



Online Digital Signal Processing

NSF Review, October 23, 2002

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Digital Feedback Systems

□ Length Sensing and Control

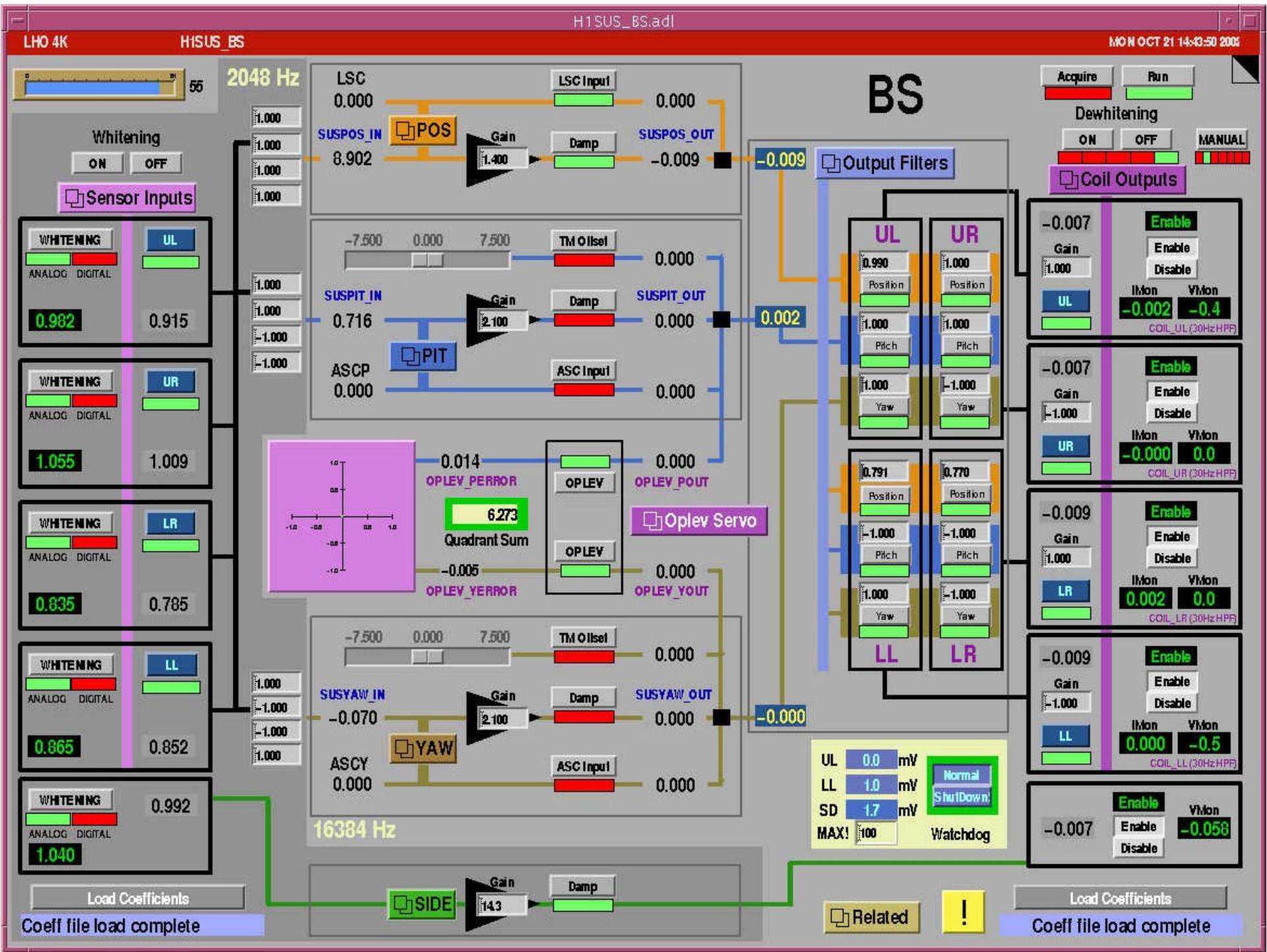
- Mode cleaner length
- DARM, CARM, MICH and PRC
- MCL common mode

□ Alignment Sensing and Control

- WFS1 to WFS5
- QPDX and QPDY

□ Digital Suspension System

- SOS: MC1, MC2, MC3, SM, MMT1, MMT2 and MMT3
- LOS: RM, BS, ITMX, ITMY, ETMX, ETMY, FMX and FMY
- Local damping and optical lever damping



2048 Hz

LSC 0.000 LSC Input 0.000
 SUSPOS_IN 8.902 POS Gain 1.400 Damp SUSPOS_OUT -0.009

SUSPIT_IN 0.716 TM OI sel 0.000
 Gain 2.100 Damp SUSPIT_OUT 0.000
 ASCP 0.000 PIT ASC Input 0.000

0.014 OPLEV_POUT 0.000
 6273 Quadrant Sum
 -0.005 OPLEV_YOUT 0.000
 Oplev Servo

SUSYAW_IN -0.070 TM OI sel 0.000
 Gain 2.100 Damp SUSYAW_OUT 0.000
 ASCY 0.000 YAW ASC Input 0.000

16384 Hz

SIDE Gain 143 Damp

BS

Acquire Run
 Dewhiting ON OFF MANUAL
 Coil Outputs

Output Filters

UL 0.990 Position 1.000
 1.000 Pitch 1.000
 1.000 Yaw 1.000

UR 1.000 Position 1.000
 1.000 Pitch 1.000
 -1.000 Yaw 1.000

LL 0.791 Position 1.000
 -1.000 Pitch 1.000
 1.000 Yaw 1.000

LR 0.770 Position 1.000
 -1.000 Pitch 1.000
 -1.000 Yaw 1.000

-0.007 Gain 1.000 Enable
 UL I_{Mon} -0.002 V_{Mon} -0.4
 COIL_UL (30Hz HPP)

-0.007 Gain 1.000 Enable
 UR I_{Mon} -0.000 V_{Mon} 0.0
 COIL_UR (30Hz HPP)

-0.009 Gain 1.000 Enable
 LR I_{Mon} 0.002 V_{Mon} 0.0
 COIL_LR (30Hz HPP)

-0.009 Gain 1.000 Enable
 LL I_{Mon} 0.000 V_{Mon} -0.5
 COIL_LL (30Hz HPP)

-0.007 Gain 1.000 Enable
 V_{Mon} -0.058

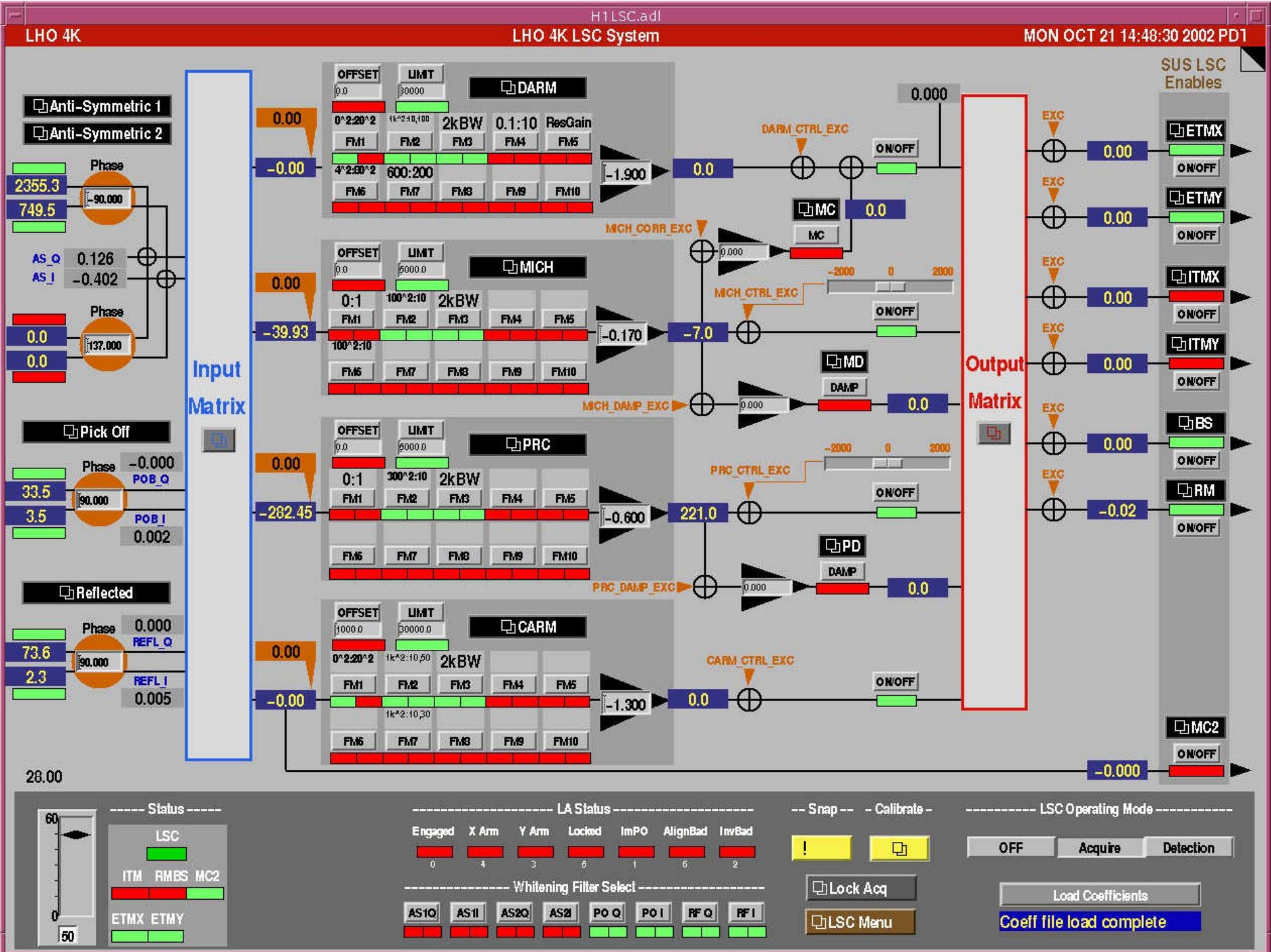
UL 0.0 mV
 LL 1.0 mV
 SD 1.7 mV
 MAX! 100 Watchdog

Related



Load Coefficients
 Coeff file load complete

Load Coefficients
 Coeff file load complete



ASC MASTER

Whitening

WFS 1
FM1 FM2
AS

WFS 2
FM1 FM2
REFL

WFS 3
FM1 FM2
REFL

WFS 4
FM1 FM2
REFL

WFS 5
FM1 FM2
AS

Pitch 0.00 Yaw -0.00
WFS 1
1.00 ON/OFF 0.004
1.00 ON/OFF 0.002

Pitch -0.00 Yaw 0.01
WFS 2A
1.00 ON/OFF 0.000
1.00 ON/OFF 0.000

Pitch -0.01 Yaw -1.00
WFS 2B
1.00 ON/OFF 0.000
1.00 ON/OFF 0.000

Pitch 0.00 Yaw -0.00
WFS 3
1.00 ON/OFF 0.000
1.00 ON/OFF 0.000

Pitch 0.00 Yaw -0.00
WFS 4
1.00 ON/OFF 0.000
1.00 ON/OFF 0.000

Pitch 0.00 Yaw 0.00
WFS 5
1.00 ON/OFF 0.000
1.00 ON/OFF 0.000

Matrix

Basis Xform

0.000 ON/OFF
ETMX

0.000 ON/OFF
ETMY

0.000 ON/OFF
ITMX

0.000 ON/OFF
ITMY

0.000 ON/OFF
RM

0.000 ON/OFF
BS

0.000 ON/OFF
MMT3



--- System Status ---

LVEA ESY ESX

TP MONITOR

QPD MASTER

ASC LOCKING

TM OFFSET



Load Coeffs

Coeff file load complete

Servos

OFF ON

Alignment gain 1.00





Interface to Analog World

- Input (16k and 2k)
 - **Whitening** (analog)
 - Anti-aliasing filter (analog)
 - Analog-to-digital converter
 - Anti-whitening (digital)
- Output (16k and 2k)
 - Anti-dewhitening (digital)
 - Digital-to-analog converter
 - Anti-image filter (analog)
 - **Dewhitening** (analog)

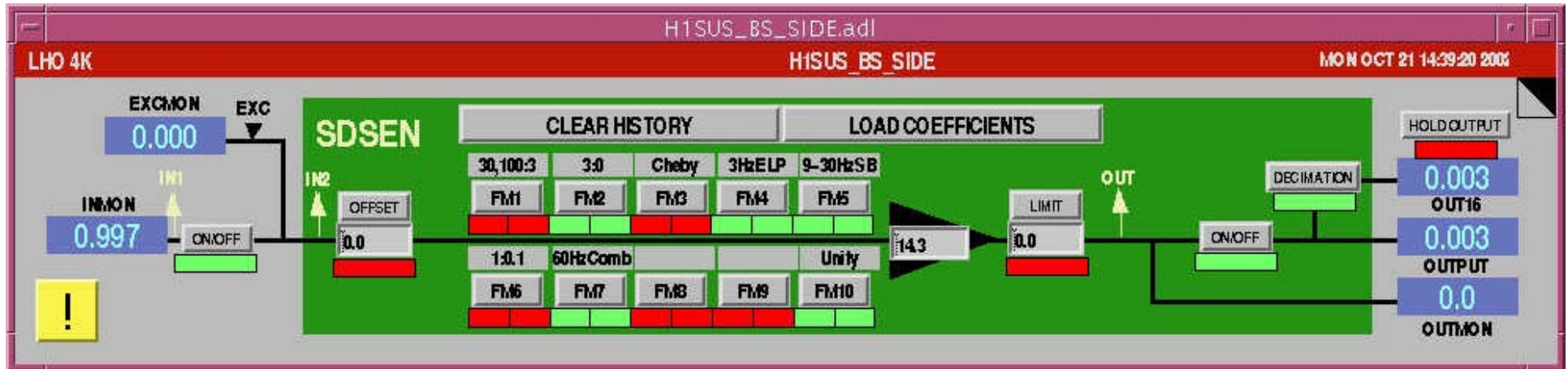


Standard Filter Module

- Filter Module
 - 10 sections w/ 10 SOS each (IIR up to 20th order)
 - On-off at input and output
 - Gain & Input offset adjust
 - Output limiter & Output hold
 - Filter coefficients loaded on-the-fly
- Filter sections
 - Can be turned on/off individually
 - Input switch: zero history, always on
 - Output switch: Immediate, ramp, zero-crossing, input-crossing
- Diagnostics
 - Excitation point at input
 - Test points at input (before and after injection) and output
 - EPICS channels



Standard Filter Module (2)




- ❑ DSC: 27–33 filter modules/optic, 13–16 optics/ifo
- ❑ LSC: 15 filter modules
- ❑ ASC: 64 filter modules
- ❑ Total: ~500 filter modules/ifo



Foton – Filter Online Tool

- ❑ Filter Design Tool w/ graphical user interface
- ❑ Read and write coefficient files for online system
- ❑ Design Methods:
 - ZPK: Zero-pole-gain
 - Resonant gain, Notch, Comb
 - Elliptic, Butterworth, Chebyshev type 1 and type 2
 - SOS and z-plane roots
- ❑ Plotting:
 - Transfer function (Bode)
 - Step, impulse and ramp response
 - Pole and zero location (z- and s-plane)

Module Selection



Path: 

- config_archive
- filter_archive
- runInfo

File:

Module:

Sections



Select:  



<input checked="" type="checkbox"/> 30,100:3	<input type="checkbox"/> 1:0.1
<input type="checkbox"/> 3:0	<input type="checkbox"/> 60HzComb
<input type="checkbox"/> Cheby	<input type="checkbox"/>
<input type="checkbox"/> 3HzELP	<input type="checkbox"/>
<input type="checkbox"/> 9-30HzSB	<input type="checkbox"/> Unity


Switching

Input:



Output:

Ramp Time:   sec

Tolerance:  

Timeout:   sec

Design





fSample:   Hz

Command:

Alternate:

s-Plane: s (rad/s) f (Hz) n (Hz, norm. gain) z-Plane: SOS Roots Online

Add:

Gain:   Hz Value:   Current:

Plotting

fStart:   fStop:   Number of Points:   Type:  

Bode Plot

Step Response

s-Plane Roots

Save

Load Coefficients

Exit

File Plot Window

Design Graphics



Style X-axis Y-axis Legend Param

Traces Range Units Cursor Config

Graph: Transfer function

0 1 2 3 4 5 6 7

 Active

Channels

A: current_in

B: current_out

Style

 Line solid 1.0 Symbol circle 1.0 Bar solid 0.10

Style X-axis Y-axis Legend Param

Traces Range Units Cursor Config

Graph: Transfer function

0 1 2 3 4 5 6 7

 Active

Channels

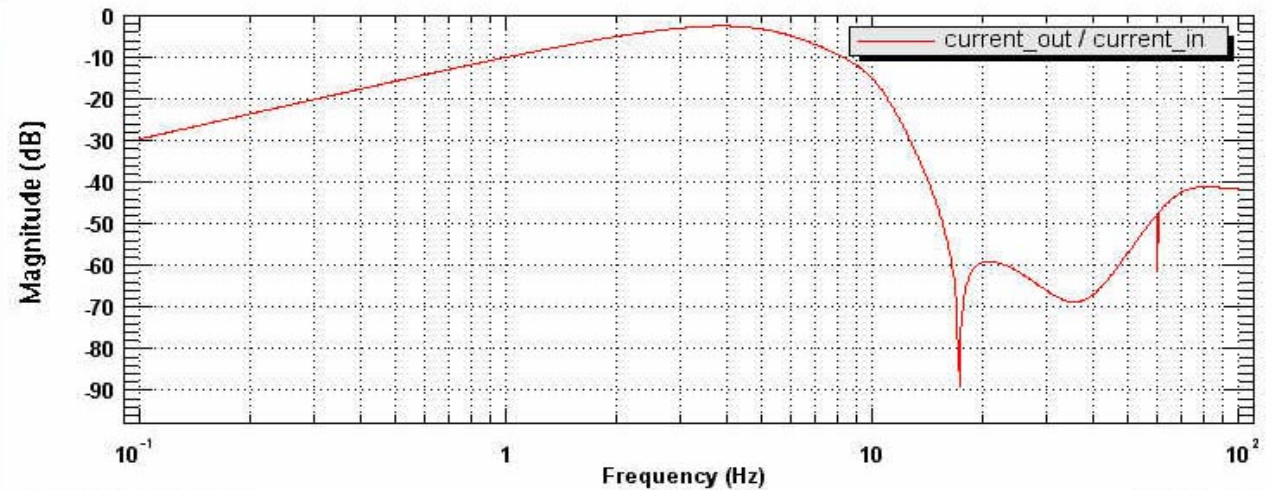
A: current_in

B: current_out

Style

 Line solid 1.0 Symbol circle 1.0 Bar solid 0.10

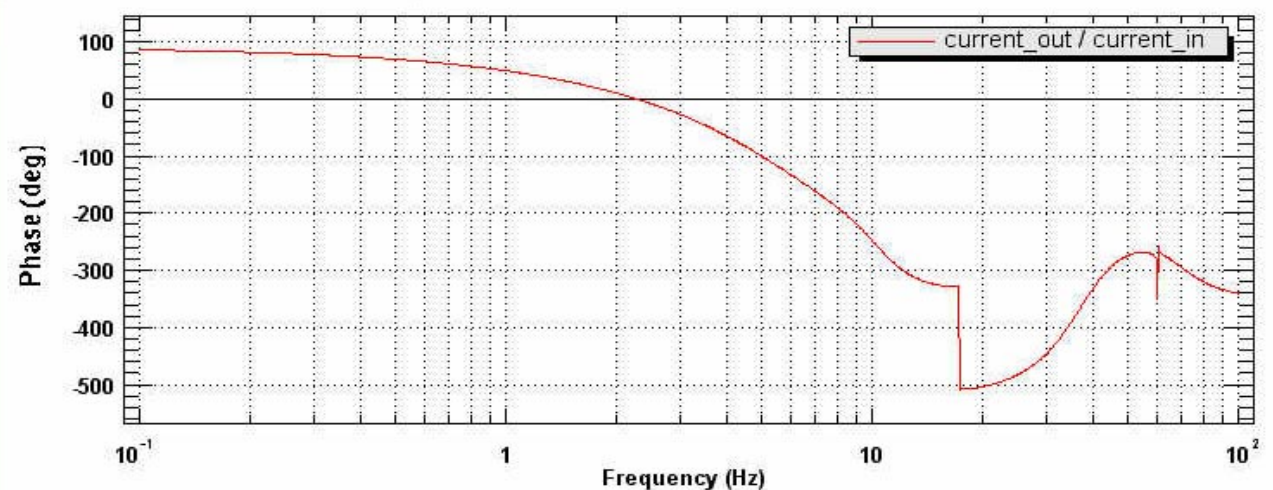
Transfer function



T0=21/10/2002 22:05:24

H1SUS BS.txt

Transfer function



T0=21/10/2002 22:05:24

H1SUS BS.txt

Reset

Zoom

Active

New

Options...

Import...

Export...

Reference...

Calibration...

Math...

Print...

Bode Plot

Step Response

s-Plane Roots

Save

Load Coefficients

Exit



DSC Status

- ❑ ~2500 process variables in DSC
- ❑ Check nominal settings
 - Nominal values and tolerances
 - Binary word and mask

H1SUS_STAT.adl
LHO 4K HISUS_STAT MON OCT 21 18:06:19 2006

DSC STATUS

- ETMX
- ETMY
- ITMX
- ITMY
- RM
- BS
- MC1
- MC2
- MC3
- MMT1
- MMT2
- MMT3
- SM

H1SUS_ETMX_STAT.adl
LHO 4K HISUS_ETMX_STAT MON OCT 21 18:06:18 2006

ETMX STATUS

- Main
- ULSEN
- LLSSEN
- SDSSEN
- SUSPIT
- ULPOS
- LLPOS
- ULPIT
- LLPIT
- ULYAW
- LLYAW
- ULCOIL
- LLCOIL
- OL1
- OL3
- OLPIT
- ASCPIT
- LSC
- Opt. Lev.
- URSEN
- LRSEN

H1SUS_ETMX_ULCOIL_STAT.adl
LHO 4K HISUS_ETMX_ULCOIL_STAT MON OCT 21 18:06:18 2006

ETMX ULCOIL STAT

	Current	Nominal	Mask/Tol.
■ SW1	0x4	0x4	0xIII
■ SW2	0x680	0x700	0xIII
■ Offset	0.0	0.000	0.000
■ Gain	1.000	1.000	0.000
■ Limit	25000.0	25000.000	0.000

H1SUS...
LHO 4K M...
4km D...