AN OPERATIONAL TWSTT MONITORING SYSTEM

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Abstract

The U.S. Naval Observatory (USNO) Time Service (TS) uses the AOA TWT-100 Atlantis Modem for its most important Two-Way Satellite Time Transfer (TWSTT) applications. A method was devised to measure delay changes due to hardware failures in an operational monitoring system. The VSAT on the Roof (VSR) of building 78 is a 1.8-meter dish using a SKYDATA RF unit and is used as the primary opreational earth station for TWSTT with the USNO Alternate Master Clock (AMC) located at Falcon AFB, Colorado and for other stations. The Mobile Earth Station (MES) mointors the VSR performance by making six experiments per day. A second 1.8-meter VSat on the Other roof (VSO) is also used as a monitoring system. As long as the hardware remains in normal operating specifications, a constant time difference should result. The MES, VSR, and VSO are co-located with a common-clock reference, Master Clock 2 (MC2). Temperature measurements were taken using a thermocouple-based temperature measuring system. The themocouple probes used to monitor the temperatures of each modem are located on top of the analog section. This paper presents the results of the estimation of time delay change with temperature difference between the modem in MES and a modem in the USNO TS earth station control room.

INTRODUCTION

A system of three Ku-band TWSTT stations has been developed to provide a routine operational monitoring system looking for delay changes from hardware failure. The three TWSTT stations are known as the mobile earth station (MES), the VSat on the Roof (VSR) and the VSat on the Other roof (VSO). TWSTT experiments are taken routinely using a common-clock as reference, MC2. This allows for monitoring the stability of the time difference between the TWSTT. If the systems are performing well, the time-series of the measured time differences will remain at a constant value. However, if a hardware component fails, the measured time delay typically changes quiet noticeably. With a three antenna system enough information is obtained to allow isolation of which individual TWSTT system has the failed component. The main goal of our TWSTT is to provide the most stable TWSTT reference to our remote users; see Figure 1 for a simple diagram of the system.

During normal operations the stability of the common-clock experiments are at the 300 picosecond level RMS. As a secondary effort, we decided it would be simple to install temperature probes on the modem to evaluate the time difference changes between MES and VSR. We installed temperature probes in the ceiling of the MES and the earth station control room (ESCR), as well as placing temperature probes on top of the analog section of each modem. This was done in order to try to gather data to allow evaluation of any temperature effects of the modems with time difference.

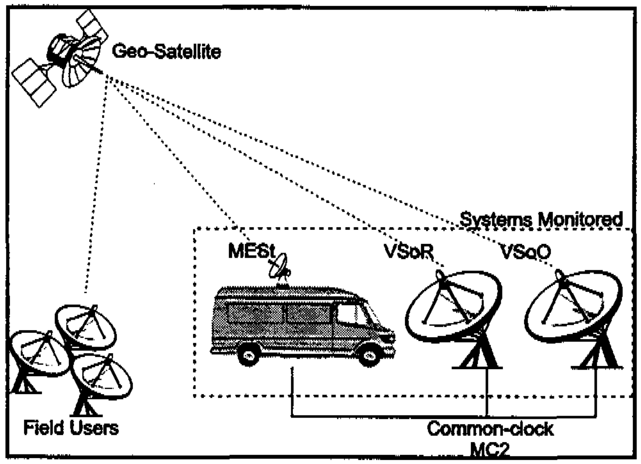

Figure 1

TERMPERATURE OF MODEMS AND TIME DELAY CHANGES

Not surprisingly there was a correlation with outside temperature and the van environment. The temperature as measured at the MES modem shows a diurnal variation locked to the outside temperature, but much reduced in amplitude. The ESCR shows little direct relationship to outside temperature. The data for temperature with respect to time difference are quite varied in the ESCR case! The behavior is very complex, depending on season, state of air conditioners and heating systems, whether rack doors were left open; etc., see Figure 2.

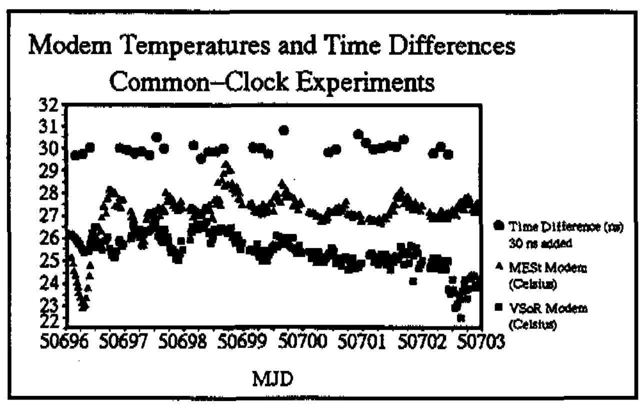

Figure 2

In order to have a small chance of making some sense of these data, we decided to select one week's worth of data (MJD 50696 to 50703) to analyze in detail. Figure 2 shows the time difference VSR-MES (nanoseconds) and the temperature as measured on top of the analog section of the MES and VSR modems. A diurnal temperature variation in phase with outside temperature is evident, especially in the MES temperatures. The earth station control room modem temperatures are a bit more confusing. For the first two days the temperature measured at the modem in the ESCR are out of phase from those measured at the MES modem, then for a while they seem to be in phase, and later seem not related at all. It is clear, therefore, that any transfer function is very complex and variable with time. Since the time difference is measured as VSR-MES, it was decided that the appropriate thing to do was to compare the VSR(modem)-MES(modem) temperature difference with modem-induced delays in the time differences.

Figure 3 shows the time delays (275 ps RMS) with temperature difference between the two modems. A peak-to-peak variation of 6 degrees Celsius is evident between the two modems. Some evidence for short-term time difference structure correlated with temperature difference is visible. There seems to be only an extremely weak long-term relationship.

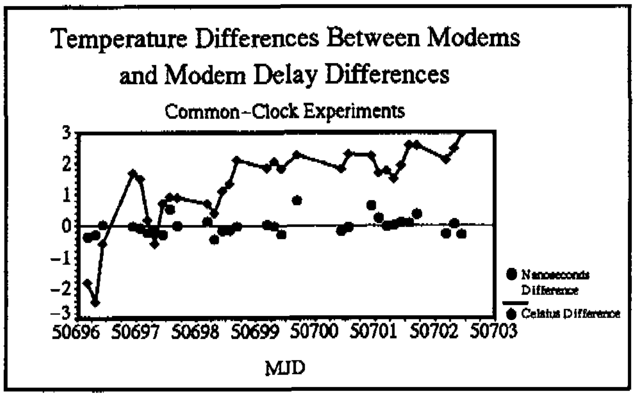

Figure 3

A linear least-squares fit to the temperature difference with time difference for the combination VSR-MES indicates a weak relationship of 85 picoseconds per degree Celsius; see Figure 4.

CONCLUSIONS

To minimize delay variations that will affect accuracy it is always important to consider the design of the complete system. Increasing the thermal stability of the systems through insulation, environmental control, etc. are easy to perform and will improve the stability. VSO can serve as a hot backup in case of failure of a critical component in the primary VSR system. A method of monitoring for long-term seasonal systematics would be a worthy, but difficult project, for future efforts.

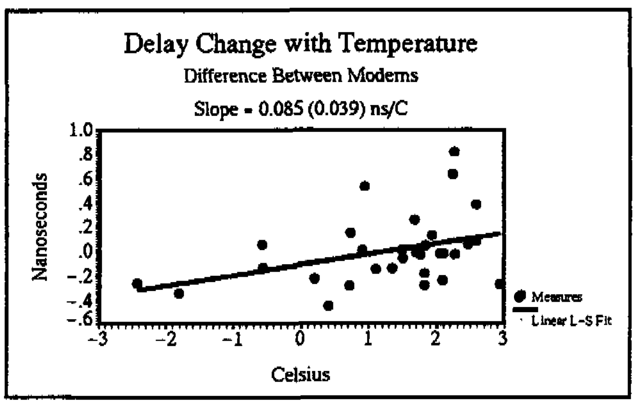

Figure 4

ACKNOWLEDGEMENTS

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