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Cover Story

APIX industrial for distributed control panel applications

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Remote touchscreens and control displays typically require a bunch of cables for video, power and control data. APIX concentrates all signal and power lanes in a single standard Ethernet cable to increase implementation flexibility and to decrease overall system cost.

Figure 1. conga-QA – an easily integrated, small size PC module based on the Intel Atom processor

The automotive pixel link (APIX) technology combines high-speed digital video transfer with full duplex, two-wire data communication, and even supports the supply of remote displays over the same cable. Based on this technology, APIX industrial offers a standardized connection of remote displays over single twisted-pair cables without sacrificing the flexibility necessary to meet the application-specific requirements for communication between graphics unit and display.

Industrial applications have always required an easy interface for the operator. Traditional human machine interfaces, such as buttons or control sticks, combined with small information panels, are increasingly being replaced or extended with digital displays. When equipped with a touchscreen, displays allow for dynamic screen content and act as an intuitive operator interface. With PC functionality available as small-sized, power-saving modules based on Intel Atom processors, control units can easily take care of the content of the digital user interface. Unlike office applications, the user interface for industrial automation applications is mostly located at a distance from the control PC. Industrial long-distance applications require expensive special cabling or use multiple PCs, connected via Ethernet, for each panel. There is an obvious need for a low-cost, robust, high-speed, full duplex link which meets the requirements of the industrial environment for electromagnetic interference (EMI) and distance. APIX technology, which defines a physical layer for display and camera links, was originally created for the automotive environment where EMI is a major requirement as it can have a severe impact on the overall system. EMI includes immunity as well as emissions, which both need to be optimized for acceptable performance. With a bandwidth of 1 Gbit/s, the APIX link supports video resolutions of 800x600 with a colour depth of 18 bits (262,144 colours). The high speed downstream channel acts as a transparent gateway for the parallel video interface, providing the data sampled at the graphics processor interface at the same clock at the display. Video data are transmitted in real-time without compression, minimizing the latency for time-critical applications and eliminating the need for decompression at the display.

In addition to a video interface, the APIX architecture offers so-named sideband data channels which provide full duplex downstream and upstream capabilities. Sideband data are sampled at either transmitter or receiver and are transparently provided at the respective pin at the remote site. Since the devices do not require any special formatting, this transparent sampling enables the flexible extension of interfaces like UART or SPI over a long distance. The differential link is independent from the video pixel clock and therefore allows the transmission of the sideband data even without an available pixel clock. The ability to carry full duplex information without a pixel interface offers significant benefits for point-to-point applications. Since the sideband data channel is available as soon as the link is powered up, it can be used as the main configuration interface of the camera or display implementation. Since the downstream and upstream data communication is transmitted over high speed differential serial lines, it offers the same distance and EMI performance as the video link.

An APIX link requires a maximum of two pairs of shielded twisted wires, transporting the downstream video and data stream on one pair, the upstream on the other pair. Due to AC coupling of the APIX physical layer, the data lines can also be used for supplying a remote system. The power supply is realized by using either one or both existing wire pairs, with inductors acting as low-pass filters to the signal lines. Since typically two pairs of wires are used, it is recommended to use the high-speed downstream line for power and the other one for ground. This way, a display can be supplied with video, data communication and power in a single cable over two pairs of wires. The APIX link, as any other differential technology, requires a twisted pair cable to ensure that the

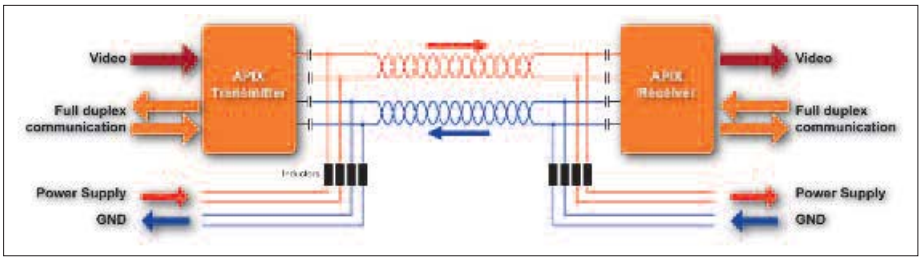

Figure 2: Power over APIX

Figure 3: congatec PCI Express APIX expansion card

positive and negative current of the differential signal negate as optimally as possible. The better the continuous cable impedance of 100 ohm, and the more even the twisting, the greater the maximum possible cable distance. In order to fulfil the EMI requirements, it is recommended to use shielded twisted pair cables, which are slightly thicker and somewhat less flexible than unshielded cables. The standard Ethernet cable CAT5, which is available in shielded or unshielded versions, offers four differential pairs of wires, enabling the transmission of APIX downstream and upstream. The remaining two pairs are available for any signalling, such as power supply, or another data bus, which offers high flexibility for different scenarios. CAT5 cables are available from many vendors at relatively low cost and with small cable diameters. However, the quality of CAT5 cables from different vendors may vary, which can cause unreliable results for the maximum transmission length. If distances above 15 meters need to be spanned, it is therefore recommended to test the desired cables and vendors. For extended distances, it is possible to use cables which are specially optimized for differential signalling of two pairs. Good examples are star-quad topology cables, offering high crosstalk attenuation at a very compact cable diameter. Due to the high quality requirements, the cost of those cables may be higher than standard CAT5 cables. The selection of connectors and plugs is equally important as the choice of cable in terms of EMI and impedance. One of the most common connectors for Ethernet applications is the RJ45 connector, which is used with CAT5 cables and is available as a plastic version or surrounded by a metal case for better EMI shielding. RJ45 connectors are specified with high contact durability, which allows many different and flexible installations. Alternatively a more rugged but more expensive connector can be used. The Rosenberger HSD connector (high speed data systems) is widely used for automotive applications. The HSD concept is optimized for high robustness in terms of connector/plug stability. The connectors are delivered already assembled with the cable to guarantee maximum signal quality. The HSD connectors are used with star-quad cables, carrying the downstream and upstream of the

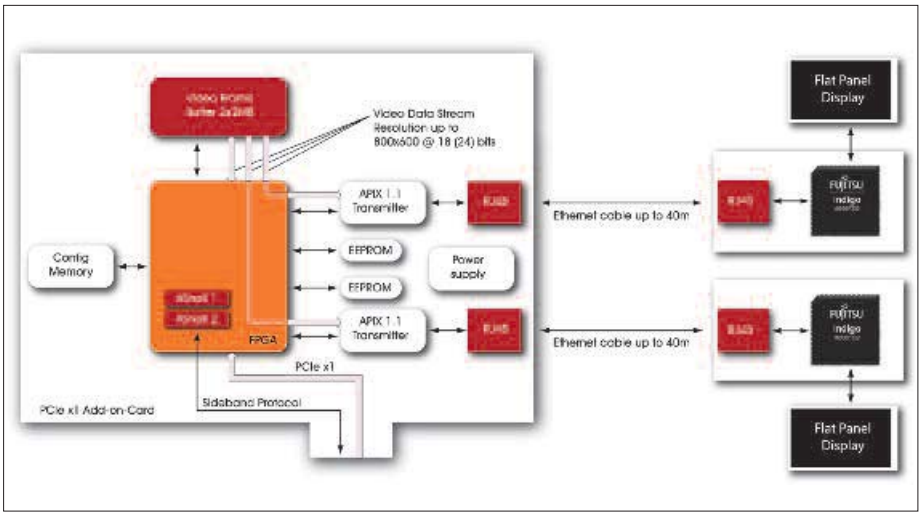

Figure 4: APIX 1.1. interface card block diagram (FPGA with PCIe core)

APIX link while still allowing transmitting power over the same cable. Standard connector pin-outs have been defined to support the independent development of display and graphics units in the industry. The basic RJ45 connector pin-out offers the following possibilities: high speed video link, robust communication channel (sideband), power supply over the data lines, additional power supply capability, and two additional lines for synchronous data transfer (like display DDC data). Since only the APIX pin-out is mandatory, the pin-out allows certain flexibility how to use the optional pins for different applications. For instance, the four pins may also be used for a USB connection. Another option is the value of the voltage, transmitted as power over APIX (PoA).

In order to enable quick and easy evaluation of the APIX display Interface, Congatec has created the complete APIX design kit. It contains a PCI Express add-on card including operating system drivers and a remote display unit with integrated touchscreen. In addition to the hardware, the design kit also features comprehensive documentation complete with schematics allowing easy implementation of a customized solution. The APIX PCI Express card features two independent APIX interfaces via RJ45 connectors. This allows for the operation of two independent display units through the use of conventional CAT 5 cables. When using multiple cards in a system, up to 8 APIX channels can be operated in parallel. The sideband signals of the APIX channels offer the possibility to transmit UART signals, which can be used for touchscreen or keyboard applications. More complex or encrypted communication can be accomplished using the MB88F332 (Indigo) graphic display controller from Fujitsu Microelectronics as a receiver at the display unit side. The corresponding graphic data and protocols are processed by a PCI Express connected FPGA chip, which passes the RGB data to the APIX transmitters. The physical transfer is handled by the APIX channels. The power transmission to the display units is configurable.

The APIX card supports PoA but can also provide 3.3V power from the PCI Express interface or can transmit external 5V or 12V power sources. The congatec Dual APIX PCI Express Card is a plug and play card and includes all necessary operating system drivers. Originally invented for the automobile industry, APIX also provides the perfect solution for low-cost digital remote user interfaces in industrial applications. With the Congatec starter kit it is possible to bring this innovative solution very quickly and easily to a customized carrier board for COM Express, ETX, XTX or Qseven embedded computer modules. ■

RJ45 Pin	Signals	APIX Transmitter	APIX Receiver
Pin 1	Video+ / PoA+	SDOUT+	SDIN+
Pin 2	Video- / PoA+	SDOUT-	SDIN-
Pin 3	(optional)		
Pin 4	Upstream+ / PoA-	SDIN+	SDOUT+
Pin 5	Upstream- / PoA-	SDIN-	SDOUT-
Pin 6	(optional)		
Pin 7	(optional)		
Pin 8	(optional)		

Table 1: APIX RJ45 pin-out