



COOLRunner™

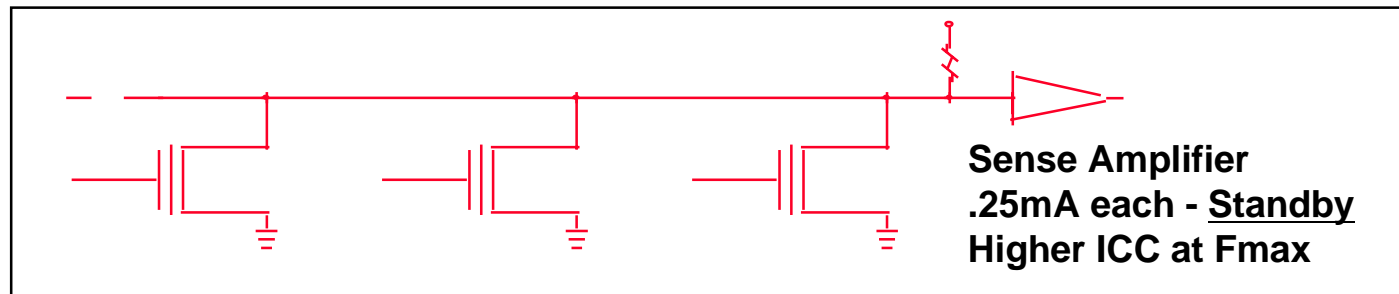
Fast Zero Power

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 ($128\text{MC} * 5\text{PTs/MC} * 250\text{uA/PT}$)
- 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**

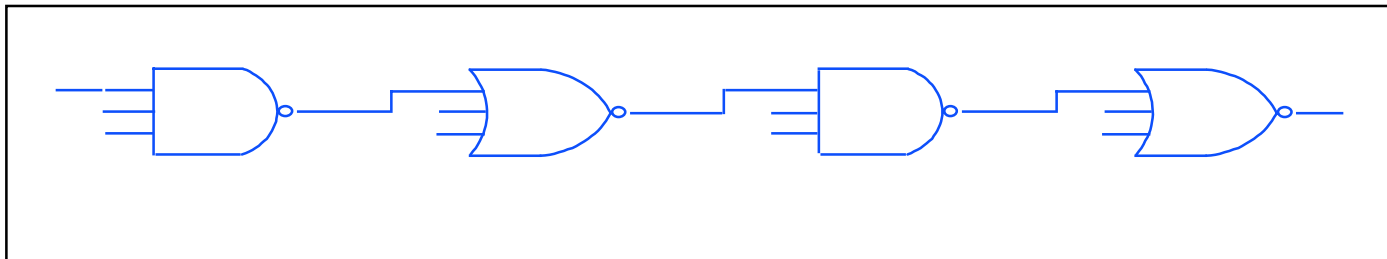
- Sense amplifier makes the device more susceptible to noise

CoolRunner CPLDs

- **New Innovative approach**

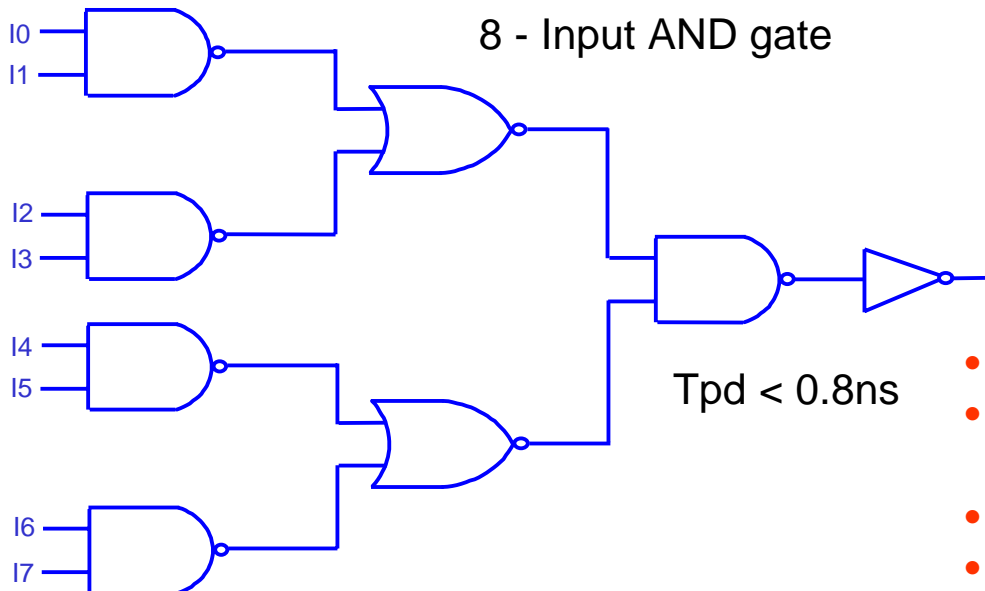
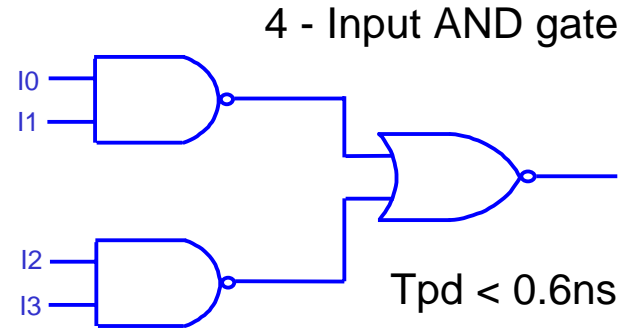
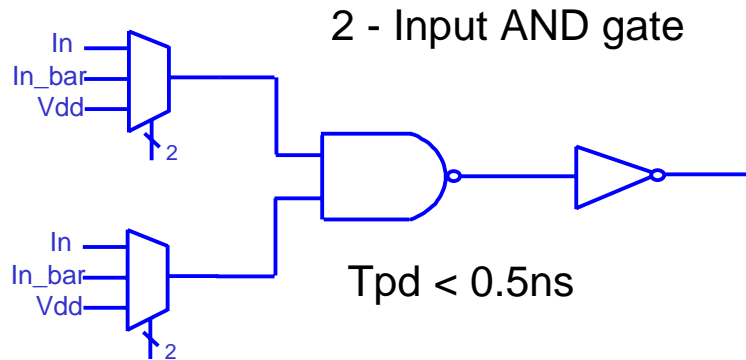
- Eliminated Sense amplifiers
- Removed Performance vs. Power Consumption trade-off
- Simultaneously deliver high performance and low power consumption

- **Product Term Construction**



- This patented approach is called Fast Zero Power (FZP™)
- Implement a product term word line without the use of sense amplifiers.
- The Fast Zero Power technology is based upon a CMOS chain of gates to implement "Product Terms"
- The primary benefit of this technique is much lower power consumption.

CoolRunner Product Term Generation

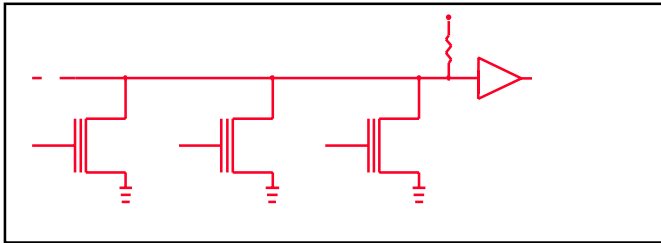


- Virtual mux controls input
- DeMorgan Tree generates logic
 - $Y = I_0 I_1 I_2 I_3 = !(!(I_0 I_1) \# !(I_2 I_3))$
- Distributes capacitance
- Instantaneous I_{dd} low

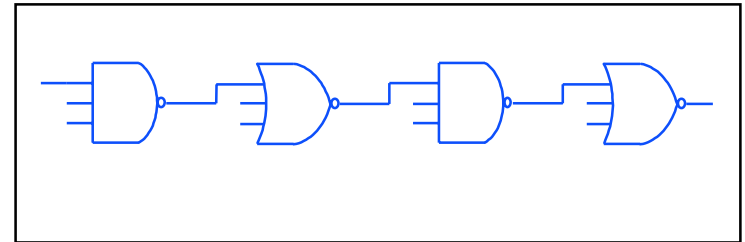
Consequences of Using FZP

- **Power Consumption**
 - 1000 times less standby current
 - 33% to 50% the dynamic power
 - Simultaneously delivers high performance and low power consumption
 - This technology also allows for tremendous amounts of logic resources to be placed in very small packages.
- **Power Down Modes**
 - Not needed
 - FZP simultaneously delivers high performance and low power consumption
- **Performance**
 - No tradeoffs between Performance and Power Consumption
- **Device Size Limitations**
 - No power limits on the device size
 - XCR3960 is the world's largest CPLD (960 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



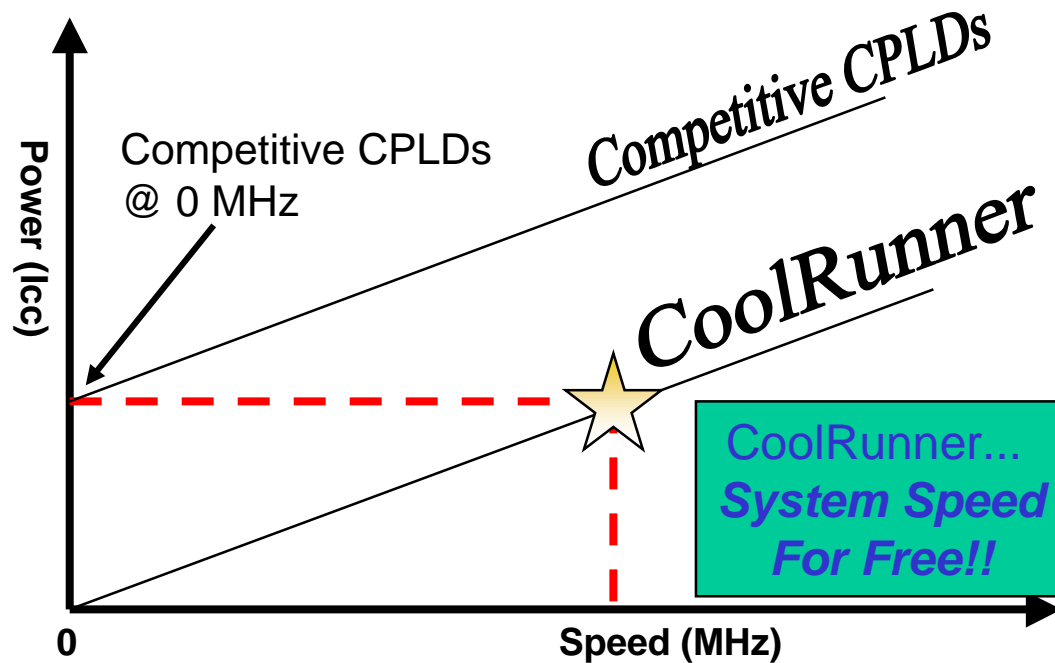
- **Competitive CPLDs - bipolar sense amp product terms**

- 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

- **Portable / Consumer**

- PDAs
- Cell phones
- MP3 players
- Laptops
- Docking stations
- Battery powered scanners
- Camcorder viewfinders
- Digital cameras
- Portable dictation systems
- Gas meters
- Handheld meters
- Penguin counters



- **Medical**

- Portable syringe pump
- Home monitoring system
- Blood analyzer

- **Telecom**

- “Neighborhood” Multiplexors
- Bay Stations
- Routers
- Multiplexors
- PBXs
- DACS
- Central office switches
- Speech recognition systems



- **PC Peripheral**

- PCMCIA memory cards
- Portable computer displays
- White board scanners
- Memory cards

- **High Performance**

- Alpha workstations and
- Video graphics cards

