AAL

Programmer's Manual

Volume 1

Second Edition

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Preface

This version of the aero-acoustic levitator (AAL) is the culmination of many years of research conducted by Physical Property Measurements, Inc. and its predecessors. Insights gained in earlier versions have been further studied and expanded to enable significantly improved system control and data collection tools.

This generation of the AAL replaces analog control systems with newly designed digital electronics. This change has enabled new software-based systems to manage everything from the transducer output, resonant frequency tracking, sensor feedback optimization, to temperature control of the transducers. We have replaced manual controls with automated processes that respond to dynamic components previously inaccessible to the experimenter.

Significant portions of the architecture were influenced by systems research conducted by the Computing Science Research Center at Lucent Technologies, Bell Labs. The firmware running in the AAL, the systems design, and implementation of the front-end graphics environment using Inferno were all shaped by ideas introduced in Plan 9 from Bell Labs. A key component of the AAL leverages the file service protocol known as 9P2000 (9P) from Plan 9 and Inferno. The standardization on 9P as an interface to the AAL has enabled a clean structure for developing the testing and data collection tools required to calibrate and optimize the instrument. All of these tools leverage software and documentation found in the Plan 9 and Inferno distributions.

The utilities *pscheck(1)* and *scanfreq(1)* detail how using a 9P exported file system can simplify the development of tools required for data collection and analysis. The key system application *console(1)* uses 9P to monitor and control the acoustic system, extending the file system metaphor throughout its architecture. The programs *sensors(1)* and *pyro(1)* utilize concurrent programming techniques of the Limbo language to simplify overall control of the system.

Many thanks are given to the early aero-acoustic levitator inventors as well as the people who worked on and made the ideas of Plan 9 and Inferno available.

Jeffrey Sickel

Corpus Callosum Corporation
June 2011

NAME

intro – introduction to the Aero-Acoustic Levitator

DESCRIPTION

The aero-acoustic levitator (AAL) by Physical Property Measurements, Inc. leverages software based on the *Plan 9* and *Inferno* operating systems. Working with these influential ideas, especially the network protocol *9P*, has enabled a significant change in the overall systems design used in this kind of instrument. The AAL combines real-time embedded controllers built into a distributed cluster, front-end tools leveraging concurrent programming techniques, higher performance CPUs for numerical and graphics processing, and serial interfaces to various third party devices.

In order to be more flexible, certain utilities used in the system are based on Plan 9 from User Space, a port of many Plan 9 programs to Unix-like systems. Information about Plan 9, Inferno, the 9P file protocol, and Plan 9 from User Space are available on-line.

The programs that make up the user interface and tool chain for calibration are written in the language Limbo. Refer to Inferno documentation to learn more about the Limbo programming language and the Dis virtual machine. Shell scripts in both Inferno and Linux terminals are used to access the AAL file system. Additional *grap* programs enable quick plotting of common data analysis tasks.

The *console*(1) is the primary interface for controlling the AAL. The interface provides a quick reference to monitor system frequency and control the driving sound pressure level (SPL) required for acoustic levitation and sample stabilization. Position and spin control parameters can be easily set by the operator and logged as a part of the experimental record.

Commands

The front end software is built around command line programs and several graphics interfaces, both described in section 1. The designers attempted to follow guidelines from various UNIX, Plan 9, and Inferno tools when implementing all of the AAL components.

Firmware

The AAL communications controller uses the file protocol 9P to provide a file system interface to end user applications as described in section 4. Familiarity with 9P, though not required, will be beneficial to the AAL application programmer. The following documentation covers the data structures and API required to tune programs and write additional utilities for the AAL.

Communication between the distributed nodes of the AAL uses a custom protocol called *AALCall* described in section 3. The *AALCall* protocol eliminates the required response messages found in 9P. This modification keeps the number of bytes transferred to a minimum.

SEE ALSO

Section (1) describes general publicly accessible commands.
Section (2) for Limbo modules, specific to the AAL.
Section (3) for firmware documentation.
Section (4) for file services (accessed by ‘mount’).
Section (5) for file formats and system conventions.
Section (6) for administrative modules and system services.

Plan 9	http://plan9.bell-labs.com/plan9/
Inferno	http://www.vitanuova.com/inferno/index.html
9P	http://plan9.bell-labs.com/magic/man2html/5/intro
Plan 9 from User Space	http://swtch.com/plan9port/

NAME

aal/calibtran – AAL transducer control board calibration

SYNOPSIS

`aal/calibtran` [`-d`][`-l` *log*] `-t` *transducer*

DESCRIPTION

Calibtran is a utility for capturing transducer controller calibration data.

The options are:

`-d`	Sends additional debugging messages to standard error.
`-l` *log*	Write collected data to *log* file instead of the default *t*.txt
`-t` *transducer*	The *transducer* and controller board number [1-6] used for data collection.

The command line interface facilitates collection of measured voltage, current, voltage phase, and current phase. Additional probes need to be attached to the backplane connection points to measure the V-I phase delta, voltage and current.
The commands are:

`freq` *n*	Set the operating frequency to *n* kilohertz.
`gain` *n*	Set the pre-amp output gain to *n*. The value is inverted with a zero output of *3584* and a maximum output of *512*.
`m`	Report the measured values from the transducer controller.
`s` *d v i*	Store and log the measured values including the entered *delta*, *voltage*, and *current*.
`help/?`	List a command summary.
`quit`	Exit the program and close the log file.

SOURCE

`aal/appl/cmd/calibtran.b`

SEE ALSO

calibtran(6)

NAME

capture – sensor phase data capture

SYNOPSIS

`aal/sensor/capture` [`-i` *file*] [`-r` *rawfile*] [`-s` *n*] [`-q`] [*sensor*]

DESCRIPTION

Capture connects to a sensor, X, Y, or Z, already running in feedback mode and redirects to standard out. The default is to only capture one second's worth of sample data.

The options are:

`-i` *file* read data from a file, do not connect to a sensor.

`-r` *rawfile*
write the data to *rawfile* instead of standard out.

`-s` *n* sample for *n* seconds.

`-q` quiet mode, do not dump data to standard out.

SOURCE

`aal/appl/cmd/sensor/capture.b`

NAME

console – a graphical AAL console

SYNOPSIS

`aal/console` [`-d`] [`-R` *path*] [`-r` *nsecs*] [`-s`]

DESCRIPTION

The AAL *Console* provides a graphical interface for monitoring and controlling an AAL device mounted over *aal9p*(4).

The *console* accepts several command line options:

`-d`	Send additional debugging messages to standard error.
`-R` *path*	Override the default AAL root path, */n/aal*, with the supplied *path* argument.
`-r` *n*	Set the reset counter modulus to *n* seconds.
`-s`	Load data from */n/stats* instead of the default */n/data*.

The *console* window is divided into two sections and additional pop-up windows described below. The default system startup settings are: 0.0 SPL, 22.2 kHz, 0° and 180° phase between each A and B transducers, feedback and SPL/Frequency tracking are off, and all fans are on.
All numeric entry fields (white background) support the use of the Up/Down arrows and PgUp/PgDown keys. The arrows will increase or decrease the value in small, ones or thousands, steps. The page up/down keys increase or decrease in larger, tens or tenths, steps.

Main Frame

The main frame provides a heartbeat connection indicator to the AAL device and enables various system controls. The two entry fields *SPL* and *Frequency* provide a quick mechanism to set the global state of the system.

The checkboxes on each row will track the SPL, frequency, and sensor feedback. The *X*, *Y*, and *Z* boxes allow for finer grain control as to which axes are actually used during frequency and sensor feedback tracking.

Valid ranges for the *SPL* entry field is between 0.0 and 2.0. Typing the number and pressing the return/enter key will send a command to match the output of each transducer to the desired SPL value and start SPL and frequency tracking. System operation does not require the end user to update the frequency as that is tracked using algorithms to match the operating resonant frequency of all six transducers.

The adjustments section provides the ability to update the *Phase A offset* and spin calibration settings. Changing the *phase A* value will update the three axes to the offset entered. The offset value does not persist when the console is exited and restarted. The *spin* button will adjust all three axes spin values to their calculated A-B phase difference based on the equation $sd = sm(F - Fab) + offset$ where *sm* is the spin multiplier, *F* is the operating frequency, *Fab* is the average of the resonant frequency of the A and B transducer.

Transducer Axes Frame

All six controllers are represented by the three transducer axes frames: X, Y, and Z. Each frame presents a quick view of the SPL, phase, spin, calculated A-B spin, fan state, and amplitude modulation. A plot view representing the phase relationship between the bottom, 'A', and top, 'B', transducers is visible below the spin settings and next to an axis reset button.

The SPL entry fields are only valid when the track SPL checkbox is not enabled in the main frame. Phase changes will move the standing wave on the given axis. The spin settings will shift both the A and B phase relative to the other two axes. The modulation section provides a mechanism to use amplitude modulation on a given transducer.

The *spin* button will update the spin settings to the value displayed in the field to the right of the spin entry field. This value is continuly updated using the above A-B equation.

Clicking the `reset` button will return the axis to its default phase and spin settings: A=0 + *phase A offset*°, B=180°, and spin=0°.

Scope Window

The `scope` button opens a graphical scope window. The X, Y, and Z spin settings are presented on the left third of the window. The remaining two-thirds is split up into six graphs, one for each transducer. The plots will show the operating voltage and current amplitude and phase.

Stats Window

The `stats` button opens a graphic view of the transducer controller settings. Each transducer set values of the frequency and output (DAC) gain are visible. The `Vo` and `Io` are sampled 12-bit values from the ADC on the transducer controller board. The `φV` and `φI` represent voltage and current phase as determined in the *phasedetector*(3).

The lower section is populated with calculated values. The fields have a direct correlation to the functions detailed in *math*(2).

FILES

`$home/lib/transducer.cfg` Stored calibration settings for each transducer.

SOURCE

```
aal/appl/wm/console.b
aal/appl/lib/scope.b
aal/appl/lib/stats.b
```

SEE ALSO

calibration(2), *common*(2), *math*(2), *timedio*(2).

NAME

dumpbin – dump TemperaSure file contents

SYNOPSIS

`basf/dumpbin` [*-a*] [*-o file*] [-] [*file*...]

DESCRIPTION

`Dumpbin` reads the contents of each TemperaSure binary formatted *file* and outputs a tab-delimited line for each record. If no file is specified then standard input is read.

The default usage will only output the *time stamp* and the *temp0* fields. Use the *-a* flag to output the complete data record. The `Exactus->Trecord` data object elements represent in each column are:

`time`	A time stamp in milliseconds since the first record in the data set. All time stamps are relative due to latency in the communication and processing of the data. The data is in a guaranteed sequence.
`temp0`	The temperature measured from the main device.
`temp1`	Temperature reading from dual wavelength models. Typically zero.
`temp2`	Temperature reading from dual wavelength models. Typically zero.
`current1`	Photodiode current in Amps form channel 1. Data will be zero if collection mode of the Exactus has been set to temperature only.
`current2`	Photodiode current in Amps from channel 2.
`etemp1`	Internal device electronics temperature.
`etemp2`	Internal device electronics temperature.
`emissivity`	Calculated emissivity value from a table stored in the pyrometer, if enabled.

It will not be unusual for there to only be values in the *timestamp* and *temp0* columns.

The option *-o* will write the output to the *file* instead of *stdout*.

FILES

`~/logs/aal/exactus`

SOURCE

`basf/appl/cmd/dumpbin.b`

SEE ALSO

pyro(1), *exactus*(2), *temperasure-bin*(5)

NAME

noisecheck – sensor detector noise check

SYNOPSIS

`aal/sensor/noisecheck` [`-s`] [`-v`] [*axis*]

DESCRIPTION

Noisecheck collects data from the sensors to assist in determining signal noise received by the Hamamatsu position sensitive detector (PSD). The sensor firmware responds to a `noisecheck` command by sending a stream of data in three columns. The values are the calculated velocity, `VposY`, and the `Vref` sample.

The options are:

`-s` Only run a single set sample set. Otherwise the user is prompted for three runs: one with no filter, one with a 0.3 ND filter, and a final run with a 0.5 ND filter.

`-v` Prompt the user for observable voltages when attaching an oscilloscope.

axis The sensor to sample.

The output data will be written to a file or files in the current working directory.

FILES

`X_noise.g`	Produce a graph of X sensor noise.
`Y_noise.g`	Produce a graph of Y sensor noise.
`Z_noise.g`	Produce a graph of Z sensor noise.

SOURCE

`aal/appl/cmd/sensor/noisecheck.b`

NAME

pscheck – sensor position sensitivity check

SYNOPSIS

`aal/sensor/pscheck` [`-a`] [`-d`] [`-r` ±*range*] [`-s` *spl*] [`-t`] [`-v`] [`-Y`] [*axis*]

DESCRIPTION

Pscheck requires the use of a polystyrene bead for sensor position sensitivity scans. The resulting scan data is used to calibrate the sensor feedback gain. Data files are collected for all three sensors X, Y, and Z, and stored in the current working directory. The data files are named pscheck_Nn.d where 'N' is the axis of sample translation and 'n' is the sensor being measured.

The options are:

`-a` Run check using all transducers. Otherwise only the single *axis* transducers will be on during the run.

`-d` Sends additional debugging messages to standard error.

`-r` *range* Set the ±range from a centered zero position that will be scanned.

`-s` *spl* Set the SPL value. Default is 0.6.

`-t` Turn off the SPL and frequency tracking.

`-v` Prompts the user for VposY and Vref peak-to-peak measurements at each position.

`-Y` Automatically take the defaults at each prompt.

`axis` Sets the axis for translating the sample.

Measurements are taken across the *range* at 10 degree intervals outside of ±40 degrees and at 2 degree intervals between the ±40 degree range. The A (bottom) transducer is the only one that changes its phase. If the *-a* flag is not used, then an *axis* is required for the scan as all of the other transducers will be turned off during the run.

Data collected from the run can be processed with additional programs to determine the proportional gain to use on each sensor.

EXAMPLE

Start up the *aal/console* and run the SPL at 0.6 for a few minutes to let the transducer frequency tracking work. Bring up a shell and start the *pscheck*:

```
aal/sensor/pscheck -a -r 200
```

Follow the instructions to complete the data collection run. On completion, the user can take the pscheck_??.d files and run them through provided grap | troff programs or any other data analysis tool. The file is tab delimited with the column formats:

1 Velocity

2 Sum of the last ten VposY measurements.

3 Sum of the last ten Vref measurements.

4 Sample position in degrees phase from 0.

FILES

`pscheck.g` Produce a graph of all three sensors on each axis.

`pscheckfit.g` Produce a graph of the X, Y, and Z axes by averaging each phase point from the data set collected.

`pscheckfit2.g` Produce a consolidated graph using averaging for each phase point. Each of the axes are centered at the 0° point before being plotted.

SOURCE

`aal/appl/cmd/sensor/pscheck.b`

SEE ALSO

pscheck(6)

NAME

pyro – graphical pyrometer robotic positioning tool

SYNOPSIS

`aal/pyro` [`-d`] [`-c` *config*] [`-e` *path*] [`-l`] [`-s`] [`-z` *path*]

DESCRIPTION

Pyro controls the Zaber linear translators used to position the Exactus pyrometer for optimal temperature measurements. The tool presents a graphical representation of the current position of the pyrometer. The user can click in the graphic frame or key in millimeter XY values to position the pyrometer. Button controls can center, return to chessman (saved) position, and scan a region. Any modifications to the position or scan regions can be saved from the file menu.

All text entry fields respond to keyboard up and down arrow and page-up and page-down keys in the following manner:

`page-up`	Move up or right by 1mm.
`arrow-up`	Move up or right by 0.125mm.
`arrow-down`	Move left or down by 0.125mm.
`page-down`	Move left or down by 1mm.

Options

`-d`	Send additional debugging information to standard error.
`-c`*config*	Use configuration file provided instead of default *$home/lib/pyro.cfg*.
`-e`*path*	Connection to Exactus *path* instead of the default *tcp!iolan!exactus*.
`-l`	Do not create scan log files.
`-s`	Run data simulator instead of requiring an Exactus connection.
`-z`*path*	Connect to Zaber through *path* instead of the default *tcp!iolan!zaber*.

The scan region X and Y buttons will open up a new window to plot data as the Zaber translator moves the Exactus across the provided axis. After the scan has been completed the user may set a new desired position by clicking near the temperature line in the scan window. The click will move the Exactus into the position and leave a mark on the view indicating the change. Clicking anywhere in the window outside of five pixels from the temperature line will not move the Exactus.

FILES

`$home/lib/pyro.cfg`

`$home/logs/aal/exactus`

SOURCE

`aal/appl/wm/pyro.b`

SEE ALSO

exactus(2), *pyroplot*(2), *zaber*(2)

NAME

scanfreq – acoustic frequency scanner

SYNOPSIS

`aal/scanfreq [ -d ][ -g` *gain* `][ -l` *low kHz* `][ -h` *high kHz* `][ -m` *ms* `]`

DESCRIPTION

Scanfreq runs a frequency scan at a given *gain* within the range of *low* to *high* frequencies and prints to standard output. It polls data from the AAL device mounted at `/n/aal` every *ms* milliseconds after setting the frequency. The scan starts at the *high* frequency, steps down in 2 Hz intervals until the *low* frequency is reached. The scan continues back to the *high* frequency.

The options are:

`-d` Send additional debugging information to standard error.

`-g` *gain* Set the fixed gain value. Minimum (zero) is 3584, maximum is 512.

`-l` *low* Set the lowest frequency in the scan, minimum is 22.1 kHz.

`-h` *high* Set the highest frequency in the scan, maximum is 22.3 kHz.

`-m` *ms* Set the millisecond delay for measuring data after the frequency is set.

EXAMPLE

```
aal/scanfreq -g 2500 -l 22.13 -h 22.24 -m 500 > g2500.txt
```

FILES

`/n/aal/data`

SOURCE

`aal/appl/cmd/scanfreq.b`

SEE ALSO

scanfreq(6)

BUGS

The *ms* setting must be coordinated with the AAL communication board to transducer controller board polling frequency.

NAME

sensors – graphical feedback sensor tool

SYNOPSIS

`aal/sensors` [`-d`] [`-c` *config*] [`-h` *host*]

DESCRIPTION

Sensors provides a graphical interface to monitor and control the three AAL feedback sensors.

The command options are:

`-d` Send additional debugging information to standard error.

`-c` *config* Use provided *config* file instead of the default *$home/lib/sensor.cfg*.

`-h` *host* Connect to *host* network address.

On startup the user will need to `connect` to the sensors. This can be accomplished either globally from the top *All: Connect* button, or on a per axis basis. A successful connection will populate the status fields *Laser kHz*, *Switch ON*, *Switch OFF*, *Gain*, and *Cap*. These status fields report the current state of the sensor system.

Feedback is turned on by entering a *gain* value and enabling the feedback (fb) checkbox. Plots on the right present the *X*, *Y*, and *Z* axes data received by the transducer controllers. These plots help the user monitor sensor noise levels and velocity phase corrections.

The entry fields *gain*, *slope*, and *cmd* are the user tools for changing parameters of the feedback system. Entering a *gain* value and pressing return will send a command to change the gain to all connected sensors. On success the sensor gain field will display the entered value multiplied by the proportional gain. The gain displayed is applied to the detected `VposY/Vref` ratio to create a phase change at the transducer.

The *slope* fields display the stored value from the *sensor.cfg* file. These values are used to calculate the proportional gain applied to the global gain value for each sensor. Updates are usually made after running *pscheck*(1). The file menu "Save Profile" will save the slope values for future use in the application.

The *cmd* field is used to send additional commands to the sensor. The commands are:

Kd=n Set the gain to *n* divided by 100.

cap=n Set the maximum phase change cap to *n*. The default is 256 where 127 ≅ 11.54°.

mod=n Set the laser modulation to *n* Hz where *n* is ≥ 100.0.

swtchon=n Toggle the switching state on *n* microseconds after the laser modulation change. The default is 220 (6µs).

swtchoff=n Toggle the switching state off *n* microseconds after the laser modulation change. The default is 397 (10.8µs).

FILES

`$home/lib/sensor.cfg`

SEE ALSO

pscheck(1), *sensor*(3)

BUGS

Connect and *disconnect* button toggling does not properly represent state if the network is down.

NAME

sim – sensor output simulator

SYNOPSIS

`aal/tests/sim` [`-a` *amp*] [`-d`] [`-f` *freq*] [`-h` *hz*] [`-w` *func*] [*path*]

DESCRIPTION

Sensorsim (sim) is a program used to generate output data in the same format as the position/velocity feedback system in the AAL. It was initially designed as a testing framework for controlling transducer phase feedback changes. Later it proved to be a good mechanism to prove out the sensor plot code used in *sensors*(1).

The options are:

`-a`*amp* Sets the output amplitude, default is 10.0.

`-d` Emits received input to stdout.

`-f`*freq* Sets the output frequency of the function.

`-h`*Hz* Sets the frequency of the output sent by the simulator.

`-w`*func* Start with the *function* out of: *random*, *sawtooth*, *sine*, *square*, or *triangle*.

`path` The control file path. This may be either a file path for reading/writing or a network address to announce a listener for incoming connections.

SOURCE

`aal/appl/tests/sensorsim/sim.b`

NAME

timing – sensor timing test tool

SYNOPSIS

`aal/sensor/timing` *sensor*

DESCRIPTION

Timing runs a series of communications tests on the *X*, *Y*, or *Z* position sensor. Each set of tests is run ten times and averaged. The final output result is in milliseconds. Reported ADC samples are from 40K samples/second with every ten samples being averaged and stored for use in the sample counter. A millisecond timer is used on the user's computer and ends up measuring the start and end time. Attempts are made to accommodate for the start and stop text transmission being counted in the total time. The tests are:

`1000` ADC samples, no PID

`1000` ADC samples, with PID, no output

`1000` ADC samples, with PID, transmit 3 byte output

`1000` Noisecheck outputs, PID with Yn, P, D, Vposyn, Vrefn

NAME

uc2k – graphical Synrad laser controller interface

SYNOPSIS

`aal/uc2k [ -c ] [ -d ]`

DESCRIPTION

Uc2k is a simple interface to the Synrad UC-2000 laser controllers. The AAL uses two controllers, labeled *one* and *two*. The interface allows for either one, two, or both laser controllers to be used to control the pulse width modulation (PWM) and lase on/off settings.

After starting the program, the user must initiate the serial connection to the controller. This is handled through two buttons to the left and right of the labels *1* and *2*. The buttons will turn green when the connection is made. Closing the connection will shut off the laser.

The PWM fields are used to manually control the values sent to the controller. All text fields will also respond keyboard up and down arrow keys as well as page-up and page-down in the following manner:

`page-up`	Increase PWM by 5.0%.
`arrow-up`	Increase PWM by 0.5%.
`arrow-down`	Decrease PWM by 0.5%.
`page-down`	Decrease PWM by 5.0%.
`a A z Z`	Set PWM to 0.0% and turn LASE off.

The *1*, *LASE*, and *2* buttons are used to turn the lasers on and off. When the laser is on the corresponding button will have a red background. Use the *LASE* button to turn both controllers on or off simultaneously.

OPTIONS

`-c` Do not use a checksum when communicating with the UC-2000 Controller. This allows uc2k use on UC-2000 Controller firmware versions prior to v2.4 or when the checksum feature has been disabled.

`-d` Output additional debugging information to standard error.

FILES

`$home/logs/aal/uc2k/`

SOURCE

`aal/appl/cmd/synrad/uc2k.b`

SEE ALSO

uc2000(2)

BUGS

The use of dial in the *uc2000*(2) module does not handle connections well when the UC controllers are not turned on by the operator.

NAME

intro – introduction to Limbo modules specific to the AAL

SYNOPSIS

```
include "aalutil.m";
include "common.m";
include "calibration.m";
include "aalmath.m";

util: AALUtil;
common: AALCommon;
      aalwrite, comm, Tstats: import common;
aal: AALCalibration;
      Tprofile: import aal;
aalmath: AALMath;
```

... etc.

DESCRIPTION

This section introduces the Limbo modules available to the AAL programmer. Corresponding manual pages describe each of the modules specific to the AAL, Exactus communication, Modbus protocol, Synrad laser controllers, and the Zaber linear translators.

The Inferno programmer's manual should be referenced for more details about Limbo and related technologies.

NAME

calibration – AAL calibration parameters

SYNOPSIS

```
include "calibration.m";
aal: AALCalibration;
      Tprofile: import aal;

Tprofile: adt {
      Bid:  string;     # AAL board id/slot
      Bsn:  string;     # AAL board serial number
      Tsn:  string;     # Transducer serial number
      IVPc: real;       # IV Phase count constant (frequency from dsPIC33F)
      Av:   real;       # Voltage calibration
      Ai:   real;       # Current calibration
      Aspl: real;
      Ag:   real;
      Bg:   real;
      A1:   real;
      A0:   real;

      cmp: fn (a, b: ref Tprofile): int;
      new: fn (bid: string): ref Tprofile;
};
tprofiles: array of ref Tprofile;
boardprofile: fn (i: int): ref Tprofile;

readfile: fn (filename: string): int;
writefile: fn (filename: string, perm: int): int;
readconfig: fn (filename: string): int;
writeconfigfile: fn (filename: string, perm: int): int;
writeconfig: fn (fd: ref Sys->FD): int;
```

DESCRIPTION

AALCalibration provides the reference Tprofile data structure for all transducer and controller boards. The profiles are loaded by *console*(1) on start up and used in *math*(2) to calculate frequency and SPL values. There are six instances of *Tprofile* in the global tprofiles array, one for each transducer–controller pair. The calls implemented are:

`cmp`	Compares two Tprofile instances.
`new`	Allocates a new Tprofile instance.
`boardprofile`	Returns the Tprofile for a provided board id (1-6).
`readfile`	Reads a tab-delimited configuration file and fills tprofiles with new instances of Tprofile.
`writefile`	Writes the array tprofiles to a tab-delimited file named by *path*.
`readconfig`	Reads in a s-expression configuration file and fills tprofiles with new instances of Tprofile.
`writeconfigfile`	Writes the array tprofiles to a s-expression file.
`writeconfig`	Writes the array tprofiles in s-expression format to the supplied file descriptor.

SOURCE

`aal/appl/lib/calibration.b`

SEE ALSO

calibtran(1), *capture*(1), *console*(1), *scanfreq*(1), *math*(2), *calibtran*(6)

NAME

common – AAL common module

SYNOPSIS

```
include "common.m";

common := load AALCommon AALCommon->PATH;
common->init();

Tstats: adt {
      online: int;
      name:   string;
      gain:   int;
      freq:   int;
      phase:  int;
      mper:   int;
      mfreq:  real;
      flags:  byte;
      Vo:     int;
      PhiV:   int;
      Io:     int;
      PhiI:   int;
      debug:  fn(s: self ref Tstats): int;
      feedback: fn(s: self ref Tstats): int;
      fan:    fn(s: self ref Tstats): int;
};
tstats: array of ref Tstats;

boardaxis: fn(bid: int): string;
boardstats: fn(bid: int): ref Tstats;
frequency: fn(t: ref Tstats): real;
gaintopercent: fn (g: int): real;
percenttogain: fn (p: real): int;
degreetophase: fn (deg: real): int;
phasetodegree: fn (p: int): real;
parsetstat: fn (line: string): Tstats;
updatestats: fn (sfd: ref Sys->FD): int;
reloaddata: fn(fd: ref Sys->FD): int;
aalread: fn (path: string): string;
aalwrite: fn(path: string, cmd: string): int;
secondtimer: fn (sync: chan of int);
timer: fn (tick: chan of int, ms: int);
isnumber: fn (s: string): int;

GAINMAX:    con 512;                    # this one goes to 2^9
GAINMIN:    con 3584;                   # a baseline for zero 2^12-2^9
GAINDEFAULT:      con GAINMIN;
FREQMIN:    con 22.0000;                # Firmware allows down to 22.0 kHz
FREQMAX:    con 22.2500;                # Firmware max set to 22.3 kHz
FREQDEFAULT:      con 22.2000;
PHASEMIN:   con 0.0;
PHASEMAX:   con 360.0;                  # degrees
PHASEDEFAULT:     con PHASEMIN;
AD9384PTWOPI:     con real 2**12;       # Analog Devices 9384 Phase 2pi
PHASERES:   con real (360. / AD9384PTWOPI);
AD9384FTWOPI:     con real 2**28;       # Analog Devices 9384 Frequency 2pi
FREQRES:    con 8000000.0 / AD9384FTWOPI;
DDSDegree:  con real 11.3778;           # 1/360 == x/4096
```

DESCRIPTION

AAL *common* module provides a Limbo interface to reading, writing, modifying, and displaying AAL statistics from the *aal9p*(4) file system. *Init* must be called before any other function in this module.

The type *Tstats* represents the available statistics for an individual transducer controller board in the AAL. The array *tstats*, initialized in the init function, stores all six transducers statistics and is updated through the `updatestats` and `reloaddata` functions covered below.

The data objects in `Tstats` are:

`online`	The current state of the controller board, on=1.
`name`	The transducer controller board slot name, t1–t6.
`gain`	Integer value written to the DAC.
`freq`	The frequency in decihertz.
`phase`	The integer phase value set to the DDS.
`mper`	The modulation percent multiplied by 100.
`mfreq`	The modulation frequency in hertz.
`flags`	A byte representing the bit field flags.
`Vo`	The ADC measured voltage output to the transducer.
`PhiV`	An integer counter for the voltage phase.
`Io`	The ADC measured current output to the transducer.
`PhiI`	An integer counter for the current phase.

The following convenience functions are provided by `Tstats:`

`debug`	Return the debug bit from the flags byte.
`fan`	Return the fan bit from the flags byte.
`feedback`	Return the feedback bit from the flags byte.

The principal functions used to access data are `updatestats` and `reloaddata`. Both take a file descriptor as their parameter to read a new set of data from the AAL controller and fill the *tstats* array. `Updatestats` parses the textual data in `/n/aal/stats`. `Reloaddata` does a binary read of `/n/aal/data` to populate the array. The `/n/aal/data` file is less than half the size of the `stats` file and thus more useful over the slow communications link.

FILES

`/n/aal/stats`

SOURCE

`aal/appl/lib/common.b`

SEE ALSO

console(1), *aal9p*(4)

NAME

exactus – Exactus pyrometer interface

SYNOPSIS

```
include "exactus.m";
exactus := load Exactus Exactus->PATH;

EPort: adt
{
      mode:   int;                              # Exactus or Modbus
      maddr:  int;                              # Modbus address
      temp:   real;                             # Last measured temperature
      rate:   int;                              # Graph rate
      path:   string;
      ctl:    ref Sys->FD;
      data:   ref Sys->FD;
      wdata:  ref Sys->FD;
      rdlock: ref Lock->Semaphore;
      wrlock: ref Lock->Semaphore;
      buffer: array of byte;                    # bytes from reader
      pids:   list of int;
      tchan:  chan of ref Exactus->Trecord;
      ms:     int;                              # ms start of last packet

      write:      fn(p: self ref EPort, b: array of byte): int;
      getreply:   fn(p: self ref EPort): (ref ERmsg, array of byte, string);
      readreply:  fn(p: self ref EPort, ms: int): (ref ERmsg, array of byte, string);
};

Emsg: adt {
      pick {
      Temperature =>
            degrees:    real;
      Current =>
            amps:       real;
      Dual =>
            degrees:    real;
            amps:       real;
      Device =>
            edegrees:   real;
            cdegrees:   real;
      Version =>
            mode:       byte;
            appid:      byte;
            vermajor:   int;
            verminor:   int;
            build:      int;
      Acknowledge =>
            c:          byte;
      }

      temperature:      fn(m: self ref Emsg): real;
      current:          fn(m: self ref Emsg): real;
      dual:             fn(m: self ref Emsg): (real, real);
      device:           fn(m: self ref Emsg): (real, real);
      acknowledge:      fn(m: self ref Emsg): byte;
      unpack:           fn(b: array of byte): (int, ref Emsg);
      text:             fn(m: self ref Emsg): string;
};
```

```
	ETmsg: adt {
		pick {
		Readerror =>
			error:	string;
		ExactusMsg =>
			msg:	ref Emsg;
		ModbusMsg =>
			addr:	byte;
			msg:	ref Modbus->TMmsg;
			crc:	int;
		}

		packedsize: fn(nil: self ref ETmsg): int;
		pack:	fn(nil: self ref ETmsg): array of byte;
		dtype:	fn(nil: self ref ETmsg): (ref Emsg, ref Modbus->TMmsg);
	};

	ERmsg: adt {
		pick {
		Readerror =>
			error:	string;
		ExactusMsg =>
			msg:	ref Emsg;
		ModbusMsg =>
			msg:	ref Modbus->RMmsg;
		}

		packedsize: fn(nil: self ref ERmsg): int;
		pack:	fn(nil: self ref ERmsg): array of byte;
		dtype:	fn(nil: self ref ERmsg): (ref Emsg, ref Modbus->RMmsg);
		tostring:	fn(nil: self ref ERmsg): string;
	};

	Trecord: adt {
		time: int;
		temp0:	real;
		temp1:	real;
		temp2:	real;
		current1:	real;
		current2:	real;
		etemp1:	real;
		etemp2:	real;
		emissivity: real;

		pack:	fn(nil: self ref Trecord): array of byte;
		unpack:	fn(b: array of byte): (int, ref Trecord);
	};

	Tdatafile: adt {
		name:	string;
		count:	int;		# should be unsigned 32-bit
		startTime:	string;		# YYYY-MM-DD HR:mm:ss
		IsDataDwl:	int;
		dataVersion: int;		# Always 3
		tempValid:	int;
		currentValid: int;
		serial:	string;
	};
```

```
init:       fn();
debug:      fn(f: int);

open:             fn(path: string): ref Exactus->EPort;
close:            fn(p: ref EPort): ref Sys->Connection;
readreply:        fn(p: ref EPort, ms: int): (ref ERmsg, array of byte, string);
write:            fn(p: ref EPort, b: array of byte): int;
exactusmode:      fn(p: ref EPort);
modbusmode:       fn(p: ref EPort);
swapendian:       fn(b: array of byte): array of byte;
escape:           fn(buf: array of byte): array of byte;
deescape:         fn(esc: byte, buf: array of byte, n: int): (int, array of byte);
lrc:              fn(buf: array of byte): byte;
ieee754:          fn(b: array of byte): real;
graphrate:        fn(p: ref EPort): int;
set_graphrate:    fn(p: ref EPort, r: int);
serialnumber:     fn(p: ref EPort): string;
temperature:      fn(p: ref EPort): real;
```

DESCRIPTION

Exactus provides an interface for controlling an Exactus pyrometer. After calling `init()` a program will `open()` a new `EPort` in order to interact with the serial protocols supported by the Exactus device. On successfully opening a new `EPort` a custom `reader` process will be spawned off and will be managed by the module. The reader handles the two protocols supported by an Exactus device, Modbus and a legacy streaming Exactus mode. The `Exactus` module supports near transparent negotiation of the two protocols to enable data collection and control of the device.

The module handles *modbus*(2) protocol dependencies for setting sampling rates and mode negotiation. A user program will use the following functions:

`set_graphrate(`*p*`,` *r*`)`	Sets the Exactus graph rate (sampling rate) to *r,* (1–1000).
`graphrate(`*p*`)`	Return the operating sampling rate.
`temperature(`*p*`)`	Read and return the temperature in Celsius, from an IEEE–754 32–bit float.
`exactusmode(`*p*`)`	Turn on Exactus mode streaming of temperature data.
`modbusmode(`*p*`)`	Turn off data streaming.

A client application will populate the `EPort.tchan` to be able to receive and process streamed data in an `alt` loop. A `Trecord` data object *pack()* is called to produce the array of bytes to be written to a `TemperaSure` log file.

SOURCE

`aal/sys/src/basf/appl/lib/exactus.b`

SEE ALSO

dumpbin(1), *pyro*(1), *modbus*(2), *pyroplot*(2), *temperasure-bin*(5)

BUGS

Opening a direct serial port connection fails to properly negotiate the *modbus*(2) transport protocol.

NAME

aalmath – floating point resonant frequency and SPL functions

SYNOPSIS

```
include "aalmath.m";
aalmath := load AALMath AALMath->PATH;

ampvolt: fn(tp: ref Tprofile, ts: ref Tstats): real;
ampcurrent: fn(tp: ref Tprofile, ts: ref Tstats): real;
amppower: fn(tp: ref Tprofile, ts: ref Tstats): real;

ivphasediff: fn(tp: ref Tprofile, ts: ref Tstats): real;
trueivphasediff: fn(tp: ref Tprofile, ts: ref Tstats): real;

gainvsvolts: fn(tp: ref Tprofile, ts: ref Tstats): real;

measuredspl: fn(tp: ref Tprofile, ts: ref Tstats): real;

resonantfreq: fn(tp: ref Tprofile, ts: ref Tstats): real;

sign: fn(a: real): real;
splgain: fn(s: real, tp: ref Tprofile, ts: ref Tstats): int;
splpower: fn(s: real, tp: ref Tprofile): real;
```

DESCRIPTION

These functions are used to track resonant frequency and SPL. The reference parameter *Tprofile* is a calibration profile for a transducer and controller board pair. The reference parameter *Tstats* is the most recently measured data from a given transducer controller board.

The function `apmvolt` returns the peak–to–peak voltage supplied to the transducer.

The function `ampcurrent` returns the peak–to–peak current measured across a 1–ohm resistor.

The `ivphasediff` function returns the measured current–voltage phase difference of the amplifier output.

`Trueivphasediff` just returns the `ivphasediff` result. This is a stub from a prior version of the AAL hardware that required the application of a 14° phase shift.

The function `amppower` is the total power delivered to the transducer.

The `measuredspl` function returns the measured SPL value, a calibration times the square root of the power.

`Splpower` returns the new power required to achieve a given SPL.

The `gainvsvolts` function is the voltage produced by the DAC gain and calibration parameters. This value is used primarily as a data point and not for further functions.

The `splgain` function calculates the new DAC gain value required to achieve a given SPL.

The function `resonantfreq` is the resonant frequency vs the current–voltage phase.

Calibration

The *Tprofile* adt is calculated with the use of the *calibtran*, and *scanfreq* programs. This data is loaded from the *transducer.cfg* file by *calibration*(2).

SOURCE

`aal/lib/math.b`, `$home/lib/transducer.cfg`

SEE ALSO

calibtran(1), *scanfreq*(1), *calibration*(2), *common*(2)

NAME

modbus – Modbus protocol

SYNOPSIS

```
include "modbus.m";
modbus: Modbus;
      TMmsg, RMmsg: import modbus;
modbus = load Modbus Modbus->PATH;
modbus->init();

TMmsg: adt {
      frame: int;
      addr: int;                                  # 1 or 2 bytes
      check: int;                                 # 0 or 2 bytes
      pick {
      Readerror =>
            error: string;
      Error =>
            fcode: byte;
            ecode: byte;
      Readcoils =>
            offset:     int;                      # 2   bytes, 0x0000 to 0xFFFF
            quantity: int;                        # 2 bytes, 0x0001 to 0x07D0
      Readdiscreteinputs =>
            offset: int;
            quantity: int;
      Readholdingregisters =>
            offset: int;
            quantity: int;                        # 2 bytes, 0x0001 to 0x007D
      Readinputregisters =>
            offset: int;
            quantity: int;                        # 2 bytes, 0x0001 to 0x007D
      Writecoil =>
            offset: int;
            value: int;                           # 2 bytes 0x0000 or 0xFF00
      Writeregister =>
            offset: int;
            value: int;                           # 2 bytes 0x0000 to 0xFFFF
      Readexception =>
            s: string;                            # not used
      Diagnostics =>
            subf: int;                            # 2 bytes, sub-function type
            data: int;                            # 2 bytes
      Commeventcounter =>
            s: string;                            # not used
      Commeventlog =>
            s: string;                            # not used
      Writecoils =>
            offset: int;
            quantity: int;
            count: int;
            data: array of byte;
      Writeregisters =>
            offset: int;
            quantity: int;                        # 2 bytes, 0x0001 to 0x007B
            count:      int;                      # 1 byte
            data: array of byte;
      Slaveid =>
            s: string;                            # not used
```

```
		Readfilerecord =>
			count: int;				# 1 byte, 0x07 to 0xF5
			data: array of byte;
		Writefilerecord =>
			count: int;				# 1 byte, 0x09 to 0xFB
			data: array of byte;
		Maskwriteregister =>
			offset: int;				# 2 bytes
			andmask: int;				# 2 bytes
			ormask: int;				# 2 bytes
		Rwregisters =>
			roffset: int;				# 2 bytes
			rquantity: int;				# 2 bytes
			woffset: int;				# 2 bytes
			wquantity: int;				# 2 bytes
			count:	int;				# 1 byte
			data: array of byte;			# 2 * count
		Readfifo =>
			offset: int;
		Encapsulatedtransport =>
			meitype: byte;
			data: array of byte;
		}

		read:	fn(fd: ref Sys->FD, msglim: int): ref TMmsg;
		packedsize: fn(nil: self ref TMmsg): int;
		pack:	fn(nil: self ref TMmsg): array of byte;
		unpack:	fn(b: array of byte, h: int): (int, ref TMmsg);
		text:	fn(nil: self ref TMmsg): string;
		mtype:	fn(nil: self ref TMmsg): int;
	};

	RMmsg: adt {
		frame: int;
		addr: int;
		check: int;
		pick {
		Readerror =>
			error: string;
		Error =>
			fcode: byte;
			ecode: byte;
		Readcoils =>
			count: int;
			data: array of byte;		# coil status
		Readdiscreteinputs =>
			count: int;
			data: array of byte;		# inputs
		Readholdingregisters =>
			count: int;
			data: array of byte;		# registers, N (of N/2 words)
		Readinputregisters =>
			count: int;
			data: array of byte;		# input registers, N (of N/2 words)
		Writecoil =>
			offset: int;
			value: int;
		Writeregister =>
			offset: int;
```

```
                value: int;
        Readexception =>
                data: byte;
        Diagnostics =>
                subf: int;                              # 2 bytes, sub-function type
                data: int;
        Commeventcounter =>
                status: int;                            # 2 bytes
                count: int;                             # 2 bytes
        Commeventlog =>
                count: int;                             # 1 byte
                status: int;                            # 2 bytes
                ecount: int;                            # 2 bytes
                mcount: int;                            # 2 bytes
                data: array of byte;                # events: (N-6) * byte
        Writecoils =>
                offset: int;
                quantity: int;                          # 2 bytes, 0x0001 to 0x07B0
        Writeregisters =>
                offset: int;
                quantity: int;
        Slaveid =>
                count: int;
                data: array of byte;                # device specific
        Readfilerecord =>
                count: int;                             # 1 byte, 0x07 to 0xF5
                data: array of byte;
        Writefilerecord =>
                count: int;
                data: array of byte;
        Maskwriteregister =>
                offset: int;                            # 2 bytes
                andmask: int;                           # 2 bytes
                ormask: int;                            # 2 bytes
        Rwregisters =>
                count: int;
                data: array of byte;
        Readfifo =>
                count: int;                             # 2 bytes
                fcount: int;                            # 2 bytes, ≤31
                data: array of byte;
        Encapsulatedtransport =>
                meitype: byte;
                data: array of byte;
        }

        read:       fn(fd: ref Sys->FD, msize: int): ref RMmsg;
        packedsize: fn(nil: self ref RMmsg): int;
        pack:       fn(nil: self ref RMmsg): array of byte;
        unpack:     fn(b: array of byte, h: int): (int, ref RMmsg);
        text:       fn(nil: self ref RMmsg): string;
        mtype:      fn(nil: self ref RMmsg): int;
};
```

DESCRIPTION

The *Modbus* module provides an interface for reading and writing Modbus messages. The module does not provide a reader as that will be a requirement for the application developer. It does provide all the functions necessary to encode and decode Modbus messages from arrays of bytes. The *exactus*(2) module implements a reader that uses the Modbus protocol.

The data types for encapsulating Modbus messages are TMmsg for transmitting request messages to a server and RMmsg to handle the response message. End user programs will need to target the specific coils and registers for the device in question. For example:

```
m := ref TMmsg.Readholdingregisters(Modbus->FrameRTU, p.maddr, -1, 16r1305, 16r0009);
write(fd, m.pack());
```

will send a request to read the Modbus holding registers in RTU mode to the Exactus pyrometer connected on *fd*. The request is for nine bytes of data representing the device serial number.

The RMmsg->unpack() function is used to decode an array of bytes. On success it will return a valid RMmsg.

SOURCE

aal/sys/src/modbus/appl/lib/modbus.b
aal/sys/src/modbus/appl/cmd/testmodbus.b

SEE ALSO

pyro(1), *exactus*(2)

NAME

pyroplot – graphical plotting of Exactus measurements

SYNOPSIS

```
include "exactus.m";
include "pyroplot.m";
pplot := load PyroPlot PyroPlot->PATH;
pplot->init(exactus);
spawn pplot->animproc(top, eport, exactus->serialnumber(eport),
                      ".pE", ecmdc, cmdc, plotc);

CLEANEXIT:  con "PyroPlot_Exit";
SAMPLE:     con "Sample";

Plotter: adt {
      sn:         string;
      panel:      string;
      p0:         Point;
      p1:         Point;
      img:  ref Image;
      paused:     int;
      pid:  int;
      mavg: real;

      logout:     ref Iobuf;
      logdir:           string;
      logfile:    string;
      dat:  ref Exactus->Tdatafile;

      startms:    int;
      rate: int;
};

init: fn(e: Exactus);
animproc: fn(top: ref Tk->Toplevel, ep: ref Exactus->EPort, sn: string,
             panel: string, cin, cout: chan of string, sync: chan of ref Plotter);
```

DESCRIPTION

PyroPlot creates a process to plot and log data from the Exactus pyrometer. It is used by the *pyro*(1) program and must be initialized with a loaded Exactus module instance. The function `animproc` is spawned off and will draw into the *panel* declared in the *top* Tk level of the application. The parent process should wait for the referenced *Plotter* data object is sent back over the *sync* channel. The Plotter stores state for the graphical plotting as well as the measurements read from the Exactus and where the log file is written.

Commands sent over the *cin* channel are:

`exit` Sets the Exactus port back into Modbus mode and exits the animation process.

`log` Toggles the running log of Exactus data. Opening a new log will create a new logfile. Closing the log flushes the logfile and creates a `.dat` file to enable the log to be read by the Exactus TemperaSure software.

`rate(`*n*`)` Change the sampling rate to *n* samples per second (1–1000).

`pause` Toggle the graphics plotting on or off and keep logging data.

`Plot_Off` Turn off the plot and stop the processing of Exactus mode data.

`Plot_On` Turn the plotting on and handle all data transmitted from the Exactus.

`Sample` Poll the PyroPlot process for the latest temperature data.

The *cout* channel is used to send data back to the parent process after processing the *cin* commands:

`exit`	Confirms that the Exactus has be set back to Modbus mode on a clean exit.
`log`	Sends the name of a newly created log file.
`Sample`	Sends back the latest temperature measurement.

SOURCE

`aal/appl/lib/pyroplot.b`

SEE ALSO

pyro(1), *exactus*(2), *zaber*(2)

NAME

scope – graphical representation of AAL acoustics

SYNOPSIS

```
include "scope.m";
scope := load Scope Scope->PATH;
(scopetop, scopectl, scopetitle) = scope->init(ctxt, nil, common, aal, aalmath);

init: fn(ctxt: ref Draw->Context, geom: string,
         common: AALCommon, calibration: AALCalibration, aalmath: AALMath):
         (ref Tk->Toplevel, chan of string, chan of string);

ctl:    fn(s: string);
wmctl:  fn(s: string);

update: fn();
raisex: fn();

drawtext: fn(dst: ref Image, p: Point, src: ref Image, sp: Point, font: ref Font,
             str: string, angle: real);
real2point: fn(r: array of real, c: int, pic: ref Image, maxamp: real):
               array of Point;
```

DESCRIPTION

The *scope* module implements basic utilities for plotting acoustic amplitude and phase. It is used in the *console*(1) program to present the spin and I-V phase data graphically.

The function `init` creates a new 640x320 window. The *geom* string may be *nil* or any valid `tkclient->toplevel` geometry string. The additional module parameters must not be *nil.*

The function `ctl` is used to pass in *checkivphase* or *spinview* control toggles from the *console*(1) run loop.

Wmctl handles additional Tk title and top commands.

The function `update` redraws the graphics based on the current state of the system *tprofiles* and *tstats.*

The function `raisex` maps and redraws the window.

The following two functions are used both internally in the *scope* module and as a convenience for drawing onto new images. Both are used in the *console*(1) to draw A–B sensor phases.

`drawtext(`*dst*`, `*p*`, `*src*`, `*sp*`, `*font*`, `*str*`, `*a*`)`
: Renders the text string *str* in the color provided by the *src* image into *dst* at the destination point *p.*

`real2point(`*r*`, `*c*`, `*pic*`, `*maxamp*`)`
: Generates an array of Point data objects from the array of Real *r* values as used by the *Image.poly* function. The starting index, *c*, is used to enable trimming the source array of reals if required, otherwise just pass a 0. The Image, *pic*, is used to size the resulting array to properly match the image destination.

SOURCE

`aal/appl/lib/scope.b`

SEE ALSO

console(1), *calibration*(2), *common*(2)

BUGS

The *drawtext* angle has never been implemented.

NAME

sensorplot – graphical sensor feedback plot

SYNOPSIS

```
include "sensorplot.m";
plot := load SensorPlot SensorPlot->PATH;
spawn plot->animproc(t, fd, axis, cin, cout, sync);

MARKLOG: con "mark";
STARTLOG: con "log";
STOPLOG: con "stoplog";

animproc: fn(win: ref Tk->Toplevel, fd: ref Sys->FD, axis: string,
            cin, cout: chan of string, pidc: chan of int);
window:     fn(ctxt: ref Draw->Context, fd: ref Sys->FD, axis: string,
            cin, cout: chan of string, pidc: chan of int);
```

DESCRIPTION

Sensorplot reads sensor feedback data from the file descriptor *fd* and renders a plot. The module supports drawing a *window* for a single sensor connection, or into a panel through *animproc* as is used in *sensors*(1). The file descriptor opened for reading should not be used by any other process. A reader is spawned off to constantly monitor all data coming from the sensor head.

Communication from the parent process to *animproc* or *window* is handled through the *cin* channel. Logging can be turned on or off by sending a *start* or *stop* command.

The *cout* channel is used to send sensor statistics to the parent process.

SOURCE

`aal/appl/lib/sensorplot.b`

SEE ALSO

sensors(1), *sensor*(3)

NAME

stats – graphical window displaying AAL statistics

SYNOPSIS

```
include "stats.m";
stats := load Stats Stats->PATH;
(statstop, statsctl, statstitle) = stats->init(ctxt, nil, common, aal, aalmath);

init: fn(ctxt: ref Draw->Context, geom: string,
         common: AALCommon, calibration: AALCalibration, aalmath: AALMath):
         (ref Tk->Toplevel, chan of string, chan of string);

ctl:    fn(s: string);
wmctl:  fn(s: string);

update: fn();
raisex: fn();
```

DESCRIPTION

The *stats* module presents a new window with the numerical statistics of the AAL. It is used in the *console*(1) program.

The function `init` creates a new window. The *geom* string may be *nil* or any valid `tkclient->toplevel` geometry string. The additional module parameters must not be *nil.*

The function `ctl` forces an update and refreshes the values on screen.

Wmctl handles additional Tk title and top commands.

The function `update` refreshes the statistics from the current state of the system *tprofiles* and *tstats.*

The function `raisex` maps and redraws the window.

SOURCE

`aal/appl/lib/stats.b`

SEE ALSO

console(1), *calibration*(2), *common*(2)

NAME

timedio – timeout functions for I/O and dial

SYNOPSIS

```
include "timedio.m";
timedio: TimedIO;

NOTIMERS    : int;

timedopen   : fn(file: string, omode, timeout: int): ref Sys->FD;
timedread   : fn(fd: ref Sys->FD, buf: array of byte, nbytes, timeout: int): int;
timedwrite  : fn(fd: ref Sys->FD, buf: array of byte, nbytes, timeout: int): int;
timedmount  : fn(fd: ref Sys->FD, afd: ref Sys->FD, old: string, flag: int,
                  aname: string, timeout: int): int;
timedunmount      : fn(name, old: string, timeout: int): int;
timedreaddir      : fn(path: string, sortkey, timeout: int): (array of ref Sys->Dir, int);
timedauclient     : fn(alg: string, ai: ref Keyring->Authinfo, fd: ref Sys->FD,
                  timeout: int): (ref Sys->FD, string);
timeddial   : fn(addr, local: string, timeout: int): (int, Sys->Connection);

init        : fn(): string;
toggletimers      : fn();
shutdown    : fn();
```

DESCRIPTION

Timedio provides an interface to standard I/O functions with an additional timeout parameter. The call will return a success unless the timeout, in milliseconds, has been reached.

SOURCE

`aal/appl/lib/timedio.b`

SEE ALSO

http://sflr.org/

BUGS

The module does not default to using timers so `timedio->toggletimers()` must be invoked before any additional functions are called.

NAME

uc2000 – support module for interfacing Synrad UC-2000 laser controllers

SYNOPSIS

```
include "uc2000.m";
uc2k = load UC2K UC2K->PATH;
uc2k->init(bufio);

UC1               : con "synradone";
UC2               : con "synradtwo";
STX               : con byte 16r5B;            # checksum commands
ACK               : con byte 16rAA;
NAK               : con byte 16r3F;

MANUAL_MODE,                                   # p 0x70
ANC_MODE,                                      # q 0x71
ANV_MODE,                                      # r 0x72
MANCLOSED_MODE,                                # s 0x73
ANVCLOSED_MODE    : con byte 16r70+byte(iota); # t 0x74

LASER_ENABLED,                                 # u 0x75
LASER_STANDBY     : con byte 16r75+byte(iota); # v 0x76

PWM_5K,                                        # w 0x77
PWM_10K,                                       # x 0x78
PWM_20K,                                       # y 0x79
GATE_PULL_UP,                                  # z 0x7A
GATE_PULL_DOWN,                                # { 0x7B
MAX_PWM_95,                                    # | 0x7C
MAX_PWM_99        : con byte 16r77+byte(iota); # } 0x7D

LASE_UP_ENABLE,                                # 0 0x30
LASE_UP_DISABLE : con byte 16r30+byte(iota);   # 1 0x31

SET_PWM_PER       : con byte 16r7F;            # del 0x7F
STATUS            : con byte 16r7E;            # ~ 0x7E

LASER_OFF   : con 0;
LASER_ON    : con 1;

Status : adt {
      b1: byte;
      b2: byte;
      pwm: byte;
      p: byte;

      new: fn(b: array of byte): ref Status;
      mode: fn(s: self ref Status): string;
      control: fn(s: self ref Status): int;
      lase: fn(s: self ref Status): int;
      gate: fn(s: self ref Status): int;
      pwmfreq: fn(s: self ref Status): string;
      laseonpup: fn(s: self ref Status): int;
      maxpwm: fn(s: self ref Status): int;
      version: fn(s: self ref Status): int;
      pwmpercent: fn(s: self ref Status): fixed(0.5, 100.0);
      power: fn(s: self ref Status): int;
};
```

```
Controller : adt {
      port: string;
      net:  ref Sys->Connection;
      ior:  ref Bufio->Iobuf;
      stats:      ref Status;
      usechecksum: int;
      debug:      int;
      rlength: int;

      new:  fn(p: string, check: int, debug: int): ref Controller;
      connect: fn(c: self ref Controller): int;
      disconnect: fn(c: self ref Controller);
      send: fn(c: self ref Controller, b: array of byte): int;
      response:   fn(c: self ref Controller): array of byte;
      setpwm:     fn(c: self ref Controller, p: real): real;
      lase: fn(c: self ref Controller, on: int): int;
      status: fn(c: self ref Controller): ref Status;
      checksum:   fn(b: array of byte): array of byte;
};

init: fn(b: Bufio);
```

DESCRIPTION

The Synrad UC-2000 laser controllers are accessed through RS-232 lines. The two controllers, UC1 and UC2, are connected to the Iolan ports 10001 and 10002.

The UC-2000 REMOTE commands are initiated by the host application. The `Controller` data object maintains the connection and state of the controller. The functions used applications are:

`new(`*p*`, `*check*`, `*debug*`)`
: Instantiates a new *Controller* object with the provided port string and whether to use a checksum and debugging output.

`connect()`
: Dials the network address of the controller.

`disconnect()`
: Sends a *lase off* command and closes the connection to the controller.

`send(`*b*`)`
: Sends an array of byte encoded command to the controller.

`response()`
: Returns the array of bytes received form the controller.

`setpwm(`*p*`)`
: Sends a command to change the PWM state of the controller.

`lase(`*on*`)`
: Turns the controller lase state on or off.

`status()`
: Queries the controller for a status and returns the data object *Status.* If debugging has been turned on then the controller state will be dumped to *stderr.*

`checksum(`*b*`)`
: Returns a new array of bytes with the checksum appended to the end.

FILES

`/lib/ndb/aal`

SOURCE

`aal/appl/lib/uc2000.b`

SEE ALSO

uc2k(1), *http://www.synrad.com/ucsc/index.html*

NAME

util – common utility functions

SYNOPSIS

```
include "aalutil.m";
util := load AALUtil AALUtil->PATH;
util->init();

IOLAN: con "iolan";
AALPORT: con "aal9p";
XPORT : con "sensorx";
YPORT : con "sensory";
ZPORT : con "sensorz";

init: fn();
kill:       fn(pid: int);
killgrp:    fn(pid: int);
pid:        fn(): int;
warn:       fn(s: string);
fail:       fn(s: string);
min, max:   fn(a, b: int): int;
abs:        fn(a: int): int;
g64, g64l:  fn(d: array of byte, o: int): (big, int);
g32, g32l:  fn(d: array of byte, o: int): (big, int);
g32i, g32il,
g16, g16l,
g8:         fn(d: array of byte, o: int): (int, int);
gethome:    fn(usr: string): string;
getuser:    fn(): string;
```

DESCRIPTION

The `AALUtil` module provides basic utility constants and functions for other AAL Limbo programs. `Init` must be called before using any other functions in the module.

The string constants map to network database entries used to make connections to the various devices utilized in the AAL. The provided functions are:

`kill(`*pid*`)` Terminate a process.

`killgrp(`*pid*`)` Terminate a process group.

`pid()` Return the current process id.

`warn(`*s*`)` Print the warning string to *stderr.*

`fail(`*s*`)` Print a warning and the terminate the current process group.

`min(`*a*`, `*b*`)` Return the minimum integer.

`max(`*a*`, `*b*`)` Return the maximum integer.

`abs(`*a*`)` Return the absolute value of *a.*

`gethome(`*usr*`)` Return the Inferno home directory of the user.

`getuser()` Return the Inferno user name.

`g8, g16, g16l, g32i, g32il, g32, g32l, g64, g64l(`d, o*)*
Return a value in the total number of bits from the provided array of byte in big or little endian format.

FILES

`/lib/ndb/aal`

SOURCE

`aal/appl/lib/aalutil.b`

NAME

zaber – interface to Zaber Technologies linear stages

SYNOPSIS

```
include "zaber.m";
zaber: Zaber;
      Instruction: import zaber;

zaber = load Zaber Zaber->PATH;
zaber->init();
p := zaber->open(path);

init: fn();
open: fn(path: string): ref Port;
close:      fn(p: ref Port): ref Sys->Connection;
getreply:   fn(p: ref Port, n: int): array of ref Instruction;
readreply:  fn(p: ref Port, ms: int): ref Instruction;
send:       fn(p: ref Port, i: ref Instruction): int;
```

DESCRIPTION

Zaber provides a small set of functions to manipulate Zaber linear stages for use in Limbo applications. The API provides all of the commands for Zaber devices running firmware version 5xx.

Init must be called before using any other function in the module.

Open takes a string path as either a file path or a network address and establishes a connection to the Zaber device chain. On successful connection, a response reader is spawned to buffer all communication returned from the Zaber device(s).

Close shuts down the *reader* associated with the Zaber port and closes the connection to free any resources used.

Getreply returns up to *n* Zaber Instructions from buffered data read.

Readreply returns an Instruction or times out in *ms* milliseconds.

Send takes a new command Instruction and writes it to the Port.

SEE ALSO

http://www.zaber.com/wiki/Manuals

NAME

intro – introduction to firmware

DESCRIPTION

This section describes firmware used in the AAL.

The firmware consists of three separate source trees. The two projects `aalcontrollers` and `CPLD` contain the code used in the communication and transducer controller boards. The `aalsensor33F` project is used for the sensor head.

CPLD

There are two versions of the CPLD code, one for the communications board (Master) and another for the transducer controller boards (Slave). The communications board has the master clock for the AAL digital module. The transducer controller boards include additional VHDL for detecting I–V phase as described in the *phasedetector*(3) manual.

AAL Controllers

The AAL controller boards all use a Microchip dsPIC33F 16-bit general purpose digital signal controller. The source is the same for both the communication and transducer controllers. Minimal bootstrapping differences are detailed in `aalcontrollers/main.c`.

AAL Sensors

The three AAL feedback sensors are controlled by a lower end Microchip dsPIC33F part. The unit is comprised of three separate boards:

detector A small carrier board for the Hamamatsu S5991-01 two-dimensional photo sensitive device (PSD).

analog A board that takes the four signals from the PSD, applies analog math to the signals, and allows for output signal gain control.

digital Hosts the dsPIC33F and serial interface for communication back to the AAL.

SEE ALSO

Controllers(3) for details on the communication and transducer controller specification.
Phasedetector(3) for details on the transducer controller board I–V phase detection.
Sensor(3) describes the dsPIC33F code used in the feedback sensors.

NAME

AALcall, aalconvM2S, aalconvS2M, aalfill, dispatchaal, transmitaal, replyaal, aalsend, aalsend8, aalsend16, aalsend32 – interface AAL controller-to-controller communication protocol

SYNOPSIS

```
include "aalcall.h"

uint8 aalfill(AALcall *a, AALCmdType t, TboardAddr addr);

uint8 dispatchaal(AALcall *a);
uint8 transmitaal(AALcall *a);
uint8 replyaal(AALcall *a);

uint8 aalconvM2S(uchar *ap, uint8 nap, AALcall *a);
uint8 aalconvS2M(AALcall *a, uchar *ap, uint8 nap);

void aalsend(TboardAddr addr, AALCmdType t);
void aalsend8(TboardAddr addr, AALCmdType t, uint8 d);
void aalsend16(TboardAddr addr, AALCmdType t, uint16 d);
void aalsend32(TboardAddr addr, AALCmdType t, uint32 d);
```

DESCRIPTION

The AALCall routines are used exclusively in the AAL *controllers*(3) firmware to simplify the conversion of messages to and from the AALcall structure:

```
typedef
struct AALcall
{
      TboardAddr addr;
      AALCmdType type;
      uint8 count;
      uchar data[Maxadata];
} AALcall;
```

This structure and the AALCmdType is defined in aal/sys/lib/aalcontrollers/aalcall.h.

Messages are initiated by transmitting an *AAL_T** command type. The byte array received will be decoded, dispatching a function and potential response back to the message sender.

Aalfill populates an *AALcall* structure with data of the *AALCmdType* to be sent to the board or boards defined by *TboardAddr*.

Dispatchaal decodes the *AALcall* data structure and implements the required command.

Transmitaal encodes the *AALcall* data in *a* and sends the message to the boards declared in the structure.

Replyaal creates a response data structure for any *AAL_Tping*, or *AAL_Tdata* message.

AalconvM2S takes a message of *nap* length and fills an *AALcall* structure *a*. It verifies that all message data has been formatted correctly and returns the number of bytes the message occupied in *ap*. A 0 is returned if the message data is invalid.

AalconvS2M is the reverse conversion. It encodes the structure *a* into a byte array *ap* of maximum length *nap*. The buffer *ap* must be large enough to hold the maximum length of *nap*.

The *Aalsend* functions are convenient mechanisms for transmitting a specific command and data.

SOURCE

aal/sys/lib/aalcontrollers/aalcall.c

SEE ALSO

controllers(3)

NAME

controllers – AAL communication and transducer controller firmware

DESCRIPTION

The communication (leftmost slot in the AAL subrack) and Transducer controller (slots 1-6) boards use the same dsPIC33F micro controller and software. The startup routine on each board establishes communication protocols and initializes to default *Frequency, Phase,* and *Gain* values. The Main board does not require any of the A/D or D/A conversion routines that the Transducer controller boards need to perform, so it skips those configuration routines and instead sets up memory structures to track data from each Transducer board.

Oscillator

The dsPIC33f *Fosc* and *Fcy* oscillator settings are configured to use a phase-locked loop (PLL) configuration chosen to support the following desired UART baud rates:

MHz		PLL			BAUD	LS	HS	BRGH	LS=0	HS=1	
Fin	Fcy	Div	Pre	Post	Desired	Real	Real	LS	Err %	HS	Err %
8.00	36.89	164	7	0	9600	9606	9606	239	0.068	959	0.068
8.00	36.89	164	7	0	14400	14409	14409	159	0.068	639	0.068
8.00	36.89	164	7	0	19200	19212	19212	119	0.068	479	0.068
8.00	36.89	164	7	0	28800	28819	28819	79	0.068	319	0.068
8.00	36.89	164	7	0	38400	38425	38425	59	0.068	239	0.068
8.00	36.89	164	7	0	57600	57638	57638	39	0.068	159	0.068
8.00	36.89	164	7	0	115200	115277	115277	19	0.068	79	0.068
8.00	36.89	164	7	0	230400	230555	230555	9	0.068	39	0.068
8.00	36.89	164	7	0	256000	256172	256172	8	0.068	35	0.068

Serial Interfaces

Each board has two UARTS (serial interfaces). UART1 is used as a bus across the backplane for all inter-board communication. The serial line is configured as a full-duplex RS-485 bus at 256 Kbps. UART2 is the external serial interface accessible through an RJ45 port on the rear side of the backplane configured to operate at 115.2 Kbps. It is configured with a RS-232 line driver on the communication board and with RS-485 drivers on all of the transducer controller boards.

The AAL communication board uses two modes over the UART2 interface:

`terminal/` A command prompt (raw character terminal, default/power-on mode).
`linked` Serves 9P to provide a file system interface for user programs.

The terminal mode has simple command line interface and presents a user prompt:

```
AAL by Physical Property Measurements, Inc.

Firmware: 1.0.0 (20110330)
Copyright (c) 2010-2011, Corpus Callosum Corporation

Board ID: 0
Frequency: 36.89 MHz

>
```

The commands that can be typed at the '> ' prompt are:

`?` Query the board id number.
`b`*N* Change the baud rate to *N,* an integer (e.g. 9600, 19200, 38400, 115200).
`D` Toggle debugging output (only used during development).
`e` Toggle the error LED.
`fb` Toggle feedback processing on or off for all transducer controllers.
`freq` *N* Set frequency to *N* decihertz (range 221000-223000).
`f`*N* Short form for 'freq N'.
`gain` *N* Set output DAC gain (inverted: 3584 == minimum, 512 == maximum).
`g`*N* Short form for 'gain N'.

`m`	Print measured values (see 'cat stats' example below).
`mod` *P F*	Transducer board only: set amplitude of modulation. A non-zero *P* and *F* turns modulation on, otherwise off it is off. *P* is the percentage of amplitude change: -100 to 127. *F* is the frequency in Hz (e.g. 0.0 to >500.0) with 0.01 precision.
`phase` *N*	Transducer board only: change the DDS phase (0-4096 is equal to 0-360°)
`p`*N*	Short form of 'phase N'.
`P`	Communication board only: toggle polling. Only used in testing as it turns data collection on and off.
`reboot`	Reboot the board.
`reset`	Reset board(s) to default values. When invoked on the communication board, a synchronized reset is sent to all boards.
`S`	Print board status details (see 'cat status' file below).
`s`*N*	Transducer board only: sensor board phase change command. Only executed when the sensor feedback bit has been set.
`t`*N cmd*	Send 9P *ctl* command string to transducer board *N* (see AAL t *N* ctl definition below).
`v`	Transducer board only: toggle fan.

The transducer boards by default do not use the external UART as a serial console. They are configured to receive data from the AAL *sensor*(3). Setting feedback processing *on* will enable the controllers to make phase adjustments based on the stream of data from the sensors. The controllers will otherwise ignore all data received over the external serial interface.
The serial bus runs at 115.2Kbps for each sensor axis. The sensor head is the master node, two transducer controller boards and an IOLAN interface port receive. Without a hardware jumper the transducer controller boards will not be able to transmit data to the sensor head.
The sensor system sends a four-byte feedback packet 250 times a second:

```
0x73 s
0x?? signed 16-bit data representing degree phase change
0x??
0x0d '\r'
```

On receiving a command from the sensor head the transducer control board changes the position phase. Both transducer boards will process the phase change within nanoseconds of each other, producing the desired result for stabilizing the sample.
Adding a hardware jumper and enabling the transducer controller board debugging mode will enable the external UART to provide a console interface for that board. In this debugging mode the transducer board will operate similar to the communication board (without the 9P support).

Interface

The main board UART2 interface is also used for the GUI support which runs over a protocol called 9p2000. It is started automatically by sniffing for a connection over the serial interface or entering the command *Styx* to the main board from the '> ' prompt. Once the connection is established, the end user's application communicates with the main control board as a file system. The structure is a simple one level directory depicted here:

```
cpu% cd /n/aal
cpu% lc
ctl    status t1err  t2err  t3err  t4err  t5err  t6err
data   t1     t2     t3     t4     t5     t6
stats  t1ctl  t2ctl  t3ctl  t4ctl  t5ctl  t6ctl
```

The files provide a running state of the system with read and write access. The *t* files are used for each transducer control board, *t1-t6*. If the *t* files do not exist, then the control board is either not installed in the backplane, or not responding to requests from the communication board.

Each file is used to read and write specific information:

`ctl`	Control file for sending commands.
`data`	Reading produces a packed byte version of the stats structure.
`stats`	Transducer controller board statistics (described below).
`status`	Communication board status details.

`tN` Transducer board statistics.
`tNctl` Control file for individual transducer board.

Reading the statistics of all transducers is performed via:

```
cpu% cat stats
ID Ai Fi Phi Mper Mfreq Flags Vo PhiV Io PhiI F
t1 2000 221677 3756 0 0.00 65 2221 0 1654 3151 0
t2 2029 221677 2048 0 0.00 193 1982 0 1640 3275 0
t3 2400 221677 0 0 0.00 65 2439 0 1538 3212 1
t4 1655 221677 2048 0 0.00 193 2636 2938 1294 0
t5 2031 221677 0 0 0.00 65 2044 0 1691 3075 0
t6 1866 221677 2048 0 0.00 65 2372 0 1724 3295 1
```

The header row in the stats file represents each space-delimited entry:

```
ID    - transducer board id
Ai    - output gain value set
Fi    - output frequency
Phi   - transducer phase on the axis
Mper  - amplitude modulation percentage
Mfreq - amplitude modulation frequency in Hz
Flags - bit field flags of the transducer control board
Vo    - Measured Voltage output
PhiV  - Voltage phase count
Io    - Measured Current output
PhiI  - Current phase count
F     - Fan state (0 = off, 1 = on)
```

Turning the fans *off* for transducers 1 & 2 (X axis):

```
cpu% echo fan 0 > t1ctl
cpu% echo fan 0 > t2ctl
cpu% cat stats
ID Ai Fi Phi Mper Mfreq Flags Vo PhiV Io PhiI F
t1 3100 222000 0 0 0.00 132 507 2922 209 0 0
t2 3100 222000 2048 0 0.00 132 538 2892 265 0 0
...
```

Setting a new gain value for all transducers:

```
cpu% echo gain 2800 > ctl
cpu% cat stats
ID Ai Fi Phi Mper Mfreq Flags Vo PhiV Io PhiI F
t1 2800 222000 0 0 0.00 195 1034 0 589 3173 1
t2 2800 222000 2048 0 0.00 195 1467 3144 915 1
...
```

Setting the frequency:

```
cpu% echo freq 222000 > ctl
cpu% cat stats
ID Ai Fi Phi Mper Mfreq Flags Vo PhiV Io PhiI F
t1 2800 222000 0 0 0.00 193 1033 0 588 3187 1
t2 2800 222000 2048 0 0.00 193 1469 3133 913 1
...
```

Read the available commands for the main ctl file:

```
cpu% cat ctl
fb
freq
gain
haltstyx
reset
spin
```

Enable amplitude modulation on one transducer:

```
cpu% echo mod 20 11 > t1ctl
```

Read the main board configuration status:

```
cpu% cat status
Firmware: 1.0.0 (20100818)
Fosc: 73.78 MHz
Frequency: 36.89 MHz
PLL DIV/PRE/POST: 164   7     0
U1 BAUD: 256172.8 BRG:8
U2 BAUD: 115277.8 BRG:19
STKERR: 0   MATHERR: 0  DMAERR 0x0
U1 PERR: 0  FERR: 0     OERR: 0
U2 PERR: 0  FERR: 0     OERR: 2
Board ID: 0

Boards: id (online)
      0: online
      1: online
      2: online
      3: online
      4: online
      5: online
      6: online
      7:
```

The *console*(1) application uses the aforementioned file system to read status updates from the Main board. It translates the transducer statistics into human readable values and facilitates sending commands to the Main board.

Transducer bit field flags:

```
 0 - feedback    -- process sensor feedback data
 1 - tstep       -- sensed fast/slow switch
 2 - tsfan       -- last state of sensed fan switch
 3 - tfan        -- fan on/off indicator
 4-6             reserved
 7 - online      -- board on and responding over the backplane
```

/n/aal/ctl commands:

```
fb N     -- globally change sensor feedback processing: 0 = off, 1 = on
freq N   -- globally change transducer frequency
gain N   -- globally change transducer gain
reset    -- software reset, on sync all boards set default state values
spin S1 S2 N   -- spin change on a given axis
            S1 is the string "X", "Y", or "Z" (case insensitive)
            S2 is either "UP" or "DOWN" (case insensitive)
            N is an 8-bit value of the phase change
```

/n/aal/t?ctl commands:

```
debug N  -- Enables (1) or disables (0) debugging output over external UART.
fan N    -- turn fan on (1) or off (0)
fb N     -- turn sensor feedback processing on (1) or off (0)
freq N   -- set frequency to N (integer range only 220000 to 223000,
            22.0 - 22.3 kHz)
gain N   -- set gain on DAC (inverted: 3584 == minimum, 512 == maximum)
mod N1 N2      -- set transducer amplitude modulation:
            N1 -- fixed point percentage range from -100 to 127
            N2 -- floating point value for frequency
phase N  -- set phase, N is in range 0-4096 (0-360°)
reset    -- set default state values
sensitivity N -- set manual knob sensitivity, N is in range 0-255
```

```
e.g.: when N = 11, a knob click ~= 1°.
```

SOURCE

aal/sys/lib/aalcontrollers

SEE ALSO

console(1), *phasedetector*(3)

NAME

phasedetector – CPLD VHDL source for I-V phase detection

SYNOPSIS

```
entity PhaseDetector is

    Port ( clk          : in  STD_LOGIC;
           reset        : in  STD_LOGIC;
           signal_a     : in  STD_LOGIC;
           signal_b     : in  STD_LOGIC;
           signal_x_out : out  STD_LOGIC;
           signal_y_out : out  STD_LOGIC;
           signal_a_div : out  STD_LOGIC);

end PhaseDetector;
```

DESCRIPTION

The phase detector is a modified shaft encoder implemented in the Xilinx CPLDs installed in the transducer controller boards. It takes the voltage and current inputs and calculates the phase difference for use in the dsPIC33F.

The three outputs are used to toggle gated timers and interrupt the dsPIC33F. The gated timers provide a counter for the current and voltage. The interrupt handler in the *controllers*(3) source code reads and resets the counter values. The resulting PhiI and PhiV values are used in *math*(2) to calculate the phase difference in degrees.

SOURCE

`aal/sys/lib/xilinx/CPLD/Slave/PhaseDetector.vhd`

SEE ALSO

math(2), *controllers*(3)

NAME

sensor – AAL velocity feedback sensor

DESCRIPTION

The *aalsensor33F* firmware is installed on each of the sensor heads in the AAL. Its tasks are to modulate an infrared laser (default at 40kHz), sample the resulting position through the Hamamatsu PSD, calculate velocity, and transmit a phase correction command over a serial line to a pair of transducer controller.

The sensor interprets commands received over an EIA-485 serial line. The commands are:

Kd=*N*	Set the velocity gain to *N*/100.
`debug=`*n*	Turn debug mode on ’1’ or off ’0’.
`fb=`*n*	Enable ’1’ or disable ’0’ feedback transmission.
`samp=`*n*	Dump sampling data from PID function *n* times.
`echo`*str*	Echo *str* back over the serial line. The string is prefixed with a ’# ’.
`dump`	Dump data from PID function (debug=1).
`halt`	Stop sending debugging data dumps, debug=0.
`noisecheck`	Dump 1000 PID results: Y[n], P, D, Vposy[n], Vref[n].
`pscheck`	Dump 32 PID results: Y[n], P, D, Vposy[n], Vref[n].
`samp`	Dump 250 PID results, P and D.
`samp10`	Dump 10 PID results, P and D.
`samp100`	Dump 100 PID results, P and D.
`samp1000`	Dump 1000 PID results, P and D.
`samp12`	Dump 12 PID results, P and D.
`samp32`	Dump 32 PID results, P and D.
`samp1m`	Dump 15000 PID results, one minute @ 250 per second, P and D.
`stats`	Print current state.
`time`	Run 1000 ADC sample sets (16 samples) without running the PID routine. The calling application uses this to time routines on the sensor head.
`timefb`	Make 1000 PID calls before echoing back a result.

SOURCE

`aal/sys/lib/aalsensor33F`

SEE ALSO

controllers(3), *sensors*(1)

NAME

intro – introduction to file servers

DESCRIPTION

This section describes 9P services as used by the AAL. The file system presents a single level tree as described in *aal9p*(4).

NAME

aal9p – distributed aero-acoustic levitator file system

SYNOPSIS

`mount -A [ -S ]` *aaladdr dir*

```
ctl    status t1err  t2err  t3err  t4err  t5err  t6err
data   t1     t2     t3     t4     t5     t6
stats  t1ctl  t2ctl  t3ctl  t4ctl  t5ctl  t6ctl
```

DESCRIPTION

The *AAL9P* file system provides distributed access to the AAL using the 9P protocol. It provides *ctl* files for sending parameter changes to the device and reading data stored in the communication node of the system. Individual transducer controller statistics and settings can be accessed through the *t[1-6]* files.

The namespace is accessed by mounting the service at the address *aaladdr on the desired directory dir*. The *aal9p* service requires the use of the `-A` option as there is no authentication provided by the device. The default address is *tcp!iolan!aal9p* and is mounted by convention at */n/aal*.

Client interface

Commands controlling the state of the AAL are written to the `ctl` files. The client reads the AAL state through the `data`, `stats`, `status` or `t?` files.

Control commands

Global changes of frequency, gain, or cooling fan state are accomplished through writing a command and one or more parameters to the `ctl` file.

`fan` *n*	Turns the fans on ’1’ or off ’0’.
`fb` *n*	Enables ’1’ or disables ’0’ velocity feedback processing.
`freq` *dhz*	Sets the operating frequency to dHz. Valid ranges are *220000* to *223000*.
`gain` *k*	Set all transducer preamp output to the gain value *k*. The inverted range is *3584* for zero output and *512* for the maximum board output.
`gains` *6k*	Set each transducer to the output gain value associated with the parameter. Six gain arguments are required.
`reset`	Set all transducers to zero output and restore default phase and spin values.
`spin` *axis up|down n*	Set the axis spin settings up or down to *n* phase.
`spl` *n*	Store the target SPL value to *n.*

The transducer *t?ctl* files are used for individual control:

`debug` *n*	Enable ’1’ or disable ’0’ debugging output over UART2.
`fan` *n*	Turns the fan on ’1’ or off ’0’.
`fb` *n*	Enables ’1’ or disables ’0’ velocity feedback processing.
`freq` *dhz*	Sets the operating frequency to dHz. Valid ranges are *220000* to *223000*.
`gain` *k*	Set transducer preamp output to the gain value *k*. The inverted range is *3584* for zero output and *512* for the maximum board output.
`mod` *per hz*	Set amplitude modulation to *percent* and *Hz*.
`phase` *n*	Set the phase 0-4096.
`reset`	Set transducer to zero output and restore default phase and spin values.

SOURCE

`aal/sys/lib/aalcontrollers`

NAME

intro – introduction to file formats and system conventions

DESCRIPTION

There are various file formats used throughout the AAL system. The Limbo programs *console*(1), *pyro*(1), and *sensors*(1) use an s-expression format for their configuration files. Log files generated by AAL programs are human readable and easily parsed with *awk* and other common utilities.

SEE ALSO

`http://en.wikipedia.org/wiki/S-expression`
`http://www.vitanuova.com/inferno/man/2/sexprs.html`

NAME

console – log file format from the console

DESCRIPTION

The *console*(1) logs data to the *$home/logs/aal/console* directory. A new file is created on program start using date-time format `yyyymmdd_HHMMSS.log`. The log is appended every ten seconds with statistics for each transducer. User events changing the SPL, velocity feedback, and tracking state changes are added as they occur. Header details at the start of the log are commented using an unquoted # character.

The tab-delimited columns for transducer statistics are:

`Time`	The number of seconds since the epoch, 00:00:00 GMT, January 1, 1970.
`Bid`	The board identifier: t1-t6.
`Gain`	DAC output gain setting.
`Freq`	The operating frequency in kHz.
`Phase`	The integer representation of the phase degrees, 0-4096 = 0-360°.
`Mper`	Amplitude modulation percentage.
`Mfreq`	Amplitude modulation frequency.
`Vo`	Voltage output measured by the ADC.
`PhiV`	Integer counter of the Voltage phase.
`Io`	Current output measured by the ADC.
`PhiI`	Integer counter of the Current phase.
`Fan`	The transducer fan on/off state.
`Vi`	Calculated voltage.
`Ii`	Calculated current.
`Phic`	Calculated I-V phase difference.
`Phi`	Calculated true I-V phase difference.
`P`	Calculated amplifier power.
`SPL`	Calculated SPL output.
`Vc`	Calculated gain voltage.
`RFreq`	Calculated resonant frequency of the transducer.

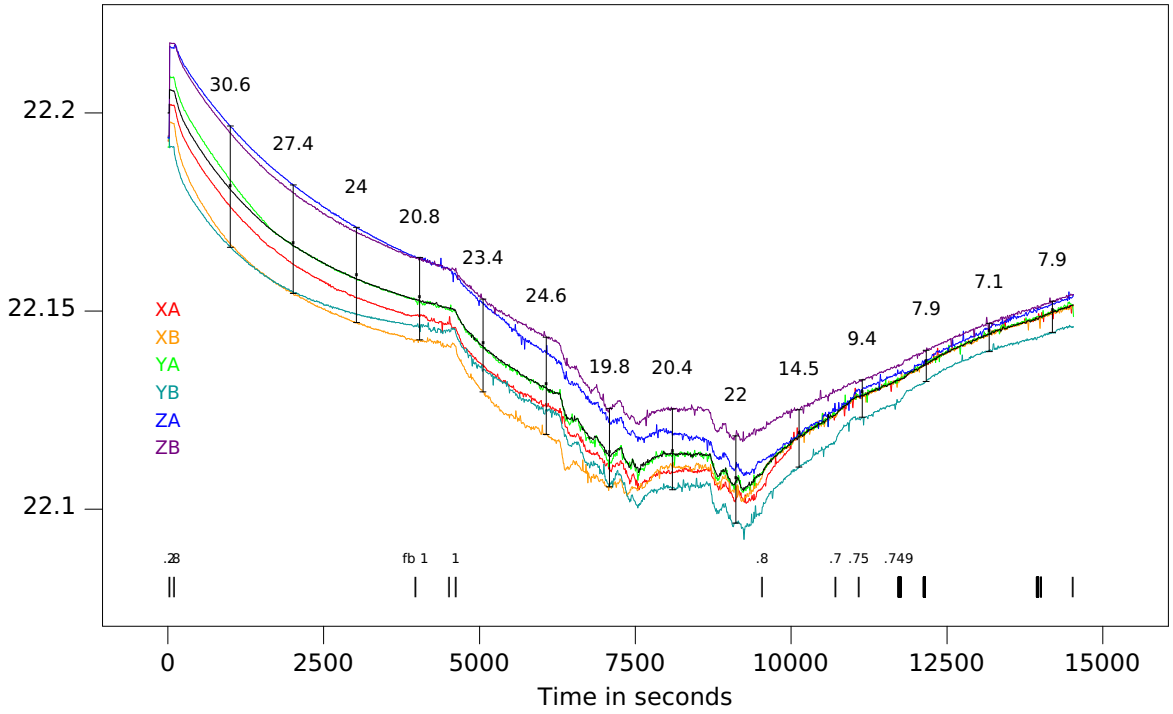
SPL changes initiated by the user are logged on a single line. The second and third columns are "Set SPL:" followed by a series of transducer gain changes, e.g.: *(t1: (1688, 1528))*. The string is a valid s-expression with the key 't1' representing transducer XA. The following two numbers represent the operating gain followed by the new gain required to achieve the new SPL.

Sensor feedback changes are logged as "Sensor feedback: 1" with a '1' turning velocity feedback processing on and a '0' when the feedback has been turned off.

User changes to resonant frequency and SPL tracking are logged with a "Track" element in the second column.

EXAMPLE

Grap is used to process the *console*(1) log file. This example depicts the resonant frequency tracking of the system during the course of an experiment. The spread between the resonant frequencies of the transducers is presented as a numeric value in Hz at regular intervals.



FILES

`$home/logs/aal/console/*.log`
`aal/sys/src/aal/man/data/console5.g`

SEE ALSO

console(1)

NAME

pyro – definition of the *pyro.cfg* configuration file

SYNOPSIS

```
(date "Fri Apr 29 17:18:38 CDT 2011")
(x "37479")
(y "37125")
(swidth "4.5")
(sheight "4.5")
```

DESCRIPTION

The *pyro*(1) configuration file stores the Zaber microstep *X* and *Y* positions, and scan width and height values in millimeters. The file can be edited in any text editor though it is easiest to save changes from the *pyro*(1) application as needed.

FILES

`~/lib/pyro.cfg`

SEE ALSO

pyro(1), *zaber*(2)

NAME

sensors – definition of the *sensor.cfg* configuration file

SYNOPSIS

```
(date "Tue Mar 29 17:15:17 CDT 2011")
(X (sensitivity ".00234562"))
(Y (sensitivity ".00231741"))
(Z (sensitivity ".00200134"))
```

DESCRIPTION

The *sensor.cfg* file stores slope sensitivity values used in calculating the digital gain applied on each sensor head. The data used to populate the values is generated using the *pscheck*(1) program and additional grap files. The file is saved directly from the *sensors*(1) application.

FILES

`~/lib/sensor.cfg`

SEE ALSO

pscheck(1), *sensors*(1)

NAME

temperasure – TemperaSure binary data storage format

DESCRIPTION

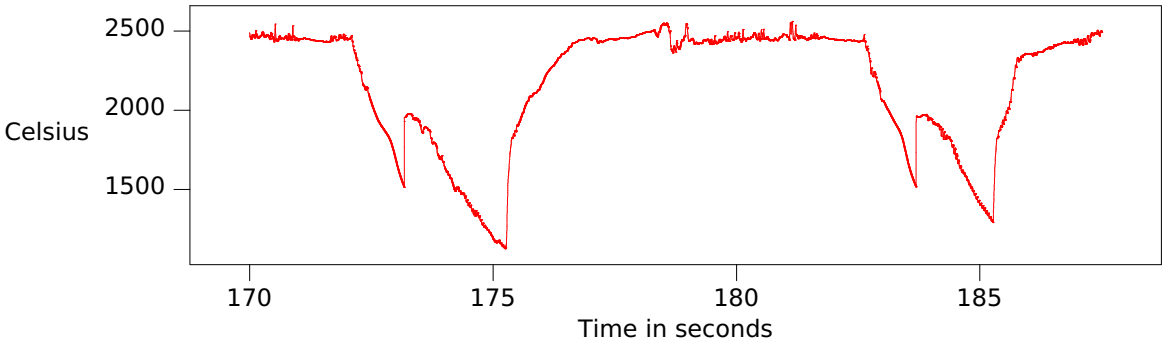
The Exactus files created when the *pyro*(1) application is logging data are in the TemperaSure binary format. This format was used as the model for the Exactus `Trecord` type. Each data object in the record is stored as a 32-bit *little endian* value.

The *timestamp* is a 32-bit unsigned integer representing the milliseconds since the first record in the data set. All timestamps are approximate due to communication and processing latency.

All the remaining data objects are 32-bit IEEE-734 floating point numbers. The *exactus*(2) *Trecord->pack()* and *Trecord->unpack()* functions handle conversion from IEEE-734 to Limbo data types.

EXAMPLE

Dumpbin(1) can be used to generated a text file usable by *grap* to generate a graph of temperature data. The following graph shows two recalescence events triggered by turning off the heating lasers for approximately three seconds before turning them back on (just after 175s and 185s). The sample is reheated in-between the two events.



The data is processed using this simple *grap* script:

```
.de CL
\X'PS \$1 \$2 \$3 setrgbcolor'\c
..
.de BK
\X'PS 0 0 0 setrgbcolor'\c
..
.G1 6.0
graph Temperature
	frame ht 1.6 wid 6.0
	draw px solid
	start = 170000
	stop = 187500
.CL 1 0 0
	copy "x-20110331_180657.txt" thru {
		if "$1" == "#" then {} else {
			if start <= $1 && $1 <= stop then { next px at ($1/1000, $2) }
		}
	}

.BK
	label bottom "Time in seconds"
	label left "Degrees" "Celsius" left .45
.G2
```

FILES

`~/logs/aal/exactus/*.bin`

SEE ALSO

dumpbin(1), *exactus*(2), *pyroplot*(2), *temperasure-dat*(5)

NAME

temperasure-dat – TemperaSure header file format

DESCRIPTION

The `.dat` file is generated by *pyroplot*(2) when closing the log file. It is used by the TemperaSure software to open the binary storage file. The file should stay in the same directory as the similarly named `.bin` file.

A subset of the entries stored in the file are:

`name`	A reference path to the binary data file this file will open.
`count`	The number of *Trecord* data objets stored in the content file.
`serial`	The Exactus serial number used to create this content file.
`startTime`	The date and time when the log file started.
`msPerPoint`	The millisecond division between points.

FILES

`~/logs/aal/exactus/*.dat`

SEE ALSO

exactus(2), *pyroplot*(2), *temperasure-bin*(5)

NAME

transducer – definition of the *transducer.cfg* configuration file

SYNOPSIS

```
(date "Mon Mar 21 16:34:02 CDT 2011")
(IVPc "7.378E+07")
(t1 (sn "12") (tsn "10A") (Av "0.004934") (Ai "0.3641")
      (Aspl "0.11320") (Ag "-1.4160") (Bg "4916.7")
      (A1 "0.4526") (A0 "-7.121"))
(t2 (sn "14") (tsn "1B") (Av "0.004884") (Ai "0.3610")
      (Aspl "0.09092") (Ag "-1.4118") (Bg "4967.8")
      (A1 "0.4754") (A0 "-6.760"))
(t3 (sn "18") (tsn "2A") (Av "0.004902") (Ai "0.3627")
      (Aspl "0.11121") (Ag "-1.4102") (Bg "5009.1")
      (A1 "0.5050") (A0 "-8.613"))
(t4 (sn "16") (tsn "3A") (Av "0.004859") (Ai "0.3637")
      (Aspl "0.11202") (Ag "-1.4096") (Bg "4939.0")
      (A1 "0.4615") (A0 "-6.213"))
(t5 (sn "17") (tsn "2B") (Av "0.004980") (Ai "0.3641")
      (Aspl "0.11335") (Ag "-1.4117") (Bg "4981.1")
      (A1 "0.4603") (A0 "-6.255"))
(t6 (sn "15") (tsn "X3") (Av "0.004876") (Ai "0.3611")
      (Aspl "0.12008") (Ag "-1.4188") (Bg "4956.2")
      (A1 "0.4334") (A0 "-5.949"))
```

DESCRIPTION

The calibration parameters for each transducer and transducer controller board pair are stored in the *transducer.cfg* file. This file is an s-expression format and is read using functions in the *sexprs* module.

A record entry for each transducer is in the file. The numbering goes from *t1* for *XA* to *t6* for the *ZB* transducer controller.

FILES

`~/lib/transducer.cfg`

SEE ALSO

calibration(2), *math*(2)

NAME

intro – introduction to administration modules and system services

DESCRIPTION

This section of the manual covers the tools used to administer and calibrate the AAL. Many of these examples are directly related to the *intro*(1) commands.

Items not covered in prior sections are details on the Inferno and IOLAN administration files that facilitate the system. *Iolan*(6) describes the configuration of the IOLAN device server to support the eight serial devices connected throughout the system. The *ndb*(6) reference details network databases used by the Inferno programs to look up the services provided by the AAL.

SEE ALSO

calibtran(6), *iolan*(6), *ndb*(6), *pscheck*(6), *scanfreq*(6)

NAME

aal/calibtran – AAL transducer control board calibration

SYNOPSIS

`aal/calibtran` [`-d`] [`-l` *log*] `-t` *transducer*

DESCRIPTION

Calibrating the paired transducer and AAL controller board requires manual verification using voltage and current probes and an oscilloscope. This program eases the collection of data used to generate the calibration data stored in the *transducer*(5) configuration file.

EXAMPLE

The end user will use an Inferno shell to generate a file for each profile. By convention `DATE` is used to represent the current year, month, and day in the form `'20110310'`. A sequence of commands is used to save the data into a file for the transducer:

```
% mkdir $home/tests/DATE
% cd $home/tests/DATE
% aal/calibtran -t 2
cmd: m
       t1     3584   222000 91     0      78     0
cmd: freq 22.2
cmd: gain 3000
cmd: s 1 1 1
cmd: s -0.4 3.52 170
cmd: gain 2600
cmd: s 1 1 1
cmd: s -0.6 6.28 304
cmd: gain 2200
cmd: s 1 1 1
cmd: s -0.9 9.2 436
...
cmd: quit
%
```

Would produce an output file:

```
Calibration scan (Thu Mar 10 11:31:01 CST 2011)
Now    Bid    Gain   Freq   Vo     PhiV   Io     PhiI   Delta  PkV    PkI

1299778588    t2     3000   222000 732    3196   487    0      1      1      1
1299778604    t2     3000   222000 732    3197   489    0      -.4    3.52   170
1299778626    t2     2600   222000 1298   3196   851    0      1      1      1
1299778646    t2     2600   222000 1282   3184   843    0      -.6    6.28   304
1299778667    t2     2200   222000 1862   3169   1196   0      1      1      1
1299778684    t2     2200   222000 1862   3150   1183   0      -.9    9.2    436
...
```

The `'s 1 1 1'` command entries mark a place where one user is stopping the oscilloscope in order to make a valid reading. At that point the operator would type in the following values read back and hit the return to finish the line. The same sequence of commands would be used to scan through a range of frequencies and output gain for each transducer.

SEE ALSO

calibtran(1), *calibration*(2) *math*(2), *transducer*(5)

NAME

iolan – IOLAN administration

DESCRIPTION

The IOLAN device server enables the access of serial devices over an Ethernet network. The AAL uses this server to bridge between the various RS-232 and RS-485 serial devices used in controlling the system.

IOLAN administration takes place through a web or shell interface. It has been configured to provide the following port mappings:

10001	RS-232 port, 9600 bps, connected to a Synrad UC-2000 controller.
10002	RS-232 port, 9600 bps, connect to a Synrad UC-2000 controller.
10003	RS-232 port, 115200 bps, connected to the Exactus pyrometer.
10004	RS-232 port, 9600 bps, connected to the Zaber XY translators.
10005	RS-485 port, 115200 bps, connected to sensor head X.
10006	RS-485 port, 115200 bps, connected to sensor head Y.
10007	RS-485 port, 115200 bps, connected to sensor head Z.
10008	RS-232 port, 115200 bps, connected to the AAL communications controller.

The ports are configured to use a raw line service application, *inraw*, running on the IOLAN. A TCP connection opens the corresponding serial port and tunnels raw bytes to and from the serial device. A modified *inraw_aal* application is used for the AAL communications controller port. The *inraw_aal* messages the AAL communication controller with a special command sequence when the TCP port has been closed.

FILES

`aal/sys/src/iolan/IOLAN-103CCB-config.txt`
`aal/sys/src/iolan/inraw.c`
`aal/sys/src/iolan/inraw_aal.c`

SEE ALSO

http://www.perle.com/products/documentation.asp?a=3&i=47

NAME

ndb – network data base

SYNOPSIS

`/lib/ndb/aal`

DESCRIPTION

The AAL network configuration is added to the Inferno supplied `/lib/ndb/local` data base. Keeping this file as a single configuration for AAL specific network services eases the administration if an Internet address needs to be modified. The added TCP services map to the ports on the IOLAN device server. The system name *iolan* is mapped to provide a simple lookup controlled by the AAL system.

EXAMPLE

```
#
# AAL port assignments
#
tcp=aal9p port=10008                # AAL Host 9p service

tcp=sensorz port=10007              # AAL Sensor connection ports
tcp=sensory port=10006
tcp=sensorx port=10005

tcp=zaber port=10004
tcp=exactus port=10003
tcp=synradtwo port=10002
tcp=synradone port=10001

#
# AAL Hosts
#
ipnet=aalnet ip=192.168.1.1 ipmask=/24

ip=192.168.1.8 sys=iolan
ip=192.168.1.10 sys=lenovo
```

FILES

`/lib/ndb/*`

SEE ALSO

Inferno *ndb* configuration.

NAME

pscheck – sensor position sensitivity check

SYNOPSIS

`aal/sensor/pscheck` [`-a`] [`-d`] [`-r` ±*range*] [`-s` *spl*] [`-t`] [`-v`] [`-Y`] [*axis*]

DESCRIPTION

The *pscheck* program is used to verify the sensor alignment using a polystyrene bead. Nine data files corresponding to the axis of sample translation and sensor collection will be created in the current working directory.

Pscheck needs full control over the AAL device to complete the sample check. The user must not be running the *console*(1) or *sensors*(1) during the experiment. The program is run from the Inferno shell:

```
% mkdir $home/tests/DATE
% cd $home/tests/DATE
% aal/sensor/pscheck -a -r 200 -Y
..
```

The resulting data files are used by a *grap* program run from a Linux shell to create output files. The plot of the slope and sensitivity values can then be entered directly into the *sensors*(1) application to calibrate the sensor feedback gain.

The Linux shell commands have examples in `~/tests`. In order to use those scripts it is usual to:

```
% cd ~/tests/DATE
% ln -s ../scripts/* .
% 9 mk pdf
```

The *ln* command links all of the files from the *scripts* directory into the local directory. The user then executes the command *'9 mk pdf'* to generate the output files in the local directory. The final output is saved in PostScript and PDF files.

FILES

`$home/tests/scripts/pscheck.g`
`$home/tests/scripts/pscheckfit.g`

SEE ALSO

pscheck(1),
Two example pages follow.

Alignment tests.

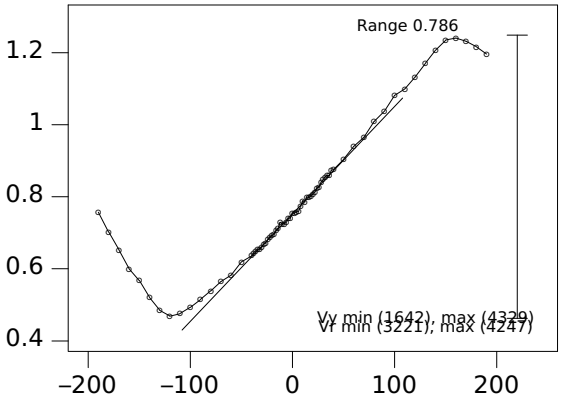


Fig 1. X Position vs Phase

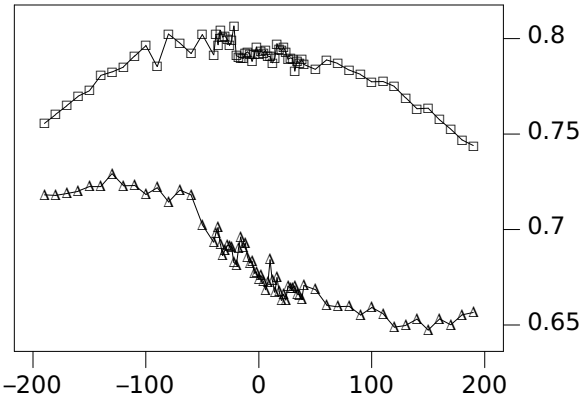


Fig 2. Y (square) and Z (delta) Position vs Phase

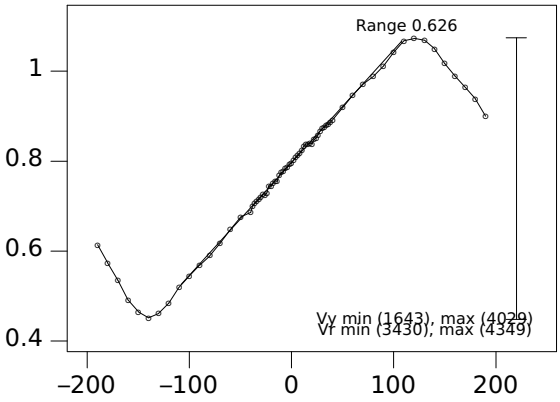


Fig 3. Y Position vs Phase

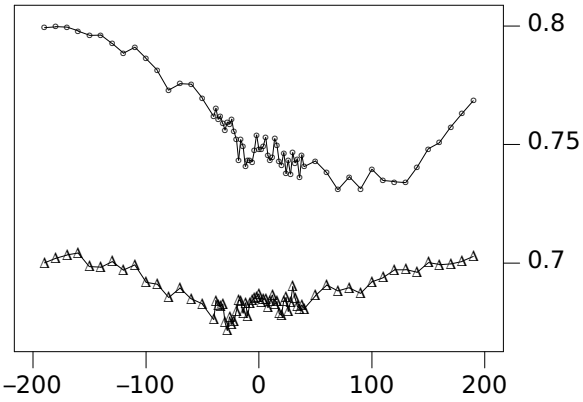


Fig 4. X (circle) and Z (delta) Position vs Phase

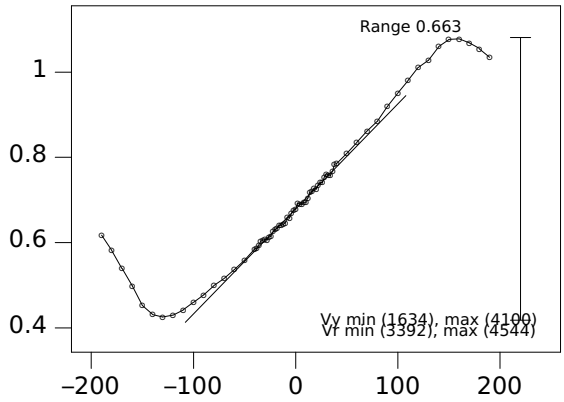


Fig 5. Z Position vs Phase

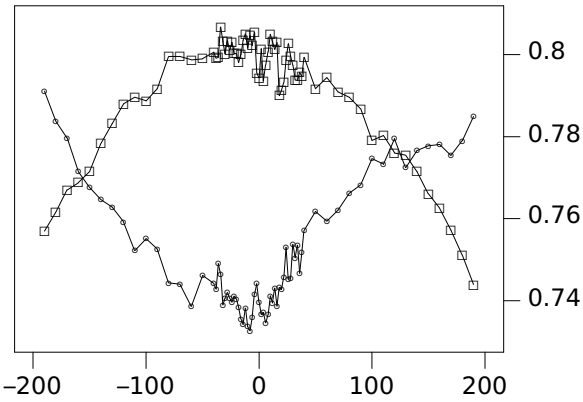


Fig 6. X (circle) and Y (square) Position vs Phase

Avg: 0.00265154

X slope 0.00298323	Y slope 0.00250751	Z slope 0.00246387
X rs 1.1251	Y rs 0.945682	Z rs 0.929222
X gain 0.888813	Y gain 1.05744	Z gain 1.07617

Alignment tests.

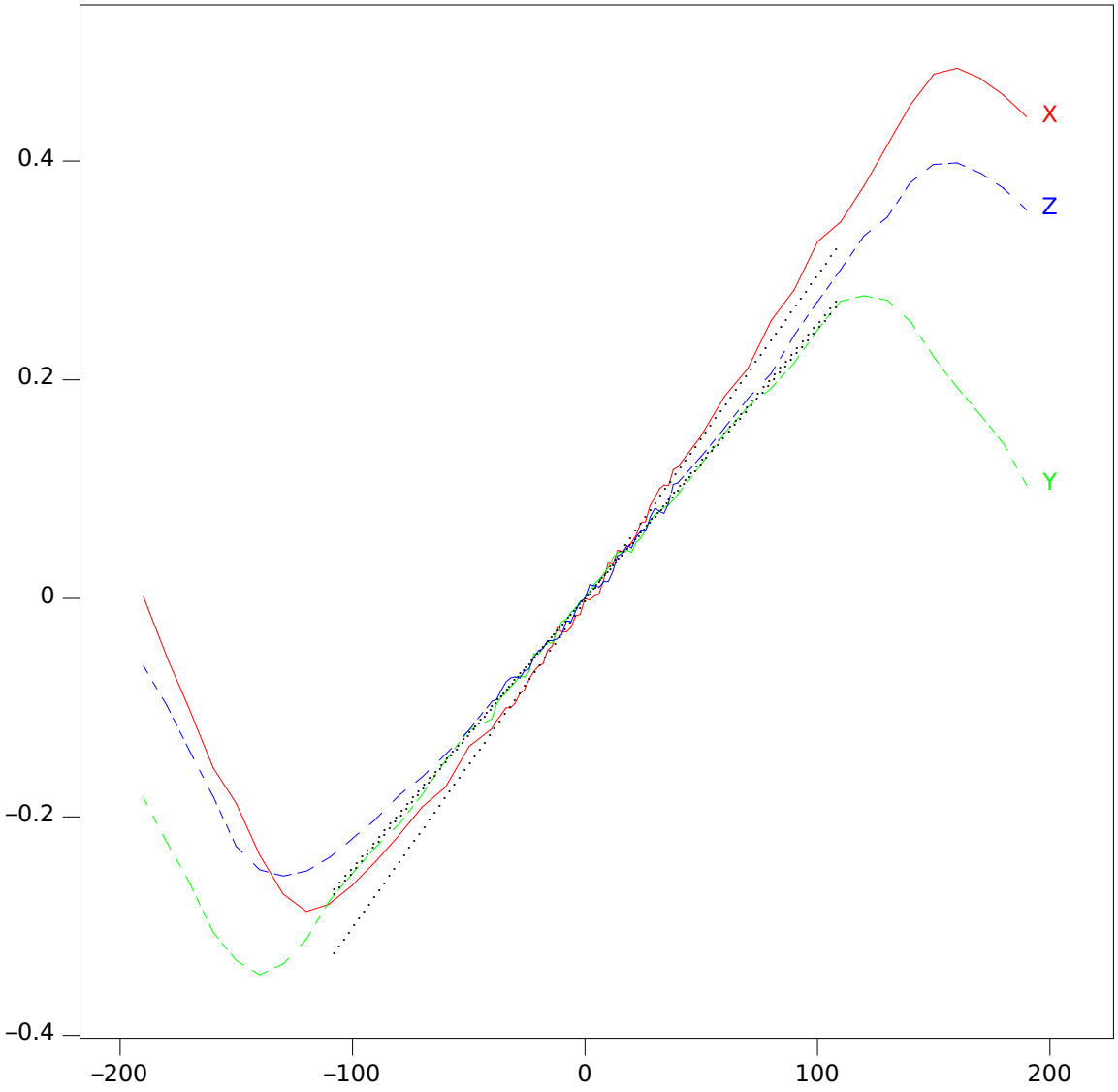


Fig 1.

Avg: 0.00265154

X slope 0.00298323	Y slope 0.00250751	Z slope 0.00246387
X rs 1.1251	Y rs 0.945682	Z rs 0.929222
X gain 0.888813	Y gain 1.05744	Z gain 1.07617

NAME

aal/scanfreq – acoustic frequency scanner

SYNOPSIS

`aal/scanfreq` [`-d`] [`-g` *gain*] [`-l` *low kHz*] [`-h` *high kHz*] [`-m` *ms*]

DESCRIPTION

Scanfreq is a simple program that collects voltage, current, and V-I phase data from the transducer control boards.

EXAMPLE

```
Frequency scan (Tue Mar 22 22:39:36 GMT 2011)
Gain=1000     22.12kHz to 22.24kHz

Delay: 500 ms
Seq    Bid    Gain   Freq   Vo     PhiV   Io     PhiI

0      t1     1000   222400 3542   0      210    3091
0      t2     1000   222400 3557   2917   246    0
0      t3     1000   222400 3580   3188   249    0
0      t4     1000   222400 3572   3214   178    0
0      t5     1000   222400 3637   2614   292    0
0      t6     1000   222400 3490   2785   280    0
1      t1     1000   222380 3541   0      213    3196
1      t2     1000   222380 3557   2844   263    0
1      t3     1000   222380 3581   3118   263    0
1      t4     1000   222380 3571   3130   184    0
1      t5     1000   222380 3639   2579   313    0
1      t6     1000   222380 3489   2741   298    0
...
```

SEE ALSO

scanfreq(1)

INDEX

Manual pages for all sections are accessible on line through *man*(1). The affliated manual page will need the prefix *'aal-'* in order to be found on the Inferno manual.

This manual was typeset in DejaVu Sans by the authors using the Plan 9 version of troff:

```
troff | tr2post | psfonts > print.ps
```

The input text was characters from the Unicode Standard encoded in UTF-8.