COMP2611: Computer Organization

Arithmetic Logic Unit (Solution)

Question 1: By referring to slides 3 and 5, explain how SLT operation can be perfromed. State the values for the control signals Binvert, CarryIn and Operation.

Solution:

SLT outputs an “1” when the upper operand A is less than the lower operand B. The subtraction operation A-B will be performed.

When A-B<0, the sign bit (result of the MSB) will be 1 and will be forwarded to ALU0 (so “Less” becomes 00…01) .

When A-B>=0, “Less” will be 00…00.

The signals Binvert and CarryIn of ALU0 should be set to “1” to enable the subtraction, the signal Operation should be set to 3 ($11_{(2)}$) to enable the resulting “set” to be forwarded to the output.

Exercises

Question 2: By referring to slides 3 and 5,derive the logic expression in the Sum of Product form (SoP) for overflow conditions.

Solution: Two types of overflows according to the table below,

1) addition overflow Binvert=0, a3=b3=0, set=1 or
Binvert=0, a3=b3=1, set=0

2) subtraction overflow Binvert=1, a3=0,b3=1, set=1 or
Binvert=1, a3=1,b3=0, set=0

Operation	Sign Bit of X	Sign Bit of Y	Sign Bit of Result
X + Y	0	0	1
X + Y	1	1	0
X − Y	0	1	1
X − Y	1	0	0

The corresponding SoP is:

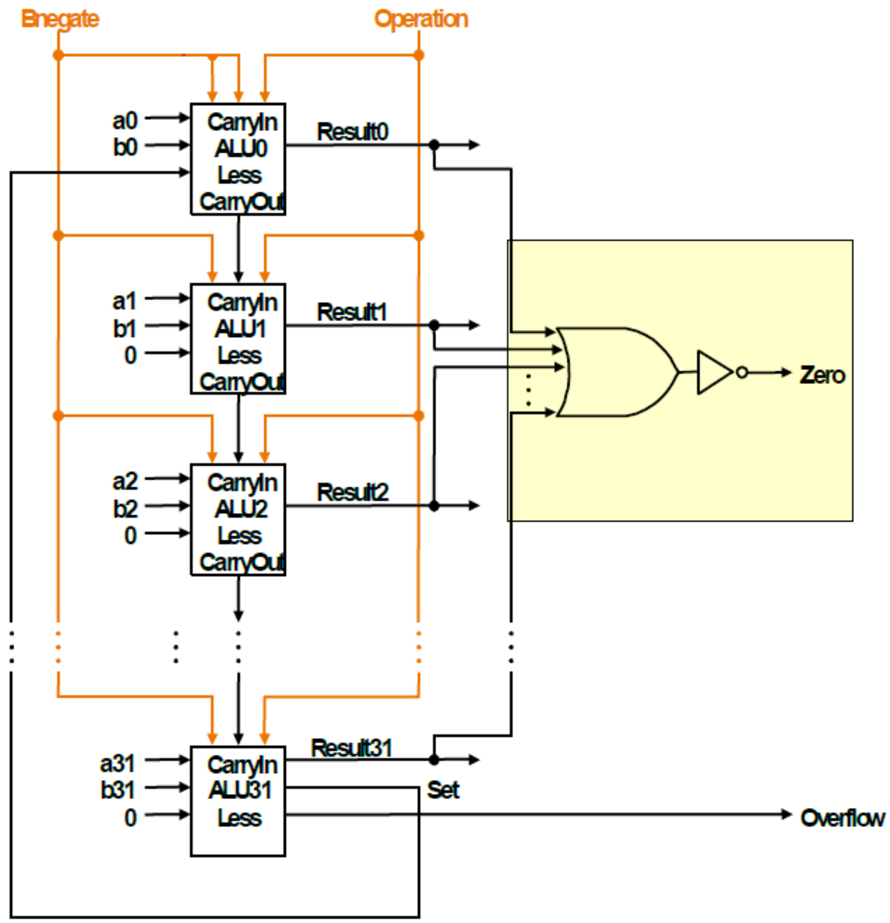
$$\overline{\mathrm{Binvert}}\cdot\overline{\mathrm{a3}}\cdot\overline{\mathrm{b3}}\cdot\mathrm{set}+\overline{\mathrm{Binvert}}\cdot\mathrm{a3}\cdot\mathrm{b3}\cdot\overline{\mathrm{set}}+\mathrm{Binvert}\cdot\overline{\mathrm{a3}}\cdot\mathrm{b3}\cdot\mathrm{set}+\mathrm{Binvert}\cdot\mathrm{a3}\cdot\overline{\mathrm{b3}}\cdot\overline{\mathrm{set}}$$

Question 3: The SLT operation depends on the result of A-B, and set whenever the sign bit of the operation is asserted. Describe a scenario such that this approach does not work correctly.

Solution: When the subtraction overflows, this mechanism does not work correctly. To see this, assume A>0, B<0, when A-B overflows, (the result's sign bit equals to 1 then) the mechanism will consider A less than B.

Exercises

Question 5: By referring to the modified 32-bit ALU below, explain how the condition A==B is detected. State the values for the control signals Bnegate and Operation.



Solution: To check A==B, we perform the subtraction A-B, if the result is 0 (i.e. result0=...=result31=0) then A==B. The NOR gate in the figure will output 1 iff all the result bits are 0. Thus if the NOR gate outputs 1, then A==B. To perform the subtraction, Bnegate is set to 1 and Operation is set to 10.