

BCI-1553

Bus Controller Documentation

REV	DATE	DESCRIPTION	PREPARED BY	APPROVED BY
1.0	04/19/2016	Initial revision.	J. Ryan Vallieres	-
1.01	05/18/2016	Updated Common API to include 'Change Mode' method. Updated troubleshooting section for operating mode mismatch.	J. Ryan Vallieres	-
1.02	05/23/2016	Corrected references to RT drivers in troubleshooting section.	Tristan Cowan	

Table of Contents

List of Figures.....	4
1 Product Description.....	5
1.1 Features	5
1.1.1 Dual Channel Bus Controller	5
1.1.2 Dual Redundant Bus.....	5
1.2 Setup & Installation.....	5
1.2.1 How to Setup Hardware for Use	5
1.2.2 How to Install Software for Use	5
1.2.2.1 Before Installing Drivers.....	6
1.2.2.2 Installing BCI-1553 Drivers from a Flash Drive.....	6
1.2.2.3 BCI-1553 and LabVIEW FPGA Projects	6
1.2.2.4 Adding the BCI-1553 Module to a LabVIEW FPGA Project	6
2 Hardware	9
2.1 Hardware General Overview.....	9
2.1.1 4-Contact Power Connector.....	9
2.1.1.1 Voltage + (9V - 24V)	9
2.1.1.2 Common.....	9
2.1.1.3 No Connect.....	9
2.1.2 DB-15 1553 Interface	9
2.1.2.1 Bus A+, Bus A-, Shield.....	9
2.1.2.2 Bus B+, Bus B-, Shield	10
2.1.2.3 External Start.....	10
2.1.2.4 External Trigger	10
2.1.2.5 Ground	10
2.1.3 LED Indicators	10
2.1.3.1 Power (LED 1).....	10
2.1.3.2 Act (LED 2).....	10
2.1.3.3 Bus-A (LED 3), Bus-B (LED 4)	11
3 Software	12
3.1 General Overview	12
3.2 Common API	12
3.2.1 Serial Number (Property).....	12
3.2.2 Module ID (Property)	12
3.2.3 Vendor ID (Property).....	12
3.2.4 Change Mode (Method).....	13
3.3 Bus Controller	13

3.3.1	Initialize BC (Method)	13
3.3.2	Receive (Method).....	13
3.3.3	Transmit (Method).....	14
3.3.3.1	Status Word	14
3.3.4	Release BC (Method)	15
3.4	Example Code.....	15
4	Troubleshooting.....	16
4.1	Common Scenarios	16
5	Appendix A: API Summary.....	18
6	Appendix B: Status Word.....	19
7	Appendix C: FPGA Utilization.....	20

List of Figures

Figure 1-A: New C Series module.....	7
Figure 1-B: New target or device.	7
Figure 1-C: Setting the details of the BCI-1553 module to add.	8
Figure 1-D: BCI-1553 module present in the project.....	8
Figure 2-A: DB-15 output diagram for the BCI-1553.	9
Figure 2-B: BCI-1553 LED Assignment.....	10
Figure 3-A: Creating a BCI-1553 Module Reference.	12
Figure 3-B: Reading the Module ID, Serial Number, and Vendor ID.....	13
Figure 3-C: A typical use of the Change Mode method.	13
Figure 3-D: Initializing a BCI-1553 Module in BC mode.	13
Figure 3-E: 32-word receive command against RT Address 1, SubAddress 1, on Bus A.....	14
Figure 3-F: Configuring BC to transmit on channel.....	14
Figure 3-G: Releases a BCI-1553 module into a default state.	15

1 Product Description

The Bloomy Controls BCI-1553 module is a redundant multi-function MIL-STD-1553 terminal designed for use in a National Instruments cRIO chassis. The BCI-1553 module supports operation as a Remote Terminal, Dual Remote Terminals, Bus Controller, or a Bus Monitor. Redundancy on the module is handled by having up to two transmission buses for any of the operation modes, each being independently configurable. This document specifically defines the operation of the Bus Controller mode of the BCI-1553.

1.1 Features

1.1.1 Dual Channel Bus Controller

The BCI-1553 supports the functionality of a single bus controller with two MIL-STD-1553B buses. Once initialized, each bus can be controlled independently. Custom transmissions can be generated for transmission on either bus and may target any collection of remote terminals on the bus.

1.1.2 Dual Redundant Bus

The BCI-1553 module has two bus interfaces available for operating on. When used in the same network, Bus B can be used as a redundant secondary bus. Alternatively, Bus A and Bus B can be independently operated for communication with two separate 1553 networks. This independent operation allows for non-redundant communication to each collection of remote terminals and bus monitors on the independent buses.

1.2 Setup & Installation

1.2.1 How to Setup Hardware for Use

The BCI-1553 module requires several external components for interfacing and power.

1. A compatible National Instruments cRIO chassis (Minimum Suggested: Kintex 7 70T FPGA).
2. An external power source capable of providing the voltage and current outlined in section 2.1.1.

After the BCI-1553 drivers have been installed, the BCI-1553 module can be placed in an empty slot in the cRIO chassis. Power can be connected to the front of the module and cabling run from the DB-15 interface onto the 1553 Bus. Once this is complete, the module can be discovered on a LabVIEW FPGA application.

1.2.2 How to Install Software for Use

When receiving a BCI-1553 module, drivers will accompany the module via flash drive, CD, or hyperlink. These various sources will contain an installer executable that will place the required drivers onto a target computer, allowing an installed version of LabVIEW to recognize the BCI-1553 module when it is present in a cRIO chassis.

1.2.2.1 Before Installing Drivers

Before attempting to install the BCI-1553 drivers, make sure that all versions of LabVIEW are closed on the target computer and no other install processes are actively running. Further, the following applications and software are required to successfully install the BCI-1553 drivers.

1. National Instruments LabVIEW 2015.
2. National Instruments LabVIEW 2015 FPGA and Real Time modules.

1.2.2.2 Installing BCI-1553 Drivers from a Flash Drive

1. Insert the flash drive into an available USB port on the target computer.
2. Navigate to the flash drive through Windows Explorer.
3. Run the *Setup.exe* file located at the root of the flash drive.
4. Follow the prompts presented by the installer.

1.2.2.3 BCI-1553 and LabVIEW FPGA Projects

Once the driver software is installed on a target computer, the BCI-1553 module can be discovered and/or added to an FPGA project. There are no slot requirements for the module and the number of modules allowable on a single system depends entirely on the FPGA space available. See Appendix C: FPGA Utilization for more information on the FPGA utilization of each operation mode.

The BCI-1553 module **requires a cRIO chassis to be running in FPGA mode** to be discovered or even added. In other words, the BCI-1553 module is **incompatible with National Instruments Scan Engine**.

1.2.2.4 Adding the BCI-1553 Module to a LabVIEW FPGA Project

The BCI-1553 module supports auto-discovery and manual addition to a project. The below steps outline the basic procedure for manually adding the BCI-1553 module to a LabVIEW FPGA project. Use the 'Existing target or device' option at step 2 for auto-discovery of the BCI-1553 module.

1. Add a new C Series module to the FPGA target.

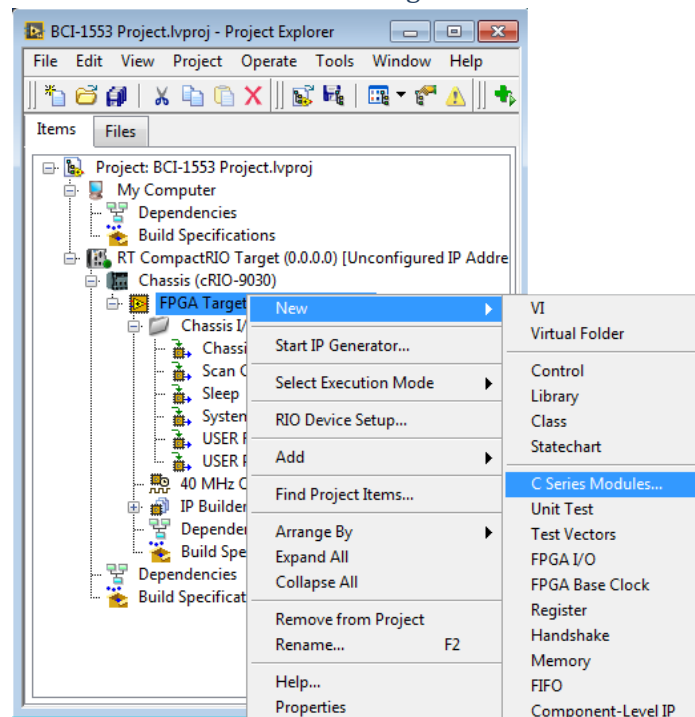


Figure 1-A: New C Series module.

2. Select to add a new target or device.

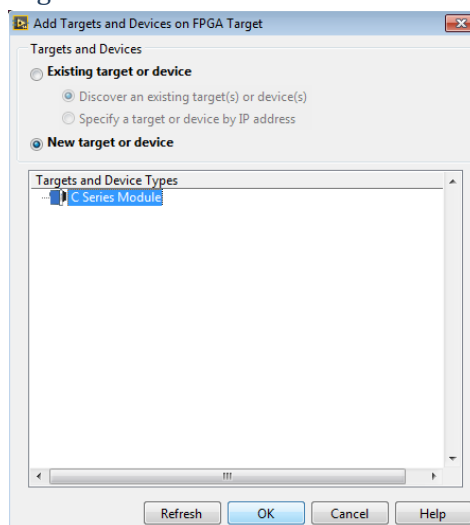


Figure 1-B: New target or device.

3. Select the module name, set the type to BCI-1553-BC, and set the slot.

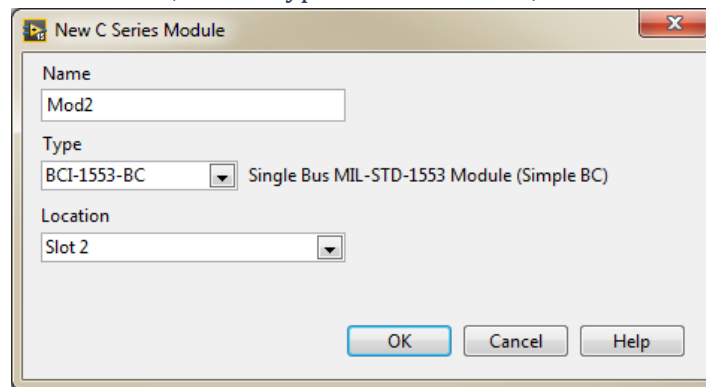


Figure 1-C: Setting the details of the BCI-1553 module to add.

4. Find the BCI-1553 module in the project.

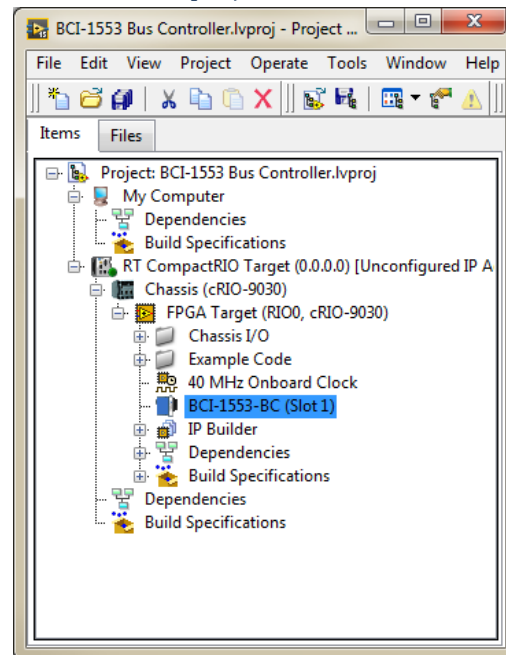


Figure 1-D: BCI-1553 module present in the project.

2 Hardware

2.1 Hardware General Overview

2.1.1 4-Contact Power Connector

This connector is the interface for an external power supply to the BCI-1553 module. An external power supply is required for the BCI-1553 to operate.

2.1.1.1 Voltage + (9V - 24V)

Pin(s): 4

The BCI-1553 module requires a stable supply of 9V - 24V for proper operation. Further, power required to maintain the operation of the module varies as the bus traffic increases relevant to the BCI-1553. When a remote terminal on the BCI-1553 is at near 100% bus load, the module requires a power supply that can maintain at least 270 mA at 24V (approx. 6.5 W).

2.1.1.2 Common

Pin(s): 3

2.1.1.3 No Connect

Pin(s): 1, 2

2.1.2 DB-15 1553 Interface

This is the primary interface to the MIL-STD-1553 buses on the BCI-1553. Additional utility functions may be accessed on this interface.

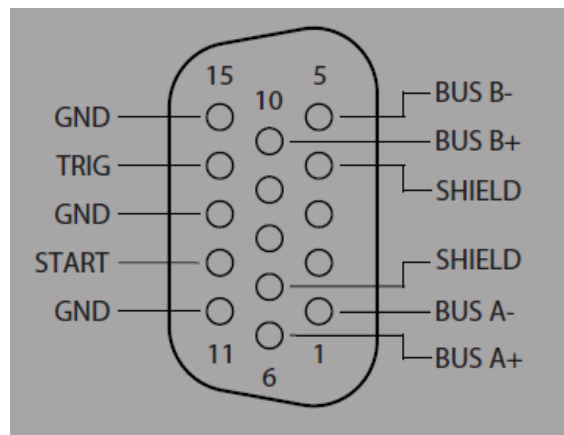


Figure 2-A: DB-15 output diagram for the BCI-1553.

2.1.2.1 Bus A+, Bus A-, Shield

Pin(s): 6, 1, 7

The primary MIL-STD-1553 bus on the BCI-1553 module. Depending on the operation mode of the BCI-1553 module, transmission on this bus can be performed selectively. Bus A is typically the main bus for communication with the BCI-1553 module. Behavior regarding activity on either Bus A or Bus B can be modified in software.

2.1.2.2 Bus B+, Bus B-, Shield

Pin(s): 10, 5, 6

The secondary MIL-STD-1553 bus on the BCI-1553 module. Depending on the operation mode of the BCI-1553 module, transmission on this bus can be selectively inhibited. Bus B is typically the redundant bus for communication with the BCI-1553 module. Behavior regarding activity on Bus B can be modified in software.

2.1.2.3 External Start

Pin(s): 12

Currently disabled for future implementation.

2.1.2.4 External Trigger

Pin(s): 14

Currently disabled for future implementation.

2.1.2.5 Ground

Pin(s): 11, 13, 15

2.1.3 LED Indicators

The LEDs present on the face of the BCI-1553 module are a quick way to discern the state of the module (Figure 2-B). As the module is interfaced through software, the state of each of these LEDs may change to indicate activity on the BCI-1553.

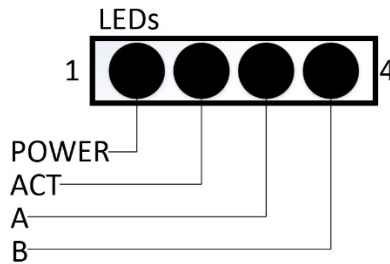


Figure 2-B: BCI-1553 LED Assignment.

2.1.3.1 Power (LED 1)

When the BCI-1553 module is connected to the backplane of a C-Series chassis and is receiving adequate power from the front connector, this LED will turn on. If there is no FPGA application running on the interfacing chassis, this LED will not turn on.

2.1.3.2 Act (LED 2)

The Act LED is used to indicate whether the BCI-1553 module is ready to be started for a particular operation mode. When in Bus Controller mode, this LED will turn on when the 'Initialize BC' (Figure 3-D) method is called and will turn off when the 'Release BC' (Figure 3-G) method is called.

2.1.3.3 Bus-A (LED 3), Bus-B (LED 4)

The Bus-A and Bus-B LEDs will flash on for brief periods of time. In general, these LEDs indicate that there is valid traffic on either bus.

3 Software

3.1 General Overview

The BCI-1553 module is capable of operating in any one of four modes: Remote Terminal, Bus Controller, Bus Monitor, and Advanced. It is not currently possible to operate a module in multiple operating modes at the same time. For example, the BCI-1553 module may not be in a remote terminal mode and a bus controller mode at the same time, while using the basic Bloomy drivers. The exception to this is when using the 'Advanced' operating mode. This mode allows for extremely precise control of the internal state of the BCI-1553 module, enabling the simultaneous operation of all three operating modes at once. When in one of the basic operating modes, it is still possible to populate a single chassis with several BCI-1553 modules, each in their own operating mode.

Each mode has its own set of API calls and its own variable FPGA utilization. To access the API for a module, it is necessary to place an I/O Device on the block diagram of an FPGA VI (Figure 3-A). Once placed, method and property nodes can be connected to the I/O Device refnum to access the API. Please note that a 1-second delay is required to accompany the I/O Device refnum instantiation to allow the BCI-1553 module the requisite time to finish internal initialization.

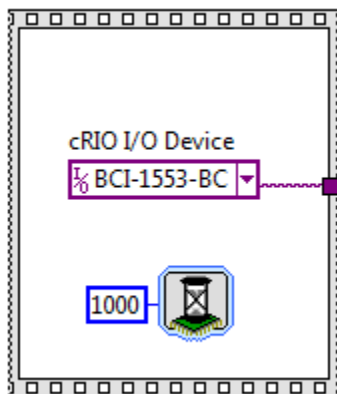


Figure 3-A: Creating a BCI-1553 Module Reference.

3.2 Common API

These methods and properties are constant across all operation modes. Most of these are read-only properties.

3.2.1 Serial Number (Property)

Returns the serial number associated with the BCI-1553 module present in the chassis (Figure 3-B).

3.2.2 Module ID (Property)

Returns the module ID associated with the BCI-1553 module present in the chassis (Figure 3-B).

3.2.3 Vendor ID (Property)

Returns the vendor ID associated with the BCI-1553 module present in the chassis (Figure 3-B).

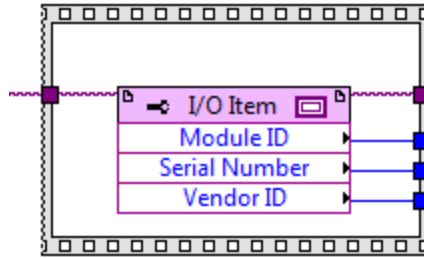


Figure 3-B: Reading the Module ID, Serial Number, and Vendor ID.

3.2.4 Change Mode (Method)

A utility for changing the operating mode of the module. This method should never be used in a final application without extreme caution.

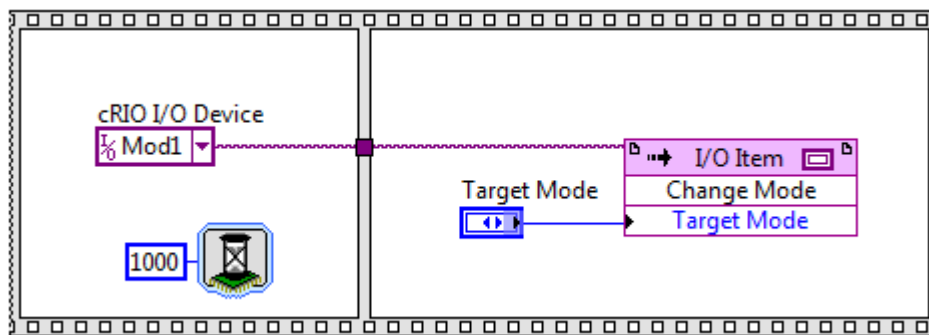


Figure 3-C: A typical use of the Change Mode method.

3.3 Bus Controller

The Bus Controller mode sets up the BCI-1553 module to act as a bus controller.

3.3.1 Initialize BC (Method)

This function (Figure 3-D) is used to initialize the BCI-1553 module into Bus Controller mode. For every call of the Initialize BC function, there should be a corresponding call of the Release BC function after the application is complete.

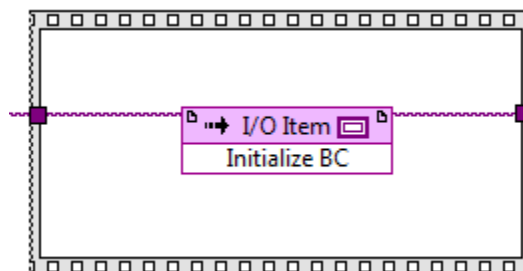


Figure 3-D: Initializing a BCI-1553 Module in BC mode.

3.3.2 Receive (Method)

Command the Bus Controller to perform a receive command on the 1553 Bus. A receive command will push data from the Bus Controller out to the Remote Terminal and SubAddress of interest.

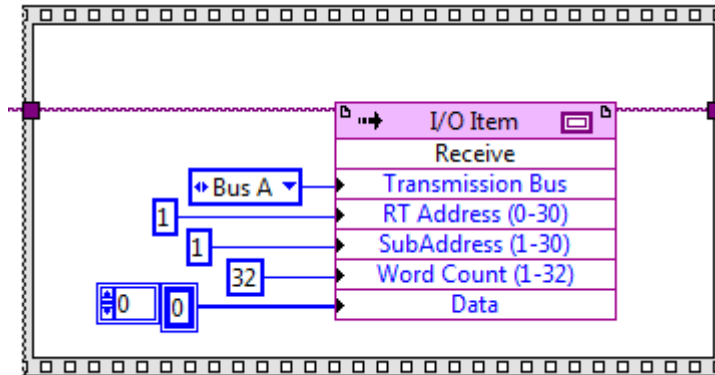


Figure 3-E: 32-word receive command against RT Address 1, SubAddress 1, on Bus A.

3.3.3 Transmit (Method)

Command the Bus Controller to perform a transmit command on the 1553 Bus. A transmit command will pull data from the Remote Terminal and SubAddress of interest back to the Bus Controller. Transmitted data requires a 34-size U16 array. The last index is always 0 and should be ignored. The data is formatted as follows:

>Data Received (Length N)
 [Addr0] – Status Word
 [Addr1] – Data0
 [Addr2] – Data1
 ...
 [AddrN] – DataN

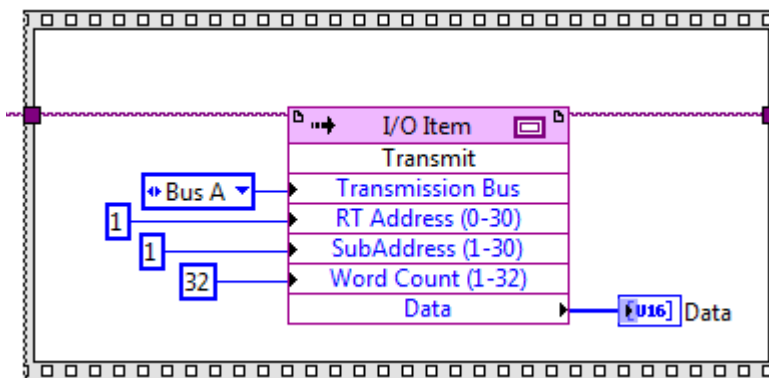


Figure 3-F: Configuring BC to transmit on channel.

3.3.3.1 Status Word

The Status Word is stored as a part of the operation of the BCI-1553. The Status Word should not be confused with the Command Word that is defined by the MIL-STD-1553 protocol. The Status Word serves to provide information on the data that has been transacted between a bus controller and the target remote terminal. See *Appendix B: Status Word* for an exact breakdown of each bit definition for the Status Word. This information is typically useful for debugging remote terminal behavior and prototyping.

3.3.4 Release BC (Method)

Releases the configured Bus Controller and sets the BCI-1553 module into a default state. This should be called at the end of the application to restore the BCI-1553 module to a known state. Not calling this function results in the BCI-1553 memory remaining in its last known state. Removing power from the module will also reset the memory to a known state.

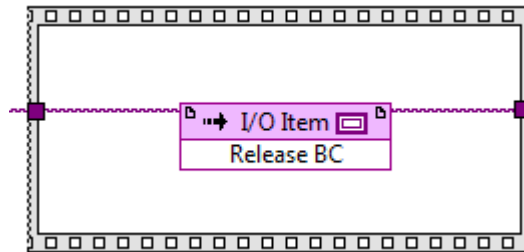


Figure 3-G: Releases a BCI-1553 module into a default state.

3.4 Example Code

The BCI-1553 installer ships with several examples for using the BCI-1553. All of these examples assume the BCI-1553 is in the first slot of a National Instruments 9030 C-Series chassis. All examples can be found in <LabVIEW 2015 Directory>\examples\Bloomy Controls\BCI-1553-BC.

4 Troubleshooting

4.1 Common Scenarios

General		
Issue	Cause	Fix
Power LED does not turn on.	FPGA code is not running on the host C-Series chassis.	When an application is not running on a C-Series FPGA, the chassis holds all modules in a sleep state. Running a simple application can verify proper power is being supplied to the BCI-1553.
	Incorrect power being supplied to the BCI-1553 module.	Make sure that the power supplied to the BCI-1553 module conforms to the details in section 2.1
BCI-1553 module does not transmit.	Incorrect bus termination.	Check that the MIL-STD-1553 bus has been setup properly.
	Module not initialized.	Call the initialize function relevant for the mode of operation the BCI-1553 module is in.
BCI-1553 module is not discoverable in a cRIO chassis	Incorrect or no power being supplied to module.	Make sure that the power supplied to the BCI-1553 module conforms to the details in section 2.1.
	Driver not installed.	Make sure that the BCI-1553 driver is installed on the target machine for the correct version of LabVIEW.
	Module not added to the FPGA of the C-Series chassis.	Make sure that the BCI-1553 module is added as a module to the FPGA resource. The module does not support being added to the chassis, which is a scan-engine interface.
Error 7 Encountered at FPGA compile time	Conflicting driver versions.	<p>This error typically only occurs when two conflicting versions of the BC driver set are present on the same machine. This issue can be avoided completely by uninstalling the original driver BEFORE installing a new version.</p> <p>If encountering this issue, please check that only the latest version of the BC driver has been installed to this location:</p> <pre>..\National Instruments\LabVIEW 2015\Targets\NI\FPGA\cRIO\other\</pre> <p>Delete the 'BCI-1553-BC' directory here and attempt to reinstall the driver.</p>

<p>Error 65221 Encountered at FPGA compile time</p>	<p>Conflicted method node state.</p>	<p>When updating from a previous driver version to a new one, LabVIEW does not immediately detect changes in the API. This results in behavior where method nodes and property nodes can have incorrect data wired to them, or indicators wired to input terminals, etc...</p> <p>To resolve this, replace the BCI-1553-BC device node on the block diagram and reselect all affected methods. The methods can be selected by clicking on the method node and selecting the same method name (or the equivalent) from the dropdown list. Once this selection is made, you should be able to detect the error by a broken run arrow.</p>
<p>Module does not appear to perform any methods or properties properly.</p>	<p>Conflicting operating mode.</p>	<p>The vast majority of BCI-1553 modules are shipped in the Remote Terminal operating mode and must be transitioned to the target operating mode.</p> <p>To do this, verify the current operating mode of the module by using auto-discovery in your LabVIEW project. Once the current operating mode has been determined, use the driver for that operating mode to transition the module to the desired operating mode. Verify the module transitioned mode as intended by using auto-discovery in the LabVIEW project again.</p>

5 Appendix A: API Summary

Bus Controller (<i>Bold = Output</i>)			
Function	I/O	I/O Data Type	Description Section
Initialize BC	Void	Null	Section 3.3.1
Receive	Bus Channel	U16	Section 3.3.2
	RT Address (0-30)	U8	
	SubAddress (1-30)	U8	
	Word Count (1-32)	U8	
	Data	[U16]*32	
Transmit	Bus Channel	U16	Section 3.3.3
	RT Address (0-30)	U8	
	SubAddress (1-30)	U8	
	Word Count (1-32)	U8	
	Data	[U16]*34	
Release BC	Void	Null	Section 3.3.4

6 Appendix B: Status Word

The Status Word is used by the BCI-1553 to provide details and debug information on data received by the remote terminal of interest. It is not the same as the Command Word that is defined by the MIL-STD-1553 protocol. Each bit in the Status Word serves to flag a certain type of failure in received data. In the case of receive data failure, the Status Word will be set and no data will be received. If there is no failure in the receive command, all data will be received and the Status Word will have a value of x8000. The table below describes the various flags and bit definitions in the Status Word. All flags are active high.

Status Word Bit Assignment		
Bit(s)	Name	Description
15	EOM	Set active at the end of data transmission between the Bus Controller and the Remote Terminal.
14	SOM	Set active when message transaction begins. Does not apply to this driver version.
13	Bus ID	Set active when transmitting on Bus B. Set inactive when transmitting on Bus A.
12	MBCE	Does not apply to this driver version.
11	STATSET	Does not apply to this driver version.
10	Format Error	Set active when the target remote terminal violates MIL-STD-1553 message validation criteria.
9	No Response Timeout Error	Set active when the target remote terminal does not respond within the requisite deadline.
8	Loopback Error	Does not apply to this driver version.
7	MSTATSET	Does not apply to this driver version.
6-5	Retry Count	These various bits will drive active based on the number of retries required (up to 2) to perform a transaction successfully with the target remote terminal. -If both bits are inactive: no retries were required. -If only bit 5 is active: 1 retry was required. -If only bit 6 is active: 2 retries were required. -If both bits are active: NULL
4	Good Transmit Data Block	Set active upon the successful completion of an error-free transmit between the target remote terminal and the bus controller. A receive transmission or any unsuccessful transmission will for this bit inactive.
3	Wrong RT Address	Set active when the target remote terminal has an incorrect RT address in the returned status word.
2	Word Count (Length) Error	Set active when a transmit command occurs with an incorrect number of data words.
1	Sync Error	Set active when there is an error in synchronization between the bus controller and the target remote terminal.
0	Invalid Word Error	Set active when a remote terminal response exhibits one of the following errors: sync encoding error, Manchester II encoding error, bit count error, parity error.

7 Appendix C: FPGA Utilization

Below are the typical results of using the entire API for a single BCI-1553 module in the Bus Controller operating mode. These results may vary based on the optimizations used when compiling FPGA code with the BCI-1553 module present. When using multiple BCI-1553 modules in a single cRIO chassis, it is expected that FPGA utilization will increase linearly, assuming full API usage.

Just having the module present in a LabVIEW project will result in a baseline impact on FPGA utilization (approx. 50% of the below estimates). For any FPGA applications not using the BCI-1553, it is strongly suggested to make sure it is removed from the LabVIEW project before compiling FPGA applications.

Remote Terminal			
FPGA Component	Number Used	% Utilized Kintex 7 70T FPGA	% Utilized Kintex 7 160T FPGA
Total Slices	2850	27.8	11.4
Slice Registers	9463	11.5	4.7
Slice LUTs	8192	20.0	8.1
Block RAMs	3	2.2	0.9
DSP48s	0	0	0