

Auto Alignment System

IFA-600-AUCME3

Operation Manual

[FMA-OMF6-MA2609A5-Rev10]

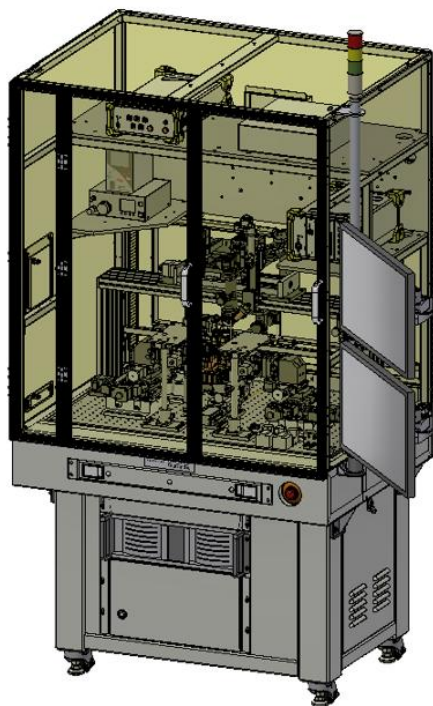


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1. System Overview

1.1. Introduction

IFA-600-AUCME3 is for the alignment/bonding of photonic-integrated circuit (PIC) devices such as an optical splitter, an arrayed waveguide gratings, and many other types of devices. The features of the system are:

- Total 24 motorized stages including 21 high precision motorized stages for active alignment.
 - 6-axis alignment stage assemblies (Left, Right, S1)
 - 3-axis center stage assembly
- 3-axis tool positioner assembly which places cameras, epoxy syringe, and UV heads.
- 3 digital cameras for vision processing and real-time process monitoring
- Multi-channel power meter/current meter for optical and electrical measurement
- Precise temperature control from +15 °C to +75 °C
- Built-in pneumatic anti-vibration table
- UV safety enclosure
- Fixtures with detachable mechanism for handling the coupling methods including:
 - Edge coupling with optical fiber / fiber block
 - Vertical coupling with optical fiber / fiber block
 - Free space lens alignment
 - Electric probing
- Analog input ports for active alignment with external signal
- Compact system size
- Various alignment methods that can be tuned with many parameters
- Precise gap control and angle alignment of FAB based on displacement sensor
- Vision processing functions and vision-based interactive stage control
- Automatic epoxy dispensing & UV curing for device assembly
- Versatile/flexible software with convenient graphic user interface
- TCP/IP server integrated in control software for remote operation

1.2. Names of each part

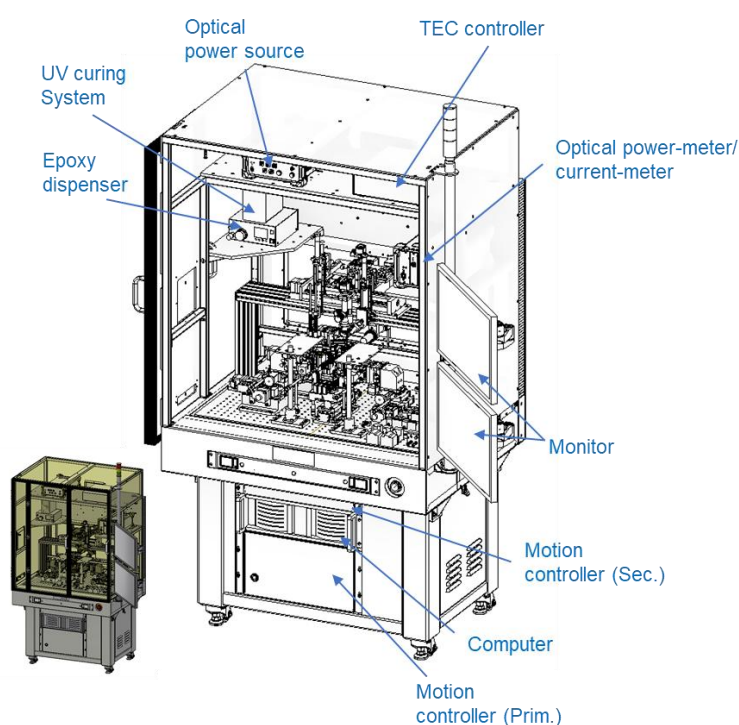


Fig. 1.1 IFA-600-AUCME3: Auto Alignment System

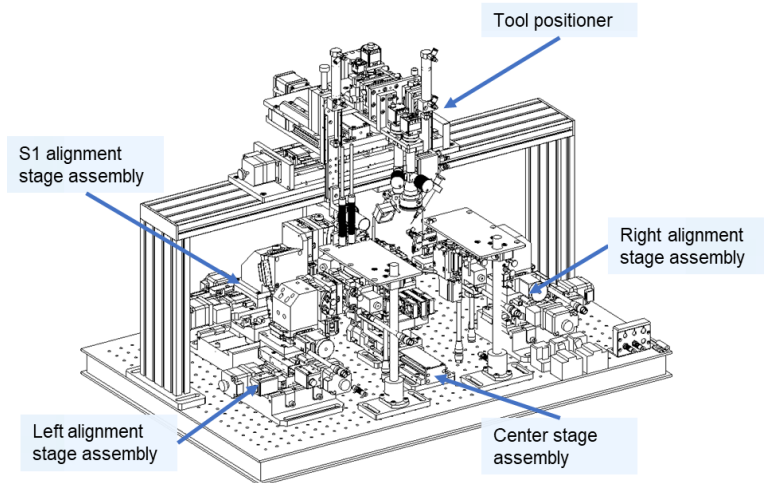


Fig. 1.2 Alignment parts

1.3. Functional block diagram

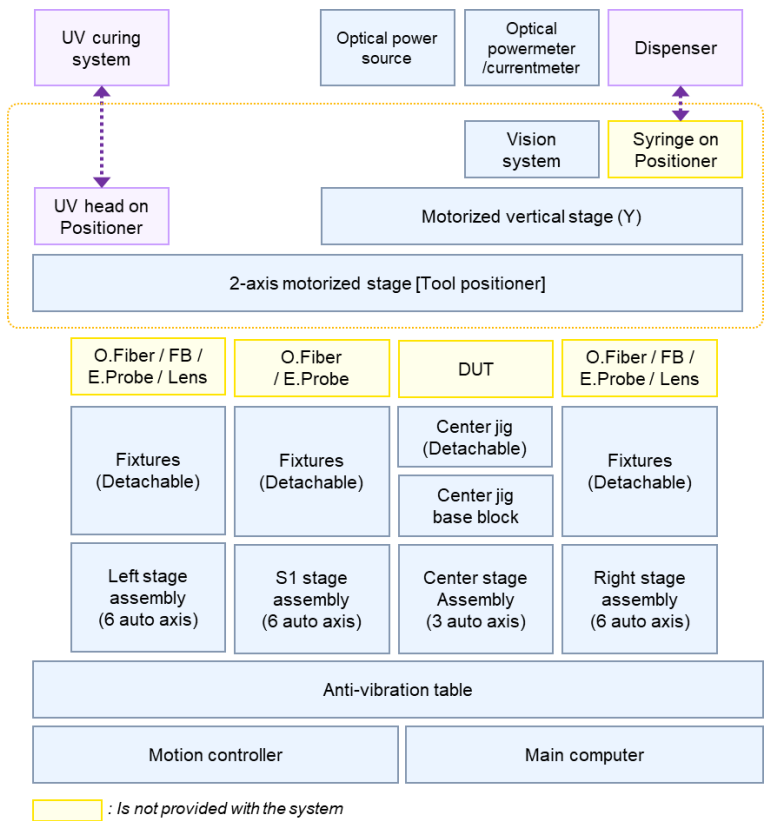


Fig. 1.3 Functional block diagram

2. Installation Guide

2.1. Names of principal parts

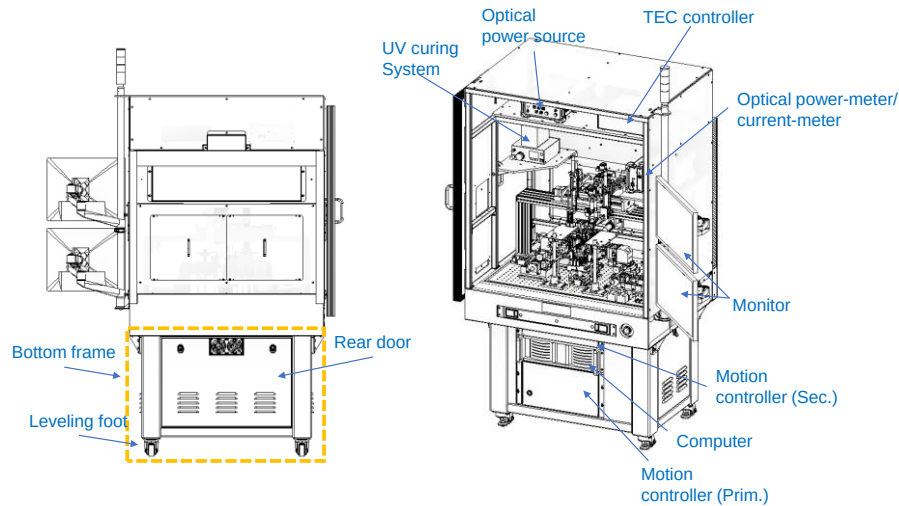


Fig. 2.1 Names of principal parts for installation

2.2. Requirements for operation

2.2.1. Electric power

- Voltage: 110 ~ 240 VAC, 50/60 Hz, single phase
- Power consumption: 1500 VA max

2.2.2. Compressed air

- Input pneumatic pressure: 0.5 ~ 1.0 MPa (equiv. to 70 ~ 145 psi)
- Flow rate: 35 liter/min max.
- 6φ air tube

2.2.3. Space

- 2220 mm x 1350 mm x 2300 mm (W x D x H)

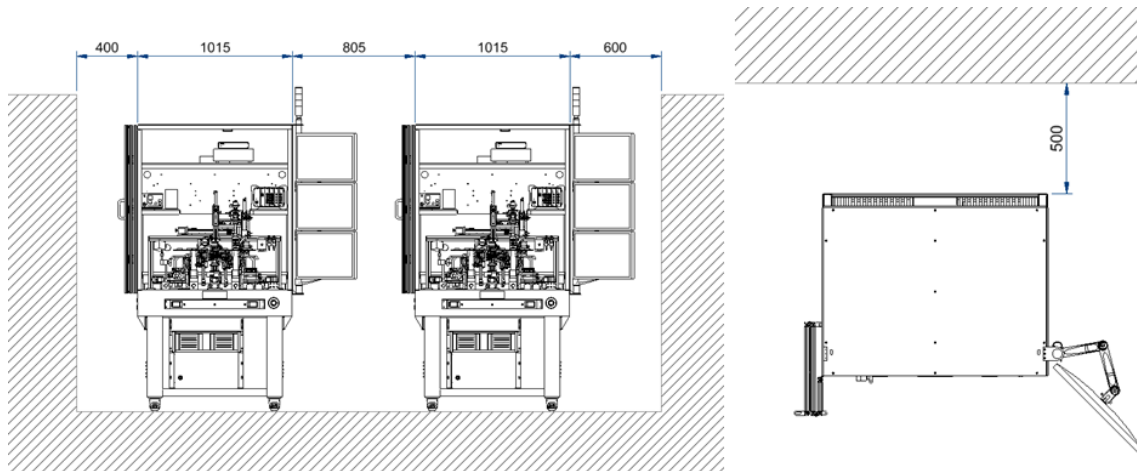


Fig. 2.2 Space requirements

2.3. Installation procedure

2.3.1. Tools

- Spanners
- Allen keys in metric version
- Leveling tool
- 16 A Power cable (IEC60320 C13 female type)



Fig. 2.3 Power cable

- 6φ tube for pneumatic line
- Ethernet cable for network connection (optional)

2.3.2. Installation of main frame

1. Set the caster wheels to move the frame with turning the level nuts by counter-clockwise.

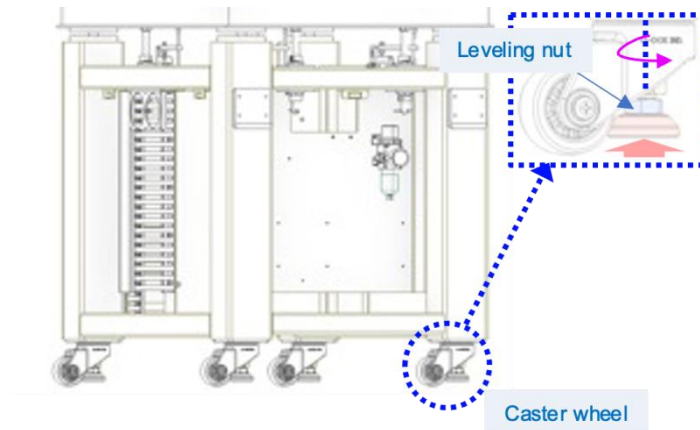


Fig. 2.4 Caster wheel setup (for moving)

2. Move the system to the installation location.
3. Open the all the bottom doors. And, remove side plates on the frame with unscrewing the screws (M3).
4. Then undo 4 bottom locking nuts (2 top and 2 bottom nuts in one side (left/right)).

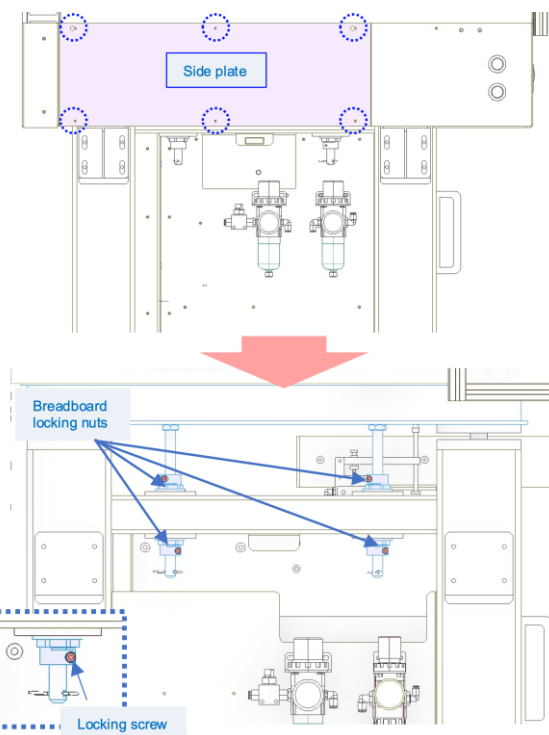


Fig. 2.5 Location of optical breadboard locking nuts

5. Connect a pneumatic tube with 6 mm diameter to the main regulator as shown in the figure below.
 - Open the regulator switch to supply the pressured air the main regulator.
 - Adjust the pressure level of both regulators.
 - Recommended level for main regulator: 0.48 MPa (equiv. to 70 psi)
 - Recommended level for optical table: 0.4 MPa (equiv. to 60 psi)
 - Confirm that the optical breadboard is lifted by the air pressure.

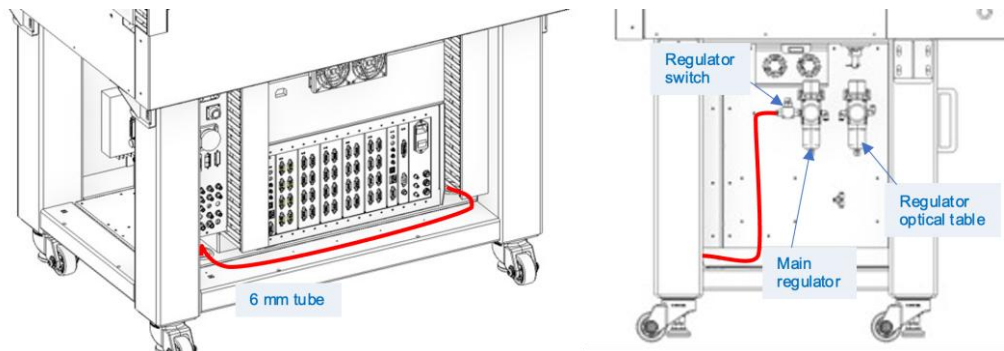


Fig. 2.6 Connecting compressed air tube

6. Open the regulator switch to supply the compressed air the main regulator.
7. Supply the air to the optical table with pressing down the metal bar on the leveling valve underneath the table, then undo 4 top locking nuts on both sides.

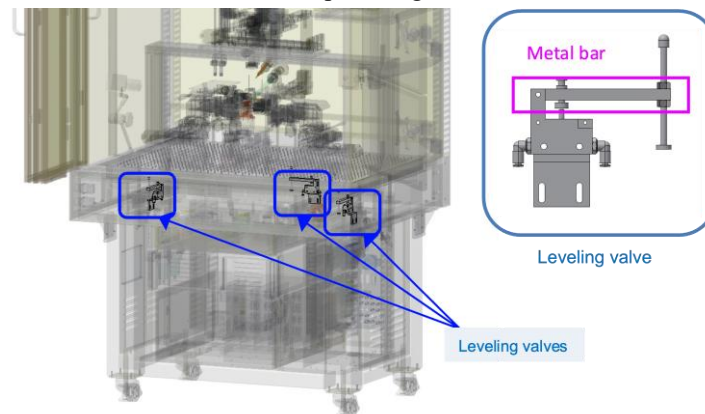


Fig. 2.7 Location of the leveling valves

8. Put a leveling tool on the frame.
9. Lift the 4 caster wheels with tightening level nut using the spanner by 8~10 mm, and make the frame to be flat with adjusting the caster.

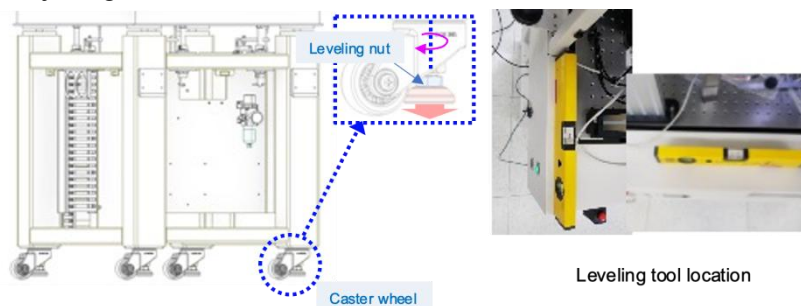


Fig. 2.8 Leveling the frame

10. Check the table is flat against the ground. If not, perform the leveling using the adjustment knob, then fix the knob using locking nuts (The recommended floating height is 8~10 mm.).

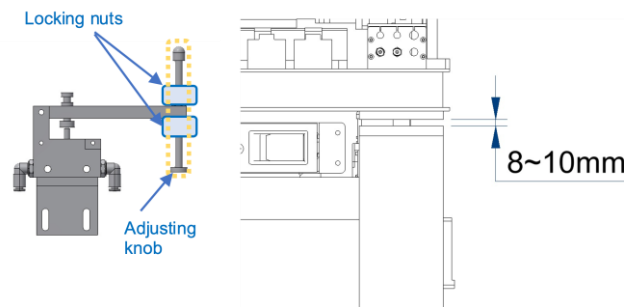


Fig. 2.9 Leveling the optical table

2.3.3. Connecting main power cord/stage stop button

1. Open the rear door.
2. Connect a power cord to the main power inlet and a stage stop button to “S.STOP” port on the rear panel of the SC7000. (refer to the figure below)
3. Check the power cable connections of all the components.
4. Turn on the main power switch, and check the light of the “power off switch” is on.
5. Push the “power on switch” to supply power to the system, and check the light of the button is on.
6. Power on all the components.
7. Close the rear door.

[For normal operation of the system, only use the “power on” button and the “power off” button]

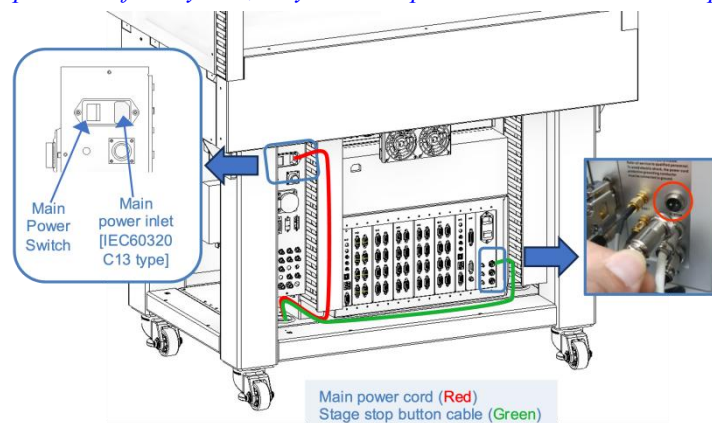


Fig. 2.10 Connecting main power cord/stage stop button

2.3.4. Installation on displacement sensor head

1. Release the screws, and insert a sensor head to the hole of the fixture. (see the figure below)
2. Insert a thin plate with the 350 μm thickness of the feeler gauge into the gap between the sensor head and the bracket. (The plate is packed in the accessories box.)
3. Push the sensor head toward the thin plate inserted for gap control, and fix the head using two set screws. Finally remove the plate.

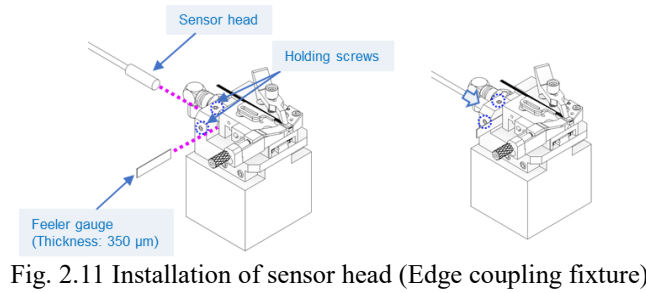


Fig. 2.11 Installation of sensor head (Edge coupling fixture)

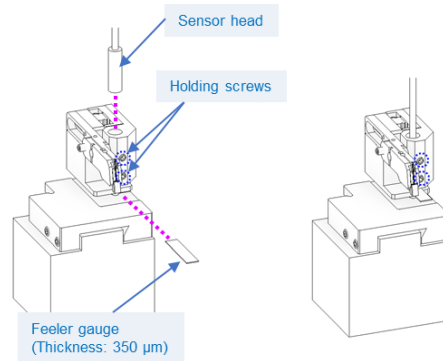


Fig. 2.12 Installation of sensor head (Vertical fixture)

4. Check the sensor value is in the specified range (~ 4000 mV) on the GUI as follows,

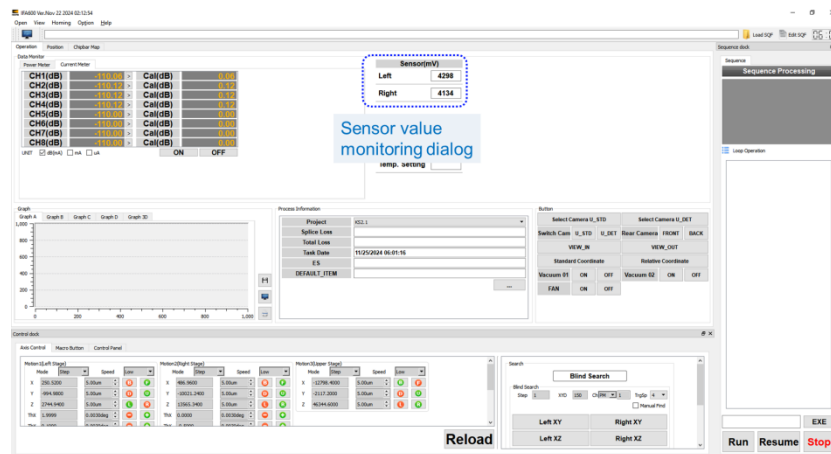


Fig. 2.13 Check sensor value on the main GUI

2.3.5. Supplying electric power

1. Open the rear door.
2. Connect a power cable to the main power inlet. (refer to the figure below)
3. Check the power cable connections of all the components.
4. Turn on the main power switch, and check the light of the “power off switch” is on.
5. Push the “power on switch” to supply power to the system, and check the light of the button is on.
6. Power on all the components.
7. Close the rear door.

[For normal operation of the system, only use the “power on” button and the “power off” button]

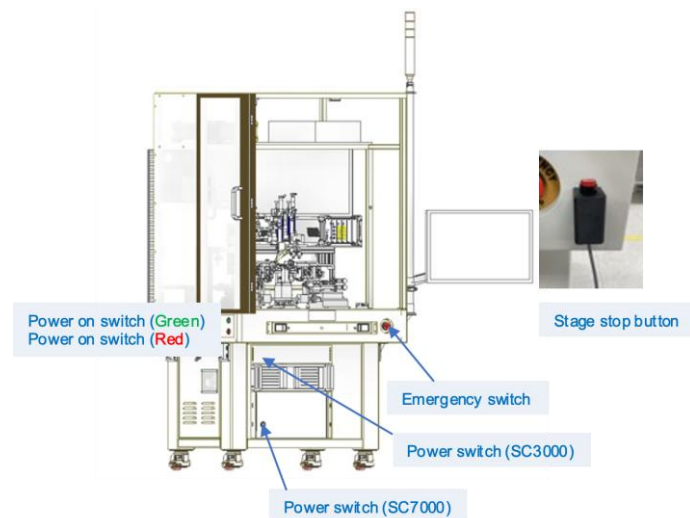


Fig. 2.14 Power on/off switches and emergency switch

2.4. Check list

2.4.1. Power connections

- Check if the main power cable is connected to the main power inlet.
- Check if the power connections of all the components (Computer, SC7000, SC3000, PM2100, displays, and etc).

2.4.2. Pneumatic line connection

- Check if the pressure levels of the regulators are following specified values.
 - Recommended level for main regulator: 0.48 MPa (equiv. to 70 psi)
 - Recommended level for optical table: 0.4 MPa (equiv. to 60 psi)

2.4.3. Emergency stop switch

- Push the emergency switch, and check the color of the tower lamp goes to “**RED**”.
- Unlock the emergency switch, and check the color of the tower lamp goes to “**GREEN**”.
- *[NOTE: The emergency button cuts the power lines of motor driver circuits in the motion controllers]*

2.4.4. Stage stop button

- Push the stage stop switch with running IFA software, and check the light of the tower lamp goes to “**YELLOW**”.
- Unlock the stage stop button, and check the color of the tower lamp goes to “**GREEN**”.

2.5. Contact sensor

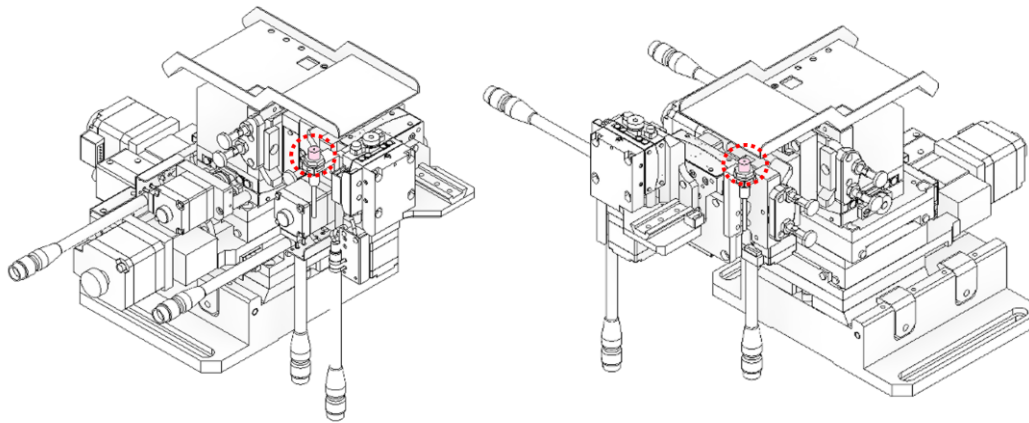


Fig. 2.15 Location of contact sensors

- Contact metal on the contact sensor heads installed on both stage assemblies, and check the light of the tower lamp goes to “**YELLOW**”.
- Remove metal from the contact sensor heads, and check the color of the tower lamp goes to “**GREEN**”.

2.5.1. Displacement sensor

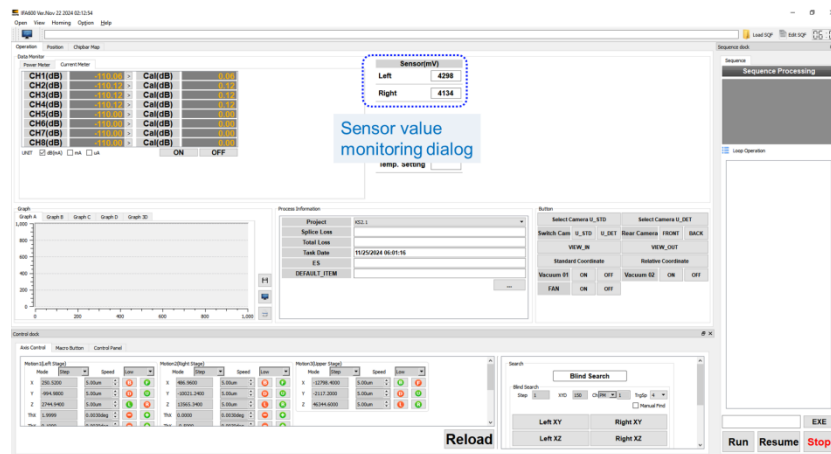


Fig. 2.16 Sensor value monitoring on the main GUI

- Run IFA software, and check the sensor value is normal range (3500 mV ~ 4200 mV) (*If the sensor value is out of range, then make the sensor value is in the normal range with adjusting sensor head position following section 2.3.4)

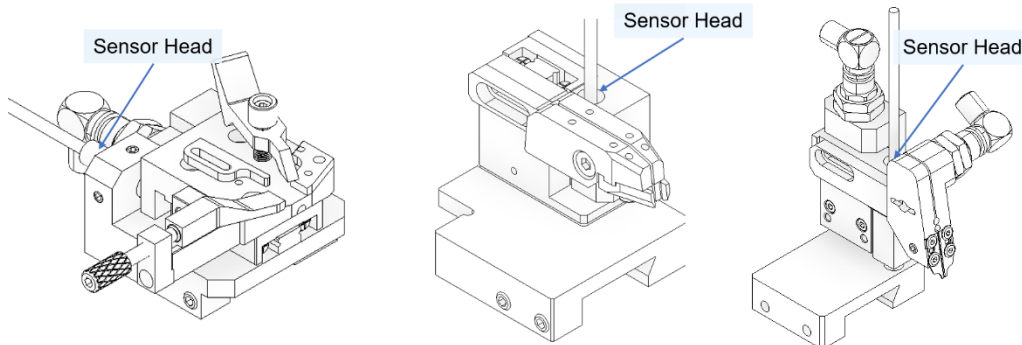


Fig. 2.17 Location of sensor heads

3. Specifications

3.1. General specifications

- Power supply: 110 ~ 240 VAC, single phase
- Power consumption: 1200 VA max
- Input pneumatic pressure: 0.48 ~ 1.5 MPa (equiv. to 70 ~ 210 psi)
- Isolation table pneumatic pressure: 0.4 ~ 0.5 MPa
- System dimensions (W x D x H) with monitors folded: 1100 x 850 x 2120 (unit: mm)

3.2. Computer system

- Main parts
 - CPU: Intel core i7
 - RAM: 16 Gbytes
 - PCI Graphic card: Nvidia chipset
 - HDD: 2 Tbytes
 - SSD: 500 Gbytes
 - Case: Rack mountable 3U
 - Operating system: Microsoft Windows 11 (English version)
- Peripherals
 - Multiple LAN ports
 - Multiple USB ports
 - Multiple serial ports
 - PCI GPIB card
- Displays
 - 2HD grade displays for system control

3.3. Left/Right/S1 stage assemblies & Fixtures

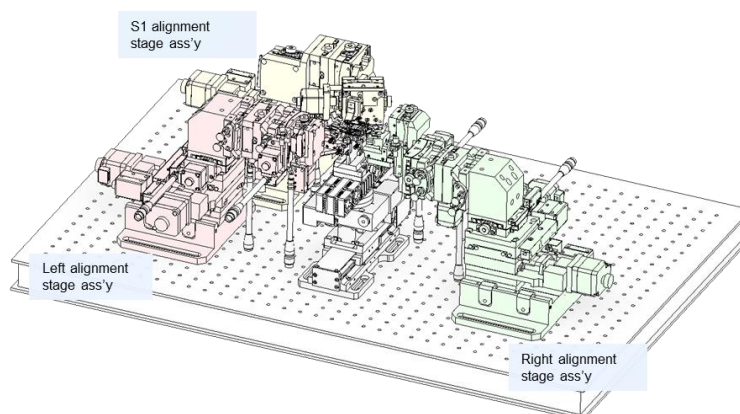


Fig. 3.1 Alignment stage assemblies

- Supplied unit:
 - Left stage assembly: 1 ea
 - Right stage assembly: 1 ea
 - S1 stage assembly: 1 ea
- 6-axis motorized stages
 - 3 linear motorized stages (X, Y, and Z) & 3 rotational motorized stages (ThX, ThY, and ThZ)
 - All automatic precision motorized stages (Manufacturer: Suruga Seiki, Japan)
 - Motors controlled with 1/50 microstep drive
- Fixture-mounting capability for the various types of the alignment
 - Left & Right: optical fiber, fiber block, lens, electric probe
 - S1: optical fiber, electric probe
- A proximity sensor to prevent collision between a stage assembly and a DC probe plate: 1 each on left & right stage assemblies (Total 2 sensors are provided.)
- Angle bracket on Left & Right stage assemblies, which can set the angle of the Y stage to 0° , $\pm 5^\circ$ and $\pm 8^\circ$ in Θ_x axis
- Detachable structure

3.3.1. Left/Right stage assemblies

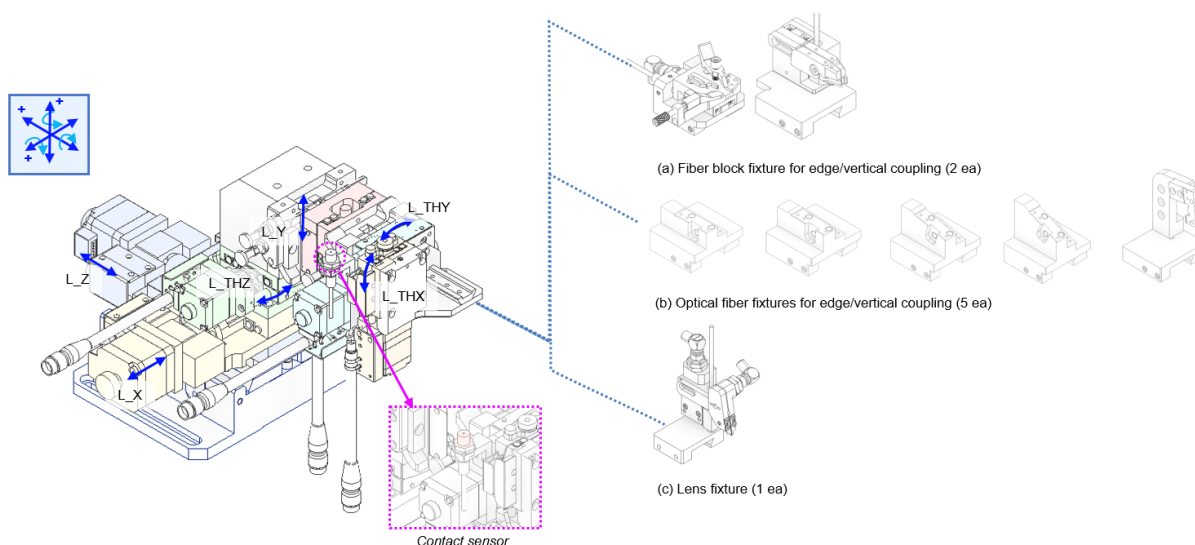


Fig. 3.2 Left stage assembly w/ various fixtures

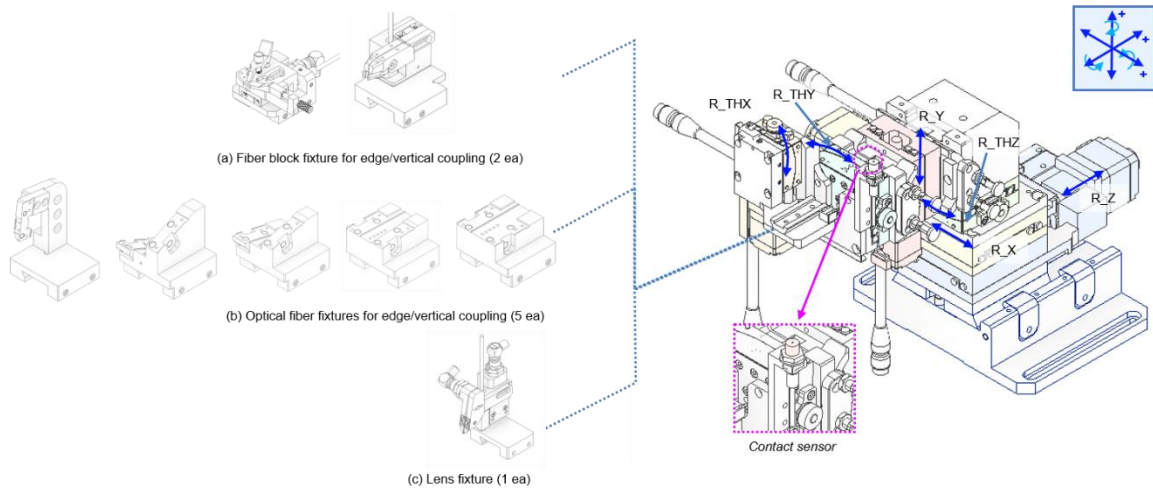


Fig. 3.3 Right stage assembly w/ various fixtures

- Left & Right stage assemblies

Axis name	Total Travel Length/Angle	Stage Resolution (1/50 microstep)
X	30 mm	$\leq 0.1 \mu\text{m}$
Y	20 mm	$\leq 0.1 \mu\text{m}$
Z	30 mm	$\leq 0.1 \mu\text{m}$
ThX (Pitch)	$16^\circ (\pm 8^\circ)$	$\leq 0.001^\circ$
ThY (Yaw)	$16^\circ (\pm 8^\circ)$	$\leq 0.001^\circ$
ThZ (Roll)	$16^\circ (\pm 8^\circ)$	$\leq 0.001^\circ$

[Note]: X direction: front-back, Y direction: up-down, Z direction: left-right

3.3.2. S1 stage assemblies

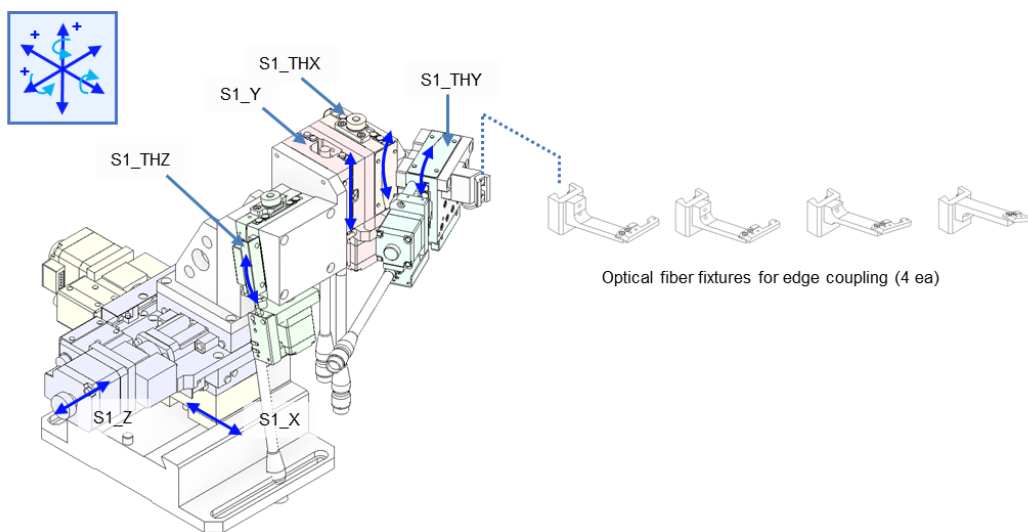


Fig. 3.4 S1 stage assembly w/ various fixtures

- S1 stage assembly

Axis name	Total Travel Length/Angle	Stage Resolution (1/50 microstep)

X	30 mm	$\leq 0.1 \mu\text{m}$
Y	20 mm	$\leq 0.1 \mu\text{m}$
Z	30 mm	$\leq 0.1 \mu\text{m}$
ThX (Pitch)	$16^\circ (\pm 8^\circ)$	$\leq 0.001^\circ$
ThY (Yaw)	$12^\circ (\pm 6^\circ)$	$\leq 0.001^\circ$
ThZ (Roll)	$10^\circ (\pm 5^\circ)$	$\leq 0.001^\circ$

[Note: X direction: front-back, Y direction: up-down, Z direction: left-right]

3.3.3. Angle bracket

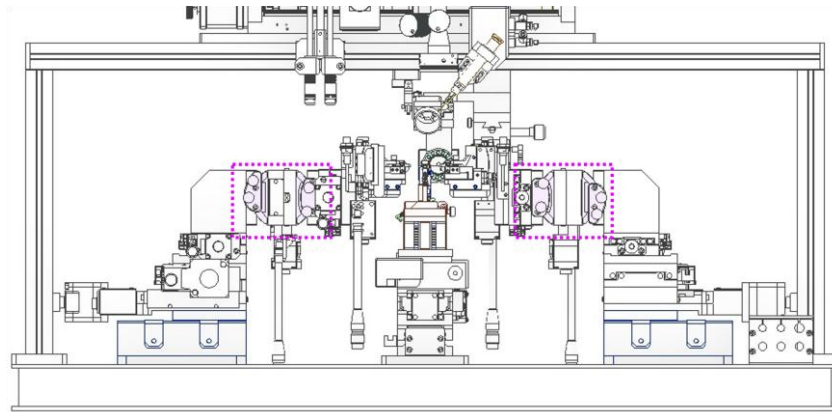


Fig. 3.5 Angle bracket

- Angle bracket which can set the angle of the Y stage to 0° , $\pm 5^\circ$ and $\pm 8^\circ$ in θ_x axis
- LEFT, RIGHT stage assemblies have angle bracket structure.
- Check how to handle angle bracket in the section 6.1

3.3.4. Fiber holder base for the edge coupling

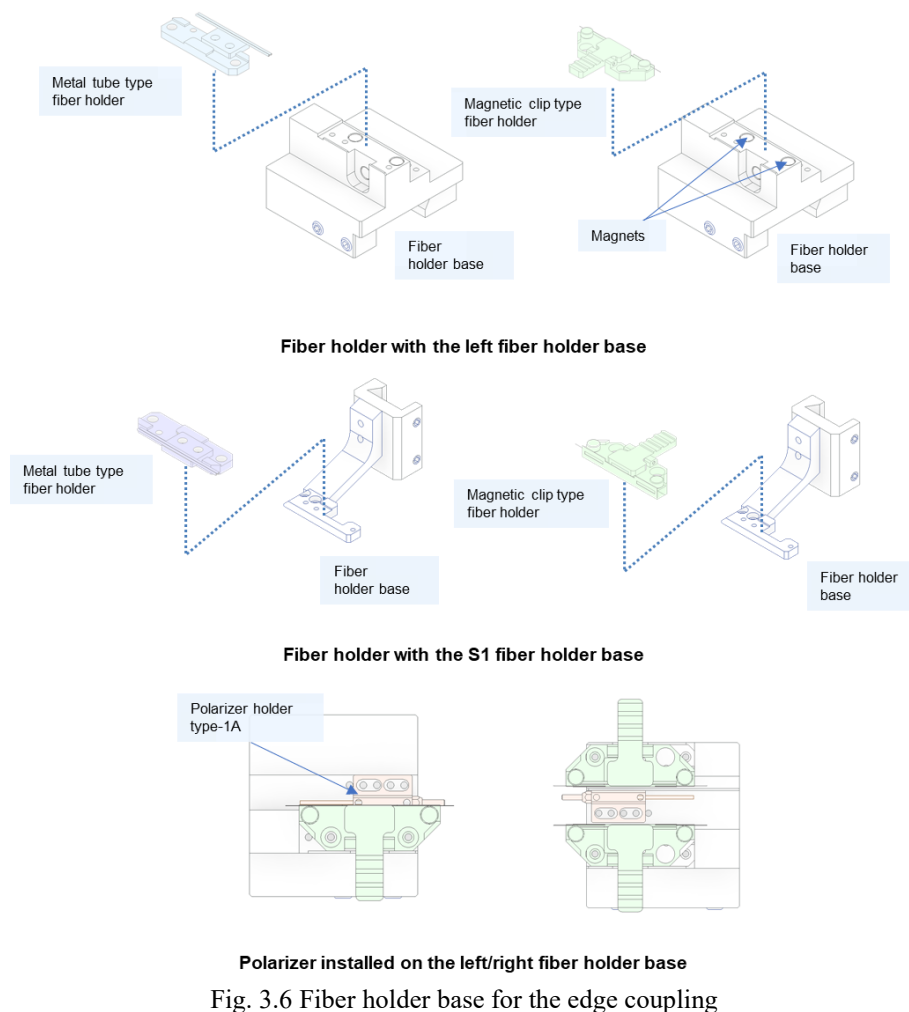


Fig. 3.6 Fiber holder base for the edge coupling

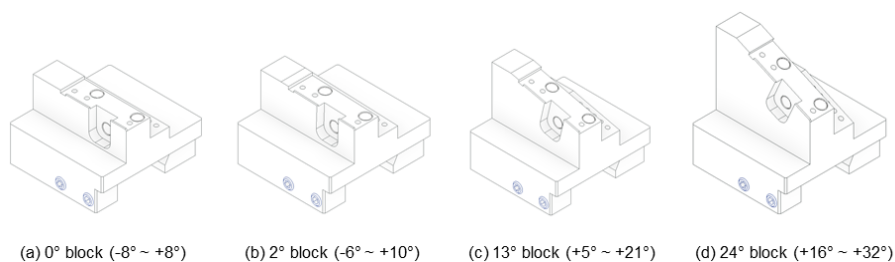


Fig. 3.7 Fiber holder base for edge coupling (Left)

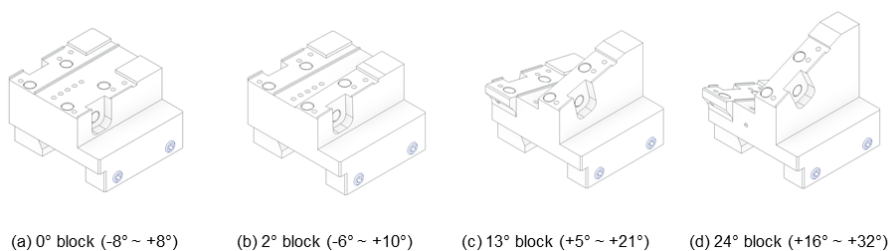


Fig. 3.8 Fiber holder base for the edge coupling (Right)

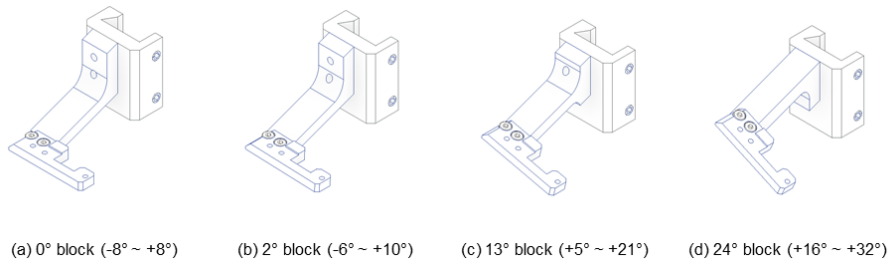


Fig. 3.9 Fiber holder base for the edge coupling (Right)

- Three types of the fiber holder bases mounted on each stage assemblies are provided as shown above. (i.e. total 12 holder bases are included.)
 - Left (in ThX direction): 0°, 2°, 13°, 24°
 - Right (in ThX direction): 0°, +/-2°, +/-13°, +/-24° (*The negative angled slots are for the reference power measurement of the optical fiber mounted on the left and S1 stage assemblies.)
 - S1 (in ThX direction): 0°, 2°, 13°, 24°
- Rotation range (in ThX direction): -8° ~ +8° (*limited by the travel range of ThX stage)
- Holding type: Mechanical holding with magnets or screws
- The polarizer can be installed on the fiber holder base.
- Installed on the dovetail optical rail

3.4. Fiber holder base for the vertical coupling

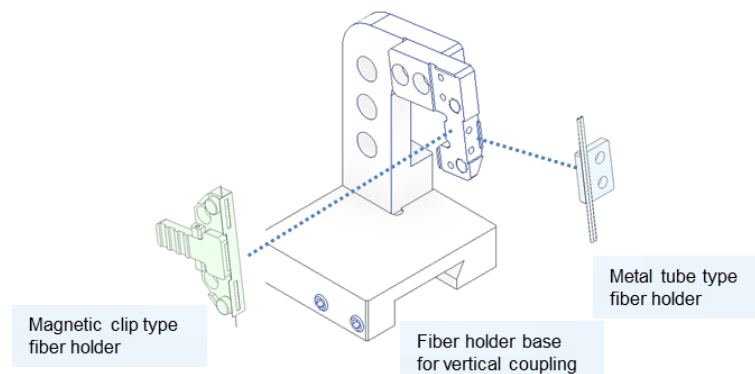
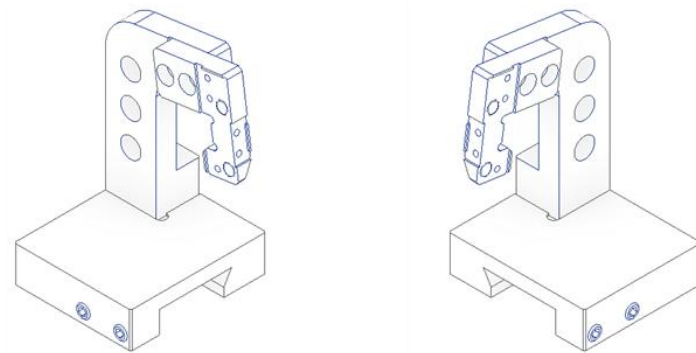


Fig. 3.10 Fiber holder base for the vertical coupling w/ fiber holder



(a) Fiber holder base type-LA

(b) Fiber holder base type-RA

Fig. 3.11 Fiber holder bases for the vertical coupling

- Supplied unit: 2 ea (Left: 1 ea, Right: 1 ea)
- Holding type: Mechanical holding with magnets or screws
- An optical fiber loaded on the base will be tilted by 82° relative to the ground in ThX direction.
- Rotation range (in ThX direction): $-8^\circ \sim +8^\circ$ (*limited by the travel range of thX stage)
- Location of the rotation center
 - Metal tube type fiber holder: The fiber tip extends 2 mm from the holder
 - Magnetic clip type fiber holder: The fiber tip extends 3 mm from the holder
- The fiber tip is capable of reaching the center of the fixture in the Z-direction (w/ Center jig type-B, when it is positioned at the rotation center.).

[Note]: With an object (optical fiber, fiber block, lens, or electric probe) placed on one side of the device, the optical fiber on the other side is limited to the center point of the chip. Consultation with FIBERPRO is required for extended access.

3.5. Optical fiber holder

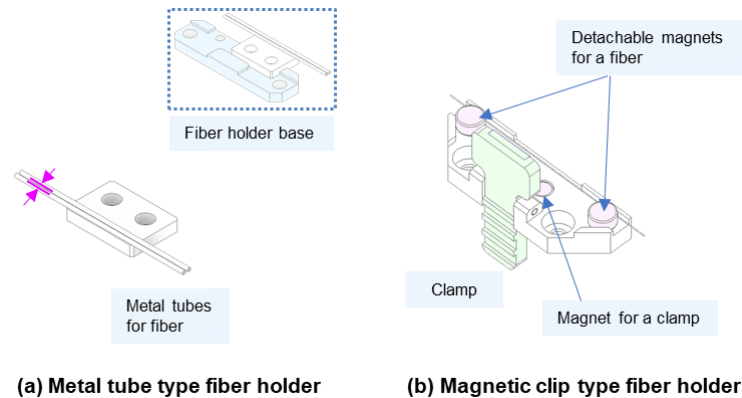


Fig. 3.4 Optical fiber holders

- Two types of the fiber holder are provided.
 - Metal tube type fiber holder & adapter
 - Supplied unit:
 - Adapter: 3 ea
 - Metal tube type fiber: 6 ea (Left-to-Right: 3 ea, Right-to-Left: 3 ea)
 - Holding type: Holding by the glue
 - 2 metal tubes to attach fiber (Metal tube pitch: 750 μm)
 - For the test at high temperature ($> 50\text{ }^{\circ}\text{C}$)
 - Mounted on the adapter to be installed on the fiber holder base
 - Magnetic clip type fiber holder
 - Supplied unit: 3 ea
 - Holding type: Mechanical clamping with magnets
 - Thickness of the side edge of the magnetic fiber holder: 100 μm (Minimum pitch of the optical fibers on both S1 and left stage: 500 μm)
 - Both types for the fiber holders are installed on the fiber holder base.

3.6. Fiber array block fixture for edge coupling

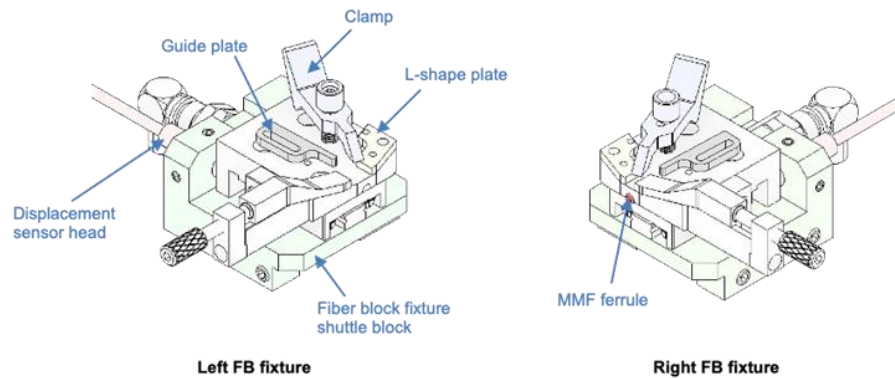


Fig. 3.5 Edge FAB fixtures

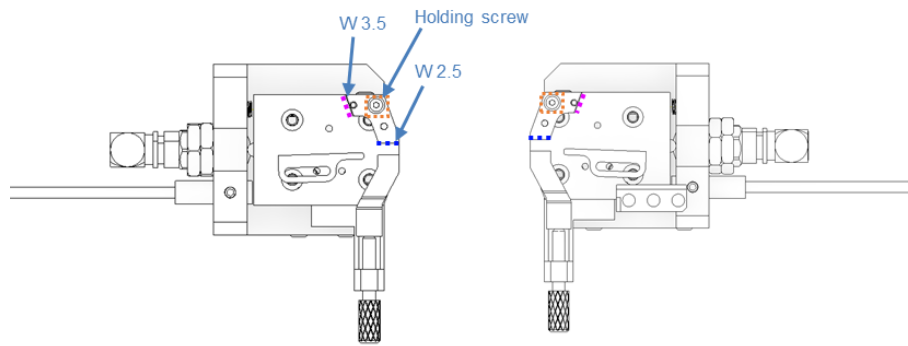


Fig. 3.6 L-shape plate

- Supplied unit: 2 ea (Left: 1 ea, Right: 1 ea)
- Holding type: Mechanical holding using screw
- Applicable fiber block dimension (WxH):
 - 2.5 mm x 2.5 mm
 - 3.5 mm x 2.5 mm

[Note]: A minimum chip thickness of 700 μ m is required to guarantee gap control and angle alignment performance.

[Note]: For other sizes or polished angle of fiber blocks, please consult with FIBERPRO.
- The fixture design is optimized for handling device with 0° facet angle. (Fixture angle: 0° relative to the z-axis)
- L-shape plate makes the center of the specific fiber block (2.5 mm and 3.5 mm width) matched with the center of rotation of the stage assembly. (Screw size: M2)
- Guide plate for the easy mount of the fiber block
- Vertical clamp for holding the fiber block
- The MMF ferrule installed on the right fiber block fixture for the input alignment
- Pneumatic fixture position locking function
- Displacement sensor mounting hole
- Capable of holding an optical fiber *[Note: a hollow metal tube required]*
- Detachable fixture
- Installed on the dovetail optical rail

3.7. Fiber array block fixture for vertical coupling

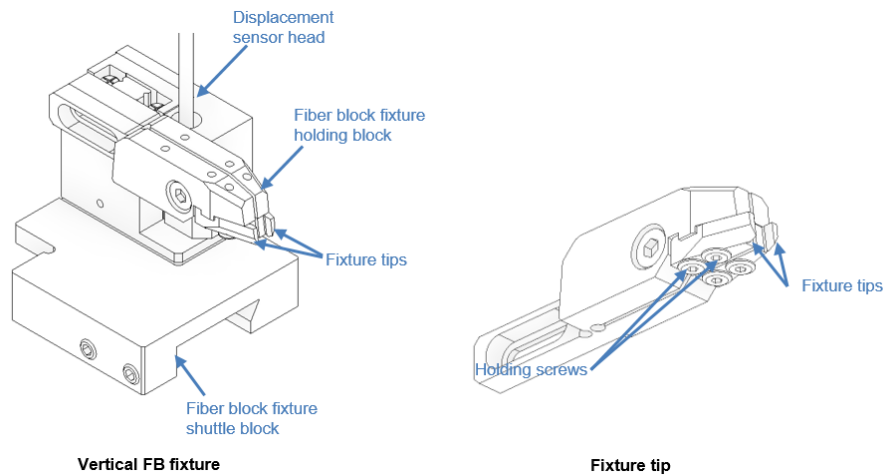


Fig. 3.7 Vertical FAB fixture w/ the fixture tip

- Supplied unit: 2 ea (Left: 1 ea, Right: 1 ea)
 - Holding type: Mechanical holding using screw (Screw size: M3, recommended torque: 0.5 kgf/cm)
 - Applicable fiber block dimension (WxH):
 - 2.5 mm x 2.5 mm
 - 3.5 mm x 2.5 mm
 - **For other sizes or polished angle of the FABs, please consult with FIBERPRO.*
 - Fixture angle: 82° (relative to the horizontal plane in Thx direction)
 - Location of the rotation center: The fiber block extends 2 mm from the fixture tips.
 - The center of fiber block is capable of reaching the center of the fixture in the Z-direction (w/ Center jig type-B, when it is positioned at the rotation center.).
- [Note]: With an object (optical fiber, fiber block, lens, or electric probe) placed on one side of the device, the fiber block on the other side is limited to the center point of the chip. Consultation with FIBERPRO is required for extended access.*

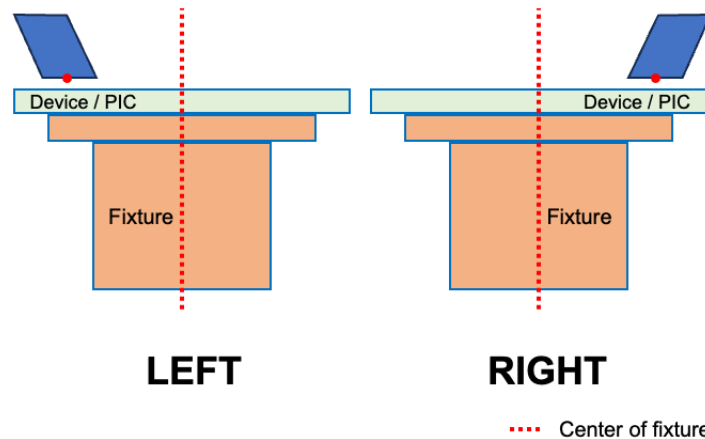


Fig. 3.16 Travel range of the fb on the device from the center of the fixture

- The fixture tip makes the center of the specific fiber block (2.5 mm and 3.5 mm width) matched with the center of rotation of the stage assembly. (Screw size: M2)
- Displacement sensor mounting hole
- Detachable fixture
- Installed on the dovetail optical rail

3.7.1. Lens fixture

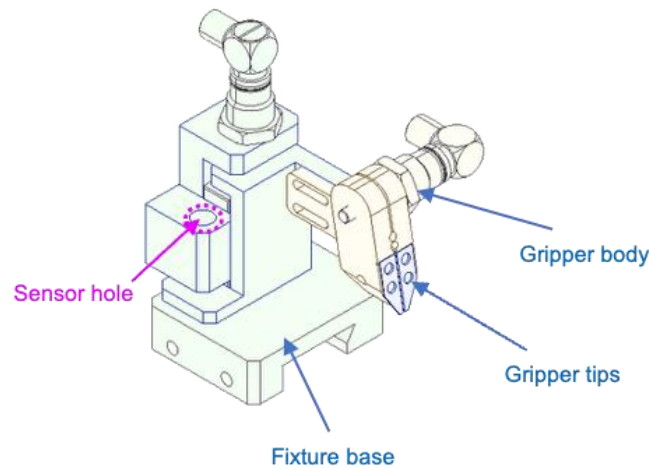


Fig. 3.17 Lens fixture

- Supplied unit: 2 ea (Left: 1 ea, Right: 1 ea)
 - Holding method: Mechanical holding using pneumatic action
 - Applicable lens dimension (W x L x H, mm):
 - 1 mm x 1 mm x 1.5 mm
 - 1 mm x 0.5 mm x 1 mm
- *For other sizes or polished angle of the lens, please consult with FIBERPRO.*

- Location of the rotation center: gripper tip end
 - The center of the lens is capable of reaching the center of the fixture in the Z-direction (w/ Center jig type-B, when it is positioned at the rotation center.).
- [Note]: With an object (optical fiber, fiber block, lens, or electric probe) placed on one side of the device, the lens on the other side is limited to the center point of the chip. Consultation with FIBERPRO is required for extended access.*

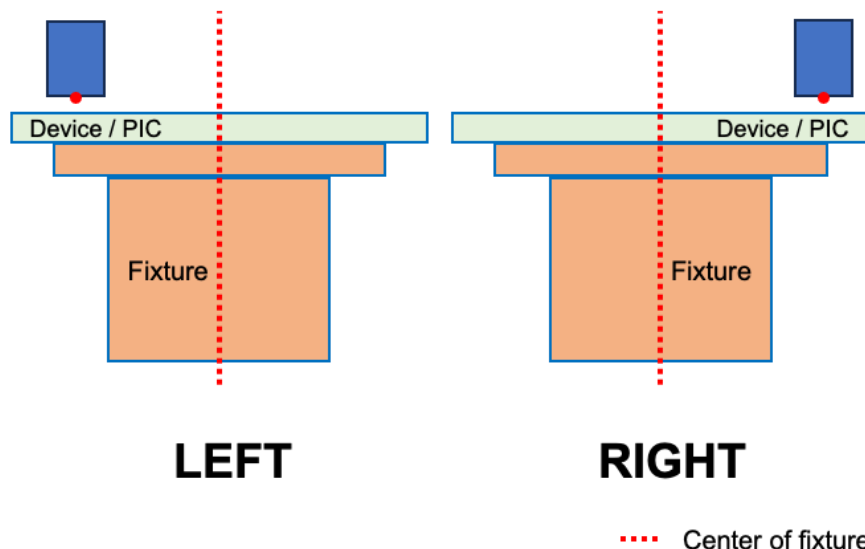


Fig. 3.18 Travel range of the lens on the device from the center of the fixture

- Pneumatic fixture position locking function
- Displacement sensor mounting hole
- Detachable fixture
- Installed on the dovetail optical rail

3.7.2. Electric probe holders

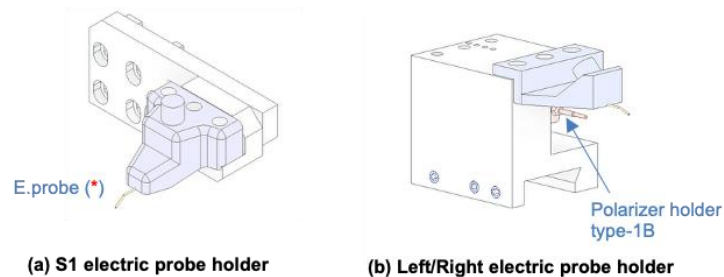


Fig. 3.9 Electric probe holders

- Supplied unit:
 - Electric probe holder on the S1 assembly: 1 ea
 - Electric probe holder on the Left/Right assembly: 1 ea
- The tip of a RF probe is placed at the point stuck out from the rotation center by 8 mm.
- 40A-GSG-100-P (GSG) or equal dimensions (link: <https://ggb.com/home/model-40a/>)
- The electric probe tip mounted on left/right electric probe holder is capable of reaching the center of the fixture in the Z-direction (w/ Center jig type-B).

[Note]: With an object (optical fiber, fiber block, lens, or electric probe) placed on one side of the device, the lens on the other side is limited to the center point of the chip. Consultation with FIBERPRO is required for extended access.

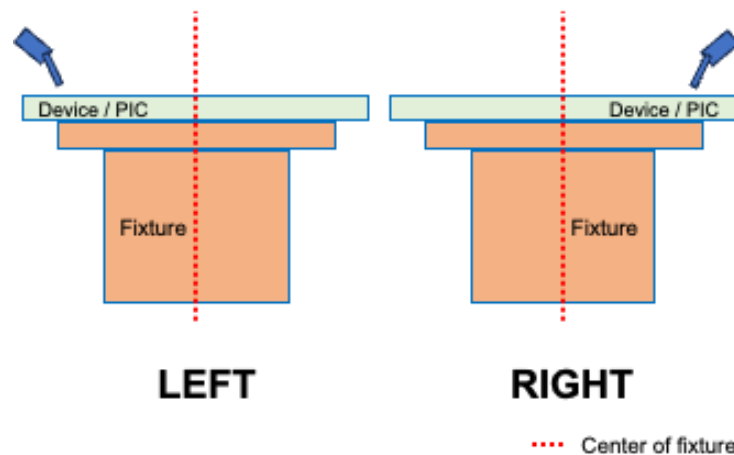


Fig. 3.100 Travel range of the electric probe on the device from the center of the fixture

- Detachable type
 - Installed on the dovetail optical rail
- [Note: An electric probe is not a part of the system.]*

3.7.3. Multimode fiber with the polarizer

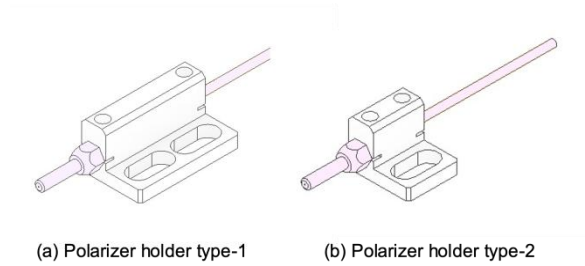


Fig. 3.11 Polarizer holders

- Multimode fiber ferrules (LC/PC) with polarizer
- Two types of the polarizer holder
 - Type-1: Long type loaded on the left/right jig
 - Type-2: Short type loaded on the center jig
- Installed on either a fiber holding block, and a center jig

3.8. Center stage assembly and center jigs

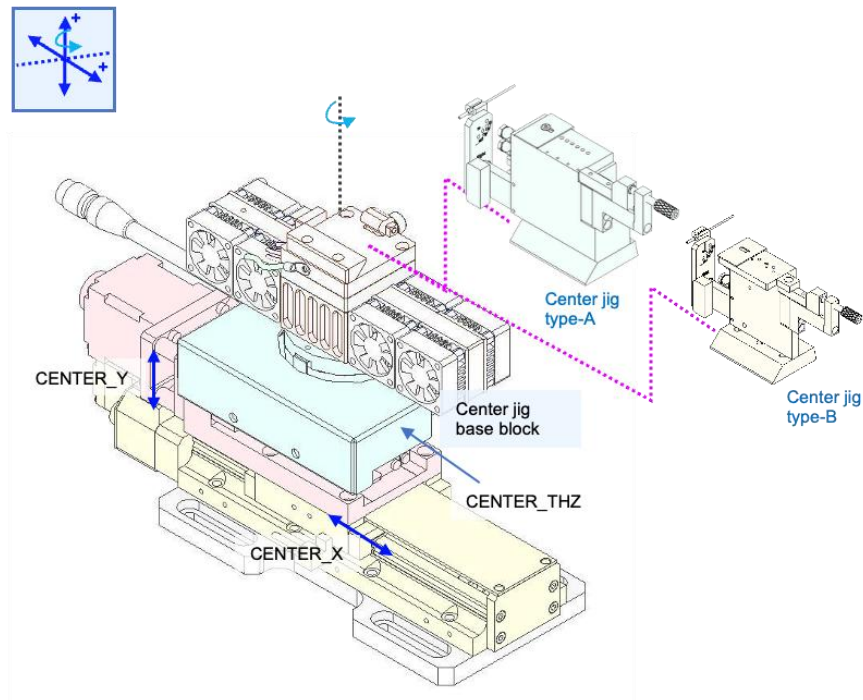


Fig. 3.12 Center stage assembly and center jigs

3.8.1. Center stage assembly

- Supplied quantity: 1 unit
- 2 linear motorized stages (X, Y) & 1 rotational motorized stage (ThY)

Axis name	Total Travel Length/Angle	Stage Resolution (1/50 microstep)
X	100 mm	$\leq 0.1 \mu\text{m}$
Y	4 mm	$\leq 0.1 \mu\text{m}$
ThY	$\pm 20^\circ$	$\leq 0.001^\circ$

[Note: X direction: front-back, Y direction: up-down, Z direction: left-right]

- Capable of mounting the center jig base block

3.8.2. Center jig

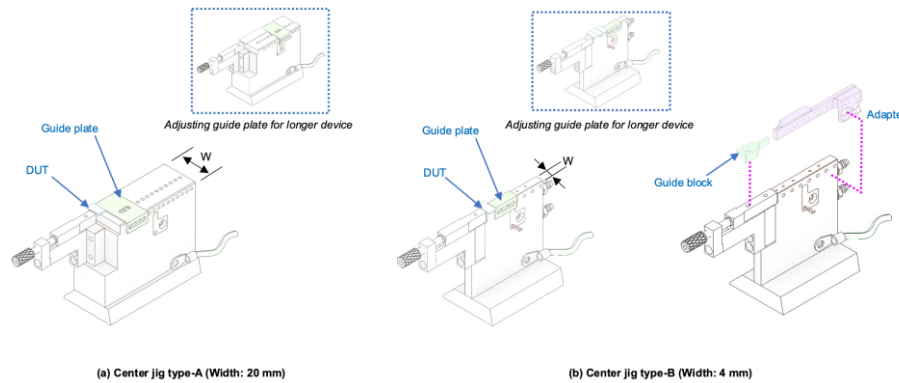


Fig. 3.23 Center jigs

- Center jig type-A
 - Mounted on the center jig base
 - Width: 20 mm (21 mm ~ 24 mm chip can be installed.)

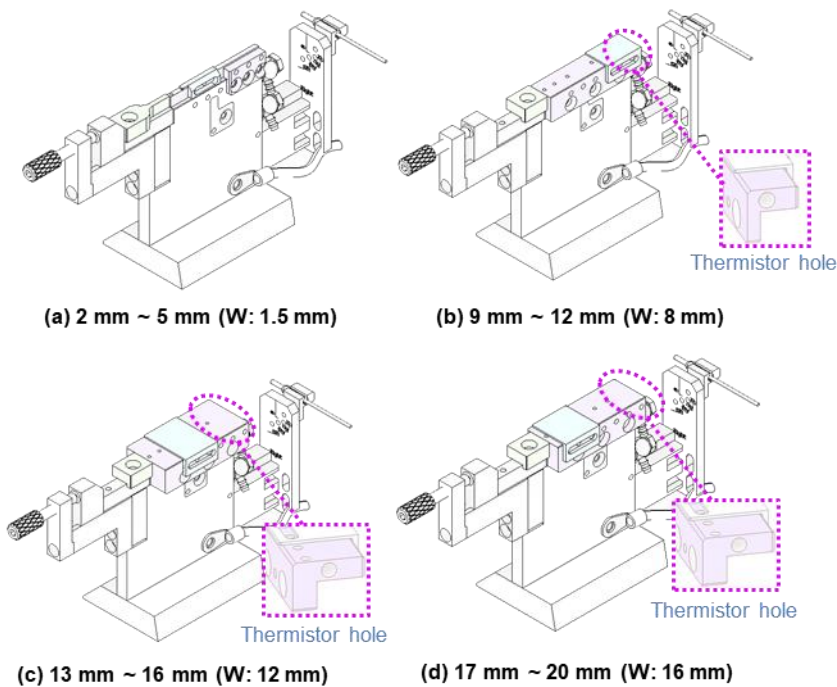


Fig. 3.13 Center jig type-B w/ various adapters

- Center jig type-B
 - Holding type: mechanical holding with screw & Vacuum holding
 - Mounted on the center jig base
 - Width: 4 mm (5 mm ~ 8 mm chip can be installed.)
 - Various width of the adapters with the guide block
 - a: 2 mm ~ 5 mm (W: 1.5 mm)
 - b: 9 mm ~ 12 mm chip can be installed. (W: 8 mm)
 - c: 13 mm ~ 16 mm chip can be installed. (W: 12 mm)
 - d: 17 mm ~ 20 mm chip can be installed. (W: 16 mm)
 - *The type-b, c, d adapters have the hole for the alternative position of the thermistor.

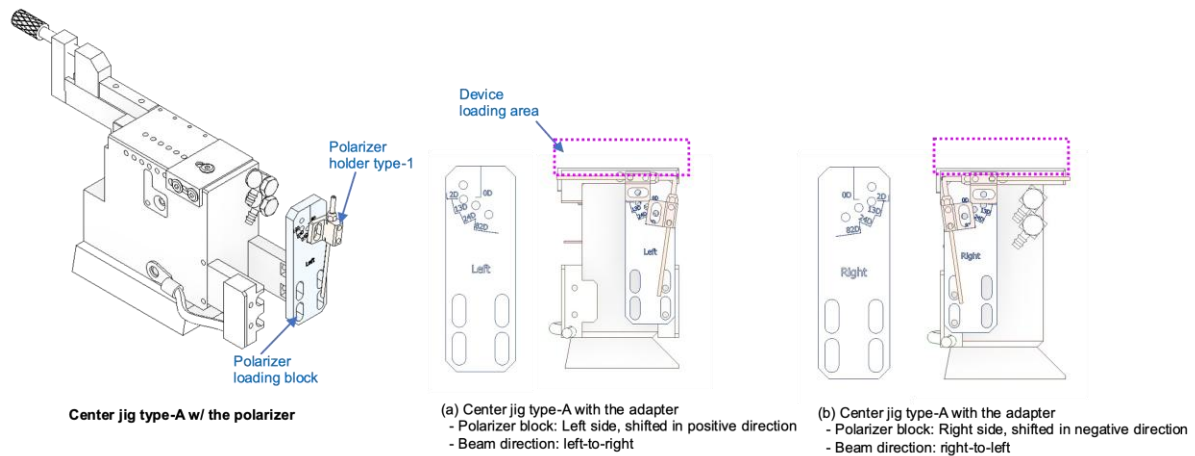


Fig. 3.14 Center jig type-A w/ the polarizer

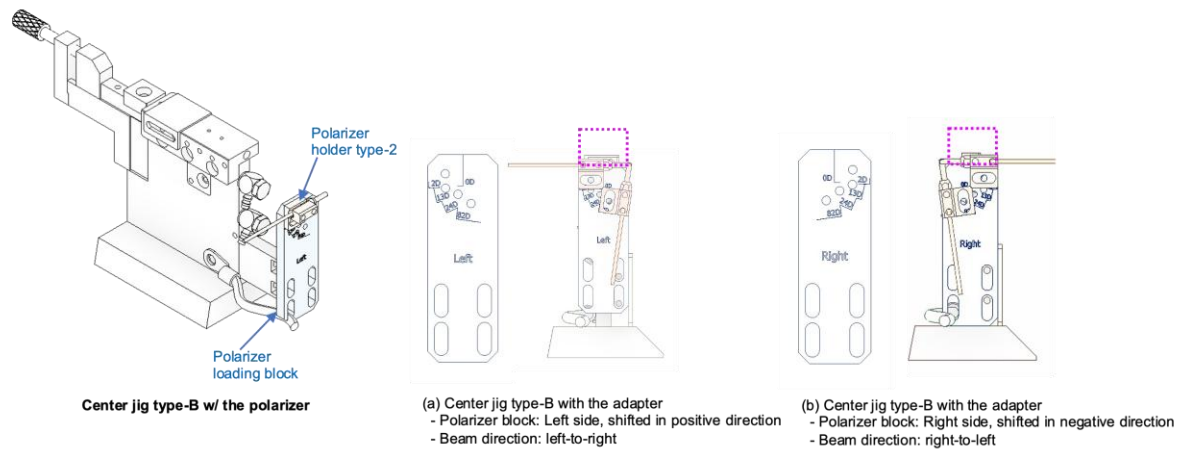


Fig. 3.15 Center jig type-B w/ the polarizer

- Polarizer loading block
 - A polarizer (with holder type-2, check the details in 3.7.1) can be installed on the side edge of the both center jigs with screw.
 - Various holes with the guide line (0°, 2°, 13°, 24°, and 82°) to show the polarizer-end and the device on the rear camera view.
 - Adjustable position in vertical direction. (*The polarizer position should be moved up if the center jig is used with the adapter to see the polarizer-end and the device on the rear camera view.)
 - Dual-sided design
 - “Left” panel (input beam direction: left-to-right)
 - “Right” panel (input beam direction: right-to-left)

3.8.3. Center jig base block

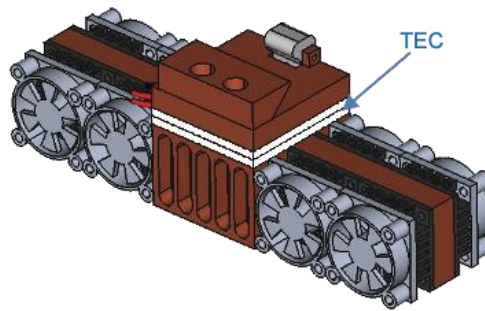


Fig. 3.16 Center jig base block

- Supplied quantity: 1 unit
 - Mounted on the center stage assembly
 - Temperature control
 - Heating/cooling type: thermoelectric cooler
 - Operation with a thermistor on the center jig
 - Performance (w/ Arroyo TEC controller 5305)
 - Temperature control range: 15 ~ 75 °C
 - Temperature stability: < ±0.1 °C
 - Environment temperature: 25±3 °C
- [Note]: Temperature control performance can be changed if the user uses other TEC controller.*
- Cooling fan(s) installed on heat sink. Automatic on/off control by system.

3.9. Tool positioner

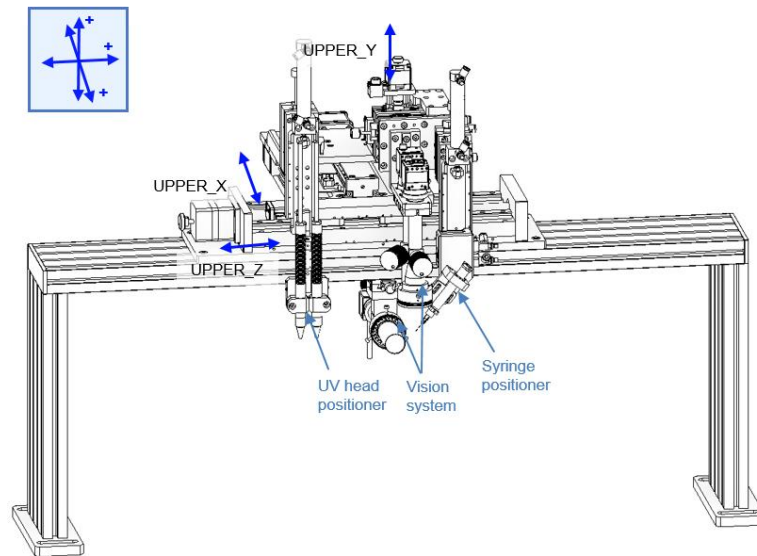


Fig. 3.17 Tool positioner

- Supplied quantity: 1 ea
- 3 linear motorized stages (X,Y, and Z)
 - All automatic precision motorized stages (Manufacturer: Suruga Seiki, Japan)
 - Motors controlled with 1/50 microstep drive

Axis name	Total travel length/angle	Stage Resolution (1/50 microstep)
X	75 mm	0.2 μm
Y	15 mm	0.04 μm
Z	200 mm	0.2 μm

- Positioning the tools such as vision system, epoxy syringe and UV heads
- Rear fan for better temperature control is installed on the tool positioner

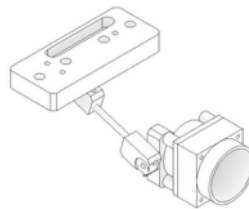


Fig. 3.29 Rear fan

3.10. Vision system

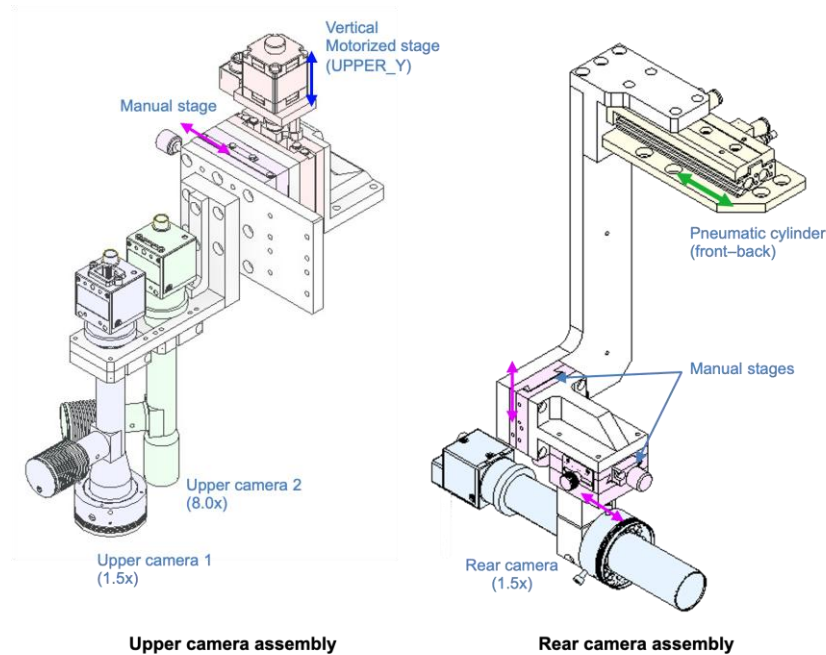


Fig. 3.30 Vision system

- Upper camera assembly
 - Supplied quantity: 1 ea
 - Upper camera 1
 - 1/3 inch CCD/CMOS camera, 1440x1080 pixels
 - 1.5x microscope with working distance of 110 mm
 - Field of View (FOV): 3312 μm x 2484 μm
 - Ring type LED lamp
 - Coaxial type lamp
 - Upper camera 2
 - 1/3 inch CCD/CMOS camera, 1440x1080 pixel
 - 8.0x microscope with working distance of 110 mm
 - Coaxial type lamp
 - 1-axis manual stage

[Note]: Upper camera assembly is mounted on a Y-axis motorized stage integrated with the tool positioner for focus control.

- Rear camera assembly
 - Supplied quantity: 1 ea
 - Rear camera
 - 1/3 inch CCD/CMOS camera, 1440x1080 pixels
 - 1.5x microscope with working distance of 156 mm
 - Field of View (FOV): 3312 μm x 2484 μm
 - View angle: 0° with relative to the horizontal line
 - Pneumatic cylinder for position shift
 - Ring type LED lamp
 - 2-axis manual stages

3.11. UV curing system and UV head positioner

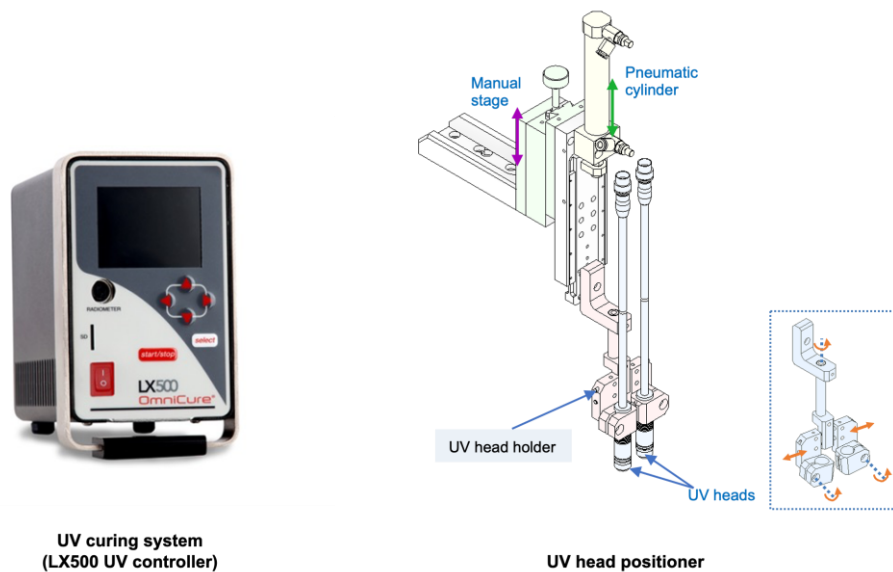


Fig. 3.18 UV curing system and UV head positioner

- UV curing system
 - Supplied quantity: 1 unit
 - LX500 UV LED Spot Curing System Controller (<https://www.excelitas.com/product/omnicure-lx500-uv-led-spot-curing-system-controller>)
 - Intensity Level: 5-100% (with 1% increments)
 - External Control Description: Via optional foot pedal, PLC, or PC through USB communication.
 - 3 mm UV LED heads (365 nm): 2 ea
 - Automatic start/stop control by system software

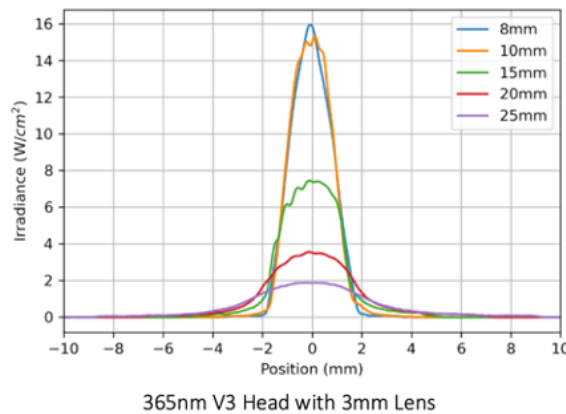


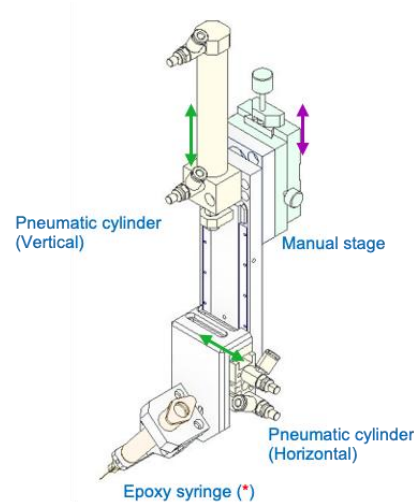
Fig. 3.32 UV beam profile (w/ 3 mm lens)

- UV head positioner
 - Supplied quantity: 1 unit
 - 1 detachable UV head holder
 - Automatic positioning of the holder in up/down direction
 - 1 axis manual stage for vertical position adjustment
 - Installed on the tool positioner

3.12. Epoxy dispenser and syringe positioner



Dispenser (Musashi ML-6000X)



Syringe positioner

Fig. 3.33 Epoxy dispenser and syringe positioner

(*: Is not provided with the system)

- Epoxy dispenser
 - Supplied quantity: 1 unit
 - Musashi ML-6000X-CTR-N-GP (<http://www.musashi-engineering.co.jp/>)
 - Dispensing Pressure Adjustment Range: 5.0 to 700.0 kPa (Maximum Supply Air Pressure: 800 kPa (Dispensing Pressure +100 kPa or More))
 - Vacuum Pressure Setting Range: 0 to -20.0 kPa
 - Discharge time setting: 0.001 to 99.999 sec, 0.01 to 999.99 sec, 0.1 to 9,999.9 seconds (Enable to switch digits by Icon Keys)
 - Interface: RS-232 Serial Communication
 - Control by system software available
- Syringe positioner
 - Supplied quantity: 1 unit
 - Applicable syringe: PSY-SEU-OR (3 ml) or similar dimensions (<https://www.musashi-engineering.co.jp/k.cn.hp.transer.com/products/syringe/syringe/PSY-FU-OR>)
 - Automatic positioning of syringe needle in 2 directions (Y, Z) based on pneumatic cylinder
 - 1 axis manual stage for vertical position adjustment
 - Installed on the Y motorized stage of the tool positioner (Fine vertical position control can be done with the Y stage)

3.13. PM2100: Multichannel optical power meter

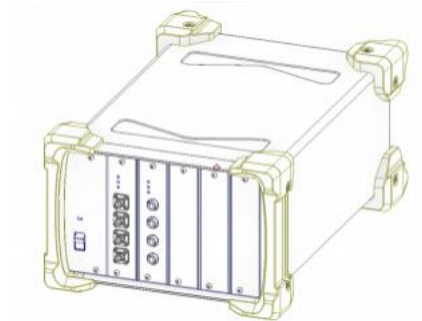


Fig. 3.34 PM2100: Multichannel optical power meter/current meter

- Optical power meter
 - Number of channels: 4
 - Dynamic range: +10 dBm ~ -80 dBm
 - Total uncertainty: $\pm 5.6\%$ @ > -60 dBm
 - Wavelength Range: 1250 ~ 1630 nm
- Current-meter
 - Number of channels: 4
 - Dynamic range: +3 ~ -70 dBmA (2 mA ~ 100 pA)
 - Accuracy: 0.2 dB @ > -45 dBmA
 - Bias voltage: -1 V
- 2 analog output ports

3.14. TEC controller



Fig. 3.19 5305: TEC source controller

- 5305 (Arroyo)
 - Current range: ± 5 A
 - Compliance voltage: 12 VDC
 - Max power: 60 W

3.15. MDU1000: Multi-purpose drive unit

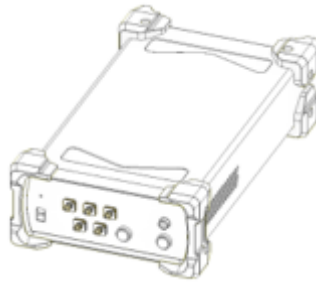


Fig. 3.20 MDU1000: Multi-purpose drive unit

- Supplied quantity: 1 unit
- Optical light source
 - Source type: DFB laser, wavelength: 1550 nm
 - Number of output channels: 4
 - Output power: ≥ -1 dBm / channel
 - Number of power monitoring port (coupling: -10dB): 1
 - FC/APC optical connectors
- Current source
 - Channel: 4
 - Current output: 200 mA max.
 - The maximum current output is 200mA/ch when all the channels are driven. The maximum current for single channel driving is 300 mA.
[Note]: 300mA driving current is only for short period time(e.g. for 5 minutes). For longer driving time, a commercial laser driver should be used.
 - Current control resolution: 2 mA typical
 - Current output error: 3% + 2mA
 - Output voltage: 0 ~ 4.5 V max

3.16. DC probe plate



- Supplied quantity: 2 ea
- Can be mounted on an optical table using tightening screws.

3.17. Motion controller

1.4.1. SC7000

- No. of axes controllable: 16
- 5-phase micro-step motor drivers. (Configured for 1/50 micro-stepping)
- 2 analog input ports are included
 - Voltage range: 0~5 V
 - Input impedance: 10 kOhm

1.4.2. SC3000

- No. of axes controllable: 8
- 5-phase micro-step motor drivers. (Configured for 1/50 micro-stepping)

4. System Operation

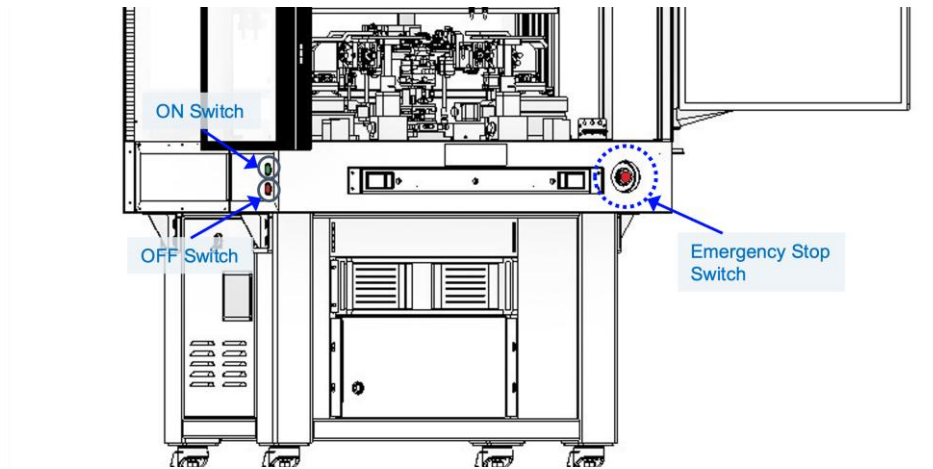


Fig. 4.1 Power switches and emergency switch

4.1. System start

1. Check the green light of the power-on switch is turned on. Turn on main power switch in rear side if both of the lights of the power-on switch and the power-on switch are off.
2. Push the power-on switch, and check the green light is on.
3. Check if the emergency stop switch status, and release the switch by rotating clockwise if it is locked.
4. Turn on the computer first, then all the instrument(SC7000, PM2100, Epoxy dispenser, UV curing system)

4.2. Control software start

4.2.1. Main GUI

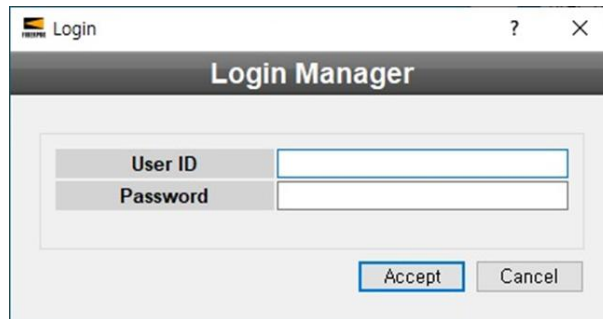


Fig. 4.2 Login manager window

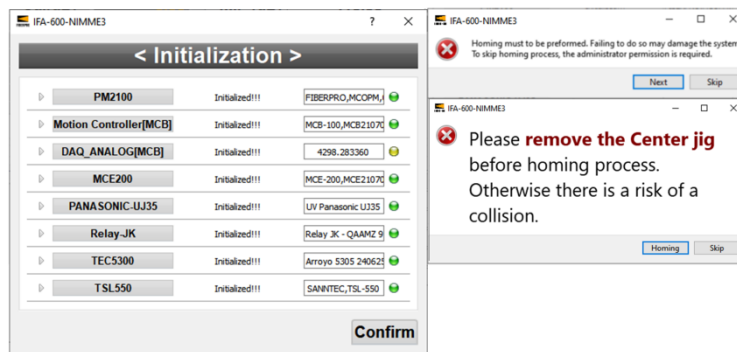


Fig. 4.3 Initialization window and homing message

1. Run the software by clicking the icon with the “IFA-600 GUI” label.
2. Enter ID/password at the login window.
3. After the login, an initialization window appears and shows the status of the peripherals such as PM2100, Motion controller, and other units under control.
4. Make sure all the icons on the right are **GREEN**, and press confirm button. If any of icons are in **RED**, close the window first and check the power status and connections.
5. If a message window requesting homing process, press the homing button to run the home process. The skip button is only for the maintenance purpose, and **MUST NOT** be used for the normal operation.

[NOTE: The homing process is a very important process to synchronize the coordinates of the stages with the reference sensors. Controlling the system without homing process may damage the system.]



(a)



(b)

Fig. 4.4 Control panel before/after homing messages

- Without “Homing process” performed, the user interface has the following limitations.
 - The caution sign is displayed on the background of the control panel.
 - Stage control with “continuous mode” is disabled.
 - The “Reload” button is changed to the “Homing” button.
 - The commands which move the specified stage to the specified position can’t be executed (Except for HOMING/HANDLE_COLLISION commands).

4.3. System shutdown

1. First move all the stages to safe region.
2. Close the software, and turn off the MS window operating system.
3. Turn off all the peripherals including the computer, SC7000, PM2100, and other units.
4. Turn off the main switch of the power strip.

4.4. Miscellaneous

4.4.1. Various sequence functions

a. Loop operation

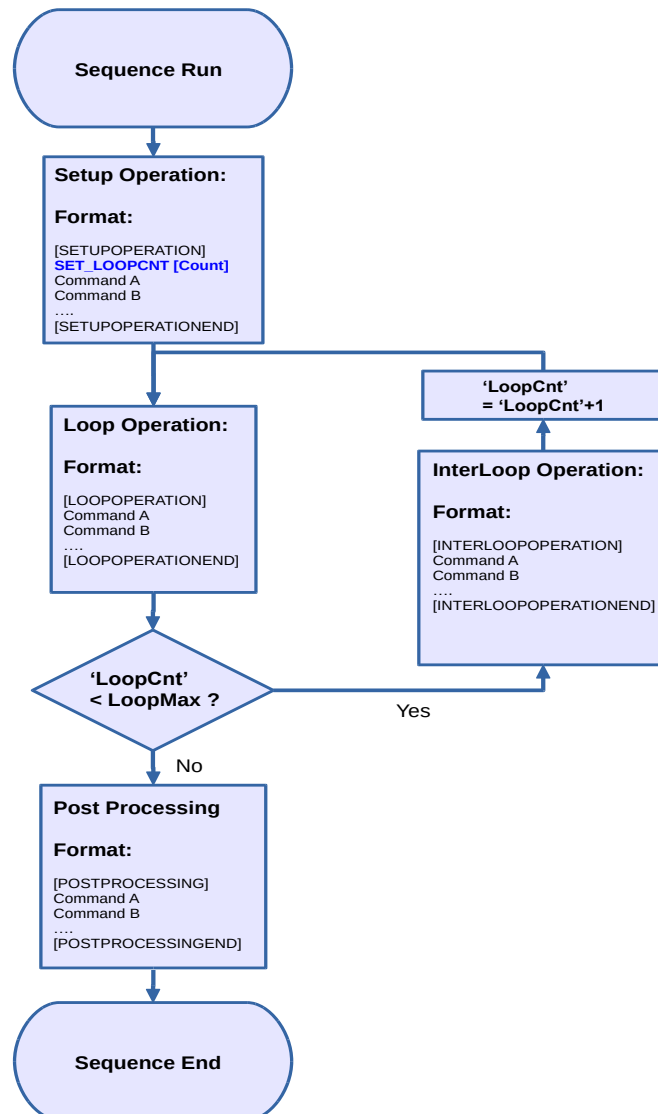


Fig. 4.5 Flow chart "Loop Operation"

- The sequence manager provides the function to repeat the command(s) in the "LOOPOPERATION" section of a sequence file by certain times. The function is activated when the user run the sequence file including "SET_LOOPCNT" command in the SETUPOPERATION section. The number of repetition(LOOPCNT) is defined the SET_LOOPCNT command. (see the programming manual)

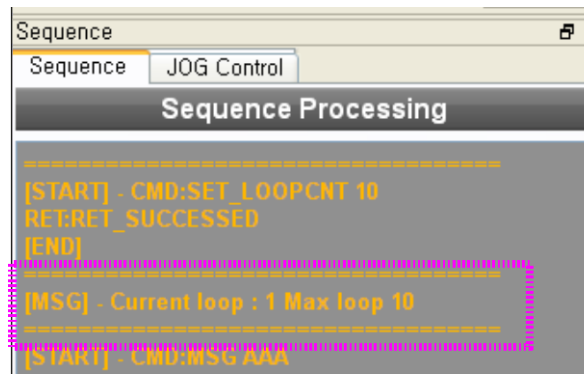


Fig. 4.6 Displays "Number of Repetition"

- The number of repetition is reset if the sequence runs.
- The user can see how many times repeats the sequence in the sequence monitoring window.
- “The maximum number of repeat loop” and “The number of loop repetition executed from the start” are saved.

b. Loading predefined position information from external sequence file (INCLUDE)

- The sequence manager provides consisting of sequence with the combination of two different sequence files with following conditions,
 - The loaded sequence file which has no specific sections.
 - The loaded sequence file which has the “INCLUDE” section as shown below:

```

INCLUDE
FILENAME: "filename(full path)"
INCLUDEEND

```

Fig. 4.7 The format of "INCLUDE" section

- The target file has the sections which loaded sequence file doesn't have (e.g Position, Rotation Center, etc).
- Specifications
 - The information of the sections is loaded ONLY from single sequence file.
 - Only “POSITION” information loaded by “INCLUDE” function can be saved in the loaded sequence file with clicking “SAVE POSITION” button.
- Example
 - With “INCLUDE” function, GUI consists of the sequence with two different sequence files as follows,
 - Conditions
 - Sequence 1.SQF: Only having LOOPOPERATION section.
 - Sequence 2.SQF: Having all of the sections such as POSITION, SETUPOPERATION, INTERLOOPOPERAION, and etc. (Refer to 4.4.14)
 - Operations

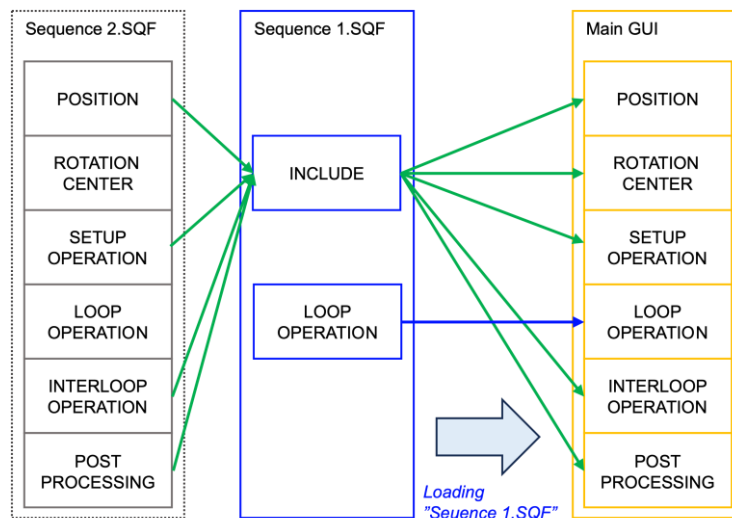


Fig. 4.8 Operation diagram "INCLUDE"

- i. Load the sequence file (Sequence 1.SQF) which has "INCLUDE" section and "LOOPOPERATION" section.
- ii. Then, the GUI loads the information of "POSITION", "SETUPOPERATION", "INTERLOOPOPERATION", and "POSTPROCESSING" section from "POSITION.SQF"(Path: C:\IFA-600\SQF\) with messages notifying the sections are loaded

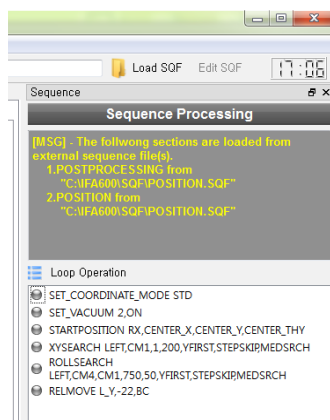


Fig. 4.9 The operation message of "INCLUDE" from which sequence file "Sequence Processing" window.

c. Toggle list

- This function makes the sub-groups including several commands, and shows/hides the contents in the sub-groups by expanding and collapsing vertically in the sequence processing window.
- A user can make sub-group with the following method:
 - i. First, write a group title (e.g. "2-Alignment") as an independent line.
 - ii. Then, add a command with a TAB at the beginning of the line.

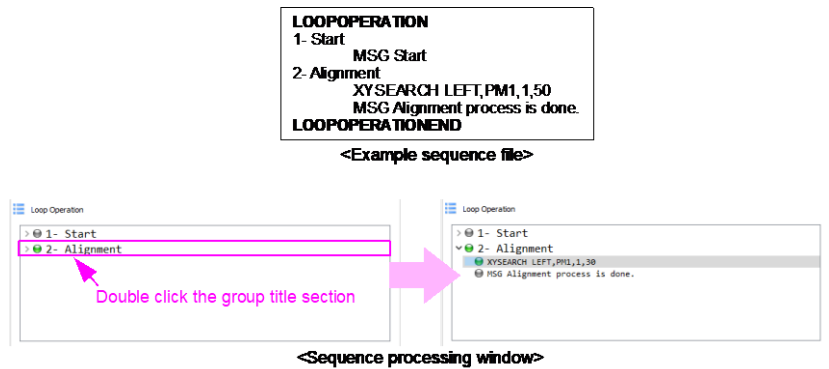


Fig. 4.10 Toggle list

4.4.2. Port Setting (“S.P”, “M.P”)

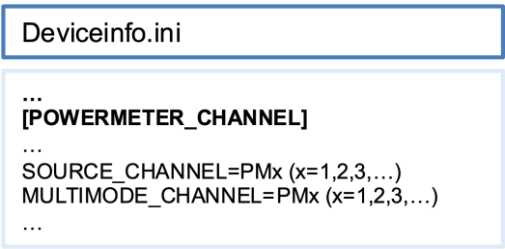


Fig. 4.11 Port setting on "Deviceinfo.ini"

- The user can set the powermeter port for monitoring source power (Connected with monitoring port of the optical power source) and multimode ferrule power (Connected with multi-mode ferrule for the coarse alignment) following configuration file,
 - Configuration file
 - File name: Deviceinfo.ini
 - Location: ./System/Device
 - Setting:
 - SOURCE_CHANNEL: Power-meter channel to show “S.P” section on GUI (PMx, x=1,2,3...)
 - MULTIMODE_CHANNEL: Power-meter channel to show “M.P” section on GUI (PMx, x=1,2,3...)

4.4.3. Configuring Macro button

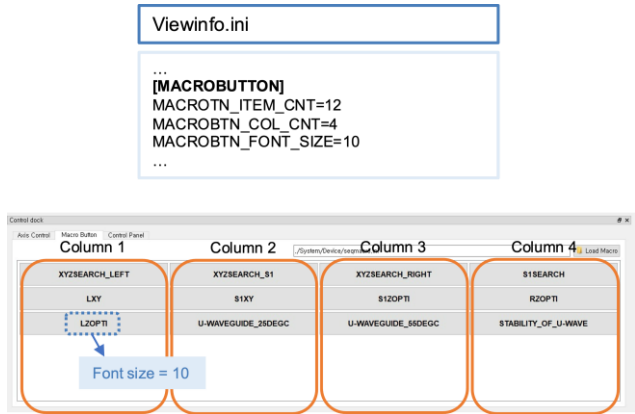


Fig. 4.12 Macro button setting

- The user can configure macro buttons with adjusting following items on the configuration file (Viewinfo.ini),
 - FILE NAME: ViewInfo.ini
 - LOCATION: /System/Device/
- The section “[MACROBUTTON]” in the file is for the configuration of the macro buttons in the “Macro buttons” tab. In this section, the number of main buttons, button layout, and text size on the buttons can be set. The modification of the settings in this section becomes effective after restart of the program.
 - MACROBTN_ITEM_CNT: The number of macro buttons displayed on the window (Default = 12)
 - MACROBTN_COL_CNT: The number of columns for the button layout (Default =4)
 - MACROBTN_ROW_CNT: The number of columns for the button layout (Default =3)
 - MACROBTN_FONT_SIZE: The font size of the text shown in the macro buttons (Default = 13)

4.4.4. Jog controller setting

- This section is used to assign hot-keys on the jog controller for the control of stages or pneumatic devices. Details on the jog controller are described in the section (4.4.9 “b. View”) in the operation manual.
- The user can configure jog controller buttons with adjusting following items on the configuration file (Viewinfo.ini),
 - File name: ViewInfo.ini
 - Location: ./System/Device
- An example of the section is shown below.

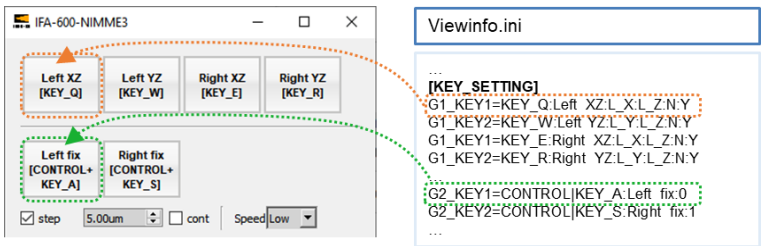


Fig. 4.13 Jog controller setting

- The jog controller has two groups of rectangular indicators with the information on the hotkeys and titles of the controls.
 - The first group: for the stage controls with the direction keys (arrows keys)
 - The second group: for the control the pneumatic devices with a key-press.
- **How to set the hot-keys for Group 1**
 - The group 1 indicators are linked to hot-keys for the stage control, and maximum 12 hot keys can be assigned in the group. For each hot key, maximum 2 stages can be controlled.

Hot-key setting for single stage control
Format: G1_KEY(n)=[Key name]:[Control title]:[Stage name]:[Reverse stage]
Parameters: • G1_KEY(n): Hot key item ID. n=1~12 (examples: G1_KEY4) • Key name: The name of key to be used in the format of “KEY_[A-Z0-9]”. (examples: KEY_S, KEY_9) • Control title: The name of the control to be displaced on the indicator • Stage name: The name of the stage to be controlled by up/down arrow keys • Reverse stage(Y/N): When “Y” flag is set, the upward arrow key moves the specified stage in the

positive direction. With “N” flag, the moving direction is reversed.

Example: G1_KEY4=KEY_S:U_LEFTRIGHT:UPPER_Z:N

Hot-key setting for dual stage control

Format: G1_KEY(n)=[Key name]:[Control title]:[Stage1 name]:[Stage2 name]:[Reverse Stage1]:[Reverse Stage2]

Parameters:

- G1_KEY(n): Hot-key item ID. n=1~12 (examples: G1_KEY1)
- Key name: The name of key to be used in the format of “KEY_[A-Z0-9]” (examples: KEY_S, KEY_9)
- Control title: The name of the control to be displaced on the indicator
- Stage1 name: The name of the stage to be controlled by up/down arrow keys
- Stage2 name: The name of the stage to be controlled by left/right arrow keys
- Reverse1 stage(Y/N): When “Y” flag is set, the upward arrow key moves the specified stage in the positive direction. With “N” flag, the moving direction is reversed.
- Reverse2 stage(Y/N): When “Y” flag is set, the right arrow key moves the specified stage in the positive direction. With “N” flag, the moving direction is reversed.

Example: G1_KEY1=KEY_Q:LEFT:L_Y,L_X:N:Y

• How to set the hot-keys for Group 2

- The group 2 indicators are linked to hot-keys for the pneumatic device control, and maximum 12 hot keys can be assigned in the group. For each hot key, single action is assigned only.

Hot-key setting for pneumatic device control

Format: G2_KEY(n)=[Key name] [Control title]:[DAQ port ID]

Parameters:

- G2_KEY(n): Hot key item ID (n=1~12, *e.g. G2_KEY1)
- Key name:
 - Single key: The name of key to be used in the format of “KEY_[A-Z0-9]” (*e.g. KEY_S, KEY_9)
 - Dual key combination: [“CTRL(CONTROL), ALT or SHIFT”]“KEY_[A-Z0-9]” (e.g. CTRL|KEY_A)
- Control title: The name of the control to be displaced on the indicator
- DAQ port ID: DAQ port ID assigned for pneumatic control command (e.g. 0: LEFTFIX, 1: RIGHTFIX, *Please contact FIBERPRO for the details.)

Example: G2_KEY1=CONTROL|KET_A:Left fix:0

4.4.5. GUI Lock setting

- Some of control panels in the GUI window can be locked/unlocked by either a setup file or “SET_GUI_LOCK” command. This function is useful to avoid the possible damage caused by manipulating wrong control panels. The control panels that can be locked/unlocked are shown in the figure below.

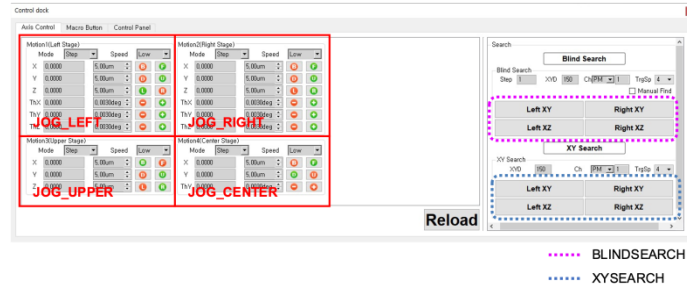


Fig. 4.14 GUI Lock item #1

- The user can set this function with adjusting following items on the configuration file (Viewinfo.ini),
 - File name: ViewInfo.ini
 - Location: ./System/Device

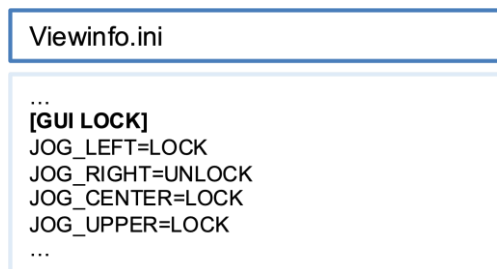


Fig. 4.15 GUI Lock setting

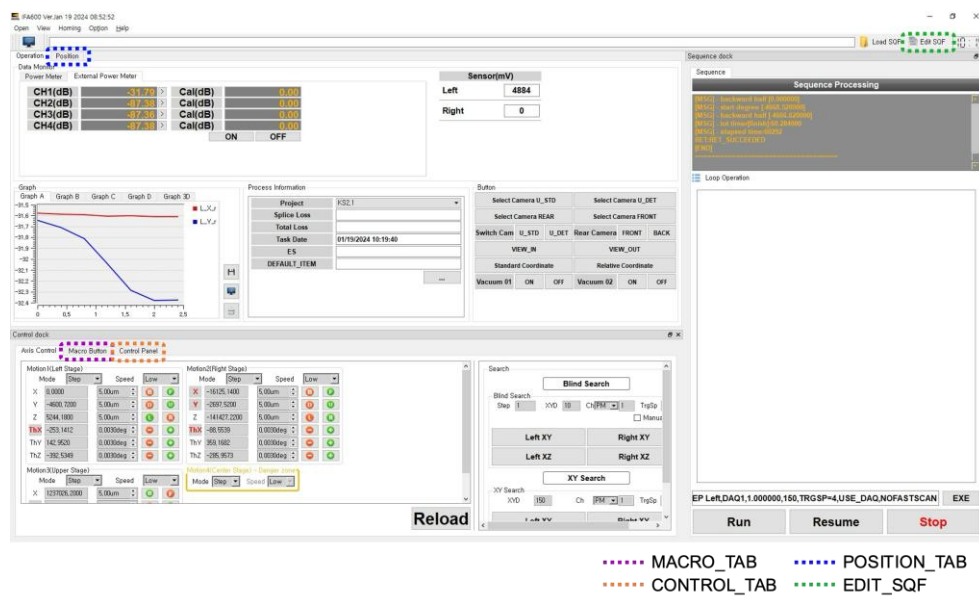


Fig. 4.16 GUI Lock item #2

- Parameters:
 - JOG_LEFT: Control panel for the left stage assembly
 - JOG_RIGHT: Control panel for the right stage assembly
 - JOG_UPPER: Control panel for the upper stage assy(tool positioner)
 - JOG_CENTER: Control panel for the center stage assy
 - BLINDSEARCH: Control panel for the BLINDSEARCH
 - XYSEARCH: Control panel for the XYSEARCH

- POSITION_TAB: The tab to allows for a user to set/update/save/load sets of stage positions for predefined actions. The information of the position sets is included a sequence file.
- CONTROL_TAB: The tab which has the predefined tool buttons
- MACRO_TAB: The tab which has the macro buttons
- EDIT_SQF: The button to open the sequence file currently loaded

4.4.6. Danger zone

- The user can set the area which should ONLY control the stage moving with “Low” speed. We call it “Danger zone”, and it is made for avoiding collision by user inattention. It ONLY works when the user controls stage moving with the “Axis Control”. If some stage is in the “Danger zone”, the yellow box will be displayed around the motion group box joined the stages.



Fig. 4.17 Activated “Danger zone”

- The user can set danger zone with adjusting following items on the configuration file (Viewinfo.ini),
 - File name: ViewInfo.ini
 - Location: ./System/Device/

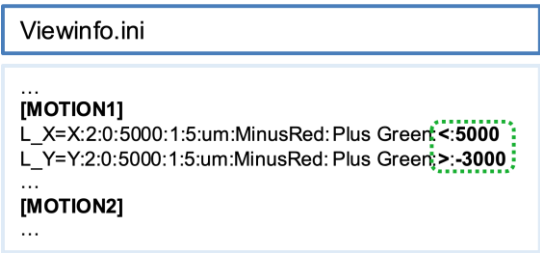


Fig. 4.18 Danger zone setting

Syntax of the stage control panel
Format: [Stage Name]=[View title]:[Decimal place]:[Min]:[Max]:[Step size]:[Default]:[Unit]:[IconType1]:[IconType2]:[Reverse]:[Sign of inequality<Danger zone>]:[Reference <Danger zone>]
Parameters for seeting “Danger zone”: [Inequality sign of “Danger zone”]: Bracket (Allowed ONLY “>”, “<”). [Reference of “Danger zone”]: A real number.
Example: ...

R_Y=Y:2:0:5000:1:5:um:MinusRed:PlusGreen:0:<:-2000

→ “Danger zone” is where the height of right stage assy. is lower than -2000 um.

- i. Open “Viewinfo.ini”(Path: ./IFA-600-CXPME3/System/Device).
- ii. Set the danger zone by editing [Inequality sign of “Danger zone”] and [Reference of “Danger zone”].
 - The danger zone is defined by combination of [Inequality sign of “Danger zone”] and [Reference of “Danger zone”]. (* If last two sections of the syntax are empty, the danger zone doesn't be set.)
 - If the user set the “Danger zone” on the several stages, the overlapping area will be “Danger zone”.

5. Control Software Overview

5.1. System configuration

The components that are controlled by the software are shown in the figure below.

[Components controlled by the software]

Name	Description	Interface
SC7000	Motion controller / DAQ Control	USB
SC3000	Motion controller	USB
PM2100	Optical powermeter	GPIB
	UV curing system	
	Dispenser	
Cameras	Upper camera 1(1.5x)	USB
	Upper camera 2(8.0x)	USB
	Rear camera (0.6x)	USB
	Front camera (6.0x)	USB

5.2. Image processor

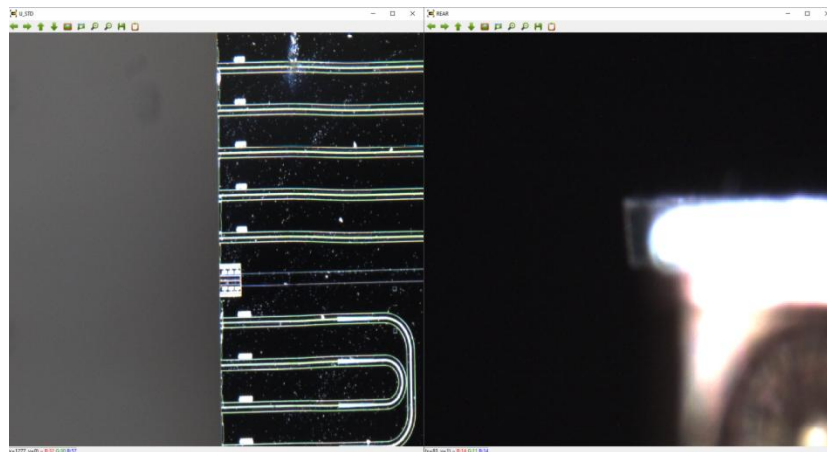


Fig. 5.1 Camera monitor layout(Left: Camera view1, Right: Camera view2)

- The camera monitor display shows three windows as shown above:
 - “Camera view1” shows the images from one of the top view cameras(1.5x camera) in real time.
 - “Camera view2” shows the images from the rear view camera(0.6x camera) in real time.
- Tool bar & status bar

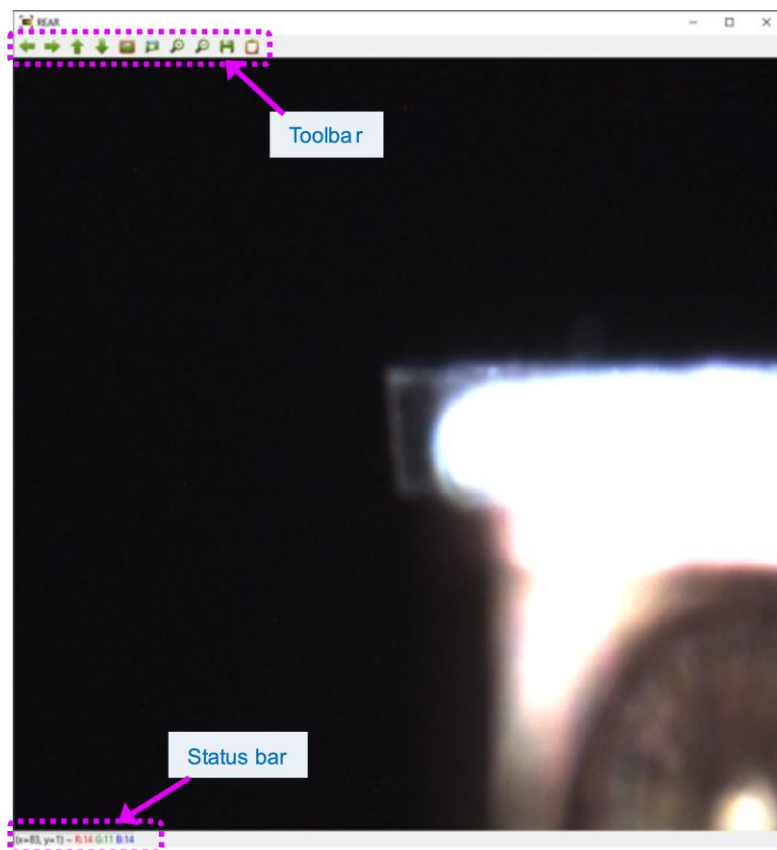


Fig. 5.2 Toolbar & Status bar



Fig. 5.3 Toolbar (Image processor)

-     : It moves zoomed image in left/right/down/up direction.
-  : It sets the view to the original magnification.
-  : It sets the view to the 30x zoomed.
-   : It sets zoom in/out.
-  : It saves current view to the image file.
-  : It copies current view to the clip board.
- Status bar
 - It shows the mouse position/RGB values

5.3. Aligner: IFA-600-AUCME3 Main Graphic user interface (GUI)

4.4.7. Initialization window

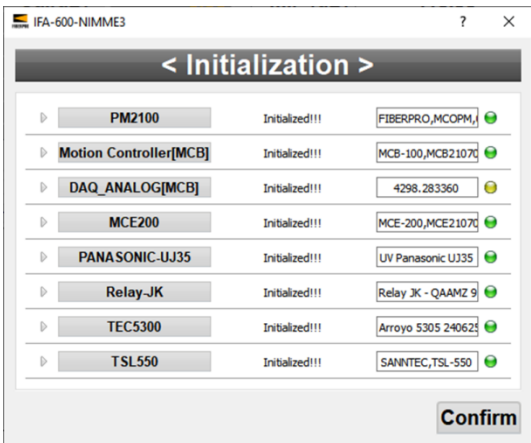


Fig. 5.4 Initialization window

When the IFA-600-AUCME3 GUI program starts, it displays an initialization window as shown in the figure. The window shows connection status of principal devices. A green circle on the right side for each item indicates the connection status is all right, otherwise a red circle is shown with “connection fail” message instead.

4.4.8. Main window layout

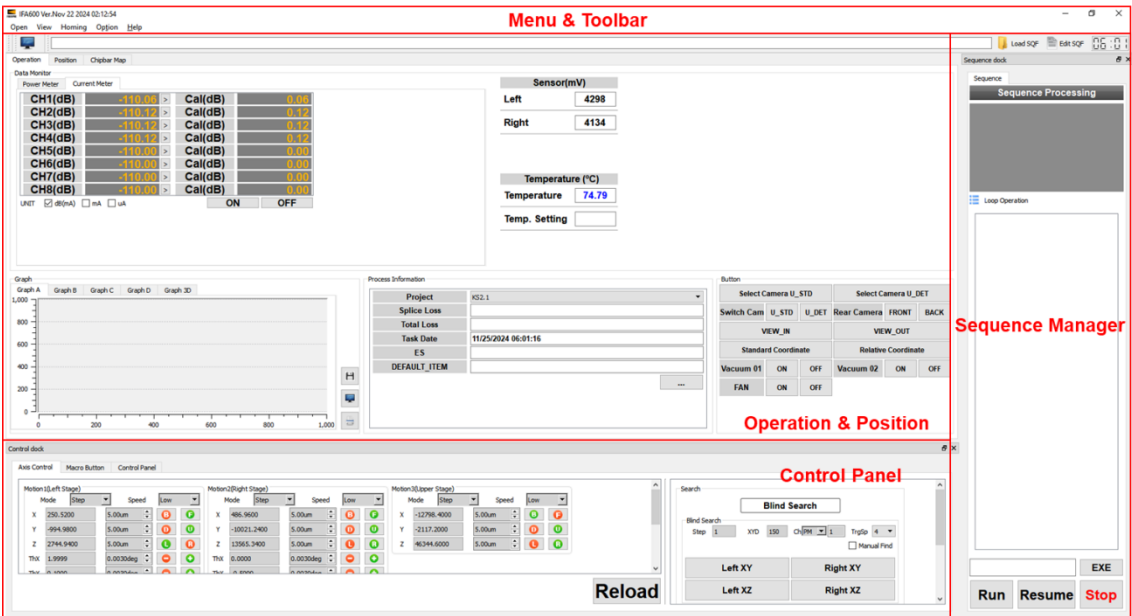


Fig. 5.5 Main window layout

The main window layout consists of four major parts as shown in the figure, and those are

- Menu & Toolbar
- Operation & Position

- Control Panel
- Sequence Manager

4.4.9. Menu & Toolbar

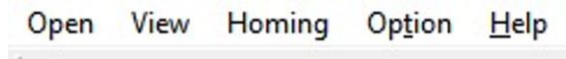


Fig. 5.6 Menu bar

a. Open

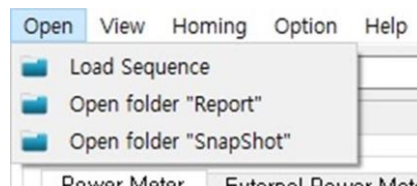


Fig. 5.7 Open menu

- Load Sequence: used to load a sequence file for bonding operation.
- Open folder “Report”: C:\IFA-600-NIMME3\REPORT Folder opens.
- Open folder “Snap Shot”: C:\IFA-600-NIMME3\SnapShot Folder opens.

b. View

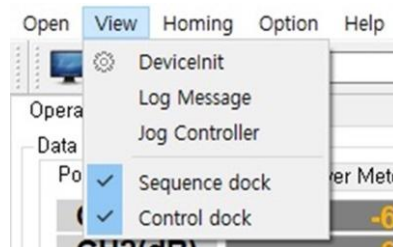


Fig. 5.8 View menu

- DeviceInit: It displays the device initialization window.
- Log Message: It displays logging message while operating the system.
- Jog Controller:

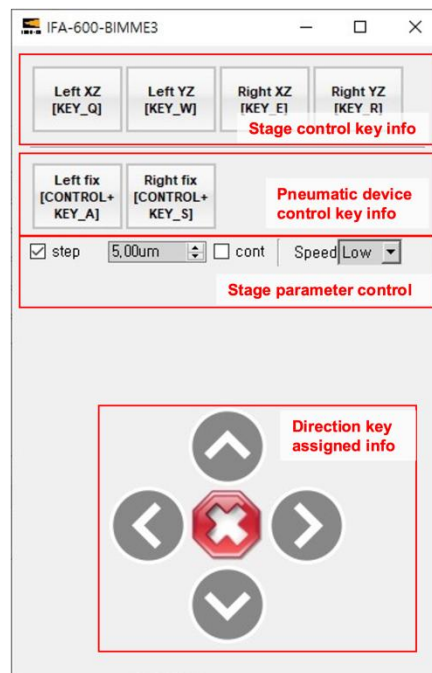


Fig. 5.9 Jog controller

- The IFA-600-AUCME3 software provides a jog controller that allow the user to control a certain set of motorized stages easily by using the keyboard. The jog controller also allows to control the pneumatic driven devices such as vacuum. The jog controller has two groups of rectangular indicators with the information on the hotkeys and titles of the controls. The first group is prepared for the stage controls with the direction keys(arrows keys), and the second group is to control the pneumatic devices with a key-press. The jog controller also has a control for stage motion parameters and the arrow shape symbol to display the stage information linked with the control when a certain jog control is activated.
- The right image in the figure shows the jog controller when the key “Q” or “q” is pressed, as an example. When the key is pressed the corresponding rectangular panel indicator lits green, and the information on the stages linked to the arrow keys in the keyboard is displayed next to the arrow shape button. In the example, “L_Z(-)” is shown next to the left arrow symbol. If the user press the left arrow key(←) in the keyboard while “Q” or “q” is pressed at the same time, the linked stage L_Z moves in the negative direction. Clicking the left arrow symbol also moves the same stage.
- All the controls in the jog controller are highly configurable, and the configuration method is described in the appendix section. (See Fig. 5.9)

c. Homing

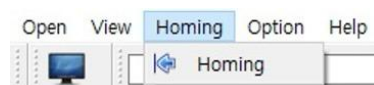


Fig. 5.10 Homing menu

- Homing: It moves the stage to a home position.

d. Option

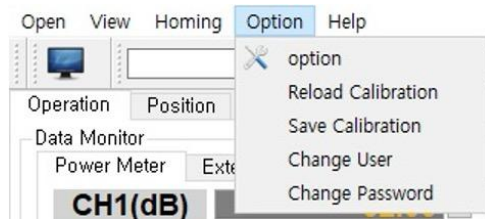


Fig. 5.11 Option menu

- “Option” menu has 5 sub-menu items,

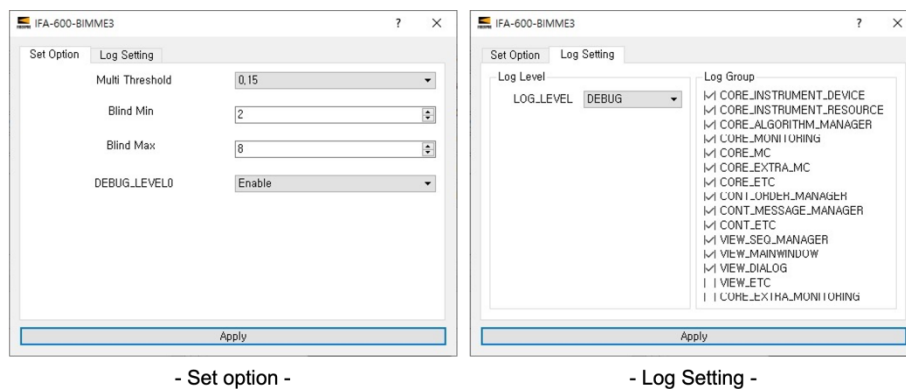


Fig. 5.12 Option dialog

- Option dialog
 - Set Option
 - Using this dialog the user can set parameters used by alignment algorithms. This part should be only modified by experienced user.
 - Log Setting
 - Using this dialog, the user can set options for the types of log messages to be written in the log files.
 - Calibration: calibration values for the power meter and current meter used in “Data monitoring window” can be loaded/saved with this menu.
 - Reload Calibration: It reloads calibration data from a data file, and apply the value to the “Data monitoring window”.
 - Save Calibration: It takes the calibration values from the “Data monitoring window”, and save them into a file.
 - User Account
 - Change user: It switches the current user.
 - Change password: It changes the password of the current user.

e. Help

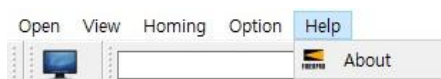


Fig. 5.13 Help menu

- About: it opens the window which shows the software version and build environment information.



Fig. 5.14 About window

f. Toolbar



Fig. 5.15 Toolbar

- A: Screen shot: It captures a screen shot of the GUI program.
- B: Load SQF: It loads a sequence file to work with.
- C: Edit SQF: It edits the sequence file currently loaded.
- D: Current time: It displays current time.

4.4.10. Operation & Position

The “Operation Window”, “Position Window” and “Chipbar Map” are positioned at the central part of the GUI by using tab window arrangement, and those can be selected by clicking the control tab.

- The “Operating Window” provides process information, measurement data on the current job and various control buttons.
- The “Position Window” provides position information used by the processes. .

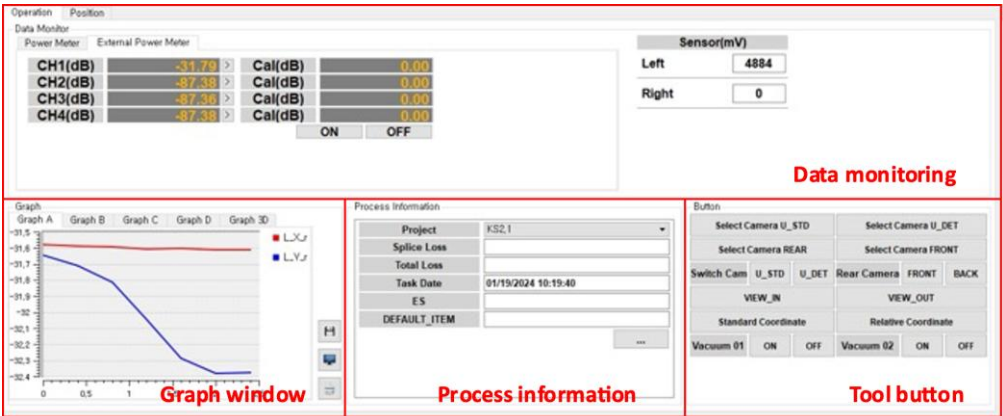


Fig. 5.16 Operation window

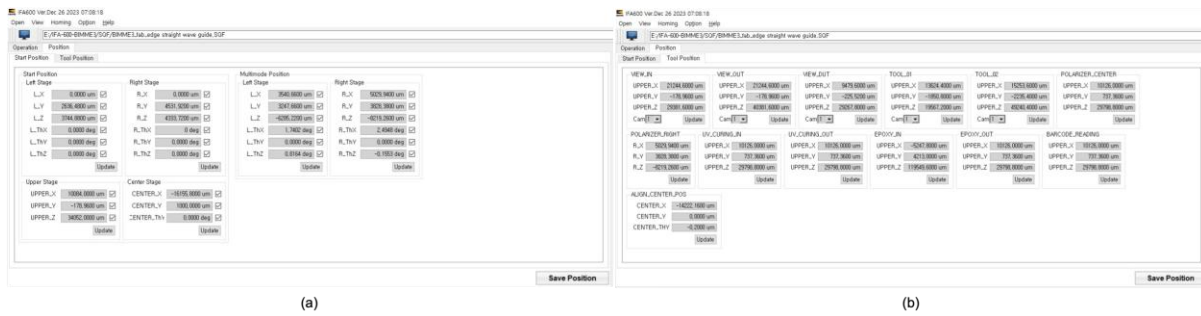


Fig. 5.17 Position window (a: Start Position, b: Tool Position)

a. Data monitoring

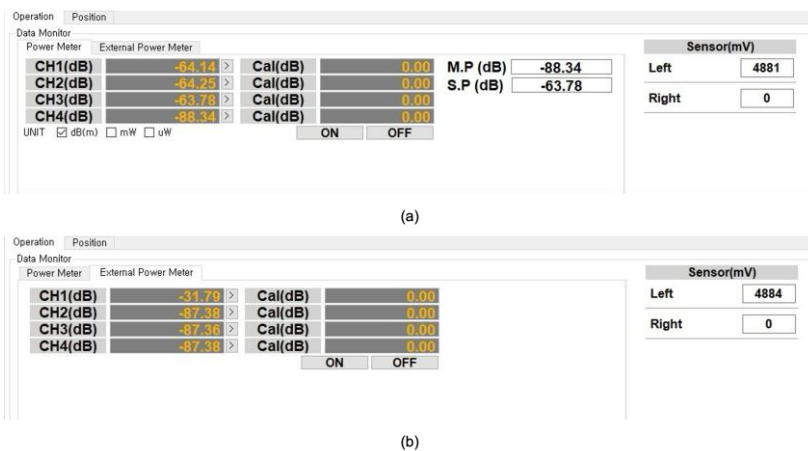


Fig. 5.18 Data monitoring window
(a: Optical power reading, b: External power reading)

- Power readings or External power readings are displayed.
- S.P: The power reading of the monitor ports on the optical power source (Default: PMCH3, see details on channel setting in 4.4.2)
- M.P: The power reading of the multimode fiber ferrule for input alignment (Default: PMCH4, see details on channel setting in 4.4.2)
- Output voltage of the DAQ Analog channel is shown in “Sensor (mV)” window.
- A user can set calibration values in “Cal” windows.
- Calibration value can be edited and loaded/saved from/to the file “Measurement_Calibration.ini” under “IFA-600-AUCME3\System\Device\” folder.
- The format of the calibration file is described in section 4.4.15.

b. Graph window

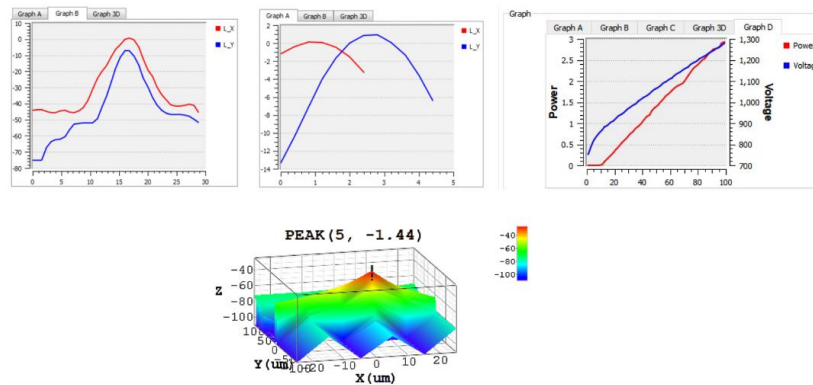


Fig. 5.19 Graph window

- Graph window shows data acquired during the alignment process for monitoring.
 - The “Graph A” tab, “Graph B” tab and “Graph C” tab display two-dimensional graph such as “Optical power versus scan distance”, “Displacement sensor value versus angle”, and others.
 - The “Graph D” tab displays two dimensional graphs which has different scales.
 - The “Graph 3D” displays 3D graph of optical power over the scan area on the XY plane.

c. Process information

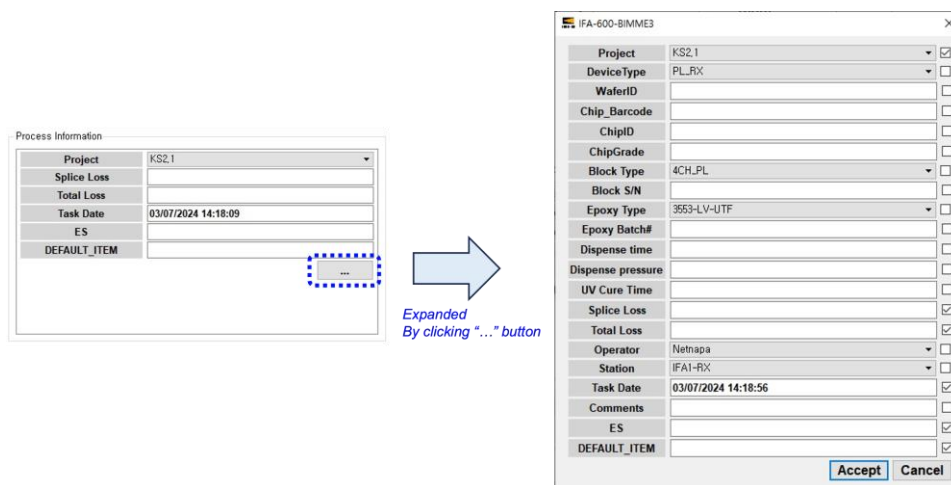


Fig. 5.20 Process information window

- The windows show the information of the current operation such as project name, device type, etc. The basic window displays only a part of information (those are user-selectable).
- “More” button creates a pop-up window that displays all the information. A user can enter some of the information into either the basic window or the detailed window.
- Some information can be loaded to the window from a file automatically.
- The process information window is configured by the file “ProcessInfo.ini” when the software starts. The format of the configuration file is described in the appendix section.
- All the process information filled in the windows is used when the system saves the process data.

d. Camera tool buttons

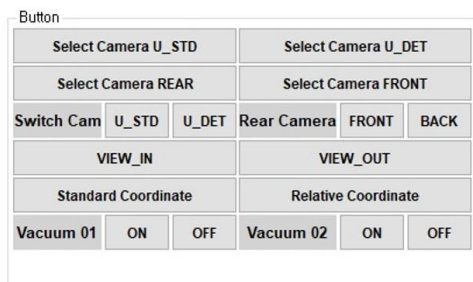


Fig. 5.21 Tool buttons

- Select Camera U_STD: It displays image from the Upper1(U_STD) camera (Magnification: 1.5x).
- Select Camera U_DET: It displays image from the Upper2(U_DET) camera (Magnification: 8.0x).
- Select Camera U_REAR: It displays image from the REAR camera (Magnification: 0.6x).
- Select Camera FRONT: It displays image from the FRONT camera (Magnification: 6.0x).
- Switch Cam U_STD/U_DET: It selects one of the upper cameras (U_STD from/to U_DET) as a source for the upper camera viewer.
- Rear Camera FRONT/BACK: It moves the rear camera to FRONT/BACK by the pneumatic action.
- View in: It moves the tool positioner to the predefined “View In”.
- View out: It moves the tool positioner to the predefined “View Out”.
- Standard Coordinate: It sets the mode to the “Standard coordinate mode”.
- Relative Coordinate: It sets the mode to the “relative coordinate mode”. All the coordinate values become zeros when this command is issued.
- Vacuum 01/02: It turns on/off the vacuum device to hold the chip on the center jig.

[NOTE: The predefined positions of “View in”, “View out” can be found from “Tool Position” tab of “Position” window(See the next section).]

e. Position window

- The panel allows for a user to set/update/save/load sets of stage positions for predefined actions. The information of the position sets is included a sequence file. The sets of positions in the panel are,
- Start Position

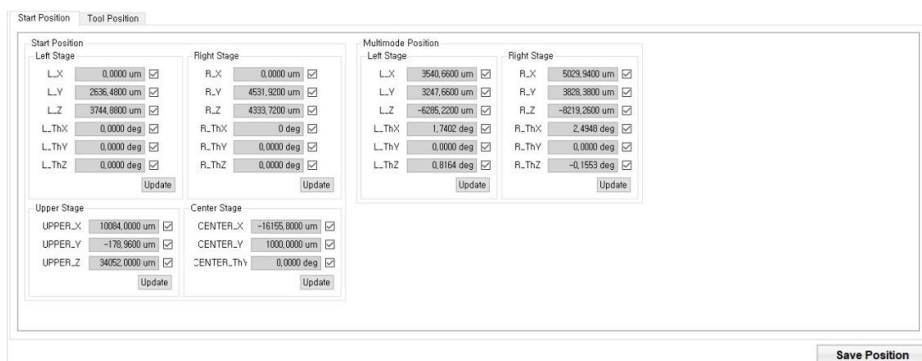


Fig. 5.22 Position window (Start Position)

- Start position (Left Stages, Right Stages, Upper Stages, Center Stages): It is the position which begins alignment process, all the devices are closed to each other.
- Multimode position (Left Stages, Right Stages): It is the position which begins input active alignment with multimode fiber. Multimode ferrule is closed to output port of the device.
- Tool Position

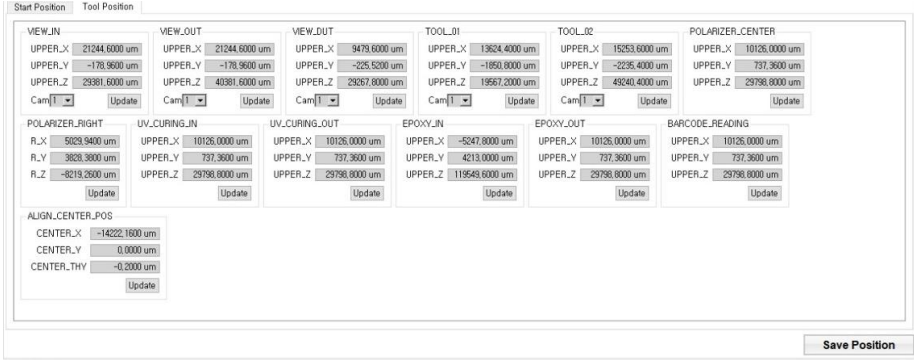


Fig. 5.23 Position window (Tool Position)

- VIEW_IN: The position of the tool positioner to monitor the input of chip
- VIEW_OUT: The position of the tool positioner to monitor the output of chip
- VIEW_DUT: The position of the tool positioner to monitor the center of chip
- TOOL_01 / TOOL_02: user-defined positions of the tool positioner
- POLARIZER_CENTER/RIGHT: The position of the center and right stage assembly
- UV_CURING_IN: The position of the tool positioner for the UV curing of the input of chip
- UV_CURING_OUT: the position of the tool positioner for the UV curing of the output of chip
- EPOXY_IN: the position of the tool positioner for the epoxy dispensing of the input of chip
- EPOXY_OUT: the position of the tool positioner for the epoxy dispensing of the output of chip
- BARCODE_READING: the position of the tool positioner for the barcode reading of chip
- ALIGN_CENTER_POS: the position of the center stage assembly for the alignment

4.4.11. Control panel

The “Control panel” is placed on the bottom part of the GUI by using tab window arrangement, and those can be selected by clicking the control tab. The “Control panel” is configured to three different panels that provide,

- Axis control: It provides motorized stage control function, Reload function, and quick search function.
- Macro button: It provides the buttons to run a series of commands defined by the user.
- Control panel: It provides the buttons to run single commands to move to predefined position, UV curing system control, Epoxy dispensing control, and etc.

a. Axis control

- The definitions on the stages assemblies are shown in the figure below.

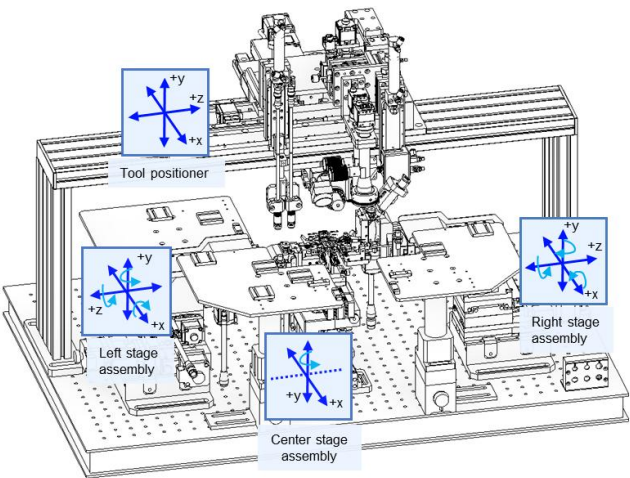


Fig. 5.24 Axis systems for motorized stage assemblies

- Stage control groups
 - It provides each motorized stages with following control parameters.

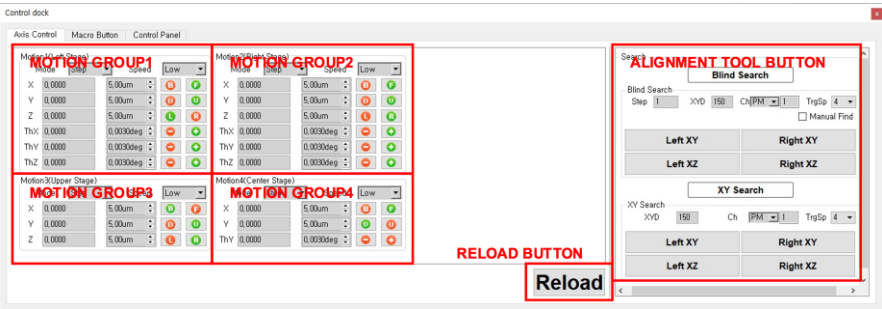


Fig. 5.25 Axis control panel

- Control parameters

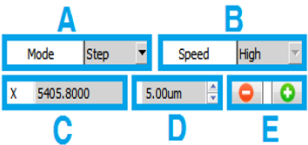


Fig. 5.26 Axis control parameters

- A: Control mode selection (Step move, Continuous move)
- B: Stage speed selection
- C: Current position

- D: Step distance
 - E: Control buttons (+/-: Increase/Decrease in the coordinate, Green: Safe to move, Red: Collision can occur)
- Motion groups
 - Motion Group 1: The left stages for alignment(6-axis)
 - Motion Group 2: The right stages for alignment(6-axis)
 - Motion Group 3(Tool positioner): 3-axis stage that moves tools such as cameras, UV, Epoxy, etc
 - Motion Group 4(Center Stage): 3-axis stages that moves center jig.
- Reload
 - With this button, all the stages to the Reload position defined in the configuration file.
- Alignment tool button
 - It provides major alignment methods that can be used for a production engineer to setup/test the IFA-600-NIMME3 system. The methods include “Blind search” and “XY search”.

b. Macro button panel

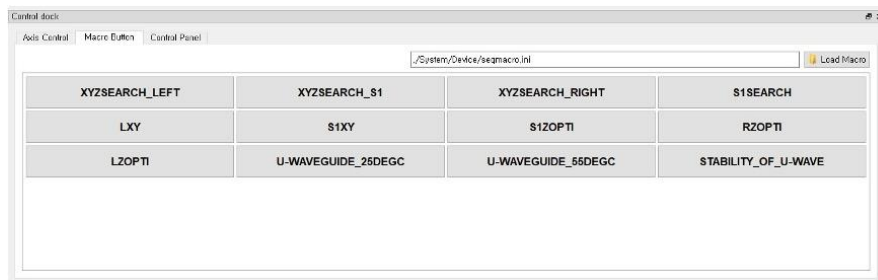


Fig. 5.27 Macro button panel

- A macro button is linked to either a command or a series of commands through a configuration file.
- This function allows for a user to control the system in a user-defined way by simply pressing one of the macro buttons.
- The macros can be loaded from a file by clicking “Load Macro button”. The software loads the file “./System/Device/Seqmacro.ini” when its starts
- The format of the macro definition is described in the appendix section.

c. Control panel

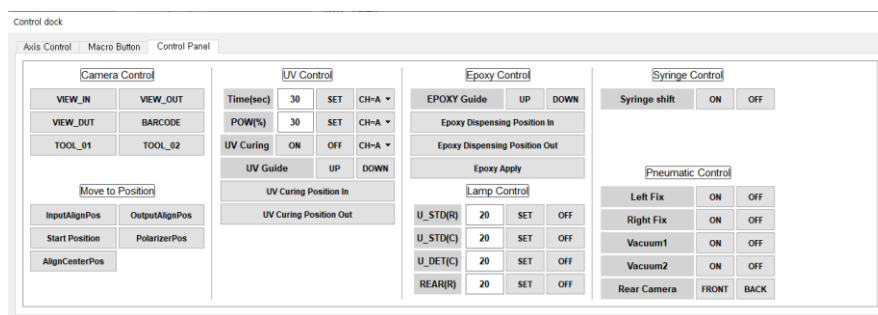


Fig. 5.28 Control panel

- The predefined tool buttons are not shown in a normal operation, and selecting a tab make the buttons appear in place of the stage control window. The controls provided by the buttons are,
 - Camera Control
 - VIEW_IN/OUT: It moves the tool positioner to the predefined position to monitor an input of chip during the process.
 - VIEW_DUT: It moves the tool positioner to the predefined position to monitor a center of chip during the process.
 - BARCODE: It moves the tool positioner to the predefined position for the barcode reading of chip.
 - ToolPos(1~2): It moves cameras to the corresponding predefined position.
 - Move to Position
 - Input Align Pos: It moves the tool positioner and the left stage assembly to the predefined position.
 - Output Align Pos: It moves the tool positioner and the right stage assembly to the predefined position.
 - Start Position: It moves all the stages to the predefined start position.
 - PolarizerPos: It moves the right stage assembly to the predefined position.
 - Align Center Pos: It moves the center stage assembly to the predefined position.
 - UV Control
 - Time: It sets the UV curing time (in seconds).
 - POW: It sets the UV curing power (in percentage).
 - UV Curing: It initiates the UV curing.
 - UV Guide: It moves the UV head up/down.
 - UV Curing Position (In/Out): It moves the tool positioner to the corresponding predefined position for the UV curing process.
 - Epoxy Control
 - Epoxy Guide: It moves the epoxy syringe holder up/down.
 - Epoxy Dispensing Position(In/Out): It moves the tool positioner to the corresponding predefined position for the epoxy dispensing process.
 - Epoxy Apply: It controls the epoxy dispenser to dispense the epoxy once.
 - Lamp Control
 - Lamp 1: It controls the brightness of the ring LED type of lamp mounted on the upper1(U_STD) camera
 - Lamp 2: It controls the brightness of the coaxial type lamp mounted on the upper1(U_STD) camera.
 - Lamp 3: It controls the brightness of the coaxial type lamp mounted on the upper2(U_DET) camera.
 - Lamp 4: It controls the brightness of the ring LED type lamp mounted on the rear camera.
 - Syringe Control
 - Syringe shift(ON/OFF): It controls the position of the epoxy syringe by using a pneumatic cylinder.
 - Pneumatic Control
 - Left fix: It turns on/off the pneumatic cylinder device to fix the sliding table of Left stage assy.
 - Right fix: It turns on/off the pneumatic cylinder device to fix the sliding table of Right stage assy.
 - Vacuum (1/2): It turns on/off the vacuum device to hold the chip on the center jig.

- Rear Camera: It moves rear camera to front/back direction.

4.4.12. Sequence manager

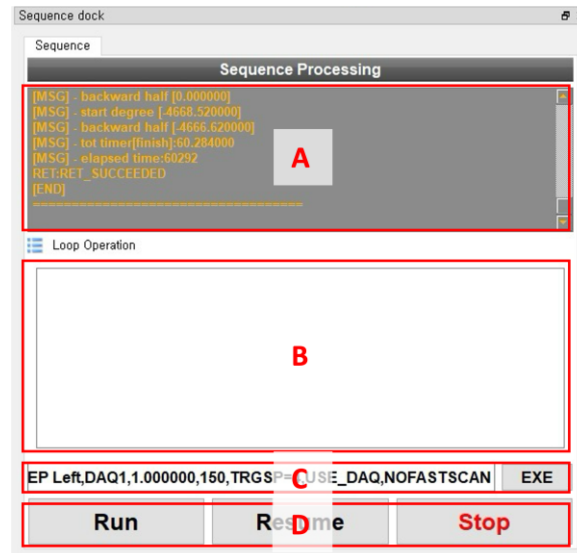


Fig. 5.29 Sequence manager

- The IFA-600-NIMME3 software provides a set of commands that control the system. Automatic alignment/bonding for a certain device can be achieved by a series of the commands. The commands include “stage control”, “complex alignment”, “data saving”, and others. At a setup phase, a production engineer needs to create a file(“sequence file”) that contains a series of the commands carefully organized for a specific type of device. The sequence file also includes a set of positions for processes such as UV curing. An example of the sequence file and format are shown in the section 4.4.14.
 - A: Sequence processing monitor: It displays information on the command currently running.
 - B: Commands list: It shows a series of commands that was loaded from a sequence file.
 - C: Command execution window: An operator can run a command by entering it into this window.
 - D: Run /Stop/Resume buttons: The buttons allow the operator to control current sequence flow.

5.4. Help

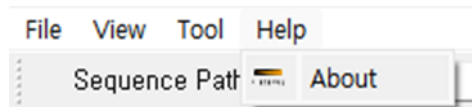


Fig. 5.30 Help



Fig. 5.31 About dialog

- “About” dialog displays the software version and build environment information.

a. Tool bar

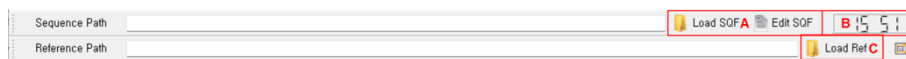


Fig. 5.32 Tool bar

- Load / Edit SQF(A): It loads and edits a sequence file to work with.
- Current time(B): It displays the current time.
- Load Ref(C): It loads a reference file.

5.4.1. Sequence manager

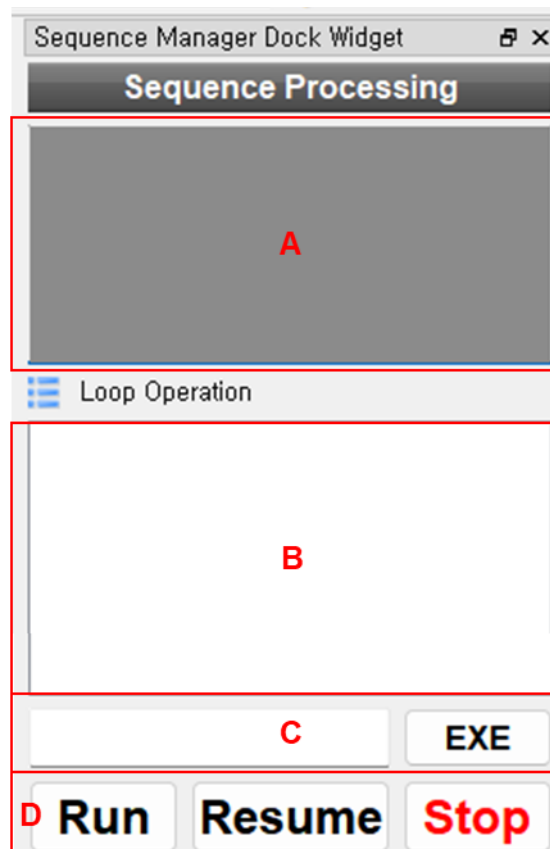


Fig. 5.33 Sequence manager

The AWG module tester software provides a set of commands that control the system. Automatic measurement for a certain device can be achieved by a series of the commands. The commands include “stage control”, “complex alignment”, “data saving”, and others. At a setup phase, a production engineer needs to create a file(“sequence file”) that contains a series of the commands carefully organized for a specific type of device.

- A: Sequence processing monitor: It displays information on the command currently running
- B: Commands list: It shows a series of commands that was loaded from a sequence file
- C: Command execution window: An operator can run a command by entering it into this window
- D: Run /Stop/Resume buttons: The buttons allow the operator to control current sequence flow

The format of the sequence file described in the appendix section.

6. Appendix

6.1. Angle bracket setting

- IFA-600 has a mechanism that changes the moving direction of the Y axis relative to the vertical direction, which is “Angle bracket”. The angle bracket is to perform the alignment process with the chips with angled polished front facet.
- The angle bracket can be configured in five different ways for the angles of $\pm 8^\circ$, $\pm 5^\circ$, 0° relative to the vertical direction. The figure show the angle bracket for 0° degree.
- The process for the angle change to 8° is as follows:

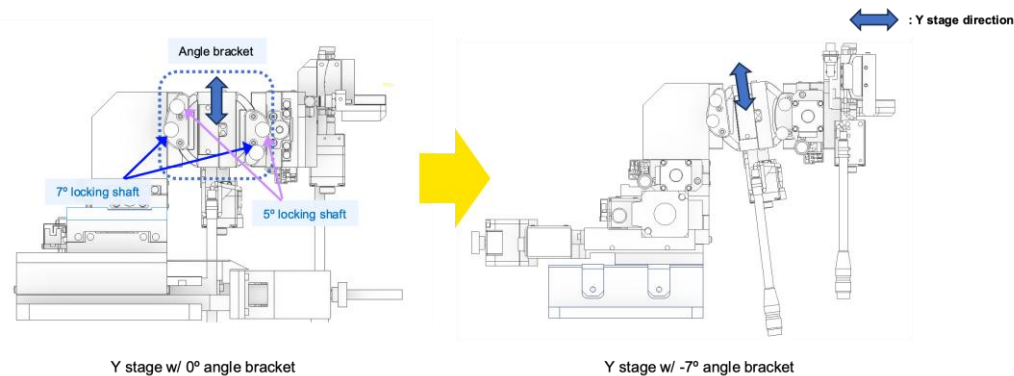


Fig. 6.1 Tilting angle bracket from 0° to -7°

1. First, loosen 4 locking screws (M4), and unlock the bracket with pulling -8° locking shaft. (see figure below)

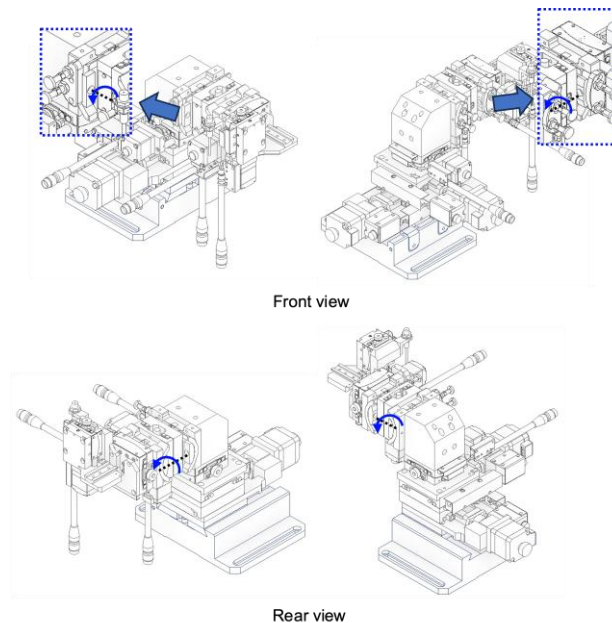


Fig. 6.2 Loosening locking screws

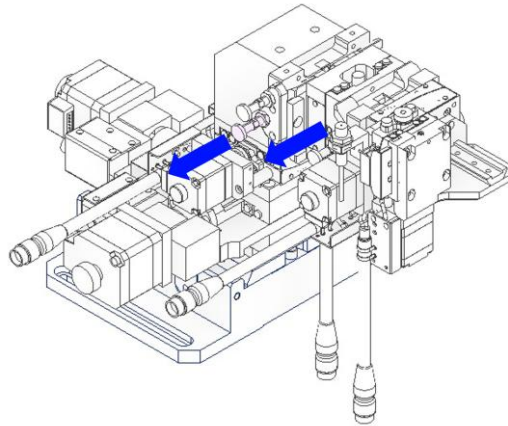


Fig. 6.3 Pulling the 7° locking shaft

2. Adjust the bracket angle to 7°, and lock the bracket with pushing knobs.

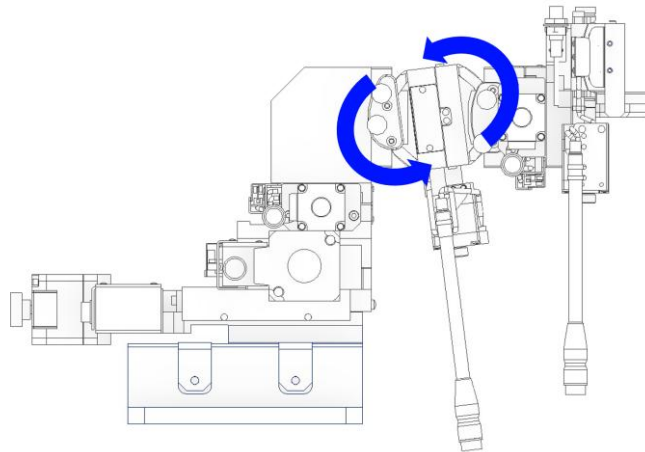


Fig. 6.4 Adjusting the bracket angle to -7°

3. Tighten 4 locking screws.

[NOTE]:

- *Frequent reconfiguration of the angle bracket may damage the bracket.*
- *All the process above must be performed only by a qualified person with great care.*

6.2. Files used with IFA-600 GUI

4.4.13. Processinfo.ini

- File name: ProcessInfo.ini
- Location: .\System\Device

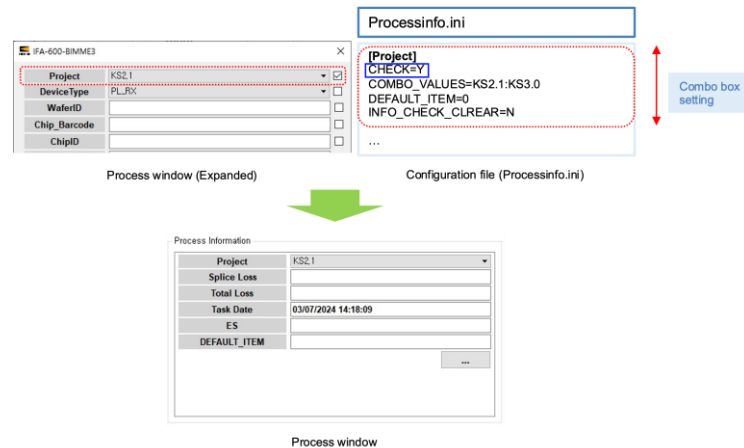


Fig. 6.5 Processinfo.ini

- [Section Name]: Sets the name of the item.
 - The items to be shown in the Process info window are defined in this section.
 - Each item needs the properties of CHECK, COMBO_VALUES, DEFALUT_ITEM, INFO_CHECK_CLEAR, LINKED_SYSVAR, FIXNAME, VARIABLE_NAME, LONGNAME, to be set, where n is the id of the item.
 - **CHECK**: Set whether the item is to be show in the main window.
 - “Y”: The item is shown in the main window.
 - “N”: The item is shown only in the process info window.
 - **COMBO_VALUES**: Set the values of the item in the combo box form. The values of the combo box should be given in the “:” separated format(e.g. COMBO_VALUES=ProjectA:ProjectB). If this properties is not defined, the item will be shown in “Editline” type.
 - **DEFAULT_ITEM**: Set default item index of the combo box. For “LineEdit” type, it sets default string to be displayed.
 - **DISPLAY_VARIABLE**: Set whether the value of the variable written on the “Default_Item” section is to be show on the section. And the displayed value is updated every 1 second.
 - “Y”: Display variable value on the section.
 - “N”: Display the characters of the variable on the section instead of the value.
 - Examples:
 - Case 1. Monitoring single variable on the “Loop Count” section

```
[Loop Count]
CHECK=Y
INFO_CHECK_CLEAR=Y
DEFAULT_ITEM=LoopCont $(LOOPCNT)
DISPLAY_VARIABLE=Y
```

- Case 2. Monitoring multiple variables on the “Display variable” section

```
[Display Variable]
CHECK=Y
INFO_CHECK_CLEAR=Y
DEFAULT_ITEM=LoopCont $(LOOPCNT) / CH1 $(PMCH1)
DISPLAY_VARIABLE=Y
```

- **INFO_CHECK_CLEAR:**
 - Y:
 - The “MAKE_REPORT” command fails when the corresponding item is empty.
 - The “CLEAR_PROCESSINFO” command clears the corresponding item and assign the default value.
 - N:
 - The system performs “MAKE_REPORT” command even if the corresponding time is empty.
 - “CLEAR_PROCESSINFO” has no effect on the corresponding time.
- **LOGNAME:** This parameter sets the title of the item to be written in a report file. If this parameter is empty, “Section Name” is used in the report file.
- **VARIABLE_NAME:**
 - The item value can be assigned to a variable. This parameter defines the name of the variable that can be used in report files and message boxes.
 - The variable name is case insensitive and cannot include space.
- **LINKED_SYSBAR:** This keyword connects the corresponding item to a system variable. It allows for the system variables modified by some commands to be updated to the corresponding item in the “Process Information window” or in report files..

UVCURINGTIME	The UV curing time set by either “UV_SET_CURING_TIME” or GUI panel
TASKDATE	Current time with the format of (MM/dd/yyyy hh:mm:ss) This value is updated by the system all the time.
BARCODE	Barcode reading value obtained from image processing “V_DECODE_BARCODE” command updates the value.
CHIPID	Chip ID obtained from the barcode reading “V_DECODE_BARCODE” command updates the value.
WAFERID	Wafer ID obtained from “Process Information”
FABID	FAB ID obtained from “Process Information”

- **CHECK_LETTERCOUNT:** For “MAKE_REPORT, MAKE_CUSTOM_REPORT and CHECK_PROCESSINFO” commands, if one of the commands is performed and the number of the given string is different from the set value, then returns failure and informs of the item with wrong number of characters to user.

4.4.14. Sequence file

- File name: “Sequence name”.sqf
- Location: Any (*In general: .\SQF)

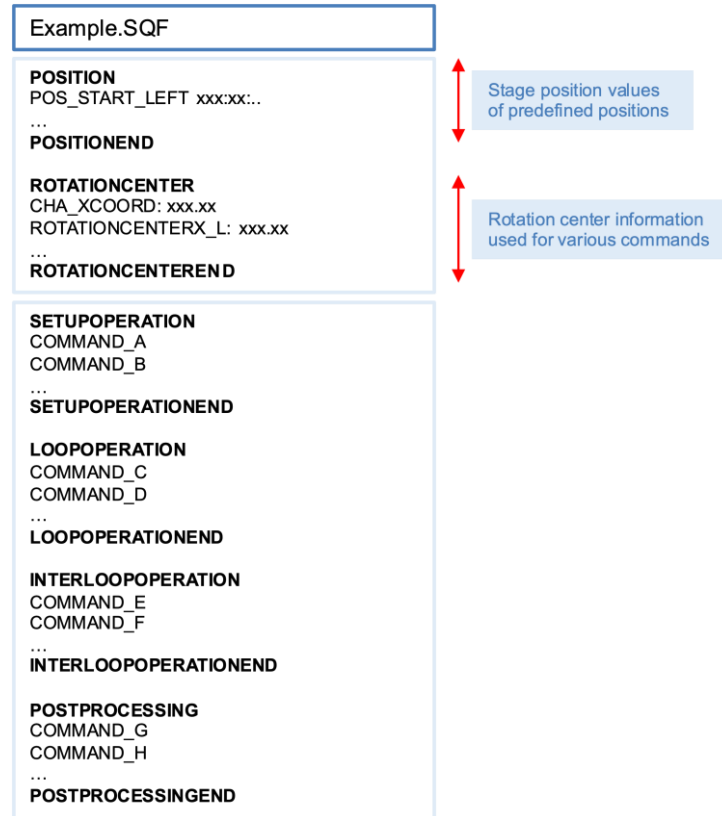


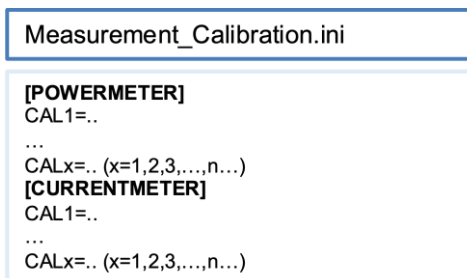
Fig. 6.6 Sequence file template

- The sequence file consists of the five sections which are:
 - POSITION
 - ROTATIONCENTER
 - SETUPOPERATION
 - LOOPOPERATION
 - INTERLOOPOPERATION
 - POSTPROCESSING
- The each section is splitted by “SectionName” and “SectionNameEND” keywords.
- The descriptions of the sections are as shown below:
 - POSITION
 - It contains predefined position values for all stage assemblies. (*Please check predefined position information on 4.4.10 “e. Position window”)
 - All the contents are located between “POSITION” and “POSITIONEND” keywords.
 - The information saved in the section is:
 - “Start position” of chip
 - Tool positions for vision processing, UV curing, etc.
 - ROTATIONCENTER
 - It contains the information for the center of rotation of the stage assembly in ThZ direction for the alignment.
 - The section is located between “ROTATIONCENTER” and “ROTATIONCENTEREND”.
 - The calculation is described and supported in “Calculate_rotation_center_Rev.02.html”.

- SETUPOPERATION
 - It contains a series of commands for the setup process. Also “Number of repetition” is defined in this section for the loop operation.
 - The section is located between “SETUPOPERATION” and “SETUPOPERATIONEND” keywords.
- LOOPOPERATION
 - The section contains a series of commands for repetition process.
 - The section is located between “LOOPOPERATION” and “LOOPOPERATIONEND” keywords.
- INTERLOOPOPERATION
 - It contains a series of commands run between each loop.
 - It is located between “INTERLOOPOPERATION” and “INTERLOOPOPERATIONEND” keywords.
- POSTPROCESSING
 - It contains a series of commands run after the loop operation.
 - The section is located between “POSTPROCESSING” and “POSTPROCESSINGEND” keywords.
 - The contents of sections(“SETUPOPERATION”, “LOOPOPERATION”, “INTERLOOPOPERATION”, “POSTPROCESSING”) are shown in the sequence manager window when the file is loaded.

4.4.15. Measurement_Calibration.ini

- FILENAME: Measurement_Calibration.ini
- LOCATION: ./System/Device/



```

Measurement_Calibration.ini

[POWERMETER]
CAL1=..
...
CALx=.. (x=1,2,3,...,n...)
[CURRENTMETER]
CAL1=..
...
CALx=.. (x=1,2,3,...,n...)
  
```

Fig. 6.7 Measurement_Calibration.ini

- The calibration data of power/current readings is saved in this file, which is shown in the data monitoring window in the GUI. The data for the optical power readings are found in the section [POWERMETER], [CURRENTMETER].

4.4.16. Mc_stageinfo_table.ini

- FILENAME: mc_stageinfo_table.ini
- LOCATION: ./System/MC/

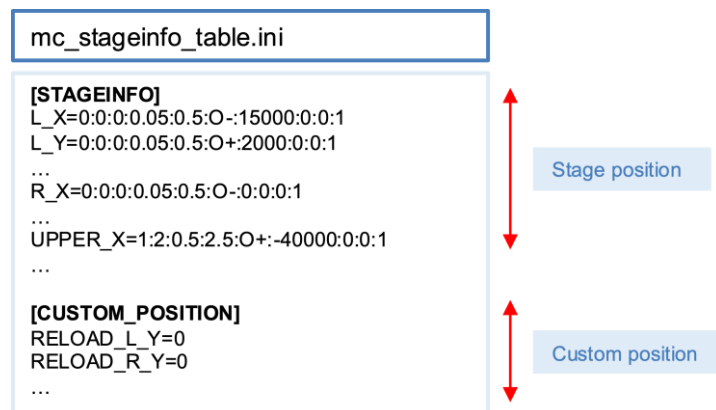


Fig. 6.8 mc_stageinfo_table.ini

- This file includes information on all the stages used in the system. The file consists of two sections. The first section “STAGEINFO” includes the connection between the specified stage and the motion controller, stage setting information, etc. The second section “CUSTOM_POSITION” includes the absolute position the stages move to when “RELOAD” command is executed.
- **[WARNING]: Changing this file with inappropriate values can cause critical problems such as stage collisions. Consult FIBERPRO before changing this file.**
- “STAGEINFO”
 - Format: [Stage-Name]=[BoardNum]:[AxisportNum]:[DistancePerPulse]:[Backoff]:[OriginType]:[OriginOffset]:[HomePosition]:[Reverse]:[Usable]:[Mirror]:[LowLimit]:[HighLimit]
 - Items:
 - [StageName]: the name of the corresponding stage (*Supported stage name: Check the programming manual.)
 - [BoardNum]: The board number of the motion controller(SC7000) the stage is connected to.
 - [AxisportNum]: The port number of the motion controller board which the stage is connected to. It ranges 0 ~ 3.
 - [DistancePerPulse]: distance in um or angle in degree which the stage moves by one control pulse.
 - [Backoff]: distance for backlash compensation
 - [OriginType]: Homing type (Origin type). There are four different types O+, O-, L+, L-
 - “O+” = Homing with origin sensor. moving direction is “+”
 - “O-” = Homing with origin sensor. moving direction is “-”
 - “L+” = Homing with “+” Limit sensor.
 - “L-” = Homing with “-” Limit sensor.
 - [OriginOffset]: Distance to move before start homing process.
 - [HomePosition]: Coordinate to move after homing process finishes
 - [Reverse]: Flip logical moving direction (FORWARD, BACKWARD direction is switched when this value is 1. (0: not reverse, 1: reverse)
 - [Usable]: Set the stage is usable or not (0: not use, 1: use)
 - [Mirror]: Flip sign of the absolute position (0: not mirror, 1: mirror)
 - [LowLimit]: lower software limit position.
 - [HighLimit]: higher software limit position.
- “CUSTOM_POSITION”

- Format – [RELOAD_STAGE_NAME]=[ABS Position]
- Items: [RELOAD_STAGE_NAME]: stage name to be used by Reload command (*Supported stage name: [Check the programming manual.](#))
- [ABS Position]: absolute coordinate to move

4.4.17. Macro file

- FILENAME: “Macro Name”.ini
- LOCATION: ./System/Device/

```
Seqmacro.ini

MACRO_SET: 1,2,3,...

<MACRO_BEGIN>
MACRO_NAME: MACRO1
MACRO_ID: 1
COMMAND A
COMMAND B
...
<MACRO_END>

MACRO_NAME: MACRO2
MACRO_ID: 2
COMMAND C
COMMAND D
...
<MACRO_END>

MACRO_NAME: MACROx
MACRO_ID: x (x=1,2,3,...)
COMMAND F
COMMAND G
COMMAND H
...
<MACRO_END>
```

Fig. 6.9 Seqmacro.ini

- The software supports macro function that a user can prepare a series of commands and run with a simple command or through UI.
- The software loads “seqmacro.ini” file to set basic macro functions. The user also can load a macro file by using the “LoadMacro” button of “Macro Button” tab in the control panel window.
- “MACRO_SET”
 - Assign the macros to the macro buttons in the GUI.
 - “MACRO_SET:4,5” assigns the macro 4 to the button 1, macro 5 to the button 2.
- Defining a macro
 - A macro is defined between <MACRO_BEGIN> and <MACRO_END> keywords.
 - A macro starts with “MACRO_NAME” and “MACRO_ID”. The “MACRO_ID” number and the “MACRO_NAME” value must be unique through a file.
 - MACRO_ID: Unique number of a macro
 - MACRO_NAME: Unique name of a macro. It is also shown in the corresponding macro button.
 - Put a series of commands to run in a row to be run with each macro.

6.3. Tower lamp signal

Condition	Tower lamp color		
	RED	YELLOW	GREEN
	Operation type		
Condition	BLINK/OFF	BLINK/OFF	ON/OFF
Emergency button pushed	BLINK	OFF	OFF
Stage stop button pushed low displacement sensor value Contact sensor enabled	OFF	BLINK	OFF
UV lamp is ON.	OFF	BLINK	ON
Normal operation	OFF	OFF	ON

6.4. Rotation center

4.4.18. Stage assembly with edge coupling fixture

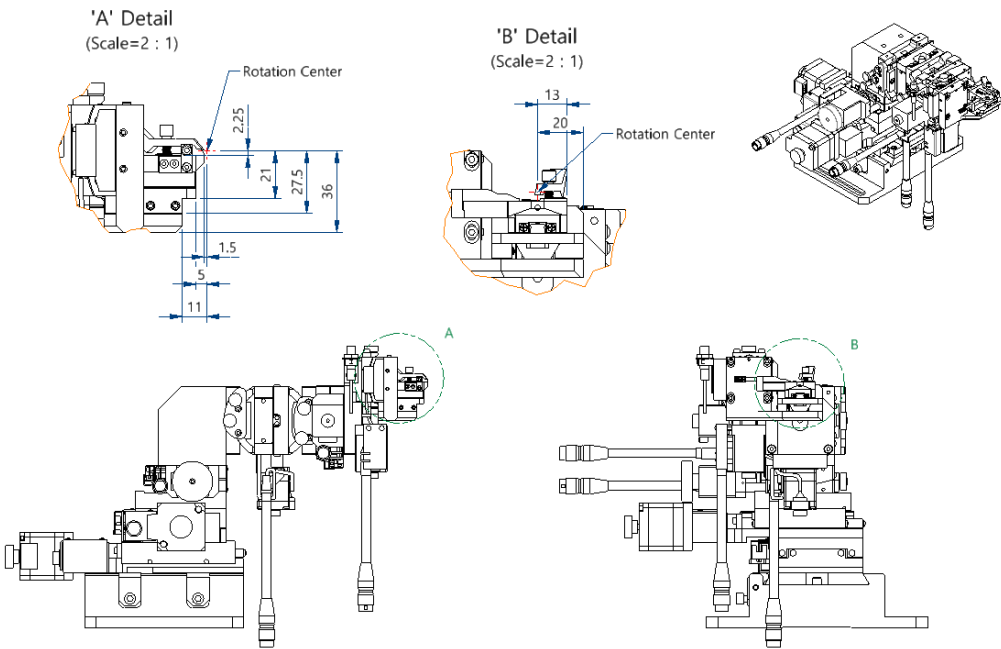


Fig. 6.10 Rotation center for edge coupling fixture

4.4.19. Stage assembly with vertical coupling fixture

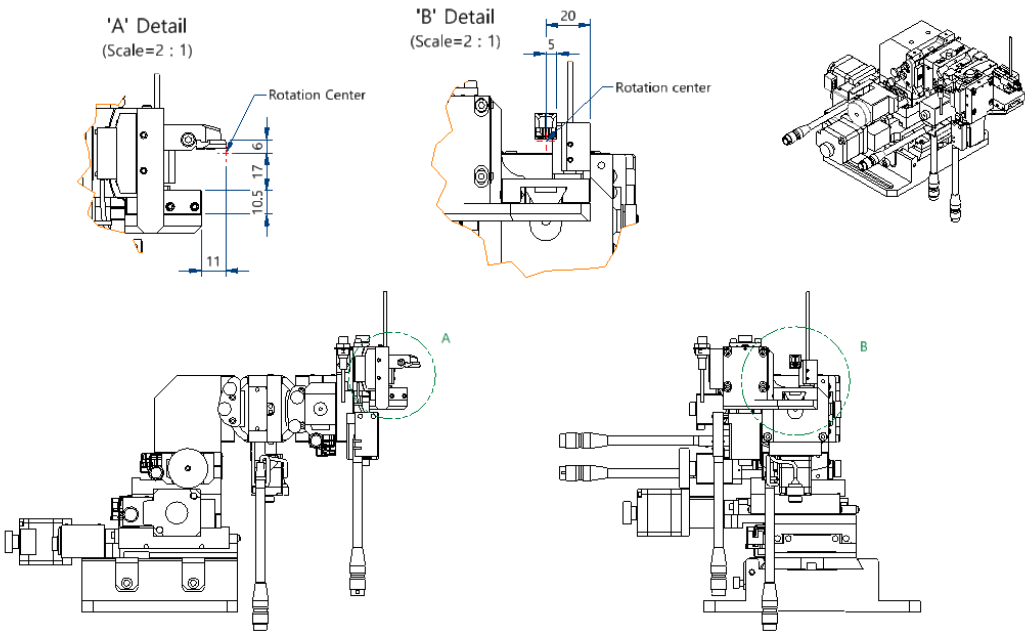


Fig. 6.11 Rotation center for vertical coupling fixture

6.5. UV beam intensity profile

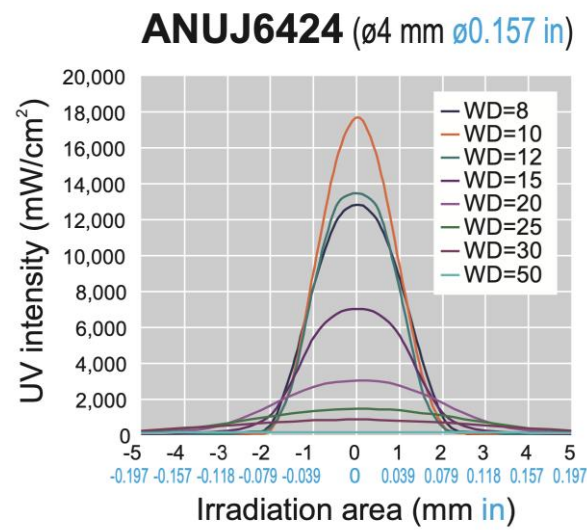


Fig. 6.12 UV beam intensity profile (ANUJ6186+ANUJ6424)

6.6. FIBERPRO limited warranty

FIBERPRO warrants its products to be in conformance to mutually agreed upon written specifications and to be free from defects in material and workmanship. **FIBERPRO**'s product warranty provides a warranty on all products for a period of 12 months. The above warranty period shall begin on the date of shipment by **FIBERPRO** to the Buyer or, if the Buyer is an authorized retailer of such **FIBERPRO** products; from the date of shipment by the retailer to the retailer's original customer. The warranty shall apply solely to products that have been shown to function properly under instructions specified within the user manual, but malfunction due to defect with part(s) installed within the instrument or defect with the instrument itself. The warranty shall not apply to product failure or deficiency caused by misuse, abnormal or excessive use, neglect, alteration, improper installation, unauthorized repair or modification, improper testing, or failure to follow instructions on the user's part. The warranty shall only apply to products and software provided by **FIBERPRO**, and shall not apply to services provided by **FIBERPRO**. In the case of buying **FIBERPRO**'s products through a separate company, **FIBERPRO**'s warranty shall not apply to the pertaining product and **FIBERPRO** shall have no liability in compensation for damages in the case where the product is beyond repair. Replaced products and parts shall become the property of **FIBERPRO**. This warranty applies to all products that the buyer purchases from **FIBERPRO**, except for cases where a separate warranty agreement is made on a product, which will then have priority. Cables and other accessories shall not apply in the product warranty.

During the warranty period, in the case of an instrument malfunction during normal use due to defect with parts that affect the quality or performance of the instrument, the buyer can receive free of charge repair service. Also, if during normal use, the same part that **FIBERPRO**'s engineer has repaired is damaged again, the buyer may receive free of charge repair for that part within the next 12 months (this period starts on the date the part has been repaired by **FIBERPRO**).

The buyer may receive Charged Repair Service in the following cases. a) In the case where the warranty period has expired, b) In the case of malfunction due to unauthorized alteration/modification on the user's part, c) In the case where the buyer removes a "DO NOT OPEN" sticker and dismantles or opens up the instrument, regardless of the warranty period, d) In the case where after initial installation, a malfunction occurs when the buyer attempts to connect an additional product or attempts to reconnect the same product, e) In the case where a third party company's product has been purchased and the buyer requests installation, f) In the case where reinstallation is required due to the buyer moving the product, g) In the case where malfunction occurs due to a third party company's product (including softwares), h) In the case where malfunction occurs due to the buyer's negligence of the warning and caution items described in the user manual, i) In the case where malfunction occurs due to user's misuse of electrical capacity, j) In the case where a malfunction occurs due to usable or optional parts not designated by **FIBERPRO**, k) In the case where malfunction occurs due to repairs made by engineers other than those from **FIBERPRO**, l) In the case where malfunction occurs due to external shock or fall, m) In the case where malfunction occurs due to natural calamities (lightning, fire, earthquake, storm/flood, etc.), n) In the case where the lifecycle of a usable part has ended.

FIBERPRO's Service shall be handled by **FIBERPRO**'s technical support team, and user repair or replacement orders for a product must be filed to **FIBERPRO**'s Quality Control Team. In the case where the buyer wishes for an on-site service, buyer will be charged the travel fee according to **FIBERPRO**'s conditions and will then be able to receive on-site service.

In-house Service takes the form of the buyer sending in the product to **FIBERPRO** for repair. If the product is under warranty and the malfunction is due to a defect with the product, repair will be provided free of charge. In the case of paid repair, the fee will follow **FIBERPRO**'s fee structure. For all cases including: when the user sends a defective product under warranty for in-house repair free of charge, when the user sends a user-caused defective product under warranty for in-house repair for charged repair, and for all other in-house charged repair service, the user and **FIBERPRO** will share the burden of shipping once each.

In the case of a product defect within the warranty period, On-site service will be provided free of charge. In the case of paid repair, parts fee, repair fee, travel fee, and examination fee will be charged according to **FIBERPRO**'s fee structure. However, even in the case that the product is still under its warranty period, if the malfunction is due to misuse or other reasons outlined above under paid repair, then a fee will be charged according to paid service fee structure.

If the product malfunctions within one month of purchase, it will be considered DOA (Dead On Arrival) and will be given top priority in warranty service repair.

FIBERPRO's warranty as set forth above shall not be enlarged, diminished or affected by, and no liability shall arise out of, **FIBERPRO**'s rendering of technical advice in connection with the buyer's order. The warranty set forth above is not assignable by the buyer. The buyer's sole remedy under the above warranty shall be repair or replacement as provided above.

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