

Applications of ARINC 818 in Avionics Video Systems

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ABSTRACT

ARINC 818, titled Avionics Digital Video Bus (ADVB), is a video protocol standard for high-bandwidth, low-latency, critical video systems. Since its introduction three years ago, many commercial and military aerospace programs have adopted the protocol, including the 787, A400M, and the A350XWB. A description of the protocol and its technical benefits is provided followed by an overview of how it is used in various systems, such as: infrared and optical sensors, map/chart systems, synthetic vision, HUDs, MFDs, video concentrators, and other subsystems. Future uses of the protocol are also explored.

INTRODUCTION

ARINC 818, titled Avionics Digital Video Bus (ADVB) is a video interface and protocol standard developed for high bandwidth, low latency, uncompressed digital video transmission. The ARINC 818 standard [1], which was released in January 2007, was advanced by ARINC and the aerospace community to meet the stringent needs of high performance, mission-critical digital video. ARINC 818 has already been adopted by major aerospace programs, including the Boeing 787, the Airbus A400M and the Airbus A350XWB, and is poised to be the de facto standard for high performance military video systems. ARINC 818 builds on the Fiber Channel Audio Video (FC-AV defined in ANSI INCITS 356-2002 [2]) protocol which was used extensively on video systems in the F/A-18F and the C130AMP.

In aircraft, an ever-increasing amount of information is supplied in the form of images, this information typically passes through a complex video system before reaching cockpit and crew displays. Video systems include: infrared sensors, visible light cameras, radar, flight recorders, map/chart systems, synthetic vision, image fusion systems, heads-up displays and heads-down multifunction displays, video concentrators and other subsystems. Video systems are used for taxi and take-off assist, cargo loading, navigation, target tracking, collision avoidance, and other critical functions.

This paper provides an overview of the ADVB protocol, followed by details of how ARINC 818 is applied in several mission critical video implementations. Finally, future uses of ADVB are described.

OVERVIEW OF ARINC 818 PROTOCOL

ADVB LOWER LAYERS - ADVB serializes data using 8b/10b encoding, a common scheme in many serial protocols, such as Fibre Channel and IEEE 1394b. There are many available SerDes that are 8b/10b compatible.

The serialization clock used for ADVB is independent of any video clocking. In cases where video is transferred from standard sources, such as cameras or computers, the ADVB embedded clock runs asynchronously to the pixel clock of the native video source. It is important to recognize this asynchronous aspect of ADVB in contrast to other point-to-point video connections, such as DVI, where the pixel clock is provided to the receiver from the

link. Since it is asynchronous, ADVB receivers are only able to recover the ADVB link clock, but not the original pixel clock of the transported video. Because of this, receiver synchronization must be addressed for all ADVB implementations. ASVB Synchronization classes are shown in Table 1.

Moving up the layers of Fibre Channel, the ADVB link is organized in 32-bit words (four 8b/10b characters), and all packet payloads must be multiples of 4 bytes. Fibre Channel defines 32-bit ordered sets that are “non-data” words that demarcate such things as the beginning of a frame or the end of a frame. For instance, a typical ADVB packet is preceded by a Start of Frame

Normal (SOFn) comprised of four 8b/10b codes (such as K28.5 D21.5 D22.1 D22.1 for a Class 3 SOFn). Ordered sets are also used as the stuffing characters between packets. ADVB uses Idle Ordered sets as the “fill” between ADVB packets. Required ordered sets and packet header information result in a link overhead of approximately 3%. The website www.arinc818.com/fcav provides a detailed description of the layers.

ADVB PACKET STRUCTURE - The ARINC 818 standard refers to the basic transport mechanism as an ADVB frame. It is important to refer to these packets as “ADVB frames” rather than simply “frames” to eliminate potential confusion with video frames. Figure 1 shows the construction of all ADVB frames.

The start of an ADVB frame is signaled by a SOF_x Ordered Set and terminated with an EOF_x Ordered Set. Every ADVB frame has a header comprised of six 32-bit words. These header words pertain to such things as the origin and intended destination (Source_ID, Destination_ID) and the position within the sequence (SEQ_CNT). The payload is variable in size, but is limited to 2112 bytes maximum. All ADVB frames have a 32-bit CRC calculated for all data between the SOF_x and the CRC word. The CRC is the same 32-bit polynomial calculation defined for Fibre Channel.



Figure 1 - ADVB Frame

ADVB CONTAINER STRUCTURE - The ARINC 818 Specification, like FC-AV, defines a Container as a set of ADVB frames used to transport video and audio. Within a container, ARINC 818 defines four objects that contain certain types of data.

In ADVB, Object 0 is a single ADVB frame that contains data relevant to that container. Object 1, not used, contains audio information, and Objects 2 and 3 contain video payload. For interlaced formats, Object 2 is used for odd field payload and Object 3 is used for even field payload.

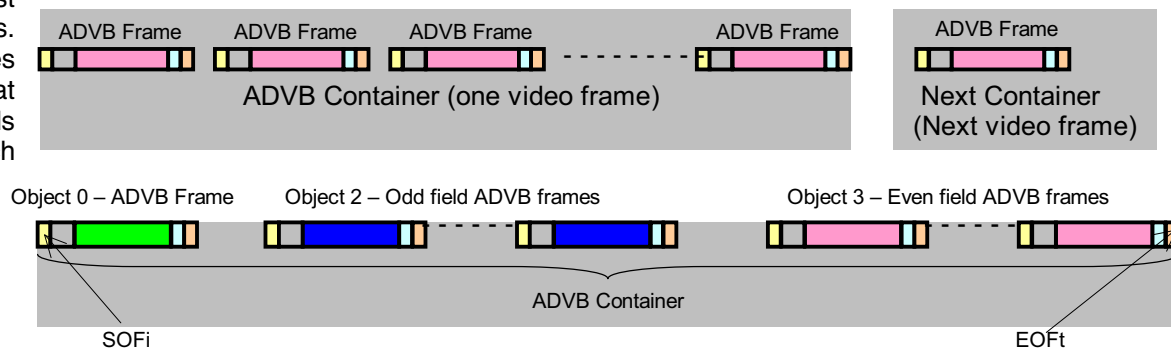


Figure 2 : ADVB Container Structure

The upper image of Figure 2 shows an ADVB container made up of a sequence of ADVB frames. The bottom image shows interlaced video that uses Object 2 for odd fields and Object 3 for even fields. All Object 2 frames come before all Object 3 frames. The first ADVB frame in a sequence includes a container header that provides a container count. Typically, each video frame is carried by one ADVB container.

LINK SPEEDS - In addition to the Fibre Channel 1x, 2x, 4x, and 8x rates, ARINC 818 permits “in between” rates of 1.5, 1.62, 2.5 and 3.1875 Gbps that are not compliant with Fibre Channel but represent legacy FCAV systems. Implementations that use the Fibre Channel rates of 1.0625, 2.125, 3.1875, 4.25, and 8.5 Gbps will have the benefit of compatibility with COTS ARINC 818 or Fibre Channel development tools such as protocol analyzers and traffic generators. Sticking to these rates will also eliminate potential hazards for using Fibre Channel chips and transceivers outside of their intended operational speed.

FLEXIBILITY AND INTEROPERABILITY - ARINC 818 allows for flexibility in the implementation of the video interface. This flexibility is desirable, because of the diverse resolutions, grayscales, pixel formats, and frame rates of avionics display systems. However, this flexibility is a problem for equipment vendors hoping for some degree of interoperability.

The ARINC 818 Specification intends that an Interface Control Document (ICD) accompany particular ADVB implementations. The ICD will specify parameters of the link such as link speed, image resolution, synchronization scheme, frame rate, etc. Typically, a military or commercial avionics development program will have an associated ICD. An ICD template is



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available from www.arinc818.com that includes all pertinent parameters to assure compatibility between ARINC 818 systems.

A particular piece of equipment that is compliant with ARINC 818 is not necessarily interoperable with another piece of equipment compliant with ARINC 818, unless they are both made to the same ICD.

VERTICAL AND HORIZONTAL LINE TIMING - To interface with a wide range of digital displays, ARINC 818 allows for implementations that impose horizontal and vertical video timing on the ADVB link. A typical implementation may set the ADVB container rate to be the same as the vertical frame rate of the transported video. Horizontal line timing may also be imposed on the transmission of ADVB frames. Since the payload of an ADVB frame is limited to 2112 bytes, it can contain a complete video line, multiple video lines or a fraction of a video line, depending on the segmentation.

SYNCHRONIZATION AND SEGEMENTATION CLASSES - ADVB has its own embedded clock that runs asynchronous to source video pixel clocks. The ARINC 818 standard itself does not place constraints on the timing of the ADVB frames during transmission or the methods of synchronizing at the pixel, line, or frame level. Synchronization methods and ADVB frame timing constraints must be captured in the ICD. However, ARINC 818 Appendix C establishes four synchronization and segmentation classes that enumerate the possibilities for timing constraints on the ADVB link: asynchronous, frame, line, or pixel synchronous.

The synchronization and segmentation classes address four separate variables that characterize delivery and timing of ADVB frames with respect to the video timing. Specifically, the classes address the following:

Vertical timing – the rate at which video frames are sent over the ADVB

Horizontal timing – the rate (and uniformity) at which video lines are sent over the ADVB

Segmentation – any constraints on how video lines are loaded in ADVB frames

Jitter - the variance in arrival times of video lines

Table 1 summarizes the classes according to these four parameters; beginning with least constrained ADVB asynchronous case (A1 with no vertical or horizontal timing imposed and no special segmentation) and moving to the most constrained synchronous case (D3 with perfect vertical and horizontal timing and orderly line segmentation into ADVB frames).

The particular class used for an ARINC 818 implementation depends on system level requirements. For instance, some systems will be concerned about hazardous stale video. To prevent the possibility of stale imagery residing within the display unit, the use of a full image memory buffers may be prohibited. In this case, the display unit will have only line FIFOs to buffer incoming data.

Receiver designs based on a line FIFO will require that the ADVB transmitter deliver line data according to horizontal timing requirements. These requirements will stem from the scan requirements of the display unit. Since horizontal scanning must be precise for some displays, the arrival times of line data will also need to be precise. This type of ADVB link is referred to as line synchronous. Classes C1, C2, D1, D2, and D3 are line synchronous.

Classes A1, A2, A3, B1, B2, and B3 are not line synchronous. For these classes there are no timing constraints for the ADVB frames within that container. When these classes are used, and when a display requires precise horizontal scanning, full image buffering must be included in the receiver design.

Variable	CLASS Non-Line Synchronous						CLASS Line Synchronous				
	A1	A2	A3	B1	B2	B3	C1	C2	D1	D2	D3
Stable vertical period?	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
Stable horizontal period?	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Object 0 or Line Segmentation?	NO	OBJ 0	Lines	NO	OBJ 0	Line	Line	Line	Line	Line	Line
Vertical jitter?	YES	YES	YES	YES	YES	YES	YES	Ext. sync	YES	YES	NO
Horizontal jitter?	YES	YES	YES	YES	YES	YES	YES	Ext. sync	NO	NO	NO

Table 1: ADVB Synchronization Classes

EMBEDDED DATA - ARINC 818 supports a wide range of resolutions, grayscales, pixel formats, and frame rates for commercial and military displays. Information about these parameters is contained in Object 0 which is carried by the first ADVB frame of each container.

In addition to the ADVB frame header, the first ADVB frame holds the 88-byte Container Header and the 16-byte Object 0 Ancillary data. The Container Header specifies characteristics of the container objects within the ADVB stream. Parameters in the Container Header include the frame rate of the video and the size (in bytes) of the objects within the container. Also within the Container Header is a container chain which