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Technical Report on

TESTING OF RFCM CARD

(Radio Frequency Control and Monitoring Card)

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GIANT METREWAVE RADIO TELESCOPE,

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Abstract

Testing of Radio Frequency Control and Monitoring card is necessary to select proper working or functioning card for GMRT Front-End system and also mass production for upgrade of GMRT Front-End receiver.

This report also describes the entire functionality of RFCM card.

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1. Introduction:

Giant Meter wave Radio Telescope (GMRT) has been designed to operate at six frequency bands centered at 50 MHz, 150 MHz, 235 MHz, 327 MHz, 610 MHz, and L-Band extending from 1000 MHz to 1450 MHz. The L-band further split into four sub-bands centered at 1060 MHz, 1170 MHz, 1280 MHz and 1390 MHz, each with bandwidth of 120 MHz. The 150 MHz, 235 MHz and 327 MHz bands have about 40 MHz bandwidth and 610 MHz band has a bandwidth of 60 MHz. Lower frequency bands from 150 MHz to 610 MHz have dual circular polarization channels (Right Hand Circular and Left Hand Circular) which have been conveniently named as CH1 and CH2 respectively.

The RFCM card used in the front-end boxes is for controlling various functionalities and monitoring of various parameters for these particular front-end systems. Each FE-Box has its own dedicated RFCM card which is being controlled and monitored by the command sent from telescope control room on common bus (RS485) through the Monitoring and Control Module (MCM-5) card that sits in the common box in the front end system. At any given time only one front-end box i.e. only one frequency band is selected and rest of the front-end boxes are kept off. The basic functionalities of the RFCM card are RF on/off, Noise level selection, Walsh Switching, Filter Selection and providing supply voltages to different RF devices that sits in the respective front-end boxes.

The RFCM card was originally designed at NCRA , PUNE before more than 15 years.

2.RFCM Card:

Function and description –

RFCM means Radio Frequency Control and Monitoring Card.

The RFCM card consists of 25 pin input D-type connector which receives input from the common box. 9 pin D-type connector for noise selection output and 25 pin D-type connector for filter select output. This card receives input from the common box and is placed (mounted) in FE-box.

RFCM card is used in front end box for controlling various functionalities and monitoring various parameters for particular front end system. Each Front end box has its own RFCM Card which is being controlled and monitored by the command sent from control room on common bus (RS485) through the monitoring and control module (MCM-5) Card which is in common box in front end system. At any given time only one FE Box is selected i.e. only one frequency band is selected and rest are kept off.

The basic functions of RFCM Card is to control various signals such as noise level selection, filter selection, RF on/off, spare bit, digital ground, walsh switching, noise on/off and providing supply voltages to different RF devices in FE box. It can monitor eight external voltages (m1 to m8) along with other internal voltages. This card receives eight bit data lines (D0 toD7) which includes four bits for noise selection (NS0 to NS3), two bits of filter selection (FS0 and FS1), one spare bit and RF on/off.

It is also used for monitoring the temperature and RF power level of each FE box with the help of temperature sensor and power detector respectively. All these data bits are TTL input (0V & +5V)that are converted into – 5V & 0V complementary analog signal for driving RF switches used for noise level setting using IC LM339 , RF on/off and filter selection. For monitoring purpose two 16:1 MUX IC’s (ADG506A) are being used which can select only one input at a time from 5bit address lines. Two ADG506A multiplexers are with 16 channels and dual 8 channels.

The ADG506A switches one of 16 inputs to a common output, depending on the state of four binary addresses and an enable input. This device has TTL and 5V CMOS logic compatible digital inputs. It can operate with single or dual power supply range and also has high switching speed. IC7486 Ex–OR gate at the input of MUX (enable pin) is used for enable or disable MUX1 or MUX2.

9 pin D-type connector gives output as four bits for noise level selection, ground and complementary four bits for noise level selection and 25 pin D-type connector gives filter selection output and Walsh switching output as shown in fig.2.

The noise on/off, Walsh function (WF1 & Wf2) bits are received through MCM interference card. The noise on/off signal is used as control signal for the bits corresponding to the middle two switches (S2 & S3) in noise generator. This is achieved through the combination of Ex-OR gate. The Walsh function data is level shifted from 0V/5V to ±10V for driving mixer in post amplifier using an op-amp (OP-37).Along with control and monitoring facility this card also provide power supply to the RF components present in FE box. For this it has four voltage regulators (7805, 7905,7812,7912) which convert ± 17V input into ± 12V & ± 5V respectively.

3.Block diagram of RFCM Card:

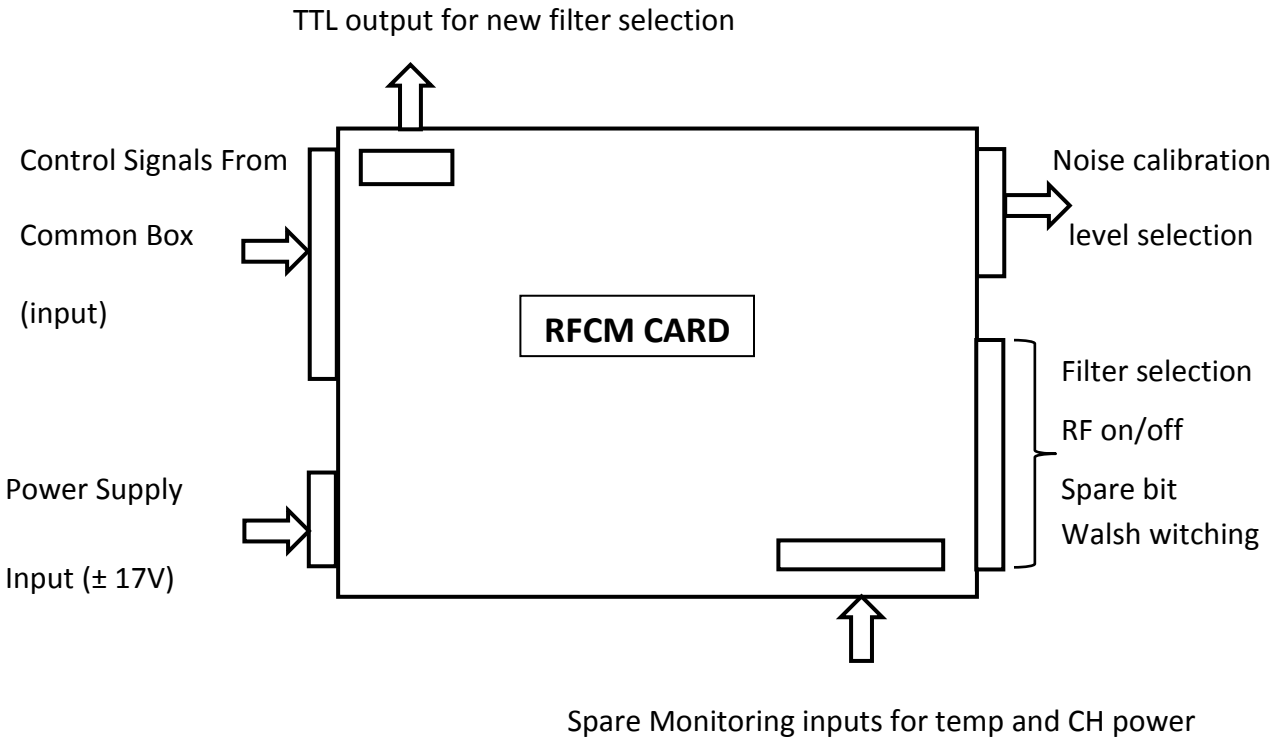

Fig.1 (Block diagram of RFCM card)

Control signals from Common Box are

1. Noise selection bits
2. RF on/off
3. Filter selection bits
4. Monitoring address bits
5. Noise on/off
6. Walsh switching
7. Spare bit

Monitoring inputs are

1. Four spare bits
2. CH1 & CH2 power monitoring
3. LNA temperature monitoring
4. FE-Box temperature monitoring

4. Schematic diagram of RFCM card:

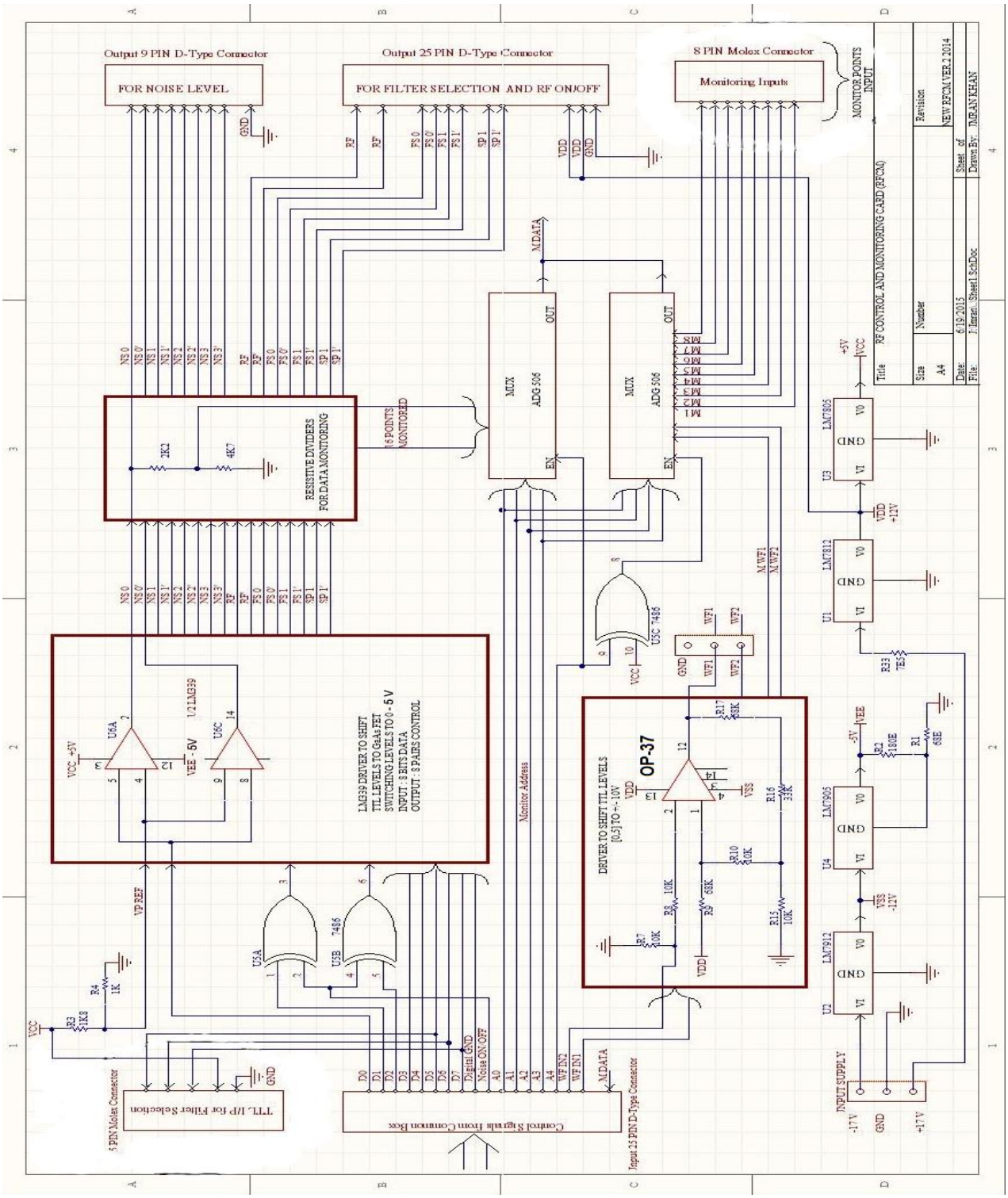

Fig.2 (Schematic dia. of RFCM card)

5.Control and Monitoring Functions:

➢ Control points	Control bits
• Noise ON/OFF	
a) Extra-H-CAL	NS0
b) HIGH-CAL	NS1
c) MEDIUM-CAL	NS2
d) LOW-CAL	NS3
• Filter selection	FS0 & FS1
a) Wide band pass/sub band pass(narrow band) (L-band/250-500/550-900MHz)	
b) Sub band pass filter-01 - 1060	
c) Sub band pass filter-02 - 1170	
d) Sub band pass filter-03 - 1280	
e) Sub band pass filter-04 – 1390	
• RF NO/OFF	RF NO/OFF
• Walsh function	
a) CH1 (Walsh-low/high)	WF1
b) CH2 (Walsh-low/high)	WF2

➢ Monitoring points(16:1 mux ADG506)

- Temperature monitoring

a) Inside LNA b) Inside FE box

- RF power monitoring

a) CH1 b) CH2

- Current

a) + 17V b) - 17V

- Voltages

a) ± 12V b) ± 5V

- Noise ON/OFF
- Noise levels (EH-CAL, HIGH-CAL, MEDIUM-CAL, LOW-CAL)
- RF NO/OFF
- Walsh function(WF1 &WF2)

a) CH1 (Walsh-low/high)

b) CH2 (Walsh-low/high)

- Filter selection

a) Wide band

b) Narrow band-01

c) Narrow band-02

d) Narrow band-03

e) Narrow band-04

6.Block diagram of control and monitoring functions:

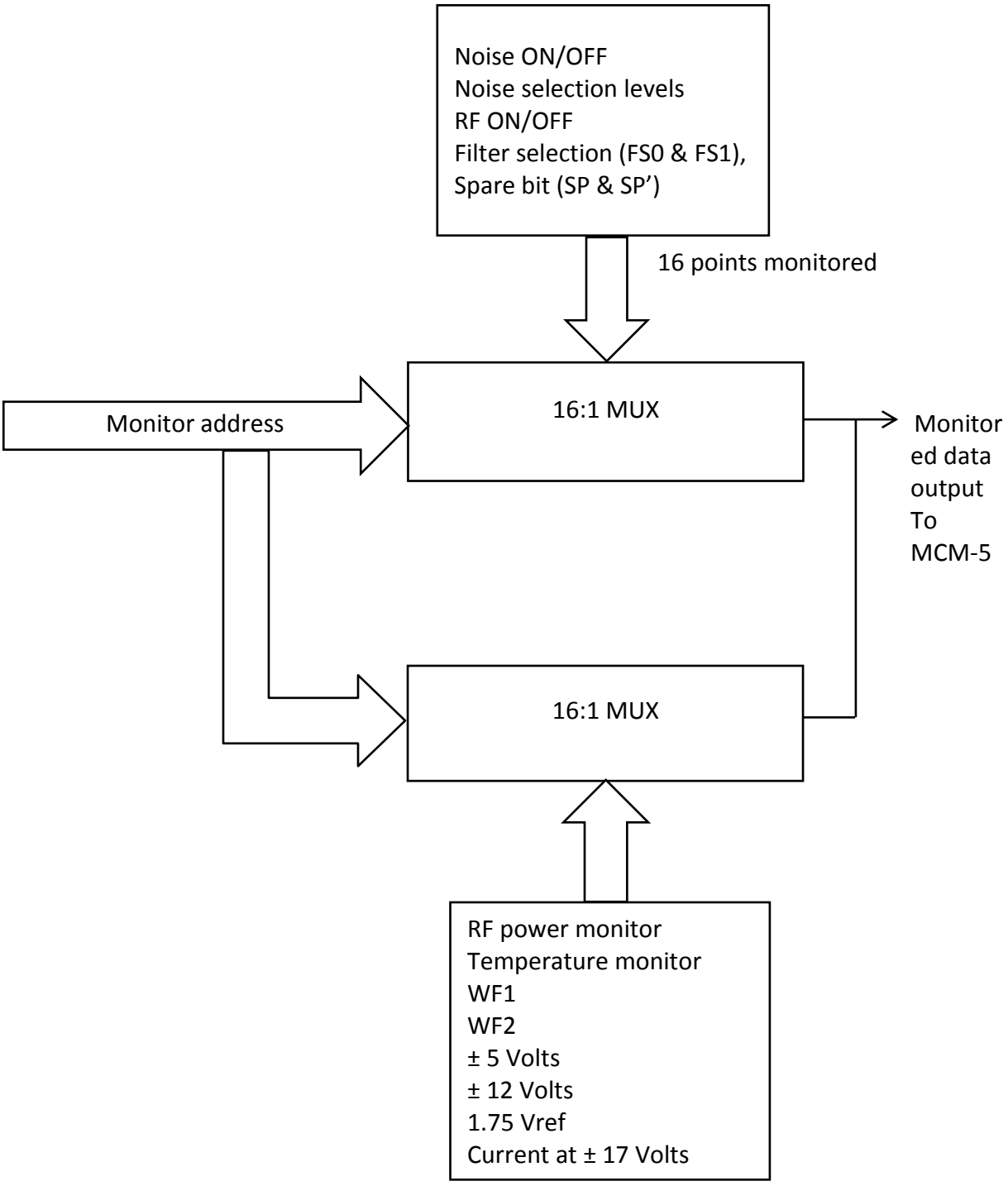

Fig.3 (Block diagram of control and monitoring functions)

7. LM339 Driver Switching Levels 0/-5V

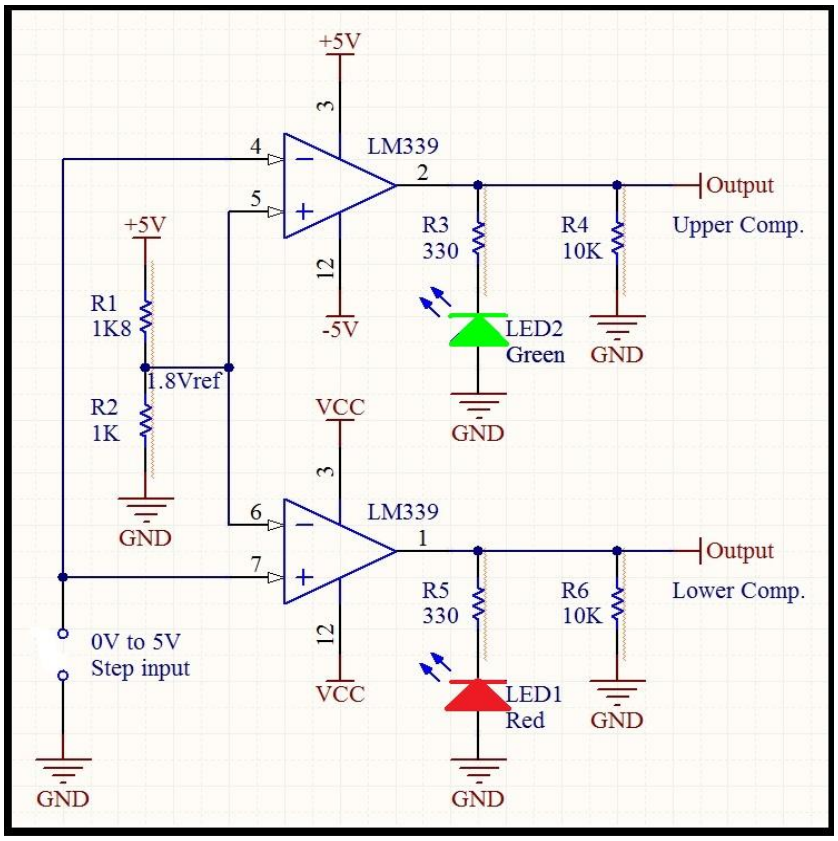

Fig.4 (LM339 driver switching)

LM339 is a quad comparator IC. It consists of four independent voltage comparators designed to operate from single power supply over a wide range. The purpose of using this IC is that it provides high gain, wide bandwidth characteristics.

The schematic shown in figure above shows LM339 driver connections along with its internal connectoin circuitry. As shown in fig.2 the LM339 is used as a driver switching from 0/-5V in that only two of them are used. It has 0 to 5V step common input at pin 4 and pin 7 and also reference input 1.8V at pin 5, 6. Now slowly vary input voltage upto which any one output LED glows. When the input voltage is between 0 to 1.78V then lower compatator output goes high (-5V) i.e. in saturation (shorted) state and ouput LED (RED) will glow and the upper comparator output remains zero i.e. in cutoff (opened) state. At a time only one comparator state is ON. Similarly if the input voltage ranges between 1.8 to 5V then upper comparator output goes high (-5V) and ouput LED (GREEN) glows (RED-OFF). The LED's (RED and GREEN) indicates ON/OFF state of comparator (upper/lower). In this way LM339 comparator switches its level to 0V or -5V.

The outputs signals which are generated at the output of LM339 are tapped by resistor dividing network as shown in the schematic of RFCM card and further given to MUX ADG506A for monitoring purpose.

8.OP-37 Walsh switching ± 10V

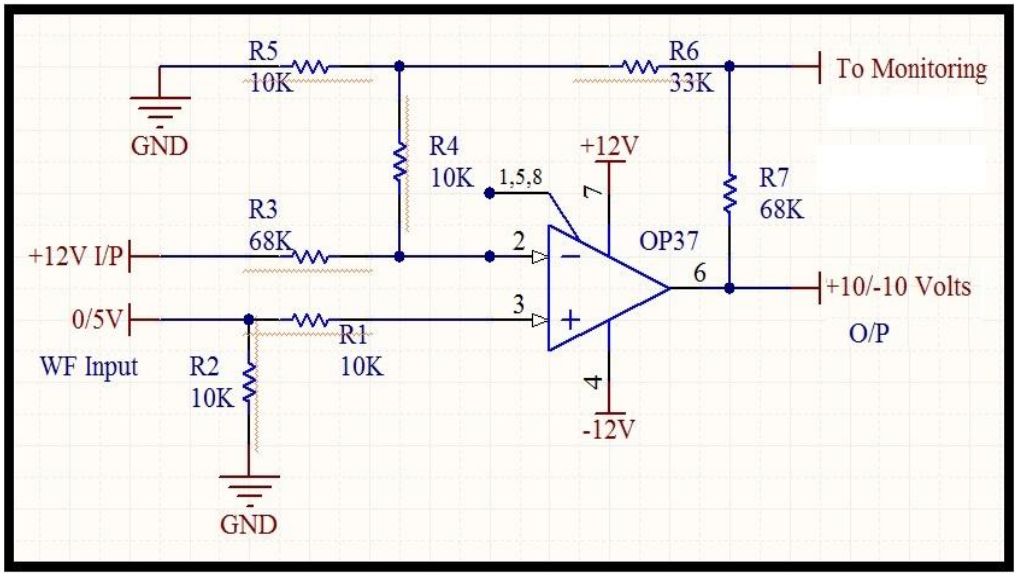

Fig.5 (OP-37 Walsh switching)

OP37 is low noise, high speed precision operational amplifier having slew rate of 17V /µS. As shown in fig.5 the circuit has +12V constant input and 0/5V TTL WF input. In this circuit at 0V input the OP-37 gives output as -10V and at 5V it gives +10V output signal. The working is described through observation table shown below. Two outputs are ±10V and other WF1 and WF2 for monitoring to MUX IC ADG506A in RFCM card. Walsh function is also a level shifter which switches its level from TTL input to ±10V output. The walsh function is required to minimize cross-talk between two different signals in FE box.

Input	Voltage Pin no. 2	Voltage Pin no. 3	Output Pin no. 6	Monitoring output
0V	1.75 V	1.15 V	-10V	– 3.30V
5V	3.70 V	4.30V	+10V	+3.27V

Observation table 1. (OP-37 Walsh switching)

The phase modulation involves addition of 180˚ and 0˚ to the RF signal in synchronism with a control digital waveform that is known as Walsh Function. The phase modulation is performed using a commercially available mixer in which the IF port is used to control the phase of RF signals by appropriate supplying a DC bias. The positive DC bias at the IF port will add 180˚ phase to the RF signal and a negative bias will add 0˚ phase to the RF signal. A current of 10 mA is passed through the bridge rectifier inside the mixer to put the diodes (ring) into saturation whenever they are made to conduct.

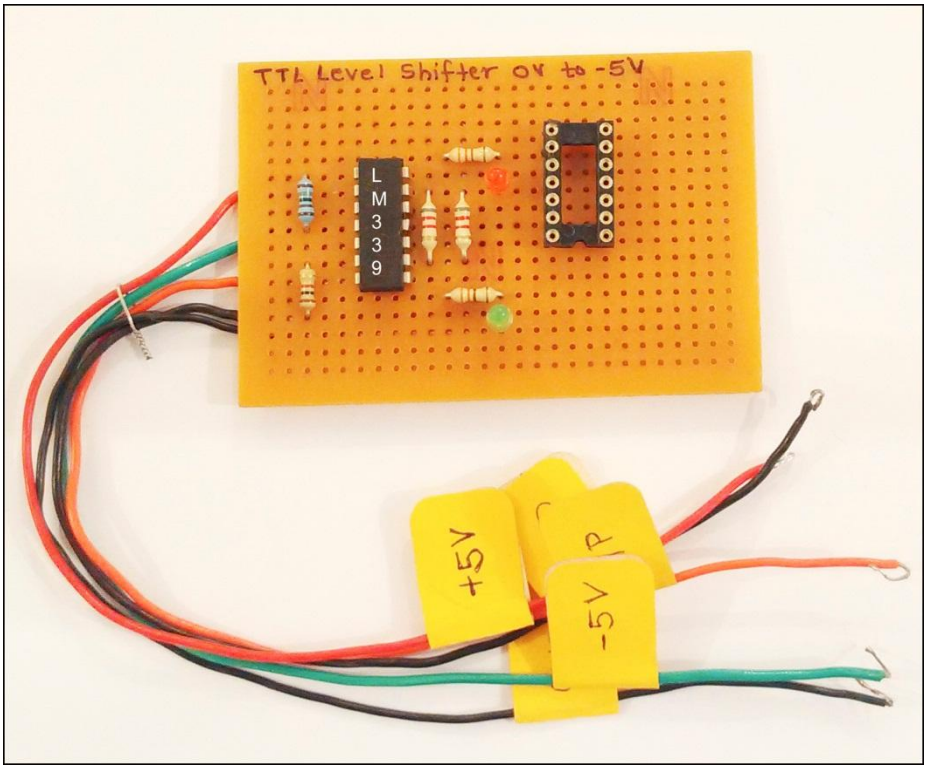

Photo 1.(Photograph of LM339 driver switching)

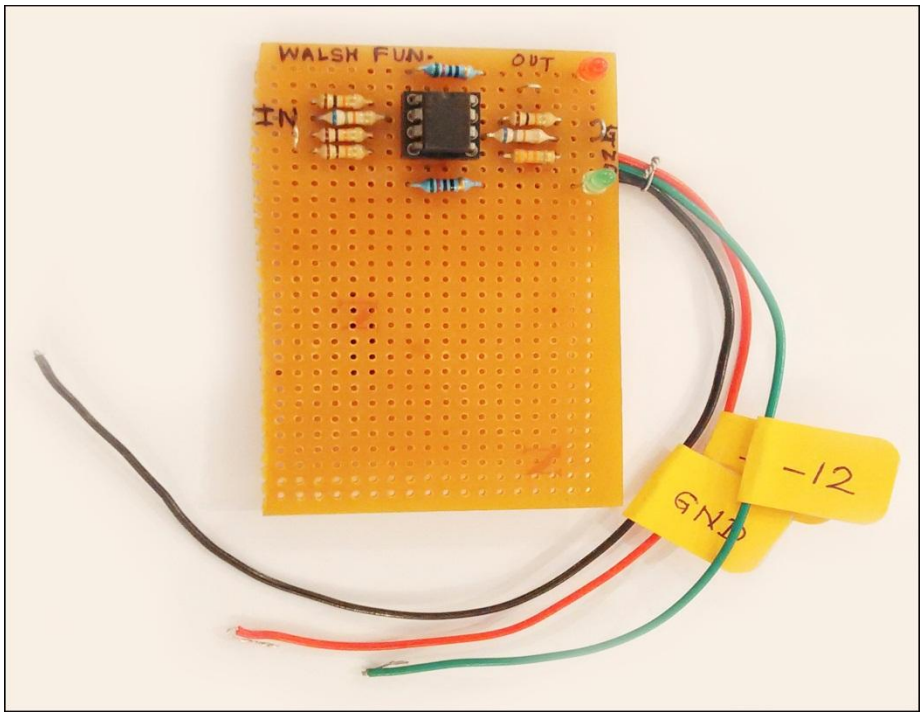

Photo 2.(Photograph of OP-37 Walsh switching)

9.Block diagram of RFCM Card testing:

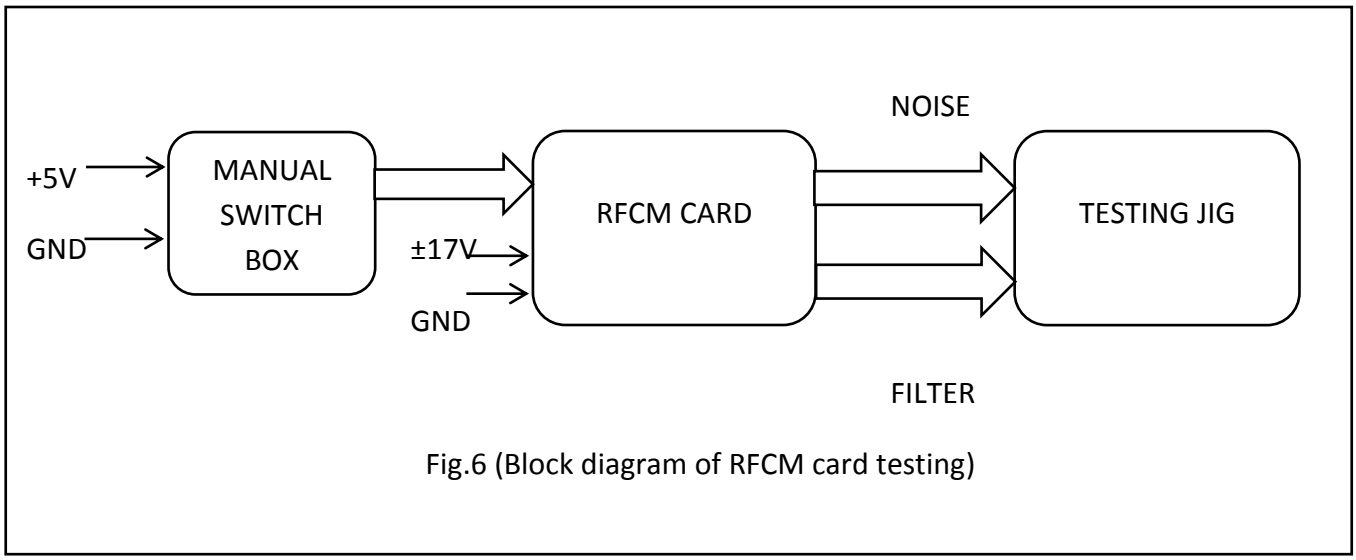

Fig.6 (Block diagram of RFCM card testing)

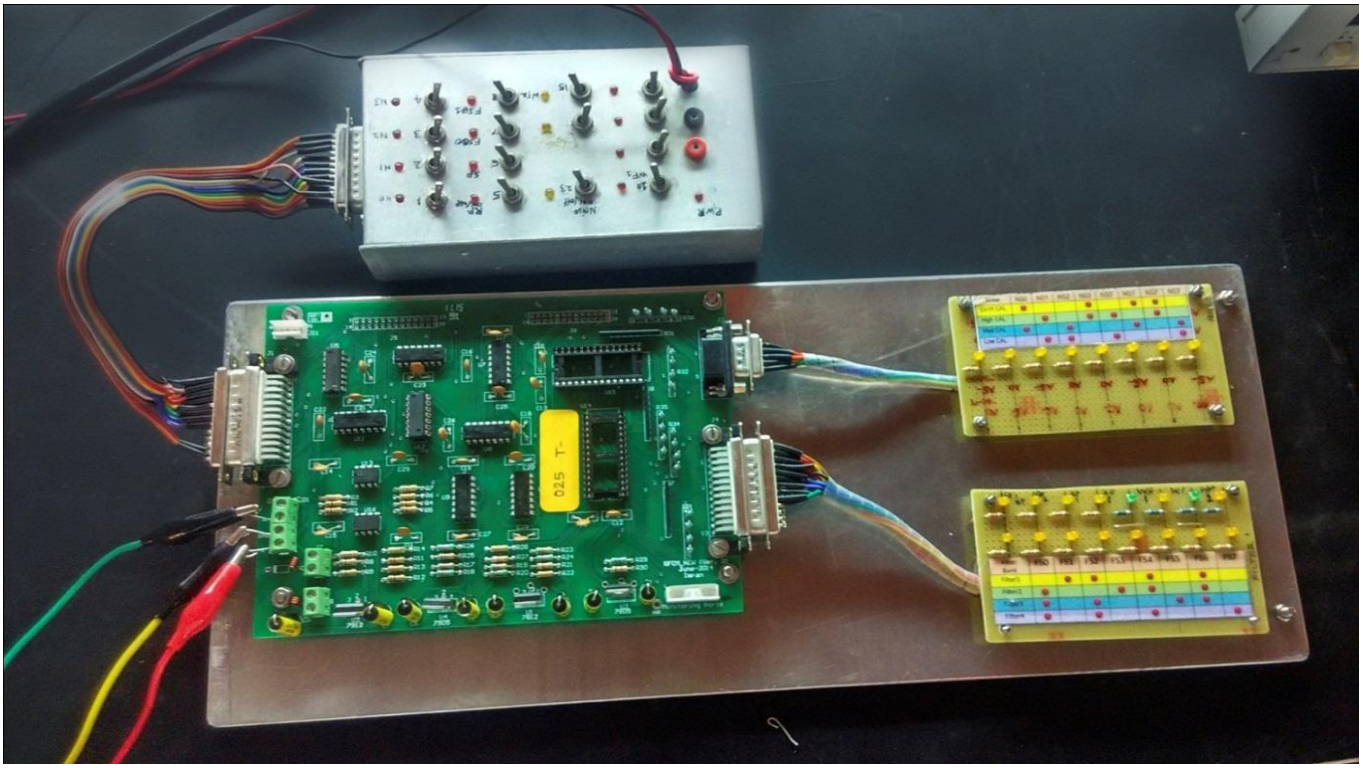

Photo 3.(Photograph of RFCM card testing)

10.Testing procedure of RFCM Card:

- Testing of RFCM card requires testing jig , RFCM card , DC power supply (±17V, +5V) , manual switch box and digital multimeter.
- RFCM card requires ± 17V DC power for further processing.
- For testing RFCM card we have made a testing jig of LEDs. The testing jig consists of two parts, one for noise level selection and another for filter selection, RF ON /OFF, walsh function (WF1&WF2) and spare bit (SP1 &SP2).
- It is having chart/table that shows how the noise and filter selection is done.
- While testing this jig is connected at the output of the card.
- Make setup as shown in the fig6 .Block diagram of RFCM card testing. Set ± 17V power in dual power supply.
- After making total setup start it and check the initial state of noise and filter on testing jig. (when all switches are off). First four LED of noise will glow and first filter band 1060 MHz will be selected.
- First check the supply voltages at different points, such as reference voltage (1.8V), ±12V and ±5V at regulator IC's input terminal on RFCM card using multimeter.
- Then check walsh switching voltage ± 10V at WF1 and WF2 at output jig (by toggling the switches available on manual switch box).
- For noise level testing at first switch on the noise on/off switch. Then one by one changing the noise level switches (NS0, NS1, NS2, NS3) check the select calibration levels (EH-Cal, H-Cal, M-Cal, L-Cal) as shown in observation table 2.
- Similarly, for filter band toggling FS0 and FS1 switches available on switch box the filter band (narrow band and wide band - 1060 MHz,1170 MHz,1280 MHz,1390 MHz) can be selected (as shown in the observation table 2) and checked.
- If LED's on the output jig glows as shown in table then it is concluded that all the functions of the card are working properly.

- RF ON/OFF and spare bits also can be checked by simply making ON/OFF the switches on box which are for this purpose.
- Thus by testing operating voltages at different points, toggling the switches and observing states of LED on jig this RFCM cards are tested.
- In other way we can also test RFCM card using common box and by giving the commands from the Linux (program). We can test same functions with testing jig or without jig on spectrum analyzer.
- All this same process is followed for testing remaining RFCM cards.

11.RFCM CARD Testing Report (Observation table)

Observation table 2. Different voltage levels

Sr.No.	Test	Description	Working Status	Remark
1	**Visual Inspection**	Correct Component Placement		
		Soldering Quality		
2	**DC Voltage**	+12.0 V		
		-12.0V		
		+5.0 V		
		-5.0 V		
		1.7 V (Vref)		
3	**DC Current**	@ +17.0 V		
		@ -17.0V		
4	**Noise Setting**	Noise ON/OFF		
5	**Walsh – Function**	WF1-Low		
		WF1-High		
		WF2-Low		
		WF2-High		
6	**RF ON/OFF**	CP1		
		CP2		
7	**Spare BIT**	SP		
		SP’		

Observation table 3. Noise Selection and Filter Selection

Noise Selection

Noise Level	Input				Output								Remark
	N0	N1	N2	N3	NS0	NS1	NS2	NS3	NS0`	NS1’	NS2’	NS3’	
EH – Cal	0	0	0	0	1	0	0	1	0	1	1	0	
H – Cal	1	1	0	0	0	1	0	1	1	0	1	0	
M – Cal	0	0	1	1	1	0	1	0	0	1	0	1	
L – Cal	1	1	1	1	0	1	1	0	1	0	0	1	

Filter Selection

Filter band	Input		Output								Remark
	F0	F1	FS0	FS1	FS2	FS3	FS4	FS5	FS6	FS7	
1060	0	0	0	1	1	0	1	0	1	0	
1170	1	0	1	0	0	1	1	0	1	0	
1280	0	1	1	0	1	0	0	1	1	0	
1390	1	1	1	0	1	0	1	0	0	1	

Date: **Signature:**

12.Conclusion:

1. I have tested total 100 nos. of RFCM cards.
2. While testing the RFCM cards some of them were not functioning properly.
3. They were having problem in their regulator ICs, soldering and power connector.
4. By replacing those ICs and making proper solder these cards starts functioning properly.

13.References:

1. RFCM card report (Imran Khan)
2. FE Lab manual (Pravin Kumar and Anil Raut)
3. http://www.analog.com/data-sheets/LM339.pdf
4. http://www.analog.com/data-sheets/OP37.pdf
5. http://www.analog.com/datasheets/ADG506A_507A.pdf