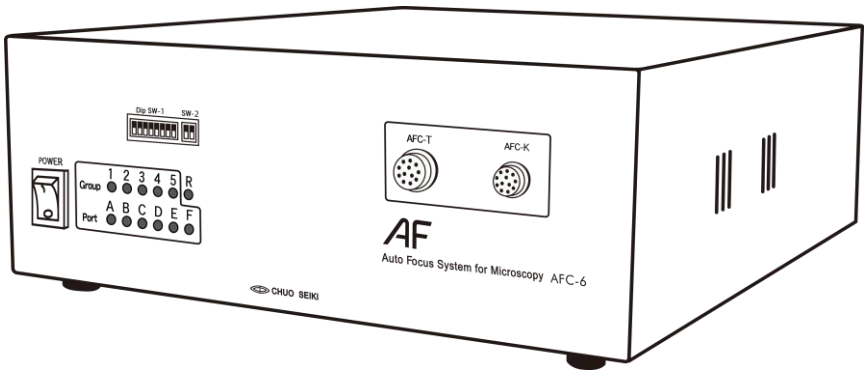
AF

Auto Focus System for Microscopy **AFC-6**

Auto Focus Controller

AFC-6

INSTRUCTION MANUAL



CHUO PRECISION INDUSTRIAL CO.,LTD.

Introduction

Thank you for purchasing our Auto Focus Controller AFC.
AFC is an exclusive controller for our Auto Focus Microscopes and Auto Focus Units. This INSTRUCTION MANUAL provides specifications, operational methods and precautions for AFC. Please read this manual thoroughly before using this product. In order to deliver sufficient information for the full understandings of the functions and performance of this product, we hope the users find this manual helpful.

Outline of this manual

AFC-6 instruction manual consists of following five sections.

Section 1	AFC Main Unit
Section 2	Parameters
Section 3	Communication Commands
Section 4	I/O Ports
Section 5	Operation Box

Please read each section carefully to understand the product and for the proper use before using AFC for the first time.

Section 1 AFC Main Unit
Describes product specifications and main functions of AFC-6.

Section 2 Parameters
Describes control parameters of AFC-6.

Section 3 Communication Commands
Description for controlling AFC-6 with communication.

Section 4 I/O Ports
Description for controlling AFC-6 with I/O port connection.
Only limited functions are controllable.

Section 5 Operation Box
Description for controlling AFC-6 with operation box.

Expressions used in this manual

■Abbreviations

Following abbreviations are used in this manual. Please refer to the following list and replace as appropriate.

AF	: Auto Focus
AFC	: Auto Focus controller
Auto Focus mode	: Collective term for following Auto Focus movements; SC0, SC1, SC2, SC3, SC4, SC5, SC6, SC7, AF0, AF2, PF, PFH, PN and PNH
AF mode	: Auto Focus mode
Search	: Search for AF signal
Peak detection	: Peak detection of AF signal
AF driving section	: Driving section to move lens tube to z-axis direction
Pattern driving section	: Driving section to project AF patterns (*not included in some models)

■Typestyle

Bold (gothic) typefaces are used to call attention or emphasize in this instruction manual.

■Numerical values

Decimal values are used in principle. "0x" is added before the first digit of a numerical value when hexadecimal values are used. For instance, "1000" in a decimal system are expressed as “0x03E8” in a hexadecimal system.

■Hardware

Hardware, such as keys, LED and switches of AFC, Auto Focus Microscope, Auto Focus Unit, are expressed in the following ways: **[…] KEY, […] LED, and […] SWITCH**.

Examples : **[Home] KEY**
[A] LED
[POWER] SWITCH

■Communications

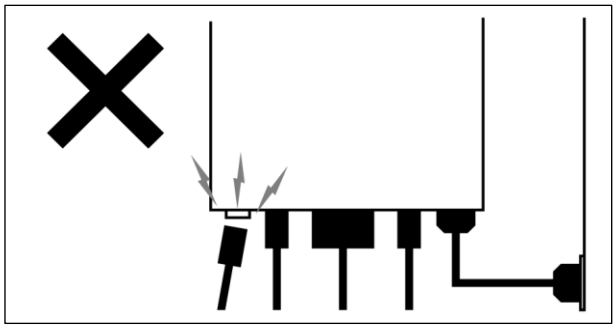
Communications are performed via RS-232C. In RS-232C communications, data sent from an external device to AFC is referred to as “**command**.” Data sent from AFC to an external device is simply referred to as “**data**”. For expressions of commands and data, special characters are used in addition to regular alphanumeric characters. These are control characters called delimiters which indicate the break (end) of commands or data. Delimiters used in AFC are ASCII code characters 10 (0x0A) and 13 (0x0D), which are referred to as “Line Feed” (L_F) and “Carriage Return” (C_R) respectively.

■I/O ports

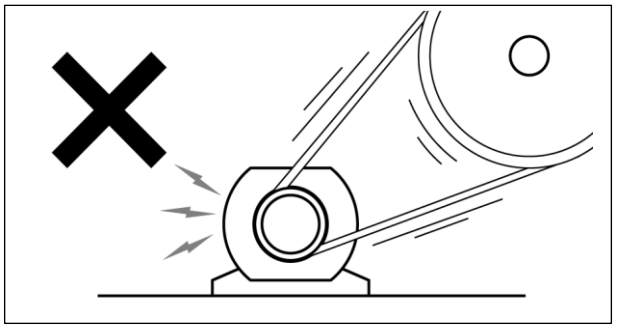
The I/O ports of AFC are normally maintained at TTL level (+5V). This state is called TTL level (+ 5V) or H level in this manual. When keeping input port at COMMON level (0V), it is referred to as input to I / O port or setting to L level.

⚠ Precautions

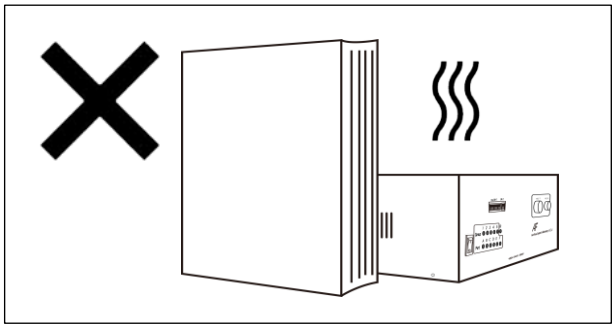
Never do the following actions as it may cause a malfunction.



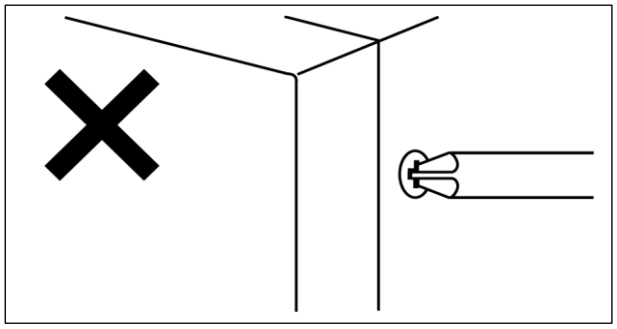
- Do not use other than the provided power cable.
- Never disconnect the connector while the power is turned on. Turn off the power before connecting and disconnecting the connector.
- Place the device where AC inlet is accessible when connecting.



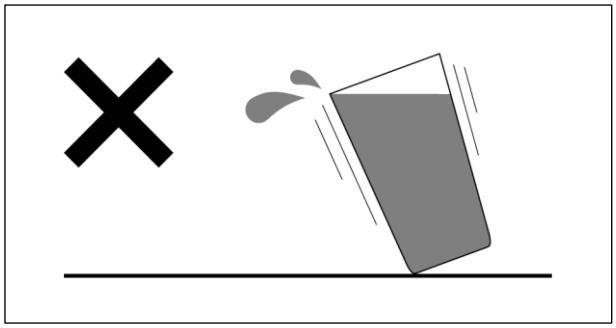
- Use the AC100-240V (50/60Hz) power source.
- Do not use the product near a large generator or heavy electrical appliances, or equipment radiating strong electro-magnetic fields in the neighborhood, as it may cause a malfunction to the product.
- As this product is composed of precision parts, avoid physical impact and minimize vibration when in use.



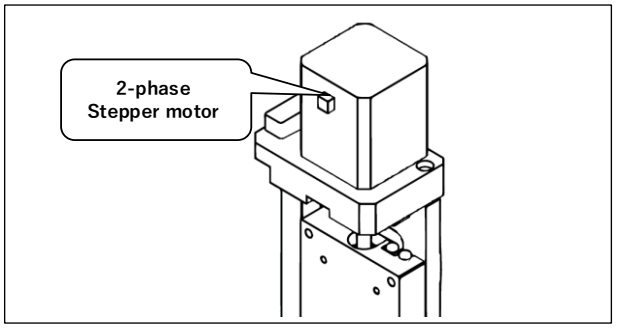
- The product generates considerable heat while it is charged with electricity. Never block the heat discharge slit. Do not use in a place where ventilation is insufficient.
- Use the product at least 100 mm away from surrounding objects.



- Do not disassemble or modify the product.
- To prevent scratches, use soft cloth to wipe only the surface when cleaning the device.
- Do not open the cabinet. Do not modify the product by replacing parts. It may cause a fire, electric shock or malfunction.



- Install on a flat surface.
- Avoid contact with water. It is extremely dangerous when the device gets wet.



- The motor that can be used with this product is 2-phase stepper motor. Any motor different from this type (e.g. 5-phase stepper mortor, servomotor) cannot be driven.

Section 1

Main Unit

Contents

1. Feature

- High repeatability has been realized based on our original line sensor method.
- Adjustable with undulation and inclination of the sample in the trace mode.
- With our rich experiences of work in various fields, AFC is usable under most of the conditions for any sample that reflect lights. We have proven results particularly in transparent samples, such as plastic and glass.
- AFC is applicable to all our Auto Focus microscopes and Auto Focus units including our Auto Focus Microscope AF-IZ.
- Capable of external control through RS-232C communications port and I/O ports.

2. Principle of operation

AFC is an Auto Focus controller using the line sensor. A pattern filter for Auto Focus is used to project a striped pattern onto a sample to generate mixed image and capture the image with a line sensor.
The Auto Focus Microscope and the Auto Focus Unit connected to AFC have an optical structure as shown in Figure 1.
A striped pattern on the pattern filter for Auto Focus is projected onto the sample by illuminator. The striped pattern reflected on the sample travels through the optical path difference prism and are divided into two images with a different optical path length. These two images are taken into the line sensor.

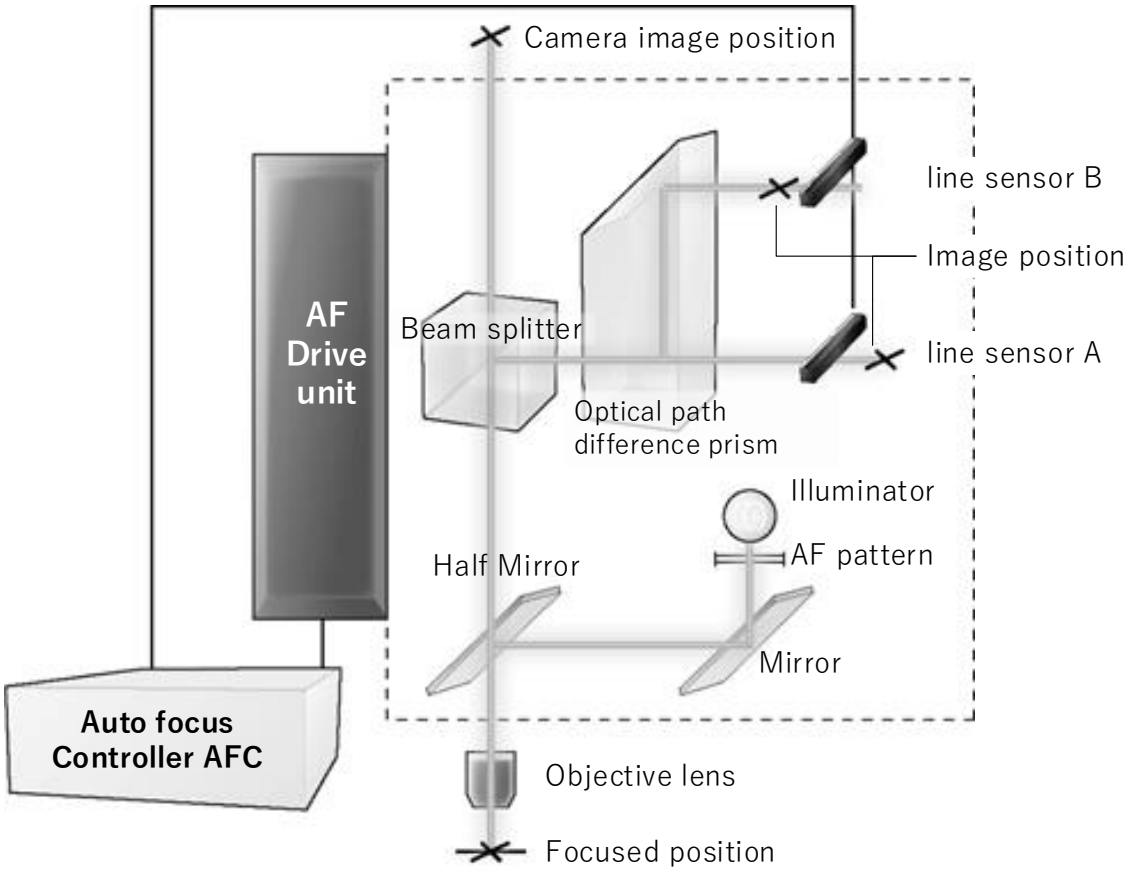


Figure 1 Summary of AFC principle

3. Connection diagram

■ Connections

Connect each device referring to the following connection diagram (Figure 2).

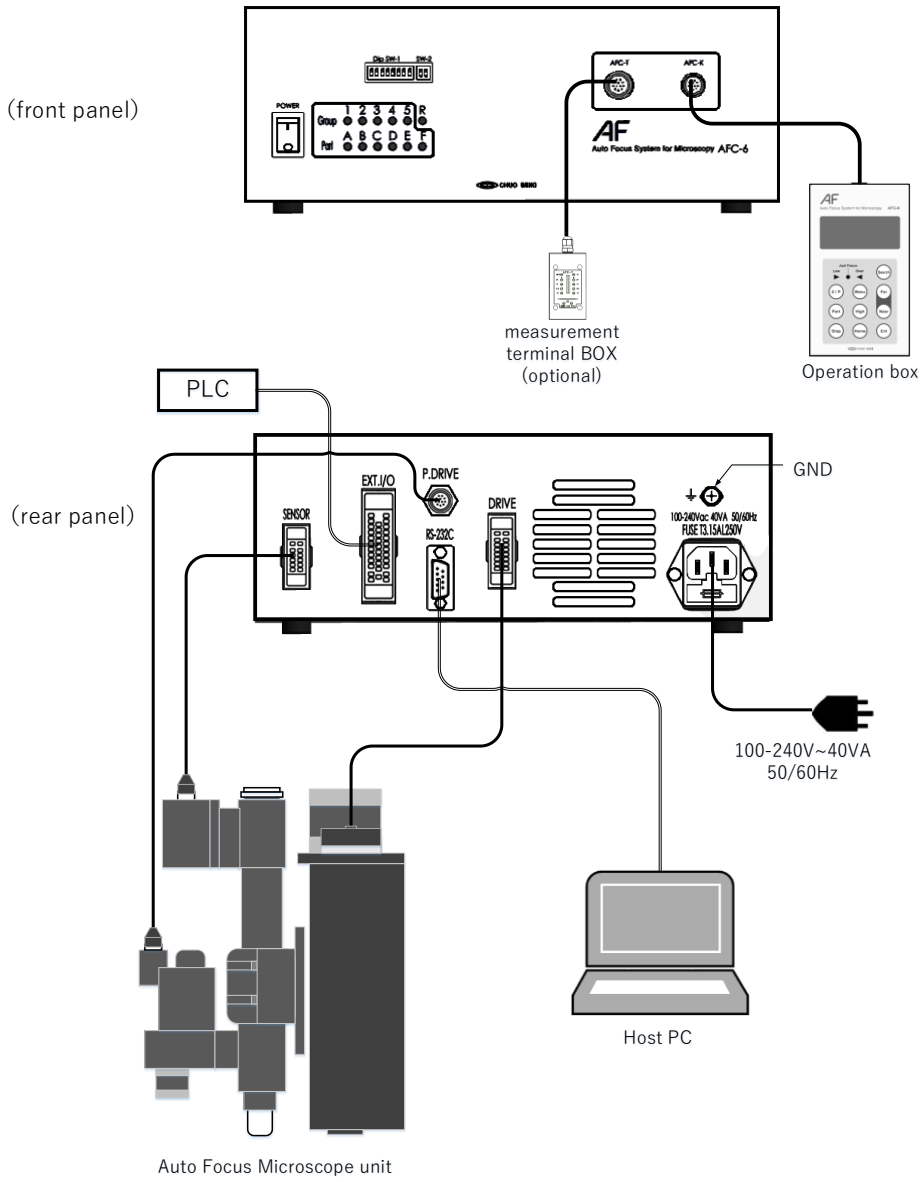


Figure 2 Connection example

CAUTION

- **Please carefully read the instruction manual and connect correctly.**
- **Figure 1.2 shows a basic connection example. The shape of the drive unit and the use of external controller might differ depending on the purpose of use.**
- **Connect and disconnect various connectors while the [POWER] SWITCH is turned OFF.**
- **Be sure to ground when using.**
- **The connection with RS-232C and EXT.I/O must be a device or appliance with "Flammability V-1" or higher.**

4. Part name and functions

■ Front panel

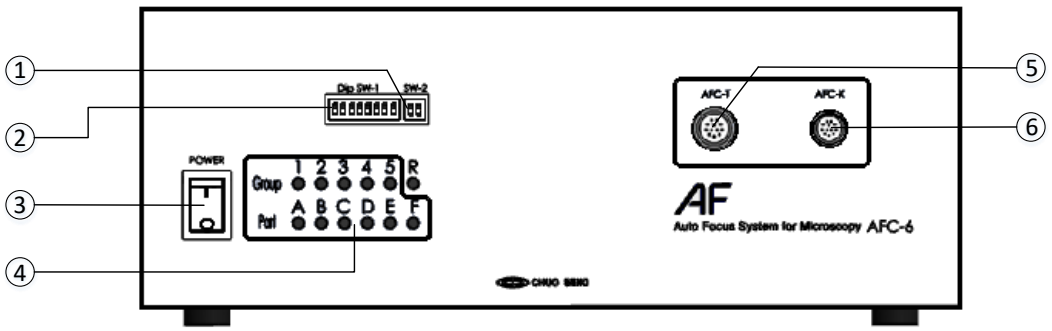


Figure 3　Front panel of main unit

① **DIP switch 2-pole**

Enables switching hardware functions.

② **DIP switch 8-pole**

Enables switching hardware functions.

③ **[POWER] SWITCH**

Switch to turn the power on and off.

When initial setting is set to "Enable to return Home", AF driving section returns to Home position.

Setting can be changed by parameter No.664：Init_Mode.

④ **LED**

LED of selected port/group turns on.

⑤ **Test pin connector (AFC-T)**

Connector for terminal box (test pin). Necessary when adjusted using an oscilloscope.

*terminal box is optional.

⑥ **Connector for operation box (AFC-K)**

Connector for operation box.

■ Rear panel

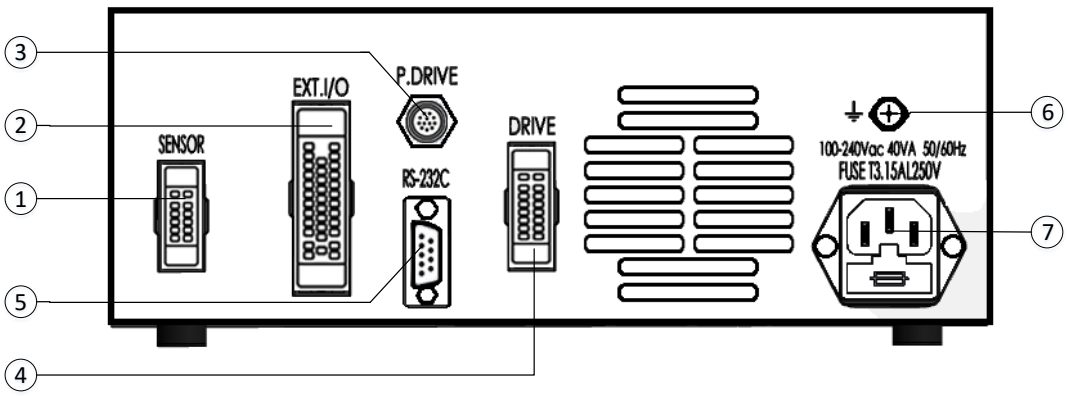


Figure 4 Rear panel of main unit

① **Line sensor signal input/output**
Connector for the signal input and output of line sensor. (See page 12)

② **I/O input/output connector**
I/O port to control AFC externally. (See page 12)

③ **Pattern driving unit input/output connector**
Connector for the pattern driving unit. (See page 12)

④ **AF driving unit input/output connector**
Connector for the AF driving unit. (See page 12)

⑤ **RS-232C input/output connector**
RS-232C port to control AFC externally. (See page 12)

⑥ **Ground connector**
Terminal of the frame ground. **Please use as necessary. It is not a protective ground.**

⑦ **Power connector**
Please remove power cable from here when problem occurs using power cable attached to this product.

WARNING **Never open the fuse box.**

■ Dip switch

(1) DIP switch 2-pole setting (BOOT/data selection at hardware reset)

Switch to select initial value of parameters at the time of BOOT and hardware reset.

SW No.	Function	OFF	ON
1	Initialization at boot	N/A (Boot with parameters set in previous setting)	Initialize with setting of SW No.2*
2	Initialization/data selection at hardware reset	Initial value at the time of manufacturing (Initial value described in parameter section)	Default value adjusted upon shipment*

*Indicates the switch position upon shipment

(2) DIP switch 8-pole setting

SW No.	機能	OFF	ON
1	AF driving unit limit sensor logic	Normal opening (A interface)*	Parameter No.641: Limit_Logic setting
2	Pattern driving unit limit sensor logic	Normal opening (A interface)*	Parameter No.646: SX_Limit_Logic setting
3	Operation box availability	Enabled*	Disabled (Accepts [STOP] key)
4	Motor driver selection	Sink (NPN open collector)*	Source (PNP open collector)
5	Communication setting	19200*	Parameter No.602: Baud_Rate setting
6	Communication circuit check (Echo back)	Disabled*	Enabled
7	AFC-5 compatible	Disabled*	Move in AFC-5 mode
8	Used for system	Unmodifiable*	Unmodifiable

*Indicates the switch position upon shipment

5. Specifications

■ General specifications

Power source	AC100-240Vac　40VA　50/60Hz
Voltage　crossover	±10%
Overvoltage category	Ⅱ（2.5kV）
Operation environment	Indoor use
Altitude	Below 2000m
Pollution degree	2 (IEC 61010-1)
Ambient temperature/humidity	10-40℃ / 20-80%RH (No condensation)
Outer dimensions (W×D×H[mm])	W250×D280×H90 (not including protrusions)
Weight	3.5kg

■ Performance specifications

Operation	RS-232C communication	
	External input/output (I/O ports)	
	Operation box	
Number of ports set	Number of ports	6 ports (Select 1 group from 5 groups of 6 ports each)
	Applicable objective lens	Nikon, Olympus, Mitutoyo
AF accuracy	Approximately 1/4 of focal depth of the object lens	
AF time	0.5 seconds (Varies depending on operating condition)	
AF driving unit travel range	CHUO standard driving unit	4mm

■ Communication specifications

Interface	RS-232C Compatible
Data communication	Half-duplex communication with two-wire
Synchronization	Start-stop synchronization system
Transmission range	15m (max) *1
Baud rate [bps]	600/2400/4800/9600/19200 (initial setting) /38400
Data length	8 bit
Parity bit	N/A
Stop bit length	2 bit
Delimiter	PC → AFC: $C_R + L_F$ AFC → PC: $C_R + L_F$ C_R: Carriage Return L_F: Line Feed

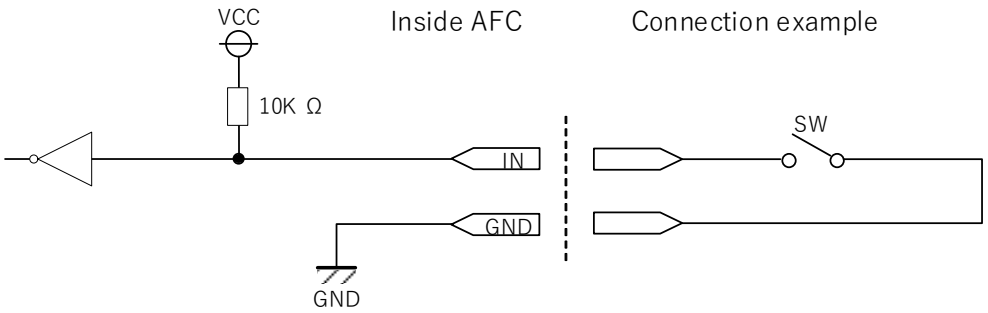
*1 Please confirm with the actual device for the transmission range which depends on the using cable and the environment.

■ External input/output

(1) IN17-IN28, IN41-IN45 Inputs (TTL)

Voltages		DC 3.3-6V
Input voltage（High level）		(greater than or equal to) DC 2.3V
Input voltage（Low level）		(less than or equal to) DC 1.0V
Response time	**L->H**	(less than or equal to) 125ns
	H->L	(less than or equal to) 25ns
Logic level		Active Low
Number of inputs		17 inputs

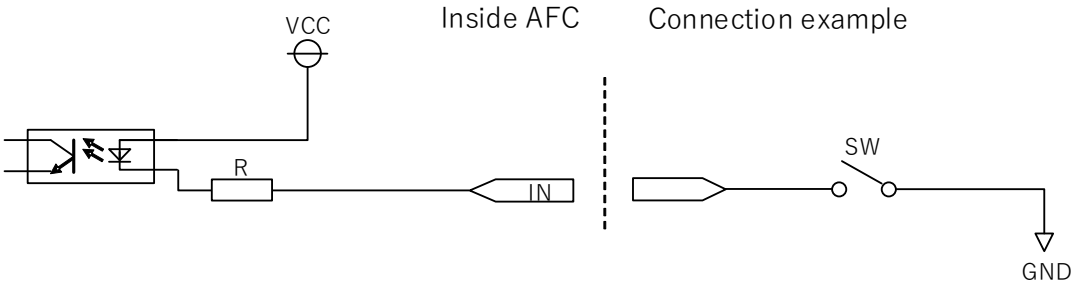
Connection example：(IN17-IN28, IN41-IN45)



(2) IN33 Inputs (RESET input)

Insulation system		photo coupler
Voltages		(less than or equal to) DC 6V
Rated input current		(less than or equal to) 5mA
Response time	**OFF->ON**	(less than or equal to) 10ms
	ON->OFF	(less than or equal to) 10ms
Logic level		Active Low
Number of inputs		1 input

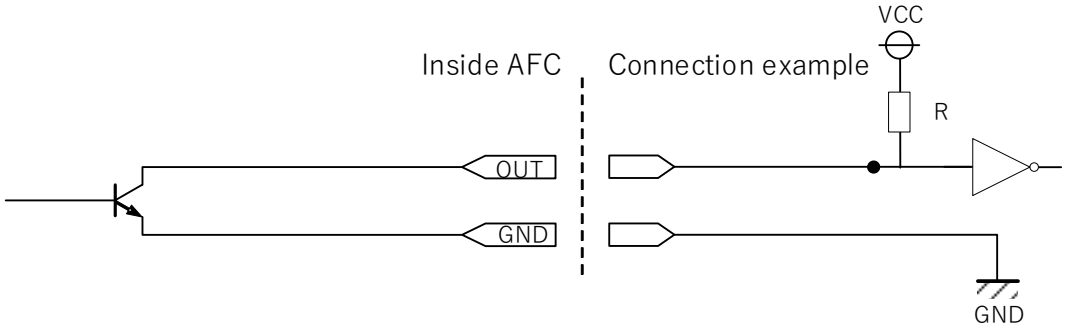
Connection example：(IN33)



(3) OUT3-16, 31, 32, 35-40 Outputs

Output format		Open collector output
Maximum allowable voltage		(less than or equal to) DC 50V
maximum load current		(less than or equal to) 100mA (Resistance load)
Response time	**OFF->ON**	(less than or equal to) 10ms
	ON->OFF	(less than or equal to) 10ms
Logic level		Active Low
Number of inputs		22 inputs

Connection example：(OUT3-16, 31, 32, 35-40)



*Appropriate resistance will be needed to the controller externally.

■ Input/output interface

Connector name	Input/ output	Contents
AF driving unit input/output (DRIVE)	Input	Limit sensor signal
	Output	Pulse signal for motor drive Power source for limit sensor (DC+5V) Timing pulse for external driving device
Pattern driving unit input/output (P.DRIVE)	Input	Limit sensor signal
	Output	Pulse signal for motor drive Power source for limit sensor (DC+5V)
Operation box signal input/output (AFC-K)	Input	AFC control signal, various commands
	Output	Return data for command
Line sensor signal input/output (SENSOR)	Input	Line sensor signal for AF (main/sub)
	Output	Power source for line sensor (DC ±12V) (DC +5V)
RS-232C input/output (RS-232C)	Input	AFC control signal, various commands
	Output	Return data for command
I/O input/output (EXT.I/O)	Input	AFC control signal
	Output	Various signals I/O reference electric potential (COMMON: 0V, TTL: +5V max: 1A)
Oscilloscope output (AFC-T)	Output	Sensor signal, trim width signal BPF output, AF integration signal

(1) AF driving unit input/output

Please connect with the attached cables.

<In case of using other than CHUO standard driving unit>

Note the following;

- Use the following motor or similar when using AFC built-in driver.
  PK264-01A 1.0A/phase Rated current (Oriental Motor made)
- Prepare another driver that can drive the selected motor when not using AFC built-in driver. The control pulse of the driving section is sent from AFC (FAR direction pulse and NEAR direction pulse).
- Initial setting of the limit logic is set at "normal opening". Settings can be changed at parameter No.641 : Limit_Logic when using "normal closing".
- Please consult CHUO or our representatives when using electromagnetic brake.
- Interfaces as follows (next page);

AFC side : S-1616A by Hirose Electric Co., Ltd.

Cable side : Equivalent to P-1616BA-C by Hirose Electric Co., Ltd.

Pin No.	Signal	IN/OUT	Description
1	A_COM	OUT	Motor A COMMON
2	Exclusive for system		Do not connect
3	$\bar{A}$	OUT	Motor $\bar{A}$
4	B_COM	OUT	Motor B COMMON
5	Exclusive for system		Do not connect
6	$\bar{B}$	OUT	Motor $\bar{B}$
7	CW	OUT	FAR direction pulse *CW when using customer prepared motor driver
8	CCW	OUT	NEAR direction pulse *CCW when using customer prepared motor driver
9	＋5V		5V output
10	GND		GND
11	N_LIMIT	IN	NEAR side hard limit
12	F_LIMIT	IN	FAR side hard limit
13	Exclusive for system		Do not connect
14	Exclusive for system		Do not connect
15	Exclusive for system		Do not connect
16	Exclusive for system		Do not connect

*7 & 8 are open connectors

***Do not connect anything 2, 5 and from 13 to 16**

(2) Pattern driving unit input/output connector

Please connect with the attached cables with pattern driving unit.

(3) Operation box signal input/output

Please connect the attached operation box when using.

(4) AF sensor signal input/output

Please connect with the attached cables.

(5) RS-232C input/output connector

Connectable with RS-232C communication. Please use **straight-through cables** for control devices communicating with AFC main unit. RS-232C connector on AFC main unit is D-sub 9 pin male type. Please use D-sub 9 pin female type connectors to connect to AFC.

AFC side : HDEB-9P by Hirose Electric Co., Ltd.

Cable side : Equivalent to HDEB-9S by Hirose Electric Co., Ltd.

Pin No.	Signal	IN/OUT	Description
1	N.C. (CD)		Carrier detection
2	RXD	IN	Received data
3	TXD	OUT	Sent data
4	N.C. (DTR)		Data terminal ready
5	GND		GND
6	DSR	IN	Data set ready
7	RTS	OUT	Request transmission
8	CTS	IN	Available for transmission
9	N.C. (RI)		Call indication

N.C. : Non-connected

Caution!! **Operation of AFC is not guaranteed using straight cables other than listed above. No communication is available with cross (reverse) cables.**

(6) I/O input/output

Interface to control AFC with I/O control

AFC side : S-1645A by Hirose Electric Co., Ltd.

Cable side : Equivalent to P-1645BA-C by Hirose Electric Co., Ltd.

Pin No.	Signal	IN/ OUT	Description
1	＋5V	OUT	+5V output (Maximum output current: 1A)
2	＋5V	OUT	+5V output (Maximum output current: 1A)
3	EXO-NEAR	OUT	AF driving unit travelling to NEAR direction
4	EXO-FAR	OUT	AF driving unit travelling to FAR direction
5	EXO-AF_MODE	OUT	AF trace operation status
6	EXO-SEARCH	OUT	Search, Peak detection operation status
7	EXO-2FC	OUT	Second function
8	EXO-OVER	OUT	Signal output over
9	EXO-UNDER	OUT	Signal output under
10	EXO-J_FOCUS	OUT	Just focus
11	EXO-A	OUT	A port selected signal
12	EXO-B	OUT	B port selected signal
13	EXO-C	OUT	C port selected signal
14	EXO-D	OUT	D port selected signal
15	EXO-E	OUT	E port selected signal
16	EXO-F	OUT	F port selected signal
17	EXI-STOP	IN	Stop signal
18	EXI-A	IN	A port enabled[*1]
19	EXI-B	IN	B port enabled[*1]
20	EXI-C	IN	C port enabled[*1]
21	EXI-D	IN	D port enabled[*1]
22	EXI-E	IN	E port enabled[*1]
23	EXI-F	IN	F port enabled[*1]
24	EXI-NEAR	IN	AF driving unit travel to NEAR direction
25	EXI-FAR	IN	AF driving unit travel to NEAR direction
26	EXI-AF_MODE	IN	AF0 enabled
27	EXI-SEARCH	IN	SC0 enabled
28	EXI-2FC	IN	Second function enabled
29	GND		GND
30	GND		GND
31	EXO-N_LIMT	OUT	NEAR limit

32	EXO-F_LIMT	OUT	FAR limit
33	EXI-RESET	IN	Reset operation Performs the same operation as power reset
34	Exclusive for system	IN	Do not connect
35	Exclusive for system	OUT	Do not connect
36	EXO-GP1	OUT	Group selected address [0]*3
37	EXO-GP2	OUT	Group selected address [1]*3
38	EXO-GP3	OUT	Group selected address [2]*3
39	ALERT	OUT	Internal monitoring signal
40	Exclusive for system	OUT	Do not connect
41	EXI-GP1	IN	Group specified address [0]*3
42	EXI-GP2	IN	Group specified address [1]*3
43	EXI-GP3	IN	Group specified address [2]*3
44	Exclusive for system	IN	Do not connect
45	Exclusive for system	IN	Do not connect

*1: Exclusion control for pin numbers 18-23.

*2: Please do not connect anything to 34, 35, 40, 44 or 45

*3: Group address (EXI-GP3, EXI-GP2, EXI-GP1)

110: Group 1

101: Group 2

100: Group 3

011: Group 4

010: Group 5

Port and group operation for I/O are invalid when 111 or 00X is set. EXO-A to EXO-F and EXO-GP1 to EXO-GP3 follow the parameters.

Port and group related parameters are rewritten from I/O setting accordingly when group address is valid. Though it is prohibited in specification, when multiple ports are enabled from EXI-A to EXI-F, only one port becomes enabled in the order of A> B> C> D> E> F. The parameter is rewritten and EXO-related also becomes valid only for this port.

（7） Oscilloscope output connector

Please connect the attached measurement terminal BOX when observing the following signals with an oscilloscope.

Pin No.	Signal	IN/OUT	Description
1	TG	OUT	CCD sync signal
2	GND	OUT	GND signal
3	SP-M	OUT	Main sensor (Ach) side sensor signal
4	SP-S	OUT	Sub sensor (Bch) side sensor signal
5	TH-M	OUT	Main sensor (Ach) side trim width signal
6	TH-S	OUT	Sub sensor (Bch) side trim width signal
7	SIG-M	OUT	Main sensor (Ach) side BPF output AF signal
8	SIG-S	OUT	Sub sensor (Bch) side BPF output AF signal
9	INT-M	OUT	Main sensor (Ach) side AF integration signal
10	INT-S	OUT	Sub sensor (Bch) side AF integration signal
11	EPS_AREA	OUT	Epsilon area signal output

*Terminal box is optional.

■ List of AF commands

(1) AF execution commands

Command	Description	Interface to use AF command		
		Operation box	RS-232C	I/O ports
SC0	Performs search operation and peak detection operation within the signal detection range followed by AF trace operation General operation of CHUO Auto Focus operation	○	○	○
SC1	Performs search operation and peak detection operation within specified signal detection range centering on previous just focus detection position followed by AF trace operation	○	○	×
SC2	Performs peak detection operation within signal detection range followed by AF trace operation	○	○	○
SC3	Performs peak detection operation within specified signal detection range centering on previous just focus detection position followed by AF trace operation	○	○	×
SC4	Performs search operation and peak detection operation within specified signal detection range centering on current position followed by AF trace operation	○	○	×
SC5	Performs peak detection operation within specified signal detection range centering on current position followed by AF trace operation	○	○	×
SC6	Performs search operation and peak detection operation within specified signal detection range from current position to [NEAR] direction followed by AF trace operation	○	○	×
SC7	Performs search operation and peak detection operation within specified signal detection range from current position to [FAR] direction followed by AF trace operation	○	○	×
AF0	Performs AF trace operation from current position	○	○	○
AF2	Performs AF trace operation after moving to previous just focus detection position	○	○	×
PF	Performs peak detection operation from current position to [FAR] direction for specified number of pulses followed by AF trace operation Number of pulses are specified in decimal	×	○	×
PFH	Specifies number of pulses for PF operation in hexadecimal	×	○	×

PN	Performs peak detection operation from current position to [NEAR] direction for specified number of pulses followed by AF trace operation Number of pulses are specified in decimal	×	○	×
PNH	Specifies number of pulses for PN operation in hexadecimal	×	○	×

(2) AF driving unit commands

Command	Description	Interface to use AF command		
		Operation box	RS-232C	I/O ports
G	Moves AF driving unit to specified coordinate (Home_Speed) (decimal)	○	○	×
GH	Specifies coordinate for G operation in hexadecimal	×	○	×
F	Moves AF driving unit from current position to [FAR] direction for specified number of pulses (Home_Speed) (decimal)	○	○	○
FH	Specifies number of pulses for F operation in hexadecimal	×	○	×
N	Moves AF driving unit from current position to [NEAR] direction for specified number of pulses (Home_Speed) (decimal)	○	○	○
NH	Specifies number of pulses for N operation in hexadecimal	×	○	×
FL	Moves AF driving unit to [FAR] side hard limit (position of limit sensor detection) (Home_Speed)	×	○	×
NL	Moves AF driving unit to [NEAR] side hard limit (position of limit sensor detection) (Home_Speed)	×	○	×
ASPD	Reads out coordinates of FSP/NSP/MSP/STOP (decimal)	×	○	×
ASP	Reads out ASP coordinate in hexadecimal	×	○	×
FSPD	Moves AF driving unit to FSP (Home_Speed) and reads out stop position (decimal)	×	○	×
FSP	Reads out stop position of FSP operation in hexadecimal	×	○	×
NSPD	Moves AF driving unit to NSP (Home_Speed) and reads out stop position (decimal)	×	○	×
NSP	Reads out stop position of NSP operation in hexadecimal	×	○	×
MSPD	Reads out coordinate of MSP (decimal)	×	○	×
MSP	Reads out MSP coordinate in hexadecimal	×	○	×
STPD	Moves AF driving unit to STOP (Home_Speed) and reads out stop position (decimal)	×	○	×
STP	Reads out stop position of STP operation in hexadecimal	×	○	×
AB	Rewrites current coordinate of AF driving unit to specified value (decimal)	×	○	×

ABH	Rewrites value specified by AB in hexadecimal	×	○	×
DP	Reads out current position of AF driving unit (decimal)	○ Always display	○	×
HP	Reads out DP coordinate in hexadecimal	×	○	×

(3) Pattern driving unit commands

Command	Description	Interface to use AF command		
		Operation box	RS-232C	I/O ports
SF	Moves pattern driving unit from current position to [FAR] direction for specified number of pulses (SX_Speed) (decimal)	○	○	×
SFH	Specifies number of pulses for SF operation in hexadecimal	×	○	×
SFL	Moves pattern driving unit to [FAR] side hard limit (position of limit sensor detection) (SX_Speed)	×	○	×
SN	Moves pattern driving unit from current position to [NEAR] direction for specified number of pulses (SX_Speed) (decimal)	○	○	×
SNH	Specifies number of pulses for SN operation in hexadecimal	×	○	×
SNL	Moves pattern driving unit to [NEAR] side hard limit (position of limit sensor detection) (SX_Speed)	×	○	×
SDP	Reads out current position of pattern driving unit (decimal)	○ Always display	○	×
SHP	Reads out SDP coordinate in hexadecimal	×	○	×

(4) Adjustment commands

Command	Description	Interface to use AF command		
		Operation box	RS-232C	I/O ports
AT	Reads out values of INT/AGC (decimal)	×	○	×
BPOD	Reads out sensor signal BPF INPUT voltage (Ach, Bch) (decimal)	×	○	×
BPO	Reads out BPO voltage value in hexadecimal	×	○	×
SIGD	Reads out sensor signal and AF signal voltage values for Ach and Bch (decimal)	×	○	×
SIG	Reads out SIG voltage value in hexadecimal	×	○	×
VR2D	Reads out setting value of BPF (decimal)	×	○	×
VR2	Reads out value of VR2 in hexadecimal	×	○	×
VR3D	Reads out setting value of Balance (decimal)	×	○	×
VR3	Reads out value of VR3 in hexadecimal	×	○	×
AJP	AF auto adjustment command Adjusts Pattern-INF automatically	○	○	×
AJB	AF auto adjustment command Adjusts Balance automatically	○	○	×
AJF	AF auto adjustment command Adjusts BPF automatically	○	○	×

(5) Other commands

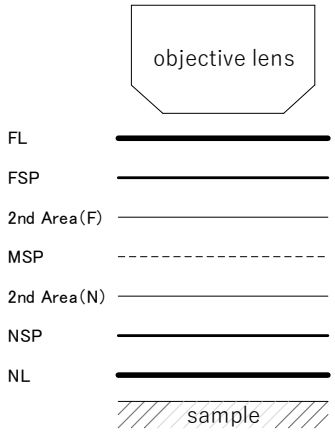
Command	Description	Interface to use AF command		
		Operation box	RS-232C	I/O ports
EPS	Reads out setting value of focus determination tolerance factor for previous just focus position If just focus determination has not been performed after power is turned on, setting value of Epsilon will be read out	×	○	×
MOT	Reads out number of steps of driving unit stepper motor (decimal)	×	○	×
RST	Returns AF driving unit to HOME position	○	○	○
RSTX	Returns AF driving unit to HOME position (travel range is between FL and NL)	×	○	×
VER	Reads out AFC version (main unit version and DSP version) *Reads out main unit version only for AFC-5 mode	○ Only upon startup	○	×
P	Reads and writes parameters (no access to backup memory) *Not supported in AFC-5 mode	○	○	×
FW	Saves all currently set parameters to backup memory *Not supported in AFC-5 mode	○	○	×
Y	Stops AF status notification during AF trace operation (AF operation continues)	×	○	×
Z	Resumes AF status notification after canceling Y command AF status notification stop status during AF trace operation	×	○	×
Q	Stops operation	○	○	○
POT	Checks current port or change port *Not supported in AFC-5 mode	○	○	○
RESET	Initializes operation for parameters *Not supported in AFC-5 mode	×	○	×
RESTA	Resets main unit to same status as power cycle *Not supported in AFC-5 mode	×	○	○

6. Auto Focus operation

■ Operation range

There is operation range as follow for AF operation. FL and NL are the travel range of microscope. Others are parameters related to AF operation.

FL	: Far Limit (reference point)
FSP	: Far Search Point
2nd_Area(F)	: Second Area (FAR side)
STOP	: Stop Point (return to HOME)
MSP	: Multi Select Point
2nd_Area(N)	: Second Area (NEAR side)
NSP	: Near Search Point
NL	: Near Limit



(1) FAR and NEAR

FAR refers to the direction to which objective lens (AF driving unit) moves away from the sample. Limit switch in this direction is called FL (Far Limit) and this FL is used as a reference point.

NEAR refers to the direction to which objective lens (AF driving unit) moves towards the sample. Limit switch in this direction is called NL (Near Limit).

FAR and NEAR are used as relative expressions. Coordinate value decreases when moving away to FAR direction, and coordinate value increases when moving back to NEAR direction.

There are two types of AF driving units for CHUO Auto Focus microscope: one is the type that lens tube is driven and another is the type that sample table is driven with the sample placed upon. In either case, the direction where the objective lens and the sample moves apart is called FAR, and the direction where the objective lens and sample gets closer is called NEAR.

(2) Reference point

For CHUO AF system, reference point is set at FL (Far Limit) with coordinate at 512.Motor decelerates and stop when it detects limit of FL (Far Limit). This reference point is where limit detection is released while AF driving unit is traveling to [NEAR] direction from FL (Far limit) limit sensor detection range of AF driving unit.

(3) FSP and NSP

For Auto Focus operation [SC0] and [SC2], FAR side of search range is called FSP and NEAR side of search range is called NSP.

(4) MSP

Coordinate information to determine the direction of signal detection operation for Auto Focus operation [SC0], [SC1], and [SC4].

(5) 2nd_Area

2nd_Area is the signal detection range of Auto Focus operation [SC1], [SC3], [SC4], and [SC5]. Auto Focus operation [SC1] and [SC3] set the distance centered on the previously detected just focus position as number of pulses. For Auto Focus operation [SC4] and [SC5], distance centered on current position is set as number of pulses.

(6) STOP

Stop position after returning to HOME position.

(7) Reference value of operation range

Search range is set within ± range based on the focal point of each objective lens. Standard search range (reference value) is set as follows according to specifications of objective lenses.

Search range for each objective lens (reference value)

Objective magnification	2.5x(2x)	5x	10x	20x	50x	100x
Search range (± μm)	300	250	250	250	150	100

Make sure to avoid contact of objective lens and the sample when setting search range. It is recommended to set soft limit in case when sample may be in contact with lens due to W.D. (working distance) of objective lens.

■ Travel speed

Travel speed of AF driving unit is set with parameters by following five methods.

- Home_Speed
- Jog-Speed
- S-Speed
- P-Speed
- AF-Speed

There are high speed, low speed and acceleration/deceleration time for travel speed and speed transition is described as follows. High speed and low speed are set in pps, and acceleration/deceleration time is set in ms.

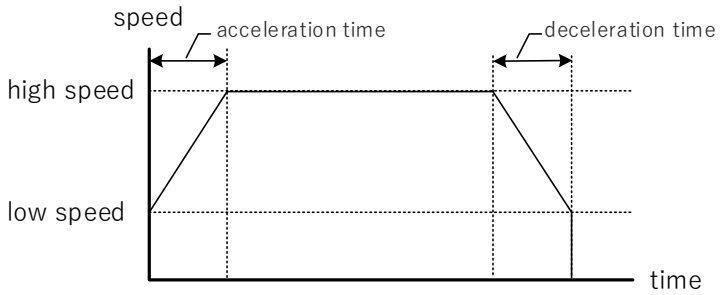


Figure 5 Travel speed

■ Coordinates (position information) and travel distance

Coordinates are in units of one pulse of AF driving unit. Distance between coordinates changes according to number of drive divisions of AF driving unit. The relation of drive divisions set for AF driving unit and distance between coordinates (resolution) is as follows.

Microstep divisions	Resolution (μm/pulse)	Supplement
1/16	0.3125	
1/32	0.15625	Initial setting
1/64	0.078125	

Caution!! **Linear movement resolution is the value when using CHUO standard driving unit (screw lead 1 mm/r). Resolution may differ when you change the screw lead.**

■ Adjustment

In order to operate Auto Focus correctly, making adjustments become necessary according to equipment and sample. Adjustment operation is highly specialized and is basically performed by CHUO engineers. This product is equipped with auto adjustment function to perform part of this adjustment operation automatically. Auto adjustment sets parameters (No.023: Pattern_INF, No.022: Balance, No.021: BPF) to optimum values automatically. These parameters are referred in Auto Focus operations. Pattern-INF is position information of pattern driving unit (valid only for products with pattern driving unit). Balance is adjustment parameter between sensors (valid only for products without pattern driving unit). BPF is parameter for adjusting intensity of sensor image. Note that auto adjustment may not be possible.
Auto adjustment shall be performed with following procedures.

(1) Preparation
  ① Focus
  ② Activate auto adjustment program
    Execute with dedicated adjustment software (PC application), operation box and communication commands
  ③ Set target focus position (Parameter No.101: Target_Point)
  ④ Set Auto Focus search range (Parameter No.001: FSP, No.004: NSP)

(2) Pattern-INF
  ① Set travel distance (number of steps) of pattern driving unit (Parameter No.102: Pattern_Step)
  ② Input parameter No.022: Balance and No.021: BPF (accepted with initial values)
  ③ Set settling range with target focus position (Parameter No.103: In-position_Area)

④ Execute

Execute Auto focus operation SC0. Travel speed is S-Speed during search operation, P-Speed during peak detection operation and AF-Speed during AF trace operation. Travel speed to return to target focus position is parameter Home_Speed.

Travel speed to change coordinates of pattern driving unit is parameter SX_Speed.

Process ends normally and parameter Pattern-INF will be updated if just focus determination is detected within settling range.

When just focus is not determined within settling range, this process will be terminated with error. Please reduce parameter Patten_Step or increase In-position_Area.

(3) Balance

① Input parameter No.022: Balance and No.021: BPF (accepted with initial values)

② Execute

Execute Auto focus operation SC0. Travel speed is S-Speed during search operation, P-Speed during peak detection operation and AF-Speed during AF trace operation. Travel speed to return to target focus position is parameter Home_Speed.

Process ends normally and parameter Balance will be updated if AF signal voltage difference between Ach and Bch at target focus position is within specified value.

When it fails to fall within the specified value for AF signal voltage difference between Ach and Bch at target focus position, this process will be terminated with error. Please reduce initial value of BPF.

(4) BPF

① Parameter No.104: Set target value of Agc

② Parameter No.021: Input initial value of BPF (accepted with initial values)

③ Parameter No.105: Set Auto Focus operation of BpfSrch

④ Execute

When Auto Focus operation is SC0, travel speed is S-Speed during search operation, P-Speed during peak detection operation and AF-Speed during AF trace operation. Travel speed is AF-Speed when Auto Focus operation is AF0.

Process ends normally and parameter BPF will be updated if INT and AGC values are near set value of parameter Agc at the time of just focus determination.

When INT and AGC values fails to fall near set value of parameter Agc at the time of just focus determination, this process will be terminated with error. Please reduce target value of Agc or increase AF illumination.

■ HOME return

This operation is to determine the reference point. STOP is the position after HOME return. Travel speed is Home_Speed. HOME return will be performed as first thing after power is turned on. It can also be executed with communication command, operation box, adjustment software and I/O ports. Following are the two commands for HOME return operation.

- RST
- RSTX

(1) RST

AF driving unit travels from current position to [FAR] direction and stops after detecting FL (Far limit). Travels to [NEAR] direction after stopping, sets 512 at position where FL is released and travels to STOP position.

(2) RSTX

AF driving unit travels from current position to [NEAR] direction, decelerates and stops after detecting NL. Travels to [FAR] direction after stopping at NL and decelerates to stop after detecting FL (Far limit). Travels to [NEAR] direction after stopping, sets 512 at position where FL is released and travels to STOP position.

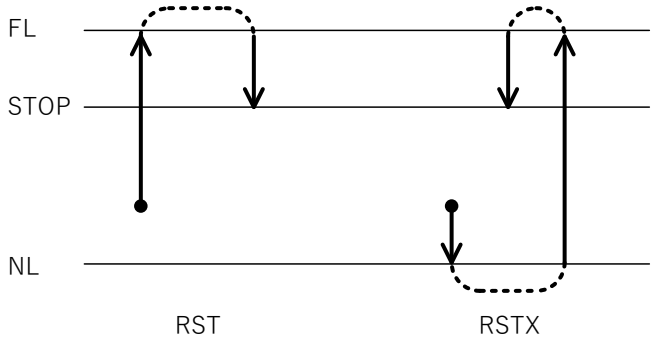


Figure6 Return to HOME operation

Caution!! **Please make sure objective lens is not in contact with sample.**
Please stop when there is a risk for objective lens to be in contact with sample.

■ Auto Focus operation commands

There are 12 Auto Focus operations: SC0, SC1, SC2, SC3, SC4, SC5, SC6, SC7, AF0, AF2, PF (PFH) and PN (PNH).

(1) SC0 operation

Following figure shows SC0 operation used as basic operation of AF execution command performed by AFC. SC0 operation is performed in three ways: search, peak detection and AF trace operation. Search starts from FAR side when current position ≤ MSP and from NEAR side when current position> MSP (figure below is when current position ≤ MSP).

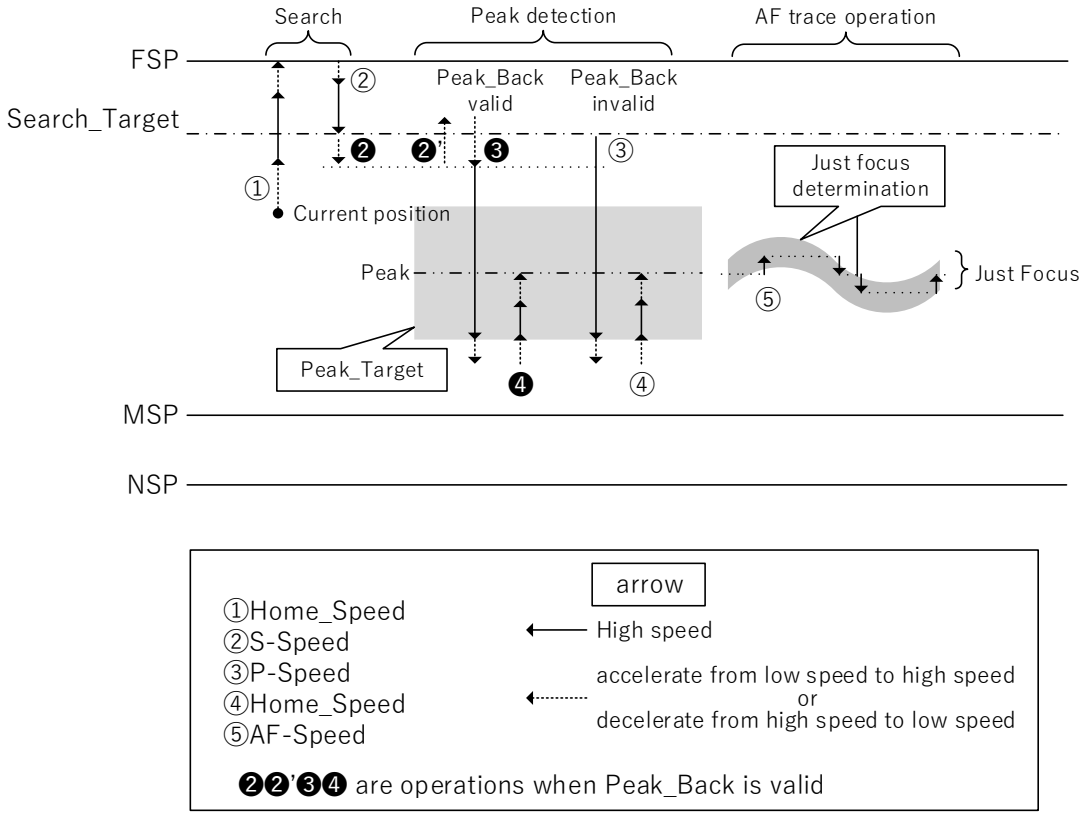
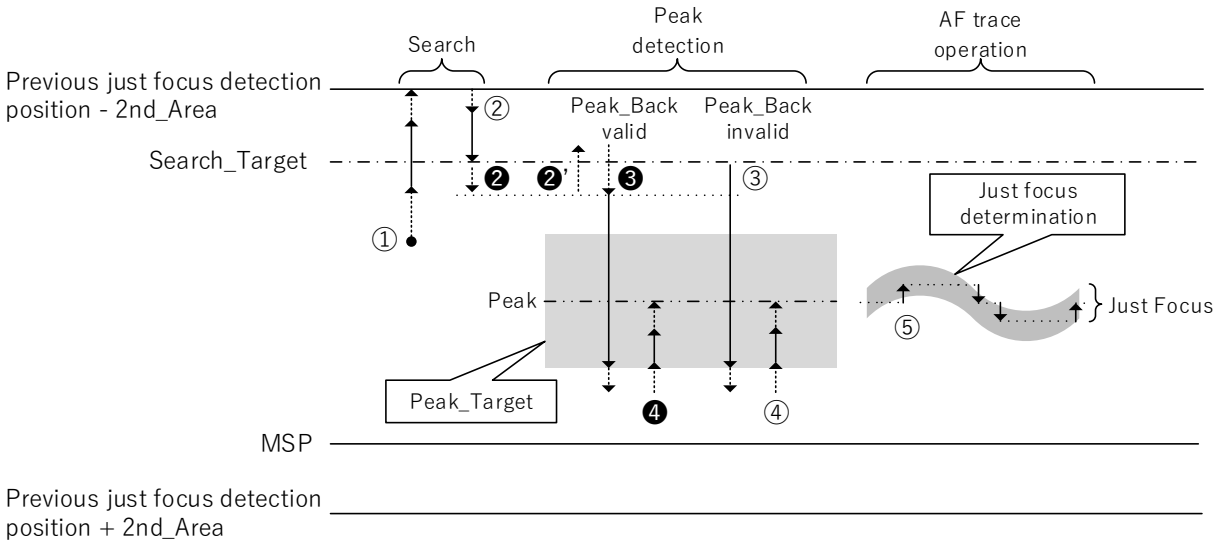


Figure 7 SC0

(2) SC1 operation

Following figure shows SC1 operation of AF execution command performed by AFC. SC1 operates in same way as SC0 among 2nd_Area centering on previous just focus detection position. Search starts from FAR side when previous just focus detection position ≤ MSP and from NEAR side when previous just focus detection position> MSP (figure below is when previous just focus position ≤ MSP).



arrow	
①Home_Speed	⟵ High speed
②S-Speed	
③P-Speed	⟵ accelerate from low speed to high speed or decelerate from high speed to low speed
④Home_Speed	
⑤AF-Speed	

❷❷'❸❹ are operations when Peak_Back is valid

＊When there is no previous just focus detection position information, previous just focus detection position is replaced with STOP position

Figure 8 SC1

(3) SC2 operation

Following figure shows SC2 operation of AF execution command performed by AFC. SC2 operation is performed in two ways with peak detection and AF trace operation. Peak detection starts from FSP when 2CK=0 and from NSP when 2CK=1 (figure below is when parameter 2CK=0).

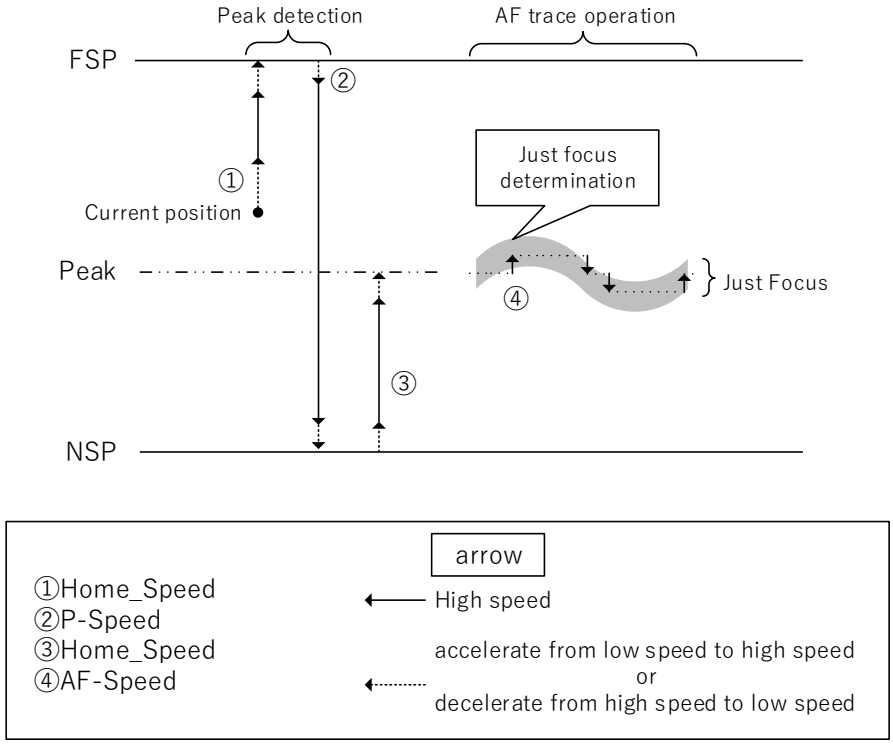


Figure 9 SC2

(4) SC3 operation

Following figure shows SC3 operation of AF execution command performed by AFC. SC3 operates in same way as SC2 among 2nd_Area centering on previous just focus detection position. Peak detection starts from FAR side when 2CK=0 and from NEAR side when 2CK=1 (figure below is when parameter 2CK=0).

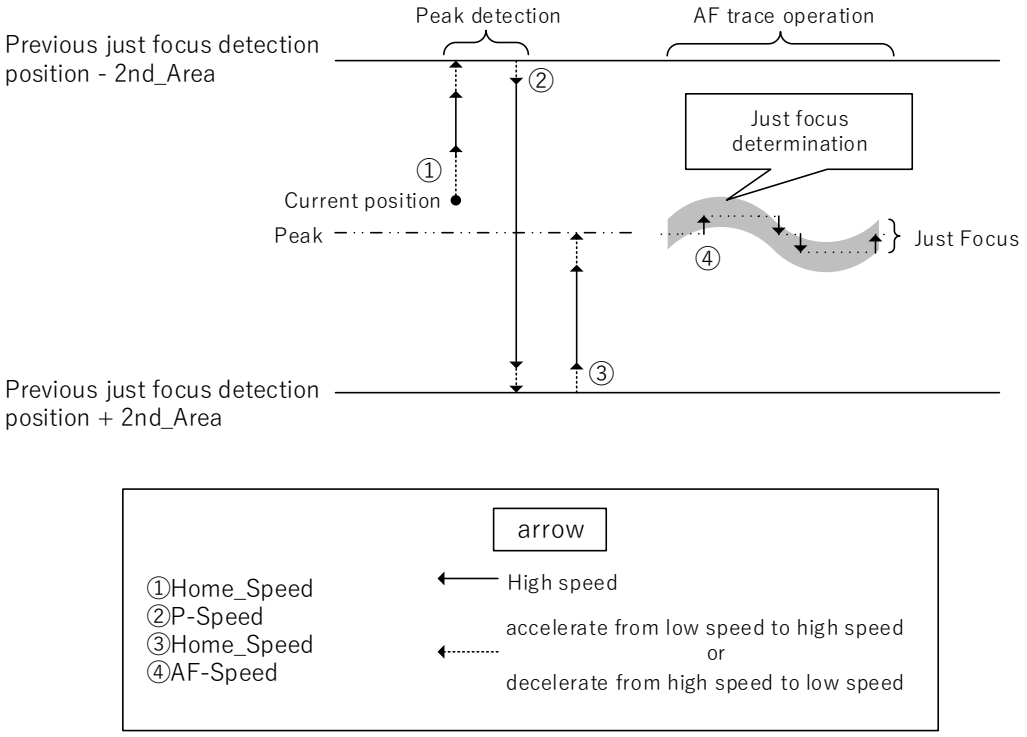


Figure 10 SC3

(5) SC4 operation

Following figure shows SC4 operation of AF execution command performed by AFC. SC4 operates in same way as SC0 among 2nd_Area centering on current position. Search starts from FAR side when "current position ≤ MSP" and from NEAR side when "current position > MSP" (figure below is when current position ≤ MSP).

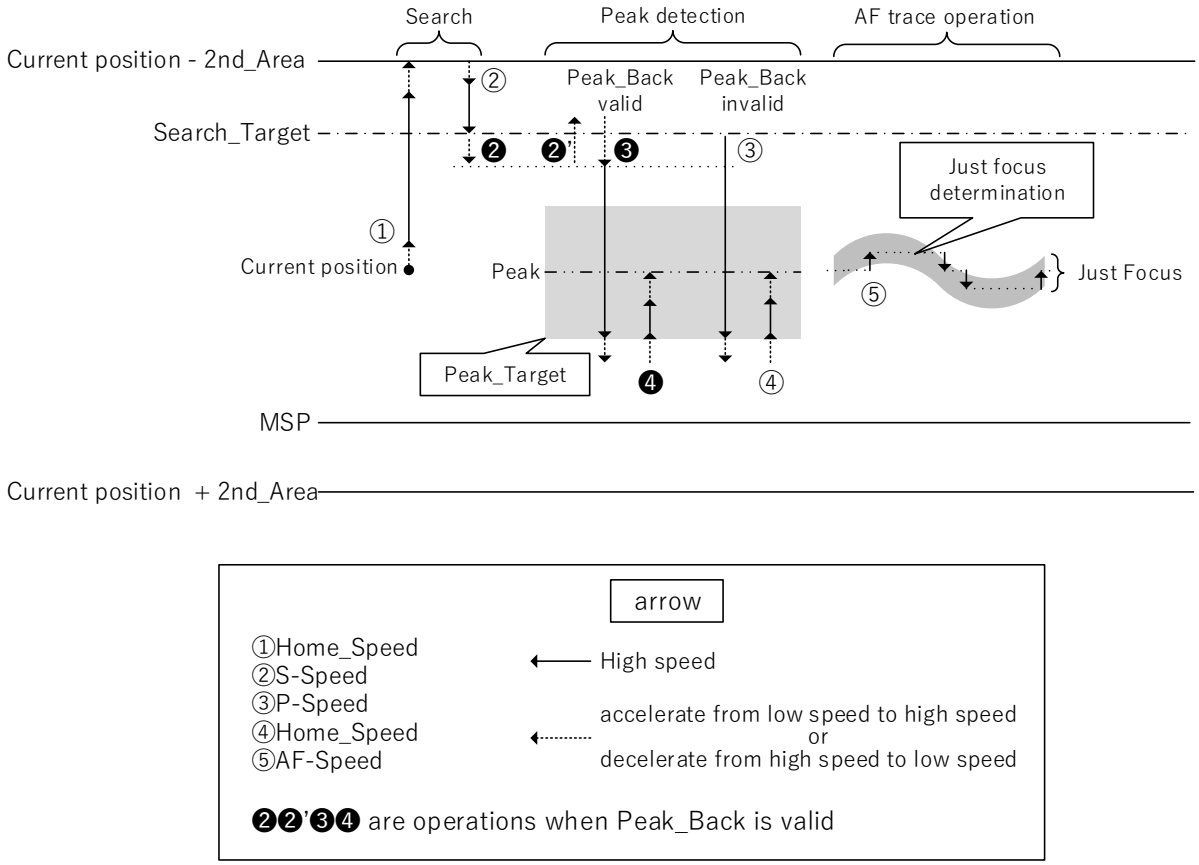


Figure 11 SC4

(6) SC5 operation

Following figure shows SC5 operation of AF execution command performed by AFC. SC5 operates in same way as SC2 among 2nd_Area centering on current position. Peak detection starts from FAR side when 2CK=0 and from NEAR side when 2CK=1 (figure below is when parameter 2CK=0).

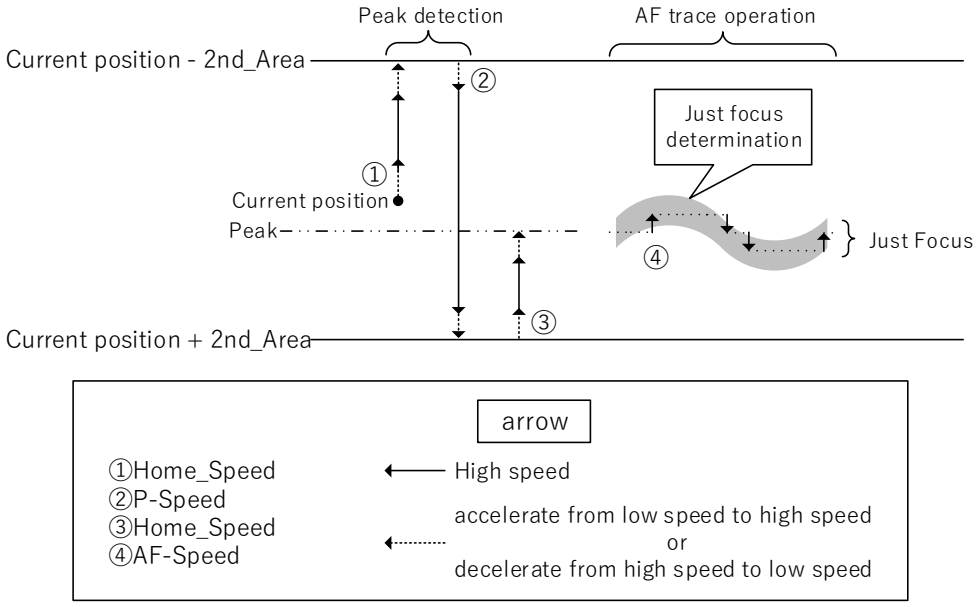


Figure 12 SC5

(7) SC6 operation

Following figure shows SC6 operation of AF execution command performed by AFC. SC6 operates in same way as SC0 among specified area from current position to NEAR direction.

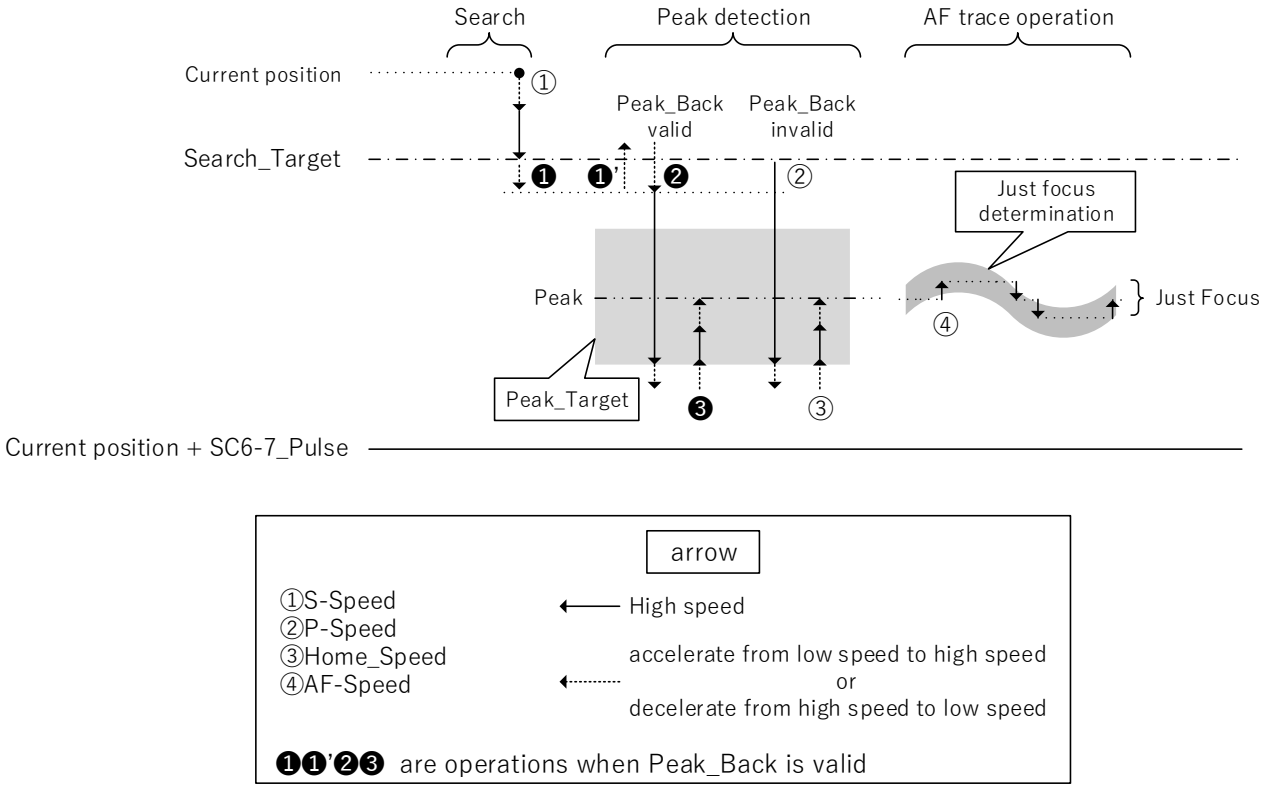


Figure 13 SC6

(8) SC7 operation

Following figure shows SC7 operation of AF execution command performed by AFC. SC7 operates in same way as SC0 among specified area from current position to FAR direction.

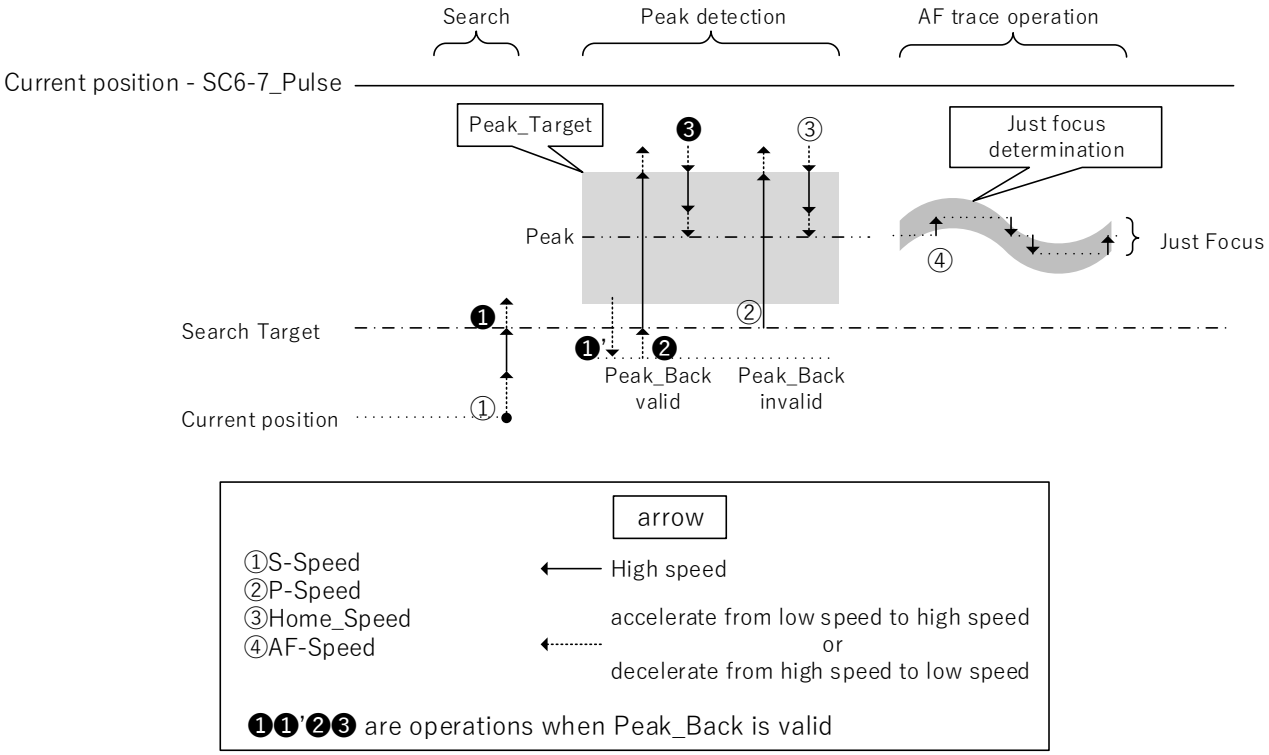


Figure 14 SC7

(9) AF0 operation

Following figure shows AF0 operation of AF execution command performed by AFC. Performs AF trace operation from current position.

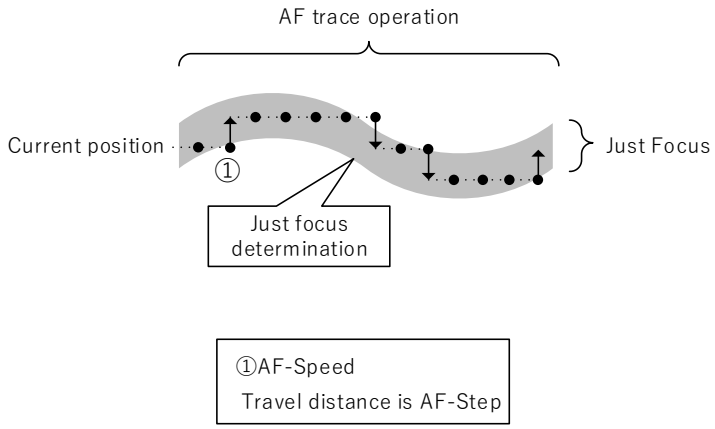


Figure 15 AF0

(10) AF2 operation

Following figure shows AF2 operation of AF execution command performed by AFC. Performs AF trace operation after moving to previous just focus detection position at high speed.

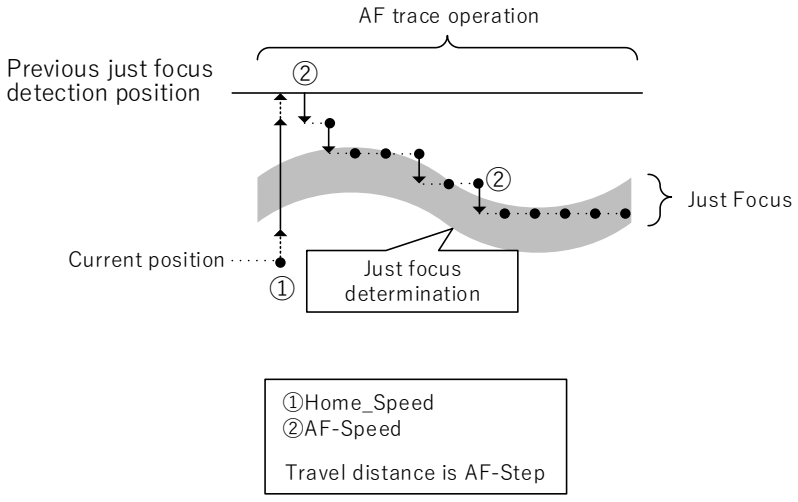


Figure 16 AF2

(11) PF/PFH operation

Following figure shows PF and PFH operation of AF execution command performed by AFC. Operates in same way as SC2 for specified number of pulses from current position to FAR direction.

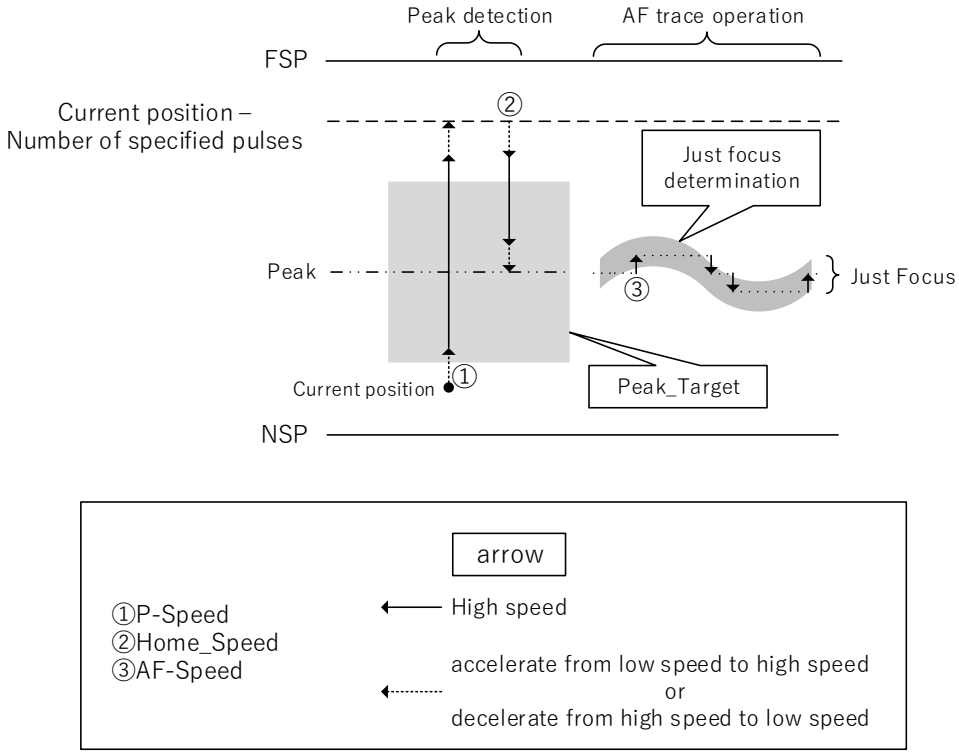


Figure 17 PF/PFH

(12) PN/PNH operation

Following figure shows PN and PNH operation of AF execution command performed by AFC. Operates in same way as SC2 for specified number of pulses from current position to NEAR direction.

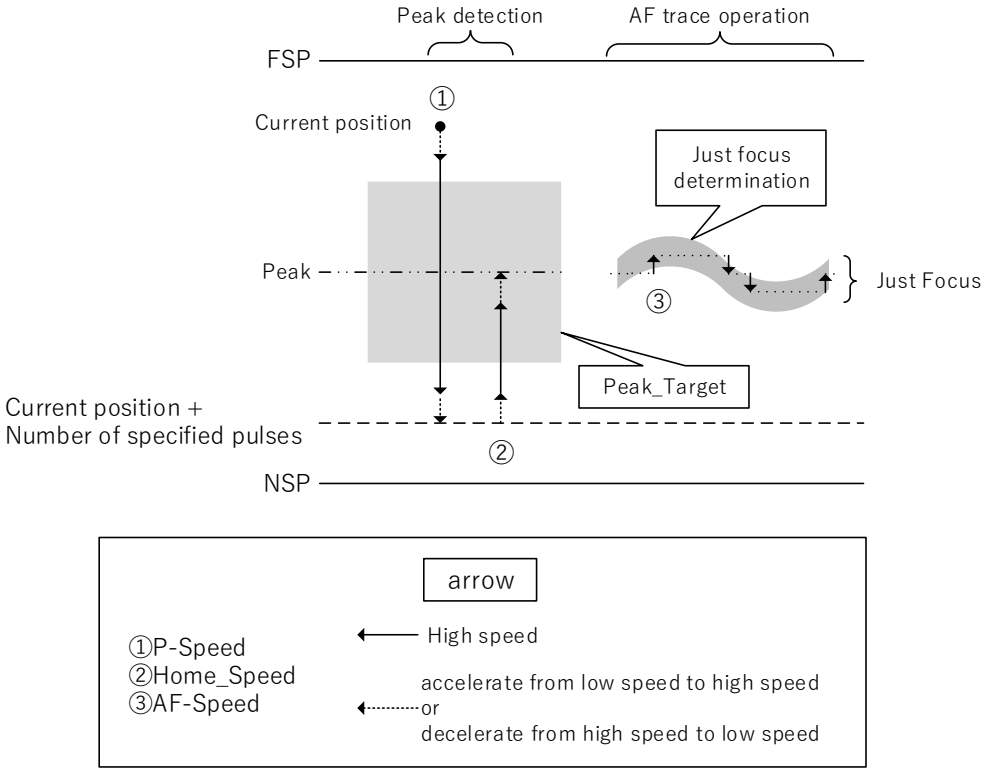


Figure 18 PN/PNH

■ Search error and Peak detection error

If the signal does not reach the level for focusing in the operating range during search and peak detection, a search error (FE) will occur for search and a peak detection error (PE) will occur for peak detection. A search error will occur if the signal exceeding parameter No. 031: Search_Target is not found within the search range. Also, within the peak detection range, a peak detection error will occur if the signal does not satisfy parameter No.032: Peak_Target .

There are three ways to handle these errors: stop processing, Re-Push AF, and hybrid mode.

Stop processing is a stop operation such as Q command or Stop operation of operation box. After the stop process, returns to the previous just focus position. If just focus determination has not been performed after power is turned on, moves to STOP position

Re-PushAF processing is enabled when Re-PushAF is 0. If the autofocus operation is executed during error detection, the error is canceled and the specified autofocus operation is started.

In the hybrid mode processing, if search error or peak detection error is detected when parameter No. 071: Hybrid_Mode is 1 or 3, re-search is automatically performed. The AF operation of the re-search depends on parameter No. 074: Hybrid_Command.

■ Just Focus

In AFC operation, just focus is means that the focusing position is within the focus determination tolerance during AF tracking. Also, when the subject is in focus and the signal level for focusing is within the specified range, it is called just focus and is represented by the symbol (J). In the focused condition, when the signal level is high, it is represented by the symbol (H) called H level, and when the signal level is low, it is represented by the symbol (L) called L level.

The focus determination tolerance is set with parameters No.051: Epsilon and No.052: 2'nd_Epsilon. The signal level is set with parameters No.624: H_Range and No.625: L_Range (in hybrid mode, parameters No.072: High_Level and No.073: Low_Level).

■ Auto Focus particular operation

AFC-6 is equipped with hybrid mode which is the combination of basic Auto Focus operations. Hybrid mode is particular operation to continue trace operation when it is difficult to trace with basic operation due to uneven shape or surface of sample.

(1) Function of hybrid mode

Hybrid mode consists of 3 modes: MSP, AF-step and Hybrid. Operation of selected mode starts automatically when designated conditions for each mode are satisfied.

Mode	Content
MSP	Performs specified AF operation when just focus determination is discontinued due to uneven sample during AF trace operation.
AF-step	Automatically changes step travel distance (number of steps) during AF trace operation
Hybrid	Operation using both MSP mode and AF-step mode

(2) MSP mode

- Outline

Re-performs specified AF operation when just focus determination is discontinued with unrecognized AF signals during trace operation due to uneven sample.

- Activating condition

Activates MSP mode when following three conditions are satisfied with hybrid mode set to MSP.

- When receiving error response (FE or PE) as a result of AF operation
- When result of focus determination is more than or equal to No.072：High_Level during trace operation and has elapsed time (ms) specified in Parameter No. 079: Timer_T1.
- When result of focus determination is less than or equal to Parameter No. 073: Low_Level during trace operation and has elapsed time (ms) specified in Parameter No. 079: Timer_T1.

- Operation details

Performs Auto Focus operation set in Parameter No. 074: Hybrid_Command when MSP activating condition is satisfied during Auto Focus operation. This operation continues until it satisfies cancel condition of MSP mode.

- Cancel condition

There are two cancel conditions; normal cancel and forced cancel.

① Normal cancel

Cancels MSP mode and continues trace operation when it reaches just focus determination during MSP mode.

② Forced cancel

Terminates operation after executing error processing of Auto Focus operation when AF operation set with Parameter No. 074: Hybrid_Command reaches number of times set with Parameter No. 078: Hyb_Count.

- MSP parameters

  Parameter No.072: High_Level
  Parameter No.073: Low_Level
  Parameter No.074: Hybrid_Command
  Parameter No.078: Hyb_Count
  Parameter No.079: Timer_T1

(3) AF-step mode

- Outline

Step travel distance during trace operation is fixed under normal operation. For this reason, trace operation takes longer time to reach just focus tolerant area for much uneven samples. Step travel distance during the trace operation is automatically changed in AF-step mode to increase trace response against uneven samples.

- Activating condition

Activates AF-step mode when just focus range is deviated during trace operation with hybrid mode set as AF-step. Sets AF-step just focus determination range with Parameter No. 077: Epsmode.

- Operation details

There are two possible status when just focus range continues to deviate during AF trace operation. One is when focus range is not found immediately after travelling to same direction, and another is when travel direction repeats switching direction (hunting) across focus range.

・ Unable to find just focus range immediately after traveling to same direction

Increases step travel distance as travel distance may be insufficient for current operation. Travel distance increases when trace operation in same direction continues without just focus and reaches set number of times for Parameter No. 055: RET in AF-step units. Current AF-Step_Table number increments by one each time parameter RET is satisfied. Maximum value of this number is set with Parameter No. 075: AF-StepRankUP and maintains the value once it reaches its maximum point. Travel distance is number of steps indicated to reference by this number.

・ Repeats direction switching (hunting)

It is called hunting where step travel distance is too large and switching of direction is repeated across just focus range. Hunting is manageable with reducing number of steps in travel distance. Travel distance changes when direction switching for each AF-step reaches number of times specified in Parameter No.056: HNC without just focus. When condition of parameter HNC is satisfied, travel amount decrements by 1 from setting number of AF-Step_Table and changes to number of steps of referenced value. Minimum value of this number is 0 and maintains AF trace operation at its number of steps once it reaches minimum point.

- Cancel condition

When the Just Focus signal reaches set number of times (parameter No. 054: JJC), AF step mode is canceled and resumes in normal operation.

- Operation example

When number of steps in AF-Step_Table is set as following table and current step travel distance is No. 2 with parameter No. 075: AF-StepRankUP set to No. 4, travel distance changes as follows.

・ Unable to find just focus range immediately after traveling to same direction in trace operation
Current AF-Step_Table number increases for 2 (4 pulses), 3 (8 pulses) and 4 (16 pulses) from current travel distance (pulse) to 4 at setting value AF-stepRankUP.

・ Repeats switching of direction (hunting) in trace operation
Current AF-Step_Table number decreases for 2 (4 pulses), 1 (2 pulses) and 0 (1 pulse) from current travel distance to No. 0.

No.	Travel distance (number of pulses)
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128

- Related parameters

Parameter No.054: JJC (Common with normal mode)
Parameter No.055: RET (Common with normal mode)
Parameter No.056: HNC (Common with normal mode)
Parameter No.071: Hybrid_Mode
Parameter No.075: AF-StepRankUP
Parameter No.077: Epsmode

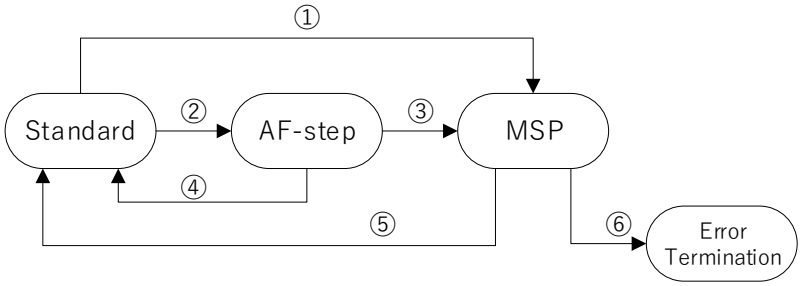
(4) Hybrid mode

- Outline

Transitions to MSP mode or AF-step mode when specified conditions are satisfied during AF trace operation.

- Operation details

Transitions to MSP mode or AF-step mode with hybrid mode set as Hybrid and the following conditions ① to ③ are satisfied. State transition is as follows.



① When MSP mode activating condition is satisfied during normal operation
② When AF-step mode activating condition is satisfied during normal operation
③ When Following two conditions are satisfied during AF trace operation
  - Number of step travel operations has reached setting value in Parameter No. 076: B_count
  - Deviated from just focus condition range 3rd ε (Parameter No.053：3rd_Epsilon)
④ When number of continuous just focus reached the number set in Parameter No. 054: JJC
⑤ When normal cancel condition in MSP mode is satisfied
⑥ When forced cancel condition in MSP mode is satisfied

- Cancel condition

There are two cancel conditions; normal cancel and forced cancel.

① Normal cancel
  Continues trace operation when cancel condition of each mode is satisfied during MSP mode or AF-step mode.
② Forced cancel
  Terminates operation after executing error processing of Auto Focus operation when forced cancel condition is satisfied in MSP mode.

- Hybrid parameters

Parameter No.053: 3rd_Epsilon
Parameter No.054: JJC (Common with normal mode)
Parameter No.055: RET (Common with normal mode)
Parameter No.056: HNC (Common with normal mode)
Parameter No.072: High_Level
Parameter No.073: Low_Level
Parameter No.074: Hybrid_Command
Parameter No.075: AF-StepRankUP
Parameter No.076: B_count
Parameter No.077: Epsmode
Parameter No.078: Hyb_Count
Parameter No.079: Timer_T1

Warranty and repair

■Warranty period

Repair services are available for free of charge in the event of technical failure under warranty period in accordance with CHUO regulations.

Warranty period	**1 year from shipment**

Repair costs will not be covered for following cases.

- Due to improper use, inappropriate repair or remodeling the product
- Due to applying external shock after purchasing the product
- Due to fire, earthquake, flood, lightning or other natural disasters
- Due to environmental pollution or by applying abnormal voltage
- For defects predetermined by CHUO not to apply this warranty
- Due to any use not following this instruction manual

■Repair service during warranty period

Please contact the authorized distributors or company of purchase for repair service.

■Repair service for out-of-warranty products

Contact the authorized distributors or company of purchase for out-of-warranty products. Repair services will be provided with charges depending on conditions. Please provide the following information in order to prepare and deliver effective repair services.

- Date of purchase, product name and manufacturing number
- Details of how the product is used
- Specific description of defects
- Matters that may be the cause of defect

Please note in advance that there may be cases that CHUO is unable to provide repair services.

All descriptions and specifications in this manual are subject to change without prior notice.
Please note in advance that products are also subject to change without prior notice.

Auto Focus Controller AFC-6　INSTRUCTION MANUAL　Ver.1.0

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