SINGLE APERTURE MULTI-MODE MONOPULSE ANTENNA POINTING WITH CORRUGATED HORN

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ABSTRACT

NASA's Deep Space Network (DSN) uses both 70-m and 34-m reflector antennas to communicate with spacecraft at S-band and X-band. To improve quality of telecommunication and to meet future spacecraft requirement, JPL has been developing 34-meter Ka-band beam waveguide antennas. Presently, Antenna pointing operates in either open loop mode with blind pointing using navigation predicts or the closed loop mode with conscan. Pointing accuracy under normal conscan operation conditions is in the neighborhood of 5 millidegrees. This is acceptable at S and X-band, but not enough at Ka-band. Due to the narrow beam width at Ka-band, it is important to improve pointing accuracy significantly (~2 millidegrees). Monopulse antenna tracking is one scheme being developed to meet the stringent pointing, accuracy requirement at Ka-band. Other advantage of monopulse tracking includes low sensitive to signal amplitude fluctuation as well as single pulse processing for acquisition and tracking. This paper presents system modeling, simulation and implementation of Ka-band monopulse tracking feed for antennas in NASA/DSN ground stations.

The design of the DSN monopulse pointing system consists of the reflector antenna, the multimode corrugated horn feed, waveguide coupler, monopulse signal processor and other associated RF electronics, see references (1) to (4). The general block diagram is shown in figure 1. Starting at the main reflector, a tapered beam is formed. The HE11 mode in the corrugated horn is excited to radiate the sum pattern while the TE21 mode waveguide coupler generates the difference pattern, see reference (5). With the assumption of perfect Ka to IF conversion, signal processing starts in the IF domain. Phase locked loop recovers the carrier phase. This is used as a reference to demodulate the elevation and cross-elevation difference channels. The sum and difference baseband signals are passed on to the monopulse signal processor from which elevation and cross-elevation pointing errors are estimated. The error signals are used to drive the antenna servo loop for pointing corrections. To predict overall systems performance, an antenna system model is needed. Based on the physics of corrugated horn and mode coupler, the classical four horns monopulse antenna is shown to produce the same open loop S-curve as the monopulse single aperture multimode antenna, i.e., the four horns model can be used as a system model for a single aperture multimode antenna.

Next, the antenna pointing simulation is developed under- the four horns model. Simulation blocks are chosen from the systems library and they are configured as in figure 1. The following cases are investigated.

1. Open loop monopulse pointing of single aperture multimode antenna with deterministic source.

2. Closed 100p monopulse antenna point ing anal ysis with deterministic sour ce.
3. Characteristics of open loop single aperture multimode antenna in random noise.

For ease 1, pointing error is simulated by introducing signal path delay among horns. The output voltage of the difference channel is recorded. The result can be compared to the mathemat ics and physics models, see figure 2. It shows that the simulat ion result closely matched the medium error mathematics as well as the physics model,

For case 2, a crude second order servo loop is used to model the antenna controller. The frequency response has a 3 dB roll-off at 0.1 Hz. Stability of the servo loop is investigated as a function of the low pass filter bandwidths in the forward path. Impulse and step response of the loop are simulated. The results show that low pass filter bandwidth used in signal processing have to be about two orders of magnitude higher than the loop bandwidth for stable loop operation.

For case 3, Gaussian noise is introduced at the horns. The signal and **noise** power arc adjusted to yield 20 dB-Hz CNR. Variances of the error voltage and pointing error arc calculated by the second moment estimator. The error voltage variance follows the inverse SNR relationship as predicted in reference (l). The pointing error standard deviation (1.02 millidegrees) differs slightly from the prediction (1.6 millidegrees) due to the more realistic S-curve used in the simulation,

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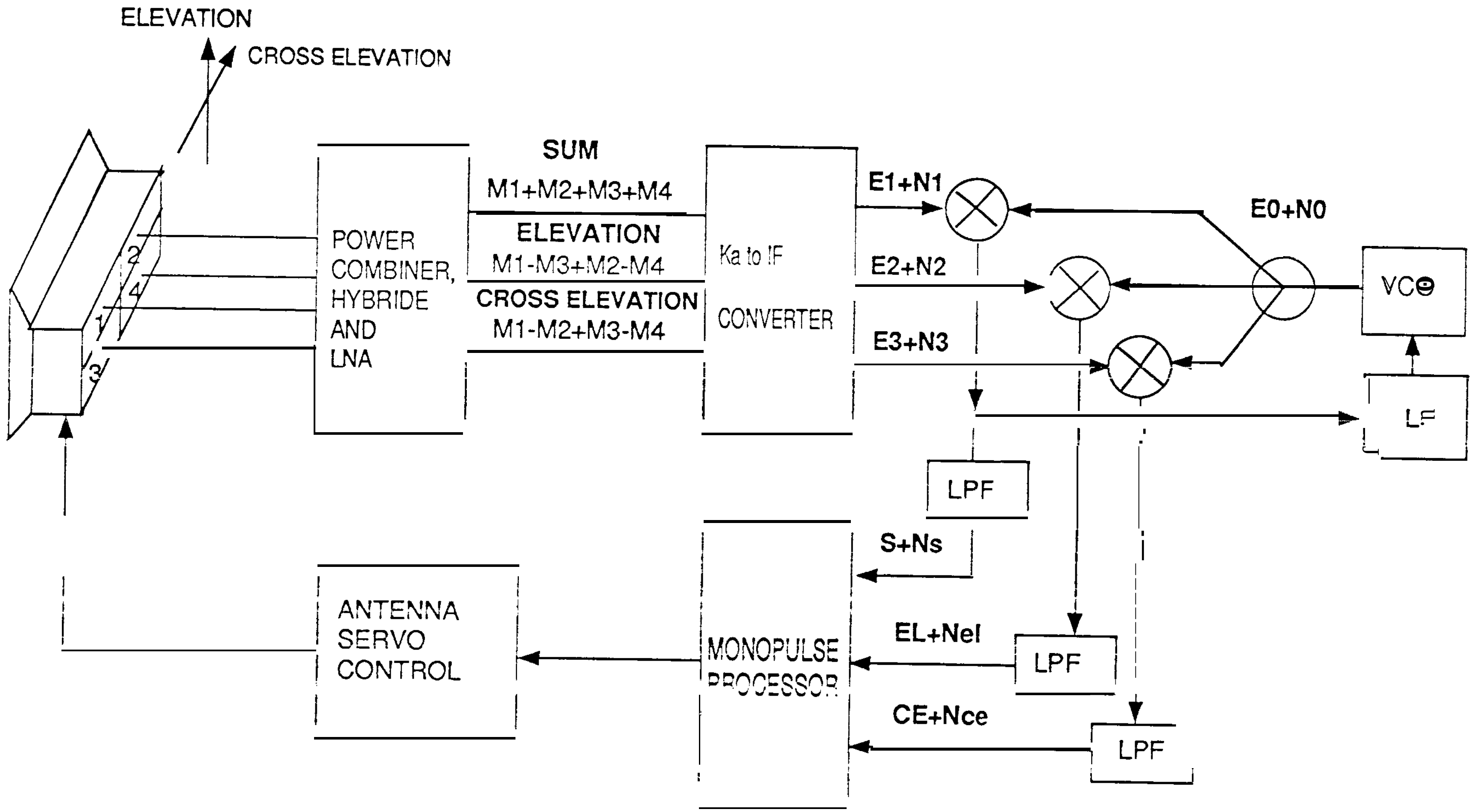

FIGURE 1 : MONOPULSE ANTENNA POINTING SYSTEM

FIGURE 2: COMPARISON AMONG SIMULATION, SMALL/MEDIUM POINTING ERROR MODELS AND SINGLE APERTURE MULTIMODE MODEL