TRIPLE FEED C-BAND ANTENNA SYSTEM TEST AND ANALYSIS

For Use in Three-Satellite Reception of DVB-S2 8PSK Television Broadcasts

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EXECUTIVE SUMMARY

This paper provides performance analysis of a triple feed antenna system for use in simultaneously accessing the three SES Center Arc satellites carrying digital video content to cable head-ends across the United States. This system is the standard offering for SES' Center Arc Antenna Program. The purpose of the antenna program is to facilitate cable operators' ability to receive television programming from SES' center arc satellites. These satellites are:

- SES-1 at 101°W
- AMC-1 at 103°W
- AMC-18 at 105°W

The triple feed antenna system analyzed consists of a C-band triple feed system coupled with Low Noise Block (LNB) down converters/amplifiers mounted to a 3.7m parabolic reflector.

The antenna was pointed to the center satellite (AMC-1 at 103°W) and the quality of the demodulated signal received in each of the three feeds was recorded. Two types of LNBs were measured – dielectric resonator oscillator (DRO) based LNBs and, in separate tests, phased locked loop (PLL) based LNBs. The measurements were repeated multiple times over a period of three months.

The results show that a 3.7m reflector using a triple feed system with DRO LNBs has acceptable downlink performance on all three satellites for typical broadcast operations into U.S. cable head ends. The triple feed antenna system is capable of providing approximately 3dB or more of downlink margin with the reception of DVB-S2 8PSK 5/6 carriers simultaneously from three adjacent satellites.

OVERVIEW

This paper provides the test results and analysis illustrating that a single 3.7m C-band parabolic reflector antenna fitted with a triple feed system to simultaneously downlink carriers from the three adjacent SES center arc satellites will provide sufficient margin for TV reception by cable head ends.

The tests consisted of television reception across SES' three center arc satellites: SES-1 (101°W), AMC-1 (103°W), and AMC-18 (105°W). Each triple-feed antenna system received the down linked saturated full transponder C-Band DVB-S2 8PSK carrier from each satellite to measure link performance. Link performance was determined by measuring link margin of the test carrier from each satellite over a variety of forward error correction (FEC) values using a DVB-S2 receiver. A carrier of 8PSK 5/6 with a minimum desired link margin of 3dB was deemed to be the benchmark for these tests as many cable TV programmers currently or will soon transmit their MPEG4 HD signals in this format. A link margin of 3dB was chosen as the figure of merit as this level of link margin is sufficient to overcome system losses and the effects of rain and atmospheric conditions that the signals may be subjected to.

PROCEDURE

Television carriers were uplinked to AMC-1, AMC-18, and SES-1 from SES' Vernon Valley Earth Station (VVES) located in northern New Jersey using a 9m C-band antenna. DVB-S2 broadcast standard with 8PSK modulation carriers were generated by a Newtec Azimuth modulator.

Reception tests were performed at the SES lab in Princeton, NJ using a Prodelin 1374 3.7m prime focus antenna with a Superior Satellite Systems SSE5-8MBF-4C triple feed, as shown in Figure 1. CalAmp 140105-1 C-Band DRO LNBs were used on all six antenna receive ports in order to receive signals simultaneously on each of the three satellites, two polarities each.

Figure 1 – Superior Satellite Systems SSE5-8MBF-4C Dual Polarized Triple Feed System

The Prodelin 3.7m reflector with the Superior Satellite triple feed assembly was installed by a professional installer hired by SES and peaked on the three satellites to ensure the antenna system would perform optimally during testing. After the LNBs were installed and powered, the receiver input signal levels were confirmed to be within input specification prior to testing.

A Scientific Atlanta D9854 Advanced Program Receiver was used to receive the DVB-S2 satellite transmissions and determine signal link margin.

VVES uplinked a full transponder, fully saturated DVB-S2 8PSK carrier to AMC-1 (the center satellite). VVES stepped the carrier through the range of modulator FEC values (3/5, 2/3, 3/4, 5/6, 8/9, 9/10) while the Princeton site measured the resulting carrier downlink margins.

This downlink measurement procedure was repeated for AMC-18 and SES-1 to provide a full quantitative analysis of the antenna system. It is important to note that the antenna was not moved at all during testing. AMC-18 and SES-1 were measured on the off-bore sight feeds of the triple feed system.

DOWNLINK TEST RESULTS

Four main conclusions were drawn from the downlink tests.

First, testing yielded positive link margin for all three spacecraft at FEC values 3/5, 2/3, 3/4, 5/6, 8/9, 9/10. Since the higher order values require additional power, link margin decreases as FEC value increases (i.e., 8PSK 3/5 had more link margin than 8PSK 9/10). Link margin versus FEC as measured from Princeton can be seen in Figure 2.

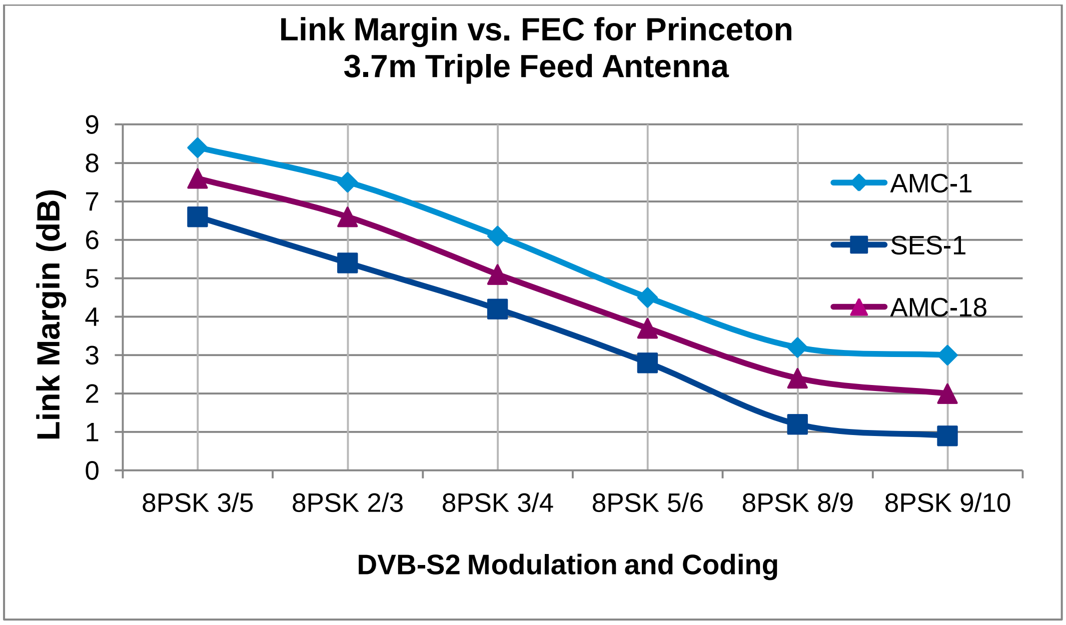

Figure 2 – SES Downlink Test Results

Second, the receiver was capable of locking onto the test carrier up to 9/10 FEC through all three antenna feeds. At 8PSK 5/6, a modulation format and FEC rate commonly used by programmers, margins were seen to be 2.8 dB and higher.

Third, when using a 3.7m Prodelin reflector, the center feed (AMC-1) performs better than the side feeds (SES-1, AMC-18), since the side feeds cannot be optimally placed at the reflectors focal point.

Fourth, SES-1 and AMC-18 were expected to have the same link margin because they were both being measured at the same distance from the reflector bore sight, and the satellites have similar EIRP values at Princeton. However, as measured they were approximately 1dB different from one another. AMC-18 has no neighboring satellite to the West whereas SES-1 has neighboring satellites to the East and West. Therefore, it is reasonable to conclude that the 1dB greater performance degradation in SES-1 is due to greater Adjacent Satellite Interference (ASI) seen by SES-1 over AMC-18.

PLL LNB VS DRO LNB COMPARISON

An interesting finding of the study is that for this specific application DRO-based LNBs performed better, in the aggregate, than PLL-based LNBs. It is well known that PLL LNBs are more stable than DRO LNBs since they utilize a more stable internal reference source (crystal oscillators) or they make use of an input from a stable external source. It follows that for low bit rate applications and/or small carriers (e.g., 50 kHz wide) PLL LNBs typically provide better performance. However, SES' testing suggests that DRO LNBs provide acceptable performance for signals with large bit rate carriers (such as DVB-S2 video signals) and in some cases actually outperform PLL LNBs.

Specific to the reception of digital video signals from the SES center arc satellites at 101°W, 103°W, and 105°W using a single 3.7m reflector with a triple feed, our direct and repeated measurements validate and confirm that in this specific application, the DROs operate better in practical terms, as discussed below.

To quantify the difference in performance between the different types of LNBs when used on a triple feed antenna system, measurements were taken with both DRO LNBs and PLL LNBs on all three feeds of the antenna. DH Satellite, an antenna systems manufacturer and integrator working with SES, replicated the test at their Wisconsin site on different sized reflectors to provide confirmation. SES tested CalAmp LNBs, while DH tested their own LNBs. No discernible performance difference was seen between brands of LNBs. However, a noticeable difference was measured between DRO and PLL LNBs

PLL LNBs were found to outperform DRO LNBs on the center feed by approximately 0.15 dB when used with a 3.7m reflector, which is in the measurement error tolerance. And, regardless of the reflector size, this level of outperformance was measured. However, DRO LNBs were found to outperform PLL LNBs on the side feeds by an average of 0.6 dB when used with a 3.7m reflector. The Wisconsin tests showed that the benefit of using DRO LNBs diminished with larger reflector sizes. The smaller the reflector, the more DRO LNBs improved link margin on the side feeds compared to PLL LNBs.

CONCLUSIONS

Using a modulation and coding of DVB-S2 8PSK 5/6 with a minimum desired margin of 3dB as a benchmark, SES has determined that a 3.7m antenna with an appropriate triple feed system and DRO LNBs is an acceptable solution for standard television downlink operations across three adjacent satellites.

This conclusion is based on the following assumptions: (i) all equipment (reflector, LNBs, cabling, triple feed mount, etc.) is new or well maintained; (ii) inter-facility links (IFLs) are short enough to not compromise signal integrity;(iii) Scientific Atlanta D9854 receivers are used to measure downlink margin and (iv) there is no physical blockage obstructing the antenna reception capabilities.

An area for further study is to more fully understand the phenomenon that results in higher performance of DRO LNBs in the side feeds and with smaller antenna reflector sizes.

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NOTICE: Findings by others may differ due to variability in the assumptions above and any alternate testing methodologies. The information provided in this document is based on testing performed by SES and does not represent a guarantee by SES of any level of performance.