DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING – 37TH CYCLE

Title of the research activity:	Millimeter-wave transceivers and radiometers for RADIO-SCIence cubesat missions (**RADIOSCI**) Scientific fields: ING-INF/01 – Electronics ING/INF 02 – Electromagnetic fields
State of the Art:	High performance transceivers are becoming increasingly important in commercial and scientific cubesats missions. Nowadays apparatuses, that operates in the K/Ka frequency bands, are required to reach data rates up 100 Mbit/s in both uplink and downlink. They are typically composed by 17.8 to 20.2 GHz (K-band) transmitter, and by a 27.8 to 30 GHz (Ka-band) receiver. The transmitter power is around 1 W, whereas the receiver noise figure is close to 3 dB. These systems are equipped with a 20 dBi, dual-band, circular polarization horn antenna, draw a 20 W from the satellite power supply unit, and fit inside a 3U cubesat. Beside the analog front-end, a Software Defined Radio (SDR) is used to perform the base-band signal processing and to make the system reconfiguration quite easy. The main novelty of the above transceivers is related to the usage of Components Of The Shelf (COTS), i.e. electronic devices originally developed for high-reliability, ground based applications (automotive, military, etc.). This choice is aimed at reducing the production costs of the cubesat electronics and is intended for Low-Earth Orbit (LEO). As a consequence the design reliability is one of the major challenge to afford. Millimeter wave radiometers are complex electronic apparatuses adopted for remote-sensing and imaging purposes. Radiometers are passive sensors that reveal the microwave black-body radiation of the matter and, through this principle, they are capable to measure, in a contactless way, the (brightness) temperature of objects. Furthermore, since various molecule and atom resonances occur in the microwave range, adiometers can identify specific substances such as the water vapor in the atmosphere. In addition, the long wavelength microwaves can penetrate through cloud

	cover, haze, dust, and even rain. Finally radiometers are at the heart of radio-telescopes and radioastronomy and the nowaday knowledge of the universe is also based on their discoveries: from the Cosmic Background Radiation (CMB) to the atomic hydrogen in stellar clouds and nebula.
Short description and objectives of the research activity:	The present Ph.D. project aims at exploring a high performance, reconfigurable mm-wave radio that can operate either in transceiver mode or in radiometer mode to allow cubesats RADIO SCIence missions. For example there are plenty Moon missions that are planned for cubesats in the next years. In these missions there is the need to set high-speed communications with the Earth (through the Lunar Gateway) as well as to perform a complete brightness temperature mapping of the Moon crust. A reconfigurable radio could perform both, thus saving space, mass and power consumption, quantities that are extremely precious onboard cubesats. In summary, the system to be studied promise a significant technological impact since it can provide high data rate links to subesats, thus enabling them as cost effective platforms for a great variety of missions. The scientific impact, instead, is related to the reconfiguration of the mm-wave receiver as a radiometer. Ground observation (atmospheric study, soil analysis, etc.), solar flares detection (microwave emission form solar flares) and other radio-astronomy experiments can be conceived with this flexible instrument. An engineering model of the transceiver has already been developed trough a cooperation between Italian Space Agency (ASI), European Space Agency (ESA), Picosats Trieste, University of Trieste and University of Perugia. Such a transceiver is now under extensive testing. The next steps will be: i) the development of the flight model, ii) a in-orbit testing, and iii) the receiver front-end modifications to perform radiometric experiments with the same hardware.
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