Assignment problems for IIT-H Renesas Altium Course

Guidelines:

1. Please form a team of 5 students
2. The problems are divided into Easy, Medium and Hard categories
3. Each team must attempt five easy, three medium and two hard problems.
4. You must submit your solution for at least 3, 2 and 1 problems in easy, medium and hard categories.
5. Please submit the Gerber file and document your solution process and simulation results.

Easy Problems

1. **Temperature Monitoring System** Design a temperature monitoring circuit using the DA14531 MCU and an I2C temperature sensor (e.g., TMP102). Include proper power supply filtering, decoupling capacitors, and I2C pull-up resistors. The circuit should include an LED indicator that toggles when temperature exceeds a threshold.
2. **Button Interface Expansion** Modify the existing DA14531 dev board design to add four tactile buttons with proper debouncing circuits. Include pull-up/pull-down resistors and ensure the buttons are connected to GPIO pins that support interrupt functionality.
3. **OLED Display Integration** Create a schematic and PCB layout to interface an SPI OLED display (e.g., SSD1306 128x64) with the DA14531 MCU. Ensure proper signal routing, decoupling, and include level shifters if necessary for compatible voltage levels.
4. **Battery Power Management** Design a battery-powered version of the DA14531 development board using a CR2032 coin cell battery. Include a power switch, battery holder, and necessary battery protection circuitry. Calculate and document the expected battery life based on typical power consumption.
5. **Light Sensor Interface** Design a circuit that interfaces a photoresistor or digital light sensor (e.g., BH1750) with the DA14531 MCU. For analog sensors, include appropriate signal conditioning circuits and connect to an ADC input. For digital sensors, implement the required communication interface (I2C/SPI).

Medium Problems

1. **High-Speed Sensor Interface with Signal Integrity Focus** Design a PCB connecting the DA14531 to a high-speed sensor (e.g., ADXL372 accelerometer) operating at maximum SPI clock rate. Implement length-matched differential pairs where applicable, controlled impedance traces, and proper termination techniques. Perform pre-layout signal integrity simulations to determine optimal trace widths and spacing. Include a detailed analysis of potential reflection points and your mitigation strategy.
2. **Mixed-Signal Design with Ground Isolation** Create a circuit connecting an analog microphone and digital audio processor to the DA14531. Design a proper ground plane strategy with isolated analog and digital grounds connected at a single point. Include power supply filtering for noise reduction, implement guard rings around

sensitive analog traces, and design a star-grounding topology. Document your ground isolation strategy and power filtering approach.

3. **Power Supply Noise Mitigation System** Design a circuit that powers the DA14531 and several noisy peripherals (motor driver, solenoid, etc.) from a single supply. Implement multiple power domains with proper isolation using ferrite beads and decoupling capacitors. Design power plane splits, filter networks, and add test points for measuring power supply noise. Include a ripple calculation for each power domain and justify your component selection.
4. **Clock Distribution with Minimal Jitter** Design a system using the DA14531 and an external precision clock source that feeds multiple synchronous peripherals. Implement controlled impedance traces for clock signals, use appropriate termination methods, and design the clock distribution network to minimize skew. Include guard traces around clock lines and analyze potential crosstalk sources. Document your clock tree design decisions and jitter mitigation techniques.
5. **EMI-Optimized Wireless Interface** Design a PCB integrating the DA14531 with a wireless transceiver operating at 2.4GHz. Implement RF shielding, proper stackup design for impedance control, and isolated ground regions. Include RF filtering components, carefully design the antenna matching network, and create a PCB layout that minimizes noise coupling from digital sections to RF components. Document your EMI reduction strategies.

Hard Problems

1. **High-Speed Multi-layer PCB with DDR Memory** Design a complex system using the DA14531 interfaced with DDR memory and high-speed peripherals. Create a detailed layer stackup (minimum 6 layers) with impedance calculations, implement proper return path design, and use power/ground plane pairs to create a low-inductance power distribution network. Include length-matched differential pairs, intra-pair length matching, and inter-pair length matching. Perform pre-layout and post-layout signal integrity simulation and document the timing budgets for critical signals.
2. **Power Integrity Analysis for Mixed Voltage System** Design a system with the DA14531 that incorporates multiple voltage domains (1.2V, 1.8V, 3.3V, 5V). Create a sophisticated power distribution network with PDN impedance analysis. Include decoupling capacitor selection optimization across multiple frequencies, implement dedicated power planes with appropriate plane splits, and design AC and DC current return paths. Document your power integrity simulation results and provide target impedance calculations for each power rail.
3. **Crosstalk Mitigation in High-Density Routing** Design an extremely compact PCB with the DA14531 and multiple high-speed interfaces (SPI, I2C, UART all running at maximum rates) in close proximity. Implement advanced crosstalk mitigation techniques including orthogonal routing between layers, strategic use of ground vias as shields, trace spacing optimization, and guard traces/planes. Perform pre-layout crosstalk simulation, identify critical nets, and document your crosstalk budget. Include near-end and far-end crosstalk analysis results.
4. **Signal and Power Integrity for Precision Analog Design** Create a precision data acquisition system using the DA14531 with a 24-bit ADC and sensitive analog front-end. Design split analog/digital ground planes with controlled impedance for critical signal paths. Implement extensive power filtering, shielding techniques, and guard rings. Create a noise budget for the system and perform worst-case analysis.

Document your simulation results showing noise coupling reduction techniques and include thermal considerations that might affect precision measurements.

5. **Advanced EMC/EMI Compliance Design** Design a DA14531-based system intended for commercial deployment with strict electromagnetic compatibility requirements. Implement ferrite-based filtering on all I/O connections, design a PCB with 20H rule implementation, create filtered connector interfaces, and design proper chassis grounding points. Include ESD protection schemes, transient voltage suppression, and common-mode filtering for differential signals. Document your EMC test plan, expected emission sources, and mitigation strategies for both conducted and radiated emissions.