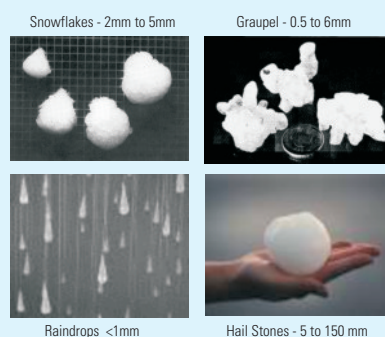




Cloud Radar Receiver and Up-Converter System

Introduction

Millimeter wave cloud radars are radar systems designed to monitor and analyse cloud properties and read the precipitation level. They operate in frequencies between 24 and 110GHz (Ka and W bands). Cloud Radar analyses hydrometeors (various forms of precipitation) depending on the size & shape, classifies it and predicts the weather.



Cloud radar uses dual polarization transmission and receive method to determine hydrometeor shape. The Radar transmits electromagnetic waves of horizontal polarization and receives the scattered wave in both horizontal and vertical polarization components. Targeting with dual-polarization reveals the form of the droplet.

This case study outlines Mistral's expertise in design and development of a Ka Band Cloud Radar Receiver and Up-converter system.

“ This case study showcases Mistral's expertise in design and development of a Ka Band Cloud Radar Receiver and Up-converter system ”

The Customer

The customer is a leading space research agency working in the field of telemetry, satellite tracking and command network among others.

The Requirement

The customer approached Mistral to design, develop, fabricate, test and qualify a Cloud Radar Receiver and Up-converter system.

This was a built-to-spec project that consists of the following modules:

- ▶ OCXO
- ▶ PLDRO
- ▶ Local Oscillators
- ▶ Transmitter Receivers
- ▶ Controller and Power supply
- ▶ AC-DC Power supply

The requirement was to design a rugged chassis that encloses the Transmitter Up-converter, two identical RF Receivers, LO Sources and Controller & DC Power Supply Card. The AC-DC Power Supply Unit was an external unit that has to be integrated with the chassis. The system had to undergo functional and ESS & QT tests, as per the ATP document approved by the customer.

Solution Provided

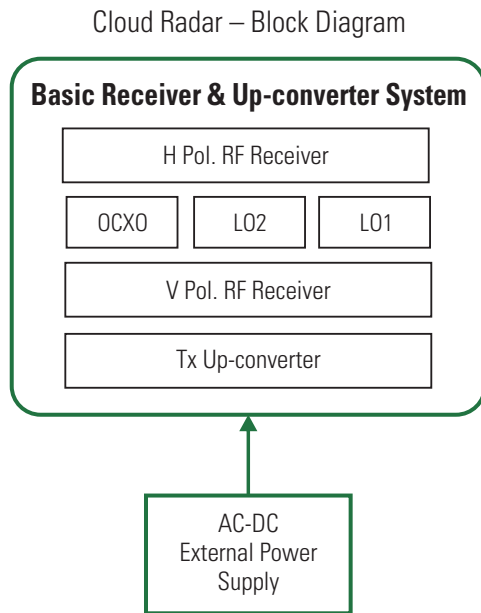
Mistral conducted a detailed requirement analysis to design and develop the Cloud Radar Receiver and upconverter.

The study covered:

- ▶ Signal flow, architecture, and specifications of the complete sub-system
- ▶ Design approach
- ▶ Design of mechanical housing
- ▶ FPGA Firmware & software requirement for testing each module
- ▶ GUI Software requirements for the testing of all modules
- ▶ System Integration
- ▶ Quality and Environmental Qualification requirements

Design Approach

Mistral designed the Cloud Radar upconverter and downconverter by integrating RF-Line replaceable modules/cards inside a rugged chassis with proper mounting provisions, along with the interconnecting RF and power supply cables, and connectors.



The Cloud Radar Receiver and Up-converter Architecture:

The architecture includes transmitter-receiver double heterodyne converters and power supply. The transmitter upconverter module up-converts the base band IF signal (120±30 MHz) to Ka-Band for transmission. Two identical receiver modules in the system down convert the incoming Ka-band receive signal to base band IF signal.

A high stability, low G-sensitivity OCXO [oven-controlled crystal oscillator] is used as a reference signal for S-Band LO and X-band LO sources. S-Band LO source uses Phase Lock Loop [PLL] and X Band LO source uses Phase Locked Dielectric Resonant Oscillator (PLDRO) for the respective LO frequency generation. These coherent LO signals are used for both up-conversion and down-conversion.

All the modules in the Radar system are controlled by the controller and power supply card. The DC Power supply required for various modules have been derived from the external AC-DC Power supply module, which takes AC power (230V ±10%, 50 Hz ± 2%) as input and generates +28V ripple free DC output. The Controller card built around Xilinx Artix-7 FPGA aids configuration and control of various RF modules through respective SPI, I2C and GPIOs. The Controller card also monitors the power supply status and the RF power status as per the check

points in the design and displays the configuration and health status of the system in GUI via the Ethernet 10/100 interface.

Features:

- ▶ Polarimetric Pulsed Radar
- ▶ Transmitter upconverter (Upconverts input frequency of 120MHz to Ka band)
- ▶ Receiver Downconverter (Down-converts received Ka band signals to 120MHz)
- ▶ OCXO for reference signal for S-Band LO and X-band LO sources
- ▶ Controller and Power Supply Card based on Artix-7 XC7A100T FPGA
- ▶ RF Modules configuration through SPI, I2C and GPIO interfaces
- ▶ Transmitter Gain Control and output Power monitoring
- ▶ Dual channel Receivers Gain Control
- ▶ Ethernet PHY Transceiver with RJ45 connector
- ▶ Interfaces for power, System control, UART, JTAG, data bus and GPIO connections.

Software and GUI

Mistral developed FPGA Firmware for IO configuration and enabling monitoring and control of various modules in the Cloud Radar. A GUI, based on LabVIEW platform, was also developed to control the LO2 frequency and gain Tx and Rx chains. The configuration of RF synthesizer and RF up/down converters and adjusting the attenuator values are also done based on the data given through GUI.

This application is interfaced with the system over LAN and supports:

- ▶ LO-2 frequency selection control
- ▶ Power supply status
- ▶ Transmitter Up-converter output power status
- ▶ LO-1 / LO-2 output power status
- ▶ Digital control Attenuators
- ▶ Tuning and standalone testing of the whole syst



Mistral also provided a custom developed ATP software to run functional tests on all deliverable units.

Quality and Environmental Qualification Tests

The Cloud Radar is designed to meet EMI/EMC standards as per MIL-STD-461-E. All interconnecting cables and connectors in the system are provided with appropriate shielding and grounding to ensure EMI/EMC protection and the mechanical enclosure is completely sealed with proper gaskets. The whole system is built using industrial grade components and the chassis is designed to meet IP65 protection standards. The product has undergone thorough electrical stress analysis and thermal analysis.

Cloud RADAR system was tested for following ESS standards:

- ▶ Vibration Tests for Sine Sweep in all three axes and Half Sine Shock [along each axis]
- ▶ IP65 Standards
- ▶ Humidity Test [Damp heat 40 C, 95% RH, 18hrs duration]

Challenges

- ▶ Phase noise is one of the most critical factors to be addressed in highly sensitive Radars. Achieving a phase noise of -90dBc/Hz at 1KHz offset for 32GHz was a big challenge in this project. This was addressed by identifying and sourcing highly stable reference oscillators and PLDRO with excellent phase noise values.
- ▶ Attaining very low receiver noise figure was another major challenge. Implementing two cascaded LNAs in the receiver front end helped in achieving higher gain and very low receiver noise figure.

Achievements

- ▶ Successfully achieved the Low Noise figure [less than 5dB] by maintaining the Gain variability feature in the RF front end.
- ▶ Group delay variation of <10nsec is achieved in the receiver chain by implementing the filters with suitable band widths

Customer Benefits

- ▶ Reduced end-to-end product development cycle and on-time deployment at the end system
- ▶ A fully integrated ready-to-deploy solution, compliant with functional and environmental standards was made available..



Mistral Solutions Pvt. Ltd.,
No.60, 'Adarsh Regent',
100 Feet Ring Road,
Domlur Extension, Bangalore - 560 071
Tel: +91-80-4562-1100
Fax: +91-80-2535-6444
E-mail: info@mistralsolutions.com

Mistral Solutions Inc.,
43092 Christy Street
Fremont, CA 94538
USA
Tel: +1-408-705-2240
E-mail: usa@mistralsolutions.com

Branch Offices:
INDIA
• Hyderabad
• New Delhi
USA
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