

Digital Receiver with Interference Suppression for Microwave Radiometry

**NASA Instrument Incubator Program
Interim Review**

PIs: Joel T. Johnson and Steven W. Ellingson

**Department of Electrical Engineering
ElectroScience Laboratory
The Ohio State University**

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PIs: Joel T. Johnson and Steven W. Ellingson, The Ohio State University

Description and Objectives

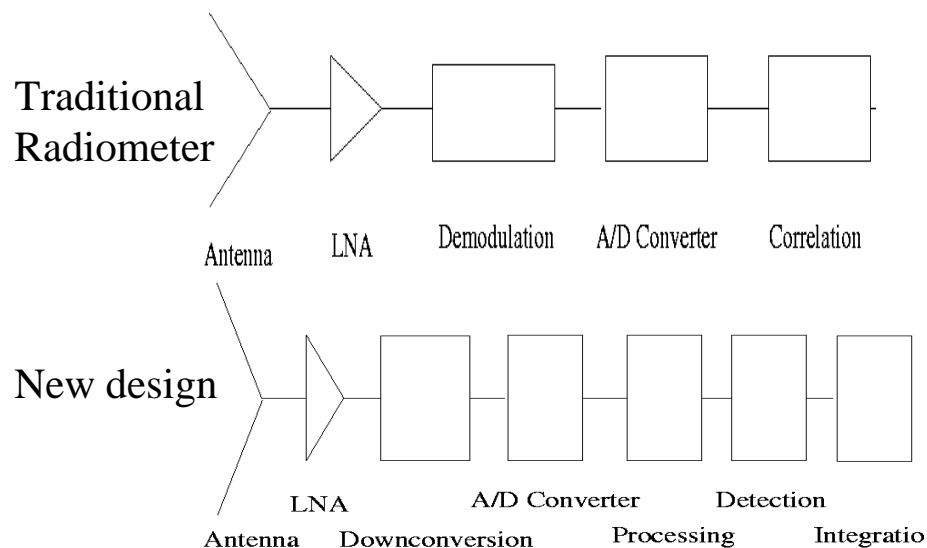
Future sea salinity and soil moisture remote sensing missions depend critically on L-Band microwave radiometry. RF interference is a major problem and limits useable bandwidth to 20 MHz. An interference suppressing radiometer could operate with a larger bandwidth to achieve improved sensitivity and more accurate moisture/salinity retrievals.

Approach

A prototype radiometer will be designed, built, and used to demonstrate operation in the presence of interference. The design includes a processing component to suppress interference.

Co-I's/Partners

Dr. Grant Hampson, OSU



Schedule and Deliverables

Year 1: Complete design and begin construction

Year 2: Finish construction and begin tests

Year 3: Demonstrations and space system design

Application/Mission

Results will apply to all future microwave radiometer missions. Future L-band soil moisture and salinity missions are primary focus.

Project Schedule

Digital Receiver with Interference Suppression for Microwave Radiometry

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Start Date	End Date	TASK	2002												2003												2004												
			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
3/11/02	8/31/02	Complete Instrument Design and Order Parts	▲										▼																										
9/1/02	11/30/02	Progress in Breadboard Instrument Fabrication and Algorithm Development											▲		▼																								
12/1/02	5/31/03	Progress in Breadboard Instrument Fabrication and Algorithm Development																																					
6/1/03	11/30/03	Complete Breadboard Instrument Fabrication; Progress in Laboratory Tests																																					
12/1/03	5/31/04	Progress of Studies of Space Deployment and Advanced Algorithms; Progress of Larger Scale Observations																																					
6/1/04	11/30/04	Progress of Studies of Space Deployment and Advanced Algorithms; Progress of Larger Scale Observations																																					

- Project “year 1” is 9 months, 3/11/02-11/30/02; interim review held at 4.5 months

Current Progress

- Progress toward the first milestone has been excellent since project inception; work has focused on
 - radiometer front end design (antenna to A/D)
 - back end processor design (after A/D)
 - planning for outdoor experiments in year two
 - measurements of local RFI environment
- Evaluation of commercial A/D and FPGA hardware has determined suitable parts for this project
- Major effort on back end processor, including downconversion, “pulse blanker” and “FFT” stages
- RFI tests show a strong 1331 MHz source: ATC radar in London, OH (~45 km away); 1325-1425 MHz proposed for instrument band
- RFI monitor system for NASA P-3 flights in progress

Radiometer Front End

- Front end design is relatively standard super-heterodyne system
- Expected receiver temperature in range 250-350 K
- Single downconversion design with a tunable LO; 1277-1427 MHz tuning range possible
- Proposed 100 MHz bandwidth split into two 50 MHz backend channels due to A/D limitations; parallel hardware in LO/Mixer stages
- Several choices made to improve stability:
 - minimize front end gain (~46 dB) due to high dynamic range A/D
 - ultimate bandwidth set digitally; use low order analog filters
 - noise source and temperature monitored terminator for internal cal
- Plan for thermal control of front end will be developed based on initial tests; may not be required for some experiments
- Analog “blanking” switch included to limit backend signal levels, remove potential IF amp transients
- Basic design complete; majority of parts have arrived

Back End Processor

- A/D survey selects Analog Devices 9410 for A/D (10 bits, 200 MSPS operation, \$200 with evaluation board)
- Sections:
 - digital IF (DIF): Each parallel channel is digitally filtered to bandwidth 50 MHz and frequency shifted so that parallel channels can be recombined into final 100 MHz complex data stream
 - asynchronous pulse blanker (APB): Data stream is compared to an adaptive threshold to detect presence of “pulsed” signals; data is blanked upon detection
 - FFT excision (FFTE): Data stream is windowed and passed through an 1024 point FFT; individual bin power levels then compared to a threshold for blanking of narrowband interference
 - Output section: Data is integrated and transferred to an external computer
- Detailed designs of digital IF and APB completed and simulated; FFTE section initial design complete
- System will be implemented in FPGA hardware; suitable parts, design systems, and board suppliers identified; now testing some blocks

Experiment Planning

- A series of experiments with the prototype will be conducted at ESL in years two and three for verification
- Observations of a large water tank planned; external cal sources are ambient absorbers and a sky reflector
- For operation in far field, spot size on ground proportional to antenna size; choose antenna diameter 1.2 m as a compromise between angular resolution and spot size
- Antenna provides ~15 deg beamwidth; operation from ESL roof yields antenna height ~10 m
- Resulting 3 dB spot size is ~ 6 m x 3 m for 55 deg operation; water tank should be approx. 20' x 10'
- Cal targets will be of identical size to reduce effect of background contributions; time series of observations will be correlated with target temperatures
- Selection of parts (antenna, feed, antenna mount, temperature recording equipment, cal loads) currently in progress

RFI Environment Studies

- Measurements of RFI at multiple locations needed to develop robust interference suppression algorithms
- Spectrum analyzer delivered 5/16/02; local environment tests in progress with low gain antenna on ESL roof
- ATC radar at 1331 MHz will provide an excellent source for testing APB design
- Characterization of weaker interferers in progress; needed for testing FFTE design
- RFI monitor sensor under development for inclusion in NASA P-3 flights; possible dates mid-late August 02
- RFI monitor will include spectrum analyzer for wideband survey, custom narrowband sensor to digitize 1413 MHz region
- Recent visit to Wallops to examine possible antenna mounts; monitor completion should be possible by flight dates
- Data will be useful for IIP project and for NASA personnel (help reduce interference susceptibility of their narrowband radiometers)

Budget Status/Personnel

- Budget for year 1: 239.5K + 21K equipment
- Remaining as of 6/30: ~110K + 0K equipment (22K/month for 5 mo)
- No cost under- or over-runs are expected

- Personnel:
 - J. T. Johnson: co-PI
 - S. W. Ellingson: co-PI
 - G. A. Hampson: Research Scientist
 - D. R. Wiggins: Graduate student (graduated June 02)
 - Currently screening graduate student candidates for Oct 02

- Document Server (password protected):
<http://esl.eng.ohio-state.edu/~swe/iip/docserv.html>

Plans for Remainder of Current Period

- Complete front end and backend processor designs (esp. FFTE block)
- Begin front end and back end processor construction
- Initial tests of front end and backend processor performance
- Continue local RFI survey
- Complete RFI monitor system and include in August P-3 flights
- Continue planning for external experiments; finalize and order necessary parts

- YEAR 2: Complete entire system construction and deploy in external measurements

- YEAR 3: Continue external measurements for conclusive demonstration; studies of deployment in space