1007ICT / 1807ICT / 7611ICT
Computer Systems & Networks

3B. Digital Logic and Digital Circuits

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Last Lecture:

Topics Covered:

- Digital logic, Basic logic gates, Boolean algebra
- Combinatorial logic gates

Lecture Content

- Learning objectives
- Logic unit, Selection logic, Decoder logic
- Multiplexing and demultiplexing
- Half and Full adders

Learning Objectives

At the end of this lecture you will have gained an understanding of:

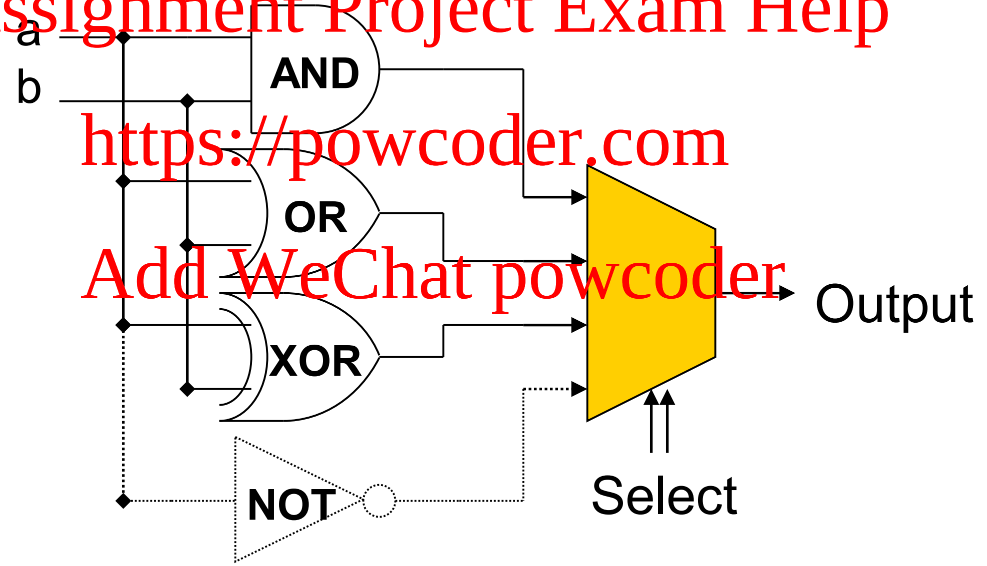
- Selection logic

- Decoder logic

- Multiplexors
- Demultiplexors
- Half and Full adders

Logic Unit

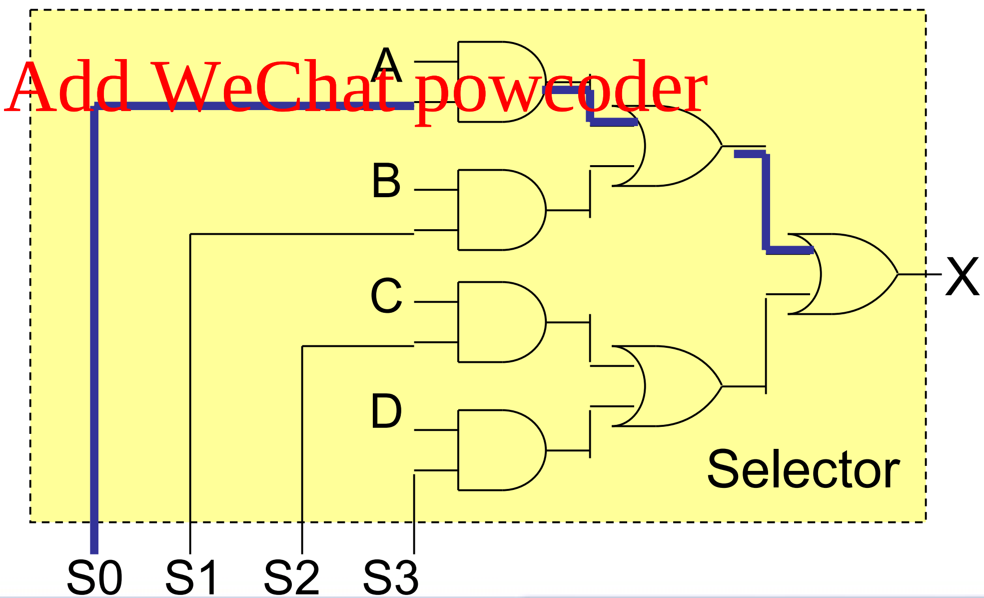
- Lets try to create a “programmable” logic unit that permits us to apply a predefined logic function to a given set of inputs.



- We need a function that lets us select what operation to perform

Selection Logic

- Say we have a number of inputs ‘A,B,C,D’ and we want to select one of them to use in a logic function.
- We need a special function to switch the selected input into the output ‘X’ based on the selection.
- We can use inputs S0 to S3 to select between A-D



Decoder Logic

- Just say we want to select between one of 100's of possible inputs – we need 100's of selection inputs as well which gets too complicated.
- Decoders with N inputs allow us to enable any one of 2^N possible selection lines.
- Basically a decoder takes a binary coded number and enables the output representing the number

Inputs		Outputs			
s1	s2	x0	x1	x2	x3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

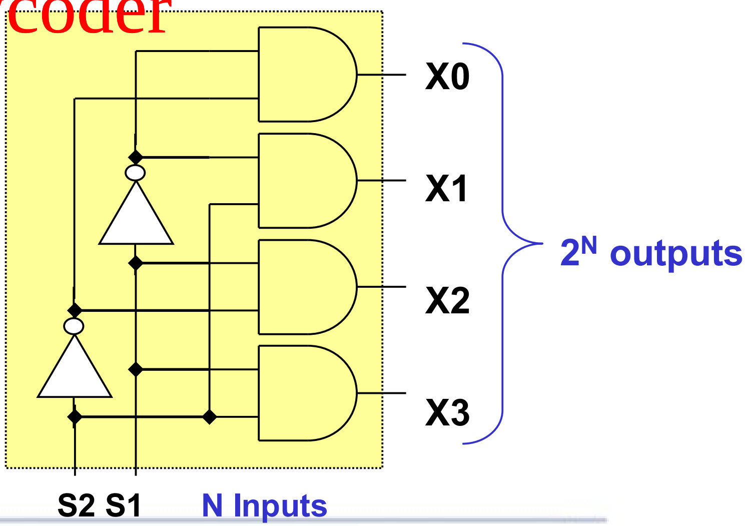
2 to 4 Decoder

$x0 = \overline{s1}\ \mathrm{AND}\ \overline{s2}$

$x1 = \overline{s1}\ \mathrm{AND}\ s2$

$x2 = s1\ \mathrm{AND}\ \overline{s2}$

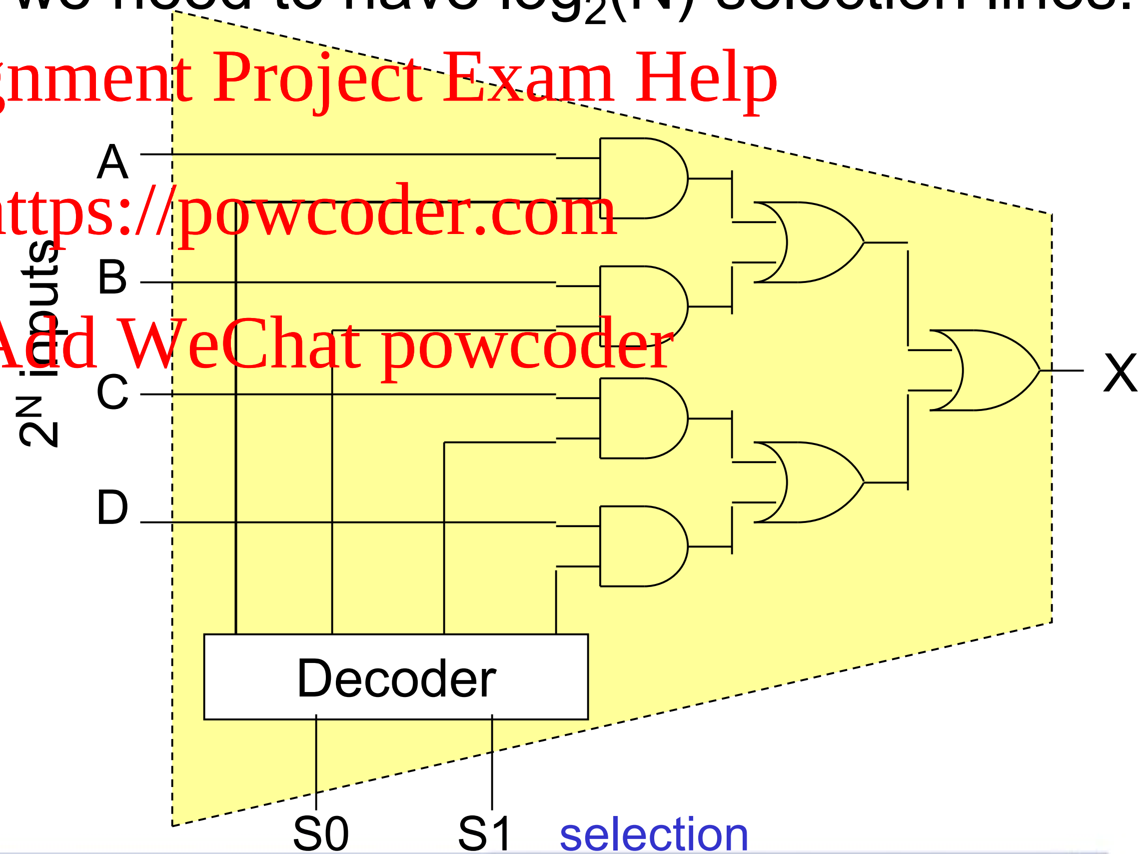
$x3 = s1\ \mathrm{AND}\ s2$



Multiplexing

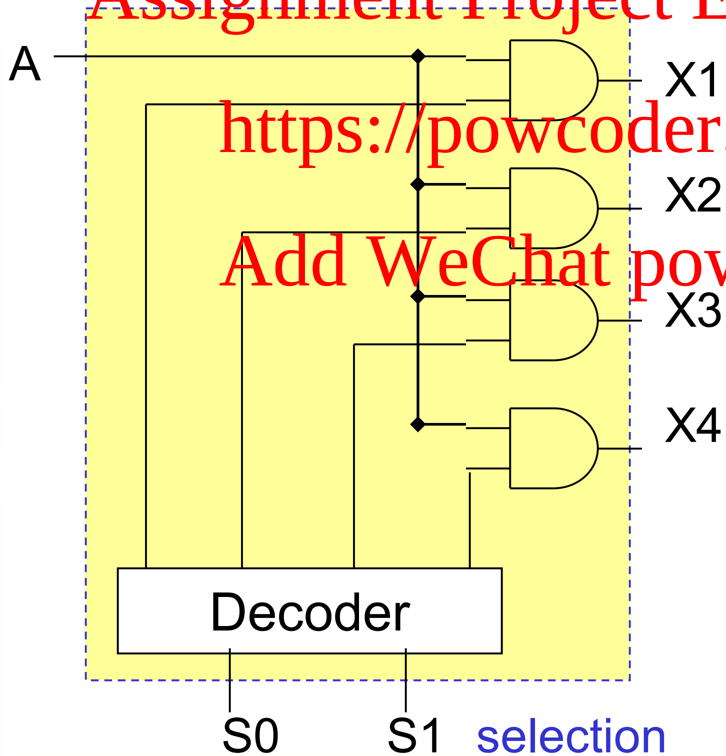
- Combining the selector and decoder we can create what is called a ***Multiplexor***
- In general if we have N inputs we want to switch between we need to have $\log_2(N)$ selection lines.

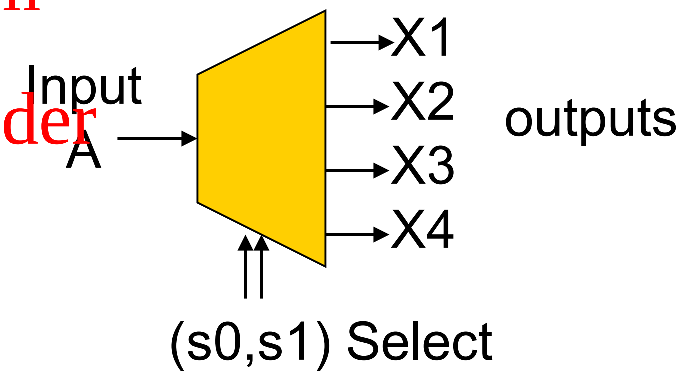
s0	s1	X
0	0	A
0	1	B
1	0	C
1	1	D



Demultiplexing

- We can also switch in the opposite direction to send one input ‘A’ into one of many different outputs (eg X1..Xn)



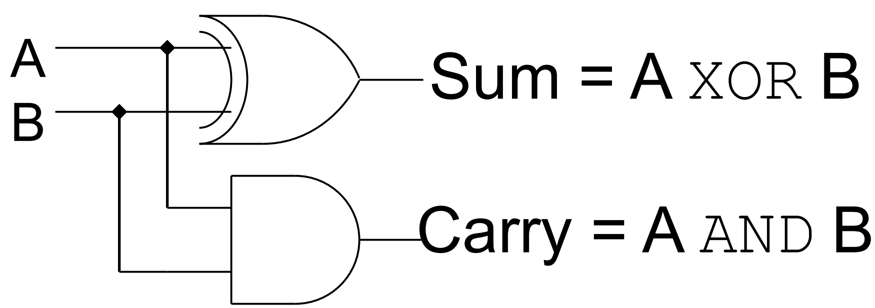


Half-Adders

- In addition to logic functions we can also create maths functions.
- The simplest math function is the half-adder which can add 2 digits (bits) to give a sum and a carry bit

0	0	1	1	A
0	1	0	1	B+
0	1	1	10	

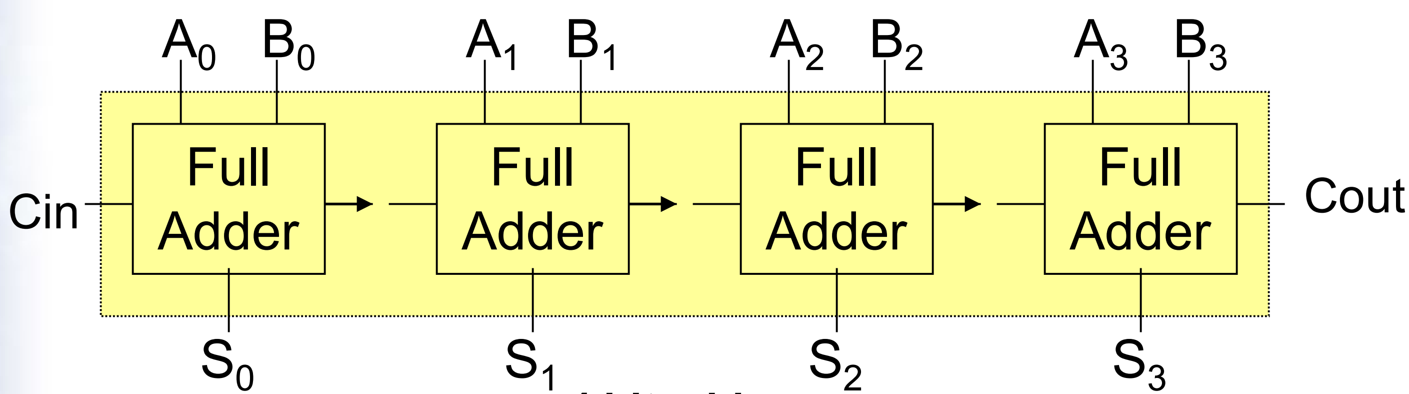
A	B	Sum	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



Full-Adders

- If we want to add more than 1 bit values together we need to deal with the carry.
- Full-adders accept the two inputs to be added plus the carry from a previous stage.
- The circuit must be able to deal with propagation delays

00	00	01	01	00	10	11	11	A
00	01	00	01	10	01	10	11	B+
00	01	01	10	10	11	101	110	



4 bit adder

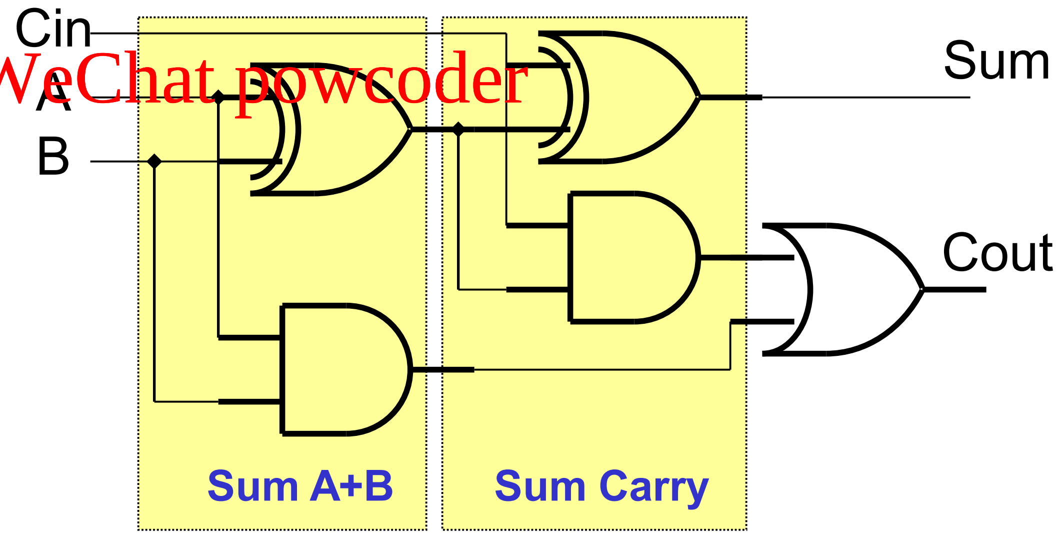
Full-Adders

- The logic to perform add with carry combines two half adders together.

Sum = A XOR B XOR Cin

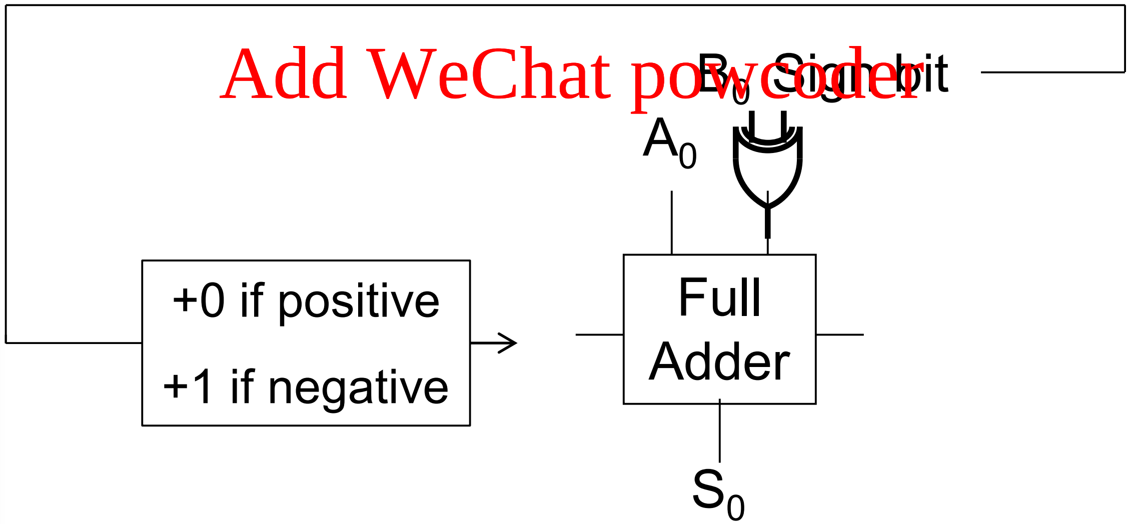
Cout = (A AND B) OR (Cin AND (A XOR B))

Cin	A	B	Sum	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



Subtraction

- A – B is the same as A + (-B)
- If we convert B to the negative equivalent of its value, we can **use the basic adder as it is.** We can use an **XOR** gate to do this.
- However, converting B to –B using two's complement also requires adding 1



Summary

Have considered:

- Selection logic
- Decoder logic
- Multiplexors
- Demultiplexors
- Half and Full adders

Next….

- Arithmetic logic unit
- Binary multiplication and division
- Shifting
- Sequential Logic
- Data latches, S-R Latch
- Clocks and synchronisation
- Registers, Buses, Computer memory
- Processors and Memory Organisation