URSI AP-RASC 2019, New Delhi, India; 09 - 15 March 2019

Mach-Zehnder Modulator – Local Oscillator Reference Test Module (MZM–LORTM): Design, Testing, Assembly and Deployment

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1 Extended Abstract

The Atacama Large Millimeter/submillimeter Array (ALMA), located on the Chajnantor Plateau in Chile, is the largest interferometer in operation at these wavelengths. The Front End (FE) systems constitute the first stage in a series of complex processes which involve signal detection and processing. The receiver cartridges for each of the ten frequency bands in each ALMA FE are integrated into the cryostat at three integration centers across the world. The MZM–LORTM, which is described in this article, is being used at the East Asia - Front End Integration Center (EA-FEIC) located in Taichung (Taiwan), to test the performance and evaluate the ALMA cartridges before being shipped to Chile.

The MZM-LORTM is based on the principle of modulation of a monochromatic laser ($\lambda \sim 1556.21$ nm) by one or more Radio Frequency (RF) signals. The Mach-Zehnder Modulator (MZM) works by creating intensity modulation of the laser by applying phase modulation [1]. The aforementioned reference describes in detail the generation of a photonics based RF Local Oscillator (LO) using the MZM. Harmonics are created, which can be used to generate RF signals by mixing the optical tones in a photomixer. These harmonics can be carefully selected or suppressed by the application of one or more DC voltage biases to the modulator in order to generate RF signals at different frequencies.

The MZM-LORTM uses two MZMs to generate three optical tones at the output of the unit; two RF signals are generated, one is designated as the Reference tone, while the other functions as the Test tone. The salient features of the unit are as follows: 1) Both MZMs are three port devices (labelled as A, B, and C) which can be biased and modulated independently. 2) There are two modes of operation, namely the full bias mode which suppresses the odd harmonics, and the null bias mode which suppresses the even harmonics and the central carrier. 3) For most bands, MZM1 is operated in the full bias mode for all ports, MZM2 is operated in full bias mode for port C and null bias mode for ports A and B. The Upper Side Band (USB) tone from MZM1 is combined with the Lower Side Band (LSB) tone(s) from MZM2 which has been further modulated and is actually composed of two closely spaced tones. 4) For bands 1 and 5, MZM1 is excluded from the signal path, while MZM2 provides the two LSB optical tones. The central carrier is then added back into the signal path to provide the three final optical tones. 5) There are three Fiber Bragg Grating (FBG) assemblies with cascaded FBG filters to suppress the unwanted tones by > 50 dB, including the central laser carrier. 6) The laser output and all the optical components are Polarization Maintaining (PM). The Polarization Extinction Ratio (PER) is maintained at > 25 dB by the use of polarizers all along the signal path. Isolator/Polarizer combinations not only maintain the PER but also prevent back propagation. 7) The use of an Erbium Doped Fiber Amplifier (EDFA) introduces a large incoherent noise pedestal which is mostly removed by an optical thin film band pass filter.

In the talk, I will present details of the design, assembly, and testing of the MZM-LORTM unit. Some of the challenges faced include heat dissipation and bias drift that were resolved prior to the final acceptance tests conducted at EA-FEIC and the incorporation of the MZM-LORTM as a test unit [2]. I will also present the details of the software system required to setup the MZM-LORTM for optimal operations.

References

[1] Kubo, DY; Srinivasan, R; Kiuchi, H; Chen, MT. 2013. Development of a Mach?Zehnder Modulator Photonic Local Oscillator Source. IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES 61(8): 3005-3014.

[2] MZM LORTM ORR Report at EA FEIC, FEND-40.09.03.00-0405-A-RE, 2011

[3] Srinivasan et al. Mach-Zehnder Modulator – Local Oscillator Reference Test Module (MZM–LORTM): Design, Testing, Assembly and Deployment 2019, (in preparation)