Signal Processing Systems (521279S), Fall 2025
Part 3 : CORDIC algorithm
Design tasks, deadline for return Thu 20.11.2025 23:59

T1. (2.0p) Read Sec. 2 of **intro3.pdf** as a background for this subtask. Pick the angle ϕ and coordinates (x, y) assigned to your group from the table on page 3.

(a) The specified angle ϕ requires an initialization step explained in Sec. 2.2.5 of **intro3.pdf**. Perform it for your angle and coordinates. The result is the starting point for the next subtasks (b) and (c).

(b) Determine what CORDIC rotations are needed to compute the Givens transform for ϕ, when the remaining angle $|z_i|$ after iterations can be at most 0.2 degrees (4-7 iterations should be sufficient). Provide in your report a table similar to Figure 4 of the introduction ($z_0 = \phi$).

(c) Using the coordinates from initialization step as a starting point $(A_0 x_0, A_0 y_0)$, compute the intermediate coordinates $(A_i x_i, A_i y_i)$ similarly to the table in Figure 5 of **intro3.pdf**. Report just decimal values for all intermediate coordinates (bit strings do not have to be given). However, discuss how the fixed-point representation changes as i grows.

(d) What is the CORDIC gain A_N of your solution? The accuracy of the answer must be 6 decimal digits to the right of the decimal point.

(e) Check the output of the final stage in (b) by compensating for the gain A_N and comparing the result with the expected values (i.e. the values of (x', y') calculated using Equation 1 of **intro3.pdf**).

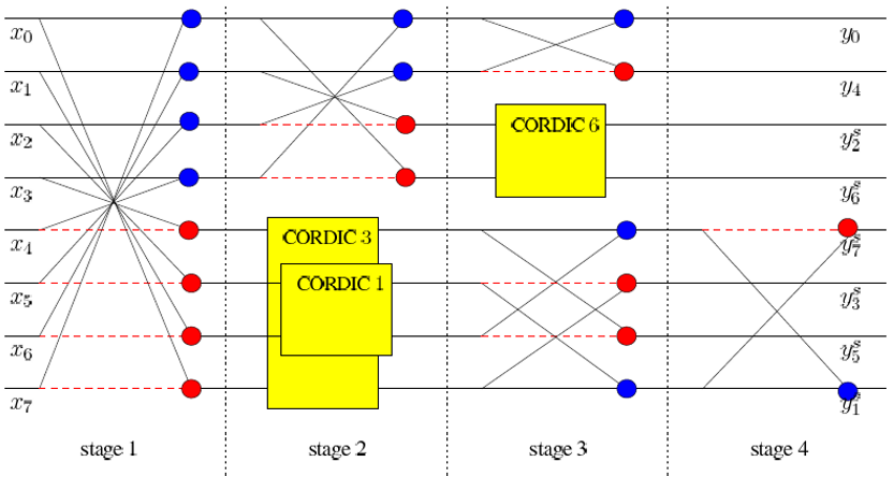
T2. (1.0p) Determine suitable parameters for a sequential CORDIC-based algorithm, which can produce samples of sine and cosine waves $sin(t)$ and $cos(t)$ at points $t = \phi_0 + n\Delta$, where $\Delta = 360/N$ (degrees) and $n = 0, 1, \ldots, N-1$. Separate values of ϕ_0 and N are given for each group in the table on page 4, and the requirement is that the absolute error of the sine and cosine value for each n is below the specified $\delta_{\max}$. Determine

- a suitable fixed-point format s$p.n$ for coordinates x_i ja y_i (p is the word length, n is the fraction length),
- a suitable fixed point format s$p.n$ for angles z_i, and
- the number of CORDIC iterations N,

which fulfill the specifications requirements. Minimize word lengths and iteration count.

Different kinds of CORDIC algorithms (see Sec. 4 "Unified CORDIC" in **intro3.pdf**) can be simulated with the Matlab function **ucordic.m** which is provided along with this handout. You can use it as a tool in T3. The file **example.m** provides an example of using it, and you can modify it for your purposes. Note: set the variable "**run_init_step**" on line 10.

T3. (1.0p) Design one CORDIC block for the simplified Loeffler structure shown below; the choice for your group is provided in the table on page 5. Determine rotations for the three-valued CORDIC, which is explained in Sec. 5 of **intro3.pdf**. Try to minimize the number of rotations, when the requirement for rotation error is $|z_i| \leq 0.2$ degrees. Compute also the CORDIC gain for your solution and provide it in the report.



Parameters for task T1 (ϕ, x, y):

Group number	ϕ [deg]	x	y
1	+156.4	2.25	2.25
2	-164.9	5.25	2.75
3	+138.6	5.25	2.25
4	+166.8	-3.25	2.00
5	+173.9	2.75	-2.75
6	-163.1	-5.00	-2.25
7	+119.0	-3.00	2.25
8	-116.8	-2.00	-2.00
9	-149.3	2.50	-2.25
10	+168.4	6.00	-2.75
11	-117.2	2.25	-2.00
12	+144.0	3.50	2.50
13	+131.3	-4.00	-3.00
14	+117.1	-4.00	-2.25
15	-131.3	-5.00	2.00
16	+115.3	-4.50	-2.75
17	-158.2	-3.00	2.50
18	+151.0	-4.75	2.25
19	-126.0	3.50	2.75
20	+163.1	3.25	2.75
21	-120.8	-4.50	-2.75
22	+159.9	4.75	2.75
23	+110.1	4.50	3.00
24	-166.7	-4.00	3.00
25	+179.2	-2.25	2.75
26	-162.9	-5.00	-2.25
27	+121.0	-3.00	2.25
28	-115.8	-2.00	-2.00
29	-149.3	2.50	-2.25
30	+168.4	6.00	-2.75

Parameters for task T2:

Group number	**Base angle** ϕ_0 [degrees]	**Number of angles** N	**Max. error** $\delta_{\max}$
1	21.0	9	1.0×10^{-4}
2	8.0	10	1.0×10^{-3}
3	10.0	9	0.5×10^{-3}
4	20.0	8	0.5×10^{-4}
5	28.0	9	0.5×10^{-4}
6	13.0	9	0.5×10^{-3}
7	26.0	8	0.5×10^{-3}
8	25.0	9	1.0×10^{-3}
9	24.0	8	0.5×10^{-4}
10	13.0	10	0.5×10^{-4}
11	16.0	8	0.5×10^{-3}
12	31.0	10	0.5×10^{-4}
13	17.0	9	1.0×10^{-3}
14	9.0	9	0.5×10^{-4}
15	27.0	8	1.0×10^{-3}
16	7.0	10	1.0×10^{-4}
17	21.0	8	1.0×10^{-4}
18	3.0	9	1.0×10^{-4}
19	6.0	10	0.5×10^{-4}
20	10.0	9	1.0×10^{-4}
21	31.0	9	0.5×10^{-3}
22	21.0	8	1.0×10^{-3}
23	23.0	8	0.5×10^{-3}
24	18.0	8	0.5×10^{-3}
25	20.0	9	0.5×10^{-4}
26	13.0	9	0.5×10^{-3}
27	26.0	8	0.5×10^{-3}
28	25.0	9	1.0×10^{-3}
29	24.0	8	0.5×10^{-4}
30	13.0	10	0.5×10^{-4}

Choice of the CORDIC block for task T3 (ϕ, x, y). Note that for "CORDIC n", the angle of rotation is $(-\pi n/16)$ radians, that is, $(-11.25 \times n)$ degrees.

Group number	**Block to design**
1	CORDIC 1
2	CORDIC 3
3	CORDIC 6
4	CORDIC 1
5	CORDIC 3
6	CORDIC 6
7	CORDIC 1
8	CORDIC 3
9	CORDIC 6
10	CORDIC 1
11	CORDIC 3
12	CORDIC 6
13	CORDIC 1
14	CORDIC 3
15	CORDIC 6
16	CORDIC 1
17	CORDIC 3
18	CORDIC 6
19	CORDIC 1
20	CORDIC 3
21	CORDIC 6
22	CORDIC 1
23	CORDIC 3
24	CORDIC 6
25	CORDIC 1
26	CORDIC 3
27	CORDIC 6
28	CORDIC 1
29	CORDIC 3
30	CORDIC 6