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Differential Signal Processing for the Antennas of the Square Kilometer Array and Integrated Circuit Package Electromagnetic Simulation

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Abstract

We present a differential signal transmission and feed board used to connect the antenna to the **LNA (Low Noise Amplifier)** in **Octagonal Ring Array (ORA)[1],** which is a novel antenna technology proposed for the **Square Kilometre Array (SKA).** The **SKA** will be the largest radio astronomy facility ever built with a collecting area equivalent to a million square metres. The board transports the RF analog signals to the Beamformer Board through SATA cables. The analog signals are digitalized by a custom A/D conversion chip. One package model has been studied using electromagnetic (**EM**) simulation to investigate the influence of packaging on the integrated circuit.

[1] Zhang Y, Brown A K. Octagonal ring antenna for a compact dual-polarized aperture array[J]. IEEE Transactions on Antennas and Propagation, 2011, 59(10): 3927-3932.

Board Design and Measurement

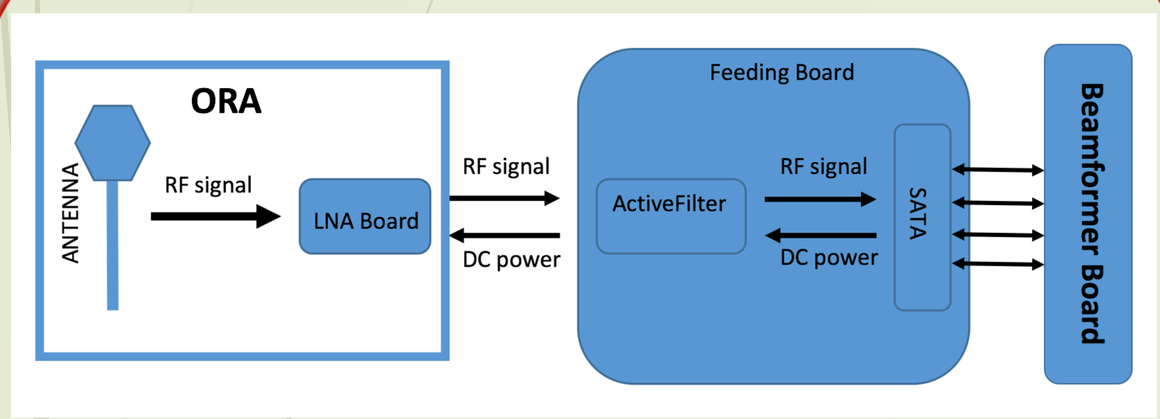


Figure 1: Block diagram of the signal chain from the antenna (ORA) through to the Beamformer Board.

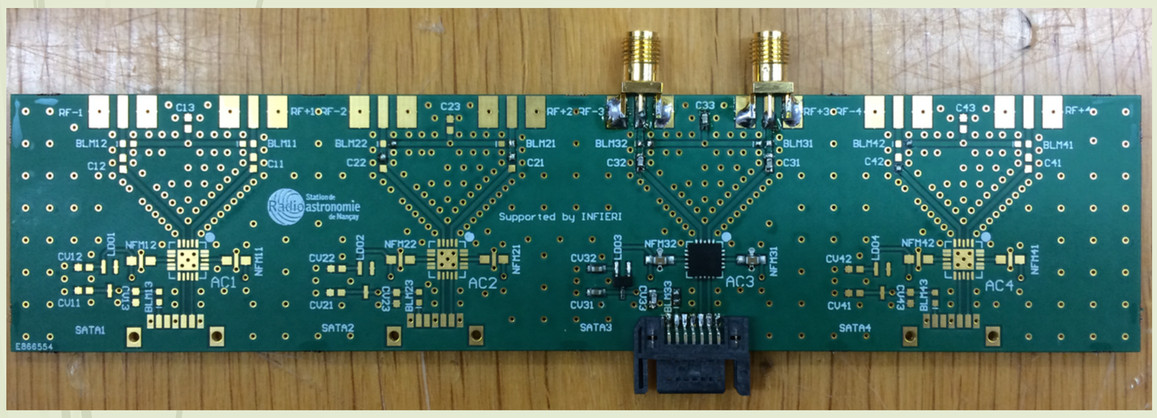


Figure 2: Feeding board. The Feeding Board is a four-layer board designed in Altium. It's 1.59mm thick, and uses FR4 substrate.

The board was measured in three different length SATA cables: 57.5cm(red line), 49cm(blue line) and 4cm(green line).

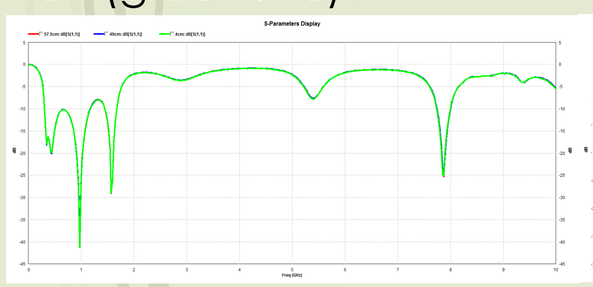


Figure 3.1: Sdd11. There is almost no difference between the three curves.

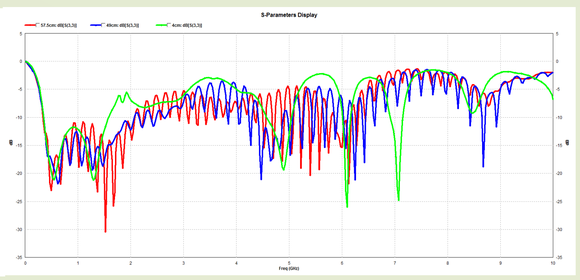


Figure 3.2: Sdd22. 4cm SATA cable reduces the oscillation.

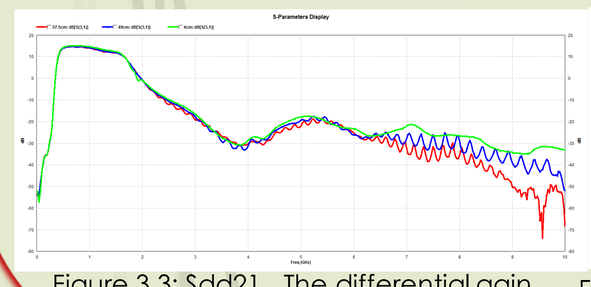


Figure 3.3: Sdd21. The differential gain remains stable in the range 400MHz-1600MHz.

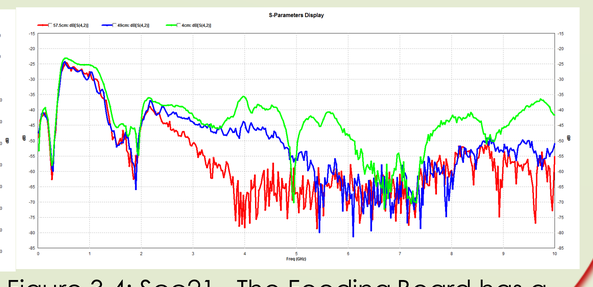


Figure 3.4: Scc21. The Feeding Board has a good common mode rejection ratio.

SATA Cable Measurement

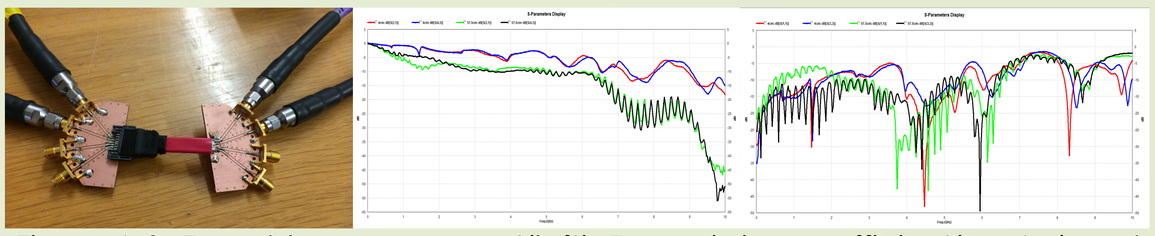


Figure 4: SATA cable measurement(left), Transmission coefficient(center) and Reflection coefficient(right).

EM Simulation of Packaging

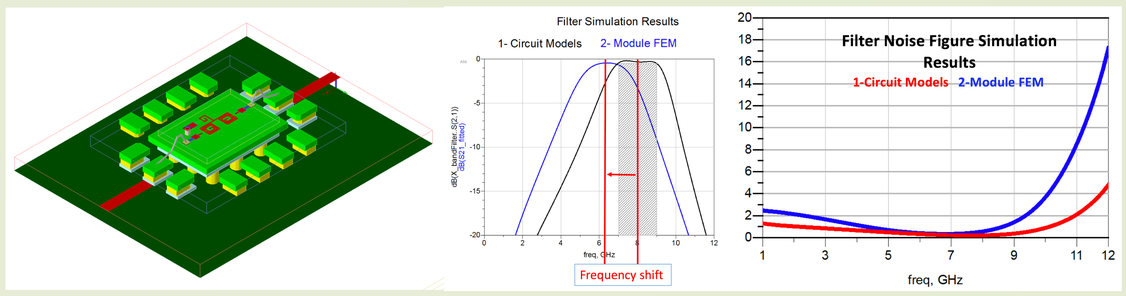


Figure 5: 3D inductor model in ADS(left), Transmission coefficient(center) and noise figure(right).

Obviously, there is a frequency shift and the noise figure increases after packaging the circuit.

EM Simulation of the Inductor

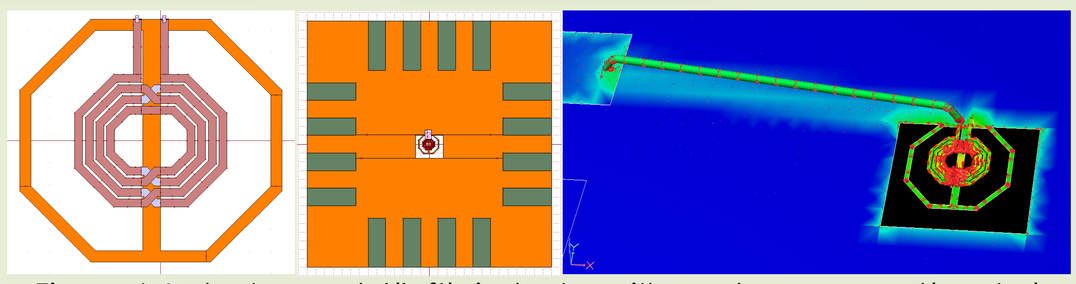


Figure 6: Inductor model(left), inductor with package ground(center) and 3D current of inductor with one bond wire(right).

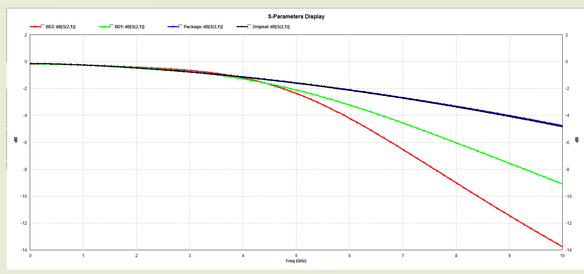


Figure 7.1: Transmission coefficient

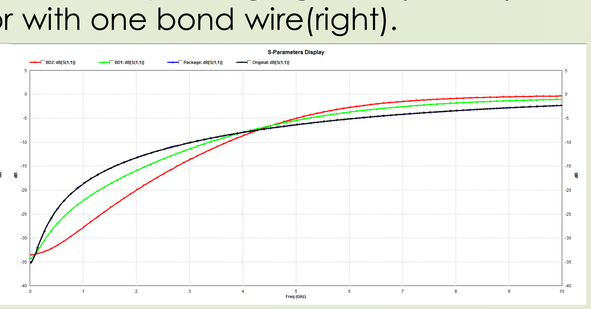


Figure 7.2: Reflection coefficient

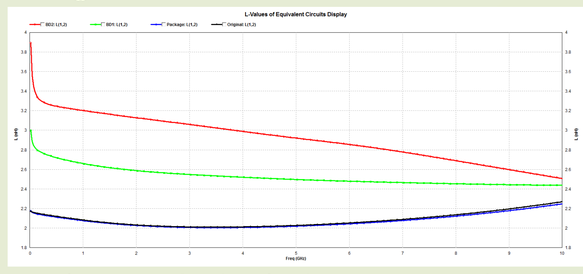


Figure 7.3: The inductance value increases after adding the bond wire.

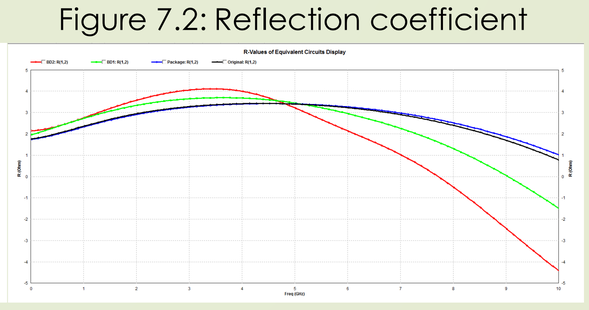
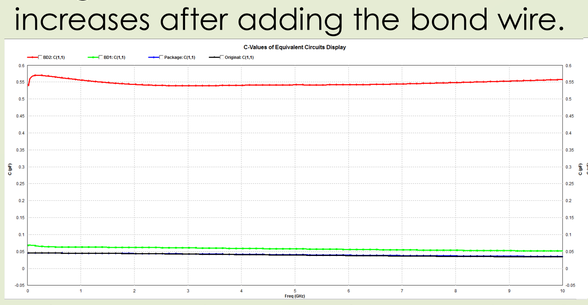


Figure 7.4: Resistance value



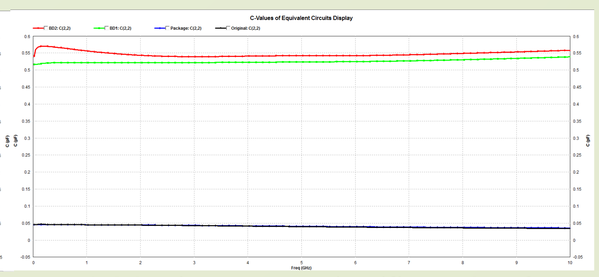


Figure 7.5: The capacitance value, C11and C21, increases significantly after adding the bond wire.

The increase of the inductance and capacitance value caused by packaging, especially bond wire, will result in the frequency shift. During the design of the integrated circuit, the packaging effects must be taken into account.

Acknowledgement

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