Jonathan W. Valvano Solutions

(12) Question 1. For each type of voltage regulator, choose the best description of that device.
(4) Part a) All linear regulators have output current that is approximately equal to input current
D) The input current is approximately equal to the output current $I_{in} \approx I_{out}$.
(4) Part b) A buck regulator reduces voltage, has an inductor, and is very efficient
H) The device uses a switching network, a diode, and an inductor to decrease the voltage ($V_{in} > V_{out}$). It is very power efficient, $V_{in}*I_{in} \approx V_{out}*I_{out}$.
(4) Part c) A boost regulator increases voltage, has an inductor, and is very efficient
F) The device uses a switching network, a diode, and an inductor to increase the voltage ($V_{in} > V_{out}$). It is very power efficient, $V_{in}*I_{in} \approx V_{out}*I_{out}$.

Not chosen:
A) "The device creates an output voltage that is a linear function of the input voltage ($V_{out} = mV_{in}$)." This describes an analog amp using an op amp with negative feedback.
B) "The device creates an output current, I_{out}, that is constant." This is wrong, no regulator generates constant current. Regulators generate constant voltage.
C) "The device creates an output voltage that is very low noise, and a maximum I_{out} of less than 1 mA." This is describing a shunt diode analog reference circuit.
E) "The device converts DC to AC, uses a transformer to increase the voltage, then converts AC to DC, so the V_{out} is a constant." Buck, boost, buck/boost use inductors (2 leads) and not transformers (4 leads). There are isolated power supplies, where the grounds are not connected, that use transformers in this way.
G) "The device converts DC to AC, uses a transformer to decrease the voltage, then converts AC to DC, so the V_{out} is a constant." Buck, boost, buck/boost use inductors (2 leads) and not transformers (4 leads). There are isolated power supplies, where the grounds are not connected, that use transformers in this way.

(16) Question 2. Let I be an n-bit unsigned integer, and J be an m-bit unsigned integer, where $m \le n$. For each operation specify the number of bits in the integer K, as a result of the integer operation.

(4) Part a) Addition: $K=I+J$

n+1, the one bit comes from the carry

(4) Part b) Multiplication: $K=I*J$

m+n

(4) Part c) Division: $K=I/1000$

n-9, you know $I<2^n$, since 512<1000<1024
$I/1000 < (2^n)/1000 < 2^{n-9}$

Or since 1000 is about 2^{10}
K is about n-10 bits

(4) Part d) Shift: $K=I>>4$

n-4

(12) Question 3. This interface uses SPI.

(4) Part a) What value should the software write to **DSS** during initialization?

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(4) Part b) What value should the software write to **SPH** during initialization?

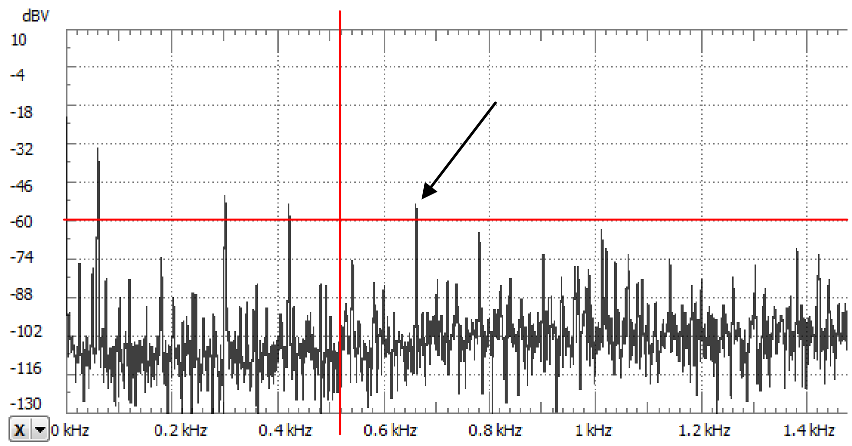
0 (fig 7.17)

(4) Part c) What value should the software write to **SPO** during initialization?

1 (fig 7.17)

(10) Question 4. This is data from the EE445M IR sensor. This is before the analog LPF (see the other exam).

$dB_{FS} = 20 \log_{10}(V/5)$
$= 20 \log_{10}(2^{-10}) = -60.2$
See Table 10.6



Yes, one peak is above -60dB for $f \geq$ 0.5 kHz

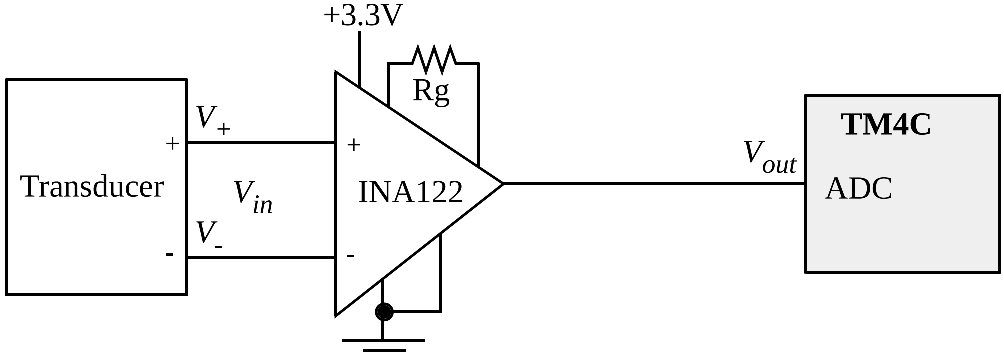
(15) Question 5.
```
int32_t sin(int32_t x){ // assume x is between 0 and 90
// start with equation, convert to C
// y = -0.0006*x*x*x - 0.0213*x*x*x + 17.921*x - 2.12;
// multiply by 10,000 and divide by 10,000 to remove floating point
// y = (-6*x*x*x – 213*x*x*x + 179210*x – 21200)/10000;
// factor to reduce number of multiplies
  y = (((-6*x-213)*x+179210)*x-21200)/10000;
  return y;
}
```
Here are the first and last terms; it is not great, but also not horrible.

angle (deg)	angle (radians)	A*sin(angle)	Approx
0	0	0	-3
1	0.017453293	17.45240644	15
2	0.034906585	34.8994967	33
3	0.052359878	52.33595624	51
87	1.518436449	998.6295348	1000
88	1.535889742	999.390827	1001
89	1.553343034	999.8476952	1001
90	1.570796327	1000	1000

(10) Question 6. "The transducer output is a differential voltage" is the trigger to consider an instrumentation amp. It can be solved with a single op amp, but the instrumentation amp will have much better performance. The gain needed to convert V_{in} (0 to +0.15V) to V_{out} (0 to 3 V) is 20. Since 0 goes to 0, no offset is needed and the Vref pin of the INA122 should be grounded.

$V_{out} = (3/0.15)(V_+ - V_-)$
$\quad = 20(V_+ - V_-)$

Rg = 200k/(20-5) = 13k



(25) Question 7. This is a part of a brushless DC motor driver (the motor needs a hardware driver circuit and the output high pins will have PWM modulation.

(15) Part a) Show the initialization code that configures Ports B and D.

```
void BushlessDCmotor_Init(void){
  SYSCTL_RCGCGPIO_R |= 0x0A; // clocks
   // delay inserted here, no variables needed
  GPIO_PORTD_DIR_R = 6;
  GPIO_PORTD_DEN_R = 7;
  GPIO_PORTD_DATA_R = 4;
  GPIO_PORTB_DIR_R = 0; // inputs
  GPIO_PORTB_DEN_R = 0x07; // enable digital
  GPIO_PORTB_IS_R = 0; // use edge not level
  GPIO_PORTB_IBE_R = 0x07; // need both edges
  GPIO_PORTB_IEV_R // not needed
  GPIO_PORTB_IM_R = 0x07; // arm all three inputs
  NVIC_PRI0_R = NVIC_PRI0_R&0xFFFF00FF; // priority 0
  NVIC_EN0_R = 0x02; // enable (weird register)
  EnableInterrupts(); }
```

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

```
void GPIOPortB_Handler(void){uint32_t in;
  GPIO_PORTB_ICR_R = 0x07;     // acknowledge all flags
  in = GPIO_PORTB_DATA_R&0x07; // input
  GPIO_PORTD_DIR_R = Dir[in];  // change direction
  GPIO_PORTD_DATA_R = Dat[in]; // set data
}
```