TI Designs: White Paper

Sercos III Communication Development Platform

TI Designs

TI Designs provide the foundation that you need including methodology, testing and design files to quickly evaluate and customize the system. TI Designs help *you* accelerate your time to market.

Design Resources

TIDEP0100	Tool Folder Containing Design Files
AM3359	Product Folder
TMDSICE3359	Product Folder
Industrial SDK	Software Folder
TLK110	Product Folder
TPS65910	Product Folder

TI E2E™ Community

ASK Our E2E Experts
WEBENCH® Calculator Tools

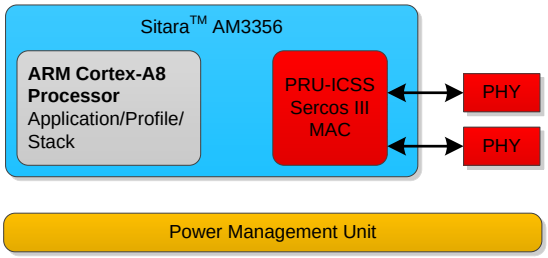
Design Features

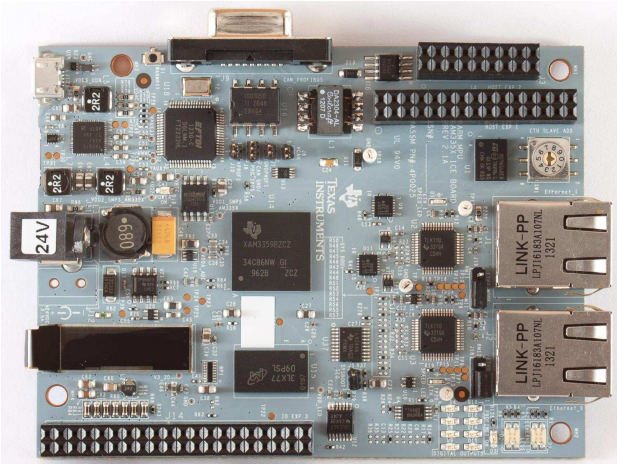
- Sercos III Conformance Tested
- Sercos III Firmware for PRU-ICSS With Sercos MAC-Compliant Register Interface
- Board Support Package and Industrial Software Development Kit Available from TI and Third-Party Stack Provider
- Development Platform Includes Schematics, BOM, User's Guide, Application Notes, White Paper, Software, Demos, and More
- Supports Other Industrial Communication Standards With Same Hardware (for Example, EtherCAT, Profinet, EtherNet/IP, Ethernet POWERLINK, Profibus)

Featured Applications

- Factory Automation and Process Control
- Building Automation
- Sensors and Field Transmitters
- Digital and Analog I/O Module
- Motor Drives
- Field Actuators
- Programmable Logic Controllers

Block Diagram





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1 System Description

For 25 years, Sercos has been one of the leading bus systems in factory automation applications like mechanical engineering and construction. Sercos III is the third-generation Sercos interface and was established in 2003. The efficient and deterministic communication protocol, based on real-time technology, merges the hard real-time aspect of the Sercos interface with Ethernet. The Sercos III technology integration requires dedicated hardware to support “on-the-fly” Ethernet frame processing, which up until now was implemented in field-programmable gate arrays (FPGAs) and application specific integrated circuits (ASICs).

This paper provides an overview of the Sercos III fieldbus technology and the implementation of the Sercos III protocol into the Sitara™ AM335x processors.

The TIDEP0010 Sercos III communication development platform combines the AM335x Sitara processor family from Texas Instruments (TI) and the Sercos III media access control (MAC) layer into a single system-on-chip (SoC) solution.

2 Technology

2.1 Introduction

In a Sercos III Industrial Ethernet network, one Sercos III master controls multiple Sercos III slave devices. Slaves are network devices such as drives, sensors, and analog and digital I/O devices (Figure 1). In a Sercos III network one master can control up to 511 slaves.

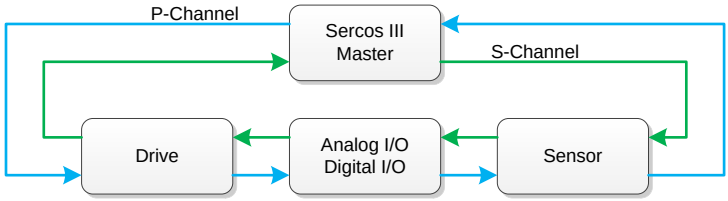

Figure 1. Example Sercos III Network in Ring Topology With P- and S-Channel

Both master and slave devices have two real-time Ethernet ports and wiring between devices can be realized either in line or ring topology. Other wiring topologies like star or stub are not supported. To simplify wiring and to reduce installation errors, the Ethernet cable can be connected to any port on a master or slave device.

Network redundancy is only supported with ring topology. The master sends out each frame twice, one over the primary channel (P-channel) and one over the secondary channel (S-channel). The transmission of Sercos III frames by the master takes place on both channels simultaneously. This mechanism is also used to synchronize timing across all slaves (see *Section 2.3*).

Sercos III combines a deterministic real-time-Ethernet channel (RT) and a best-effort-Ethernet channel (unified communication channel (UCC)) on the same Ethernet cable using time multiplexing (see Figure 2). During the time slot of the Sercos III real-time channel, only the master is allowed to start the transmission of a Sercos III Ethernet frame. The frame is received by all slaves and is being processed on-the-fly, that is, each slave that receives the Sercos III Ethernet frame processes the bytes from the byte-stream without changing the overall frame length. At the end of the frame, the slave recalculates and replaces the frame check sequence (FCS) in case the content has been modified.

The overall processing delay in a slave from incoming port to outgoing port is constant and approximately 1 µs. Hence, the frame roundtrip delay in a network with 10 slaves is 10 µs in ring topology and 20 µs in line topology.

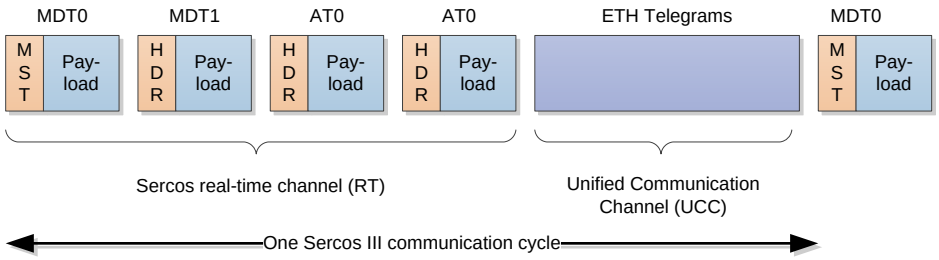

Figure 2. Sercos III Communication Cycle

During the time slot of the RT channel, only the master transmits master data telegram (MDT) and axis telegram (AT) Sercos III frames, which contain the cyclic process-data and asynchronous communication-data. The UCC channel is used by the master and the slaves to transmit Ethernet frames using the best-effort standard Ethernet approach.

Slaves are not allowed to transmit Ethernet frames in the RT channel and they have to buffer any UCC frames in the local memory. In line topology, it is common practice to add a service computer to the last slave to check or configure the slaves while the Sercos III network is operational. The last slave buffers UCC frames that are received during the RT channel and starts transmitting them after the UCC channel is opened.

Sercos III supports bus cycle times of down to 31.25 µs, which is used in dedicated drive applications where the programmable logic controller (PLC) handles the motor control loop. In less demanding applications, bus cycle times in the millisecond range are used.

After startup, the Sercos III network goes through different communication phases before it reaches the operational state when real-time process data is exchanged. These are called communication phases (CP0, CP1, CP2, CP3, and CP4); it starts from CP0 (detecting of slaves) to CP4 (operational state, cyclic and acyclic data communication).

2.2 Sercos III Frame

Only the master can generate Sercos III MDT and AT Ethernet frames. The MDT frame transfers data from the master to the slave while the AT frame transfers data from the slaves to the master. Figure 3 shows the generic Sercos III frame structure. Sercos III frames are broadcast frames. Each slave processes the frame by taking or placing data from the data field while forwarding the modified/unmodified content to the secondary port. The master receives back the modified frame; hence, in line topology, the last slave loops-back the frame and in ring topology the frame is received on the master's secondary port.

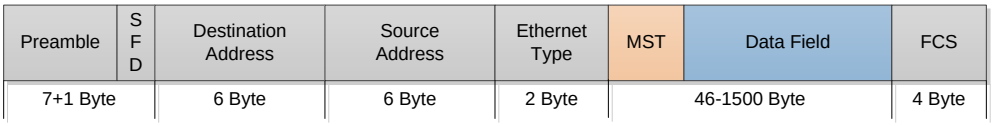

Figure 3. General Sercos III Frame Structure

The data field contains the cyclic and acyclic data for each slave. Each slave has a descriptor list that describes the location in the frame where it can read or write data. The slave validates the received FCS at the end of the frame. If the FCS is invalid, the frame content is not processed by the slave. If the slave has modified the content of the frame, it has to update the FCS; otherwise, the frame is corrupted and will be ignored by the next slaves or the master.

Because a Sercos III frame is based on standard Ethernet, it has a minimum and maximum frame length. The minimum frame is 72 bytes, which takes 5.8 µs to transmit at 100 Mb/s. The longest frame is 1526 bytes and takes 122 µs to transmit. The frame length as well as the number of MTD and AT frames is set by the master and is configured in the slaves during CP2.

2.3 Synchronization

The master sync telegram (MST) field in the MDT0 frame is used by the master for slave synchronization. The MST field has its own FCS. Each slave validates the MST FCS and uses the MST time reference as an internal synchronization event.

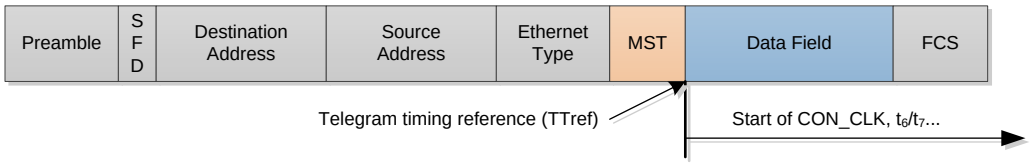

Figure 4. MDT0 Frame Synchronization Method

In CP2, the master measures the port-to-port delay of each slave, calculates the frame round-trip time and programs a different port delay time into each slave's ports. Finally, all slaves are synchronized in CP4 to the master's reference clock. The slave uses the MST synchronization events to internally synchronize the RT and UCC channel time slot as well as to generate a hardware synchronization signal called CON_CLK.

The CON_CLK hardware signal is used to synchronize a coprocessor or application to the Sercos III communication cycle.

2.4 Service Channel (SVC)

The MDT and AT frames embed an asynchronous communication channel that is used by the master to transfer communication, parameter and diagnostic data. The master issues SVC read and write requests to defined data structure (identification number (IDN)) in each slave. The IDNs are, for example, used to configure Sercos III network parameters and UCC channel parameters.

2.5 Topology

A Sercos III network is configured as line or ring topology. When using line topology a daisy-chain cabling is used and only one port of the master is connected to the first slave. The last slave in the chain loops-back the MDT/AT frames, so they are received back by the master (see Figure 5).

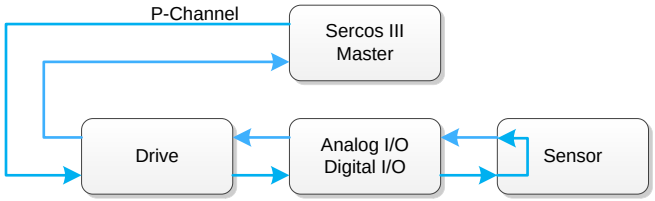

Figure 5. Line Topology With Last Device in Loopback Mode

To support network redundancy, use ring topology (see Figure 1). The primary port of the master is connected to the first slave and the secondary port is connected to the last slave. The master transmits Sercos III frames simultaneously on both ports. In case of an Ethernet cable break (called ring-break), the slave that detects the break immediately starts the loopback-mode. The slave sends the MDT/AT frames back on the same port where the frames were received. The master detects the ring-break-scenario in the status information of the AT frames. After the ring-break is physically resolved, the master issues a ring-heal command to the slaves to restore ring topology connection. Ring-break and ring-heal can occur anytime, but the master continues to operate the network in CP4.

3 Sercos III Slave Solution With Sitara Processor from TI

3.1 Components of Sercos III Slave

Many existing Sercos III slave solutions consists of an application processor, a FPGA, two industrial Ethernet physical layer devices (PHYs) and power management (see Figure 6). The application processor executes the customer's application, the Sercos III user profile and slave stack. The FPGA implements the Sercos III real-time Ethernet MAC that handles the real-time critical functions of the Sercos III standard. The MAC in the FPGA is connected to two industrial Ethernet PHYs that provide the Sercos III network ports. The devices need to be powered by a dedicated power management solution.

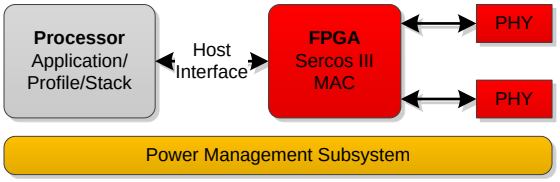

Figure 6. Sercos III Slave Solution Processor and FPGA

The AM335x Sitara TI design (TIDEP0010) combines the Sercos III MAC function blocks of an FPGA with the application processor. This leads to an integrated solution combining the customer application, the profile and stack with the Sercos III MAC on a single system-on-chip (SoC) (see Figure 7).

The powerful ARM® Cortex®-A8 application processor handles the application, the Sercos profile and stack. The Sercos III real-time critical functions are handled by the programmable real-time unit in the industrial communication subsystem (PRU-ICSS), which is integrated on the AM335x Sitara family of MPUs. A dedicated power management unit (PMU) device supplies the Sitara device enabling a simplified power management solution.

The fast internal interconnect between the ARM Cortex-A8, the PRU-ICSS, internal memory, and other peripherals allow fast exchange of real-time process data.

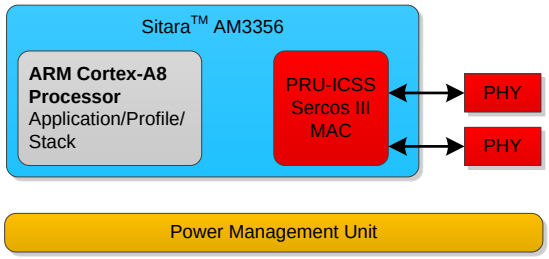

Figure 7. Integrated Sitara Sercos III Slave Solution

3.2 Sitara AM335x Peripheral Block Diagram

The Sitara AM335x device family is a low-power application processor with an ARM Cortex-A8 RISC core and a broad range of integrated industrial peripherals (see Figure 8). The ARM Cortex-A8 supports clock frequency ranges from 300 MHz for simple I/O applications up to 1 GHz for complex control applications that require more CPU performance.

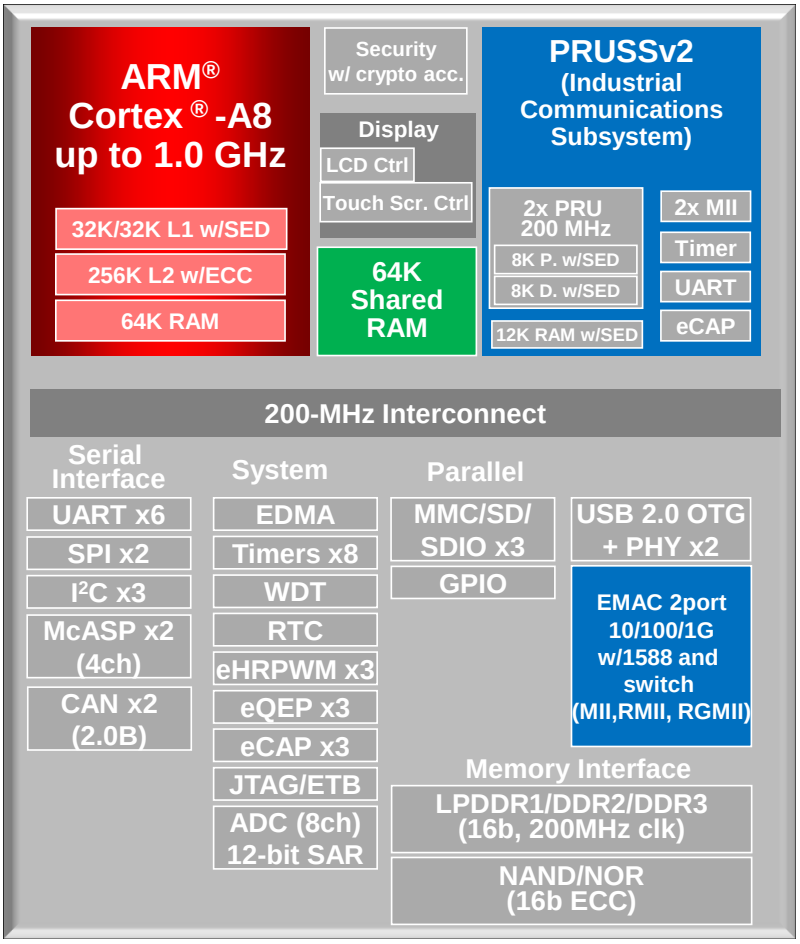

Figure 8. AM335x Family Block Diagram

3.3 Sercos III Slave System / Software Architecture

The hardware layer of Sercos III requires 100 Mb/s Ethernet for the physical layer (PHY). In the TIDEP0010, this is implemented with two TLK110 Ethernet PHYs from TI. The PHY's MII interface connects to the PRU-ICSS that handles the real-time functions of the Sercos III standard. The PRU-ICSS exchanges real-time data, Ethernet frames, control, and status information through the internal shared memory interface with the Sercos- and Ethernet-stack. The Sercos III stack and the function-specific profile (drive, I/O, …) provides an application programming interface (API) to the customer's application. The standard Ethernet frames are placed by PRU-ICSS in a dedicated shared memory area. Ethernet applications like web-server and trivial file transfer protocol (TFTP) can access the Ethernet frames through a dedicated frame queue.

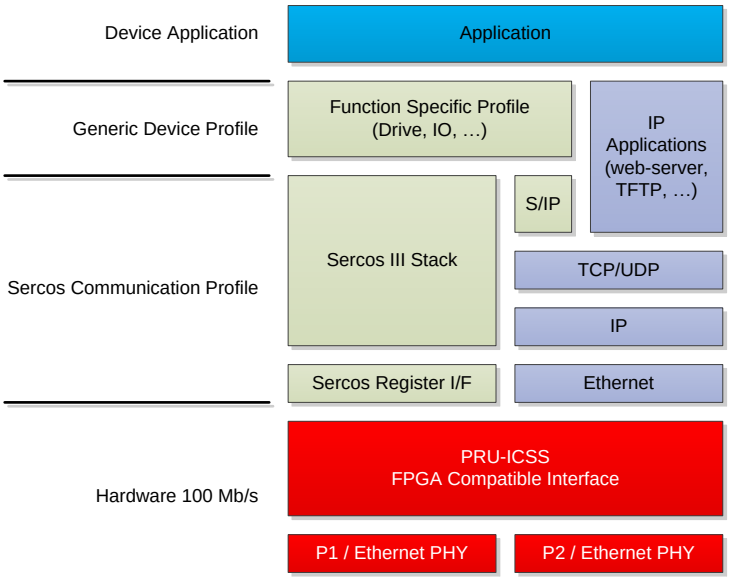

Figure 9. Sitara Sercos III Slave System/Software Architecture

3.4 Sercos III Stack Integration and Solution Validation

The TIDEP0010 solution has been validated with the Sercos III stack from third-party stack provider Cannon-Automata, using the Sercos III Conformizer validation tool. All required communication tests cases have been tested and confirmed. Customers can leverage this integrated solution by contacting the third-party stack provider, who gives them access to the validated Sercos III solution to jumpstart product development. The Sercos III firmware for PRU-ICSS has been implemented with a register interface equivalent to the Sercos III FPGA to allow customers to reuse existing stack solutions.

3.5 Development Tools

The TIDEP0010 solution can be evaluated with the industrial communication engine (ICE) board (see Figure 10). The board is intended for developing industrial Ethernet protocols for master and slaves devices, for example, I/O modules, sensors, actuators, motor controls, and PLCs. The two real-time Ethernet ports of the PRU-ICSS are accessible by two RJ45 connectors. Additionally, the board is equipped with digital inputs and outputs through onboard connectors.

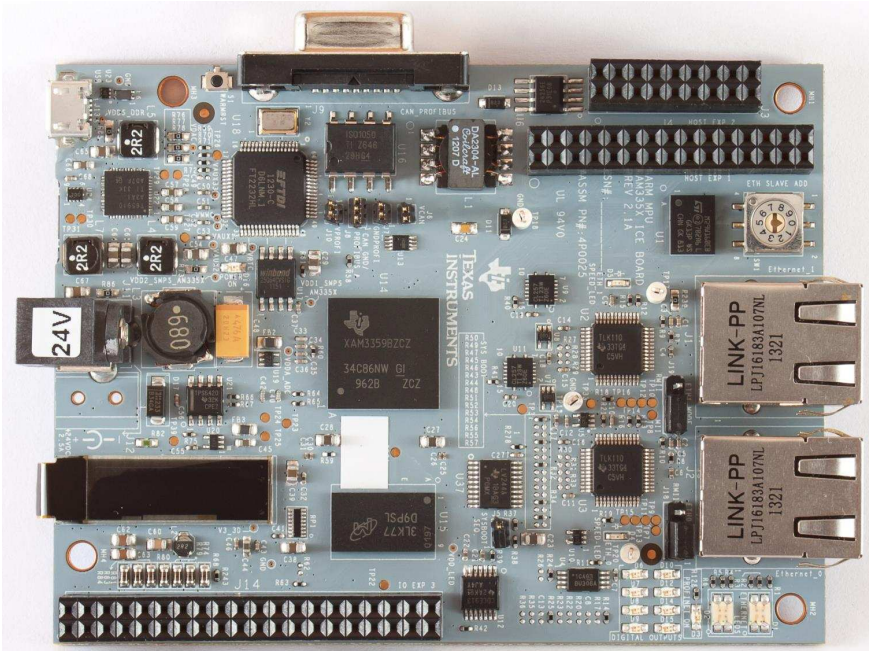

Figure 10. TMDSICE3359 ICE Board

Further software development can be done using the industrial software development kit (SDK), which combines SYS/BIOS (real-time operating system (RTOS) from TI) and example projects using industrial Ethernet protocols.

One key advantage of the Sitara AM335x family is that it allows for a flexible and dynamic exchange of the industrial Ethernet protocol within the PRU-ICSS (see Figure 11). The application processor loads new fieldbus firmware in the PRU-ICSS during device initialization, making external fieldbus ASICs or FPGAs redundant. This enables customers to support various industrial Ethernet protocols including EtherCAT, PROFINET, Sercos III, EtherNet/IP, and Ethernet POWERLINK with one single hardware platform.

4 Block Diagram

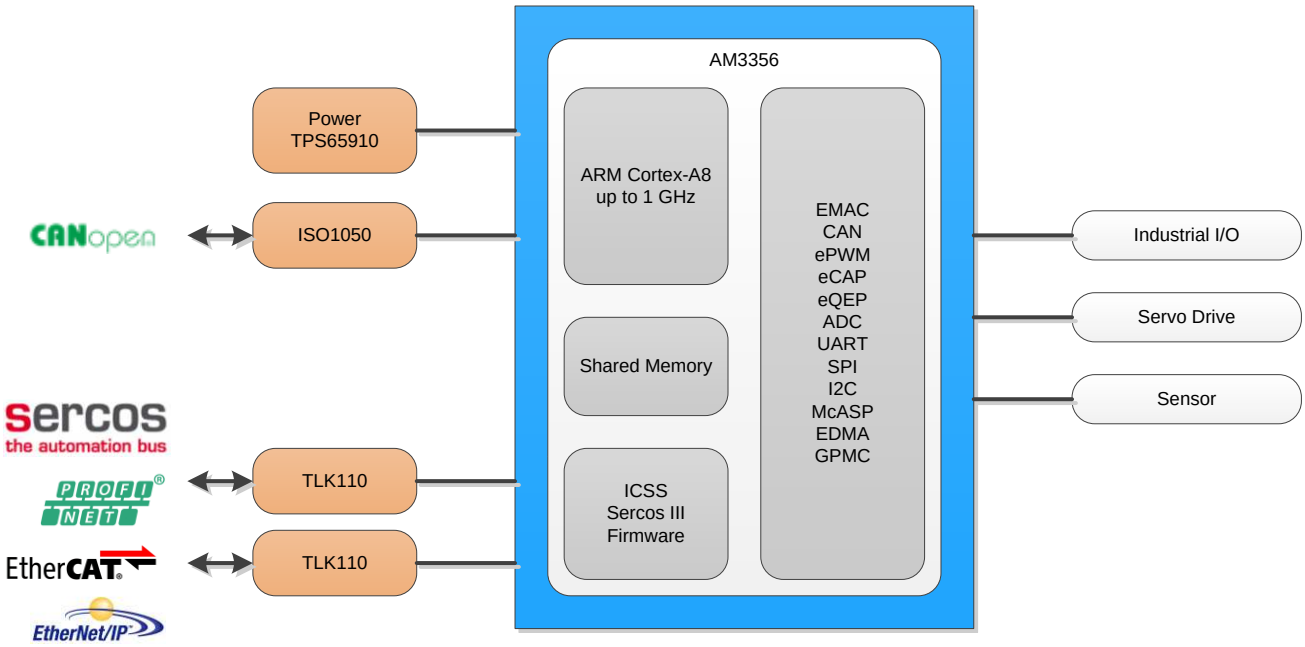

Figure 11. TMDSICE3359 ICE Board System Block Diagram

5 Test Data

sercos
the automation bus

Certificate of Product Conformance

Sercos International e.V. (SI) hereby issues this
Declaration of Conformity (Certificate No. **C-S3-1.0060**)
for the following product:

Product Name:	**Sitara AM3359 Industrial Communication Engine**
Vendor Name:	**Texas Instruments Deutschland GmbH**
Vendor Site:	**Freising, Germany**
Vendor Code:	**111**
Vendor Device:	TMDSICE3359
Sercos Version:	V1.1.2

This certificate confirms that the above named product successfully passed the official Sercos III conformance test. Compliancy to IEC 61784-2 (Ed.2.0) CP 16/3 and the Sercos Version stated above is attested.

The certificate was issued based on the Test Report
[20141125_Conformizer_2_1_1_certified] dated November 25, 2014.

This certificate is submitted on the basis of Sercos International's guidelines for testing and certification.

Stuttgart, 18/12/2014

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(Official in charge)

Figure 12. Sercos Certificate of Product Conformance

6 Summary and Conclusion

The TIDEP0010 Sercos III slave communication development platform combines the Sercos III firmware for the PRU-ICSS and an equivalent Sercos III register interface with the TMDSICE3359 ICE board. Third-party service provider Cannon-Automata offers customers a Sercos III reference stack and example application. Alternatively, customers can use an existing stack and interface it to the TIDEP0010 Sercos III slave solution.

With the TIDEP0010 Sercos III slave communication development platform, customers can jumpstart their development of Sercos III-based industrial applications like industrial I/Os, drives, sensors, and actuators. The solution saves development efforts and production cost by integrating the industrial Ethernet protocol into the microprocessor (MPU) and shortens time to market.

It also demonstrates that customers can remove the external FPGA or fieldbus ASIC without compromising the functional or operational requirements.

7 Design Files

7.1 Schematics

To download the schematics, see the design files at TIDEP0010.

7.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDEP0010.

Table 1. BOM

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
1	1	A1	OSD-9616	LCD Passive Matrix Monochrome 96x16	OSD Displays	OSD9616P0899-10	-
2	83	C1 C2 C3 C5 C9 C10 C11 C12 C15 C34 C35 C36 C37 C43 C46 C56 C68 C69 C98 C106 C108 C109 C110 C111 C112 C113 C114 C116 C119 C120 C123 C124 C125 C130 C131 C132 C134 C135 C137 C139 C142 C143 C148 C149 C150 C151 C152 C155 C157 C160 C163 C164 C166 C169 C170 C171 C172 C173 C175 C177 C181 C182 C187 C189 C190 C192 C193 C194 C196 C197 C201 C202 C203 C204 C218 C219 C229 C236 C240 C254 C264 C275 C277	0.01uF	Capacitor 0.01uF 16V 10% 0402	Panasonic	ECJ-0YB1C103K	SM-7351-CAP-0402
3	53	C4 C6 C7 C14 C16 C17 C18 C19 C20 C21 C22 C32 C41 C55 C70 C71 C72 C73 C74 C75 C77 C78 C79 C80 C82 C83 C85 C86 C87 C88 C91 C93 C96 C159 C162 C167 C185 C188 C206 C207 C208 C213 C214 C220 C221 C225 C227 C230 C231 C232 C265 C269 C272	0.1uF	Capacitor 0.1uF 16V 10% 0402 X7R	Kemet	C0402C104K4RACT	SM-7351-CAP-0402
4	0	C8	DNI	DNI	DNI	DNI	DNI
5	0	C13	DNI	DNI	DNI	DNI	DNI
6	32	C23 C27 C28 C29 C38 C39 C47 C54 C61 C64 C65 C67 C81 C84 C92 C94 C95 C101 C102 C104 C107 C121 C154 C178 C179 C205 C209 C210 C212 C215 C251 C260	10uF	Capacitor 10uF 16V 10% Ceramic 0805	AVX	0805YD106KAT2A	SM-7351-CAP-0805
7	2	C24 C191	4.7uF	Capacitor 4.7uF 16V 20% Tantalum Low ESR	Nichicon	F951C475MRAAQ2	sm-7351-cap-0805

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
8	32	C25 C26 C30 C31 C103 C105 C115 C117 C118 C122 C126 C127 C128 C129 C133 C136 C138 C140 C141 C144 C146 C147 C153 C156 C158 C161 C165 C168 C174 C176 C180 C183	0.1uF, 6.3V	Capacitor 0.1uF 6.3V 10% 0201 X5R	Murata	GRM033R60J104KE19D	SMD0201
9	3	C33 C216 C273	0.001uF	Capacitor 0.001uF 50V 5% 0402	AVX	04025C102JAT2A	SM-7351-CAP-0402
10	2	C40 C42	22pF	Capacitor 22pF 50V 10% 0402	Panasonic	ECJ-0EC1H220J	SM-7351-CAP-0402
11	9	C44 C45 C57 C58 C59 C66 C186 C257 C263	4.7uF	Capacitor Ceramic 4.7uF 16V 10% 0603	Taiyo Yuden	EMK107ABJ475KA-T	SM-7351-CAP-0603
12	1	C48	47uF	Capacitor 47uF 10V 10% Tantalum 2917	AVX	TAJD476K010RNJ	7343
13	0	C49	DNI	DNI	DNI	DNI	DNI
14	5	C50 C53 C244 C245 C261	2.2uF	Capacitor 2.2uF Ceramic, 6.3V, X5R, 20%	Taiyo Yuden	JMK105BJ225MV-F	SM-7351-CAP-0402
15	3	C51 C52 C237	2.2uF, 10V	Capacitor 2.2uF 10V 20% Ceramic 0402	Taiyo Yuden	LMK105BJ225MV-F	SM-7351-CAP-0402
16	5	C60 C97 C217 C234 C258	2.2uF	Capacitor 2.2uF 16V 10% 0805	Kemet	C0805C225K4RACTU	SM-7351-CAP-0805
17	2	C62 C63	2.2uF	Capacitor 2.2uF 35V 20% Ceramic 0805	TDK	C2012X7R1V225M	SM-7351-CAP-0805
18	13	C76 C195 C198 C199 C200 C223 C226 C228 C238 C266 C268 C270 C271	1uF	Capacitor 1uF 10V Ceramic 10% 0402	AVX	0402ZD105KAT2A	SM-7351-CAP-0402
19	4	C89 C90 C211 C222	18pF, 50V	Capacitor NPO 18pF 50V 5% 0402	TDK	CGA2B2C0G1H180J	SM-7351-CAP-0402
20	2	C99 C100	24pF	Capacitor 24pF 50V 5% 0402	TDK	C1005C0G1H240J	SM-7351-CAP-0402
21	2	C145 C184	100pF25V10%	Capacitor 100pF 25V 10% 0402	Panasonic	ECJ-0EB1E101K	SM-7351-CAP-0402
22	1	C224	4.7uF	Capacitor 4.7uF Ceramic, 6.3V, X5R, 20%	Taiyo Yuden	JMK107BJ475KA-T	SM-7351-CAP-0603
23	4	C233 C248 C249 C262	10uF	Capacitor 10uF 50V 10% Ceramic 1206	TDK	C3216X5R1H106K	SM-7351-CAP-1206
24	0	C235	DNI	DNI	DNI	DNI	DNI
25	9	C239 C241 C246 C247 C250 C253 C256 C259 C267	0.022uF	Capacitor 0.022uF 16V 10% Ceramic 0402	TDK	C1005X7R1C223K	SM-7351-CAP-0402
26	2	C242 C243	0.1uF	Capacitor 0.1uF 50V 10% 0402 X7R	TDK	C1005X7R1H104K	SM-7351-CAP-0402
27	1	C252	1uF	Capacitor 1uF 50V 10% Ceramic 0603	Taiyo Yuden	UMK107BJ105KA-T	SM-7351-CAP-0603
28	1	C255	10pF	Capacitor 10pF 50V 1% Ceramic 0402	AVX	04025U100FAT2A	SM-7351-CAP-0402

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
29	2	D1 D2	Red_Green_Yellow_LED	LED RedGreenYellow Tricolor 20mA 1.9/2.1V 1210 smd	Bivar	SM1210RGY	LED-SM1210
30	10	D3 D6 D7 D8 D9 D10 D12 D14 D15 D16	Green LED	LED Green SMD 20mA 2V 0805	Dialight	598-8170-107F	sm_led_0805
31	2	D4 D5	LED Yellow	LED Yellow SMD 20mA 2V	LiteOn	LTST-S220KSKT	LEDLTST-S220
32	3	D11 D13 D20	MBR0520LT1	Diode 500mA 20V 0.3V Forward Drop	On Semiconductor	MBR0520LT1	mbr0520L
33	1	D17	B340A-13-F	Diode Power Rectifier 3A 40V Schottky	Diodes Inc	B340A-13-F	DO157LS_116X220 SMA
34	1	D18	MBRS140T	Diode 1A 40V 600mV Forward Drop	On Semiconductor	MBRS140T3G	mbrs140t
35	1	D19	SMCJ26CA	Voltage Surpressor 26.0V	LittleFuse	SMCJ26CA	SMCJ36CA
36	1	F1	Fuse 4A	Fuse Block with 4A Fuse	Littelfuse	0154004.DRT	smdfuseblk
37	7	FB2 FB3 FB9 FB10 FB11 FB12 FB13	150OHM800mA	Ferrite Bead 150 Ohm 800mA	Laird-Signal Integrity Products	LI0805H151R-10	sm-7351-ind-0805
38	2	J1 J2	RJ-45 10_100Mb	Connector RJ-45 Jack w/mag_orgLED 10_100Mb AMDIX	Link	LPJ16183A107NL	CNRJ45-1X1WLED
39	1	J3	Header 9x2 Female	Header 9x2 0.1in pitch female throughhole	FCI	66953-009LF	HDR2X9VER_335M
40	1	J4	Header 15x2 Female	Header 15x2 0.1in pitch female throughhole	FCI	66953-015LF	HDR2X15-344M
41	2	J5 J8	TMS-103-01	Header 1.27mm pitch 3pin	Samtec	TMS-103-01-G-S	SIP3_50LS
42	3	J6 J7 J10	TMS-102-01	Header 1.27mm pitch 2pin	Samtec	TMS-102-01-G-S	SIP2_50LS
43	1	J9	Conn_DB9F	Connector DB9 Female RA SMD	Norcomp	190-009-263R001	NorComp_db9F_SMD
44	1	J11	Power Jack RAPC722X	Jack Power Right Angle 2conductor 2.1mm center	Switchcraft	RAPC722X	CNRAPC722
45	0	J12	DNI	DNI	DNI	DNI	DNI
46	1	J13	USB_MicroAB	Connector Micro USB AB RA	Hirose	ZX62-AB-5PA(11)	ZX62-AB-5PA
47	1	J14	Header 20x2 Female	Header 20x2 0.1in pitch female throughhole	FCI	66953-020LF	HDR2X20-335M
48	0	J15	DNI	DNI	DNI	DNI	DNI
49	1	J16	SCHA5B0200	Connector compact low-profile Push Type Micro SD	ALPS	SCHA5B0200	SD-MICRO-SCHA5B0300
50	1	J17	10051922-1410ELF	Connector 0.5mm pitch, 14 Pin, FPC	FCI	10051922-1410ELF	CON14_P5MM_3P75X9P5SMD
51	2	J18 J19	HEADER 3	Single Line Header 3pin Tin 0.1in pitch	Sullins	PEC03SAAN	header_3x1

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
52	1	L1	DA2304-AL	Power Transformer 45uH RS-485	Coilcraft	DA2304-ALB	DA2304
53	1	L2	2.2uH	Inductor 2.2uH smt 1A 20%	TDK	VLF3010AT-2R2M1R0	IND108SMD_110X102
54	1	L3	68uH	Inductor 68uH smt 1A 20%	TDK	VLF10040T-680M1R4	IND_354SMD_400SQ
55	3	L4 L5 L7	2.2uH	Inductor 2.2uH smt 2.6A, 58 milliohm	TDK	VLCF5020T-2R2N2R6-3	VLCF5020T
56	1	L6	ACM2012	Common Mode Filter for USB/HDMI	TDK	ACM2012H-900-2P	ACM2012H
57	1	PCB1	AM335x ICE V2.0Board Bare PCB	AM335x ICE V2.0 EVM PCB Bare	TI	3H0013	DNP
58	4	Q1 Q2 Q3 Q4	DMC564040R	Dual Transistor NPN 50V 100mA	Panasonic	DMC564040R	SMINI6-F3-B
59	13	R1 R2 R3 R4 R5 R6 R89 R93 R94 R98 R128 R130 R131	330	Resistor 330ohm 1/16W 5% 0402	Stackpole Electronics	RMCF0402JT330R	SM-7351-RES-0402
60	25	R7 R8 R15 R16 R18 R19 R61 R90 R92 R95 R97 R110 R112 R113 R114 R124 R129 R135 R145 R174 R196 R205 R207 R243 R244	2.2K	Resistor 2.2Kohm 1/16W 5% 0402	VishayDale	CRCW04022K20JNED	sm-7351-res-0402
61	2	R9 R10	4.87K	Resistor 4.87Kohm 1/10W 1% 0402	Panasonic	ERJ-2RKF4871X	SM-7351-RES-0402
62	13	R11 R37 R44 R45 R50 R54 R55 R63 R178 R184 R188 R191 R195	10K, 1%	Resistor 10Kohm 1/10W 1% 0402	Panasonic-ECG	ERJ-2RKF1002X	SM-7351-RES-0402
63	9	R12 R13 R42 R154 R179 R180 R181 R182 R186	33	Resistor 33ohm 1/16W 5% 0402	Panasonic	ERJ-2GEJ330X	SM-7351-RES-0402
64	9	R14 R24 R25 R39 R70 R71 R137 R277 R278	4.7K	Resistor 4.7Kohm 1/16W 5% 0402	Stackpole Electronics	RMCF0402JT4K70	SM-7351-RES-0402
65	0	R17 R22 R23 R26 R35 R36 R126 R138 R139 R222 R223 R224	DNI	DNI	DNI	DNI	DNI
66	0	R20	DNI	DNI	DNI	DNI	DNI
67	20	R21 R65 R67 R75 R101 R111 R125 R187 R197 R199 R200 R206 R210 R211 R231 R233 R234 R235 R236 R237	10K	Resistor 10Kohm 1/16W 5% 0402	Rohm	MCR01MZPJ103	SM-7351-RES-0402
68	0	R27 R28 R29 R30 R31 R32 R33 R34 R134 R148	DNI	DNI	DNI	DNI	DNI
69	14	R38 R152 R153 R157 R158 R161 R162 R163 R165 R166 R167 R168 R171 R176	100K	Resistor 100Kohm 1/16W 1% 0402	Stackpole Electronics	RMCF0402FT100K	SM-7351-RES-0402
70	17	R40 R41 R59 R87 R88 R99 R100 R102 R103 R104 R106 R107 R108 R109 R115 R127 R177	1K	Resistor 1Kohm 1/16W 5% 0402	Panasonic	ERJ-2GEJ102X	SM-7351-RES-0402

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
71	0	R43 R46 R47 R48 R49 R51 R52 R53 R56 R57 R159 R160 R164 R169 R170	DNI	DNI	DNI	DNI	DNI
72	1	R58	22	Resistor 22 ohm 1/16W 1% 0402	ROHM	MCR01MZPF22R0	SM-7351-RES-0402
73	27	R60 R64 R69 R72 R91 R96 R105 R142 R146 R147 R149 R150 R156 R175 R190 R192 R194 R198 R201 R202 R203 R204 R209 R225 R228 R229 R230	0	Resistor Zero ohm Jumper 0402	Panasonic	ERJ-2GE0R00X	SM-7351-RES-0402
74	0	R62	DNI	DNI	DNI	DNI	DNI
75	1	R66	3.24K	Resistor 3.24Kohm 1/10W 1% 0402	Panasonic	ERJ-2RKF3241X	SM-7351-RES-0402
76	8	R68 R74 R79 R80 R81 R83 R84 R226	1.2K, MELF	Resistor 1.2Kohm 1/3W 1% MELF0102	Vishay	MMU01020C1201FB300	smd_melf0102
77	17	R73 R76 R77 R78 R85 R86 R213 R214 R215 R216 R217 R239 R240 R241 R242 R279 R280	0	Resistor Zero ohm Jumper 0603	Panasonic	ERJ-3GEY0R00V	SM-7351-RES-0603
78	1	R82	25K	Resistor 25Kohm 1/10W 0.1% 0603	Vishay	PNM0603E2502BST5	SM-7351-RES-0603
79	9	R116 R117 R118 R119 R120 R121 R122 R123 R185	49.9	Resistor 49.9ohm 1/16W 1% 0402	Panasonic	ERA-2AEB49R9X	SM-7351-RES-0402
80	9	R132 R133 R136 R140 R143 R151 R155 R173 R208	150	Resistor 150ohm 1/16W 5% 0402	Stackpole Electronics	RMCF0402JT150R	SM-7351-RES-0402
81	0	R141	DNI	DNI	DNI	DNI	DNI
82	0	R144	DNI	DNI	DNI	DNI	DNI
83	0	R172	DNI	DNI	DNI	DNI	DNI
84	1	R183	240, 1%	Resistor 240 OHM 1/10W 1% 0402 SMD	Panasonic-ECG	ERJ-2RKF2400X	SM-7351-RES-0402
85	1	R189	4.75K, 1%	Resistor 4.75KOHM 1/10W 1% 0402 SMD	Panasonic-ECG	ERJ-2RKF4751X	SM-7351-RES-0402
86	1	R193	12.1K, 1%	Resistor 12.1K OHM 1/16W 1% 0402 SMD	Yageo	RC0402FR-0712K1L	SM-7351-RES-0402
87	2	R212 R219	0.05ohm1% Sense	Resistor 0.05ohm 0.5W Sense 1% 1206	Ohmite	LVK12R050FER	SM_RES_LVK12
88	0	R218	DNI	DNI	DNI	DNI	DNI
89	1	R220	1.62M	Resistor 1.62Mohm 1/16W 1% 0402	Vishay/Dale	CRCW04021M62FKED	SM-7351-RES-0402
90	1	R221	180K	Resistor 180Kohm 1/16W 1% 0402	Stackpole Electronics	RMCF0402JT180K	SM-7351-RES-0402
91	1	R227	49.9	MELF Resistor 49.9ohm 1/3W 1% MELF0102	Vishay	MMU01020C4999FB300	smd_melf0102

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
92	1	R232	392K	Resistor 392Kohm 1/10W 1% 0402	Panasonic	ERJ-2RKF3923X	SM-7351-RES-0402
93	1	R238	120	Resistor 120ohm 1/16W 1% 0402	Vishay_Dale	CRCW0402120RFKED	SM-7351-RES-0402
94	3	RP1 RP2 RP3	33x8	Resistor 33ohmx8 1/16W 5% Array SMD	Panasonic	EXB-2HV330JV	EXB-2HV330JV
95	1	S1	SwitchTactile3Pos	Tactile switch 3 position smd	Omron	B3U-1100P	SW3_4X2P5
96	1	SW1	Rotary Switch	Rotary Switch, Screw Driver Actuated	Nikkai	ND3FR10P	SW-ND3FR10
97	4	TP17 TP18 TP19 TP20	TP		Keystone Electronics	5002	TH_TP_5002
98	1	U1	M29W160EB	Flash Memory 16Mbit (2Mx8/1Mx16) 70ns	Micron	M29W160EB70ZA6E	TFBGA48
99	1	U13	SN74AUP2G08	Low Power Dual AND Gate	TI	SN74AUP2G08DCU	U_8_DCU
100	1	U14	AM335X_15x15		TI	AM3359ZCZ	am33xx_15x15
101	2	U2 U3	TLK110	Industrial Ethernet 10/100 Mb/s PHY Transceiver	TI	TLK110PT	HTQFP_48pin
102	1	U4	SN74CB3Q3306APWR	Dual FET Bus Switch	TI	SN74CB3Q3306APWR	PW8
103	1	U5	SN74LVC1G08	Single logic AND Gate	TI	SN74LVC1G08DCK	sm-so-sc70-5
104	1	U6	CAT24C256W	EEPROM 256Kb I2C SOIC8	On Semiconductor	CAT24C256WI-G	soic8_208
105	2	U7 U8	SN74LVC1G32DCK	Single 2input positive OR gate	TI	SN74LVC1G32DCK	SC70-5-43M
106	2	U9 U11	SN74CBTLV3257RGY	4bit 1-4 FET Mux/Demux	TI	SN74CBTLV3257RGY	QFN4X3P5-16-39M
107	1	U10	SN74LVC1G06DCK	Single inverter buffer/driver w/open drain output	TI	SN74LVC1G06DCK	DCK5
108	1	U12	CDCE913	Programmable 1-PLL VCXO Clock Synthesizer	TI	CDCE913PWR	TSSOP5X4-14-47M
109	1	U15	MT41J128M16JT-125	DDR3 SDRAM 2Gb (128Mx16) 1.5V	Micron	MT41J128M16JT-125	BGA14X10-96
110	1	U16	ISO1050	Isolated CAN Transceiver	TI	ISO1050DUB	so8_w_dub
111	1	U17	W25Q64	Flash Memory SPI 64Mb	Winbond	W25Q64CVSSIG	SOIC8_265
112	1	U18	FT2232HL	USBHS Dual UART/FIFO	FTDI	FT2232HL-REEL	LQFP64_10X10
113	1	U19	LM94022	Multi-Gain Analog Temperature Sensor	TI	LM94022QBIMG/NOPB	SC70-5
114	1	U20	SN74LVC1G07	Driver Open Drain output	TI	SN74LVC1G07DCK	DCK5
115	1	U21	TPS5420D	Step down power switch converter,2A	TI	TPS5420D	SOIC-8
116	1	U22	TPS65910A3	Integrated Power Management Unit for DDR3	TI	TPS65910A3A1RSL	U_48_RSL
117	1	U23	TPD4S012	ESD 4channel USB Interface	TI	TPD4S012DRY	U_6_DRY

Table 1. BOM (continued)

Item	Qty	Reference	Value	Part Description	Manufacturer	Manufacturer Part Number	PCB Footprint
118	1	U24	TPD6E001	ESD Protection Array 6Chan +-15kV	TI	TPD6E001RSE	U_10_RSE
119	1	U25	PCA9536DGK	I2C to IO Expander 4 bit	TI	PCA9536DGK	MSOP3X3-8-43M
120	1	U26	SN74ALVCH16374DGV	16-Bit Edge-Triggered D-TYPE Flip-Flop	TI	SN74ALVCH16374DGV	TVSOP-48
121	1	U27	TPS76650	Low Dropout Voltage Regulator 250mA Low Q Current	TI	TPS76650D	soic_8
122	1	U28	ISO1176T	Isolated Profibus RS-485 Transceiver	TI	ISO1176TDW	u_16_dw
123	1	U29	TPS51200	DDR Termination Regulator SinkSource	TI	TPS51200DRC	drcpso_10pin
124	1	U30	TPS71718	Low Dropout 1.8V 150mA Linear Regulator	TI	TPS71718DCK	smdsc70-5
125	1	U31	TPIC2810	8bit LED Driver with I2C Interface	TI	TPIC2810D	u_16_d
126	1	U32	TPS78633	Linear Power Regulator 3.3V 1.5A	TI	TPS78633DCQ	sot223_6pin
127	1	U33	93LC56B	2K Microwire-Compatible Serial EEPROM	Microchip	93LC56B-I/OT	SOT23-6
128	1	U34	TPS61041	DC to DC Boost Converter 1.8V to 6.0V Input Range	TI	TPS61041DBV	DBV5
129	1	U35	SN65HVS882	Industrial 8digit Input Serializer	TI	SN65HVS882PWP	u_28_pwp
130	2	U37 U38	SN74LV244A	Octal Line Buffer	TI	SN74LV244APWRG3	TSSOP4X6-20
131	1	Y1	25MHz	Crystal 25MHz	Abracon	ABM3-25.000MHz-B2-T	SM_OSC_ABM3
132	1	Y2	12MHz,+/-50ppm	CRYSTAL 12.000 MHZ 20PF SMD	ECS Inc	ECS-120-20-30B-TR	XTAL4_3P2X5SMD
133	1	Y3	24MHz	Crystal 24MHz 30ppm load cap 18pF	Citizen	CS325-24.000MABJ-UT	XTAL4_3P2X2P5_SMD
134	1	Y4	32.768KHz MC-306	Crystal 32.768KHz	Epson	MC-30632.7680k-A	MC-306

7.3 Layer Plots

To download the layer plots, see the design files at TIDEP0010.

7.4 PCB Layout Project

To download the PCB layout project files, see the design files at TIDEP0010.

7.5 Gerber Files

To download the Gerber files, see the design files at TIDEP0010.

7.6 Software Files

To download the software files, see the design files at TIDEP0010.

To find more information about the Sercos III Slave Communication Stack, please visit our TI Design Network website.

8 References

1. AM3359 data manual, *AM335x Sitara Processors*, AM3359
2. TMDSICE3359 white paper, *EtherCAT® on Sitara™ AM335x ARM® Cortex™-A8 Microprocessors*, TMDSICE3359 and ICE board: http://www.ti.com/tool/tmdsice3359
3. TLK110 data sheet, *PHYTER® Industrial Temperature 10/100Mbs Ethernet Physical Layer Transceiver*, TLK110
4. TPS65910 data manual, *TPS65910x Integrated Power Management Unit Top Specification*, TPS65910

9 About the Author

THOMAS MAUER is a system applications engineer in the factory automation and control team at Texas Instruments Freising, where he is responsible for developing reference design solutions for the industrial segment. Thomas brings to this role his extensive experience in industrial communications like industrial Ethernet and fieldbuses and industrial applications. Thomas earned his electrical engineering degree (Dipl. Ing. (FH)) at the University of Applied Sciences in Wiesbaden, Germany.

TIDEP0100 Revision A History

Changes from Original (September 2014) to A Revision	Page
• Added Section 5: Test Data	10
• Added link for Sercos III Slave Communication Stack information	19

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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