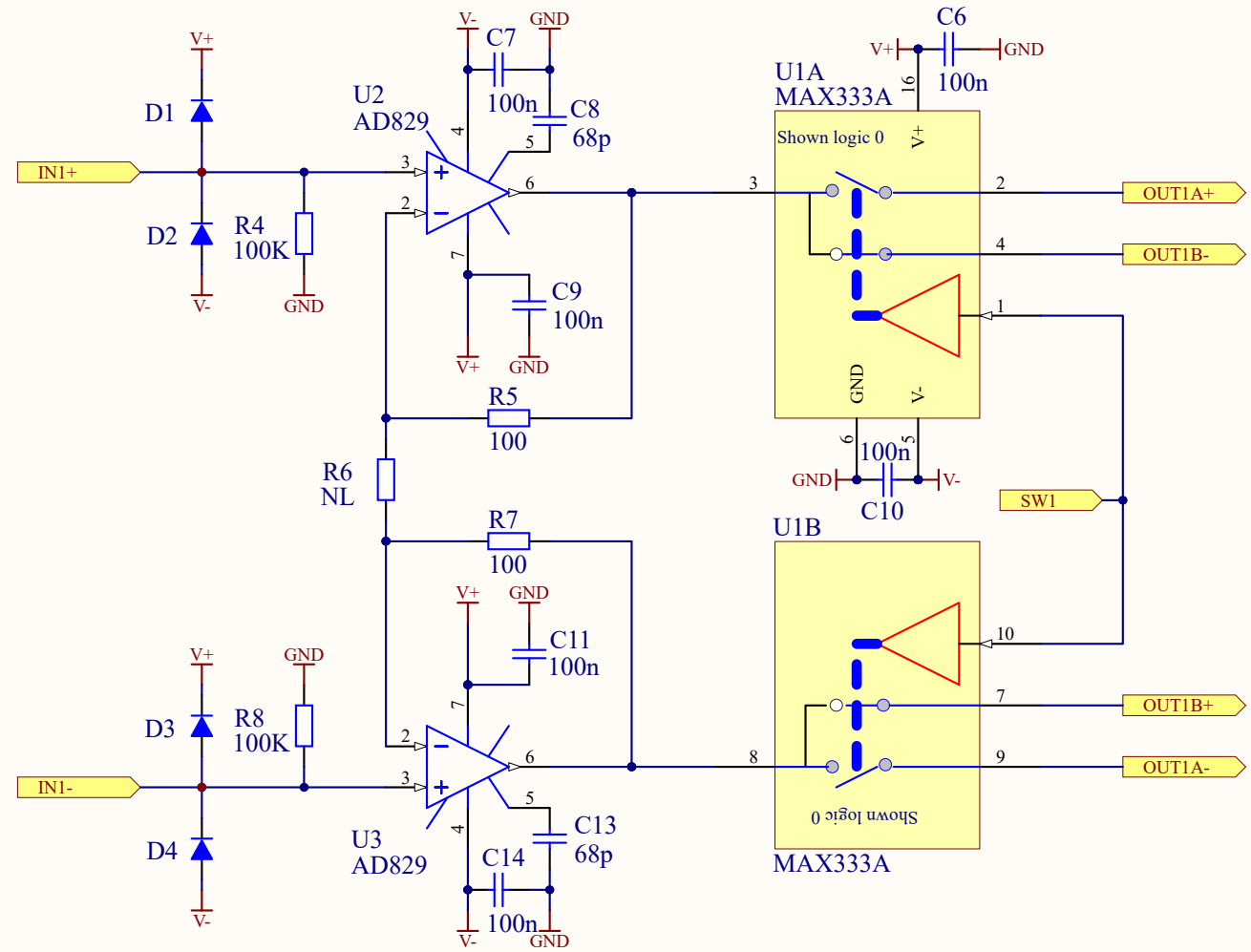
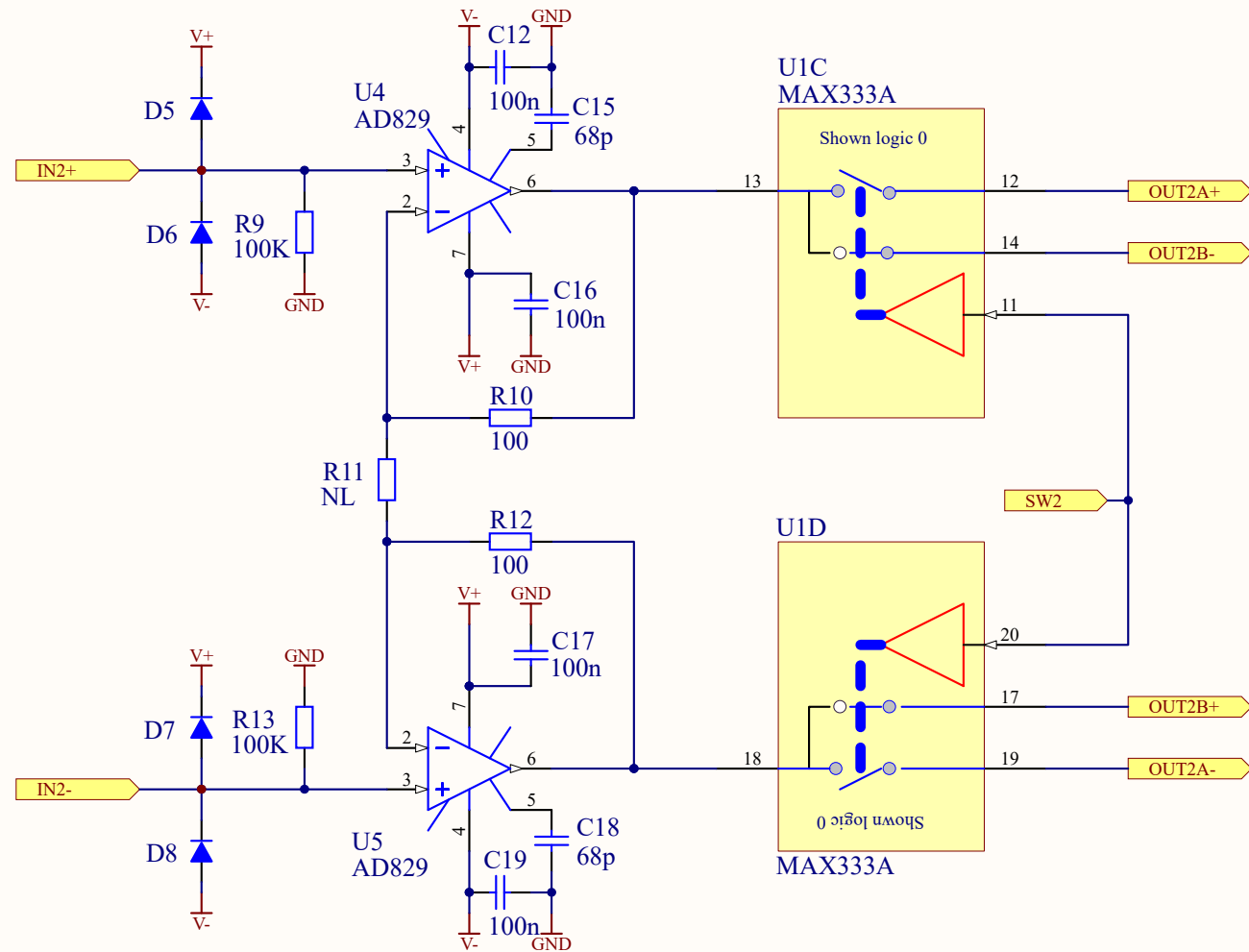


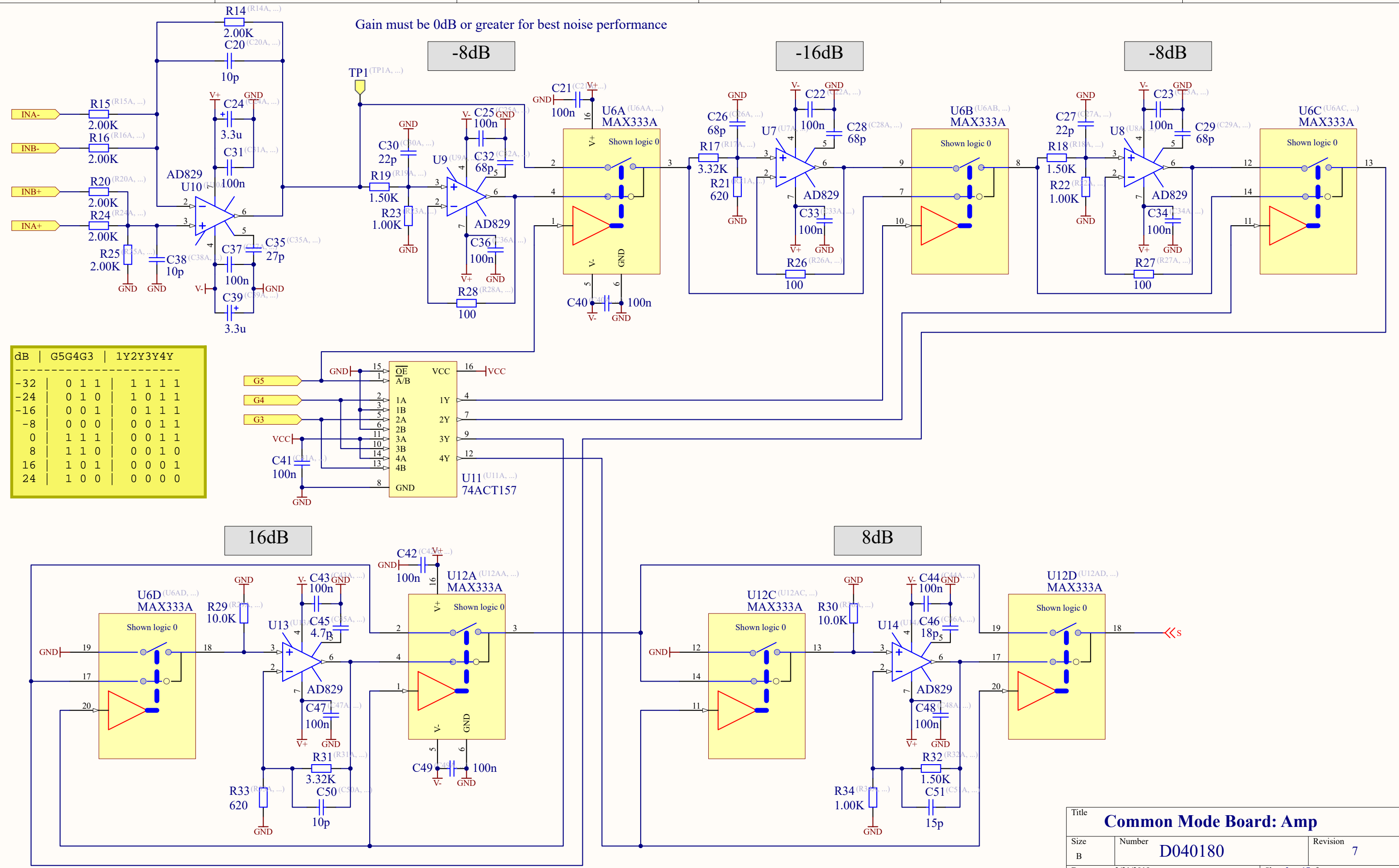
The PCB is marked rev E

Title		
<b>Common Mode Board</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet 1 17of
File:	C:\Users\...\CM0.SchDoc	Drawn By: Daniel Sigg

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

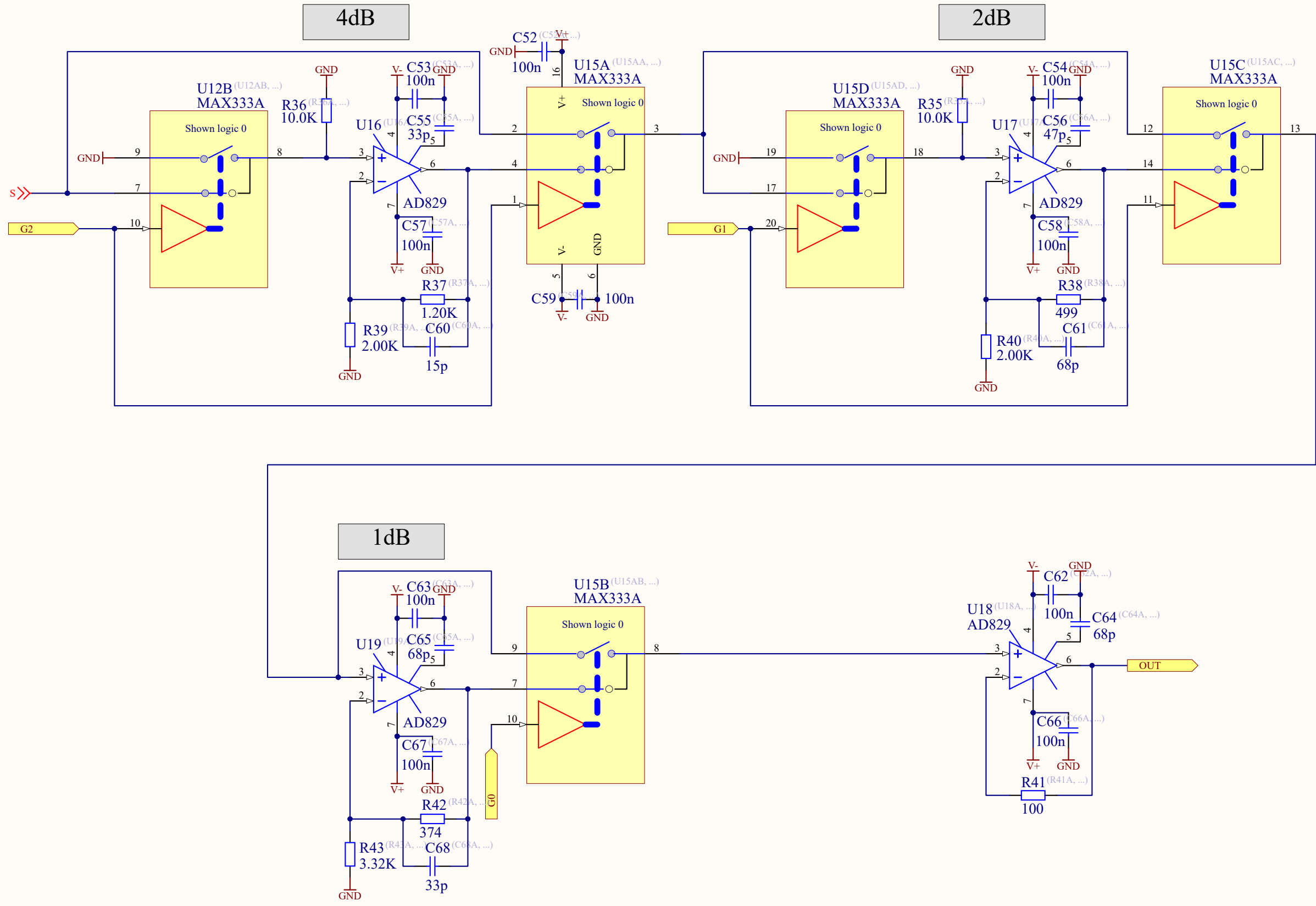


Title		
<b>Common Mode Board: Input</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet2 17of
File:	C:\Users\...\CM1.SchDoc	Drawn By: Daniel Sigg

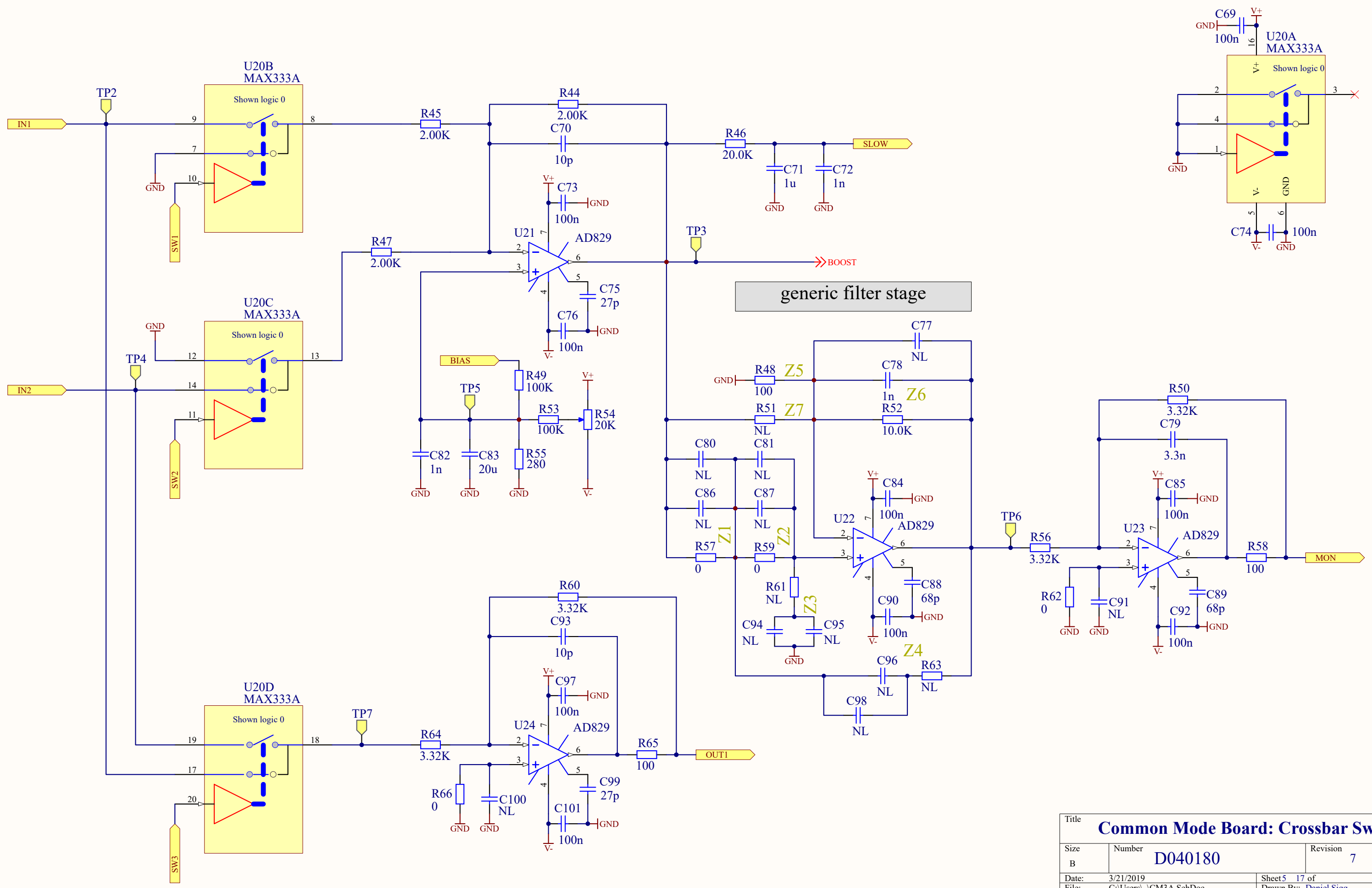


dB	G5G4G3	1Y2Y3Y4Y
-32	0 1 1	1 1 1 1
-24	0 1 0	1 0 1 1
-16	0 0 1	0 1 1 1
-8	0 0 0	0 0 1 1
0	1 1 1	0 0 1 1
8	1 1 0	0 0 1 0
16	1 0 1	0 0 0 1
24	1 0 0	0 0 0 0

Title			<b>Common Mode Board: Amp</b>		
Size	Number	Revision			
B	D040180	7			
Date:	3/21/2019	Sheet3	17of		
File:	C:\Users\...CM2A.SchDoc	Drawn By: Daniel Sigg			



Title		
<b>Common Mode Board: Amp</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet 4 17 of
File:	C:\Users\...\CM2B.SchDoc	Drawn By: Daniel Sigg



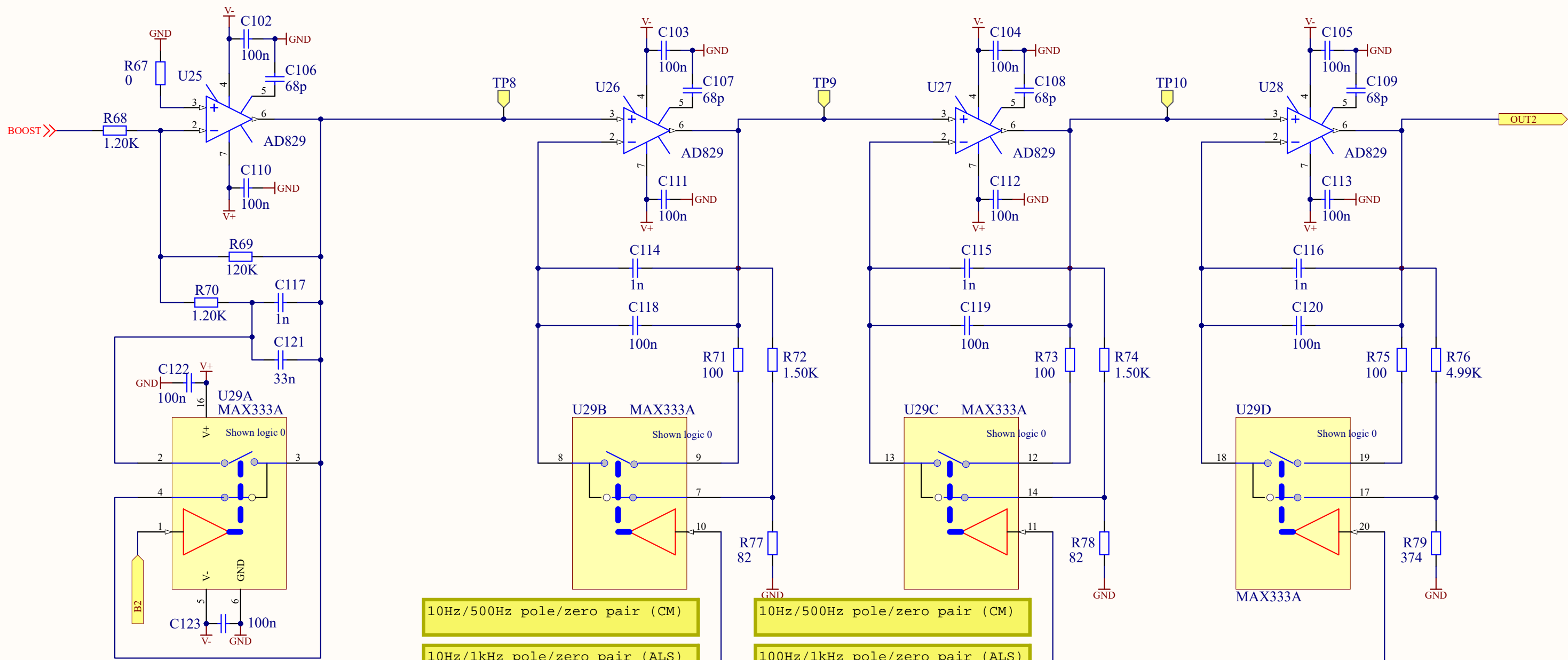
Title			<b>Common Mode Board: Crossbar Switch</b>		
Size	Number	Revision			
B	D040180	7			
Date:	3/21/2019	Sheet 5	17 of		
File:	C:\Users\...\CM3A.SchDoc	Drawn By:		Daniel Sigg	

40Hz/4kHz pole/zero pair

1kHz/20kHz pole/zero pair

1kHz/20kHz pole/zero pair

300Hz/4.5kHz pole/zero pair



1.35Hz/4kHz pole/zero pair (LL)

40Hz/200Hz pole/zero pair (ALS)

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

10Hz/500Hz pole/zero pair (CM)

10Hz/1kHz pole/zero pair (ALS)

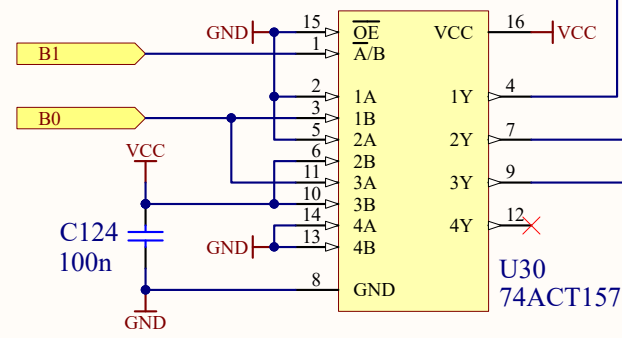
0Hz/10Hz pole/zero pair (SQZ)

10Hz/500Hz pole/zero pair (CM)

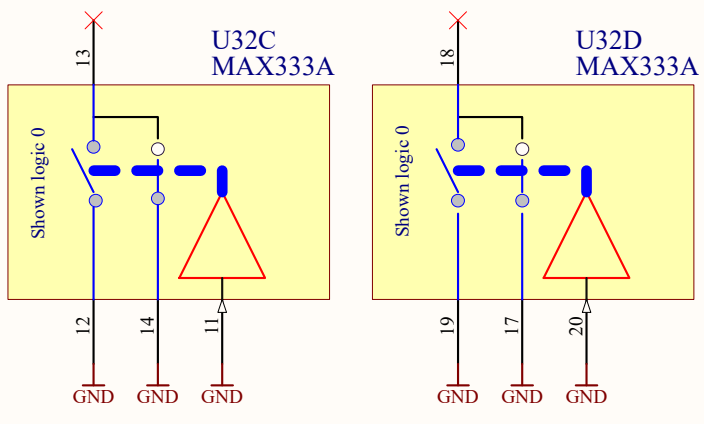
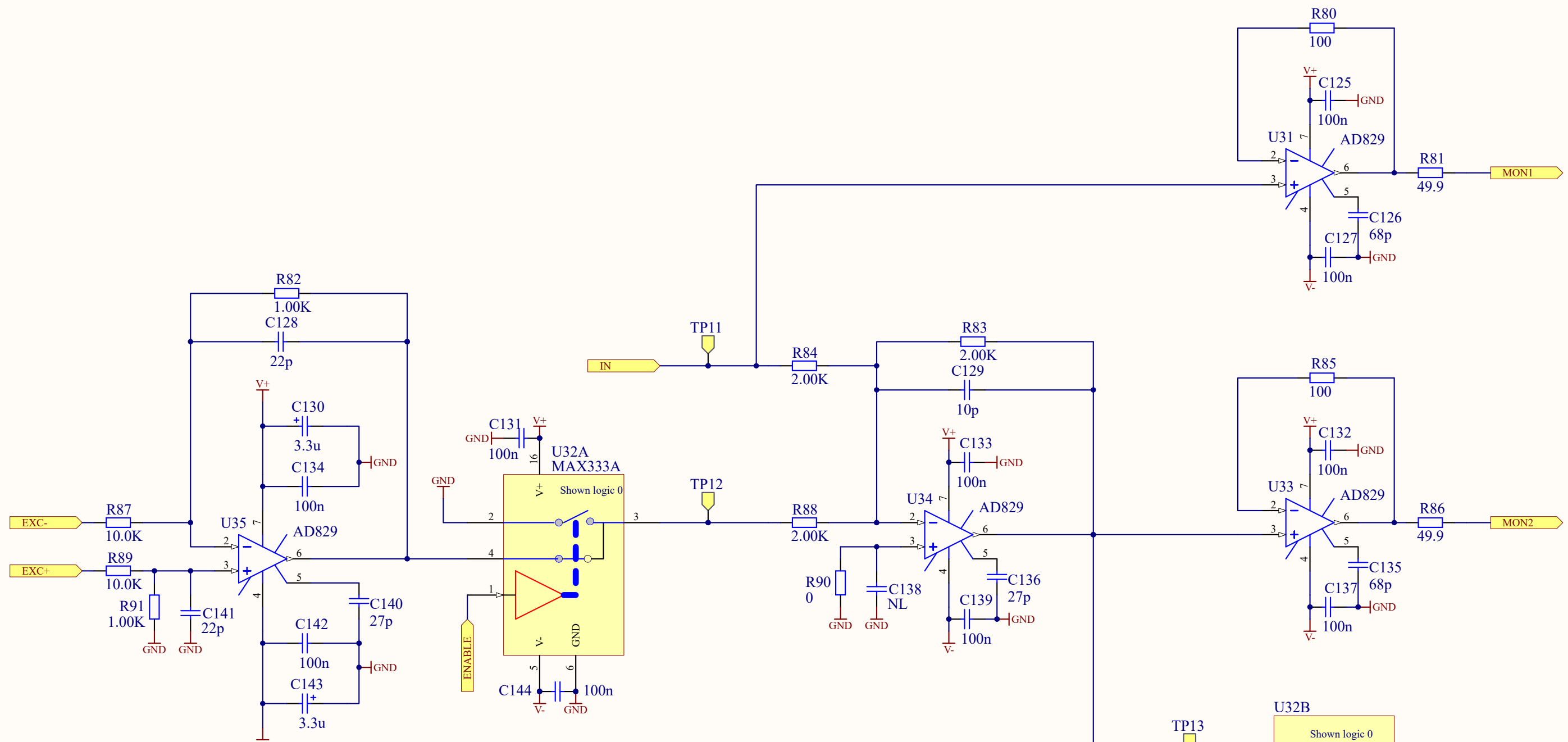
100Hz/1kHz pole/zero pair (ALS)

20Hz/2kHz pole/zero pair (SQZ)

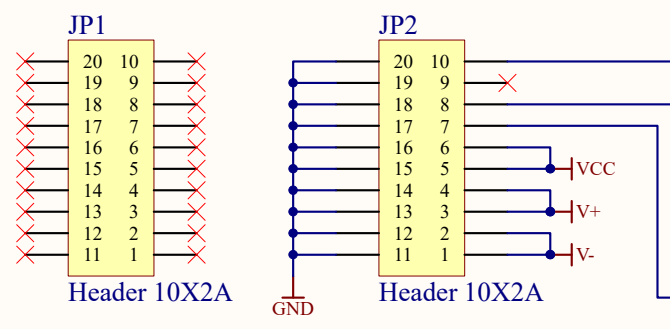
20Hz/2kHz pole/zero pair (SQZ)



Title <b>Common Mode Board: Boost</b>		
Size B	Number <b>D040180</b>	Revision 7
Date: 3/21/2019	Sheet 6	17 of 17
File: C:\Users\...\CM3B.SchDoc	Drawn By: Daniel Sigg	

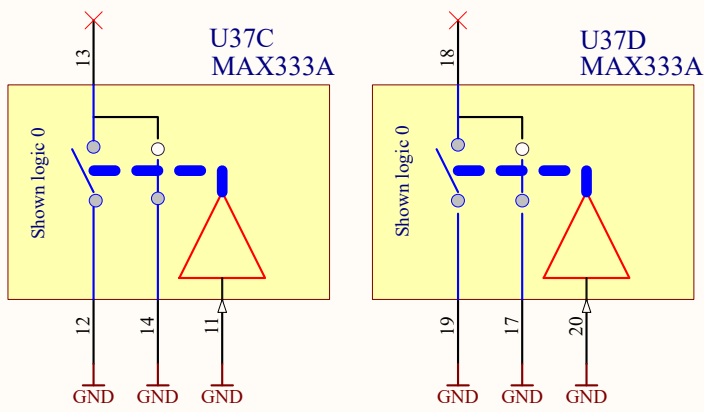
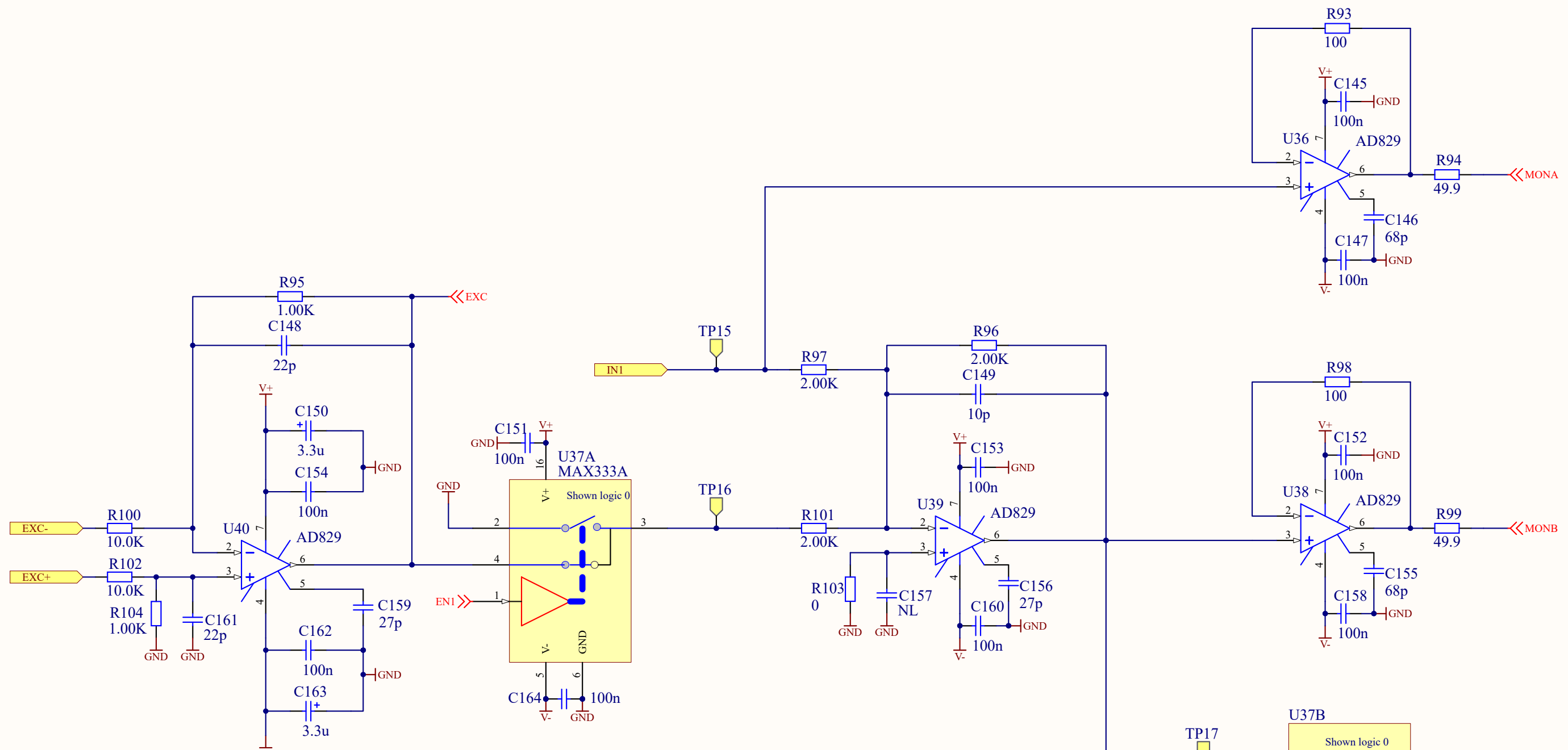


- M1 M3 standoff, 12mm
- M2 M3 pan, 8mm
- M3 M3 standoff, 12mm
- M4 M3 pan, 8mm
- M5 M3 standoff, 12mm
- M6 M3 pan, 8mm
- M7 M3 standoff, 12mm
- M8 M3 pan, 8mm
- M9 M3 standoff, 12mm
- M10 M3 pan, 8mm
- M11 M3 standoff, 12mm
- M12 M3 pan, 8mm
- M13 M3 pan, 8mm
- M14 M3 pan, 8mm
- M15 M3 pan, 8mm
- M16 M3 pan, 8mm
- M17 M3 pan, 8mm
- M18 M3 pan, 8mm
- McMaster-Carr  
90317A115

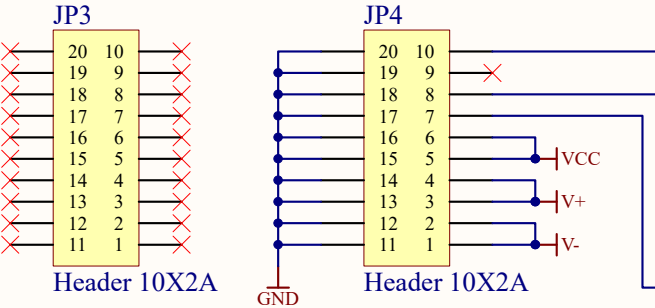


optional daughter board

Title <b>Common Mode Board: Com. Excitation</b>		
Size B	Number <b>D040180</b>	Revision 7
Date: 3/21/2019	Sheet 7 17 of	Drawn By: Daniel Sigg
File: C:\Users\...\CM4A.SchDoc		



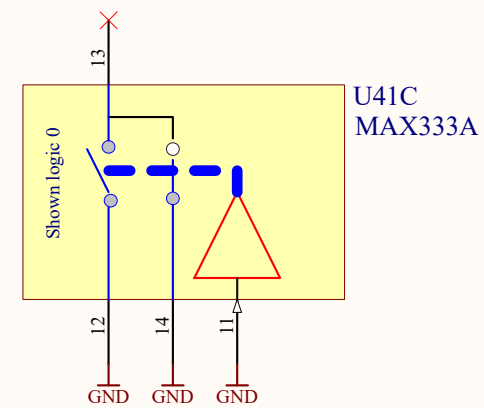
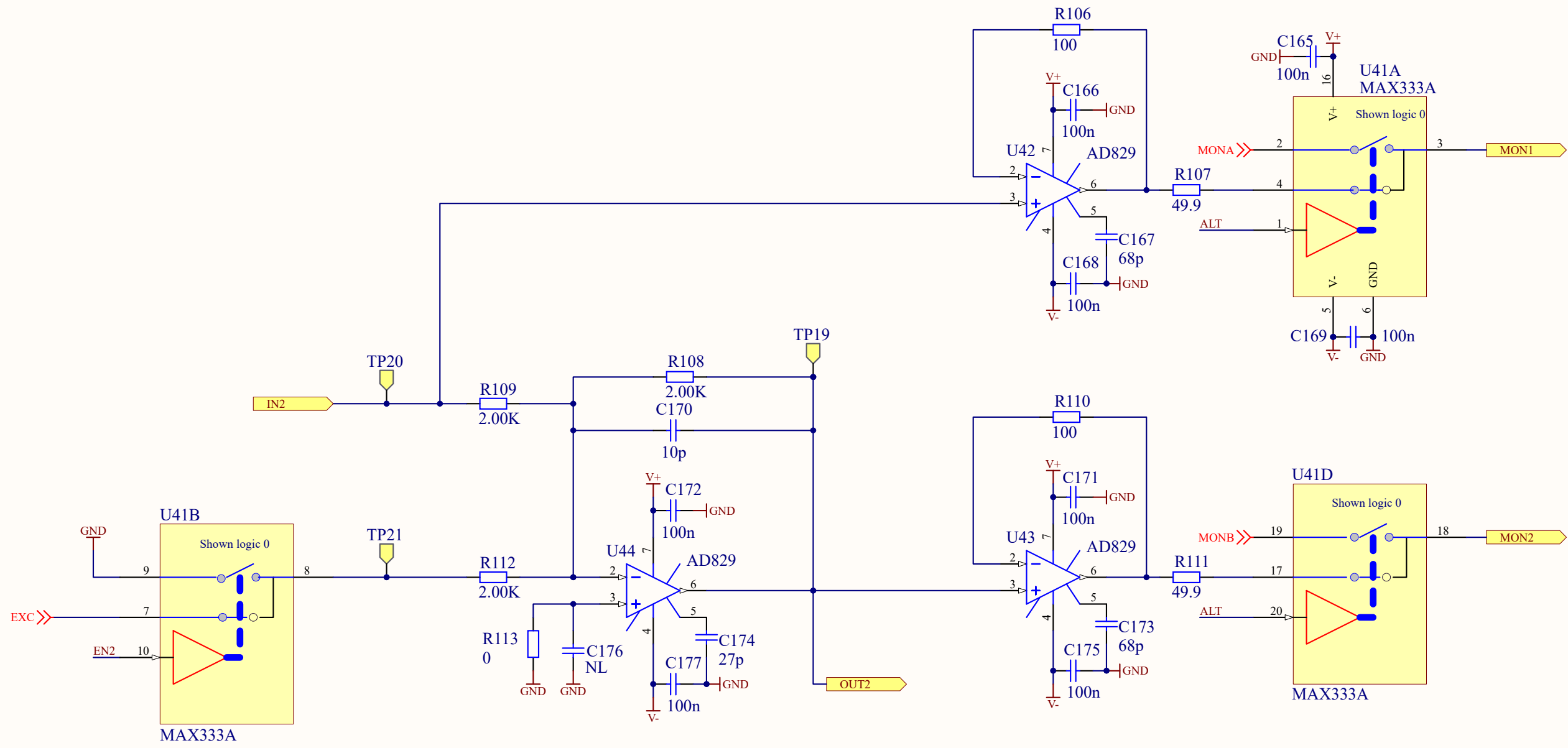
- M19 M3 standoff, 12mm
- M20 M3 pan, 8mm
- M21 M3 standoff, 12mm
- M22 M3 pan, 8mm
- M23 M3 standoff, 12mm
- M24 M3 pan, 8mm
- M25 M3 standoff, 12mm
- M26 M3 pan, 8mm
- M27 M3 standoff, 12mm
- M28 M3 pan, 8mm
- M29 M3 standoff, 12mm
- M30 M3 pan, 8mm
- Digi-Key 24434K-ND
- M31 M3 pan, 8mm
- M32 M3 pan, 8mm
- M33 M3 pan, 8mm
- M34 M3 pan, 8mm
- M35 M3 pan, 8mm
- M36 M3 pan, 8mm
- McMaster-Carr 90317A115



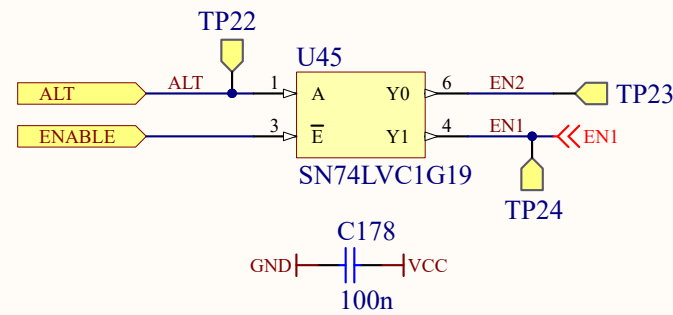
optional daughter board

Title <b>Common Mode Board: Fast Excitation</b>		
Size B	Number <b>D040180</b>	Revision 7
Date: 3/21/2019	Sheet 8	17 of
File: C:\Users\...\CM4B.SchDoc	Drawn By: Daniel Sigg	





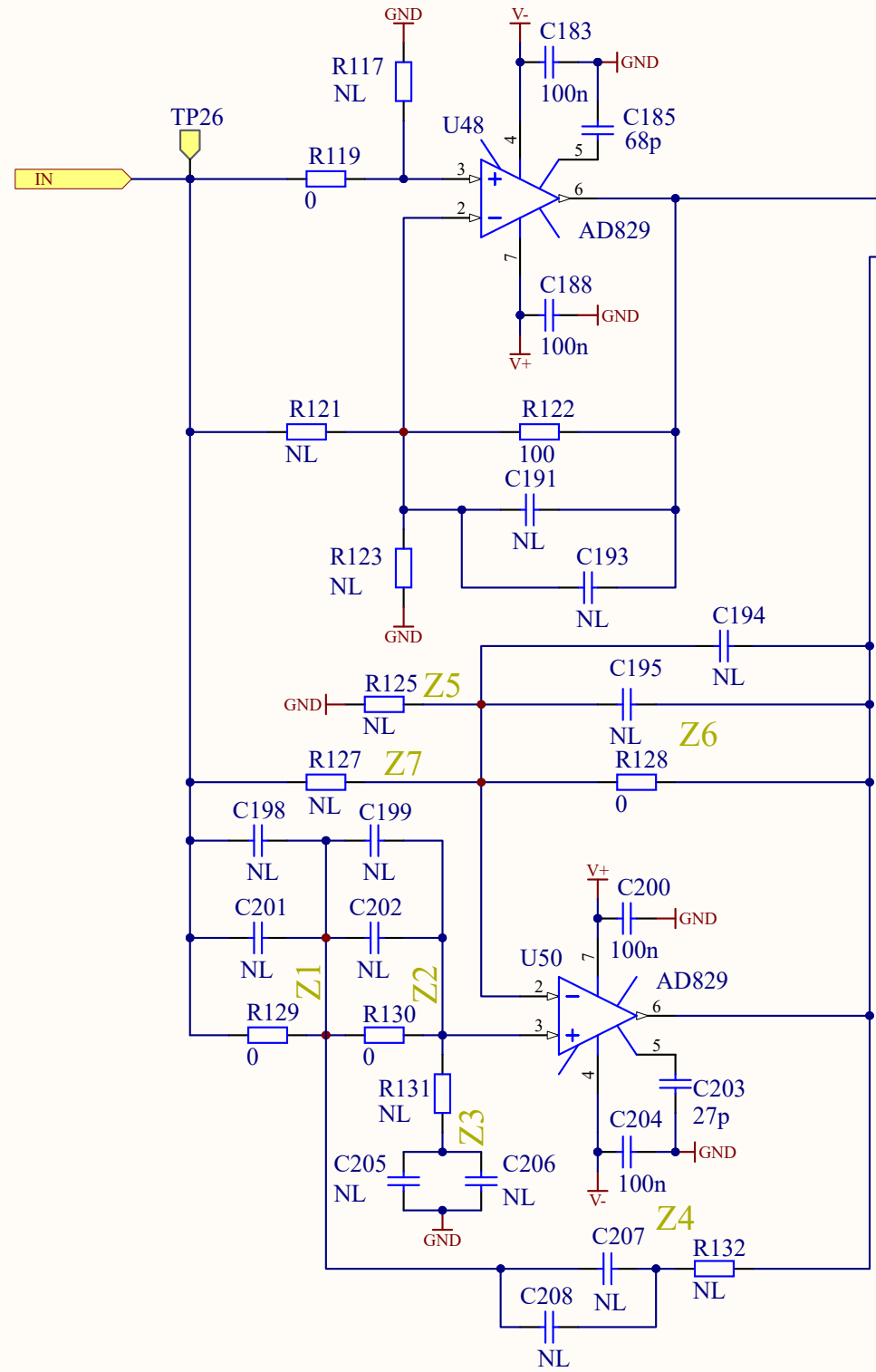
ENABLE	ALT	PATH	EN1	EN2
1	1	FAST	1	1
0	1	FAST	0	1
1	0	SLOW	1	1
0	0	SLOW	1	0



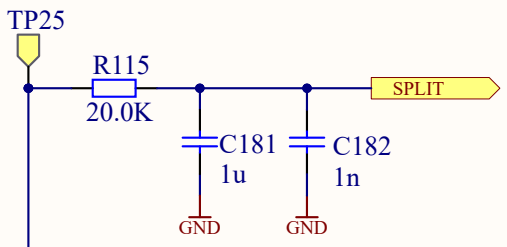
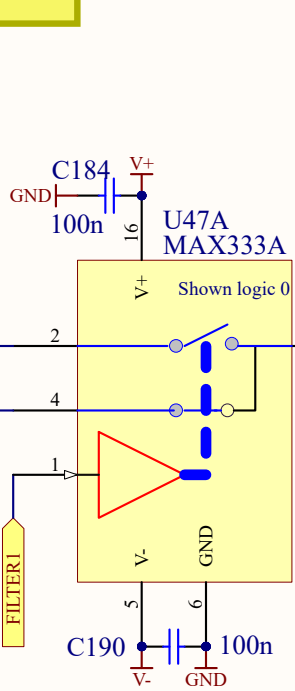
4kHz/17kHz pole/zero pair (MC):  
 Z5: 374  
 Z6: 33n || 1.2K

4kHz pole (SQZ):  
 Z7: 1.2K  
 Z6: 33n || 1.2K

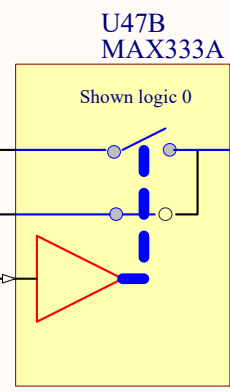
100kHz double pole/Q=0.85 (LL):  
 Z1: 2.7K      Z2: 1.3K  
 Z3: 470p      Z4: 1.5n  
 Z6: 0



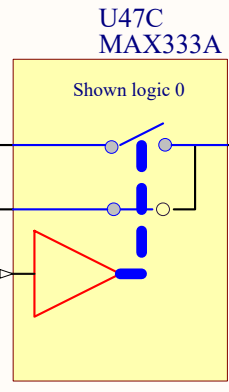
generic filter stage



SLOWBYPASS



POLARITY1



POLARITY2

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

GND

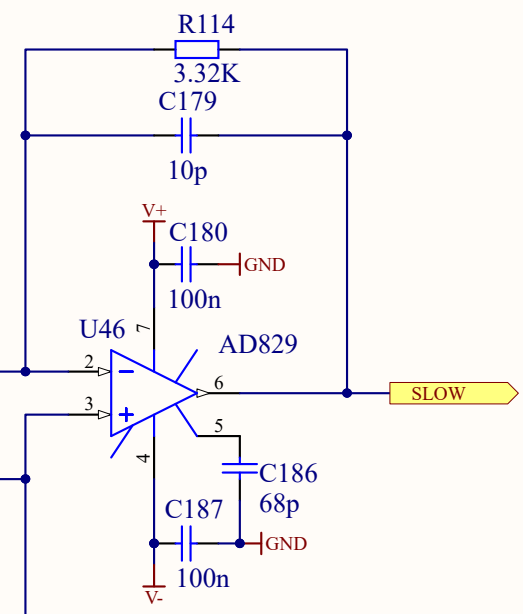
GND

GND

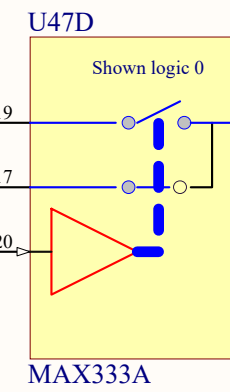
GND

GND

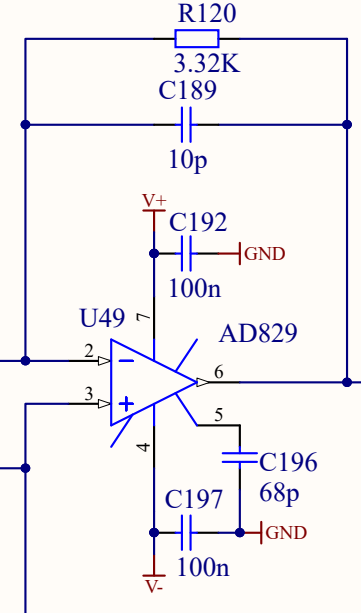
GND



SLOW



POLARITY1



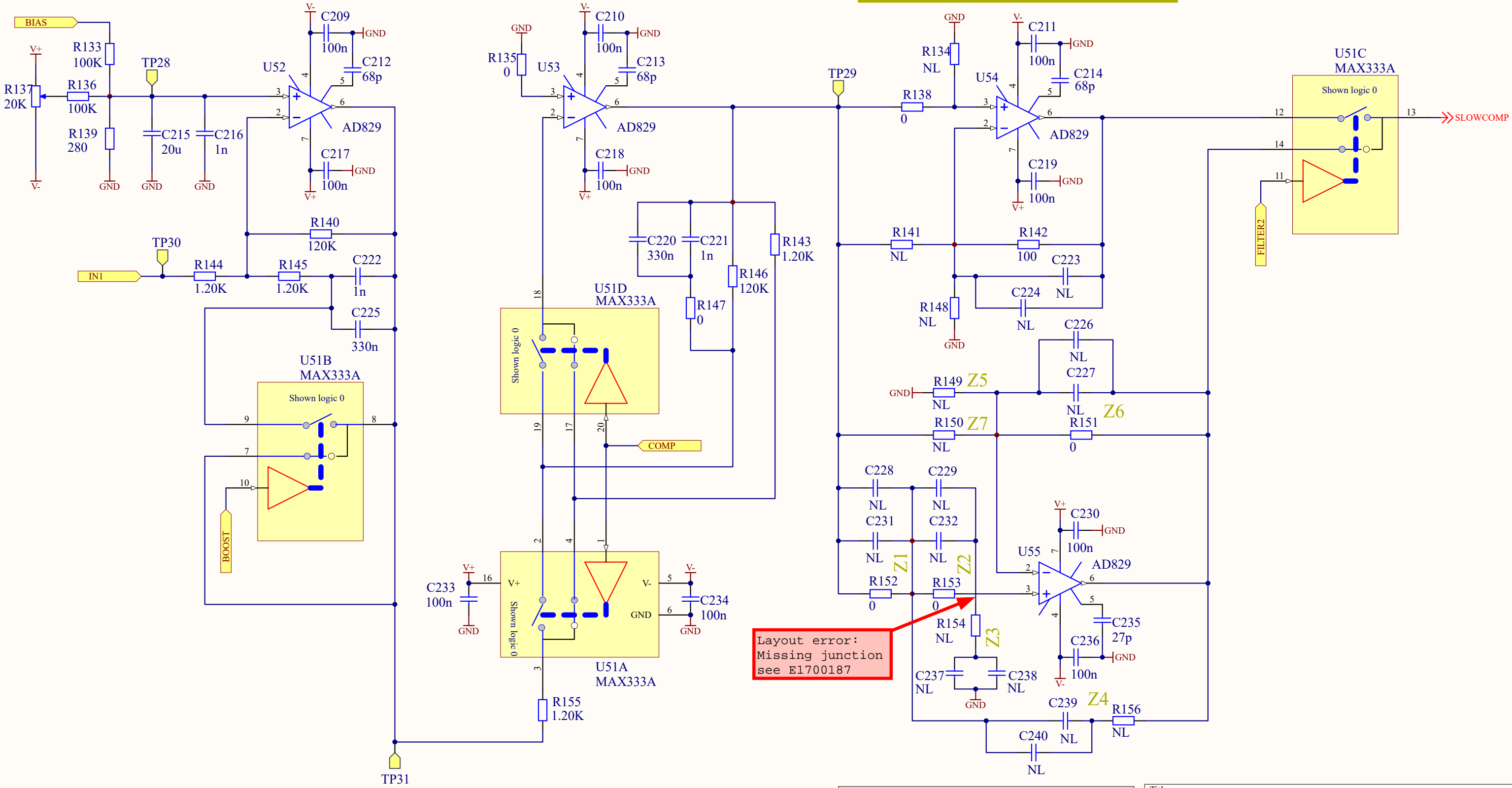
FAST

Title		
<b>Common Mode Board: Servo Split</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet10 17of
File:	C:\Users\daniel\Documents\CM5A.SchDoc	Drawn By: Daniel Sigg

4Hz/400Hz pole/zero pair

4Hz pole

1.2kHz/400Hz pole/zero pair (SQZ)  
Z5: 33n + 1.2K; Z6: 2.4K || 10p



Layout error:  
Missing junction  
see E1700187

generic filter stage

Title			<b>Common Mode Board: Slow</b>		
Size	Number			Revision	
B	D040180			7	
Date:	3/21/2019	Sheet11	17of		
File:	C:\Users\daniel\Documents\CM5B.SchDoc	Drawn By:	Daniel Sigg		

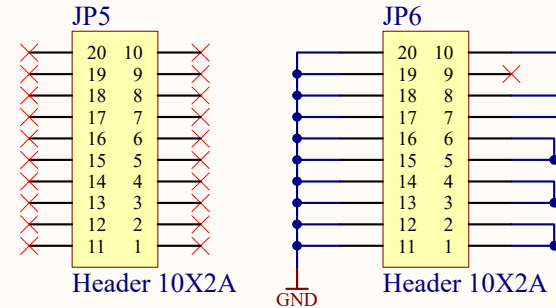
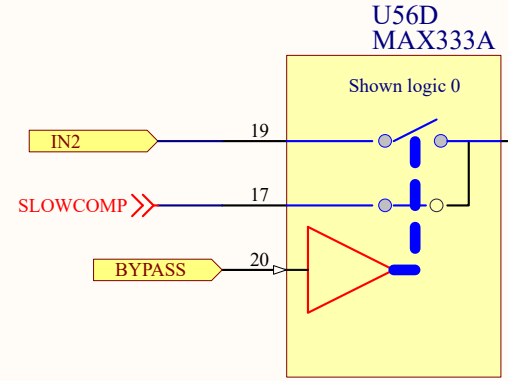
generic filter stage  
 2 real zeros at 10Hz  
 2 real poles at 100Hz  
 dc gain of 0.1

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

100kHz pole

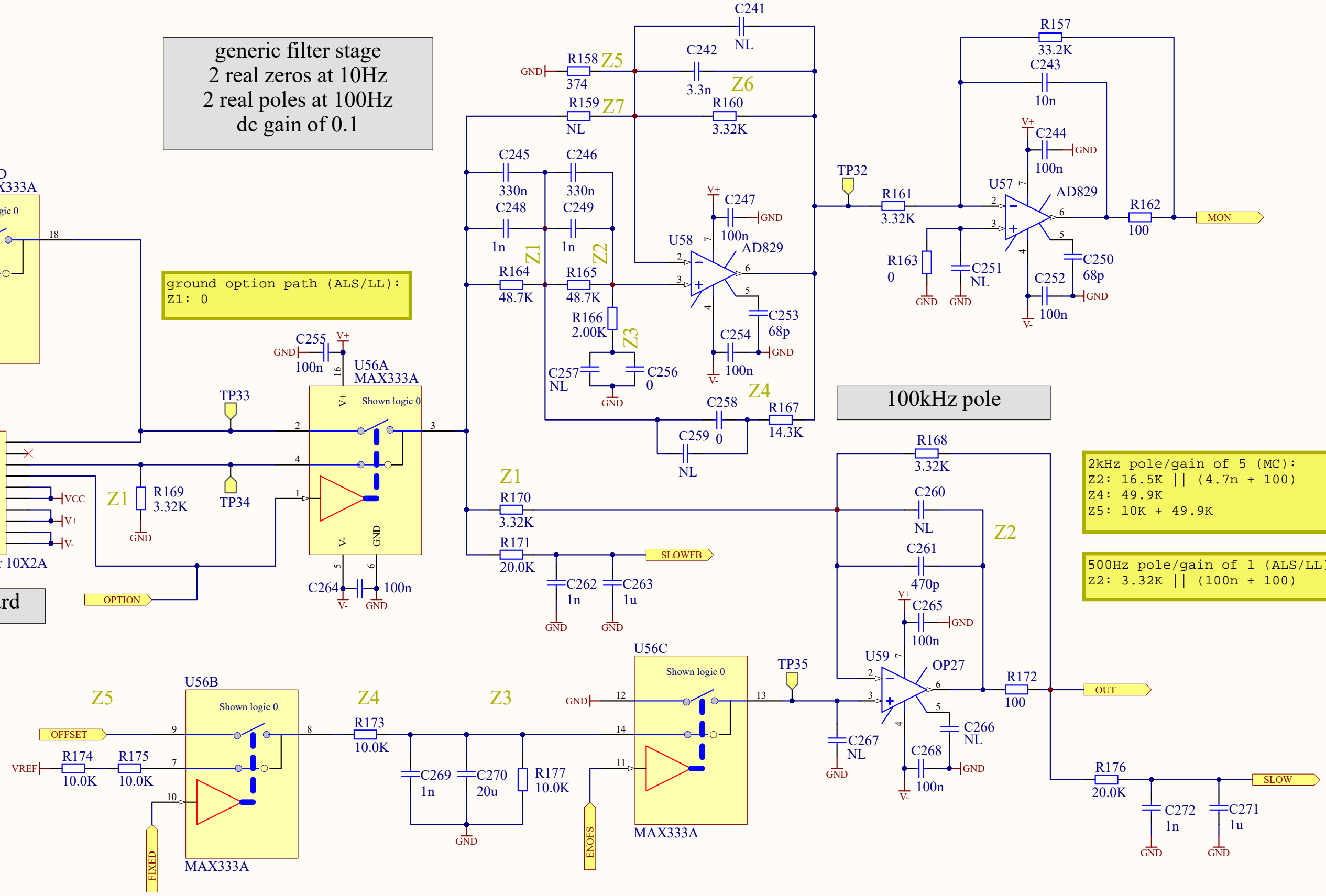
2kHz pole/gain of 5 (MC):  
 Z2: 16.5K || (4.7n + 100)  
 Z4: 49.9K  
 Z5: 10K + 49.9K

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



optional daughter board

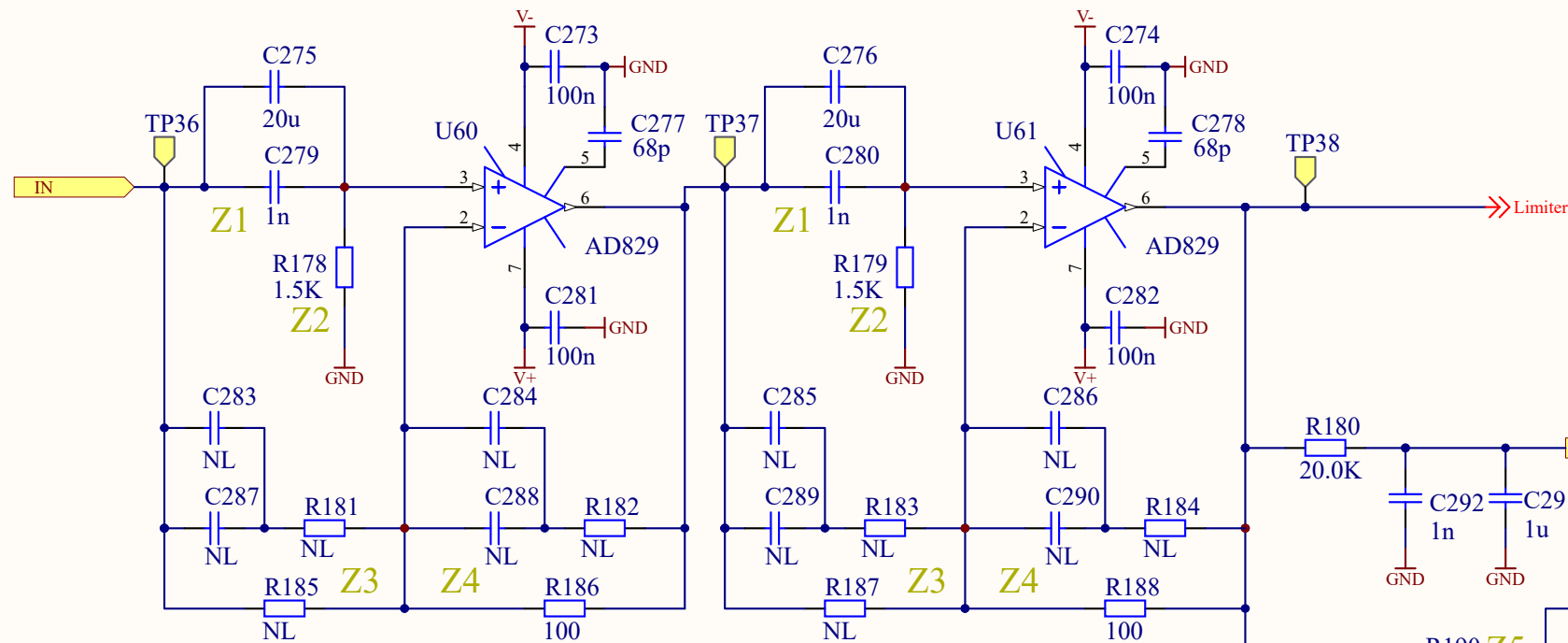
- M37 M3 standoff, 12mm
- M38 M3 pan, 8mm
- M39 M3 standoff, 12mm
- M40 M3 pan, 8mm
- M41 M3 standoff, 12mm
- M42 M3 pan, 8mm
- M43 M3 standoff, 12mm
- M44 M3 pan, 8mm
- M45 M3 standoff, 12mm
- M46 M3 pan, 8mm
- M47 M3 standoff, 12mm
- M48 M3 pan, 8mm
- Digi-Key 24434K-ND
- M49 M3 pan, 8mm
- M50 M3 pan, 8mm
- M51 M3 pan, 8mm
- M52 M3 pan, 8mm
- M53 M3 pan, 8mm
- M54 M3 pan, 8mm
- McMaster-Carr 90317A115



Title <b>Common Mode Board: Slow</b>		
Size B	Number <b>D040180</b>	Revision 7
Date: 3/21/2019	Sheet12	17of
File: C:\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 (ALS/LL/SQZ):  
 Z1: 0 Ohm  
 Z2: NL  
 Z3: NL  
 Z4: 100 Ohm

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

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

Filter Design Examples:

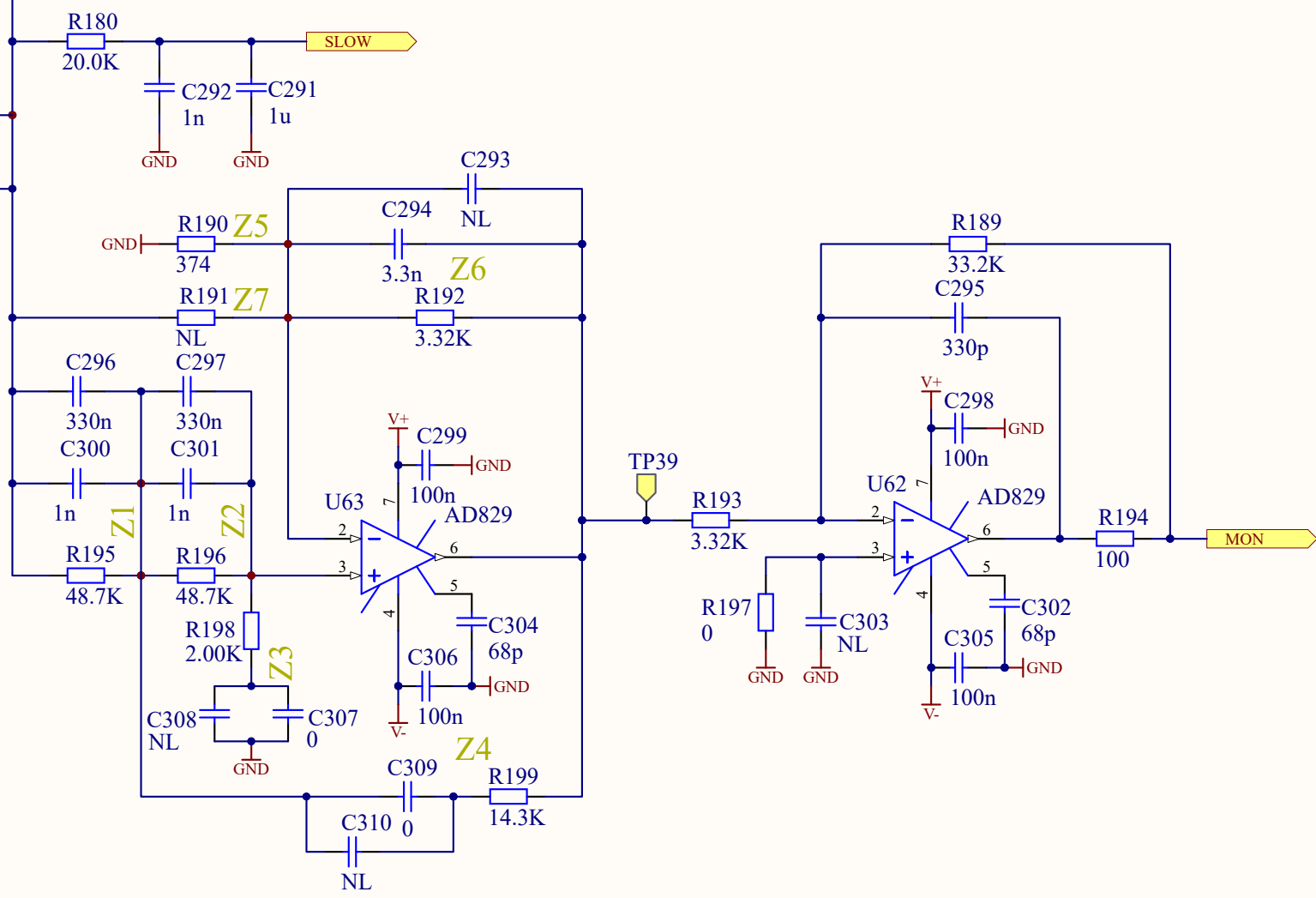
Butterworth high pass:  $G = 1.586$ ,  $Z1 = Z2 = 1/sC$ ,  $Z3 = Z4 = R$   
 two zeros at 0Hz, two complex poles at  $f = 1/(2 \pi R C)$

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

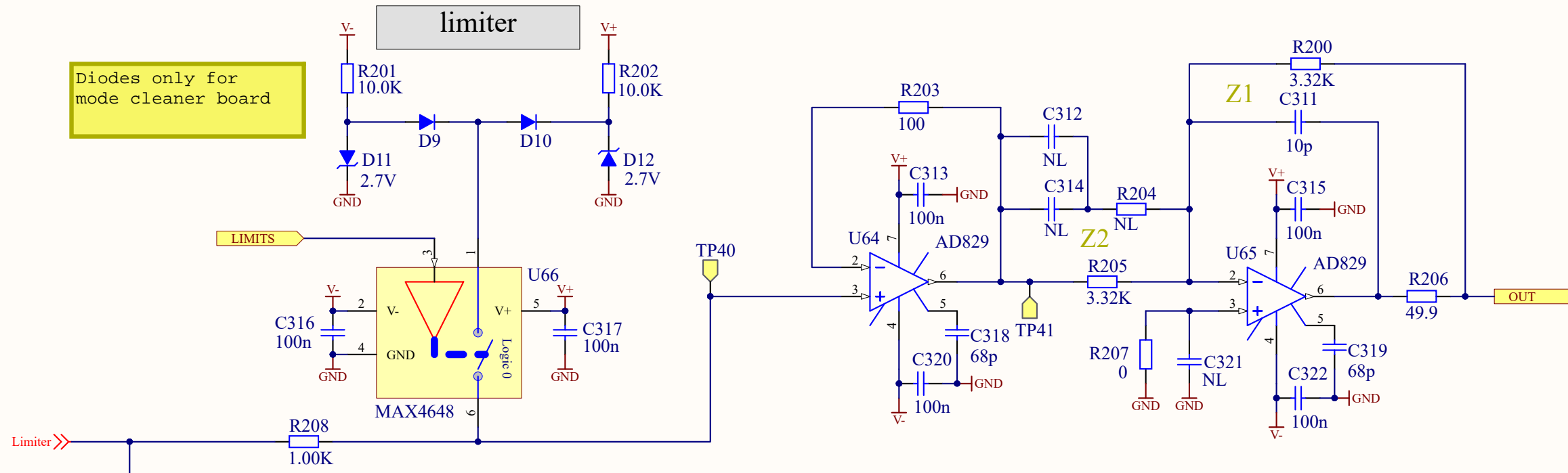
Whitening:  $G = 1$ ,  $Z1 = Z2 = (1/sC) || R2$ ,  $Z3 = Z4 = R1$   
 two real zeros at  $f = 1/(2 \pi R2 C)$ , two real poles at  $f = 1/(2 \pi (R1 || R2) C)$

Dewhitening:  $G = 1$ ,  $Z1 = Z2 = R1$ ,  $Z3 = Z4 = 1/sC + R2$   
 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

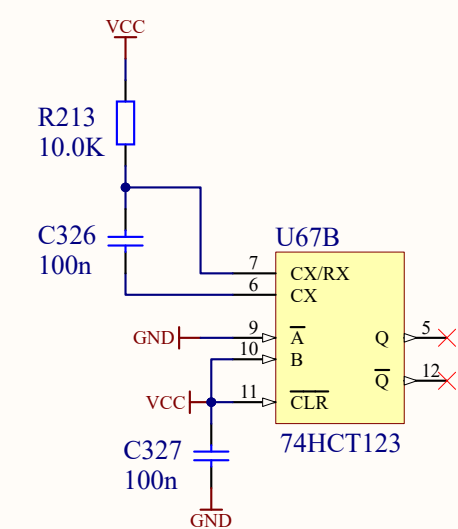
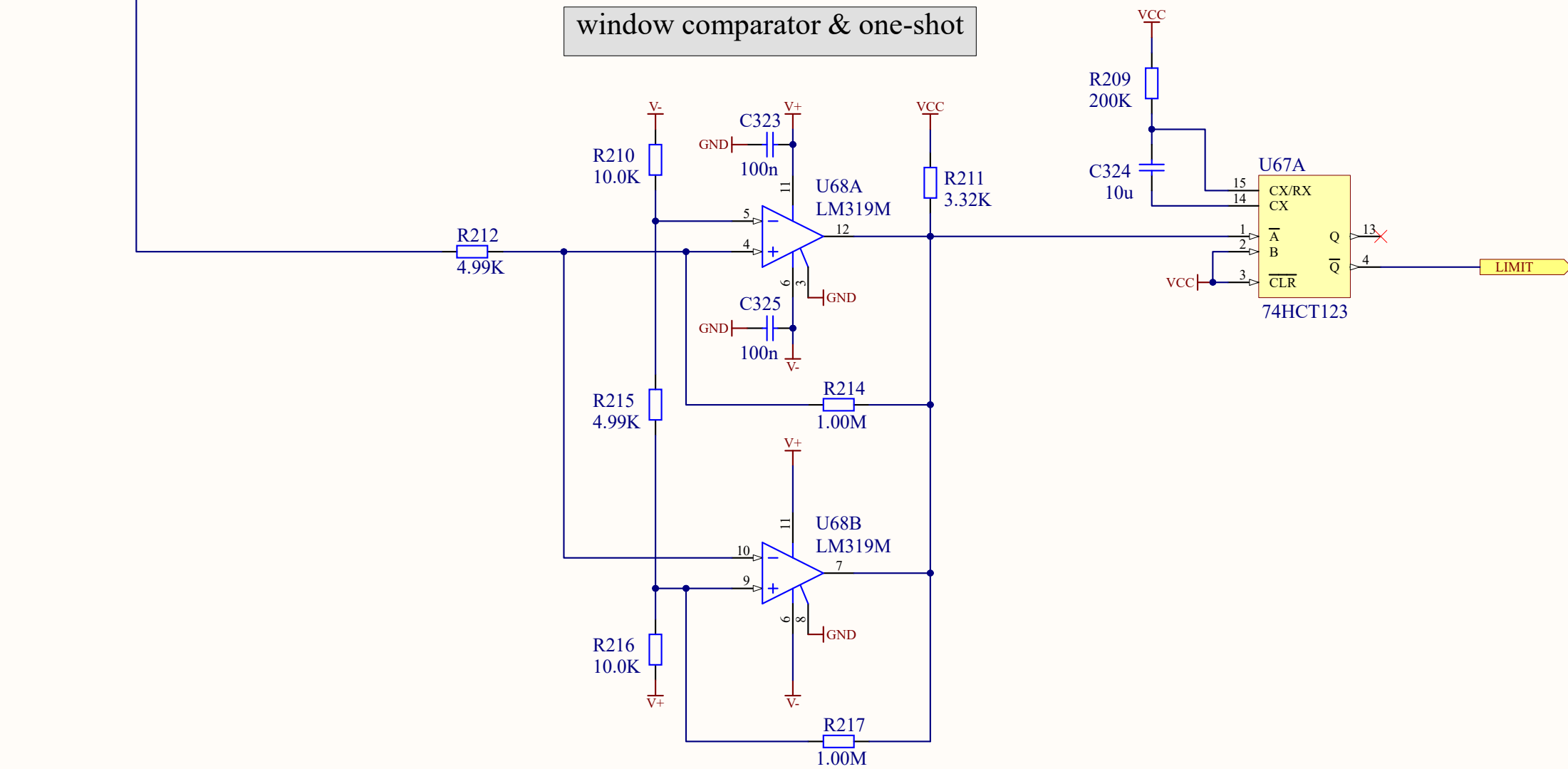


Title		
<b>Common Mode Board: Fast Path</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet13 17of
File:	C:\Users\...\CM6A.SchDoc	Drawn By: Daniel Sigg

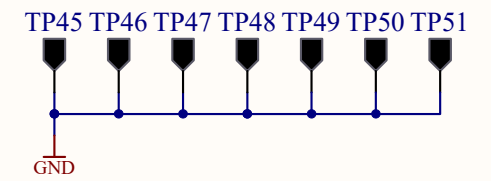
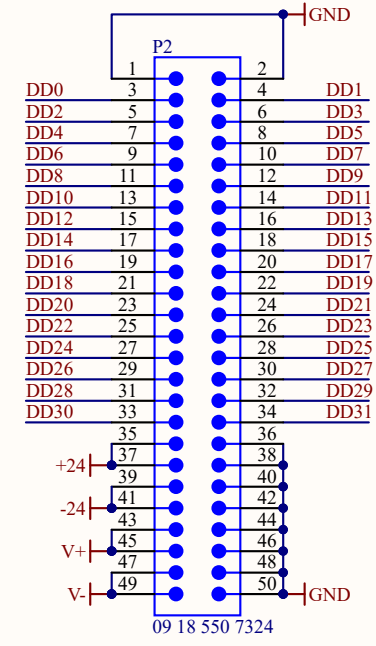
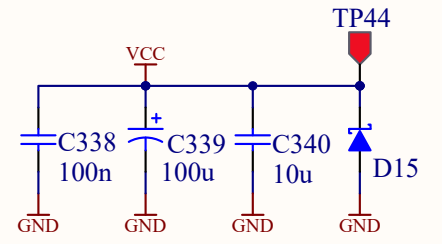
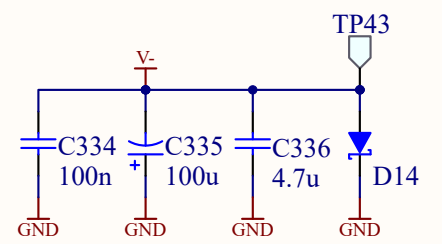
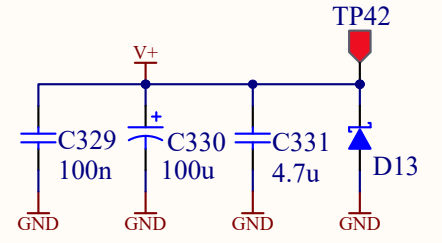
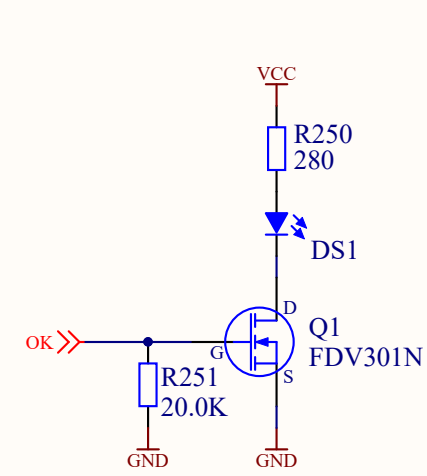
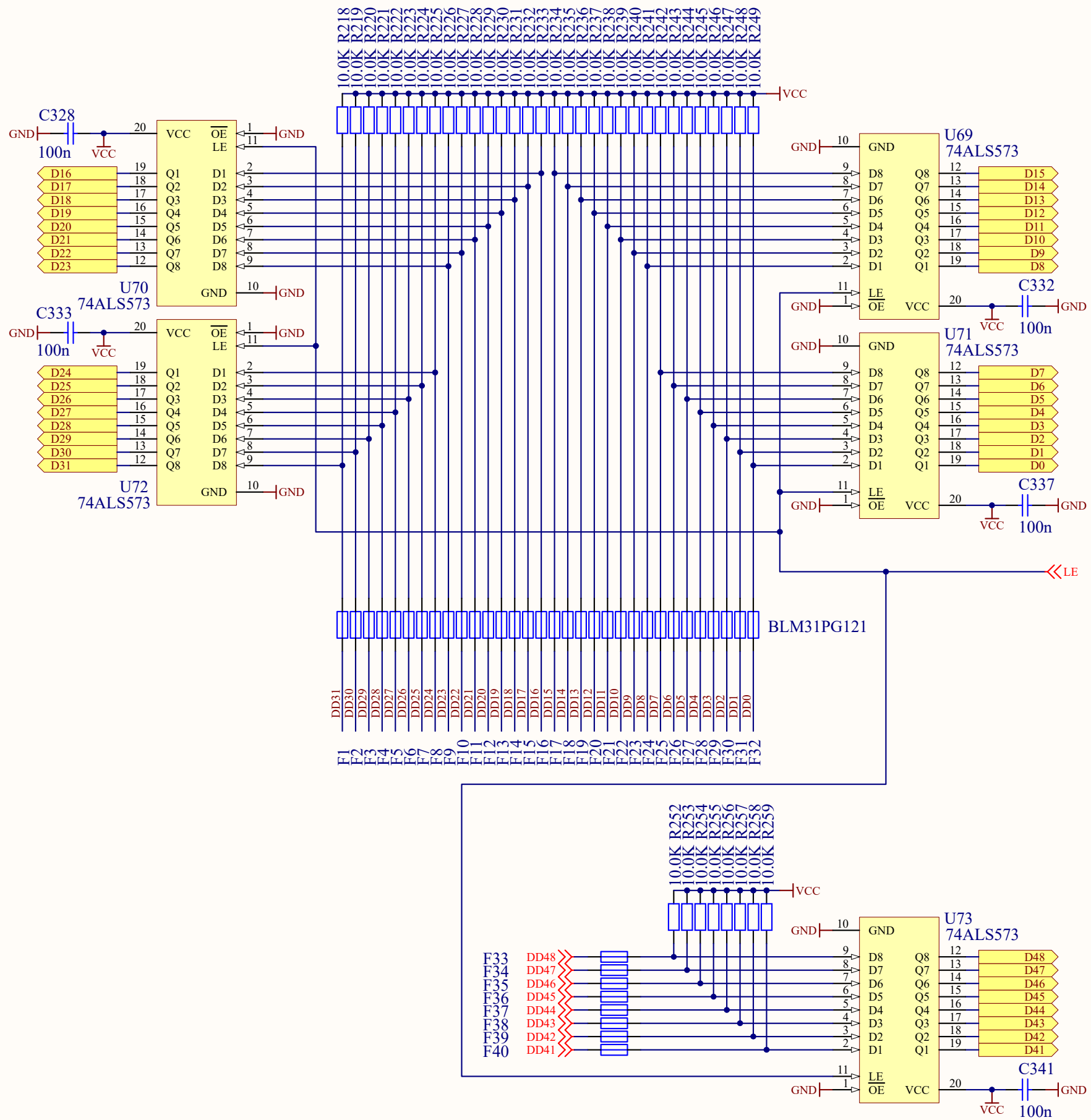


Diodes only for mode cleaner board

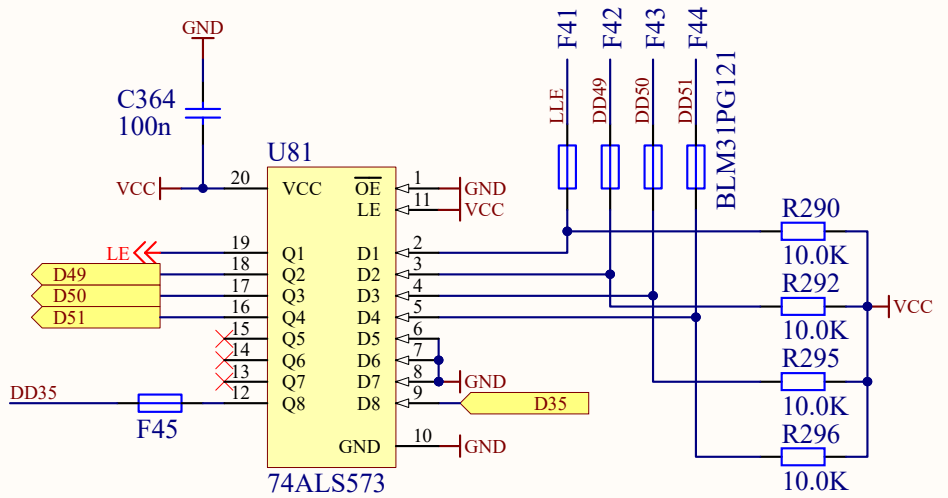
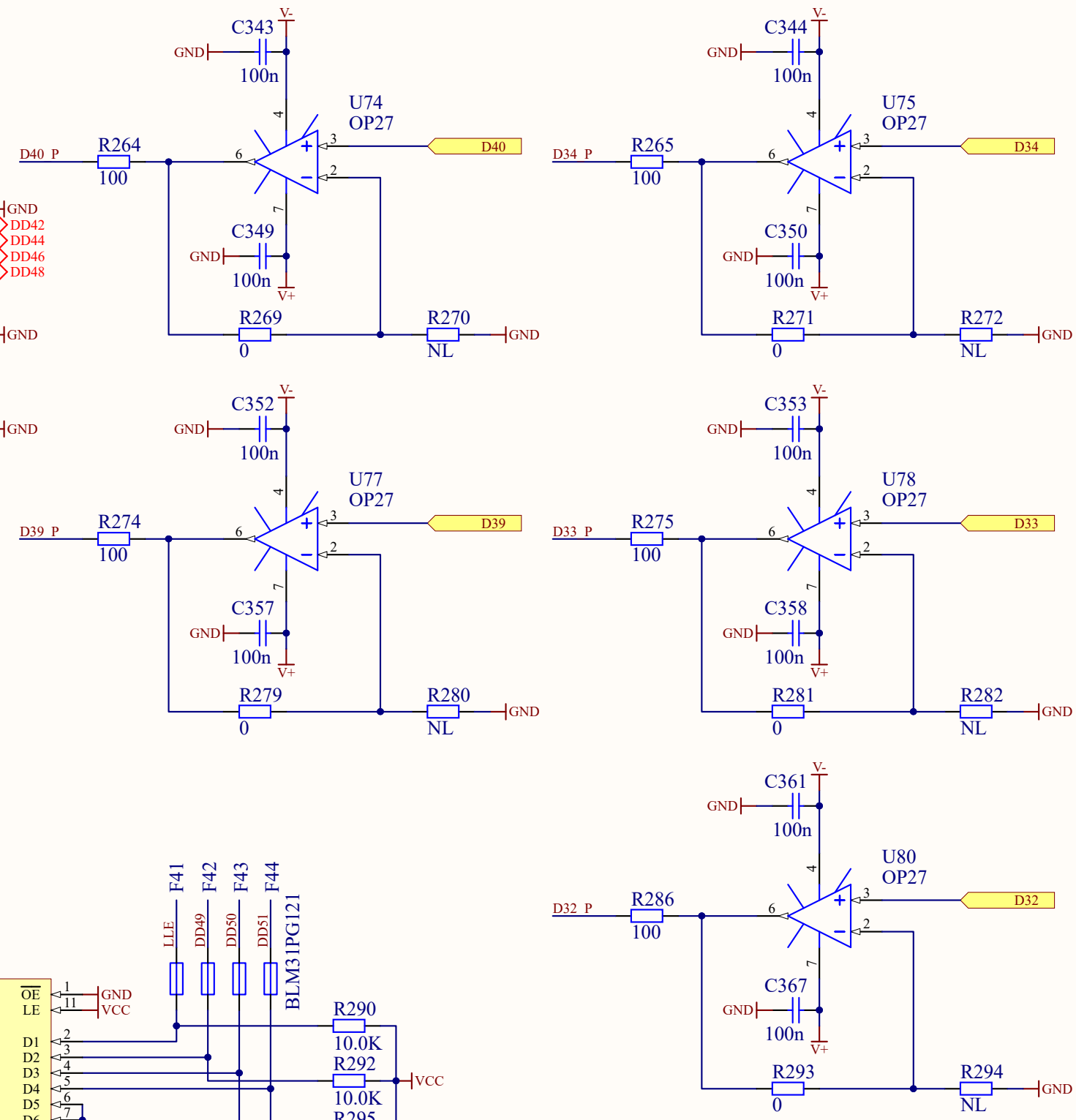
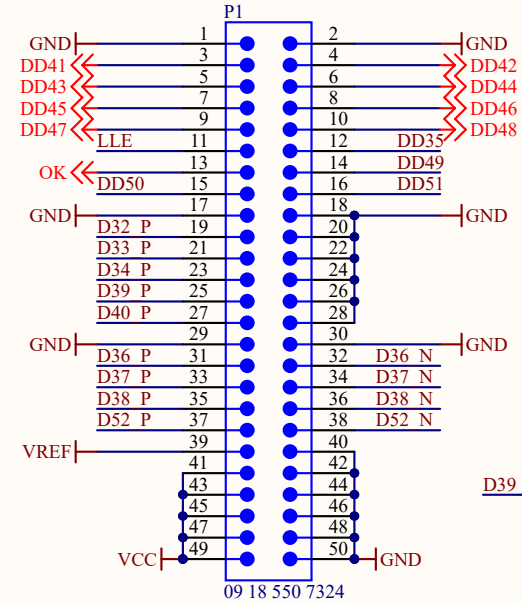
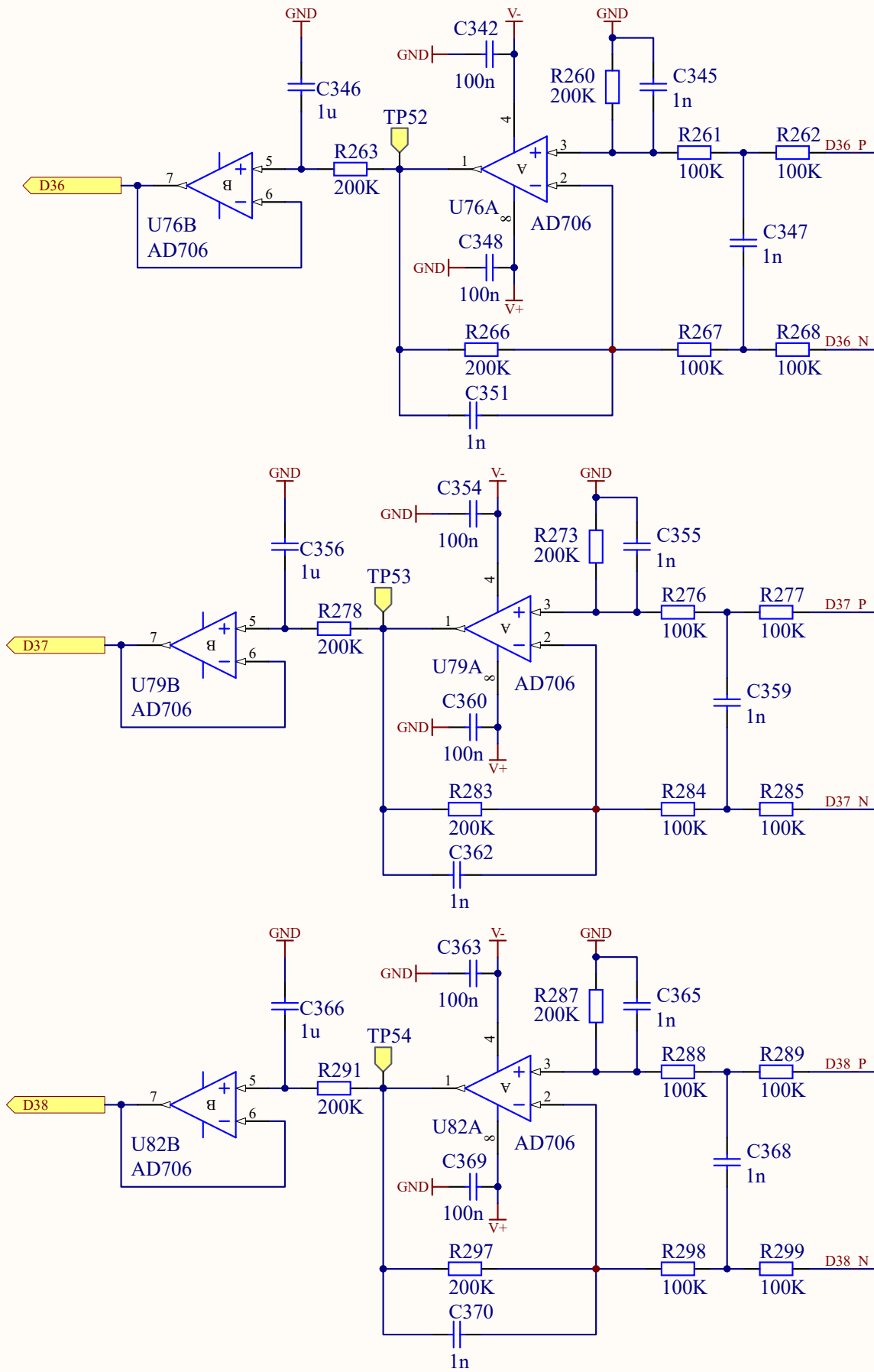
window comparator & one-shot



Title		
<b>Common Mode Board: Output Limiter</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet14 17of
File:	C:\Users\...\CM6B.SchDoc	Drawn By: Daniel Sigg

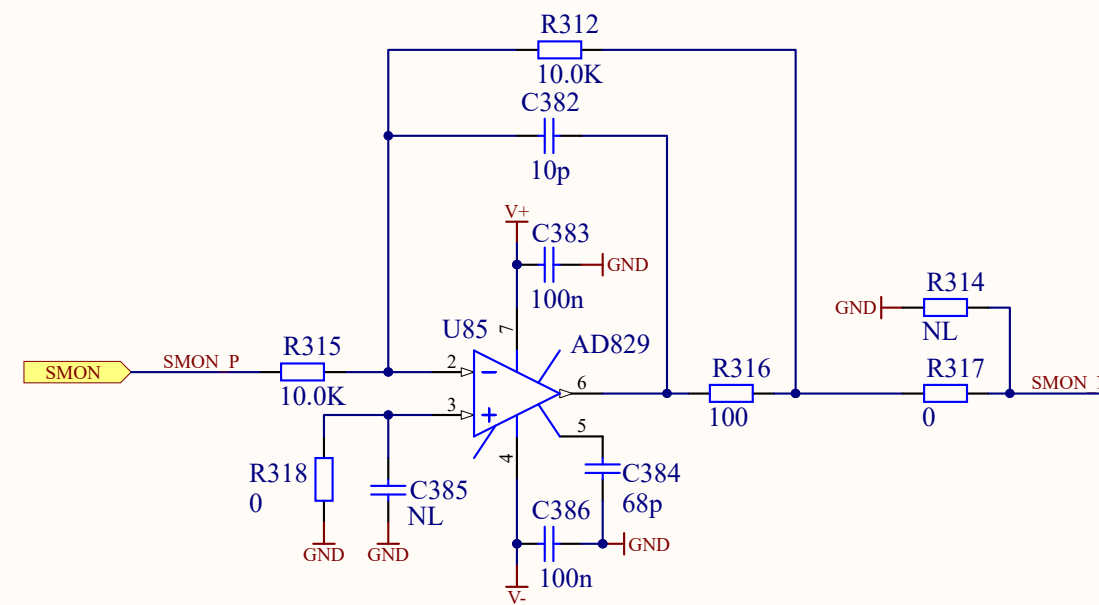
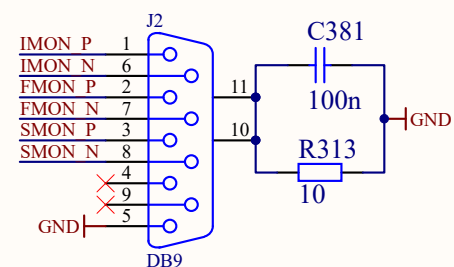
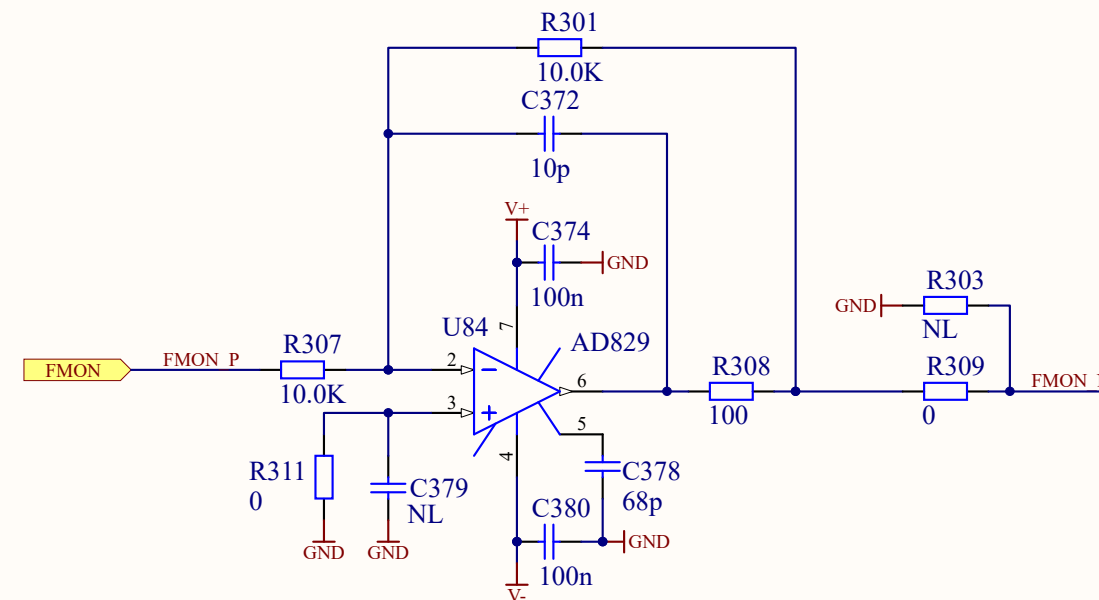
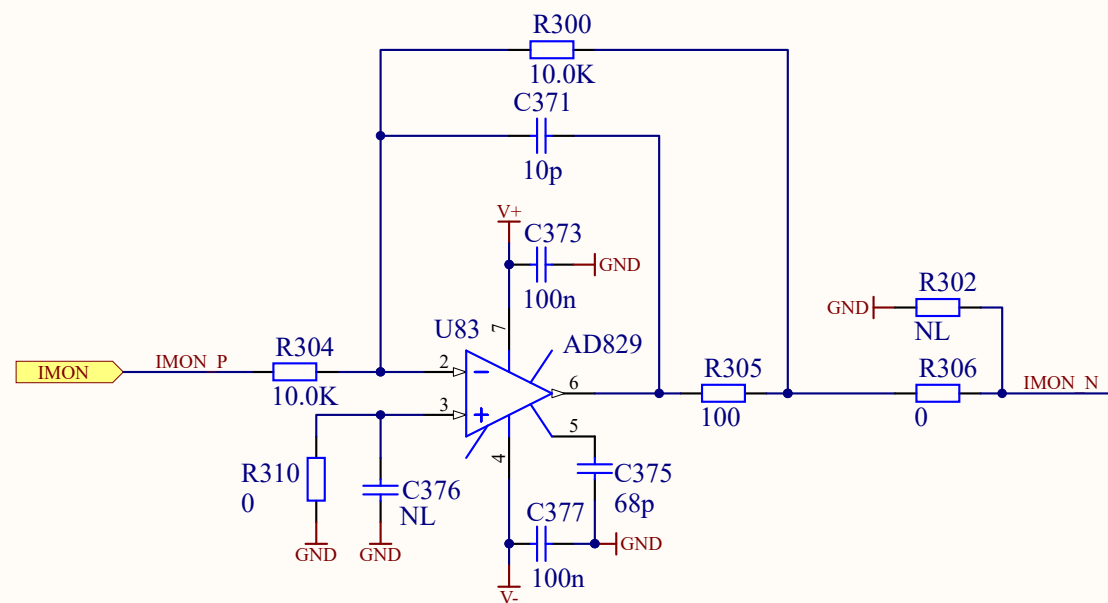


Title		
<b>Common Mode Board: Backplane(P1)</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet15 17of
File:	C:\Users\...\CM7A.SchDoc	Drawn By: Daniel Sigg



Title		
<b>Common Mode Board: Backplane(P2)</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet16 17of
File:	C:\Users\...\CM7B.SchDoc	Drawn By: Daniel Sigg





Title		
<b>Common Mode Board: DAQ</b>		
Size	Number	Revision
B	D040180	7
Date:	3/21/2019	Sheet17 17of
File:	C:\Users\...\CM8.SchDoc	Drawn By: Daniel Sigg