Sercos SoftMaster is now ready for production

Bosch Rexroth makes – as part of its Sercans XS package – the Sercos SoftMaster available as open-source software and free of charge.

On December 8, 2016, a new stage of availability of Sercos® technology for control systems began. On this date, the Sercos SoftMaster package was released on www.sourceforge.net/projects/sercos-soft-master-core, making it possible to equip any application with this technology free of charge.

Over the past three years, numerous prototype systems at over 15 evaluating companies and organizations worldwide were equipped with the precursors to the software package. This made it possible to ensure an extremely high quality level on the release date.

What is available?

With the Sercos SoftMaster package, over 95% of the Sercos Master solution is available. It is set up in such a way that the user does not have to make any code changes except for a few configuration steps.

The operating system abstraction and a test application are available free of charge as an example from Bosch Rexroth on request at Sercos@BoschRexroth.de. The following operating systems are supported and systematically incorporated into the release tests:

- Linux PREEMPT_RT ("OSADL Linux")
- QNX Neutrino
- Windows Embedded Compact
- TenAsys INtime
- IntervalZero RTX /RTX64
- Wind River VxWorks
- Linux (standard Ubuntu 14 LTS)
- Windows Embedded Standard

The ANSI-C implementation is kept completely platform-independent and can thus be adapted to every operating system and every platform, meaning the user is free to choose the operating system.

The featured solution is scalable, as evidenced by the Sercans series for instance:

- For all entry-level solutions that already cover the

requirements with bus cycle times of ≥500 µs and a line topology and synchronization between the system components in the microsecond range, an individual standard Ethernet controller combined with a suitable real-time operating system is already sufficient. It is estimated that this applies to at least 50% of all applications.

- For medium to high synchronization requirements in the range of <100 ns and bus cycle times ≥125 µs, the use of a TTS-capable Ethernet controller together with the suitable real-time system offers an excellent solution. If two of these Ethernet controllers are synchronized, the support of ring architecture with seamless redundancy is also possible, meaning over 90% of applications are covered.

For all applications
- that have higher requirements in terms of bus cycle time or
- for which the hardware and operating system platform requirements cannot be met,

the familiar HardMaster solutions are still available.

The package includes the following Ethernet modes, which correspond to the extension levels:

Economy: In the generic Ethernet mode, the cyclic telegram transmission is triggered by an operating system timer. In conjunction with a data packet supply via raw sockets, operation with every Ethernet controller is hereby facilitated.

Basic: In Time-triggered send (TTS) mode, hardware support is required. Here, the application provides the data packet to be sent well in advance in a prioritized queue, and the Ethernet controller carries out the transmission at precisely the right time. The Intel i210 controller already has these features. It has already been integrated into a multitude of industrial products as a standard Ethernet controller. It is expected that many Texas Instruments Sitara processors will also have these functions on board in the future via the real-time processing units PRU-ICSS.

By means of the generic mode, virtually every Ethernet controller is suitable for use with the Sercos SoftMaster. However, the synchronization accuracy is reduced by the telegram jitter caused by this. For higher requirements in terms of synchronization and cycle time, the NIC/TTS mode is available. Here, the Ethernet controller (NIC) precisely

	Sercans XS Economy (SoftMaster)	Sercans XS Basic (SoftMaster)	Sercos FPGA/Sercans S, M, L (HardMaster)
Architecture	RTOS — Host application / Master stack / CoSeMa / SoftMaster / RTOS abstr. / std. Eth. HW	RTOS — Host application / Master stack / CoSeMa / SoftMaster / RTOS abstr. / 2 * NIC (TTS)	RTOS1 Host / HW / RTOS2 Core / HW — Host application / DP HAM / Master stack / CoSeMa / S3M FPGA / Ethernet PHYs
Hardware (HW)	1 x standard Ethernet controller	2 x Intel i210 Ethernet controller TI Sitara PRU-ICSS (TTS-capable HW)	Sercos FPGA/ Sercans PC board; 2 x Ethernet PHY
Cycle time	500 µs +	125 µs +	31.25 µs FPGA/62.5 µs; 125 µs; 2 ms (Sercans L, M, S)
No. devices	Only limited by host	Only limited by host	511+ / 255, 128, 16 (Sercans L, M, S)
Synchronization	20–50 µs (~1 µs by device PLL)	20–40 ns	20–40 ns
Topology	Line	Ring (redundancy), line, dual line	Ring (redundancy), line, dual line
UCC	Within line	Routing@Master, within ring/line	Routing@Master, within ring/line
CPU load	<5% load on host	<5% load on host	Minimum load on host
NIC: Network Interface Controller (precise timing)		* **TTS:** Time-triggered send	+: Depends on host system

Figure 1: The Sercans XS extension levels Economy and Basic extend the range of solutions to cover cost-efficient and compact solutions for more simple requirements as well. (Source: Bosch Rexroth AG)

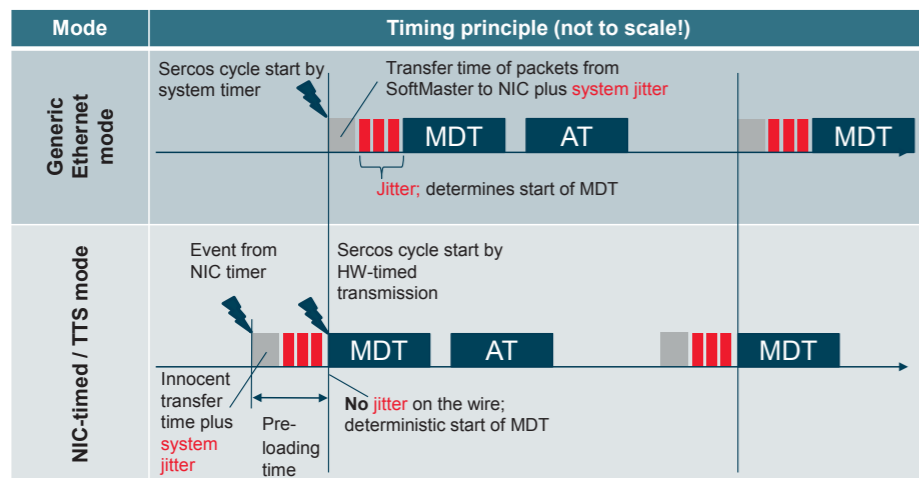| Mode	Timing principle (not to scale!)

Figure 2: In generic mode, the jitter present in the real-time system is visible 1:1 as tele-gram jitter, while in NIC/TTS mode, the timer of the Ethernet controller is used for a precise telegram transmission, thus ensuring maximum synchronization. (Source: Bosch Rexroth AG)

Dr. Andreas Schiffler,
one of the developers of the open-source CNC solution MachineKit/LinuxCNC

Figure 4: Screenshot of the operating interface of MachineKit with Sercos SoftMaster (Source: Dr. Schiffler)

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determines the telegram transmission using its own timer, and software is decoupled by means of an early provision.

With the release in December 2016, the status of the following functions has changed from "prototypical" to "supported":

- Several connections per slave
- Support of direct cross communication (CC)
- Ring topology
- Time-triggered send (TTS) and NIC timing
  (based on Network Interface Controller)

Suitable for evaluation tests – still with prototypical status – the following additional functions are included:

- Standard Ethernet communication
  (Unified Communication Channel, UCC) via the master
  (not to be confused with the same function within the line or the ring that is always available)
- Redundancy and ring recovery

Which license model applies and which business models are possible?

Despite the easy access to software technologies, many industrial users are nevertheless worried that when using open-source software in embedded systems, such as automation solutions, the applicable license conditions could force them to disclose their expertise. This aspect was taken into account with a conversion of the license model from LGPL (https://opensource.org/licenses/lgpl-license) to an MIT license (https://opensource.org/licenses/MIT).

Figure 3: License conditions and license text according to MIT

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/**
 * \file      SIII_nnn.c
 *
 * \brief     Sercos III SoftMaster Stack - nnn
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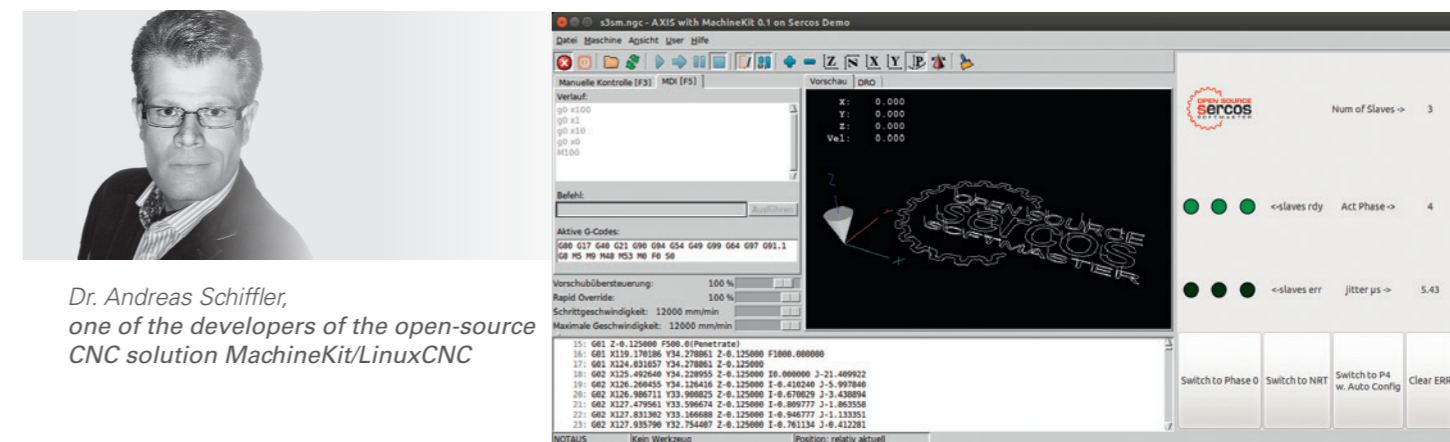
Thanks to the license model, potential uses are offering approaches for a wide range of business models and to all interested companies and organizations. Here are a few examples:

- Bosch Rexroth itself provides the sources free of charge and offers free sample code and integration assistance as part of the Sercans XS solution package. This way, the support of users is guaranteed in all important global markets. In doing so, Bosch Rexroth is not only supporting its own Sercos-based components, but also ensures that every Sercos-compliant product can be operated with it.
- Every automation software manufacturer for PLC, motion and robot control, or CNC solutions can also integrate the technology in his own solutions and market it as desired in conjunction with their own products.
- Companies whose business model consists in providing software services can use this technology in order to extend their customers' solutions.
- So there is nothing to stop machine manufacturers with their own control solutions from easily integrating the Sercos technology into their OEM solution.

Interested companies can book integration training via Sercos International (p.lutz@sercos.de) or Bosch Rexroth (Sercos@BoschRexroth.de).

In this way, users not only have the outstanding functions of the Sercos technology at their disposal, but can also use all of the over 240 Sercos III products with this fully open and free software module. This provides a scope for comprehensive and cost-efficient Sercos-based solutions that has never been possible before.

What experiences did users already make?

The users' projects are in different stages of integration. In the following, a few examples will illustrate the experiences and the wide range of possible applications.

Machine tools – MachineKit/LinuxCNC

The open-source software MachineKit has developed as a branch and an advancement of the software LinuxCNC. This has the advantage that a simple real-time kernel extension can also be used. This means MachineKit is open for a lot of platforms, such as PC, embedded PC or ARM single board computer.

Thanks to its independence from operating systems, the open-source Sercos SoftMaster can be ideally integrated on the one hand into a real-time Linux operating system and on the other hand into highly versatile software such as MachineKit. The integration must take place at two points. Firstly, at the point at which the real-time operating system abstracts the access to the standard Ethernet hardware, and secondly, at the top application layer. This approach has now been adopted in the open-source community and is showing its first demonstrative approaches, see links to Sercos SoftMaster on:

Dr. Schiffler's YouTube channel:
https://www.youtube.com/watch?v=Sw9DAKn6hoY,

the MachineKit website:
http://www.machinekit.io/,

GITHUB for MachineKit / LinuxCNC Sercos3:
https://github.com/aschiffler/linuxcnc-sercos3).

Dr. Schiffler, one of the developers, says: "The use of Sercos technology as a practical SoftMaster with standard Ethernet hardware and PC provides countless possibilities, ranging from simple automation tasks, including CNC axes, right up to IoT applications. The latter in particular is brilliantly facilitated by the Sercos bus, as standard Ethernet and Sercos telegrams pass through the same line. The first exemplary implementation in the software MachineKit can certainly provide impetus for more exciting developments here. Maybe we will be seeing the CNC control system on a NanoPi soon."

Packaging technology – Rovema

Rovema GmbH supplies packaging solutions and has been relying on Sercos since the introduction of industrial Ethernet technology.

Already in 2015, Rovema GmbH began integrating the Sercos SoftMaster technology and is about to proceed with the product launch.

Siegfried Wacker, Head of Product Development, talks about the objectives and experiences: "We made a conscious decision in favor of the Sercos technology as a system bus in our equipment, as it brings crucial advantages with respect to determinism and interoperability. In particular, the high degree of functional standardization makes
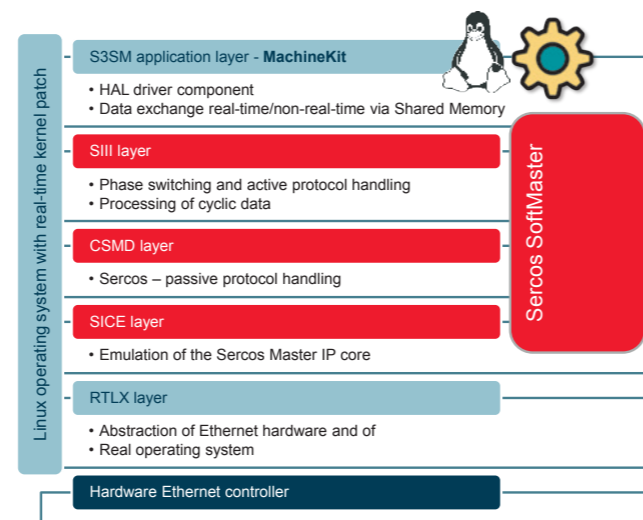

Figure 5: Integration (operating system and application) of the Sercos SoftMaster in MachineKit/LinuxCNC (Source: Dr. Schiffler)

it possible to use equipment from different manufacturers alternatively without any limitations in functionality.

The integration of the Sercos SoftMaster technology has enabled us to reduce hardware components and costs further, which is of great importance especially in the entry-level segment (e.g. our tubular bag machine type BVK)."

Siegfried Wacker
Head of Product Development
Rovema GmbH

Figure 6: Tubular bag machine series BV from Rovema GmbH, which could be adapted to better meet customer requirements using the Sercos SoftMaster technology. (Source: Rovema GmbH)

Hannes Richter
Business Development Manager
ISG Industrielle Steuerungstechnik GmbH

Food processing – machine manufacturer (OEM)

For many decades, an American machine building company has been providing its products and services in the field of meat and fish processing, and has now started integrating the open-source Sercos SoftMaster technology with the assistance of Bosch Rexroth AG.

The responsible software developer talks about the first steps of the integration and the experiences in the support of the technology: "We feel especially encouraged using the Sercos SoftMaster technology, knowing that this technology is based on a knowledgeable and competent software engineering team at Bosch Rexroth, that stands for sustainable support of the technology. During the training we learned a lot and will soon be implementing our next iteration prototype system. We expect the system to work very well and meet all of our requirements."

Machine tools and robotics – ISG-kernel

Industrielle Steuerungstechnik GmbH develops and integrates NC and robotic control solutions into their customers' control systems in the form of the software component ISG-kernel. In addition, the company provides a real-time simulation system, ISG-virtuos, which can be integrated into customer solutions and is suitable as a hardware-in-the-loop (HiL) system for virtual commissioning.
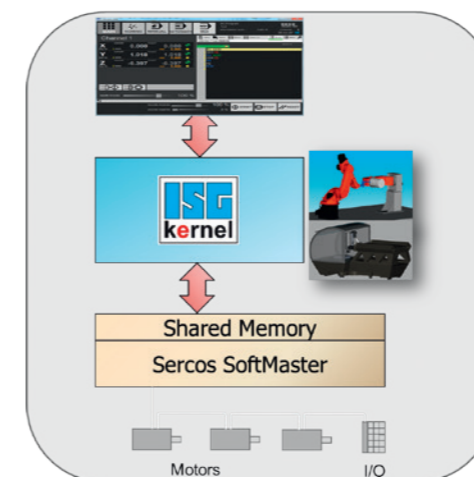
During the evaluation, several demonstration systems were realized using both products in cooperation with TenAsys, Phoenix Contact, the Institute for Control Engineering of the University of Stuttgart, and Bosch Rexroth AG.

Hannes Richter, Business Development Manager, talks about his experiences with the technology: "The NC kernel product is ideal for the integration of fieldbus interfaces. Use of the Sercos SoftMaster is characterized by particularly simple interfaces that are perfectly suited to our Shared Memory concept.

We intend to include the technology with the availability of the released software package as an option for our ISG-kernel product."

Summary

The requirements for implementation of the Sercos SoftMaster technology in a broad field of application – conservatively estimated, over 90% of all fieldbus applications are covered – are met thanks to

- the sustainable anchoring of the technology as an open-source project and in the solution package Sercans XS from Bosch Rexroth,
- and the license model according to MIT.

With the integration of the Sercos SoftMaster into the open-source CNC solution MachineKit/LinuxCNC, a free evaluation platform is available for motion control with I/O auxiliary functions. Based on the demonstration systems that were set up with ISG Industrielle Steuerungstechnik GmbH and additional evaluation projects, it can be deduced that integration into every available automation system with a fieldbus interface designed for this purpose is possible within four to eight weeks.

The framework conditions described in this article demonstrate that nothing stands in the way of industrial application regardless of location and industry sector.

Figure 7: ISG-kernel in use with the Sercos SoftMaster (Source: ISG Industrielle Steuerungstechnik GmbH)