# Datapath – Trigonometric Overview

**DesignWare**
*Foundation*
**Building Blocks**

The trigonometric IP, many of which can be inferred, are applicable to ASIC or SoC designs. These IP are high performance trigonometric implementations (based on a fast carry look-ahead architecture).

## Related Topics

For a listing of Building Block components and associated datasheets, see:

- DesignWare Building Block IP Documentation Overview

## Theory of Operation

DW_sincos performs the sine or cosine of $\pi$ times the input angle A. If the control signal SIN_COS port is LOW, DW_sincos calculates $\sin(\pi A)$. If SIN_COS port is HIGH, DW02_sincos calculates $\cos(\pi A)$.

The input angle A is treated as a binary fixed point number which is a binary subdivision of the range $0 \leq A < 2$ (unsigned) or the range $-1 \leq A < 1$ (signed). It does not matter whether the input is signed or unsigned because the sine or cosine from $-\pi$ to zero is the same as it is from $\pi$ to $2\pi$.

The sine function can be converted to the cosine function because of the following:

$$\cos(\pi A) = \sin\left(\pi A - \frac{\pi}{2}\right) = \sin\left(\pi\left(A - \frac{1}{2}\right)\right)$$

Parameter A_width is the width of input angle A. It can have a value of 2 to 34.

Therefore, if SIN_COS = 0, then
$$A[A\_width-1:A\_width-2] = A[A\_width-1:A\_width-2]-1$$

If $A[A\_width-2] = 1$, then $A[A\_width-3:0] = -A[A\_width-3:0]$

Now, if $A[A\_width-1]$ xor $A[A\_width-2] = 1$, then set a change_sign bit.

The problem has been reduced to a quarter-wave cosine function, where $0 \leq A < 1/2$.

If A_width $\leq$ 8, then the quarter-wave cosine function is directly decoded from $A[A\_width-3:0]$.

Else, if `A_width > 8`, there are three cases as follows:

- `wave_width ≤ 16`
  Perform a linear interpolation of the quarter-wave cosine as 64 straight-line segments.

- `16 < wave_width ≤ 24`
  Perform a quadratic polynomial interpolation of the quarter-wave cosine as 64 second-order equation curve segments.

- `24 < wave_width ≤ 34`
  Perform a cubic polynomial interpolation of the quarter-wave cosine as 64 third-order equation curve segments.

Finally, if `change_sign` was set, the answer is negated.

## Related Topics

- DesignWare Building Block IP Documentation Overview

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