TI Designs: TIDEP-0089

CC-Link IE Field Basic Master and Slave Reference Design for Sitara™ AM335x

Description

This CC-Link IE Field Basic reference design operates on the Sitara™ AM335x processor with both Processor SDK RTOS and Processor SDK Linux®. For RTOS the design uses a network development kit (NDK) transport layer, and the examples in both NIMU (EMAC) and NIMU_ICSS (PRU-ICSS Dual-emac firmware) layers support RTOS. For Linux the design uses the Linux networking stack, which can be based on either EMAC or PRU-ICSS. The implementation can use either the master station or slave station configuration.

Resources

TIDEP-0089	Design Folder
AM3359	Product Folder
DP83822I	Product Folder
TMDSICE3359	Product Folder

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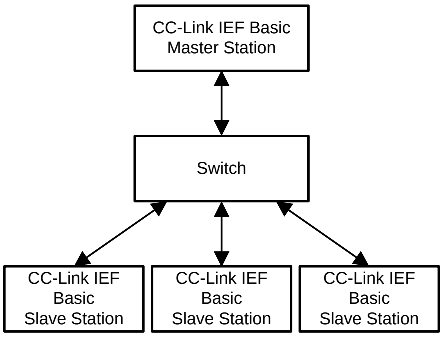
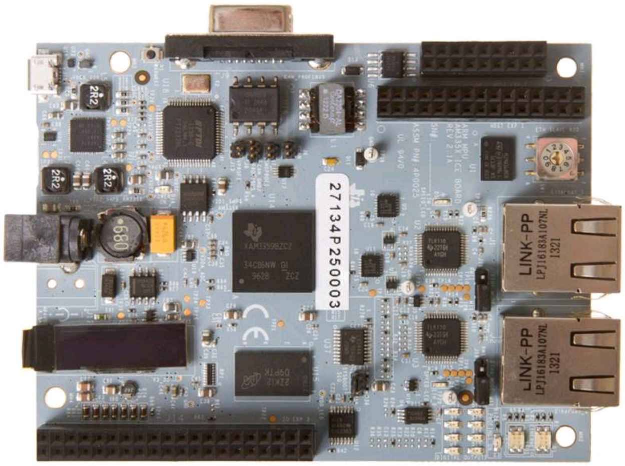
Features

- CC-Link Industrial Ethernet Field Basic Master and Slave Implementation
- Supports 100 Mbps
- Seamless Message Protocol (SLMP) Compliant—Slave Station
- Supports Maximum 64 Slave Station—Master Station
- Maximum Number of Occupied Station is 16 per Group
- Fully-Customizable With Source Code Packaged With Processor SDK
- Support on Other EVMs Also Available Using Processor SDK

Applications

- Industrial Ethernet
- Servo Drives and Motion Control
- Programmable Logic Controllers (PLC)
- Industrial Communication Module
- Industrial Input-Output (IO) Modules
- Industrial Sensors and Actuators


CC-Link IEF Basic Master Station
Switch
CC-Link IEF Basic Slave Station
CC-Link IEF Basic Slave Station
CC-Link IEF Basic Slave Station



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1 System Description

Control and Communication Link (CC-Link) is an open network administered as a fully-open architecture by the CC-Link Partner Association (CLPA). CC-Link guarantees 10-Mbit/s performance across the fieldbus network, regardless of device type, which eliminates hidden bottle necks that are common with other open systems. For the Industrial Ethernet version of CC-Link IE Field, the speed is 1 Gbit. CC-Link offers the freedom to integrate a wide variety of automation components into a single, seamless automation system on the network. CC-Link is available in multiple formats: CC-Link, CC-Link Safety, CC-Link IE (Industrial Ethernet) Control, and CC-Link IE Field.

CC-Link IE Field Basic (or *IEF Basic*) is a new addition to the family of CC-Link IE open network technologies that enable device vendors to easily add CC-Link IE compatibility to any product with a 100-Mbit Ethernet port. IEF Basic is easily implemented on devices or master controllers by software alone, which enables added compatibility to existing products without any hardware modification. IEF Basic's stack is compatible with TCP/IP and UDP/IP; the stack blends seamlessly with other Ethernet technologies (including switches, cables, connectors, and wireless systems). Finally, a master controller for the network is also purely software based, so any industrial PC or other Ethernet equipped controller can be rapidly deployed to run an IEF Basic network without requiring any special interface cards, driver development, or other additional work. The devices all communicate using cyclic (synchronous) exchange of data, which means network updates are performed on a regular, deterministic schedule.

Seamless Message Protocol (SLMP) is a common protocol for achieving seamless communication between applications without awareness of network hierarchy or boundaries between the CC-Link family network and general-purpose Ethernet devices. SLMP is implemented on network hierarchies, such as TCP/IP, CC-Link IE, and CC-Link. SLMP implementation makes client and server-type and push-type communication possible between general-purpose Ethernet devices, CC-Link IE devices, and CC-Link devices.[21]

2 System Overview

This section gives a basic overview of CC-Link IEF Basic protocol. Most of this information here is from the IEF Basic User Guide. For additional details on IEF Basic, refer to the CC-Link IEF Basic User Guide available from CLPA.

2.1 Block Diagram

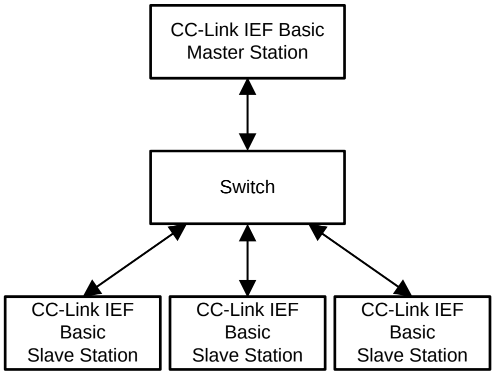
CC-Link IEF Basic Master Station
Switch
CC-Link IEF Basic Slave Station
CC-Link IEF Basic Slave Station
CC-Link IEF Basic Slave Station

Figure 1. CC-Link Block Diagram

2.2 Highlighted Products

2.2.1 AM3359

- Up to 1-GHz Sitara ARM® Cortex™-A8 32-bit RISC processor
- NEON™ SIMD coprocessor
- 32KB of L1 Instruction and 32KB of data cache with single-error detection (parity)
- 256KB of L2 cache with error correcting code (ECC)
- 176KB of on-chip boot ROM
- 64KB of dedicated RAM
- Emulation and debug - JTAG
- Interrupt controller (up to 128 interrupt requests)
- PRU-ICSS:
  - Supports protocols such as EtherCAT®, PROFIBUS®, PROFINET®, EtherNet/IP™, and more
  - Two PRUs 32-bit load and store RISC processor capable of running at 200 MHz
  - 8KB of instruction RAM with single-error detection (parity)
  - 8KB of data RAM with single-error detection (parity)
  - Single-cycle, 32-bit multiplier with 64-bit accumulator
  - Enhanced GPIO module provides shift-in or shift-out support and parallel latch on external signal
  - 12KB of shared RAM with single-error detection (parity)
  - Three 120-byte register banks accessible by each PRU INTC for handling system input events
  - Local interconnect bus for connecting internal and external masters to the resources inside the PRU-ICSS
  - Peripherals inside the PRU-ICSS:
    - One universal asynchronous receiver and transmitter (UART) port with flow control pins that supports up to 12 Mbps
    - One enhanced capture (eCAP) module
    - Two MII Ethernet ports that support industrial Ethernet, such as EtherCAT
    - One management data input and output (MDIO) port
  - On-chip memory (shared L3 RAM):
    - 64KB of general-purpose on-chip memory controller (OCMC) RAM
    - Accessible to all masters
- External memory interfaces (EMIF):
  - mDDR(LPDDR), DDR2, DDR3, and DDR3L controller:
  - mDDR: 200-MHz clock (400-MHz data rate)
  - DDR2: 266-MHz clock (532-MHz data rate)
  - DDR3: 400-MHz clock (800-MHz data rate)
  - DDR3L: 400-MHz clock (800-MHz data rate)
  - 16-bit data bus
  - 1GB of total addressable space
  - Supports one x16 or two x8 memory device configurations
- General-purpose memory controller (GPMC)
- Flexible 8-bit and 16-bit asynchronous memory interface with up to seven chip selects (NAND, OR, Muxed-NOR, or SRAM)
- Uses BCH code to support 4-, 8-, or 16-bit ECC
- Uses hamming code to support 1-bit ECC

See the *AM335x Sitara Processors*[1] datasheet for a complete list of features.

2.2.2 DP83822I

- IEEE 802.3u compliant: 100BASE-FX, 100BASETX and 10BASE-Te
- MII, RMII, and RGMII MAC Interfaces
- Low-power single supply options:
  - 1.8-V average (AVD) < 120 mW
  - 3.3-V AVD < 220 mW
- ±16-kV HBM ESD Protection
- ±8-kV IEC 61000-4-2 ESD Protection
- Start of frame detect for IEEE 1588 time stamp
- Fast link-down timing
- Auto-crossover in force modes
- Operating temperature: –40°C to 125°C
- IO voltages: 3.3 V, 2.5 V, and 1.8 V
- Power savings features:
  - Energy efficient Ethernet (EEE) IEEE 802.3az
  - Wake-on-LAN (WoL) support with magic packet detection
  - Programmable energy savings modes
- Cable diagnostics
- BIST
- Management data clock (MDC) and MDIO interface

See the *DP83822 Robust, Low Power 10/100 Mbps Ethernet Physical Layer Transceiver*[2] datasheet for a complete list of features.

2.2.3 TMDSICE3359 ICE EVM

Hardware specifications:

- AM3359 ARM Cortex-A8
- DDR3, NOR flash, and SPI flash
- Organize light-emitting diode (OLED) display
- TPS65910 power management 24-V power supply
- USB cable for JTAG interface and serial console

PRU-ICSS subsystem for industrial communication, capable of supporting:

- CC-Link IEF Basic Master/Slave
- PROFIBUS interface
- CANOpen
- EtherNet/IP
- PROFINET
- Sercos III
- Digital IO
- SPI
- UART
- JTAG

2.3 System Design Theory

2.3.1 CC-Link

The following is an overview of the characteristics of IEF Basic:

1. Realization of cyclic transmission using IP packets
   - Using an Internet Protocol with an EtherType of Ethernet frame, IP packets allow the realization of cyclic transmission for periodically updating linked devices.
   - Protocols using other IP packets (including HTTP, FTP, SLMP, and so on) can transmit on the same IP network.
   - Data periodically communicates between the master station and slave stations using link devices.
2. Defining protocol at the application layer
   - Because the application layer defines the protocol, there is no required special hardware to realize IEF Basic, and implementing the software allows cyclic transmission realization.
3. Simple protocols
   - Protocol is request-response type with a simple status and status transition that is managed at the station. In addition, the small number of frame types allows simple implementation in machines.
4. Inheritance of CC-Link IE Field Network protocols
   - Because the primary components in CC-Link IE Field are inherited as much as necessary, configuration of the IEF Basic network is similar to that of the CC-Link IE Field Network.

2.3.1.1 Types of Communication

CC-Link IEF Basic performs transmission and reception of frames related to cyclic transmission. By storing the information related with cyclic transmission and station information within this frame type, a single frame can be used for cyclic transmission and network management functions.

2.3.1.2 Protocol Hierarchy

Figure 2 shows the protocol hierarchy of CC-Link IEF Basic.

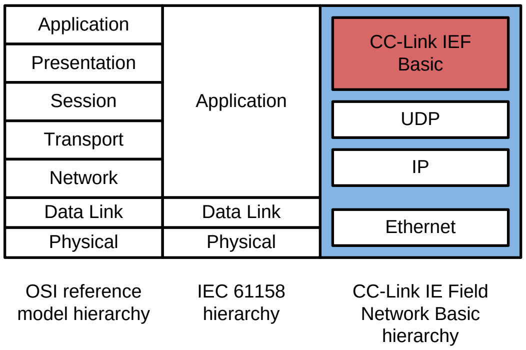

Figure 2. CC-Link IEF Basic Overview

2.3.2 SLMP

Figure 3 shows an overview of SLMP.

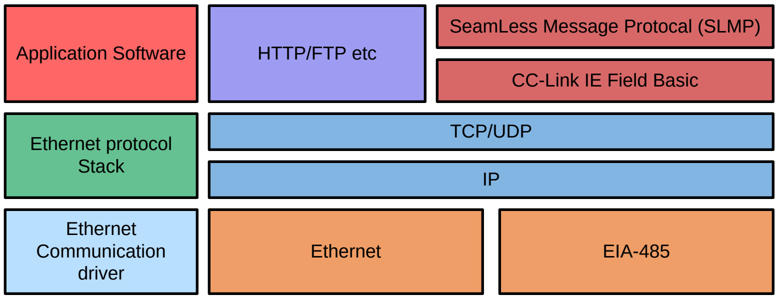

Figure 3. SLMP Overview

2.3.2.1 Features

SLMP offers the following features:

1. Access to network information
   - SLMP communication makes it possible to access (read and write) information (stored memory) within a server from a client. This stored memory may include internal memory, drive memory, expanded module memory, and so on as well as other information, such as device operation status information, production status information, and sequence program and parameter files.
2. Control from a remote location
   - SLMP-based communication makes it possible to perform server remote control from a client. The control operations include remote control (remote run, stop, pause, clear latch, reset), remote password setup and clearance, and error code initialization.
3. On-demand communication
   - SLMP-based communication makes it possible to transmit urgent data without request from the server to a client, which is called on-demand communication.
4. Efficient data collection
   - Using SLMP, the client can collect data within the server If the data to be collected is registered in the service in advance, the data distributes without a request by the client.
5. Access to device information
   - SLMP provides a meaning of directly accessing device information. For example, the connected device is automatically detected using the SLMP command and parameter setting. Monitoring and diagnosis can be performed for any device using the same procedure.
6. Integration of other open networks
   - For transient transmission in other open networks, access is enabled from CC-Link Family Network to other open networks from the conversion model using SLMP. For example, the connected devices in other open networks are automatically detected using SLMP, and parameter setting and diagnosis can be performed for any device using the same procedure.

2.3.3 Protocol Overview

The following sections show the sequencing of the communication between master and slave station in an IEF Basic network.[20]

2.3.3.1 Overall Processing Sequence

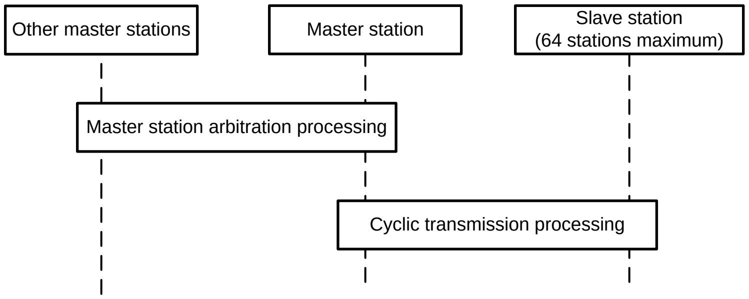

Figure 4. Basic Sequence of Processing

The processing is performed in the following sequence:

1. The master station performs master station arbitration processing.
2. If master station duplication was not detected in master station arbitration processing, the master station performs cyclic transmission processing.

2.3.3.2 Master Station Arbitration

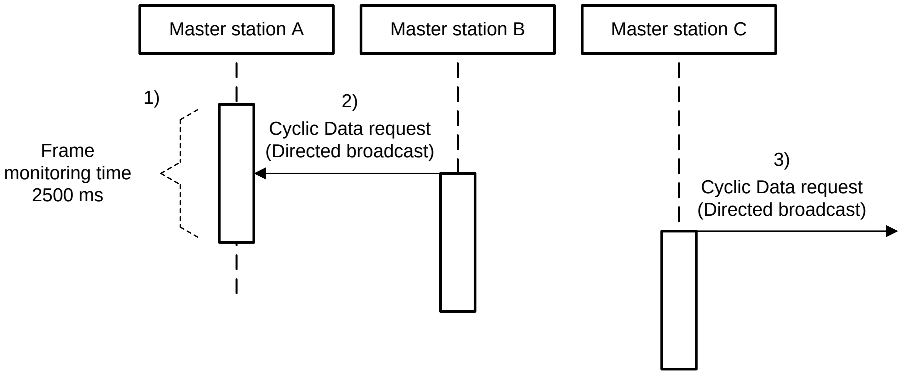

Figure 5. Master Station Arbitration

The processing is performed in the following sequence:

1. The master station monitors the frame for 2500 ms to check whether the station receives *Cyclic Data* command requests from other master stations, as master station arbitration, prior to performing cyclic transmission processing with the slave station.
2. If the master station receives a Cyclic Data command request, the station judges that there is master station duplication.
3. If the master station does not receive a Cyclic Data command request, the station judges that there is no master station duplication.
4. The master station performs cyclic transmission processing when master station duplication is not detected. If detected, the master station does not perform cyclic transmission processing.

2.3.3.3 Cyclic Transmission

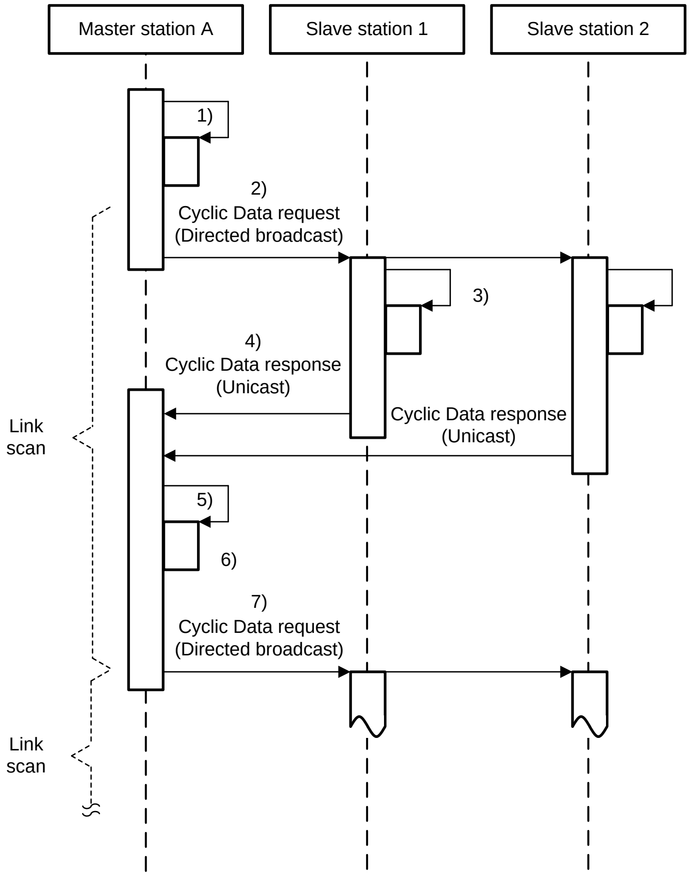

Figure 6. Cyclic Transmission

The processing is performed in the following sequence:

1. The master station creates cyclic data RY (Remote IO Request bits) and RWw (Remote Register words) before starting a link scan.
2. The master station sends the Cyclic Data command request using a directed broadcast.
3. After receiving a Cyclic Data command request, each slave station transfers the station's specific cyclic data from the request.
4. Each slave station creates its cyclic RX (Remote IO Response bits) and RWr (Remote Register word) data and sends the Cyclic Data command response through a unicast.
5. The master station receives the response from all slave stations with a cyclic transmission status bit turned on. When the constant link scan is used, the master station waits until the constant link scan time elapses.
6. The master station transfers the cyclic data RWr and RX from the Cyclic Data command response and creates the new cyclic data RY and RWw for the next cyclic transmission.
7. Steps 2 to 6 repeat. When multiple groups exist, after step 1 completes, steps 2 to 6 repeat independently for each group.

The upper limit of the link scan time is the total of the response waiting time and the processing time for completion of link scans, such as device transfers. The slave stations process the cyclic data of the Cyclic Data command requests as valid data when the cyclic transmission status bit of the own station is turned on (cyclic data is acquired).

The slave station does not return any command response if the Cyclic Data command request does not include the slave station ID of the own station. If the master station receives a command response from the slave station with a cyclic transmission status bit turned on, and the frame sequence number corresponds with the value of the request message, the master station processes the cyclic data as valid data (cyclic data is acquired).

2.3.4 State Transition

The general state transition of the master station and slave stations of IEF Basic is shown in the following subsections.

2.3.4.1 State Transition of Master Station

The status of the master station consists of a group status and an individual status of each slave station (sub status).

Figure 7 shows the state transition of a group status of a master station.

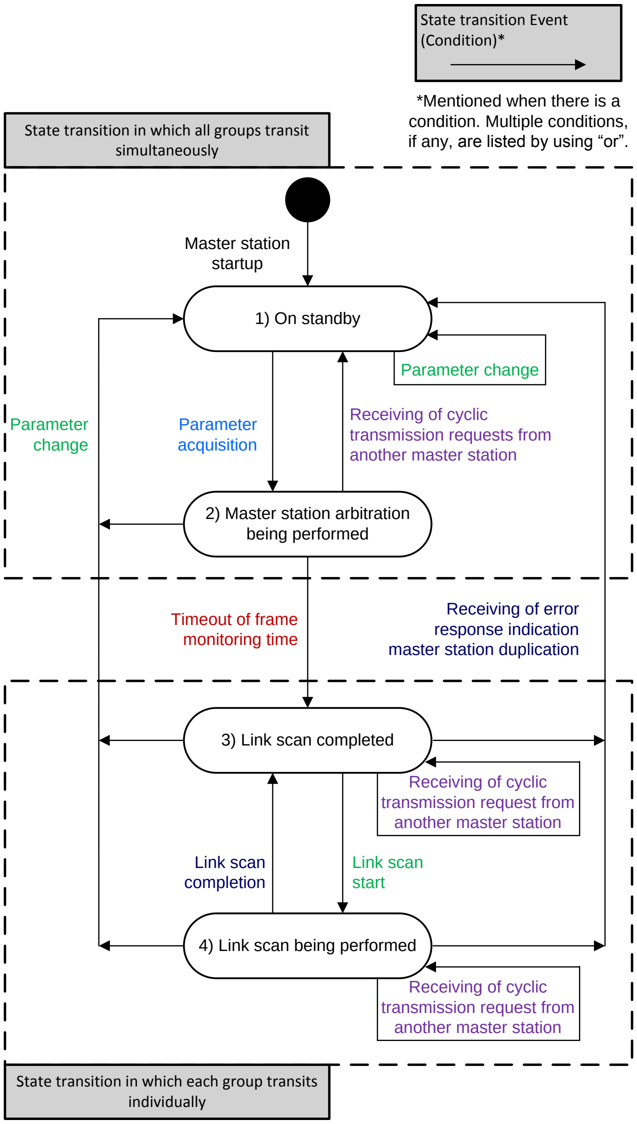
State transition Event (Condition)*
*Mentioned when there is a condition. Multiple conditions, if any, are listed by using “or”.
State transition in which all groups transit simultaneously
Master station startup
1) On standby
Parameter change
Parameter change
Parameter acquisition
Receiving of cyclic transmission requests from another master station
2) Master station arbitration being performed
Timeout of frame monitoring time
Receiving of error response indication master station duplication
3) Link scan completed
Receiving of cyclic transmission request from another master station
Link scan completion
Link scan start
4) Link scan being performed
Receiving of cyclic transmission request from another master station
State transition in which each group transits individually

Figure 7. State Transition of Group Status of Master Station

The group status is the status of each group. When multiple groups exist, there are multiple group statuses and two types of state transition—transition where all groups transit simultaneously and where each group transits individually. Each group status connects with the individual status of each slave station belonging to each group.

Figure 8 shows the state transition for an individual status of each slave station.

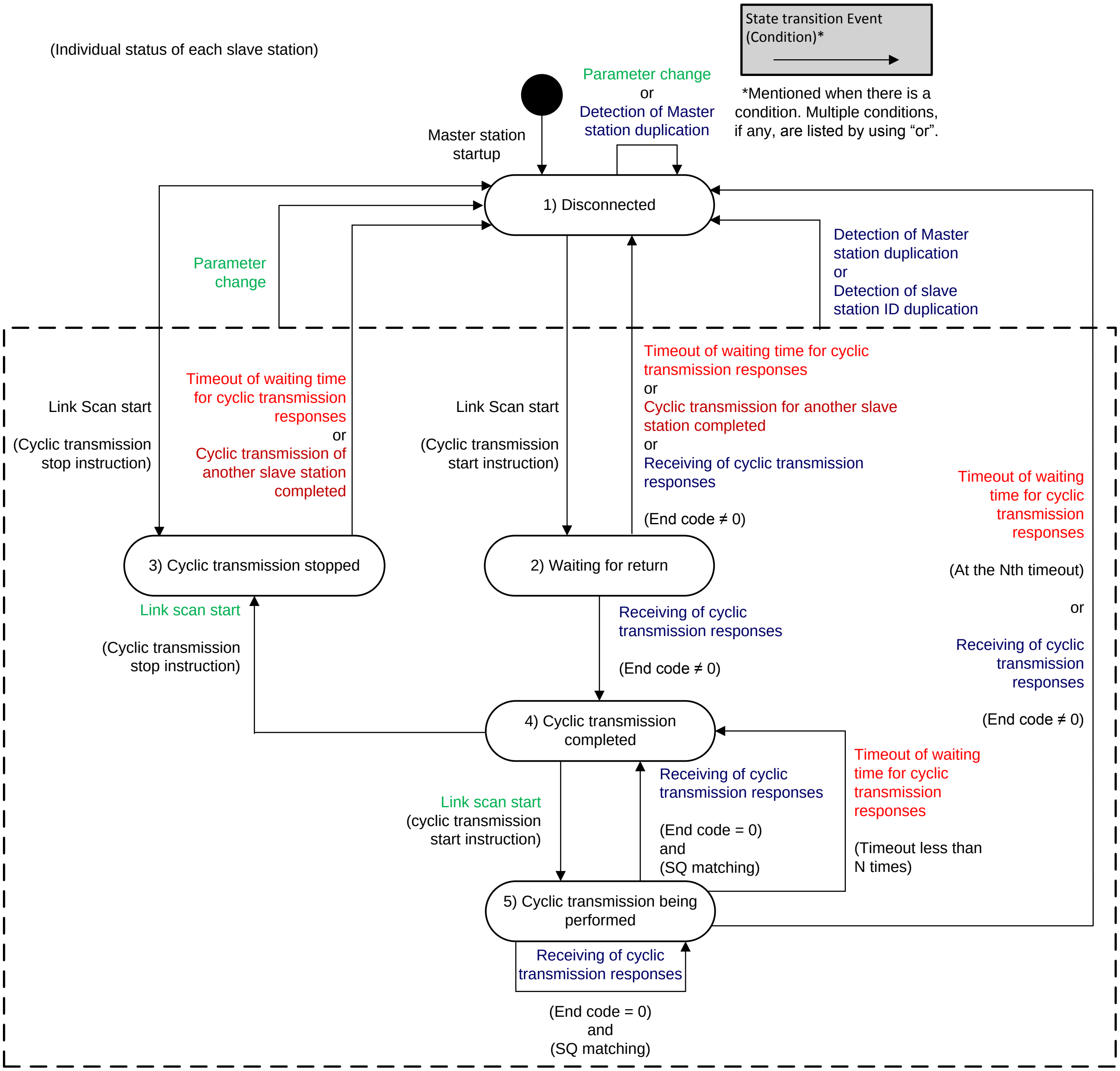
State transition Event (Condition)*
*Mentioned when there is a condition. Multiple conditions, if any, are listed by using "or".
(Individual status of each slave station)
Master station startup
Parameter change or Detection of Master station duplication
1) Disconnected
Parameter change
Detection of Master station duplication or Detection of slave station ID duplication
Link Scan start (Cyclic transmission stop instruction)
Timeout of waiting time for cyclic transmission responses or Cyclic transmission of another slave station completed
Link Scan start (Cyclic transmission start instruction)
Timeout of waiting time for cyclic transmission responses or Cyclic transmission for another slave station completed or Receiving of cyclic transmission responses (End code ≠ 0)
Timeout of waiting time for cyclic transmission responses (At the Nth timeout) or Receiving of cyclic transmission responses (End code ≠ 0)
3) Cyclic transmission stopped
2) Waiting for return
Link scan start (Cyclic transmission stop instruction)
Receiving of cyclic transmission responses (End code ≠ 0)
4) Cyclic transmission completed
Link scan start (cyclic transmission start instruction)
Receiving of cyclic transmission responses (End code = 0) and (SQ matching)
Timeout of waiting time for cyclic transmission responses (Timeout less than N times)
5) Cyclic transmission being performed
Receiving of cyclic transmission responses
(End code = 0) and (SQ matching)

Figure 8. State Transition Diagram for Individual Status of Each Slave Station Possessed

The master station possesses the individual status of each slave station to control for the number of connected devices. Each status connects with the group status of the group that each slave station belongs.

2.3.4.2 State Transition of Slave Station

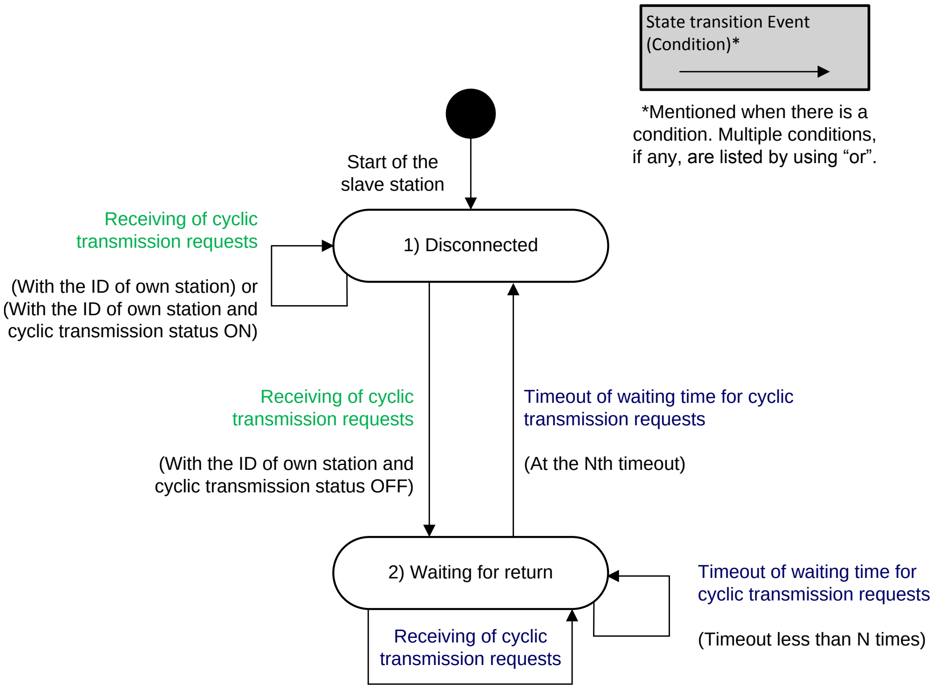
State transition Event
(Condition)*
*Mentioned when there is a condition. Multiple conditions, if any, are listed by using "or".
Start of the slave station
1) Disconnected
Receiving of cyclic transmission requests
(With the ID of own station) or (With the ID of own station and cyclic transmission status ON)
Receiving of cyclic transmission requests
(With the ID of own station and cyclic transmission status OFF)
Timeout of waiting time for cyclic transmission requests
(At the Nth timeout)
2) Waiting for return
Receiving of cyclic transmission requests
Timeout of waiting time for cyclic transmission requests
(Timeout less than N times)

Figure 9. State Transition Diagram of Slave Station

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

3.1.1 Hardware

This reference design requires the following:

- AM3359 Sitara Processor (as shown in Figure 10)

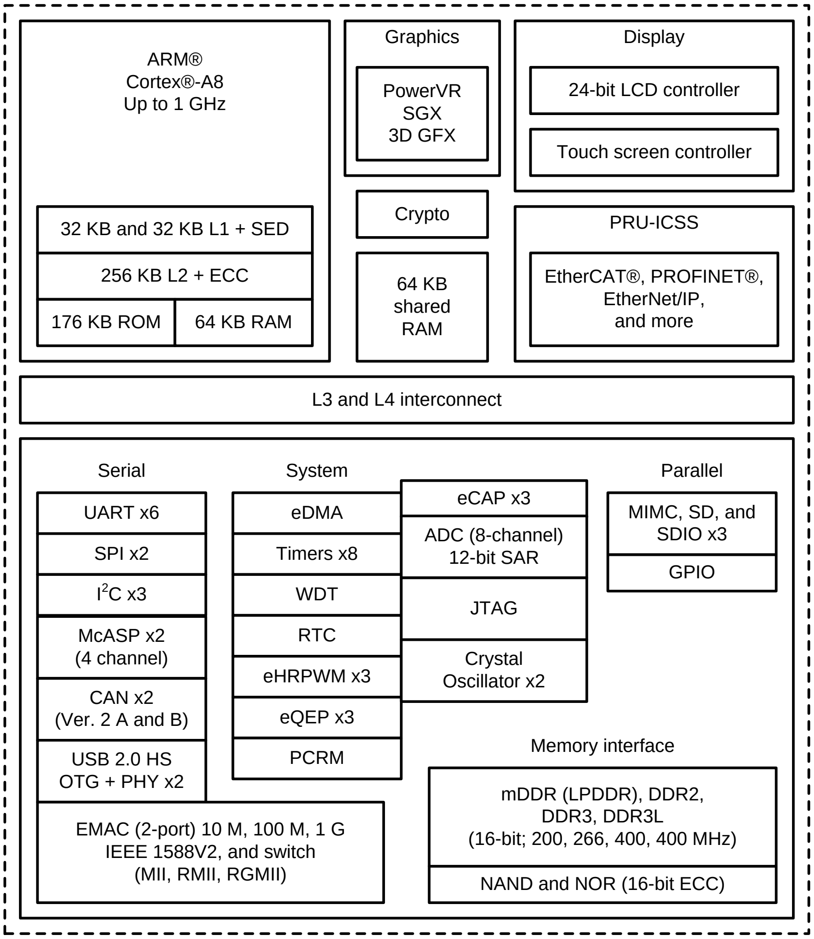

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Figure 10. Functional Block Diagram of AM335x SOC

- DP83822I Transceiver

- TMDSICE3359 ICE EVM (as shown in Figure 11)

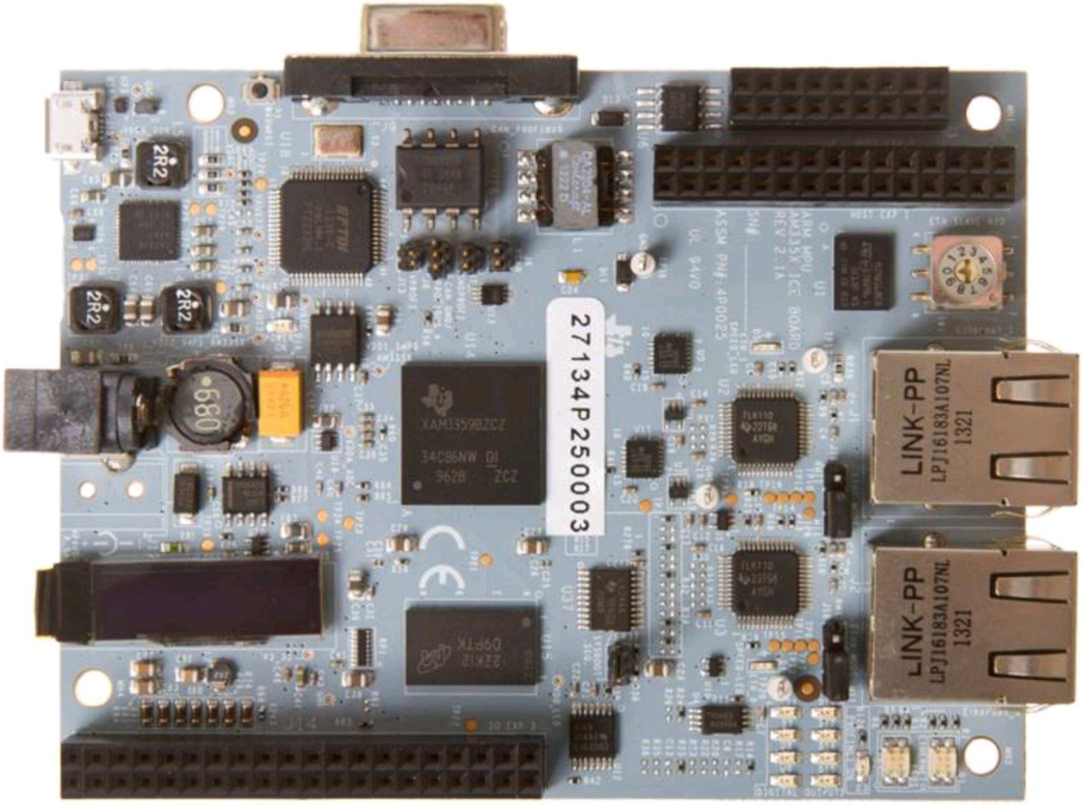


Figure 11. TMDSICE3359 ICE EVM

3.1.1.1 Additional EVMs Supported

In addition to icev2AM335x board, the IEF Basic master and slave station example also supports other EVMs. Table 1 details the additional supported EVMs.

Table 1. Additional EVMs Supported

DEVICE	EVM	IEF Basic on EMAC		IEF Basic on PRU-ICSS	
		Linux	RTOS	Linux	RTOS
AM572x	AM572x EVMxx	X	X		
	AM572x IDK	X	X	X	X
AM571x	AM571x IDK	X	X	X	X
AM437x	AM437x EVM	X	X		
	AM437x SK	X	X		
	AM437x IDK	X	X	X	X
AM335x	AM335x EVM	X	X		
	AM335x BeagleBoneBlack	X	X		
	AM335x SK	X	X		
	AM335x ICE	X	X	X	X
K2G	K2G EVM	X	X		
	K2G ICE EVM	X	X	X	X

3.1.2 Software

3.1.2.1 CC-Link in Processor SDK RTOS

3.1.2.1.1 Software Stack

In *Processor SDK RTOS* the ARM application creates the OS (TI-RTOS) task for supporting various server end functionality.[20] The application creates the network stack for basic networking functionality using NDK. The application then initializes the PRU-ICSS subsystem for NIMU_ICSS and CPSW for NIMU.

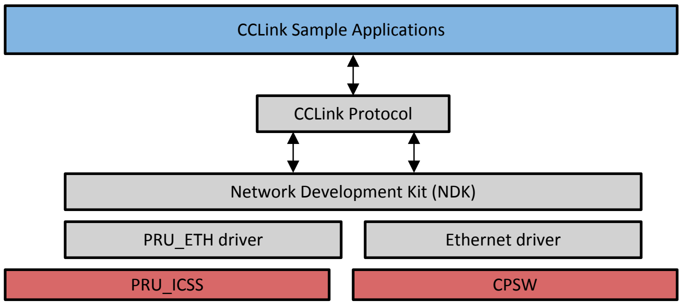


Figure 12. CC-Link IEF Basic Software Stack

3.1.2.1.1.1 RTOS Adaptation

The general available IEF Basic source code supports Windows® and Linux operating systems. Required modifications enable IEF Basic on RTOS. Most of the modifications are done the on *Hardware Abstraction* layer. The following is the list of changes made. RTOS has a default IP address as *192.168.3.10* for the slave station and *192.168.3.100* for the master station. In order to change this parameter, the RTOS application *.cfg files must be updated.

1. Socket
   - The network layer for RTOS is different than Windows and Linux. The network layer is provided by NDK layer for RTOS. TI NDK is compatible with standard BSD socket layer. All the network functionalities are supported using NDK stack.
2. RTC
   - In case of Windows and Linux, the timing information is extracted from RTC call in both OS. RTOS provides an abstraction layer for RTC call. RTOS configures the timers available in the SOC.
3. SYSBIOS
   - RTOS requires a top-level application to first configure the EVM parameters and set up the board. The application creates the NDK stack and the system configuration. The application then creates a task for IEF Basic application, which runs on top of the stack.
4. UART
   - RTOS provides the output to be printed on UART console.

3.1.2.1.2 Run CC-Link IEF Basic Sample RTOS Application

The following software is required:

- Code Composer Studio™ (CCS) v6 or higher
- PRU Compiler for CCSv6 (install through CCS add-on)
- PROCESSOR SDK RTOS AM335X

Software setup:

1. Install CCS development tool.
2. Install PROCESSOR SDK RTOS AM335X.

3. Create application projects depending on target application.
4. Import IEF Basic application project into CCS. Connect to one of the boards, and run the master application example. Connect to the other board, and run the slave application on it.
5. Output result will be printed on UART console.

NOTE: Review Section 6 for wiki links with additional details.

3.1.2.2 CC-Link in Processor SDK Linux

3.1.2.2.1 Software Stack

In Processor SDK Linux, the IEF Basic application runs on top of the Linux networking, which can be based on either EMAC (CPSW) or PRU-ICSS.

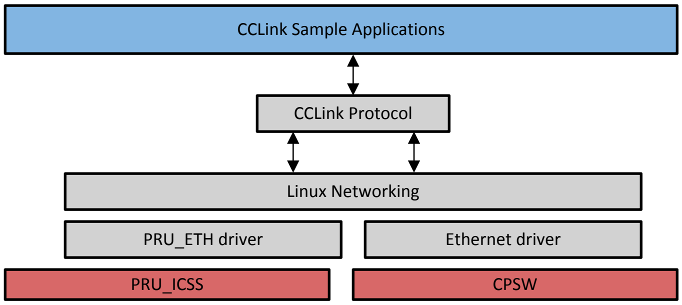


Figure 13. CC-Link IEF Basic Software Stack

3.1.2.2.2 Run CC-Link IEF Basic Sample Linux Application

The following software is required:

- PROCESSOR SDK Linux RT AM335X

Software setup:

1. Download PROCESSOR SDK Linux RT AM335X.
2. Follow the instructions on the wiki pages to create SD cards.
   - For a Windows machine, follow the instructions in *Processor SDK Linux Creating a SD Card with Windows*.
   - For a Linux machine, follow the instructions in *Processor SDK Linux create SD card script*.
3. Follow the instructions at *Processor SDK Linux CCLINK* to obtain the source code of the IEF Basic master and slave sample applications.

To run the IEF Basic sample application:

1. Boot the two icev2AM335x boards with the SD cards inserted.
2. On the master icev2AM335x board, modify *Slave1 IP address* in MasterParameter.csv to use the IP address of the slave icev2AM335x board.
3. Run *Master_sample* application on the master icev2AM335x board.
4. Run *Slave_sample* application on the slave icev2AM335x board.

3.2 Testing and Results

3.2.1 Test Setup

Figure 14 shows the test setup for the IEF basic master and slave application running on icev2AM335x board.

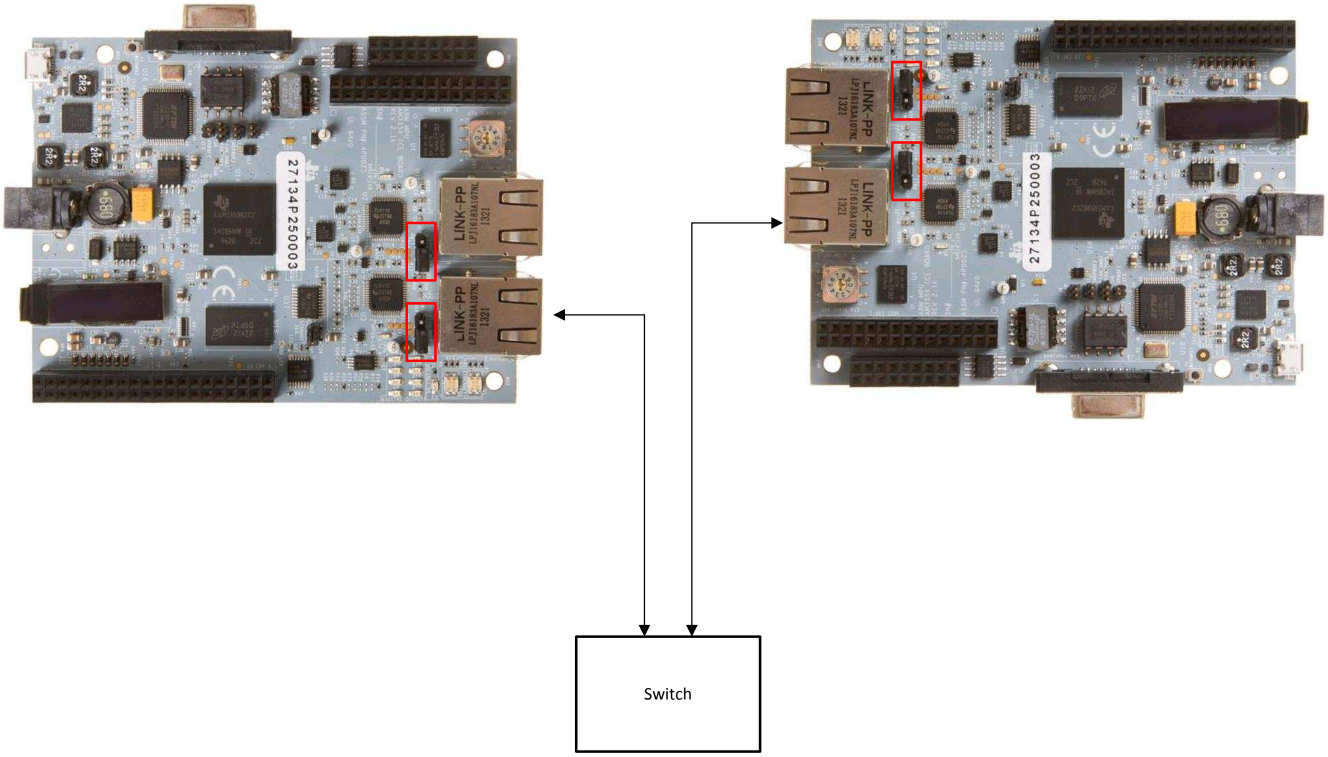


Figure 14. Hardware Test Setup

Connect port 0 of the design board with an Ethernet cable to a standard switch for both master and slave station. Make sure the jumper setting is correct and based on the type of application demonstrated.

- If running with EMAC, connect the jumper J18 and J19 for both boards into EMAC mode. Hence, connect pin1 and pin2.
- If running with PRU_ICSS, connect the jumper J18 and J19 for both boards into ICSS mode. Hence, connect pin2 and pin3.

In order to get best performance result, do not make any other connection with the switch or hub.

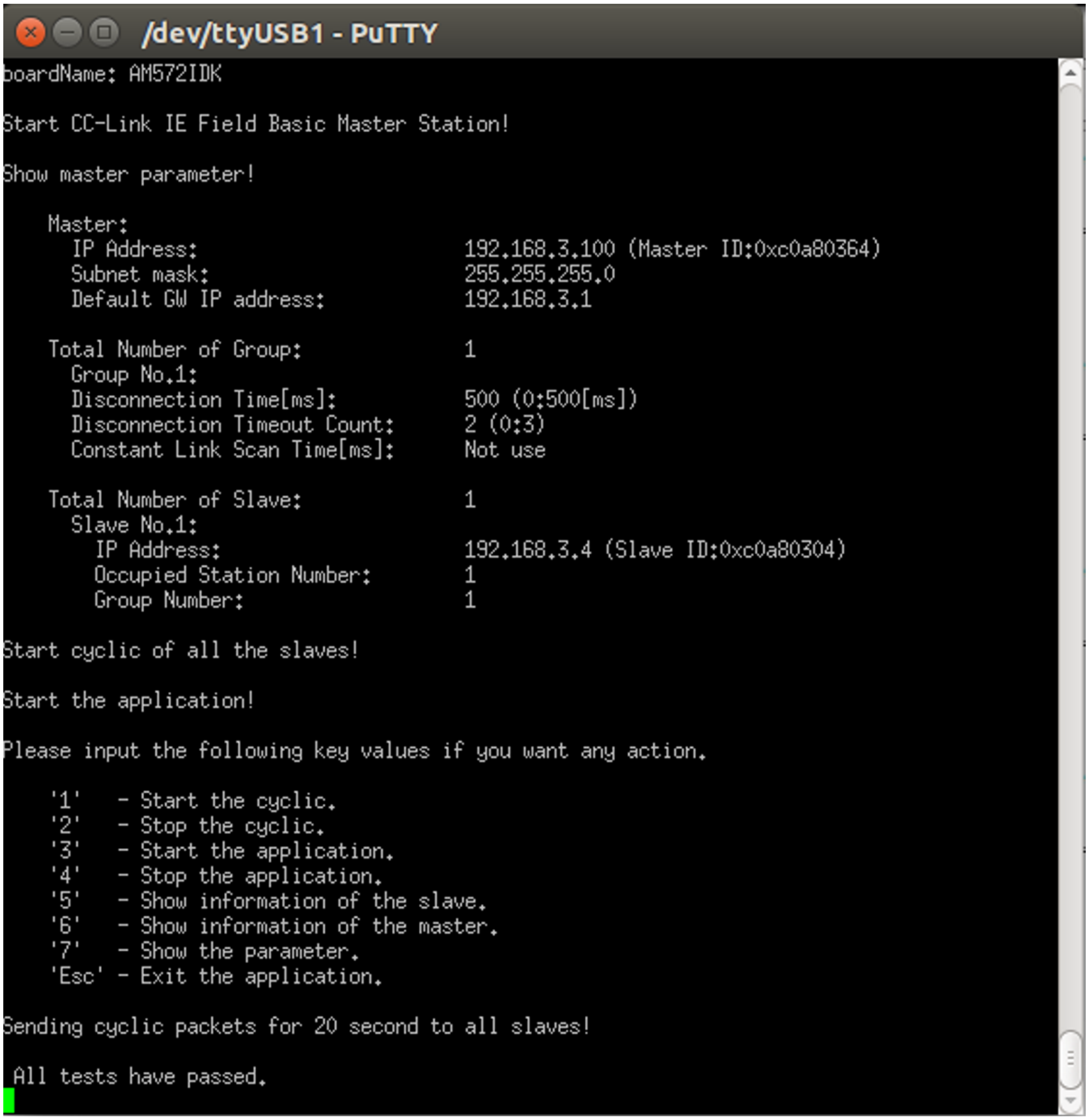
3.2.2 Test Results

3.2.2.1 RTOS

3.2.2.1.1 Sample Output

The following figures show the displays on the UART console when the link is up and communication takes place between slave and master. The default configuration of master and slave would be printed in their respective port.

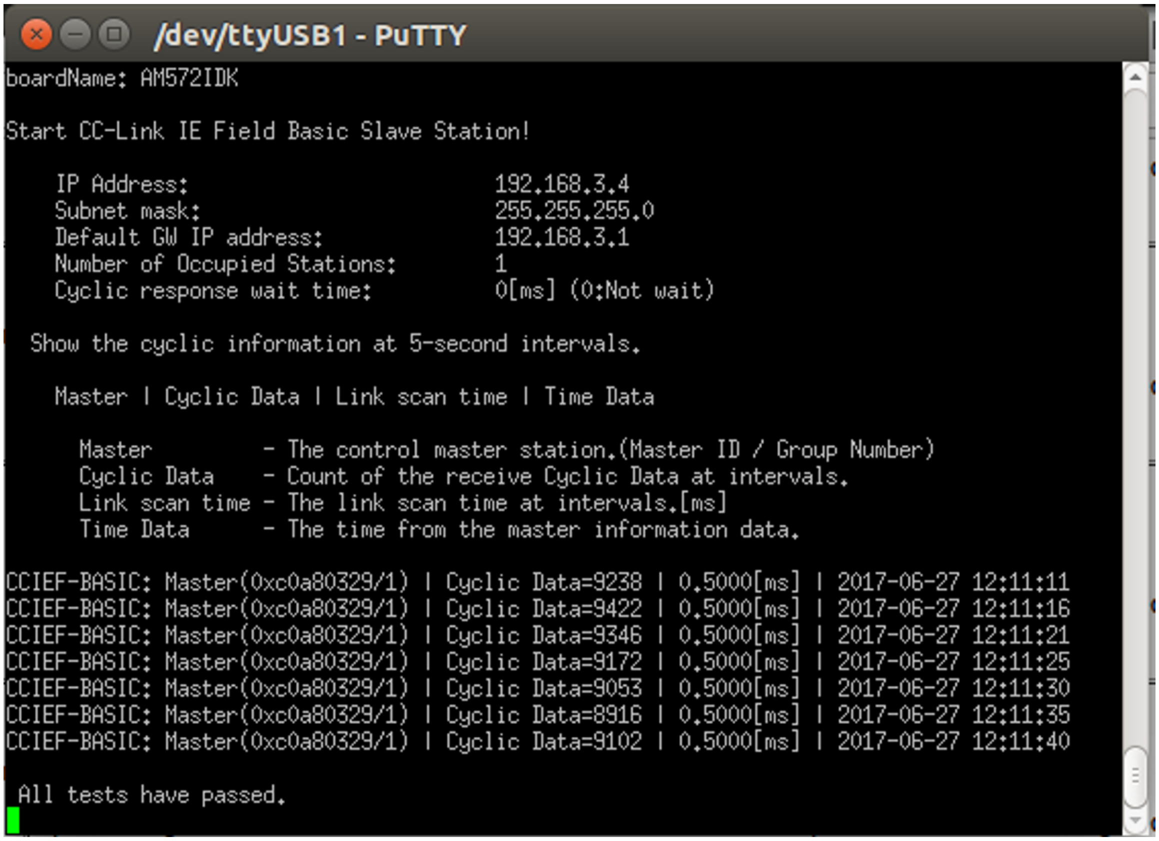
Figure 15 shows the master UART console.



```
boardName: AM572IDK

Start CC-Link IE Field Basic Master Station!

Show master parameter!

    Master:
      IP Address:                     192.168.3.100 (Master ID:0xc0a80364)
      Subnet mask:                    255.255.255.0
      Default GW IP address:          192.168.3.1

    Total Number of Group:            1
      Group No.1:
      Disconnection Time[ms]:         500 (0:500[ms])
      Disconnection Timeout Count:    2 (0:3)
      Constant Link Scan Time[ms]:    Not use

    Total Number of Slave:            1
      Slave No.1:
        IP Address:                   192.168.3.4 (Slave ID:0xc0a80304)
        Occupied Station Number:      1
        Group Number:                 1

Start cyclic of all the slaves!

Start the application!

Please input the following key values if you want any action.

    '1'   - Start the cyclic.
    '2'   - Stop the cyclic.
    '3'   - Start the application.
    '4'   - Stop the application.
    '5'   - Show information of the slave.
    '6'   - Show information of the master.
    '7'   - Show the parameter.
    'Esc' - Exit the application.

Sending cyclic packets for 20 second to all slaves!

 All tests have passed.
```

Figure 15. Master UART Console

Figure 16 shows the slave UART console.



```
boardName: AM572IDK

Start CC-Link IE Field Basic Slave Station!

    IP Address:                      192.168.3.4
    Subnet mask:                     255.255.255.0
    Default GW IP address:           192.168.3.1
    Number of Occupied Stations:     1
    Cyclic response wait time:       0[ms] (0:Not wait)

  Show the cyclic information at 5-second intervals.

    Master | Cyclic Data | Link scan time | Time Data

      Master         - The control master station.(Master ID / Group Number)
      Cyclic Data    - Count of the receive Cyclic Data at intervals.
      Link scan time - The link scan time at intervals.[ms]
      Time Data      - The time from the master information data.

CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9238 | 0.5000[ms] | 2017-06-27 12:11:11
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9422 | 0.5000[ms] | 2017-06-27 12:11:16
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9346 | 0.5000[ms] | 2017-06-27 12:11:21
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9172 | 0.5000[ms] | 2017-06-27 12:11:25
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9053 | 0.5000[ms] | 2017-06-27 12:11:30
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=8916 | 0.5000[ms] | 2017-06-27 12:11:35
CCIEF-BASIC: Master(0xc0a80329/1) | Cyclic Data=9102 | 0.5000[ms] | 2017-06-27 12:11:40

 All tests have passed.
```

Figure 16. Slave UART Console

3.2.2.1.2 Compliance Testing

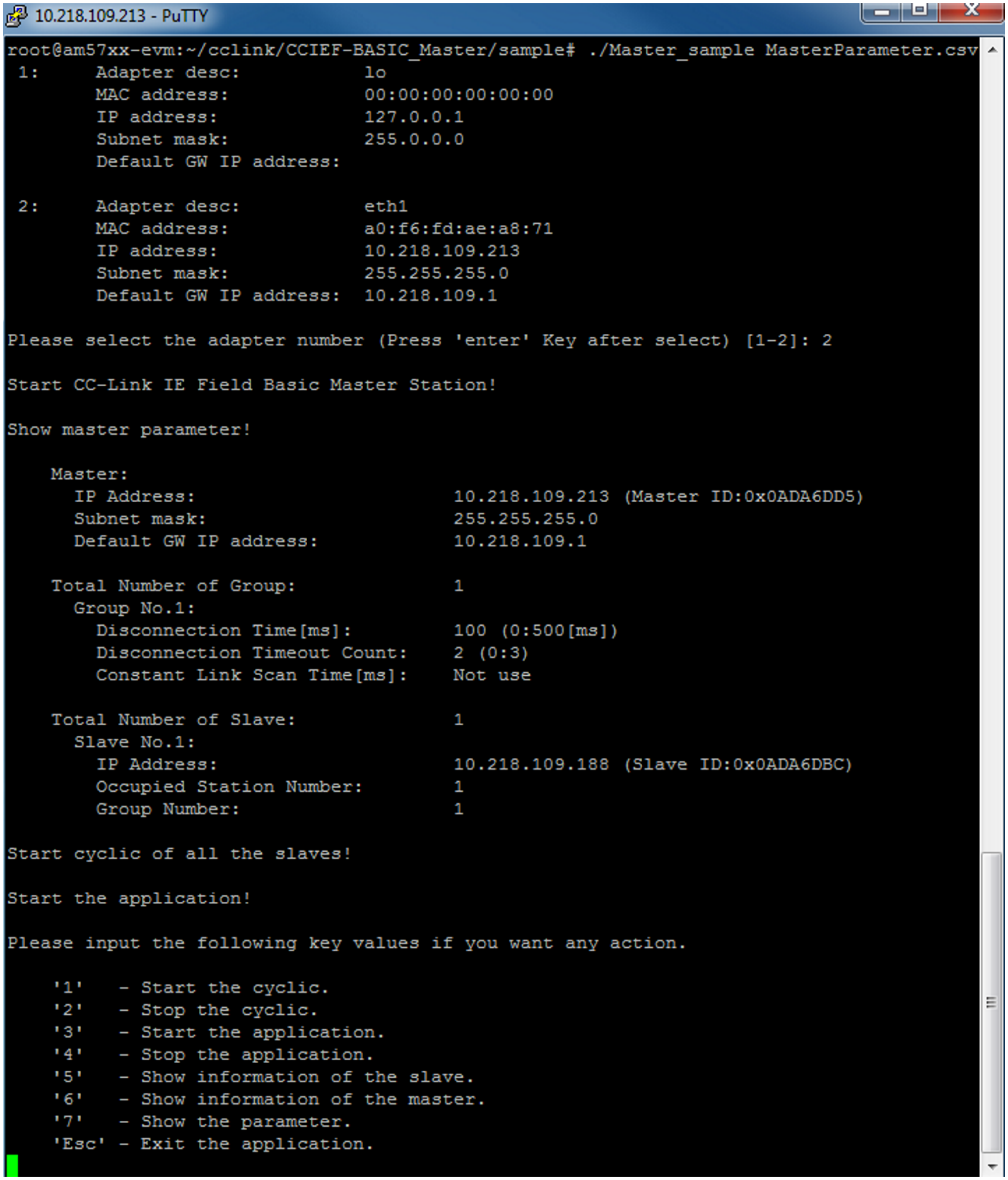
Every IEF Basic application when demonstrated on any platform has to pass the conformance testing for various functionalities of IEF Basic. The conformance test results are sent to CLPA for approval. Upon approval from CLPA, the platform is accepted as CC-Link IEF Basic complaint. See the conformance test results for TI EVMs at *Processor SDK RTOS CCLINK*.

3.2.2.2 Linux

3.2.2.2.1 Sample Output

The following figures show the displays on the console when communication takes place between the slave and master boards. The default configuration of master and slave would be printed in their respective console.

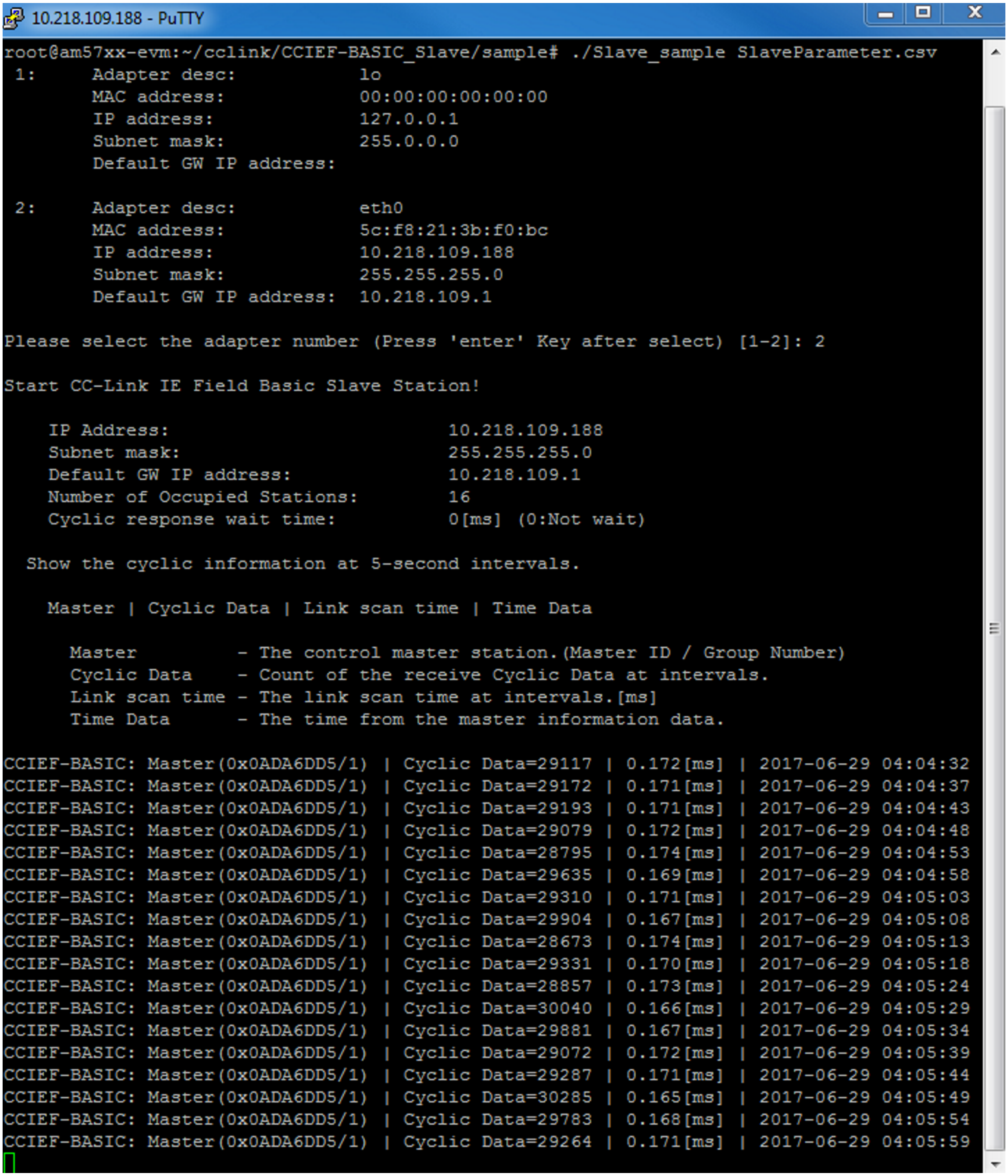
Figure 17 shows the master console for the master board.



```
root@am57xx-evm:~/cclink/CCIEF-BASIC_Master/sample# ./Master_sample MasterParameter.csv
 1:      Adapter desc:            lo
         MAC address:             00:00:00:00:00:00
         IP address:              127.0.0.1
         Subnet mask:             255.0.0.0
         Default GW IP address:

 2:      Adapter desc:            eth1
         MAC address:             a0:f6:fd:ae:a8:71
         IP address:              10.218.109.213
         Subnet mask:             255.255.255.0
         Default GW IP address:   10.218.109.1

Please select the adapter number (Press 'enter' Key after select) [1-2]: 2

Start CC-Link IE Field Basic Master Station!

Show master parameter!

    Master:
      IP Address:                       10.218.109.213 (Master ID:0x0ADA6DD5)
      Subnet mask:                      255.255.255.0
      Default GW IP address:            10.218.109.1

    Total Number of Group:              1
      Group No.1:
        Disconnection Time[ms]:         100 (0:500[ms])
        Disconnection Timeout Count:    2 (0:3)
        Constant Link Scan Time[ms]:    Not use

    Total Number of Slave:              1
      Slave No.1:
        IP Address:                     10.218.109.188 (Slave ID:0x0ADA6DBC)
        Occupied Station Number:        1
        Group Number:                   1

Start cyclic of all the slaves!

Start the application!

Please input the following key values if you want any action.

    '1'   - Start the cyclic.
    '2'   - Stop the cyclic.
    '3'   - Start the application.
    '4'   - Stop the application.
    '5'   - Show information of the slave.
    '6'   - Show information of the master.
    '7'   - Show the parameter.
    'Esc' - Exit the application.
```

Figure 17. Master Console

Figure 18 shows the slave console for the slave board.



```
root@am57xx-evm:~/cclink/CCIEF-BASIC_Slave/sample# ./Slave_sample SlaveParameter.csv
 1:     Adapter desc:           lo
        MAC address:            00:00:00:00:00:00
        IP address:             127.0.0.1
        Subnet mask:            255.0.0.0
        Default GW IP address:

 2:     Adapter desc:           eth0
        MAC address:            5c:f8:21:3b:f0:bc
        IP address:             10.218.109.188
        Subnet mask:            255.255.255.0
        Default GW IP address:  10.218.109.1

Please select the adapter number (Press 'enter' Key after select) [1-2]: 2

Start CC-Link IE Field Basic Slave Station!

    IP Address:                         10.218.109.188
    Subnet mask:                        255.255.255.0
    Default GW IP address:              10.218.109.1
    Number of Occupied Stations:        16
    Cyclic response wait time:          0[ms]  (0:Not wait)

  Show the cyclic information at 5-second intervals.

    Master | Cyclic Data | Link scan time | Time Data

      Master          - The control master station.(Master ID / Group Number)
      Cyclic Data     - Count of the receive Cyclic Data at intervals.
      Link scan time  - The link scan time at intervals.[ms]
      Time Data       - The time from the master information data.

CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29117 | 0.172[ms] | 2017-06-29 04:04:32
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29172 | 0.171[ms] | 2017-06-29 04:04:37
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29193 | 0.171[ms] | 2017-06-29 04:04:43
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29079 | 0.172[ms] | 2017-06-29 04:04:48
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=28795 | 0.174[ms] | 2017-06-29 04:04:53
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29635 | 0.169[ms] | 2017-06-29 04:04:58
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29310 | 0.171[ms] | 2017-06-29 04:05:03
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29904 | 0.167[ms] | 2017-06-29 04:05:08
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=28673 | 0.174[ms] | 2017-06-29 04:05:13
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29331 | 0.170[ms] | 2017-06-29 04:05:18
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=28857 | 0.173[ms] | 2017-06-29 04:05:24
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=30040 | 0.166[ms] | 2017-06-29 04:05:29
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29881 | 0.167[ms] | 2017-06-29 04:05:34
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29072 | 0.172[ms] | 2017-06-29 04:05:39
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29287 | 0.171[ms] | 2017-06-29 04:05:44
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=30285 | 0.165[ms] | 2017-06-29 04:05:49
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29783 | 0.168[ms] | 2017-06-29 04:05:54
CCIEF-BASIC: Master(0x0ADA6DD5/1)  | Cyclic Data=29264 | 0.171[ms] | 2017-06-29 04:05:59
```

Figure 18. Slave Console

3.2.2.2.2 Compliance Testing

See the conformance testing results for icev2AM335x with Processor SDK Linux at *Processor SDK Linux CCLINK*.

3.2.2.3 Additional EVMs

Follow the same procedure as mentioned in Section 3.2.2.1 and Section 3.2.2.2 for both RTOS and Linux.

3.2.2.3.1 Compliance Testing

3.2.2.3.1.1 RTOS

See the conformance test results for TI EVMs with Processor SDK RTOS at *Processor SDK RTOS CCLINK*.

3.2.2.3.1.2 Linux

See the conformance test results for TI EVMs with Processor SDK Linux at *Processor SDK Linux CCLINK*.

4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDEP-0089.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDEP-0089.

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDEP-0089.

4.4 Altium Project

To download the Altium project files, see the design files at TIDEP-0089.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDEP-0089.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDEP-0089.

5 Software Files

To download the software files, see the design files at TIDEP-0089.

6 Related Documentation

1. Texas Instruments, *AM335x Sitara Processors*, Datasheet (SPRS717)
2. Texas Instruments, *DP83822 Robust, Low Power 10/100 Mbps Ethernet Physical Layer Transceiver*, Datasheet (SNLS505)
3. Texas Instruments, *Processor SDK RTOS IEF Basic*, Wiki
4. Texas Instruments, *Download CCS*, Code Composer Studio TI Wiki
5. Texas Instruments, *CCS Getting Started Guide*, Wiki
6. Texas Instruments, *Processor SDK RTOS_CCS_Setup*, Wiki
7. Texas Instruments, *Creating and importing examples in Processor SDK RTOS*, Wiki
8. Texas Instruments, *Processor SDK RTOS AM335X*, Download Page
9. Texas Instruments, *Processor SDK RTOS AM437X*, Download Page
10. Texas Instruments, *Processor SDK RTOS K2G*, Download Page
11. Texas Instruments, *Processor SDK RTOS AM57X*, Download Page
12. Texas Instruments, *Processor SDK Linux IEF Basic Wiki Page*, Wiki
13. Texas Instruments, *SDK Linux create SD card script*, Wiki
14. Texas Instruments, *Processor SDK Linux Creating a SD Card with Windows*, Wiki
15. Texas Instruments, *Processor SDK Linux RT AM335X*, Download Page
16. Texas Instruments, *Processor SDK Linux RT AM437X*, Download Page
17. Texas Instruments, *Processor SDK Linux RT K2G*, Download Page
18. Texas Instruments, *Processor SDK Linux RT AM57X*, Download Page
19. Texas Instruments, *Processor SDK Software Page*, Product Page
20. Texas Instruments, *Category:SYSBIOS*, Wiki
21. CC-Link Partner Association, *CLPA Reference Material and Support*

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7 Terminology

- CCS - Code Composer Studio
- ICSS - Industrial communication system
- PLC - Programmable logic controller
- PRU - Programmable real-time unit

8 About the Author

SURAJ DAS is a Software Engineer at Texas Instruments, where he is responsible for developing PRU-ICSS based solution for the Catalog segment. Suraj brings to this role his extensive experience in Computer architecture & PRU cores, and has supported Catalog RTOS SDK release for various peripherals. Suraj earned his Master of Engineering degree in Computer Engineering from Virginia Tech in Blacksburg, VA.

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