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(5) Question 1. E) Energy

(4) Problem 2. 17 bytes = 2+2 up to and including MOVB
+2 for BSR in main
+9 from interrupt PC,Y,X,A,B,CCR
+2 for BSR in handler (LowPassFilter is reentered)

(4) Problem 3. There is a critical section in the read-modify-write sequence in LowPassFilter.

```
$4002 F60802      LDAB  q
$400D 7B0802      STAB  q
```

(2) Question 4. C) Reg B

(2) Question 5. B) On the stack

(2) Question 6. B) the value is fixed and can not be changed by the function

(2) Question 7. D) stored in permanent RAM

(4) Question 8. B) implements minimally intrusive functional debugging

(10) Question 9.

(3) Part a) The smallest **T1** is tw = 20ns

(4) Part b) The smallest **T2** is th+$tdis_{min}$ = 5ns

(3) Part c) The smallest **T3** is ten_{max}+tsu = 38+25 = 63ns

(5) Question 10.

(3) Part a) The pulse widths are 2ms, 3ms and 4ms. The greatest common divisor of these three numbers is 1ms. The width of the frame is about 9ms+a stop bit.

(2) Part b) The 10-bit frame is start+data+stop = 0 0 0 0 1 1 1 0 0 1, data bits are bit 0 to bit 7,
data = 0011,1000 = $38

(4) Question 11. D) it runs slower and potentially will damage the input pin

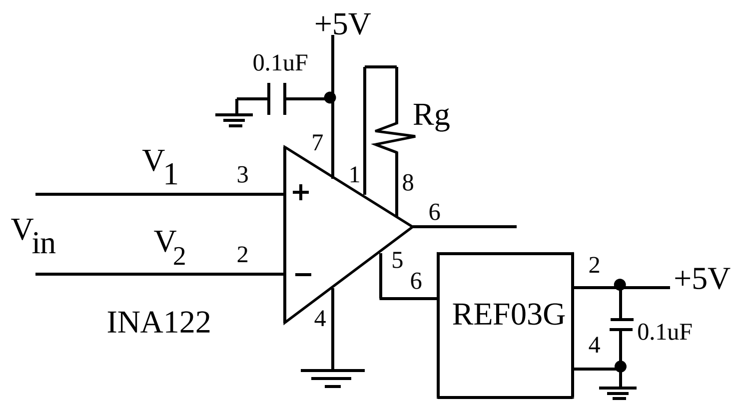
(4) Question 12. If you notice a potential safety hazard, follow standard protocol and have it investigated.

(5) Question 13. *Shannon channel capacity*: C = W $\log_2$ (1 + SNR) =100 kHz $\log_2$ (1 + 10000) = 1329 kbps

(15) Question 14. Write software to measure the number rising edges on PT4.

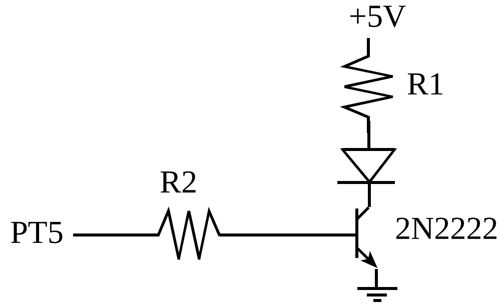
```
unsigned short Count;
void Ritual(void){
asm sei              // make atomic
  Count = 0;
  DDRT_DDRT4 = 0;    // input
  TSCR1 = 0x80;      // enable TCNT
  TIOS_IOS4 = 0;     // input capture 4
  TCTL3_EDG4x = 1;   // rising edge
  TIE_C4I = 1;       // arm
  asm cli            // enable
}
void interrupt 12 IC4Han(void){
  Count++;
  TFLG1 = 0x10;      // clear C4F
}
```

(10) Question 15. The gain is 50 = 5+200kΩ/Rg,
Rg = 200kΩ/45 = 4.4 kΩ.



(15) Question 16. Interface QE113 IR LED to the 9S12.

Part a) I_F = 100 mA, V_F = 1.5V. The 2N2222 is selected because its $I_{CE} > I_F$. V_{CE} = 0.3V, R1 = (5-0.3-1.5)/0.1 = 32Ω h_{fe}=50, so I_b = 2mA. We want V_{BE}>0.8V, so R2 = (5-0.8)/0.002 = 2k, to be safe make R2 = 470Ω.



Part b) Show the software including the three functions and the OC6 ISR

```
void Init(void){
asm sei                 // make atomic
  DDRT_DDRT5 = 1;       // output
  TSCR1 = 0x80;         // enable TCNT, 8 MHz
  TIOS_IOS5 = 1;        // output compare 5
  TCTL1_OM5 = 0;
  TCTL1_OL5 = 1;        // TC5 toggle on OC
  TIE_C5I = 0;          // disarm, initially off
  asm cli               // enable
}
void interrupt 13 OC5Han(void){
  TC5 = TC5+200;        // interrupt every 25us
  TFLG1 = 0x20;         // clear C5F
}
void On(void){
  TIE_C5I = 1;          // arm, start wave
  TC5 = TCNT+20;        // soon
}
void Off(void){
  TIE_C5I = 0;          // disarm, stop wave
}
```

Part c) The time constant of the LED (1 μs) is 50 times shorter than the period of the flashing software (50 μs); so yes, it will emit light at 20 kHz.