UNC CHARLOTTE

CORDIC: An Efficient Trigonometric Algorithm for Embedded Systems

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Introduction

- CORDIC, is an acronym for **CO**ordinate **R**otation **DI**gital **C**omputer.
- These algorithms are a class of iterative solutions for trigonometric and other transcendental functions that use only shifts and adds.
- The trigonometric functions are based on vector rotations.

Introduction Cont'd….

The CORDIC algorithm has found its way into diverse applications,

- Ø 8087 math coprocessor ,
- Ø The HP-35 calculator,
- Ø Radar signal processors,
- Ø Robotics,
- Ø Computing Discrete Fourier,
- Ø Discrete Cosine,
- Ø Discrete Hartley and Chirp-Z Transforms,
- Ø Filtering.

CORDIC THEORY

A general rotation transformation is given as,

$$x' = x\cos\phi - y\sin\phi$$
$$y' = y\cos\phi + x\sin\phi$$

Which rotates a vector in a cartesian plane by the angle Φ,

$$x' = \cos\phi \cdot [x - y\tan\phi]$$
$$y' = \cos\phi \cdot [y + x\tan\phi]$$

Taking $\Phi = 2^{-i}$, we get,

$$x_{i+1} = K_i[x_i - y_i \cdot d_i \cdot 2^{-i}]$$
$$y_{i+1} = K_i[y_i + x_i \cdot d_i \cdot 2^{-i}]$$

where:

$$K_i = \cos(\tan^{-1} 2^{-i}) = 1/\sqrt{1+2^{-2i}}$$
$$d_i = \pm 1$$

CORDIC THEORY Cont'd….

The factor A_n, can be used to start of the iteration.

$$A_n = \prod_n \sqrt{1+2^{-2i}}$$

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

where

d_i = -1 if $z_i < 0$, +1 otherwise

CORDIC THEORY Cont'd….

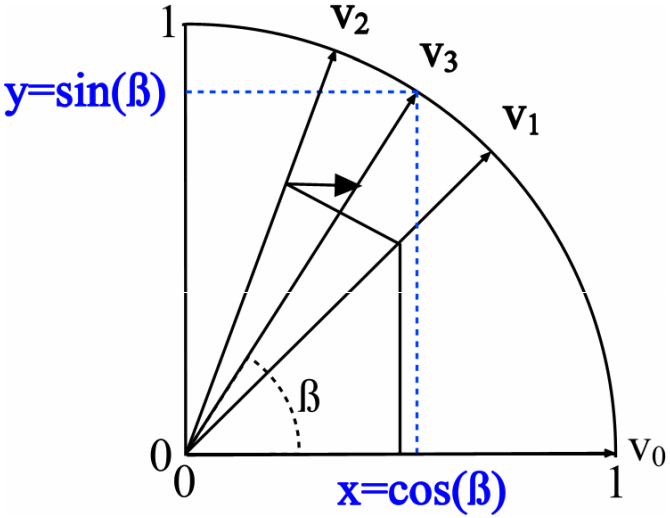

Figure 1: Step by step iteration

Hardware Block Diagram

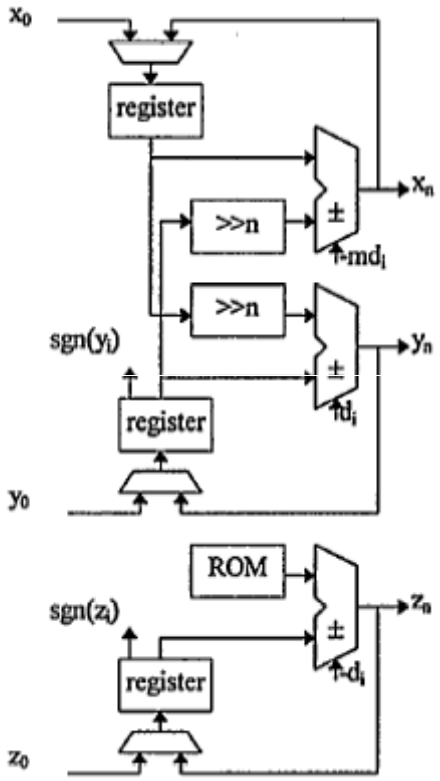

Figure 2: Iterative CORDIC Structure

Code Stamps on a Renesas MC62P

With Math Library

```
DATA        0002424(00978H) Byte(s)
ROMDATA     0000418(001A2H) Byte(s)
CODE        0008416(020E0H) Byte(s)
```

CORDIC Implementation

```
DATA        0002880(00B40H) Byte(s)
ROMDATA     0000404(00194H) Byte(s)
CODE        0003273(00CC9H) Byte(s)
```

Pros and Cons

- CORDIC is a iterative based approach with just shifts, adds and table look-up.
- It is commonly used when no hardware multiplier is available.
- CORDIC is particularly well-suited for handheld calculators, an application for which cost (i.e., chip gate count has to be minimized) is much more important than is speed

Pros and Cons Cont'd …..

When a hardware multiplier is available (e.g. in a DSP microprocessor), table-lookup methods and power series are generally faster than CORDIC.