ALMA Band 2+3
Down-Convertor & Local Oscillator System

[1]E-M. Butroid, [1]H. Wang, [1]B. Ellison, [2]G. Fuller, [2]D. George, [2]D. Cuadrado-Calle

[1]STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot, OX11 0QX, UK

[2]Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy,
University of Manchester, Manchester, M13 9PL, UK

Introduction and Overview of the System

The ALMA Band 2+3 system is designed to operate over an input signal frequency range of 67-116GHz. The receiver system uses cryogenic low noise amplifiers (LNAs) at its input, the output of which must be frequency translated (down converted) to the ALMA intermediate frequency (IF) range of 4-12GHz. The down-convertor comprises a subharmonic sideband separating mixer (one for each polarisation), local oscillator (LO) and IF amplifier chain. The LO must be frequency tunable and provide sufficient output power to pump the mixer. The LO chain includes a voltage controlled oscillator (VCO) which is amplified and harmonically up converted and encompasses the frequency range 39-52.5GHz, with typical +8dBm output power . A digital interface connected to a control computer via a standard universal serial bus (USB) is used to set the VCO, and hence LO output, frequency.

Development Objectives

A combined Band 2+3 receiver system has the advantage of allowing simultaneous observations of spectral lines that span the combined Band 2 and Band 3 frequency range. Its wide operational bandwidth requires demonstration, however, and key technologies need to be proven. In support of this key objective, the Science and Technology Facilities Council (STFC) has funded the development of a pre-prototype down-convertor chain suitable for use with Band 2+3 front-end LNAs. The objectives of the development include:

- Design and construction of the necessary LO chain;
- Development of suitable down conversion mixers;
- Development of appropriate electronic interfaces and software control;
- Integration of the system into a pre-prototype form;
- Use of the system to support cryogenic LNAs performance testing.

The basic down-convertor system is shown in Figure 1.

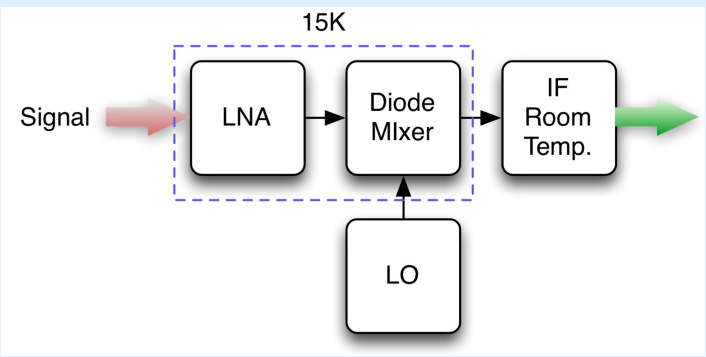

Figure 1: Basic down-convertor system.

Band 2+3 Receiver Concept

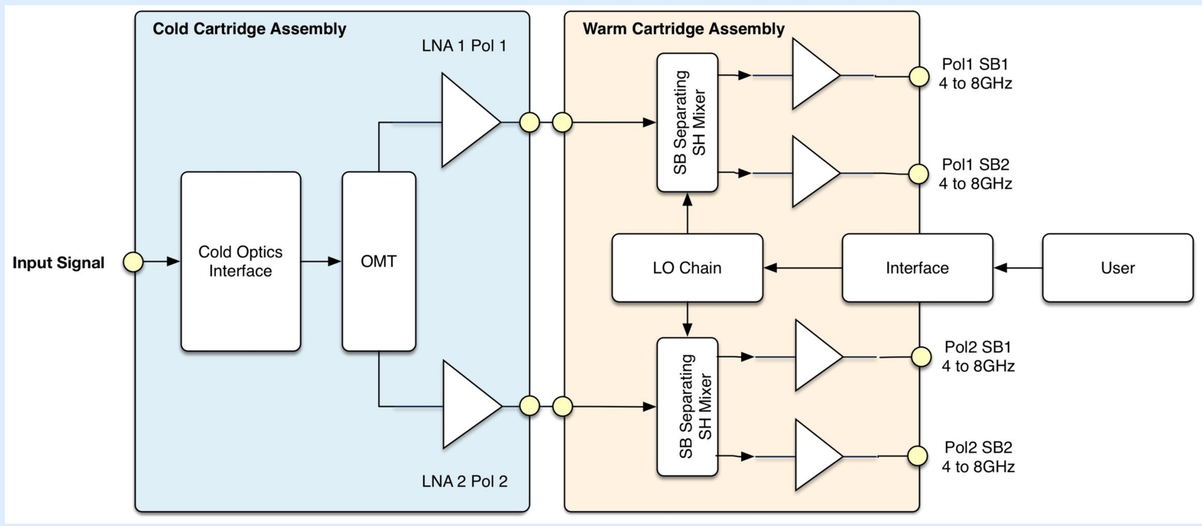

Figure 2: Band 2+3 receiver schematic including front-end and down-convertor.

The Band 2+3 receiver will comprise cold and warm sections. The down-convertor operates at room temperature and consists of a subharmonic mixer, LO and IF chains. A single LO source pumps sideband separating subharmonic mixers in a dual polarisation configuration.

A digital interface consisting of control circuitry and driver software allows a user to set the LO frequency simultaneously for each polarisation. Down-converted signals are amplified to meet the ALMA IF interface requirements.

Due to their unique nature, the subharmonic mixers are developed at the Rutherford Appleton Lab. An initial development phase prototype double sideband subharmonic unit has been demonstrated.

Mixer Design

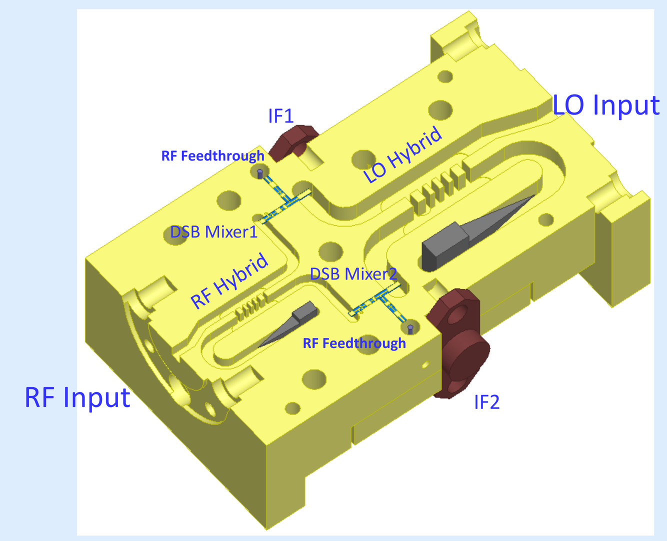

Figure 3: Sideband separating subharmonic mixer design concept.

The sideband separating subharmonic mixer uses RAL fabricated Schottky barrier diodes. Signal input and LO division is accomplished within a single mixer block housing, as shown in Figure 3. Design simulations indicate the expected mixer noise and conversion loss performance to be approximately 1000K (SSB) and -8dB respectively for a typical LO power level of +8dBm. The mixer block and internal circuitry is currently being manufactured at RAL.

Local Oscillator Chain

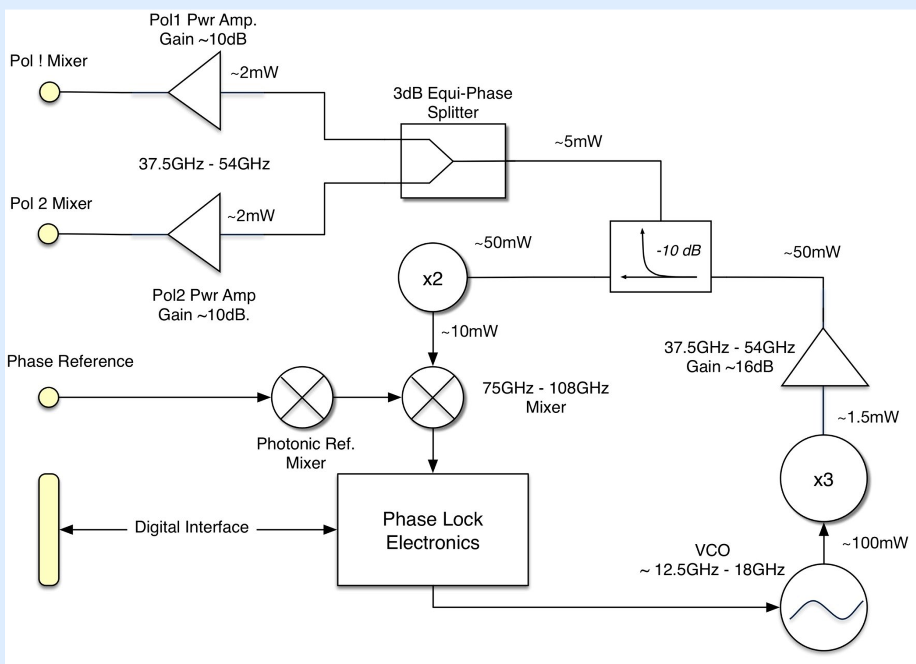

Figure 4: Schematic representation of the LO chain.

The local oscillator chain consists of a VCO followed by a x3 multiplier, power amplifier, directional coupler, and quadrature hybrid coupler. A further stage of power amplification is added to each of the output ports of the hybrid coupler. Table 1 provides the pertinent signals.

Table 1: Maximum frequency ranges of the VCO and overall LO frequency range.

VCO Frequency	**13 – 17.5 GHz**
LO O/P Frequency	**39 – 52.5 GHz**

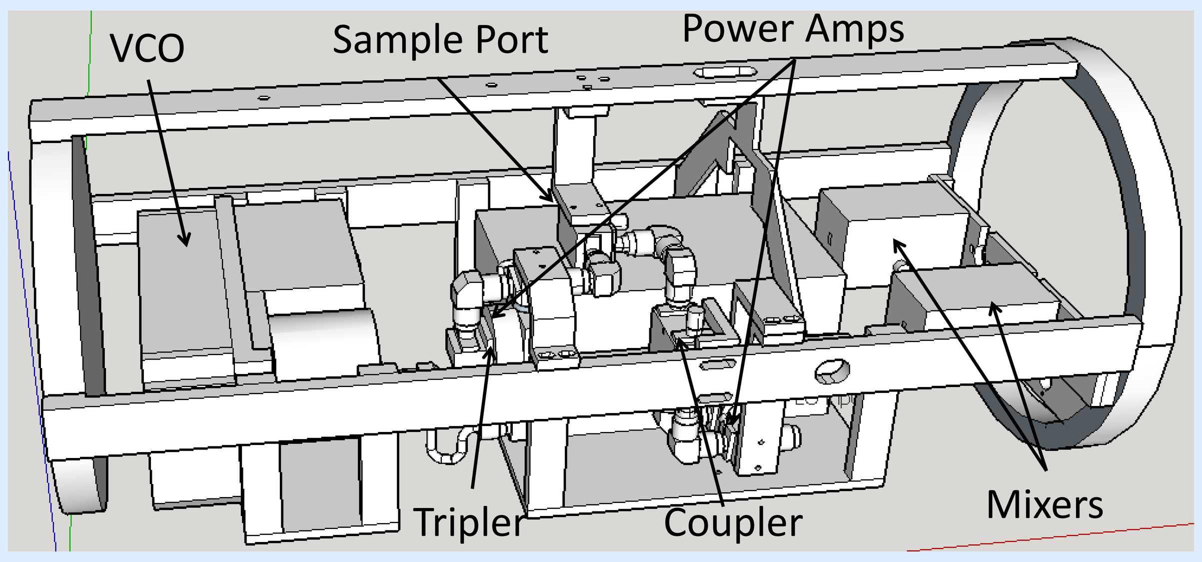

Figure 5: Design of the down-convertor chain within a standard ALMA WCA.

The down-convertor chain is incorporated into a standard ALMA warm cartridge assembly (WCA) as shown in Figure 5. This provides a standard ALMA mechanical interface with a cold cartridge. For LNA testing at RAL, an adaptor has been developed that allows interface of the WCA to a laboratory cryogenic system capable of achieving a temperature of order 20K.

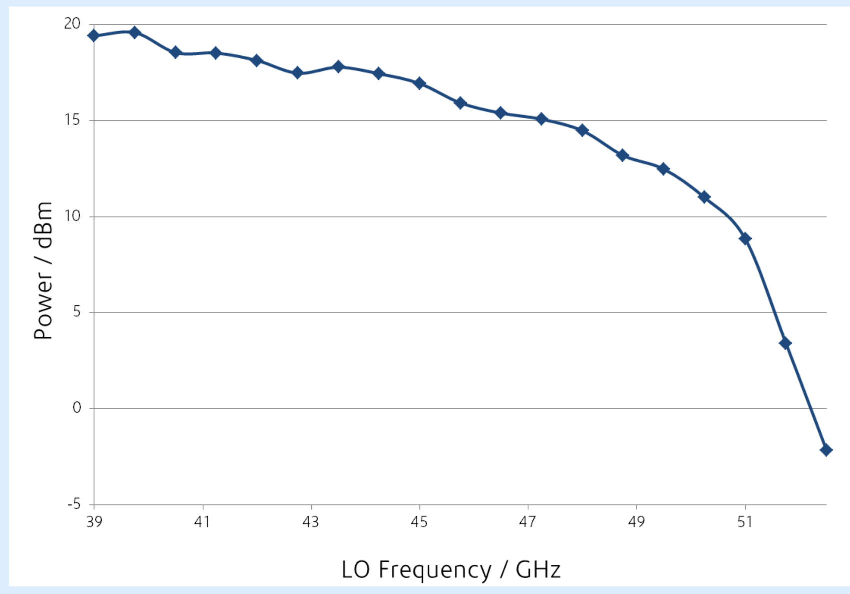

Figure 6: Output power of the LO chain measured across the required frequency range.

The mixers require a minimum LO pump power of approx. +8dBm and for the majority of the frequency range this is accomplished – see Figure 6. The roll-off above 50GHz is due to the reduced gain of the commercial amplifier. A future non-standard amplifier enhancement will extend the output power level to encompass 52GHz. Fixed power levelling will be introduced once the mixer characteristics are known.

LO Control Interface

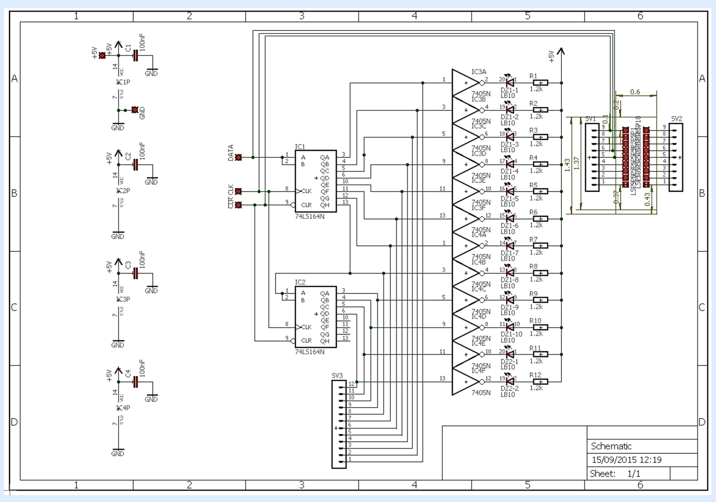

Figure 7: Schematic diagram showing the digital circuit interface to the LO VCO.

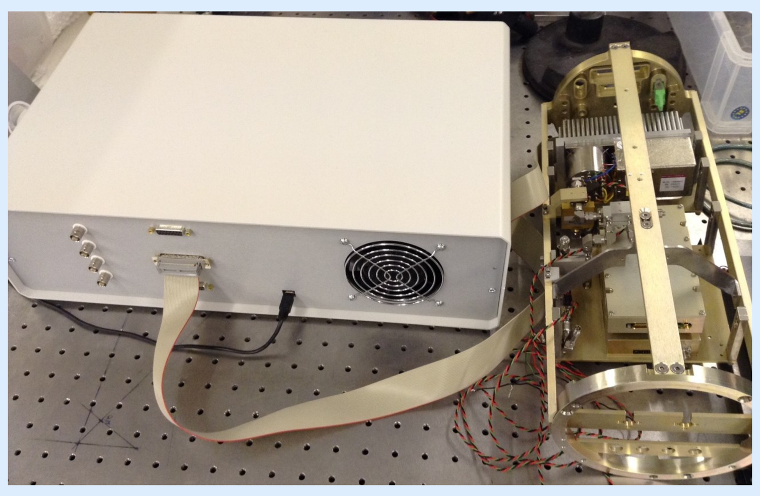

Figure 8: The complete down-convertor system including the mixer, LO and IF chains and control unit.

An objective encoded software application has been developed to provide a user interface to the down-convertor. VCO frequency is the single control functional and which is set by the user and transferred to the VCO via a USB and digital interface circuit. Data is serially clocked into the circuit with a total of 12 bits defining the frequency resolution. The digital interface and supporting power supplies are integrated within a single housing which is located separately to the WCA and connected via a ribbon cable, see Figure 8.

LNA Testing

The down-convertor is currently being integrated with a cryogenic system that will, in turn, be used to test LNAs developed by the University of Manchester.

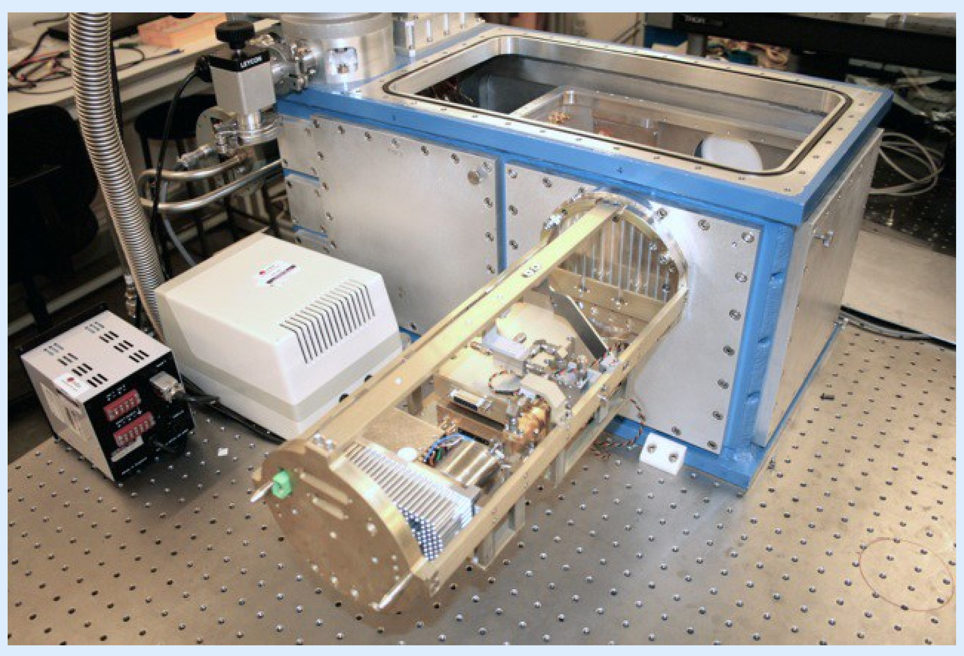

Figure 9: Down-convertor chain integrated with a RAL general purpose low temperature cryogenic system.

Conclusions

A down-convertor chain comprising sideband separating mixers, LO and IF chains is being developed in support of the ALMA Band 2+3 system. The LO chain and user interface control has been constructed and tested with a RAL fabricated double sideband subharmonic mixer. A next stage of development is to integrate the sideband separating mixers and use the system to support front-end cryogenic LNA measurements.

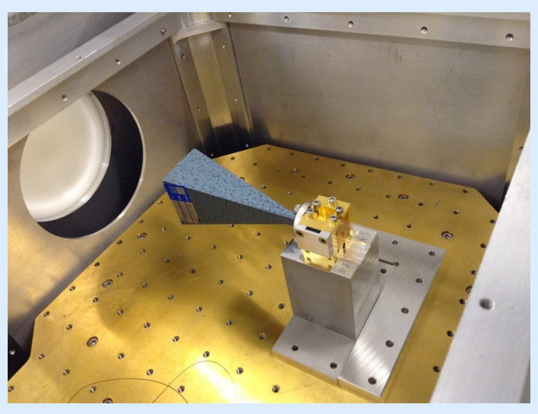

Figure 10: Current setup for cryogenic testing of the low noise amplifier in the RAL cryogenic system.

Acknowledgements

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