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ATCRBS / Mode S Transponder MOPS Maintenance

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Information Paper On DPSK Phase Reversal Impact On Test Equipment

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This Information Paper is provided in response to Working Paper ASP TSG WP09-14R1.
This Information Paper addresses the impact I & Q modulation would have on existing test equipment.

Introduction:

This information paper addresses the impact of recommendations suggested in working paper ASP TSG WP09-14R1, which was presented at the TSG meeting in Paris June 2010. The recommendations are specific to test equipment currently being used. The working paper suggests that Annex 10 Volume IV is too specific on how to establish the sync phase reversal in terms of using an amplitude drop. Numerous recommendations were suggested and subsequently generalized for these requirements to allow alternate forms of implementations to be utilized, specifically the I & Q modulation technique presented in the working paper. It was recognized in the WP that the current SARPs section §3.1.2.1.4.2.1:

3.1.2.1.4.2.1 *Phase reversal duration.* The duration of the phase reversal shall be less than 0.08 microsecond and the phase shall advance (or retard) monotonically throughout the transition region. There shall be no amplitude modulation applied during the phase transition.
Note.— The minimum duration of the phase reversal is not specified. Nonetheless, the spectrum requirements of 3.1.2.1.2 must be met.

It was noted by the WP that the last sentence of this requirement is inconsistent with interrogators using a modulation technique that causes amplitude variations that switch sources or other techniques that create amplitude variations. As detailed below, amplitude variations are produced by existing test equipment when generating the phase reversal and could be considered non compliant with this requirement.

A recommendation was also entertained to add the following statement to §3.1.2.1.4.2.1 into ICAO Annex 10 Volume IV stating:

There should be no amplitude variation during the phase transition.

As this information paper will illustrate, the current requirement that prohibits amplitude variations or even the recommended statement above would impact current test equipment used to provide Mode-S interrogations to the Transponder.

Discussion:

The following figures provide a depiction of current test equipment that may be found in a lab environment or in the field along with their respective Mode-S Interrogation. The first set of outputs is obtained from the S-1403DL IFR test set.

Figure 1: S-1403DL IFR

Figure 1 above illustrates IFR, a Mode-S Interrogation was captured portraying the Sync Phase Reversal (SPR) with an amplitude drop as shown below in Figure 2.

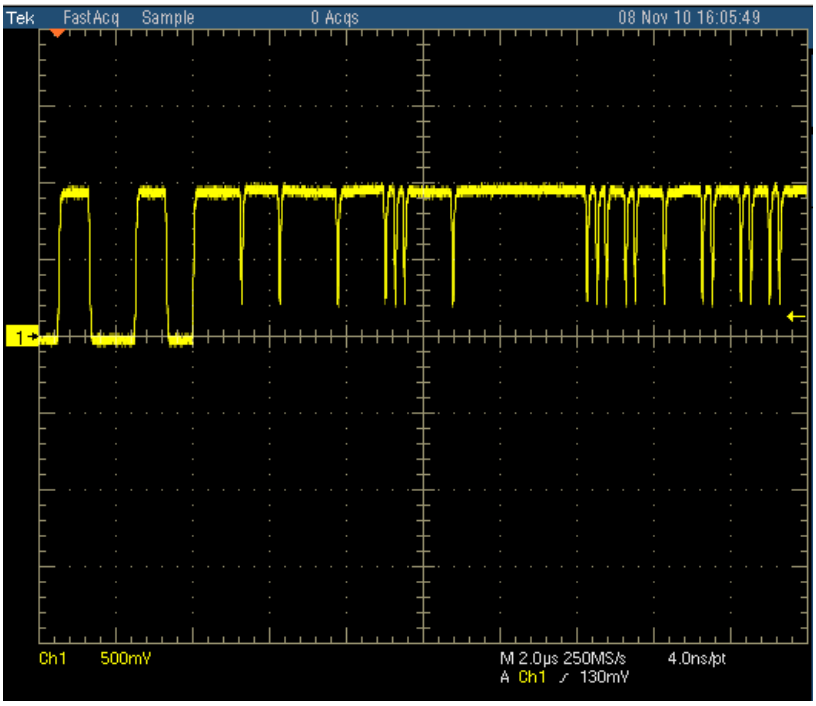

Figure 2: S-1403DL Mode-S Interrogation

Various measurements were taken to determine the proper location of the Sync Phase Reversal in the Interrogation, thus ensuring the test equipment indeed has an amplitude drop as the SPR. See Figure 3 below.

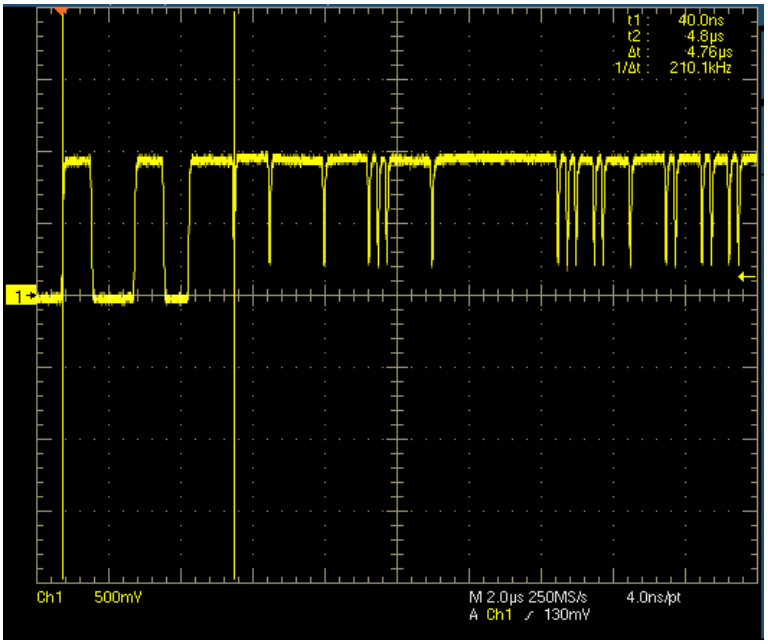

Figure 3: SPR as measured from P1

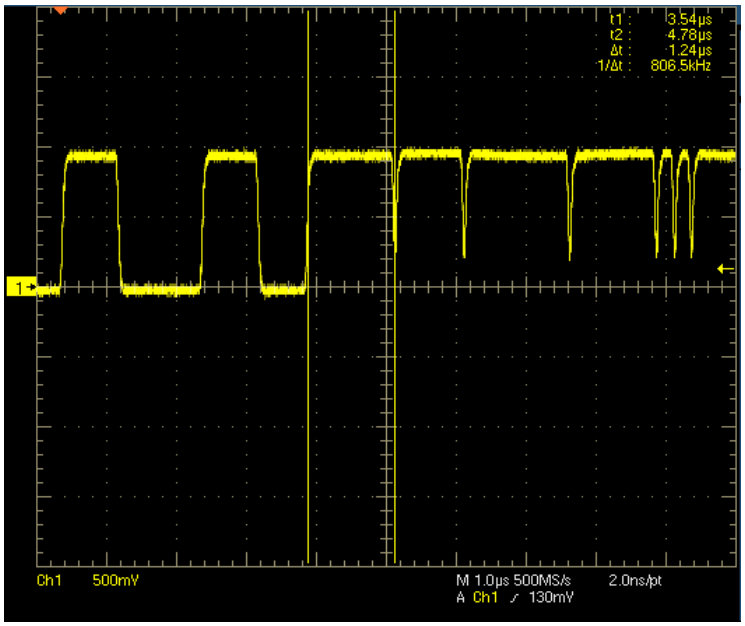

Figure 4: SPR measured after P2

The values obtained were approximately 4.76uSec and 1.24 uSec which verify that the correct location is being observed as per Figure 3-4 of ICAO Annex 10 Volume IV. Figures 1 through 4 above illustrate that the S-1403DL IFR has an amplitude drop at the location of the SPR. This amplitude drop is approximately 750mV as depicted in Figure 5 below.

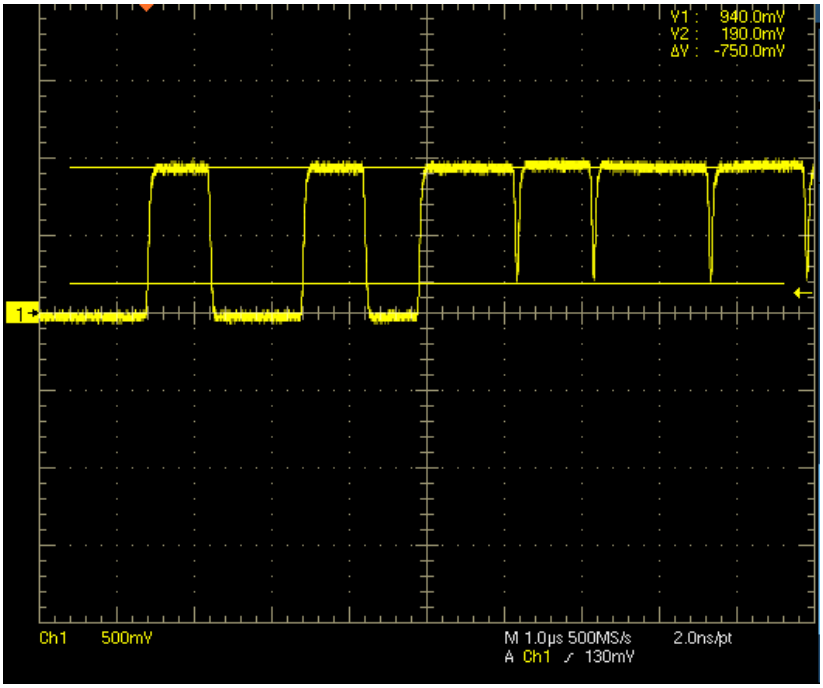

Figure 5: Amplitude drop of SPR from S-1403DL

The second equipment represented in this paper is the IFR 6000. The figures below illustrate the amplitude drop at the location of the SPR.

Figure 6: IFR 6000

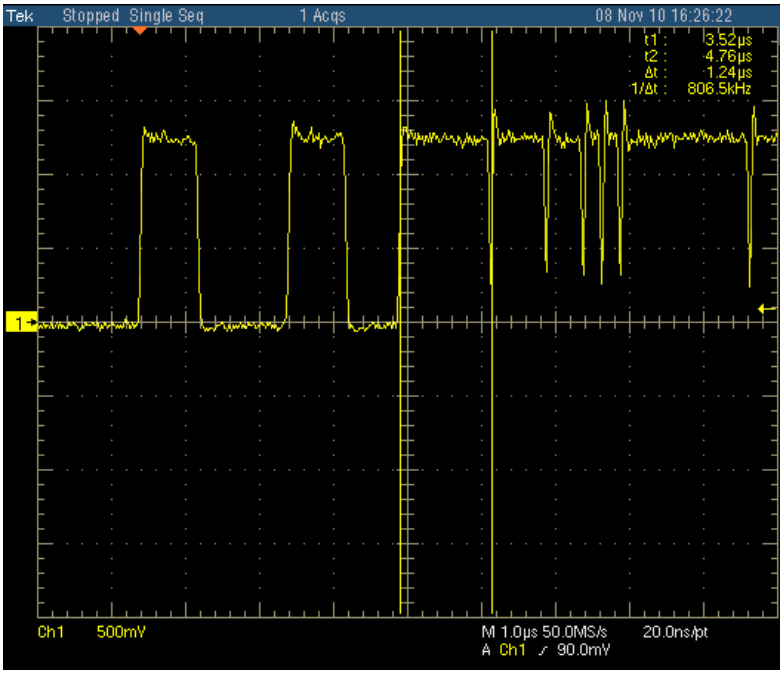

Figure 7: IFR6000 Mode-S Interrogation as measured after P2

It can be observed that the SPR is located at approximately 1.24 uSec from the beginning of the set of pulses after the P2 pulse. Figure 8 provides a measurement of the SPR amplitude drop from the IFR 6000.

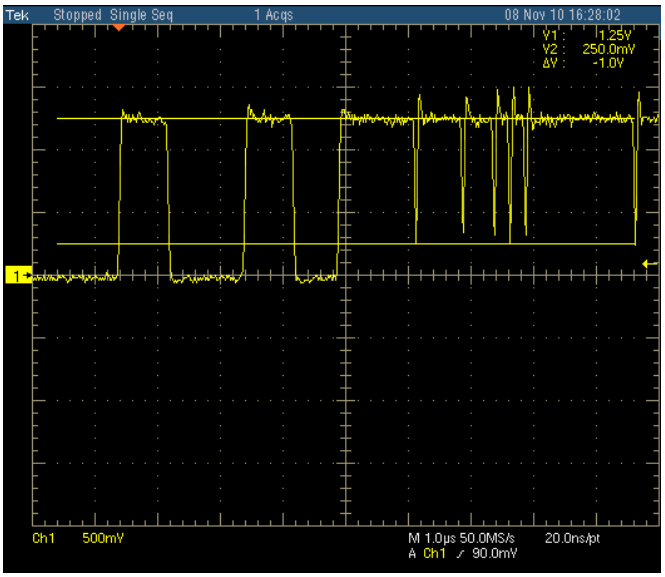

Figure 8: Amplitude drop of SPR from IFR 6000

Figure 8 above shows that the IFR 6000 uses an amplitude drop of about 1V. The use of the amplitude drop allows for the Transponder to determine the SPR; consequently, the phase reversals of P6 can properly be determined.

Conclusion:

The data above shows that by not allowing amplitude variations during the phase transition, it would affect the test equipment that is currently being used to test Transponder equipment. Notes may be added to clarify that other techniques can be used to implement the determination of phase transition, but if such an implementation is used then the implementer should ensure that the equipment is meeting proper ICAO Annex 10 requirements.