FIRST RESULTS FROM A SATELLITE DATA LINK RADIO INTERFEROMETER

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Since 1967 radio astronomers have been using the Very Long Baseline Interferometer (VLBI) technique to link together radio telescopes separated by continental or intercontinental distances, forming a radio telescope with extremely high resolving power. This high resolving power has had important results in radio astronomy, and is of interest for a wide variety of possible applications including highly precise time transfer, earthquake prediction, and station location. Previous experiments have relied on recording the signals from each antenna on television-type video recorders. This technique has several disadvantages. It is limited in bandwidth and thus sensitivity, cannot produce real-time results and is inherently quite unreliable. In November 1976 our group completed the first successful demonstration of an improved method of operating a long baseline radio interferometer, using a geosynchronous satellite as the connecting data link. The experiment was carried out by an international team of Canadian and American scientists. Large radio astronomy antennas in Lake Traverse, Ontario, and Green Bank, West Virginia were connected via satellite link. The satellite used was the Communications Technology Satellite, a joint Canadian-U. S. effort. As shown in Figure 1, signals from a cosmic radio source were received at an antenna in West Virginia, retransmitted via a wideband data link to the satellite, which sent them to a receiver at the Ontario antenna where they were correlated with the other received signal. The correlated radio source output was observed in real time on an oscilloscope. Figure 2 is a tracing of such an output for a strong radio source with one minute's integration. The width of the correlation function is about 125 nanoseconds, corresponding to the 10 MHz data bandwidth. The time difference between the two station clocks can be determined to a small fraction of this number.

Figure 3a represents the output as a function of fringe frequency when using hydrogen masers at both stations. For a brief period we replaced one frequency standard with a rubidium standard. The resulting deterioration in fringe frequency stability was easily visible (Figure 3b).

This technique, which allows real-time viewing of interferometer results, makes feasible many extensions of VLBI techniques and is of particular importance for all operational and applied uses of VLBI, including precise time transfer, earthquake prediction, and location of a moving vehicle. In all of these, the laborious and failure-prone use of magnetic tape has proved a major practical handicap. The real-time link also makes possible the simultaneous comparison and analysis of data from several stations by time or frequency multiplexing.

The real-time system also eliminates the artificial restriction placed on signal bandwidth by video tape techniques. The bandwidth of our experimental system, 10 MHz, is five times that of the currently-common "Mark II" video-tape system. Since signal-to-noise ratio for a wideband radio astronomy signal increases as the square root of the bandwidth, this results in a significant improvement. Bandwidths up to 50 MHz are possible using existing digital technology, and data bandwidths much higher yet should eventually be possible using analog correlation.

A further possibility is the development of a true phase-coherent interferometer by a two-way transmission of the local oscillator signal via the satellite, thus enabling compensation for the phase change over the satellite path. With this technique, an angular measurement precision of 10^{-4} arcseconds should be possible. This is of importance to radio astrometry and to measurements of Universal Time. We are currently developing equipment for such an experiment.

Low cost is vital to the successful use of this system by scientists. The preliminary experiment reported here was made possible by the granting of time on the CTS satellite by the Canadian Department of Communications. It is hoped that the coming Space Shuttle low-cost satellite era will permit more permanent arrangements to be made.

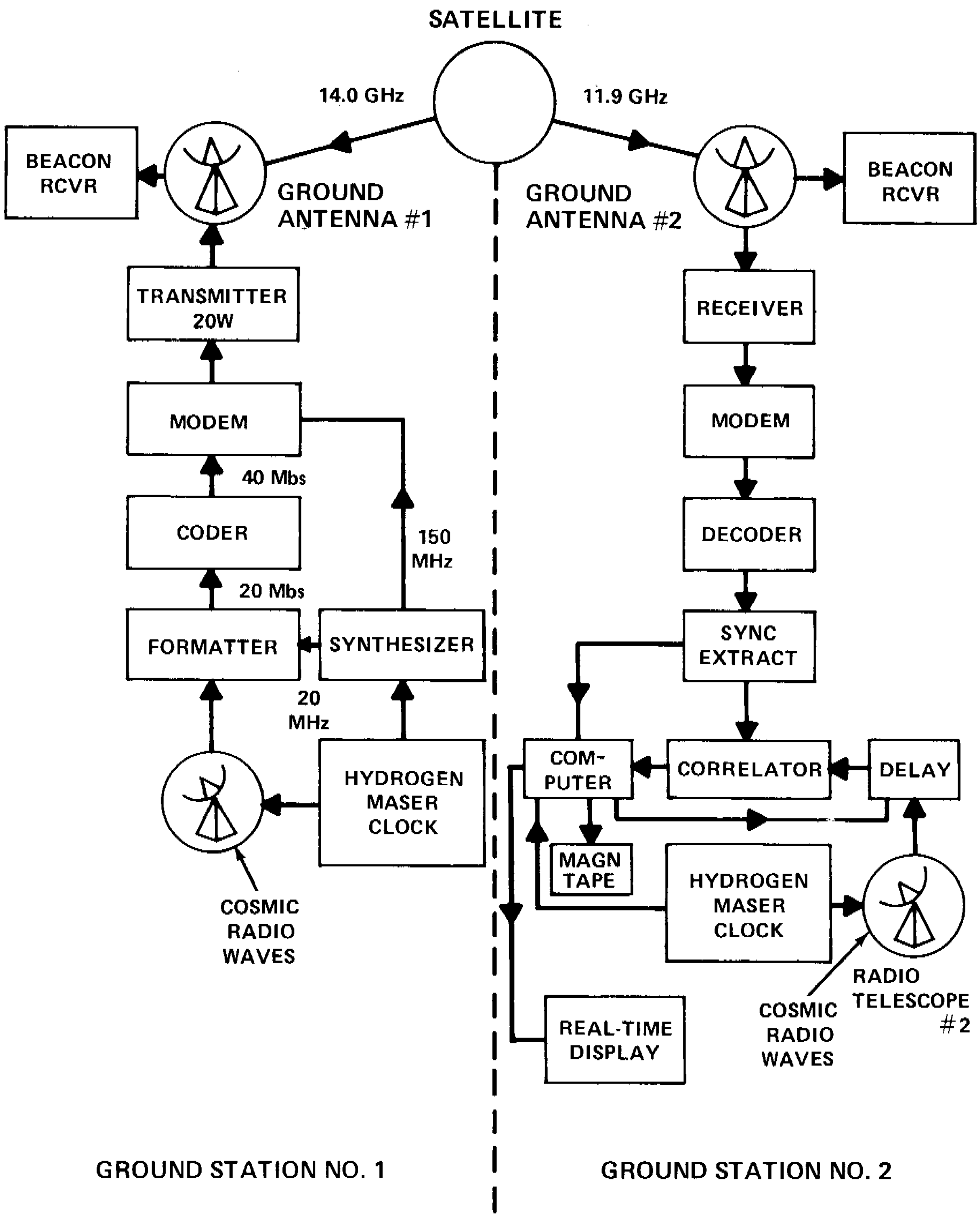

Figure 1. Satellite-Link Interferometer Block Diagram

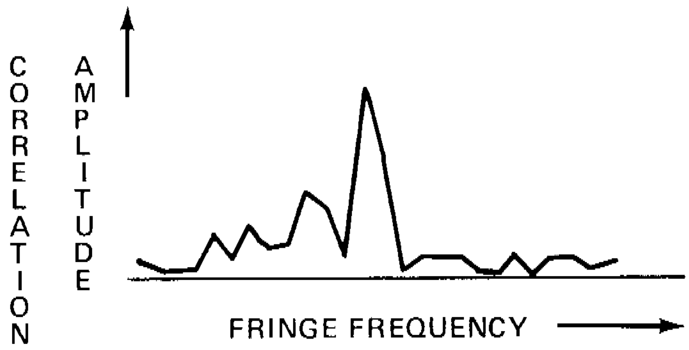

Figure 2. Correlation Amplitude vs. Delay

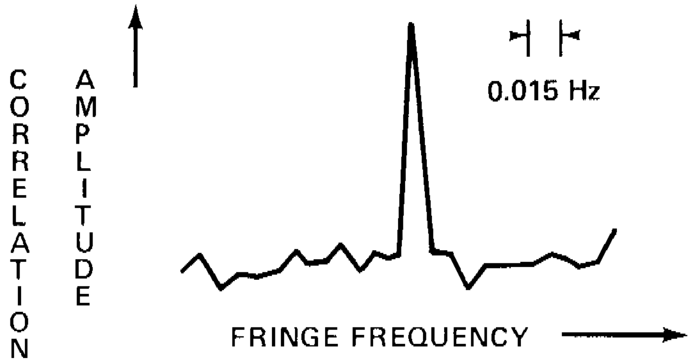

Figure 3a. Correlation Amplitude vs. Fringe Frequency -- Hydrogen Masers

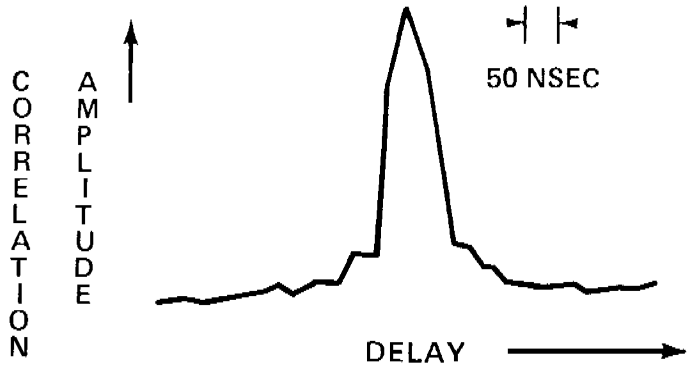

Figure 3b. Correlation Amplitude vs. Fringe Frequency -- Rubidium Standard and Hydrogen Maser