RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS

Meeting #5

Conditions for Declaring Preambles in Reference to Lead Edge Positions

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SUMMARY

This paper is in response to Action Item 3-8 that was assigned at Meeting #3 to examine the conditions for declaring the preamble in reference to lead edge position. The action item was assigned during a discussion of the RMF gold standard reception technique that requires at least 1 leading edge to be declared in the reference position before declaring a preamble. This requirement is not specifically stated in the MOPS. However, if the enhanced reception preamble detection requires a minimum of 2 leading edges to be declared within the defined sample tolerance of the four preamble pulses, then at least one will be located in the reference position as explained in this paper. In which case, the RMF gold standard technique is consistent with the MOPS. However, as a result of researching these conditions, it was discovered that it is not clear if the 2 leading edge minimum that is required in the current Mode S reception method is supposed to be carried into the enhanced reception method. A proposed change to Appendix I is included in this paper for clarification with the assumption that the 2 leading edge requirement belongs in the enhanced reception technique. In addition, there is discussion as to whether or not the one sample timing tolerance that is allowed for the subsequent preamble pulses should be extended to include the first preamble pulse.

Introduction

At Meeting #3 of WG-3 the details of the RMF "Gold Standard" enhanced reception technique were presented. During the presentation, it was pointed out that, with the gold standard implementation, a preamble would not be declared unless there was at least 1 leading edge out of the 4 preamble pulses declared in the reference position. There currently is no such specific requirement in the MOPS under Preamble Detection (Appendix I, Section I.4.1.2.2.2). The reason this restriction was imposed, was because in the MOPS Reference Level Generation (Appendix I, Section I.4.2.2.4) section, it is required that only samples from preamble pulses that have leading edges declared in their reference position will be used to generate the reference level. There was concern expressed that this restriction may prevent the detection of otherwise valid messages that have a distorted preamble due to overlapping fruit. The question is that if the rules for the enhanced preamble declaration are properly followed, will there always be at least 1 leading edge in the reference position? Or should the reference level generation process be changed to include a 1-clock tolerance for lead edge position? Action Item 3-8 was assigned to address the location of leading edges in reference to preamble declaration, and this working paper is in response to that Action Item.

Preamble Pulses and Leading Edges

The RMF Gold Standard preamble declaration process requires that at least 2 of the preamble pulses have leading edges declared within the 1-clock timing tolerance. The enhanced preamble declaration process limits the timing tolerance to once sample plus or one sample minus but not both in the same preamble. In addition, if two or more pulses have leading edges that represent a timing offset (either plus 1 or minus 1) relative to the reference position, the reference time of the preamble will be shifted one clock in the appropriate direction. Within these constraints there will always be at least 1 leading edge in the reference position. The following represents the 3 possible scenarios for a preamble containing the minimum 2 leading edges:

A. Both leading edges are in the reference position.

B. One leading edge is in the reference position, the other is offset 1 sample.

C. Both leading edges are offset 1 sample in the same direction. The reference time is shifted 1 sample resulting in both leading edges being located in the reference position.

Note: An increase in the number of preamble pulses with leading edges declared can only add to the number of leading edges in the reference position.

The careful analysis of the Appendix I preamble declaration process for the above exercise has led to two issues for Working Group 3 consideration. One issue is in reference to the minimum 2 leading edges required for preamble declaration, and the other is for allowing a 1-sample tolerance on the first preamble pulse.

Minimum of 2 Preamble Leading Edges

It is not clear in Appendix I (I.4.1) whether or not the enhanced preamble declaration technique requires a minimum of 2 leading edges out of the four preamble pulses. The 2 lead edge minimum was included in the RMF Gold Standard because the requirement was inferred from Section I.4.1.2.2.2 (Preamble Detection)

> Excerpt 1 (I.4.1.2.2.2 end of 1st paragraph): "To declare a Mode S preamble, 4 pulse reference points must exist in the waveform with the appropriate preamble spacing, with at least two of the reference points being declared leading edges. A plus or minus one sample timing tolerance is allowed for each of the subsequent preamble pulse positions relative to the first pulse reference."
>
> Note: I.4.1.2.2.2 1st paragraph is a description of the current Mode S downlink preamble detection algorithm.
>
> Excerpt 2 (I.4.1.2.2.2 end of 3rd paragraph): "Detection of the preamble pulses is done similarly to the current algorithm with the following exceptions.
>
> 1. Pulse sample timing tolerance is limited to either one sample plus or one sample minus but not both in the same preamble (as described above in section I.4.1.2.1).
>
> 2. If two or more of the subsequent pulses have leading edges that represent a timing offset (either plus 1 or minus 1) relative to the first pulse reference point, the reference time for the preamble is shifted one clock in the appropriate direction" ...

The first paragraph in I.4.1.2.2.2 is describing the current Mode S downlink preamble detection algorithm not the enhanced technique. However, the 2 leading edge minimum is not included in the third paragraph as one of the exceptions. It could be concluded that the 2 leading edge minimum should be carried into the enhanced technique but it is not certain. It would be less confusing if the rules for the enhanced method were explicitly stated.

The following is a proposed change to I.4.1.2.2.2 for clarification assuming that the 2 leading edge minimum is intended to be part of the enhanced technique.

I.4.1.2.2.2 Preamble Detection

(3rd paragraph)

The improved Mode S downlink preamble detection algorithm does not use a dynamic threshold level. All pulses above the receiver threshold are detected. Like the current algorithm, to declare a Mode S preamble, 4 pulse reference points must exist in the waveform with the appropriate preamble spacing. However, pulse sample timing tolerance is limited to either one sample plus or one sample minus but not both in the same preamble (as described above in section I.4.1.2.1). At least two of the reference pulse positions must contain leading edge declarations within the limited sample timing tolerance. If two or more of the subsequent pulses have leading edges that represent a timing offset (either plus 1 or minus 1) relative to the first

pulse reference point, the reference time for the preamble is shifted one clock in the appropriate direction ... etc.

1-Sample Tolerance for the first preamble pulse

The improved preamble detection algorithm allows a one sample timing tolerance on the three subsequent preamble pulse positions relative to the first pulse reference position. It seems reasonable that the detection algorithm could allow a one clock position tolerance for the first preamble pulse as well as the subsequent pulses. Consider the following pulse position and leading edge alignment:

PP nn LE PP nn PP PP nn PP PP

NOTE: In the above example each character pair represents a sample where PP =Pulse Position, LE =Leading Edge, and nn =Neither a PP or LE. The first PP is at the reference position (center of P1) for the potential preamble and the other groups of 3 samples are located at the appropriate preamble reference points with a plus or minus one clock timing tolerance.

With the pulse position and leading edge alignment represented above, there will not be a preamble declaration because there is only one leading edge declared.

If a one sample timing tolerance was allowed on the first pulse in a similar situation as in the example below, a preamble would be declared.

LE PP nn nn LE PP nn PP PP nn PP PP

If the above pulse configuration occurs in conjunction with a successful preamble validation it seems that it should be considered a valid preamble just as the configuration shown below which will pass the enhanced algorithm as it is currently defined.

PP nn LE PP LE PP nn nn PP PP