

TwinCAT Scope: Increased performance via multi-core technology

Especially against the background of Industry 4.0 and "Big Data", advanced data acquisition for machines is no longer an issue just for test bench operators. More and more production machines require reliable data acquisition over the entire lifecycle of the machine: data is collected during commissioning for setting and optimizing the machine, during production in the plant, and for condition monitoring systems in order to increase machine availability.

In terms of requirements, there are virtually no differences between the engineering phase and service operation. As a basic rule, data must be presented in the right sequence, with maximum performance, and in a clear and transparent manner. The integration of a charting tool into the development environment for machine software is therefore essential to achieve maximum engineering performance. The TwinCAT Scope meets all these requirements, and has been further optimized with regard to the representation of multiple channels.

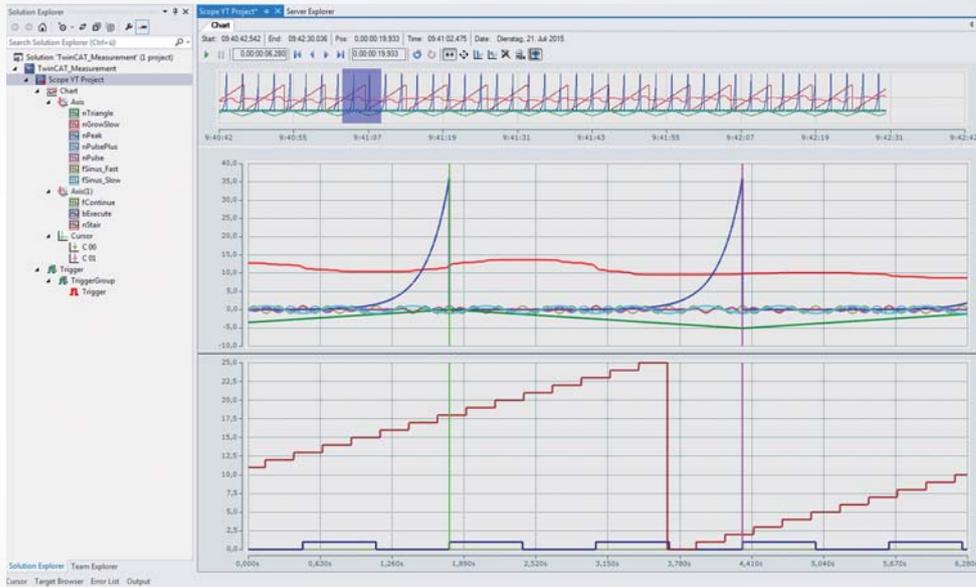


Fig. 1: Scope configuration in Visual Studio®, with overview chart also shown



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Architecture

TwinCAT 3 Scope is a software oscilloscope for the graphical display and analysis of variables from the automation system. The TwinCAT 3 Scope consists of two main components: Scope View for the graphic display of the signal curves, and the Scope Server for the actual data logging. For logging purposes, the Scope Server can be installed on the target device without the View component. In this case, it is controlled via a PLC function block, which can handle the loading of configurations, starting and stopping of recordings, and data storage. If Scope View is used for control purposes, the Scope Server can be installed on the remote device or locally on the engineering device. In view of the fact that the local server is sufficient for recording data, Scope is ideal for service technicians, because no additional software has to be installed on the target device in order to perform a highly accurate and graphically enhanced analysis of the machine. The service technician can connect directly and start a trigger-controlled configuration, for example. A "stop-record trigger", in which a pre- and post-trigger time can be set, often lends itself in service situations. Here, logging takes place in the ring buffer, with the period prior to the trigger event and the effects of the event being logged in one recording.

Like the engineering of TwinCAT 3 itself, the configuration and display part of the Scope is integrated into Microsoft Visual Studio®. Particularly during machine commissioning, it is very advantageous if the Scope View hosted in the measurement project can exist in parallel with the TwinCAT project within the same solution in Visual Studio®. The Windows docking feature can be used to display the Scope View and the program code or the hardware configuration directly side by side. In this way, the effects of executed program sections or newly set hardware parameters are always directly processed graphically, which can be very useful for user analyses. At the same time, Scope View can exist on its own in a solution, i. e. independent of a TwinCAT project, due to the fact that it has its own project. If Visual Studio® is not available on a runtime system,

Scope View automatically installs the Visual Studio® shell and integrates itself into it. An additional Microsoft installation is therefore not required.

Applications

The original development objective for the TwinCAT Scope was a tool that supports engineers, technicians and programmers during machine commissioning and troubleshooting. Therefore, it is very important that this tool collects data in a manner that is exactly synchronous with the cycle – even at cycle times of 50 µs. With oversampling technology, it is possible to scan signals even faster than the actual PLC cycle time. Naturally, it should also be possible to display these values. The chart display therefore enables zooming right into the µs range. Cycle-matched analysis is assisted by the cursors available in Scope View, which can be used to display differences on x- and y-axes, for example. The data picker, which appears as a tooltip when data points are selected and shows the values for the x- and y-axis, is also very helpful. Furthermore, the TwinCAT Scope is often used for the commissioning of drive axes, since signals can be viewed and compared side by side in charts or y-axes, even during recording. The XY plot feature can be used to graphically display travel paths of drives – particularly for CNC applications. Just five mouse clicks are sufficient to record the first drive axis in a TwinCAT configuration with all key parameters: select an appropriate NC template in the Project Wizard, then press the Start Record button, and the recording starts with the main axis data (position, velocity, etc.). The Copy and MultiSelect functions can be used to extend the template to any number of axes within the controller configuration.

A TwinCAT 3 Engineering installation always includes a Scope View and a local Scope Server. Both components are included in the basic version, with the described functionalities and many more – all without additional license costs. Many TwinCAT Scope functions are also ideal for process monitoring. The main

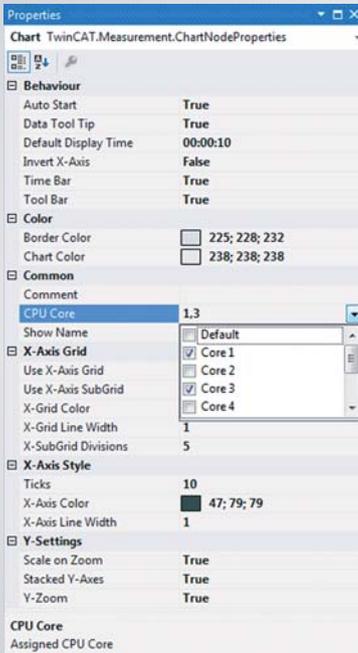


Fig. 2: Property window for the chart settings under the new multi-core support

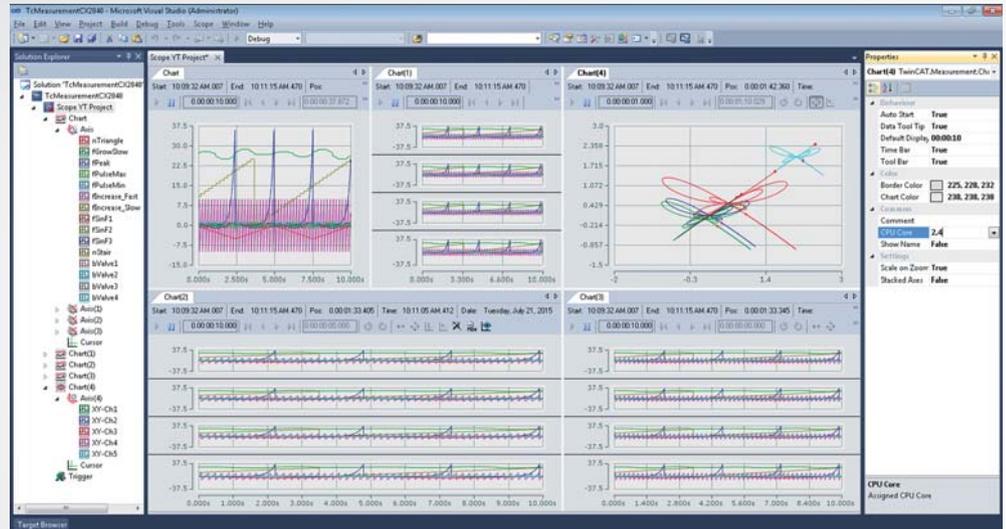


Fig. 3: Visual Studio® shell on a CX2040 with more than 230 signals in Scope View

feature in this case is the ability to carry out long-term recordings over several days. Trigger-controlled intermediate results can be stored consistently on the hard drive in parallel with long-term recordings. The Scope-specific data files can be exported to various other data formats, either manually or automatically via command line calls. Even during a long-term recording, the user can stop the online display for closer examination of the results with different zoom functionalities. An overview chart is available to keep track of complex diagrams with many curves. This "chart in chart" shows the data arriving in the background on an absolute time axis. The blue window in the overview chart in Figure 1 indicates the current position in the main chart. This marker is variable and makes it easy to jump from event to event, without having to scroll and zoom in the main chart.

Long-term recordings naturally generate very large data volumes. These data quantities are a result of sampling rates of 20 kHz or more per channel, and are fittingly described by the keyword "Big Data". They have to be managed and stored appropriately, to ensure that they are available for subsequent analysis and evaluation.

Example

The fieldbus cycle time of 1 ms corresponds to a sampling rate of 1 kHz.

Number of measuring channels	Data type	Comment
5	REAL	10-times oversampling
40	INT	
20	BOOL	

In the example with 65 channels, even a recording duration of just one hour generates a data volume of more than 3.8 GB, including timestamp. Sometimes it is not necessary to record each process record with the control cycle time as a

sampling rate. Cycle-matched sampling may be required for drive axis or acceleration sensor data, but not necessarily for temperature sensors which are also present in the system. In Scope View, it is therefore possible to set an individual sampling rate for each channel. For example, if the sampling rate for the 40 integer variables is reduced from 1000 values per second to just 1 value per second, the memory usage reduces by more than 1.5 GB per hour.

Performance

The bottleneck for complex Scope configurations is rarely data logging, per se. Apart from high data traffic volumes, it is the display of multiple channels with a high sampling rate that present the main challenges. The key parameters are system resources, such as CPU performance, the graphics card, and RAM. However, even if the system itself offers high performance, the software must be able to utilize the available resources efficiently. TwinCAT 3 is just such a software: in the TwinCAT 3 runtime, it is possible to execute real-time PLC, NC, C++ or MATLAB®/Simulink® tasks at different cycle times on different CPU cores. In this way, the automation software can benefit directly from advancements in PC technology, which provides processors with more and more cores, increasing performance. Scope View is now also able to make full use of multi-core systems, by using one or several CPU cores for displaying the signals. For each chart within the Scope configuration, the user can select the cores the processing power to be used for signal displays. For complex charts, e. g. with several channels and axes in XY plots, several CPU cores can be used for one chart. The user can make the selection in the Property window (see Figure 2) of Visual Studio® for the selected chart.

If CPU cores on the target device were reserved for exclusive use by the TwinCAT configuration, so that they are no longer available for Windows, they are automatically no longer available for selection in the Scope configuration. In this way, the TwinCAT real-time retains the reserved cores for exclusive use.



Fig. 4: CPU load; top: graphics load on one core, bottom: graphics load distributed across all four cores

In order to further improve the display performance and adapt it to the existing device, Scope View also supports two graphics libraries: GDI+ and DirectX. For DirectX-capable devices, this library significantly increases the graphics performance, as DirectX outsources the diagram calculations to the graphics card, thus considerably reducing the CPU load. The graphics chipset is designed for graphics rendering and can display significantly more data points than the GDI+ variant of the CPU. Multi-core support, in combination with DirectX graphics, enables a considerable performance boost for the display of signals.

Example

On a CX2040 Embedded PC from Beckhoff, which features an Intel® Core™ i7 2715QE 2.1 GHz quad-core processor, it is possible to display around 60 signals simultaneously within five charts. By switching from GDI+ to DirectX, and by allocating each chart to one or several dedicated CPU cores, it is possible to record and display more than 230 signals live. Figure 3 shows Scope View during such a recording, in which all signals are sampled with a cycle time of one millisecond.

Both features, i. e. multi-core support and the graphics libraries, are also available for the so-called Scope Control integration. Scope Control integration refers to the option of integrating Scope View charting into a custom, .NET-based visualization as a ready-made control element, as shown in Figure 5 with an XY and a YT chart. This includes not only data handling during the recording, but also control functions such as zoom, panning, and overview of the chart, among others. Therefore, neither a custom charting tool nor a third-party tool is necessary for customer-specific visualizations, significantly reducing engineering effort. Ultimately, the user has the benefit of using a standard product, which is maintained by Beckhoff, to create a software oscilloscope with fully customizable configuration and appearance.



Fig. 5: Two Scope controls integrated in a .NET application

Conclusions

TwinCAT 3 Scope is a core product within the TwinCAT system and is continuously evolving. This product benefits from more than seven years of development experience. It simplifies the engineering during application development, but also troubleshooting and parameter optimization at the machine. Its modularity enables integration into customer-specific visualizations. The new functionalities, particularly multi-core CPU support, underline the status of TwinCAT Scope as an high-performance charting tool for the TwinCAT software world.

Further information:

www.beckhoff.com/tc3-scope