NRL Report 7148

Field Strength Measurements for NWC, North West Cape, Australia, From September to December 1967

C. B. Brookes and J. E. Raudenbush

Electromagnetic Propagation Branch
Communications Sciences Division

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NAVAL RESEARCH LABORATORY
Washington, D.C.

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ABSTRACT

In the period from September to December 1967, the newest of the very-low-frequency (VLF) transmitting stations operated by the Navy, NWC, at North West Cape, Australia, had scheduled transmissions on six different frequencies in the VLF band. In order to obtain information on propagation paths not previously investigated, the Naval Research Laboratory installed instrumentation to collect data at selected sites in Japan, Madagascar, and Bahrain Island. Transmissions were recorded continuously for a three-month period. Examination of the data allows determination of the optimum frequency for each path investigated.

PROBLEM STATUS

This is a final report on one phase of this problem; work on other phases continues.

AUTHORIZATION

NRL Problem R07-22

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FIELD STRENGTH MEASUREMENTS FOR NWC, NORTH WEST CAPE, AUSTRALIA, FROM SEPTEMBER TO DECEMBER 1967

INTRODUCTION

The Naval Research Laboratory (NRL) has been engaged for approximately ten years in an extensive research program concerned with the propagation of electromagnetic energy in the very-low-frequency (VLF) range of the spectrum. The approach employed by NRL in conducting VLF propagation studies has been to gather data over fixed propagation paths spanning a long period of time, usually several years, so that a good statistical picture can be obtained. The distance dependence is obtained by means of airborne measurements, in which one of the NRL aircraft is used to traverse the path. Background information on some of the airborne measurements can be obtained from Rhoads and Garner (1) and from Hauser, Garner, and Rhoads (2).

With the commencement of transmissions from the newest of the Navy VLF transmitters, NWC, located at North West Cape, Australia, a data collection program was begun in September 1967 to gather propagation information over paths not previously observed in the Pacific and Indian Ocean areas. During the three-month period, starting in September 1967, the transmitter operated at several frequencies on a cyclic basis, which provided a unique opportunity to gather propagation information under conditions of multifrequency operation. The field strengths and relative phase of the NWC transmissions were recorded by NRL at ground sites in Japan, Madagascar, and Bahrain Island. Data recording at the operating frequency continued after this three-month period in Japan and Madagascar. This report deals with the field strength and signal-to-noise ratio data collected by NRL from 1 September to 1 December 1967.

EXPERIMENTAL APPROACH

The hourly format employed for transmissions from NWC during the three-month period encompassed by the experiment is presented in Table 1, while Table 2 lists the various frequencies employed. The operating frequencies were used for the normal communication traffic and also provided a two-minute, continuous, unmodulated-carrier (locked-key) transmission once each hour. The test frequencies were employed for a two-minute period of continuous unmodulated carrier, once each hour. Both operating and test frequencies were changed weekly, in a pattern that ensured a good statistical distribution over the three-month period.

TABLE 1

HOURLY TRANSMISSION SCHEDULE FOR NWC

TRANSMISSION	TIME (Minutes Past Each Hour)
Normal Communication	00-50
No Transmission	50-53
Continuous Unmodulated Transmission on "Test" Frequency	53-55
No Transmission	55-58
Continuous Unmodulated Transmission on "Operating" Frequency	58-60

TABLE 2

TRANSMISSION FREQUENCIES EMPLOYED BY NWC

OPERATING FREQUENCIES*	TEST FREQUENCIES**
15.5 kHz	18.0 kHz
19.8 kHz	24.5 kHz
22.3 kHz	26.8 kHz

*Changed each Tuesday at 0600 UT

**Changed each Friday at 0600 UT

A description of the equipment employed to obtain the data, along with the details concerning calibration and daily operation of the recording equipment, is outlined by Kronschnabel and Raudenbush (3). Both amplitude and the relative phase of the received signal were recorded; however, this report will be concerned only with the amplitude data. The atmospheric noise was also measured at the operating and test frequencies immediately before or after the two-minute continuous unmodulated carrier transmissions. The atmospheric noise was also measured for ten minutes of each hour, at each of three frequencies; namely, 15.25 kilohertz (kHz), 21.0 kHz, and 27.3 kHz.

Table 3 lists the data recording sites, along with their geographic coordinates and their bearing and distance from the transmitting station at North West Cape, Australia. The paths to NWC from each of the sites are predominantly over seawater.

TABLE 3

DATA RECORDING SITES

SITE	GREAT CIRCLE DISTANCE TO NWC (km)	GEOGRAPHIC BEARING*	GEOGRAPHIC COORDINATES
Bahrain Island	8681.19	55.2°W	26.2°N 50.6°E
Choshi (Inubo), Japan	6983.57	24.2°E	35.7°N 140.8°E
Tananarive, Madagascar	6895.79	100.4°W	18.8°S 47.6°E

*Short path bearing of receiver from the transmitter.

DATA PROCESSING

The raw data, which were in the form of ink, strip-chart recordings, were manually transcribed from the strip charts to computer cards. In

processing the field strength data, normalization to a reference power level was made at each frequency employed. This normalization is required to eliminate possible changes in radiated power during the conduct of the experiment from influencing the magnitude of the field strength values. The power levels employed for normalization of the data at each frequency were representative of typical transmitter operation and were determined by the selection of nominal current values as recommended by CNO. A tabulation of these values is presented in Table 4, along with the previously determined values of radiation resistance as given by Garner, et al (4).

TABLE 4

NWC RADIATION RESISTANCES
AND NORMALIZED ANTENNA CURRENTS

FREQUENCY (kHz)	RADIATION RESISTANCE (Ohms)	NORMALIZED ANTENNA CURRENTS (Amperes)
15.5	0.142	2500
18.0	0.196	2400
19.8	0.241	2200
22.3	0.323	2000
24.5	0.404	1800
26.8	0.490	1650

While great care was taken at all of the sites to minimize the effects of man-made noise, it was found necessary to discard some of the field strength data because of the severe man-made noise experienced occasionally at some of the sites.

DISCUSSION AND RESULTS

The field strength data are presented in Figs. 1 through 18 and show the diurnal variation for the mean and standard deviation of the received signals at each site during the three-month period for each frequency employed. The mean field strength values derived from the hourly locked-key observations are connected with a straight line, and the standard deviation for each hour is indicated. The lowest hourly locked-key value is represented on the graph by a triangle (Δ), and in addition, the lowest value recorded between each hourly locked-key for the operating frequency data is denoted by a square (□).

The mean values of field strength recorded at Bahrain, Figs. 1 to 6, do not show any appreciable difference between the daytime and nighttime levels at any of the six frequencies. However, the sunset dip at 1300 UT is rather broad and deep, which shows that a relatively low signal level is experienced over a period of several hours. The Japan mean field strength levels are remarkably uniform throughout the 24 hours for the lower frequencies of 15.5, 18.0, and 19.8 kHz as shown in Figs. 7, 8, and 9; however, at the higher three frequencies, as seen in Figs. 10, 11, and 12, the nighttime levels exceed the daytime levels with a maximum difference of 15 decibels (dB) at 26.8 kHz. At Madagascar for 15.5 kHz, the day and night levels are about equal, but at 18.0 kHz, the daytime mean is slightly higher than at night, as seen in Figs. 13 and 14. At 19.8, 22.3, and 24.5 kHz, the nighttime levels are again several dB higher than the daytime levels, as shown in Figs. 15, 16, and 17, while Fig. 18 shows that at 26.8 kHz the average nighttime

level is about 10 dB higher than the daytime level. In general, for all of the sites and frequencies employed, the standard deviations are larger at night and during transition periods than during the day.

The signal-to-noise ratio data are presented in two forms of graphs for each frequency at the different ground sites. The plots of the mean signal-to-noise ratio levels, Figs. 19 through 101, illustrate the diurnal variation of these values on an hourly basis, with the standard deviation indicated to show how much the signal-to-noise ratios vary from day to day for each hour. Both weekly and summation plots for the entire three-month period are presented. The normal distribution plots, Figs. 102 through 133, illustrate the variation of the signal-to-noise ratio levels at a particular site on a 24-hour basis. Furthermore, a mean and standard deviation for a 24-hour period can be obtained from the normal distribution plots. Average measured noise values are employed in all of the signal-to-noise ratio results presented in this report.

The mean and standard deviation of the signal-to-noise value (in dB) for the hourly locked-key values are plotted against a 24-hour time base in a similar manner to the field strength data with a line connecting the mean signal-to-noise value for each hourly locked-key sample taken. The figures above the hourly values indicate the number of signal-to-noise samples used to determine the mean and standard deviation. The lowest value of signal-to-noise ratio between the hourly locked-key samples is indicated by a square (□). Figures 19 through 101 represent the mean and standard deviation for the three receiving sites. The plots are arranged in the

order of frequencies and time. For example, Figs. 19 through 21 are plots for Bahrain Island at 15.5 kHz for the weeks of 17 October, 7 November, and 28 November 1967, respectively. Figure 22 is the mean and standard deviation plot of 15.5 kHz for the total period from September to December 1967 at Bahrain Island.

Particular attention should be called to the mean and standard deviation curves for signal-to-noise ratio recorded in Japan. The summary plot for the whole season from September to December exhibits large values for the standard deviations as shown in Figs. 27, 43, 55, 70, and 83. These large values for the standard deviations in the three-month plot were caused by a distinct change in the value of the signal-to-noise ratio during this period. Closer examination shows that at 1200 UT in Japan for 24.5 kHz the average signal-to-noise reading for the month of September was 32.7 dB and the average noise reading was 30.9 dB. At the same time of day and frequency, the average signal-to-noise reading for the month of November was 39.1 dB and the average noise reading was 26.2 dB. Still considering the Japanese site at 1200 UT, but now at 15.5 kHz, the average signal-to-noise reading for September was 17.4 dB and the average noise reading was 42.4 dB. During the month of November, the average signal-to-noise reading was 34.7 dB and the average noise reading was 28.9 dB. These examples are used to show that the large standard deviation values on the three-month plot were caused by a higher atmospheric noise level during the month of September than during the month of November. The effect was evident over the entire frequency band considered, but affected the lower frequencies more than the higher frequencies.

Environmental factors which may have been responsible for the observed changes in atmospheric noise will now be discussed. First, the NWC field strengths over the three-month period do not exhibit any significant change other than the expected diurnal variation. An extensive survey of the area where the antenna systems were located revealed that there were no apparent man-made sources interfering with the equipments. However, the monopole antenna system was relocated some 30 meters from its original location as a precautionary measure. The change in atmospheric noise level was not immediately noticeable in the recordings after this relocation, but did occur a short time later. Unfortunately, since the anomaly was not immediately corrected when the relocation was made, it cannot be conclusively determined whether there was man-made interference in the original location which was not detectable with the portable equipment used, or whether there was an actual change in the atmospheric conditions during this period.

As previously mentioned, the data are presented by two forms of graphs. Besides the plots of mean and standard deviation, the normal distribution for the signal-to-noise ratio is presented in Figs. 102 through 133. From a statistical standpoint, in order to present a valid normal distribution for the recorded data, only complete days (days with a sample for each hour of the 24 hours) should be considered. The number of complete days, however, were somewhat limited in number because of equipment malfunctions; therefore, probability plots were also made considering all the data. This approach was justified on the basis that the missing portions of data occurred at random periods. It was further justified by the fact that a

probability plot of one or even three complete days in a four-week period is hardly representative of propagation conditions over a given path. Therefore, the comparison of both the "complete day" probability plots and the "total data" probability plots provides a more meaningful picture statistically. The dates given on the "complete day" probability plots indicate the period during which the stated number of complete days is found. Figures 102 through 133 represent the probability plots for the data recorded at the three sites from September to December 1967. For example, Fig. 104 is the probability plot for nine complete days of field strength data recorded in Japan at a frequency of 15.5 kHz. Figure 105 represents the probability plot of all the field strength values recorded in Japan during the September to December 1967 period. In general, the two types of probability curves are quite similar for the same frequency and site; however, there is some difference in levels in many instances.

The data presented in Table 5 represent an average signal-to-noise value in dB for each site at each frequency for the period from 1 September to 1 December 1967. The signal-to-noise ratio values in Table 5 were derived from average measured noise employing measuring equipment having a 41 hertz effective noise bandwidth. Because of equipment limitations, no attempt was made during the conduct of the experiment to measure root-mean-square (rms) noise values, although for many purposes, signal-to-noise ratios based on rms noise are more meaningful. A CCIR report (5) gives information relating average to rms noise, and by employing the curves given, a conversion factor (V_d) can be obtained. The latter must be used with caution, however, as there is no random variation given for this conversion factor.

TABLE 5

AVERAGE MEAN SIGNAL-TO-NOISE RATIO VALUES
FOR SEPTEMBER TO DECEMBER 1967 FOR NWC

FREQUENCY (kHz)	SIGNAL-TO-NOISE RATIO AT EACH SITE		
	Bahrain (dB)	Japan (dB)	Madagascar (dB)
15.5	10.4	26.2	18.3
18.0	14.3	29.0	15.6
19.8	13.9	24.8	22.1
22.3	17.0	30.9	22.9
24.5	12.5	27.7	23.6
26.8	11.1	44.0	24.0

CONCLUSIONS

The overall, average signal-to-noise ratio values presented in Table 5 show 22.3 kHz to be the optimum frequency for reception at Bahrain and Japan if the 26.8 kHz average for Japan is not included. Since the amount of data taken at 26.8 kHz in Japan was very sparse compared with the other frequencies, the rather high value of signal-to-noise ratio for this frequency cannot be given equal weight with the other values, and quite conceivably could be the result of a statistical fluctuation. In Madagascar the higher frequencies, 19.8 kHz and above, show a somewhat greater signal-to-noise ratio than for 15.5 kHz and 18.0 kHz, but with no one frequency being significantly better than the others from 19.8 to 26.8 kHz.

In general, the diurnal patterns of the signal-to-noise ratio plots for the weekly data exhibit relatively small standard deviations from the mean values except during the transition periods. The summation plots for all the recorded field strengths from September to December 1967 show a much larger standard deviation.

The weekly plots of signal-to-noise ratio show that the average daytime and nighttime levels are about the same at all frequencies in Japan, while for Bahrain the daytime values are 10 dB higher than the nighttime values at 15.5 kHz, but the differences become less with increasing frequency. In Madagascar the daytime average was higher or equal to the nighttime average at all frequencies except 26.8 kHz, for which the nighttime average was a few dB higher.

ACKNOWLEDGMENTS

It is impossible to thank each person who contributed to this project; however, special gratitude is expressed to the personnel at Inubo Radio Wave Observatory at Choshi, Japan, and the personnel at the Scientific Observatorie, University of Madagascar, Malagasy Republic. Also, to NRL personnel including M. Kronschnabel, E. Elwood, J. McCabe, and E. Bryan for preparation and installation of the equipment and for their help in the reduction of the data.

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3. Kronschnabel, M. C., and Raudenbush, J. E., "A Semi-Automatic System for Measuring and Recording the Phase and Amplitude of Transmissions from NWC," NRL Memorandum Report 1773, 4 May 1967.

4. Garner, W. E., Raudenbush, J. E., and Brookes, C. B., Jr., "Radiation Parameters of the VLF Transmitting Station NWC, North West Cape, Australia," NRL Memorandum Report 1783, 21 June 1967.

5. International Radio Consultative Committee (CCIR), "World Distribution and Characteristics of Atmospheric Radio Noise," International Telecommunication Union, Report 322, Geneva, 1964.

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TYPE OF DATA	DATA RECORDING SITES	FIGURE NUMBERS AT EACH FREQUENCY					
		15.5 kHz	18.0 kHz	19.8 kHz	22.3 kHz	24.5 kHz	26.8 kHz
Field strengths; mean and standard deviation of	Bahrain	1	2	3	4	5	6
	Japan	7	8	9	10	11	12
	Madagascar	13	14	15	16	17	18
Signal-to-noise ratios; mean and standard deviation of	Bahrain	19-22	34-38	49-52	61-65	76-80	89-93
	Japan	23-27	39-43	53-55	66-70	81-83	94-95
	Madagascar	28-33	44-48	56-60	71-75	84-88	96-101
Signal-to-noise ratios; probability distribution of	Bahrain	102, 103	108, 109	114, 115	120, 121	126, 127	130, 131
	Japan	104, 105	110, 111	116, 117	122, 123	128	
	Madagascar	106, 107	112, 113	118, 119	124, 125	129	132, 133

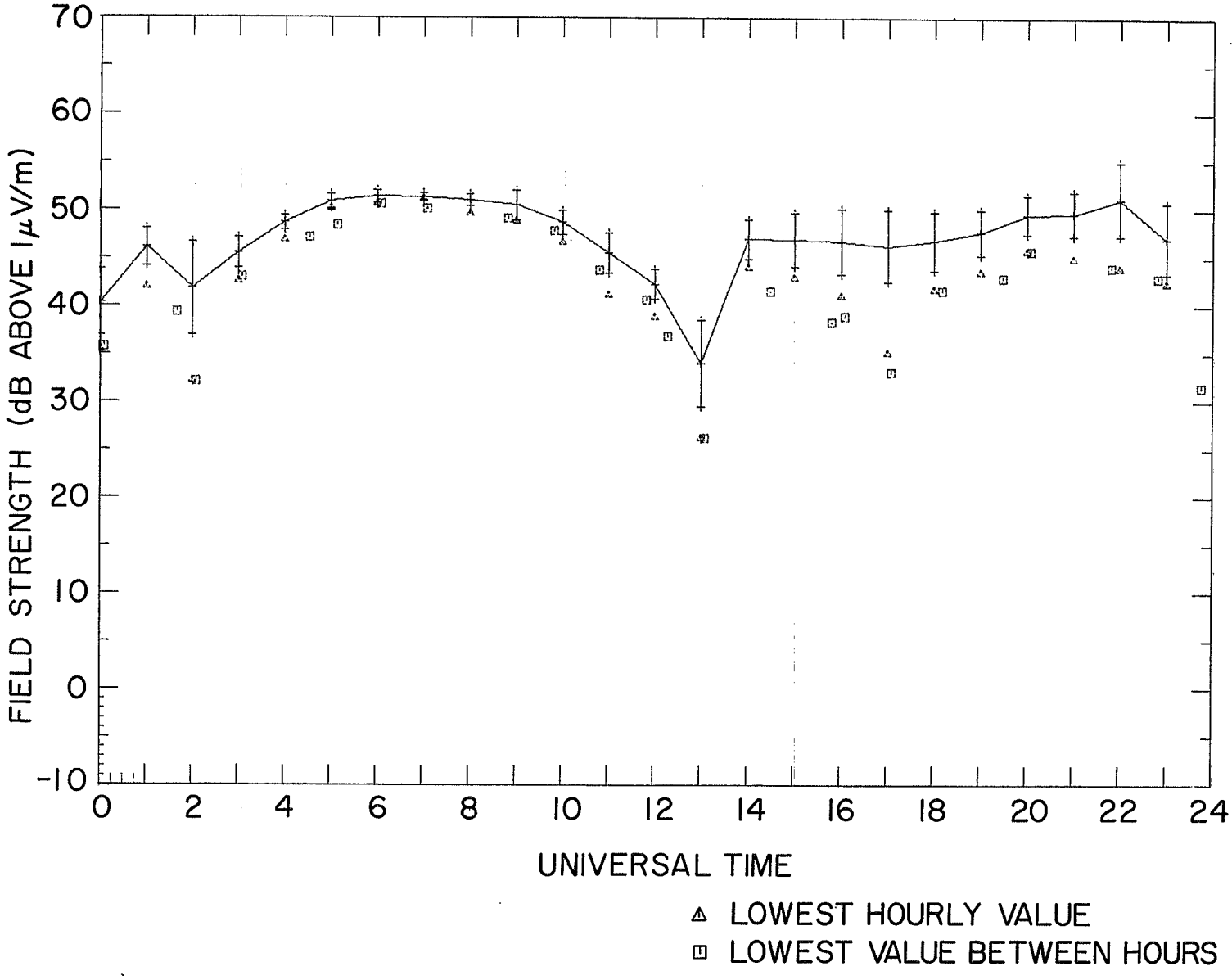


Fig. 1 - Mean and standard deviation of the field strength for NWC at Bahrain, 15.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 29.5 dB above 1 kw.

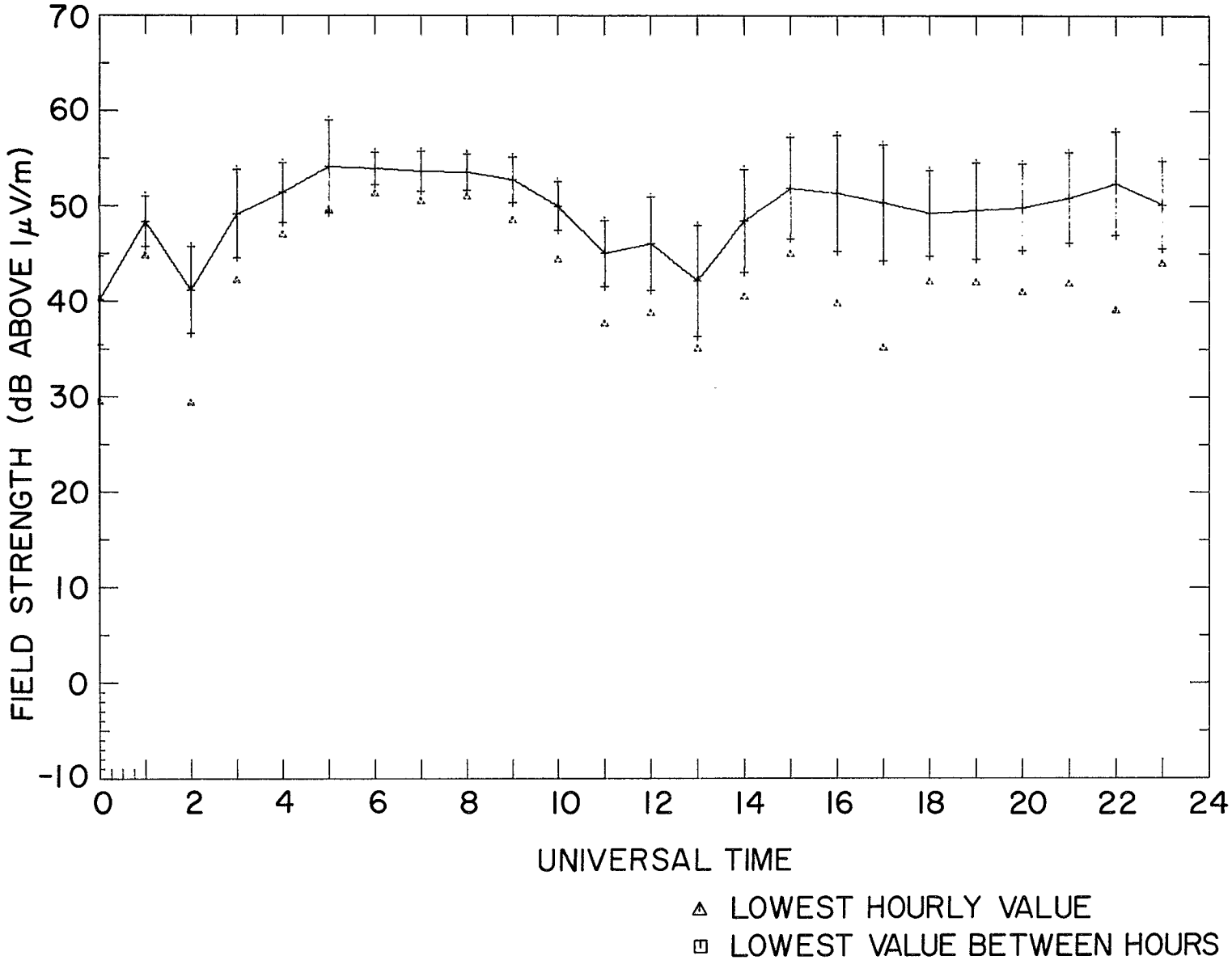


Fig. 2 - Mean and standard deviation of the field strength for NWC at Bahrain, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.5 dB above 1 kw.

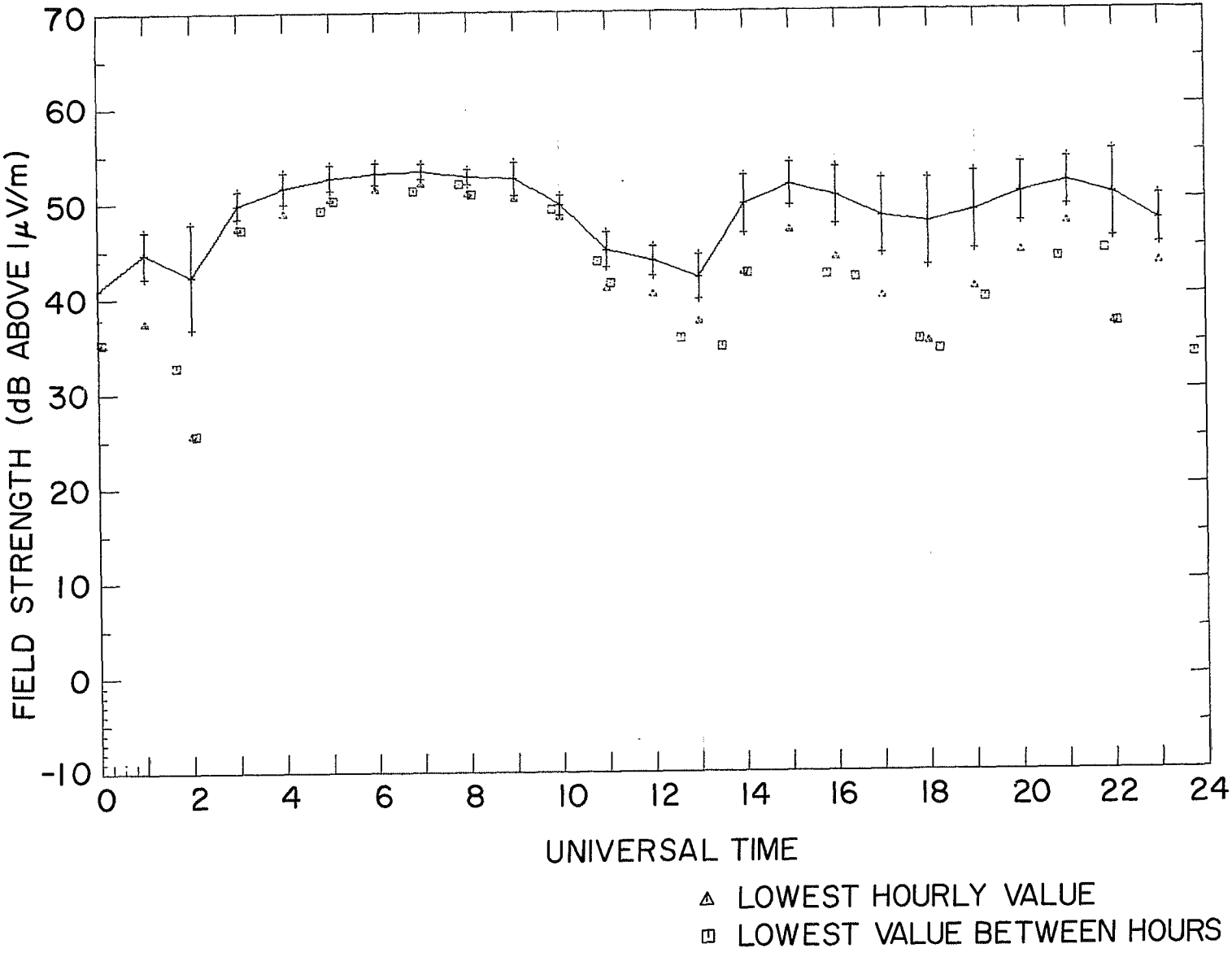


Fig. 3 - Mean and standard deviation of the field strength for NWC at Bahrain, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.7 dB above 1 kw.

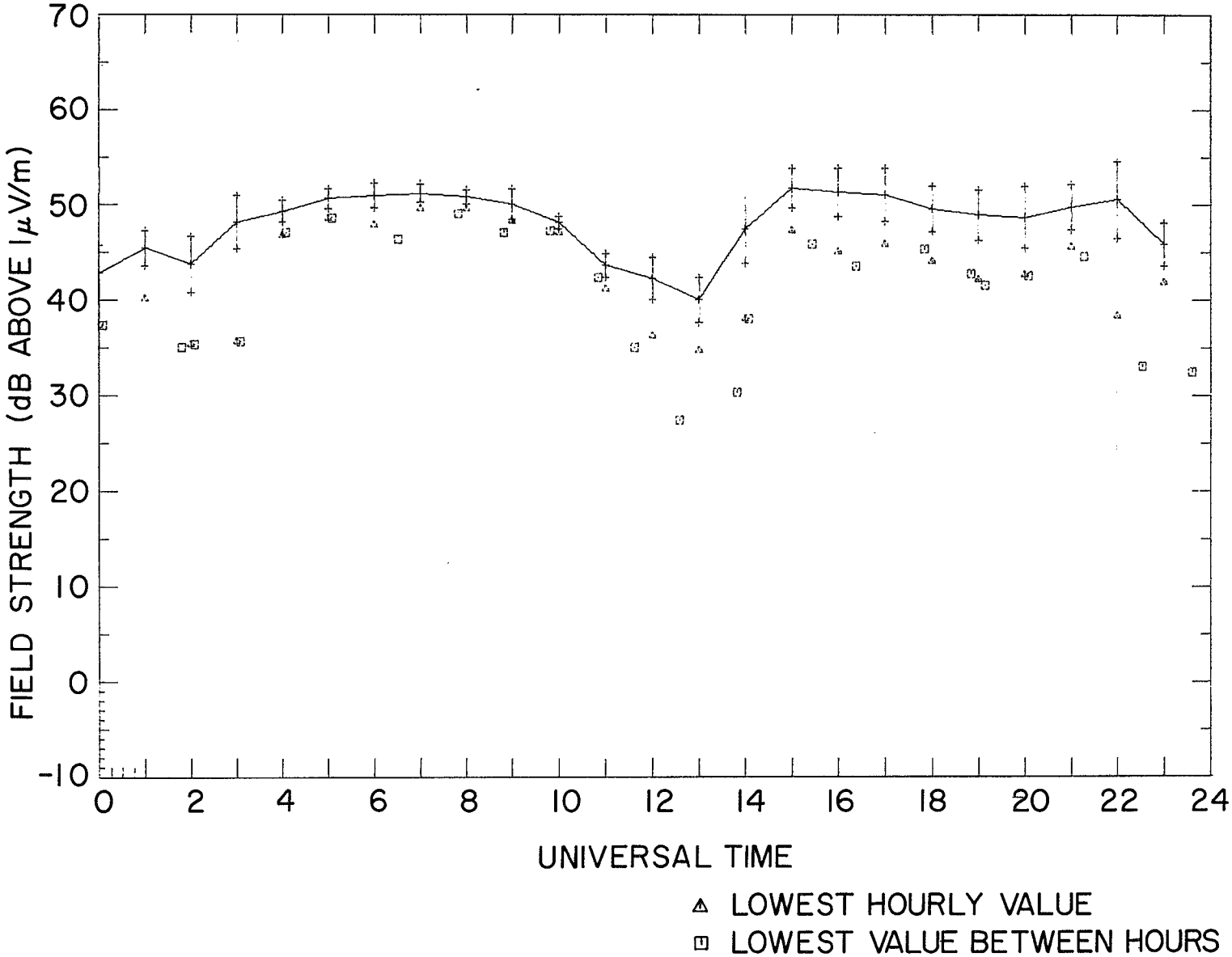


Fig. 4 - Mean and standard deviation of the field strength for NWC at Bahrain, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

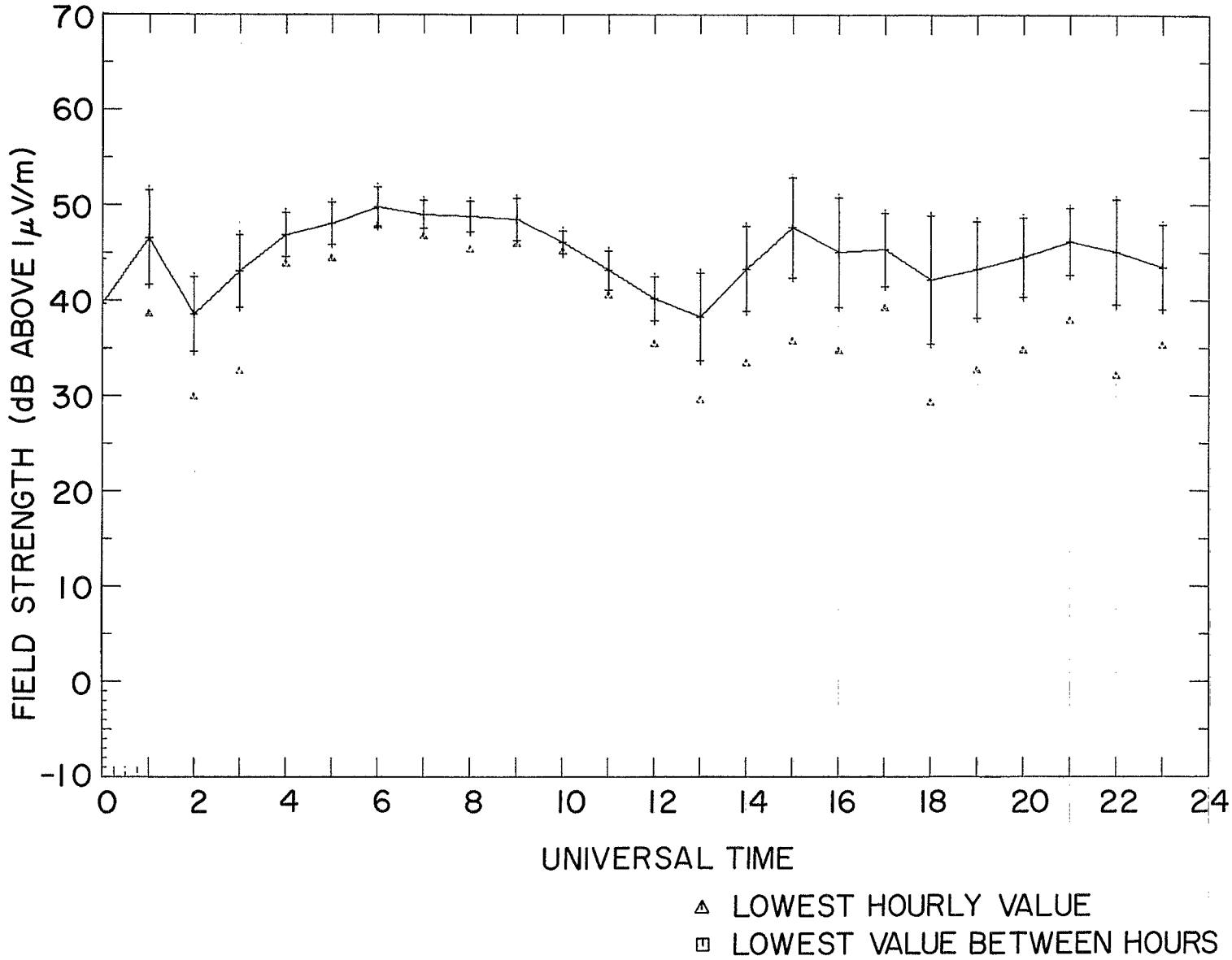


Fig. 5 - Mean and standard deviation of the field strength for NWC at Bahrain, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

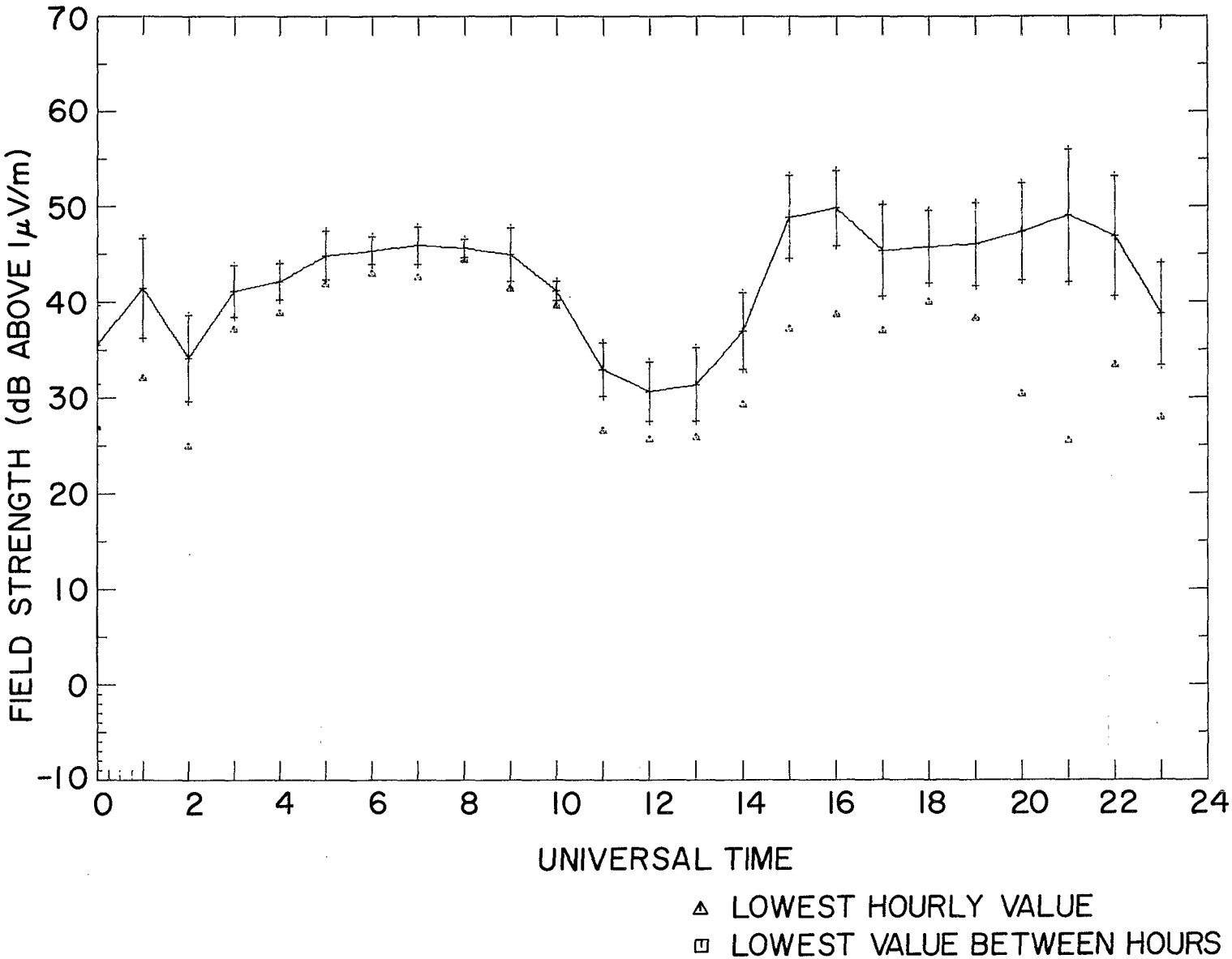


Fig. 6 - Mean and standard deviation of the field strength for NWC at Bahrain, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.2 dB above 1 kw.

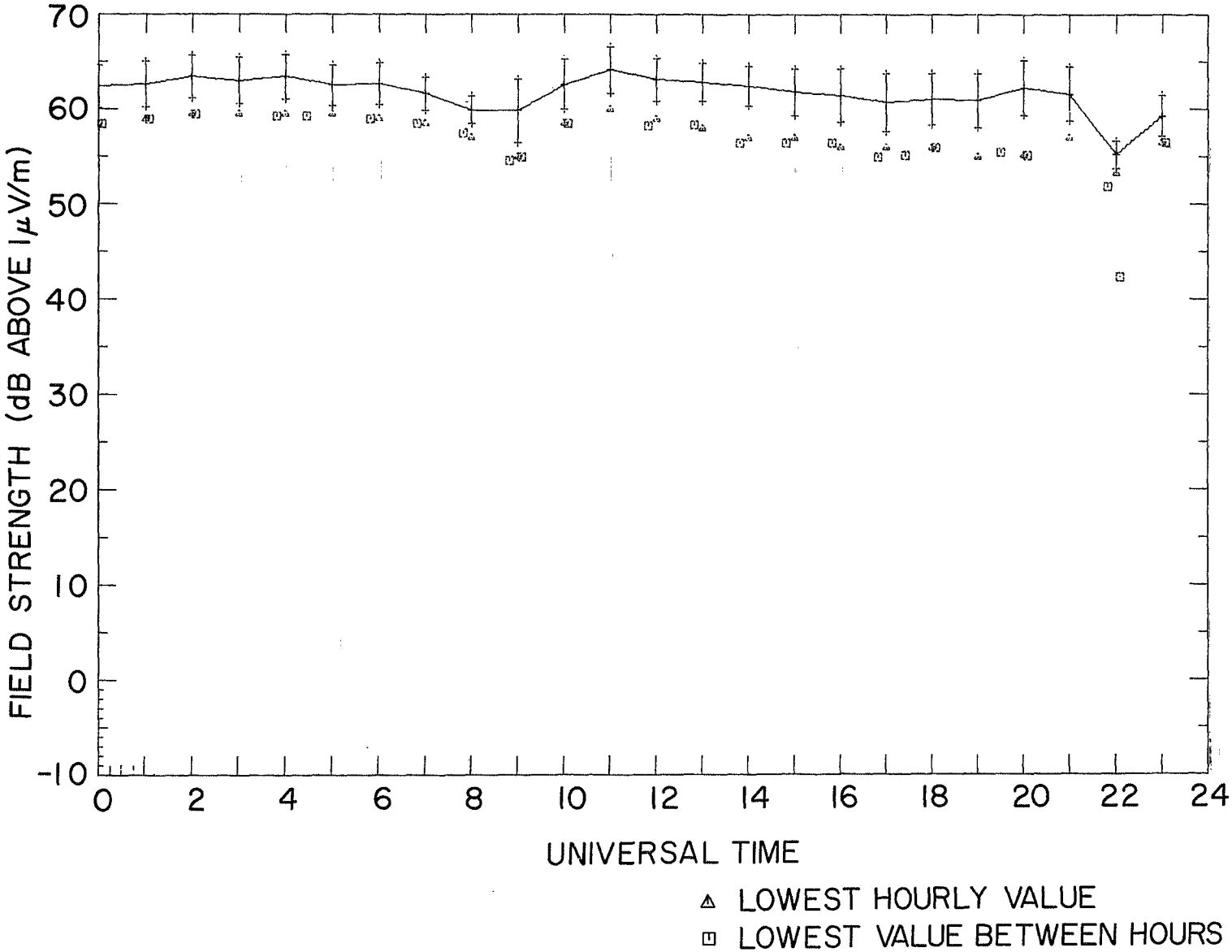


Fig. 7 - Mean and standard deviation of the field strength for NWC at Japan, 15.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 29.5 dB above 1 kw.

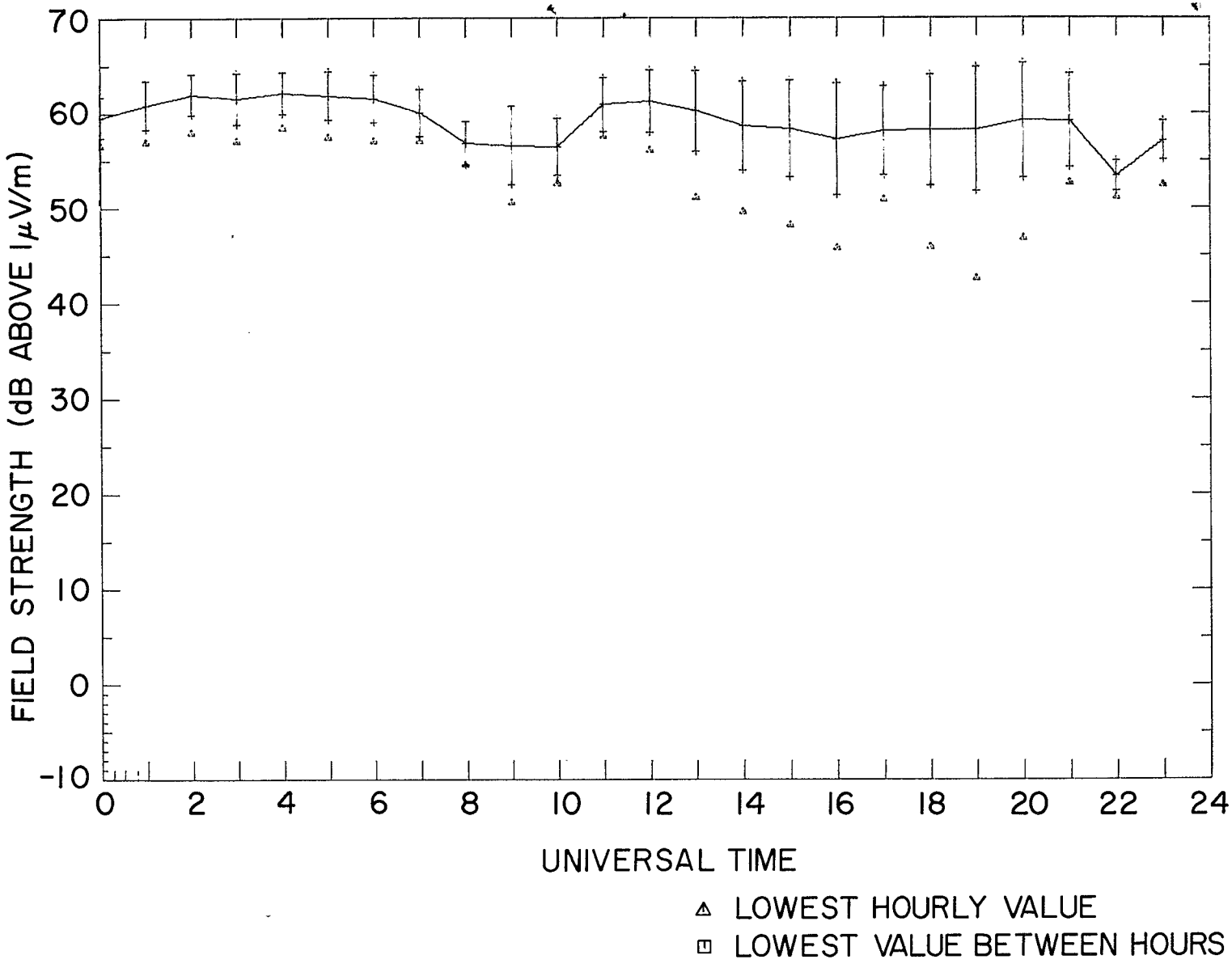


Fig. 8 - Mean and standard deviation of the field strength for NWC at Japan, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.5 dB above 1 kw.

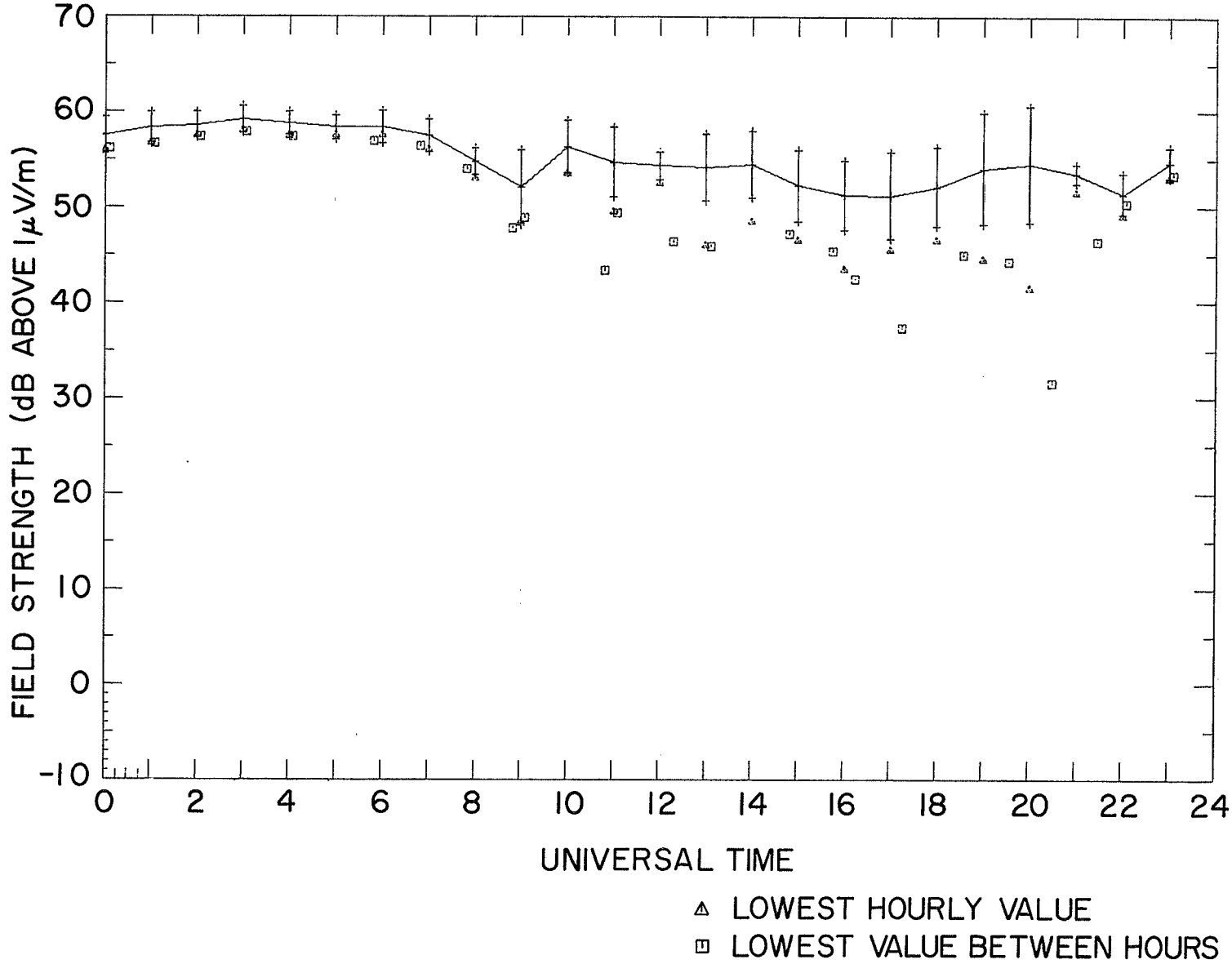


Fig. 9 - Mean and standard deviation of the field strength for NWC at Japan, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.7 dB above 1 kw.

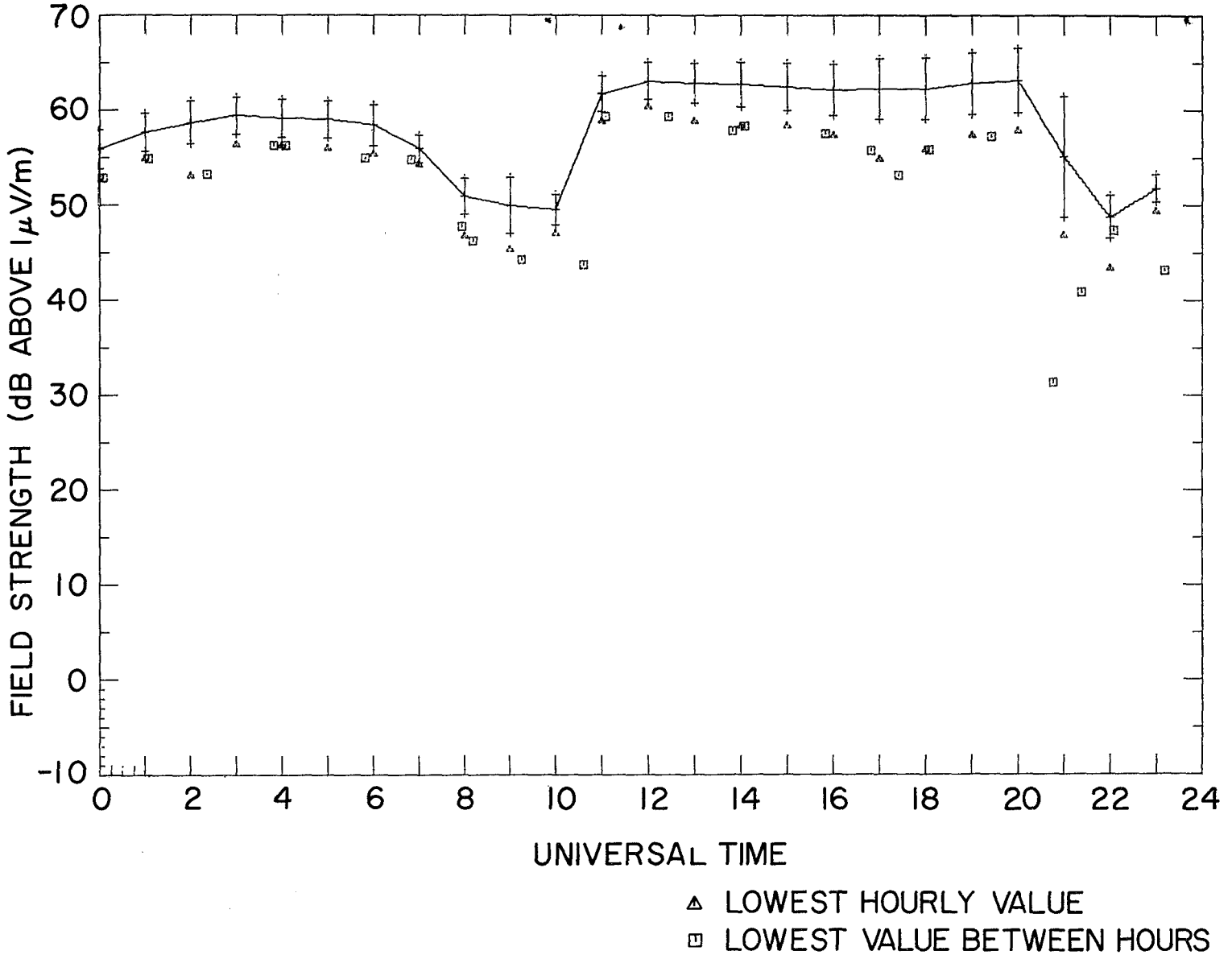


Fig. 10 - Mean and standard deviation of the field strength for NWC at Japan, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

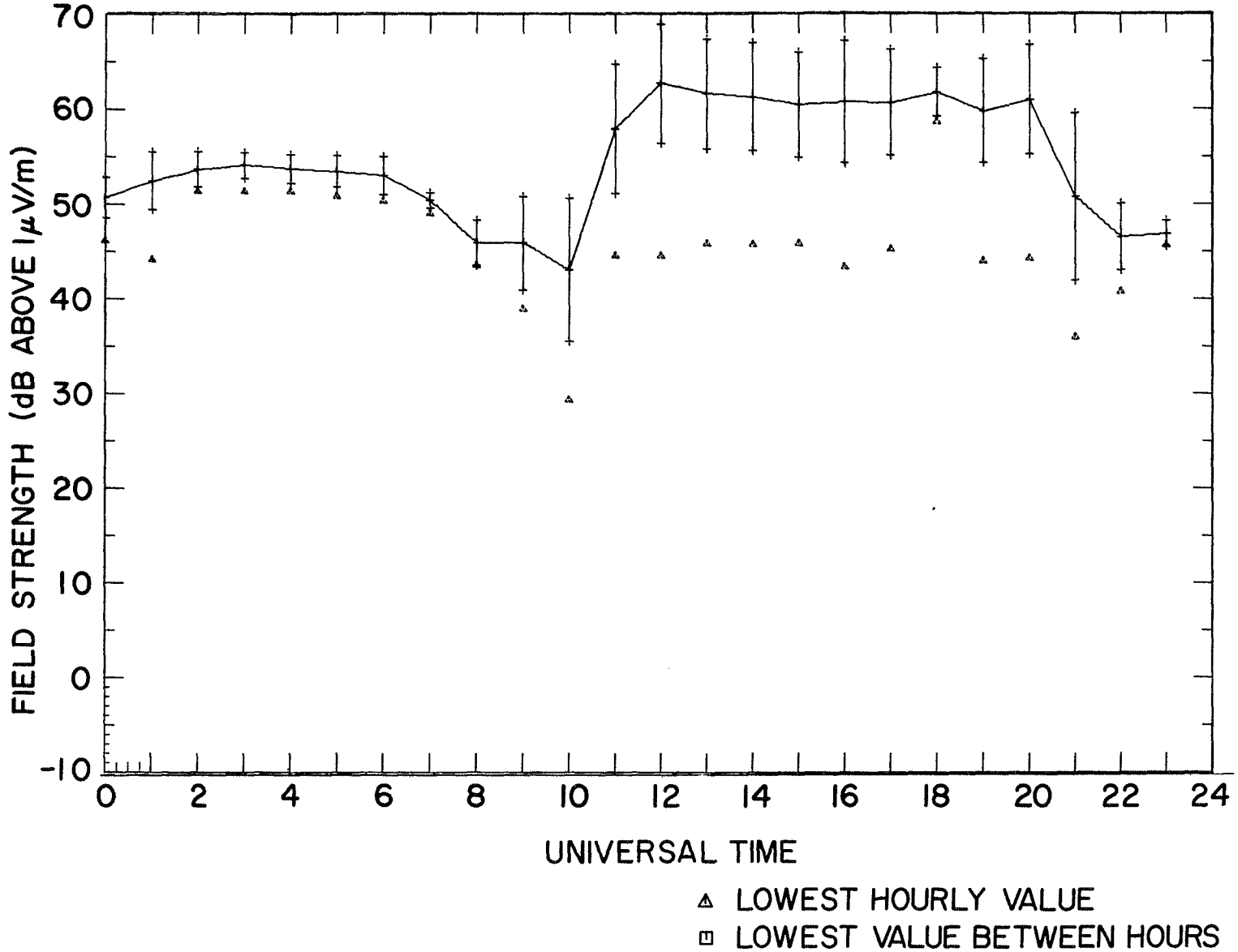


Fig. 11 - Mean and standard deviation of the field strength for NWC at Japan, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

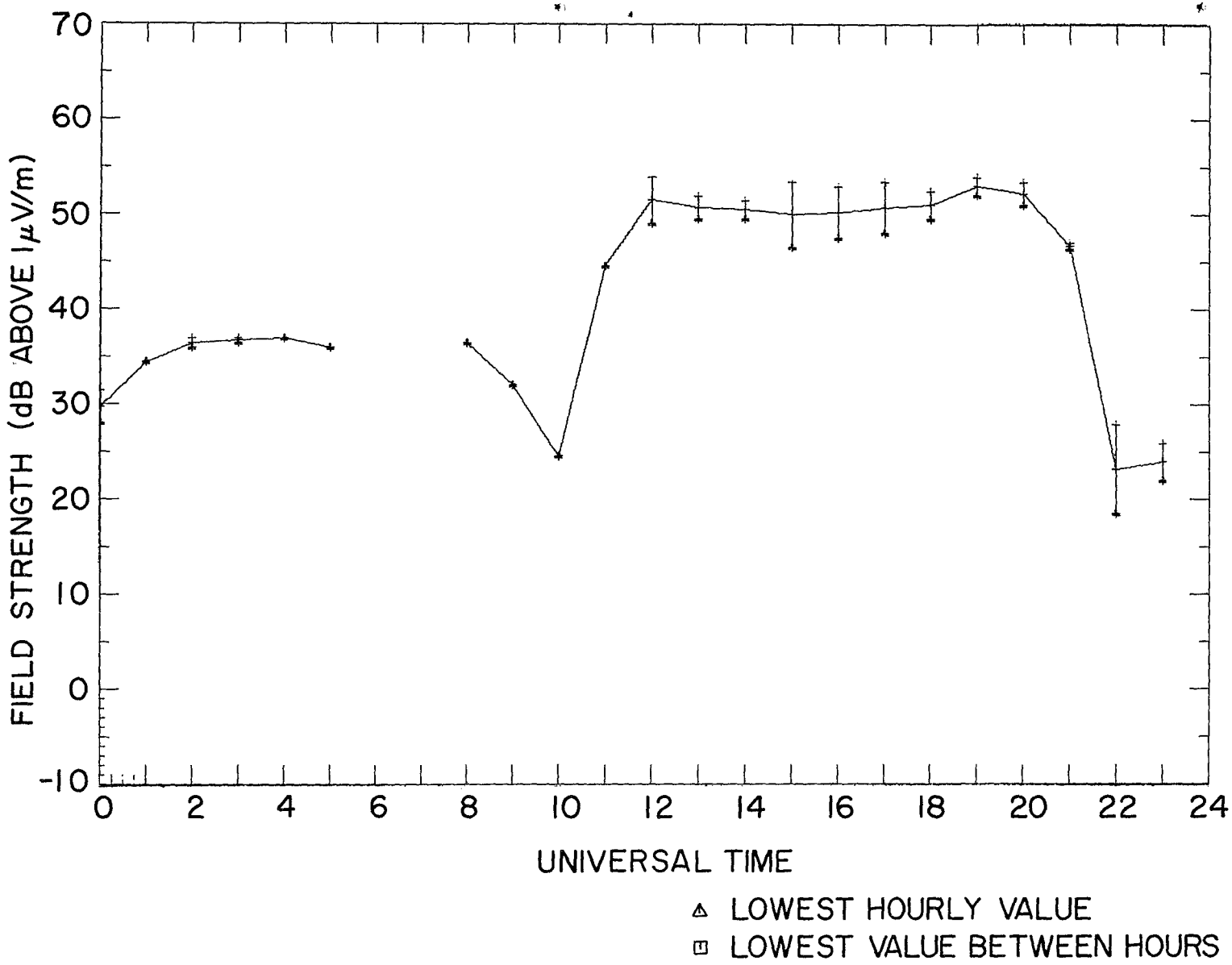


Fig. 12 - Mean and standard deviation of the field strength for NWC at Japan, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.2 dB above 1 kw.

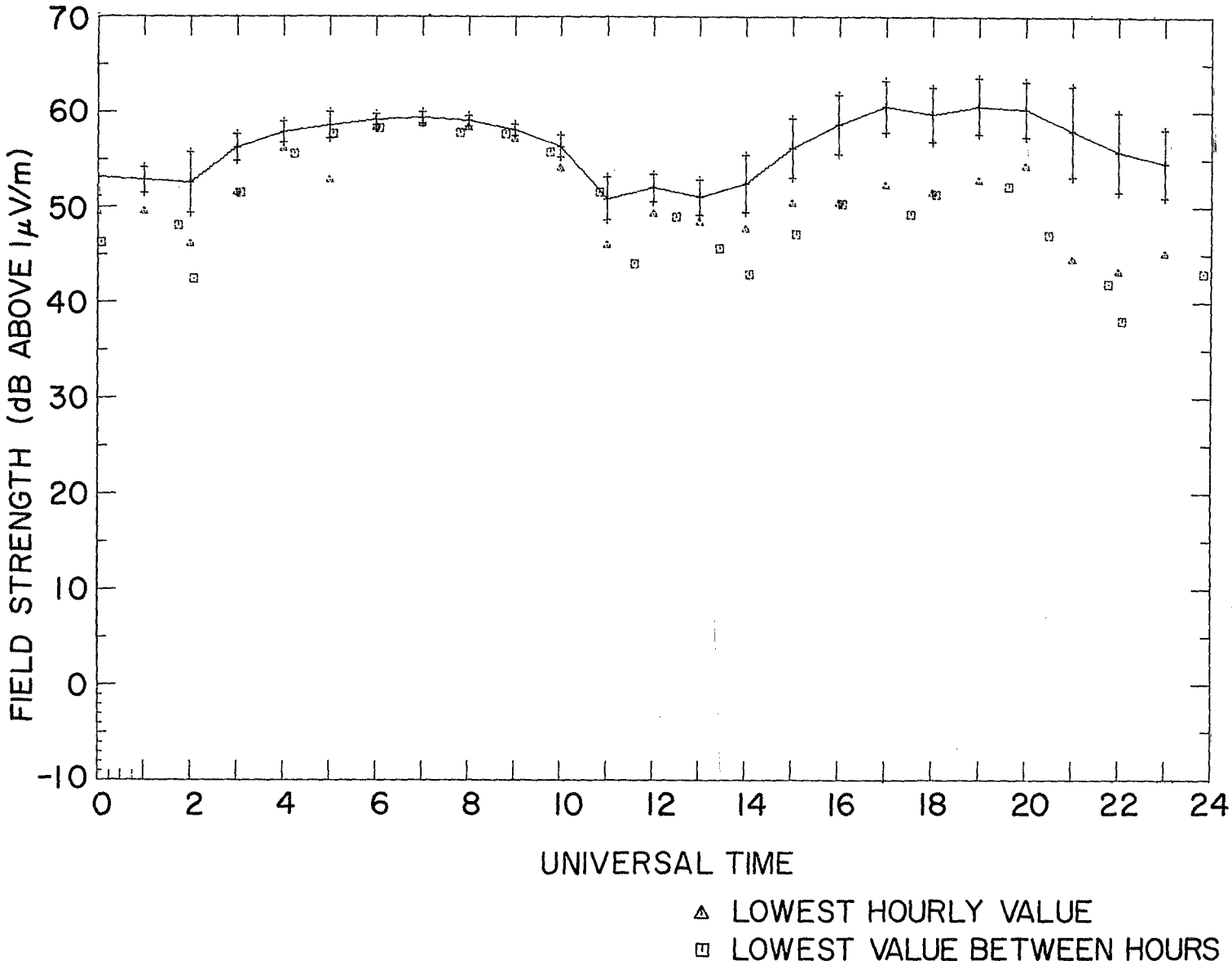


Fig. 13 - Mean and standard deviation of the field strength for NWC at Madagascar, 15.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 29.5 dB above 1 kw.

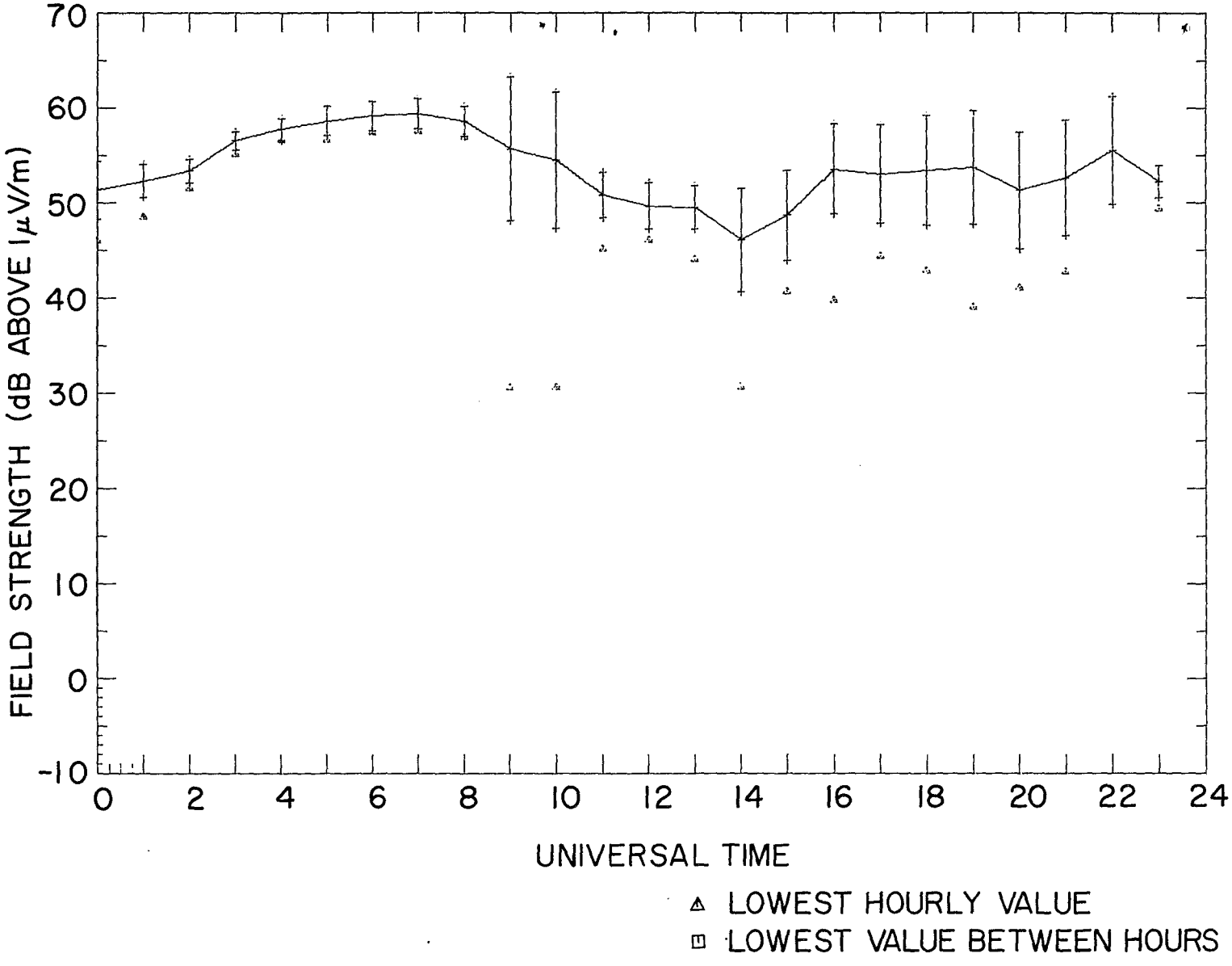


Fig. 14 - Mean and standard deviation of the field strength for NWC at Madagascar, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.5 dB above 1 kw.

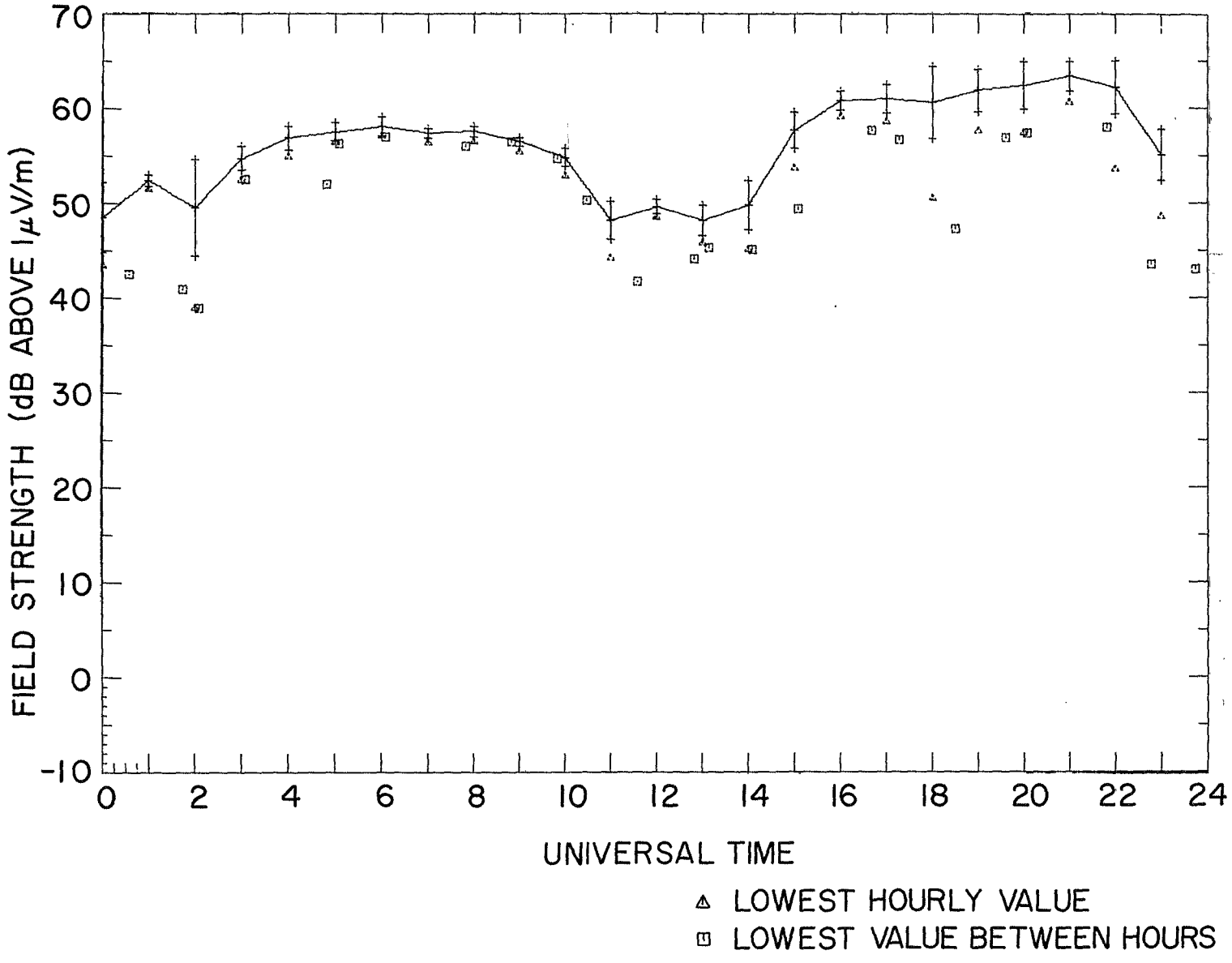


Fig. 15 - Mean and standard deviation of the field strength for NWC at Madagascar, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 30.7 dB above 1 kw.

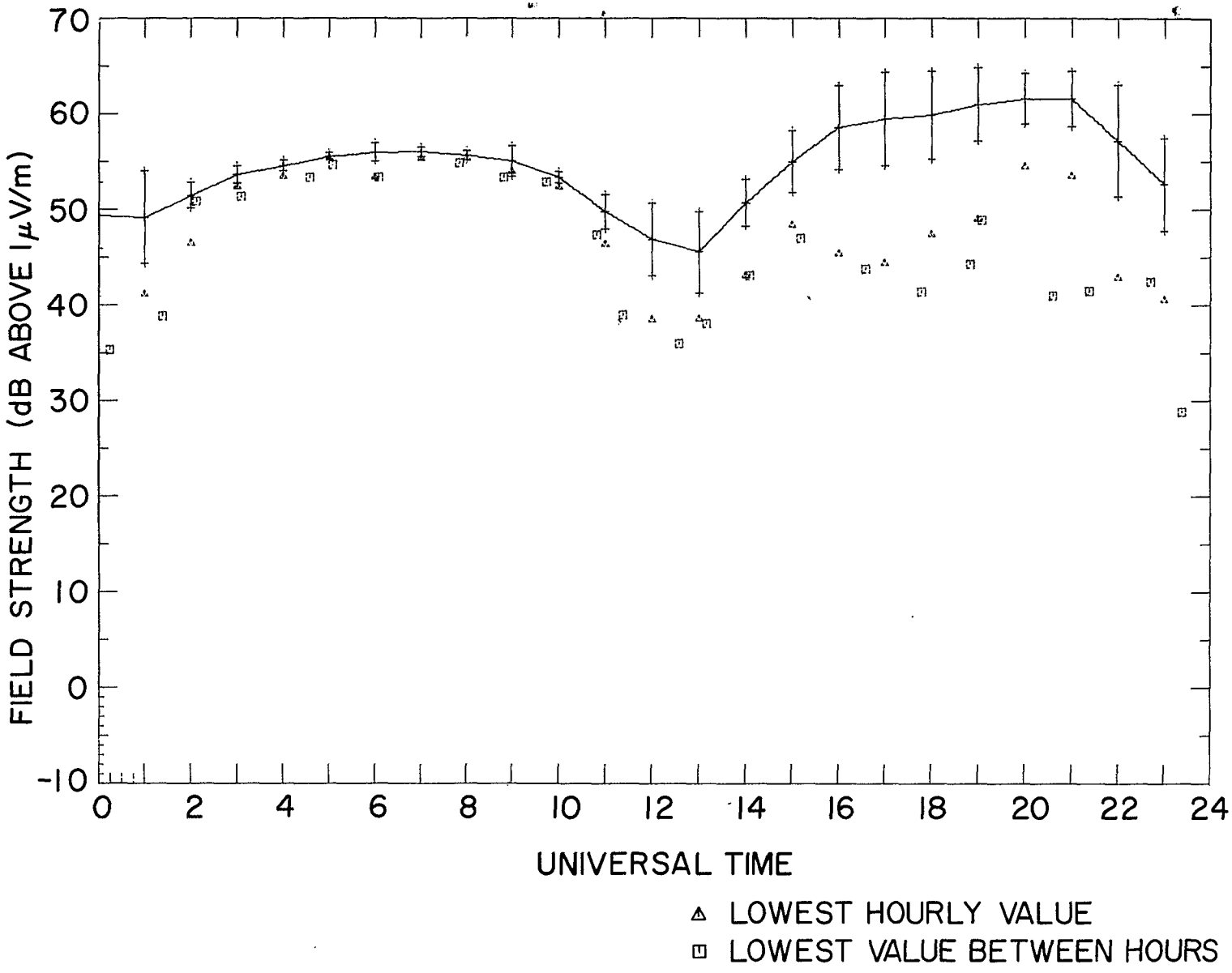


Fig. 16 - Mean and standard deviation of the field strength for NWC at Madagascar, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

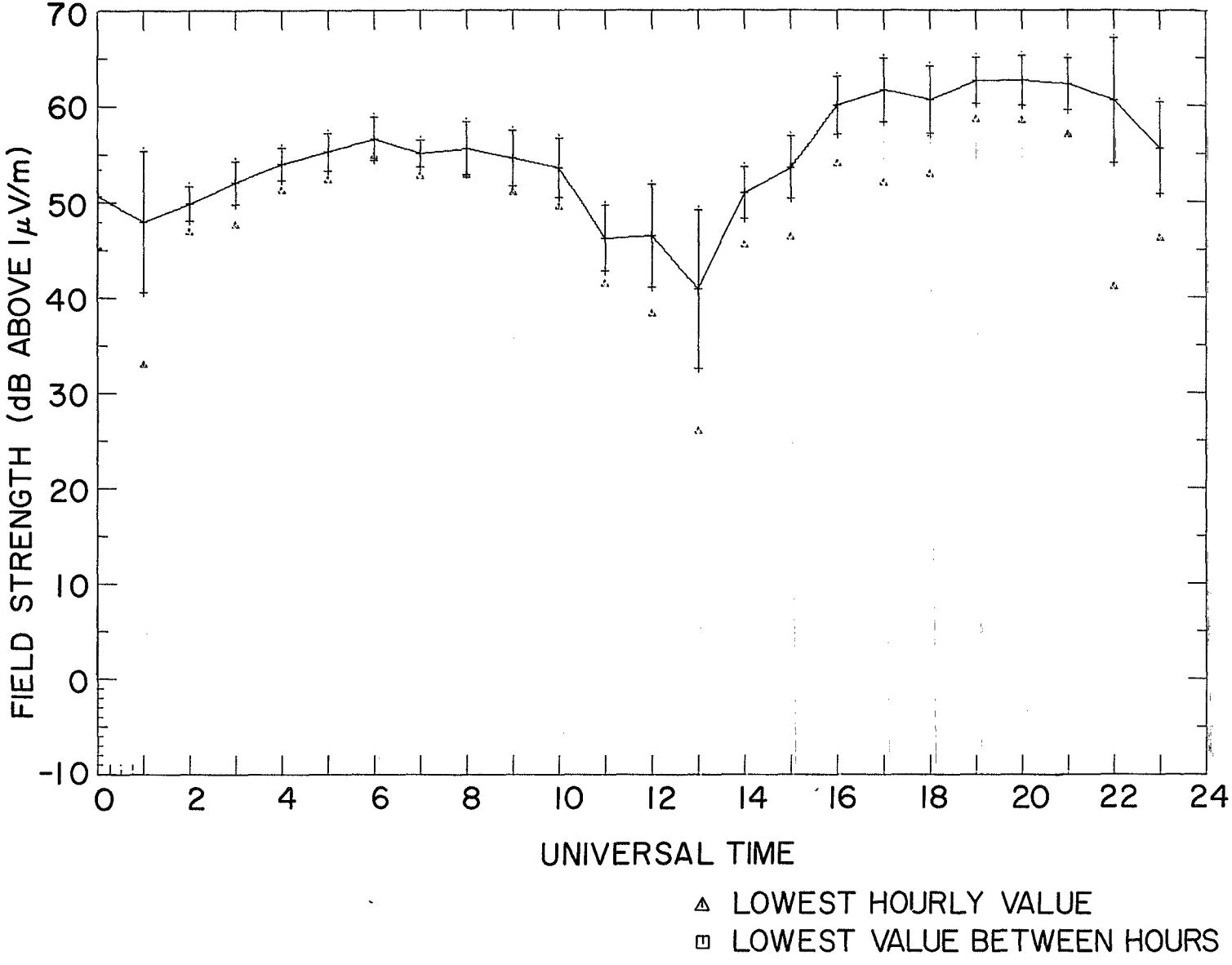


Fig. 17 - Mean and standard deviation of the field strength for NWC at Madagascar, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.1 dB above 1 kw.

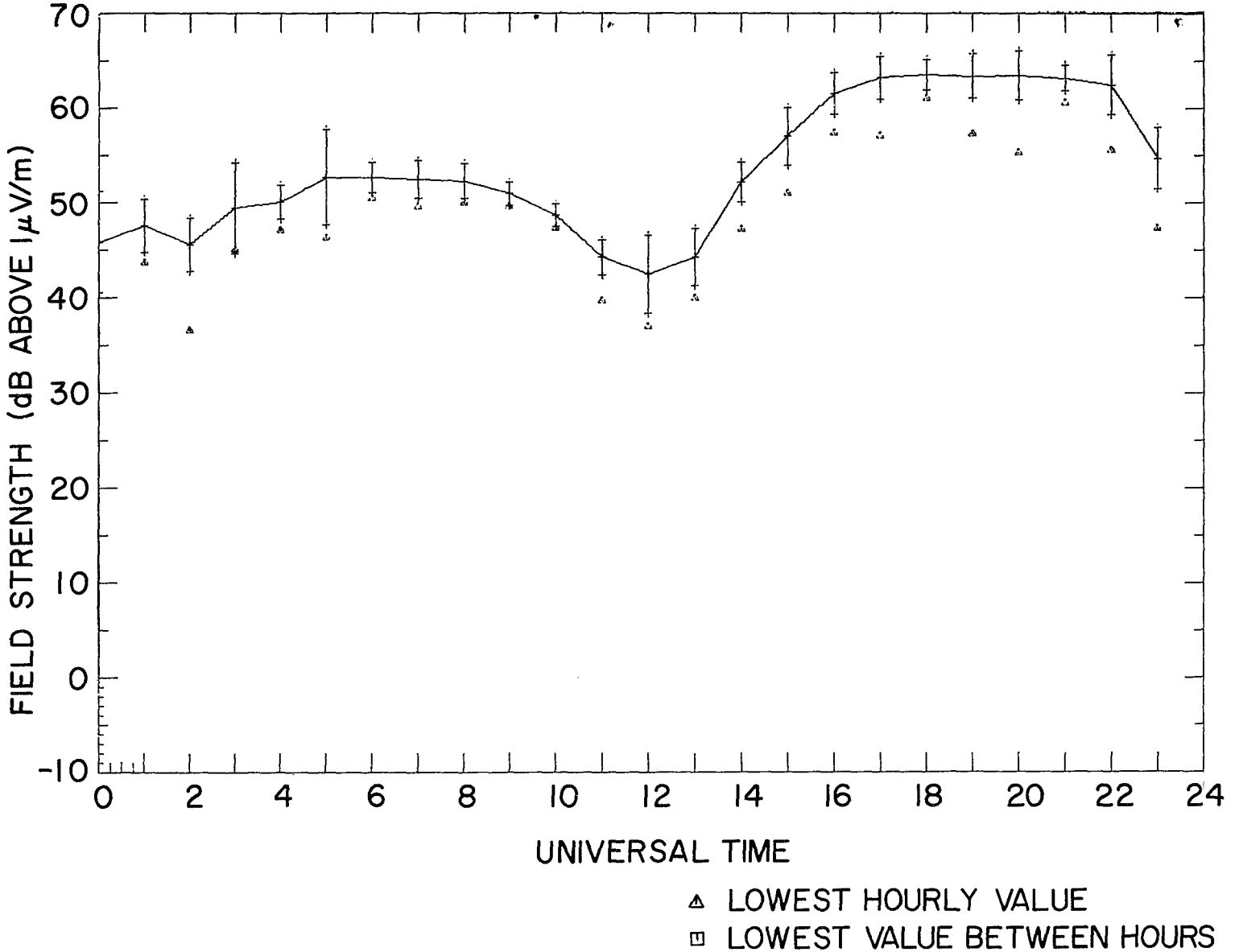
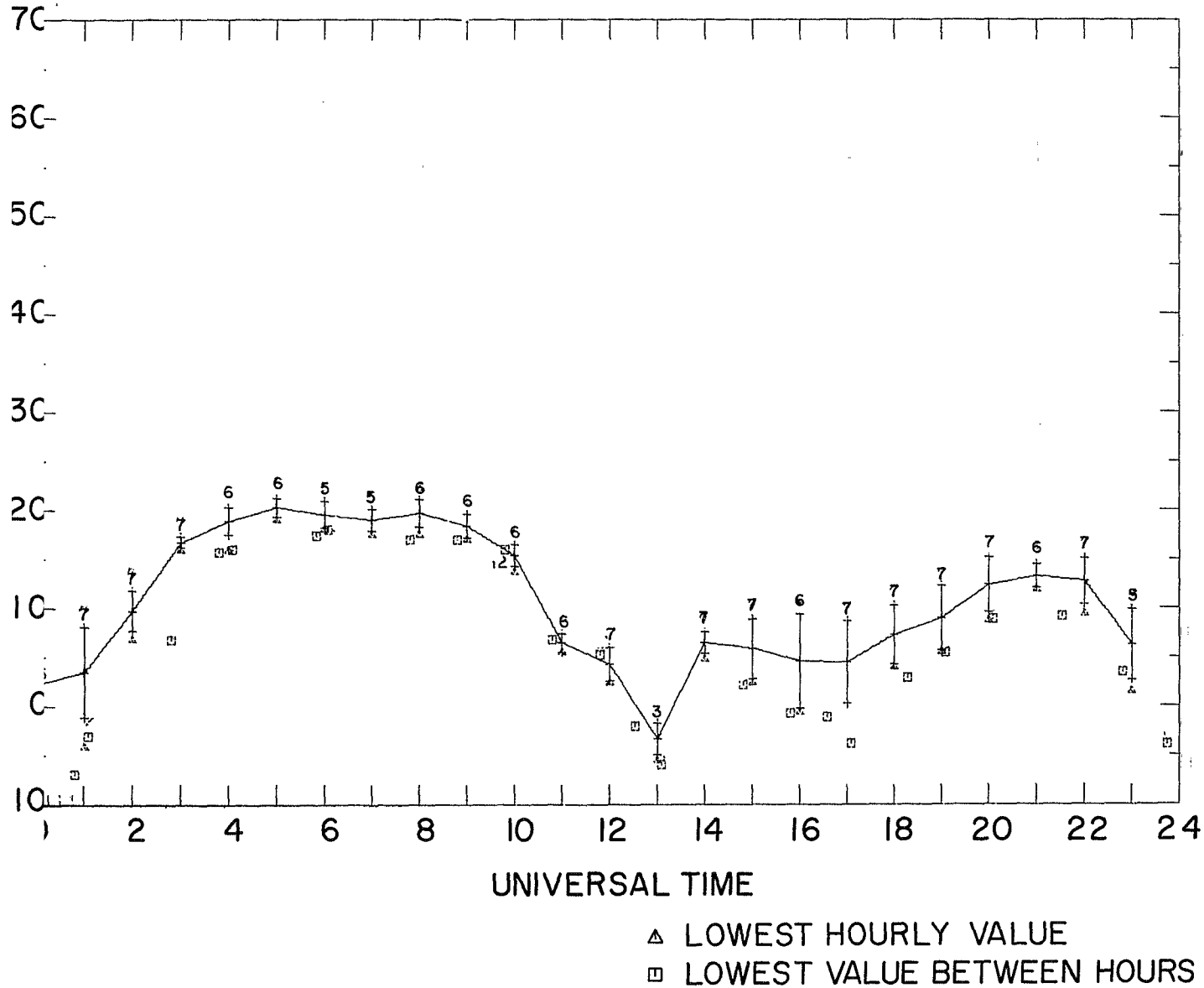


Fig. 18 - Mean and standard deviation of the field strength for NWC at Madagascar, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power is 31.2 dB above 1 kw.



g.) - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded om7 October to 24 October 1967 at a frequency of 15.5 kHz. Normalized radiated power of VCs 29.5 dB above 1 kw.

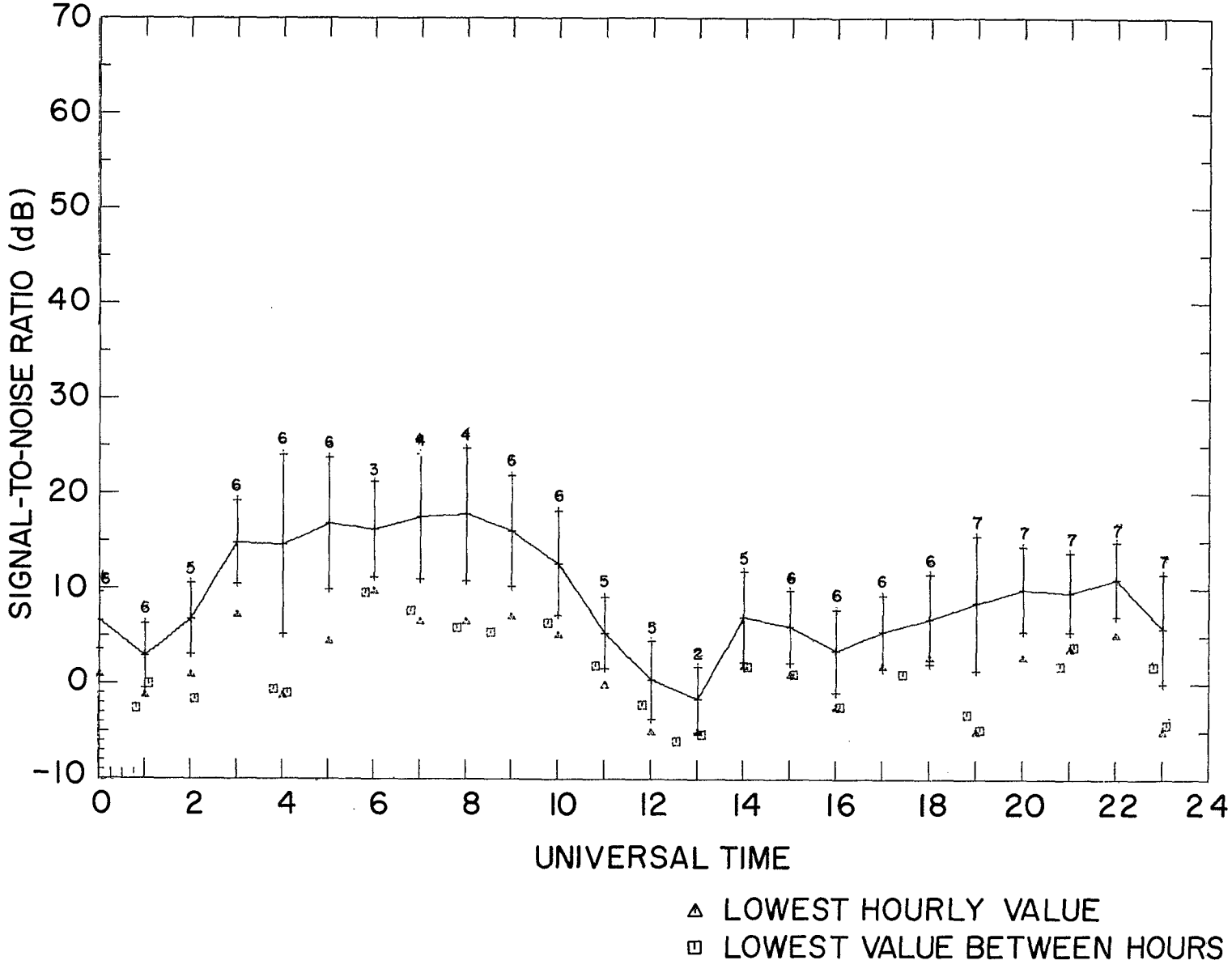


Fig. 20 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 7 November to 14 November 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.

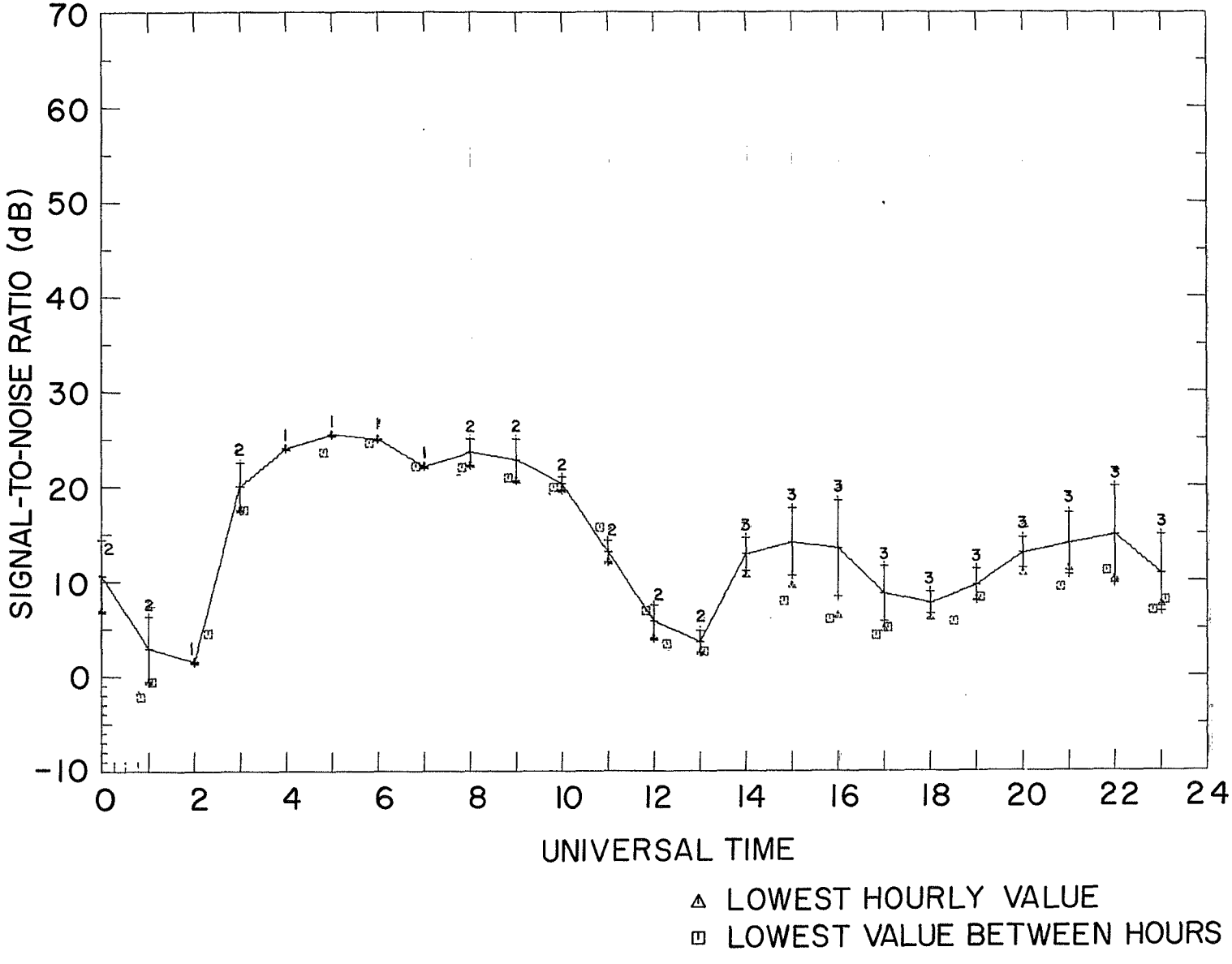


Fig. 21 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 28 November to 30 November 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.

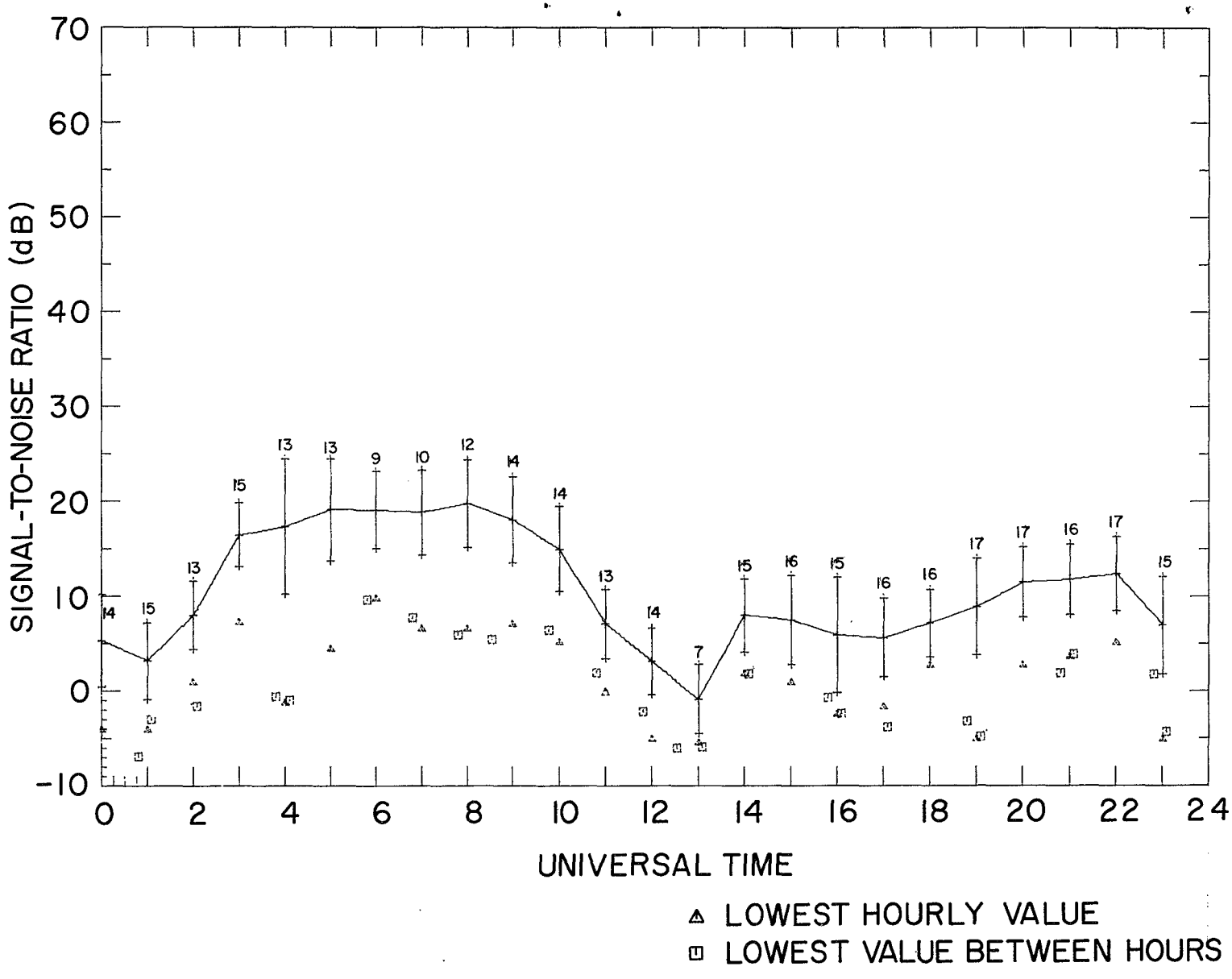
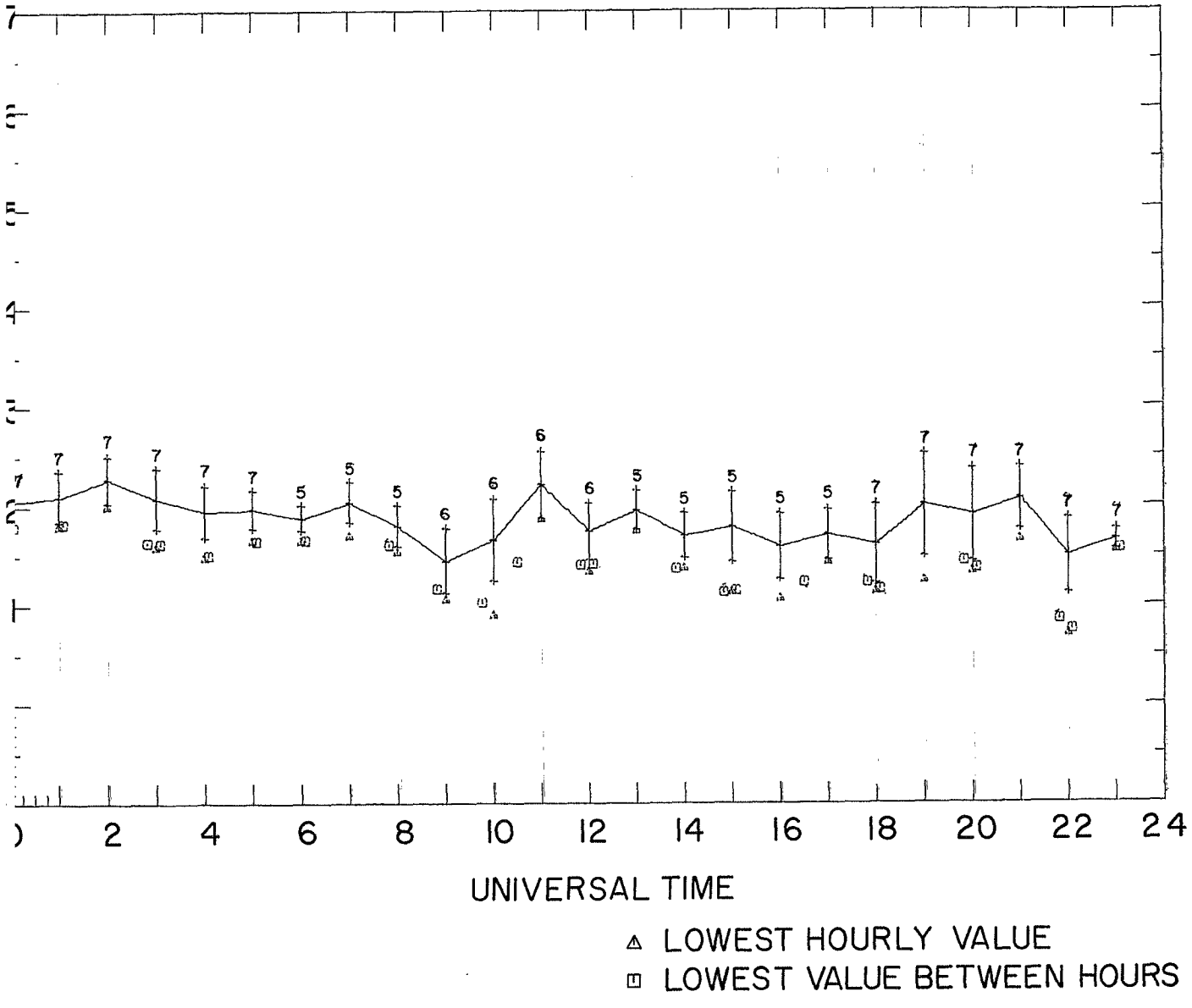


Fig. 22 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 15.5 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 29.5 dB above 1 kw.



g - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded
o6 September to 3 October 1967 at a frequency of 15.5 kHz. Normalized radiated power
C is 29.5 dB above 1 kw.

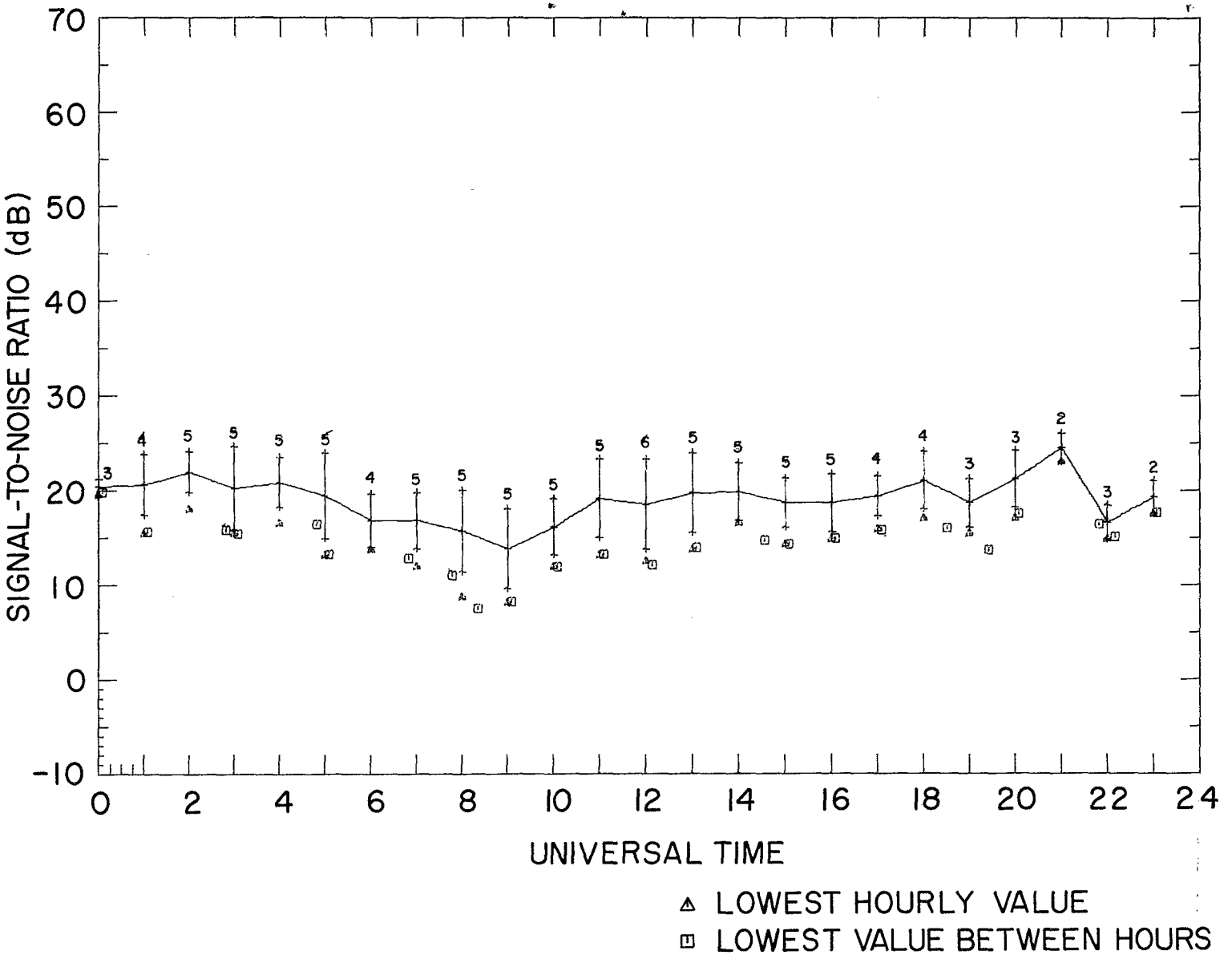
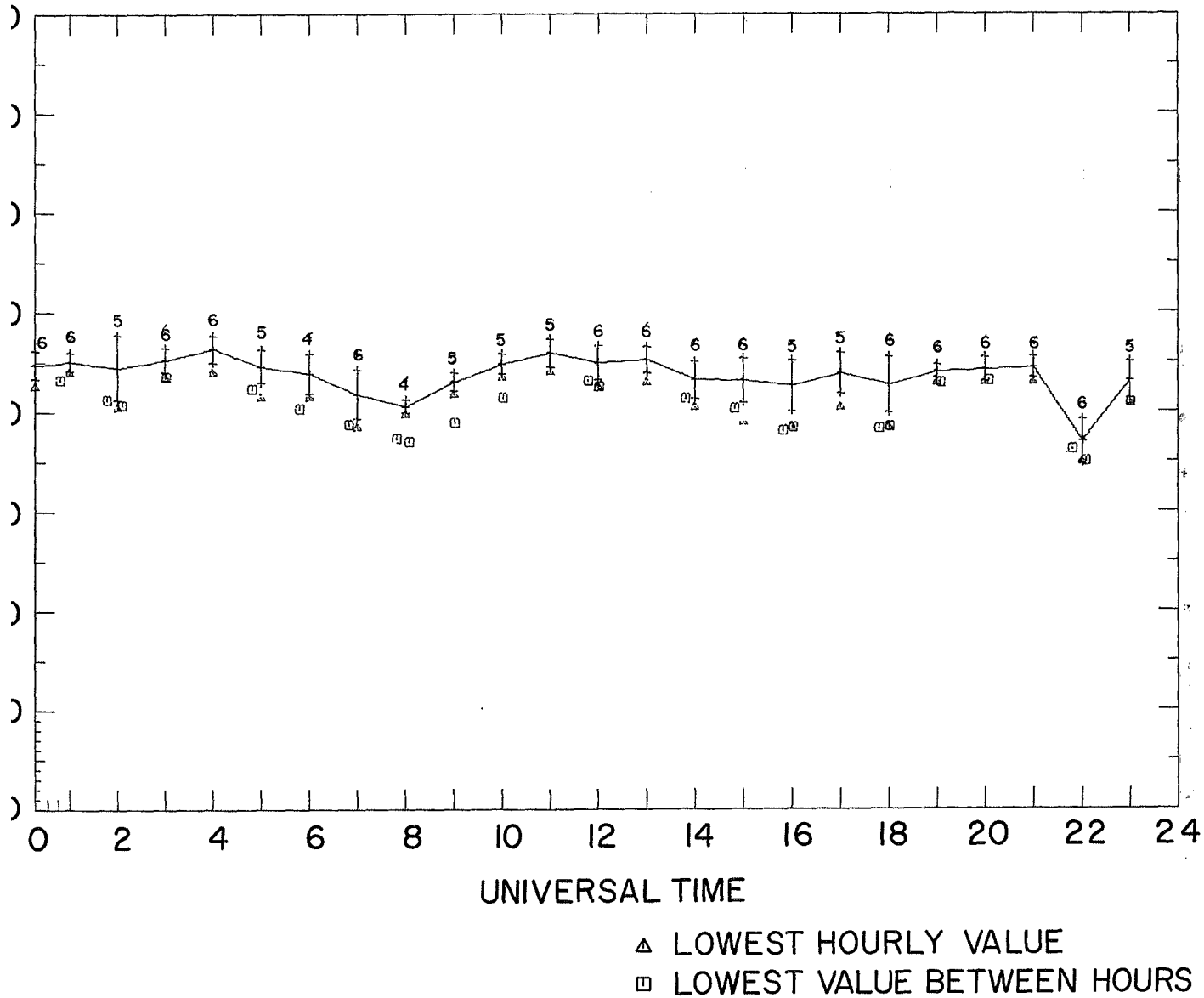


Fig. 24 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 17 October to 24 October 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.



:5 -Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded 7 Nvember to 14 November 1967 at a frequency of 15.5 kHz. Normalized radiated power 'C i 29.5 dB above 1 kw.

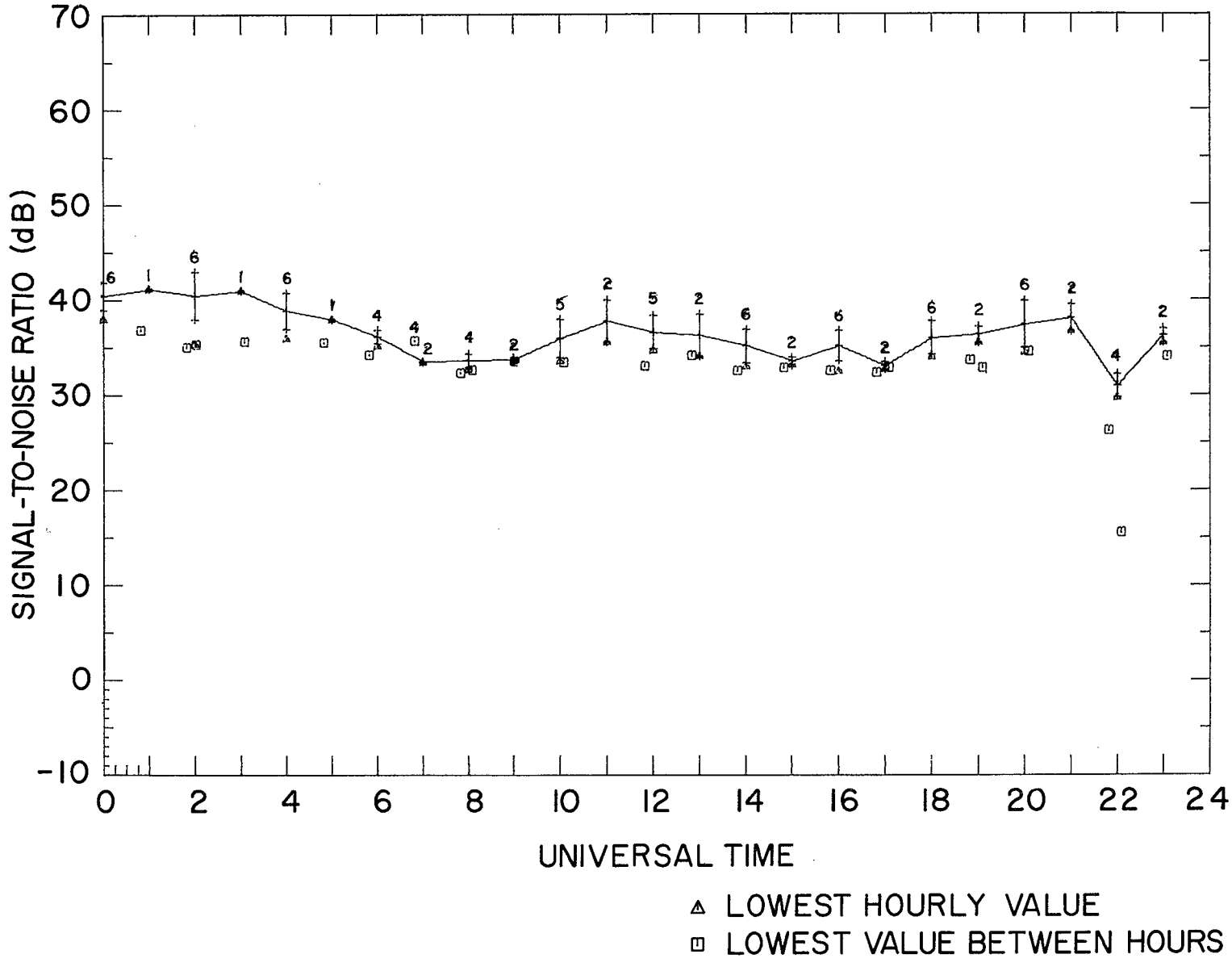
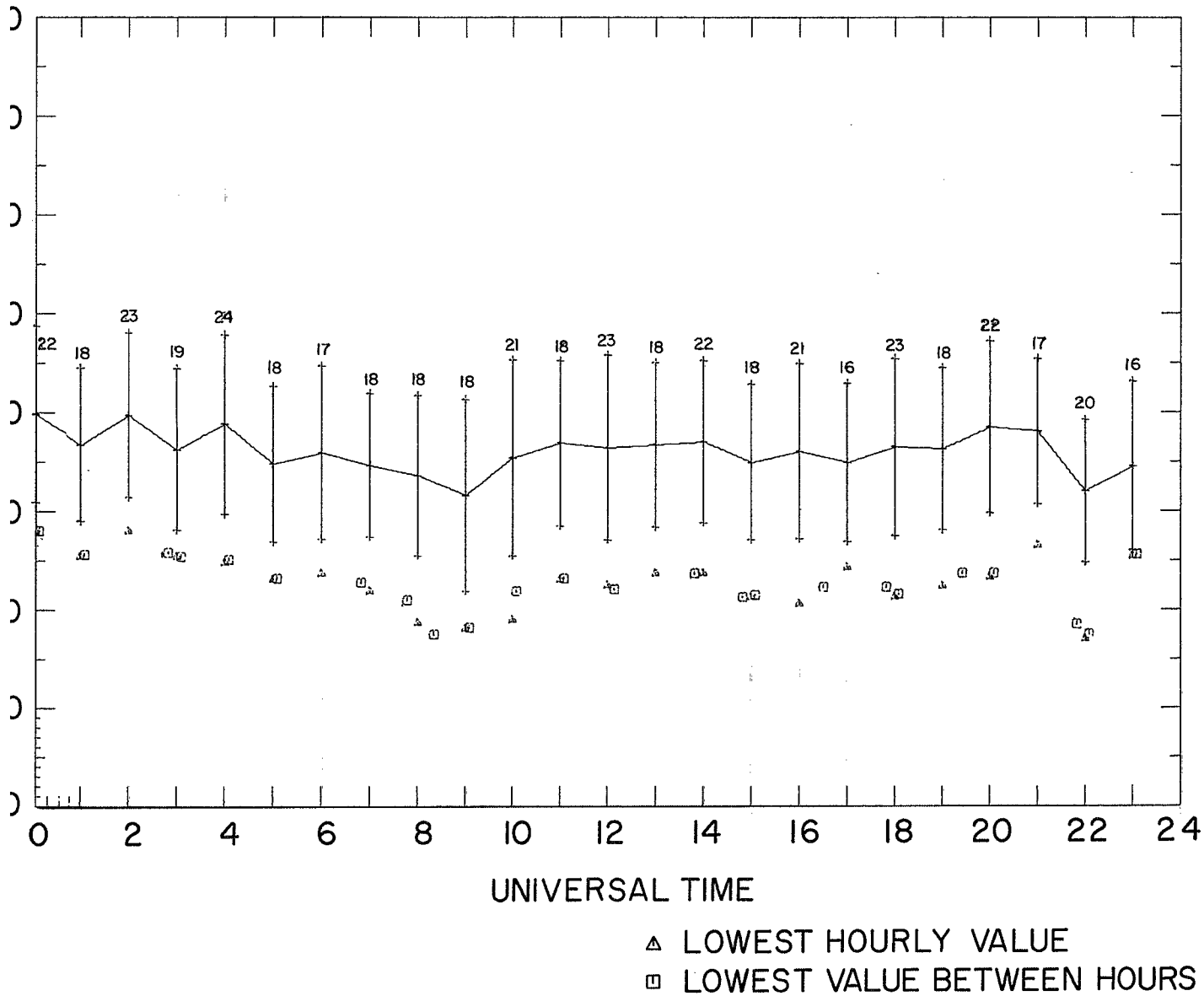


Fig. 26 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 28 November to 5 December 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.



.g. 27 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 15.5 kHz, r a :hree-month period from September to December 1967. Normalized radiated power NWC is 29.5 dB above 1 kw.

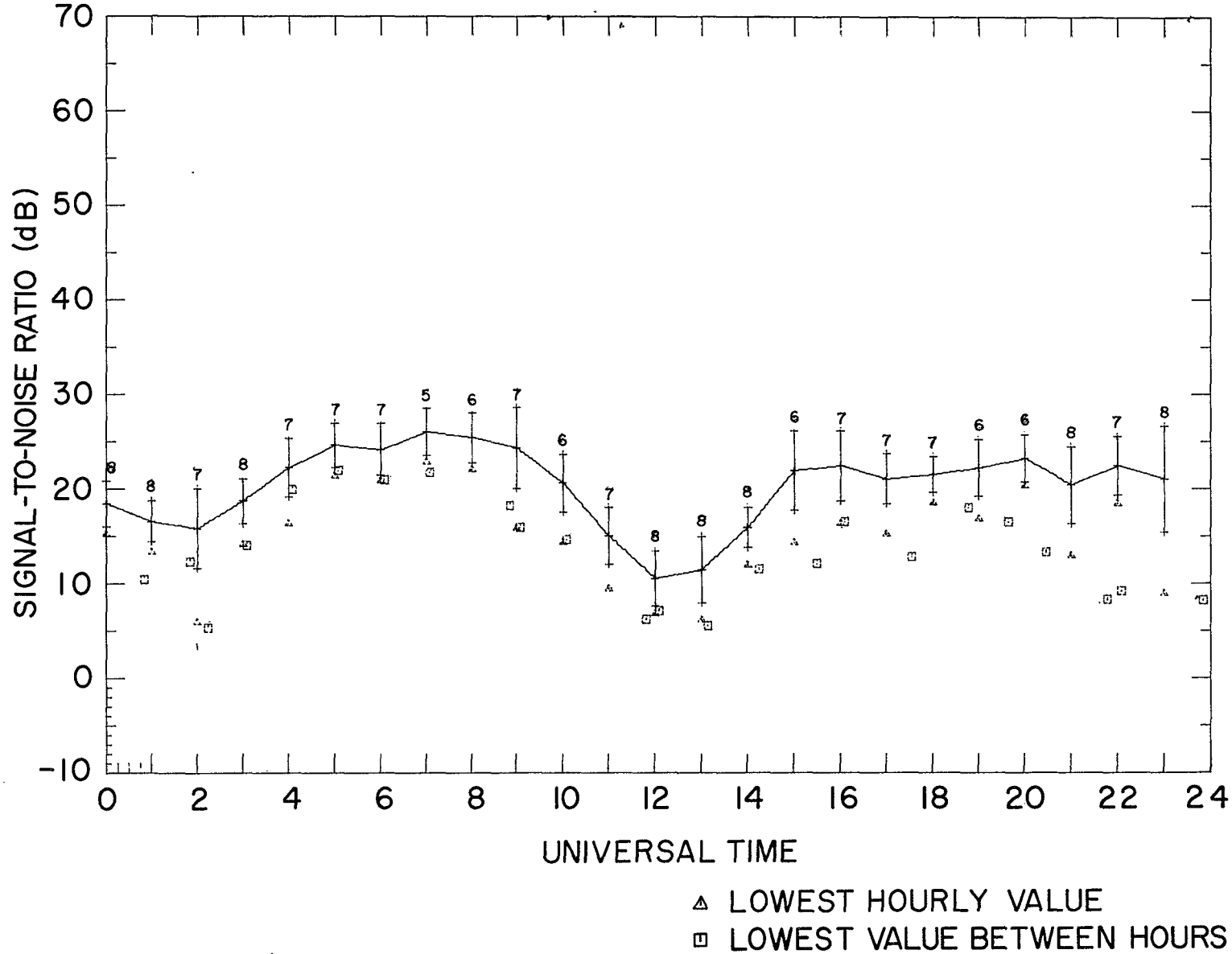


Fig. 28 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 4 September to 12 September 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.

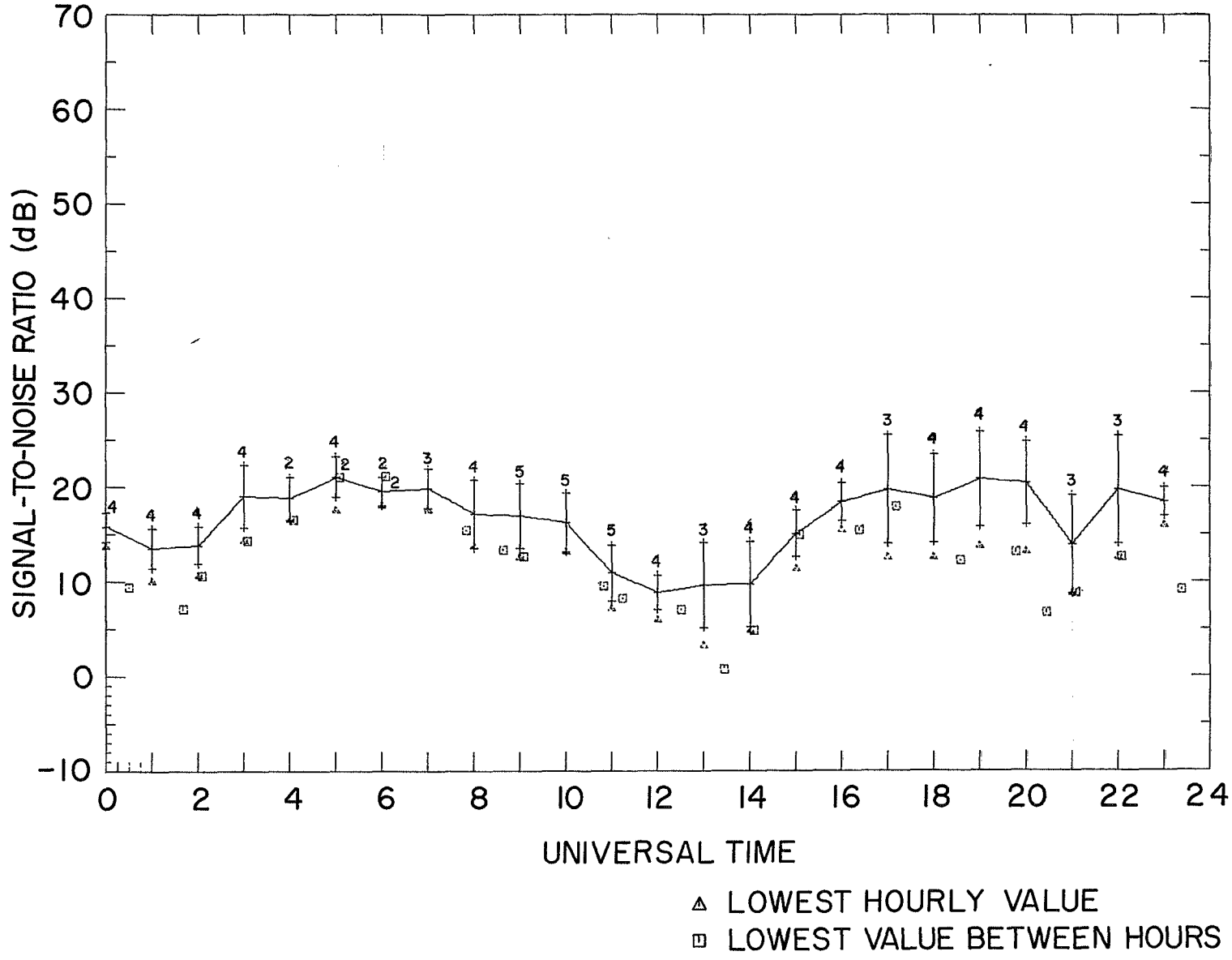


Fig. 29 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 26 September to 2 October 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.

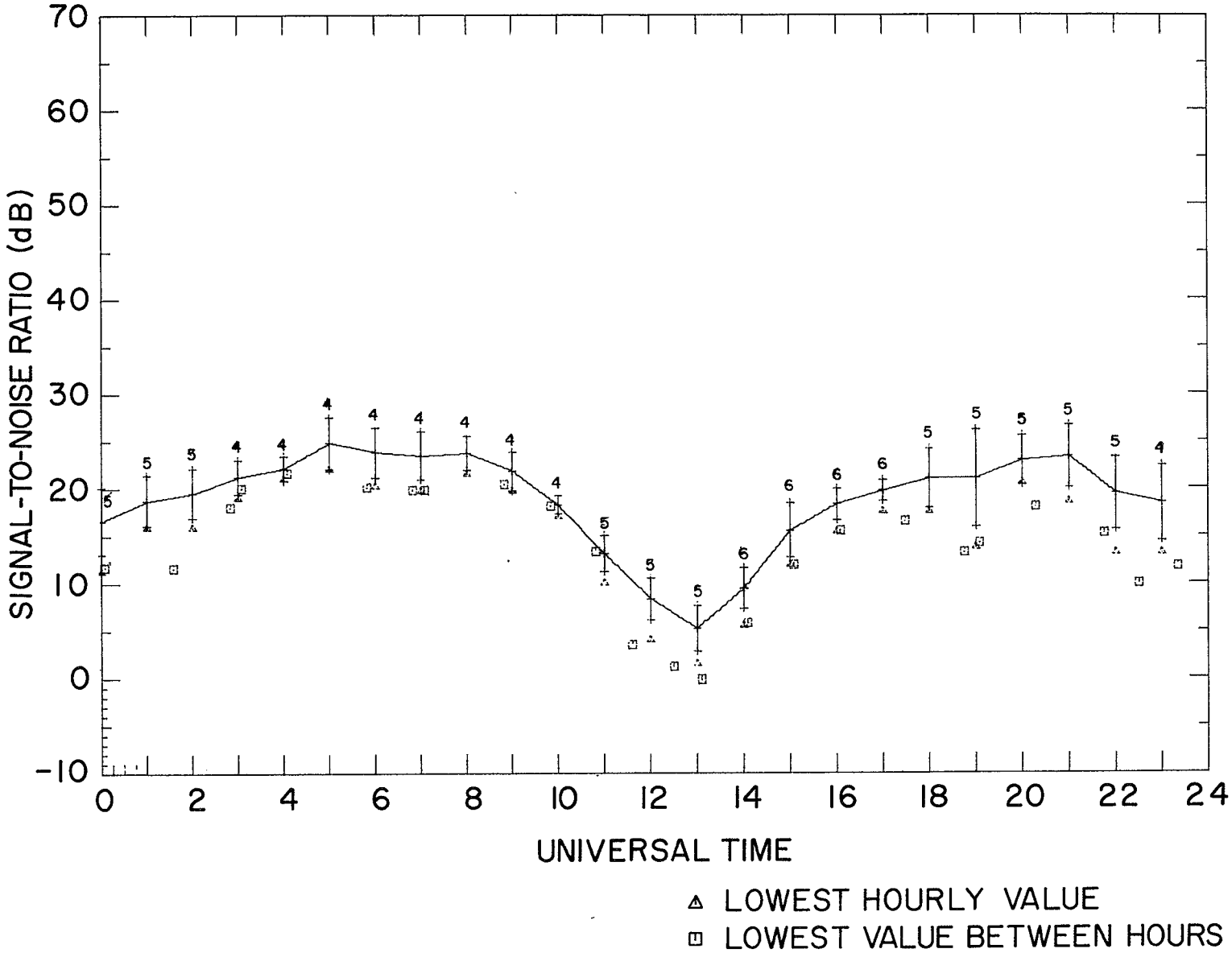
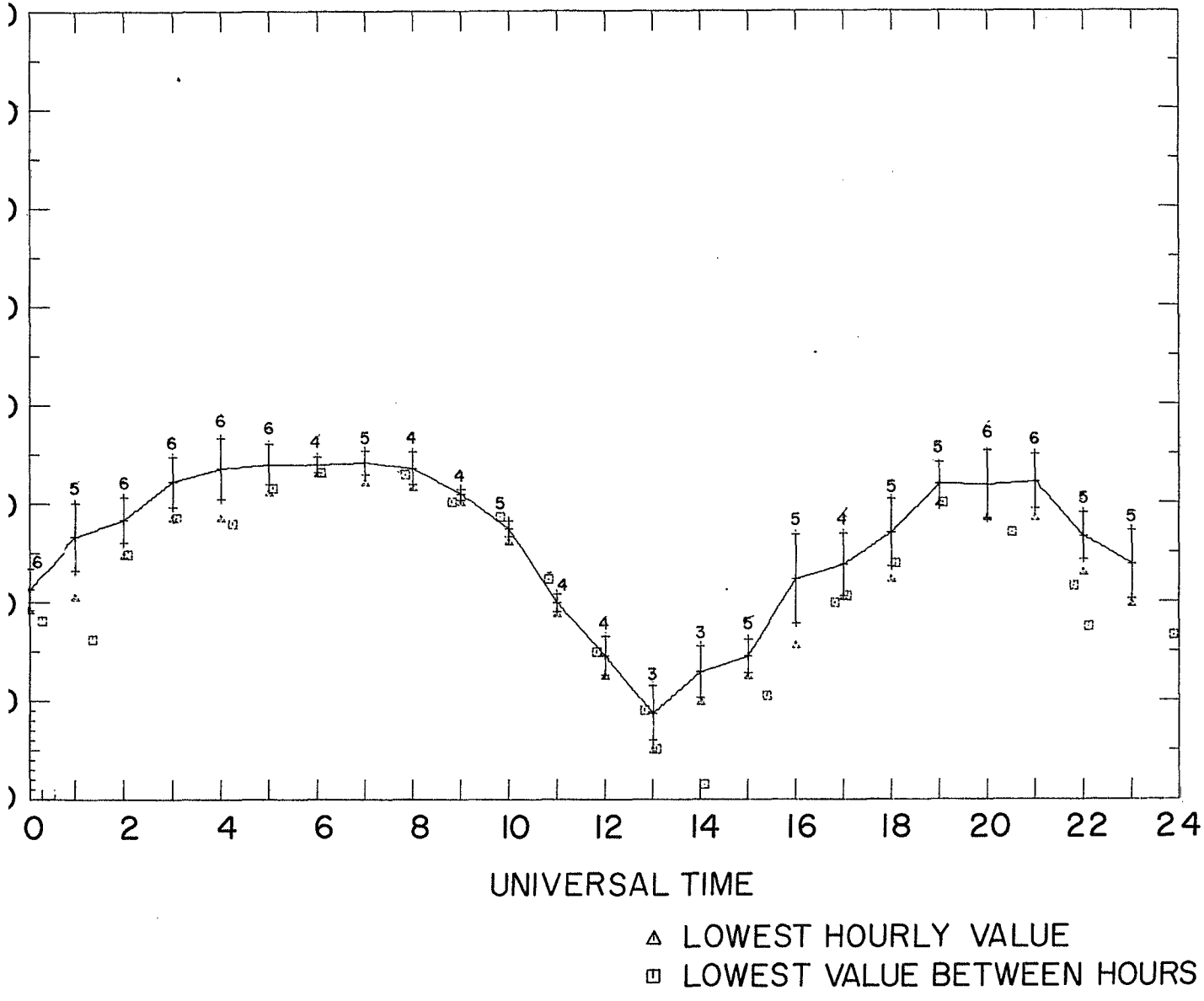
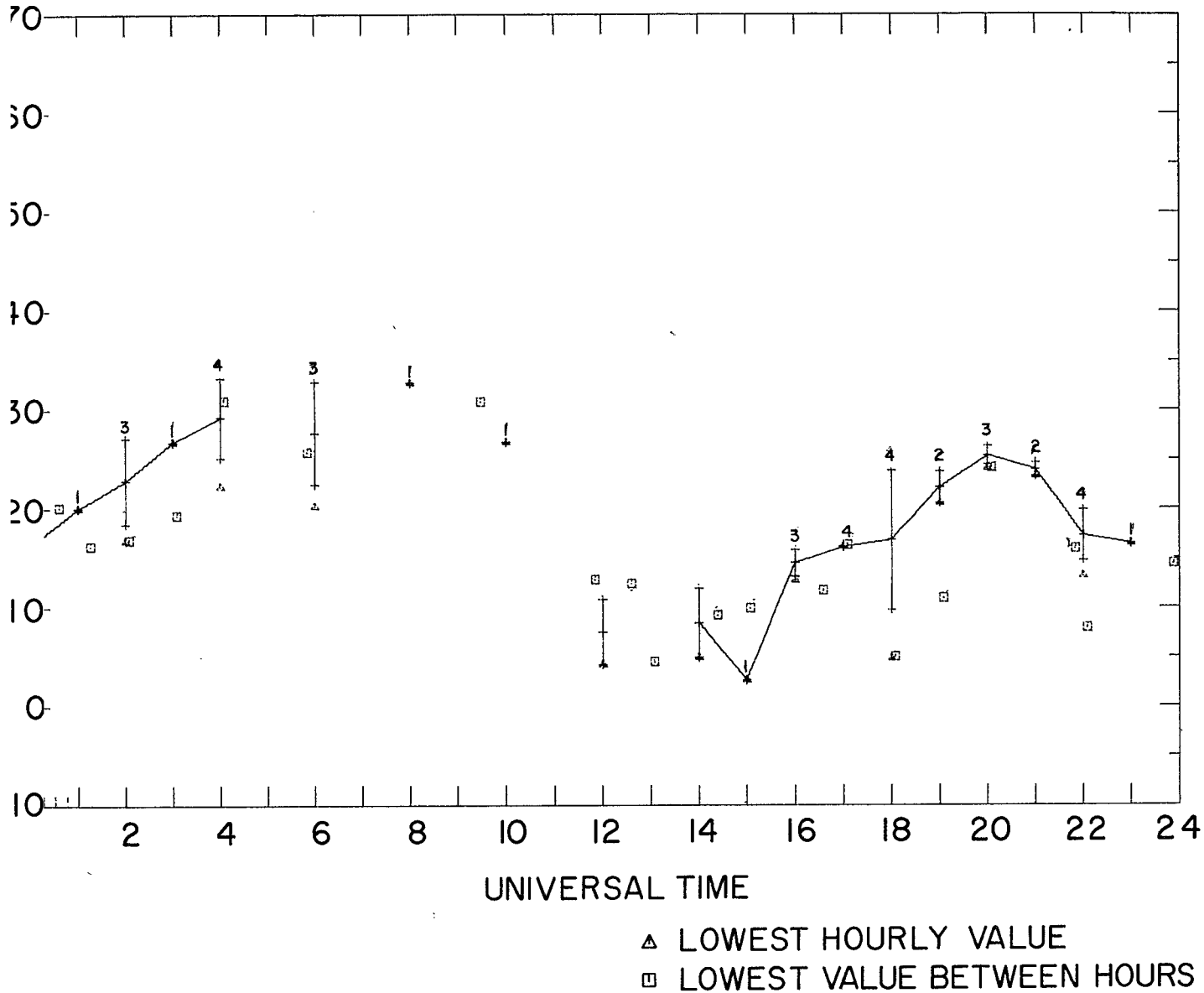


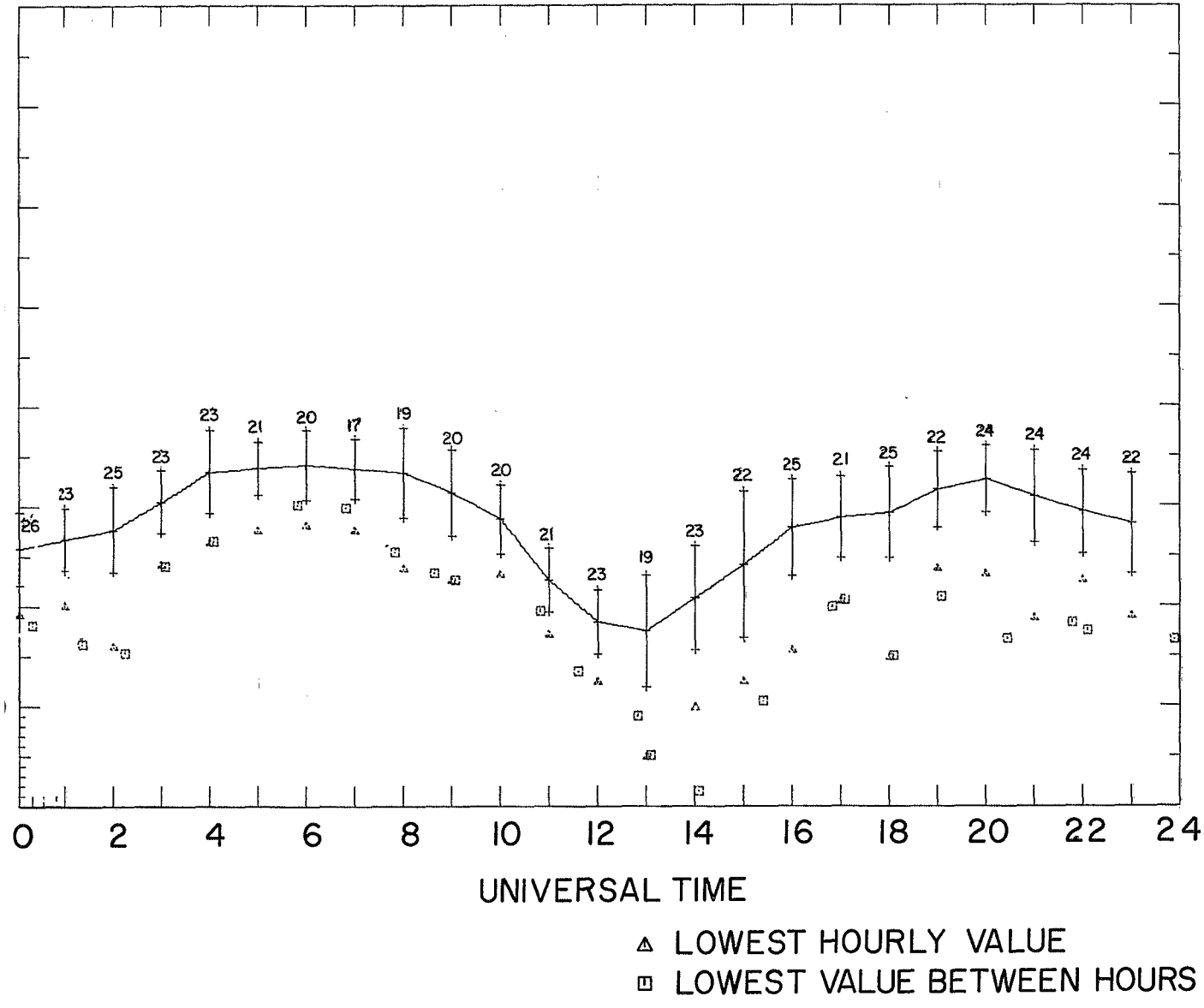
Fig. 30 - Mean and standard deviation of signal-to-noise ratio for NWC at Madgascar as recorded from 17 October to 24 October 1967 at a frequency of 15.5 kHz. Normalized radiated power of NWC is 29.5 dB above 1 kw.



g. 31 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as corded from 7 November to 14 November 1967 at a frequency of 15.5 kHz. Normalized diated power of NWC is 29.5 dB above 1 kw.



Fi 32 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as rerded from 29 November to 5 December 1967 at a frequency of 15.5 kHz. Normalized raated power of NWC is 29.5 dB above 1 kw.



'ig. 33 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 5.5 kHz, for a three-month period from September to December 1967. Normalized adiated power of NWC is 29.5 dB above 1 kw.

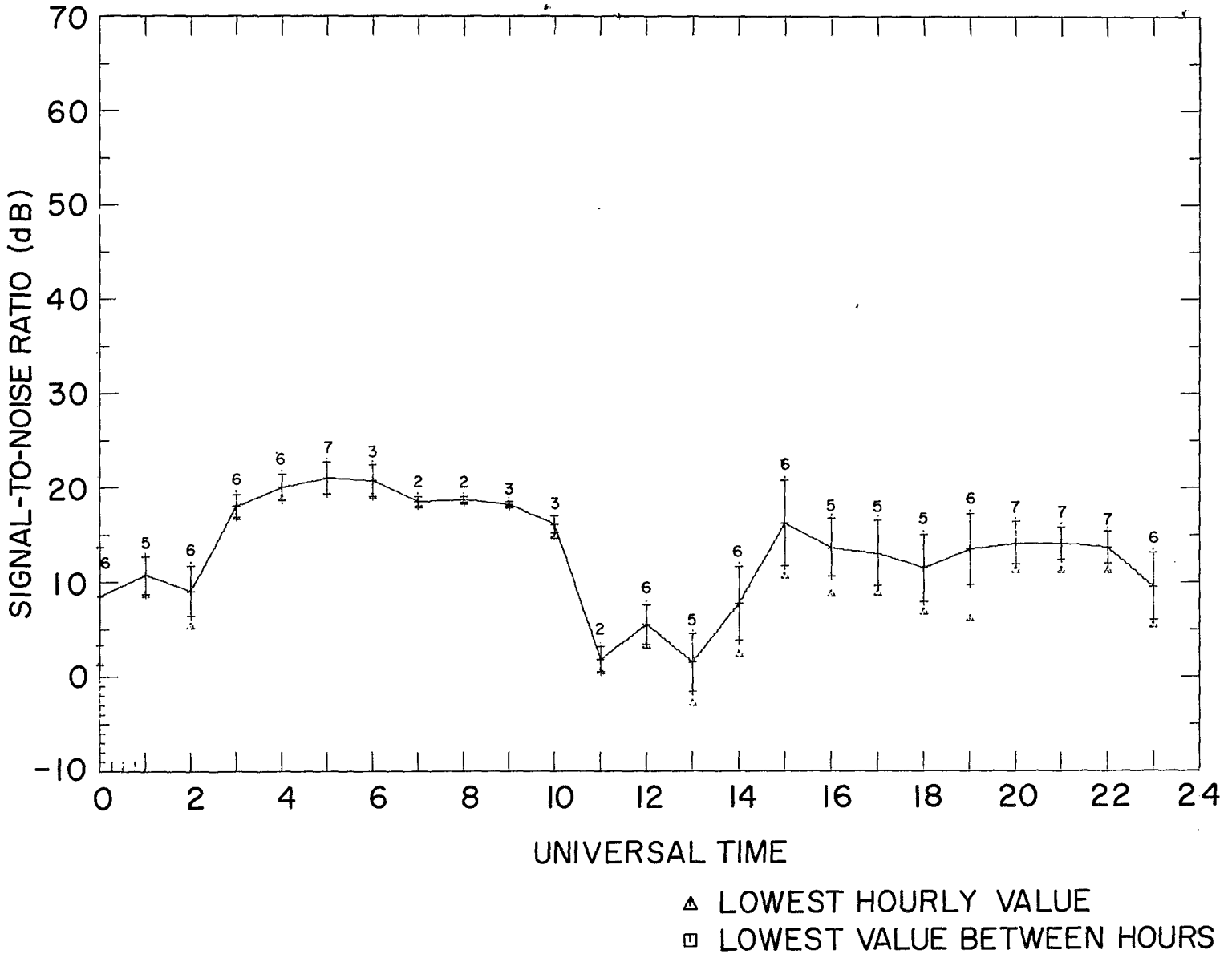


Fig. 34 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 6 October to 13 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

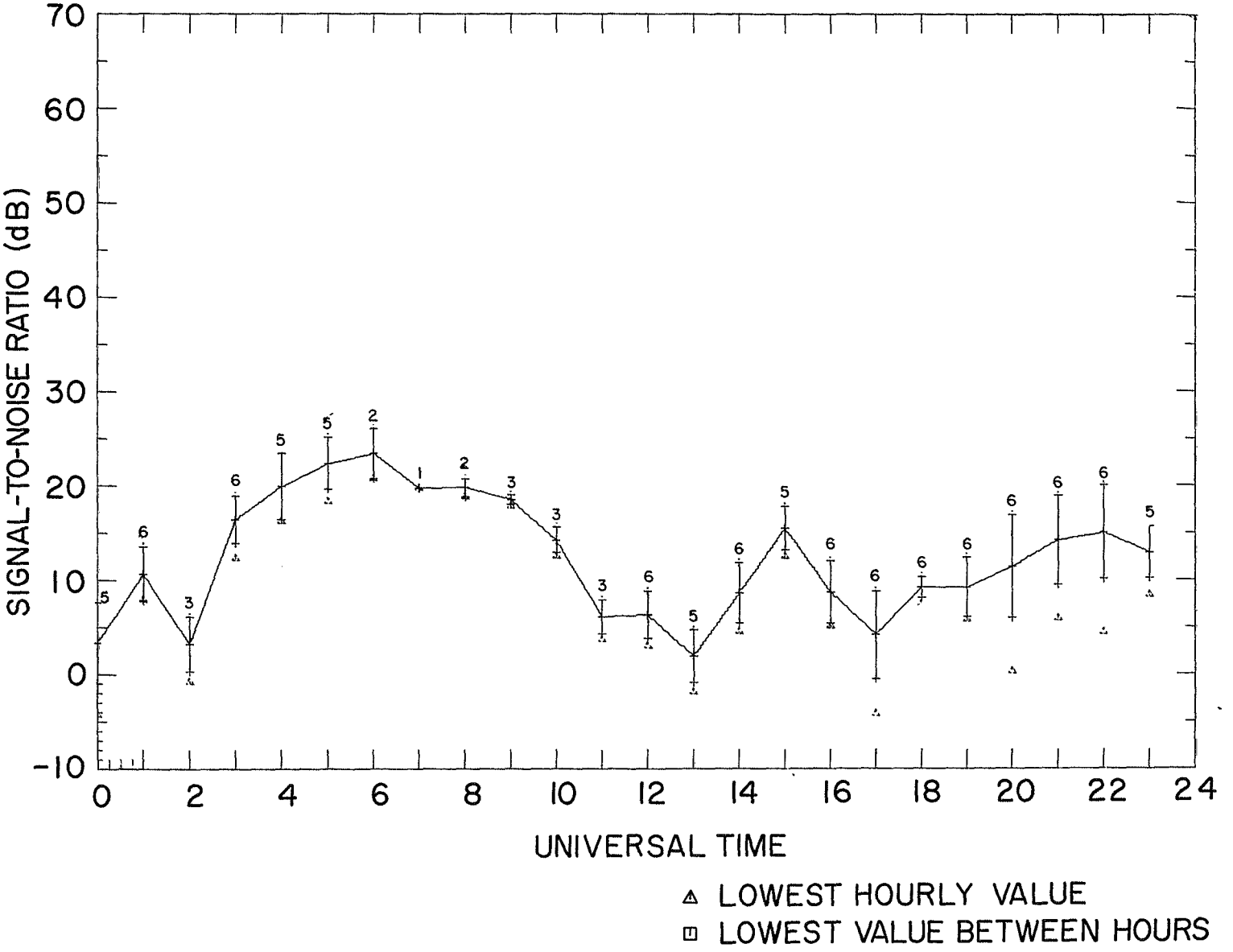


Fig. 35 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 21 October to 27 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

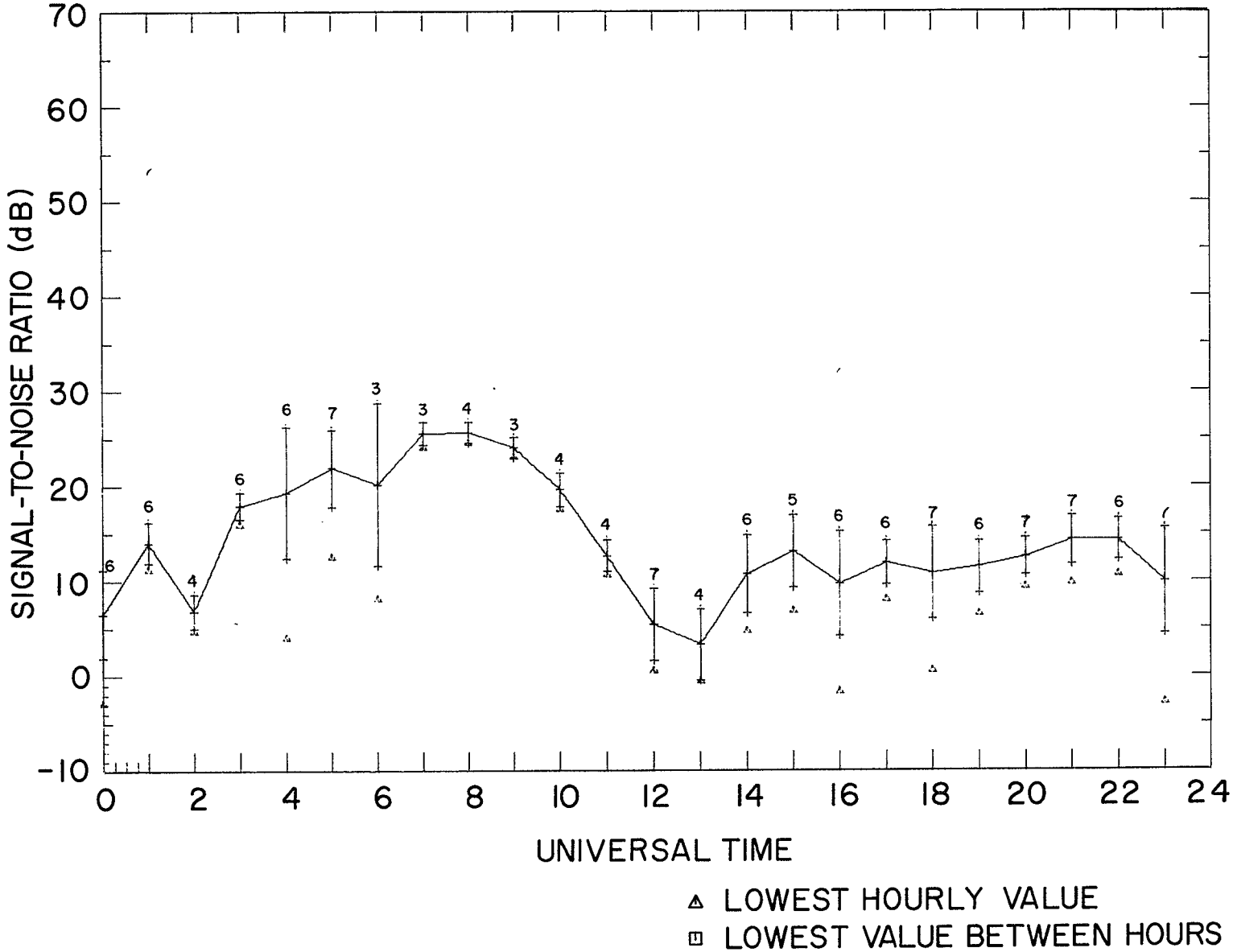
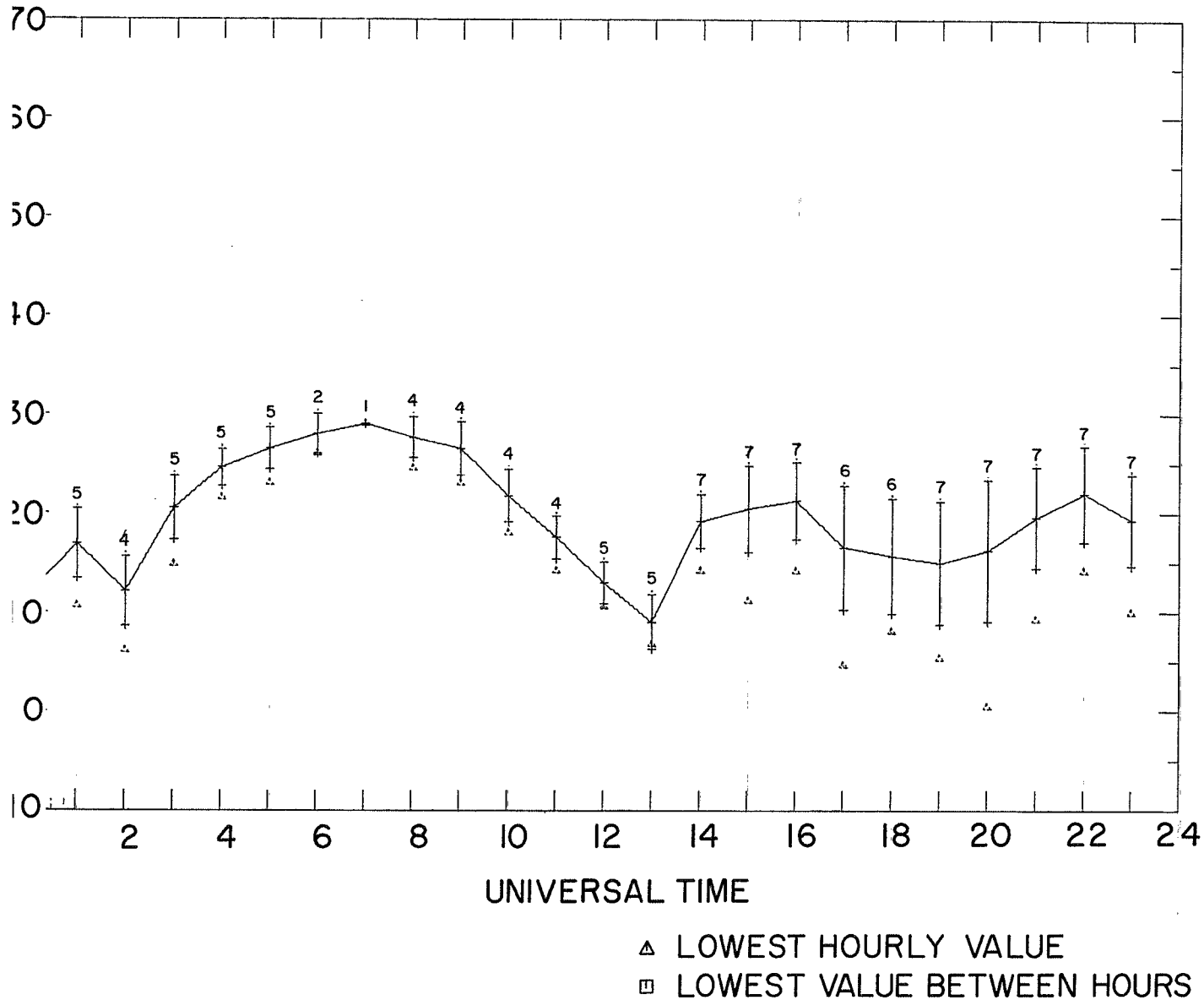


Fig. 36 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 3 November to 10 November 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.



. 3- Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded n 2November to 30 November 1967 at a frequency of 18.0 kHz. Normalized radiated power NWis 30.5 dB above 1 kw.

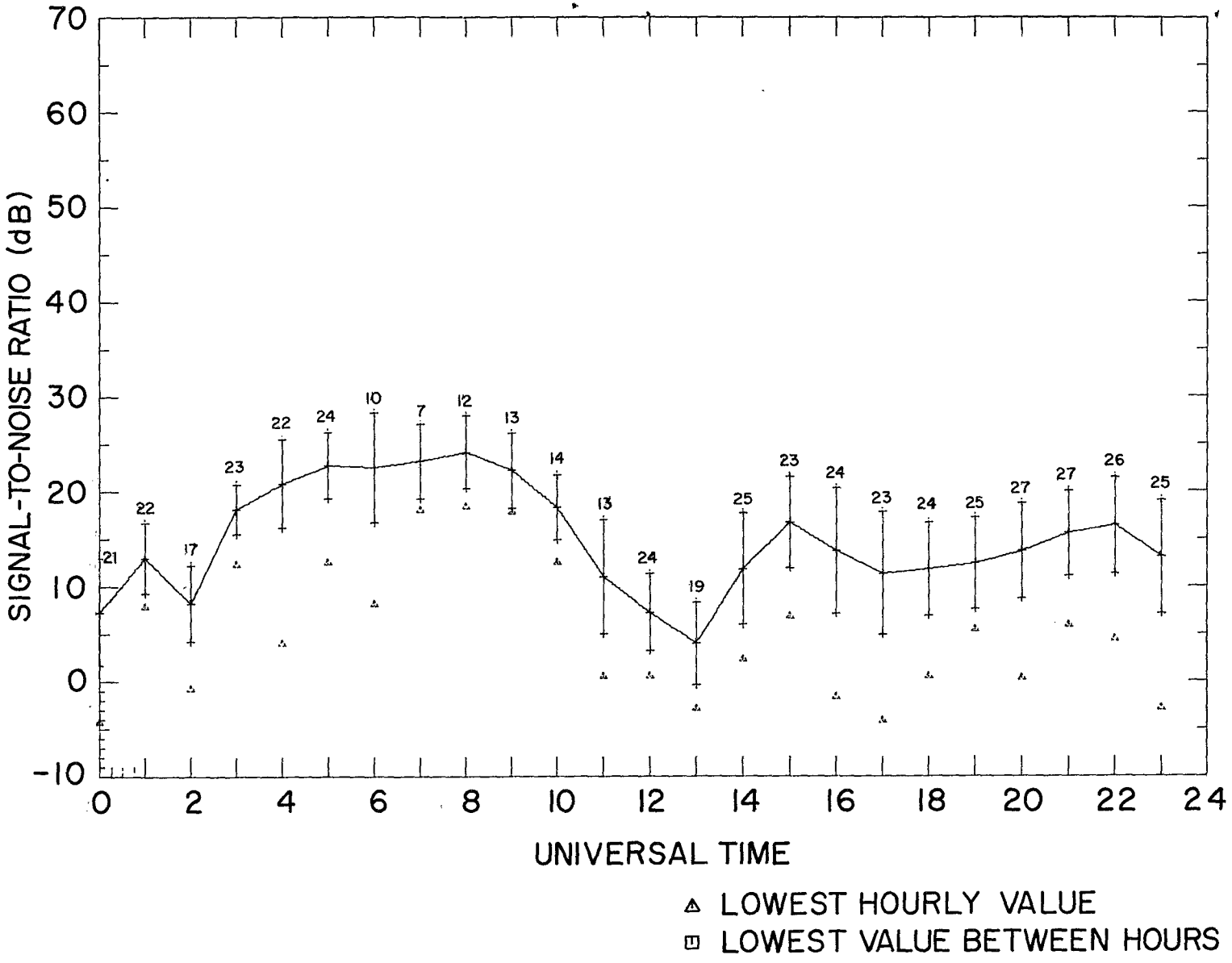
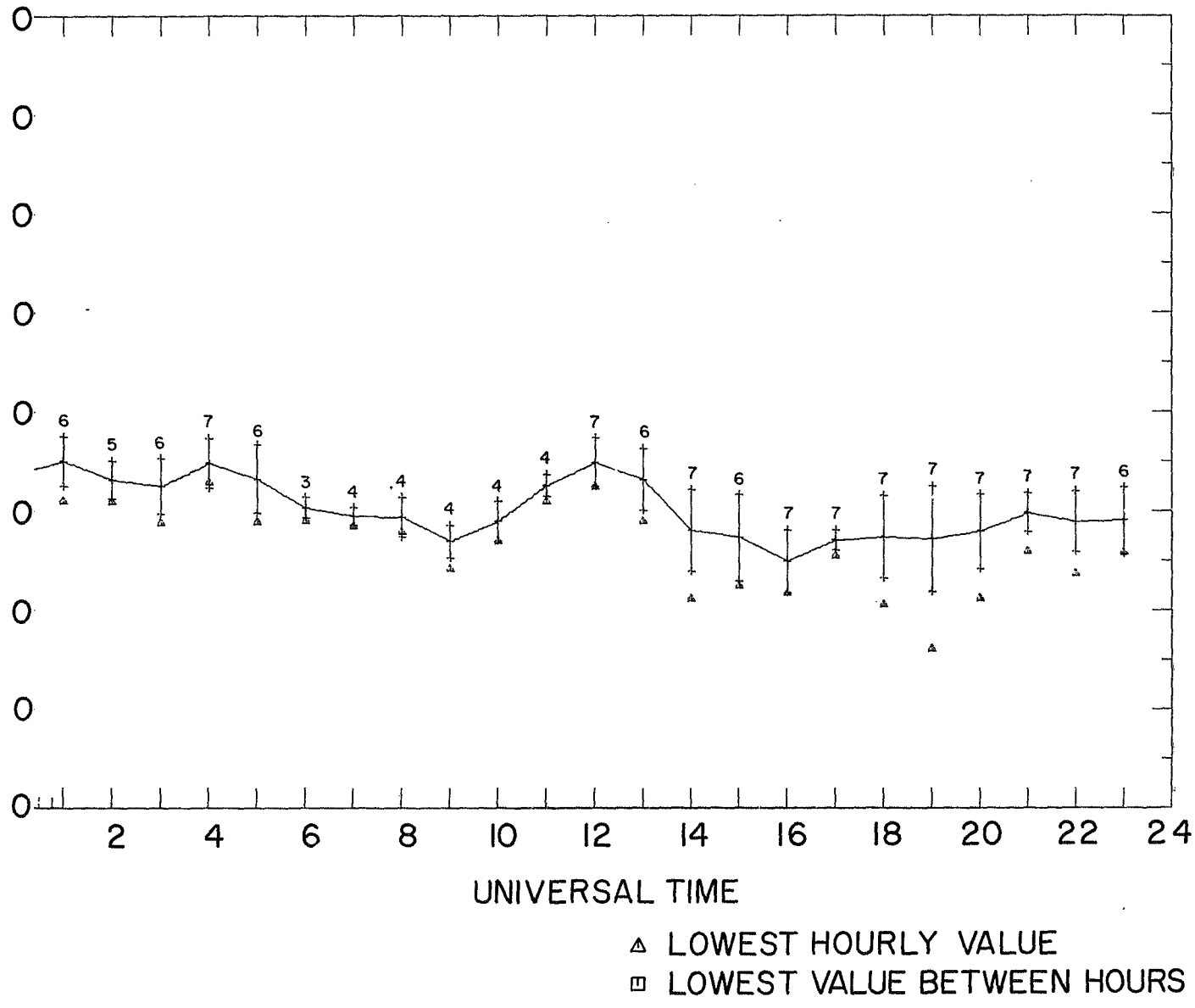


Fig. 38 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.5 dB above 1 kw.



;. - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded m October to 13 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of C 30.5 dB above 1 kw.

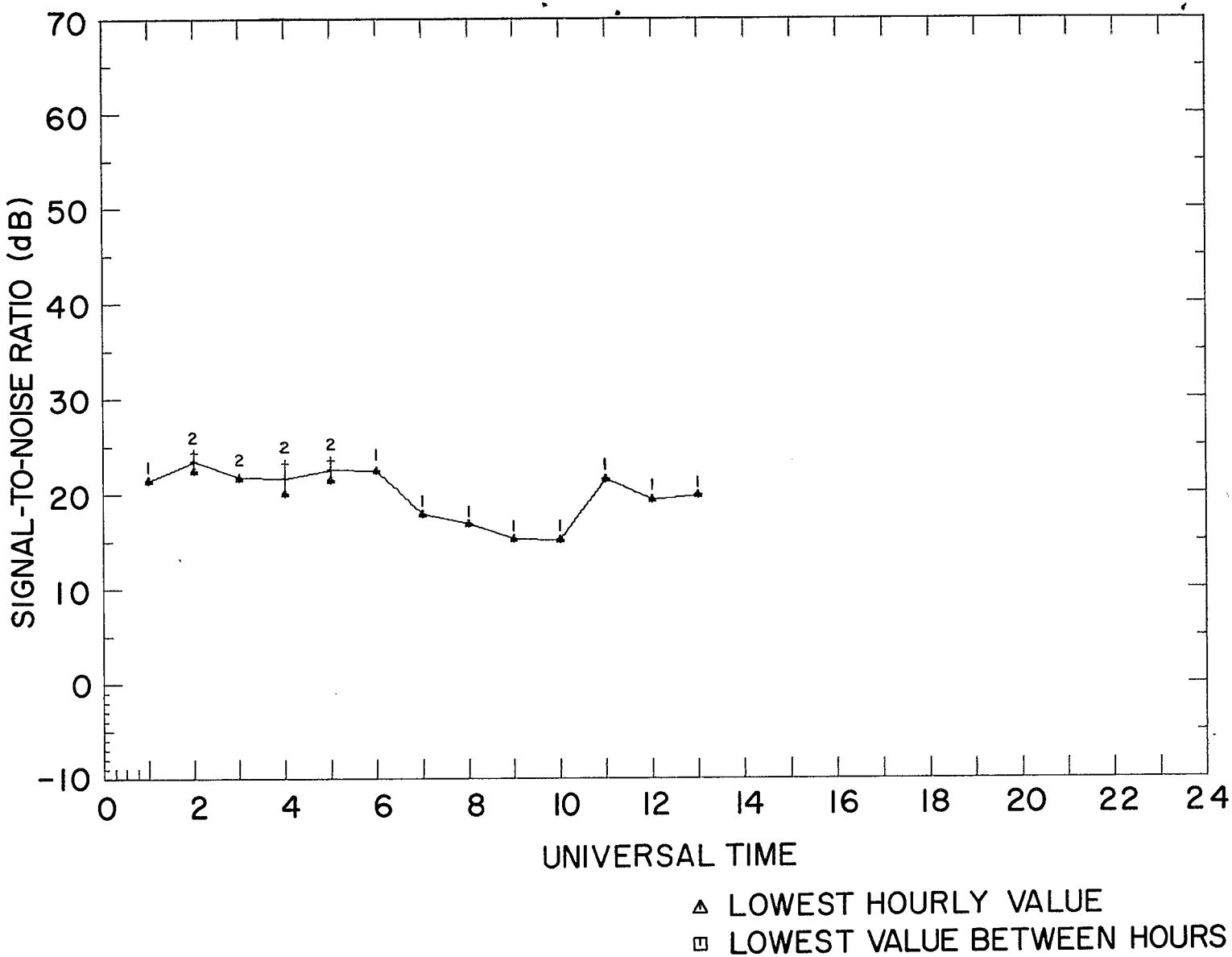
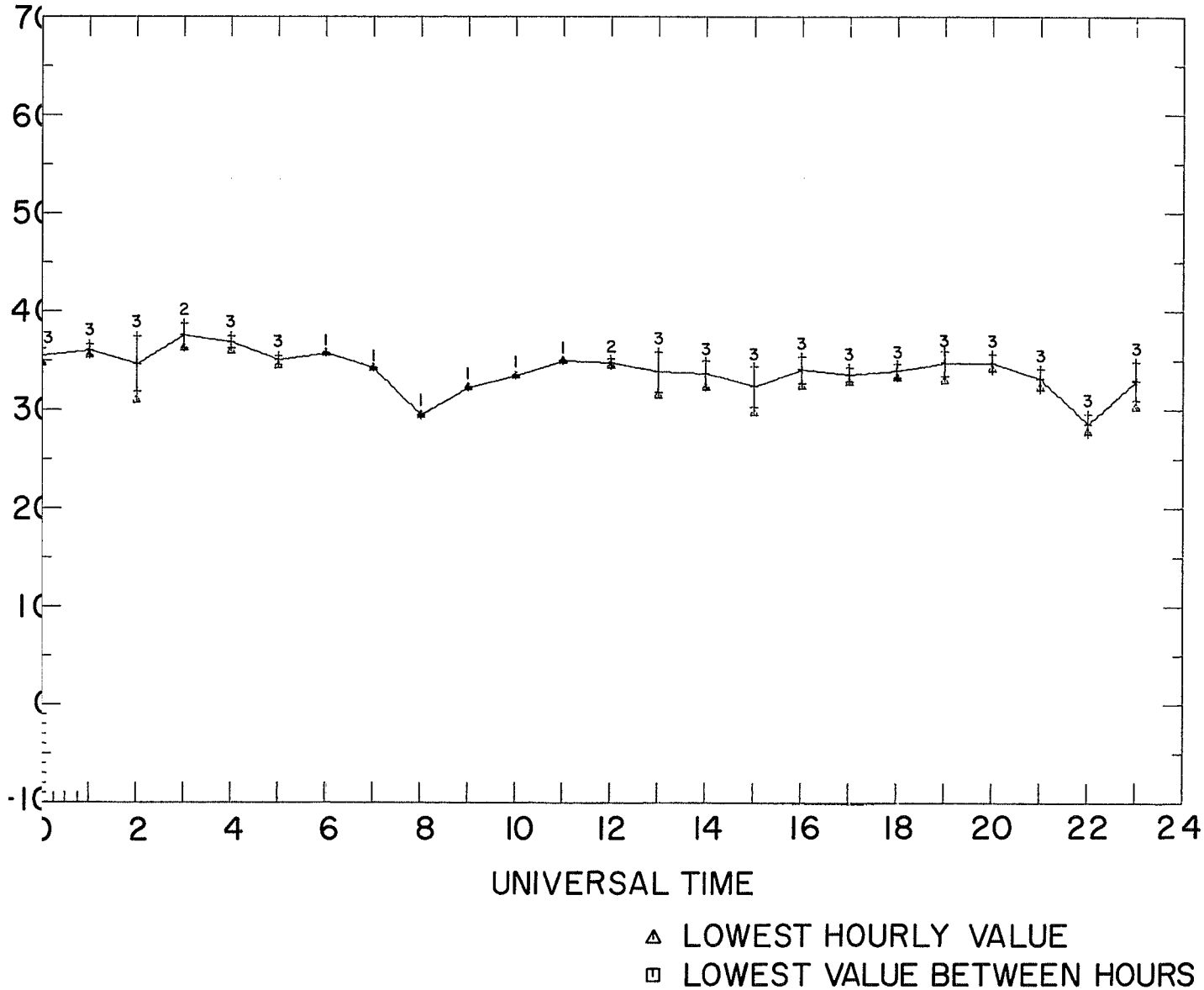


Fig. 40 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 21 October to 23 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.



;. 4- Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded m November to 10 November 1967 at a frequency of 18.0 kHz. Normalized radiated power NW is 30.5 dB above 1 kw.

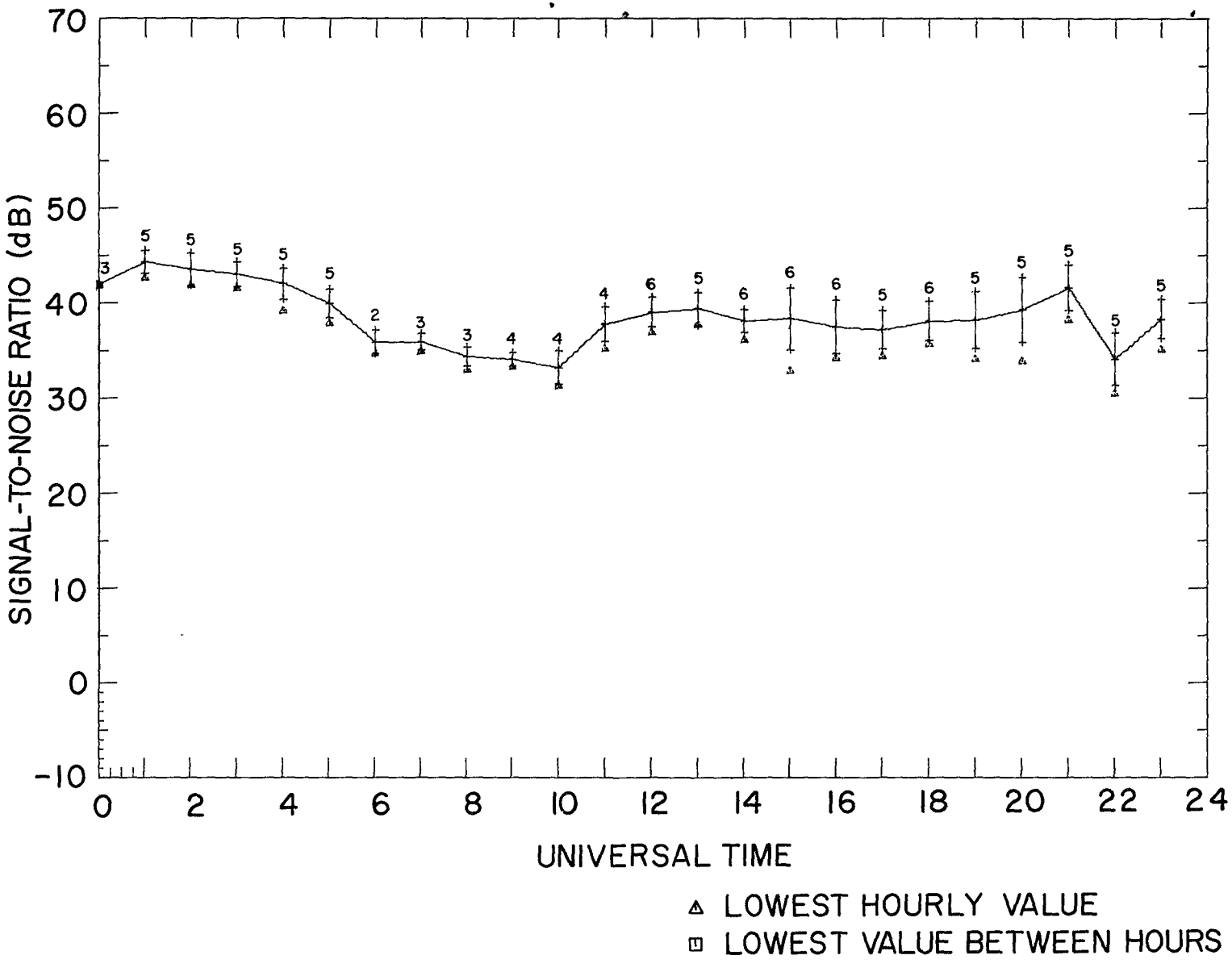


Fig. 42 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 24 November to 30 November 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

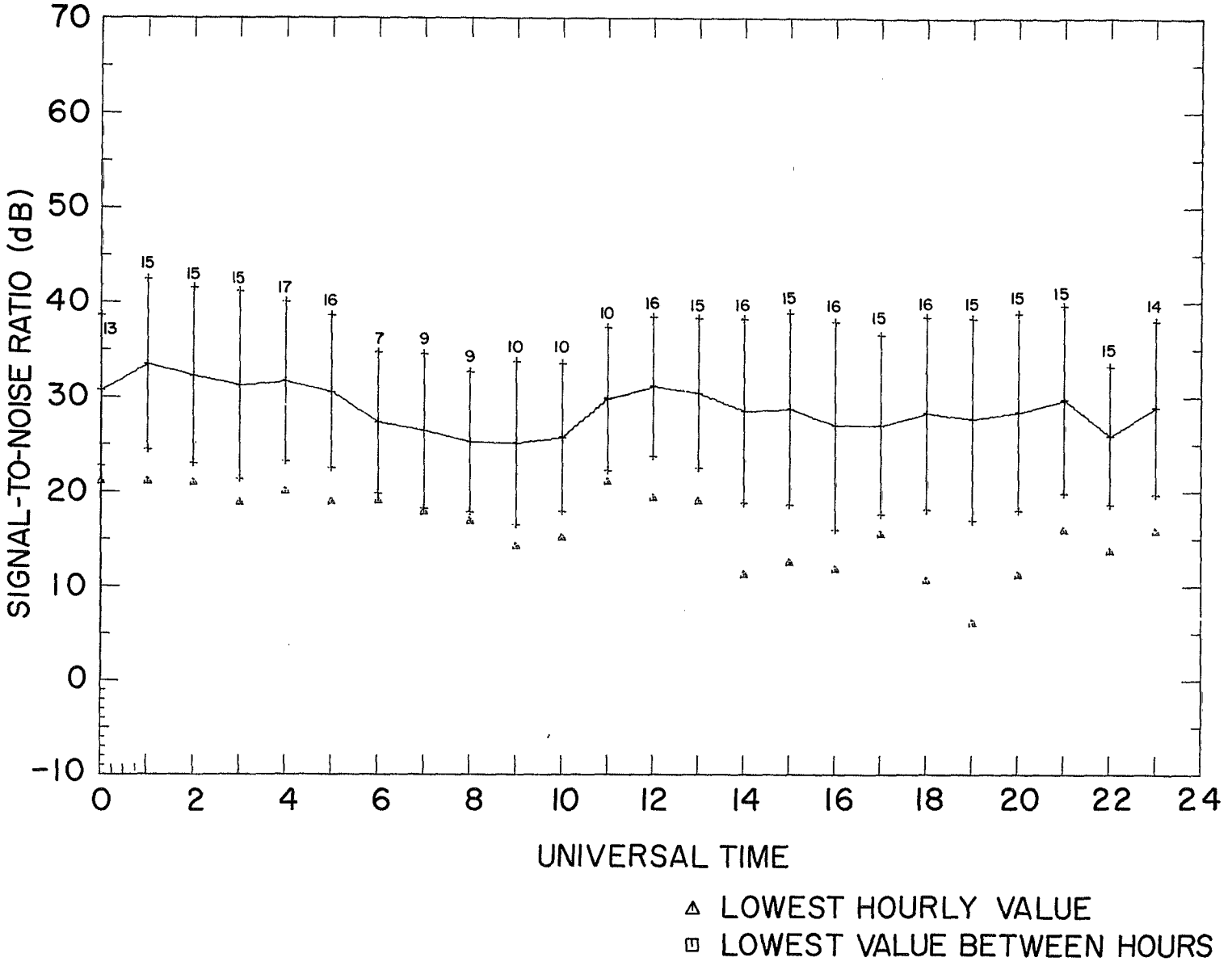


Fig. 43 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.5 dB above 1 kw.

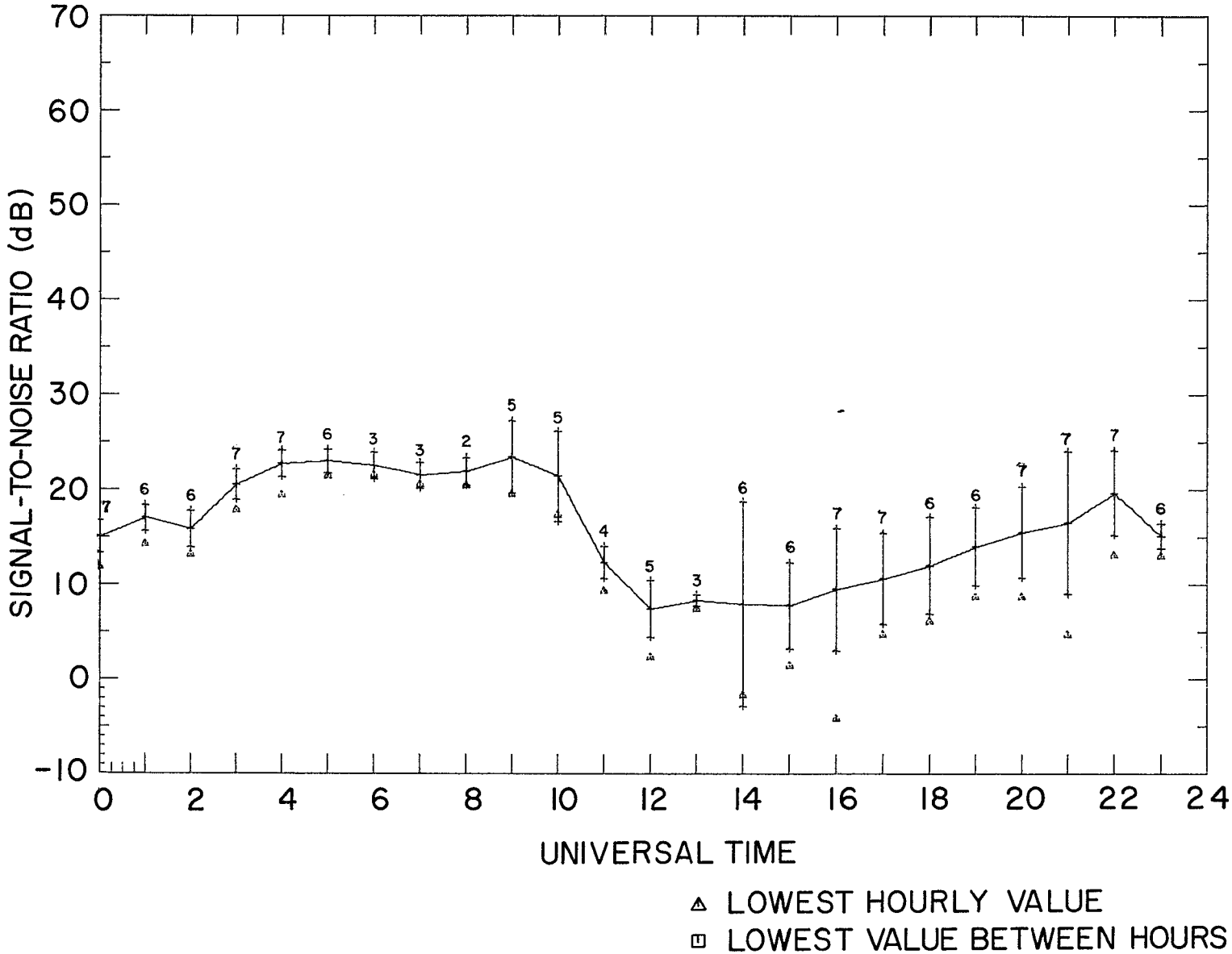


Fig. 44 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 6 October to 13 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

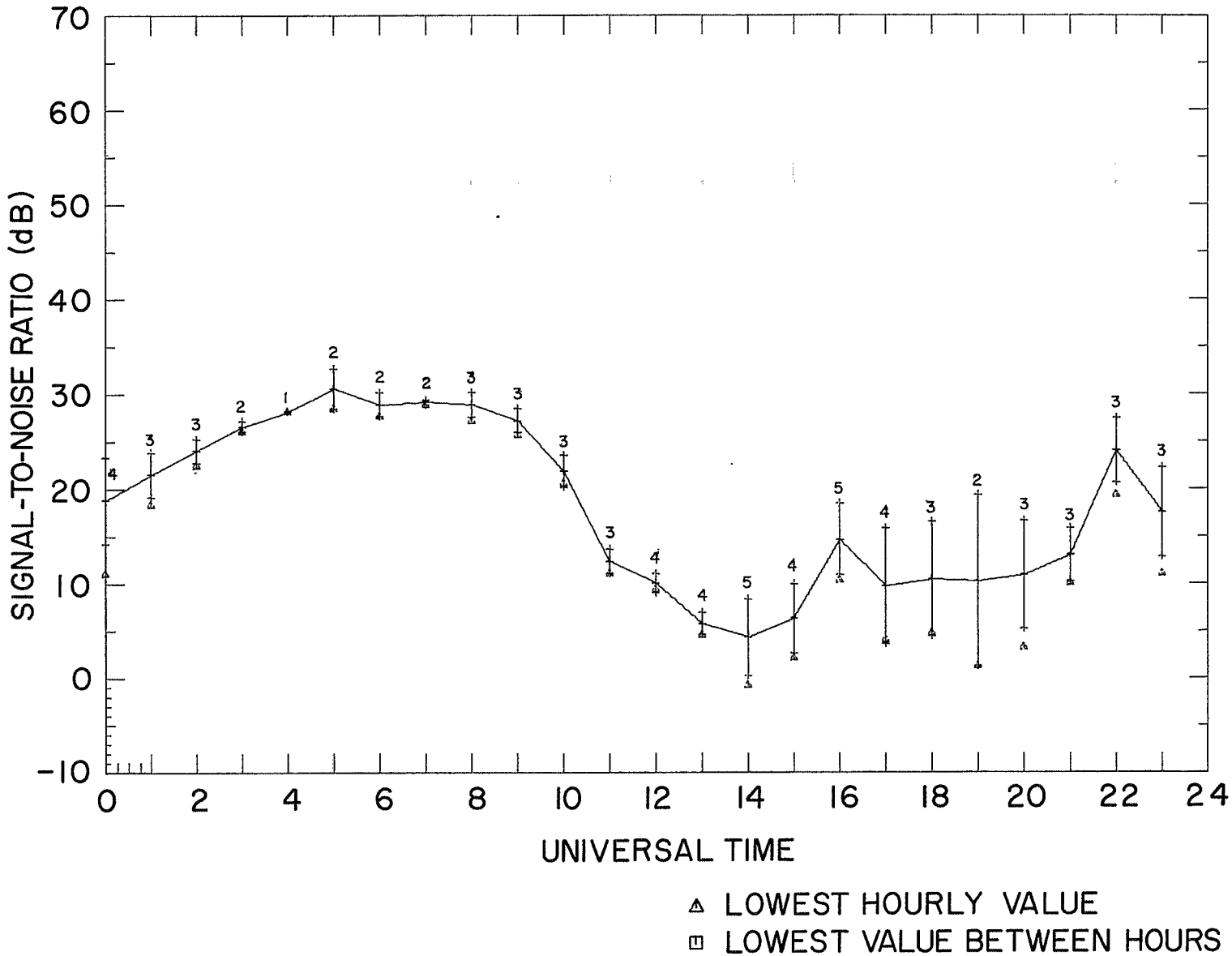


Fig. 45 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 20 October to 25 October 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

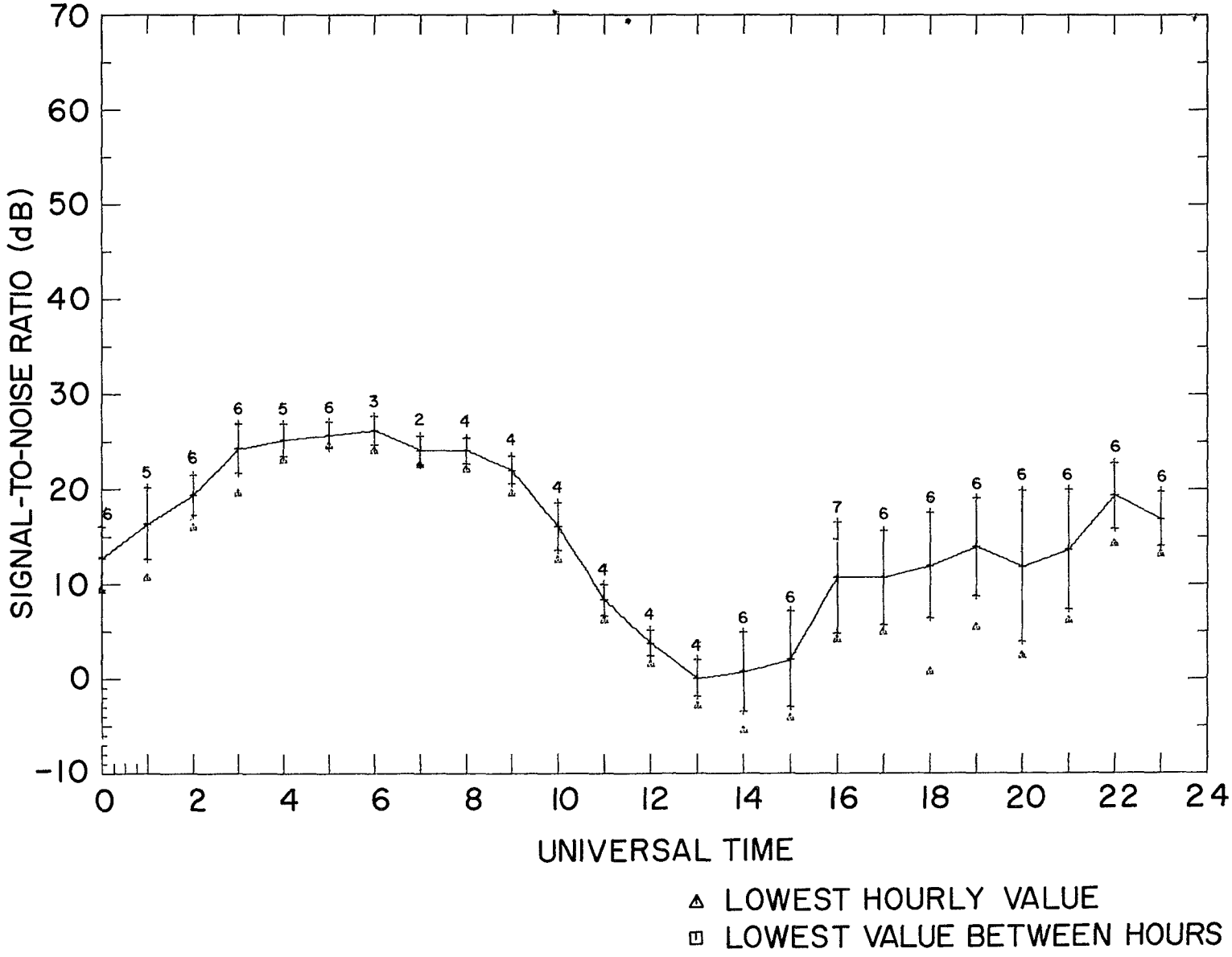


Fig. 46 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 3 November to 10 November 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

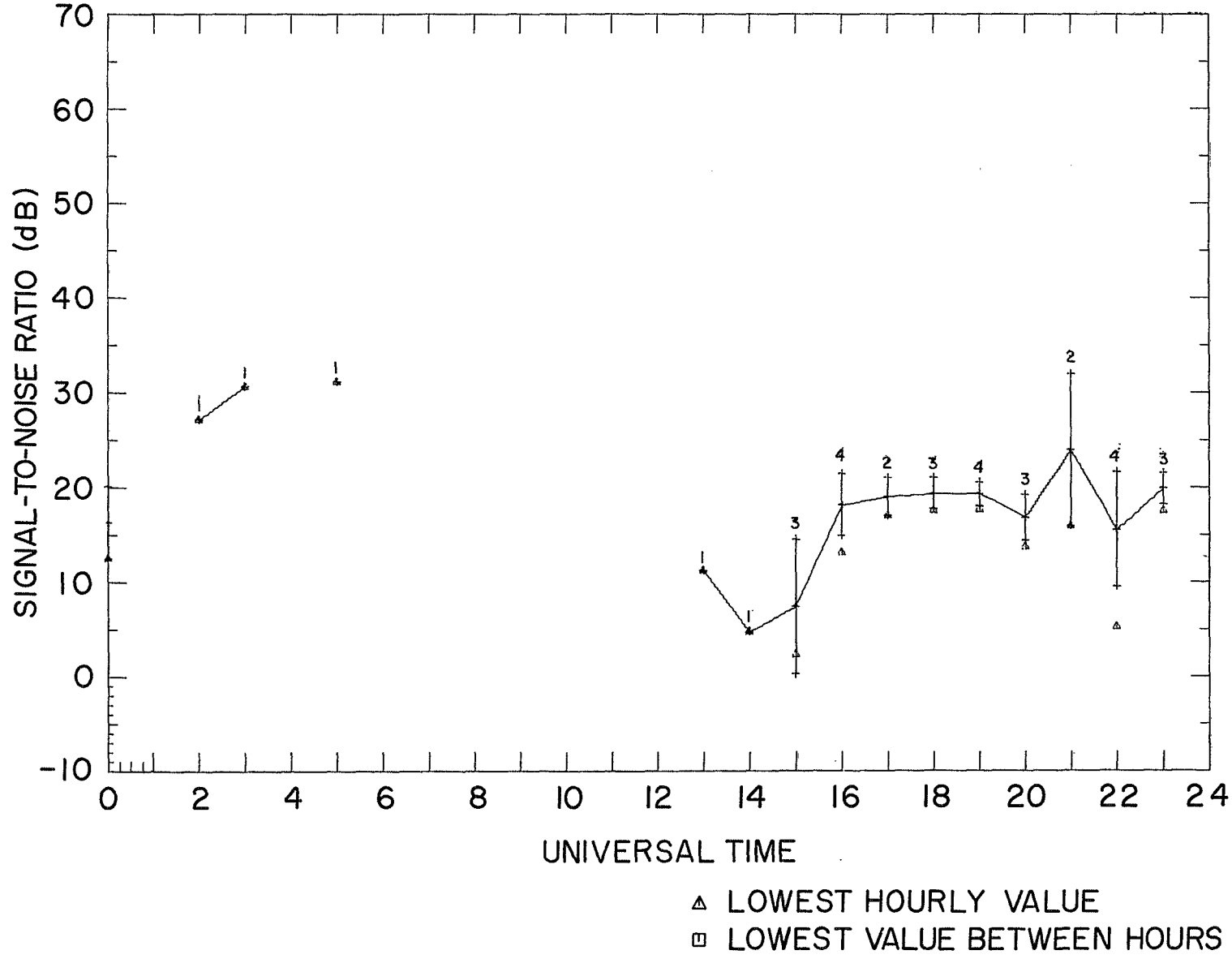


Fig. 47 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 25 November to 1 December 1967 at a frequency of 18.0 kHz. Normalized radiated power of NWC is 30.5 dB above 1 kw.

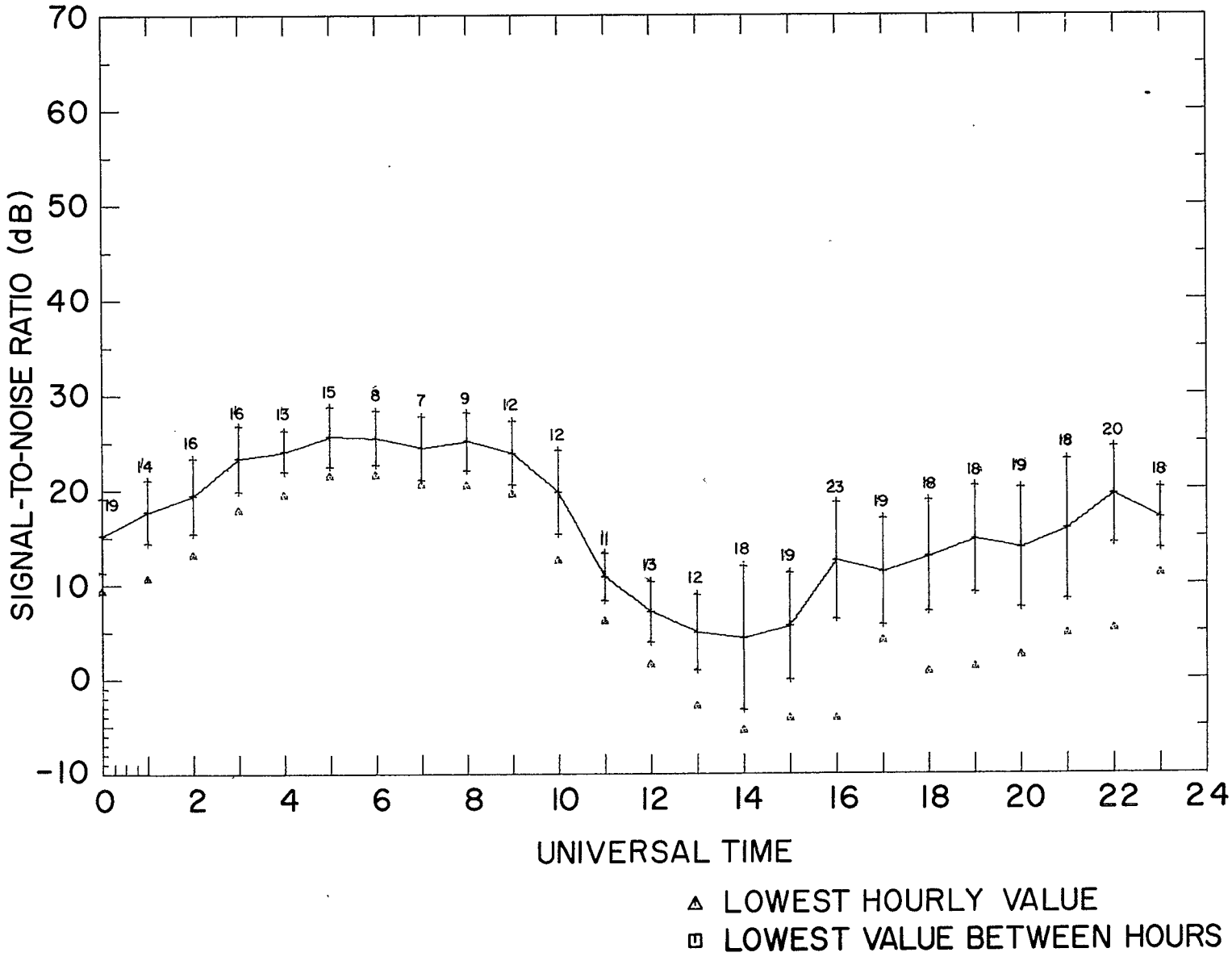


Fig. 48 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 18.0 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.5 dB above 1 kw.

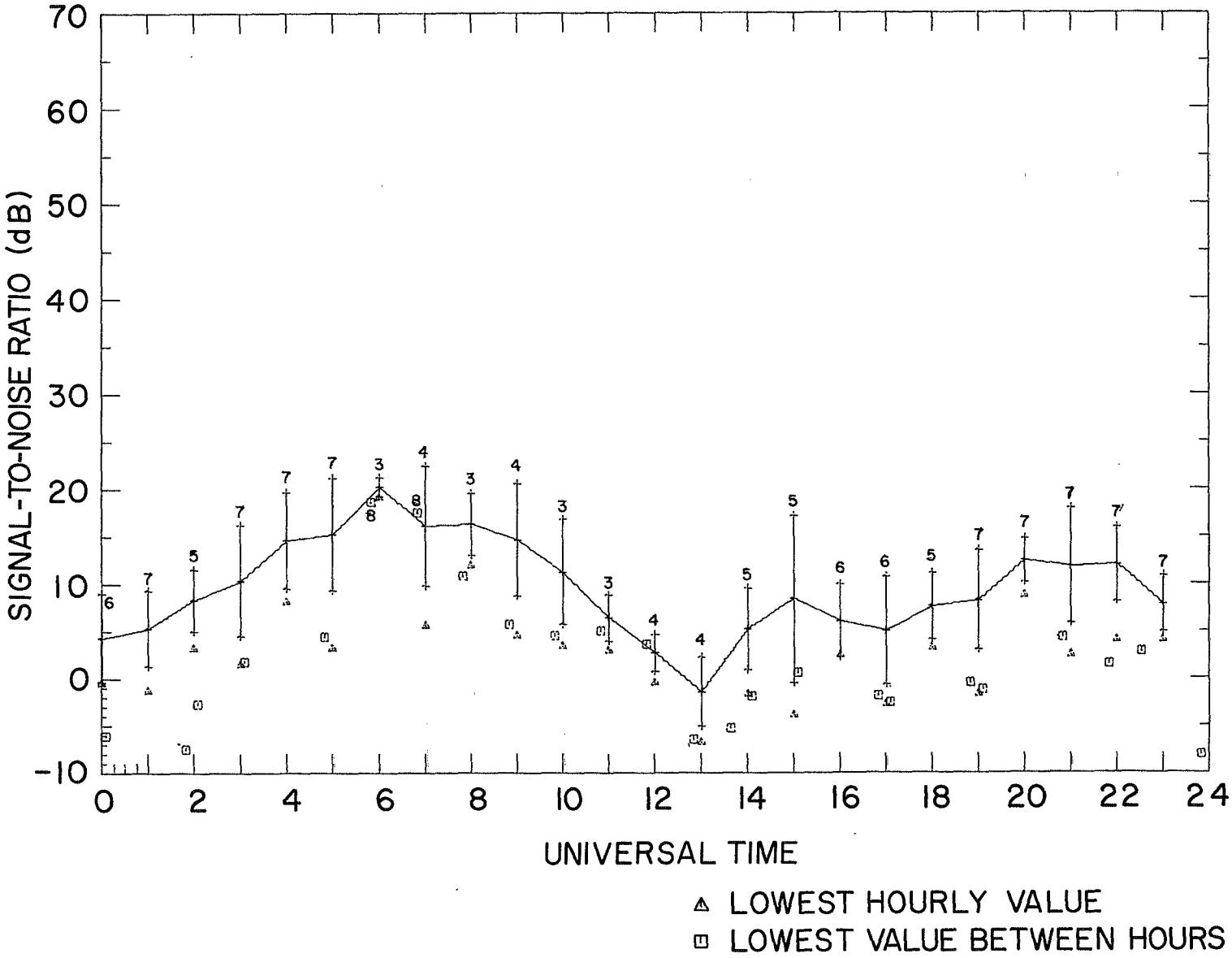


Fig. 49 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 3 October to 10 October 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

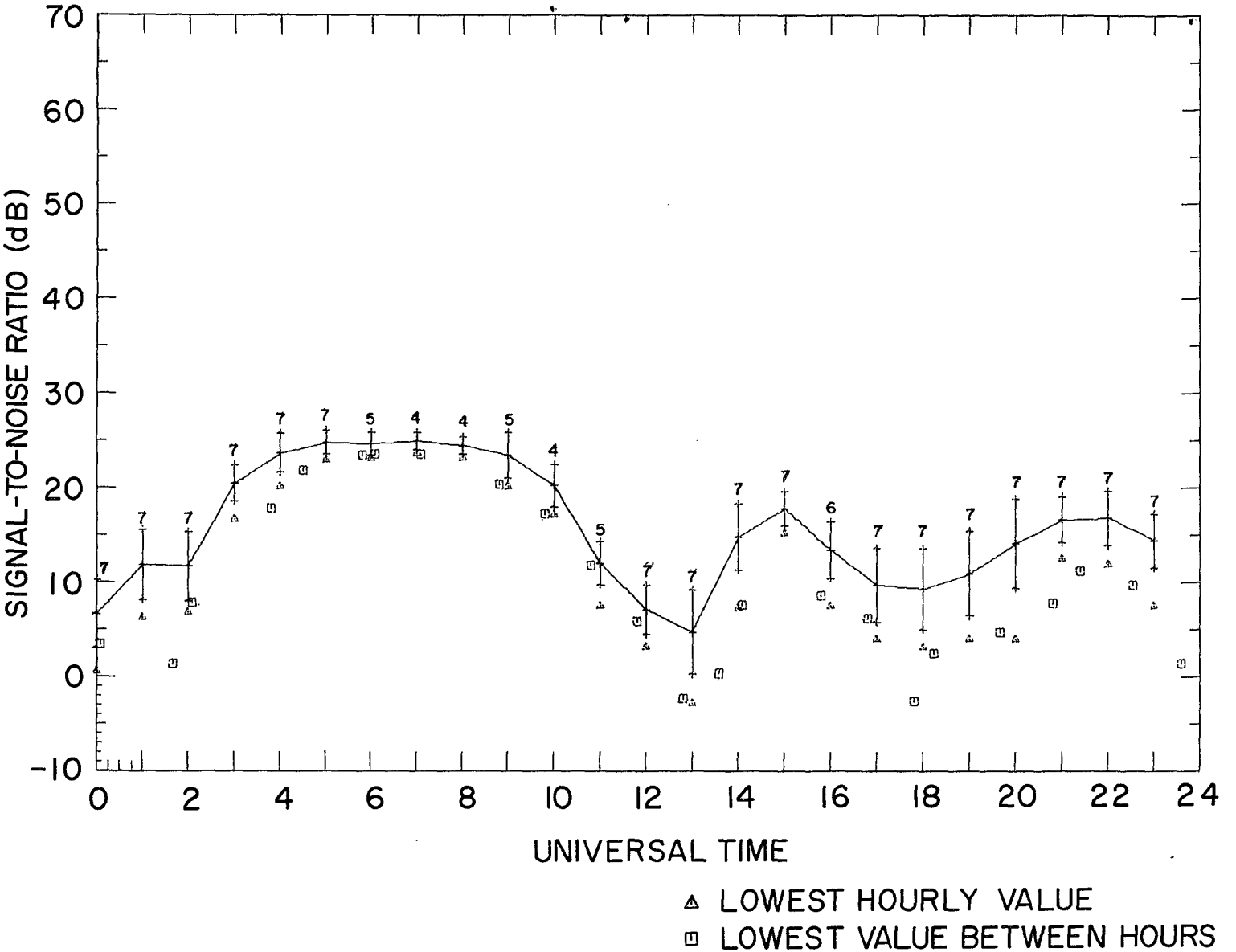


Fig. 50 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 24 October to 31 October 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

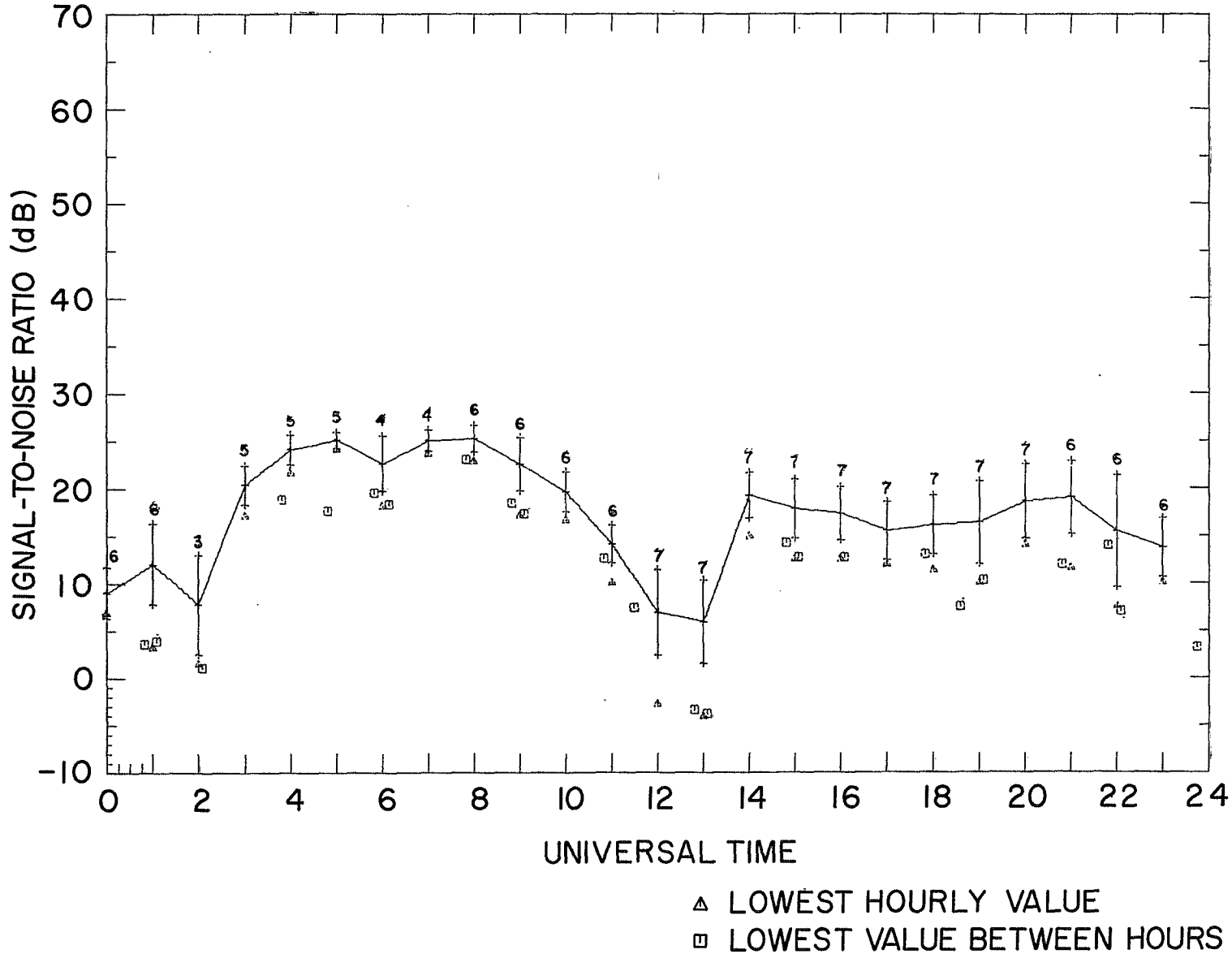


Fig. 51 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 14 November to 21 November 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

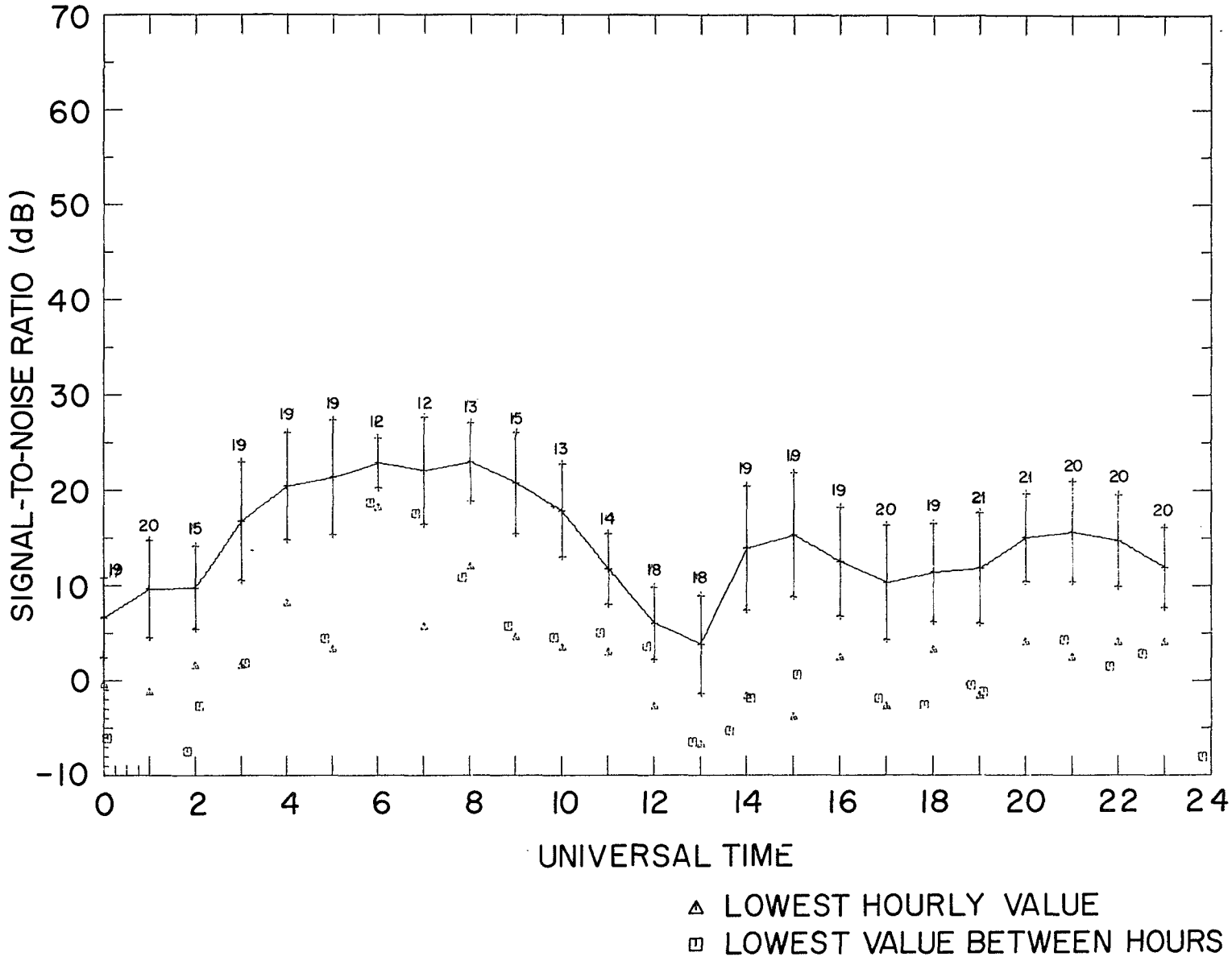


Fig. 52 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.7 dB above 1 kw.

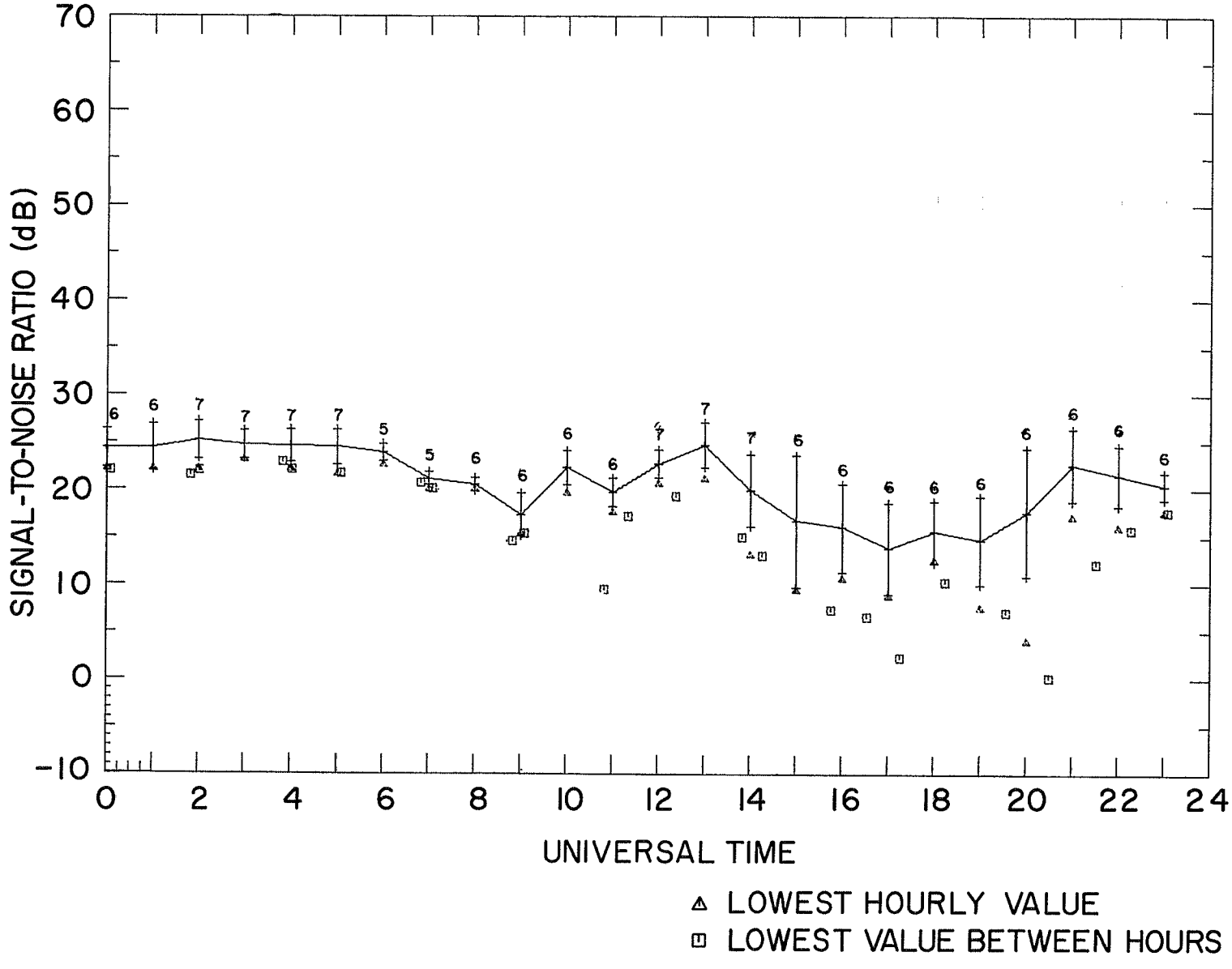


Fig. 53 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 3 October to 10 October 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

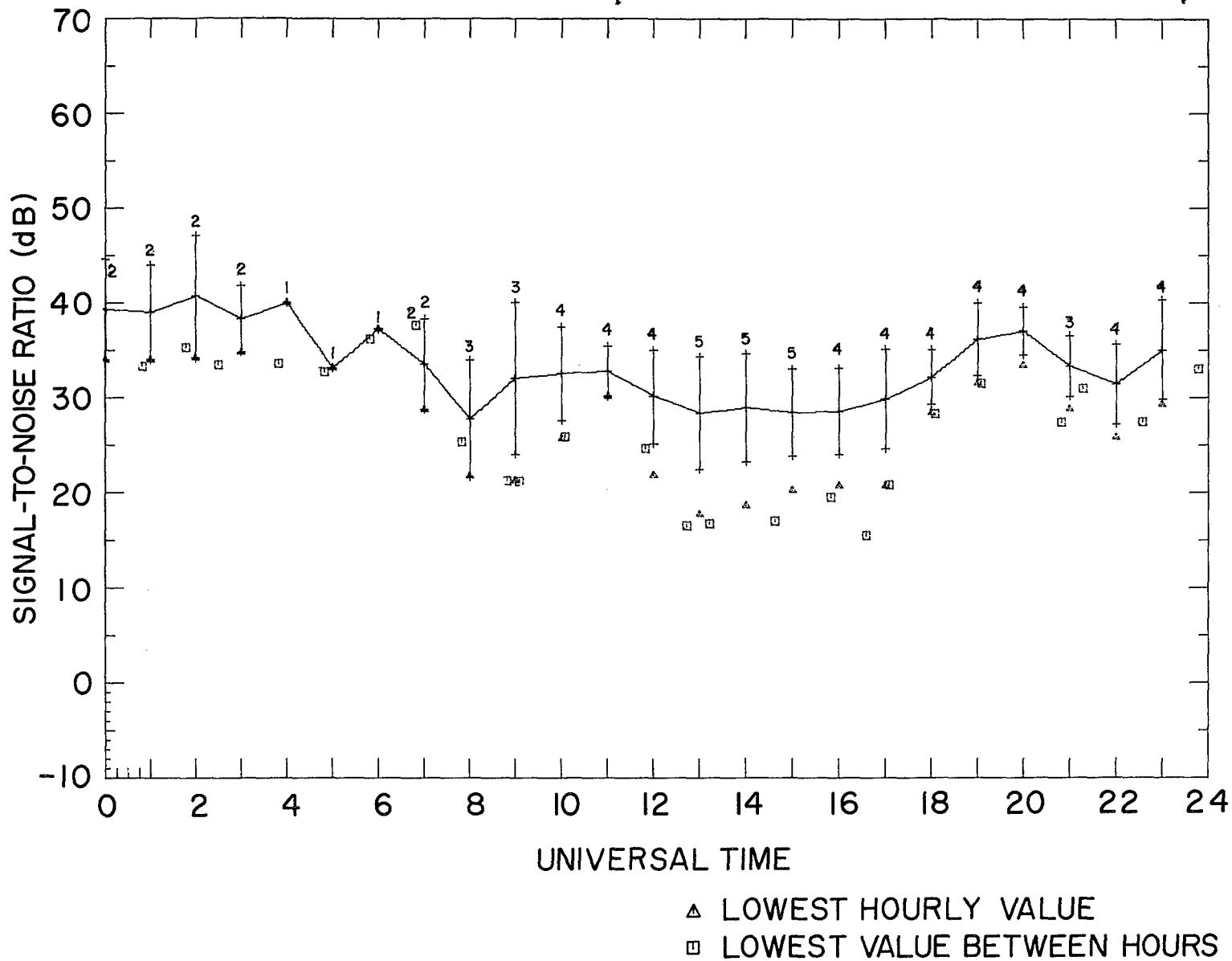


Fig. 54 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 14 November to 21 November 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

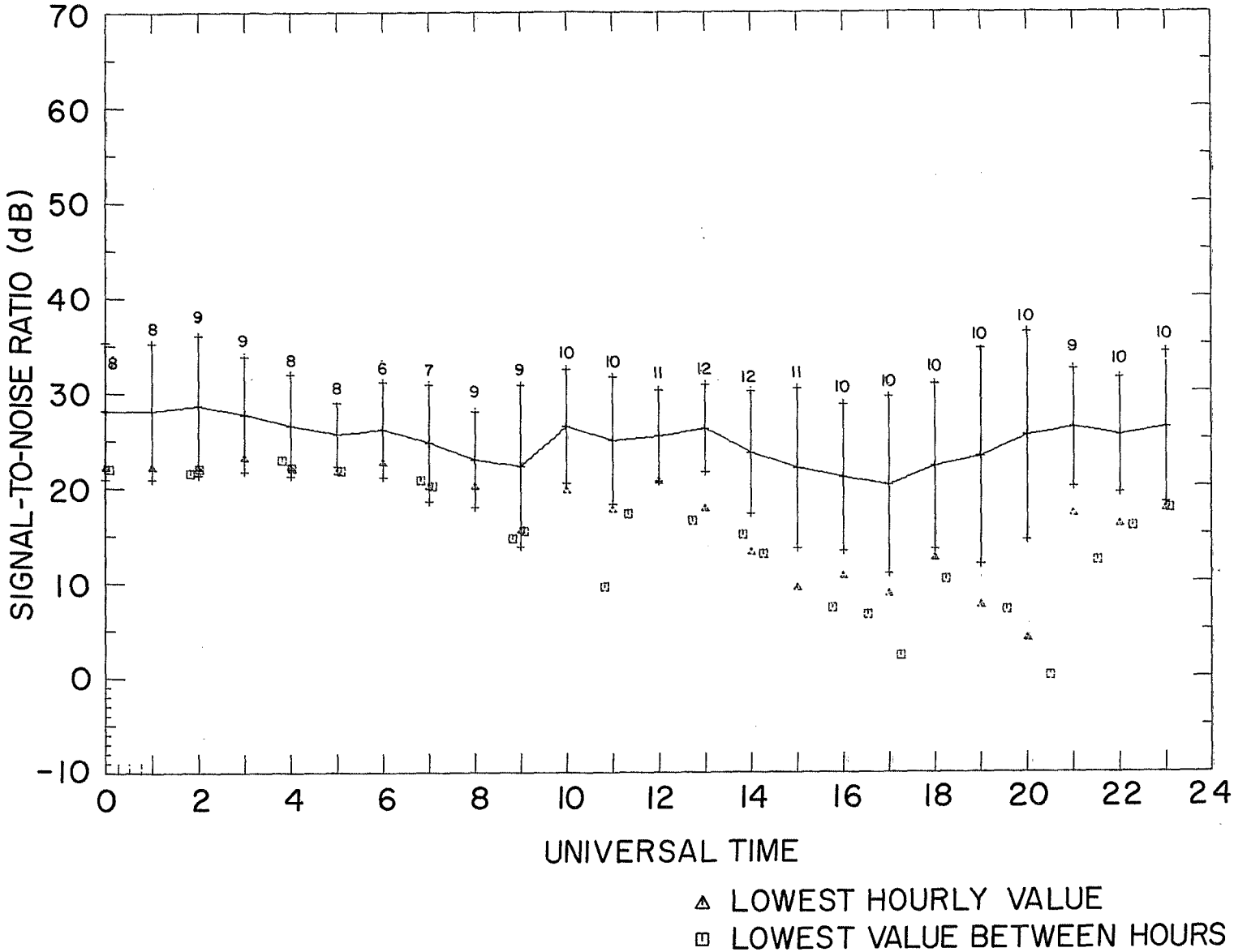


Fig. 55 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.7 dB above 1 kw.

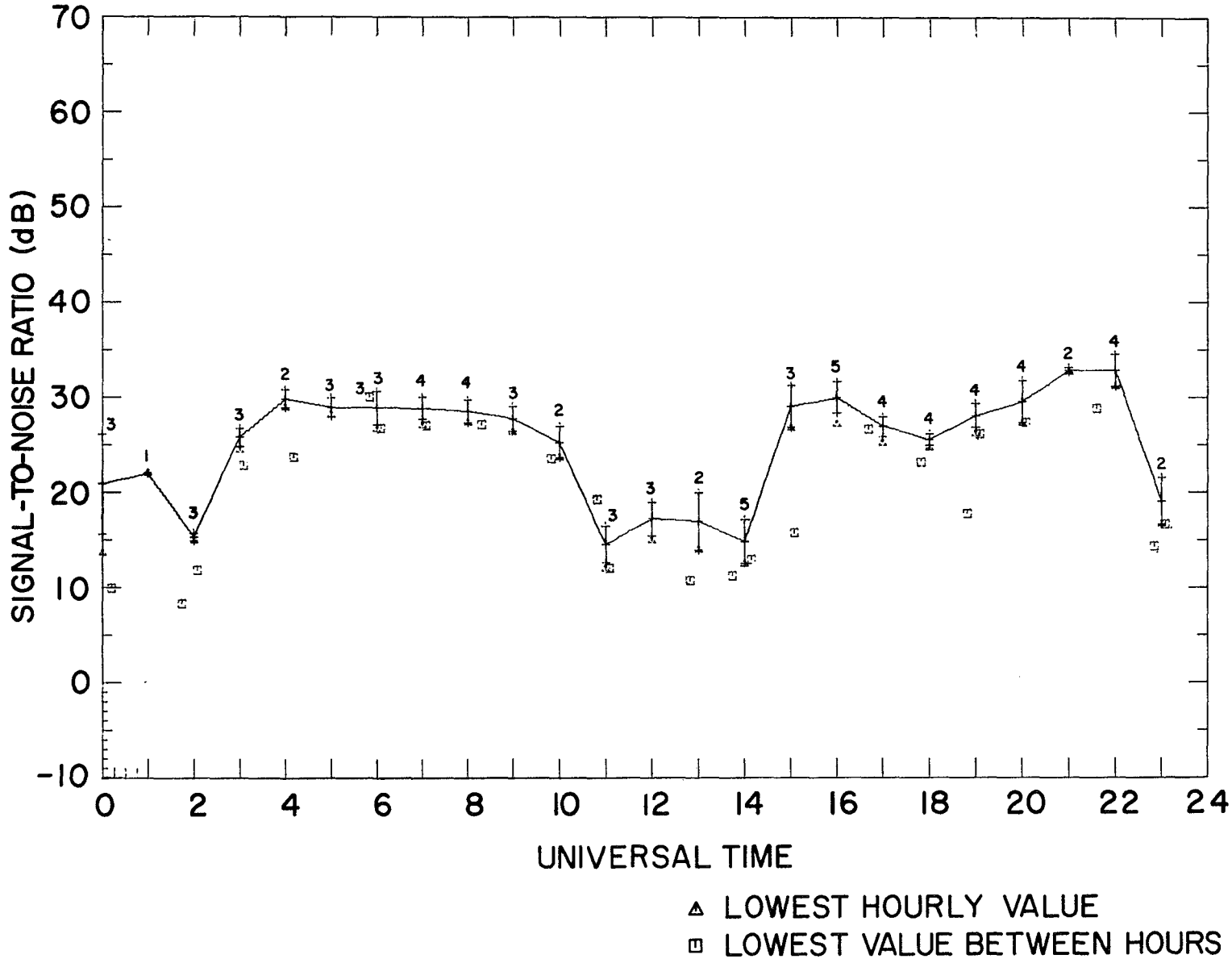


Fig. 56 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 12 September to 17 September 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

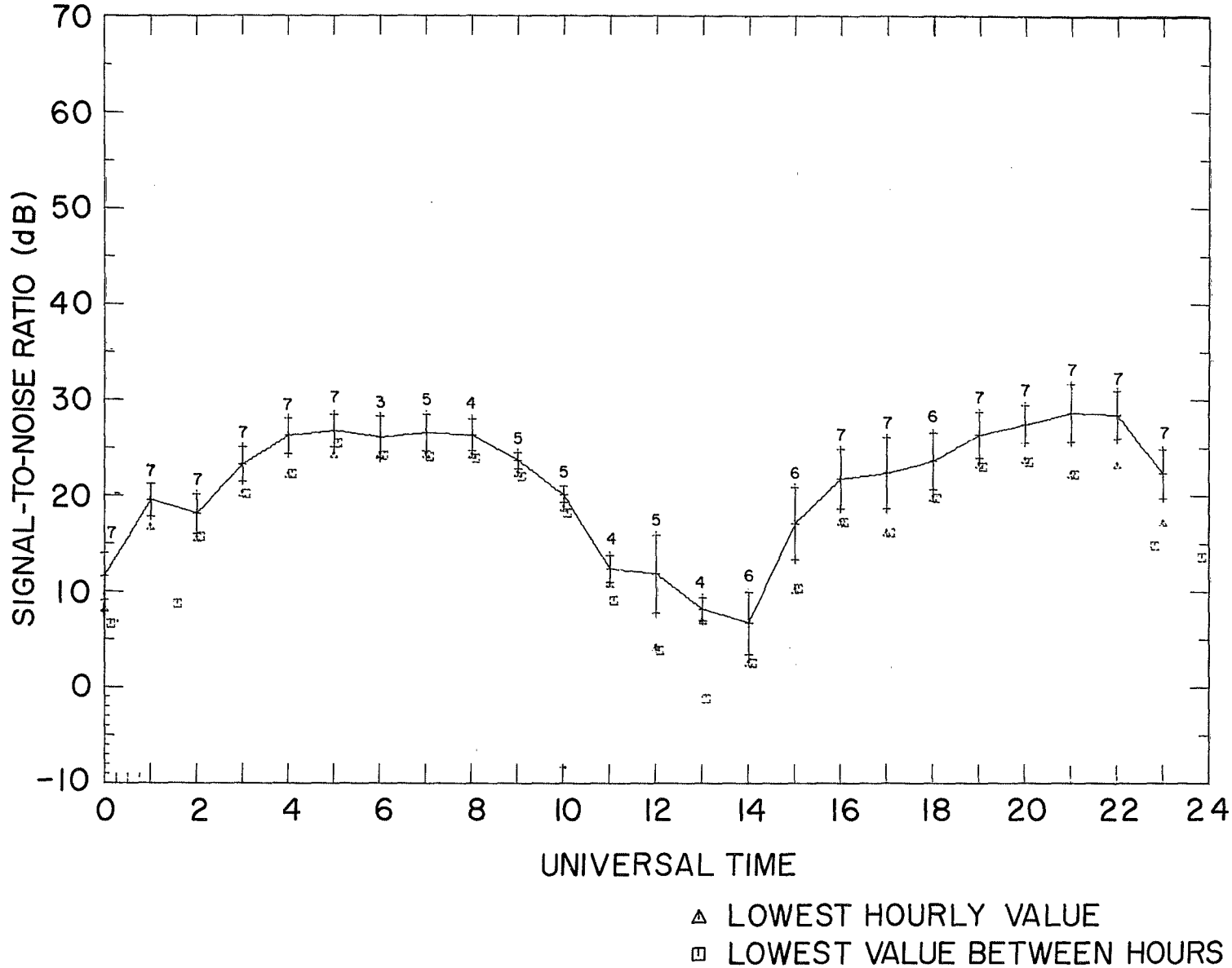


Fig. 57 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 3 October to 10 October 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

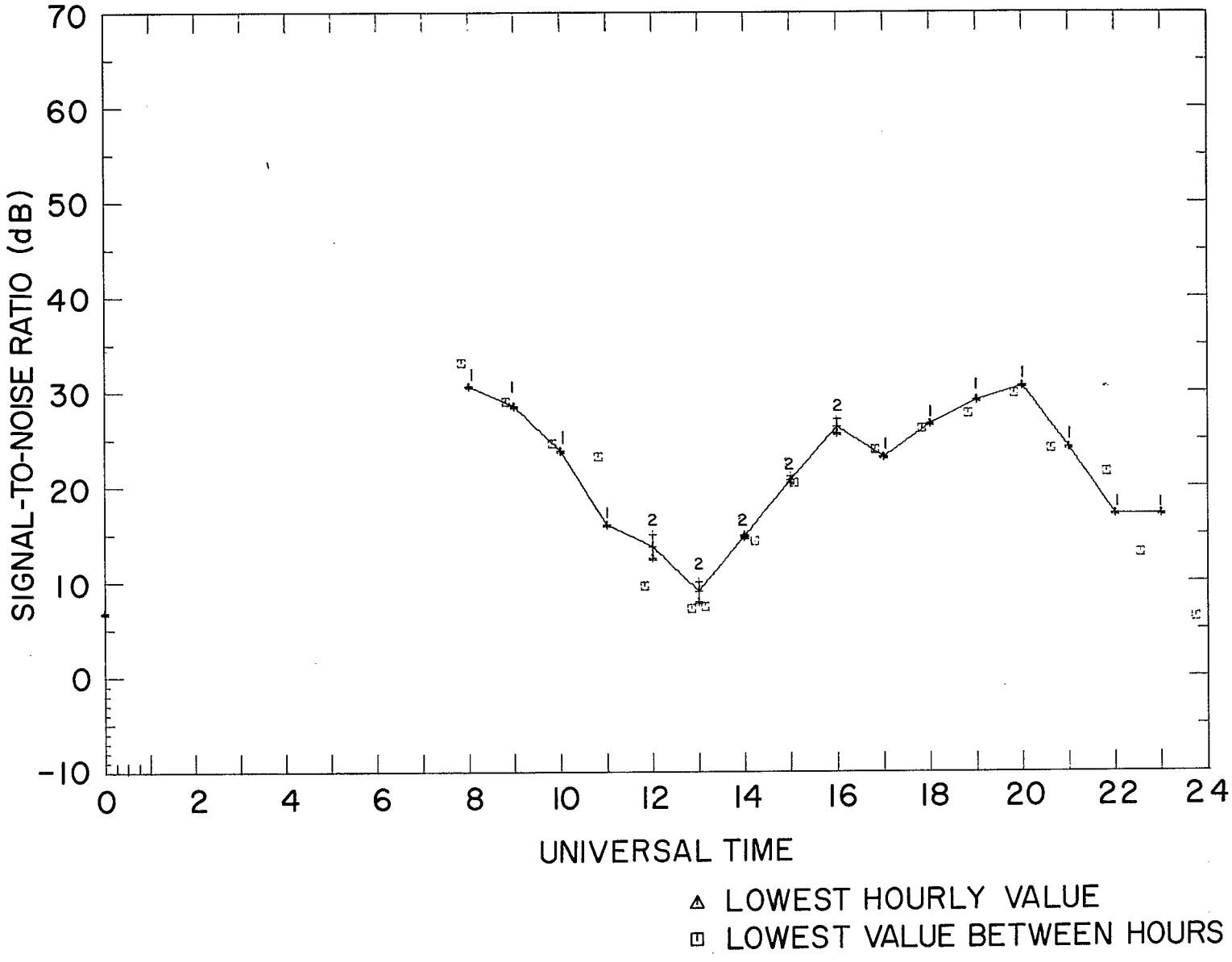


Fig. 58 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 24 October to 25 October 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

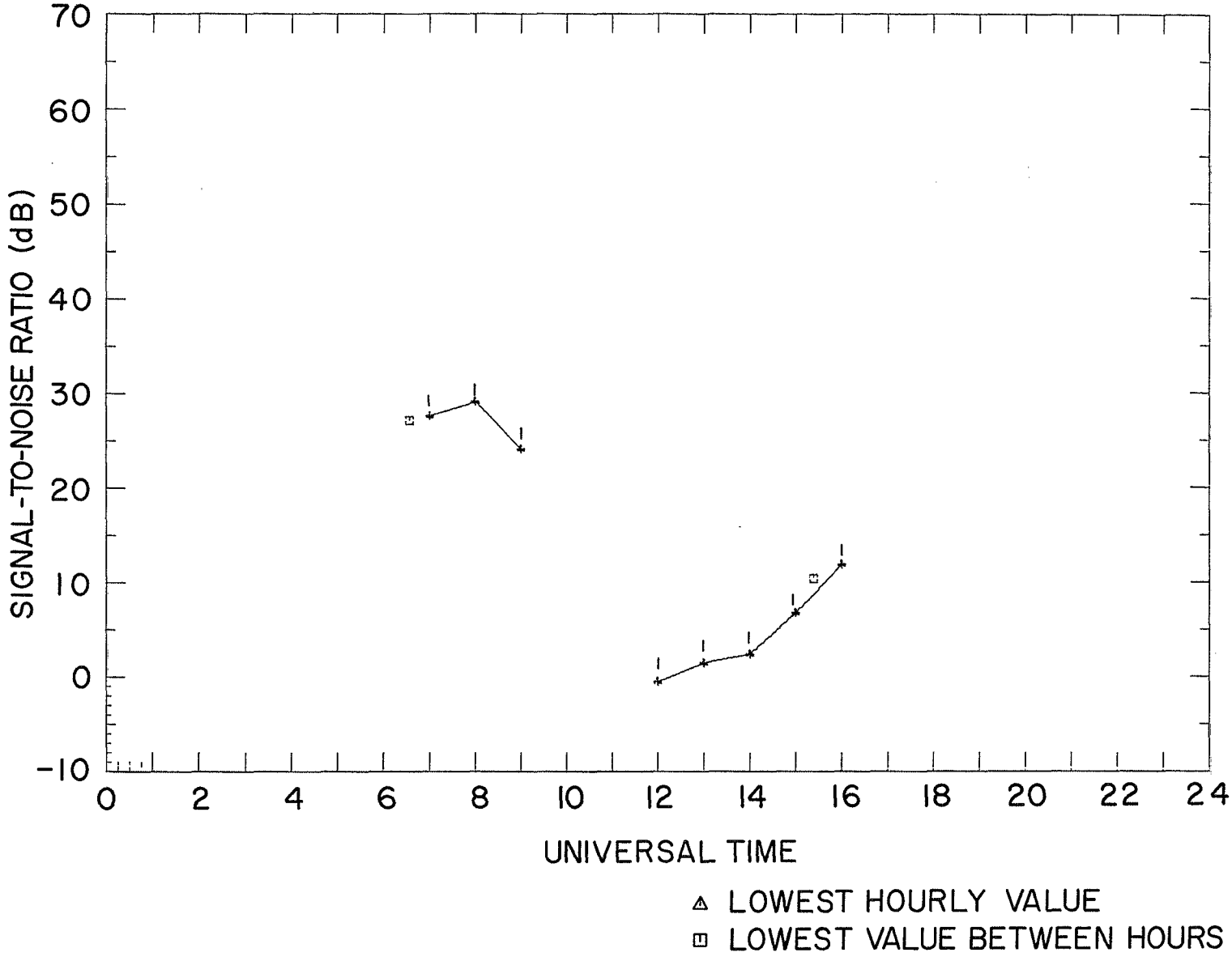


Fig. 59 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded on 14 November 1967 at a frequency of 19.8 kHz. Normalized radiated power of NWC is 30.7 dB above 1 kw.

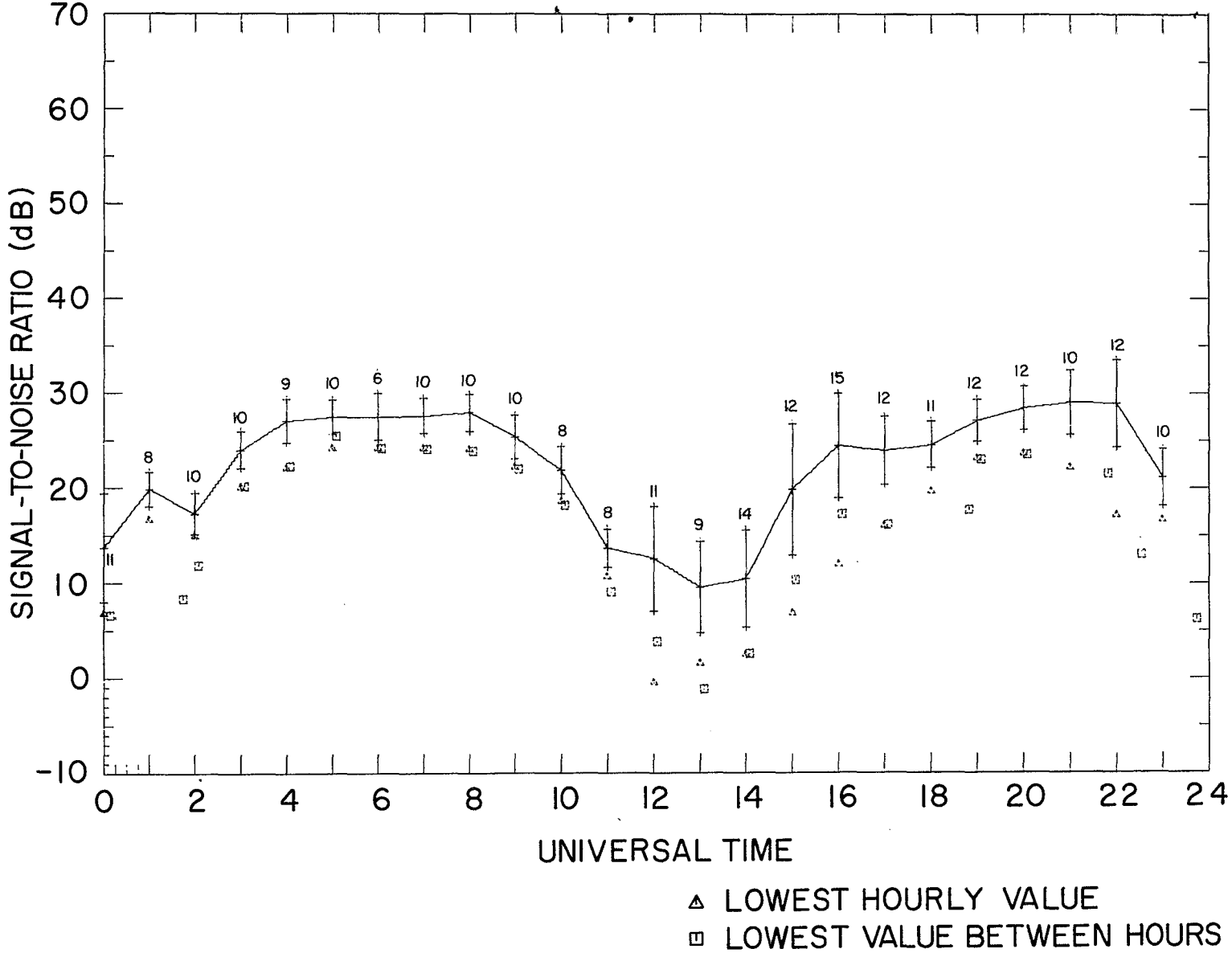


Fig. 60 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 19.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 30.7 dB above 1 kw.

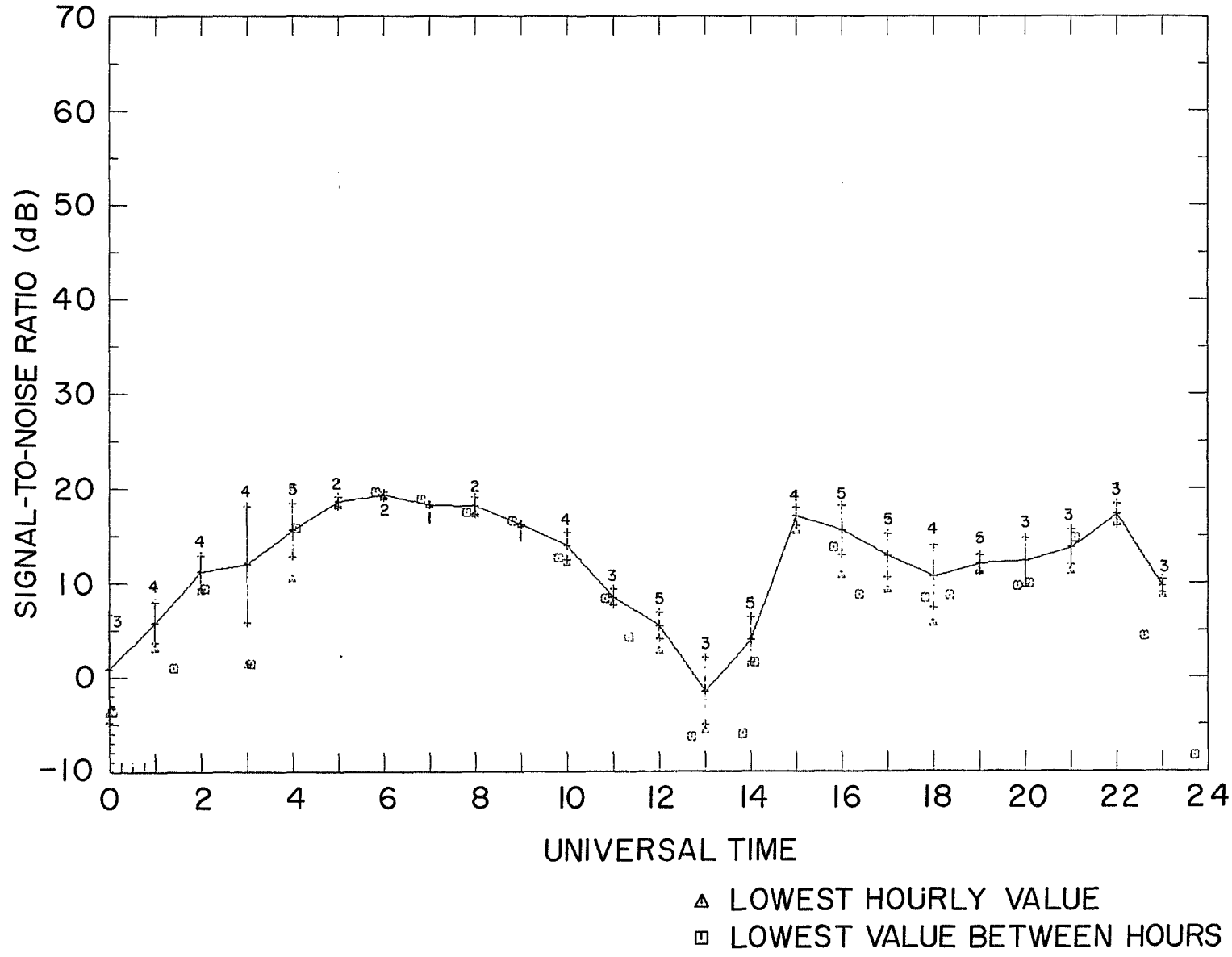


Fig. 61 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 20 September to 25 September 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

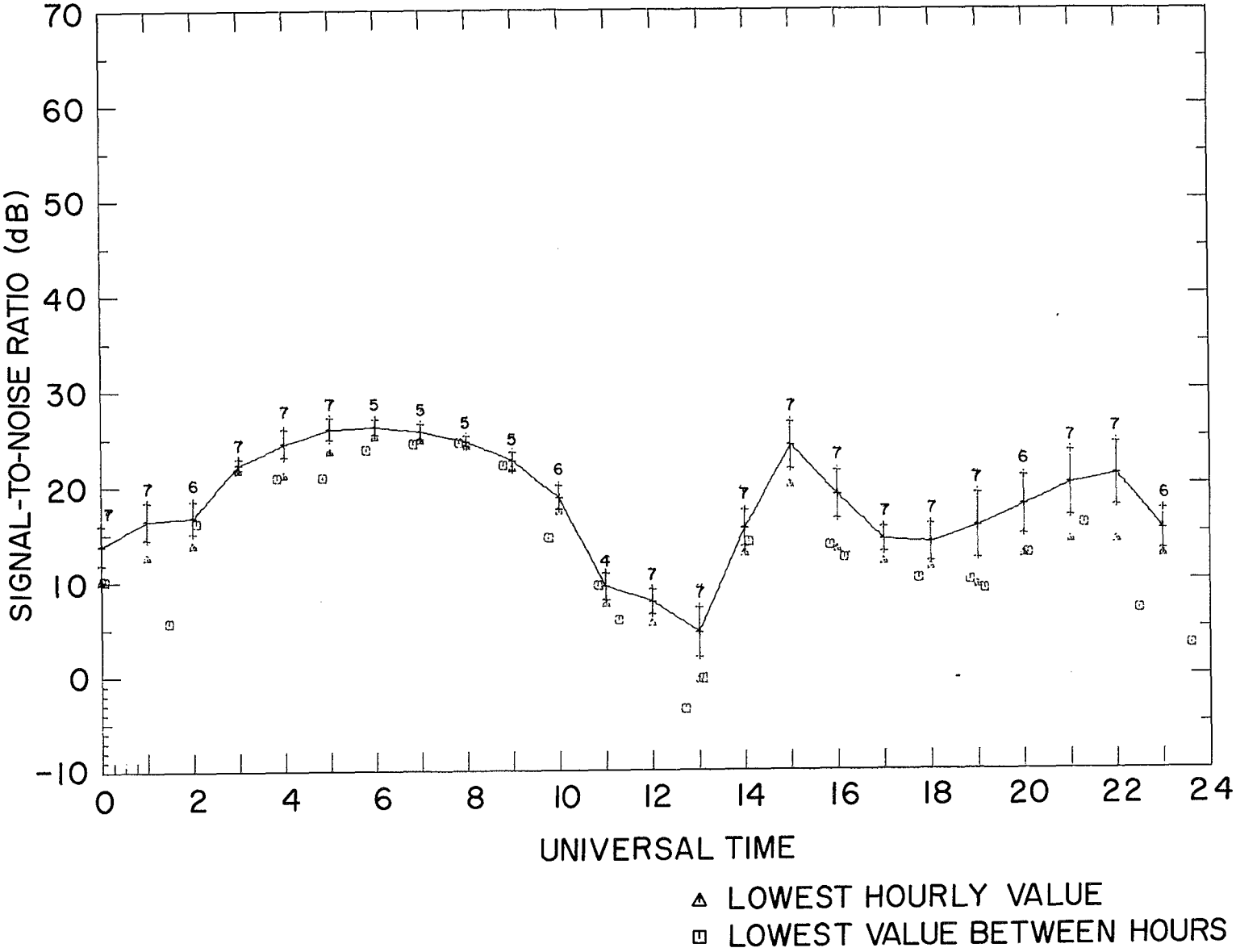


Fig. 62 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 10 October to 17 October 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

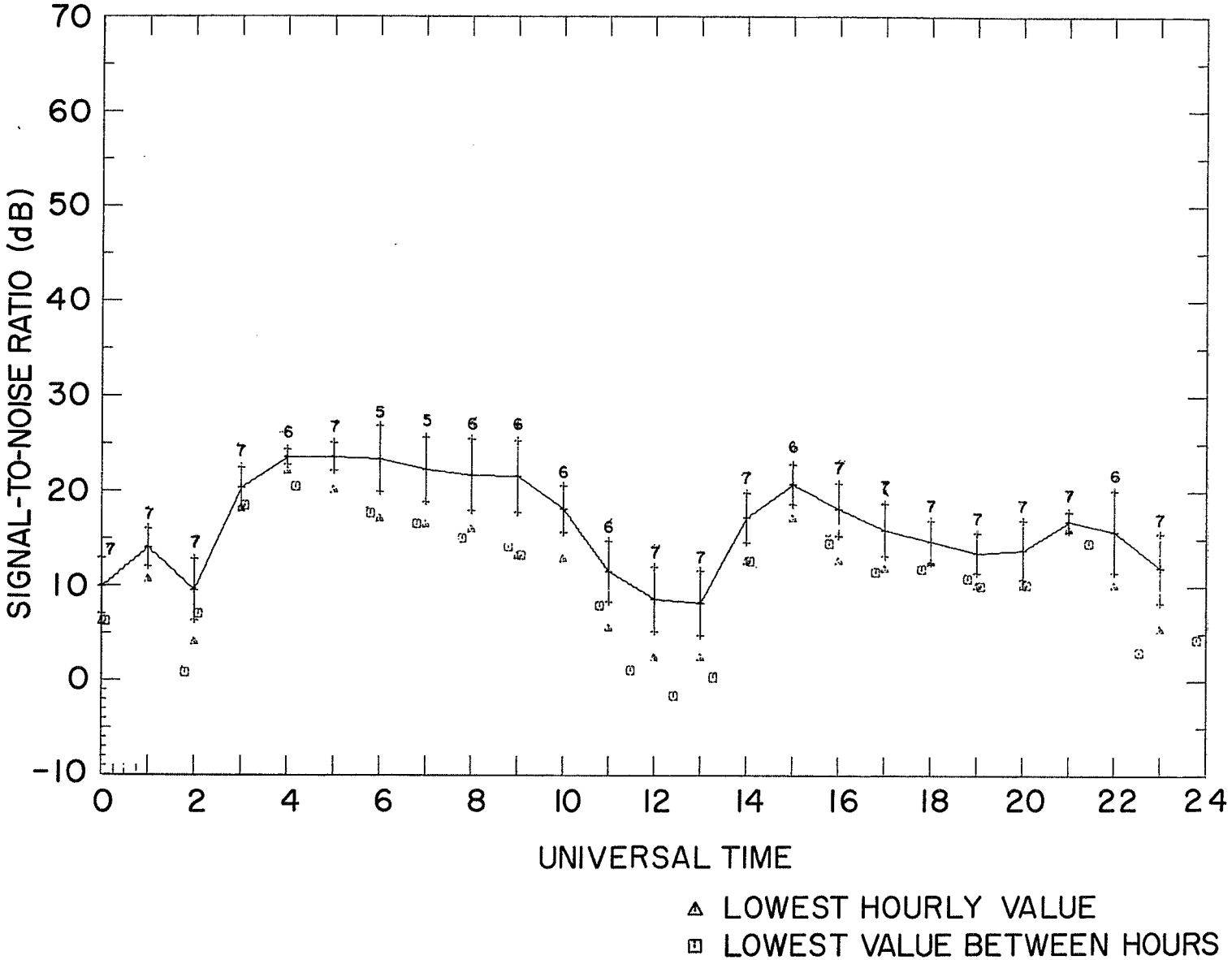


Fig. 63 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 31 October to 7 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

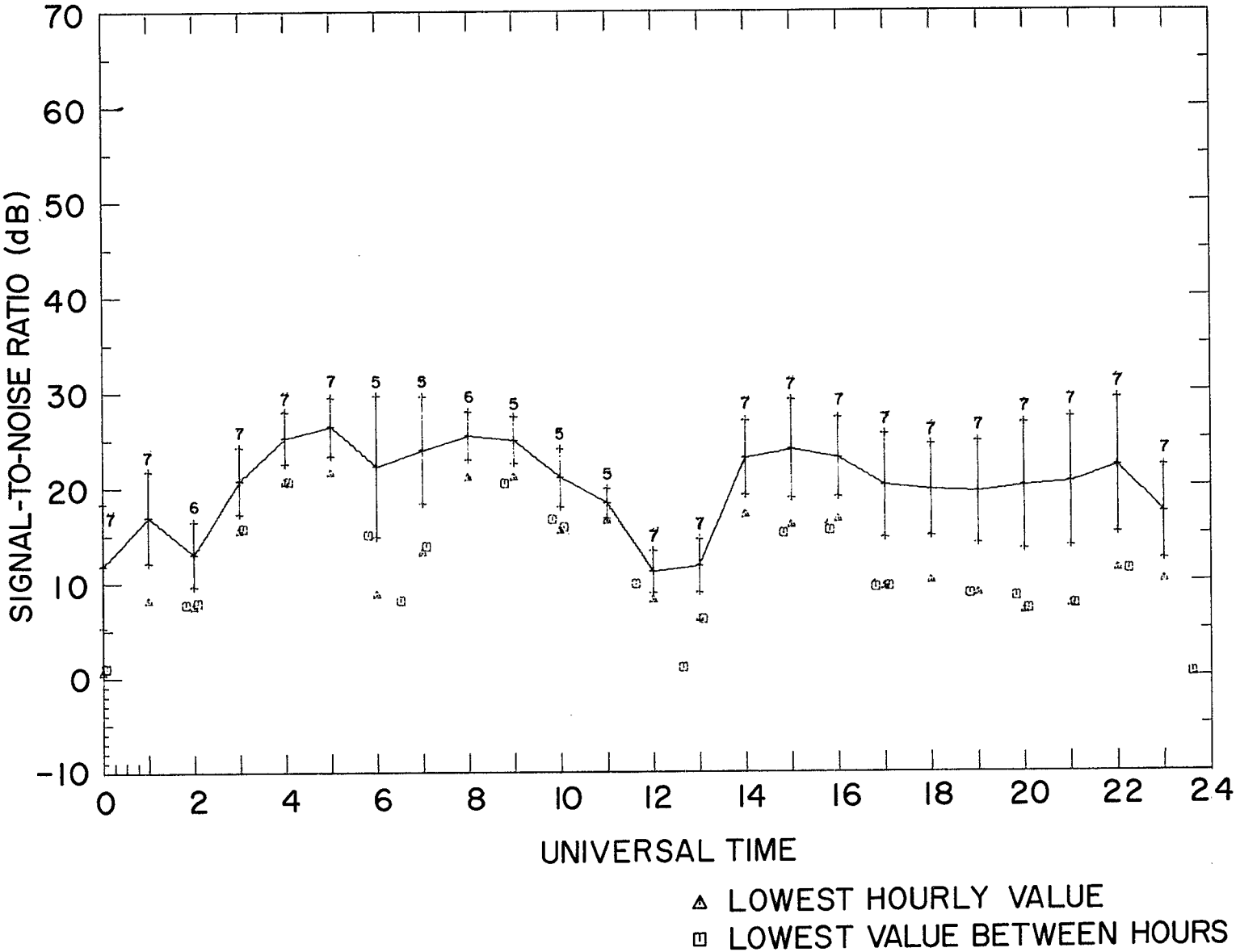


Fig. 64 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 21 November to 28 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

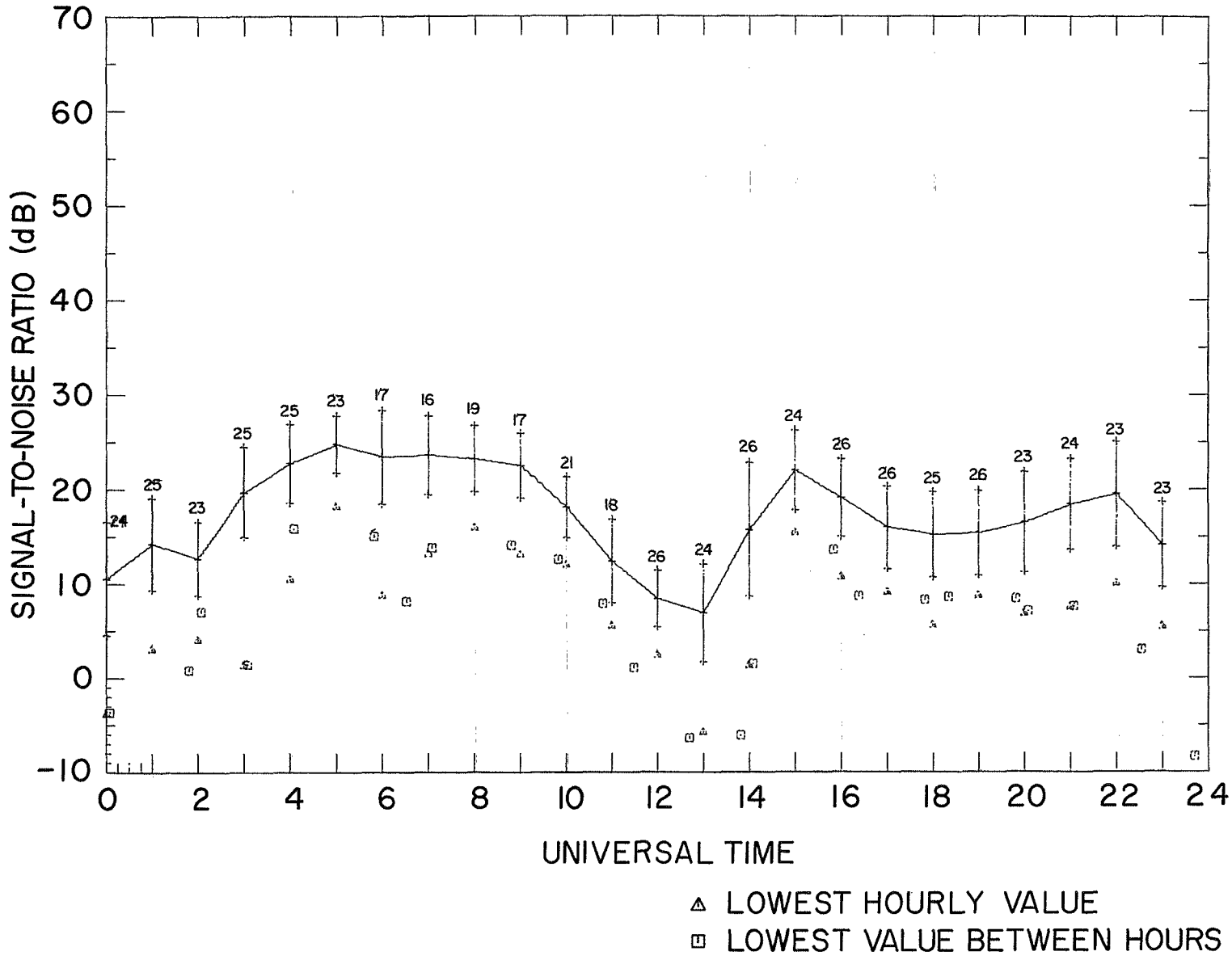


Fig. 65 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

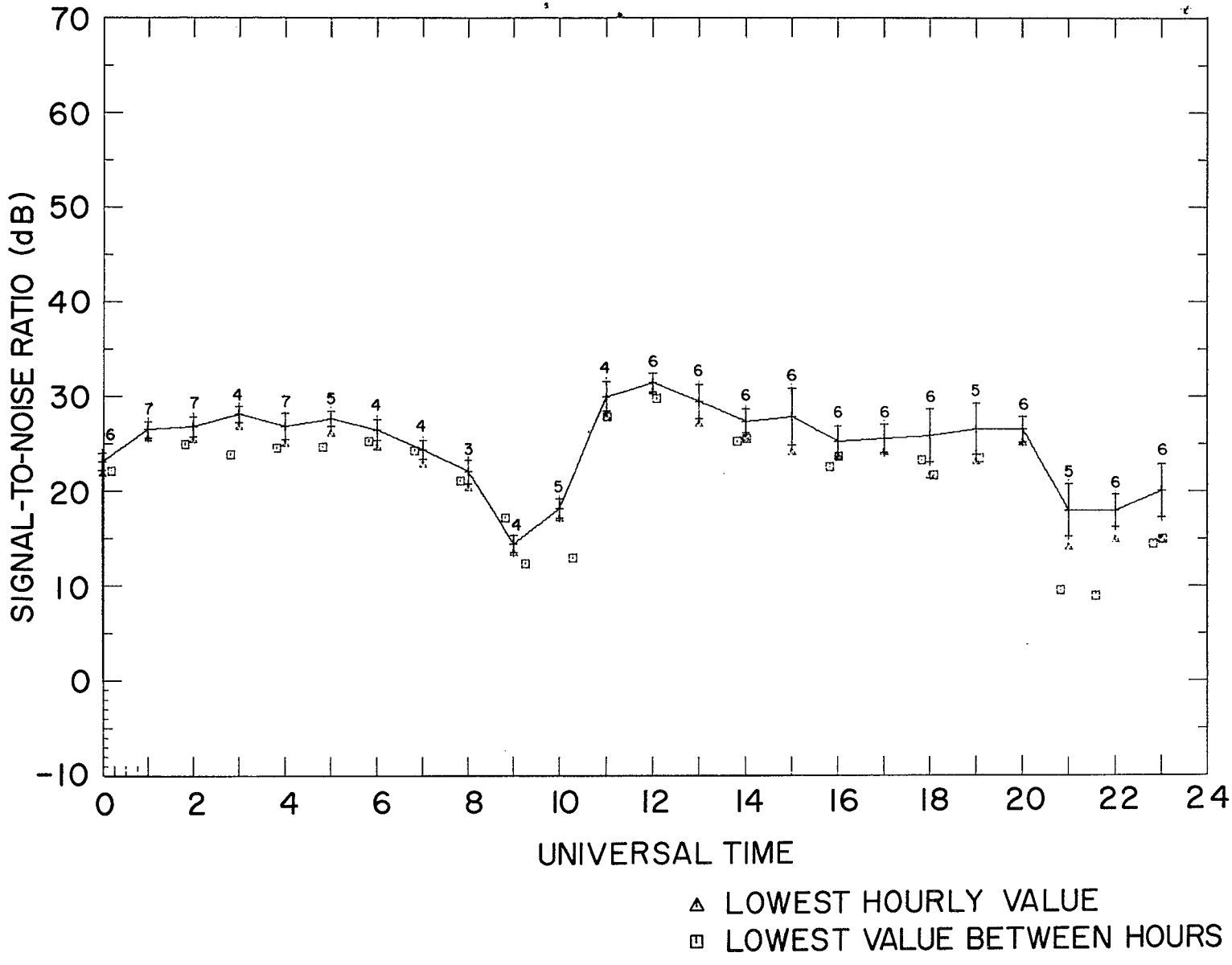


Fig. 66 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 19 September to 26 September 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

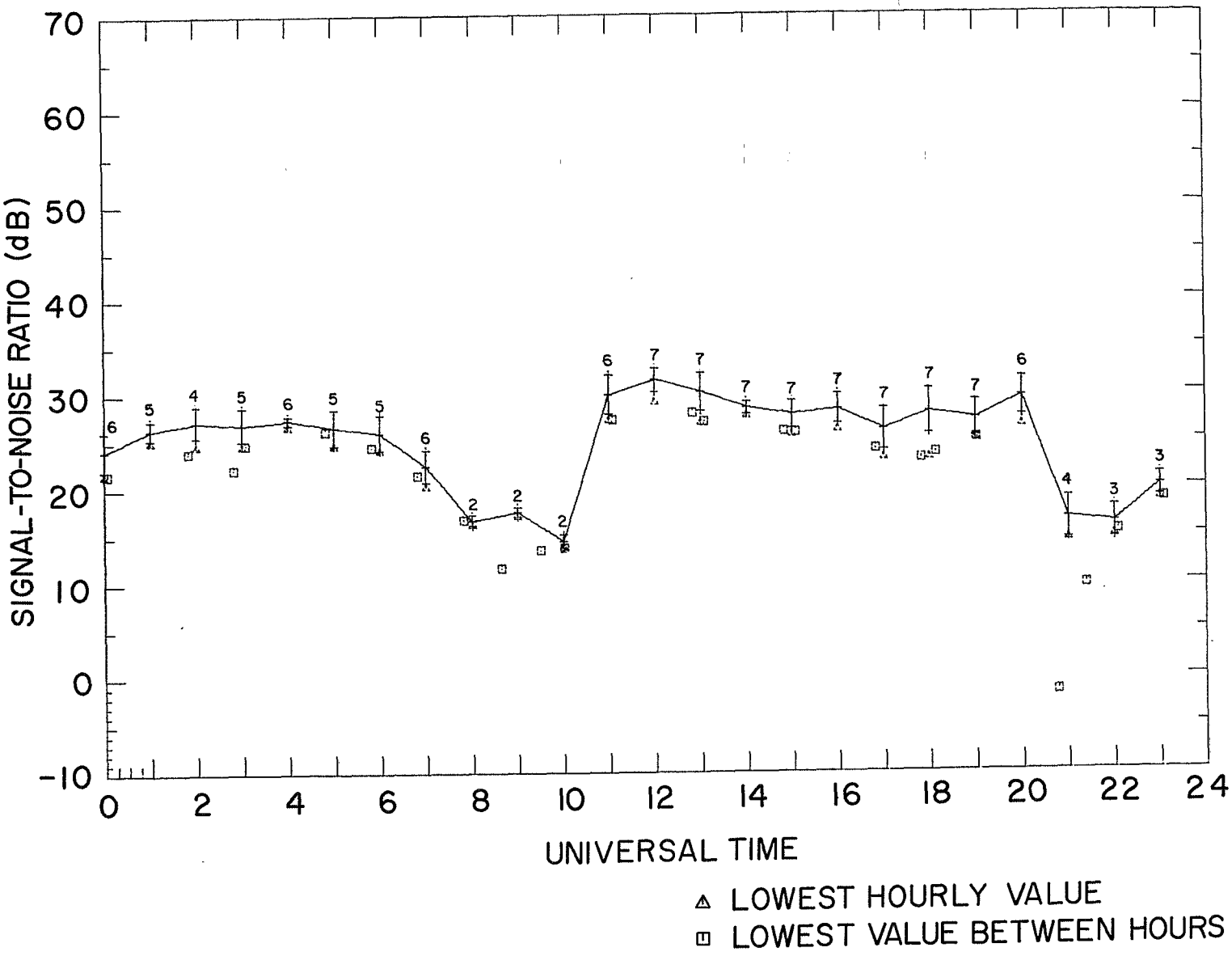


Fig. 67 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 10 October to 16 October 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

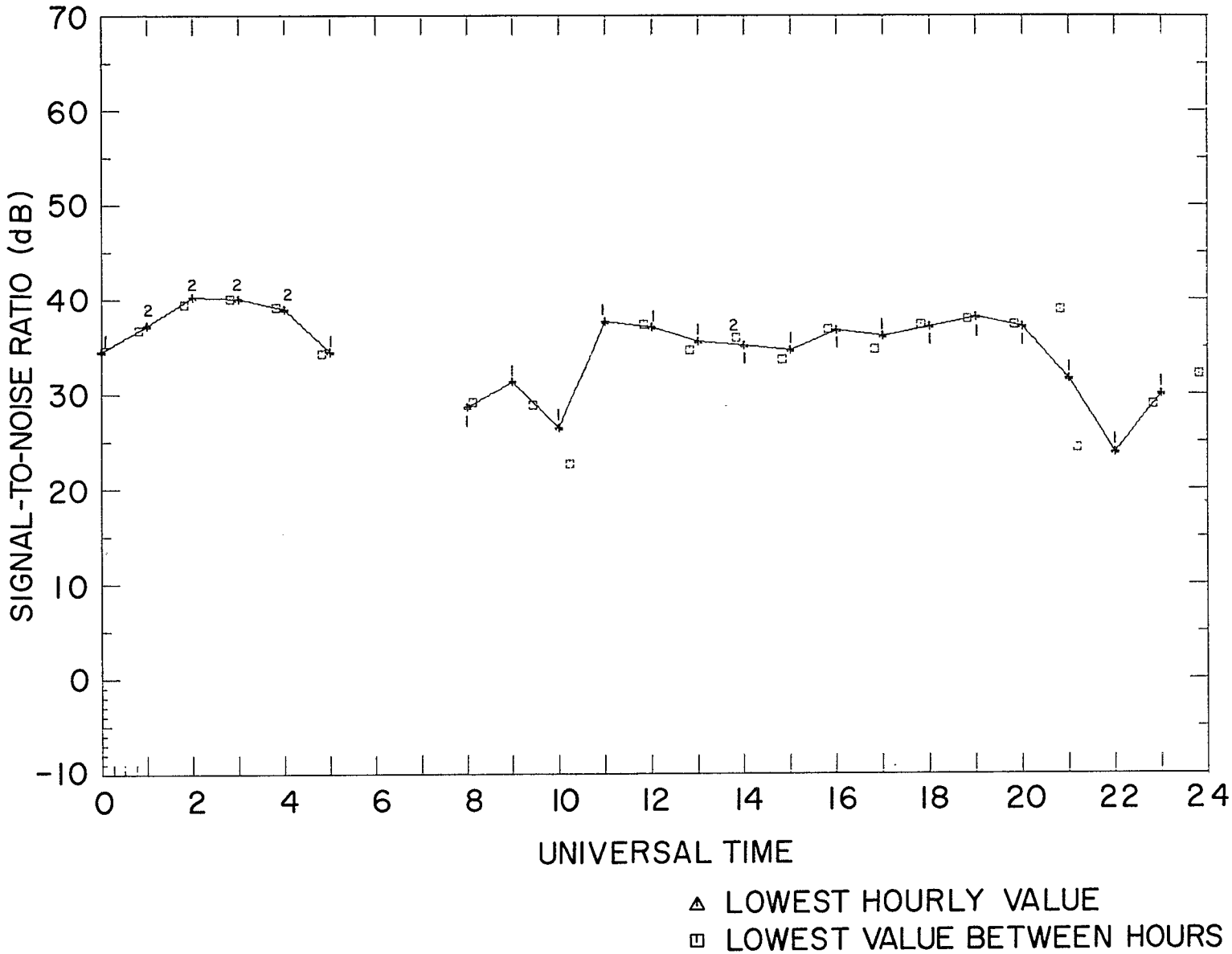


Fig. 68 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 6 November to 7 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

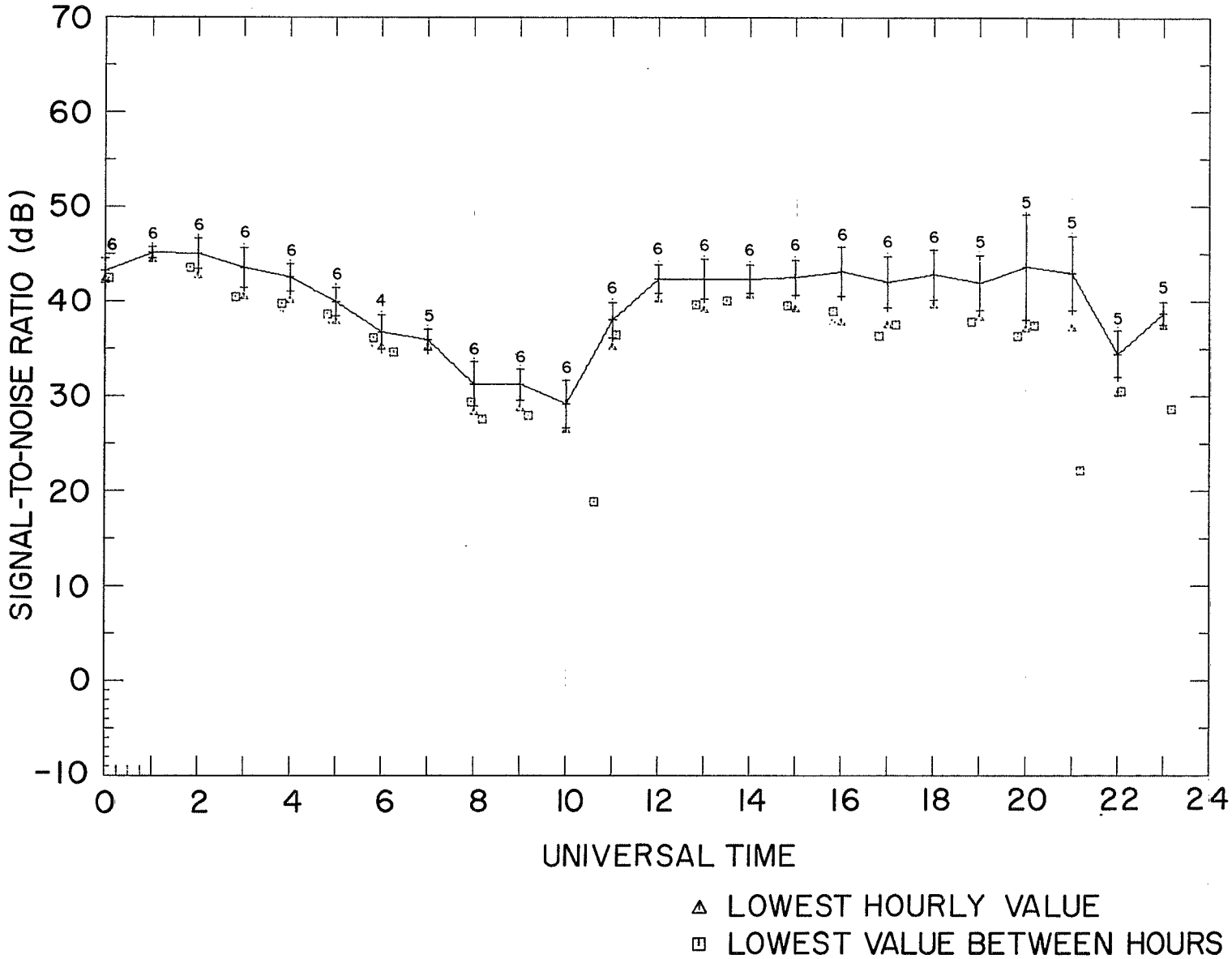


Fig. 69 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 21 November to 28 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

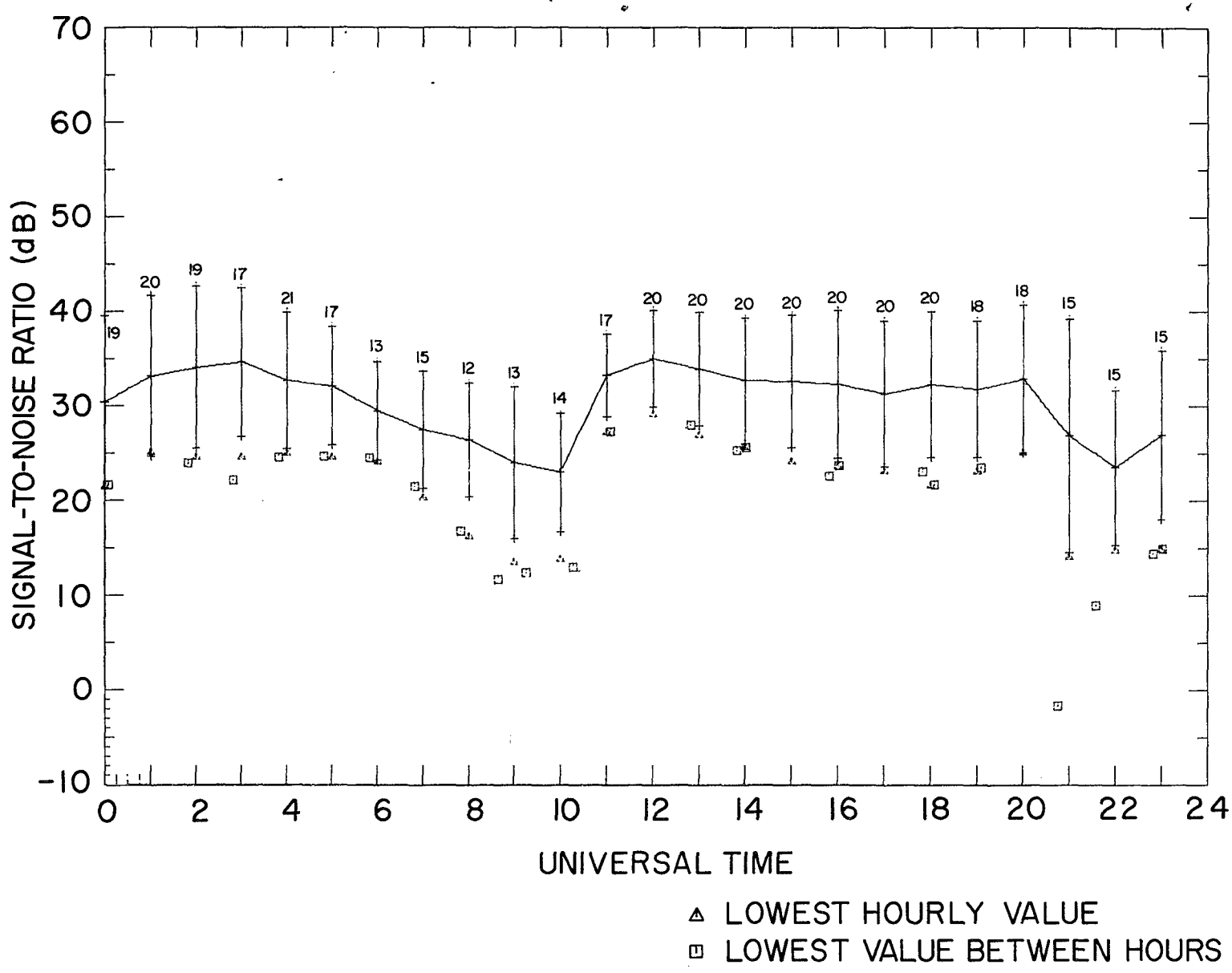


Fig. 70 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

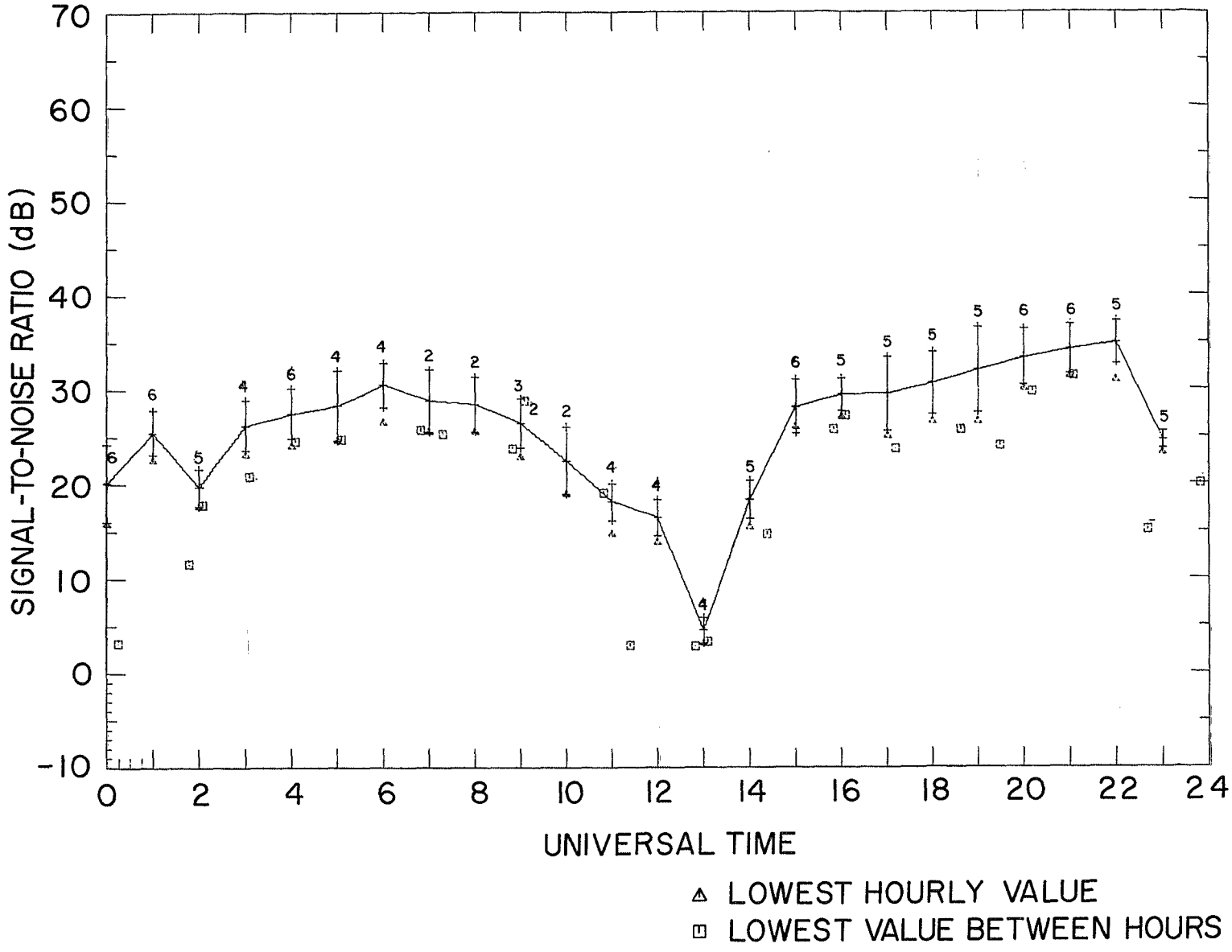


Fig. 71 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 20 September to 26 September 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

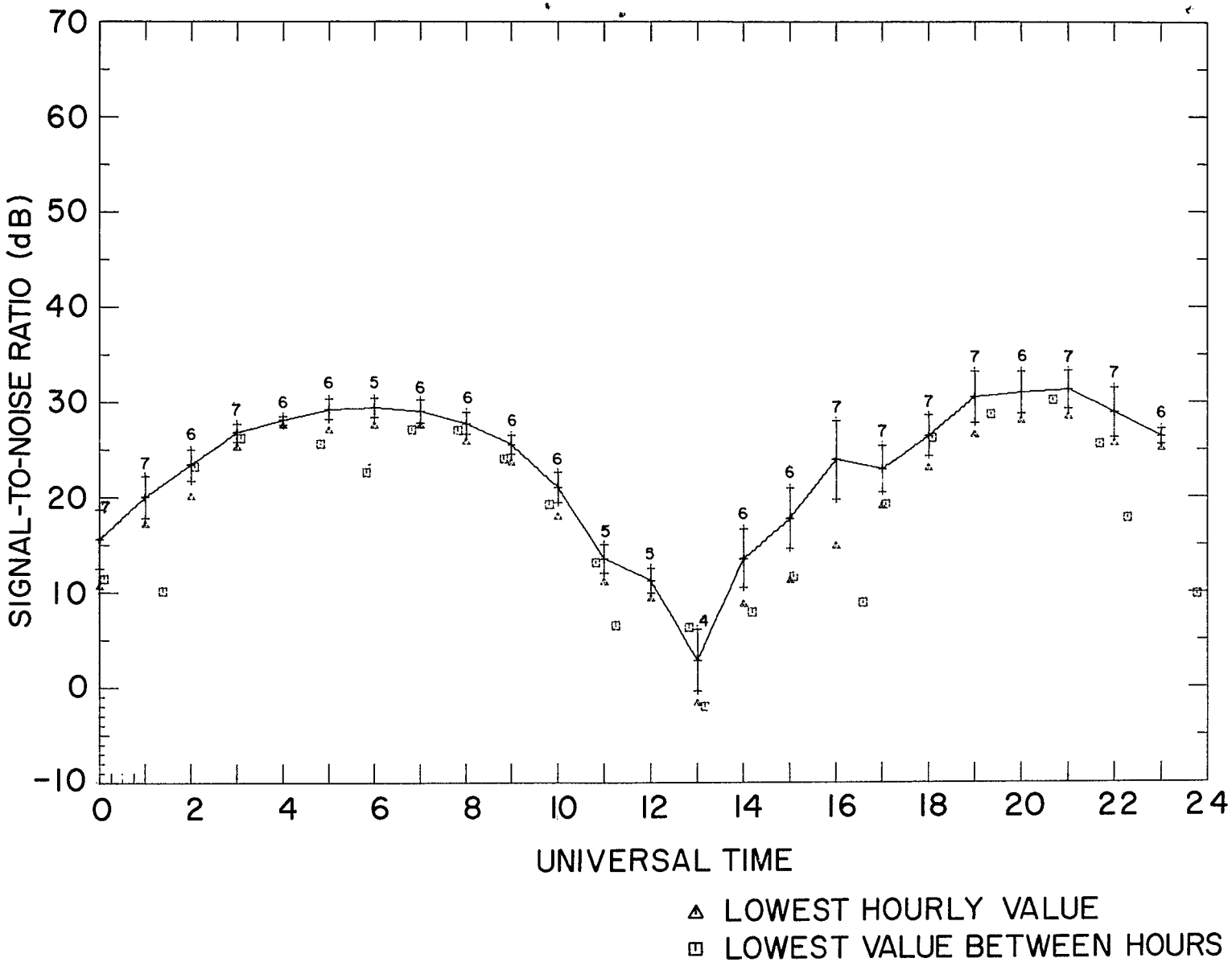


Fig. 72 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 10 October to 17 October 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

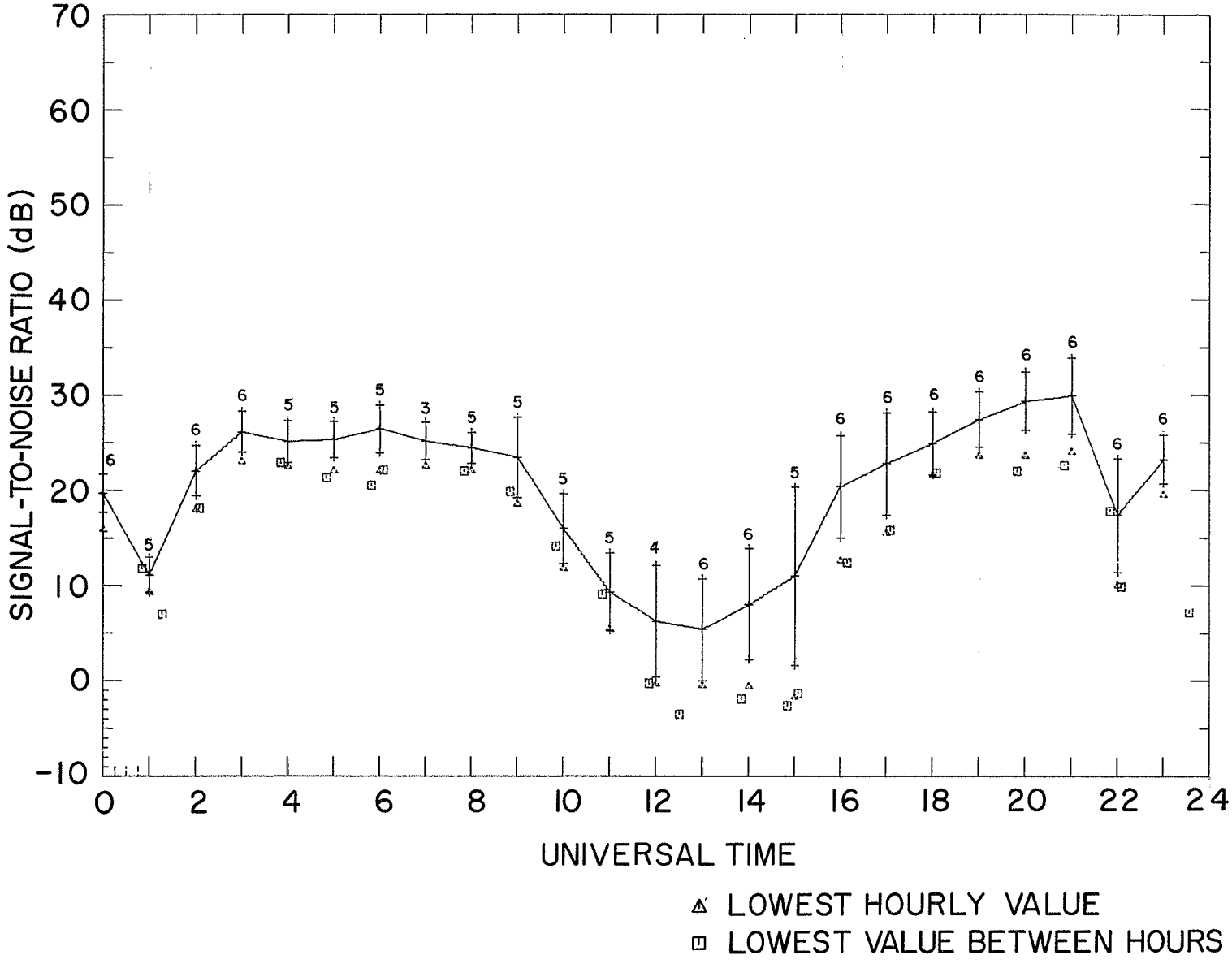


Fig. 73 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 1 November to 7 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

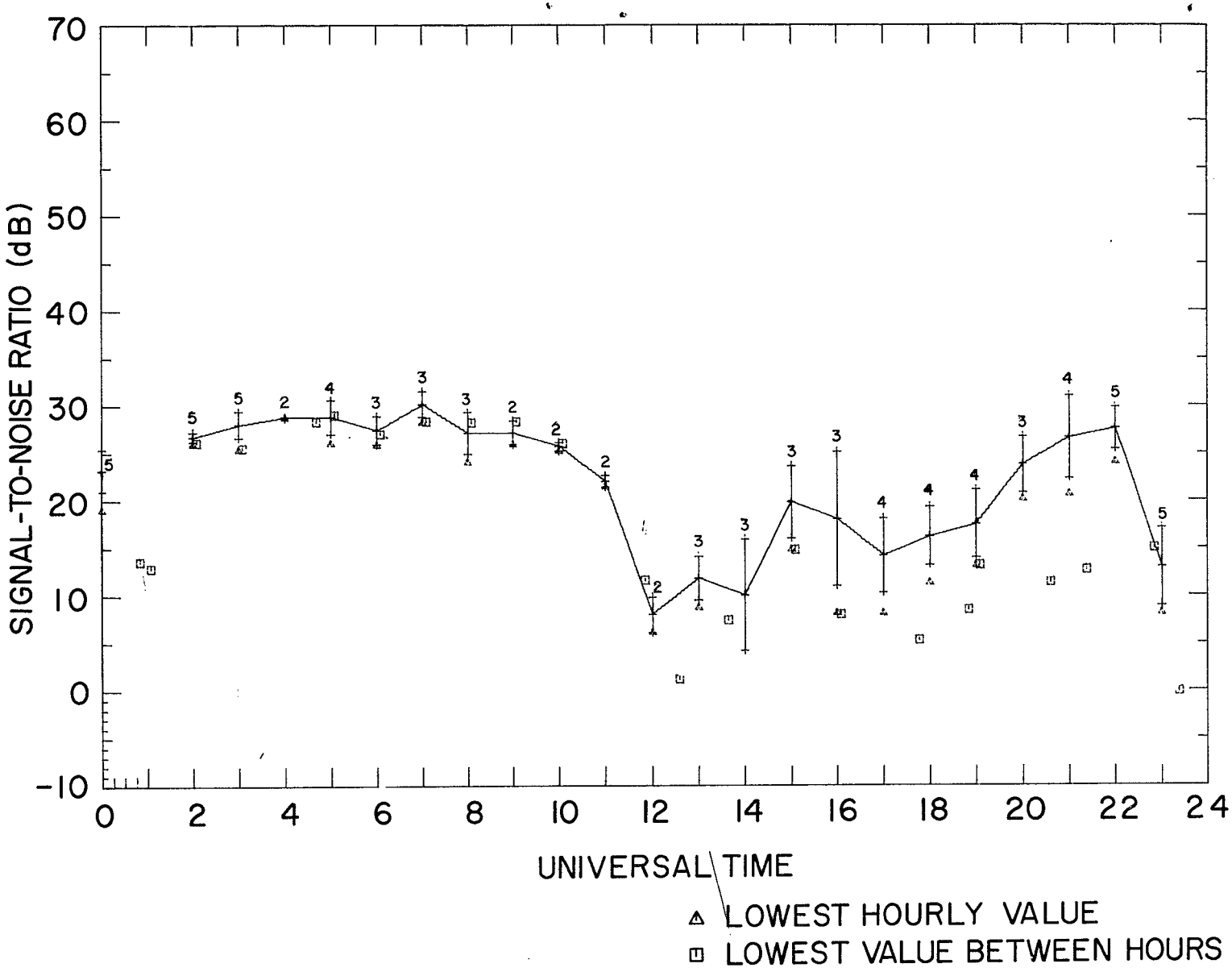


Fig. 74 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 22 November to 28 November 1967 at a frequency of 22.3 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

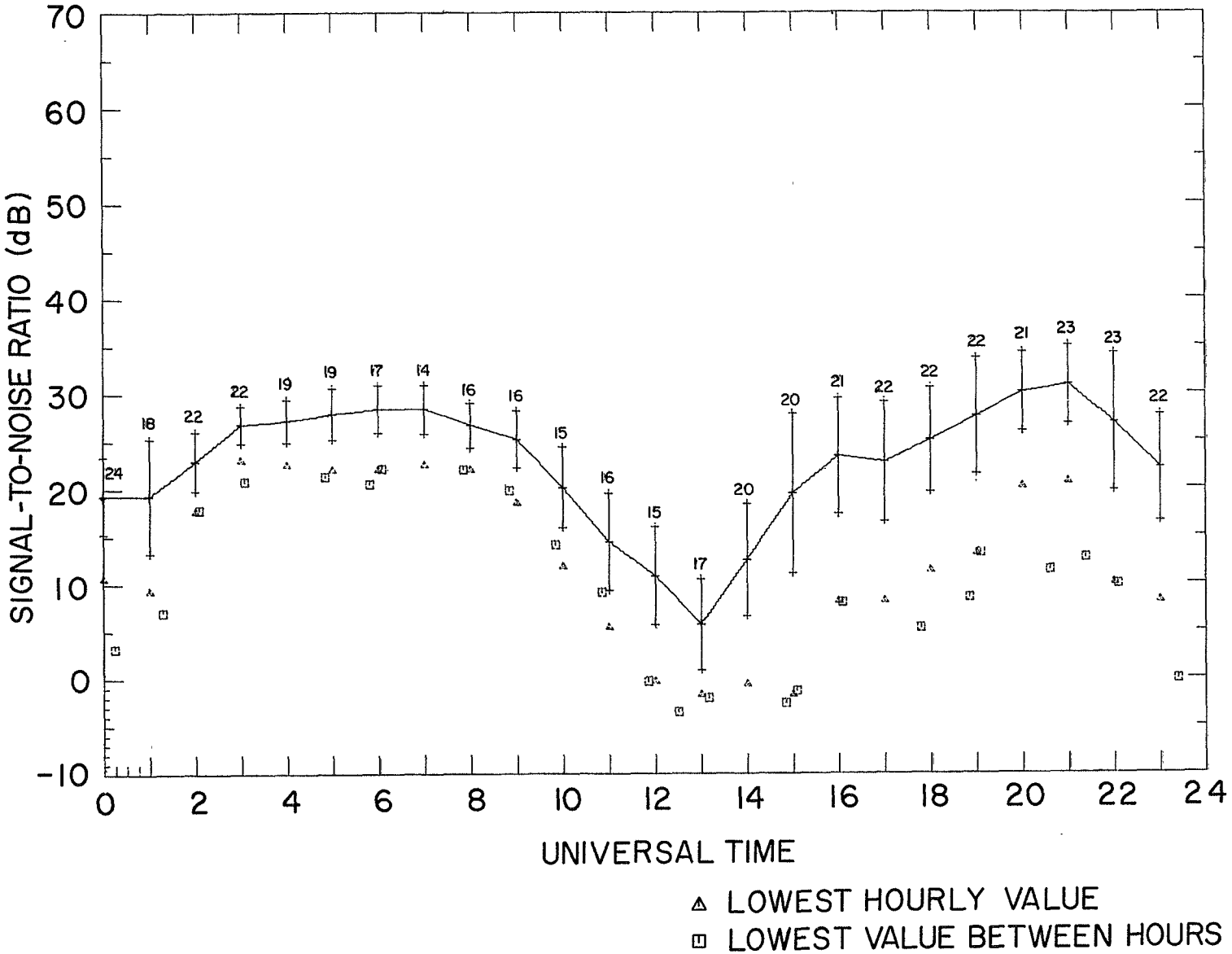


Fig. 75 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 22.3 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

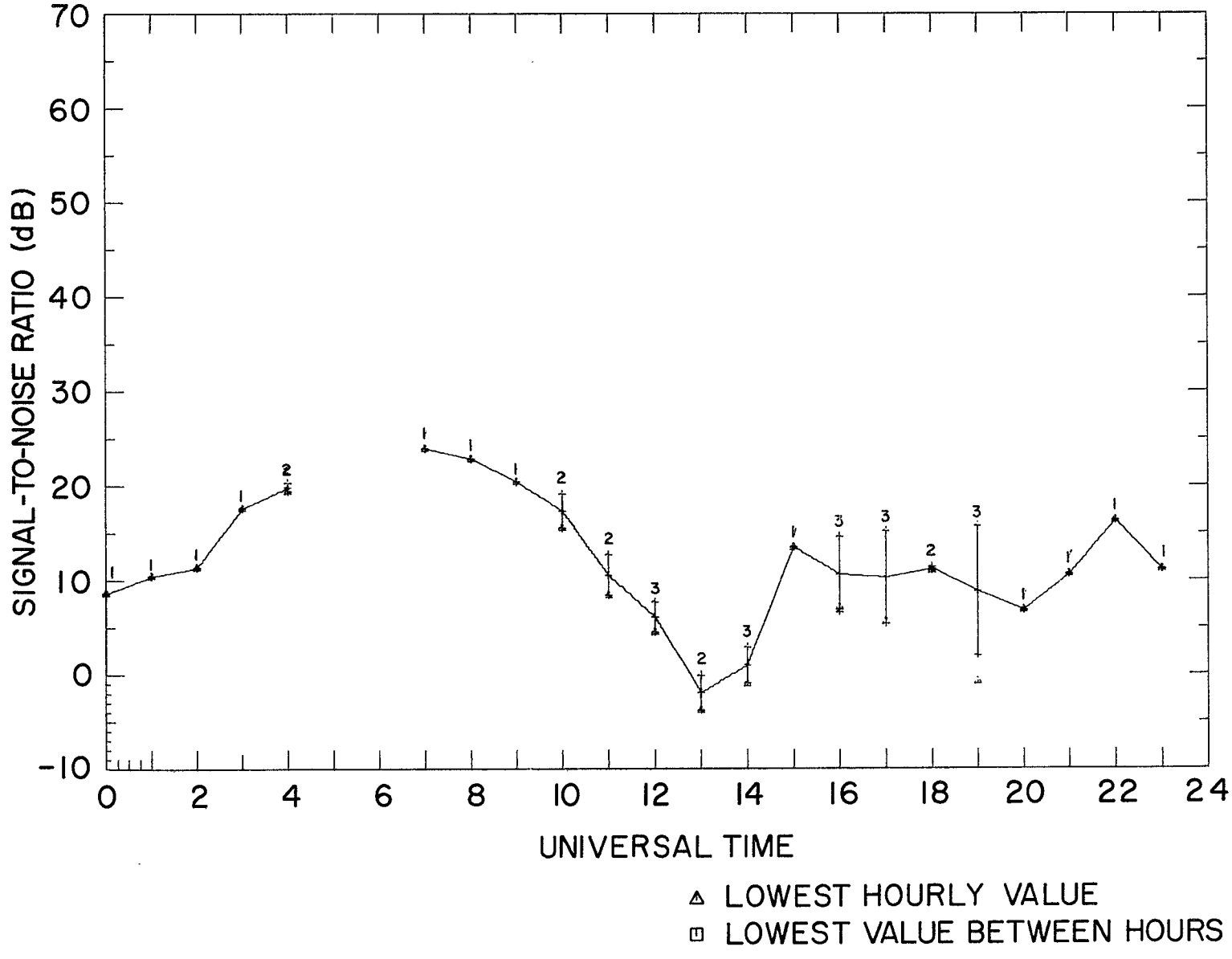


Fig. 76 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 22 September to 25 September 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

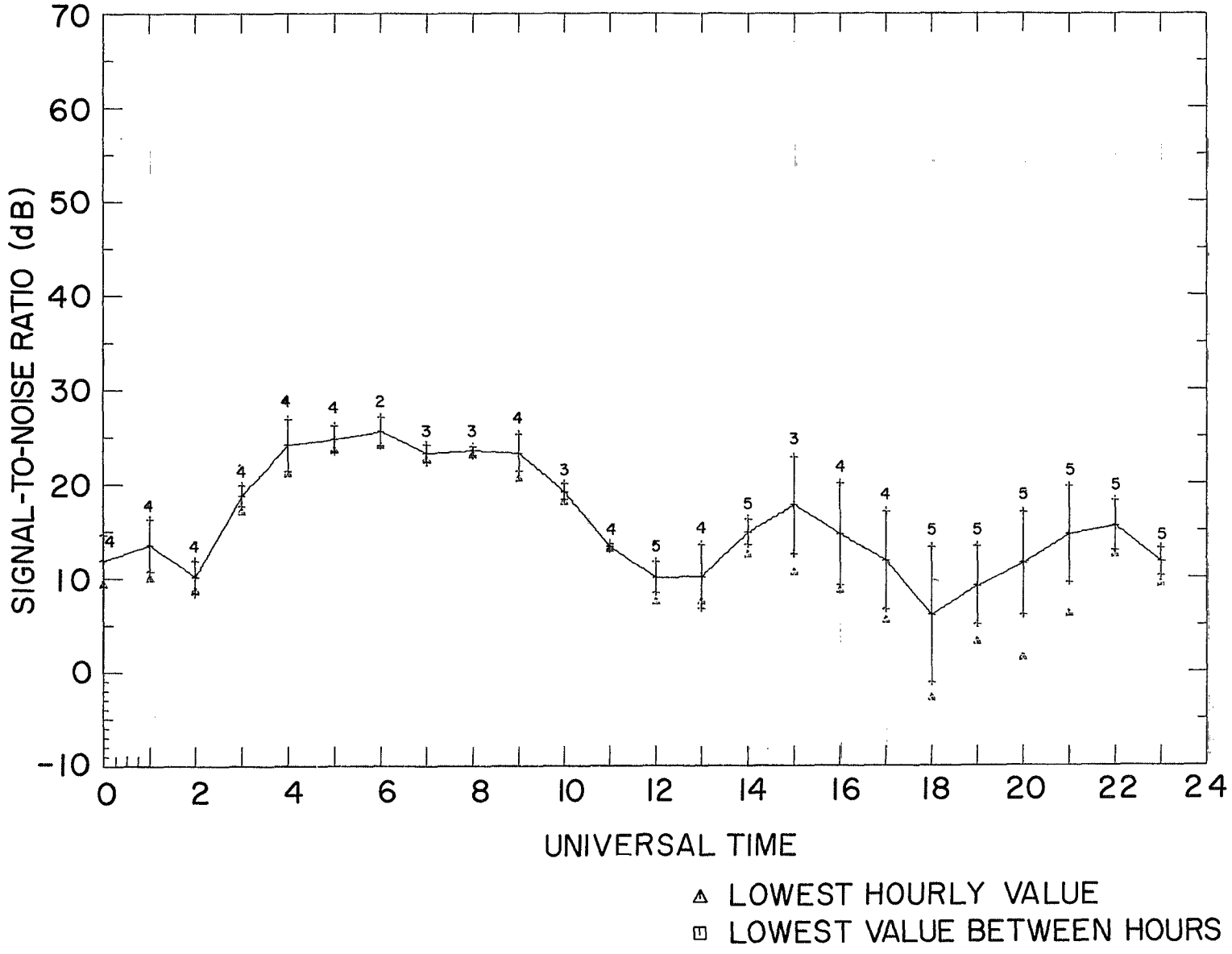
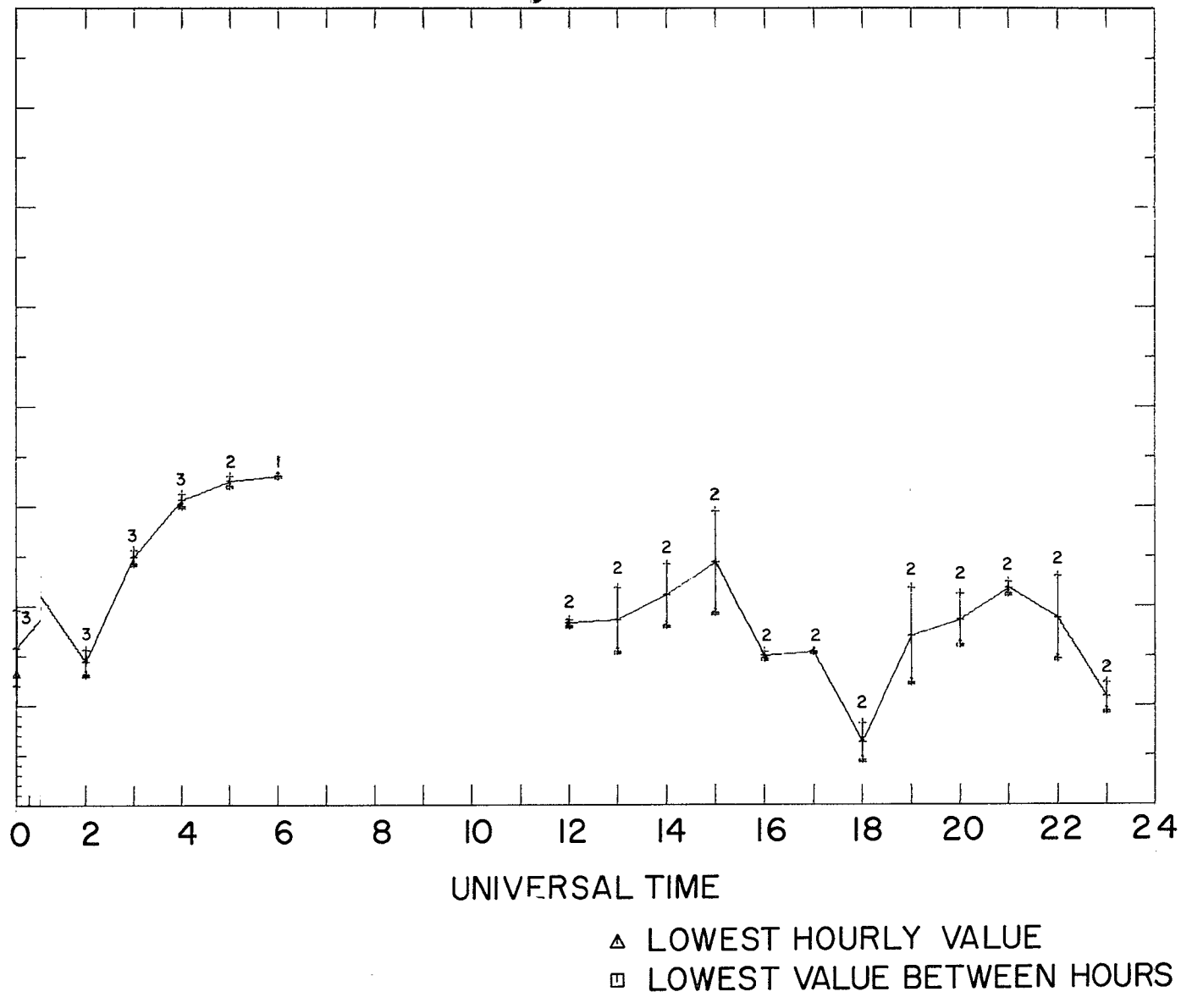


Fig. 77 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 27 October to 31 October 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.



78 Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded
1 ovember to 3 November 1967 at a frequency of 24.5 kHz. Normalized power of NWC
.1 6 above 1 kw.

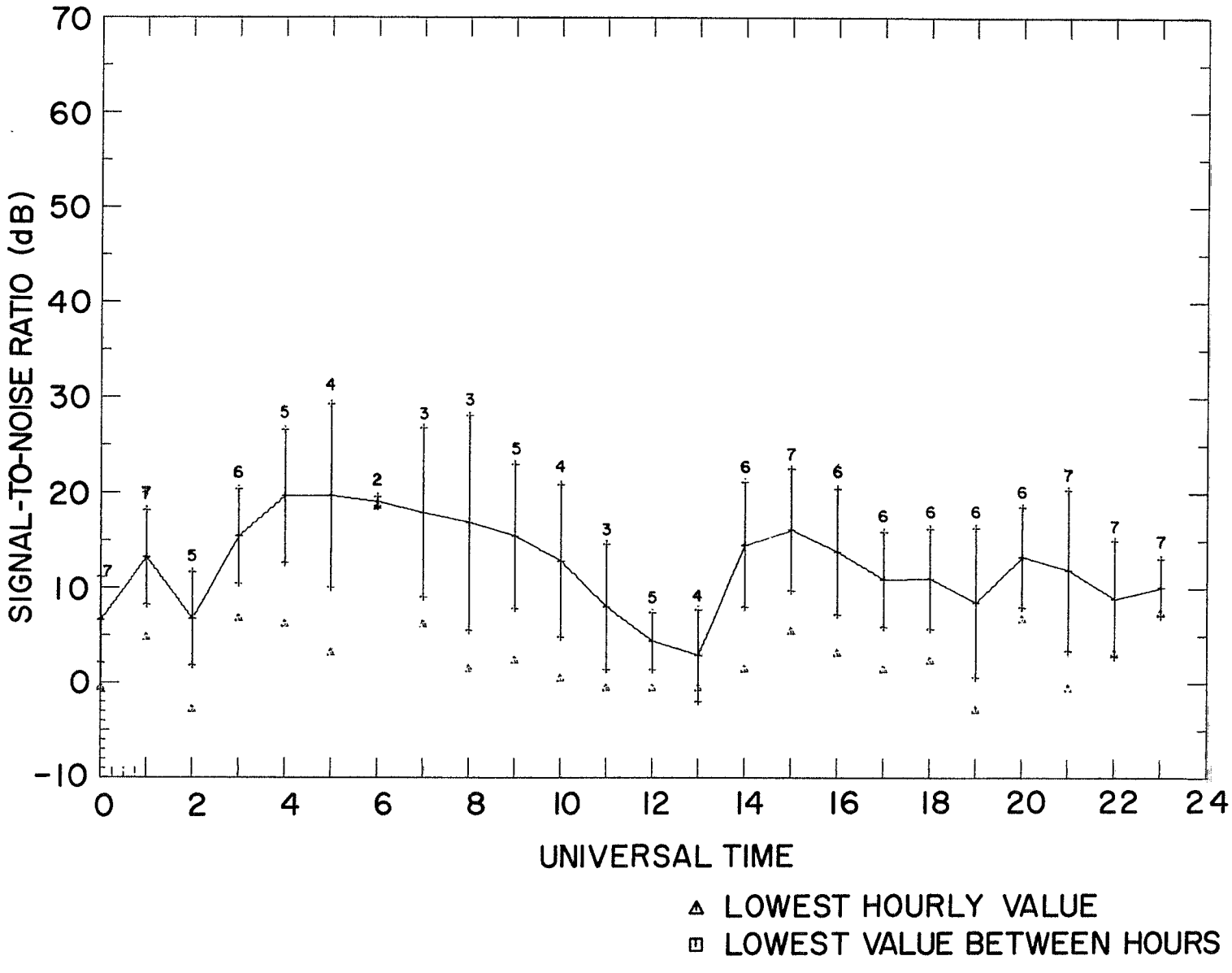


Fig. 79 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 10 November to 17 November 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

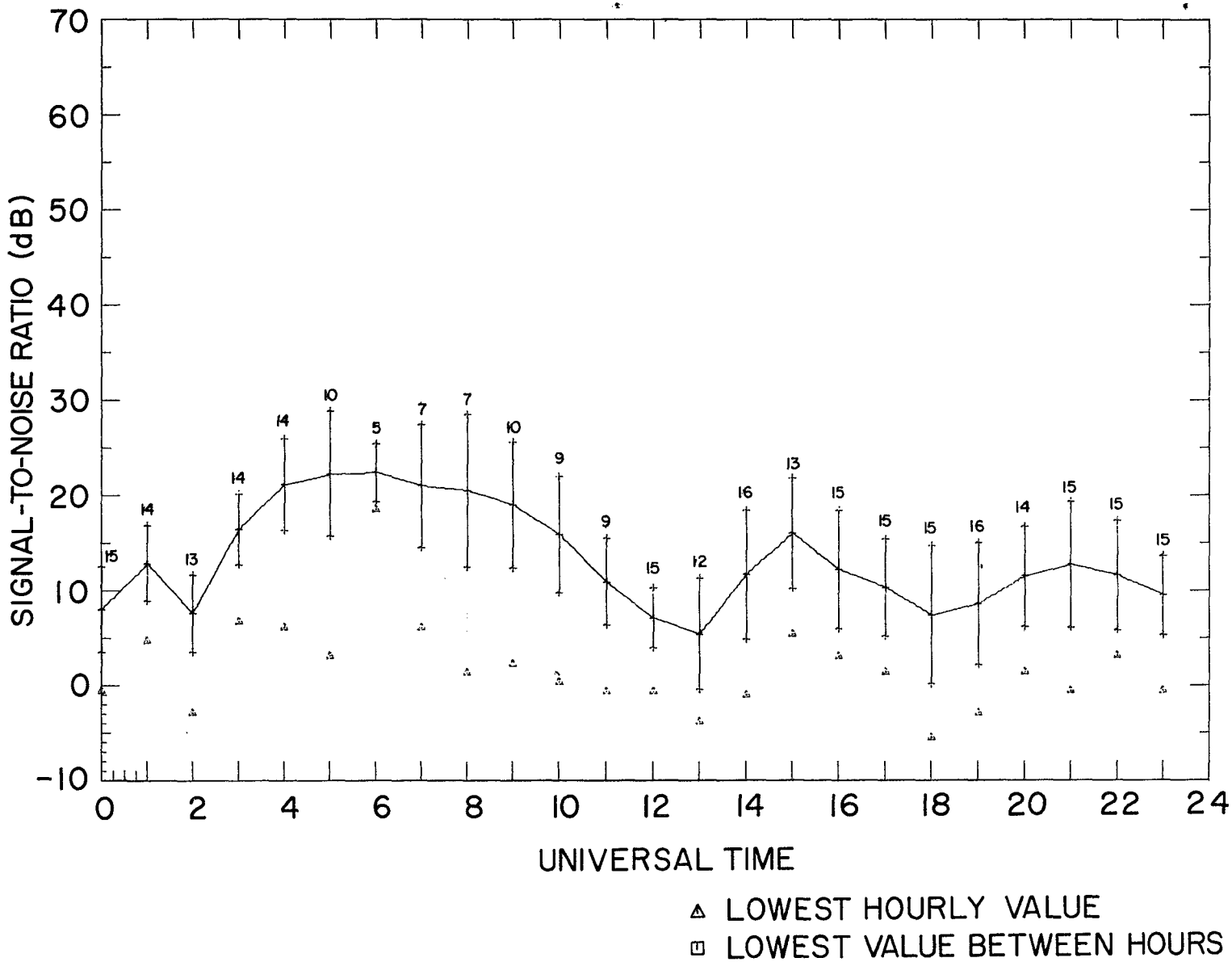


Fig. 80 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

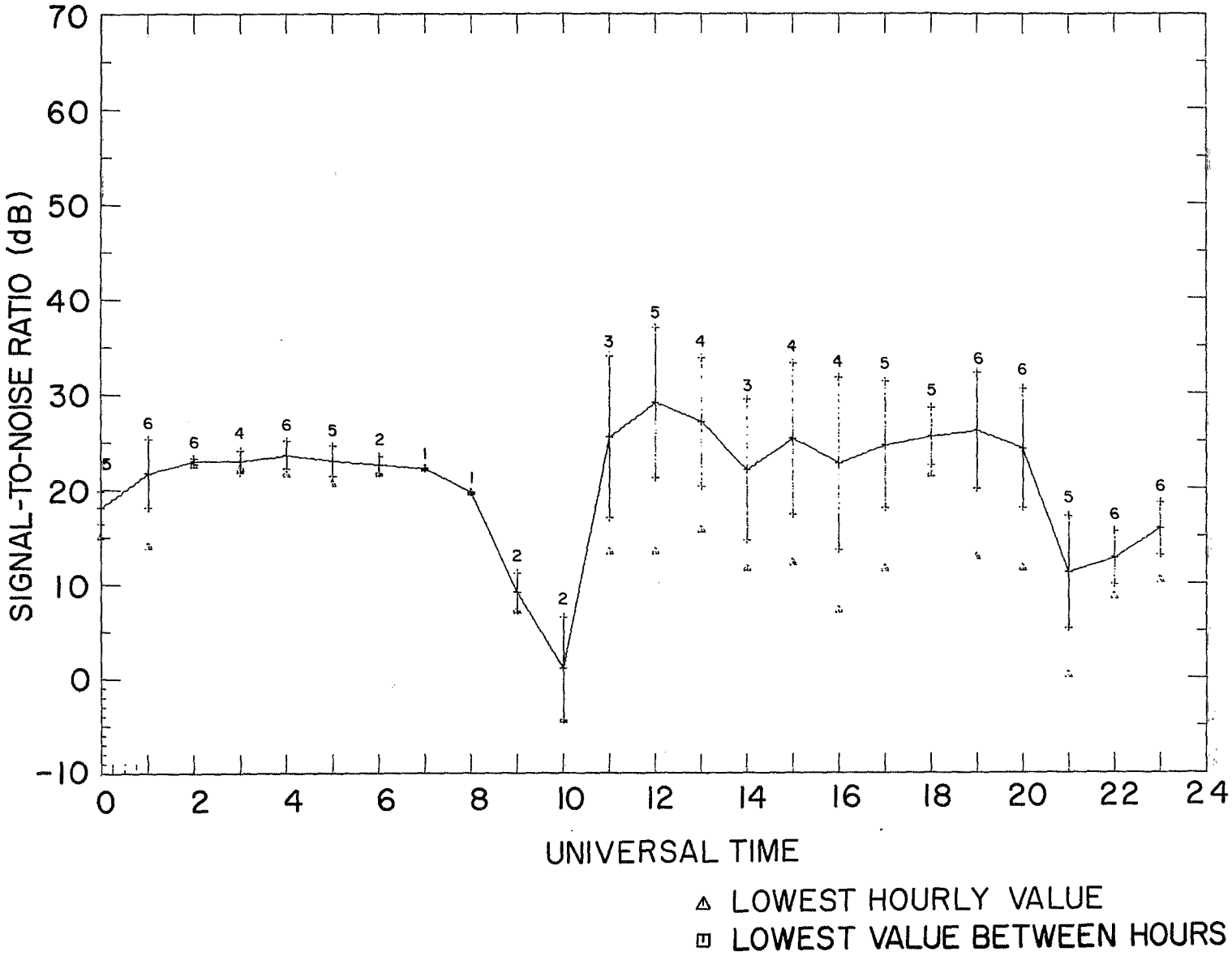


Fig. 81 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 23 September to 29 September 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

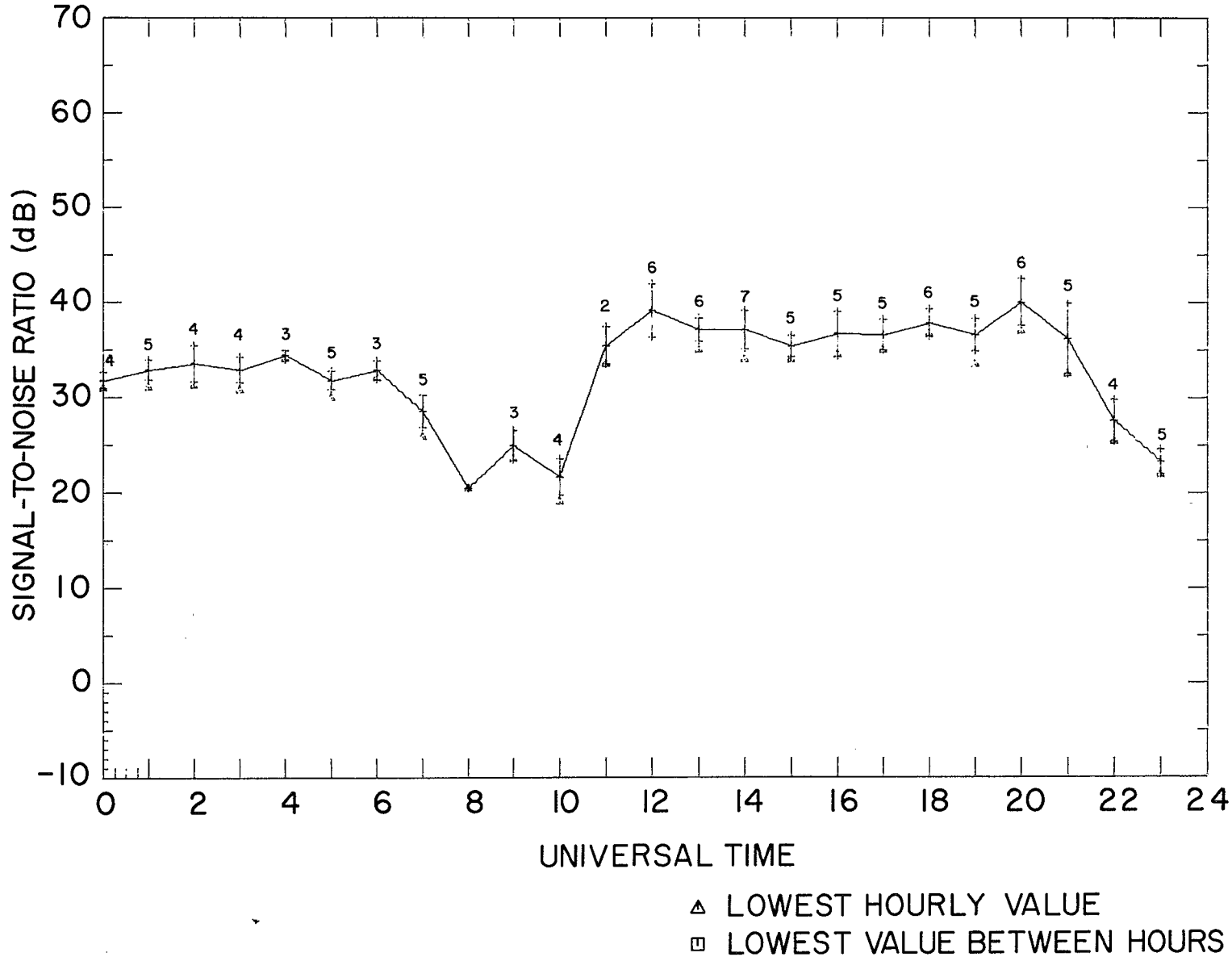


Fig. 82 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 10 November to 16 November 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

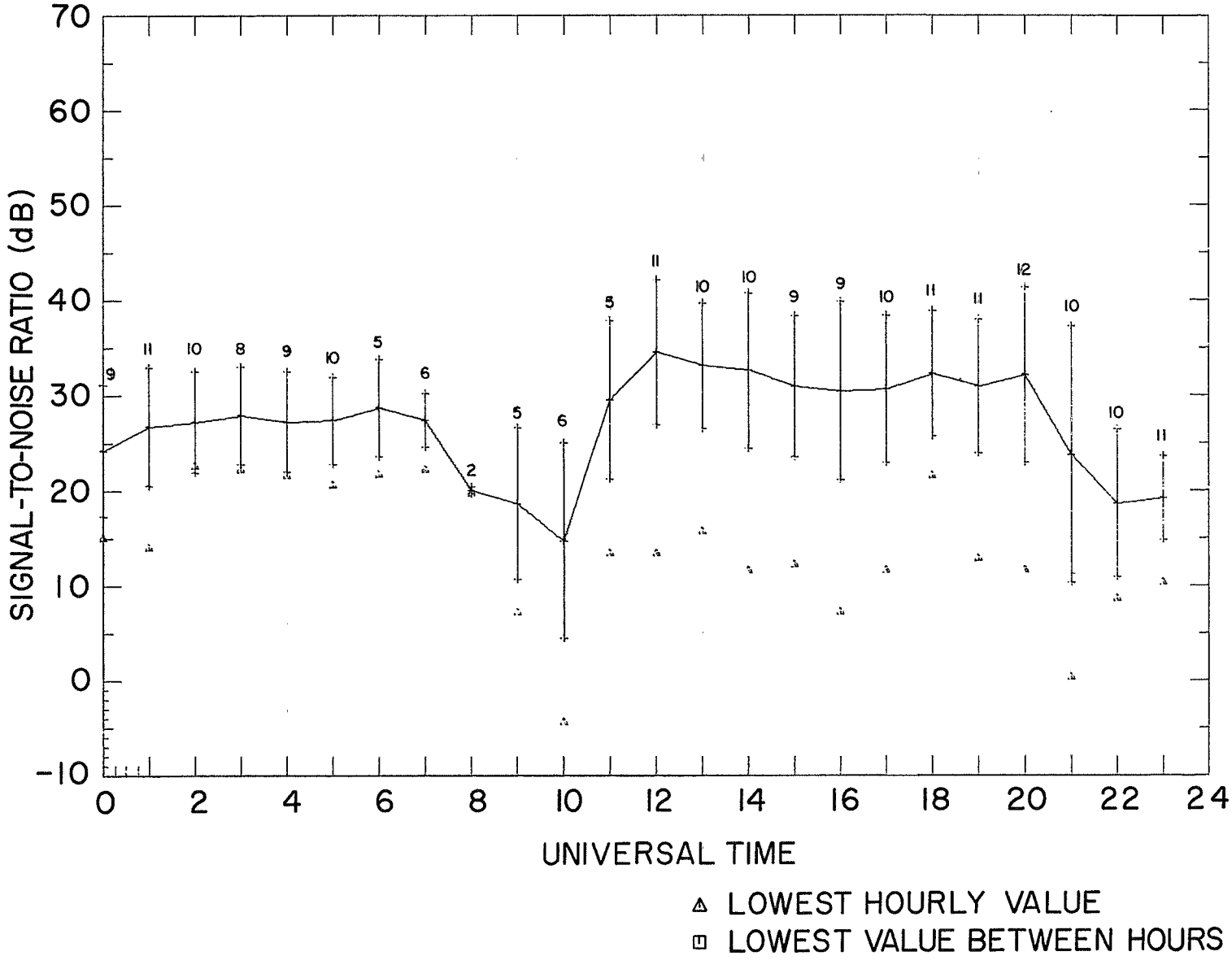


Fig. 83 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

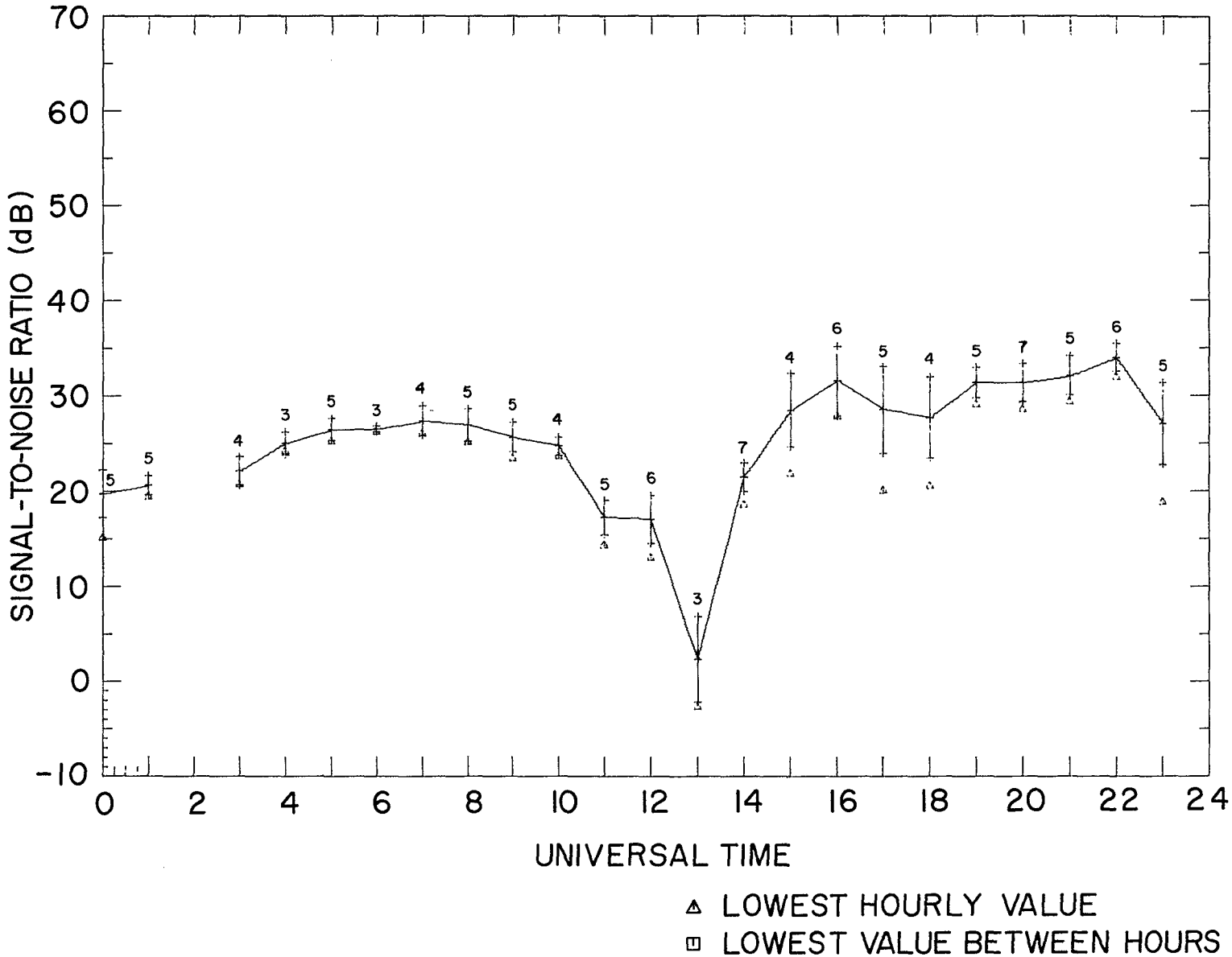


Fig. 84 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 8 September to 15 September 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

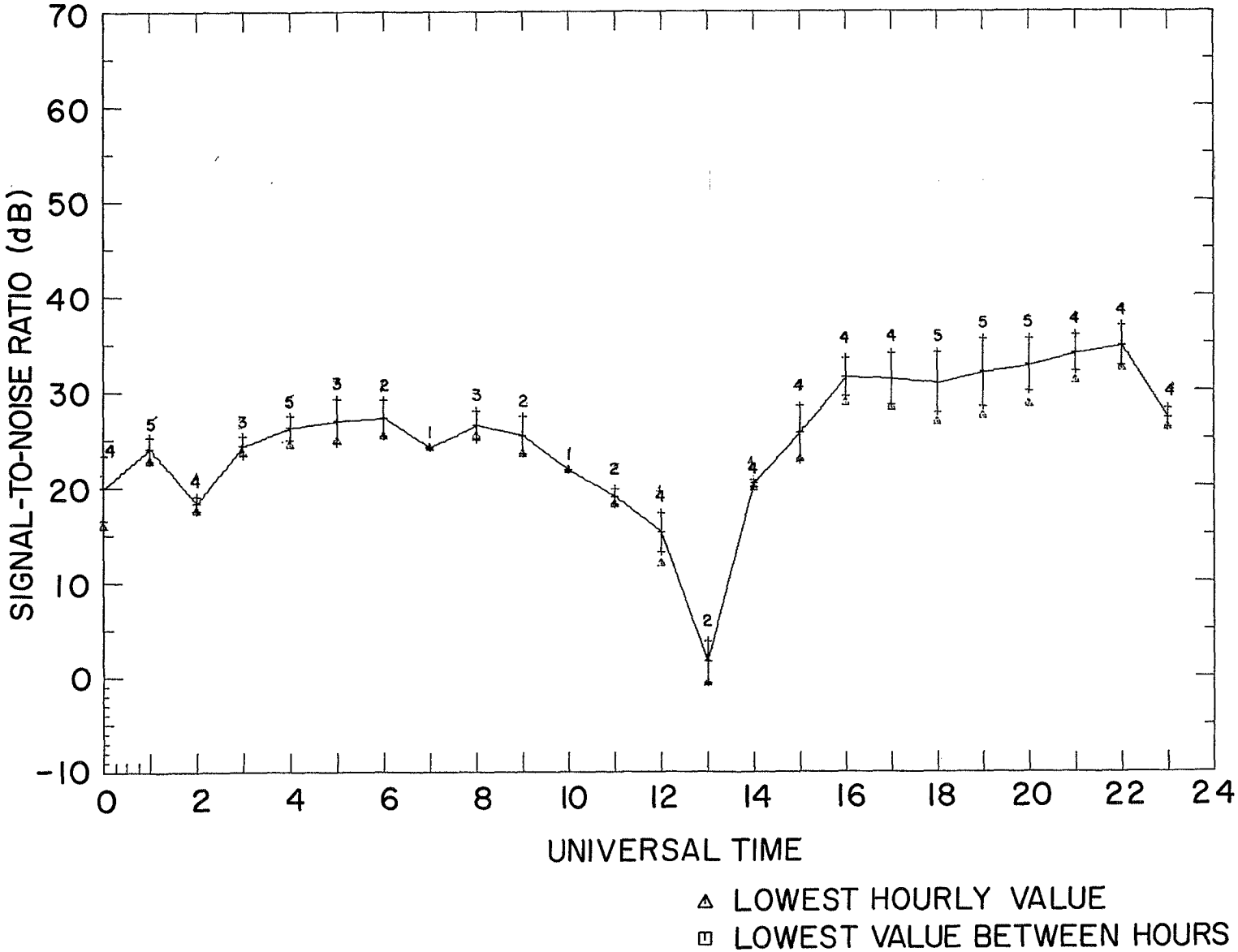


Fig. 85 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 22 September to 29 September 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

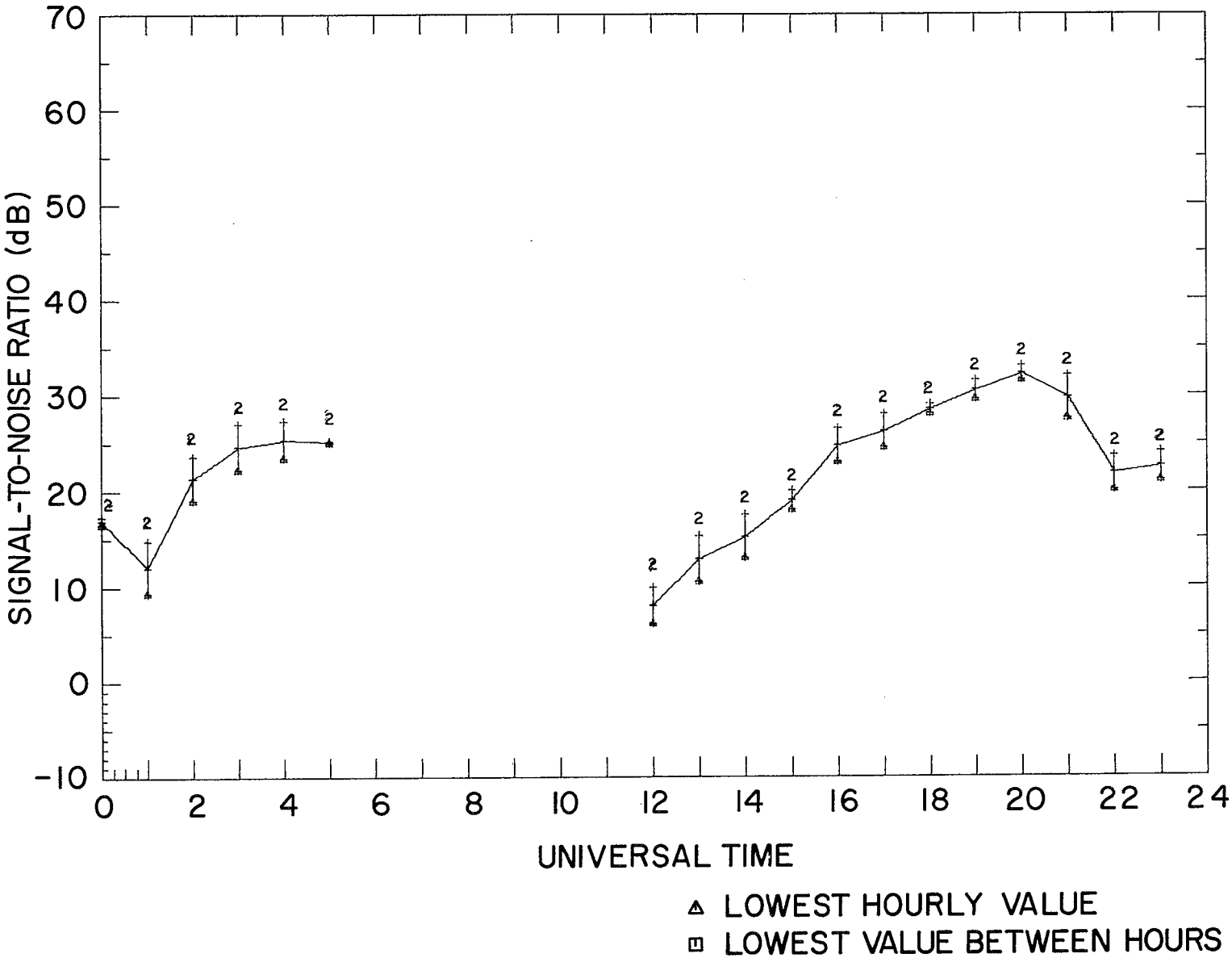


Fig. 86 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 1 November to 3 November 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

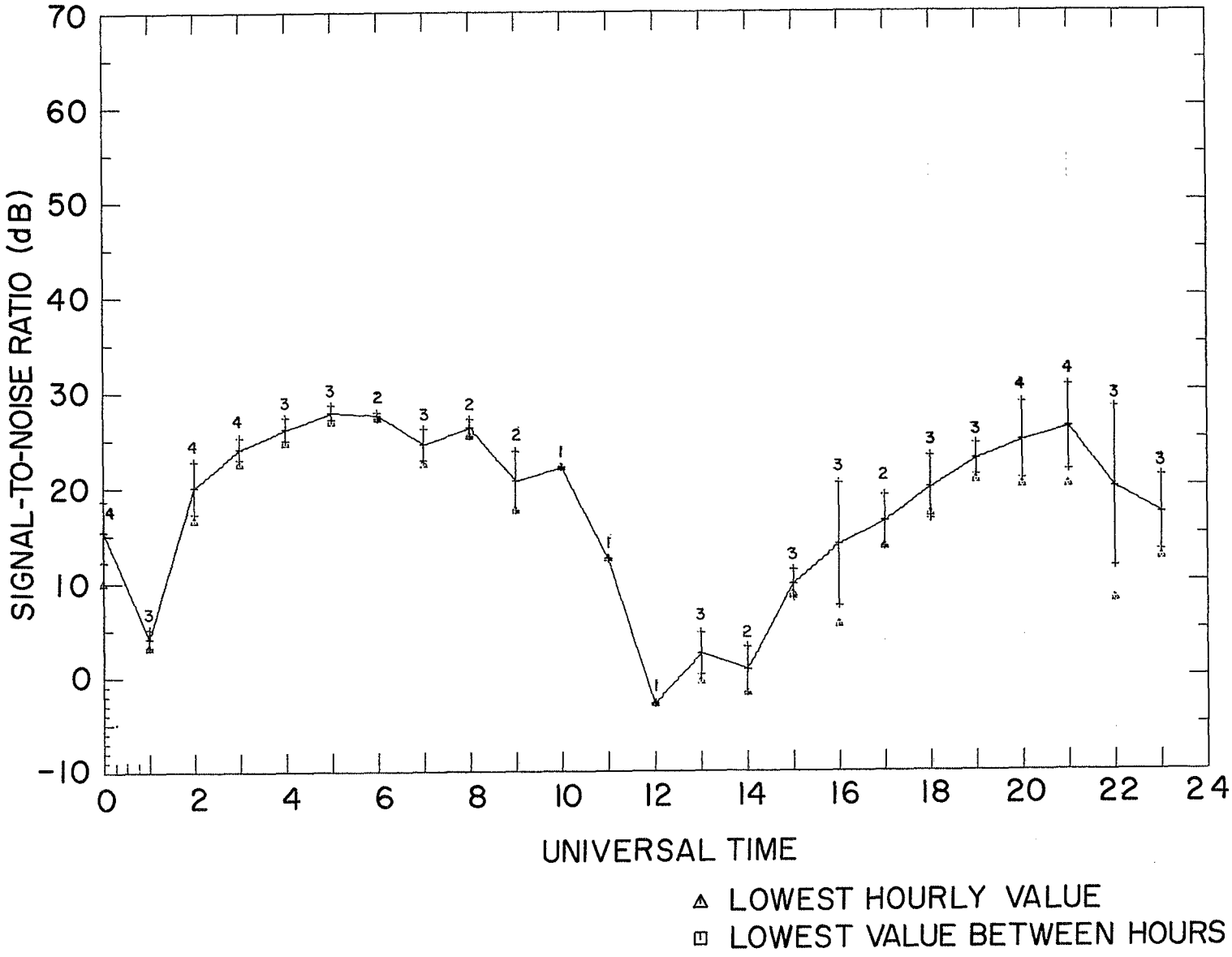


Fig. 87 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 10 November to 14 November 1967 at a frequency of 24.5 kHz. Normalized radiated power of NWC is 31.1 dB above 1 kw.

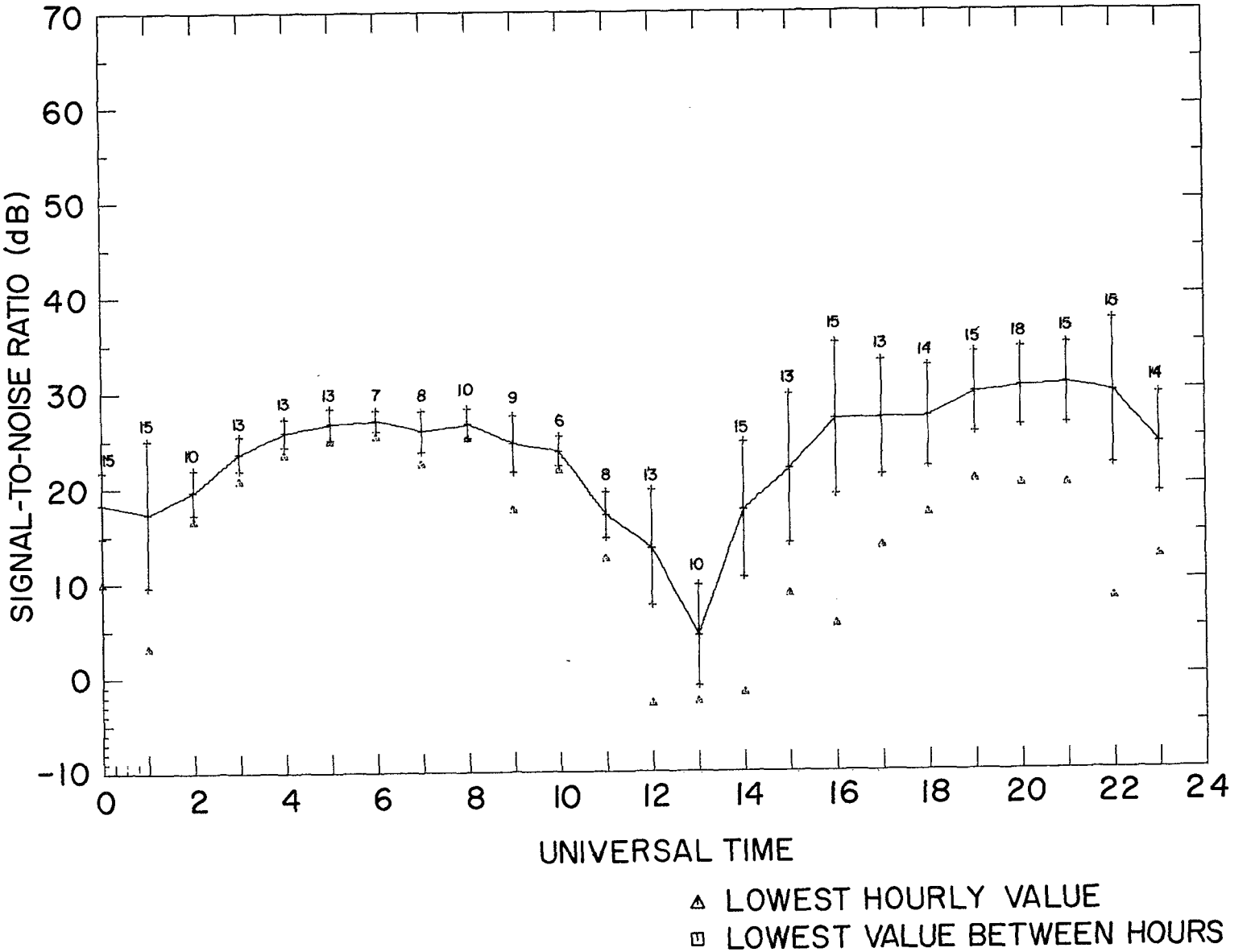


Fig. 88 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 24.5 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.1 dB above 1 kw.

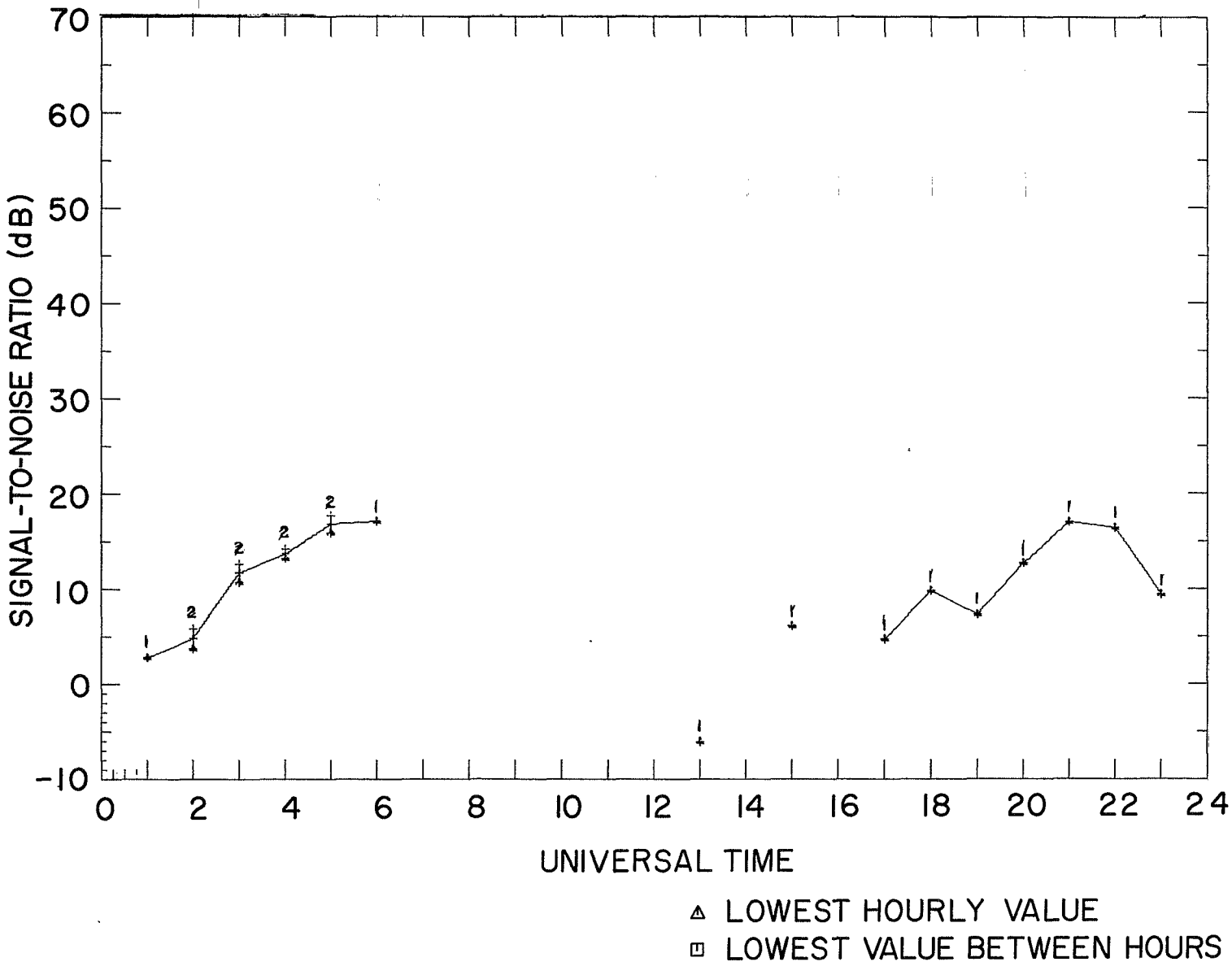


Fig. 89 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 20 September to 22 September 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

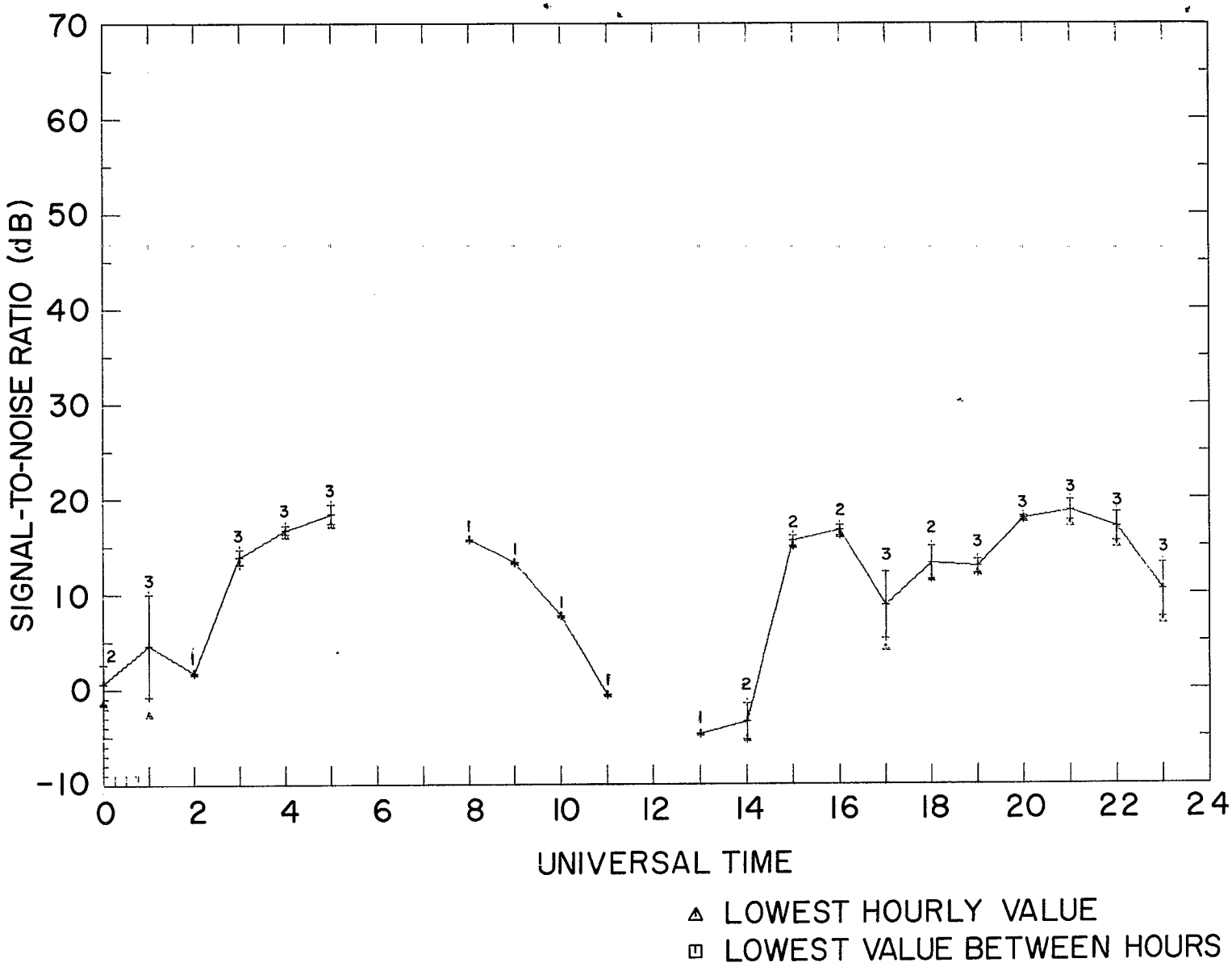


Fig. 90 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 3 October to 6 October 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

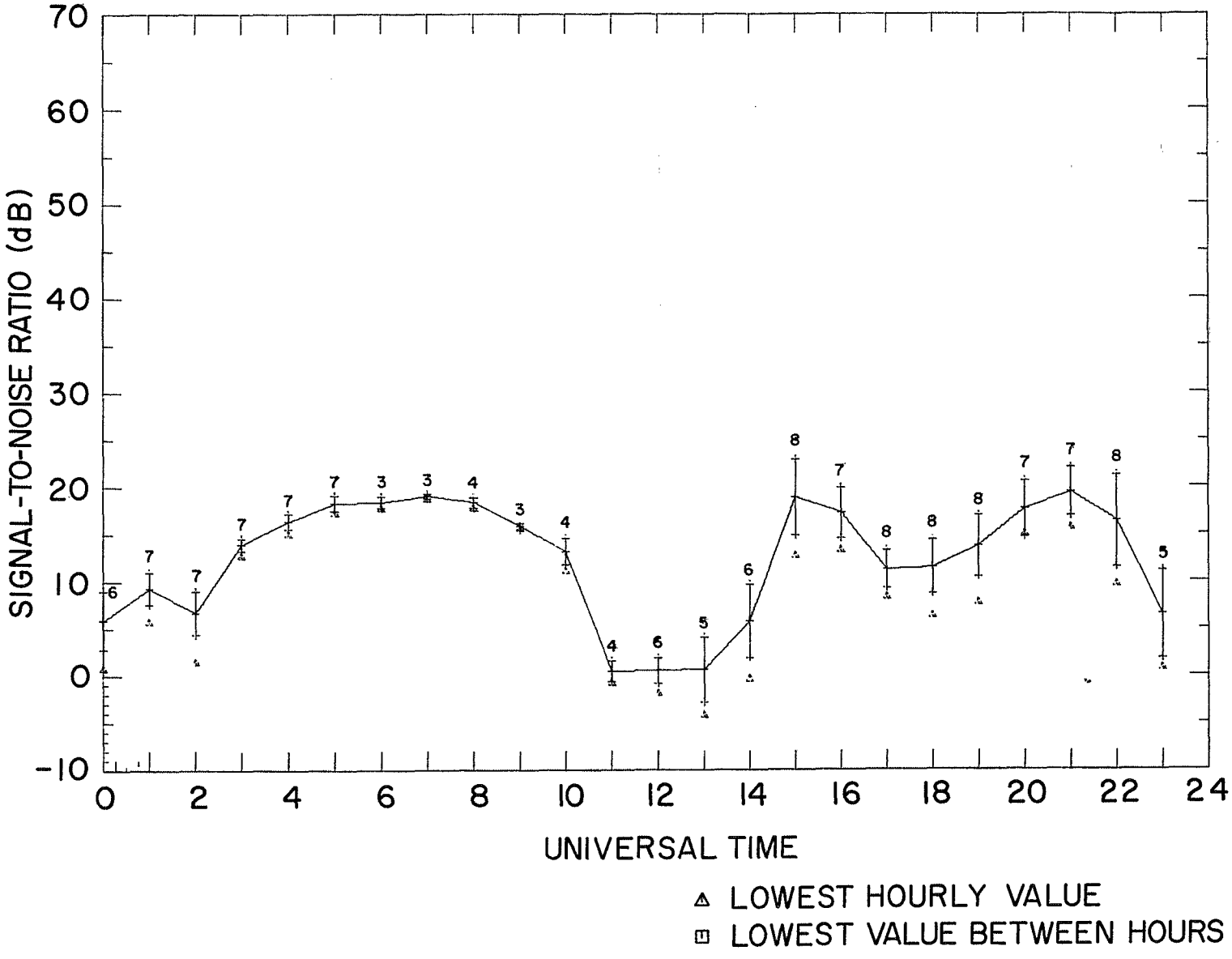


Fig. 91 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 13 October to 20 October 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

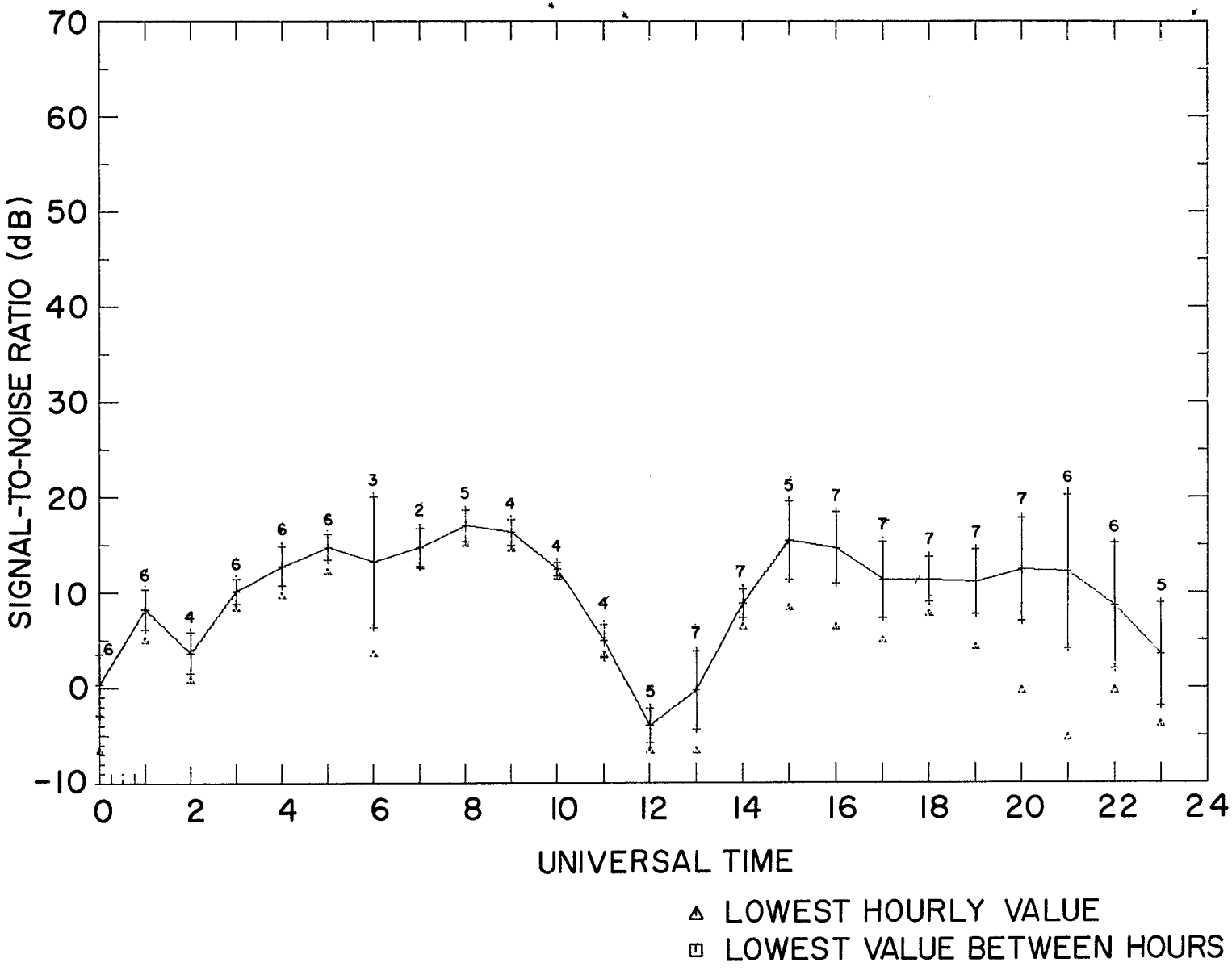


Fig. 92 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 17 November to 24 November 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

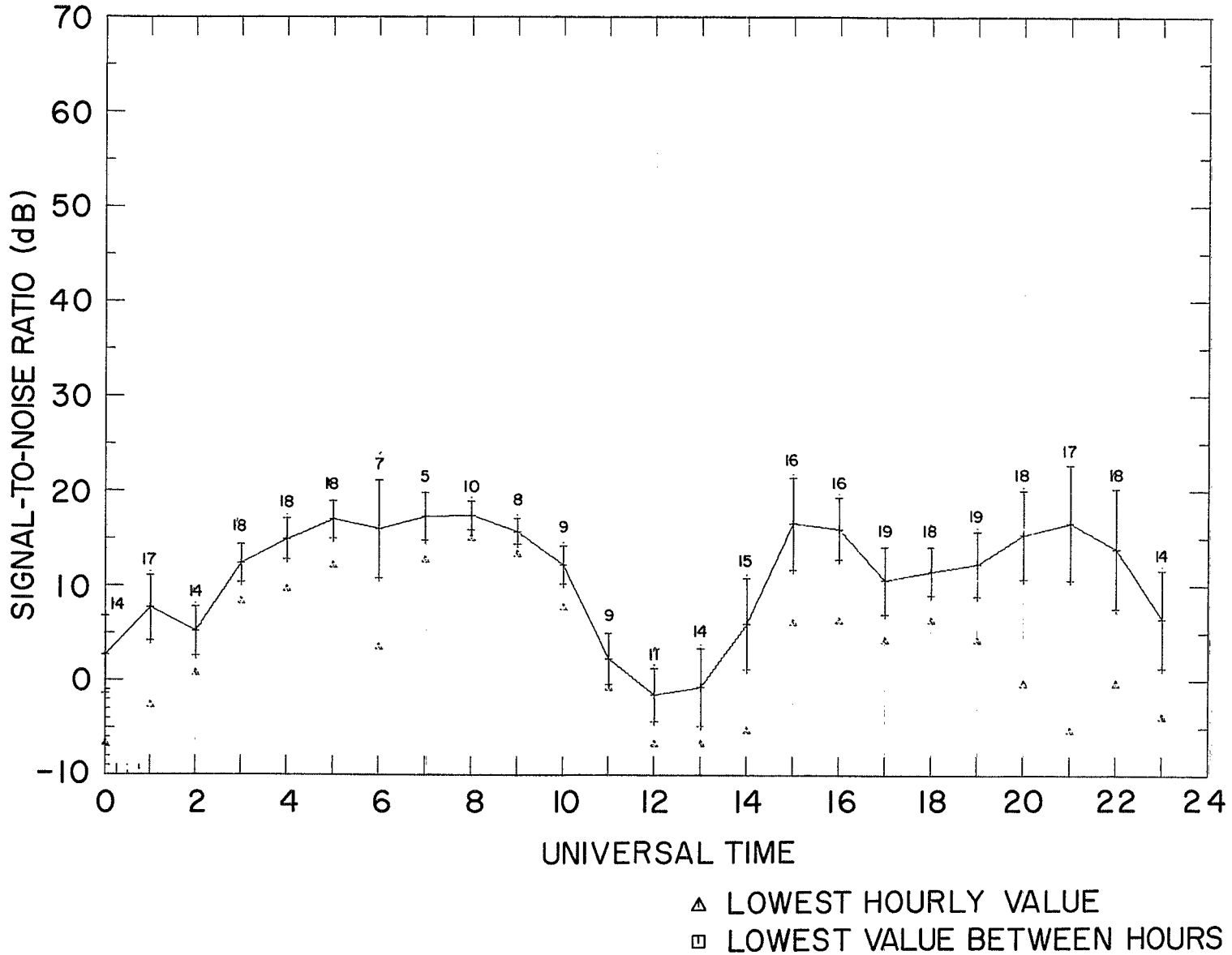


Fig. 93 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.2 dB above 1 kw.

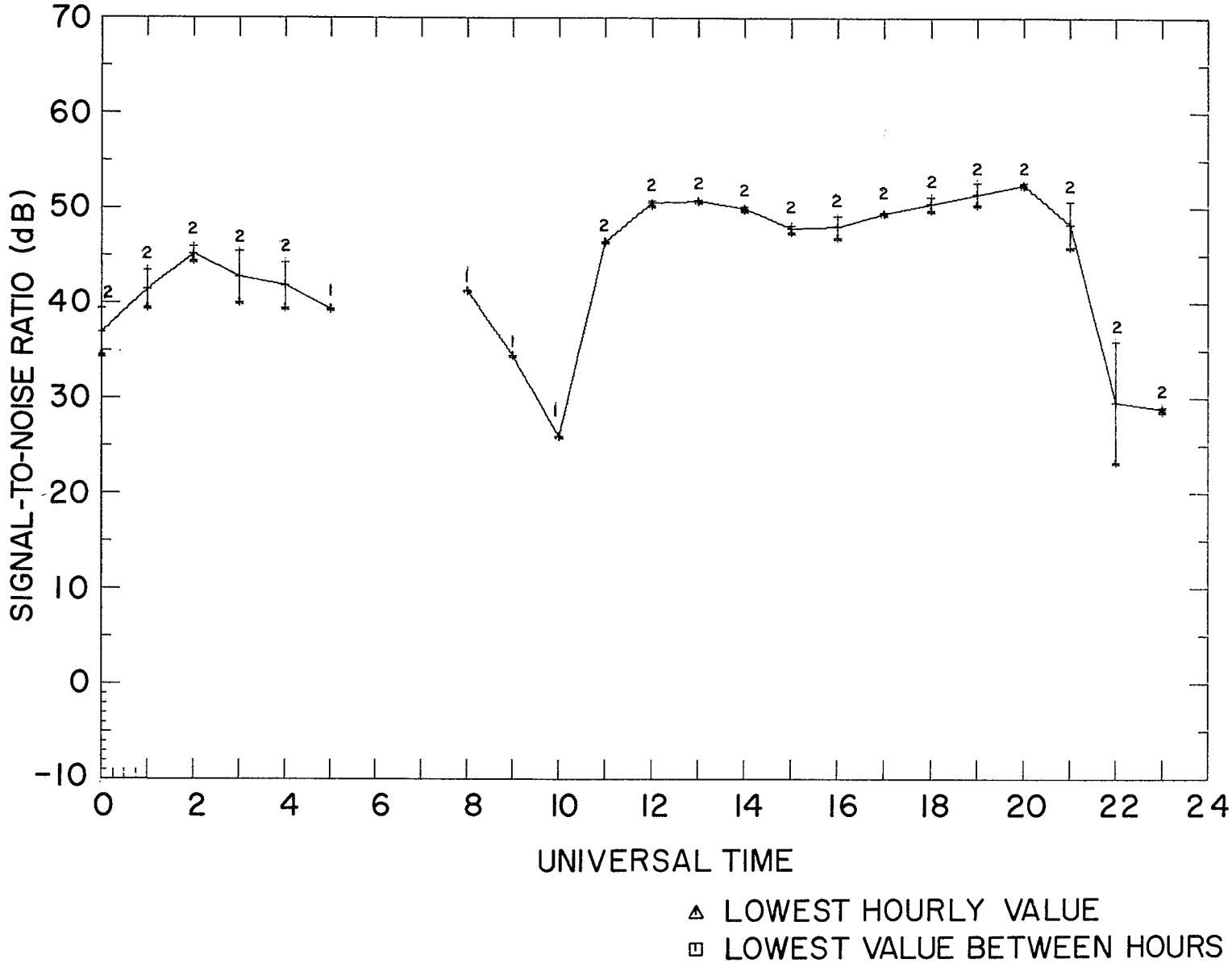


Fig. 94 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan as recorded from 17 November to 24 November 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

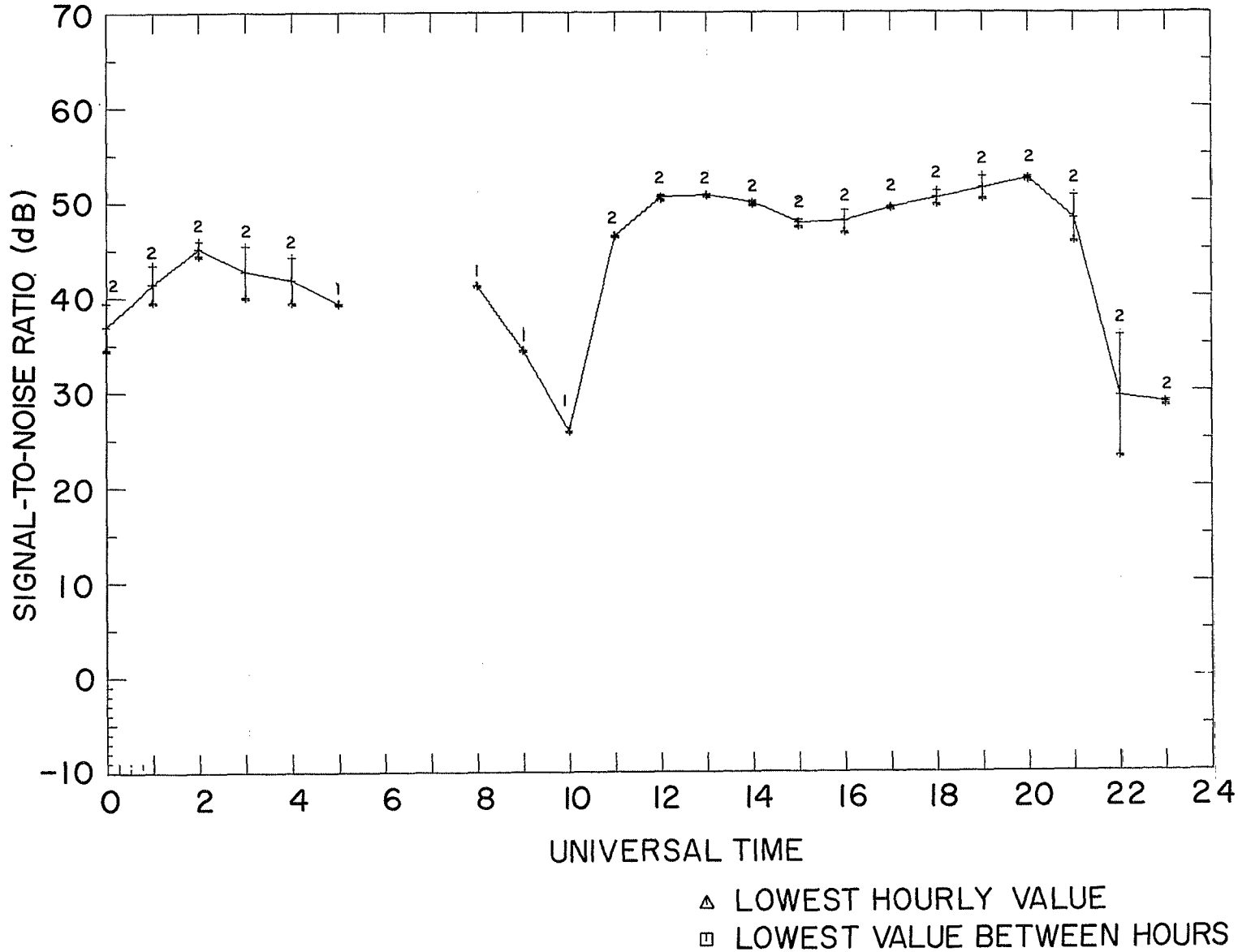


Fig. 95 - Mean and standard deviation of signal-to-noise ratio for NWC at Japan, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.2 dB above 1 kw.

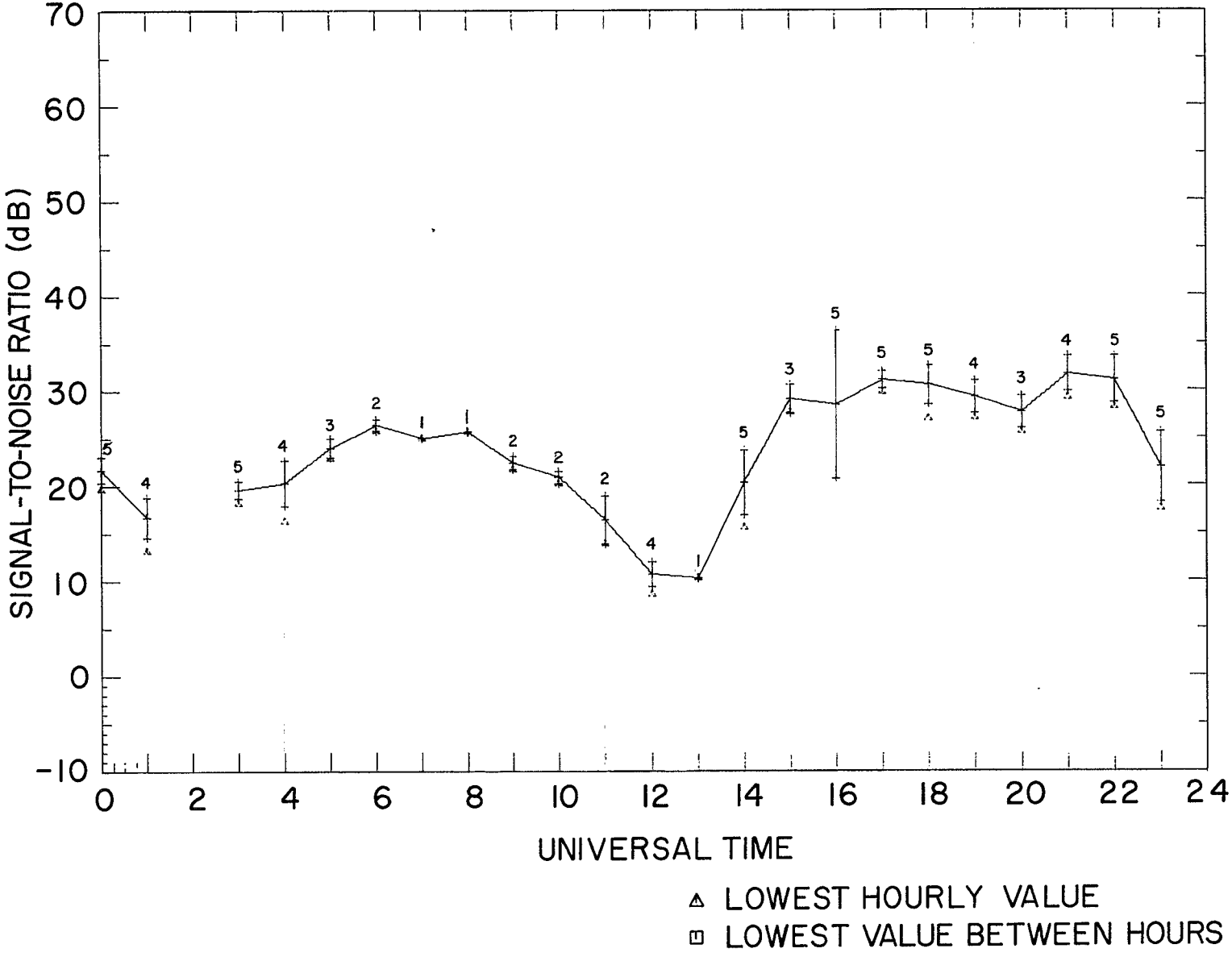


Fig. 96 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 3 September to 8 September 1967 at a frequency of 26.8 kHz, Normalized radiated power of NWC is 31.2 dB above 1 kw.

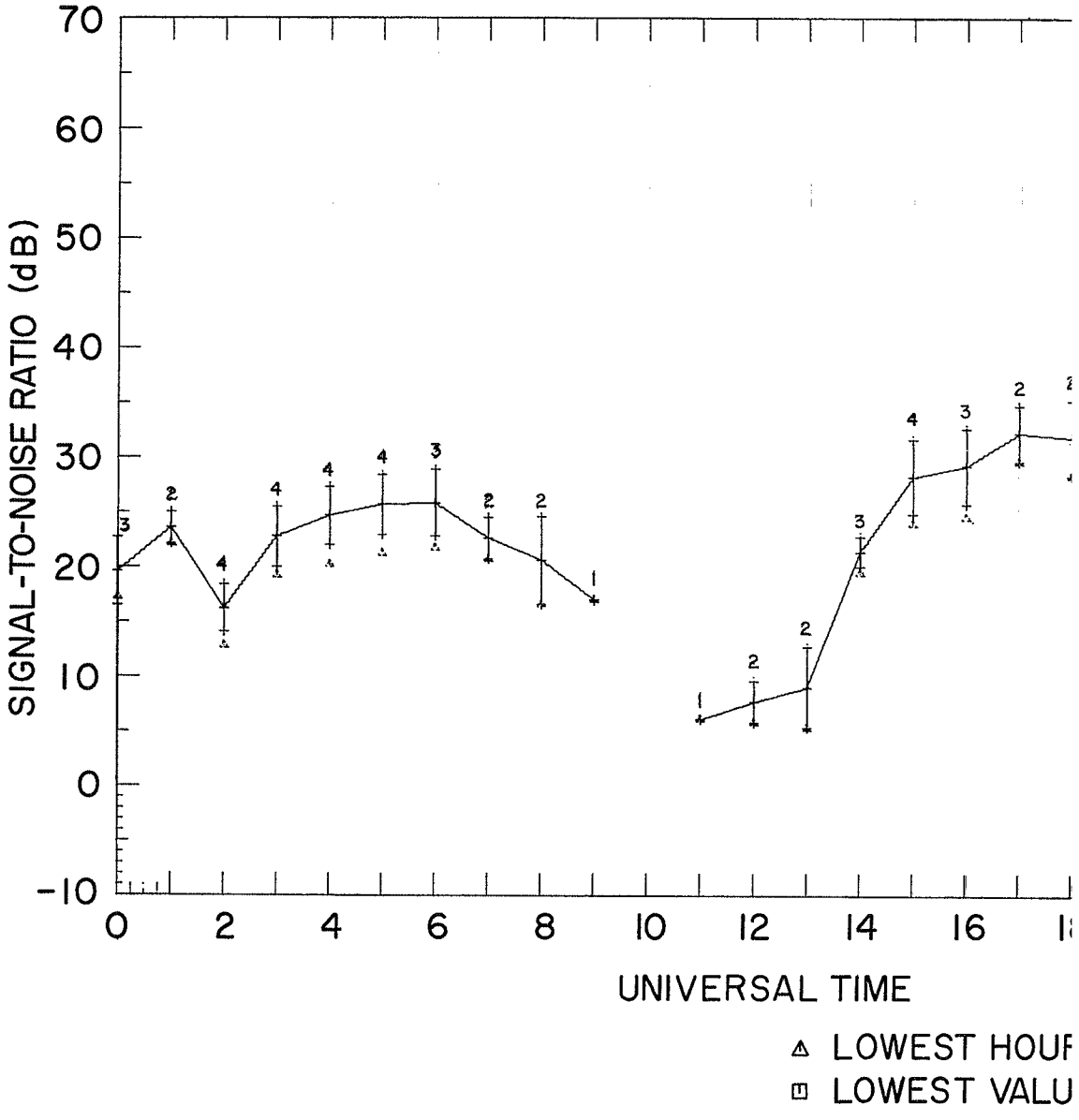


Fig. 97 - Mean and standard deviation of signal-to-noise ratio for N' recorded from 15 September to 22 September 1967 at a frequency of 2 radiated power of NWC is 31.2 dB above 1 kw.

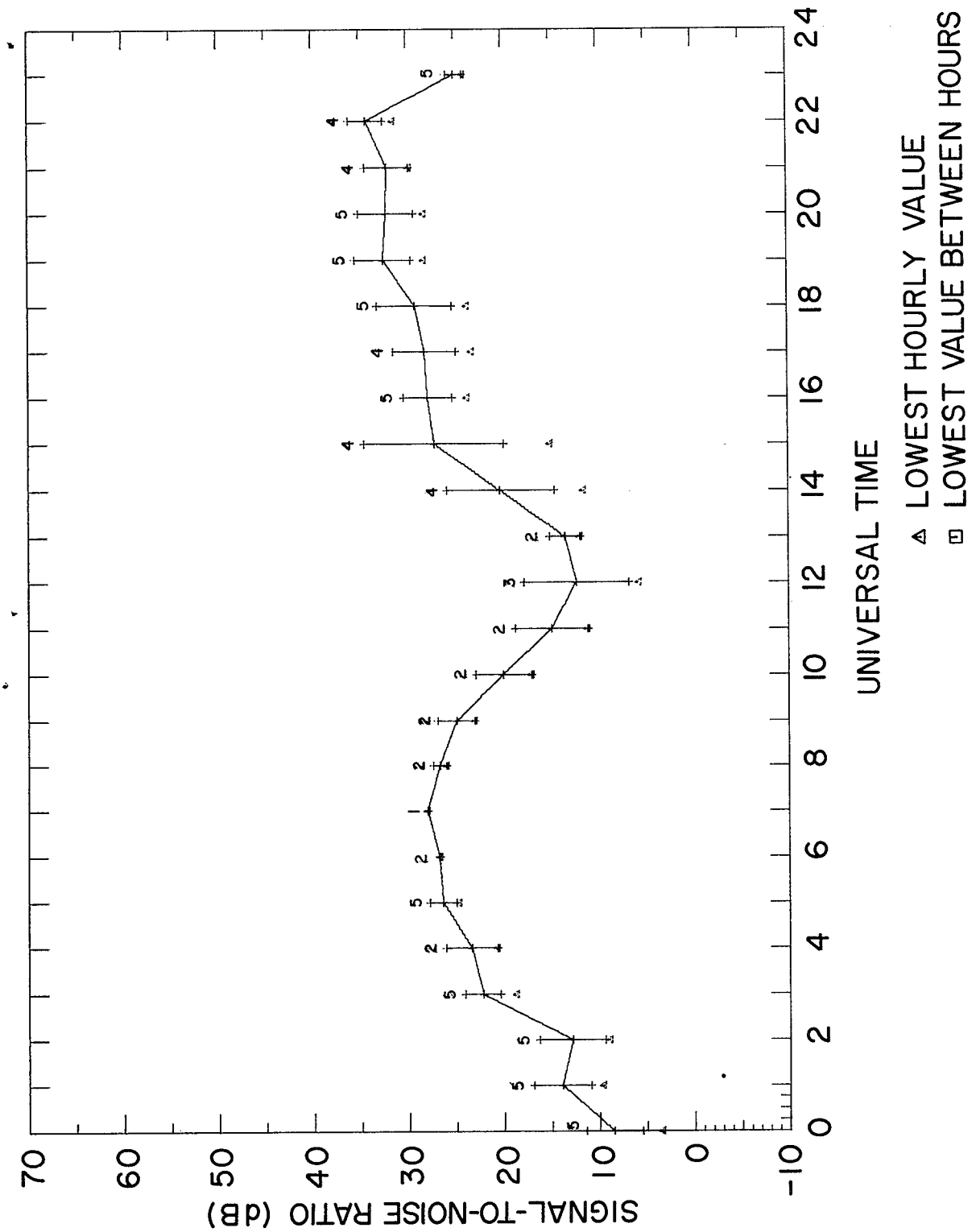


Fig. 98 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar as recorded from 30 September to 6 October 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

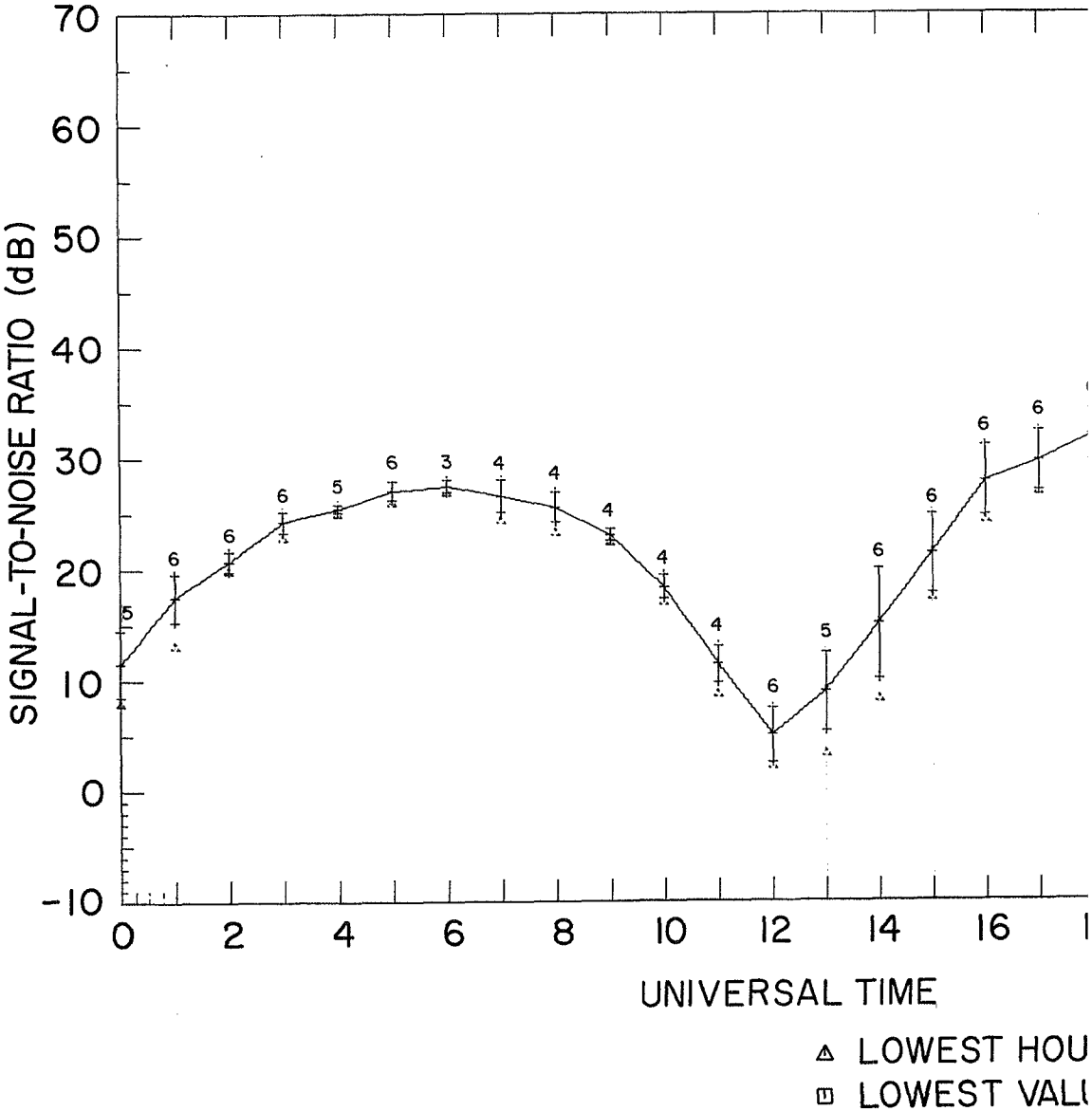


Fig. 99 - Mean and standard deviation of signal-to-noise ratio for N recorded from 13 October to 20 October 1967 at a frequency of 2 radiated power of NWC is 31.2 dB above 1 kw.

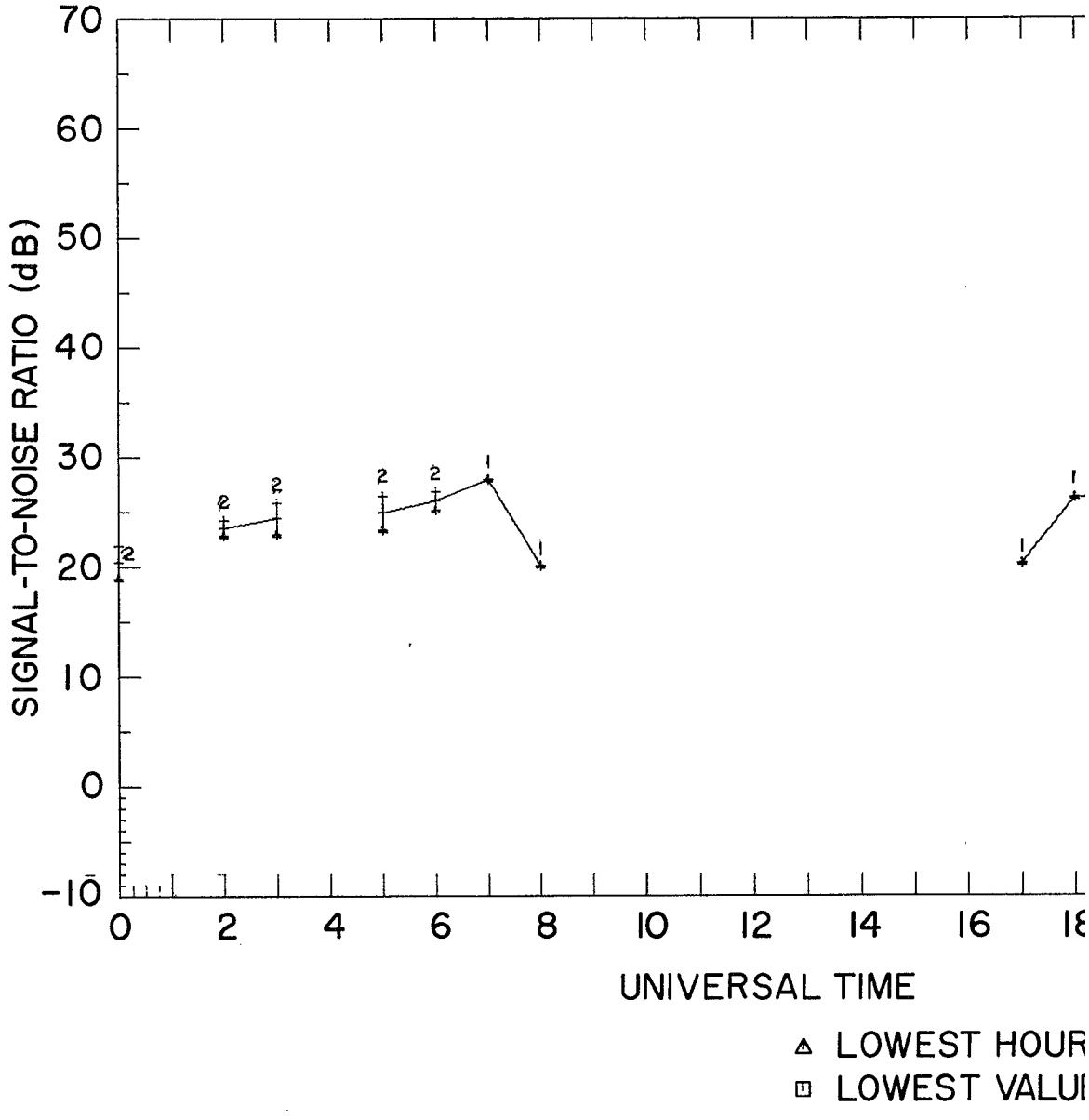


Fig. 100 - Mean and standard deviation of signal-to-noise ratio for NW recorded from 22 November to 24 November 1967 at a frequency of 2(radiated power of NWC is 31.2 dB above 1 kw.

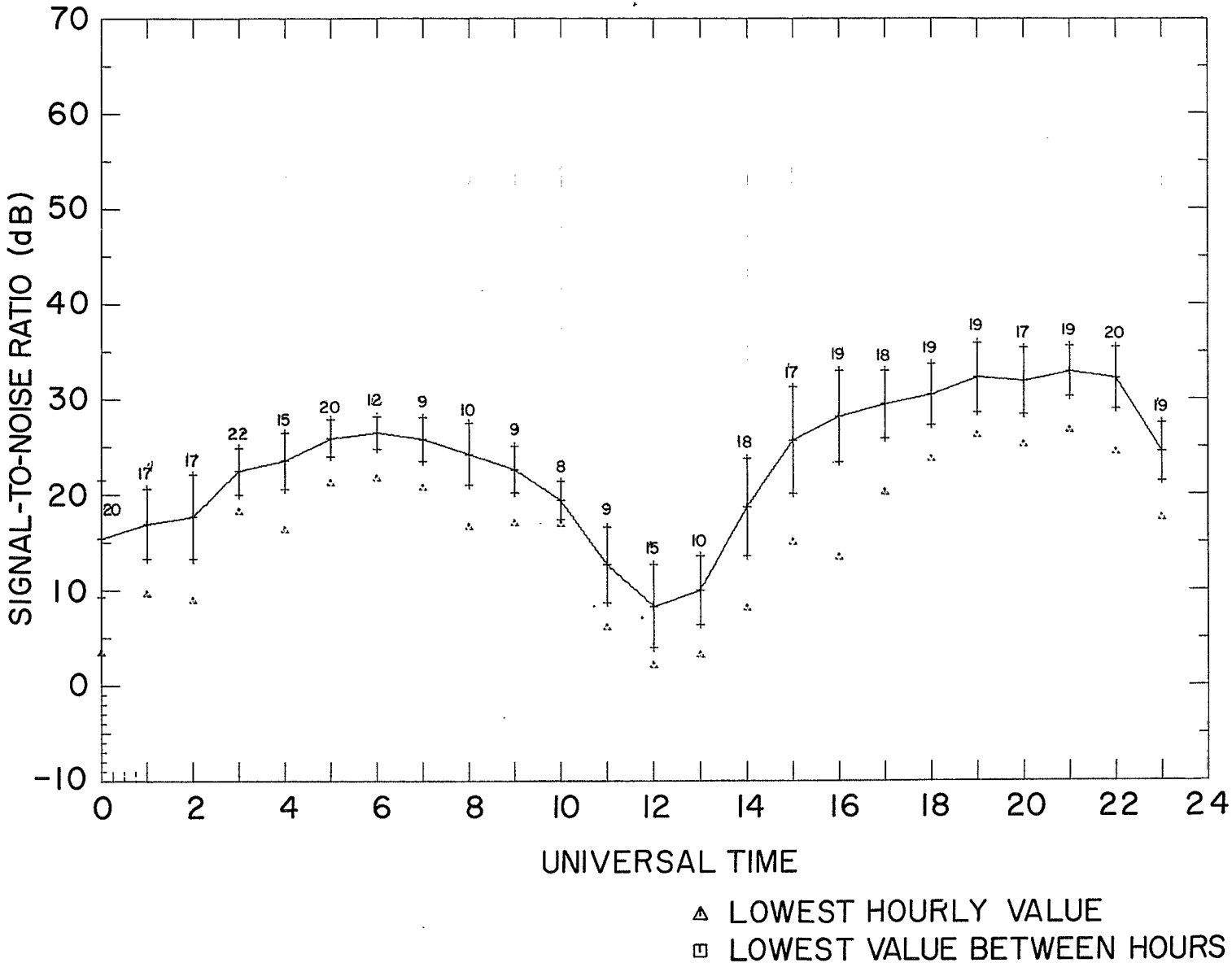


Fig. 101 - Mean and standard deviation of signal-to-noise ratio for NWC at Madagascar, 26.8 kHz, for a three-month period from September to December 1967. Normalized radiated power of NWC is 31.2 dB above 1 kw.

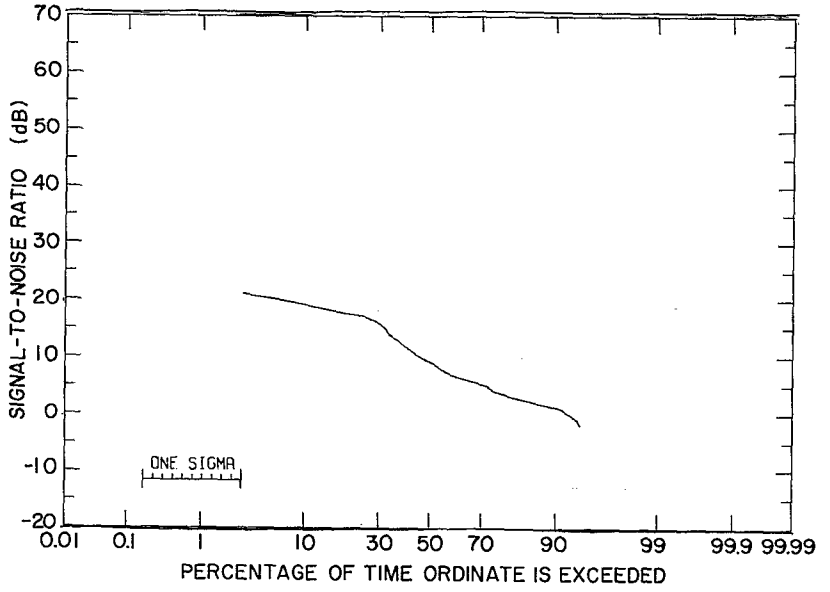


Fig. 102 - Probability plot of signal-to-noise ratio for NWC at Bahrain at a frequency of 15.5 kHz for three complete days during the period from 21 October to 11 November 1967.

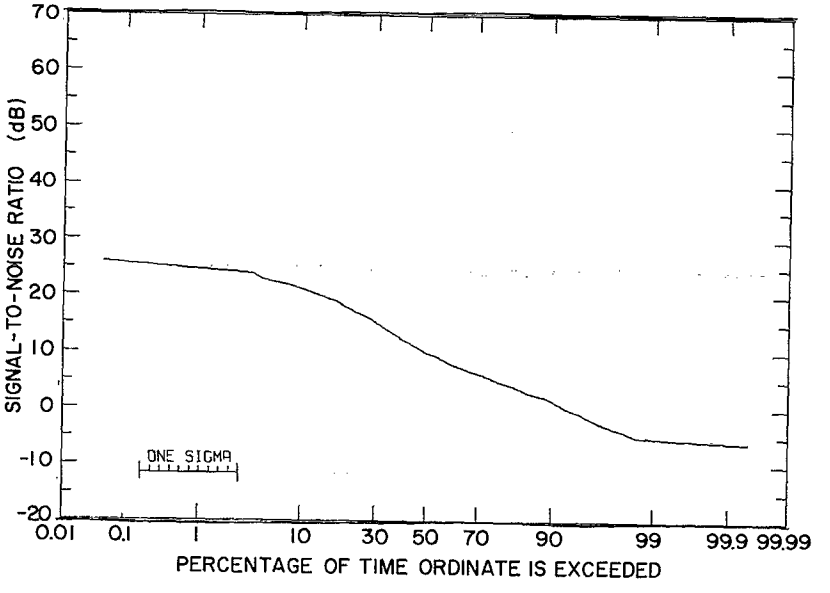


Fig. 103 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 15.5 kHz for all data recorded during the period from 17 October to 30 November 1967.

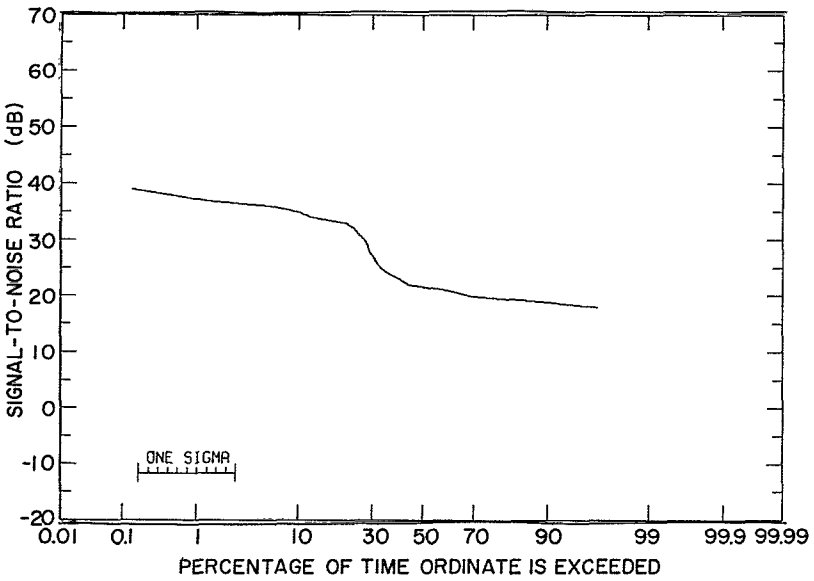


Fig. 104 - Probability plot of signal-to-noise ratio for NWC at Japan at a frequency of 15.5 kHz for nine complete days during the period from 27 September to 11 November 1967.

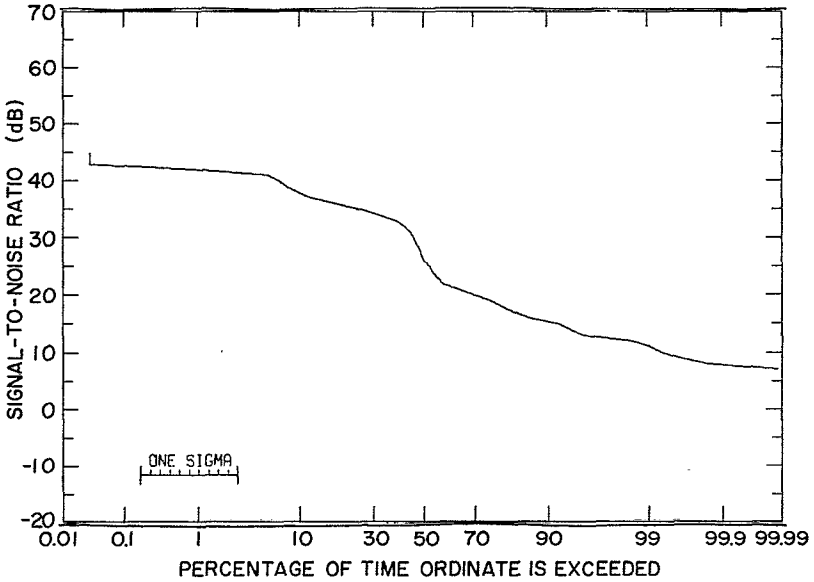


Fig. 105 - Probability plot of signal-to-noise ratio data for NWC at Japan at a frequency of 15.5 kHz for all data recorded during the period from 26 September to 5 December 1967.

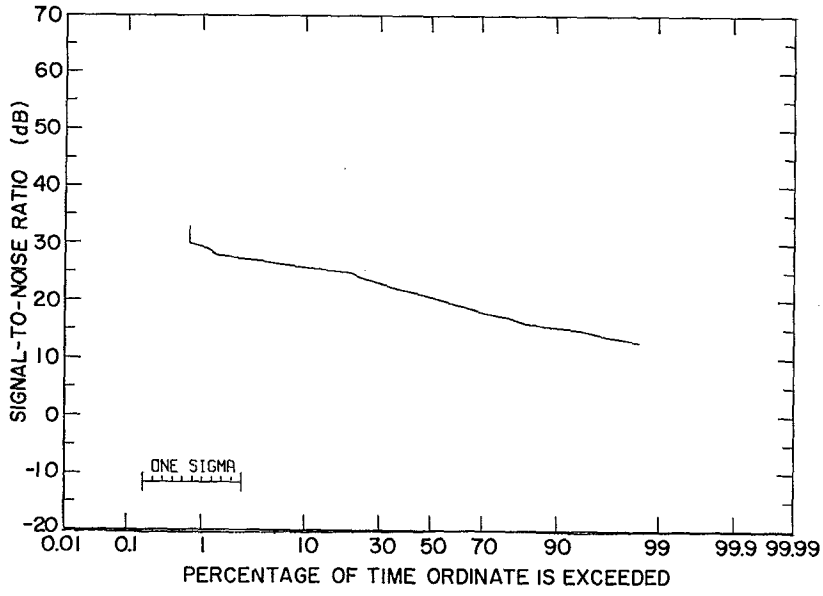


Fig. 106 - Probability plot of signal-to-noise ratio for NWC at Madagascar at a frequency of 15.5 kHz for seven complete days during the period from 4 September to 13 November 1967.

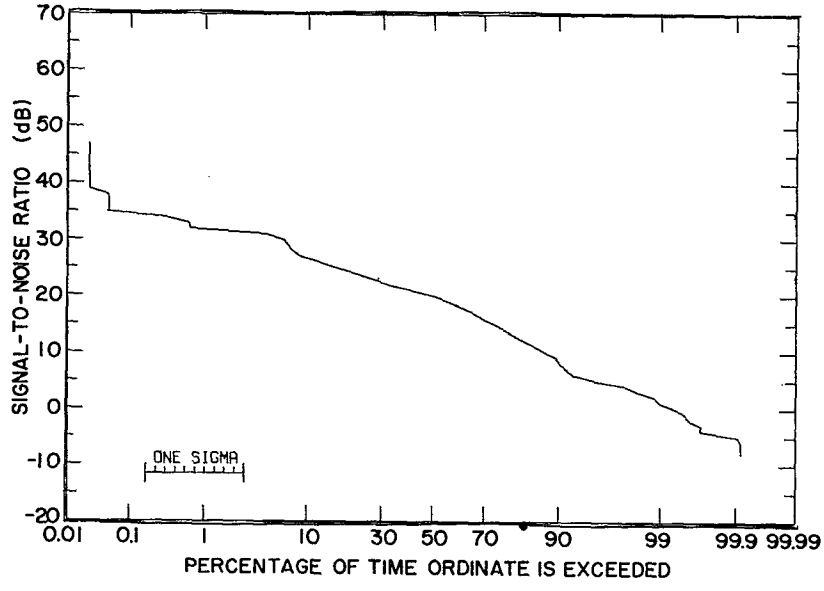


Fig. 107 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 15.5 kHz for all data recorded during the period from 4 September to 5 December 1967.

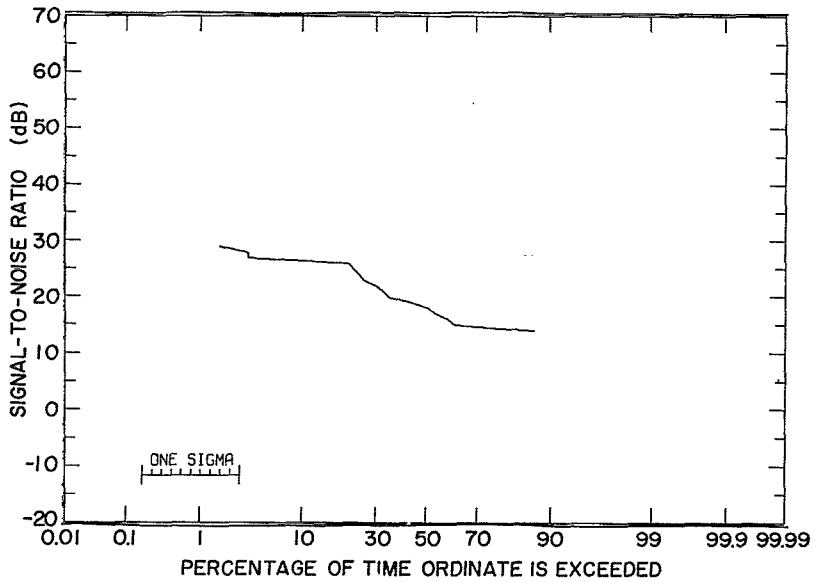


Fig. 108 - Probability plot of signal-to-noise ratio for NWC at Bahrain at a frequency of 18.0 kHz for five complete days during the period from 6 October to 27 November 1967.

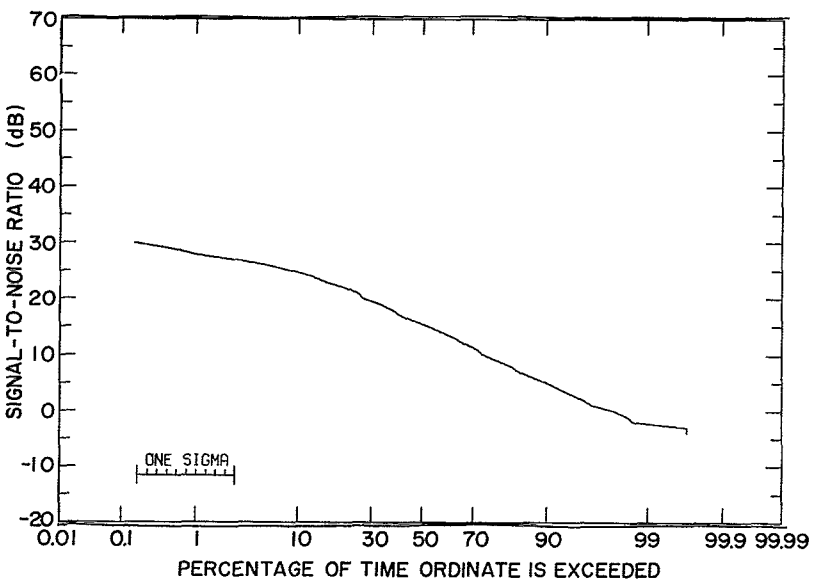


Fig. 109 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 18.0 kHz for all data recorded during the period from 6 October to 30 November 1967.

Fig. 89 - Mean and standard deviation of signal-to-noise ratio for NWC at Bahrain as recorded from 20 September to 22 September 1967 at a frequency of 26.8 kHz. Normalized radiated power of NWC is 31.2 dB above 1 kw.

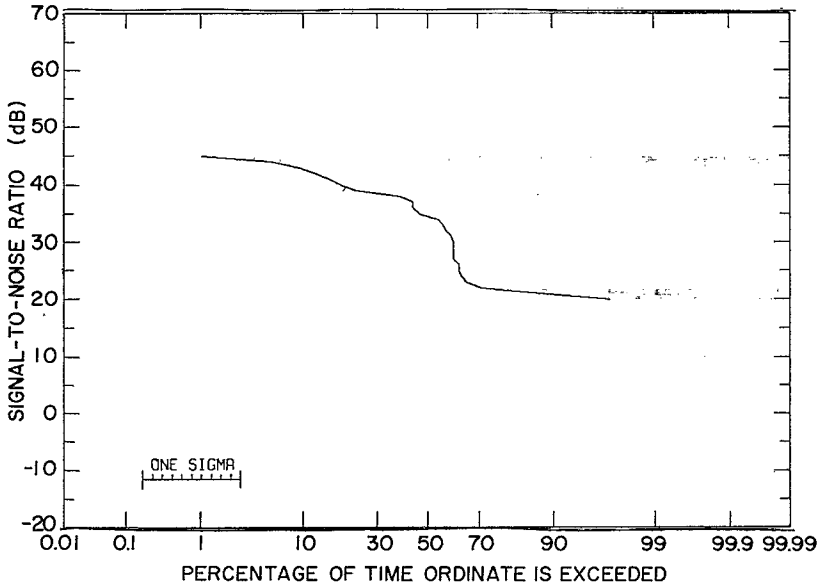


Fig. 110 - Probability plot of signal-to-noise ratio for NWC at Japan at a frequency of 18.0 kHz for four complete days during the period from 6 October to 26 November 1967.

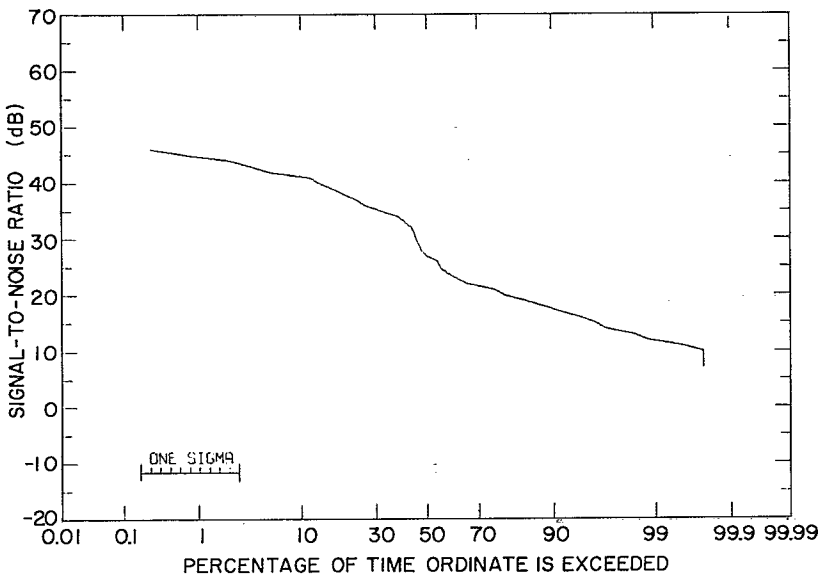


Fig. 111 - Probability plot of signal-to-noise ratio data for NWC at Japan at a frequency of 18.0 kHz for all data recorded during the period from 6 October to 30 November 1967.

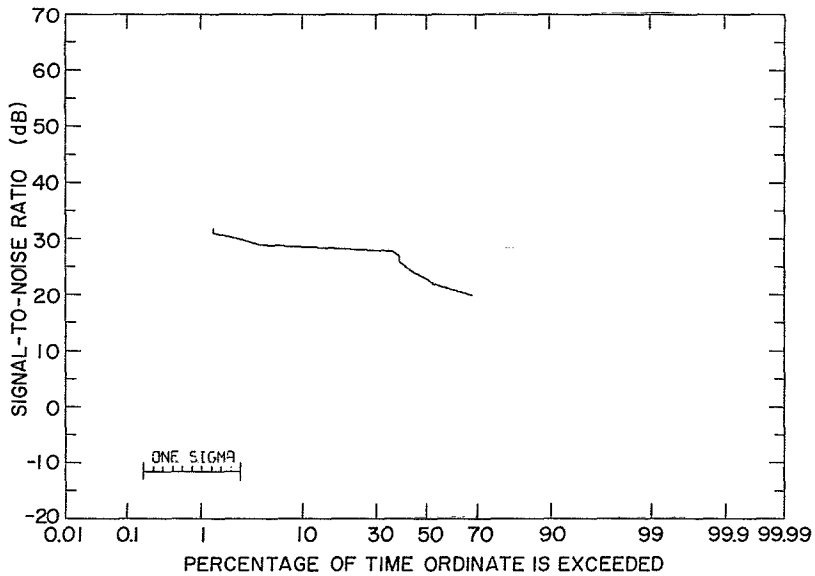


Fig. 112 - Probability plot of signal-to-noise ratio for NWC at Madagascar at a frequency of 18.0 kHz for three complete days during the period from 8 October to 5 November 1967.

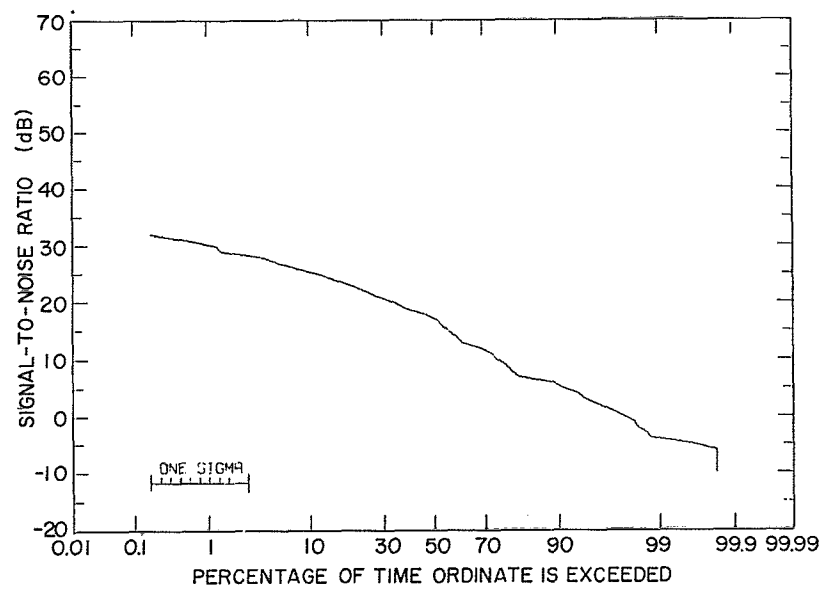


Fig. 113 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 18.0 kHz for all data recorded during the period from 6 October to 1 December 1967.

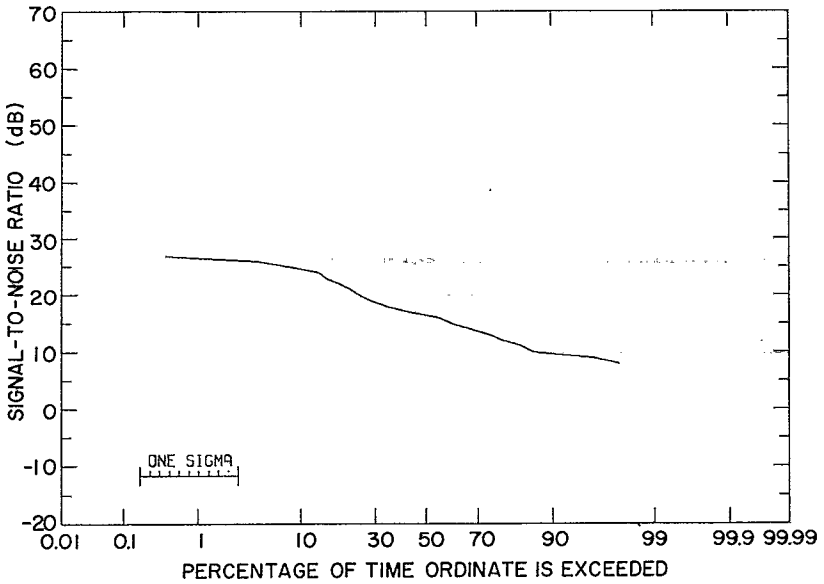


Fig. 114 - Probability plot of signal-to-noise ratio for NWC at Bahrain at a frequency of 19.8 kHz for seven complete days during the period from 7 October to 20 November 1967.

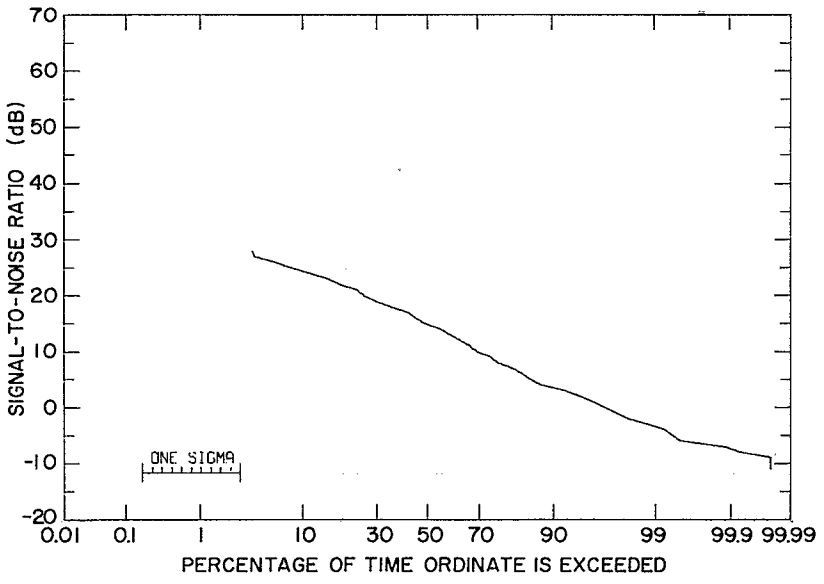


Fig. 115 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 19.8 kHz for all data recorded during the period from 3 October to 21 November 1967.

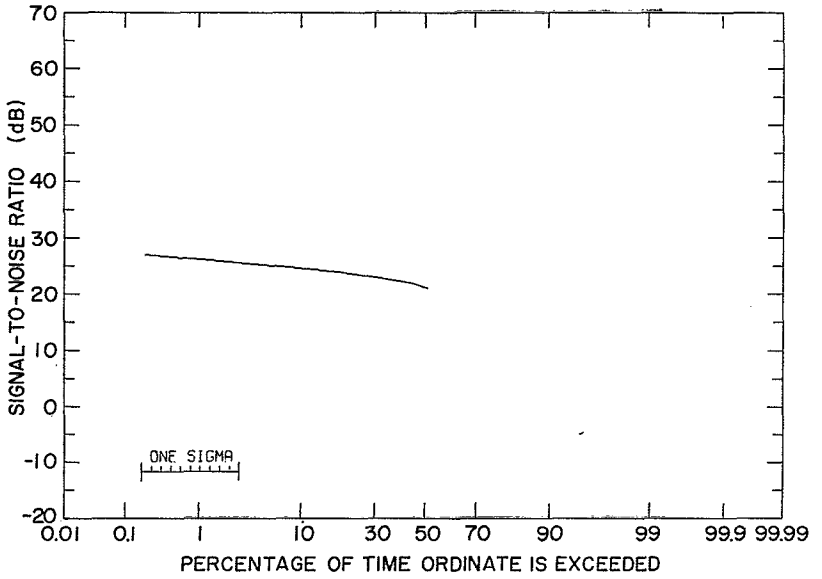


Fig. 116 - Probability plot of signal-to-noise ratio for NWC at Japan at a frequency of 19.8 kHz for three complete days during the period from 4 October to 8 October 1967.

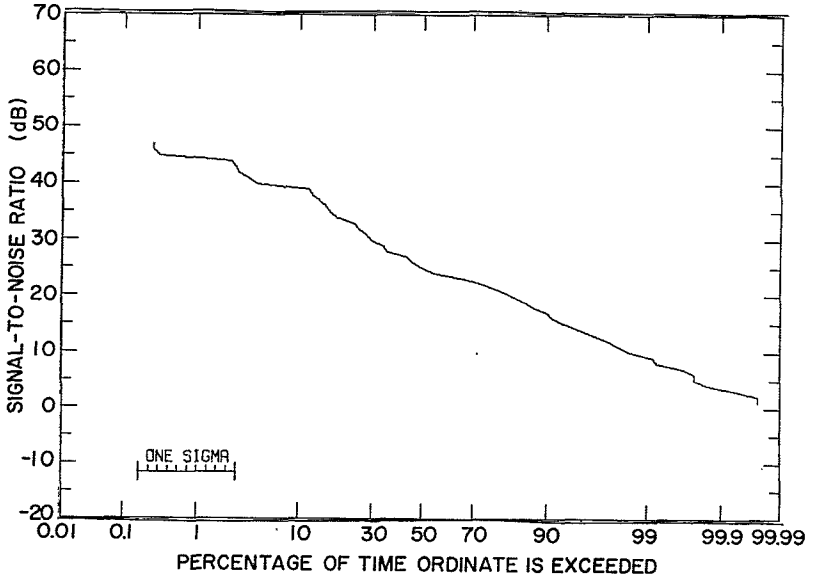


Fig. 117 - Probability plot of signal-to-noise ratio data for NWC at Japan at a frequency of 19.8 kHz for all data recorded during the period from 3 October to 21 November 1967.

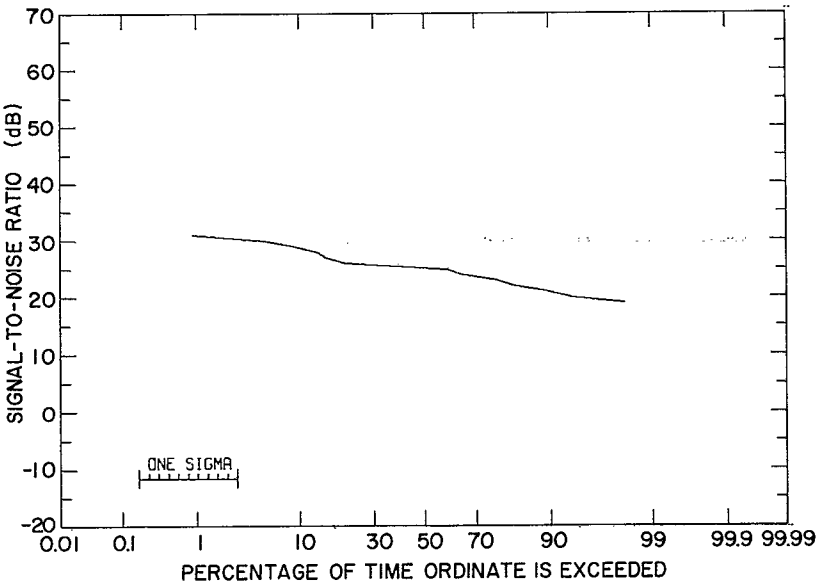


Fig. 118 - Probability plot of signal-to-noise ratio for NWC at Madagascar at a frequency of 19.8 kHz for two complete days during the period from 5 October to 8 October 1967.

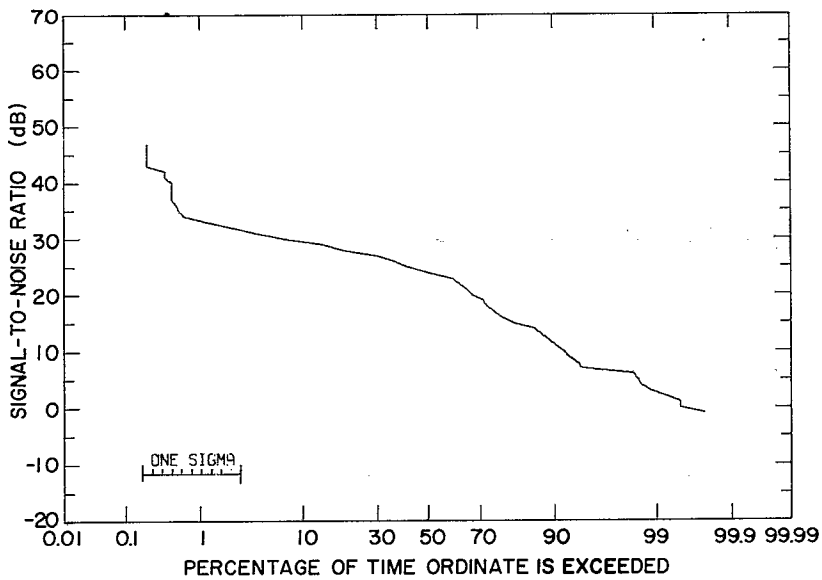


Fig. 119 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 19.8 kHz for all data recorded during the period from 12 September to 14 November 1967.

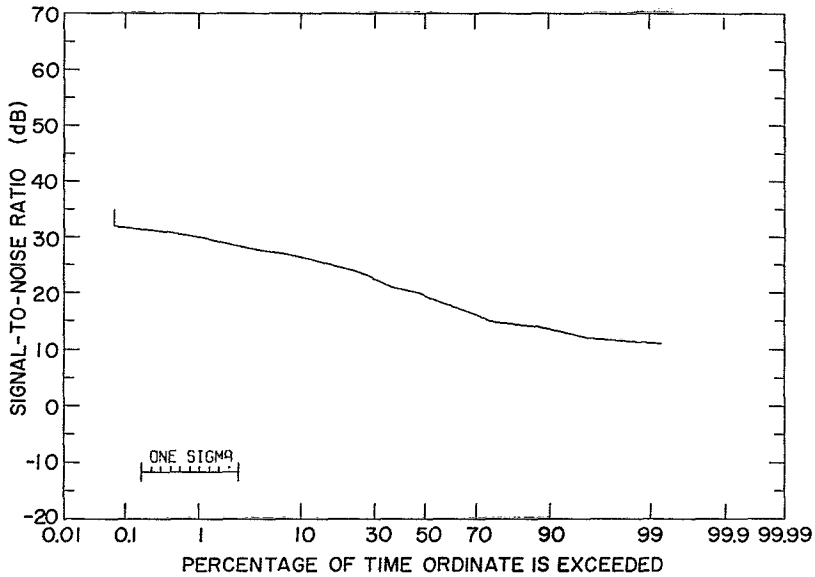


Fig. 120 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 22.3 kHz for eleven complete days during the period from 22 September to 28 November 1967.

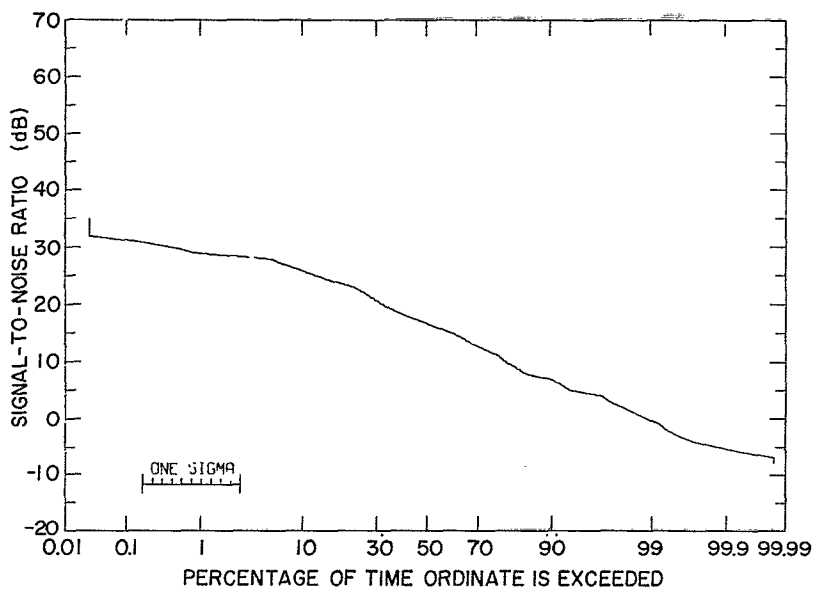


Fig. 121 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 22.3 kHz for all data recorded during the period from 20 September to 28 November 1967.

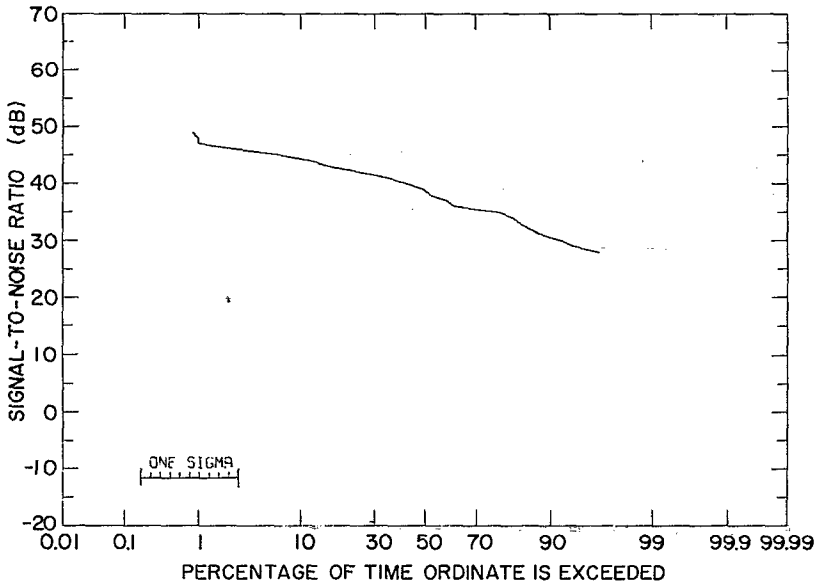


Fig. 122 - Probability plot of signal-to-noise ratio for NWC at Japan at a frequency of 22.3 kHz for five complete days during the period from 24 September to 27 November 1967.

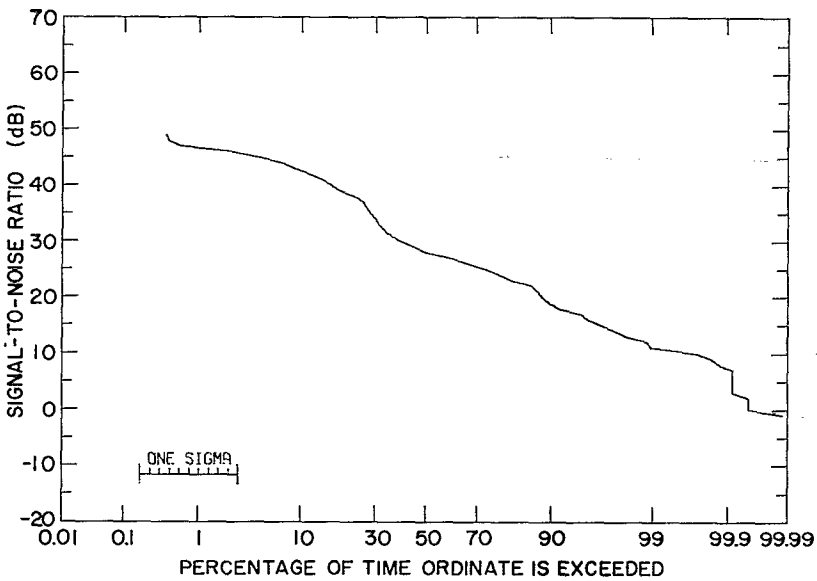


Fig. 123 - Probability plot of signal-to-noise ratio data for NWC at Japan at a frequency of 22.3 kHz for all data recorded during the period from 19 September to 28 November 1967.

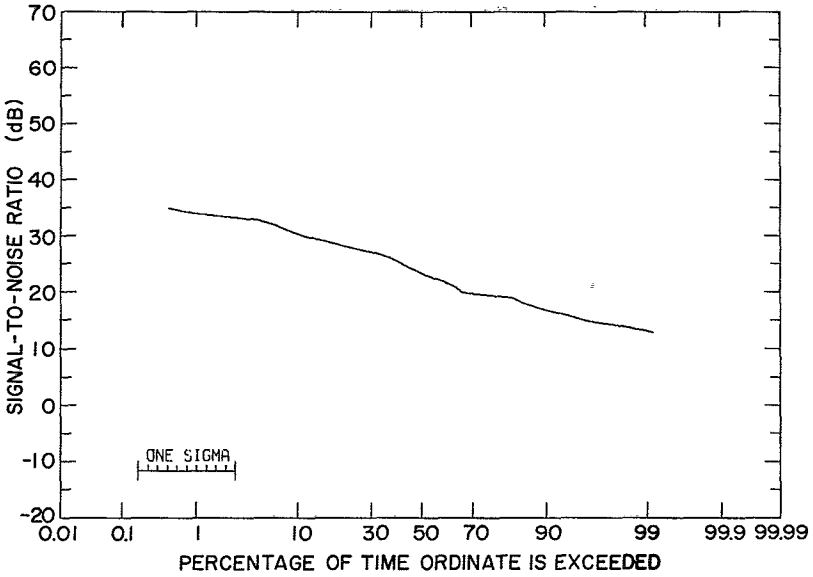


Fig. 124 - Probability plot of signal-to-noise ratio for NWC at Madagascar at a frequency of 22.3 kHz for four complete days during the period from 13 October to 4 November 1967.

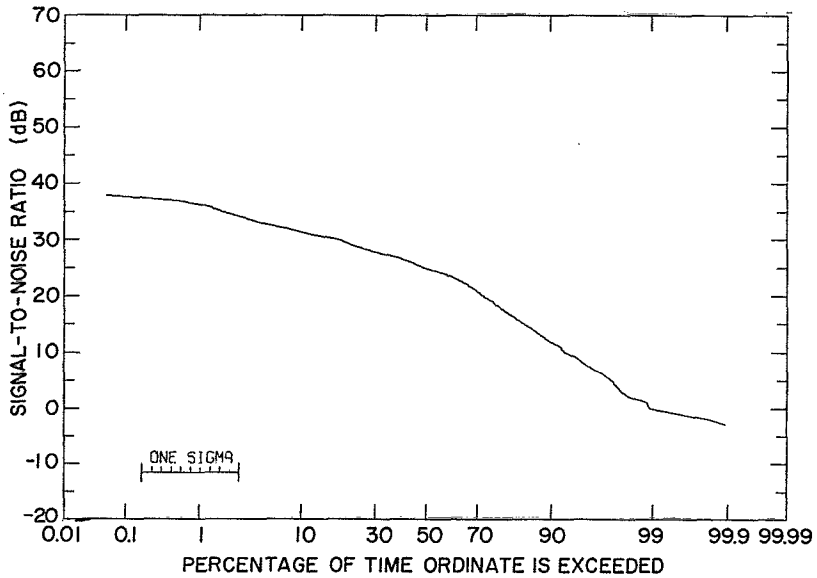


Fig. 125 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 22.3 kHz for all data recorded during the period from 20 September to 28 November 1967.

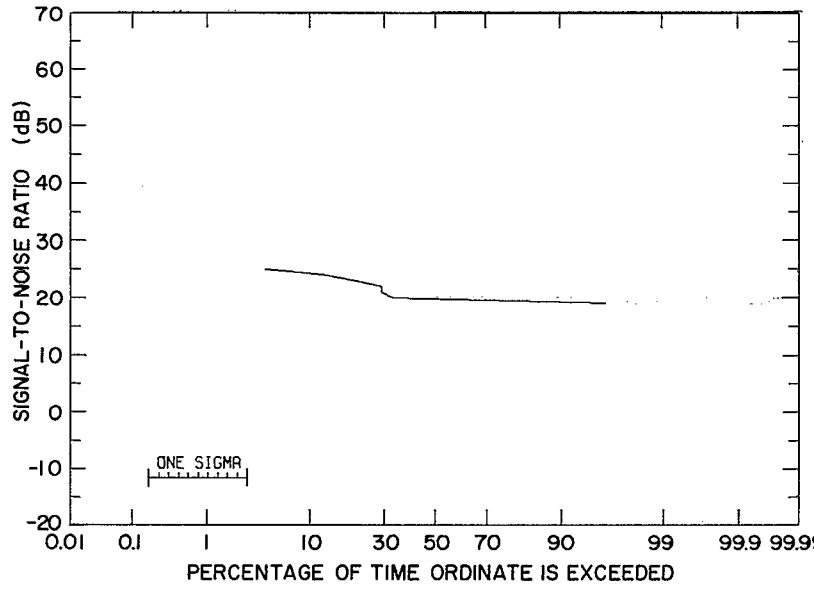


Fig. 126 - Probability plot of signal-to-noise ratio for NWC at Bahrain at a frequency of 24.5 kHz for one complete day during the period from 27 October to 28 October 1967.

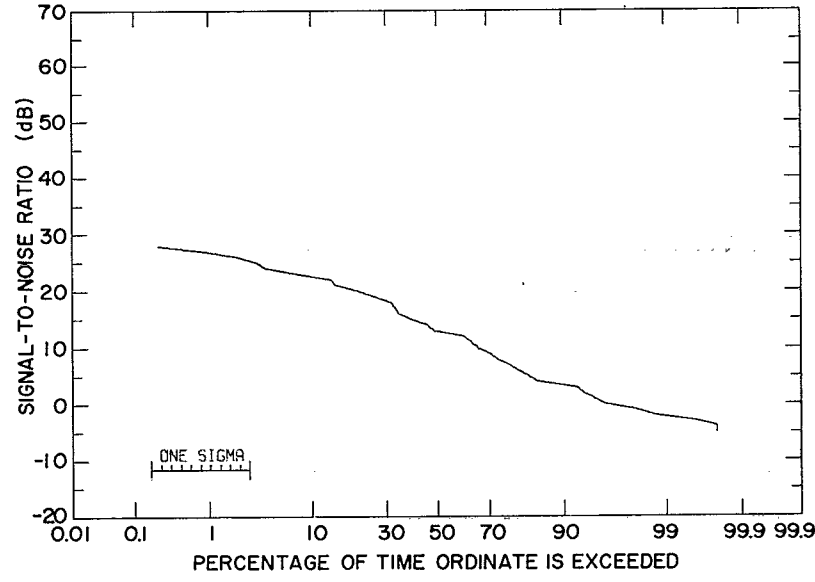


Fig. 127 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 24.5 kHz for all data recorded during the period from 22 September to 17 November 1967.

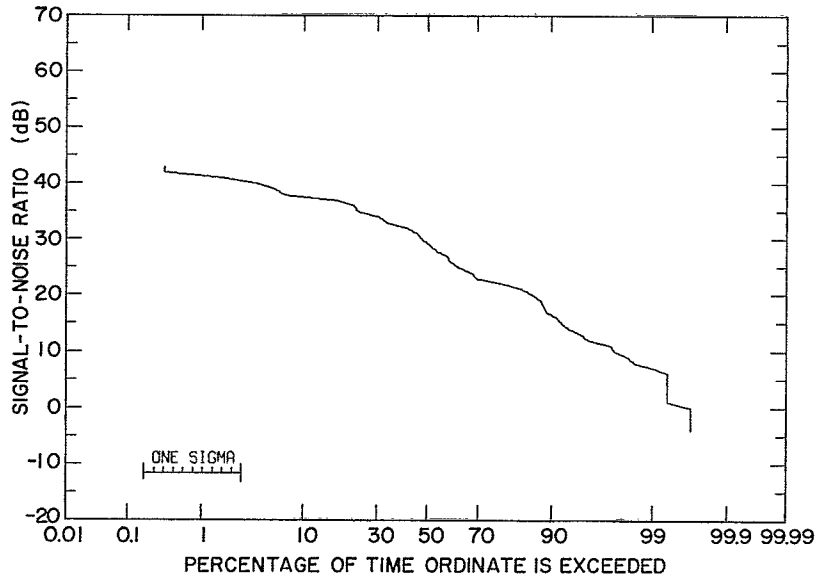


Fig. 128 - Probability plot of signal-to-noise ratio data for NWC at Japan at a frequency of 24.5 kHz for all data recorded during the period from 23 September to 16 November 1967. There were no data available for complete days during this period for 24.5 kHz at this site.

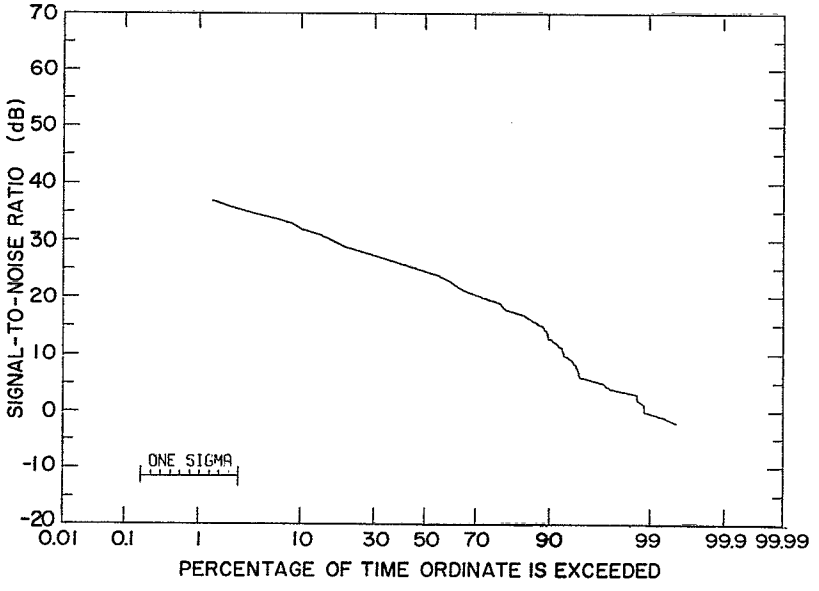


Fig. 129 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 24.5 kHz for all data recorded during the period from 8 September to 14 November 1967. There were no data available for complete days during this period for 24.5 kHz at this site.

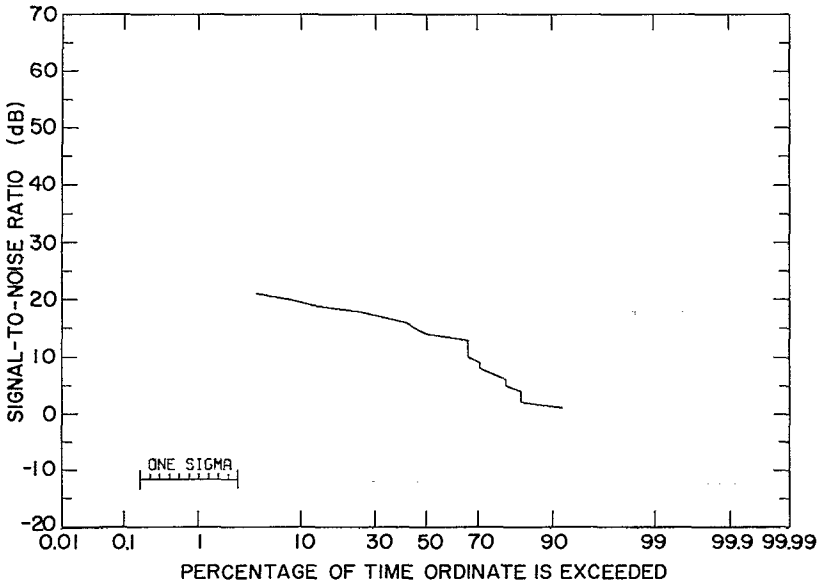


Fig. 130 - Probability plot of signal-to-noise ratio for NWC at Bahrain at a frequency of 26.8 kHz for one complete day recorded on 15 October 1967.

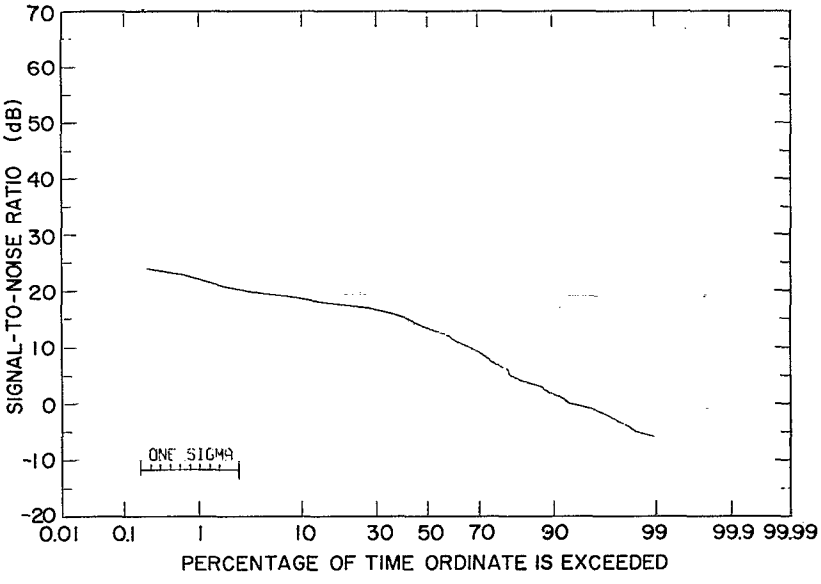


Fig. 131 - Probability plot of signal-to-noise ratio data for NWC at Bahrain at a frequency of 26.8 kHz for all data recorded during the period from 20 September to 24 November 1967.

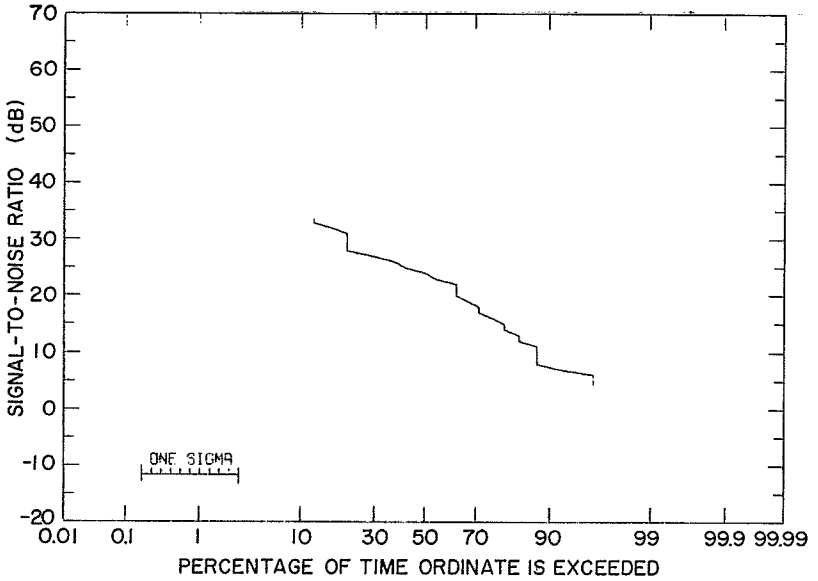


Fig. 132 - Probability plot of signal-to-noise ratio for NWC at Madagascar at a frequency of 26.8 kHz for one complete day recorded on 15 October 1967.

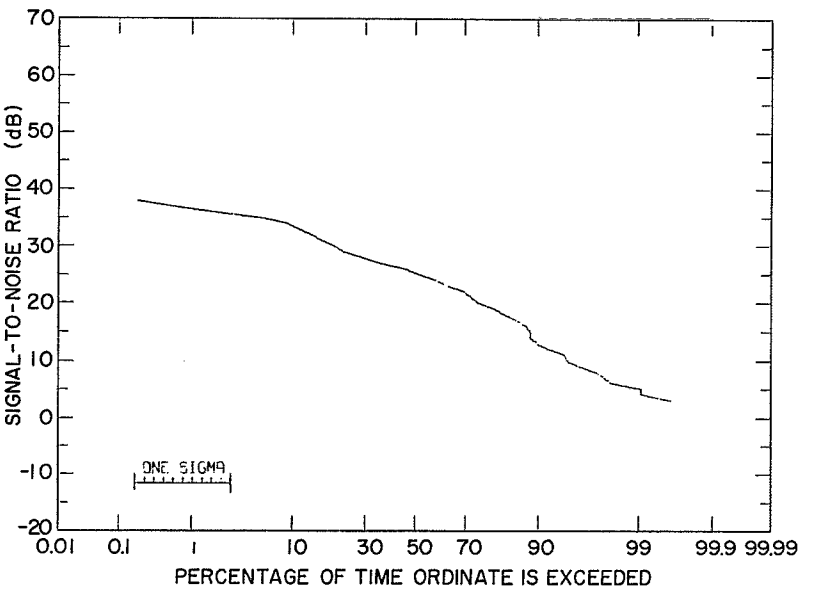


Fig. 133 - Probability plot of signal-to-noise ratio data for NWC at Madagascar at a frequency of 26.8 kHz for all data recorded during the period from 3 September to 24 November 1967.

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13. ABSTRACT

In the period from September to December 1967, the newest of the very-low-frequency (VLF) transmitting stations operated by the Navy, NWC, at North West Cape, Australia, had scheduled transmissions on six different frequencies in the VLF band. In order to obtain information on propagation paths not previously investigated, the Naval Research Laboratory installed instrumentation to collect data at selected sites in Japan, Madagascar, and Bahrain Island. Transmissions were recorded continuously for a three-month period. Examination of the data allows determination of the optimum frequency for each path investigated.

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