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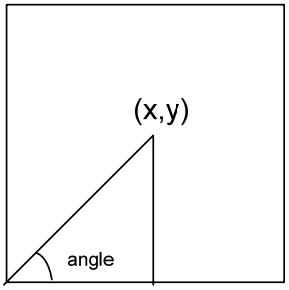
VHDL Homework #2

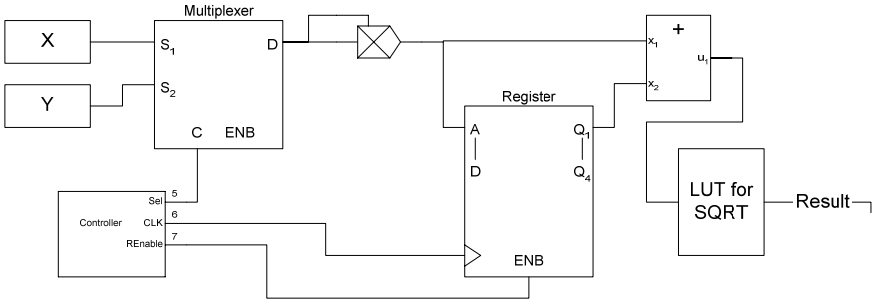
Problem Statement

For computer vision, it is sometimes necessary to calculate the length of a vector. Hardware implementation of such a calculation will enable significant performance improvement over a software approach.



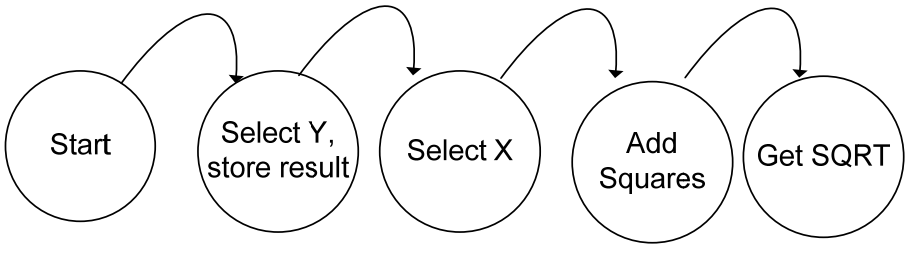
We note that the length of the vector from the origin to the point (x,y) is defined by the Pythagorean theorem: $h = \sqrt{x^2 + y^2}$

Hardware Block Diagram



Here we are computing the sum of squares and then using a lookup table to compute the square root of the sum.

Controller State machine

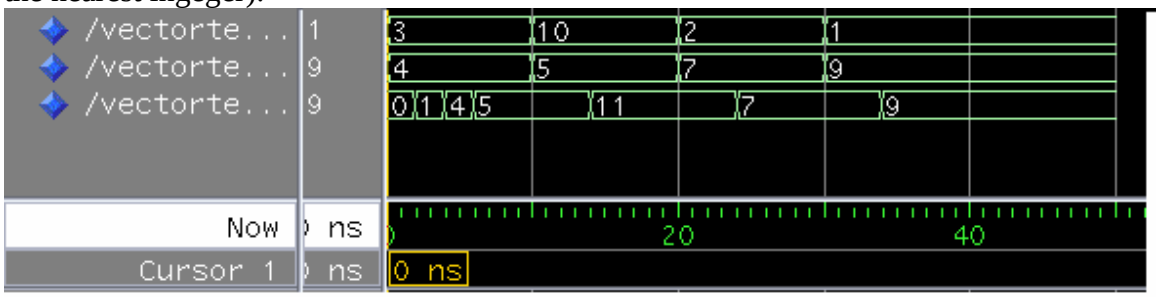


VHDL Implementation

```
entity VectorLength is
            port(XIn: in integer :=0;
                YIn: in integer:=0;
                Distance: out integer:=0);
--
end VectorLength;

architecture behavior of VectorLength is

    signal sel:bit :='0';   --Initialize variables
    signal isq: integer:=0;
    signal ysq: integer:=0;
    signal renable: bit:='0';
    signal sqsum: integer:=0;

    TYPE LU_TABLE is array(0 to 199) of real;

   --Implement the LUT for square roots less than 14.12
   CONSTANT SQRT: LU_TABLE := (1.0,1.414213562,1.732050808,
   2.0,2.236067977,2.449489743,2.645751311,2.828427125,…
   14.0,14.03566885,14.07124728,14.10673598,14.14213562);

    begin


My_mux: process (sel,renable)           --Here is the register storage
   Begin                                --and squaring operation
      if sel='0' then
        isq <= xin *xin;
      elsif sel = '1' then
        isq <= Yin *Yin;
      end if;

      if Renable='1' then
          ysq <= isq;
      elsif Renable='0' then
          ysq <= 0;
      end if;
end process my_mux;
my_controller : process                    --Here is the state machine
   constant interval: time :=1 ns;
   begin
        sel <= '0';
        renable <= '0';
        wait for interval;
        sel <='1';
        renable <= '1';
        wait for interval;
        sqsum<=YSq +Isq;
        Distance <= integer(sqrt(sqsum));

    end process my_controller ;

end architecture behavior;
```

Results

As we can see from the timing diagram, the circuit computes the distance of a vector (to the nearest ingeger).



The first two lines are the X and Y inputs, and the third line is the distance to the origin.

Discussion

This implementation contains tradeoffs. A lookup table is fast for computing the square root, but takes up more memory as the size of the image is increased. We also see that there is some initial glitching in the circuit, which may be able to be refined.