Kithara | The Pulse of Real-Time

Kithara RealTime Suite

Real Time for Windows

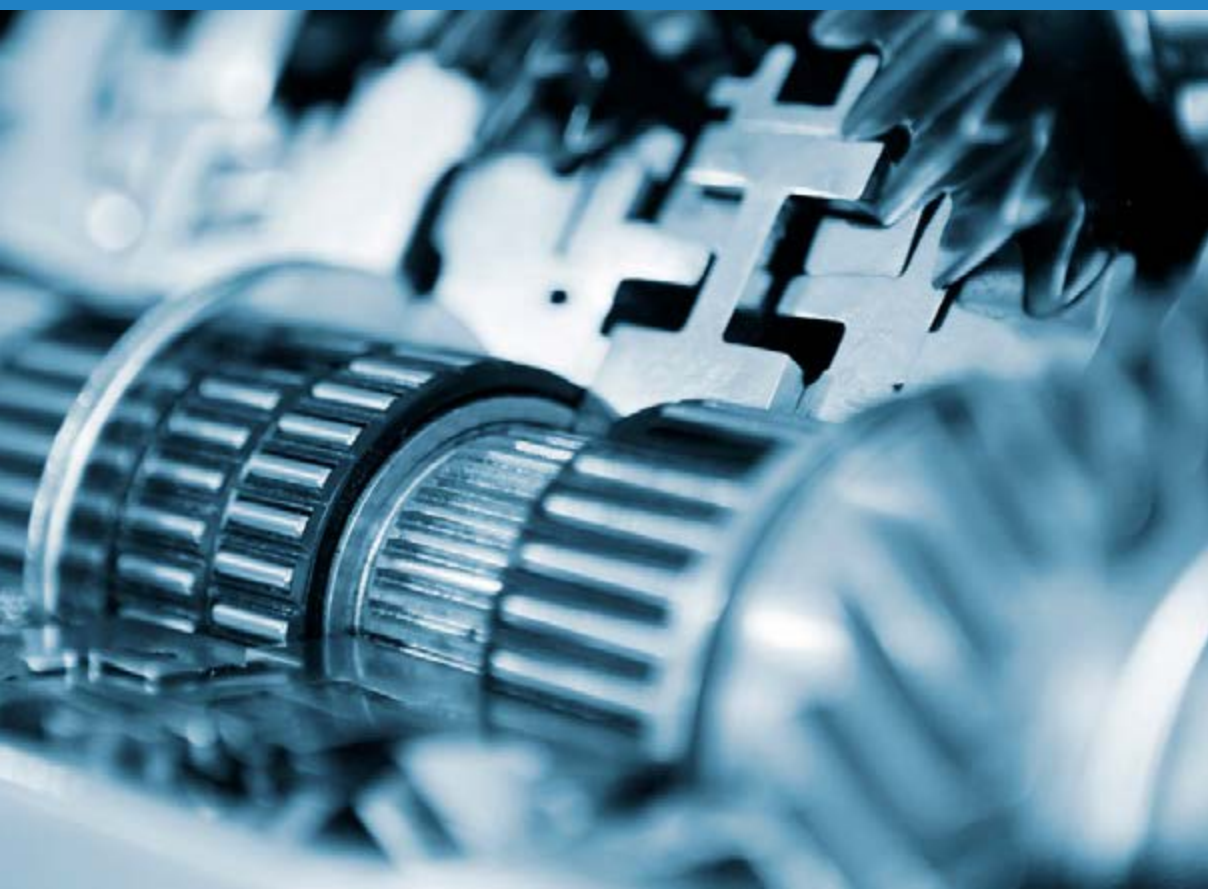
Hardware-dependent programming

Real-time communication

Automation

Real-time machine vision

Automotive protocols



Precise timing

Real-time for Windows

In the modern world, time is a crucial factor. Automated processes on an industrial level require precise communication between application and machine. High-performance devices generate enormous amounts of data that need to be immediately processed.

Kithara develops software for accurate control, monitoring and analysis down to the microsecond for processes in industry and research. Our products can be found in the automotive sector, the aerospace industry, in food manufacturing as well as medical engineering. Even in the cutting-edge field “autonomous driving”, Kithara is an important contributor.

Problem and Solution: Operating systems such as Microsoft Windows sometimes override priorities of running processes in order to execute their own programs and maintenance functions. This can lead to unwanted interruptions in the sequence of applications.

Kithara basically creates its own protected area, which is independent and unrestricted by the operating system.

Kithara RealTime Suite

Windows real-time extension for PC-based automation

Kithara RealTime Suite is a modular real-time extension for Windows, combining hardware-dependent programming, communication, automation protocols as well as image capturing and image processing into a single high-performance real-time system. Due to seamless integration of modules, users are provided with all the necessary functions in one piece.

Efficient real-time Ethernet drivers via TCP and UDP are the basis for both socket communication including image capturing with GigE Vision® cameras as well as for modern Industrial Ethernet protocols. The software is further supplemented by real-time drivers for CAN and UART interfaces. Among the supported automation protocols is a comprehensive EtherCAT® master implementation including Distributed Clock, Safety-over-EtherCAT, hot-plug capability and cable redundancy.

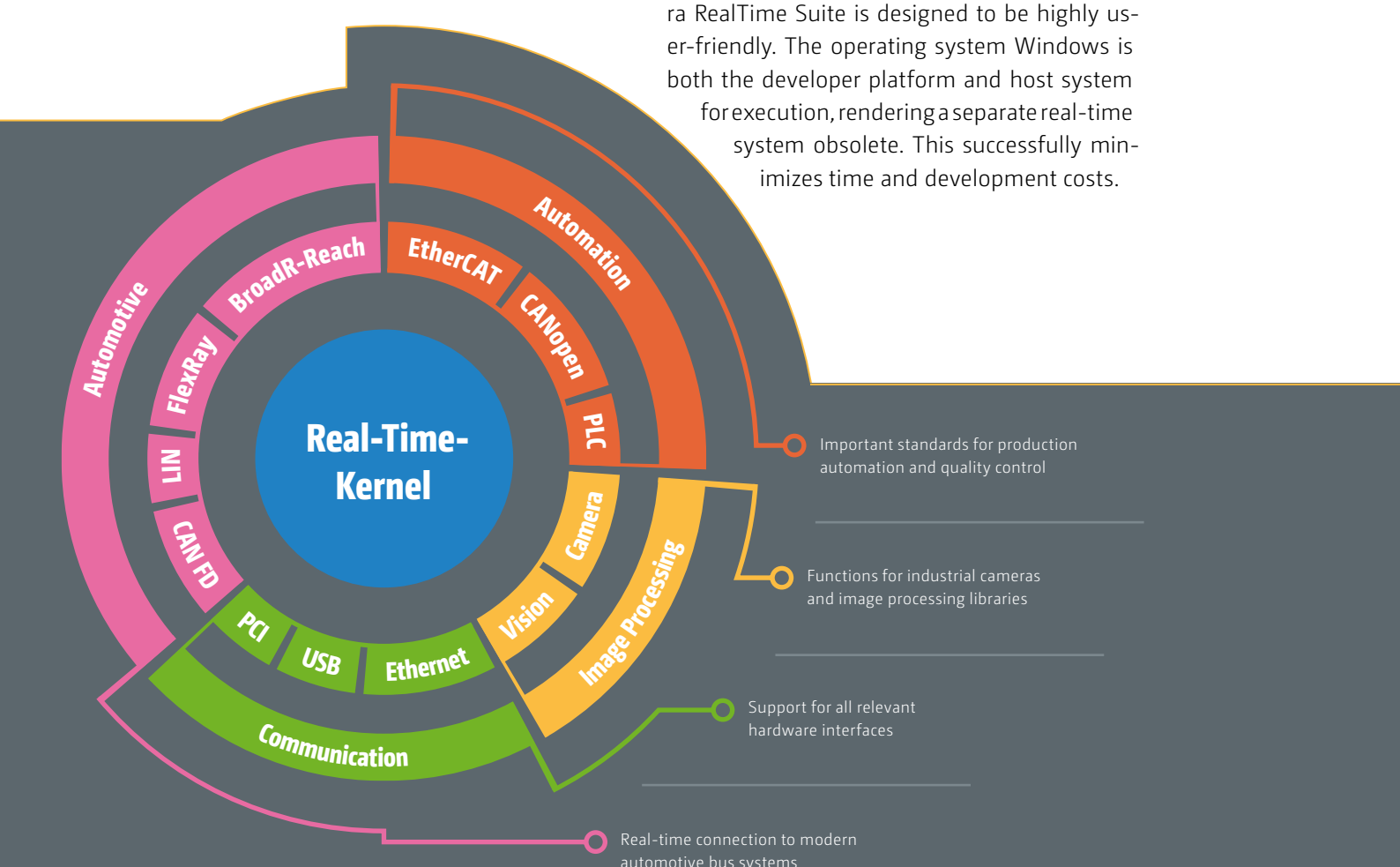
Furthermore, a CANopen® master is provided via a variety of different CAN interfaces, which can also be integrated into EtherCAT®.

Hardware-dependent programming includes direct I/O access, memory access and interrupt handling as well as a convenient high level interface for multifunction boards.

For processing image data captured by GigE Vision® or USB3 Vision®, it is possible to run comprehensive image processing libraries, such as Halcon or OpenCV, within the real-time environment.

For fast real-time data storage, SSDs with NVMe interface (can be multiplied with RAID 0) are supported. Additionally, data sets can be immediately stored as hierarchically structured files in MDF or PCAPng format.

The software is easily accessible and intuitive. Due to the use of familiar programming languages and development environments, Kithara RealTime Suite is designed to be highly user-friendly. The operating system Windows is both the developer platform and host system for execution, rendering a separate real-time system obsolete. This successfully minimizes time and development costs.



Our products for your real-time project

Windows is optimally suited for the implementation of industrial applications due to the following traits ...

- popular: intuitive and familiar user interface
- modern: access to the latest communication interfaces
- productive: powerful development tools
- cost efficient: low implementation and training costs
- future-proof: long-living due to its high market share and continual further development

The necessary real-time capabilities, which Windows is missing, is complemented by Kithara RealTime Suite and allows for the execution of time-critical applications due to ...

- deterministic behavior
- extremely low maximum response times
- familiar programming language and tools
- powerful and easy-to-apply functions
- short training time—cost efficient development
- broad support for industrial protocols and standards

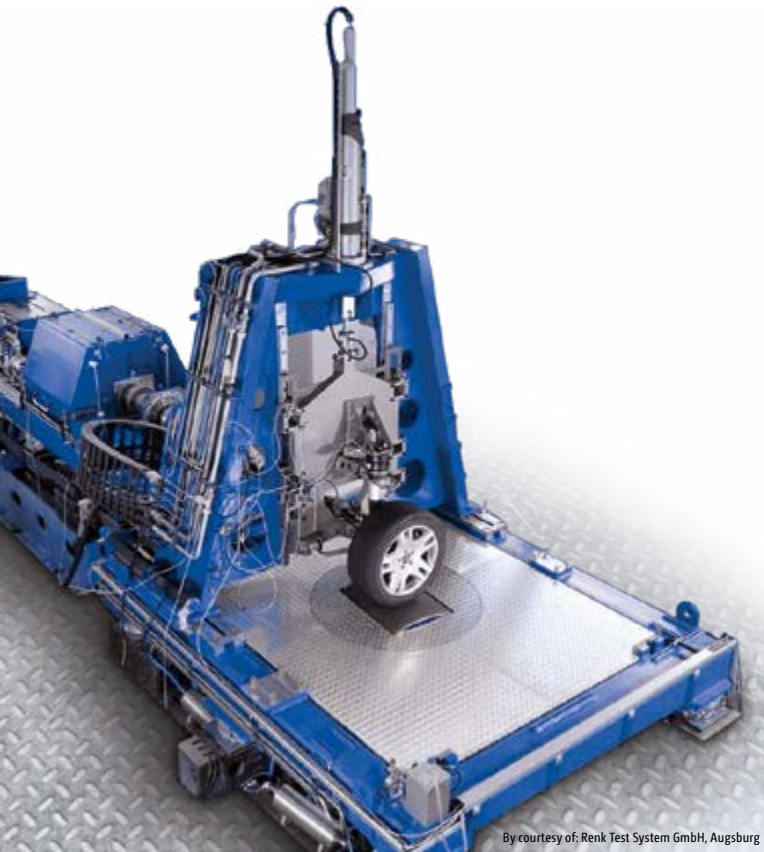
Kithara RealTime Suite makes it possible to have both real-time control and visualization within the same system. The application runs in dedicated mode on separate CPU cores, whose quantity can be configured freely. At the same time, Windows is responsible for visualization and user interaction on the remaining CPU cores. This way, both parts run separately without influencing each other.

The combination of Windows and Kithara RealTime Suite allows for the implementation of a diversity of solutions, among them the following fields:

- mechanical engineering, special machine construction and testing systems
- production automation and quality assurance
- lab automation and mobile applications
- measurement and test stations in automotive engineering and aerospace industry
- medical engineering
- laboratories in science and research

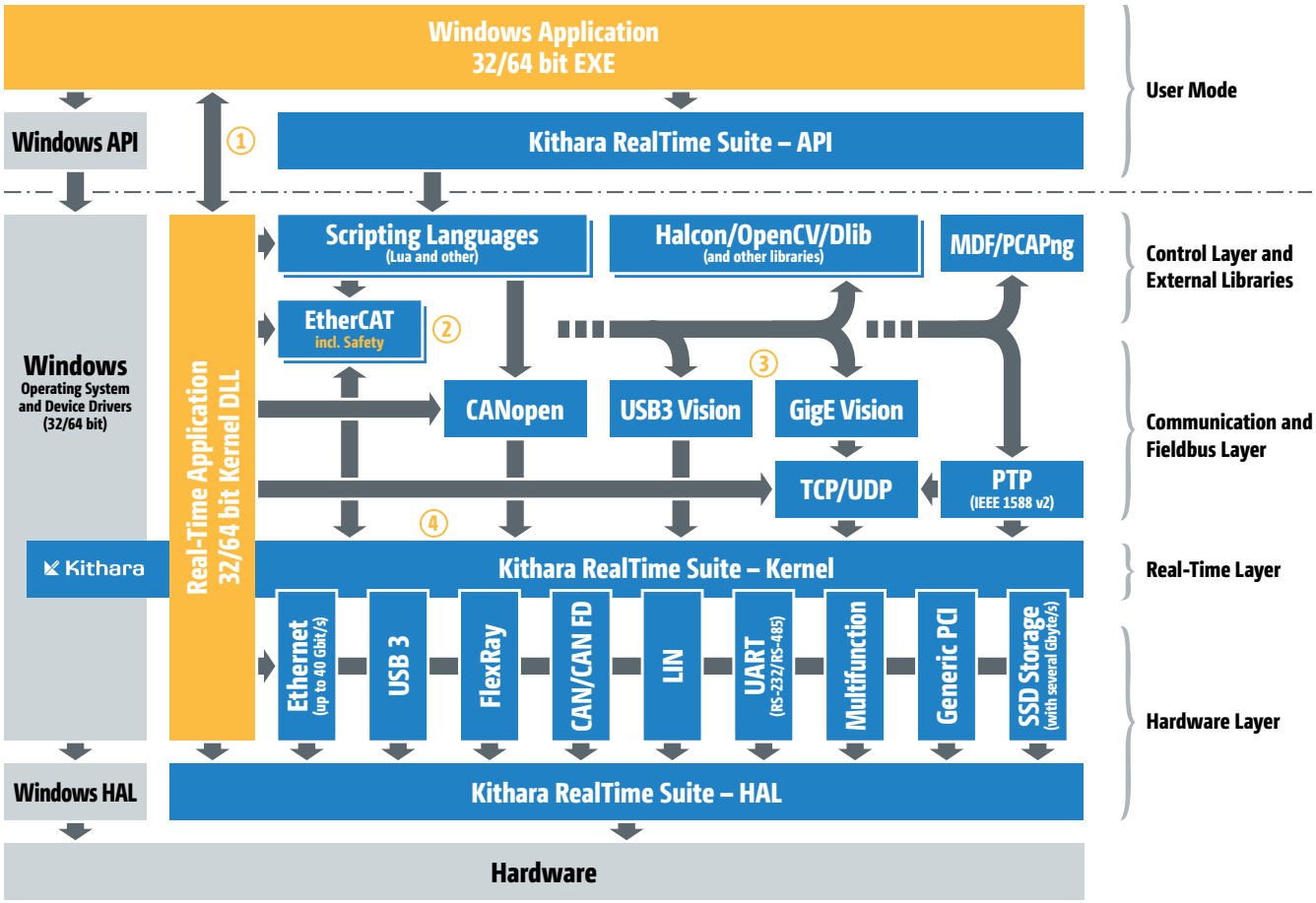
Conclusion

Kithara simplifies your project significantly. You will not need a separate real-time system, thus avoiding an expensive implementation of communication between different systems. Instead, you can utilize the advantages of a uniform solution and benefit from drastically reduced development efforts, coherent programming tools and toolchain. This shortens time to market, lowers costs and results in reduced resource consumption. That makes Kithara RealTime Suite together with Windows the ideal foundation for successful real-time solutions.

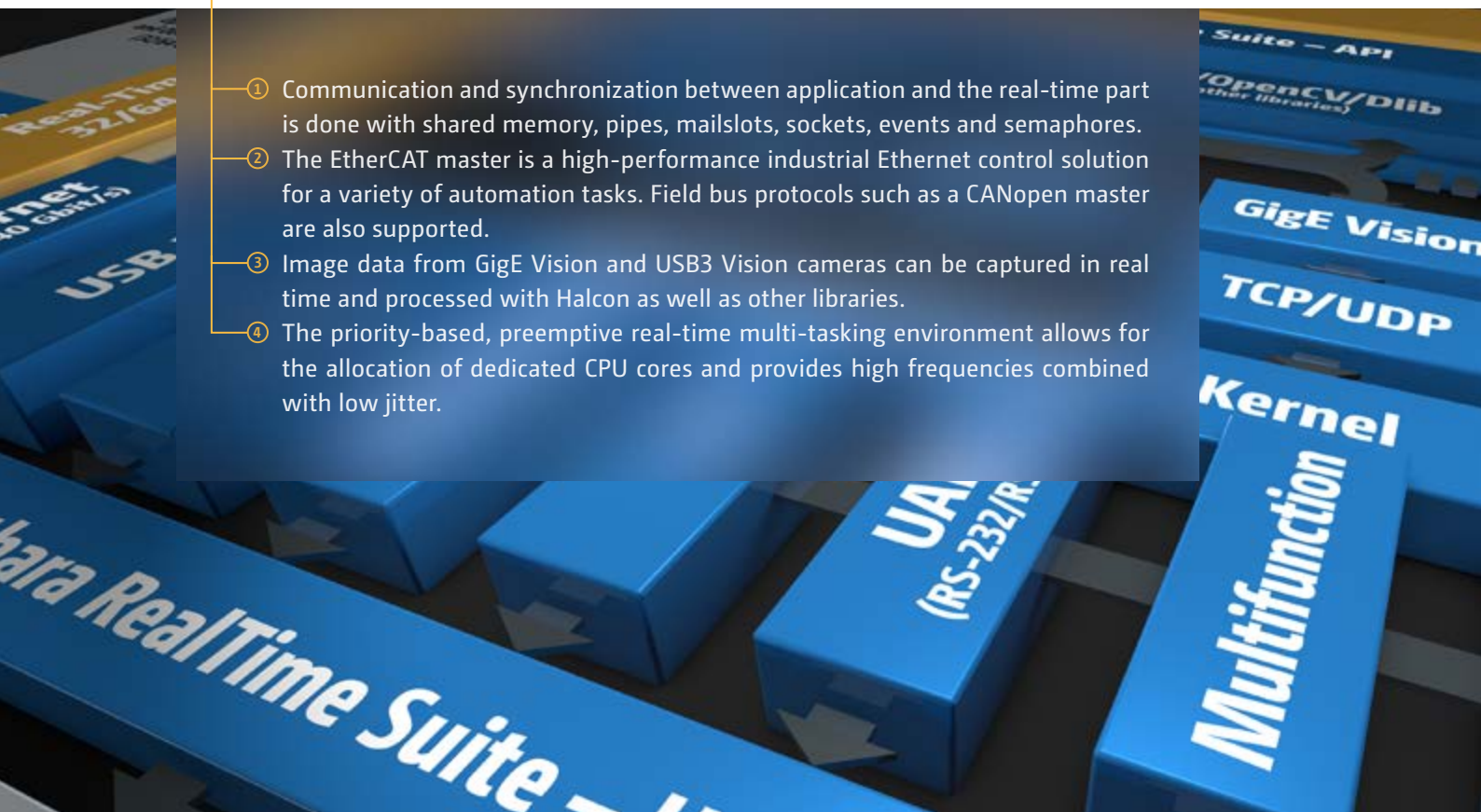


By courtesy of: Renk Test System GmbH, Augsburg

The following diagram shows with a layer model how Kithara RealTime Suite is connected to the different software and hardware components of a system.



1. Communication and synchronization between application and the real-time part is done with shared memory, pipes, mailslots, sockets, events and semaphores.
2. The EtherCAT master is a high-performance industrial Ethernet control solution for a variety of automation tasks. Field bus protocols such as a CANopen master are also supported.
3. Image data from GigE Vision and USB3 Vision cameras can be captured in real time and processed with Halcon as well as other libraries.
4. The priority-based, preemptive real-time multi-tasking environment allows for the allocation of dedicated CPU cores and provides high frequencies combined with low jitter.

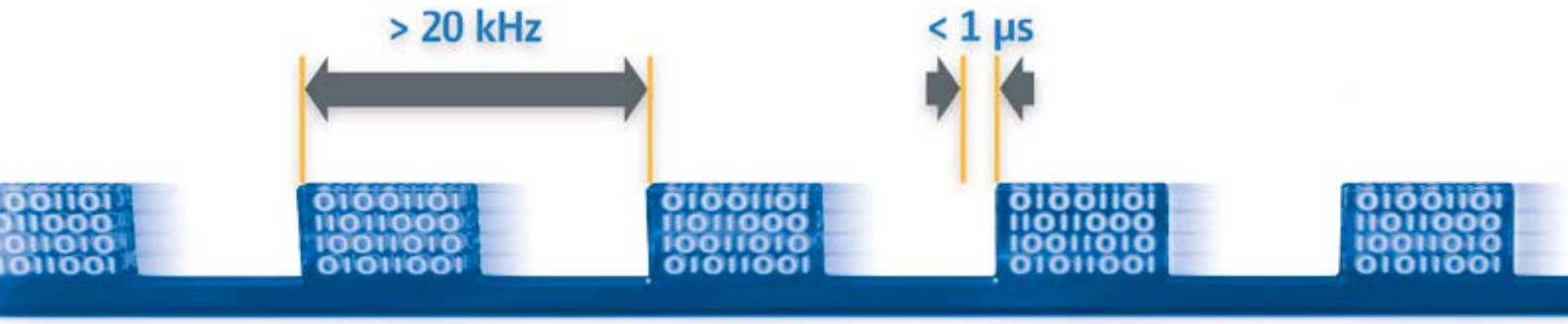


“Hard” real-time for the Windows platform

Due to the modular-built system with its broad range of possible implementations, Kithara RealTime Suite is the optimal base for developing efficient applications in automation, hardware communication and machine vision, since these fields are often dependent on time-critical functions.

Kithara RealTime Suite uses the reliable dedicated mode, where single logical CPUs (CPU cores) are run completely autonomous and without any influence from Windows. This way, by using appropriate hardware, cyclical timer calls with frequencies in the upper double-digit kilohertz range can be implemented with deviations (jitters) of only a few microseconds.

At the real-time start, the system first analyzes the hardware, such as all available clocks, and calibrates them. However, not only timer routines can be run with high frequencies. The preemptive real-time multitasking provides tasks (threads) with up to 255 priority levels so that the action with the highest priority is always executed first. Less prioritized actions are interrupted immediately and are continued only after the completion of higher prioritized actions.



For the synchronization between kernel DLL and Windows application, events, semaphores, mutexes, data and message pipes, sockets as well as shared memory are provided. Individual tasks can be specifically allocated to different logical CPUs in order to further optimize performance and integrity of specialized tasks as well as the scalability of the entire system.

Built around the kernel are a variety of other modules for the connection of external devices and systems via different communication and access interfaces as well as for specialized tasks. One example is the Storage Module, which allows for fast data storing on SSDs with a sustained throughput rate of several gigabytes per second. Captured measurement data can also be stored in future-proof Measurement Data Format (MDF) as terabyte-sized files. Furthermore, powerful diagnosis and programming tools such as Kithara Kernel Tracer and Kithara Performance Analyzer are at the user's disposal, making the whole development process even more flexible and efficient.

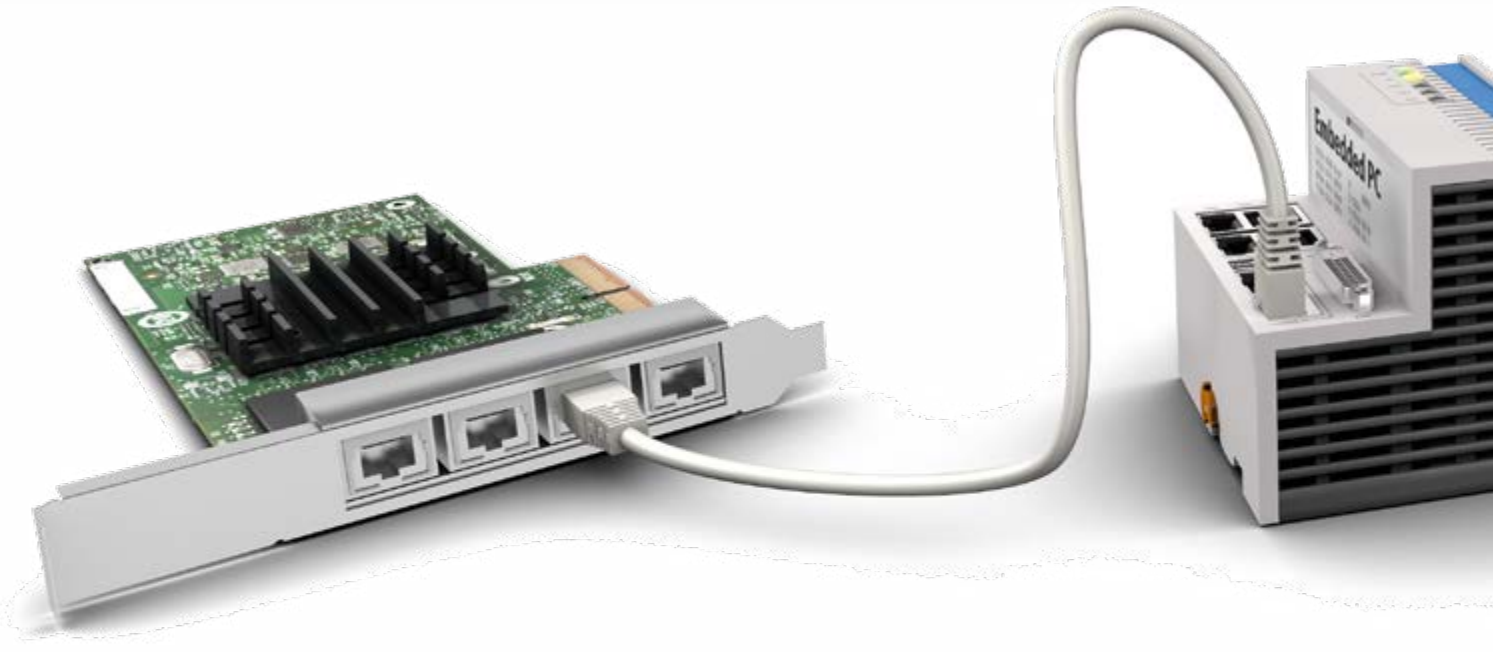
Software solutions for PC-controlled automation

In automation technology, standardized protocols have become mandatory by now. As one of the most popular field busses, the open and fast industrial Ethernet variant EtherCAT has established itself and has since enjoyed considerable growth. For this, Kithara RealTime Suite also includes a high-performance EtherCAT master.

Its “hard” real-time capabilities allow for plant automation with cycle times of only 50 µs or less. The master also provides all necessary mechanisms ranging from automatic determination of the connected topology, support for slaves as distributed clocks (DC) to special features such as hot-plug capability and cable redundancy.

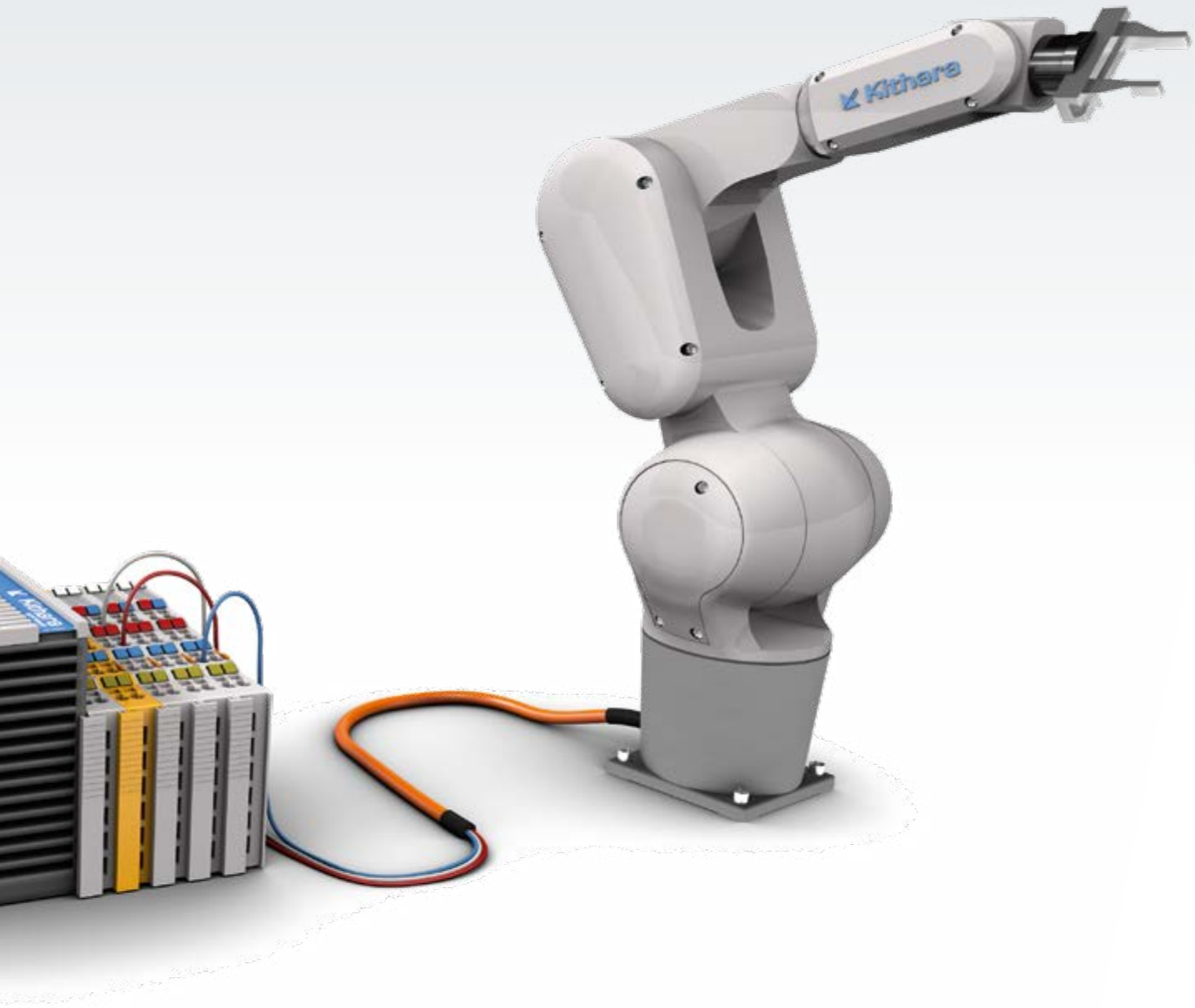
For the implementation of safety applications, the Safety-over-EtherCAT (FSoE) can be integrated as well. In this case, the EtherCAT master handles the data package exchange between safety input, output as well as safety logic components. This way, applications up to SIL3 can be implemented—an otherwise separate wiring, such as for an emergency deactivation, is not necessary.

Furthermore, the integration of PCs as EtherCAT slaves is possible in order to create flexible nodes for scalable EtherCAT networks. To achieve this, special PCIe cards can be used to embed PCs into EtherCAT topologies and operate them as slaves. Such EtherCAT PC slaves benefit from the graphical interface and input options of regular PCs and can be specialized for various tasks, such as the allocation or scaling of processing power.



Also available is the CANopen master which can be utilized to operate CAN interfaces or to embed into higher-level EtherCAT networks.

For embedding EtherCAT topologies into higher levels and even company networks, the EtherCAT Automation Protocol (EAP) is available. It enables devices and whole production segments of identical as well as different levels to exchange data with up to 40 Gbit/s. This allows not only for master-master communication, but also for the connection to higher-level production systems (MES, ERP) and departments (logistics, distribution etc.). This universal connecting of automated facilities makes EAP the base for the execution of cyber-physical systems.

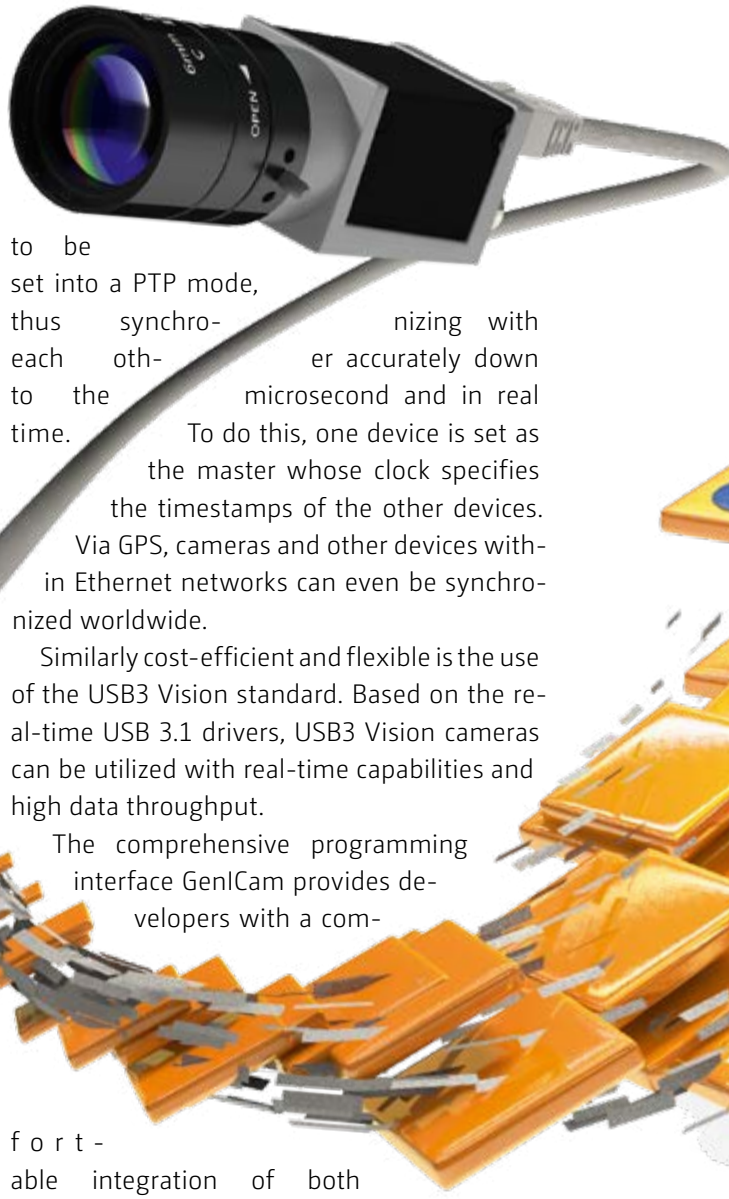


Machine vision in real time

Many automated plants rely on machine vision, be it for manufacturing, packaging, monitoring or quality assurance. The applied vision interface standards for industrial cameras as well as the use of image processing libraries, however, require low reaction times in order to meet a variety of specific tasks. Kithara RealTime Suite is a leading pioneer in the field of real-time image capturing and processing.

The support of automation protocols within a closed real-time cycle offers the decisive benefit of transmitting the result of the algorithm-based image analysis directly to the process without having to leave the real-time context. This means that even systems on sensor/actor level can be directly controlled by processed image data.

For Ethernet-based camera systems, a real-time-capable GigE Vision driver is provided, which can respond to an incoming complete camera image within a few microseconds. Link aggregation is also supported, enabling parallel transmission on multiple channels. Depending on the deployed hardware, data rates can go up to more than a gigabyte per second. The advantages of GigE Vision coincide with those of Ethernet, meaning the use of cost-efficient and interchangeable, standardized hardware as well as data rates of up to 10 Gbit/s and long cable lengths. With GigE Vision 2.0, the Precision Time Protocol (IEEE 1588) has been introduced. It allows for multiple cameras to be set into a PTP mode, thus synchronizing with each other accurately down to the microsecond and in real time. To do this, one device is set as the master whose clock specifies the timestamps of the other devices. Via GPS, cameras and other devices within Ethernet networks can even be synchronized worldwide.

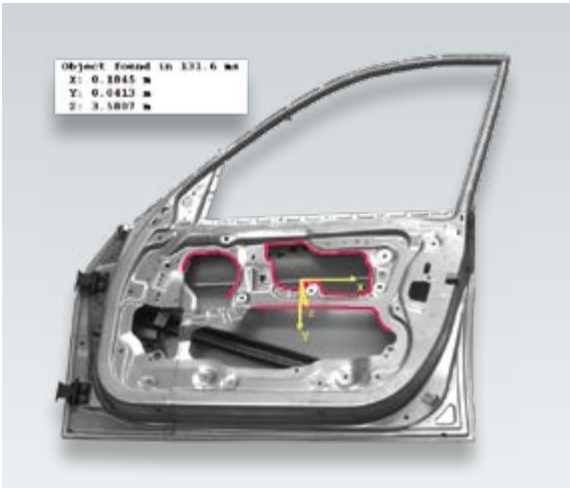


Similarly cost-efficient and flexible is the use of the USB3 Vision standard. Based on the real-time USB 3.1 drivers, USB3 Vision cameras can be utilized with real-time capabilities and high data throughput.

The comprehensive programming interface GenICam provides developers with a comfortable integration of both standards. With optional hardware, even CameraLink™ can be supported.

By deploying an external frame grabber, which converts CL control information and data packages to GigE Vision, all CL configurations including “Full” can be integrated via a 10 gigabit Ethernet connection into the real-time environment. This also increases the previously short cable lengths to Ethernet levels. For immediate further processing and analysis of image data, certain algorithms

or external image processing libraries such as Halcon or OpenCV are usable. In order to do so, the respective library is loaded into the real-time context. When using Halcon, procedures created with the development environment HDevelop can be executed directly in real time.



For manufacturing and quality assurance, especially in the automotive field, the use of camera systems has increased significantly. This often includes high-precision recognition and accurate interpretation of captured images. Without “hard” real-time capabilities for image capturing and processing, this would not be feasible. Kithara provides the necessary technical basis for these tasks.

Hardware access and communication in real time

Several modules of Kithara RealTime Suite are used for the connection of PC hardware. Via access to I/O registers of a PC, the physical memory as well as interrupt handling, drivers for individual hardware components and plug-in cards can be created. For many common communication interfaces, efficient, ready-to-use drivers are already available.

Especially in industrial fields, the significance of Ethernet applications with high time-critical requirements has increased substantially. The specially developed drivers for this field support all common Ethernet network controllers by Intel and RealTek with data rates of up to 40 Gbit/s. All functions, traits and benefits of Ethernet, such as the use of flexible and cost-efficient standard hardware, can be utilized as usual but also complemented with real-time capabilities. In this manner, special hardware features of applied controllers, such as jumbo frames, advanced data flow control due to interrupt optimization, can be used effectively.

In order to achieve real-time capability, network controllers are accessed directly. This way, the whole bandwidth of a connection is available and the reaction to incoming data packages takes place immediately. In order to guarantee high-performance network communication, all redundant Windows mechanisms that otherwise would impair the transmission rate or negatively impact immediate reactions, are bypassed. For the implementation of socket communication, a special driver layer for datagram (UDP) or stream-oriented (TCP) communication applications is provided.

For fast communication with USB up to version 3.1, Kithara provides a specially programmed, easy-to-apply access to the Extensible Host Controller Interface (XHCI). Thanks

to its cost-efficient implementation with standardized hardware combined with good transfer rates, USB has become one of the most widespread communication standards. The SuperSpeed mode, introduced with USB 3.0, which achieves even higher data rates and full-duplex communication, has since enabled USB to be applied productively even in advanced industrial fields.

Thunderbolt can also be used in real time, allowing for an immediate communication of components, that are connected via this interface at the lowest possible delay. This Thunderbolt implementation also enables the use of appropriate hardware extensions in real time such as for connecting PCIe cards to laptops. This helps improve the mobility of software-based real-time solutions, for example when testing or measuring directly at the machine on site.

Furthermore, serial UART and COM interfaces can be addressed as well, supporting the common standards RS-232, RS- 422 and RS-485; with baud rates of 115.200 and 921.600 bit/s. This also includes running UART functions from real-time tasks on dedicated CPUs as well as directly controlling handshake and signal lines.

A special additional programming interface allows for the handling of operating system function calls for the communication of device drivers at kernel level. Even “virtual” COM interfaces, for example, can be generated this way. Furthermore, we also support a range of high-performance multifunction cards by National Instruments, which can be accessed via digital and analog input/output. Prime examples for the practical application of time-critical hardware communication, among others, are machine vision with industrial cameras (GigE Vision, USB3 Vision) or sophisticated automation tasks with EtherCAT.

Kithara RealTime Suite – The modules

Base/Kernel Module
System Module
Clock Module
RealTime Module
MultiTasking Module
PTP Module
Storage Module
MDF/PCAPng

Real-time system

- Clock: monitoring of system time in different predefined or user-specific time formats, resolution up to 0.1 µs; highly accurate short-time delays; long-term synchronization with EtherCAT Distributed Clocks (DC) and IEEE 1588
- RealTime: programming of highly accurate real-time timers due to highest system priority; maximum programmable frequency over 20 kHz, jitter in microsecond range
- MultiTasking: priority-based, preemptive real-time multitasking; up to 255 priority levels, prevention of priority inversion caused by priority inheritance, dynamic priority adjustments; events, semaphores, mutexes, timer, support for multiple CPU cores, tasks can be assigned to individual cores
- Storage: real-time data storage via NVMe SSD with the most recent capacities; high-speed reading and writing with several gigabytes per second; UDF data system; interconnection of multiple SSDs via RAID 0
- MDF: storage with future-proof binary format for measurement data MDF, Version 4.1.1 (Measurement Data Format)
- PCAP: capturing of measurement data in PCAPng format (Packet Capture)

EtherCAT Module
ECAT PC Slave Module
ECAT Autom. Protocol
CANopen Module

Automation

- EtherCAT®: EtherCAT® master (down to 50 µs cycle or less), automatic determination of EtherCAT topologies, process data and service data communication (PDO + SDO), mailbox communication and CoE; Distributed clocks (DC), Safety-over-EtherCAT® (FSoE), Ethernet-over-EtherCAT® (EoE), Fileaccess-over-EtherCAT® (FoE), ServoDrive-Profile-over-EtherCAT® (SoE), hot-connect capability for dynamic topologies, cable redundancy, EtherCAT® Automation Protocol (EAP) for data transfer at control level with up to 40 Gbit/s, PC as EtherCAT slave with PCIe card
- CANopen®: CANopen® master in real-time, automatic determination of CANopen topologies, management of CANopen slave states, process data and service data communication (PDO + SDO), mailbox communication

Camera Module
Halcon Extension
Open CV Extension

Machine Vision

- Camera: Image capturing with GigE Vision® cameras and USB3 Vision® cameras in real-time, support of GigE Vision® Version 2.0, polling or event-triggered, multiple simultaneous cameras, hot-plug capability, error handling, configuration according to GenICam 2; support of link aggregation (up to 250 Mbyte/s) and 10 GbE (1,250 Mbyte/s)
- Vision: running external image processing libraries in real-time with Halcon or OpenCV, others on request

Communication

- Network: up to 40 Gbit/s in real-time; polling or event-triggered; UDP/TCP, IP and MAC multi-cast, broadcast, jumbo frames depending on controller; automatic address determination via ARP support, server or client
- USB 3.1 in real-time, direct access to the XHCI; Low, Full, High and Superspeed; control, bulk, interrupt and isochronous transfer; plug and play, power management
- UART: serial communication in real-time with specific hardware drivers on UART-16550-compatible hardware, signal and handshake lines directly accessible; handlers for all interface events
- CAN: CAN 2.0B in real-time; highly accurate time stamps for every received CAN message; filter, RTR mode, independent API for boards of different manufacturers (PCI, PCIe, USB); support for CAN FD
- LIN: in real-time, based on USB-to-LIN module by Peak or LIN level converter
- FlexRay: in real-time, based on PCIe card PMC II by Star Cooperation
- BroadR-Reach: real-time support for Ethernet transport layer

Network Module
USB RealTime Module
UART Module
CAN/LIN Module
FlexRay Module
BroadR-Reach

Hardware access

- IoPort: access to all I/O registers of a PC; determination of PC configuration data and resource information
- Memory: access to external physical memory (dual ported RAM), allocation for external hardware (DMA memory)
- Interrupt: handling of hardware interrupts (PCI, PCIe, ISA, PC104, PC104+, Cardbus and ExpressCard)
- MultiFunction: support of multifunction boards with vendor-independent API, bit-wise or word-wise digital I/O, analog I/O as single value, channel sequence, limited sequence progression or unlimited mode with half-full interrupts

IoPort Module
Memory Module
Interrupt Module
MultiFunction Module

Base functions

- Base/Kernel: functions for opening the driver, device handling, debugging support, system information, application threads, events, callbacks, shared memory, data pipes and message pipes, fast mutex objects
- System: interception of system events, such as faults and system crashes at kernel level (e.g. FailSafe Handler/"BlueScreen Handler")
- Device: Windows API for device communication (ReadFile, WriteFile, DeviceIoControl), any device names possible, virtual COM ports
- Library Module: mathematical/trigonometrical as well as string and memory functions in real-time; support for external libraries
- Dlib: real-time functions for machine learning
- SigProc: real-time control with PID algorithm; digital signal processing in realtime; 20 predefined or user-defined filters; low-pass/high-pass/band-pass or bandstop, Chebyshev, Hanning, Hamming

Base/Kernel Module
System Module
Device Module
Library Module
Dlib Extension
SigProc Module

Selected references

The following companies and institutions are among our customers:

ALSTOM | Audi | BMW | BOMBARDIER | BOSCH

DAIMLER | DB | DIEHL | DLR | EADS

Fraunhofer | HEIDELBERG | Hundegger | KMW | KROHNE

LIEBHERR | MTU Aero Engines | NXP | PHILIPS

PTB | RENK | SELGRON | SENNHEISER | SICK

SIEMENS | thyssenkrupp | ZEISS | ZF

Some of our partners:

BASLER | Baumer | BECKHOFF | MTEC | PEAK System

For further questions regarding features, supported hardware, operating systems or programming languages, please visit our website > **www.kithara.com**. We recommend downloading the free trial version. Please contact us for any questions about your project!

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Kithara

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