Problem 1. A 120Vrms, 60Hz wall outlet voltage powers a lossless DBR, which in turn supplies power to a laptop computer. The computer draws a constant 25W. Suppose that there is a sudden outage of AC voltage. The DBR capacitor continues to supply 25W to the computer, but when capacitor voltage Vdc falls to 100V, the computer shuts off. The elapsed time is known as ride-through capability.

Assuming negligible voltage ripple on the capacitor, how many μF are needed to provide 15 seconds of ride-through capability?

Store\_ed energy in the battery provides the power for the constant power load

\[ \frac{1}{2} C (V_{\text{peak}}^2 - V_{\text{min}}^2) = T_{\text{ride\_thru}} \cdot P \]

\[ C = \frac{2 \cdot T_{\text{ride\_thru}} \cdot P}{V_{\text{peak}}^2 - V_{\text{min}}^2} = \frac{2(15) \cdot 25}{[120\sqrt{2}]^2 - [100]^2} = \frac{39900 \mu F}{(or 0.0399 F)} \]
Problem 1. A 120Vrms, 60Hz wall outlet voltage powers a lossless DBR, which in turn supplies power to a laptop computer. The computer draws a constant $35\text{W}$. Suppose that there is a sudden outage of AC voltage. The DBR capacitor continues to supply $35\text{W}$ to the computer, but when capacitor voltage $V_{dc}$ falls to 100V, the computer shuts off. The elapsed time is known as ride-through capability.

Assuming negligible voltage ripple on the capacitor, how many $\mu\text{F}$ are needed to provide 15 seconds of ride-through capability?

\[
\frac{1}{2} C \left( V_{\text{peak}}^2 - V_{\text{min}}^2 \right) = P \cdot T_{\text{ride thru}}
\]

\[
C = \frac{2P T_{\text{ride thru}}}{\left( V_{\text{peak}}^2 - V_{\text{min}}^2 \right)} = \frac{2 \times (35)(15)}{\left[ 120\sqrt{2} \right]^2 - [100]^2}
\]

\[
C = 55,851 \mu\text{F} = 0.0569 \text{ F}
\]
Problem 1. A 120V rms, 60Hz wall outlet voltage powers a lossless DBR, which in turn supplies power to a laptop computer. The computer draws a constant 35W. Suppose that there is a sudden outage of AC voltage. The DBR capacitor continues to supply 35W to the computer, but when capacitor voltage Vdc falls to 80V, the computer shuts off. The elapsed time is known as ride-through capability.

Assuming negligible voltage ripple on the capacitor, how many μF are needed to provide 15 seconds of ride-through capability?

\[ \text{Energy balance} \]
\[ \frac{1}{2} C (V_{\text{peak}}^2 - V_{\text{min}}^2) = P \cdot T_{\text{ride thru}} \]

\[ C = \frac{2 P T_{\text{ride thru}}}{(V_{\text{peak}}^2 - V_{\text{min}}^2)} = \frac{2(35)(15)}{[120 \sqrt{2}]^2 - [80]^2} \]

\[ C = 46.875 \mu F \]
\[ = 0.0469 \text{ F} \]
**Problem 2.** A common mistake is to assume that the negative terminal of the DC bus of a rectifier is at zero potential with respect to the building neutral. Consider a rectifier operated directly from a 120Vrms, 60Hz wall outlet. The load is resistive, and there is no DC capacitor.

Analyze the rectifier circuit and determine the voltage waveform of point b with respect to point n. Explain your reasoning very clearly, and neatly sketch the V\text{bn} waveform.

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**Forward bias (V_s > 0)**

- b & n same potential
- \( V_{bn} = 0 \)

**Reverse bias (V_s < 0)**

- b same as top of source, so
- \( V_{bn} = V_s \)
A buck converter is operating in steady-state and converts 48Vdc to 12Vdc. The switching frequency is 100kHz, and the load is 60W. L = 10μH, and C = 1000μF. Assume that Vout has very low ripple.

With regard to your graphs: Assume that the MOSFET switch closes at t = 0. Your x and y axes scales should both include zero.

a. Sketch one cycle of the inductor current, showing values for min and max currents and the times at which they occur. Compute the rms value of the current. The reason for this question is that inductors are rated in rms amperes. Use \( I_{rms} = I_{avg} + \frac{1}{12} I_{peak-to-peak} \).

b. Sketch the diode current and use your sketch to determine its peak value. The reason for this question is that diodes are rated in peak amperes.

c. Assuming that Vout is constant, sketch the capacitor current and use your sketch to determine its peak-to-peak magnitude. The reason for this question is that capacitors are often rated in peak-to-peak amperes.

d. Use the graph from Part c. to graphically compute the peak-to-peak ripple voltage on the capacitor and express it in percent of Vout. The reason for this question is that it is desirable for the load voltage ripple to be less than 1%.

25 points total
\[ \Delta I_L = (2.5 \text{μsec})(3.6 \text{A/μsec}) = 9 \text{A}, \quad \Delta I_L = (-1.2 \text{A/μsec})(7.5 \text{μsec}) = -9 \text{A} \]

\[ \Delta I_L = 9 \text{A}, \quad \Delta I_L = -9 \text{A} \]

\[ \text{AVG} = I_{\text{out}} = 5 \text{A} \]

\[ \overline{v_{\text{rms}}} = \frac{1}{\Delta t} \int v(t) \, dt = \frac{5^2}{12 + 9} = \frac{25}{21} \Rightarrow \overline{v_{\text{rms}}} = 1.19 \text{V} \]

Switch closed, \( i_d = 0 \). Switch open, \( i_d = i_L \)

Peak Diode Current = 9.5A

KCL, \( i_C = i_L - I_{\text{out}} \) (same curve as \( i_L \), but shifted down by 5A)

\[ \dot{q} \quad \Delta Q \]

\[ \Delta q = \frac{1}{2} (4.5)(5 \mu \text{sec}) = 11.25 \mu \text{C} \]

\[ \Delta q = C \Delta V, \quad \Delta V = \frac{11.25 \mu \text{C}}{1000 \mu \text{F}} = 0.011 \text{ Volts PP} \]
Regarding the PWM Control Circuit:

1. If you are operating with a Vcont connected to the LEFT input and \( ma = 1 \), what will happen if you simultaneously connect Vcont to the RIGHT input?

\[ \text{(L+R) becomes } 2V_{\text{cont}}. \text{ So } ma \text{ jumps to } 2.0. \]

\[ \text{CK+ goes into heavy saturation.} \]

2. If a Vcont input signal is peaking at 1.5V, what gain multiplier do you need to hold ma as close to 1 as possible without exceeding 1?

Triangle wave peaks at 4V. So the gain boost needed is

\[ \frac{4}{1.5} = \frac{4}{3/2} = \frac{8}{3} = 2.67 \]

3. Why do we need two comparators instead of just one?

Two comparators in one chip.

One compares \( V_{\text{cont}} \) to \( V_{\text{tri}} \). The other compares \( -V_{\text{cont}} \) to \( V_{\text{tri}} \).

4. If 1.5nanoF results in a 120kHz triangle wave, how many nanoF will give you approximately a 10kHz triangle wave?

\[ F \propto \frac{1}{C} \cdot \frac{F_1}{F_2} = \frac{C_2}{C_1} \]

\[ C_2 = C_1 \cdot \frac{F_1}{F_2} = (1.5) \cdot \frac{120}{10} \]

\[ C_2 = (1.5) \cdot (12) = 18 \text{ nanoF} \]

5. The output has VA and VB signals. If you view VA with respect to the PC board reference, with \( ma = 0 \), explain what you will see. Show the min/max values.

This was a checkout step.

VA with respect to -12V was

\[ \text{So with respect to 0V it is} \]

\[ 0 \]

\[ 12 \]

\[ -12 \]

\[ D = 0.50 \]
Regarding the H-Bridge Circuit:

6. Explain why we need the 1500 microF input capacitor.

This cap provides the "punch" needed by the load. The Vdc supply may have too much resistance to supply large power pulses. The cap stiffens the DC power supply bus, so that the driver chips can turn MOSFETs on quickly.

7. What is the purpose of the two 10 microF capacitors at the bottom of the circuit?

Like Question 6, except this stiffens the 12Vdc wall wart supply so that the driver chips can turn MOSFETs on quickly.

8. If both A+ and A- switches accidently close at the same time, and the 1500 microF input capacitor has 100V, and the parasitic inductance of the current path is 1 microH, how long will it take for the A+ and A- MOSFET current to reach 30A burnout?

\[
L = \frac{V}{I_{short}} = \frac{100\text{V}}{100\text{A/msec}} = 1\text{microH}
\]

\[
\frac{\text{di}}{\text{dt}} = 100\text{A/msec}
\]

Reaches 30A in 0.3 \mu s

9. and 10. The series output filter consists of 100 microH and a net 0.2 microF. If the H-bridge is producing 120 V ac of 60 Hz, and 50 V ac of 250 kHz, how many amperes of 60 Hz and 250 kHz current are flowing through the filter capacitors?

\[
1.2 \times 10^{-4} = 1.4312\Omega
\]

\[
\frac{1}{2\pi(60)(1.2 \times 10^{-6})} = 9\text{mA RMS}
\]

\[
\frac{1}{2\pi(250 \times 10^3)(0.2 \times 10^{-6})} = 0.32\text{A RMS}
\]