Robust Mechatronics, MF2042

Solutions to Exam April 2015

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Part A

Q 1: If you have a series pass voltage regulator (linear, like the 7805), why is that givin less noise than a switched regulator?

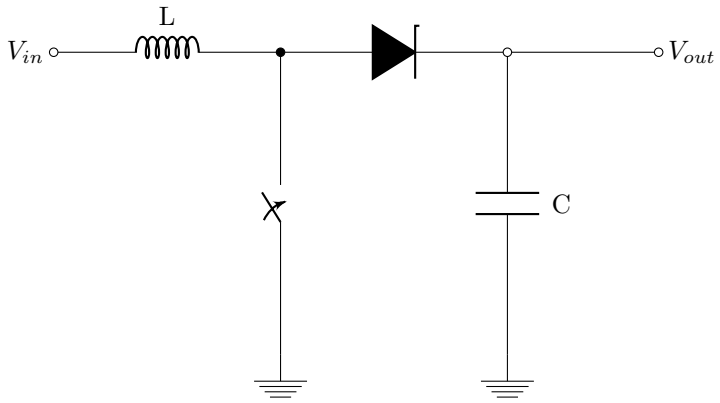
A: The current in a linear regulator is always on and the transforming (always down) is done by "burning" surplus voltage. In contrast, the switching regulator regulates the voltage by switching parts of the regulating circuit on and off. Quickly changing current means EMI and the "hot loop" (switching part of circuit) cand even act as an antenna.

Q 2: What differences are there for a ground wire compared to a ground plane?

A: In a ground plane, the return signals (at higher frequencies, kHz) are able to trace back under the original signal, giving lower impedance than in a ground wire.

Q 3: Sketch a step up (Boost) converter. Show the current path in both on and off. Is there part of it that is more sensitive to radiated emissions and why?

A: What if i add some text first?



When the switch is off, the current is flowing through the coil and into the load through the diode with the capacitance as filter. When the switch is on, the current is going through the coil via the switch into ground. The hot loop (radiating part) is through the coil and switch. This is where the current differences are largest at the switching.

Q 4: You have an analog sensor signal that you should sample with your microcontroller. When should you apply (also discribe shortly why)...

(a) ...an analog filter?

(b) ...a digital filter?

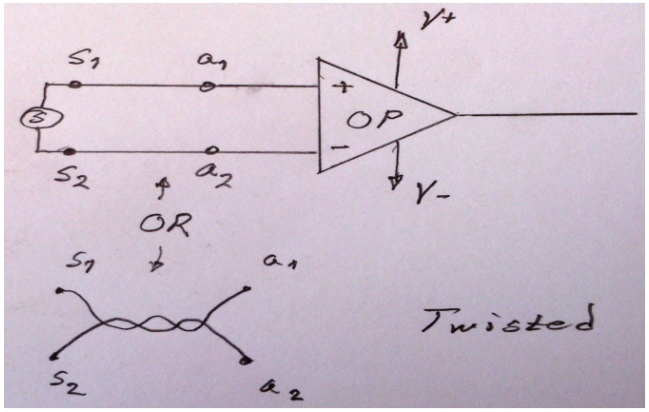
A: (a) An analog filter should be used before the ADC to avoid aliasing. The cutoff frequency should be no lower than the Nyquist frequency, $\omega_s/2$, where ω_s is the sampling frequency.

(b) A digital filter is well suited for more advanced filters such as higher order filters and filters of Butterworth and Chebyshev type.

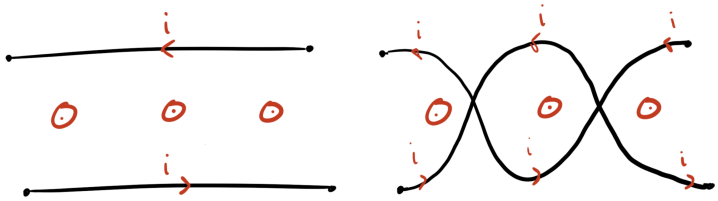
Q 5: If you have an electric vehicle and battery voltage 600 V, you have to isolate the low voltage (48 V) from the high voltage. How do you do that for both digital and analog signals?

A: One solution is to use an isolated DC-DC converter which galvanically isolates the two voltages. This is expensive though. One way of separating digital and analog signals is the use of partitioning which means that the PCB has dedicated parts for analog and digital and a zone between where no signal paths are allowed.

Q 6: A sensor is connected to an amplifier either by straight wires or a twisted pair, see picture. What will be the difference with respect to radiated susceptability if you put these two setups into an electromagnetic field? Why will there be a difference?



A: If put in an electromagnetic field, the cabling becomes a loop antenna. The direction of the current is dependant on the direction of the magnetic field. In the untwisted pair, interference currents will start flowing causing interference. In the twisted pair, the polarity is switched at every intersection. This will cause alternating currents in every twist, canceling each other out (mostly).



Q 7: You have a common mode voltage of 8V into an instrumentation amplifier and 1V of signal. What voltage can you measeure on the two pins? (It does not matter which pin the voltage is measured on)

A: Common mode voltage is calculated

$$U_{CM} = \frac{U_1 + U_2}{2}$$

If $U_{CM} = 8V$ and $U_1 - U_2 = 1V$, then

$$U_1 = U_{CM} - 0.5 = 8 - 0.5 = 7.5\text{V and } U_2 = 8.5\text{V}.$$

Part B