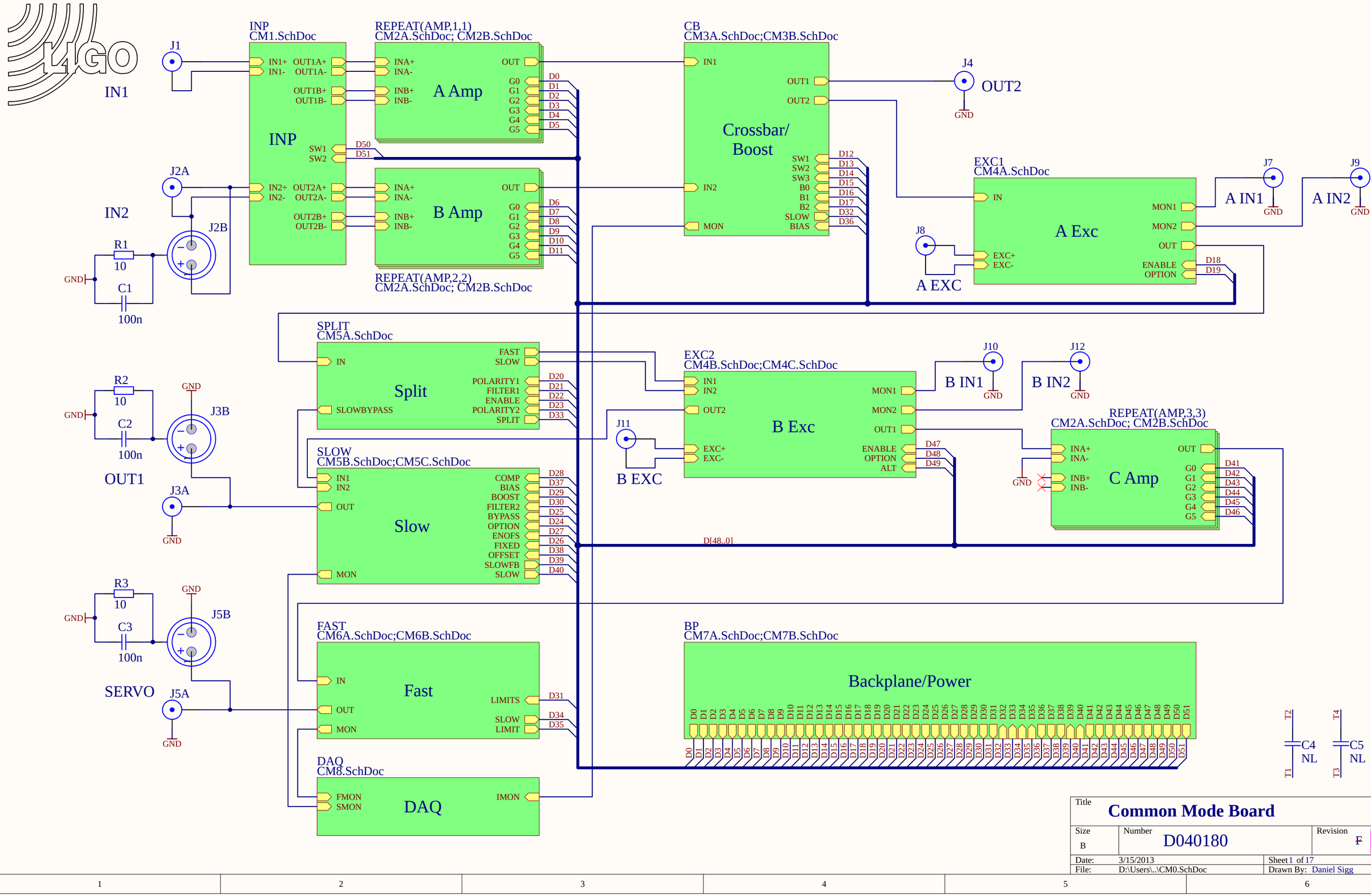
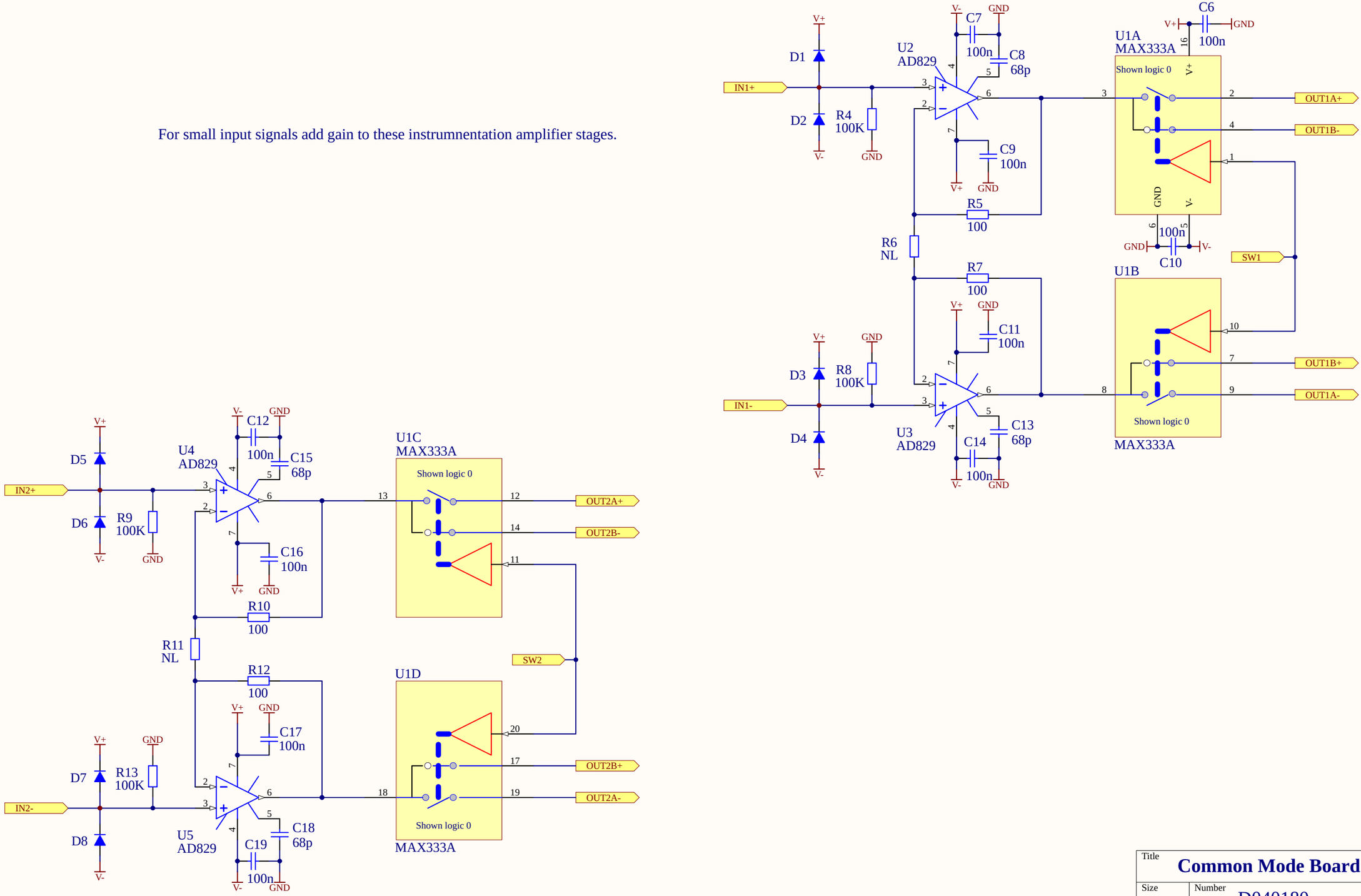

INP
CM1.SchDoc
REPEAT(AMP,1,1)
CM2A.SchDoc; CM2B.SchDoc
CB
CM3A.SchDoc;CM3B.SchDoc
J1
IN1
IN1+
IN1-
OUT1A+
OUT1A-
OUT1B+
OUT1B-
INP
SW1
SW2
D50
D51
A Amp
INA+
INA-
INB+
INB-
OUT
G0
G1
G2
G3
G4
G5
D0
D1
D2
D3
D4
D5
Crossbar/
Boost
IN1
IN2
MON
OUT1
OUT2
SW1
SW2
SW3
B0
B1
B2
SLOW
BIAS
D12
D13
D14
D15
D16
D17
D32
D36
J4
OUT2
GND
J2A
IN2
IN2+
IN2-
OUT2A+
OUT2A-
OUT2B+
OUT2B-
B Amp
D6
D7
D8
D9
D10
D11
REPEAT(AMP,2,2)
CM2A.SchDoc; CM2B.SchDoc
J2B
R1
10
C1
100n
EXC1
CM4A.SchDoc
IN
EXC+
EXC-
A Exc
MON1
MON2
OUT
ENABLE
OPTION
D18
D19
J7
A IN1
J9
A IN2
J8
A EXC
SPLIT
CM5A.SchDoc
IN
SLOWBYPASS
Split
FAST
SLOW
POLARITY1
FILTER1
ENABLE
POLARITY2
SPLIT
D20
D21
D22
D23
D33
EXC2
CM4B.SchDoc;CM4C.SchDoc
IN1
IN2
OUT2
EXC+
EXC-
B Exc
MON1
MON2
OUT1
ENABLE
OPTION
ALT
D47
D48
D49
J10
B IN1
J12
B IN2
J11
B EXC
REPEAT(AMP,3,3)
CM2A.SchDoc; CM2B.SchDoc
INA+
INA-
INB+
INB-
C Amp
OUT
G0
G1
G2
G3
G4
G5
D41
D42
D43
D44
D45
D46
R2
10
C2
100n
J3B
OUT1
J3A
SLOW
CM5B.SchDoc;CM5C.SchDoc
IN1
IN2
OUT
MON
Slow
COMP
BIAS
BOOST
FILTER2
BYPASS
OPTION
ENOFS
FIXED
OFFSET
SLOWFB
SLOW
D28
D37
D29
D30
D25
D24
D27
D26
D38
D39
D40
D[48..0]
R3
10
C3
100n
J5B
SERVO
J5A
FAST
CM6A.SchDoc;CM6B.SchDoc
IN
OUT
MON
Fast
LIMITS
SLOW
LIMIT
D31
D34
D35
DAQ
CM8.SchDoc
FMON
SMON
DAQ
IMON
BP
CM7A.SchDoc;CM7B.SchDoc
Backplane/Power
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15 D16 D17 D18 D19 D20 D21 D22 D23 D24 D25 D26 D27 D28 D29 D30 D31 D32 D33 D34 D35 D36 D37 D38 D39 D40 D41 D42 D43 D44 D45 D46 D47 D48 D49 D50 D51
T2
C4
NL
T1
T4
C5
NL
T3
Title
Common Mode Board
Size
B
Number
D040180
Revision
F
v5
Date:
3/15/2013
Sheet 1 of 17
File:
D:\Users\..\CM0.SchDoc
Drawn By:
Daniel Sigg

For small input signals add gain to these instrumnentation amplifier stages.



Title	**Common Mode Board: Input**	
Size: B	Number: D040180	Revision: ~~F~~ v5
Date: 3/15/2013	Sheet 2 of 17	
File: D:\Users\..\CM1.SchDoc	Drawn By: Daniel Sigg	

Gain must be 0dB or greater for best noise performance

-8dB

-16dB

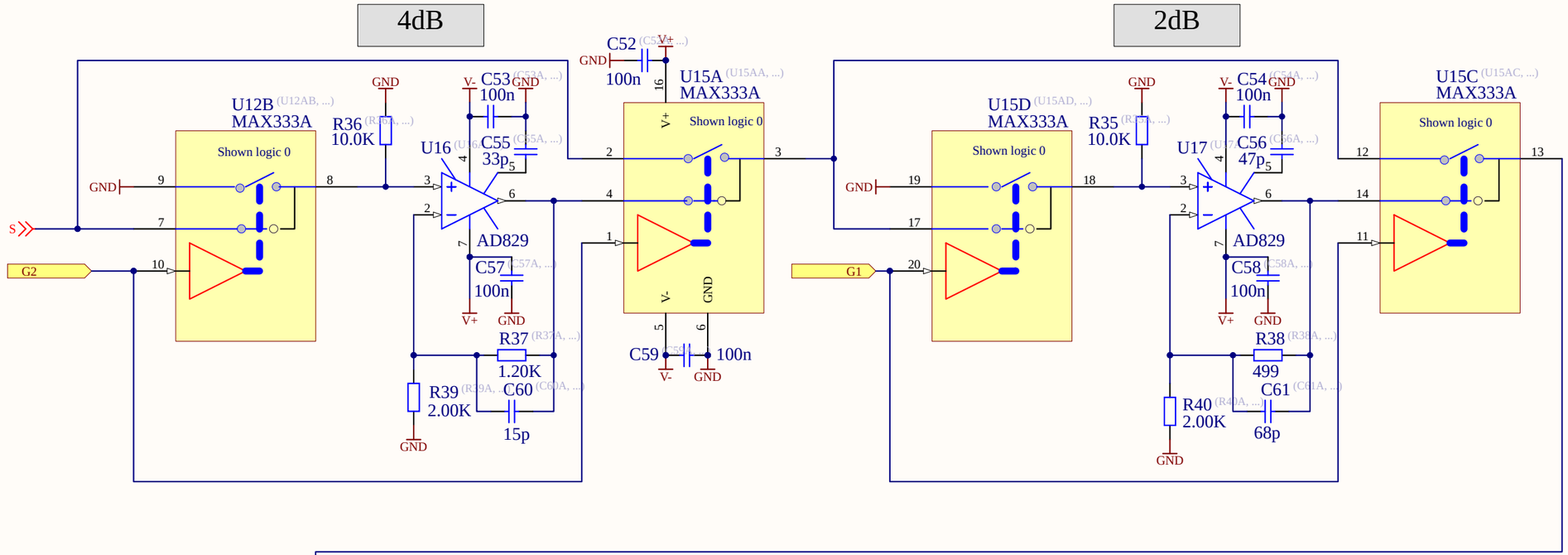
-8dB

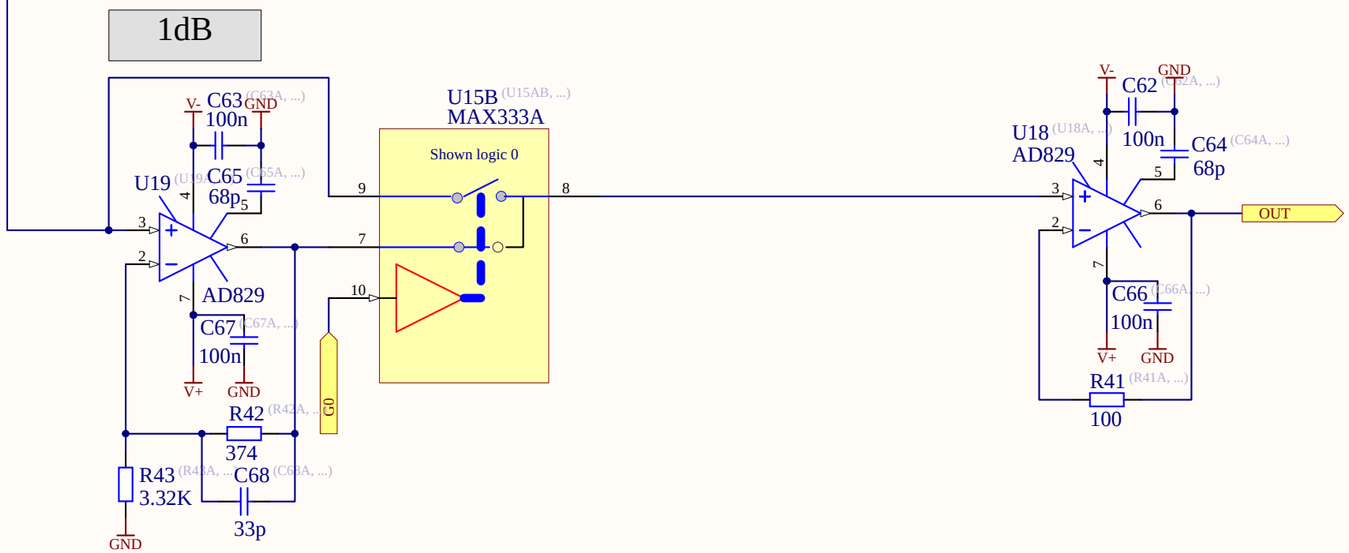
dB	G5G4G3	1Y2Y3Y4Y
-32	0 1 1	1 1 1 1
-24	0 1 0	1 0 1 1
-16	0 0 1	0 1 1 1
-8	0 0 0	0 0 1 1
0	1 1 1	0 0 1 1
8	1 1 0	0 0 1 0
16	1 0 1	0 0 0 1
24	1 0 0	0 0 0 0

16dB

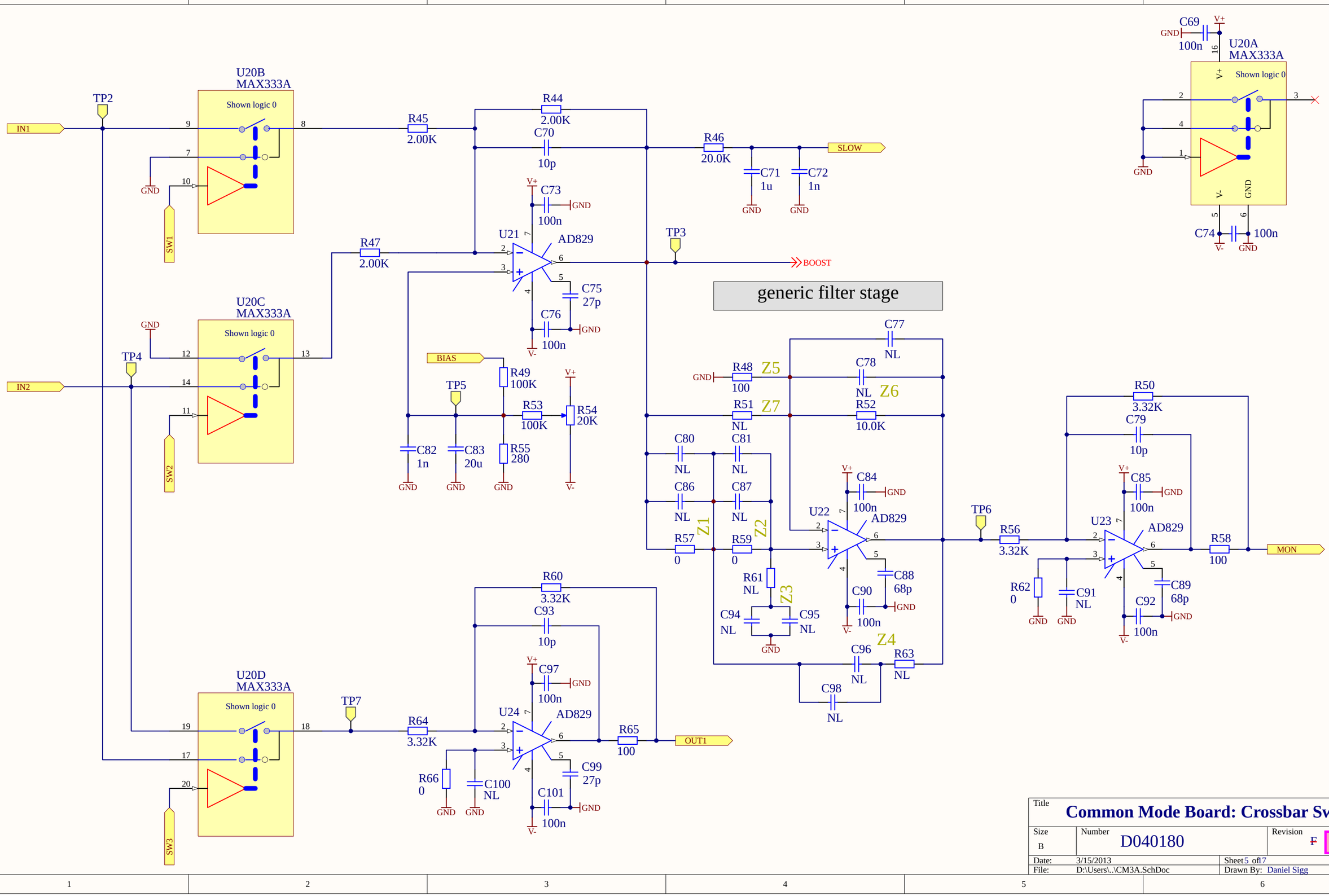
8dB

Title	Common Mode Board: Amp
Size	B
Number	D040180
Revision	~~F~~ v5
Date:	3/15/2013
Sheet	3 of 17
File:	D:\Users\..\CM2A.SchDoc
Drawn By:	Daniel Sigg





Title	**Common Mode Board: Amp**
Size: B	Number: D040180
Revision: ~~F~~ v5	
Date: 3/15/2013	Sheet 4 of 17
File: D:\Users\..\CM2B.SchDoc	Drawn By: Daniel Sigg



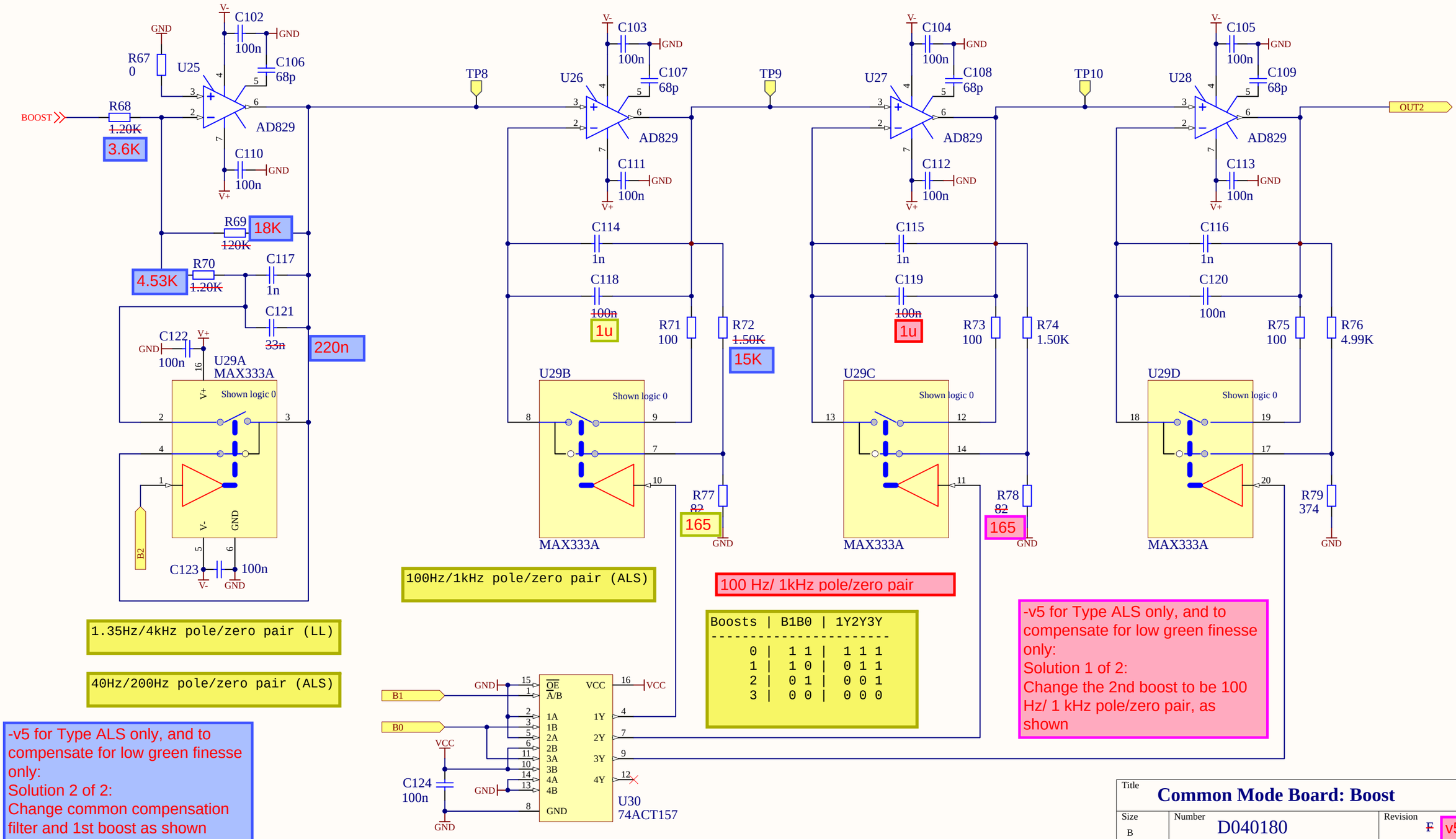
Title	**Common Mode Board: Crossbar Switch**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013	Sheet 5 of 17		
File: D:\Users\..\CM3A.SchDoc	Drawn By: Daniel Sigg		

40Hz/4kHz pole/zero pair

1kHz/20kHz pole/zero pair

1kHz/20kHz pole/zero pair

300Hz/4.5kHz pole/zero pair



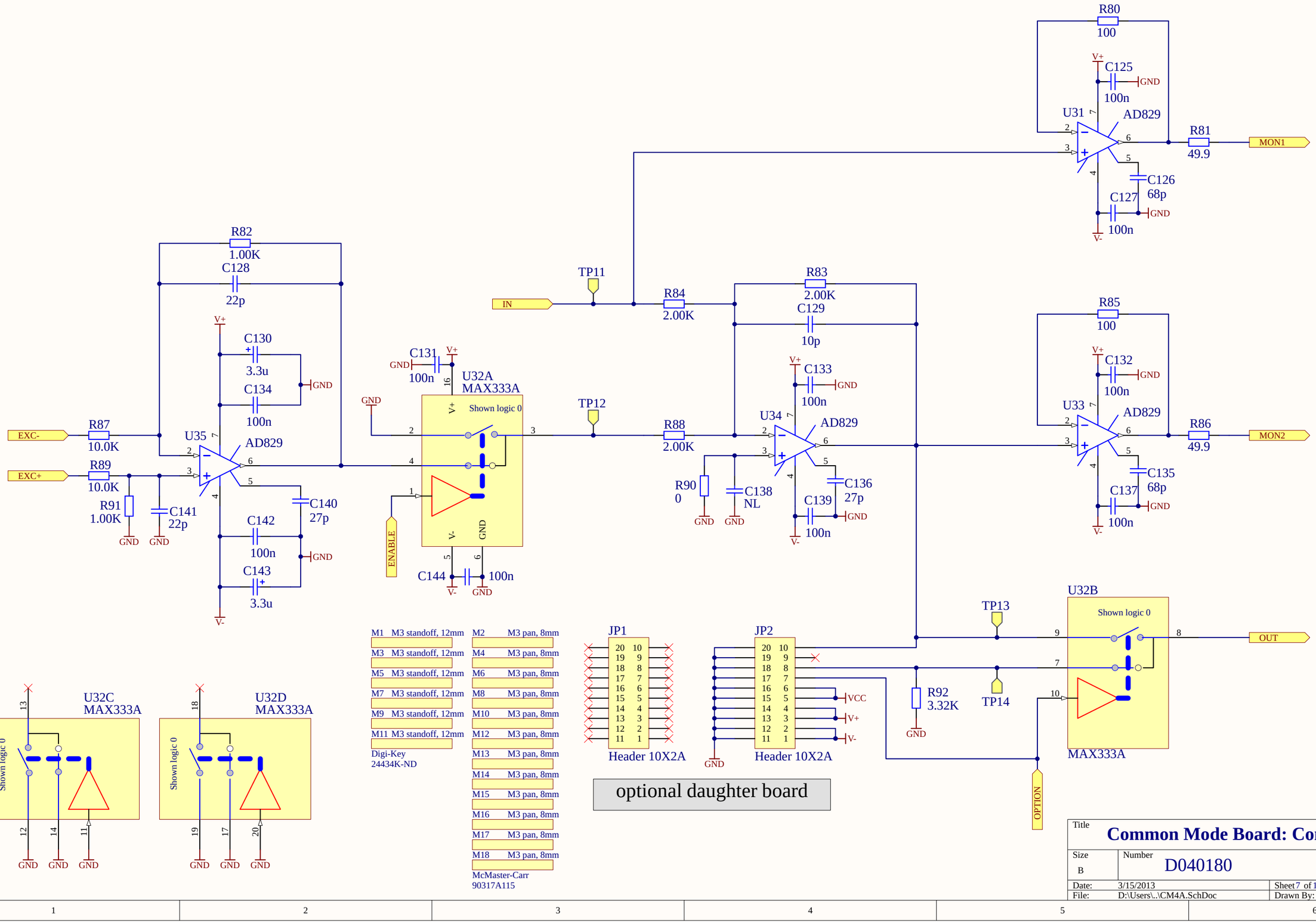
100 Hz/ 1kHz pole/zero pair

Boosts	B1B0	1Y2Y3Y
0	1 1	1 1 1
1	1 0	0 1 1
2	0 1	0 0 1
3	0 0	0 0 0

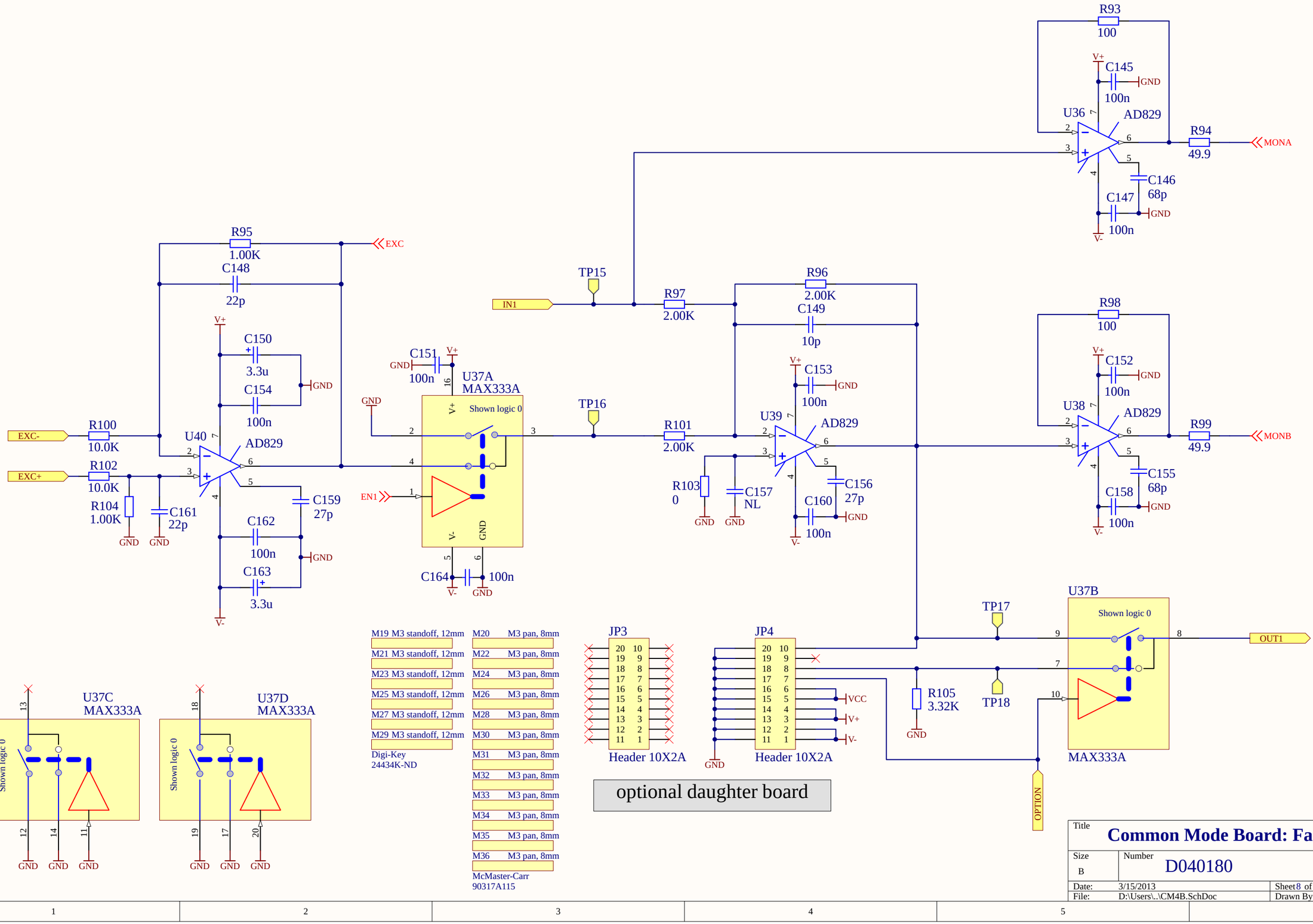
-v5 for Type ALS only, and to compensate for low green finesse only:
Solution 1 of 2:
Change the 2nd boost to be 100 Hz/ 1 kHz pole/zero pair, as shown

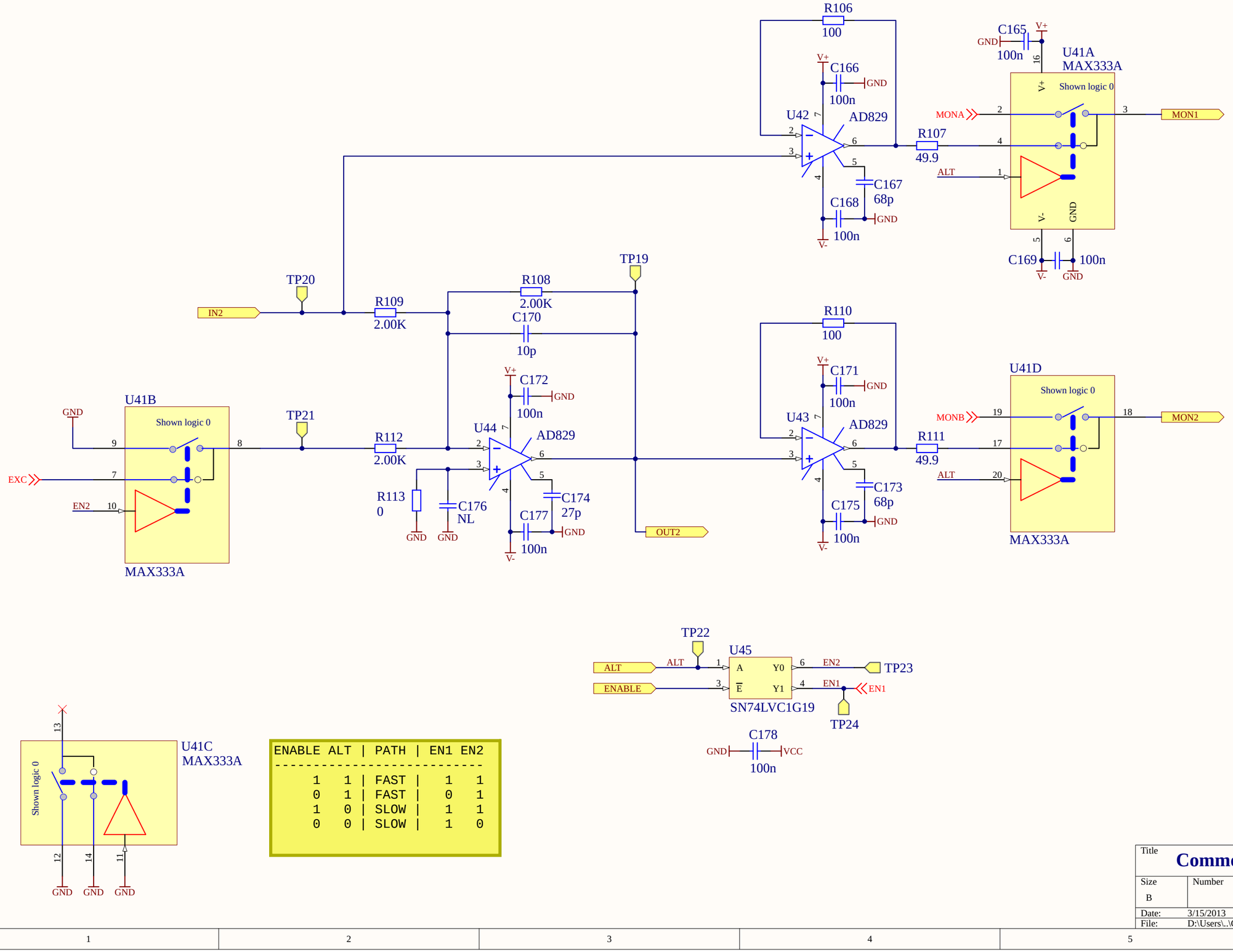
-v5 for Type ALS only, and to compensate for low green finesse only:
Solution 2 of 2:
Change common compensation filter and 1st boost as shown

Title	**Common Mode Board: Boost**	
Size: B	Number: D040180	Revision: ~~F~~ v5
Date: 3/15/2013	Sheet 6 of 17	
File: D:\Users\..\CM3B.SchDoc	Drawn By: Daniel Sigg	



Title	**Common Mode Board: Com. Excitation**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013		Sheet 7 of 17	
File: D:\Users\..\CM4A.SchDoc		Drawn By: Daniel Sigg	


R93
100
V+
C145
GND
100n
U36
AD829
R94
49.9
MONA
C146
68p
C147
GND
100n
V-
R95
1.00K
EXC
C148
22p
TP15
IN1
R97
2.00K
R96
2.00K
C149
10p
V+
C150
3.3u
C154
GND
100n
C151
GND
100n
V+
U37A
MAX333A
Shown logic 0
GND
TP16
R98
100
C152
GND
100n
U38
AD829
R99
49.9
MONB
C155
68p
C158
GND
100n
V-
EXC-
R100
10.0K
U40
AD829
EXC+
R102
10.0K
R104
1.00K
C161
22p
GND
GND
C162
100n
C163
3.3u
C159
27p
EN1
C164
100n
V-
GND
R101
2.00K
U39
AD829
C153
GND
100n
R103
0
C157
NL
C156
27p
C160
100n
GND
GND
V-
TP17
TP18
U37B
Shown logic 0
OUT1
MAX333A
R105
3.32K
GND
OPTION
U37C
MAX333A
Shown logic 0
GND
GND
GND
U37D
MAX333A
Shown logic 0
GND
GND
GND
M19 M3 standoff, 12mm
M21 M3 standoff, 12mm
M23 M3 standoff, 12mm
M25 M3 standoff, 12mm
M27 M3 standoff, 12mm
M29 M3 standoff, 12mm
Digi-Key
24434K-ND
M20 M3 pan, 8mm
M22 M3 pan, 8mm
M24 M3 pan, 8mm
M26 M3 pan, 8mm
M28 M3 pan, 8mm
M30 M3 pan, 8mm
M31 M3 pan, 8mm
M32 M3 pan, 8mm
M33 M3 pan, 8mm
M34 M3 pan, 8mm
M35 M3 pan, 8mm
M36 M3 pan, 8mm
McMaster-Carr
90317A115
JP3
Header 10X2A
JP4
VCC
V+
V-
Header 10X2A
optional daughter board
Title
Common Mode Board: Fast Excitation
Size
B
Number
D040180
Revision
F
v5
Date:
3/15/2013
Sheet 8 of 17
File:
D:\Users\..\CM4B.SchDoc
Drawn By:
Daniel Sigg

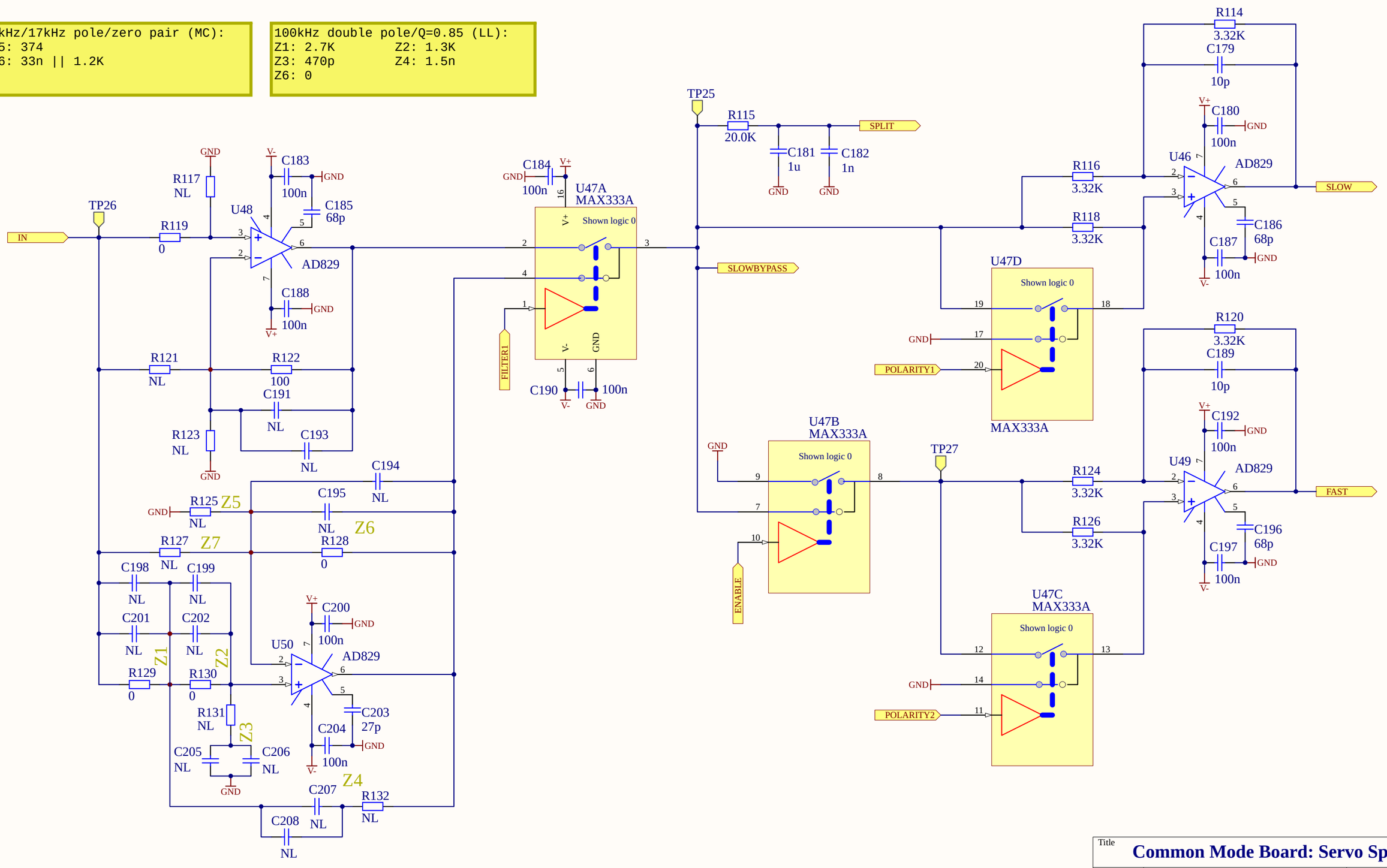


ENABLE	ALT	PATH	EN1	EN2
1	1	FAST	1	1
0	1	FAST	0	1
1	0	SLOW	1	1
0	0	SLOW	1	0

Title	**Common Mode Board: Slow Excitation**	
Size: B	Number: D040180	Revision: ~~F~~ v5
Date: 3/15/2013	Sheet 9 of 17	
File: D:\Users\..\CM4C.SchDoc	Drawn By: Daniel Sigg	

4kHz/17kHz pole/zero pair (MC):
Z5: 374
Z6: 33n || 1.2K

100kHz double pole/Q=0.85 (LL):
Z1: 2.7K Z2: 1.3K
Z3: 470p Z4: 1.5n
Z6: 0

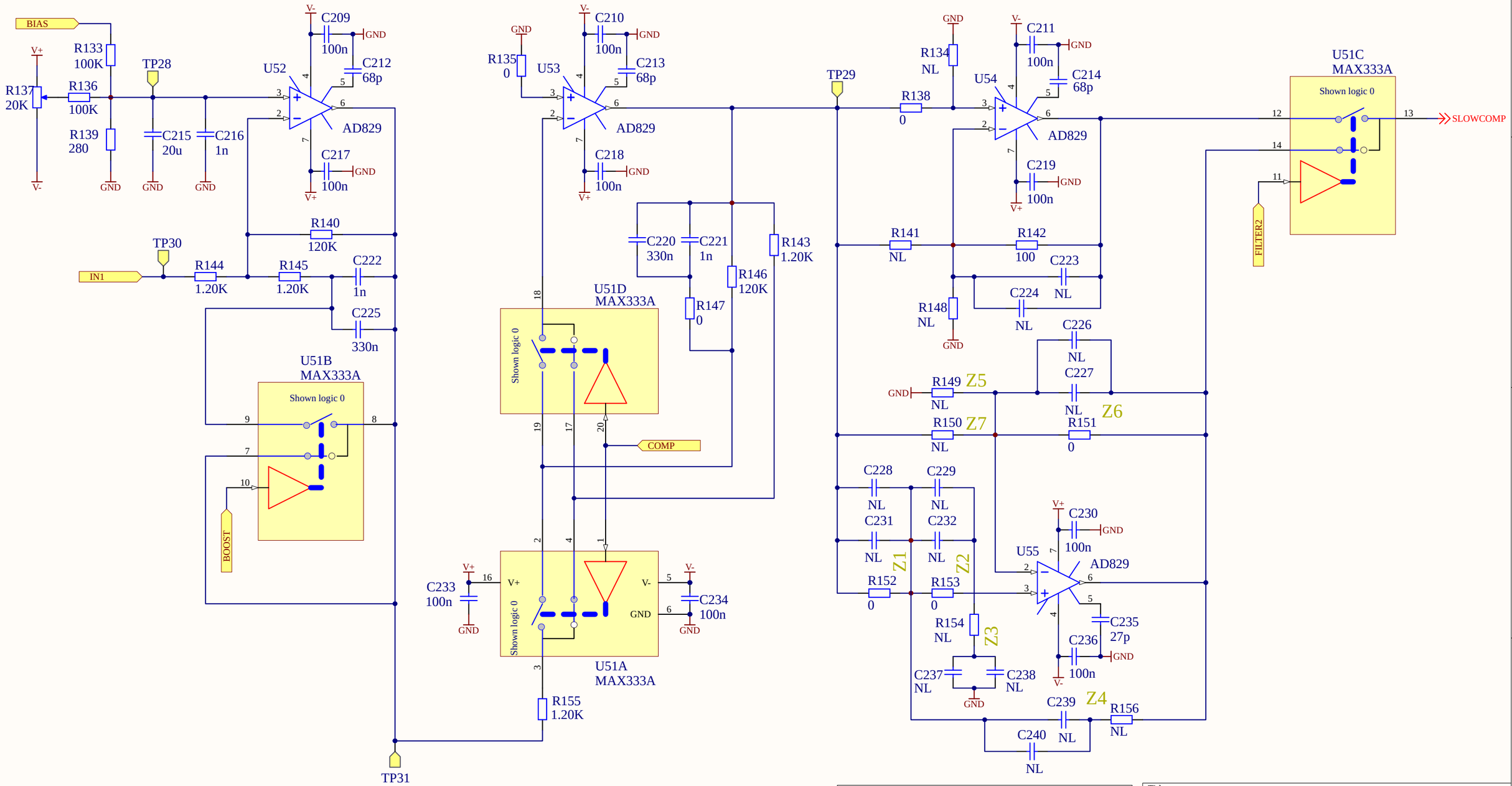


generic filter stage

Title	Common Mode Board: Servo Split		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013		Sheet 10 of 17	
File: D:\Users\..\CM5A.SchDoc		Drawn By: Daniel Sigg	

4Hz/400Hz pole/zero pair

4Hz pole



generic filter stage

Title	**Common Mode Board: Slow**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013	Sheet 11 of 17		
File: D:\Users\..\CM5B.SchDoc	Drawn By: Daniel Sigg		

generic filter stage
2 real zeros at 10Hz
2 real poles at 100Hz
dc gain of 0.1

ground option path (ALS/LL):
Z1: 0

100kHz pole

2kHz pole/gain of 5 (MC):
Z2: 16.5K || (4.7n + 100)
Z4: 49.9K
Z5: 10K + 49.9K

500Hz pole/gain of 1 (ALS/LL):
Z2: 3.32K || (100n + 100)

optional daughter board

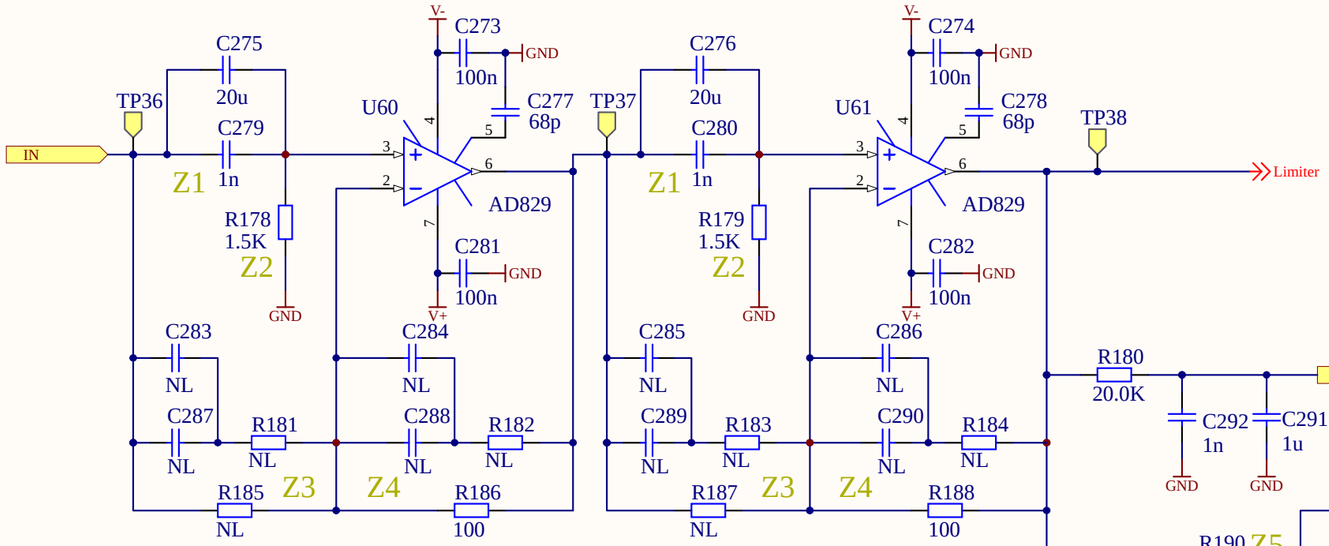
M37 M3 standoff, 12mm
M39 M3 standoff, 12mm
M41 M3 standoff, 12mm
M43 M3 standoff, 12mm
M45 M3 standoff, 12mm
M47 M3 standoff, 12mm
Digi-Key
24434K-ND

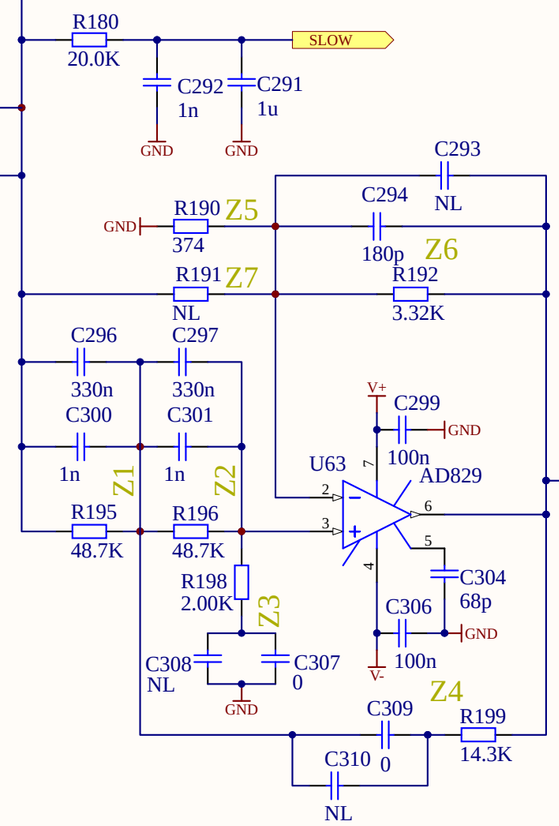
M38 M3 pan, 8mm
M40 M3 pan, 8mm
M42 M3 pan, 8mm
M44 M3 pan, 8mm
M46 M3 pan, 8mm
M48 M3 pan, 8mm
M49 M3 pan, 8mm
M50 M3 pan, 8mm
M51 M3 pan, 8mm
M52 M3 pan, 8mm
M53 M3 pan, 8mm
M54 M3 pan, 8mm
McMaster-Carr
90317A115

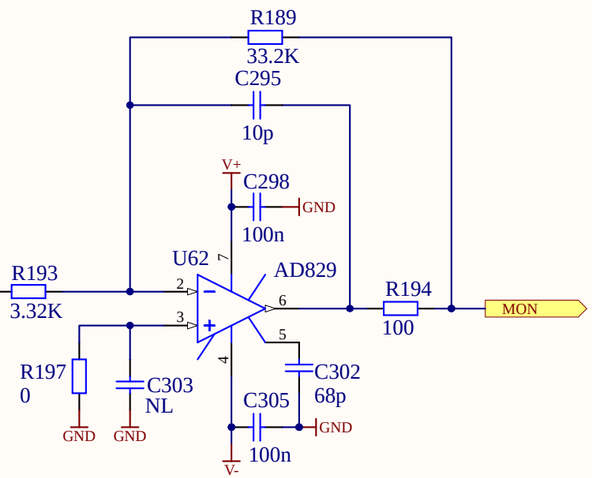
Title	Common Mode Board: Slow		
Size B	Number D040180	Revision ~~F~~ v5	
Date: 3/15/2013		Sheet 12 of 17	
File: D:\Users\..\CM5C.SchDoc		Drawn By: Daniel Sigg	

5Hz high pass

5Hz high pass








```
70kHz zero/140kHz pole (MC):
Z1: NL
Z2: 0
Z3(330p + 3.32K) || 3.32K
Z4: 3.32K || 10p
```

```
voltage follower (MC):
Z1: 0 Ohm
Z2: NL
Z3: NL
Z4: 100 Ohm
```

```
voltage follower (ALS/LL):
Z1: 0 Ohm
Z2: NL
Z3: NL
Z4: 100 Ohm
```

```
voltage follower (ALS/LL):
Z1: 0 Ohm
Z2: NL
Z3: NL
Z4: 100 Ohm
```

Filter Design Examples:

Butterworth high pass: G = 1.586, Z1 = Z2 = 1/sC, Z3 = Z4 = R
two zeros at 0Hz, two complex poles at f = 1/(2 pi R C)

Butterworth low pass: G = 1.586, Z1 = Z2 = R, Z3 = Z4 = 1/sC
two complex poles at f = 1/(2 pi R C)

Whitening: G = 1, Z1 = Z2 = (1/sC) || R2, Z3 = Z4 = R1
two real zeros at f = 1/(2 pi R2 C), two real poles at f = 1/(2 pi (R1 || R2) C)

Dewhiteninig: G = 1 Z1 = Z2 = R1, Z3 = Z4 = 1/sC + R2
two real poles at f = 1/(2 pi (R1 + R2) C), two real zeros at f = 1/(2 pi R2 C)

generic filter stage
2 real zeros at 10Hz
2 real poles at 100Hz
dc gain of 0.1

Title	**Common Mode Board: Fast Path**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013	Sheet 13 of 17		
File: D:\Users\..\CM6A.SchDoc	Drawn By: Daniel Sigg		

limiter

Diodes only for
mode cleaner board

V- R201 10.0K D11 2.7V GND
V+ R202 10.0K D12 2.7V GND
D9
D10

LIMITS

U66 MAX4648
C316 100n
C317 100n
Logic 0

TP40

R203 100
C312 NL
C313 100n
C314 NL
R204 NL
U64 AD829
C318 68p
C320 100n
TP41

R200 3.32K
Z1
C311 10p
Z2
C315 100n
U65 AD829
R205 3.32K
R206 49.9
OUT
R207 0
C321 NL
C319 68p
C322 100n

Limiter
R208 1.00K

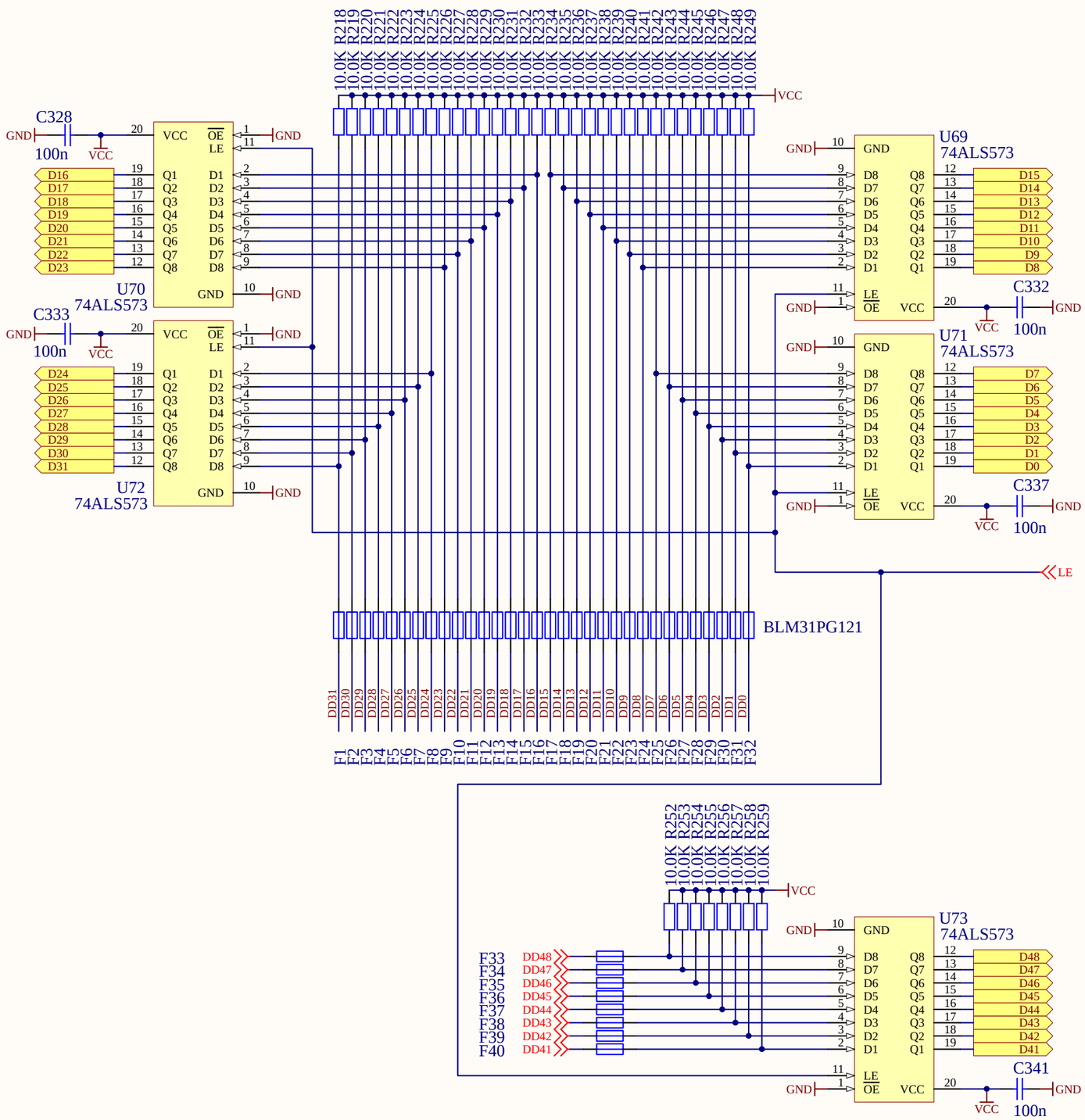
window comparator & one-shot

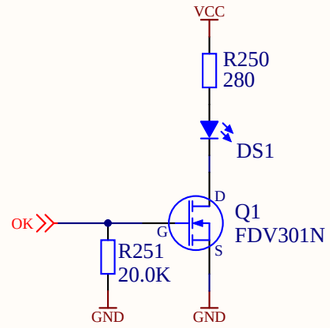
R209 200K
C324 10u
U67A
74HCT123
LIMIT

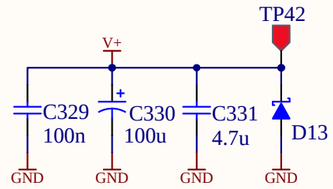
R210 10.0K
C323 100n
U68A LM319M
R211 3.32K
R212 4.99K
C325 100n
R214 1.00M
R215 4.99K
U68B LM319M
R216 10.0K
R217 1.00M

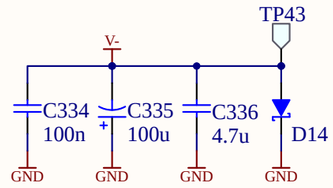
R213 10.0K
C326 100n
U67B
74HCT123
C327 100n

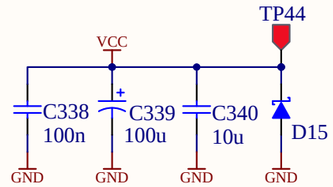
Title	**Common Mode Board: Output Limiter**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013		Sheet 14 of 17	
File: D:\Users\..\CM6B.SchDoc		Drawn By: Daniel Sigg	

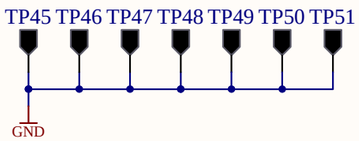


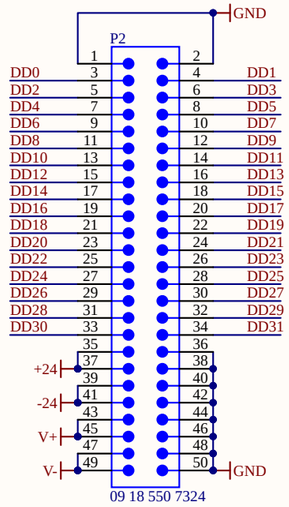




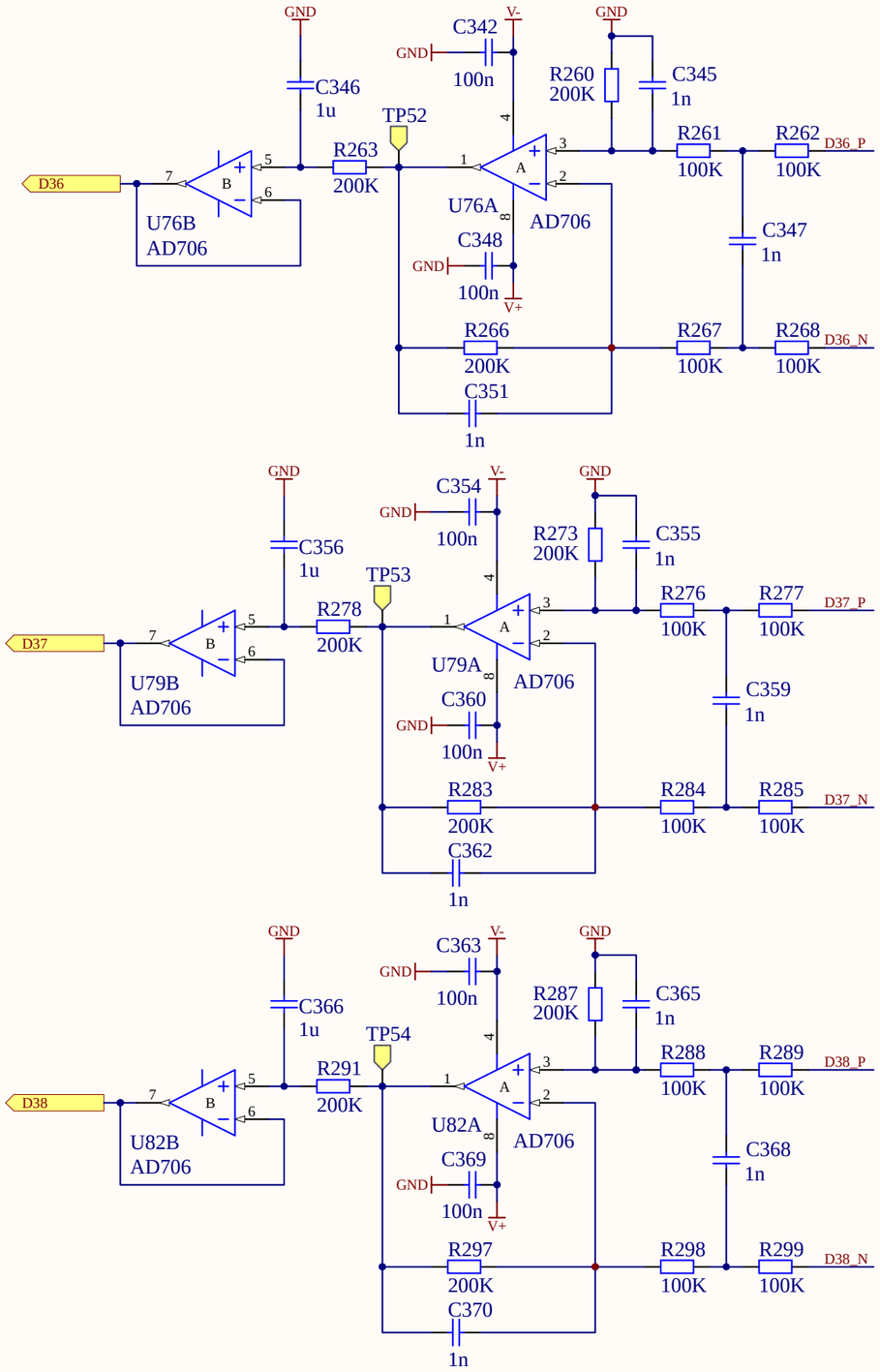


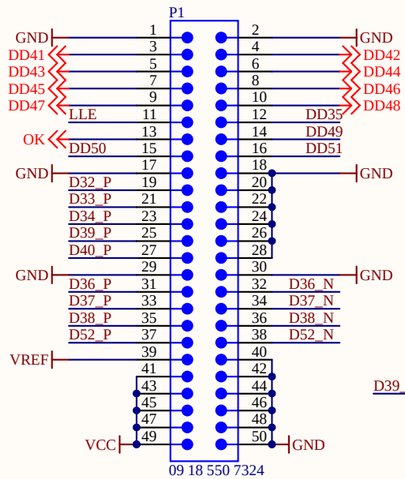


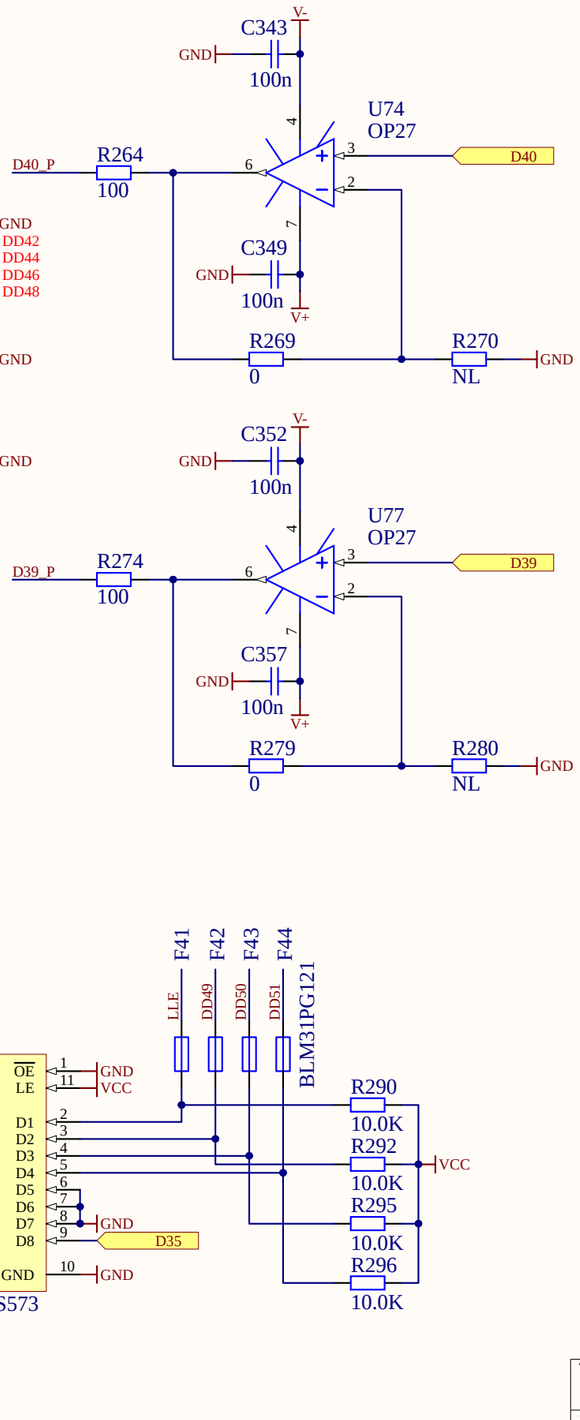


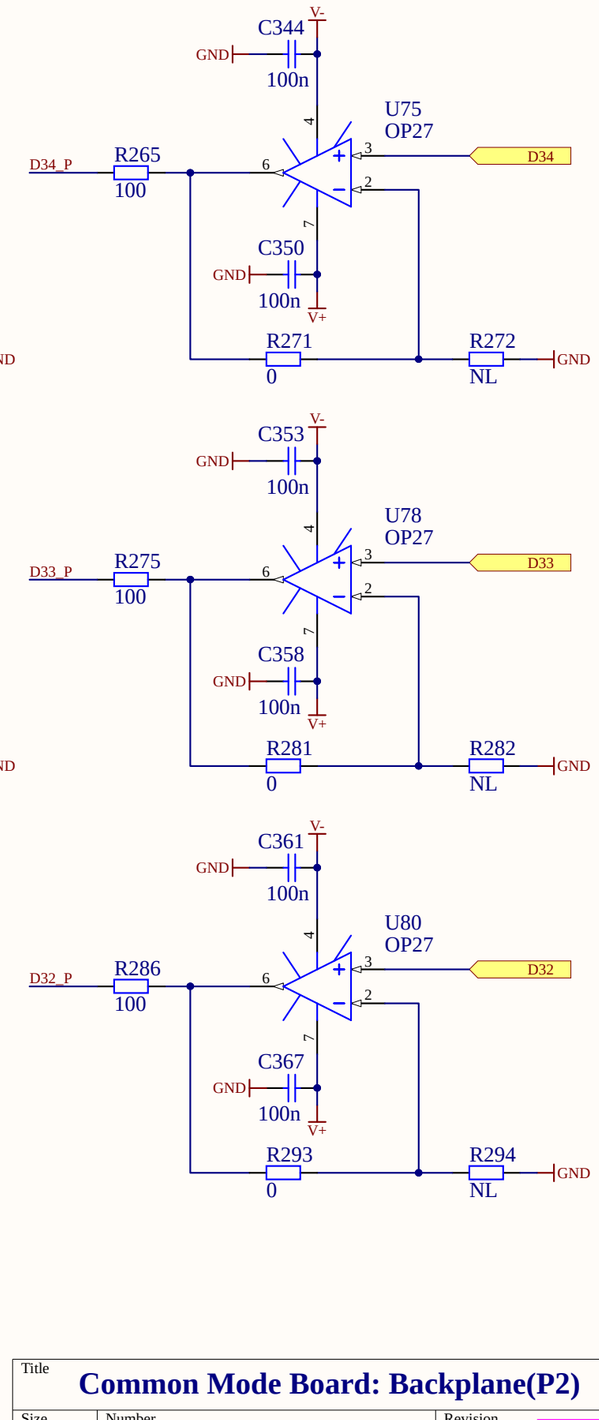


Title	**Common Mode Board: Backplane(P1)**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013	Sheet 15 of 17		
File: D:\Users\..\CM7A.SchDoc	Drawn By: Daniel Sigg		



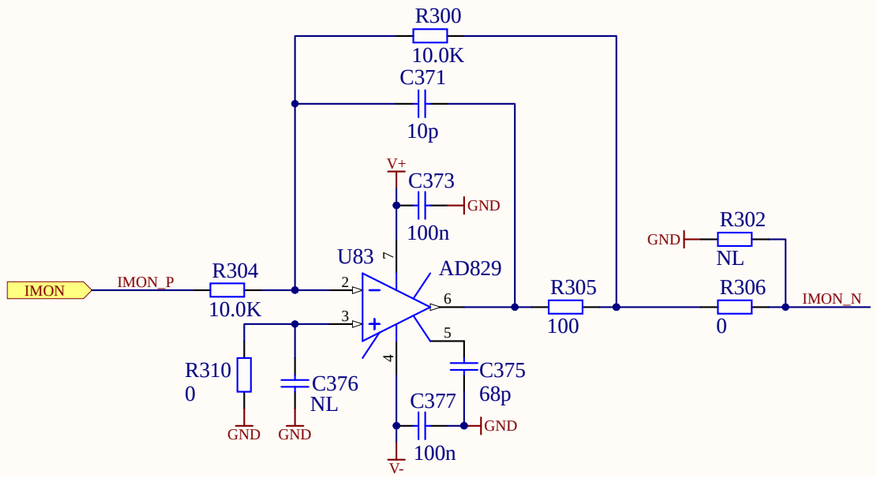


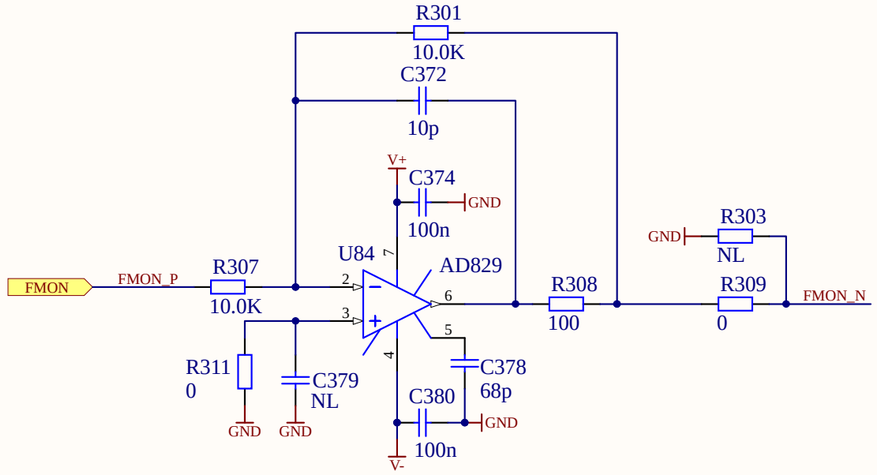


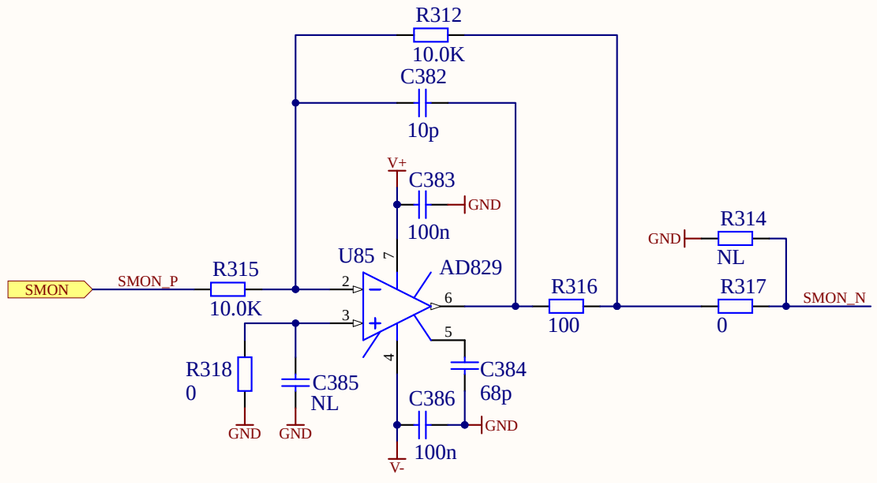


Title: **Common Mode Board: Backplane(P2)**

Size	Number	Revision
B	D040180	~~F~~ v5
Date: 3/15/2013		Sheet 16 of 17
File: D:\Users\..\CM7B.SchDoc		Drawn By: Daniel Sigg







Title	**Common Mode Board: DAQ**		
Size: B	Number: D040180	Revision: ~~F~~ v5	
Date: 3/15/2013		Sheet 17 of 17	
File: D:\Users\..\CM8.SchDoc		Drawn By: Daniel Sigg	