CANopen in semiconductor manufacturing

By Martin Rostan (Beckhoff)

Whilst field-bus systems like Profibus and DeviceNet are generally chosen because the favorite control system comes with this interface, the decision for CANopen is more technology driven. Engineers look for an open, reliable communication system that can be tailored for the specific application needs and is easy to implement on special function devices that are not available with field-bus connectivity yet.

They are fascinated by intelligent medium access control (MAC) method and the built in error detection and control mechanisms provided by the Controller Area Network (CAN) technology and then look for an appropriate application layer. They find that CANopen takes advantage of the various CAN features and is readily available in a wide range of devices.

Mattson Wet Products is a worldwide supplier for semiconductor manufacturing equipment that pretty much followed this route. Having used CANopen with VMEbus systems in selected lines before, Mattson decided to introduce PC-based controls as their next generation control architecture. And CANopen was chosen to be the communication system. The company launched a full-scale evaluation project and finally chose Beckhoff as main supplier for both hardware (Industrial PCs and field-bus I/O) and software (TwinCAT control system). Mattson later stated that Beckhoff's CANopen expertise had an important share in this decision.

Mattson Wet Products is specialized in the wet process of semiconductor manufacturing. After each lithographic production step, the wafers have to be etched, flushed and cleaned. Reliability of controls and communication is crucial in this application: if a system breakdown may cause the tray of wafers to be left in the acid for too long, this obviously would destroy the entire tray load. The resulting damage might exceed several Million USD, depending on the number and type of wafers that have been destroyed. Therefore, Mattson use a bus system that due to the CAN technology provides significant leeway for electromagnetic noise and disturbance.

Position control with CANopen

Mattson first introduced the CANopen technology in the products AWP300 and the Kronos 300, which are processing 300-mm wafers. All machines are fully modular designed. According to the customers requirements the number of process units and tanks varies, and so does the software. Within the AWP300 and the Kronos 300, a 500k bit/s CANopen network connects the PC controller with several servo axis, fast I/O modules and a control panel. Less time critical I/Os, valve manifolds, control panels and special function devices like megasonic and ultrasonic systems use a second CANopen network with 125k bit/s. In total, there are more than 500 discrete and 50 analogue I/O channels.

The drives close the position control loop locally on the drive controller. Therefore the main controller just has to transmit new position commands whenever a new motion segment starts. In order to start several axis simultaneously, the position command Process Data Objects (PDOs) are communicated using the CANopen sync mechanism. The resulting transmission type for these PDOs is "0", where the PDO is sent only when the data has changed but is set valid at the next following SYNC message. As the main controller closely supervises the resulting drive motion path, the actual position data is communicated in a cyclic synchronous PDO (transmission type 1). The digital I/O data is sent in the event driven communication mode: whenever an input or output changes, the resulting PDO is transmitted. This leads to short reaction times combined with minimal bus bandwidth utilization. In order to avoid a "flooding" of the bus due to ever changing analogue signals, the analogue data is sent cyclically, triggered by the sync telegram. Slow changing analogue values such as temperatures are communicated every second, third or fifth sync message, making use of the tuning mechanisms of CANopen that allow one to make best use of the available bandwidth.

In the AWP300 and the Kronos 300, Mattson finds typical busloads of 30 to 40% that leave enough bandwidth for unlikely but possible bursts of event driven messages and for acyclic parameter communication using Service Data Objects (SDO). Mattson uses the FC5102 two-channel PCI CANopen card that constantly measures the busload and provides the actual value in a

CANopen protocol stack

Ixxat's (www.ixxat.de) protocol software for CANopen, which is available since many years and proofed in many applications, has been extended by three versions. Besides the already supported micro-controller families Intel 8051, Siemens C16xC, Motorola 68HC08, Motorola PowerPC and ST7 by STMicroelectronics, also the micro-controller families Fujitsu F2MC-16LX, Mitsubishi M16C/N6 and Motorola DSP56800 families are supported. The protocol stack is compliant to the latest CiA DS 301 specification (version 4.01) and available as Slave or combined Master/Slave version. By means of the modularity and scalability the software can be adapted to the requirements of the device. The provided programming interface also allows an easy integration into already existing applications. An adaptation of the software to other micro-controllers, which are currently not supported can be done by using the ANSI-C versions of the software packages. These can be adapted with low effort and in short time to other micro-controllers.

Servos and frequency inverters for slicer

In the refrigerated counters of the supermarkets ham and cold cuts are just as tempting as accurately cut Cheddar or Swiss cheese. And, since the way in which food is presented is an important factor inducing customers to buy a product, the food industry requirements for precise cutting machinery are continuously increasing. Especially, when so-called portion slicers are used. If you want to slice and pack large quantities of sausage you need a slicer, which does not only have a sharp knife. Slicers like the 402 Slice manufactured by Weber Maschinenbau located in Germany have a performance of up to 600 cuts per minute. A wide feed shaft allows the processing of four products at the same time. This means that a maximum of 2,400 slices can be cut per minute - provided that the individual drives are precisely matched. The 402 Slicer uses a drive system from Lenze (www.lenze.de). An 8200 frequency inverter controls the knife speed. Two 9300 servo inverters - both programmable according to IEC 61131-3 - are used for product feed and conveyor belt control. Due to the integrated PLC in the drive controller, a central PLC was no longer required. As a result, costs could be saved and the control cabinet size and wiring time reduced. The control was directly integrated into the process. The 9300 Servo PLCs are programmable according to IEC 61131-3 and enable the use of a modular software architecture. With the 402 Slicer, drives are used to control the material supply and portioning belt. The servo inverter of the feeding drive controls the tasks of the whole machine. The CAN system bus is used for communication.

variable in the process image.

Four PLC run-time systems on one PC

The TwinCAT application program written in IEC 61131-3 languages (mainly structured text) has to fulfil many tasks: besides the mechanical wafer handling, fluid and temperature control and tool supervision an important job is to trace all process steps and store that data in an Access data base. As the process requires constant adaptation of the acid composition, formula management makes up for a large proportion of the software.

The tool controller runs 4 software PLCs simultaneously, each of them consisting of several tasks. The source code of the control application exceeds 4M byte of data and uses around 150,000 variables, not counting the visualization application.

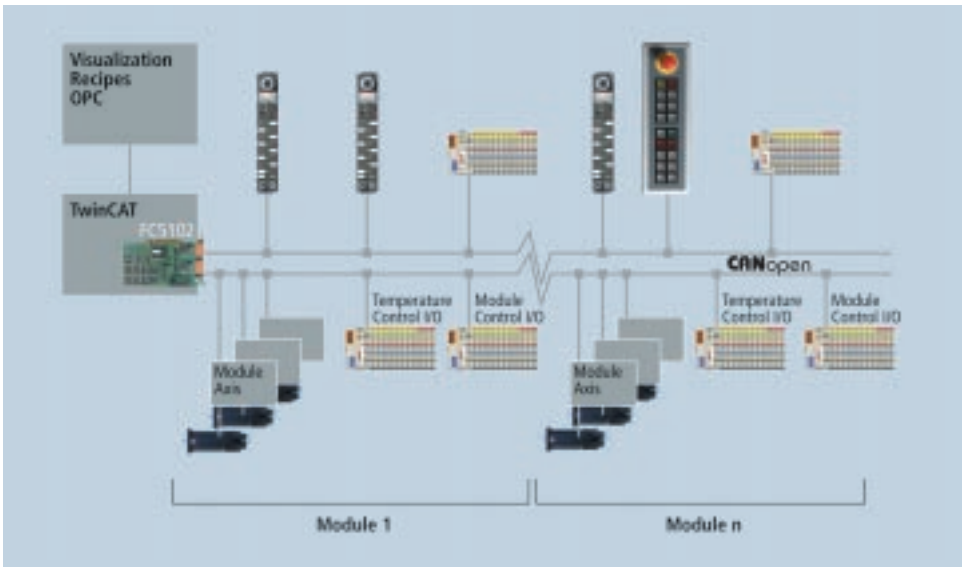
A second PC unit is used for visualization, as the SCADA package requires significant processing power. Both PCs are linked via Ethernet and TCP/IP and OPC is used for data exchange with the tool controller application. More than 7500 tags indicate the large size of the visualization application and the extensive use of the OPC interface. Interestingly the OPC server runs on the visualization PC and not on the tool controller: the Beckhoff ADS communication via Ethernet that transports the data from the tool controller application to the OPC server is much faster than an OPC connection via TCP/IP.

Software temperature controller replaces hardware

Beckhoff developed a self-tuning temperature controller with integrated sensor supervision system that now controls the liquid temperatures in the various tanks of the plant. The algorithm for determination of optimal controller parameters greatly simplifies the process of commissioning the controller. The controller has been implemented as software function block so that multiple in-

stances can be generated. The control algorithm itself is PID-based with an additional pre-regulator that can be inserted to minimize overshot. It operates independently of whichever field-bus and sensor/actuator system is installed. All parameters can be observed directly in the software PLC for diagnostic purposes. These parameters can, moreover, be displayed in the visualization system, and linked to other function blocks in the PLC. By using this software temperature controller Mattson replaces a number of dedicated hardware temperature controllers and thus considerably reduces the hardware footprint.

In semiconductor manufacturing equipment size does matter, as clean room environment is expensive.



IP20- and IP67-compliant I/O modules

Small footprint, high protection class and fast wiring were decisive for the use of Beckhoff's Field-bus Box series. The product line consists of the stand alone Compact Box, the Coupler Box and the Extension Box modules. The modules meet the Protection Class IP 67 and are wired using either pre-molded cord sets or field-wireable connectors. Together with the IP67 Fieldbus Box Mattson has selected Beckhoff's IP20 Bus Terminal series. The CANopen bus coupler supply up to 64 electronic terminal blocks for any type of signal. Different voltage groups can be set up to fully replace the mechanical terminal blocks.

The system ensures that control cabinets and terminal boxes are constructed more economically. Using the 4-wire terminating system, all of the usual sensors and actuators with different signal types of can be connected directly without other connection systems. This significantly reduces costs involved in controller design and saves space, material, work and hence money. The CANopen I/O products provide full CANopen functionality: up to 32 PDOs support all transmission types. Variable mapping, boot up message and comprehensive diagnosis via emergency message are additional features. The parameters can be stored in non volatile memory. Smart PDO triggering through delta functions and limit value settings for analogue inputs allows one to fine-tune the bus bandwidth utilization. Flash upgradeable firmware gives easy access to new features. All bus couplers come with an additional serial interface for configuration, but all parameters including the settings of the intelligent terminals are accessible via CANopen SDOs as well.

In 2001, Mattson delivered the first tools, which are equipped with the new AWP300/Kronos 300 software and electronic. The electrical design team found that the setup time for the electrical installation equipment was reduced by 70%.

www.beckhoff.com

CAN starter kits

The CAN starter kit from Hitex (www.hitex.com) comprises CAN board with ISA or PCI interface or PC/104 module and an I/O module. The I/O device provides 4 digital outputs, 4 digital inputs, 1 analog output (10 Bit) and 1 analog input (10 Bit). C libraries for DOS, Windows DLL (32-Bit), CAN software monitor, and sample application programs for Windows comes with the starter kit.

HiCOCAN-ISA, HiCOCAN-PCI and HiCOCAN-104 are based on the MC68332 micro-controller from Motorola and the SJA 1000 CAN controller from Philips. The interface to the bus-lines is provided by an 82C251 transceiver from Philips and optocouplers. The PC interface boards are separately available, too.

The HICOCAN-IO module is based on the SLIO 82C150 from Philips. It provides digital I/Os connected to dip switches and LEDs, a potentiometer plus an LED for analog signals. All port pins of the SLIO are accessible via solder pins in order to make user-specific hardware extensions easy. The supplied sample application demonstrates the use of the DLLs and allows the user to operate the HICOCAN-IO module under Windows. Source code (Microsoft C) is included. The CAN monitor is a tool that allows the user to monitor the CAN net, transmit individual or cyclical messages and to set the bus timing. In addition, error conditions on the bus can be easily detected.