Data Acquisition Close to Sensors in the Vehicle and on the Test Bench

New method for deterministic transfer of measurement data at high rates via XCP-on-Ethernet

By Burkhard Triess, ETAS

Each module is installed in the immediate proximity of the sensor being monitored. A number of innovative physical features enable the rugged devices to fit into the smallest nooks and crannies in the engine compartment, for example. In addition to their ultra-compact dimensions (H x W x D 1.5 x 1.6 x 4.8 in. or 37 x 40 x 124 mm), all modules feature rugged MIL-SPEC I/O connections on their small front panel, moisture protection to IP67 (NEMA Enclosure Type 4X) specifications, and a working temperature range of between 40 °F to 248 °F (-40 °C to +120 °C). Keeping cable clutter to a minimum, several measuring modules can be daisy-chained, and a single cable connects all systems to a PC or Ethernet network. ETAS has slated the market roll-out of the first devices of the ES400 hardware family for October 2006. These will be the ES411 A/D Module and the ES420 Thermodio Module (8 channels).

A new method for deterministic data transfer

ES400 modules use a new method for deterministic data transfer on an Ethernet daisy chain. Efficient module-to-module communication thus ensures low latency. The use of the 100 Mbit/s Ethernet protocol offers extensive data communications bandwidth. Within the overall instrumentation, the daisy-chained Ethernet modules behave in a similar manner as a single Ethernet device featuring one MAC address. The last module in each Ethernet chain periodically generates quart-accurate time slices in the form of blank, consecutively numbered Ethernet frames. As a result, the clock cycle remains unaffected by delays and/or jitter in the network traffic extraneous to the Ethernet chain. Because the use of time slices prevents collisions on the Ethernet data line between modules, real-time behavior is assured. The time slice frequency is selectable: it is adjusted to match the measuring channel having the highest acquisition rate in the chain. The Ethernet frames are handed off from module-to-module within the chain, and freely selectable time slices can be assigned to any of the daisy-chained modules. Modules can use these time slices to append measurement data to the Ethernet packet. The diagram in figure 1 shows an example of three daisy-chained modules using different acquisition rates. The resulting transfer scheme is depicted in Figure 2.

The method utilizes the Ethernet network in duplex operation. In this way, it provides the maximum Ethernet bandwidth for both measurement data and control variables. The transmission of measurement data from the modules to the master (PC) is time driven, i.e., no repeated requests are required. As a result, the protocol overhead is drastically reduced, favoring the payload data rate.

In the event that a given measuring channel acquires several high-speed and many low-speed signals, the transfer of the latter can be time-multiplexed. This can become the basis for data transfer optimization with respect to low latency, minimum cycle time, and/or optimized bandwidth utilization.

Although the data transmission does not require the synchronization of the local time bases of individual ES400 modules, the time stamps are synced by the system regardless. Once the data transfer has concluded, this makes it possible to correlate measurement data and scanning instances of different modules on a timeline. To this end, the ES400 modules perform a time and drift synchronization with better than 1 µs accuracy by means of a hardware circuit.

In contrast to the time synchronization as per IEEE1588 (Precision Time Protocol), this method does not require bandwidth. Instead, the modules insert the time stamp for each piece of measurement data in the respective Ethernet data packet. The combination of time stamp synchronization and time slice assignment provides the ES400 series modules with a very high payload data rate. At a time slice frequency of 10 kHz and an Ethernet bandwidth of 100 Mbit/s, the resulting time slices are 1250 bytes in size.

In the event that smaller configuration packets of no more than 100 bytes are to be interlaced with the measurement data, and assuming a header size of 70 bytes, some 1000 bytes remain for the measurement data. In this realistic example, up to 80 percent of the Ethernet bandwidth, i.e., 80 Mbit/s, can be used to transfer both measurement data and protocol management data.
Virtual Prototyping –
The New
INTECRIÖ PC-Connector

By Walburga Zahn and Johannes Wagner, ETAS

Function prototyping on the Windows PC

The new PC-Connector for INTECRIÖ enables developers to create virtual prototypes and test them on the PC without additional hardware. Function developers can use system models already in early project phases in order to validate new functions using Model-in-the-Loop technologies.

Light simulators have been indispensable in the training of new pilots for a long time. Since the digital computer has become powerful enough, simulators and their virtual world have also become an integral part of aircraft development. In fact, the pressure to reduce risk, cost, and time has forced developers in the aircraft industry to find methods that allow them to validate their systems already in the design phase of a new plane. Creating a virtual world of the overall system (comprising environment, hardware and software systems) enables aircraft developers to evaluate more potential flight conditions and design configurations than ever before, which gives them the confidence that their design is valid and robust. The method is called “Virtual Prototyping” and the idea behind it is to do things right as early as possible.

Doing things right as early as possible is as important in the development of Earthbound vehicles as it is in that of flying machines. It is a well-known and often cited fact that 90 percent of new functionality in road vehicles is realized through electronic solutions. For function and software developers in the automotive industry this fact translates into pressures to deliver new functionality quickly and with superior quality while keeping costs down. This is where virtual prototyping with the new PC-Connector for INTECRIÖ comes in.

Creating synergies between development domains

While INTECRIÖ does not offer a complete virtual world, the new PC-Connector allows function developers to create virtual prototypes of automotive electronic systems and test them on the PC. A virtual prototype of this kind comprises:

Automotive embedded software
- application software (functions for control and monitoring)
- OSEK operating system
- Plant model
- vehicle
- environment

The PC-Connector for INTECRIÖ thus enables collaboration in very early development phases between function developers on one hand and system developers and simulation experts on the other. Without virtual prototyping, these domains often do not come into contact until very late in the process, e.g., during HiL (Hardware-in-the-Loop) testing. With virtual prototyping, developers can use system models (such as chassis or engine models) in early stages of the process as well, and thus validate their functions through Model-in-the-Loop (ML) technology.

Access to system knowledge (and corresponding models) early in the process creates synergies between function development and system development and thus fosters a more efficient development process.

Target-close prototyping

INTECRIÖ, models can be created using a variety of different tools or a combination thereof (MATLAB®, Simulink®, ASCET, C code). With the new PC-Connector, developers can now work within their familiar tool environment and execute their virtual prototype directly at their desks on a standard Windows PC under target-close conditions. Already in the function design phase, developers can thus validate the functional architecture and verify the electronic architecture against the plant model. Moreover, they can do all of this under target-close conditions.

Openness

On the application layer, the data transfer method utilizes the XCP-on-Ethernet protocol (ASAM standard), which is widely accepted in the automotive industry. Consequently, ES400 modules are easily integrated in partner applications. The Ethernet transport and network layer uses the UDP/IP protocol. The XCP (Universal Measurement and Calibration) protocol provides transmission of measurement and/or stimulation data to and from different Ethernet modules within a highly precise and predictable time frame. A PC application that does not have to meet hard real-time requirements will synchronize itself with the modules by means of the time stamps.

For data acquisition, an off-the-shelf PC or drive recorder can therefore be directly connected to an ES400 measuring chain. On the one hand, due to the cyclical data transfer behavior, using an off-the-shelf PC enables the efficient acquisition of high data volumes. Using a real-time capable master, such as a rapid prototyping or an auto calibration system, on the other hand, enables access to a variety of I/O signal types, even in the presence of extremely short cycle times.

Integration of ES400 modules with IAV Drive Recorders

Starting in October 2006, IAV GmbH will offer the integration – based on the open XCP-on-Ethernet interface of the ES400 product family – of its IAV Drive Recorders with the ES411 A/D Module with Sensor Power Supply and the ES420 Thermo Module. The configuration is accomplished by downloading an ASAM standard A2L file into the IAV Drive Recorder. The file describes all of the measured variables to be captured by the connected ES400 measuring chain, and the bus signals to be measured are selected by simple Drag & Drop. The A2L description file can be easily generated by means of a stand-alone configuration tool from ETAS.

The integration of the ES400 represents an ideal extension of IAV’s vehicle bus-oriented endurance measurement technology through the addition of the powerful sensor signal measuring modules by ETAS. The user benefits from gaining access to ES400 measurement data for endurance measuring captured in vehicle or on the test bench, with the virtual absence of extra cabling efforts. Connecting the Ethernet cable of the ES400 measuring chain to the IAV Drive Recorder is all that is required.