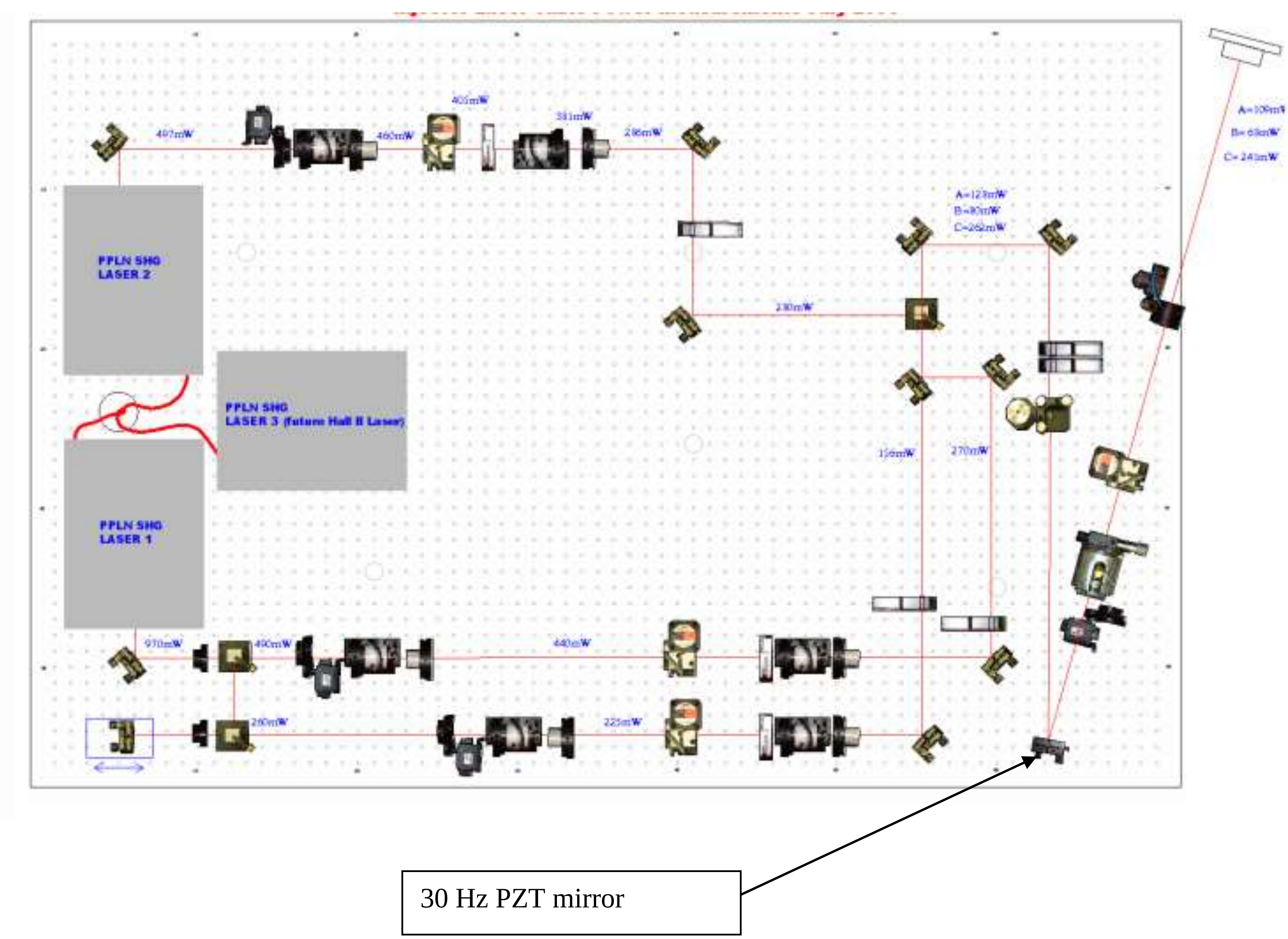
Note by Hansknecht 1-7-2019. This system was designed in 2007 as a "quick solution" to a request by CASA. It was not intended to be permanent, so there is no spare and there is no PicBasicPro on a pc to recreate the code. It is my belief that it has only been used a handful of times in the 11 years it has been installed. It is best to use as is and if it fails it should be redesigned to not utilize a microcontroller. This would have been easy in standard TTL logic, but for a while I was using microcontrollers because they were easier. I failed to realize the future would make them obsolete. Original documentation follows below:

30 Hz PZT Documentation

Purpose: The 30 Hz PZT is a device used by CASA to help analyze the orbit of the electron beam and perform adiabatic damping calculations.

Ownership: The system is maintained by the Electron Gun Group.

How it works: The laser beams from the three hall lasers get combined into a single beam as demonstrated below.



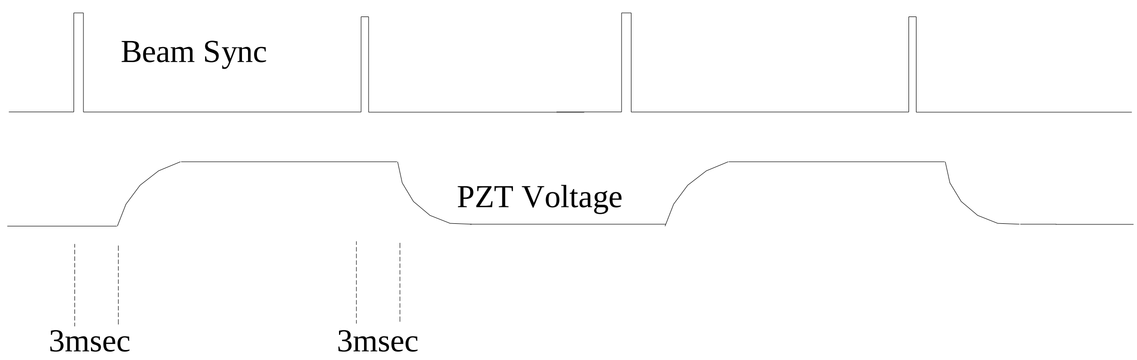
The 30 Hz PZT mirror is the last mirror that the beams hit before entering the vacuum chamber and striking the photocathode. When this mirror is wiggled in the X plane or the Y plane, the beam striking the photocathode moves left-right or up-down respectively.

The piezo mirror is rated to move +/- 18 arc seconds when a maximum voltage of 150 volts is applied. When this anglular motion is applied over the distance of throw to the cathode, the resulting spot motion is on the order of 300 um. ??

A PZT mirror assembly. Thorlabs Part # KC1-T-PZ ($590 in 2007)

Because the PZT assembly is moving a large mass, the speed of the motion is limited. (i.e. it can't move in microseconds) If we drive the PZT hard, it can damage the ceramic element, so we purposely slow down the motion. Since the BPM's are triggered on beam sync we wanted to make sure that the mirror is settled at the proper position prior to the arrival of a beam sync pulse.

The diagram below shows the timing utilized to drive the PZT.



As you can see, the beam sync signal comes in at 60 Hz. The PZT drive circuit is triggered by beam sync, delays by 3 msec and then applies a voltage to the PZT. This gives the PZT plenty of time to get to the next position before the beam sync comes again. There are two benefits to this type of control:

1. The 60 Hz beam sync becomes a 30 Hz PZT motion
2. The PZT is always in position prior to the BPM sample trigger.

Electronics:

The 30hz PZT is not a machine operations critical device, and is subject to future enhancements or modifications. As such, the electronics that drives the PZT mirror is a "one-off" design. The extent of documentation for this device is contained within this documentation package. There is one unit that is operational and one hot spare in the possession of the electron gun group.

The following is a description of operation of the drive electronics:
(Refer to attached schematic)

The DAC IN pin receives 0 to 10 VDC from the DAC DVME-628 Card #1 channel 7 on IOC-IN3. The R12/R13 voltage divider drops the maximum voltage to 5VDC, (the maximum programming voltage permitted by the EMCO model C02 power supply.)

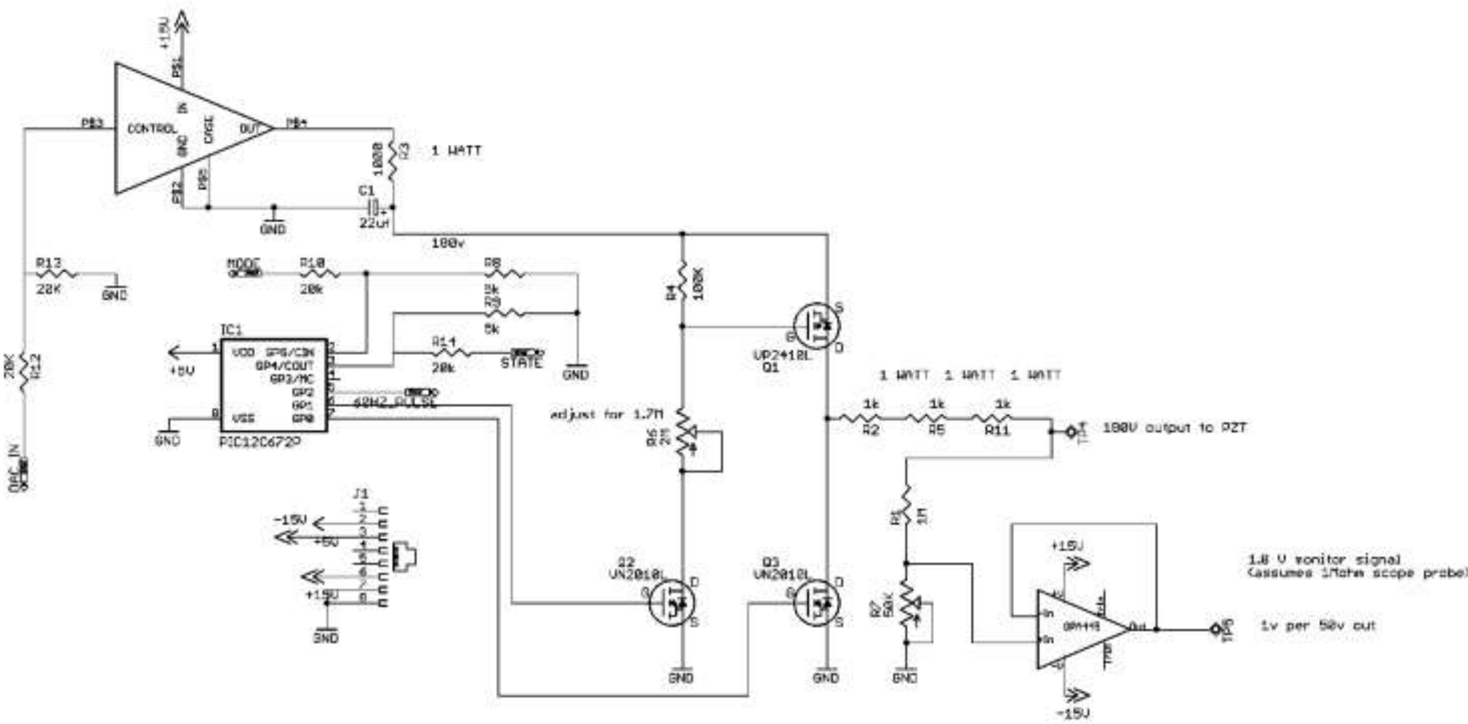
The 0 to 5 VDC is applied to the control input of the EMCO model CO2. This is a programmable DC power supply that will produce up to 200 Volts DC with 5 volt programming. The current from this supply is less than 5mA, so the entire circuit is Jlab Class 1 safe.

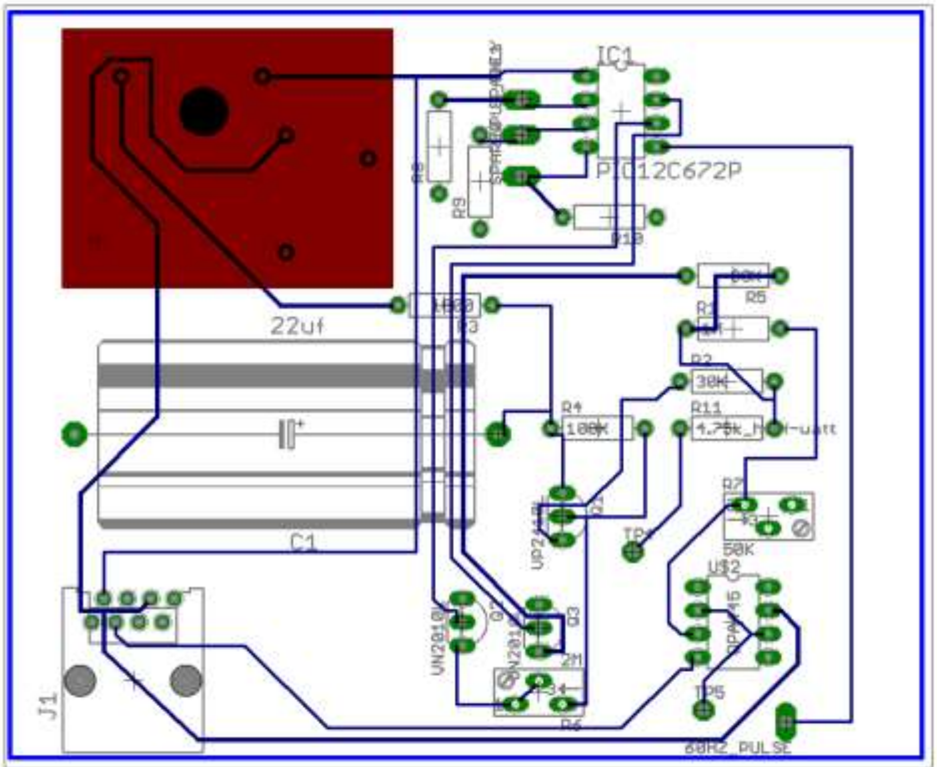
The 200V output is applied to the source pin of FET Q1, and the bias resistors leading to the drain of FET Q2. When Q2's Gate is taken to 5V, the transistor turns on. This projects a ground up to R6, which in turn pulls the gate of Q1 negative with respect to the source. Q1 turns on and applies 200 volts to the output resistor chain.

The resistor chain of R2, R5 and R11 form a voltage divider with R1 and R7. This results in a maximum drive voltage of 180 Vdc at TP4 to drive the PZT. The 3K total resistance times the capacitance of the PZT drive cable form a gentle RC time constant to protect the piezo element from mechanical shock. The OPA-445 Operational amplifier provides a buffered test point for checking the output voltage. 1 volt measured = 50 volts delivered.

Q3 is a FET that can pull the voltage down to ground potential. It is important to ensure that Q1 and Q3 are never on at the same time. IC1, a PIC12C672 microcontroller performs the control timing for driving the FET's.

Circuit power is provided via a CAT5 connector on the board. The circuit required +/- 15Vdc at a maximum 50mA, and about 1 mA of 5Vdc.



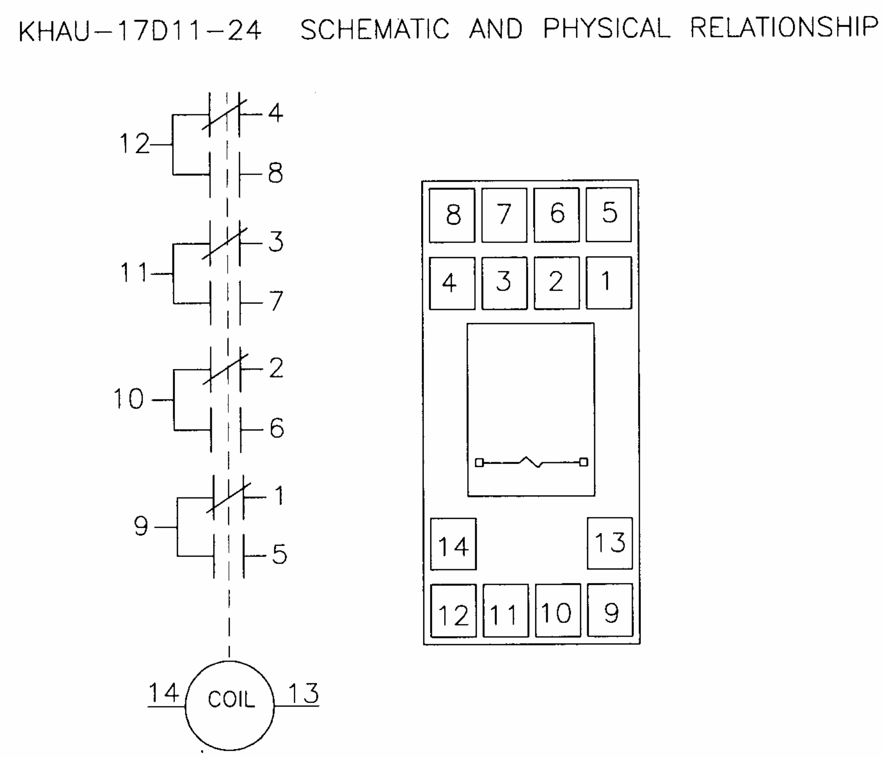


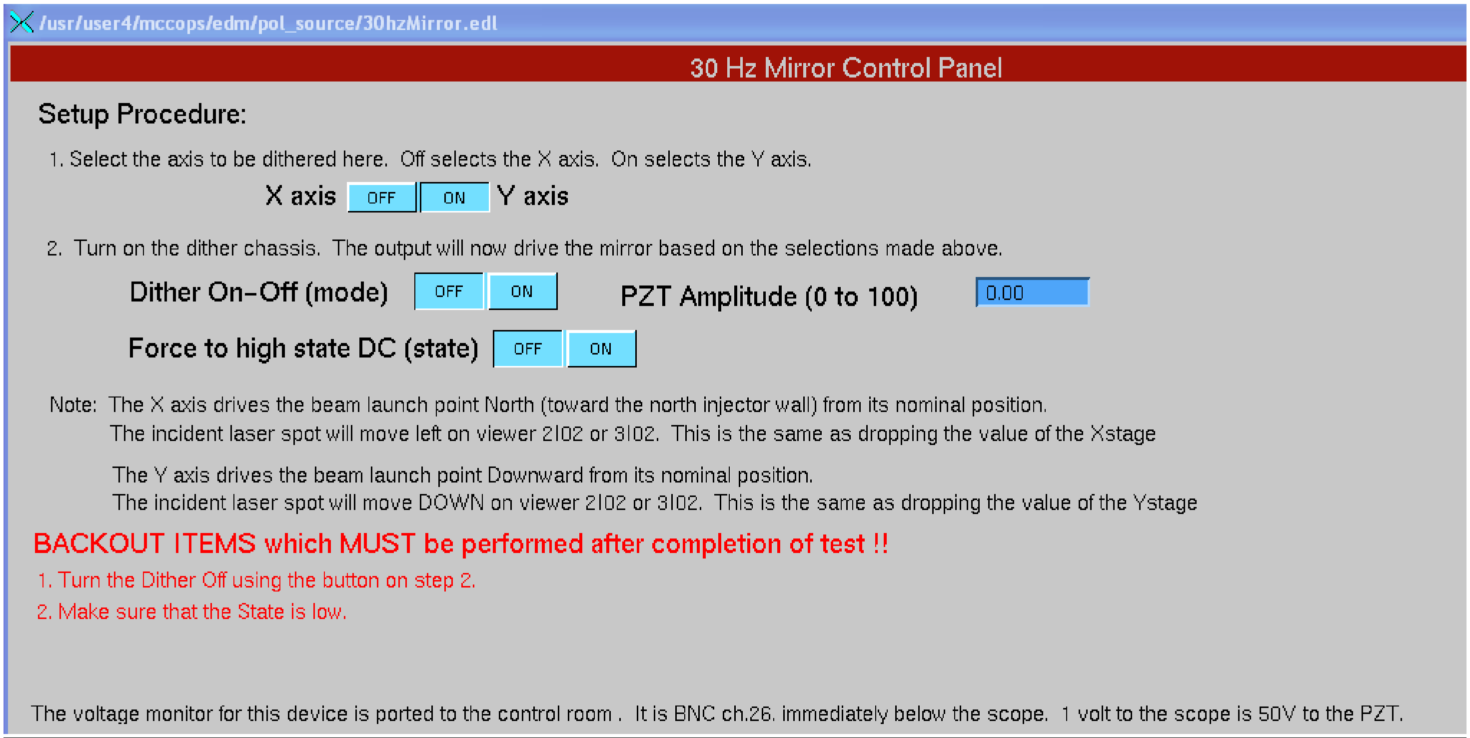
Firmware Code:
The attached code, titled 30hzPZTdrive.pbp, is a PicBasicPro program that is loaded into the PIC microcontroller. The microcontroller has an internal oscillator and runs the looping program when powered. The code is running at 8 MHz, so it has no problem triggering on the 350usec beam sync pulse and setting the transistors to the proper levels. The simple code is extensively commented and can be easily reproduced in C or assembly.

```
'*****************************************************************
'*  Name    : 30hzPZTdrive.pbp                                 *
'*  Author  : John Hansknecht   Josh Brittian                  *
'*  Notice  : Copyright (c) 2004 Jefferson Lab                 *
'*          : All Rights Reserved                              *
'*  Date    : 3/2/2004    Verified to work 3/2/04              *
'*  Version : 1.0                                              *
'*  Notes   :  Program will use PIC12CE674 as a 30hz signal    *
'*          :   source (square wave) locked to beam sync       *
'*****************************************************************
'Programmer settings:  INTRC Oscillator, NO PWup Timer
'                      NO MCLR enabled
'Chip configuration:
      'Pin 1 is VCC (5VDC)
      'Pin 8 is ground
      'Pin 6 is the 30 Hz output
      'Pin 5 is the 60 hz beam sync input


       OSCCAL=$88          'oscillator cal for UV chips. update for each

      ' DEFINE OSCCAL_2K 1  'This sets oscillator calibration in OTP chips
       ADCON1=7             'Sets all pins to digital I/O, not ADC
       TRISIO=%11111101     'Sets GPIO0,as output, all others input.
       'Now let's define the actual pin numbers used in this code
       Pin6 var GPIO.1  'Pin6 is the 30 Hz output (Q3 drive)
       Pin5 var GPIO.2  'Pin5 is the 60 hz beam sync input
       Pin7 var GPIO.0  'Pin7 is the Q2 drive (see schematic)
       high Pin6
       low Pin7

Main:
    If Pin5 = 1 && Pin6=1 then 'beam sync input present and Q3 drive high.
        pause 3                'wait 3 milliseconds
        toggle Pin6             'take Q3 drive low to remove ground from PZT.
        pauseus 500             'wait 500 microseconds
        toggle Pin7             'take Q2 high to apply 180V to PZT
        endif

    If Pin5 = 1 && Pin7=1 then 'beam sync present and Q2 is high.
        pause 3                 'wait 3 milliseconds
        toggle Pin7             'take Q2 low to remove 180V drive from PZT
        pauseus 500             'pause 500 microseconds
        toggle Pin6             'Take Q3 high to apply ground to PZT
        endif
    goto Main
```

Physical Placement:

It is obvious by looking at the schematic above that the circuit in its present form is designed to drive a single piezo element at 30 Hz. The small black plastic box containing this circuit is mounted in the back of rack IN01-B04. The output drive cable with the 30Hz signal is sent down to the laser cleanroom in the injector on BNC patch panel in rack INO1-B03. Mounted under the laser table is a small box containing a KHAU-17D11-24 Potter & Brumfield relay. This relay splits the drive signal from one incoming BNC to two outgoing BNC connectors. Incoming signal is on Pin 12 and outgoing signal is on pins 4 and 8. The coil is driven from IOC-IN3 IP-Opto driver card channel 11, which physically resides on terminal 21 of the IP-Opto breakout connector. The EPIC channel variable name for this signal is ICS1I00MoveT




/usr/user4/mccops/edm/pol_source/30hzMirror.edl
30 Hz Mirror Control Panel
Setup Procedure:
1. Select the axis to be dithered here. Off selects the X axis. On selects the Y axis.
X axis
OFF
ON
Y axis
2. Turn on the dither chassis. The output will now drive the mirror based on the selections made above.
Dither On-Off (mode)
OFF
ON
PZT Amplitude (0 to 100)
0.00
Force to high state DC (state)
OFF
ON
Note: The X axis drives the beam launch point North (toward the north injector wall) from its nominal position.
The incident laser spot will move left on viewer 2I02 or 3I02. This is the same as dropping the value of the Xstage
The Y axis drives the beam launch point Downward from its nominal position.
The incident laser spot will move DOWN on viewer 2I02 or 3I02. This is the same as dropping the value of the Ystage
BACKOUT ITEMS which MUST be performed after completion of test !!
1. Turn the Dither Off using the button on step 2.
2. Make sure that the State is low.
The voltage monitor for this device is ported to the control room . It is BNC ch.26. immediately below the scope. 1 volt to the scope is 50V to the PZT.