Measurement of Carrier-to-Noise due to Sun Interference Effect on C-band for THAICOM 2 Down-link Station at Mung, Khon-kaen

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Abstract : This paper studies on Sun interference effects or Sun outage effects on C-band satellite reception signal for THAICOM2. The THAICOM2 satellite is at 78.5 degree East [co-located with THAICOM3]. The down link station was located in Khon-kaen, longitude 102.83 degree East and latitude 16.43 degree North. The antenna diameter is 4.6 meters for C-band downlink station. Total 9 times of sun interference events were occurred during summer and fall of 2001 and those about 53 minutes altogether. The Maximum C/N degradation of the THAICOM2 system was around 11dB. The Sun interference events of 53 minutes of one year are 0.0122 percents of the C-band contact time when 21 hours of contact time is used for broadcasting a day.

Keyword: Sun interference, Sun outage, C-band

1. Introduction

THAICOM2 satellite was launched on October 7th, 1994 and used for television, radio broadcasting and nation communication. The C-band footprint coverage includes Thailand, Laos, Cambodia, Myanmar, Vietnam, Malaysia, Philippines, Korea, Japan and The East cast of China, with a nominal EIRP of 36dBW. The Ku-band footprints of THAICOM2 provide a high powered spot beam for Thailand with a nominal EIRP of 50dBW which is ideally suited to direct broadcasting applications. The satellite is flying over the equator at a height of around 38,600km. It flying speed is corresponding to angular velocity of the earth [1].

The Sun interference will be occurred when the Sun is just behind the spacecraft, view from the ground antenna system. During the moment, the noise temperature of the receiving antenna rises abruptly and the communication link is failed due to the noise from the Sun. For geostationary satellite system, the Sun interference happens once a day for several minutes during a few days near the spring and fall equinoxes. The number of Sun interference and their duration depend on the minimum tolerable carrier-to-noise (C/N) ratio [2]. It also depends on the movement of the Earth with respect to the Sun. This phenomenon commonly leads to total disruption of service in C- or Ku-band networks, this can degrades of availability to 99.98 percent [3]. For the geostationary satellite system, the sun outage phenomenon is well predicted and the Sun outage prediction programs have been developed by many Authors [4].

Figure 1 shows geometric position of Earth, Satellite and the Sun. When Sun interference phenomenon occurred we found they were in the straight line.

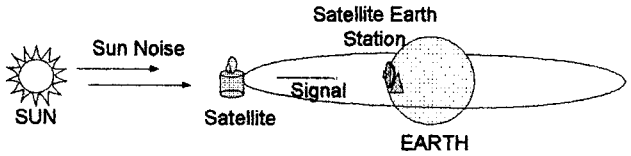

Figure 1. Earth, Satellite and the Sun are in the straight line when Sun phenomenon occurs.

In this paper, we performed the measurement of Sun interference event for the THAICOM2 in 2001 and summer of 2002 to observe and compare with prediction from THAICOM network operation control.

2. Theory

For satellite communications for C-band, the main allocations were 5.925 to 6.425GHz for uplinks and 3.700 to 4.200GHz for downlinks for commercial systems.

The Noise temperature is a useful concept in communications receiver, since it provides a way of determining how much thermal noise generated by action and passive devices in receiving systems. Noise temperature are also on antenna, we call "Antenna Noise Temperature (T_{ant})". An increase in T_{ant} will occur when attenuation in the atmosphere is present due to rain and noise from the Sun when just behind the satellite and located to antenna beam because brightness temperature of the Sun is about 12,000 K in 4GHz frequency band (ITU-R recommendation PI. 372-6). For the results, T_{ant} must take C/N at receiver to low level when Sun outage is present.

The system noise temperatures (T_{sys}) of a noise source located at the input of a noiseless receiver will increase follow the antenna noise temperature (T_{ant}). The link equation for performance of receiving systems can be written in terms of Carrier-to-Noise ratio (C/N) at earth station Eq(3).

$$(C/N)_{down} = EIRP + G_R - FSL - k - T_{sys} - B_N \quad (1)$$

when

$(C/N)_{down}$ = Down link Carrier-to-Noise ratio [dB]

$EIRP$ = Effective Isotropic Radiation Power [dBW]

G_R = Receiver Antenna Gain

$= 10 \log \eta (\pi D/\lambda)^2$ [dBi]

when

η = Antenna efficiency

D = Diameter of receiver antenna (m)

λ = Wave length (m)

FSL = Free space loss

$= 10 \log (4\pi r/\lambda)^2$ [dB]

when

r = Distance from earth station to satellite is 38,600km

k = Boltz man's constant

= -228.6 dBW/K/Hz

T_{sys} = System noise temperature

$= T_n + T_{ant}$

when

T_n = Noise temperature of source in kelvins (290K) [dBK]

T_{ant} = Antenna noise temperature [dBK]

B_N = The equivalent noise band width

$= 10 \log (B)$ [dB]

when

B = Band width of power measurement [dBHz]

When occurred of the Sun interference, the Δ(C/N) has to concern. The (C/N) ratio degradation is expressed by Eq.(2) [1][4].

$$\Delta(C/N) = [T_{sys} + T_{sun}]/T_{sys} \quad (2)$$

where T_{sys} is the system noise temperature [dBK] and T_{sun} is the antenna noise temperature [dBK]

3. Experimental Details

3.1 Measurement Setup

We used satellite downlink station of CH3 (BEC) and CH9 (MCOT) television broadcasting stations at Mung, Khonkaen province to receive signal from THAICOM2.

Table 1. Measuring apparatus parameters

Frequency [MHz]	3,950 and 3,865
Band width [MHz]	18
ANDREW satellite antenna[m]	4.6
STANDARD satellite receiver [Band]	C
GARDNER COM. LNB Gain [dB]	58
RG6 cable feeder [m]	40
Mode of dowlinks	Analog and Digital
Polarization	H

The 4.6m satellite antenna of ANDREW model ESA46-114 and C-band satellite receiver of STANDARD model MT900 was setup for observations. Also the frequency of 3,950 MHz for CH3 and 3,865 MHz for CH11 (PRD) were used for measurements. Table 1 shown the parameters of our measuring apparatus. Antenna look angle for THAICOM2 at Khonkaen province is elevation 56.1° and azimuth 238.0°. The spectrum analyzer of ADVENTEST model R4131C is used for measurement and data are recorded on 11st to 16th March 2002.

3.2 Measurement results and calculations

Figure 2 and 3 show normal condition of broadcasting when no Sun interference effects. Figure 2 shows frequencies response of CH11 (PRD) on digital mode.

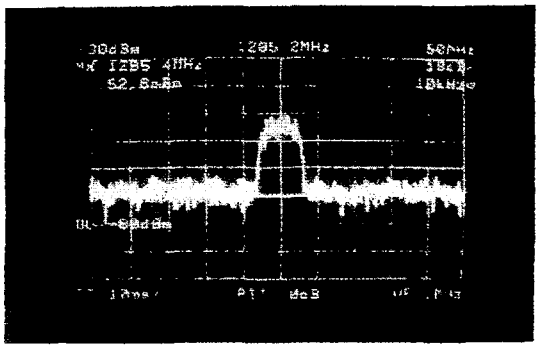

Figure 2. The digital L-band satellite signal at 1,285.2 MHz when no Sun interference.

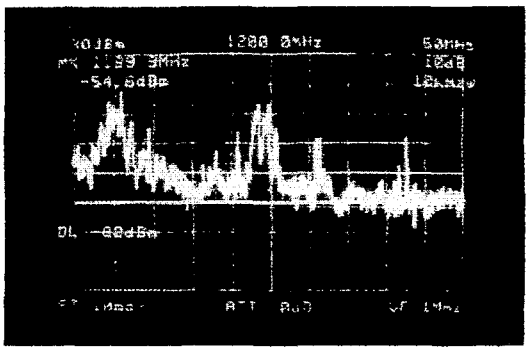

Figure 3. The analog L-band satellite signal at 1,200 MHz when no Sun interference.

The downlink frequency is 3,865MHz and L-band is 1,285MHz(5,150-3,865MHz). The signal level is around –56dBm while noise floor is –75dBm and the C/N is around 19dB. The C-band analog mode is shown in Figure 3. This is CH3 of Bangkok Entertainment Company (BEC). Downlink frequency is 3,950 MHz and L-band frequency is 1,200 MHz. The signal is –54.6dBm and carrier-to-noise is around 15dB. Figure 4 shows spectrum of frequencies response when Sun interference effect. The observed C/N results in Figure 5 on normal broadcasting condition is around 15dB, the first day of the Sun interference is on March 12th, 2002. The C/N at 14:06pm is degraded from 15dB to 6dB at 14:10pm and increased to 15dB at 14:14pm. The duration time of the Sun interference is 8 minutes. The maximum C/N change was around 11dB as shown on Table 2. The most effect of Sun interference has occurred on the second day (Mar 13th, 2002).

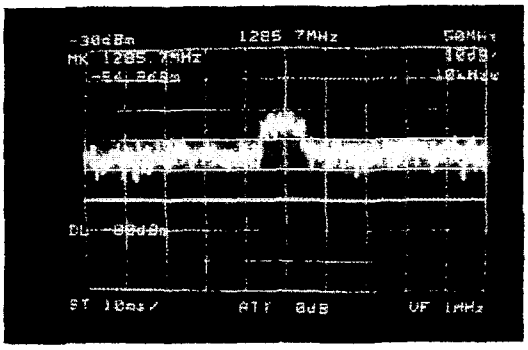

Figure 4. The digital L-band satellite signal at 1,285 MHz *with Sun interference effects.*

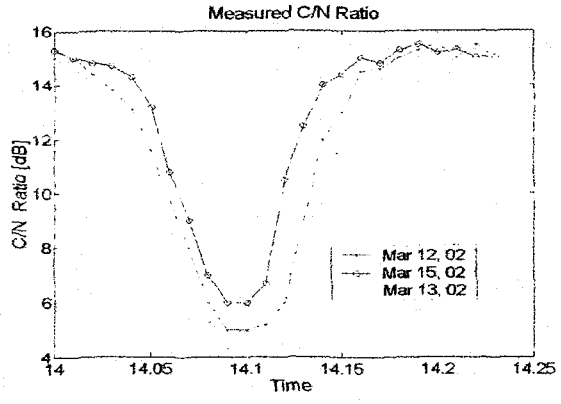

Figure 5 C/N ratio on 12nd to 15th March 2002 at downlink station of CH3 frequency at Mung, Khonkaen. The C/N level is lowest around 4dB, on 13th March 2002.

The C/N ratio at 14:10pm is around 4dB and is the lowest value. The duration time is about 9 minutes. March 15th, 02 is the last day of Sun interference that effects on broadcasting. The C/N is around 6dB at 14.10pm. No Sun interference phenomenon appear in March 11st, 2002 and March 16th, 2002.

Table 2. The Sun interference phenomena effects on summer 2002.

Case	D/M/Y	Start Time h:m	Stop Time h:m	Duration h:m	Maximum Δ(C/N) [dB]
1	12/03/02	14:06	14:14	00:08	10
2	13/03/02	14:06	14:15	00:09	11
3	14/03/02	14:06	14:14	00:08	10
4	15/03/02	14:05	14:11	00:06	9

Shows sun interference phenomena occurred in March 12nd, 2002 to March 15th, 2002 on Table 3. The duration time is 14.06pm to 14.11pm. The maximum C/N degradation is 11dB.

Table 3 shows list of the Sun interference effect for THAICOM2 downlink station at Mung, Khonkaen in year 2001. There are total 9 times of Sun interference, 4 times in March 2001, 3 times in September 2001 and 2 times in October 2001. The duration time in March 2001 are around 14.04-14.11pm while in September and October 2001 are around 13.46pm-13.54pm. The Maximum ΔC/N degradation is around 11dB.

Table 3. Sun interference was measured for the THAICOM2 downlink station at Mung, Khonkaen in year 2001

Case	D/M/Y	Start Time h:m	Stop Time h:m	Duration h:m	Maximum ΔC/N [dB]
1	12/03/01	14:05	14:09	00:04	9
2	13/03/01	14:04	14:09	00:05	10
3	14/03/01	14:04	14:11	00:07	11
4	15/03/01	14:07	14:11	00:04	8
5	28/09/01	13:50	13:57	00:07	9
6	29/09/01	13:48	13:55	00:07	10
7	30/09/01	13:46	13:54	00:08	11
8	01/10/01	13:46	13:53	00:07	9
9	02/10/01	13:48	13:52	00:04	8

From ITU-R recommendation PI.372-6[1]. The brightness temperature of quiet Sun in 3GHz band is 13000K, provided that antenna pattern we got antenna noise temperature of 3GHz in Figure 6.

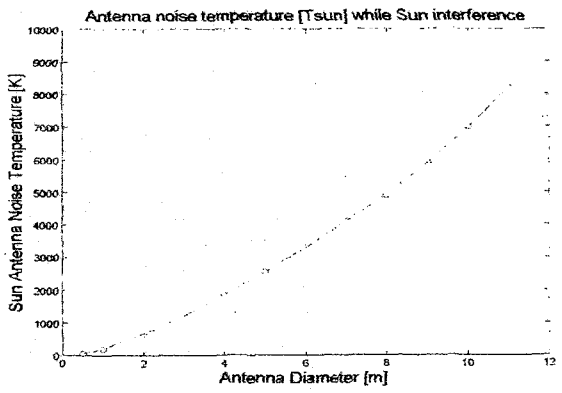

Figure 6. Plot of antenna diameter vs the Sun antenna noise temperature. (From ITU-R recommendation PI.372-6 at C-band frequency.)

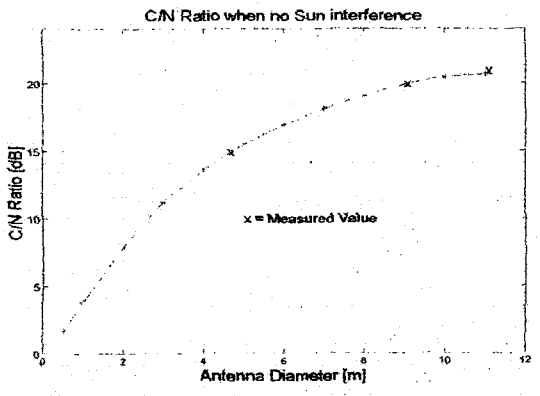

Figure 7. The results of C/N ratio calculation when no Sun interference effect compared with antenna diameter.

The calculation of C/N ratio when no Sun interference effect compared with antenna diameter by using link equation in Eq.(1) is given in Figure 7. The results of 4.6m antenna diameter is around 15dB, this value is near the measured value of earth station at Mung, Khonkaen. The results of 9m antenna diameter is around 19dB, this value is near the measured value of earth station at Kaoyaitieng, Nakornrajasima and for the 11m antenna diameter we found that the C/N is 22dB, which near the measured value of 11m antenna diameter of earth station, Nongkaem, Bangkok.

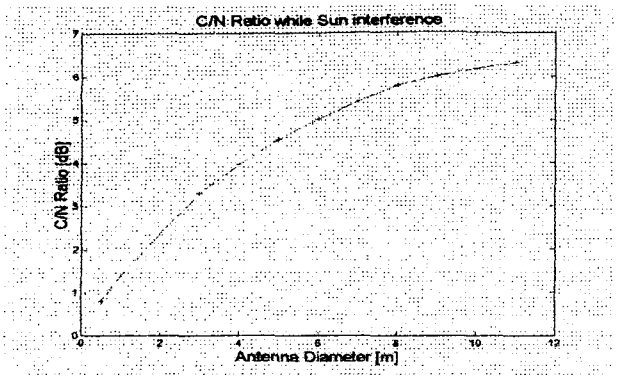

Figure 8.The C/N ratio with Sun interference effect.

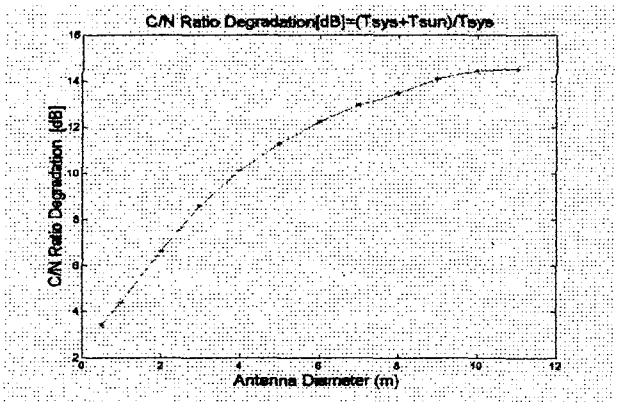

Figure 9. C/N degradation when Sun interference

The average C/N ratio on clear sky day from observation is 15dB at Khonkaen and 22dB at Bangkok. The system noise temperature was calculated as 23dBK(200K) and 24.5dBK (290K) respectively.

With the Sun antenna noise temperature in the link equation Eq.(1), we can show the C/N ratio with Sun interference in Figure 8. We found that the results of 4.6m antenna diameter, the C/N is 3.9dB. This value is nearly the measured value in March 13th, 2002 at Khonkaen. The 8m and 11m antenna size are 5 and 6.5dB respectively. These values are near the measured value at Nakornrajasima station on May 13th, 02 and Bangkok station on May 14th, 2002 respectively.

The C/N ratio degradation by Eq.(2) can be ploted as in Figure 9. We found that, for the large diameter of antenna, the C/N degradation in 4GHz is up to 15dB.

4. Discussions

For C-band satellite broadcasting, we found that while Sun noise occurred, the noise floor is grow up that can be able to reduce C/N ratio both in digital mode (CH11) and analog mode (CH3). The C/N ratio degradation was about 9dB to 11dB for 4.6m earth station antenna in Figure 5. The duration time was about 4 to 9 minutes in Table 2 and 3.

Sun antenna noise temperature can be rise around 13000K from ITU-R recommendation for 3GHz band. The actual temperature raises considerably with solar activity in Figure 6.

We found that the calculations and observations of C/N ratio when no Sun noise occurs for 4.6m, 9m and 11m antenna size are close together as in Figure 7.

From observation of Sun noise effect at CH3, CH9 downlink station at Mung, Khonkaen compared with prediction on Sun outage by THICOM Network Control System, we found that prediction has an error on 11st and 16th Mar 2002, as no Sun noise occurred on those days.

The Sun interference was occurred total 4 times in summer of year 2002. The most sun noise effect occurred in March 13rd, 2002. From observation we found that if C/N ratio lower than 10dB, it started the effect on picture of TV monitor.

5. Conclusions

In this paper we observed and calculated Sun noise effected on C-band satellite broadcasting for THAICOM2 dowlink station at Mung, Khonkaen.

The paper shows maximum C/N ratio degradation and the time of Sun interference. In year 2001, total 9 times of the Sun interference was occurred and they are total 53 minutes. When 21 hours of contact time is used for broadcasting in a day, those about 0.0122 percents of C-band contact time in one year are effected by sun interference.

6. Acknowledgements

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