Polarized Target Digital Controls

July 22, 2001

1 Introduction

Many of the devices used to operate the target require and/or generate digital (TTL) signals for control and readback. Most of these devices are capable of remote control via a computer interface. To provide this interface, we have chosen the National Instruments PCI-DIO-96 card, a 96-channel TTL-level device. Banks of channels on the card may be configured for input or output, in groups of 8 channels at a time. The connector on the back of the card is a 100-pin HDB-style male connector. Typically, a National Instruments cable (CB100-5050) is used to break these 100 lines onto two 50-pin ribbon cables with 0.1 inch polarized header connectors.

Since there are several devices that need to connect to the DIO card, an interface box was constructed to allow proper distribution of the signals. This document will describe the construction of this box, and discuss the control interfaces provided by each of the devices connected to it.

2 DIO Interface Box

This unit serves as a distribution point from the DIO card to the various devices controlled and read by it. The front of the box contains indicator lights to display some of the settings controlled by the DIO card, while the back of the box contains connectors for cables to the computer and to the various other devices.

The DIO Interface Box requires power to illuminate the LED indicators, but not to pass most of the control signals to the other devices. An exception would be the reed relays used to select QMeters. These devices do not require a TTL signal, but rather a relay closure. These relays are located inside the DIO Interface Box, and run off its power supply.

The DIO Interface Box is designed to operate with a DIO-96 card, or other digital interface card that connects via a polarized 50-pin ribbon cable. Inside, a breakout board is used to provide screw terminals for ease of connection.

It is important to note that the numbering scheme for the channels of the DIO-96 card does not follow the numbering scheme for the pin numbers of the ribbon cable. Thus, the numbers next to the screw terminals unfortunately do not reflect the channel numbers of the DIO card. Table 1, below, shows the channel assignments. Pin 50 is ground and Pin 49 is +5V. Channels 0 to 23 are mapped to the odd-numbered pins from 47 to 1, with Pin 47 being Channel 0, and Pin 1 being Channel 23. Channels 24 to 47 are mapped to the even-numbered pins from 48 to 2, with Pin 48 being Channel 24, and Pin 2 being Channel 47.

Table 2 shows the connectors that are provided on the back of the DIO Interface Box. For each controlled device, the connector on the back of the box is the same style and gender as on the back of that device. In this way cables can be made that are wired "straight through" (pin 1 to pin 1, etc.) and also that are reversible (either end can connect to the interface box or to the device - it's impossible to put the cable on backwards).

The following sections will describe the interfaces to the various devices controlled by the DIO Interface Box.

3 QMeters and Yale Cards

The QMeters used in the NMR system are fitted with a reed switch that disables their RF output by shorting it through a 50 ohm load to ground. To prevent spurious signals from interfering with the NMR measurement, all QMeters except the one being used should be disabled. This is accomplished by shorting two pins of a DB25 connector together for each QMeter to be disabled. An LED on each QMeter will illuminate to indicate that it is disabled.

The Yale amplifier cards connect to the QMeters and provide amplification of the NMR signal to improve the signal-to-noise ratio of the system. They also allow the subtraction of up to 3 volts from the NMR signal through adjustment of the bias on an operational amplifier on the card.

Chan 23 (APC7)	1	2	Chan 47 (BPC7)
Chan 22 (APC6)	3	4	Chan 46 (BPC6)
Chan 21 (APC5)	5	6	Chan 45 (BPC5)
Chan 20 (APC4)	7	8	Chan 44 (BPC4)
Chan 19 (APC3)	9	10	Chan 43 (BPC3)
Chan 18 (APC2)	11	12	Chan 42 (BPC2)
Chan 17 (APC1)	13	14	Chan 41 (BPC1)
Chan 16 (APC0)	15	16	Chan 40 (BPC0)
Chan 15 (APB7)	17	18	Chan 39 (BPB7)
Chan 14 (APB6)	19	20	Chan 38 (BPB6)
Chan 13 (APB5)	21	22	Chan 37 (BPB5)
Chan 12 (APB4)	23	24	Chan 36 (BPB4)
Chan 11 (APB3)	25	26	Chan 35 (BPB3)
Chan 10 (APB2)	27	28	Chan 34 (BPB2)
Chan 09 (APB1)	29	30	Chan 33 (BPB1)
Chan 08 (APB0)	31	32	Chan 32 (BPB0)
Chan 07 (APA7)	33	34	Chan 31 (BPA7)
Chan 06 (APA6)	35	36	Chan 30 (BPA6)
Chan 05 (APA5)	37	38	Chan 29 (BPA5)
Chan 04 (APA4)	39	40	Chan 28 (BPA4)
Chan 03 (APA3)	41	42	Chan 27 (BPA3)
Chan 02 (APA2)	43	44	Chan 26 (BPA2)
Chan 01 (APA1)	45	46	Chan 25 (BPA1)
Chan 00 (APA0)	47	48	Chan 24 (BPA0)
+5V DC	49	50	GND

Table 1: Pinout for Channels 0 to 47 of the DIO-96 card

Device	Connector
Shim Heater	4x BNC
QMeter Reed Relays & Yale Card	DB25M
Microwave Bellows and Switch	MS3120E16-26s
Target Mover	MS3120E14-19s
Microwave Attenuator	MS3120E10-6p

Table 2: Connectors on back of the DIO Interface Box

Connector: DB-25M	
Pin	Function
1&14	QMeter 1 Select
2&15	QMeter 2 Select
3&16	QMeter 3 Select
4&17	QMeter 4 Select
5&18	QMeter 5 Select
6&19	QMeter 6 Select
21	DC Convert
22	Ground
23	Gain 20 Select
24	Gain 50 Select
25	Ground

Table 3: Pinout for QMeter & Yale Card Cable

The gain settings on the Yale cards are selected with two TTL signals. These signals activate up to two amplification stages on the card. If both lines are low, both stages are bypassed and a gain of unity is selected. If the first line is high, the first stage is selected, and a gain of 20 is provided. If both lines are high, both stages are selected and the gain is 50. If only the second line is high, but the first is low, the gain is still 1, since the second stage of amplification only feeds off the first.

To set the amount of the DC subtraction, a TTL pulse of greater the 10ms is presented on a third input line. This pulse sets the subtraction equal to the voltage present on the amplifier's input at the time of the pulse. Typically, this pulse is sent at the beginning of an NMR sweep, although it would be more appropriate to trigger it in the middle of the sweep, when the voltage is nearer its middle value.

4 Microwaves

Three aspects of the microwave system are controlled by TTL signals: the adjustment of the bellows tuning motor, the position of the microwave switch, and the position of the microwave attenuator. Since the attenuator was incorporated into the system after the bellows and switch, it is controlled

Connector: MS3120E16-26s	
Pin	Function
A	Ground
B	+12V DC
J	+5V DC
K	Bellows Potentiometer Readback
L	Bellows Direction
M	Bellows Run
N	Microwave Switch, bit 0
P	Microwave Switch, bit 1

Table 4: Pinout for Microwave Bellows & Switch Cable

Connector: MS3120E10-6p	
Pin	Function
A	Ground
B	Direction
C	Run

Table 5: Pinout for Microwave Attenuator Cable

through a separate cable than the other two devices.

The bellows is controlled by two TTL lines. One selects the desired direction of motion - an increase or decrease in the frequency. The other line causes the bellows to move in that direction for as long as the line is high. Many other devices in the system, such as valves and tuning knobs, are controlled in a similar way. The bellows motor has a potentiometer connected to it that allows coarse readback of its position. This is not a TTL signal, and is currently not read by the computer.

The microwave switch has four positions which are selected by decoding a number from 0 to 3 from a two-bit binary number carried on two TTL lines.

The attenuator is controlled in a manner similar to the bellows: one TTL line selects desired direction of rotation - less power or more power - and the other line causes motion in that direction for as long as the line is high.

5 Target Table Mover

The Target Table Mover is an air-powered motor connected to a worm gear that lifts or lowers the table in order to place the various target positions in the beam. Fitted to the motor is a rotational encoder that is read out by serial line. As the table moves, micro-switches are closed to indicate alignment of each of the target positions. At each extreme of the table's travel, two micro-switches indicate that a limit has been reached. The first switch to activate is a soft limit. The table can still be moved if an override button or signal is presented. The second switch to activate is at the absolute limit of the table's travel. If this switch is activated, no further control of the table is possible, and the table must be moved back off this limit manually, with a wrench or by disconnecting the switch.

Control of the table is achieved with three TTL lines. One line moves the table up when low. When high the table does not move. A second line moves the table down when low. The third provides the soft limit override function when low. Indication of the table's position is given either as an encoded position number on three TTL lines or through individual lines which may be connected to LEDs.

To provide an additional test, the TTL outputs for the move up and move down signals are connected to TTL input lines in the DIO Interface Box, so that it may be verified that the motion request is being generated by the computer.

6 Shim Switch Heater

The power supply for the Shim Switch Heater is controlled by two TTL lines and its status is read back by three TTL lines. One line toggles the supply between remote and local modes. A second line requests the heater to turn on or off. For readback, a TTL signal indicates the local or remote status of the device. A second signal indicates if current is flowing through the switch heater, and a third is wired in the DIO Interface Box to the local/remote TTL output for readback purposes.

Connector: MS3120E14-19s	
Pin	Function
A	Ground
B	+5V DC
C	Move Up
D	Override Limit
E	Move Down
F	Hard Up Limit
G	Hard Down Limit
H	Soft Up Limit
J	Soft Down Limit
K	Position 1
L	Position 2
M	Position 3
N	Position 4
P	Position 5
R	Encoded Position, bit 1
S	Encoded Position, bit 0
V	Encoded Position, bit 2

Table 6: Pinout for Target Table Mover Cable

Bit 2 (Pin V)	Bit 1 (Pin R)	Bit 0 (Pin S)	Function
0	0	0	No Position Indicated
0	0	1	Position 1 Indicated
0	1	0	Position 2 Indicated
0	1	1	Position 3 Indicated
1	0	0	Position 4 Indicated
1	0	1	Position 5 Indicated
1	1	0	Soft Up Limit Indicated
1	1	1	Soft Down Limit Indicated

Table 7: Encoded Position Definitions

Connectors: BNC (four)	
Cable	Function
?	Enable Heater
?	Local/Remote
?	Local Sense
?	Heater Confirm

Table 8: Function of Shim Heater Cables

Screw Pos'n	DIO Chan	Function	Device Pin	Screw Pos'n	DIO Chan	Function	Device Pin
49	N/A	+5V DC		50	N/A	GND	
47	0	Shim Enable Heater	?	48	24	Shim Local Sense	?
45	1	Shim Local/Remote	?	46	25	Shim Heater Confirm	?
43	2	QMeter 1 Select	1&14	44	26	Shim Loc/Rem Readback	?
41	3	QMeter 2 Select	2&15	42	27	Mover C1	S
39	4	QMeter 3 Select	3&16	40	28	Mover C2	R
37	5	QMeter 4 Select	4&17	38	29	Mover C3	V
35	6	QMeter 5 Select	5&18	36	30	Mover Up Readback	
33	7	QMeter 6 Select	6&19	34	31	Mover Down Readback	
31	8	Yale Gain 20	23	32	32		
29	9	Yale Gain 50	24	30	33		
27	10	Yale DC Convert	21	28	34		
25	11	Bellows Direction	L	26	35		
23	12	Bellows Run	M	24	36		
21	13	uWave Switch LSB	N	22	37		
19	14	uWave Switch MSB	P	20	38		
17	15	Mover Move Up	C	18	39		
15	16	Mover Move Down	E	16	30		
13	17	Mover Override	D	14	41		
11	18	Attenuator Direction	B	12	42		
9	19	Attenuator Run	C	10	43		
7	10			8	44		
5	21			6	45		
3	22			4	46		
1	23			2	47		

Table 9: Channel Assignments in the DIO Interface Box