
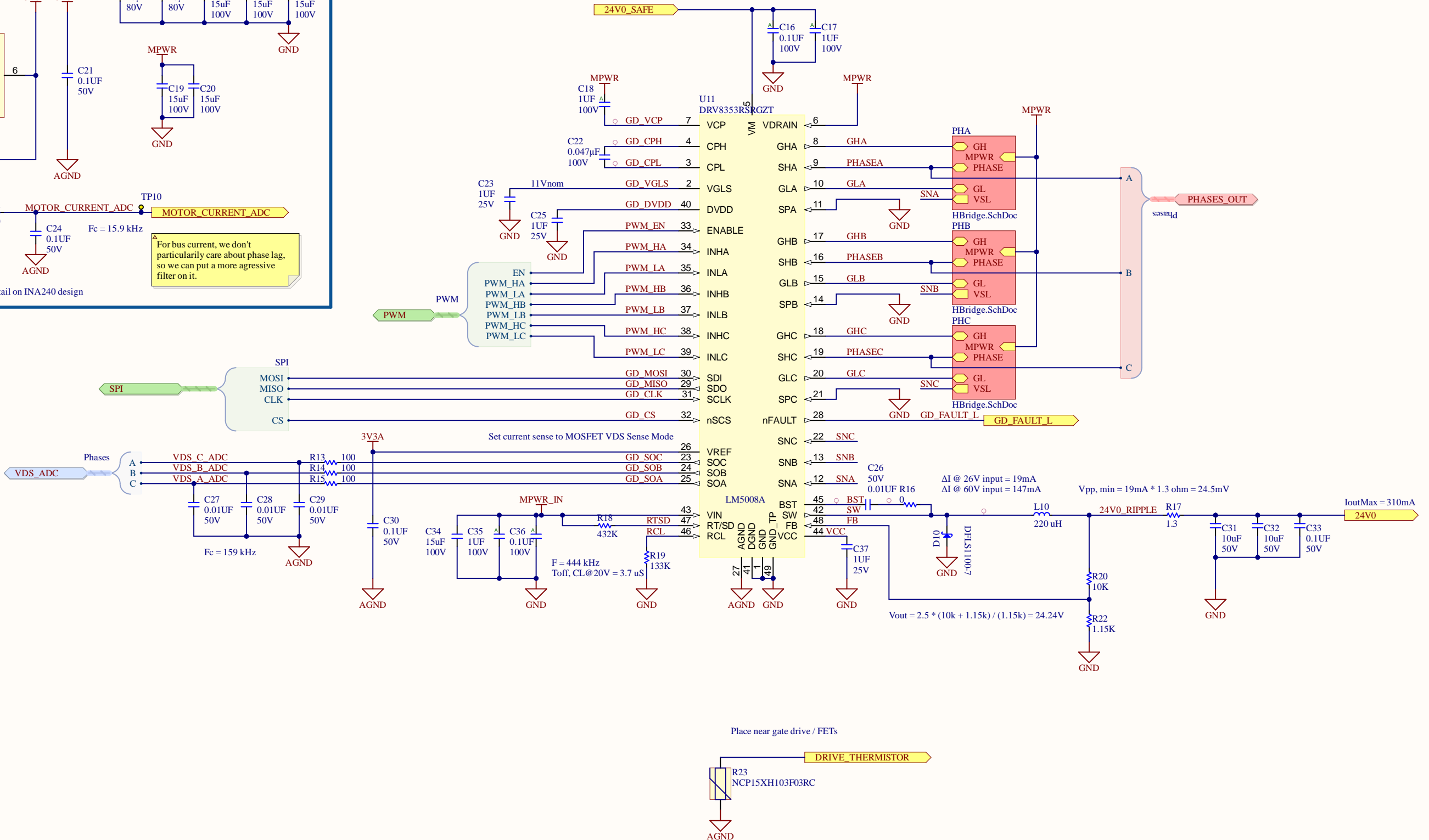
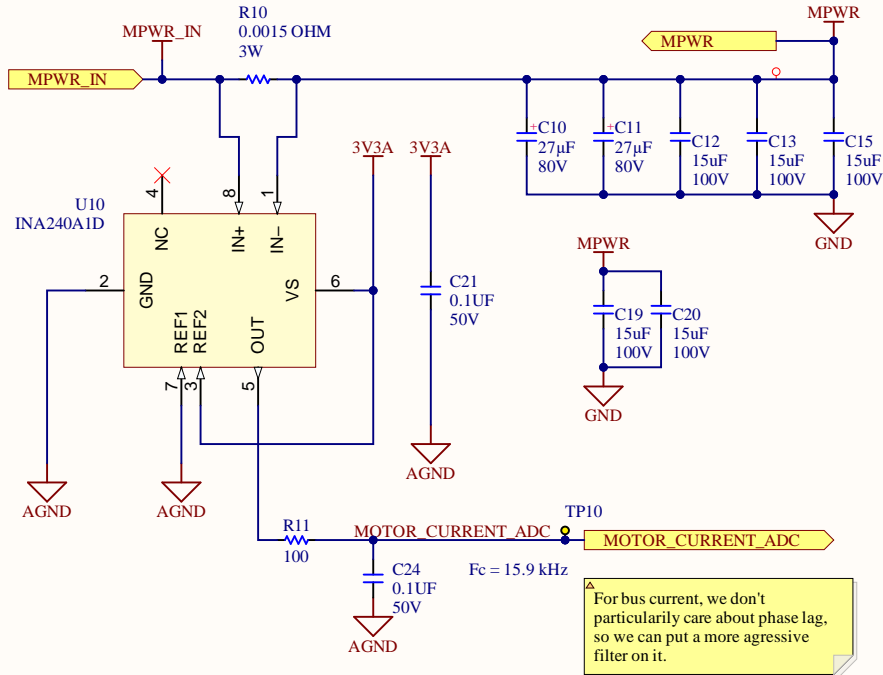


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	APPROVED	GOOGLE LLC	<div></div> <div>1600 AMPHITHEATRE PARKWAY MOUNTAIN VIEW CA 94043</div>		
	DWG NO	650-02976-04			
	RELEASED	2024/05/09			
	FILE	1-Top.SchDoc	SIZE	A3	SHEET 1 OF 6

Motor Current Measurement & Bulk Decoupling



Place near gate drive / FETs

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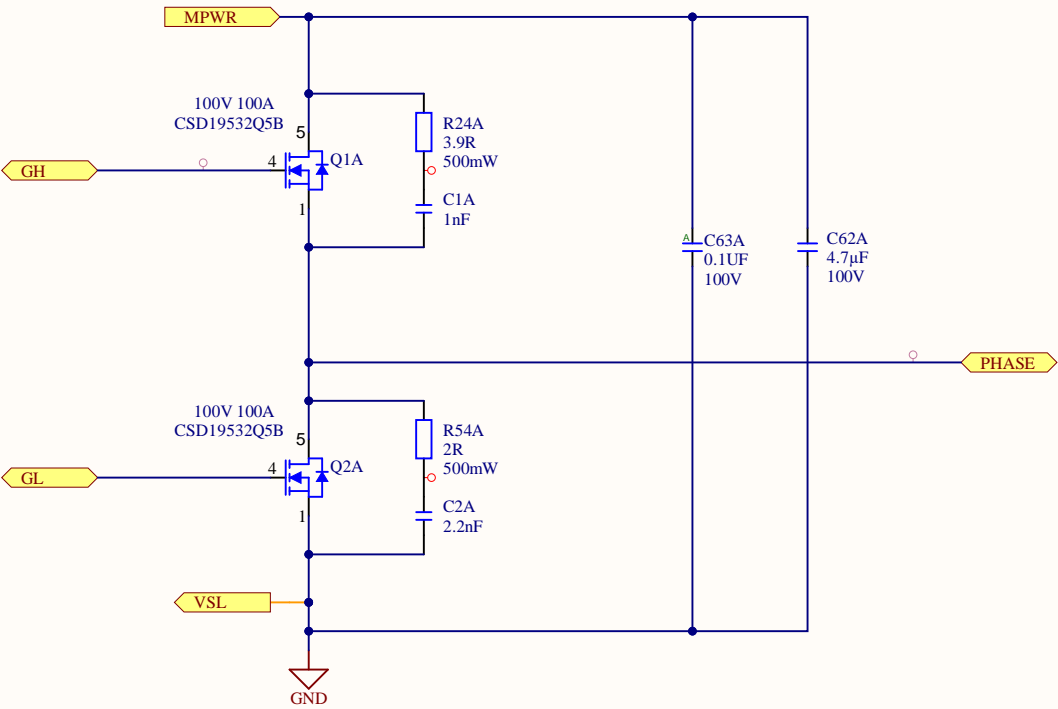
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1600 AMPHITHEATRE PARKWAY
MOUNTAIN VIEW CA 94043

SIZE A3 SHEET 2 OF 6



TI Snubber Design procedure for Motor Drivers

STEP 1
Measure the oscillation frequency f0 of VDS ringing with no RC snubber:
 $f0L = 111.11\text{MHz}$, $f0H = 114.94\text{MHz}$

STEP 2
Add capacitor C1 (>> MOSFET Crss) in parallel and measure shifted oscillation frequency f1:
 $Crss = 14\text{pF}$; $C1 = 100\text{pF}$
 $f1L = 104.17\text{MHz}$, $f1H = 102.04\text{MHz}$

STEP 3
Calculate frequency shift ratio $m = f0/f1$
 $mL = 1.067$, $mH = 1.126$

STEP 4
Calculate circuit parasitic capacitance $C0 = C1 / (m^2 - 1)$
 $C0L = 722.1\text{pF}$, $C0H = 373.3\text{pF}$

STEP 5
Calculate circuit parasitic inductance $L = (m^2 - 1) / ((2\pi f0)^2 * C1)$
 $L_L = 2.825\text{nH}$, $L_H = 5.154\text{nH}$

STEP 6
Calculate snubber capacitor value $Csnub = 3C0$
 $CsnubL = 2.179\text{nF} \rightarrow 2.2\text{nF}$, $CsnubH = 1.116\text{nF} \rightarrow 1\text{nF}$

STEP 7
Calculate snubber resistor value $Rsnub = \sqrt{L/C0}$
 $RsnubL = 1.97 \rightarrow 2.0\Omega$, $RsnubH = 3.72 \rightarrow 3.9\Omega$

BONUS STEP
Calculating resistor power rating
<https://www.ti.com/seclit/an/srup100/srup100.pdf>
Page 2-5
 $P = fCV^2$
We have experimented with frequencies up to 40kHz and will use a battery with peak voltage of 60V.
 $P = 40e3 * 2.2e-9 * 60^2$
 $P = 318\text{mW}$

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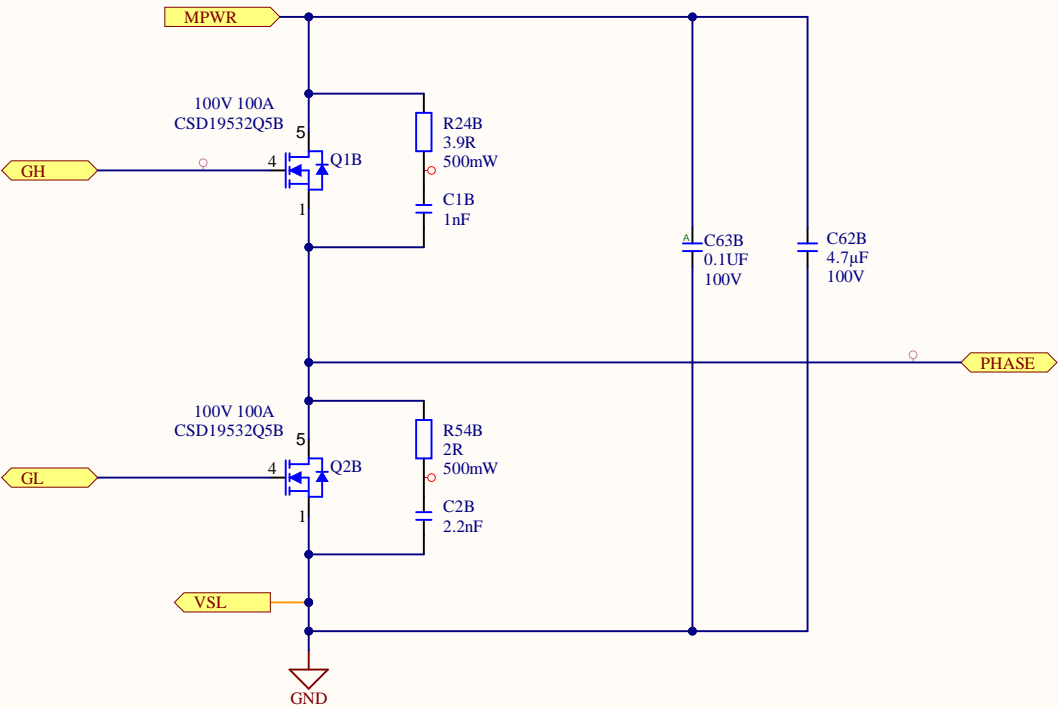
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SIZE A3 SHEET 3 OF 6



TI Snubber Design procedure for Motor Drivers

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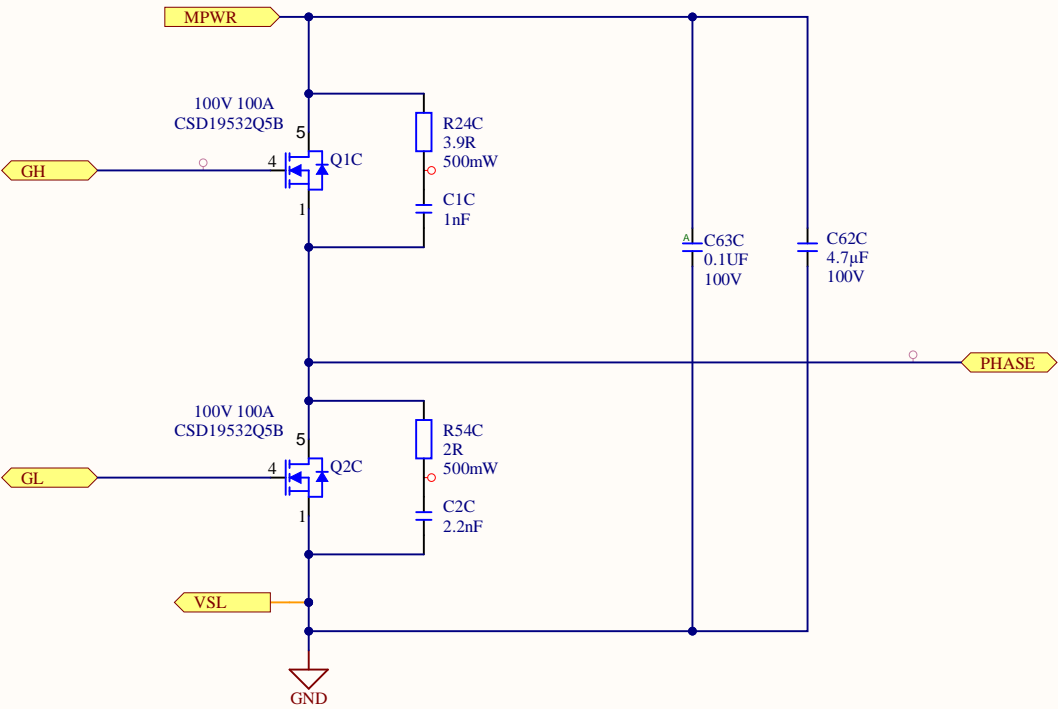
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TI Snubber Design procedure for Motor Drivers

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 $f_{0L} = 111.11\text{MHz}$, $f_{0H} = 114.94\text{MHz}$

STEP 2
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 $C_{rss} = 14\text{pF}$; $C_1 = 100\text{pF}$
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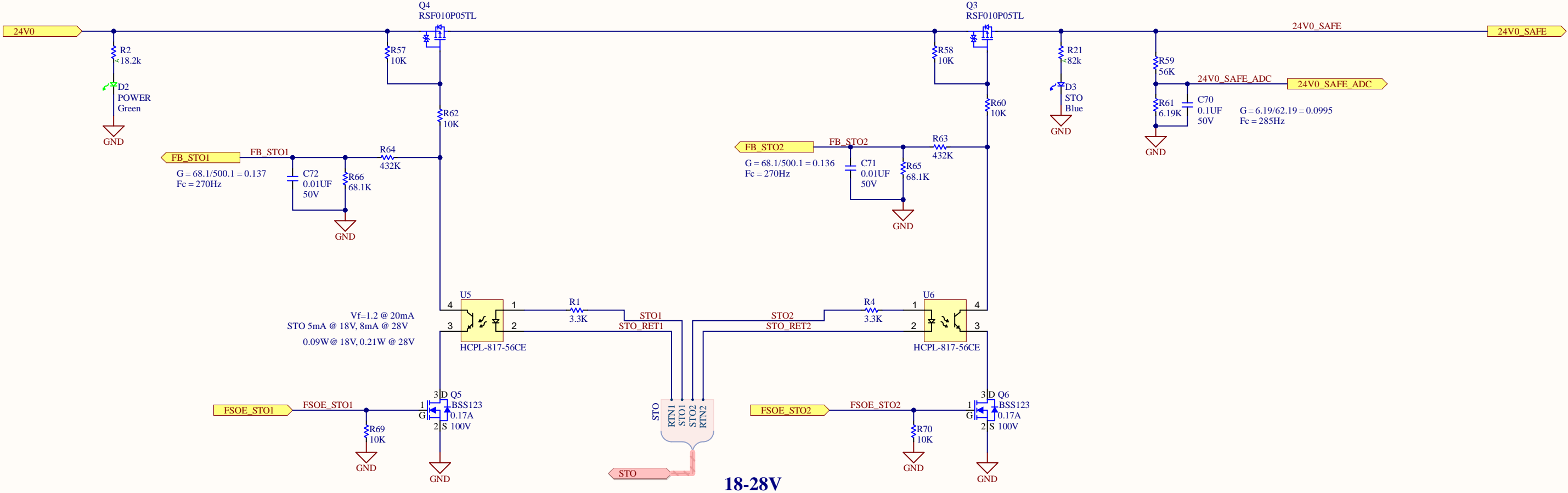
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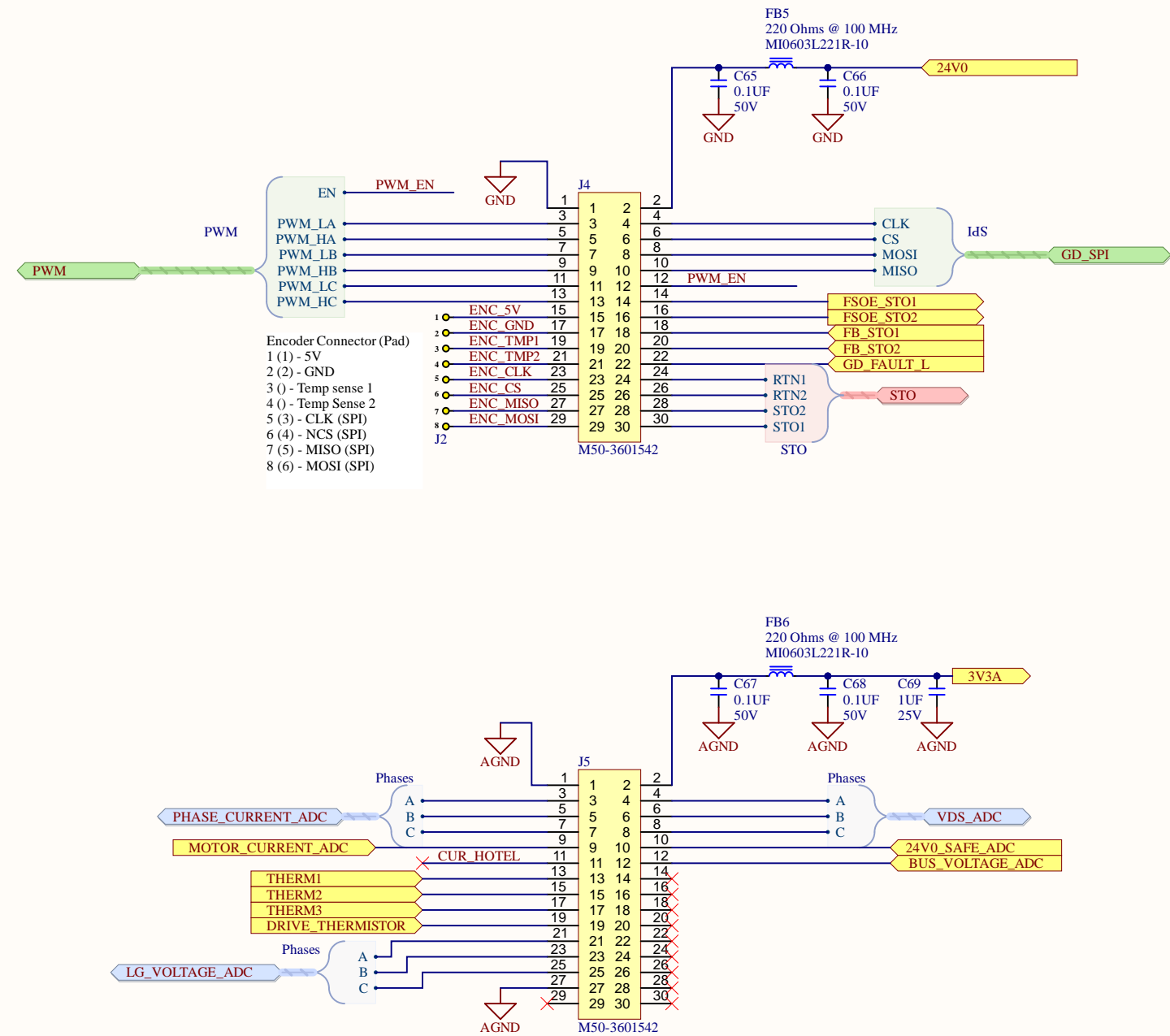
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SIZE A3 SHEET 3 OF 6



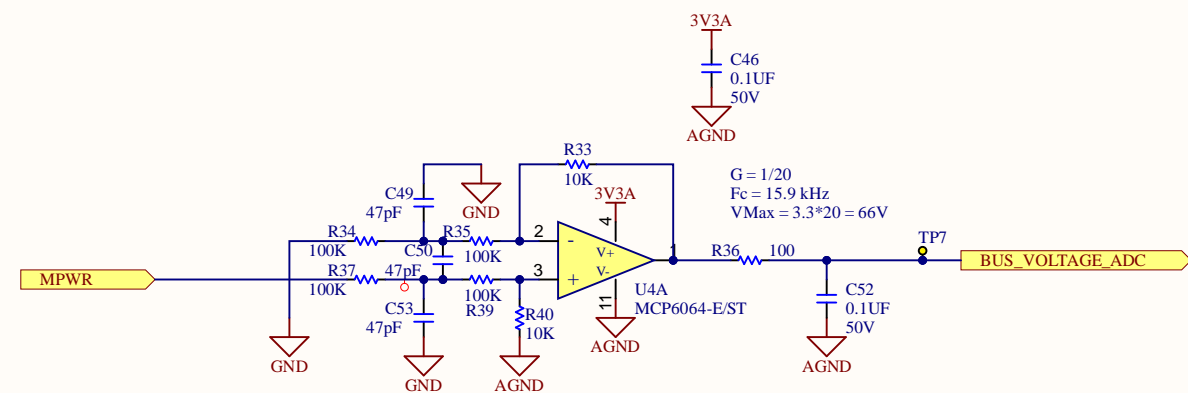
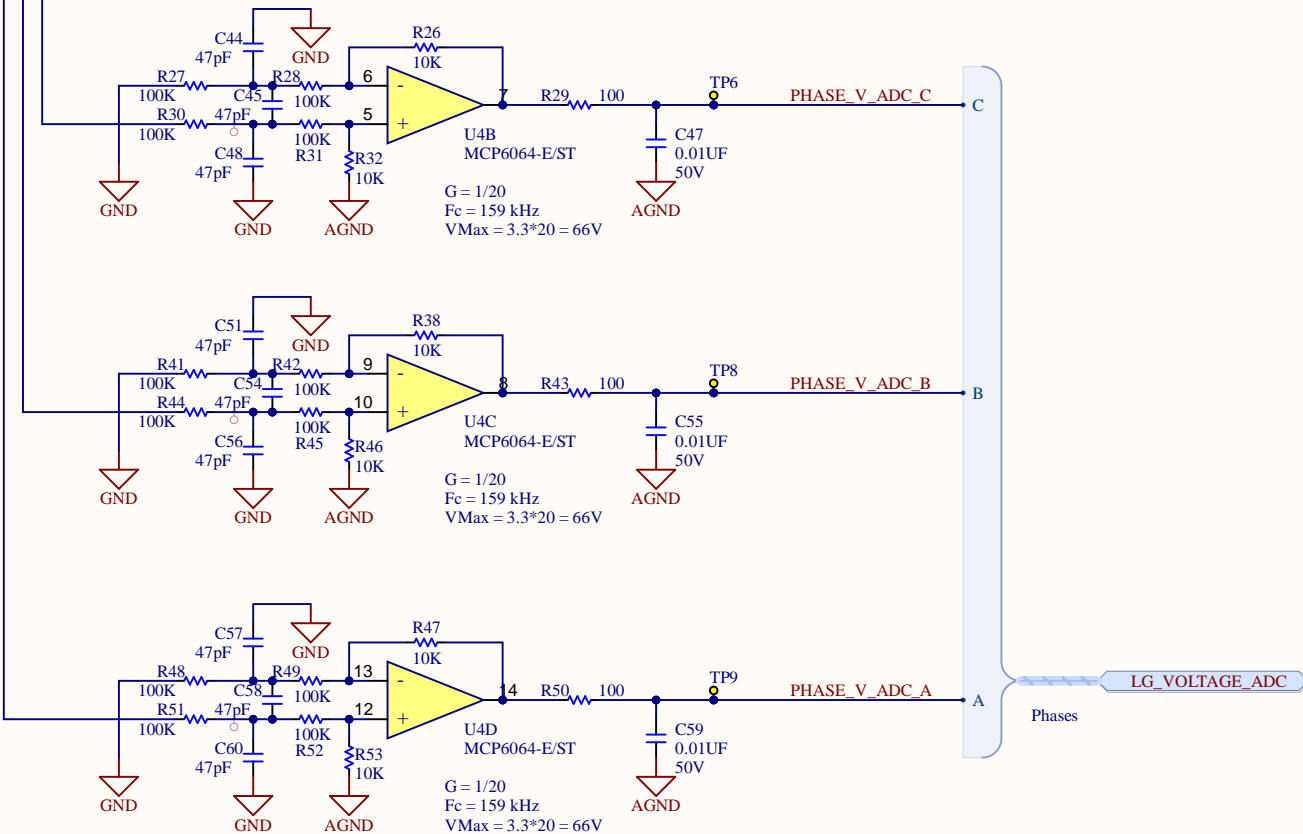
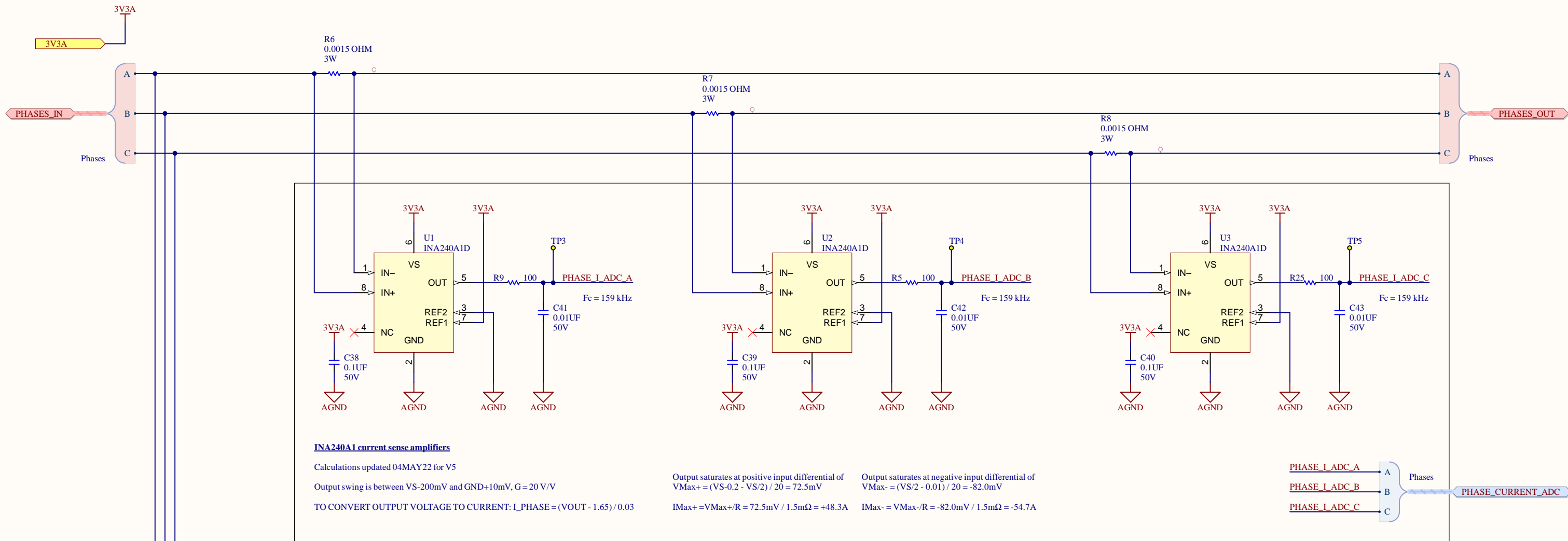
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