LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

S1107539

Technical Note LIGO-T1100458-v1 08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~004~~ S1107539

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

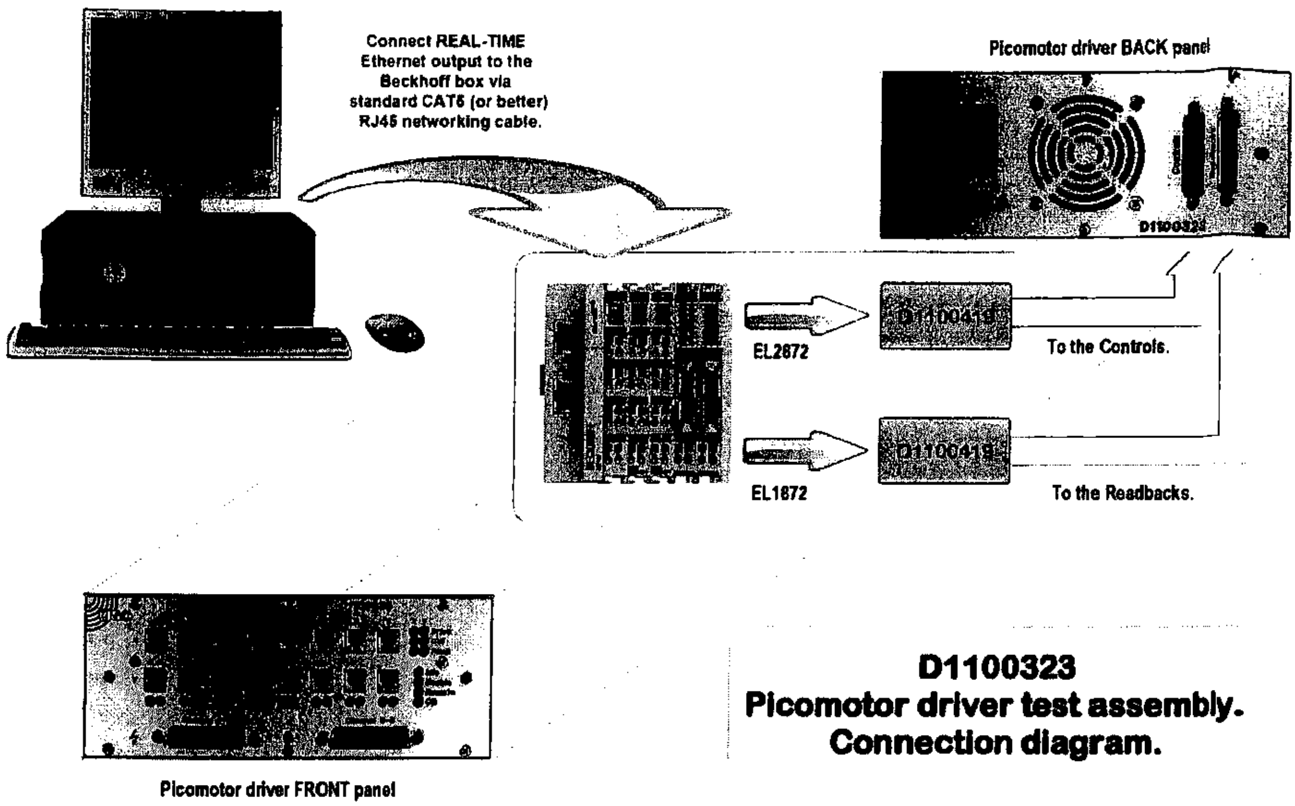
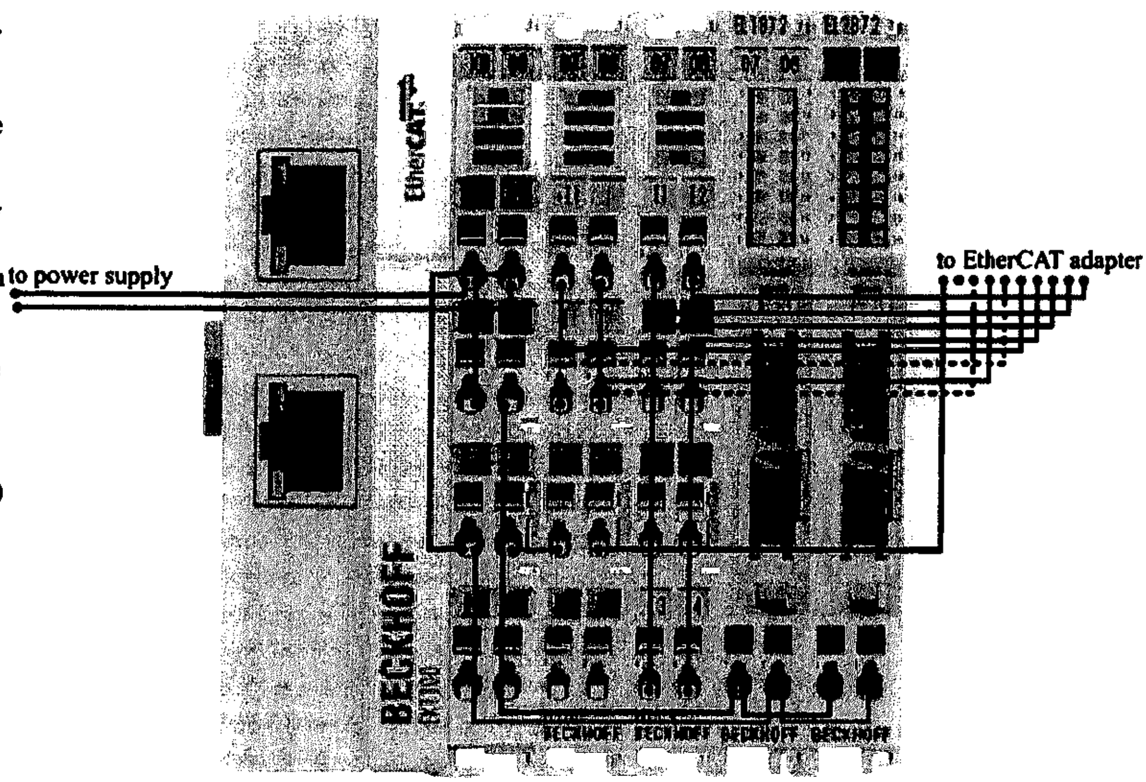


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.03	27.90
2	29.03	28.99
3	30.03	30.12
4	30.96	31.10
5	31.75	32.04
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/23/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

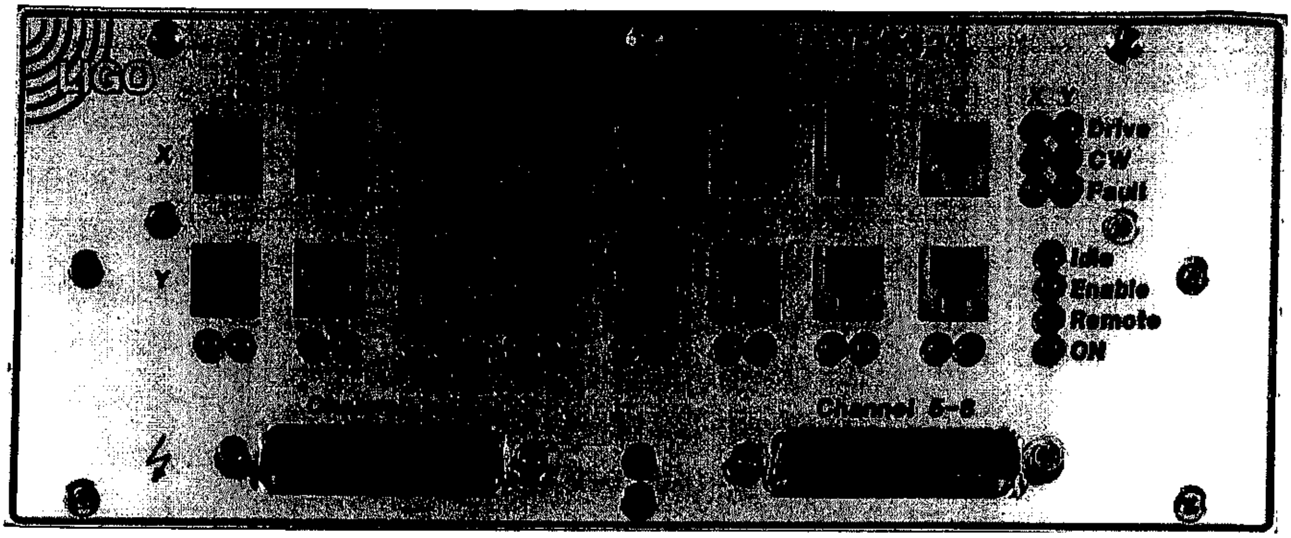


Figure 3: Picomotor driver chassis rear panel

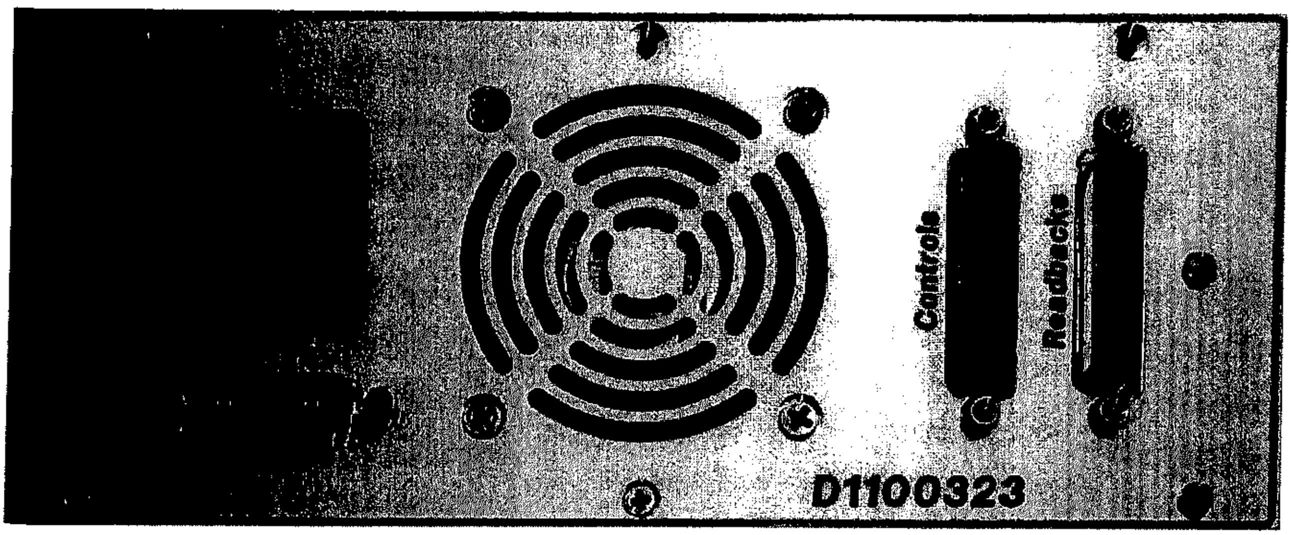
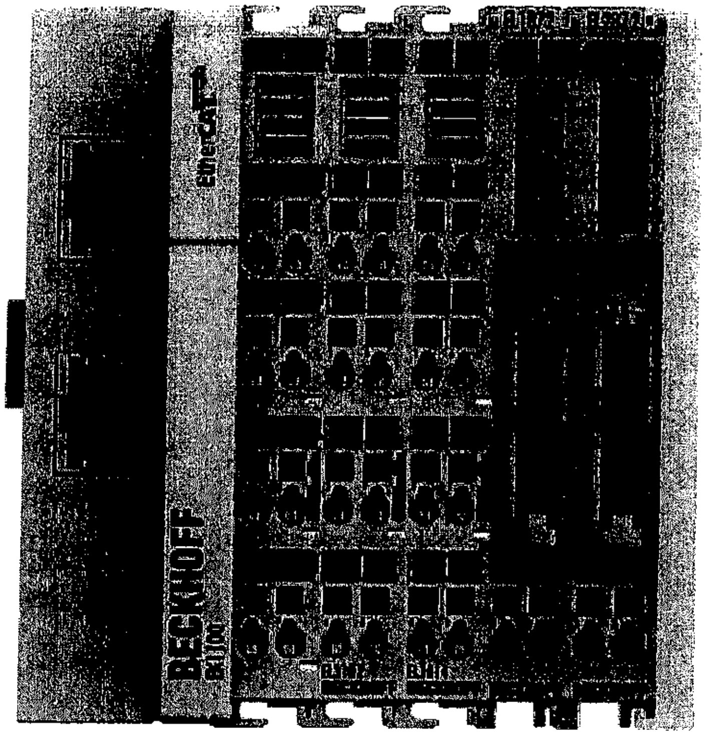


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

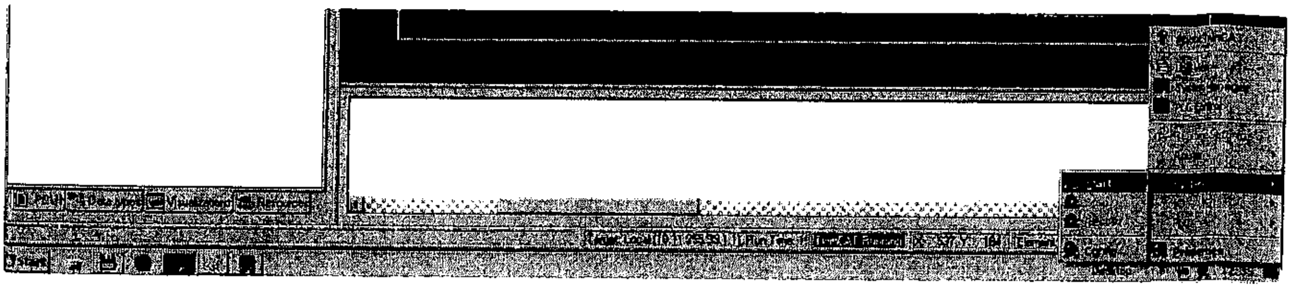
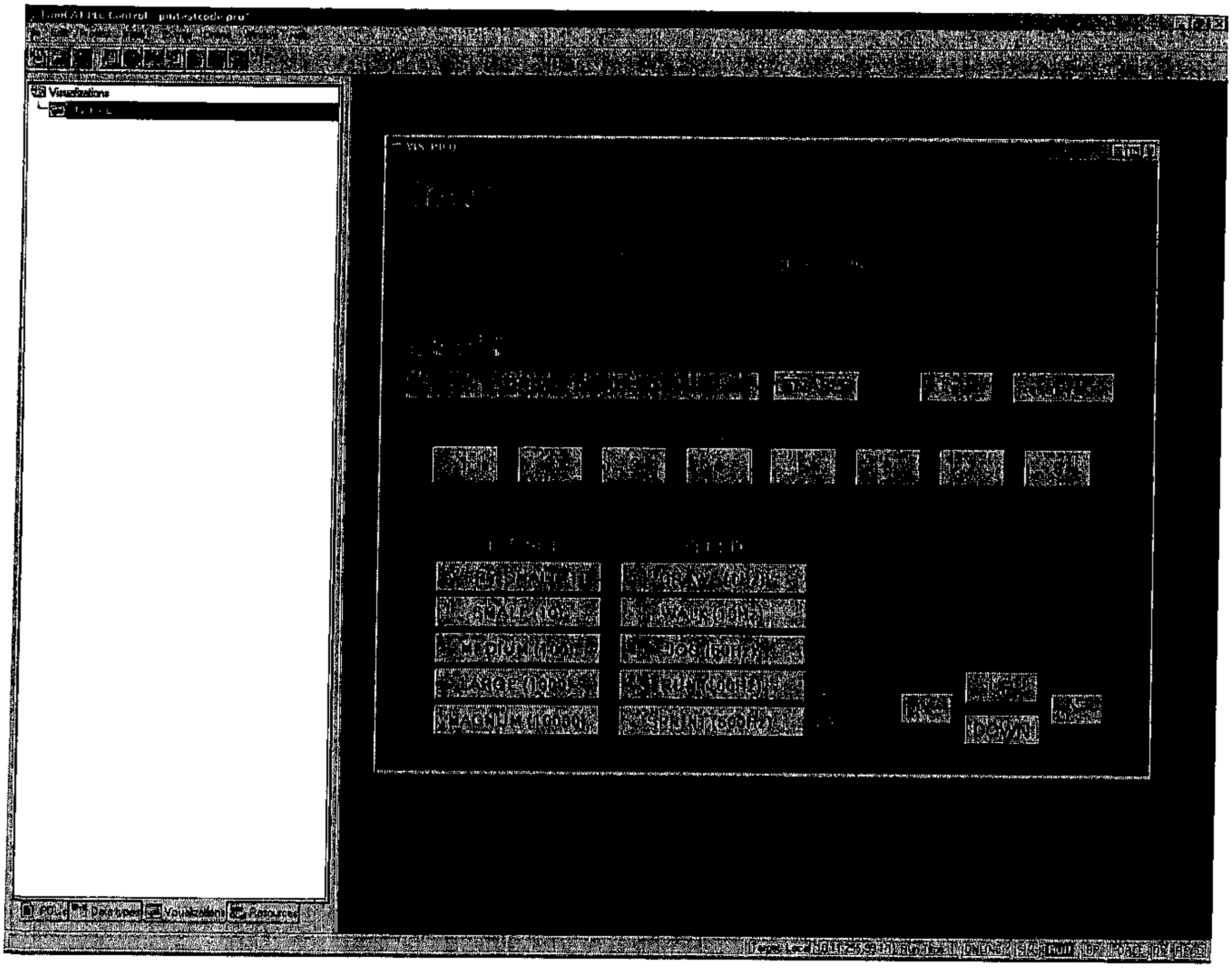


Figure 6: Step 5 of PLC controls setup



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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~[illegible]~~ S/n S1107540

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

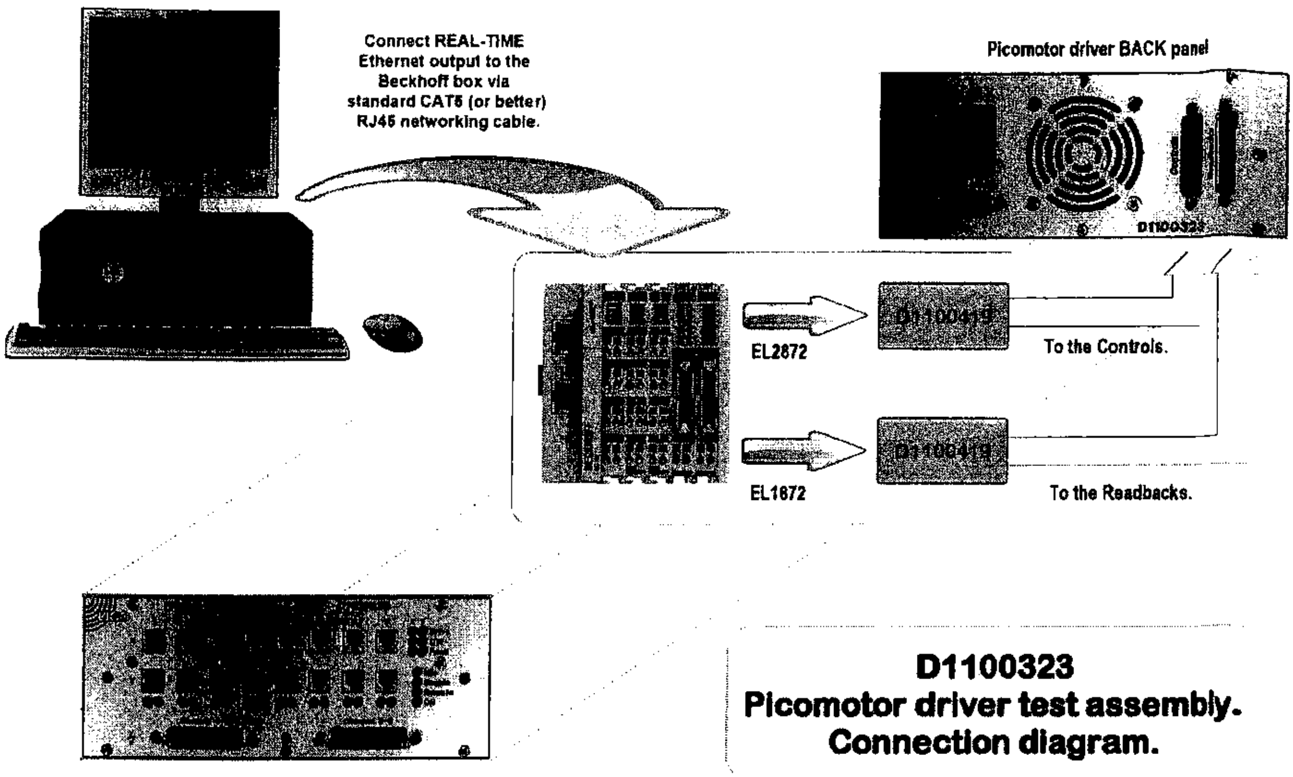
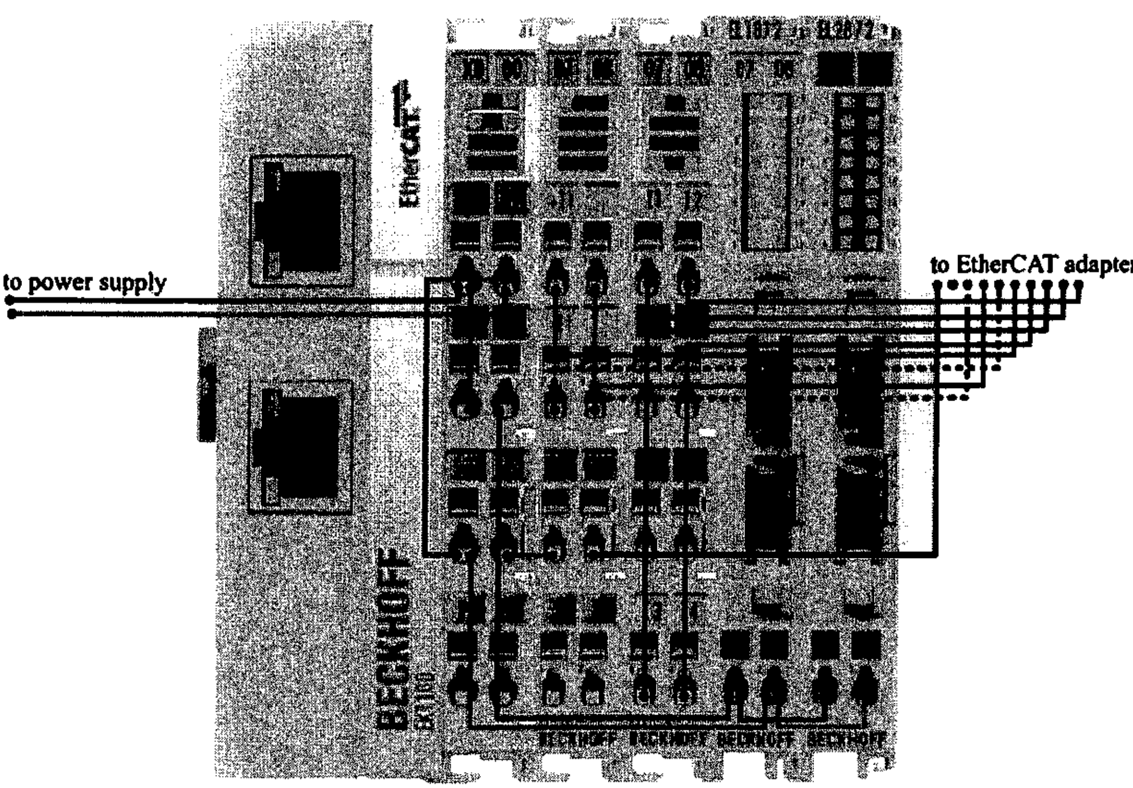


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

<u>**Steps for setting up the PLC controls:**</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓	[✓
MEDIUM (100)	[✓	[✓
MAGNUM (10000)	[✓	[✓

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓	[✓
JOG (50Hz)	[✓	[✓
SPRINT (500Hz)	[✓	[✓

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	30.61	27.32
2	31.76	28.47
3	32.93	29.66
4	33.92	30.72
5	34.90	31.68
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

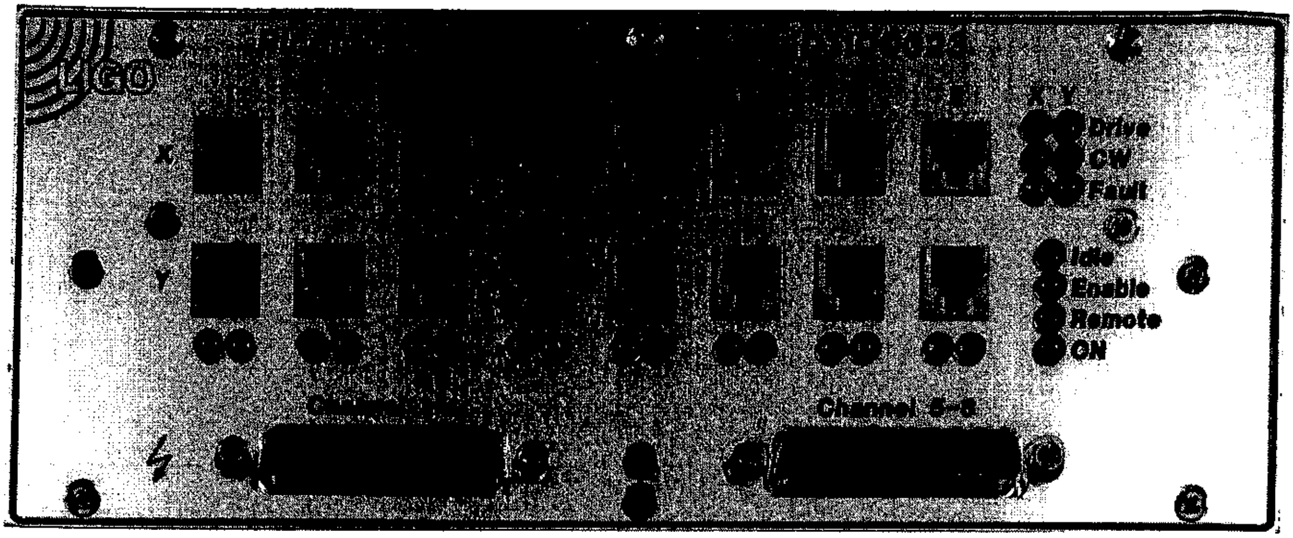


Figure 3: Picomotor driver chassis rear panel

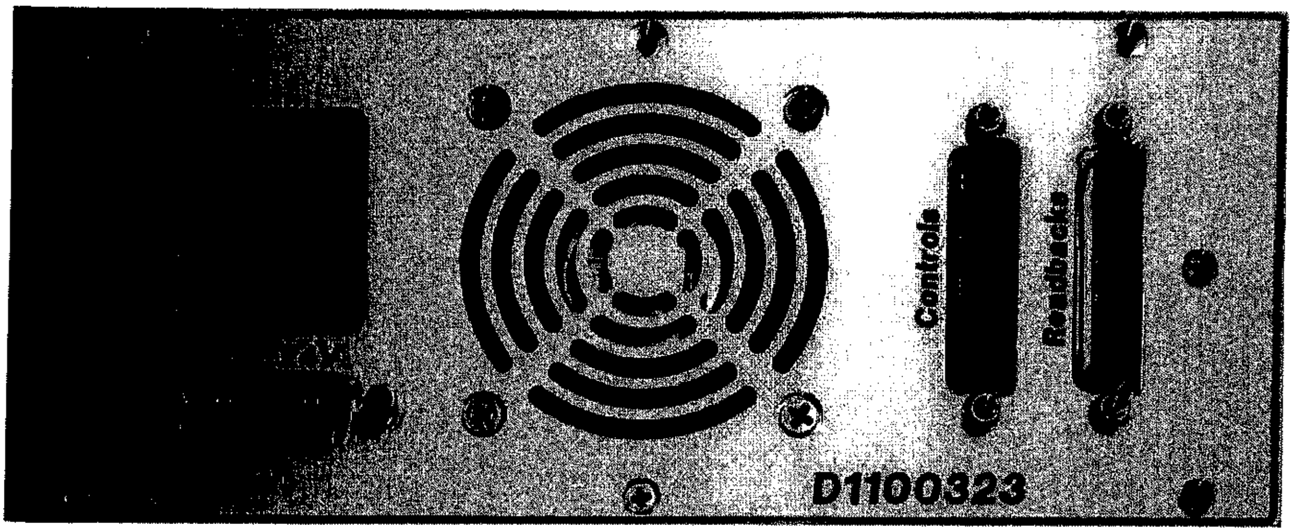
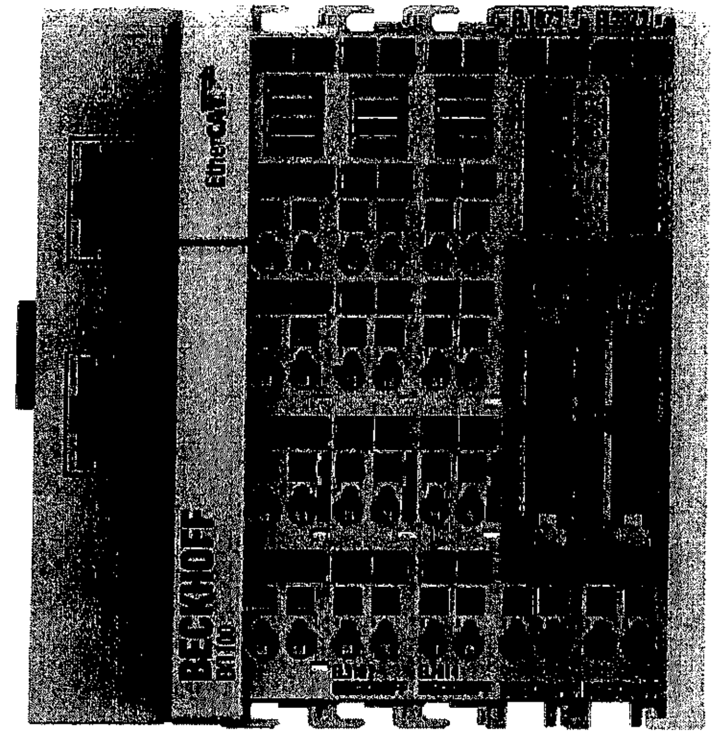


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

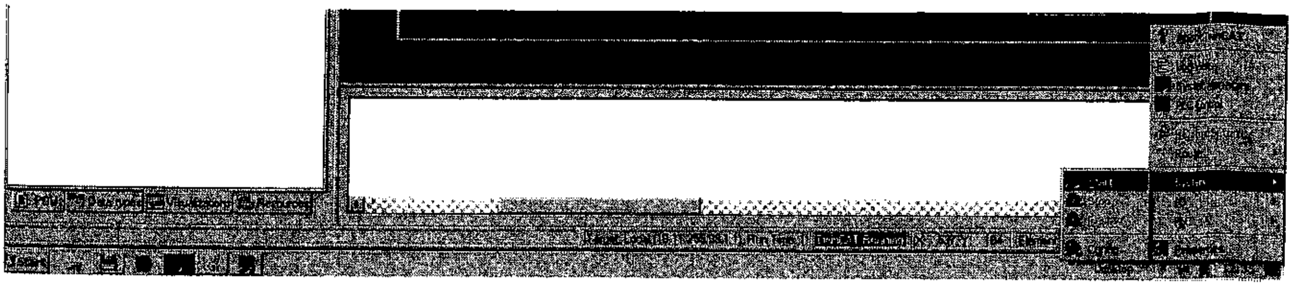
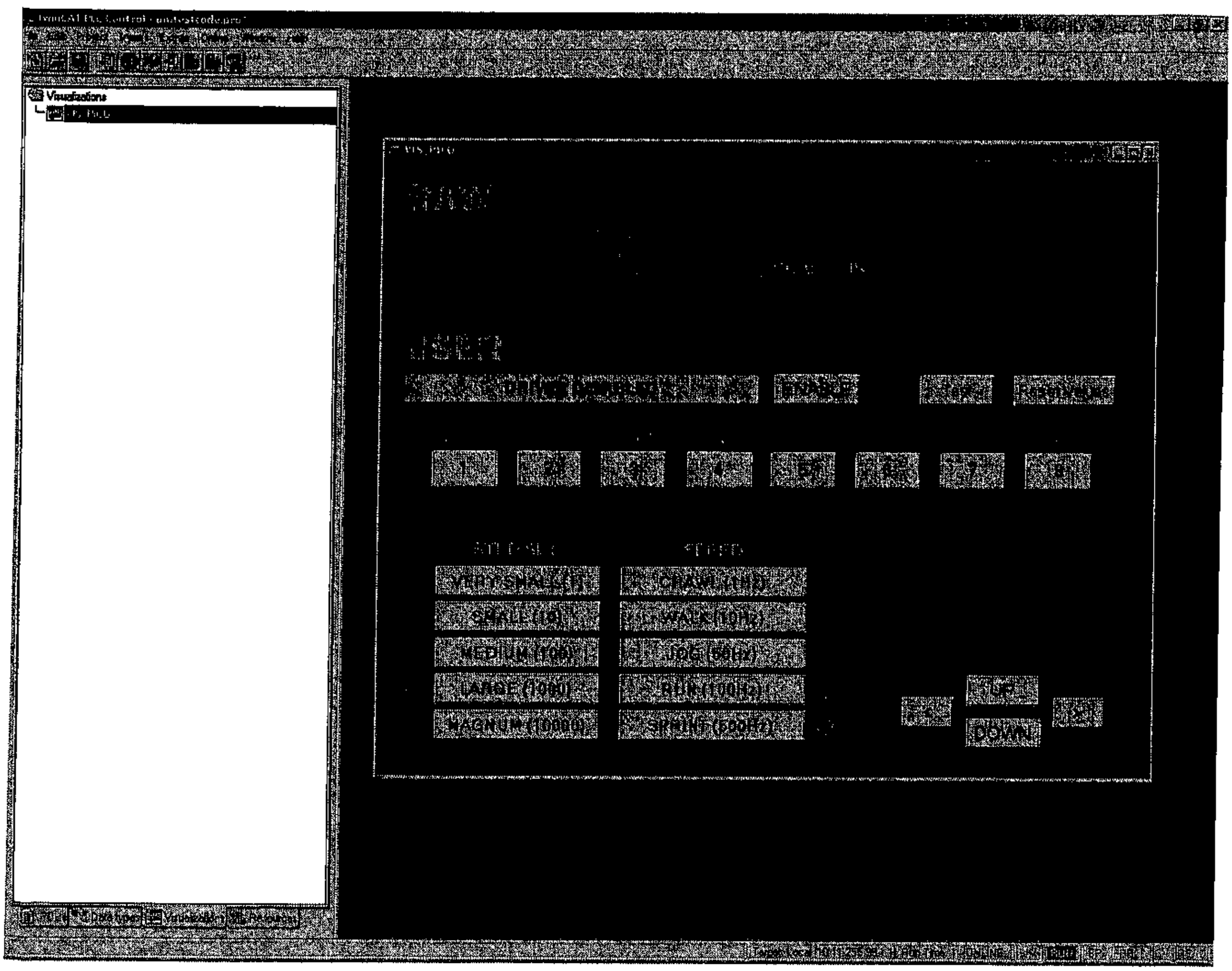


Figure 6: Step 5 of PLC controls setup



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Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107541

Test Engineer: Zach G

Test Date: 1/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

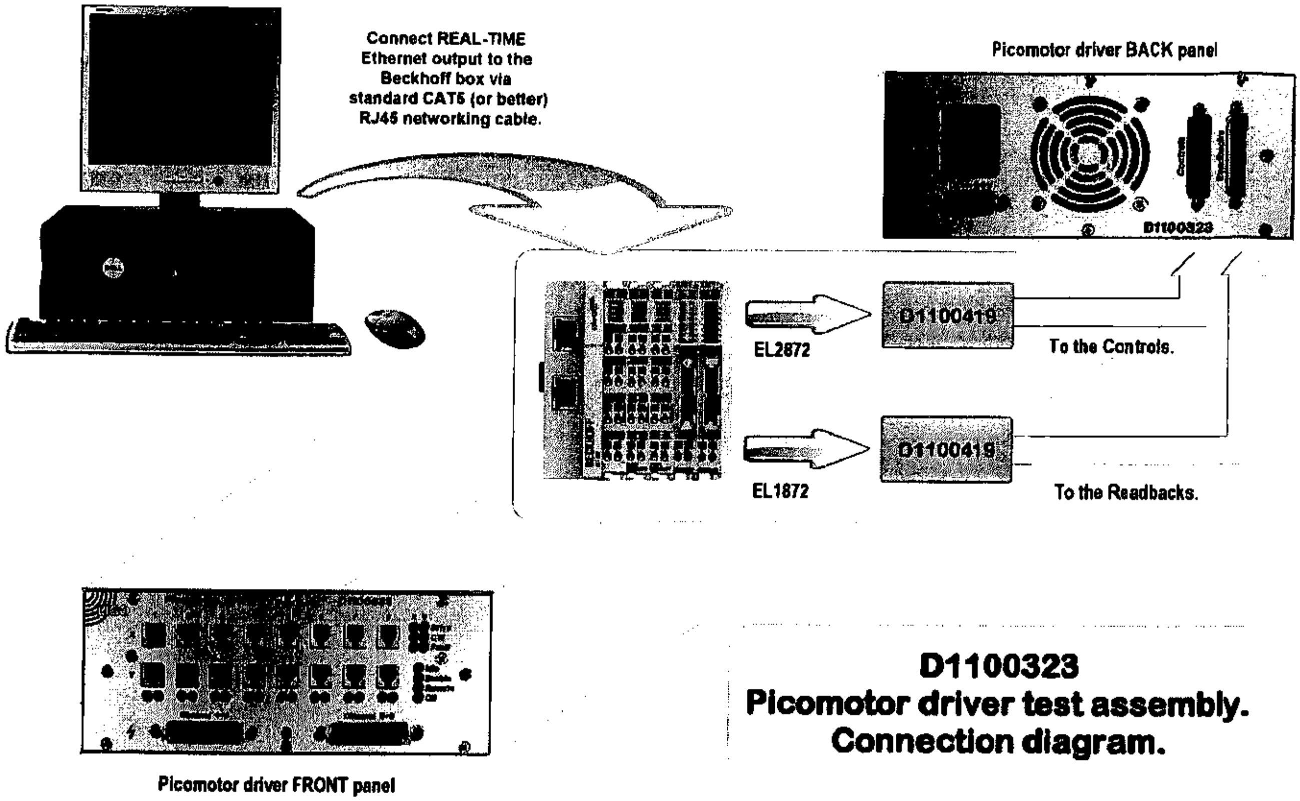
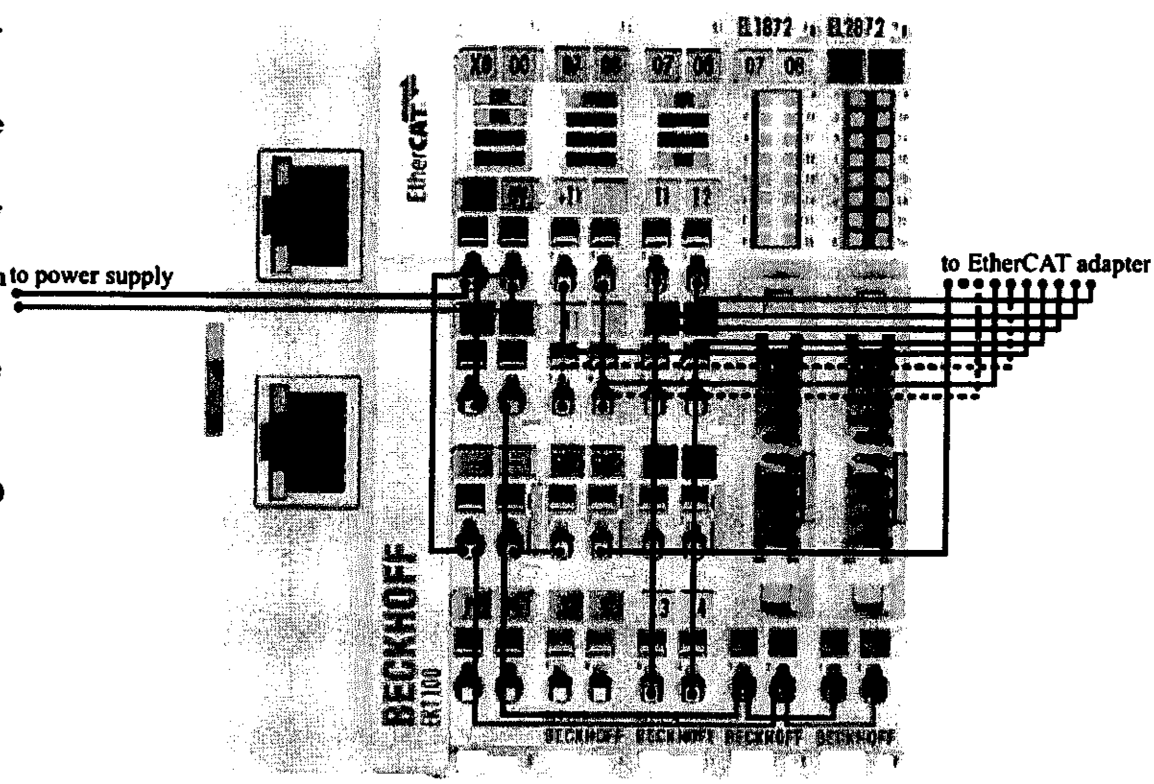


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ ] Check that the fan is running and blowing air out of the box (rear panel).

[ ] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	29.44	27.67
2	30.62	28.78
3	31.75	29.93
4	32.79	30.98
5	33.60	31.83
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 1/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

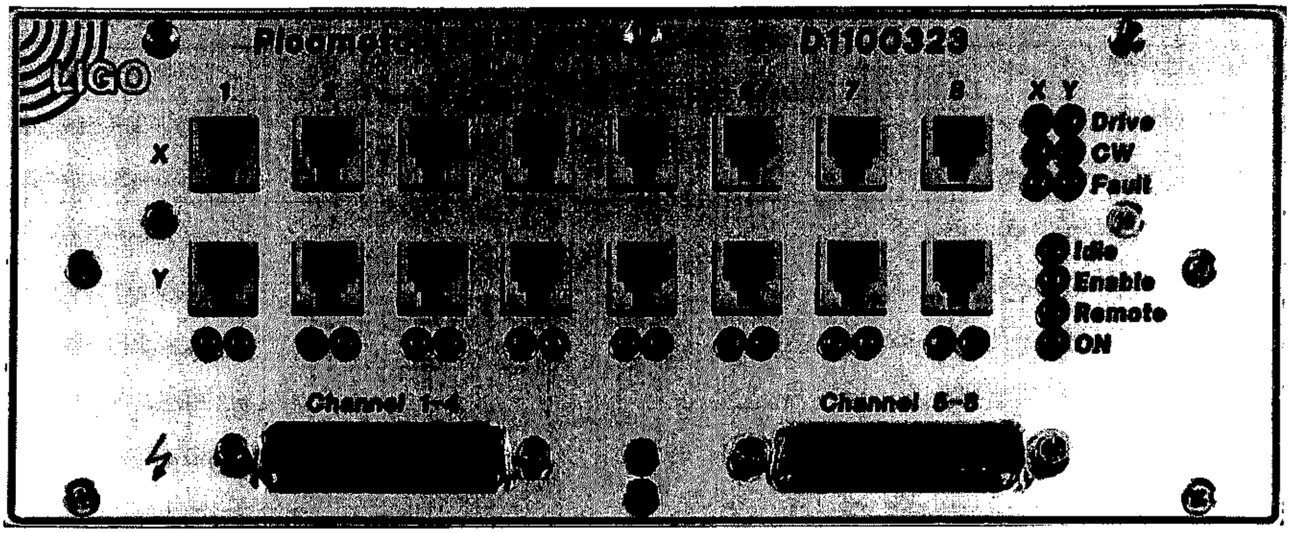


Figure 3: Picomotor driver chassis rear panel

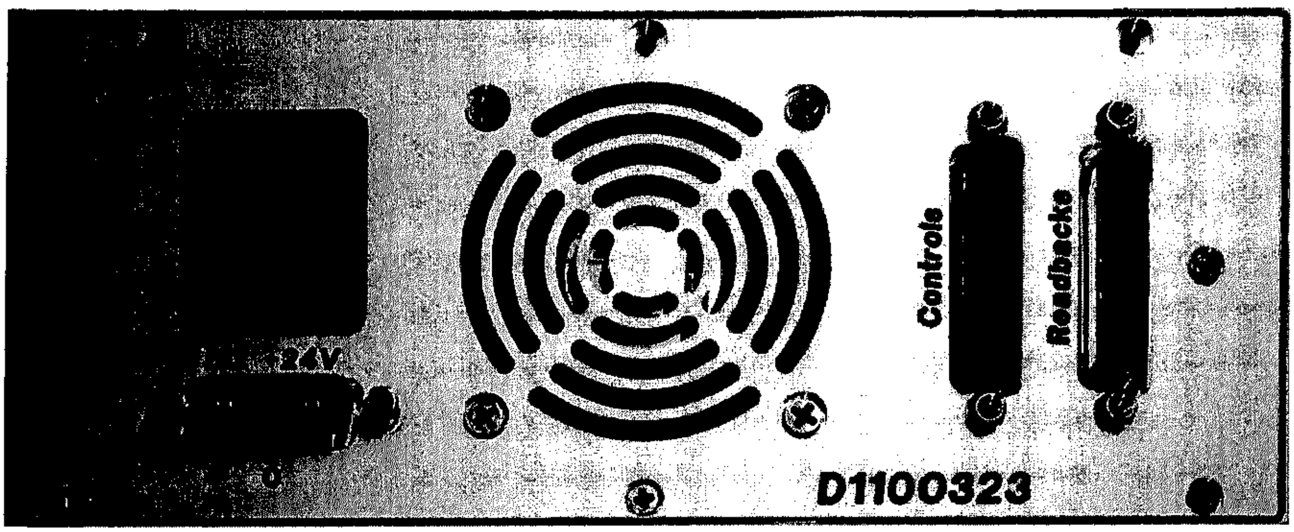
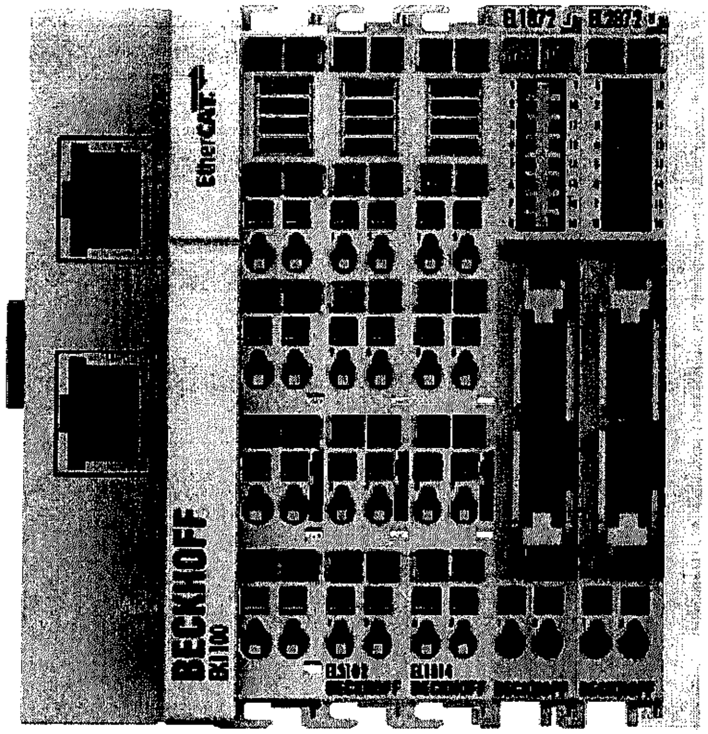


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

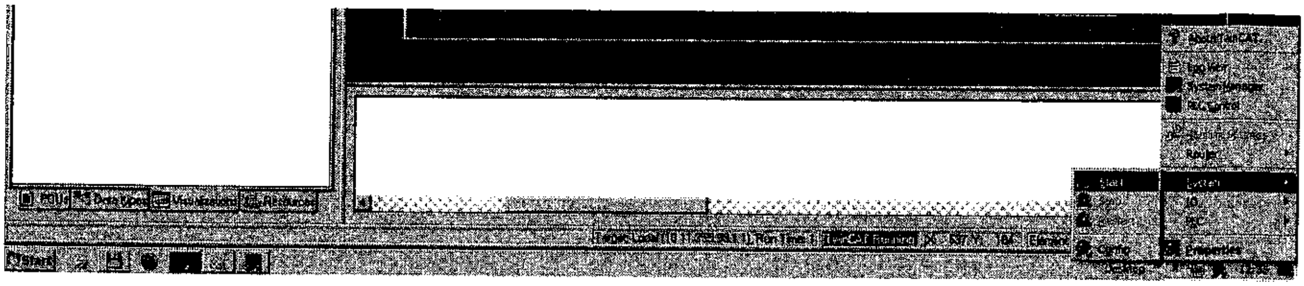
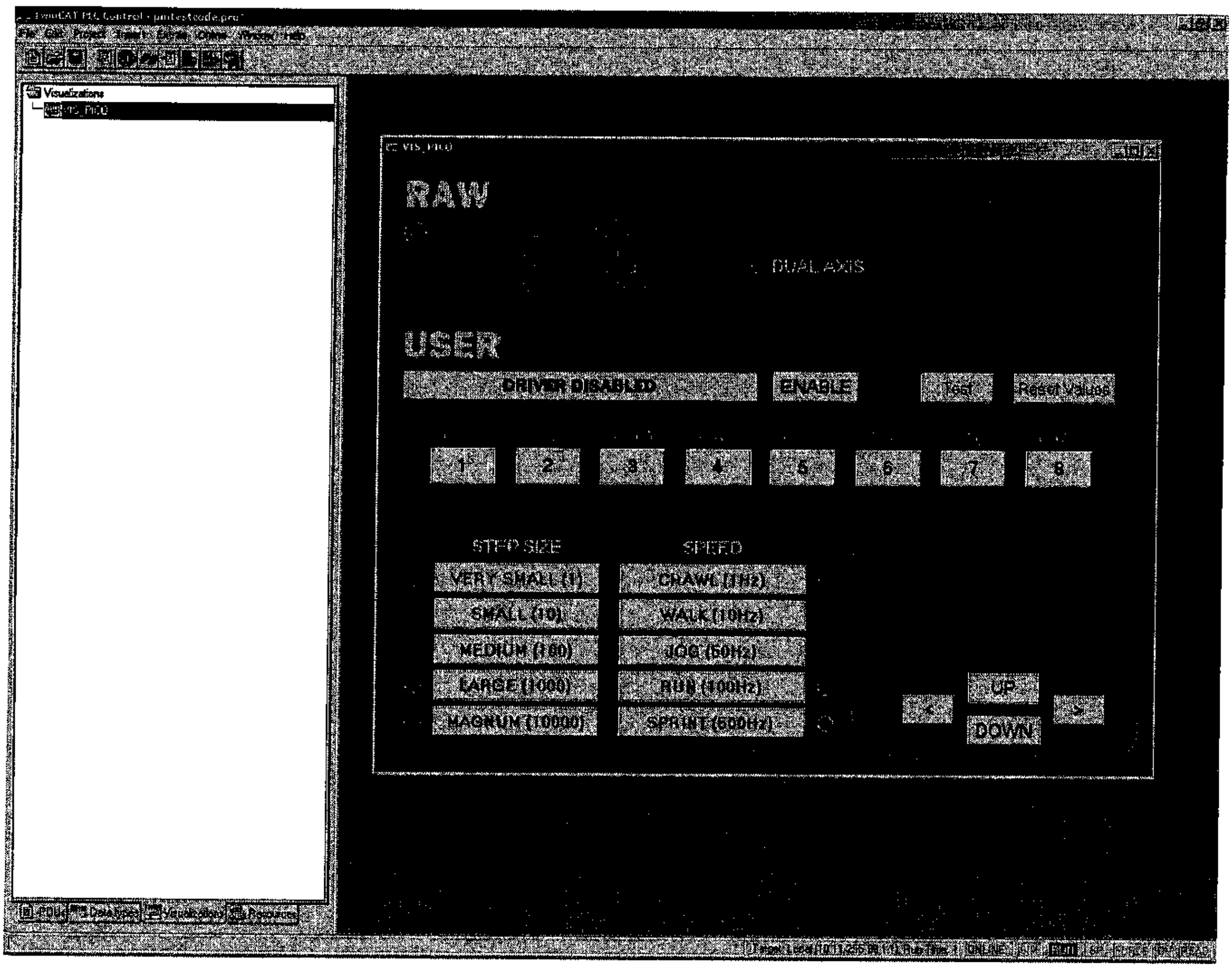


Figure 6: Step 5 of PLC controls setup



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~000~~ S1107542

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
6. Connect the EK1100 Beckhoff box to a DC power source (24V)
7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

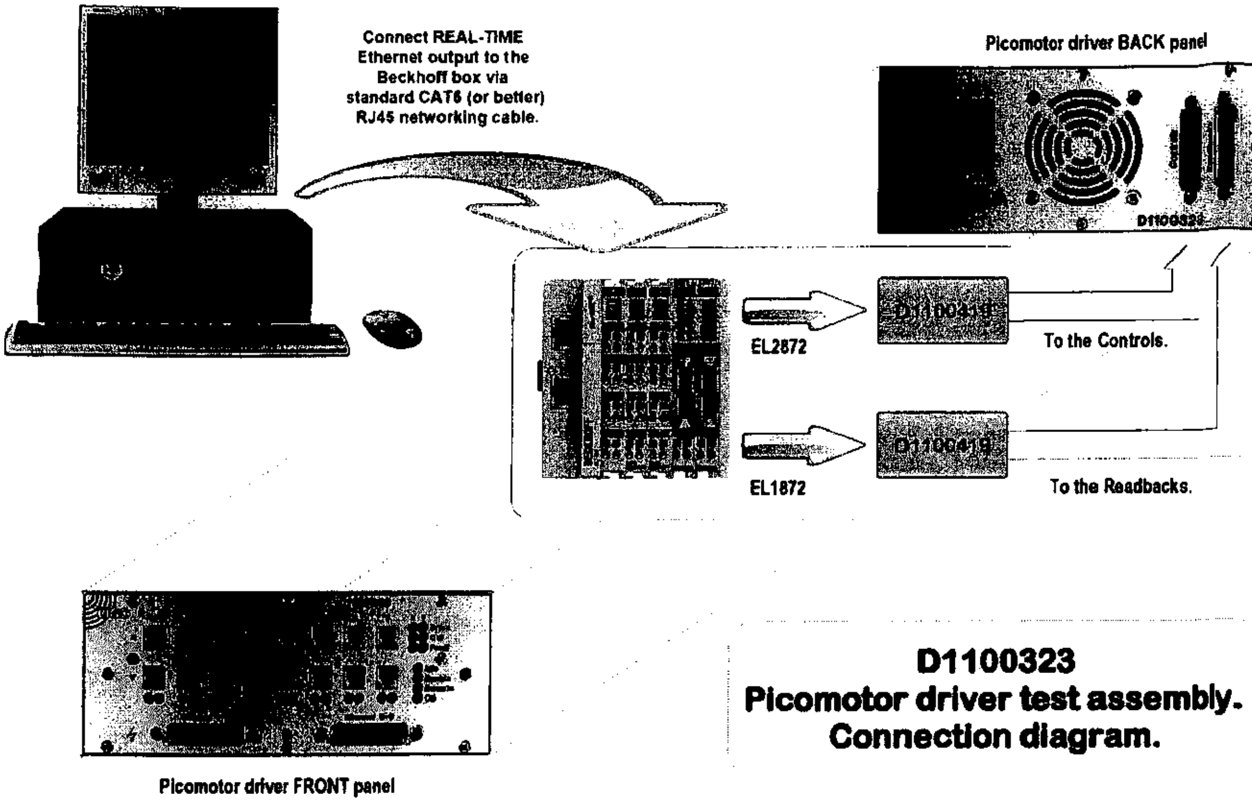
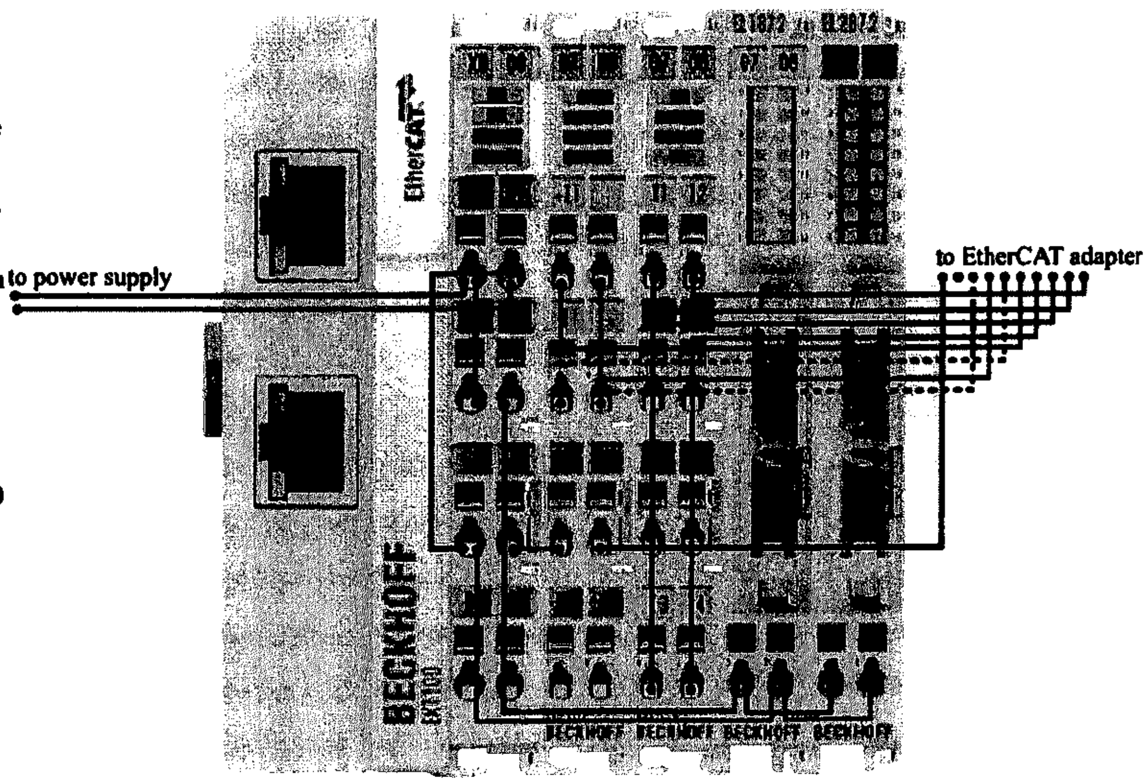


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[Y	[Y
MEDIUM (100)	[Y	[Y
MAGNUM (10000)	[Y	[Y

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[Y	[Y
JOG (50Hz)	[Y	[Y
SPRINT (500Hz)	[Y	[Y

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.09	29.87
2	29.17	31.06
3	30.24	32.20
4	31.22	33.17
5	32.09	34.16
Check if passed:	M	H

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

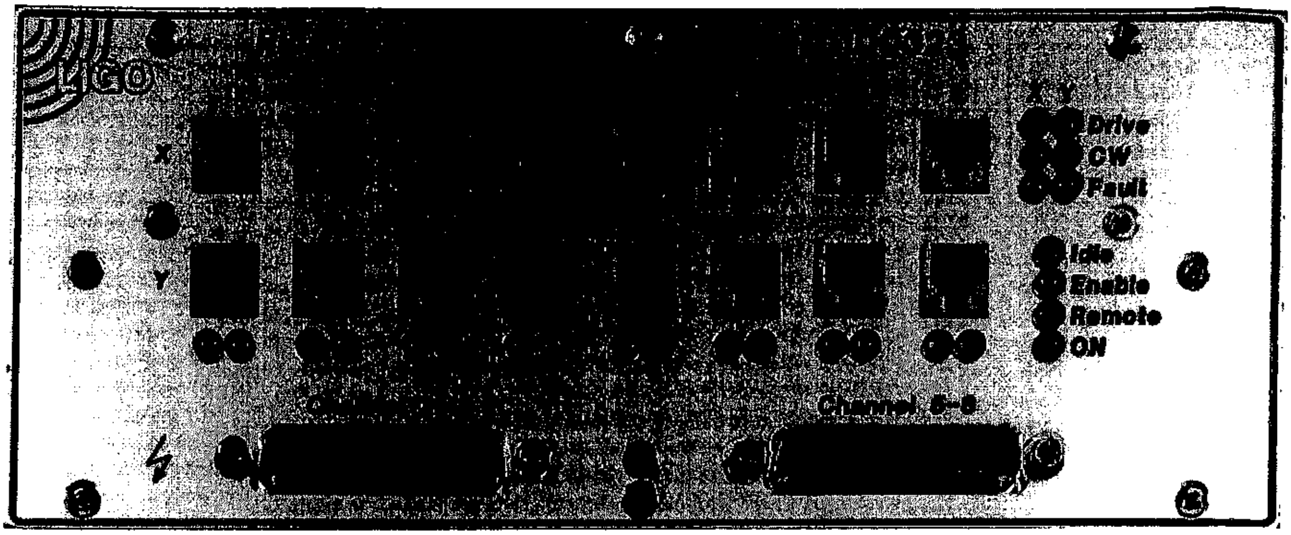


Figure 3: Picomotor driver chassis rear panel

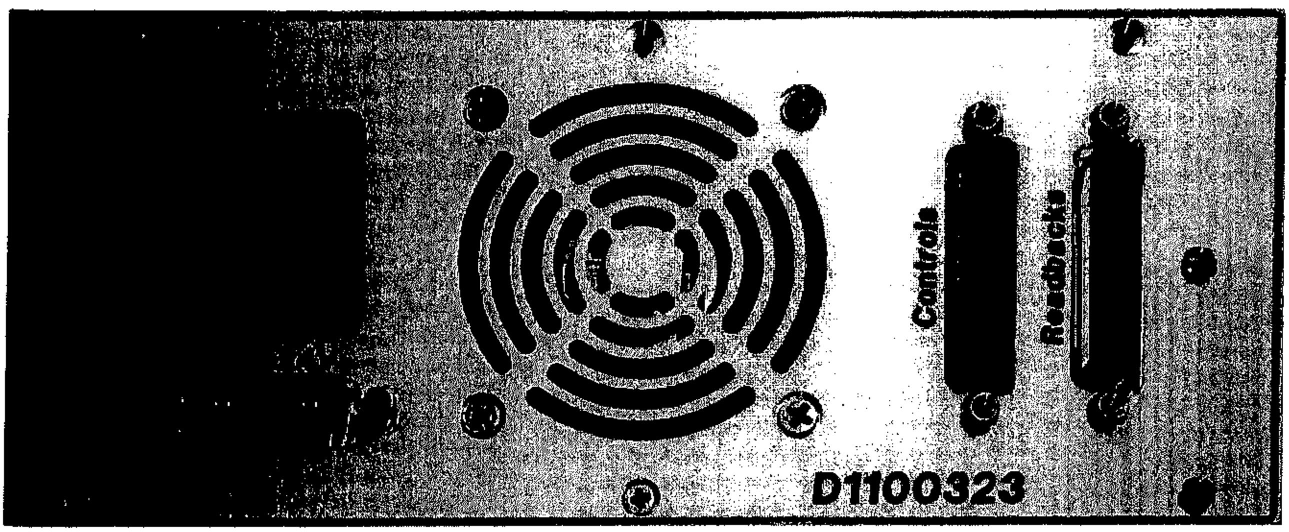
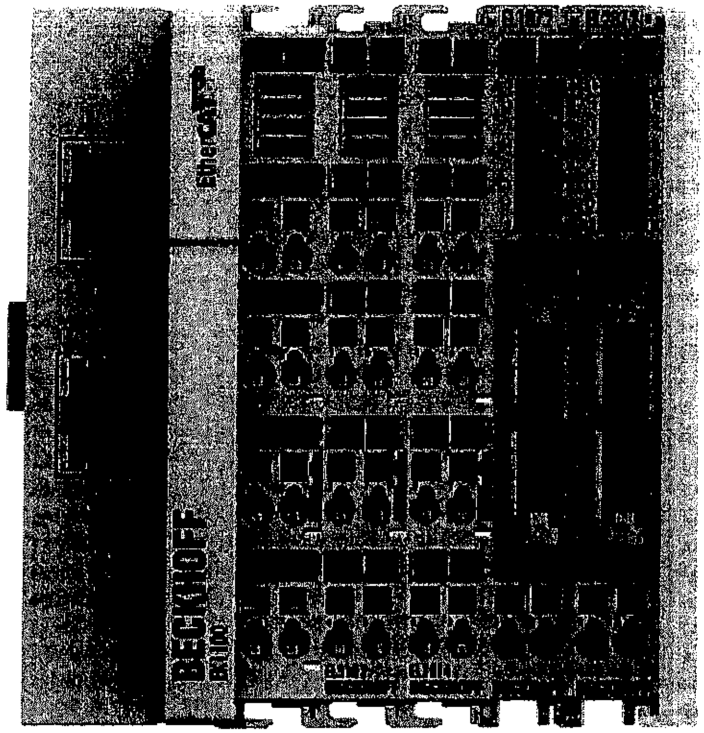


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

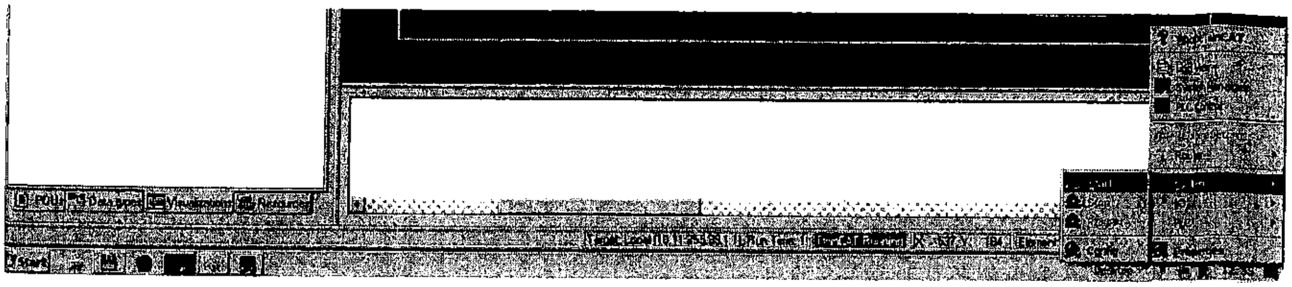
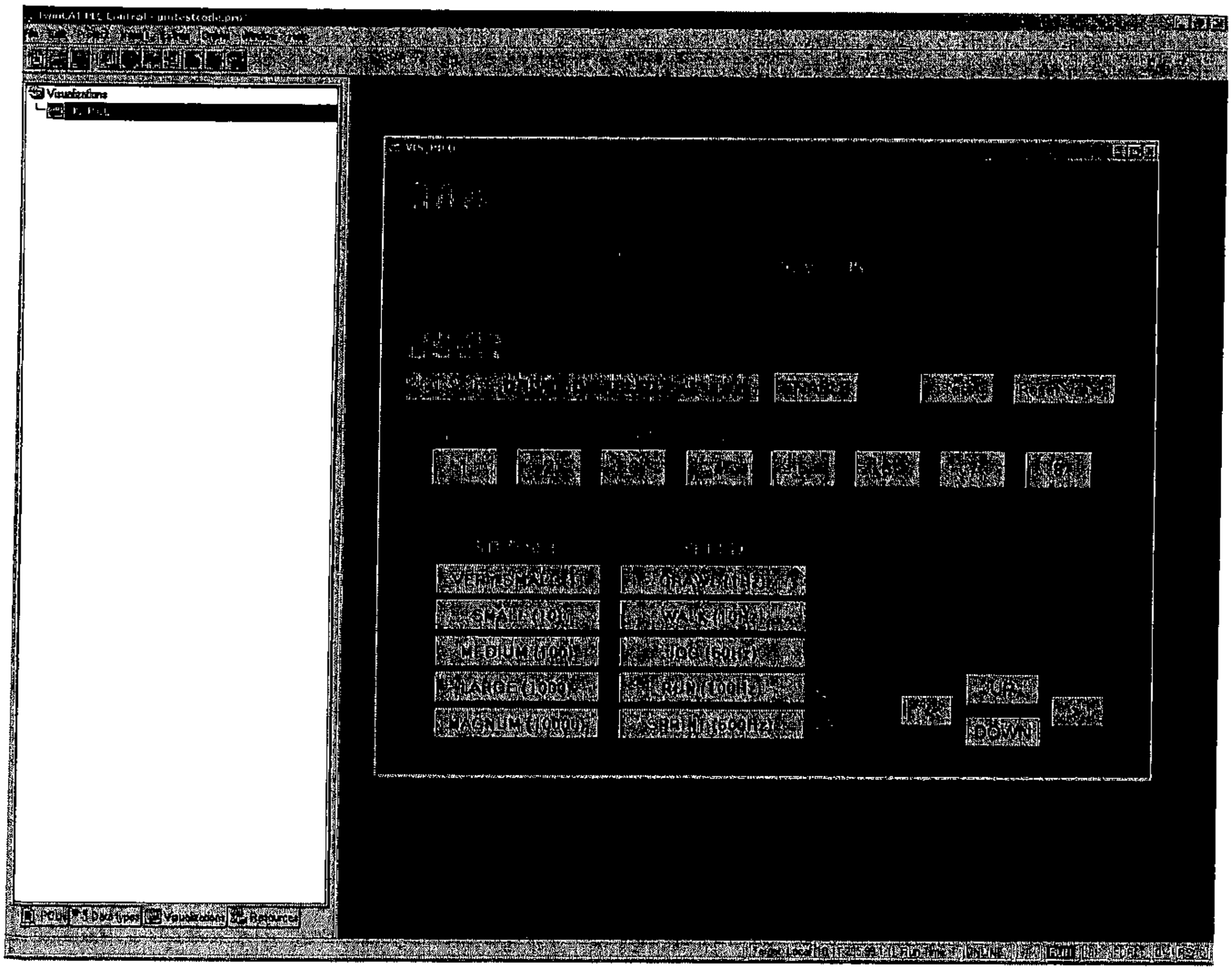


Figure 6: Step 5 of PLC controls setup



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Technical Note LIGO-T1100458-v1 08/26/11
Testing Procedure for the Picomotor Driver for Advanced LIGO
Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~062~~ S1107543

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

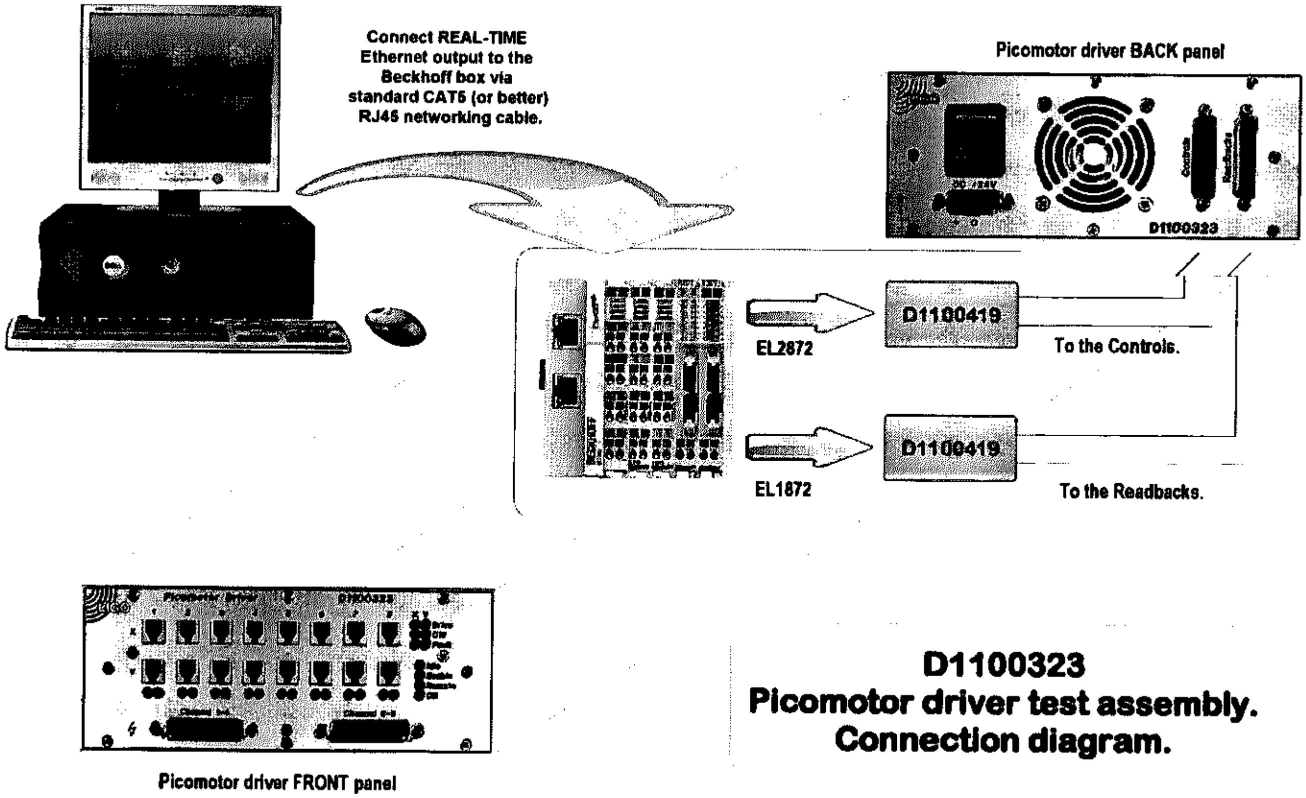


Figure 1a: A connection diagram of the picomotor setup.

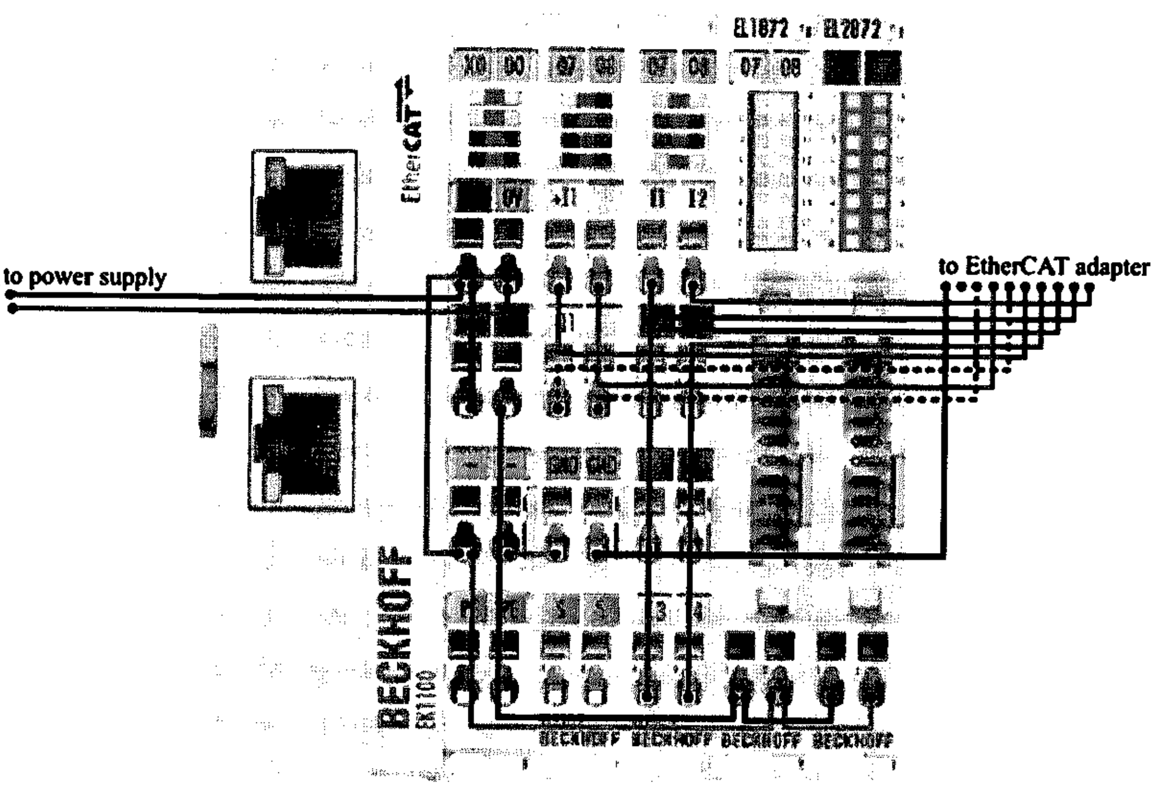


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off			
STARTING UP...	off	on	flashes	flashes			
READY	off	on	off	off			
Check if passed:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ ] Check that the fan is running and blowing air out of the box (rear panel).

[ ] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	22.67	22.84
2	24.07	24.28
3	25.25	25.55
4	26.42	26.78
5	27.42	27.81
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

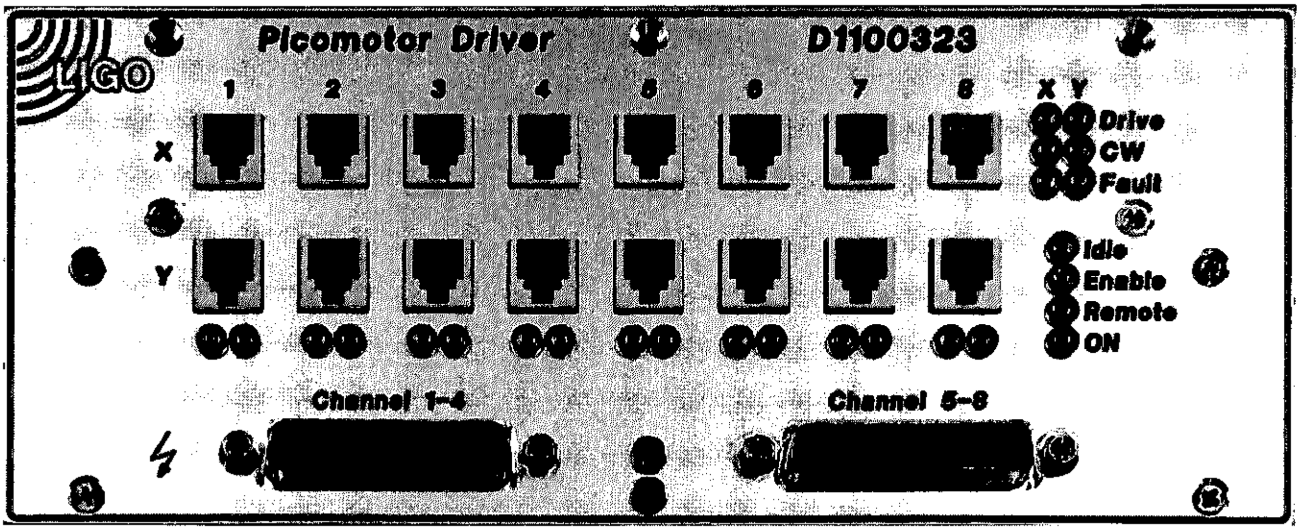


Figure 3: Picomotor driver chassis rear panel

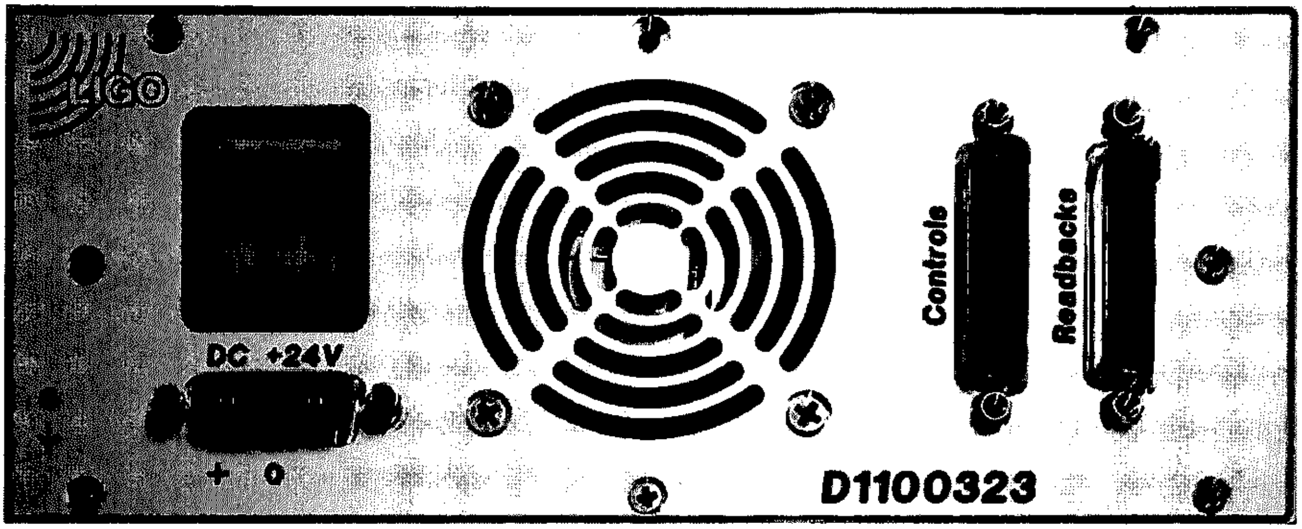
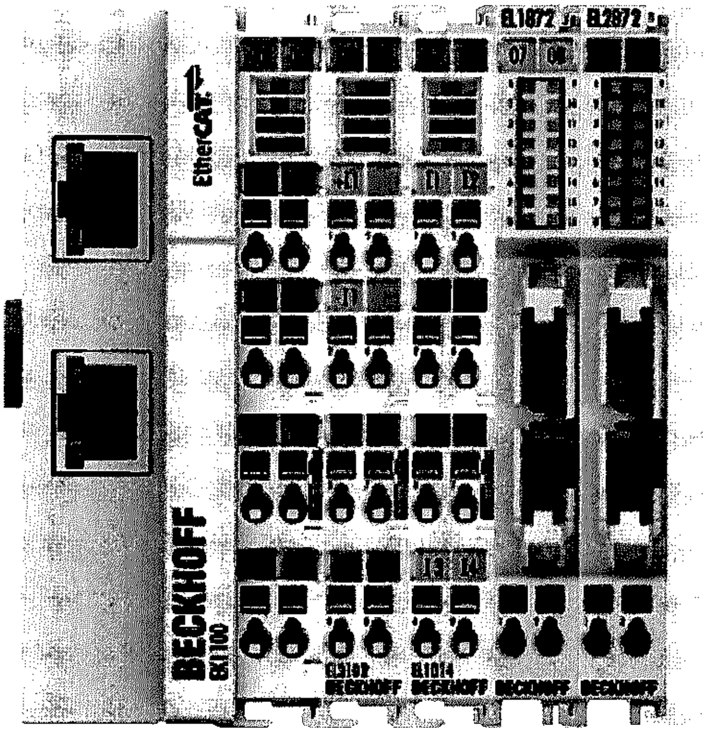


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

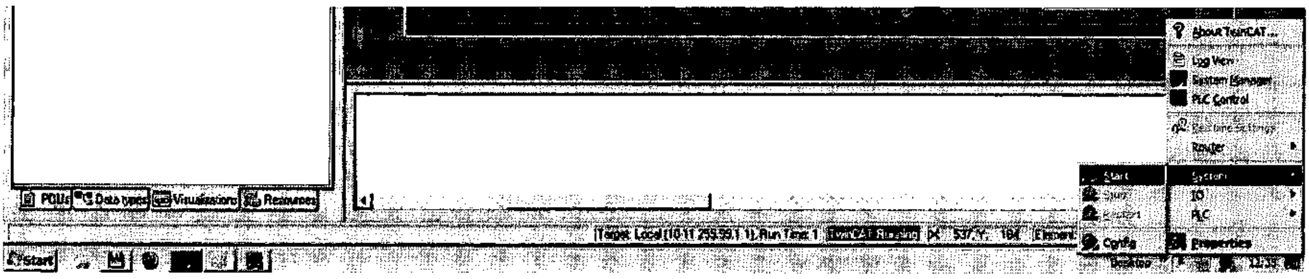
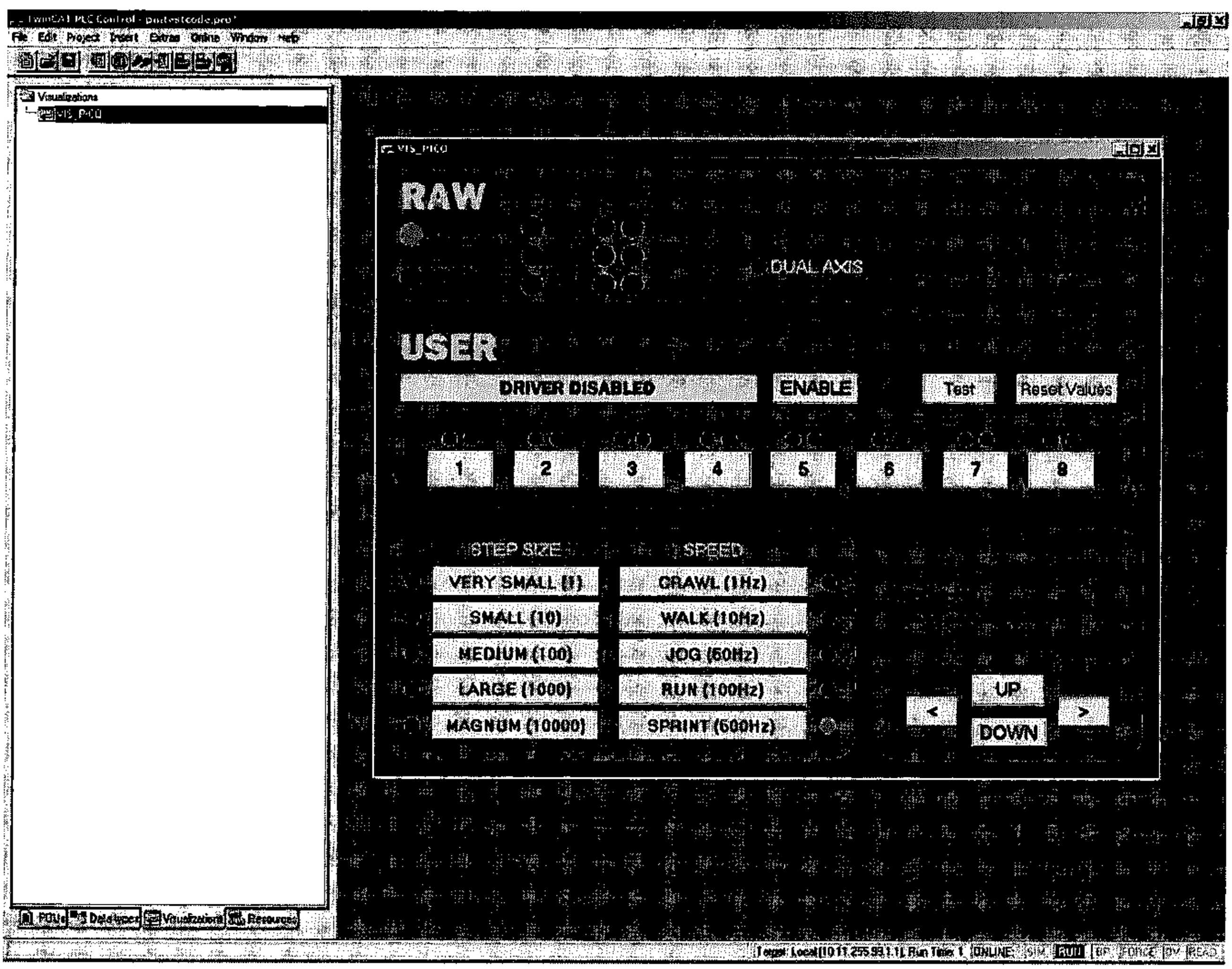


Figure 6: Step 5 of PLC controls setup



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~003~~ S1107544

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
6. Connect the EK1100 Beckhoff box to a DC power source (24V)
7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

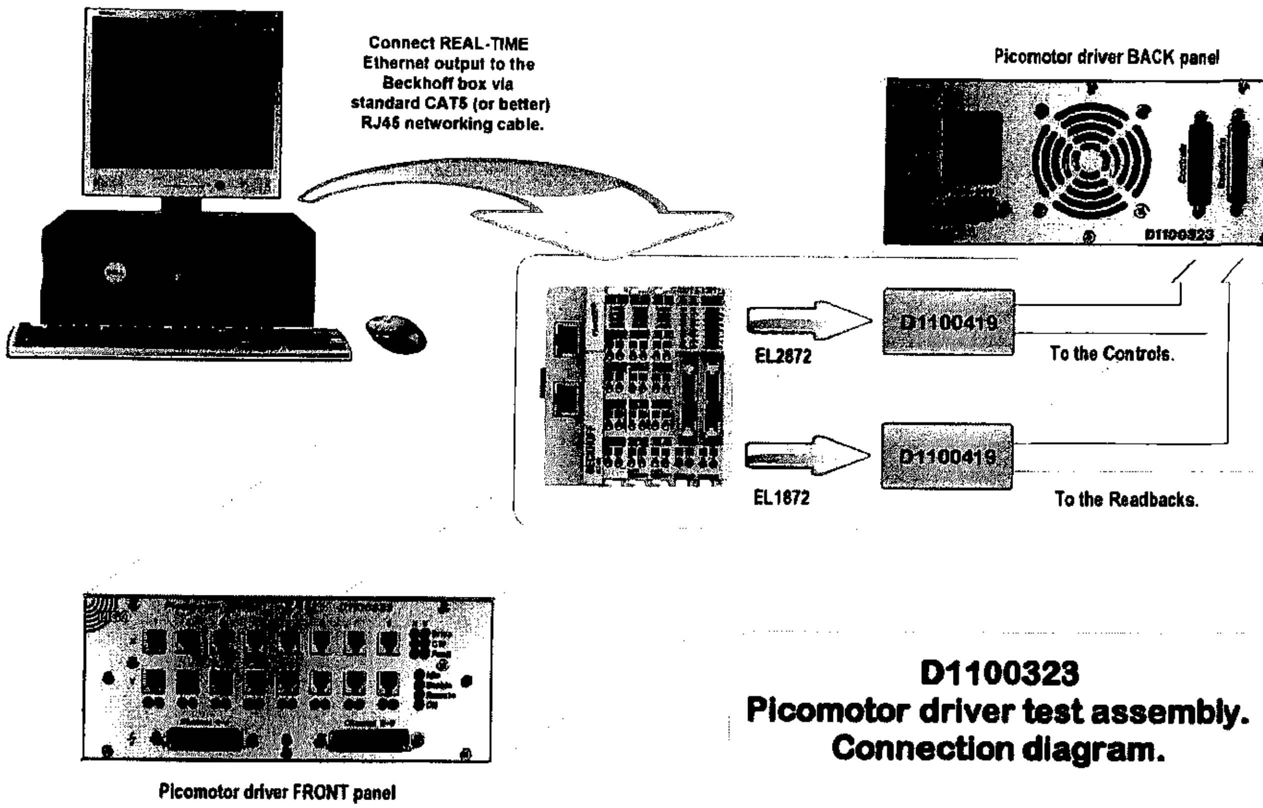
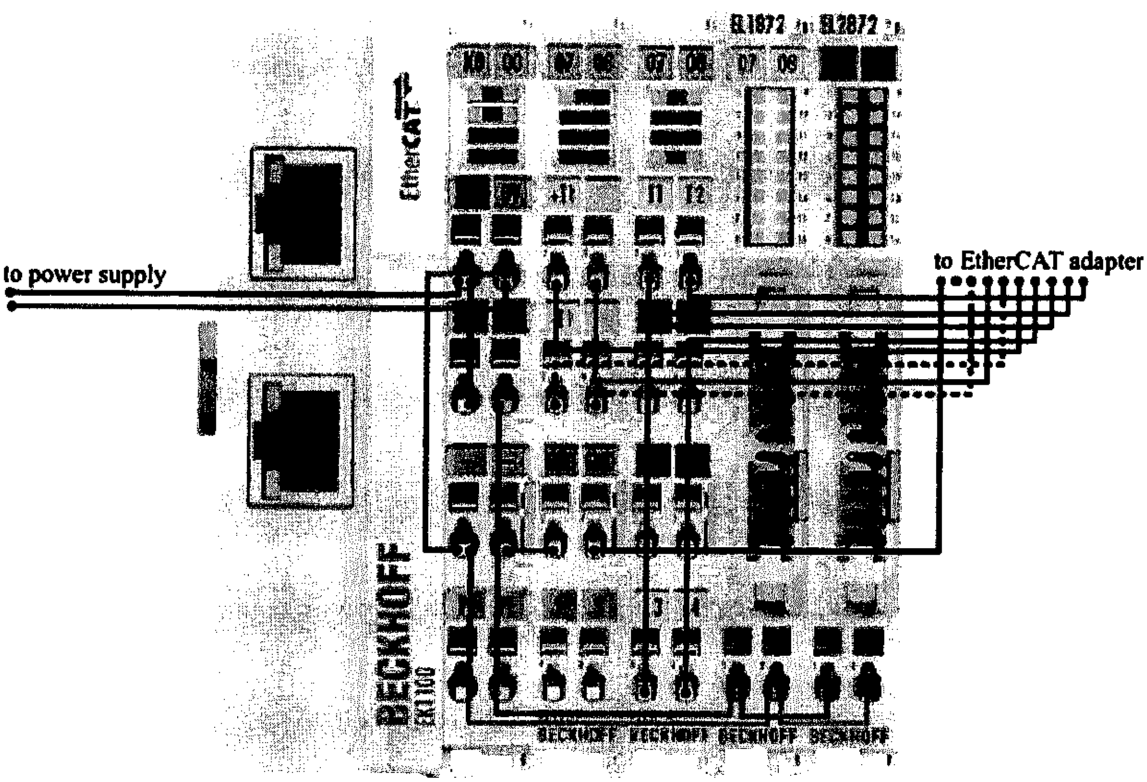


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- [✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [✓] Check that the "ON" indicator on the visualization also responds to the power switch.
- [✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [✓] Before the next step, check that the fan (rear panel) is off.
- [✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

- [✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.59	28.77
2	29.65	29.90
3	30.66	31.02
4	31.60	32.00
5	32.49	32.99
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

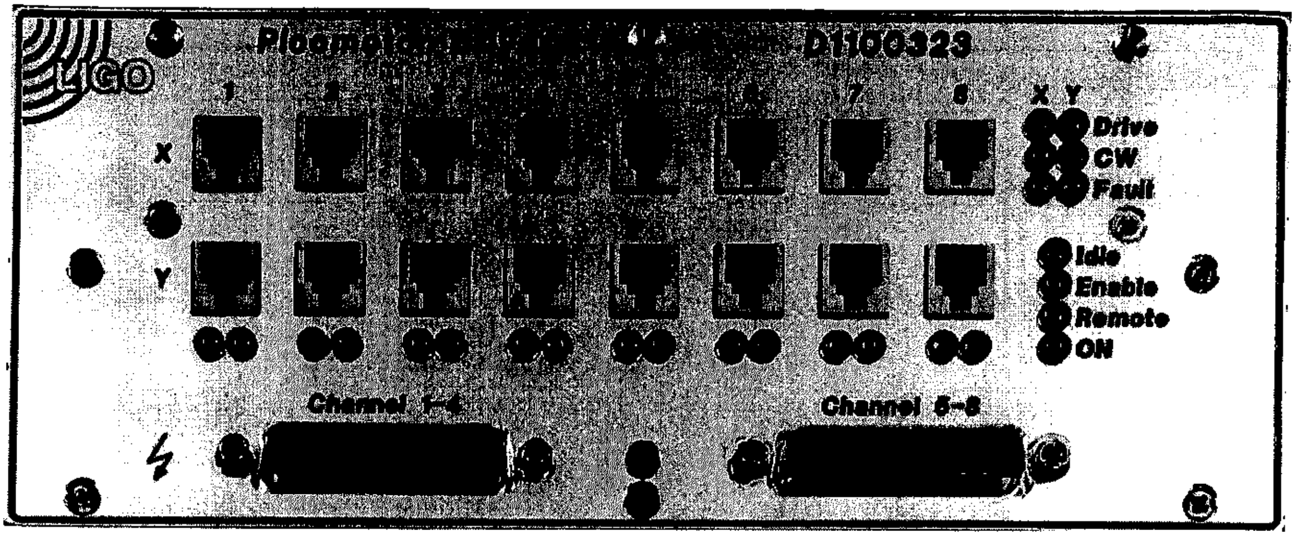


Figure 3: Picomotor driver chassis rear panel

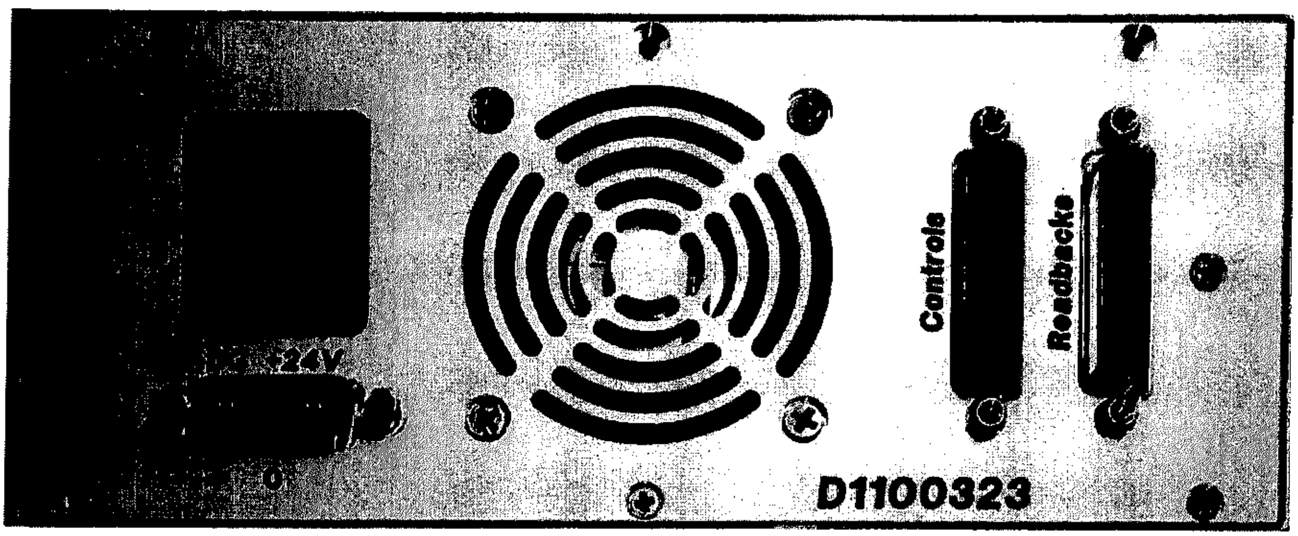
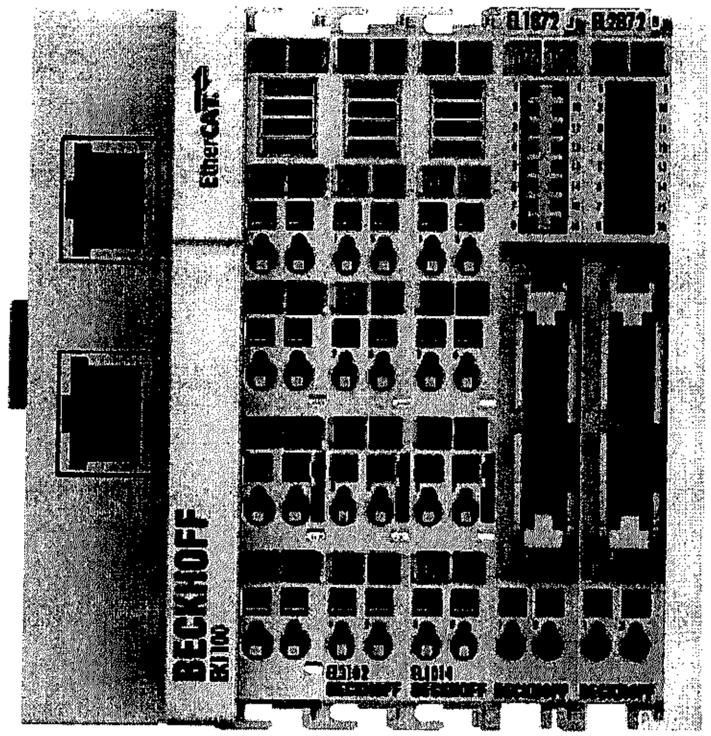


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

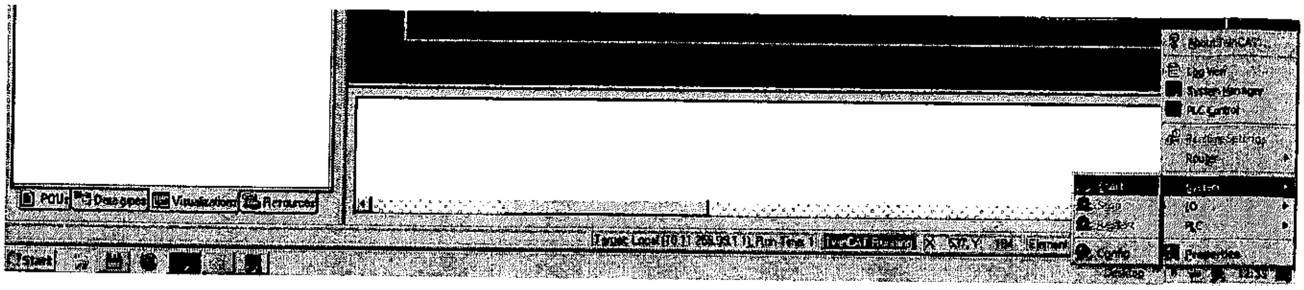
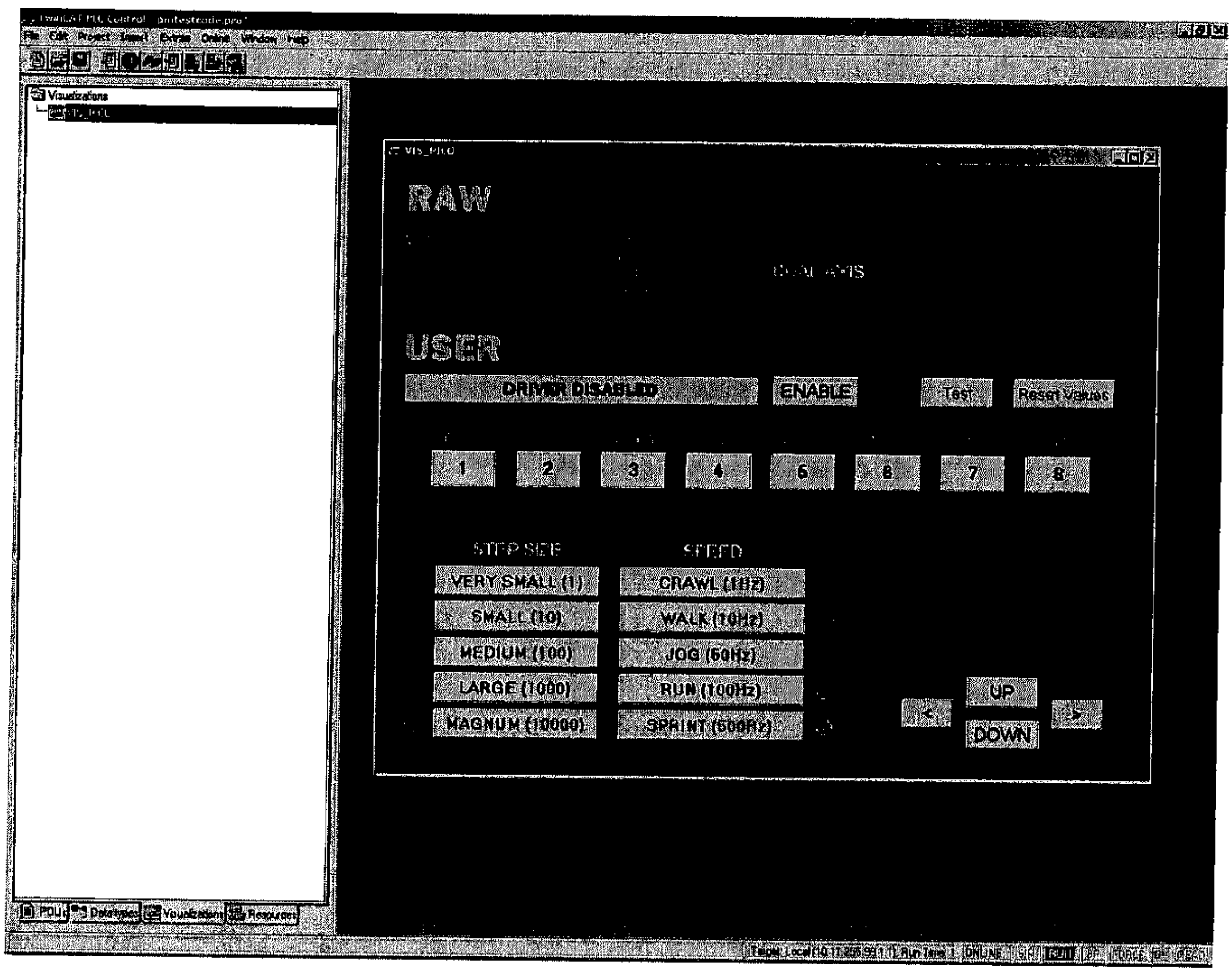


Figure 6: Step 5 of PLC controls setup



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	**LIGO-T1100458-v1**	**08/26/11**

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~[illegible]~~ S1107545

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

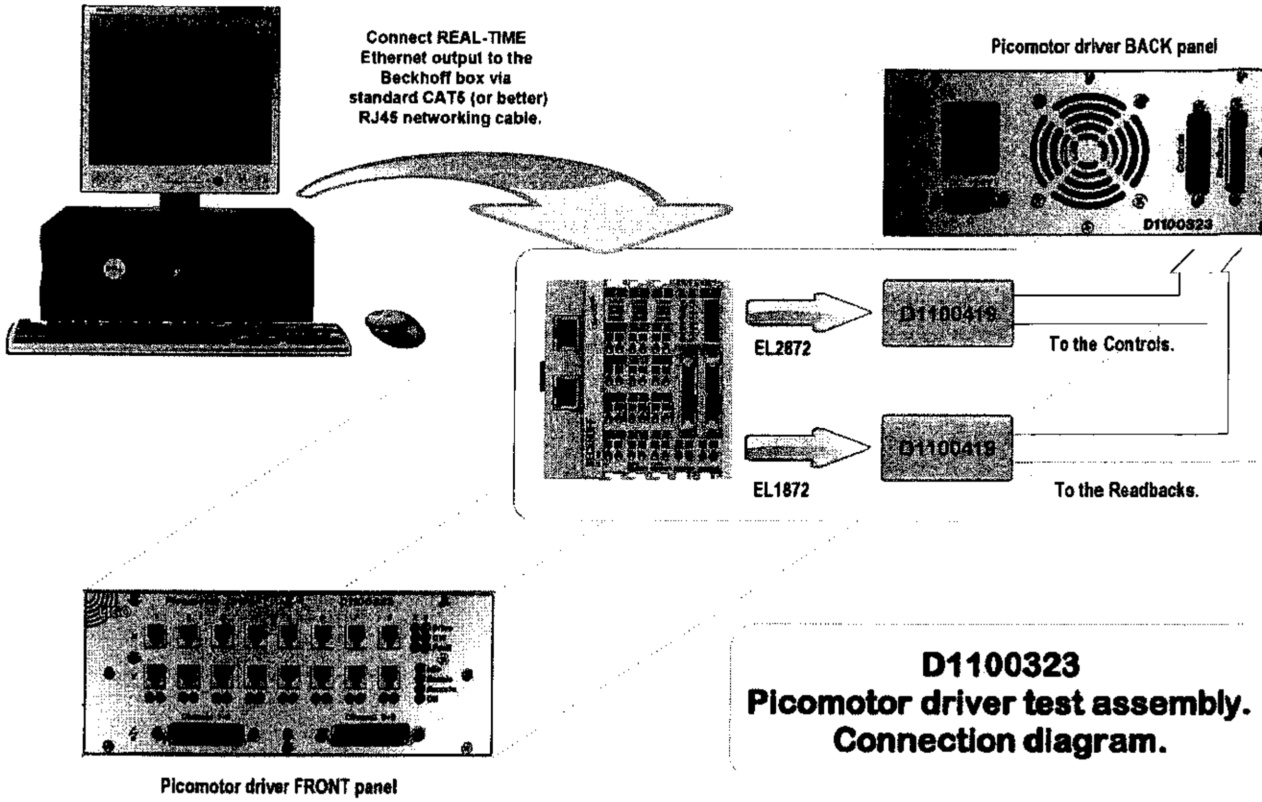


Figure 1a: A connection diagram of the picomotor setup.

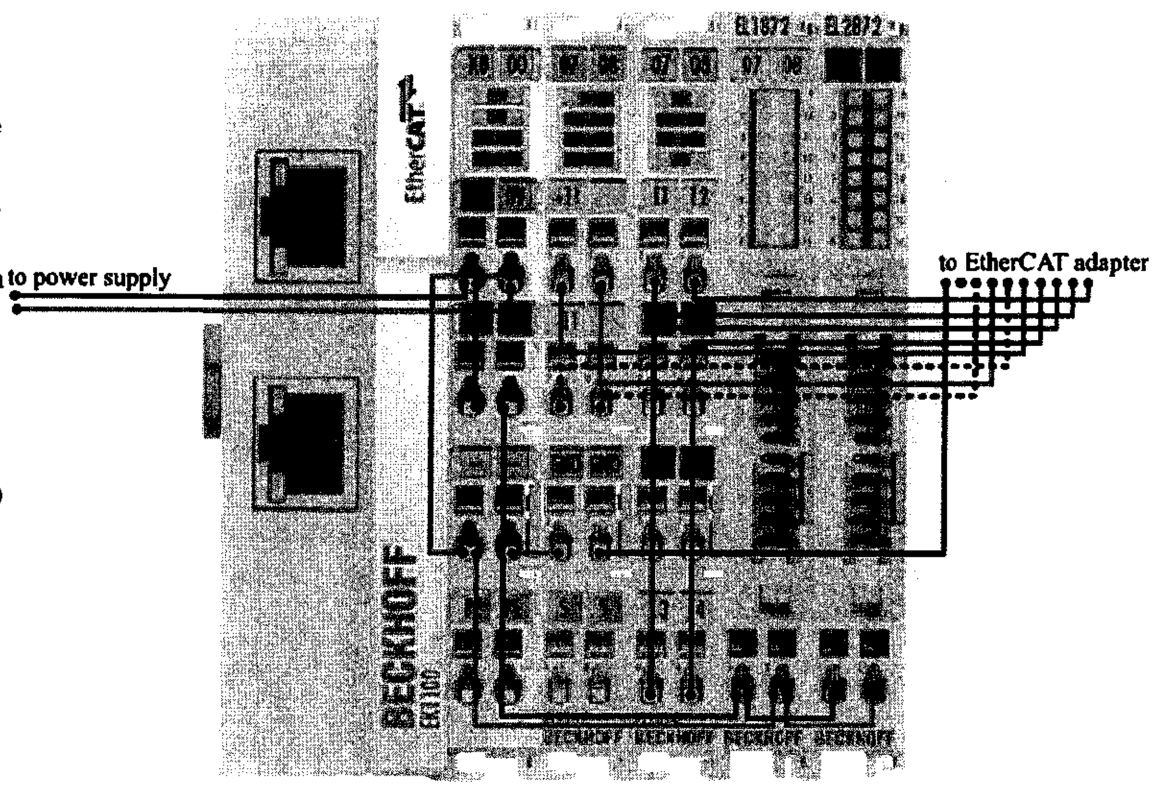


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear. *(see Figure 6 in Appendix B for a screenshot)*

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[ ] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.60	25.90
2	29.68	26.96
3	30.75	27.99
4	31.68	28.97
5	32.59	29.89
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

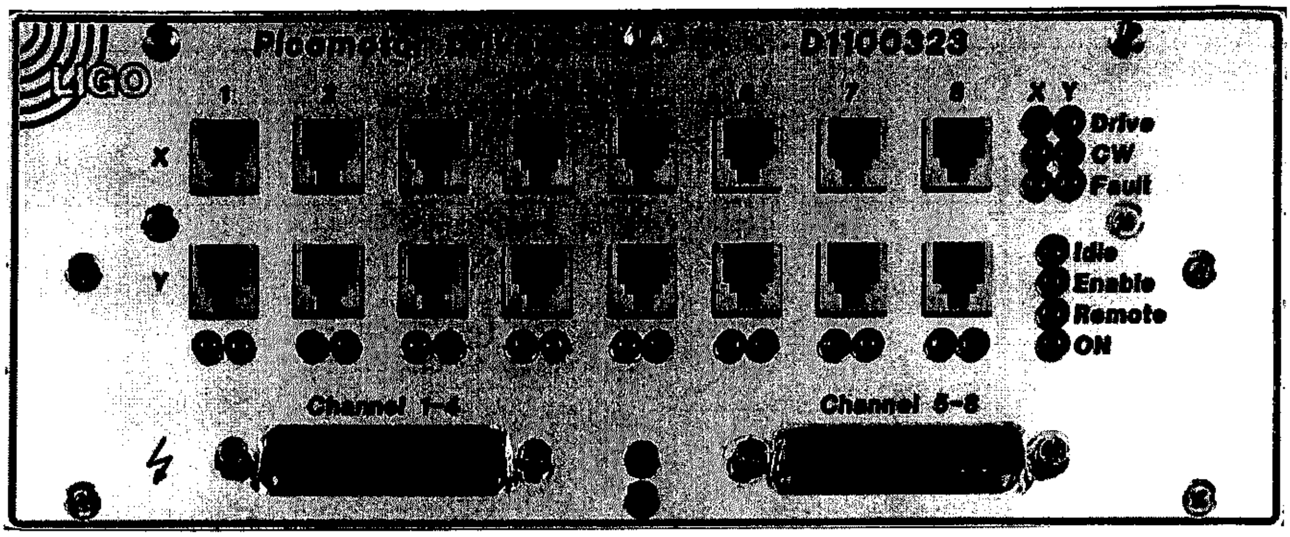


Figure 3: Picomotor driver chassis rear panel

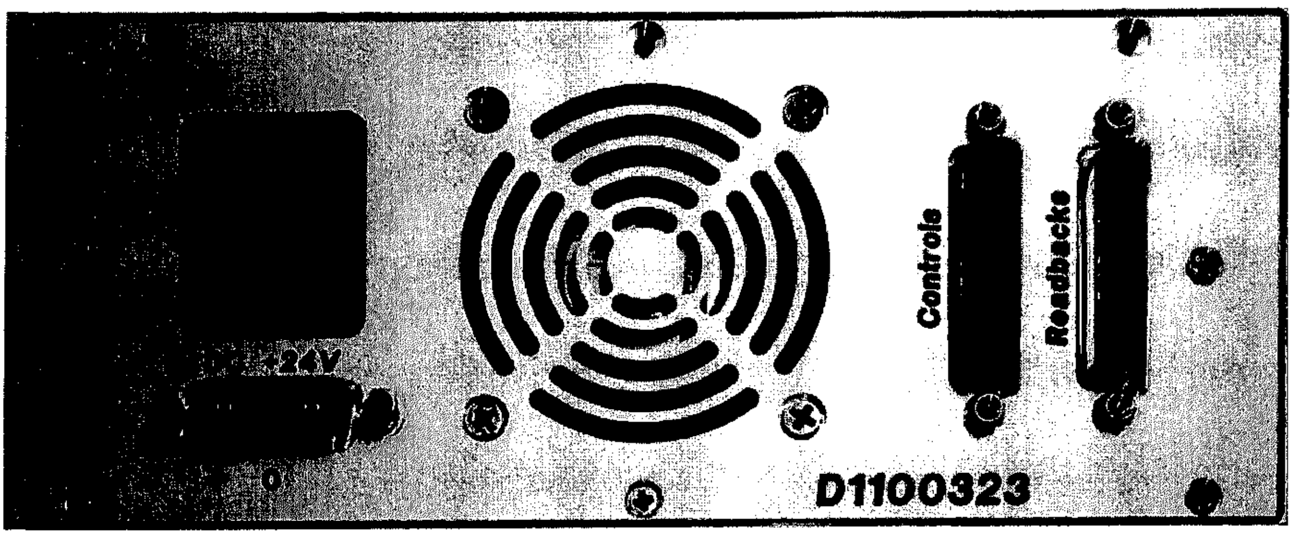
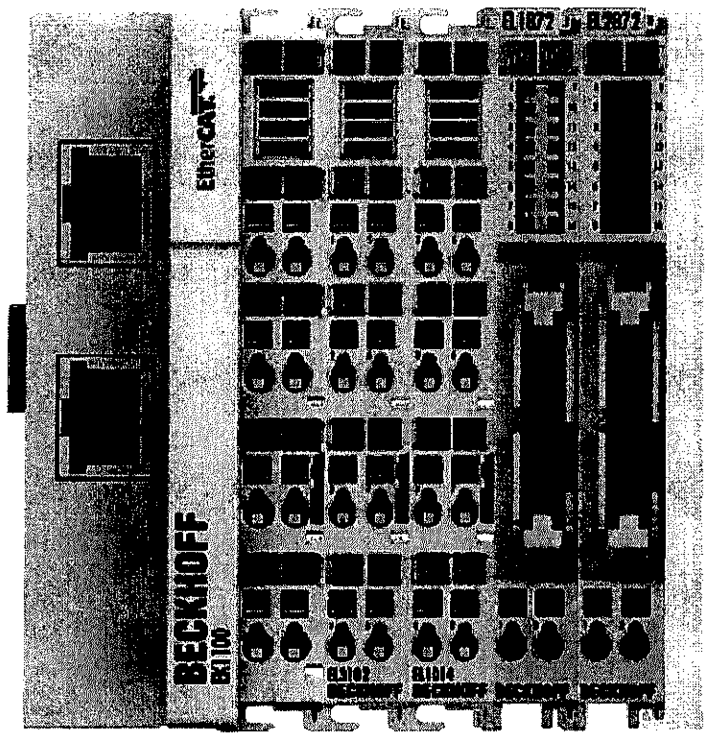


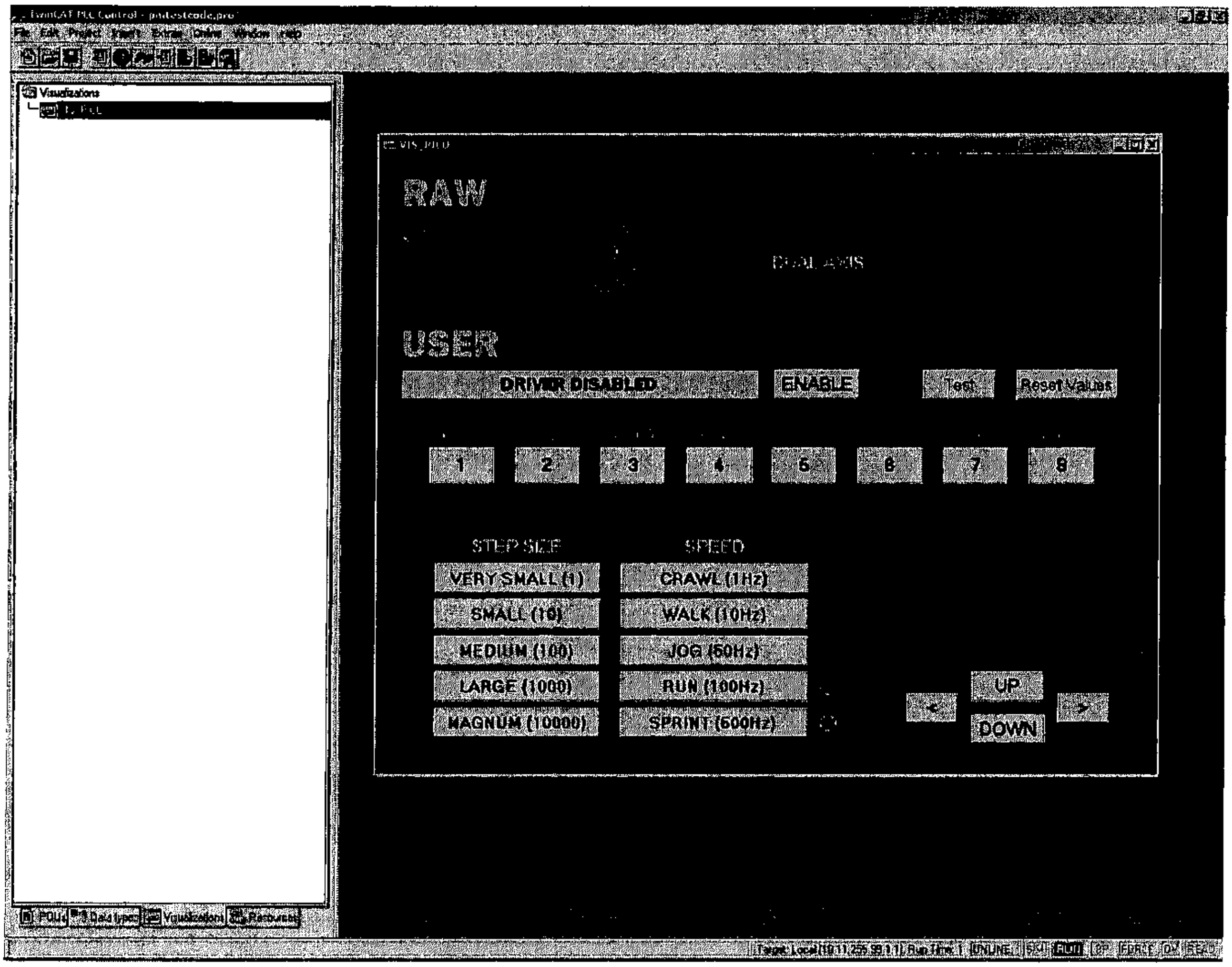
Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~00#~~ S1107546

Test Engineer: Zach C

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

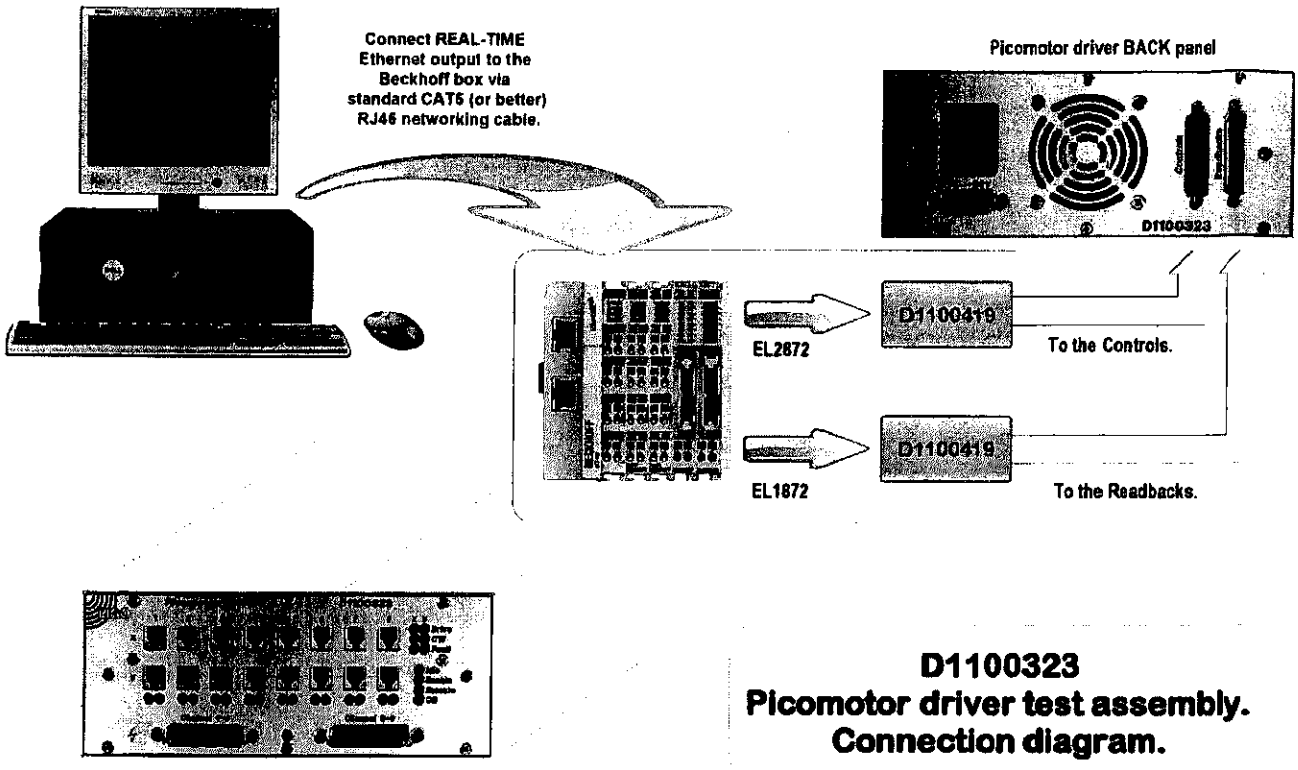
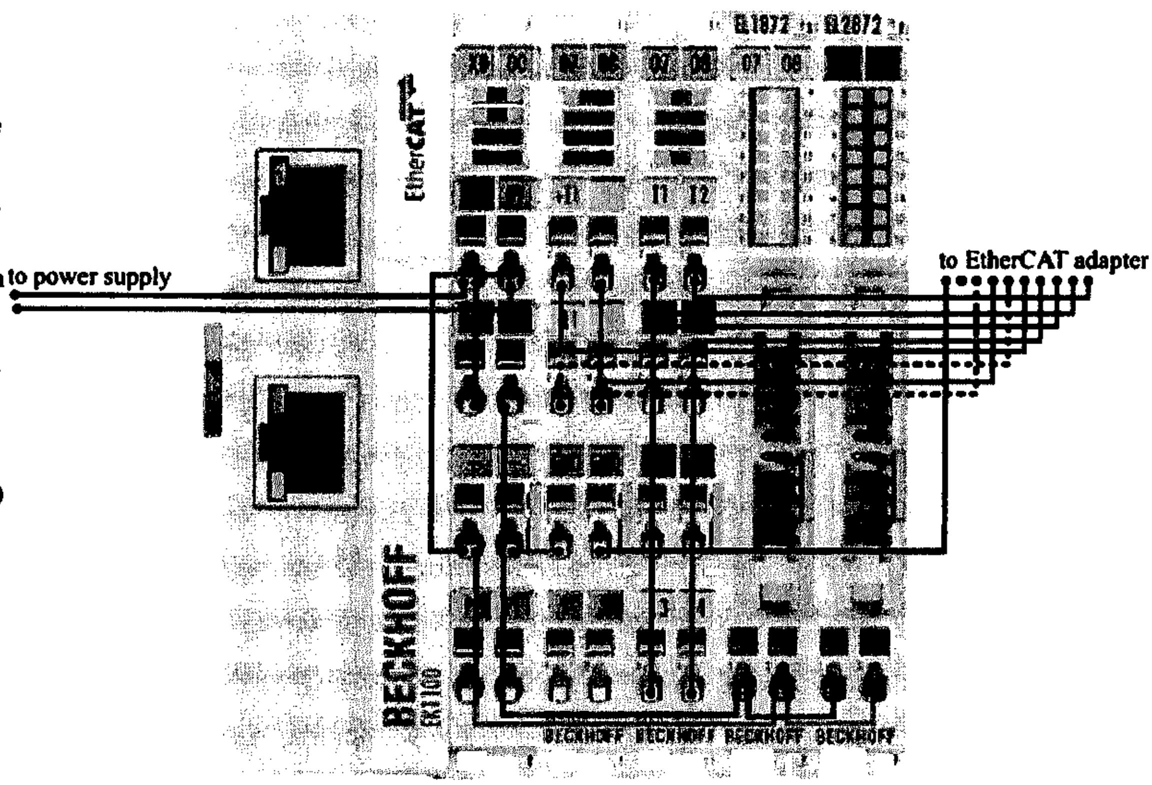


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.01	27.98
2	27.54	29.12
3	28.85	30.15
4	29.85	31.13
5	30.66	31.90
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer:

Test Date:

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

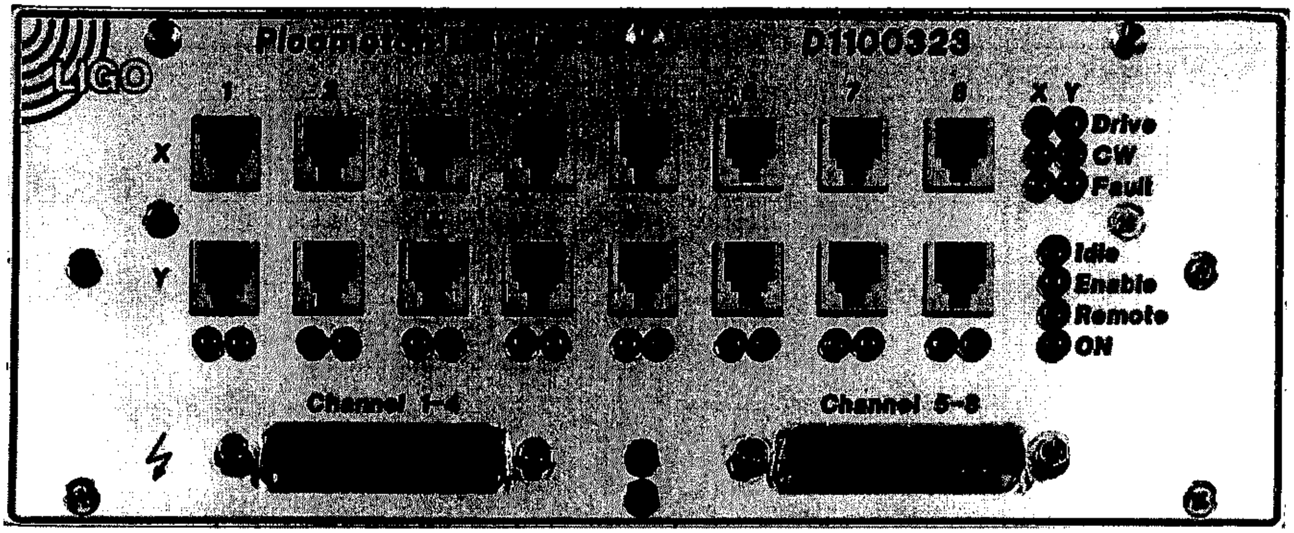


Figure 3: Picomotor driver chassis rear panel

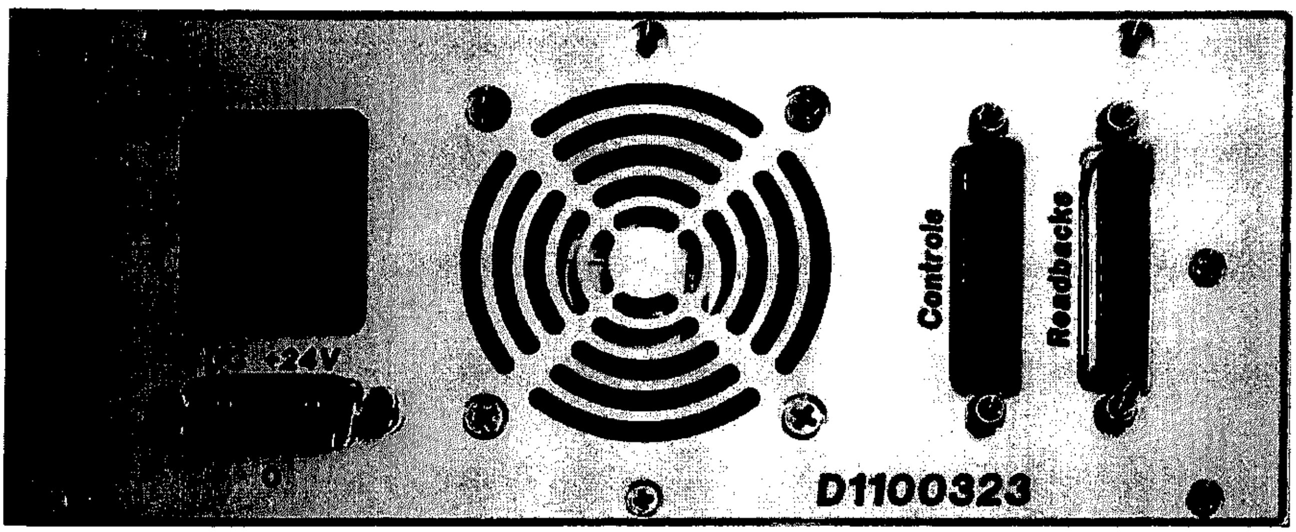
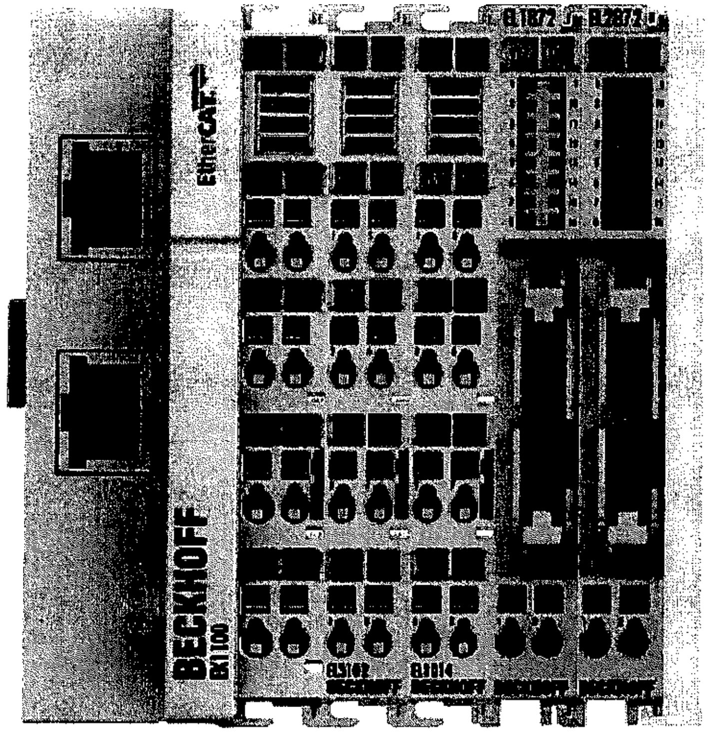


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

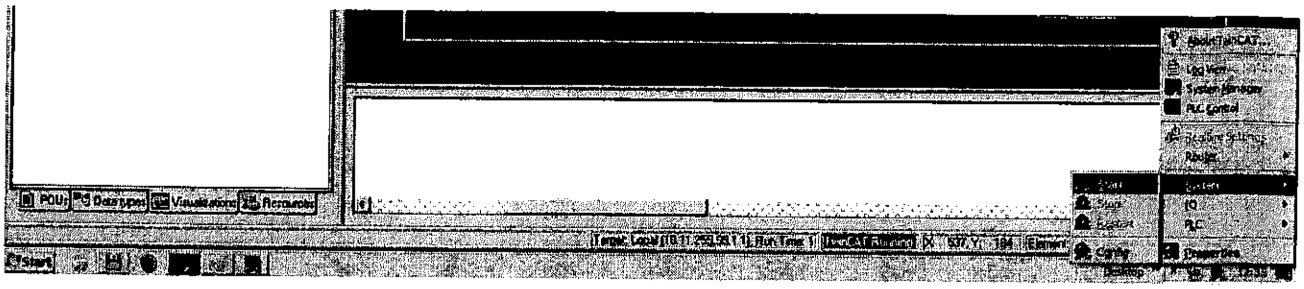
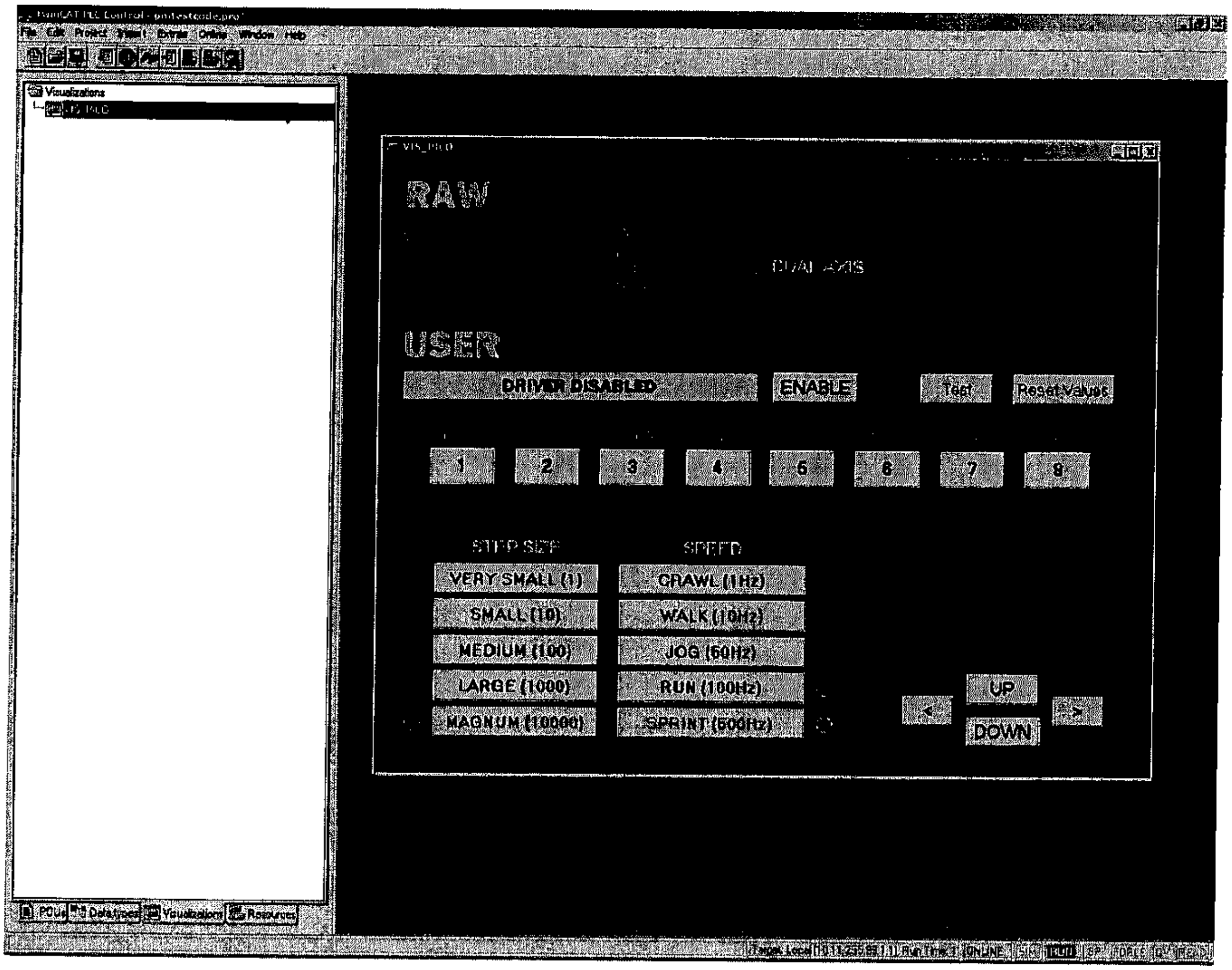


Figure 6: Step 5 of PLC controls setup



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Technical Note LIGO-T1100458-v1 08/26/11
Testing Procedure for the Picomotor Driver for Advanced LIGO
Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # ~~005~~ S1107547

Test Engineer: Zach G

Test Date: 11/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

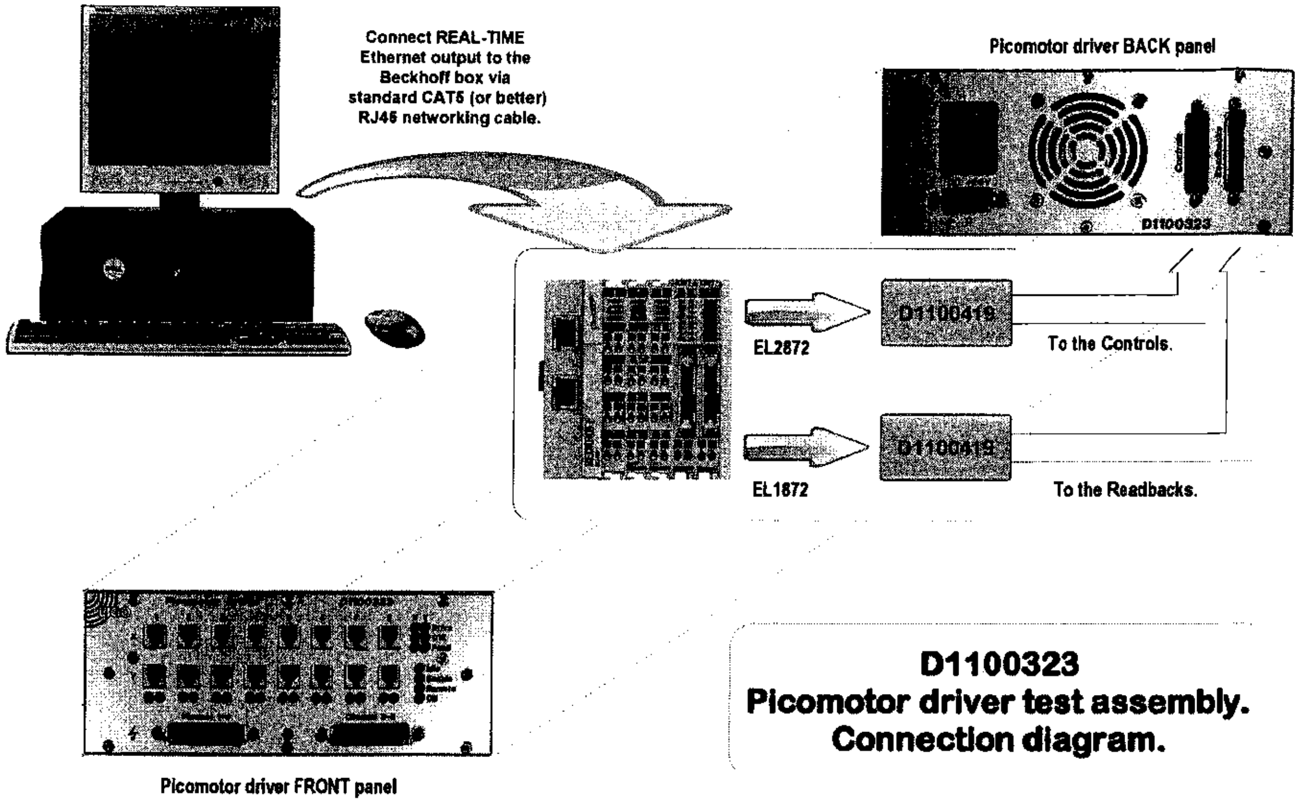


Figure 1a: A connection diagram of the picomotor setup.

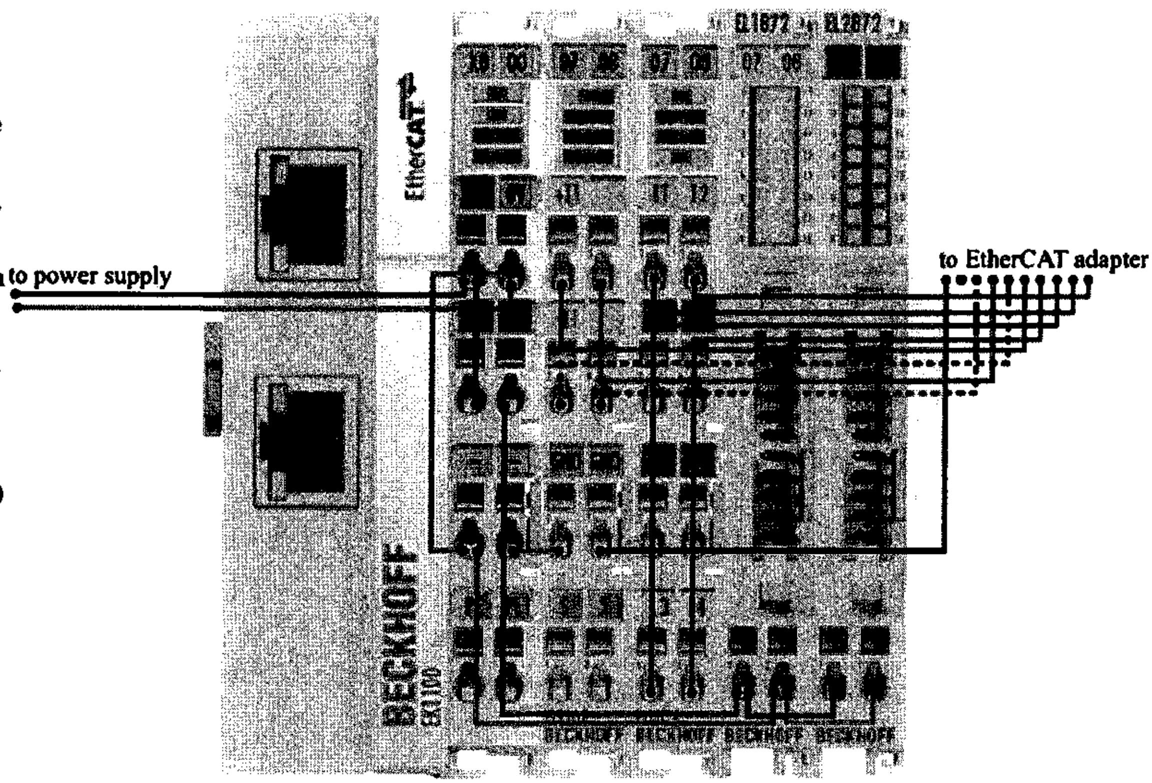


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- [✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [✓] Check that the "ON" indicator on the visualization also responds to the power switch.
- [✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [✓] Before the next step, check that the fan (rear panel) is off.
- [✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

- [✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[/] Check that the fan is running and blowing air out of the box (rear panel).

[/] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.43	27.18
2	28.49	28.40
3	29.58	29.53
4	30.57	30.65
5	31.42	31.54
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

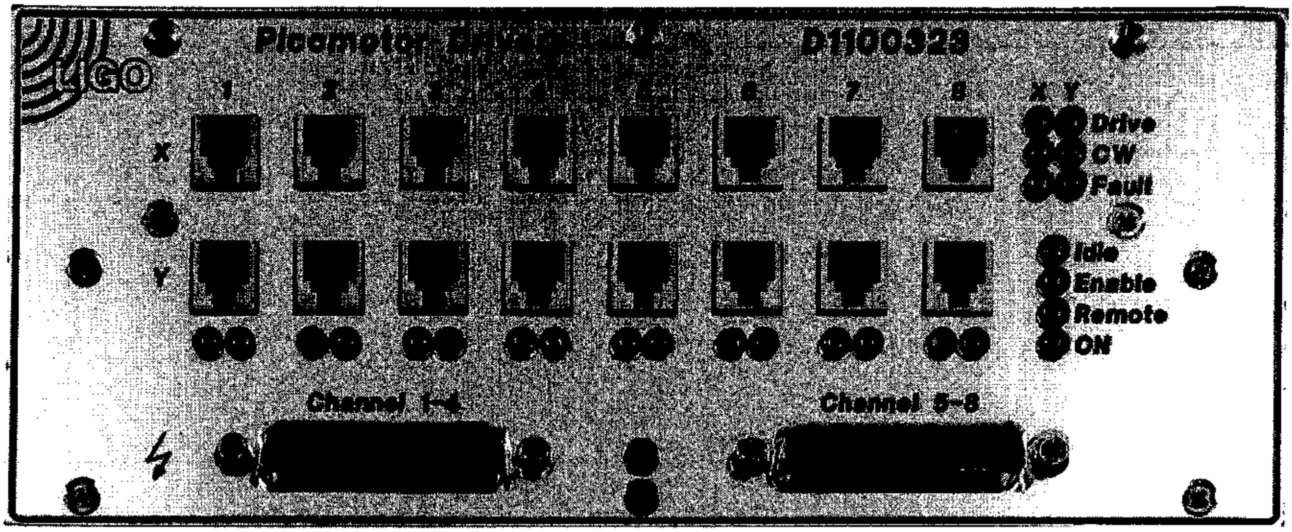


Figure 3: Picomotor driver chassis rear panel

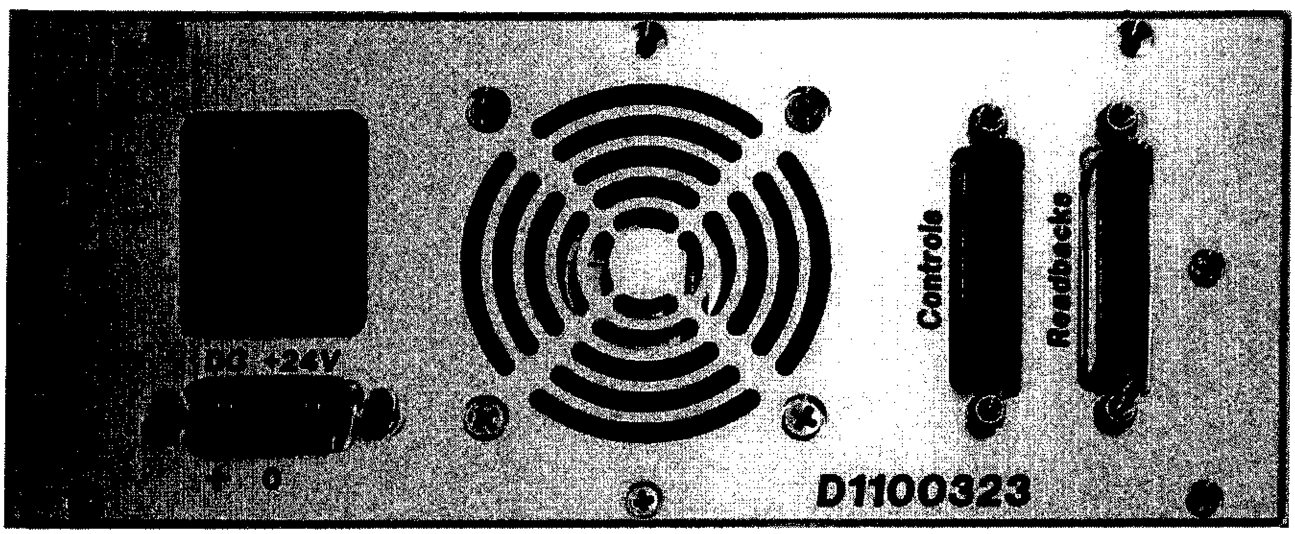
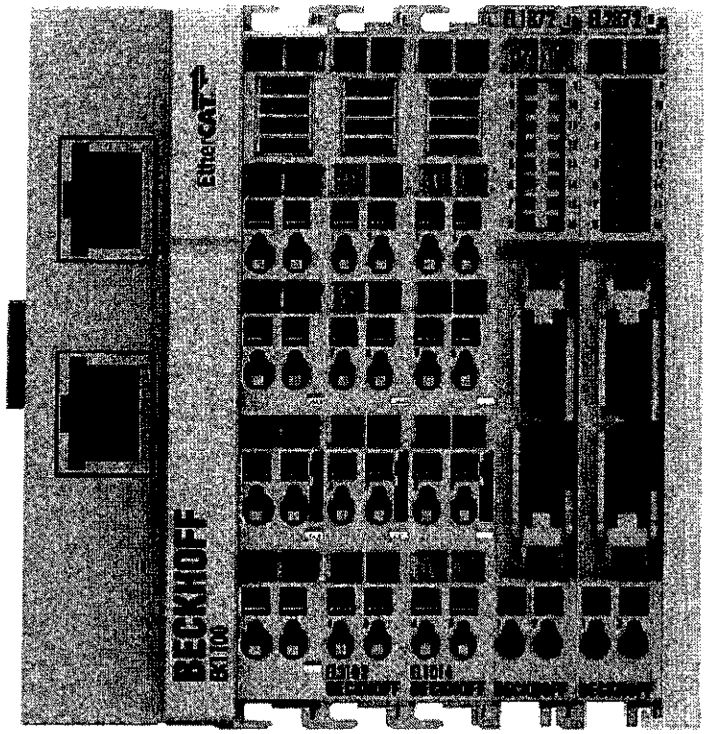


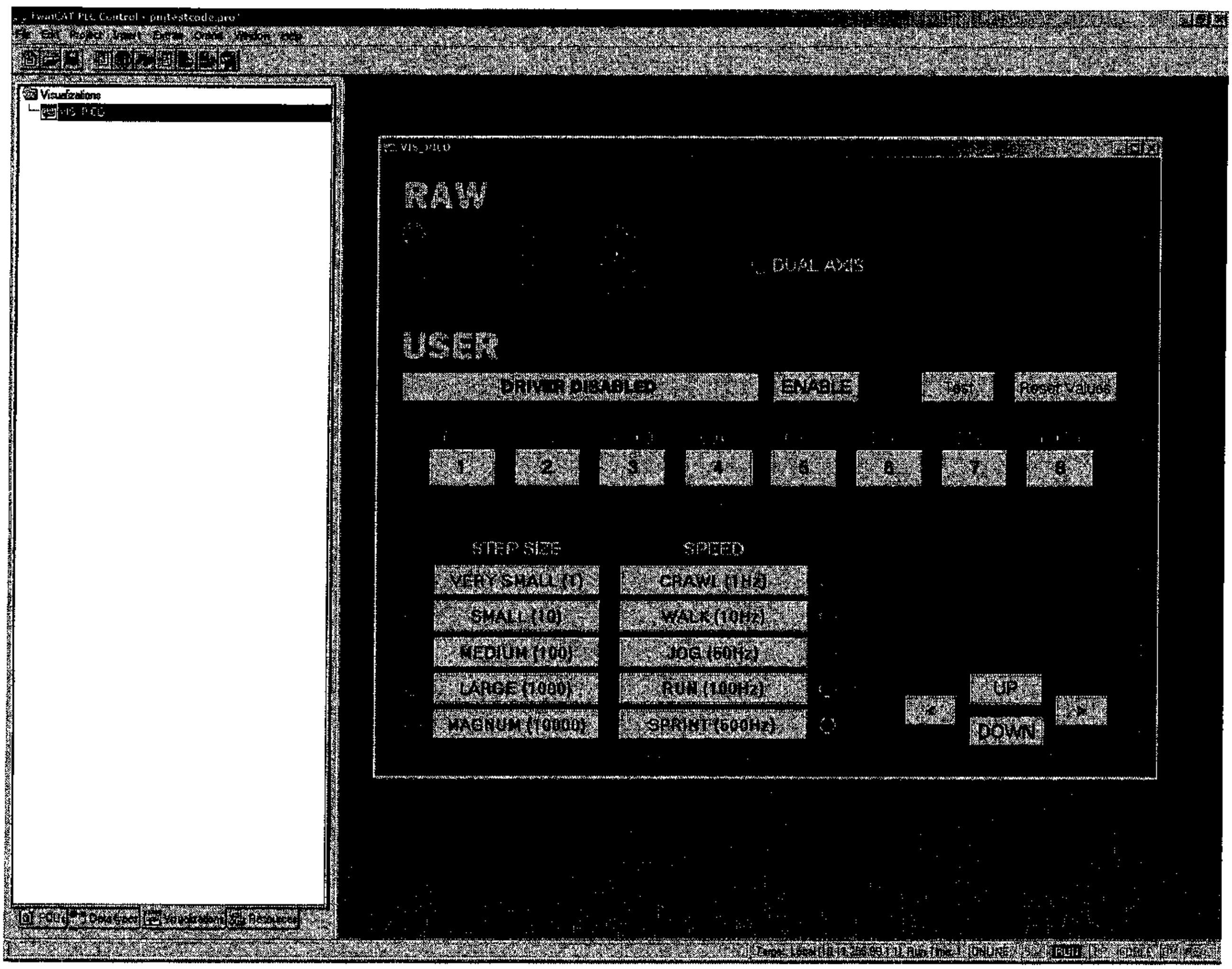
Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107548

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

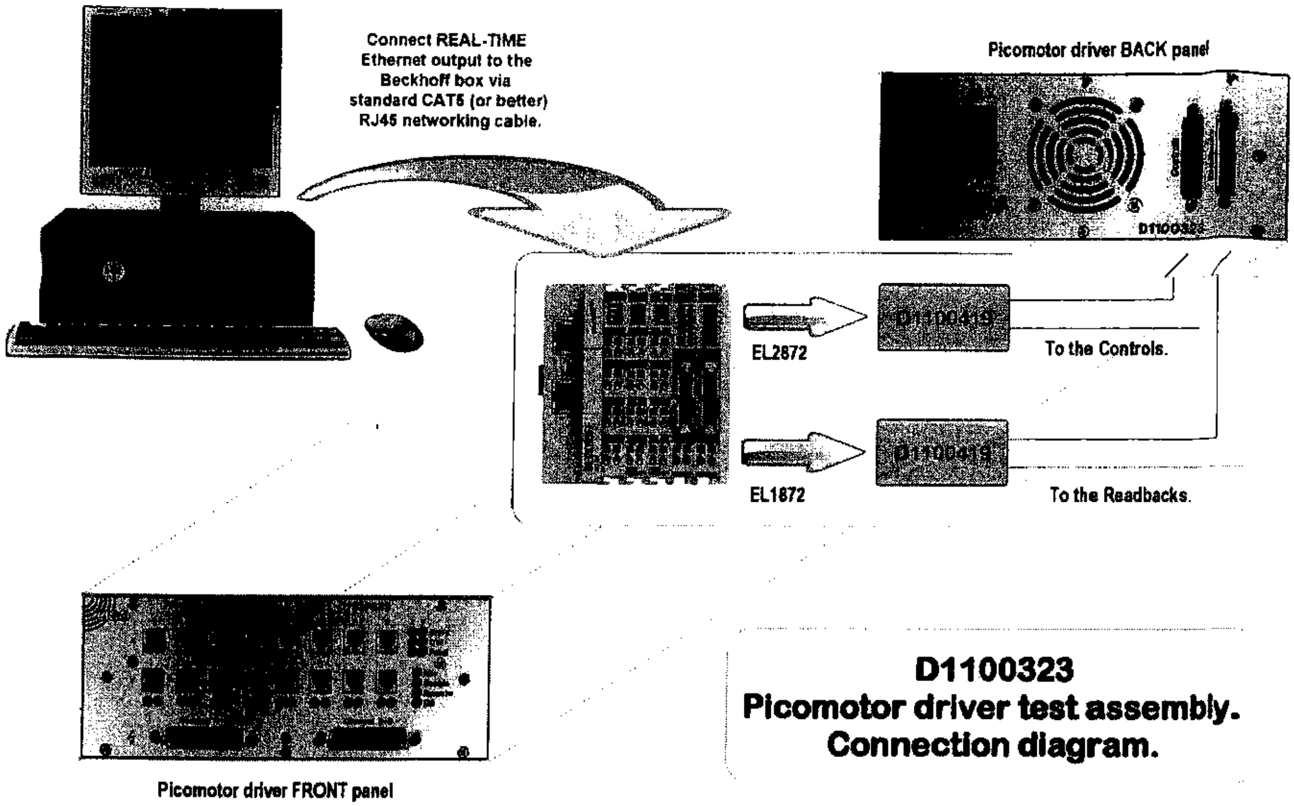


Figure 1a: A connection diagram of the picomotor setup.

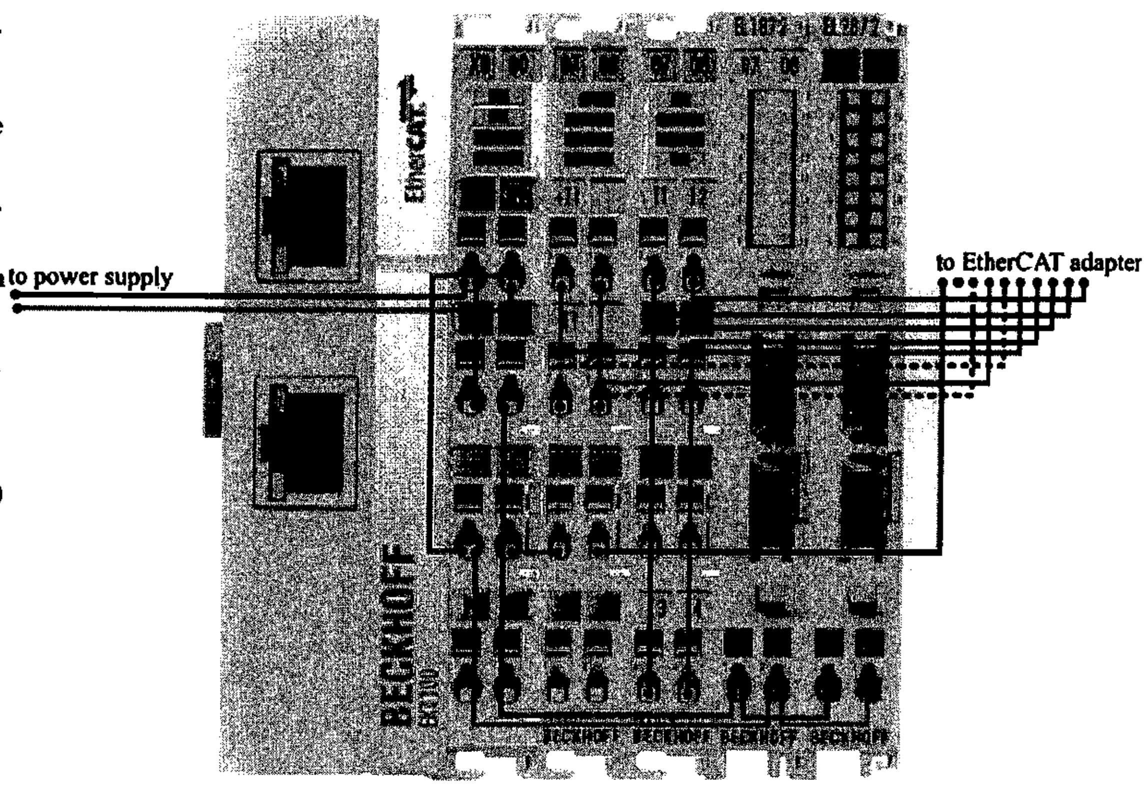


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	30.07	29.93
2	31.01	30.93
3	31.89	31.82
4	32.71	32.70
5	33.51	33.50
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

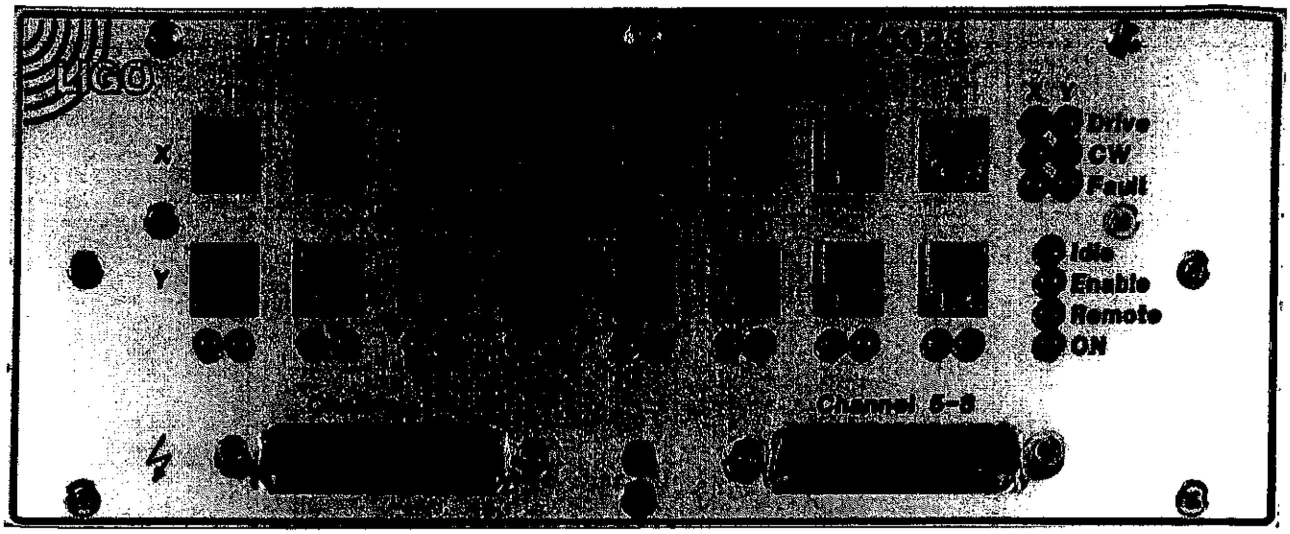


Figure 3: Picomotor driver chassis rear panel

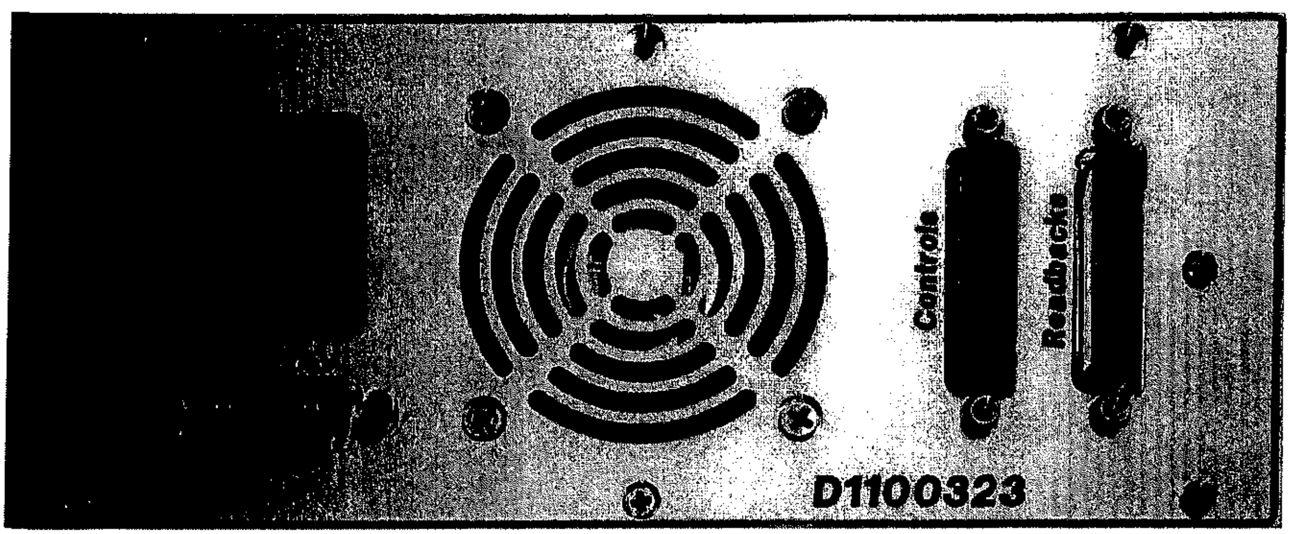
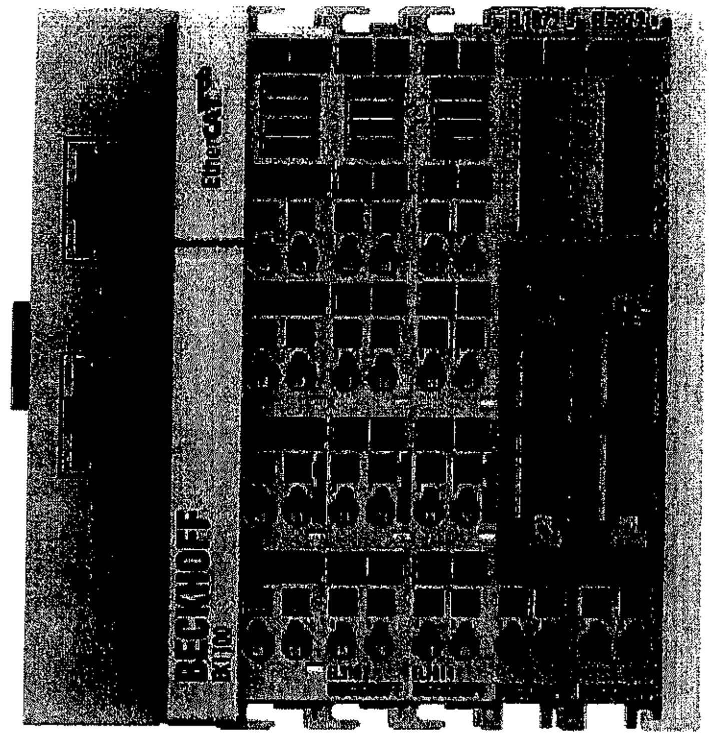


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

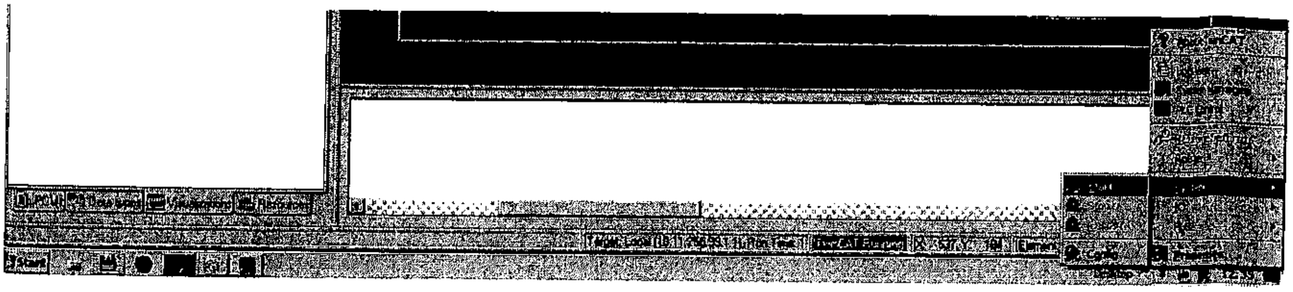
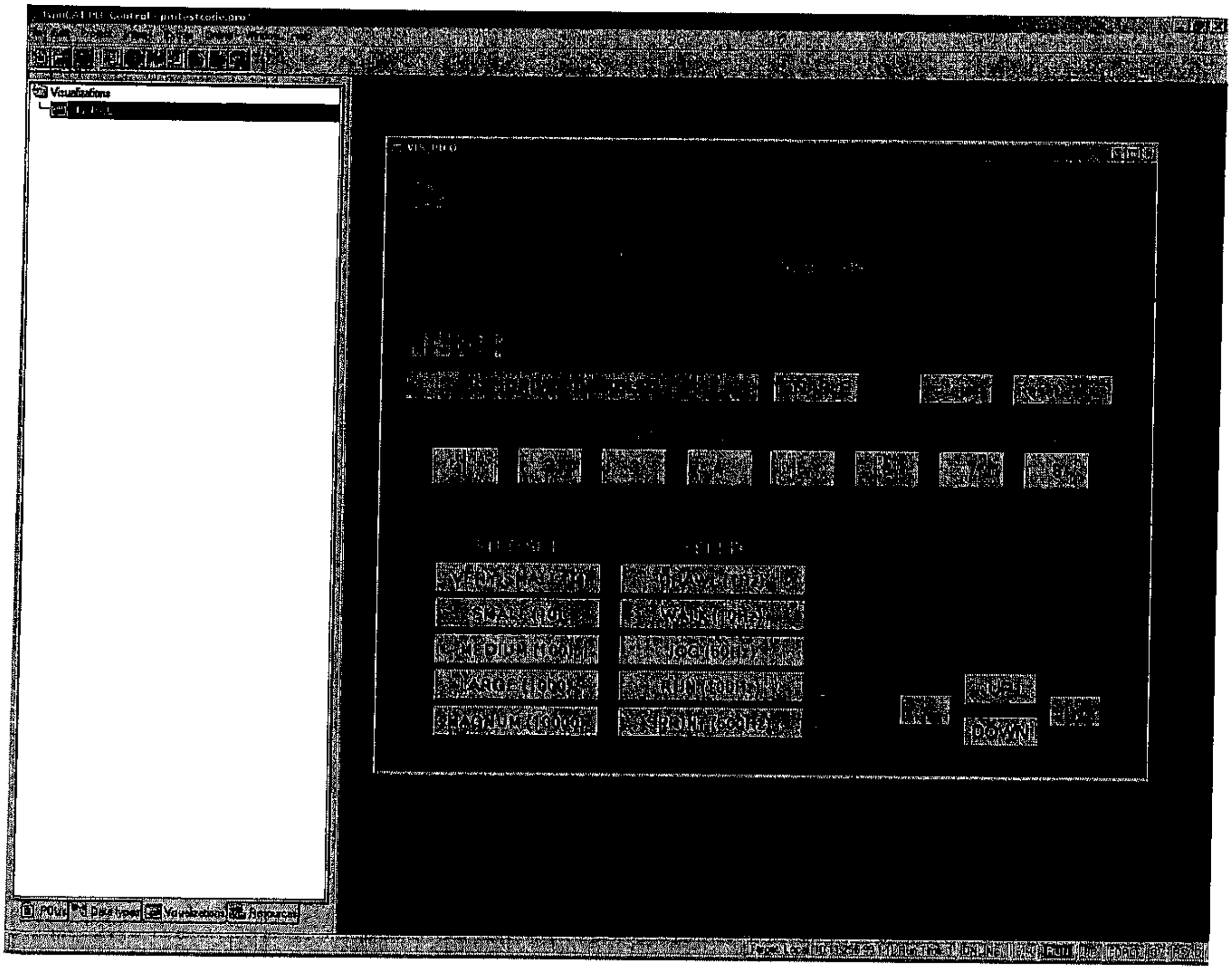


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S 1107549

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

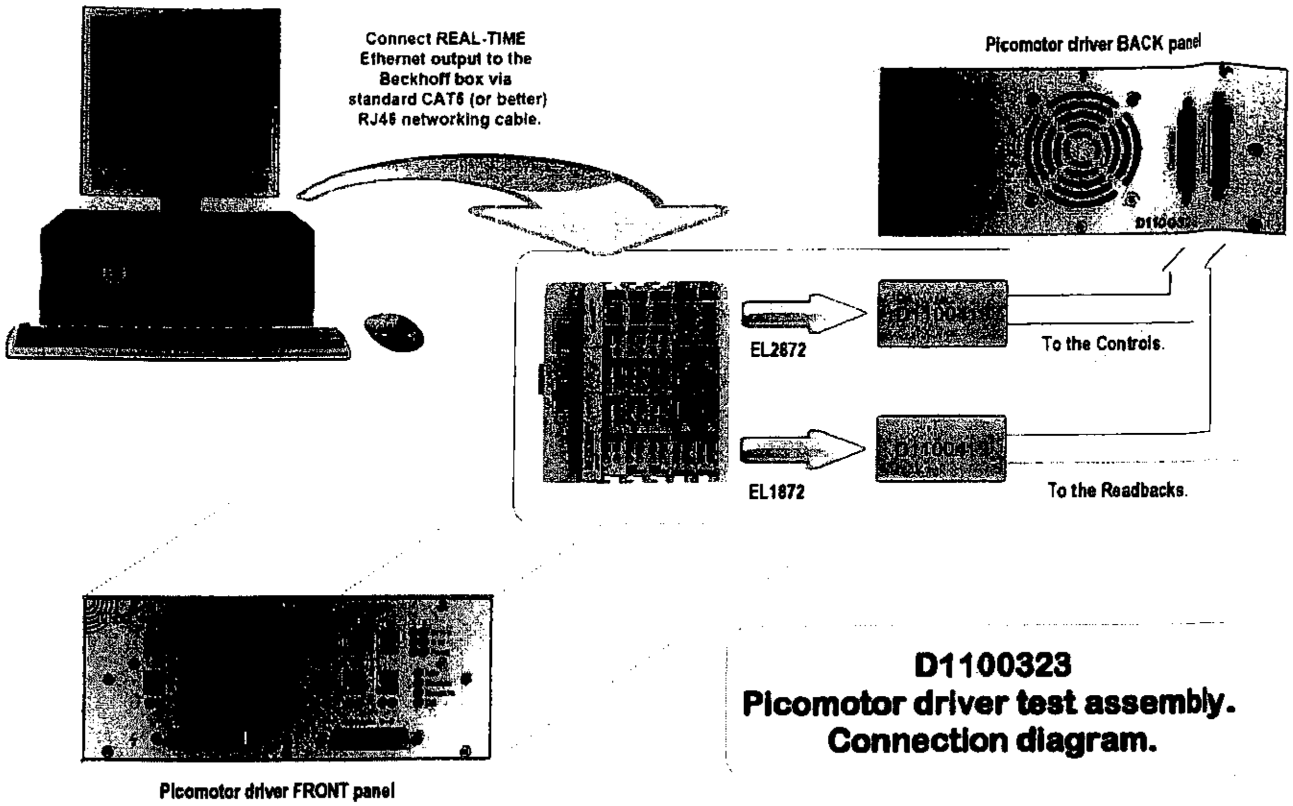
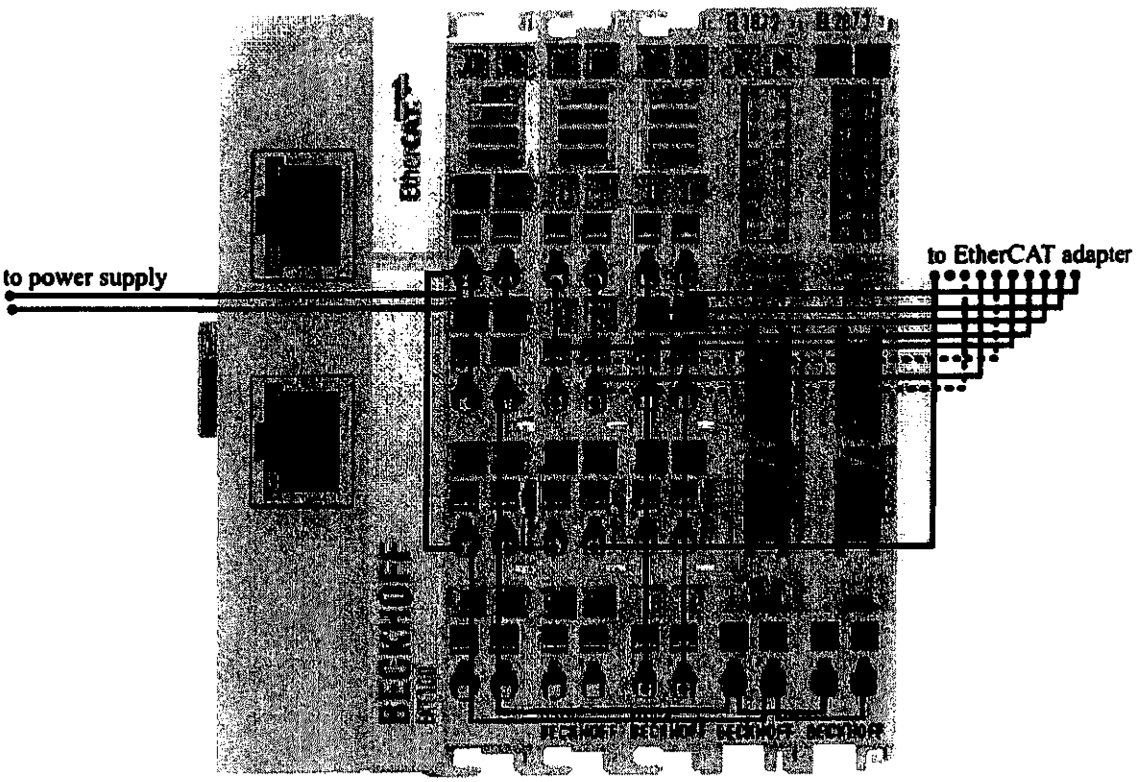


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[Y]	[Y]
MEDIUM (100)	[Y]	[Y]
MAGNUM (10000)	[Y]	[Y]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[Y]	[Y]
JOG (50Hz)	[Y]	[Y]
SPRINT (500Hz)	[Y]	[Y]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	26.90	28.90
2	27.98	29.65
3	29.12	30.87
4	30.05	31.83
5	30.99	32.79
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

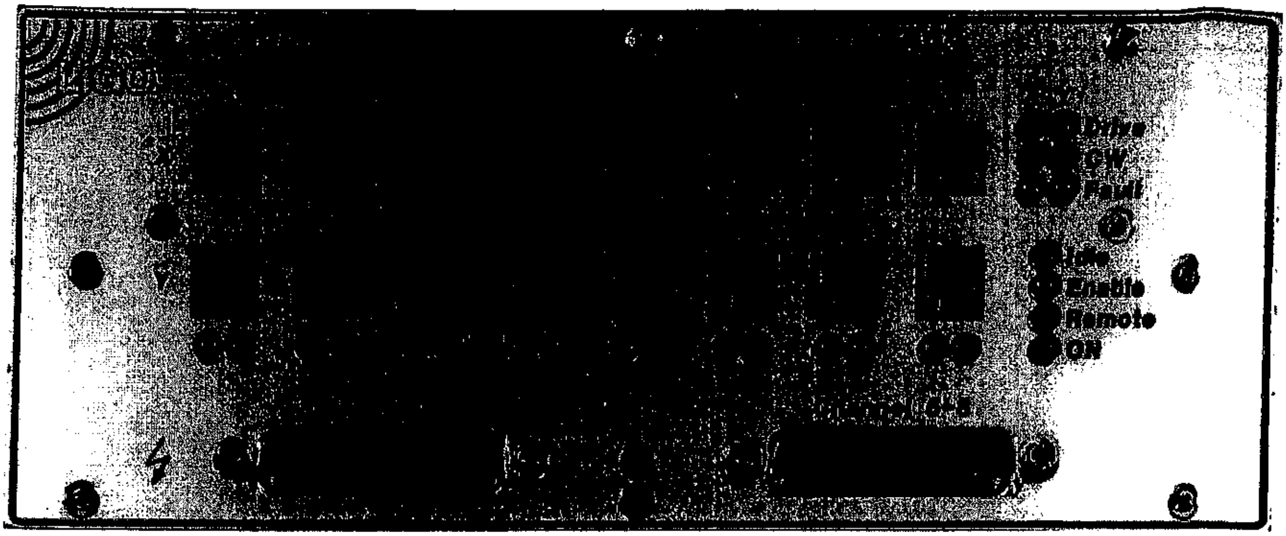


Figure 3: Picomotor driver chassis rear panel

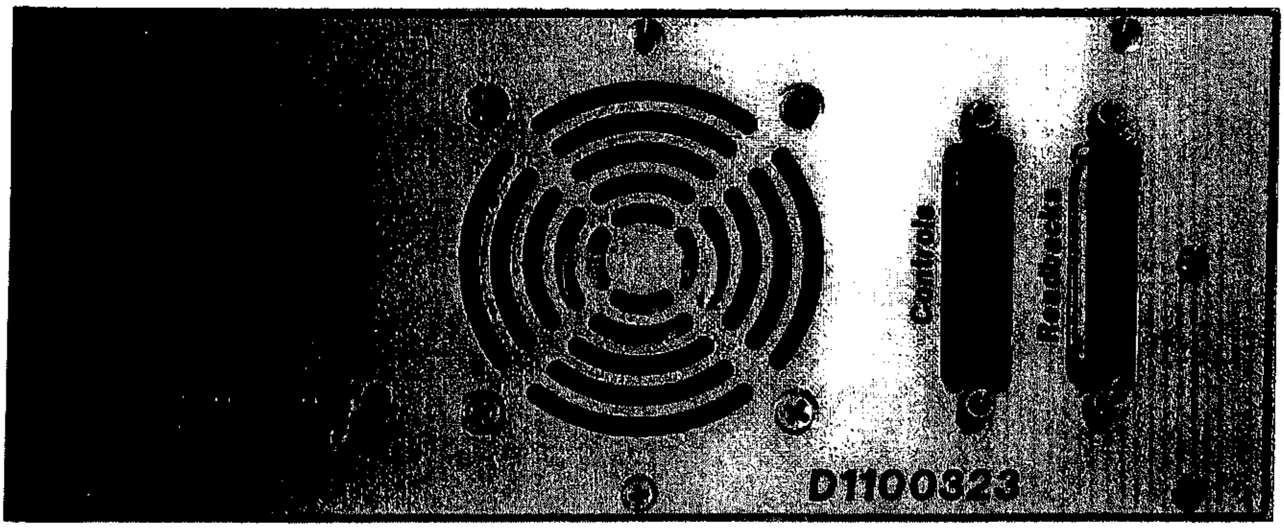
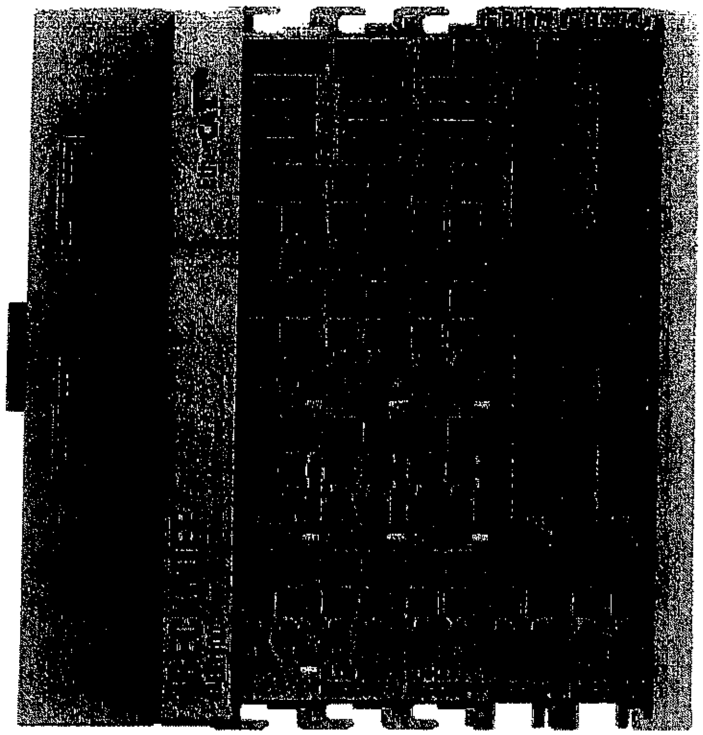


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

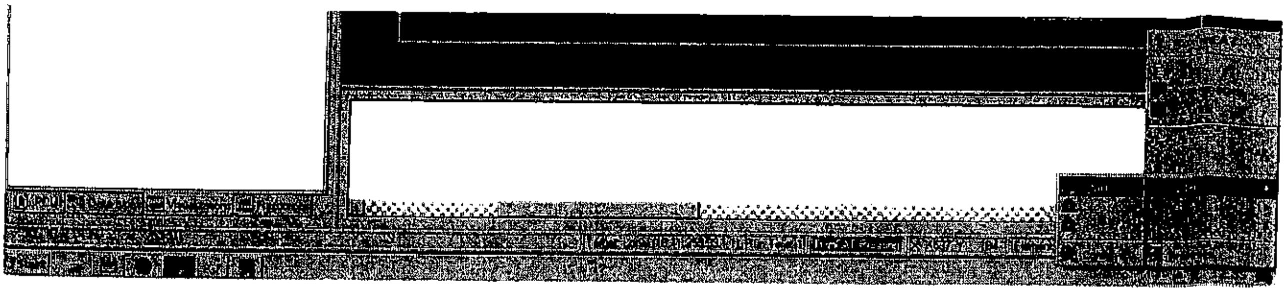
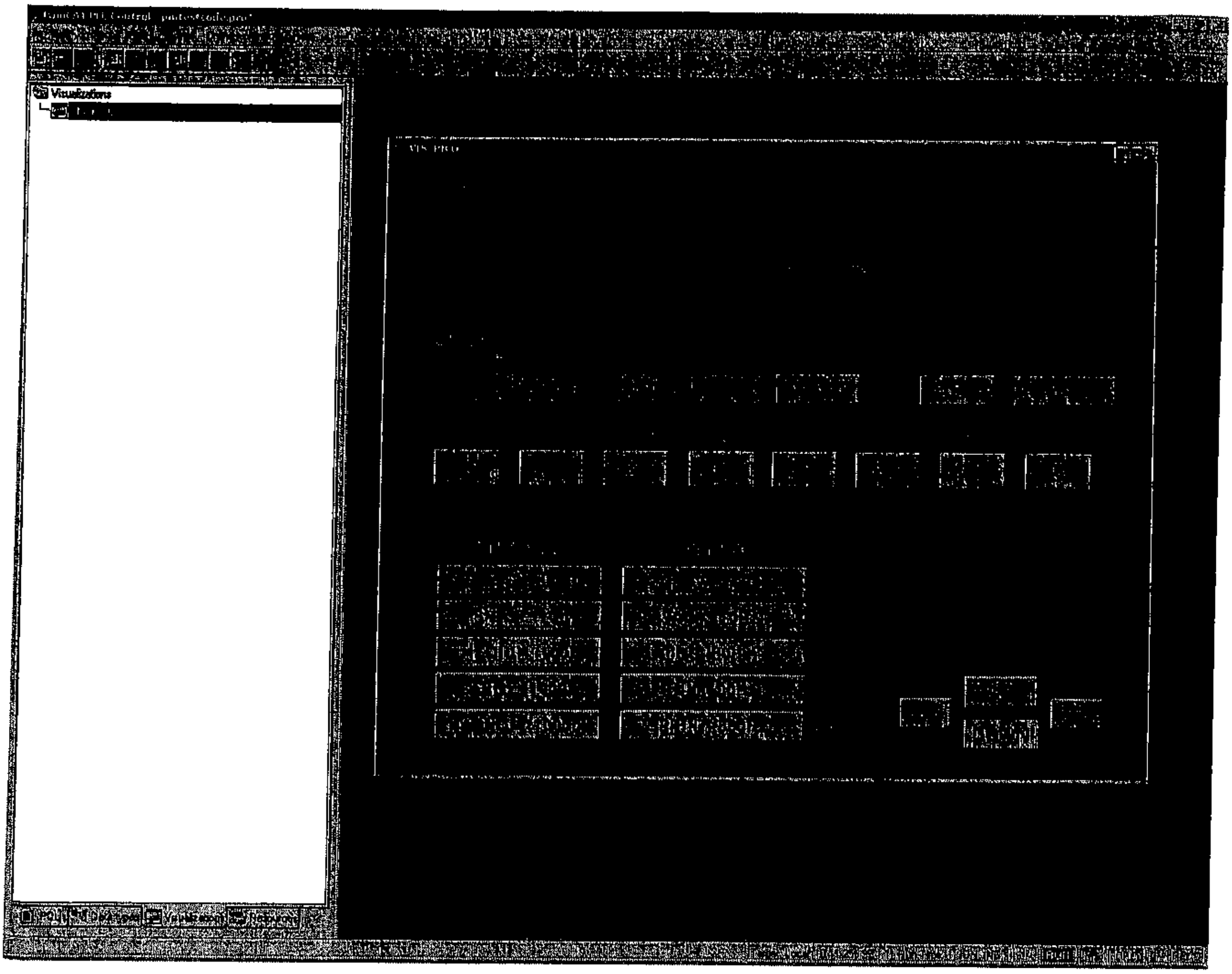


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107550

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

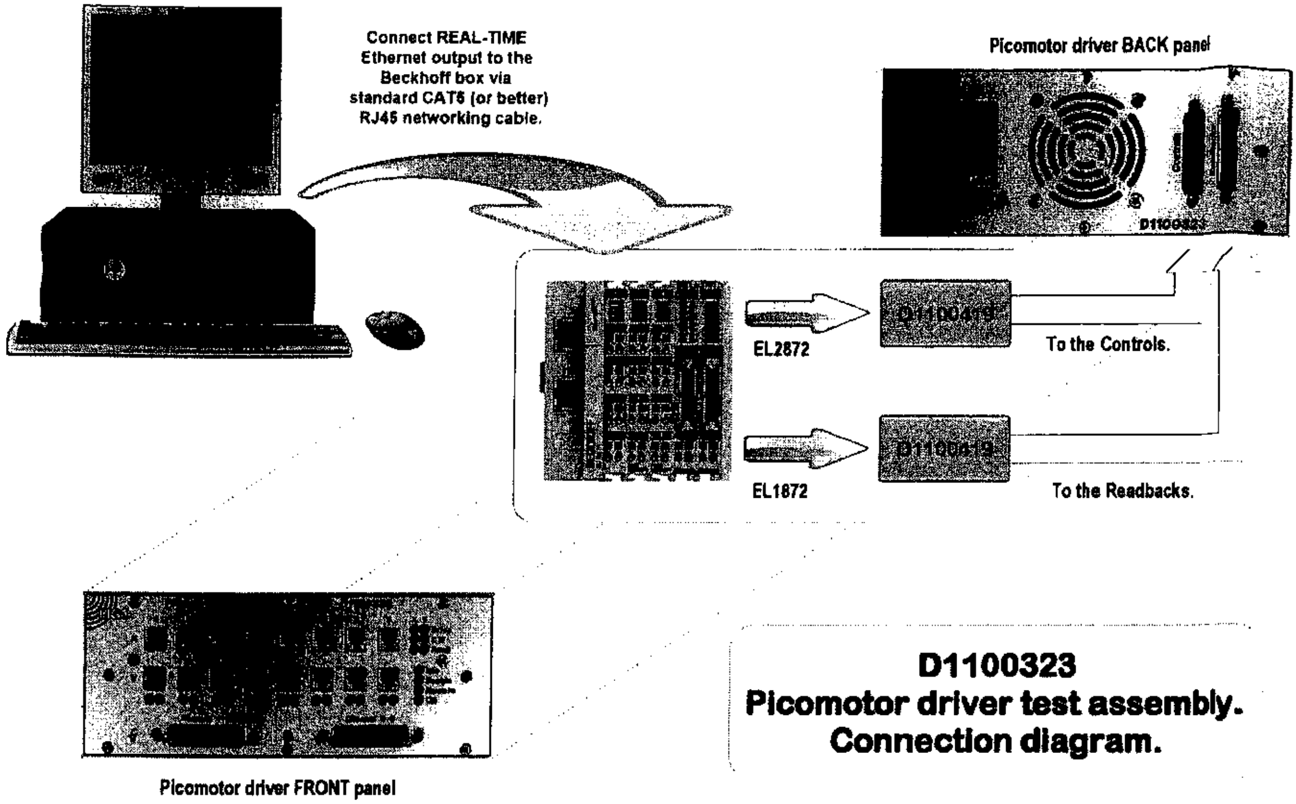
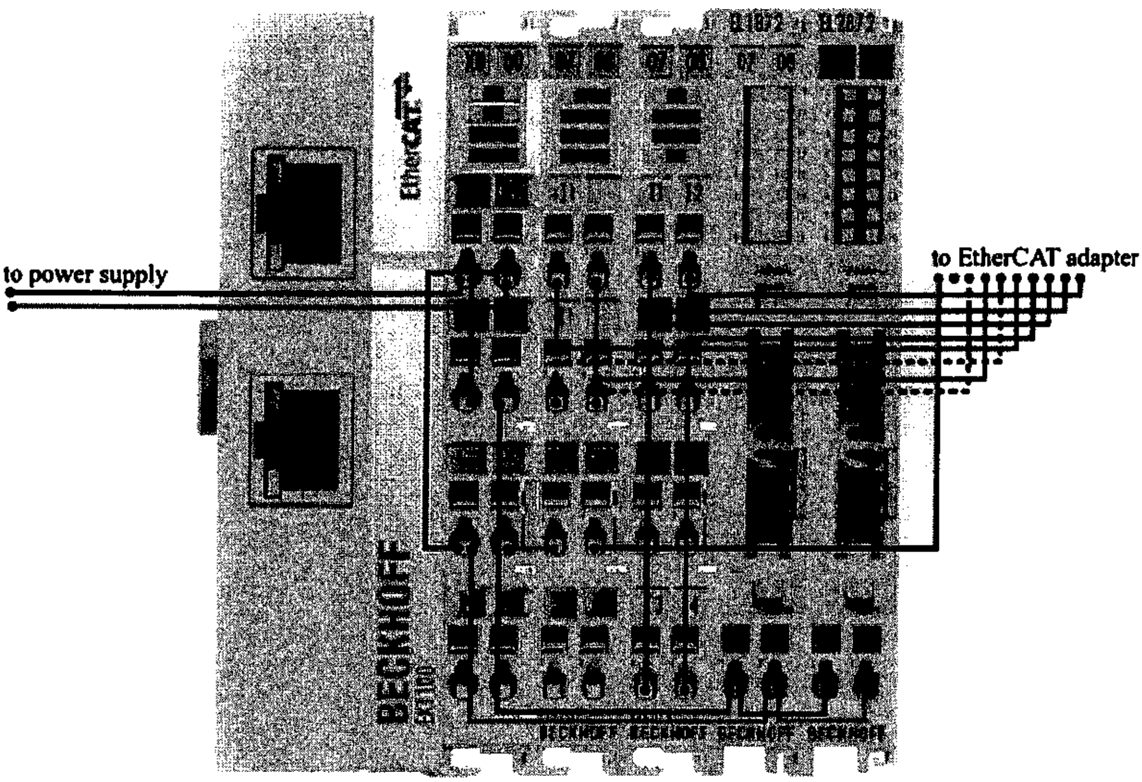


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- [✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [✓] Check that the "ON" indicator on the visualization also responds to the power switch.
- [✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [✓] Before the next step, check that the fan (rear panel) is off.
- [✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

- [✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.87	28.51
2	27.14	29.97
3	28.20	31.22
4	29.33	32.41
5	30.23	33.45
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

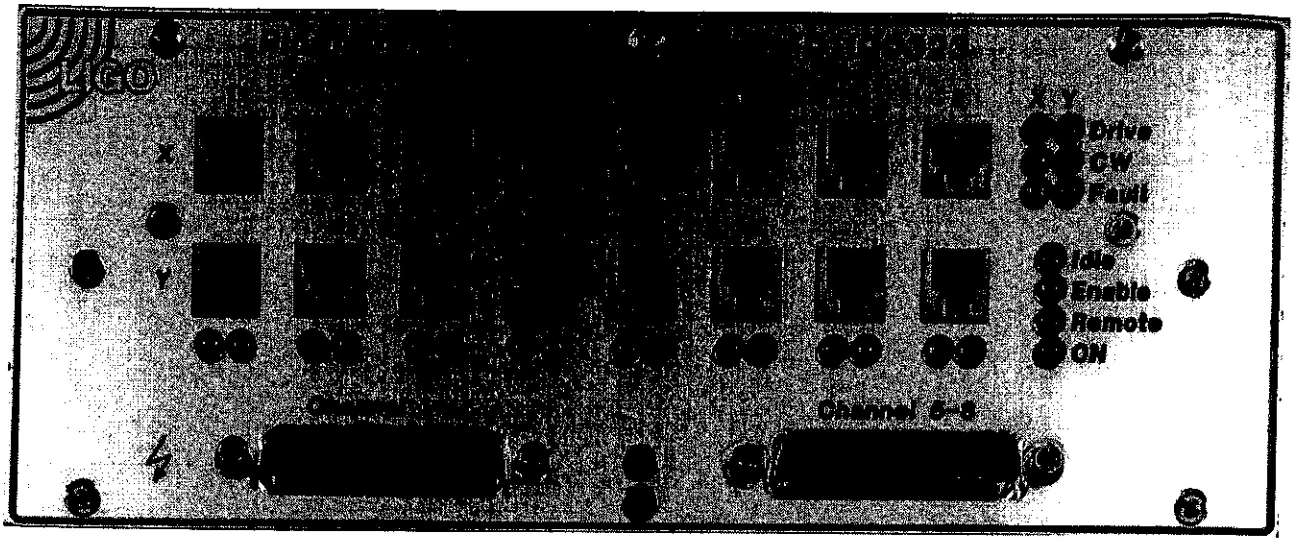


Figure 3: Picomotor driver chassis rear panel

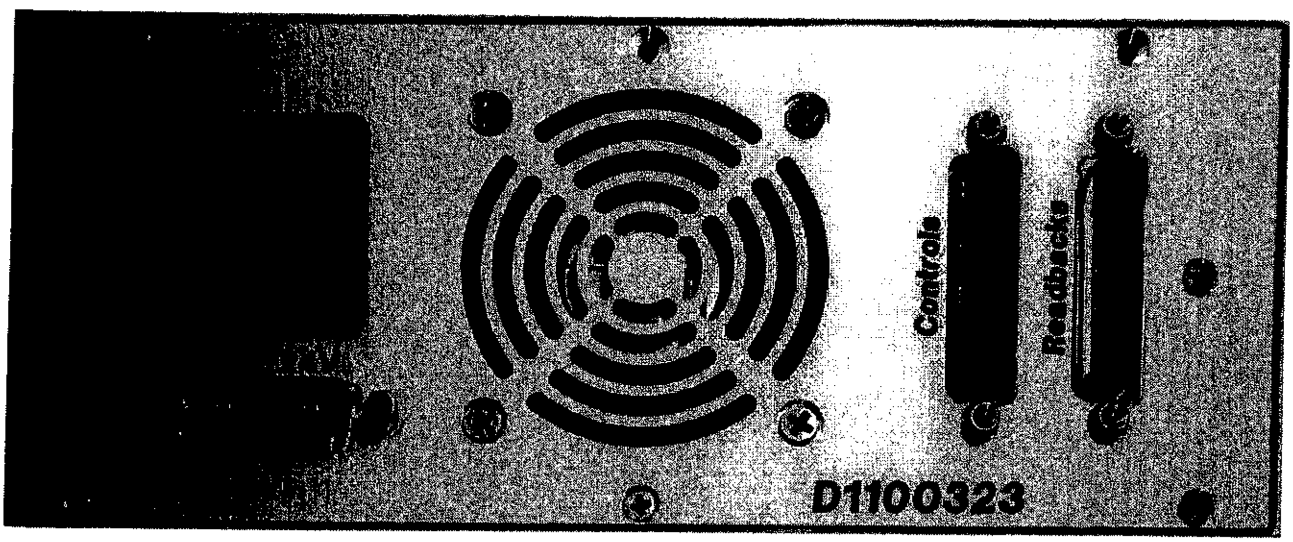
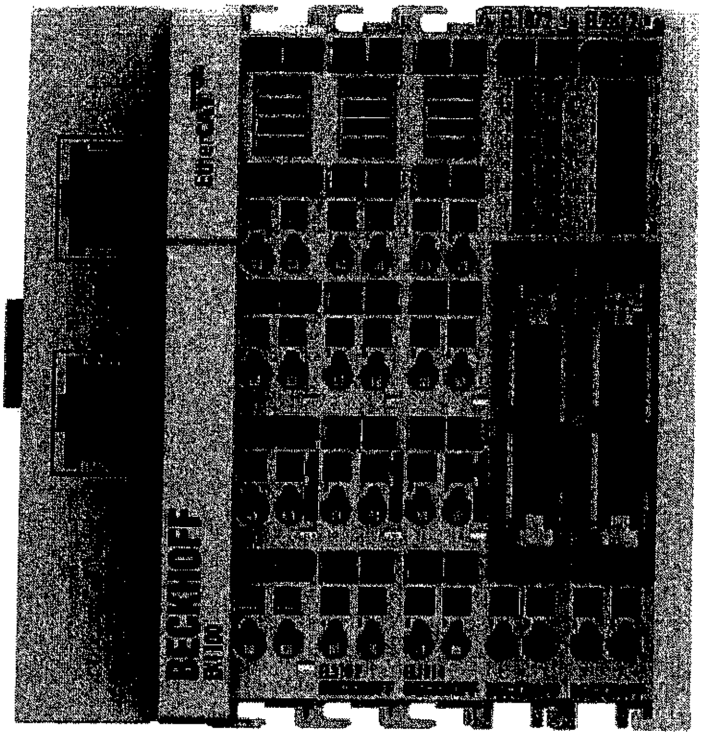


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

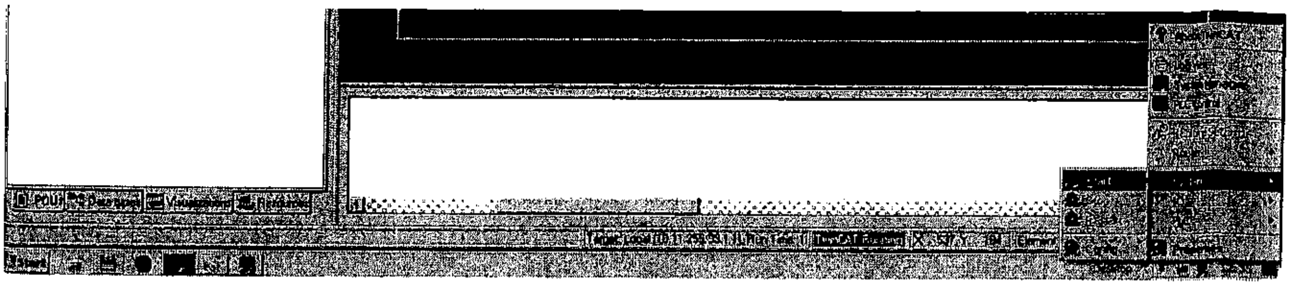
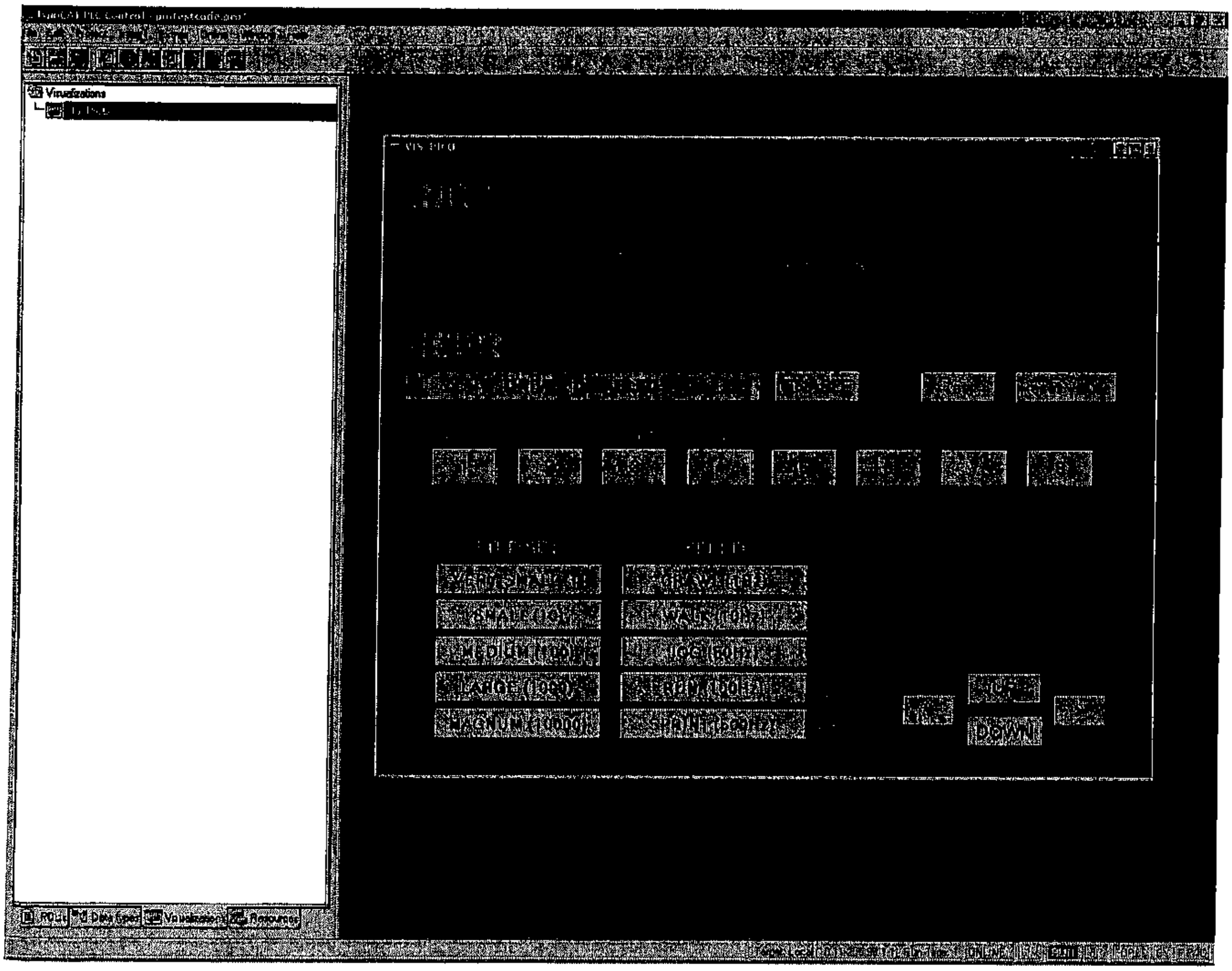


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # 31107551

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

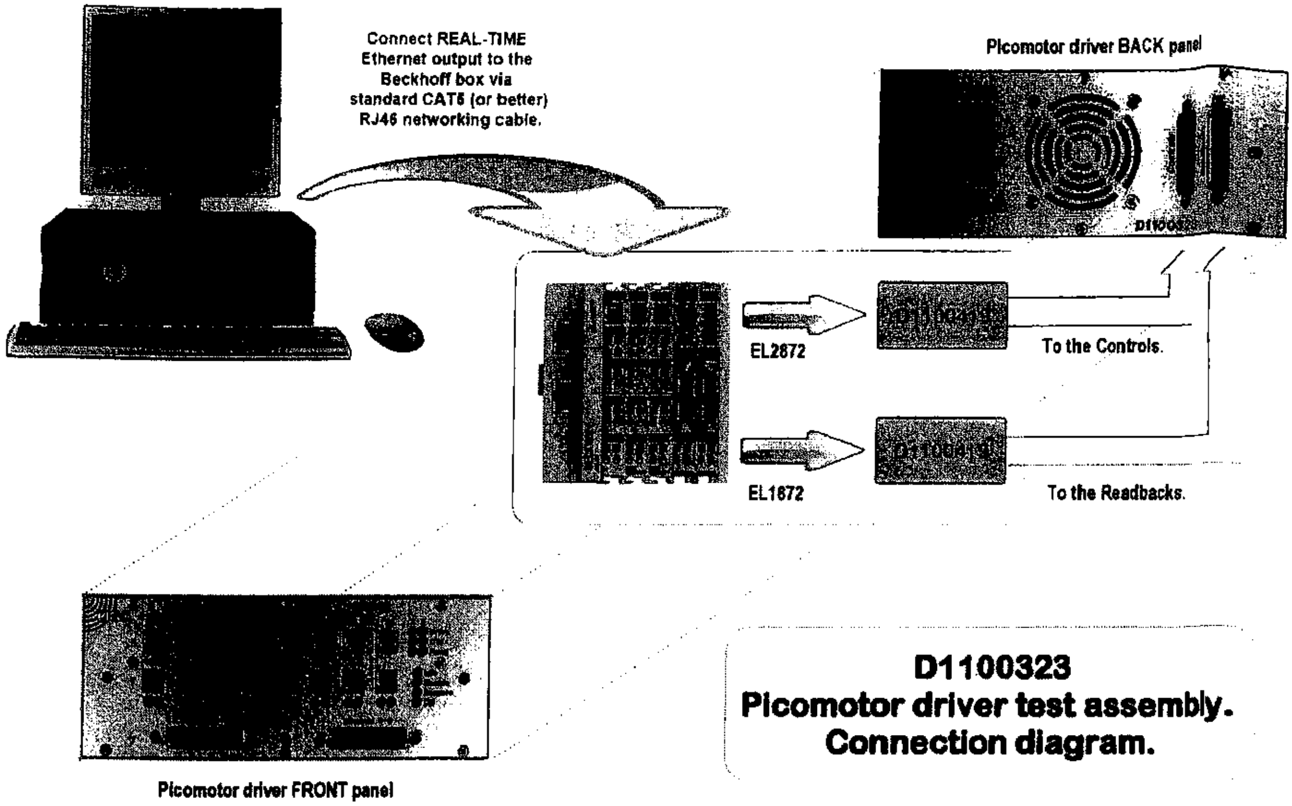
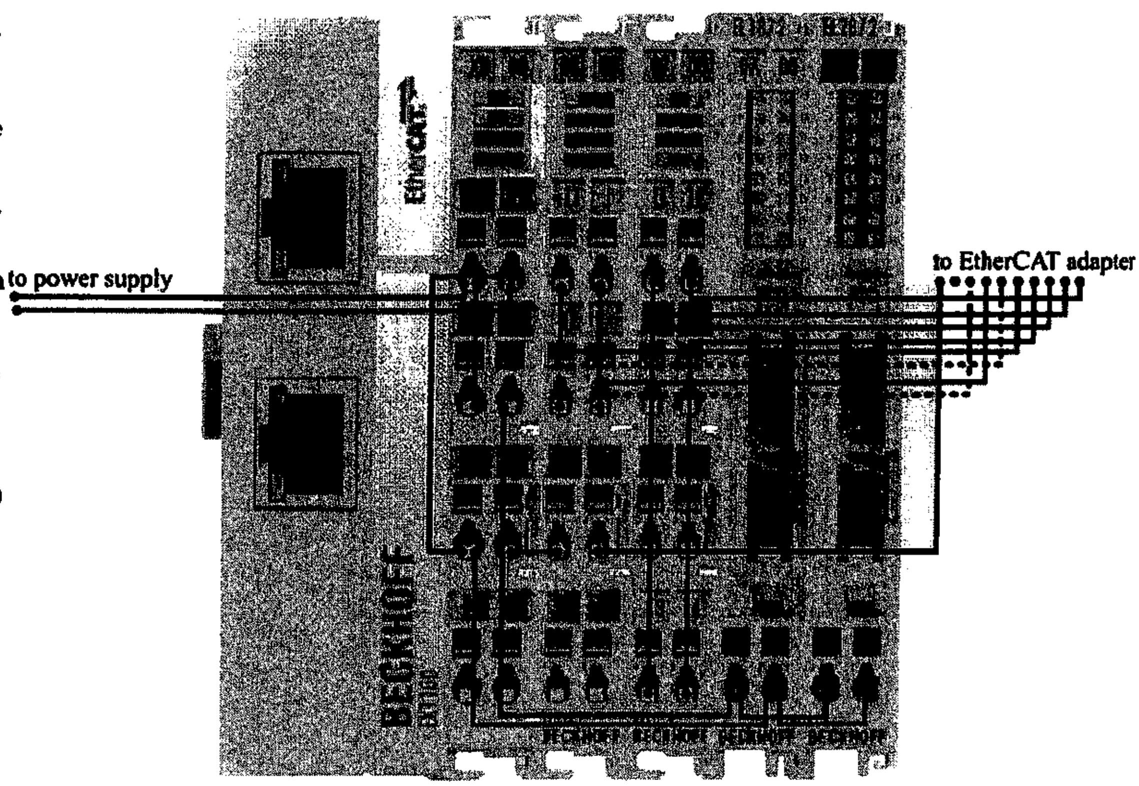


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.25	26.20
2	26.43	27.65
3	27.57	28.83
4	28.72	29.98
5	29.65	31.62
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

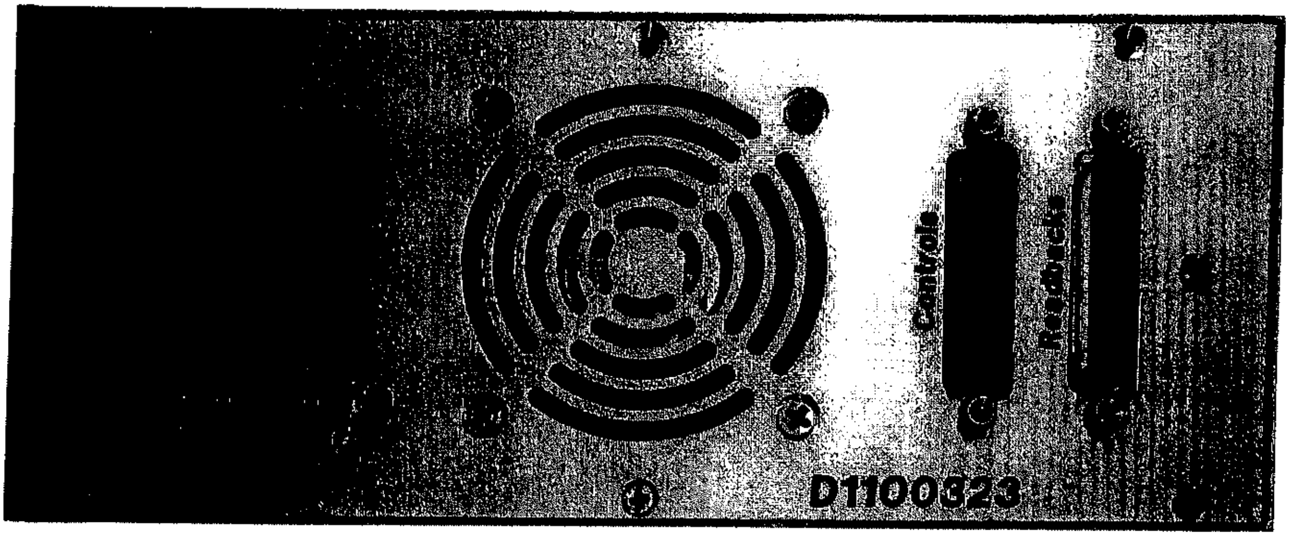
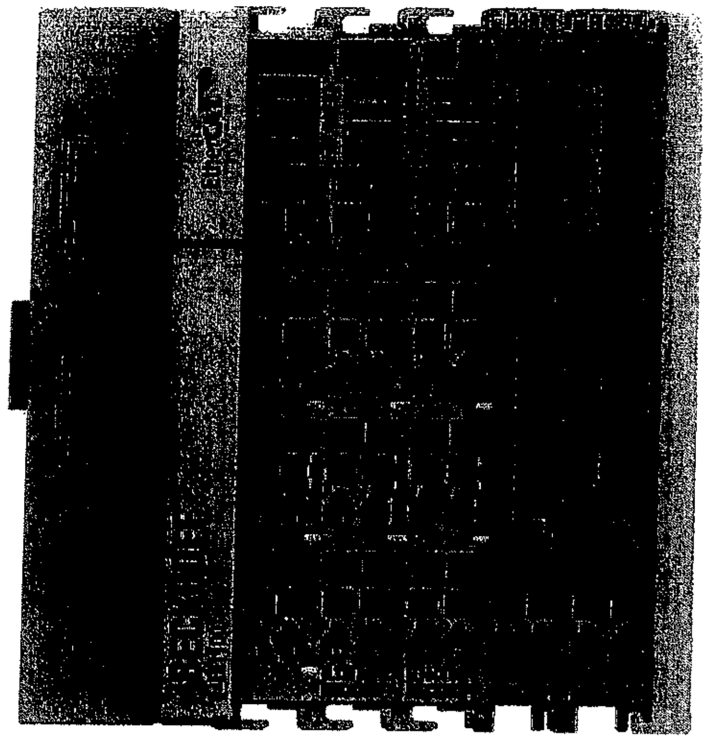


Figure 4: EtherCAT configuration



LSC

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

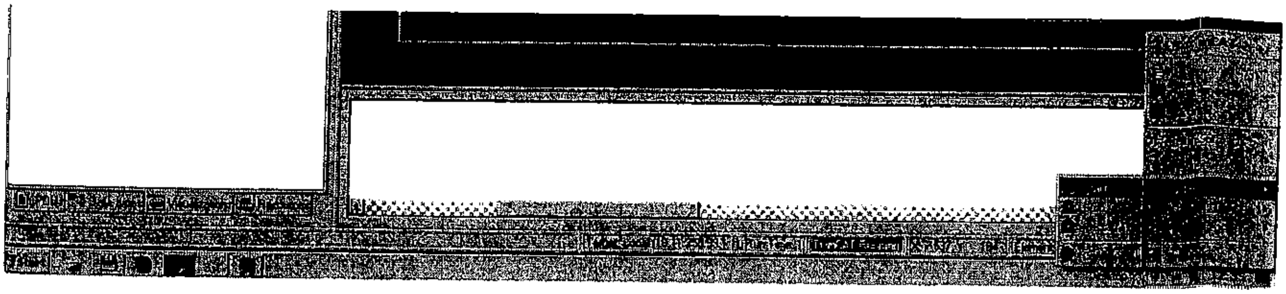
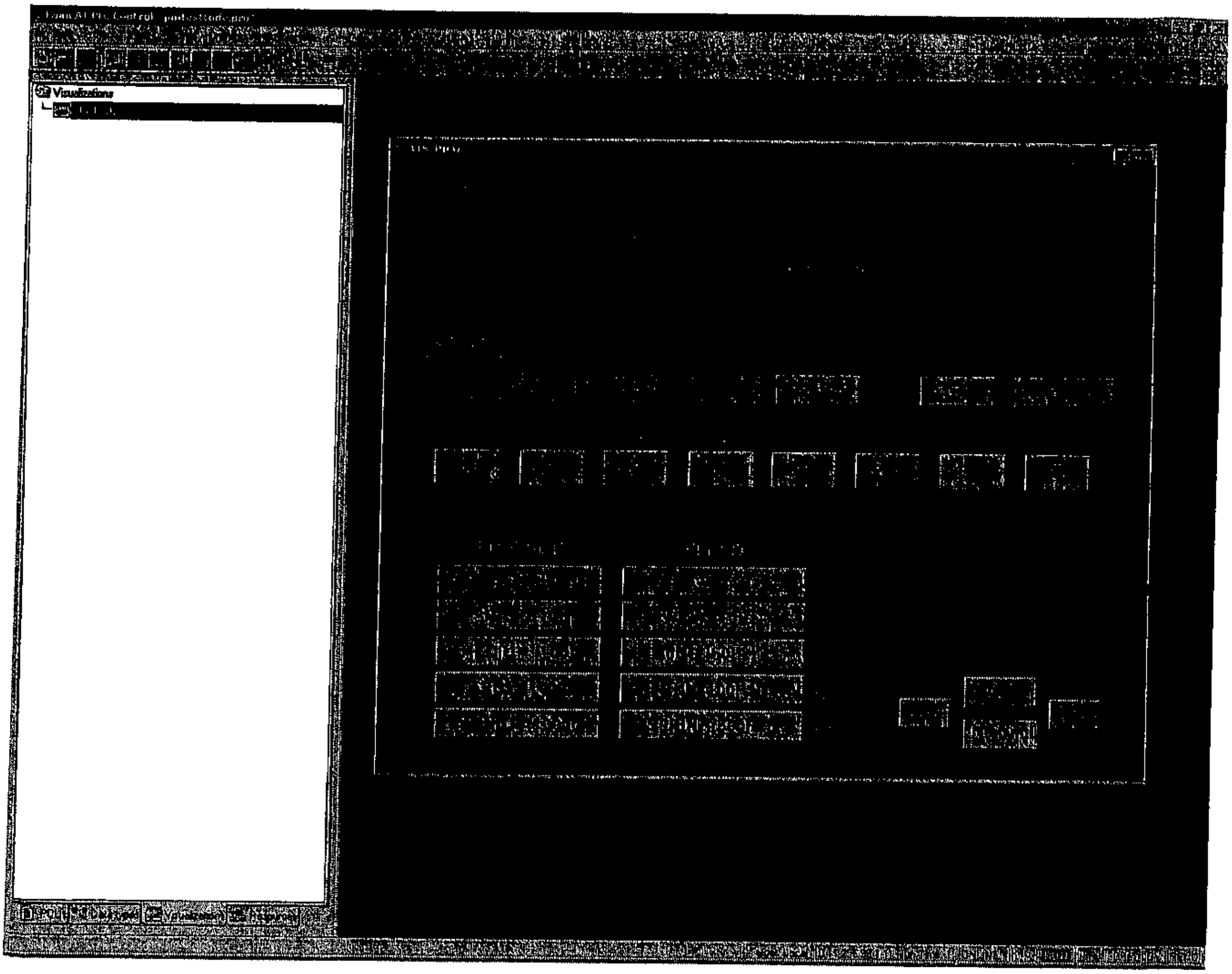


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107552

Test Engineer: Zach C

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

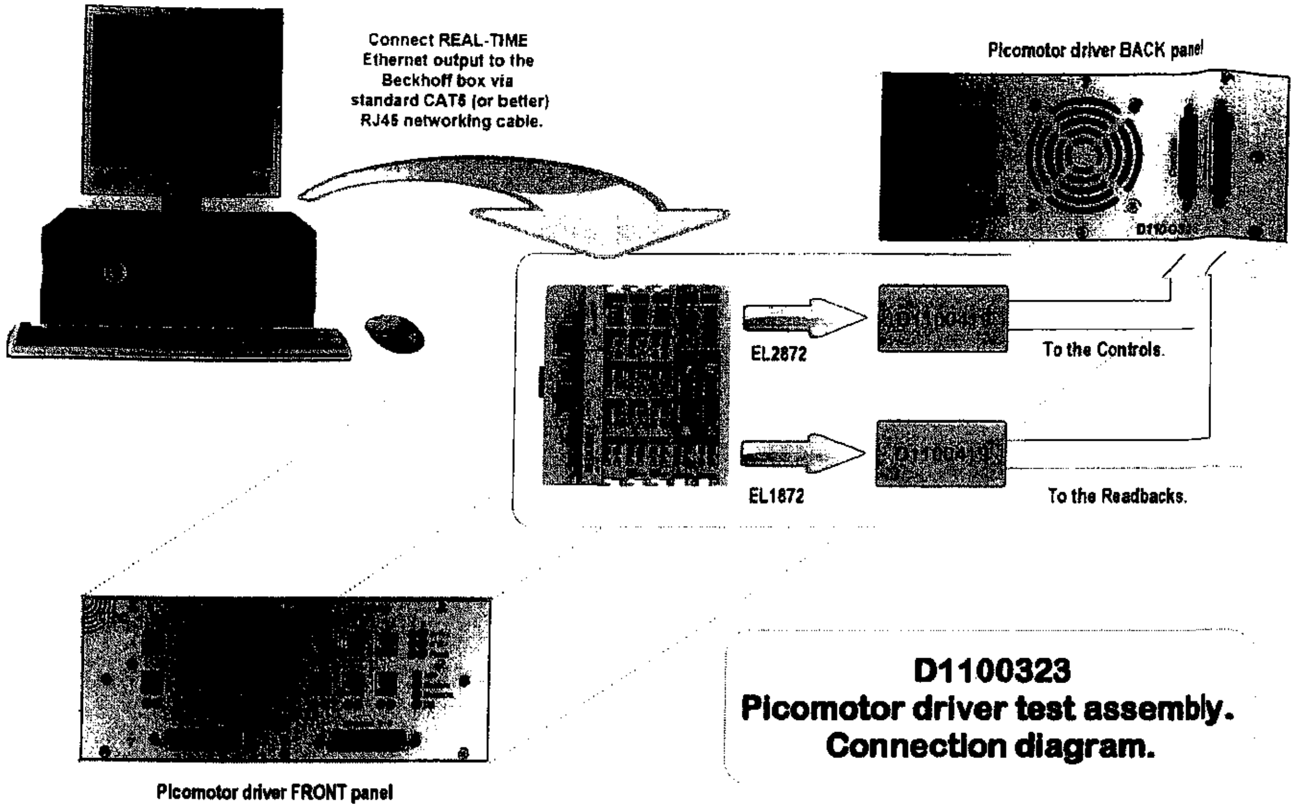
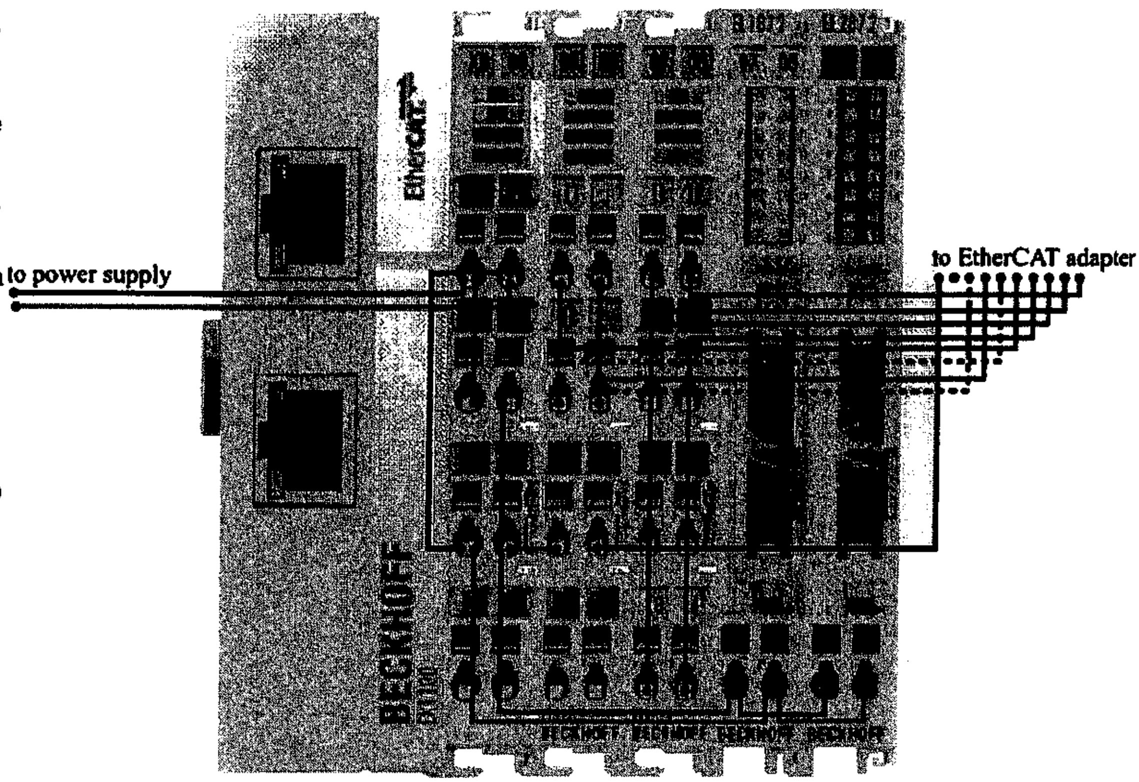


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	29.33	27.19
2	30.32	28.29
3	31.46	29.43
4	32.37	30.31
5	33.30	31.28
Check if passed:	[✓	[✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

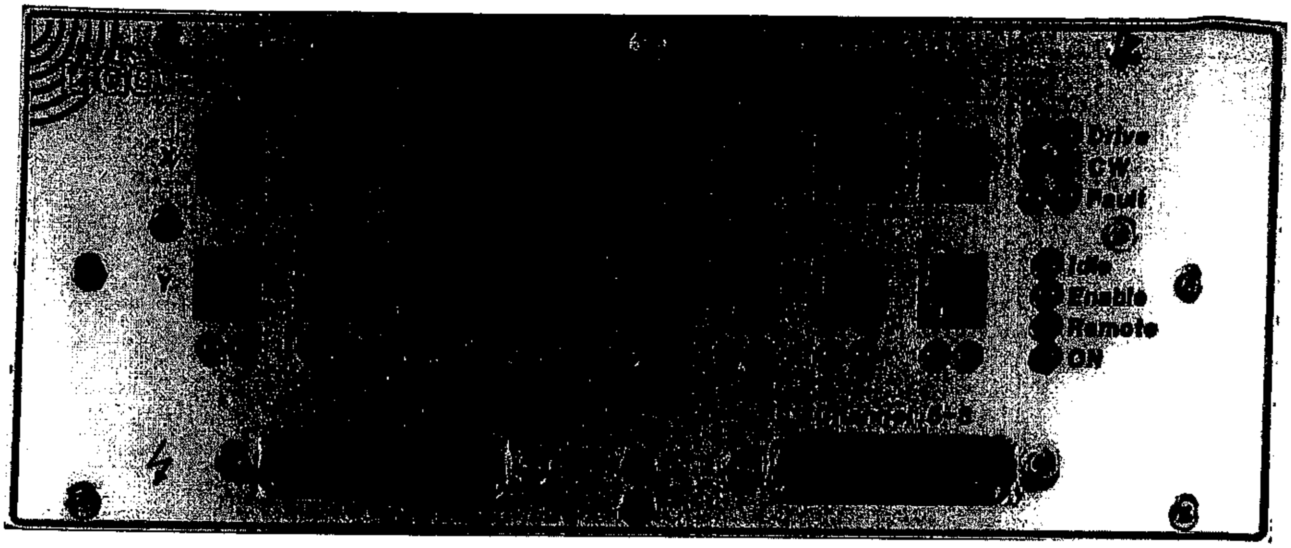


Figure 3: Picomotor driver chassis rear panel

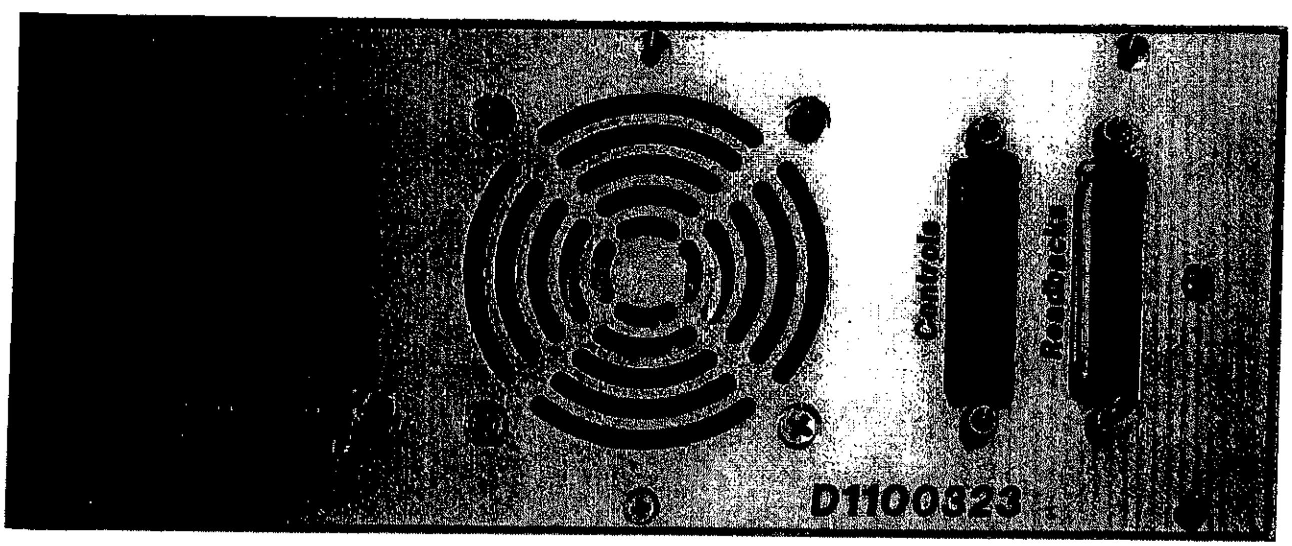
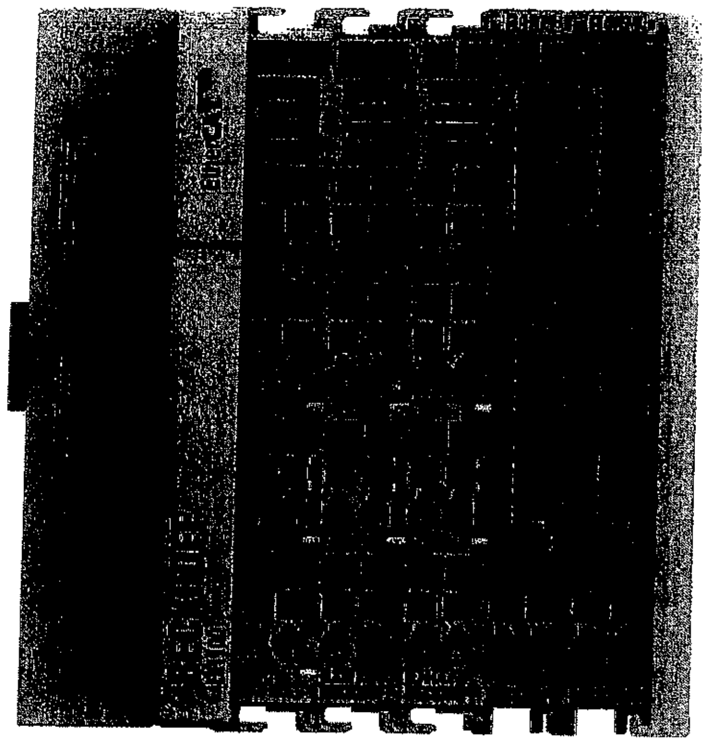


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

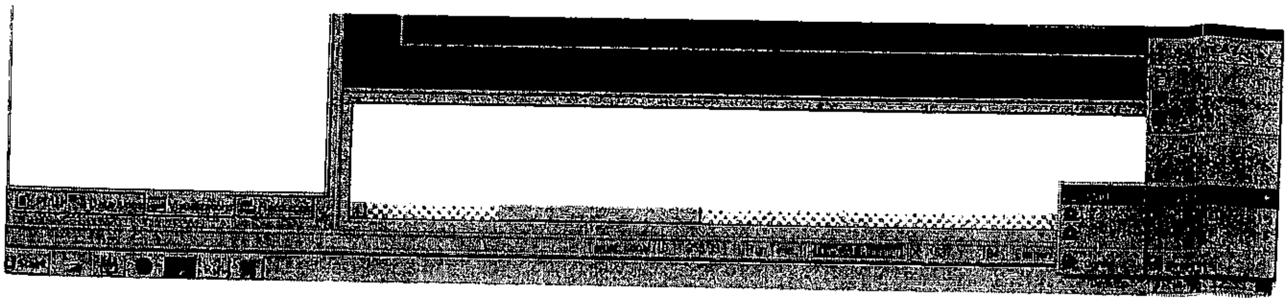
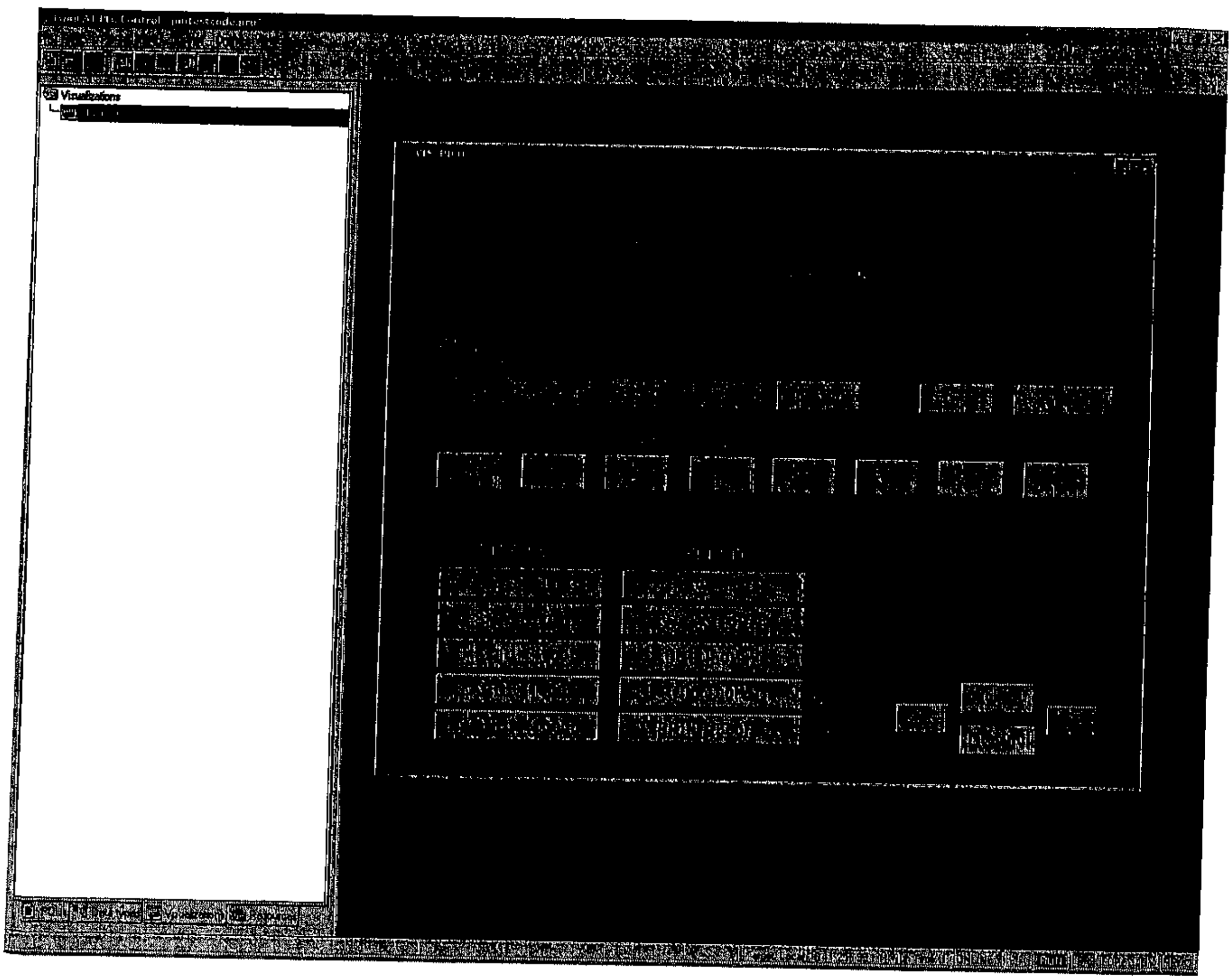


Figure 6: Step 5 of PLC controls setup



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107553

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

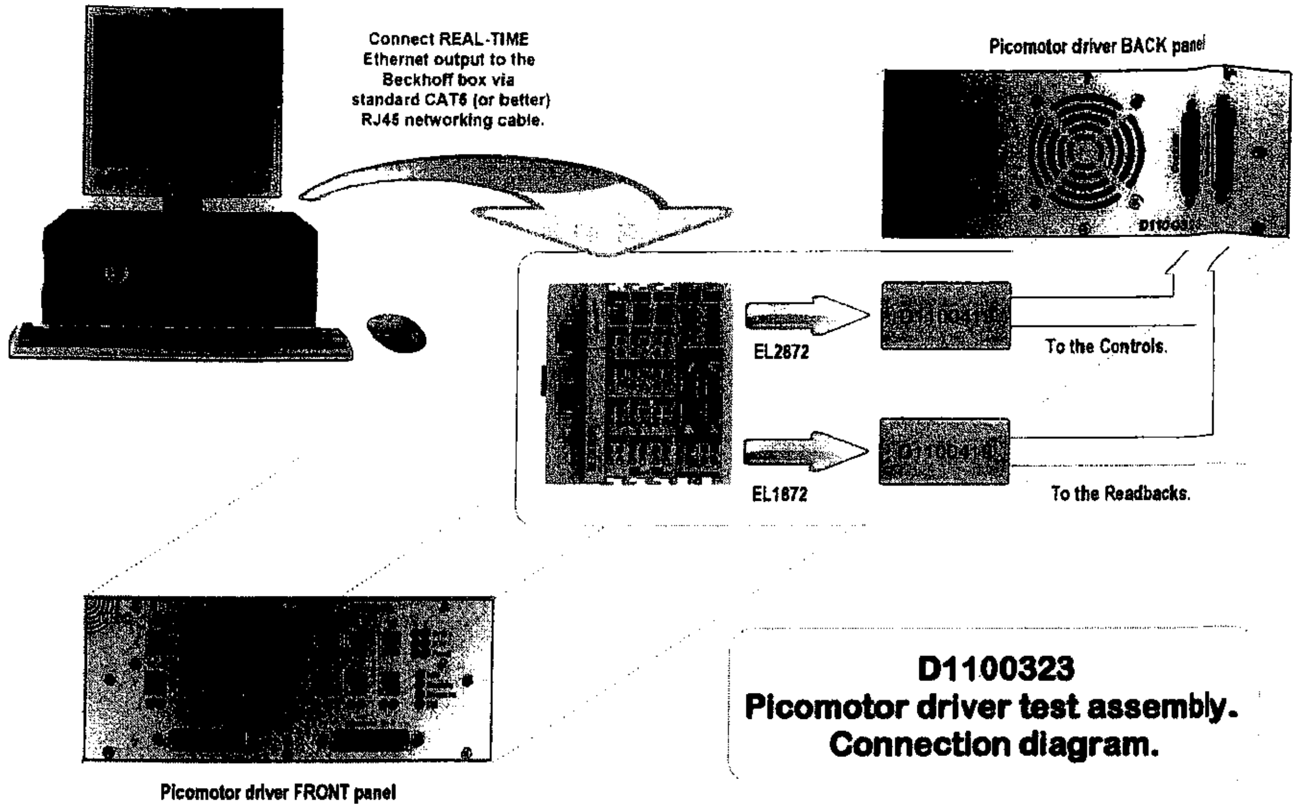
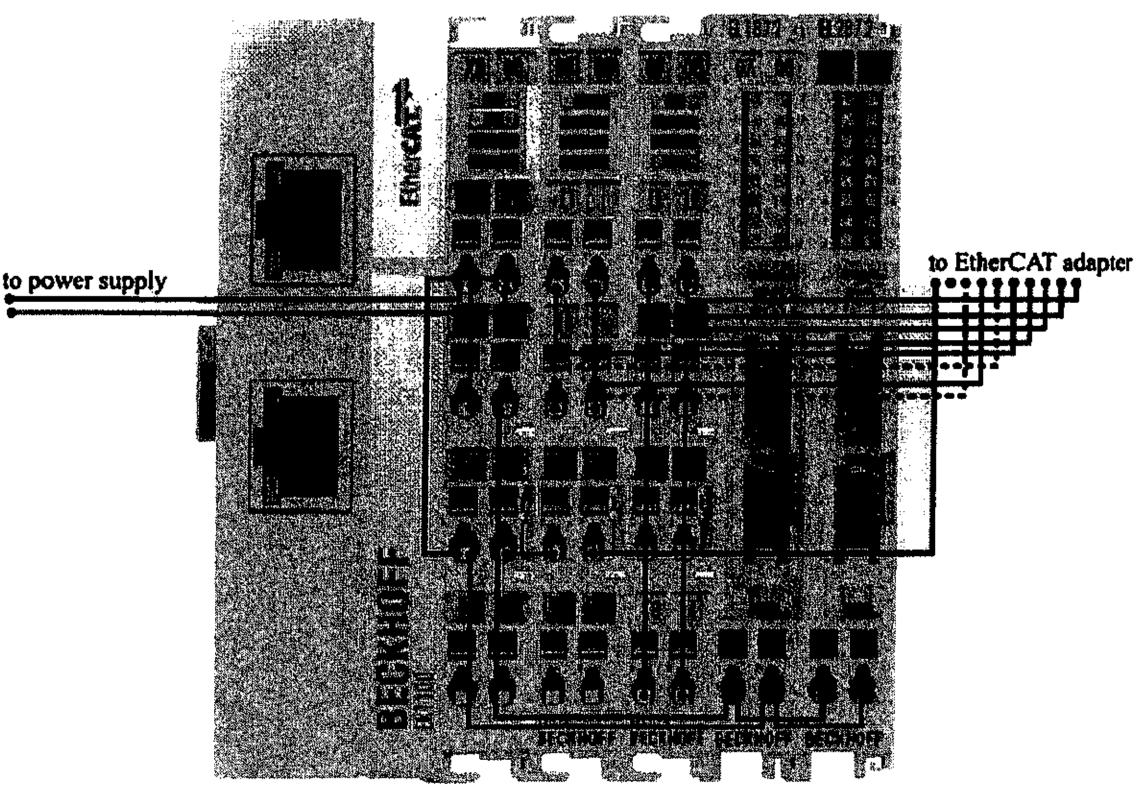


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	31.55	30.02
2	32.61	31.19
3	33.77	32.40
4	34.81	33.50
5	35.72	34.47
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

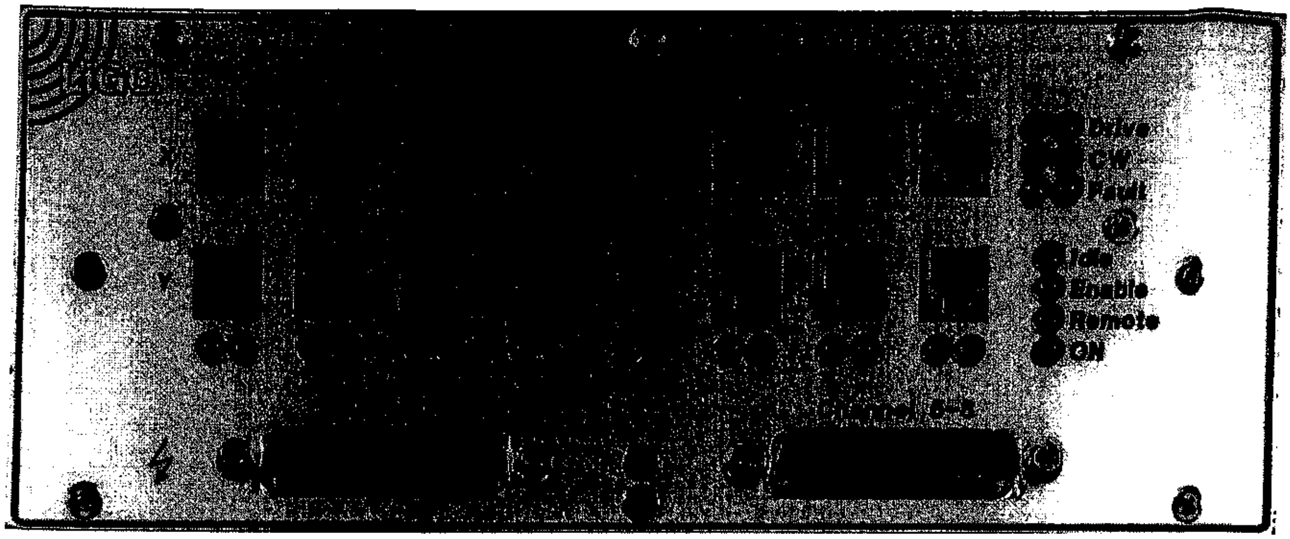


Figure 3: Picomotor driver chassis rear panel

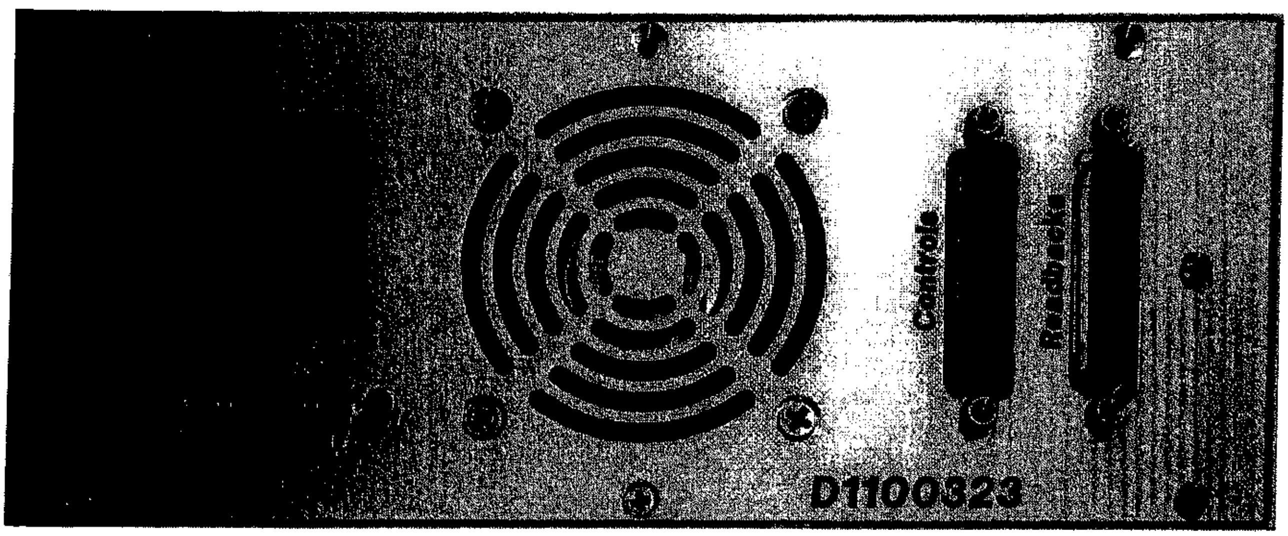
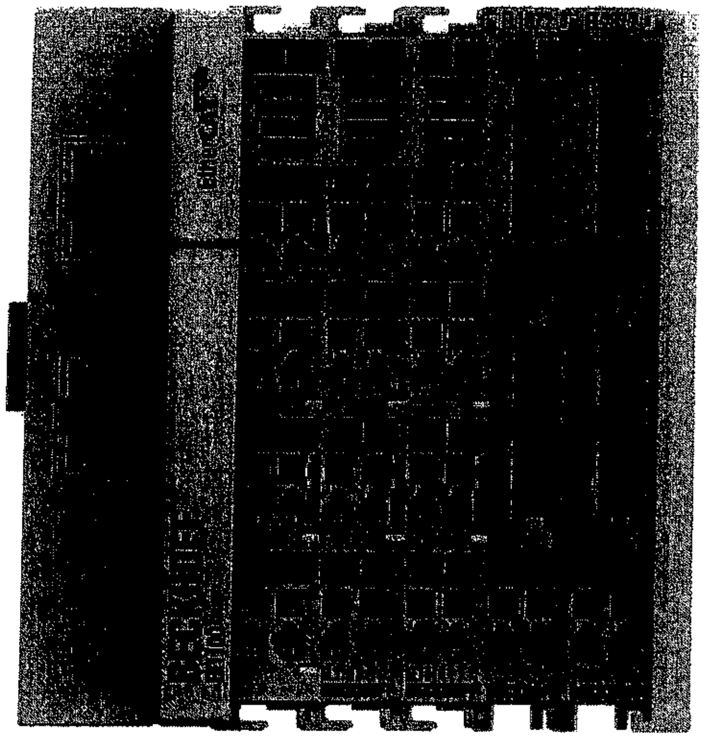


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

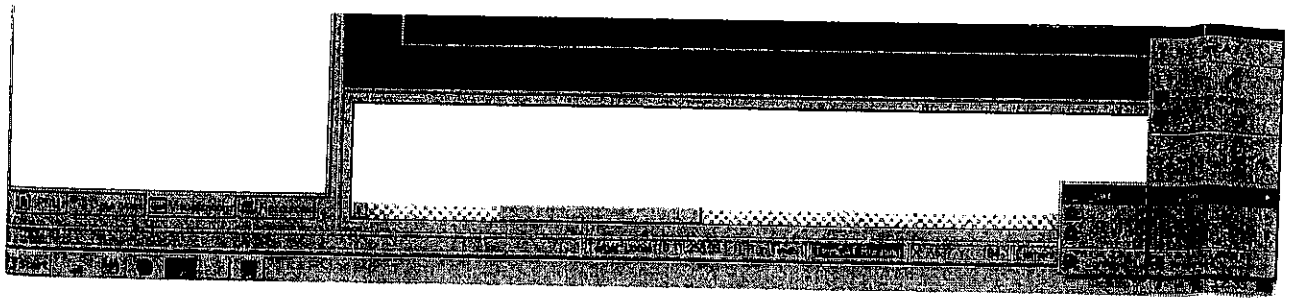
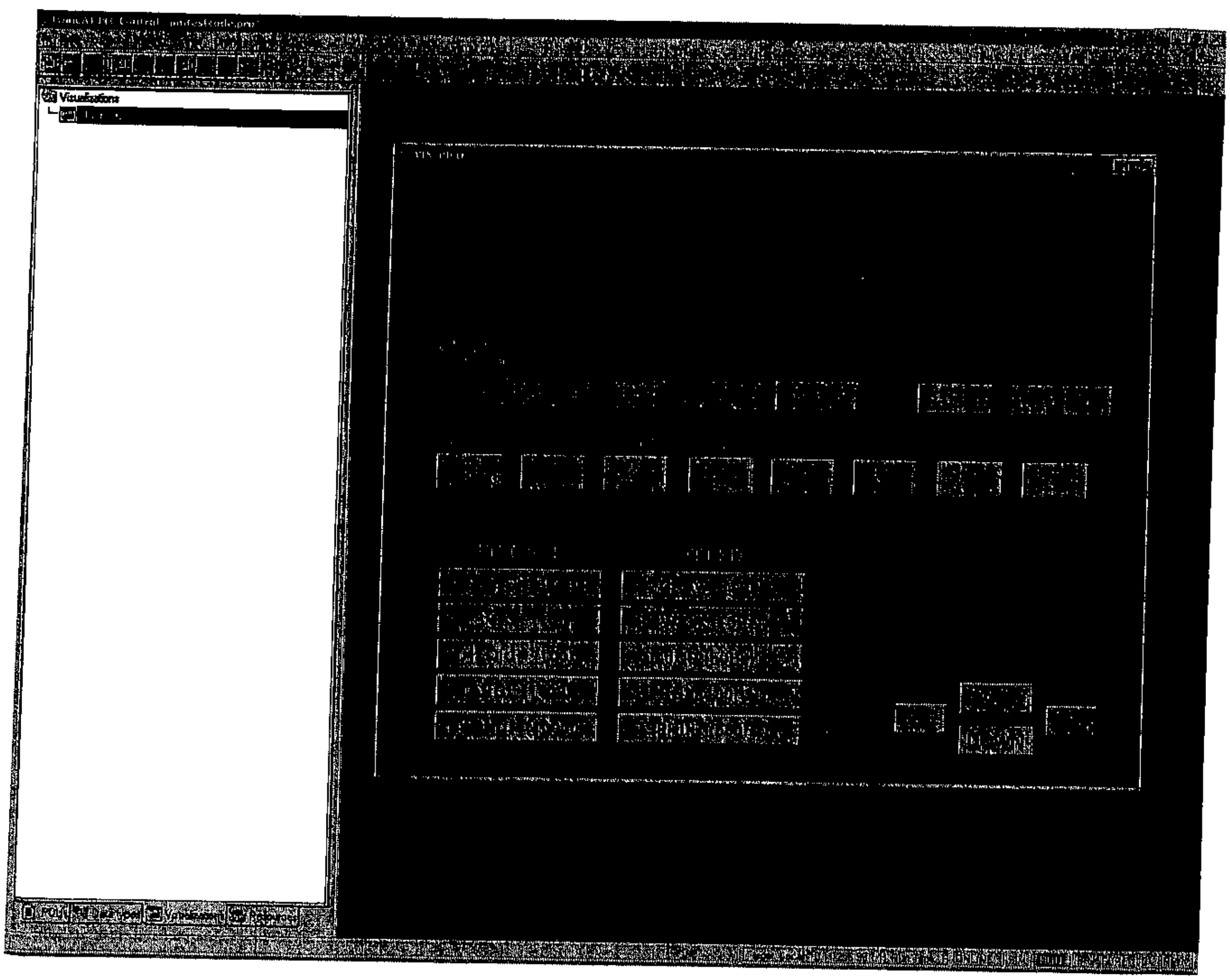


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107554

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

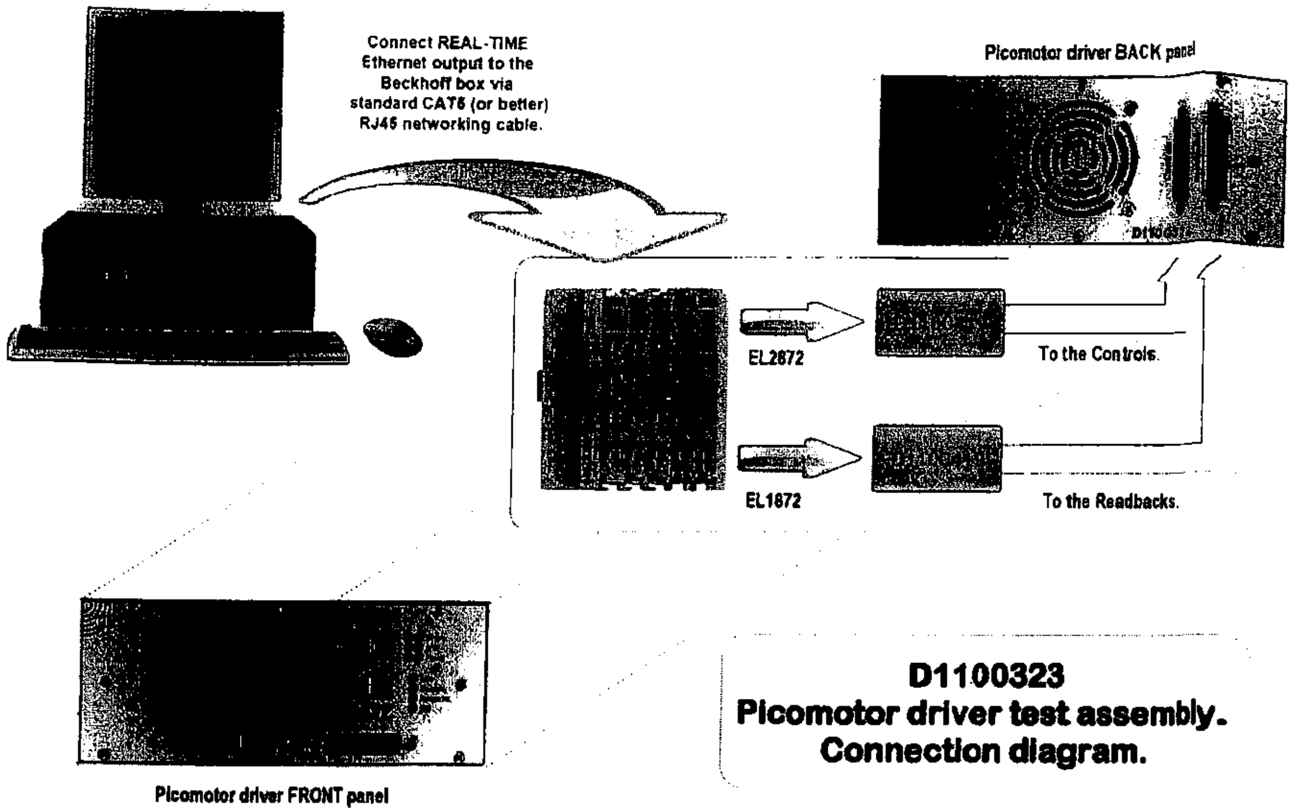
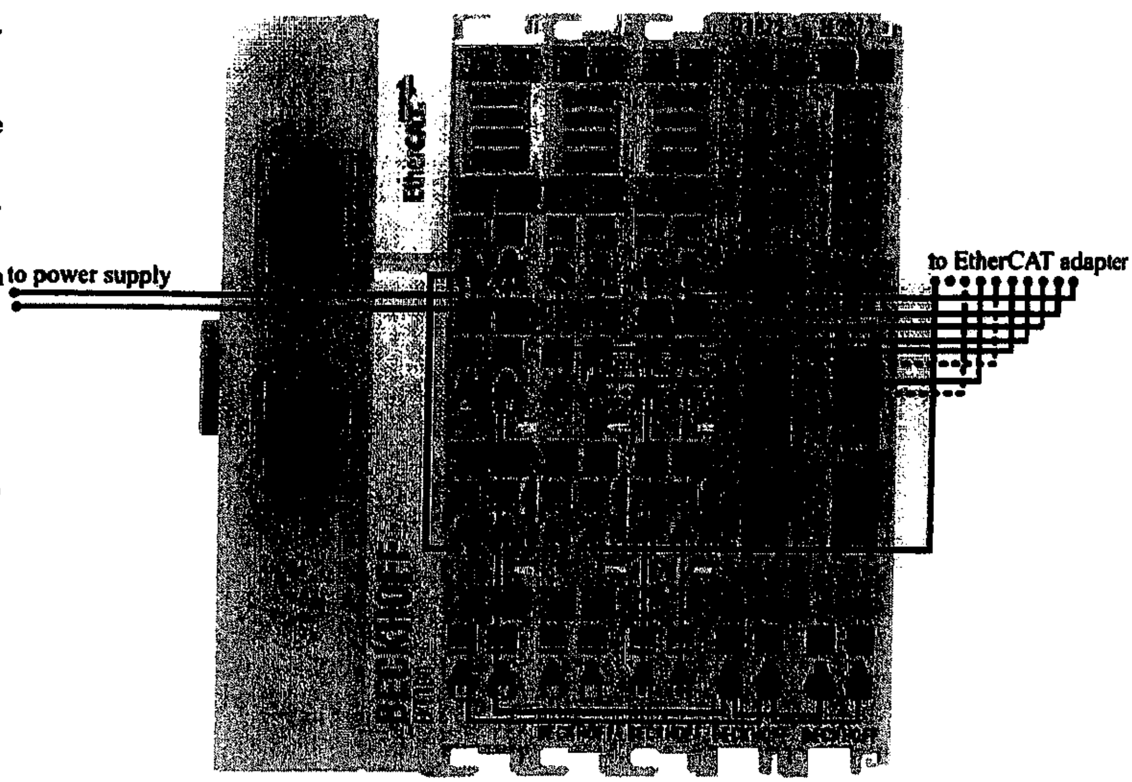


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	34.57	33.77
2	35.56	34.84
3	36.44	35.81
4	37.21	36.64
5	37.91	37.40
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 1/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

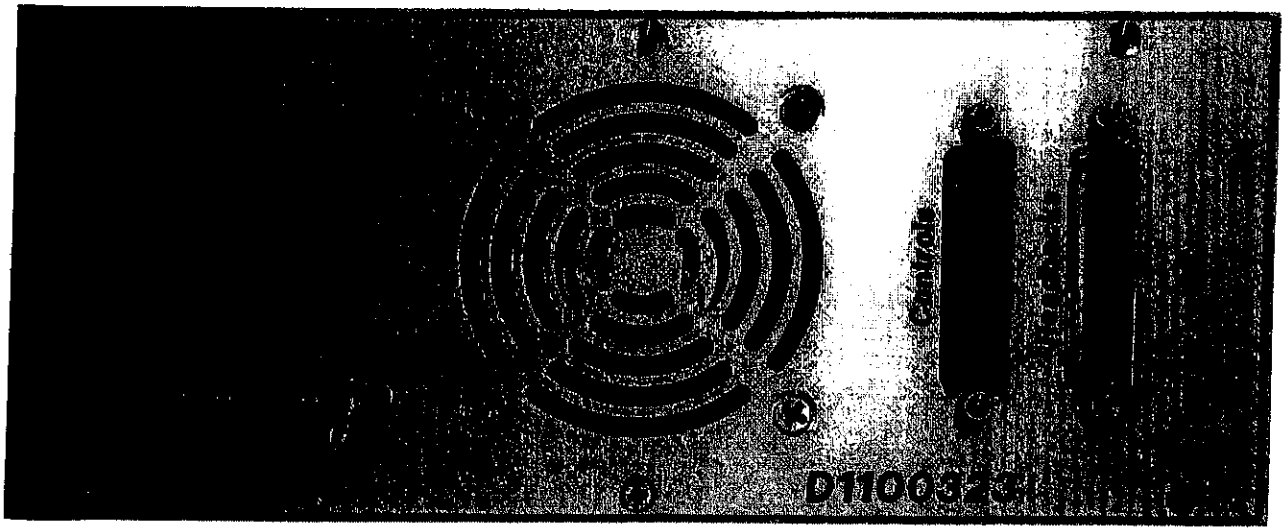
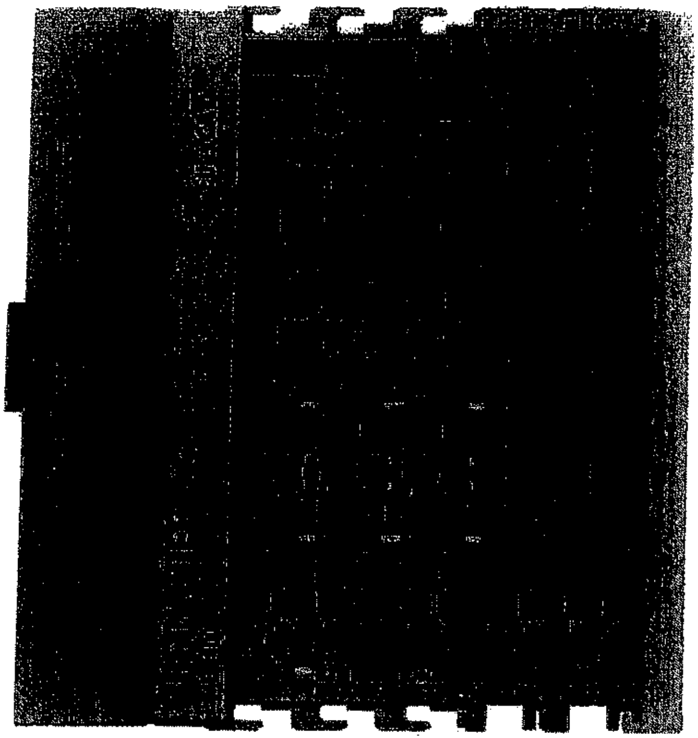


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

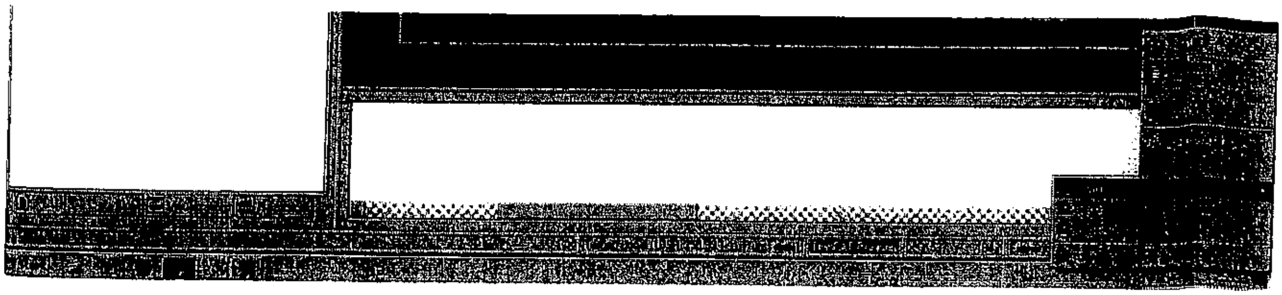
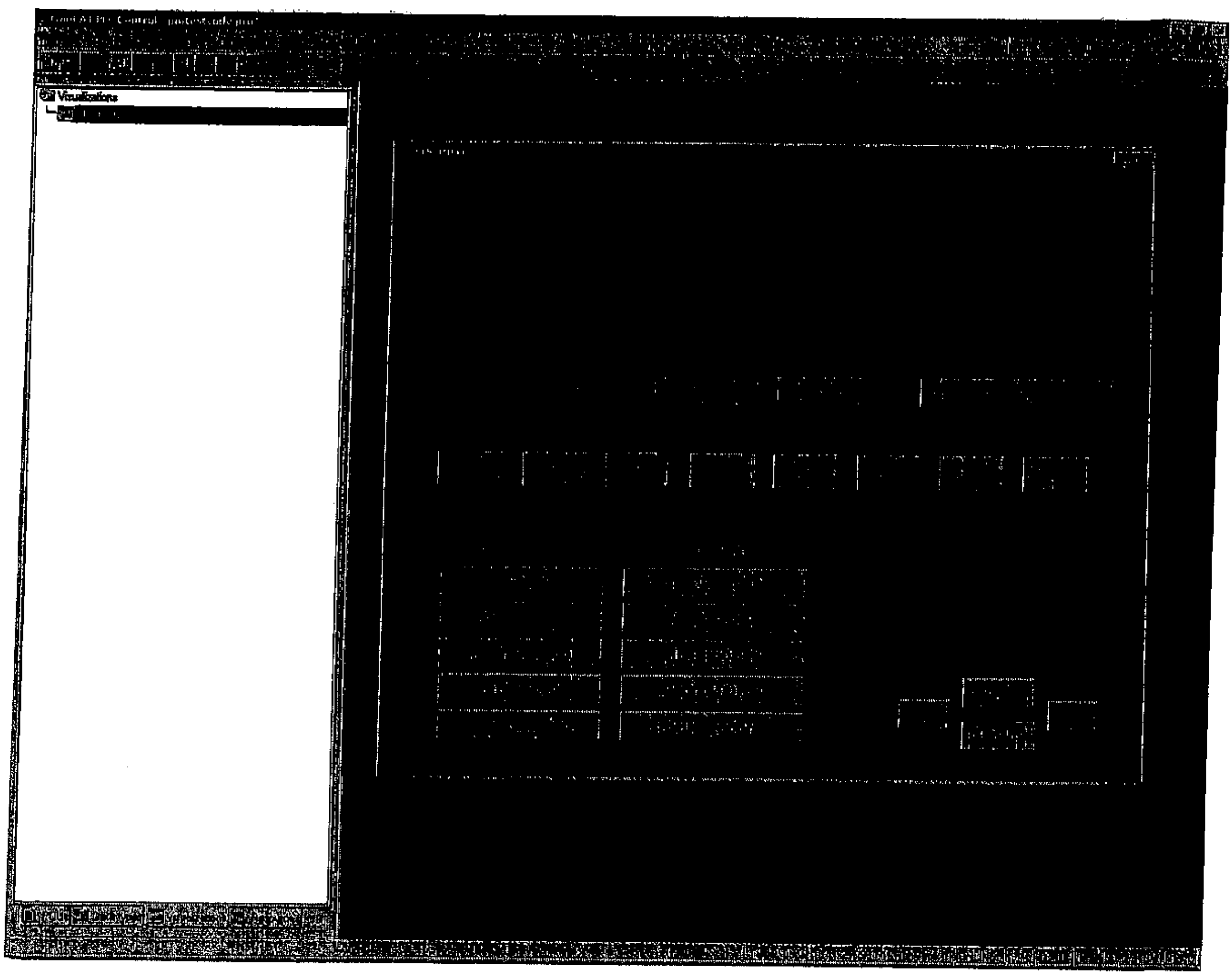


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107555

Test Engineer: Zach G

Test Date: 1/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

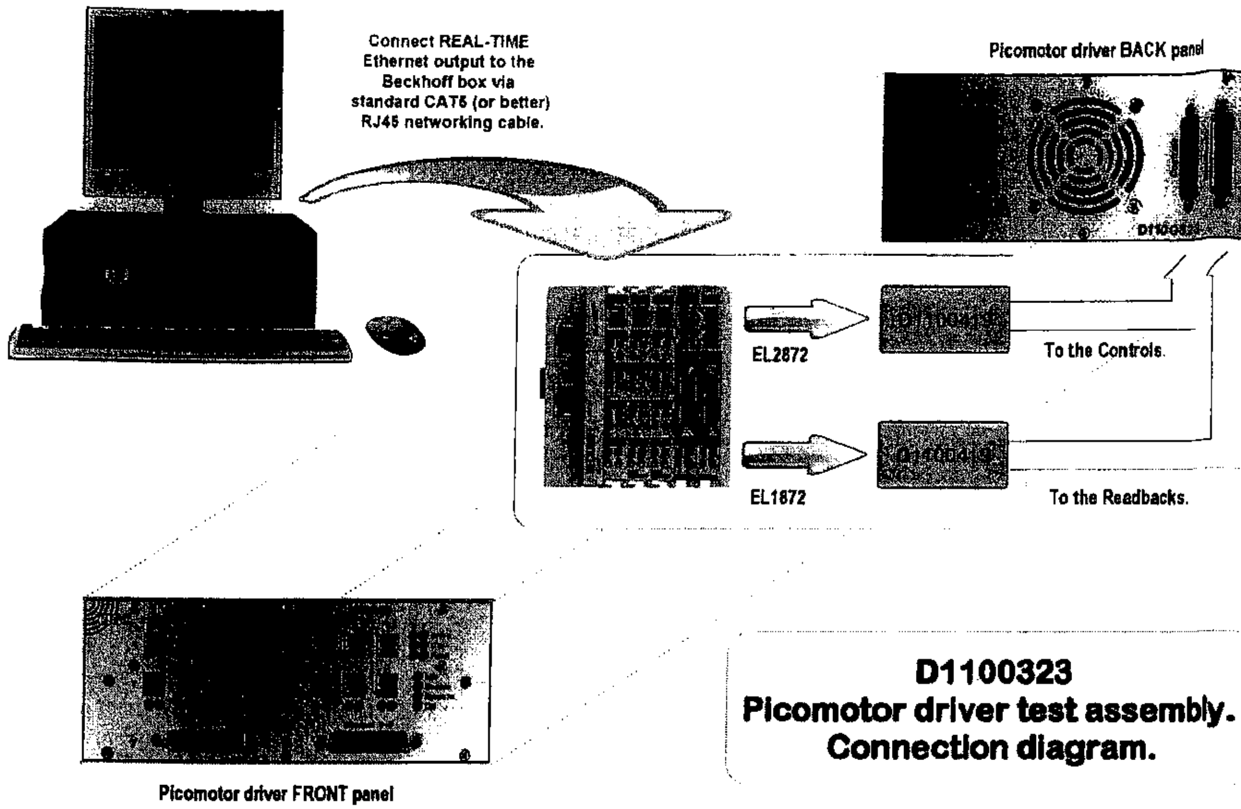
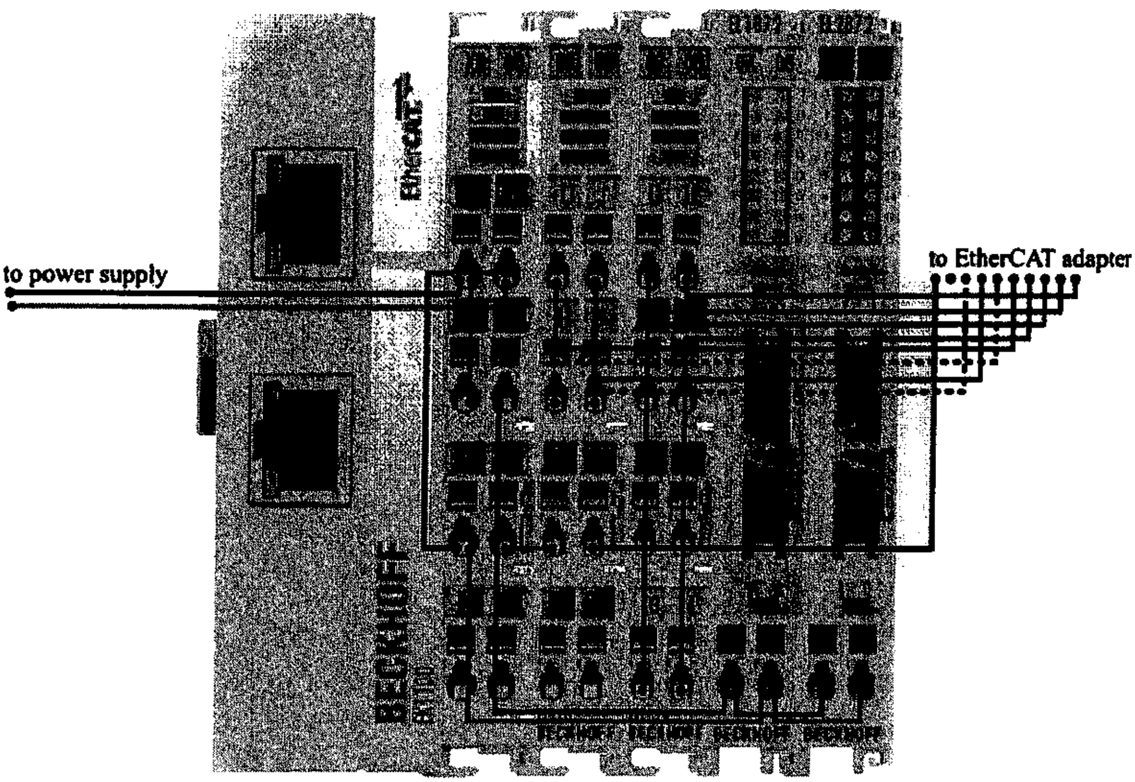


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.94	27.99
2	28.40	28.48
3	28.86	28.91
4	29.35	29.40
5	29.77	29.77
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

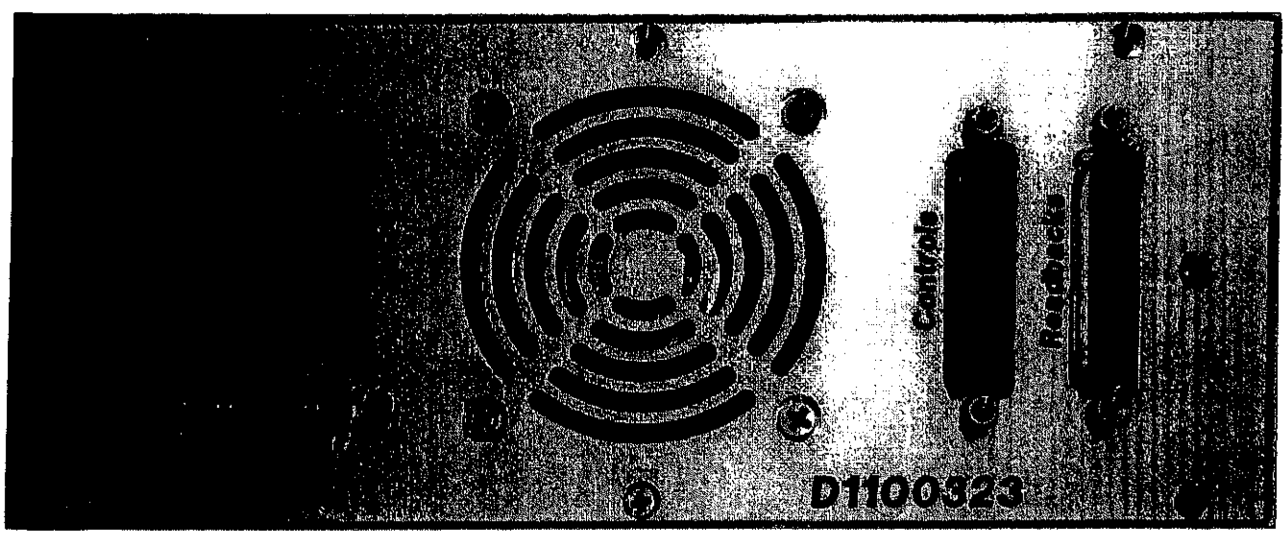
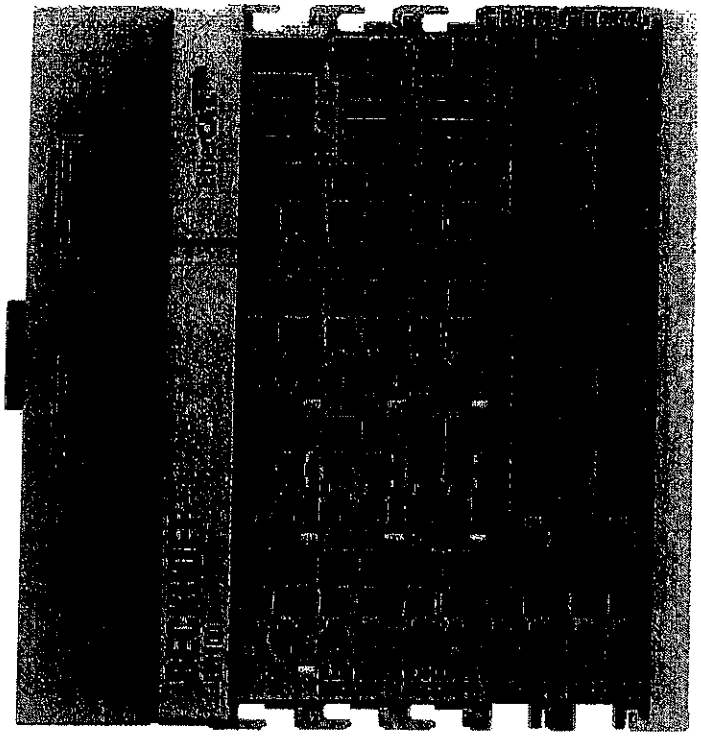


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

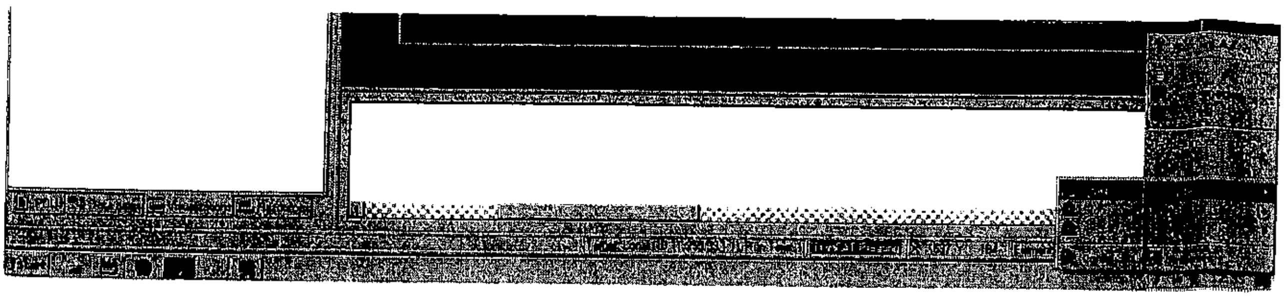
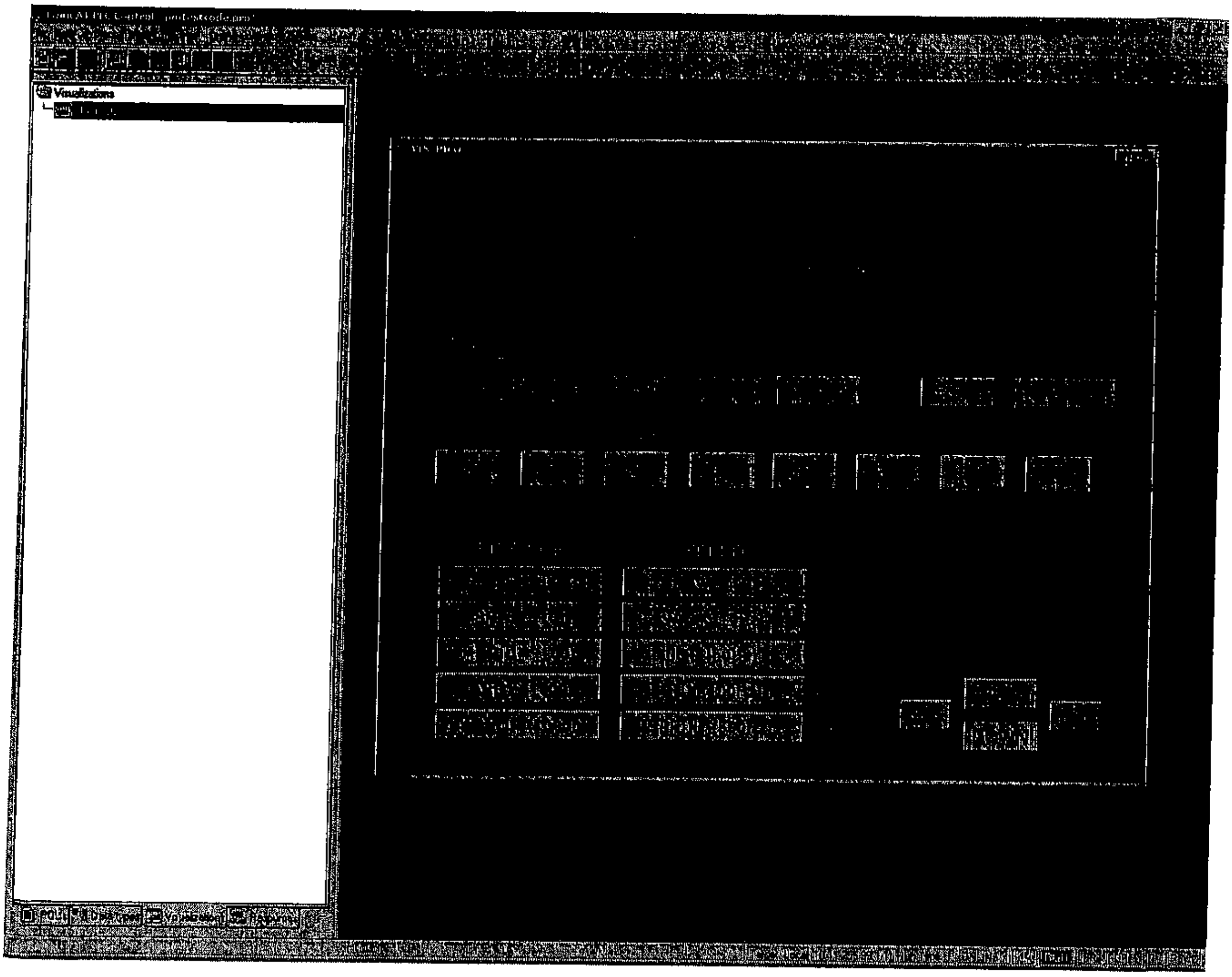


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107556

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

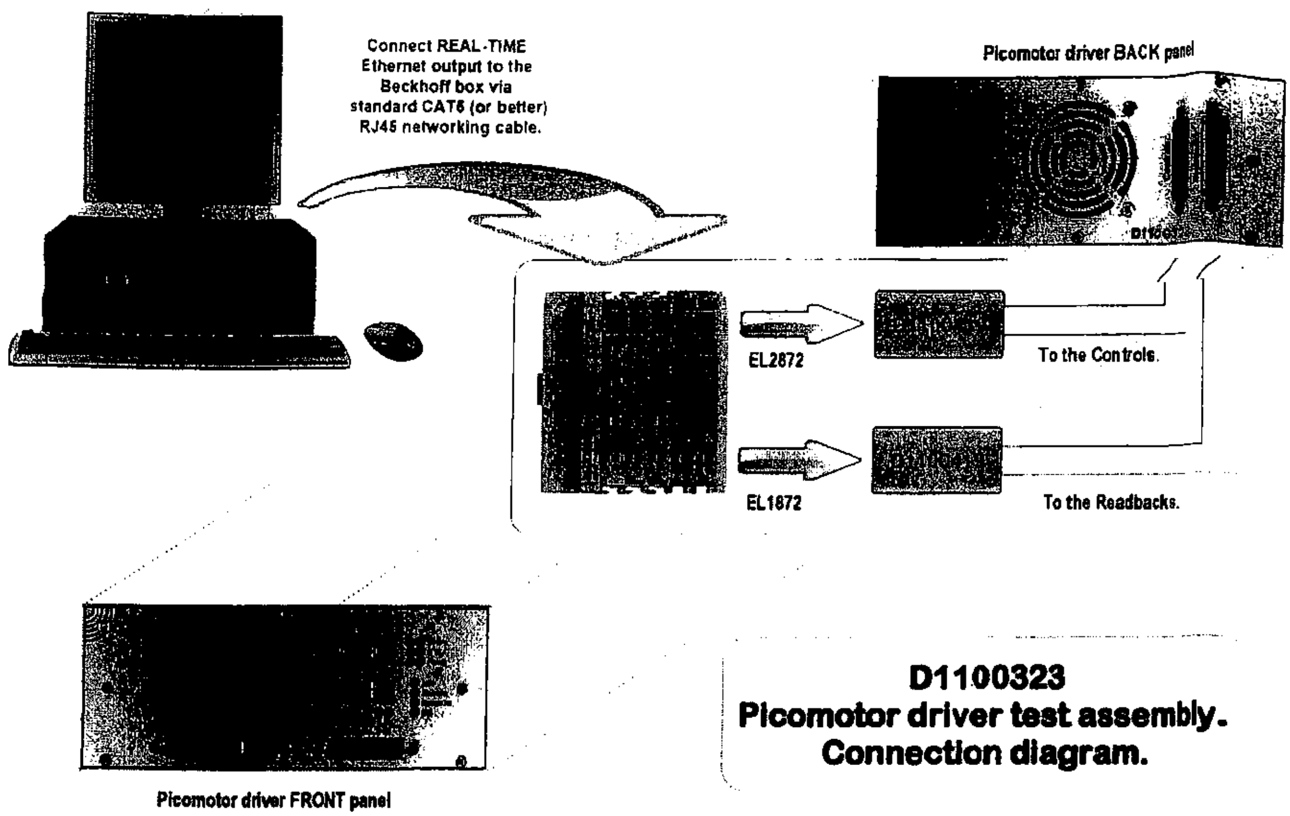
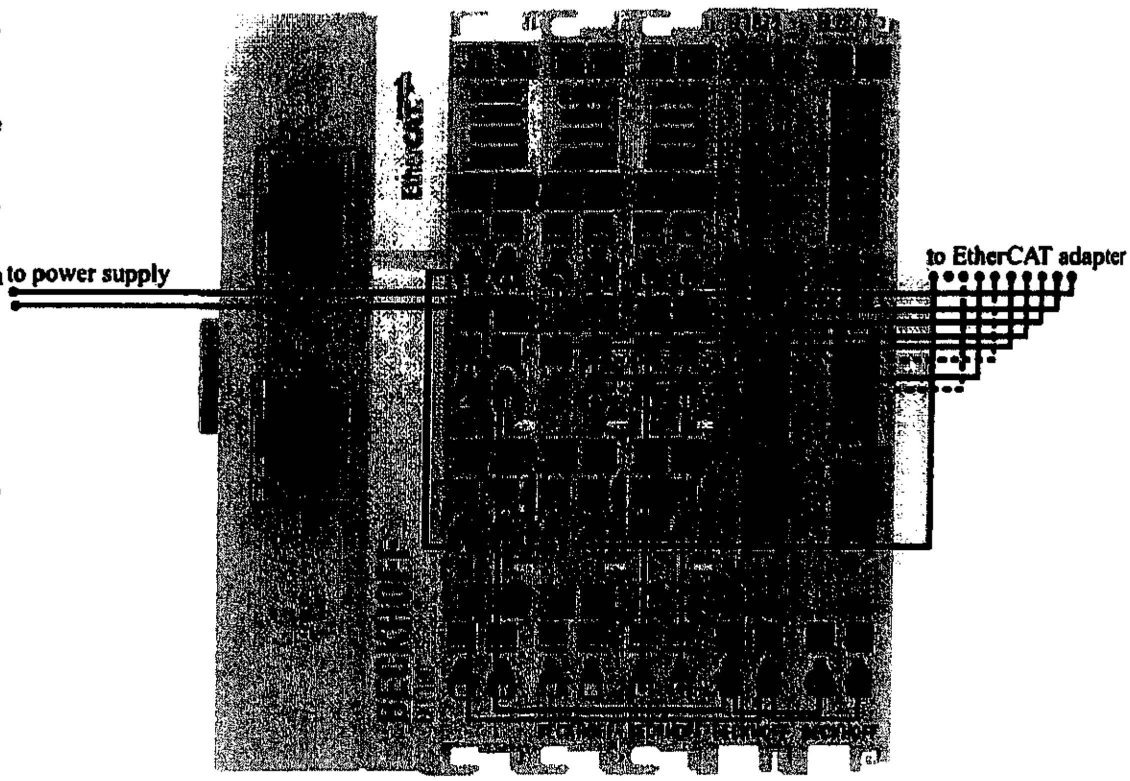


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	32.47	29.61
2	33.54	30.69
3	34.57	31.72
4	35.46	32.64
5	36.30	33.45
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail

Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

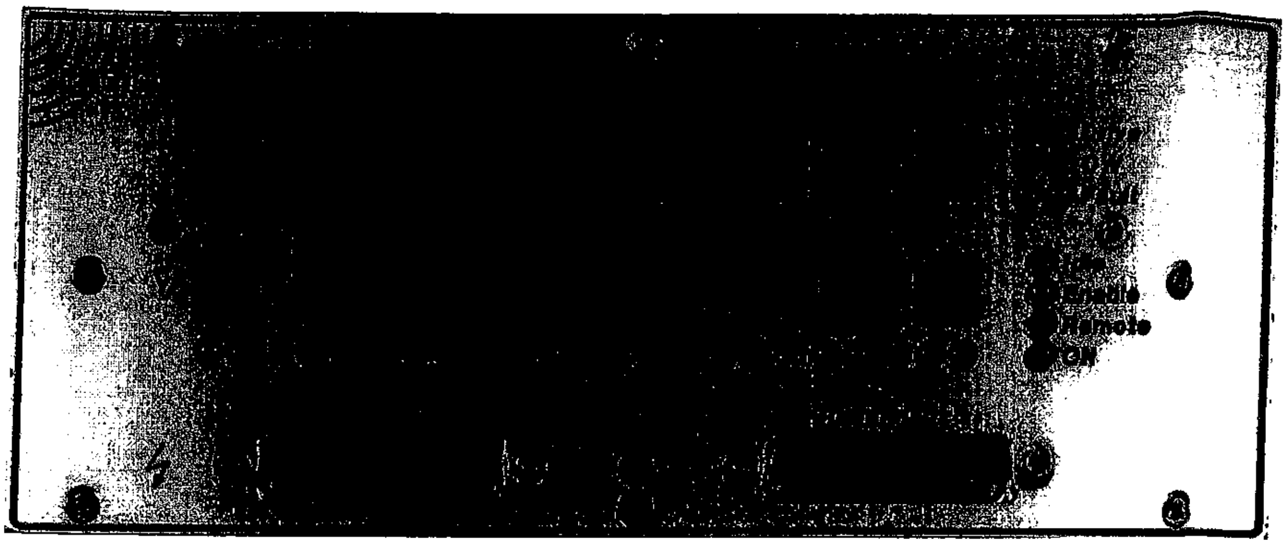


Figure 3: Picomotor driver chassis rear panel

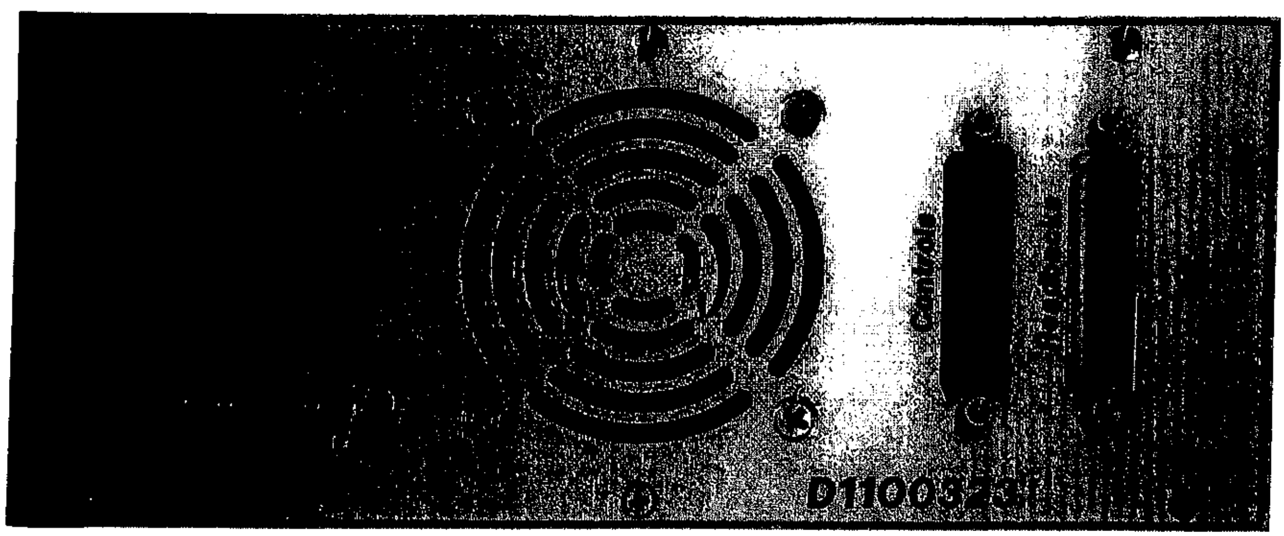
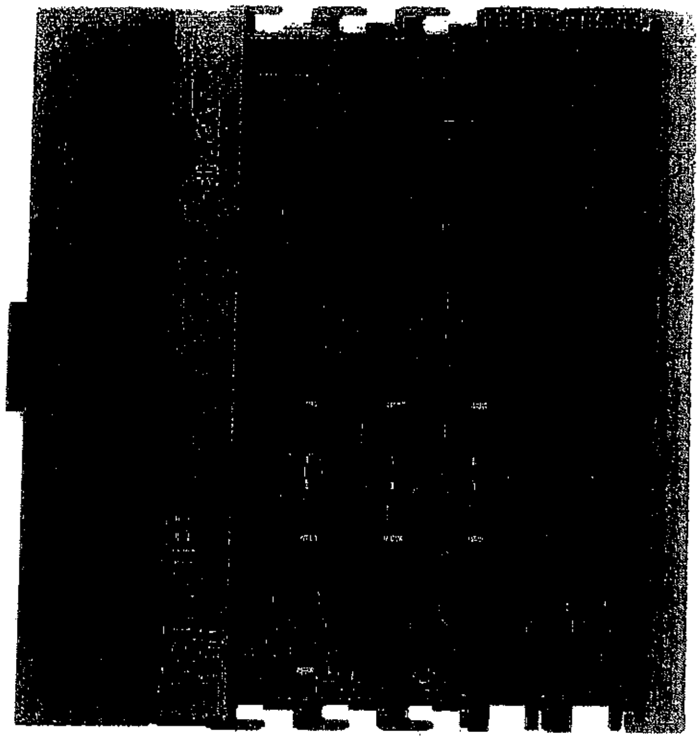


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

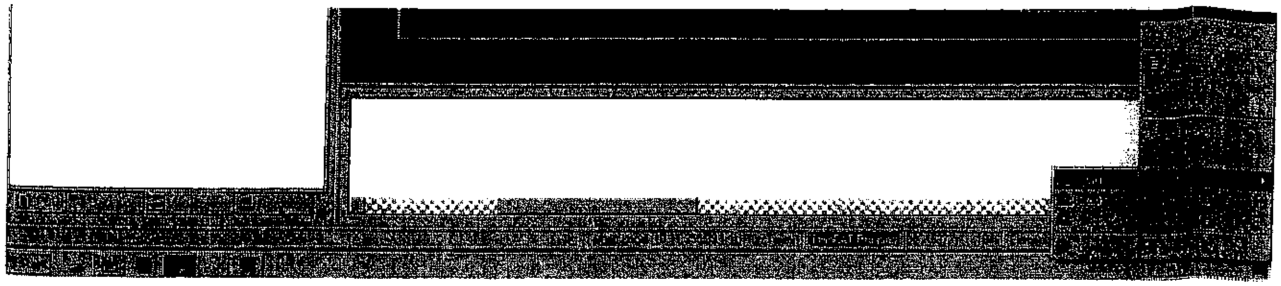
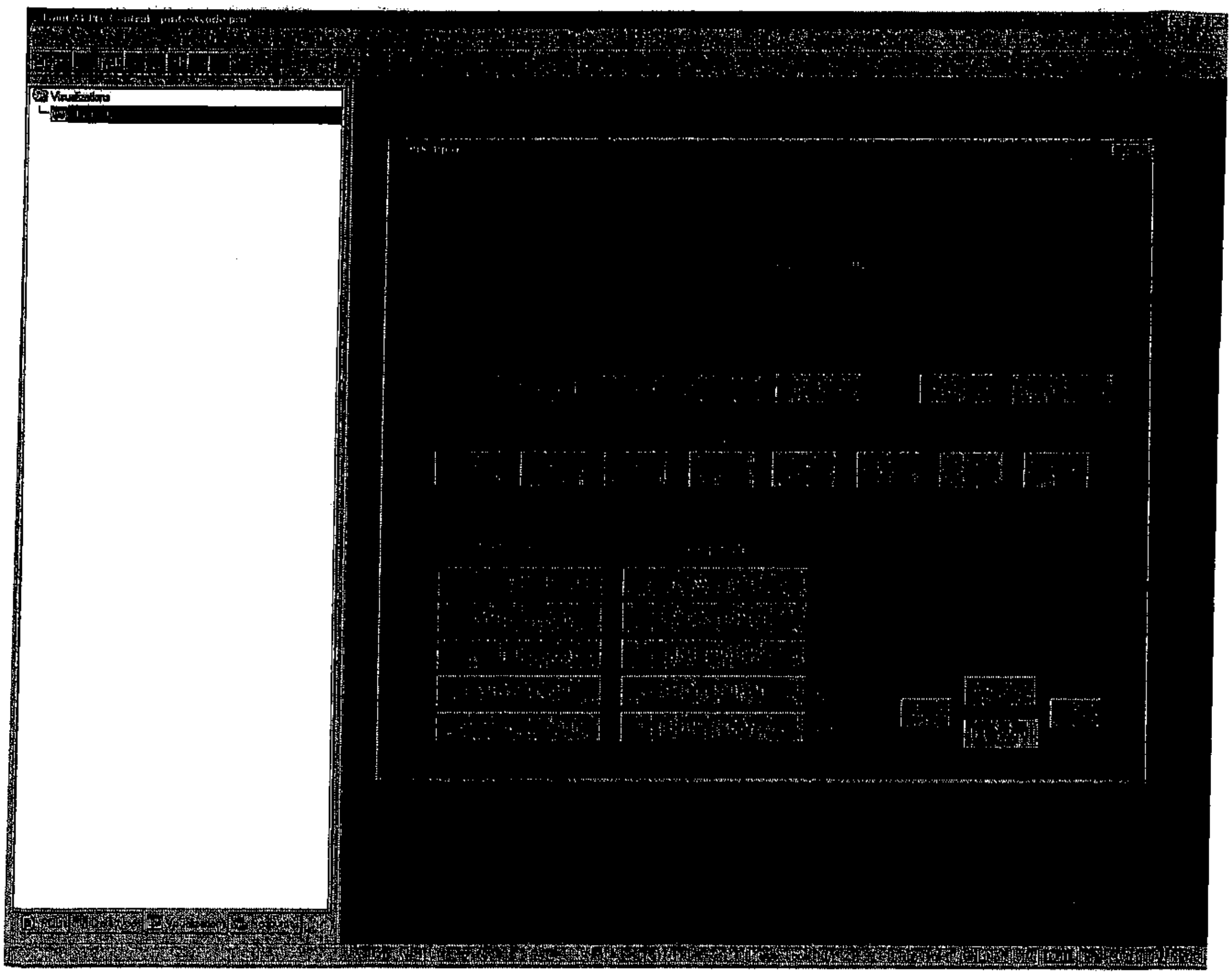


Figure 6: Step 5 of PLC controls setup



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	**LIGO-T1100458-v1**	**08/26/11**

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

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of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107557

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
6. Connect the EK1100 Beckhoff box to a DC power source (24V)
7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

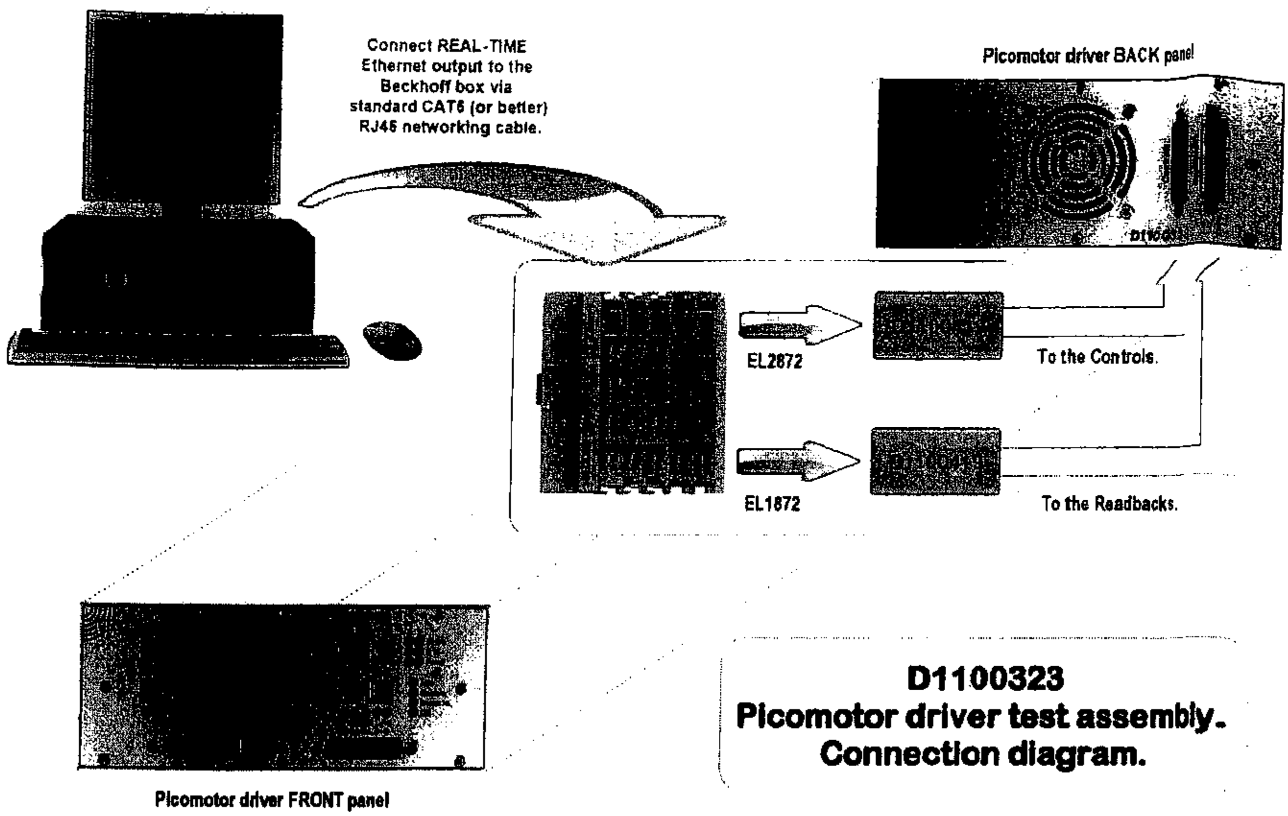


Figure 1a: A connection diagram of the picomotor setup.

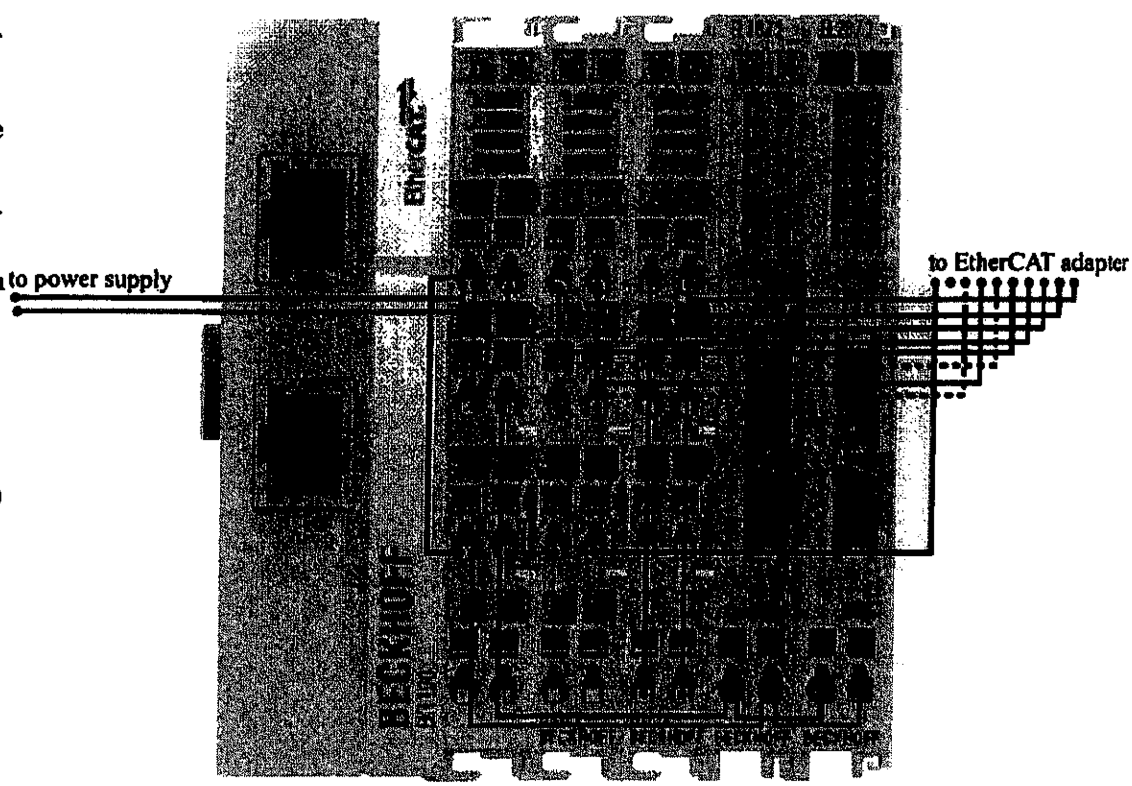


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the “ON” indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the “DUAL AXIS” indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the “RAW” section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.36	27.29
2	29.54	28.52
3	30.67	29.71
4	31.66	30.69
5	32.6	31.69
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

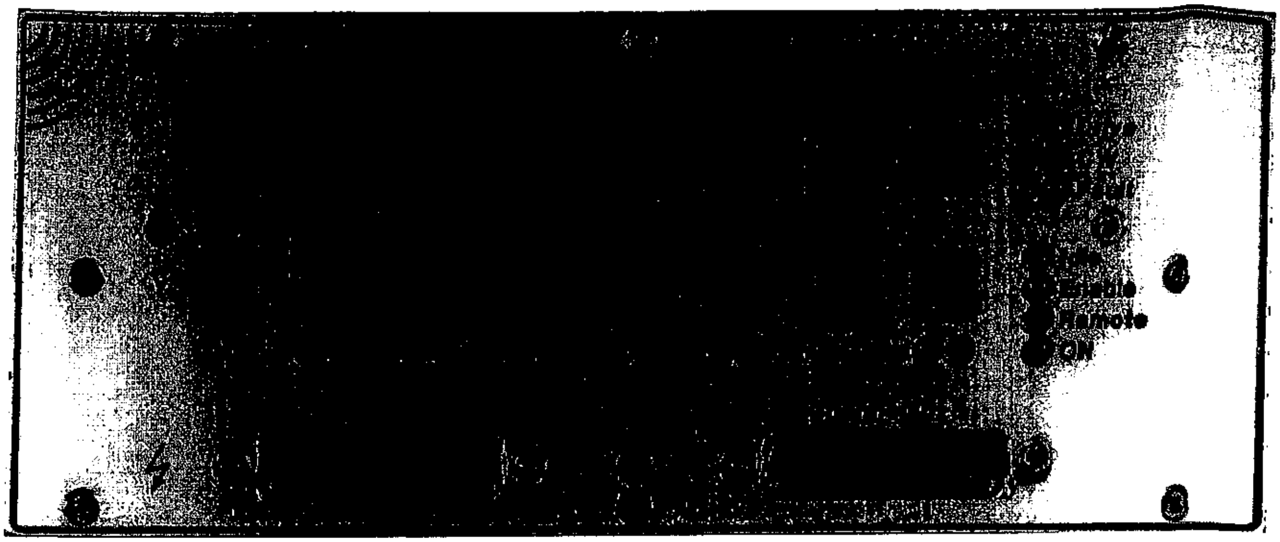


Figure 3: Picomotor driver chassis rear panel

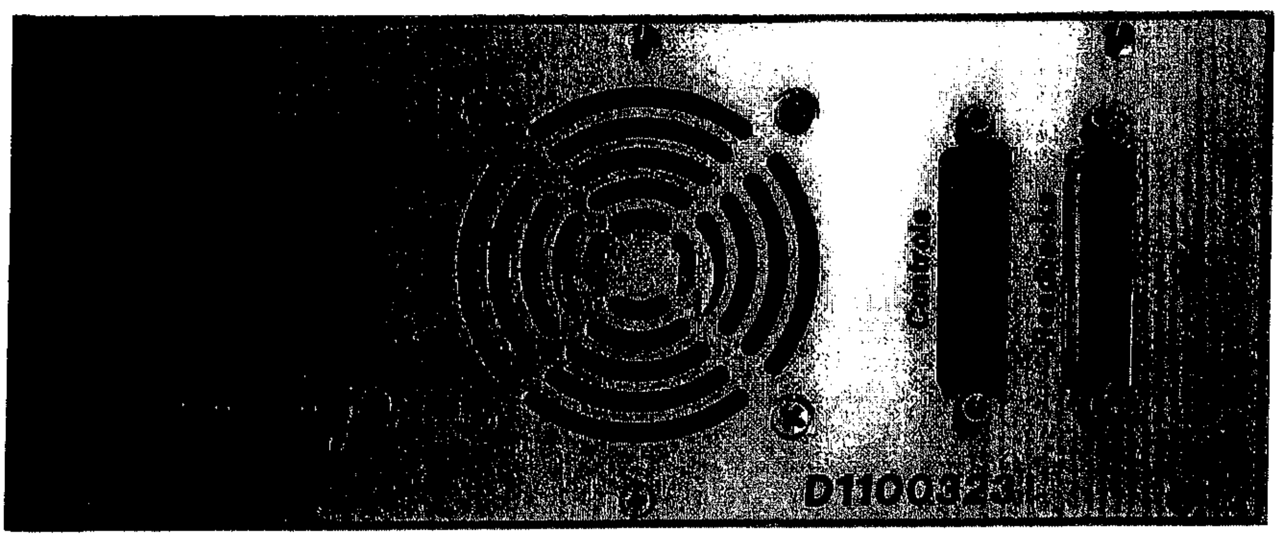
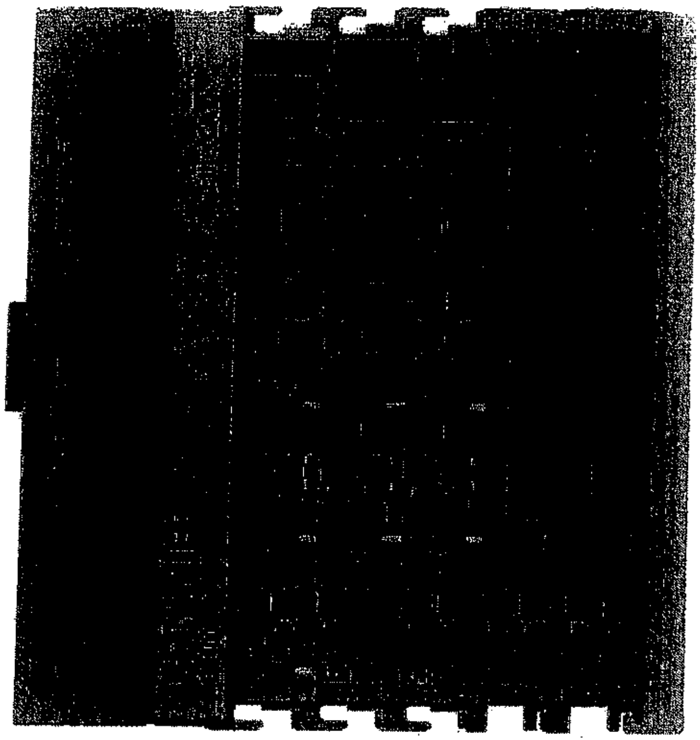


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

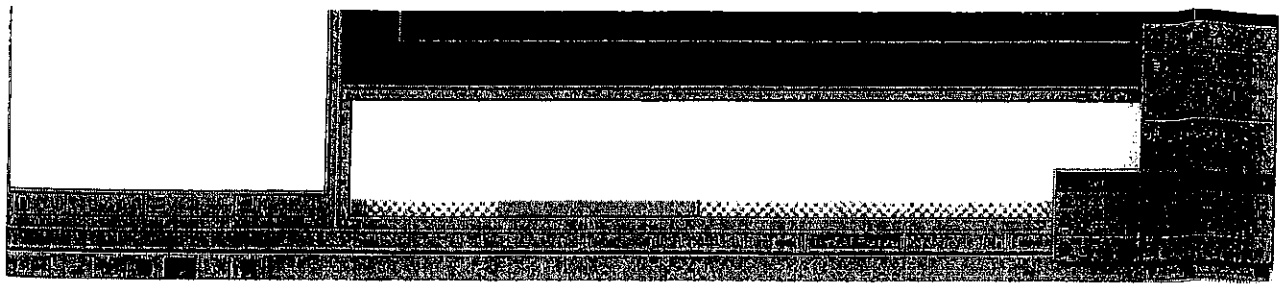
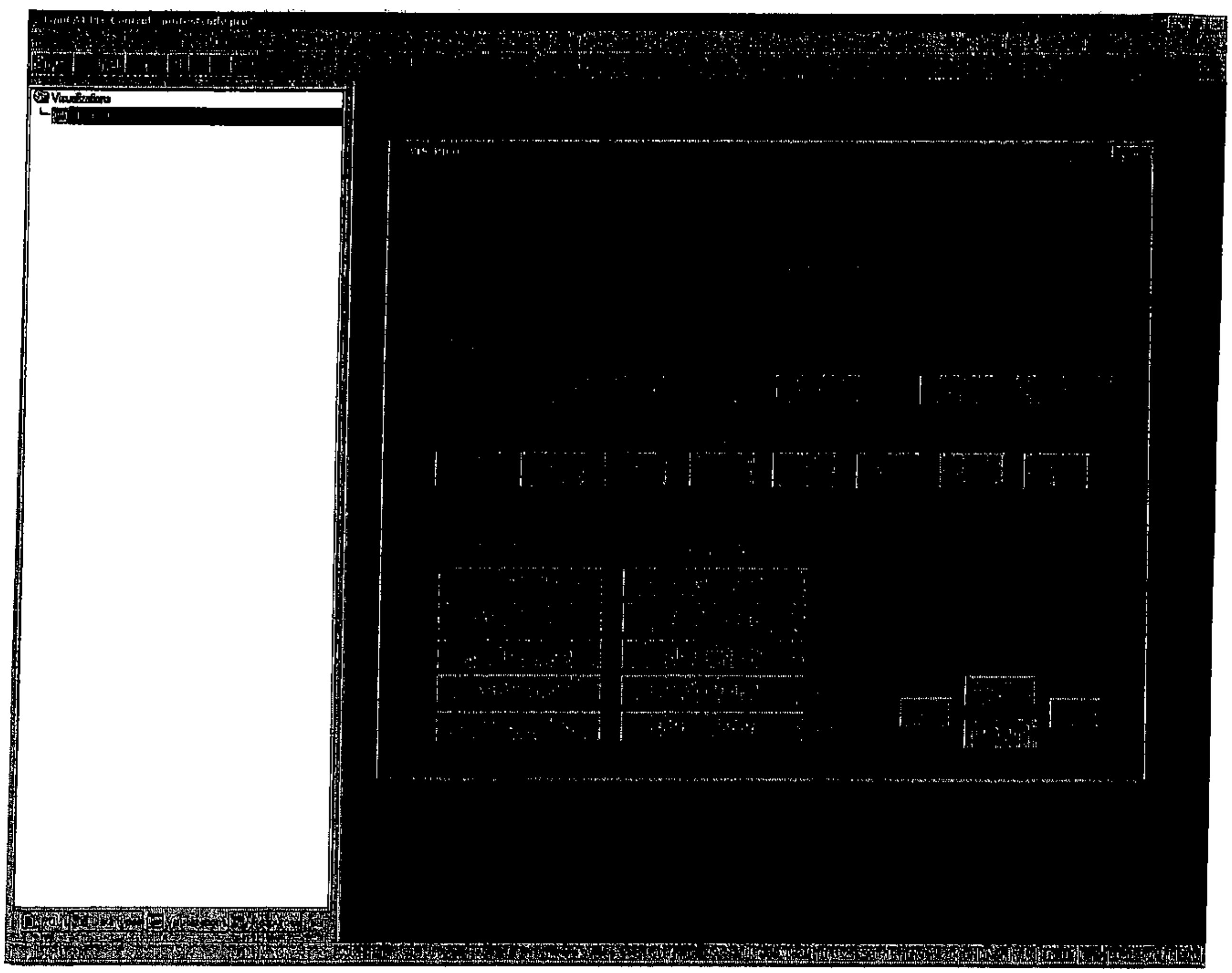


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107558

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

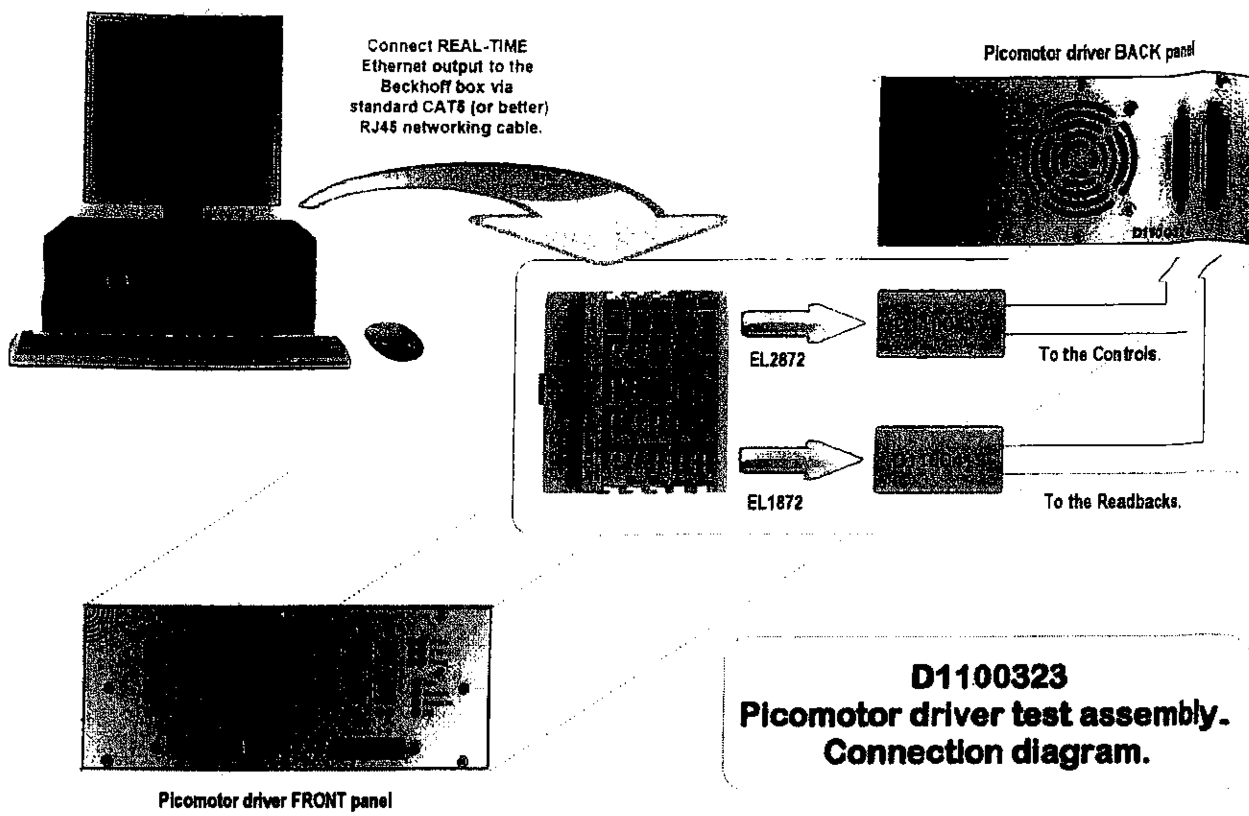


Figure 1a: A connection diagram of the picomotor setup.

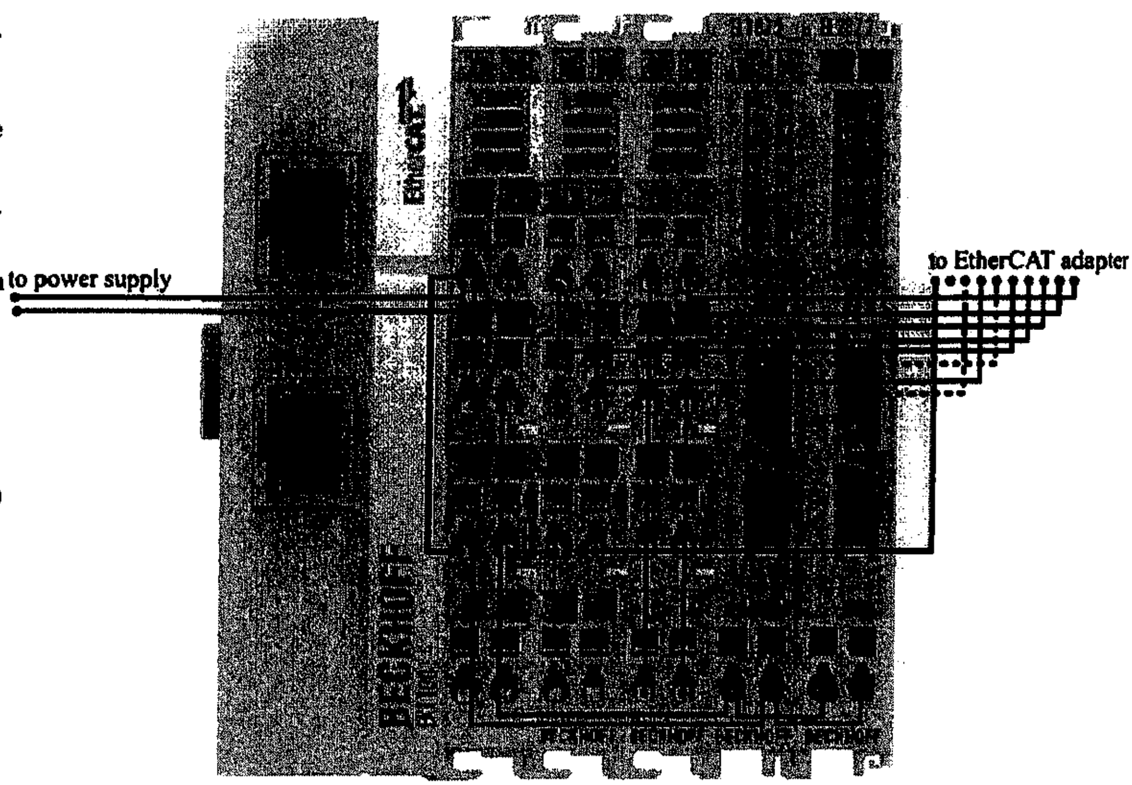


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)
** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	33.30	34.41
2	33.95	35.24
3	34.77	36.05
4	35.57	36.86
5	36.16	37.53
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/27/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

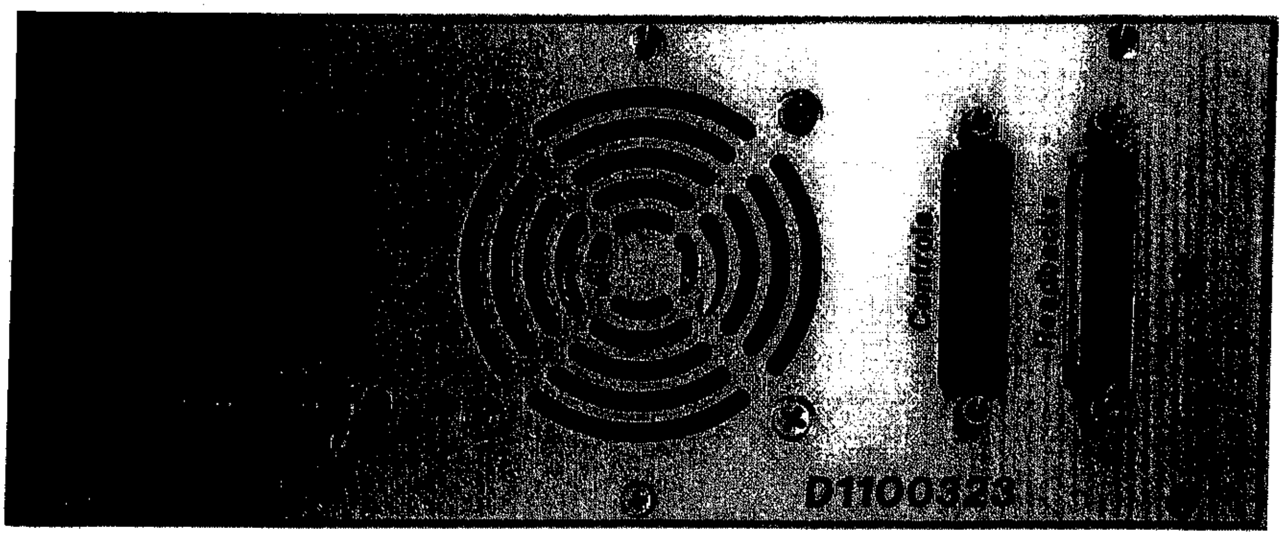
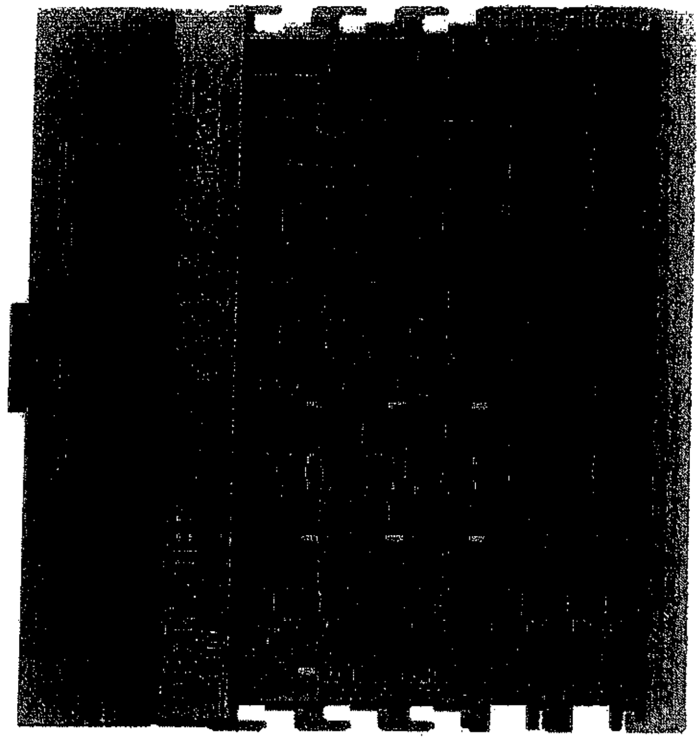


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

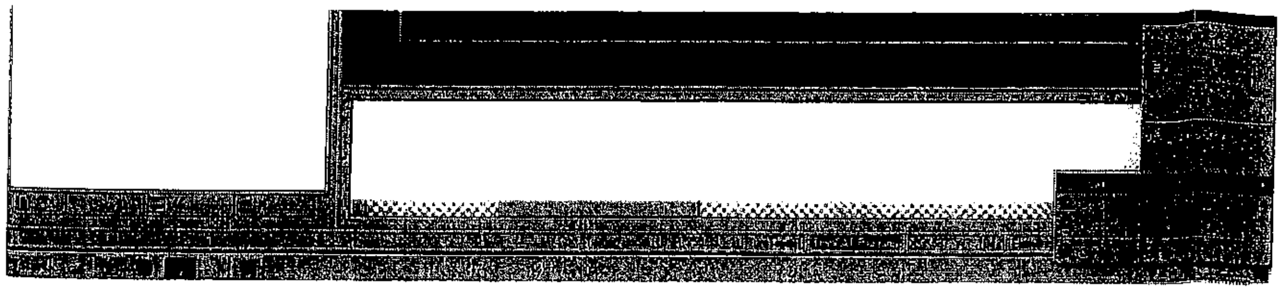
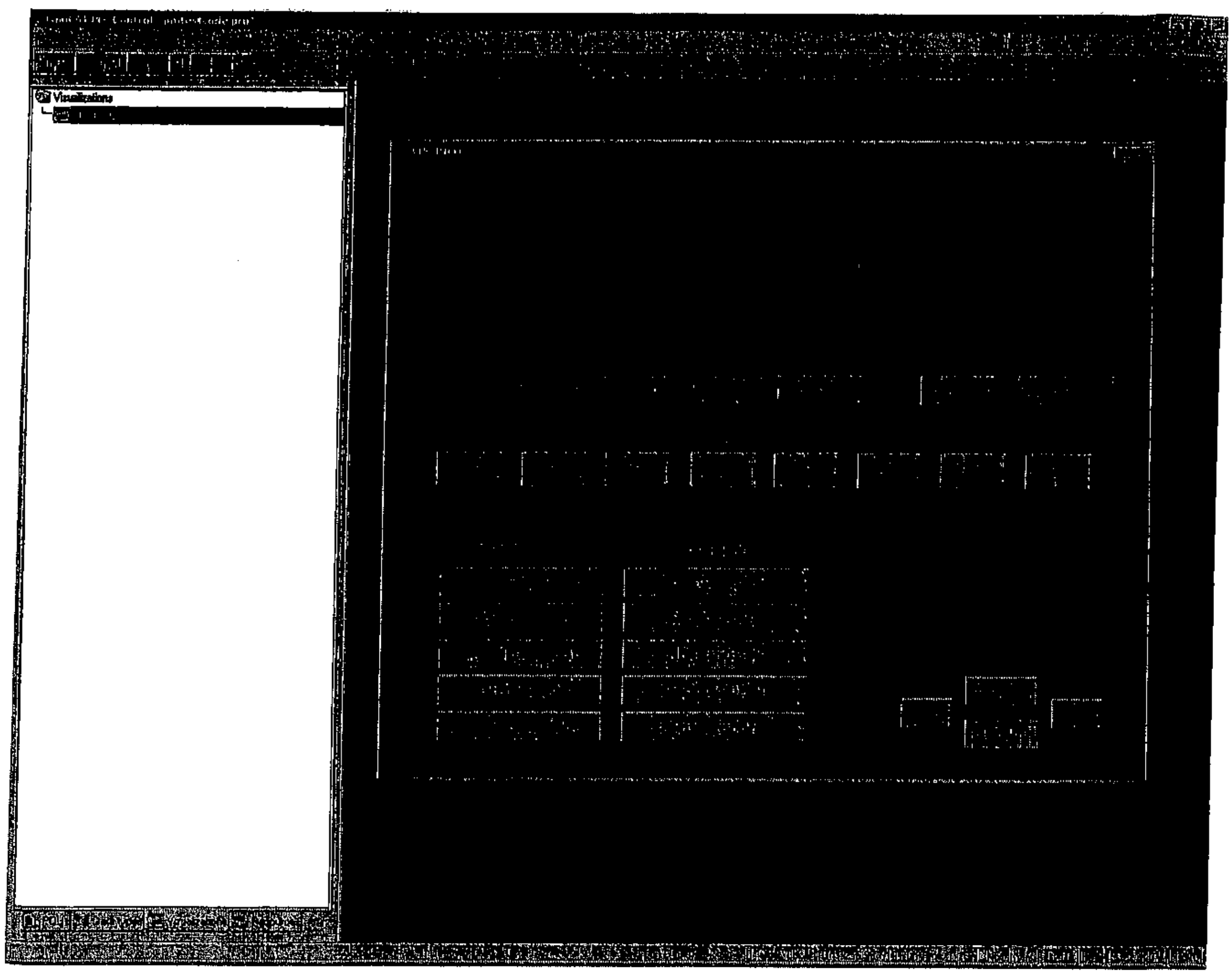


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107559

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

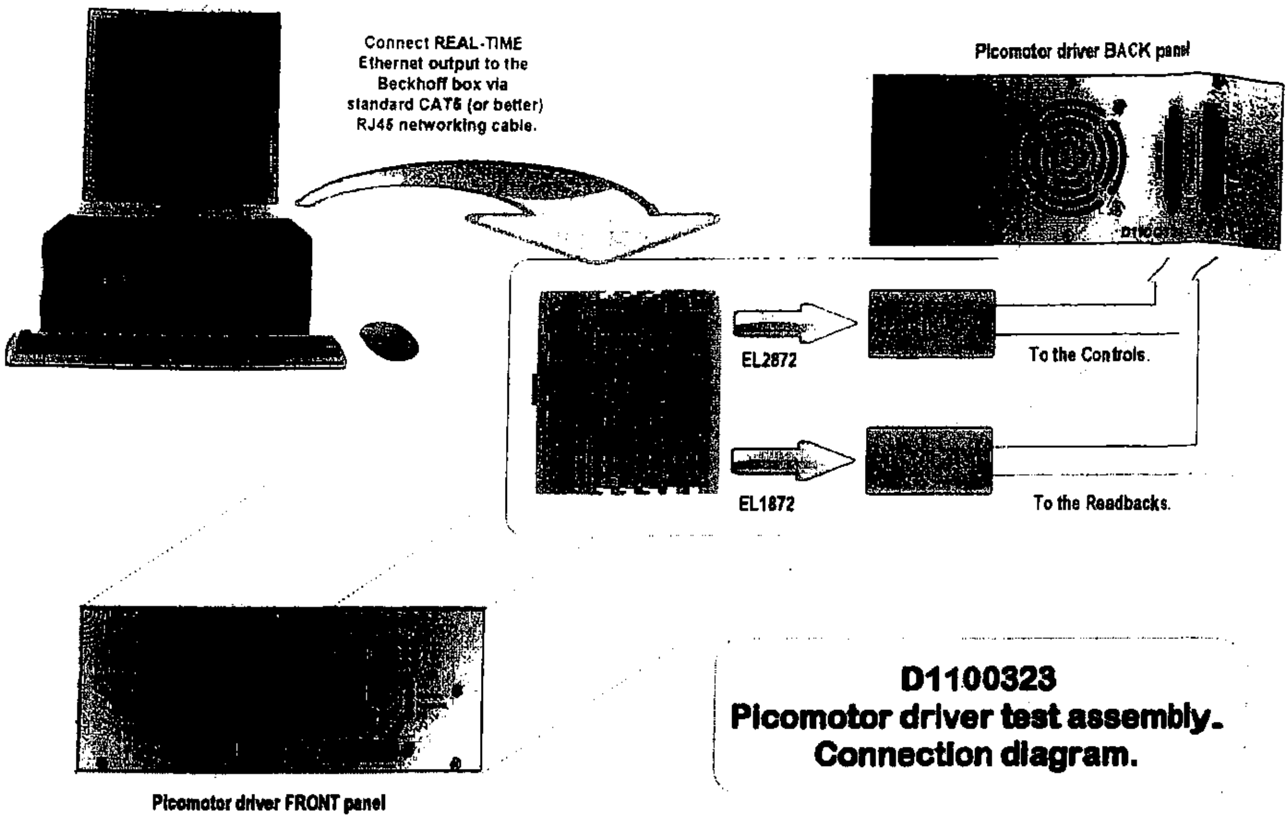
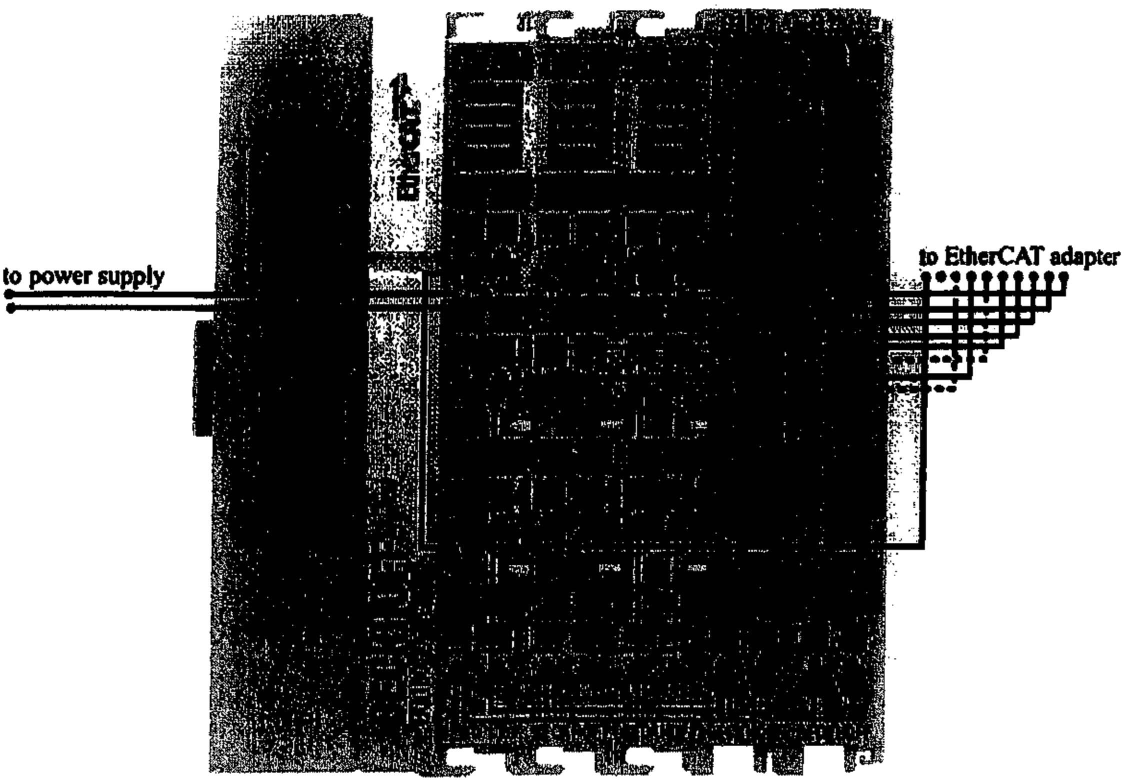


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.41	27.26
2	28.55	28.41
3	29.82	29.63
4	30.77	30.66
5	31.74	31.57
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

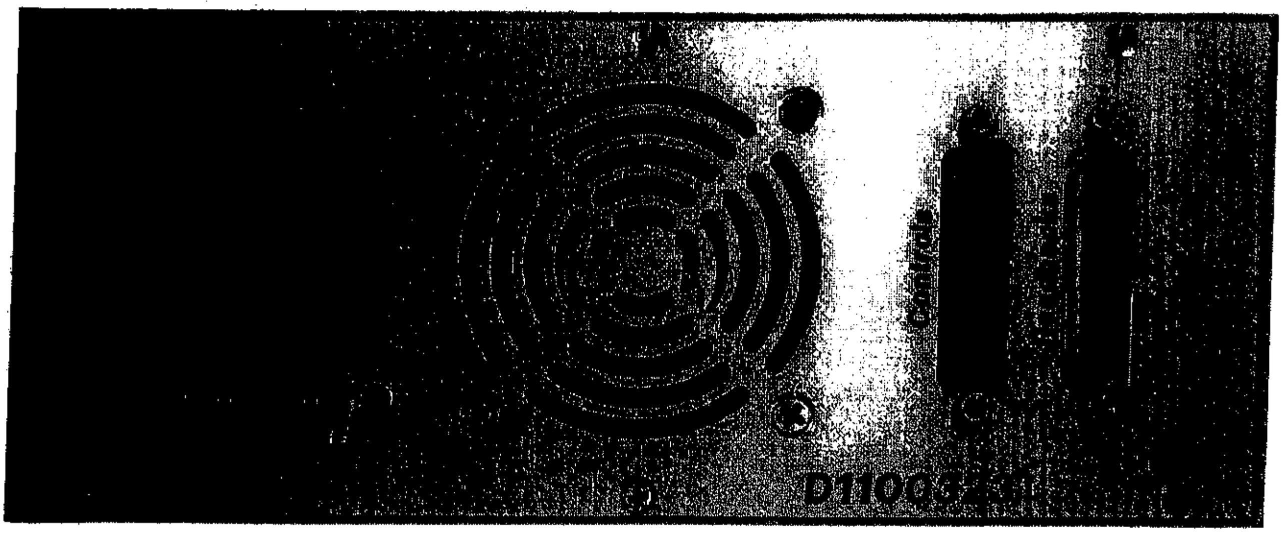
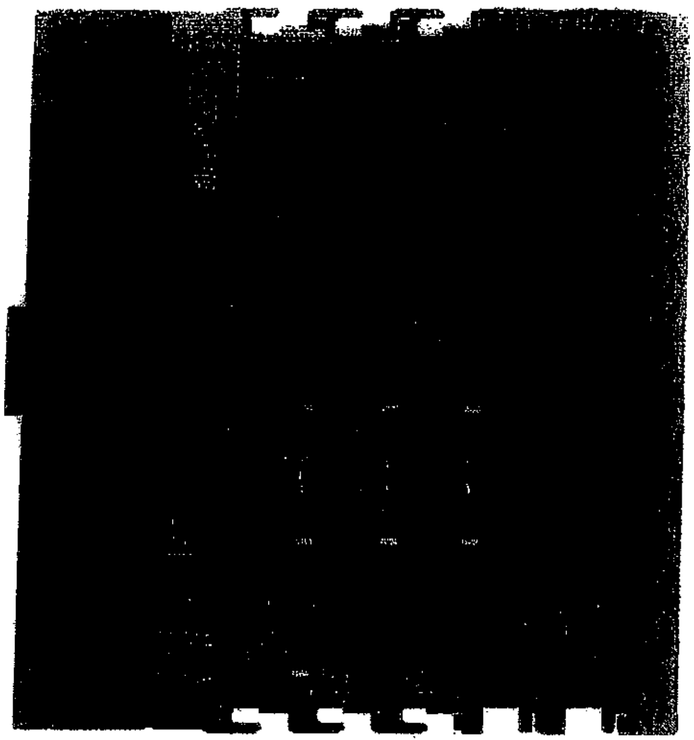


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

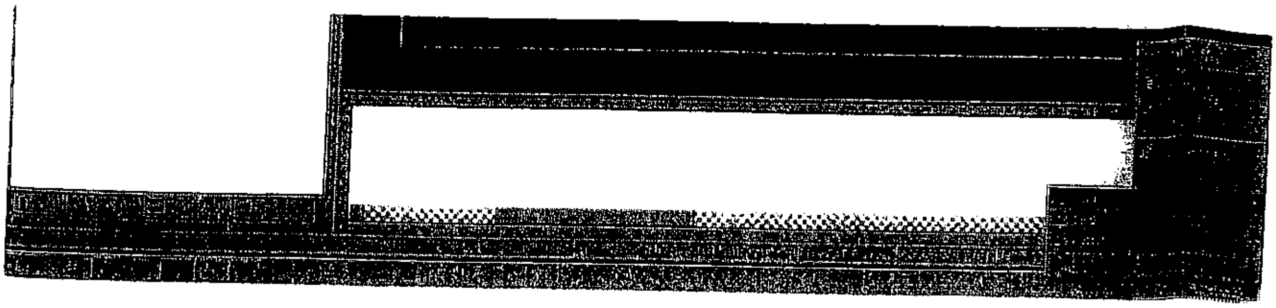
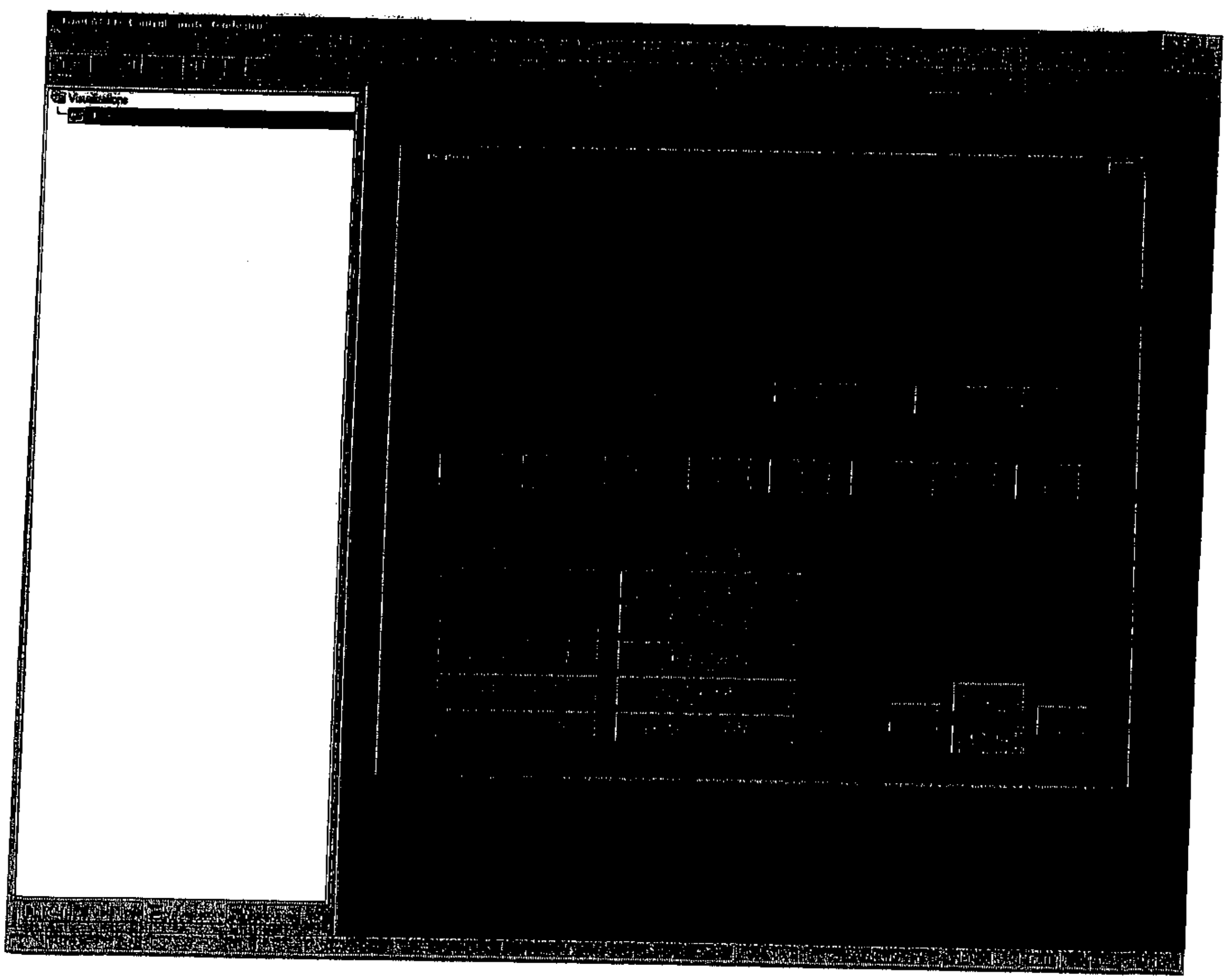


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107560

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

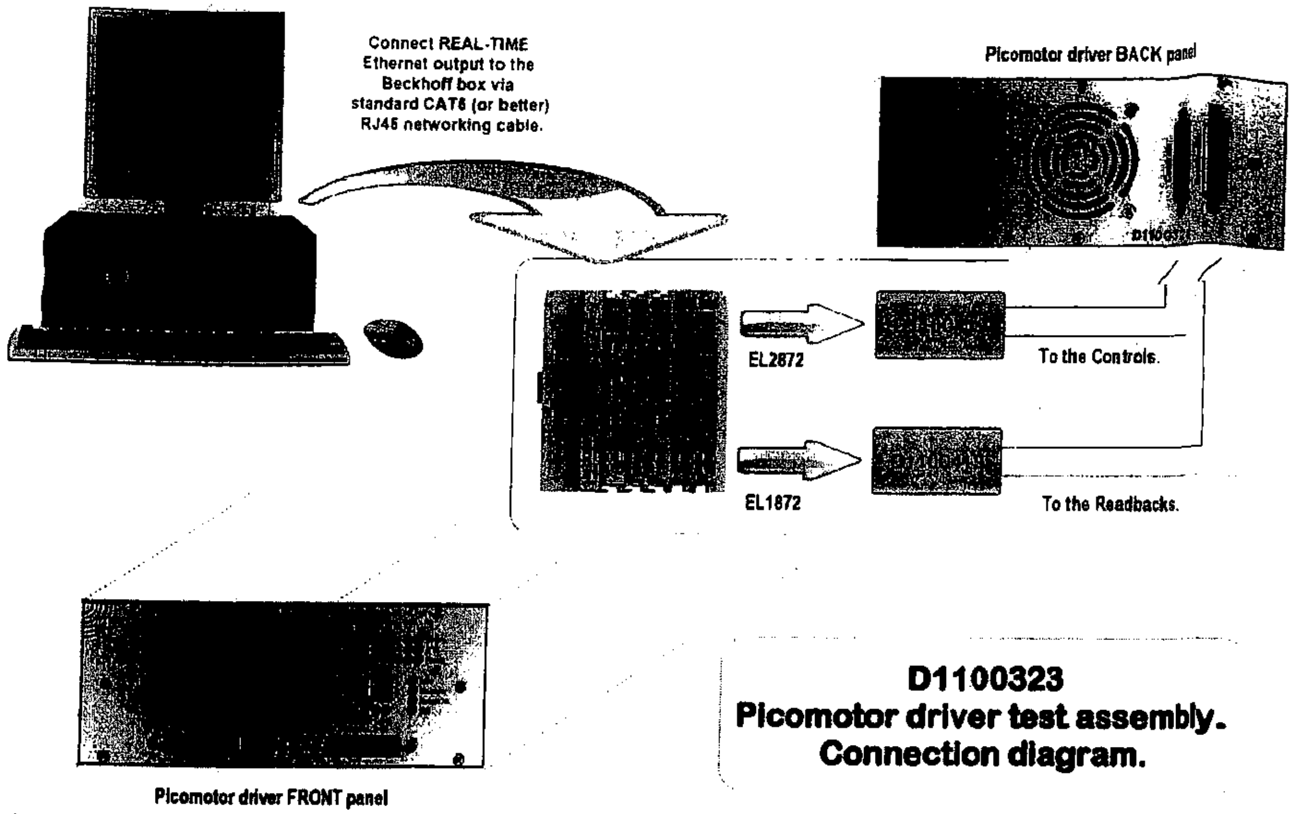


Figure 1a: A connection diagram of the picomotor setup.

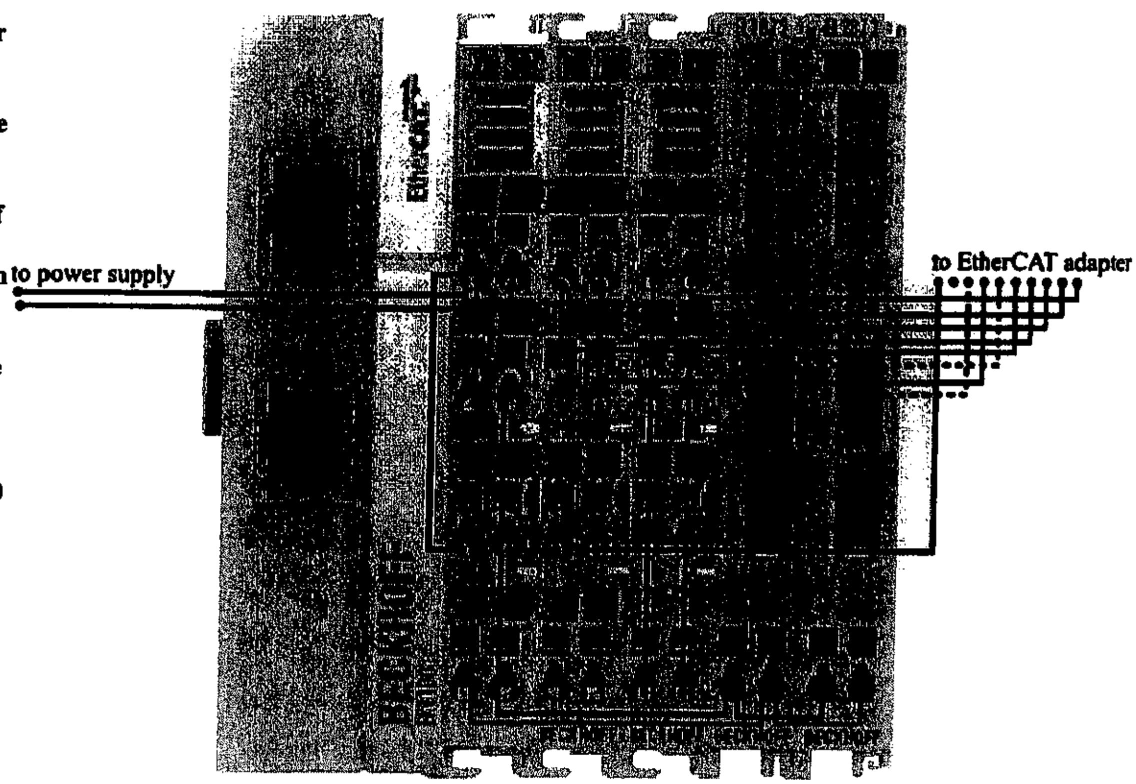


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

✓ [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	24.48	24.76
2	25.80	26.16
3	27.01	27.48
4	28.17	28.76
5	29.09	29.79
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

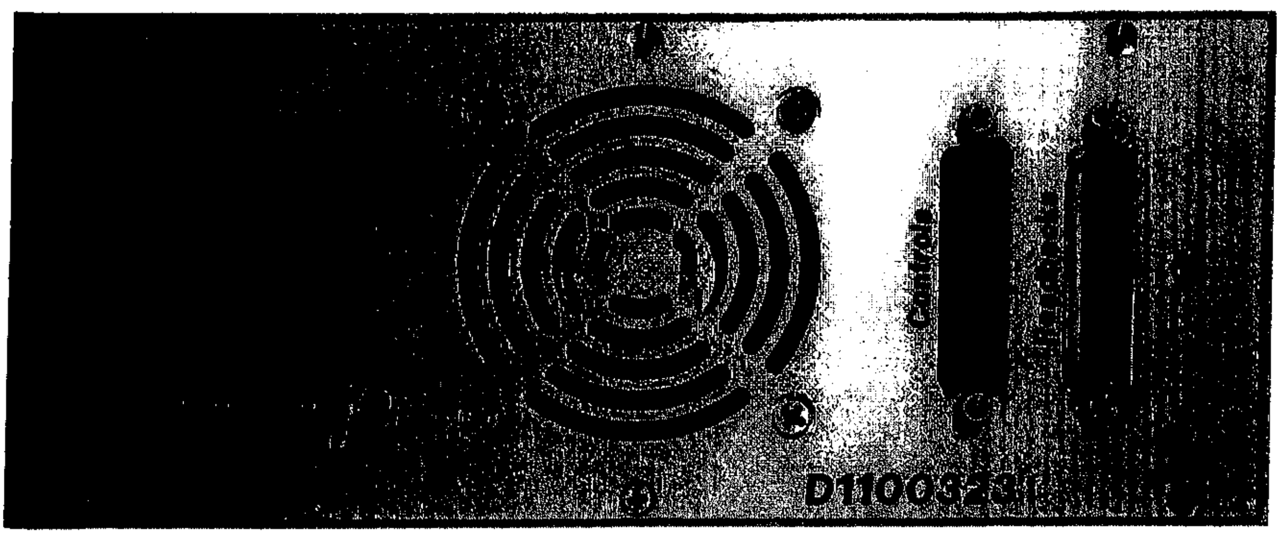
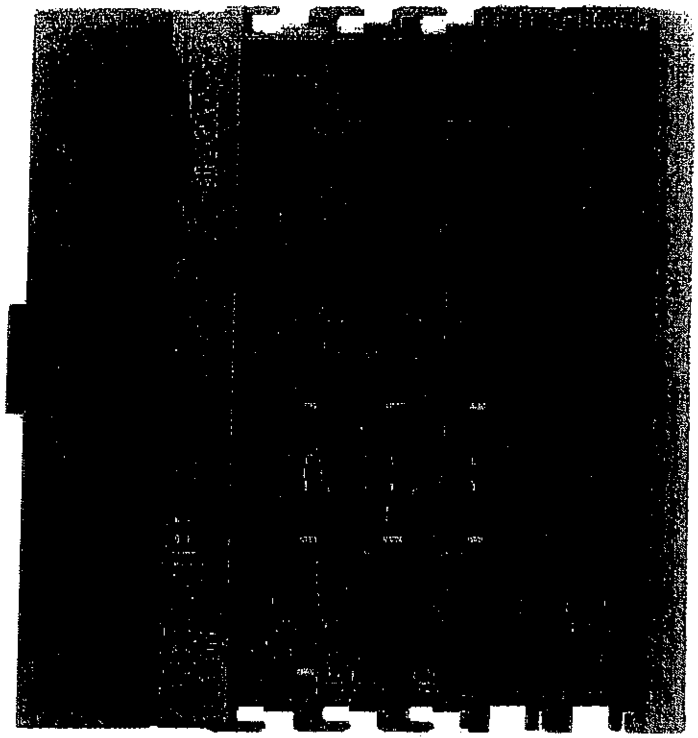


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

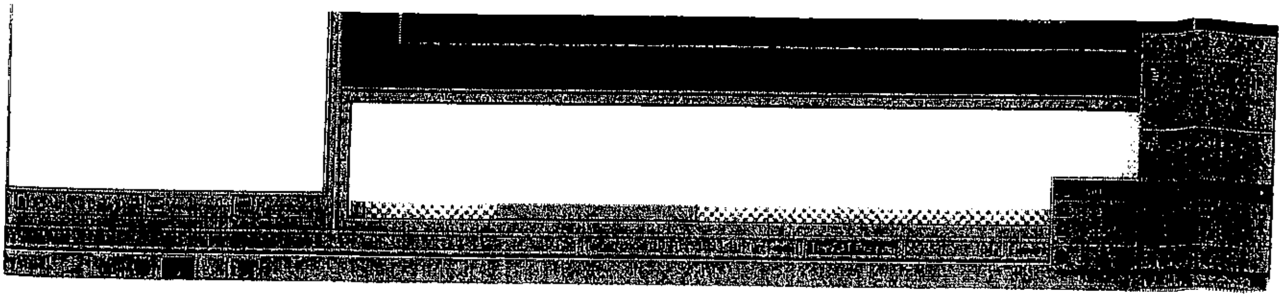
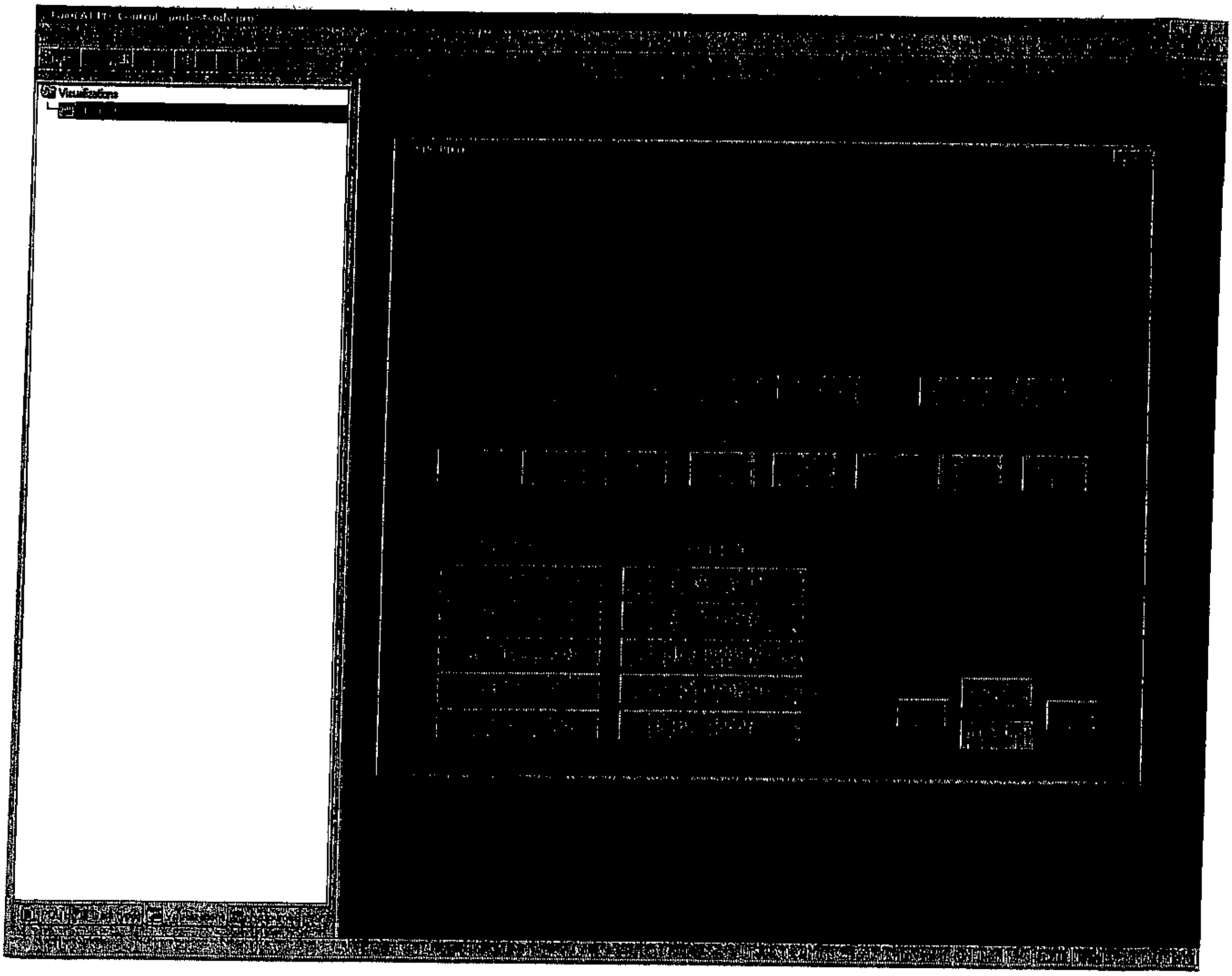


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107561

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

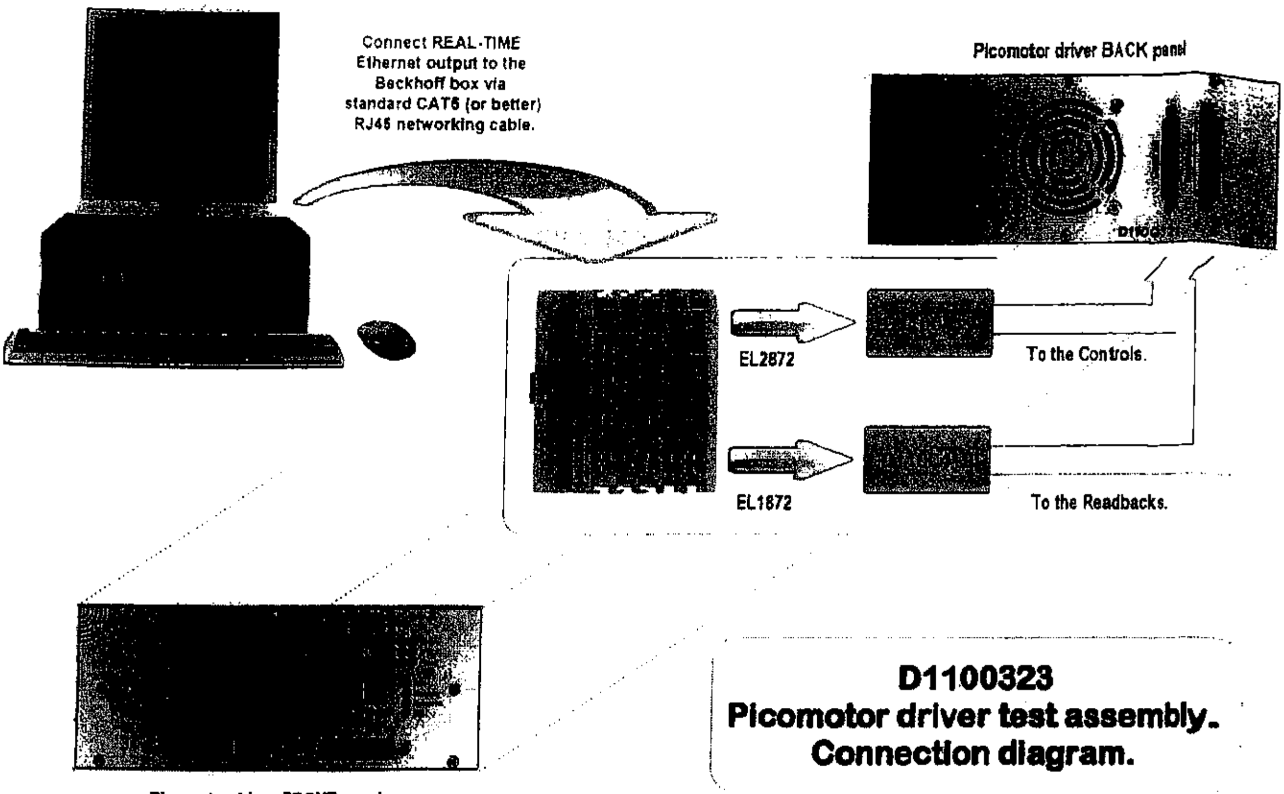
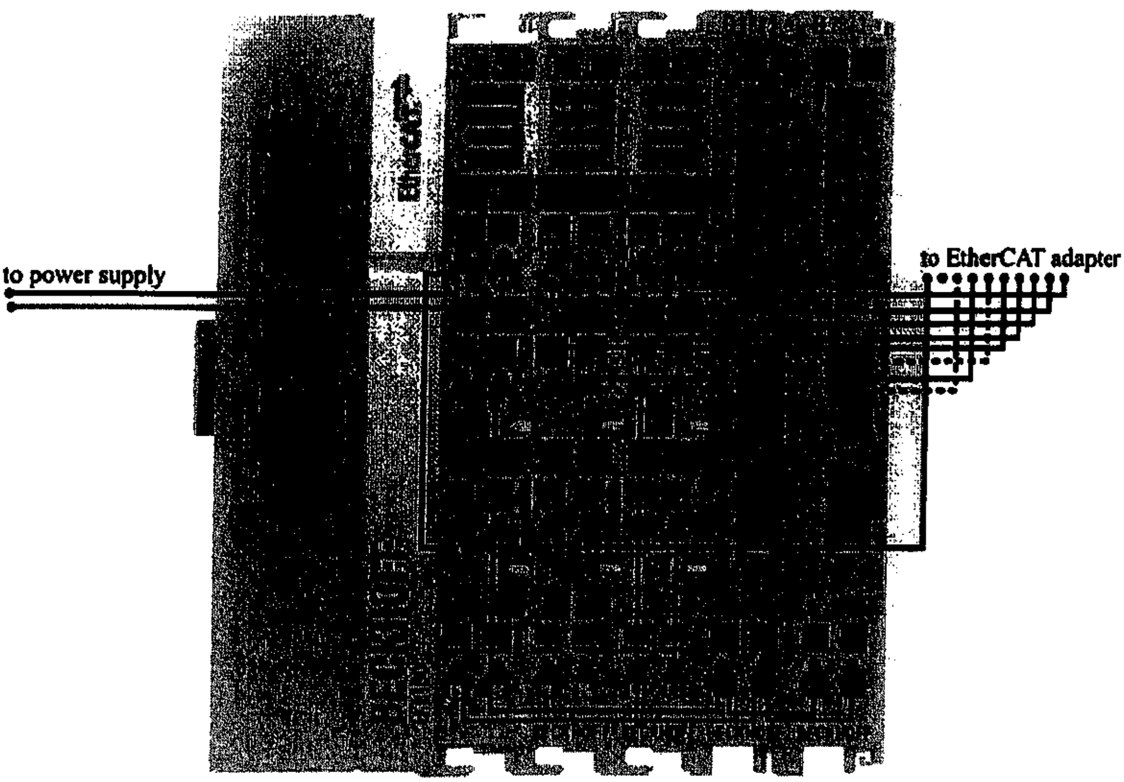


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[ ]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.92	23.89
2	25.43	25.44
3	26.76	26.88
4	27.92	28.08
5	28.98	29.29
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

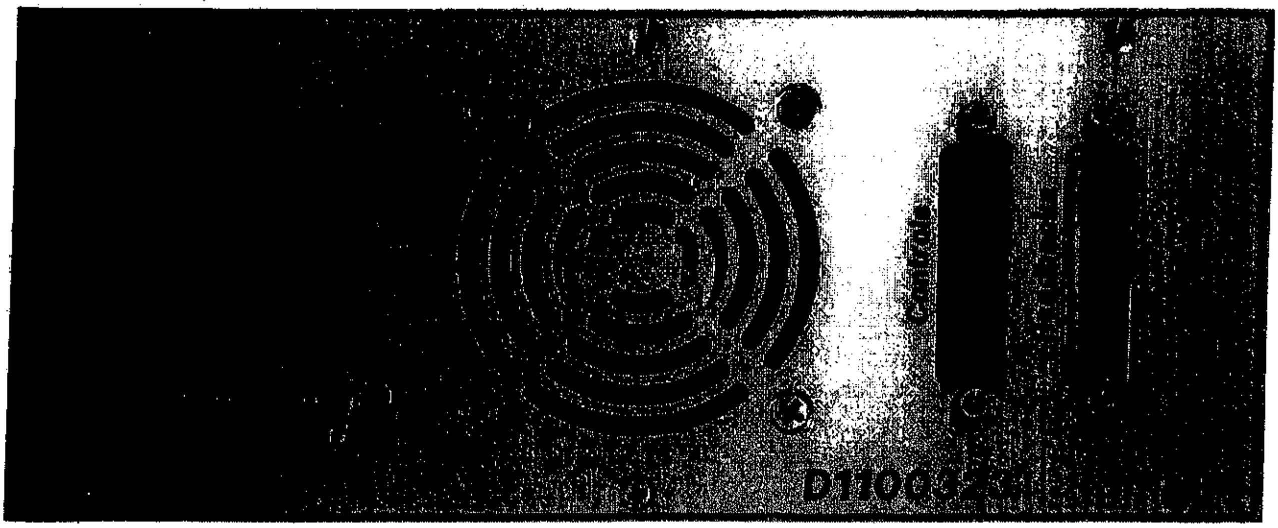
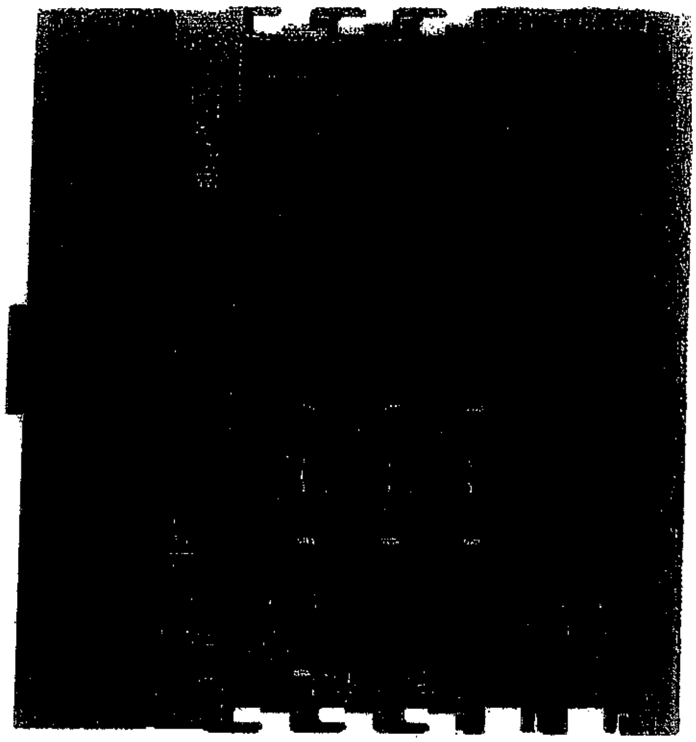


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

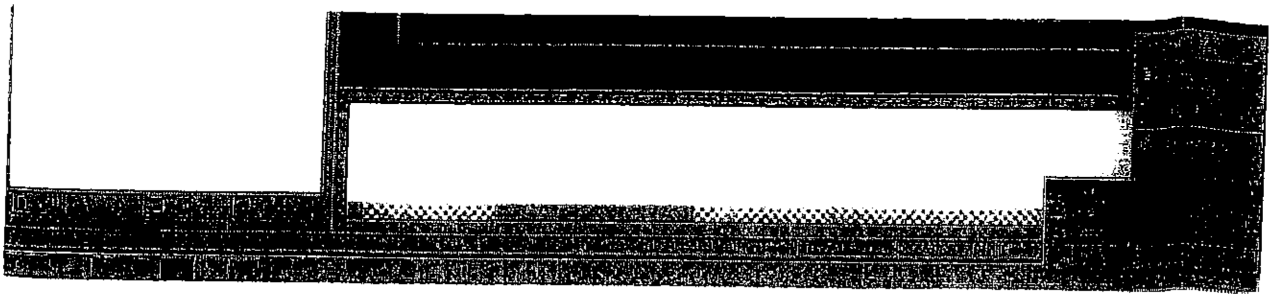
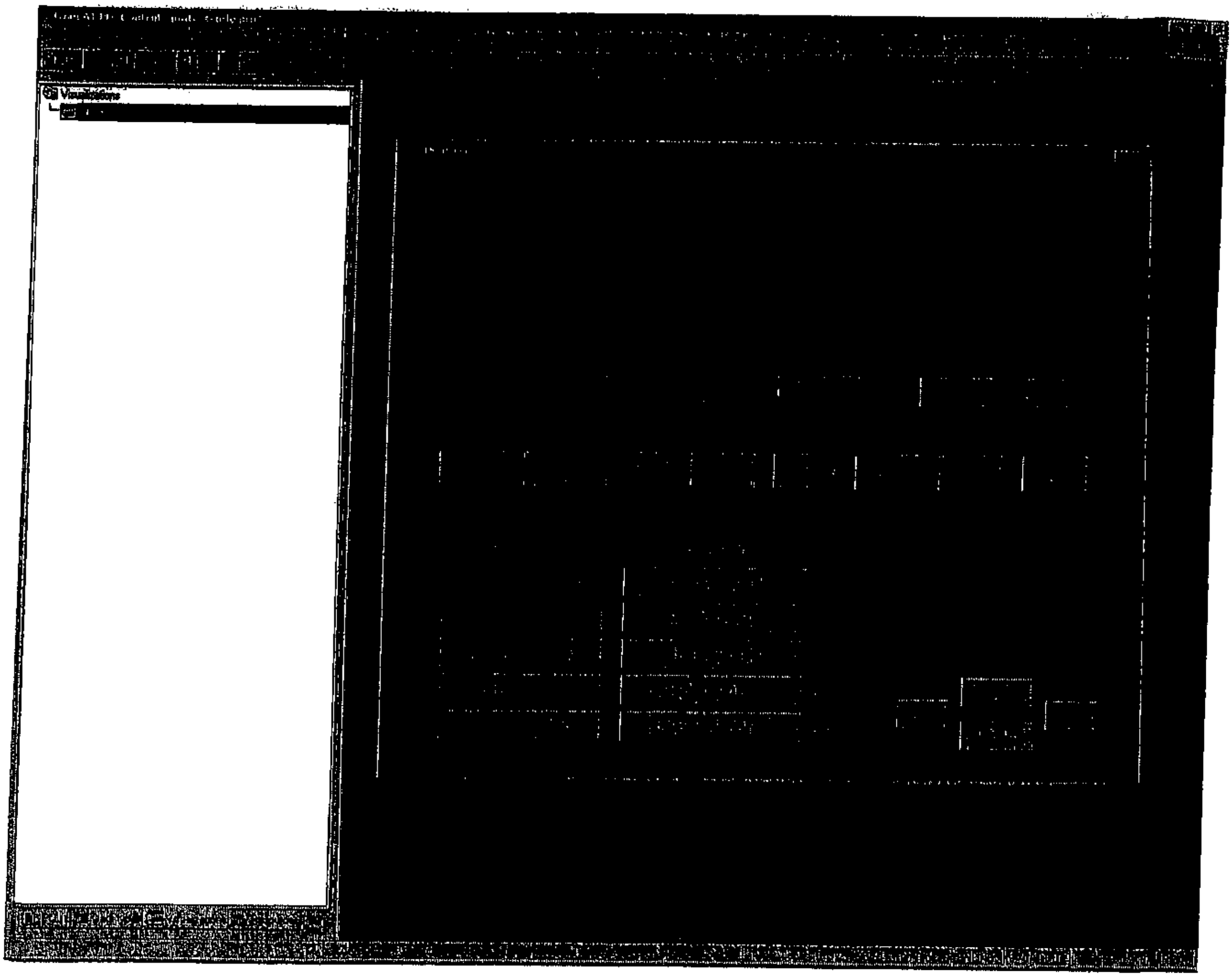


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107562

Test Engineer: Zach G

Test Date: 11/22/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

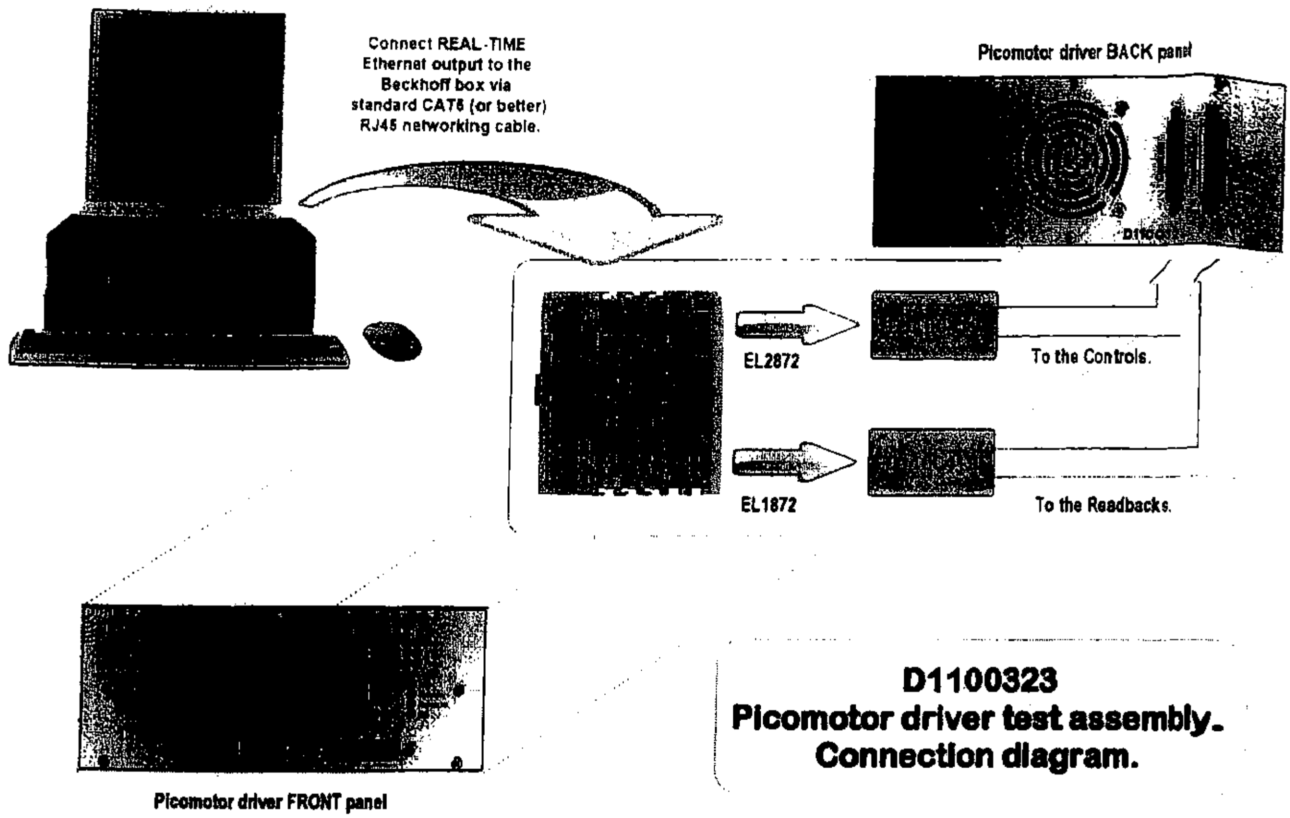
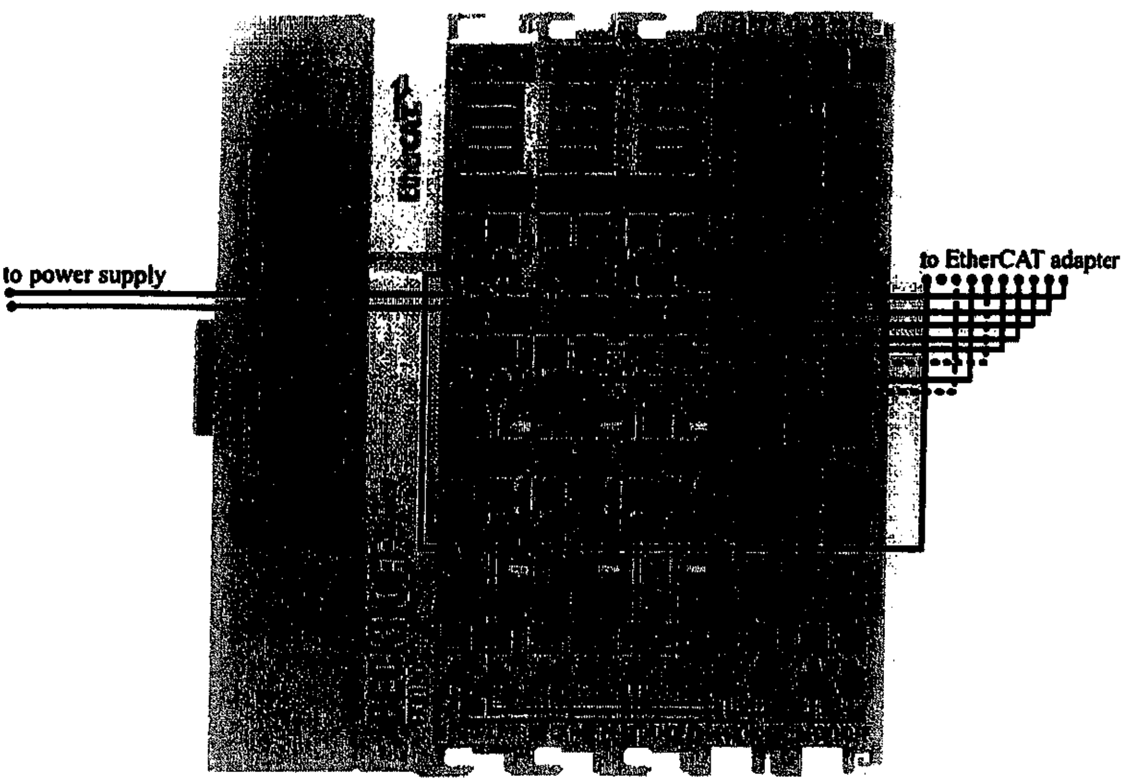


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.64	27.46
2	28.82	28.77
3	30.00	29.97
4	31.00	31.05
5	31.91	32.01
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

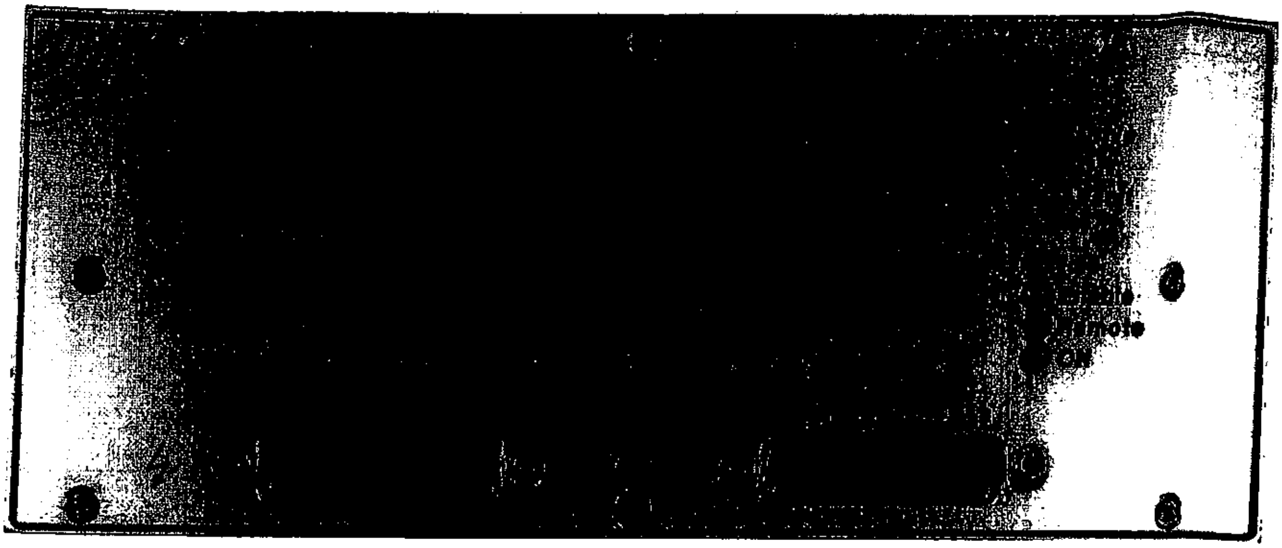


Figure 3: Picomotor driver chassis rear panel

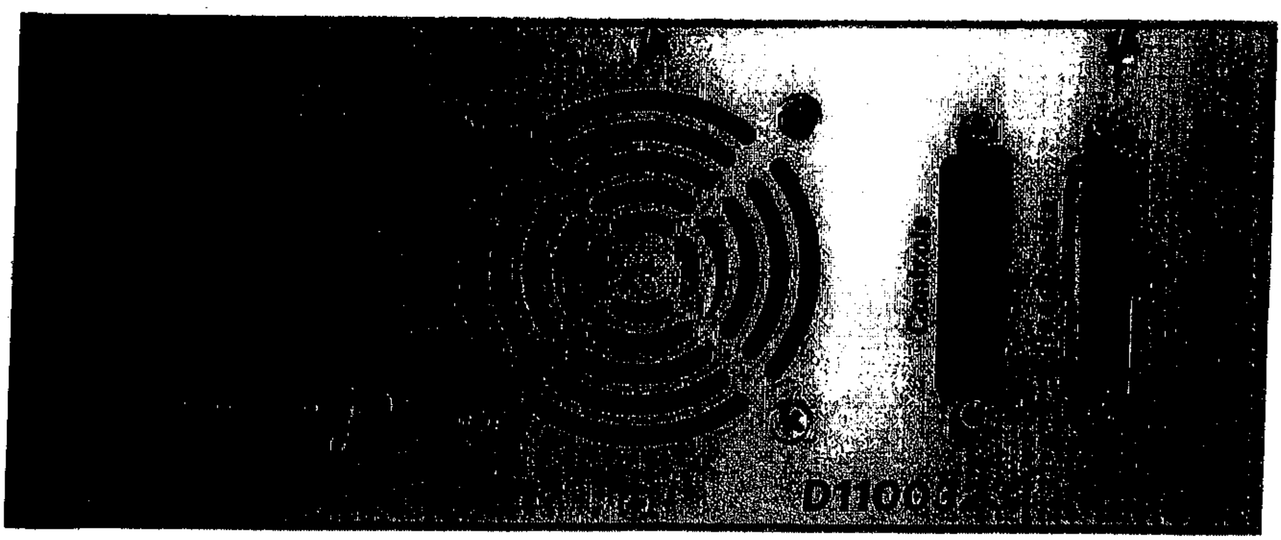
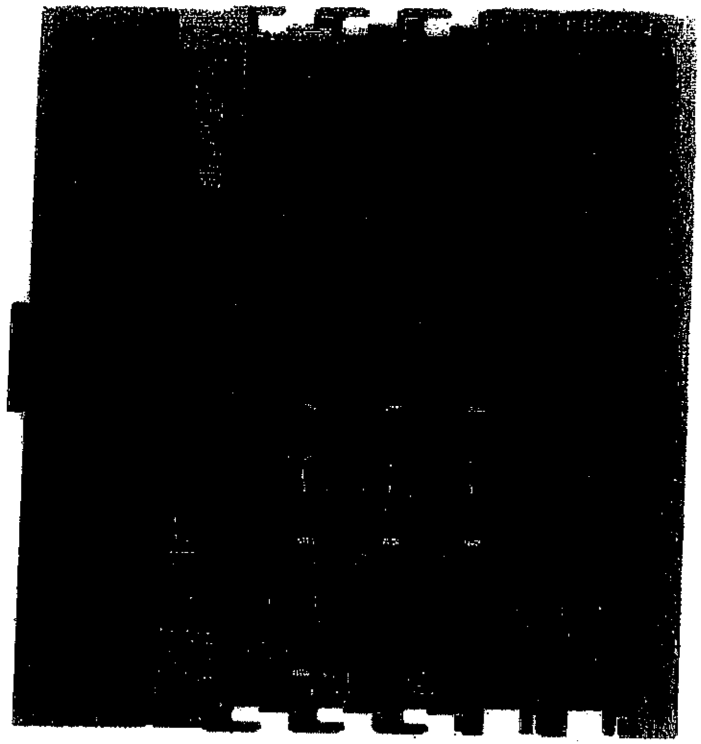


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

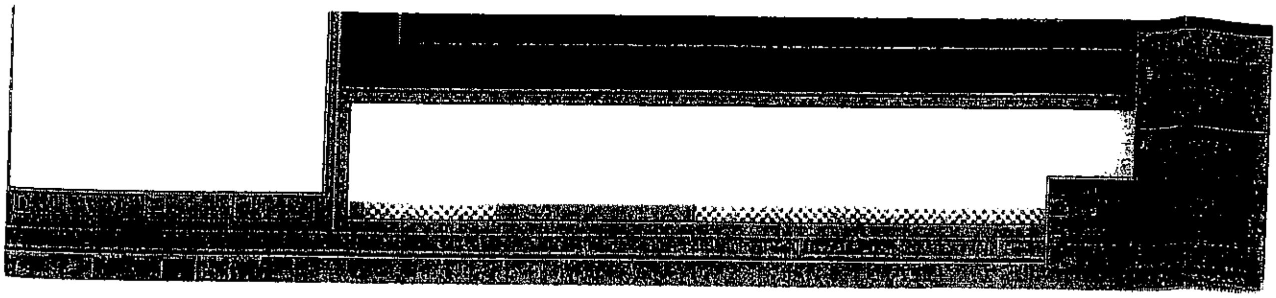
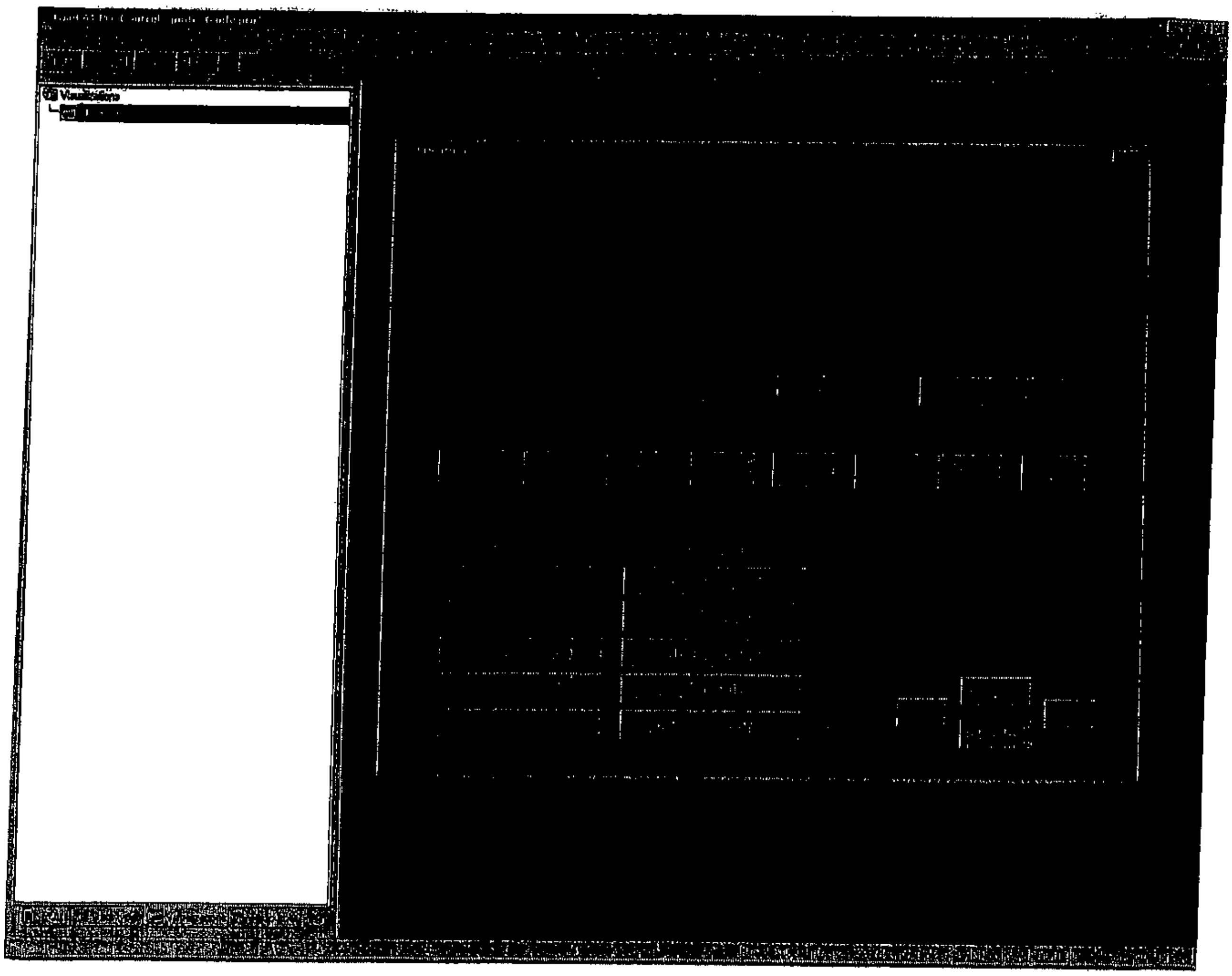


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107563

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302
2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)
3. LIGO standard 24V M-F-M DB3 power cable
4. EtherCAT adapter D1100419-v3 (1)
5. DB25 F/M cables (2)
6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple
7. IDC 20-pin cable assemblies (2)
8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)
9. 24V power supply for Beckhoff boxes (1)
10. Ethernet cable (1)
11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit
2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

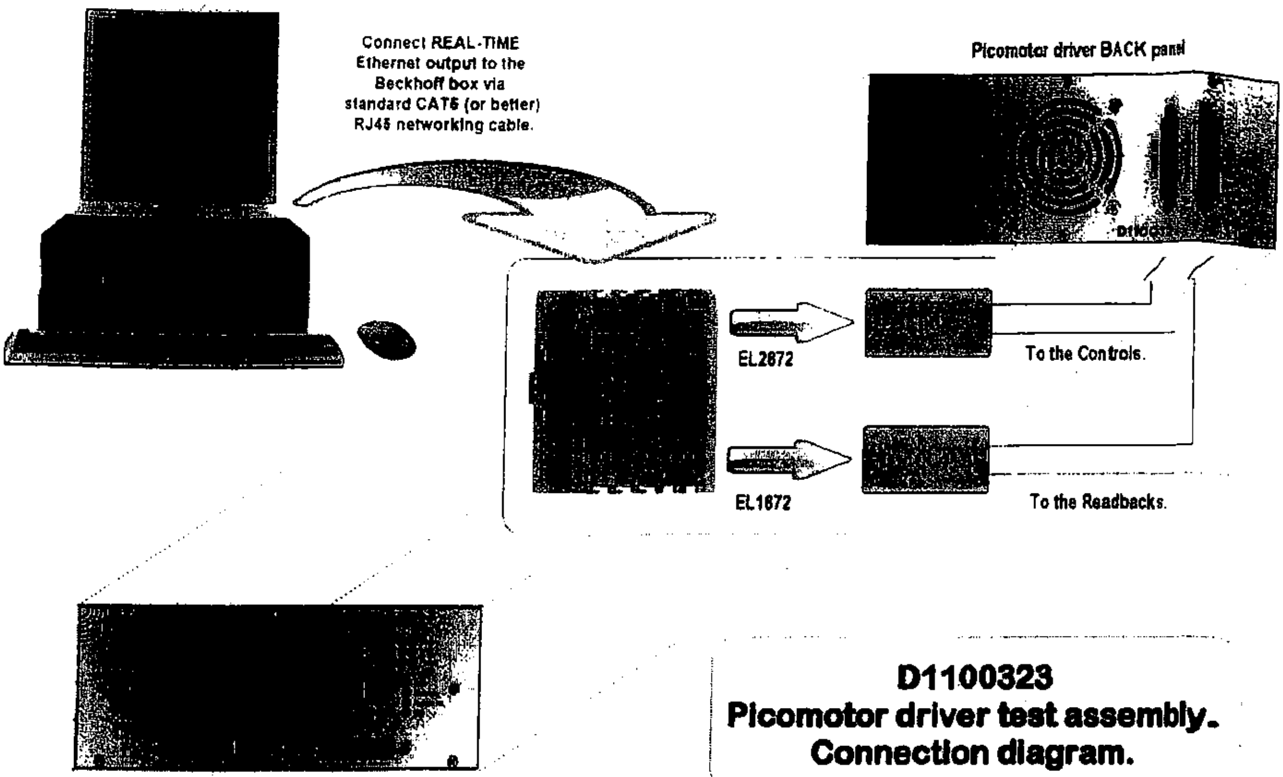


Figure 1a: A connection diagram of the picomotor setup.

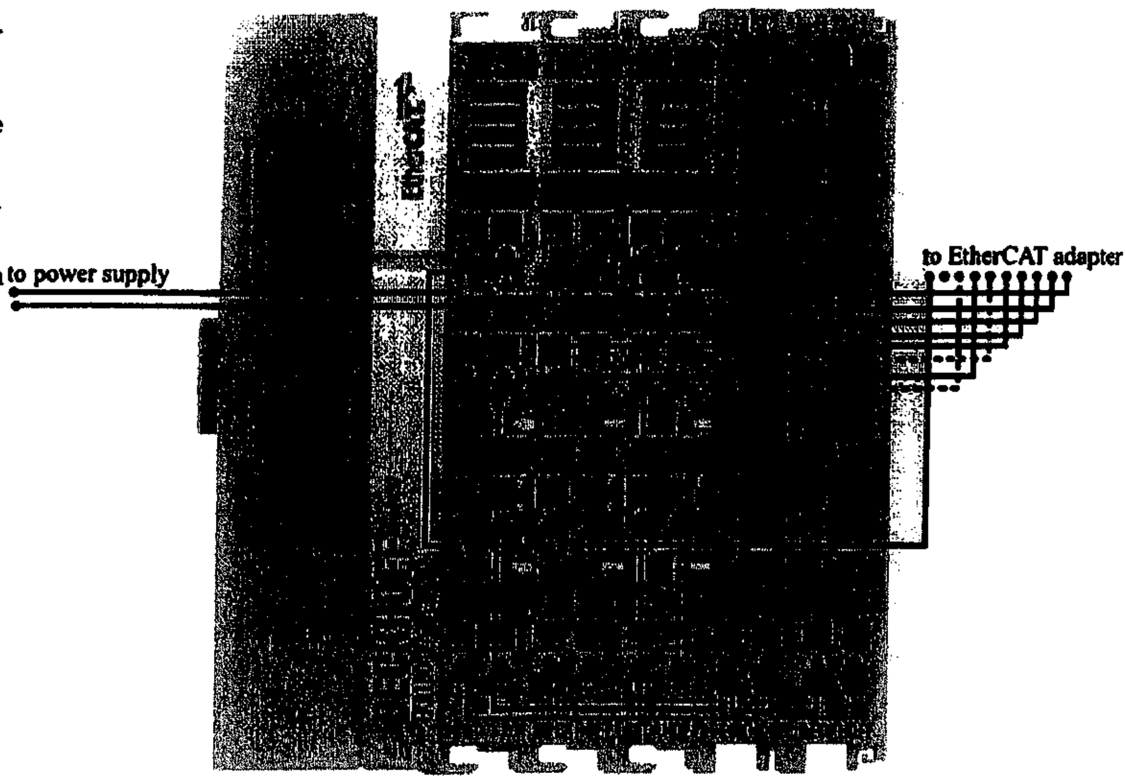


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	26.75	24.88
2	28.63	26.23
3	29.19	27.99
4	30.24	28.63
5	31.18	29.61
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/28/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

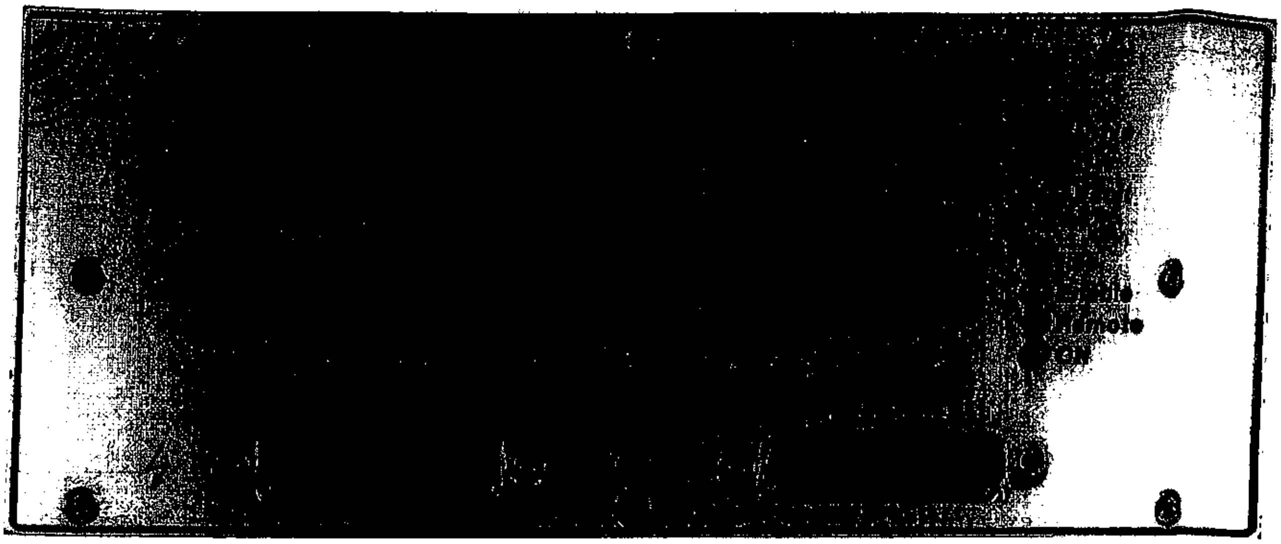


Figure 3: Picomotor driver chassis rear panel

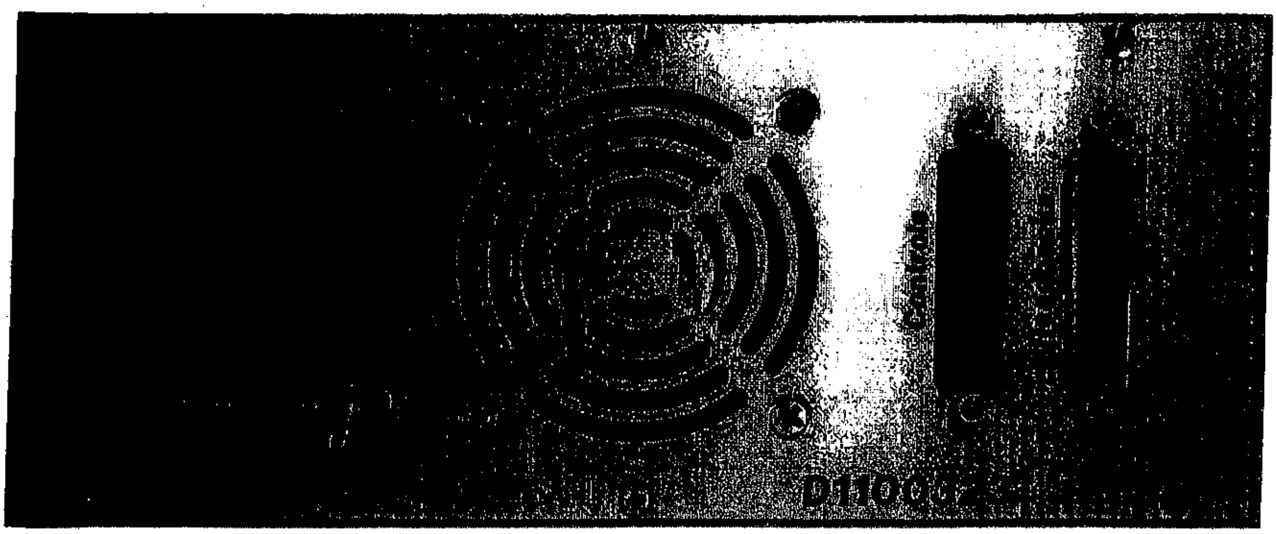
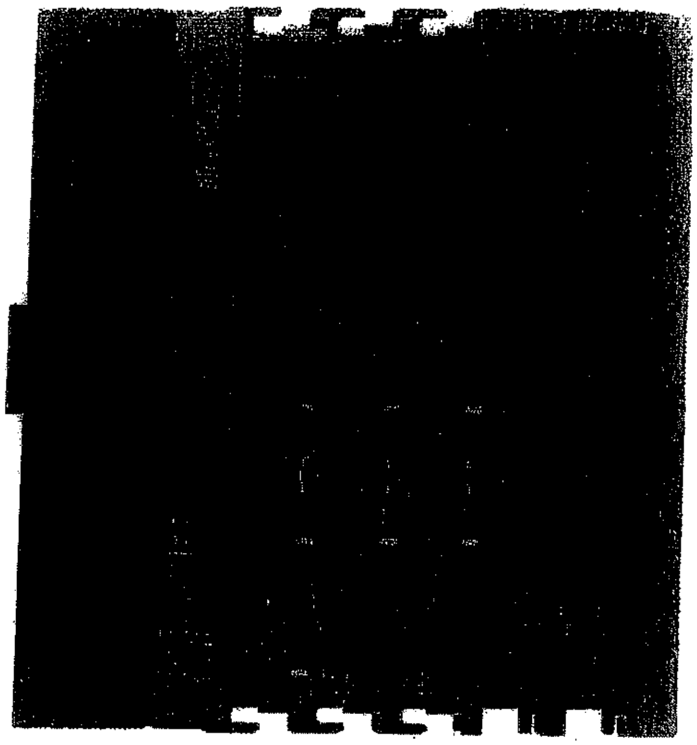


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

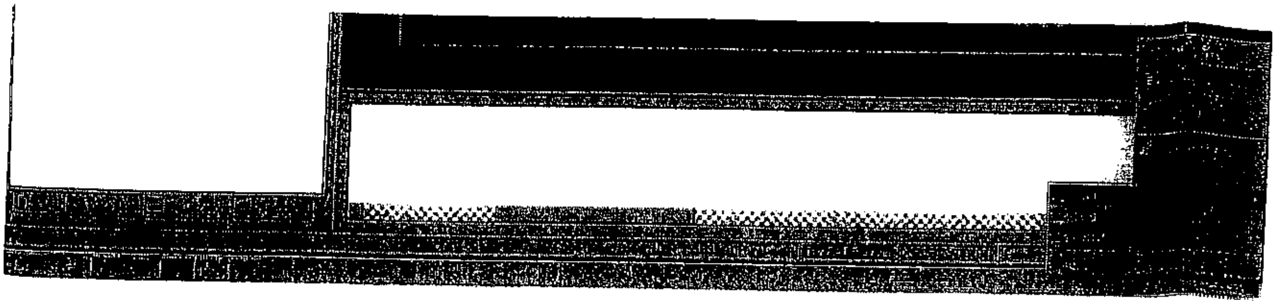
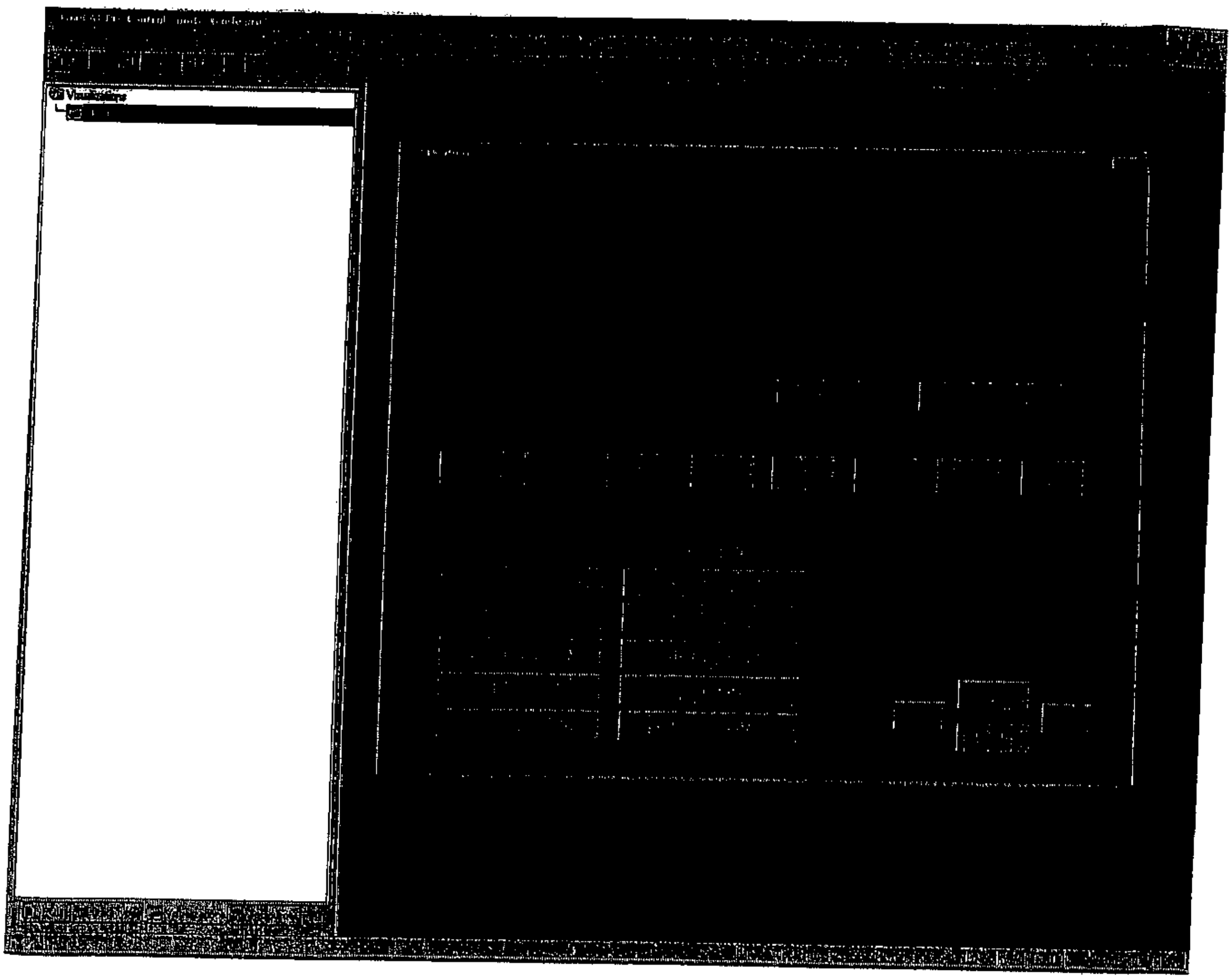


Figure 6: Step 5 of PLC controls setup



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Technical Note LIGO-T1100458-v1 08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107564

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

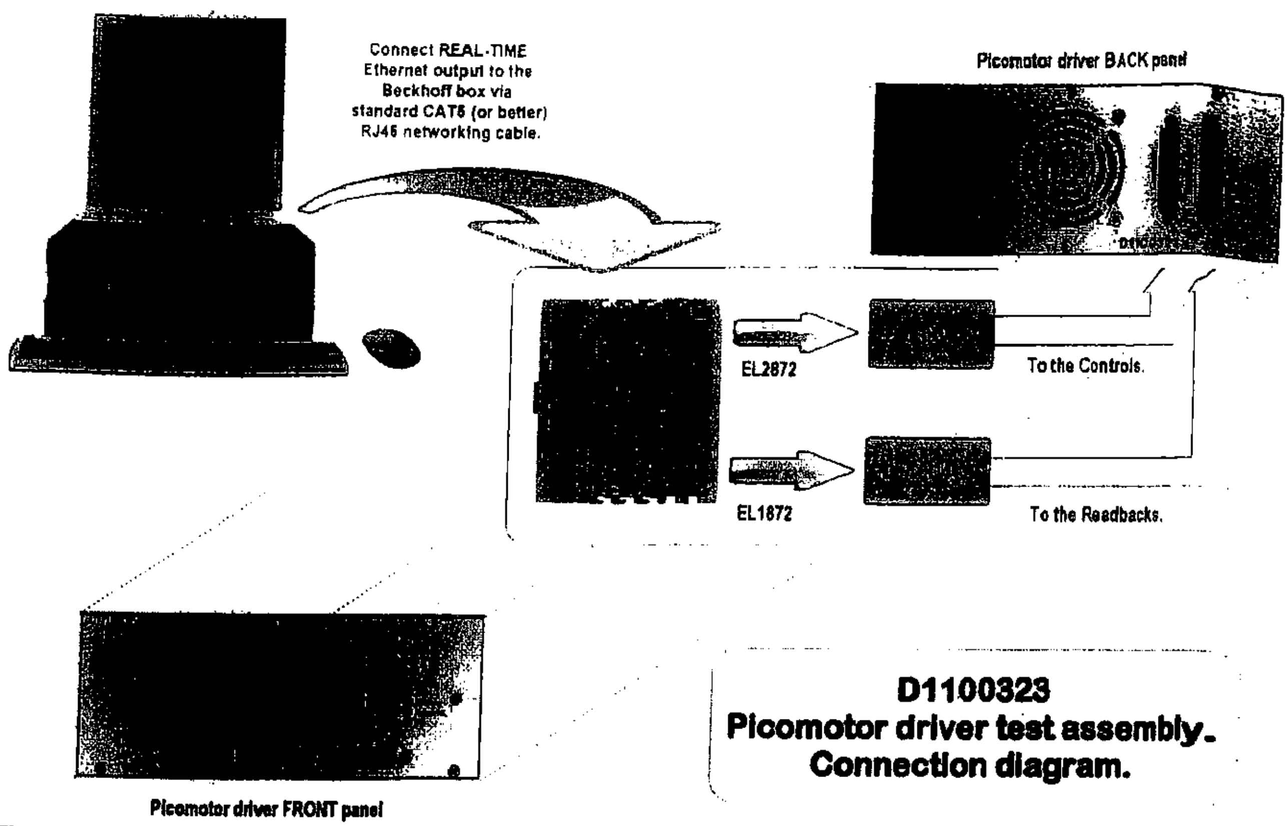
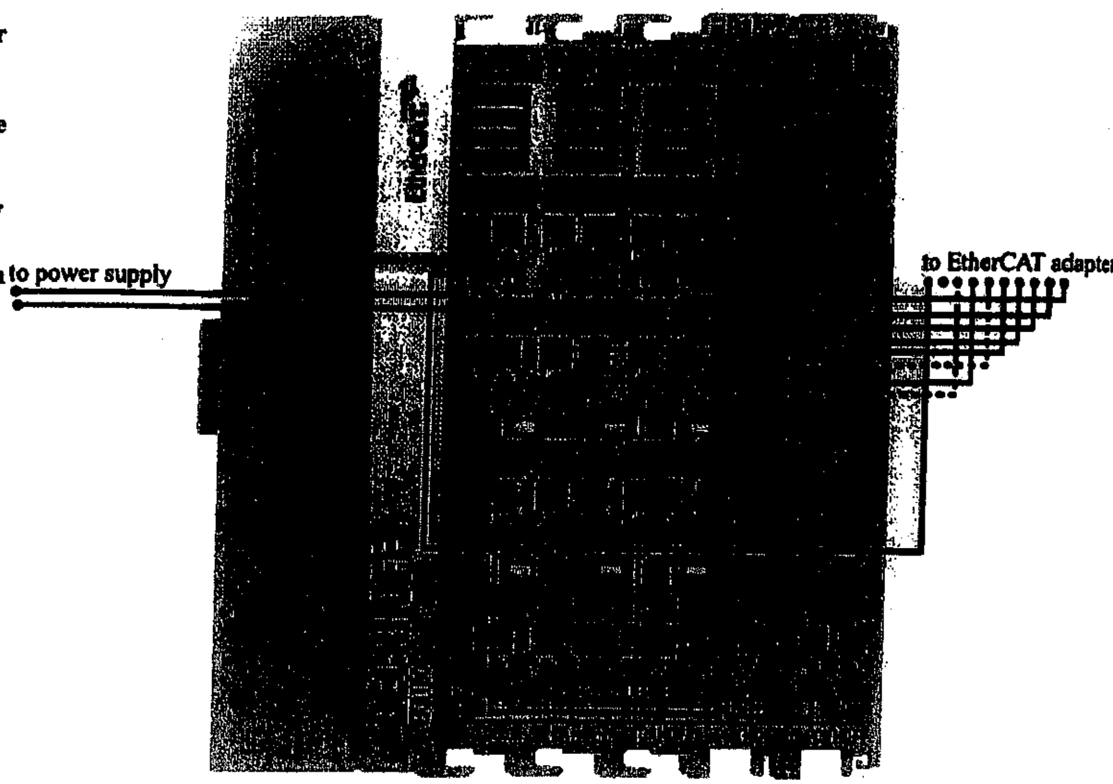


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.92	25.16
2	25.22	26.56
3	26.40	27.90
4	27.44	28.94
5	28.42	30.02
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] **Pass**	[ ] Fail

Test Engineer: Zach G

Test Date: 11/28/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

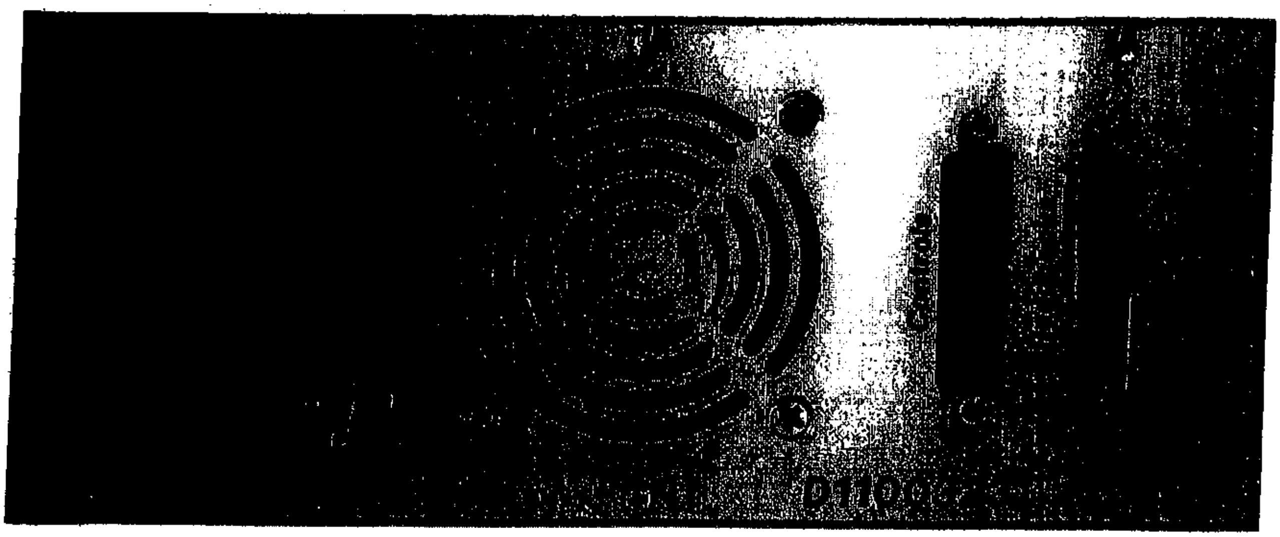
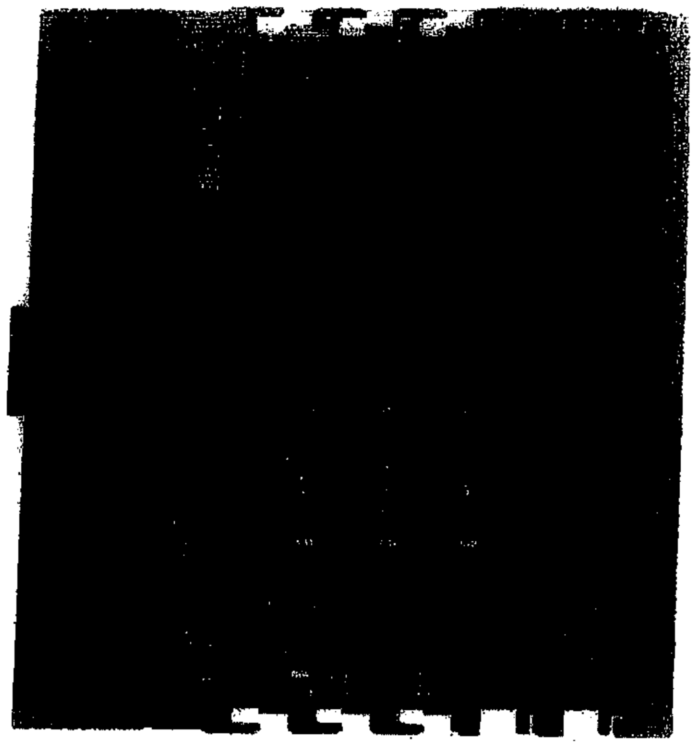


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

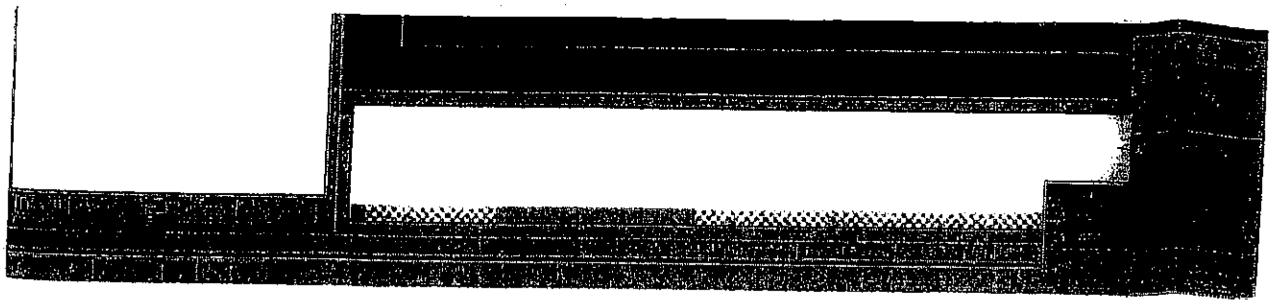
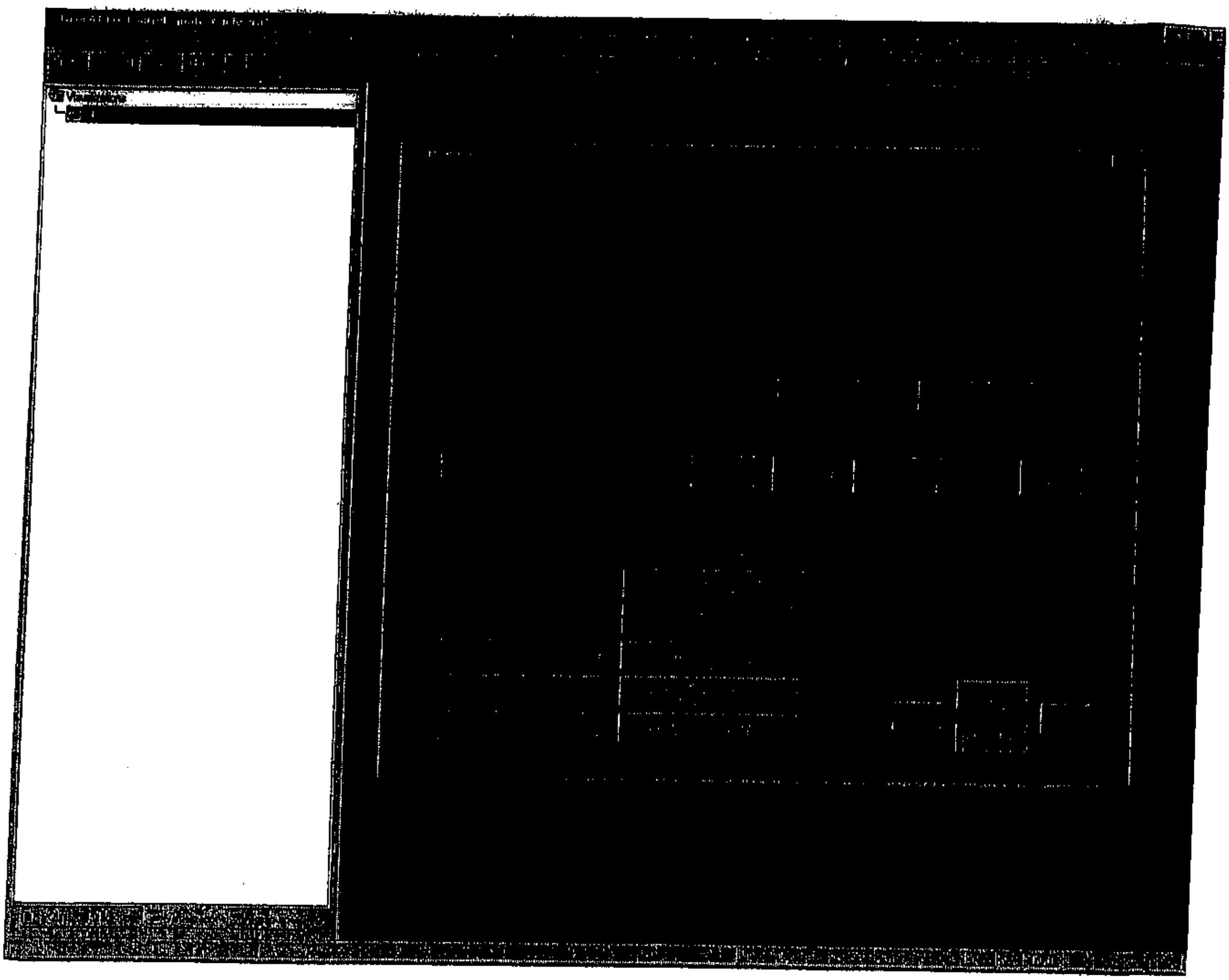


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107565

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [ ] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

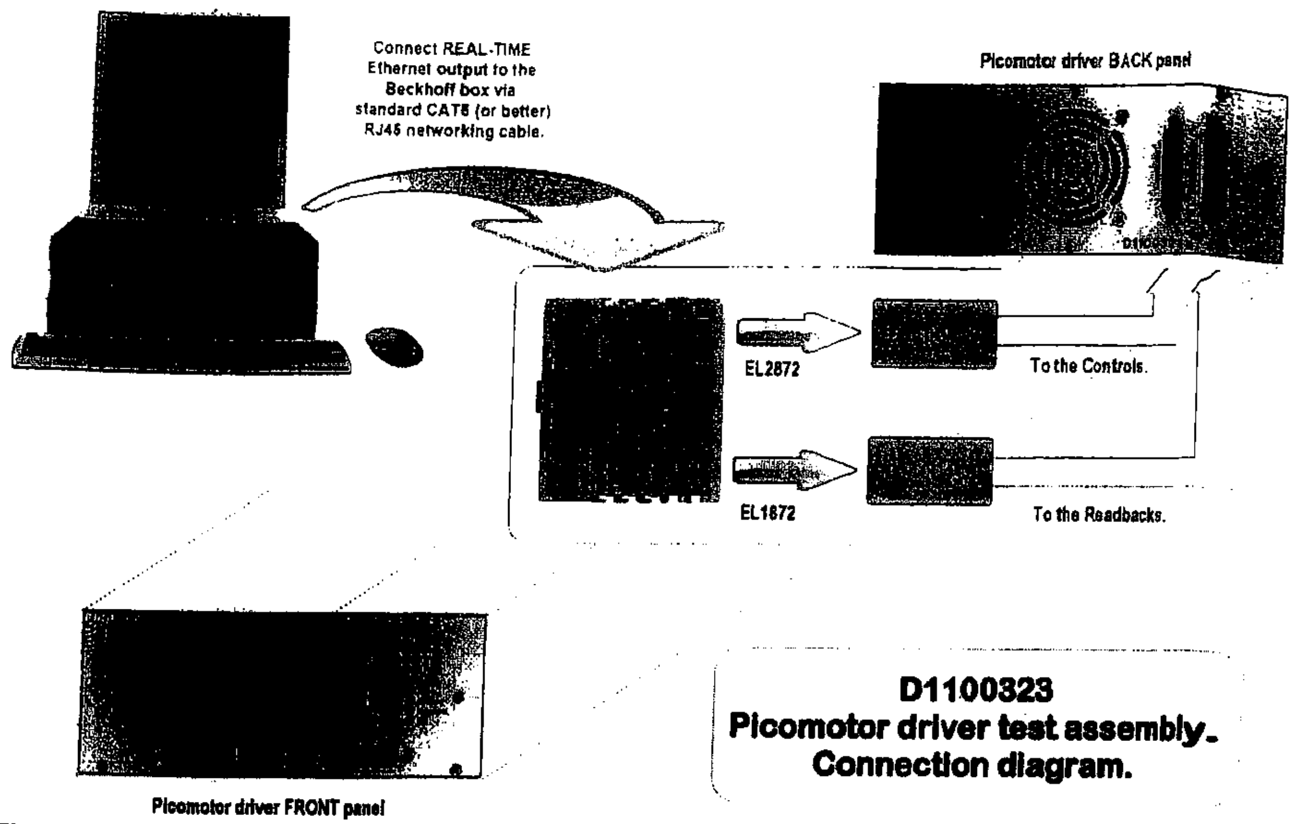
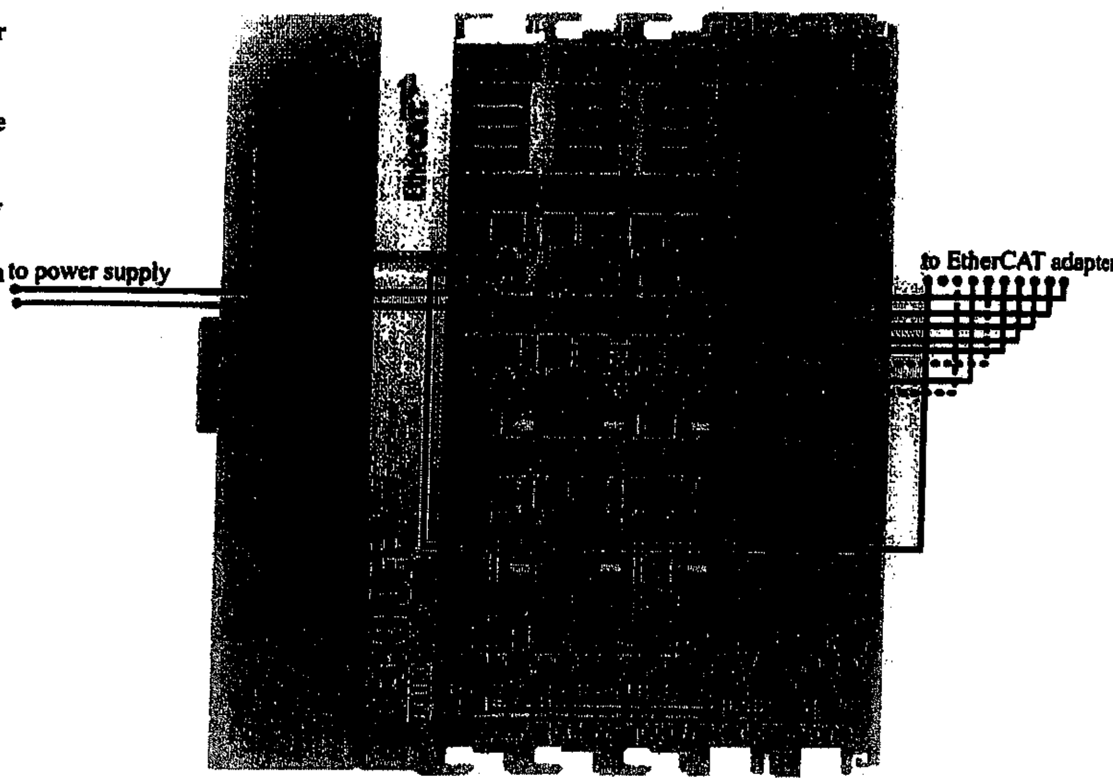


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	24.76	24.21
2	26.00	25.62
3	27.31	26.89
4	28.49	28.09
5	29.43	29.19
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/28/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

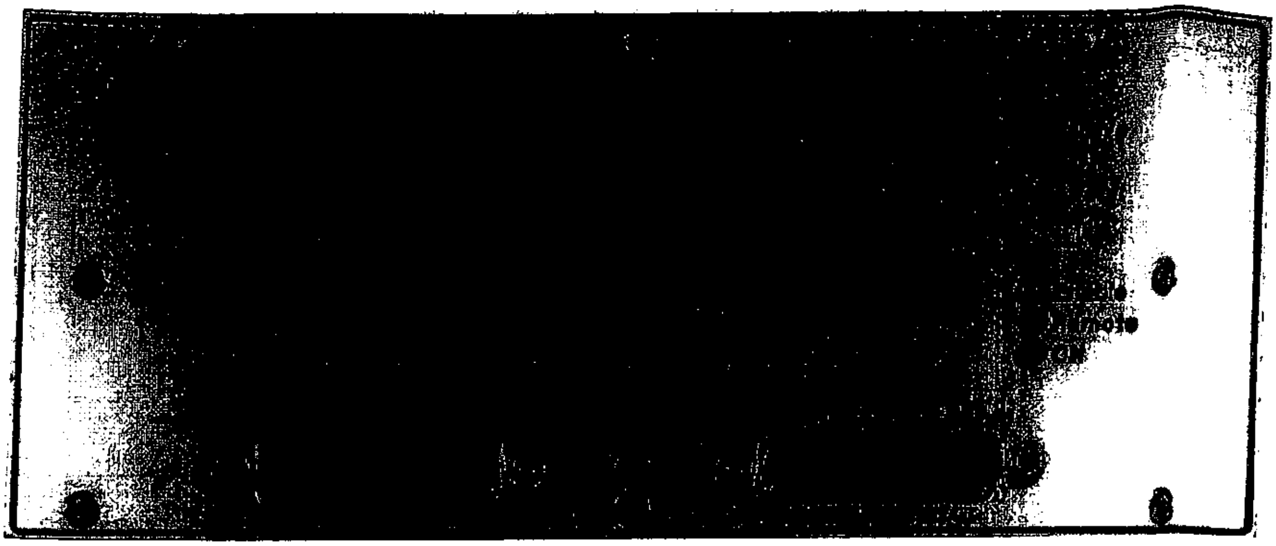


Figure 3: Picomotor driver chassis rear panel

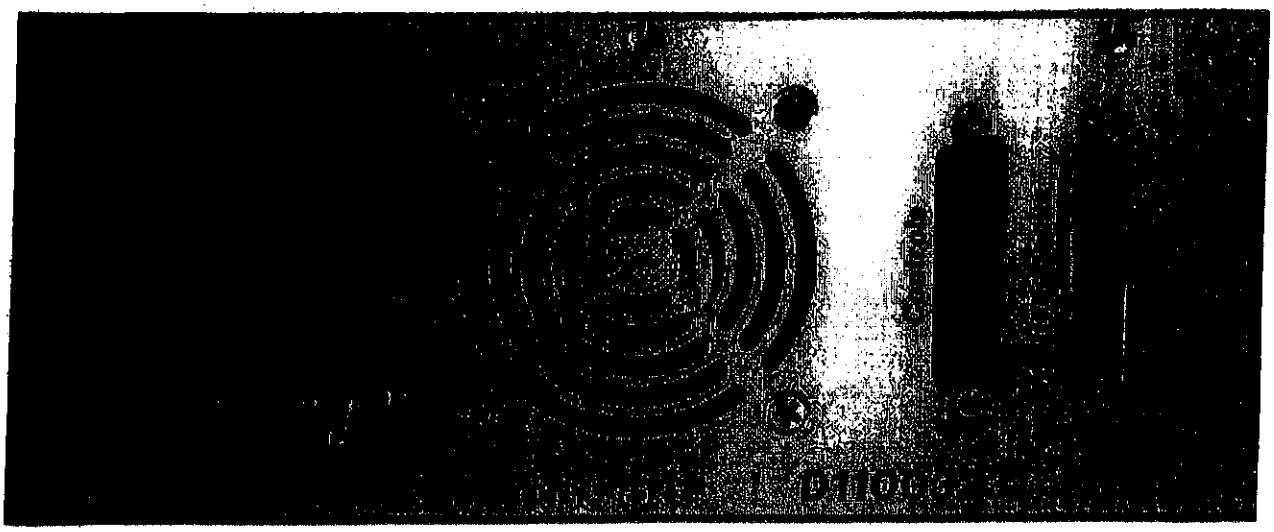
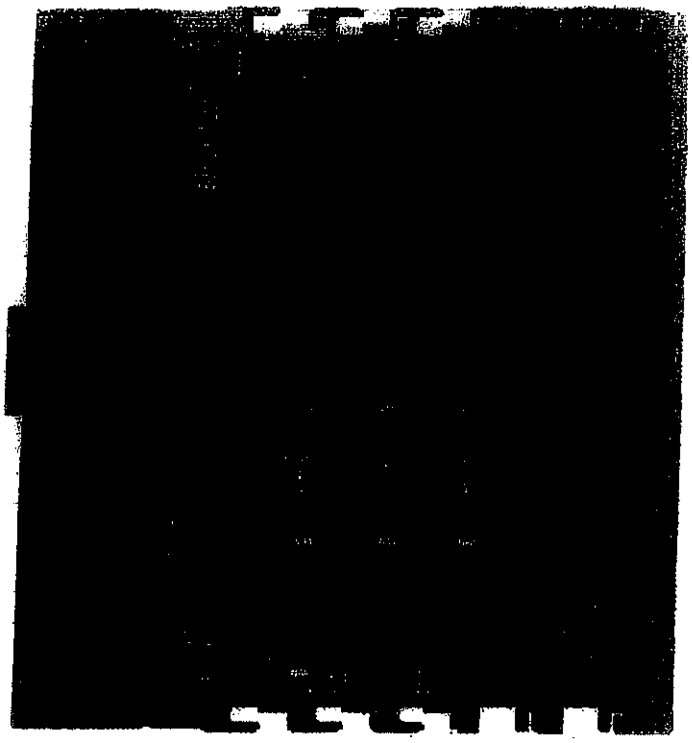


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

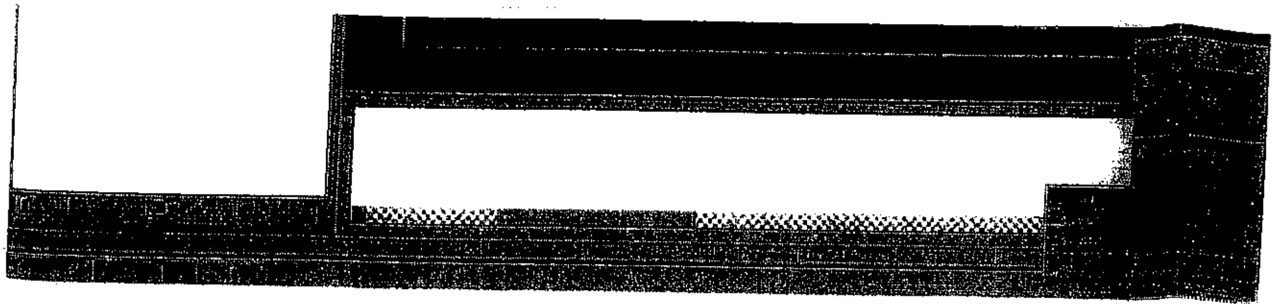
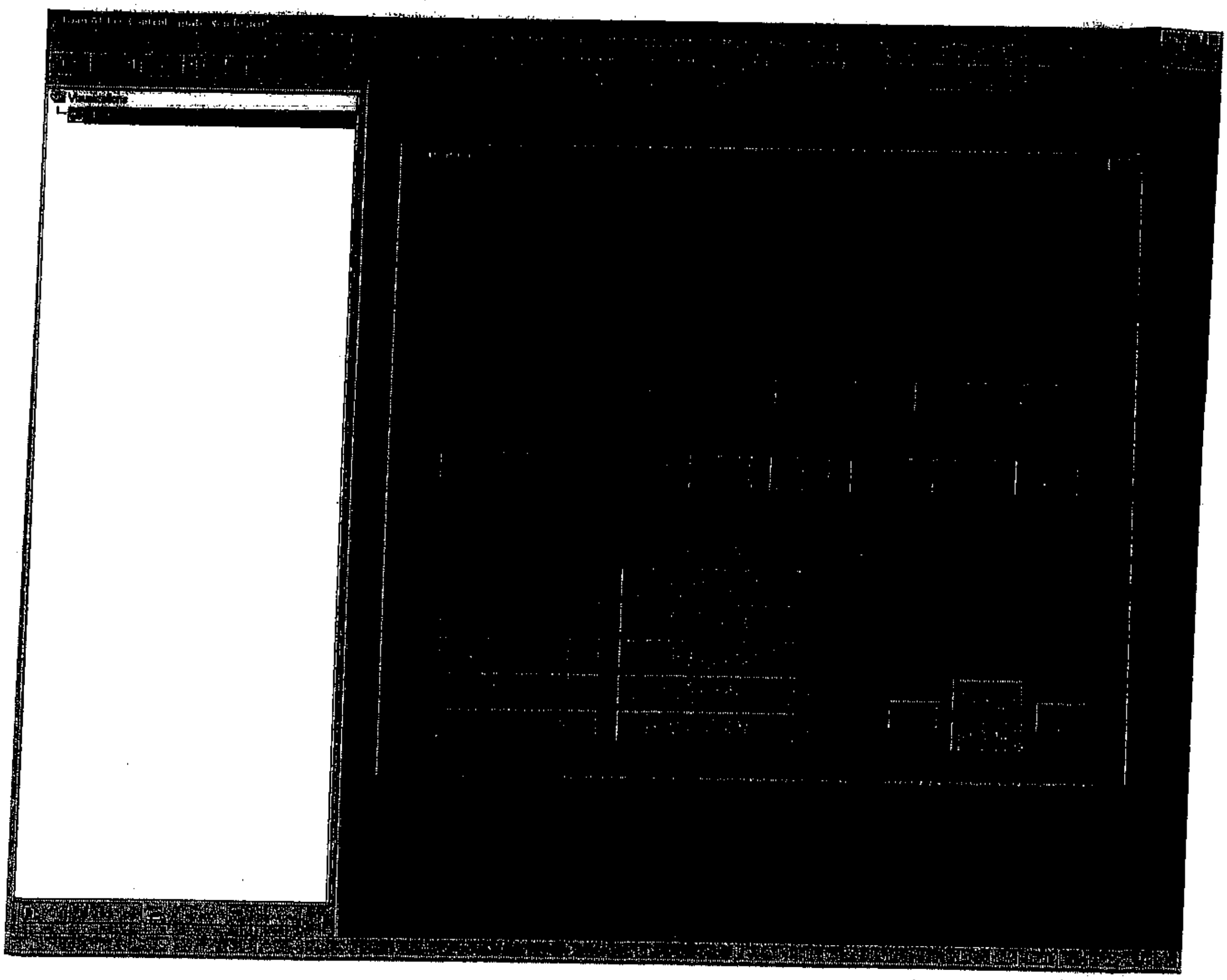


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Technical Note LIGO-T1100458-v1 08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107566

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302
2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)
3. LIGO standard 24V M-F-M DB3 power cable
4. EtherCAT adapter D1100419-v3 (1)
5. DB25 F/M cables (2)
6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple
7. IDC 20-pin cable assemblies (2)
8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)
9. 24V power supply for Beckhoff boxes (1)
10. Ethernet cable (1)
11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit
2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

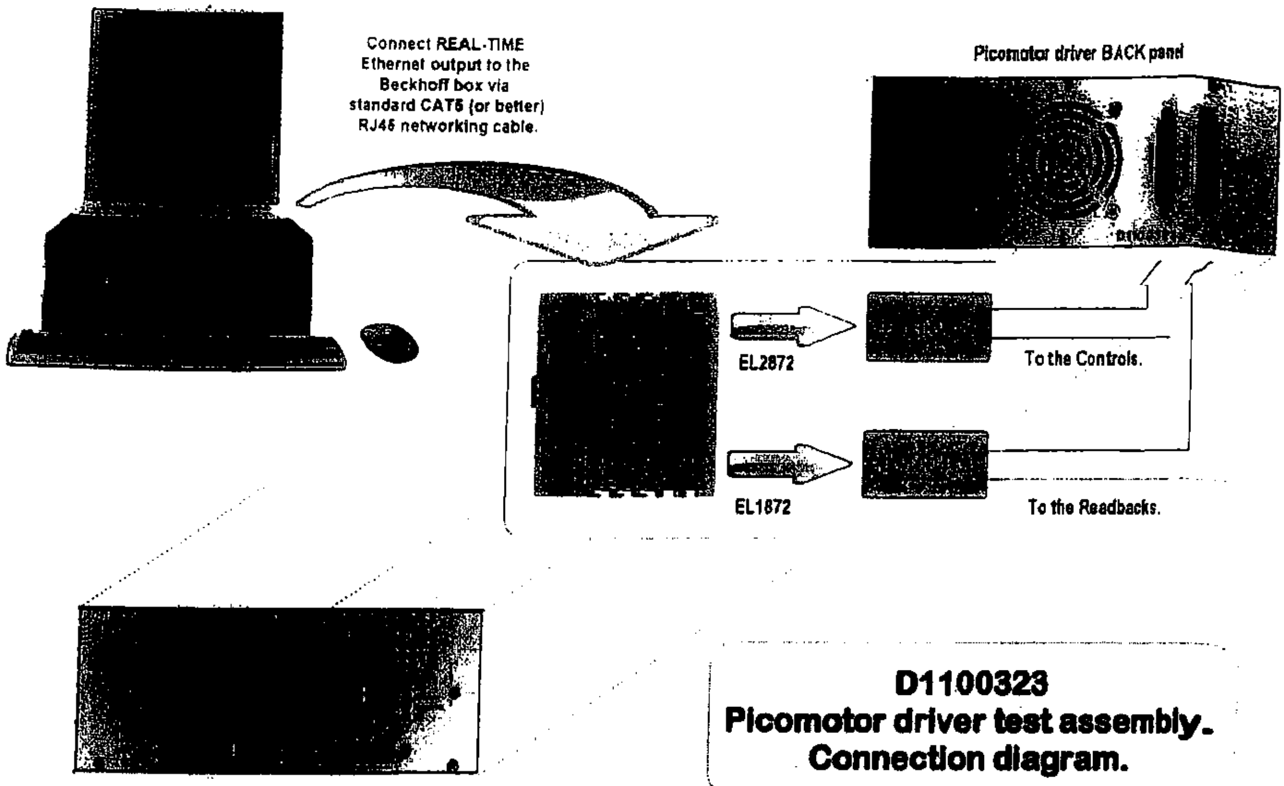
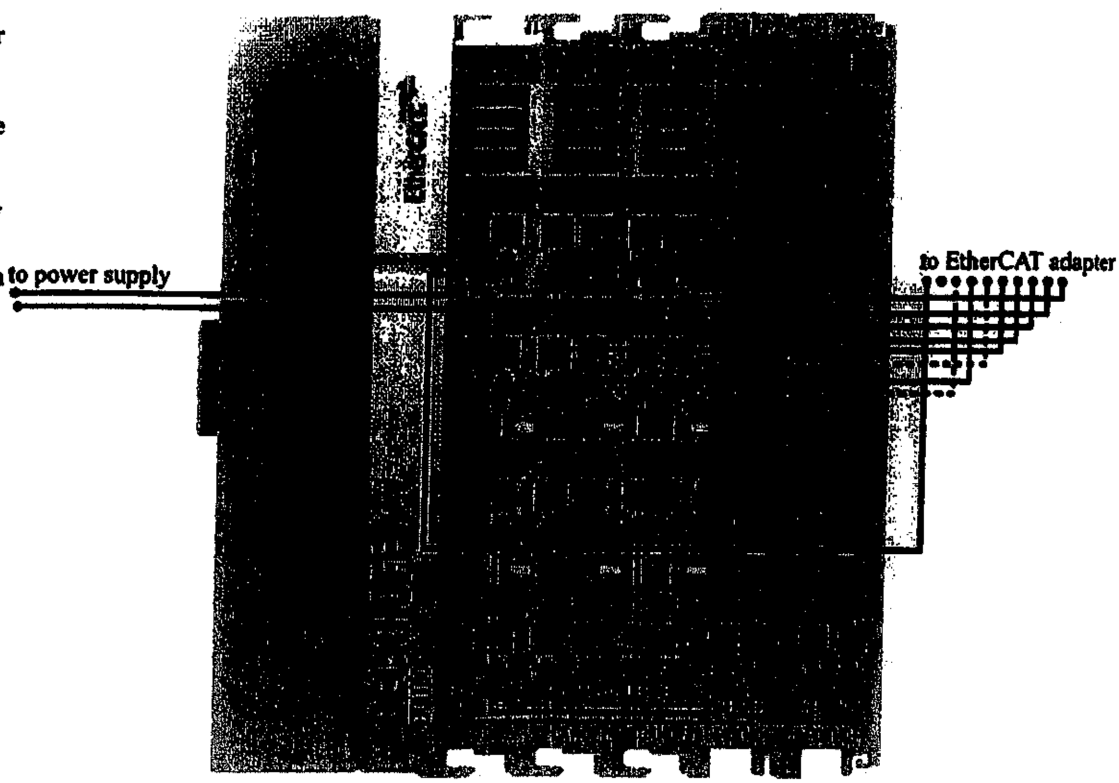


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>**Steps for setting up the PLC controls:**</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.74	24.43
2	24.91	25.67
3	26.13	26.95
4	27.12	28.07
5	28.12	29.09
Check if passed:	[✓	[✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail

Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/28/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

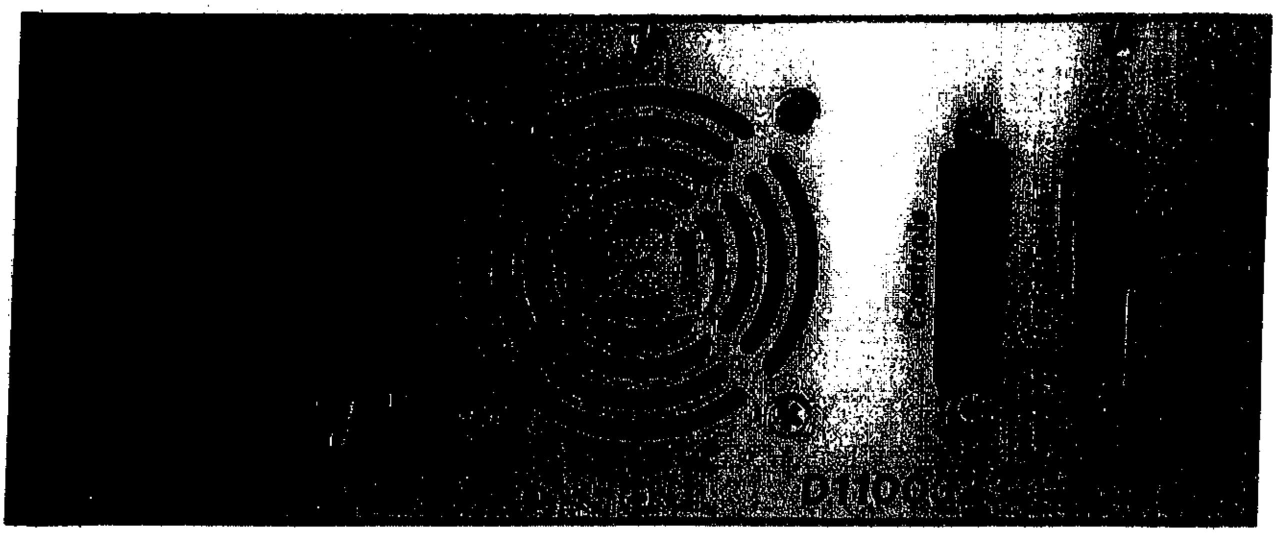
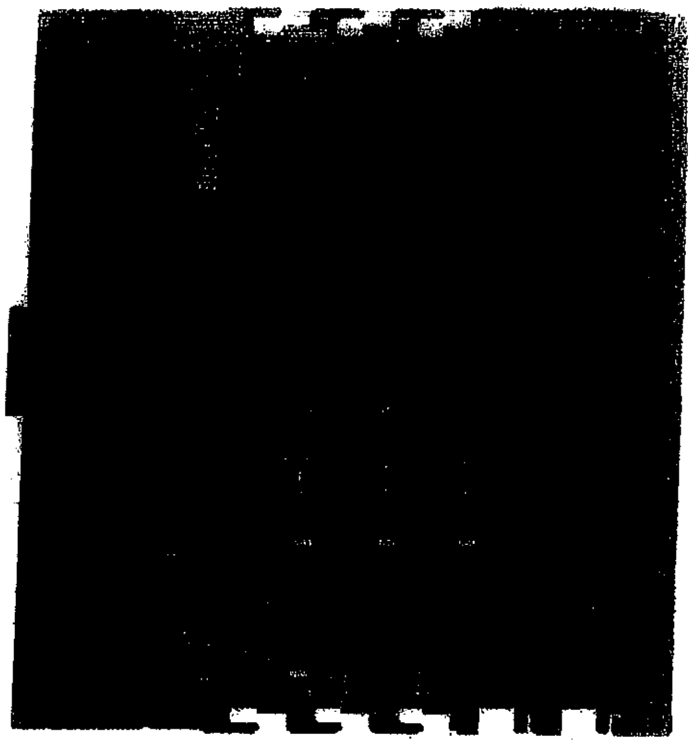


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

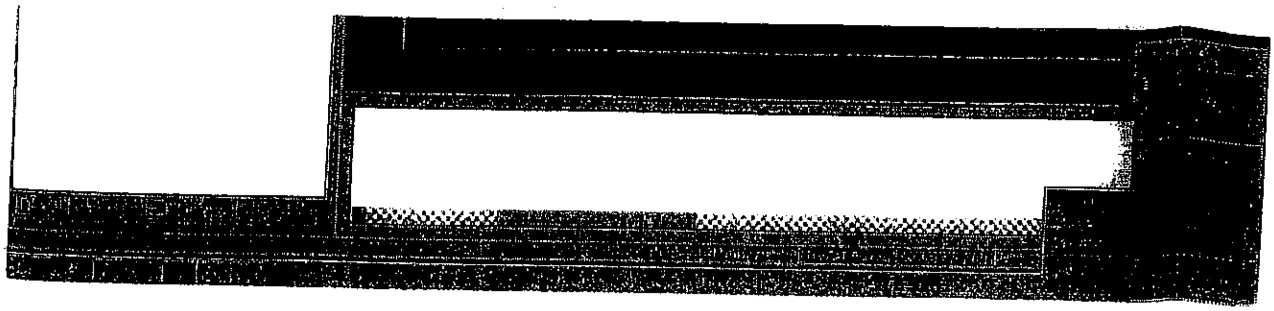
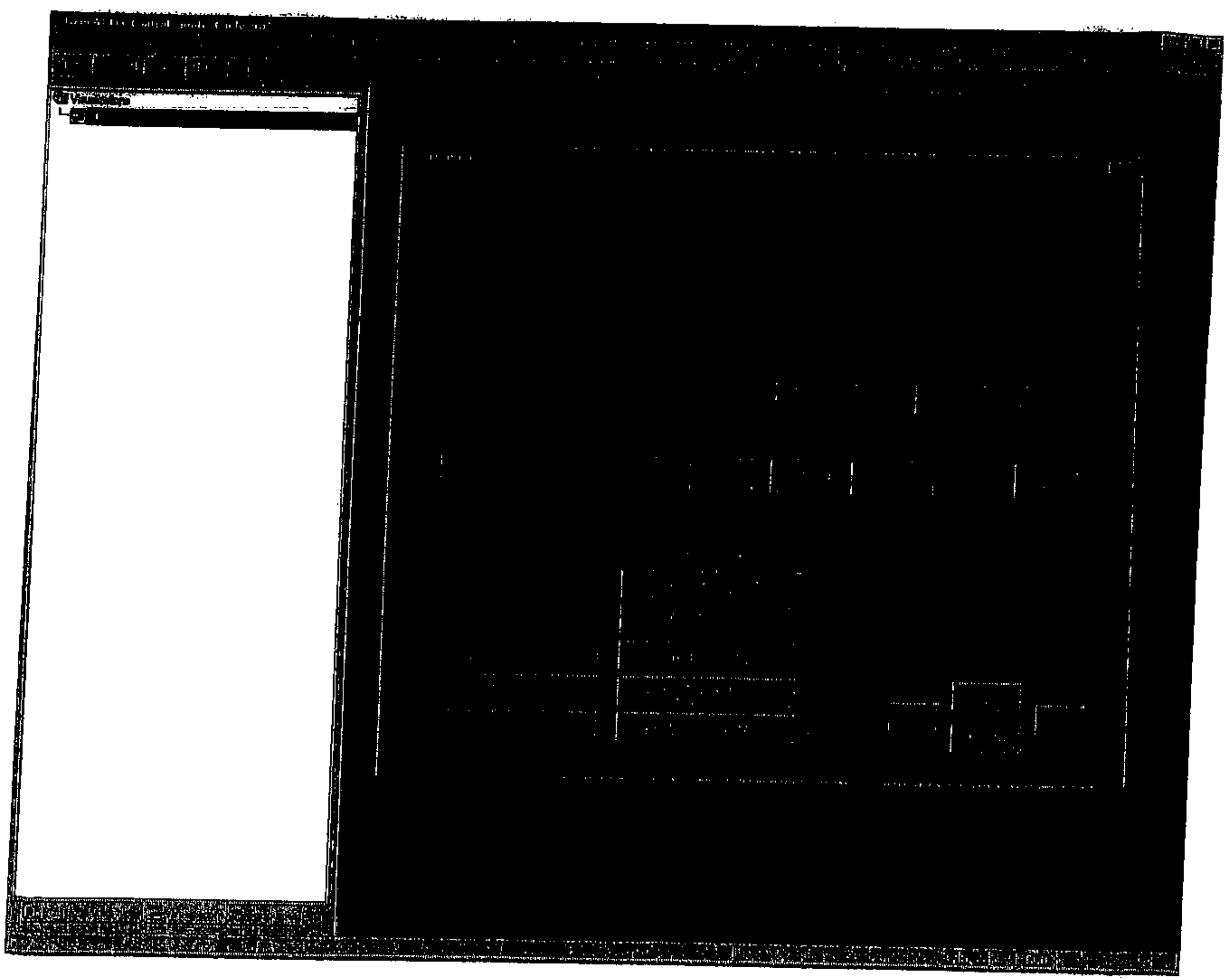


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107567

Test Engineer: Zach G

Test Date: 1/28/11

Overall picomotor chassis testing: [ ] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

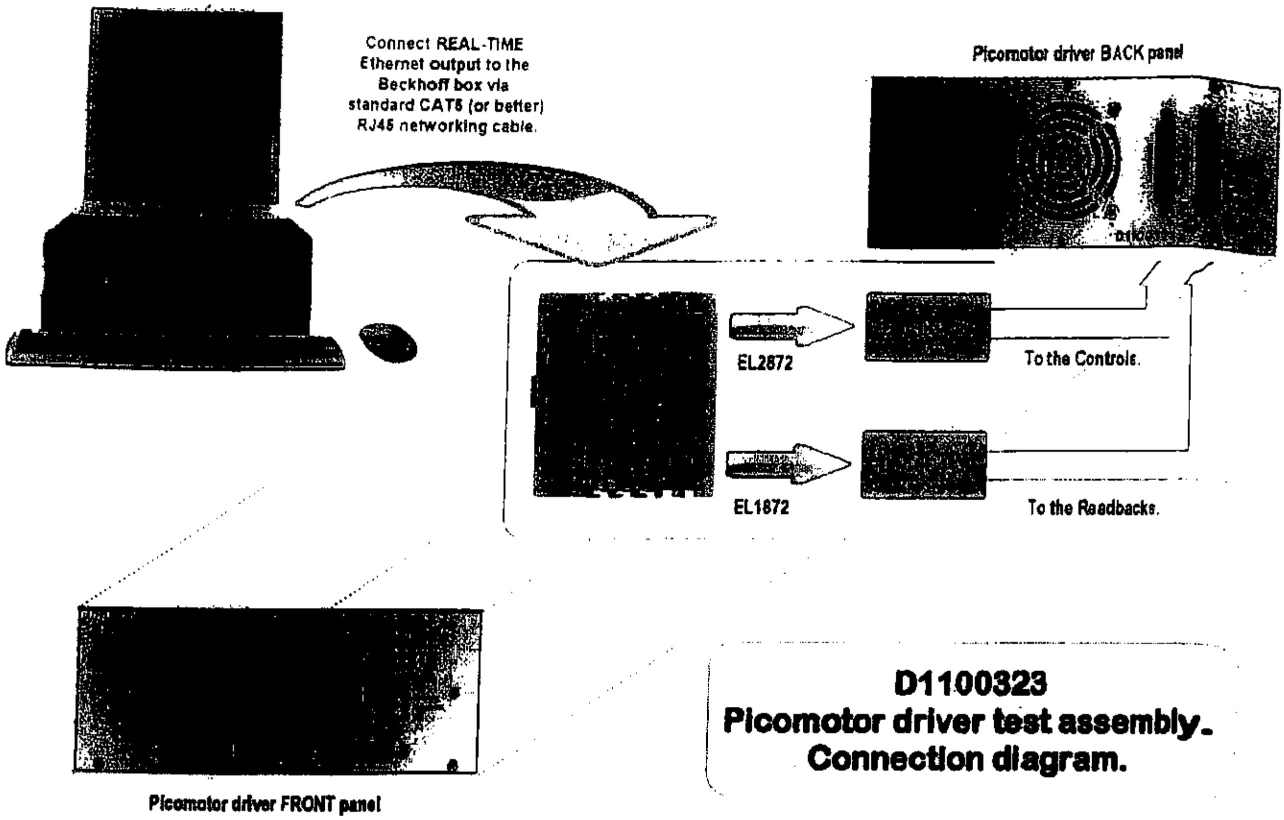
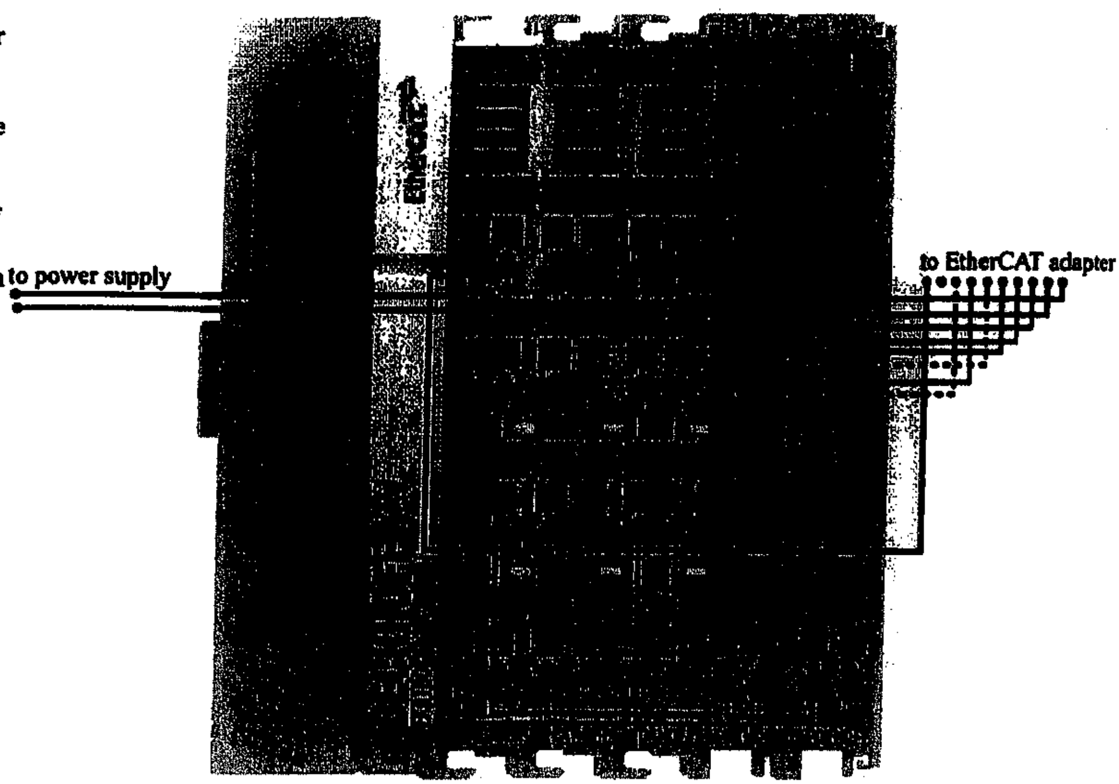


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	24.46	25.02
2	25.72	26.74
3	26.91	27.67
4	28.12	28.91
5	29.05	29.90
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] **Pass**	[ ] **Fail**

Test Engineer: Zach G

Test Date: 11/28/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

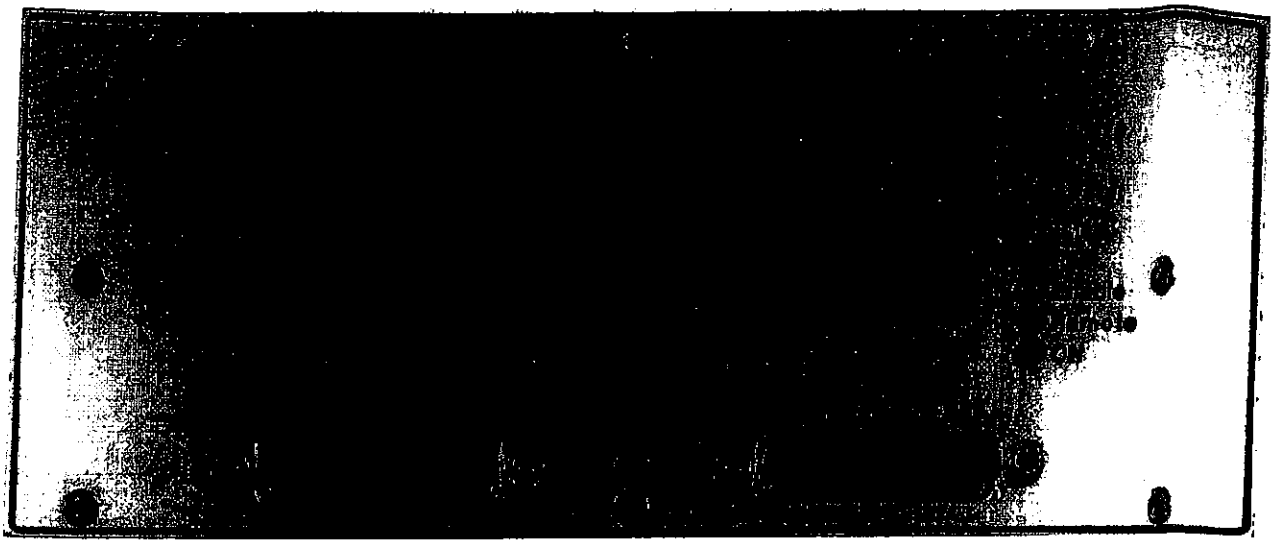


Figure 3: Picomotor driver chassis rear panel

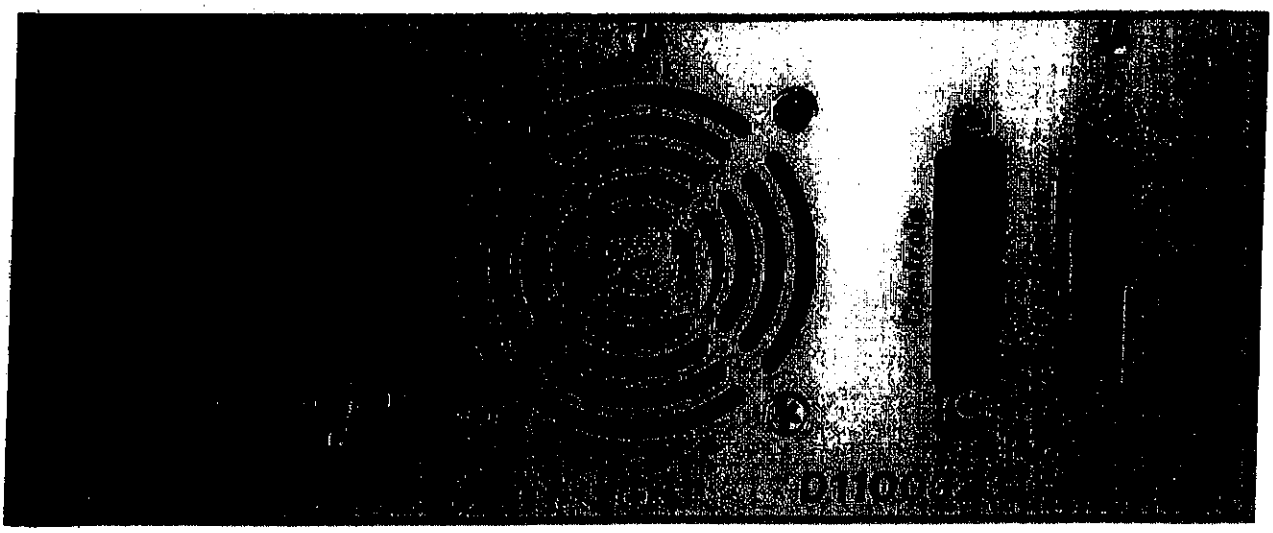
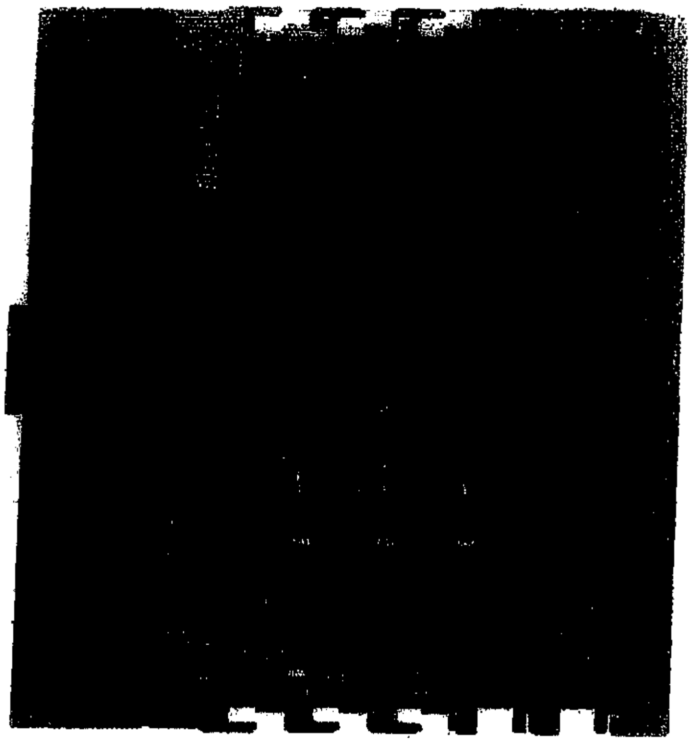


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

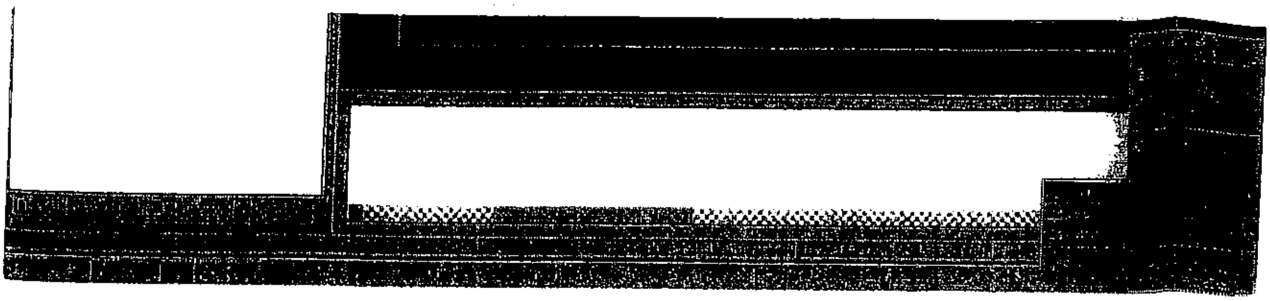
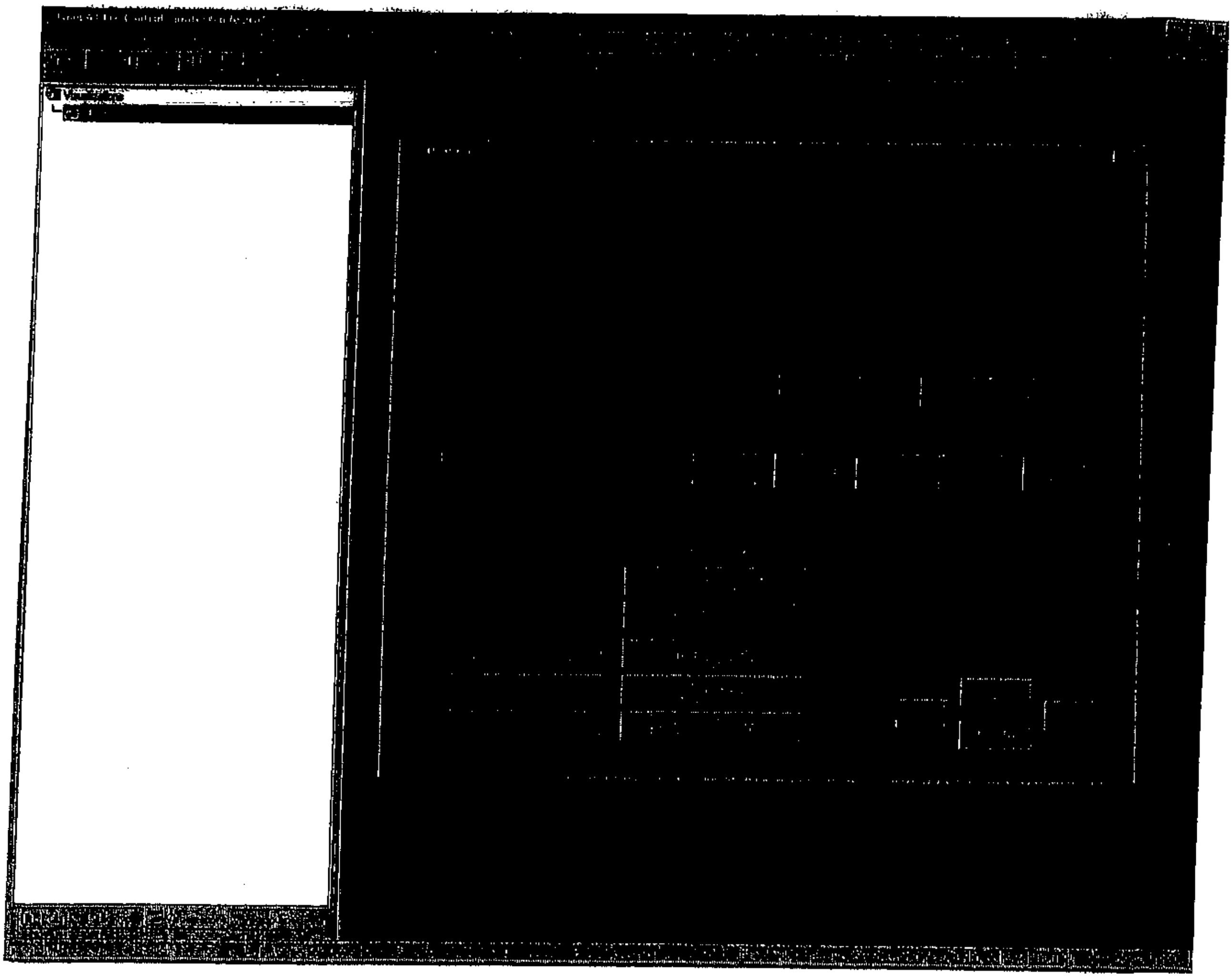


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107568

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302
2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)
3. LIGO standard 24V M-F-M DB3 power cable
4. EtherCAT adapter D1100419-v3 (1)
5. DB25 F/M cables (2)
6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple
7. IDC 20-pin cable assemblies (2)
8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)
9. 24V power supply for Beckhoff boxes (1)
10. Ethernet cable (1)
11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit
2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

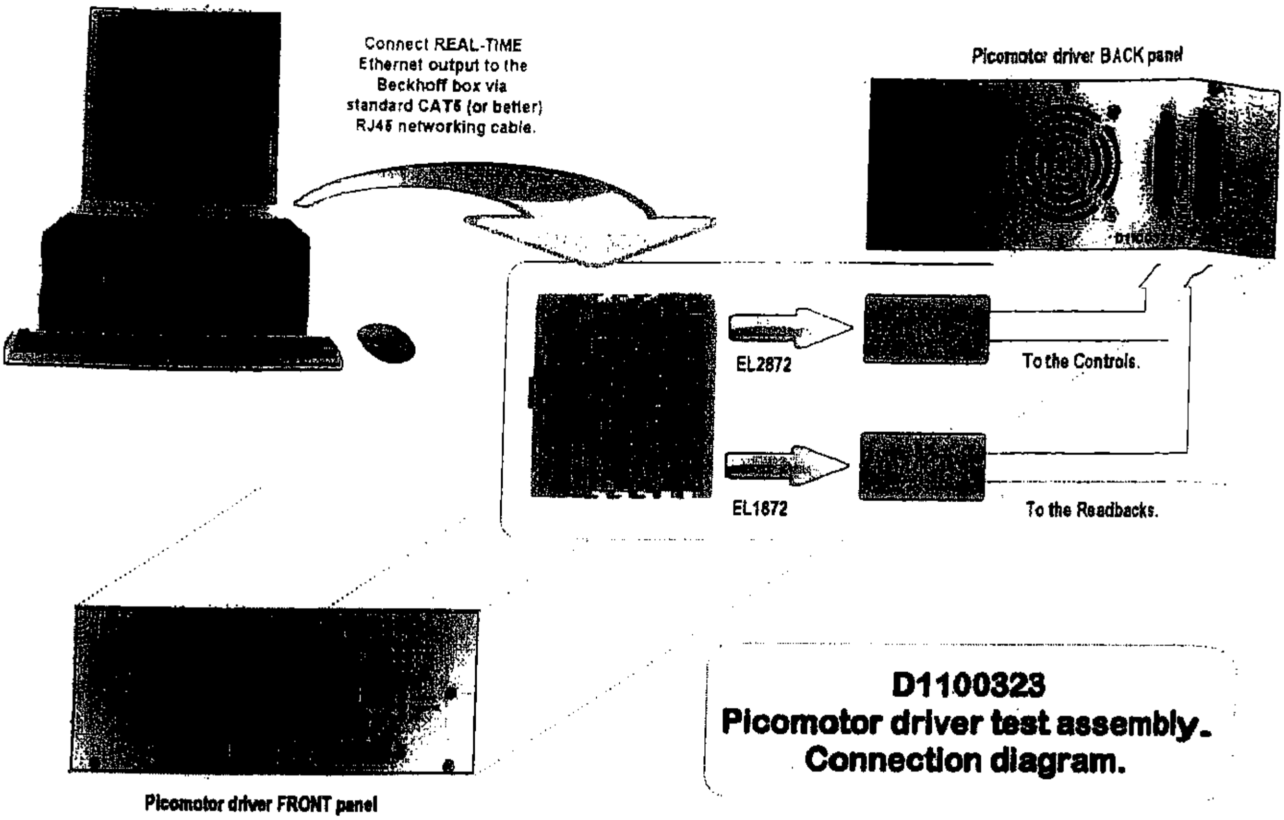
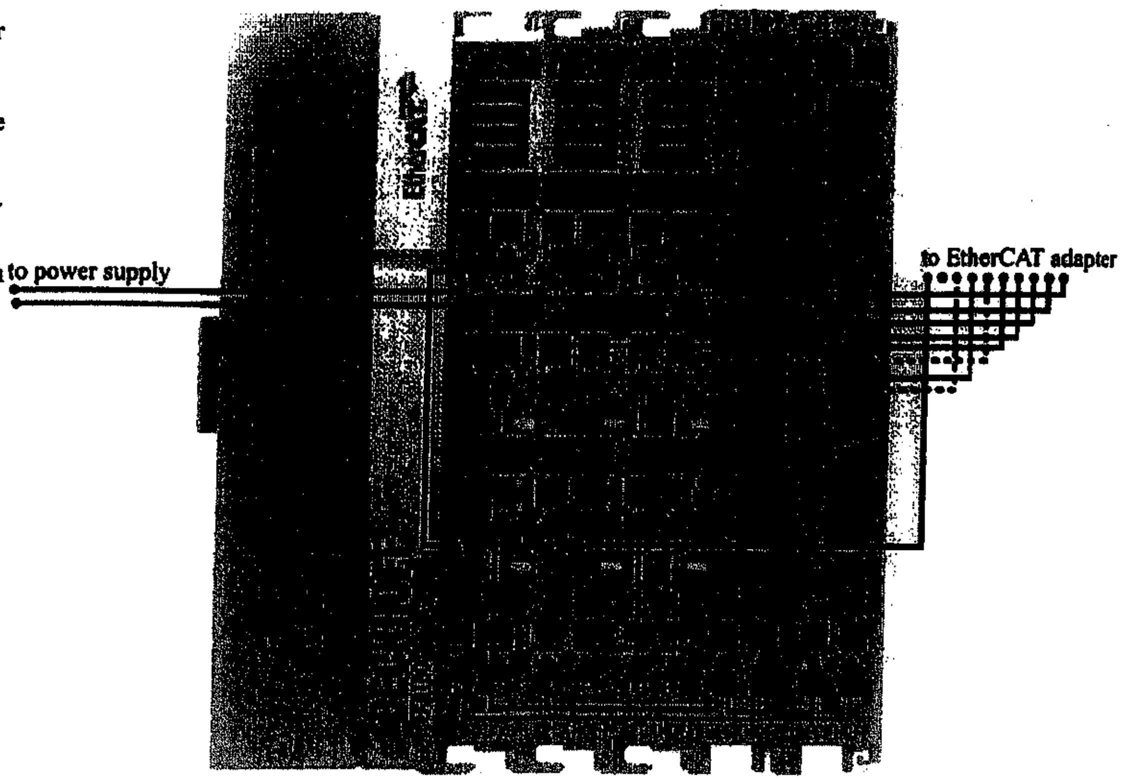


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.15	26.79
2	26.48	28.25
3	27.76	29.60
4	28.82	30.74
5	29.79	31.81
Check if passed:	[✓	[✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/28/11

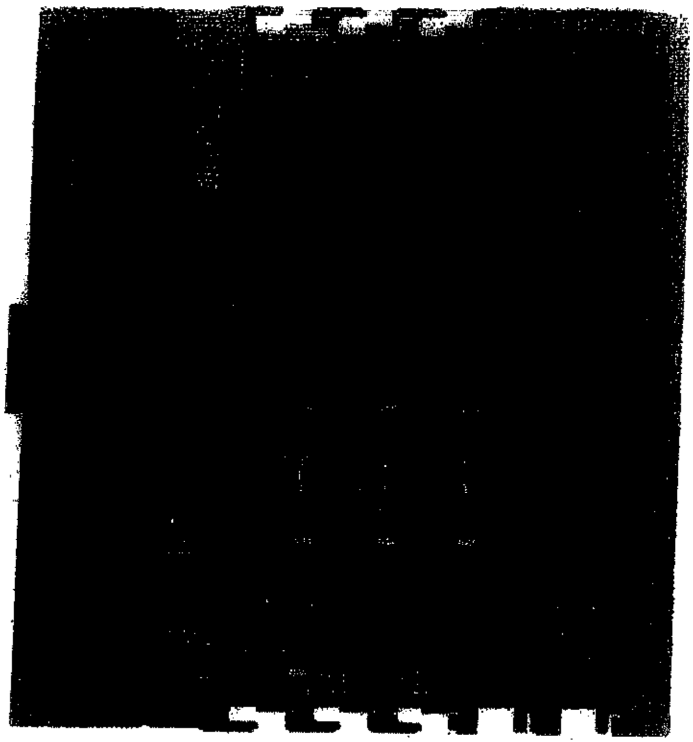
Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

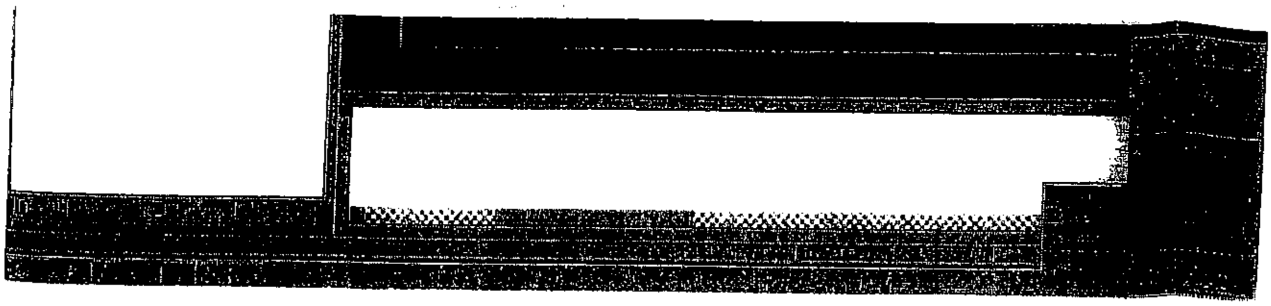
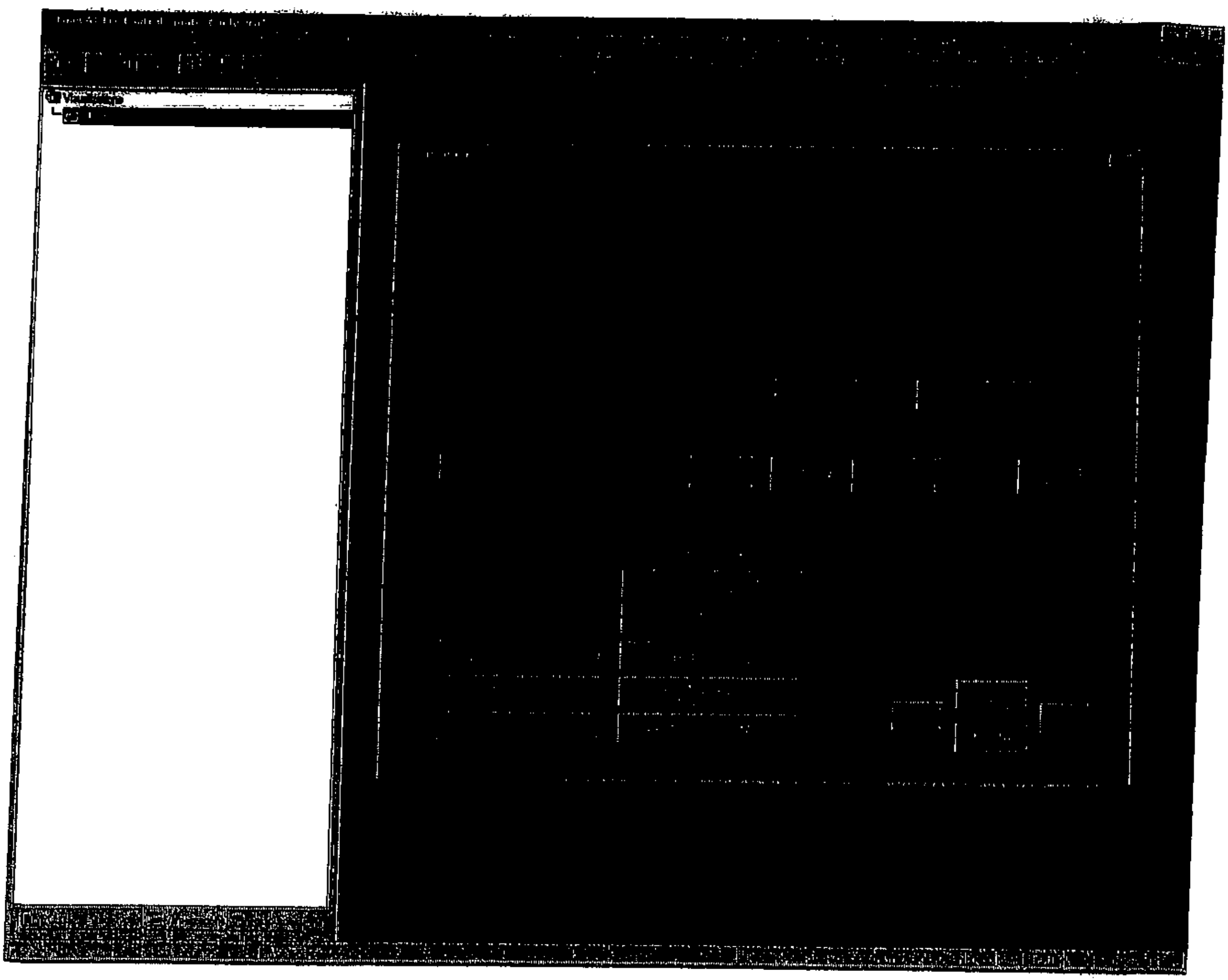


Figure 6: Step 5 of PLC controls setup



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Technical Note	**LIGO-T1100458-v1**	**08/26/11**

Testing Procedure for the Picomotor Driver for Advanced LIGO

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Technical Note	LIGO-T1100458-v1	08/26/11

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107565

Test Engineer: Zach G

Test Date: 11/28/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

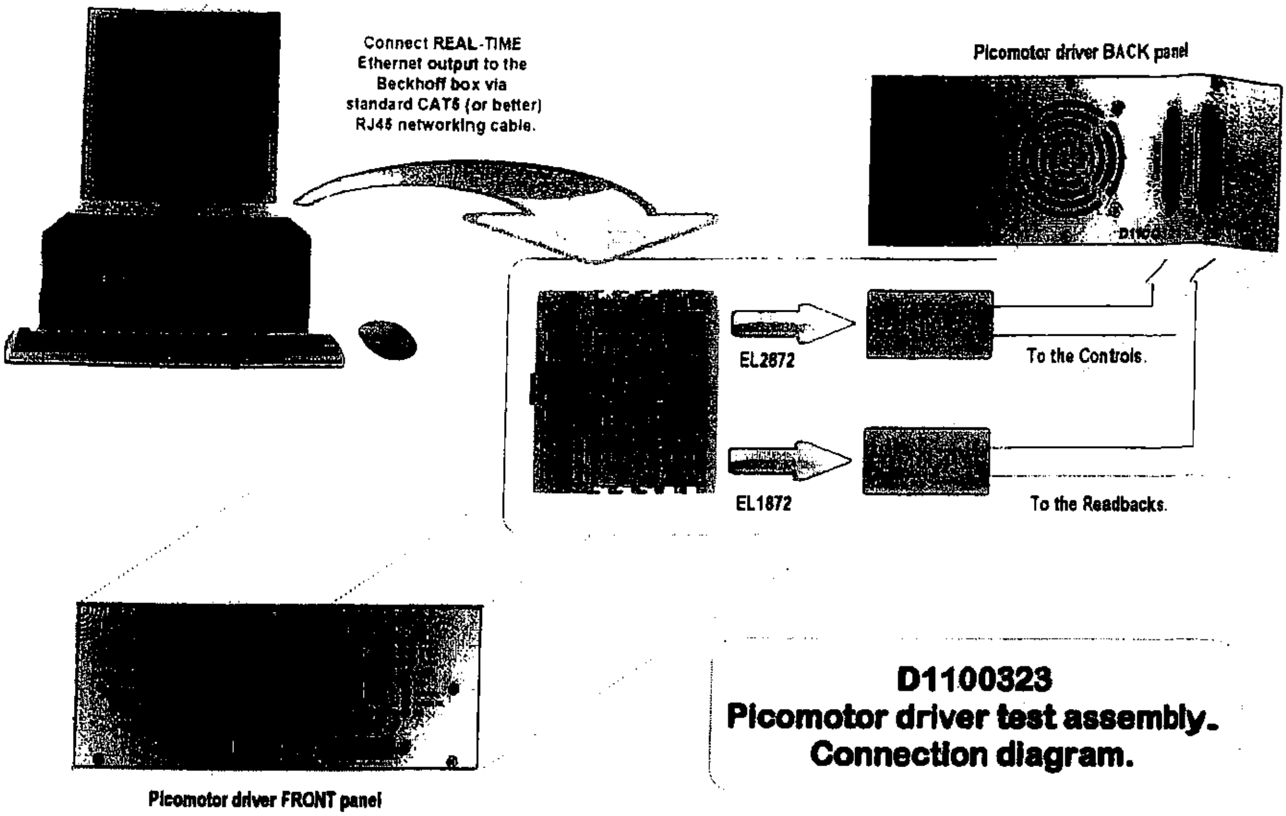


Figure 1a: A connection diagram of the picomotor setup.

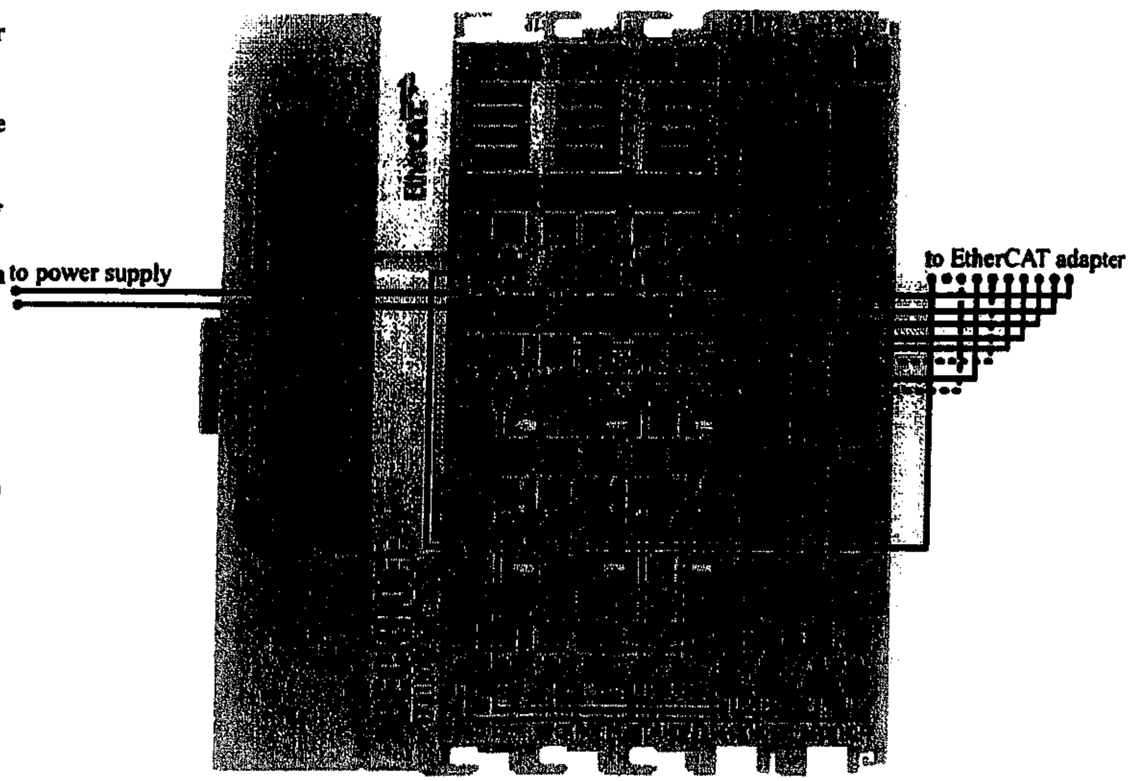


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	35.00	34.64
2	35.83	35.47
3	36.54	36.27
4	37 16	36.96
5	37.70	37.62
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

Figure 3: Picomotor driver chassis rear panel

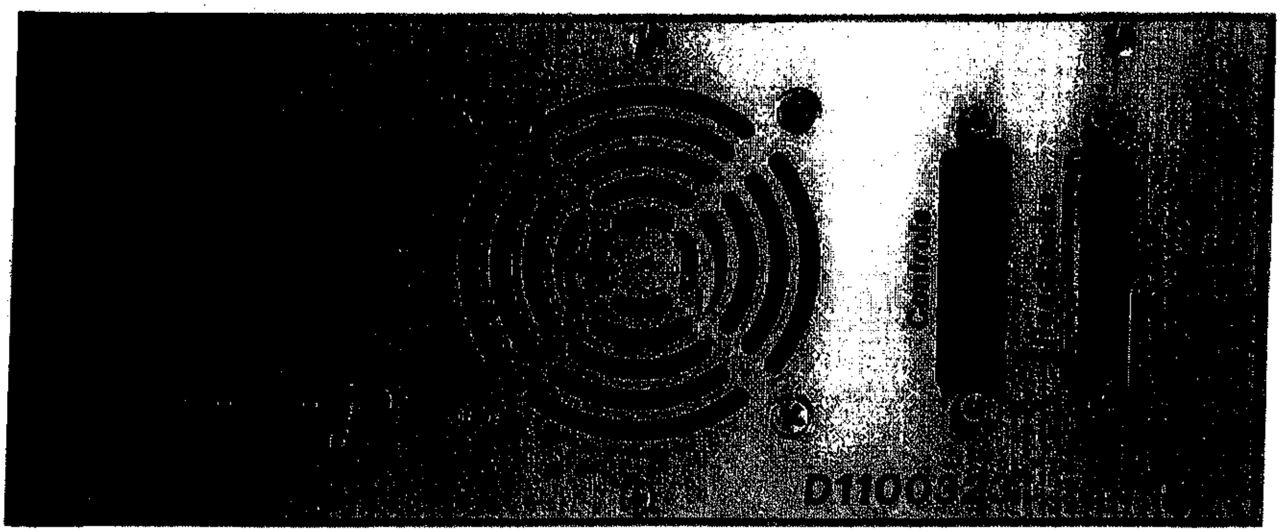
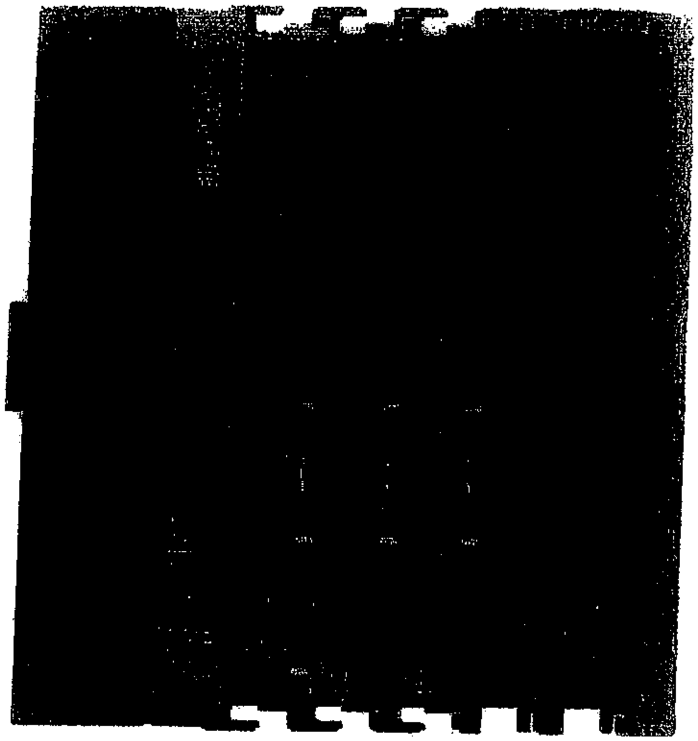


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

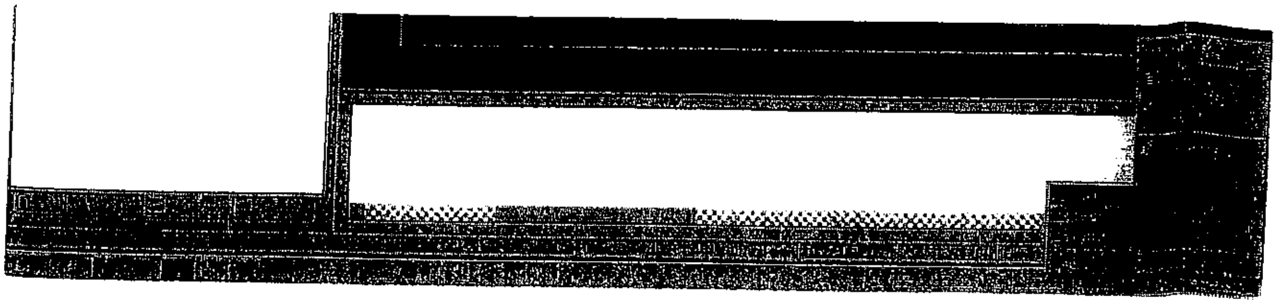
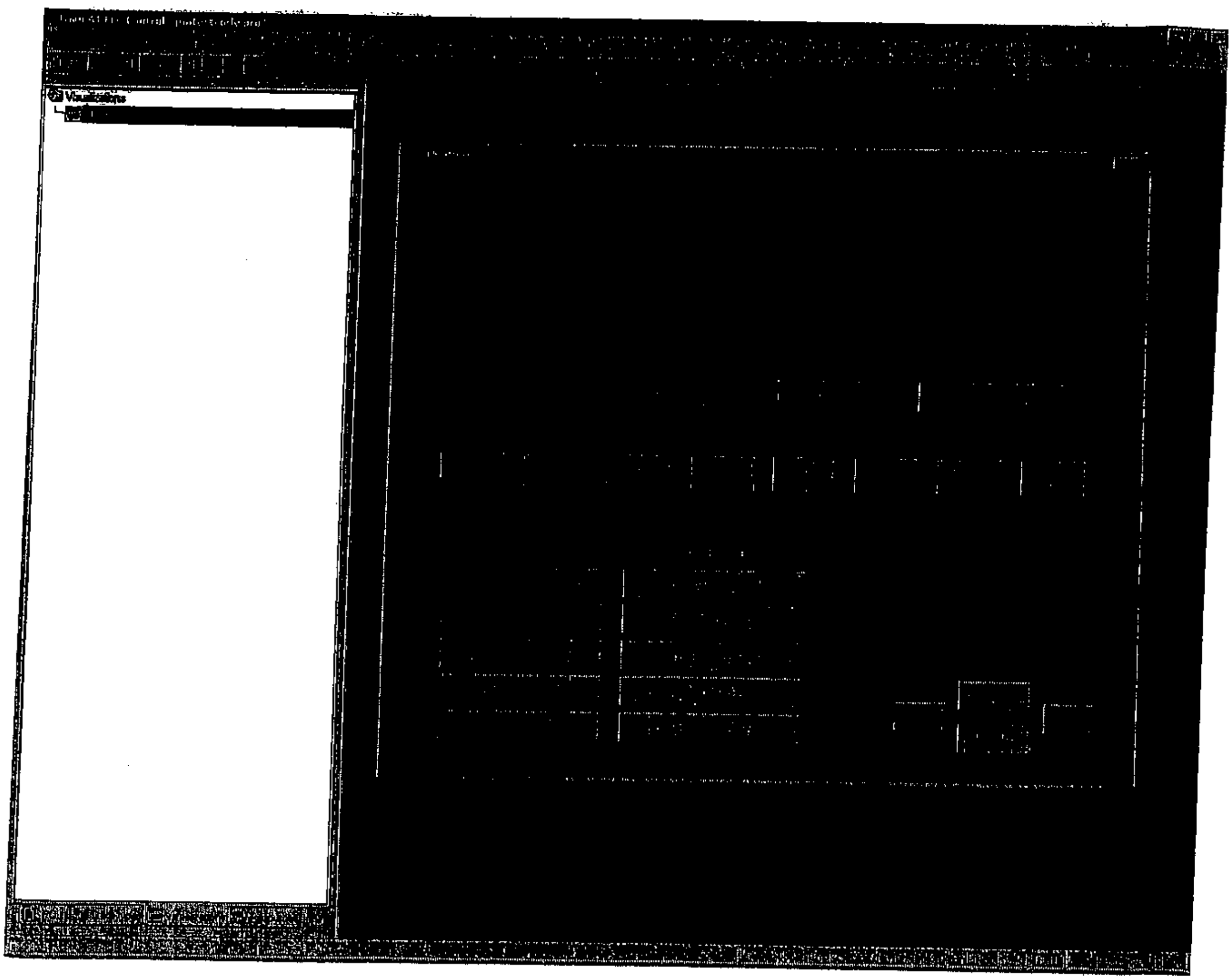


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note LIGO-T1100458-v1 08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107570

Test Engineer: Zach G

Test Date: 11/29/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302
2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)
3. LIGO standard 24V M-F-M DB3 power cable
4. EtherCAT adapter D1100419-v3 (1)
5. DB25 F/M cables (2)
6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple
7. IDC 20-pin cable assemblies (2)
8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)
9. 24V power supply for Beckhoff boxes (1)
10. Ethernet cable (1)
11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit
2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

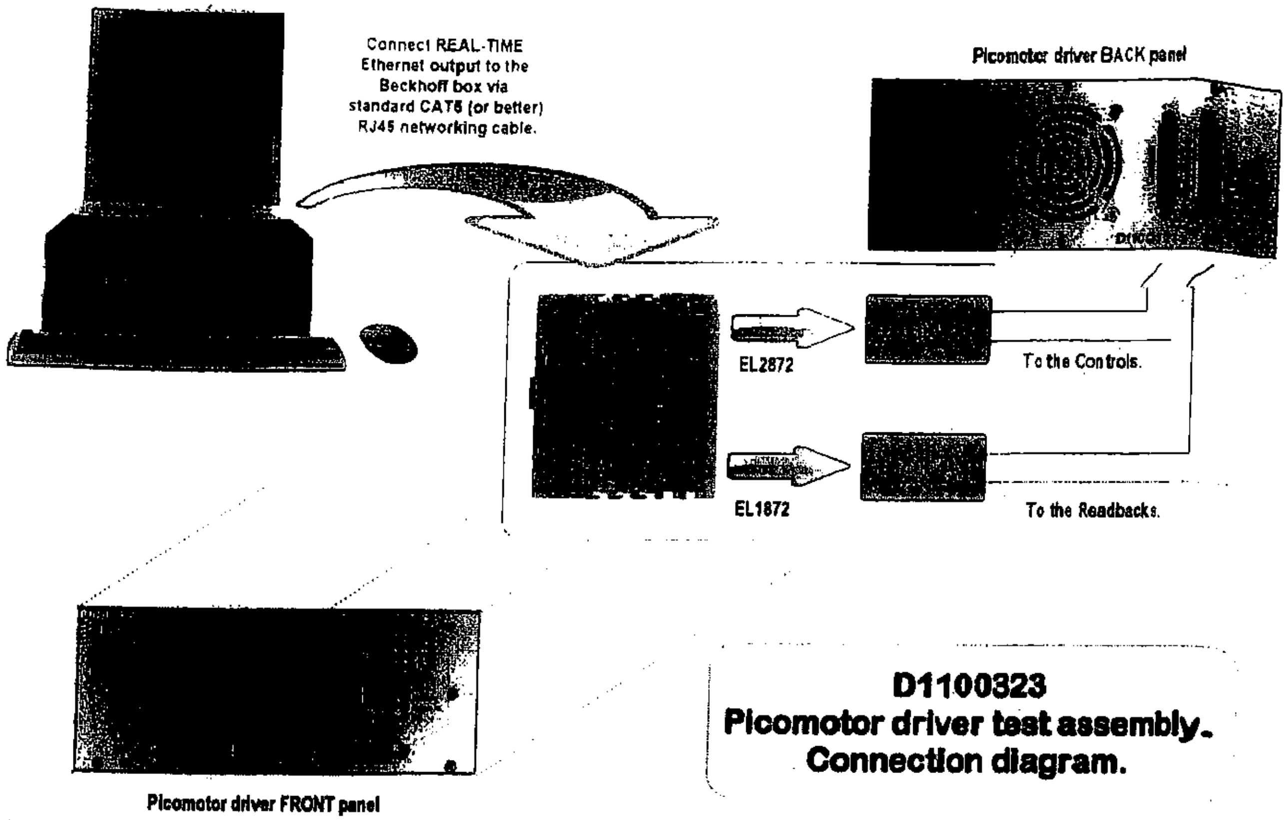
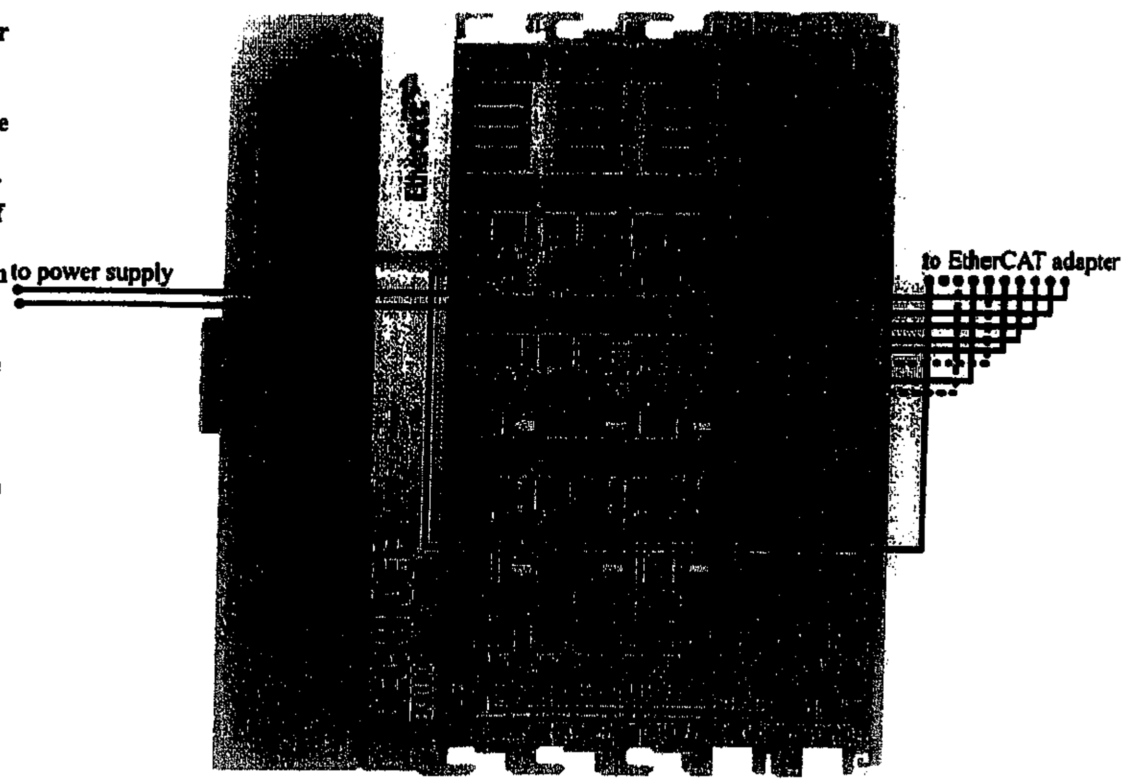


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>**Steps for setting up the PLC controls:**</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.93	25.70
2	27.12	27.00
3	28.35	28.24
4	29.44	29.44
5	30.39	30.46
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

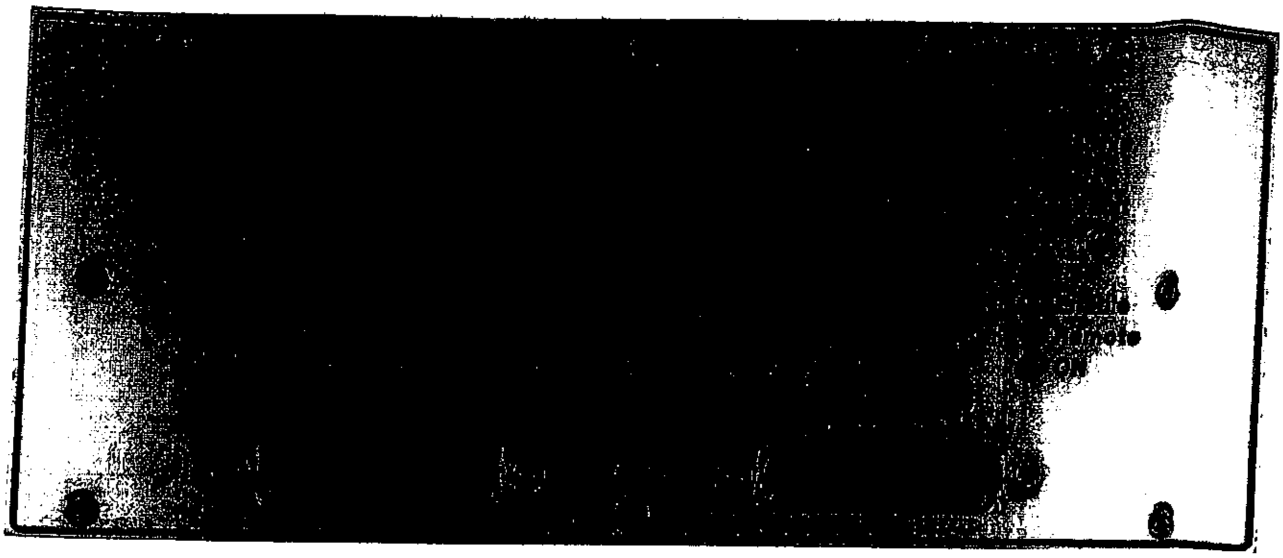


Figure 3: Picomotor driver chassis rear panel

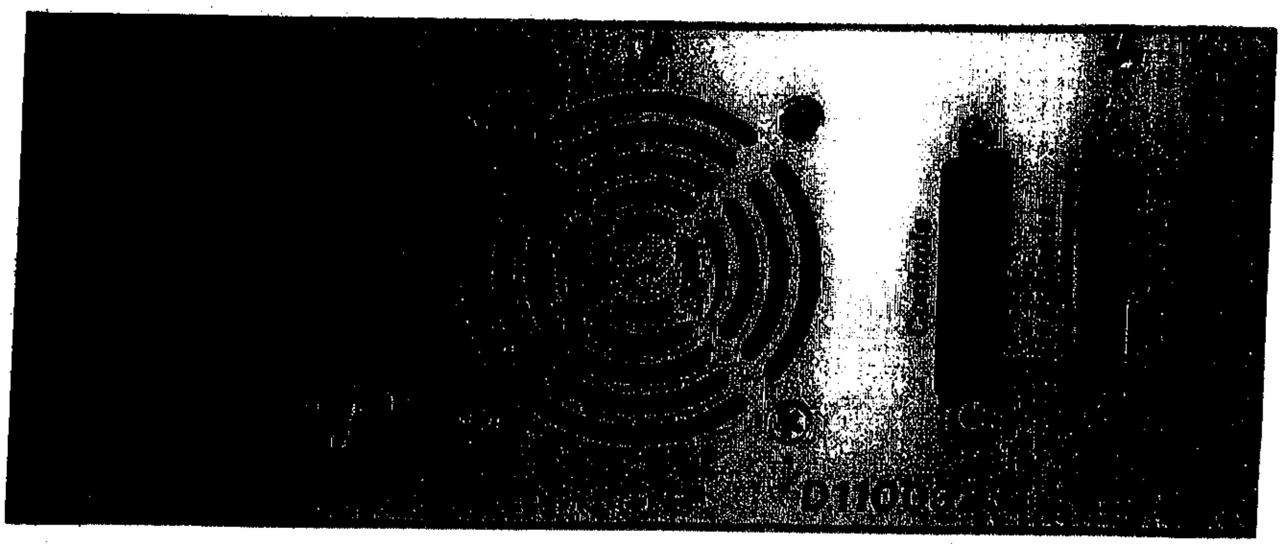
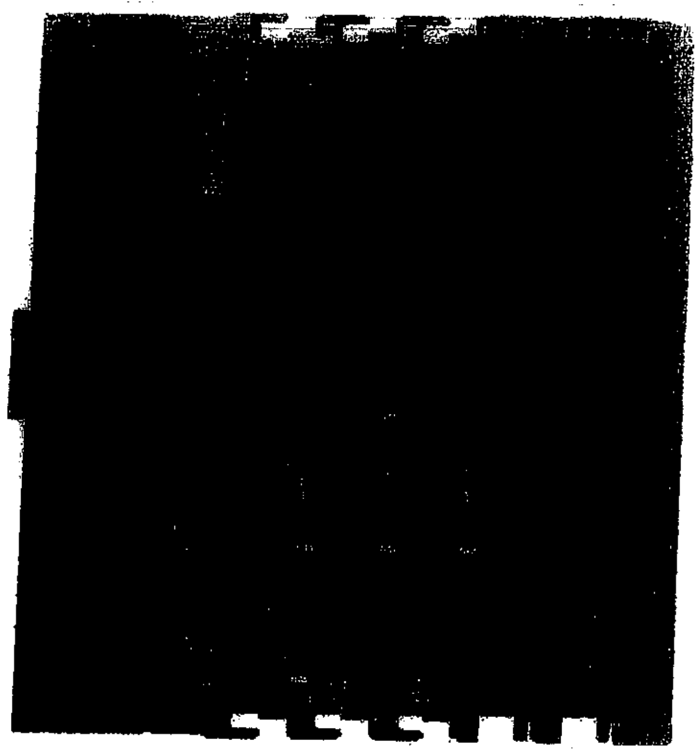


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

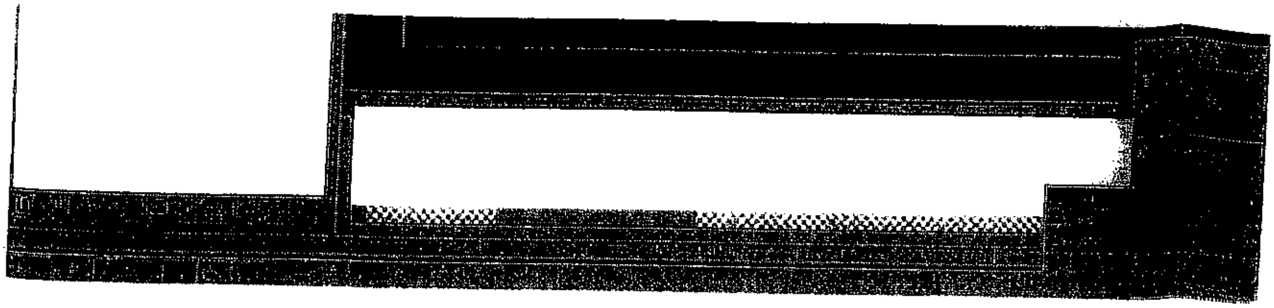
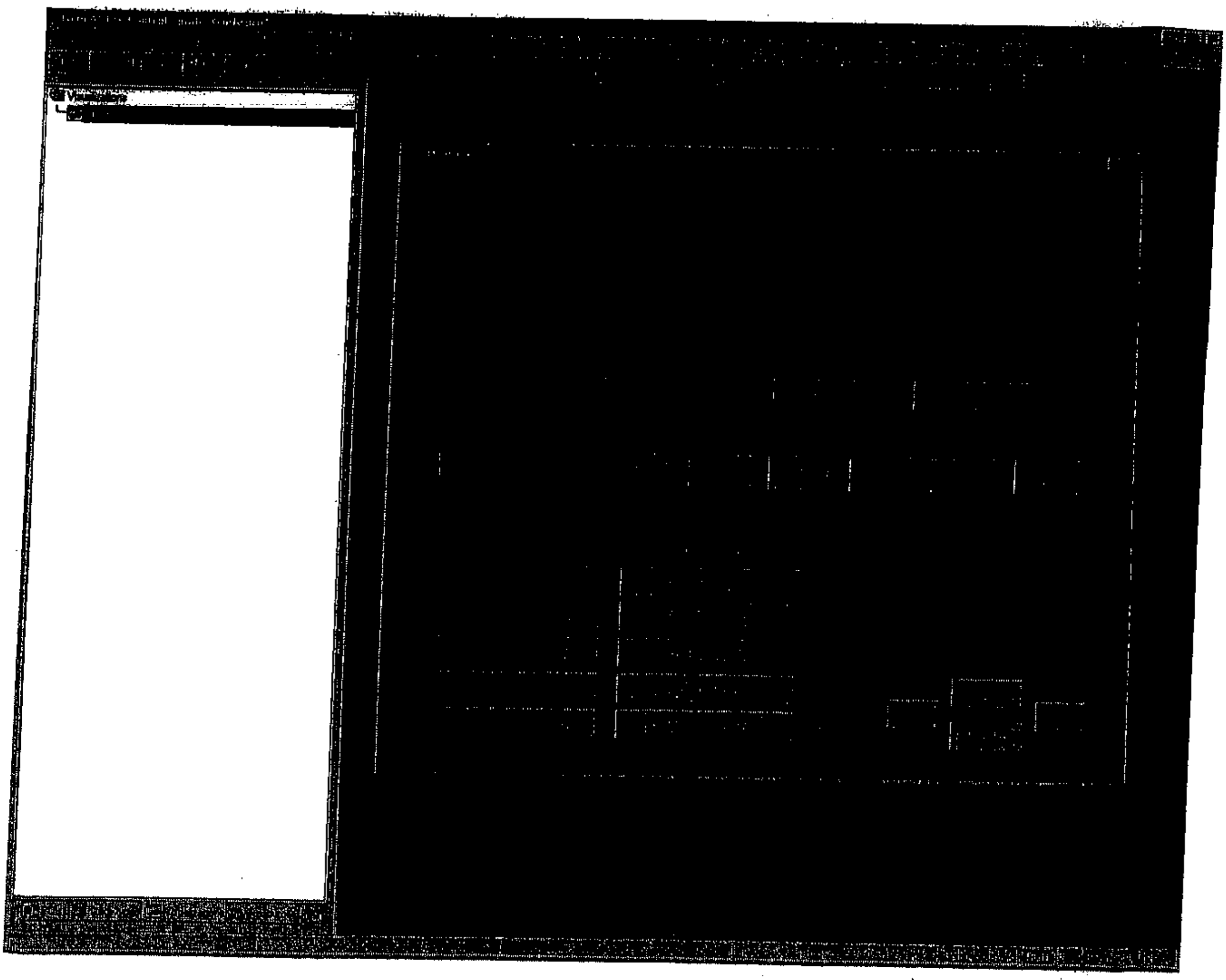


Figure 6: Step 5 of PLC controls setup



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Technical Note	LIGO-T1100458-v1	08/26/11

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107571

Test Engineer: Zach G

Test Date: 11/29/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

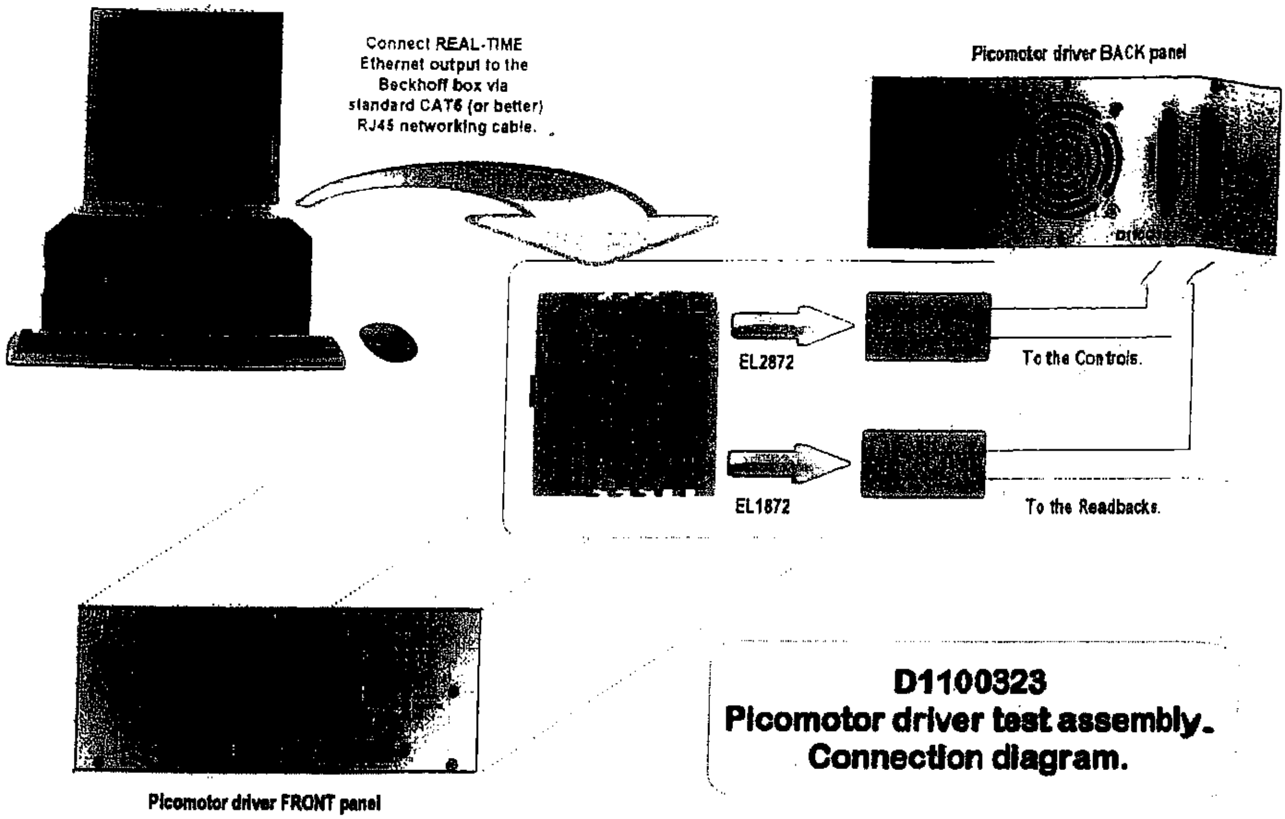
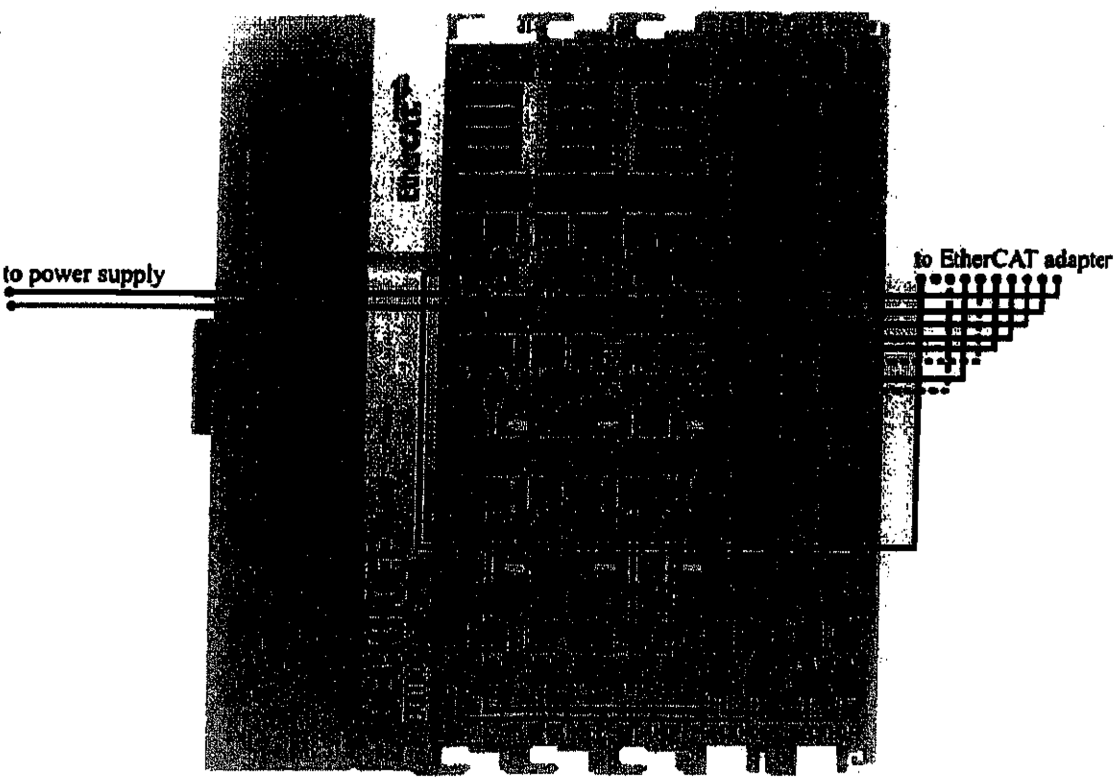


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	22.64	21.41
2	23.90	22.76
3	25.15	24.07
4	26.23	25.21
5	27.28	26.27
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

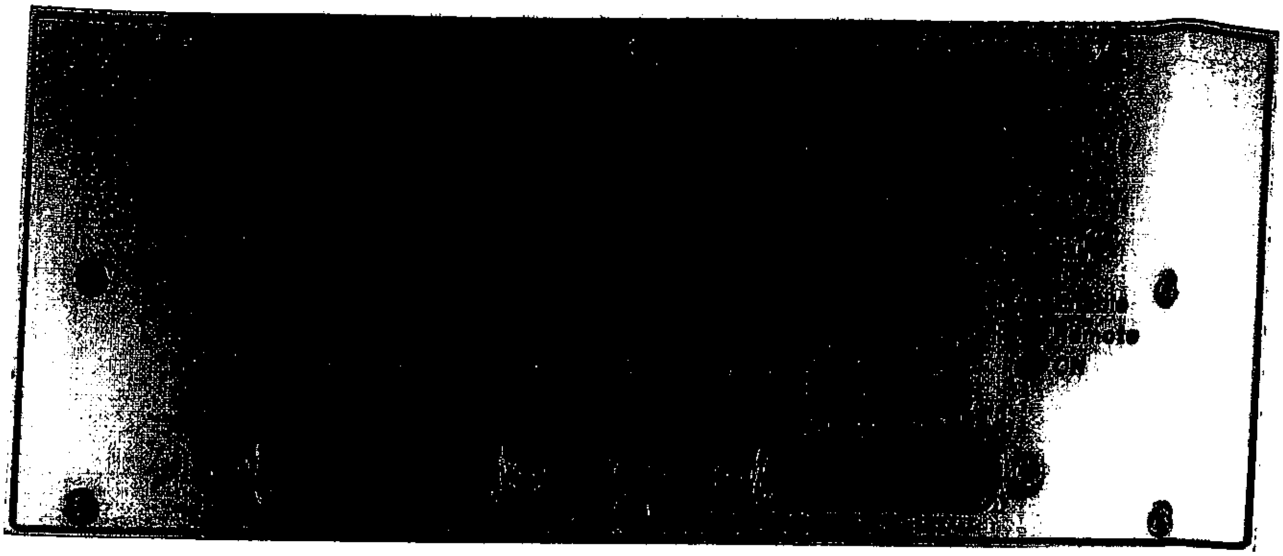
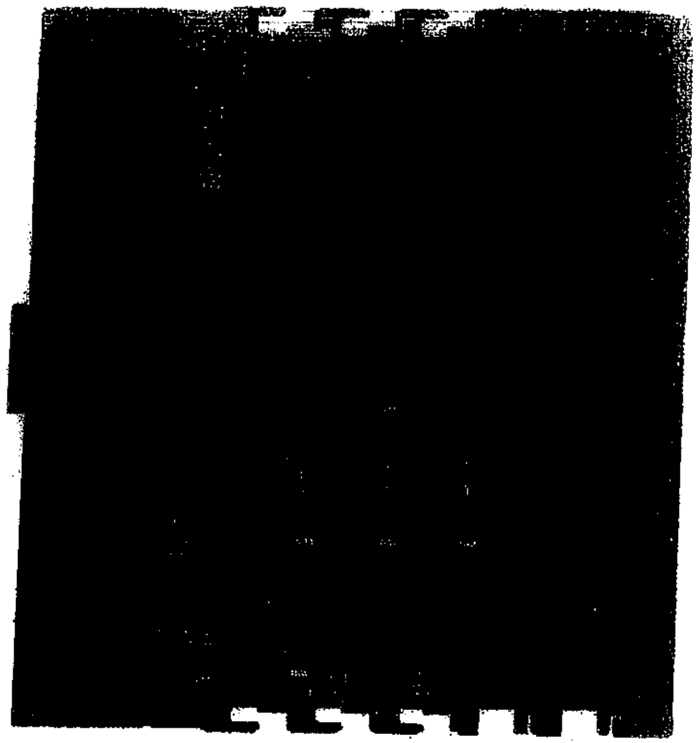


Figure 3: Picomotor driver chassis rear panel

Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

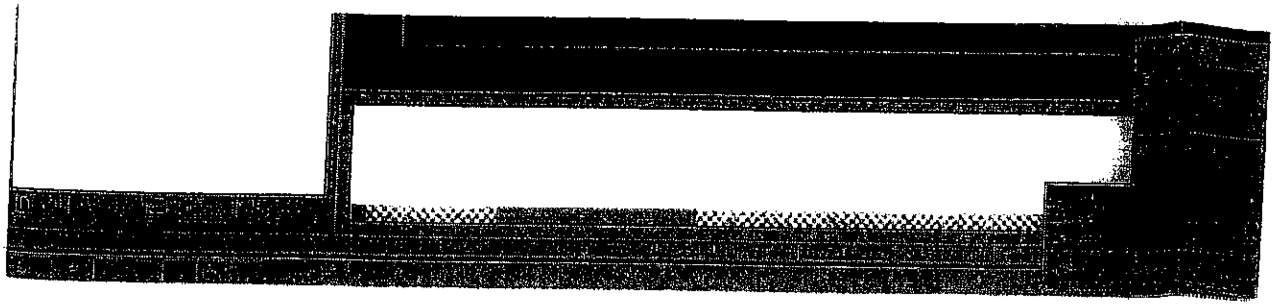
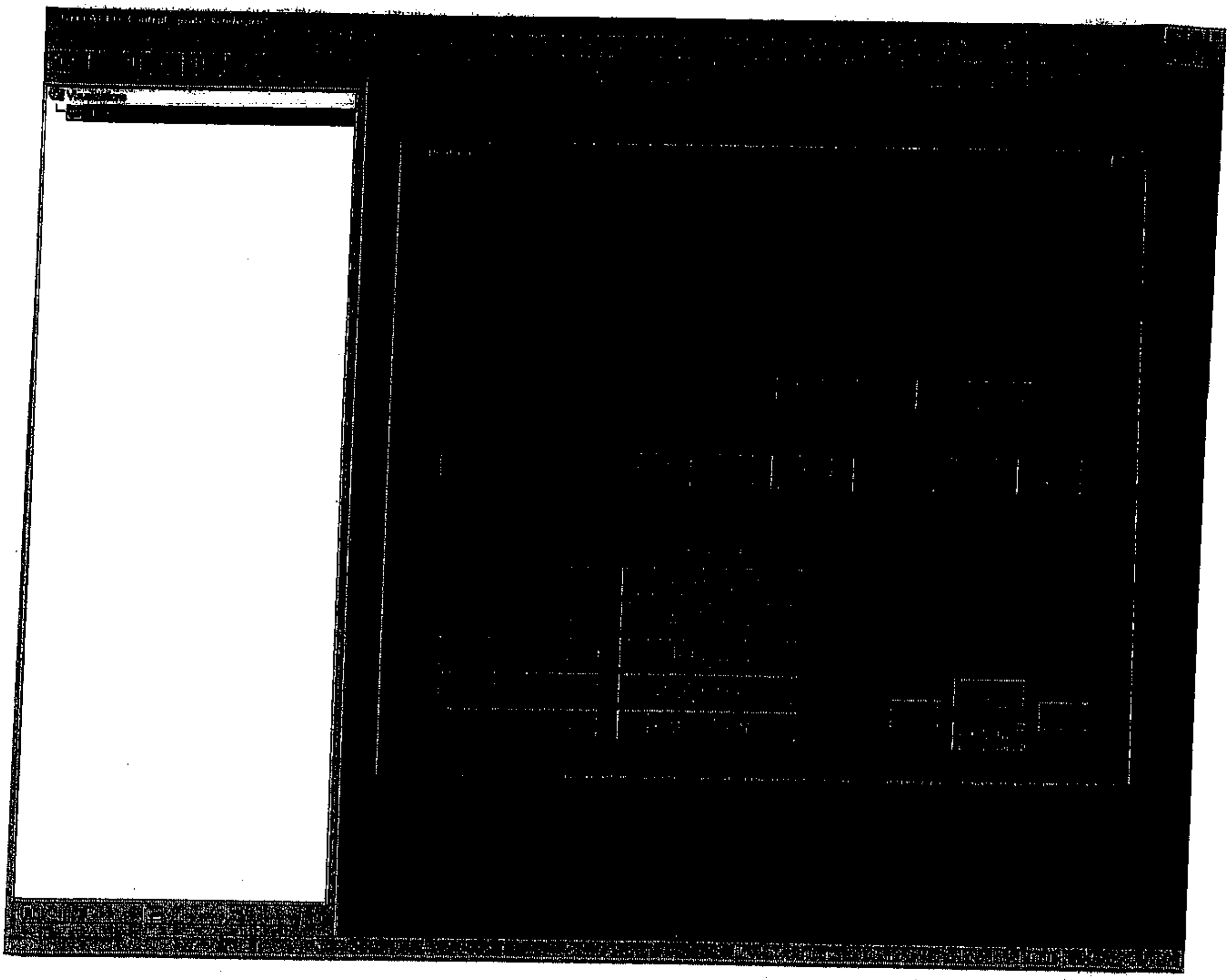


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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Picomotor controller chassis LIGO DCC#		D1100323-v1

EtherCAT Adapters LIGO DCC#		D1100419-v3

Controller Serial #		S1107572

Test Engineer:		Zach G

Test Date:		11/29/11

Overall picomotor chassis testing:		[✓] PASS		[ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
6. Connect the EK1100 Beckhoff box to a DC power source (24V)
7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

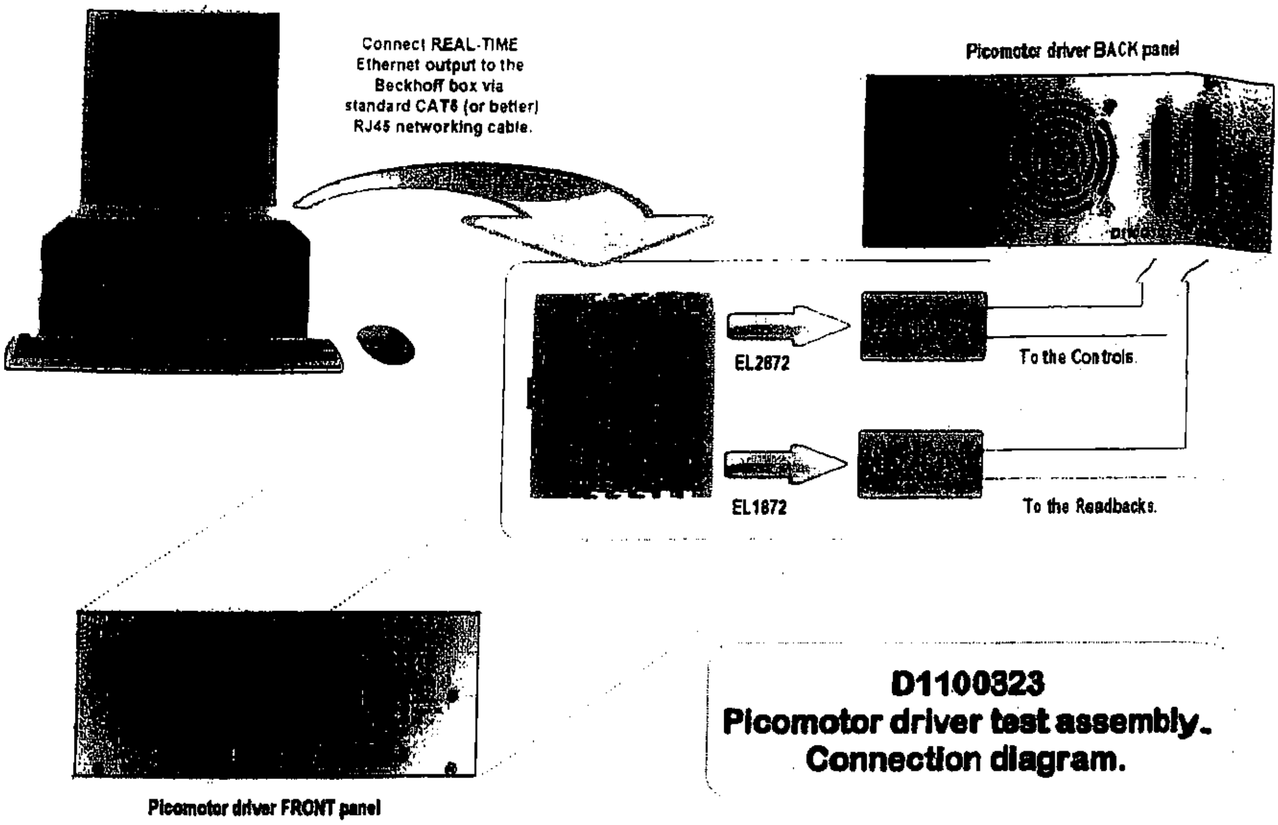
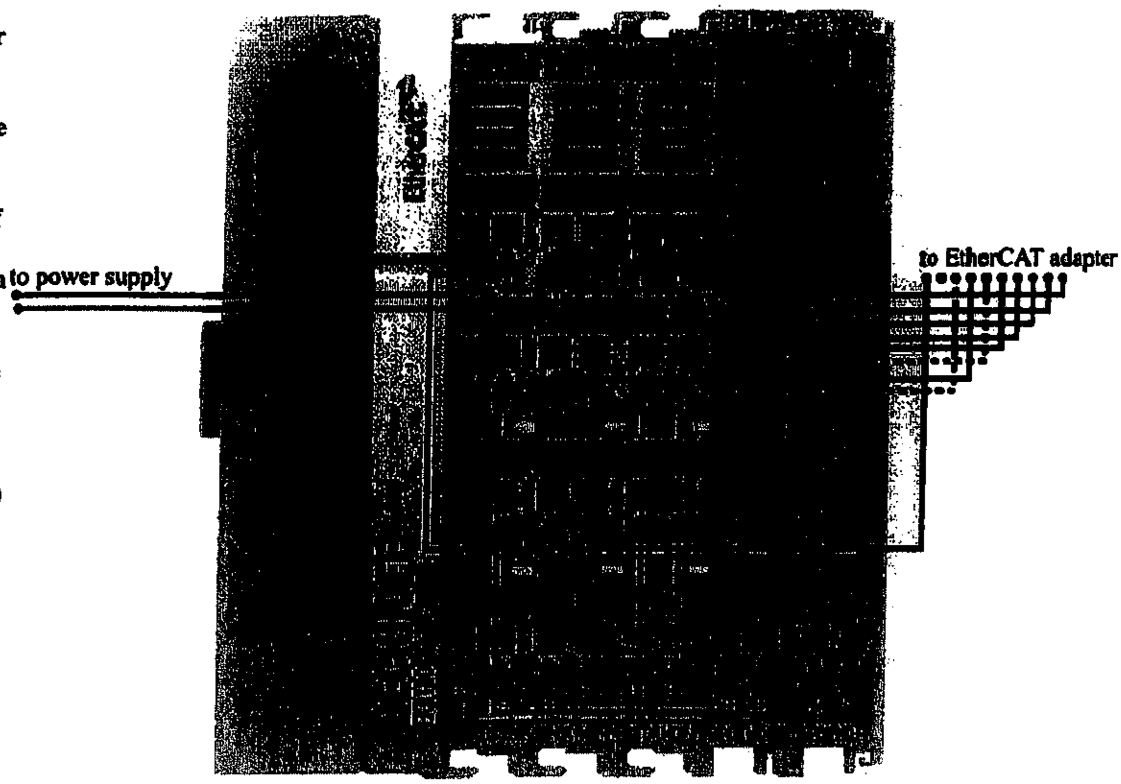


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

__Steps for setting up the PLC controls:__

1. Open up the TwinCAT System Manager software and go to:

    File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

    File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
    (see Figure 5 in Appendix B for a screenshot)

    System > Start

4. Go to the TwinCAT PLC Control window and go to:

    Online > Login (F11)
    Click "Yes" at the dialog:
        "No program on the controller! Download the new program?"
    Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
    (see Figure 6 in Appendix B for a screenshot)

    In the "VIS_PICO" visualization window:

        in the "RAW" section, the "IDLE" indicator should be lit
        in the "USER" section, the status should read "DRIVER DISABLED"

    On the controller front panel:

        the "IDLE" LED should be lit
        the "Enable" LED should be off
        the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.06	22.79
2	24.52	24.33
3	25.79	25.77
4	26.93	26.95
5	27.92	28.67
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

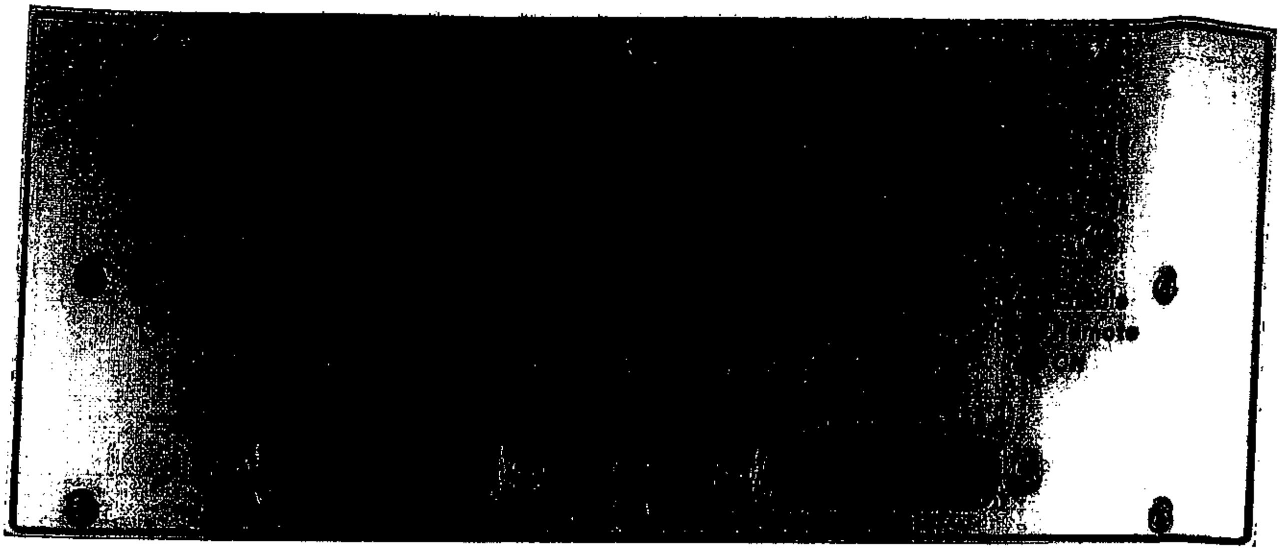


Figure 3: Picomotor driver chassis rear panel

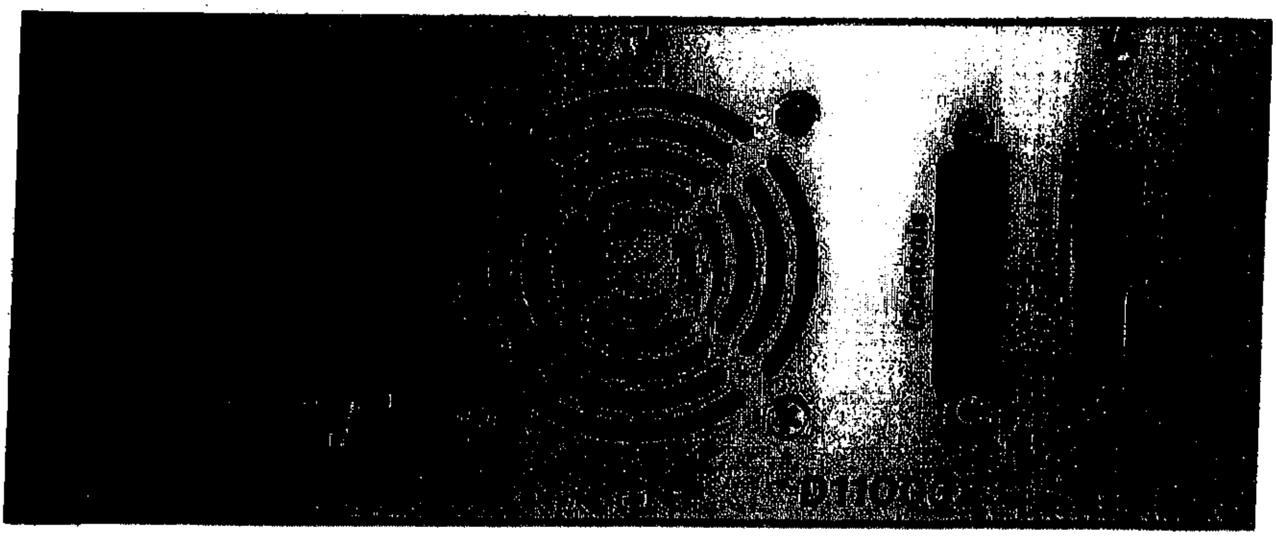
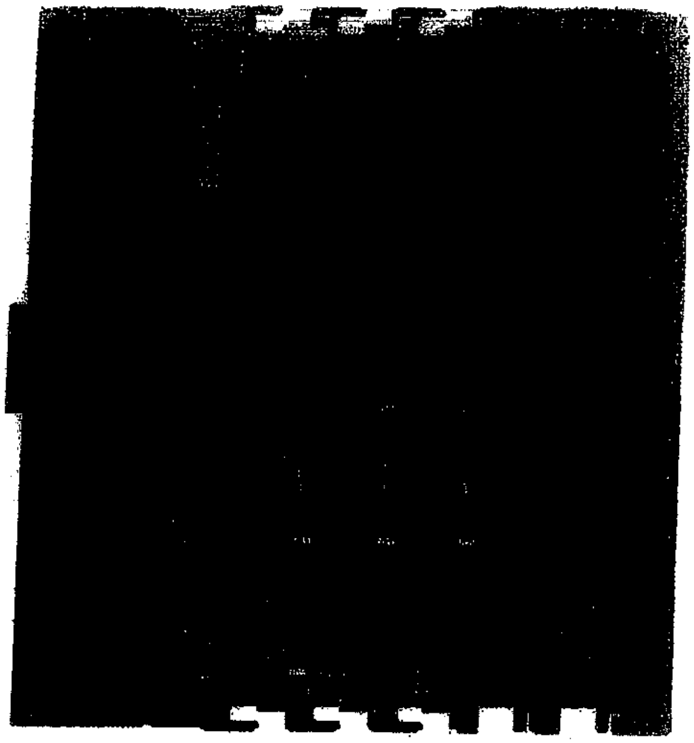


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

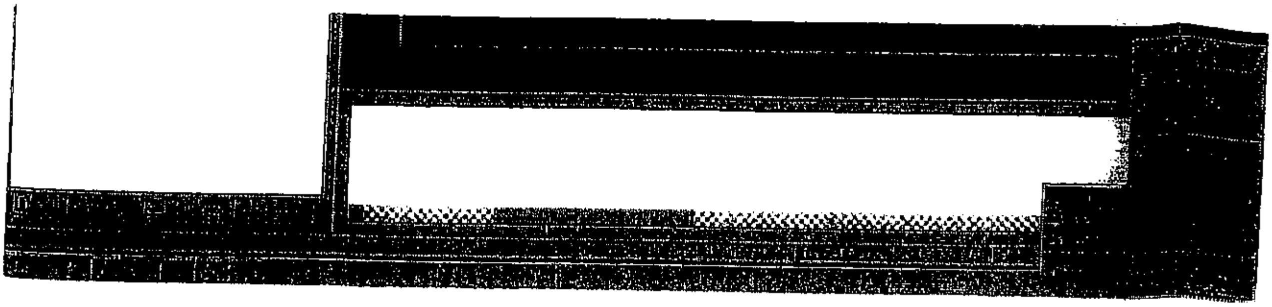
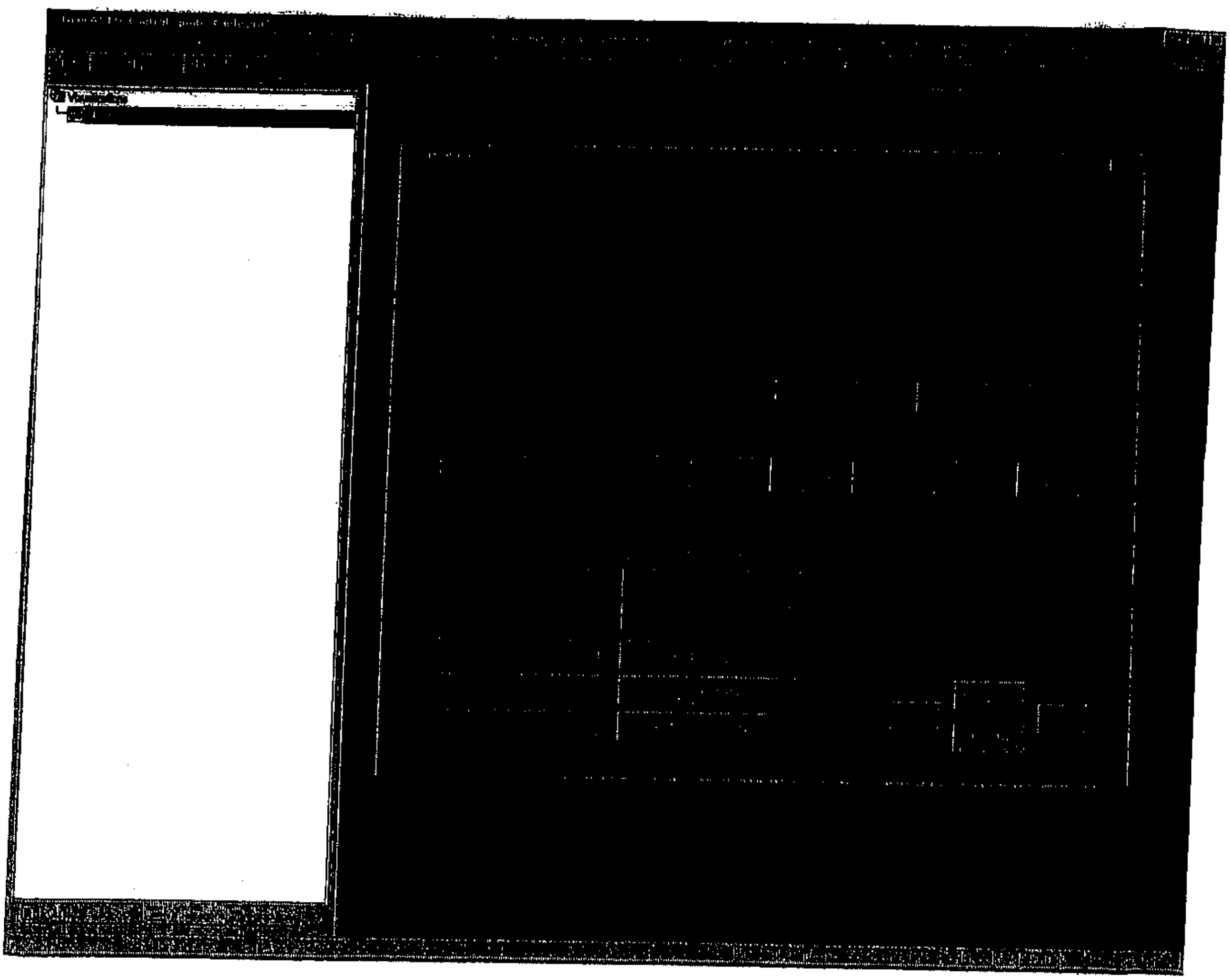


Figure 6: Step 5 of PLC controls setup



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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107573

Test Engineer: Zach G

Test Date: 11/29/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

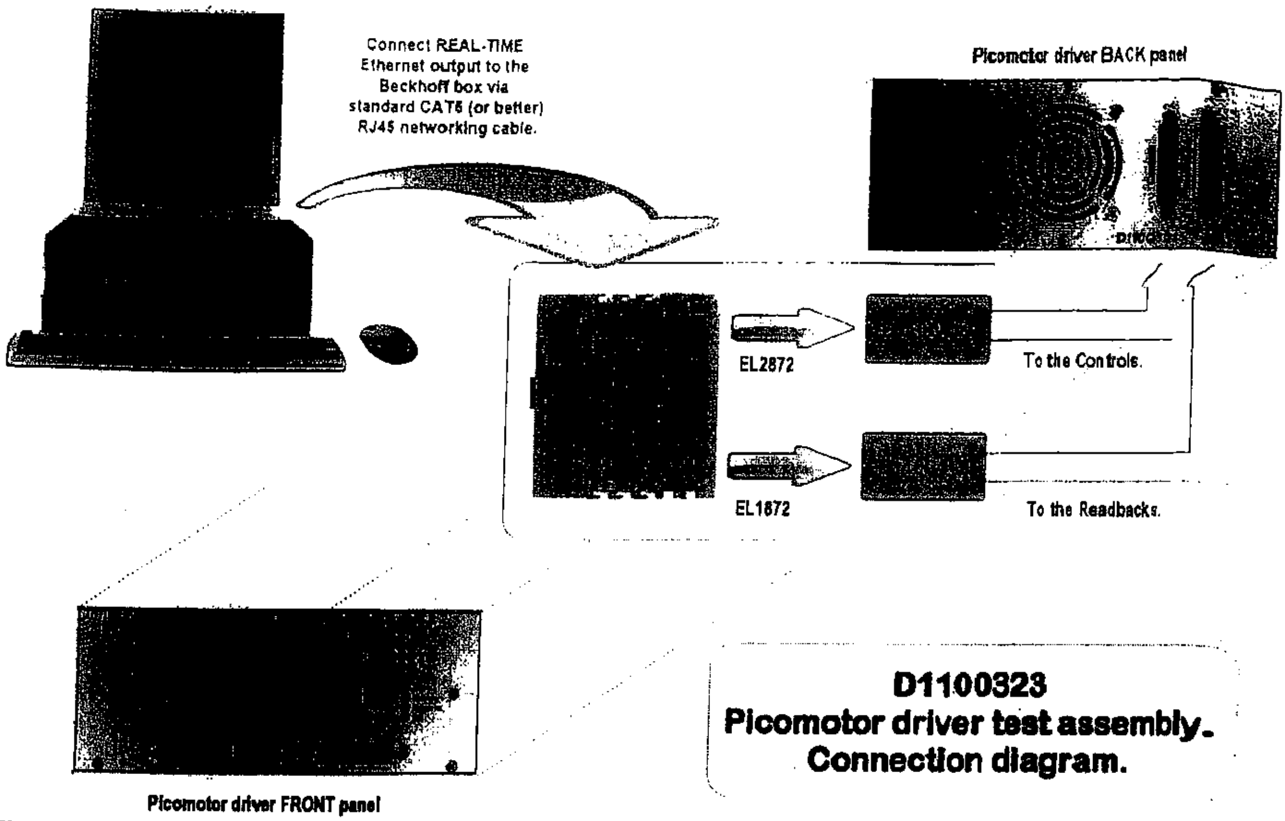


Figure 1a: A connection diagram of the picomotor setup.

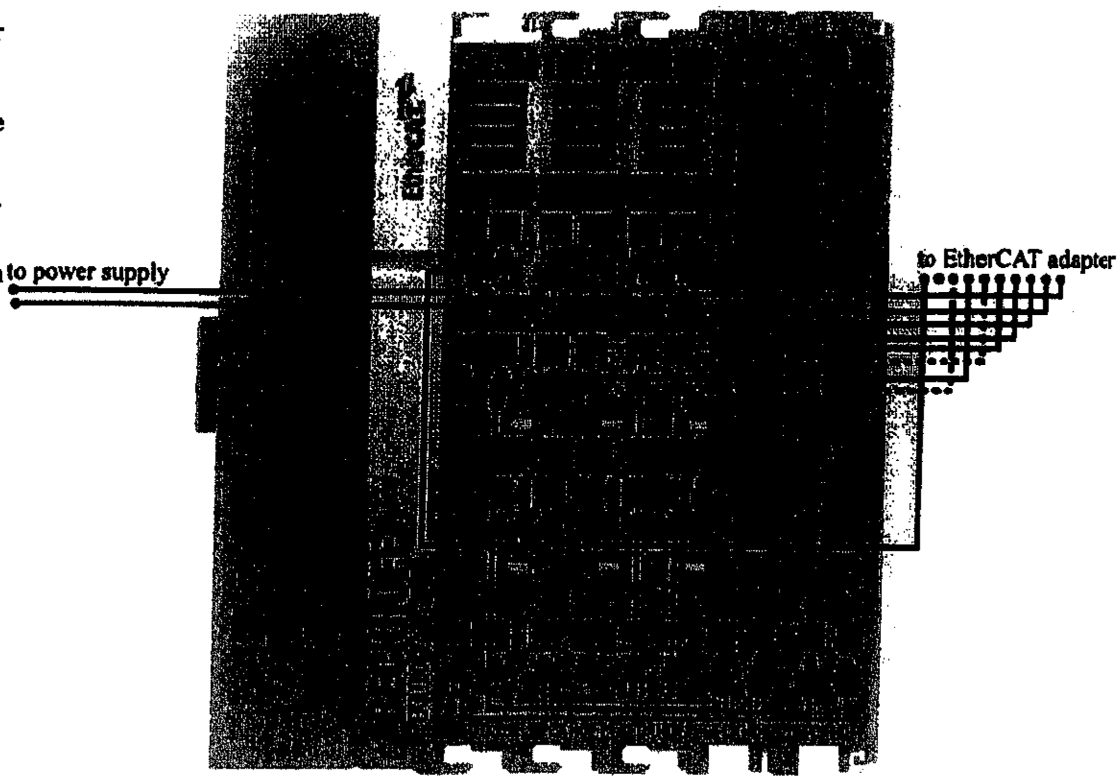


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)

Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓	[✓
MEDIUM (100)	[✓	[✓
MAGNUM (10000)	[✓	[✓

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓	[✓
JOG (50Hz)	[✓	[✓
SPRINT (500Hz)	[✓	[✓

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.85	26.33
2	27.16	27.77
3	28.43	29.11
4	29.51	30.27
5	30.59	31.40
Check if passed:	✓	✓

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[ ]	[✓]
3	[ ]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

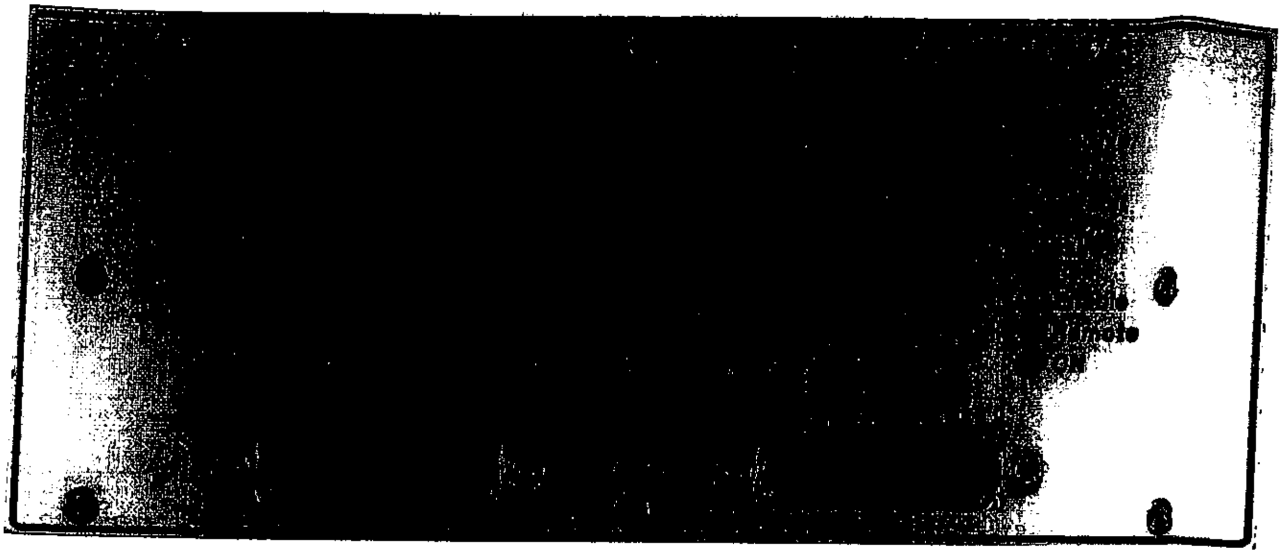


Figure 3: Picomotor driver chassis rear panel

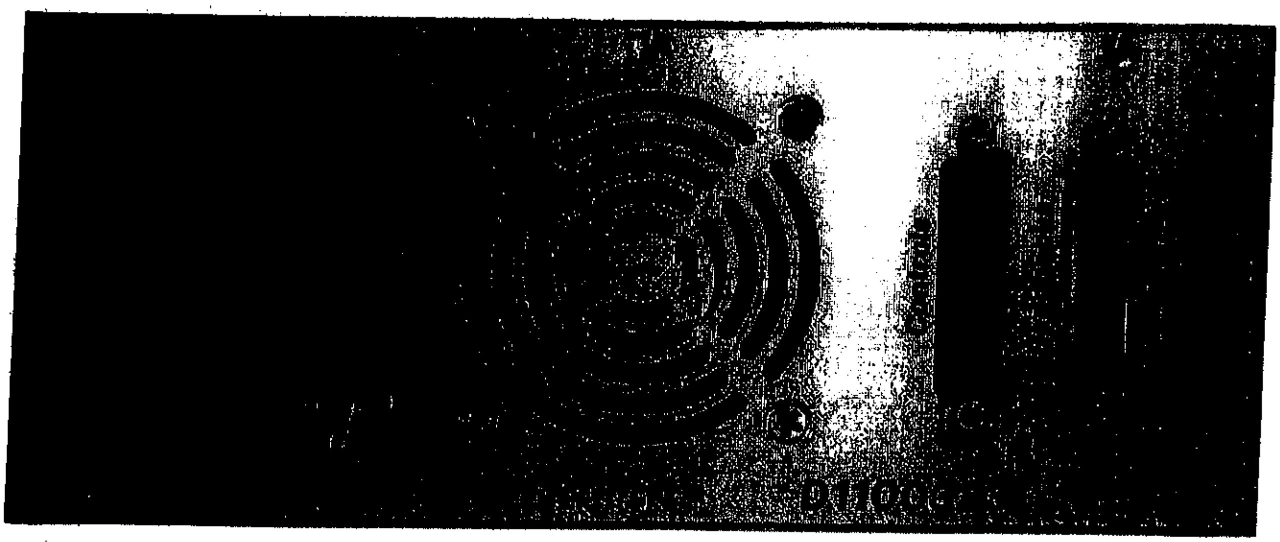
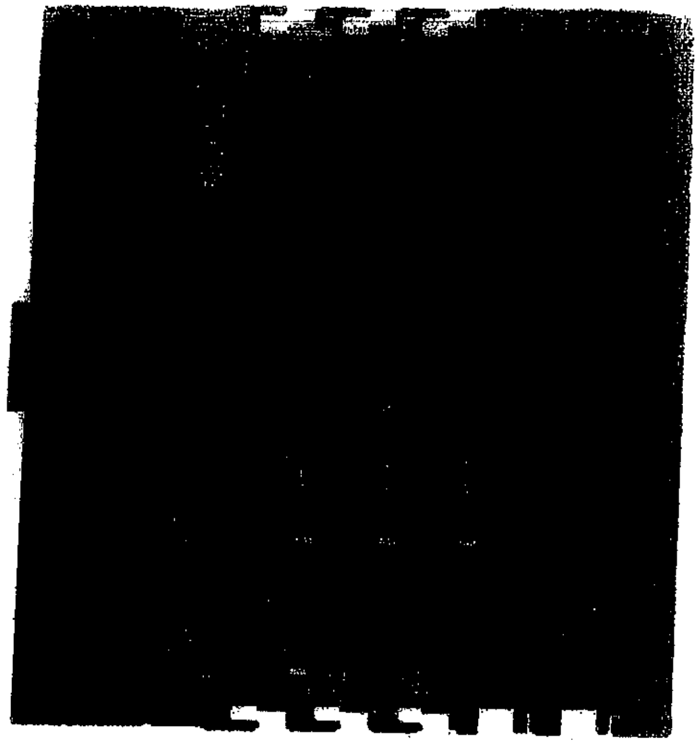


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

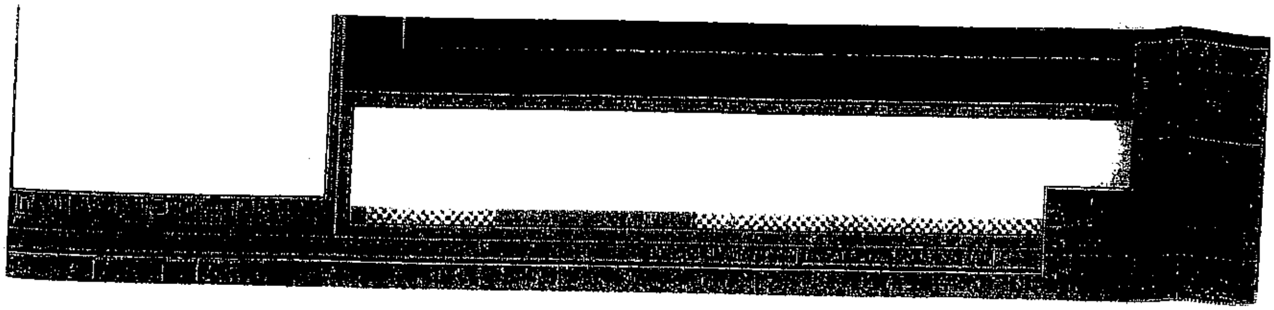
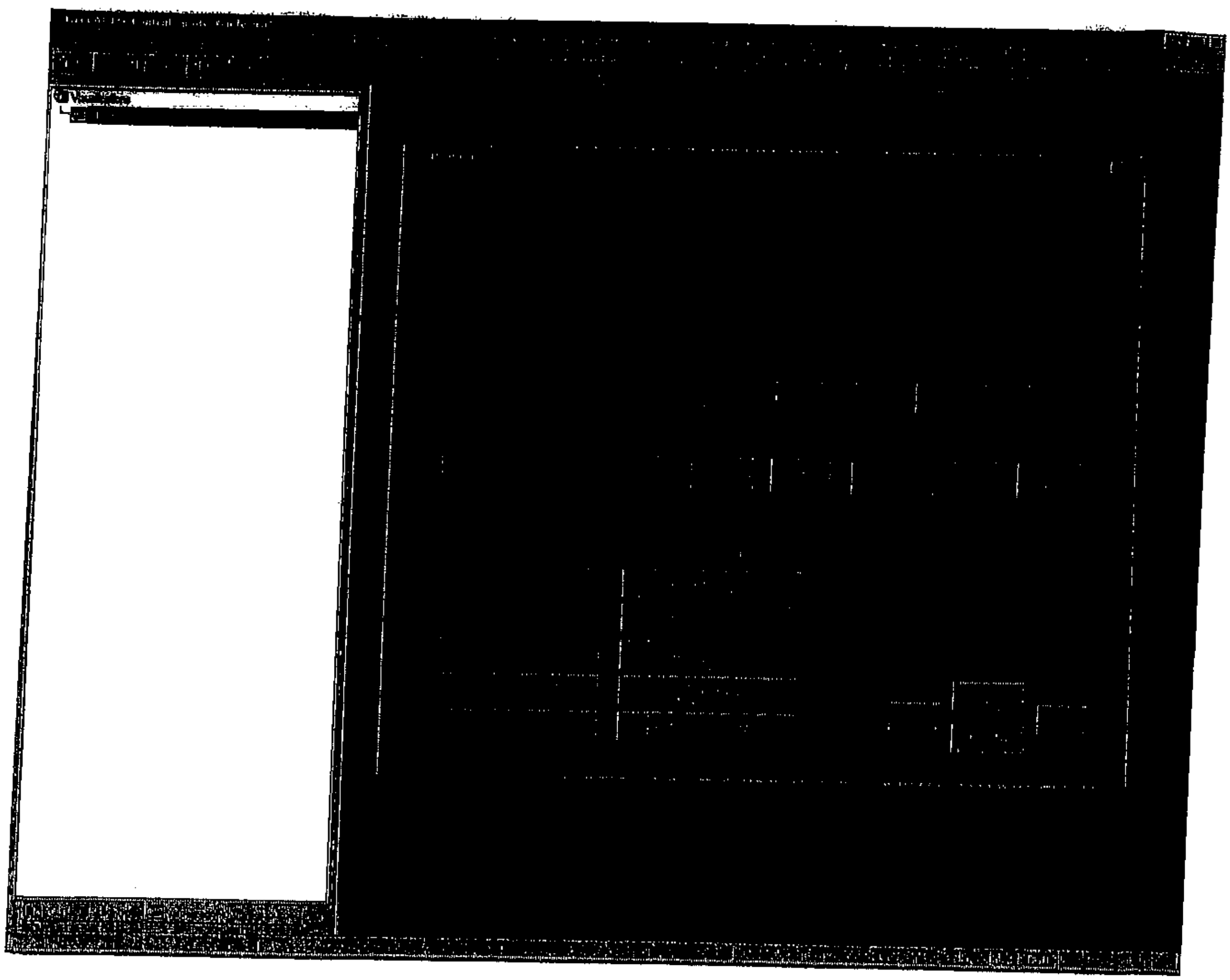


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Technical Note **LIGO-T1100458-v1** **08/26/11**

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC#   D1100323-v1

EtherCAT Adapters LIGO DCC#   D1100419-v3

Controller Serial #   S1107674

Test Engineer: Zach C

Test Date: 11/29/11

Overall picomotor chassis testing: [✓] PASS   [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

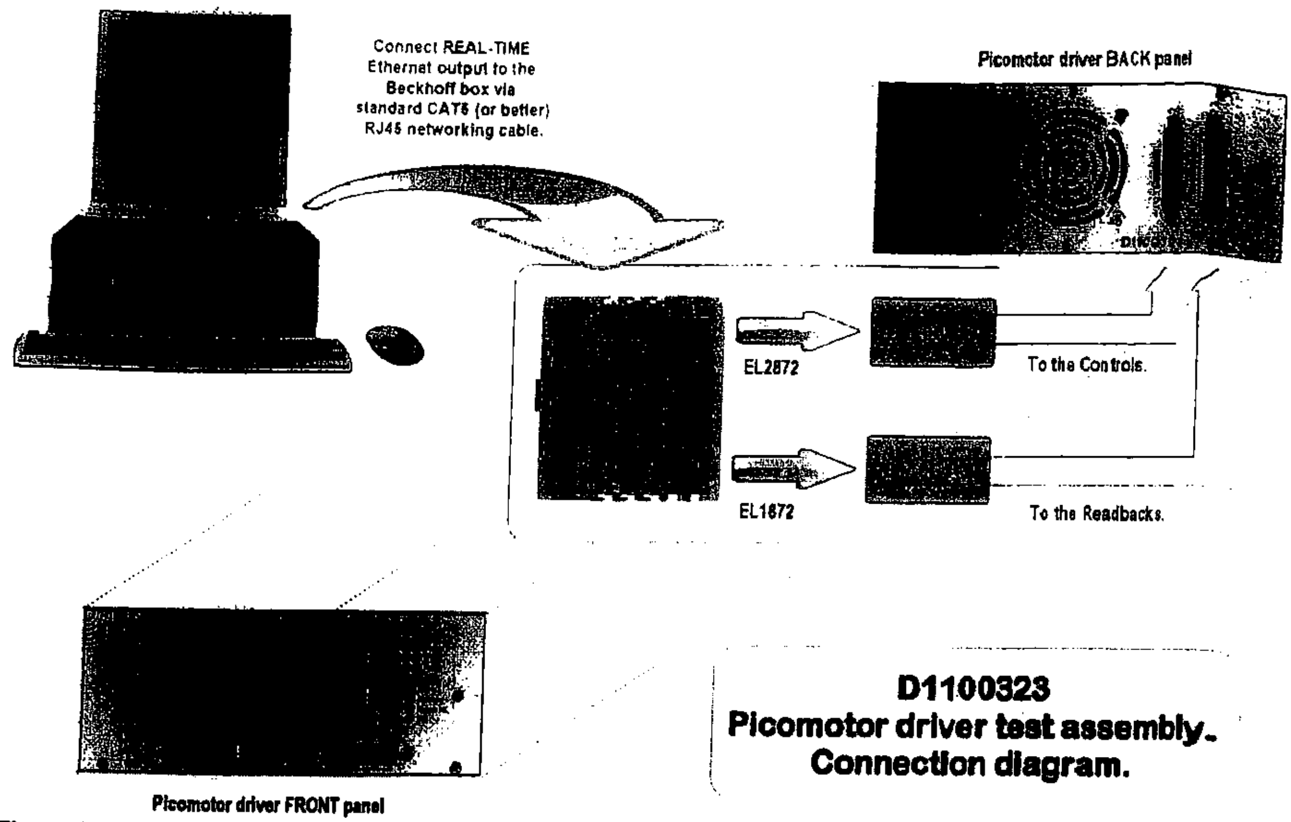
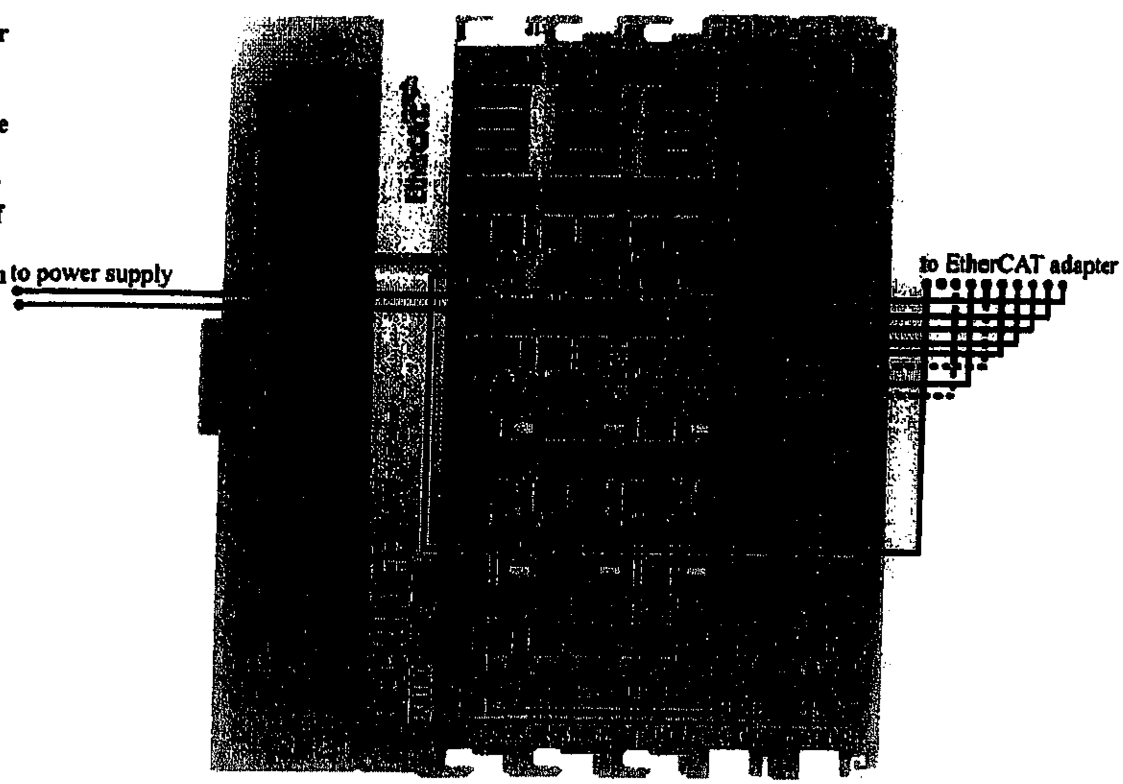


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

    File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

    File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: *(see Figure 5 in Appendix B for a screenshot)*

    System > Start

4. Go to the TwinCAT PLC Control window and go to:

    Online > Login (F11)
    Click "Yes" at the dialog:
        "No program on the controller! Download the new program?"
    Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
(see Figure 6 in Appendix B for a screenshot)

    In the "VIS_PICO" visualization window:

        in the "RAW" section, the "IDLE" indicator should be lit
        in the "USER" section, the status should read "DRIVER DISABLED"

    On the controller front panel:

        the "IDLE" LED should be lit
        the "Enable" LED should be off
        the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	22.23	22.37
2	23.54	23.85
3	24.80	25.20
4	25.90	26.32
5	26.90	27.46
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

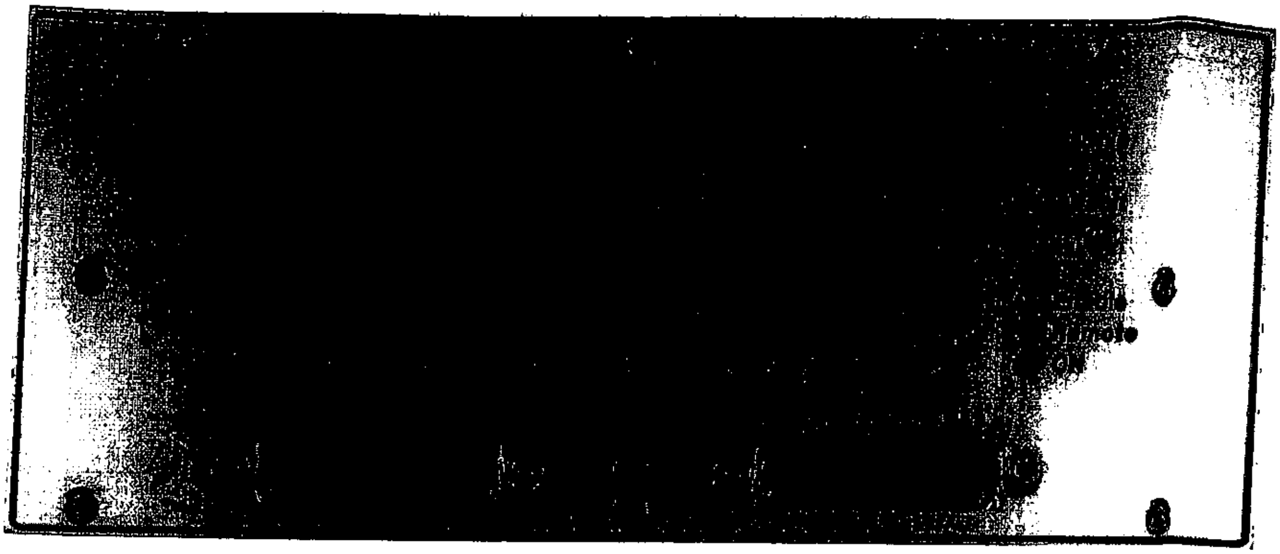


Figure 3: Picomotor driver chassis rear panel

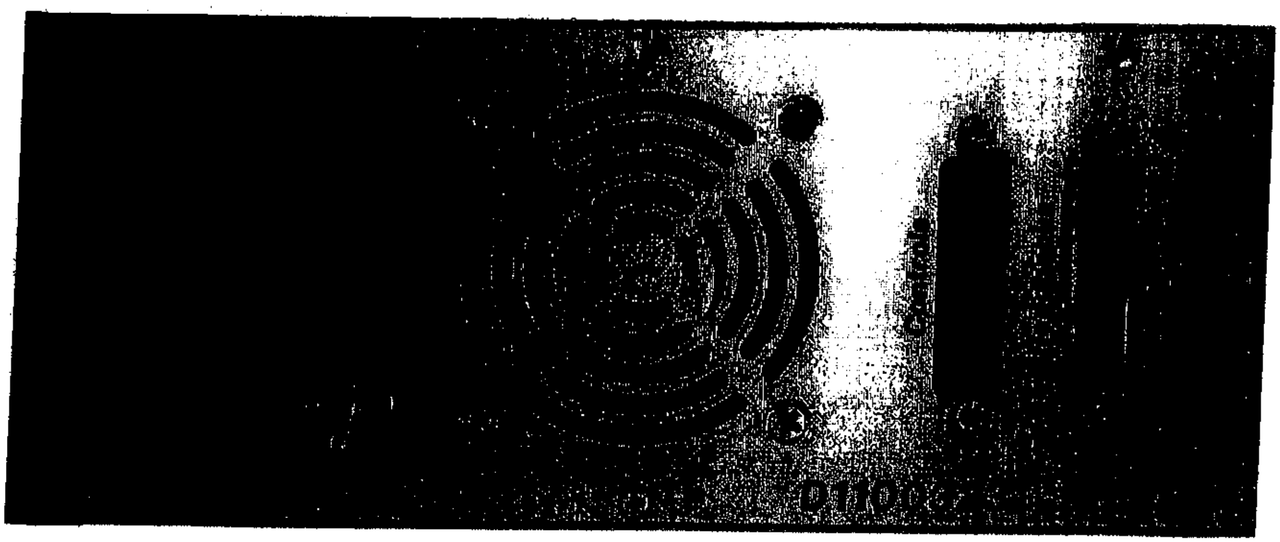
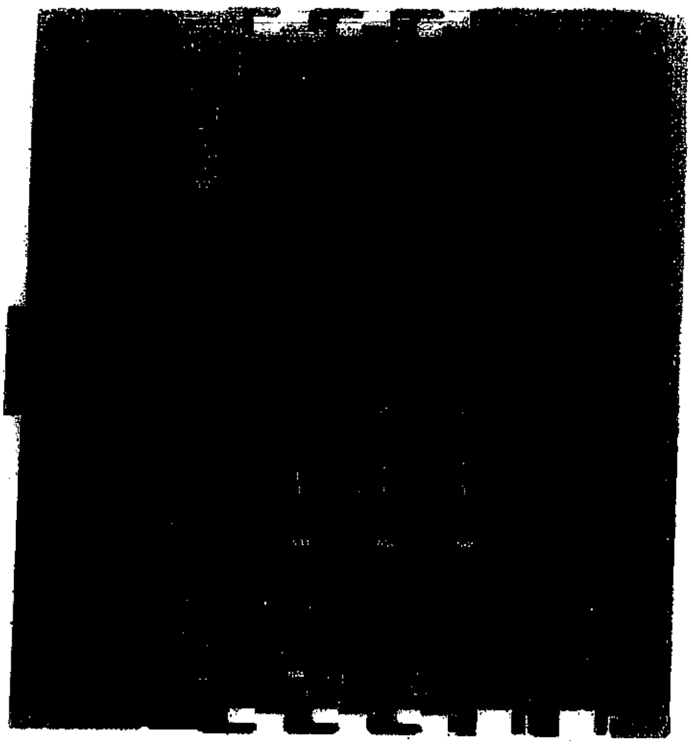


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

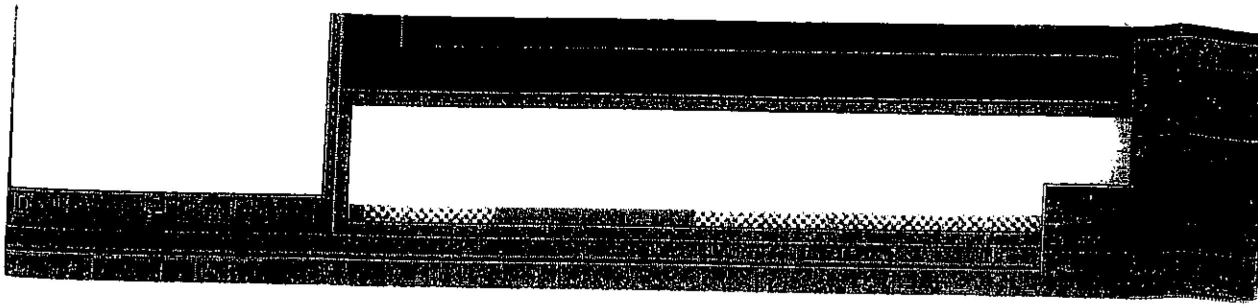
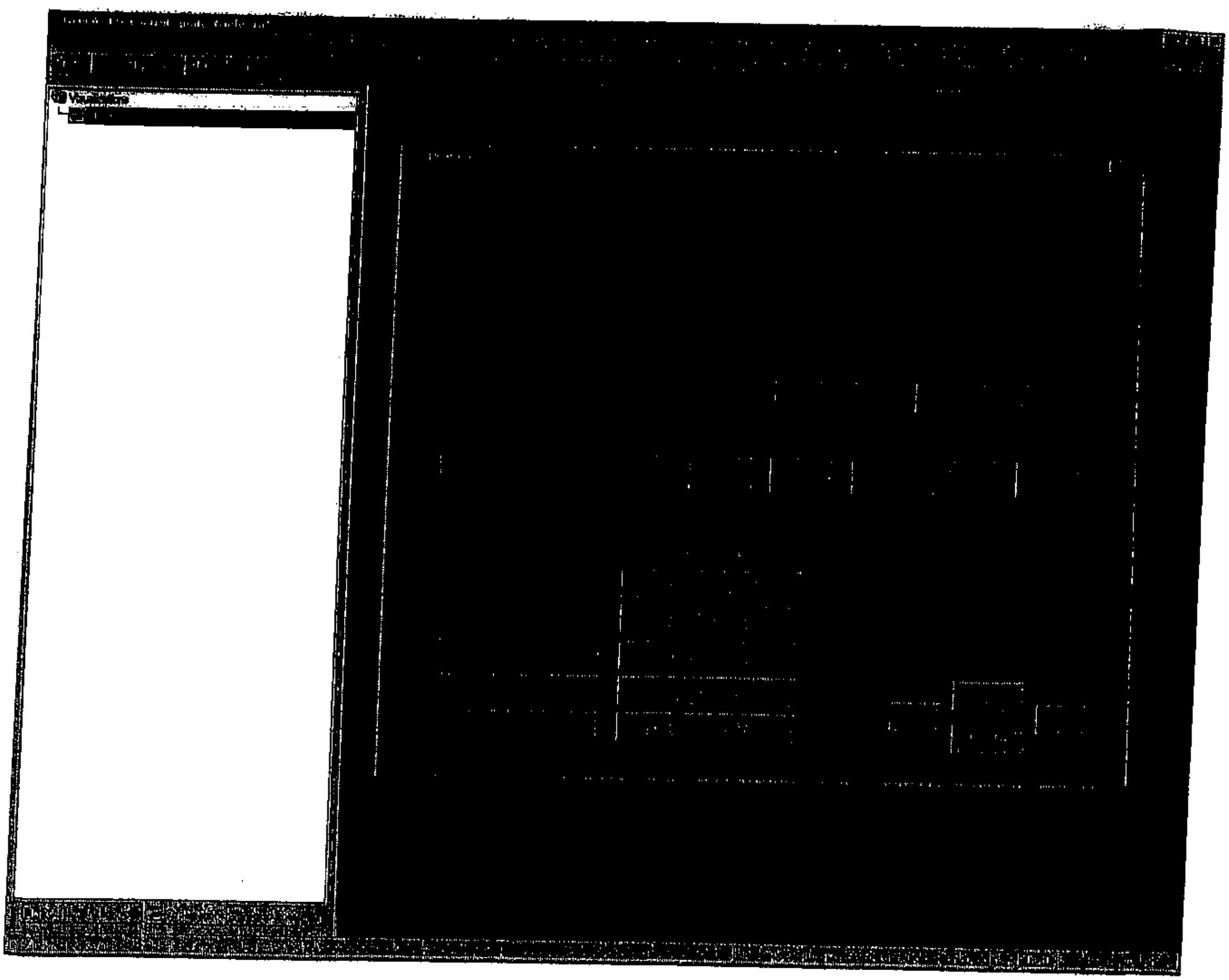


Figure 6: Step 5 of PLC controls setup



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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107575

Test Engineer: Zach G

Test Date: 11/29/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

Steps for setting up the picomotor:

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

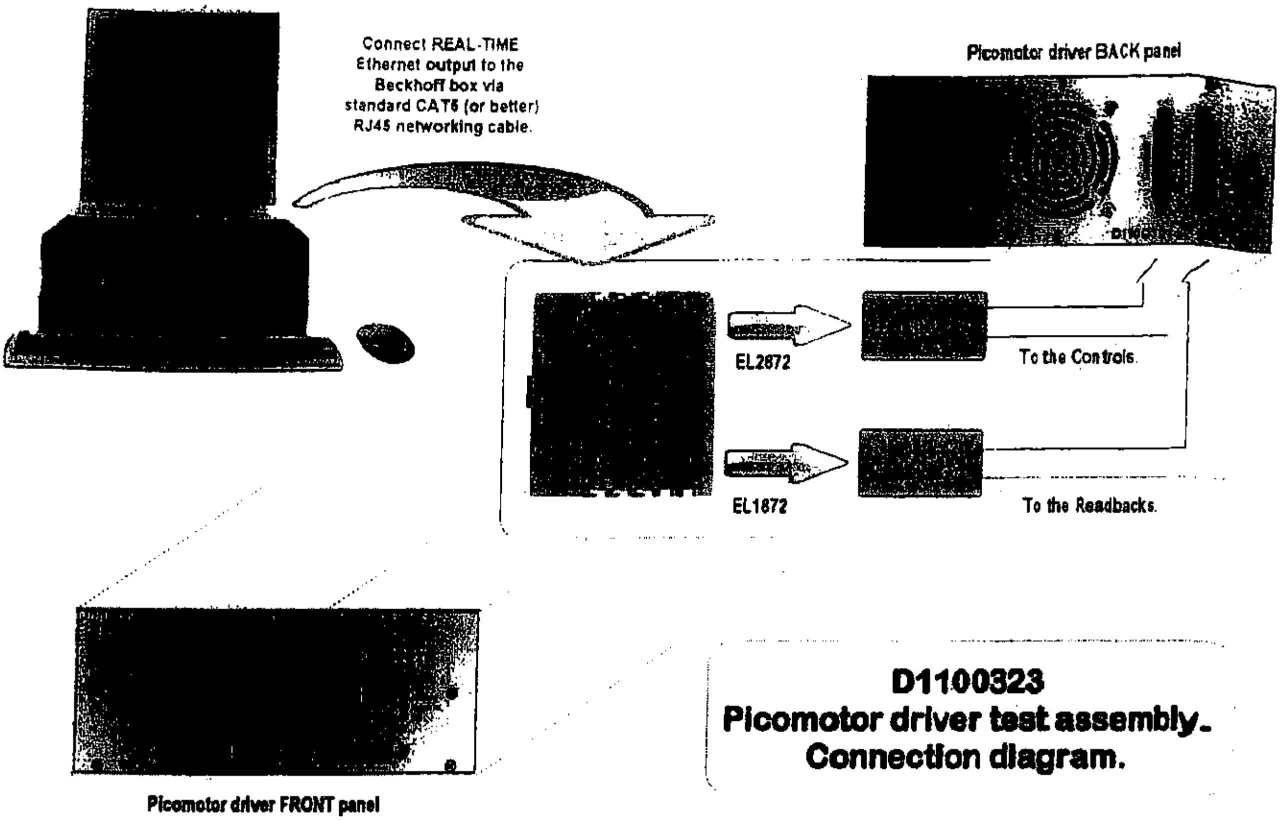


Figure 1a: A connection diagram of the picomotor setup.

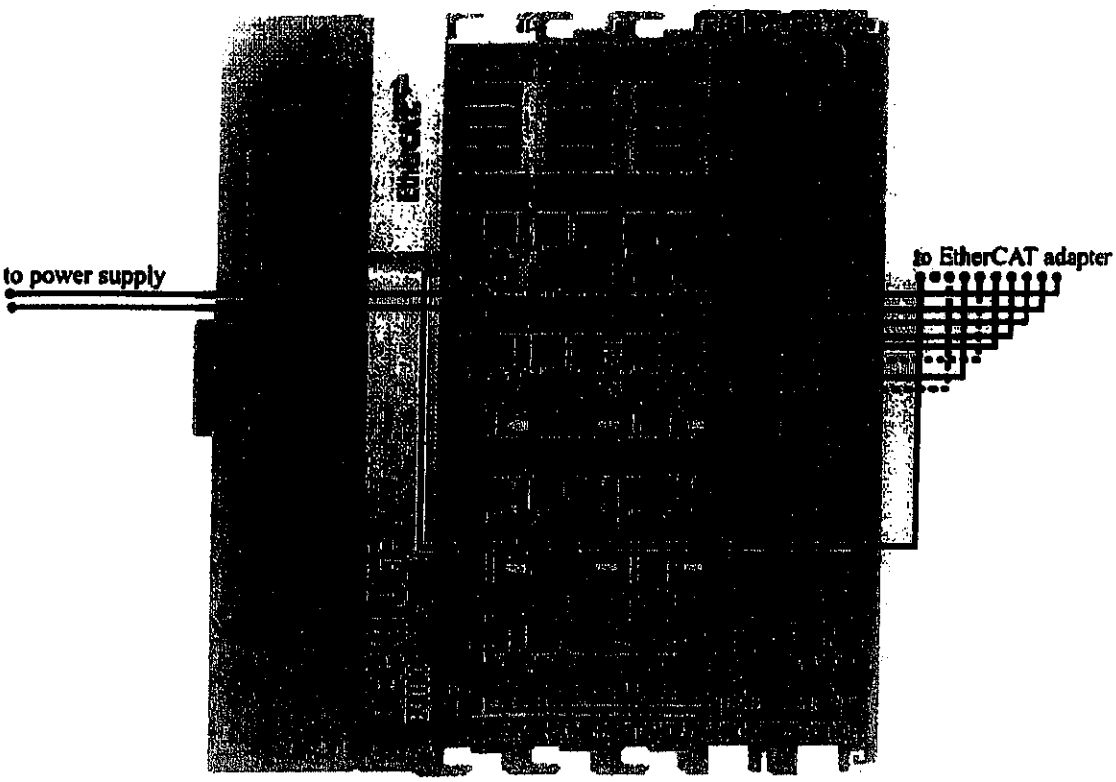


Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white).

Setting up

Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.48	23.90
2	26.75	25.14
3	27.89	26.40
4	29 04	27.57
5	30.04	28.59
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

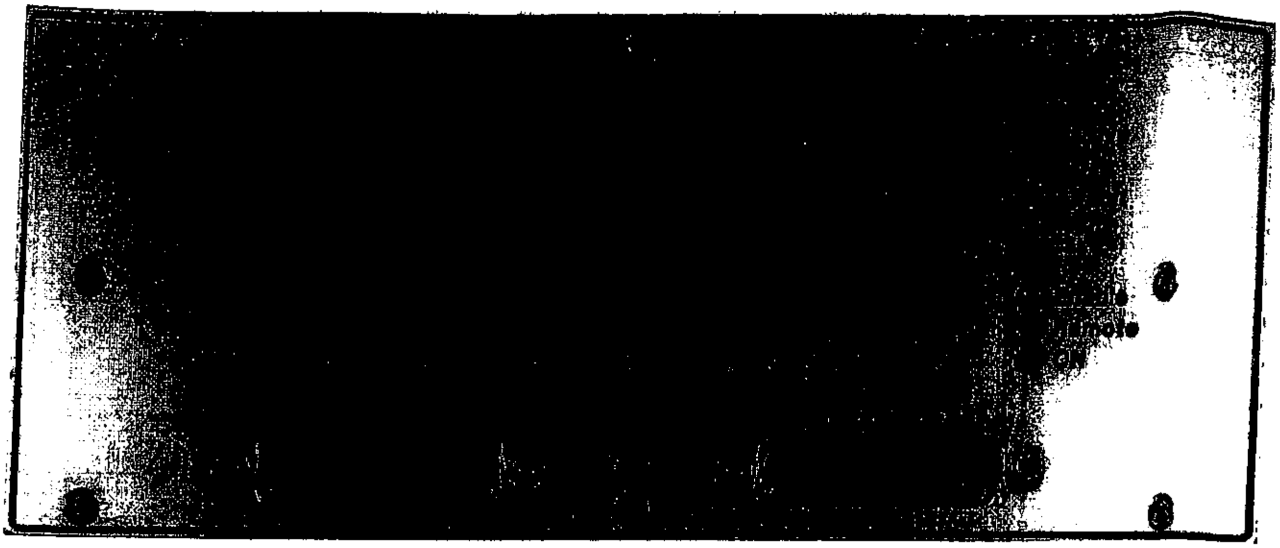


Figure 3: Picomotor driver chassis rear panel

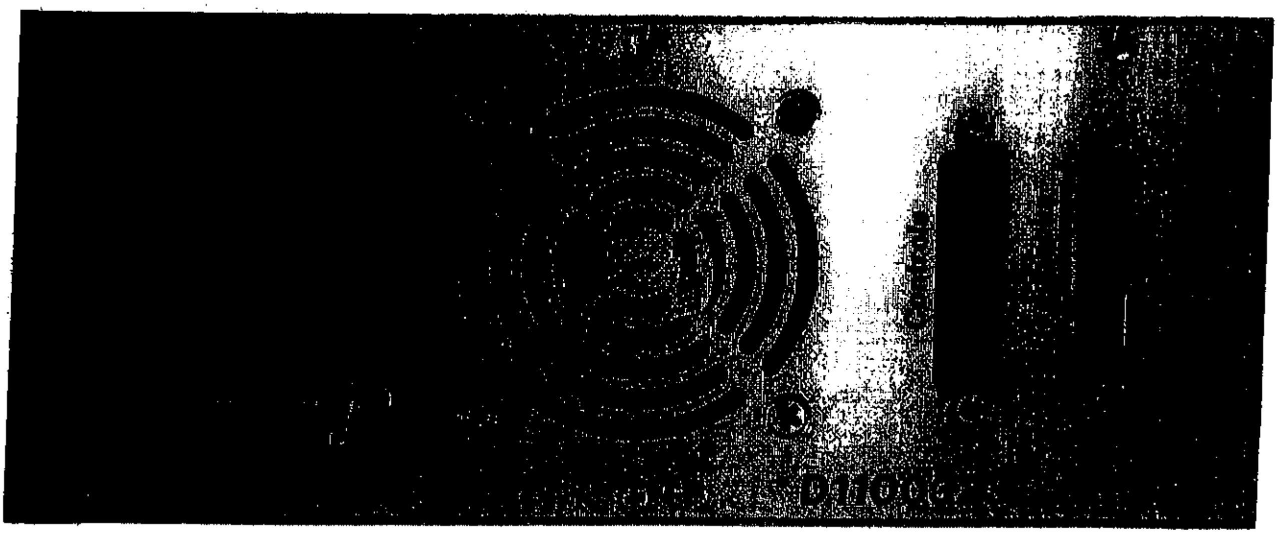
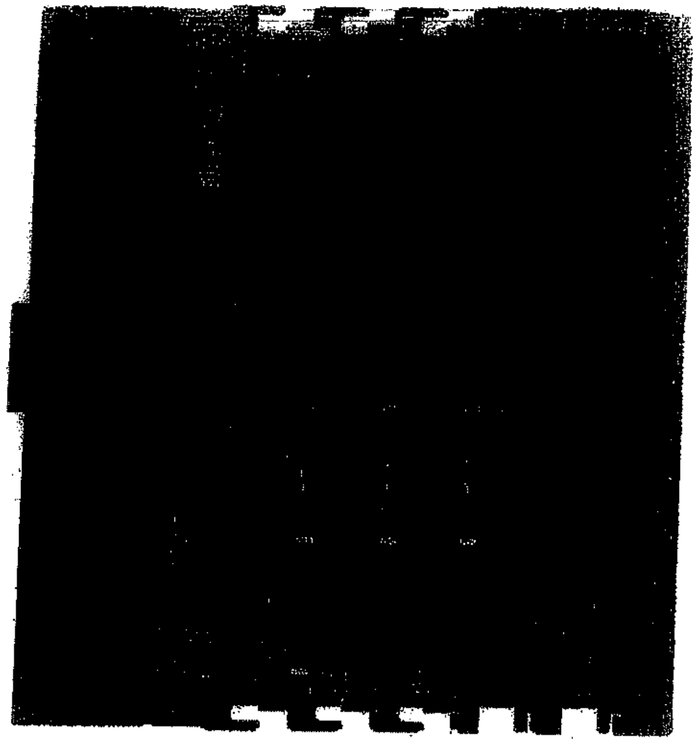


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

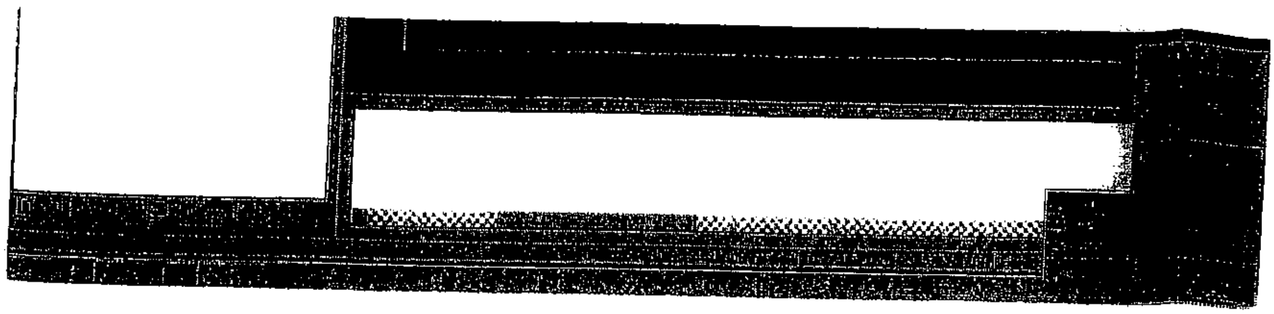
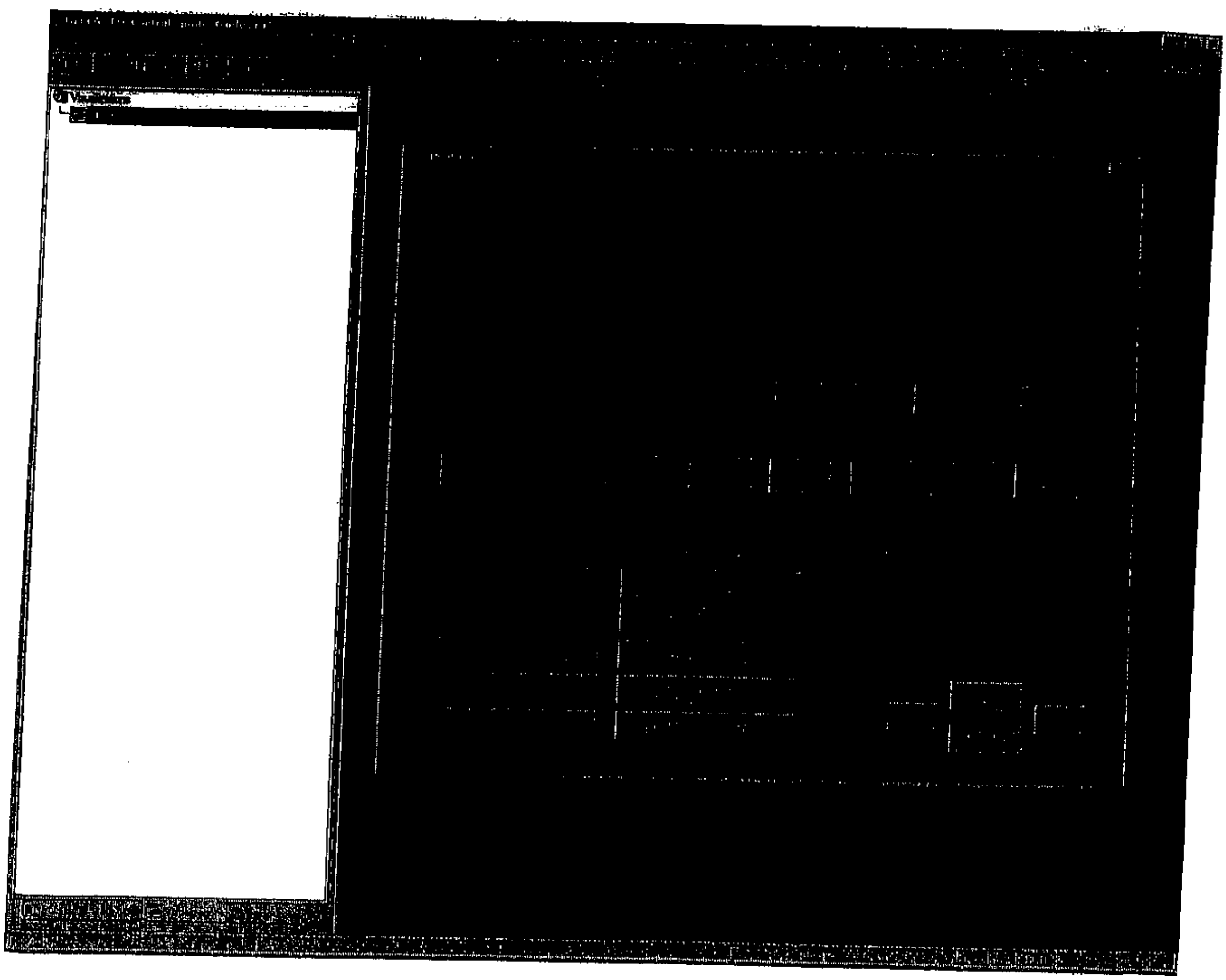


Figure 6: Step 5 of PLC controls setup



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1100458-v1	08/26/11

Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note
of the LIGO Project.

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Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107576

Test Engineer: Zach

Test Date: 8/12/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1 Picomotors (2)
Compatible models: Newport 8302

2 Picomotor driver D1100323-v2 (1)
(Figures 2 and 3 in Appendix A)

3 LIGO standard 24V M-F-M DB3 power cable

4 EtherCAT adapter D1100419-v3 (1)

5 DB25 F/M cables (2)

6 Hook-up wires
Brown, Green, White, Black, Grey, Purple

7 IDC 20-pin cable assemblies (2)

8 Beckhoff EtherCAT boxes (5)
EK1100, EL3102, EL1014, EL1872, EL2872
(Figure 4 in Appendix A)

9 24V power supply for Beckhoff boxes (1)

10 Ethernet cable (1)

11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1 MS Windows XP/7, 32-bit

2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

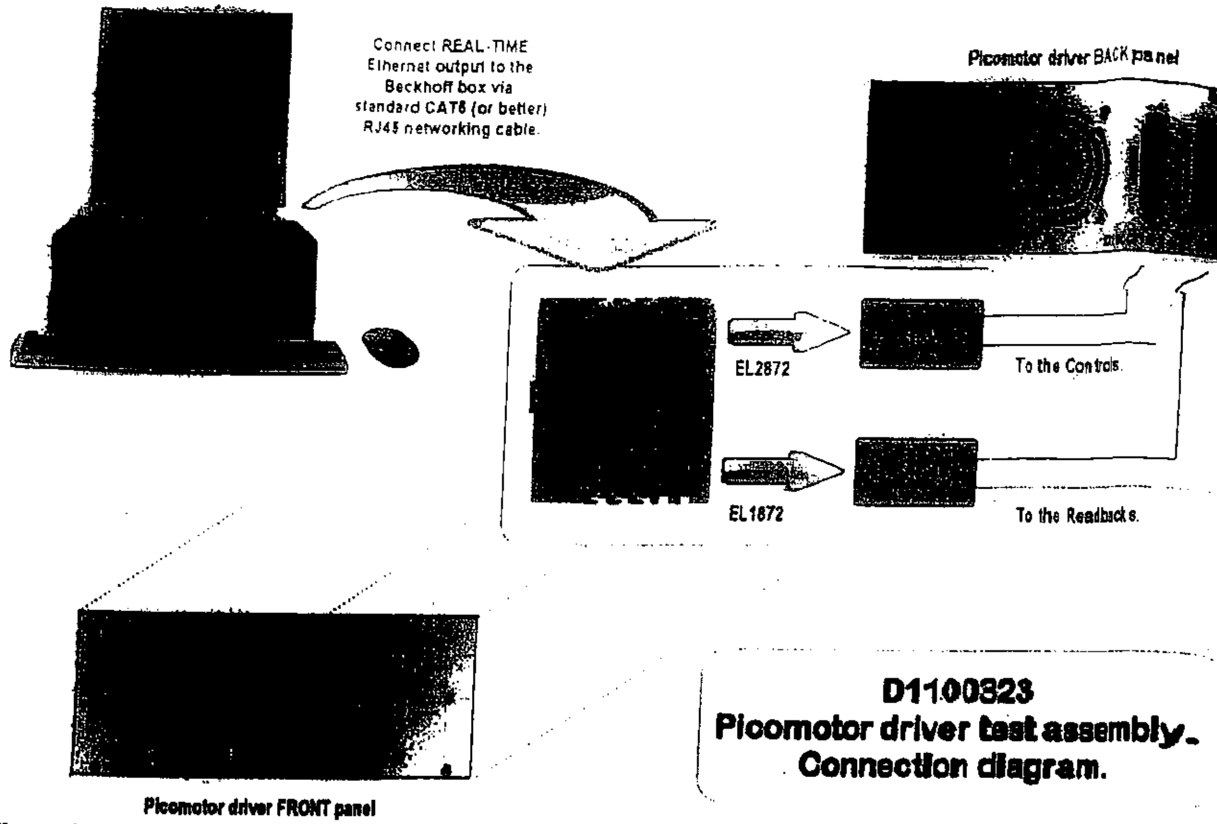
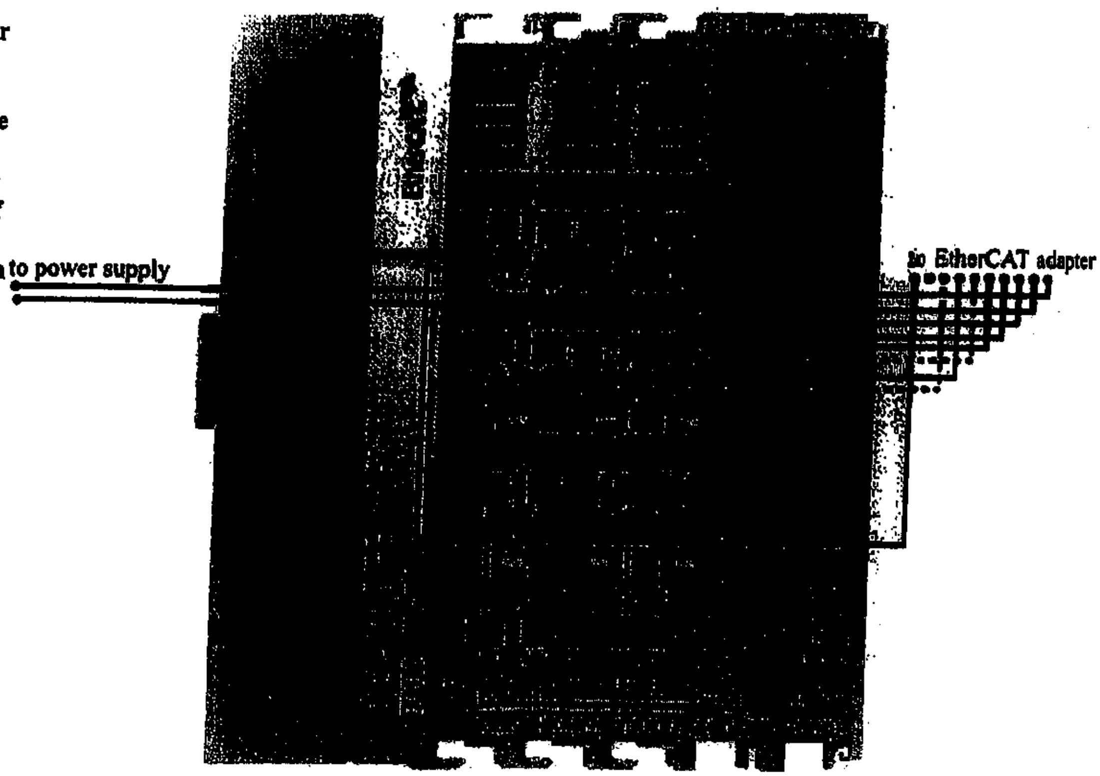


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	On
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[ ] **Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:**

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[ ]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.56	24.45
2	24.95	25.94
3	26.27	27.34
4	27.38	28.62
5	28.45	29.80
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail

Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 12/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

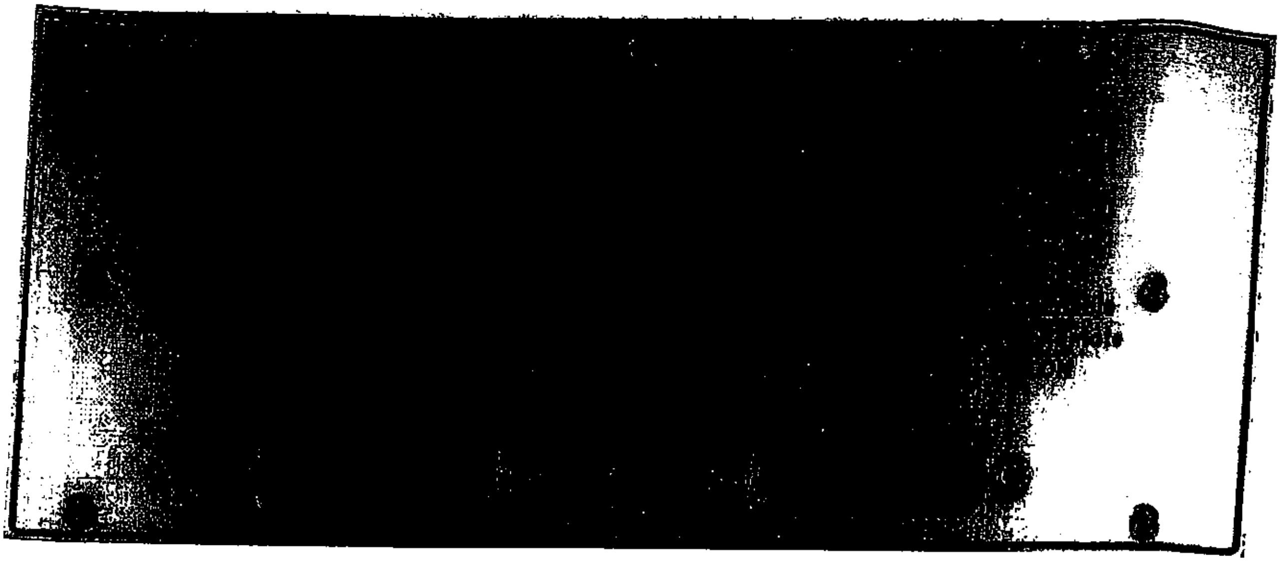


Figure 3: Picomotor driver chassis rear panel

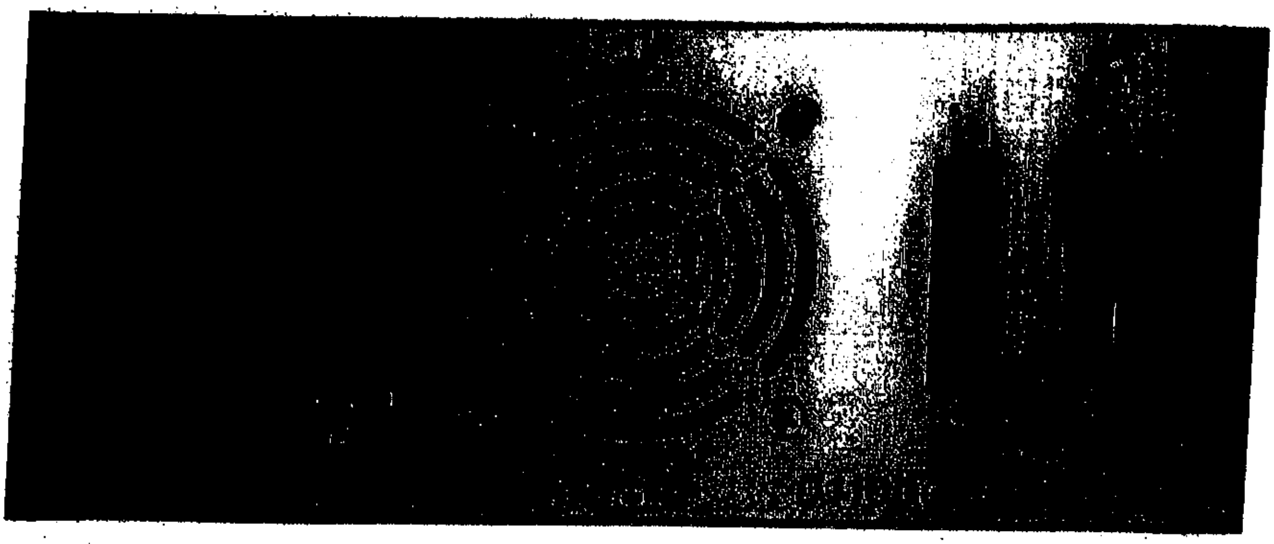
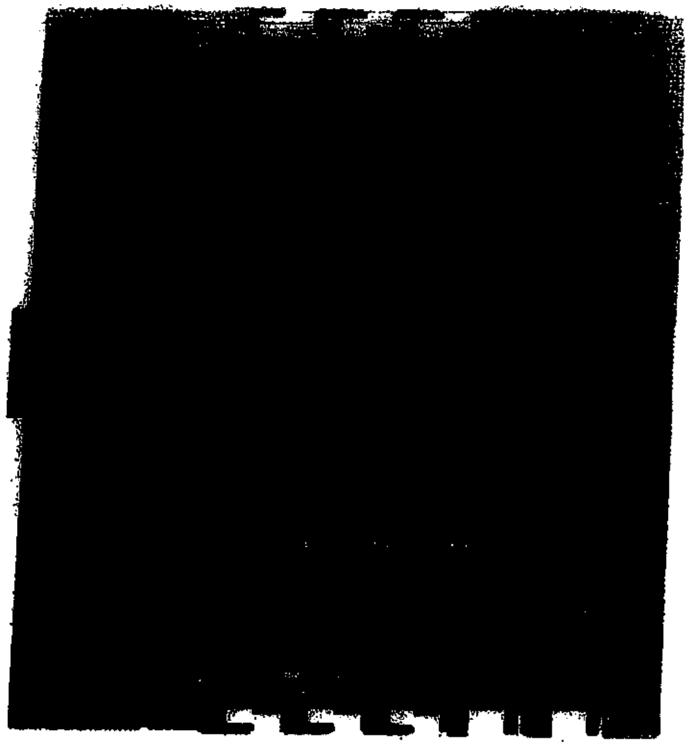


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

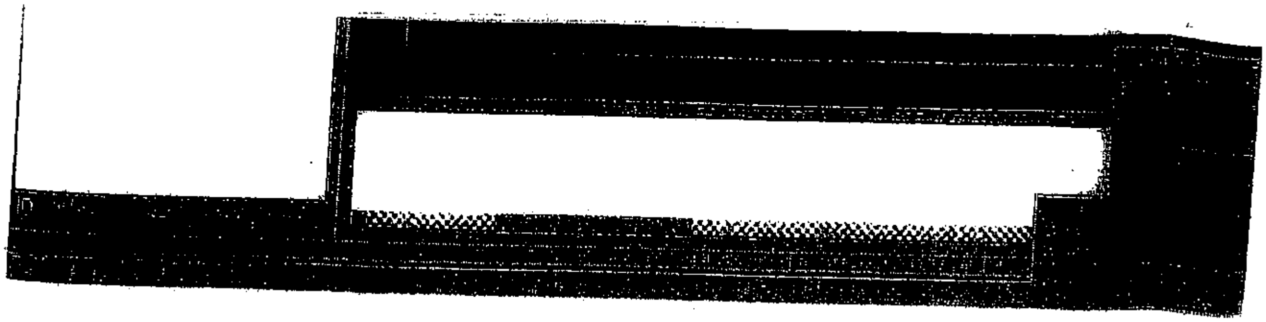
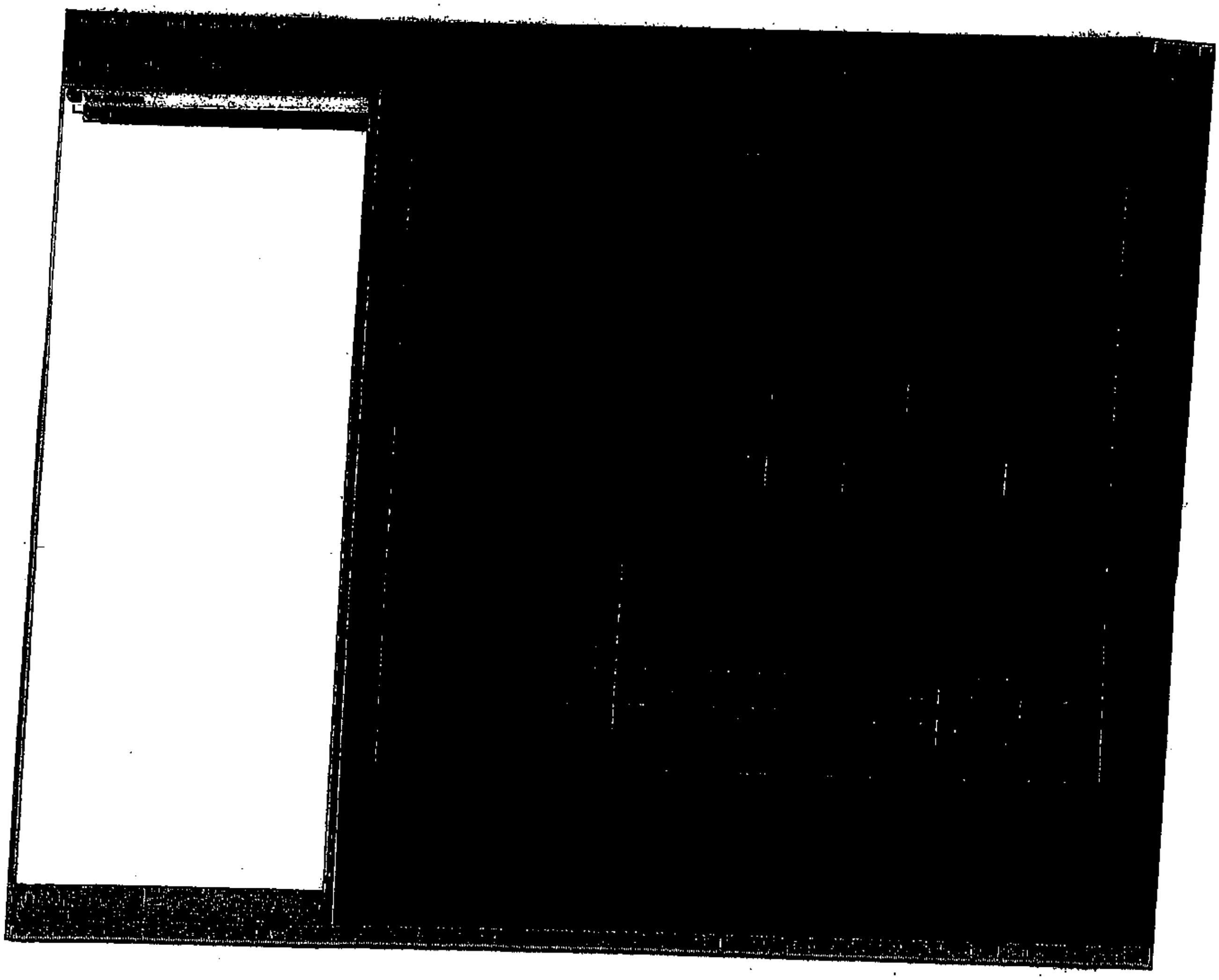


Figure 6: Step 5 of PLC controls setup



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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC# D1100323-v1

EtherCAT Adapters LIGO DCC# D1100419-v3

Controller Serial # S1107577

Test Engineer: Zachary

Test Date: 12/21/11

Overall picomotor chassis testing: [✓] PASS [ ] FAIL

Signature/Initials:

Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

Testing Schedule:

1. Front panel LEDs
2. Step sizes
3. Speeds
4. Temperature
5. Output terminals

System requirements

Hardware:

1. Picomotors (2)
   Compatible models: Newport 8302

2. Picomotor driver D1100323-v2 (1)
   (Figures 2 and 3 in Appendix A)

3. LIGO standard 24V M-F-M DB3 power cable

4. EtherCAT adapter D1100419-v3 (1)

5. DB25 F/M cables (2)

6. Hook-up wires
   Brown, Green, White, Black, Grey, Purple

7. IDC 20-pin cable assemblies (2)

8. Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)

9. 24V power supply for Beckhoff boxes (1)

10. Ethernet cable (1)

11. Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

Software:

1. MS Windows XP/7, 32-bit

2. Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<u>Steps for setting up the picomotor:</u>

1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis

2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis

3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box

4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box

5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box

6. Connect the EK1100 Beckhoff box to a DC power source (24V)

7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port

8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

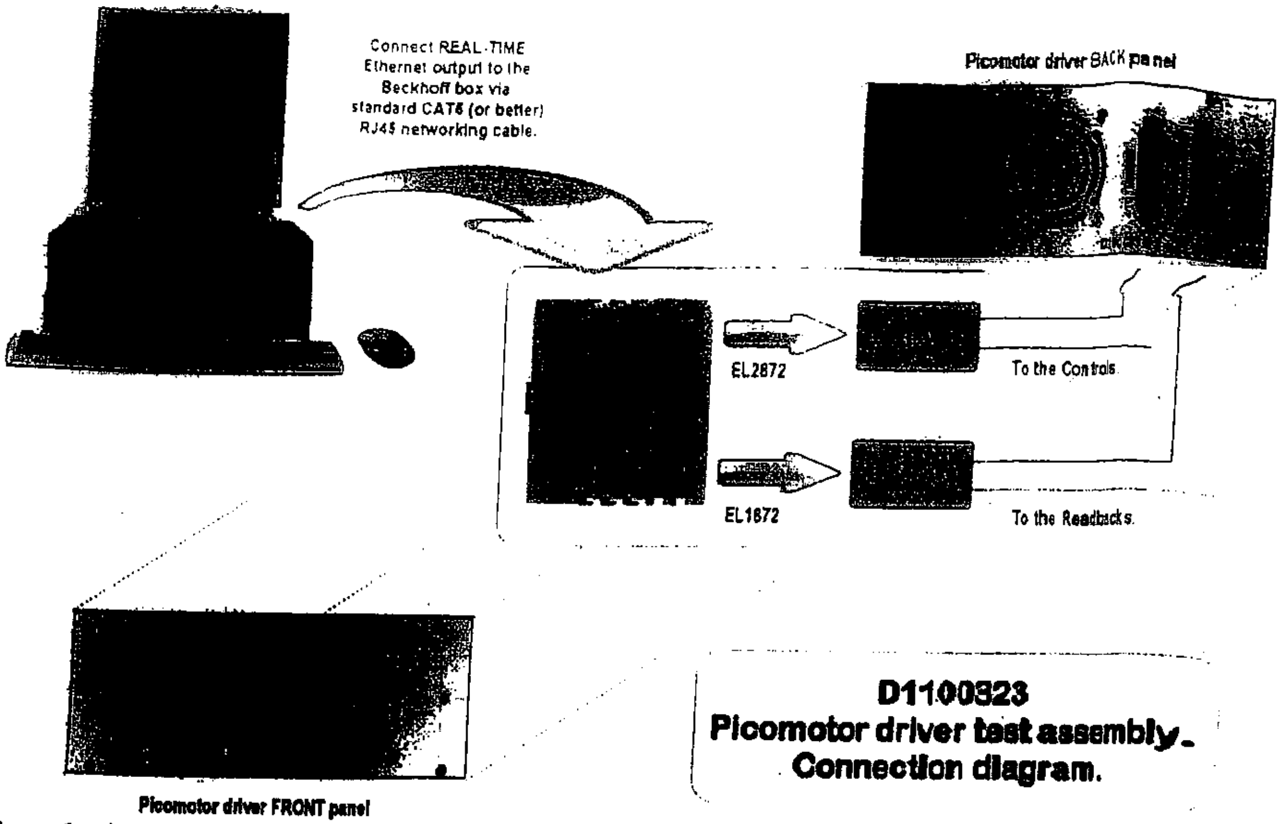
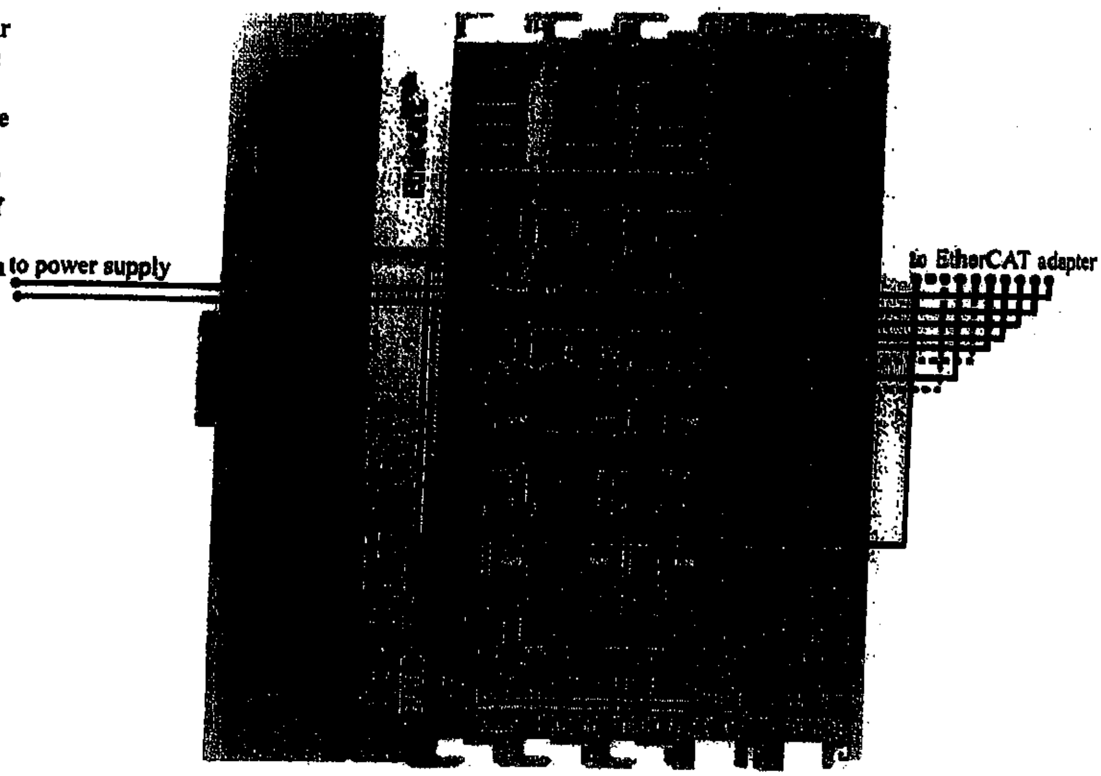


Figure 1a: A connection diagram of the picomotor setup.

Figure 1b: A connection diagram of the Beckhoff setup (dotted black line = white)



Setting up

<u>Steps for setting up the PLC controls:</u>

1. Open up the TwinCAT System Manager software and go to:

   File > Open > Picomotor_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

   File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to:
   (see Figure 5 in Appendix B for a screenshot)

   System > Start

4. Go to the TwinCAT PLC Control window and go to:

   Online > Login (F11)
   Click "Yes" at the dialog:
   "No program on the controller! Download the new program?"
   Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS_PICO", and a visualization window should appear.
   (see Figure 6 in Appendix B for a screenshot)

   In the "VIS_PICO" visualization window:

   in the "RAW" section, the "IDLE" indicator should be lit
   in the "USER" section, the status should read "DRIVER DISABLED"

   On the controller front panel:

   the "IDLE" LED should be lit
   the "Enable" LED should be off
   the "ON" LED should be on

1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[✓] Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.

[✓] Check that the "ON" indicator on the visualization also responds to the power switch.

[✓] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[✓] Before the next step, check that the fan (rear panel) is off.

[✓] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP...	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	on
Check if passed:	[✓]	[✓]	[✓]	[✓]	[ ]	[ ]	[✓]

Table 1: LED response to picomotor status

[✓] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[✓] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[✓] Check that the fan is running and blowing air out of the box (rear panel).

[✓] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED	
	Left	Right
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Select output terminal 1 and do the following:

[✓] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CW Y
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[✓]	[✓]	[✓]	[✓]

Table 2: LED response to picomotor direction

* (while motor is running)

** (stays on after motor is finished running, until opposite direction is selected)

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[✓]	[✓]
MEDIUM (100)	[✓]	[✓]
MAGNUM (10000)	[✓]	[✓]

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[✓]	[✓]
JOG (50Hz)	[✓]	[✓]
SPRINT (500Hz)	[✓]	[✓]

4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.55	23.43
2	25.00	25.40
3	26.32	26.92
4	27.50	28.18
5	28.59	29.37
Check if passed:	[✓]	[✓]

Check the "pass" box for each above if the temperature increases over time.

5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[✓]	[✓]
2	[✓]	[✓]
3	[✓]	[✓]
4	[✓]	[✓]
5	[✓]	[✓]
6	[✓]	[✓]
7	[✓]	[✓]
8	[✓]	[✓]

Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs	[✓] Pass	[ ] Fail
Step sizes	[✓] Pass	[ ] Fail
Speeds	[✓] Pass	[ ] Fail
Output terminals	[✓] Pass	[ ] Fail
Overall picomotor driver testing:	[✓] Pass	[ ] Fail

Test Engineer: [illegible signature]

Test Date: 12/21/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

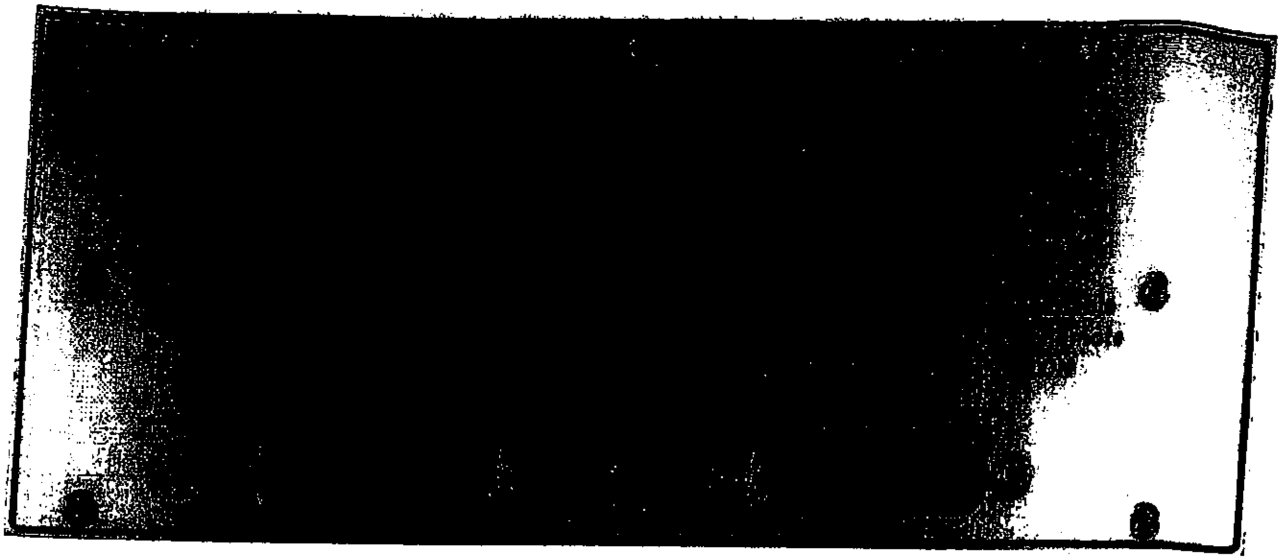
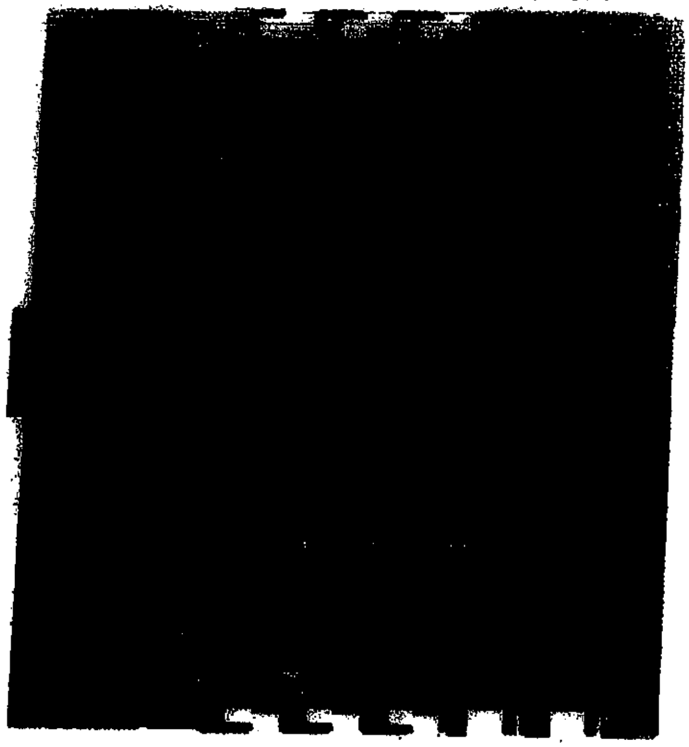


Figure 3: Picomotor driver chassis rear panel

Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

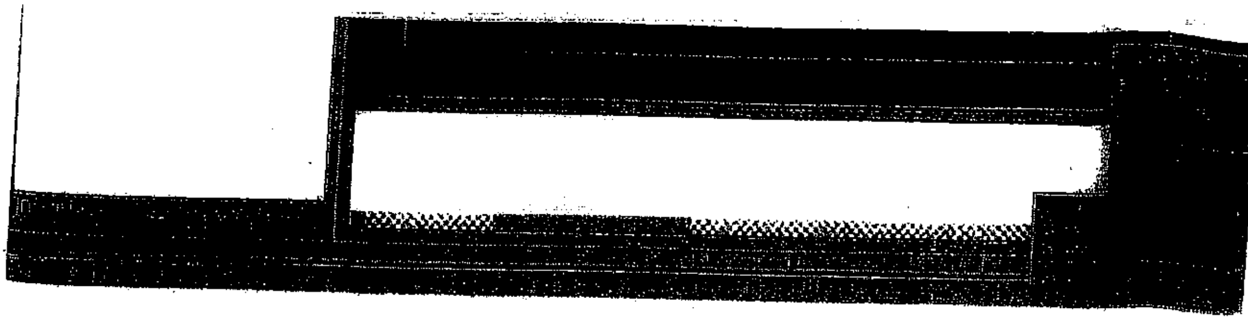


Figure 6: Step 5 of PLC controls setup