Real Time Distortion Compensation in Large Reflector Antennas: Algorithms for Estimating Distortion

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Over the past decade, extensive work has been performed at JPL on the use of a Deformable Flat Plate (DFP) and Array Feed Compensation System (AFCS) to correct for the gravity-induced distortions on a large reflector antenna (Imbriale, *Large Antennas of the Deep Space Network*, John Wiley and Sons, 2003). The DFP is placed in the beam path and deformed in order to compensate for the gravity-induced distortions as the antenna moves in elevation. Actuators controlling the plate surface are driven via a look-up table. Values in the look-up table are derived using the measured antenna distortions, ray tracing, and a structural finite element model of the DFP. The Array Feed Compensation System (AFCS) consists of a small array of horns, low noise amplifiers, down converters, and digital signal processing hardware and software for optimally combining the signals received by the horns. Each system acting alone and a combined system consisting of both the DFP and the AFCS were demonstrated on the Deep Space Network (DSN) 70-meter antenna. The combined system worked better than either one of the systems acting alone. However, even in the combined experiment, each system was operated independently in that there was no feedback from the AFCS to the DFP.

Recent experiments (Imbriale, et. al., “Toward Real Time Compensation with a Combined DFP/AFCS System”, 2002 IEEE APS Symposium, San Antonio, TX, 2002), carried out during tracks of Ka-band signals from the Cassini spacecraft, demonstrated the feasibility of real time compensation using the AFCS to update the DFP actuator positions. The combined system corrected, in real time, for intentionally introduced sub reflector offsets. This experiment also demonstrated that once the reflector geometry was know, the actuator positions could be computed and updated in less than 2 seconds. This was a precursor to a more complete system for compensating any time varying (not necessarily gravity dependent) deformations.

The purpose of this paper is to discuss algorithms for estimating the reflector distortions from the amplitude and phase of the signals received in the AFCS. A simple statement of the problem is; given the relative amplitude and phase of the signals received by an array feed in a distorted reflector, compute the reflector distortions required to produce the given signals. The problem is solved in two parts. First, the focal plane field is estimated by best fitting a postulated focal plane field with the given signals. Then, the focal plane fields are used to compute the distortions.