Technical Document **7/11/02** **LIGO-T010105-01-Z**

Description of the LockLoss DMT Monitor

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1 Function

The LockLoss Data Monitoring Tool (DMT) monitor watches for losses and acquisitions of lock in the interferometer arms. It sends triggers to the MetaDataBase when these events occur. The monitor also serves data in the form of lock history to the DMT Viewer program and produces a summary web page..

2 Algorithm

LockLoss monitors one channel for each arm of a specified interferometer: XX:LSC-LA_PTRR_NORM for the X-arm, and XX:LSC-LA_PTRT_NORM for the Y-arm, where the XX in the channel name is to be replaced by H1, H2, or L1 for the Hanford 4K, 2K, and Livingston 4K interferometers, respectively. These channels correspond to currents measured from photodiodes that see the light transmitted through the ends of the two arms. When an arm is resonant, the light power in the arm increases dramatically, and the relatively small fraction that leaks out the highly reflective end mirrors increases accordingly. These channels are normalized such that 1.0 represents full power buildup in a single arm in the absence of recycling.

To make the "in lock" definition used here robust against transient resonances but not unduly sensitive to downward in-lock power fluctuations, we require that the mean power detected by the end photodiodes over a one second interval be at least one third of the nominal resonant power for that arm when locked in isolation. The definition used here for both arms being locked is (as of the E8 engineering run) more stringent than merely requiring both arms to exceed the one-third threshol, however. Instead, both arms must exceed a threshold of 100 (where more than 1000 is nominal with recycling), in order to ensure that the arms are locking in the lowest-order TEM_{00} optical mode. (The successful acquisition of a recycling lock magnifies the power in the arms

because the carrier power is not resonant in the recycling cavity until both arms lock together.)

[Note that prior to the E6 engineering run, the LA_PTRR/T channels were treated as test points in the data acquisition system, making them unreliable for use in the DMT. During that period, the raw photodiode current channels `XX:ASC-QPDX/Y_DC` were used. Because conditions changed with time during commissioning (*e.g.*,, laser power, photodiode gains), we found it necessary to change from time to time the numerical values of the thresholds applied to the `QPDX/QPDY` channels. For reference, during the August 2001 E5 engineering run, the Hanford 2K X-arm power threshold was set to 25 ADC counts, and the Y-arm threshold to 30 counts.]

To give better guidance to astrophysical analysis of the data, conditions and corresponding triggers have also been defined to flag locked-interferometer data that is considered to be in "run mode", i.e., the operator has pushed a button to declare that interferometer control parameters are frozen. EPICS software ensures that even inadvertent subsequent parameter changes will disable this button variable. LockLoss monitors the lowest-order bit in the channel `XX:IFO-STATE_VECTOR` to determine the run mode.

3 Triggers

The `LockLoss` monitor sends triggers to the MetaDataBase whenever one or more arms changes its lock state, *i.e* if lock is acquired or lost. The following table lists the presently defined trigger labels, where the meanings are self-evident:

Trigger Name
`XX:X_arm_lock_acquired`
`XX:Y_arm_lock_acquired`
`XX:Both_arms_lock_acquired`
`XX:Both_arms_lock_runmode_acquired`
`XX:X_arm_lock_lost`
`XX:Y_arm_lock_lost`
`XX:Both_arms_lock_lost`
`XX:Both_arms_lock_runmode_lost`

Table 1: Trigger set

The trigger record also includes the ID of the interferometer (H1, H2, L1) and a time stamp.

4 DMT Viewer Interface

The `LockLoss` monitor also serves data for display in the DMT Viewer program. At present, the data served are 10-minute, 1-hour, 4-hour 8-hour and 12-hour histories of physical lock state for each arm, and a more general state variable for simultaneous arm locks. The definitions of the levels shown are

Value	Meaning
-1	No data available
0	Not locked
1	Locked
2	Locked and operator has pushed physics mode button
3	Same as 2 and conlog has detected no control parameter changes
4	Same as 3 and interferometer is in common mode feedback mode
5	All state vector bits are on (ignoring the excitation bit)

Histograms of lock segment lengths are also visible via the DMT viewer.

5 Trend Files

The `LockLoss` monitor also produces 1-minute trend files of the physical lock state of each arm and both arms together every hour, which can be displayed via the control room data viewer.

6 Summary web page

LockLoss also provides a summary page for each interferometer, giving the current lock status and the livetime fractions averaged over the preceding 10 minutes, 1 hour, 4 hours, 8 hours and 12 hours. The summary page can be reached via the "spi" links, for example,
`http://blue.ligo-wa.caltech.edu/gds/dmt/Monitors/STONE_spi.html`.

7 Implementation

`LockLoss` uses the `OperStateCondList` DMT class[1] to define conditions. For illustration, part of the Hanford 4K section of the configuration file used during the E8 engineering run is shown below (taken from the standard LockLoss config file on sand at `/export/home/ops/pars/LockLoss.conf`):

```
######################
#                    #
#  Begin H1 Section #
#                   #
###################

#
# H0:DAQ-DDCU4k1_fault is a boolean channel. It's OK if value is 0
```

```
# (false), in Fault if value is 1 (true)
#
H1:DDCU_OK      valuebelow "H0:DAQ-DDCU4k1_fault" threshold=0.5

H1:sgl_X_arm_thres     meanabove    "H1:LSC-LA_PTRR_NORM"     threshold=0.3
H1:sgl_Y_arm_thres     meanabove    "H1:LSC-LA_PTRT_NORM"     threshold=0.3

H1:X_arm_locked        boolean     "H1:DDCU_OK & H1:sgl_X_arm_thres"
H1:Y_arm_locked        boolean     "H1:DDCU_OK & H1:sgl_Y_arm_thres"

H1:One_arm_locked      boolean     "H1:X_arm_locked | H1:Y_arm_locked"

H1:dbl_X_arm_thres     meanabove    "H1:LSC-LA_PTRR_NORM"     threshold=100.
H1:dbl_Y_arm_thres     meanabove    "H1:LSC-LA_PTRT_NORM"     threshold=100.

H1:Both_arms_locked    boolean     "H1:dbl_X_arm_thres & H1:dbl_Y_arm_thres"

H1:X_arm_lock_acquired transitup   "H1:X_arm_locked"
H1:X_arm_lock_lost     transitdown "H1:X_arm_locked"

H1:Y_arm_lock_acquired transitup   "H1:Y_arm_locked"
H1:Y_arm_lock_lost     transitdown "H1:Y_arm_locked"

H1:Both_arms_lock_acquired transitup   "H1:Both_arms_locked"
H1:Both_arms_lock_lost     transitdown "H1:Both_arms_locked"
```

8 Known Bugs

LockLoss trigger entries in the MetaDataBase through the end of the E5 engineering run have time stamps that are exactly one second later than intended. The bug was corrected in the source code after E5.

References

[1] D. Chin and K. Riles, "Defining and Testing Operational State Conditions in the Data Monitoring Tool", LIGO-T-010104-00-Z (September 2001).