ENDCAP Alignment

CMS CCD OPTICAL POSITION SENSOR
INTERFACE BOARD

User's Manual

FNAL – PNPI
2003

Contents

1. Introduction

The DCOPS interface boards provide the following features for each chamber layer:
- Low voltage distribution between other interface boards (periphery link),
- Low voltage distribution to a group of the readout board (radial link),
- RS-422 / LVDS interface for DAQ (both periphery and radial links),
- RS-422 / LVDS interface for JTAG (both periphery and radial links),
- Test Access Port (TAP) control.

Intended for the work with long cables the interface boards perform the conditioning of signals.

To understand purpose of the interface boards it is necessary to issue from a general organization of the DCOPS readout subsystem. Its structure for the ME2 chamber layer is shown in Fig. 1. Other subsystems contain various numbers of elements, but they are similar to this one. Communication of the layer subsystem is realized by means of a hub connected to a host with an optical Ethernet. On the other hand, the hub has eight ports programmed for RS-422 serial protocol. As it seen from Fig. 1, the first interface board has a connection with the RS-422 hub ports while all others are connected together through the LVDS serial links. In addition, the first interface board only contains the TAP controller; others pass LVDS/JTAG signals through. Thus, the first interface board differs from others.

The interface board provides two links for the readout boards: a data acquisition (DAQ) link and a JTAG link for in-system programming of CPLDs. The DAQ link (see Fig. 2) supplies all readout boards connected to it with host commands. These commands are translated also to the next interface boards with their readout boards. A group control is achieved by such way. The only readout board can be active in the same time, so this single board can transfer data to the host. No arbitrary is required. The interface boards transfer data from the active readout board to the host. Really, all transferred to the host data are mixed with OR; error do not occur due to a single source of data.

The JTAG link contains four signal wires: Test Mode Select (TMS), Test Clock (TCK), Test Data In (TDI), and Test Data Out (TDO). The TMS and TCK signals are transferred to all readout boards like a command in DAQ link The TDI and TDO signals form a daisy chain, as it shown in Fig. 3. The last TDO signal returns to the host through all interface boards. To provide a return of TDO to the host the last interface board should differ form others.

Thus, three kinds of the interface boards should exist: the first one (# 1), middle (# 2 – 5), and the last (# 6). All these kinds of the interface boards are shown in Fig. 4 – 6.
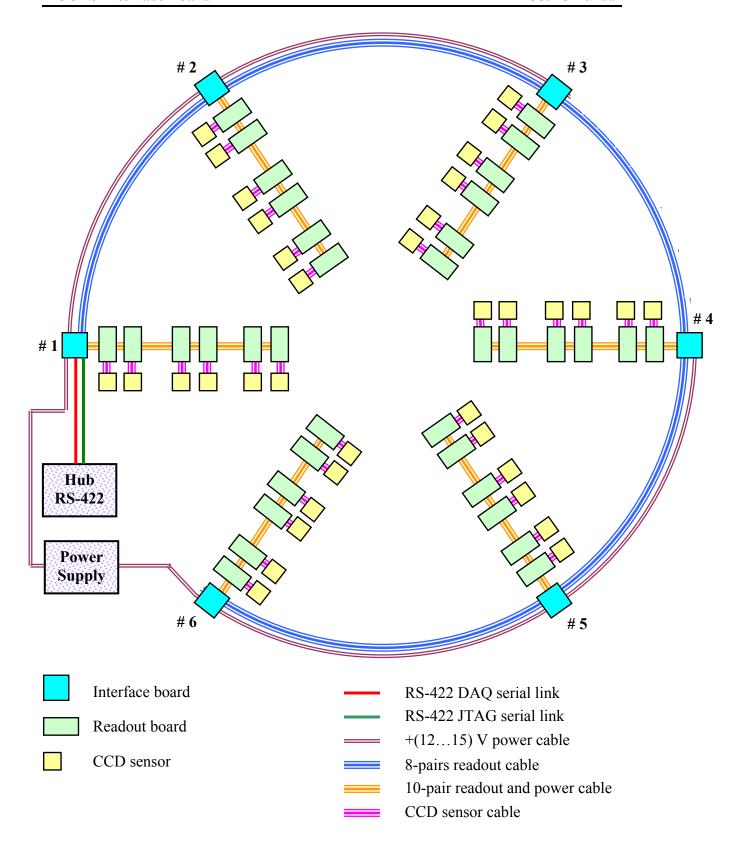
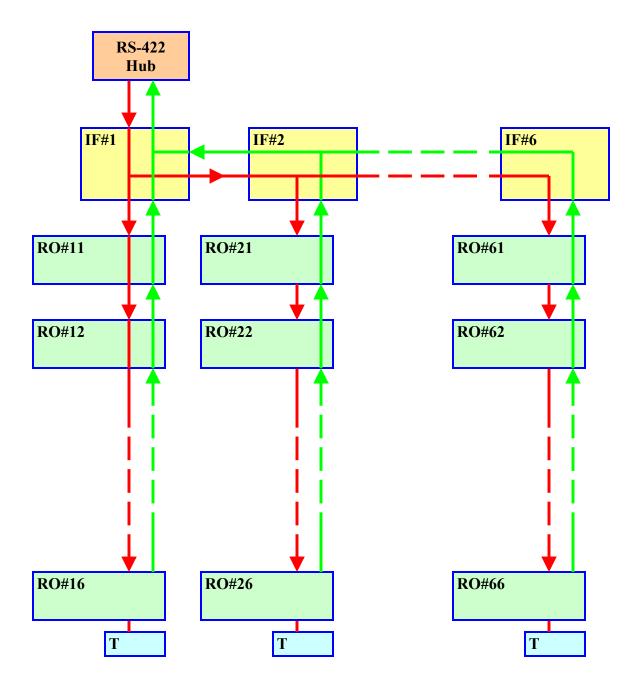Fig. 1. Diagram of the ME2 DCOPS subsystem

Fig. 2. Diagram of Control and Data acquisition

The interface board has no own address. It is transparent for all commands addressed to the readout boards and does not decode them. A separate serial port is used for JTAG only. TAP controller realized in a microcontroller generates a sequence of signals in accordance to host commands.
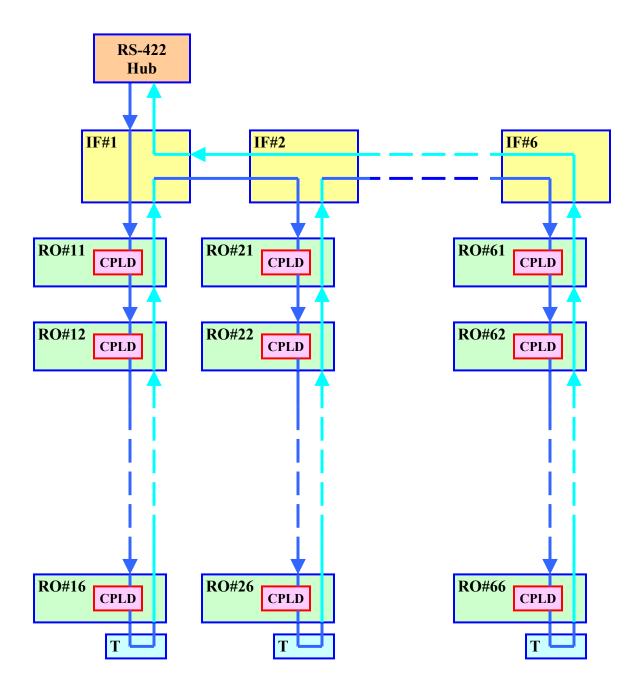
Fig.3. Diagram of Verification and Downloading of CPLDs

The interface board has one programmed component (MSP430F112I microcontroller) that **must** be programmed before using it. The microcontroller is mounted to the printed circuit board; it can be programmed through the input connector J3.

2. Construction

To decrease a cost all three kinds of the interface boards are realized at the same printed circuit board with a selective assembly. There are four rectangular areas on the board marked as:

- Install on the board # 1 only

  It contains RS-422/CMOS interface with J1, J2 serial port connectors and the TAP controller with J3 connector for download.

- Do not install on the board # 1

  It contains LVDS/CMOS interface.

- Install on the board # 6 only

  It contains RS-422/CMOS interface with J8 connector and TAP controller for JTAG.

- Do not install on the board # 6

  It contains two resistors only: R17 (22k ohm) pulls up RXN signal from the non-existing next board to high level, and R18 (1.0 ohm) connects TDI and TDO lines to provide a return path for TDO.

All other components must be assembled on all kinds of the boards.

There are eight connectors on the board (not all of them are assembled):

J1 – DAQ serial port, marked as "DAQ",
J2 – JTAG serial port, marked as "JTAG",
J3 – Download port for the microcontroller,
J4, J5 – Power distribution connectors,
J6 – input data exchange connector (upstream), marked as "Previous IFB",
J7 – readout data exchange connector, marked as "Readout board",
J8 – output data exchange connector (downstream), marked as "Next IFB",
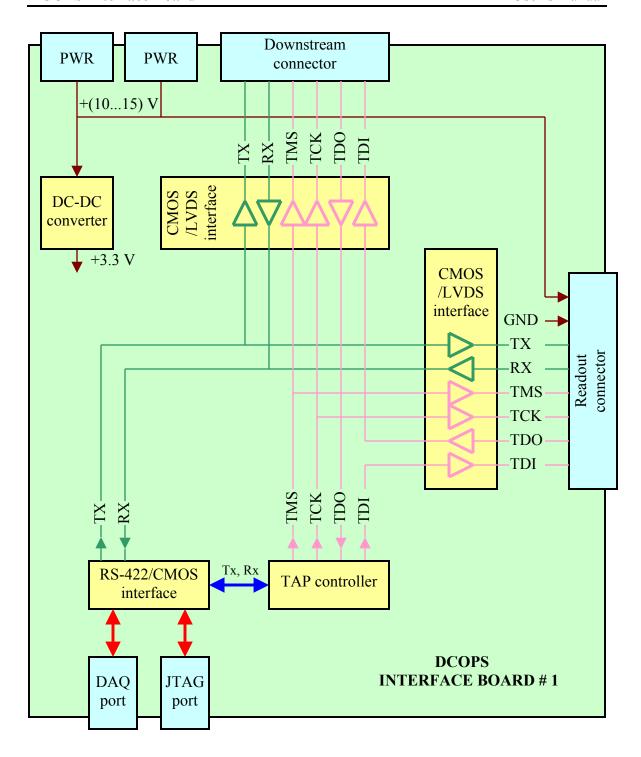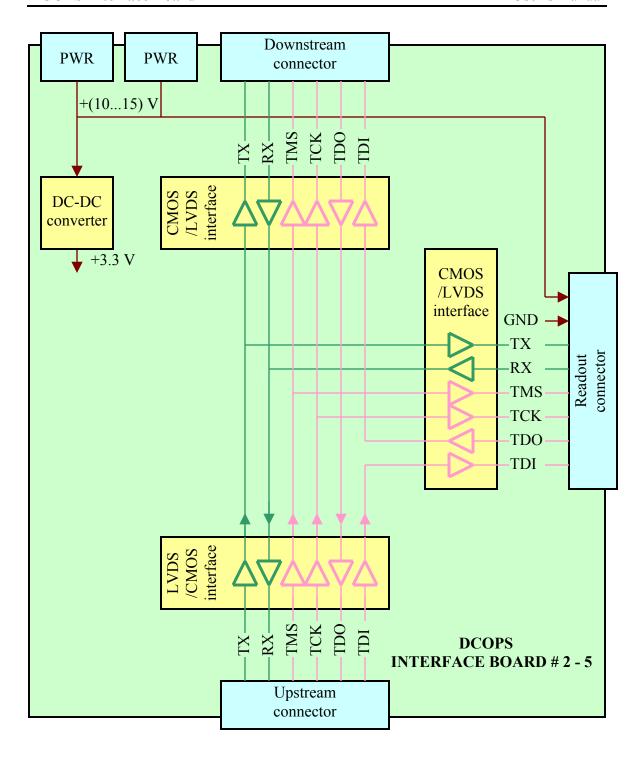
Fig. 4. Diagram of the DCOPS interface board # 1
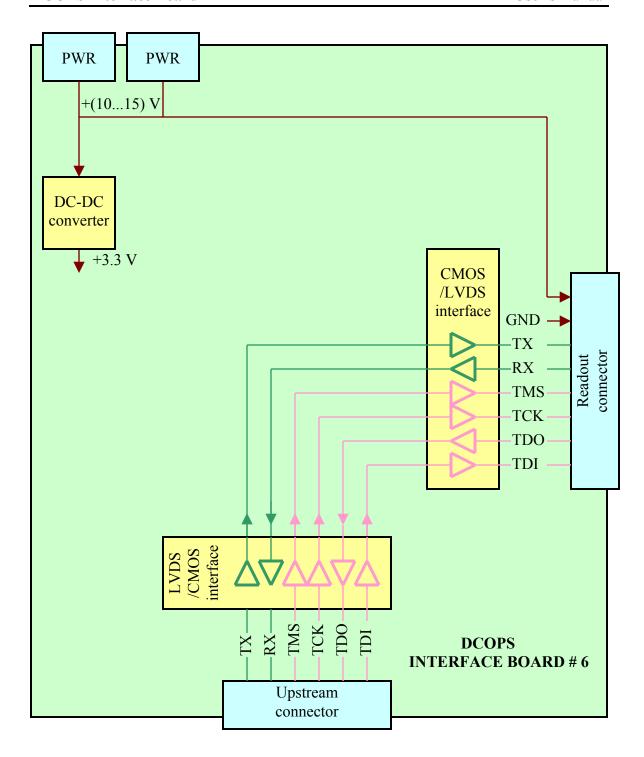
Fig. 5. Diagram of the DCOPS interface boards # 2 – 5

Fig. 6. Diagram of the DCOPS interface board # 6

3. Circuit Diagram

The interface board consists of the following basic parts:
  ◊ RS-422/CMOS interface (see Fig. 3)
  ◊ LVDS/CMOS interface (see Fig. 4, 5)
  ◊ One or two CMOS/LVDS interfaces (see Fig. 3 - 5)
  ◊ TAP controller (see Fig. 3)
  ◊ DC-DC converter

RS-422/CMOS interface (see scheme, page 1) provides RS-422/CMOS and reverse level conversion for DAQ (U1) and JTAG (U2) operations. A connection with a host (hub) is realized through RJ11 connectors J1, J2. This circuitry is used at the interface board # 1 only. All others operate with LVDS signals.

LVDS/CMOS interface (see scheme, page 1) provides LVDS/CMOS and reverse level conversion for received/transmitted data and JTAG signals. It includes LVDS receivers U5, U7 and LVDS drivers U6. Connector J6 is upstream. Signals from the RS-422/CMOS and LVDS/CMOS interfaces are mixed with wired OR. Outputs of the U1 and U5 do not permit wired OR, therefore only one of these interfaces can present on the board.

CMOS/LVDS interface (see scheme, page 2) translates signals to the readout board through U9, U11 drivers, U10 receivers, and J7 connector. Another branch of the CMOS/LVDS interface translate the same transmitted signals apart from TDI to the next interface board through U12, U14 drivers, U13 receivers and J8 connector. TDI and TDO signals form a daisy chain as shown in Fig. 2. Data received from the readout boards and the next interface board are mixed with OR at U8. There is now collision due to the only readout board can transfer data at the same time. The interface board #6 has a pull up resistor R17 to enable data flow through U8 because U13 receiver is absent.

TAP controller (see scheme, page 1) is implemented into the MSP430F112I microcontroller (U3). It provides CPLDs arranged on the readout boards with JTAG signals in accordance with data and commands coming from the port J2. JTAG signals include TMS (Test Mode Select), TCK (Test Clock), TDI (Test Data In), and TDO (Test Data Out). The TAP controller passes input data TDI to the CPLDs and receives from them output data TDO. The TMS signal is used to select a certain register inside of the CPLD as shown in Fig. 7. The TAP controller changes the TMS signal in accordance with commands from a host. Both data and command always contain two bytes; the first byte defines is it command or data. The TAP controller produces the clock signal TCK also.

DC-DC converter (see scheme, page 1) provides +3.3V to supply digital circuitry on the board. It uses the LTC1474 step-down converter U4. Using an air core inductor permits it to work in a strong magnetic field. The converter is switched on always.
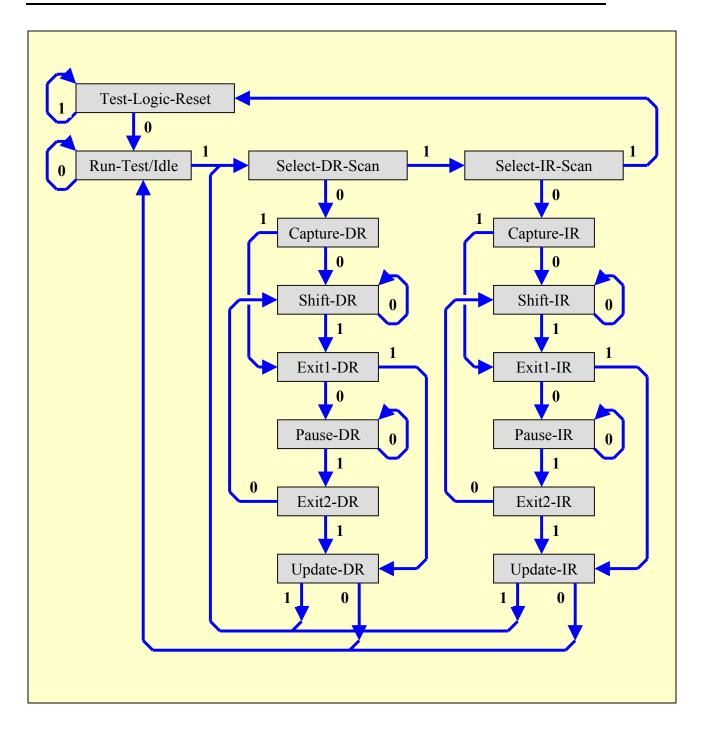
Fig. 7. Diagram of the TAP controller states

4. Application Note

Turn off power before connecting or disconnecting any cable apart from serial ones at J1 and J2 jacks.

5. Functioning

The DCOPS interface board is a passive transparent device for a host. It has no control and passes commands and data through itself in any direction.

The DAQ commands arrive from jack J1 and transceiver U1 (at the board # 1) or from connector J6 and receiver U5A (at the other boards) to connectors J7 and J8 through drivers U9B and U12B respectively. The board # 6 does not contain the connector J8 and associated with it circuitry.

Data from the readout boards connected to the current interface board arrive from the connector J7 and receiver U10A. Data from the readout boards connected to the next interface board arrive from the connector J8 and receiver U13A. These data are mixed by OR for negative signals. There is no conflict due to the only readout board can transfer data at the same time. Data are transferred to the host directly through the transceiver U1 and jack J1 if this interface board has # 1. Otherwise, data are transferred to the upstream connector J6 through the driver U6B.

The TMS and TCK signals from the TAP controller (or from the upstream connector J6) translated both to the connector J7 and to the downstream connector J8. The TDI signal is directed to the connector J7 only in accordance with Fig. 3. The TDO output of the nearest readout board is used as TDI for the downstream connector J8 forming a daisy chain for subsystem in whole. The TDI signal from the downstream connector is translated to the upstream connector J6 as TDO closing a daisy chain.

6. Microcontroller Programming

Necessary equipment:

o Computer running under Windows (9x, NT, 2000)
o MSP430 serial download cable
o Power cable for JTAG adapter
o 10 – 15 V power supply
o Digital voltmeter

Software to be used:

o MSP430 Programmer application

Warning:
   Before programming of the microcontroller, check +3.3V on the board.

Connect the MSP430 serial download cable to the serial port of a computer and to a power supply. Connect an output connector of the download cable to the J3 connector of

the interface board, as shown in Fig. 8. Switch on a power and check presence of +3.3V voltage on the readout board.

Run MSP430 Programmer application (see Fig. 9). Load the file JTAG.s43, select serial port connected to the download cable, and select baud rate 9600 bps. Then select a mode "Program".
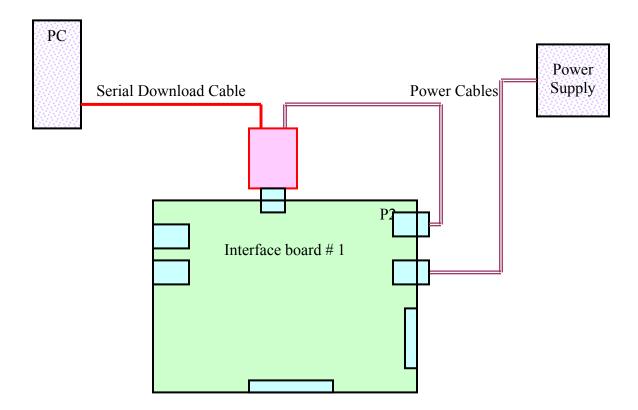

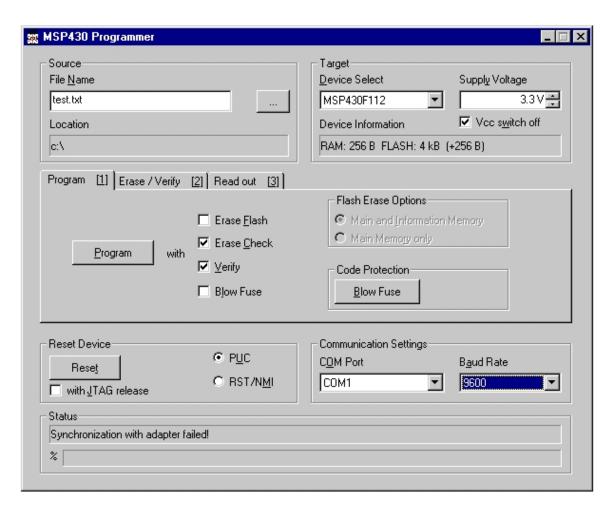Fig. 8. Programming of the microcontroller MSP430F112I

Fig. 9. MSP430 Programmer window

7. Debugging and Testing

Necessary equipment:

- o Computer running under Windows (9x, NT, 2000)
- o RS-232/RS-422 adapter
- o Interface board #1
- o Reference readout board
- o RS-232 serial link DB9/DB9 cable
- o RS-422 serial link RJ11/RJ11 cable
- o Power cable for RS-232/RS-422 adapter
- o Power cable for the interface board
- o Three 20-conductor ribbon cables for connection of the readout board to the interface board, reference sensor, and reference readout board
- o 10 – 15 V power supply
- o Digital voltmeter

Software to be used:
- o Hyper Terminal application

Properly manufactured readout boards do not require any adjustments. They should work at once after programming of the CPLD and flash memory. This procedure is planned for the worst case. If you have any problem, it is recommended to perform all operations sequentially. The Quick-Fit male terminal P4 can be used as a ground pin during measurements.

1. Check the assembled board visually. It must not have visible damages. All components and their values must be in accordance with documents.

2. Program the microcontroller as described in a chapter 6.

3. Connect the reference readout board to the tested interface board as shown in Fig. 10 and switch on power. Check +3.3V output voltage of the DC-DC converter.

4. Run Hyper Terminal application and configure the serial port COM1 as 8N1 with 115,200 bps baud rate.

5. Turn on power; input the board number followed by "Enter". You should receive a prompt containing the board number as a response. If response is not received, try once more in the following sequence: "Enter", the board number, "Enter" (you could input illegal character). If response is not received again, see chapter 8.

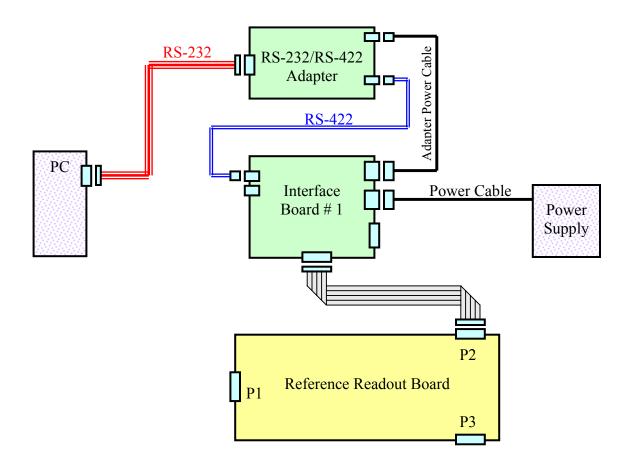**Warning:**   **All reconnections must be performed with power turned OFF**

Fig. 10. Diagram of connections

8. Troubleshooting and Maintenance

Necessary equipment:
- o Computer running under Windows (9x, NT, 2000)
- o RS-232/RS-422 adapter
- o Interface board #1
- o Reference interface board
- o Reference readout board
- o RS-232 serial link DB9/DB9 cable
- o RS-422 serial link RJ11/RJ11 cable
- o Power cable for RS-232/RS-422 adapter
- o Power cable for the interface board
- o 20-conductor ribbon cable for connection of the readout board to the interface board
- o 16-conductor ribbon cable for connection to the reference interface board
- o 10 – 15 V power supply
- o Digital voltmeter
- o Oscilloscope

Software to be used:
- o Hyper Terminal application

Warning: All reconnections must be performed with power turned OFF

1. **Output voltage of the +3.3V DC-DC converter is wrong.**

   - Check an input voltage; it must be 10 to 15 V.
   - Check soldering points.
   - Check values of the R45 and R46 resistors.
   - Check polarity of the V3 diode (a silver band marks a **negative** pad).
   - Check polarity of the C11 and C17 tantalum capacitors (a white band marks a **positive** pad).
   - If the previous checks do not discover a reason of failure, replace the U17 LTC1474 integrated circuit.

2. **There is no communication with the readout board connected to J7**

   - Connect the reference readout board to the readout connector J7.
   - Set the reference readout board number to **0**, press the **Reset** button. The readout board produces the continuous prompt until any key pressed.
   - Follow TX signal from the J7 connector to the J1 or J6 connector.
   - Replace found invalid components.
   - If the previous test has no result, check RX signal.
   - Set the reference readout board number to **1**, press the **Reset** button.
   - Press and hold key "1" on a keyboard.
   - Follow RX signal from the J1 or J6 connector to the J7 connector.

- Replace found invalid components.

3. There is no communication with the readout board connected to J8 through the reference interface board

- Connect the reference readout board to the readout connector J7 of the reference interface board.
- Connect the reference interface board to the downstream connector J8 of the board under test.
- Set the reference readout board number to **0**, press the **Reset** button. The readout board produces the continuous prompt until any key pressed.
- Follow TX signal from the J8 connector to the J1 or J6 connector.
- Replace found invalid components.
- If the previous test has no result, check RX signal.
- Set the reference readout board number to **1**, press the **Reset** button.
- Press and hold key "1" on a keyboard.
- Follow RX signal from the J1 or J6 connector to the J8 connector.
- Replace found invalid components.

9.   Specification

General

Dimensions of the board	6.7" x 2.9"
DAQ serial port connector J1	Modular jack 6-4 Tyco 555979-1
JTAG serial port connector J2	Modular jack 6-4 Tyco 555979-1
Download port connector J3	5 x 1 single row socket strip
	Mill-Max 801-93-050-10-001 (modified)
Power connectors J4, J5	Molex Sabre 43160-3102
Upstream connector J6	8 x 2 header 3M 3408-6002
Readout connector J7	10 x 2 header 3M 3428-6002
Downstream connector J8	8 x 2 header 3M 3408-6002

Power characteristics

Minimum input voltage	+10 V
Maximum input voltage	+15 V
Power consumption	150 mW @ 15.0 V
On board power protection:	
Fuse	0.5 A
DC-DC converter limits its output current	
Output current threshold	0.4 A

Communication features

Protocol	asynchronous serial
Transfer format	8N1 (8 bits, Non-parity, 1 stop bit)
Signal levels	LVDS
Baud rate	115,200 bps
Termination	118 Ohm

Specification of connectors

J1 (Serial Port 1 - DAQ)

Pin	Net
1	GND
2	TX
3	RX
4	GND

J2 (Serial Port 2 - JTAG)

Pin	Net
1	GND
2	TX
3	RX
4	GND

J3 (Download Port)

Pin	Net
1	GND
2	TEST
3	0RST
4	RCV
5	TRF

J4 (Power Input)

Pin	Net
1	+12V
2	GND

J5 (Power Output)

Pin	Net
1	+12V
2	GND

J6 (Previous IFB)

Pin	Net	Net	Pin
1	TCK+	TCK-	2
3	TDO+	TDO-	4
5	TMS+	TMS-	6
7		GND	8
9	TDI+	TDI-	10
11	GND	GND	12
13	RX+	RX-	14
15	TX+	TX-	16
17	GND	GND	18
19	+12V	+12V	20

J8 (Next IFB)

Pin	Net	Net	Pin
1	TCK+	TCK-	2
3	TDI+	TDI-	4
5	TMS+	TMS-	6
7		GND	8
9	TDO+	TDO-	10
11	GND	GND	12
13	TX+	TX-	14
15	RX+	RX-	16
17	GND	GND	18
19	+12V	+12V	20

J7 (Radial Readout Link)

Pin	Net	Net	Pin
1	TCK+	TCK-	2
3	TDO+	TDO-	4
5	TMS+	TMS-	6
7		GND	8
9	TDI+	TDI-	10
11	GND	GND	12
13	TX+	TX-	14
15	RX+	RX-	16
17	GND	GND	18
19	+12V	+12V	20