Energy Efficient Speed-Independent 64-bit Fused Multiply-Add Unit

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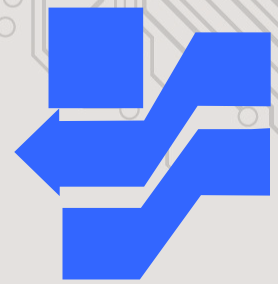

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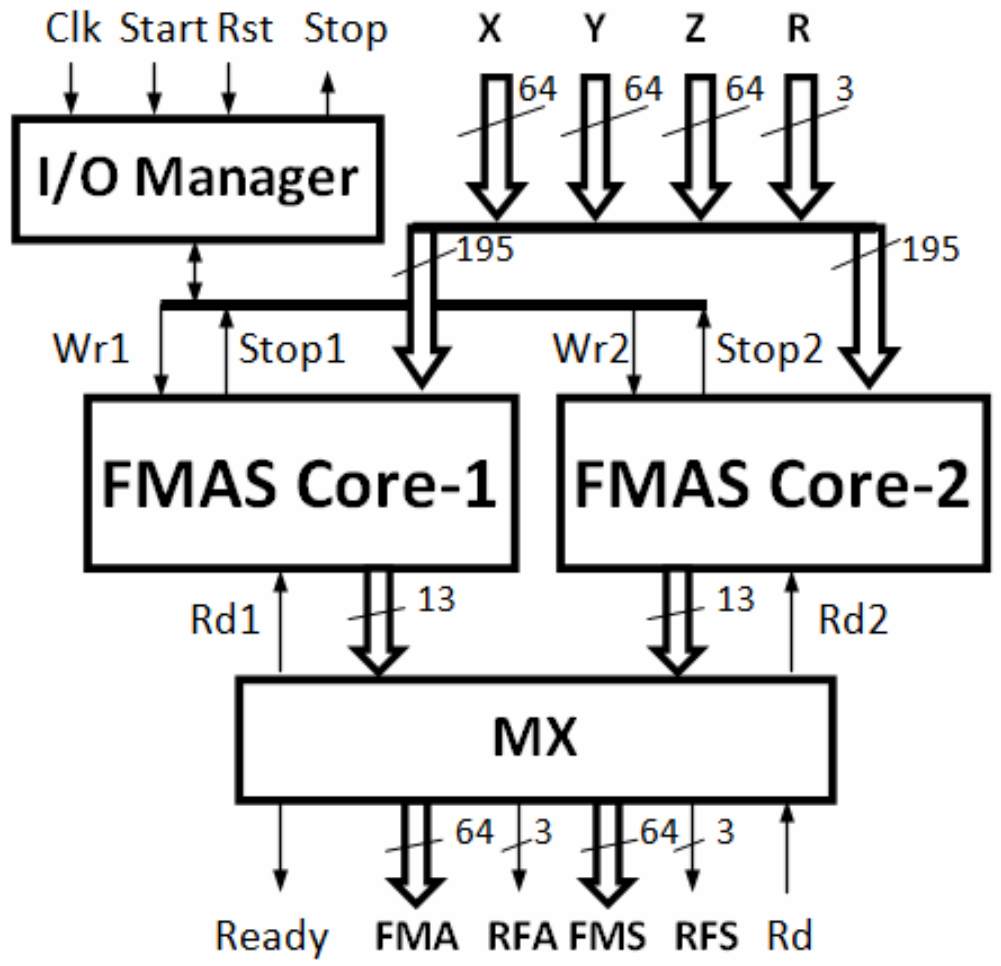
Content

- Features of the Speed-Independent circuits
- Flowchart of the Speed-Independent FMA
- Ways for increasing FMA performance
- Pipelining multiplier
- Input and output FIFO implementation

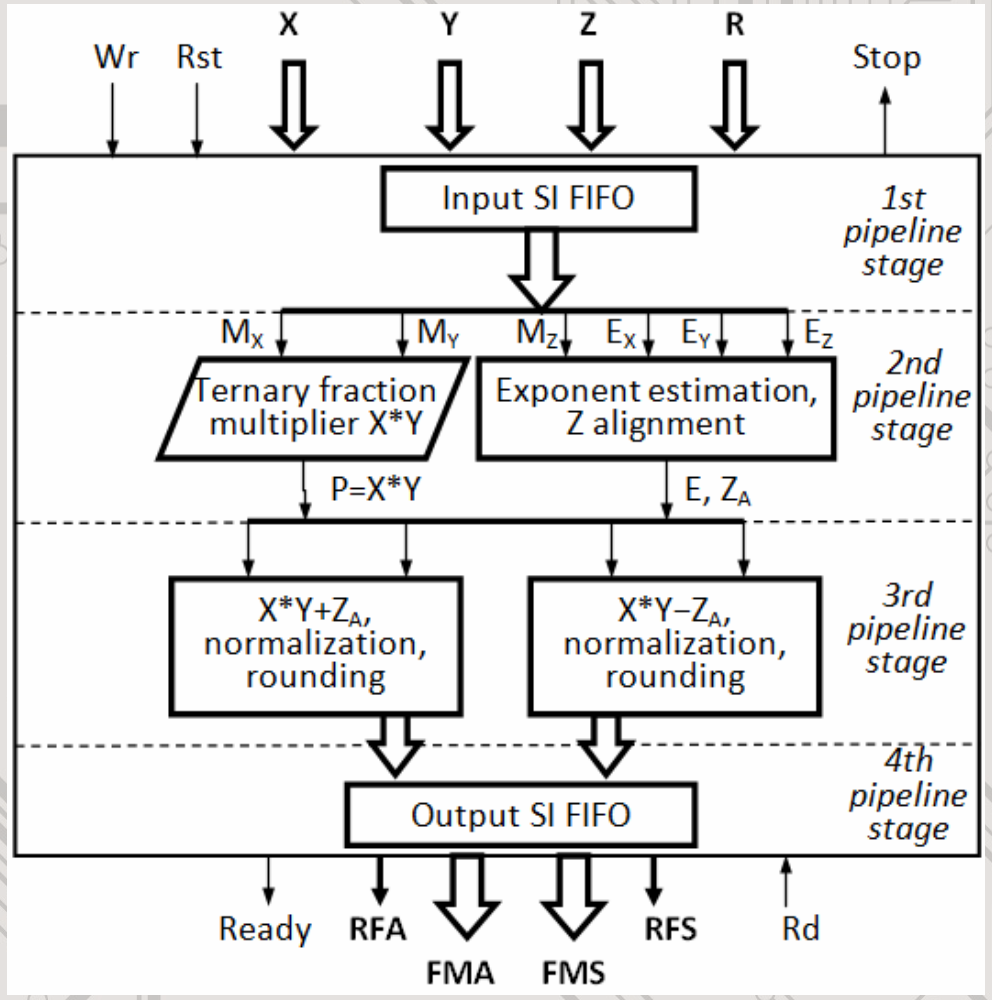
Speed-independent (SI) circuits

- **Advantages:**
  lack of hazards,
  self-testing,
  real performance,
  wide workability range.
- **Disadvantages :**
  design difficulty,
  higher hardware costs,
  increased number of signals

Flow-chart of previous SI FMA



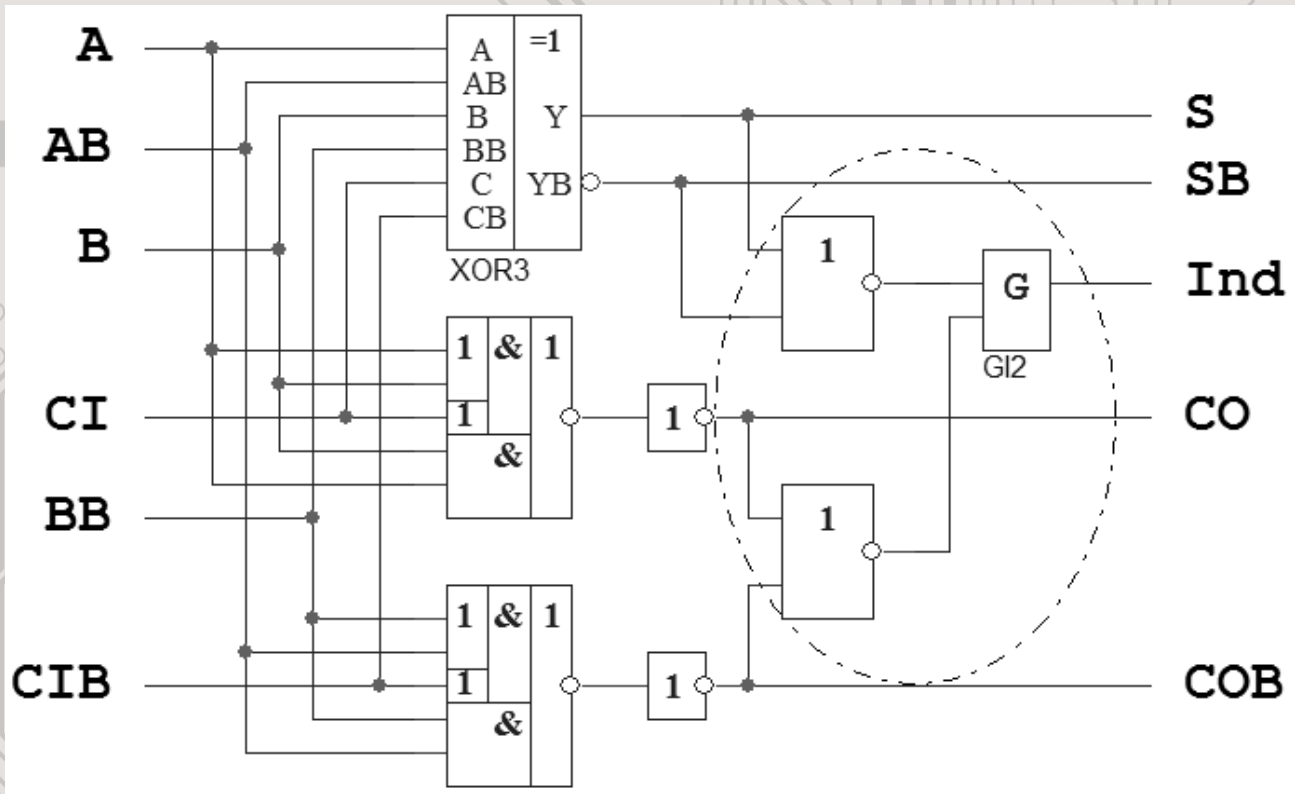
Flow-chart of new SI FMA



Quaternary encoding

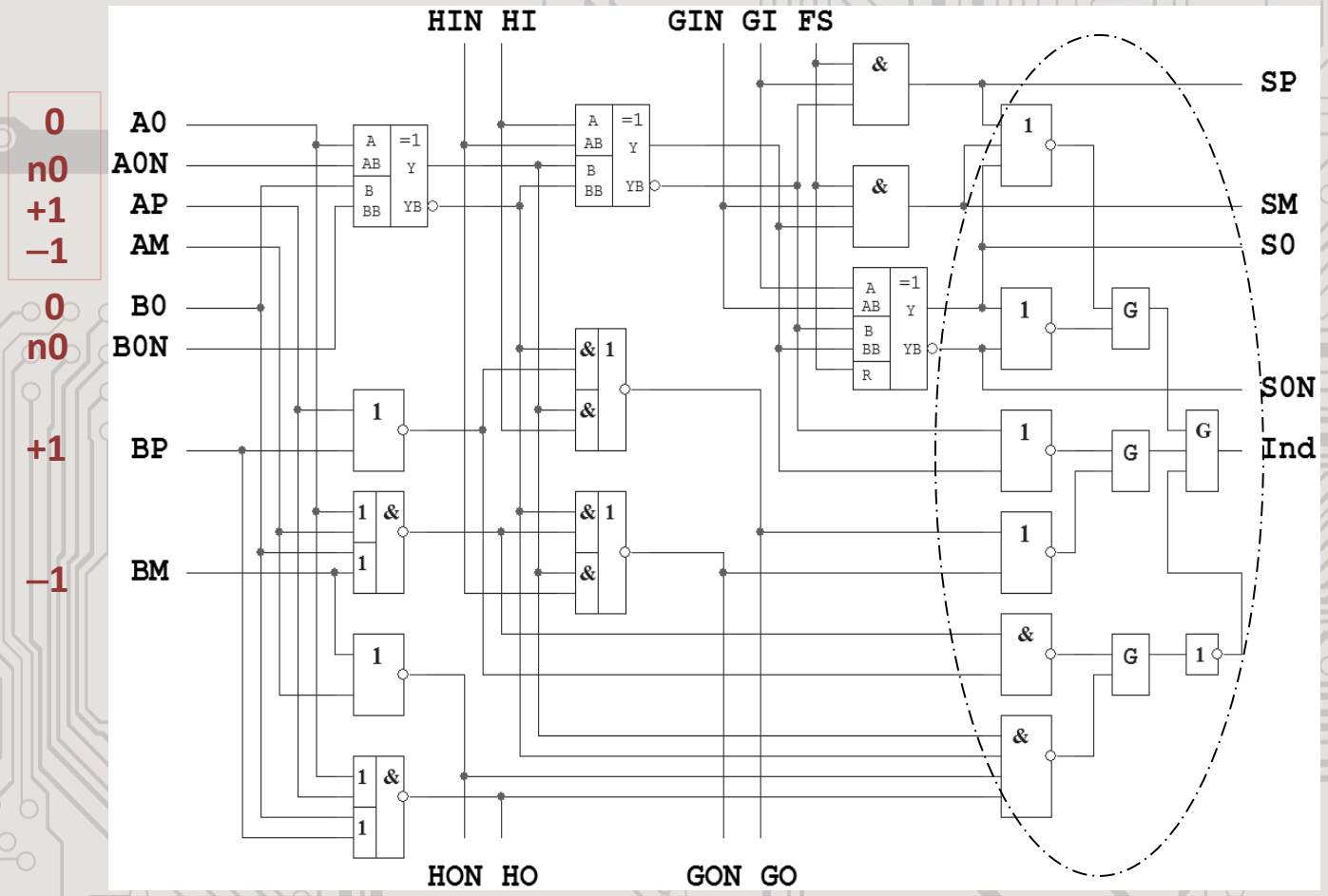
Number	Binary redundant code		Quaternary code			
	A	B	AP	AM	A0	A0N
+1	1	0	1	0	0	1
0	0	0	0	0	1	0
–1	0	1	0	1	0	1
spacer	_	_	0	0	0	0

Dual-rail SI adder



- **68 CMOS transistors,**
- **3:2 Compression**

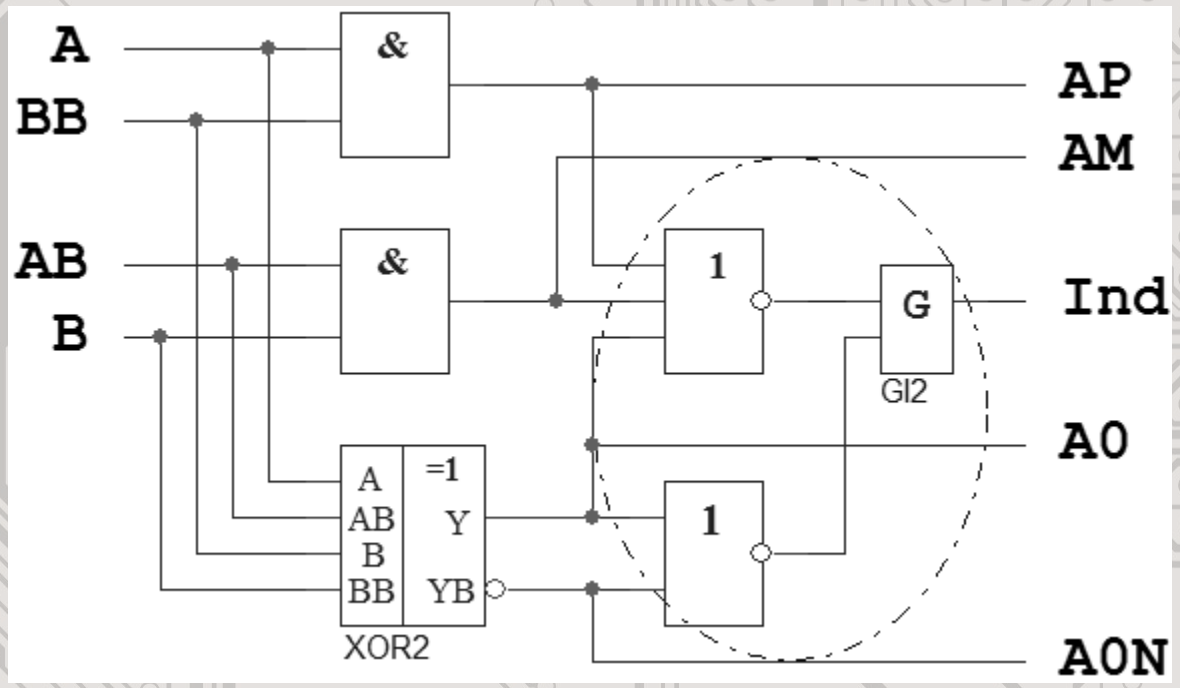
Quaternary SI adder



180 CMOS transistors; 2:1 Compression

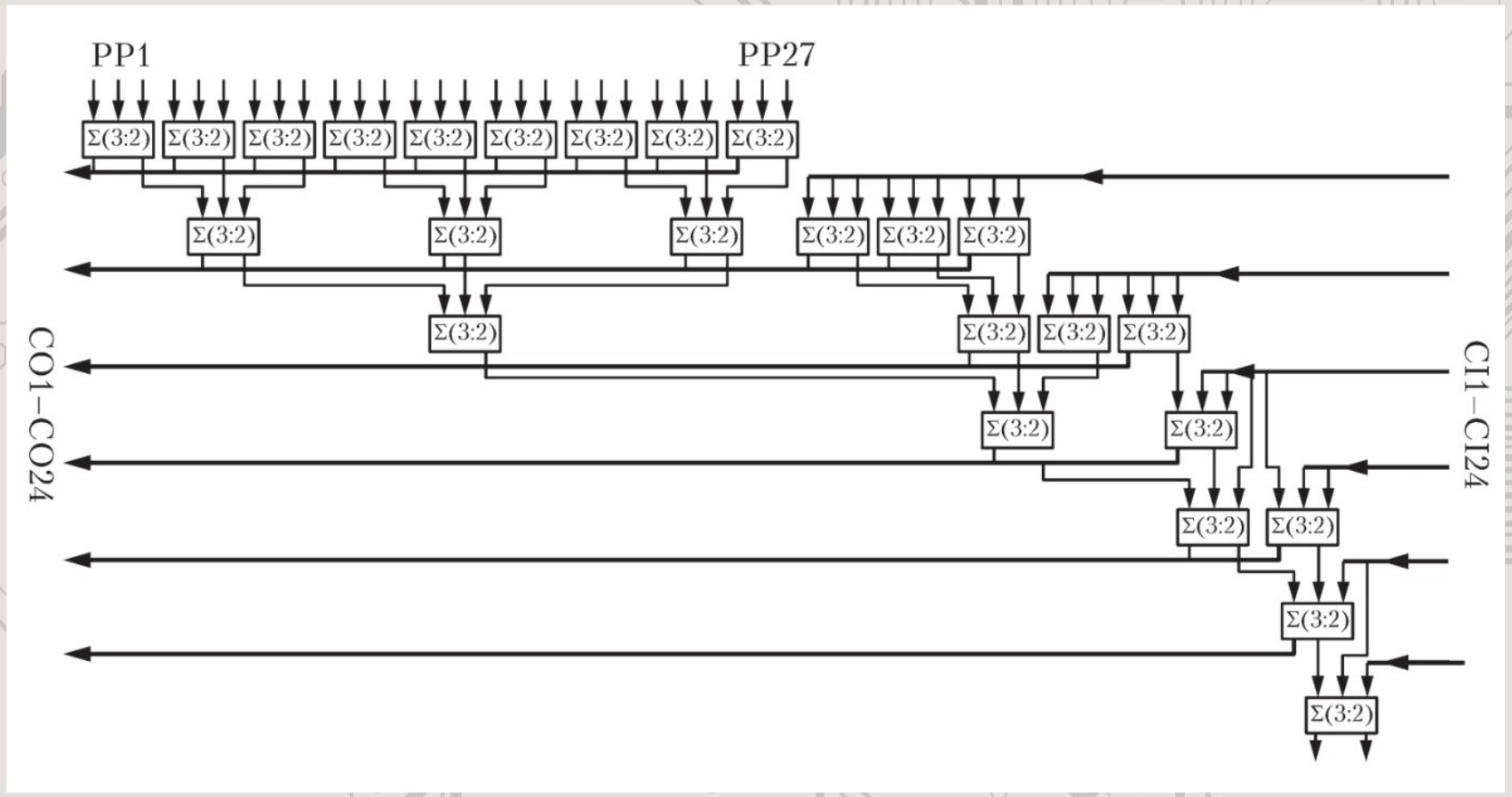
Two Dual-Rails to Quaternary converter

{A,AB} – {B,BB} = {AP,AM,A0,A0N}

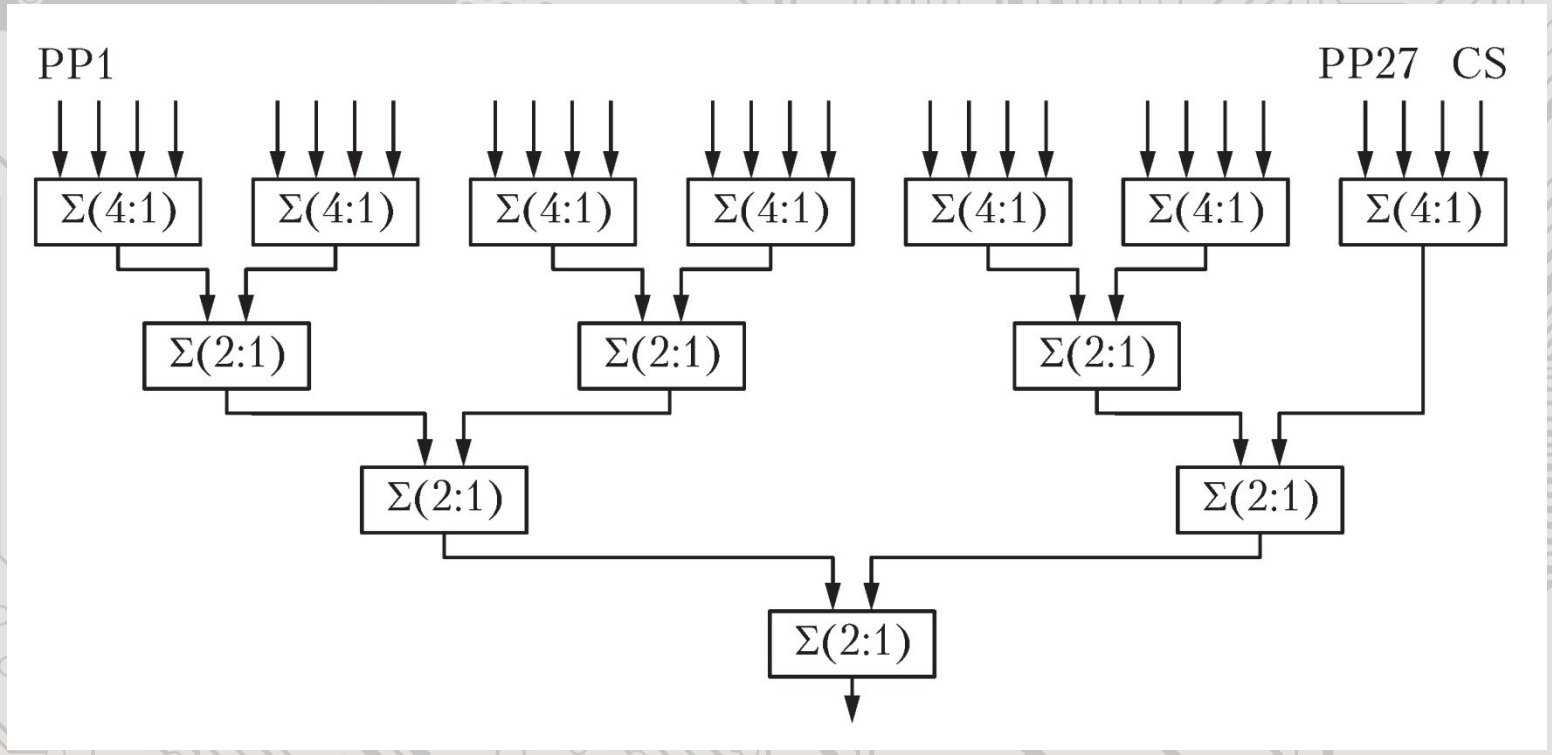


48 CMOS transistors

Dual-rail SI implementation of the Wallace tree: 7 Stages



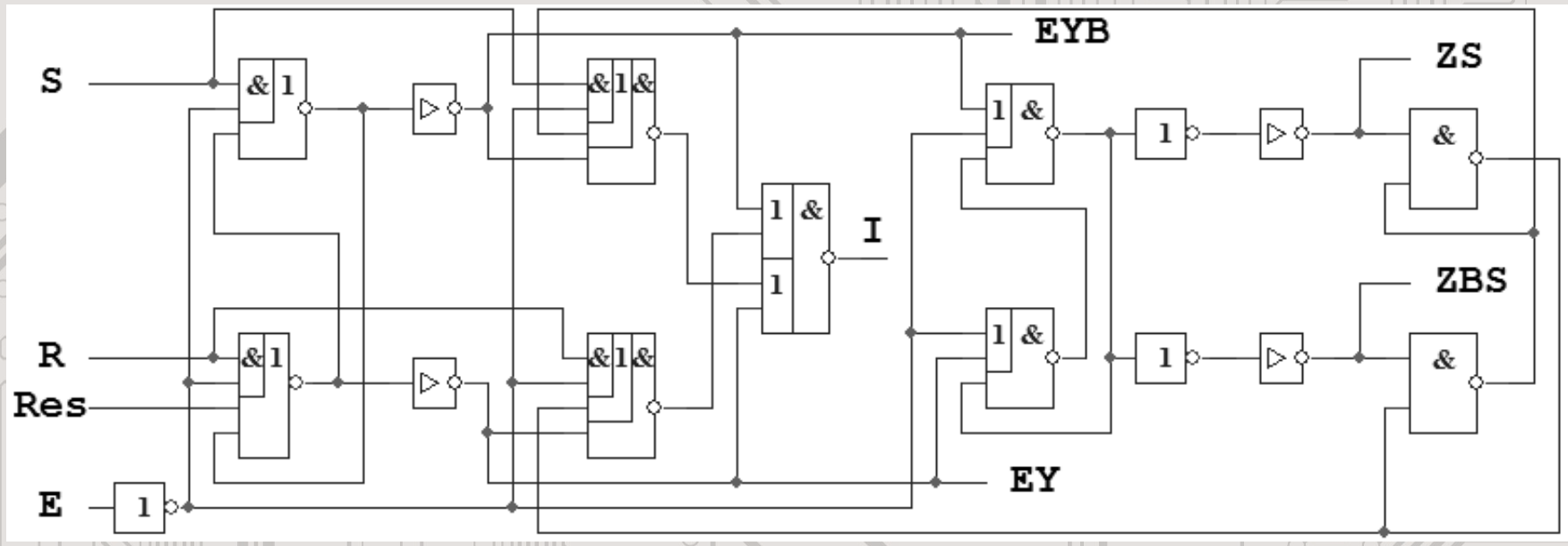
Quaternary SI implementation of the Wallace tree: 4 Stages



Acceleration techniques

- **Forced transition of the Wallace tree adders into spacer phase.**
- **Providing simultaneous switching Booth encoder together with some part of the Wallace tree layers into spacer phase and executing complete work cycle by remaining Wallace tree layers.**

Dense FIFO: Control Unit



Conclusions

- Development of the SI circuits is always a compromise between their performance and complexity. The necessity of an indication of all cells in the designed SI circuit significantly affects this compromise
- Three-stage pipeline implementation of SI multiplier provides 3 Gflops performance of the SI FMA
- Single-stage multiplier release provides the best "performance/complexity" ratio and the highest energy-efficiency
- Proposed few-stage SI FIFO on basis of SI dense shift register provides the best characteristics and higher energy-efficiency

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