Improved RF Calibration Techniques: System Operating Noise Temperature Calibrations

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The system operating noise temperature performance and other calibration data of the low-noise research cones at the Goldstone Deep Space Communications Complex are reported for June 1, 1972, through September 30, 1972. The performance of the following cones is presented for this reporting period: the S-band radar operational cone at DSS 13, the S-band megawatt transmit cone at DSS 14, and the polarization diversity S-band cone at DSS 14. In addition to the above S-band calibration data, elevation profile measurements were made at fixed azimuth at 8415 MHz on the multifrequency X- and K-band cone.

The system operating noise temperature performance of the low-noise research cones at the Goldstone Deep Space Communications Complex is reported for the period of June 1, 1972, through Sept. 30, 1972. The operating noise temperature calibrations were performed with the ambient termination technique[1] (Ref. 1). System temperature calibrations were made on the following cones:

(1) S-band radar operational (SRO) cone (and the gain standard horn) at DSS 13.

(2) S-band megawatt transmit (SMT) cone at DSS 14.

The averaged operating noise temperature calibrations for the SRO cone (and the gain standard horn) at DSS 13, along with other calibration data, are summarized in Table 1. The maser in operation in the SRO cone throughout this reporting period was serial number 96S5. Measurements made with this maser connected to the gain standard horn at 2278.5 MHz are also shown in Table 1.

Averaged operating noise temperature calibrations and other calibration data are presented in Table 2 for the SMT cone at DSS 14, both in the low-noise path mode with the maser in the SMT cone (serial number 96S4) and diplexed with the maser in the Mod. 3 section (serial number 80S1). All SMT cone data were taken at 2295 MHz, with the subreflector correctly aligned.

The calibration data were reduced with JPL computer program 5841000, CTS20B. Measurement errors of each data point average are recorded under the appropriate

[1]Most of the measurements were taken by DSS 13 (Venus) and DSS 14 (Mars) personnel.

number in the tables. The indicated errors are the standard deviation of the individual measurements and of the means, respectively. They do not include instrumentation systematic errors. The averages were computed using only data with:

(1) Antenna at zenith.

(2) Clear weather.

(3) No RF spur in the receiver passband.

(4) Standard deviation of computed operating noise temperature due to measurement dispersion less than 0.15 K.

Figure 1 is a plot of system operating noise temperature of the SRO cone at DSS 13 as a function of time in day numbers. The frequency was 2278.5 MHz and the maser was No. 96S5. Figure 2 is a similar plot at 2388 MHz. Figures 3 and 4 show SMT cone operating noise temperatures as a function of time in day numbers, for the low-noise path (maser 96S4) and diplexed (maser 80S1), respectively. The frequency in Figs. 3 and 4 was 2295 MHz. In all these figures, data that satisfy the four conditions stated above are plotted as solid circles, while data that fail one or more conditions are plotted as open circles.

System operating noise temperatures of the polarization diversity S-band (PDS) cone are presented in Fig. 5 as a function of time. The frequency was 2295 MHz for all data. Both low-noise path and diplexed data are shown and the period covered is Jan. 1, 1972, through Sept. 30, 1972. In this figure, the averaged precision measurements reduced by computer program CTS20B have been augmented by single Y-factor numbers. Although these latter data were taken using the ambient termination method, most of them were not reduced by computer program CTS20B, and therefore a greater time period is presented. These data were taken with the antenna at zenith, the subreflector correctly positioned in each case, but with no regard for weather conditions.

In addition to the above S-band system temperature calibrations, all of which were performed with the antenna at zenith, elevation profile measurements were made at X-band with various subreflector configurations. These data are presented in Figs. 6 and 7. In Fig. 6, system temperature is plotted as a function of elevation angle for 8415 MHz. The solid curve was obtained when the subreflector was correctly aligned on the appropriate main horn. When the subreflector was positioned on the PDS cone, the X-band radiometer yielded the dotted curve. Figure 7 is a similar plot of system temperature as a function of antenna elevation angle with the subreflector positioned on the SMT cone. In this figure, the correctly aligned subreflector data have been repeated for reference. The solid curve changes only an insignificant amount when the subreflector is switched between the X- and K-band main horns. The azimuth was fixed at 180 deg for all curves in Figs. 6 and 7, and the weather was clear and dry.

All elevation profile data were obtained with the Noise Adding Radiometer (NAR) developed at JPL (Ref. 2). System temperatures at X-band were first obtained at zenith using the ambient termination technique. Several Y-factors were computed, and an average operating noise temperature computed. This value was checked by using a microwave absorber placed over the X-band main horn. The radiometer noise diode temperature was then adjusted to calibrate the NAR.

References

1. Stelzried, C. T., "Operating Noise-Temperature Calibrations of Low-Noise Receiving System," *Microwave J.*, Vol. 14, No. 6, pp. 41–48, June 1971.

2. Batelaan, P. D., Goldstein, R. M., and Stelzried, C. T., "A Noise-Adding Radiometer for Use in the DSN," in *The Deep Space Network*, Space Programs Summary 37-65, Vol. II, pp. 66–69, Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1970.

Table 1. System operating noise temperature calibrations of the SRO cone (maser 96S5) and the gain standard horn (maser 96S5) on the 26-m-diameter antenna at DSS 13

Parameter	At 2278.5 MHz		At 2295 MHz	At 2388 MHz
	Gain standard horn	SRO cone		
Maser gain, dB	43.4 ±0.95/0.43 5 measurements	43.5 ±1.65/0.21 61 measurements	43.4 ±0.78/0.56 2 measurements	32.0 ±2.6/0.54 23 measurements
Follow-up receiver contribution, K	0.09 ±0.01/0.003 5 measurements	0.27 ±0.21/0.03 61 measurements	0.13 ±0.05/0.03 2 measurements	0.53 ±0.05/0.01 23 measurements
System operating noise temperature, K	30.2 ±0.68/0.30 5 measurements	16.4 ±0.50/0.07 61 measurements	16.2 ±0.38/0.27 2 measurements	17.1 ±0.33/0.07 23 measurements

Table 2. System operating noise temperature calibrations of the SMT cone at 2295 MHz on the 64-m-diameter antenna at DSS 14

Configuration	Low-noise path	Diplexed
Maser serial number	96S4	80S1
Maser gain, dB	48.1 ±0.52/0.12 18 measurements	38.1 ±2.3/0.57 16 measurements
Follow-up receiver contribution, K	0.18 ±0.05/0.01 18 measurements	0.06 ±0.01/0.002 16 measurements
System operating noise temperature, K	15.6 ±0.18/0.04 18 measurements	26.9 ±0.28/0.07 16 measurements

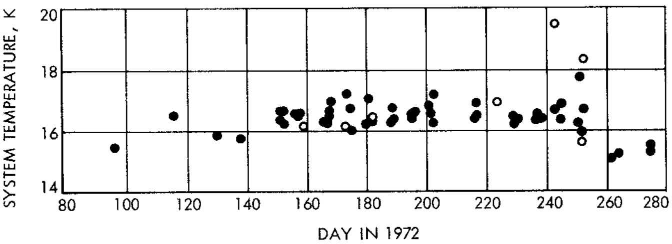

Fig. 1. System operating noise temperature calibrations of the SRO cone at 2278.5 MHz, plotted as a function of time in day numbers

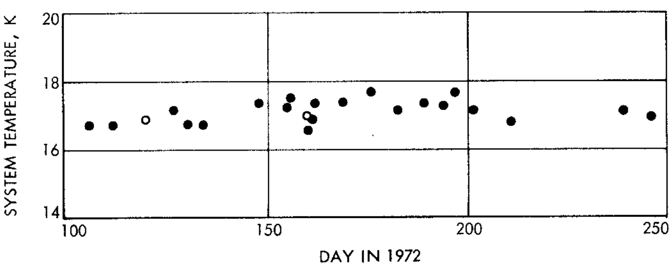

Fig. 2. System operating noise temperature calibrations of the SRO cone at 2388 MHz, plotted as a function on time in day numbers

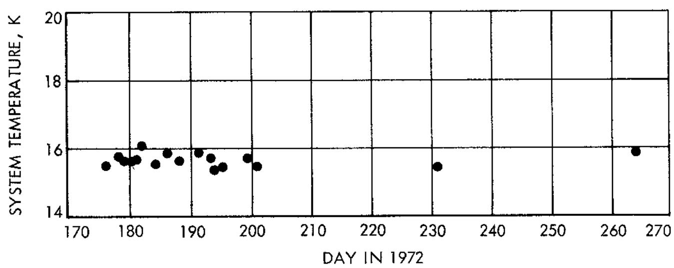

Fig. 3. System operating noise temperature calibrations of the SMT cone. low-noise path at 2295 MHz, plotted as a function of time in day numbers

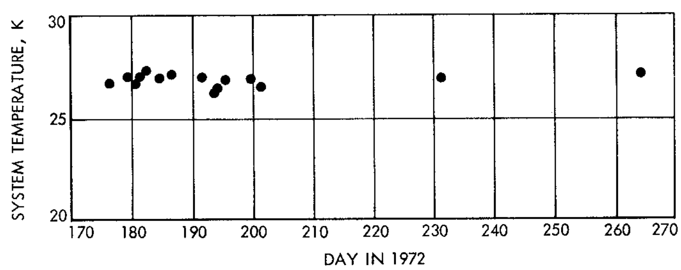

Fig. 4. System operating noise temperature calibrations of the SMT cone, diplexed at 2295 MHz, plotted as a function of time in day numbers

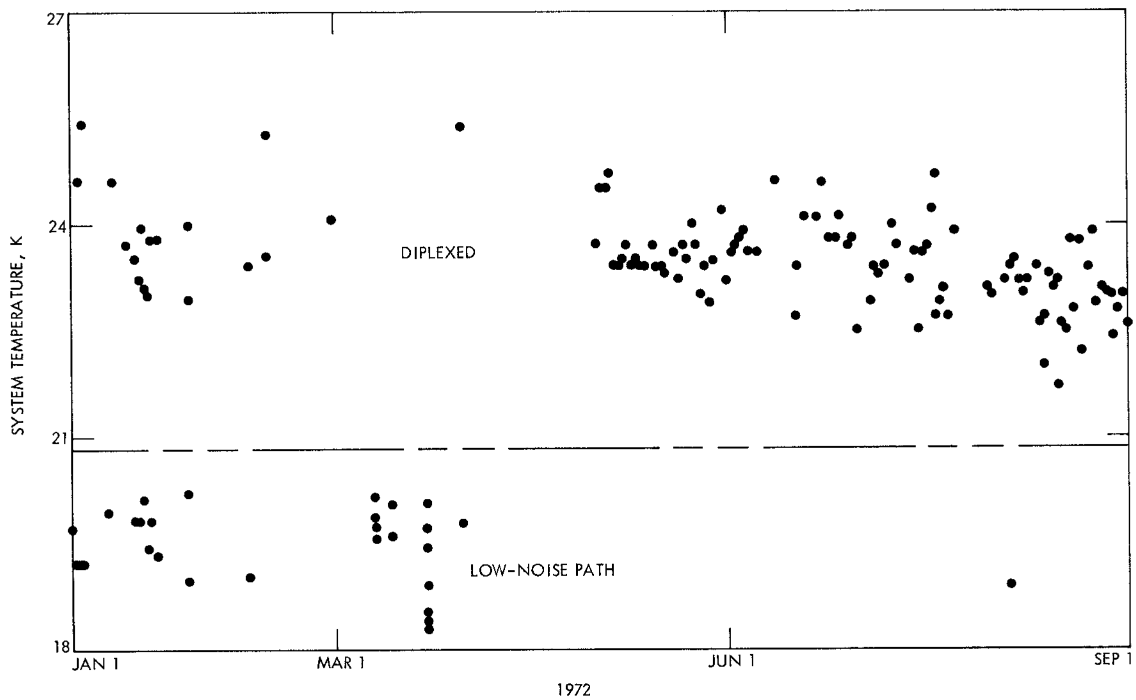

Fig. 5. System operating noise temperature calibrations of the PDS cone at 2295 MHz, both low-noise path and diplexed, plotted as a function of time in day numbers

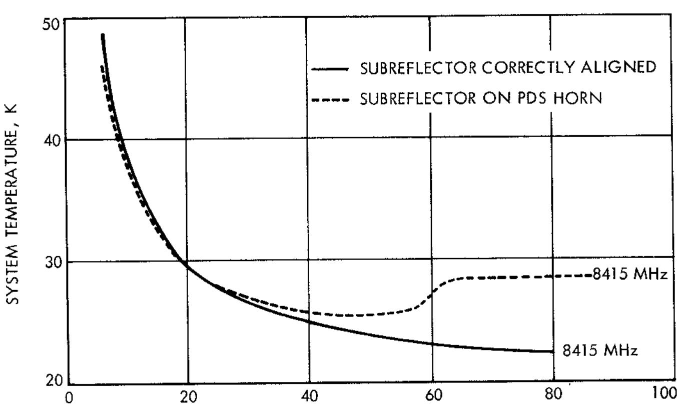

Fig. 6. System temperature elevation profiles at 8415 MHz with the subreflector correctly aligned and on the PDS horn

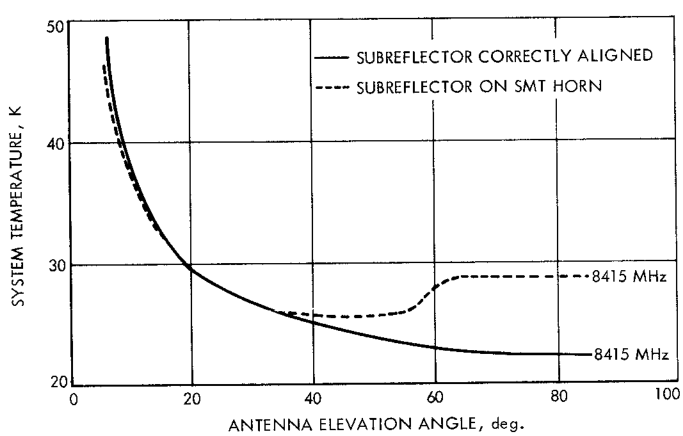

Fig. 7. System temperature elevation profiles at 8415 MHz with the subreflector correctly aligned and on the SMT horn