Full digital video solution as a forward-looking technology for High Speed ISOBUS

M. Sc. **N. Niebrügge**, ANEDO GmbH, Eydelstedt
M. Ensink, Stoneridge-Orlaco, Barneveld
Dipl.-Eng. (FH), MBA **Matthias Terhaag,** ANEDO GmbH, Eydelstedt

Abstract

The use of analog video systems consisting of one or more cameras is currently experiencing increased demand in the context of advancing automation in agricultural engineering. But analogue video technology is outdated and image artifacts can be easily reproduced through interference signals in the line and power supply. Based on the research project “Next Generation ISOBUS” between ANEDO GmbH and the Hochschule Osnabrück, ANEDO GmbH developed a modern Ethernet based digital video interface for current and next generation ISOBUS HMIs to replace the analogue technology. This interface is also intended to lay the foundation for digital camera communication on the High Speed ISOBUS (HSI).

This paper starts with the current state of the art of used camera systems, the resulting user problems and the current state of the specification of High Speed ISOBUS. Thereafter the advantages of Ethernet based digital video are described and the added value when combined with a High Speed ISOBUS wiring harness and the ISO17215 “Road vehicles - Video communication interface for cameras” for dynamic video systems is stated out. As a first step to digital video in ISOBUS apps are presented, which were developed by ANEDO and combine a digital video stream and ISOBUS implement operations through a native integration in the Universal Terminal or with the help of windows masks. Finally the paper explains the custom video stack that is the core of these applications and enables low latency video streaming.

State of the art and user problems

Especially self-propelled mobile machines can accomplish several work steps in parallel in order to make the work process more efficient. As a side effect these machines are becoming bigger and less overviewable. For this reason, analogue camera systems with several cameras are used as standard today to monitor their work processes. ISOBUS terminals or dedicated video monitors serve as display systems. Meanwhile, however, also more and more manufacturers of mobile implements want to offer camera solutions. This is why electronics suppliers like ANEDO GmbH see themselves contrasted with an increased request to ISOBUS terminals with video interfaces.

Although the PAL format is established as an analogue video interface in Europe, it is limited and does no longer justice to modern technology. A major disadvantage of the analog interface is the susceptibility of the analog video signal to interference from signal crosstalk from other lines or from interference signals from the operating power source [1]. Apart from the susceptibility of the signal, there are further restrictions due to the prescribed format of analogue video signals (in Europe PAL) such as a maximum of 576 image lines and 25 frames per second (FPS) [2].

Another problem of the analogue video technology is that only one video stream can be transmitted per video line. To view several video streams on a display a monitor either needs several video inputs, a switcher or an external video multiplexing device to switch sequentially between the video lines. In all cases an additional wiring harness is needed, which leads to higher costs and complexity for the whole electronic system on the machinery.

A further aspect is the demand for multi view systems to monitor several work processes at once. Though there are static analogue monitor solutions at the cost of a complex wiring harness, customers have no flexibility e.g. to customize the video layout.

Current State of High Speed ISOBUS (HSI)

In the AEF group PT10 for HSI Ethernet is already set as the transmission medium. For the transmission of ISOBUS messages the carrier protocols OPC Unified Architecture (OPC UA), Scalable service-Oriented MiddlewarE over IP (SOME/IP) and OneM2M come into question. Currently the decision has to be made whether to pursue only one or more of the carrier protocols in parallel to build up demonstrators. Regardless of the decision, the international standard ISO17215 “Road vehicles - Video communication interface for cameras” is pursued for the integration of digital video into the HSI. [3]

As SOME/IP [4] is also the carrier protocol of the ISO17215 [5] it will generate synergy effects when also used for the transmission of ISOBUS messages. Cameras or camera services can be a native part of the HSI communication to provide ECUs directly with image processing results like object distances, sizes or positioning while streaming the live stream to ISOBUS terminals.

Why digital video over Ethernet?

Digital video over Ethernet in general offers the same base features as its analogue PAL / NTSC counterpart but at a higher quality, as the bandwidth offers the possibility to stream variable resolutions up to Ultra HD to adequately supply a modern operator terminal's high resolution display. While the cost of a digital camera remains higher than an analogue version, the cost difference for a whole video system is more and more declining, especially because of the simpler wiring harness. On top of that the Ethernet based digital cameras offer additional features like digital image stabilization to counteract vibrations, digital pan, digital zoom or high dynamic range colours to solve contrast problems e.g. through bright sunlight.

Furthermore several video streams can be transmitted over the same cable using Unicast, Multicast or Broadcast to address one or more destinations at the same time, also wireless. As the used transmission medium Ethernet is the same as in HSI, it fully integrates into the same wiring harness and results in a cost and complexity reduction when a video system shall be integrated or retrofitted into a HSI machine. Compared to the analogue multi view systems the monitoring of several work processes at once requires no complex wiring harness anymore.

Digital Video According to ISO17215

The in 2014 released and SOME/IP based ISO17215 standard "Road vehicles - Video communication interface for cameras" defines the detailed behaviour for service discovery (camera identification), error handling, timeouts, events and remote procedure calls. A Plug-and-Play functionality is reached due to the SOME/IP Service Discovery (SOME/IP SD) whereby the digital camera broadcasts its service or an operator terminal can request the specific camera service in the network. During the initial step the camera and the operator terminal do not need to know their counterpart's IP-Address or the machine infrastructure. [5]

In comparison to the static analogue video systems this is a huge advantage on tractor implement combinations as camera changes are recognized dynamically and settings can be applied based on the specific camera use case. Where an analogue video system cannot identify a camera at all, the digital cameras are identified by their unique MAC-Address.

The remaining definitions of the ISO17215 refer to the configuration of a camera and the streaming process itself. On the configuration side the ISO17215 enables these configurable main features and more during runtime [5]:

- Start and Stop of a stream
- Camera sensor input area (Region of Interest)
- Camera stream output resolution
- Camera side image rotation / mirroring
- Used video codec (e.g. MJPEG, h.264, RAW)
- Variable Framerate
- Maximum stream bandwidth (on the cost of image quality)
- Unicast, Multicast and Broadcast of a video stream
- Camera manufacturer specific configurations / features via I/O registers

For the streaming process the transmission protocol AVTP is specified, which is part of Time-Sensitive Networking (TSN) (formerly known as Audio/Video Bridging (AVB)). This enables lower latencies compared to the standard TCP / IP communication, but requires physical support in the Ethernet PHY [5][6].

Because most of the current generation of HMIs do not have hardware support for AVB / TSN, ISO17215 compliant digital cameras often implement a hybrid mode. The service discovery and configuration is done via ISO17215. Using the manufacturer specific register configuration the streaming via AVTP is disabled and the camera switches to the Real-Time Transport Protocol (RTP). [7][8]

This means a maximum compatibility of the cameras to operator terminals. On the other hand operator terminals have a manufacturer independent plug and play compatibility to any ISO17215 compliant camera.

Results

Based on the results of the research project “Next Generation ISOBUS“ ANEDO pursued the digital video aspect further. As a result ANEDO developed a digital video core stack and created several applications that support digital video.

Fig. 1: Current panel apps with digital video support; Cam-Digi (top), UT (bottom left) and Layout Manager (bottom right)

panel:app Cam-Digi (see Fig. 1) displays and customizes video streams for each individual use case based on end user settings. It supports full screen view, snap shots and an automatic toggle mode through a configurable range of cameras. The app generates video widgets that allow other apps to integrate a video stream into their GUI. An important use case here is the combination of a digital video stream and ISOBUS implement operations.

Therefore ANEDO integrated digital video into the UT server panel:app UT (see Fig. 1) to place a video stream directly into the data mask of an UT client without the need for window masks. With standard ISOBUS objects the client defines the camera source, position and size of the video stream and the UT server adjusts dynamically while staying AEF compliant. Because of this native integration on the client side no critical machine information are mistakenly concealed. As an example a baler application could display and hide the video stream as needed in critical situations like driving backwards or bale release.

For UT clients that support window masks, panel:app Layout (see Fig. 1) enables operators to build a custom layout made of several window masks also combined with a digital video stream or widgets of other internal apps.

This leads to maximum interoperability between the apps and UT clients of several generations. Additionally implement manufacturers can build up and manage their own video system independent from a tractor's video system or simply combine with it.

The video core

The heart of the apps is a video stack that covers middleware and backend functionality to offer app developers a comfort video interface API. After the initialisation the stack works fully autonomous so that developers focus on the user interface and use the stack on a functional level.

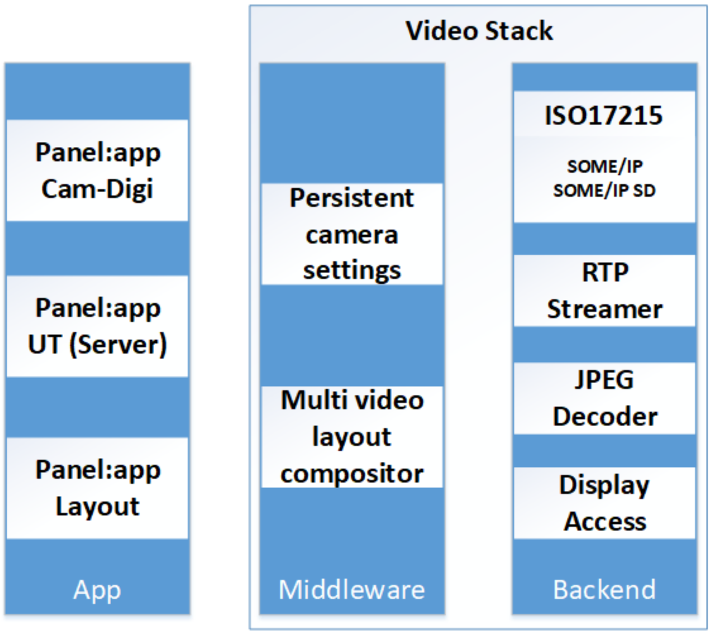

Fig. 2: Overall video system overview

In detail the stack's Backend consists of four main components (see Fig. 2). The ISO17215 client offers the full API for camera configuration and service discovery. The service discovery feature is enhanced so that not only ISO17215 cameras but distinct cameras and their manufacturers are identified to support manufacturer specific additional features like the hybrid mode for video streaming. Currently the Stoneridge-Orlaco EMOS camera [7] is supported for manufacturer specific settings but the component is designed modular so that additional camera models can be added any time. The RTP Streamer receives the video stream and forwards the data to the hardware accelerated JPEG Decoder. The decoded data can be either written into a buffer provided by the app or it is handled by the hardware accelerated component Display Access to forward the stream directly to the display, as long as a device context is provided. As a result these low level implementations reach a mean latency below 100 ms from the frame recording to the image display on the operator terminal. The middleware is essential for the comfort API for app developers. It stores all known cameras and their settings on persistent memory and makes them accessible for read and write commands. Further it informs an app when new cameras are found or camera settings have changed, so the app always has an overview of the current state of the video system. For the use case of multi view on an operator terminal ANEDO also developed a multi video layout compositor that enables video layout configurations and the positioning of video streams to set up split and also layered views like picture in picture. Apps can position horizontal and vertical border lines to define the position and size of the different video streams.

Summary

Compared to analogue cameras the Ethernet based digital cameras offer additional features like digital image stabilization, digital pan, digital zoom or high dynamic range colours at a higher resolution quality. Additionally digital multi view solutions need a less complex wiring harness compared to their analogue counterparts and the compatibility to the High Speed ISOBUS wiring harness simplifies the matter even more. In the context of Ethernet based communication the standard ISO17215 “Road vehicles - Video communication interface for cameras” offers an interface to set up flexible digital video systems with dynamic plug and play compatibility and specific camera identification as well as configurations for any compliant camera. Hybrid modes on cameras also provide the streaming protocol RTP and guarantee the compatibility to operator terminals that do not fulfil the hardware requirements for AVB / TSN.

ANEDO developed several apps with the support for digital video compliant to ISO17215 to combine ISOBUS implement operations with a video stream on the GUI. To reach maximum interoperability ECU clients without the support of window masks natively define position, size and source of the video stream and the UT Server displays it dynamically. Additionally operators can create their own layouts to combine a digital video stream, window masks and other internal app widgets on the GUI. The hardware accelerated low level implementation of the video core provides a mean latency below 100 ms from frame recording to the display on the operator terminal. Simultaneously it offers a comfort API to integrate digital video functionality into new apps, also on other platforms.

References

[1] Werner M., „Signale und Systeme“, Wiesbaden, Springer Vieweg, 3rd revision, 2008

[2] Fickers, A., „»Politique de la grandeur« versus »Made in Germany«. Politische Kulturgeschichte der Technik am Beispiel der PAL-SECAM-Kontroverse“, Munich, R. Oldenbourg Verlag, 2007.

[3] Smart D. and Brill V, “High Speed ISOBUS, an AEF Project for next generation Ag networking” in *VDI Berichte Nr. 2361,* Hanover, VDI Wissensforum GmbH, 2019, pp. 91-106.

[4] AUTOSAR, „SOME/IP Protocol Specification - AUTOSAR FO Release 1.1.0“, AUTOSAR, Munich, 2017.

[5] International Standard Organization, “ISO 17215: Road vehicles—Video communication interface for cameras (VCIC)“, Geneva, ISO, 1st revision, 2014

[6] IEEE, “1722-2011 - IEEE Standard for Layer 2 Transport Protocol for Time Sensitive Applications in a Bridged Local Area Network”, New York, IEEE, 2011

[7] Stoneridge-Orlaco, “Ethernet RTP/AVB EMOS Kameras”, 2020. [Online]. Available: https://www.orlaco.de/article-group/ethernet-rtp-avb-emos-kameras. [Last Accessed 01.09.2020].

[8] Schulzrinne H. et al., “RFC 3550 - RTP: A Transport Protocol for Real-Time Applications”, Fremont, IETF, 2003.