Table of Contents

```
% Test and verification script
```

Initialization

```
% Generics
w_bits = 32;
f_bits = 16;
diff = w_bits - f_bits;
N_iterations = 3;

% Fimath properties
Fm = fimath('RoundingMethod','Nearest',...
'OverflowAction' ,'Wrap',...
 'ProductWordLength' ,w_bits,...
 'ProductFractionLength' ,f_bits,...
 'SumMode' ,'SpecifyPrecision',...
 'SumWordLength' ,w_bits,...
 'SumFractionLength' ,f_bits);
```

Read from stimulus file

```
fileID = fopen('stim.txt','r');

a = [];

% Convert fixed point bit-string to decimal value
for i = 1:100

    float = 0;
    int = 0;
    frac = 0;

line_a = fgetl(fileID);

     % Calculate integer component
     for i = 1:diff
        int = int + str2num(line_a(i))*2^(diff-i);
     end

     % Calculate fractional component
     for i = diff+1:w_bits
         frac = frac + str2num(line_a(i))/(2^(i-diff));
     end

     float = int + frac;

     % Convert to fixed-point datatype
     fixed = fi(float,0,w_bits,f_bits);

     a = [a fixed];

end
fclose(fileID);
```

Perform inverse sqrt on STIM

```
testbench = [];

y0 = 1;


% Emulate rsqrt calculation made in ModelSim
for i = 1:100

    vector = bin(a(i));

    % Count leading zeros

    check = 0;
    lzc = 0;

    for j = 1:diff
        if(vector(j) == '1')
            check = 1;
        end

        if(check == 0 && vector(j) == '0')
            lzc = lzc + 1;

        end
    end

    % Make initial guess y0
    B = w_bits - f_bits - lzc - 1;

    if(mod(B,2) == 0)
        even = 1;
    else
        even = 0;
    end

    if(even == 1)
        A = 1.5*B;
    else
        A = 1.5*B + 0.5;
    end

    Xa = bitsrl(a(i),A);
    Xb = bitsrl(a(i),B);
    Xb_dec = ufi(Xb);

    % Use 7-bit addressing to match format of LUT in simulation
    Xb = fi(Xb_dec.data,0,8,7);


    % Convert from fixed point to decimal for -3/2 power exponent
    Xb_dec = ufi(Xb);
    Xb_data = Xb_dec.data ^ -1.5;
    LUT = fi(Xb_data,0,w_bits,f_bits);


    if(even ==1)
        y0 = fi(Xa * LUT,0,w_bits,f_bits);
    else
        y0 = fi(Xa * LUT*0.7071067812,0,f_bits,f_bits);

    end

    y0 = fi(y0,0,w_bits,f_bits);

    % Update y0 using Newton's iterations
    for k = 1:N_iterations
        input_y = y0;

        y0 = fi(a(i)*y0*y0,0,w_bits,f_bits);
        y0 = fi(3-y0,0,w_bits,f_bits);
        y0 = fi(y0*input_y*0.5,0,w_bits,f_bits);
    end

    testbench = [testbench fi(y0,0,w_bits,f_bits)];



end
```

Read from ModelSIM output file

```
fileID = fopen('output.txt','r');

a = []

for i = 1:100

    float = 0;
    int = 0;
    frac = 0;
    line_a = fgetl(fileID);

     % Calculate integer component
     for i = 1:diff
        int = int + str2num(line_a(i))*2^(diff-i);
     end

     % Calculate fractional component
     for i = diff+1:w_bits
         frac = frac + str2num(line_a(i+1))/(2^(i-diff));
     end

     float = int + frac;
     fixed = fi(float,0,w_bits,f_bits);

     a = [a fixed];

end

ModelSim = a;
MATLAB = testbench;

fclose(fileID);
```

```
a =

     []
```

Verification

```
   Inputs_verified = 0;

% Compare results between ModelSim output and MATLAB emulation
for i = 1:100
   fprintf('\n')
   disp("Input: " + i + "
 --------------------------------------------")
   ModelSim_Result = bin(ModelSim(i))
   MATLAB_Result = bin(MATLAB(i))

   check = 0;
   for j = 1:w_bits
       if(ModelSim_Result(j) ~= MATLAB_Result(j))
           check = 1;
           disp('Verification failure in bit ')
           disp(w_bits-j)
       end
   end

   if(check == 0)
```

```
       disp('Verification success!')
       Inputs_verified = Inputs_verified + 1;
   end

end

Inputs_verified


Input: 1 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100001110'


MATLAB_Result =

    '00000000000000000000000100001110'

Verification success!

Input: 2 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001100100000'


MATLAB_Result =

    '00000000000000000000001100100000'

Verification success!

Input: 3 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100001001'


MATLAB_Result =

    '00000000000000000000000100001001'

Verification success!

Input: 4 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101011010'
```

```
MATLAB_Result =

    '00000000000000000000000101011010'

Verification success!

Input: 5 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000111000111'


MATLAB_Result =

    '00000000000000000000000111000111'

Verification success!

Input: 6 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101011100'


MATLAB_Result =

    '00000000000000000000000101011100'

Verification success!

Input: 7 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001111110000'


MATLAB_Result =

    '00000000000000000000001111110000'

Verification success!

Input: 8 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100011110'


MATLAB_Result =
    '00000000000000000000000100011110'

Verification success!

Input: 9 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101000101'


MATLAB_Result =

    '00000000000000000000000101000101'

Verification success!

Input: 10 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100011010'


MATLAB_Result =

    '00000000000000000000000100011010'

Verification success!

Input: 11 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001000110001'


MATLAB_Result =

    '00000000000000000000001000110001'

Verification success!

Input: 12 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000001'


MATLAB_Result =

    '00000000000000000000000100000001'
```

```
Verification success!
Input: 13 --------------------------------------------
ModelSim_Result =

    '00000000000000000000000100000100'


MATLAB_Result =

    '00000000000000000000000100000100'

Verification success!
Input: 14 --------------------------------------------
ModelSim_Result =

    '00000000000000000000000101000100'


MATLAB_Result =

    '00000000000000000000000101000100'

Verification success!
Input: 15 --------------------------------------------
ModelSim_Result =

    '00000000000000000000000100111010'


MATLAB_Result =

    '00000000000000000000000100111010'

Verification success!
Input: 16 --------------------------------------------
ModelSim_Result =

    '00000000000000000000000011111111'


MATLAB_Result =

    '00000000000000000000000011111111'

Verification success!
```

```
Input: 17 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000010'


MATLAB_Result =

    '00000000000000000000000100000010'

Verification success!

Input: 18 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000111011010'


MATLAB_Result =

    '00000000000000000000000111011010'

Verification success!

Input: 19 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100100010'


MATLAB_Result =

    '00000000000000000000000100100010'

Verification success!

Input: 20 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101110010'


MATLAB_Result =

    '00000000000000000000000101110010'

Verification success!

Input: 21 --------------------------------------------
```

```
ModelSim_Result =

    '00000000000000000000000100010101'


MATLAB_Result =

    '00000000000000000000000100010101'

Verification success!

Input: 22 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001100001010'


MATLAB_Result =

    '00000000000000000000001100001010'

Verification success!

Input: 23 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001001011100'


MATLAB_Result =

    '00000000000000000000001001011100'

Verification success!

Input: 24 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101010111'


MATLAB_Result =

    '00000000000000000000000101010111'

Verification success!

Input: 25 --------------------------------------------

ModelSim_Result =
    '00000000000000000000001001111000'


MATLAB_Result =

    '00000000000000000000001001111000'

Verification success!

Input: 26 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100110110'


MATLAB_Result =

    '00000000000000000000000100110110'

Verification success!

Input: 27 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101010110'


MATLAB_Result =

    '00000000000000000000000101010110'

Verification success!

Input: 28 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001000111110'


MATLAB_Result =

    '00000000000000000000001000111110'

Verification success!

Input: 29 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101000100'
```

```
MATLAB_Result =
    '00000000000000000000000101000100'
Verification success!
Input: 30 --------------------------------------------
ModelSim_Result =
    '00000000000000000000100000110011'

MATLAB_Result =
    '00000000000000000000100000110011'
Verification success!
Input: 31 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100010011'

MATLAB_Result =
    '00000000000000000000000100010011'
Verification success!
Input: 32 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111101'

MATLAB_Result =
    '00000000000000000000000011111101'
Verification success!
Input: 33 --------------------------------------------
ModelSim_Result =
    '00000000000000000000001001100001'
```

```
MATLAB_Result =

    '00000000000000000000001001100001'

Verification success!

Input: 34 -------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000010'


MATLAB_Result =

    '00000000000000000000000100000010'

Verification success!

Input: 35 -------------------------------------------

ModelSim_Result =

    '00000000000000000000000100010011'


MATLAB_Result =

    '00000000000000000000000100010011'

Verification success!

Input: 36 -------------------------------------------

ModelSim_Result =

    '00000000000000000000011101010101'


MATLAB_Result =

    '00000000000000000000011101010101'

Verification success!

Input: 37 -------------------------------------------

ModelSim_Result =

    '00000000000000000000000110100111'


MATLAB_Result =
    '00000000000000000000000110100111'

Verification success!

Input: 38 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100011110'


MATLAB_Result =

    '00000000000000000000000100011110'

Verification success!

Input: 39 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000110100010'


MATLAB_Result =

    '00000000000000000000000110100010'

Verification success!

Input: 40 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100001100'


MATLAB_Result =

    '00000000000000000000000100001100'

Verification success!

Input: 41 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000000'


MATLAB_Result =

    '00000000000000000000000100000000'
```

```
Verification success!
Input: 42 -------------------------------------------------
ModelSim_Result =
    '00000000000000000000000101101110'

MATLAB_Result =
    '00000000000000000000000101101110'
Verification success!
Input: 43 -------------------------------------------------
ModelSim_Result =
    '00000000000000000000000100010100'

MATLAB_Result =
    '00000000000000000000000100010100'
Verification success!
Input: 44 -------------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111011'

MATLAB_Result =
    '00000000000000000000000011111011'
Verification success!
Input: 45 -------------------------------------------------
ModelSim_Result =
    '00000000000000000000000100000011'

MATLAB_Result =
    '00000000000000000000000100000011'
Verification success!
```

```
Input: 46 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100010001'


MATLAB_Result =

    '00000000000000000000000100010001'

Verification success!

Input: 47 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100100111'


MATLAB_Result =

    '00000000000000000000000100100111'

Verification success!

Input: 48 --------------------------------------------

ModelSim_Result =

    '00000000000000000000011100101000'


MATLAB_Result =

    '00000000000000000000011100101000'

Verification success!

Input: 49 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100001100'


MATLAB_Result =

    '00000000000000000000000100001100'

Verification success!

Input: 50 --------------------------------------------
```

```
ModelSim_Result =

    '00000000000000000000000111110010'


MATLAB_Result =

    '00000000000000000000000111110010'

Verification success!
Input: 51 --------------------------------------------------
ModelSim_Result =

    '00000000000000000000000100110110'


MATLAB_Result =

    '00000000000000000000000100110110'

Verification success!
Input: 52 --------------------------------------------------
ModelSim_Result =

    '00000000000000000000000101100001'


MATLAB_Result =

    '00000000000000000000000101100001'

Verification success!
Input: 53 --------------------------------------------------
ModelSim_Result =

    '00000000000000000000000101110001'


MATLAB_Result =

    '00000000000000000000000101110001'

Verification success!
Input: 54 --------------------------------------------------
ModelSim_Result =
    '00000000000000000000000100010110'

MATLAB_Result =

    '00000000000000000000000100010110'

Verification success!

Input: 55 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101111000'

MATLAB_Result =

    '00000000000000000000000101111000'

Verification success!

Input: 56 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100010101'

MATLAB_Result =

    '00000000000000000000000100010101'

Verification success!

Input: 57 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101011100'

MATLAB_Result =

    '00000000000000000000000101011100'

Verification success!

Input: 58 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100001011'
```

```
MATLAB_Result =

    '00000000000000000000000100001011'

Verification success!

Input: 59 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000110010100'


MATLAB_Result =

    '00000000000000000000000110010100'

Verification success!

Input: 60 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001001010100'


MATLAB_Result =

    '00000000000000000000001001010100'

Verification success!

Input: 61 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000011111111'


MATLAB_Result =

    '00000000000000000000000011111111'

Verification success!

Input: 62 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000110'


MATLAB_Result =
    '00000000000000000000000100000110'
Verification success!
Input: 63 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100000100'

MATLAB_Result =
    '00000000000000000000000100000100'
Verification success!
Input: 64 --------------------------------------------
ModelSim_Result =
    '00000000000000000000010111100110'

MATLAB_Result =
    '00000000000000000000010111100110'
Verification success!
Input: 65 --------------------------------------------
ModelSim_Result =
    '00000000000000000000001100010001'

MATLAB_Result =
    '00000000000000000000001100010001'
Verification success!
Input: 66 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000101001100'

MATLAB_Result =
    '00000000000000000000000101001100'
```

```
Verification success!

Input: 67 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100000110'


MATLAB_Result =

    '00000000000000000000000100000110'

Verification success!

Input: 68 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100101100'


MATLAB_Result =

    '00000000000000000000000100101100'

Verification success!

Input: 69 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101010011'


MATLAB_Result =

    '00000000000000000000000101010011'

Verification success!

Input: 70 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001011101110'


MATLAB_Result =

    '00000000000000000000001011101110'

Verification success!
```

```
Input: 71 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000101110011'

MATLAB_Result =
    '00000000000000000000000101110011'
Verification success!
Input: 72 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000101111010'

MATLAB_Result =
    '00000000000000000000000101111010'
Verification success!
Input: 73 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100010100'

MATLAB_Result =
    '00000000000000000000000100010100'
Verification success!
Input: 74 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111100'

MATLAB_Result =
    '00000000000000000000000011111100'
Verification success!
Input: 75 --------------------------------------------
```

```
ModelSim_Result =

    '00000000000000000000001000100001'


MATLAB_Result =

    '00000000000000000000001000100001'

Verification success!

Input: 76 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101000000'


MATLAB_Result =

    '00000000000000000000000101000000'

Verification success!

Input: 77 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000111101101'


MATLAB_Result =

    '00000000000000000000000111101101'

Verification success!

Input: 78 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001101110000'


MATLAB_Result =

    '00000000000000000000001101110000'

Verification success!

Input: 79 --------------------------------------------

ModelSim_Result =
    '00000000000000000000000100001100'

MATLAB_Result =

    '00000000000000000000000100001100'

Verification success!

Input: 80 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000110011001'

MATLAB_Result =

    '00000000000000000000000110011001'

Verification success!

Input: 81 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101000100'

MATLAB_Result =

    '00000000000000000000000101000100'

Verification success!

Input: 82 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000110001011'

MATLAB_Result =

    '00000000000000000000000110001011'

Verification success!

Input: 83 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000100010110'
```

```
MATLAB_Result =
    '00000000000000000000000100010110'
Verification success!
Input: 84 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000110100010'

MATLAB_Result =
    '00000000000000000000000110100010'
Verification success!
Input: 85 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111010'

MATLAB_Result =
    '00000000000000000000000011111010'
Verification success!
Input: 86 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100011101'

MATLAB_Result =
    '00000000000000000000000100011101'
Verification success!
Input: 87 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111101'
```

```
MATLAB_Result =
    '00000000000000000000000011111101'
Verification success!
Input: 88 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000011111011'

MATLAB_Result =
    '00000000000000000000000011111011'
Verification success!
Input: 89 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000101000111'

MATLAB_Result =
    '00000000000000000000000101000111'
Verification success!
Input: 90 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100001001'

MATLAB_Result =
    '00000000000000000000000100001001'
Verification success!
Input: 91 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100011000'

MATLAB_Result =
    '00000000000000000000000100011000'

Verification success!

Input: 92 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001001001101'


MATLAB_Result =

    '00000000000000000000001001001101'

Verification success!

Input: 93 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101000110'


MATLAB_Result =

    '00000000000000000000000101000110'

Verification success!

Input: 94 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101110111'


MATLAB_Result =

    '00000000000000000000000101110111'

Verification success!

Input: 95 --------------------------------------------

ModelSim_Result =

    '00000000000000000000001010110100'


MATLAB_Result =

    '00000000000000000000001010110100'
```

```
Verification success!
Input: 96 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100001010'

MATLAB_Result =
    '00000000000000000000000100001010'
Verification success!
Input: 97 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000110010010'

MATLAB_Result =
    '00000000000000000000000110010010'
Verification success!
Input: 98 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100011111'

MATLAB_Result =
    '00000000000000000000000100011111'
Verification success!
Input: 99 --------------------------------------------
ModelSim_Result =
    '00000000000000000000000100100110'

MATLAB_Result =
    '00000000000000000000000100100110'
Verification success!
```

```
Input: 100 --------------------------------------------

ModelSim_Result =

    '00000000000000000000000101100001'


MATLAB_Result =

    '00000000000000000000000101100001'

Verification success!

Inputs_verified =

   100
```

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