TI DSP, MCU 및 Xilinx Zynq FPGA
프로그래밍 전문가 과정

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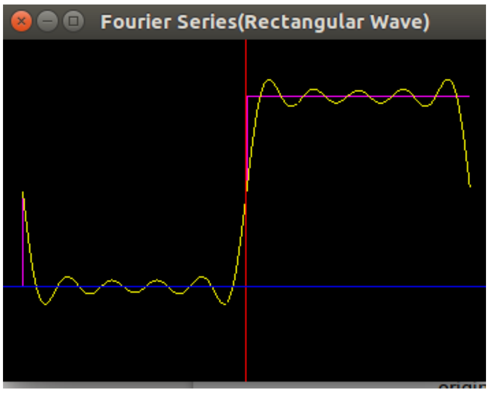
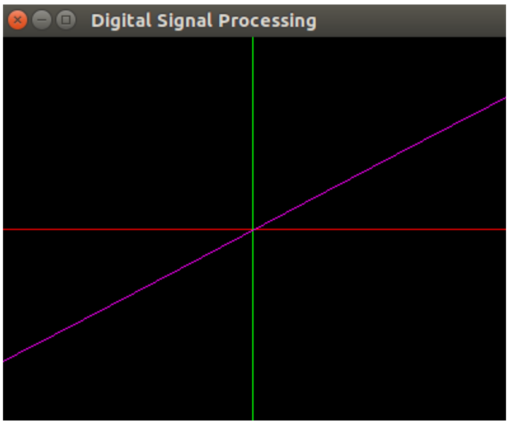
72 일차
컴파일 : gcc (파일이름) -lGL -lglut -lGLU -lm

scale_rect_wave.c



```
#include <math.h>
#include <stdio.h>
#include <stdlib.h>
#include <GL/glut.h>
#include <GL/glu.h>
#include <GL/gl.h>
#include
<GL/freeglut.h>

void originAxis(void);
void sineWave(void);
void idle(void);

void display(void)
{
        glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);

        originAxis();
        sineWave();

        glutSwapBuffers();
}

void sineWave(void)
{
        float wavelength = 2.0 * M_PI;
        float amplitude = 1;
        float inc = 2.0 * M_PI / 1024.0;
        float k, x, y, yp = 0, y2, y2p = 0, cx, cy, cy2;
        int i, cache = 0;

        glBegin(GL_LINES);
        glColor3f(1,1,0);
        for(x=-M_PI;x<=M_PI;x+=inc)
        {
                yp = 0;

                for(i = 1; i < 10; i++)
                        yp += ((1.0 - cos(i * M_PI)) / (i * M_PI)) * sin(i * x);

                y = yp + 0.5;

                if(cache)
                {
                        glVertex2f(cx, cy);
                        glVertex2f(x, y);
                }

                cache = 1;
                cx = x;
                cy = y;
        }
        glEnd();

        cache = 0;
        glBegin(GL_LINES);
        glColor3f(1,0,1);
        for(x=-M_PI;x<=M_PI;x+=inc)
        {
                yp = 0;

                for(i = 1; i < 10000; i++)
                        yp += ((1.0 - cos(i * M_PI)) / (i * M_PI)) * sin(i * x);

                y = yp + 0.5;

                if(cache)
                {
                        glVertex2f(cx, cy);
                        glVertex2f(x, y);
                }

                cache = 1;
                cx = x;
                cy = y;
        }
        glEnd();
}

void originAxis(void)
{
        glBegin(GL_LINES);
        glColor3f(0,0,1);
        glVertex3f(-100,0,0);
        glVertex3f(100, 0, 0);
        glColor3f(1,0,0);
        glVertex3f(0,-100,0);
        glVertex3f(0, 100, 0);
        glColor3f(0,0,1);
        glVertex3f(0,0,0);
        glVertex3f(0, 0, 1);
        glEnd();
}

int main(int argc, char **argv)
{
        glutInit(&argc, argv);
        glutInitDisplayMode(GLUT_RGB | GLUT_DOUBLE | GLUT_DEPTH);
        glutInitWindowSize(800, 800);
        glutCreateWindow("Fourier Series(Rectangular Wave)");

        glOrtho(-1.1 * M_PI, 1.1 * M_PI, -0.5, 1.3, -1.0, 1.0);
        glEnable(GL_DEPTH_TEST);

        glutDisplayFunc(display);
        glutMainLoop();

        return EXIT_SUCCESS;
}
```

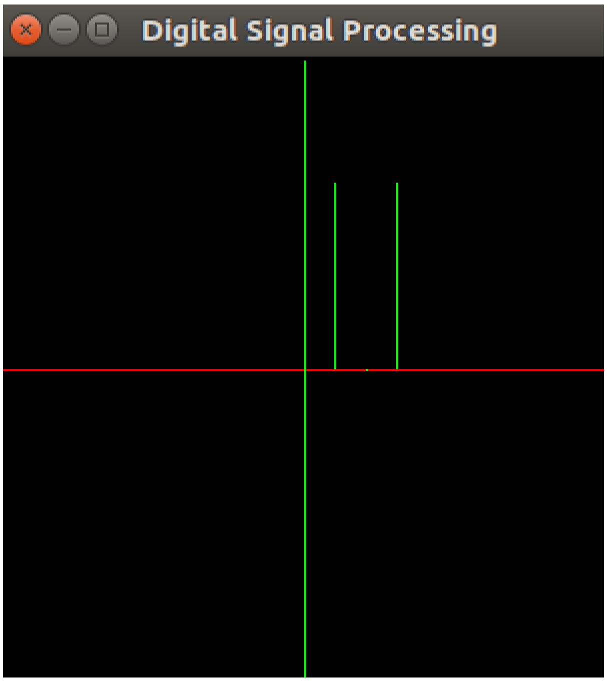
fourier_series_line.c



```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

#define _USE_MATH_DEFINES
#include <math.h>
#include <GL/glut.h>
#define SLICE       360

void rect_pulse_signal(void)
{
        float t, T = 0.01;
        float amp = 100;
        float step = 0.0;
        float omega = 2 * M_PI * 100;           // frequency = 5 Hz
        float x = 0, x2 = 0, y, cx, cy;
        int cache = 0;
        int i;

        //t = step = T / 100;
        step = T / 100;
        t = -1 * T;

        //printf("step = %f\n", step);

        if(t > T)
                t = 0.0;

        glColor3f(1.0, 0.0, 1.0);
        glBegin(GL_LINES);
        for(; ; t += step)
        {
                y = 0;

                if(t > 1 * T)
                {
                        break;
                        t = 0.0;
                }

                //y = amp * (sin(omega * t) / (omega * t));
                for(i = 1; i < 101; i++)
                        y += 100 * ((1 - cos(i * M_PI)) / (i * M_PI) * sin(i * t));

                if(cache)
                {
                        glVertex2f(cx * 6000, cy * 1);
                        glVertex2f(t * 6000, y * 1);
                }

                cache = 1;
                cx = t;
                cy = y;
                //printf("t = %f, y = %f\n", t * 6000, y * 1);
        }
        glEnd();
}
```

```
void display(void)
{
        glClearColor(0.0, 0.0, 0.0, 1.0);
        glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
        glLoadIdentity();

        //gluLookAt(0.0, 0.0, 3.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);

        glColor3f(1, 0, 0);

        glBegin(GL_LINE_LOOP);
        glVertex3f(100.0, 0.0, 0.0);
    glVertex3f(-100.0, 0.0, 0.0);
    glEnd();

    glColor3f(0.0, 1.0, 0.0);

    glBegin(GL_LINE_LOOP);
    glVertex3f(0.0, 100.0, 0.0);
    glVertex3f(0.0, -100.0, 0.0);
    glEnd();

        rect_pulse_signal();
        glutSwapBuffers();
}

void reshape(int w, int h)
{
    GLfloat n_range = 20.0f;

    if(h == 0)
        h = 1;

    glViewport(0, 0, w, h);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();

    if(w <= h)
        glOrtho(-n_range, n_range, -n_range * h / w, n_range * h / w, -n_range,
n_range);
    else
        glOrtho(-n_range * w / h, n_range * w / h, -n_range, n_range, -n_range,
n_range);

    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity();
}

void keyboard(unsigned char key, int x, int y)
{
        switch(key)
        {
                case 27:
                        exit(0);
                        break;
        }
}

int main(int argc, char **argv)
{
        glutInit(&argc, argv);
        glutInitDisplayMode(GLUT_DOUBLE);
        glutInitWindowSize(1200, 800);
        glutInitWindowPosition(0, 0);
        glutCreateWindow("Digital Signal Processing");

        glutDisplayFunc(display);
        glutReshapeFunc(reshape);
        glutMainLoop();

        return 0;
}
```

cos_dft4.c



```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>
#include <math.h>

#include <GL/glut.h>

#define SLICE       4

void draw_omega_sin(void);
void draw_spectrum(void);

float common_angles[5] = {15.0, 30.0,
45.0, 60.0, 75.0};
float freq_table[5] = {1000.0, 2400.0,
5000.0, 24000.0, 77000.0};

float theta = 0.0;

typedef struct complex
{
        float cosx[32][32];
        float isinx[32][32];
} c;

void display(void)
{
        glClearColor(0.0, 0.0, 0.0, 1.0);
        glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
        glLoadIdentity();

        //gluLookAt(0.0, 0.0, 3.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);

        glColor3f(1, 0, 0);

        glBegin(GL_LINE_LOOP);
        glVertex3f(100.0, 0.0, 0.0);
    glVertex3f(-100.0, 0.0, 0.0);
    glEnd();

    glColor3f(0.0, 1.0, 0.0);
```

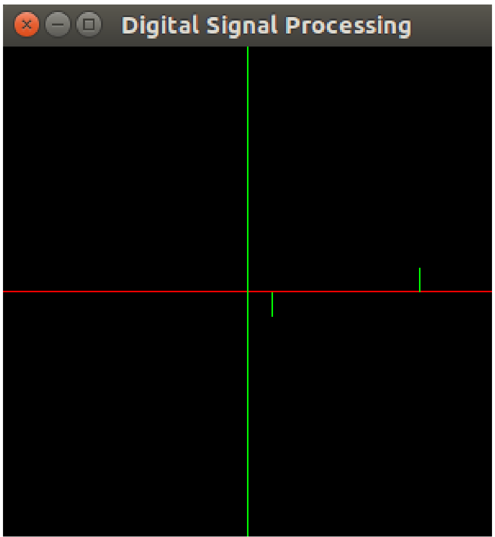
```
	glBegin(GL_LINE_LOOP);
	glVertex3f(0.0, 100.0, 0.0);
	glVertex3f(0.0, -100.0, 0.0);
	glEnd();

		//draw_omega_sin();
		draw_spectrum();
		glutSwapBuffers();
}

void reshape(int w, int h)
{
	GLfloat n_range = 100.0f;

	if(h == 0)
		h = 1;

	glViewport(0, 0, w, h);
	glMatrixMode(GL_PROJECTION);
	glLoadIdentity();

	if(w <= h)
		glOrtho(-n_range, n_range, -n_range * h / w, n_range * h / w, -n_range,
n_range);
	else
		glOrtho(-n_range * w / h, n_range * w / h, -n_range, n_range, -n_range,
n_range);

	glMatrixMode(GL_MODELVIEW);
	glLoadIdentity();
}

void keyboard(unsigned char key, int x, int y)
{
		switch(key)
		{
				case 27:
						exit(0);
						break;
		}
}

void set_rand_amplitude(float *amp)
{
		*amp = rand() % 3 + 3;
}

void set_angle_with_common_angles(float *angle)
{
		*angle = common_angles[rand() % 5];
}

void angle2radian(float *angle, float *radian)
{
		*radian = *angle * M_PI / 180.0;
}

void radian2angle(float *angle, float *radian)
{
        *angle = *radian * 180.0 / M_PI;
}

void set_rand_frequency(float *freq)
{
        *freq = freq_table[rand() % 5];
}

void calc_period(float *freq, float *period)
{
        *period = 1 / (*freq);
}

void calc_angular_velocity(float *freq, float *ang_vel)
{
        *ang_vel = 2 * M_PI * (*freq);
}

float get_step(float slice, float period)
{
        return period / slice;
}

void cos_sim(float amplitude, float ang_vel, float period)
{
        int cnt = 0;
        float step, t = 0.0;

        t = step = get_step(SLICE, period);

        while(cnt++ < 36)
        {
                printf("%.1fcos(%f * %.8f) = %f\n", amplitude, ang_vel,
                        t, amplitude * cos(ang_vel * t));
                t += step;
        }
}

void sin_sim(float amplitude, float ang_vel, float period)
{
        int cnt = 0;
        float step, t = 0.0;

        t = step = get_step(SLICE, period);

        while(cnt++ < 36)
        {
                printf("%.1fsin(%f * %.8f) = %f\n", amplitude, ang_vel,
                        t, amplitude * sin(ang_vel * t));
                t += step;
        }
}

void draw_spectrum(void)
{
        float x = 0, x2 = 0, y2, cx, cy;
        float t, step = 0.0;
        int i, j, cnt = 0, cache = 0;
        float period, freq = 100.0;
        float res_real[32] = {0};
float res_image[32] = {0};
float y[32] = {0};
c exp = {0};

calc_period(&freq, &period);
step = get_step(SLICE, period);

for(i = 0; i < SLICE; i++)
{
		for(j = 0; j < SLICE; j++)
		{
				exp.cosx[i][j] = cos(-(2 * M_PI * j * i) / SLICE);
				exp.isinx[i][j] = sin(-(2 * M_PI * j * i) / SLICE);
				printf("exp.cosx[%d][%d] = %f\n", i, j, exp.cosx[i][j]);
				//printf("exp.isinx[%d][%d] = %f\n", i, j, exp.isinx[i][j]);
		}
}

if(t > period)
		t = 0.0;

i = 0;
t = 0.0;
for(; i < SLICE; t += step)
{
		//if(t > 3 * period)
		if(t > period)
		{
				break;
				t = 0.0;
		}

		y[i] = 10 * cos(200 * M_PI * t);
		printf("y[%d] = %f\n", i++, y[i]);
		//printf("exp.cosx[%d] = %f\n", i, exp.cosx[i]);
		//printf("exp.isinx[%d] = %f\n", i, exp.isinx[i]);
		//printf("res_real[%d] = %f\n", i, res_real[i]);
		//printf("res_real = %f\n", res_real);
		//printf("res_image = %f\n", res_image);
}

for(i = 0; i < SLICE; i++)
		for(j = 0; j < SLICE; j++)
		{
				res_real[i] += y[j] * exp.cosx[i][j];
				res_image[i] += y[j] * exp.isinx[i][j];
				//printf("res_real[%d] = %f\n", i, res_real[i]);
				printf("res_image[%d] = %f\n", i, res_image[i]);
		}

//printf("OK");


for(i = 0; i < SLICE; i++)
{
		glBegin(GL_POINTS);
		glVertex2f(i * 10, res_real[i] * 3);
		//glVertex2f(i * 10, res_image[i] * 3);
		glEnd();
```

```
                glBegin(GL_LINE_STRIP);
                glVertex2f(i * 10, res_real[i] * 3);
                glVertex2f(i * 10, 0);
                //glVertex2f(i * 10, res_image[i] * 3);
                //glVertex2f(i * 10, 0);
                glEnd();
        }
#if 0
        glBegin(GL_LINE_STRIP);

        for(j = 0; j < SLICE; j++)
        {
                glVertex2f(j * 10, res_real[j] * 2);
                glVertex2f(j * 10, 0);
        }

        glEnd();
#endif
#if 0
                //if(cache && !(cnt % 16))
                if(cache)
                {
                        glBegin(GL_POINTS);
                        glVertex2f(cx * 4000, cy * 6);
                        glVertex2f(t * 4000, y2 * 6);
                        glEnd();

                        glBegin(GL_LINE_STRIP);
                        glVertex2f(t * 4000, y2 * 6);
                        glVertex2f(t * 4000, 0);
                        glEnd();
                }

                cache = 1;
                cx = t;
                cy = y2;
                cnt++;
        }
#endif
}

void draw_omega_sin(void)
{
        float amp, angle, period, freq, rad, omega, t, step = 0.0;
        float radius = 3.0;
        float x = 0, x2 = 0, y2, cx, cy;
        float tmp;
        int cnt = 0, cache = 0;

        srand(time(NULL));

        amp = 10;
        angle = 45.0;
        freq = 100.0;

        angle2radian(&angle, &rad);
        calc_period(&freq, &period);
        calc_angular_velocity(&freq, &omega);
        t = step = get_step(SLICE, period);
```

```
	printf("step = %f\n", step);

	if(t > period)
		t = 0.0;

	//glLineStipple(1, 0xFFEE);
	//glEnable(GL_LINE_STIPPLE);
	//glBegin(GL_POINTS);
	for(; ; t += step)
	{
		if(t > period)
		//if(t > 3 * period)
		{
			break;
			t = 0.0;
		}

		y2 = amp * sin(omega * t);

		if(cache && !(cnt % 16))
		{
			glBegin(GL_POINTS);
			glVertex2f(cx * 6000, cy * 6);
			glVertex2f(t * 6000, y2 * 6);
			glEnd();

			glBegin(GL_LINE_STRIP);
			//glVertex2f(cx * 4000, cy * 2);
			//glVertex2f(cx * 4000, 0);
			glVertex2f(t * 6000, y2 * 6);
			glVertex2f(t * 6000, 0);
			glEnd();
		}

		cache = 1;
		cx = t;
		cy = y2;
		cnt++;
	}
	//glEnd();
	//glDisable(GL_LINE_STIPPLE);
}

int main(int argc, char **argv)
{
	float amplitude, angle, period, frequency, radian, angular_velocity;
	float step = 0.0;

	glutInit(&argc, argv);
	glutInitDisplayMode(GLUT_DOUBLE);
	glutInitWindowSize(1200, 800);
	glutInitWindowPosition(0, 0);
	glutCreateWindow("Digital Signal Processing");

	glutDisplayFunc(display);
	glutReshapeFunc(reshape);
	glutMainLoop();

	return 0;
}
```

결과값 :

```
...
exp.cosx[0][0] = 1.000000
exp.cosx[0][1] = 1.000000
exp.cosx[0][2] = 1.000000
exp.cosx[0][3] = 1.000000
exp.cosx[1][0] = 1.000000
exp.cosx[1][1] = 0.000000
exp.cosx[1][2] = -1.000000
exp.cosx[1][3] = -0.000000
exp.cosx[2][0] = 1.000000
exp.cosx[2][1] = -1.000000
exp.cosx[2][2] = 1.000000
exp.cosx[2][3] = -1.000000
exp.cosx[3][0] = 1.000000
exp.cosx[3][1] = -0.000000
exp.cosx[3][2] = -1.000000
exp.cosx[3][3] = 0.000000
y[0] = 10.000000
y[1] = 0.000000
y[2] = -10.000000
y[3] = -0.000001
res_image[0] = 0.000000
res_image[0] = 0.000000
res_image[0] = 0.000000
res_image[0] = 0.000000
res_image[1] = 0.000000
res_image[1] = -0.000000
res_image[1] = -0.000000
res_image[1] = -0.000001
res_image[2] = 0.000000
res_image[2] = -0.000000
res_image[2] = -0.000000
res_image[2] = -0.000000
res_image[3] = 0.000000
res_image[3] = 0.000000
res_image[3] = 0.000000
res_image[3] = 0.000001
```



sine_fft8.c

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>
#include <math.h>

#include <GL/glut.h>

#define SLICE                  8
#define HALF_SLICE             (SLICE >> 1)

int glob = 4;
int count = 0;

#define TWID_FACTOR     (SLICE >> 1) + 1

typedef struct complex
{
        double re;
        double im;
} c;

void draw_omega_sin(void);
void draw_spectrum(void);

float common_angles[5] = {15.0, 30.0, 45.0, 60.0, 75.0};
float freq_table[5] = {1000.0, 2400.0, 5000.0, 24000.0, 77000.0};

float theta = 0.0;

void display(void)
{
                glClearColor(0.0, 0.0, 0.0, 1.0);
                glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
                glLoadIdentity();

                //gluLookAt(0.0, 0.0, 3.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);

                glColor3f(1, 0, 0);

                glBegin(GL_LINE_LOOP);
                glVertex3f(100.0, 0.0, 0.0);
        glVertex3f(-100.0, 0.0, 0.0);
        glEnd();

        glColor3f(0.0, 1.0, 0.0);

        glBegin(GL_LINE_LOOP);
        glVertex3f(0.0, 100.0, 0.0);
        glVertex3f(0.0, -100.0, 0.0);
        glEnd();

                //draw_omega_sin();
                draw_spectrum();
                glutSwapBuffers();
}

void reshape(int w, int h)
{
        GLfloat n_range = 100.0f;
```

```
    if(h == 0)
        h = 1;

    glViewport(0, 0, w, h);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();

    if(w <= h)
        glOrtho(-n_range, n_range, -n_range * h / w, n_range * h / w, -n_range,
n_range);
    else
        glOrtho(-n_range * w / h, n_range * w / h, -n_range, n_range, -n_range,
n_range);

    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity();
}

void keyboard(unsigned char key, int x, int y)
{
        switch(key)
        {
                case 27:
                        exit(0);
                        break;
        }
}

void set_rand_amplitude(float *amp)
{
        *amp = rand() % 3 + 3;
}

void set_angle_with_common_angles(float *angle)
{
        *angle = common_angles[rand() % 5];
}

void angle2radian(float *angle, float *radian)
{
        *radian = *angle * M_PI / 180.0;
}

void radian2angle(float *angle, float *radian)
{
        *angle = *radian * 180.0 / M_PI;
}

void set_rand_frequency(float *freq)
{
        *freq = freq_table[rand() % 5];
}

void calc_period(float *freq, float *period)
{
        *period = 1 / (*freq);
}

void calc_angular_velocity(float *freq, float *ang_vel)
```

```
{
            *ang_vel = 2 * M_PI * (*freq);
}

float get_step(float slice, float period)
{
            return period / slice;
}

void cos_sim(float amplitude, float ang_vel, float period)
{
            int cnt = 0;
            float step, t = 0.0;

            t = step = get_step(SLICE, period);

            while(cnt++ < 36)
            {
                        printf("%.1fcos(%f * %.8f) = %f\n", amplitude, ang_vel,
                                    t, amplitude * cos(ang_vel * t));
                        t += step;
            }
}

void sin_sim(float amplitude, float ang_vel, float period)
{
            int cnt = 0;
            float step, t = 0.0;

            t = step = get_step(SLICE, period);

            while(cnt++ < 36)
            {
                        printf("%.1fsin(%f * %.8f) = %f\n", amplitude, ang_vel,
                                    t, amplitude * sin(ang_vel * t));
                        t += step;
            }
}

void draw_spectrum(void)
{
            float t, step = 0.0;
            float period, freq = 100.0;

            c y[8] = {0};
      int ix;
      int ju;
      int iy;
      int i;
      double x[8] = {0};

            int tst;
      double temp_re;
      double temp_im;
      int iheight;
      int istart;
      int j;
      double twid_re;
      double dv0[5] = {0};
```

```
    double twid_im;
    double dv1[5] = {0};

    int ihi;

    calc_period(&freq, &period);
    step = get_step(SLICE, period);

    if(t > period)
        t = 0.0;

    i = 0;
    t = 0.0;
    for(; i < SLICE; t += step)
    {
        //if(t > 3 * period)
        if(t > period)
        {
            break;
            t = 0.0;
        }

        x[i] = 10 * sin(200 * M_PI * t);
        printf("x[%d] = %f\n", i++, x[i]);
        //printf("exp.cosx[%d] = %f\n", i, exp.cosx[i]);
        //printf("exp.isinx[%d] = %f\n", i, exp.isinx[i]);
        //printf("res_real[%d] = %f\n", i, res_real[i]);
        //printf("res_real = %f\n", res_real);
        //printf("res_image = %f\n", res_image);
    }

t = 0;
    step = 2 * M_PI / SLICE;

for(i = 0; i < 5; i++)
{
     dv0[i] = cos(t);
     dv1[i] = -sin(t);
     t += step;
}

    t = 0;

    ix = 0;
    ju = 0;
    iy = 0;
    printf("Before Reverse Order\n");
    for (i = 0; i < 7; i++) {
        y[iy].re = x[ix];
        y[iy].im = 0.0;

        printf("y[%d].re = %lf\t", iy, y[iy].re);
        printf("y[%d].im = %lf\n", iy, y[iy].im);

        iy = 8;
        tst = 1;
        while (tst) {
            iy >>= 1;
            ju ^= iy;
            tst = ((ju & iy) == 0);
        }

        iy = ju;
        ix++;
    }
    y[iy].re = x[ix];
    y[iy].im = 0.0;

    printf("\nAfter Reverse Order\n");
    for(i = 0; i < SLICE; i++)
    {
        printf("y[%d].re = %lf\t", i, y[i].re);
        printf("y[%d].im = %lf\n", i, y[i].im);
    }
    printf("\nN-2 First Butterfly\n");

    for (i = 0; i <= 7; i += 2) {
        temp_re = y[i + 1].re;
        temp_im = y[i + 1].im;
        y[i + 1].re = y[i].re - y[i + 1].re;
        y[i + 1].im = y[i].im - y[i + 1].im;
        y[i].re += temp_re;
        y[i].im += temp_im;

        printf("y[%d].re = %lf\t", i, y[i].re);
        printf("y[%d].im = %lf\n", i, y[i].im);
        printf("y[%d].re = %lf\t", i+1, y[i+1].re);
        printf("y[%d].im = %lf\n", i+1, y[i+1].im);
    }

    iy = 2;
    ix = 4;
    ju = 2;
    iheight = 5;
    while (ju > 0) {
        // 0 ~ 4
        printf("\nN-%d Butterfly(처음은 짝수 오더)\n", glob);
        for (i = 0; i < iheight; i += ix) {
            temp_re = y[i + iy].re;
            temp_im = y[i + iy].im;
            y[i + iy].re = y[i].re - temp_re;
            y[i + iy].im = y[i].im - temp_im;
            y[i].re += temp_re;
            y[i].im += temp_im;

            printf("y[%d].re = %lf\t", i, y[i].re);
            printf("y[%d].im = %lf\n", i, y[i].im);
            printf("y[%d].re = %lf\t", i+iy, y[i+iy].re);
            printf("y[%d].im = %lf\n", i+iy, y[i+iy].im);
        }
        printf("\n");

        istart = 1;
        printf("\nN-%d Butterfly(처음은 홀수 오더)\n", glob);
        for (j = ju; j < 4; j += ju) {
            printf("twid_re = dv0 =  cos(2 * pi * f * t / fftN 의절반)\n");
            printf("twid_im = dv1 = -sin(2 * pi * f * t / fftN 의절반)\n");
            twid_re = dv0[j];
```

```
                        twid_im = dv1[j];
                        i = istart;
                        ihi = istart + iheight;
                        while (i < ihi) {
                                temp_re = twid_re * y[i + iy].re - twid_im * y[i
+ iy].im;
                                temp_im = twid_re * y[i + iy].im + twid_im *
y[i + iy].re;
                                y[i + iy].re = y[i].re - temp_re;
                                y[i + iy].im = y[i].im - temp_im;
                                y[i].re += temp_re;
                                y[i].im += temp_im;

                                printf("y[%d].re = %lf\t", i, y[i].re /
HALF_SLICE);
                                printf("y[%d].im = %lf\n", i, y[i].im /
HALF_SLICE);
                                printf("y[%d].re = %lf\t", i+iy, y[i+iy].re /
HALF_SLICE);
                                printf("y[%d].im = %lf\n", i+iy, y[i+iy].im /
HALF_SLICE);

                                i += ix;
                        }

                        istart++;
                }

                ju /= 2;
                iy = ix;
                ix <<= 1;
                iheight -= iy;

                if(ju > 0)
                {
                        count++;
                        printf("\nFinished N-%d Butterfly\nNow Starting N-%d
Butterfly", glob, glob *= 2);
                }
                else
                        printf("\nFinished N-%d Butterfly\n", glob);
        }

        //printf("OK");

        for(i = 0; i < SLICE; i++)
        {
                glBegin(GL_LINE_STRIP);

                if(y[i].re == 0 && y[i].im == 0)
                        continue;

                glVertex2f(i * 10, y[i].re / HALF_SLICE);
                glVertex2f(i * 10, 0);

                glEnd();

                glBegin(GL_LINE_STRIP);

                glVertex2f(i * 10, y[i].im / HALF_SLICE);
```

```
		glVertex2f(i * 10, 0);

		glEnd();
	}

#if 0
		//if(cache && !(cnt % 16))
		if(cache)
		{
			glBegin(GL_POINTS);
			glVertex2f(cx * 4000, cy * 6);
			glVertex2f(t * 4000, y2 * 6);
			glEnd();

			glBegin(GL_LINE_STRIP);
			glVertex2f(t * 4000, y2 * 6);
			glVertex2f(t * 4000, 0);
			glEnd();
		}

		cache = 1;
		cx = t;
		cy = y2;
		cnt++;
	}
#endif
}

void draw_omega_sin(void)
{
	float amp, angle, period, freq, rad, omega, t, step = 0.0;
	float radius = 3.0;
	float x = 0, x2 = 0, y2, cx, cy;
	float tmp;
	int cnt = 0, cache = 0;

	srand(time(NULL));

	amp = 10;
	angle = 45.0;
	freq = 100.0;

	angle2radian(&angle, &rad);
	calc_period(&freq, &period);
	calc_angular_velocity(&freq, &omega);
	t = step = get_step(SLICE, period);

	printf("step = %f\n", step);

	if(t > period)
		t = 0.0;

	//glLineStipple(1, 0xFFEE);
	//glEnable(GL_LINE_STIPPLE);
	//glBegin(GL_POINTS);
	for(; ; t += step)
	{
		if(t > period)
		//if(t > 3 * period)
		{
```

```
                        break;
                        t = 0.0;
                }

                y2 = amp * sin(omega * t);

                if(cache && !(cnt % 16))
                {
                        glBegin(GL_POINTS);
                        glVertex2f(cx * 6000, cy * 6);
                        glVertex2f(t * 6000, y2 * 6);
                        glEnd();

                        glBegin(GL_LINE_STRIP);
                        //glVertex2f(cx * 4000, cy * 2);
                        //glVertex2f(cx * 4000, 0);
                        glVertex2f(t * 6000, y2 * 6);
                        glVertex2f(t * 6000, 0);
                        glEnd();
                }

                cache = 1;
                cx = t;
                cy = y2;
                cnt++;
        }
        //glEnd();
        //glDisable(GL_LINE_STIPPLE);
}

int main(int argc, char **argv)
{
        float amplitude, angle, period, frequency, radian, angular_velocity;
        float step = 0.0;

        glutInit(&argc, argv);
        glutInitDisplayMode(GLUT_DOUBLE);
        glutInitWindowSize(1200, 800);
        glutInitWindowPosition(0, 0);
        glutCreateWindow("Digital Signal Processing");

        glutDisplayFunc(display);
        glutReshapeFunc(reshape);
        glutMainLoop();

        return 0;
}
```