



EECS 150 - Components and Design Techniques for Digital Systems

Lec 18 – Arithmetic II (Multiplication)

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Review

- **Circuit design for unsigned addition**
 - Full adder per bit slice
 - Delay limited by Carry Propagation
 - » Ripple is algorithmically slow, but wires are short
- **Carry select**
 - Simple, resource-intensive
 - Excellent layout
- **Carry look-ahead**
 - Excellent asymptotic behavior
 - Great at the board level, but wire length effects are significant on chip
- **Digital number systems**
 - How to represent negative numbers
 - Simple operations
 - Clean algorithmic properties
- **2s complement is most widely used**
 - Circuit for unsigned arithmetic
 - Subtract by complement and carry in
 - **Overflow when c_{in} xor c_{out} of sign-bit is 1**



Computer Number Systems

- Positional notation

- $D_{n-1} D_{n-2} \dots D_0$ represents $D_{n-1}B^{n-1} + D_{n-2}B^{n-2} + \dots + D_0 B^0$ where $D_i \in \{0, \dots, B-1\}$

- 2s Complement

- $D_{n-1} D_{n-2} \dots D_0$ represents: $-D_{n-1}2^{n-1} + D_{n-2}2^{n-2} + \dots + D_0 2^0$
- MSB has *negative weight*

