

The Digital Forest

Part 3: Oracle of Stars

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Story

As you journey further into the **Digital Forest**, you come across a towering structure known as the **Oracle of Stars**. This ancient device was designed to predict the celestial movements that guide the forest's creatures through the seasons. However, its computational core has long since deteriorated, leaving the stars' paths unwritten.

The Oracle tasks you with restoring its ability to compute complex astronomical calculations, starting with the foundational **cosine values**, which are essential to predicting the movements of celestial bodies.

As you set out to repair the **Oracle of Stars**, you instinctively reach for your trusty Python script to quickly calculate the **cosine values**. But before you can type a single line of code, a radiant figure appears—a guardian spirit of the **Digital Forest**.

"Foolish mortal!" the spirit declares. "This is the realm of hardware purity. In the Digital Forest, the use of Python, C, or any high-level programming language is strictly forbidden. To restore the Oracle's power, you must prove your worth by designing the computation in pure hardware description language, without relying on the conveniences of modern software. Only then will the Oracle regain its celestial insight!"

With your Python script banished and no shortcuts in sight, you must rely on your mastery of FPGA design to accomplish the task. The fate of the Oracle—and the Digital Forest—rests on your ability to compute **cosine values** with nothing but Verilog and determination.

Mission Objectives

Design an FPGA-based system to calculate **cosine values**. **Pre-designed or vendor-provided IP cores are not allowed.**

Computation Logic

1. Input Number:

- The input angle is provided as a 16-bit unsigned integer using **Switches[15]** to **Switches[0]**.
- The 16 switches represent values from 0 to $2^{16}-1$.

- These values correspond to angles from 0 degrees to 360 degrees, where the input value 0 maps to 0 **degrees** and $2^{16}-1$ maps to 360 **degrees**. Intermediate values are linearly scaled.

2. Cosine Calculation:

- Use a **Taylor series approximation** or a **CORDIC** algorithm to compute the cosine value.

3. Button-Triggered Calculation:

- A **Button[0]** press initiates the cosine calculation.
- Once the calculation is complete, the result is displayed on the seven-segment display.

4. Output Results:

- The computed cosine value is displayed on the **seven-segment display** with a precision of three decimal places (e.g., 0.001).
- For example, an input of 90 degrees would result in a display of 0.000, and an input of 60 degrees would display 0.500.

Constraints

- All the specified logic must be implemented on an FPGA development board using a hardware description language (HDL) without using any vendor-specific IP cores or external libraries.
- The implementation should use **switches** and **button** as input devices, **seven-segment displays** as output devices.

Challenge Yourself

The **Oracle of Stars** has placed its trust in you to restore its computational core and rekindle its celestial wisdom. By accurately calculating the cosine of the given angle, you will ensure that the creatures of the forest can once again navigate by the light of the stars.

This is no ordinary task—it is a trial of precision, efficiency, and your mastery of FPGA design. Rise to the challenge, and let the light of your ingenuity shine as brightly as the stars above. The fate of the Digital Forest’s harmony rests in your hands!