EEL 3744
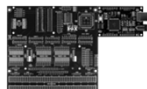
Menu

• Debugging
>Why do we need to debug?
>When do we need to debug?
>How do we debug?
– Before/as we code
– After we code
>Common bugs

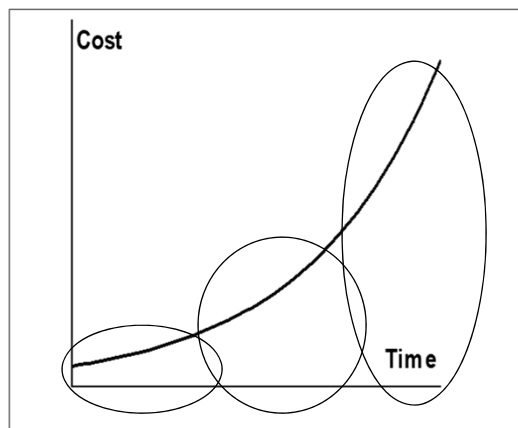Look into my ...

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The Cost of Debugging

• Increases exponentially in time

Cost

Time

Example:

    int i,j;
    for (;i++;i<50)

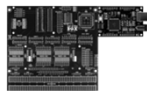Cost:

80 hrs * $18/hr = $1.4k

with overhead, $2.8k
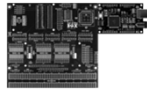
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When should we start debugging?

- Before we code (easiest)
- As we code
- After we code (hardest)

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How to debug before and as we code
- Make code modular
  - > Should be small, independent, self-contained
  - > Inter-modular bugs are the worst kind
- Well defined functions and parameters
- Start simple; work toward more complex
- Evaluate all degenerate cases
  - > Code defensively
- Run, debug each small module as we write it
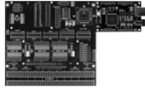
# EEL 3744 Which of the principles does this code violate?

```
.ORG 0x0000
    rjmp MAIN
.ORG 0x200
MAIN:
; Load stack pointer

    ldi  R16, 0x37
         :
ISR:
    ADD  R16,R17
         :
    RETI
```

- Modularity
  - > ISR depends on the main routine to initialize R16

  | **Warning: Dangerous bug!** |

- Well defined parameters
  - > R16 is probably not documented as a parameter to ISR
- Degenerate cases
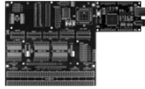 - > What if Main or some other previously executed subroutine ever changes R16?

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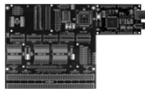
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How to debug after we code (1)

- Be creative
- **Cardinal rule of debugging: Isolate the Error**
  - > Where does the problem occur?
- What do the hardware and software do?
- Stare at code
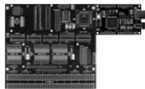 - > Look at list file
- Memory dumps and stack traces

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How to debug after we code (2)

- Use breakpoints and single stepping
  - >Make sure memory and registers are as expected
- Write debug code
  - >Print
  - >Tags
  - >Outputs, LEDs
- **Keep it simple**

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Example of using tags

```
.ORG 0x0000
    rjmp MAIN
.ORG 0x200
MAIN:
; load stack pr
    CLR   R25
    :
    ldi   R25, 1
    :
    ldi   R25, 2
    :
    ldi   R25, 3
    :
```

- The goal is to locate an error
- Set up (and clear) a register e.g., R25, (or a variable in memory)
- Change the value in the register (or memory) at certain strategic locations
- You could use LEDs or print statements, if available

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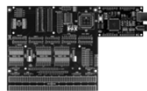© Dr. Eric M. Schwartz & H.C. Lilly

4
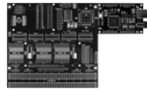
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Remember common error types

- Off by 1
- Zero case, -1 case, +1 case, MaxInt, MinInt
- No termination condition for a loop
- Variables not initialized
- Unexpected side effects
- Inter-modular bugs

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Example of Common Errors

```
.equ Size = 256
.org 0x2000
Table:  .byte Size
...
MAIN:
   ldi  XL, low(Table)
   ldi  XH, high(Table)
   ldi  R18, Size
Loop:
   dec  R18
   ld   R17, X+
   add  R16, R17
   brne Done
   beq  Loop
Done:
           :
```

- This program sums the contents of Table, in R16
- Can not put 256 into 8-bit register R18 (too big!)
- The first time through the loop, we add the contents of @Table+0 to R16
  > R16 is **not** initialized to zero!
- DEC should be last thing before branches (since ADD could change flags)
- First branch should be BEQ or BRSH, not BRNE
- Degenerate case: R16 is probably too small to hold the sum of so many numbers
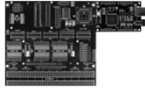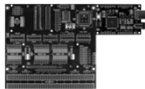
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Additional Comments

- Do something; divide and conquer
- Errors in ISRs are especially dangerous so take extra precautions
- Other assemblers may be available (for $$$) that give better warning messages when things are "funny"
- When writing code (and designing hardware) keep in mind how you can test it
  > Design in extra things that can help you test modules (hardware OR software)

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The End!

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