nsma
national spectrum managers association

Report WG 16.89.006

APPLICATION FOR ANGULAR DIVERSITY ANTENNA SYSTEMS
and
DISCUSSION OF ANTENNA PATTERN MEASUREMENTS

www.nsma.org

1990

Source: Working Group 16

REPORT

Subject: Angular Diversity / Antenna Pattern Measurements

Title: Application of Angular Diversity Systems and Discussion of Antenna Pattern Measurements

Consideration for the application of Angular Diversity Systems and the possible need to expand characterizing azimuthal and elevational measurements of terrestrial microwave antennas.

REPORT WG 16.89.006

1. PURPOSE

This paper reports the results of the Working Sub-Group # 16's study to determine the needs for addition measurements to further define the electrical characteristics of Terrestrial Microwave Antennas for improving the evaluation of direct and terrain reflective scatter interference The introduction presents a brief culmination don of inter-dependent conditions contributing to system degradation and general corrective actions In considering direct and reflective terrain scattering interference and the application of Angular Diversity Systems empirical data from 2170 separate cases are analyzed and the results provide a basis concluding that only the vertical angle up to 26° below the m in beam is necessary

2. INTRODUCTION AND EVALUATION

during the pest several years, the telecommunications done industry has become more aware of the quality of service and the impact of controlling microwave path propagation and interference The conversion to Digital Transmission has necessary a continuous us evolution of technical advancements in sophisticated equipment operating at higher levels of modulation states and faster bit rates Many of the improvements address hardware problems that can be effectively controlled by employing stability and linearity refinements to solid state components precision filtering adaptive power control adaptive and transversal equalizers and delay compensation that dynamically enhance the signal processing However a remaining source of system degradation is the reflective characteristics along the microwave path that the wavefronts encounter as they are propagated to the distant receive antenna Frequently the intended electrical field polarization is rotated dynamically delayed or severely altered by frequency selective dispersive multipath fading or flat attenuation within the channel bandwidth combined with overreach interference The< application of interference negators frequency and antenna diversity systems have barn successfully utilized to gain supplemental improvements to control inter-symbol distortion To ova effectively improve the and the quality of transmission performance, angular antenna diversity has been considered in an attempt to control dispersive type fading along with the traditional antenna space diversity being utilized to reduce the impact of flat fading The angular antenna diversity systems present a unique set of circumstances

First, let's consider the path condition being addressed with the antenna-diversity systems.

1) Terrain reflective scattering occurs below the main beam (boresight) of the transmit and receive antenna on the common path or when a foreign signal intersects with and/or adjacent to the intended path at a point where sufficient land cover may cause a low level reflected signal to be radiated out of phase and at a reduced level combined with the desired signal at the victim receiver Other signals from other sources may also be reflected from objects in the foreground of either the transmit or receive antenna to produce a similar result

2) Multipath a atmospheric fading occurs whenever there are variations causing the density to change. Usually large variations in temperature and humidity (summer and fall of 1988) accompany multipath fading which is characterized by deep, fast, frequency selective signal attenuation over a period of time. Since at a given moment in tine, each frequency in the band width is affected differently, dispersive fading usually results and angular diversity may be utilized to control these rapid varying conditions.

Either space or angular diversity systems can be effective in stabilizing these conditions to minimum variations when used with continuous, in-band power combiners in digital microwave applications.

The concerns for the calculation of interference and the possible need to conduct a range of measurements in the elevational plane on or near the boresight of antenna can best be demonstrated by observing the following histogram based on the results of 2170 separate cases analyzed through December 1988:

ANALYSIS OF TERRAIN REFLECTIVE AND FOREGROUND SCATTERING INTERFERENCE

ANGLE BELOW BORESIGHT	FREQUENCY BAND		(CASES)
	4 GHz	////////////////////////////|	348
≤ 26° (25.072)	6 GHz	//////////////////|	194
	11 GHz	//|	5
	4 GHz		
≤ 13.5° (.5532)	6 GHz	////|	12
	11 GHz		
	4 GHz	/|	3
≤ 6.9° (.507%)	6 GHz	///|	8
	11 GHz		
	4 GHz	/|	1
≤ 5.1° (.968%)	6 GHz	//////|	20
	11 GHz		
	4 GHz	/|	3
≤ 2.5° (2.17%)	6 GHz	//////////|	44
	11 GHz		
	4 GHZ	/////|	15
≤ 1.6° (3.59%)	6 GHz	///////////|	63
	11 GHz		
	4 GHz		
≤ 1.2° (3.64%)	6 GHz	///////////////|	79
	11 GHz		
	4 GHz		
≤ 0.9° (1.89%)	6 GHz	////////|	41
	11 GHz		
	4 GHz	//////////////////////|	291
≤ 0.41° (61.47%)	6 GHz	///////////////////////////|	1043
	11 GHz		

4 GHz = 661 CASES ANALYZED
6 GHz = 1504 CASES ANALYZED
11 GHz = 5 CASES ANALYZED

2170 TOTAL CASES ANALYZED

The large variance of results observed in the study, the current limitation of the terrain reflective scatter interference algorithms and the increased expense necessary to obtain elavatlonal measurements to further characterize terrestrial microwave antennas, suggests that there would not presently be significant practical payoff to justify the additional efforts. However, further review of the study results reveals that all interference sources reside below the antennas boresight displaced directly adjacent to or beneath and within the main beam width. This is true, with the exception of foreground clutter in the immediate "shadow" of the tower (within approximately 1000 feet from the base of the tower along the path azimuth) Therefore, the industry practice of conducting measurement I ± 5° In the elevational plane on the boresight azimuth is sufficient.

3 INTERFERENCE EVALUATION AND ANTENNA DIVERSITY SYSTEMS

Recently, much discussion has been heard on the issue of evaluating possible interference with other terrestrial microwave systems employing various forms of antenna diversity. Specifically, angular diversity systems employing a dual beam, single antenna or two separate single beam antennas oriented on the same azimuth but with small vertical angular displacement have increased concern for determining the composite (azimuthal and elevational) antenna discrimination. This issue becomes more complex when considering terrain reflective scatter with direct interference since there are two "normal" angular diversity configurations utilized.

1) Asymmetrical - The Lover (Sum) main beam is oriented on boresight with the mating antenna at the distant and of the common terrestrial microwave path. This Lower (Sum) main be am can be used to transmit ant receive signals on the common path dependent upon the type of translations, loading and frequency separation The Upper (Difference) main beam is oriented at a small elevations angle above the boresight with the mating antenna at the distant and of the common terrestrial path and is utilized only to receive the distant signals.

2) Symmetrical - The antenna(s) are aligned at the cross-over or null point of the Upper and Lower beams oriented relative to the boresight with the mating antenna at the distant end of the common terrestrial microwave path. Both beams are utilized in a receive only node in conjunction with in-band intermediate frequency combiners.

Typically, the antenna gain specified is at the mid-band frequency in the main beam for compliance with the FCC Rules and Regulations, Part 21 108 but the discrimination characteristics for angular diversity systems are not always relative to this sane point of referenced antenna gain. This is especially of concern when a symmetrically aligned dual bean, single antenna receive angular diversity system is utilized. To generate the radiation pattern envelope (RPE) for this arrangement, the azimuthal cut is made at the null or vertical crossover point of the two main beams. This represents a conservative approach since the discrimination is actually superior in either main beam and the gain difference is approximately 4 to 6 dB. A similar case exists for asymmetrically oriented antenna systems. The Lower Beam is aligned on boresight with the mating antenna on the distant end of the path and foreground reflections into the Lower and Upper beam have typically larger angles and hence greater discrimination is available. Terrain reflective scatter typically varies due to the polarization rotation and constant chancing of multiple signal phase delay originating from objects below the boresight of the antennas relative to the direct path.

The current algorithms utilized to evaluate terrain reflective scattering interference does not include elevational angular discrimination for the antennas and the large skewness of variance in predicting the combined reflected energy a from land clutter and man made objects define the bounds of accuracy. In consideration of the additional processing time and expense, our suggestion is that presently little value would be gained by conducting on azimuth, elevational cuts beyond a maximum of 5° below boresight while antennas are being measured on the test range.

4. RECOMMENDATION

At a minimum the following data should be reported for the characteristics of each antenna:

1.) Antenna Manufacturer

2.) Model Number ant Revision

3.) Symmetrical or Asymmetrical Alignment*

- o Symmetrical alignment shall mean that the “RPE” resulted from data taken from the teat range when the single antenna, dual bean antenna was oriented at the main beam (null) crossover point on boresight. Only one "RPE" and one FCC identification code number will be assigned.

- o Asymmetrical alignment shall mean that the “RPE” from data taken from the test range where the single antenna, dual bean antenna was oriented with the Lover main beam on boresight. The second “RPE” resulted from data taken from the test range on the Upper main beam while the Lower lobe retained boresight alignment in the main bean.

  * This information will be entered as the shirt line of date in the comment field (30 data).

4.) Reverse Pattern Identification Number

5.) Date of Data

6.) Manufacturer Identification Number

7.) Frequency Range

8.) Mid-Band Gain

- o Measured gain of the antenna Lower main bean aligned on boresight relative to an isotropic radiator regardless of symmetrical or asymmetrical alignment applications.

9.) Half Power Beam Width

10.) Polarization (HH, HV, VV, VH)

- o Both Upper and Lower main beams azimuthal (-180° via 0° through +180°) cuts and ELHH, ELHV, ELVV , ELVH for both the Upper and Lower main beam elevational (0° through +5°) cuts from boresight to 5° below and 5° above boresight with 0° azimuthal alignment.

A standard format for the electronic transfer of terrestrial antenna pattern data has been recommended to the NSMA board for approval. With the inclusion of the symmetrical/asymmetrical alignment provision, sufficient details and standards exist to accommodate this recommendation.

Report: REP.WG16.89.006
Approved: 02-08-90
To Membership: 03-90
Notes: To membership for comments 11-08-89. Per 01-26-93 mtg, WG 16 to review and issue revised report.