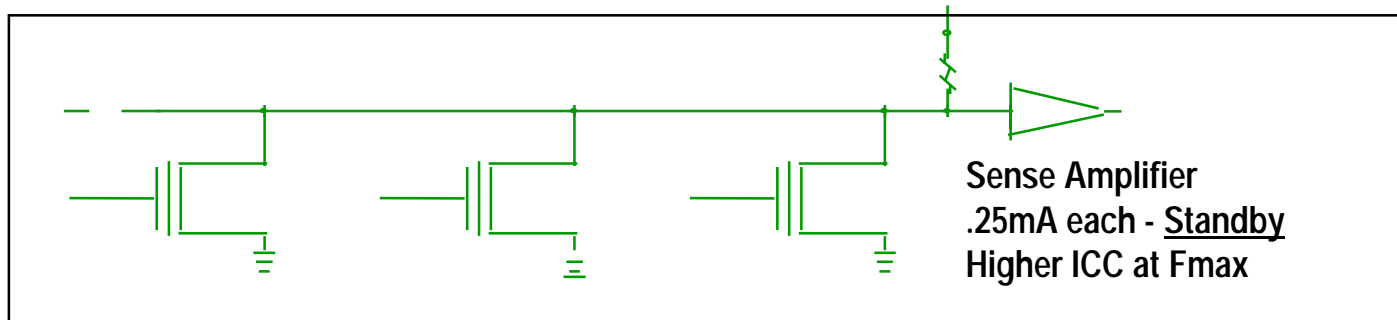




Traditional CPLDs

- ◆ CPLDs migrated from Bipolar to CMOS
 - Easier platform to design upon
 - Lower power consumption
 - Continued to use the same Bipolar design technique to implement Product Terms
- ◆ Product Term Construction



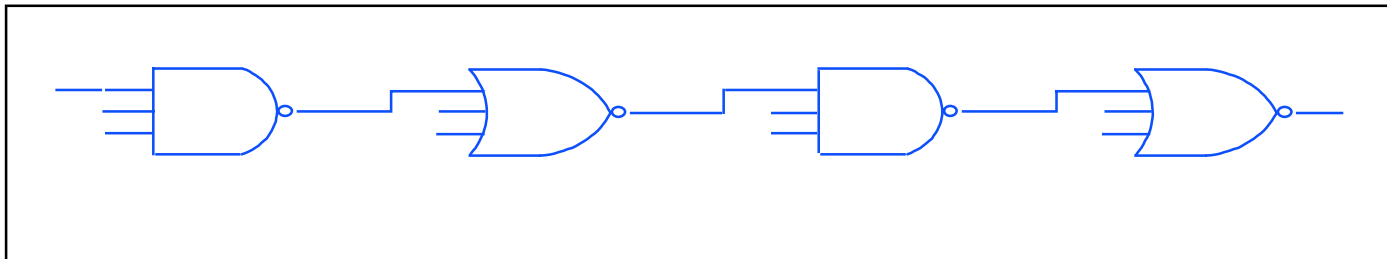
This technique involves building up a word line using 'wired nor' inputs to a node. As more of these inputs are attached to the node, the capacitance increases and so does the time constant. In order to speed up propagation time, this node is followed by a sense amplifier, which examines the node for approximately a 100mV change to indicate a logic level transition.

Consequences of Using Sense Amplifiers

- ◆ **Power Consumption**
 - Sense amplifiers are linear elements which always draw a substantial amount of current
 - Each sense amplifier consumes 250uA during standby
 - 128 Macrocell device: 160mA of standby current ($128MC * 5PTs/MC * 250uA/PT$)
 - Dynamic power increases as frequency increases
- ◆ **Power Down Modes**
 - These modes reduce power consumption and performance
 - Complicate timing model (additional delays depending on power down level)
 - Are often associated with “wake-up” modes which have to be designed around
- ◆ **Performance**
 - Performance versus Power Consumption trade-off
- ◆ **Device Size Limitations**
 - Power consumption limits the size of the device you can build
- ◆ **Noise immunity**
 - Sense amplifier makes the device more susceptible to noise

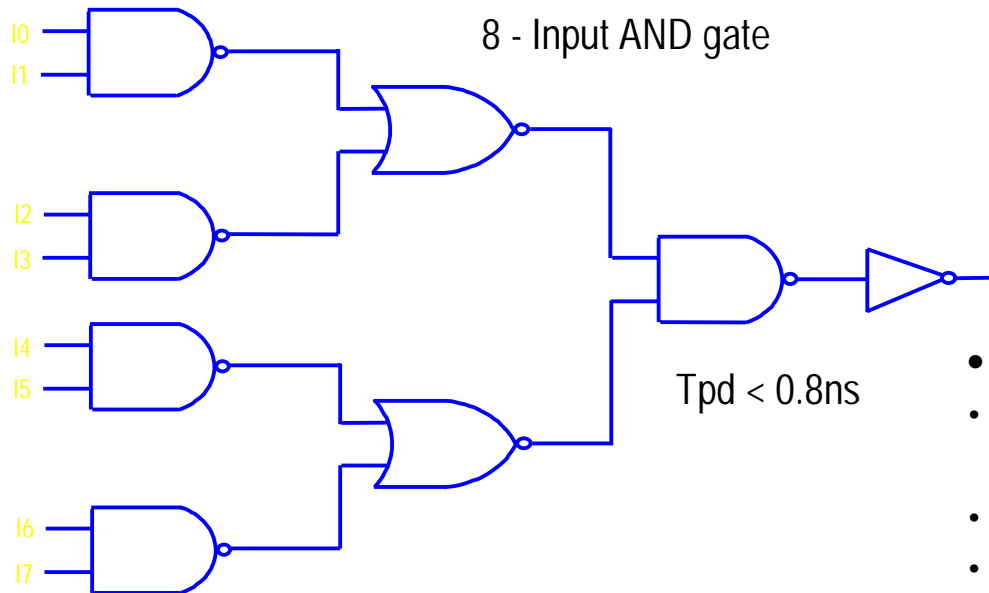
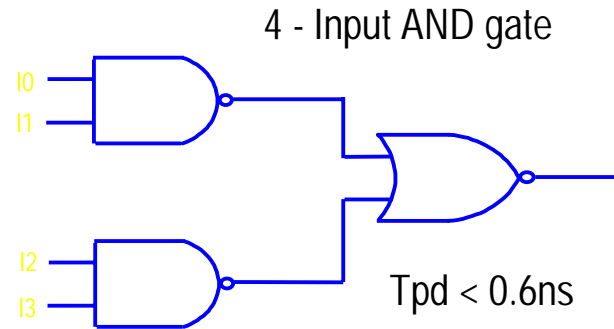
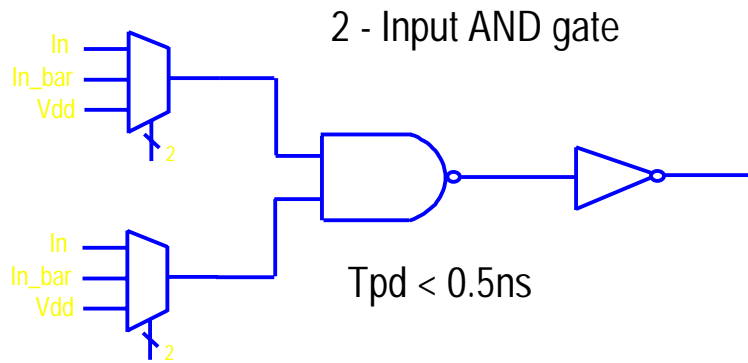
CoolRunner CPLDs

- ◆ New Innovative approach
 - **Eliminated Sense amplifiers**
 - **Removed Performance vs. Power Consumption trade-off**
 - **Simultaneously deliver high performance and low power consumption**
- ◆ Product Term Construction



This patented approach is called Fast Zero Power (FZP™), and product term word lines are implemented without the use of sense amplifiers. This FZP technology actually uses a CMOS chain of gates to implement product terms. This implementation offers the benefit of much lower power consumption.

CoolRunner Product Term Generation



- Virtual mux controls input
- DeMorgan Tree generates logic
 - $Y = I_0 I_1 I_2 I_3 = !(!(I_0 I_1) \# !(I_2 I_3))$
- Distributes capacitance
- Instantaneous Idd low

Consequences of Using FZP

- ◆ **Power consumption**

- 1000 times less standby current
- 33% to 50% the total device power consumption
- Simultaneously delivers high performance and low power consumption
- Allows for tremendous amounts of logic resources to be placed in very small packages

- ◆ **Power Down modes**

- No power down modes needed
- FZP simultaneously delivers high performance and low power consumption

- ◆ **Performance**

- No tradeoffs between performance and power consumption

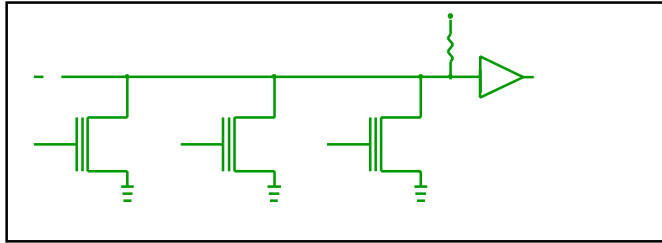
- ◆ **Device size /Speed tradeoffs**

- No speed tradeoff for larger devices - high speed and low power even at 384 macrocells

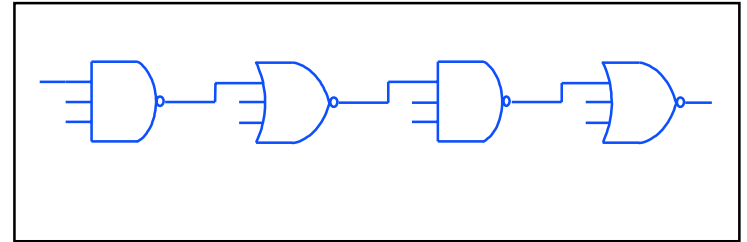
- ◆ **Noise immunity**

- Better noise immunity than sense amp based CPLDs

Technology Difference Summary



Sense Amplifier .25mA each - Standby
Higher ICC at Fmax



FZP: CMOS Everywhere - Zero Static Power



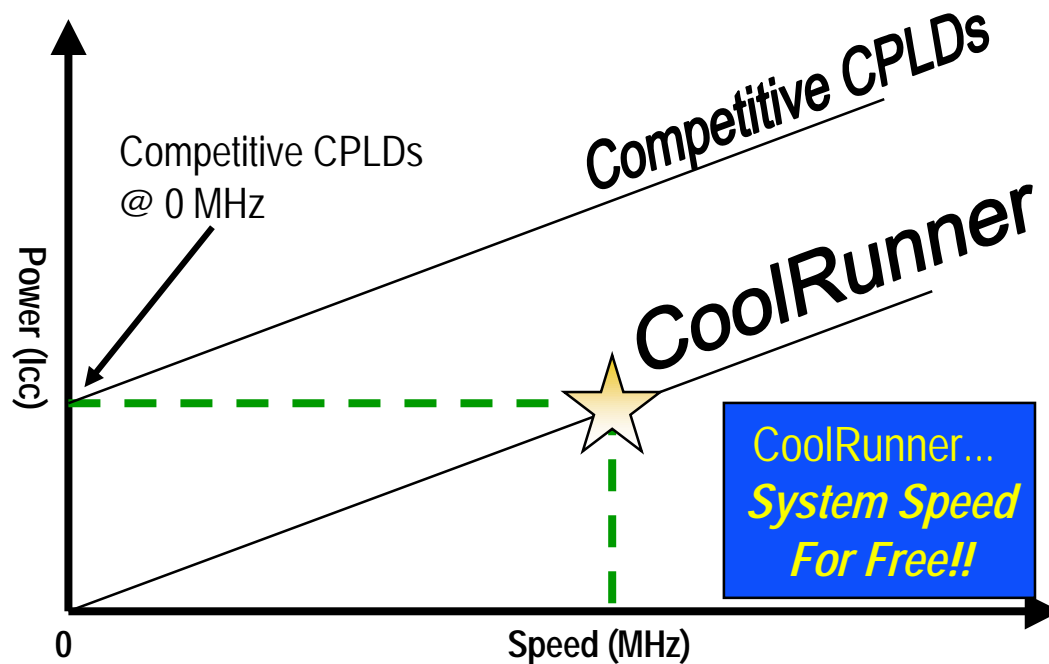
- ◆ **Competitive CPLDs - bipolar sense amp product terms**

- Always consumes power--even at standby
- Designer must choose between high performance and low power consumption
- Limits maximum device size due to power consumption

- ◆ **CoolRunner FZP design uses TotalCMOS for product terms**

- Virtually no standby current
- Dynamic currents 1/3 the competition at F_{max}
- Simultaneously delivers high performance and low power
- No power limits on device size

CoolRunner Delivers Lowest Power @ Any Speed



- ◆ Reduce Icc requirements while increasing system reliability
 - Smaller power supply
 - Eliminate fans
 - Smaller equipment
- ◆ Smaller device packaging
 - Less board area & more logic packing density

CoolRunner Design Win Examples

- ◆ Consumer / Industrial
 - PDA
 - Cell phone
 - MP3 player
 - Battery powered scanner
 - Camcorder viewfinder
 - Digital camera
 - Portable dictation system
 - Gas meter
- ◆ High Performance
 - Alpha workstation and server
 - Digital video data link
- ◆ Medical
 - Portable syringe pump
 - Home monitoring system
 - Blood analyzer
- ◆ PC Peripheral
 - PCMCIA memory card
 - USB based data acquisition
 - Portable computer display
 - White board scanner