March 09, 2006

KIPP & ZONEN INC.

BREWER SOFTWARE

DESCRIPTION (#12340021)

1. INTRODUCTION

This is a description document. This document describes how the design will meet the specific physical, operational and performance specifications for a product or process.

1.1 Purpose

This document describes, in as much detail as required, the fundamental design of the Brewer software. This document is used as a high level design reference to allow individual members of the design team to understand all of the aspects of the design at a high level.

1.2 Scope

This document applies to the development of a Brewer and includes all components of a Brewer. This document describes how the specifications will be met.

1.3 Organization

This document is divided into sections and organized as follows :

1. Introduction — This section is about the document itself. It describes the usefulness of the document and its relationship to other documents.
2. General — This section contains useful general information to help understand how the software works.
3. Structure — This section describes the structure of the program and how the files work together.
4. Main Program — This section describes, in detail, the organization of the main program module, providing algorithms, variable lists, and a table of routines.
5. File Formats — This section provides detailed lists of the most important file formats, both old and new.
6. Motor Info — This section provides details about all Brewer motors.

1.4 Related Documents

The following documents provide further information related to this document.

Document/Issue	Title	File
OM-BA-C01/B	Brewer Mark IV Spectrophotometer Operators Manual	

1.5 Conventions

It is assumed that the reader is well versed with the usage and general maintenance of a Brewer instrument. This should include, but is not limited to, Brewer customers.

2. GENERAL

3. STRUCTURE

The Brewer software consists of four main parts: a batch file (usually called BREWER.BAT), GWBASIC.EXE, a Basic module (MAIN.BAS, or B2.BAS in older software), and a variety of .RTN files. The main module runs the whole show, loading .RTN files into memory as needed. GW-BASIC is the operating environment, and batch file gets it all started.

3.1 Module Files

This section documents all known module files that exist for the Brewer software, along with a brief description of their usage. Modules are run in one of three ways: they can be Automatic (used internally by the software, never directly), Direct (ie. the operator specifically runs one), or Scheduled.

Filename	Comments
AB_SK.RTN	Abort schedules (internal use)
AP.RTN	Display and print A/D values
AU.RTN	Automatic operation
AUC.RTN	Automatic operation (continuous)
AZ.RTN	Azimuth zeroing
CF.RTN	Constants file editor
CI.RTN	Complete lamp scan
CS.RTN	Set up command sequence
DA_LO.RTN	Date and location
DS.RTN	Direct sun observation
DSP.RTN	Dispersion test routine
DSP1.RTN	Called by DSP as part of dispersion test
DSSUM.RTN	Direct sun summary
DT.RTN	Dead time test
ED.RTN	Automatic end of day sequence
ED-PD.RTN	Modified ED routine that prints to disk instead of printer.
END_DAY.RTN	ED for a chosen date
ENDDAY.RTN	Part of END_DAY routine
Filename	**Comments**
FF.RTN	Printer form feed
FM.RTN	Focused moon
FMSUM.RTN	Focused moon summary
FR.RTN	Micrometer and filterwheel reset

FZ.RTN	DS done at low sun angles
FZSUM.RTN	FZ summary
GS.RTN	Calculate grating slope/intercept (MKIII only)
HG.RTN	Mercury lamp alignment test
HGSUM.RTN	HG test aummary
HP.RTN	Alignment of two spectrometers (MKIII only)
HV.RTN	High voltage test
IC.RTN	Instrument configuration editor
INIT.RTN	Software initialization
LF.RTN	Location file display
LL.RTN	Location file editor
ND.RTN	Format new data disk
NO.RTN	Change instrument number
NOSUM.RTN	NO2 summary (MKIV only)
OZSUM.RTN	Ozone summary
PB.RTN	Data playback
PO.RTN	Print out instrument constants
QS.RTN	Lamp quick scan (MKII and MKIV only)
RE.RTN	Reset the Brewer
REP.RTN	Concise summary file
RS.RTN	Run stop test
SA.RTN	Generate list of solar/lunar angles
SC.RTN	Sun scan
SE.RTN	Schedule editor
SH.RTN	Slitmask motor test
SI.RTN	Sun sighting
SIM.RTN	Moon sighting
SK.RTN	Run schedule
SKC.RTN	Run schedule continuously
SL.RTN	Standard lamp test
SLSUM.RTN	Standard lamp summary
SR.RTN	Calculate azimuth steps/revolution
SS.RTN	Extended sun scan
ST.RTN	Brewer status tests
SUM.RTN	Generate daily summary file
SW.RTN	Switch from NO2 to O3 operation or vice-versa (MKIV only)
TCSUM.RTN	Temperature constant summary
TT.RTN	Teletype mode
Filename	**Comments**
TU.RTN	Test UVB alignment
UB.RTN	DUV summary for the day
UL.RTN	Lamp scan
UM.RTN	Umkehr measurement
UV.RTN	Standard UV scan
UVSUM.RTN	UV summary
W0.RTN	One minute time delay
W1.RTN	Five minute time delay
W2.RTN	Ten minute time delay

W3.RTN	Twenty minute time delay
W4.RTN	Thirty minute time delay
XL.RTN	Extended lamp scan (MKIII and MKIV only)
ZB.RTN	Zenith blue measurement
ZC.RTN	Zenith cloudy measurement
ZE.RTN	Zenith zeroing
ZP.RTN	Zenith parallel measurement
ZS.RTN	Automated zenith sky measurement
ZSSUM.RTN	Zenith sky NO2 data summary

4. MAIN PROGRAM

This section contains information about the operation of the main program, MAIN.BAS (B2.BAS in the old software).

4.1 Routines

Name	Description	Input	Output
Main	Initialize the program		
50	Display status window		
1260	Test if the Brewer is operating normally		
1300	Reset the Brewer		
1360	Set up local date and file header; test for a schedule		
1500	Generate screen menus		updated PC$
2000	Get string from keyboard (with buffer clear)	RM%	B$, VB
2010	Get string from keyboard	B$	B$, VB
2030	Get a single character from keyboard (with buffer clear)		A$, VA
2035	Get a single character from keyboard		A$, VA
2050	Get two characters from keyboard		B$, VB
2080	Clear keyboard buffer		
2090	Test for Home key depression		HF%, TA%
2300	Change azimuth tracker status on/off (new electronics only)		
2400	Shell to DOS		
2440	Input humidity		updated AH
Name	**Description**	**Input**	**Output**
2450	Input temperature	PC, RC$, TG%, TH%	updated TE$, TE%, TF$, TF%, TG
2480	Update global temperature flags	PC, TH%	updated TE%, TF$, TG
2500	Determine status information		BF$ (input to 2550)
2550	Format two-line status bar at top of screen	BF$	CL$
2600	Set up requested menu		
2700	Test for non-overloaded routines		
2900	Test for various menu selections	C$	FLAG
3000	Enter comment from user		B$, C$
3050	Write out any comment to buffer	B$, C$	A1$(IO), IO
3100	Printer error routine		updated FP%
3200	Output buffer if full (3200/3215/3220/3225)	A1$(IO), IO	updated A1$(IO), IO
3300	Get time from Brewer clock and set PC clock	Q6%	T$, updated system time
3363	Convert from HEX format to decimal (time)	I$, XI	FL, N, T$
3400	Execute command sequence (CS or schedule)		
3500	Set up command sequence from command line	B$	G$(..), QC, QR

3600	Update observation cycles	CY$	updated CY$
3650	Point zenith prism to zenith		
3700	Enter lamp name and distance		DI, LM$
3850	Set up recording to disk		updated DN%
3900	Write out status window to temporary file		
4200	Print out summary statistics	C$, S(1, 4..11, 19..26)	
4300	Write out summary statistics to buffer	C$, S(1, 4..11, 19..26)	A1$(IO), IO
4400	Output SL, DS, ZS, or FM data	F(WL..WU), MS(WL..WU)	A1$(IO), IO
4450	Set up data header		A1$(IO), IO
4500	Write instrument constants to B file		
4900	Sleep		
5000	Constants file error message		
5100	Tracking setup	TR$	M4$, M5$, SM$
5200	Record operating state in disk file		
5300	Read operating state from disk file		
5400	Read all instrument constants	I	
5600	Set last day of month flag		updated LD%, LY%
5650	Set new month of year		updated date variables
5700	Set PC date	date variables	date
5800	Add another GMT day		
5900	Add another local day		
6000	Print message indicating file merge	C$, time	
6100	Prompt for new date (from user)		
6500	Get motor position	M1$	Y
6550	Get motor discrepancy from from init (new firmware)	FLAG, M1$	Y
6610	Print 'measurement procedure' message		
6620	Set filter #1 to position 0 (using 9780)		
6630	Set filter #1 to position 1 (using 9770)		
Name	**Description**	**Input**	**Output**
6635	Set filter #1 to position 3 (using 9785)		
6636	Set filter #1 to position 4 (using 9784)		
6637	Set filter #1 to position 5 (using 9787)		
6640	Screen message about new filter #1 position		
6650	Set filter #2 to M5$ (plus screen message)	M5$	
6660	Set filter #1 to M4$ (plus screen message)	M4$	
6680	Screen message about new filter #2 position		
6690	Close iris; inform user with screen message		
6700	Open iris; inform user with screen message		
6800	Lamp warmup delay		
6850	Timer for HG		
6900	Check if lamp on		LO%
7000	Calculate wait time	TD, time	TD
7050	Calculate wait time	TA, time	TA
7080	Calculate wait time	TB, time	TB
7120	Time delay (TA = 60 is one second)	TA, time	
7220	Time delay (X = 1 is one second)	X, time	
7300	Set PC clock and Brewer clock		
7400	Set Brewer clock from PC clock	time	
7470	Convert decimal number to BCD	X	N$
7500	Test signal and adjust attenuation filterwheel	M5$	updated M5$

7700	Calculate year number from 1965	DA%, MO%, YE%	T
7750	Update tracker position (azimuth and zenith)	TR$	
7800	Calculate solar angles	FLAG	AZC%, M2, RA, ZA, ZC, ZEC%
7950	Set azimuth/zenith to AZC%/ZEC%	AZC%, ZEC%	updated AZ%, ZE%
8000	Zero magnitude reading array	S(0)	S(..)
8025	Zero magnitude reading array	Z(0)	Z(..)
8050	Accumulate readings	MS(..), S(0)	updated S(..)
8075	Accumulate readings	MZ(..), Z(0)	updated Z(..)
8100	Calculate mean and standard deviation	S(0)	updated S(..)
8150	Calculate mean and standard deviation	Z(0)	updated Z(..)
8200	Print corrected counts and logs	TR$, F(WL..WU)	
8300	Correct raw counts for dark/dead/temp/rayleigh	F(WL..WU)	updated F(WL..WU)
8350	Correct counts for dark and dead time	VA	updated VA
8400	Calculate lunar position		
8500	Calculate micrometer positions	DC(..), GS, GI, NDC(..), SQ, WV	M1, M2
8600	Convert seconds into hours/minutes/seconds	T0	H$, H%, M%, S%
8700	Calculate ratios	F(WL..WU)	MS(..)
8800	Calculate ozone/SO2 values	MS(..)	MS(10), MS(11)
8900	Calculate F/NO2 values	MS(..)	MS(10), MS(11)
9000	Start up RS232 interface	nothing	IN%, IS%, OS%
9100	Read I$ value	I1$, IN%	I$, VA
9250	Change RS232 speed to 30 chars/sec		
9270	Change RS232 speed to 120 chars/sec		
Name	**Description**	**Input**	**Output**
9300	Receive input from Brewer (in receive buffer)		I$, IN%, VA
9375	Flush Buffer	DELAY, time	I1$
9400	Transmit command to Brewer when ready	O1$	
9450	Transmit command to Brewer and wait for response	O1$	
9460	Send break key signal		
9500	Wait until Brewer is ready		
9550	Prompt Brewer; force reset upon failure		
9610	Force Brewer reset	RM%	
9650	Wait for Enter keypress (unless RM% set)	RM%	
9670	Screen update (measurement in progress)		
9700	Run cycle read for specified slit range	CZ$, TR$, WL$, WU$, time	
9740	Close iris		
9750	Open iris		
9760	Set iris state	M3$	
9770	Set filter #1 to 256		
9780	Set filter #1 to 320		
9784	Set filter #1 to 64		
9785	Set filter #1 to 128		
9787	Set filter #1 to 0		
9790	Set filter #1 to specified value	M4$	
9800	Set filter #2 to specified value	M5$	
9805	Move micrometer #1 (and #2) to new position	M8$	
9810	Move micrometer #1 to new position	M8$	
9815	Move micrometer #2 to new position	M8$	
9820	Turn on standard lamp		TA = warmup time
9830	Turn on mercury lamp		TA = warmup time

9840	Turn off both lamps		
9850	Set lamp to M9$	M9$	TA = warmup time
9860	Set zenith to lamps		
9870	Set zenith	M1$	
9880	Determine WL/WU/CY	CZ$, WL$, WU$	CY, WL, WU
9890	Write updated screen information		
9891	Write updated screen info (with position restore)		
9892	Attempt to turn on mercury lamp	time	
9894	Attempt to turn on standard lamp	time	
9896	Attempt to turn off both lamps	time	
9900	Get observation from Brewer and convert to numbers		

4.2 Variable List

WARNING: This list is not complete. There is no guarantee that a variable not on this list will not already be in use by the program, although every attempt has been made to keep this list current. To be absolutely certain of usage, use the text search feature of your editor to find all occurrences of the variable that you intend to use.

Variable Name	Variable Usage
A1	Ozone/ozone ratio
A1$(..)	Array to buffer recently read data until written to data file
A2	SO2/SO2 ratio
A3	Ozone/SO2 ratio
AD	Address of COM port in use
AF(..)	Neutral densities of filters in FW#2
AF%	Current neutral density filter in use
AZ%	Current azimuth position (*DO NOT SET*, read only!)
AZC%	Calculated azimuth position, used to set AZ%
B1	ETC on ozone ratio
B2	ETC on SO2 ratio
B0$ to B9$	Symbols: (+, -, +, +, -, +, +, +, ¦)
BC	Byte count; number of bytes read from Brewer
BF#	Number of disk bytes free (long integer)
BR$	Symbol: (¦)
BREWDIR$	Directory of the Brewer software (from an environment variable)
C$	Current .RTN filename
CL$	Command line text
CP$	COM port Brewer is connected to (string)
CP%	COM port Brewer is connected to (number)
CR$	Carriage return character
CT$()	Formatting strings for Q6% value
CY	Number of observation cycles (number)
CY$	Number of observation cycles (string)
DA$	Current day number (string)
DA%	Current day number (number)
DB$	Current day number, with a "/" after it
DC(.., ..)	Dispersion constants (ozone) for all slits
DC$	Date constant string
DCF$	Dispersion constants filename (no extension)
DD$	Data directory (path) for all instrument data
DELAY	Buffer delay
DI	Lamp distance to Brewer (default 40 cm)
DI$	Used in schedules to track current routine being executed (menu when none)
DL$	Slitmask motor delay
DN%	Disk recording on (8) or off (0)
DK	Dark count
E$	Subroutine file extension (always .RTN)
ED%	End of day flag
Variable Name	**Variable Usage**
EL$	End of line character from Brewer (always >)
ER$	Zenith steps per 360° revolution (string)
ER%	Zenith steps per 360° revolution (integer)
FG%	Flag to indicate whether to run another routine (found in C$)

FP%	Data printout destination (0 = screen, 1 = printer, 2 = file)
G$(..)	List of command names to be executed
GI	Grating intercept (used for MKIII only)
GS	Grating slope (used for MKIII only)
H%	Hours, as extracted from a time string hh:mm:ss
HC%	Zenith horizon correction
HD$	Letter of instrument data filename (always B)
HF%	Home flag; indicates whether the HOME key was pressed or not
HLAST%	PMT temperature during last mercury lamp scan
HTIME$	Time of last mercury lamp scan
I$	Text, as read from Brewer
I1$	Raw text, as read from Brewer
I2$	Current text fragment, as read from Brewer
ICF$	Instrument constants filename (no extension)
IJ	Current command number in a command sequence
IO	Number of entries stored in A1$(..) array
IN%	Length of text in I1$ that is "actual" text from the Brewer
IRIS	Number of steps needed to open iris
IS%	Input status from Brewer (42 or 32)
JD$	Current Julian (solar) day (string)
JD%	Current Julian (solar) day (number)
JJ	Current count of number of times cycled through a command sequence
JDAY$	Julian day stored in mean daily data - used to determine whether to start collecting new data or not
L1$	Latitude of instrument site
L2$	Longitude of instrument site
L3$	Air pressure of instrument site (millibars)
LA	Latitude of instrument location
LD%	Last day; indicates if the current day is the last day of the month
LE%	Number of failed attempts to read the Brewer clock
LF$	Linefeed character (ASCII 0x0A)
LM$	Lamp name (four characters, default ????)
LO$	Name of instrument site (location)
LX$	String of seven - symbols
LY$	String of thirty - symbols
LY%	Leap year; indicates whether the current year is a leap year
M%	Minutes, as extracted from a time string hh:mm:ss
MC$	Wavelength calibration step number
MD$	String containing 3-char day of year, listed by month (ie. 000, 031, 059...)
MDD$	Current instrument mode (o3 for ozone, n2 for NO2)
MDS	Mean direct sun ozone reading for today
MM$	Airmass
MN$	String containing 3-char month abbreviations, listed by month
Variable Name	**Variable Usage**
MO$	Current month
MP$	Current month as a three-letter abbreviation
MSO2	Mean direct sun SO2 reading for today
MX%	Filterwheel #3 position for SO_2/O_3 operation
MY%	Micrometer #2 diode offset (MKIII only)
MZ%	Micrometer #1 diode offset for SO_2/O_3 operation
MZS	Mean zenith sky ozone reading for today
NA1	NO_2 absorption coefficient
NB1	NO_2 direct sun extraterrestrial constant (ETC ds)

NB2	NO_2 zenith sky extraterrestrial constant (ETC zs)
NC%	Azimuth north correction
NDC(.., ..)	Dispersion constants (NO2) for all slits
NMX%	Filterwheel #3 position for NO_2 operation
NMZ%	Micrometer #1 diode offset for NO_2 operation
NO$	Instrument number (three digits)
NOFW1	NO2 filterwheel #1 position
NTC(..)	NO2 temperature constants (one per slit)
NTQ(..)	NO2 temperature constants, as read from B file (one per slit)
O1$	Command string to send to Brewer
OS%	Output status value
OZFW1	Ozone filterwheel #1 position
PC$	Internal name of last .RTN file read (the one currently in memory)
PI	3.14157...
PO	PI/180
PO%	Long (1) or short (0) data format
POFW2	Filterwheel #2 position
Q0$	Insert key
Q1$	Delete key
Q1%	Zenith drive motor present (1) or not present (0)
Q2$	Home key
Q2%	Azimuth drive motor present (1) or not present (0)
Q3$	Ctrl-Home key (reset)
Q3%	Iris drive motor present (1) or not present (0)
Q4$	Cursor Left key
Q4%	Filter #1 drive motor present (1) or not present (0)
Q5$	Backspace key
Q5%	Filter #2 drive motor present (1) or not present (0)
Q6$	Cursor Right key
Q6%	Brewer clock present (1) or not present (0)
Q7$	Cursor Up key
Q7%	A/D board present (1) or not present (0)
Q8$	Cursor Down key
Q8%	UVB port present (1) or not present (0)
Q9$	Alt-Left Arrow key
Q9%	Filter #3 drive motor present (1) or not present (0)
Q10%	New temperature circuit (1) or old temperature circuit (0) present
Variable Name	**Variable Usage**
Q11%	Second film polarizer present (1) or not present (0)
Q12%	NOBREW mode operation enabled (1) or disabled (0)
Q13%	Wide HG slit present (1) or narrow slit present (0)
Q14%	New Brewer electronics board present (1) or not present (0)
Q15%	Humidity sensor present (1) or not present (0)
QA$	Asterisk
QB$	Ctrl-End
QC	Number of RTN commands (files) to be executed
QC$	Ctrl-Cursor Right
QD$	Ctrl-Cursor Left
QE$	Page Up
QF$	Page Down
QR	Number of times to repeat RTN command sequence
R$	Always carriage return + linefeed

R%	State flag used while reading Brewer temperature
RA	Right ascension; RA=0 occurs when the sun is at the horizon
RM%	Mode flag to determine whether a sequence is active or not (1 for sequence)
S%	Seconds, as extracted from a time string hh:mm:ss
SK$	Schedule name (without extension)
SLAST	Ratio of last (ozone) standard lamp reading
SM$	Secondary mode; used to temporarily hold tracking mode
SP	Column to start drawing menus at
SP$	String of space characters
SR%	Azimuth steps per revolution
STIME$	Time of last standard lamp reading
SWITCH%	Number of steps to switch NO_2 and O_3 modes
T1	Dead time between successful photon responses
TC(..)	Ozone temperature constants (one per slit)
TD	Time delay variable (in 60ths of seconds)
TE$	Current temperature (in volts)
TE%	Current temperature (also used as a temporary variable in many SUM routines)
TF$	Formatted Brewer temperature string
TF%	Last read temperature (°C)
TQ(..)	Ozone temperature constants, as read from B file (one per slit)
TR$	Tracking mode (ds, sa, fm, ma)
TYP$	Brewer type (mkii, mkiii, mkiv)
UC%	Umkehr correction to azimuth (always 0 unless UM routine is running)
UF$	Filterwheel #2 UV position
ULAST	Calculated DUV of last reading
UO$	Umkehr offset
UTIME$	Time of last UV reading
UVR$	UV response filename (no extension)
VA	Text read from Brewer, converted to an integer value
YE$	Current year (two digit)
YF$	Current year (two digit; same as YE$?)
ZA	Zenith angle; always positive
Variable Name	**Variable Usage**
ZC	Signed zenith angle; equal to ZA if RA>0, equal to -ZA otherwise
ZE%	Current zenith position (*DO NOT SET*, read only!)
ZEC%	Calculated zenith position; used to set ZE%
ZERO	Micrometer zero position (3469 for MKII, 2469 for MKIII, 2669 for MKIV)
ZF	Destination zenith angle; used to indicate when to continue schedule (ie. schedule waits until ZA > fixed ZF value)
ZO%	Zenith offset to zero position from sensor
ZSC(1)..ZSC(9)	Zenith sky coefficients
ZSF$	Zenith constants filename (no extension)
ZU%	Zenith UVB position

5. FILE FORMATS

This section documents the formats of the various files in the Brewer software system that are not documented elsewhere.

5.1 OP_ST.FIL

	Version 3.73x		Version 3.74	
OP_ST.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
1	NO$	113	NO$	000
2	MM$		DD$	\bdata\
3	SA%	2	ICF$	icfval
4	DN%	8	ZSF$	zsfval
5	RM$	disk	DCF$	dcfval
6	DA$	24	UVR$	uvres
7	MO$	08	DA$	13
8	YE$	94	MO$	03
9	LO$	Saskatoon	YE$	94
10	L1$	52.108	LO$	Saskatoon
11	L2$	106.713	L1$	52.108
12	L3$	960	L2$	106.713
13	TE$	3.13	L3$	960
14	NC%	190	TE$	4.13
15	HC%	-9	NC%	-985
16	SR%	14681	HC%	-3
17	Q1%	1	SR%	14667
18	Q2%	1	Q1%	1
19	Q3%	1	Q2%	1
20	Q4%	1	Q3%	1
21	Q5%	1	Q4%	1
22	Q6%	1	Q5%	1
23	Q7%	1	Q6%	1
24	Q8%	1	Q7%	1
25	DI$	menu	Q8%	1
26	SK$		Q9%	1
27			Q10%	0
OP_ST.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
28			Q11%	0
29			Q12%	0
30			Q13%	0
31			Q14%	0
32			Q15%	0
33			DI$	menu
34			MDD$	o3
35			SK$	

5.2 ICFVAL.FIL (formerly #nnn.FIL)

MKII	Version 3.73x		Version 3.74	
#nnn/ICFVAL.FIL	Name	Typical Value	Name	Typical Value
1	Temp coef wave 1	0	o3 Temp coef 1	TC(2) = 0
2	Temp coef wave 2	-.6094	o3 Temp coef 2	TC(3) = -.7941
3	Temp coef wave 3	-1.183	o3 Temp coef 3	TC(4) = -1.103
4	Temp coef wave 4	-2.2133	o3 Temp coef 4	TC(5) = -1.376
5	Temp coef wave 5	-3.7437	o3 Temp coef 5	TC(6) = -2.949
6	Micrometer steps/deg	-.3	Micrometer steps/deg	PC = 0
7	O3 on O3 Ratio	.3393	O3 on O3 Ratio	A1 = .3461
8	SO2 on SO2 Ratio	2.35	SO2 on SO2 Ratio	A2 = 2.35
9	O3 on SO2 Ratio	1.1373	O3 on SO2 Ratio	A3 = 1.1565
10	ETC on O3 Ratio	2726	ETC on O3 Ratio	B1 = 3448
11	ETC on SO2 Ratio	2534	ETC on SO2 Ratio	B2 = 3558
12	Dead time (sec)	.00000004	Dead time (sec)	T1 = .000000044
13	WL cal step number	296	WL cal step number	MC$ = 292
14	Chopper motor delay	84	Slitmask motor delay	DL$ = 78
15	Umkehr Offset	1781	Umkehr Offset	UO$ = 1777
16	ND filter 0	0	ND filter 0	AF(0) = 0
17	ND filter 1	5000	ND filter 1	AF(1) = 5000
18	ND filter 2	10000	ND filter 2	AF(2) = 10000
19	ND filter 3	15000	ND filter 3	AF(3) = 15000
20	ND filter 4	20000	ND filter 4	AF(4) = 20000
21	ND filter 5	25000	ND filter 5	AF(5) = 25000
22	Zenith steps/rev	2816	Zenith steps/rev	ER$ = 2816
23	Dispersion Int 1	2796.837891	Brewer Type	TYP$ = mkii
24	slope 1	.072878	COM Port #	CP$ = 1
25	quadratic 1	-.00000056037	o3 Temp coef hg	TC(7) = 0
26	Dispersion Int 2	2837.065186	n2 Temp coef hg	NTC(7) = 0
27	slope 2	.072142	n2 Temp coef 1	NTC(2) = 0
28	quadratic 2	-.00000056962	n2 Temp coef 2	NTC(3) = 0
29	Dispersion Int 3	2874.019043	n2 Temp coef 3	NTC(4) = 0
30	slope 3	.071648	n2 Temp coef 4	NTC(5) = 0
31	quadratic 3	-.00000060715	n2 Temp coef 5	NTC(6) = 0
32	Dispersion Int 4	2909.6521	O3 Mic #1 Offset	MZ% = 1885
33	slope 4	.071039	Mic #2 Offset	MY% = 2310
#nnn/ICFVAL.FIL	Name	Typical Value	Name	Typical Value
34	quadratic 4	-.00000063774	O3 FW #3 Offset	MX% = 242
35	Dispersion Int 5	2944.632813	NO2 absn Coeff	NA1 = -3
36	slope 5	.070365	NO2 ds etc	NB1 = 745
37	quadratic 5	-.00000066768	NO2 zs etc	NB2 = 742
38	Offset to diode	2780	NO2 Mic #1 Offset	NMZ% = 5089
39	(*) Micrometer Zero	3469	NO2 FW #3 Offset	NMX% = 178
40	(*) Iris Open Steps	250	NO2/O3 Mode Change	SWITCH% = 3204
41	(*) Buffer Delay (s)	.2	Grating Slope	GS = 0
42			Grating Intercept	GI = 0
43			Micrometer Zero	ZERO = 3469
44			Iris Open Steps	IRIS = 75
45			Buffer Delay (s)	DELAY = 0.2

46			NO2 FW#1 Pos	NOFW1 = 64
47			O3 FW#1 Pos	OZFW1 = 256
48			FW#2 Pos	POFW2 = 0
49			uv FW#2 Pos	UF$ = 64
50			Zenith Offset	ZO% = 40
51			Zenith UVB Position	ZU% = 2112
52	** New to version 3.73x*		Release date	Jul 12 1994

MKIII	**Version 3.73x**		**Version 3.74**	
#nnn/ICFVAL.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
1	Temp coef wave 1	0	o3 Temp coef 1	TC(2) = 0
2	Temp coef wave 2	.001	o3 Temp coef 2	TC(3) = -.7941
3	Temp coef wave 3	-.4845	o3 Temp coef 3	TC(4) = -1.103
4	Temp coef wave 4	-1.1904	o3 Temp coef 4	TC(5) = -1.376
5	Temp coef wave 5	-2.9716	o3 Temp coef 5	TC(6) = -2.949
6	Micrometer steps/deg	0	Micrometer steps/deg	PC = 0
7	O3 on O3 Ratio	.3392	O3 on O3 Ratio	A1 = .3461
8	SO2 on SO2 Ratio	2.35	SO2 on SO2 Ratio	A2 = 2.35
9	O3 on SO2 Ratio	1.138	O3 on SO2 Ratio	A3 = 1.1565
10	ETC on O3 Ratio	1820	ETC on O3 Ratio	B1 = 3448
11	ETC on SO2 Ratio	1240	ETC on SO2 Ratio	B2 = 3558
12	Dead time (sec)	.000000044	Dead time (sec)	T1 = .000000044
13	WL cal step number	284	WL cal step number	MC$ = 292
14	Chopper motor delay	74	Slitmask motor delay	DL$ = 78
15	Umkehr Offset	1687	Umkehr Offset	UO$ = 1777
16	ND filter 0	0	ND filter 0	AF(0) = 0
17	ND filter 1	5000	ND filter 1	AF(1) = 5000
18	ND filter 2	10000	ND filter 2	AF(2) = 10000
19	ND filter 3	15000	ND filter 3	AF(3) = 15000
20	ND filter 4	20000	ND filter 4	AF(4) = 20000
21	ND filter 5	25000	ND filter 5	AF(5) = 25000
22	Zenith steps/rev	2816	Zenith steps/rev	ER$ = 2816
23	Dispersion Int 1	2856.727539	Brewer Type	TYP$ = mkiii
#nnn/ICFVAL.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
24	slope 1	.077032	COM Port #	CP$ = 1
25	quadratic 1	-.00000075285	o3 Temp coef hg	TC(7) = 0
26	Dispersion Int 2	2896.492188	n2 Temp coef hg	NTC(7) = 0
27	slope 2	.07626	n2 Temp coef 1	NTC(2) = 0
28	quadratic 2	-.00000076623	n2 Temp coef 2	NTC(3) = 0
29	Dispersion Int 3	2933.831299	n2 Temp coef 3	NTC(4) = 0
30	slope 3	.075256	n2 Temp coef 4	NTC(5) = 0
31	quadratic 3	-.0000007535	n2 Temp coef 5	NTC(6) = 0
32	Dispersion Int 4	2968.512207	O3 Mic #1 Offset	MZ% = 1885
33	slope 4	.074657	Mic #2 Offset	MY% = 2310
34	quadratic 4	-.00000077758	O3 FW #3 Offset	MX% = 242
35	Dispersion Int 5	3002.670166	NO2 absn Coeff	NA1 = -3
36	slope 5	.073934	NO2 ds etc	NB1 = 745
37	quadratic 5	-.00000079552	NO2 zs etc	NB2 = 742
38	Mic #1 Offset	6324	NO2 Mic #1 Offset	NMZ% = 5089
39	FW#3 Set	50	NO2 FW #3 Offset	NMX% = 178
40	Mic #2 Offset	5434	NO2/O3 Mode Change	SWITCH% = 3204

41	Grating Slope	.9933	Grating Slope	GS = 0
42	Grating Intercept	29.05	Grating Intercept	GI = 0
43	(*) Micrometer Zero	2469	Micrometer Zero	ZERO = 3469
44	(*) Iris Open Steps	250	Iris Open Steps	IRIS = 75
45	(*) Buffer Delay (s)	.2	Buffer Delay (s)	DELAY = 0.2
46			NO2 FW#1 Pos	NOFW1 = 64
47			O3 FW#1 Pos	OZFW1 = 256
48			FW#2 Pos	POFW2 = 0
49			uv FW#2 Pos	UF$ = 64
50			Zenith Offset	ZO% = 40
51			Zenith UVB Position	ZU% = 2112
52	** New to version 3.73x*		Release date	Jul 12 1994

MKIV	Version 3.73x		Version 3.74	
#nnn/ICFVAL.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
1	Temp coef wave 1	0	o3 Temp coef 1	TC(2) = 0
2	Temp coef wave 2	-.7442	o3 Temp coef 2	TC(3) = -.7941
3	Temp coef wave 3	-1.5658	o3 Temp coef 3	TC(4) = -1.103
4	Temp coef wave 4	-2.7648	o3 Temp coef 4	TC(5) = -1.376
5	Temp coef wave 5	-4.5538	o3 Temp coef 5	TC(6) = -2.949
6	(*1) Micrometer steps/deg	-.3	Micrometer steps/deg	PC = 0
7	O3 on O3 Ratio	.3467	O3 on O3 Ratio	A1 = .3461
8	SO2 on SO2 Ratio	2.35	SO2 on SO2 Ratio	A2 = 2.35
9	O3 on SO2 Ratio	1.1582	O3 on SO2 Ratio	A3 = 1.1565
10	(*2) ETC on O3 Ratio	2816.055	ETC on O3 Ratio	B1 = 3448
11	(*3) ETC on SO2 Ratio	2832.448	ETC on SO2 Ratio	B2 = 3558
12	Dead time (sec)	.000000042	Dead time (sec)	T1 = .000000044
13	WL cal step number	291	WL cal step number	MC$ = 292
#nnn/ICFVAL.FIL	**Name**	**Typical Value**	**Name**	**Typical Value**
14	Chopper motor delay	88	Slitmask motor delay	DL$ = 78
15	Umkehr Offset	1699	Umkehr Offset	UO$ = 1777
16	ND filter 0	0	ND filter 0	AF(0) = 0
17	ND filter 1	5000	ND filter 1	AF(1) = 5000
18	ND filter 2	10000	ND filter 2	AF(2) = 10000
19	ND filter 3	15000	ND filter 3	AF(3) = 15000
20	ND filter 4	20000	ND filter 4	AF(4) = 20000
21	ND filter 5	25000	ND filter 5	AF(5) = 25000
22	Zenith steps/rev	2816	Zenith steps/rev	ER$ = 2816
23	Dispersion Int 1	2842.467285	Brewer Type	TYP$ = mkii
24	slope 1	.076812	COM Port #	CP$ = 1
25	quadratic 1	-.00000073985	o3 Temp coef hg	TC(7) = 0
26	Dispersion Int 2	2882.362061	n2 Temp coef hg	NTC(7) = 0
27	slope 2	.075998	n2 Temp coef 1	NTC(2) = 0
28	quadratic 2	-.00000074573	n2 Temp coef 2	NTC(3) = 0
29	Dispersion Int 3	2919.325195	n2 Temp coef 3	NTC(4) = 0
30	slope 3	.075203	n2 Temp coef 4	NTC(5) = 0
31	quadratic 3	-.0000007548	n2 Temp coef 5	NTC(6) = 0
32	Dispersion Int 4	2954.395996	O3 Mic #1 Offset	MZ% = 1885
33	slope 4	.074528	Mic #2 Offset	MY% = 2310
34	quadratic 4	-.00000077274	O3 FW #3 Offset	MX% = 242
35	Dispersion Int 5	2989.583252	NO2 absn Coeff	NA1 = -3

36	slope 5	.073266	NO2 ds etc	NB1 = 745
37	quadratic 5	-.00000072217	NO2 zs etc	NB2 = 742
38	(*4) Offset to diode	5972	NO2 Mic #1 Offset	NMZ% = 5089
39	M-10 Mode Change	2520	NO2 FW #3 Offset	NMX% = 178
40	(*5) M-6 Ozone Set	242	NO2/O3 Mode Change	SWITCH% = 3204
41	(*) Micrometer Zero	2669	Grating Slope	GS = 0
42	(*) Iris Open Steps	250	Grating Intercept	GI = 0
43	(*) Buffer Delay (s)	.2	Micrometer Zero	ZERO = 3469
44			Iris Open Steps	IRIS = 75
45		** New to ver 3.73x*	Buffer Delay (s)	DELAY = 0.2
46	*NO2 Mode Notes:*		NO2 FW#1 Pos	NOFW1 = 64
47	**1 NO2 absorption coeff*		O3 FW#1 Pos	OZFW1 = 256
48	**2 NO2 ds etc*	*(Version 3.74 no*	FW#2 Pos	POFW2 = 0
49	**3 NO2 zs etc*	*longer requires NO2*	uv FW#2 Pos	UF$ = 64
50	**4 NO2 offset (Mic #1)*	*and O3 versions of*	Zenith Offset	ZO% = 40
51	**5 (M-6) FW#3 NO2 set*	*this file.)*	Zenith UVB Position	ZU% = 2112
52			Release date	Jul 12 1994

5.3 DCFVAL.nnn (formerly part of #nnn.FIL)

All Brewer models	Version 3.74		
DCFVAL.FIL	Name	Variable	Typical Value
1	Dispersion Int 1	DC(1,1)	2797.237
2	slope 1	DC(1,2)	.07283272
3	quadratic 1	DC(1,3)	-.00000057826
4	Dispersion Int 2	DC(2,1)	2837.617
5	slope 2	DC(2,2)	.07210223
6	quadratic 2	DC(2,3)	-.00000058722
7	Dispersion Int 3	DC(3,1)	2874.798
8	slope 3	DC(3,2)	.07143592
9	quadratic 3	DC(3,3)	-.00000060409
10	Dispersion Int 4	DC(4,1)	2910.288
11	slope 4	DC(4,2)	.07085672
12	quadratic 4	DC(4,3)	-.00000063685
13	Dispersion Int 5	DC(5,1)	2945.481
14	slope 5	DC(5,2)	.06988658
15	quadratic 5	DC(5,3)	-.00000060847
16	Dispersion Int hg (0)	DC(0,1)	2755.701
17	slope hg (0)	DC(0,2)	.07597
18	quadratic hg (0)	DC(0,3)	-.00000064887
19	NO2 Dispersion Int 1	NDC(1,1)	2797.237
20	slope 1	NDC(1,2)	.07283272
21	quadratic 1	NDC(1,3)	-.00000057826
22	NO2 Dispersion Int 2	NDC(2,1)	2837.617
23	slope 2	NDC(2,2)	.07210223
24	quadratic 2	NDC(2,3)	-.00000058722
25	NO2 Dispersion Int 3	NDC(3,1)	2874.798
26	slope 3	NDC(3,2)	.07143592
27	quadratic 3	NDC(3,3)	-.00000060409
28	NO2 Dispersion Int 4	NDC(4,1)	2910.288
29	slope 4	NDC(4,2)	.07085672
30	quadratic 4	NDC(4,3)	-.00000063685
31	NO2 Dispersion Int 5	NDC(5,1)	2945.481
32	slope 5	NDC(5,2)	.06988658
33	quadratic 5	NDC(5,3)	-.00000060847
34	NO2 Dispersion Int hg (0)	NDC(0,1)	2755.701
35	slope hg (0)	NDC(0,2)	.07597
36	quadratic hg (0)	NDC(0,3)	-.00000064887
37	Release date	-	Jul 12 1994

5.4 ZSFVAL.FIL (new)

All Brewer Models	Version 3.74		
ZSFVAL.FIL	**Name**	**Variable**	**Typical Value**
1	Zenith sky coefficient 1	ZSC1	-.0064
2	Zenith sky coefficient 2	ZSC2	-.01968
3	Zenith sky coefficient 3	ZSC3	.01654
4	Zenith sky coefficient 4	ZSC4	.17077
5	Zenith sky coefficient 5	ZSC5	.28053
6	Zenith sky coefficient 6	ZSC6	-.06126
7	Zenith sky coefficient 7	ZSC7	-.49136
8	Zenith sky coefficient 8	ZSC8	.45626
9	Zenith sky coefficient 9	ZSC9	-.04506
10	Release date	-	Jul 12 1994

6. MOTOR INFORMATION

6.1 Motor Movement Commands

All Brewer motors are given a number to reference them by. For example, motor 10 refers to the micrometer present in all models of the Brewer. In the MKIII, there is also a second micrometer, referred to as motor 6. It should be noted that motor 6 is also the third filterwheel on the MKIII and MKIV; this is explained in greater detail below.

The following chart shows all of the motor numbers and their meaning:

Old Electronics	New Electronics	Description	I/O Board	Addresses*
1	1	Zenith prism	c/d	D,16895,16896
2	2	Azimuth half-tracker	c/d	D,16907,16908
3	3	Iris viewing port	b	D,16919,16920
4	4	Filter wheel #1	b	D,16931,16932
5	5	Filter wheel #2	b	D,16943,16944
6 (MKIV only)	6	Filter wheel #3	d	D,16979,16980
6 (MKIII only)	9	Micrometer #2	d	D,16979,16980
10	10	Micrometer #1	a	D,16955,16956
10 (MKIII only)	N/A	Filter wheel #3**	a	D,16955,16956
11	11	Slit mask	a	D,16967,16968

*The calculated motor position is done using the formula (first value) * 256 + second value. In the new Brewer electronics, substitute the command "?MOTOR.POS[<motor number>]".

**The sequence "B,3;M,10,xxxx;B,0" is needed to access this motor. All other movement commands are simply "M,<motor number>,xxxx".

The micrometer positions are first defined by the type of Brewer. As shown in Figure 1(a), multiboard Brewers have a reference diode sensor at one end of the micrometer range (far left in the diagram). In Figure 1(b), a singleboard electronics Brewer may have two reference sensors, but the one that is used for reset purposes is at the opposite end of the micrometer range (far right in the diagram). In Figure 1(a), the MZ% variable is used to define the distance from the reference sensor to the ozone “zero” position. In the case of a MKIII the micrometer offset for the second micrometer is MY% and refers to the distance from the sensor to the ozone measurement position. For the singleboard Brewer, the software does not use the MZ%. The UV zero position is defined by the MOTOR.ORIGIN values and the ZERO value. All other micrometer positions and distances remain unchanged from there.

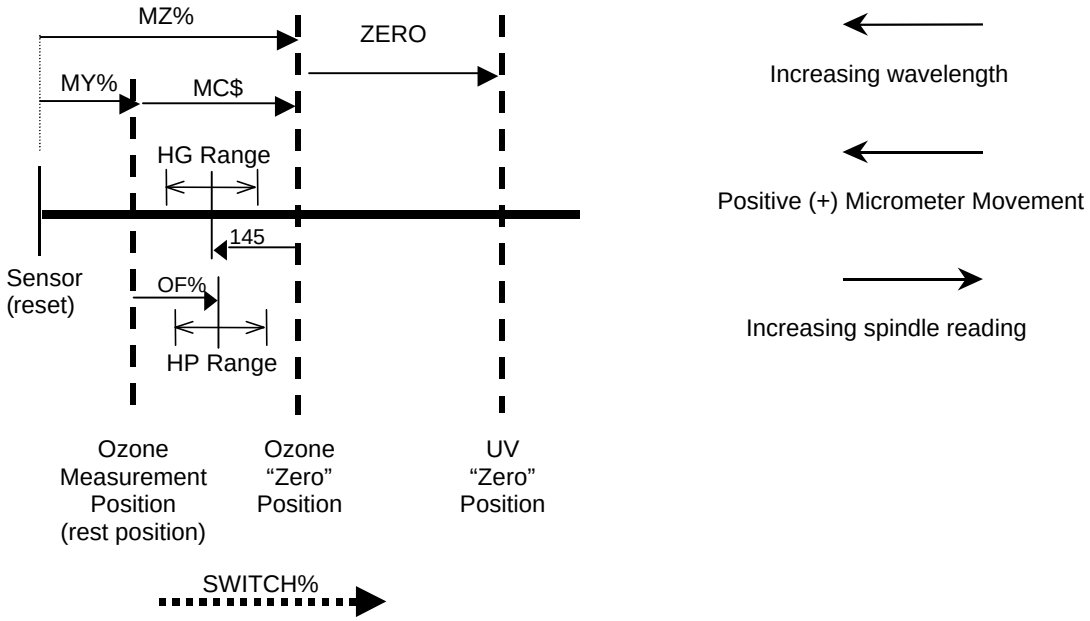

Figure 1(a) Micrometer positions for Multiboard Brewer

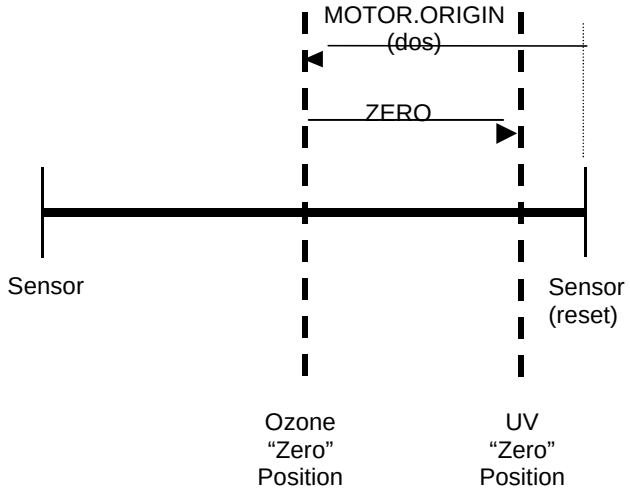

Figure 1(b) Micrometer positions for Singleboard Brewer

The reference point for micrometer positions is defined in the software by a zero counter. The sign of the motor position in the micrometer movement command determines either an absolute or relative movement from the zero counter position. A positive motor position in the command will move the motor to that step position in either the positive or negative step direction. This is an absolute step position as defined from the zero counter position. A negative motor position in the command will move the micrometer the defined number of steps in the negative micrometer movement direction, and will reset the zero counter. The example outlined in the table below will help make this more clear.

Motor Command*	Counter Contents	Action Taken by Micrometer
-none-	???	
M,10,-1	0	Move right one step and reset counter to zero
M,10,2000	2000	Move left 2000 steps
M,10,1500	1500	Move right 500 steps (to position 1500)
M,10,3000	3000	Move left 1500 steps (to position 3000)
M,10,-1000	0	Move right 1000 steps and reset counter to zero

*Substitute “6” for “10” to access the second micrometer (or “9” if using the new electronics).

For ozone measurements, the micrometer moves to a position that is MC$ steps from the ozone “zero” position (defined by the zero counter). All NO2 positions are based on their counterpart ozone positions, offset by SWITCH%. For example, the NO2 “zero” position is defined as SWITCH% from the ozone “zero” position; the NO2 measurement position is defined as SWITCH% from the ozone measurement position; and so on. For UV measurements, the zero counter is reset to relate positions from the UV “zero” position. The UV “zero” position is defined to be ZERO steps from the ozone “zero” position. In this way, when the HG routine adjusts the ozone “zero” position, all other measurement positions are affected. One last note is that all dispersion step numbers are relative to the UV “zero” position.

Motor Number and Name	Step Number	Position	Command String
(1) - Zenith Prism	0	Pointing at standard lamp (internal)	M,1,0
	1408	Pointing at zenith sky (external)	M,1,1408
	2112	Pointing at UVB port (external)	M,1,2112
(2) - Azimuth Tracker	0	Reference direction (north)	M,2,0
	14670	Reference direction, 1 full turn clockwise from step #0	M,2,14670
(3) - Iris	0	Iris fully closed	M,3,0
	75 or 250	Iris fully open	M,3,75 or M,3,250
(4) - Filter Wheel #1	320	0 - Film polarizer (horizontal)	M,4,320
	256	1 - Quartz diffuser (translucent)	M,4,256
	192	2 - Blocked aperture (opaque)	M,4,192
	128	3 - Clear aperture (transparent)	M,4,128
	64	4 - Clear (MKII only) or Quartz diffuser; ND of f=2.0 (translucent)	M,4,64
	0	5 - Clear (MKII only) or Film polarizer (vertical)	M,4,0
(5) - Filter Wheel #2	0	0 - f = 0	M,5,0
	64	1 - f = 0.5 (f = neutral density	M,5,64
	128	2 - f = 1.0 factor)	M,5,128
	192	3 - f = 1.5	M,5,192
	256	4 - f = 2.0 Attenuation = 10^f	M,5,256
	320	5 - f = 2.5	M,5,320
(10) - Micrometer #1 (top)	~292	Calibrated micrometer setting (Nominally 6 ± 1.5mm; 576 steps/mm)	M,10,xxxx
(6) - Micrometer #2 (bottom, MKIII only)		(wavelength change of 0.006 nm/step) (positive steps increase wavelength and decrease micrometer setting)	M,6,xxxx
Motor Number and Name	**Step Number**	**Position**	**Command String**
(6) - Filter Wheel #3 (MKIII */MKIV only)	50	UG11 glass filter	M,6,50
	114	Blocked aperture (opaque)	M,6,114
	178	Clear (MKIII only) or BG-12 filter	M,6,178
	242	NiSO4 + UG11 filter	M,6,242
(11) - Slit Mask	0	0 - slit 0 (HG): 303.2 - 426.4 nm	M,11,xxxx
	2	1 - Dark count: ----------	
	4	2 - slit 1: 306.3 - 431.4 nm	Note:
	6	3 - slit 2: 310.1 - 437.3 nm	R,0,6,2;O;A
	8	4 - slit 3: 313.5 - 442.8 nm	gives a real time listing of the registers from position 0 to 6.
	10	5 - slit 4: 316.8 - 448.1 nm	<delete> to stop.
	12	6 - slit 5: 320.1 - 453.2 nm	
	14	7 - dead time: ----------	

***Note**: To use filter wheel #3 on a MKIII, you must first set micrometer #1 to a zero position (with a M,10,0 command). Save the original position before doing this. Then use B,3 to change motor 10 to refer to the filter wheel. Move the filter wheel as desired, and then use B,0 to restore the motor. Finally, restore the micrometer position to the saved position. The complete command should look like the following:

<save the old micrometer position>

B,3;M,10,50;B,0 (Replace 50 with the position you are moving to)

<restore the old micrometer position>