Minutes of OTC telecon, Thursday, December 20th 2007, 15:30 UTC.

Last revised 2007-12-20, DTE.

OTC members present: Rich Bradley, Walter Brisken, Darrel Emerson (chair), Rick Fisher, Tony Kerr, Rich Lacasse, Matt Morgan, Peter Napier, Roger Norrod, Marian Pospieszalski, Art Symmes,, Dick Thompson & John Webber.

Dial-in number:

Note that this is a new number, which has not been used for an OTC telecon before.

Toll-free number: 888-981-0239
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Passcode information:

Participant Passcode: 6242692
(Leader Passcode: 3471986)

Agenda :

1. Recent R & D developments at NRAO..... Rick Fisher

2. Reports from some specific development projects..... Peter Napier
   This is the first of a series of reports to the OTC,
   designed to keep everyone informed of technical
   development efforts taking place work around NRAO.

3. The future role of the OTC.
   Suggestions and comment from..... Darrel Emerson

1. Recent R & D Developments at NRAO

In advance of the meeting, Rick distributed some summaries. These are reproduced at the end of these minutes below, and are also available via the OTC web page at http://www.nrao.edu/~demerson/OTC/ . Tony Kerr distributed a summary of SIS Receiver Development Projects 2006-2007, which is available at http://www.tuc.nrao.edu/~demerson/otc/SISprogress20062007.pdf .
The reports include brief status reports on the three R&D projects funded in FY07 from the $75K R&D fund. The reports are not intended in any way to be an exhaustive list of development projects, but it is impressive to see how much is going on in the various labs.

In discussion, Rick mentioned that we have more resources than ways of using the resources. A serious limitation is the pressure on research engineers within projects, with their deadlines, making it difficult to find time for true research activities; inevitably the projects take higher priority. There is a slight problem with available space lab, although this is now less tight at Socorro, with EVLA and ALMA now over the main hump of activity, then it is at the NTC. A small amount of space for offices may be available, but lab space is more of a problem. This situation will certainly continue at the NTC until ~2012.

There is pressure from NSF for NRAO to consolidate, and there is to be an operations review from AUI. However, there are still 6 years left on the lease of the NTC.

Should we be managing R&D activities more, perhaps actively soliciting individual engineers to take part in research activities? This may make it easier for engineers to free some time up from their project commitments.

Darrel asked that OTC members send thoughts on this to him, which he would collate. This will probably be the subject of a future OTC meeting.

2. Research Activities in Socorro

Peter gave a summary of projects in progress in Socorro; there is a summary at the end of these minutes.

3. Future Role of the OTC

Darrel introduced this topic; the role of the OTC has now changed somewhat, since R&D activities are being marshalled by Rick Fisher. One purpose of the OTC was to advise the Director, but much of that is taken over directly by Rick, with some advice from the OTC.

Tony reminded us that one function of the OTC is to review R&D proposals; this will continue.

Another role of the OTC is to facilitate communication between different technical groups at NRAO; perhaps the OTC should be putting more effort now into this aspect. This might involve inviting Heads of Electronics from different sites to participate in OTC meetings; we might recommend that there be regular – perhaps quarterly – meetings of Electronic Division managers from across the observatory. We should also ensure that there is adequate representation on the OTC from all sites.

Darrel asked OTC members to think about this, and to send email to himself and the OTC with ideas of what we should be doing. Further discussion will be held at a future OTC meeting.

Action Items:

Please send ideas and suggestions to Darrel and the OTC, on (1) the evolving role of the OTC, and in particular (2) on how to improve communication between different technical groups of NRAO.

DTE, 2007-12-20

REPORTS sent to the OTC

(See also Tony's summary of SIS Receiver Development Projects 2006-2007, available at http://www.tuc.nrao.edu/~demerson/otc/SISprogress20062007.pdf .)

R&D Report to OTC, December 2007

October 1 of this year marks the beginning of the R&D program that is intended to grow over the next few years from its FY08 budget of $200K. The core theme is "radio cameras" or, more specifically, centimeter-wave beam-forming arrays. This is a report on activities so far.

After consultation with Jim Ulvestad, Head of the NIO, and Richard Prestage, Green Bank Site Director, we decided that beam-forming arrays are within the scope of NRAO contributions to SKA so most of Roger Norrod's half-time assignment to SKA can be devoted to this effort. We hoped to add half-time research engineer from the CDL to the R&D program this year, but John Webber tells us that the production demands of ALMA will not free anyone in FY08. We are looking into the possibility of offering a short-term visiting appointment to a PhD-level engineer with experience in relevant technology. Hopefully, we can engage the interest of CDL research engineers on an informal basis.

The biggest impetus to this effort has come from our BYU collaborators, who built a 19-element dipole array and installed it on the 20-meter dish in Green Bank. Preliminary results from their test session in early November showed that they could calibrate the array on a strong point source (Cygnus A) using a covariance matrix optimization for best SNR. This algorithm gave a 39% increase in Cyg A to Tsys ratio over that measured with the central dipole alone. Array calibration has been an issue for which we did not have a clear solution, and the BYU group may pointing us in the right direction. They also demonstrated effective RFI cancellation with the array beam-forming algorithms with constraints on main beam and sidelobe gain to minimize side effects on the astronomical measurements. They still have a lot of data to analyze from this run. Their array had a fairly high system temperature of about 120K, but it's a start. They intend to install lower noise room-temperature LNA's to reduce Tsys below 50K and add the second linear polarization for more trials on the 20-meter, possibly in the spring. They have submitted an ATI proposal to the NSF to continue this work when their current grant expires at the end of FY08. Norrod and Fisher are Co-PI's on this proposal. More information about the BYU-20meter experiment project is available at:

http://wiki.gb.nrao.edu/bin/view/Electronics/ByuFpa and
http://wiki.gb.nrao.edu/bin/view/Electronics/ResultPresentations

The NRAO side of this collaboration on beam-forming array research primarily addresses low-noise issues and validation of electromagnetic simulations of array performance on the antenna range.

Because the LNA's are closely coupled to the array elements, the whole array probably needs to be cooled and, unlike horn feeds, the entire forward hemisphere of the feed must be clear of lossy and conductive materials. This presents a challenging thermal isolation problem. Our first experiments will attempt to draw a vacuum in a cavity hollowed out of low-loss foam that has been used for waveguide vacuum windows. If this is successful, we'll try cooling an L-band dipole in this cavity to measure its heat load. Simulations with the CFdesign thermal analysis software suggests that heat loss through foam in contact with the dipole will be excessive, but radiative loading in the vacuum should be tolerable.

Another thermal issue that needs to be addressed is how much of a noise penalty will we suffer from cooling the array to 50 Kelvin physical temperature instead of 15 or 20 K. For a given cooling capacity, 50 K refrigerators are much smaller and lighter than the 15 K Gifford-McMahon that we are currently using. We purchased a Sunpower CryoTel Model GT Stirling cycle unit for evaluation, and we are in the process of building a Dewar for it in Green Bank. Before making this purchase, Norrod, White, and Fisher visited the Sunpower plant in Athens, Ohio to learn more about the technology and discuss possibilities for lower temperature Stirling cycle designs. They built an experimental unit on a NASA contract that achieved better than 30 K, but it required a rare-earth regeneration material that is too expensive to produce for small quantity applications. A two-stage device is a possibility but requires a substantial R&D contract to determine its feasibility. We need to determine the noise performance vs physical temperature trade-offs for our applications before talking further with Sunpower. Information on the Sunpower refrigerators can be found at:

http://www.sunpower.com/index.php?pg=79

To evaluate the computed electromagnetic properties of our beam-forming arrays we need to enhance the efficiency of the Green Bank outdoor antenna range. This facility is in need of a substantial overhaul so several engineers from Green Bank and Charlottesville met in November to discuss plans for upgrading the range's capabilities. We need to be able to measure at least 37 array element patterns simultaneously and automate the turret, frequency generators, and polarization rotator so that data can be acquired and processed reasonably quickly and efficiency. This upgrade will extend at least through next summer. Because the array elements are low gain, wide beamwidth devices, we need to characterize the antenna range for errors due to reflections from surrounding structure and, if necessary, take steps to mitigate them.

Additional report to the OTC on R&D activities for discussion at the Dec. 20, 2007 meeting

Three projects were funded in FY07 from the $75K R&D fund. The following is a brief status report on each:

Evaluation of HBT MMIC Processes for Second-Stage Cryogenic LNAs ($7K), Morgan and Bryerton

Three different sizes of 0.8um emitter width InP HBTs have been characterized cold: 5um, 8um, and 12um. Based on these measurements, we have seen increases in Beta at 12K of about 15% and small differences in gain (Gm). We will be testing one more size device, the 6um HBT. Using small-signal models provided by NGST, we will integrate these temperature dependencies into the noise model to predict the noise improvement cold. Based on measurements so far, it can be estimated that the improvement will be fairly marginal since the dominant contribution to noise is the shot noise from the base current, which is dependent on Beta. The devices do work cold, however, and their performance may perhaps be good enough as second or third stage transistors in a hybrid HEMT/HBT amplifier. We should also investigate further recent, and extremely promising, results of SiGe HBTs at cryogenic temperatures [1], where the Beta and Gm undergo huge improvements when cooled.

Further information can be obtained from this project's wiki page

https://wiki.nrao.edu/bin/view/Main/CryoHBT

[1] S. Weinreb, J. Bardin, and H. Mani, "Design of cryogenic SiGe low-noise amplifiers," IEEE Trans. Microwave Theory Tech., vol. 55, no. 11, Nov 2007, pp. 2306-2312

A Broadband Cryogenic Active Feed ($15K), Bradley, Norrod, and Gawande

We are developing a second generation conical sinuous feed aimed toward meeting the FASR design requirements. This is also a prototype for a cryogenic version that may have application to the SKA and other projects that require a very broadband feed. With the latest modifications we expect better control of the feed-point impedance by placing the amplifier behind the ground plane. A new amplifier was developed to provide an improved noise match to the feed over the 0.5 - 2.5 GHz band. Assembly is nearing completion and will be evaluated in Green Bank early next year.

Dielectric and loss tangent measurements at room temperature on various samples of rigid foams have been performed and the results will be published shortly in an upcoming EDIR (in progress). A test fixture has been developed for measuring the thermal conductivity of foam samples at cryogenic temperatures. Construction of the test apparatus is currently underway. Such foams are being studied for use in integrated feed / amplifier structures of a new generation of cryogenic receivers, including a cooled version of the conical sinuous feed..

Slides from a talk about this project given recently at the NTC by Rohit Gawande may be found at

http://www.cv.nrao.edu/~rfisher/Misc/elf_3.pdf

Test Equipment for Wafer-Probe Test Station ($53K), Morgan and Bryerton

We have collected a considerable amount of new equipment and have almost everything working. Some of the highlights:

We upgraded the objective lense on the microscope for a wider field of view, allowing us to see both ends of the MMIC at one time which is much safer for landing the probes.

We had the shop make for us a number of mounting brackets and other hardware to give us maximum flexibility in positiong the probes. We can now use up to four probes at once in the North, South, East, and West positions. Two of our positioners can carry up to 10kg, which is useful for mounting test modules like mixers and signal sources very close to the chip under test. While the micropositioners allow precise movement within a half-inch radius, the special adapter plates we made give you course adjustment over several inches in any direction. Even more significantly, we can adjust the vertical height of the probes by inches as well. This is quite different from most commercial setups where they only probe single chips on-wafer, which are very small and always at the same height. The flexibility we have with this system allows us to also probe whole MMIC-chains inside a module which might be 3/4 of an inch high and could extend laterally by several inches.

Most of our effort so far has actually been getting the surplus 8510 VNA that we acquired up and running. We got a new synthesizer and a millimeter-wave test set which allows it to operate up to 50 GHz. We still need to make a few minor repairs: the fan on the millimeter-wave test set needs to be replaced, and the disk drive on the 8510 is twitchy. But basically it works.

We have acquired all the probes and calibration substrates we need to do probe-measurements up to 50 GHz. All we lack is a single cable for which the supplier lost our order.

Here is a sample of other development projects going on around NRAO:

At the CDL:

Microwave loss reduction, Kerr and Finger

In addition to the microwave loss reduction measurements performed on machined conductors of copper and aluminum, and electro plated copper and gold (see attached) we are going to include measurements on annealed gold-plated and copper-plated resonators. In order to do this we will nickel plate brass conductors (nickel as a diffusion barrier), then copper or gold plate the conductors, and then anneal them. We expect a more pronounced loss reduction for the annealed units at cryogenic temperatures. The same measurement set-up will be used.

Submillimeter radomes, Finger and Kerr

Simulations of the performance of different materials commonly used in radomes have been performed. A model to estimate the overall loss of sensitivity due to the radome was developed. The Goretex RF membrane, evaluated at ALMA frequencies, is found to fall out of spec for bands 2 to 5, producing an overall loss of sensitivity of more than 6%. We are now working to

characterize FEP samples at submillimeter wavelengths and an FEP full size membrane will be tested in Chile in the next month.

A new technique for measuring low-frequency antenna patterns (A PAPER project spin-of, Bradley's lab):

A system is being developed to measure the power pattern of a low frequency antenna or array using signals from a constellation of ORBCOMM satellites operating at 137.5 MHz. Preliminary results are encouraging in that a beam pattern can be measured with a dynamic range of over 45 dB and nearby scattering surfaces are clearly visible. Improvements to the receiver hardware and data acquisition / analysis software are
underway.

In Socorro:

(1) EVLA project has demonstrated a 3 bit, 4 Gsps digitizer using a commercial Teledyne part. The digitizer is lower cost than the ALMA approach and will be used for the EVLA.

(2) By placing a high frequency Teledyne track and hold device in front of the 4 Gsps digitizer EVLA has demonstrated direct 2 GHz bandwidth bandpass sampling at frequencies up to 20 GHz.

(3) EVLA is making custom DDS's in FPGA's that perform better than commercial DDS chips at frequencies of a few tens of MHz.

(4) VLBA is collaborating with the Berkeley CASPAR group using the Vertex V FPGA to develop an IBOB-2 board. This will enable 4 Gbps observing with the VLBA.

(5) A computer cluster has been purchased to demonstrate a 4 Gbps software correlator for VLBA.

(6) VLBA is collaborating with Haystack to develop a 4 Gbps Mk V-C digital recorder.

(7) EVLA is now using its new 1-2 GHz cooled OMT for observations. The OMT has recently been modified to make it more manufacturable.

(8) VLA is developing a new fully digital Antenna Control Unit for VLA and VLBA.

(9) VLBA is developing a new Focus Rotation Mount for the subreflector using modern digital controllers and stepping motors to replace obsolete motors on the existing units.

(10) EVLA is now deploying an active 2-4 GHz gain-slope equalizer.

(11) At the ATF work is now underway understanding and using the photonic phase stabilization system used to correct for fiber-length variations in the ALMA LO distribution system.

(12) At the ATF recent testing has led to improved understanding of error sources in near-field holography.

In Green Bank:

FPGA system for the next GBT pulsar processor:

https://wikio.nrao.edu/bin/view/CICADA/NGNPP

K-Band focal plane horn array for the GBT:

https://wikio.nrao.edu/bin/view/Kbandfpa/WebHome