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

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Technical Note	LIGO-T1100458-v1	08/26/11	
 Testi	ng Procedure for t	he	
	comotor Driver for		
1	Advanced LIGO		
 Maxim Facto	urovich, Daniel Sigg and Ma	ggie Tse	

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

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D1100419-v3

Zach G 11/22/11

[YPASS []FAIL

Overall picomotor chassis testing:

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

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System requirements

Hardware:

1400

- 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

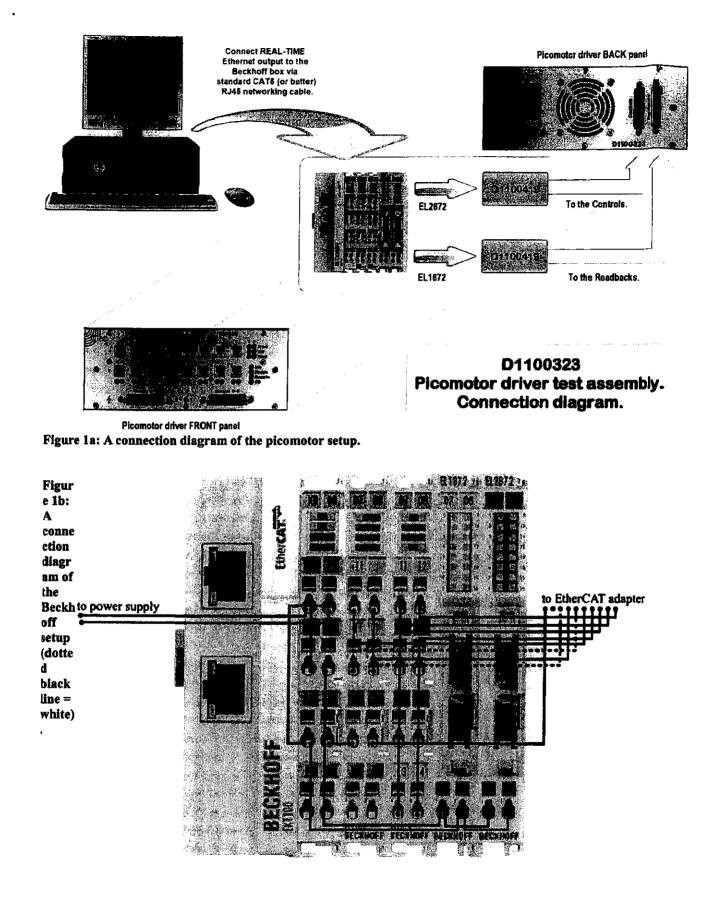
Setting up

JAGO

<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

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Setting up

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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 pieomotor 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.
- $[\int]$ Check that the "ON" indicator on the visualization also responds to the power switch.
- [Ψ Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- $[\mathcal{Y}]$ /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	50	A	on
STARTING UP	off	on	flashes	flashes	off	in	01
READY	off	on	off	off	off		on
Check if passed:	[4]	H	[]				

Table 1: LED response to picomotor status

[]

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

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

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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).

[Y 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	L	ED
	Left	Right
1	[4	
2	[4]	· [4
3	[4]	[]
4	[4]	IJ
5		[]
6		H
7		[1]
8	[]	[]

Select output terminal 1 and do the following:

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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	CWY			
DOWN	off	on *	off	on **			
UP	off	on *	off	off			
>	on *	off	on **	off			
<	on *	off	off	off			
Check if passed:	14	[]	[]	Ľ			

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

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On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck 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)	M	IY			
MEDIUM (100)	[]	M			
MAGNUM (10000)	[4	[4]			

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)	N	[-]			
JOG (50Hz)	[]	[]			
SPRINT (500Hz)	[]	[X]			

4. Testing the temperature readout

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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	21.90			
2	24.03	28.99			
3	30.03	30.12			
4	20.96	31.10			
5	31.75	32.01			
Check if passed:	[4]	[]			

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

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5. Testing the output terminals

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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	[4]	[1]					
2		[1]					
3	[]	H					
4		[1]					
5	[1]	[1]					
6		[]					
7		[1]					
8		[1]					

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

Terminal	Axis					
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[/]	[]				
2		[1				
3		[]				
4		[X				
5	[]	[]				
6	<u>۲</u>]	[X				
7		[]				
8	[/	[]				

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Testing Summary

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

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

Test Engineer: Z.J. G Test Date: 1/73/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

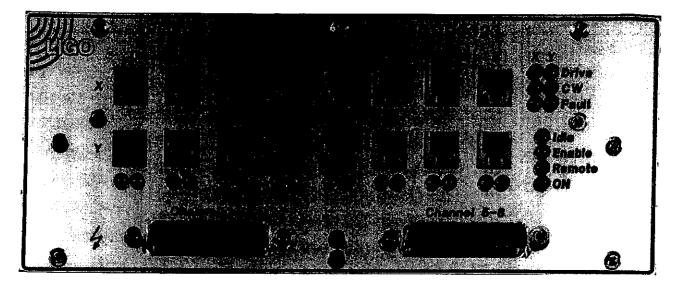


Figure 3: Picomotor driver chassis rear panel

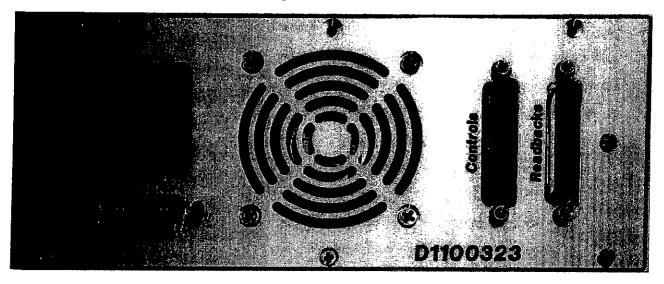
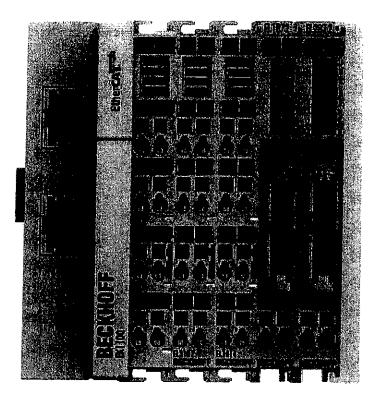


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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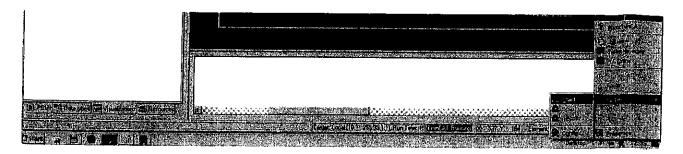


Figure 6: Step 5 of PLC controls setup

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

 Testing Procedure for the
 Picomotor Driver for

 Advanced LIGO
 Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

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

licomotor controller chassis LIGO DCC#

D1100323-v1

D1100419-v3

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

JAGO

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Zach is PASS

5/1 51107540

[]FAIL

Overall picomotor chassis testing:

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:

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- 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:

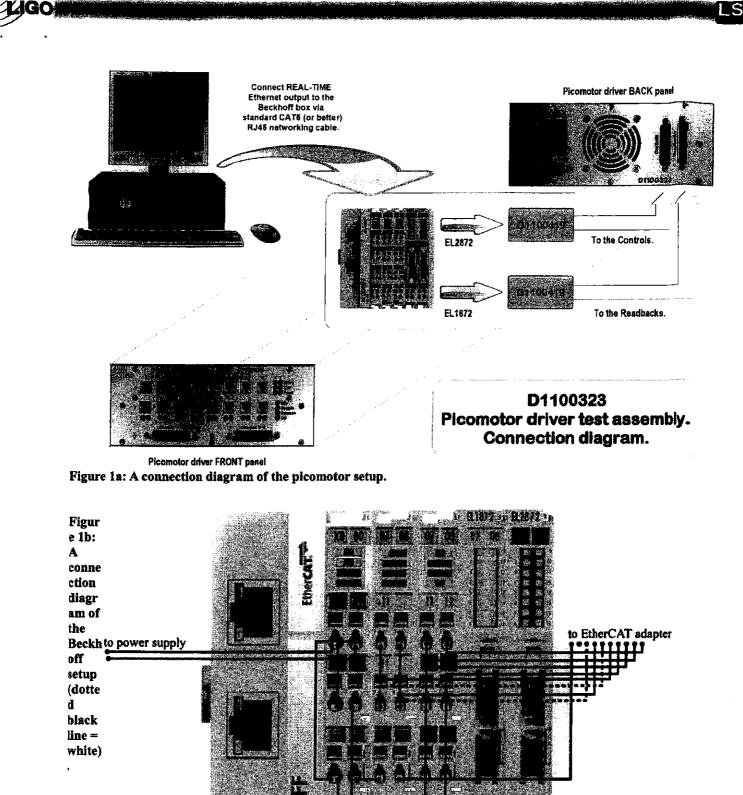
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

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<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



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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	m	088	m	
STARTING UP	off	on	flashes	flashes	æ	on	50	
READY	off	on	off	off	aff	on	on	
Check if passed:	[4	[4	[]		M	[4	·[-]-	

Table 1: LED response to picomotor status

- [Y 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).

[4] 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	I	ED
	Left	Right
1	[4]	[4]
2	[-]	[4]
3		[]
4	[1]	[]
5	[J	
6	[]	
7		
8	H	[]

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)

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and thek 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)	[¥	[لم
MAGNUM (10000)	[4	[]

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)	[]	14
JOG (50Hz)	[4	[9
SPRINT (500Hz)	[]	1

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4. Testing the temperature readout

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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)	Tem	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	30,61	27.32	
2	31.76	28.47	
3	32.13	29.66	
4	33.92	30.72	
5	34.90	31.68	
Check if passed:	[4	W N	

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

5. Testing the output terminals

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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	[1]	[9
2	[4	[4
3	[]	[]
4	[4]	[4]
5	[1]	[4]
6	[1]	[4]
7		[]
8	[4	[]

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

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[]	[]
2		[4
3	[]	[]
4	[4]	
5		[4]
6	[9	
7	[]	[4]
8	[4]	[]

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Testing Summary

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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

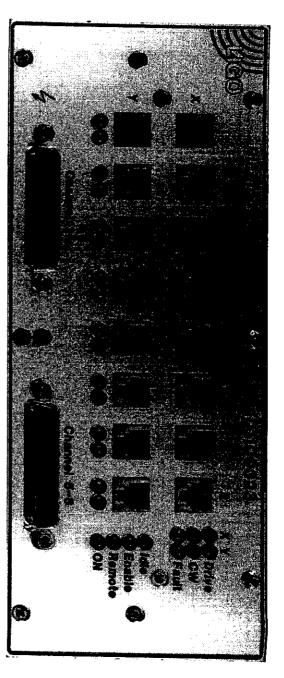


Figure 3: Picomotor driver chassis rear panel

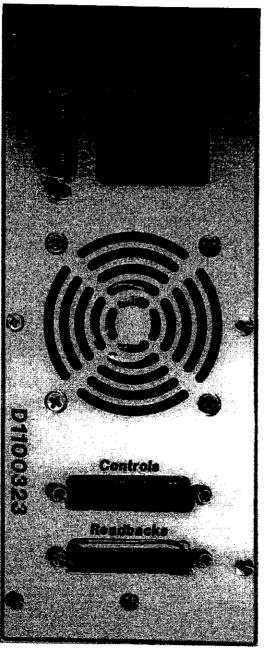
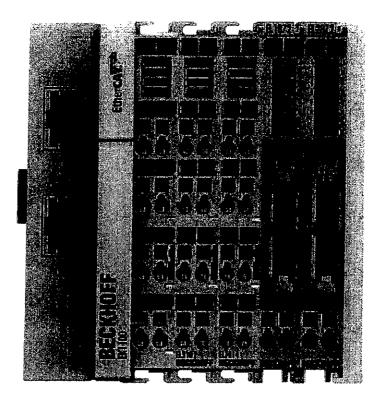


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

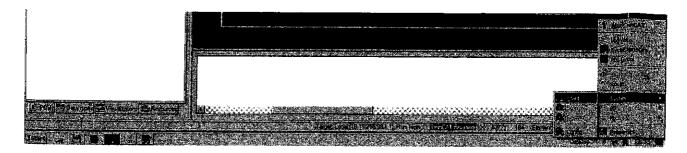


Figure 6: Step 5 of PLC controls setup

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

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ItherCAT Adapters LIGO DCC#	<u>D1100419-v3</u>
Controller Serial #	SIL07541
Test Engineer:	Zach G

|/21/11 [1] PASS [] FAIL

Overall picomotor chassis testing:

Picomotor controller chassis LIGO DCC#

Signature/Initials:

Reference:

Test Date:

J.GO

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

D1100323-v1

System requirements

Hardware:

XJGO

- 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)
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- 10 Ethernet cable (1)
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Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

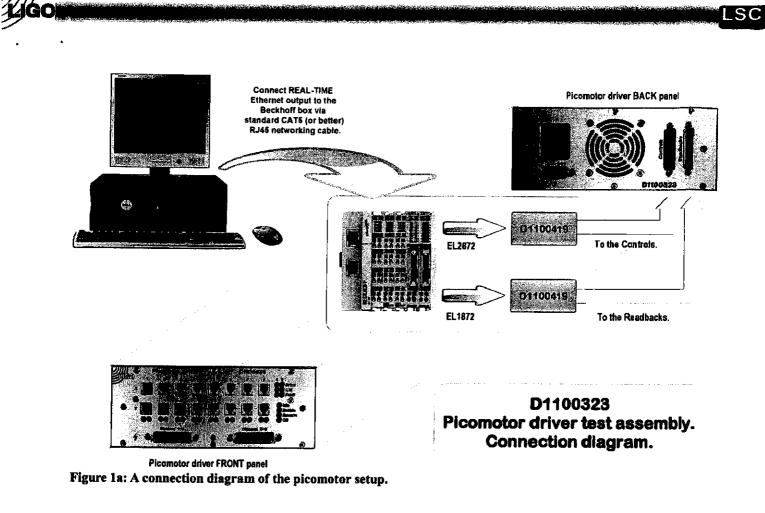
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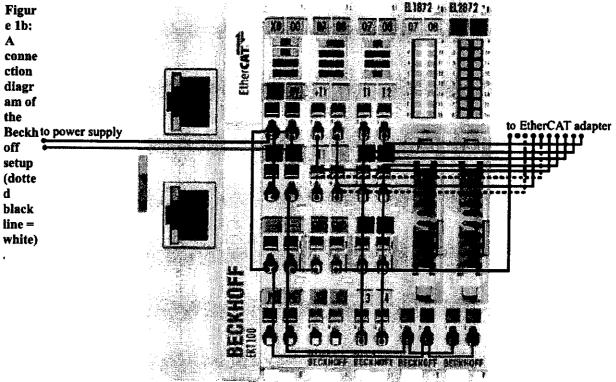
Setting up

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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





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.

[]

4GO

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	C	hassis Front	Panel LEI	Ds	Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	Sn
STARTING UP	off	on	flashes	flashes	688	5	cn
READY	off	on	off	off	off	on	51
Check if passed:	М	[1]	[]	4	-11	[]	[4

Table 1: LED response to picomotor status

[1]

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

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

LS

Inable 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	L	ED
	Left	Right
1	[4]	М
2	[4]	[]
3	[1]	[]
4	[4	[]
5	[4]	[4]
6	M	[4
7	M	[4]
8	[4]	M

Select output terminal 1 and do the following:

4GO

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		LE	Ds	
	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:	[4]	M	М	[1]

Table 2: LED response to picomotor direction

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

LS

2. Testing the step sizes

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On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck 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)	[4]	[4]
MEDIUM (100)	[]	[4]
MAGNUM (10000)	[4]	[9

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)	[1]	iy i		
JOG (50Hz)	[]	[Y		
SPRINT (500Hz)	[]	[}		

LS

4. Testing the temperature readout

14GO

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	25.93		
4	32.79	30.98		
5	33.60	31.83		
Check if passed:	V	[4]		

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

5. Testing the output terminals

4**G**O

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	И	[4				
2	[4]					
3	[4]	[4				
4		[4]				
5	I II	M				
6		[4]				
7		[4]				
8	[Y	Ľ1				

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

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[4]	[1]
2	[1]	
3		[1]
4		[1]
5	[1]	[1
6	[X]	[]
7		[]
8	۲ (۲	[]

Testing Summary

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

Overall picomotor driver testing:	[] Pass	[] Fail
Output terminals	[~] Pass	[]Fail
	I VDara	
Speeds	[^] Pass	[] Fail
Step sizes	[] Pass	[] Fail
Front panel LEDs	[M] Pass	[] Fail

Test Engineer: Zach G Test Date: 1/21/11

Additional Comments:

Appendix A: Physical Components



LIGO

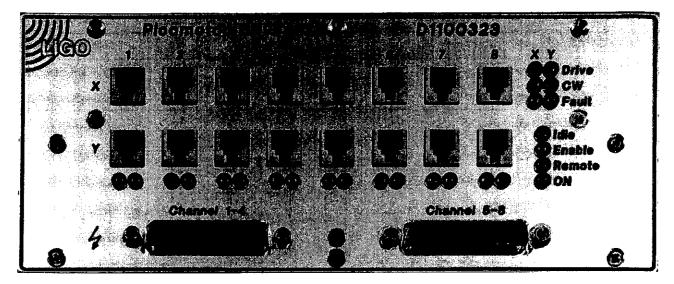


Figure 3: Picomotor driver chassis rear panel

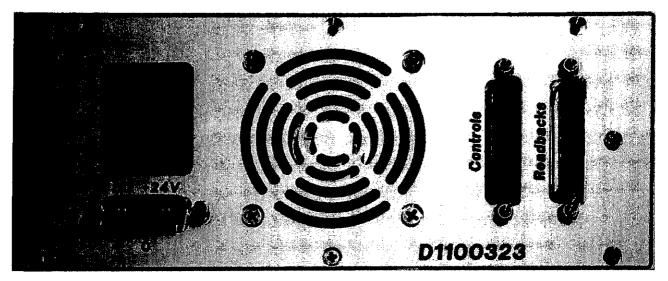
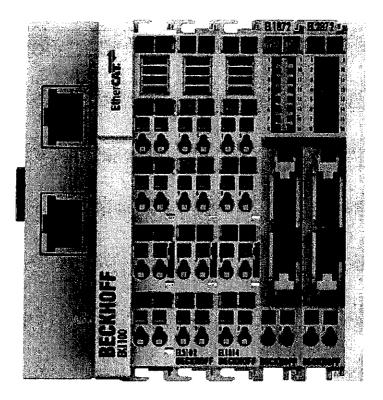


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

J/GO

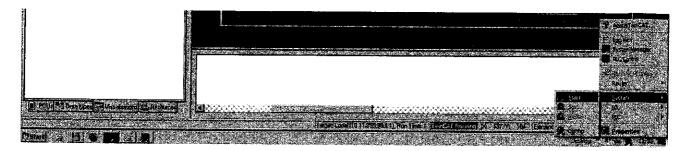


Figure 6: Step 5 of PLC controls setup

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

	Technical Note	LIGO-T1100458-v1	08/26/11	
	Testi	ng Procedure for t	he	
	Pic	comotor Driver for	•	
	Ĩ	Advanced LIGO		
<u> </u>	Maxim Facto	ourovich, Daniel Sigg and Ma	ggie Tse	

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

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licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

I' PASS [] FAIL

Overall picomotor chassis testing:

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:

4GC

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- 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:

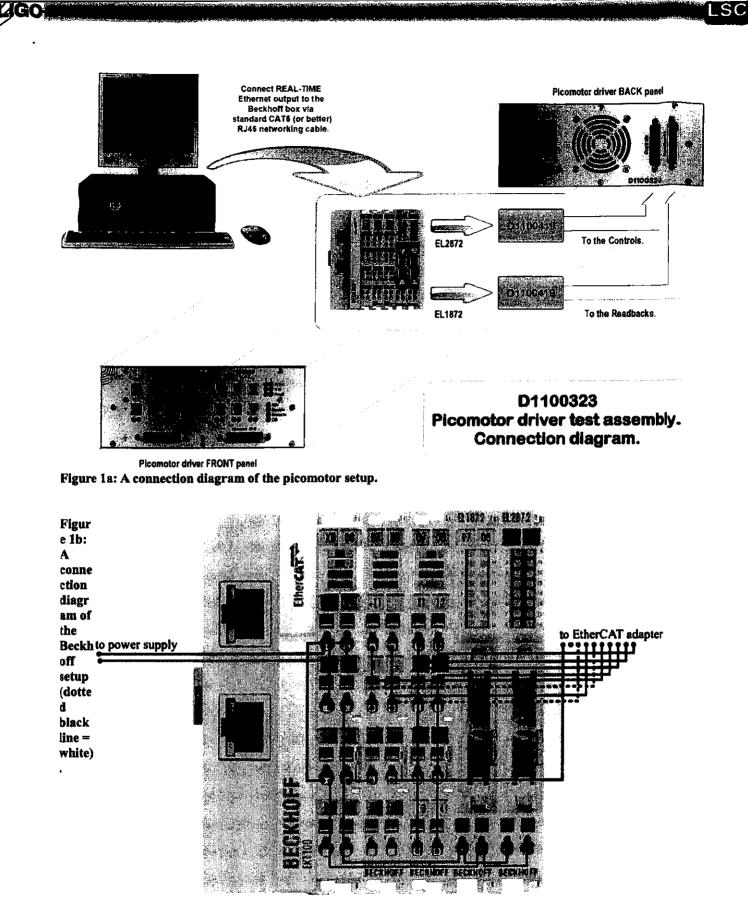
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

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<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



Setting up

i

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.
- [\mathcal{L} 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	C	hassis Fron	t Panel LEI	Ds	Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	m	off	m
STARTING UP	off	on	flashes	flashes	oH	on	54
READY	off	on	off	off	off	on	on
Check if passed:	H	H	[4	[1]	[]	-[]-	[4

Table 1: LED response to picomotor status

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

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Inable 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).

[1] 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	[4]	[]	
2	[4]	[}	
3	[]	[1]	
4	[]		
5			
6	 []	[了]	
7	[]	[1]	
8	[1]	[/	

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:	6	[4	[4]	[7	

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 thek 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)	[4]	[9	
MEDIUM (100)	[4	[]	
MAGNUM (10000)	[]	[4	

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)	[4]	[Y	
JOG (50Hz)	[]	[4]	
SPRINT (500Hz)	[]	[]	

4. Testing the temperature readout

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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	31.00		
3	30.24	52.20		
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

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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	М	L.		
2	[4]	[]		
3		[]		
4	[]	[4]		
5	M	[]		
6		[4]		
7	[Y]	[4]		
8	[1]	[]		

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

Terminal	Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[1]	[1]			
2	[9	[]			
3		[]			
4		[]			
5		[]			
6		[]			
7	[1]	[]			
8		[]			

Testing Summary

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

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

Test Engineer: Zach Co Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Nigure 2: Picomotor driver chassis front panel

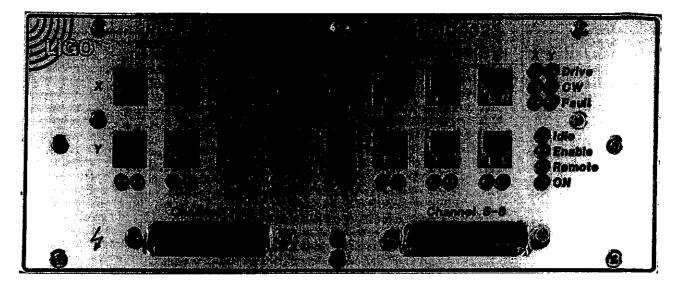


Figure 3: Picomotor driver chassis rear panel

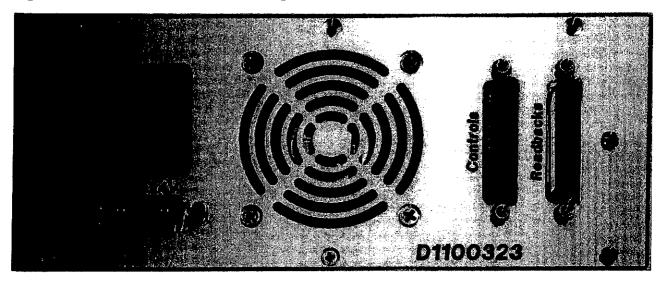
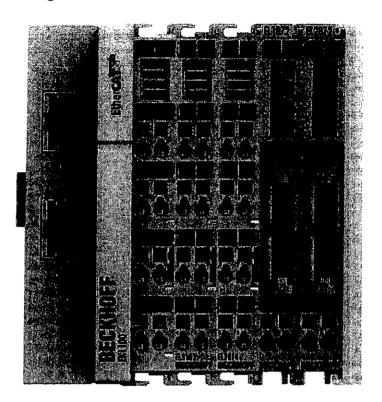


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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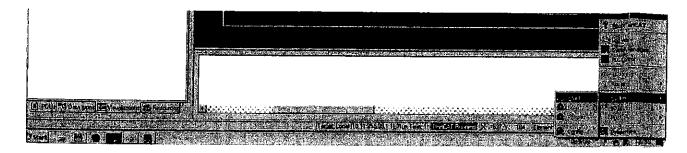


Figure 6: Step 5 of PLC controls setup

- DemtATHE Control - unit-off-ode-pro- and - Control - Unit-off-ode-pro- DIP - Unit-ode-pro- DIP - Unit-	ADDA AND TAR STRATEGY STRATEGY AND A STRA AND A STRATEGY AND A
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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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

 EtherCAT Adapters LIGO DCC#
 D1100419-v3

 Controller Serial #
 Image: Silon 543

 Test Engineer:
 Image: Image: Silon 543

 Test Date:
 Image: Image: Image: Silon 543

 Overall picomotor chassis testing:
 Image: Silon 543

D1100323-v1

Signature/Initials:

Reference:

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

Testing Schedule:

1. Front panel LEDs

Picomotor controller chassis LIGO DCC#

- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

System requirements

Hardware:

LIGO

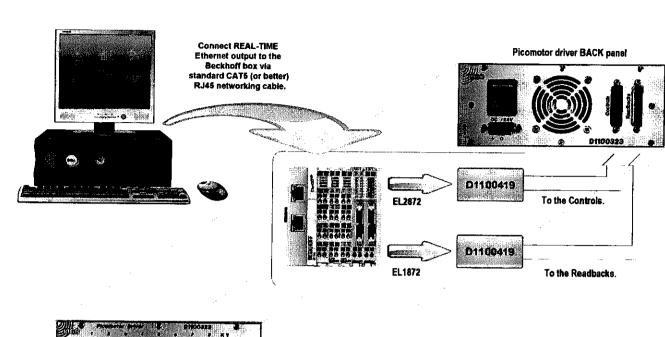
1	Picomotors (2) Compatible models: Newport 8302
2	Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
3	LIGO standard 24V M-F-M DB3 power cable
4	EtherCAT adapter D1100419-v3 (1)
5	DB25 F/M cables (2)
6	Hook-up wires Brown, Green, White, Black, Grey, Purple
7	IDC 20-pin cable assemblies (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

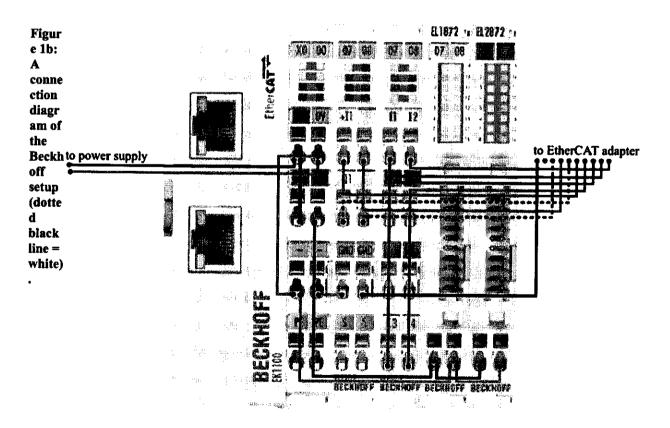




LIGO

D1100323 Picomotor driver test assembly. Connection diagram.

Picomotor driver FRONT panel Figure 1a: A connection diagram of the picomotor setup.



Setting up

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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

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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.



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[V]

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.

LSC

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		[ſ	
2	[<i>1</i>	[X]	
3	[[1]	
4	M	[1]	
5		[]	
6	[]	[1]	
7	[/	[1]	
8	<u>[1</u>	[1	

Select output terminal 1 and do the following:

G

[] 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	CWX	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4		[]	[]

Table 2: LED response to picomotor direction

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

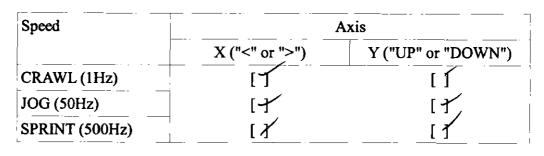
2. Testing the step sizes

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)	[1]	[1]	
MEDIUM (100)	[4	[]	
MAGNUM (10000)	[]	[子	

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):



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	76.42	26.78	
5	27.42	27.81	
Check if passed:	: [J/	[4]	

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		
	X ("<" or ">")	Y ("UP" or "DOWN")
	M	[1]
2	M	[4]
3	[Y	[]
4	[1	
5		
6		[1]
7		[1]
8	[<i>X</i>	[]

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

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

Testing Summary

LIGO

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

Front panel LEDs	[] Pass	[] Fail
Step sizes	[YPass	[] Fail
Speeds	[/ Pass	[] Fail
Output terminals	[] Pass	[] Fail
• • • • ••• ••	10 Mart 11 11 11	
Overall picomotor driver testing:	Pass	[] Fail

Test Engineer: Zach G 11/21/11

Test Date:

Additional Comments:

Appendix A: Physical Components

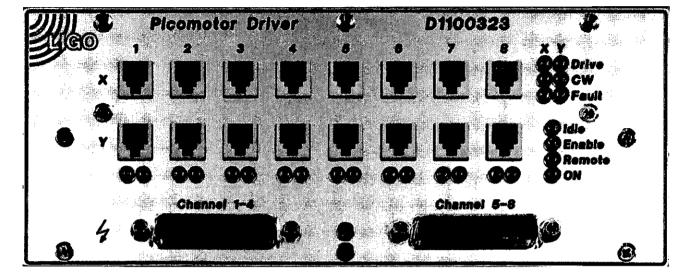


Figure 2: Picomotor driver chassis front panel

LIGO

Figure 3: Picomotor driver chassis rear panel

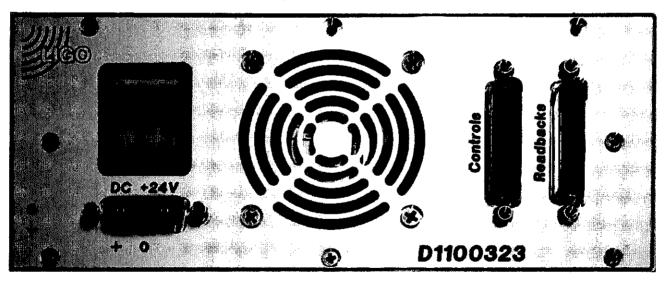
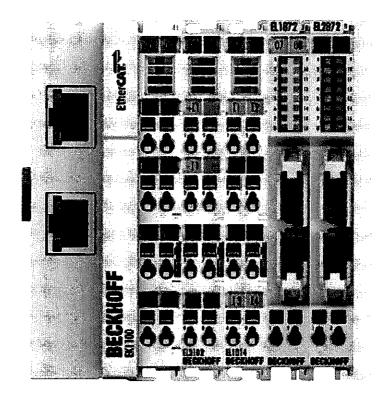




Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

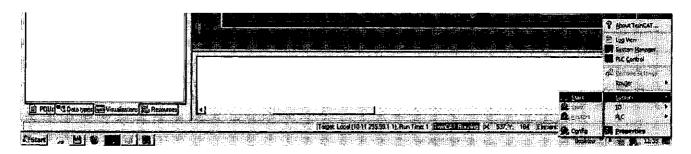


Figure 6: Step 5 of PLC controls setup

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	SMALL (19) WALK (19/2)
	MEDIUM (100)
	LARGE (1000) RUN (100H2) CARDEN UP
	MAGNUM (10000) SPRINT (500H2)
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PUtte Determer Waustzeinen Th. Resources	그의 그는 그 방법 그는 것 같은 것은 그 것 같은 것이 같아. 그 것이 말했다. 것 같은 것 같은 것 같은 가 있는 것 같은 것 같은 것 같은 것 같은 것 같이 있는 것 같은 것 같이 많이 있는 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없는 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없는 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없는 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없 않는 것 같이 없다. 것 같이 없는 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없다. 않은 것 같이 없는 것 같이 없다. 않은 것 같이 않는 것 같이 않는 것 같이 않는 것 않는 것 같이 않는 것 않는 것 같이 않는 것 않는 것 같이 않는 것 않는 것 같이 않는 것 같이 않는 것 같이 않 않는 것 않는 것 않는 않는 것 않는 않는 것 않는 않는 않는 것 않는

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

LSC

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ItherCAT Adapters LIGO DCC#	<u>D1100419-v3</u>
Controller Serial #	203-S1107544
Test Engineer:	Zach G
Test Date:	1/21/11
Overall picomotor chassis testing:	[JPASS []FAIL

Signature/Initials:

Reference:

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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:

LIGO

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:

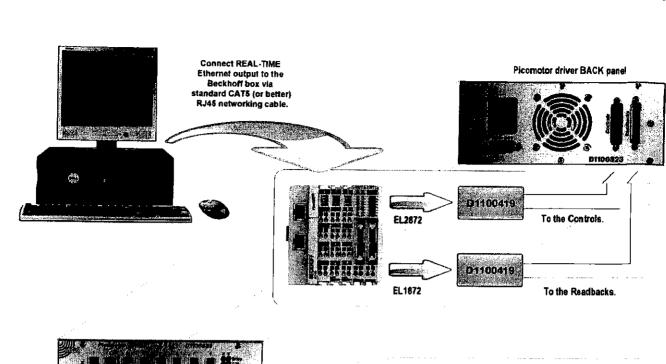
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

14GO

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

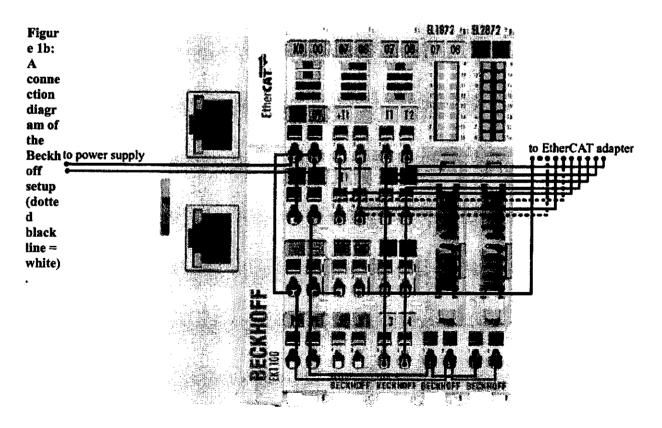
- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 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



D1100323 Picomotor driver test assembly. Connection diagram.

Picomotor driver FRONT panel Figure 1a: A connection diagram of the picomotor setup.

GO



Setting up

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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

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1. Testing the front panel LEDs

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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	m	688	on
STARTING UP	off	on	flashes	flashes	off	SN	0
READY	off	on	off	off	085	51	on
Check if passed:	[1]	M	[4]	[1]	Ŵ	U	[1]

Table 1: LED response to picomotor status

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

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

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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		ED
	Left	Right
1	[4]	[4]
2	[-}	[]
3		[]
4	[1]	[]
5	[]	[1
6	[1]	[1]
7	[1]	[1]
8	[1]	[]

Select output terminal 1 and do the following:

M

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			
Ì	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:	[]	[]	4	M

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)	[4]	[]	
MEDIUM (100)	[]	[]	
MAGNUM (10000)	[4	[]	

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)	[1]	[4	
SPRINT (500Hz)	[]	[]	

4. Testing the temperature readout

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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	28.55	28.77		
2	29.65	29.90		
3	30.60	31.02		
4	31.60	32.a		
5	32.41	32.99		
Check if passed:	LY	L/		

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

5. Testing the output terminals

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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	[4]	[1]		
2	[1]	[]		
3	[1]	[4]		
4	[]			
5	[Y			
6		[]		
7	[]			
8		[1		

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

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

Testing Summary

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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



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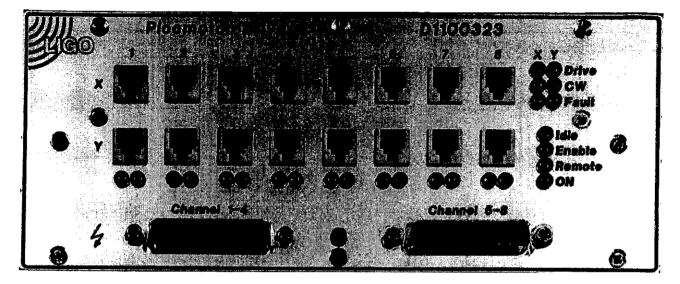
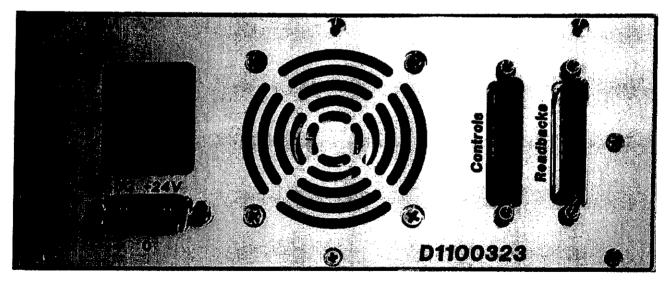


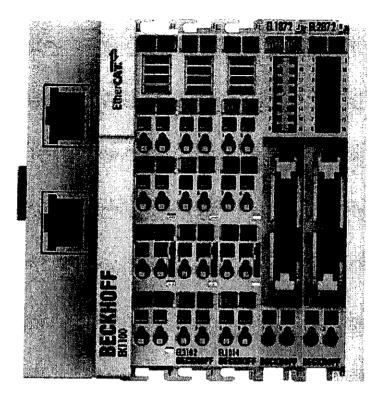
Figure 3: Picomotor driver chassis rear panel



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Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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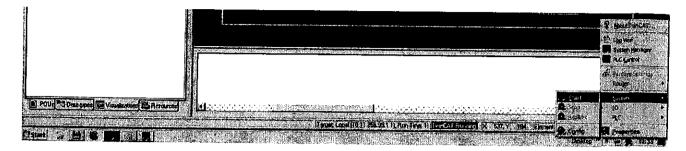


Figure 6: Step 5 of PLC controls setup

Constant of the Control Control Control open The Charles Same Control Control open Charles Control Control open Control Control Contr	
	USER DRIVER DESARU D. ENABLE Lest Reservations
	1 2 3 4 5 8 7 8 STEP SEE SEE <td< th=""></td<>
	MEDIUM (100) JOG (60H2) UP LARGE (1000) RUN (100H2) UP MAGNUM (10000) SPRINT (500H2) DOWN
PDUJ 3 Datagon 2 Voustation 3 Respective	

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

Technical Note LIGO-T1100458-v1

08/26/11

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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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Test Engineer:

Controller Serial #

Test Date:

1JGO

2.2.6 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:

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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:

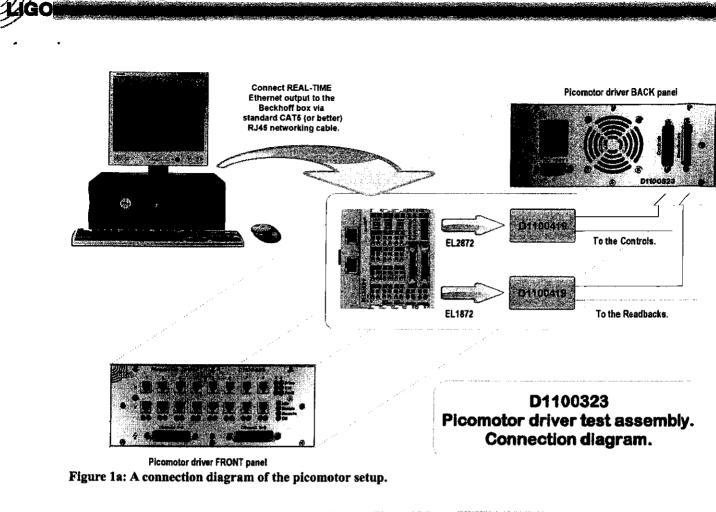
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

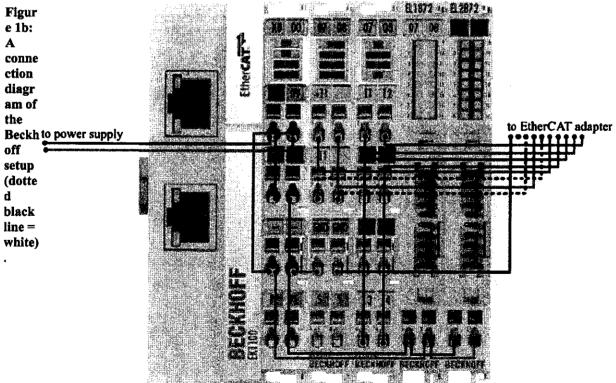
Setting up

14GO

<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





Setting up

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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:

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- 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.
- [1] 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.
- [\mathcal{Y} 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	07
STARTING UP	off	on	flashes	flashes	058		m.
READY	off	on	off	off	off	Ch	on
Check if passed:	[1]	[]	[]	[]	- [-]	-11-	

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	L	ED
	Left	Right
1	[]	[]
2	[]	[]
3		H
4		$[\lambda]$
5		[]
6	[]	[X]
7	[1]	[1]
8		[]

Select output terminal 1 and do the following:

 $[\mathbf{V}]$

[] 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	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[4	[4]	[]

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 theck 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)	[1]	[]	
MEDIUM (100)	[4	[4	
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)	[4]	[]	
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	26.60	2590	
2	29.68	26.96	
3	30.75	27.99	
4	31.68	28.97	
5	32.59	29.89	
Check if passed:	[4	4	

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	[4]	M		
2	[/	[4]		
3	[1			
4		[1]		
5	[J	[1]		
6	[J	[1]		
7	[Y	[1		
8	[4	[1		

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

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

Testing Summary

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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: 2-ch G Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components

Ngure 2: Picomotor driver chassis front panel

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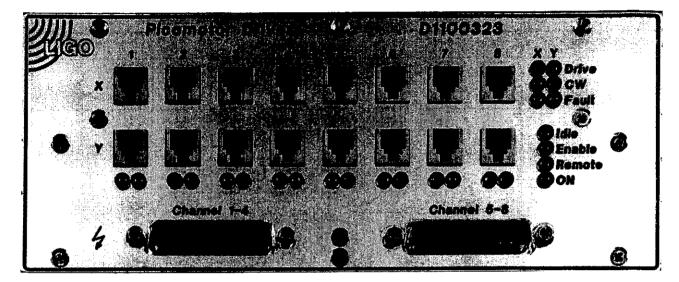


Figure 3: Picomotor driver chassis rear panel

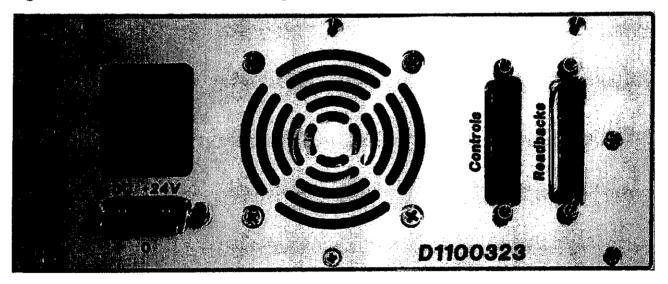
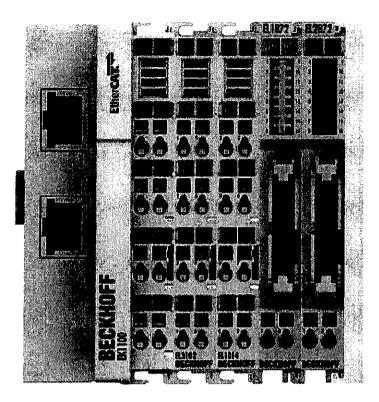


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup





EVINAL FIC Control - parts storic pro-	
C Visuefizations	
	RAW DUDLAVIS
	2 73 6 8 7 8
	STEP SLE SPEED WERTSHALL(I) CRAW (UR2)
	SMALL (10) WALK (10Hz) MEDILIM (100) JOG (50Hz) LARGE (1000) RUN (100Hz)
	MAGNUM (10000) SPRINT (600H2)
D POLI T Das und Prunktenen Baransen	

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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu

4**C**i0

Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St.,Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: <u>geco.cu@gmail.com</u>

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

LIGO

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

D1100419-v3

Test Date:

Zach C 11/21/11 [] FAIL

Overall picomotor chassis testing:

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

2 of 15

System requirements

Hardware:

GO

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

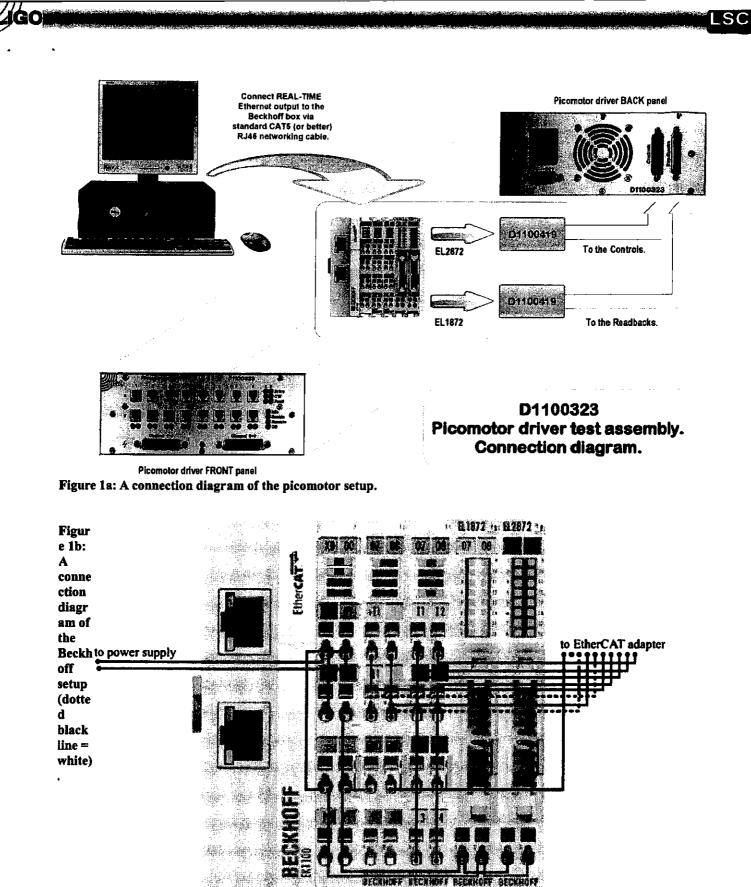
Setting up

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<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



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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

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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.
- [4] 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	000	08	5
STARTING UP	off	on	flashes	flashes	off	on .	on
READY	off	on	off	off	1 ST	on	m
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.

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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	L	ED
	Left	Right
1	M	M
2	[4]	_ [Y]
3	M	[4
4		
5		[]
6	Ξ Η	[]
7	Ł1	[1]
8		[]

Select output terminal 1 and do the following:

[J

[] 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:	[4]	[1	[]	[]		

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

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On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and thek 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)	H'_			
MEDIUM (100)	[]	J,		
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)	[1]	[4]		
JOG (50Hz)	[4]	[]		
SPRINT (500Hz)	[]	[4]		

4. Testing the temperature readout

LIGO

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)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.01	27.98
2	27,14	24,12
3	28.85	30,15
4	24.85	31.13
5	30.66	31 90
Check if passed:	[4	[4

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

5. Testing the output terminals

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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	[4	[4]		
2	[1]	LT _		
3	[1]			
4	[4]	IJZ,		
5		[4]		
6	[4	[J		
7		[4]		
8	[1]	[4		

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

Terminal	inal Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	EY,	L/	
2		[\	
3	[4]	[1]	
4		[Y	
5	[\	[]	
6	[4]	U/	
7		M _	
8	[4	[4	

Testing Summary

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

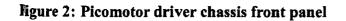
Front panel LEDs	[A] Pass	[] Fail
Step sizes	Pass	[] Fail
Speeds	[JPass	[] Fail
Output terminals	[] Pass	[] Fail
Overall picomotor driver testing:	[] Pass	[] Fail

Test Engineer:

Test Date:

Additional Comments:

Appendix A: Physical Components



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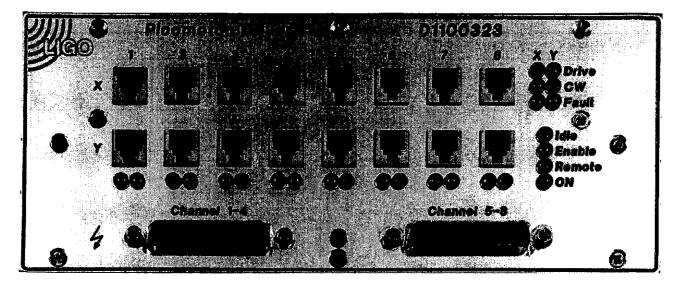


Figure 3: Picomotor driver chassis rear panel

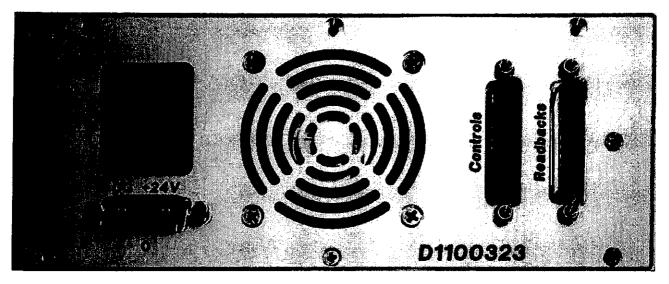
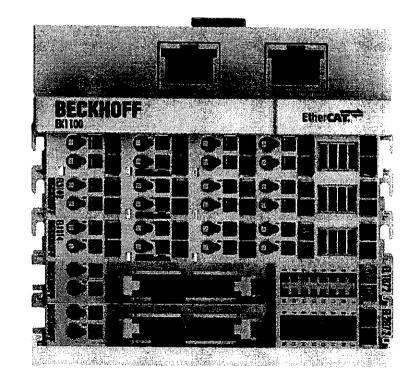


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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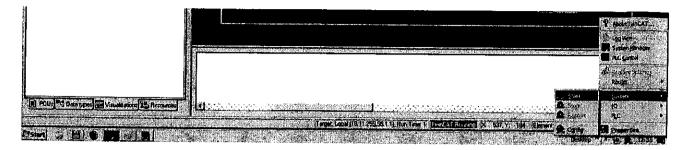


Figure 6: Step 5 of PLC controls setup

- PantATTE Centrol - protestable pro FC / C / Elgers : To by Tolenty Junder (1997)	
	57 A 34
	CHIVER DISABLED
	1 2 3 4 6 8 7 8
	STEP SEE SPEED VERY SMALL (1) CRAWL (1Hz)
	SMALL(10) WALK((10H2)
	MEDIUM (100) JOG (6012)
	LARGE (1000) RUN (100H2).
	MAGNUM (10000) SPRINT (E0012) C
Pous To Destroy Provention & Reserves	

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

Technical Note LIGO-T1100458-v1

08/26/11

LSC

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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St.,Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

Picomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

D1100419-v3

Test Date:

4**GO**

2007547 Zach G 1/21/11 [] PASS

[] FAIL

Overall picomotor chassis testing:

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:

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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:

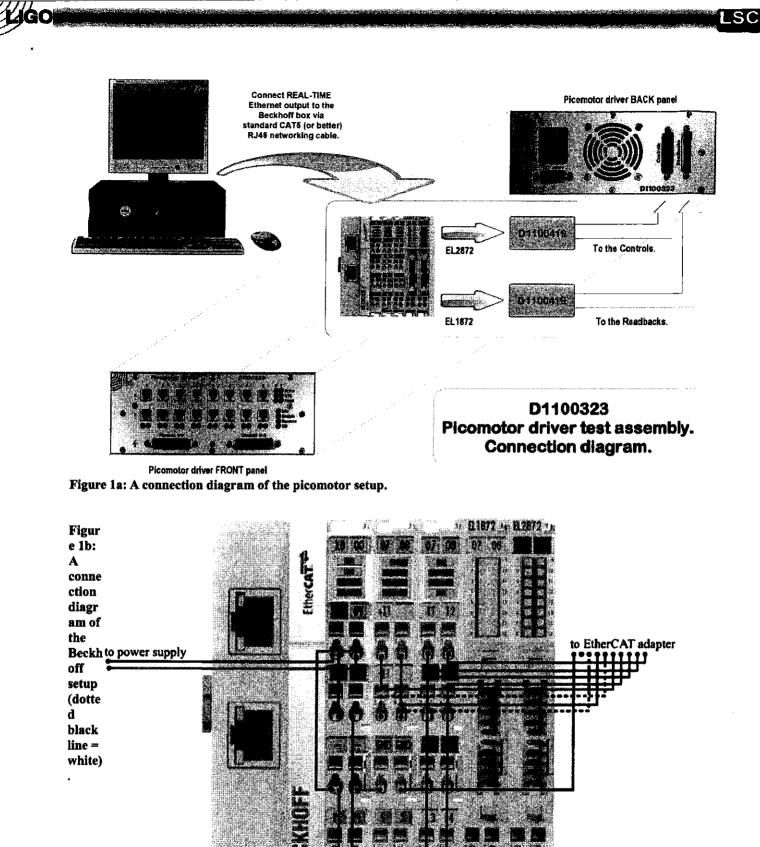
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

4**G**

<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



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Setting up

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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.
- [1] 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	Sn	on
READY	off	on	off	off	088	on	on
Check if passed:		[1	[]	H	H	1	[]

Table 1: LED response to picomotor status

[1]

Check that the "DUAL AXIS" indicator on the visualization lights up when the procomotor is enabled.

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

Inable 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	LE	ED
	Left	Right
1	[1]	[1]
2		
3	[4]	[1]
4	[J	[1]
5	[]	[1]
6	[1]	[1]
7	[1]	[/]
8	[]	[1]

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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	IY	[Y	[4]	[+		

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

4**G**

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)	[1]	[]	
MEDIUM (100)	[1]	[1]	
MAGNUM (10000)	[4	[4	

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)	[1]	N,		
JOG (50Hz)	[1]	[4]		
SPRINT (500Hz)	[J	[4		

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4. Testing the temperature readout

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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	2850		
3	29.58	29.53		
4	30.57	30.65		
5	31.42	31.51		
Check if passed:	[7]	[1]		

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

5. Testing the output terminals

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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		IJ
3	[4]	[4]
4	[4]	[]/
5	[1]	
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	[4	[]
2		[]
3	[]	
4	[]	[]
5	[]	[]
6	[]	[]
7		[]
8		[]

Testing Summary

LIGO

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

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

Test Engineer: Zach C Test Date: 11/21/11

Additional Comments:

Appendix A: Physical Components



LIGO

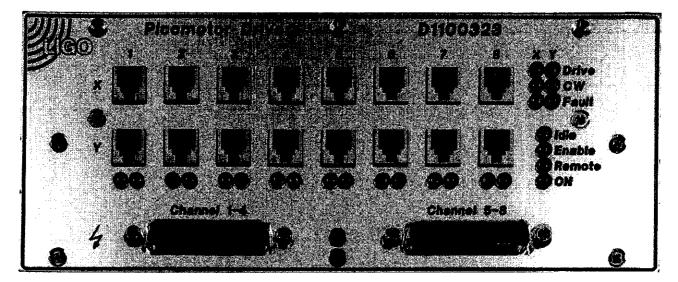


Figure 3: Picomotor driver chassis rear panel

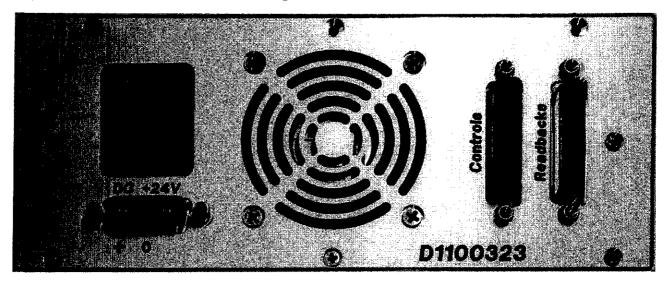
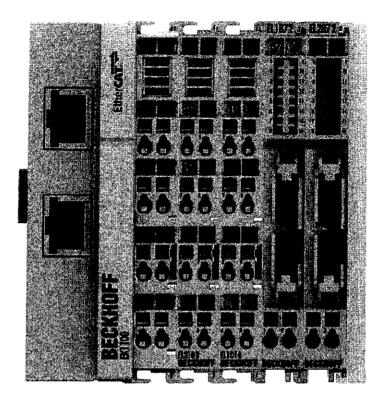


Figure 4: EtherCAT configuration

JGO



14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

LIGO

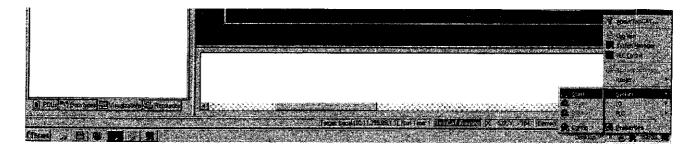


Figure 6: Step 5 of PLC controls setup

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

 Technical Note	LIGO-T1100458-v1	08/26/11	
	ng Procedure for t comotor Driver for		
	Advanced LIGO		
 Maxim Facto	urovich, Daniel Sigg and Ma	aggie Tse	

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St.,Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

sc

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

JAGO

D1100419-v3

SII07548 Zach G 1/22/11

M PASS [] FAIL

Overall picomotor chassis testing:

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:

2**G**0

- 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)
- 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

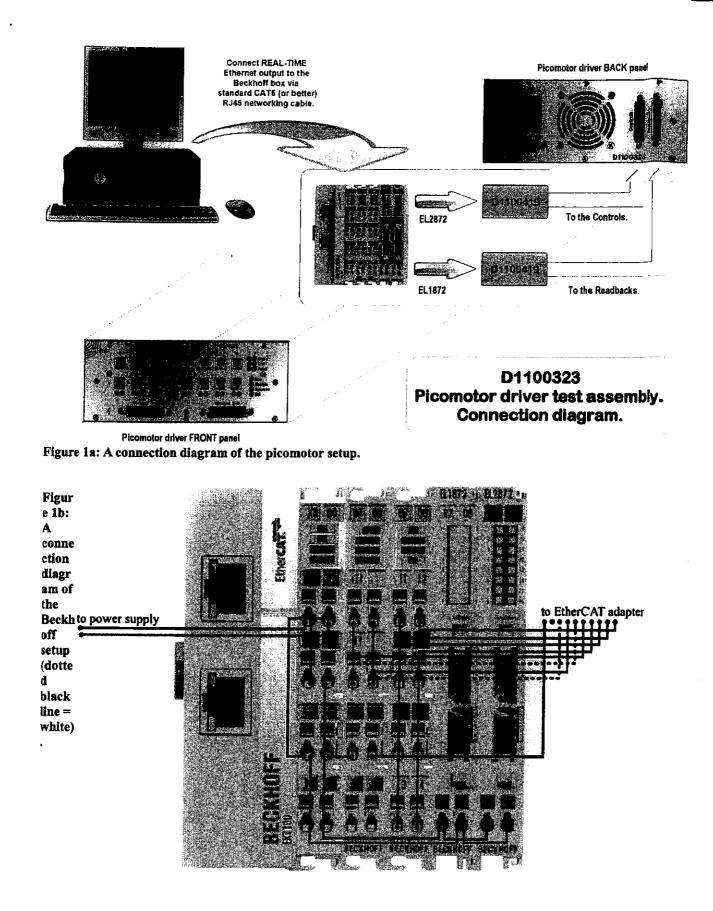
Setting up

JJGO

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

LSC



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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.
- [Y Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
 - \checkmark 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	~8F	on
STARTING UP	off	on	flashes	flashes	6SF-	S	on
READY	off	on	off	off	off	on	on
Check if passed:	[7]	[4]	[]	M	[4	[1]	H

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.

LSC

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

[U] 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	LI	ED
	Left	Right
1	[Y]	M
2	[4]	[1]
3	[1]	[]
4		[]
5		[4]
6		
7	N [[]
8	[-]	[√]

Select output terminal 1 and do the following:

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[] 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:	[4]	ΓΨ	[]	

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 theck 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	[]	
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	36.07	29.93	
2	31.01	20.93	
3	31.89	31.82	
4	32.71	32.10	
5	33.51	33.50/	
Check if passed:	[4]	[4	

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	[1]	Γ _L
2	[4]	ET .
3	IY,	
4	[4]	[J
5	[4	[]
6		[4]
7	[Y	[1]
8	E E E	[]

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

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

Testing Summary

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

Front panel LEDs	[YPass	[] Fail
Step sizes	[]Pass	[] Fail
Speeds	[9 Pass	[] Fail
Output terminals	[]Pass	[] Fail
·····	f	
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

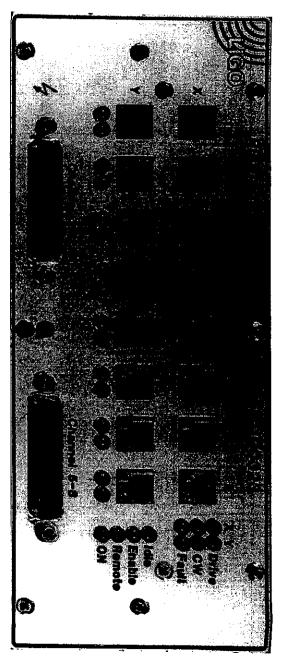


Figure 3: Picomotor driver chassis rear panel

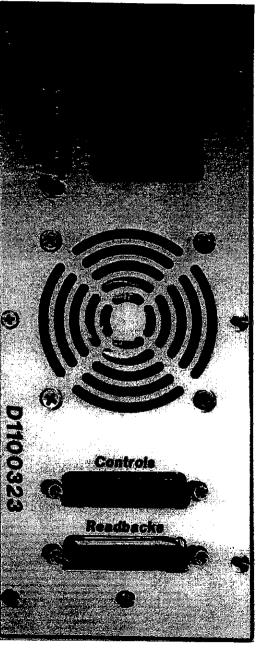
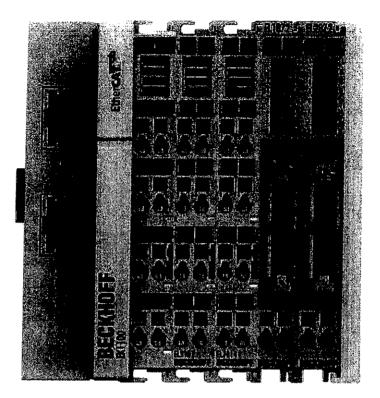


Figure 4: EtherCAT configuration

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14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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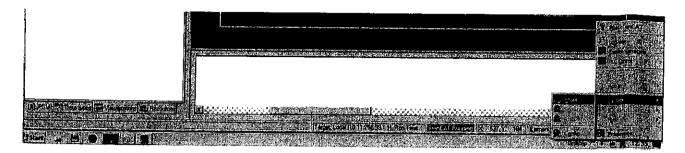


Figure 6: Step 5 of PLC controls setup

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

Technical Note	LIGO-T1100458-v1	08/26/11	<u> </u>
Testi	ng Procedure for t	he	=
Pic	comotor Driver for	•	
Ē	Advanced LIGO		
Maxim Facto	urovich, Daniel Sigg and Ma	ggie Tse	

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

Test Engineer:

Test Date:

<u>S 1107549</u> Zach G 11/22/11

[] FAIL

[4PASS

Overall picomotor chassis testing:

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:

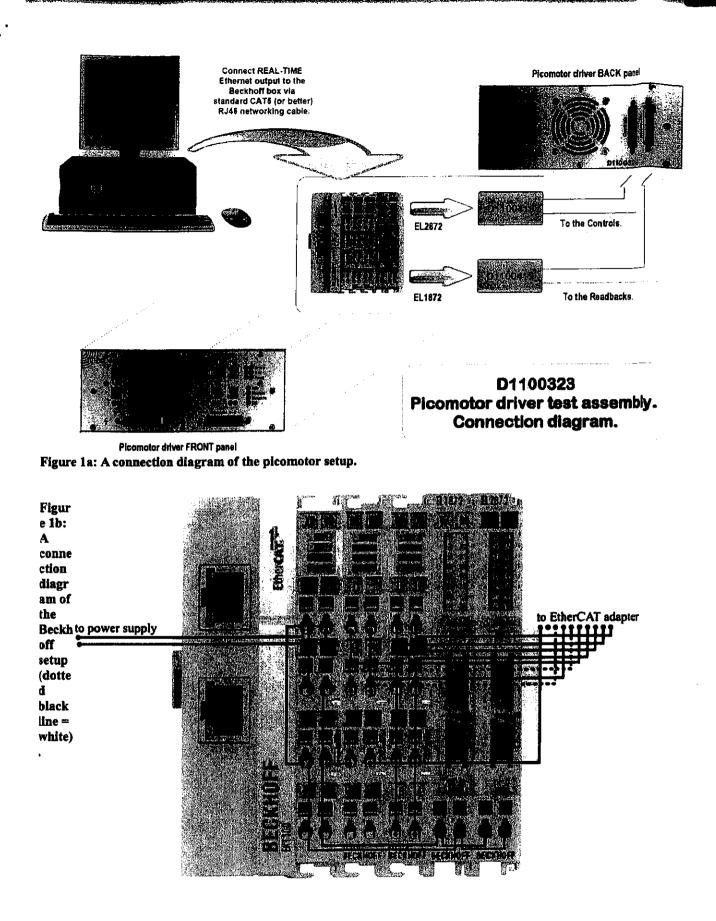
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

L 0

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



1

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.
- $[\checkmark]$ 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	C	Chassis Front Panel LEDs			Software Readbacks		backs
· · · · · · · · · · · · · · · · · · ·	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	M	180	on
STARTING UP	off	on	flashes	flashes	8	5	m
READY	off	on	off	off	off	m	Sn
Check if passed:	[1	[4	[}	[]	[]	[4	[]

Table 1: LED response to picomotor status

[]

[1]

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.

SC

Inable 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	L	ED
	Left	Right
1	[4]	[4]
2		
3	[1]	[4
4	[4]	[4]
5	[J	[]
6		Ы
7		[]
8	[4	[]

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:	[4]	14	[4	M	

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 there is the 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):

(00001) MUNDAM	<u>/</u>]	<u> </u>
MEDIUM (100)	ليلر [[بلر
VERY SMALL (1)	[المر	
	X ("<" or ">") X	Y ("UP" of "DOWN")
Step Size	· · · · · · · · · · · · · · · · · · ·	sixA

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):

(2H005) TNLAAS	<u>_</u> {]	
10G (20Hz)	[المر	[يلر
CKAWL (1Hz)	[h]	[مر
	$X (^{n < n} $ or $^{n > n})$	Y ("UP" or "DOWN")
Speed	,	sixA

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4. Testing the temperature readout

/**14GO**

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	28.70		
2	27.98	29,65		
3	29.12	30-87		
4	30.05	31.83		
5	30-99	32.77		
Check if passed:	M	[4]		

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	И	[]		
2	[4	[]		
3	[]	[J		
4		[]		
5		[]		
6	[4	[]		
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	[4	[]	
2		[-]	
3		[]	
4	H	[]	
5		[]	
6		[]	
7	[]		
8			

Testing Summary

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

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

Test Engineer: Zach Test Date: 1/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

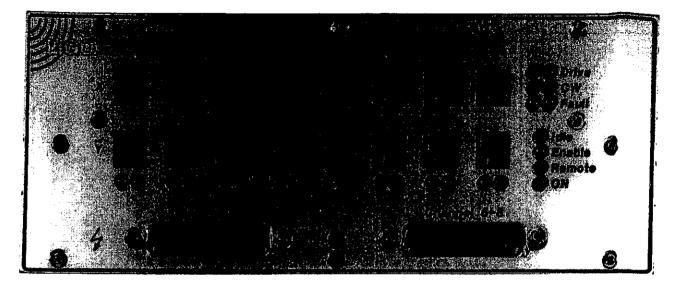


Figure 3: Picomotor driver chassis rear panel

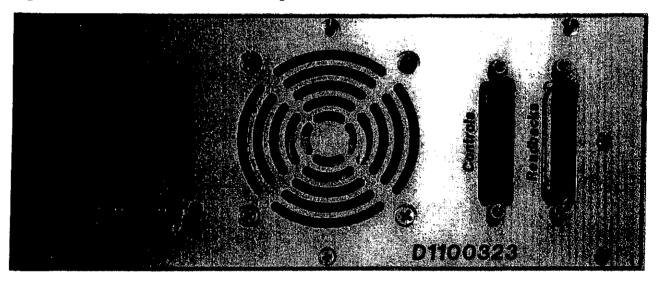
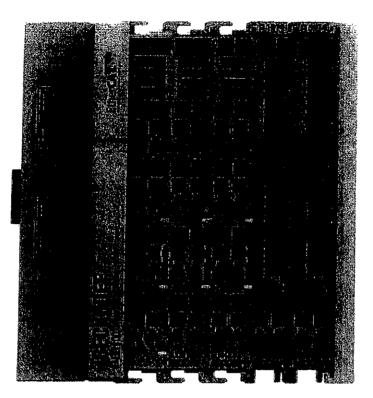


Figure 4: EtherCAT configuration



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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

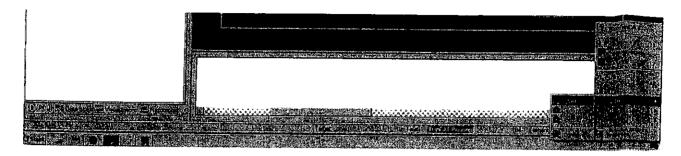


Figure 6: Step 5 of PLC controls setup

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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

LSC

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

[4]PASS

[] FAIL

S1107350 Zach G 11/22/11

Overall picomotor chassis testing:

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

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

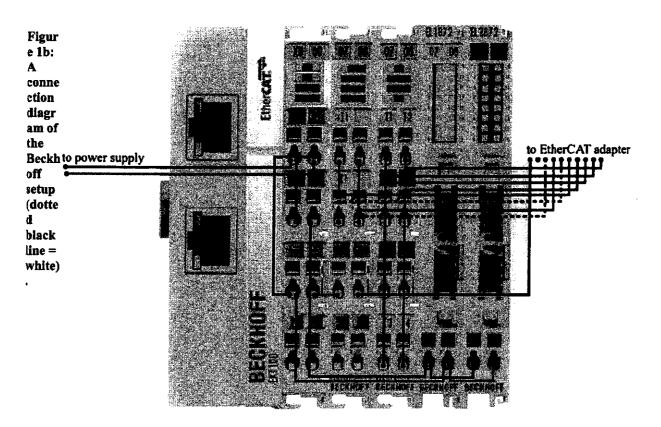
- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 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

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sindard CATB (or bestrip)

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Picomotor driver FRONT panel Figure 1a: A connection diagram of the picomotor setup.

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Setting up

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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

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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	380	on
STARTING UP	off	on	flashes	flashes	off	cn	or'
READY	off	on	off	off	off	m	on
Check if passed:	[1]	LY	[4]	H	H	14	14

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.

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Inable 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	H	H		
2	[}			
3				
4	[1]	(T)		
5	H	[]		
6	[<i>X</i>]	[[Y		
7	۲] [۲	Í IY		
8	[1]	[1		

Select output terminal 1 and do the following:

2 (C

[4] 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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:		[]	[1]	F-7-	

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 theck 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)		14
MEDIUM (100)	[4]	IV I
MAGNUM (10000)	[4]	

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)	М	14
JOG (50Hz)	[}	11
SPRINT (500Hz)	[]	

4. Testing the temperature readout

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1

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	29.35	32.41	
5	30.23	33.45	
Check if passed:	H/	14	

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

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5. Testing the output terminals

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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	[4-	[']		
2	[4	[4]		
3	[4	[]		
4	[¥			
5	[]	H		
6	[]	[]		
7	<u>Г</u>	[]		
8	[9	[1		

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	[/	[7		
5		[]		
6	[1	[7		
7		[/]		
8	[]	15		

Testing Summary

1440

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

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

Test Engineer: Zach G Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

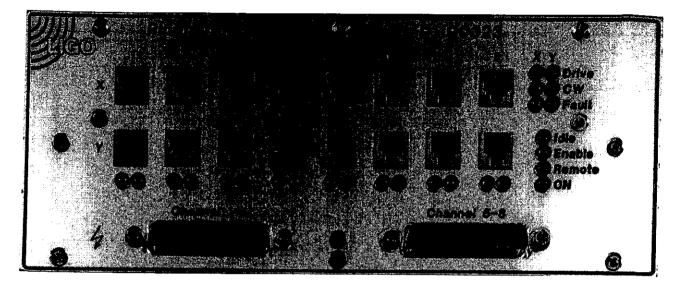


Figure 3: Picomotor driver chassis rear panel

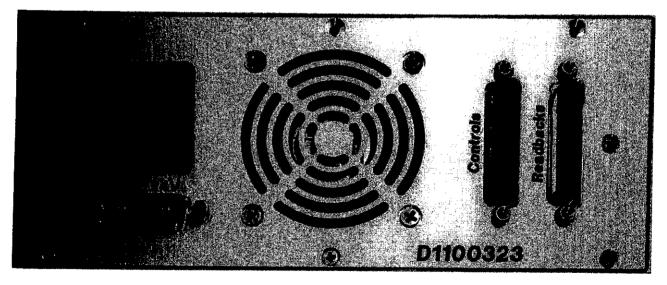
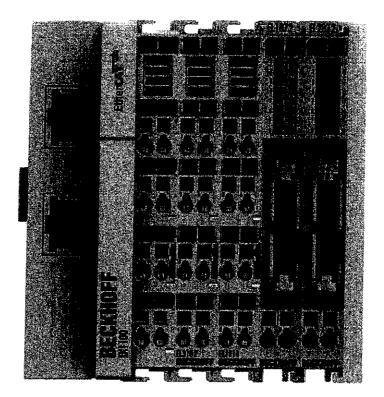


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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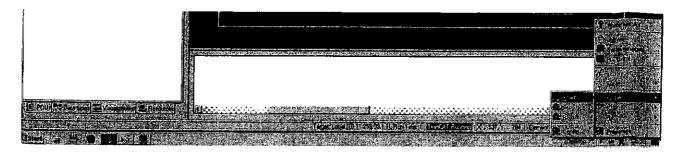


Figure 6: Step 5 of PLC controls setup

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

Technical Note	LIGO-T1100458-v1	08/26/11
Testi	ng Procedure for t	the
Pic	comotor Driver for	•
	Advanced LIGO	
Maxim Facto	urovich, Daniel Sigg and Ma	nggie Tse

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

31107551 Zach G 11/22/11

[] FAIL

PASS

Overall picomotor chassis testing:

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:

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- 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)

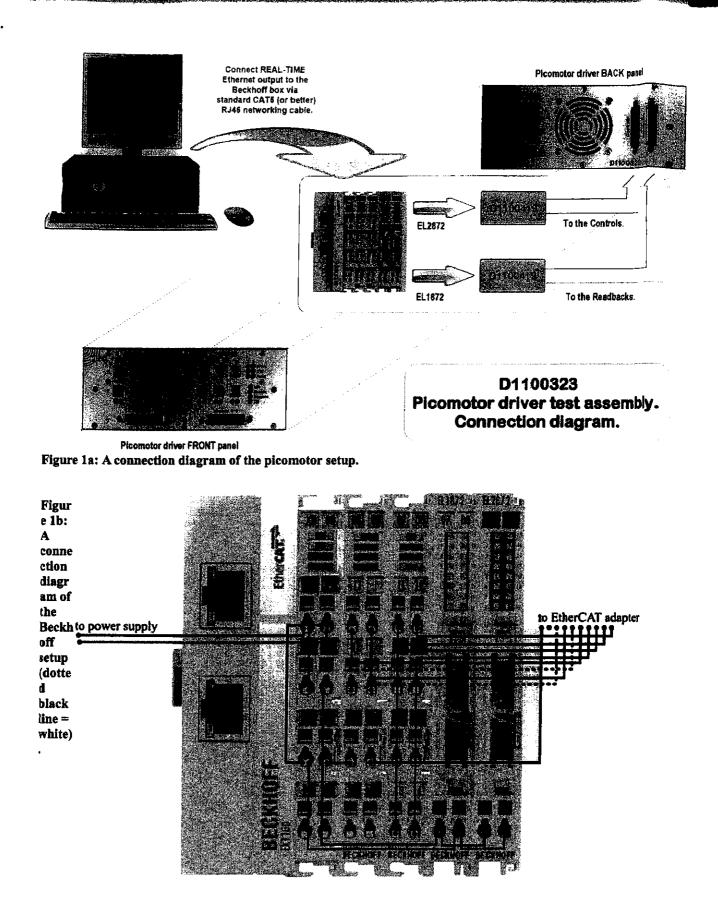
Software:

- 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



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.
- [Y 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.
- [Y 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	S	off	m
STARTING UP	off	on	flashes	flashes	off	on	m
READY	off	on	off	off	off	on	m
Check if passed:	[]	[]	[]	[]	19		

Table 1: LED response to picomotor status

N

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.

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

 $[\downarrow]$ 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	L	ED
	Left	Right
1	[4]	М
2	[4]	[4
3	[4	[4
4		[4]
5	[]	[]
6	[]	[]
7		[Y]
8	K	[]

Select output terminal 1 and do the following:

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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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	/ off	off	off		
Check if passed:	ſĬ	$\Gamma $	1	1		

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 there it runs) as you increase the step size for each axis (X and Y): when it runs) as you increase the step size for each axis (X and Y):

sixA	sziz qətz	
X ("UP" or "DOWN")	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
<u>t</u>]	[بلر	VERY SMALL (1)
	[مر	MEDIUM (100)
[بل_	<u>[]</u>	(00001) MUNDAM

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". Selecta 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):

<u></u>		SPRINT (500Hz)
	[بلر	10G (20Hz)
[بلر	[بار	CRAWL (1Hz)
	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
sixA		Speed

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	29.18		
5	29.65	31.62		
Check if passed:	[4	1/1		

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	[4]	[7]			
2	[4	[]			
3	[]	[-]			
4	[.]	[]			
5		$[\mathcal{X}]$			
6	[1]	[]			
7		[1]			
8	[]	[]			

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

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

Testing Summary

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

Front panel LEDs	[YPass	[] Fail	
Step sizes	[]Pass	[] Fail	
Speeds	[JPass	[] Fail	
Output terminals	[-]Pass	[] Fail	
Overall picomotor driver testing:	['] Pass	[] Fail	

Test Engineer: Zach G Test Date: 11/22/11

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Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

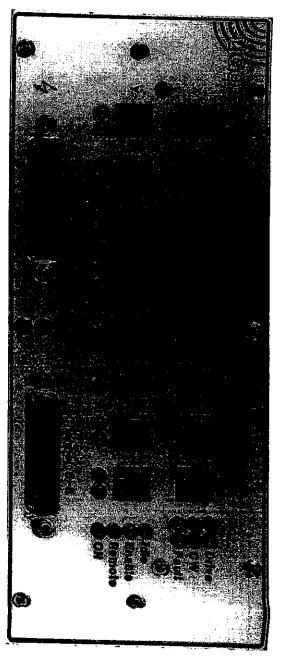


Figure 3: Picomotor driver chassis rear panel

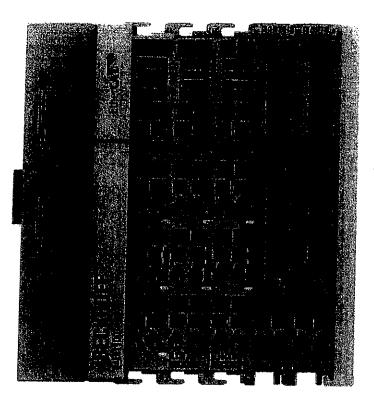
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Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

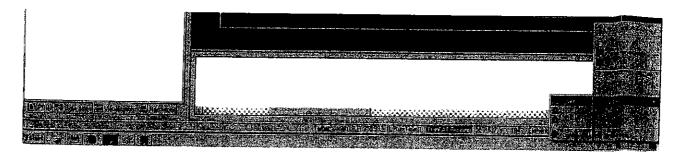


Figure 6: Step 5 of PLC controls setup

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

Technical Note LIGO-T1100458-v1
Testing Procedure for the

08/26/11

esting Procedure for th Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

Picomotor controller chassis LIGO DCC#

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

2

D1100419-v3

[PASS

D1100323-v1

S1107552 Zach C 1/22/4

[] FAIL

Overall picomotor chassis testing:

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)

<u>Software:</u>

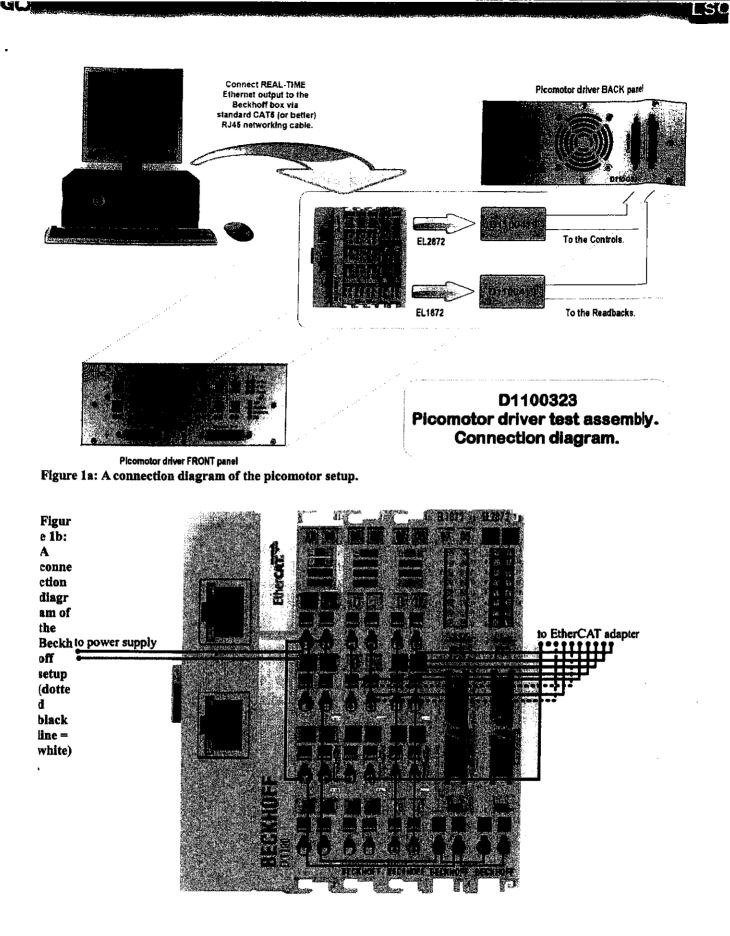
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

LSC

<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

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5 of 15

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.
- [Ch

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	æ	En
STARTING UP	off	on	flashes	flashes	off	6n	one
READY	off	on	off	off	of	en	on
Check if passed:	М	[1]	[4	[1]	[]	H	- [-]

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.

Inable 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).

[V] 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	L	LED	
	Left	Right	
1	М	[4]	
2	[1]	[4	
3	[4	[]	
4	- I-	[4]	
5	[4]	[]	
6		[1]	
7		[4]	
8	[]	[1]	

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	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	M	[4]		M

Table 2: LED response to picomotor direction

* (while motor is running)

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

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2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and thek 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)	[4	[]
MEDIUM (100)	M	[]
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)	[]	[1]
JOG (50Hz)		[1]
SPRINT (500Hz)	[]	[1

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4. Testing the temperature readout

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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	29.29
3	31.46	29.43
4	32.37	30 31
5	33.30	31.28
Check if passed:	[1]	[4

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

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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 "DQWN")		
1	[1]	[L]		
2	[4]	[]		
3	[4			
4	[4]	[1		
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		[1	
3			
4	[1	[1]	
5		[1]	
6	[1]	[]	
7	[1]	[1]	
8	ι <u>΄</u>	[]	

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Testing Summary

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

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

Test Engineer: Zob C Test Date: 1/24/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

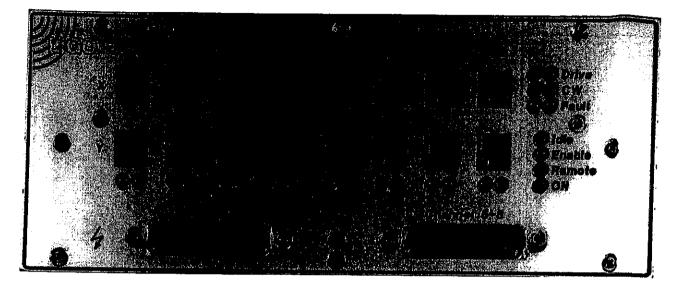
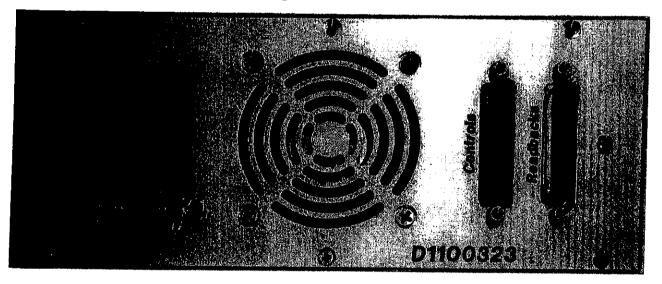
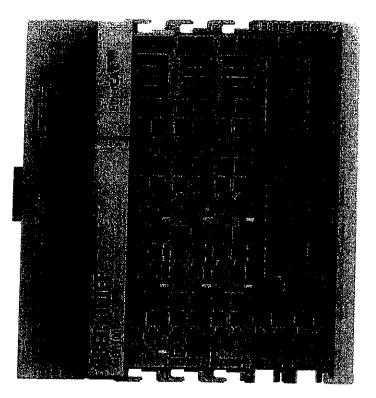


Figure 3: Picomotor driver chassis rear panel



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Figure 4: EtherCAT configuration



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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

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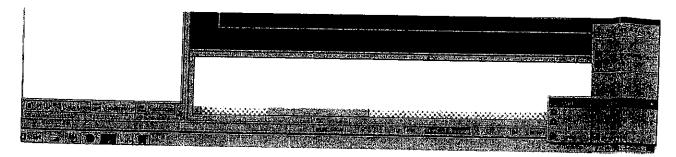


Figure 6: Step 5 of PLC controls setup

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Technical Note LIGO-T1100458-v1
Testing Procedure for the

08/26/11

esting Procedure for th Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

TASS

D1100323-v1

51107553 Zach G 11/22/11

[] FAIL

Overall picomotor chassis testing:

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

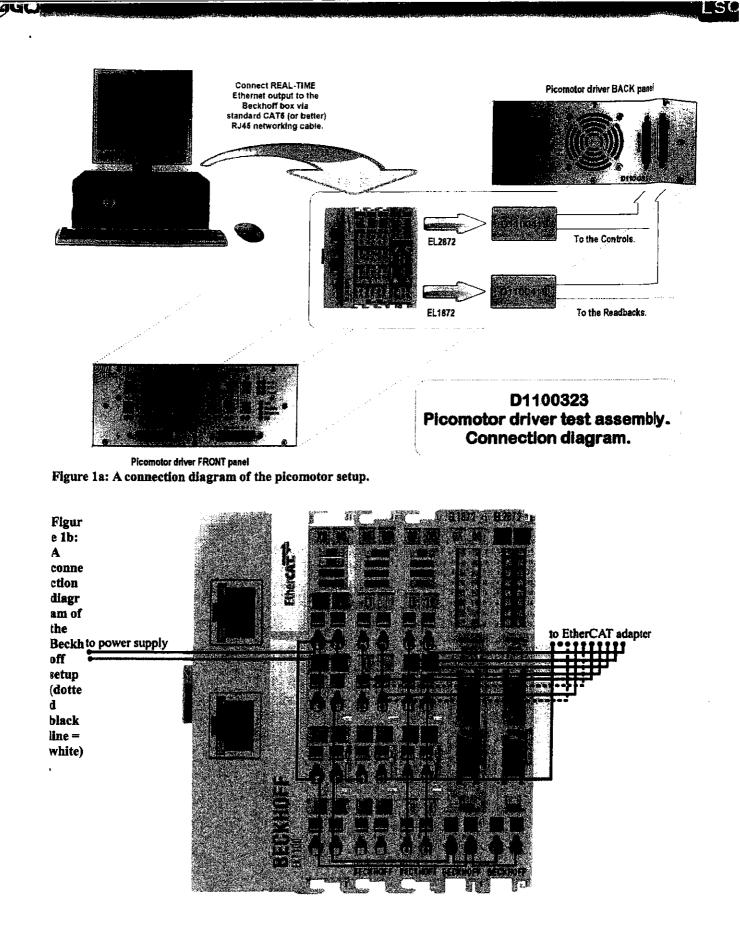
Setting up

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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

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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.
- $[\cancel{1}]$ 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	of	m
STARTING UP	off	on	flashes	flashes	off	on	m
READY	off	on	off	off	off	on	52
Check if passed:	[1]	[J	H	17	M	FT	17-

Table 1: LED response to picomotor status

[/

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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.

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

[\checkmark 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	L	ED
	Left	Right
1	M	[٢
2	[]	[]
3	[]	[]
4	[]	[Y]
5	[4]	[]
6	[]	[1]
7	[]	[1]
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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:		1	М	[1		

Table 2: LED response to picomotor direction

* (while motor is running)

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

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2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is output terminal I 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):

sixA	7	szis qəts
Y ("UP" or "DOWN")	$X (\stackrel{i}{i} \stackrel{i}{o} \stackrel{i}{i} \stackrel{i}{o} \stackrel{i}{i})$	
	h]	VERY SMALL (1)
	[بلر	WEDINW (100)
F1	<u>t</u>	(00001) MUNDAM

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):

<u>_</u> {1	[٦]	SPRINT (500Hz)
<u>الم (</u>	[جر	10G (20Hz)
[]	[عر	CRAWL (1Hz)
Y ("UP" of "DOWN")	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
sixA	,	Speed

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:	[4]	M	

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

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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	[Y	[1]
2	[4]	[4]
3		[]
4	[4]	[]
5		[]
6	[]	[1]
7	[Y	[1]
8	- I-1	[1

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

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

Testing Summary

2

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

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

Test Engineer: Zach G Test Date: 11/22/11

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Additional Comments:

Appendix A: Physical Components

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Figure 2: Picomotor driver chassis front panel

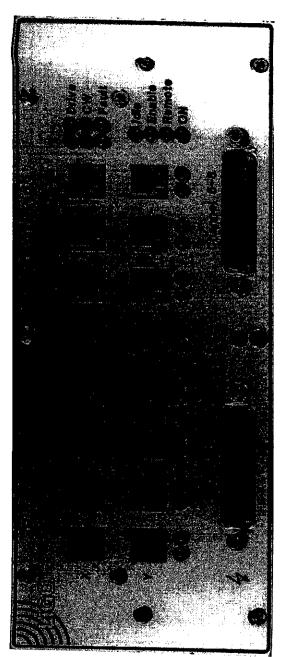


Figure 3: Picomotor driver chassis rear panel

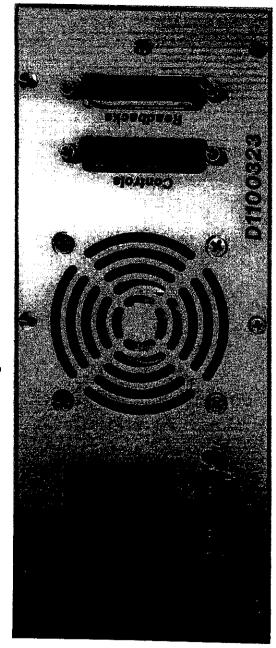
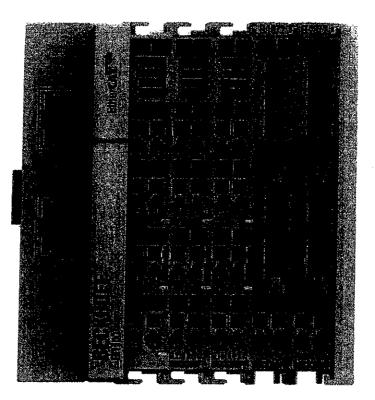


Figure 4: EtherCAT configuration



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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

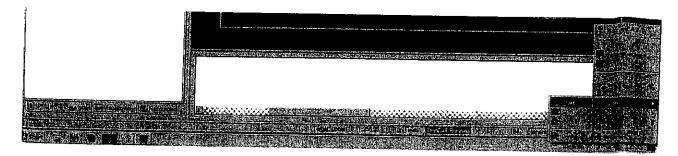


Figure 6: Step 5 of PLC controls setup

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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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

S1107 554 Zach G 11/22/11

Overall picomotor chassis testing:

Signature/Initials:

PASS

[]FAIL

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:

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- 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

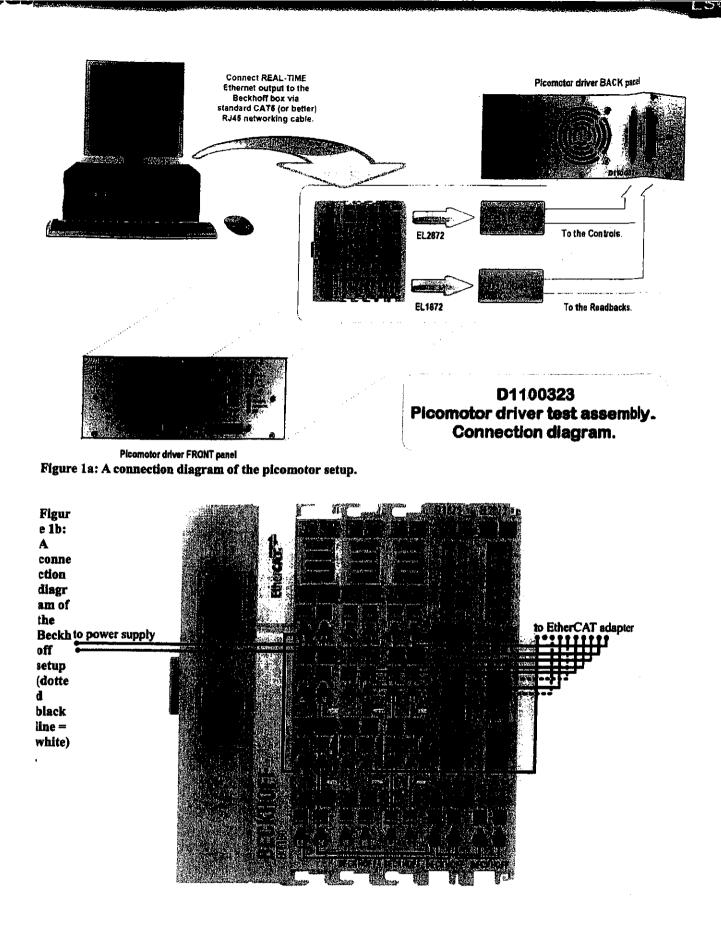
Setting up

1

<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

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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)

 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 $\Box S$

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	df-	GN
STARTING UP	off	on	flashes	flashes	off	(N	5M
READY	off	on	off	off	off	\sim	on
Check if passed:	[]	M	[]	1	1	ΓΛ	1

Table 1: LED response to picomotor status

[1]

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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.

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

 \sim 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	[4]	[]
2	M	[4]
3	[]	
4	[J	[]
5	[]	[]
6	N/	[]
7	[]	
8	[]	[1

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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[Y	[<u>]</u>	M	[4]	

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 the 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	, <u></u>	Axis
_	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[4	[4
MEDIUM (100)	[4	14
MAGNUM (10000)	\mathbb{N}	[]

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)	[4	[4]
JOG (50Hz)	[9	[]
SPRINT (500Hz)	[]	1

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	34.89		
3	36.44	35.81		
4	37.21	36.64		
5	37.91	37.40,		
Check if passed:	[4	[4]		

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	[4]	[]		
2		[]		
3	M	[]		
4	[]	[]		
5		[1]		
6		1		
7		i 1		
8	[]	[1		

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

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

Testing Summary

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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

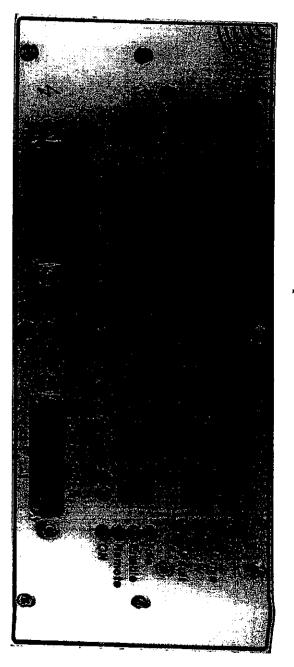
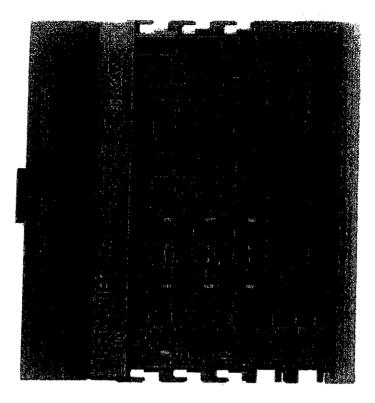


Figure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration



14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

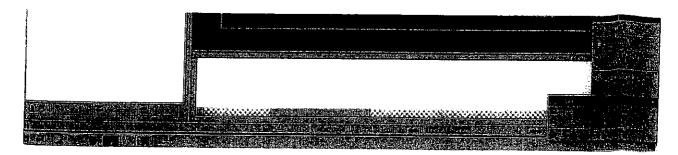


Figure 6: Step 5 of PLC controls setup

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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.

California Institute of Technology LIGO Project -- MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u>

Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

icomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

51107555 Zaeh G 1/22/11

[] FAIL

Overall picomotor chassis testing:

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

50

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)

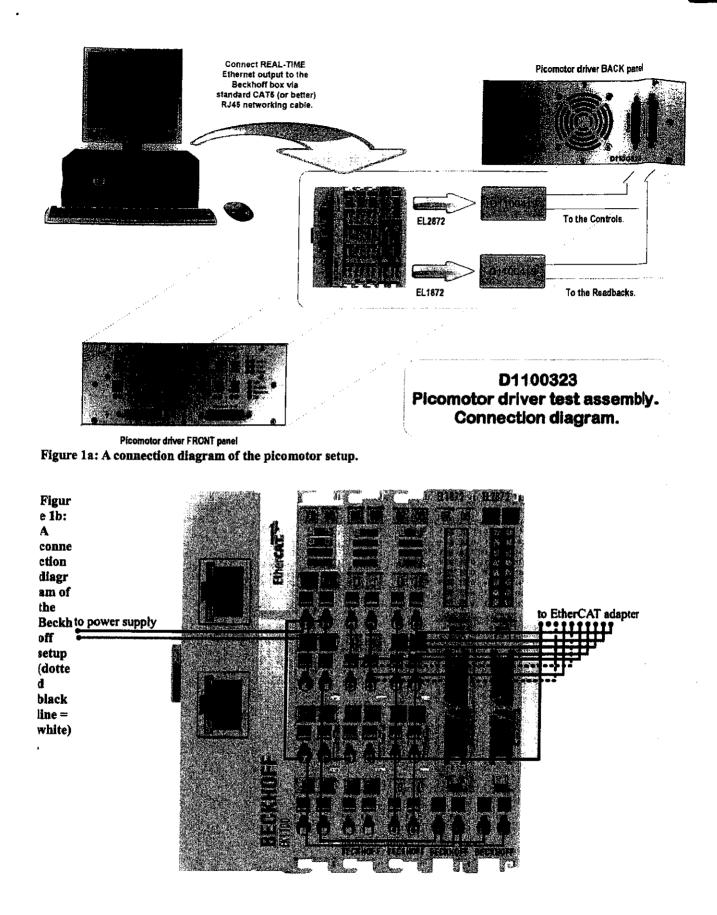
Software:

- 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



5 of 15

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.
- [7 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	m	A	6n
STARTING UP	off	on	flashes	flashes	off	m	01
READY	off	on	off	off	off	m	on
Check if passed:	[]	[]	[}		[Ĵ	[]	1

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.

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

[1] 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	LI	ED
	Left	Right
1	[]	[]
2	[4]	H,
3	[4]	[}
4	[4	[1]
5		[X]
6		[/]
7		1
8	[]	[1

Select output terminal 1 and do the following:

[Y 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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	11	IV			

Table 2: LED response to picomotor direction

* (while motor is running)

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

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2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is 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):

	لم ا	(00001) MUNDAM
[مر	[مر]	MEDIUM (100)
[Jr]	[۲]	VERY SMALL (1)
Y ("UP" of "DOWN")	(^{"<"} or ">") X	
sixA	Step Size	

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 "SIMALL (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):

SPRINT (500Hz)	[ب]	
10G (20Hz)	[۲]	[مر]
CRAWL (1Hz)	[m]	[بلر
	$X (\mathbb{I} < \mathbb{I} $ or $\mathbb{I} > \mathbb{I})$	Y ("UP" of "DOWN")
Speed	sixA	

4. Testing the temperature readout

<u>J</u>40

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	25.77/
Check if passed:	[Y	[4]

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	IY.	[]
2	M	[1
3		
4	[]	[]
5		ر آ
6		[1]
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	[4]	[1
2		[]
3		[1
4		
5		[]
6	 [<i>X</i>	[]
7	[了	
8		[]

Testing Summary

2

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

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

Test Engineer: Zad G Test Date: 11/22/11

11

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Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

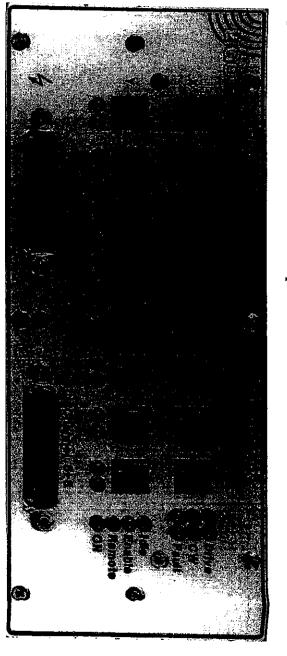


Figure 3: Picomotor driver chassis rear panel

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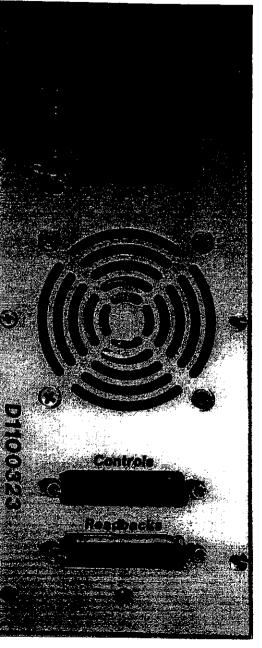
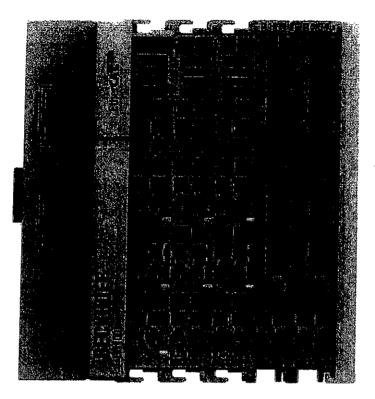


Figure 4: EtherCAT configuration



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Appendix B: PLC Controls



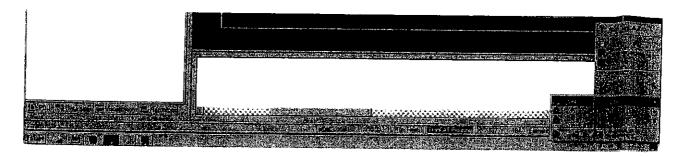


Figure 6: Step 5 of PLC controls setup

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Tech	nical Note	LIGO-T1100458-v1	08/26/11
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	· F	Advanced LIGO	
	Maxim Facto	urovich, Daniel Sigg and Ma	ggie Tse

This is an internal working note of the LIGO Project.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

Test Engineer:

Test Date:

S1107556 Zach G______ 11/22/11

Overall picomotor chassis testing:

MASS

[] 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

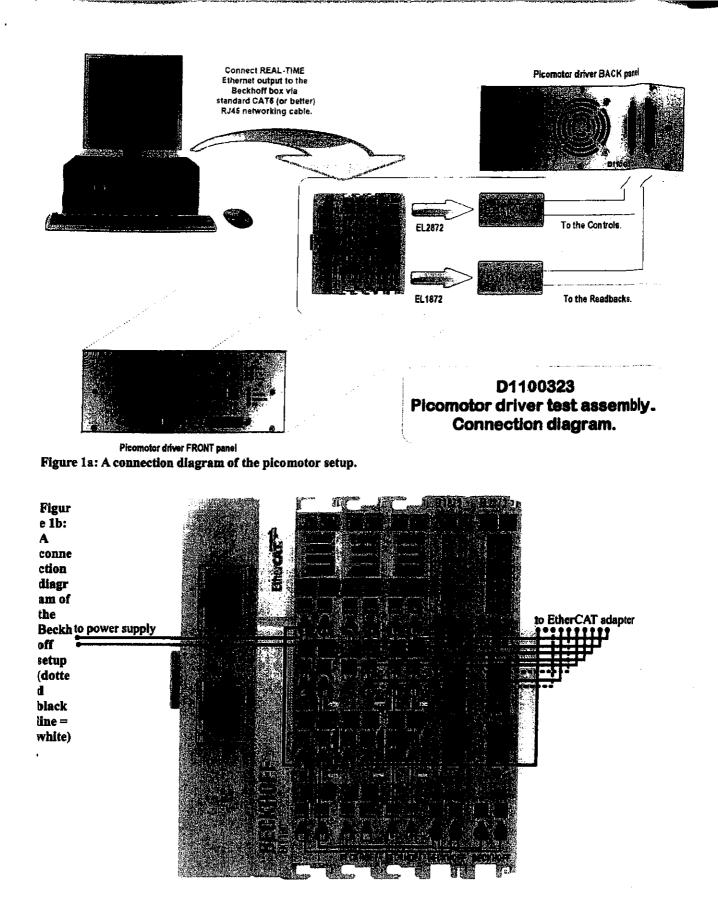
Setting up

1

1111

<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



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:

- [U] 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.
- [4 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.

 \mathcal{X} 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 Readbac		backs	
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	GR	on
STARTING UP	off	on	flashes	flashes	Off	on	on
READY	off	on	off	off	off	on	SN
Check if passed:	И	V	[]	14	14	11	

Table 1: LED response to picomotor status

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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.

Inable 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).

[4] 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	L	ED
	Left	Right
1	[4]	[1]
2	[Y]	[]
3		[]
4	[] []	[]
5	[]	[]
6	[′]	$\left[\right] /$
7		1/
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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	M	[]		17		

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 there is the nutput terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a tep size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns used it runs) as you increase the step size for each axis (X and Y):

		(00001) MUNDAM
		MEDIUM (100)
[.]	[مر	VERY SMALL (1)
Y ("UP" or "DOWN")	("<" or ">") X	
sixA		Step Size

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 "SIMALL (10)" under "STEP SIZE". Selecta 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):

[بر	[بر	SPRINT (500Hz)
		10G (20Hz)
[سکر 🔪	[بر]	CRAWL (1Hz)
Y ("UP" or "DOWN")	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
sixA	•	Speed

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	32.69
5	36.30	33.45,
Check if passed:	[4	[]

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	[4	[]	
2	M		
3	[]	[]	
4		H	
5		[]	
6	[]	[]	
7		$[\mathcal{Y}]$	
8			

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

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[]	[1		
2				
3				
4				
5		11		
6				
7	[]			
8				

Testing Summary

2

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 Co Test Date: 11/22/11

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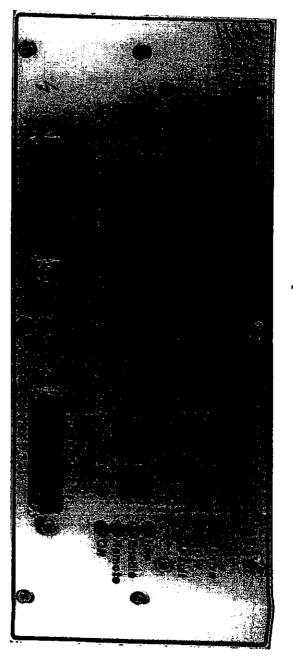
:

Additional Comments:

12 of 15

Appendix A: Physical Components

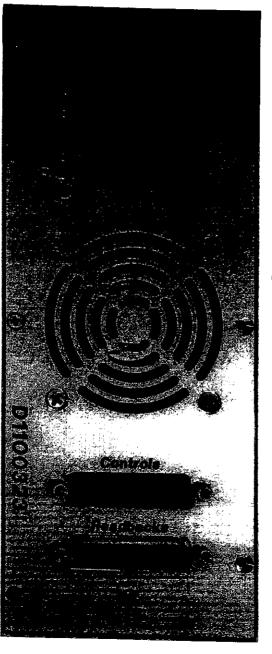
Figure 2: Picomotor driver chassis front panel



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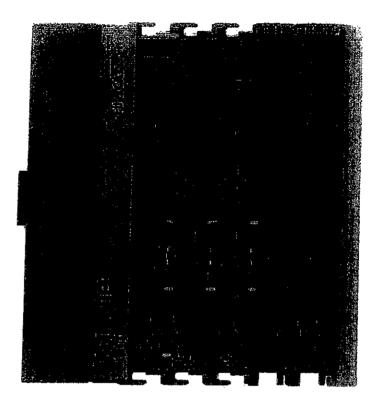
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Figure 3: Picomotor driver chassis rear panel



13 of 15

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	
Testi	ng Procedure for t	he	
Pic	comotor Driver for	,	
- E	Advanced LIGO		
Maxim Facto	urovich, Daniel Sigg and Ma	ggie Tse	

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California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

icomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

PASS

51107557 Zach G 11/22/11

[] FAIL

Overall picomotor chassis testing:

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)

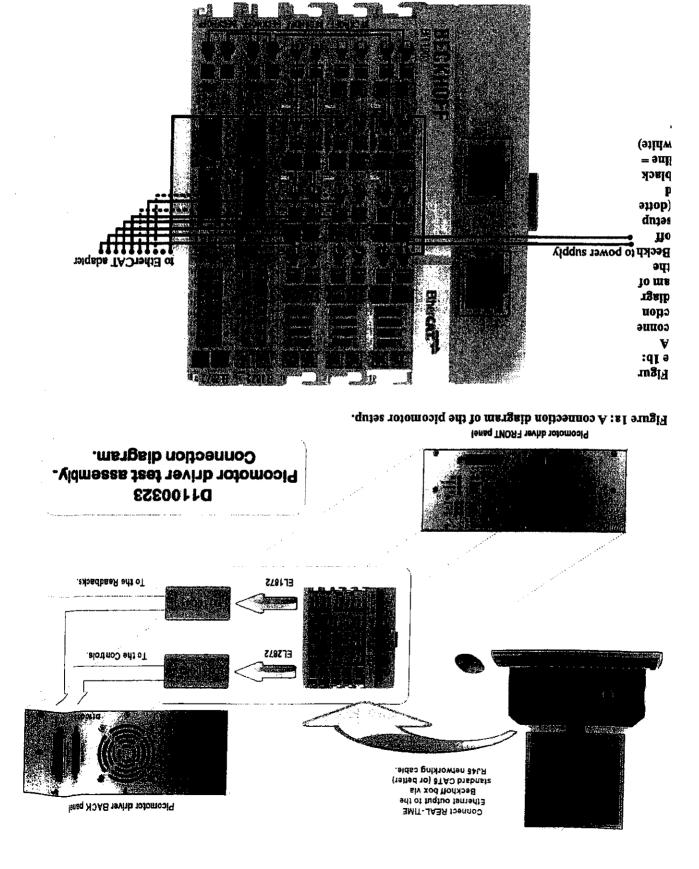
Software:

- 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



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)

 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.
- [9] Check that the "ON" indicator on the visualization also responds to the power switch.
- Y 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	of	on	m
READY	off	on	off	off	off	on	on
Check if passed:	[]	[]	[]	[]	[]	H	H-

Table 1: LED response to picomotor status

[]

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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.

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

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

[V] 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	М	[4]	
2	[J]	M	
3	M	$[\uparrow]$	
4	M	[4]	
5	[1]	[4]	
6	[]	[]	
7		[4]	
8	[]	[4]	

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	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	M	[4]	IV	-17

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 the deck that output terminal I 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 runns when it runs) as you increase the step size for each axis (X and Y):

	<u>[</u>]	(00001) MUNDAM
[h]	[المر	MEDIUM (100)
	[مر	VERY SMALL (1)
Y ("UP" of "DOWN")	X ("<" or ">") X	
sixA	7	Step Size

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):

	<u></u>]	SPRINT (500Hz)
h	[1]	10G (50Hz)
[T]	(م)	CRAWL (1Hz)
Y ("UP" or "DOWN")	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
sixA	,	Speed

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. (do	30.66		
5	32.6	31.4		
Check if passed:	Ĩ.	[4]		

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	[L]	[/		
2		[]		
3		[]		
4		[]		
5		[]		
6		[]		
7		[1]		
8		1		

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

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	N	[/	
2		[]	
3	[]	[]	
4	[/]	[]	
5	[}		
6			
7	- V	[]	
8			

Testing Summary

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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: 11/24/11

Additional Comments:

Appendix A: Physical Components





Figure 3: Picomotor driver chassis rear panel

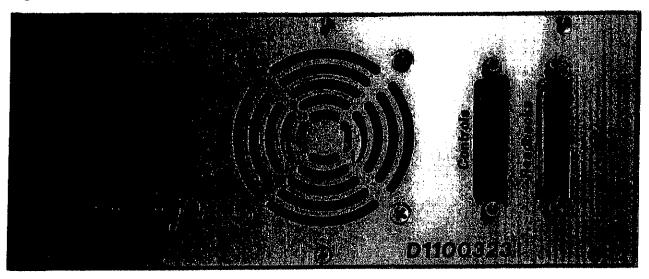
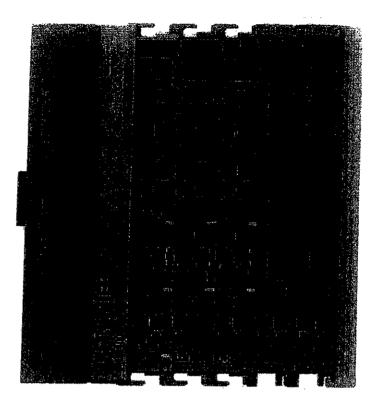


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

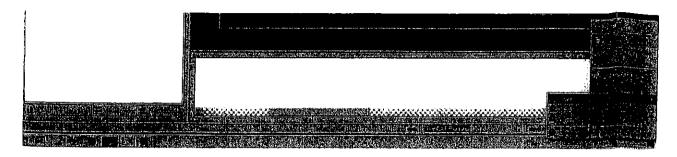


Figure 6: Step 5 of PLC controls setup

2.1. Set 1. A. (1) Set 0.1 (2) - B. (20) (20) (20) (20) (20) (20) (20) (20)	
	Arton and a state

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

PASS

Controller Serial #

Test Engineer:

Test Date:

51107558 Zach G 11/22/11

[] FAIL

Overall picomotor chassis testing:

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:

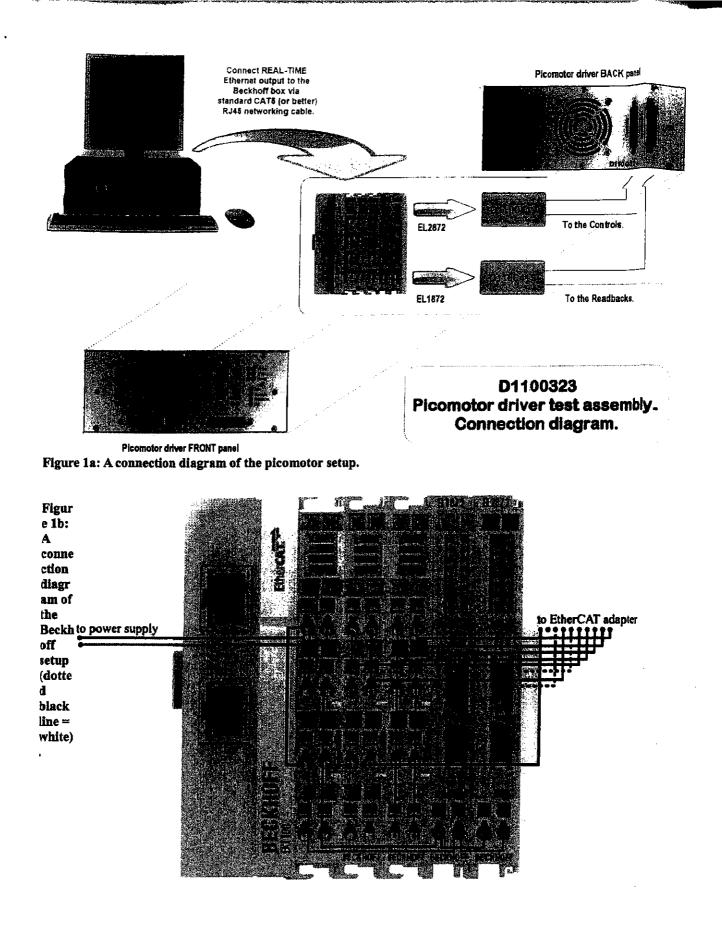
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

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<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



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.
- [J 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	m	off	on
STARTING UP	off	on	flashes	flashes	off	m	on
READY	off	on	off	off	of	on	on
Check if passed:	[4]	[]	[]	[]	[9	[]	19

Table 1: LED response to picomotor status

 $[\mathcal{V}]$

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

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

Inable 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	LI	ED
	Left	Right
1	[4]	[4]
2		$[\mathbf{T}]$
3	M	[4]
4		H
5	[1]	[]
6	[1]	[1]
7	[X]	[1]
8	[/]	[1]

Select output terminal 1 and do the following:

[1]

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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[]	1	5	[1		

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 the visualization screen, make sure the picomotor is enabled and that the motor clicks 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):

	۲)	(00001) MUNDAM
F]		MEDIUM (100)
h	لم /	VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA	y	Step Size

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 I is selected, then select "SMALL (10)" under "STEP SIZE". Selects 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):

[]	[]	SPRINT (500Hz)
[]	<i>[</i> ا	10G (20Hz)
	[بر	CKAWL (1Hz)
Y ("UP" or "DOWN")	X (^{n < n} OL ^{n > n} $)$	
sixA		beed

4. Testing the temperature readout

2

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	34.97	36.05		
4	35.57	36.86		
5	36.16	37.53		
Check if passed:	[]	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	M	[4			
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	M	[4			
2		[]			
3	[4	[]			
4	[J	[]			
5	[]				
6	[]	[1]			
7		[1]			
8		[1]			

Testing Summary

/

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

Step sizes	[]Pass	[]Fail
Speeds	[] Pass	[] Fail
Output terminals	[JPass	[] Fail
Overall picomotor driver testing:	[]Pass	[] Fail

Test Engineer: Z. \mathcal{L} G Test Date: $11/2^{2}/11$

Additional Comments:

Appendix A: Physical Components

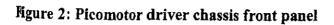




Figure 3: Picomotor driver chassis rear panel

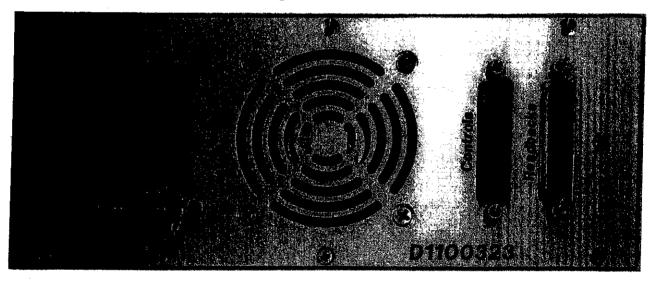
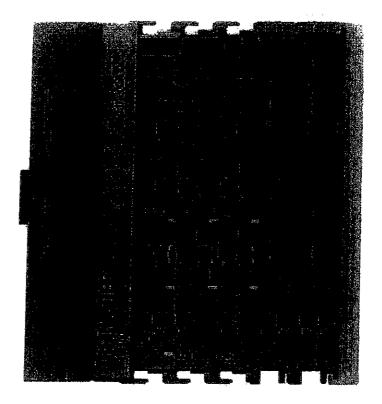


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

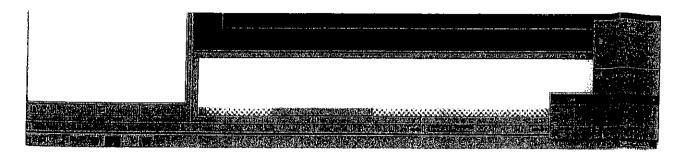


Figure 6: Step 5 of PLC controls setup

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	earth and the state of the stat	

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

Technical Note	LIGO-T1100458-v1	08/26/11	
Testi	ng Procedure for t	he	
Pic	comotor Driver for	•	
· I	Advanced LIGO		
 Maxim Facto	urovich, Daniel Sigg and Ma	ggie Tse	

This is an internal working note of the LIGO Project.

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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

D1100419-v3

Test Date:

51107559 Zach G 11/22/11

Overall picomotor chassis testing:

[4] 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)

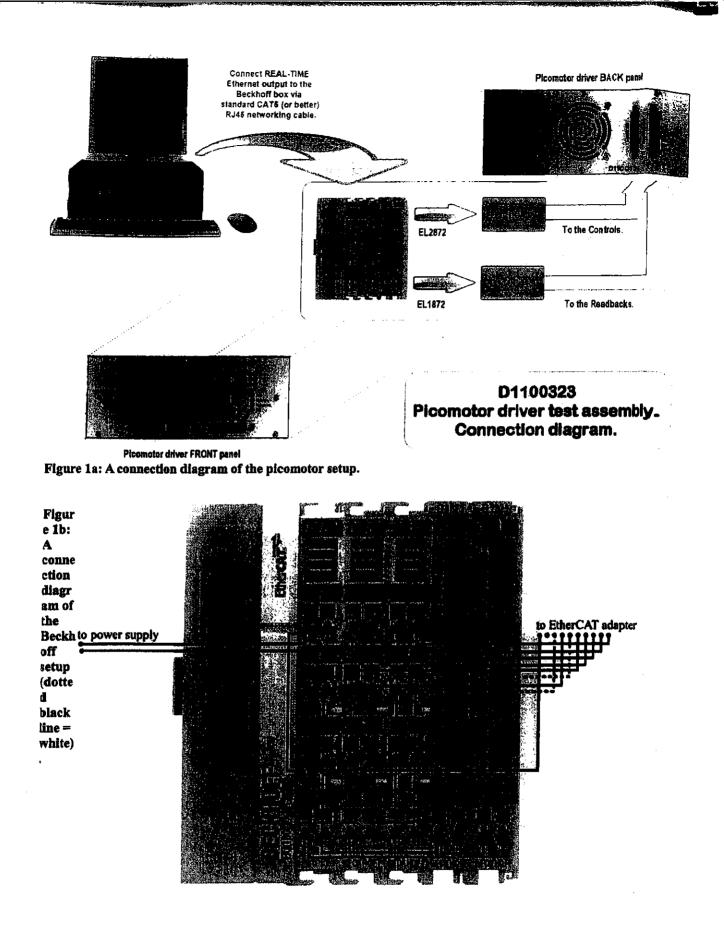
Software:

- 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



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:

- [4] 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.
- [9 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.
- [\downarrow 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	57
STARTING UP	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	BO	on	on
Check if passed:	[]	[]	I	4	[]	19	17

Table 1: LED response to picomotor status

 $[\mathbf{1}]$

11

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the *i*comotor 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
	Lef	t Right
1	[4	M
2	[·]	(M
3	M	[]
4	M	I.
5	្រ	
6	[Y	
7	M	
8	[4	[1]

Select output terminal 1 and do the following:

M

[4]

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	CWY			
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 theck 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)	M	ľý ,
MEDIUM (100)	[4]	M
MAGNUM (10000)	M	19

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)	[9]	[1]		
JOG (50Hz)	[4]	19		
SPRINT (500Hz)	[]	14		

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	24.55	28.41			
3	29.82	29.63			
4	30.17	30.66			
5	31.74	31.57			
Check if passed:	[]	I			

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	[J]	M,				
2	E E	[]				
3						
4						
5		[]				
6	- II	[]				
7	[ſ	$[\mathcal{X}]$				
8		[]				

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

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[.]	[9				
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 Co Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components





Figure 3: Picomotor driver chassis rear panel

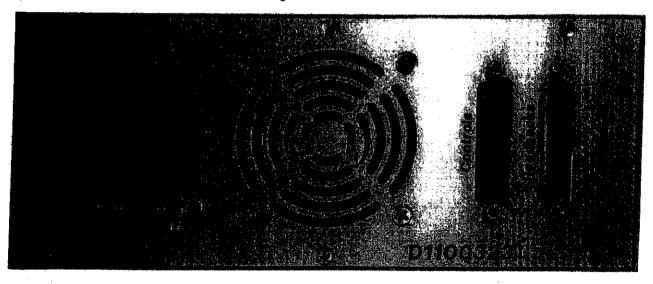
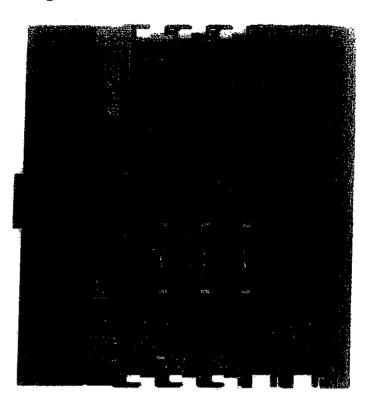


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

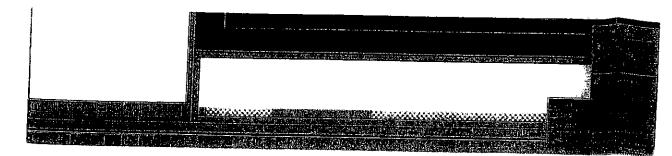


Figure 6: Step 5 of PLC controls setup

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				1.			
			- -				

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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Signature/Initials:

D1100419-v3

Test Date:

~

51107560 Zech Co 11/22/11

Overall picomotor chassis testing:

[1] PASS [] FAIL

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:

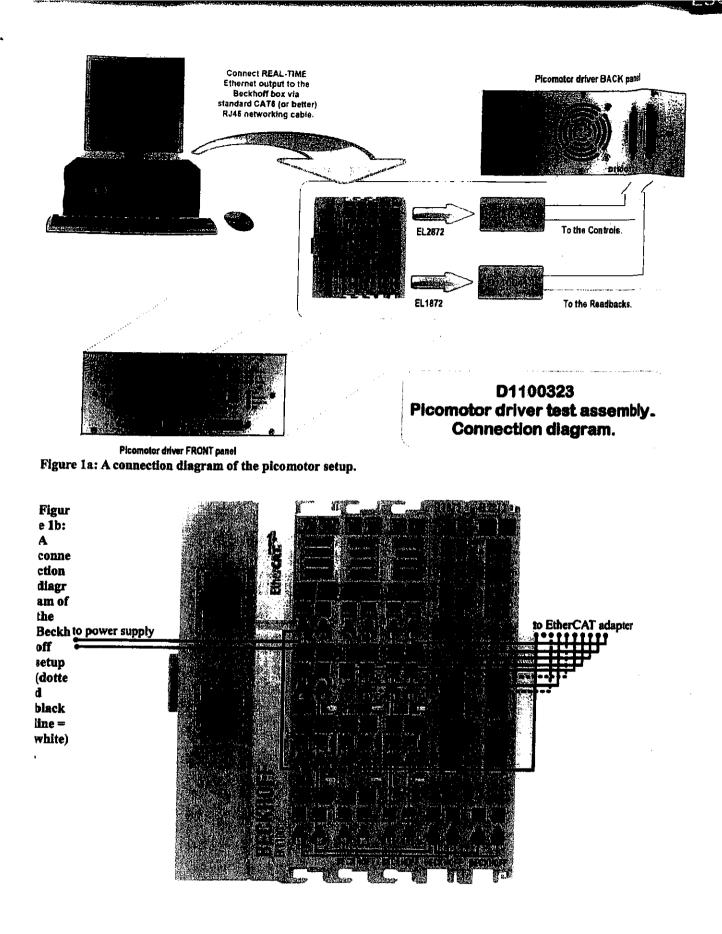
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

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



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.
- [U 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.
- \mathcal{Y} 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	Cl	hassis Fron	Software Readbacks				
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	df	on
STARTING UP	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	5	on
Check if passed:	H	[-]	[]	[]	[]	[]	

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.

^[1]

Inable 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	MM
2	[] []
3	M M
4	
5	IT IT
6	H M/
7	
8	

Select output terminal 1 and do the following:

~

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[] 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	CWY			
DOWN	off	on *	off	on **			
UP	off	on *	off	off			
>	on *	off	on **	off			
<	on *	off	off	off			
Check if passed:	[]		[1]	[1			

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 the visualization screen, make sure the picomotor runs for a longer time (the motor clicks and turns 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):

L.	[(00001) MUNDAM
F		MEDIUM (100)
- L	(h)	VERY SMALL (1)
Y ("UP" or "DOWN")	X (^{n<n< sup=""> or ^{n>n}$)$</n<>}	
sixA		Step Size

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the atatus 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):

[][]	1	(SPRINT (SOOHZ)
	<u></u>	10G (20Hz)
		CRAWL (1Hz)
Y ("UP" or "DOWN")	X(u < u OL u > u)	
sixA		Speed

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:	N	ľ	

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

5. Testing the output terminals

2

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	H,	[4]	
2	[4]	M	
3		[/	
4	E E	[]	
5		[]	
6	íſ	[1]	
7			
8		[1]	

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

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	ιΨ.	H,
2	· · · · · · · · · · · · · · · · · · ·	[]
3		[]
4	[Y	H
5	U.	[]
6		[]
7	[]	
8		

Testing Summary

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

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

Test Engineer:

Test Date:

Zach 6 11/22/11

Additional Comments:

Appendix A: Physical Components





Figure 3: Picomotor driver chassis rear panel

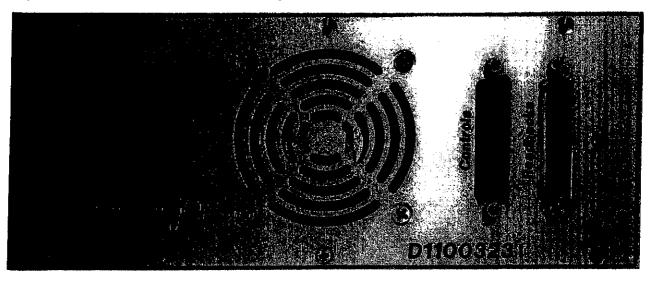
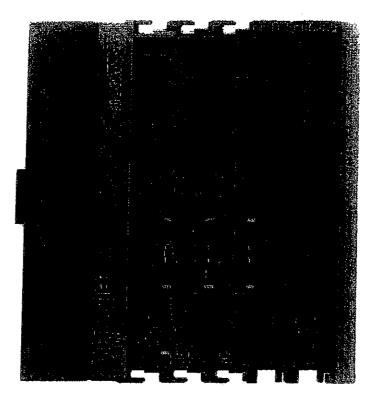


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

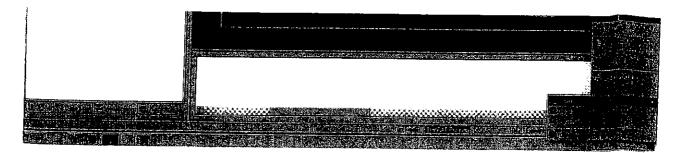


Figure 6: Step 5 of PLC controls setup

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	n an	- NY 1 Set 2 Kit All all start and provide an advance of the set of the se

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.

California Institute of Technology LIGO Project -- MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

Test Engineer:

Test Date:

51107561 Zich G 11/22/11 ['JPASS []FAIL

Overall picomotor chassis testing:

Reference:

Signature/Initials:

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:

- 1Picomotors (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)

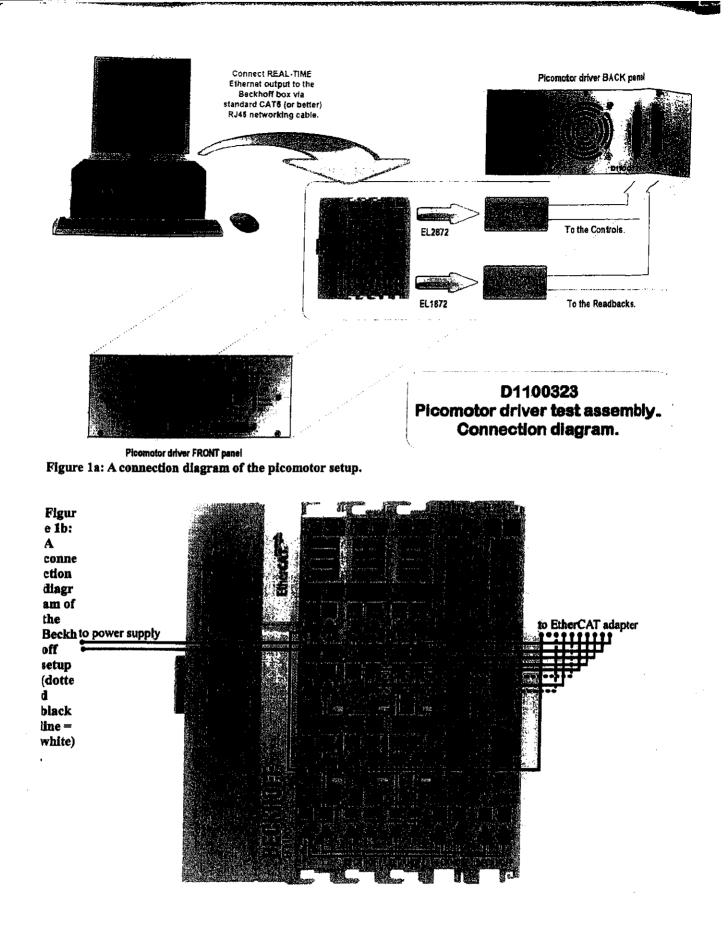
Software:

- 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



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	Cl	Chassis Front Panel LEDs			Software Readbacks		backs
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	m
STARTING UP	off	on	flashes	flashes	off	on	m
READY	off	on	off	off	off	sn	or
Check if passed:	[}	[]	IJ	[]	[]	1	

Table 1: LED response to picomotor status

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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 icomotor 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		[1]	
2	[]/	[1]	
3	$\left(1 \right)$	[1]	
4	[1]	[]	
5	[]	[X]	
6	[]	[]	
7	[1]	[1]	
8	[]/	[]	

Select output terminal 1 and do the following:

14

[U]

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:		11	IX	11	

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 "READ", and the visualization screen, make sure the picomotor is enabled and that the status is "READ". Select a the size and then a direction. Check that the motor runs for a longer time (the motor clicks and furms when it runs) as you increase the step size for each axis (X and Y):

[مر	[بلر	(00001) MUNĐAM
[آسر]	[سر	MEDIUM (100)
[]]	h]	VERY SMALL (1)
Y ("UP" of "DOWN")	X ("<" or ">")	
eixA	7	Step Size

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 "SIMALL (10)" under "STEP SIZE". Selecta 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):

[الحر	<u></u>	SPRINT (500Hz)
[]	[小]	10G (20Hz)
H		CRAWL (1Hz)
Y ("UP" of "DOWN")	$X_{(n < n \text{ or } n > n)}$	
sixA	7	Speed

4. Testing the temperature readout

1

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	25.13	25.44	
3	26.76	26.88	
4	27.92	28.08	
5	25.98	29.29	
Check if passed:	[1]	1	

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	[Y	[Y
2		
3		[]
4	M	[]
5	H	[]
6	H	[]
7		[1
8	[]	[]

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

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	L/	[]
2		[]
3		$[\mathcal{X}]$
4	[]	[/
5		[]
6	[1]	[1
7	[1	[1]
8		[]

Testing Summary

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

Step sizes	[]Pass	[] Fail
Speeds	[]Pass	[]Fail
Output terminals	[]Pass	[] Fail
Overall picomotor driver testing:	[]Pass	[] Fail

Test Engineer: Zoch G Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

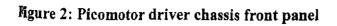




Figure 3: Picomotor driver chassis rear panel

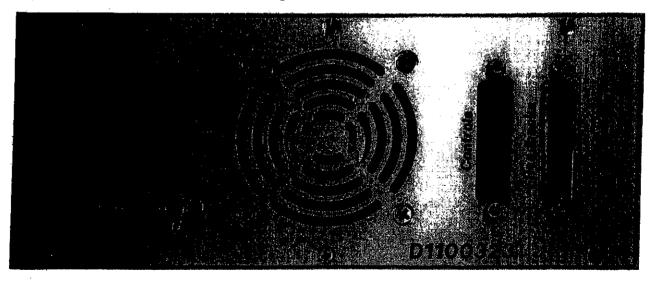


Figure 4: EtherCAT configuration

14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

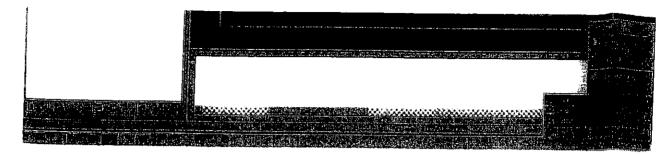
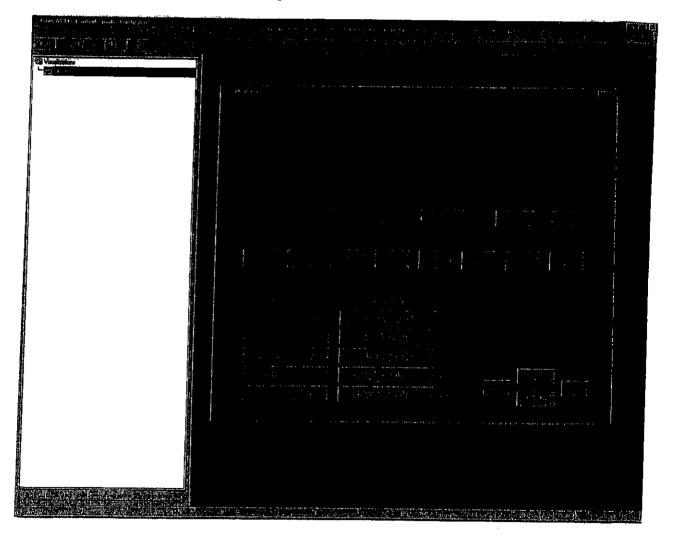


Figure 6: Step 5 of PLC controls setup



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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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

lest Engineer:

Controller Serial #

Test Date:

51107562 2ach C 11/22/11

Overall picomotor chassis testing:

[YPASS [] 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)

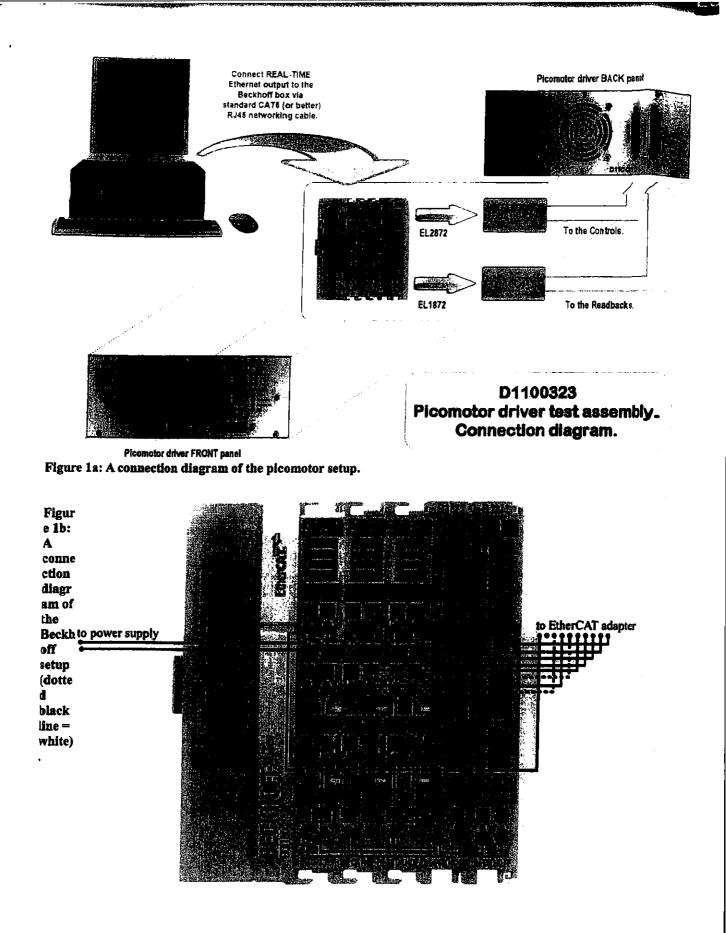
Software:

- 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



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 **M** 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	62	64	m
STARTING UP	off	on	flashes	flashes	df-	on	m
READY	off	on	off	off	of	on	m
Check if passed:	[]	[4]	[4]	U/	57	12	M

Table 1: LED response to picomotor status

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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.

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

[1] 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	L	ED
	Left	Right
1	[Y	[4
2	[\/	
3	[] []	[]
4		[]
5	[]	[Y]
б		[]
7	[Y	[7]
8		[]

Select output terminal 1 and do the following:

M

[] 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:	IJ	[]	[]	N-	

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 theck 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)	[4]	[]		
MEDIUM (100)	[]			
MAGNUM (10000)	[4	[]		

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	31-51	32.01		
Check if passed:	[]	14		

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	[4	N			
2	[4	H			
3		[]			
4	L/	[]			
5	[]	[]			
6	H	[1]			
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	[1]			
2	11	1		
3	[]	1		
4	[<i>X</i>			
5		K -		
6	L/	[1_		
7				
8				

Testing Summary

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

Overall picomotor driver testing:	[] Pass	[] Fail
Output terminals	[]Pass	[] Fail
Speeds	[}Pass	[] Fail
Sep sizes	[]Pass	[] Fail
Front panel LEDs	[YPass	[] Fail

Test Engineer: Zach Co Test Date: 11/22/11

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

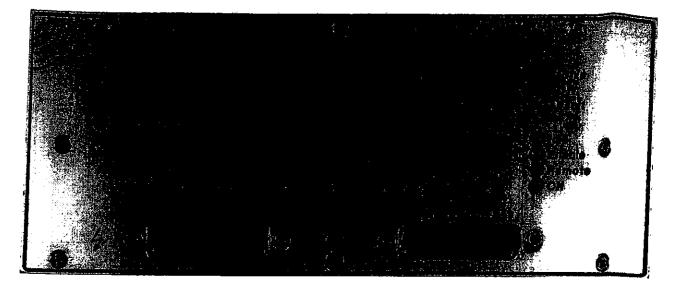


Figure 3: Picomotor driver chassis rear panel

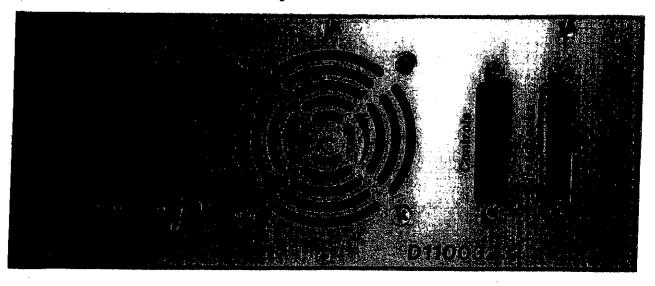
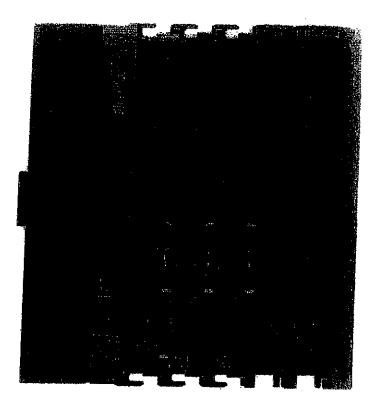


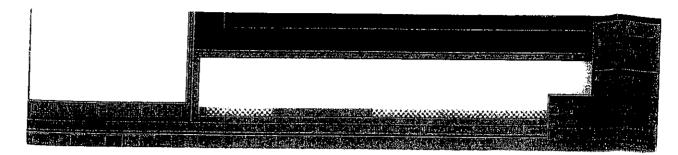
Figure 4: EtherCAT configuration



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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup





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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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Test Engineer:

Signature/Initials:

Controller Serial #

Test Date:

5/107563 Z.J.C 11/28/11

Overall picomotor chassis testing:

[YPASS

[] FAIL

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)

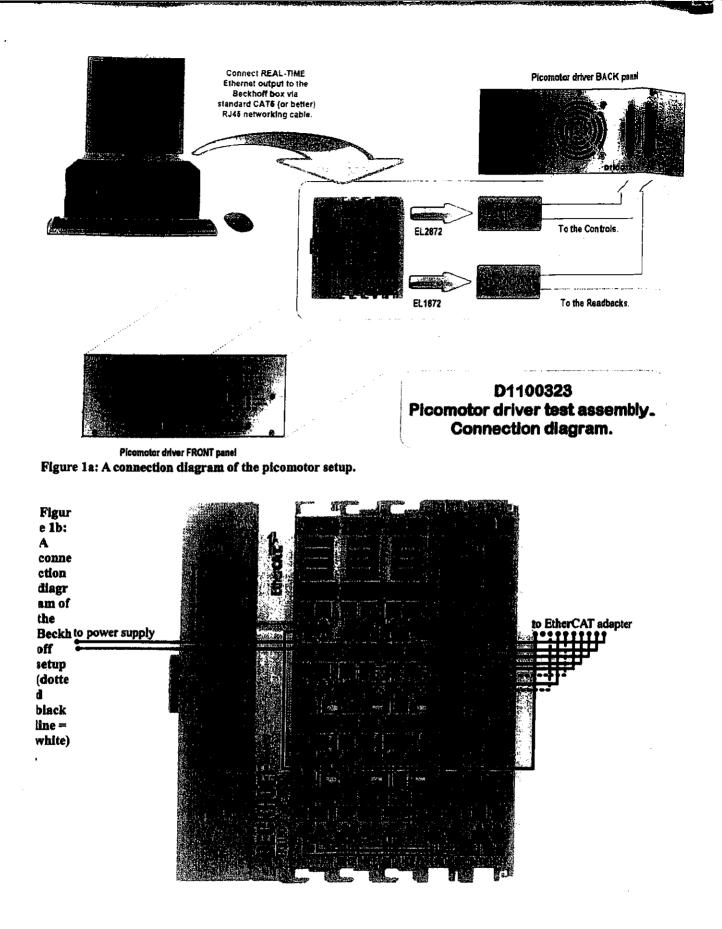
Software:

- 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



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	m	68	SI	
STARTING UP	off	on	flashes	flashes	off	on	m	
READY	off	on	off	off	off	S	m	
Check if passed:	11	r í	[]	11	1	11		

Table 1: LED response to picomotor status

 $[\mathcal{X}]$

M

[4]

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	L	ED
	Left	Right
1	[L]	
2		1
3		[1]
4		
5		[1]
6		
7		[]
8	[1]	[]

Select output terminal 1 and do the following:

[1

M

N

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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[4	N	[]			

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 theck 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)	[~]	14
MEDIUM (100)	[4	H
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)	[4]	[]		
JOG (50Hz)	LY	Ŋ		
SPRINT (500Hz)		1		

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)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	26.75	24.88
2	28.03	26.23
3	29.19	27.99
4	30.24	28.63
5	31.18	29,61
Check if passed:	[4	[]

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	[*]	[4]
2	[4]	[]
3	[1]	[]
4	[9	[]
5		
6		[]
7		[]
8		[1]

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

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[]	[1				
2		[]				
3	[]	[]				
4		IX				
5		IT I				
6	[]	Γ <i>X</i>				
7	N	[X				
8		[<i>1</i>]				

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: Zech G Test Date: 1/2/11

Additional Comments:

Appendix A: Physical Components

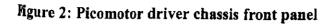




Figure 3: Picomotor driver chassis rear panel

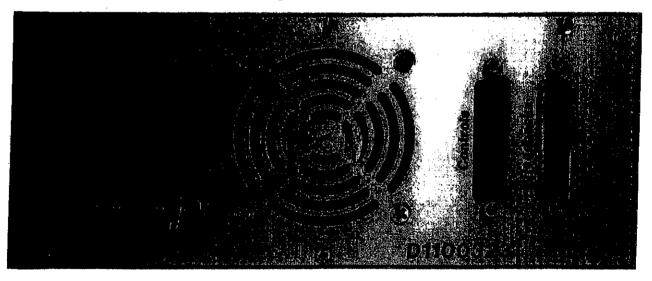
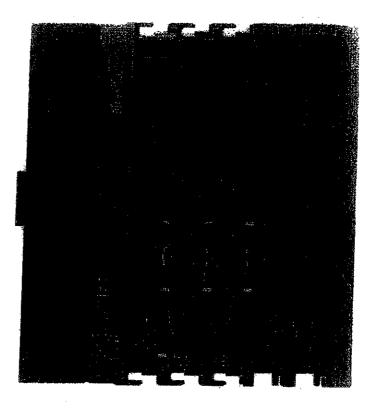


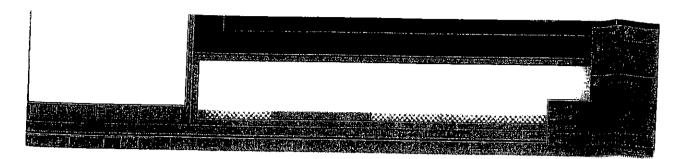
Figure 4: EtherCAT configuration



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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup





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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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

lest Engineer:

Test Date:

D1100419-v3

51107569 Zech C-11/28/11 PASS

[] FAIL

Overall picomotor chassis testing:

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:

- 1Picomotors (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)

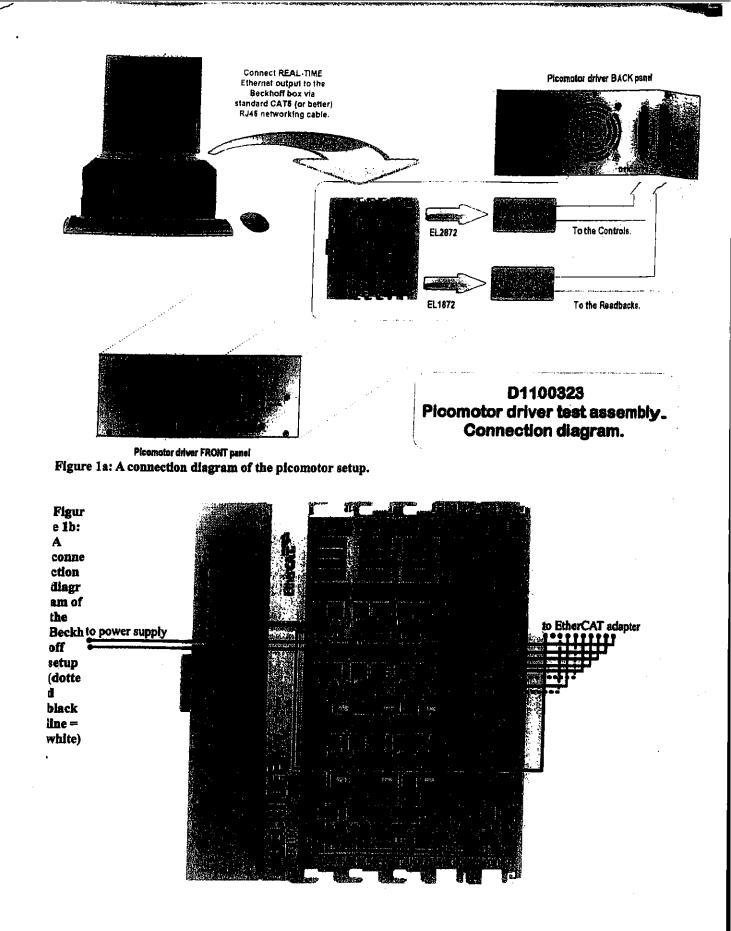
Software:

- 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



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			
ľ	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power	
DRIVER DISABLED	on	off	off	off	onc	off	on	
STARTING UP	off	on	flashes	flashes	08	m	on	
READY	off	on	off	off	GF	m	(51)	
Check if passed:	[1	[1	N	[]	[7		H	

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.

^[]

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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		ED
	Left	Right
1	[4	[4]
2	[4]	[4]
3		[4
4	[Y	[4]
5	[J	[]
6	[4]	[J]
7	IY	[]
8	[]	[1]

Select output terminal 1 and do the following:

[N

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	CWX	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[]	[]	[]

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 thek 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)	[]	17
MAGNUM (10000)	[1]	17

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)	[4	L L	
JOG (50Hz)	[]		
SPRINT (500Hz)	[-]	19	

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	26.50	
3	26.40	27.90	
4	27.44	28.94	
5	28.42	30.02	
Check if passed:		[4]	

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")	
	[?]	M	
2	[4]	M	
3	[]		
4	IY		
5	N.		
6			
7	M		
3	M		

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

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[4]	14	
2	[4		
3	[]		
4	14		
5			
6		[7]	
7			
3	- N		

Testing Summary

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

Output terminals	[1] Pass	[] Fail	
Speeds	[] Pass	[] Fail	
Step sizes	[]Pass	[] Fail	
Front panel LEDs	[] Pass	[] Fail	

Overall picomotor driver testing: [/Pass

[] Fail

Test Engineer: Zach C Test Date: 1/28///

Additional Comments:

Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel

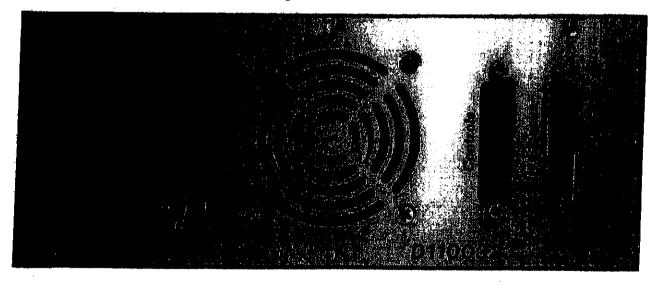
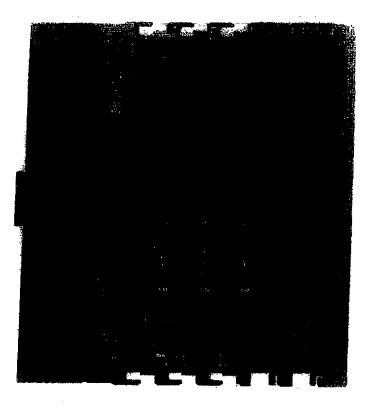


Figure 4: EtherCAT configuration

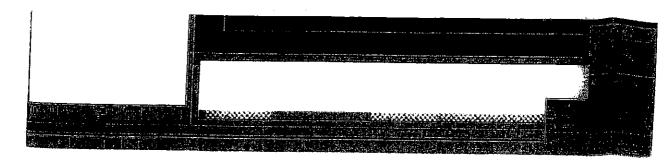
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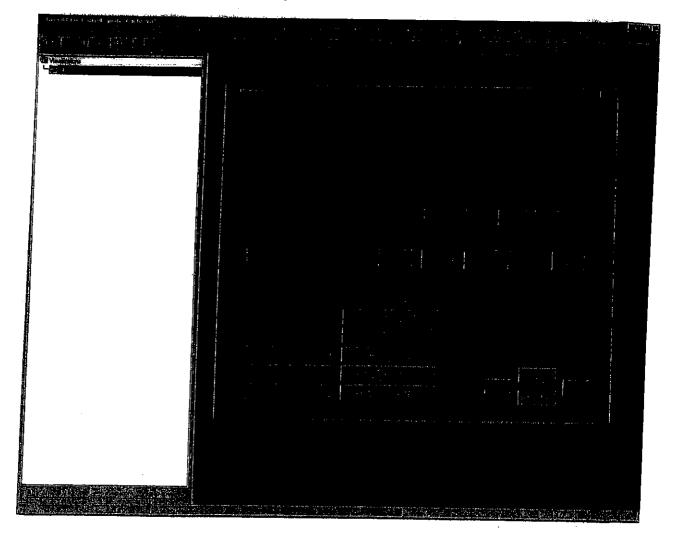
14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@lig</u>o.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

lest Engineer:

Test Date:

D1100419-v3

51107565 Zach G 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)

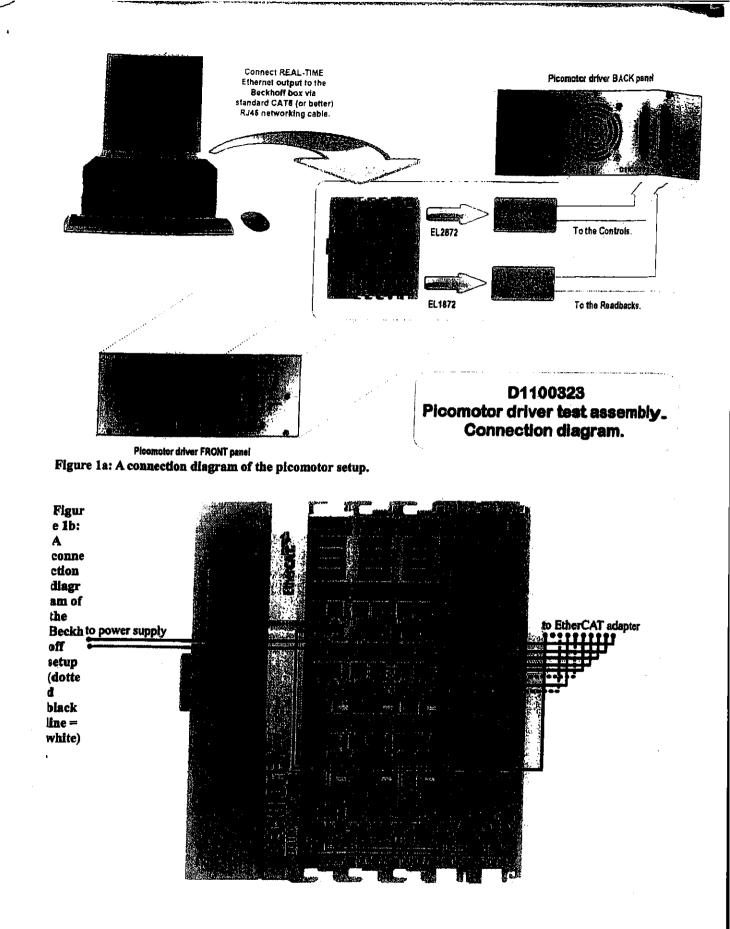
Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

<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



5 of 15

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:

- [4] 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	C	hassis Fron	sis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power	
DRIVER DISABLED	on	off	off	off	on	of	on	
STARTING UP	off	on	flashes	flashes	of	on	m	
READY	off	on	off	off	off	on	m	
Check if passed:	[1]	[]	[]	٢ſ	[]	[]	1	

Table 1: LED response to picomotor status

[A

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	L	ED
	Left	Right
1	[4	[4]
2	[4	[]
3	[Y	[]
4	[J	$[\Lambda]$
5	[J/	[]
6		[1]
7	[4	[1
8	[]	[1]

Select output terminal 1 and do the following:

[U

1

[] 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	CWX	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[4]	[]	[]	[]		

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 "READ", $\exists nd$ theck that output terminal I 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 tors) when it runs) as you increase the step size for each axis (X and Y):

	[·]	(00001) MUNDAM
<u> </u>	[J]	MEDIUM (100)
	<u></u>	VERY SMALL (1)
Y ("UP" of "DOWN")	X ("<" or ">") X	
zixA	7	Step Size

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the starus is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Selecta 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):

sixA	7	pəədS
	X (^{n<n< sup=""> of ^{n>n}$) X$</n<>}	
	<u></u>	CKAWL (1Hz)
[بر	<u> </u>	10G (\$0Hz)
Je I	[/	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)	Tem	perature
	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	29.93	29.19
Check if passed:	[4	M

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	M	PI				
2	M	[1				
3	[Y					
4	[4	[]				
5		17				
5		1				
7		1				
3	H	[1				

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

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[1	17				
2	[1	1				
3		11				
4	[]	[1				
5		r í				
6		[1				
7		ΓX				
8	1. [1					

Testing Summary

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

Front panel LEDs	[] Pass	[]Fail	
Sep 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

Rgure 2: Picomotor driver chassis front panel

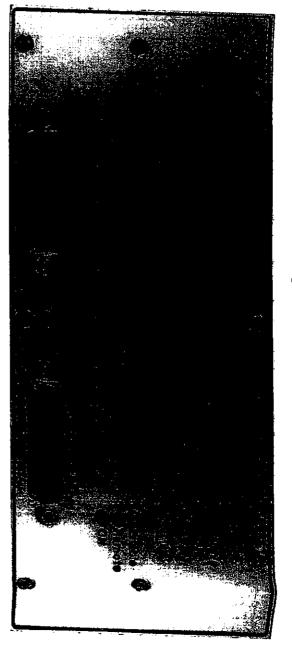


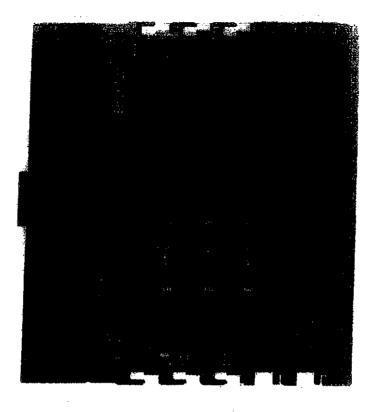
Figure 3: Picomotor driver chassis rear panel

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Figure 4: EtherCAT configuration



14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

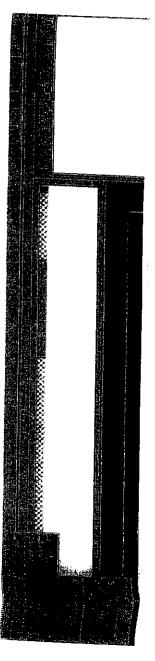
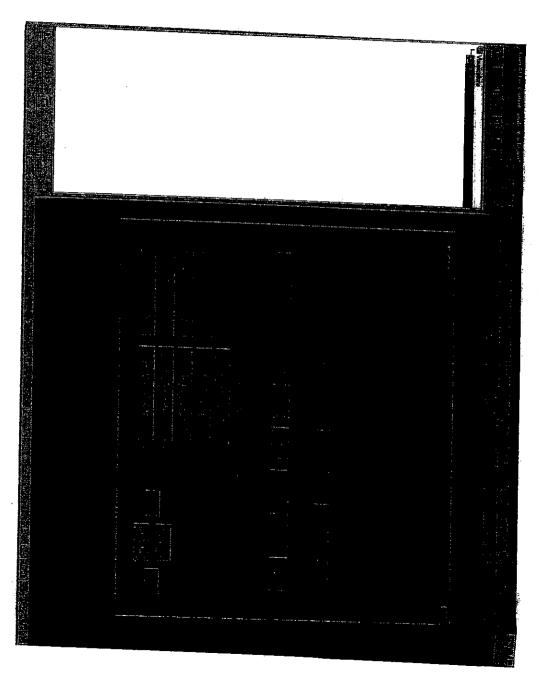


Figure 6: Step 5 of PLC controls setup



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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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

- 51107566 Zech G - 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)

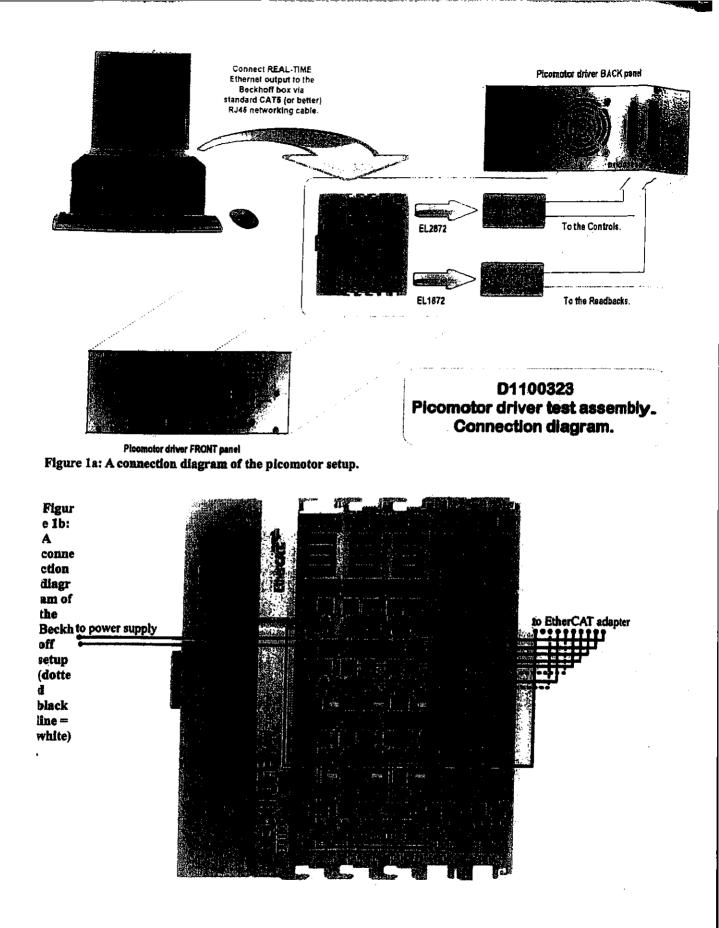
Software:

- 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



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.
- [4 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:	[]	[1	[]	[]	[1]	1	[]

Table 1: LED response to picomotor status

ſ

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	L	ED
	Left	Right
1	[]	[]
2	[\$	H
3		
4	[]	
5	[/	[]
6		[1
7	[]	[7]
8	[/]	[1

Select output terminal 1 and do the following:

14

M

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	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[1]	[1	[]	[]		

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 thek 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)	M	[+]
MEDIUM (100)	[4	19
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)	M	IY.	
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:	[]	[9-		

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		1
2		[]
3		[1]
4		[]
5		17
5		[7
7		
}		

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

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[Y	1/			
2	[4]	18			
3		IX			
4	[]	IX			
5		1			
6		۲) ۲			
7					
8		r Y			

Testing Summary

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

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

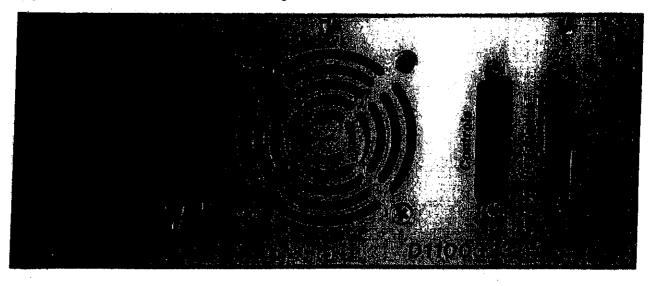
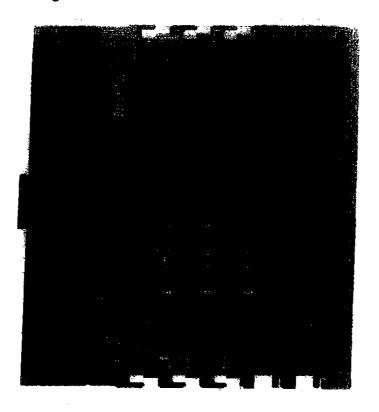


Figure 4: EtherCAT configuration

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14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

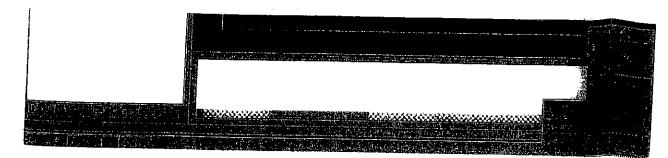


Figure 6: Step 5 of PLC controls setup -----

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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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: <u>info@ligo.mit.edu</u>

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

51107567 Zach G 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)

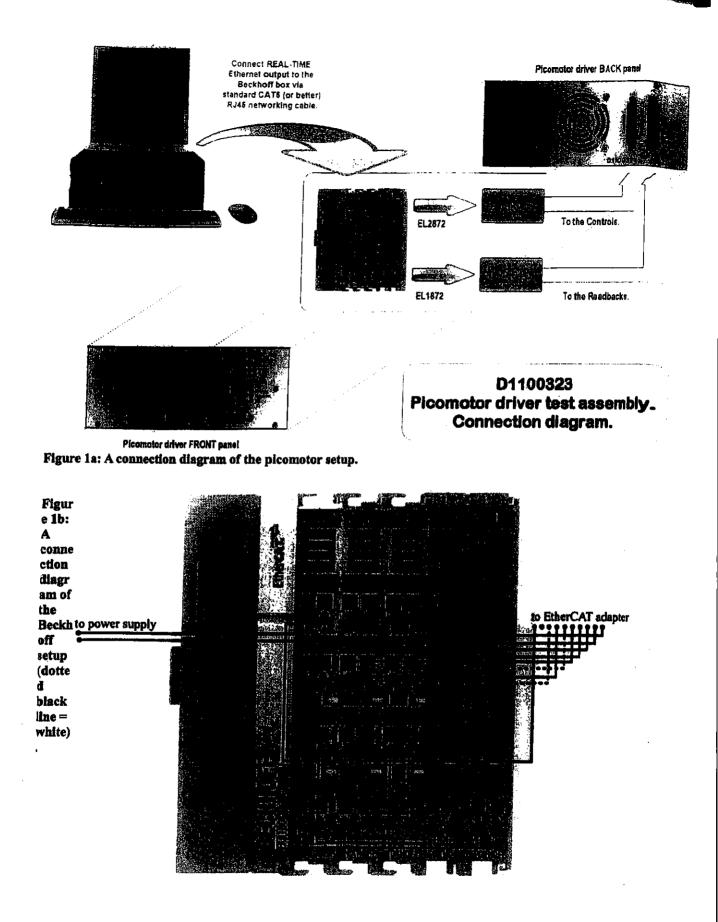
Software:

- 1 MS Windows XP/7, 32-bit
- **2** Beckhoff TwinCAT software bundle, v2.11.1551

Setting up

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



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.
- $[\mathcal{J}]$ 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	Cl	nassis Fron	Software Readbacks				
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	GN
STARTING UP	off	on	flashes	flashes	off	SM	on
READY	off	on	off	off	off	on	on
Check if passed:	[-]	И	11	N	[/]	[]	UY

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.

 $[\]left[\Lambda \right]$

Inable 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	L	ED
	Left	Right
1	[4	[1
2		[1]
3	M	[1]
4	[1	[]
5		[]
6	[1]	[]
7		[1]
8	[]	[]

Select output terminal 1 and do the following:

M

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	CWY			
DOWN	off	on *	off	on **			
UP	off	on *	off	off			
>	on *	off	on **	off			
<	on *	off	off	off			
Check if passed:	H	[]	[]	[]			

Table 2: LED response to picomotor direction

* (while motor is running)

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

 $^{[\}mathcal{X}]$

2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READ", and sheck that output terminal I 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 furns when it runs) as you increase the step size for each axis (X and Y):

	<u>_</u> []	(00001) MUNDAM
	لمر	MEDIUM (100)
L.	<u>[</u>]	VERY SMALL (1)
Y ("UP" of "DOWN")	X ("<" or ">") X	
sixA		Step Size

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". Selecta 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):

JE I	[]	SPRINT (500Hz)
FI	[م]	10G (20Hz)
_ 1]	[م]	CRAWL (1Hz)
Y ("UP" or "DOWN")	X ((((((((((((((())))	
sixA		Speed

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	28.51	
5	29.09	29.90	
Check if passed:	H	N	

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	M	[7	
2		[]	
3		[]	
4			
5			
6		[]	
7	[]	17	
3		[]	

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

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[4]	1	
2	[]	11	
3		11	
4	[]	11	
5		1	
6		[]	
7			
8		IT IT	

Testing Summary

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

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

Test Engineer: Zach Co 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

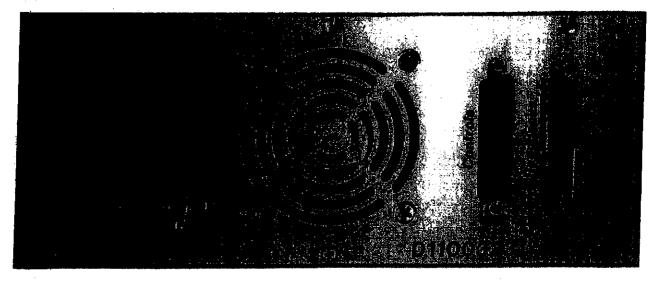
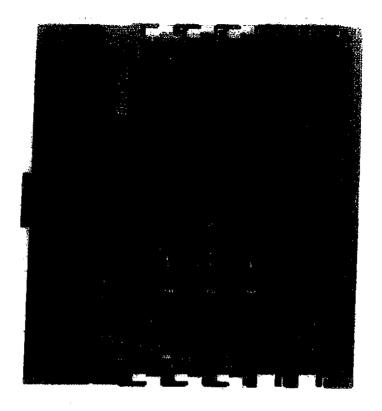
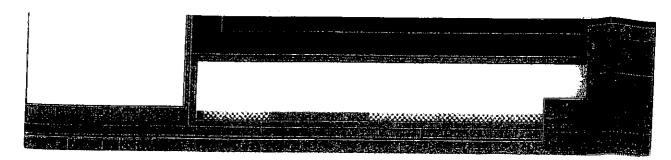


Figure 4: EtherCAT configuration

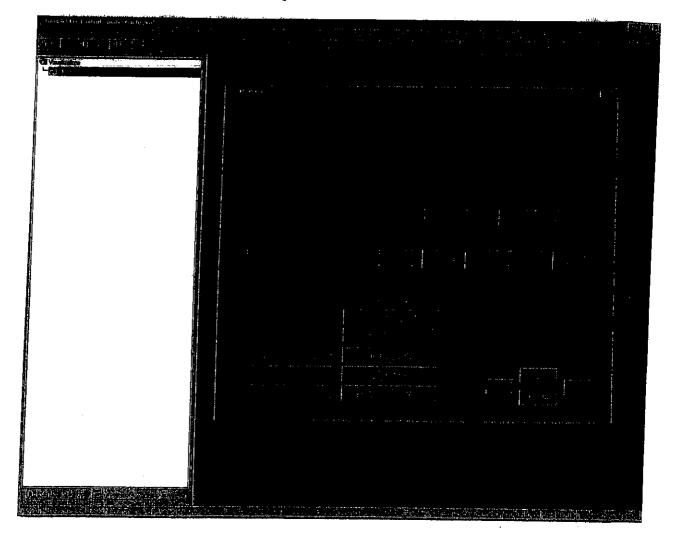


Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup







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

Picomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

Test Engineer:

Signature/Initials:

Test Date:

51107568 Z.ch G 11/28/11

Overall picomotor chassis testing:

[PASS

[] FAIL

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:

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- 7 IDC 20-pin cable assemblies (2)
- 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)

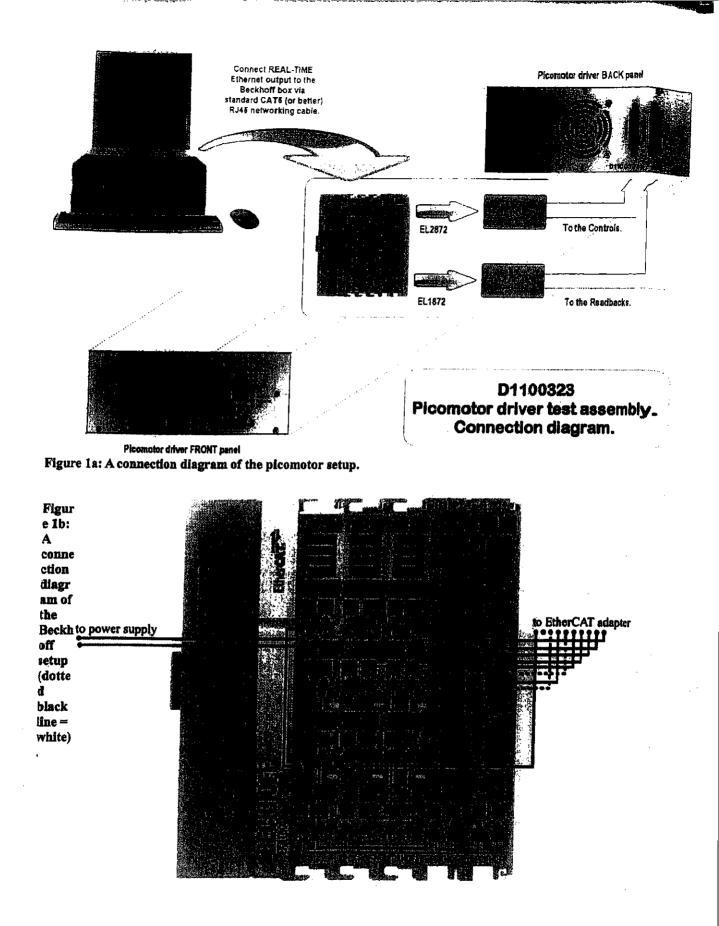
Software:

- 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 partel 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



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:

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 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.
- [7] 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	61
STARTING UP	off	on	flashes	flashes	of	57	m
READY	off	on	off	off	off	5	on
Check if passed:	H	F	Ы	[1]	[]	HI.	11

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.

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

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

V

1Y

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	L	ED
	Left	Right
1	1	1
2		[才
3		[7]
4	[/	[1]
5		[]
6	[1]	M
7	[イ	[1
8	[1]	[1

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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[/]	[1]	[]	[]	

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 "READ", and theck that output terminal I 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 torn when it runs) as you increase the step size for each axis (X and Y):

[سار	<u>}</u>]	(00001) MUNDAM
<u> </u>	<i>[</i>]	MEDIUM (100)
	<u></u> [VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">") X	
sixA		szis qəts

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):

sixA	/	Speed
	X (^{n<µ} or ^{n>µ})	
[الر		CRAWL (IHz)
[ير	£]	10G (20Hz)
[ع]	£]	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	[4	[4		

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	M	[J				
2	[Y	[J				
3						
4	[9]	1				
5		17				
6	U U					
7						
3		[1]				

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

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	M	IJ IJ				
2	[4	H				
3	[]	11				
4	[]	11				
5		17				
6	[]					
7						
3						

Testing Summary

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

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

Test Engineer: Zach () Test Date: 11/28///

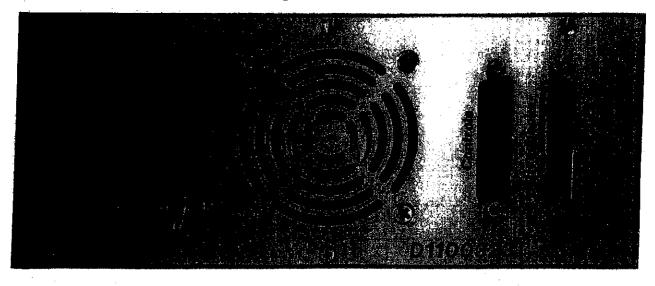
Additional Comments:

Appendix A: Physical Components



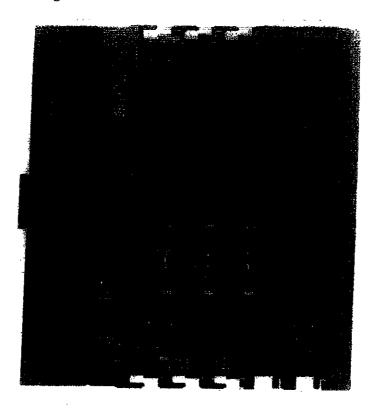


Figure 3: Picomotor driver chassis rear panel



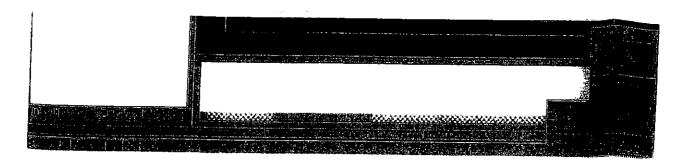


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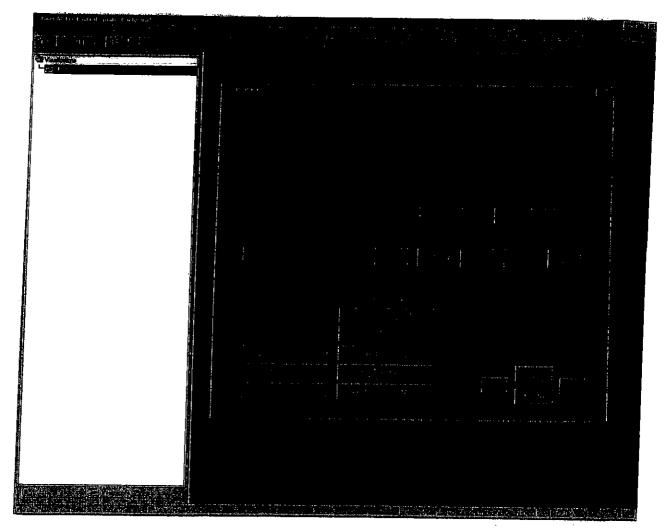


Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup







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Technical Note LIGO-T1100458-v1

08/26/11

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licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

D1100419-v3

[PASS

Test Engineer:

Test Date:

51107565 Zach C= 11/28/11

[] FAIL

Overall picomotor chassis testing:

Signature/Initials:

Reference:

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

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- 1. Front panel LEDs
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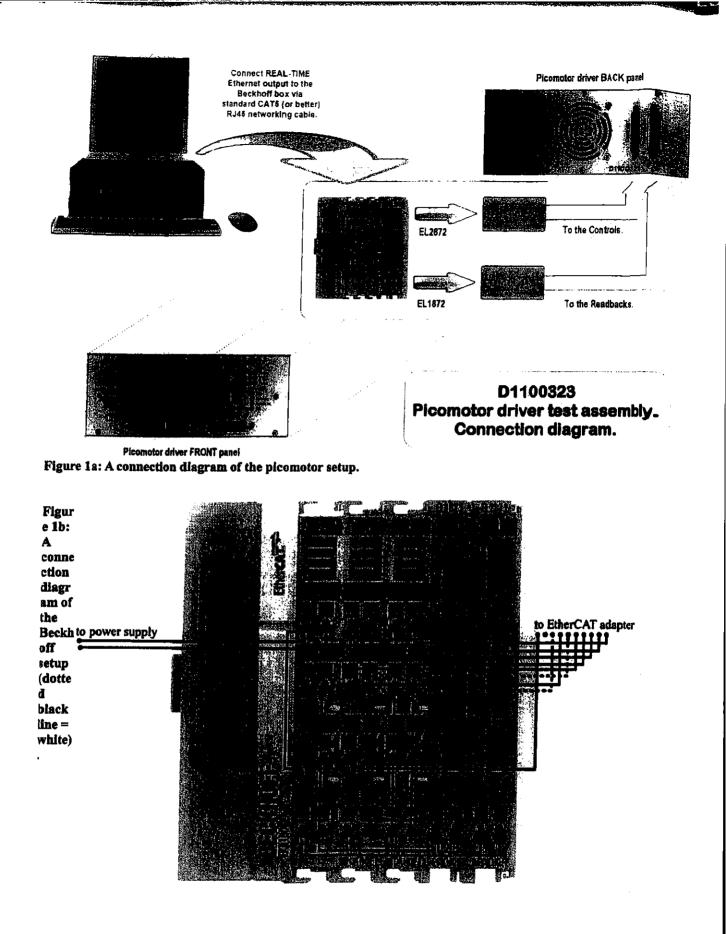
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- 1 MS Windows XP/7, 32-bit
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Steps for setting up the picomotor:

- 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
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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.
- \bigcirc 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	af	on
STARTING UP	off	on	flashes	flashes	of	m	(17)
READY	off	on	off	off	off	m	m
Check if passed:	H	[4	-++ 	5		FT	1

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.

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

[4 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	L	ED
	Left	Right
1	[4]	[J
2	[]	[]
3	[Y	[]
4	[Y	M
5	M	[]
6	[<i>X</i>	[]
7	[.Y	[个
8		[/]

Select output terminal 1 and do the following:

[V

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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	M	_ []	N	17	

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 theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a tep 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)	M		
MEDIUM (100)	[4		
MAGNUM (10000)	[4		

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)	[4]	[}	
JOG (50Hz)	[4	14	
SPRINT (500Hz)	[4]	[4]	

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	26.27	
4	37 16	36.96	
5	37.70	37. 42	
Check if passed:	[1]	14	

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	[Y	[]	
2	[Y	[]	
3	[4]	[]	
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	[1]	[4]	
2	14	[]	
3	[4]	1	
4		1	
5		[]	
6		I T	
7		1	
8		1	

Testing Summary

~

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

Front panel LEDs	[L]Pass	[] Fail	
Sep sizes	[-]Pass	[] Fail	
Speeds	[Pass	[] Fail	
Output terminals	[-]Pass	[] Fail	
Overall picomotor driver testing:	[1 Pass	[] Fail	

Test Engineer: Zach G Test Date: 11/29/1

Additional Comments:

Appendix A: Physical Components

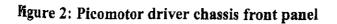




Figure 3: Picomotor driver chassis rear panel

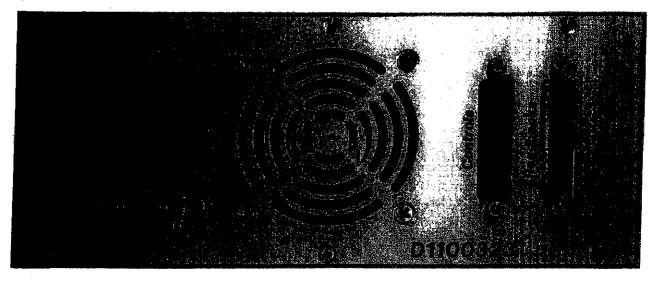
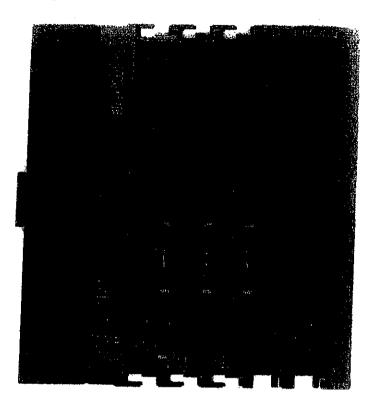
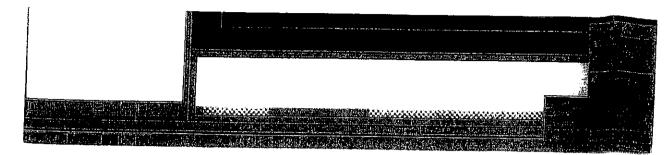


Figure 4: EtherCAT configuration



Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup





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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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

lest Engineer:

Test Date:

SILO7570 Zach G 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)

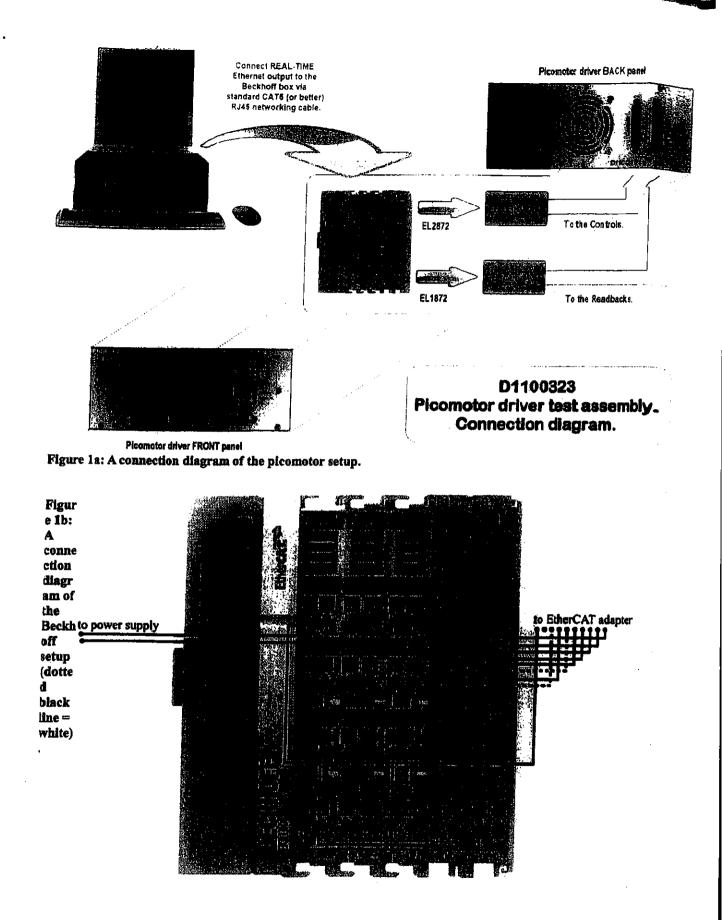
Software:

- 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



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)

 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 powerswitch.
- 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.
- [J 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	of	on
STARTING UP	off	on	flashes	flashes	6¥	on	on
READY	off	on	off	off	GF	m	on
Check if passed:	[4	[4	14	M	[9	ET 1	TT I

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.

^{[4}

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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		[4]	[]	
2		[]	[JV	
3		[]	[]	
4		[]	[]	
5		H	[]	
6	_	arphi	[4	
7		\mathcal{V}	[]	
8		[]	[}	

Select output terminal 1 and do the following:

М

CZ

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	CWX	CW Y	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[]	[]	[]	[1-	

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 theck 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)	[4	M		
MEDIUM (100)	[]			
MAGNUM (10000)	[]	19		

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)	[]	17		
JOG (50Hz)	[]	II		
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)	Terr	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.93	25.70
2	27.1C	27.00
3	28.35	28.24
4	29,44	29.44
5	36.39	36.46
Check if passed:	H	14

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 0 n e 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	[4]	[4]				
2	[4	[]				
3	[4]	[]				
4	[4]	17				
5	[4]	11				
б	- IY					
7		[1				
3	M					

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

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[Y	11				
2	[4]	11				
3	[4]	17				
4	[4]	11				
5		[]				
5		[]				
7						
3	N N	[+				

Testing Summary

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

Front panel LEDs	Pass	[] Fail	
Sep 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

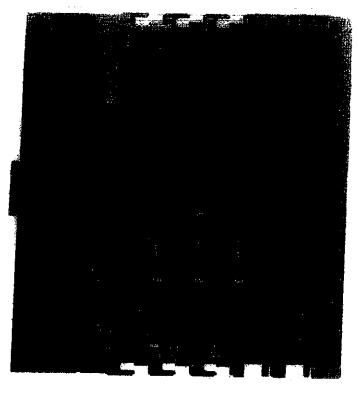
Ngure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel

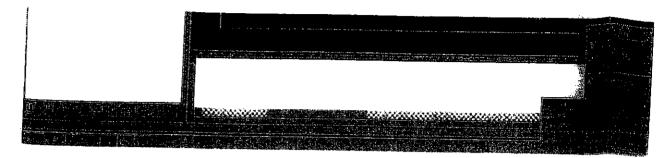




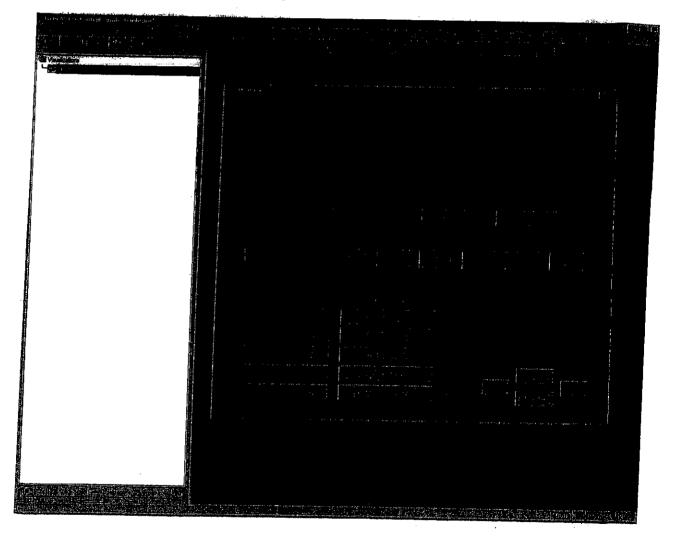


Appendix B: PLC Controls

Figure 5: Step 3 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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: <u>geco.cu@gmail.com</u>

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ltherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

[4PASS

51107571 ZachG 11/29/4

[] FAIL

Overall picomotor chassis testing:

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)

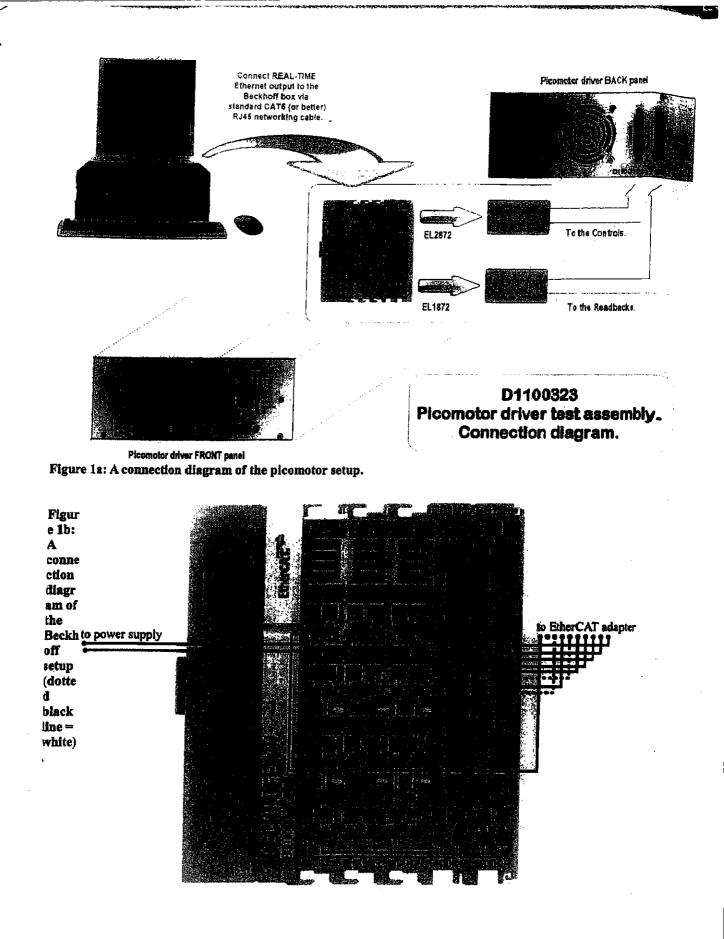
Software:

- 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



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:

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Check that the "ON" LED is lit if the power cable is connected and the powerswitch 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 powerswitch.

[] 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	SN	off	on
STARTING UP	off	on	flashes	flashes	6H	on	on
READY	off	on	off	off	64	m	57
Check if passed:	[]	[7	[1	17	17	H	H

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	L	ED
	Left	Right
1	[4]	[]
2	[/ [/	[]
3		[1
4	[}	[]
5		[]
6		1
7	E E	[1]
8		[]

Select output terminal 1 and do the following:

14

M

[] 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:	[]	Ł	[]	[]		

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 theck 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)	[4]		
MEDIUM (100)	[4	1	
MAGNUM (10000)		11	

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)	[1]	1		
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	29.07		
4	26.23	25.21		
5	27.28	26.27		
Check if passed:	[]	[4		

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" of "DOWN")				
1	[4]	[/				
2	[.]					
3	[]	[/				
4		11				
5		[]				
6		[]				
7	1 1					
3		[¥]				

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

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[1	[]			
2	[1	11			
3	[]	[<i>1</i>			
4	[1	[1			
5	[1	[7			
б	[]	ΓX			
7					
3		[<i>X</i>			

Testing Summary

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

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

Test Engineer: Zach C Test Date: 11/24/11

Additional Comments:

24

Appendix A: Physical Components

Ngure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel

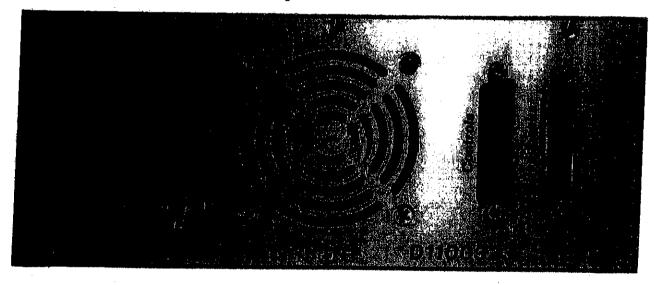
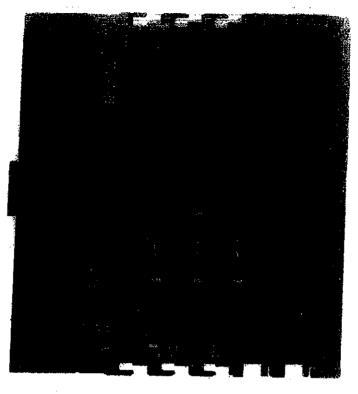


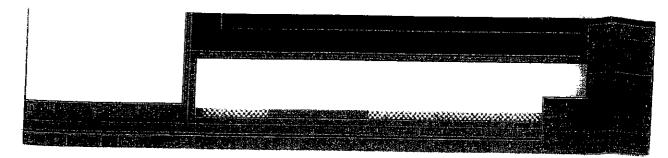
Figure 4: EtherCAT configuration



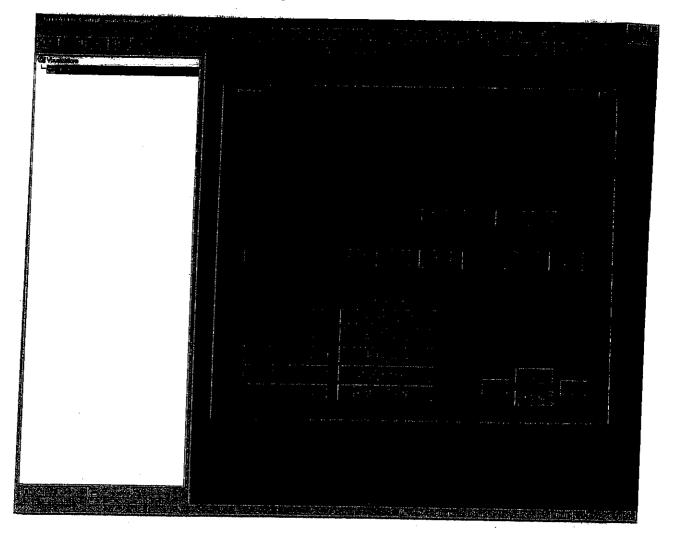
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Appendix B: PLC Controls

Figure 5: Step 3 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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: info@ligo.caltech.edu Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor	controller	chassis	LIGO	DCC#	

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

[YPASS

D1100323-v1

na na kalendara kalendara ya

51107572 Zach G 11/29/11

[] FAIL

Overall picomotor chassis testing:

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)

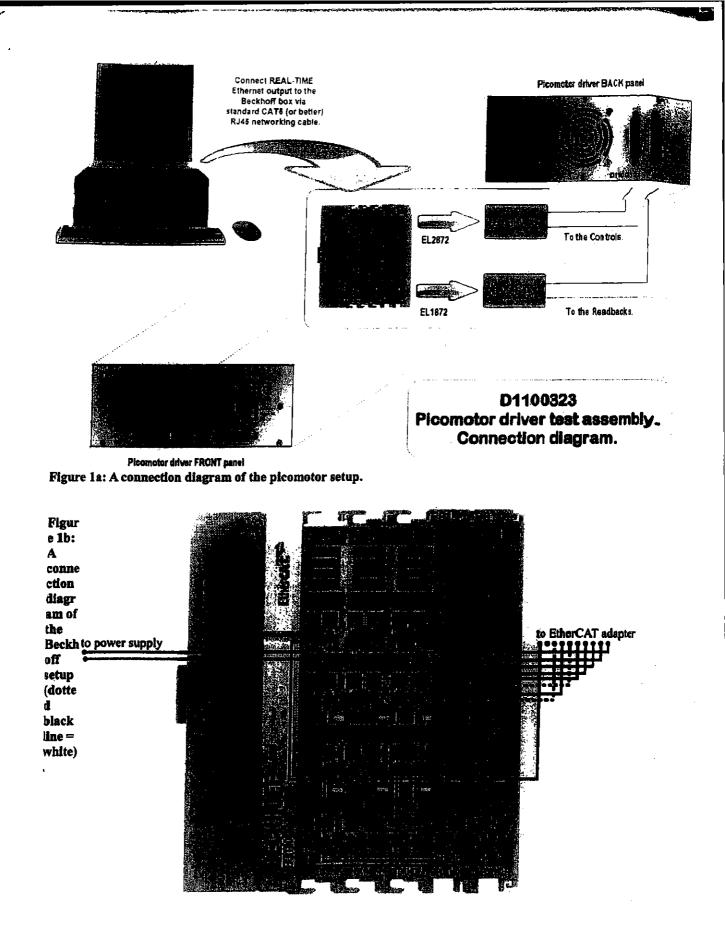
<u>Software:</u>

- 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



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 powerswitch 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 powerswitch.

['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	COFF	on
STARTING UP	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	m	5
Check if passed:	[4	[4]	[4]	14	14	1	-14-

Table 1: LED response to picomotor status

[4]

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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		
	Lei	ft Right		
1				
2	[۲	Y Y		
3		V II		
4	[4]	r, rí,		
5	- V			
6	H	· H		
7	[]			
8	N [์ เวิ		

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:	М	[]	IJ	[]	

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 there visualization screen, make sure the picomotor is enabled and that the motor clicks and then a direction. Check that the motor runs for a longer time (the motor clicks and turns at truns) as you increase the step size for each axis (X and Y): when it runs) as you increase the step size for each axis (X and Y):

	<u>[]</u>	(00001) MUNDAM
[بر]		MEDIUM (100)
		NEKK SWFLL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA	7	szis qəts

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the atatus is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Selecta 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):

[]	[]	SPRINT (500Hz)
<u>ا</u> ر ا	[/]	10G (20Hz)
[v]	[م]	CRAWL (1Hz)
Y ("UP" of "DOWN")	X(u < u of u > u)	
sixA	Speed	

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	:	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	[4	[]			
2		[]			
3		[]			
4	[]	1			
5		[]			
6		[]			
7		r1			
3		EI			

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

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	U V	[]			
2		IT.			
3		[]			
4	[7	[]			
5	- [}	[7			
6	- V	[]			
7	[]				
8		ĨZ			

Testing Summary

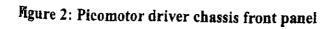
For each test, indicate the results in the table below:

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

Test Engineer: Z_a ch C Test Date: $1/2^{n}/1$

Additional Comments:

Appendix A: Physical Components



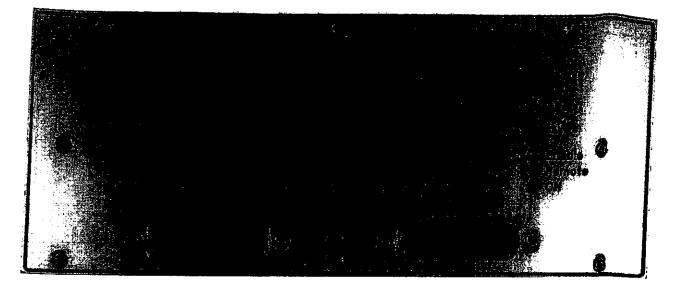


Figure 3: Picomotor driver chassis rear panel

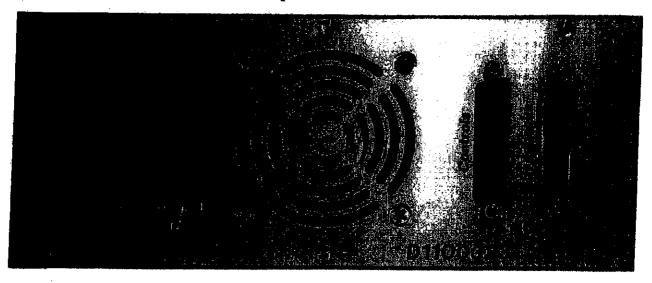
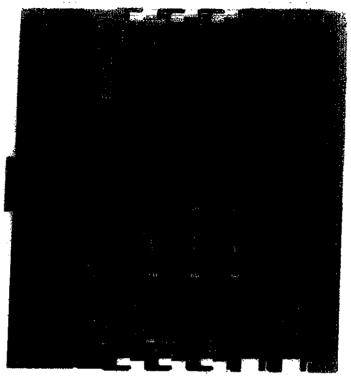
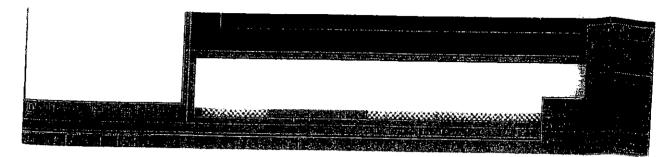


Figure 4: EtherCAT configuration

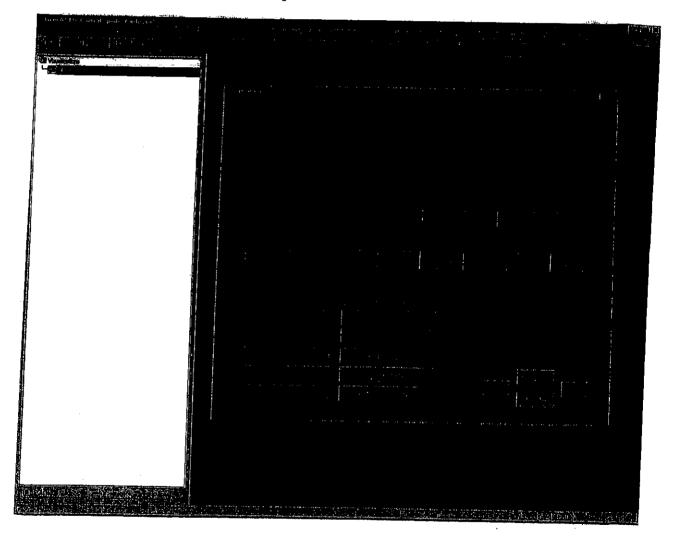


Appendix B: PLC Controls

Figure 5: Step 3 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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

D1100419-v3

[PASS

51107573 Zach G 11/29/11

[] FAIL

Overall picomotor chassis testing:

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)

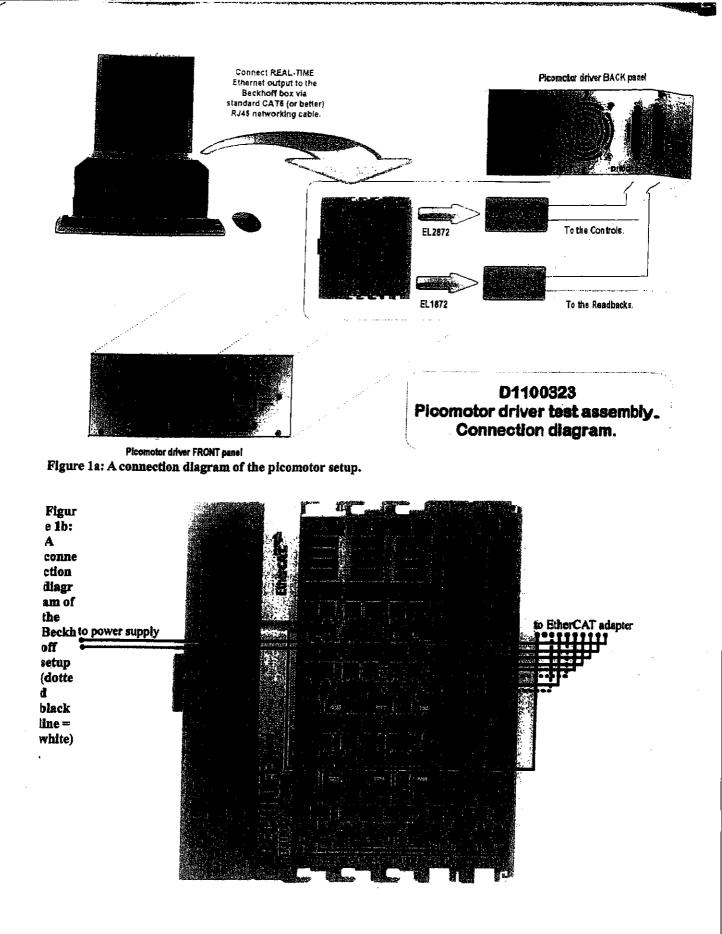
Software:

- 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



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 powerswitch 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 powerswitch.

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	OA	00
STARTING UP	off	on	flashes	flashes	off	m	67
READY	off	on	off	off	off	m	(m)
Check if passed:	[]	[]	[]	11	[]	[]	IY

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	L	ED
	Left	Right
1	[1]	[4]
2	[4]	[Y]
3	M	[4]
4		[]
5	[4	[]
6		[]
7	[1	[1
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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[4]	[]	[}	-1	

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 theck 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)	[4	[9	
MEDIUM (100)	[4		
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)	[T]	17	
SPRINT (500Hz)	[}	17	

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:	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" of "DOWN")			
1	64	[1			
2	[v]				
3	[•]	[]			
4	[.]	[]			
5		[1			
6		[}			
7	[1	[]			
3	[]	57			

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

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	H	15			
2		1			
3	[1]	[T			
4	[]	[]			
5		[+			
5	1 1	[]			
,					

Testing Summary

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

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

Test Engineer: Zach G Test Date: 11/24/11

Additional Comments:

Appendix A: Physical Components

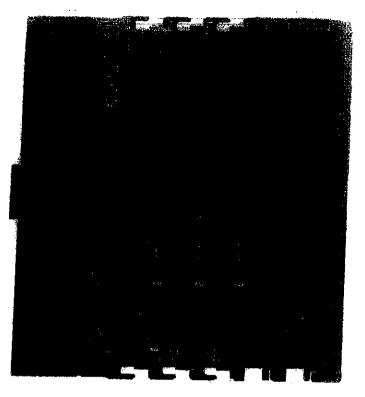
Ngure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration



14 of 15

Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

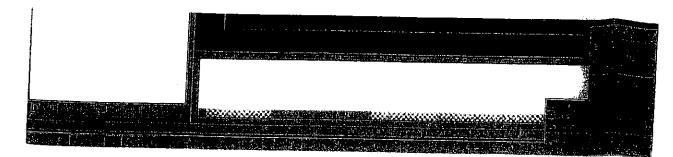


Figure 6: Step 5 of PLC controls setup

			<u>Produk</u> Rođeni

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.

California Institute of Technology LIGO Project – MS 51-33 Pasadena CA 91125 Phone (626) 395-2129 Fax (626) 304-9834 E-mail: <u>info@ligo.caltech.edu</u> Massachusetts Institute of Technology LIGO Project, MIT NW22-295, 185 Albany St., Cambridge, MA 02139 USA Phone (617) 253 4824 Fax (617) 253 7014 E-mail: info@ligo.mit.edu

Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

D1100323-v1

D1100419-v3

ItherCAT Adapters LIGO DCC#

Controller Serial #

Test Engineer:

Test Date:

Overall picomotor chassis testing:

PASS [] FAIL

S1107674 Zach C

11/29/11

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:

- IPicomotors (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)

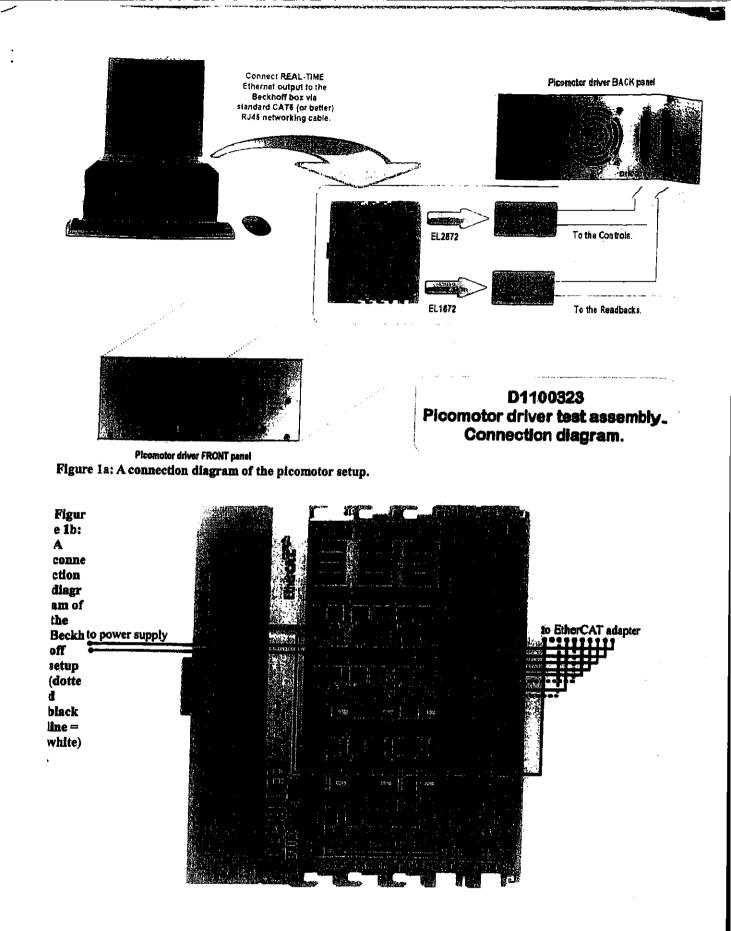
<u>Software:</u>

- 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



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 powerswitch 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	C	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power	
DRIVER DISABLED	on	off	off	off	m	of	01	
STARTING UP	off	on	flashes	flashes	off	Sn	m	
READY	off	on	off	off	off	m	on	
Check if passed:	[4	[4]	[]	[4]	1	H	1+	

Table 1: LED response to picomotor status

[4

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.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor 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	[4	[]
2	[4	[]
3		[X
4	L L	[1]
5	[]	
6	H	[1]
7	[Y	[1]
8	N	[1]

Select output terminal 1 and do the following:

[~

M

[] 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	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[-]	H		[]	

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 theck 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)	[4	11
MEDIUM (100)	[]	1
MAGNUM (10000)		1

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)	M	1	
JOG (50Hz)	[]	11	
SPRINT (500Hz)	[了	1	

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)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	12.23	22.31
2	23.54	23.85
3	24.80	25.20
4	25.90	26.32
5	26.90	27.46
Check if passed	H H	[4]

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	[']	[4			
3		[]			
4	[]	[] []			
5	- U	IV			
6		[]			
7	[1	رې ۲			
3	[]	[]			

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

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	N	[1	
2	[]	11	
3	[1]	[7	
4	[1]	[]	
5	[X	[X	
5	[}	[1]	
7			
3		[-] [-]	

Testing Summary

• 4

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

Front panel LEDs	[JPass	[] 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:

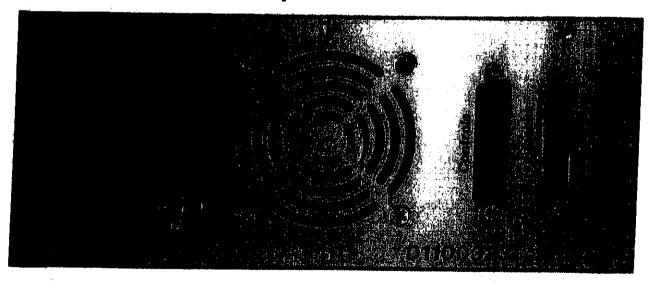
1.1

Appendix A: Physical Components

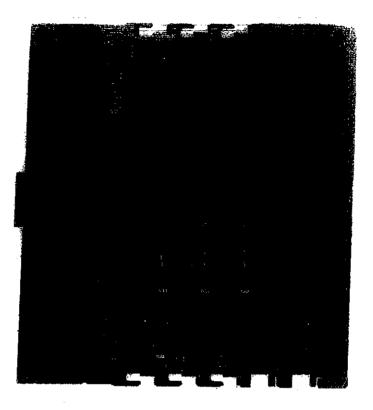
Ngure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel

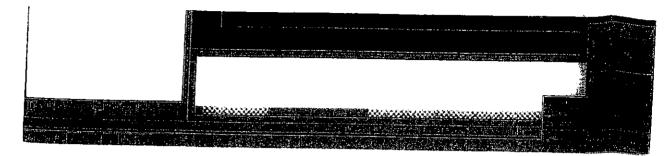




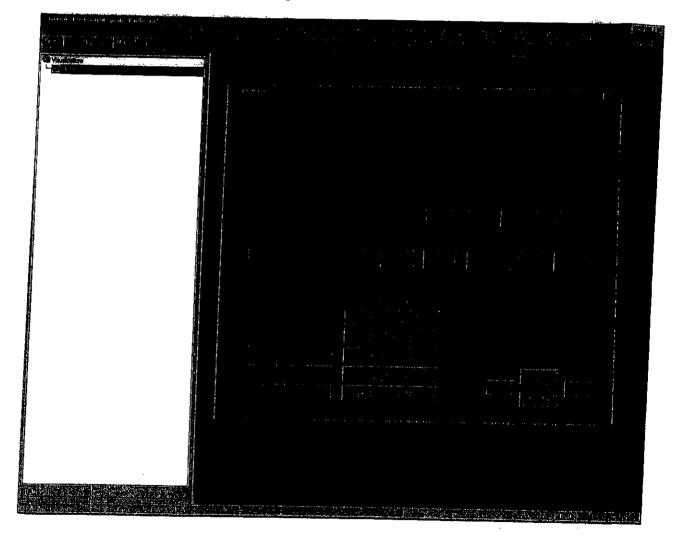


Appendix B: PLC Controls

Figure 5: Step 3 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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

Controller Serial #

fest Engineer:

Test Date:

D1100419-v3

PASS

SH07575 Zach G 11/29/11

[] FAIL

Overall picomotor chassis testing:

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)

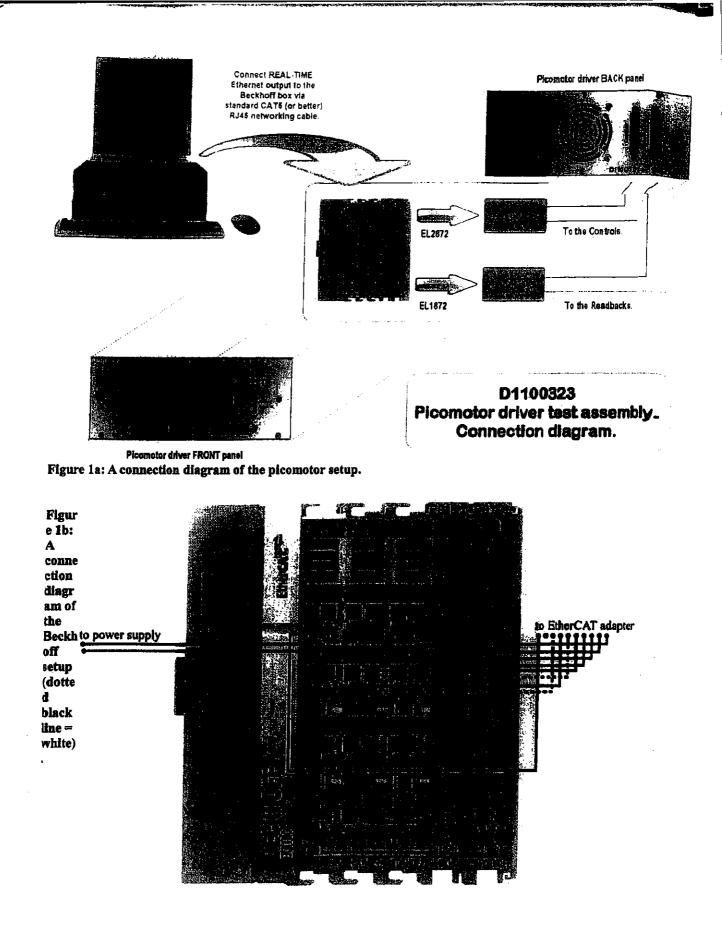
Software:

- 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



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 powerswitch 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 powerswitch.

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

[4] 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	cn	off	on
STARTING UP	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	J.
Check if passed:	[Y]	[4]	[4]	H	ET	[7	1

Table 1: LED response to picomotor status

1

ГЛ

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.

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

[U 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	L	ED
	Left	Right
1	[4	[1]
2	[4	$\{\mathcal{F}\}$
3	[Y	[]
4	[]	[]
5	[]	[7
6		[}
7	(X	[]
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	CWX	CW Y			
DOWN	off	on *	off	on **			
UP	off	on *	off	off			
>	on *	off	on **	off			
<	on *	off	off	off			
Check if	passed: [y	[]	[7]	£]			

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 the visualization screen, make sure the netor then select "SPRINT (500Hz)" under "SPEED". Select a the size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns the size and then it runs) as you increase the step size for each axis (X and Y):

		(00001) MUNDAM
<u>_</u> []	_h]	MEDIUM (100)
[الم	[مر	VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA	·	Step Size

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", Selecta 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):

sixA		Speed
	X (^{n < n} OL ^{n > n} $)$	
	<u></u>	CRAWL (1Hz)
	_₹]	10G (20Hz)
		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	2904	27.57		
5	30.04	28.59		
Check if passed:	[4	4		

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	[4]	[7			
2	[1]	[]			
3	M	[7]			
4	[]	[1			
5		[]			
6		[1			
7	[}	1			
8	[7	[1			

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

Terminal		Axis					
	X ("<" or ">")	Y ("UP" or "DOWN")					
1	[1	1					
2	1	И					
3	 [Ă	11					
4	۲ [۲	17					
5	[1	[]					
6	1 11	r ī					
7		[1]					
3	1	ر ۲ ۲۲					

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

Hgure 2: Picomotor driver chassis front panel

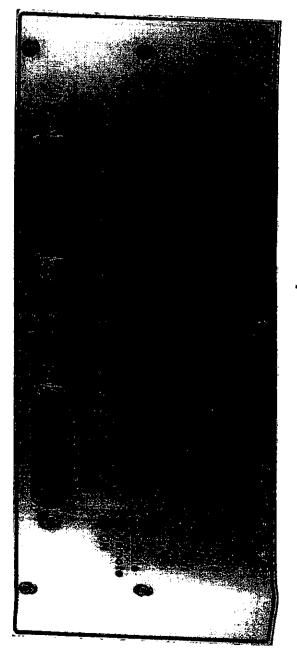
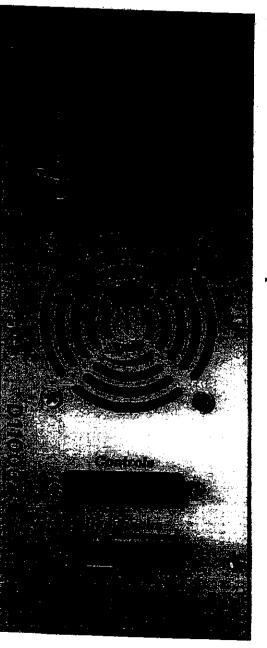
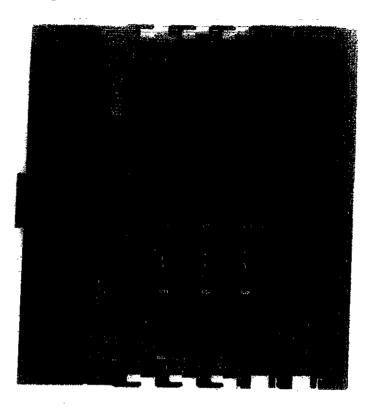


Figure 3: Picomotor driver chassis rear panel







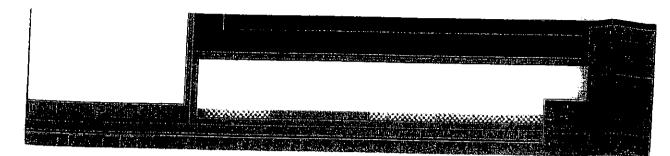
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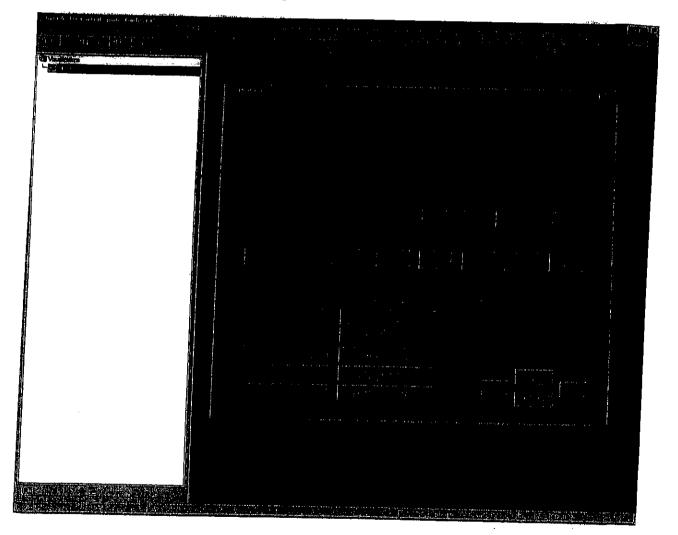
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Appendix B: PLC Controls

Figure 5: Step 3 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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Columbia University Columbia Astrophysics Laboratory Pupin Hall - MS 5247 New York NY 10027 Phone (212) 854-8209 Fax (212) 854-8121 E-mail: geco.cu@gmail.com

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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

Controller Serial #

Test Engineer:

Test Date:

Overall picomotor chassis testing:

Signature/Initials:

5/167576 Zach 12/21/11

[9 PASS

[]FAIL

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)

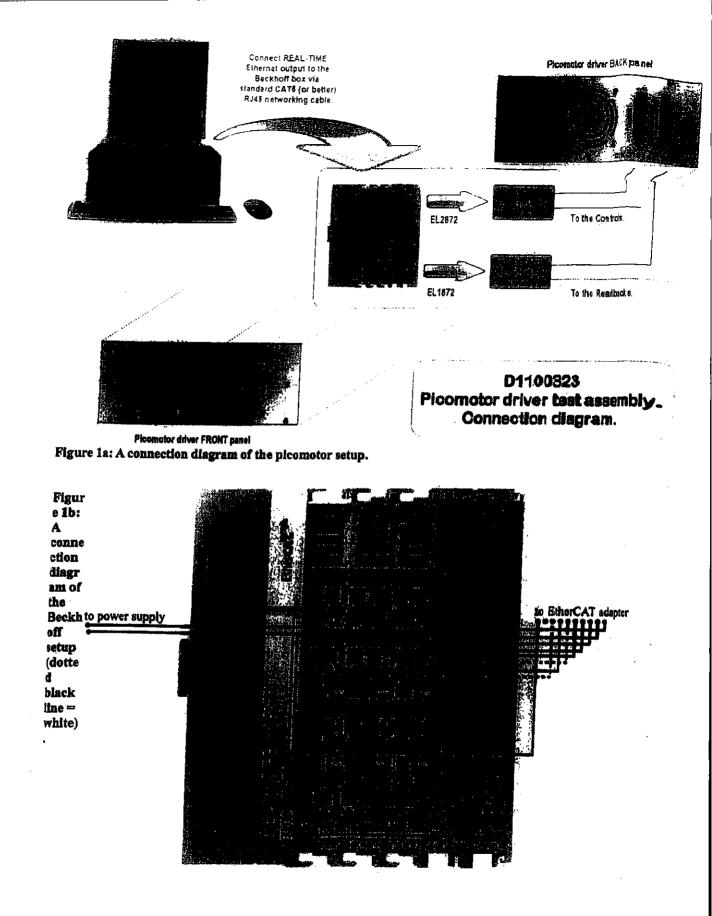
Software:

- 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



5 of 15

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 popsup, 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	m
READY	off	on	off	off	085	on	on
Check if passed:	[]	[]	[]	H	[]	[]	[]

Table 1: LED response to picomotor status

[1]

[1]

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	L	ED
	Left	Right
1	[9	[]
2	[]	[]
3	[]	[]
4	[]	[]
5	[]	[]
5	[]	[]
7	[]	[]
3	[]	

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:	[]	[1	[Y]	P1		

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 theck 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)	[]	K	
MEDIUM (100)	[]	IT	
MAGNUM (10000)	1	5	

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)	[]	11	
JOG (50Hz)	[]	IT	
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:	H	K		

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" of "DOWN")			
1	[0]	[]			
2	[4	1			
3	[]	17			
4	[]	17			
5		11			
5		1			
7	[]	[1			
3		Γ <i>Χ</i>			

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

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[]	11			
2	-[]	1			
3	[]	1			
4					
5	1	r 1			
6	1	ГЛ			
7		ГТ			
3	7. 17				

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: 12/21/11

Additional Comments:

12 of 15

Appendix A: Physical Components

Ngure 2: Picomotor driver chassis front panel



Fgure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration

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14 of 15

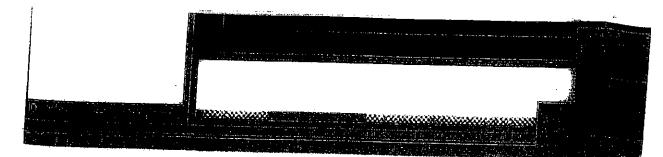
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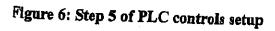
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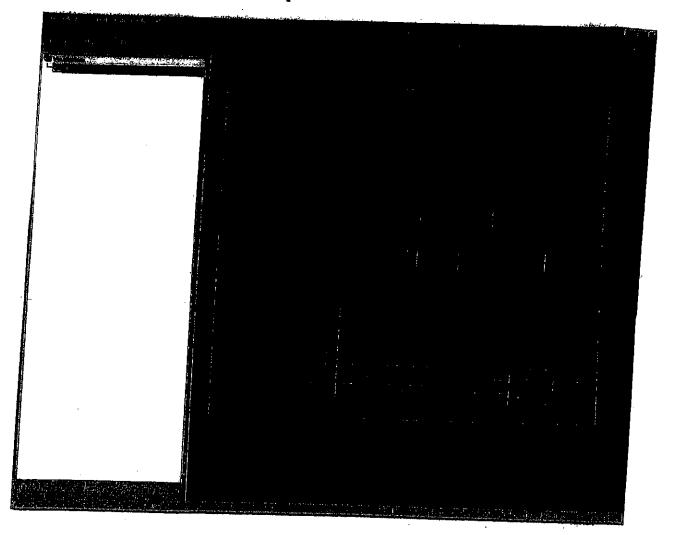
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Appendix B: PLC Controls

Figure 5: Step 3 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

licomotor controller chassis LIGO DCC#

D1100323-v1

ItherCAT Adapters LIGO DCC#

D1100419-v3

5 1107577 Zachary 12/21/11

Controller Serial #

Test Engineer:

Test Date:

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)

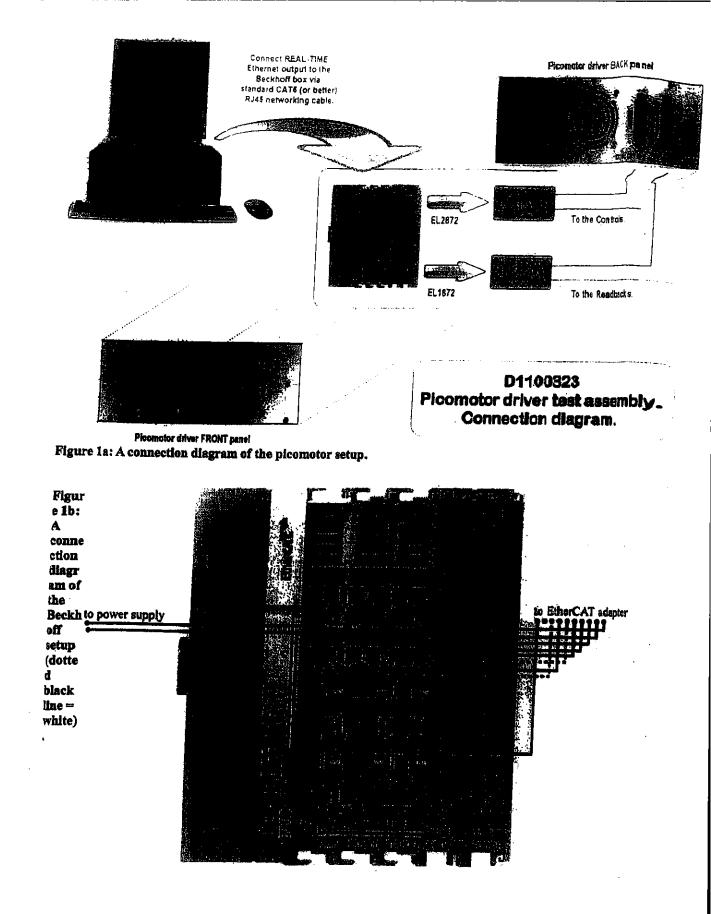
Software:

- 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



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 popsup, 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.
- [Y Check that the "ON" indicator on the visualization also responds to the powerswitch.
- [] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [f 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	m	off	02
STARTING UP	off	on	flashes	flashes	off	000	
READY	off	on	off	off	Æ	on	m
Check if passed:	[4]	[4]	[]	[]	ET	FT	11

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).

[9 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	L	ED
	Left	Right
1	[4	[]
2	[]	[]
3	[]	[]
4	H	[]
5	[]	[]
б	[]	[]
7	[]	EJ
3	[]	H

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	CWX	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 the visualization screen, make sure the picomotor is enabled and that the status is "READY", select a there is and then a direction. Check that the motor runs for a longer time (the motor clicks and tourns when it runs) as you increase the step size for each axis (X and Y):

	<u>[]</u>	(00001) MUNDAM
	[-]	MEDIUM (100)
	F]	VERY SMALL (1)
J") Y	X ("<" or ">") X	
sixA		szis qəts

3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and 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):

sixA		pəədS
Y ("UP" or "DOWN")	("<" ro ">") X	
£]	[]	CKAWL (1Hz)
_{]	[]	10G (20Hz)
	N	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	210-32	26.92		
4	29.50	28.18		
5	28.59	29.37		
Check if passed:	[]	IT		

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" of "DOWN")			
1	[]	[]			
2	[]	[]			
3	[]	17			
4	[]	IT			
5	[7]	[]			
5	[r	5			
	[]	[X			
	[]	[1			

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

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[]	11		
2	1	[]		
3	[]	[Y		
4	[]	IX		
5	[1]	L.		
б		r/1		
7		r í		
3		1		

Testing Summary

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

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

Test Engineer: Z= CF 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

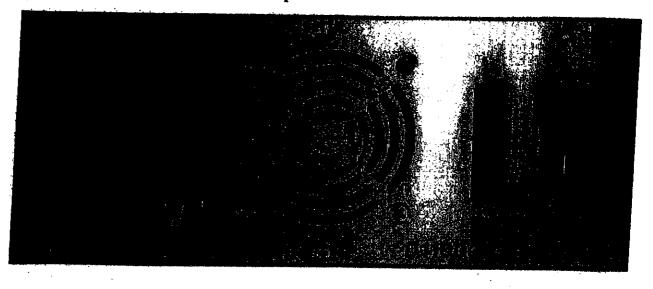
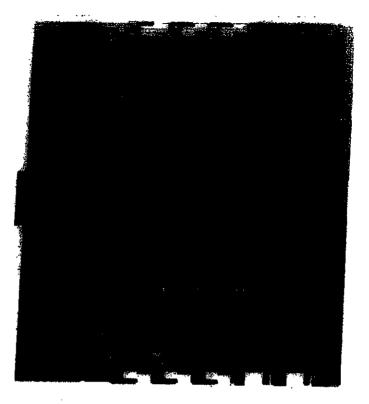


Figure 4: EtherCAT configuration

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Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

