

工學碩士 學位論文

**A Study on the Development of a Sunlight Collection System
Using a Sensor Array Technique**

指導教授 金 鍾 和

2000 2

韓國海洋大學校 大學院

制御計測工學科

徐 勝 源

本 論 文 徐勝源 工學碩士 學位論文 認 准 .

委員長 工學博士 趙 爽 濟 印

委 員 工學博士 河 潤 秀 印

委 員 工學博士 金 鍾 和 印

2000 1 11

韓 國 海 洋 大 學 校 大 學 院

制 御 計 測 工 學 科 徐 勝 源

A Study on the Development of a Sunlight Collection System Using a Sensor Array Technique

Seung-Won Sue

*Department of Control & Instrumentation Engineering,
Graduate School, Korea Maritime University*

ABSTRACT

Nowadays, concerns about the discovery and the development of alternative energies are increased day by day, and naturally researches on the development of alternative energies are reported in every country of the world. Moreover, it is very important to find alternative energies in this country which has little resources. There are many types of energies which belong to alternative energy, such as solar energy, wave energy, wind energy, and so forth. Solar energy is one of the most attractive alternative energies for the future because it is clean, consistently supplied, and widely distributed throughout the earth. Especially, it has high potential to be used in this country which has much better daylights a year.

By the way, the density of the solar energy is too low to use the solar energy directly. In order to use it effectively it must be needed to comprise a system to collect the sunlight. To comprise the sunlight collection system, first of all, a solar tracking system is necessary to track the sun during daylighting.

This thesis describes a sunlight collection system during daylighting which comprises a solar tracking element, sunlight collection element, and sunlight transmitting element. The most important element of them

is the solar tracking element and this thesis proposes a new type solar tracking system which uses a full sensor method with a two-axis sensor array. And it also develops an algorithm which operates the overall system effectively. Especially, an algorithm called holding mode algorithm is developed to reduce the execution time for the real time tracking.

The developed system has the characteristic that it is applicable the place where the mounted base is moved or where the orientation is changed with time. Because the suggested solar tracking system tracks the sun only using the two-axis sensor array regardless of the information of the position.

Abstract

1	1
2	4
2.1	4
2.2	7
2.3	10
2.4	15
3	19
3.1	19
3.2	23
3.3	26
4	29
5	33
	34

1

CO₂, NO_x, SO_x 가

[1-3].

(Framework Convention on Climate Change, FCCC)

가 가 ,
2000 가 1990 [3].

(97 가 97.5% [4])

가 가 [1-3].
가

가

가 가

[1].

1m² 0.33Kcal , 가

1 4.2 × 10¹³Kcal , 30%

가 , 3 × 10¹³Kcal .

1989 1 × 10¹⁷Kcal 1

15 20%

가

[15].

[67]가

가

가

11 × 11

가

가

2

3

4

5

, , 가 .
, 가 , 가 .
.
가 .
, 가 .
가 , 가 , .
가 .
가 .
가 .
가 .

, .

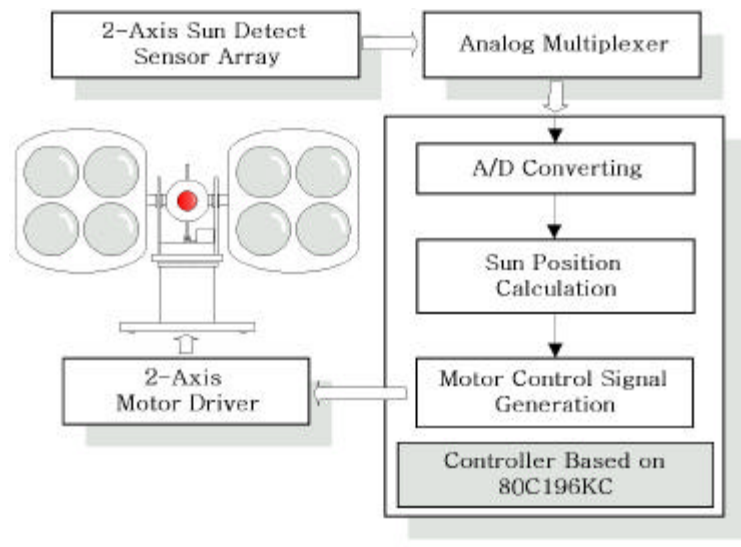
2

2
A/D

X Y DC

8 (Fresnel lens)

2.1

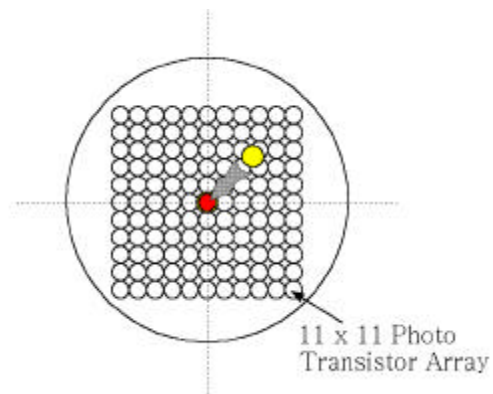


2.1

Fig 2.1 Block diagram of a sunlight collection system

2.2

4 가 ,
가
가 가
가 가
가 가
2.2 KODENSHI
ST-7L 11 x 11



2.2

Fig 2.2 Structure of a photo transistor array

가 ,

가 ,
(Dead zone)

P9

, 2.3, 2.2

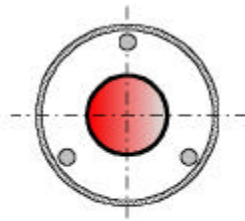
Model No : P9 lens assembly

- Focal length (mm) : 180.01
- Back focal length (mm) : 163.49
- Construction component-element : 4-4
- Illumination (%) : more than 72.6
- Barrel size (∅/length)(mm) : ∅41/41

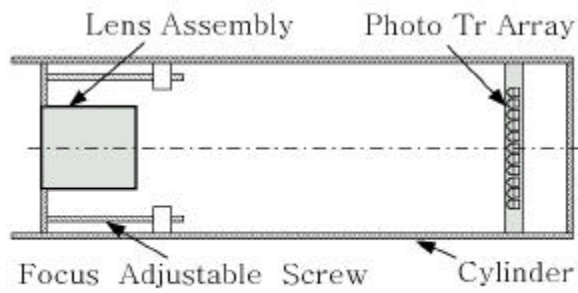


2.1

Photo 2.1 Lens assembly mounted for sensor module



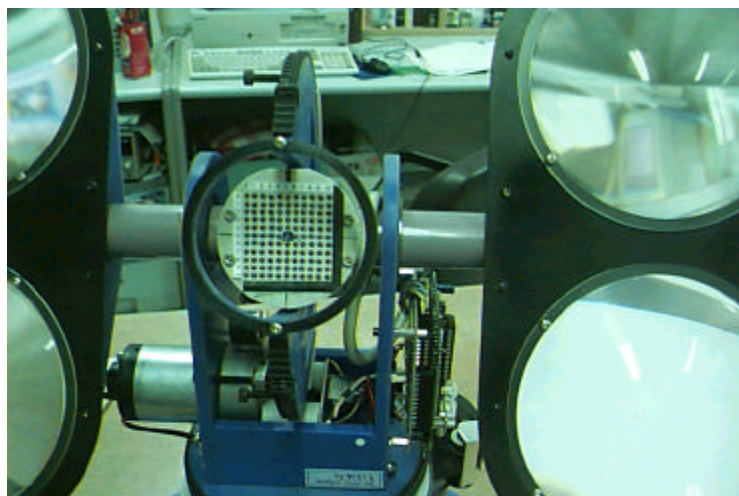
(a) Front view of sensor module



(b) Side view of sensor module

2.3

Fig 2.3 Structure of sensor module



2.2

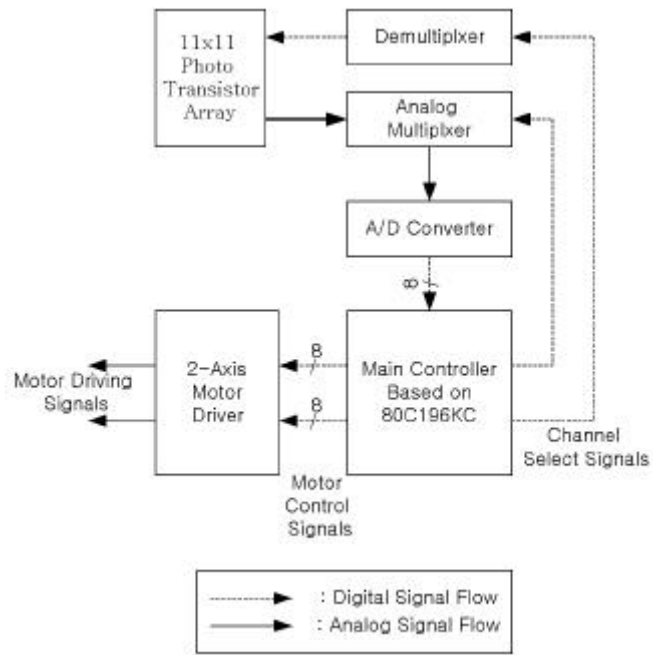
Photo 2.2 Photograph of a physical sensor module

2.3

A/D

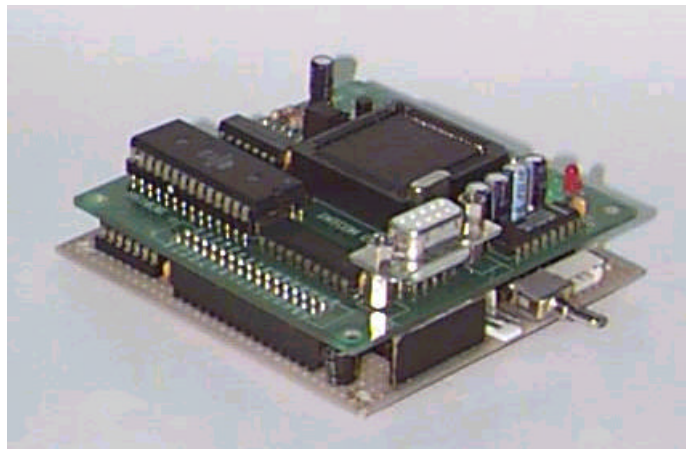
,
Intel 16
80C196KC . 8 A/D DC
PWM(Pulse Width Modulation)
20MHz , 121
15msec
가
Intel 80C196KC
- 8 I/O
- / 8/10 A/D
- PWM
- 4 16
- 1.75 μ s 16 \times 16 (16MHz)
- 8 /16
- 16 /
- 4 (HSO)
- 4 (HSI)
- 20MHz 가
- 28 /16

11 × 11
 A/D 121 A/D ,
 4 to 16 (Demultiplexer)
 74HC154 MAXIM 16 (Analog
 multiplexer) MAX396 , A/D 121
 A/D
 .
 (Angular position)
 Spectrol 10K , 10 (Potentiometer)
 10bit .
 가 , 가
 DC
 . PWM
 가 .
 2.4 80C196KC
 . 2.3
 , 2.5
 , 2.6 .



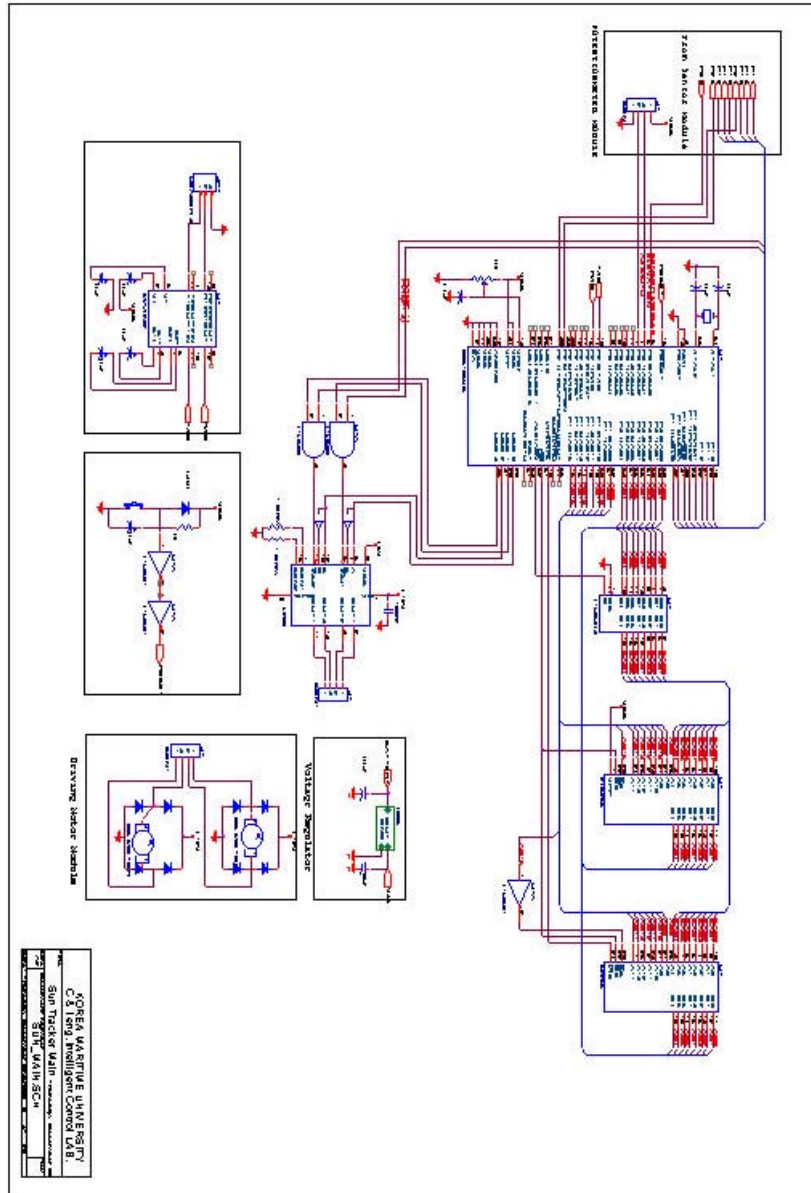
2.4 80C196KC

Fig 2.4 Configuration of 80C196KC main controller and sensor module



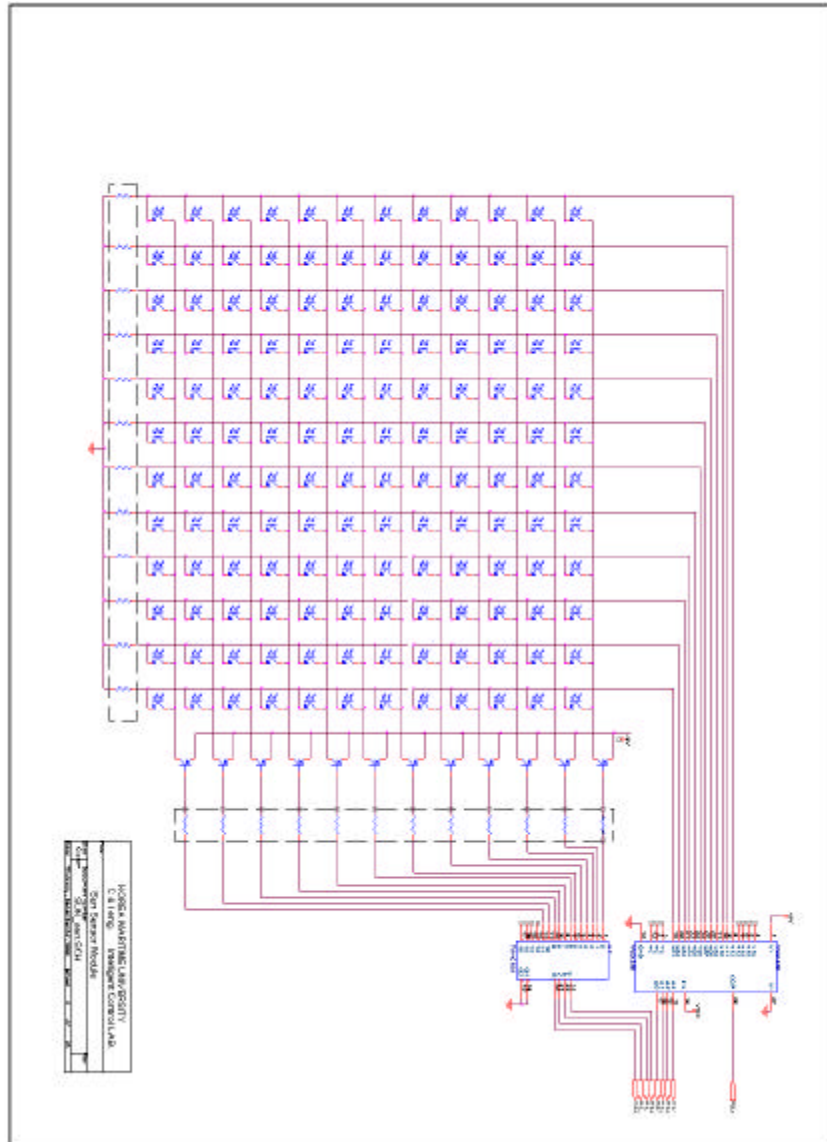
2.3

Photo 2.3 Photograph of a physical main controller



2.5

Fig 2.5 Circuit diagram of the main controller



2.6

Fig 2.6 Circuit diagram of the sensor module

$$\beta = \tan^{-1}\left(\frac{d}{f}\right) = \sin^{-1}(n \sin \alpha) - \alpha \quad (2.1)$$

f n . (Groove)
 , . (Concentration ratio)

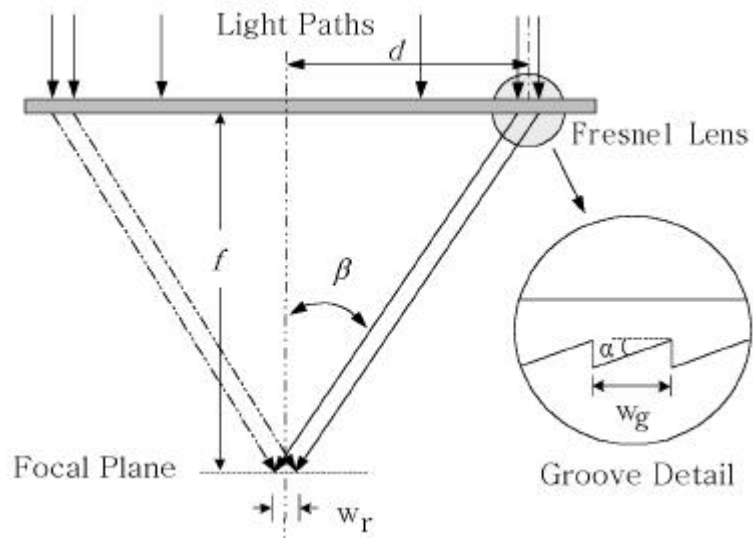
C

$$C = w_g / w_r \quad (2.2)$$

$$w_g = w_r \quad C = 1$$

w_g

w_r



2.7

Fig 2.7 Structure of fresnel lens

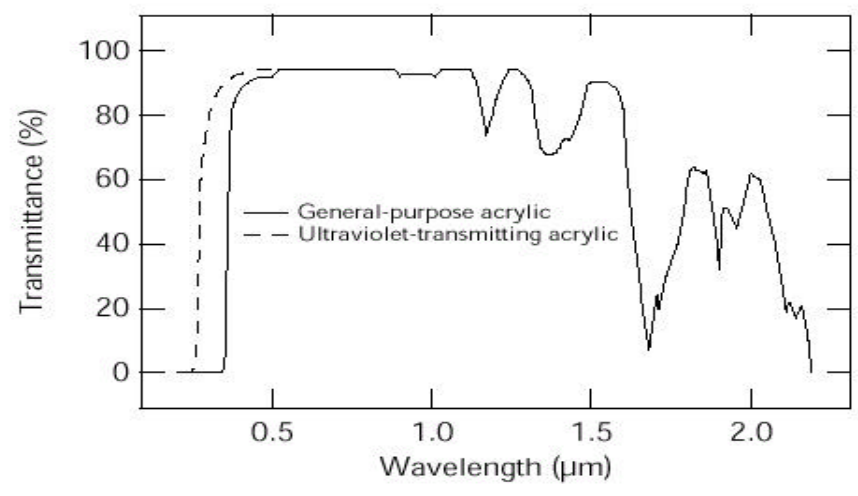
100 1,000
 Fresnel Technologies
 6 , 6 , 1.5mm, 1 100
 가 . 2.8 Fresnel Technologies

(Simple lens) (Chromatic aberration)가

가

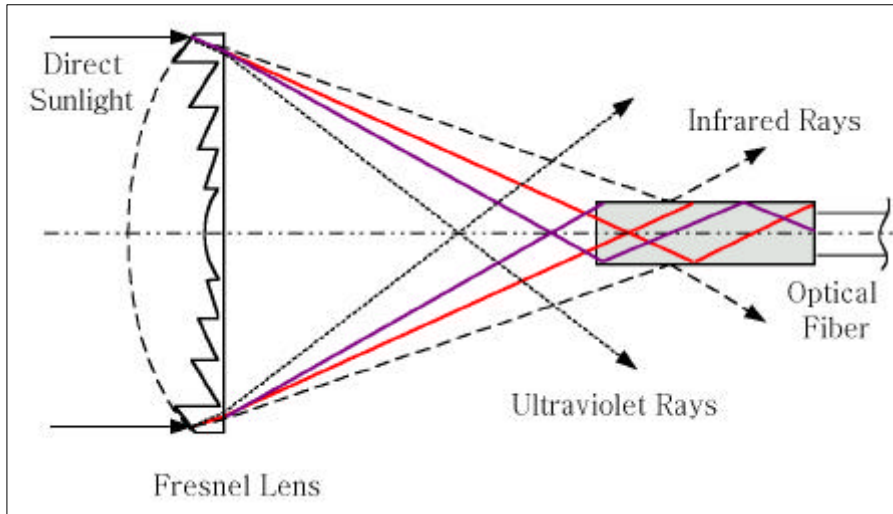
2.9 가

가



2.8

Fig 2.8 Transmittance characteristic of acrylic lens according to wave lengths



2.9

Fig 2.9 Connection method between fresnel lens and optical fiber

0.5mm

15

120

15m

가

가

가

가

가

3

가

3.1

가

10bit A/D

가

PWM

DC

가

가

가

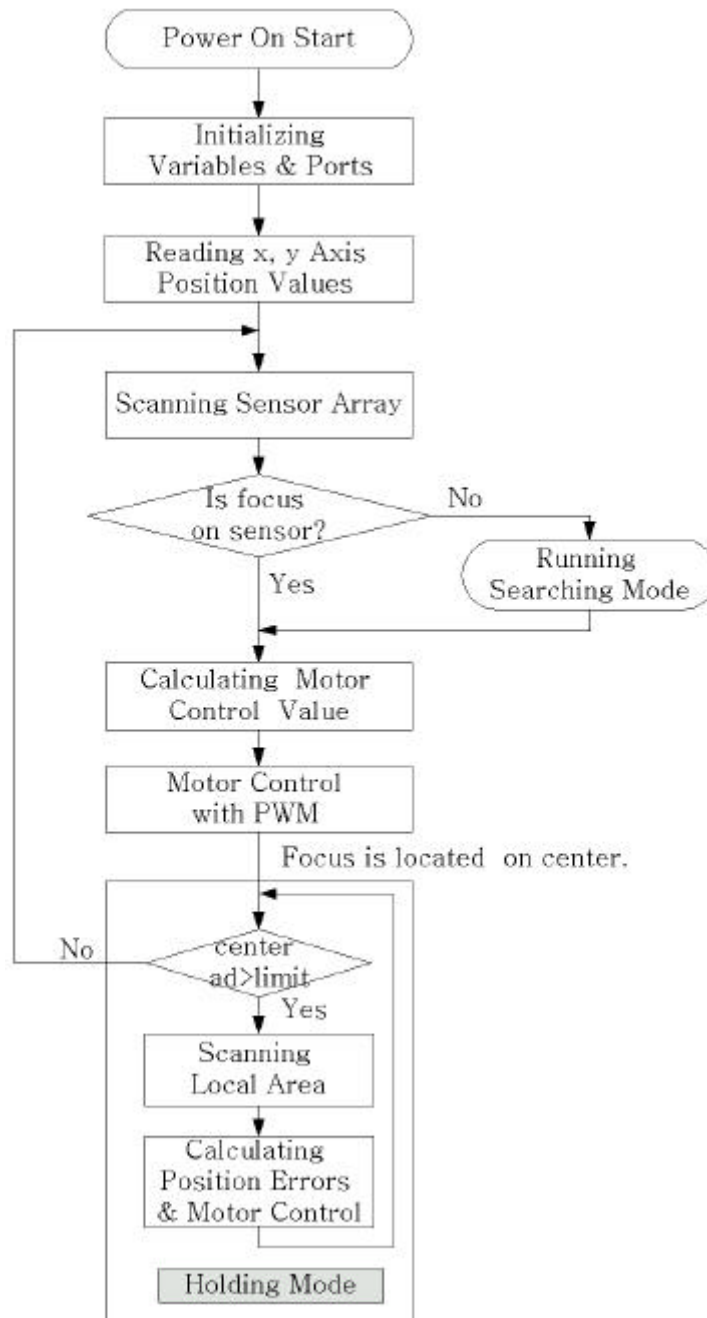
가,

가

3.2

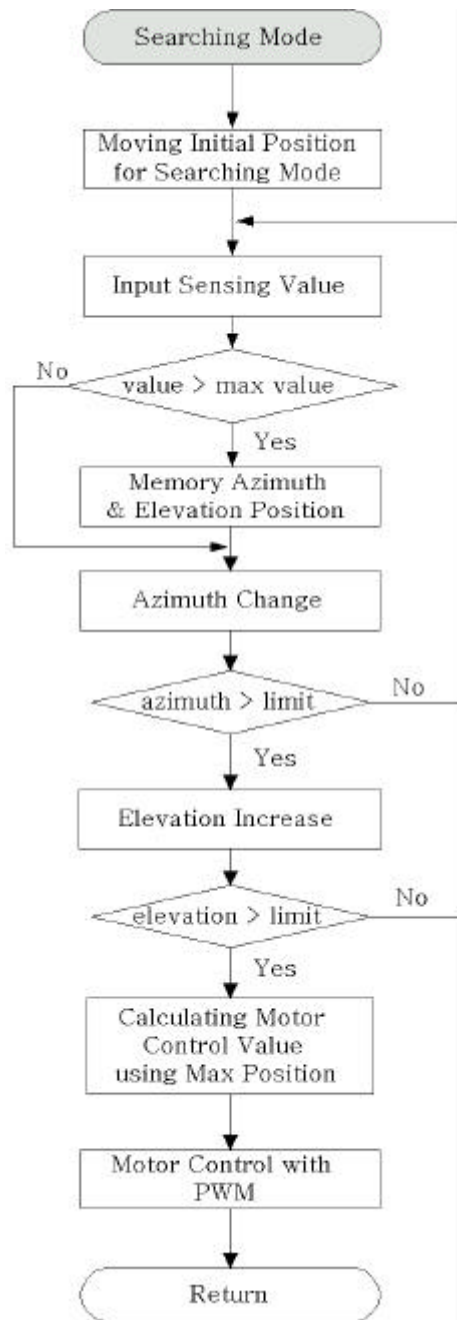
3.1

, 3.2



3.1

Fig 3.1. Flowchart of control program for the overall system



3.2

Fig 3.2 Flowchart of searching mode program

3.2

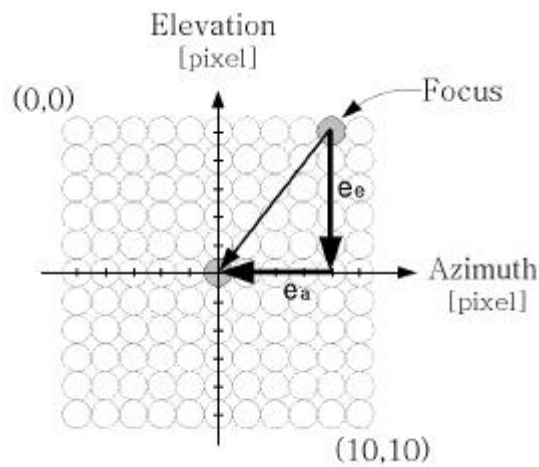
3.3

$$e_a = (c_c - f_c) \times r_a [\text{deg}] \quad (3.1)$$

$$e_e = (c_r - f_r) \times r_e [\text{deg}] \quad (3.2)$$

e_a , e_e , c_r , f_r , c_c , f_c
 (Row) (Column) . r_a , r_e

1 가



3.3

Fig 3.3 Structure of a photo transistor array

10 A/D

(Degree)

A/D

$$ca = ea \times \text{step size}_{\text{azimuth}} + pa \quad (3.3)$$

$$ce = ee \times \text{step size}_{\text{elevation}} + pe \quad (3.4)$$

ca, ce

, step size_{azimuth}

A/D 4 , step size_{elevation} 8 가 . pa, pe

가 가 PWM

(Duty ratio)

3.4

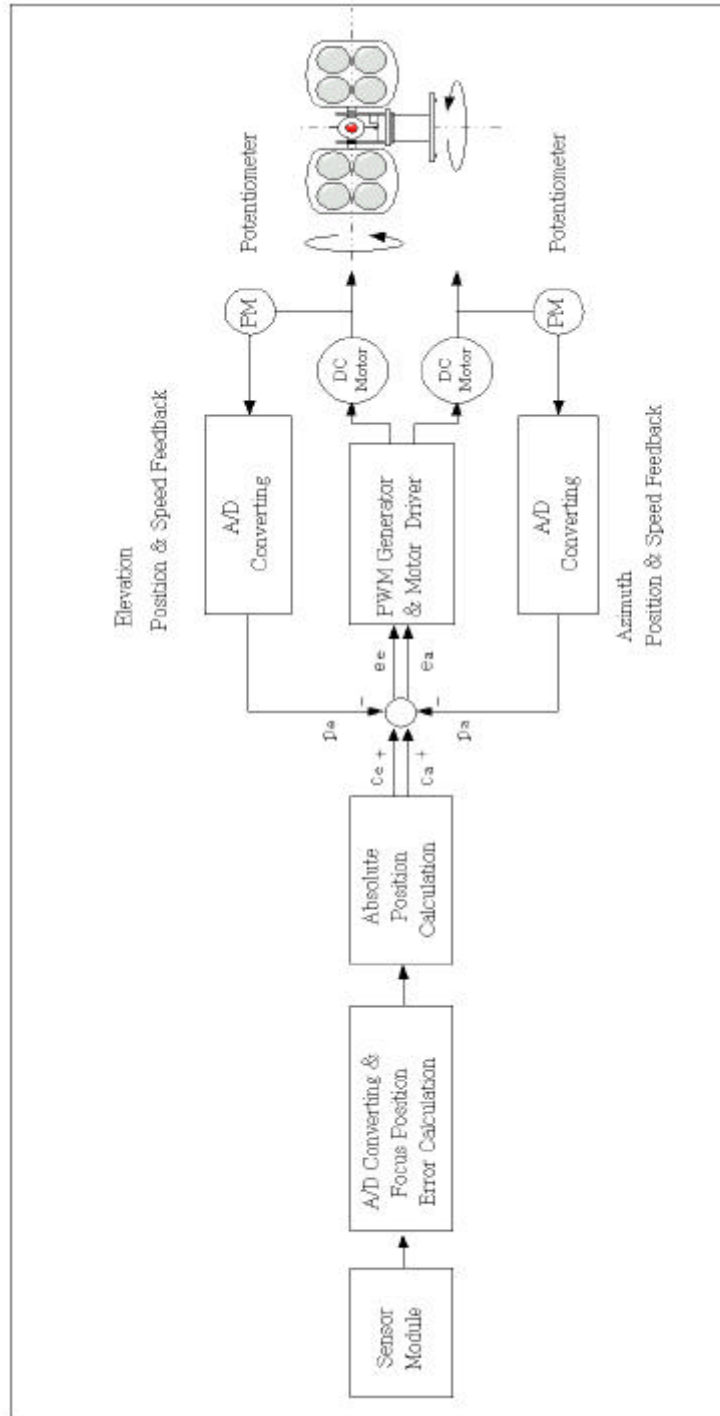


그림 3.4 태양추적 제어시스템의 블록선도
 Fig 3.4 Block diagram of sun tracking control system

3.3

가

가

9

3.5

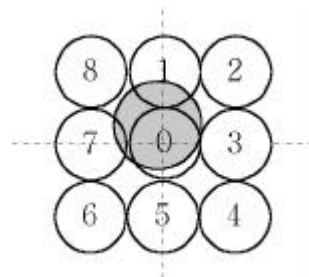
A/D

3D

3.6 ,

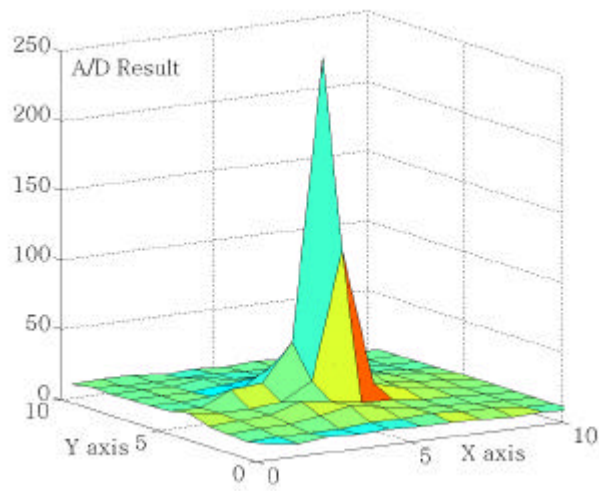
3.1

가



3.5

Fig 3.5 Sequence of sensor value scanning in the holding mode



3.6 8bit A/D 3D
 Fig 3.6 3D graph of the 8bit A/D converting results

		x - Axis										
		0	1	2	3	4	5	6	7	8	9	10
y - Axis	0	4	4	4	2	3	2	3	1	0	0	0
	1	6	4	4	4	4	3	3	1	1	0	0
	2	5	6	5	8	5	4	4	3	2	1	0
	3	6	6	5	8	10	7	6	4	4	2	0
	4	6	6	7	10	24	22	19	9	5	4	1
	5	7	6	16	18	44	246	26	8	5	3	1
	6	10	7	7	9	21	112	14	8	4	2	1
	7	5	6	7	14	11	8	7	4	3	2	1
	8	4	5	5	8	12	9	5	4	3	2	1
	9	3	3	3	3	5	5	6	4	4	2	1
	10	6	3	5	4	5	4	4	3	2	3	1

3.1
 Table 3.1 Example of sensor module value
 when focus is deviated from center

가

,
가

A/D

$$e_a^* = \frac{c_a}{2(a_{\max} - a_{\min})} \times r_a \text{ [deg]} \quad (3.5)$$

$$e_e^* = \frac{c_a}{2(e_{\max} - e_{\min})} \times r_e \text{ [deg]} \quad (3.6)$$

ea*, ee*

c a

A/D

, amax , amin

A/D

, emax , emin

A/D

4

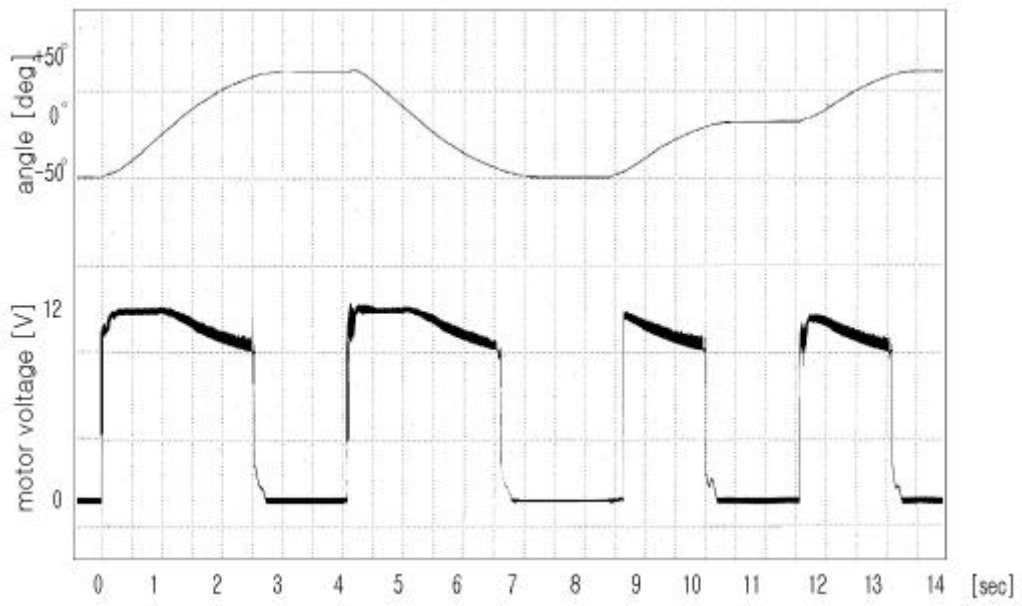
4.1

± 50° ,
- 50° , +50° , 0° 가
가
PWM 4.1
가 PWM



4.1

Photo 4.1 Photograph of a sunlight collection system



4.1 가

Fig 4.1 Tracking response of the control system for a reference input

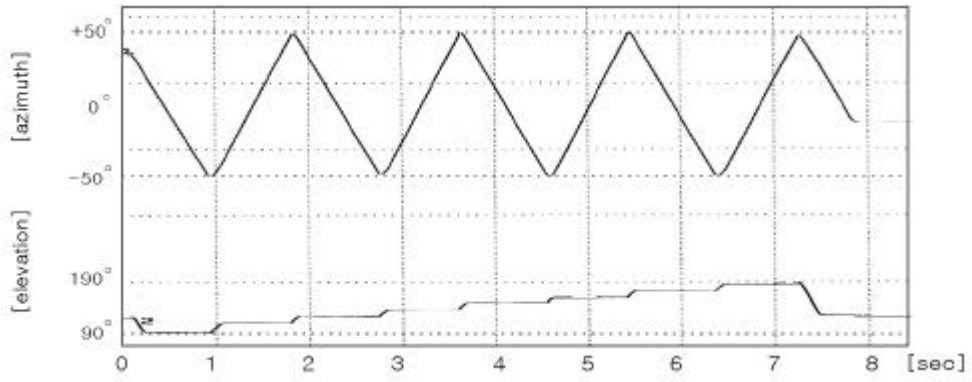
가

4.2

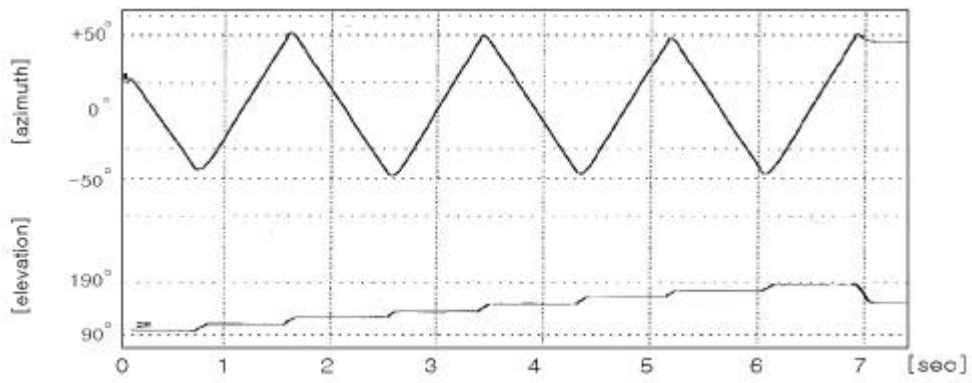
- 50. +50. , 10. 가

가

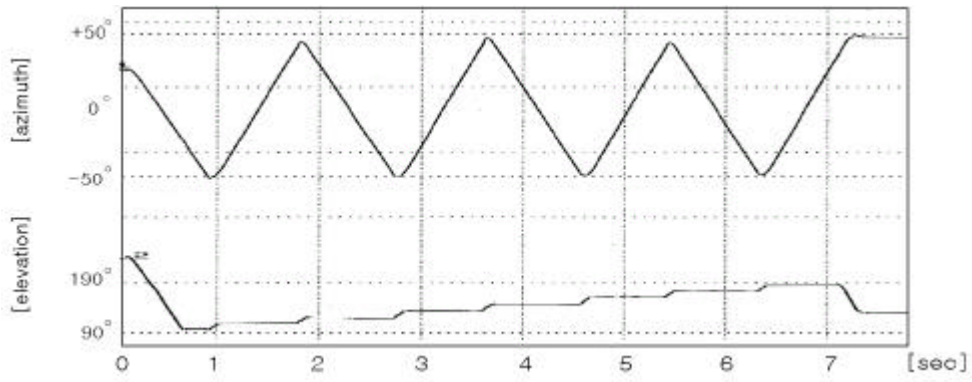
4.3



(a)



(b)



(c)

4.2

Fig 4.2 Searching mode results for various initial position

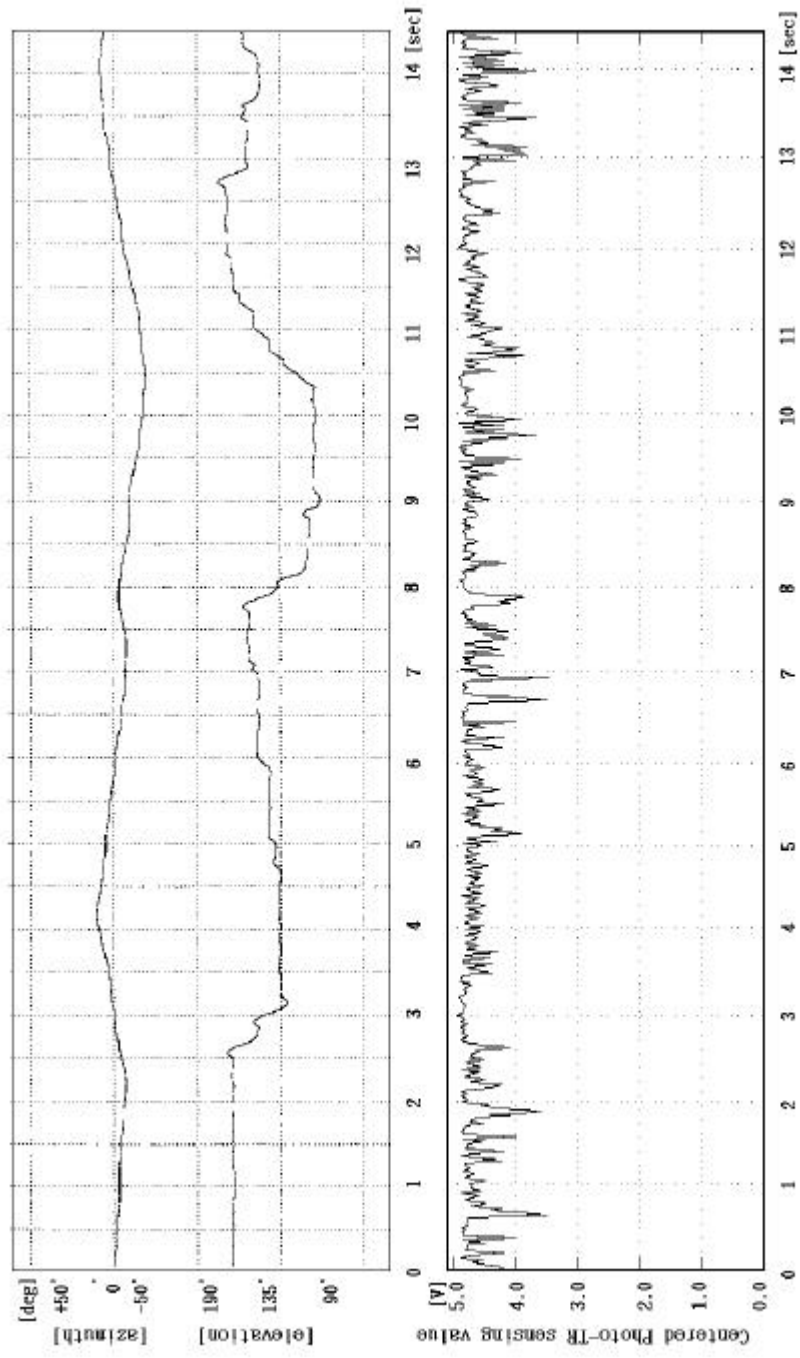


그림 4.3 홀딩 모드에서의 시스템 응답

Fig 4.3 System response on holding mode

5

2

. Full sensor

가

- [1] , “ 가 가 ,”
가 , 1998.
- [2] , “ ;”
, , 1997.
- [3] , “ ;”
.
- [4] , <http://www.kier.re.kr/>
- [5] 太陽光採光システム ひまわり, <http://www.himawari-net.co.jp>
- [6] , (II), , 1991.
- [7] , “ ;”
碩士論文, 1994.
- [8] A. J. N. Khalifa , S. S. Almutawalli, "Effect of Two- Axis Sun Tracking on The Performance of Compound Parabolic Concentrators," *Energy Conversion & Management*, Vol. 39 No. 10, pp. 1073- 1079, 1998.
- [9] A. Y. Hasan, "Design and Implementation of a Fuzzy Logic Computer- Controlled Sun Tracking System," *Proc. of the IEEE International Symposium on Industrial Electronics*, Vol. 3, pp. 1030- 1034 , 1999.
- [10] E. Hecht, *Optics*, 2nd edition, Addison- Wesley Longman, 1987.
- [11] T. Hawat, "Suntracker for Atmospheric Remote Sensing," *1998 Society of Photo- Optical Instrumentation Engineers*, pp. 1633- 1642, 1998.

- [12] R. Jurgen, *Meyer-Arendt*, , , , 1998.
- [13] Fresnel Lenses, fresnel technologies inc., 1995.
- [14] Maxim Full-Line Data Catalog, Maxim, 1999.
- [15] 光素子應用 Knowhow, , 1992.
- [16] 久野治義, 赤外線工學, 電子情報通信學會, 東京, 1994.
- [17] グウェアノユキノリ, 가, ,1998.
- [18] , <http://www.keei.re.kr/>
- [19] , Microcontroller 80196, , , 1997.
- [20] , <http://www.sun.or.jp/>
- [21] <http://www.sunoptics.com/>
- [22] Hiroyuki Furuune, “太陽光採光システムの現状と動向”, 建築設備と配管工事, Vol. 36 No.13, pp. 12- 17, 1998.

. 가 가 .