CORDIC Background (2B)

- FPGA Architecture
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Please send corrections (or suggestions) to youngwlim@hotmail.com.

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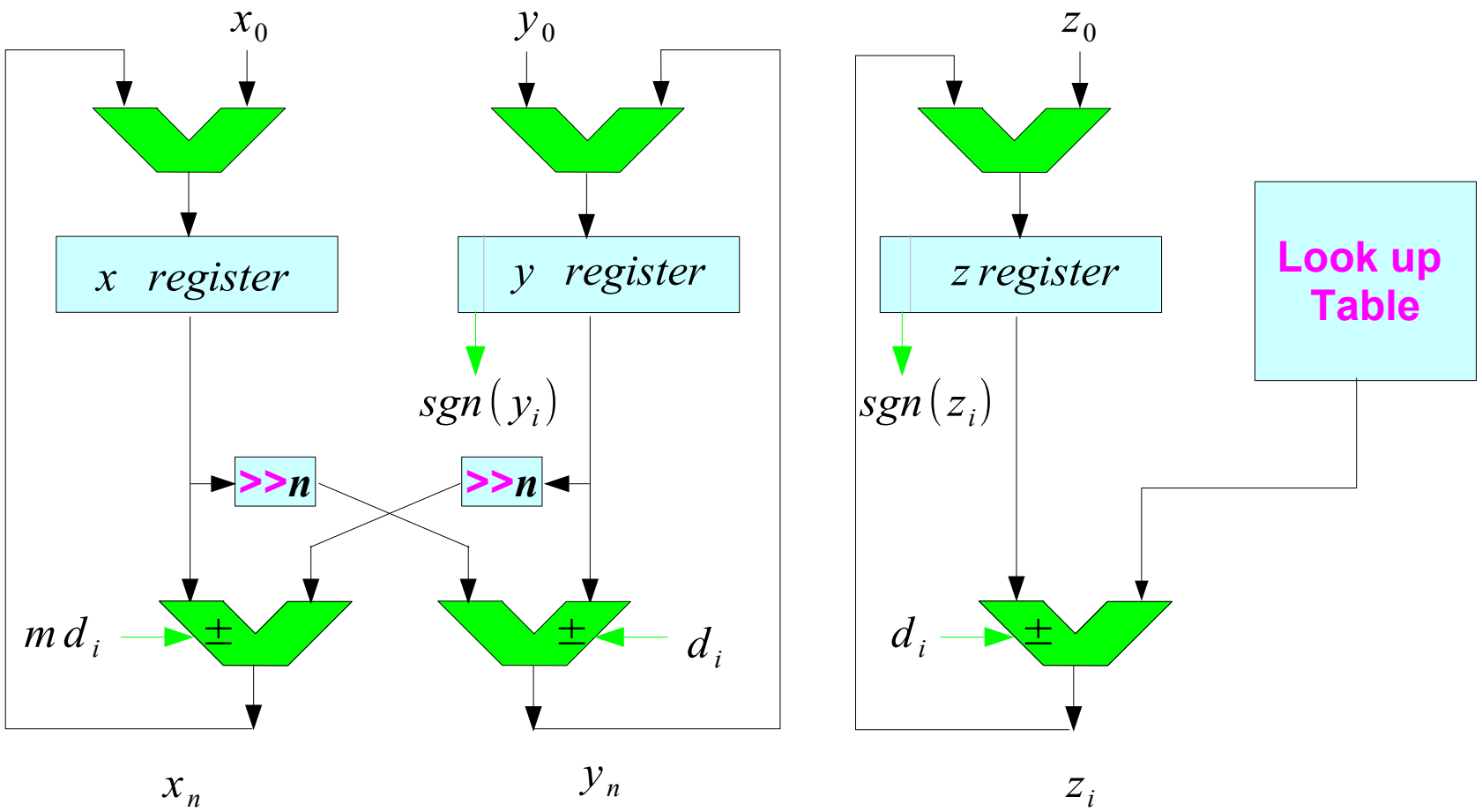
CORDIC Background

1.A survey of CORDIC algorithms for FPGAs, Ray Andraka,
www.andraka.com/cordic.htm

Bit-Parallel Iterative CORDIC Structure



Vector Rotation (2)

Decision Function d_i

In rotation mode

$$x_{i+1} = x_i - y_i \cdot d_i \cdot 2^{-i}$$
$$y_{i+1} = y_i + x_i \cdot d_i \cdot 2^{-i}$$
$$z_{i+1} = z_i - d_i \cdot \tan^{-1}(2^{-i})$$

$$d_i = -1 \quad if \quad z_i < 0$$
$$d_i = +1 \quad otherwise$$

sign of z register

In vectoring mode

$$x_{i+1} = x_i - y_i \cdot d_i \cdot 2^{-i}$$
$$y_{i+1} = y_i + x_i \cdot d_i \cdot 2^{-i}$$
$$z_{i+1} = z_i - d_i \cdot \tan^{-1}(2^{-i})$$

$$d_i = +1 \quad if \quad y_i < 0$$
$$d_i = -1 \quad otherwise$$

sign of y register

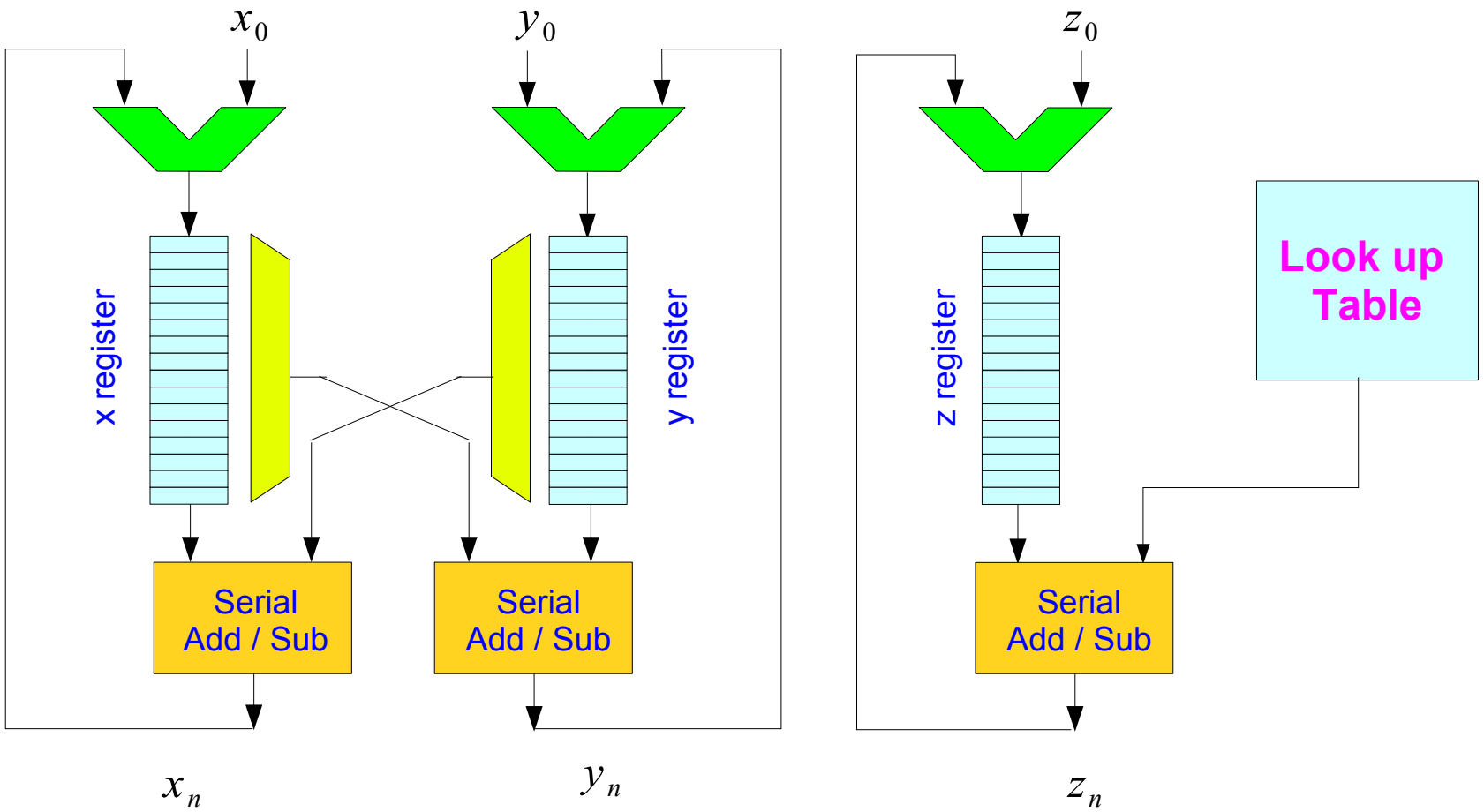
Unified CORDIC Iteration Eq

N iteration (clock cycles)
Variable Shifters
Adder- Subtractors
the amount of shift
the address of ROM LUT
the proper elementary angle
to z add/ subtractor

Bit-parallel variable shifter
Not good for FPGA
High Fan-in
→ several layers of logic
→ many cells to be traversed

- Slow design
- Large Area

Bit-Serial Iterative CORDIC Structure



Unified CORDIC Iteration Eq

$$x_{i+1} = x_i - \boldsymbol{m} \cdot y_i \cdot d_i \cdot 2^{-i}$$
$$y_{i+1} = y_i + x_i \cdot d_i \cdot 2^{-i}$$
$$z_{i+1} = z_i - d_i \cdot \boldsymbol{e}_i$$

$$\boldsymbol{m} = 1 \quad \Rightarrow \quad \boldsymbol{e}_i = \tan^{-1}(2^{-i})$$
$$\boldsymbol{m} = 0 \quad \Rightarrow \quad \boldsymbol{e}_i = (2^{-i})$$
$$\boldsymbol{m} = -1 \quad \Rightarrow \quad \boldsymbol{e}_i = \mathbf{tanh}^{-1}(2^{-i})$$

$$\mathbf{cosh}\, i\,x = \frac{1}{2}(e^{ix} + e^{-ix}) = \cos x \qquad \mathbf{cosh}\, x = \frac{1}{2}(e^{x} + e^{-x}) = \cos i\,x$$

$$\mathbf{sinh}\, i\,x = \frac{1}{2}(e^{ix} - e^{-ix}) = i\,\sin x \qquad \mathbf{sinh}\, x = \frac{1}{2}(e^{x} - e^{-x}) = -i\,\sin ix$$

$$\mathbf{tanh}\, i\,x = \frac{(e^{ix} + e^{-ix})}{(e^{ix} - e^{-ix})} = i\,\tan x \qquad \mathbf{tanh}\, x = \frac{(e^{x} + e^{-x})}{(e^{x} - e^{-x})} = -i\,\tan i\,x$$

Unified CORDIC Iteration Eq

References

[1] http://en.wikipedia.org/
[2] CORDIC FAQ, www.dspguru.com
[3] R. Andraka, A survey of CORDIC algorithms for FPGA based computers
[4] J. S. Walther, A Unified Algorithm for Elementary Functions