5.2A CAPABILITIES AND LIMITATIONS OF THE JICAMARCA RADAR AS AN MST RADAR

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LOCATION

The Jicamarca radar (Long. 76.52W, Lat. 11.56S) is located at 20 km from Lima at approximately 500 meters over sea level. It is surrounded by mountains which provide a good shield from man-made interference. The radio horizon goes from a few hundred meters, across the dry valley where it is located, to 15 km, along the valley in the direction of the continental divide. This limits the clutter to 15 km, except for one high peak at 21 km. It is the most equatorial of all existing MST radars. Its proximity to the Andes, makes its location unique for the study of lee waves and orographic-induced turbulence.

ANTENNA

The Jicamarca antenna is the largest radar antenna in the world. It is a flat and almost horizontal array of cross-dipoles, covering an area of 300 m by 300 m (9 Ha). It has a center frequency of 50 MHz with a bandwidth of 1 MHz (determined by power combiners and splitters at the feed point of the antenna).

The antenna consists of 64 identical and fixed squared modules of 144 cross-dipoles each. They are grouped into 4 squared sections with 2 independent feeds for each quarter, one for each linear polarization. Steering of the full antenna, or of each of the quarters, can be accomplished by manually inserting phasing cables into each of the modules. Each linear polarization can be steered independently, at both the quarter and full antenna level. Maximum practical steering is $\pm 3°$ from the on-axis position. On-axis position is 1.4° to the SW from zenith. Exact vertical pointing can be achieved with a special set of cables. Positions $\pm 3°$ from zenith have been used to determine vertical and E-W and N-W projections of MST horizontal velocities (WOODMAN and GUILLEN, 1974). Full aperture radar beam width is of the order of 0.5 degrees. This is an important parameter for MST spectral width interpretation, since it reduces the effect of beam width spectral broadening to a fraction of turbulent broadening.

Maximum power handling capacity is at least 6 MW.

Performance of the antenna is very close to that of a full squared aperture with an ohmic efficiency of 0.8-0.9.

Vertical as well as horizontal projections of MST velocities are obtained by simultaneously pointing with different sections of the antenna into 3 or 4 different directions. Usually positions at $\pm 3°$ and north or south from the on-axis vertical position are used for this purpose.

The possibility of splitting the antenna into different sections permits observations in an interferometer mode to determine size, position and velocity of structure smaller than the beam width (RUSTER and WOODMAN, 1976).

TRANSMITTERS

The transmitting system consists of a battery of 4 independent transmitters with a nominal power of 1.5 MW each. Maximum real obtainable power, when the tubes are new is of the order of 4 MW total. Maximum duty cycle is

5%, which translates into 200 kW of average power.

The output power of the transmitters can be combined, or split, in a variety of modes to feed either the full antenna or fractions of each, forming in this way independent transmitter-antenna units. The relative phase of the transmitters can be changed at exitation level permitting the synthetization of different polarization via Hybrid combiners.

The bandwidth of the transmitters is limited by a fairly large cathode to grid capacitance, which, when turned, produces a high Q circuit with a bandwidth of the order of 50 kHz. This relative narrow bandwidth limits the altitude resolution to $\simeq 2$ km.

The combination of antenna size, power and frequency makes Jicamarca the most sensitive MST radar in the world. Even at this level, its sensitivity to obtain echoes at 45-km altitude is marginal.

The operating frequency at 50 MHz is an asset. Given sufficient power aperture product the maximum altitude obtainable by an MST radar is determined by the altitude at which the turbulence inner scale is comparable to the radars wavelength. The longer the wavelength the higher the altitude.

The Jicamarca radar is the only MST radar in existence which can obtain echoes all the way from tropospheric to mesospheric altitudes, including a region of very weak echoes around 45-km altitude.

A part of the large power transmitters, there are four smaller transmitters, similar to the ones used at the Poker Flat array. Each unit is capable of transmitting 10 kW of peak power at 1% maximum duty cycle. Their bandwidth is much wider than the larger transmitters, permitting 1 µsec pulses which correspond to 150 meter resolution.

Recently, one of the 1 MW transmitters has been modified to take a different final amplifier tube. The new tubes, apart from costing a fraction of the cost of the present ones, has one order of magnitude wider baudwidth. Preliminary tests with the new design indicate that 1.5 MW peak power and 1 µsec rise could be obtained. At present the only limitation of the radar for optimum MST observations is its reduced altitude resolution. With the new modifications a 150-meter resolution will be achieved with the largest power aperture of all MST radars.

RECEIVERS

There are 4 independent receivers, sharing a common L.O. Signals are converted to a 30 MHz IF, where most amplification is performed and then converted down to two quadrature signals (complex coherent detection) at zero frequency. Bandwidth is determined at this level with Bessel filters. They are manually adjusted to match 1, 3, 5, 10, 30, 50, 100, 300 or 500 µsec pulses. Receiver noise figure is of the order of 3 dB. But signal sensitivity at these frequencies is determined by sky noise.

DATA ACQUISITION, PROCESSING AND CONTROL

Data acquisition, processing and control is based on a general-purpose computer and two in-house-designed units, one for control of the radar and sampling and the other for data acquisition.

The computer is Harris/6 model, with 156 kiloword (24 bit) of memory running under a Vulcan System. It has two disk units with 80 Megabytes of

storing capacity each. Bulk recording is made on a 25 in/sec tape recorder for 800 and 1600 bbi/sec (three other 24/sec, 800 bbi. Transports from a previous unit are being modified and integrated.) There are two CRT, 1 graphics, 1 alphanumeric terminals and 2 Heathkits Z-81 microcomputers connected to the computer. Usually two, one CRT and one graphics, are assigned to the radar for operations. There is a Versatec electrostatic and an Annadex dot-matrix printer, both with graphic possibilities, connected to the system.

The data acquistion system is under development. A minimum working configuration is already in operation. Plans include a preprocessor, capable of coherent integrating and other incoherent scatter processing operations, which is now under construction.

The working configuration consists of an 8 bit ADC with a maximum converting speed of 20 Mega-samples per second. Eight channels can be sampled and processed simultaneously. The 8 input signals are connected to 8 sample-and-hold units whose output is multiplexed into the ADC. The ADCs are now connected to a computer channel assigned exclusively to this function, eventually through a buffer memory and preprocessor. Maximum input rate into the computer is closed to 1.2 megabytes per second. When the buffer memory of the preprocessor becomes operational, the maximum sampling rate will be .8 μsec^{-1} for two receiver channels in parallel corresponding to a maximum resolution of 125 meters.

The radar controller is designed around the original idea of the first radar controller built at Jicamarca, now a popular scheme in many incoherent scatter and MST radars. A sequence of two parallel words, one defining the state of 8 control lines and the other the duration of the state, are read consecutively from a memory unit preprogrammed by the main computer.

Experiments can be pre-scheduled using a Harris Job Control language sequence which is defined by the user. At any time, the defining parameters can be changed interactively by editing the contents of a software panel which is displayed continuously on a CRT and contains all variable parameters. These parameters can also be preset by editing a set of the panels to be used in an experiment beforehand, in accordance with the requirements. Usual observing programs are provided by the Observatory. The user can also write his own programs. There are existing real-time data acquisition and control subroutines, which relieve the user from the need of familiarizing himself with the computer and data-acquisition system. (See Figure 1 for schematic diagram of the Jicamarca radar.)

(The reference in this paper is included in the Publications listed below.)

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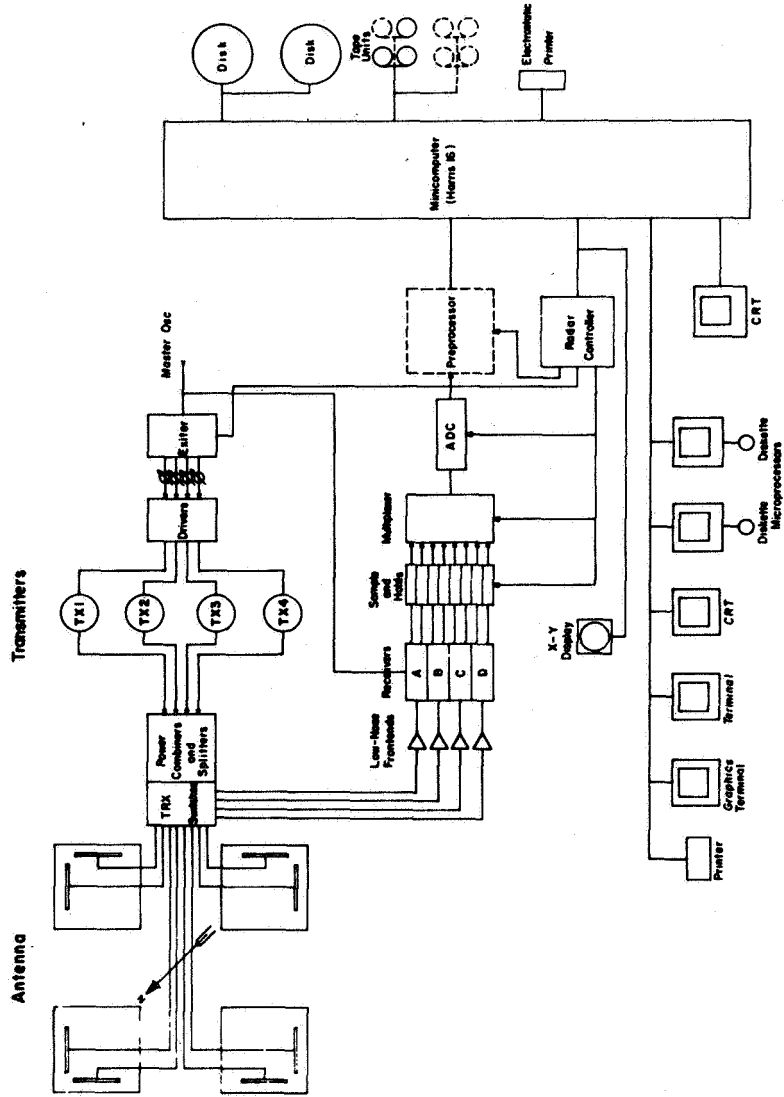
Figure 1. Schematic diagram of the Jicamarca radar.

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