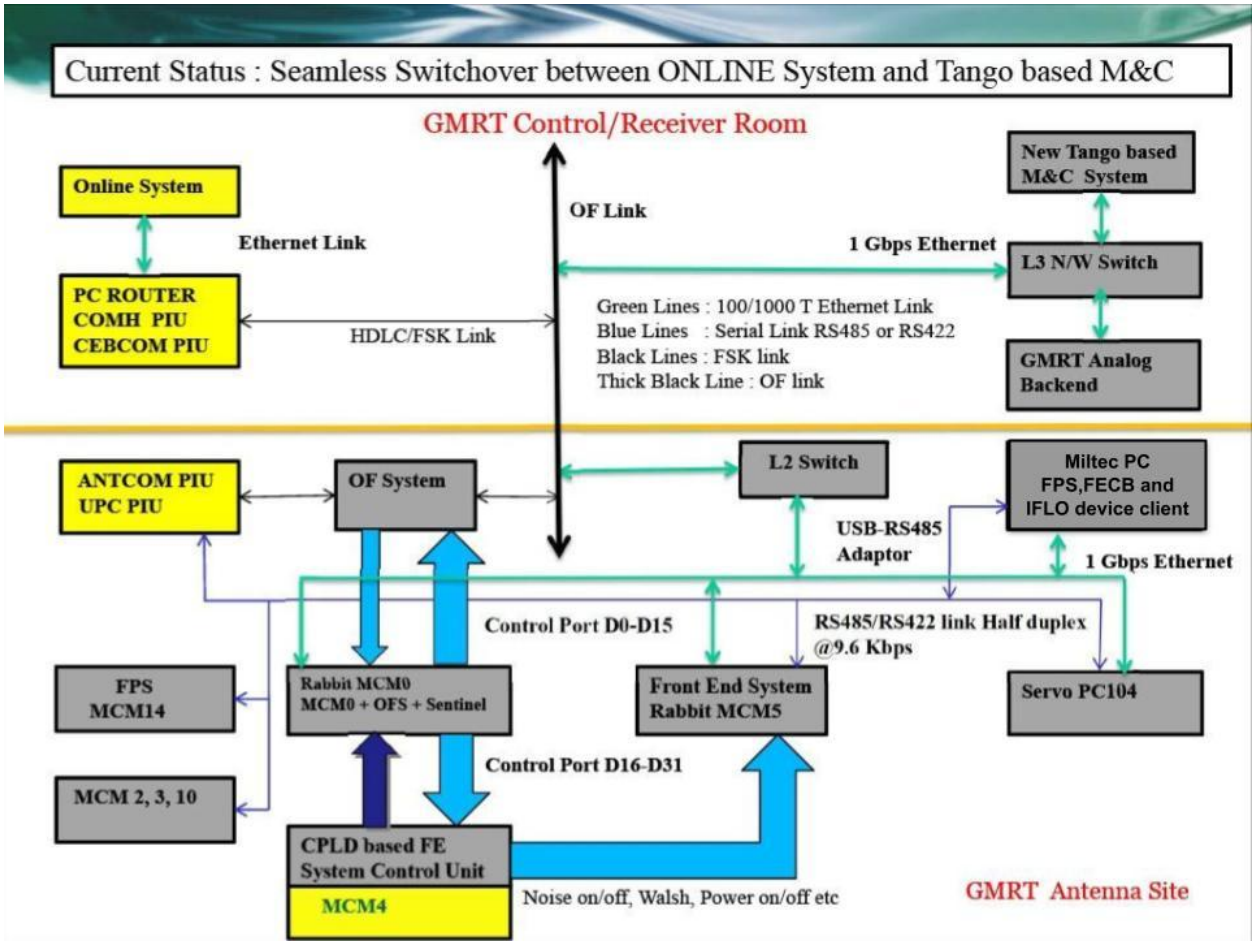

Fig 3.1) Block Diagram 1- Current Status -> The Hardware Interconnections at the antenna base.

Currently, as shown in Block diagram 1, figure 3.1, GMRT subsystems are controlled using hybrid communication methods to provide backward compatibility for legacy

hardware systems and upgraded hardware systems. The OF System, Sentinel, and MCM0 are controlled over Serial and Ethernet links. The seamless switchover between the ONLINE system and the TGC system can be achieved through software without changing interface connections. The ONLINE system uses a serial link and the TGC system uses Ethernet for controlling the same set of hardware but one at a time.

The Rabbit MCM0 has taken over the functions of MCM0. It Control and Monitor Optical Fibre System and Sentinel system.

The OF attenuation level settings and monitoring of OF system parameters are possible.

The Rabbit MCM0 generates Servo Reset and FPS reset signals. The remote Power control of the LMC machine at the antenna base is also possible.

The Rabbit MCM0 is used to monitor Sentinel system parameters like antenna shell temperature, Fire and Smoke detector, Three phase monitoring over an Ethernet link.

The Front End system is controlled using an RS485 serial link and an Ethernet link. The FE system device client, FECB, is running on an LMC machine that sends commands to Rabbit MCM5 for action.

The CPLD-based FE parameter control unit of MCM4 sends digital I/O signals like Noise on/off, Walsh bits, Power on/off, etc. to Rabbit MCM5 over 100-meter differential lines.

The Front End and Common Box system's monitoring of parameters like FE temperature, LNA temperature, and RF power are possible.

The Servo System Control and Monitor over an Ethernet link using PC104 based control card.

The FPS system Control and Monitors over RS485 differential serial link using a PC104-based control card.

The Legacy MCM 2, MCM 3, and MCM 10 are controlled by IF-LO Device Clients running on the LMC machine over RS485 differential serial link.

The Yellow blocks shown in Block diagram1 represent the Legacy ONLINE M&C system. This includes hardware systems COMH, CEB-COM, Telephone Exchange at the Receiver Room, and ANTCOM, UPConveter, and MCM cards in GMRT subsystems at the antenna base. The Legacy hardware system works under an ONLINE M&C system.

The uGMRT works under the TGC M&C system with options of switching back to the ONLINE M&C system, if required.

4. Proposed System changes

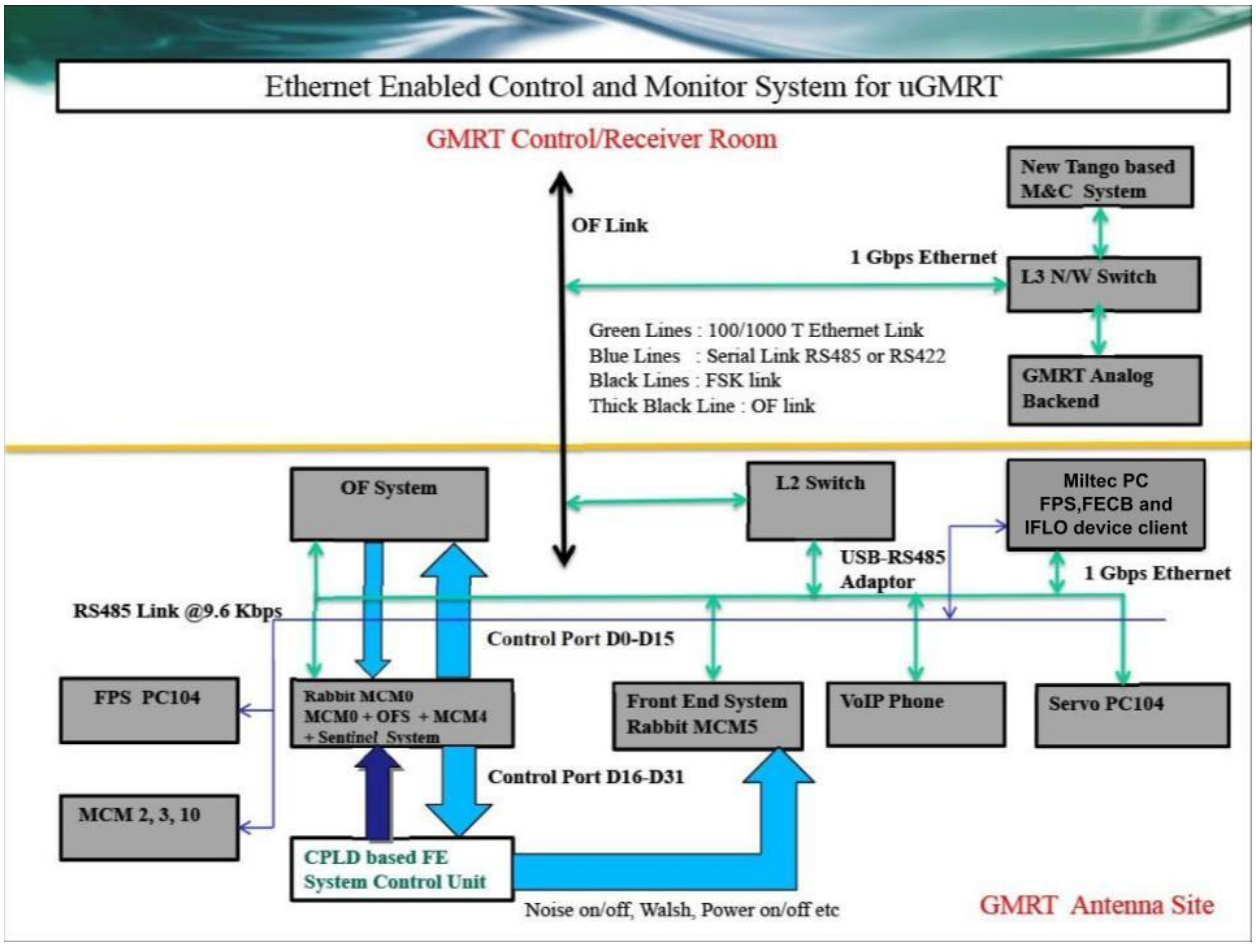

Fig 4.1) Block Diagram 2: Ethernet-based System: The Hardware Interconnections at the antenna base.

As shown in Block Diagram 2, figure 4.1, the upper section of Block Diagram 2, the hardware setup includes a TGC server machine, Layer 3 Ethernet switch, and GMRT Analog Backend (GAB) system. The GAB system uses Ethernet-enabled Rabbit MCM cards for control and Monitor.

The lower section shows the hardware setup including 1 Gbps OF link, Layer 2 Ethernet switch, Rabbit MCM0, Rabbit MCM5, VoIP phone and PC104-based Servo System, and FPS system at the antenna base.

The Rabbit MCM0 is used to control and Monitor OF system, and Sentinel system over 1 Gbps Ethernet link. The 32-bit wide control port of the Rabbit MCM0 card has helped in combining the functions of MCM0 and MCM4.

The Rabbit MCM0 card receives high-level ASCII commands from TGC and generates command codes for underlying subsystems.

The OF system has got 12 bits (6 bit/Channel) for setting OF attenuation levels starting from 1 dB to 31dB which can be further increased to 63 dB(max). The OF system monitoring includes Laser supply voltage, APC indicator voltage, RF amplifier voltage, Laser bias voltages, and control bits that set OF attenuation levels.

The Servo Reset and FPS Reset signals are generated for resetting respective systems by sending high-level commands from TGC GUI.

The LMC machine at the antenna base can be powered on/off using Rabbit MCM0 web page.

The Sentinel system Monitoring includes antenna base room temperature, Smoke and Fire detection, and Interlock system.

The CPLD-based FE parameter control unit in MCM-4 PIU is now controlled by Rabbit MCM0. The higher 16 bits of the control port (D16-D31) are used to send command codes to the CPLD card. The appropriate digital I/O signals like Noise on/off, Walsh bits, Power on/off, etc. are generated and sent to Rabbit MCM5 over 100-meter differential lines.

The Front End system is controlled and monitored by Rabbit MCM5 over a 1 Gbps ethernet link under TCG.

The VOIP phone is installed at each antenna base for voice communication.

The Servo system is controlled by Ethernet base PC104 cards, implemented by Servo Group. The FPS system is also PC104 based but the communication protocol used is RS-485 where an FPS deviceClient running on an LMC machine decodes the higher level ASCII command into hexadecimal code.

The Opto Isolator card is used to provide ground isolation between Rabbit MCM0 ground and Servo system ground and FPS system ground.

5. Rabbit MCM0 Software Architecture block diagram

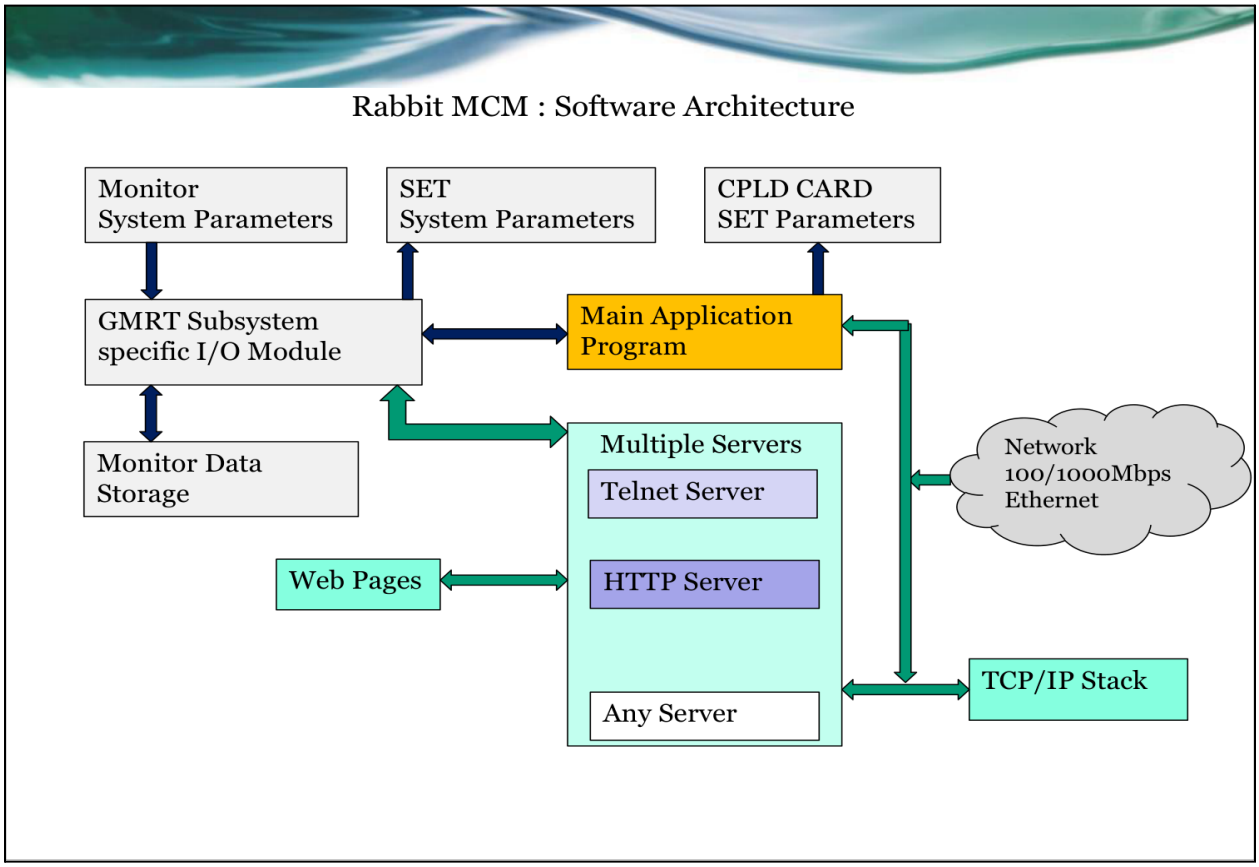

Fig 5.1) Software Architecture Block Diagram

The above Software Architecture Block Diagram, figure 5.1,shows different components of software running on the Rabbit MCM0. The GMRT subsystems are controlled and monitored by the Main Application Program through GMRT Subsystem specific I/O Module. For controlling the OF system, MCM0, MCM4 and Sentinel system, "fnl_mcm0withmcm4" is an application program running on Rabbit MCM0 card under Dynamic C, Version 10.74. The subsystem specific I/O module generates appropriate command codes for each command. The SET System Parameters component controls the 32 bit wide Rabbit MCM0 Control Port that is used to send command codes to underlying subsystems over interface cable. The CPLD based card is used to generate FE system digital I/O signals (Noise, Walsh) are controlled by the SET parameter component for CPLD Card. The monitoring of system parameters is done through the Monitor System Parameter component. The monitored parameters are in analog or digital form with varying or state nature. This component activates the Analog to Digital Conversion unit on the card and sends corresponding digital data to the main application program. The Multiple Servers activated by Dynamic C are used to connect

the Rabbit MCM0 card to the Ethernet network and send command codes over 1 Gbps Ethernet connection and display Monitored data on Web pages. The Web pages are also used for control purposes like LMC remote power ON/OFF control, setting OF attenuation level, and monitoring raw data values independently.

Dynamic C is an integrated development system for writing embedded software for use with Rabbit controllers and other controllers based on the Rabbit microprocessor. Dynamic C comes with many function libraries, all in source code. These libraries support real-time programming, and machine-level I/O. Dynamic C compiles directly to the RabbitCore Module's memory. The functions and libraries are compiled and linked and downloaded on-the-fly.

6. The utilization of the 32-bit wide Control Port of Rabbit MCM 0

- The LSB 12 bits are used for setting OF attenuation levels i.e. (D0-D11).
- The next 2 bits are used for Servo reset and FPS reset signals i.e. (D12-D13).
- The next 2 bits are used for Remote Power ON/OFF of the LMC machine i.e. (D14-D15).
- Next 16 bits are used for controlling the CPLD-based FE control Unit i.e. (D16-D31).

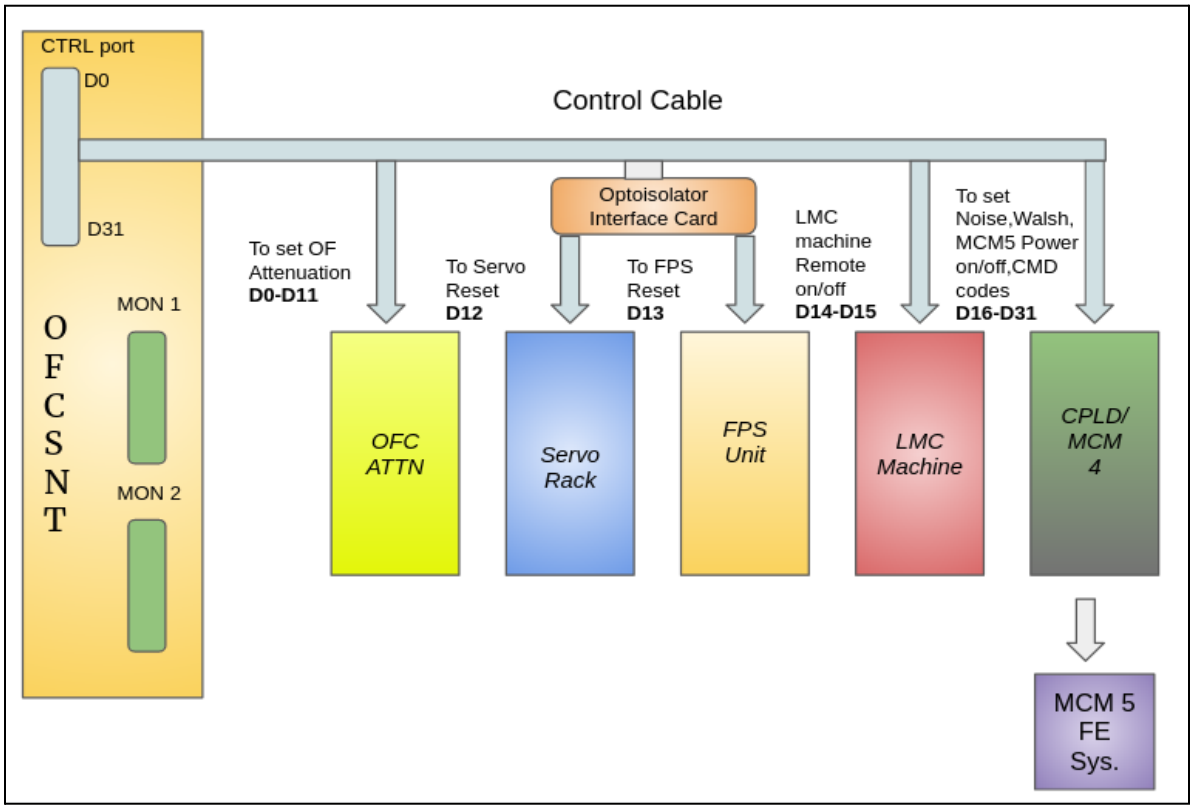

Fig 6.1) Block Diagram of Control Port Bit Utilization of Rabbit MCM0

7. Hardware Interface Wiring with OF System, Sentinel, and CPLD card

The Rabbit MCM0 control port interface cable, 37 wire, needs to be split in the middle to control OF System attenuation settings, Servo reset, and FPS reset signals, LMC remote Power ON/OFF control by one part interface cable, and control of CPLD-based FE parameter control unit by other parts. The wires shown in Green color are digital input/output control lines, as shown in Figure 7.1.

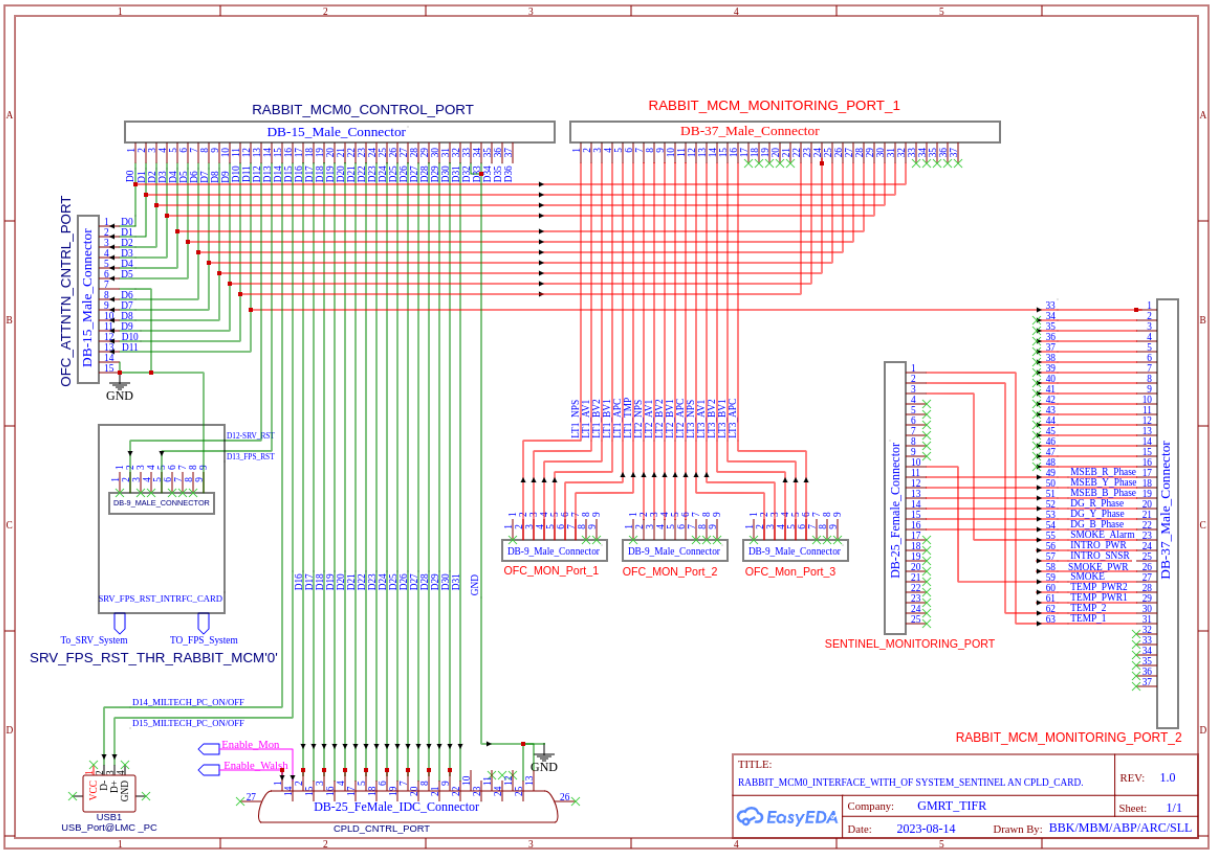

Fig 7.1) Hardware Interface wiring diagram of Rabbit MCM0.

The Rabbit MCM0 has 64 monitoring channels for monitoring parameters from the OF system and Sentinel system. As shown in figure 7.1, the wiring diagram and the monitoring channels are shown in the Red-colored lines. The parameters of Laser Transmitter 1,2 and 3 that are available on OFC_Mon_1, OFC_Mon_2, and OFC_Mon_3 connectors respectively are monitored through Rabbit_MCM_Monitoring_Port_1 (DB-37, Female Connector). There are 33 parameters to be monitored from the OF system like Transmitter Bias Voltages, Supply voltages, and Transmitter temperature.

The Sentinel system parameters are monitored through Rabbit_Mon_Port_2 (DB-37, Male Connector). There are 15 parameters to be monitored from Sentinel systems that include Antenna shell Temperature, Fire and Smoke detection, MSEB, and DG Set power status.

- **The Opto Isolator card.**

The Opto Isolator card was required to isolate the Servo ground and FPS ground from the Rabbit MCM0 card. This patch card was designed by Shri. Mahadev Misal. The Lab-made patch card was tested by Shri. Mahadeo Misal and Shri. Ajit Pawar in the Telemetry Lab as well as at C04 and C10 antennas.

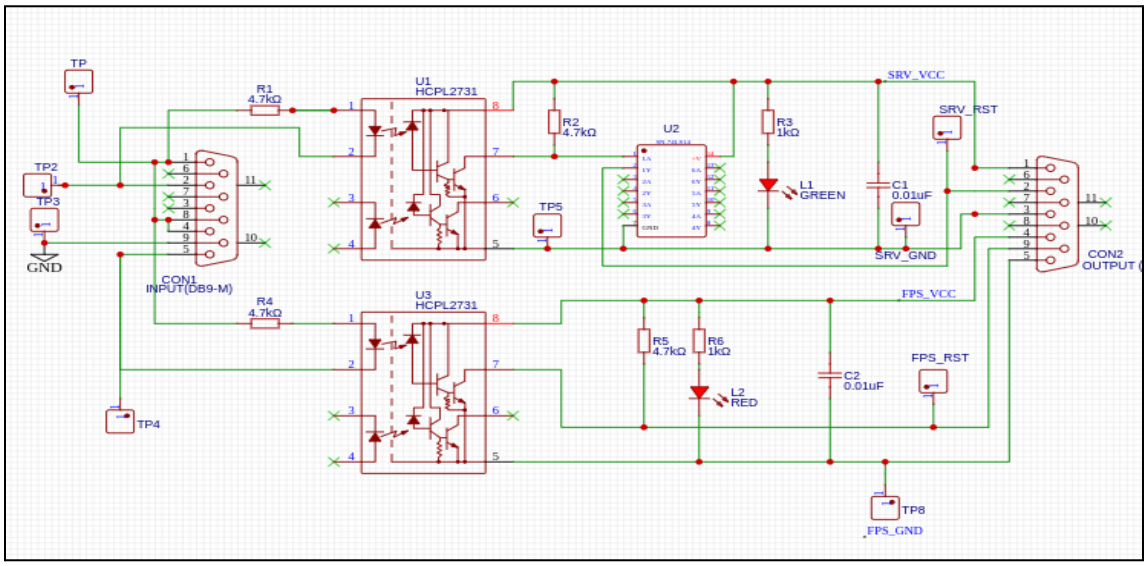

Fig 7.2) Opto Isolator Card Circuit Diagram.

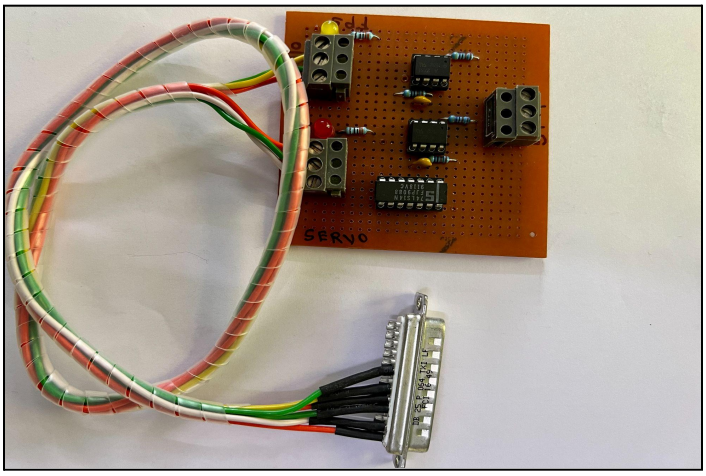

Fig 7.3) Servo And FPS Reset through Rabbit MCM0 using Opto Isolator Card.

8. Implementation and testing at Antennas

The Ethernet-enabled Rabbit MCM0 and Rabbit MCM5 were installed at C04 and C10 antennas for testing purposes due to the availability of a 1 Gbps ethernet link at the antenna base. In subsequent weeks we also installed Rabbit MCM0 in C00, C01,C13, S01, W01 and E03.

Shri. Jitendra Kodilkar did the configuration of commands related to MCM0 and MCM4 in the OFCSNT system in LMC as well as the CMC configuration database. Shri Deepak Bhong has added the commands related to Rabbit MCM0 in the M&C Script Manager.

The Legacy system hardware was powered OFF at the antenna base. The interface cables were made as per the new connections. The connector on MCM-4 PIU was rearranged to accommodate the interface cable connector (DB-25) on the CPLD-based FE parameter control unit end.

The Servo Reset and FPS Reset signals passed through the Opto Isolator card to isolate Rabbit MCM ground from the Servo system ground and FPS system ground.

We have tested all commands related to MCM0 and MCM4 like setting OF attenuation, MCM 5 On/Off, Walsh pattern, Noise, Servo and FPS reset, Miltech On/Off.

We are also able to monitor all parameters which we were previously monitoring like 3 Phase mains and DGSET power, Antenna shell temperature, Smoke and fire alarm, Optical fiber system parameters like LT[1-3] power values. Optical system monitoring values were verified by Shri Sanjit Rai.

9. GUI: Monitoring of Sentinel, OF system, FE System Parameters

Below are snapshots of LMC GUI, Which displays the monitoring of OFCSNT and FrontEnd System.

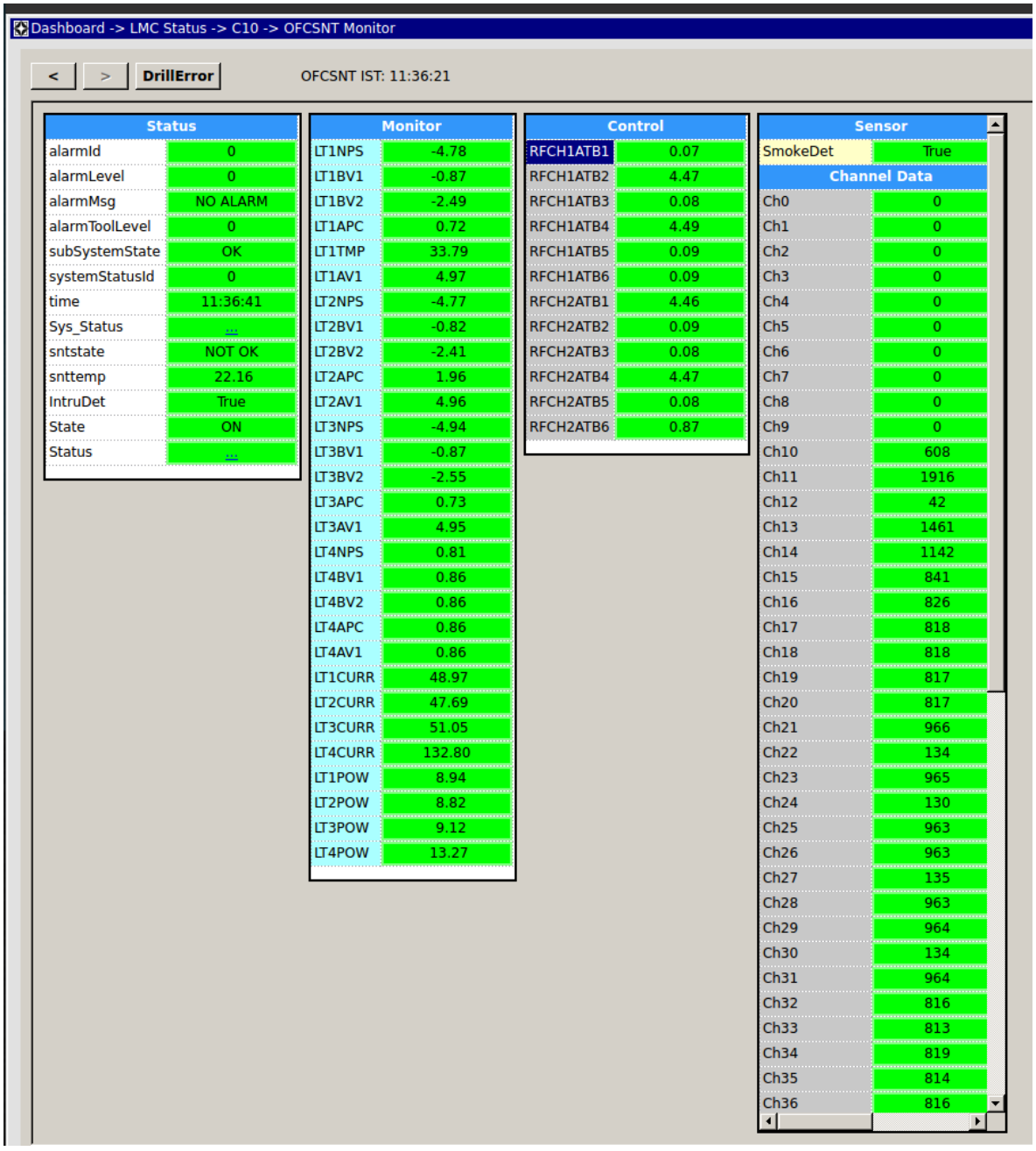

Fig 9.1) C10 OFCSNT Monitoring page on LMC GUI

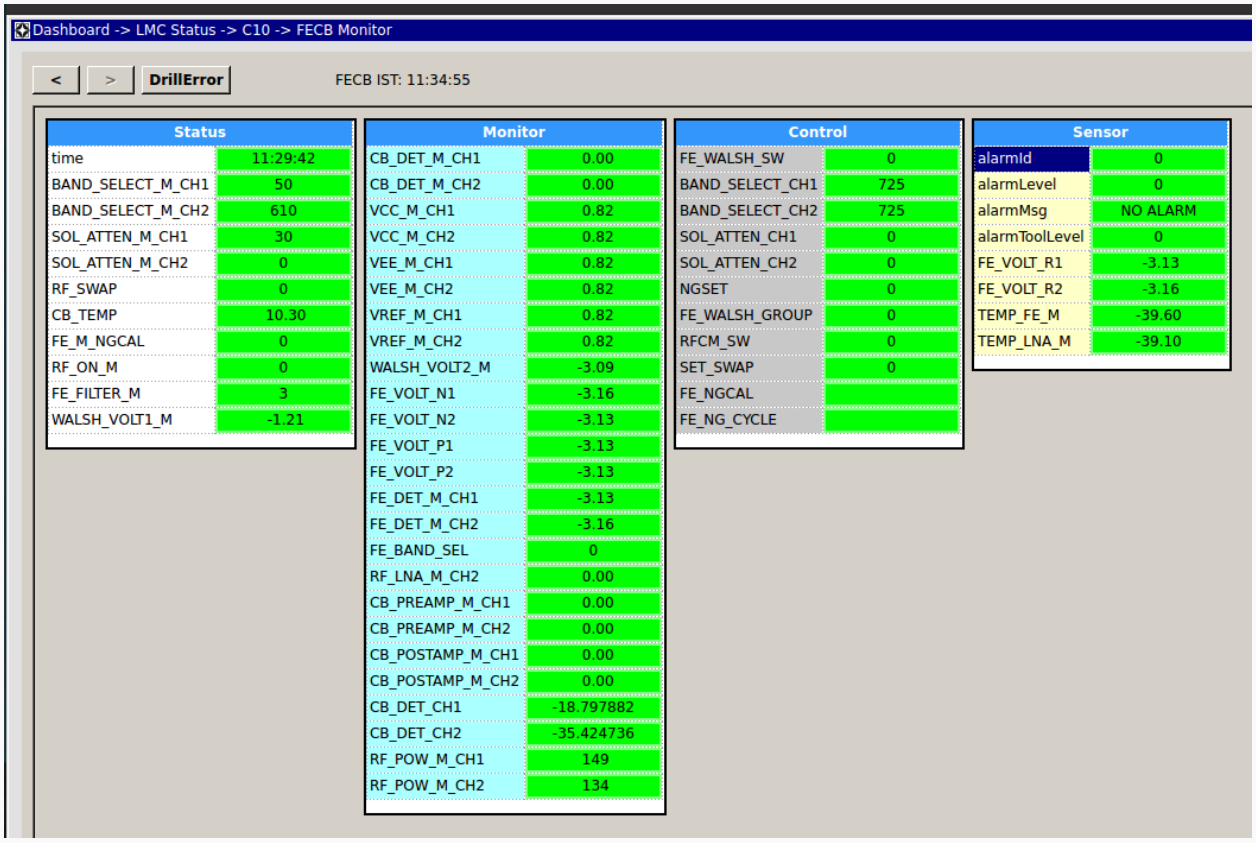

Fig 9.2) C10 FECB Monitoring page on LMC GUI

10. Results

1. The Rabbit MCM0 has been installed in C04, C10, C13 and S01 antennae and found working fine at antennae.

2. From the last month, there has been a significant reduction in problems related to Rabbit MCM0.

3. The Rabbit MCM0 provides a very reliable, robust and stable system which has reduced the downtime of the antenna.

4. The installation of Rabbit MCM0 has also reduced the many problems like ABC timeout, ABC Reset, MCM bus loading, dual master control related issues, to the Telemetry system in the past. Some problems were transient and ambiguous in nature which were hard to debug and troubleshoot which are not seen anymore.

5. Antenna visits have been reduced, and most of the issues can be solved remotely. Which in turn saves crucial manpower hours and vehicle fuel.

11. Contributors

- Rabbit MCM Card Hardware Development: Charudatta Kanade.
- Rabbit MCM0 Firmware Development : Charudatta Kanade and Raju Uprade.
- Command Configuration in CMC and LMC : Jitendra Kodilkar.
- Opto-Isolator Circuit Design and Testing : Mahadev Misal, Ajit Pawar.
- Interface Cable preparation : Mahadev Misal, Ajit Pawar and Sameer Lokhande.
- Antenna Installation And Testing : Bhavesh Kunbi, Amol Chavan, Mahadev Misal, Sameer Lokhande, Ajit Pawar, Bharat Shete and Anil Mule.
- MCM-4 PIU Modification: Sweta Gupta, Abhijit Dhende, Ajay Vishwakarma, Suvarna Mule.
- M&C script Modification for Rabbit MCM0 Commands: Deepak Bhong.
- Walsh Functionality Testing and Validity : Sandeep Chaudhari, Prakash Hande.
- Report Generation : Bhavesh Kunbi, Mahadev Misal.
- Guidance, Review and Suggestion : Shri Anil Raut, Group Coordinator, Operations Group, GMRT.

12. A Glance at the Future

We are planning to implement Rabbit MCM0 in the remaining 28 antennas in the upcoming MTAC cycle in October 2023. We have started procurement of components, cables, and connectors, making interface cables, and making proper PCB for the Opto Isolator card.

Annexure A1: Photo of Rabbit MCM Card.

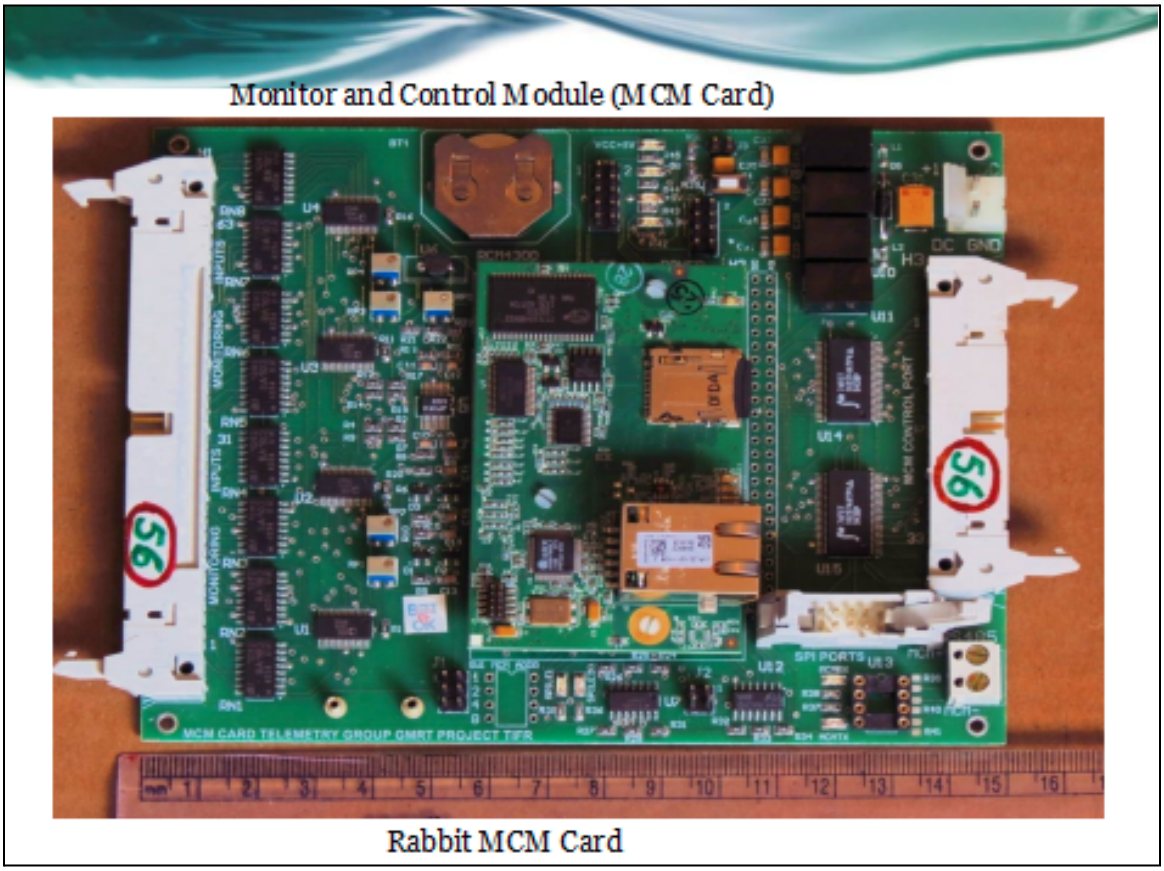

Fig. A1) Photo of Rabbit MCM Card.

Annexure A2: **Schematic of Rabbit MCM Card.**

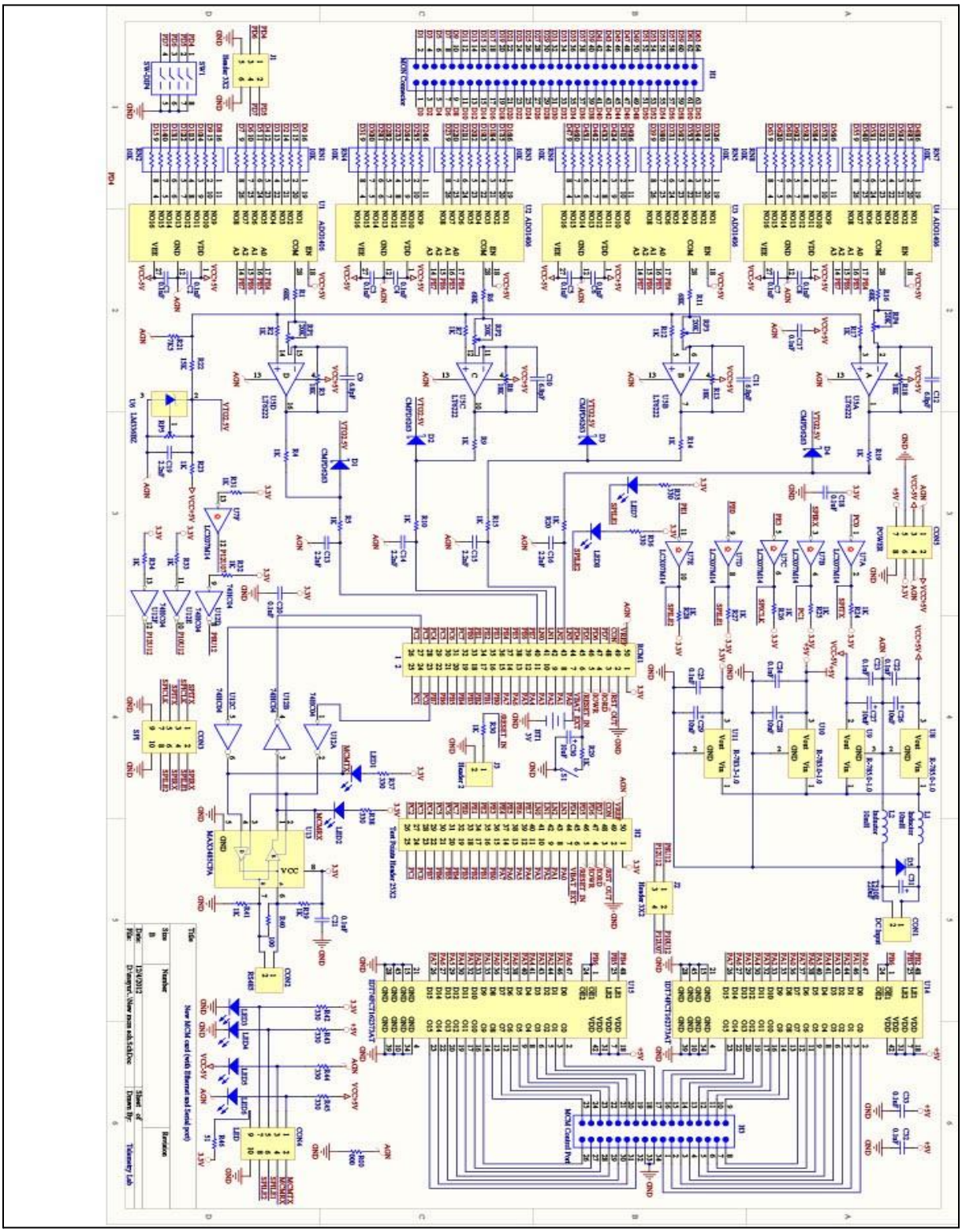

Fig. A2) Schematic of Rabbit MCM Card.