

DCCDL LAB5

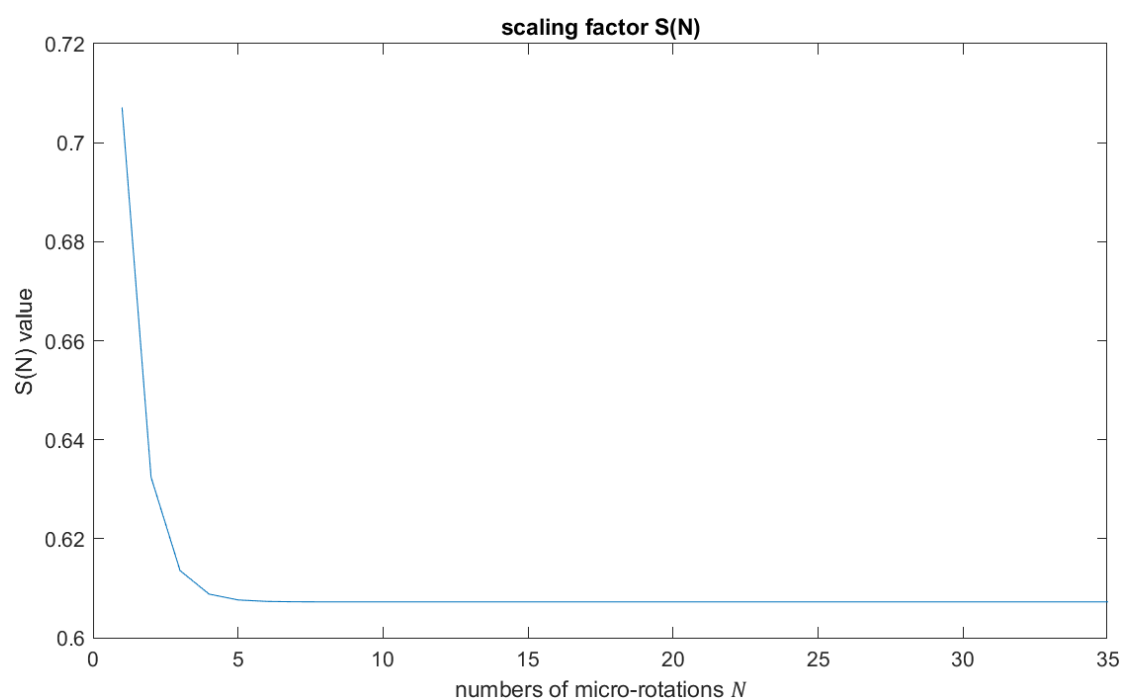
matlab

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1. Please show how you calculate the scaling factor, write down the N value that you use and the result of $S(N)$.

```
procedure.m  CSD.m  porcedures6.m  +
1  %% procedure1
2
3  format long
4
5  s_n = ones(1,35);
6  temp_2 = zeros(1,35);
7
8  for i = 1:35
9      temp_2(1,i) = 1/(sqrt(1+2^(-2*(i-1))));
10 end
11
12 for i = 1:35
13     for j= 1:i
14         s_n(1,i) = s_n(1,i)*(temp_2(1,j));
15     end
16 end
17
```

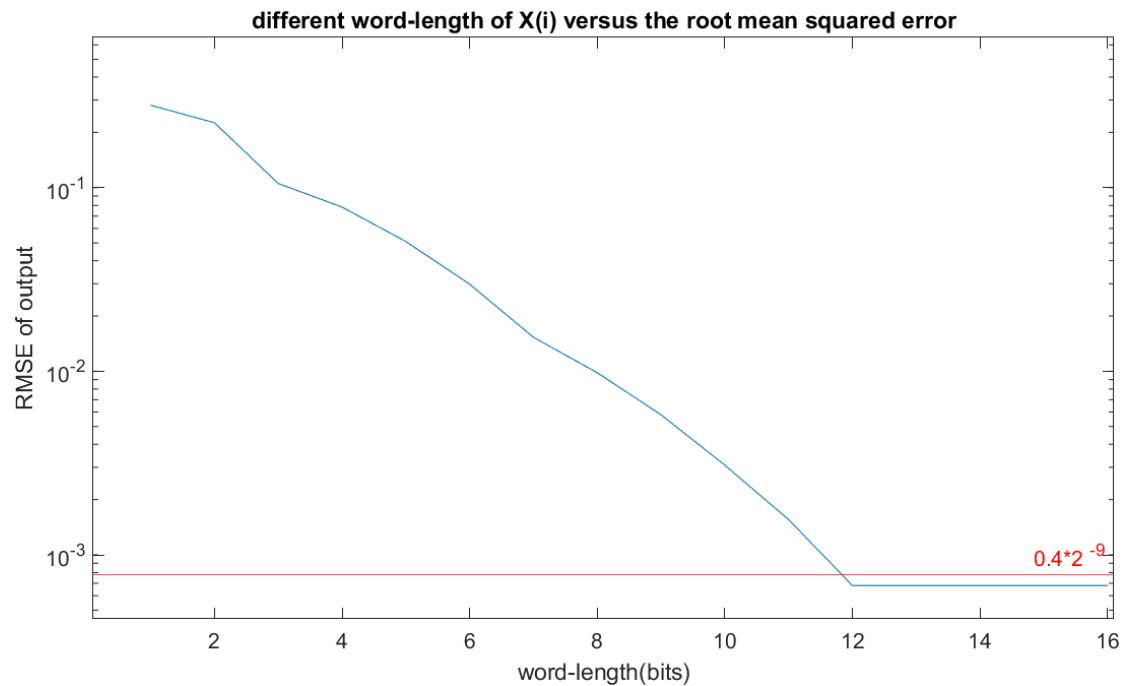
$$S(N) = \frac{1}{\prod_{i=0}^{N-1} \sqrt{1+2^{-2i}}}$$



$S(N) = [0.70710678118654746 \ 0.63245553203367577 \ 0.61357199107789628 \ 0.60883391251775243 \ \dots$
 $\ 0.60764825625616825 \ 0.607351770141296 \ \ 0.60727764409352614 \ 0.60725911229889284 \ \dots$
 $\ 0.60725447933256249 \ 0.60725332108987529 \ 0.60725303152913446 \ 0.607252959138945 \ \dots$
 $\ 0.60725294104139727 \ 0.60725293651701029 \ 0.60725293538591352 \ 0.60725293510313938 \ \dots$
 $\ 0.60725293503244582 \ 0.6072529350147724 \ 0.607252935010354 \ \ 0.60725293500924948 \ \dots$
 $\ 0.60725293500897337 \ 0.60725293500890432 \ 0.60725293500888711 \ 0.60725293500888278 \ \dots$
 $\ 0.60725293500888167 \ 0.60725293500888144 \ 0.60725293500888144 \ 0.60725293500888144 \ \dots$
 $\ 0.60725293500888144 \ 0.60725293500888144 \ 0.60725293500888144 \ 0.60725293500888144 \ \dots$
 $\ 0.60725293500888144 \ 0.60725293500888144 \ 0.60725293500888144];$

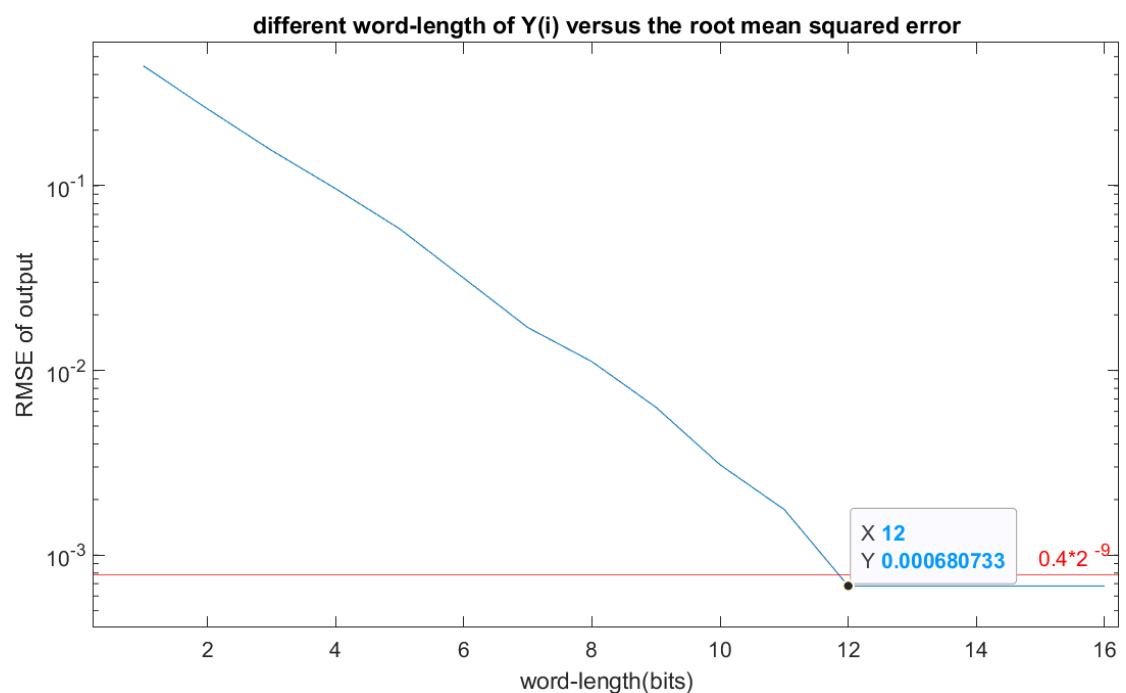
此次架構我預計使用 $N=20$ ， $S(N) = 0.60725293500924948$ 。

2. Write down the word-length of $X(i)$ and $Y(i)$ that you use. Please explain it.



word-length of $X(i)$ = S2.12, 15bits

上圖為不同的 $X(i)$ word-length 與相對應的 RMSE 的關係圖，從結果來看我將小數位定為 12bits。考慮到 $X(i)$ 成長的可能性，為防止其溢位將整數位多增加一位。



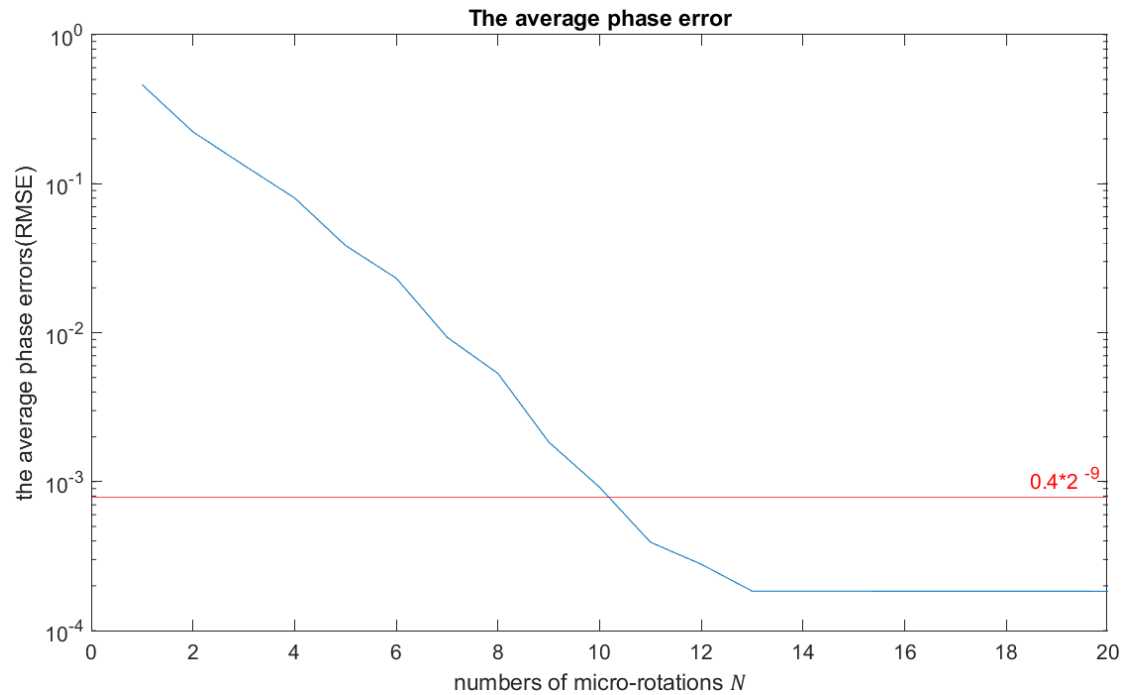
word-length of $Y(i)$ = 2.12, 15bits

上圖為不同的 $Y(i)$ word-length 與相對應的 RMSE 的關係圖，從結果來看我將小數位定為 12bits。但是在每級計算中 $Y(i)$ 皆與 $X(i)$ 做加減法，因此將其長度與 $X(i)$ 設為相同長度。

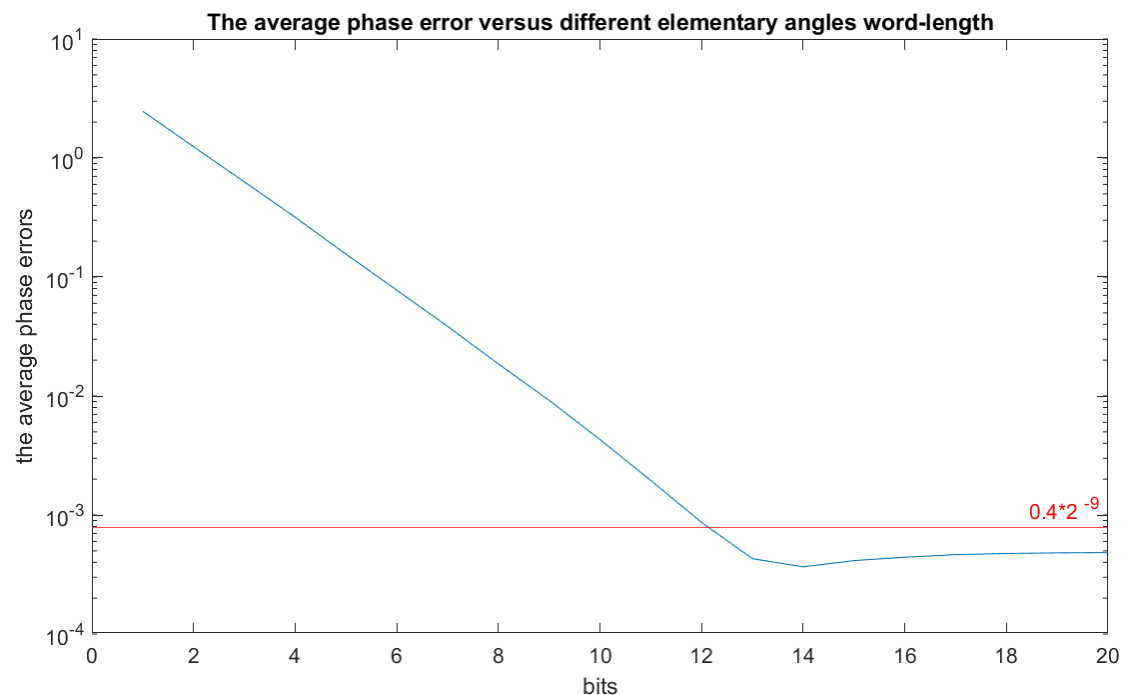
3. Please draw a figure to denote the average phase errors of 11 input pairs (X, Y) versus different numbers of micro-rotations N and draw a figure to show the resulted phase errors of 11 input pairs versus the word-length of quantized elementary angles. Explain how you determine it. Also list a table of the elementary angles (both in floating-point representation and binary fixed-point representation).

學號尾數為 5 , $\beta=2$, $a = 0.4 \times 2^{-9}$

The average phase errors of 11 input pairs (X, Y) versus different numbers of micro-rotations N :



The resulted phase errors of 11 input pairs versus the word-length of quantized elementary angles:



Elementary angle word-length: s1.13 (15bits)

Table of the elementary angles (floating-point representation):

Form $N=1 \sim N=11$, table of the elementary angles:

0.785278320312500	0.463623046875000	0.244873046875000
0.124267578125000	0.0623779296875000	0.0311279296875000
0.0155029296875000	0.00769042968750000	0.00378417968750000
0.00183105468750000	0.000854492187500000	

Table of the elementary angles (fixed-point representation):

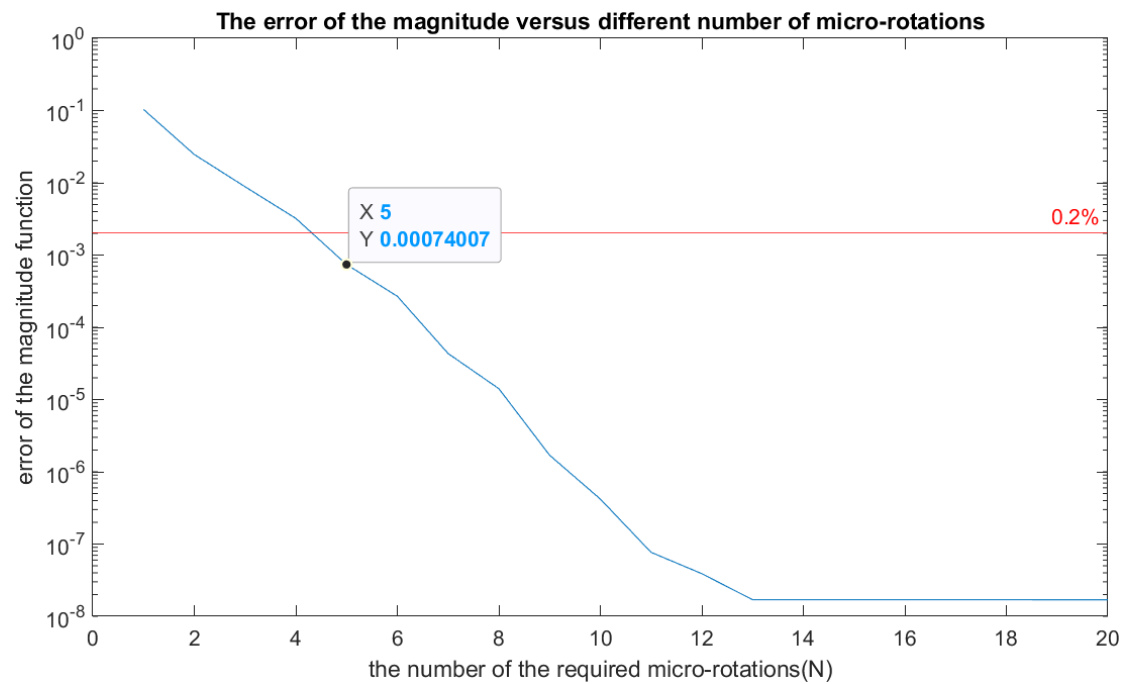
Form $N=1 \sim N=11$, word-length:16bits(s1.14), table of the elementary angles:

0.463623046875000	0.244964599609375	0.124328613281250
0.0624084472656250	0.0312194824218750	0.0155944824218750
0.00778198242187500	0.0038757324218750	0.00192260742187500
0.000946044921875000	0.0004577636718750	

Binary: ($N=1 \sim 11$)

1100100100001
0111011010110
0011111010110
0001111111010
0000111111111
0000011111111
0000001111111
0000000111111
0000000011111
0000000001111
0000000000111
0000000000011

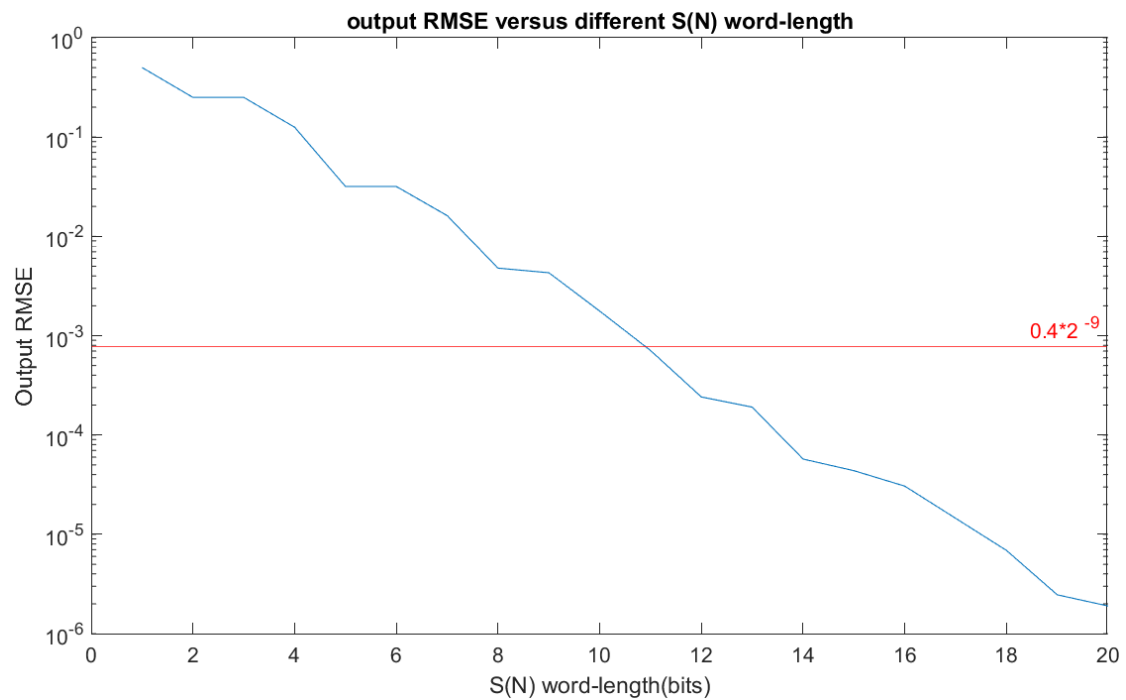
4. Please show how you decide the number of micro-rotations for the magnitude function with error tolerance of 0.2%.



Need 5 times of micro-rotations.

考慮 Q3 需要 11 次的 micro-rotations，而 Q4 只需要 5 次即可達到 magnitude error 小於容忍值的結果，因此採用 11 次 micro-rotations 的架構。

5. Write down the power-of-2 expression for the scaling factor $S(N)$. Depict your design for the shift-and-add block. (Using CSD)



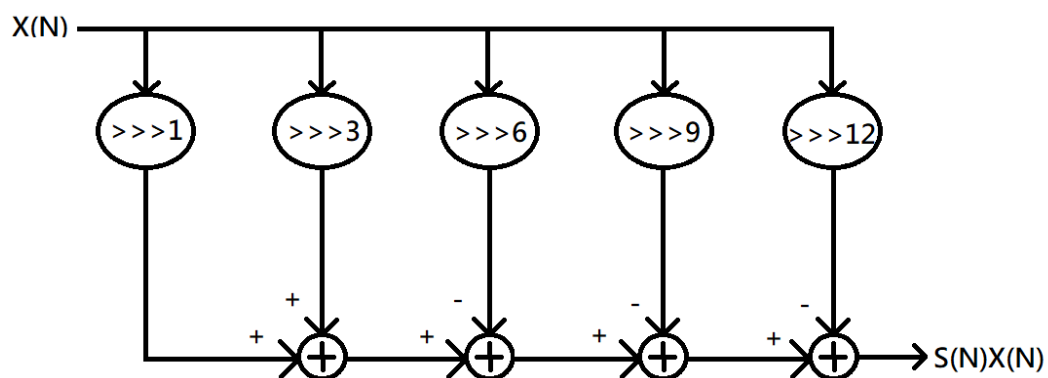
$S(N) = 0.607253031529135$;

運算時將 $S(N)$ 的 word-length 設為 $s1.12$

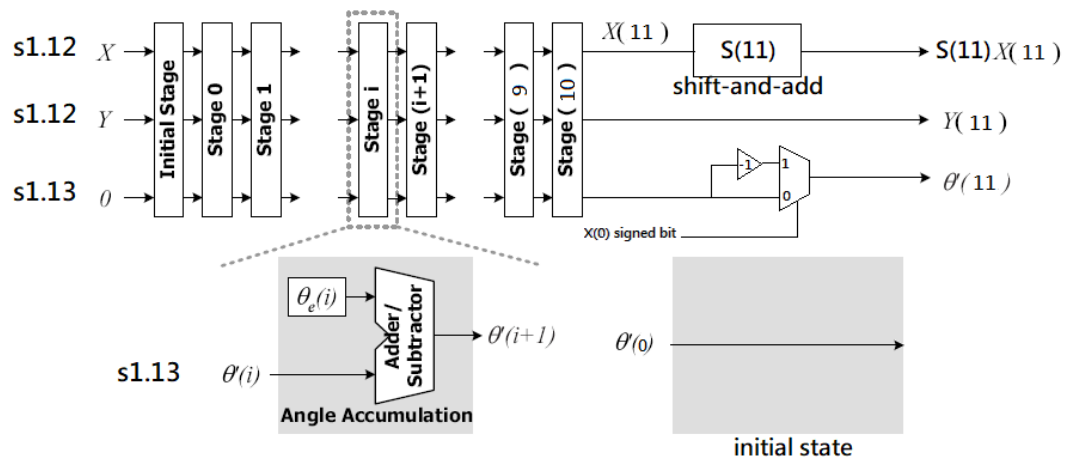
將 $S(N)$ 量化之後乘上 2^{12} 後的值為 2487

其二進位表示法為 00 1001 1011 0111

經過 CSD 運算後為 00 1010 0-100 -100-1



6. Depict your design of the complete CORDIC architecture for the arctangent function. Mark the word-length in the block diagram.



7. Depict your design of the complete CORDIC architecture for the magnitude function. Mark the word-length in the block diagram.

