AN LO PHASE LINK USING A COMMERCIAL GEO-STATIONARY SATELITTE

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01/08/2005
An LO Phase Link Using a Commercial Geostationary Satellite

- Motivation
- Two Way Time Transfer
- System Design
- Hardware
- Experimental Results
- Conclusions
• Hydrogen Masers
  – Extremely Costly
  – Exhibit significant drift over time scales on the order of days
• Fiber Optic Links
  – Requires buried fibers
  – Difficult to implement over more than 100km
  – Round trip correction system required
ALTERNATIVE LO DISTRIBUTION APPROACH

• Two Way Satellite Time Transfer
  – Commercial satellites available
  – Significant cost reduction when compared to Hydrogen Masers
  – Large footprint- entire US (including Hawaii) with just one satellite.

Goals of current work:
• Determine feasibility of achieving 1ps level time transfer using a satellite link.
• Make use of inexpensive Ku band transmit/receive equipment.
\[ \phi_{RESIDUAL} = \phi_{ONE-WAY} - \frac{\phi_{ROUND-TRIP}}{2} \]
MODULATION SCHEME

14.0196GHz
(IF=969.6MHz)

300MHz

14.3196GHz
(IF=1269.6MHz)
• Signal to noise ratio
  - SNR sets an upper limit on achievable performance

• Ionospheric Dispersion
  - Frequency dependent effect related to the total electron content in the ionosphere. Violates assumption of path reciprocity. Important effect which can be corrected for by either ASA and BSB measurements or ionospheric modeling.
• Telstar 5 is a commercial communications satellite with ___-wide 100W transponders in the 12/14GHz band.

• Caltech leased three 100kHz bands in transponders 1 and 17 for $1600/month.
STATION A HARDWARE
OUTPUT POWER: 1W
NEW JAPAN RADIO PHASELOCKED LNB

NF = 0.9dB (66.8K), Gain = 55dB
MEASURED SATELLITE RADIAL MOTION

Distance travelled by satellite

Distance travelled, km

Time, days

Distance travelled by satellite over a period of 3.5 days, showing oscillatory motion.
Allan Standard Deviation

Integration Time, $\tau$, sec

$\sigma(\tau)$

- One Way
- Round Trip
- H-Maser
- Cannon et. al (1982)
- Ables et. al (1989)
RMS TIME ERROR

This Experiment

H-Maser

Cannon et. al (1982)

Ables et. al (1989)
## RESULTS

Achieved RMS time error

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<th>Authors</th>
<th>$\tau=1$ sec</th>
<th>$\tau=10$ sec</th>
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<td>3ps</td>
<td>1.2ps</td>
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<td>x</td>
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CONCLUSIONS

- TWTT may provide a cost effective alternative to Hydrogen Masers for use in VLBI
- In this experiment, we were able to achieve better than 3ps time error for integration times ranging from 1 to 2000 seconds
- The limiting factor seems to be earth station thermal stability

POSSIBLE FUTURE WORK

- Temperature stabilization
- Distributed experiment with interferometry
Acknowledgements

- This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

REFERENCES