**UAT-WP-19-14**
**26 February 2004**

**RTCA Special Committee 186, Working Group 5**

**ADS-B UAT MOPS (Do-282), Revision A**

**Meeting #19**

# DPSK Tests with Optional Passive Diplexer

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| Summary |
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| Testing was performed to determine the effects of a prototype optional passive antenna diplexer on the sensitivity of subject transponders as the interrogation frequency was varied. Mode S interrogation formats were used in this case to determine the effect of interrogations containing many Digital Phase Shift Keying (DPSK) modulation variations to verify that the diplexer bandwidth is adequate to allow proper detection of interrogation signals with wider bandwidth requirements. Of interest is whether the diplexer will accommodate the wider bandwidth required by Mode S DPSK interrogation types, and whether the pass-band of the diplexer has any limiting effects as the frequency is varied. |

**Note: This document was created and posted after Meeting #19, but is associated with Meeting #19 in so much as the requirements that were proposed to modify RTCA DO-282 to specify the requirements for the optional passive Diplexer were proposed in Working Paper UAT-WP-19-10R1, and the data presented in this Working Paper are relevant to the decisions made in that Working Paper.**

# ANALYSIS OF SENSITIVITY VARIATION WITH FREQUENCY WITH ANTENNA DIPLEXER

Testing was performed to determine the effects of a prototype optional passive antenna diplexer on the sensitivity of subject transponders as the interrogation frequency was varied. Mode S interrogation formats were used in this case to determine the effect of interrogations containing many Digital Phase Shift Keying (DPSK) modulation variations to verify that the diplexer bandwidth is adequate to allow proper detection of interrogation signals with wider bandwidth requirements. Of interest is whether the diplexer will accommodate the wider bandwidth required by Mode S DPSK interrogation types, and whether the pass-band of the diplexer has any limiting effects as the frequency is varied.

Three Mode S type transponders were tested both with and without the diplexer installed in order to make a direct comparison of the diplexers effect. The transponders were from three different manufacturers and are anonymously labeled MS-1, MS-2 and MS-3 for this report. The installation of the diplexer affects the Voltage Standing Wave Ratio (VSWR) of the antenna ports so a slotted line and stub tuner were used to monitor and control VSWR. The stub tuner was used to set the VSWR to the same minimum value obtainable with and without the diplexer. This was done to minimize the VSWR influence on the sensitivity measurements. Figure 1 shows the two test configurations used.

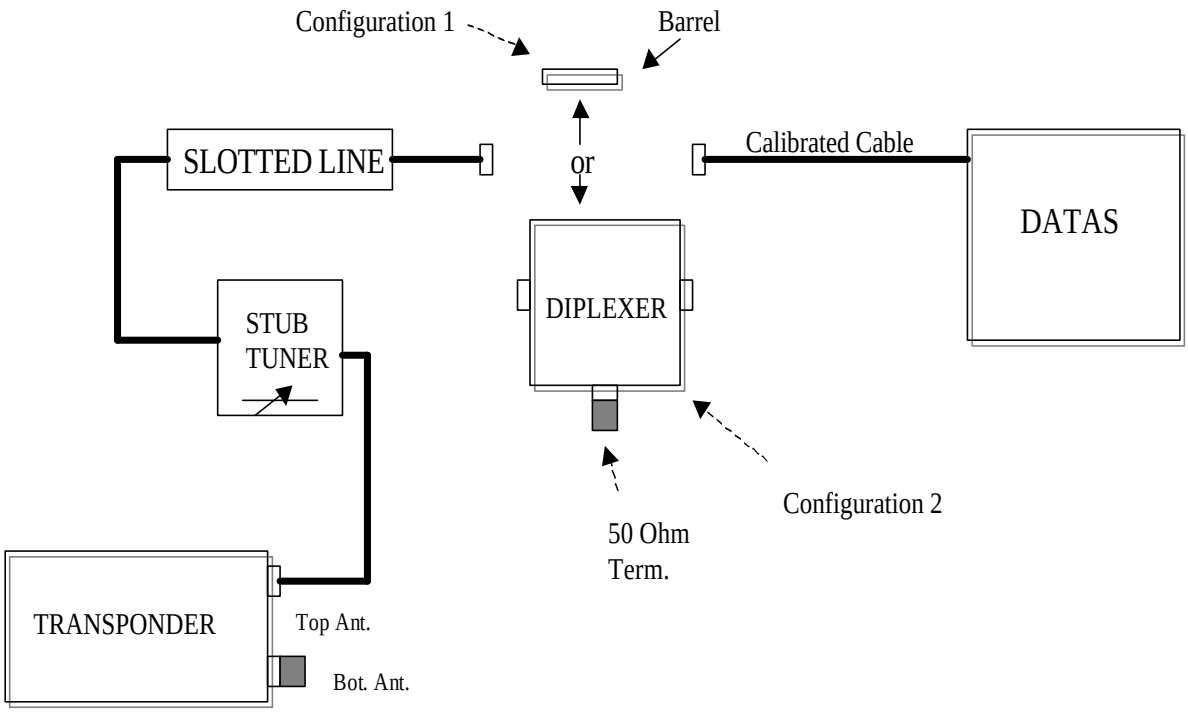
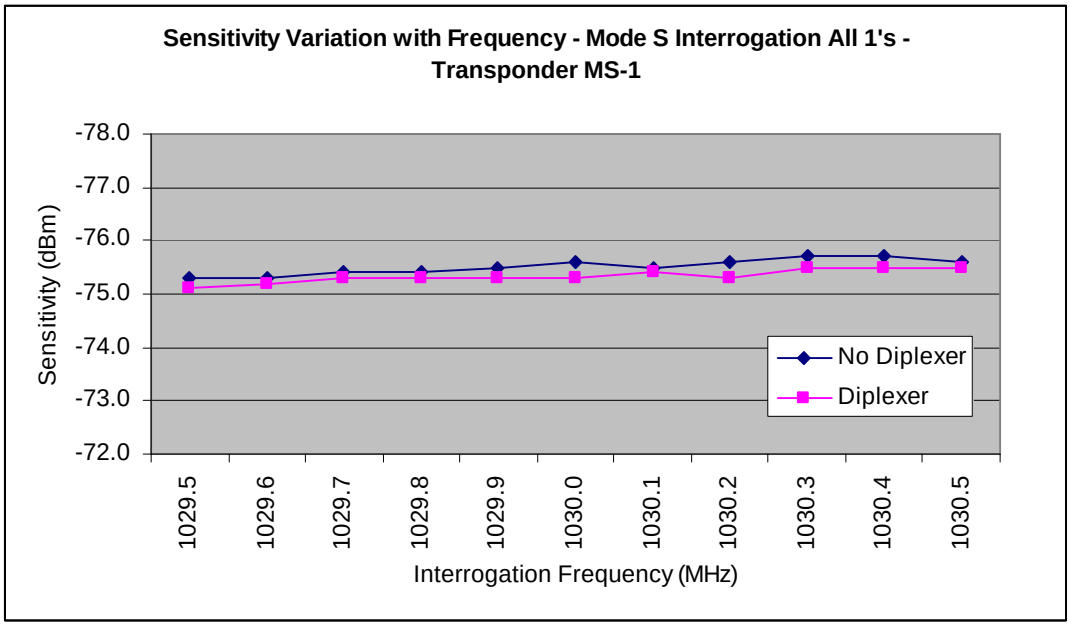



**Figure 1: TEST CONFIGURATION**

The Data and Transponder Analysis System (DATAS) was used to perform the tests. DATAS is a system specifically designed to measure performance of the ATCRBS/Mode S transponders and provide detailed test results.

Figure 2 shows a plot of the Sensitivity Variation with Frequency measurements for transponder MS-1. The interrogation used consisted of a UF code of '4' and all other data bits equal to binary '1' except the Address Parity (AP) field which was properly coded to elicit a response from the transponder. The all binary 1's format was used to maximize the number of phase shifts in the uplink interrogation. This was the primary interrogation format used to test all three transponders. It was intended to use a long format interrogation. However, since there was no adequate means of connecting the ARINC 429 interface of the three transponders, the transponders would not reply to long interrogation formats. The data shows a consistent average reduction in sensitivity of about 0.2 dBm that does not vary significantly with frequency.




**<u>Figure 2:</u> SENSITIVITY VARIATION WITH FREQUENCY, ALL 1's INTERROGATION, TRANSPONDER MS-1**

Figure 3 shows the Sensitivity Variation with Frequency of transponder MS-1 with a Mode S interrogation using all variable data bits set to binary '0' (again, except for UF and AP fields). This interrogation format will minimize DPSK phase shifts in the interrogation. A subset of the data points was run in this case since the data showed no significant difference between this and the all 1's interrogation format. Subsequent spot checking using the all 0's interrogation with the other two transponders also showed no significant effect from the interrogation data content of the interrogation.

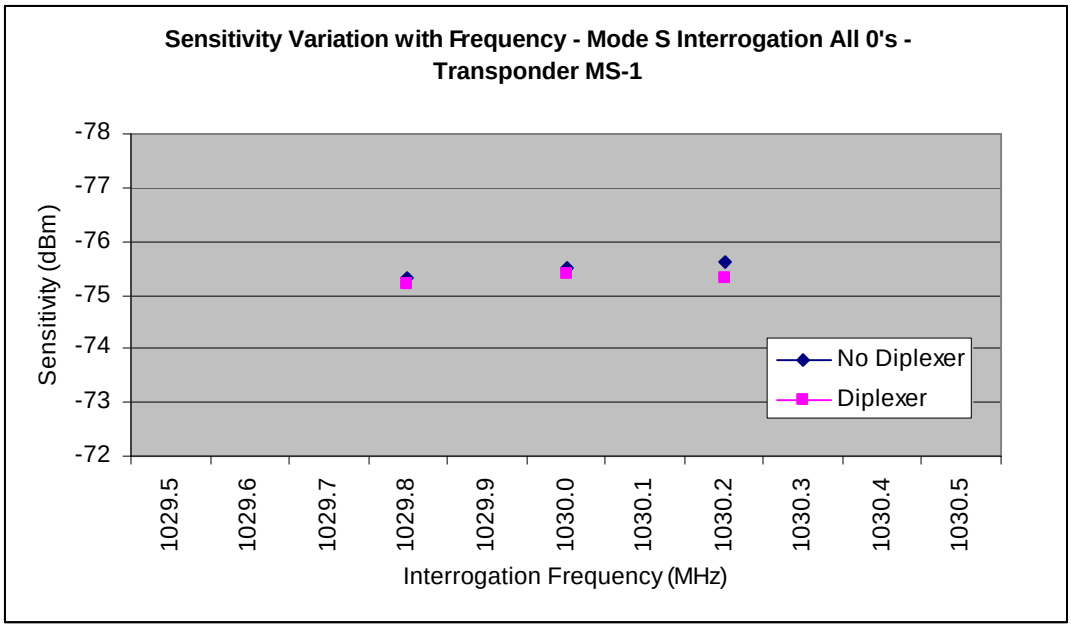



**Figure 3: SENSITIVITY VARIATION WITH FREQUENCY, ALL 0's INTERROGATION, TRANSPONDER MS-1**

Figure 4 shows the Sensitivity Variation with Frequency data from transponder MS-2. The data is similar to transponder MS-1 with a consistent sensitivity offset of 0.3 dBm with no significant variation with frequency.

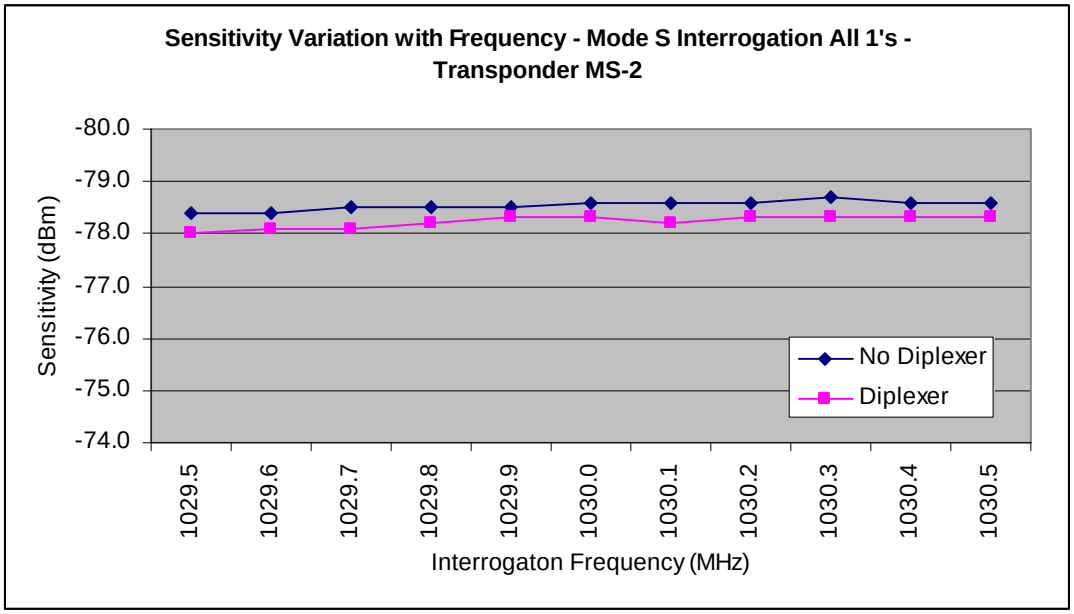



**Figure 4: SENSITIVITY VARIATION WITH FREQUENCY, ALL 1's INTERROGATION, TRANSPONDER MS-2**

Figure 5 shows the Sensitivity Variation with Frequency data from transponder MS-3. The data is similar to that of the other 2 transponders with a consistent sensitivity offset of 0.3 dBm. The data point at frequency 1029.5 MHz does deviate from the others, not because of any direct effect from the diplexer, but because it is near the edge of the transponders bandwidth for Mode S format interrogations. All three transponders exhibit a Mode S interrogation acceptance band of very close to plus or minus 500 kHz. In the case of transponder MS-3, at 1029.5 MHz the sensitivity is significantly reduced and varies as the test is repeated.

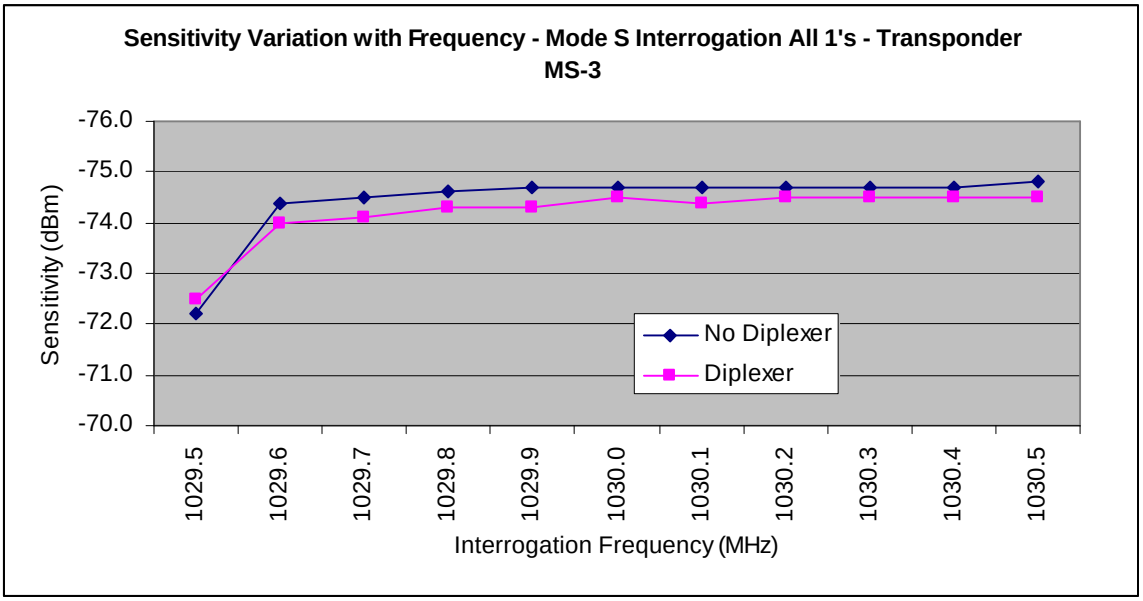



**Figure 5: SENSITIVITY VARIATION WITH FREQUENCY, ALL 1's INTERROGATION, TRANSPONDER MS-3**

The conclusion from running these tests is that there is the expected 0.2 to 0.3 dB reduction in the transponder receiver sensitivity from the diplexer, but the Mode S sensitivity is not affected as a function of frequency within the operating bandwidth of the transponders. Using interrogations with increased DPSK variations shows that the diplexer characteristics handle Mode S interrogations with the wider bandwidth requirements of interrogations with significant DPSK variations.