SKY TEMPERATURE BEHIND THE MOON [redacted]

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INTRODUCTION

It is common knowledge that if an antenna is pointed at the sky, it will receive radio noise. This noise is generated chiefly by our galaxy, the milky way. The intensity of the emissions will, of course, depend on the particular part of the sky at which the antenna is pointed; the "hottest" direction being that of the galactic center ($\alpha = 17^h 43^m$, $\delta = -28.8^\circ$).

If, now, one desires to communicate with some object that is silhouetted against the sky, and whose position in the sky changes, it is important to know the background sky temperature in the vicinity of that object. (the "temperature" is a measure of the radiated noise power). In a situation such as an amateur VHF moonbounce attempt, this information can make the difference between success and failure.

METHOD

To obtain the data, the position of the moon was determined (in equatorial coordinates) from The American Ephemeris and Nautical Almanac for 12 noon each day of the month of December 1965. These positions were then converted into galactic coordinates with the aid of appropriate coordinate conversion tables[2]. Knowing the position of the moon in galactic coordinates allowed the background sky "temperature" to be read from a radio map of the galaxy. The particular one used was plotted by Baldwin[1] at 81Mc using a $2^\circ \times 15^\circ$ beamwidth.

Since the moon's precession rate is small, the gross features of the data are valid for a year or so. Because the data varies in a periodic manner, similar plots can be made for any desired month in this valid period by simply shifting the abscissa of the curve by a multiple of one lunar orbital period (about $27\frac{1}{4}$ days). The values can also be extrapolated to other frequencies by the approximate formula:

$$T_x = T_o \left(\frac{f_o}{f_x}\right)^{2.7}$$

While the details of the radio sky may vary with frequency somewhat, the main features will not change.

RESULTS

The end result of all this work is the curve shown in figure 1, ~~plotting background sky~~ temperature behind the moon for 144Mc. Note that for about 3 days out of the month the moon is passing directly across the center of the milky way, resulting in very high noise temperatures in the antenna beam. As an example of what effect this can have on 2 meter moon bounce communications, consider the following case:

bandwidth - 1 kc
Pre-amp noise figure = 2 db
Sky temperature = 400° K
Received signal = -140 dbm

The pre-amp noise figure can be converted to an equivalent noise "temperature" by the relation:

$$T = 290\ (N-1) \text{ degrees Kelvin}$$

where N is the noise factor. The sky radiation can then be added directly to this pre-amp noise temperature, since they have the same effect and are in the same units. The total noise can then be converted back to more familiar units of power by:

Noise power = KTB
where: $K = 1.6\text{X}10^{-23}$ = Boltzman's Constant
T = sky temp. + pre-amp temp.
B = system bandwidth

[redacted]

Under these conditions, the noise power is computed as being -142 dbm, and the received signal to noise ratio will be:

$$S/N = +2 \text{ db}$$

Now consider what happens if the same system is used when the moon is in front of the galactic center. In this case:

Sky temperature = 3000° K,

so Noise power = KTB = -133 dbm.

The signal, however, is still only -140 dbm, so that the received signal to noise ratio under these conditions has dropped to -7 db! This kind of variation can easily make the difference between success and failure.

Values for other frequencies can be determined by dividing readings from figure 1 by the appropriate factor from figure 2 (a table showing the relative noise strengths for various amateur bands). Clearly the problem lessens with increased frequency, and becomes negligible at 1296Mc.

Table 3 gives a list of approximate dates of future "noise maxima" which should be avoided for VHF moon bounce attempts (unless the system is designed to handle these conditions).

FIGURE - 1

SKY TEMPERATURE BEHIND THE MOON VS. DATE

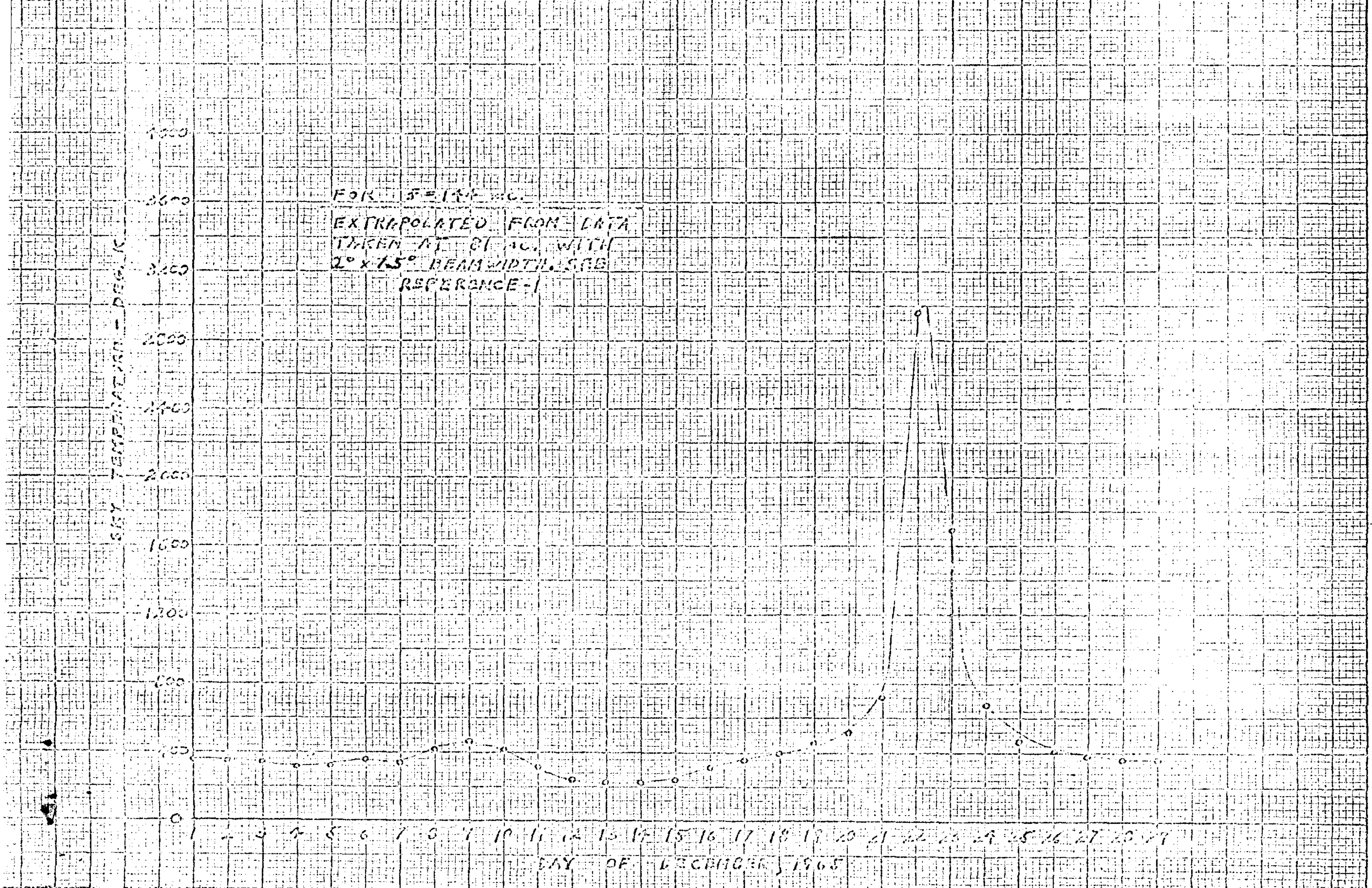

Figure 2

FREQUENCY CONVERSION FACTORS

For a Freq. of:	Divide Values of Curve by:
50 Mc.	0.058
144	1.00
220	3.15
430	19.3
1296	380

Figure 3

Dates of Noise Maxima

(for a moon-tracking antenna)

July 27, 1964
August 23
September 20
October 17
November 13
December 10

Jan. 1, 1965
Jan. 28
Feb. 25
March 24
April 21
May 18
June 14
July 11
August 8
September 4
October 1
October 29
November 25
December 22

REFERENCES

(1) Baldwin, J.E. — "A survey of the Integrated Radio Emission at a Wavelength of 3.7M.", Monthly Notices of the Royal Astronomical Society 115, Pages 684-689.

(2) Annals of the Lund Observatory, No. 15, 16, 17.