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6.19 SYSTEM ASPECTS OF THE INDIAN MST RADAR FACILITY

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One of the major objectives of the Indian Middle Atmosphere Programme is to investigate the motions of the middle atmosphere on temporal and spatial scales and the interaction between the three height regions of the middle atmosphere viz., mesosphere, stratosphere and troposphere. Realizing the fact that radar technique has proved to be a very powerful tool for the study of earth's atmosphere, the Indian Middle Atmosphere Programme (IMAP) has recommended establishing a MST radar as a national facility for atmospheric research. The major landmarks in this endeavour to setup the MST radar as a national facility are as follows:

The first major step was the constitution of a National Committee on MST Radar in July 1981, by the Chairman of the Advisory Committee for Space Sciences (ADCOS) of the Department of Space. User scientists from different national laboratories like the Physical Research Laboratory, Ahmedabad; National Physical Laboratory, New Delhi; and Space Physics Laboratory, Trivandrum; the different Indian universities involved in atmospheric research, as well as engineers with experience in design and development of radar systems, drawn from the Department of Space, the Department of Electronics, Tata Institute of Fundamental Research, Bombay, and public sector industries like the Electronics Corporation of India, Hyderabad and Bharat Electronics Limited, Bangalore, participated in the deliberations of this National Committee. The Committee submitted its report in early 1982, generating the user requirements and identifying the major specifications for the subsystems for the Indian MST radar.

Based on this, the Chairman of ISRO and the Secretary, Department of Space, made a decision in middle 1982 to entrust the overall responsibility for the design, development and commissioning of this radar system to the public sector undertaking M/s. Bharat Electronics Limited. The overall responsibility for establishing this national facility rests with the Department of Space, identified as the Nodal Agency with financial contributions coming from different departments of the Government of India, like the Department of Electronics, the Department of Science and Technology, and the Council of Scientific and Industrial Research, etc.

The Chairman of ADCOS constituted a committee in the middle of 1982 for site selection. This had representation from the user scientists, the Frequency Management Office of the Department of Space and M/s. Bharat Electronics Limited. The Site Selection Committee, after considering various locations, recommended a site near the temple town of Tirupathi in the state of Andhra Pradesh. Some of the important considerations which formed the basis for this selection are the following: 1) proximity to a university or a national scientific laboratory, 2) remoteness to industrial activity, 3) availability of natural shielding, and 4) moderate separation from the geomagnetic equator, so that the facility could be used to study the ionosphere at the same time and not get saturated by the equatorial electrojet.

The toughest challenge in trying to establish the MST radar as a national facility in India continues to be the frequency and siting clearance. Out of th six candidate sites surveyed by the Site Selection Committee, five have to be rejected in view of possible interference to existing VHF communication facilities, radio astronomy groups or military installations. After considerable deliberation by inter-agency groups, the WPC, a wing of the

Ministry of Communications (connected with frequency clearance), Government of India, have tentatively sanctioned the operating frequency of 53 MHz with an operating bandwidth of 1 MHz (3 dB) with severe restrictions on the type of emission and spectrum usage.

The siting clearance is still awaited as there is an objection from the point of view of possible interference to the international air traffic overflying the chosen site. Based on this objection, a second site at Tirupathi has been studied. Once the siting clearance is obtained, work on the facility is expected to start in full swing.

Table I gives the salient features and the important system level parameters for the Indian MST radar facility.

It is also contemplated to establish a SODAR at the MST site for the investigation of 0 to 5 km height range in detail, and a lidar to cover the stratosphere region. Plans also exist for using the MST system with its large power aperture product for the study of the ionosphere in the incoherent backscatter mode. Figure 1 gives a simplified block diagram of the Indian MST radar. Figure 2 gives an artist's impression of the proposed MST site showing the antenna array and the control building. Figure 3 shows a subarray feeding network.

It can be concluded that when this facility is fully established, it will provide valuable data on the middle atmosphere over lower latitudes in the Indian Ocean region, not only for Indian scientists, but for atmospheric scientists all over the world who are interested in global modelling of the middle atmosphere.

Table I

Indian MST radar system specifications

Type of system	:	Pulse Doppler
Operating frequency	:	53 MHz
Operating bandwidth	:	1 MHz
Power aperture product	:	$\simeq 7 \times 10^8$ wm^2
SUBSYSTEMS:		
ANTENNA:		
Type	:	coaxial collinear/Yagi
Gain	:	36 dB (Min)
Beam width	:	$3° \pm 0.3°$
Beam switching	:	(a) zenith (b) $\pm$ 20° E-W from zenith (c) $\pm$ 20° N-S from zenith (d) $\simeq$ 12° due north from zenith
Pointing accuracy	:	$\pm$ 0.1° for zenith beam TBD for other beams
Sidelobe level	:	15 dB below main lobe (design goal 20 dB)
Maximum tolerable Antenna gain towards the horizon	:	+ 1 dB
Additional null	:	additional null at 12° north during normal MST operation

Null depth	:	40 dB
Polarization	:	2 orthogonal polarizations

ADDITIONAL REQUIREMENTS:

1) The antenna system should be capable of being used separately either in ST mode or MST mode.
2) The antenna system should have provision for time delay compensation when excited with coded waveforms to avoid code smearing on the antenna axis.
3) Provision to use antenna in SA mode at a later stage.

TRANSMITTER

Configuration	:	(a) 24 modules of $\simeq$ 100 kW each are combined to generate a peak power of 2.5 MW and average power of 60 kW for the radar. Specifications of individual module is enumerated below. (b) Pulse width and PRF will be selected such that the averaged power is maintained at $\leq$ 60 kW.
Peak power	:	100 kW $\pm$ 10%
Average power	:	2.5 kW $\pm$ 10%
Duty ratio	:	2.5%
Bandwidth	:	1 MHz
Pulse width & wave form	:	
(a) Uncoded	:	1, 2, 4, 8, 16, 32, 64, 128 μsec
(b) Coded	:	16 μsec 32 μsec Complementary code using $\pm$ π phase modulation (BPSK) with subpulse length of 1 μsec
PRF	:	62.5, 125, 250, 500, 1K, 2K, 4K, 8K PPS selectable
Spurious signal output	:	2nd and 3rd harmonics and spurious output should be 60 dB below fundamental
T/R switch isolation	:	50 dB (design goal 60 dB)
Limited input to Rx	:	+ 13 dBm

RECEIVER SYSTEM	:	
Preamplifier	:	
Frequency	:	53 MHz
Bandwidth	:	5 MHz $\pm$ 10%
Noise figure	:	3 dB or better
Gain	:	20 dB $\pm$ 1 dB
Maximum input signal handling without saturation	:	+ 4 dBm
Overload recovery	:	7 μsec

RECEIVER	:	
IF	:	30 MHz
Local oscillator	:	Frequency to suit 53 MHz carrier using USB or LSB

Total gain	:	110 dB (Min)
Dynamic range	:	70 dB (Min)
Deviation of linearity over the 70 dB dynamic range	:	$\pm$ 1 dB
IF bandwidth (3 dB)	:	1 MHz
Video bandwidth	:	$\frac{1.2}{\text{pulse width}}$
I & Q video amplitude	:	$\pm$ 2 V P P
VSWR	:	$\bar{1}.5:1$
Local oscillator stability	:	
(1) Short term	:	1×10^{10} (for 15 min)
(2) Long term	:	1×10^{9} (for 36 hrs)

SIGNAL PROCESSING :

The signal processing system consists of:

(1) The system synchronizer unit which generates all the baseband waveforms for waveform generation, triggering, gating and clock generating and timing under the control of the overall system control.

(2) Data acquisition unit which digitizes I & Q channel outputs, performs coherent integration, decoding, sweep integration, FF transform and velocity estimation.

(3) System controller & data processor unit which controls all the subsystems based on the system operating modes selected, coordinates the data acquisition, processing, real-time display, recording and generation of hard copy outputs.

The important specifications of these three units are listed below:

SYSTEM SYNCHRONIZER UNIT	:	
PRF	:	62.5, 125, 250, 500, 1000, 2000, 4000, 8000, PPS (selectable)
Range gates	:	150 m, 300 m, 600 m, 1.2 km, 2.4 km, 4.8 km (selectable)
Basic clock	:	10 MHz

DATA ACQUISITION UNIT	:	
Type of A/D converter	:	Flash converter
Sampling rate	:	2 MHz
Data resolution	:	12 bits (desirable) 10 bits (essential)
Analog input	:	$\pm$ 2 volts
Number of range slots for FF transform	:	64 maximum
Number of points for spectral estimation	:	64, 128, 256, 512
Maximum velocity	:	12 (11.75) m/sec or 24 (23.5) m/sec or 47 m/sec (selectable)
Velocity resolution	:	0.182 or 0.09 m/sec (selectable)
Spectrum integration period	:	Selectable from 5 sec to 10 min in suitable steps

Type of signal processor : Dedicated FFT processor

SYSTEM CONTROLLER :
Functions:

(1) Mode control for all subsystems like transmitter, receiver and signal processor
(2) Antenna control, for beam position, polarization, etc.
(3) Data display, storage and archiving and hard copy generation.

Type of computer	:	General purpose minicomputer based on 16-bit μprocessor chip.
Operating system	:	Real-time operating system, with multitasking feature
Peripherals and storage devices	:	(1) CRT terminals with colour graphic capability (2) Hard copy device for terminal (3) Graphic printer (4) Magnetic tape drives (5) Floppy disk drives (6) Winchester hard disk drives.
Power supply	:	400 V 3 Ø ac 50 Hz

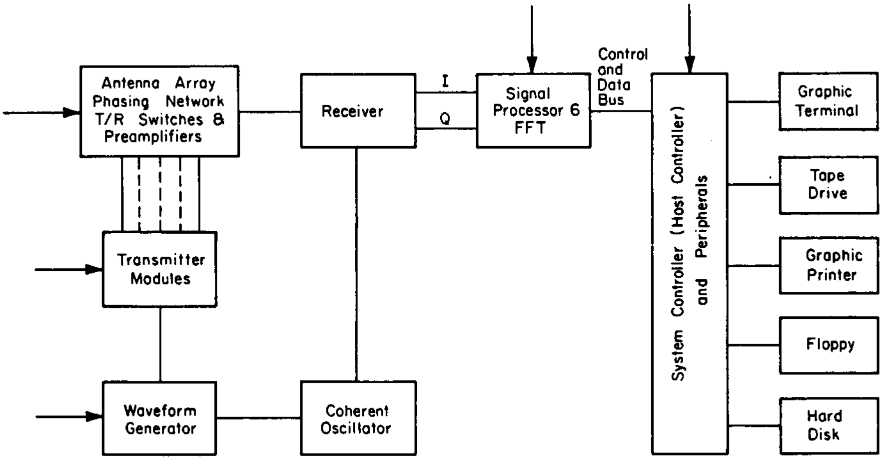

Figure 1. Simplified block diagram: Indian MST radar.

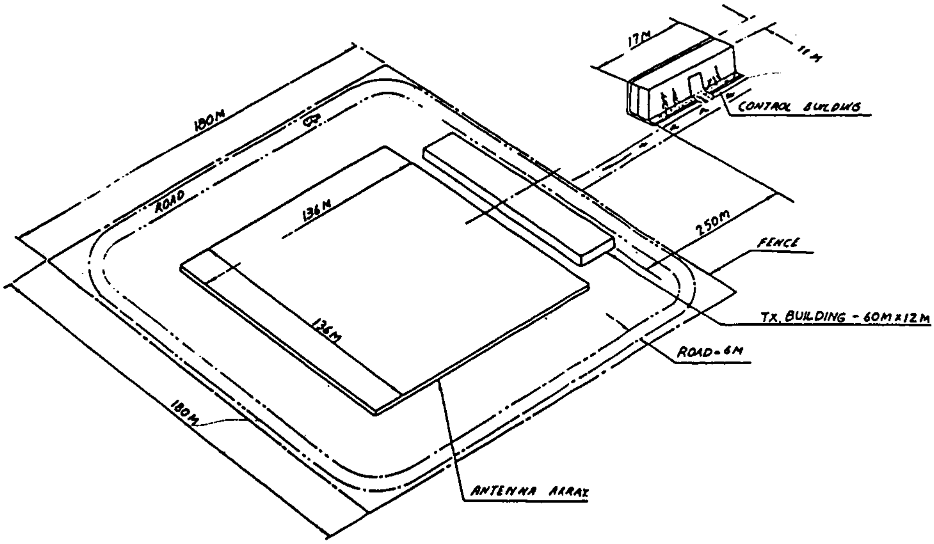

Figure 2. View of antenna site and equipment buildings for MST radar.

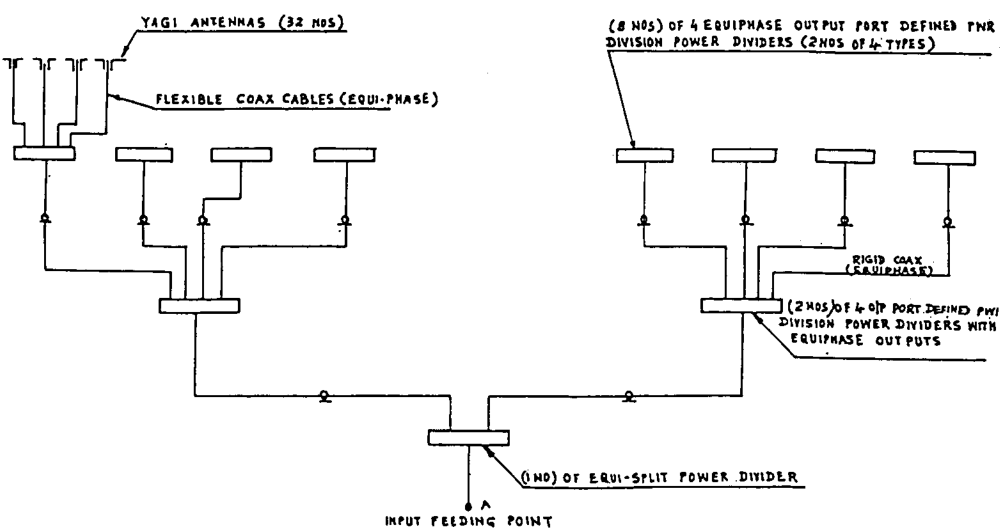

Figure 3. Subarray feeding network.