Magnitude Estimator using CORDIC README

Peimin Chi

Block Functionality

The Magnitude block takes real and imaginary components of a complex number as inputs and estimates the magnitude based on CORDIC rotations.

Block Interface

Input Word Length: Total number of bits of inputs. (X and Y are assumed to have the same format.)

Binary Point: Number of fraction bits for inputs.

Number of stages: User can choose either 2, 3, or 4 rotation stages. (see Figure 1 for normalized error plot.)

Scaling Factor

Since CORDIC does pseudo-rotation instead of ideal rotation, the resulting magnitude is also scaled by a constant factor. The factors is

$$K = \prod_{i=1}^{N\_stage} \sqrt{1+\tan^2(\text{angle}_i)} = \prod_{i=1}^{N\_stage} \sqrt{1+2^{2(1-i)}}$$

For the available choices of stages, the factors are listed in Table 1.

Stages	Scaling Factor
2	1.5811
3	1.6298
4	1.6425

Table 1 Scaling Factors

How Many Stages to Choose

The number of stages to choose depends on the accuracy of the result required. Figure 1 plots the normalized error of estimation for different stages. It is clear from

Figure 1 that at some particular angles, the normalized error becomes biggest. For example, for a CORDIC with only one stage, large error occurs at -180^o, -90^o, 0^o, 90^o, 180^o. This observation can be explained with the following reasoning. With one stage CORDIC amplitude estimator, the input vector has to be rotated by either 45^o or -45^o. For a vector whose phase is one of the above angles, this one time rotation produces a resultant vector that has the greatest Euclidean distance from the original vector. For instance, if the input is $[1\ 0]^T$, we could estimate the amplitude by just reading the x value without doing any rotation. However, CORDIC blindly rotates the input to $\left[\frac{\sqrt{2}}{2}\ \ \frac{\sqrt{2}}{2}\right]^T$ (after scaling correction), therefore the greatest error. It is also interesting to see that for certain input angles, the estimation is perfect due to the same reason explained above. For a one stage CORDIC, the angles of zero estimation error are -135^o, -45^o, 45^o, 135^o.

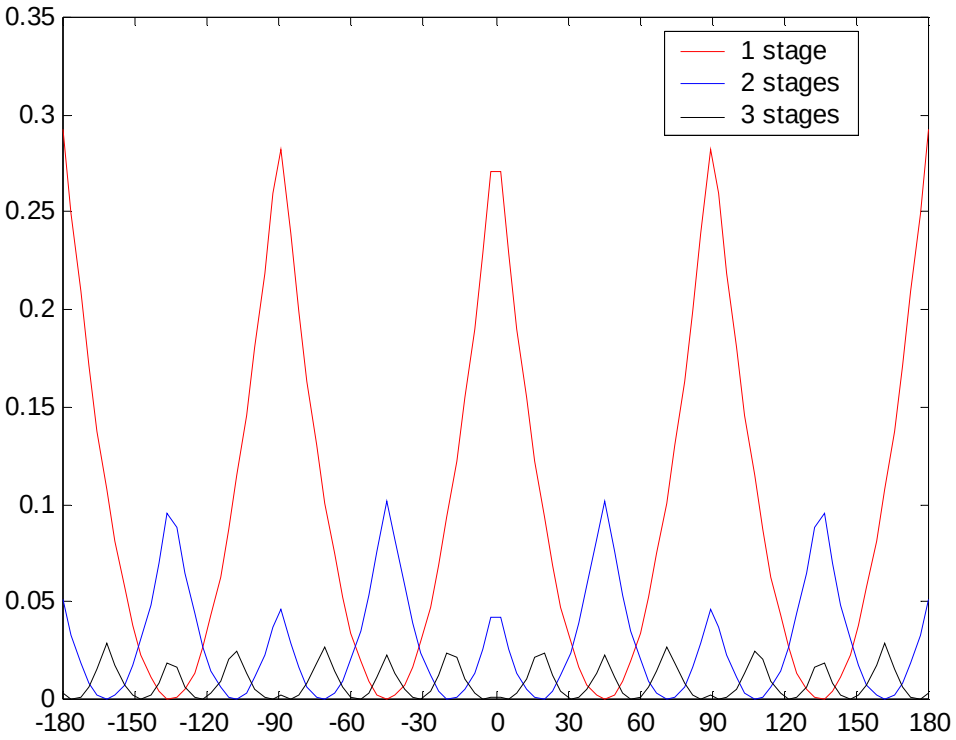

Figure 1 Normalized Amplitude Estimation Error for CORDIC