Signed 4-Bit Calculator with UART Display

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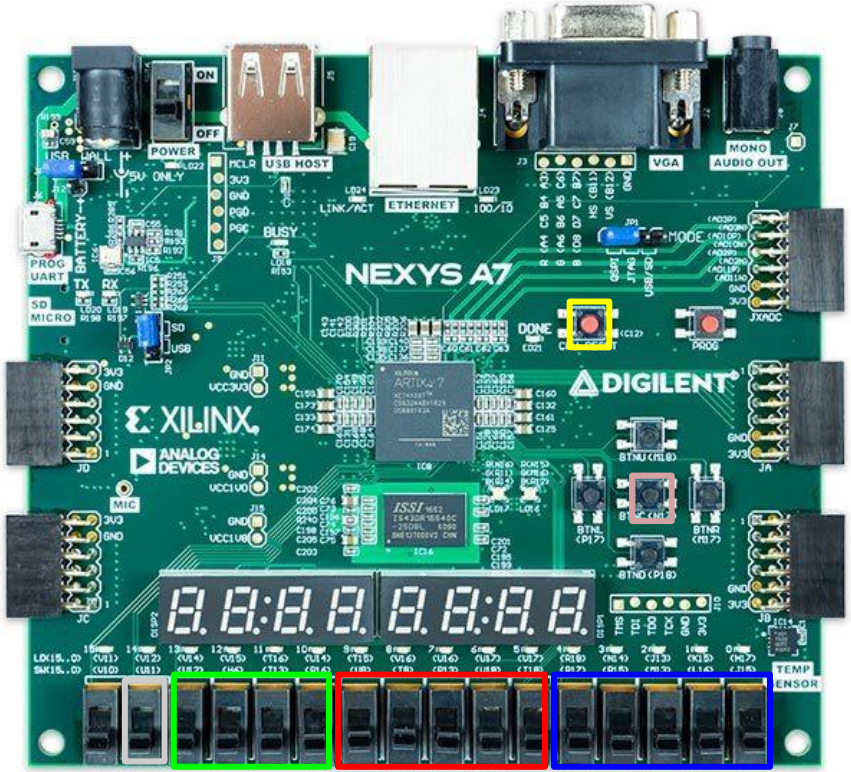
Introduction

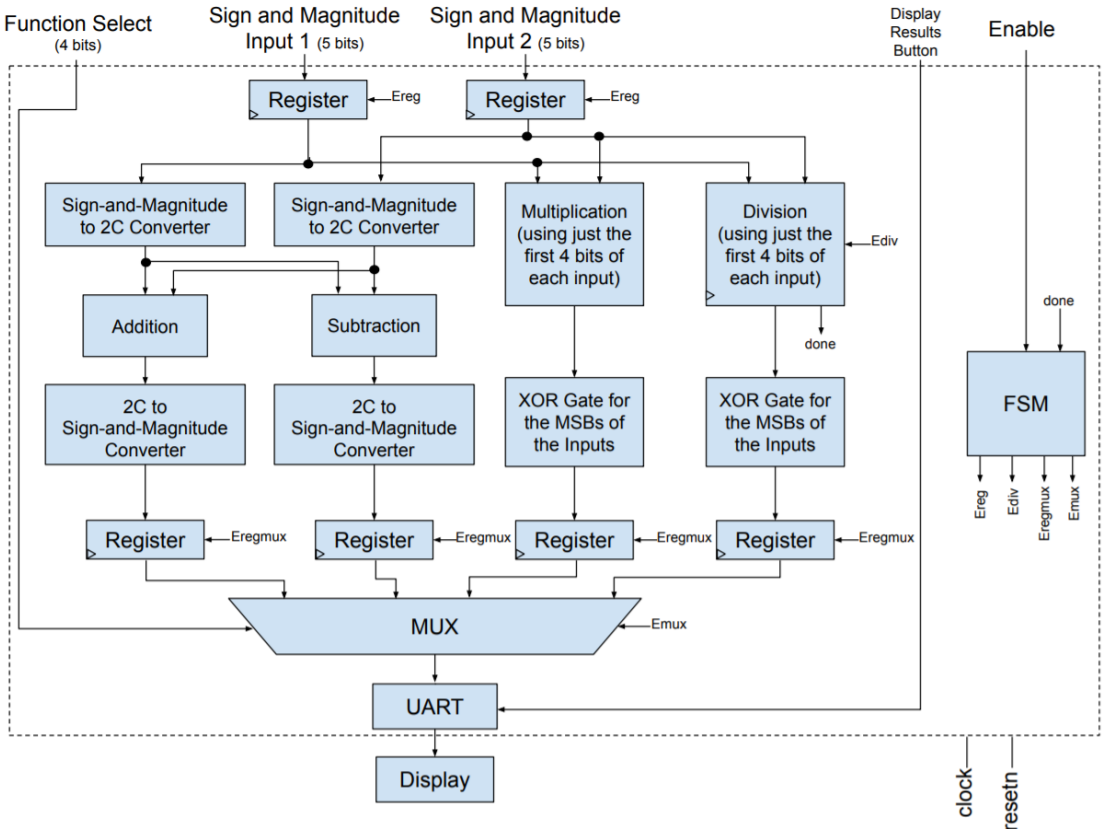
- Signed 4-bit input using switches in Sign and Magnitude. Total of 5 switches for each input, with the MSB switch being the sign of the input.
- User can select between add, subtract, multiply, and divide. Each function is assigned a switch on the board.
- Once the input and math function has been entered, the enable switch is activated. By pressing the center button of the button layout, the equation and result will show on the PuTTY screen.
- To reset the system for the next input, either turn off the enable, or press the CPU Reset button.

Overview

- Input A
- Input B
- Math Function Select
- Enable
- Reset
- Display Results



Block Diagram



Components

Sign and Magnitude / 2’s Complement Converter

- Used for the addition and subtraction math functions.
- The 5 bit input is first sent to the sign and mag. to 2C converter, and the sign bit is checked using if statements.
- If the sign is negative, then the input will be converted into 2C. If the sign is positive, it will be passed through with no changes.
- After the math operation, the output will be sent to the 2C to sign and mag. converter, and 2C will be applied accordingly.

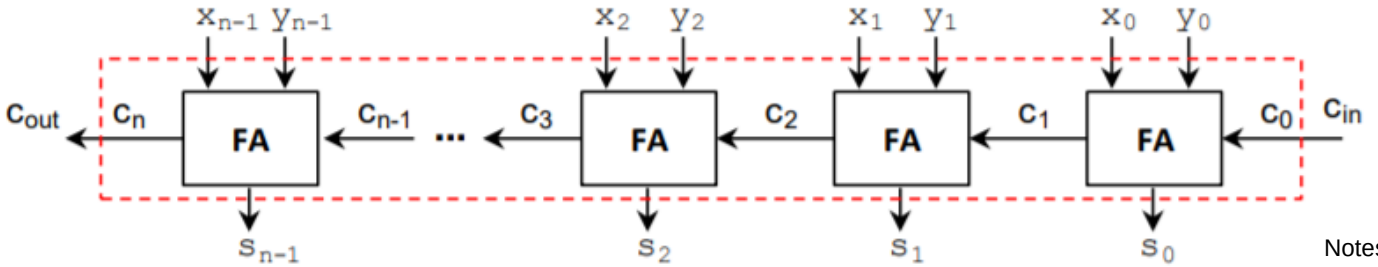
Addition and Subtraction

Addition:

- Used Full Adders to create a 6 bit adder
- The input to the block is in sign-extended 2C, which will prevent overflow since the input to the system is 5 bits

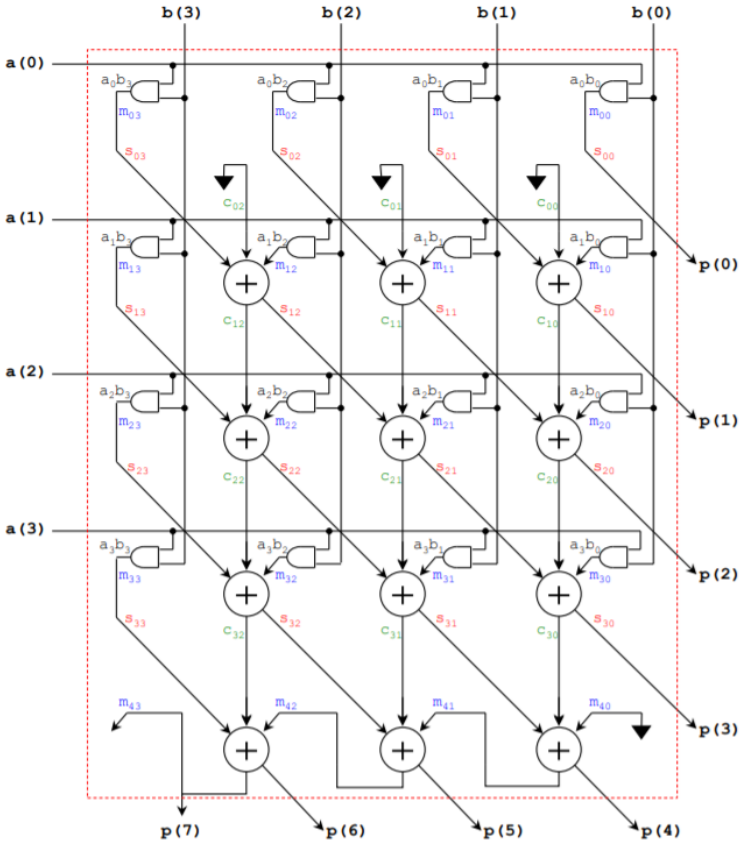
Subtraction:

- Same as addition, but with one of the inputs negated before they are added



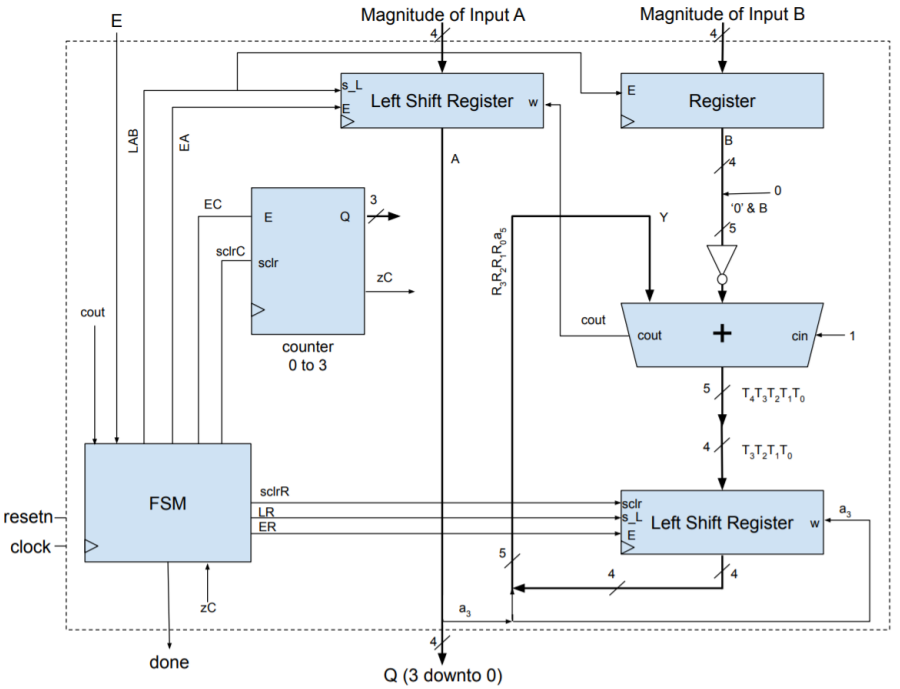
Multiplication

- Takes the magnitude of the input (4 bits) and outputs 7 bit result
- Input 1 sign xor Input 2 sign to determine the output sign
- Total output of the operation is 8 bit sign and magnitude



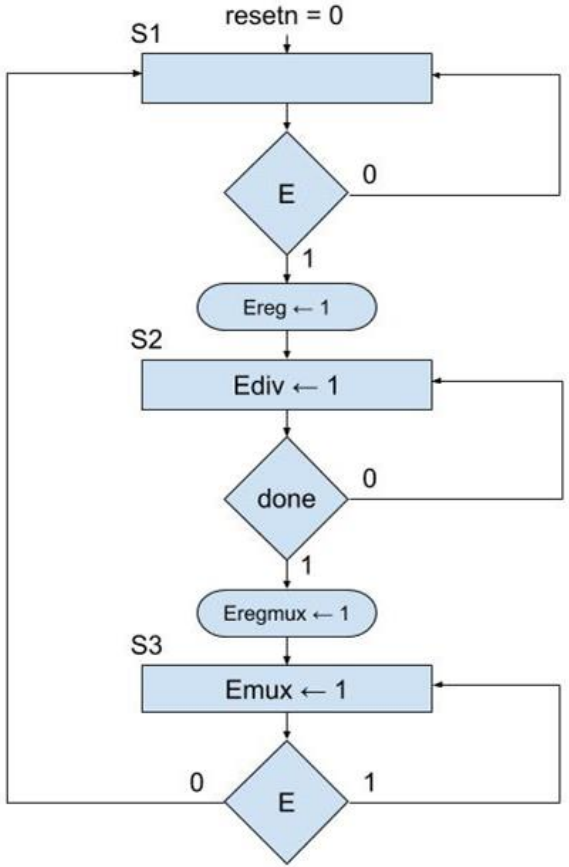
Division

- Takes the 4-bit magnitude of the input and outputs 4 bits
- Lab 6 was used with some modifications
- The MSBs of the inputs are put through an XOR to get the output sign and becomes the 5th bit of the output



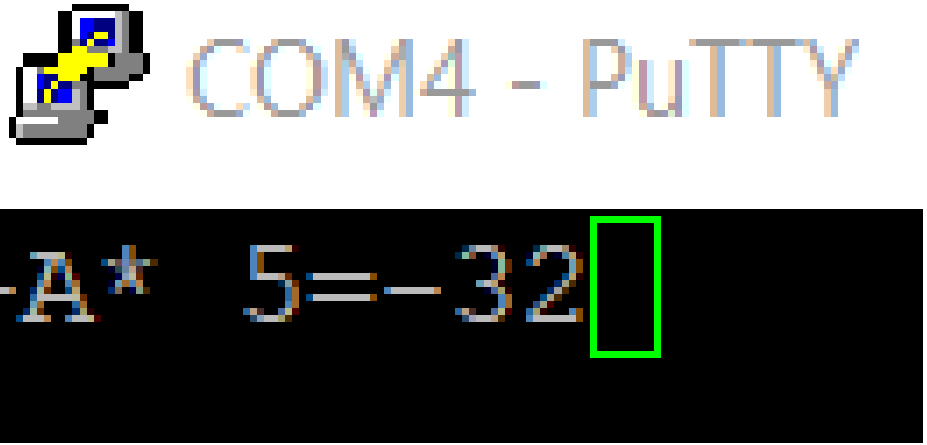
Calculations Top File

- A multiplexer is used to switch between function outputs since all are computed when the enable goes high
- A state machine was added so the flow of the values could be controlled through the registers, the division, and the MUX



UART Display

- Displays input sign and magnitude in hexadecimal
- Shows sign of calculation being performed: addition, subtraction, multiplication, or division
- Displays sign and magnitude of calculation output in hexadecimal



Simulation