TECHNICAL DEVELOPMENTS AT GMRT

B. Ajith Kumar Group Head : GMRT Back-end Systems



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VLBI using GMRT

- Data recording systems in Backend
- Time & Frequency Standards at GMRT
- Recent developments in T&F Standards
- Other single dish telescopes for VLBI

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GMRT SOFTWARE BACKEND (GSB)



A fully software based back-end for GMRT : 32 stations, 32 MHz BW, dual polarization real-time interferometer + beam former

Also support *raw dump* mode : can record raw voltages from 32 stations (dual poln) for ~ 12 hrs (sustained)

GSB for VLBI :

 Raw ADC voltage for 30 antennas, 2 pols (4 bits/sample, 16.66 Mhz BW 56GB/hr per pol channel) Data Acquisition : Node 1 – Node 16 Data Recording : Node 33 – Node 48 Storage : (16 X 4 X 500 GB)

Phased Array Voltage BW 16.66 Mhz (32 MB/sec per pol)

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GMRT WIDEBAND BACKEND (GWB)



A hybrid FPGA+GPU back-end for GMRT : 32 stations, 400 MHz BW, dual pol real-time interferometer + beam former

GWB for VLBI :

- Raw ADC voltage for 30, 2 pols in development stage (4 bits/sample, 400 Mhz BW, 1.44 TB/hr per pol channel) Data Sampling & Packetisation : Roach 1 – Roach 16 Data Recording : being planned in Parallel Backend
- Phased Array Voltage BW 200 Mhz (400 MB/sec per pol) (Recording facility being implemented)

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Time & Frequency Standards



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GPS10RBN : PTS make GPS-Rb unit

Phase Noise : -135 dBc/ Hz at 10 Hz Allan Variance : 1 X 10 E-11 (over 10 sec) : 1 X 10 E-13 (Over a Day) : 1 MHz, 5 MHz and 10 Mhz Output Freq O/P Time sync : PPM and PPS with 50 % duty cycle and jitter < 300ps PPS/PPM aligned to UTC time \pm 20ns NTP server output on the Ethernet port



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Test Results : GPS10RBN



Stability : 6 x10⁻¹¹ at 10 second

Phase noise : -95 dBc/Hz at a 1 Hz offset

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iMaser-3000 : T4 SCIENCE AHM

- Low Phase Noise (10 MHz) : -125 dBc/Hz at 1Hz
- Allan Variance : 7 X 10 E-14 at 1 sec
- Long Term Drift : 2 X 10 E-16 at 1 day
- Output Frequency : 5MHz, 10MHz, 100 MHz
- Output Power level : 13 dBm
- Output Time Sync : PPS with jitter < 200ps</p>
- External Time in Sync : PPS input with 2V level
- Auto tuning ceramic cavity technology
- Low thermal sensitivity < 8 X 10E-16/°C</p>
- Ethernet port based remote control and monitoring



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Maser : Test Results (10 Mhz)



Phase Noise -123 dBc/Hz @ 1Hz





Output level : 12.3 dBm



Spurious : -90 dBc



Isolation o/p1 to o/p2 : -93.5 dB



Time Scale solution at GMRT

Test setup established at GMRT in collaboration with ISTRAC Team The solution is ensemble of one AHM, one GPS-RB, one Rb Osc The Time and Frequency is steered to IRNSS Network Time Use an IRNSS Common View Time Transfer Receiver Traceability of Time to UTC using GNSS common view Receiver

Precise Time and Frequency signals made available :

1. 10 MHz
 2. 1 PPS
 3. IRIG-B
 4. NTP
 5. PTP

Similar tests recently done using RAC, Ooty Maser also.

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Time Scale solution : Results

Test Results :

Observed Frequency offset (AHM 5 Mhz) : 5.125*10⁻⁶ Hz Accumulated Phase offset in a day (AHM signal) : -88 ns

Frequency offset of 5 Mhz timescale signal : 1*10⁻⁷ Hz Accumulated Phase offset in a day (timescale signal) : 1 ns

Courtesy : ISTRAC report on Timescale establishment at GMRT

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ISTRAC 32mtr Dish



32 mtr Parabolic reflector antenna RF: S – band (2.2-2.3 GHz) X- band (8.025-8.5GHz) Polarisation : LCP / RCP IF Freq : 70 MHz IF BW : 40 Mhz (S-band) : 50 Mhz (X-band) T&F Standard : AHM based

Digitisation : Amplified IF signal Direct Bandpass sampling Sampling clock : 100 Mhz No. of Bits : 8 bits Freq Channels : 512 Integration : 1 sec Raw voltage : 100 MB/s Raw voltage : 4 bits / sample

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32mtr Dish – Test Results



Source		S – 1	Band				
	IDSN IF 70MHz		IDSN GAB OUT		IDSN Correlator OUT		Expected Deflection
	LCP	RCP	LCP	RCP	LCP	RCP	18dB @ S-band
	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	4.00D @ 3-Dand
Deflection in dB (CYG-CYG1)	3.91	4.02	3.99	4.28	3.9	4.13	
Deflection in dB (CYG-CYG2)	4.02	4.09	4.14	4.31	3.96	4.2	

	Source		X – 1								
Expected Deflection		IDSN IF 70MHz		IDSN GAB OUT		IDSN Correlator OUT					
		LCP	RCP	LCP	RCP	LCP	RCP				
		(dB)	(dB)	(dB)	(dB)	(dB)	(dB)				
1.6dB @ X-band	Deflection in dB (CYG-CYG1)	0.68	0.75	0.64	0.68	0.64	0.68				
Nov 14, 2019	Deflection in dB (CYG-CYG2)	0.69	0.83	0.63	0.71	0.76	0.82				



Raw voltage from 30 ant / 2 pol from GSB 16.66 Mhz BW
 Phased Array Voltage (spectrum) from GSB at 16.66 Mhz BW
 Raw voltage from 30 ant / 2 pol from GWB 400 Mhz BW

 Recording scheme tested on prototype, need to procure storage
 Phased Array Voltage (spectrum) from GWB at 200 Mhz BW

 Recording system being implemented
 Phased Array Voltage (spectrum) from GWB at 25 Mhz BW
 Time & Frequency standards upgraded to support VLBI
 To check possibility of use of single dish telescopes for VLBI

