PHASED ARRAY RADIOMETER CALIBRATION USING A RADIATED NOISE SOURCE

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1. INTRODUCTION

Electronic beam steering capability of phased array antenna systems offer significant advantages when used in real aperture imaging radiometers. The sensitivity of such systems is limited by the ability to accurately calibrate variations in the antenna circuit characteristics. Passive antenna systems, which require mechanical rotation to scan the beam, have stable characteristics and the noise figure of the antenna can be characterized with knowledge of its physical temperature [1],[2]. Phased array antenna systems provide the ability to electronically steer the beam in any desired direction. Such antennas make use of active components (amplifiers, phase shifters) to provide electronic scanning capability while maintaining a low antenna noise figure. The gain fluctuations in the active components can be significant, resulting in substantial calibration difficulties [3]. In this paper, we introduce two novel calibration techniques that provide an end-to-end calibration of a real-aperture, phased array radiometer system. Empirical data will be shown to illustrate the performance of both methods.

2. ONE DIODE TECHNIQUE

Fig 1 shows a simplified block diagram of a two load radiometer system [4] with a phased array antenna array. Fig 2 shows the configuration of each active antenna element and the center element of the array. The center element of the array radiates a Gaussian noise of known amplitude. A controller steps the radiometer between target scene observations (with the radiated source turned off), internal load observations and an observation of the target scene with the radiated noise source turned on. The difference between the emission temperature measured with the noise source turned on and off provides a method to compute the gain of the antenna electronics. Though the plane of reference for the calibration is the front-end of the radiometer, this technique can account for drifts in the gain of the antenna electronics, thus providing a quasi- end-to-end calibration.

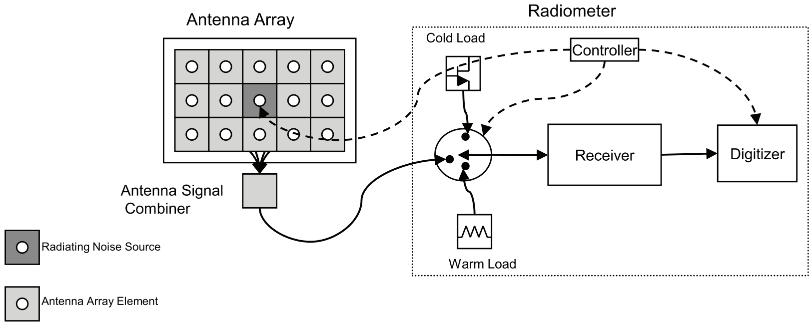
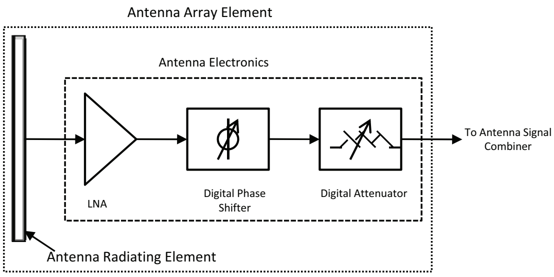
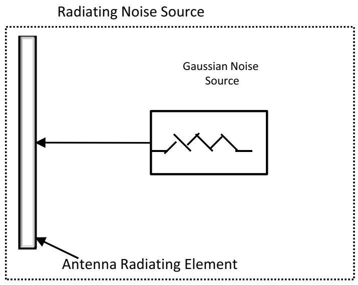


Fig. 1. Simplified block diagram of a radiometer system incorporating the one diode technique



(a) Active antenna element



(b) Center element

Fig. 2. Configuration of the antenna electronics

3. TWO DIODE TECHNIQUE

Fig 3 shows a modified radiometer and antenna array system. The individual active antenna element is modified from the one diode method to include a front-end RF switch on each antenna element as illustrated in fig 4. The center element of the array is the same as the one diode method. In this setup, the two internal loads in the radiometer are replaced by a noise source injected directly into the antenna array through a feed network. The controller now steps between the target scene observation (with the radiated noise source turned off), an observation of the target scene with the radiated noise source turned on and the injected load. In this method, the plane of reference for the calibration is the antenna itself, providing an complete end-to-end calibration.

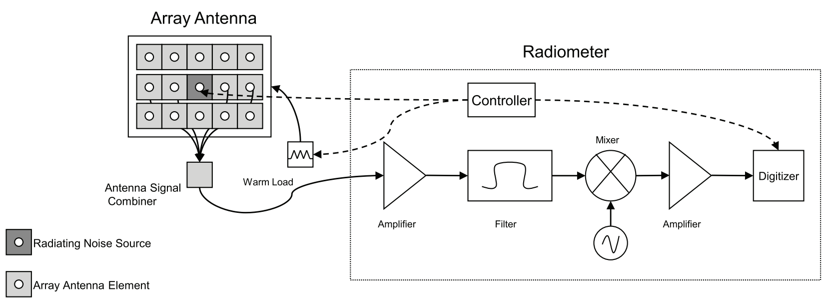


Fig. 3. Simplified block diagram of a radiometer system incorporating the two diode technique

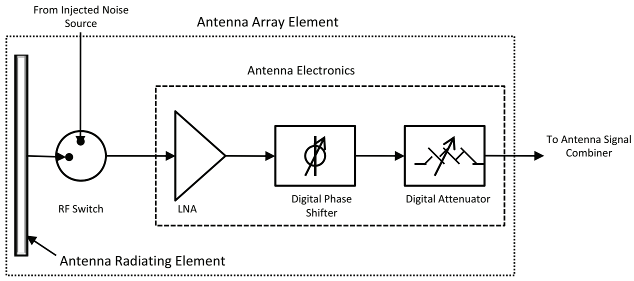


Fig. 4. Configuration of the antenna electronics

4. CONCLUSION

This paper presents two novel methods to calibrate real-aperture microwave radiometer systems with phased array antennas. The proposed techniques make use of mutual coupling between antenna elements to measure the instantaneous gain of the antenna electronics. The one diode technique uses three calibration loads (one radiated antenna load and two loads internal to the radiometer) to compute the gain of the antenna electronics and the receiver while using the radiometer input as the calibration plane of reference. The two diode method uses only two calibration loads (one load is radiated from the antenna and the second load is injected into the antenna electronics) to obtain the overall system gain. The plane of reference for this method is the input to the antenna. The performance benefits of the two methods will be shown using empirical results.

5. REFERENCES

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