CABLE HEADEND POLARIZATION ALIGNMENT CONCERNS DURING PEAK SUNSPOT CYCLE

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ABSTRACT

The polarization angles of satellite dishes used for cable headends may have more error during the next few years than ever before. This is due to the diurnal variation of incident polarization angle, which is on an upswing recently due to heavy solar activity which should persist and worsen before abating.

A combination of night and day time polarization alignment of cable headend dishes may be preferred by cable operators in some parts of the world where this effect is strongest. This paper describes the phenomena of Faraday Rotation which causes polarization mis-alignment. It identifies regions of the earth where cable headends would find the strongest effect and recommends methods to minimize degradation due to this effect. Prediction data from NOAA (National Oceanic and Atmospheric Administration) is reported, showing the anticipated peak period of polarization rotation to be early 1990.

BACKGROUND

Some satellite users have experienced interference recently on C-band satellites due to a propagation phenomena called Faraday Rotation. Under current conditions of above normal solar activity, uplink and downlink signals are skewed in polarization as they encounter the ionosphere (see Figure 1.). As a result, a signal in one polarization may bleed into the opposite polariza- tion enough to cause interference (cross-pol interference).

Since cross-pol interference is usually caused by incorrect earth station antenna alignment, many satellite uplinkers have recently received close scrutiny in order to determine the source of interference. During this period of high solar activity, it is more difficult to maintain proper antenna polarization alignment for all users because the amount of rotation depends on frequency and time of day.

The present high level of Faraday rotation is anticipated to abate during the summer before reaching a maximum next winter (see Table 1.). The last maximum was reached in winter 1957/58 and it should be a similar period in the future before the next maximum occurs. What follows is a technical description of Faraday rotation with advice regarding ways to prevent or mitigate interference.

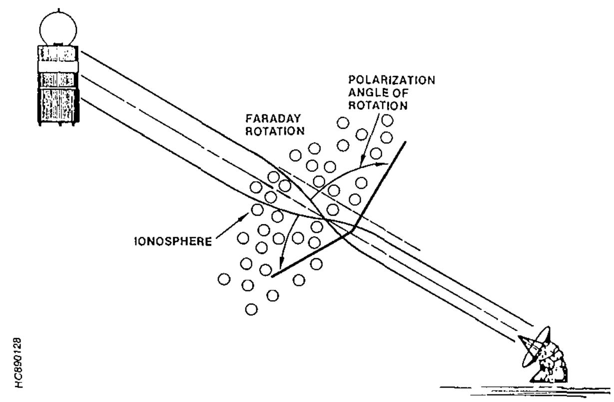

FIGURE 1. POLARIZATION ROTATION

INTRODUCTION

Faraday rotation, a natural occurrence arising from the introduction of ions into the ionosphere via solar radiation, has recently caused interference to some users of C-band satellites. Faraday rotation is the rotation of the electric field vector of a signal as it passes through the ionosphere.

SMOOTHED (OBSERVED AND PREDICTED) SUNSPOT NUMBERS: CYCLES 21 AND 22 (VALUES AFTER APRIL 1988 ARE PREDICTED)												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	164	163	161	159	156	155	153	150	150	150	148	143
1981	140	142	143	143	143	142	140	141	143	142	139	138
1982	137	133	129	124	120	117	115	109	101	96	95	95
1983	93	90	86	82	77	70	66	66	68	68	67	64
1984	60	56	53	50	48	46	44	40	34	29	25	22
1985	20	20	19	18	18	18	17	17	17	17	17	15
1986	14	13	13	14	14	14	14	13	12*	13	15	16
1987	18	20	22	24	26	28	31	35	39	44	47	51
1988	58	64	71	77	84	90	99	108	115	122	127	132
1989	135	139	147	154	161	166	169	172	179	184	185	186
1990	186	186	184	178	172	168	167	164	157	149	142	138

*SEPTEMBER 1986 MARKS THE ONSET OF SUNSPOT CYCLE 22.

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TABLE 1. (FROM THE JOURNAL OF SOLAR-GEOPHYSICAL DATA, OCT. 1988

The degree of Faraday rotation is now approaching a maximum linked to the long term solar cycle, and interference is arising in cases where it never before existed. The present prediction is that the peak will occur near February 1990, but this date is uncertain. Seasonal and diurnal(daily) variations also occur.

If interference occurs strongest in the middle of the day, and not at all at night, then Faraday rotation may have contributed to the interference.

There is no procedure known which eliminates Faraday rotation. What follows are some recommendations to satellite users of ways to minimize Faraday-induced interference.

RECOMMENDED PROCEDURES TO MITIGATE EXCESS INTERFERENCE

If you have not yet created or experienced any interference due to Faraday rotation, it is possible that you will neither create nor experience any such interference in the future. In this case there is no need to adjust any antennas.

If you have created or experienced interference due to Faraday rotation, or if you wish to take precautionary measures, we recommend following these guidelines.

a. For Fixed Transmit-Only Antennas

The polarization orientation of a transmit-only antenna should be adjusted to be midway between the extreme positions of proper uplink polarization angle (midway should be reached by rotating the top of the polarizer to the East from its nominal position). (See section 4.a for a step-by-step procedure.)

b. Fixed Receive-Only Antennas

The polarization orientation of a receive-only antenna should be adjusted to be midway between the extreme positions of proper downlink polarization angle (midway should reached by rotating the top of the polarizer to the West from its nominal position). (See section 4.b for a step-by-step procedure.)

c. For Fixed Transmit-Receive Antennas

The polarization orientation of a transmit-receive antenna should be adjusted to be midway between the extreme positions of proper uplink polarization angle (midway should be reached by rotating the top of the polarizer to the East from its nominal position). (See section 4.a for a step-by-step procedure.)

d. For Transportable Uplinks

If the uplink is for a short period (hours vs. days), then present day practices are unchanged. If the uplink is for a period of a few days, then follow the guidelines for a fixed uplink (3.a).

STEP-BY-STEP PROCEDURES

a. For Fixed Transmit-Only Antennas

Step 1. Conduct Night and Noon X-pol Checks. Contact your satellite operator to schedule a nighttime cross-pol (X-pol). Check for a time when it will be dark at the uplink site and a subsequent daytime X-pol check near local noon.

Step 2. Conduct Night X-pol Check. It should be dark during the first X-pol check so that the nominal polarization orientation of the dish may be determined. Mark the nominal polarization angle thus determined.

Step 3. Conduct Noon X-pol Check. Repeat the X-pol check near midday to determine proper noon polarization. Mark the noon polarization angle thus determined. Before ending noon X-pol check, adjust antenna polarization to the point midway between the nominal and noon polarization marks, checking to see if this yields a satisfactory value of X-pol.

On some days the amount of rotation will be higher than other days. Peak rotation for a given day is difficult to impossible to predict. Therefore, if interference persists, it may be required to perform the foregoing procedure again.

b. For Fixed Receive-Only Antennas

Step 1. During dark hours adjust polarization to nominal and mark. (Two port systems should adjust by nulling the opposite polarization.)

Step 2. Near noon readjust polarization to noon position and again mark.

Step 3. Final antenna polarization adjustment should be midway between the nominal and noon polarization marks.

On some days the amount of rotation will be higher than other days. Peak rotation for a given day is difficult to impossible to predict. Therefore, if interference persists, it may be required to perform the foregoing procedure again.

c. For Fixed Transmit- Receive Antennas

Step 1. Follow procedure outlined in 4.a.

Step 2. Observe receive signals for cross-pol interfer- ence. If there is none, the antenna is adjusted properly. If there is cross-pol interference, again adjust cross-pol near local noon and rotate antenna polariza- tion angle from noon mark towards nominal mark (top of polarizer from West to East) until acceptable cross-pol is achieved. Mark as minimum noon position.

The unfortunate fact that the adjustments for transmit and for receive during extreme rotation are opposite, forces the above compromise, which insures adequate uplink cross-pol discrimination while achieving the best possible simultaneous downlink cross-pol discrimination.

TEMPORAL VARIATION OF ROTATION

Diurnal, seasonal and long term variations are such that the night-time rotation is approxi- mately the minimum rotation (nominal) - see Figure 2. Maximum rotation varies a great amount each day during concurrent seasonal and long term maxima. Considering this, one would like to align one's antenna's polarization using the step-by- step procedures previously outlined on a very active solar day, in order to not have to repeat the procedure.

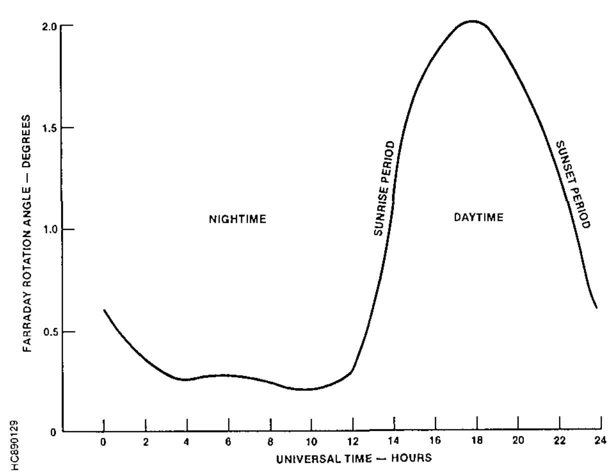

FIGURE 2. TYPICAL DAILY VARIATION OF POLARIZATION ANGLE (1982, NEW YORK @ 4 GHz)

Seasonal and diurnal variations are shown in Figure 3.

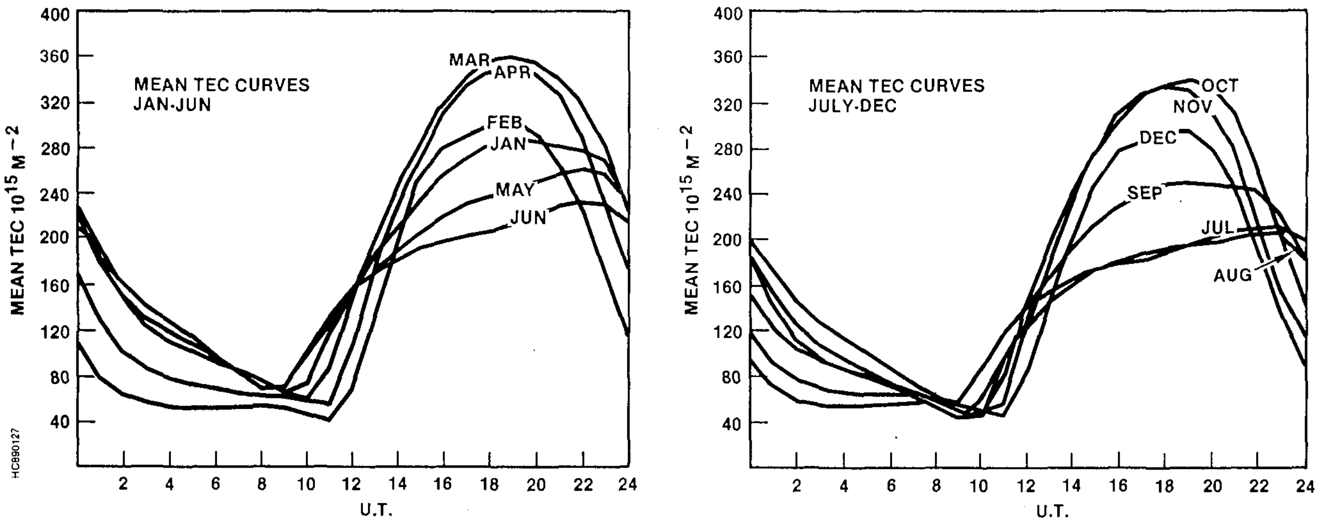

FIGURE 3. DIURNAL VARIATIONS IN TEC, MEAN MONTHLY CURVES FOR 1967 TO 1973 AS OBTAINED AT SAGAMORE HILL, MA USING 136 MHz SIGNALS FROM ATS-3 (AFTER HAWKINS AND KLOBUCHAR, 1974)

DIRECTION OF ROTATION

The downlink rotation experienced in the northern hemisphere is counterclockwise when looking towards the satellite (see Figure 4.). The uplink rotation experienced in the northern hemisphere is also counterclockwise when looking towards the satellite. In the downlink case a counterclockwise correction (top of the feedhorn to the East) is required. In the uplink case a clockwise correction (top of the feedhorn to the West) is required.

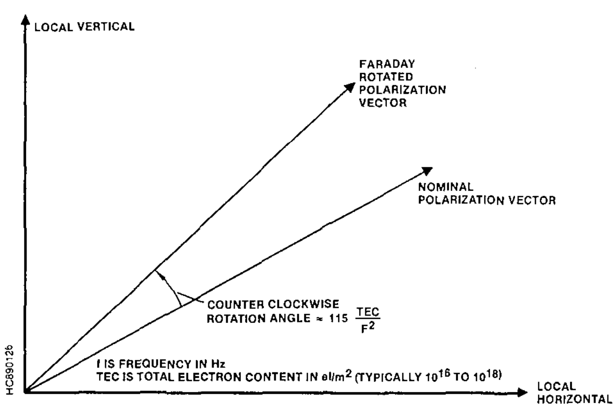

FIGURE 4. FARADAY ROTATION (SATELLITE DIRECTION IS INTO THE PAPER)

FACTORS DETERMINING DEGREE OF ROTATION

The degree of Faraday Rotation primarily depends on: the frequency of signal transmission, the ionization level of the ionosphere, the angle between the direction of propagation and Earth's magnetic field, Earth's magnetic field strength where the signal passes through the ionosphere, and the signal path length through the ionosphere.

The resultant crosspolarization discrimination as a function of rotation angle is shown in Figure 5.

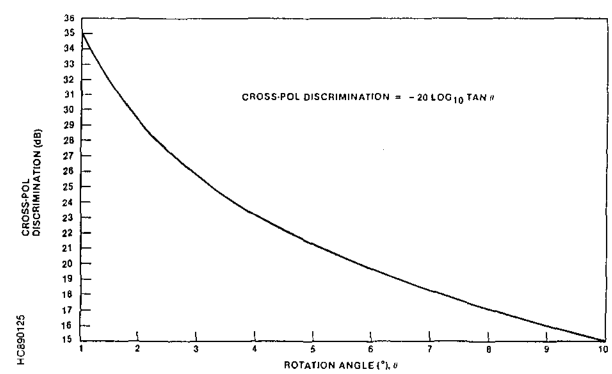

FIGURE 5. CROSS POLARIZATION DISCRIMINATION VS. MIS-ALIGNMENT ANGLE (i.e., FARADAY ROTATION ANGLE)

FREQUENCY DEPENDENCE

Polarization rotation is inversely proportional to the square of transmitted signal frequency (e.g. the relative rotation at twice a certain frequency is one-fourth of the amount found at the lower frequency). If an antenna is aligned at one end of the frequency spectrum, it may be misaligned at the other. Therefore, care should be taken to adjust for the proper polarization orientation at the frequency which is to be used, or at a middle-frequency of the signal frequencies used by an antenna. The polarization orientation disparity for transmit-receive antennas (due to differing transmit and receive frequencies) requires a slight sacrifice of receive polarization discrimination in order to insure (by adjusting for optimal transmit polarization orientation) that interference is not caused by the transmit operation of such an antenna.

TELEMETRY CARRIER AS RECEIVE POLARIZATION REFERENCE

A particularly pure polarization reference for receive-only antenna polarization alignment is the satellite telemetry carrier located between 4,198 MHz and 4,200 MHz (in the horizontal polarization for the Galaxy Satellites). A signal may be present at the same frequency as the telemetry carrier but in the opposite polarization (trans ponder 24), necessitating careful use of a spectrum analyzer in order to null properly. Frequency correction for proper polarization orientation is important when using the telemetry carrier for initial alignment if the antenna is to be used to receive signals at the lower end of the receive band (near 3,700 MHz) as the telemetry carrier is located at the uppermost extreme end of the receive frequency band.

CONCLUSION

Faraday rotation has become a concern to satellite users. Its impact can be minimized by the method described. The best predictions indicate that this rotation will be at its worst near February 1990. The physics of Faraday rotation is well understood (see references) and the variables which determine the degree of rotation are predictable but there is significant uncer- tainty in these predictions and the variables themselves are impossible to control.

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