W-Band ARM Cloud Radar – Specifications and Design

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Abstract

The Atmospheric Radiation Measurement (ARM) Program and ProSensing, Inc. have teamed to develop and deploy the W-band ARM Cloud Radar (WACR) at the SGP central facility. The WACR will be co-located with the ARM millimeter wave cloud radar (MMCR) with planned operation to begin in early 2005. This radar will complement the measurements of the MMCR and will aid in filtering out insect contamination in the data. In this poster we present the design goals, expected performance characteristics, and the detailed design for the WACR.

Introduction

The MMCR has been operating at the Southern Great Plains (SGP) site since 1998. It has proven to be one of the most sensitive cloud radars in the world. Operating at 35 GHz, it has also proven to be highly sensitive to insects in the boundary layer. This makes retrieving cloud properties extremely difficult during a major portion of the year (typically spring through autumn). Culminating with the Multi-Frequency Radar intensive operational period (IOP) in 2001, a recommendation was submitted to the ARM Cloud Properties Working Group to support the permanent addition of a W-band cloud radar at the SGP site. With this approval, an ad hoc working group was formed to develop specifications for such a radar. After several iterations, the specification was sent out with a Request for Proposal to build this radar. ProSensing, Inc. of Amherst, Massachusetts was awarded the contract to design and build this radar. The contract was placed in October 2003. Delivery of the WACR is expected in early 2005.

Key Design Specifications

- Radar type   zenith pointing pulse Doppler radar
- Frequency   95.04 GHz
- Range   15 km
- Range resolution   45 meters (minimum)
- Sensitivity   -40 dBZ at 2 km

- Polarization — transmit single linear polarization, receive co-polarization and cross-polarization
- Spectral resolution — 512 point FFTs
- Data storage — spectral moments, full spectra, and I/Q raw data
- Enclosure — mounted in same shelter as the MMCR
- Antenna — 0.6 m Cassegrain
- Transmit power — 1.7 kW typical (1.4 kW minimum) 1% duty cycle

Radar Design

The WACR will inherit many of the design features of previously fielded ground based and airborne cloud radars.

The Preliminary Design Review was held on November 7, 2003. The design was refined and a Critical Design Review was successfully completed at ProSensing's facility on February 3, 2004. The WACR consists of eight major subsections:

1. RF unit containing the millimeter wave section, IF section, and power supplies.
2. 24" diameter Cassegrain antenna mounted inside the MMCR shelter with a flat Rexolite radome window.
3. High flow blower to keep the radome window clear of precipitation.
4. Remotely adjustable flat-plate reflector for periodic corner reflector calibration.
5. Host computer with digital receiver.
6. Oscilloscope for monitoring detected RF signal.
7. Chiller for temperature stabilization of the RF unit.
8. Uninterruptible power supply (UPS).

RF Design

The block diagram (Figure 1) shows the design of the RF sections for the WACR. The design uses a transmitter based on an Extended Interaction Klystron Amplifier (EIKA). The EIKA has proven reliability over many years of use throughout the world. A variation of this tube is being used on CLOUDSAT. Technological advances have also made available Low Noise Amplifiers (LNA) with very good noise figures.

Radar Mounting

The WACR will be mounted in the same shelter as the MMCR. We are planning on mounting it towards the northeast corner of the shelter as shown in Figure 2.

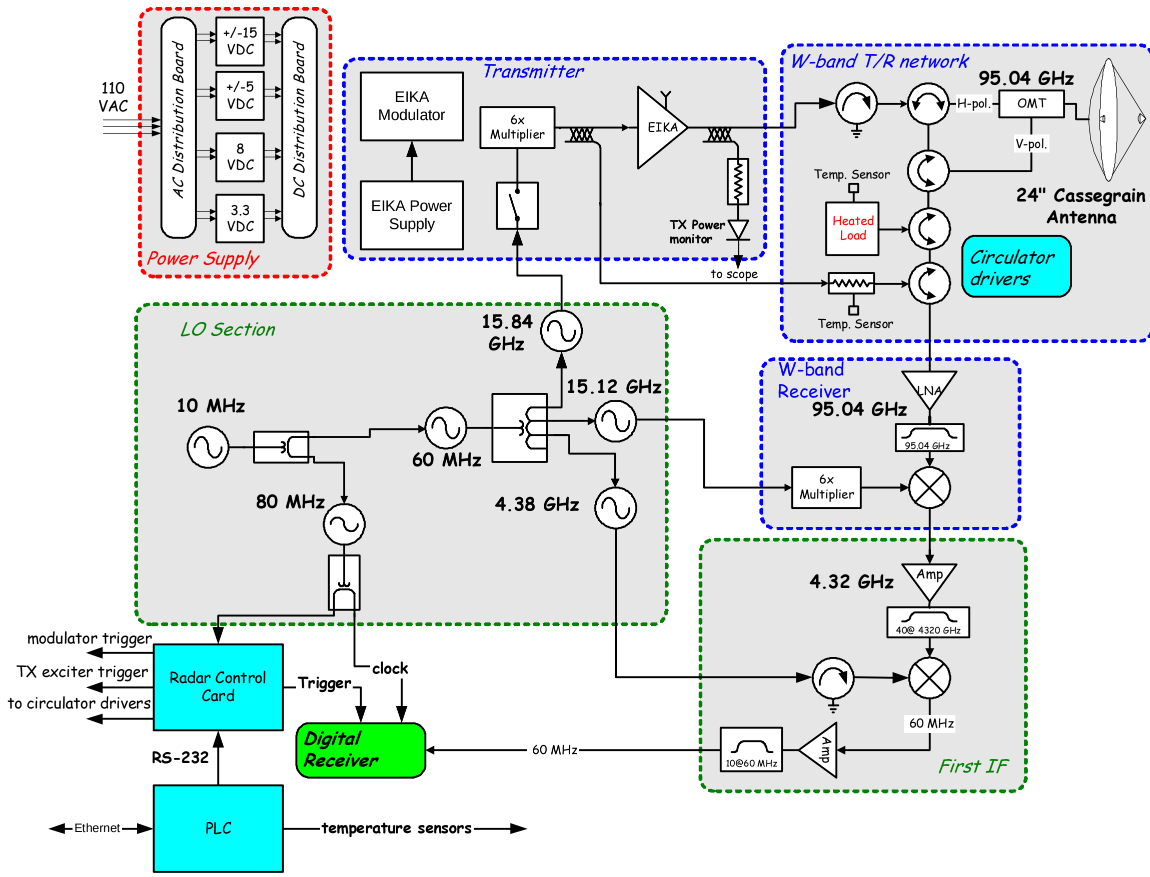

Figure 1. Block diagram.

Figure 2. Northeast corner of the shelter.

Figure 3 shows how the WACR will be mounted to the radar shelter. During normal operation, the splash plate is horizontal. The blower run continuously, keeping the radome free from precipitation (and birds!). During corner reflector calibration (see below), the splash plate will raise and direct the beam at the corner reflector. The turntable allows azimuth adjustment of the splash plate.

The RF unit will be temperature stabilized using a chiller system. With the internal temperature of the radar shelter controlled to moderate room temperatures (4°C to 35°C), the chiller will control the coolant temperature ± 0.1°C.

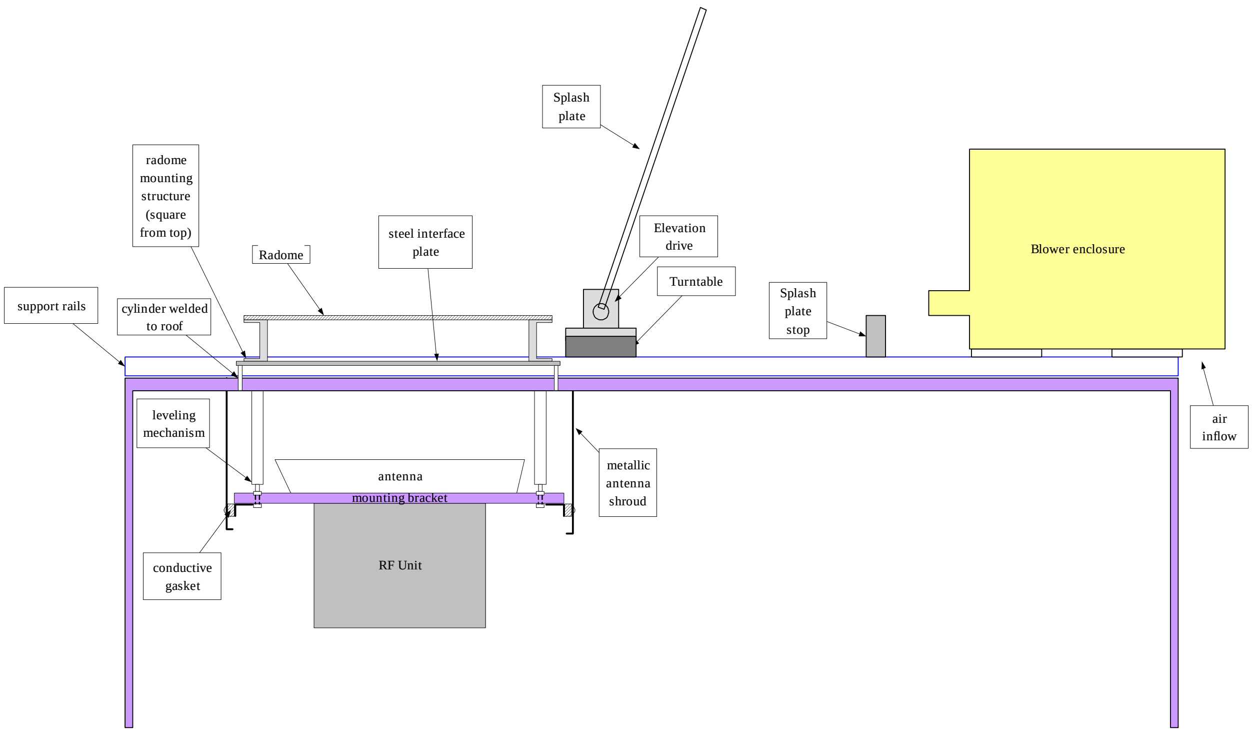

Figure 3. Diagram of WACR mounting.

Calibration

There are two methods to calibrate the WACR. Relative calibration is maintained and checked through the use of two loads, one heated and the other at ambient temperature. The transmitter power is also monitored. However, this doesn't check the calibration of the receiver switches/circulators, the antenna, the radome, and the ortho-mode transducer (OMT).

Absolute calibration will be obtained by raising the splash plate so that the radar beam is aligned with a trihedral corner reflector of known radar cross section. This will be done approximately once per day. Since various environmental factors (wind, rain, ice buildup, etc.) can affect this measurement, we will not automatically adjust the radar constant based on these measurements. This calibration will be tracked. If there is a significant difference from one calibration to the next that cannot be attributed to environmental effects, we will then investigate further to determine the cause of the change.

An added benefit of the corner reflector calibration is that it will help ARM close the calibration between the WACR and the MMCR.

Data Acquisition

As shown in the block diagram (Figure 4), the double converted IF (@ 60 MHz) is digitized by an Echotek digital receiver. The digital receiver performs I/Q demodulation and decimation filtering. The PCI receiver will be installed in a high performance PC running Linux. The control software will be a client/server architecture allowing selected users to view the real time data. This will be quite useful for IOP participants, operations, and mentors. Clients written for both Linux and Windows will be supplied.

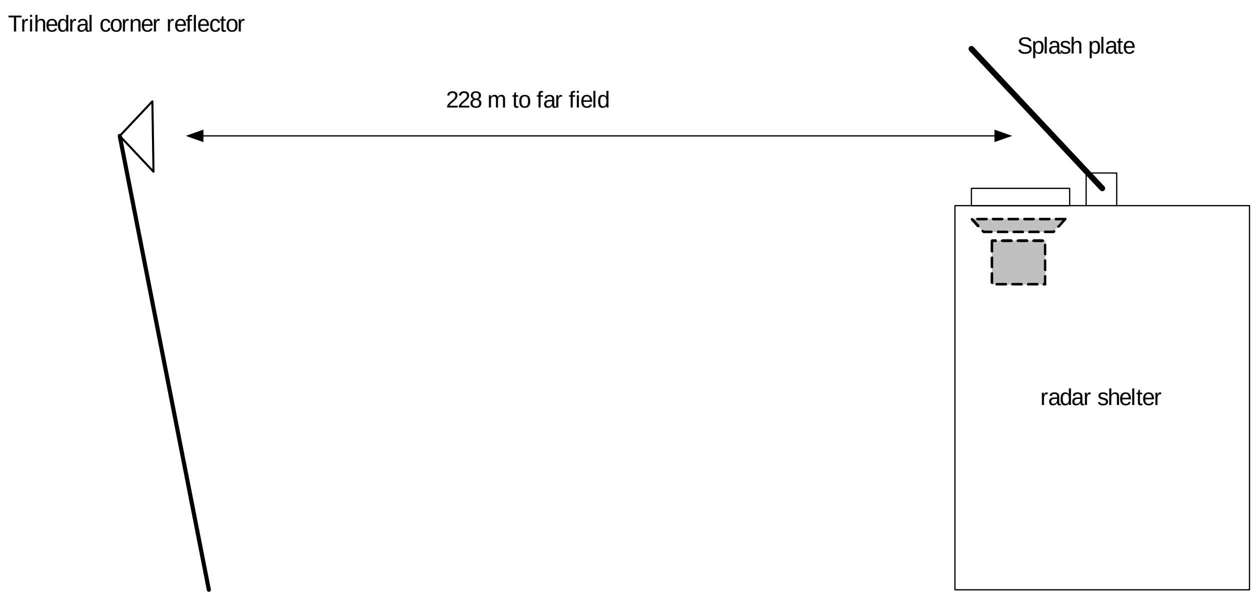

Figure 4. Block diagram.

A Programmable Logic Controller will be used to independently monitor system parameters such as supply voltages and temperatures.

Science Products

The WACR will produce two types of files. Time tagged moment files (reflectivity, Doppler velocity, and spectral width) will be the files most WACR data users will request. Daily data rates are estimated at 400-500 MB/day. We will also be collecting spectra data at rates or approximately 10 GB/day (assuming 512 point FFTs). Spectra files will be save to a removed disk drive for delivery to the ARM Archive. Due to the large size of the files, electronic transfer is not feasible.

The WACR data will also be processed by the active remotely sensed cloud locations value-added procedure. This is the product were users will see the removal of insects.

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