Bonus Practice HW1 Fall 2026— Answer Key

Q1. Power distribution network

a. Maximum impedance [3 points]

Allowed deviation from nominal: $\Delta V = \min(3.33 - 3.30, 3.30 - 3.27) = 0.03$ V. With a worst-case current transient of 1.5 A:

Answer: $Z_{target} = \Delta V / I = 0.03 \text{ V} / 1.5 \text{ A} = 0.020\ \Omega = 20\ \text{m}\Omega$.

The impedance should remain at or below 20 mΩ from 10 kHz to 900 MHz (using the usual target-impedance approximation).

b. Fewest capacitors from the spreadsheet [12 points]

Include the PCB power/ground plane (85 nF in the sheet), in addition to the DC/DC converter model (ESR = 0.1 mΩ; ESL = 700 nH). Set these quantities in column C:

Spreadsheet row	Component	Quantity
C7	330 µF tantalum	2
C8	1.0 µF ceramic	1
C9	0.1 µF ceramic	3
C10	0.01 µF ceramic	0
C11	0.001 µF ceramic	0
C12	PCB plane (85 nF)	1

Total: six discrete capacitors. The plane capacitance is counted as part of the PCB

Peak calculated impedance: about 19.5 mΩ near 51 MHz, satisfying the 20 mΩ target. I cannot find a 5-capacitor solution that works. Thus, six is the minimum within this model and component list.

Q2. Batteries

a. Figure 1

i. Highest voltage per cell [2]: $LiMnO_2$ (yellow). About 52–54 V from 13 cells during most of discharge gives ≈4.0–4.2 V/cell, higher than $LiFePO_4$ (16 cells) or lead-acid (24 cells).

ii. Easiest remaining-charge measurement [2]: Lead-acid (blue). Its pack voltage varies substantially and fairly continuously with the fraction of capacity used, whereas the lithium chemistries have much flatter voltage curves.

iii. Best for a 48 V LDO [2]: Probably $LiMnO_2$ (yellow), as it will minimize the LDO power dissipation while using nearly all the capacity. It stays above 48 V for most of the discharge but has less excess voltage than $LiFePO_4$ (so less heat).

You could also make an argument for the $LiFePO_4$ (red) if you prioritize longer margin above 48 V. Lead-acid falls below 48 V too early to use most of its nominal capacity.

b. Figure 2

i. Peukert effect [2]: Higher discharge rates deliver less usable capacity before reaching the voltage cutoff. The 1C curve reaches around 2.7 Ah, but the 43C curve reaches only around 2.3 Ah.

ii. Time above 3.4 V at 3 A [4]: Nominal capacity is 2.6 Ah, so 3 A is roughly 1.15C. From the nearly corresponding 1C curve, about 2.6–2.7 Ah is used when the loaded voltage falls through 3.2 V. Therefore t ≈ (2.6–2.7 Ah)/(3 A) ≈ 0.87–0.90 h, or about 52–54 min. 60A is about 23C, which gives us about 2.3Ah. 2.3Ah/60A= 2.3 minutes.