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Report of Contributions

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Contribution ID: **8** Type: **not specified**

WELCOME & INTRODUCTION

Wednesday, 22 January 2020 11:05 (15 minutes)

ESA Technical Officer

Presenter: Dr ANGELETTI, Piero

Contribution ID: **79** Type: **not specified**

Closing Remarks

Wednesday, 22 January 2020 17:25 (10 minutes)

Contribution ID: **80** Type: **not specified**

Kinetic inductance bolometers for radiometric sub-millimeter wave imaging

Wednesday, 22 January 2020 14:25 (25 minutes)

We present the results achieved in the LASTKID (Full name: Large area staring kinetic inductance focal plane arrays operating at elevated temperature) project. The project concentrated on developing passive, (sub-)millimeter wave imaging technology based on kinetic inductance bolometers (KIBs). The space applications in this frequency range include radio astronomy, planetary science and remote sensing. For example, the spectrum of cosmic background radiation (CMB) peaks at this frequency band. An interesting property of (sub-)millimeter waves is that it can penetrate through dielectric materials while still possessing an acceptable spatial resolution as limited by diffraction. This is utilized in person security screening, a terrestrial application that in recent years has started to fulfill its commercial potential.

The basic operating principle of KIB is to absorb THz radiation on a nanomembrane with a resistive absorber, for example, and to detect corresponding temperature variations using the temperature dependence of kinetic inductance in superconducting strip. This leads to a detector technology that can be scaled into large detector arrays as the multiplexed readout of such detector arrays becomes possible by addressing each detector with a characteristic resonant frequency. Furthermore, unlike their millikelvin counterparts, kinetic inductance detectors, KIBs can be operated at an elevated temperature range above 5 K.

To understand the capacity of the technology in space applications and derived ground applications, a feasibility study was first conducted on the subject. In the later stage, a fully-staring THz video camera prototype compatible with ground application specifications was constructed. The camera is equipped with a kilo-pixel detector array, large field-of-view optics, intermediate-scale cryogenics operating at 6 K, and low-noise electronics to read out the whole detector array. Finally, the imaging capabilities of the system were demonstrated through measurements, including radiometric performance characterization and actual imaging experiments.

ESA Technical Officer

Elena Saenz

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Contribution ID: **81** Type: **not specified**

SATREC – software for identification of object on satellite SAR imagery by modelling and recognition of radar signatures

Wednesday, 22 January 2020 17:00 (25 minutes)

Presentation concerns SATREC software that was developed by SATIM within the ESA project "Development of an innovative software called SATREC for identification of objects on satellite SAR imagery by modelling and recognition of radar signatures". SATREC allows stakeholders, even not necessarily familiar with SAR technology, to conduct highly advanced analysis and interpretation of radar images in the context of objects recognition. This software is made flexible enough to be a stand-alone application and, in parallel, a batch processing software that can be incorporated into one of the ESA's Thematic Exploitation Platforms and used by a wide range of users. The developed version of SATREC software consist of two key aspects: modelling synthetic SAR signatures for selected 3D objects (using SSIG module) and recognition of objects based on generated synthetic signatures on real SAR images (using OREC module). The SSIG module is based on a ray tracing technique, which simplifies wave propagation in medium by considering geometrical lines from the wave source to the receiver (forward method) or from the receiver to the source (backward method). Responses of the ray traversal through the virtual scene is interpreted to reproduce that scene as an image. The adaptation of ray tracing technique in SSIG requires a 3D scene and object of which SAR signature needs to be simulated. Therefore, SSIG uses a triangle-based 3D object, the most popular method of object representation for ray tracing technique. By using special programming techniques and GPU cards for computations, the generation of the database of synthetic signatures of selected 3D objects is performed in near real time. This way, the database of signatures is regenerated for each SAR image used for analysis, based on its incidence angle, pixel spacing and other parameters. This helps to significantly decrease the degrees of freedom in the recognition procedure. In the SAR signature simulation Phong reflection model was used. The OREC module implement the idea of objects recognition on satellite SAR imagery using the simulated SAR signatures of objects. The process involves matching those objects (understood as a selected region of a SAR image with an unknown object) with existing patterns from the established database. Object recognition on SAR images within OREC software is conducted based on comparison of the object with database patterns using template matching method. For this method to operate correctly, it is crucial to prepare a database of signatures, which contains all possible representations of analyzed objects. Then OREC recognize an object based on its comparison with patterns, and provide a feedback about patterns, which are visually the most similar and are available in a database. It also provides information about the similarity of analyzed object to the patterns from the database.

ESA Technical Officer

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Contribution ID: **82** Type: **not specified**

Dual probe THz Receiver

Wednesday, 22 January 2020 14:00 (25 minutes)

For the next generation of THz radiometer instruments for deep-space mission exploration, space-borne weather and climate research, as well as for the upcoming class of heterodyne cryogenic receiver arrays for radio astronomy, new integrated solutions are necessary at both circuit and package level. Membrane integrated Schottky diode MMIC technology will continue to play an important role, both as receiver element and for LO generation. We present a high-performance multichip dual-polarisation receiver based on membrane integrated Schottky diode and cryogenic InP HEMT MMIC circuit designs. The concept is based on a practical low-loss GaAs membrane integrated orthomode transducer (OMT) at 424 GHz, which is composed of two orthogonal open-ended E-plane probes in a circular waveguide, integrated with a smooth wall spline horn antenna package. The proposed structure is suitable for building compact dual-polarisation receivers in the lower THz range (~100 GHz – 1 THz) and is readily integrated directly to the first receiver element, in this case a subharmonic GaAs Schottky diode mixer, without any additional penalty in terms of loss or manufacturability.

A on-chip integrated dual polarization 424 GHz receiver employing membrane integrated GaAs Schottky diode circuits with a measured 20 dB cross-polarization discrimination and 900 K typical DSB receiver noise at room temperature, is presented. The receiver utilizes a package integrated smooth-wall spline-horn antenna with a planar ultra-low loss on-chip ortho-mode transducer consisting of two orthogonal open-ended E-field probes. The E-field probes are integrated and co-optimized with the sub-harmonic GaAs Schottky diode membrane mixer circuits. InP HEMT MMIC's covering the 0.2-6 GHz IF band are co-integrated with the mixers for improved gain, noise and stability response. A record low receiver noise of 680 K DSB was measured at 421.7 GHz effective LO frequency and 0.5 GHz IF frequency with excess 10 seconds Allan variance times. The estimated mixer DSB noise was 600 K assuming 9 dB conversion loss and a minimum LNA noise temperature of 20 K. Antenna E-,D-, H-, and cross polar beampatterns were in good agreement with simulations up to +-15 degrees in azimuth direction limited by the truncation of the antenna fixture test setup. The demonstrated novel integrated dual polarization receiver topology offers optimum sensitivity at minimum package envelope and is readily scale able to lower as well as higher frequency bands.

This activity has in part been funded under a GSTP 6.2 ESA contract (No. 4000119261/16/NL/GLC) "Dual probe THz receiver". The research has been carried out in the GigaHertz Centre in a joint project financed by the Swedish Government Agency for Innovation Systems (VINNOVA), Chalmers University of Technology, Omnisys Instruments, Low Noise Factory, Wasa Millimeters Wave, and RISE.

ESA Technical Officer

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Contribution ID: **83** Type: **not specified**

Single GaN Chip HPA/LNA for RADAR Applications

Wednesday, 22 January 2020 11:20 (25 minutes)

A Single GaN chip front-end (SCFE) integrating high power amplification, low noise and robust receiving amplification and high-power switching functionalities has been designed and realised in Leonardo SpA GaN/Si 0.25um technology. The SCFE is aimed at operating in C-Band (5.405 GHz center frequency), for eventual use in ESA Sentinel satellites.
The realised chip is featured by an output power over 40W, with a PAE in the range of 40%, with a 300MHz bandwidh in Tx Mode, while in Rx condition the chip exhibits a noise figure lower than 2.5 dB with an associated gain over 30dB.
The relevant performance of the chip itself, together with the in-Jig ones will be presented and commented, together with the status of the Leonardo 0.25um GaN/Si technology for Space applications.

ESA Technical Officer

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Contribution ID: **84** Type: **not specified**

ITI - Acoustic Transversal Filters

This work has been performed in the frame of an Innovation Triangle Initiative (ITI) and describes a joint collaboration between UPC, QORVO and ESA for the development of verywideband filters based on electroacoustic technology. To achieve this responses a novel filter configuration has been proposed and developed, resulting in a transversal filter topology. In contrast with the most standard filter implementation in acoustic technology, ladder configuration, the filter response does not depend on the so-called electroacoustic coupling coefficient, allowing to achieve acoustic filters with arbitrary position of transmission zeros and bandwidth. The methodology proposed also allows for controlling the impedance of the resonators and their resonant frequencies.
The activity consists on describing all the mathematical procedure for the synthesis of transversal filters with the special emphasis on the non-dependence with the electro-acoustic coupling coefficient. An additional circuit transformation procedure is used to define the filter designing curves where the resonant frequency of each resonator of a given impedance can be selected individually. This allows synthesized filters where all resonator have equal impedance (size) or simple set the resonant frequencies of the resonators in a feasible manufacturing range.
The activity continues by performing an accurate analysis of the practical implementation of a transversal filter, as is the sensitivity with the resonant frequency of the resonator, the losses of the resonators and external components and the effects of deviation in the resonator impedance. Finally the effects of having a non-ideal balun is also considered.

The project concludes by the synthesis, desing and implementation of a first prototype. The presented filter offers a fractional bandwidth and centred close to 4 GHz, being the first presented prototype in transversal topology.

The development is generic although the main application is related to Telecommunications.

ESA Technical Officer

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Contribution ID: **85** Type: **not specified**

Additive Manufacturing of Leaky Wave Antennas

Wednesday, 22 January 2020 12:35 (25 minutes)

Within the frame of a ESA - Networking/Partnering Initiative (NPI) PhD project, the proposed work aims to explore additive manufacturing techniques for fabricating challenging antennas at K and Ka-Band. Stereolithography (SLA) and selective laser melting (SLM) are both investigated, as well as the effect of surface treatments for SLM pieces. The proposed structure is based on a dual-moded waveguide propagating two leaky-waves radiating through crossed-slots cut on the top face. Single and dual-linearly polarized antennas with low sidelobes are conceived at 30 GHz and 23.28 GHz, then manufactured with the high precision and low roughness provided by SLA. Their complexity relies on the fact that both the geometry of the slots and the height of the ridges inside the waveguide are modulated. Especially, the dual-polarized antenna is exhibiting tapered ridges on three internal faces and an orthomode transducer, which make it almost impossible to be done without multiple assembly steps and subtractive fabrication processes. An array of eight leaky-wave antennas operating at 20 GHz has also been produced monolithically with its folded BFN using SLM. Finally, the potential of the proposed structure is pushed further to generate circular polarization, leading to SLM prototypes working at 20 GHz. Measurements show that additive manufacturing techniques allow for high performance antennas operating at microwave frequencies.

The study focuses both in Telecommunications and Earth Observation applications.

ESA Technical Officer

Petronilo Martín-Iglesias

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Contribution ID: **86** Type: **not specified**

Potential of Spaceborne GNSS-R for Land Applications

Wednesday, 22 January 2020 16:35 (25 minutes)

The possibility to use navigation signals for remote sensing purposes has been investigated for several decades. Over the years the potential of this technique has been consolidated for wind scatterometry and sea surface altimetry and resulted in mission concepts being put forward (e.g. TDS-1, CYGNSS, GEROS-ISS).
Over land, the GNSS-R concept was investigated more recently. Its potential to measure soil moisture and vegetation biomass – initially demonstrated through theoretical models and simulators - was confirmed through the analysis of ground-based and airborne measurements. These campaigns also contributed to consolidate the physical understanding of the measurement as well as to mature the supporting theoretical models. However GNSS-R spaceborne observations were so far missing in order to give full confidence in the capability of this technique to provide science products of interest over land from space.
In this activity, the now available spaceborne GNSS-R data (from TechDemoSat-1 and from CYGNSS) were used to assess and consolidate the GNSS-R remote sensing technique over land. The goal was to reach a stage where retrieval performance can be estimated and error sources can be identified.
Several intermediate objectives have been met on the way. They include:
1/ getting an understanding of the sensitivity of the GNSS-R observables over land to the variables of interest (including at least soil moisture and vegetation biomass) and of the factors limiting this sensitivity;
2/ consolidating and validating end-to-end simulation tools in a spaceborne context;
3/ assessing the retrieval performance - in particular in relation to other current/future spaceborne missions providing soil moisture and vegetation biomass - and setting-up prototype retrieval algorithms.
These objectives were met through a combination of GNSS-R data analysis (spaceborne, airborne, ground-based) and the development of physically based forward simulations and inversion algorithms.

ESA Technical Officer

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Presenter: FLOURY, Nicolas

Contribution ID: **87** Type: **not specified**

Development of a highly integrated low cost X-band SSPA

Wednesday, 22 January 2020 12:10 (25 minutes)

SSPAs in X-Band are typically used for downlink transmitters in earth observation missions. This work shows development of a highly integrated SSPA based on GaN HPA for new space market up to TRL 5. The device is included in a small, light-weight chassis and allows to achieve 20 Watt output in the frequency range of 8.025 GHz - 8.4 GHz at a high PAE. The amplifier is able to achieve the nominal output power in the desired frequency range with input signal power range of -20 dBm to 0 dBm. Included are also ALC for thermal and power stabilization based on a custom bias asic and voltage regulators. The SSPA will be further developed up to an EQM in a follow up ESA activity with Tesat Spacecom as partners.

ESA Technical Officer

Vaclav Valenta

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Contribution ID: **88** Type: **not specified**

X-Band TT&C and K-Band Downlink Antennas for Future LEO Missions

Wednesday, 22 January 2020 15:15 (25 minutes)

Recently, a novel X-band multi-filar helix downlink antenna has been developed at RUAG Space. The antenna has been brought to an EQM status within an ESA GSTP program, and flight models are currently manufactured and tested for the MetOp SG satellites, as well as for several US missions. The antenna achieves a peak gain of around 6.5 dBi at EOC and an XPD better than 18 dB, which is superior to much larger aperture type antennas. In another recent ESA study (X-Band TT&C and K-Band downlink antennas for future LEO Missions) X-band TT&C antennas as well as Ka-Band downlink antennas have been designed using the knowledge from the above mentioned multi-filar helix design.

The X-Band TT&C antenna developed is a compact and low mass dual band design for 7.19-7.25 GHz (RX band) and 8.025- 8.400 GHz (TX Band) operation. It thus has a wider transmit frequency band than normally used. It has a hemispherical coverage with an EOC gain of better than -2 dBi to -1 dBi depending frequency. The antenna is fed through a conventional strip-line network to keep the height low and no protrusion inside the spacecraft needed. This antenna is now being manufactured as an EM activity in an add-on to the original study. For high power applications a waveguide fed antenna ca be envisaged.

The machining of the multi-filar helix is challenging, as the cross-section and the required tolerances are quite small. Hitherto, conventional CNC machining has offered a satisfactory yield. As the RF performance is excellent for the X-band antennas in the ESA GSTP program, it is tempting to scale to even higher frequencies. Recently, development was started with ESA/EOPP funding for a Ka-band (26 GHz) beacon and data downlink antenna for LEO earth observation missions. This antenna is one of the alternatives that were in the trade-off for Ka-band antennas in the study for X-Band TT&C and K-Band Downlink Antennas for Future LEO Missions. The frequency scaling makes the antenna very small; including radome and waveguide interface the total height is 76 mm, the interface diameter 50 mm, and the mass less than 130 g. The multi-filar helix radiator per se is only 44 mm tall, and the diameter is less than 2 mm. With such small dimensions, the machining now becomes very challenging. However a prototype of this antenna has been conventional manufactured with very good results. We have also looked in to the possibility to use additive layer manufacturing for the antenna.

ESA Technical Officer

Maurice Paquay

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Contribution ID: **89** Type: **not specified**

Proof-of-concept miniaturized monopulse FMCW radar sensors fit for small satellites utilizing MMICs developed specifically for low-power radar frontends.

Wednesday, 22 January 2020 11:45 (25 minutes)

This paper presents two novel X-band MMICs which constitute a complete FMCW radar front-end solution. The chips have been designed by the SIRC company and have been manufactured at the IHP research institute. The aim of the developed MMICs was to minimize the size as well as the power consumption of the end-devices. To verify the design not only the MMICs has been manufactured and individually measured but also two proof-of-concept miniature FMCW radar sensors has been developed. The first of the two experimental radars is a sensor with two fully coherent RX channels allowing for a precise target angle measurement in a single plane by utilizing the monopulse technique. The second radar sensor is a major enhancement of the original design while retaining its small size of only 80x100 mm. The number of the RX channels has been increased to 4 which allows full determination of the target spatial location via the two-plane monopulse method. The microcontroller onboard the sensor has also been substantially upgraded to a model capable of executing advanced DSP operations at real-time thus eliminating the need for external computing machine. The measurement results of both the MMICs themselves as well as the proof-of-concept radar sensors built upon them fully matched the theoretical calculations thus ultimately verifying the design goals with positive outcome.

ESA Technical Officer

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Contribution ID: **90** Type: **not specified**

Lunar spectral irradiance measurement and modelling for absolute calibration of EO optical sensors

Wednesday, 22 January 2020 16:10 (25 minutes)

Our knowledge of the moon full disk irradiance variations as seen from Earth, through lunar cycles, is however still not sufficient to use it as an absolute radiometric calibration target. The typical absolute calibration requirement of EO space sensors is generally between 2% (e.g.: ocean colour missions) and 5% (e.g.: land monitoring missions) traceable to the Système International (SI). The moon disk spectral irradiance model commonly used by the EO community is the USGS ROLO model (Kieffer et al. (2005), see http://www.moon-cal.org). Kieffer et al. (2005) describe the variations of the lunar irradiance with lunar orbital variables, wavelength and polarisation. The USGS ROLO model was built from lunar observations made from a terrestrial telescope at different moments in the lunar cycle(s). Deriving such model requires a time series of lunar irradiance measurements. In fact, the Moon orbit is not circular but elliptic. Its rotational axis is not perpendicular to its orbital plane (around the Earth) and the orientation of its orbit ellipse axis is not fixed in space, but rotates in about 9 years. The ROLO model seems to be well capable of predicting the lunar spectral irradiance, at a given phase angle however it still suffers from large absolute radiometric uncertainties and it is estimated that it's absolute accuracy is only of the order of 10 % (see Kieffer et al. (2005)). The ROLO model accuracy is thus not sufficient for EO optical imager with abslute radiometric requirement below 5%.
The objectives of the activity were to: 1)Define a strategy for the measurement of the lunar spectral irradiance variation from the ground, 2) Demonstrate the feasibility of such measurements, 3) Compile a database of such measurements and on that basis improve the modelling of the lunar disk irradiance variations through its cycles (targeting sub-2 % absolute radiometric accuracy) and 4) Compare the improved lunar disk irradiance model to various independent sources of lunar observations from space.
A new ground-based sun photometer was customized for lunar observations. It was characterized and calibration at about 2% absolute radiometric accuracy. The instrument was operated (Tenerife / Spain) and lead to the generation of a large database of lunar disk irradiance measurements. The measurements were used to fit a lunar irradiance model which absolute radiometric uncertainty is estimated to be about 2%. The model output was compared to lunar observations from several space sensors.

ESA Technical Officer

Bouvet Marc

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Contribution ID: **91** Type: **not specified**

DTU-ESA Coordinated Antenna Laboratory Performance Upgrade

Wednesday, 22 January 2020 14:50 (25 minutes)

DTU has undertaken the ESA project "DTU-ESA Coordinated Antenna Laboratory Performance Upgrade" with the objective of upgrading the performance of the DTU-ESA Spherical Near-Field Antenna Test Facility for high-accuracy testing of space-technology antennas. This upgrade included central instruments of the measurement system; one instrument is the theodolite used for mechanical alignment of the antenna and probe positioners, as well as the antenna under test, while the other instruments form an integrated part of the RF and data acquisition system.

The procurement process conducted in 2018 was based on the Requirement Specification Document and the System Specification Document. The installation of the theodolite from Leica Geosystems took place in December 2018 in parallel with the installation of the new probe positioner top table, developed in-house at DTU as part of the 2017-2018 upgrade of building 353 housing the DTU-ESA Facility. The installation of the instruments from NSI-MI for the RF and data acquisition system took place in January 2019.

During the installation in January 2019, a series of acceptance tests were conducted to assess the functionality of the new instruments/system. These acceptance test successfully demonstrated that instruments are working correctly, that instruments are connected correctly, that the data acquisition, including the triggering functions, are working correctly, and that measurement data are in the correct format for processing.

A first full-scale measurement took place in February- March 2019; this concerned L-band, low-gain satellite communication and navigation antennas.
A second full-scale measurement took place in May 2019; this concerned L-band antenna elements of the SMOS-IRMI remote sensing antenna system.
Though these 2 measurement projects are not formally part of the present project, their successful completion contributes to demonstrating that the new measurement system is operational.

The formal validation of the operational capability of the new MI-750 system and the new measurement procedure was based on the Validation Test Campaign which comprised 4 Antennas Under Test at 4 frequencies. The results were compared with results from corresponding measurements with the previous MI-1797 system. The 4 validation measurements were conducted between March 2019 and November 2019.
The antennas for the 4 validation measurements are summarized in the following table.

No……Centre Freq…..Antenna Under Test
…….1…….0.435 GHz…….Satimo SH-400 dual-ridged horn
…….2…….5.355 GHz…….DTU KRAS slotted-waveguide array
…….3…….12.00 GHz…….DTU-ESA 12 GHz Validation Standard antenna
…….4…….48.16 GHz…….DTU-ESA mm-VAST antenna

Besides some minor issues, to be solved as regular maintenance, it was concluded that the DTU-ESA Spherical Near-Field Antenna Test Facility was succesfully upgraded and is operational with the new equipment and procedures.

ESA Technical Officer

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