S/X Experiment: A Study of the Effects of Ambient Temperature on Ranging Calibrations

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A study has been made of the effects of the outside air temperature at DSS 14 on ground system range calibrations. Some correlation was found on range data obtained with the 20-kW transmitter system configuration, but no correlation was found for the 100-kW transmitter system configuration.

I. Introduction

In a previous report (Ref. 1), Mariner 10 pre- and post-tracking pass range calibration data were presented for 1974 Day 12 through Day 150. A cursory examination of the data showed that differences between pre- and post-calibration data for the same day's track could be attributed to ambient temperature changes. Since outside air temperatures at DSS 14 have been tabulated in the ranging calibration log book, it was possible to perform a correlation analysis of these data. This article presents the result of this study.

II. Calibration Configuration

Ranging calibrations on the ground system at DSS 14 are currently being performed with the zero delay device (ZDD) in the cable configuration that was described in Ref. 2. The ranging calibrations are normally done during pre- and post-calibration periods of Mariner 10 tracking passes at the signal levels and frequencies applicable to the particular tracking pass. These ZDD pre- and post-calibration data are used along with the ground station Z-correction (Ref. 3) and spacecraft radio system bias correction to enable determination of the true range to the spacecraft (Ref. 4).

A block diagram of the present ZDD configuration for the S/X ground system calibrations at DSS 14 is shown in Fig. 1. As was described in Ref. 2, the ZDD is a ground station antenna-mounted transponder that samples the uplink 2113 MHz from the transmitter and generates coherent downlink S- and X-band test signals of 2295 and 8415 MHz. These test signals are transmitted to the respective masers through calibrated cables of known delay.

Figures 2 and 3 show the ZDD in the cable configuration as it is currently installed in the Mod-3 section of the 64-m antenna at DSS 14. Since this ZDD assembly is located in the air-conditioned environment of the Mod-3 area, this portion of the range calibration system should not be affected by outside air temperature changes. It is believed that most of the range changes attributed to outside air temperature changes will occur in the uplink and downlink cables between the tricone area and the control room. Only about 97.5 m (320 ft) round trip cable length is actually exposed to the outside air temperature environment. Most of this cable run is Spiroline RG 252 cable, but about 12.2 m (40 ft) of round trip RG 214 cable is used in the elevation cable wrapup.

III. Test Results

As was discussed in previous reports (Refs. 1 and 5), the Block 4 range calibration data are also a function of signal level and differ when using the 20-kW or the 100-kW transmitters. Therefore, it was necessary to group the data as those belonging to either the 20-kW or 100-kW transmitter calibrations. Through the use of range change versus signal level curves presented in Ref. 5 it was possible to correct the data and normalize them to a common signal level reference, which was arbitrarily chosen to be −145 dBm. Only calibration data from 1974 Day 85 to Day 172 were used; it was only after Day 85 when both the doppler and system configurations were left unaltered.

The ranging calibration data are shown plotted as functions of outside air temperature in Figs. 4 through 7. It can be seen that some correlation of range change to temperature is evident for the 20-kW transmitter system for both S- and X-band.

For the purposes of comparison, X-band group delay data as a function of temperature are shown in Figs. 8 and 9 for 3.05-m (10-ft) lengths of Spiroline RG 252 and RG 214 cables, respectively. These data were obtained in a temperature-controlled oven and group delay measured by a phase versus frequency measurement technique with a network analyzer. It can be seen that the Spiroline RG 252 characteristics are similar to those measured for the 20-kW data. As was mentioned previously, most of the DSS 14 ranging system cable run consists of RG 252 cable.

No correlation was seen for the data plotted for the 100-kW transmitter system data. This lack of correlation for the 100-kW transmitter data is difficult to explain. It is possible that there are more random noise and range changes associated with the 100-kW transmitter itself. The effect on connector and cable mismatches could also cause departure from expected trends.

IV. Discussion and Conclusions

The results presented in this article show that some correlation of range change with ambient temperature changes was found. However, the results should be interpreted to show trends only and not be used as a correction curve. The data quality is understandably poor for this type of analysis since it is based on two data points a day for a period of about three months. Many systematic and random errors could easily be introduced. It would have been preferable to obtain ranging stability data in one continuous run over a period of about 12 hours. This test should begin in the early morning hours and continue to nighttime hours so as to include the large temperature change periods.

Although time at DSS 14 had been scheduled for performing some of this type of testing, other system problems and test requirements made it difficult to obtain a long continuous run of good ranging stability data.

References

1. Otoshi, T. Y., "S/X Experiment: DSS 14 Pre- and Post-Track Ranging Calibrations for Mariner 10 Tracking Passes and Associated Problems," in *The Deep Space Network Progress Report 42-22,* pp. 81–89, Jet Propulsion Laboratory, Pasadena, California, August 15, 1974.

2. Otoshi, T. Y., and Stelzried, C. T., "S/X Experiment: A New Configuration for Ground Range Calibrations With the Zero Delay Device," in *The Deep Space Network Progress Report 42-20,* pp. 57–63, Jet Propulsion Laboratory, Pasadena, California, April 15, 1974.

3. Batelaan, P. D., "S/X-Band Experiment: Zero Delay Device Z Correction," in *The Deep Space Network Progress Report 42-20*, pp. 78–83, Jet Propulsion Laboratory, Pasadena, California, April 15, 1974.

4. "TRK-2-8 Module of DSN System Requirements Detailed Interface Design Document 820-13, Rev. A.," July 1, 1973 (JPL internal document).

5. Otoshi, T. Y., and Batelaan, P. D., "S/X Experiment: DSS 14 S/X Ground System Ranging Tests," in *The Deep Space Network Progress Report 42-22*, pp. 90–100, Jet Propulsion Laboratory, Pasadena, California, August 15, 1974.

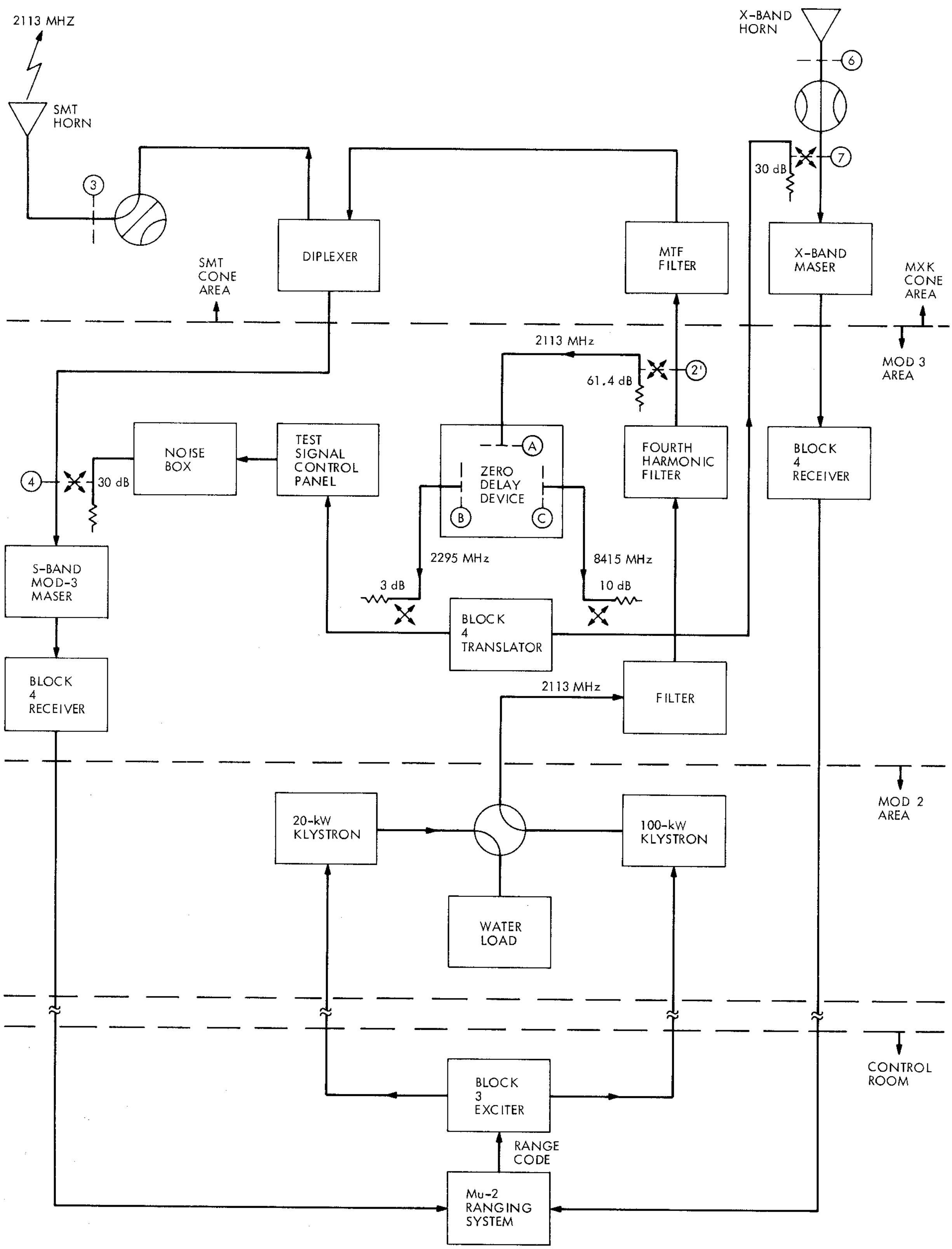

Fig. 1. Block diagram of the new configuration at DSS 14 for ground system range calibrations

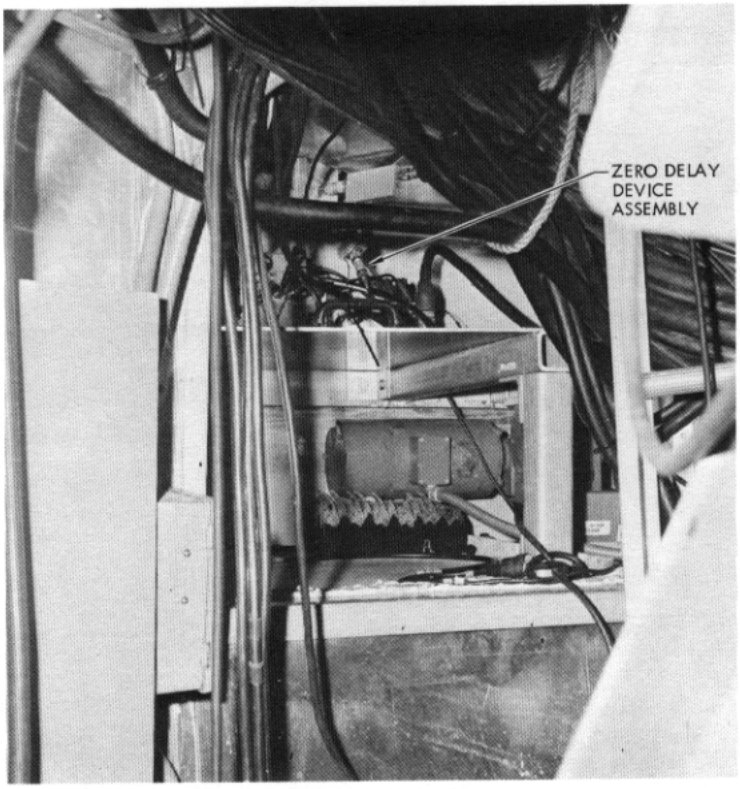

Fig. 2. Zero delay device assembly as seen inside the Mod 3 area

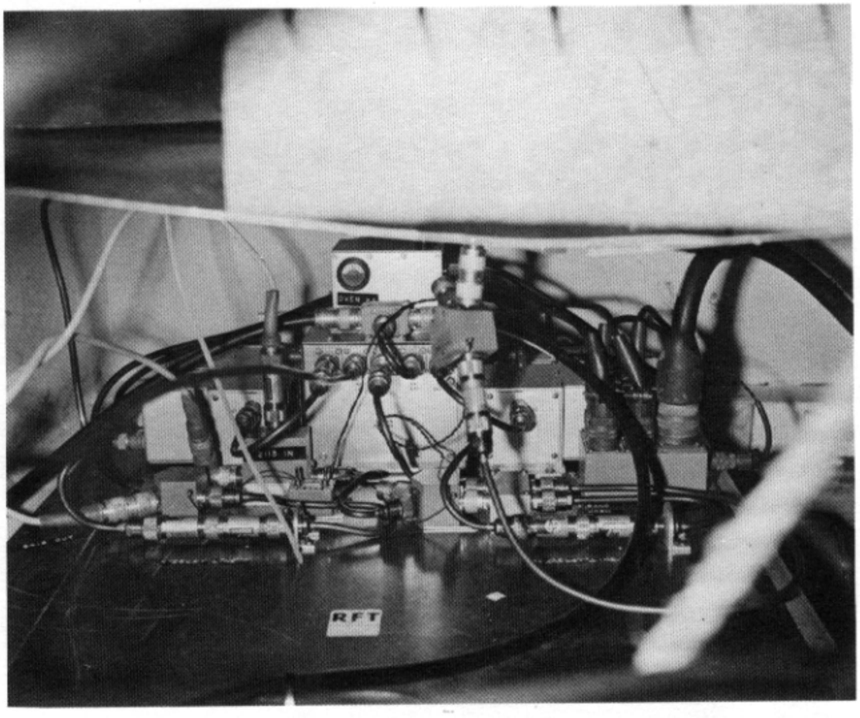

Fig. 3. Closeup view of the zero delay device assembly as currently installed in the Mod 3 area

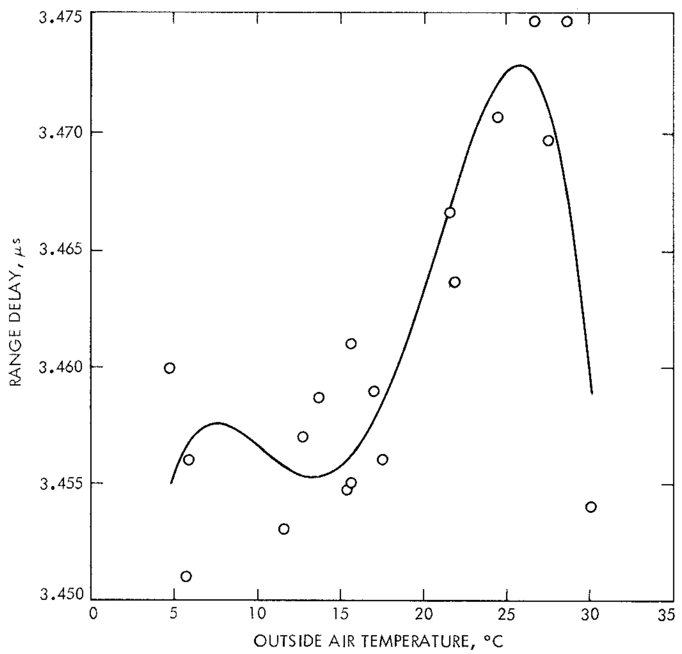

Fig. 4. S-band range as a function of outside air temperature at DSS 14. Data taken after 1974 Day 85 for 20-kW transmitter configuration and corrected to the −145-dBm signal level

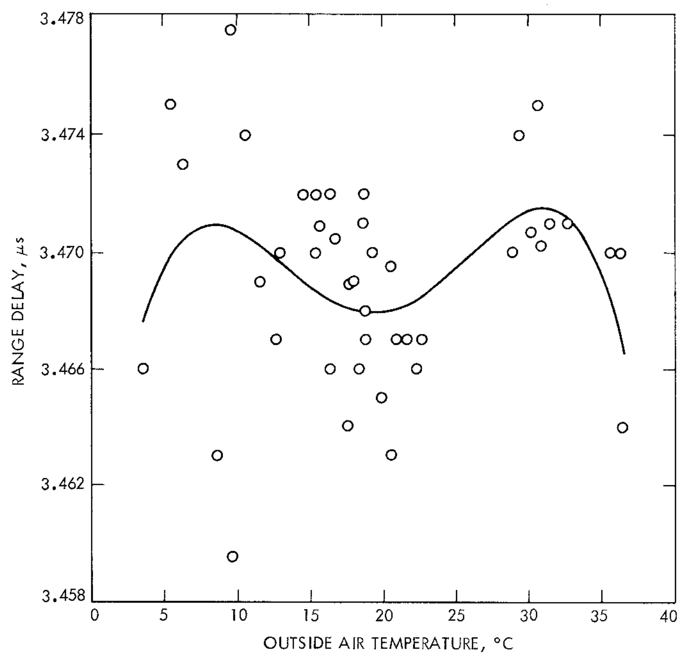

Fig. 6. S-band range as a function of outside air temperature at DSS 14. Data taken after 1974 Day 85 for 100-kW transmitter configuration and corrected to the −145-dBm signal level

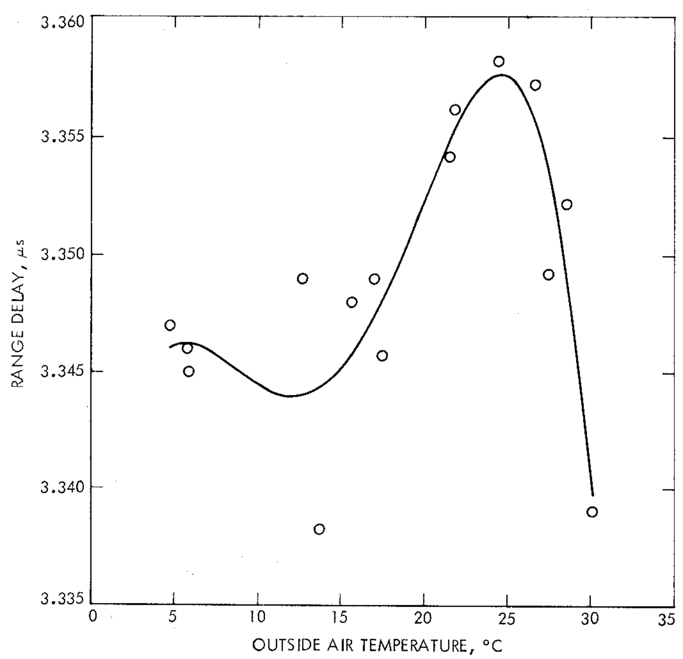

Fig. 5. X-band range as a function of outside air temperature at DSS 14. Data taken after 1974 Day 85 for 20-kW transmitter configuration and corrected to the −145-dBm signal level

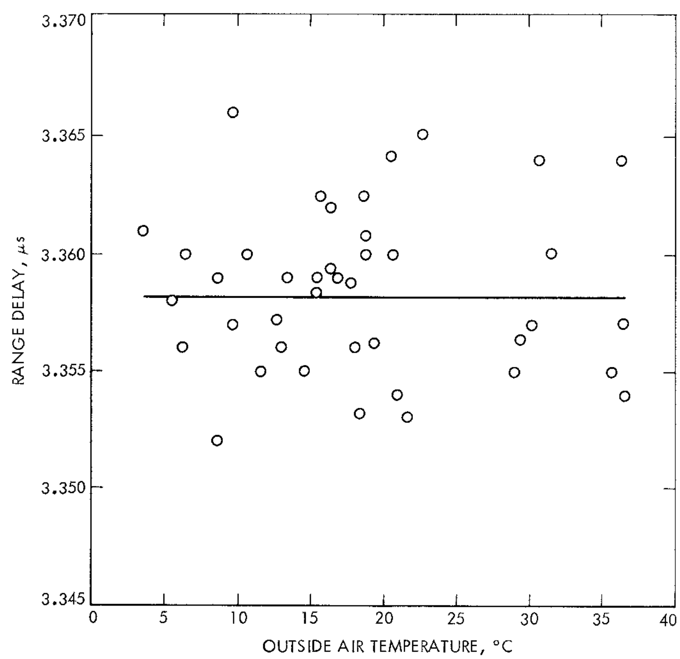

Fig. 7. X-band range as a function of outside air temperature at DSS 14. Data taken after 1974 Day 85 for 100-kW transmitter configuration and corrected to the −145-dBm signal level

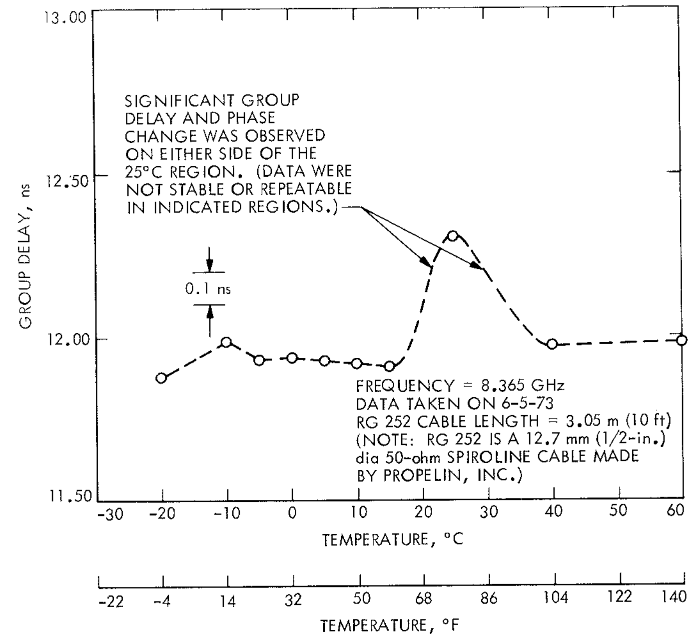

Fig. 8. X-band group delay as a function of temperature for 3.05-m (10-ft) length of Spiroline RG 252 cable

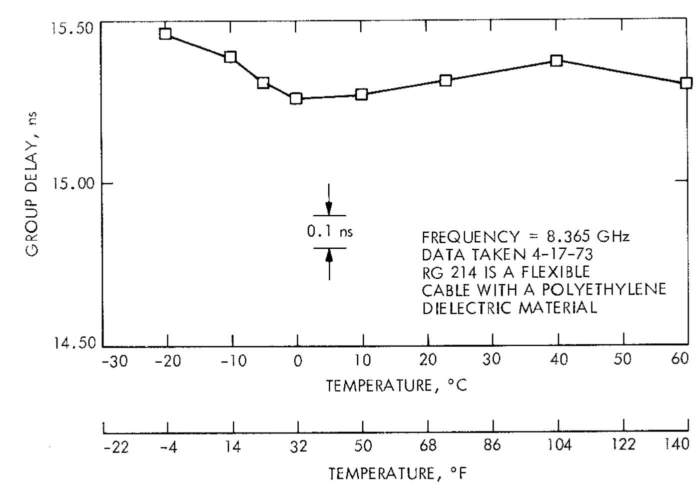

Fig. 9. X-band group delay as a function of temperature for 3.05-m (10-ft) length of RG 214 cable