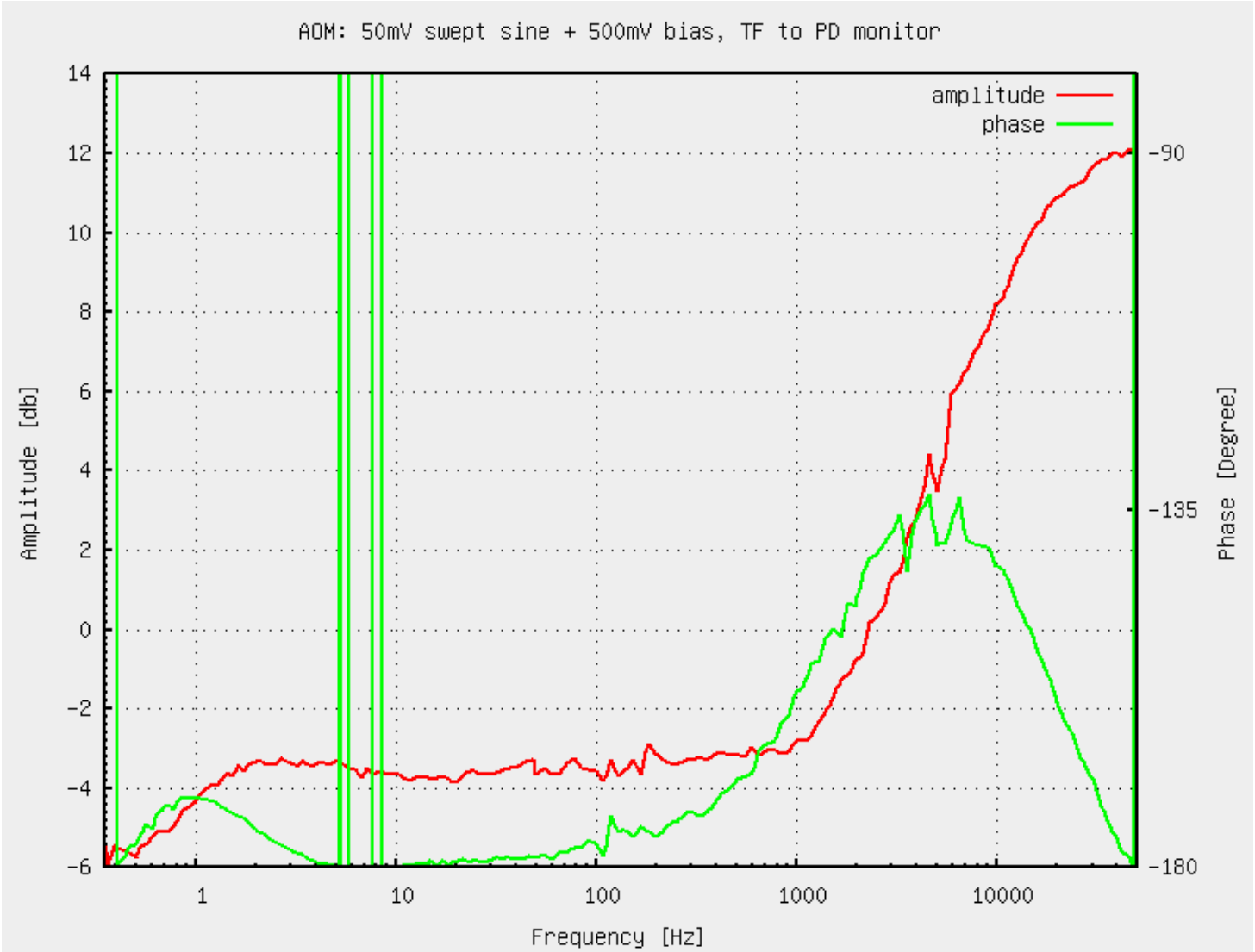
Optimization of the ISS

- ISS trouble in LLO on Oct. 2008
- For some time the actuator seemed weaker than usual, but even when it looked fine again, ISS was still not working
- ISS was in slow oscillation state
- Subsequent work on ISS loop shape , offsets and other aspects

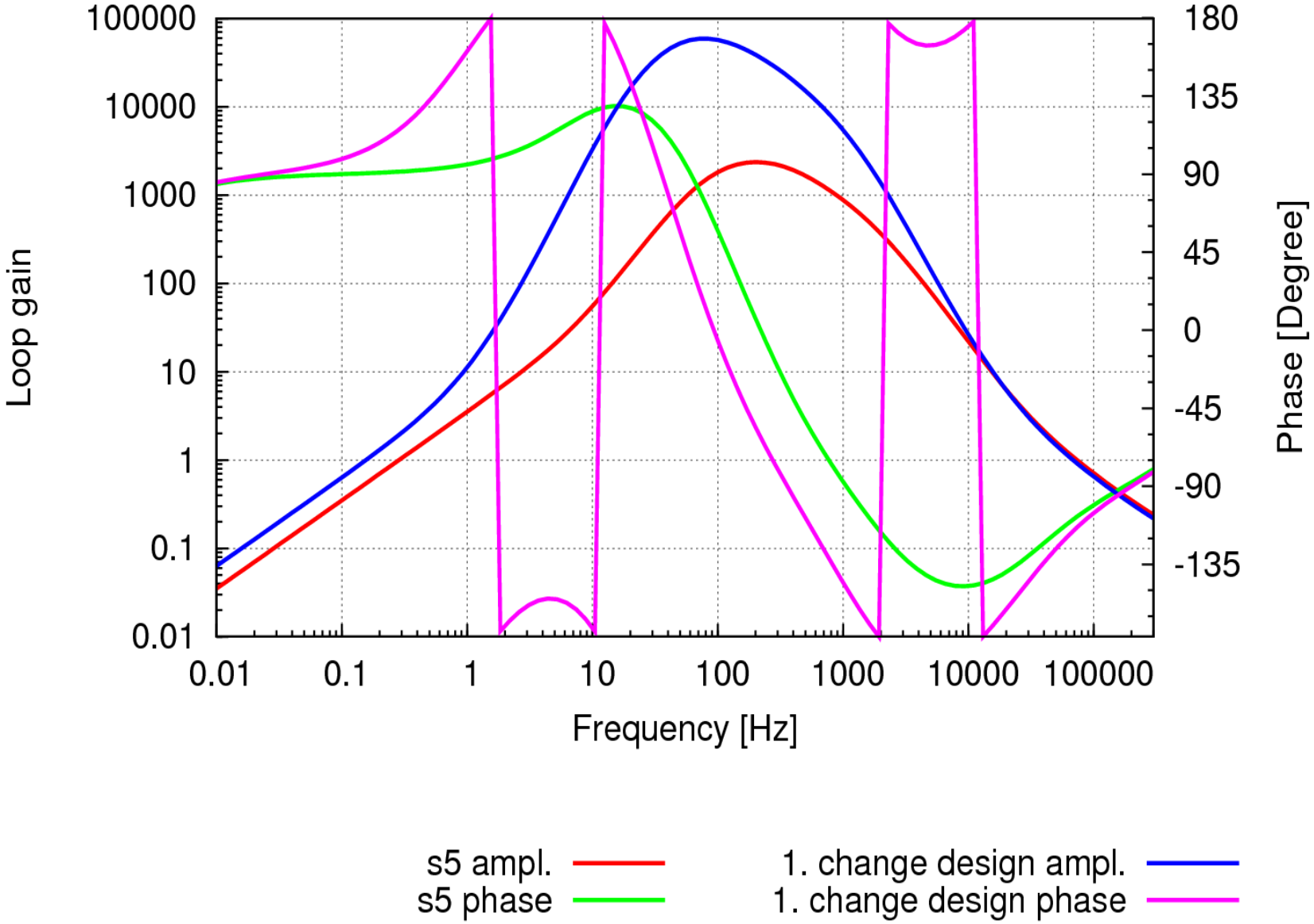
3 things coming together to make potential trouble

- AOM transfer function and drive characteristics
- Loop shape modification after s5
- Offset drift problems of ISS (2 causes)

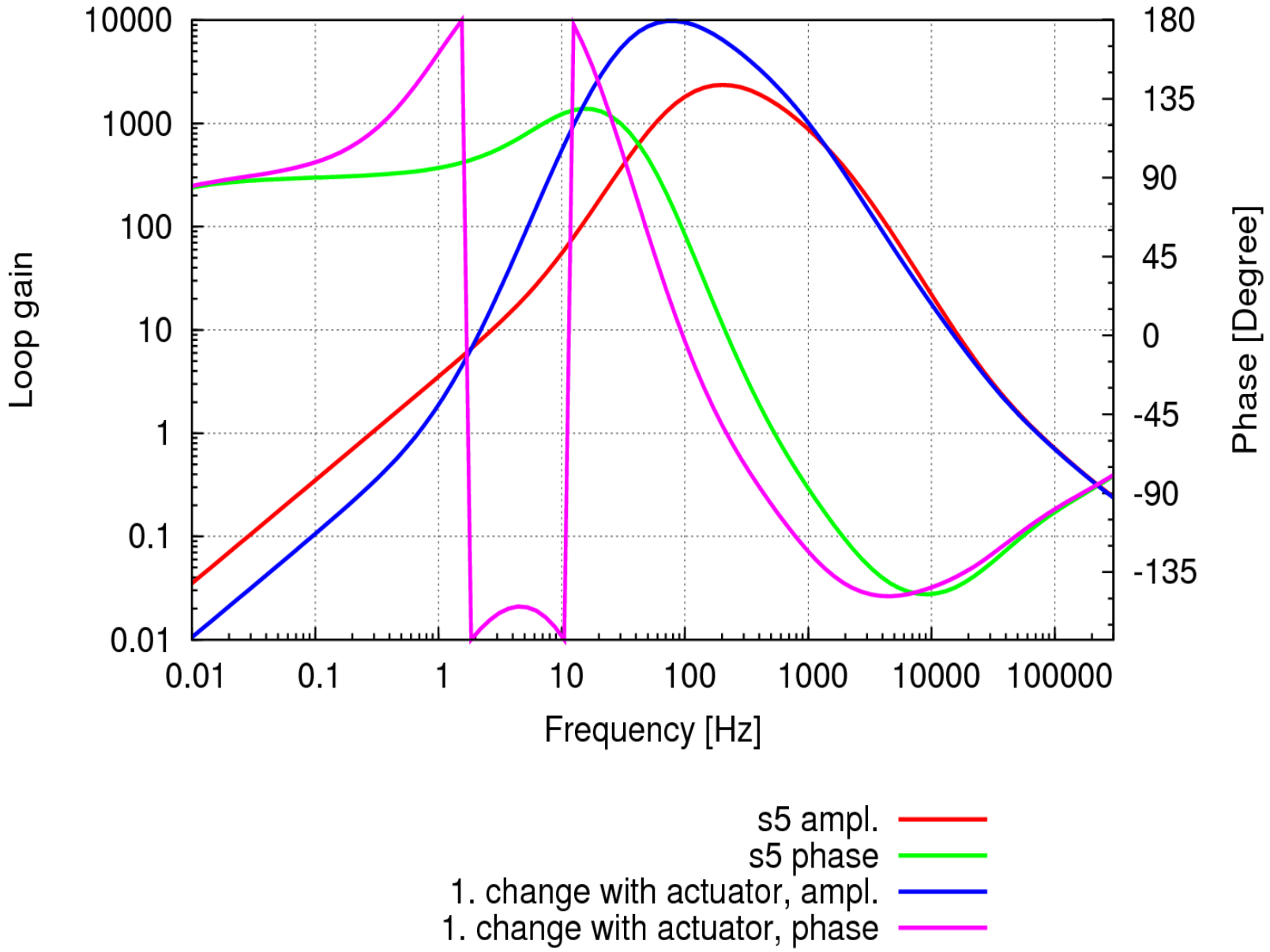
Enhanced Ligo Laser:
AOM Actuator Transfer Function



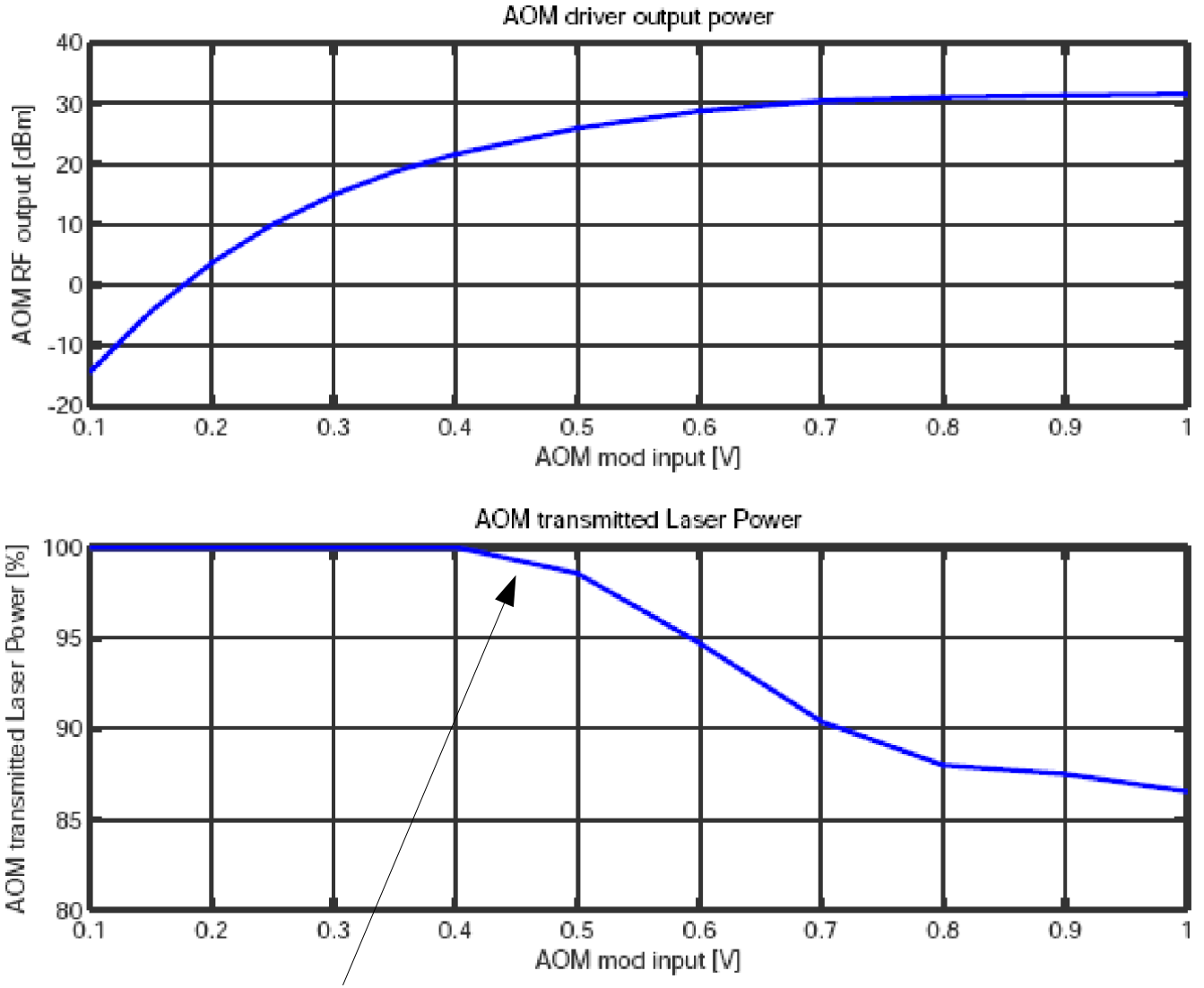
Intended new loop shape



...with AOM actuator TF



AOM actuator chain is non-linear

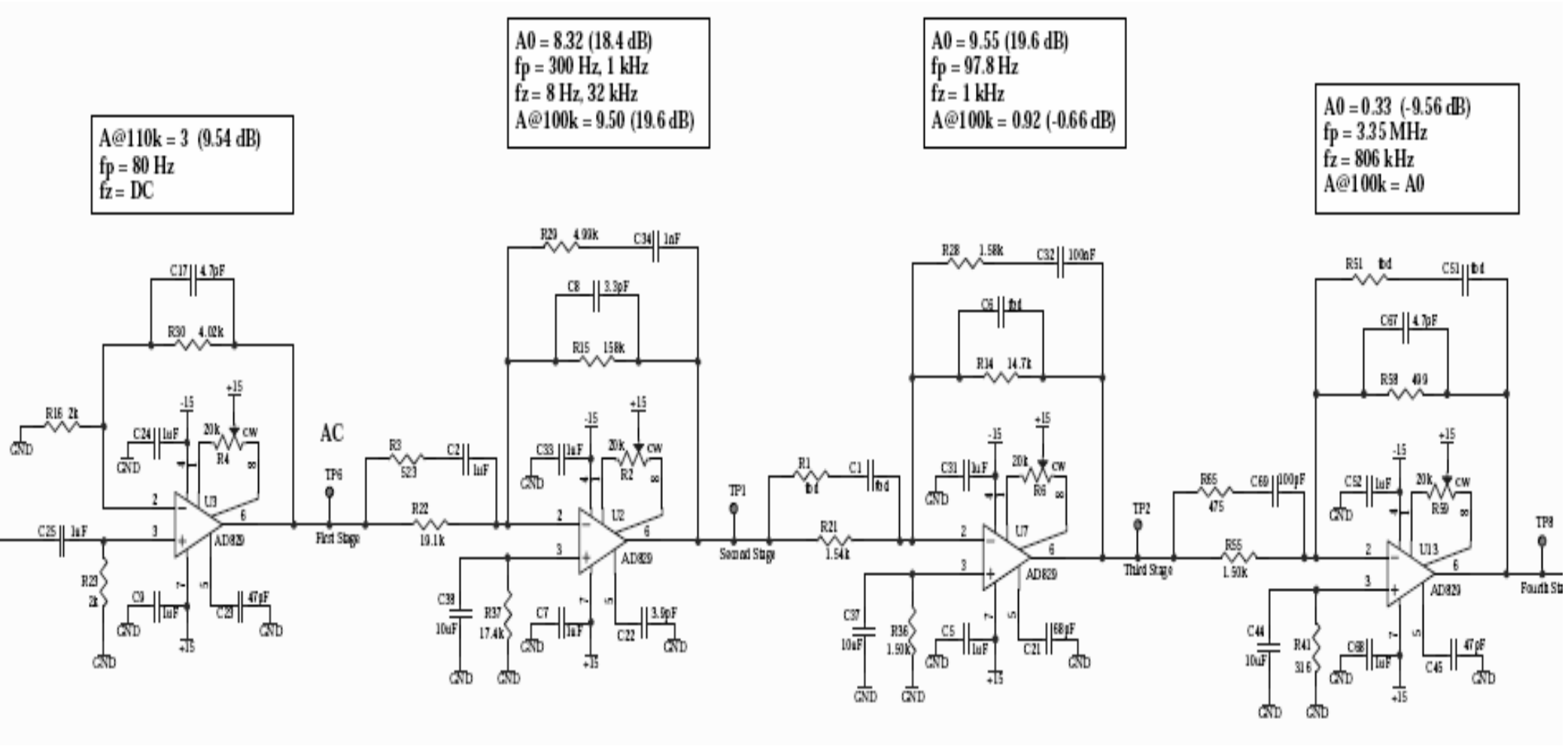


measurement:
S.Ballmer

need offset (bias) to get to this operating point

Main Servo Section

(after AC-coupling)



Nominal Offset Null Adjust

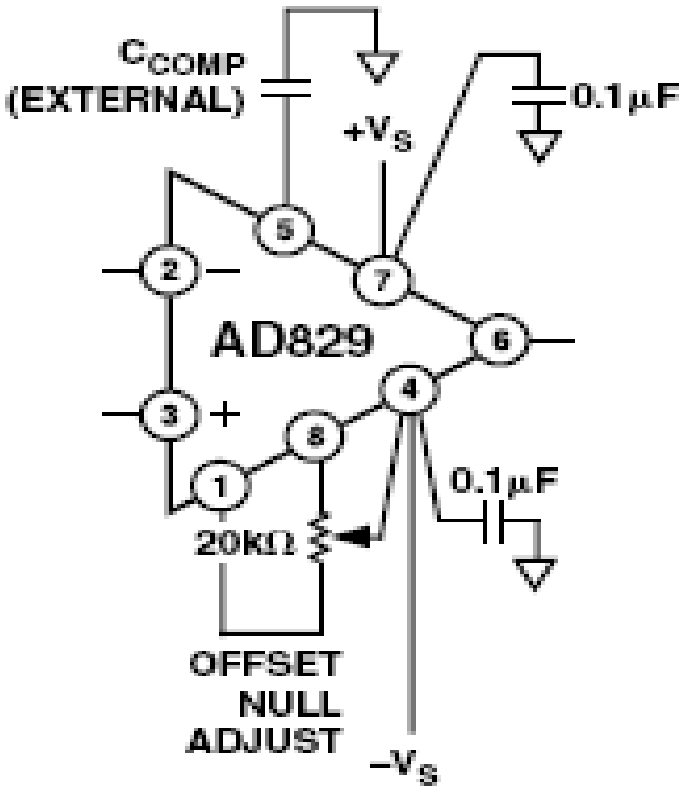


Figure 2. Offset Null and External Shunt Compensation Connections

AD829 Internal Schematic

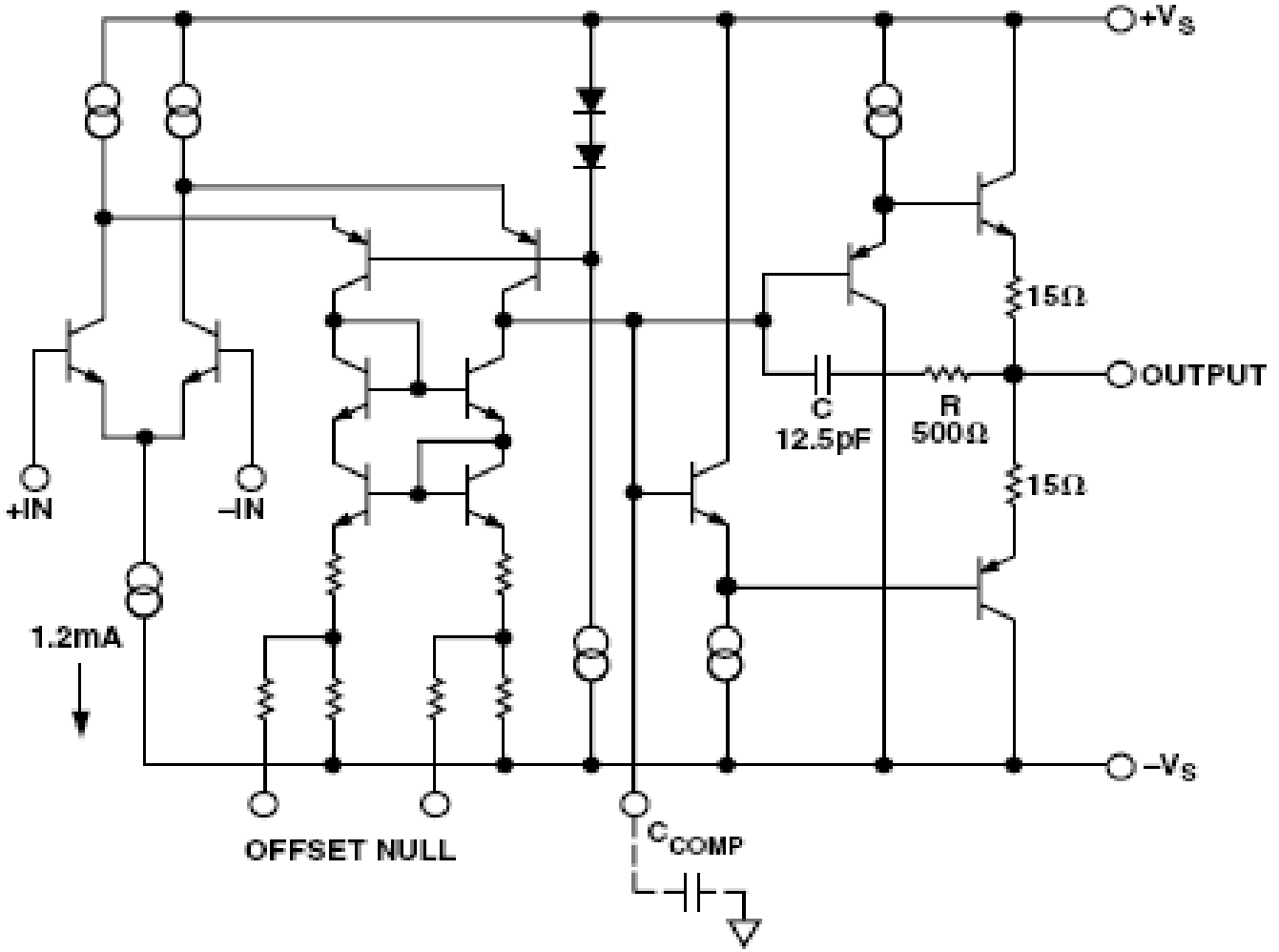
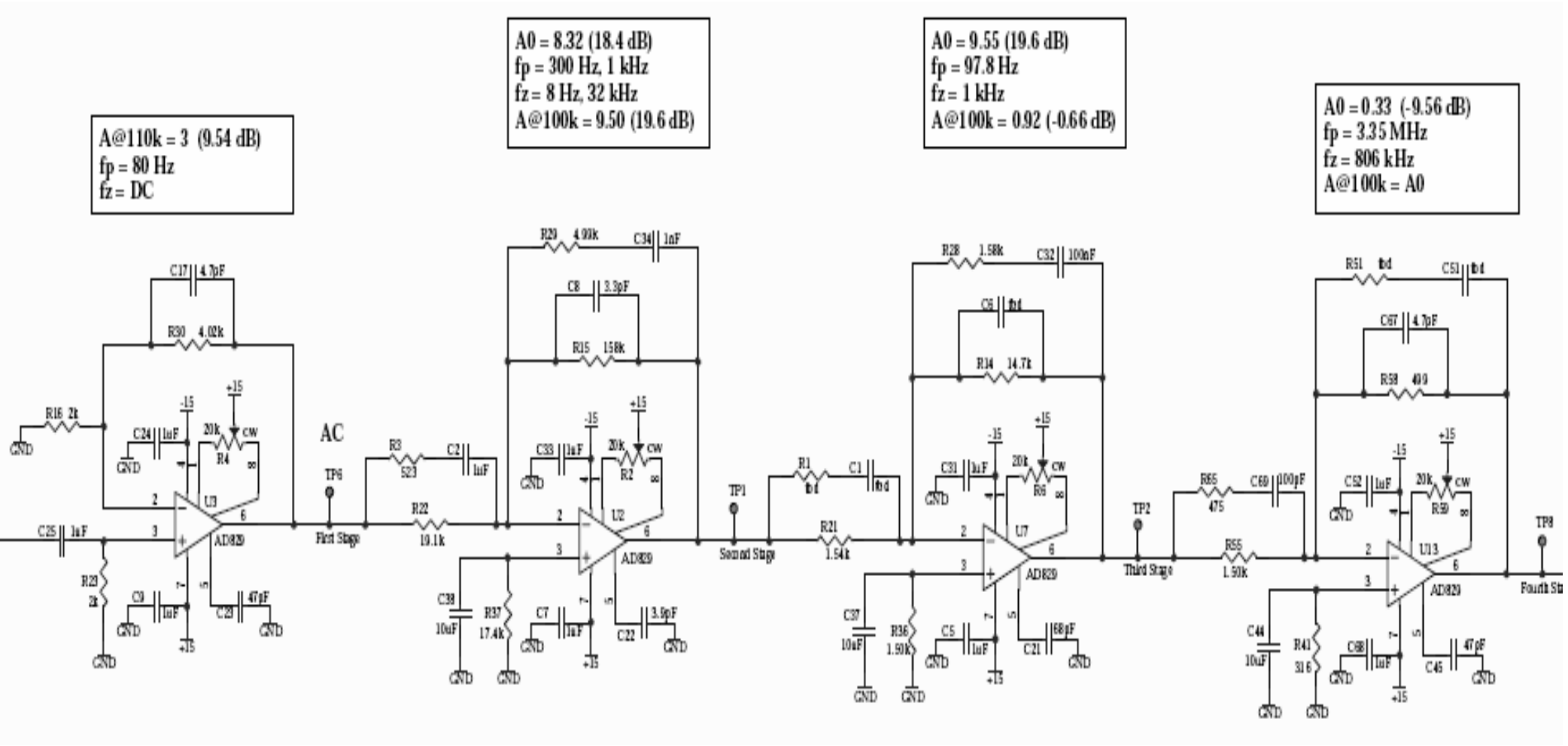


Figure 6. Simplified Schematic

Main Servo Section

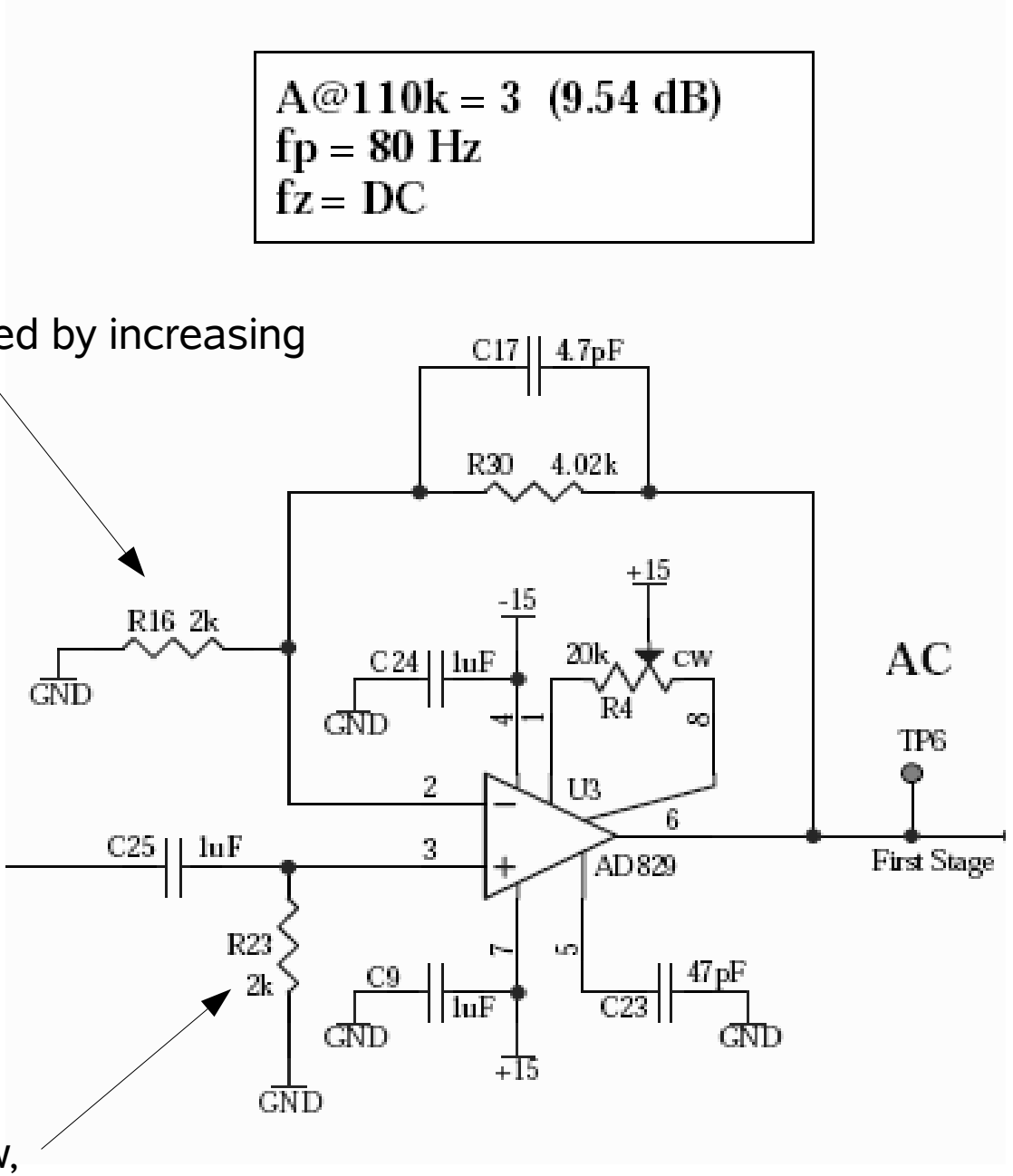
(after AC-coupling)



Offset from mismatched resistors

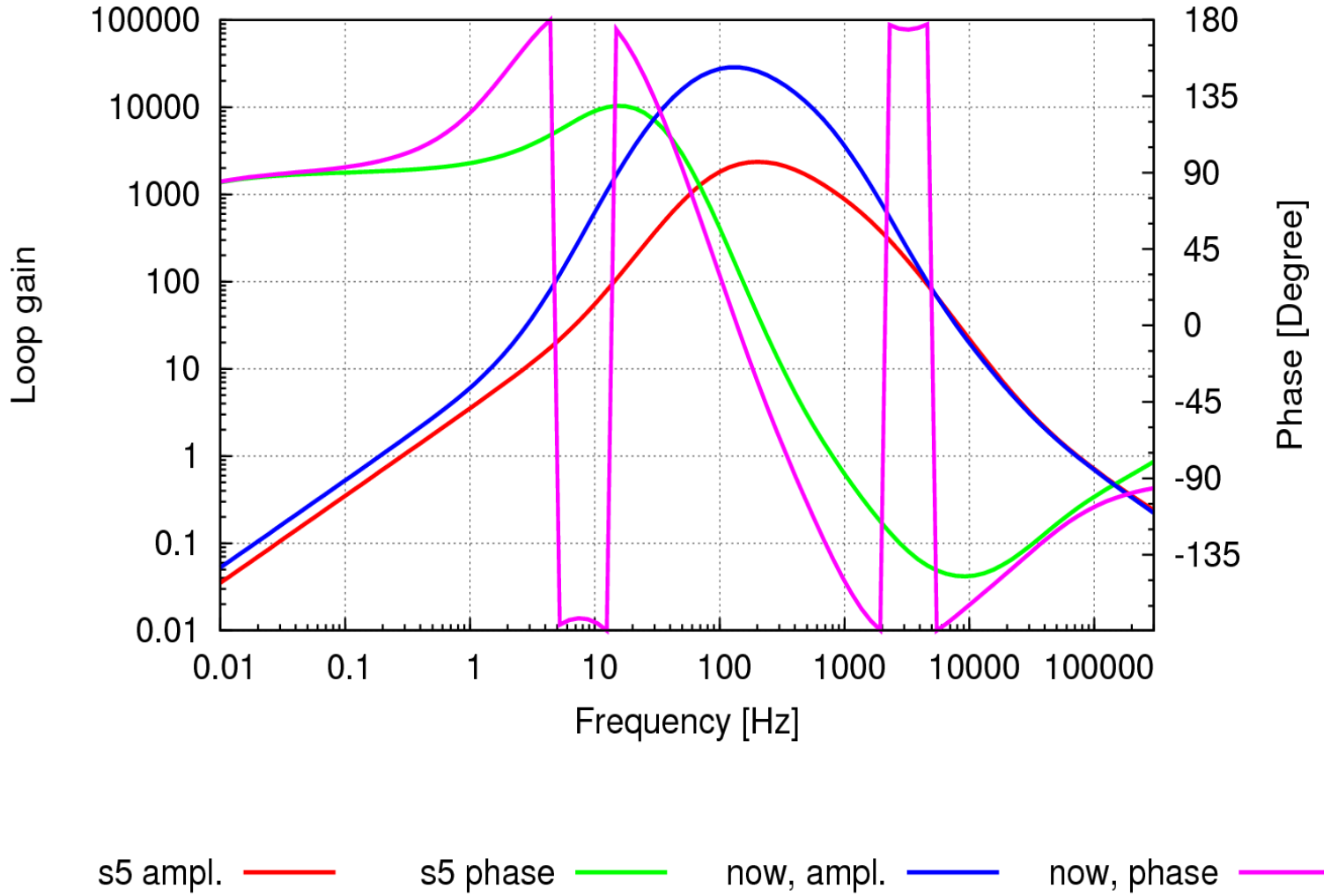
A@110k = 3 (9.54 dB)
fp = 80 Hz
fz = DC

gain was increased by increasing resistor here.

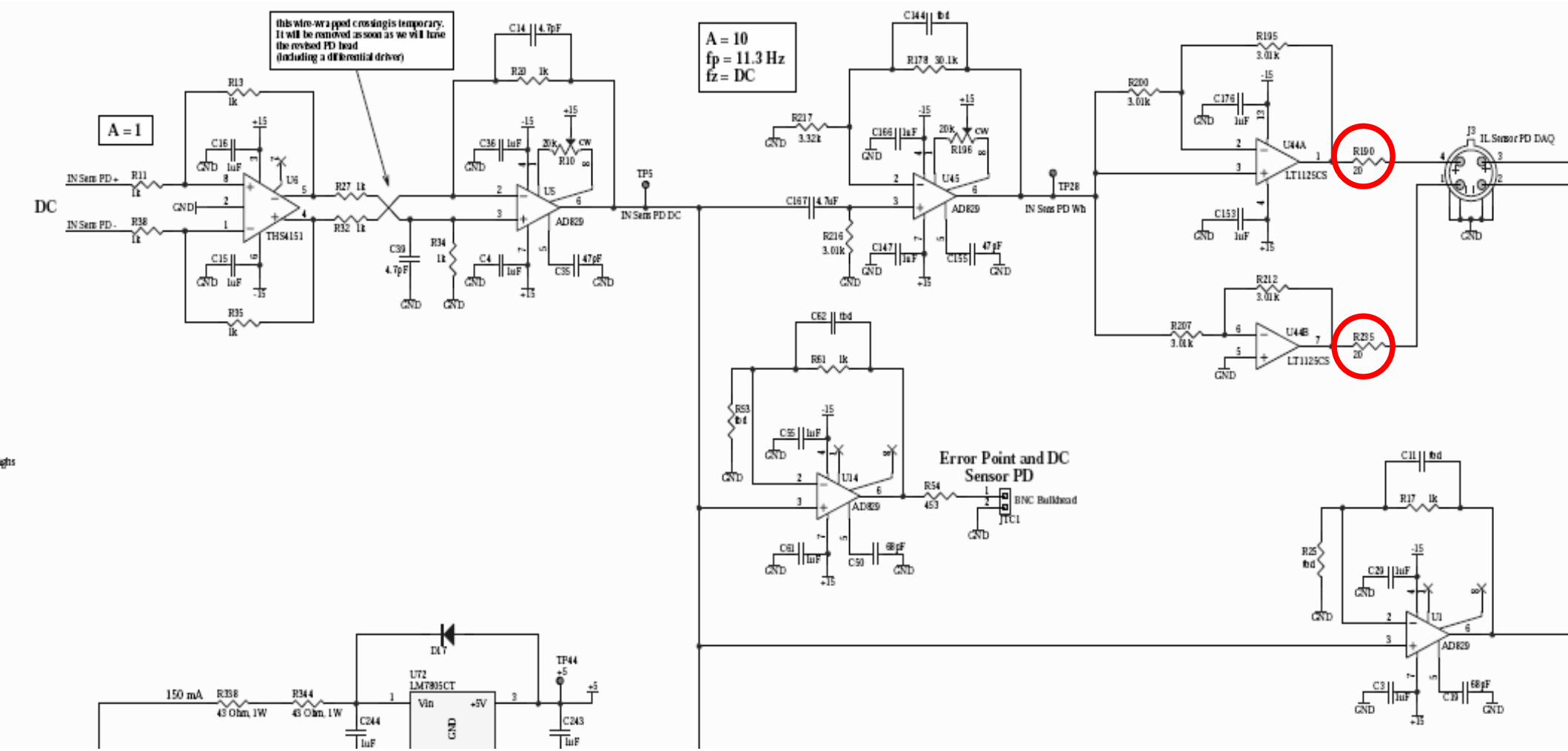


to keep offset low, resistor here has to be matched

Loop shape now

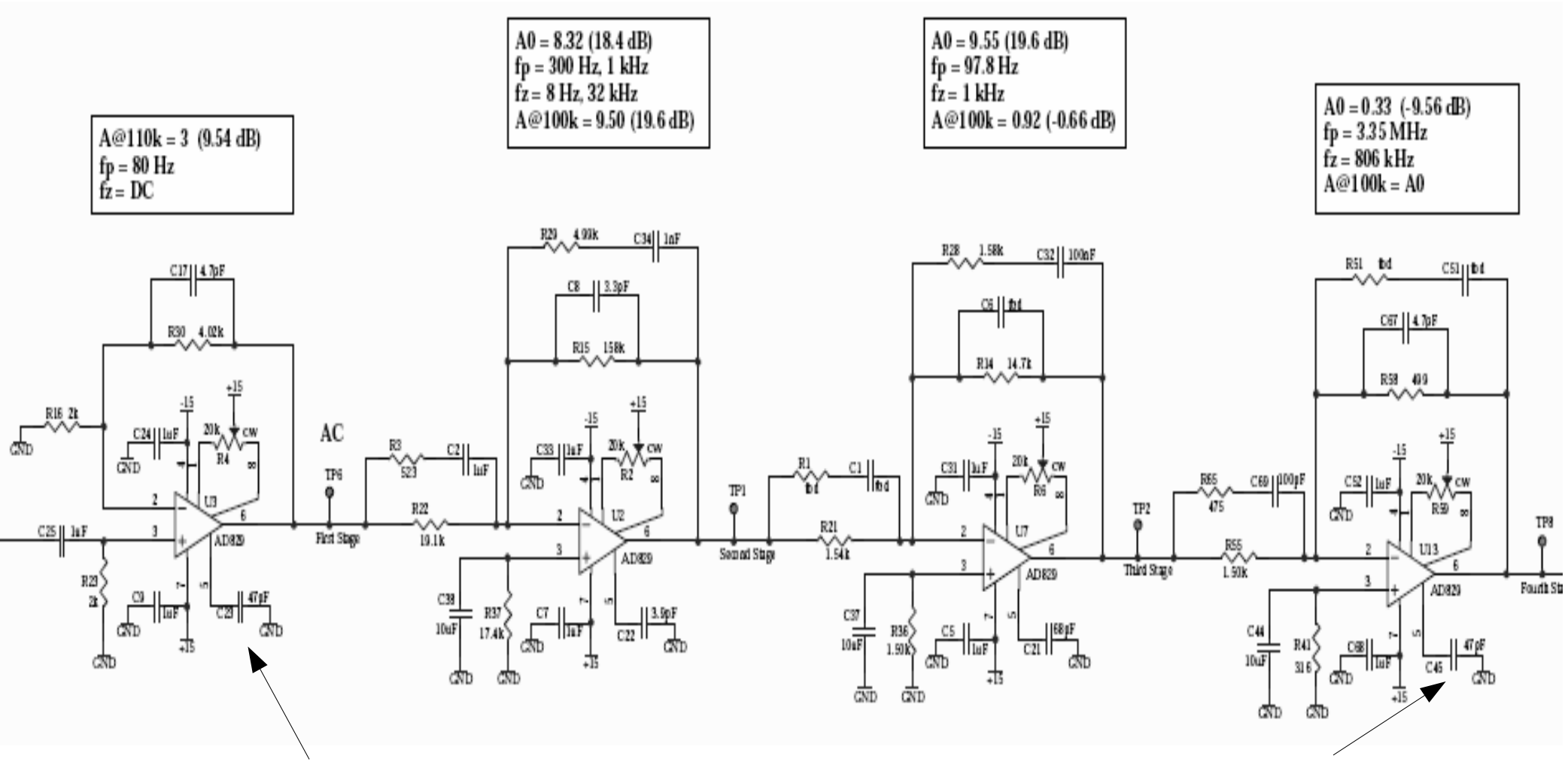


Oscillations at DAQS-Monitor outputs



Main Servo Section

(after AC-coupling)



Increase of compensation capacitors in few places

find document in LLO elog from Nov. 2008

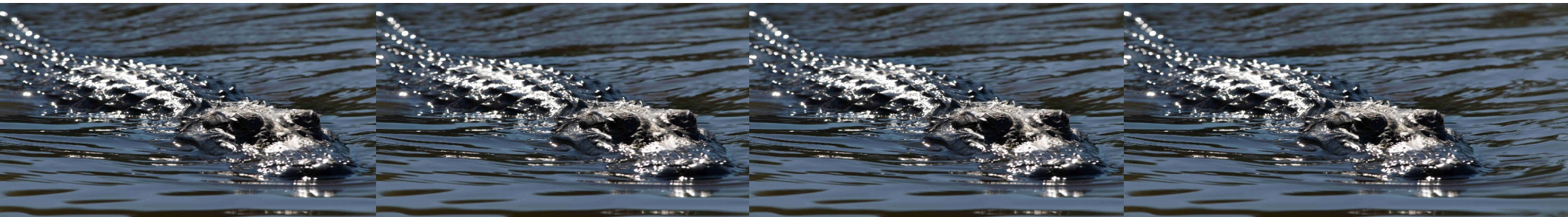
LIGO T0900113

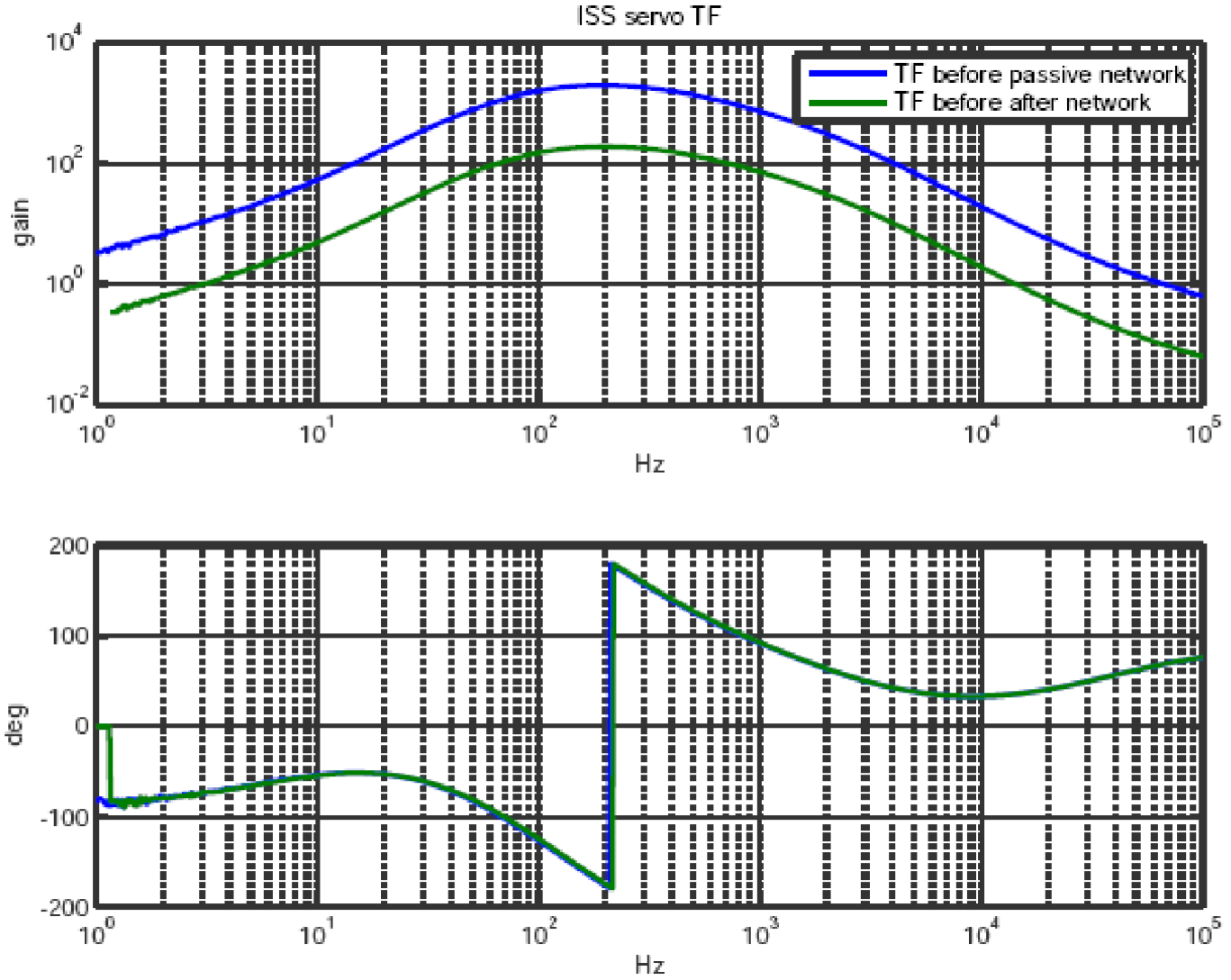
SN 115 rev. D02 component	SN 111 rev. D00 component	former value	new value	comment
C2	C2	10 μF	2 μF	shifts zero-pole structure in frequency
R28	R30	1.58 k	300	shifts pole from 1 kHz to 5 kHz
R65	R66	475	remove	remove zero-pole at 0.8-3 MHz
C60	C69	100 pF	remove	remove zero-pole at 0.8-3 MHz
R23	R24	2 k	360	R-matching at 1. stage after AC-coupl.
C25	C25	2 μF	10 μF	R-matching at 1. stage after AC-coupl.
C23	C23	15/47 pF	68 pF	make OPamp loop stable
C22	C22	3.9 pF	10 pF	make OPamp loop stable
R10	R11	20 k	remove	less noise/drift at no penalty
R246	R232	20 k	remove	"
R67	R70	20 k	remove	"
R293	R279	20 k	remove	"
R5	R5	20 k	remove	"
R4	R4	20 k	remove	"
R6	R7	20 k	remove	"
R59	R60	20 k	remove	"
R2	R2	tap at +Vss	tap at -Vss	"
C144	C144	1 nF	2.7 nF	pole from 50 kHz to 20 kHz
C189	C187	1 nF	2.7 nF	pole from 50 kHz to 20 kHz
R190	R188	20	200	make line drive stable
R235	R230	20	200	"
R189	-	20	200	"
R234	-	20	200	"
R242	R235	20	200	"
R277	R267	20	200	"
R241	-	20	200	"
R276	-	20	200	"
-	R187	20	1k+110 to gnd	attenuate outputs by 20 dB
-	R229	20	1k+110 to gnd	"
-	R234	20	1k+110 to gnd	"
-	R266	20	1k+110 to gnd	"
R230	R226	20	200	make line drive stable
R191	R189	20	200	"
R231	R227	20	200	"
R192	R190	20	200	"

Table 1: Detailed list of changes

Summary

- Loop shape modified, to accomodate actuation by AOM
- Offset / drift largely reduced by
  - removing (wrongly connected) trim potentiometers
  - matching opamp input resistors
- Removed oscillations from DAQS monitor outputs by increasing output series resistors
- Removed ~100MHz oscillations by increasing opamp compensation capacitors
- LIGO T0900113




ISS servo TF
TF before passive network
TF before after network
gain
10^4
10^2
10^0
10^{-2}
10^0 10^1 10^2 10^3 10^4 10^5
Hz
deg
200
100
0
-100
-200
10^0 10^1 10^2 10^3 10^4 10^5
Hz