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Name of the Course: 168584 Embedded Systems Hardware Design
Course Number: ECE-40292
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Date: 01/27/2023

Quiz 3 (Week 3)

1. What tolerance the resistor marked as 1.01k must have? Justify your solution. Look at Slide 4 of today's lesson and do not mention any color coding - assume the value is written on the resistor.

   For resistors, common logic dictates to choose a logarithmic scale of values so that all values are equally spaced on a logarithmic scale and match the tolerance of the range. For example, for a tolerance of ±10%, it makes sense to cover a decade (the interval from 1 to 10, 10 to 100, etc.) in 12 steps: 1.0, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, 4.7, 5.6, 6.8, 8.2, then 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82. These values are called preferred values and are standardized as E series of preferred numbers, which are used not only for resistors, but also for capacitors, inductors. For 1.01k resistors, the only value I can find is under E192 standard series, and the tolerance value should be at least 0.5%.

2. What is the unit to measure electrical capacitance? Relation of Ic(t) to Vc(t).

   Capacitance (C) = charge (Q) / volts (V). The size of a capacitor (C) is specified in terms of the ratio of the charge it holds (Q) to the voltage across it (V). The unit of capacitance (C) is the farad (F), the SI unit is $A^2 s^4 kg^{-1} m^{-2}$. Ic(t) = C * dV / dt, The current flow onto a capacitor equals the product of the capacitance and the rate of change of the voltage. This equation also shows again that whenever the voltage is constant (dV/dT=0), there is no capacitance current.

3. What is the unit to measure electrical inductance? Relation of Vi(t) to Ii(t).

   V = L * dI / dt, The relationship between current and voltage involves the time derivative of the current. This is because a changing current produces a changing magnetic field, which induces a voltage. The unit is [L] = voltage / (current / time) = voltage-sec / Amp = Henry (H) ($kg\, m^2 s^{-2} A^{-2}$)

4. Describe I2C vs. SPI pros and cons.

   I2C advantage:

   Simplicity: I2C works as a 2-wire bus, needing only serial data (SDA) and serial clock (SCK) lines for data transmission and synchronization. SPI, on the other hand, requires four wires to control a single slave: SCK, master out slave in (MOSI), master in slave out (MISO), and slave select (SS).

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Easy add-ons: When users need more than one slave device, SPI implements an additional SS pin for each one. When an I2C system needs to implement new slave devices, they can simply “clip on” to the existing bus using a 7-bit addressing system to identify each module. This I2C scheme requires a proper address configuration but avoids the burden of extra wiring for each device.

SPI advantage:

Communication: Separate MISO/MOSI data lines mean that it’s capable of full-duplex communication, as opposed to I2C’s half-duplex operation, meaning that data send and receive transmissions must alternate.

Speed: I2C originally defined data transfer rates at 100kbps, though we have seen it bump up to 400kbps or even up to 5Mbps in Ultra Fast-mode. SPI, however, does not define a top communications speed, and can be implemented at speeds of 10 Mbps or more.

You might say that SPI is a better choice for the small number of peripherals that need to transfer a large amount of data. I2C is the best option if you need to control many peripherals, especially if you are transferring a small amount of data to each one.

5. What types of communication interfaces used in the STM32L475 board? How many signal lines does each one require?

I2C: 2 signal lines, SDA and SC

SPI: 4 signal lines, MISO, MOSI, CLK, CS

USART: 4 signal lines, RX, TX, CTS and RTS

DFSDM: 2 signal lines, CLK, data line

USB OTG: 6 signal lines, USB_OTG_FS_VBUS, USB_OTG_FS_ID, USB_OTG_FS_DM, USB_OTG_FS_DP, USB_OTG_FS_PWR_EN, USB_OTG_OVRCR_EXTI3

QSPI: 6 lines, QUADSPI_CLK, QUADSPI_NCS, QUADSPI_BK1_IO0, QUADSPI_BK1_IO1, QUADSPI_BK1_IO2, QUADSPI_BK1_IO3

SWD for debugging: 5 signal lines, SYS_JTCK-SWCLK, SYS_JTMS-SWDIO, SYS_JTDO-SWO, ST-LINK-UART1_RX, ST-LINK-UART1_TX

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6. What properties and what for - should be assigned to a standard electrical symbol in KiCAD?

   Reference: Reference designators are unique identifiers for components in a design. They are often printed on a PCB and in assembly diagrams, and allow you to match symbols in a schematic to the corresponding components on a board.

   Value: The value of the symbol

   Footprint: Footprints define the copper connections between physical components and the routed traces on a circuit board.

   Datasheet: The data sheet of the component

7. Which of the following are essential features in a battery-powered home thermostat? Why? 1. High throughput MCU, 2. Very low sleep power, 3. Wake-up time of 1 microsecond, 4. Fast radio interface

   I would say high throughput MCU and very low sleep power might be essential features in a battery-powered home thermostat. Since home thermostat might need to interact with different sensors, like motion senors to detect how many people are there in the house, temperature sensors to detect the current temperature, etc. There will be large amount of data transfer in a single time frame, so high throughput MCU will be helpful. In addition, low sleep power can help save the energy, thus reduce the cost. Although fast wakeup time is also a great feature, however, it might not need to be as fast as 1 microsecond. Fast radio interface is also an add-on feature, but not essential for the thermostat.

8. Give five examples of embedded systems in your home appliances (not a thermostat, please) and describe their (ES) functions.

   Embedded systems in **washing machine** includes closing and opening of valves to let water through into the system at set intervals (pre-wash, washing) and then out when it needs to drain.

   Embedded system in a **microwave** oven includes command device. It is designed to take directions from the keypad and turn them into commands. If, for instance, you program a microwave oven to operate on high for two minutes, the embedded system triggers the high voltage transformer to operate on full blast for two minutes. When the two minutes expire, the embedded system commands the transformer to turn off.

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Embedded system in the a **domestic fridge appliance** implements control of the Fridge Compressor Induction Motor based on air temperature measurement, including some energy and cost saving features.

Embedded system in the **hair dryer** includes infrared or temperature sensor (or camera) in order to detect an individual's hair condition moisture level to determine a user specific, customizable dryer setting.

Embedded system in the **soundbar** includes audio processing feature, remote control capability, bluetooth and wifi connection.

9. What types of requirements and specifications are considered for design of a new product?

   Product Requirements: Describe what the product is.

   Functional Requirements: Describe what the product must do.

   Engineering Specification: Describes how the design will be implemented and how the requirements will be met.

   Hardware Specifications: Describe how specific hardware is designed.

   Firmware Specifications: Describe how the firmware for specific processors will be designed.

   Test Specifications: Describe what must be tested and how to verify that the system operates correctly.

10. What type of product testing is required for certification of the product?

    Validation: The assurance that a product, service or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers.

    Verification: The evaluation of whether or not a product, service, or system complies with a regulation, requirements, specification, or imposed condition. It is often an internal process.