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(5) **Question 1.** What is dropout voltage of a linear regulator?

C) A linear regulator produces a constant output voltage under conditions of variable current. In order to operate properly, a linear regulator needs an input voltage greater than or equal to the output voltage plus a fixed constant. (fixed constant is the dropout voltage)

(25) **Question 2.** The goal is to transmit synchronous serial data

(10) **Part a)** Show the initialization code that configures PD2, PD1, and PD0. Be friendly.

```
void SS_Init(void){ volatile unsigned long delay;
  SYSCCTL_RCGC2_R |= 0x00000008; // activate port D
  delay = SYSCCTL_RCGC2_R;
  GPIO_PORTD_DIR_R |= 0x07; // PD2, PD1, PD0 outputs
  GPIO_PORTD_DEN_R |= 0x07; // enable digital I/O on PD2, PD1, PD0
  PD2 = 0;
  PD0 = 1;
}
```

(15) **Part c)** Show the function that outputs one byte to the PD2-PD0 pins.

```
void SS_Output(unsigned char data){int i;
  PD0 = 0; // frame select low
  for(i=0;i<8;i++){
    PD1 = data>>6; // bit 1 is high or low depending on bit 7
    PD2 = 4; // clock high
    data = data << 1; // shift next bit into bit 7 position
    PD2 = 0; // clock low
  }
  PD0 = 1; // frame select high
}
void SS_Output(unsigned char data){ // faster
  PD0 = 0; // frame select low
// bit 7
  PD1 = data>>6; // bit 1 is high or low depending on bit 7
  PD2 = 4; // clock high
  PD2 = 0; // clock low
// bit 6
  PD1 = data>>5; // bit 1 is high or low depending on bit 6
  PD2 = 4; // clock high
  PD2 = 0; // clock low
// bit 5
  PD1 = data>>4; // bit 1 is high or low depending on bit 5
  PD2 = 4; // clock high
  PD2 = 0; // clock low
// bit 4
  PD1 = data>>3; // bit 1 is high or low depending on bit 4
  PD2 = 4; // clock high
  PD2 = 0; // clock low
// bit 3
  PD1 = data>>2; // bit 1 is high or low depending on bit 3
```

```

    PD2 = 4;           // clock high
    PD2 = 0;           // clock low
// bit 2
    PD1 = data>>1;     // bit 1 is high or low depending on bit 2
    PD2 = 4;           // clock high
    PD2 = 0;           // clock low
// bit 1
    PD1 = data;        // bit 1 is high or low depending on bit 1
    PD2 = 4;           // clock high
    PD2 = 0;           // clock low
// bit 0
    PD1 = data<<1;     // bit 1 is high or low depending on bit 0
    PD2 = 4;           // clock high
    PD2 = 0;           // clock low
    PD0 = 1;           // frame select high
}

```

(10) Question 3. You are building a quantitative data acquisition system that measures voltage.

Part a) Gain is used to match the range of the input to the ADC range. $\text{Gain} = 3\text{V}/100\text{mV} = 30$.

Part b) We must pass the signals of interest 0 to 200 Hz. We must reject signals above 500Hz to prevent aliasing.

Part c) The maximum allowable voltage noise is the resolution referred to the input, $100 \mu\text{V}$.

(5) Question 4. As applied to EE445L labs 5 and 9, how are resolution and accuracy related?

D) Accuracy depends on resolution in addition to calibration drift.

(10) Question 5. 2π is about 6434/1024 (2π is about 6.283203125)

C = (6434*R)>>10; // circumference is 2pi times radius)

(20) Question 6. Design an analog circuit with the following transfer function $V_{\text{out}} = 25*(V_{\text{in}}+0.05)$. The input is a single voltage (not differential). The input range is -0.05 to 0.05 V and the output range is 0 to 2.5V. Use an analog reference and one rail to rail op amp (not an instrumentation amp). Show your work and label all chip numbers and resistor values, including R1 and R2. You do not have to show pin numbers.

$$V_{\text{out}} = 25*(V_{\text{in}}+0.05).$$

$$V_{\text{out}} = 25*V_{\text{in}}+1.25$$

Create a 1.25 V reference with LM4041

$$V_z = 1.233 (1+R_2/R_1), \quad (1.233 \text{ is the fixed voltage of the zener})$$

$$1.25 = 1.233(1+R_2/R_1), \quad R_2/R_1 = 0.017, \quad R_2 = 1\text{k}\Omega, \text{ and } R_1 = 58.8\text{k}\Omega$$

$$V_{\text{out}} = 25*V_{\text{in}} + V_{\text{ref}}$$

Add ground gain of -25 to make all gains sum to 1

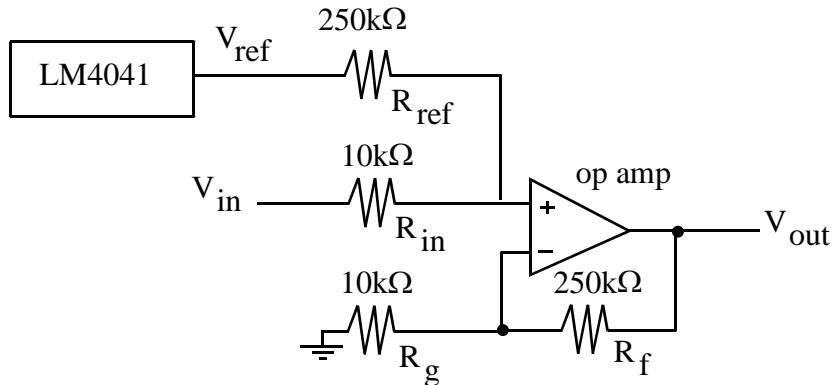
$$V_{\text{out}} = 25*V_{\text{in}} + V_{\text{ref}} - 25*V_g$$

Choose R_f to be common multiple of 1, 25

$$R_f = 250\text{k}\Omega,$$

Choose other resistors to create needed gains,

$$R_{\text{in}} = 10\text{k}\Omega, \quad R_{\text{ref}} = 250\text{k}\Omega, \quad R_g = 10\text{k}\Omega$$



(25) **Question 7.** The goal is to toggle the output PD0 every time there is a rising edge of PD1 input.

(10) **Part a)** Show the initialization code that configures PD1 and PD0.

```
void PORTD_Init(void){ volatile unsigned long delay;
    SYSCTL_RCGC2_R |= 0x00000008; // activate port D
    delay = SYSCTL_RCGC2_R;
    GPIO_PORTD_DIR_R |= 0x01; // PD1 output, PD1 input
    GPIO_PORTD_DEN_R |= 0x03; // enable digital I/O on PD1, PD0
    GPIO_PORTD_IS_R &= ~0x02; // edge
    GPIO_PORTD_IBE_R &= ~0x02; // not both
    GPIO_PORTD_IEV_R |= 0x02; // rise
    GPIO_PORTD_IM_R |= 0x02; // arm
    NVIC_PRI0_R = (NVIC_PRI0_R & 0x00FFFFFF) | 0x00000000;
    NVIC_EN0_R |= 8; // enable
    EnableInterrupts();
}
```

(15) **Part b)** Show the edge-triggered interrupt service routine.

```
void GPIOPortD_Handler(void){
    GPIO_PORTD_ICR_R = 0x02; // acknowledge flag1
    PD0 ^= 0x01; // toggle PD0
}
```