Improved RF Calibration Techniques: System Operating Noise Temperature Calibrations

M. S. Reid
Communications Elements Research Section

System operating noise temperatures and other calibration data of the S-band radar operational (SRO) cone at DSS 13 and the tricone system at DSS 14 are reported for the period February 1 through May 31, 1972. During this reporting period the tricone system consisted of the polarization diversity S-band (PDS) cone, the S-band megawatt transmit (SMT) cone and the multifrequency X- and K-band (MXK) cone. S-band calibration data for various configuration modes of the PDS and SMT cones are reported as well as X-band calibration data for the MXK 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 February 1 through May 31, 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 at DSS 13.

(2) Polarization diversity S-band (PDS) cone at DSS 14.

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

(4) Multifrequency X- and K-band (MXK) cone at DSS 14.

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

The averaged operating noise temperature calibrations for the SRO cone at DSS 13, and 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 Tables 2 and 3 for the tricone system on the 64-m-diameter antenna at DSS 14. Table 2 presents data for the MXK cone at K-band (15.3 GHz) and the SMT cone, both low noise path, with the maser in the SMT cone (serial number 96S4), and diplexed with the maser in the 3A section (serial number 80S1). All the SMT cone data are for 2295 MHz.

PDS cone data are shown in Table 3, where all measurements were taken at 2296 MHz. Maser 80S1 is located in the 3A section and maser 96S3 is in the PDS cone.

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

In Tables 2 and 3 the subreflector was correctly positioned on the horn of the system under test for all the calibration data. Table 3 shows two columns of low noise path data for the PDS cone maser. The low noise path system temperature at zenith for the PDS system was running somewhat higher than expected. An investigation was carried out and the problem, which was found to be ruby heating, was cleared by changing the klystron pump conditions. Measurements made after the pump conditions were changed are shown in the second column of low noise path data, where the averaged system operating noise temperature is 18.5 K, as expected.

The PDS cone has been optimized for diplexed operation and therefore has a lower diplexed system temperature than the SMT cone. This is illustrated in Tables 2 and 3 where the PDS and SMT diplexed system temperatures are reported as 23.5 K and 25.7 K, respectively. The SMT cone, however, has been optimized for receive-only operation, and this may also be seen from Tables 2 and 3.

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 96S5. Figure 2 is a similar plot of system temperatures with the maser connected to the gain standard horn. SRO cone system temperatures (with maser 96S5) at 2388 MHz are shown in Fig. 3. In 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.

Figure 4 is a plot of SMT cone system temperatures as a function of time in day numbers. Both the low noise path with maser 96S4 and the diplexed path with maser 80S1 (3A section) are shown in the figure. Figure 5 is a similar plot for the PDS cone. Low noise and diplexed paths are shown, both using maser 96S3, as well as the date when the klystron pump conditions were changed. The PDS cone system temperature data from the previous reporting period, October 1, 1971 through January 31, 1972 (Ref. 2) have been included in this figure for reference.

In both Figs. 4 and 5 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. These data were taken with the antenna at zenith, the subreflector correctly positioned in each case, but with no regard for weather conditions.

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. Reid, M. S., "Improved RF Calibration Techniques: System Operating Noise Temperature Calibrations," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VIII, pp. 61–67. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1972.

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

Frequency, MHz	2278.5		2295	2388
	Gain Standard Horn	SRO Cone		
Maser gain, dB	41.6 ±4.10/0.88 22 measurements	42.1 ±4.03/0.48 70 measurements	43.5 ±0.40/0.20 6 measurements	32.4 ±5.9/1.4 12 measurements
Follow-up receiver contribution, K	0.07 ±0.07/0.02 22 measurements	0.07 ±0.06/0.008 63 measurements	0.27 ±0.04/0.02 5 measurements	0.13 ±0.04/0.01 18 measurements
System operating noise temperature, K	29.2 ±0.53/0.12 22 measurements	16.1 ±0.56/0.07 63 measurements	15.6 ±0.44/0.20 5 measurements	17.1 ±1.0/0.23 18 measurements

Table 2. System operating noise temperature calibrations of the SMT and MXK cones on the 64-m antenna at DSS 14

Cone	SMT		MXK
Frequency, MHz	2295		15300
Maser serial number	96S4	80S1 3A Section	148K1
Configuration	Low noise path	Diplexed	Subreflector on K-band horn
Maser gain, dB	–	–	–
Follow-up receiver contribution, K	–	–	0.13 ±0.06/0.05 2 measurements
System operating noise temperature, K	15.7 ±0.11/0.05 55 measurements	25.7 ±0.21/0.08 28 measurements	26.7 ±0.07/0.05 2 measurements

Table 3. System operating noise temperature calibrations of the PDS cone on the 64-m antenna at DSS 14

Maser serial number	80S1 (3A Section)		96S3		
Configuration	Low noise path	Diplexed	Low noise path before pump conditions changed	Low noise path after pump conditions changed	Diplexed
Maser gain, dB	40.2 ±0.21/0.12 2 measurements	40.4 1 measurement	49.4 ±1.08/0.71 36 measurements	49.6 ±2.3/1.0 5 measurements	50.4 1 measurement
Follow-up receiver contribution, K	0.06 ±0.01/0.007 2 measurements	0.04 1 measurement	0.05 ±0.03/0.005 36 measurements	0.09 ±0.05/0.02 5 measurements	0.05 1 measurement
System operating noise temperature, K	24.9 ±0.72/0.42 2 measurements	29.2 ±0.31 1 measurement	19.8 ±0.26/0.04 36 measurements	18.5 ±0.24/0.10 5 measurements	23.5 ±0.25 1 measurement

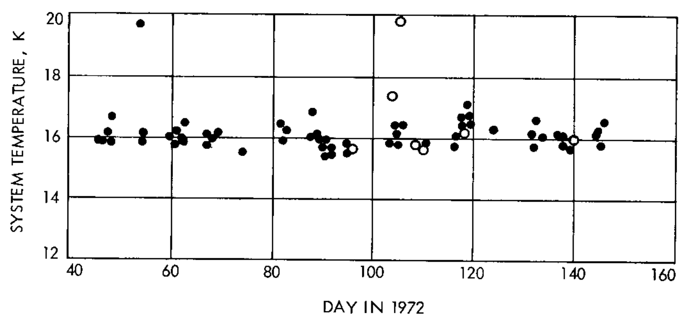

Fig. 1. System operating noise temperatures of the SRO cone at 2278.5 MHz plotted as a function of time in day numbers

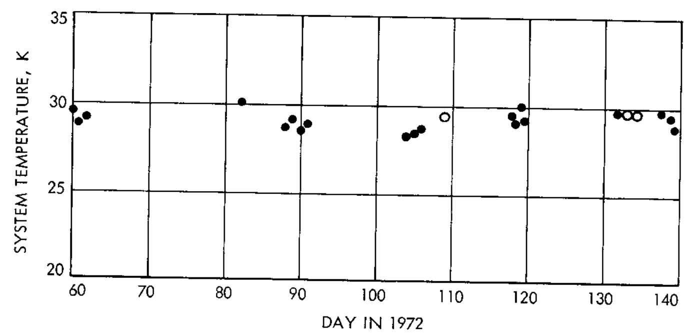

Fig. 2. System operating noise temperatures with the gain standard horn at 2278.5 MHz plotted as a function of time in day numbers

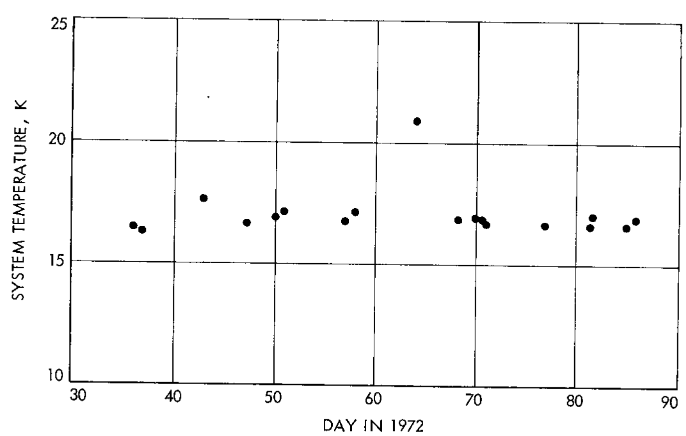

Fig. 3. System operating noise temperatures of the SRO cone at 2388 MHz plotted as a function of time in day numbers

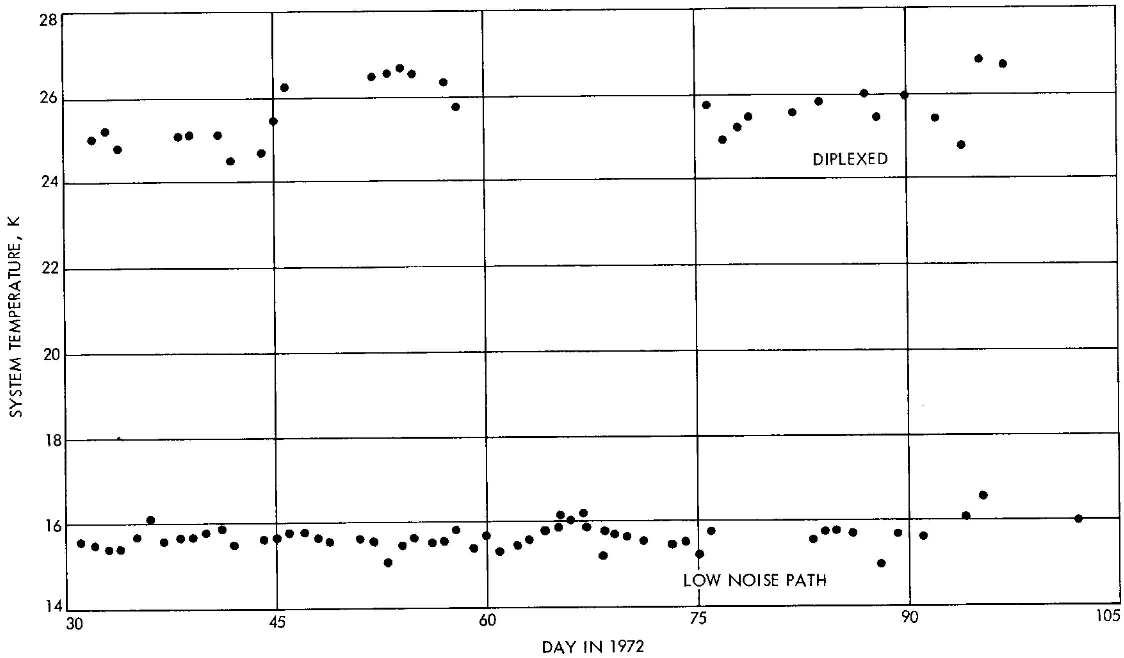

Fig. 4. System operating noise temperatures of the SMT cone, low noise path and diplexed, plotted as a function of time in day numbers

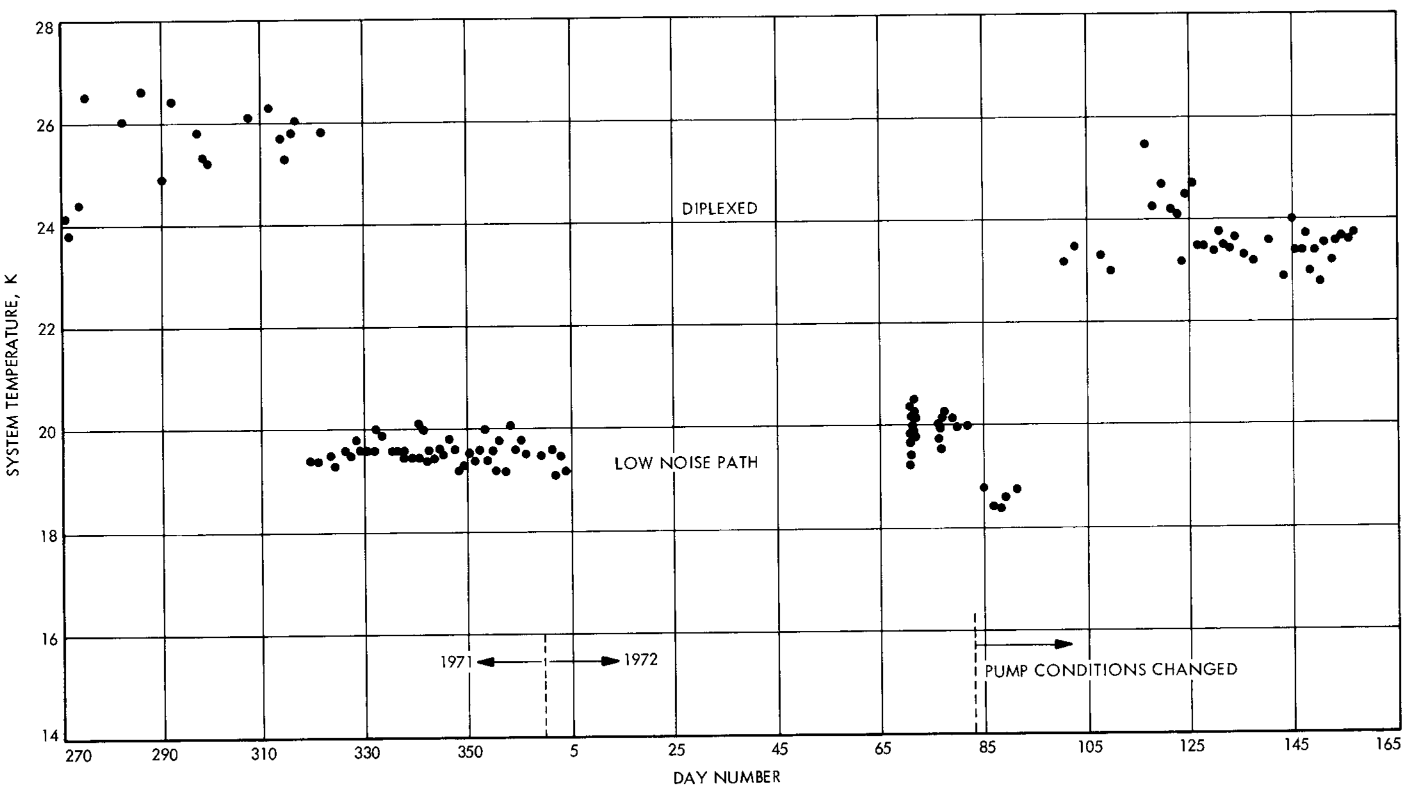

Fig. 5. System operating noise temperatures of the PDS cone, low noise path and diplexed, plotted as a function of time in day numbers