# 1 An Investigation of Calibration Algorithms for Tower Top Deployed Adaptive Antenna Systems.

This paper presents a set of algorithmic approaches to the calibration of a tower top deployment of an adaptive antenna array. The adaptive antenna system deploys base station electronics to the tower top. The motivation behind relocating the base station electronics is to provide a versatile system that provides savings on space and reduced capital cost due to reduced feeder cables.

The adaptive antenna system consists of phased transceiver elements that are interconnected to reference elements via directional couplers, as shown in figure 1. This structure provides a calibration path for each element by closed feedback loop provided by digital baseband circuitry, as shown in figure 2. The advantages of the system are offset by some challenges, such as reliability and accurate phasing of the array. The accuracy of the calibration is conditional on these paths between that antenna feed point and the reference elements being equal, the path provided by the directional coupler. This calibration path

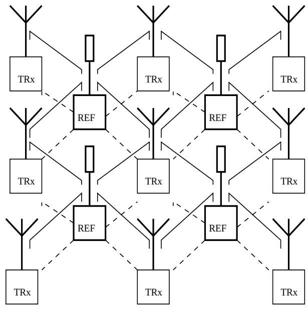


Figure 1: The Rectolinear Array

has been utilized by several different algorithmic approaches to improve the performance of the system, to find the most suitable one for this particular system. The algorithms that were investigated were a reference calibration algorithm, a radiative calibration algorithm and a multipath calibration algorithm.

The reference calibration algorithm starts from the centre of the array, and calibrated the array in quarters. The calibration of each element is preformed by calibrating each antenna element around each of the reference elements with respect to the middle antenna reference element, starting from the center and working through each of the array quarters in turn.

The radiative calibration algorithm also starts from the center of the array, and calibrated each of the elements directly surrounding the reference antenna element. Then the algorithm calibrates the next ring of algorithms directly surrounding the first set of elements, and so on until the whole array has been calibrated.

Finally the multipath calibration algorithm sets the top left element of the array as the reference antenna element. Then calculated the elements directly connected to the reference antenna element, then calculates two paths to each of the elements directly connected to them, averaging the correction values and then feeds this back. The algorithms are simulated by applying them to a component block model of the system, each of the component blocks are modelled as values of a normal distribution whose mean and standard deviation, which models the potential imbalances between calibration paths due to thermal effects, antenna mutual coupling, component aging and finite manufacturing tolerances, are shown in figure 2. This implementation achieves a consistently better performance from the multipath calibration in comparison to the other two algorithms. The results of these simulations are presented as the overall standard deviation of 1000 arrays

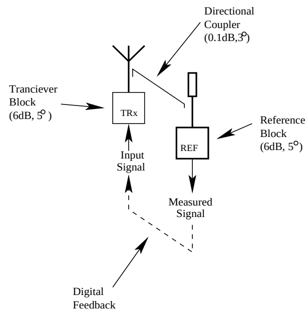


Figure 2: The Calibration Path of an Antenna Element

as the size of the arrays is scaled up. The standard deviation of one thousand 16 element arrays calibrated by the multipath calibration algorithm achieves a 0.4135dB and $1.4153^o$ standard deviation, which compares to 0.5568dB, and $1.87417^o$ for reference calibrated arrays, and 0.4932dB and $1.6705^o$

The radiative calibration algorithm is an implementation of the theoretical shortest path calibration algorithm, which is clear from its improved performance over the reference calibration algorithm. However the multipath algorithm is provides an improvement over the radiative calibration algorithm, as it averages out large directional couplers variations, thus improving the overall performance of the system.