Broadband Array Architectures for Reducing Antenna Noise Temperature

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BACKGROUND

Mitigating the impact of interference on the delicate measurements of passive remote sensing applications has become imperative for maintaining reliability and precision. A critical factor influencing the performance of these systems is that of the Signal-to-Noise Ratio (SNR). Thus, studying the noise coming from a receiver system design could serve as a useful tool to understand which components contributes said noise and find methods mitigate said noise.

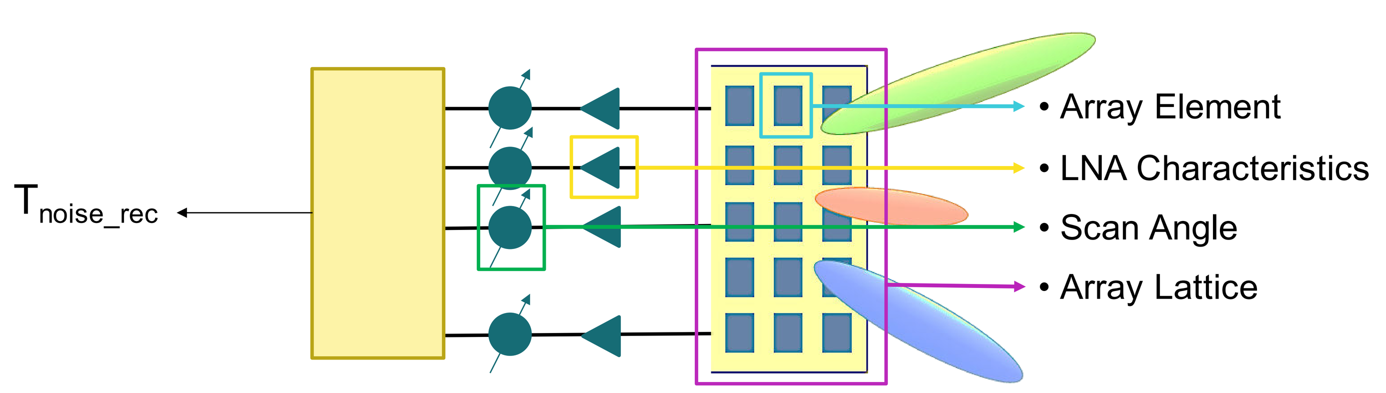
RESEARCH QUESTIONS

Develop a method of measuring noise performance for a wide variety of antenna array receiver systems.

- Establish **method of noise study** for receiver systems.
- Study effect of **scan angle** and **element separation**.
- Evaluate **low noise amplifier (LNA) designs**.
- Evaluate **broadband elements** for array.
- Study noise performance using **periodic tilings**.
- Study noise performance using **aperiodic tilings**.

METHODS AND MATERIALS

System Architecture:



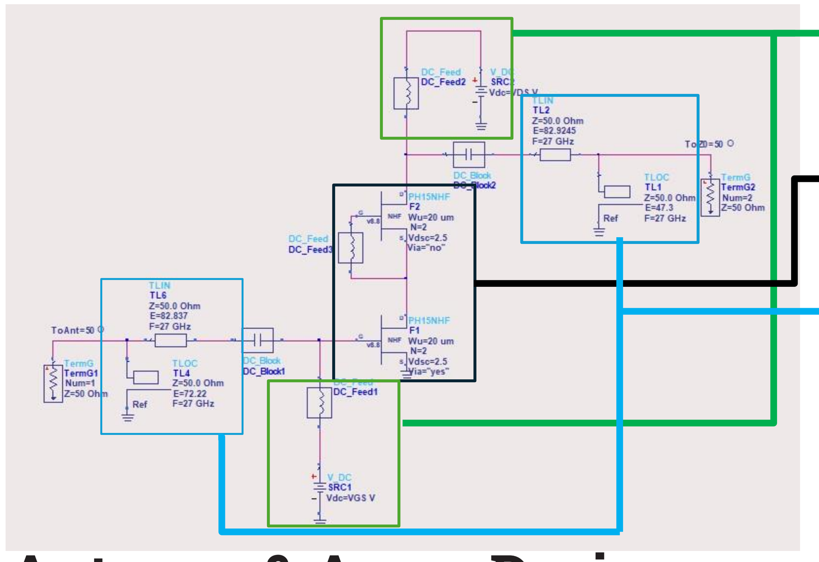
The system's noise characterization design is split into four sections:

- **LNA Design**: noise figure, gain, Γ_{opt}, broadband design.
- **Antenna Design**: Ka-band, broadband, noise temperature.
- **Array Design**: scan angle, separation, lattice geometry.
- **Receiver Design**: multi-port antenna representation, system noise.

RESULTS

LNA Design

- Following design procedure described in [2] we can alter specific LNA characteristics:



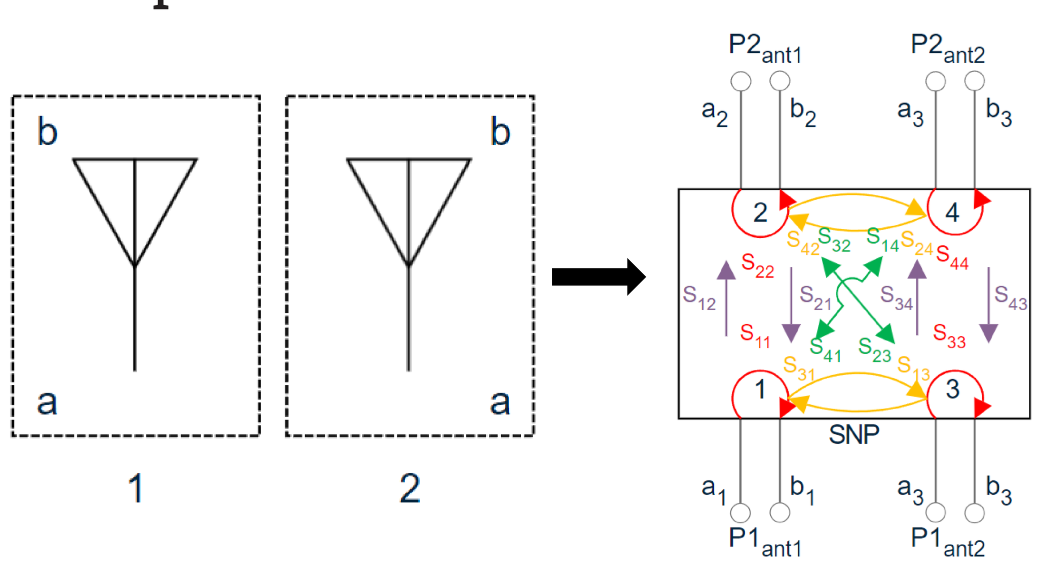
- DC Bias Network:
  - Q-Point
- Transistor:
  - Frequency, Gain, Noise Figure
- Matching Network:
  - Gamma optimum (Γ_{opt})

Antenna & Array Design

- We can calculate the antenna noise temperature using the formula described in [1]:

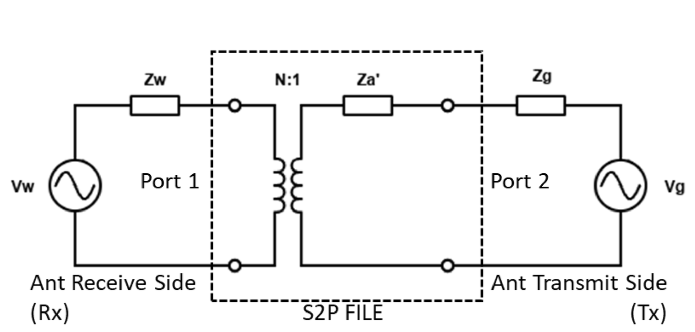
$$T_A = \frac{\int_0^{2\pi}\int_0^{\pi} T_B(\theta,\phi)G(\theta,\phi)\sin\theta\, d\theta\, d\phi}{\int_0^{2\pi}\int_0^{\pi} G(\theta,\phi)\sin\theta\, d\theta\, d\phi}$$

- We can transform our antenna into a multi-port representation as such:



$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

- Ant 1 and Ant 2 S-parameters quadrants are calculated using the following equations described in [3]:



$R_r = \eta R_a$ = radiation resistance

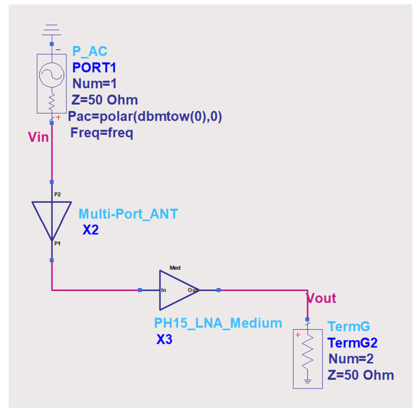
$R_l = (1-\eta)R_a$ = dissipative loss

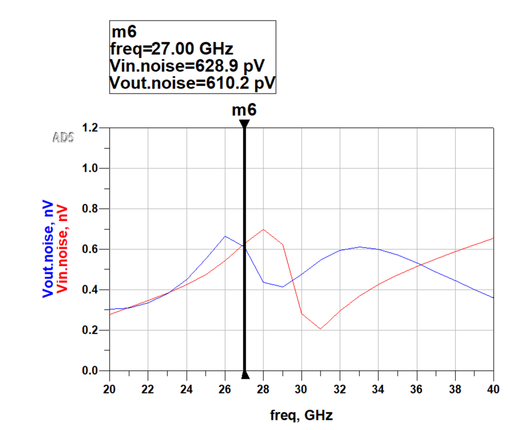
$N = \sqrt{R_r/Z_0}$

$$S_{11} = \frac{Z_a+Z_g-2\eta R_a}{Z_a+Z_g},\ S_{12} = \frac{2\sqrt{Z_g R_r}}{Z_a+Z_g},\ S_{21} = \frac{2\sqrt{Z_w Z_g}}{Z_a+Z_g},\ S_{22} = \frac{Z_a-Z_g}{Z_a+Z_g}$$

Receiver System Design

- The resulting system and noise measurement is:





CONCLUSION

Conclusion and Discussion

From the data recollected so far, we can deduce:

- This method can be used to accurately measure noise performance for a receiver system.
- Converting antenna arrays into a multi-port network will pose a challenge particularly for larger sized arrays. The use of scripts to automate S-parameter calculations is advisable.

Future studies will focus on applying this method for a variety of broadband devices and LNA characteristics.

ACKNOWLEDGEMENTS

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