Operational State and Servo Instability DMT Software

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Outline:

- Operational State Condition
  - Motivation
  - Definition of interface
  - Status
- Servo Instability Detection
  - What we want to detect
  - Definition of interface
  - Status

Operational State Condition Software

Before undertaking an analysis, one often needs to specify required machined conditions (Operational State)

Examples:

- Before seeking instability in Recycling Mirror (RM) servo:
  - Require lock of RM and Beam Splitter (BS) servos
  - Require wave front sensing engaged (or not engaged)
- Require laser intensity above certain threshold
- Require seismic RMS below ceiling (or above threshold)

Want to specify Boolean combinations of conditions:

Cond1 = "RM servo locked"

Cond2 = "BS servo locked"

Cond3 = Cond1 & Cond2

Want convenience of standard conditions,
i.e., "Full_Lock" or "IFO_quiet"

Also want run-time convenience of ascii configuration file

Operational State Condition Software

Sample Configuration File (April engineering run)
(To define quiet seismic motion at Hanford LVEA and locked single 2-km arm)

```
[name]       [type]       [definition]          [double parms]  [int parms]

x_quiet      rmsrange     "H0:PEM-LVEA_SEISX"   0.    150.
y_quiet      rmsrange     "H0:PEM-LVEA_SEISY"   0.    150.
z_quiet      rmsrange     "H0:PEM-LVEA_SEISZ"   0.    300.
all_quiet    boolean      "x_quiet & y_quiet & z_quiet"

arm_locked   valueabove   "H2:ASC-QPDX_DC"      10000.

stable       boolean      "all_quiet & arm_locked"
```

Condition types supported in initial release:

boolean	Boolean condition
valueabove	Any value in time interval above threshold
valuebelow	Any value in time interval below ceiling
valuerange	Any value in time interval in range
meanabove	Mean value in time interval above threshold
meanbelow	Mean value in time interval below ceiling
meanrange	Mean value in time interval in range
rmsabove	RMS value in time interval above threshold
rmsbelow	RMS value in time interval below ceiling
rmsrange	RMS value in time interval in range

Operational State Condition Software

More types supported in initial release:

bitandany	All bits in mask present in at least one value
bitnandany	Not all bits in mask present in at least one value
bitorany	At least one bit in mask present in at least one value
bitnorany	No bits in mask present in at least one value
bitandall	All bits in mask present in all values
bitnandall	Not all bits in mask present in all values
bitorall	At least one bit in mask present in all values
bitnorall	No bits in mask present in all values

Operational State Condition Software

Internally, conditions defined by OperStateCond class with methods not (normally) accessed by users.

User interacts via a linked list (class OperStateCondList) of related condition objects

Example

Initialization:

```
OperStateCondList osclist;

osclist.readConfig(``myconfig.file'');
```

When processing frames:

```
if (osclist.satisfied(``all_quiet'') ) {

    do analysis

}
```

(Actual monitor should be derived from DatEnv class and pass data accessor object to osclist at initialization – see sample program `osc_sample.cc` for guidance.)

Operational State Condition Software

Status:

- Initial package integrated into production DMT
- Source code, sample program, makefile & documentation in ~`dmt/cvs/dmt/src/dmtlib/osc/` on sand
- New condition types for servo instability detection defined in development version in ~`keithr/osc/` on sand (next part of talk)

Servo Instability Detection Software

Servo "instability" refers here not only to real instability (runaway behavior), but also to any servo state with too high gain, giving excess noise just below the unity gain frequency.

Another worry is excitation of out-of-band resonances, *i.e.*, internal test mass normal modes

Want an early-warning system on all vulnerable servos to inform operator of impending problems

Signatures:

- Rapidly increasing band-limited rms in servo channel (broad band for gain peaking, narrow band for resonance excitation)
- Significant deviation from nominal spectral shape

Want flexible ascii config file to allow tuning of spectral parameters and derivatives that define instability

Want to combine servo instability conditions with other operational state conditions

Natural solution: define new operational state condition types

Servo Instability Detection Software

Sample Configuration File

```
[name]       [type]       [channel]    [double parms]  [int parms]

butterfly  poweravemag  "H2:LSC-GW_TO"   6700 6800 2.       10
```

Condition above satisfied if power in 6.7-6.8 kHz band increases by $\geq$ factor of two in 10 time intervals
$\Longrightarrow$ Looking for excitation of "butterfly" test mass resonance

Eventually hope to have standard set of config file conditions to monitor all longitudinal and orientation servos with spectral and derivative parameters tuned for high sensitivity under nominally stable conditions

In the meantime, though, must deal with unstable absolute power levels and even unstable spectral shapes
$\Longrightarrow$ Provide flexibility for development
$\Longrightarrow$ Many possible servo instability conditions defined

Servo Instability Detection Software

Types supported in current development version:

abspowerabove	Power in band above threshold
abspowerbelow	Power in band below ceiling
fractpowerabove	Fractional power in band above threshold
fractpowerbelow	Fractional power in band below ceiling
abspoweranyrise	Power in band rises fast in any interval
abspoweranyfall	Power in band falls fast in any interval
fractpoweranyrise	Fractional power rises fast in any interval
fractpoweranyfall	Fractional power falls fast in any interval
abspoweraverise	Power in band rises fast over N intervals
abspoweravefall	Power in band falls fast in over N intervals
fractpoweraverise	Fractional power rises fast over N intervals
fractpoweravefall	Fractional power falls fast over N intervals
poweranymag	Power in band magnified fast in any interval
poweranydemag	Power in band demagnified fast in any interval
poweravemag	Power in band magnified fast over N intervals
poweravedemag	Power in band demagnified fast over N intervals

Servo Instability Detection Software

New operational state conditions provide tools, but also need a dedicated background monitor to apply those tools

Monitor should read osc config file and monitor control file

Sample monitor control file

```
interval 2.0
logfile  /export/home/keithr/sample.log
trigger  butterfly warn epics 60. meta 3600.
```

Above config file requests:

- Monitoring at 2-second time intervals (default = 1.0 second, minimum=$\frac{1}{16}$ second)
- Logging of all output to the file **`/export/home/keithr/sample.log`** (default = console)
- Triggering if "butterfly" condition (defined in osc config file) is satisfied. The trigger is given a warning priority, sets an EPICS alarm (but no more frequently than every 60 seconds), and generates a meta-database entry (but no more frequently than every 3600 seconds).

The epics and/or meta keywords can be omitted. Default disposition is merely the logging of triggers.

Servo Instability Detection Software

Status:

- Development version of revised osc package available in `~keithr/osc/` on sand
  (includes private enhancements to dmt Sine class and temporary kludge to handle 1st-bin inconsistency in dmt FSpectrum class)
- Directory also contains sample program with makefile and osc config file
  (but without EPICS or meta-database triggers – output logging only)
- Will deliver background monitor program with EPICS / meta-database triggers by September 15
- Will deliver revised monitor with support for graphical display of defined conditions, run-time spectra and thresholds by November 15, along with config and monitor control files tuned to key 2-km servos. (Will work with Dick Gustafson on tuning.)