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QUARTERLY PROGRESS REPORT

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Signal Processing

Only minor changes have been made to the one-transmitter model code since the last report. Most changes were small and improved either code legibility or speed. Several redundant calculations were removed from the inner loop of the program.

Work has begun on a program to model a two-transmitter system. The extra transmitter, oriented perpendicular to the first, will allow us to determine the complete orientation of the sphere as well as the orientation of each of the transmitters. To this end the code has been changed to describe orientations in terms of Euler angles rather than direction cosines. This has the added benefit of allowing us to easily test theoretically, as well as experimentally, how the code reacts to a sphere that is rotating as well as translating.

We performed a series of experiments to determine how well the single-transmitter model matches the actual measured voltages, and how the differences between the predicted and actual behavior of the voltage in the antennas affects the inverse transformation. These experiments used many different linear trajectories and several different sets of calibration points. For most known trajectories we were able to reproduce the path from the measured voltages with an accuracy of no worse than two inches for the worst points. (Most points are substantially more accurate.)

We have, however, identified two problem regions. The model encounters difficulty when the transmitter crosses the plane of an antenna or when the transmitter is almost parallel to an antenna and is moving nearly parallel to that antenna. When the transmitter crosses an antenna the measured voltage is significantly higher than the model would predict. Currently we're attributing this to small asymmetries and extra wiring in the test transmitter that only becomes significant on a scale of a couple of inches. These will not be present in the actual transmitter. If the new, more symmetric transmitter still has this problem we have worked out an iterative scheme for selectively choosing which antennas to use to calculate the position of the sphere at a given place.

When a transmitter oriented parallel to an antenna moves parallel to that antenna, the measured voltages are shifted in space relative to the predicted voltages. This is likely caused by the small changes in signal in this situation. The addition of the second transmitter along with an appropriate scheme to choose which transmitter to use in this situation should remedy this source of uncertainty.

Electronics

The tracking system operating with a single-frequency provides a three-dimensional xyz position measurement at the rate of 75 data acquisitions per second. The addition of a second transmitter in the tracked particle can permit numerical determination of the orientation of the tracked particle in addition to the currently available information. The single transmitter operates at 2.0MHz carrier frequency, and the second transmitter operates at 3.65MHz. The two transmitting antennas are mounted in the particle orthogonally to eliminate interference between the two local transmitters and provide easier-to-manipulate data for the orientation algorithm. The two frequencies are not harmonically related. In theory, a large number of frequencies can be used with two frequencies assigned to each tracked particle to permit tracking of a number of particles. The diameter of each transmitter is 1.27cm and the particle diameter is 2.54 cm.

During the quarter, a total of 18 printed circuit boards have been populated with devices and

tested as filter/amplifiers. These boards are used to establish the additional frequency capability for acquisition. Also, prototype dual-frequency transmitters have been fabricated and tested in the system during the quarter.

The power dissipation of the individual transmitter is 4.8mW. This dissipation will double for the particles containing two transmitters. The received signal at the loop antennas is a function of frequency. The received signal from the 3.65MHz transmitter at similar loops is 10 to 20 percent higher than that of the 2.0 MHz transmitter. A single receiving antenna is used to receive both frequencies. At the receiver tuned rf amplifier, networks are used to separate the two signals (2.0 and 3.65 MHz). The bandwidth of the filter at the receiver amplifier for the 2.0 and 3.65 MHz signals is 60 and 90 kHz, respectively.

An additional 48 ports have been added to the analog-to-digital converter subsystem to supplement the existing 16 ports. The capability permits us to acquire data from 64 single-ended or 32 differential input ports. We have found that the signal-to-noise ratio is improved with the differential input mode for data conversion into the analog to digital converter. With the differential mode, the common mode noise pickup is greatly reduced by eliminating circulating current loops. Also, the differential-mode data acquisition reduces error due to common mode-voltages.

The present chute used 10 antennas on the upper chute area and 10 antennas on the lower chute area. The larger number of antennas provides the opportunity for increased position and angle resolution determination.

The data acquisition software has been updated with capability for the increased number of transmitters and antenna. The data acquisition system used is the 486 PC and ADC interface to the custom-designed rf amplifiers and filters.

Radio-Transparent Chute Section

Presently, the entire chute assembly, consisting of upper and lower supports, chutebase, attenaes, hopper and gate, is completed. Several components of the spherical packaging assembly have been constructed and await the mounting of the dual coil electronic transmitter. Following this, the packaged sphere will be dynamically balanced to assure conformity with the other acrylic spheres to be used in the experiment.

Sphere Packaging

Fabrication of the critical components for sphere packaging was conducted during this quarter. The electronics components are to be packaged within a radio-transparent (acrylic) sphere substantially identical to the other spheres within the flow mass. Details on the design appear in the Jan. 92 - March 92 Quarterly Progress report.

The sphere packaging design entailed a pair of half spheres bored and threaded to accept an externally-threaded collar, which itself was bored to accept the electronics components. The collar served to connect the two half spheres. Assembly and disassembly necessary to replace the battery is convenient with this design.

To machine the acrylic hemispheres, it was first necessary to machine a fixture to hold the spheres in the lathe spindle. This was a mandrel made of steel. One end was machined to a No. 3 Morse taper to fit into the lathe spindle. The other end was cut with a ball end mill to mount the

sphere on center. The outside of the spindle was threaded and a cap machined to retain the acrylic ball. A hole was machined in the cap to give access to the ball. Machining of the hemisphere consisted of mounting the acrylic ball in the fixture and boring a hole to tap size and proper depth in the ball. Then the hole was threaded using a tap.

The ball was then removed from the fixture and the fixture removed from the lathe. The ball was then mounted on the threaded end of the mandrel held in the lathe spindle. Following this operation, a cutoff tool was used to cut the ball into a half sphere, the waste material being on the headstock end of the mandrel. The completed hemisphere was removed from the threaded mandrel.

The collar was machined from acrylic rod. It was collet mounted in the headstock, turned to diameter, threaded, bored and cut off.

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