RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #12

Action Item 11-1

Proposed Text to add to Appendix I

Presented by John Van Dongen

SUMMARY
Action Item 11-1 was assigned to add text describing the RMF decoder preamble detection process to Appendix I. The text is based on Working Paper 1090-WP-11-02.

NOTE: If accepted, the following text will be inserted into Appendix I in the appropriate subsection and all subsequent figures must be re-labeled.

I.4.1.2.4 Enhanced Preamble Declaration Process Implementation Description

I.4.1.2.4.1 Overview

An enhanced preamble declaration process was implemented as part of an enhanced reception algorithm that was developed and used to assess current reception performance potential in high fruit environments such as Frankfurt, Germany. In addition, the application was used to determine the required reception probabilities for the enhanced surveillance processing test procedures and was used in studies of reception probability in predicted future high fruit environments.

The algorithm is a non-real time software package that processes a recorded digitized video signal input from a 1090 MHz RF Receiver. It is designed to detect and decode extended squitter messages using enhanced decoding techniques, error detection, and acceptable error correction processes. The post-processing aspect of the implementation provides the ability to repeat processing of the same data that led to refinements in the enhanced preamble declaration process. Although the refinements have been captured in appendix I, the details of the algorithm are contained here to provide a description of a specific implementation that has proven to meet the performance required of an enhanced preamble declaration process.

Development and testing of the enhanced preamble declaration process has shown that key elements of good performance are the ability to trigger at the correct time on valid preambles by minimizing false triggers and having a sound re-triggering mechanism. Although re-triggering is required in the enhanced preamble declaration process, and it is defined at what relative amplitude re-triggering should occur, it is left open as to what time in reference to the start of a declared preamble the receiver should be able to re-trigger. Testing has shown that if a receiver has the ability to re-trigger continuously, even within a previously declared preamble, the performance is significantly better than if re-triggering capability is delayed for example until the data block portion of a signal.

The enhanced preamble declaration software processes the digitized video signal in steps that relate to the process defined previously in Appendix I. The process is illustrated in Figure I-3. Unlike the 8 MHz sampling rate used to describe the process in Appendix I, the sampling rate used by the implemented process is 10 MHz. The combination of the Preamble detection and Preamble Validation steps will require an input of approximately 130 samples that span from the sample preceding the current potential trigger point to 4 samples past the last possible lead edge location of the 5th data bit (2nd chip).

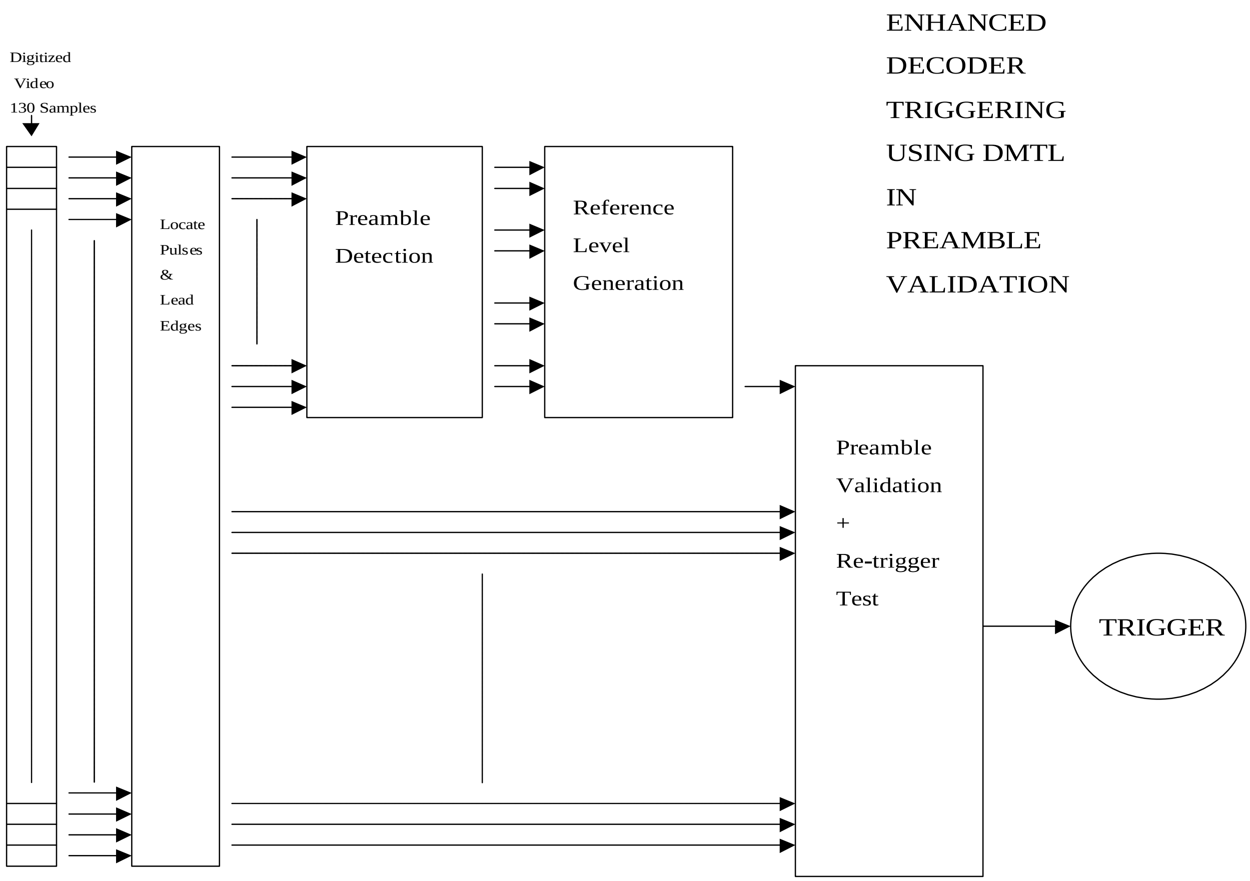

Figure I-3: **Implemented Enhanced Decoder Triggering Process**

I.4.1.2.4.2 Locate Pulses and Leading Edges

The first step in the enhanced decoding process is to locate pulses and their leading edges. Each sample that is above threshold and is followed by 3 or more successive samples above threshold is defined to be a pulse position. A leading edge is a valid pulse position that is 4.8 dB or more greater than its preceding sample and less than 4.8 dB lower than its succeeding sample**.** This is different than with the 8 MHz sampling rate described in the above sections of Appendix I. With the 8 MHz sampling rate, a pulse position is a sample above threshold followed by 2 or more successive samples above threshold and a leading edge is declared using a 6 dB amplitude rise criteria.

I.4.1.2.4.3 Preamble Detection

The digitized video data is continuously shifted into the Preamble Detector until a pulse or leading edge is located in the reference position. When this occurs, the nine video samples that correspond to the nominal leading edge positions of the remaining 3 preamble pulse locations (relative to the reference position) and plus and minus one clock from each are examined to contain pulses or leading edges. If pulses are found in the 3 remaining locations, it is required that there are at least 2 leading edges declared within the + or - 1 sample tolerance range of the four pulses with at least one of them in the reference position. The pulse sample timing tolerance is limited to either one sample plus or one sample minus but not both in the same preamble. If there are 2 or more lead edges in either the +1 clock offset or –1 clock offset direction, then the reference position will be shifted in that direction (as described above in section I.4.1.2.2.2).

I.4.1.2.4.4 Reference Level Generation

The Reference Level Generation process works as described in section I.4.1.2.2.4 above with one minor exception. Because of the 10 MHz sampling rate, the <u>three</u> amplitude samples (instead of two samples as with the 8 MHz sample rate) after each valid lead edge position are entered into the reference level declaration algorithm (up to 12 samples are possible). As described in section I.4.1.2.2.4, for each qualified sample, the amplitude is compared to all other qualified amplitude samples and the number that lies within plus or minus 2 dB is counted. If the highest count is unique, then the reference level is set to the amplitude of that sample. If there is a tie, it is resolved by removing all amplitudes from the tied set that are greater than 2 dB above the lowest amplitude in the tied set. The reference level is set to the average of all remaining samples.

I.4.1.2.4.5 Preamble Validation

The enhanced preamble declaration implementation described here, uses an alternate processing order: preamble detection, reference level generation, then preamble validation. This is done so the reference level can be used to enhance preamble validation. A dynamic threshold is set to 6 dB below the reference level. Preamble Validation proceeds to examine the samples within + or – 1 clock of the expected location of the lead edges of the first 5 data pulses (both bit halves). A leading edge or pulse must be located in either chip of all 5 data pulses, and the amplitude of the pulse must meet or exceed the dynamic threshold.

I.4.1.2.4.6 The Re-trigger Test

The implemented algorithm is a continuous triggering process. Whenever it triggers on a preamble, it is able to trigger again even during the preamble. However, because it takes a stronger signal to re-trigger, the receiver is desensitized when a signal is in progress. The timing and reference level of the latest trigger is stored. If the timing of the current trigger is such that it has occurred anywhere within the time-span of the previous signal, the current signal must meet certain amplitude criteria to proceed as a valid re-trigger. The current reference level, and the peak amplitude of <u>all</u> 5 of the data pulses must be at least 3 dB greater in amplitude than the reference level of the previous signal. If the criteria for re-triggering is met, the new signal is passed to the Bit and Confidence Decoding process, the message that was in process is cancelled, and the receiver is now even further desensitized to any subsequent triggers. If the criteria for re-triggering is not met, the new trigger is ignored. In either case, the whole process will continue with the next sample, hence, the receiver has the ability to continuously trigger.

I.4.1.2.4.7 Other Implementation Considerations

The algorithm described above for the Enhanced Decoder is a variation of the basic enhanced decoder process that is defined earlier in Appendix I. Here, the Reference Level Generation Step was placed before the Preamble Validation step so that the reference level could be used to set up a dynamic threshold as additional criteria for preamble validation. The purpose of this was to mitigate the effects of false early triggers caused by low level fruit combining with the first 2 preamble pulses. This is a phenomenon that was observed in higher fruit environments like Frankfurt. However, this re-ordering of processes places the Reference Level Generation step in series with the Preamble Validation step. This could (but not necessarily) increase processing time that could introduce or increase a potential dead time if it is decided that one cannot be avoided. An alternative process could look like that in Figure I-4. The process depicted in Figure I-4 is more like the conventional approach documented in Appendix I. The advantage here is that the Preamble Detection and Preamble Validation processes are done in parallel. A “False Trigger” test was added to the Preamble Detection step to replace the Dynamic threshold used in the above method. The False Trigger test could compare amplitudes of the preamble pulses and reject those that have too great of a variation between pairs. The specifics of this False Trigger test are unknown, but some type of implementation would likely be required to produce the same performance as the implemented Enhanced Decoder.

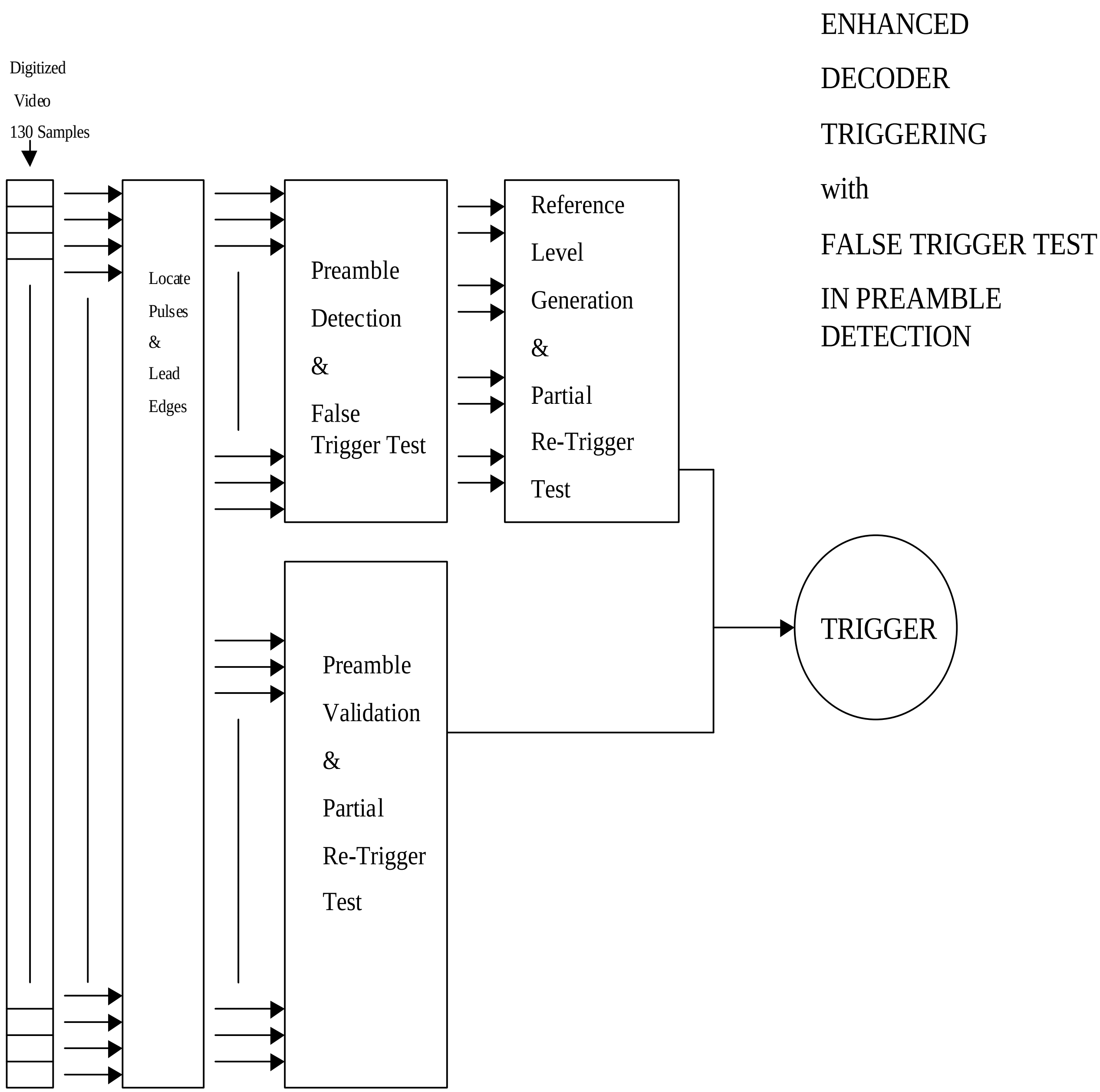

Figure I-4: Conventional Enhanced Decoder Triggering Process